Carbon Accounting and Sustainable Designs in Product Lifecycle Management

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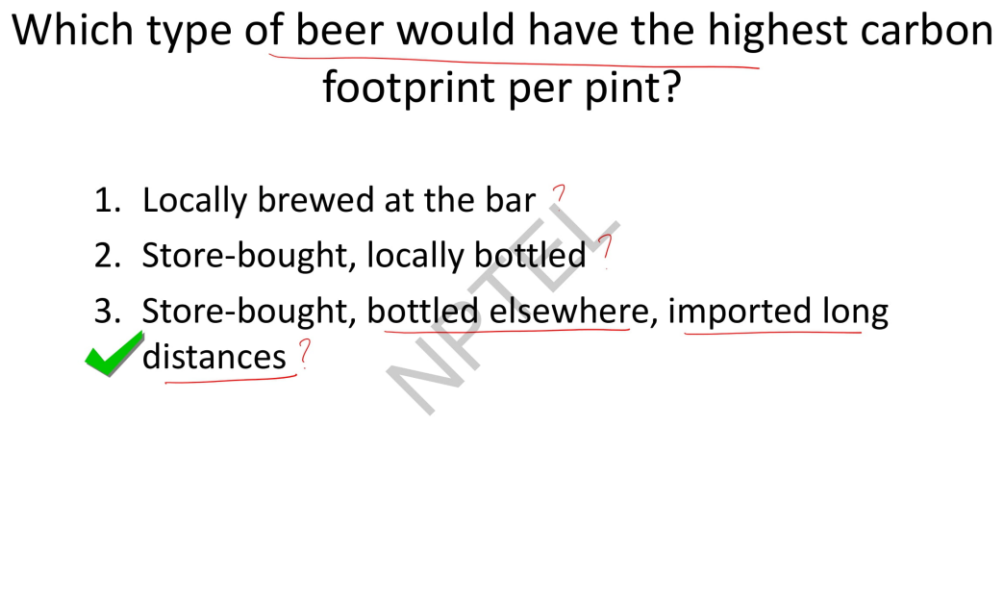
Week 03

Lecture 12

Some More Green Thoughts and Footprints

Good afternoon, everyone. Welcome to the course NPTEL MOOC's course titled Carbon Accounting and Sustainable Designs in Product Lifecycle Management. And I'm Dr. Deepu Philip. I am from IIT Kanpur. And along with me, Dr. Amandeep Singh Oberoi and Dr. Prabal Pratap Singh are co-teaching this course.

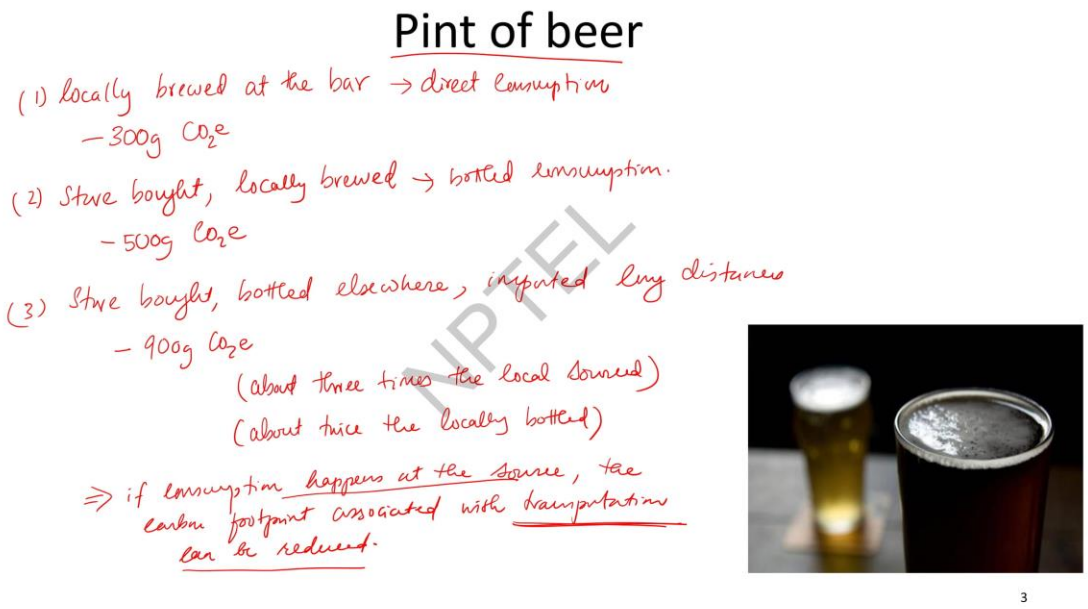
And in this course, we have gone through a lot of aspects of the sustainability, carbon accounting, how to quantify the sustainability in the design. And how to encompass that kind of sustainability thought process throughout the entire life cycle of a product. So, we were talking about carbon footprints and now we will talking more about that. So, in today's lecture, we are talking a little bit more on the title is Some More Green Thoughts and Footprints. And we acknowledge the inputs by Dr. Mike Lee and Dr. Paul Schillings in this topic.



So, we will start with a simple question today. So, which type of beer would have the highest carbon footprint per pint? So, if you look into the slides, you can see that we are just asking for beer. I am not asking you to drink alcohol, but just a simple question. It will be like an interesting question.

So, there are three options. Number one is a locally brewed beer. Is this the right answer or store-bought locally bottled or store-bought bottle, elsewhere imported long distances? So, among these three, which one would have the highest of the carbon footprint? And the answer is obviously Store-bought, bottled elsewhere, imported long distances.

Because the transportation and the footprint associated. So, when you are bottling elsewhere, we don't know about the process. And when you are importing long distances, it is actually traveling along and then it may be on a ship or a truck or something else. So that actually would create a quite a lot of carbon footprint.



So now let's talk about this, approximately, what is the footprint about the Pint of a Beer, it's like a glass, okay.

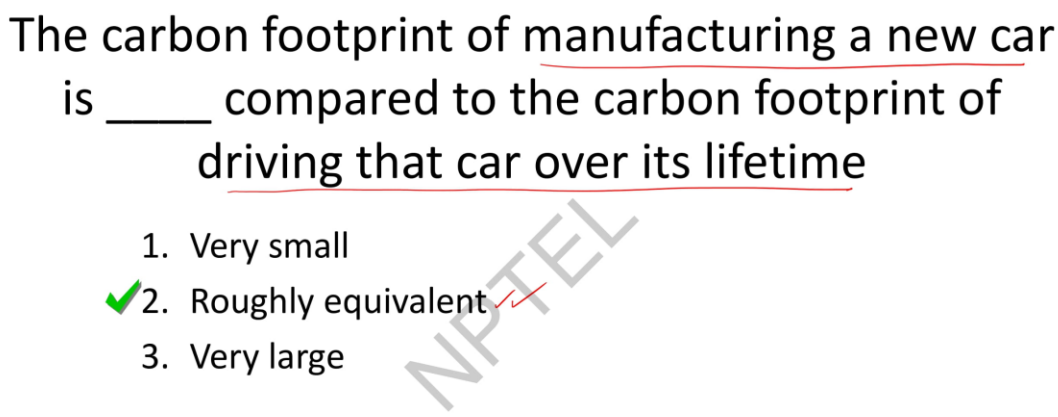
So number one is locally brewed at the bar, okay. Such type of beers, you can see in Bangalore pubs, they do this. It's about 300 grams of carbon dioxide equivalent, CO_2e, okay. That's typically how much the estimated values are. Things can change, but reasonably these are numbers that we can use for calculations, right.

If you talk about store-bought, okay. You are locally brewed. So, you are, it is, in the one case, this is you are directly drinking at the bar, okay. This is direct consumption, okay. Here it is a bottled consumption.

But it is locally brewed and locally bottled, okay. That is the case, the carbon dioxide equivalent is 500 grams of CO_2e, okay. But if we take the third one, which is store-bought. You are buying from a store, bottled elsewhere, someplace else and imported long distances, okay. If that is the case, then we are getting what you call as 900 grams of CO_2e, carbon dioxide equivalent.

So, you can see that this is about three times the local sourced and about twice the locally bottled. So, the logic behind this is, if consumption happens at the source, the carbon footprint associated with transportation can be reduced. So the main thing is that if you consume it at the source itself. Then the transportation footprint, the carbon footprint

associated with the transportation can be reduced. And in slides below, in the remaining sections, we will see how this transportation is actually a very big issue or very big part of the carbon footprint.



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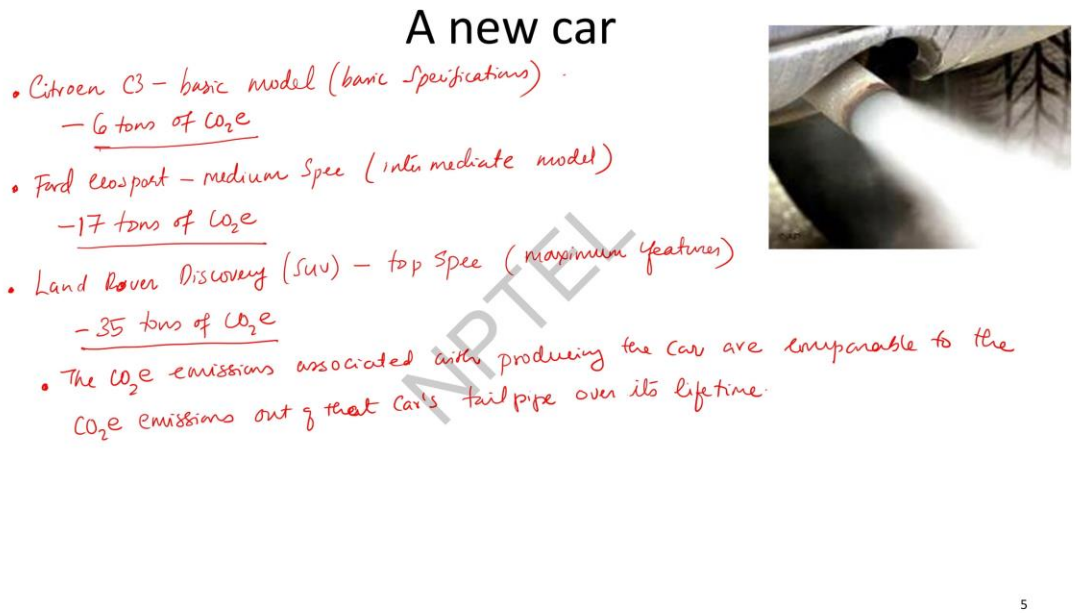
Now, let us take the next question. So, the carbon footprint of manufacturing a new car. So, the key question here is manufacturing a new car. We are making a new car, its dash, it's a fill in the blanks. Is dash compared to the carbon footprint of driving that car over its lifetime.

So, which value among 1, 2, 3 will be the correct choice? The carbon footprint of manufacturing a new car and the carbon footprint of driving that car over its lifetime is typically taken as 20 years, okay. So, one is very small, roughly equivalent, very large, okay. And the right answer to that question is roughly equivalent. Both are almost the same. So, this is the right answer.



And so, with that, now let us look at some of the carbon footprints. So, let us take some new cars that we know and where the carbon footprints have been calculated. So, one of the car we are talking about is the Citroen C3, which is a car that is now available in India, C3, okay. And we are talking about a basic model, okay.

Basic model, very basic thing, okay. The carbon dioxide equivalence is 6 tons of CO_2e, okay. So, a basic spec, basic model means basic specifications. Not many 5 things are there in this car, okay. Now, let us take another model.

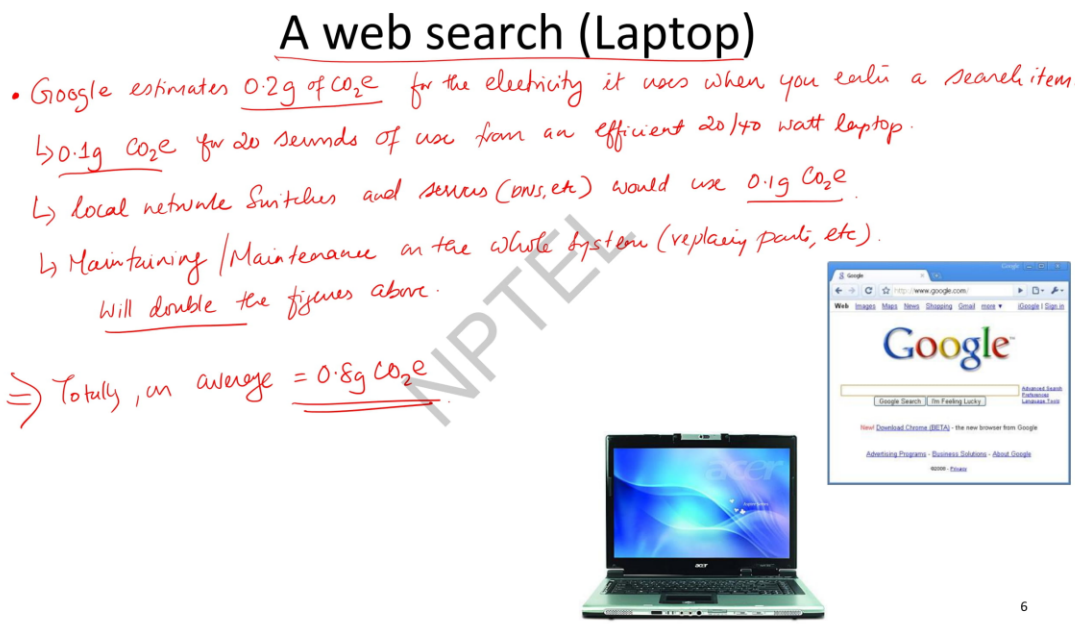
Ford EcoSport. We are taking these models because these carbon values are available, they calculated it. Let us talk about the medium spec. Let us make this like an intermediate model. Okay. That is about 17 tons of CO_2e.

That's the Ford EcoSport. Now, let's talk about a third model. Land Rover Discovery. It's a big SUV. Let's say top of the range, Top specs, Maximum features, okay.

That one is about 35 tons of CO2e, carbon dioxide equivalent. Okay. So, the main thing that you should understand as part of it is the CO2e. The carbon dioxide equivalent emissions associated with Producing the car. The car are comparable to the CO_2e emissions, out of that car's tailpipe over its lifetime. So, what it says is that, if you buy a Citroen C3, okay.

Basic model and you drive it around, let us say you take the life of the car as 20 years. Then what that means is to produce a car, it would have costed us 6 tons of CO_2e and to drive the car, it will be roughly same 6 tons. If you look at a Ford EcoSpot medium specs, the cost. The carbon dioxide equivalence will be 17 tons to produce it and the equal amount you will get out of the pipe if you drive it for about 20 years, okay. And same thing is true for Land Rover Discovery top model, 35 tons of CO_2e.

And we use these three examples because these values are calculated. So, now let us look at what you call as a web search, okay.



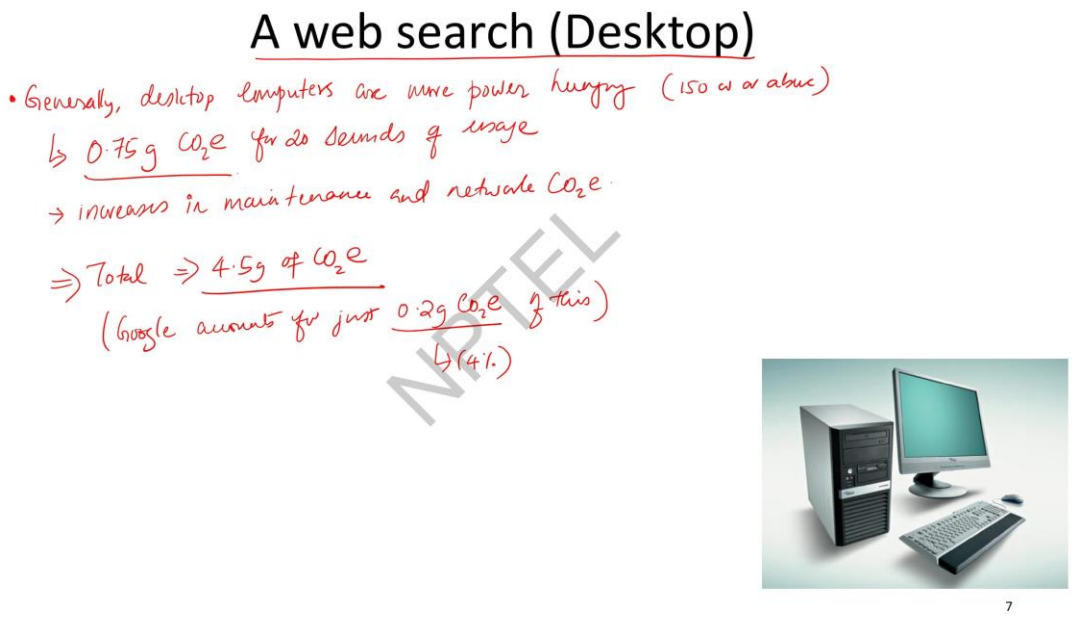
We all do web search Google on a laptop. Okay. Lot of us, almost everybody does on a daily basis. So, what is the carbon footprint associated?

So, even many of the companies are now estimating this. Okay. So, Google estimates 0.2 grams of CO_2e for the electricity it uses when you enter a search item, okay. When you go to Google, open it and type some search. So, like something like Uttarakhand flood or something, when you do that. Then that entire search and other things, 0.2 grams of CO_2e.

So, it is like 0.1 gram CO_2e for 20 seconds of use. From an efficient 20-40 watt laptop, okay. So if you use a efficient laptop, then that's 0.1 grams you have to eat, okay. Then

another thing is local network and server, local network switches and servers, DNS, etc, okay. Those kind of servers would use 0.1g CO_2e.

That is another estimate. Then, if you ask, maintaining or maintenance on the hall system which includes replacing parts, etc, will double the figures above. The important thing is if you have to do any maintenance, all these values will double. So, this also means that totally, on average, it comes to 0.8 gram per gram CO_2e. So, when you take the large number of cases in this and average it across for a longer time period, then it will come to 0.8 grams of carbon dioxide equivalents.



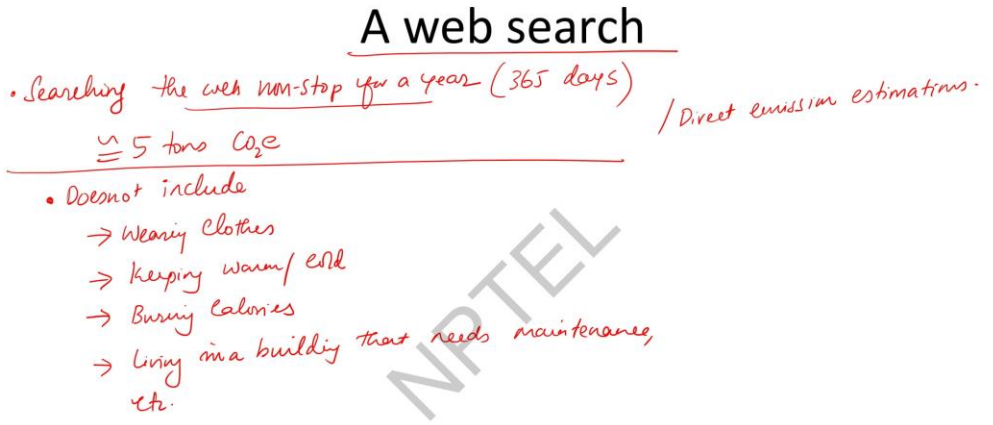
So, what if you use a desktop? So, this web search using a desktop, there is one assumption. Generally, desktop computers are more power hungry, which means it is 150 watt or above, okay. So, that would be about, okay. So, if you look into this, the previous case, it is 0.2, right.

So, in this case, E will be looking at something like 0.75 gram CO_2e for 20 seconds of usage, okay. That is the 0.75 grams of this. And then the network increases in maintenance. And network carbon dioxide equivalent. That also will happen if you use a desktop.

So, in the previous case, we can see that we are talking about 0.8 gram, but in this case, we are looking at a total of is 4.5 gram of CO_2e. So, it is far bigger than the other one,

okay. So, remember, Google accounts for just 0.2 gram CO_2e of this, okay. So, that is about, I would say, 4%, approximately 4%. So, the Google will take about only 4% of it, but maintaining, powering the screen, keyboard, mouse, all those kind of things put together, it's actually more expensive.

Or more, not more expensive, more carbon footprint. So, some more numbers on web search, okay.



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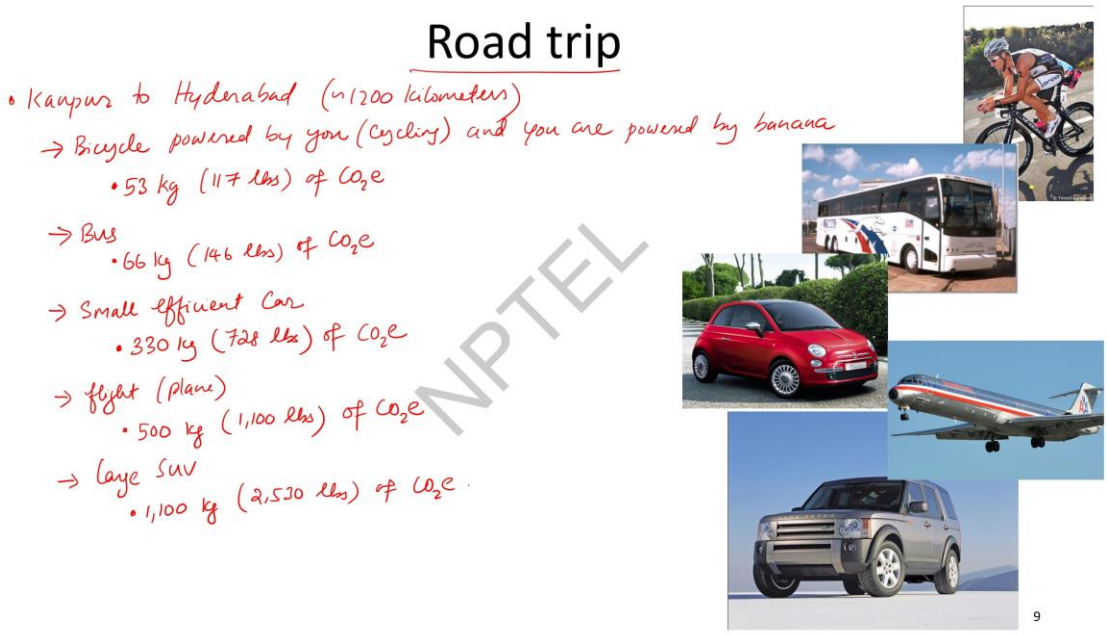
So, number one is searching. If you continue to search, searching the web non-stop for a year. If you do this 365 days. Okay.

If you take 365 days and you search web non-stop without any stop, then that's approximately about 5 tons of CO_2e, carbon dioxide equivalents, okay. Again, this does not include, okay. Number one, wearing clothes. If we wear clothes, then the clothes will have a carbon footprint. Keeping warm, cold.

If it is a cold place, you will have to heat it. If it is a hot place, you have to cool it. So, that is not there. Added in, burning calories, eating, your food is not there. Then, living in a building that needs maintenance etc.

So, this is only just the what I said earlier is remember you are talking only about the direct emissions or direct emission estimation. The indirect parts are not calculated as

part of this. So, just, these are some of the things that can actually or easily be quantified. These are being quantified by people. So, we can refer to this. Okay.



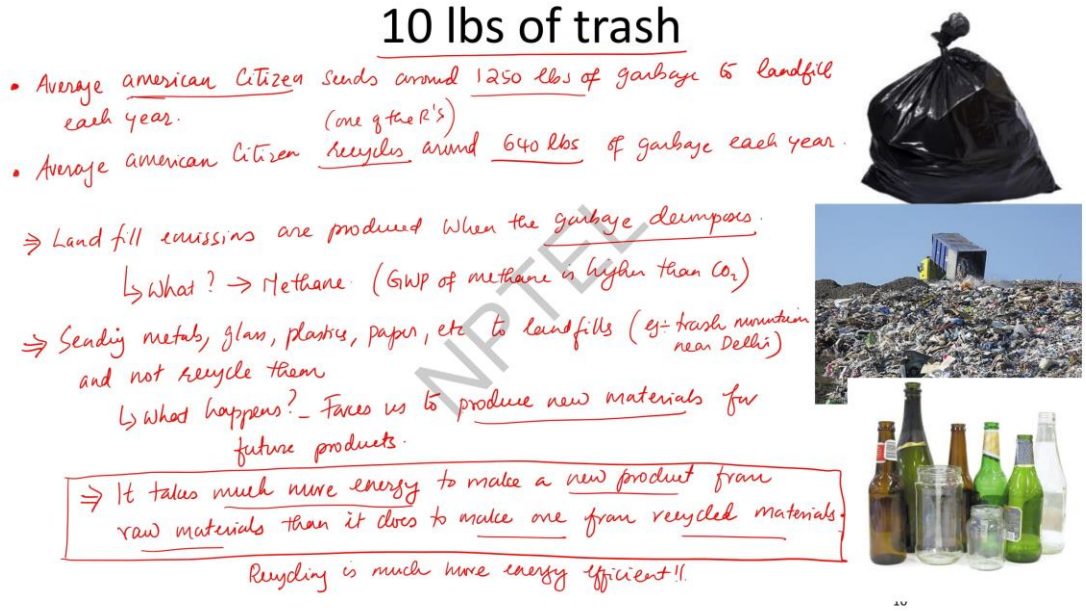
Now, let us talk about road trip. An interesting thing. Okay. Many things you can talk about. So, let us talk about a road trip from Kanpur to Hyderabad approximately 1200 kilometers. It's one side is 1200 kilometers.

Two side will be 2400. Approximately that's 800 miles almost. So, if you bicycle powered by you. You are pedaling, so you are cycling and you are powered by banana, only banana. You are just eating banana and pedaling.

That is approximately 53 kg or 117 pounds lbs of CO_2e, carbon dioxide equivalents. If you take a bus, a public transport, it's about 66 kg, 146 lbs of CO_2e because the public transport. So everybody is joining together, so the carbon footprint gets divided, okay. Take a small efficient car. I added a Fiat Punto here, but that's, if you look into this, that's 330 kilogram, about 728 lbs of pounds of carbon dioxide equivalent.

Small efficient car. If you take a flight or plane. That is about 500 kg, 1100 lbs of CO_2e, carbon dioxide decarbon. So, if you take a flight, that is what it is. If you drive a large SUV.

Big SUV, then that is about 1100 kilogram. That is 2530 lbs of CO_2e. So, a large SUV, if you drive like a Land Rover Defender or something, then you are looking at 1100 kilograms of carbon dioxide equivalent. That will be the, so it will be largest emissions as part of it.



Now, let us look at trash. Okay. We all generate trash at our homes and the trash typically gets put in a bag and then goes into the landfill and different type of, so here is an example of a landfill. Okay. Trash being, you might have seen similar landfills in around Delhi. Okay. Some picture like this. So, what it is about? So, we have not quantified this very well in India. Okay.

So we will use the American numbers. Average American citizen generates or sends around 1250 pounds of garbage to landfill each year. So, every year, an American citizen, an average American citizen sends around 1250 pounds of garbage to landfill each year. Okay. Similarly, average american citizen recycles around 640 pounds of garbage each year. So, that means, remember, reduce, recycle, refuse.

So, this is one of the R, okay. Recycle, okay. One of the R's of sustainability, okay. So, about 640 pounds of it is being recycled, okay. Then, one thing you should notice is landfill emissions, okay.

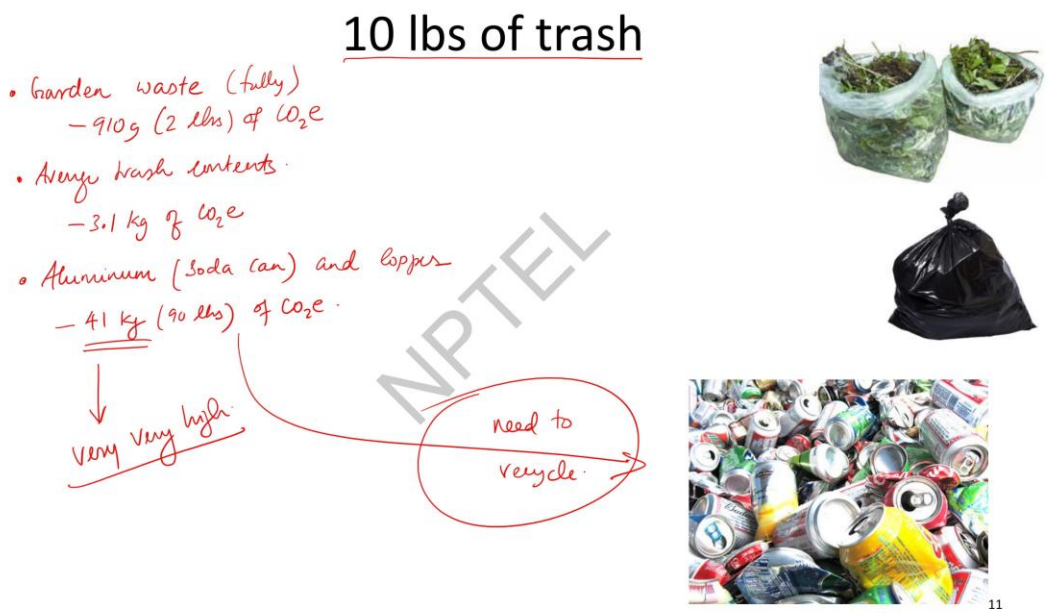
Emissions are produced when the garbage decomposes. When the garbage goes into the soil and it decomposes, it produces landfill emissions. What is the major landfill emission? What is the emission? That is methane.

If you remember, methane is more than, 20 times more than, more potential than carbon dioxide. So, methane, GWP of methane is higher than CO_2. Please look at the older lectures, okay. So, then another thing is, another point you should also understand is sending metals, metals, glass, plastics, paper, etc to landfills, okay. If you send these to landfills, okay.

Landfill means you put it in like, what is a landfill? Landfill is like, example, trash mountain near Delhi. So, you will know what I am talking about. That's what a landfill is, okay. If you send metals, glass, plastics, paper, etc to landfill and not recycle them.

And if you don't recycle them, then what happens. The main thing is, what happens? If you don't recycle them and just send them to landfill, what happens? It forces us to produce new materials for future products. Okay. For future products, we have to make new materials.

So, the key note here is, it takes much more energy to make a new product from raw materials. Than it does to make one from recycled materials. So, this is a key thing that you should remember. It actually would cost us to make, we will have to spend more energy, much more energy to make a new product from the raw materials than to make it the same from the recycled materials. So, recycling is, so another way to think about it is, recycling is much more energy efficient. That is the other observation that we need to think about. It's much more energy efficient.

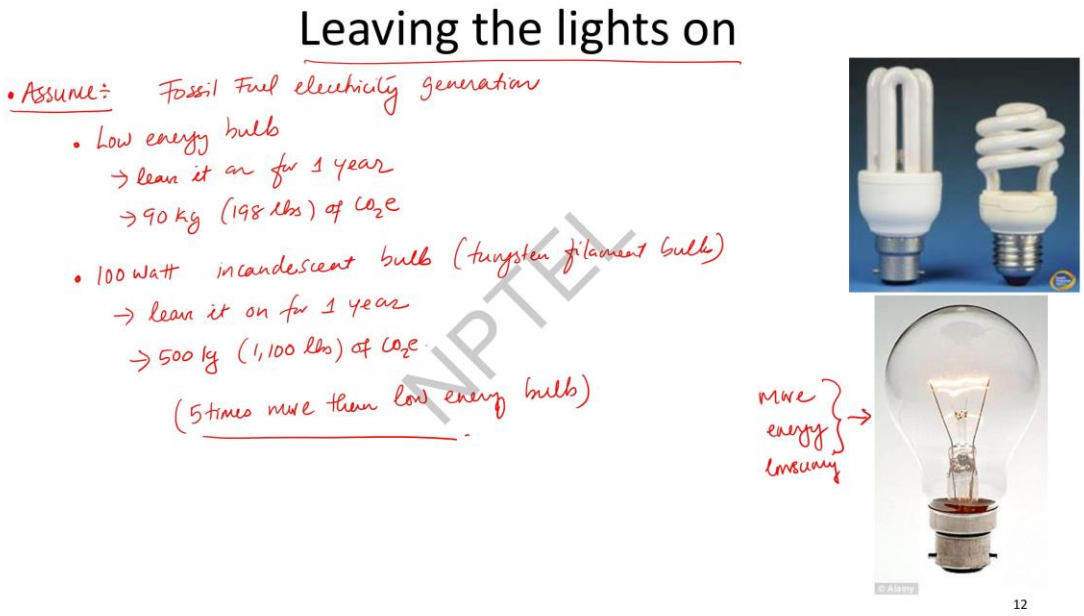


So then, let's talk about 10 pounds of trash. What it is? Again, put some numbers into perspective as part of this.

So, if it is just garden waste. If it is just garden waste, if that is the whole trash. It is about 910 grams of, that is about 2 pounds of CO_2e, carbon dioxide equivalent, if it is just garden waste. Okay. It is an average trash contents. okay. Average trash contents, if it is not just, so this garden waste means it's fully garden waste.

But the other case it's average trash contents, it includes both, then that's about 3.1 kilogram of CO_2e, okay. If it is just aluminum, that is soda cans or Pepsi cans, what we call it, and copper. I am just adding copper for the time being. That is about 41 kilogram. That is 90 lbs of CO_2e.

Just put things into perspective. So, this is something that is why need to recycle because the carbon footprint associated with this is way much higher than these two things, very high. That is why people always say recycle the cans.

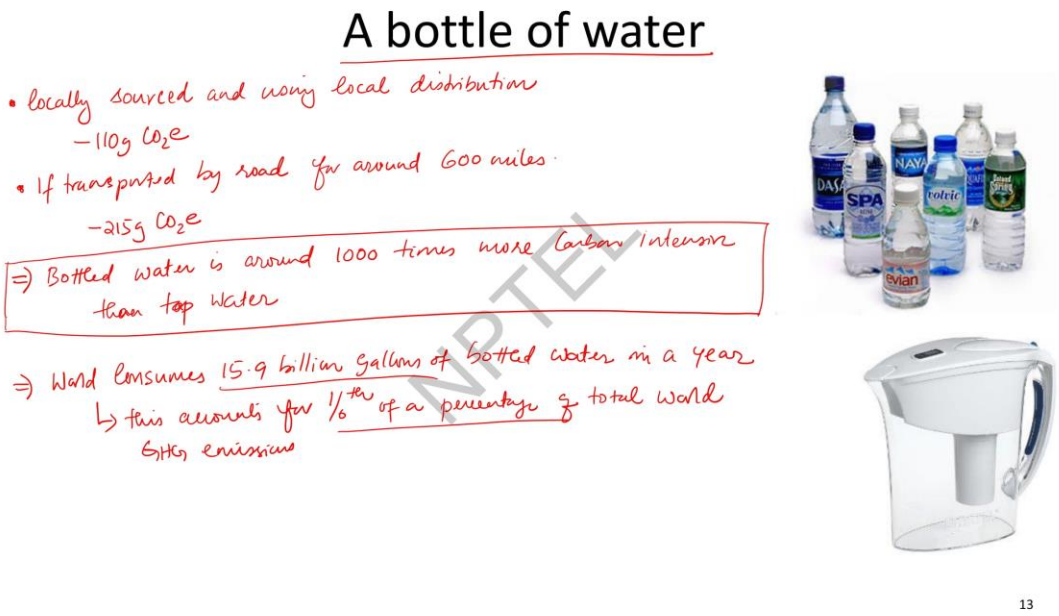


Now, if you decide to leave the lights on, what will happen? So, the main assumption is assume. What are you assuming? Fossil fuel electricity generation. You are generating electricity through the fossil fuel, okay. And low energy bulb somewhere like 40 watts or something, okay. And leave it on for one year.

That's about 90 kilogram, okay, about 198 lbs of CO_2e. If we take a low energy, like a 40 watt bulb. And leave it on for one year, it is about 90 kilograms of carbon dioxide equivalent. I can talk about low energy bulb as a CFL also. CFL is another example.

But if you talk about a 100 watt Incandescent bulb. That's like the tungsten filament bulb, okay. Tungsten filament bulb. That's the incandescent bulb, right. And leave it for, leave it on for one year, okay.

So that is 500 kilogram. That's about 1100 lbs of CO_2e. So, you can see that about this is 5 times more than low energy bulb. That is the reason why people always say use LED bulbs, use CFL, etc. Instead of the normal, this one. So, this is more energy consumption, consuming. This bulb is more energy consuming.



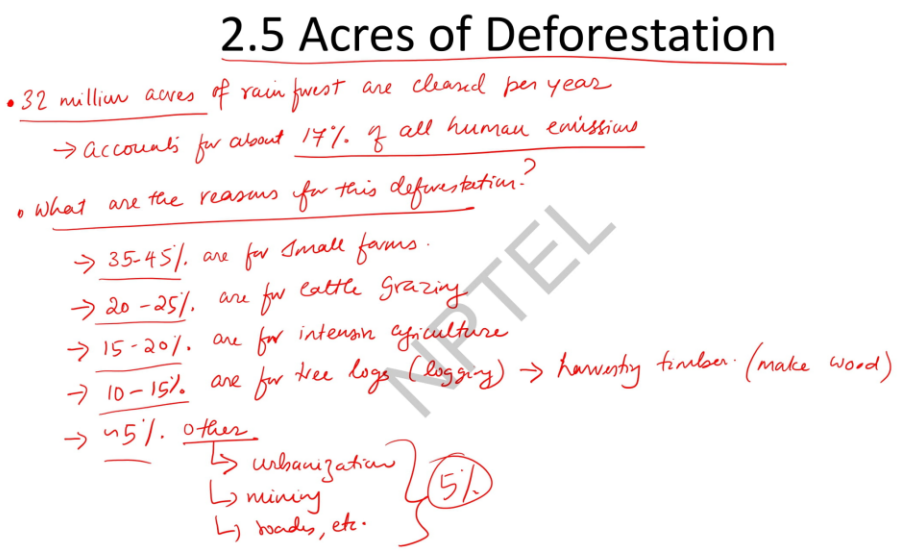
So, now let us proceed with a bottle of water, okay. And bottle of water is something that is everybody drinks it on a daily basis, okay. And it's one of the most popular way of drinking water now.

So, let's see some of the criterias. Locally sourced is like the beer. Locally sourced and using local distribution, okay. You are locally sourced in bottle and it is using local distribution. We have already seen what, how much is the, the bottle is not part of this.

It is just the water. 110 gram of CO_2e, okay. If transported by road, for around 600 miles. If we just take a 600 miles as a distance, that is about 215 grams of CO_2e. You are not just carrying one bottle, you will be carrying in a big truck.

So, divide that entire thing, it will come to 215 grams of CO_2e per this one. So, the main important observation here is, bottled water is around 1000 times more carbon intensive than tap water. So, what we are saying is carbon intensity means more carbon footprint than tap water. So, another thing is world consumes 15.9 billion gallons of bottled water in a year, okay. This accounts for accounts for one-sixth of a percentage of total world.

GHG (Greenhouse Gas) emissions. So, the total world GHG emissions of the one-sixth of a percentage is this actually accounts for this 15.9 billion gallons of bottled water in a year.



So, now let us talk about deforestation, okay. Another economic activity that happens a lot commonly, okay. And deforestation is people always say it's very bad, how it is that bad, okay.

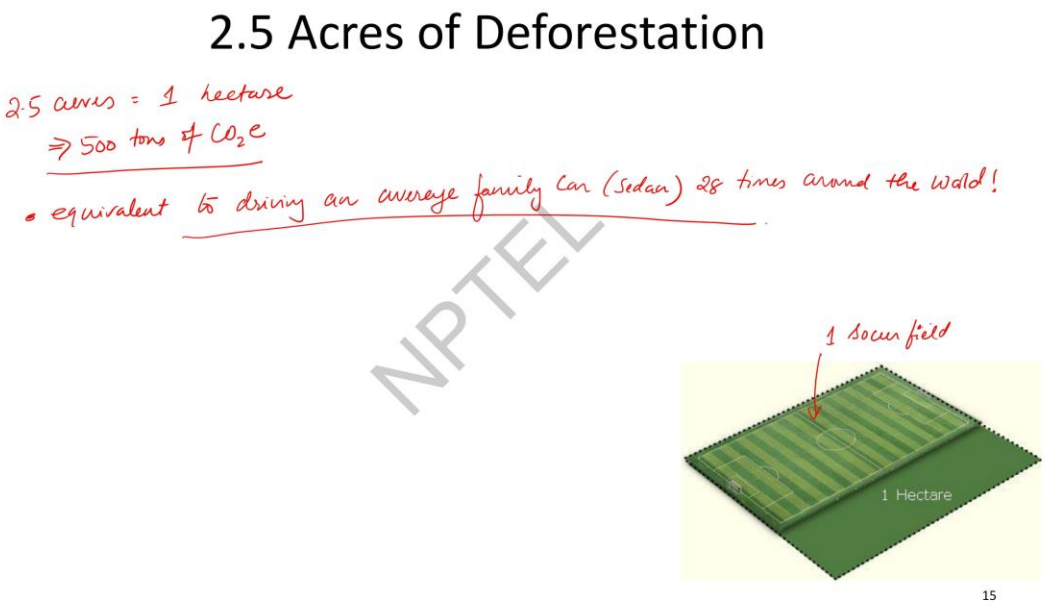
So some of the statistics now, 32 million acres of rainforest forest are cleared. For each year, 32 million acres of rainforest gets cleared. Accounts for about 17% of all human emissions. So, the deforestation, cutting down the forest or cutting down the trees, removing the trees, that accounts for about 17% of all human emissions. And what are the reasons for this deforestation, okay.

What causes this deforestation, okay. So, number one, 35 to 45 percentage are for small farms, okay. Small farming gives you 35 to 45 percentages for small farming, 20 to 25 percentage are for cattle grazing, okay. Cattle includes goat, cow, etc. Everything 15 to 20% are for intensive agriculture, okay.

So, like cocoa farming, etc, is part of that, 10 to 15 percentage are for tree logs. It's called logging, cutting the timber. So, harvesting timber. So, you cut down the tree and you cut it down logs and then from there timber or what we call as make wood. Yes, for the purpose of creating wood, right.

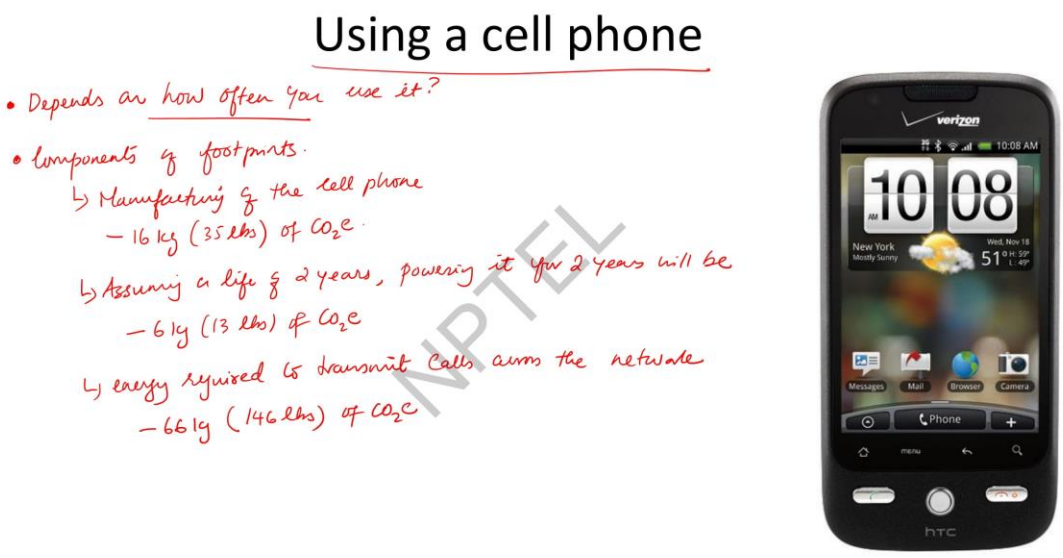
Then, approximately 5 percentage other, okay, what is this other includes? Other includes urbanization, mining, roads, etc. So, all these things put together is about approximately 5%. So, the majority is for small farms, 35 to 45% are for small farms. It is not very clear.

So, let me write it clearly here, 35 to 45 percentage. That is for the small farms, 20 to 25 are for cattle grazing, 15 to 20 are for intensive agriculture, 10 to 15 are for logging or harvesting, making timber. And 5% is for the urbanization or mining.



So, again, how much is 2.5 Acres of Deforestation. This is 1 hectare. So, if you think about this, this is 1 soccer field. Slightly larger than 1 soccer field, that is what 1 hectare is. So, 2.5 acres is equal to 1 hectare, okay. And that's approximately 500 tons of CO2e, okay. So, if you cut down 2.5 acres of forest, then that's about 500 tons of carbon dioxide equivalent.

To put that in perspective, it's equivalent to driving an average car, average family car or sedan, like Honda City and all, 28 times around the world, okay. So, that's very interesting that if you cut down about one hectare of forest. That's equivalent to basically driving about as an average family car, a sedan, 28 times around the world. So, you should be careful of not cutting the forest. It's very important that we preserve forest, okay.



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Now, one other major thing that we now do or all of us use is using a cell phone. Keep on using cell phone. We keep on calling people. It is very convenient for us. So, what is it about?

Main thing is it depends on how often you use it. How often you use it. Often you use it, okay. How often you use it, okay. The components of footprints.

What are the components of the footprints associated? First one is manufacturing of the cell phone or the mobile phone, okay. That's about approximately estimated at about 16 kilogram, okay. Or 35 lbs of CO_2e carbon dioxide equivalent, okay. Then assuming a life of two years power, powering it, the mobile phone for 2 years will be, assuming a life of 2 years and you power it for the 2 years, that is about 6 kg, okay.

13 lbs of CO_2e that's not very much, but still are you assuming that you are just making regular usage. You are not using whatsapp mobile internet you're just making phone calls, then energy required to transmit. We are talking only on calls, okay. Not we are talking about internet and nothing, just calls. To transmit calls across the network, okay.

That is about 66 kg. That is 146 lbs of CO_2e, okay. So that is the using of the cell phone as part of this.

An International Flight

- Economy class
  – 3.4 tons of CO_2e
- Average across all class
  – 4.6 tons of CO_2e
- First class → less number of seats in first class.
  – 13.5 tons of CO_2e

⇒ One trip is equivalent to 3.4 lakhs (340,000) disposable plastic bags

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So now we talk about an international flight at this point. So this is another aspect and we will stop quickly here. An international flight is, let us take few aspects of it. An economy class. If you're flying by an economy class, it's about 3.4 tons of CO_2e, okay. That's the average for an economy class, okay. Most of the time in a smaller aircraft, the average is, average across all class, 4.6 tons of CO_2e.

If you fly first class, that's about 13.5 tons of CO_2e, okay. So, if you take the, and this is because, okay, understand that less number of seats in first class. So, 1 PRIP is equivalent to 3.4 lakhs, as 4 lakhs disposable plastic bags, okay. So when you do an international trip assume that you have bought three lakh forty thousand plastic bags, disposable plastic bags and throw it into the ground.

Let us look at another international flight some more aspects from the engineering aspect quickly this is a 747, just using it as an example.

So when a boeing 747 takes off, around one-third of its weight is fuel, okay. This is ATF (Aviation Turbine Fuel), okay. So, as the fuel burns, fuel, aviation turbine fuel or Jet Turbine Fuel (JTF), both names are, okay. As the fuel, aviation turbine fuel or jet turbine fuel, it burns, burns. It creates three times its weight in CO_2, carbon dioxide.

So, what it does is, when you burn it, it creates 3 times its weight in CO_2. So, if you burn 1 kilogram of fuel, it actually creates 3 kilogram of carbon dioxide equivalent weight in CO_2e, not carbon dioxide, carbon dioxide equivalent, okay. So, with this, we come to the end of this presentation. This presentation was more like putting into perspective, what are some of the daily activities we do. And how each one of those daily activities impact the earth and what is the carbon footprint associated with it.

So that we can see that every time we do an economic activity, generate trash, build cars, drive vehicles, take a flight, etc. Or call in a mobile phone, we are adding to the carbon footprint. So, just to make that point, that is why these numbers are given, so that you also have an idea of the associated carbon footprint with each activity. So, thank you for your patient hearing, and we will continue with the new topic in the next class. Thanks again. Thank you.