Technologies for Clean and Renewable Energy Production

Prof. Prasenjit Mondal
Department of Chemical Engineering
Indian Institute of Technology-Roorkee

Lecture-01
Introduction

Hi, friends I welcome you all to the course "Technologies for Clean and Renewable Energy Production". This is the introductory module of this course and I will give you some introduction about this course. What are the topics will be discussed? What energy is? What is the importance of energy? What is clean energy? And what is renewable energy? And how we can produce these energies and how we can use efficiently this energy.

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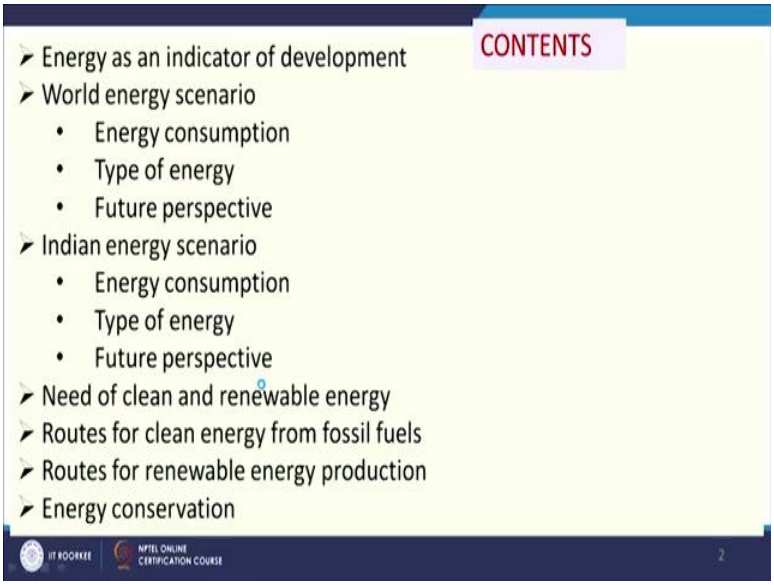

So, that will be the topic of discussion in this course and the contents of this module are energy as an indicator of development, world energy scenario including energy consumption, type of energy and future perspective, Indian energy scenario, energy consumption, type of energy, future perspective, the need of clean and renewable energy. Then routes for clean energy from fossil fuels and then routes for renewable energy production and energy conservation.

So, energy is considered as an indicator of development and we can say it is the currency of civilization. So, if a person does not have any currency he or she cannot be considered as a rich person on the similar way a nation cannot be developed if its energy utilization is very less.

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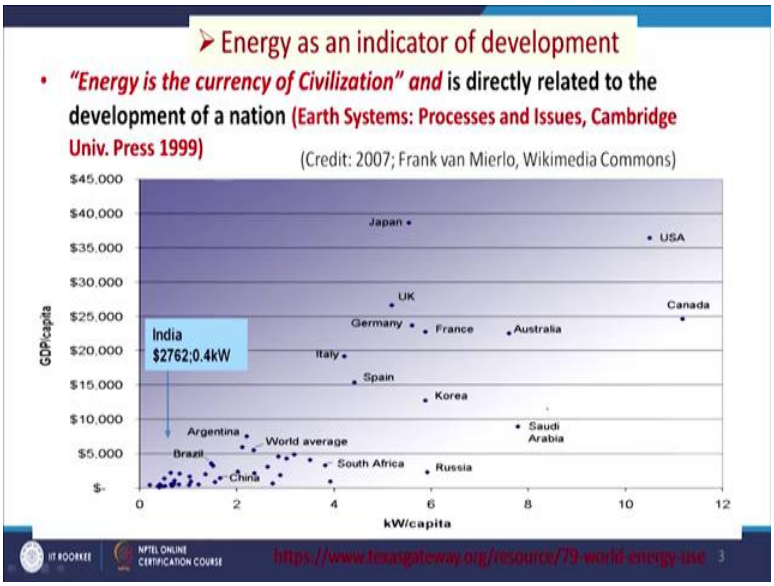

If we see here in the graph we see it is it is very clear to us that developed countries like USA, Canada, Japan, UK, France, Australia, Germany all these countries the GDP is very high and they are also consuming more energy per capita. But if we see for our case in India we have very less GDP with comparison to these countries as well as the per capita energy consumption is also very less.

So, if we want to develop we need to increase our energy production. But if we produce more energy at the same time the more pollution is also generated. So, growth that is the GDP, GDP and the efficient use of energy that its energy efficiency are being considered in recent years as the indicator for sustainable development. Now we will see what GDP is?

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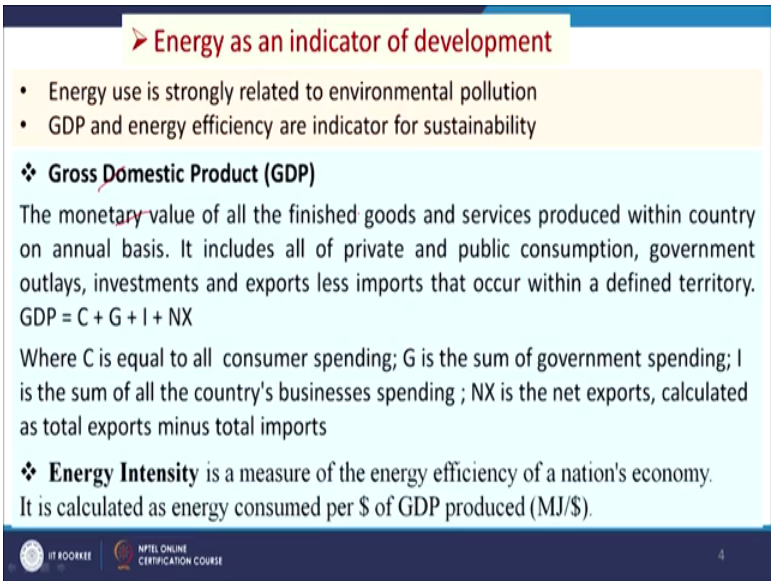

GDP is gross domestic product and this is the monetary value of all finished goods and services produced within country on annual basis. So, GDP is equal to C + G + I + NX. So, here C is the consumer spending, G is the sum of government spending, I is the sum of all country's business spending and NX is the net export that is export minus import. So, GDP is very important to assess the economic condition of a nation.

Similarly, the new indicator which is being considered that is energy intensity which also gives a measure of the energy efficiency of a nation and it is defined as the energy consumed per dollar of GDP produced that is mega Joule per dollar unit.

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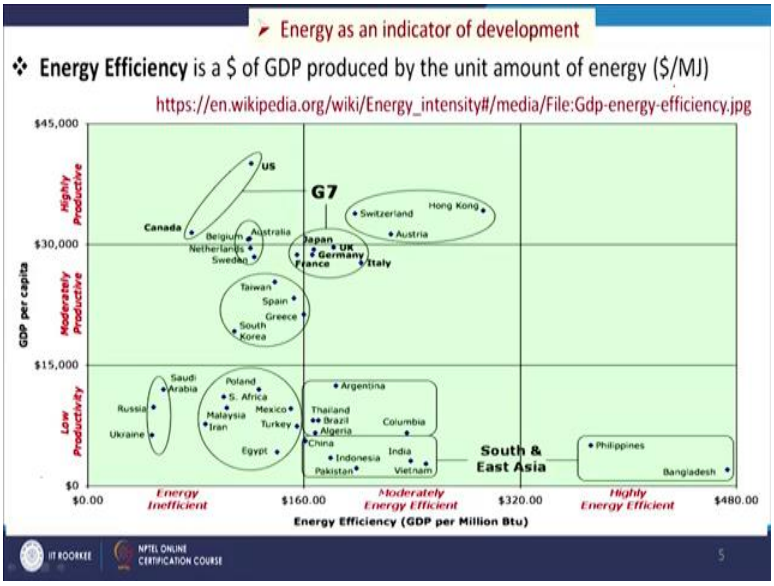

An energy efficiency is a dollar of GDP produced by the unit amount of energy. Now if we see this graph, it is very clear to us that the developed countries like say Canada, Us, Australia, Belgium, Netherlands, Sweden even G7 countries including Japan, UK, Germany, France, Italy all these countries are not that energy efficient. They are not able to use the energy in more efficient way but we in India we are under moderately energy-efficient country.

And highly energy-efficient countries are Philippines and Bangladesh as got from this graph. So, on the basis of this information it is clear to us that as a moderately energy-efficient country we have a scope to produce more energy and to increase our energy efficiency. Now we will see the energy scenario in the world.

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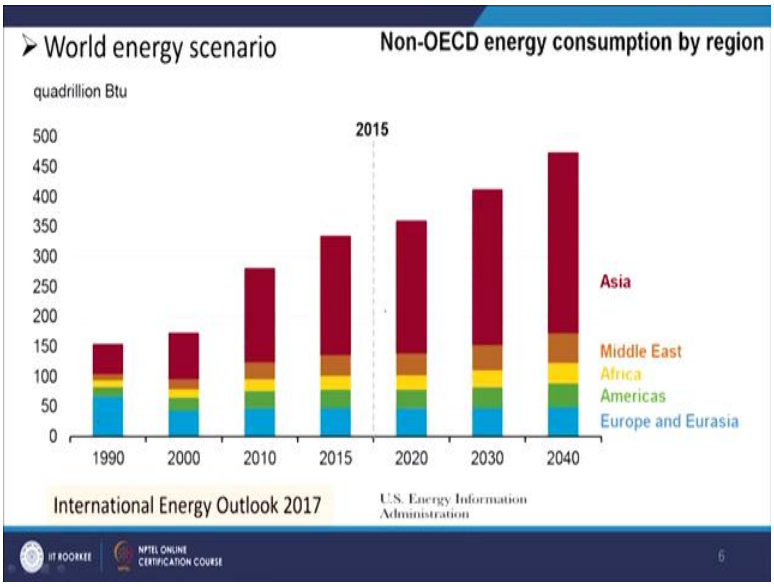

World energy scenario; if we see this graph, it clearly shows that energy utilization will increase around the world in near future. However, it is very interesting that Europe and America they are not going to increase much energy utilization in future. Whereas the Asian countries where the energy utilization is expected to increase significantly in near future up to 2040, the forecast is available here.

So, as India as an Asian country the energy production and utilization in India will also increase. And what type of energy will be used in higher extent in near future?

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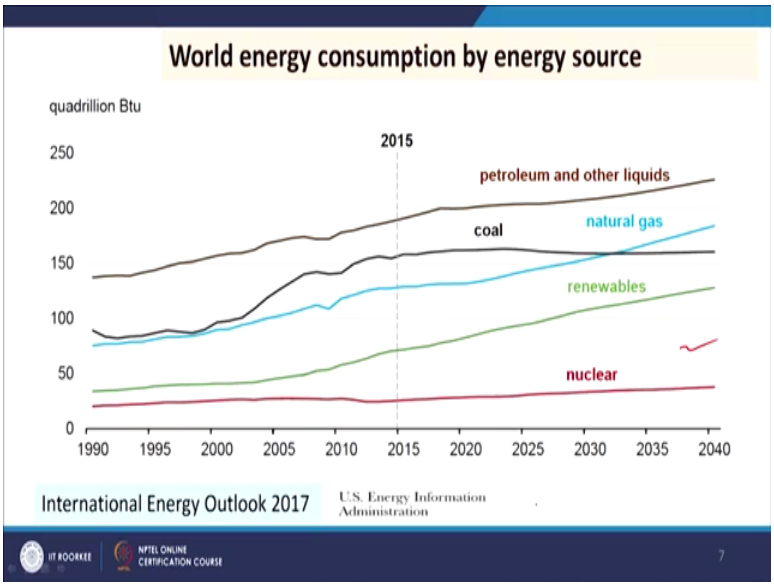

This slide gives us that idea it is very clear that petroleum and other liquids, coal, natural gas and renewable will be used for the production of energy in higher extent along with some nuclear energy production. And it is very interesting that renewables are expected to increase gradually; in 2018 we are here, but we will be reaching up to this point, as per this graph.

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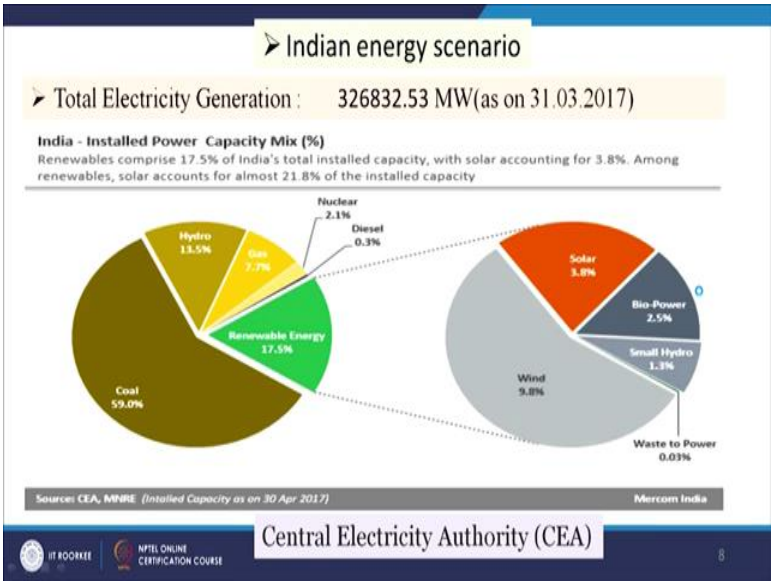

Now we will see the Indian energy scenario. In Indian energy scenario if we consider on the basis of 31st March 2017 so 326832.53 megawatt installed electricity production capacity the country is having. Out of these electricity production 59% is from coal 13.5% is from hydro energy and 7.7% from gas and 17.5% from renewable energy. And if we see this renewable

energy, the wind is 9.8% solar is 83.8% bio power is 2.5% and small hydro is 1.3% and waste to power is .03%.

So what is the need of the clean and renewable energy? If we consider the facts which we have discussed just now then it is very clear that India is dependent on coal 59% of utilization for energy production by coal. But with increasing population growth energy demand is increased and pollution load is also being increased. So, we need some technology which will supply us sufficient energy in cleaner route.

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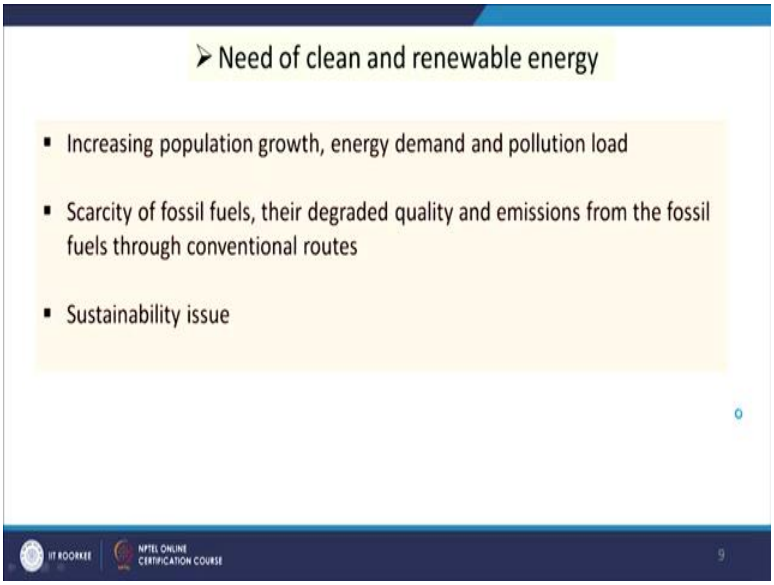

Then scarcity of fossil fuels, their degraded quality and emissions is also a reason to consider the cleaner routes for the production of energy. And then sustainability issue, the in 21st century sustainability is a major issue, we are under threat of environmental pollution, energy security, and public health. So, we need to produce more energy to supply to everyone in a cleaner way and we need to use the renewable resources, so that the non availability of fossil fuels will not make any impact to the supply of energy in sufficient amount.

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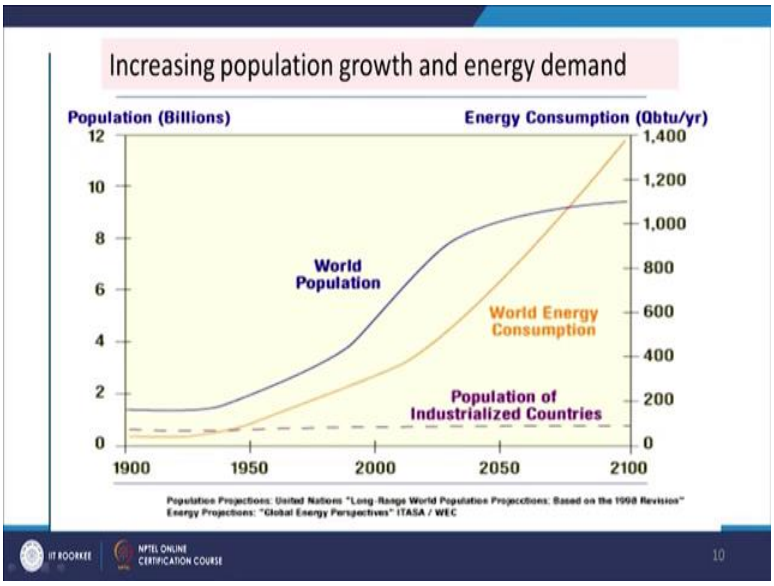

Now if we see this graph the world population we are here 7 million so now it is going to be 9 million and world energy consumption is continuously increasing. And at the same time the pollution is also increased.

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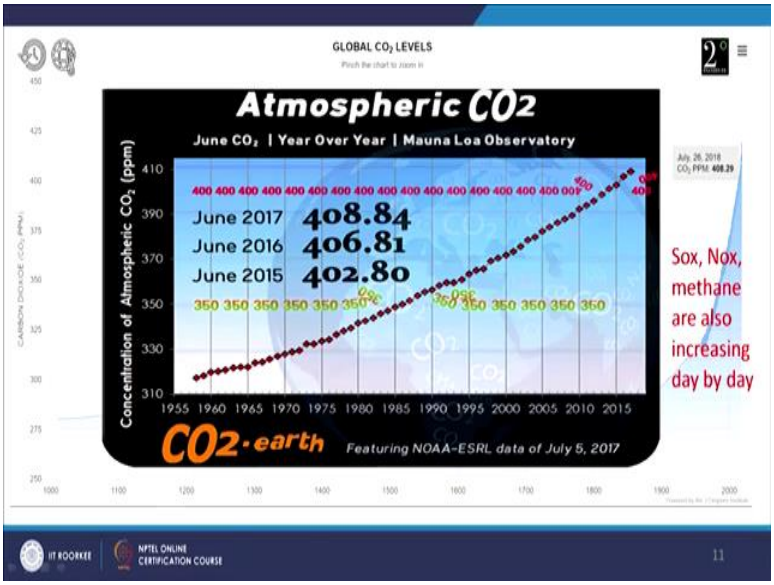

If we see the graph here the carbon dioxide concentration is gradually increasing see 1955 and 60, if we consider it was below 330 ppm, and in 1992 was around 350 ppm and now in 2015 it is more than 400 ppm. And the recent data as on July 26th 2018 carbon dioxide in air that is 408.29 ppm, this is global data; not only the carbon dioxide, the Sox, NOx, methane are also increasing day by day.

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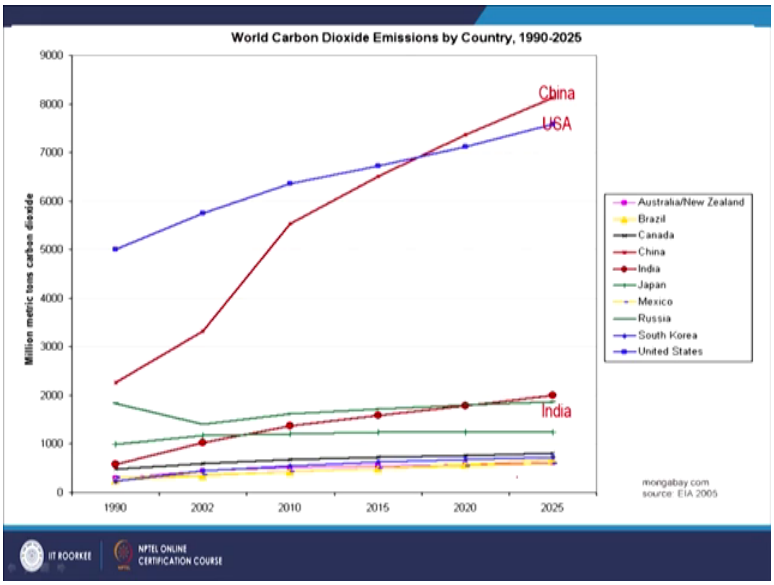

If we see the carbon dioxide production by different countries so this figure gives us some idea that China and USA are the major carbon dioxide polluting country. In India we are here we do not produce much carbon dioxide but still we have to work to reduce the carbon emission. Then the scarcity of fossil fuels as you know that crude oil reserve is limited and the quality of the crude is also not good in the recent years.

Its quality is degraded in terms of more sulphur more s content and more viscosity. So, we need to develop new technology for the accommodation of these variations in the composition. And coal is sufficiently available in India but its quality is also not superior; it has high S content.

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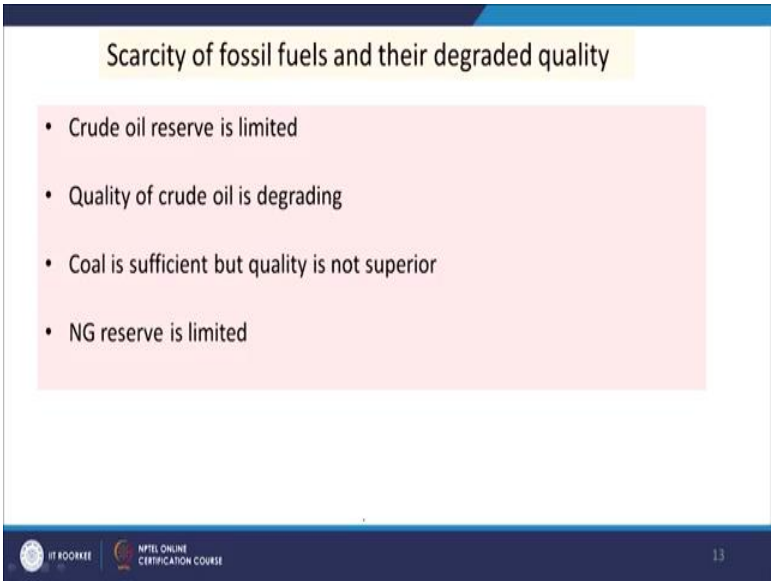

So, new technology or cleaner route is required to use this low quality coal, and natural gas reserve is also limited, so we need to use more renewable in that respect to meet the energy demand. Now this table shows us that the conventional route in which the coal or fossil fuel is burned in furnace and the fuel gas is used for the production of steam and then steam is used in the steam turbine to produce electricity.

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Emissions from the fossil fuels through conventional routes

Elements	Emission (g/kWh)	
	Sub-Critical	Supercritical
CO2	926	835
NOx	2.22	2.00
SO2	6.82	6.16
PM	0.17	0.15

And this steam production basically takes place in subcritical condition where the carbon dioxide NOx Sox and particulate matter emissions are higher. So, there is a good scope to change the technology and if we produce the steam in supercritical condition then the emissions can be reduced significantly from 926 to 835, 2.22 to 2.0, 6.82 to 6.16, 0.17 to 0.15.

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Now sustainability; I have mentioned just now that we need to produce electricity for everyone, as population is increasing so more energy is required. So, we have to explore the renewable energy as this is the social need. And for clean energy we need to use the cleaner routes so that the pollutions will be less. So, clean energy for environmental variability and then energy conservation is very important to use less amount of energy to perform the same amount of work so that we can preserve some amount of fossil fuels for our future applications, so that is the concept of energy Conservation's and these are related to sustainability issues. Now we will see different routes through which the clean energy can be produced from fossil fuels. So, clean energy is basically related with the utilization of fossil fuels in a cleaner route.

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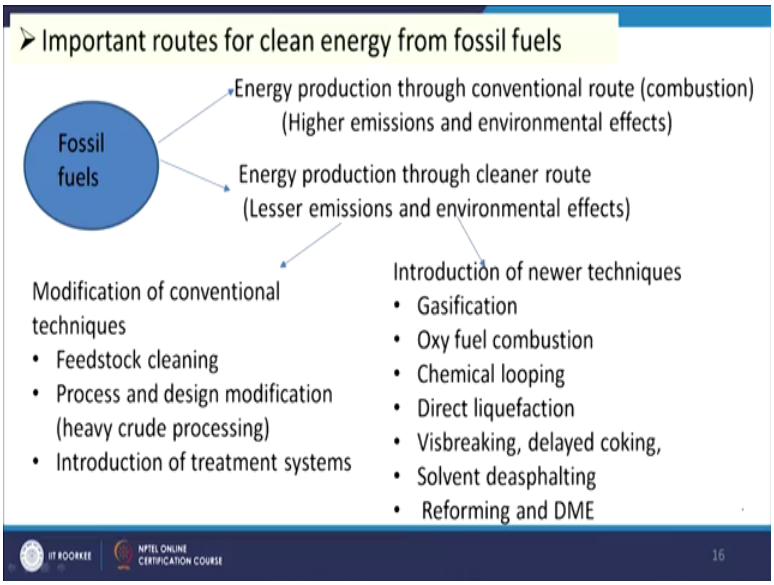

And here if we consider the conventional route, the combustion based process, I have just discussed that it is used in furnace then fuel gas is formed which is used to produce steam. And then steam is used to produce electricity so that way high emissions and environmental effects we can get. So our objective here to explore the technologies which are available or which can be implemented to produce energy with less emissions and environmental effects.

So, how this can be done? Basically by modification of conventional techniques or introduction of newer techniques. So, what are the modifications of conventional techniques? The feedstock cleaning; feedstock cleaning that we have seen that the feedstock's like say coal may have sulphur, may have ash. So, we can remove these sulphur and ash from the feedstock so that during processing steps it will not produce much pollution.

Process and design modification; so we can take one example of heavy crude processing. Conventional refineries are suitable to refine the light crude having low sulphur. But if it has more sulphur then we need to change the refinery configuration. So, the new plants which are coming up those are able to accommodate inferior quality of the crude. Then introduction of treatment systems; although we are taking actions to reduce the emissions but still there will be some emissions.

So, we need to introduce some treatment technology for the removal of the pollutants which is

emitted. Now if we think about the introduction of newer technologies, one is your gasification. So, you can replace the combustion based technology by gasification based technology in that case controlled amount of oxygen will be used and we will be getting a chance to capture carbon dioxide in between.

Oxy-fuel combustion; in this case we can use pure oxygen in place of air for the combustion. So, that eighty percent of nitrogen in air will not be used here only oxygen will be used, as a result we will be getting more carbon dioxide concentration, more than 90% even in case of flue gas. So, it will be easy to capture the carbon dioxide from the flue gas after extracting heat from it. Then chemical looping system; chemical looping is another concept the people are working and new techniques are coming up.

In this case some oxymetal oxides are used, some oxides are used which give oxygen in the reactor for the combustion purpose. After the reactions then these oxides are again reduced in another reactor and after reductions again oxidized in another reactor and then again used in the combustion chamber. So, this is the chemical looping system so chemical looping system is also helping by reducing the use of air or nitrogen.

So flue gas volume will be less and carbon dioxide concentration will be higher so this is the beauty of the chemical looping. And direct liquification is another method in which coal can be converted to liquid directly. This method is also being investigated widely around the world and it is expected to have cleaner route for the production of energy from coal. Now if we think about the utilization of crude oil.

Then crude oil after refinery we get vacuum residue so that vacuum residue can be upgraded so that good amount from the vacuum residue can be converted to usable liquid fuels. So, Visbreaking, delayed coking and solvent deasphalting, these are the technologies through which the vacuum residue can be upgraded and liquid fuels can be produced. And the remaining part which will be having coke, that coke will be converted to valuable products like say needle coke or can be used for the gasification to produce syngas.

And otherwise reforming and DME synthesis, natural gas if we use directly then there will be chance of leakage of it. It is also a global warming gas and so if we convert it the methane or natural gas to singas through reforming then this route may be cleaner route and the syngas can be converted to methanol, the basic chemicals and DME which can be used as a liquid fuel.

So these are the cleaner routes which we can use and extensive research is going on, some technologies have come up and we will discuss these in consecutive chapters or topics.

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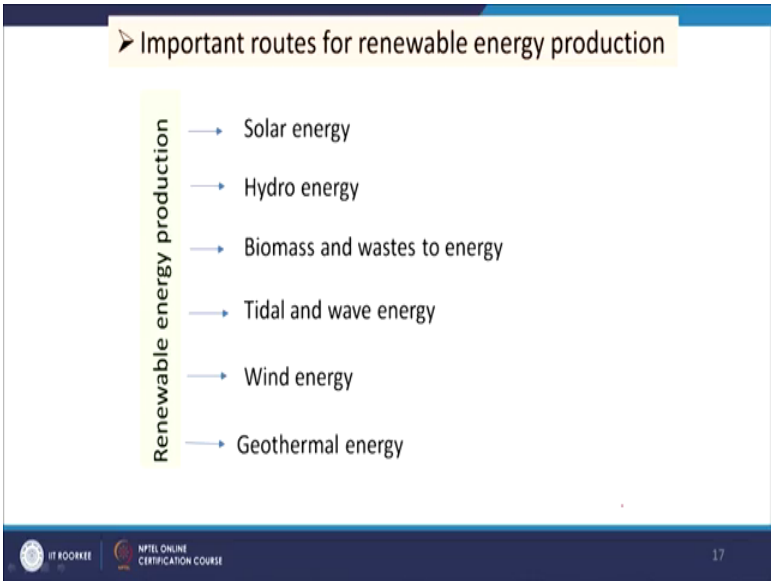

And then important routes for renewable energy production; if we see, the solar energy, hydro energy, biomass and waste to energy, tidal and wave energy, wind energy and geothermal energy, these are the important energy sources which we can use to produce renewable energy. The solar energy; as you know Government of India had initiated Jawaharlal Nehru solar mission in 2010 with an expectation to produce 20,000 megawatt by 2022.

But in 2015 on the basis of success of this mission the government has revised it and it is expected to produce 1 lakhs megawatt of electricity from this solar energy source. Hydro energy also as mentioned we have good contributions in the country through the hydro energy in renewable energy sources. And biomass and waste, India has some biomass to electricity production facilities.

But waste to energy conversion is very less but this area is being developed gradually. Tidal and wave energy; this is not widely used but we have scope, it is not used in India but we have scope but there are some issues we will be discussing these. And wind energy; already India is focusing on the development of more wind energy and we have already some capacity in the country. And geothermal energy; this is also another type of energy renewable energy which uses the hot springs or temperature available under the earth to convert it into usable energy.

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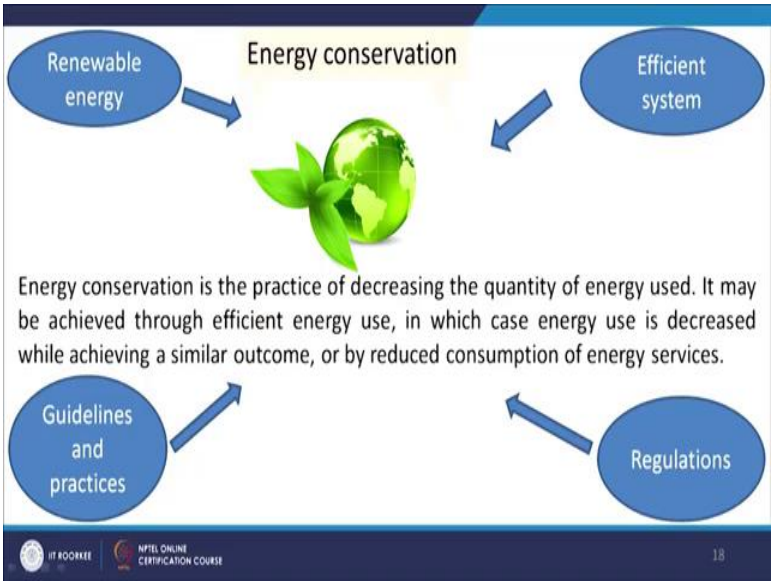

India has some potential but we have not yet explored. Now we are coming to energy conservation; so what is energy conservation? This is nothing but a practice by which we can optimize the utilization of energy. We can reduce the wastage of energy and how this can be achieved? This can be achieved by using renewable energy. How? Because when we are using renewable energy at the same time we are saving our fossil fuels.

So, one way this is helping us to conserve our energy security. Efficient systems: We need efficient systems; if the efficiency of a system for the energy conversions is increased obviously we will be able to produce more energy in useful form. For example, I have given one, that the subcritical and supercritical condition, if we use supercritical steam then obviously we will be getting more energy efficiency.

So, same amount of coal will produce more amount of energy when we are using the

supercritical boiler. We need some guidelines and practices and we also need some regulations.

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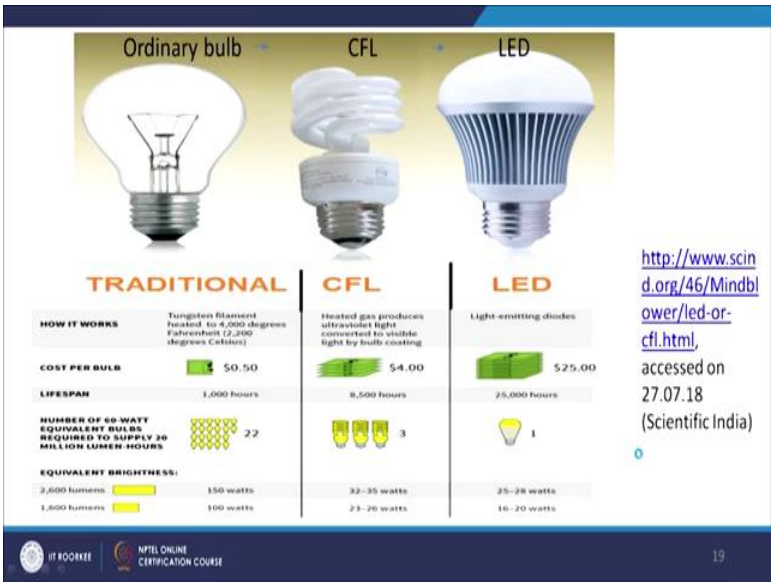

So, already people are working on this, so new technologies are being developed which are more efficient in terms of energy efficiency. So, here some example is traditional bulb, ordinary bulb, and CFL and LED. See, compare these three types of technologies, then we see cost is different we also see to give same amount of intensity of light different number of bulbs are required. And their lifespan is also different.

So, if we compare here to get the same amount of light intensity we can use 1 LED, we can use 3 CFL, we can use 22 traditional bulbs. And you see the energy consumptions for 2500 lumens we need 150 watts in case of traditional bulb but it needs 30 to 35 watts for CFL and for LED it is 25 to 28 watts. So, if increases the efficiency of the system we are able to reduce the use of energy.

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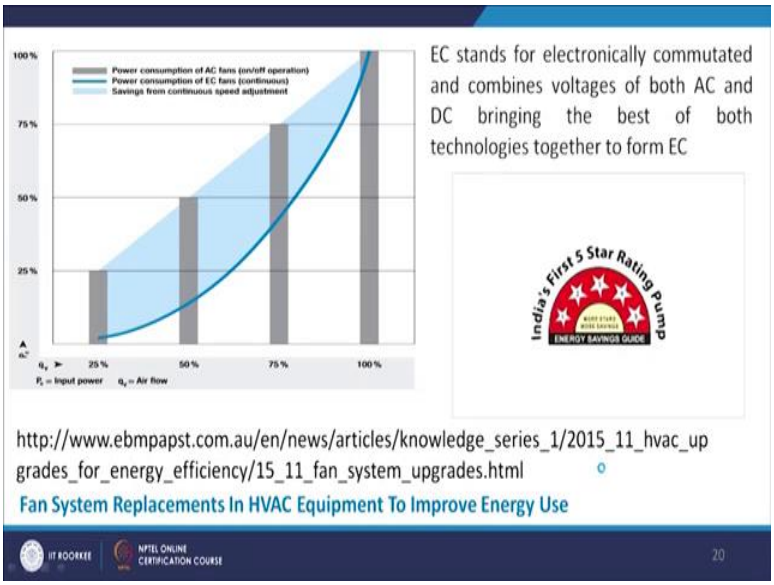

Another example is your power consumption of AC fans and EC fans. If we compare, so this is our EC fan power consumption and here this is AC. So, this much of energy we can save. how it is possible? By the improvement in the technology, you see here EC stands for electronically commutated and combines voltage of both AC and DC. Bringing the best of both technologies together to form EC, another is we are talking about the regulations and guideline.

So, in that aspect Government of India has taken initiations, bureau of energy efficiency has been created. And nowadays some regulations are also available so you see here India's first five-star rating form. So, all electronic appliances have been given star rating and below 3 stars it is not supposed to use it in houses, it is not allowed to use in government buildings and many other applications.

So, on the basis of the discussion it is clear to us that there is a need of the production of clean and renewable energy to ensure the energy security and sustainability in the 21st century and we will be discussing all those topics with greater extent with more explanation in consecutive modules, thank you very much.