Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
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Lecture - 15
Renewable Energy Engineering

Good morning everyone and welcome to this course on renewable energy engineering today is the first lecture of module 6. So, content of the module 6 lecture 1 are shown here on the screen classification of energy resources, biomass and its broad classification, composition of biomass. Let us first discuss what is mean by energy.

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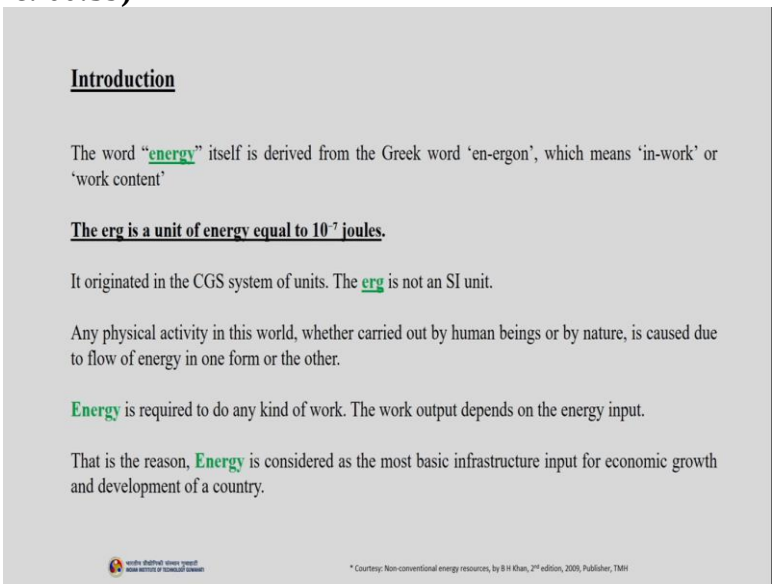

The word energy itself is derived from the Greek word en ergon which means, in work or work content, the erg is unit of energy and is equivalent in Joules is 10 is to power -7, it originated in the CGS system of units. The erg is not an SI unit, any physical activity in this world, whether carried out by human beings or by nature is caused due to flow of energy from one form to other. Energy is required to do any kind of work; the work output depends on the energy input. That is the reserve energy is considered as the most basic infrastructure input for economic growth and development of a country.

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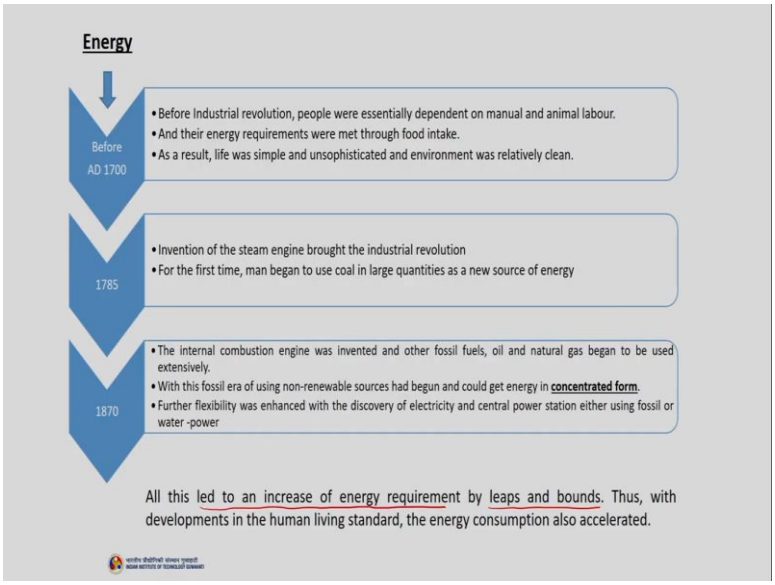

Before the industrial revolution, which started around 200 years ago, people were essentially dependent on manual and the animal labour and their energy requirements were met through food intake. As a result, life was simple, unsophisticated, but the environment was relatively clean, then, in 1785, the invention of steam engine by James Watt of Scotland brought the Industrial Revolution.

It was the beginning of mechanical age, the advent of internal combustion engine in the late 19th century brought further momentum to this trend, the internal combustion engine was invented with that, other fossil fuels such as oil, natural gas began to be used extensively with this fossil era of using non-renewable resources had begun and could get energy in the concentrated form.

Further flexibility was enhanced with the discovery of electricity and central power station either using fossil and water power. All these lead to an increase of energy requirement by leaps and bounds does with development in the human living standard, the energy consumption also accelerated.

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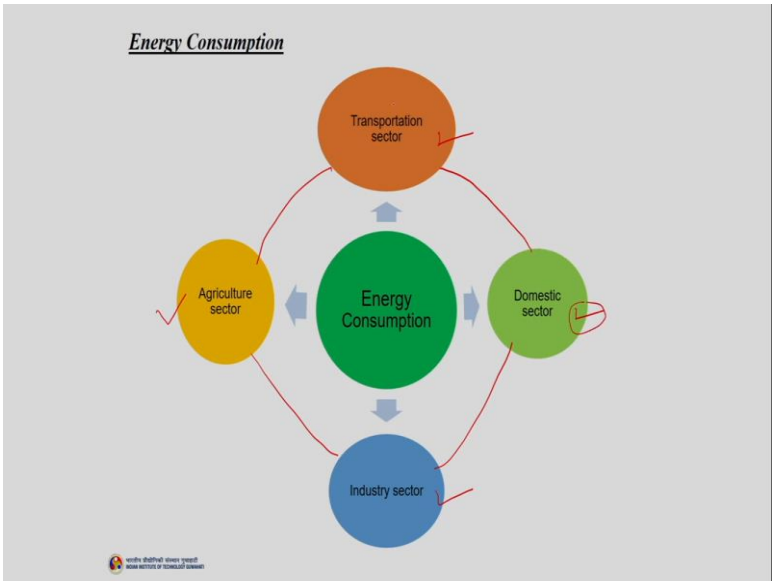

Energy consumption of a nation can broadly classified into following 4 sectors or areas depends on energy related activities. The sectors which contribute the large amount of energy consumption, the first one is the domestic sector, transportation sector, agriculture and industrial sector, the consumption of large amount of energy in a country indicates increased activities in all these 4 sectors. This implies sophisticated life due to use of various appliances at home, better transportation facilities, more agriculture and industrial production.

All these amounts to a better quality of life to match the energy consumption, demand of all this sector, certain renewable energy sources are required, which can fulfil the energy demand of all these sectors.

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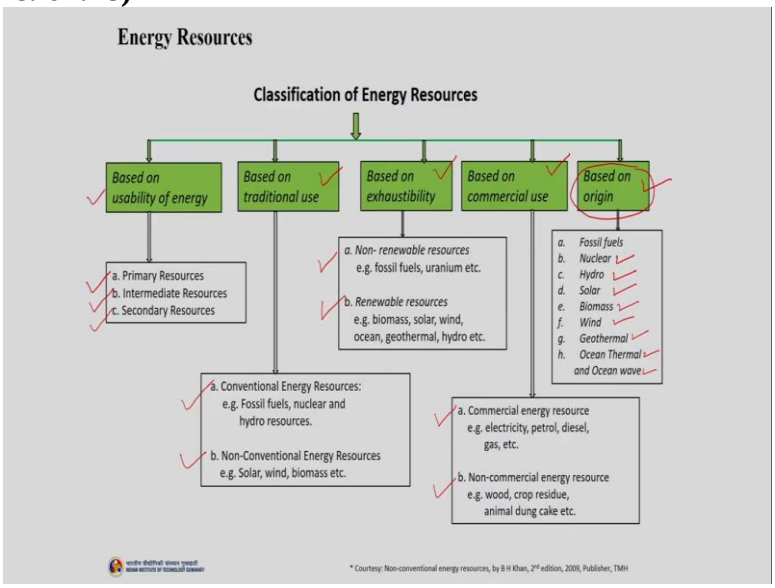

The energy resources, which are broadly been used for the large-scale production of energy are classified in the following way. First, which is based on usability of energy second, based

on traditional use, based on exhaustibility of energy based on commercial use and at last, which is nothing but the based-on origin. So, let us discuss these classifications and further their sub classification one by one.

Based on usability of energy, it is further sub classified as primary energy resource, intermediate energy resource and secondary energy resource. Now, if you try to see based on the traditional uses, it is sub classified as non-conventional energy resource and conventional energy resource based on exhaustibility it is further classified as non-renewable energy resource and renewable energy resource based on commercial use, it is sub classified as commercial energy resource and non-commercial energy resource.

Now, at the last if you see the last classification, which is based on origin under this classification, it is sub classified as fossil fuels, nuclear, hydro, solar, biomass, wind, geothermal, ocean thermal and ocean wave energy. Now, if you just try to see all these resources, these are combined together under the single umbrella based on the origin because, here the sub classification has been done based on the origin of the resources. As a result, all these are clubbed into a single sub classification under the category of based on origin. Let us discuss these resources one by one.

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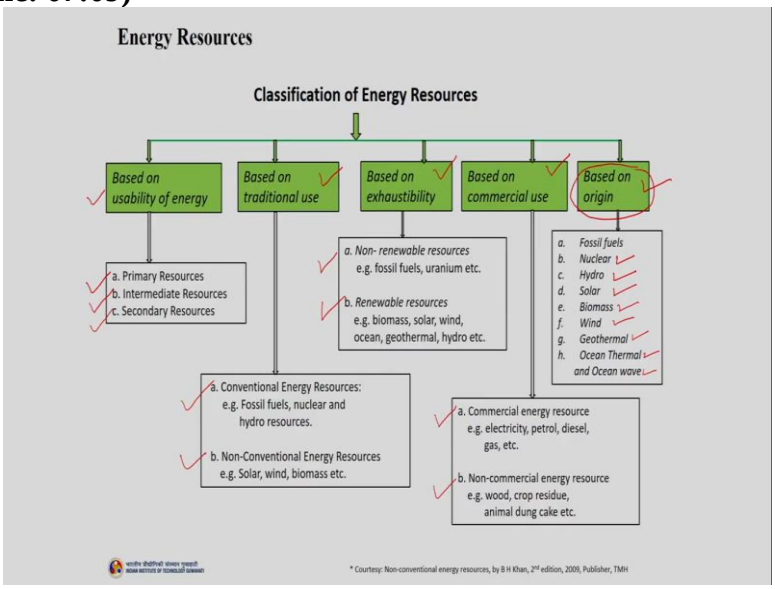

Based on usability of energy, so, let us discuss first the primary resource. This form of resources are embedded in nature before undergoing any human made conversion or transformation. The example of these resources are coal, oil, solar, wind, hydro etcetera.

These resources are generally available in its raw form in nature. And these are called as raw form of energy.

Generally, these resources cannot be used directly for utilization purpose, because these resources first need to be located, explored, extracted process and further converted into a form as required by consumer further utilization does some amount of energy is spent in making these resources and conversion of these resources into a usable form that is called as energy yield ratio.

The energy yield ratio of resources is defined as the energy obtained from raw energy source divided by energy spent to obtain this raw energy source, the energy yield ratio of any resource is not fairly high, then it is considered as not worthy of exploration. Hence, the energy, yield a ratio of a resource should be substantially high, which can be further utilized for the production of energy.

Let us consider the example of coal, oil or you can say uranium the energy spent in recovering these particular resources is relatively less than what they can produce by combustion or chemical reaction. And that is why these resources are considered as worthy of exploration and further utilization for the energy purpose. Second is intermediate energy resource. This form of energy can be obtained from primary energy resources by one or more steps of transformation and is used as vehicles of energy.

The third sub classification under this category is secondary resources. The form of energy which is finally supplied to a consumer for the utilization is called as secondary energy resource or usable energy. The example of these resources, are electrical, thermal and chemical. In thermal to be specific, we talk about here the steam and the heat energy and in chemical we talk about hydrogen and fossil fuel energy.

Now, let us see the next classification that is based on traditional use, it is further sub classified as conventional energy resource and non-conventional energy resource the energy resources which are traditionally being used for many decades and were in common use during the oil crisis of 1973 are termed as conventional energy resources. The example of these resources are fossil fuels, nuclear, hydro resources, uranium etcetera.

Now, let us talk about the non-conventional energy resources. The energy resources which are being used for large scale use after the oil crashes of 1973 atom as non-conventional energy resources and an example of these resources are solar, wind, biomass etcetera.

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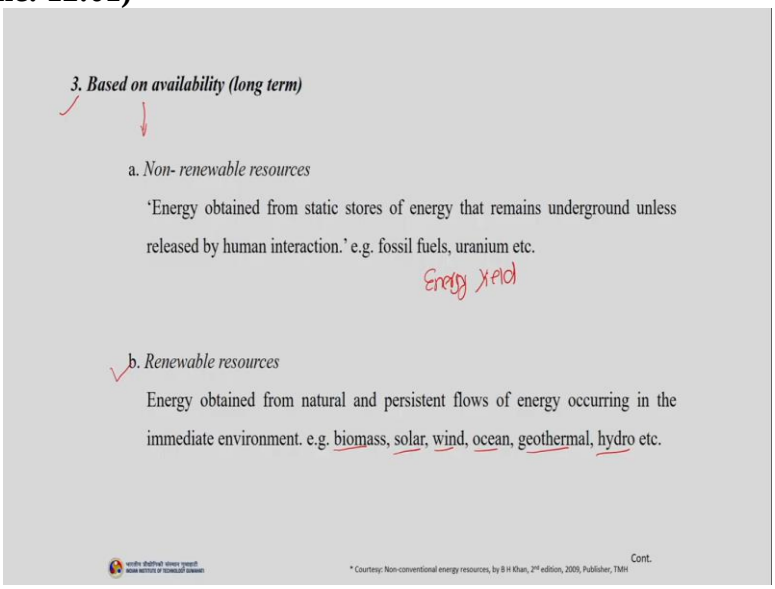

Now, let us discuss the next classification that is based on the availability. So, these are further sub classified as non-renewable energy resources and renewable energy resources, energy obtained from static source of energy that remains underground unless released by human interactions are termed as non-renewable energy resources, examples are fossil fuels, uranium, etcetera.

Please note that the energy in this case is initially an isolated energy potential and external action is required to make it available for the utilization purpose. So, the energy which we spend to recover this source of energy is relatively less compared to the energy which we obtained from these resources. So, as a result, the energy yield ratio for these resources is substantially high.

That is why these resources are considered as worthy of exploration. Now, let us discuss about the renewable energy resources, energy obtained from natural and persistent flows of energy occurring in the immediate environment. And the obvious examples of these kinds of resources are biomass, solar, wind, ocean, geothermal and hydro. In this case, please note that the energy is already flowing in the environment as a form of current or flow irrespective whether being a device or intercept to harness this energy.

That means, there is particular energy resources are continuously flowing in the environment as a current or flows. So, that is the reason these energy resources are called as green sources of energy or we can say that renewable energy resources. So, to better understand that, these 2 terminologies will just try to elaborate our discussion in more, better way using these 2 schematic representations here.

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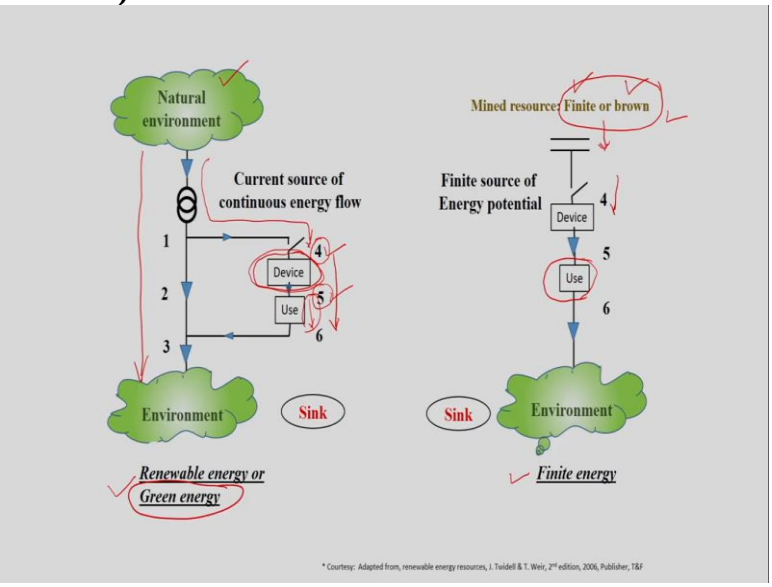

So, first schematic representation it represents the renewable energy or green energy and the second it indicates the finite source of energy. So, now, let us discuss first of all about the finite sources of energy in use requirement of this energy it varies with time. So, for example, if you see here, I mentioned here the use that is nothing but the end use requirement of this energy and it always varies with time.

For example, we can see that the energy requirement in the morning and in the evening, hour is relatively high compared to in the night or you can say throughout the night, as a result, if we see the energy production from this finite energy resources, so, we can control the supply of these resources and accordingly, we can produce the energy as per the demand. So, that means, we can better control the supply as well as the demand of these kind of resources by using the supply chain management.

As a result, we can see that the control of this device can be done very effectively and efficiently without allowing any wastage of energy or we can say that, the energy will remain stored in this field itself say energy will remain stored in this finite resource itself. However,

if you take the example of natural energy in the environment, we can see that, as I mentioned in the previous slide.

These kinds of energies are already flowing in the environment like this irrespective of whether we are keeping any device or intercept to hardness this energy. Now, suppose, if you try to put a device to hardness this energy source, here, we can see that also the end use is uncontrollable. Similarly, the supply of these resources is also uncontrollable. Adhesive mean that these resources and their supply is not predictable.

We cannot predict the supply of these resources throughout the day whether it will remain constant or not. Similarly, we cannot make sure that the sunshine throughout the day will remain constant. On the other hand, you cannot ensure that the supply of wind or you can say the wind flow will remain constant throughout the day, it always varies with the time as a result, the supply itself is uncontrollable.

As a result, because we know the end use of this particular energy is also uncontrollable. So, we need to have a device to match the demand, which can counter the supply as well as the demand as shown here in step number 4 and 5, which need to be met dynamically so as the result the energy which we obtain from this natural energy source is obviously a green energy.

Whereas, if you see here, the finite source of energy utilization of these resources causes extra burden to the environment and hence, these resources are called as finite and brown energy resources. I think with this it is more, clear now, what is the difference between the renewable energy resources and non-renewable energy resources, which are also termed as finite energy resources. Now, let us discuss about the next classification that is based on the commercial application.

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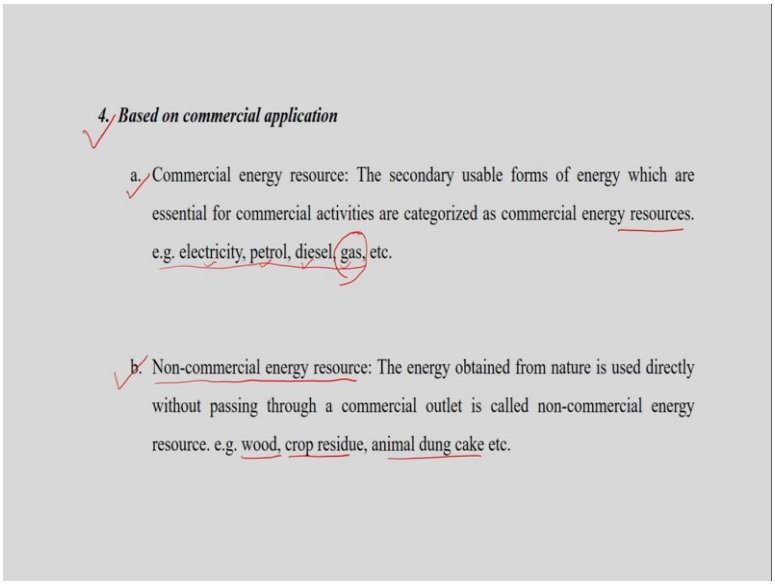

So, it is further sub classified as commercial energy resources and non-commercial energy resources. So, let us discuss first of all about the commercial energy sources. The secondary usable forms of energy which are essential for commercial activities are categorized as commercial energy resources. The example of these resources are electricity, petrol, diesel and gas as the commercial outlet of this energy resources are already in place.

And these are available at the commercial outlet. That is why these resources are called as commercial energy resources. Now, let us talk about the non-commercial energy resources. The energy obtained from nature is use directly without passing through a commercial outlet is called non-commercial energy resource. And the examples are wood, crop residue, animal dung cake extra.

As these resources are not available at commercial outlet for the distribution. That is the reason these are termed as non-commercial energy resources. These resources are generally used to fulfil the local energy demand. And that is why these resources are called as non-commercial energy resources. So, now, next classification is based on origin. So, as I already discussed in the previous slide, based on origin.

We have sub classified all the resources under the single umbrella that is nothing but based on the origin and these are nothing but nuclear energies, fossil energies, solar energy, wind energy, geothermal energy, oceanic energies and ocean wave energy.

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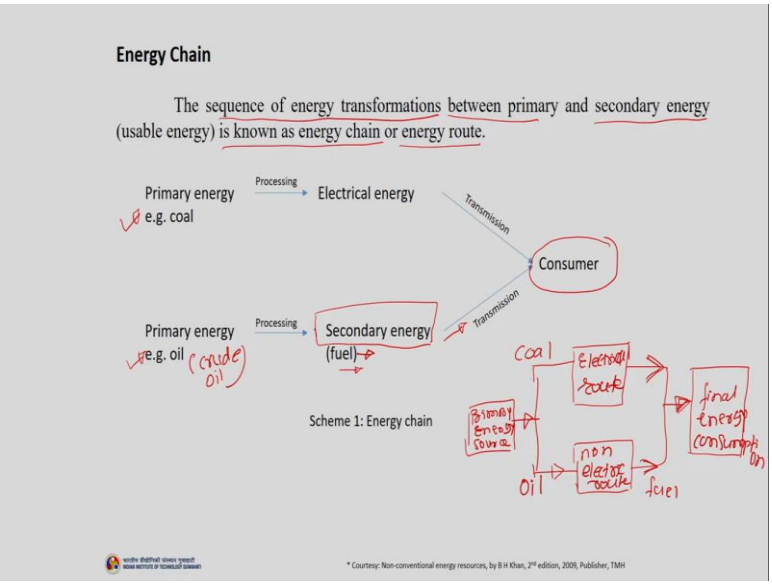

So, now, let us see the next topic of discussion that is energy chain. Generally, but not always the primary energy resources cannot be used directly for the utilization purpose. For example, suppose if we use coal or we can say uranium or biomass directly to drive a motor, so, it is not possible to drive a motor with coal or biomass or uranium directly. So, as a result, these particular resources first need to be transformed to convert it into a usable form of energy.

And once it gets converted into a energy, this particular resources can be used effectively for the utilization purpose. Therefore, the sequence of energy transformation between the primary and secondary energy resources is known as energy chain or energy route. So, let us try to understand this concept using this particular slide. If you see here, I have first given the example of core.

Which is nothing but also termed as primary energy source for coal while passing through a various conversion or you can see a transformation steps it gets converted into electrical energy once electrical energy is produced, it is transferred to a consumer for the utilization purpose. Now, let us see a second example, which are highlighted here as oil. So, the oil which is nothing but I would say here crude oil.

With the help of crude oil, we cannot run vehicle directly or that reason the crude oil need to be process using several transformation stages once we transform the crude oil into a pure fuel that particular fuel, which is again nothing but the secondary energy source it can be transferred to a consumer for the utilization purpose. So, with these 2 examples, we can understand that what is the difference between the primary, secondary energy resources.

And how these particular resources are utilized by the consumer for the utilization purpose all these term as energy chain. So, to make you better understand about this concept, let us try to take a simple example to understand this concept in a better way. Say for example, we have primary energy source. So, once we have the primary energy source depends on the source available.

It can be converted into a usable form of energy by 2 different routes. So, for example, if you see here, we have drawn a single energy chain diagram that is, which explained about the utilization of energy for consumption. So, if you see here the primary energy source first take example of support coal. So, if you transform this coal from primary energy source to a secondary energy source which is nothing but you can say electric route electrical.

So, the coal during this transformation stage converted into a secondary energy which is nothing but coal, because mostly we use coal for the either thermal energy or for the production of the electrical energy. So, once the electrical energy is available, then it is transferred to the consumer for final utilization purpose. Similarly, if you try to take the example of oil that is nothing but the crude oil as I mentioned in the slide.

So, the primary energy source which is crude oil, once you transform it through non electric route it converts into a fuel and once the pure fuels are available for the utilization, this particular resource is transferred to consumer for the utilization purpose. So, this entire process is called as energy chain. So, now, with the help of this energy chain, we can understand that the difference between also the primary energy source and the secondary energy source.

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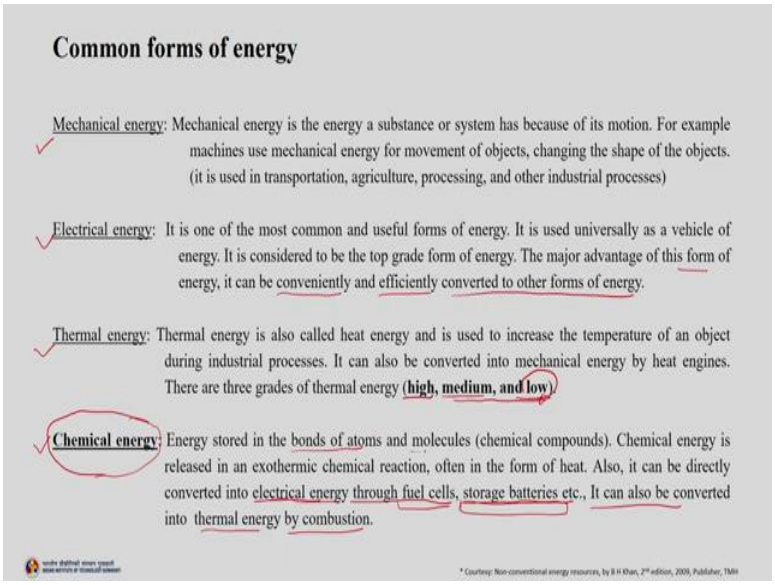

So, the next let us discuss about the common forms of energy. The common forms of energy can also be classified in the following way. The first is mechanical energy, mechanical energy is the energy or substance or a system has because of its motion for example, machine use mechanical energy for movement of the objects changing the shape of objects, it is used in transportation, agriculture, processing and other industrial processes.

So, the next classification under this category is electrical energy, it is one of the most common forms of energy it is used universally as a vehicle of energy, it is considered to be one of the top great form of energy. The major advantage of these forms of energy is it can be conveniently and efficiently converted to other forms of energy and that is the reason the electrical energy is called as vehicles of energy.

So, the next classification under the common forms of energy is thermal energy. Thermal energy is also called heat energy and is used to increase the temperature of an object during industrial processes, it can also be converted into mechanical energy by heat engines, these are divided into 3 different grades of thermal energy, that is, high grade energy, medium grade energy and low-grade energy.

Let us discuss these 3 grades of energy one by one high grade of energy in case of high grade of energy, the temperature range varies from 500 degrees Celsius to 1000, degree Celsius and it can be easily and efficiently converted into mechanical energy. In case of medium grade energy, the temperature range varies from 105 degrees celsius to 500, degree Celsius. And it

can also be converted into a mechanical energy but not as efficiently as high-grade thermal energy.

The next is low grade thermal energy. In case of low-grade thermal energy, the temperature range varies from 80 to 105, degree Celsius. This form of thermal energy cannot be converted into mechanical energy and is used directly as a thermal energy in an industrial application. The last classification under the common forms of energy is chemical energy. Chemical energy is stored in the bonds of atoms and molecules or we can say chemical compounds.

Chemical energy is released in an exothermic chemical reaction, often in the form of heat. Also, it can be directly converted into electrical energy through fuel cells, storage batteries, extra. It can also be converted into thermal energy by combustion. So, the advantage of this form of energy is substantially high, because it can also be converted into electrical energy with the help of fuel cells, or we can once we store this energy.

We can utilize the energy which is stored in the batteries whenever we require. Similarly, it can also be converted into thermal energy by combustion. And that is the reason in this module as well as in subsequent module, our focus mostly will be on the chemical energy and how to utilize this energy which is available in the bonds of atoms and molecules for neutralization purpose.

With this we can understand that the chemical energy is available in the bonds of atoms and molecules, which we need to extract, so, that it can be further utilized for the practical purposes. So, before going in detailed discussion about the chemical forms of energy, let us first discuss about the importance of the non-conventional energy resources.

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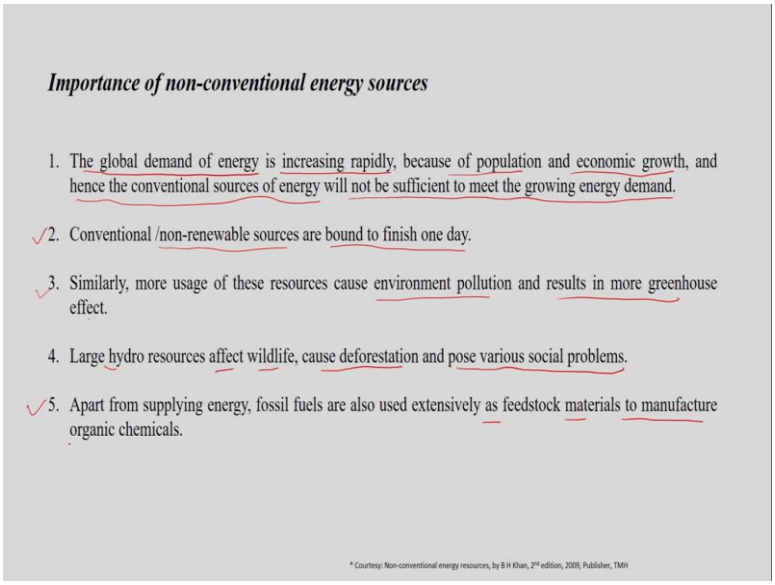

And why we are putting more emphasis on the utilization of these non-conventional energy resources for practical purposes. The first importance of the non-conventional energy resource is the global demand of energy is increasing rapidly because of population and economic growth and hence, the conventional sources of energy will not be sufficient to meet the growing energy demand.

Similarly, if you see the second importance of non-conventional energy resources is conventional energy resources or in the other term, I would say the non-renewable energy resources are bound to finish 1 day. Similarly, more usages of these resources cause environmental pollution and results in more greenhouse effect. Large hydro resources affect wildlife cause deforestation and pose various social problems.

Apart from that, supplying energy from fossil fuels, these resources are extensively as feedstock materials to manufacture organic chemicals. So, due to this reason, it has become important to develop new non-conventional energy resources to reduce too much dependence on the conventional energy resources. However, the recent trend of the development of a non-conventional energy resources indicates that this will serve as a supplement rather than the substitute for the conventional energy resources.

With this will end this particular lecture in the next lecture, which will be a continuation of the lecture 1 only. We will discuss some more topics related to non-conventional energy resources and how to find how to classify the biomass. And also, we will discuss about the composition of biomass.