Energy Conversion Technologies (Biomass and Coal)

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Lecture 7

Environmental aspects of energy

Good morning everyone.

Welcome to part 4 of lecture 3 under the same module. So, in this module we will practice few example on the concept discussed in the previous lecture. If you recall, in the previous lecture we discussed about ecology and the environment followed by greenhouse gas and global warming and in particular this topic we discussed about the global warming potential. In addition we discuss about pollutant from various fuel based power plants. So, in that we discuss about the various pollutant ranging from particulate matter, carbon dioxide, carbon monoxide, NOx, SOx and other pollutant.

So, in this lecture we will practice example in line with the concept of global warming potential as well as the pollutant emitted from various fuels and how to calculate the amount of CO_2 release into the environment on burning of such conventional fuel that means fossil fuels. So, before that we will just recap our discussion on the global warming potential.

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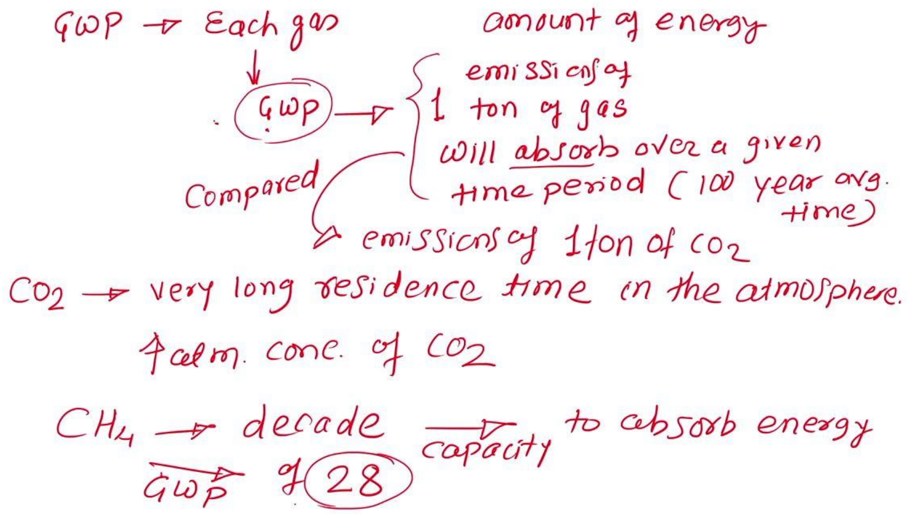

Global warming potential: So, each gas has a specific global warming potential which allows comparison of amount absorb over a given time period. So, basically here each gas has a specific global warming potential which allows the comparisons of amount of energy the emissions of 1 ton of gas will absorb over a given time period. And usually we consider 100 year average time and the comparison is with respect to the emission of 1 ton of CO_2. So, this comparison is based on emissions of 1 ton of CO_2 in the atmosphere because this CO_2 has a very long residence time in the atmosphere. And its emission cause increase in the atmospheric concentration CO_2 that will almost last for say thousands of years.

For example, if you remember in the previous lecture we discussed about the global warming potential. If you remember the methane's average atmospheric residence time is about decade. And if you see its capacity to absorb energy is substantially more than CO_2 and that gives its global warming potential of 28. So, the global warming potential of the methane is 28.

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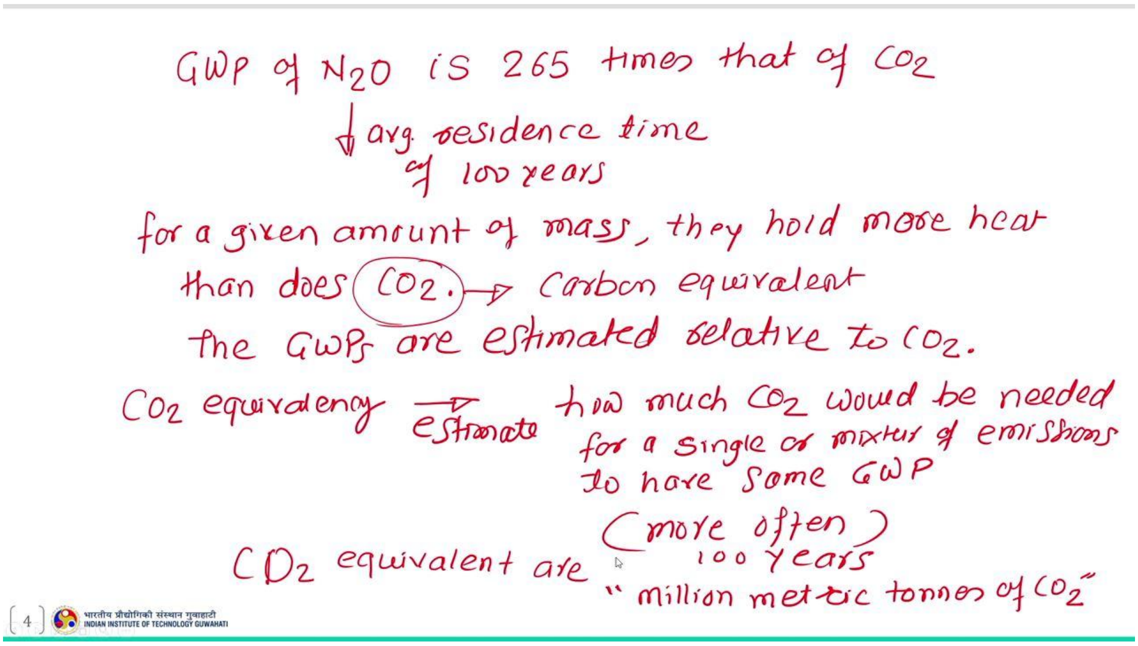

Similarly, if you remember the global warming potential of nitrous oxide is 265 times that of CO_2. And the average residence time is time of century that is close to 100 years.

So, that means for a given amount of mass they hold substantially more heat than does CO_2 because their global warming potential is relatively high and for that reason the global warming potential are estimated relative to carbon dioxide. Because in general we try to measure the impact of these various pollutants that is greenhouse gases on the environment in terms of its carbon dioxide equivalent or sometimes as carbon equivalent. Because carbon dioxide equivalency is one way to estimate how much CO_2 would be needed for say single gas that is for example like methane, nitrous oxide and others or mixtures of emissions to have same global warming potential. And it is measured over definite period of time that is more often 100 years. And this CO_2 equivalent is often measured in terms of million metric tons of carbon dioxide equivalent.

If you recall our discussion, so these are the points which we discussed in the previous lecture. So, in this lecture we will practice few examples on the similar concept.

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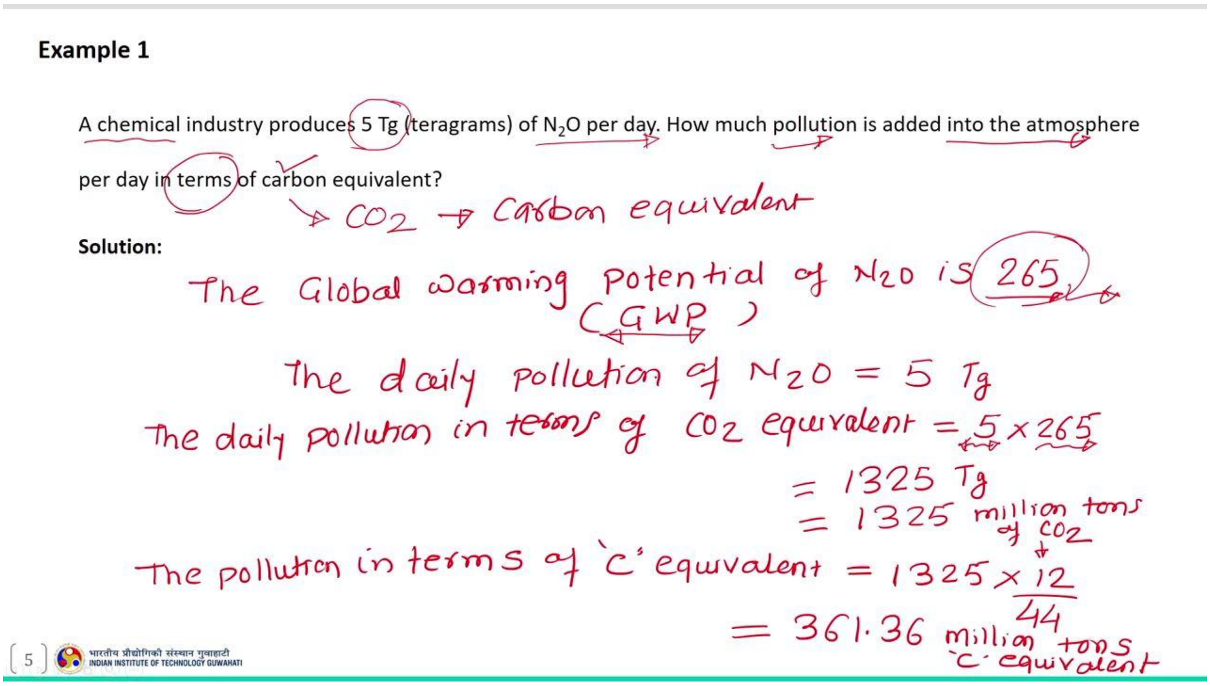

So, let us try to solve first example. So, in this example, it is mentioned that a chemical industry it produces 5 teragram of nitrous oxide per day. So, with this value we have to just calculate the amount of pollution which is added in the atmosphere per day in terms of carbon equivalent.

So, to solve this example first we need to calculate the value in terms of carbon dioxide equivalent and further you can convert that value into carbon equivalent. So, let us begin with this example. So, the global warming potential that is we also nomenclature it as GWP of nitrous oxide is 265 and this value we have obtained from one of the table from previous lecture. The daily pollution of nitrous oxide is given as 5 teragram. So, now if you just try to see the daily pollution in terms of carbon dioxide equivalent, in that case we have to simply multiply this 5 into 265. Because if you remember, the global warming potential of CO_2 is 1. And here the global warming potential of the nitrous oxide is given as 265. That means we have obtained this value from the table from the previous lecture.

So, now if you have to calculate this daily pollution in terms of CO_2 equivalent, so there you can simply multiply this value of pollution of nitrous oxide to its global warming potential. Then we will get the value in the form of 1325 teragram. And if you convert this it will comes out to be around like 1325 million tons of CO_2 as we have been asked to calculate the carbon equivalent value.

So, here we have to just go for the simple conversion because as we know the molar mass of CO_2 is 44 whereas the molar mass of carbon is 12. So, now if you have to calculate the pollution in terms of carbon equivalent. Then since this value is for the carbon dioxide equivalent if you have to convert it into carbon equivalent then you have to just simply use the molar mass of carbon and the molar mass of CH. That is the ratio of these two into the daily pollution in terms of carbon dioxide equivalent will results into a value of 361.36; this is million tons carbon equivalent.

So, this is very easy to solve this example once we know the global warming potential of a specific gas. So, in the similar line we can also calculate the carbon dioxide equivalent for other gases as well for example, for methane, ozone and other gases.

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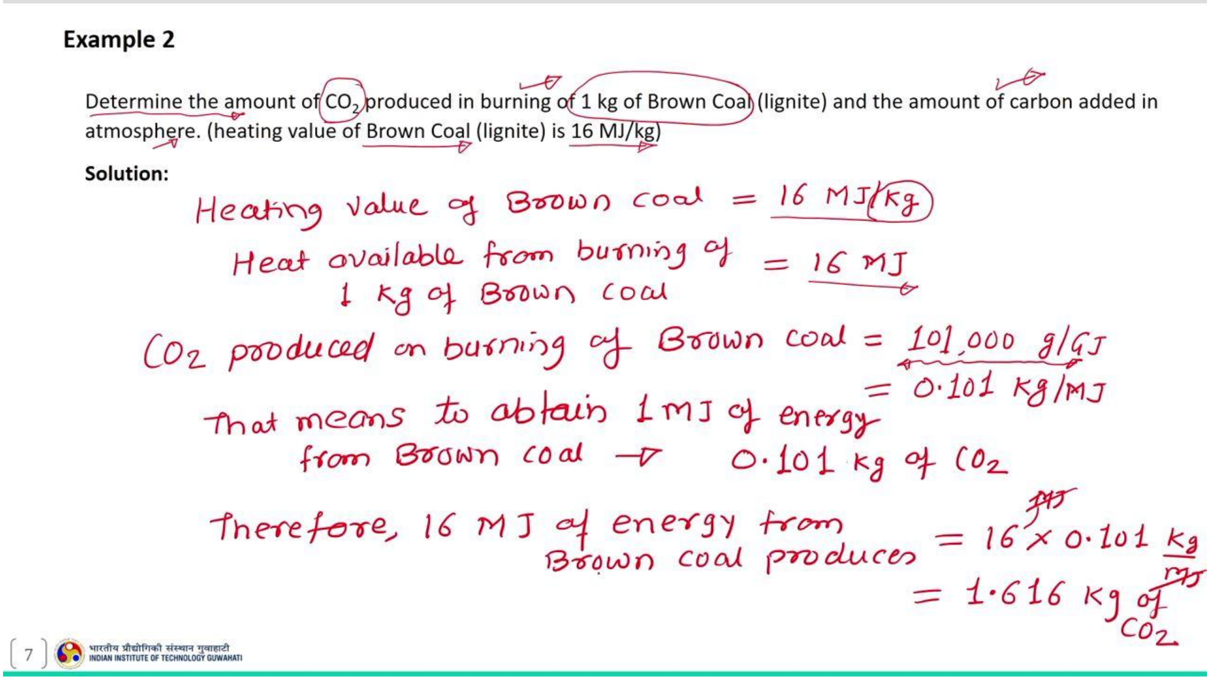

Similarly, in the previous lecture we discussed about pollutant from various fuel based power plant. In that we discussed about the different pollutants which get released into the atmosphere on burning of such fuels in the power plant and those pollutants are mainly particulate matter, carbon dioxide, carbon monoxide, NOx, SOx and other gases.

So, this particular example is in line with the concept of the pollutant which get released into the atmosphere on burning of the specific fuel in the power plant. So, in this example we need to determine the amount of CO_2 produced on burning of 1 kg of brown coal and also the amount of carbon added in the atmosphere. So, we need to calculate the CO_2 produced on burning of this fuel and also the amount of carbon which is added in the atmosphere on burning of this specific fuel. And the heating value of this fuel is given as 16 mega joule per kg. So, let us try to solve this example.

The heating value of brown coal is given as 16 mega joule per kg. So, which indicates the heat available from burning of 1 kg of brown coal which is equal to 16 MJ. Because the heating value of this brown coal is 16 MJ/kg. So, heat released on burning of say 1 kg of brown coal is equivalent to 16 MJ. And the CO_2 produced on burning of brown coal is 101,000 gram per gigajoule and this value also we have obtained from previous lecture.

So, if you recall in the lecture, we discussed about the pollutant from various fuel based power plant and there we have listed various fuels and the CO_2 produced from those particular fuel. So, this value is obtained from that specific table from the previous lecture. And if you convert this value it will be 0.101 kilogram per mega joule. That means it indicates to obtain 1 mega joule of energy from brown coal 0.101 kg of CO2 is produced that is the meaning here. That means to obtain 1 mega joule of energy from brown coal it produce 0.101 kilogram of CO_2.

Now, therefore, as we know 1 kg of brown coal it produces heat equivalent to 16 mega joule. So, therefore, 16 mega joule of energy from brown coal produces 16 into 0.101 kilogram per mega joule and this value is in MJ. So once it cancels out so it gives the answer in the form of 1.616 kilogram of carbon dioxide. So 16 mega joule of energy from brown coal it produces around 1.616 kilogram of carbon dioxide.

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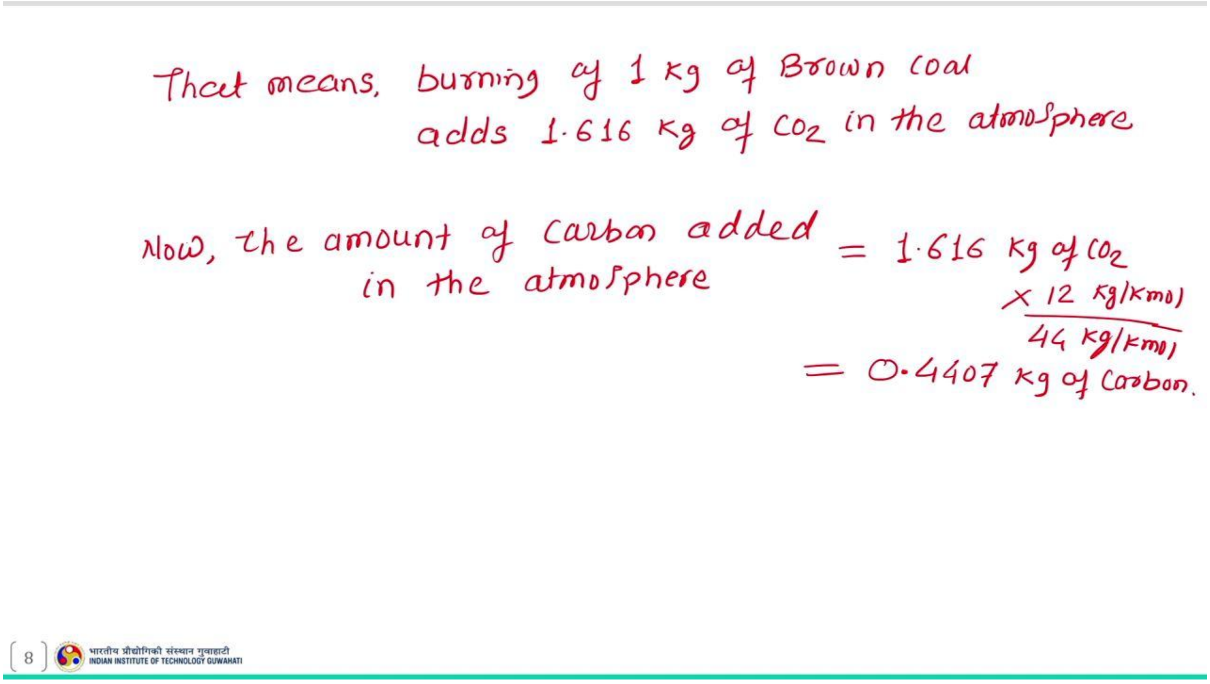

That means burning of 1 kg of brown coal adds 1.616 kilogram of CO_2 in the atmosphere. Now suppose, now we need to calculate the amount of carbon added in the atmosphere, which is equal to because we know the carbon dioxide produced is 1.616 kilogram. So, once you multiply this value by again the molar mass of carbon by molar mass of carbon dioxide.

So, this gives the value in terms of carbon added in the atmosphere and which comes out to be around 0.4407 kilogram of carbon. So, this is basically the example which gives us insight on the amount of CO_2 which gets released into the atmosphere on burning say 1 kg of brown coal. So, in the similar line we can also solve the example for the other fuels say for example the hard coal, the oil and the gas.

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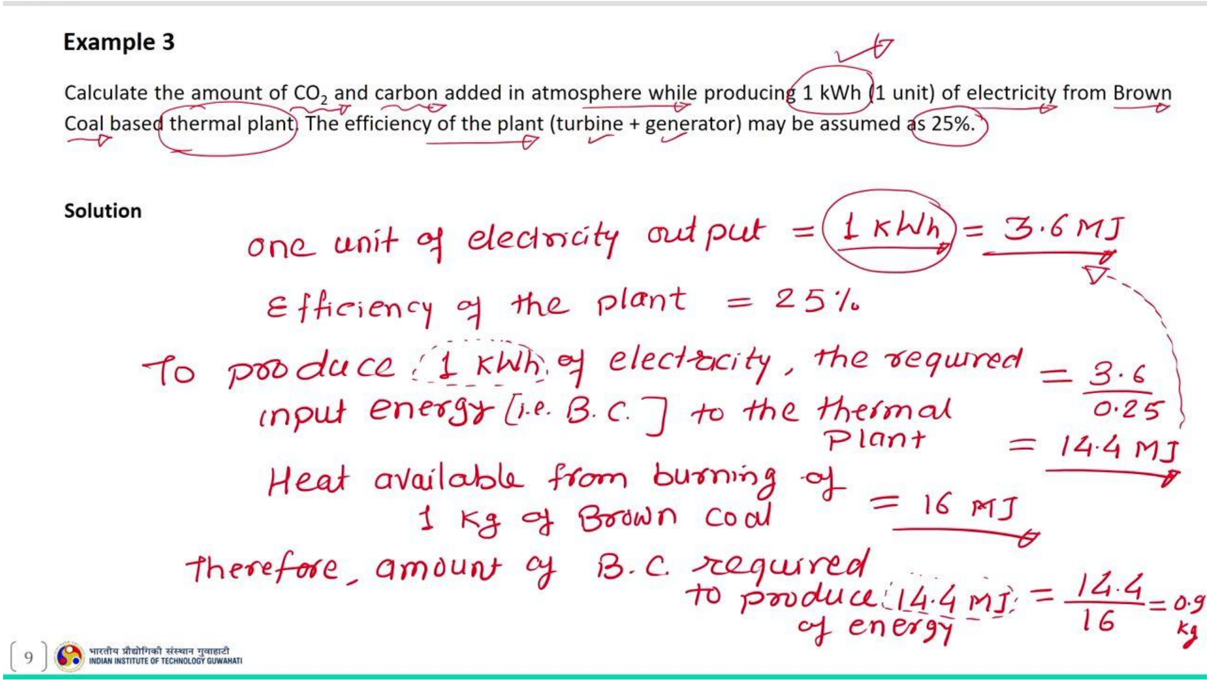

So, now let us solve one more example which is on the similar line where we need to calculate the amount of CO_2 and carbon added in the atmosphere while producing 1 kilowatt hour electricity. And again the fuel use here is brown coal in thermal power plant. And efficiency of this plant that is turbine plus generator efficiency is given as 25%.

So, now based on this given data we need to calculate the amount of CO_2 and the carbon added in the atmosphere while producing this much amount of the electricity. So, this example is basically in line with the previous example from where we will be using some of the data to solve this example as well. So, here if you see the 1 unit of electricity output is equal to 1 kilowatt hour and once we convert this value into mega joule it comes out to be 3.6 mega joule. And the efficiency of the plant is given as 25 percent.

So, now to produce this 1 kilowatt hour of electricity the required input of energy to the thermal power plant we need to calculate. Therefore to produce 1 kilowatt hour of electricity the required input energy because here the input energy is nothing but in the form of brown coal to the thermal plant is, so here it will be 3.6 divided by the efficiency of the plant which is 25 and we will get the value in the form of 14.4 mega joule. So, that means to produce 1 kilowatt hour of electricity the required input energy to the thermal power plant is 14.4 mega joule. So that means the 14.4 MJ of energy is getting converted into close to 3.6 MJ which is equivalent to 1 kilowatt hour of electricity.

Now the heat available from burning of 1 kg of brown coal is 16 MJ. This is basically the heating value of the brown coal that is 16 MJ/kg, the amount of brown coal which is required to produce 14.4 MJ of energy. So, here simply we can divide by this heating value of the brown coal and the value comes out to be around 0.9 kg. So, basically to produce 14.4 mega joule of energy the amount of the brown coal required is 0.9 kg.

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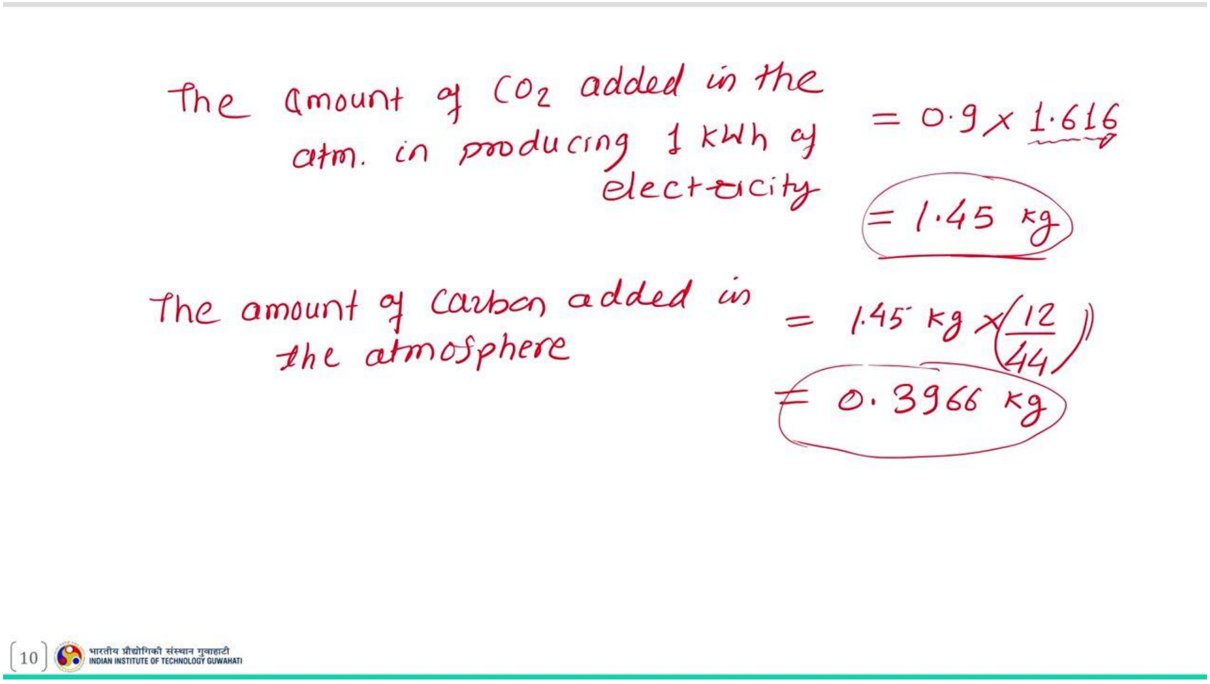

So, once you know the amount of the brown coal which is required to produce 1 kilowatt hour of electricity, then we can easily calculate the amount of CO_2 added in the atmosphere while producing 1 kilowatt hour of electricity which is 0.9 into 1.616. And this value we have obtained from the previous example.

So, after multiplying these two values we will get the final answer in the form of 1.45 kg. And similarly from this value we can calculate the amount of carbon added in the atmosphere. So, from this obtained value of CO_2 we can easily calculate the amount of carbon added in the atmosphere which is equal to 1.45 kg into molar mass of again carbon divided by the molar mass of carbon dioxide. So we will get the value in the form of 0.3966 kilogram. So, this is basically the value which indicates the amount of carbon added in the atmosphere on burning of around 0.9 kg of brown coal which eventually produces 1 kilowatt hour of the electricity.

So, likewise we can also solve the example for the other fuel as well. The assignment will also follow the similar examples, where you will be asked to calculate the CO_2 which is added in the atmosphere on burning of the specific fuel as I mentioned. Because if you recollect our discussion, so in the previous lecture we have discussed about the different fuels and their harmful effects on the environment. So, with this we will end our lecture here. So, in the next lecture we will discuss about concept of solid and the liquid fuels, basic understanding of various properties of different fuels.

So, mainly we will start with the solid fuels. So, in that we will discuss about the heating value of fuel, ultimate analysis and proximate analysis. Regarding this lecture, if you have any doubt, feel free to contact me at vvgoud@iitg.ac.in.

Thank you.