Fuels, Refractory & Furnaces

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Lecture No. # 01

Energy Resources and Environment

Energy is the prime mover of economic growth and is vital for the sustenance of the modern economic. Future economic growth depends upon the long term availability of the energy resources which are affordable, excisable and environmental friendly. Industrialization contributes to the growth of economy and requires energy. Consumption of energy and industrialization, they go together. If the economy has to go, then energy consumption will also grow. The growth of economy depends upon the growth of infrastructure; and the infrastructure demands the consumption of energy.

If I give you the data, for example, the major energy intensive industries in around 2005 requires or required energy of the order of 68 percent of the total energy consumption. That means, of the total energy consumption 68 percent was utilized for the growth of energy intensive industries.

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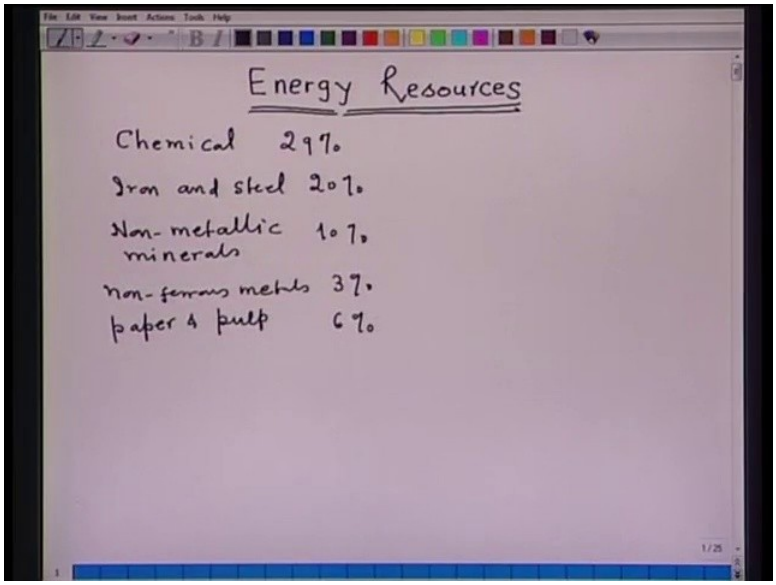

Now, with that I mean for example, the chemicals;the sector which produces chemicalsfor example, cement and all others, it has consumed around29 percent of the total energy. Iron and steel iron and steel sector has consumed around20 percent of energy. Now steel and cement are the two major infrastructure materials. Non-metallic minerals nonmetallic minerals have consumed around10 percent of the total energy; non ferrous metals non ferrous metals around 3 percent energy,and pepper and pulp around 6 percent of energy. Though, these data correspond to 2005 but, similar train of energy consumption is also there in the subsequent years.

India has set up around 8 to 9 percent economic growth in the years to come. With this high economic rate of growth, the demands on infrastructure material like cement,steel, non-ferrous metals are bound to grow. In an estimate,India would need around600 million tons of cement by the end of 2030 and around300 million tons of steelby the year 2030. So,these suggest that industrialization, growth of economy and energy consumption is interrelated; it is in this perspective. Let us see what are the energy resources available because I have already said, the long term sustenance of the economy will depend upon the availability of energy resources which are affordable remember; which are accessible and on the top of it; they should be environmental friendly.

So, as such, energy resources. Now, ultimate energy resource is a sun,it is a solar power that gives energy to the mankind. Now, part of this energy is stored below the earth crust and part is available above the earth crust.

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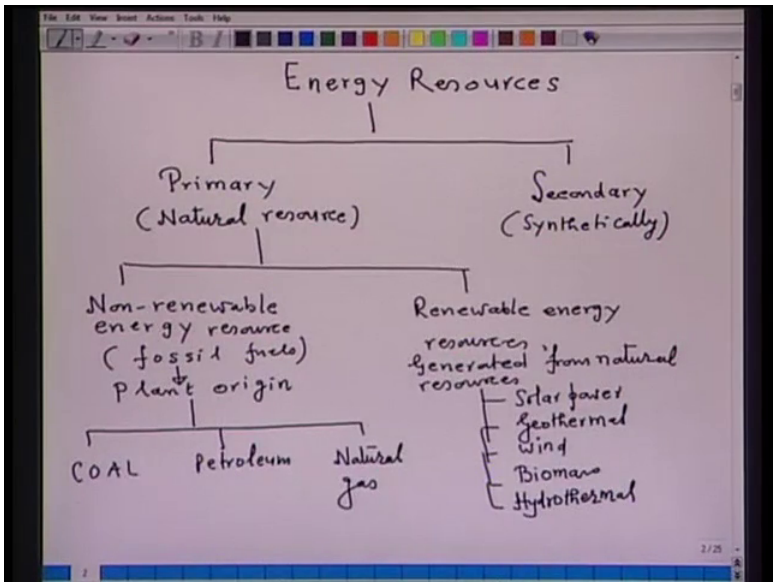

To as such, I am going to divide energy resources into two parts. One that is the primary energy resources and second is the secondary energy resources. Primary you can also called natural resources; they are the natural resources.Whereas, secondary they are synthetically they are synthetically manufacturedas per the demand of the industry. Now, let us take first of all the primary resources; now under the primary resources, they can further sub divide; one is a non-renewablenon non renewable energy resource and another is a renewable energy resource renewable energy resources. The non-renewable means, it takes several millions of years to form non-renewable resources. It is in this perspective. We have non-renewable and renewable; the renewable energy resources are available to usevery time.

Non-renewable energy resources in fact, they are fossil fuels they are fossil fuels and renewable energy resources they are generated they are generated from natural resources from natural resources. The renewable means they are constantly renewable, they never exhaust as long as the solar power is but, the non renewable energy resources since it takes several millions of years to form and they form below the earth crust, it is in this time scale the fossil fuels are termed as a non-renewable energy resource vise a versa the renewable energy resources.

Now, among these fossil fuels they are in fact plant origin; fossils fuels they are plant origin.And among fossil among these fossil fuels, one have again threedifferent type of fuel;

one has all of his know is a coal, second is the petroleum and third is the natural gas.Among the renewable energy resources, I think all of you know most important one is a solar power; second is the geothermal geo thermal, third is the wind,fourth biomass; then we have hydrothermal we have hydrothermal. Now, let us say first of all little bit how these non-renewable energy resources are formed?

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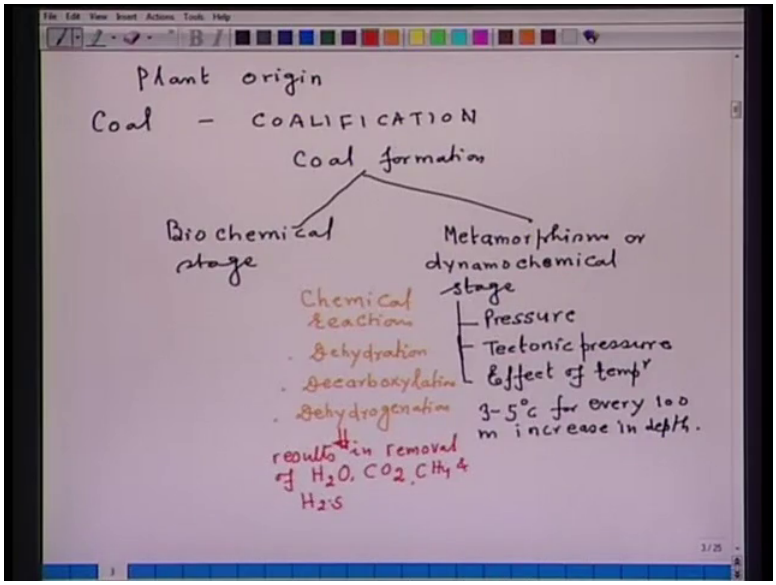

So, let us take little bit of it. As I said, the non renewable resources are from plant origin.They are special type of plants; that give petroleum, natural gas or coal. Coal formation - it consists of two stages; first stage is a biochemical stage biochemical stage. In the biochemical stage,the plant materials decay under the earth crust and they are attacked by the bacteria under moist condition. After this, you know there are severalearth movements below the earth crust; several geological forces are also acting on the earth crust to the deposit which has been there at a particular time; it gets further buried into the earth crust or below the earth crust. And as a result of temperature and pressure the process of coal formation begins to as a second stage is called metamorphism metamorphism or it is also called dynamo chemical stage. Now, in this stage what happens there is an effect of pressurebecause of the depth; because of the movement below the earth crust. The deposit which has been occurred earlier gets buried further and as a result of it is the effect of pressure begins as you go down the depth. Again, there is a tectonic pressurethere is a tectonic pressure which is caused by movement of the earth and as a result the deposit may be buried into the some type of rocks below the earth crust.

Then, there comes effect oftemperature then there comes effect of temperature because there is a rise in 3 to 5 degree Celsius for every hundred meter increase in depth. So, what happens in this stage? And this is a most important stage for the formation of the coal deposit; and some in substance there is the effect of temperature and very high pressure, and on account of its severalphysicochemical reactions take place during the life of formation of the coal. So, certain chemical reactionwhich occur in this stage, I will just put it over here; certain chemical reactions which occur in the dynamo chemical stage. They are for example, dehydration that is the symbol of water;then another is decarboxylation; then third dehydrogenation. And on account of this 3 chemical reaction which are occurring because of the very large increase in pressure and temperature their results in theremoval of these reactions results in removal of in removal of h two o, carbon dioxide, c h four and h two s. So, on account of this physicochemical reaction or dynamo chemical reaction the formation of coal occurs.

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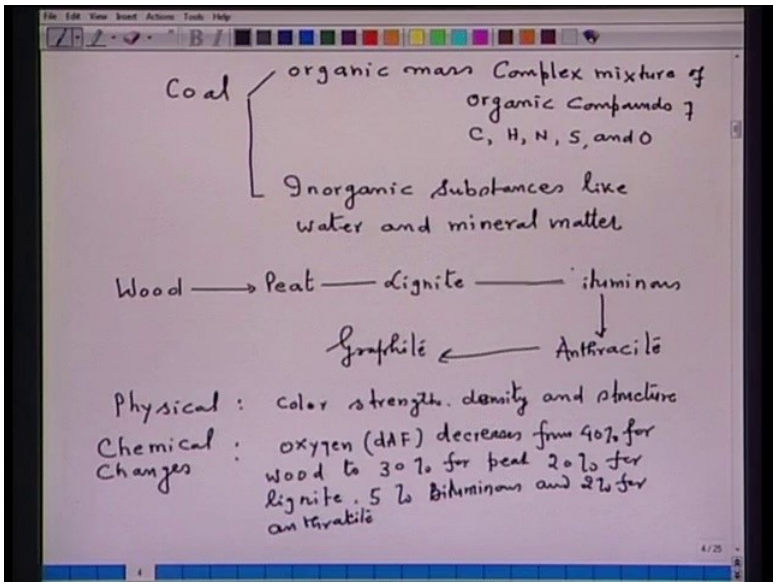

And in fact the coal, it consists of organic mass because it is from the plant origin. Organic mass and this organic mass is a complex mixture of is a complexmixture oforganic compounds of organic compounds of carbon, hydrogen, nitrogen, sulphur and oxygen. So, coal is the very complex mixture of all these things then also coal contains inorganic substances contains inorganic inorganic substances like water and mineral like water and mineral matter.So, as a result of this physicochemical reaction which are a function of depth that is a pressure and temperature? The coal formation occurs to several stages. So, the stages

of coal formation are, start with the wood is the first stage and followed by pit. I mean, I am writing in the increasing order of the life of formation. That means, if you stop the process at this after wood then you will get a pit; then further depth you get lignite; then followed by bituminous which is followed by anthracite and thenultimately goes to graphite.

So, this in in the orders to wood to peak to lignite bituminous anthracite and graphite this shows the ages of the coal. That means, the first stage of the formation is the pit; the further time it converts to lignite then to bituminous coal and ultimately to anthracite, and finally,to the graphite. So, as a result of physicochemical changes, the physical appearance changes the physical appearance for example, color, strength and then density, and structure.From the point of the user, it is the chemical changes are important chemical changes are important from the point of view of the user. Now, this chemical changes are for examples, oxygen contained oxygen contained on dry as free basis on dry as free basis it decreases, say from 40 percent for wood to 30 percent for pit and20 percent forlignite,5 percent for bituminous coal and 2 percent for anthracite. So, you see that the progressive action of the pressure and temperature brings all the oxygen down the value to the around two percent two percent for anthracite.

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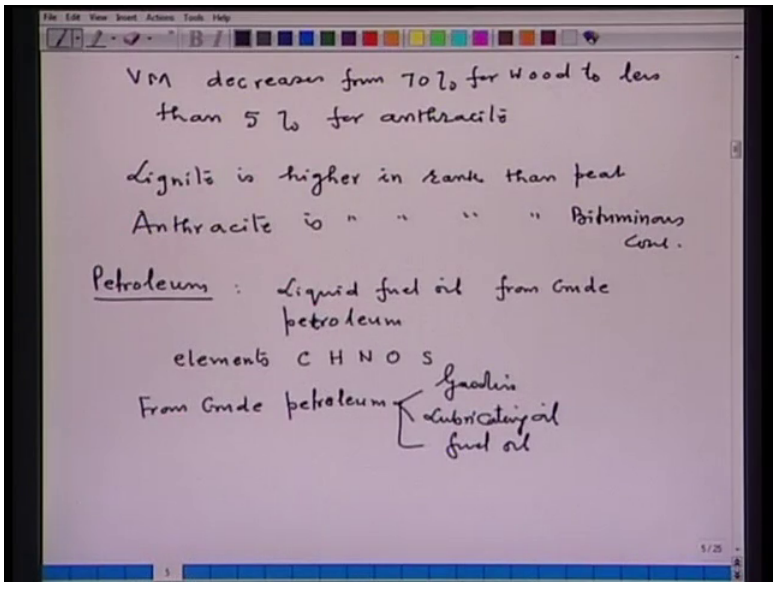

As a result of this, the volatile matter decreases from about 70 percent for wood to less than five percentfor anthracite. So, decrease in oxygen and volatile matter content, it increases the available carbon from about 30 percent for wood and pit; to almost 100 percent for anthracite

based on the extinct of qualification. One can say, lignite is higher in rank lignite is higher in rank than pit and anthracite is higher in rank than bituminous coal and thenbituminous coal.

Now,similarly, the petroleum is also found under the earth crust by special type of plants and these plants are gelatinous in nature. Again in the near sea coast, such type of plants are there I mean the same process of as I have described for coal buried under the earth crust andover the time period of millions years the deposits of petroleum are formed below the earth crust.

So, the liquid fuel oil liquid fuel oil is derived from crude petroleum from crude petroleum.You know liquid fuel oil is not a natural resource, it is obtained from petroleum; petroleum is a natural resource and petroleum comes from in Greek,Petra means rock and Olium means oil. That is, it is deposited below the earth crust; below the rock and when you drill the rock then the petroleum is available for the users. Petroleum,it also contains elements; this is important for the user point of view elements like carbon, hydrogen, nitrogen, oxygen and sulphur. Now, from crude petroleum from crude petroleum several type ofproducts are obtained, one is gasolinethen you have lubricating oil; then we have fuel oil and so on several products can be obtained from this.

Now, these are the non-renewable energy resources; also natural gas it occurs along with the petroleum.

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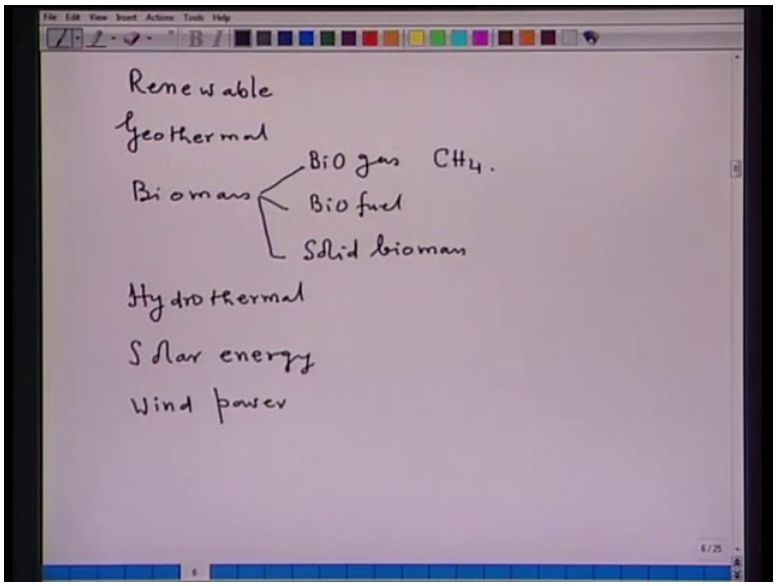

Now, about this a renewable resources about renewable energy resources one is the geothermal as I said geothermal that is energy obtained by taking the heat of the earth below its surface. That means we have hot underground water or steam is used to produce electricity because of thesolar power which and which partly absorbed by the earth and there arethe hot water;here this hot water is used for the generation of electricity. The geothermal plants, there only where thehot water is available below the earth crust.

Then another important source is the biomass that is the biomass energy and this consist of say for example, one is the bio gas which is produced from current vest streams such as paper and sugar production, animal vest and so on. So, in bio gas, c h four is the main product. Then we have bio fuel like bio diesel, ethanol they are derived again from plants; then we have solid biomassthen we have solid biomass. Wood fuel biogenic portion of municipal vest and certain plants. So, this is a biomass is a very important source of renewable energy that I will come little later.

Another is the hydrothermal is the hydrothermal energy; now, hydrothermal energy;energy in the water in the form of kinetic energy then to the difference and as such we have so hydrothermal power stations for conversion of kinetic energy of water into the electrical energy. Then we have solar energy;energy collected from sunlight it can be used in many ways for example, generation of electricity using photo voltage cells;then generation of electricity using concentrating solar power but, the photovoltaic cells have a very low efficiency factor.

Another source of energy is wind power. Now, wherever, this wind power is available this can be used for production of electricity. Now, what I wanted to say from here I wanted to view you a picture of energy resources which are available to the mankind. Now, let us see what under the Indian conditions? Now,India, it ranks 6 in that world in terms of total energy consumption and needs to accelerate the development of energy sector in order to sustain 8 to 9 percent growth in the country. Because energy infrastructureand growth, they are interrelated.India though reach in coal and abundantly endured with the renewable energy, it has a very small hydro carbon results of the order of point four percent of the total world results with the hydrocarbon results I mean the fossil fuel results. For your information,India is a net importer of energy. More than 25 percent of the primary energy needs being met to imports in the form of crude oil and natural gas. So, this is the important point to note when

we relate our economic growth with the energy we are also based on the import of the energy resources.

As regards, the energy production now,when we come down to the energy production sector; coal and oil, they account for 54 percent and 34 percent net respectively, to the natural gas around 6 percent.India's total energy production is contributed by fossil fuel to the extent of 90 percent. Now, rest say hydro contributes around 6 percent, nuclear around 1 percent and that contributing to the rest wind or geothermal and so on. So, what is meant over here? India is a very large consumer of the fossil fuel energy resources. Not only India, around the world 80 to 90 percent of the energy is being produced byprimary energy resources that are coal,oil and natural gas. Now, industrial sector in India, it consumes around 5.2 percent of energy. Another important point to note, when we relate energy with the economy then it is also has a relation with the standard of living and the standard of living, it can be measured or it is measured in terms of energy consumption per man. Now, consumption of primary energy in India is 530 k g of oil equivalent per person. Remember,530 k g of oil equivalent per person, it was in 2004 compare to 1240 k g oilequivalent per person in china and the world average of 1770 k g of oil equivalent per person. So, what you see from here? The standard of living, growth in economy is highly related with the energy consumption. So, in terms of energy consumption we are at leastthreeto four times lower than the world average. So, what I wanted to convey to you is that the primary energyprimary energy consumption per person if it is an indicator of the economy growth, it will grow. Energy consumption has to grow because the economy has to grow, because economy is an index of countries prosperity.Now, when this is the picture say 90 percent of the energy is derived from the fossils fuels. We are also convinced, if the economy has to grow with the country has to prosper then energy consumption must increase. The question is how that can be met? In another way, I pose the question over here. Are there certain issues related to fossils fuel? Why there is so much human cry? That the world isusing eighty to ninety percent of fossil fuel for the production of energy,India is also more than 90 percentusing fossil fuel for the production of and why there is so much human cry? Why you are crying that well?What is the problem?What are the issues related to the use of fossil fuel as the energy resource? Because it is all at the moment the contribution from the renewable energy sources is very less because of the economical considerations. In the years to come, the fossil fuel will remain a dominant source of energy not only in India, but around the world.

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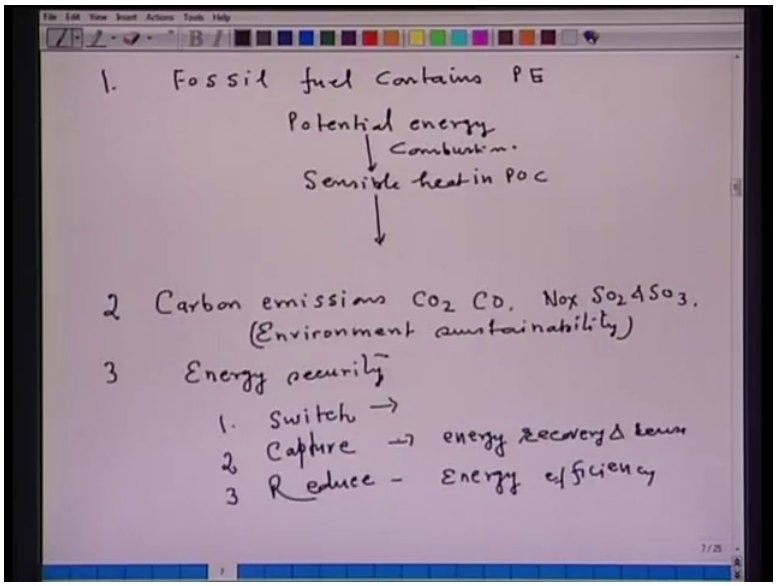

Let us see what are the issues? Issue number one, first of all fossil fuels contains potential energy. What does it mean? You take a k g of coal; put it before you, it has energy butyou cannot use it. So,the potential energy of the fuel is obtained by combustion in terms of sensible heat of products of combustion. So,the potential energy of fuel potential energy of fuel is converted to sensible heat in products of combustion converted to sensible heat in p o c that is on combustion. Now, this heat transfer occurs between the source which is the products of combustion and the sink which gives you the required amount of energy. After taking the requiredamount of energy, the source it exits the system after imparting its energy. So,that means the potential energy of the fossil fuel is available by combustion and the products of combustion are discharged into the atmosphere. What does it mean? So, depending on the temperature of the sink the products of combustion they are discharged into the atmosphere. So, if higher is the temperature of the sink, higher amount of energy will be carried away by the products of the combustion. Could you understand the issue? Here it calls for recovery, recirculation and reuse of the heat which is being discharged with the products of combustion. Issue number one is that the potential energy of the fuel is obtained by combustion and theproducts of combustion are discharged into the atmosphere and depending on the temperature of the sink, the products of combustion will carry the large amount of heat. So, unless the concept of recovery, reuse and recirculation are not activated by energy from the fossil fuel or a large portion of the energy of the fossil fuel will go to vest.

Number two issues, fossil fuel they are all carbonaceous fuel. If I combust10 k g of carbon then10 k g of carbon will be in the output. So, that means the carbon emissions is one of the important issues. Carbon emissions as c o two or c o and emissions in general for example, n o x, s o twoand s o 3.What is this issue over here? Now, I give you an example. Nature has its own carbon cycle, if for the time moment we think that we are not using any fossil fuel resource from the earth crust. Then whatever carbon which is emitted by the biological activity of the human beings on the earth will be absorbed by the plant; say c o two again we use. So, there is a carbon net carbon recycling is zero. What we are doing by using the carbonaceous fuel from the earth crust? We are bringing extra amount of carbon to the earth and we are disturbing the carbon cycle. So, that means the issue number two in terms of carbon emissionthat is the environmental sustainability. If we want to sustain the environment for the long years for the future generation to come then we have to think how to use the fossil fuel, so that environment remains sustainable.

Issue number three:So, the issue which is coming or which is arising out of carbon emission is environment sustainability. That is a major issue as you often or hearing in the newspaper the global warming or I do not know what. Third point that you should think, fossil fuel results are limited. You also know as I said in the lecture, a very large amount of primary energy is imported that25 percent of the energy is imported in the form of oil. What does it mean?We have to ensure energy securitywe have to ensure energy security; energy security and environment sustainability are the important issues and they can be achieved by applying the concept of switch, capture and reduce. So, the concept of environment sustainability and energy security can be achieved by switch; switch means wherever, you are using fossil fuel as the energy source either for direct energy source for example, generation of thermal energy or using for reduction purposes because it is a carbon and hydrogen,it can do the reduction (( )) . So, if it is possible to replace a portion or the entire part of it with the fuel which is renewable that is called switching. Another important concept is capture. As I said, it is in the inherent way of deriving thermal energy from the fossil fuel that is by way of combustion and the combustion product exits the furnace or wherever the thermal energy is being derived at the temperature of the sink, a large amount of heat is going to vest. So, in workthe possibility of capturing the heat and recycle and do whatever you like.

Third concept is reducing: If you can reduce it for example, today you are using 100 k g of carbon by developing the technology or by optimum utilization. Can you reduce to 80 k g or

can you reduce to 70 k g? And this reduction brings the concept of energy efficiency the concept of energy efficiency, capture brings the concept of energy recovery energy recovery and reuse, and switching it rather allows you to innovate tothink what portion of the energy uses can be replaced by this so called renewable energy. That means that switching modes should have a energy which does not contain carbon.

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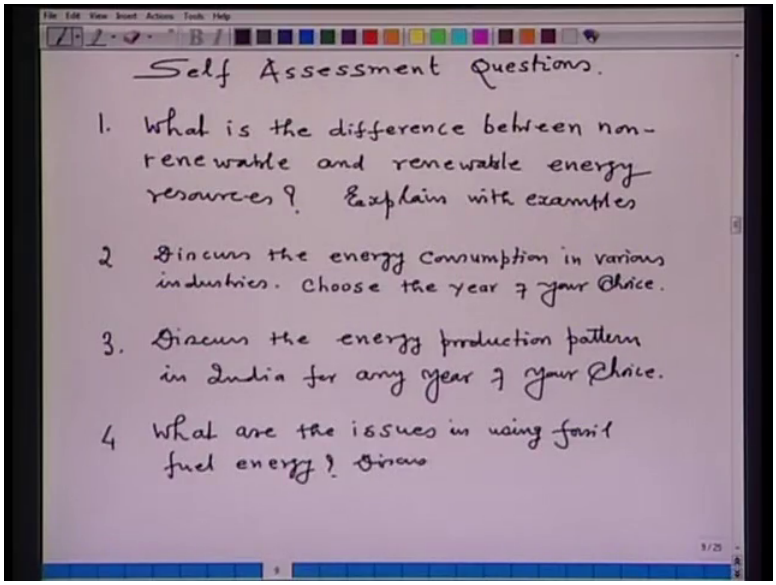

Now, if I give you a simple example say for example, of an iron and steel industry say India has produce around 50 million tons of steel fifty million tons of steel in the year 2006,2007;40 percent of a steel is being produced by blast furnace and basic oxygen furnace rube that means 20 million tons.

Now,1000 k g of hot metal will yield around 750 k g of steel becauseof losses of iron and slag;20 million tons of steel would require27 million tons of hot metal. One ton of hot metal requires600 k g of coke but, one ton of coal it yields 750 k g of coke. That means one ton of coal that means one ton of coal will produce around 1.25 tons of hot metal. So, if we need around27 million tons of hot metal you need around 20 seven million tons of hot metal then we will be consuming around 20 to21 million tons of coal to 20 to 21million tons ofcoal of cocaine quality of the best quality of the coal. So, what I mean to say with this; that there is the large consumption of coal and it is here if some technological innovations are being made to cut down this consumption then it is the beneficial not only from the energy security point of view, butalso from environment sustainability point of view.

Now,similarly, anothercarbon emission industry is that of the cement the very large amount of fuel is being used. So, here a switching for example, as a cement industries doing by the use of tires they contain very large amount of energy. So, in some substance what I want to say is that, this switching reduces and capture will bethe basis of further development of the lectures. Now, the course contained in fact essentially comprises of the basic application of the above concepts: the switch reduction and capture, in particular to furnished industries and in general to other industries also. Now, to end the lecture, I will like to give you few self assessment questions.

So here I am giving you few questions which are based on this lecture. First question, what is the difference say what is the difference between non renewable non renewable andrenewable energy resources energy resources? This I had already explained to you, in term of the life span one is term nonrenewable, another is renewable because renewable energy is obtained always whereas, non renewable it takes a millions of years in order a energy resource can form. Now, explain with the examples explain with examples.So, here try to give the example of the non renewable as well as renewable energy resources. If it is possible you can give the deposits, then it is very good.

Second question is that discuss the energy consumption discussthe energy consumption in various industries. Now, here you can choose the year of your choice choose the year of your choice. You may choose 2007 or 2008 that is just to generate a feeling in you that there are energy consuming industries and hence about the energy resource. Third, discuss the energy production patterndiscuss the energy production pattern in India for any year of your choice. Here get a feel that the biggest source of energy production they are the fossil fuel try to know their percentage and so on. Then what are the issues what are the issues in using fossil fuel energy? Here you have to discuss how in fact energy is obtained.

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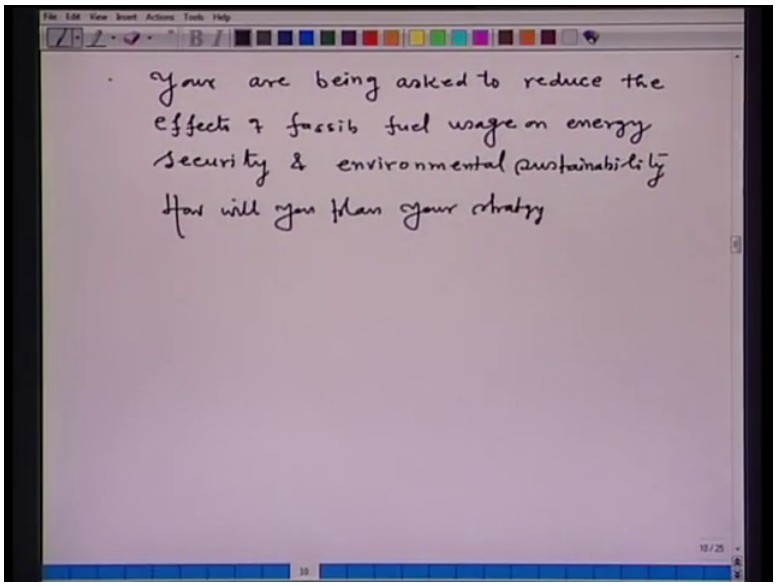

Now, the last question is said you are being asked you are being asked to reduce the effects of fossil fuel uses on energy security and environmental sustainability and environmental sustainability. How will you plan or how will youplan your strategy? That is I mean here the required to reduce the fossil fuel consumption, how will you do it? I can give you the hint as I have said thethreeapproaches capture, reduce and switching. You can also give an example of iron and steel industry which uses a large amount of coal, also cement industry which also uses large amount of coal and develop your answer.

Now, assuch after having a feeling of the energy resources and the problem associated with that we will proceed in the next lecture about the characterization of fossil fuel and we will now limitto the application of the concept of switching, reduce and capture to the furnace industries. In particular, this concept can also be equally applied to other industries also.