Energy Conversion Technologies (Biomass and Coal)

Prof. Vaibhav V. Goud

Department of Chemical Engineering

Indian Institute of Technology, Guwahati

Lecture 1

Sources of energy

Good morning everyone and welcome to this course on Energy Conversion Technologies. So, today is the first lecture of module 1. So, the content of this lecture are shown here on the screen.

(Refer slide time: 00:47)

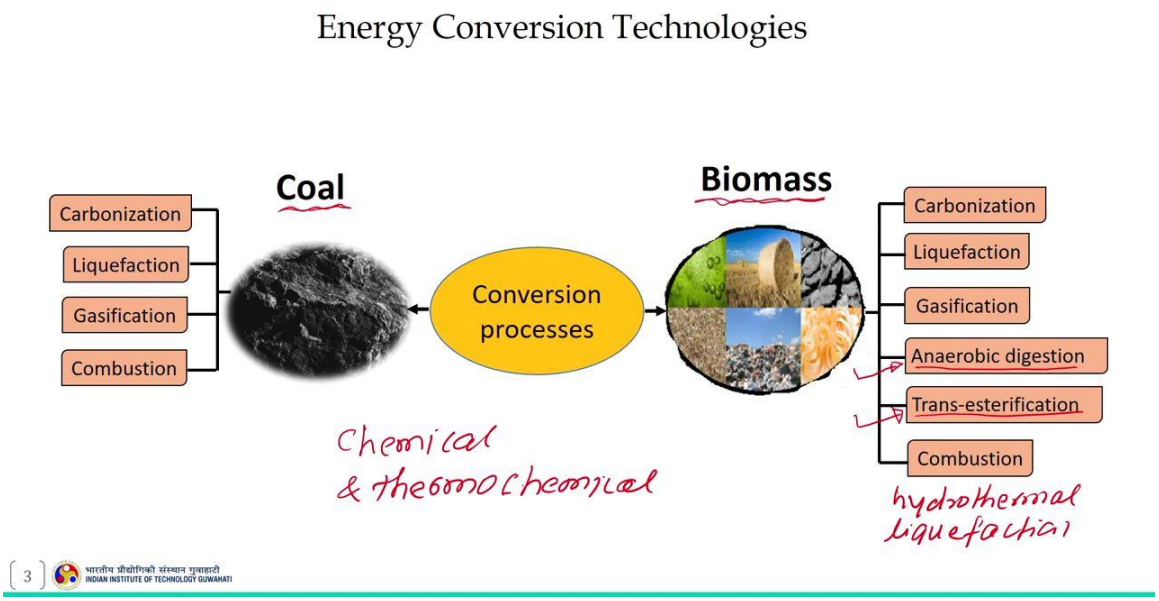
Module	Module Name	Week	Lecture No	Title of the lecture
01	Introduction	1	1 (Part-I)	Sources of energy: Classification of Energy Sources, Energy chain, (primary and secondary energy sources) Major sources of energy

So, in this lecture we will discuss about the sources of energy. In that first we will discuss about the classification of the energy sources followed by energy chain and at the end we will discuss about the major sources of energy. Since the advent of industrialization coal has been the most common source of energy. However, in the last few decades globally there is a switch over from coal to oil as a major source of energy because it is simpler and cleaner to obtain useful energy from oil. But there is a growing concern on utilization

of these resources for sustainable fuel and chemical production because oil production has been constantly decreasing. So, with this increasing scarcity of natural fluid and gaseous energy carriers coal has to be substituted for former computing resource and possibly in the same state of aggregates.

Thus in the recent years much efforts have been made in the field of vulgarization of organic compounds from coal and biomass. Coal as an abundant resource and biomass as an abundant renewable energy resource have been recognized as an increasingly important raw material for sustainable production of fuel and high value chemicals.

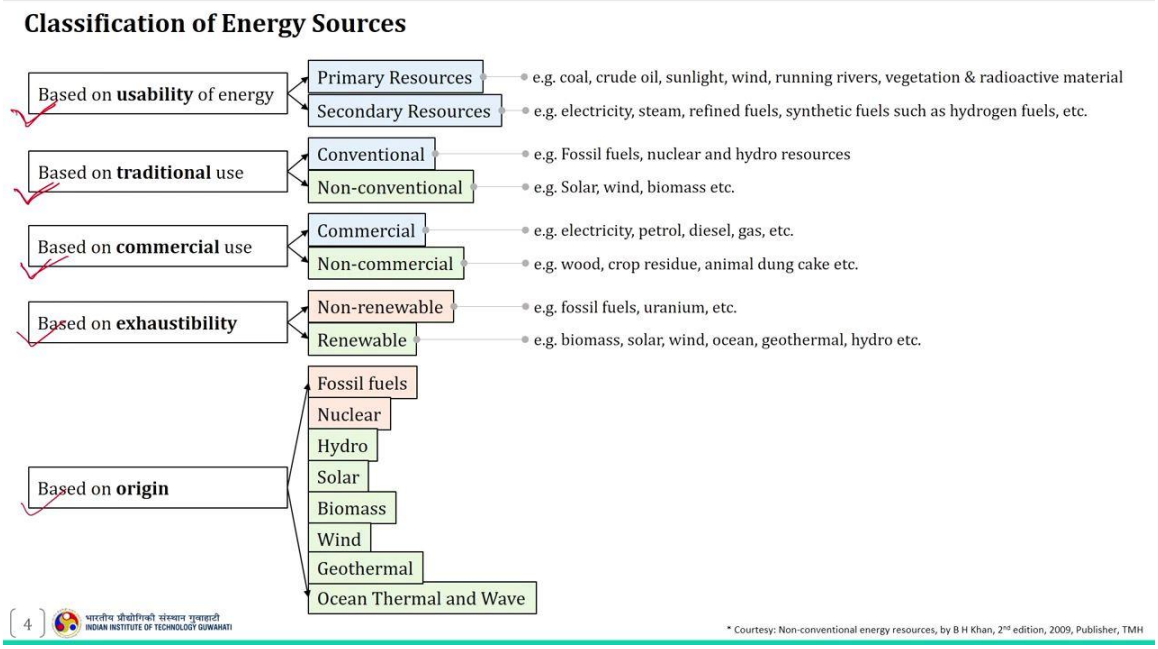
(Refer slide time: 02:19)



So, if you take a look at this particular slide here, it shows that there is a significant similarity between coal and biomass conversion technologies. That too, majorly in the chemical and thermochemical conversion technologies except few technologies which are additionally available for the conversion of biomass to a useful product. And such technologies are anaerobic digestion and transesterification reaction. In the recent year there is one more addition in the biomass conversion technologies is liquefaction.

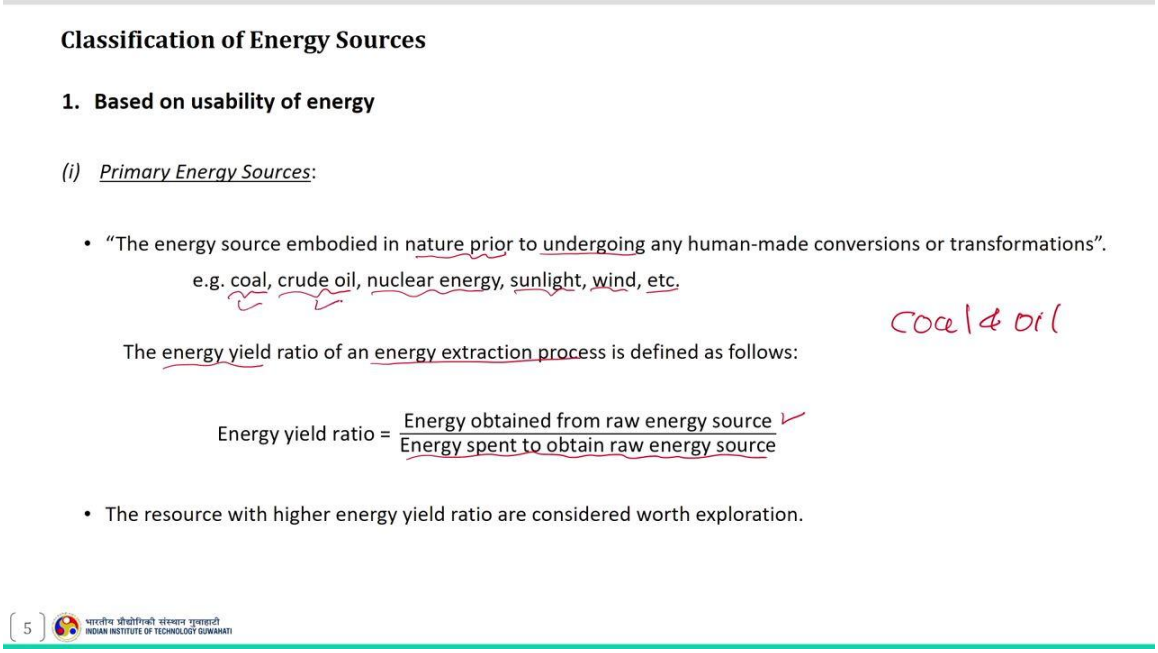
So, all these technologies we will be discussing in detail in this course. So, first we will discuss about the biomass conversion technologies followed by the coal conversion technologies and at the end we will discuss about the integrated energy conversion system. So, to begin with let us discuss about these resources and then we will start our discussion on biomass conversion system.

(Refer slide time: 03:43)



So, let us first discuss about the classification of energy sources. The sources which are broadly being used for large scale energy production are classified in the following ways that is based on usability of energy, based on traditional use, based on commercial use, based on exhaustibility and based on the origin. So, now let us discuss about this classification of energy sources one by one.

(Refer slide time: 04:19)



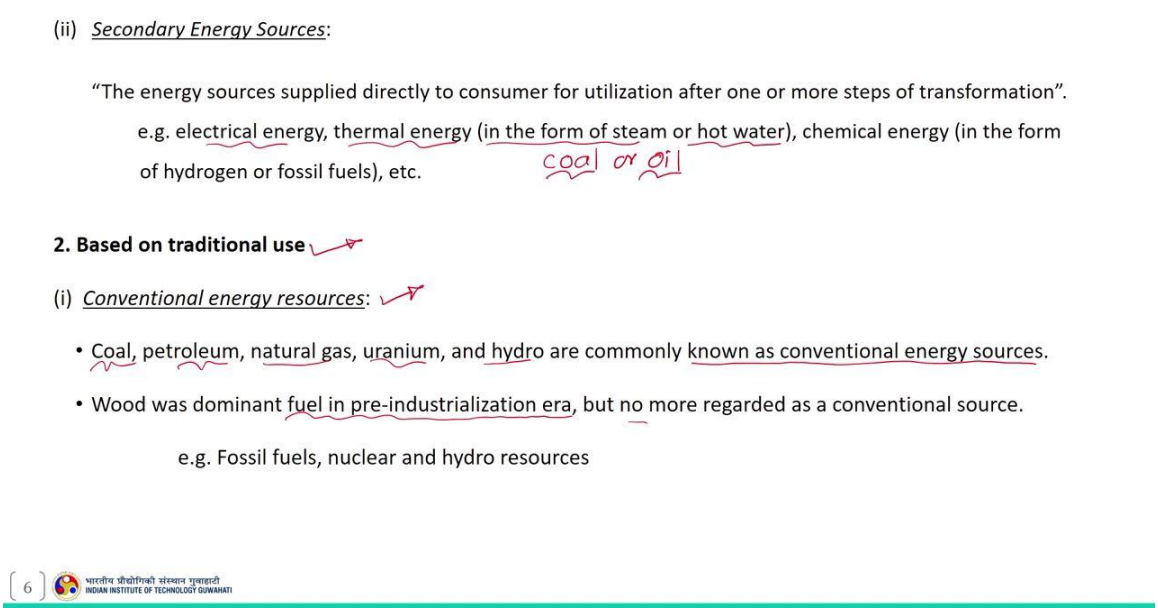
So, to begin with let us start our discussion on based on usability of energy. So, here it is sub classified into primary energy source and the secondary energy source. The primary energy sources. These sources are embedded in nature prior to undergoing any human made conversion or transformation. And the examples of these resources are coal, crude oil, nuclear energy, sunlight, wind, etc. These resources are generally available in the raw form and are therefore known as raw energy sources. Generally these resources cannot be utilized directly as such thus these energy resources first need to be located, extracted, explored, processed and then converted into a usable form required by consumer. Therefore, some amount of energy is spent in making these resources available to a user in a usable form.

So, if you take a look at this particular slide here. So, to understand this concept of primary energy sources, let us take the example of coal and oil. So, the amount of energy spent on recovering these particular resources is relatively less than what it can be obtained by combusting these resources. So, because of that the energy yield ratio of these resources is significantly high and hence these particular resources are considered worth of exploration. So, to understand this concept of energy yield ratio, let us see this

particular equation here, which shows that the energy yield ratio of an energy extraction process is defined as follows.

So, the energy yield ratio is the ratio of energy obtained from raw energy source by energy spent to obtain raw energy source. So, in this case, this particular ratio is significantly high for majorly these kinds of resources and hence these resources are considered worthy of exploration. So, in general only resources for which this energy yield ratio is fairly high are considered worth exploration. So, this is about the primary energy sources.

(Refer slide time: 07:06)



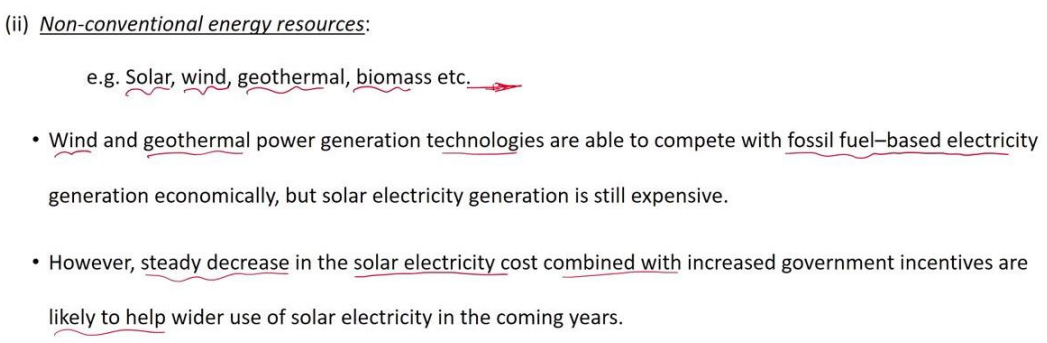
Now if you just discuss about the secondary energy sources here, so the secondary energy sources supplied directly to consumer for utilization after one or more steps of transformation. And the examples of these energy resources are electrical energy, thermal energy. So, in the thermal energy it is mainly in the form of steam or hot water. So, let us discuss about this thermal energy concept in detail here. So, in this case the raw energy source that is either coal or oil undergoes one or two steps of conversion or transformation to produce final product that is in the form of heat and the produced heat

is being utilized either as a process heat in the industries or being used to produce steam. So, as a result here the raw form of energy that is coal and oil got converted into a usable form of product in the form of steam or heat energy.

So, that is the reason this heat produced from the primary energy sources further can be used to produce electricity using one or more steps of transformation. And that is the reason this electrical energy is considered as the secondary energy source. So, now let us discuss about the next classification that is based on traditional use. So, here it is sub classified into non-conventional energy resources and conventional energy resources. So, let us discuss about the conventional energy resources.

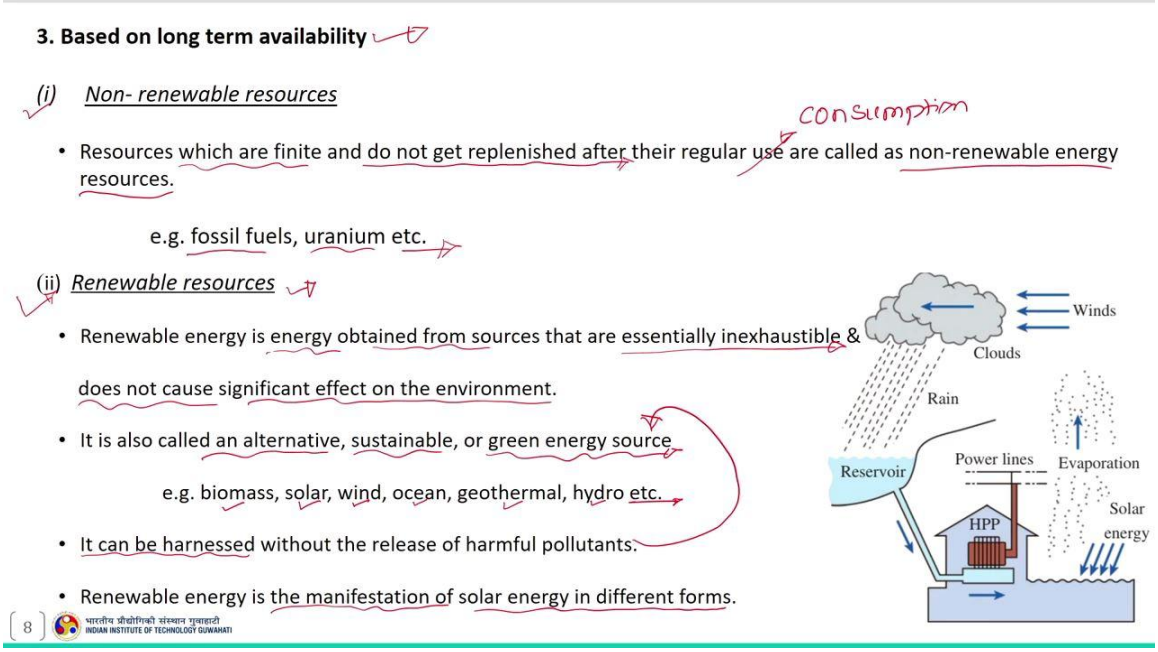
The conventional energy resources are those resources which are traditionally being used for many decades or were in common use around the era of oil crisis are termed as conventional energy resources. Coal, petroleum, natural gas, uranium and hydro are commonly known as a conventional energy sources. Whereas wood was dominant fuel in pre-industrialization era, but no more regarded as a conventional energy resource. So, the examples of these conventional energy resources are fossil fuels, nuclear and hydro resources.

(Refer slide time: 09:50)



So, let us discuss about non conventional energy resources. The energy resources which are considered for large scale production after the era of oil crisis are known as non-conventional energy resources. And the examples of non-conventional energy resources are solar energy, wind, geothermal, biomass, etc. Wind and geothermal power generation technologies are able to compete with the fossil fuel based electricity generation economically, but solar electricity generation is still expensive. However, steady decreases in the solar electricity cost combined with the increased government incentives are likely to help wider use of solar electricity in the coming years.

(Refer slide time: 10:55)



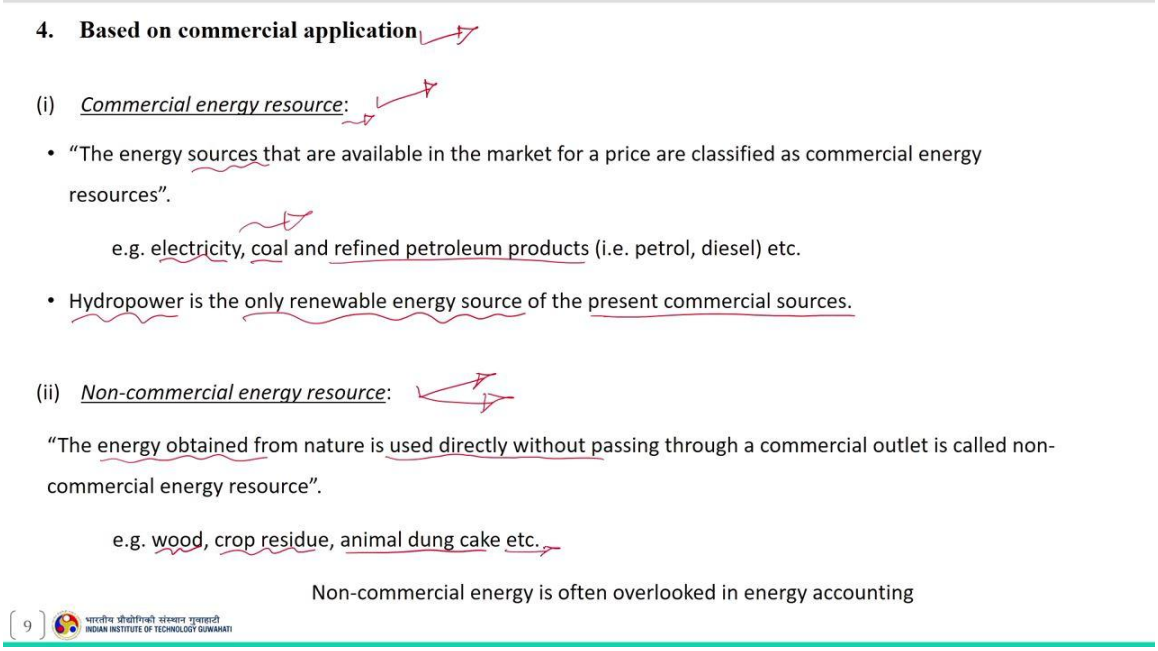
So, now let us discuss about the next classification that is based on long term availability. Here it is sub-classified into non-renewable energy resources and renewable energy resources. So, let us first discuss about the non-renewable energy resources. The resources which are finite and do not get replenished after their regular use. So, rather than use we can say the better word is consumption. So, after their regular consumption are called as non-renewable energy resources and the example of these resources are fossil fuels, uranium, etc. So, another classification under this based on long term availability is renewable resources. So the renewable energy is energy obtained from

sources that are essentially inexhaustible that means the resources which does not get exhausted over its regular consumption and does not cause significant effect on the environment. So these resources are also called as alternative or sustainable or green energy sources. And the examples of these sources are biomass, solar, wind, ocean, geothermal, hydro, etc.

These particular sources can be harnessed without the release of harmful pollutant and because of that these sources are called as green energy sources. So, the renewable energy is the manifestation solar energy in different forms. So, let us discuss about this last point in more detail. So, for example, biomass is produced in nature through photosynthesis achieved by solar energy conversion.

Similarly, if you take an example of wind, wind is also the indirect source of solar energy conversion. So, to better understand this concept of renewable energy source let us take the help of this schematic shown here on the screen. If you look at this particular schematic, solar energy drives this cycle by evaporating water from lakes, ocean and river. The water vapor rises up in the sky to become part of the clouds which will float off with the winds and eventually releasing water back to the earth system by precipitation. So in this particular case if you see here, the water which is lost due to the process of evaporation released back to the earth system by precipitation and because of that this particular source is considered as renewable source.

(Refer slide time: 14:34)



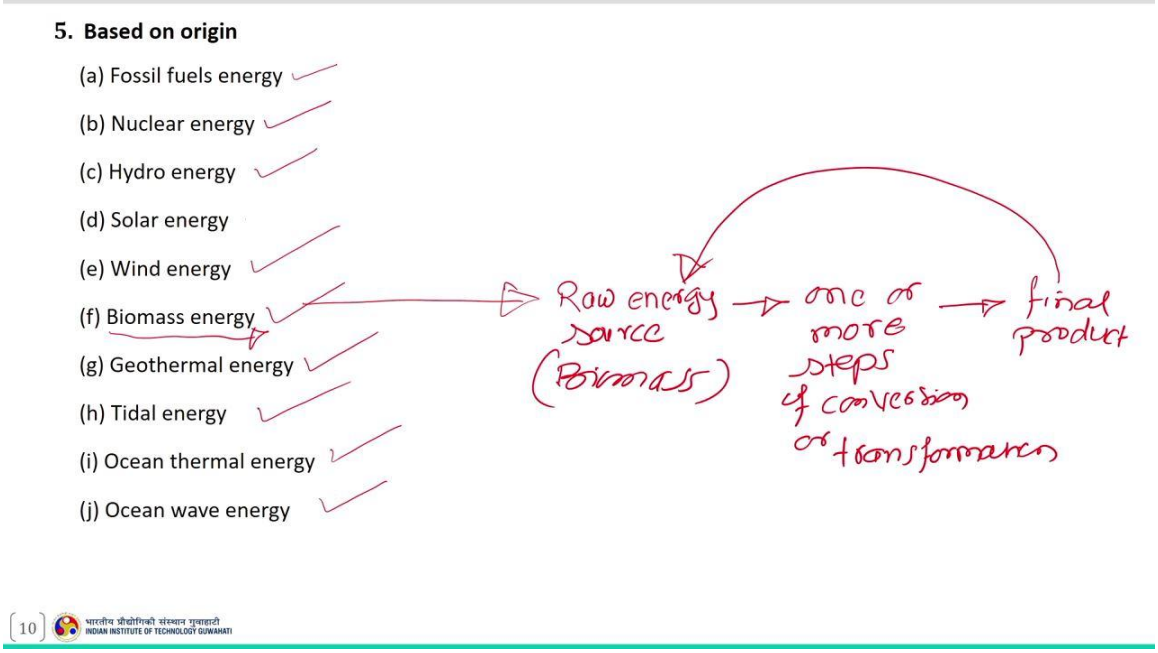
So, let us discuss about another classification that is based on commercial application. Here it is sub-classified into commercial energy resource and non-commercial energy resource. So, let us first discuss about the commercial energy resource. The energy sources that are available in the market for a price are known as commercial energy resources. Or in the other word the secondary usable form of energy which is essential for commercial activities are categorized as commercial energy resources.

And the example are electricity, coal, refined petroleum product. Because these resources are available in the market for a price and there are commercial outlets are in place for this kind of resources and that is why these resources are termed as commercial energy resources. However hydropower is the only renewable energy source of the present commercial sources. So, if you take a look at other commercial sources among those hydropower is the only renewable resource categorized under the commercial energy sources. So, now the next is non commercial energy sources.

The energy obtained from nature is used directly without passing through a commercial outlet is called as non-commercial energy resources. And the examples are wood, crop

residue, animal dung, cake, etc. However, most of these resources are getting utilized locally and hence there is no accounting of these resources.

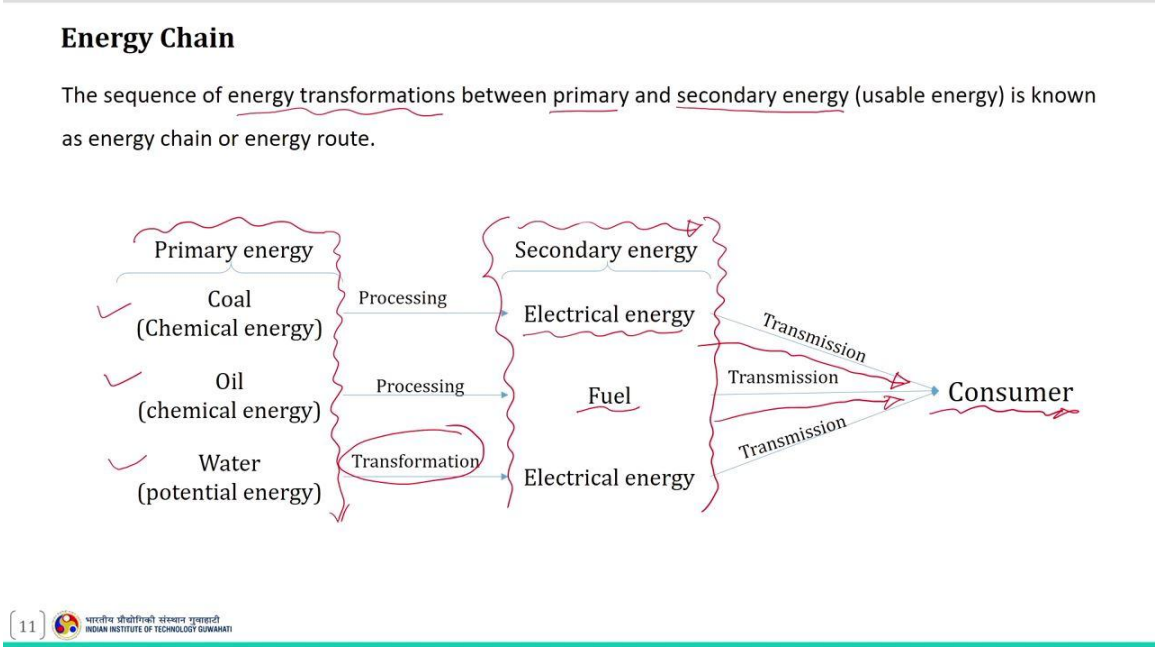
(Refer slide time: 16:45)



So, now let us discuss about the next classification that is based on origin. Here it is sub classified into following ways that is fossil fuel energy, nuclear energy, hydro energy, solar, wind, biomass energy, geothermal energy, tidal energy, ocean thermal energy and ocean wave energy.

So, to understand this concept of based on origin, let us discuss about this biomass energy source. So, in this case, so biomass as a raw energy source undergoes one or more steps of conversion or you can say transformation before releasing final product. So since this final product is obtained from the primary energy source which is majorly a biomass hence thus these are classified as biomass energy source. So likewise other classifications are also been done based on the origin that means from where it has been originated. So accordingly the classification has been done here based on the origin.

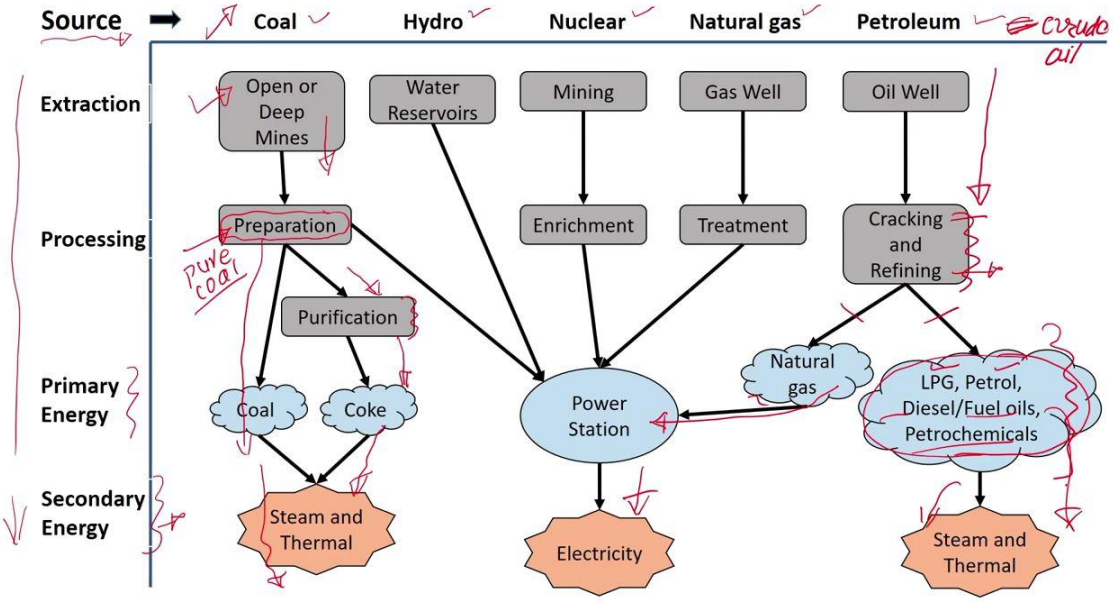
(Refer slide time: 18:35)



So now let us discuss about the next topic that is energy chain. Generally the energy available from the primary energy source is termed as raw energy. So here the primary energy sources are coal, oil or you can say water. So these energy sources undergo one or more steps of transformation or you can say the conversion to produce the product which is being utilized finally by the user. So, the product which is obtained by these one or more steps of transformation is either in the form of electrical energy fuel right.

So, these are termed as secondary energy source and this secondary energy source is being utilized by consumer by different mode of transmission and by this different mode of transmission it reaches to consumer for utilization purpose. So, the sequence of energy transformation between primary and secondary energy source is known as energy chain or energy route.

(Refer slide time: 20:02)



So, let us discuss about this concept in more detail by using this schematic. So, in this case if you see here on the top different sources are named like coal, hydro, nuclear, natural gas and petroleum. On the other side if you can see here these are the different modes of transformation or you can say the conversion to produce first the primary energy source from this raw source and then convert this primary energy source into a secondary energy resources.

So, just take an example of coal. So, in case of coal, the first the coal need to be recovered from the deep mines. After recovery of the coal, it needs to be processed to obtain relatively a pure coal. So, the produce coal can further be used directly to obtain steam or thermal energy. Or this can undergo further processing stage that is called as a purification which gets converted into a coke as a product. So, produce coke can further be utilized to produce either steam or thermal energy.

So, similarly if you take an example of oil that is called as a crude-oil. So, in this case what happen is like the oil after exploration undergoes cracking and refining operation to produce these two different kinds of product that is natural gas or other products like

LPG, petrol, diesel, fuel oils and petrochemicals. So, the natural gas can further be utilized directly in the power station to produce electricity or this other fractionated product can be utilized to produce either steam or thermal energy or can be also utilized as a value added chemical. So, likewise these raw materials undergoes one or more steps of transformation and that is why it is termed as energy chain.

So with this, we will end our lecture here. So in the next lecture, we will discuss about major sources of energy. Regarding this lecture, if you have any query, feel free to contact me at vvgaud@iitg.ac.in.

Thank you.