Energy Resources, economics and Environment
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Lecture 2P3
Emission Factor

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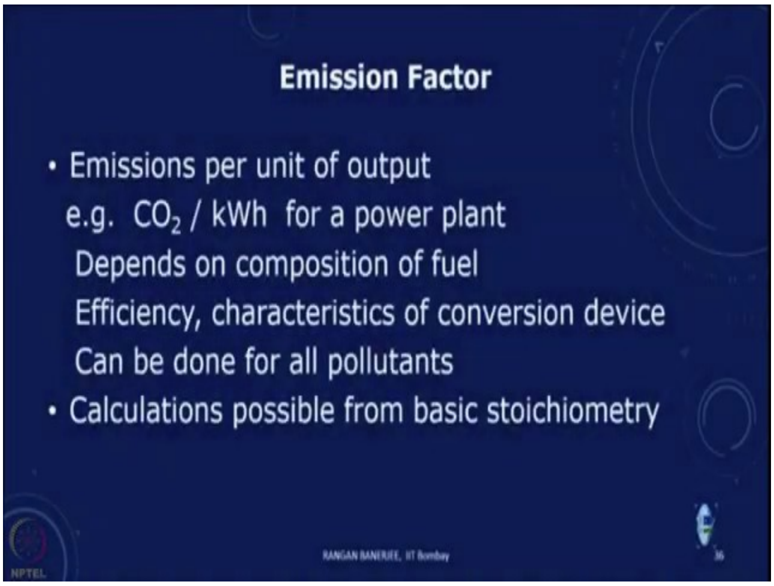

When we talked about the Kaya identity, one of the factors that we need to look at is what is the emission factor? So and this is something that we can do from first principle. So, whenever we look at, we are looking at a useful energy or a useful output that is being produced, for instance, tons of steel, kilowatt hour electricity how much electricity we are getting in a power plant.

So we would like to see as we do that how much is the carbon dioxide emission. So this will depend on the composition of the input or the fuel, the efficiency and the characteristics of the conversion device, similar calculations instead of CO2 can be also done for SOx particulate matter and this methodology is the same for all pollutants. The calculations are all possible from a basic stoichiometry and understanding of the process.

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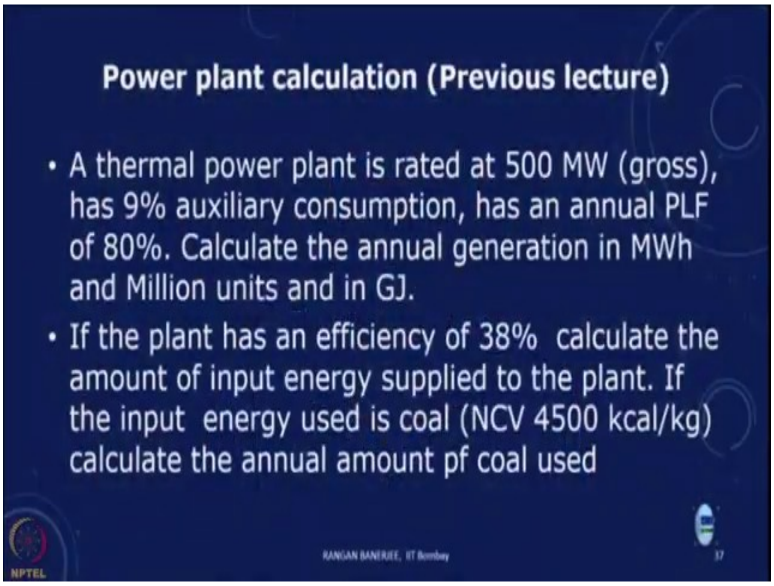

So, we will take an example. The same example that we took in the last class when we talked about in the previous lecture we talked about thermal power plant degraded at 500 megawatts and using coal and we calculated how much coal and how much energy is used.

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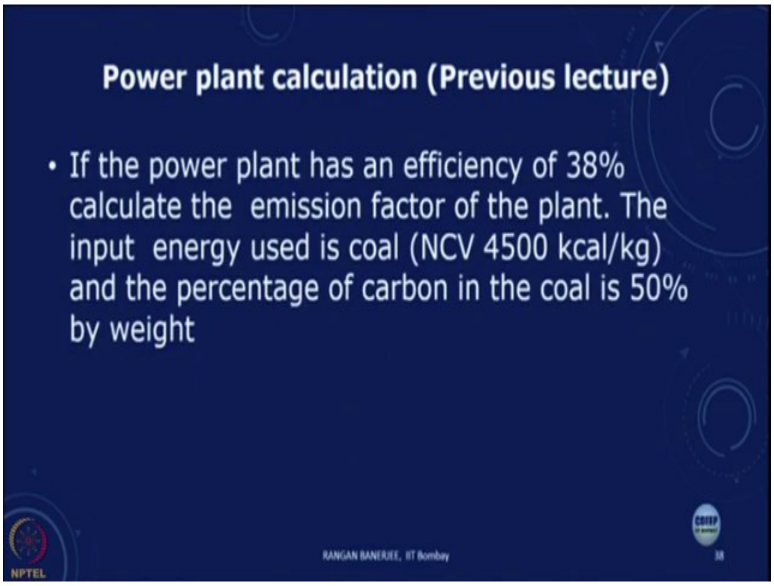

So, let us just recast that question – If this thermal power plant has an efficiency of 38 % calculate the emission factor of the plant. So the input energy used is coal with net calorific value of 4500 kcal/kg and the percentage of carbon in the coal is 50 % by weight.

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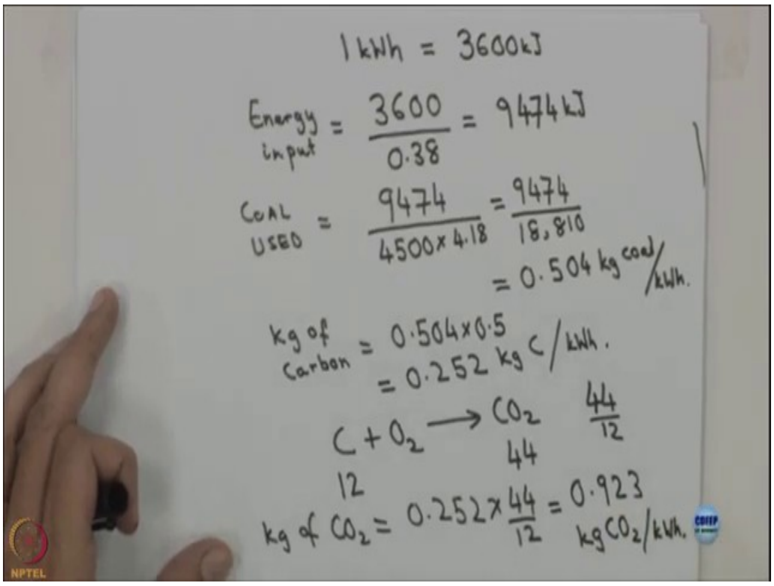

So, let us start this calculation.

1 kwh = 1 kW joules/sec x 60 x 60

1kWh = 3600 kJ

$$Energy\ input = \frac{3600}{0.38} = 9474\ kJ$$

$$Coal\ used = \frac{9474}{4500\ x\ 4.18} = \frac{9474}{18810} = 0.504\ kg\ \ coal/kWh$$

$$kg\ of\ carbon = 0.504\ x\ 0.5 = 0.252\ kg\ \ C/kWh$$

$$C + O_2 = CO_2$$

1 mole of carbon = 12 kg

1 mole of oxygen = 32 kg

So , $C + O_2 = CO_2 \qquad \frac{44}{12}$

12 44

$$kg\ of\ CO_2 = 0.252\ x\ \frac{44}{12} = 0.923\ kg\ CO_2/kWh$$

Now what you could do is you can see there is a Central Electricity Authorities – CEA, it gives norms of CO2 emission factors for different power plants in the country, I think you will have probably 2016 data is the latest which you can get, you can look at it and you will see many of these plants are in this kind of range. So this is something that you can calculate. Just like we have done this we can do a similar thing for a vehicle, we can do a similar thing for an industrial process, for any place where you are doing this you can get the emission factor.

Emission factor into the activity level will give you the total emissions, sum it up overall all these and you get the cumulative, so this is a simple calculation and something that you should be able to do on your own, please remember on the web you will find different emission factors for let us say power plants, they maybe for Australian coal in Australia, they maybe for European coal, the calorific value is different, the efficiencies are different so do not use emission factors from other context, for your context do the calculation yourself.

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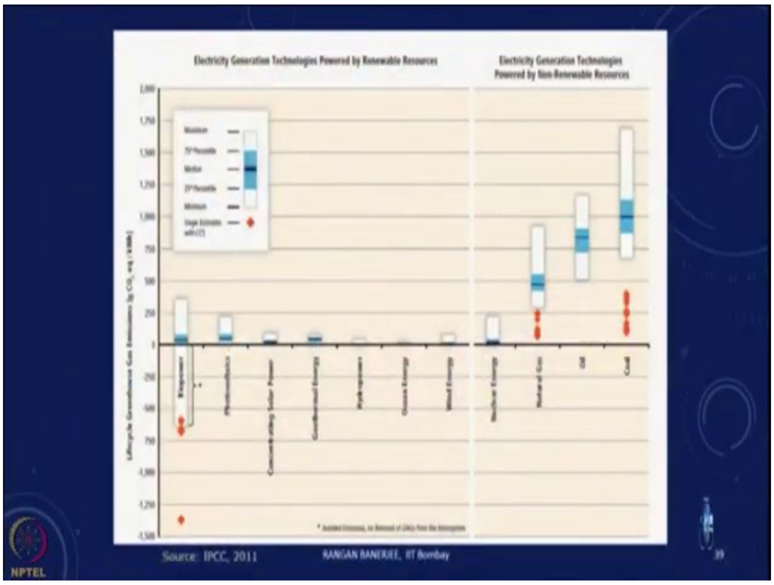

If you look at the different fuels when we will looked at coal, if you look at oil or natural gas you will see that the net calorific value is different, the percentage of carbon is different, you will find that all fuels have either have combinations of carbon and hydrogen and natural gas has more of hydrogen content so that on a per unit basis when we look at it the CO2 emission factors are lower.

So this table shows you the kind of norms of emission CO2 per gram CO2 gram equivalent per kilowatt hour and you can see that for coal you have a whole range going up the average being of the around 0.9 to 1 kg. You can see that for natural gas it is about half that number. And when you look at renewables you see here all the renewables are in the range of 20 to 50 grams less than a hundred and almost since some cases biomass is neutral all of this is including the entire life cycle. So for instance if you look at a wind turbine it will be the steel which is there and what is been the CO2 emissions to produce that steel.

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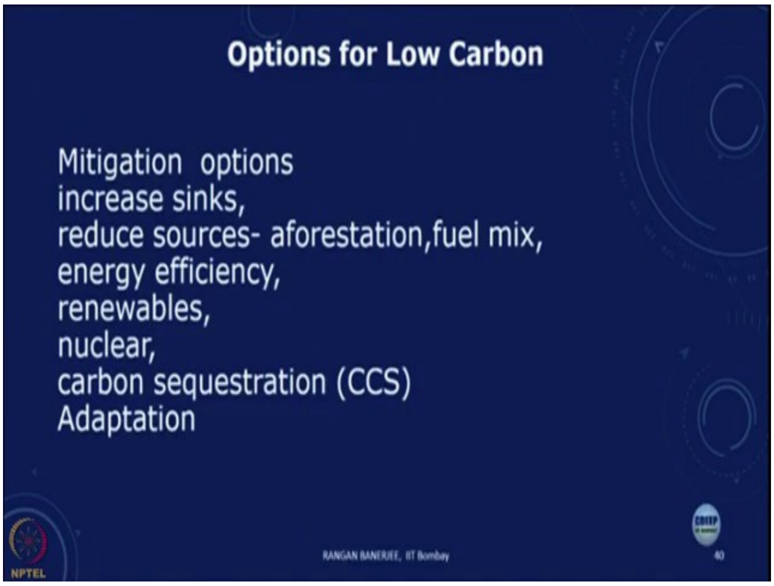

So, when we think in terms of managing the CO2, the options that we have are increased the sinks or reduce the sources, increase the sinks means we can do afforestation, in reducing the sources we can look at the fuel mix, changing from coal to oil to natural gas, we can look at the energy efficiency, we can look at renewables, we can look at nuclear, we can also look at carbon capture and storage and which technology will use depends on the kind of scale, depends on technology development, depends on cost.

So in a sense as we go forward, we have the choices between mitigation, adaptation and suffering and the decisions that we take today will decide the combination of this. So, either we can mitigate, if we do not mitigate and then there is some temperature rise and climate change we need to be able to adapt and we need to look at when that changes happen what will we do, and if you cannot adapt or mitigate then we will suffer. So this is a problem which is a global problem and this is a problem which needs all countries to get together and come up with solutions.

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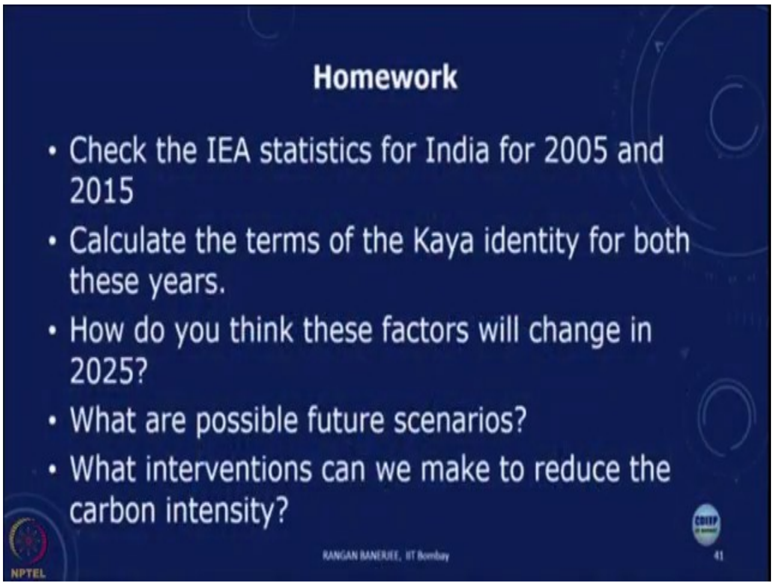

You can do as homework, you can look at check the IEA statistics for India for 2 years, I am suggesting 2005 and 2015, calculate the terms of the Kaya identity for both these years and see and think how this factors can change in another 10 years or another 20 years. What are the possible futures scenarios, what interventions can we make to reduce the carbon intensity.

As we go along in this course and we look at economics and policies towards the end we will discuss some of these. We will also have a recording of some of the country studies where some of our students will present some of the countries and what are they doing in terms of the Kaya identity and the policies. In Paris we had the Paris agreement a couple of years back essentially where all countries got together and in the IPCC meetings there was the problem in this is that it is difficult to get a consensus.

There are countries which are emitting much-much more than their global share but they are also highly develop, they do not want to change their trajectory. So even to decide whether we should have an emission norm which is CO2 per person and give a right to emit which is on a per capita basis was not agreed upon.

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Several countries which have developed more want that CO2 emission to be based on historical numbers one that CO2 emission to be on a per GDP basis so that the increase level of GDP is taken care of. However, developing countries are not willing to do this and hence there could not be any binding mandatory agreements. Finally, what was decided was every country decided that this is a problem that we would like to tackle. So, there was a process by which there were voluntary commitments made by different countries and these was then ratified into the national commitments.

In the case of India the commitments that we have made are: reducing the emissions intensity of GDP by about one third of the 2005 level in 2030, we are planning to create 40 % of cumulative non-fossil power bi installed capacity by 2030 and we expect that would get some finance from the International Green Climate Fund for this. We also plan to create an additional carbon sink of 2.5 to 3 billion tons of CO2 equivalent through additional tree cover and forest.

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So we will discuss some of this and the economics of this and in the future lectures. In this lecture we have looked at the environment. We found that it is a key driver for future energy systems. We concluded that the existing patterns are not sustainable into the future and we have a real problem in terms of climate change. We also problems in terms of local emissions and urban air quality. We looked at the quantification through the Kaya identity and the emission factors. In future classes we will explore the interaction between energy economics and environment and carry on with same thread. Thank you. These are some of the references.