Petroleum Economics and Management
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Module - 01
Introduction
Lecture - 03
Energy and Sustainability

Hi everyone, I am Dr. Anwesha Aditya your instructor for the course Petroleum Economics and Management, we are in module 1 where we are discussing overall Introduction of the course. In first lecture of module 1 we discussed about the relevance of having a course on Petroleum Economics and Management and then we outlined our syllabus.

In the second lecture of module 1 we discussed about the Use of Oil and its advantages over other sources of energy. Then historically we discussed the use of oil and how the oil industry has evolved over time as it is in the current form. Third we also discussed about the importance of oil in global politics. Now in the 3rd lecture of module 1 we are discussing the issue of Energy and Sustainability.

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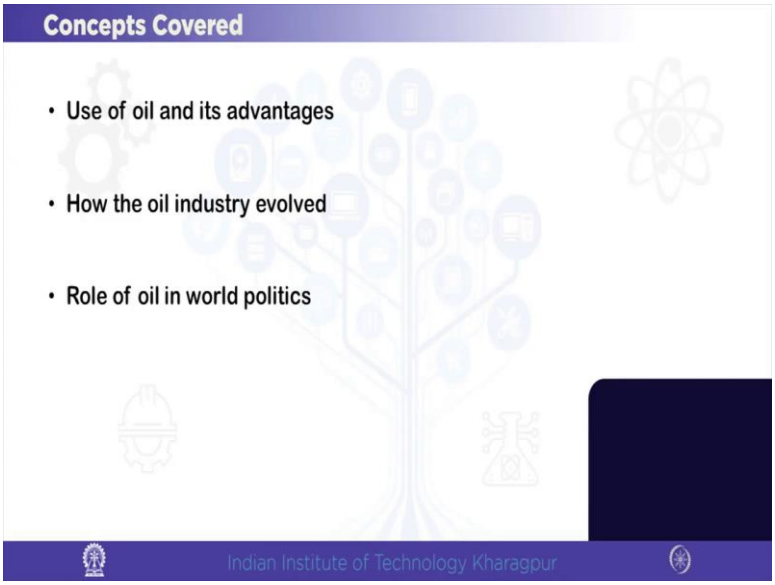

So, the concept covered in today's class will be what do we mean by sustainability. So, how the use of energy should be done from the point of view of sustainable

development, then we will discuss about the fossil fuel and the greenhouse gas emissions. So, while discussing these issues we will discuss about the different forms of energy which are sustainable and which are not sustainable; that means, the renewable and the non-renewable sources of energy.

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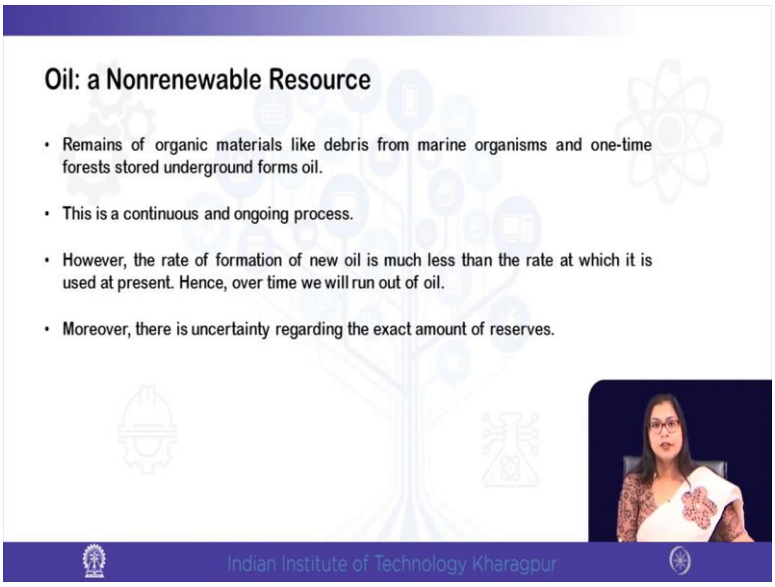

So that means, in today's class the first concept we need to know is regarding what do we mean by sustainable. So, what is sustainable development? So, sustainable development means a development regime in which the need of the present generation can be fulfilled without compromising the ability of the future generation to fulfill their needs.

That means, say for example, if we have a resource which is in more or less fixed quantity like petroleum or coal or any other type of natural resource, any minerals or mining product which is in fixed quantity. So, if we are using at a very fast rate we may run out of the resource at some point of time.

So that means, that use fast use of resource without considering the availability in the future is not a sustainable use of resource. If we run out of the oil our future generations will not be able to consume the resource in future. So, therefore, we have to use the resource in optimal fashion, so that we have the resource for our future generation.

At the same time if we do not use the resource so, if we become so futuristic we do not use the resource at all then we know that we have so many technological discoveries and technological advancement and breakthroughs that for example, a new alternate mode of technology comes in where the resource can become almost redundant there will be no use of resource that particular resource.

So, the resource will become just useless, so that should not also be a case. Therefore, we should find out an optimal balance between using the resource in a sustainable way, so that we do not run out of the stock of the resource and at the same time with the resource should not become useless also. So, this optimal rate of use of resource in a sustainable manner is the need of the hour.

So, with this we define what do we mean by a resource which is sustainable or not so, the very important concept of non-renewable and renewable resource. So, very first we give the example of oil as a non-renewable resource. So, what do we mean by non-renewable? So, non-renewable means it cannot be renewed.

So, it is exhaustible in nature, it will be finished, if the rate of use at present goes on in the same way it may be finished we may run out of oil at some point of time, why is it so, because we know that oil is fossil fuel. So, the oil we are currently using is not formed currently, but these are the gifts from the past millennium. These are the remains of organic materials like debris from marine organisms and one time forest which are stored underground and that is the oil that we are currently using.

So, we are using the gift of the past. So, this is a continuous and ongoing process. So, for example, currently also new stock of oil is being formed, but see; the rate of formation of new oil is very less extremely less because we are using the oils which are the fossil fuels which are stored millenniums over millenniums. So, the rate of current formation oil is much less than the rate at which it is presently being used.

So that means, if we keep on using at the existing rate at some point of time we may run out of oil. And also the issue becomes even more important because there is uncertainty regarding the exact amount of oil reserve we have, because we do not know how much oil reserve is exactly there, because there are discovered oil fields in which we know how much oil reserve is there, but there are many undiscovered unexplored fields also.

So, the exact quantity of oil at particular point of time is not known. So, that makes oil a non-renewable or exhaustible resource in nature.

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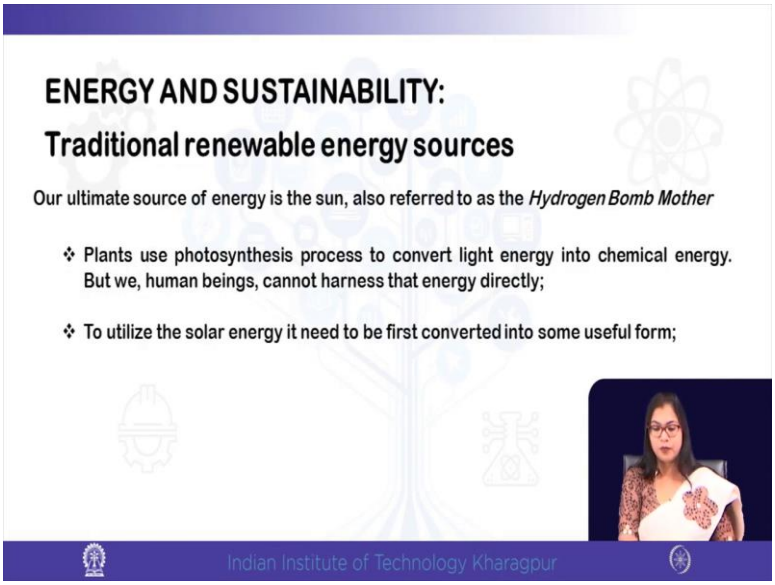

This we compare with other traditional sources of energy which are renewable in nature or they are also referred to as non-exhaustible. So, they will not be finished or exhausted, what are the sources of energy? So, first and foremost; obviously, it is sun, sun is our ultimate source of energy which is also commonly referred to as the hydrogen bomb mother. However, the unfortunate part is that we cannot use a photosynthesis process like the plants that is why we need to be dependent on the other sources of energy.

So, we know that the plants use photosynthesis process and they convert the light energy into chemical energy, but we the human beings cannot do that. So, if we could do it our life would have been easier perhaps we do not know. So, to utilize the solar energy we need to convert into some useful form which can be used by the human.

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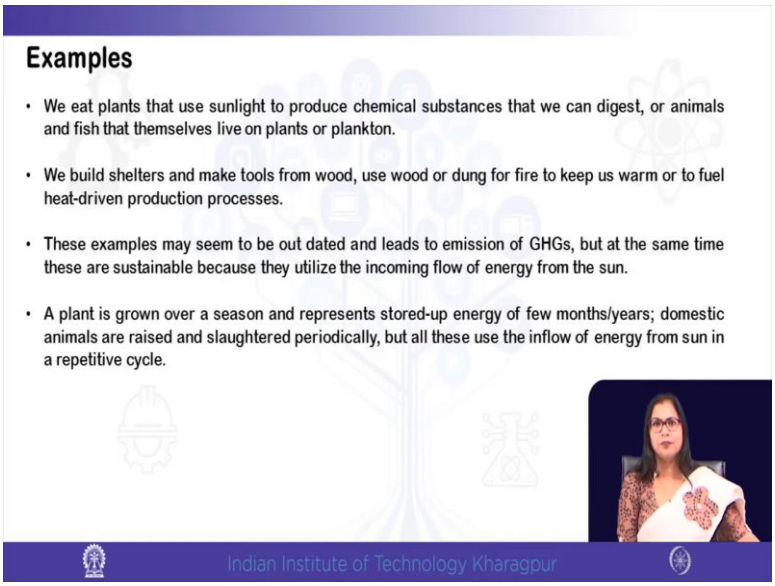

For example, we see we eat the plants, the plants are dependent on the sunlight the plants use the photosynthesis process. So, we eat the plants or we also eat meats. Now, see the animals are also again dependent on the plants or the plankton. So, indirectly we are also dependent on sun. So, we are either dependent on plant or animals now plants directly use the solar energy and the animals are again dependent on plant and we are dependent on plants and animals.

We build shelters and houses, furniture using wood or we used earlier days we used cow dung for fire. So, even in nowadays also in the less developed countries in the primitive societies they use cow dung or wood for fire. Now these are the examples of renewable sources of energy they can be renewed why, because they are dependent on the continuous flow of sunshine.

See; sun can also burn out sometimes we do not know, but at least in the near future we are not worried about that, because if the solar system is disrupted our entire ecological balance will be disrupted. So, we are assuming that the sun will be there in the near future right. So, just in a time frame that we need not worry about the sun will be there.

So; that means, the plants they are using the sun the solar energy which is a continuous flow. So, these can be renewed these will not be finished, these are non-exhaustible in nature as compared to petroleum which is a fossil fuel, because see the plants are grown

over season we know there is a seasonality, ok in one season it is grown then the crops are cut and then we eat the foods.

So, the animal the domestic animals are raised and slaughtered periodically. So, all this happen in a repetitive flow in a cyclical fashion which dependent on the energy from the sun.

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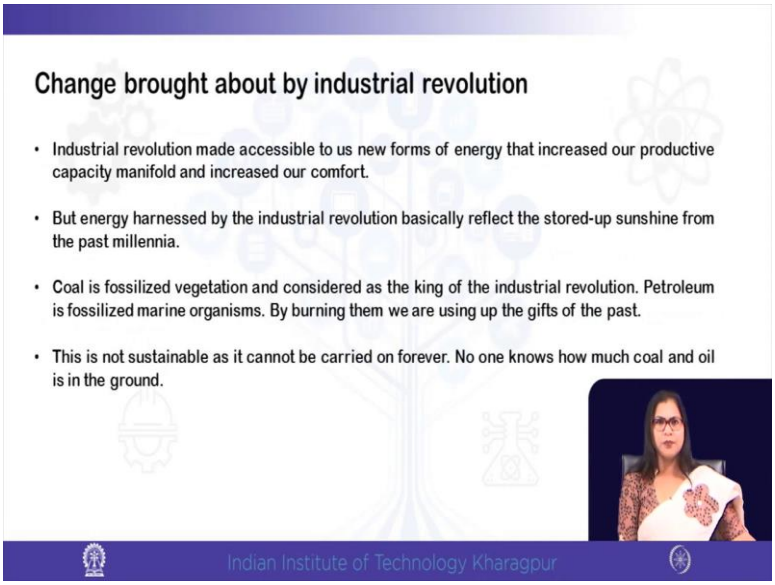

So, the traditional renewable sources of energy were the main sources of energy in the period before industrial revolution. Now, what is the industrial revolution? We all know that industrial revolution started in almost in 1760 and lasted about 1830 to 1840 and it started in the Great Britain and Europe and US mainly. So, it started in Great Britain and then it spread to other parts of Europe and US. So, where in industrial revolution what happened the manufacturing process were entirely transformed.

Now, this industrial revolution marked a major change as far as energy use is concerned. Why? Because industrial revolution made accessible to us new forms of energy which increased our productive capacity many times. Before industrial revolution we are dependent on cow dung, wood, this type of renewable sources of energy and our productive capacity was very less, but industrial revolution was marked by the use of steam engine and that multiplied our productive capacity.

So, the energy harnessed by industrial revolution basically reflect the stored up or the saved sunshine from the past millennium because the fossil fuel like coal, petroleum, petroleum is fossil fuel and coal is also from the fossil so, fossilized vegetation. So, these are the reflection of the stored up energy of the past millennium, like you are discussing that plants are dependent on solar energy, animals are in turn dependent on plants. So, basically plants and animals are dependent on solar energy.

So, coal is fossilized vegetation and it is considered as the king of industrial revolution. Whereas, petroleum is fossilized marine organism and by burning the coal and petrol we are actually using the gifts from the past millennium so; that means, if we continue use them to continue to use them in a fast rate we may run out of the resource. So, this is not sustainable because this cannot be carried on forever.

So, even though industrial revolution changed the pattern of energy use and the global economy is now much more industrialized, the developed countries have already industrialized, the developing countries are also in the phase of industrialization. But what we need to look for is a more sustainable source of energy because we are unsure about the amount of coal and oil which we have in endowment, because we cannot say that with certainty.

We have unexplored oil fields so, we do not know how much is there, there can be more or less amount also. So, we have to use the resources prudently and more importantly we have to look for other renewable and sustainable sources of energy. So, we do not run out of the stored energy. So, if you are dependent on the stored energy at some point of time we are going to exhaust those.

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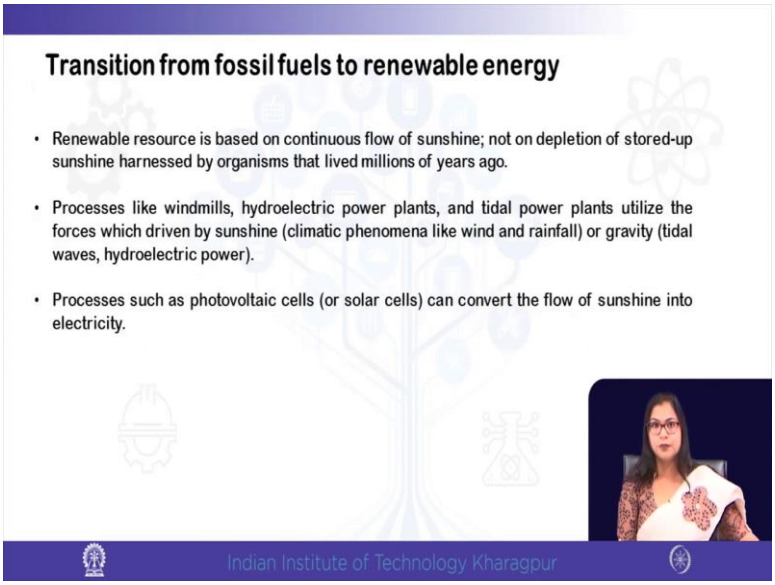

So, we come to a point where we need to make a transition from fossil fuel to renewable energy sources and sustainable sources and not only that we can also show that these fossil fuels lead to huge amount of environmental pollution and these are responsible for climate change.

Nowadays we are so much concerned about climate change, the greenhouse gas emissions, CO_2 emissions leading to global mean, temperature, extreme natural calamities, extreme weather conditions, drought, rise in sea level so, these are the threats of climate change.

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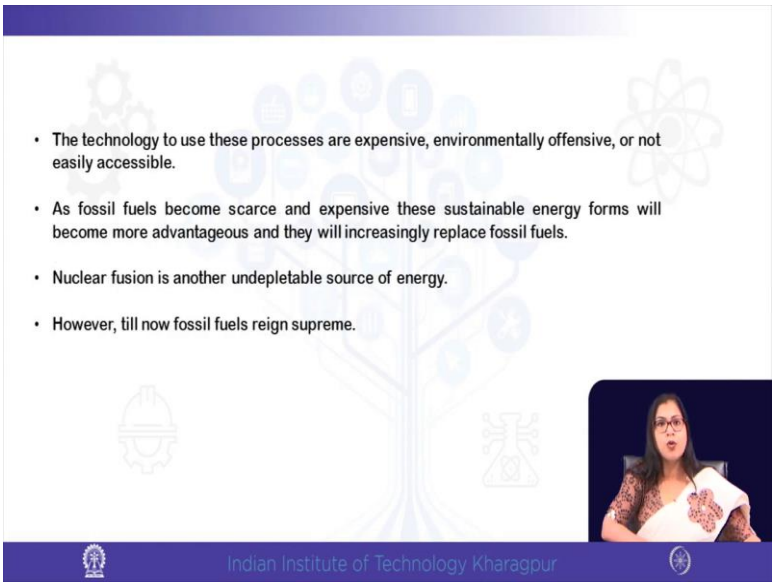

And we can show with some empirical observation that the fossil fuels are responsible for climate change.

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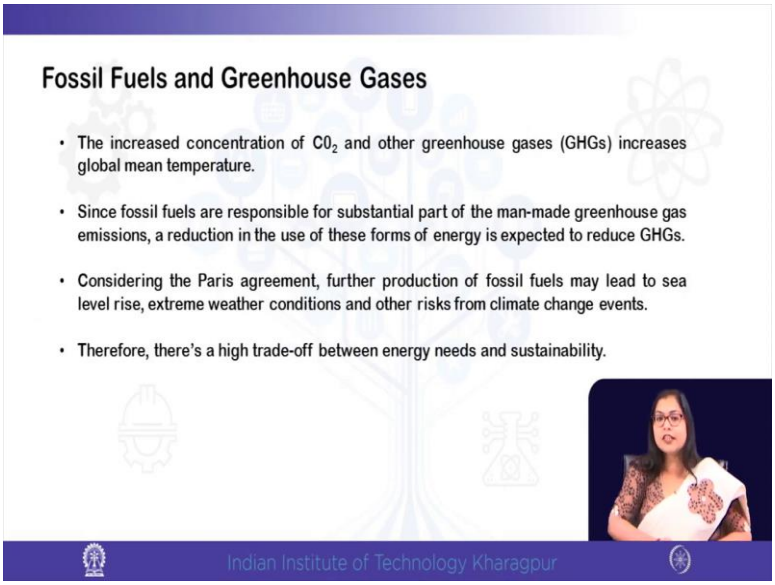

So, the increased concentration of carbon dioxide and other greenhouse gases generally are found to increase the global mean temperature.

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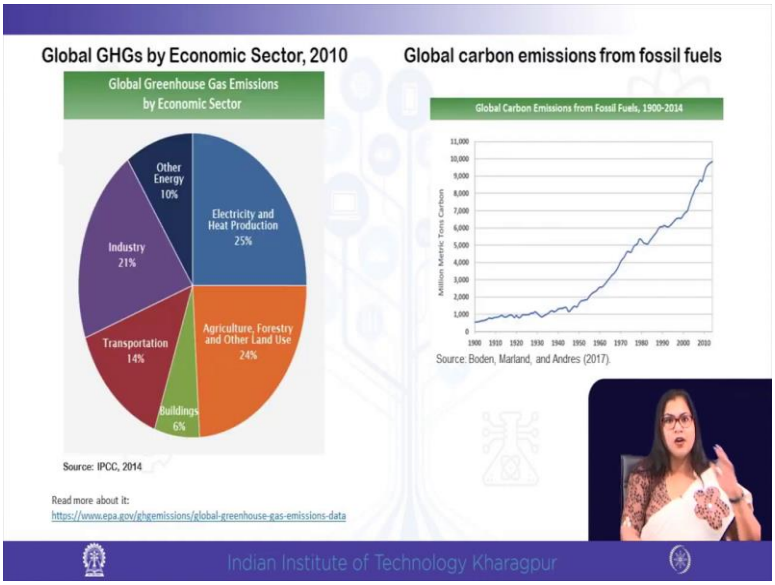

If we look at some data we can show that. So, this is the source of the data is IPCC 2014 reports. So, intergovernmental panel on climate change 2014 report shows the Global Greenhouse Gas Emission by Economic Sector. So, what we see is that electricity and heat production dominates the global greenhouse gas emission it is almost one-fourth. So, 25 percent of global greenhouse gas comes from electricity and heat production in 2014.

This is followed by agriculture forestry and other land use so, mainly the primary sector so 25 percent 24 percent very small difference between the two sectors. The third most polluting or greenhouse gas emitting sector is industry the industrial sector generates around 21 percent . So, next is transportation which creates 14 percent of global greenhouse gases and the remaining is divided into two, the other energy sources which constitute 10 percent and the buildings the real estate leading to 6 percent.

So, we can show that electricity and heat production is very much responsible for global greenhouse gas emission and these are till now we are mainly dependent on fossil fuel. So, as our dependence on fossil fuel increases we are using more and more of fossil fuel and coal which is the fossilized vegetation we are actually increasing the global greenhouse gas emission leading to increase in the global mean temperature and climate change.

So, again we can see the global carbon emission data from fossil fuel from 1900 to 2014 thousand fourteen. So, for a long time series we plot the 1900 to 2014 data of global carbon emissions. So, this figure is from Boden, Marland and Andres 2017. So, all the papers will be shared with you in due course. So, those who are interested should go through the papers in detail.

So, we see that it shows the global carbon emission from fossil fuel shows a positively rising trend it is rising over time, but you can see that the rise has been steeper from 1950 onwards is not it. So, from 1950 onwards it is much steep and after again after there was a slight slump in 1979-80, but then again it has started increasing, but overall it showing a rising trend. So, global carbon emission from fossil fuel is thoroughly increasing.

So, if we are not reducing our consumption and use of fossil fuel then global greenhouse gas emission will increase and that will has enormous impact on climate change.

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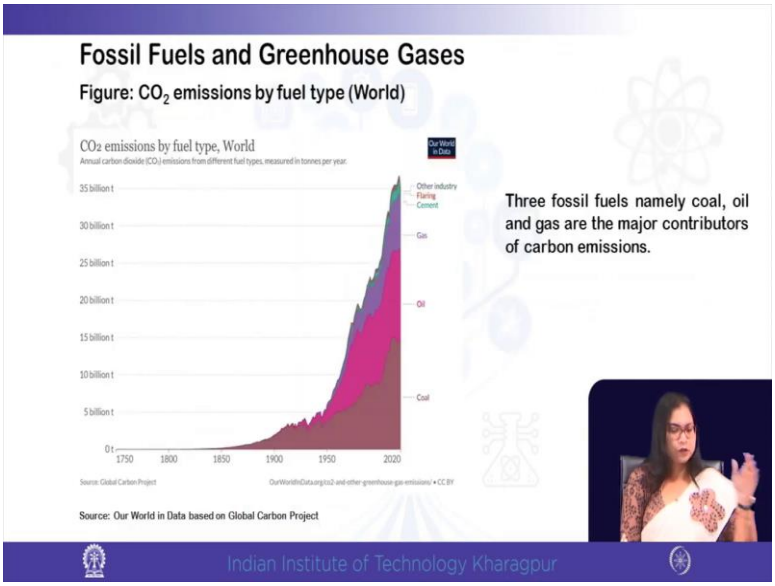

Next, we show the carbon dioxide emission by fuel type for the world economy. So, from which source of energy how much carbon dioxide comes in? So, from which fuel how much carbon dioxide comes in? So, the source of the data is our world in data based on global carbon project. So, we plot the data here also it is a very long time series 1750 to the latest 2020.

So, mainly see after industrial revolution this fossil fuels are in place, coal is in place so, it has started coal has started rising from the period of industrial revolution and the use of petroleum comes after coal. So, it is mainly rising after 1900 and in the recent year what we see, there is steep increase of the different sources of energy or different fuels as per as their CO_2 emission is concerned and the highest is coal followed by oil and gas.

So, these three fossil fuels; that means, coal oil and gas these are the three major contributors of CO_2 emission; that means, there is urgent need that we should look for reduction of the use of this type of fossil fuel, otherwise our climate change issue will not be taken care of and our climate will suffer more the ecological balance will be disrupted.

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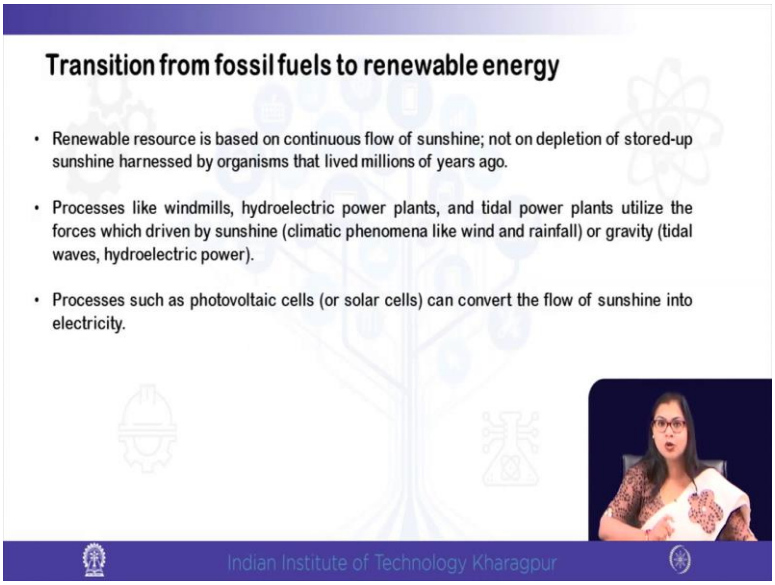

Therefore, with the data we can easily say that we should look for other alternate sources of energy ok. So, which type of sources of energy we should look for? We should look for, for example, the energy source like windmill which is driven by wind and that is sustainable or that is renewable. Second is say hydroelectric power plants which is dependent on flow of water or tidal waves which is again renewable or non-exhaustible ok.

So, these type of resources these type of sources of energy are more sustainable because they will not be finished in the near future because they are from the continuous flow of either from sunshine or wind or from gravity forces of gravity or for example, solar

energy. So, process like photovoltaic cell or solar cell that also can convert the flow of sunshine into electricity. So, the need of the hour is to make a transition from fossil fuel to renewable energy sources.

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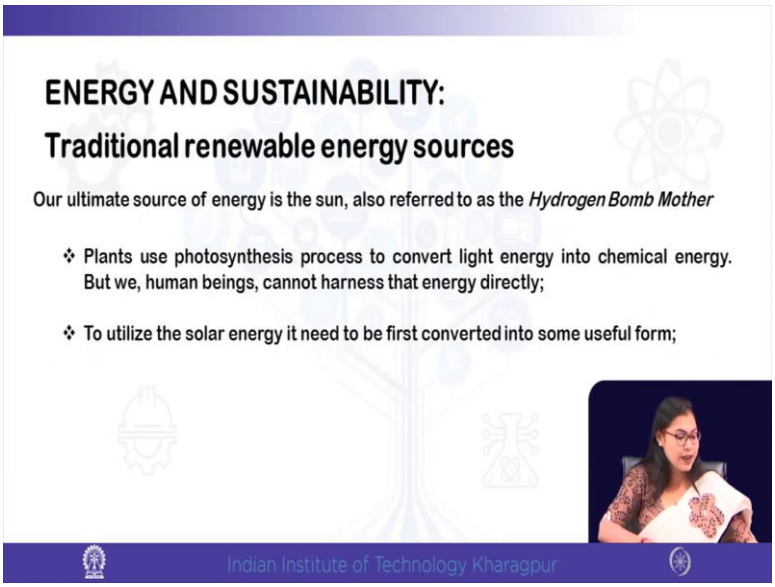

So, see historically what happened. So, first we are dependent on the traditional sources of energy like wood or cow dung.

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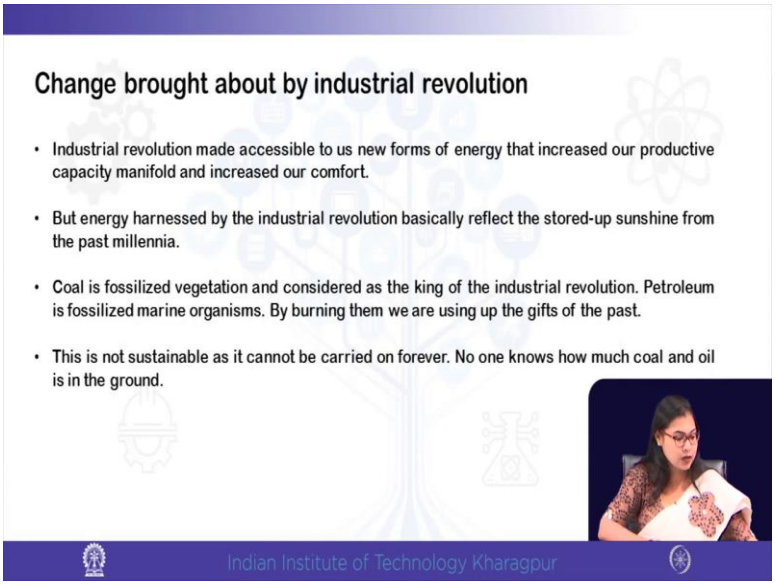

Then industrial revolution increased our productive capacity and led to huge growth of the manufacturing sector by changing the pattern of energy used from the traditional to

the fossil fuels because industrial revolution changed, it brought the use of steam engine. So, steam engine use marks the beginning of industrial revolution and that process led to finally, use of petrol.

So, again we should now go back. So, we started with our human civilization started progressing with the traditional sources of energy, then human the industrial revolution changed the pattern of energy used from the traditional sources to the non-renewable sources, but again time has come where not only we are threatened by the exhaustive nature of the non-renewable sources of energy, but also we are threatened by the issues of climate change and greenhouse gas emission.

So, again we should make a transition from fossil fuel to renewable sources of energy.

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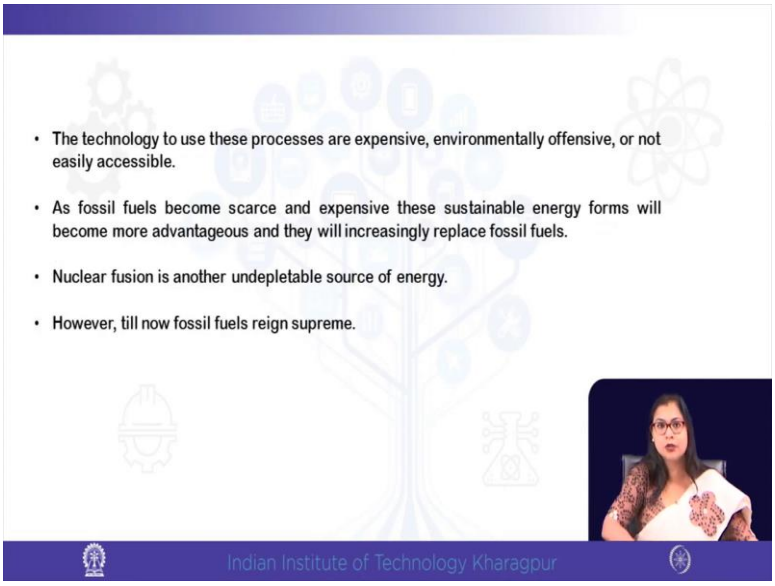

However, it is not as easy as it can be said in terms of words because the technology to use this process is not easily accessible these are often very expensive, these are also environmentally offensive. For example, say hydroelectric power plants it can have consequences on the environment.

And these are also very expensive to set up a hydroelectric power plant in the hill region can be expensive and that may not be accessible the developing countries especially the less developed countries may not have sufficient fund or may not have that technological

advancement or the technological know-how as well as the human capital to build this type of power plants.

So, as fossil fuels become more in scarcity and expensive so, we have to depend more on the sustainable ways of energy, but till now the availability of the sustainable ways of energy are very less in the developing countries and the less developed countries especially. So, what is the way to the future, what do we do?

So, we should depend on nuclear fusion which can be another undepletable source of energy, but again you see nuclear fusion has also lot of environmental consequences, it leads to radioactive wastage which is also not good for ecological balance as well as environment.

Secondly, it is also nuclear power can be a threat for global peace, also the technology for the most important point of using nuclear fusion the most important constraint is that the technology is not available in the developing countries or the less developed countries, we can hardly think of using nuclear power for day to day use of energy.

Therefore, fossil fuel till now is reigning it is dominating all other sources of energy, but we have to look for the process which are easily accessible, not only in the developed countries, but in the developing countries because the developing countries are very much dependent on fossil fuel, the developed countries to some extent they have used they are making a transition from the non-renewable to renewable sources of energy.

But the developing countries to a great extent are dependent, they have technological constraint, they have constraint in research and development fund, they have constraint of human and physical capital. So, the alternate sources of energy the renewable sources of energy are not that easily accessible or available in the developing countries.

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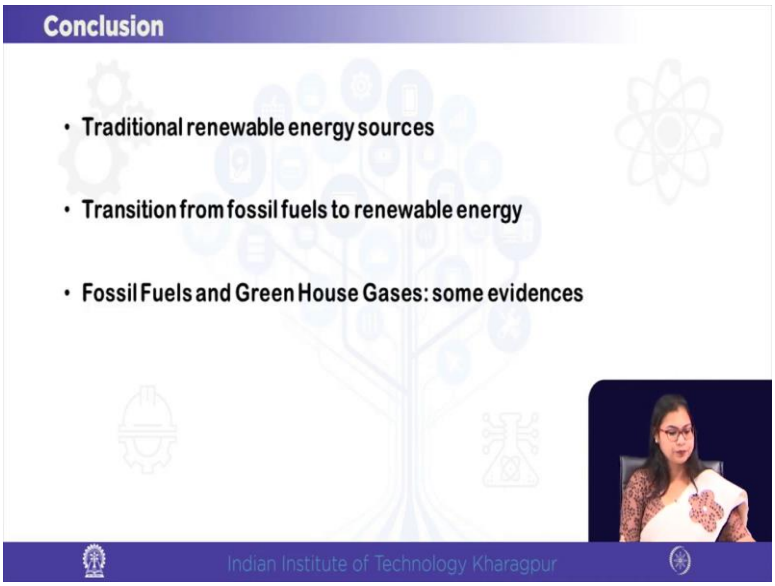

So, with this we summarize today's class. So, in today's class we distinguish between the renewable versus nonrenewable sources of energy. We did, so by defining what do we mean by sustainability and then we categorize the resources into the renewable vis a vis the non-renewable sources of energy.

So, we took examples of the traditional energy sources like wood or cow dung which are the traditional renewable sources of energy and compared to the fossil fuel fossilized vegetation like petroleum and coal which are the non-renewable sources of energy. And how we made a transition so, how industrial revolution led to a change in pattern of energy use from traditional to fossil fuel and then we show that our greater dependence on fossil fuel is causing a harm to the environment, it is causing a harm to the climate it is leading climate change concerns, it is increasing the global greenhouse gases.

So, again the time has come. So, that we should try to reduce the dependence on fossil fuel and we look for other alternate sources of energy, which are more sustainable and these energy sources should not be confined in the developed countries only, but they should be made available to the poor less developed and developing countries as well.

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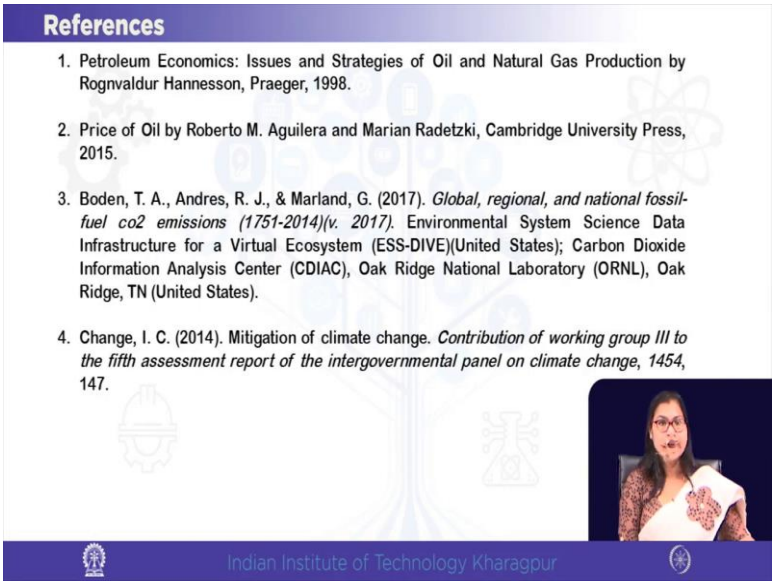

So, these are the references. So, those who are interested should go through the references in detail, even though the PPT also discussed the main issues. So, the references will provide the detailed discussion.

Thank you, see you in the next class.