Carbon Accounting and Sustainable Designs in Product Lifecycle Management

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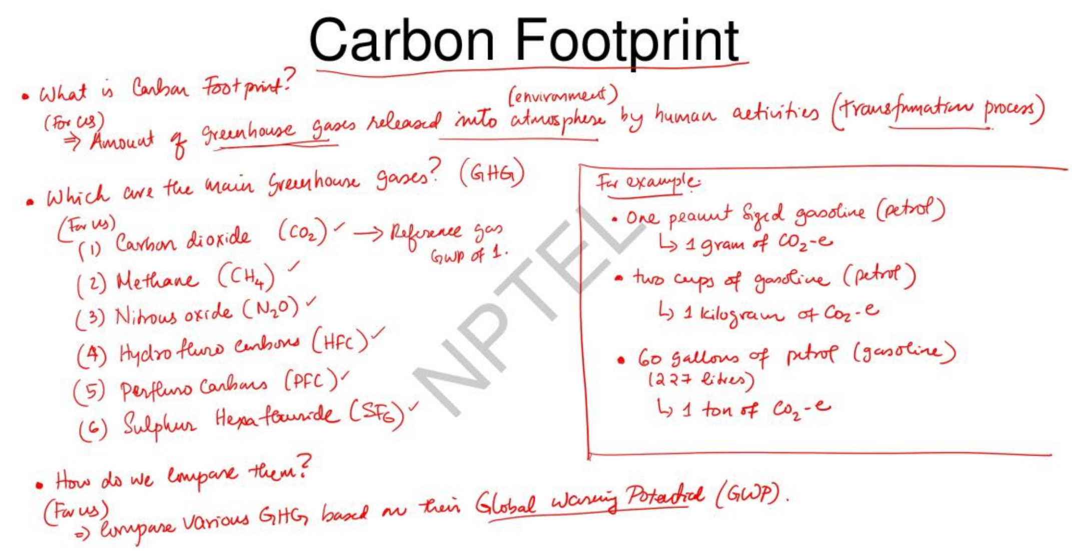
Week 02

Lecture7

Carbon Footprint

Good afternoon, everyone. Welcome back to the course on Carbon Credits and Sustainability for Product Lifecycle Management as part of the NPTEL MOOCs.



And we were studying, what we in the previous lecture, we call us Carbon Footprint. And now we are trying to take a look more into it, so we defined, what is Carbon Footprint? We talked about greenhouse gases and the release of them into the environment due to the transformation process, and what's the transformation process, we have already seen as part of the systemic approach, and there are so many greenhouse gases but for us, there are six majors of them they are carbon dioxide, methane nitrous oxide, hydrofluorocarbon, perfluorocarbon, and sulfur hexafluoride. Now, the third main question that we have is, all these gases are different. So, how do we compare them? Okay. This is the third question.

How do we compare them? This is one. There are people who use other gases also, but for the purpose of this course, we limit ourselves to these six ones. So, for us, again, for this course, it is compared various GHGs, greenhouse gases, based on their global warming potential, okay, or what we call as GWP. So, we use a metric or a factor called global warming, potential to compare these gases, okay?

So, now, how do these gases can be calculated? So, let us take an example, a simple example. So, for example, okay. So, if we burn, okay. So, let us say, peanut sized gasoline or petrol.

That will usually translate to 1 gram of CO2 E. So, it is called as carbon dioxide equivalent. So, we will talk about, what is carbon dioxide equivalent in a way, but what it is is that. The carbon dioxide, this is also known as the reference gas because of the warming potential GWP of 1. Since it is a reference gas, it is a warming potential of 1. So, if when you burn petrol, you will get many types of gases.

There will be carbon dioxide. There will be nitrous oxide. There is sometimes methane also coming out of it. So, all of those gases coming out together will give enough global warming, as of one gram of carbon dioxide. That is what the one peanut size of gasoline is we talk about.

Now let us talk about two cups of gasoline. Two cups of gasoline, okay. Two cups of gasoline or petrol, whatever you want to call it. Two cups of it. okay. So, imagine, two teacups and full of that.

That will give you one kilogram of CO2E equivalent. So, if you burn two cups of gasoline, then the gases that get emitted out, all of that together gives you enough warming, global warming, as equivalent to 1 kilogram of carbon dioxide, is released into the atmosphere. It doesn't mean that, if you burn 2 cups of gasoline, you are going to get 1 kilogram of carbon dioxide. It means that the effect of all the gases, the greenhouse gases that comes out after burning gasoline, together gives you enough global warming, as is equivalent to the 1 kilogram of carbon dioxide equivalent. That is the advantage of GWP. So, this comparison is based on GWP. Now, let us talk about the third one. So, if you burn something like 60 gallons of petrol or gasoline, if you do that, so 60 gallons is, it is equivalent to 227 liters.

This gallon is an American measure, 227 liters. If you burn 227 liters of petrol or gasoline, what do we get is, we get approximately 1 ton of carbon dioxide equivalent. So, all the gases that put together, if you burn 227 liters or 60 gallons of gasoline, it will give enough warming as that of one ton of carbon dioxide being put into the atmosphere. But really that does not mean that one ton of carbon dioxide is there.

It means that the carbon dioxide, the methane, the nitrous oxide, sulfur emissions, etc, that is all coming out of the tailpipe together gives you a global warming potential of one ton of carbon dioxide equal to that. So, hopefully, this way, so this gives you an idea of, how when you burn something, so this burning is something like you are driving a car. So, when you are driving and if you consume 227 liters of petrol, then you can think about roughly that, okay, I have emitted one ton of carbon dioxide equivalent into the atmosphere.

Global Warming Potential (GWP)

- GWP is the global warming impact that a GHG would have over a 100-year timeframe.
  - CO_2 → Reference Gas: GWP is of 1.
    - if there is 1 ton of CO_2 the same warming potential is there for $\frac{1}{24}$ tons of CH_4.
  - CH_4 → GWP is 24 → Major Source: oil drilling.
  - N_2O → Major Source → Motor Vehicle tail pipes. GWP - 310.
    - 1 ton of CO_2 ⇒ $\frac{1}{310}$ ton of N_2O.
  - HFC → Major Source → cooling & refridgeration. GWP: 140 – 11700. (Family of gases)
  - PFC → Major Sources ⇒ polymers, synthetic fibres, pharmaceuticals, etc. GWP: 6500 – 9200 (Family of Gases)
  - SF_6 → Major Sources ⇒ insulation, glazed windows, etc. GWP: 23,900
    - ↳ has the highest warming potential among all six.
    - if 1 ton of CO_2 is there ⇒ same warming can be achieved by $\frac{1}{23,900}$ tones of SF_6.

So, now, how does this global warming potential is calculated is the next point that we need to consider. And we will do more examples as we progress, but this is the foundation of that.

So, for us, when we talk about this, let us imagine that GWP is the global warming impact that a GHG would have over a 100-year time frame. Okay. So, the warming potential is the warming impact. That the GHD, would have over a 100-year, time frame. So, if you take that particular gas and put it over finder for 100 years, then that is how much it will have an impact. That is the warming potential, so whatever we have now, it can actually impact it at, if you think about that much of quantity of gas is present for a period of 100 years.

Then the warming potential of that much of quantity of gas or a particular quantity of gas is quantified for increasing like 1 degree Celsius or whatever the criteria that you are going to put it in. So, let us take these six gases. So, the first one is carbon dioxide. As I mentioned earlier, it is the reference gas and its GWP is of 1. So, that means there is a particular quantity of gas, carbon dioxide gas, that is if it is present in the atmosphere for 100 years, then the warming potential of that it is 1.

It can actually impact the temperature of the earth by 1 D. Not 1 degree, but you can imagine that it can actually do that for simplicity. Now, let us take what equal as methane, CH_4. The warming potential, GWP, is 24. And major source is oil drilling, natural gas.

So, one way to compare this is, if there is 1 tonne of CO_2, the same warming potential is there for 1 by 24 ton of methane. So, if you have 1 ton of carbon dioxide, then 1 by 24 ton of methane will give you the same warming as that of 1 ton of carbon dioxide. So, you probably would now know how you can use GWB to compare them. The third one is nitrous oxide, N_2O, okay.

Major source is motor vehicles, tailpipe emissions, okay. And what is the GWP of this, GWP is 310. So, the comparison is 1 ton of CO_2 is equivalent to 1 by 310 ton of N_2O. So, you require nitrous oxide in a much smaller quantity to create the same warming potential, as that of the one ton of carbon dioxide. Then comes the fourth one, HFC, hydrofluorocarbons.

Major source is cooling and refrigeration. And the GWP, the global warming potential of this GWP, it varies from 140 to 11,700. So, depending on the type of gas, this is a family of gases. So, depending upon which one that we are talking about, it can vary from 140 to 11,700. So, that means it has very high warming potential.

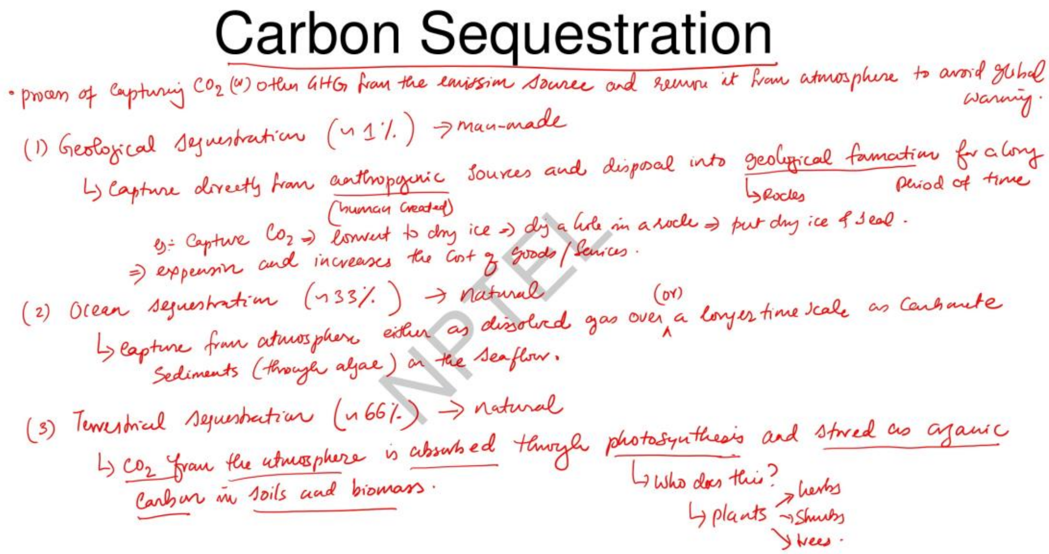
Some of them might be having lower warming potential than nitrous oxide, but some of them has very high warming potential. Now, we have is the fifth one, which is PFC, perfluorocarbons. So, the major sources include nitrous. Which are the major sources? One is polymer industry, polymers, synthetic fibers, then pharmaceuticals, etc.

Now, the GWP. This is also again a family of gases. But the GWP can vary from 6,500 to 9,200. It's again family of gases. So, this is much more dangerous.

Obviously, you can see that these numbers are very, large compared to all of the gases that we have discussed so far. Except that some of the HFCs might have a number larger than this. But mostly as a family, this is much more dangerous. Then comes the last one, SF6. That is called as the, sulfur hexulfurite.

The major sources include, insulation, glazed windows, tempered glass, all those kinds of things, okay. The GWP of this is very interesting. It is 23,900, that is the GWP, that means this has the highest warming potential among all six. So, if you think about this is, if one ton of CO_2 is there, okay, same warming can be achieved by 1 by 23,999 tons of SF_6, so you can see that instead of 1 ton of carbon dioxide, imagine this room has 1 ton of carbon dioxide weight.

Then you require 1 by 23,900 much smaller quantity of SF_6 to achieve the same warming potential or achieve the same warming or same increase in temperature of the globe. So, this global warming potential is one way for us to treat or compare these emissions or these gases.



So now what if we emit all these gases, we put all of them into the atmosphere, how do we solve this problem? How do we deal with it? So, the way we solve this problem is by a philosophy or by an approach called carbon sequestration.

So, the carbon sequestration is process of capturing CO_2 or other GHG from the emission source and remove it from atmosphere to avoid global warming. So, if the gas is coming out, if you capture it and remove it from the environment or the atmosphere, so then the global warming won't happen. So, there is three types of sequestration, three major types of sequestration. The number one is called as geological sequestration, okay. This accounts for approximately 1% of the total carbon or the greenhouse gas emission, okay.

So, what is do here is capture directly from anthropogenic, that means human created anthropogenic sources and dispose or disposal into geological formation, for long period of time for a long period of time. What is a geological formation? You can think about it as rocks or big quarries or something like that. So, let us talk about it as rocks for the time being.

So, what do we do is, we capture the carbon dioxide? Let us take carbon dioxide as an example. So, example capture CO_2, convert to dry ice, dig a hole in a rock, not even a large rock, put dry ice and seal. So, what happens is you, carbon dioxide is emitting, you capture that, make it into dry ice. Dry ice is the solid form of carbon dioxide, dig a big hole in a rock, put the dry ice there, seal it with cement, that you can think about it as the one way of geological sequestration.

The problem with the geological sequestration is, it is expensive and increases the cost of goods and services. By doing this, drilling a hole in the rock, taking this, solidifying it, putting it, sealing it with cement, all those kinds of things actually increases a lot of cost into this. So, the number two, this is called as the ocean sequestration. This accounts for about 33% of the total sequestration in the earth. So, what happens here is, it is captured from atmosphere.

Ether has dissolved gas over a longer time scale as carbonate sediments, okay, this is done through algae on the sea floor so what happens here is, you have ocean and the gas ore over a long time, so what happens is, sorry, I missed an ore, so you capture it from the atmosphere because there is ocean, then there is water and carbon dioxide will slightly dissolve in water, become carbonic acid. So, it is either dissolved in the gas, the gas gets dissolved in water slightly, and it is taken in by various living organisms, or otherwise, the carbonized sediment, so algae is the water algae, we are talking about, or the water green plants, which actually would use this carbon dioxide, do photosynthesis, convert it in the form of starch or glucose, other things.

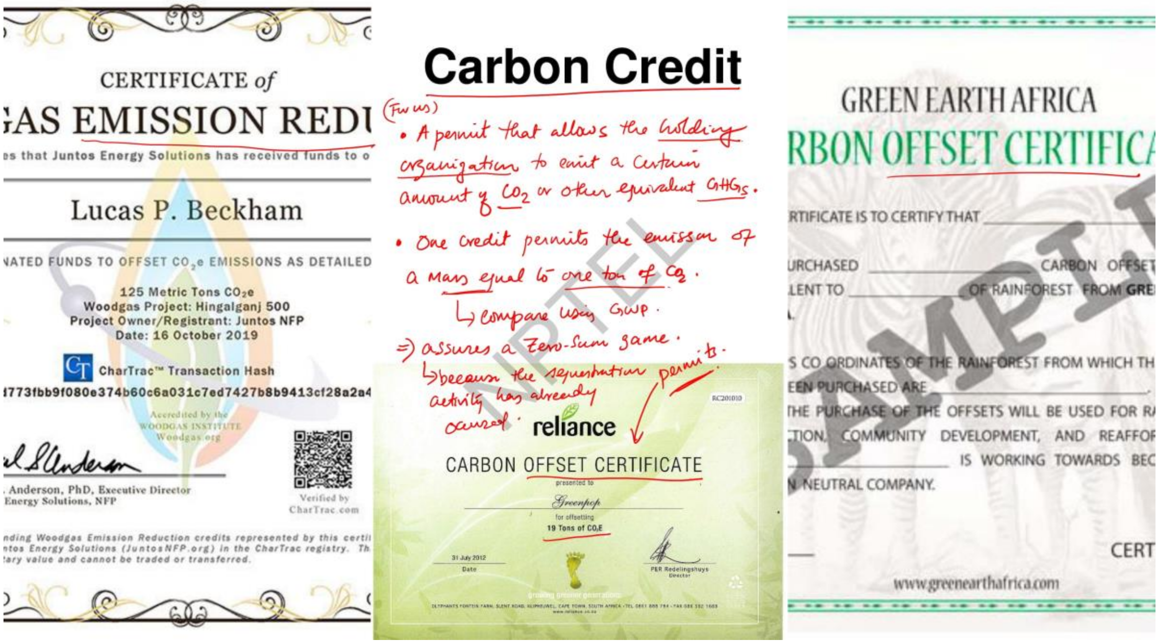
And then they keep it in their body, and when they die, along with them, this captured carbon dioxide or the starch also goes into the bottom of the seafloor, and because there's a lot of water in it, it actually would, because of the pressure of the water, it actually would get sequestered into the seafloor. That's also one of the other reasons people always say that the seafloor is also a good place where slowly, crude oil actually gets generated because such kind of carbon sedimented, there will slowly convert to crude oil or hydrocarbons. Then comes the third one, which is called as terrestrial sequestration.

The terrestrial sequestration accounts for about 66% of the total sequestration. So, the logic here is CO_2, carbon dioxide from the atmosphere. We are talking carbon dioxide here, is because most of the other gases, the plants cannot really absorb. Carbon dioxide from the atmosphere is absorbed through photosynthesis and stored as organic carbon in soils and biomass. So that's why people say planting trees would actually reduce the global warming because what happens is the carbon dioxide from the atmosphere, the plants capture them.

So, who is doing the photosynthesis? Who does this? The answer is plants. So that is herbs, shrubs and trees. Right from the grass till the big trees, mango trees, banyan trees, etc., all of them do photosynthesis.

And photosynthesis is, you remember probably, the use of carbon dioxide, water, and sunlight to create stars. And the photosynthesis also releases oxygen into the atmosphere. And due to the photosynthesis, whatever the starch that you make, that's organic carbon, it gets stored in the plant in the form of the leaves, the stem, the fruits, etc. And otherwise in the roots also. And then slowly when the plant dies, it actually gets stored in the soil and also part of the biomass because when the leaf falls down and decay, that remains in the leaf as part of the soil and stay there.

So, these are the three ways, this is geological sequestration, this is man-made, whereas the ocean sequestration is natural phenomena and terrestrial sequestration is also natural phenomena. So, there are two natural phenomena and one man-made phenomena. But the man-made one is the most expensive. Other two are the cheaper version of this. And we will elaborate these kinds of things in the coming lectures.



Now we talk about the big word which is called as the Carbon Credit. And what is Carbon Credit is also we need to understand now. So, a Carbon Credit for us, again, for this course, okay, these definitions are slightly modified for our course specifically. So, for us, it is a permit, okay, that allows the holding organization to emit a certain amount of carbon dioxide, a certain amount of CO_2 or other equivalent GHGs or other equivalent greenhouse gases, okay.

So, it is actually a permit that allows the holding organization or the individual who is holding it to emit a certain amount of carbon dioxide or other equivalent GHGs, okay. So, if you say one credit permits the emission of a mass equivalent, mass equal to 1 ton of CO_2. So, one carbon credit, that means, I have one credit that will allow the emission of a mass equivalence of one ton of carbon dioxide. So, if I am emitting one ton of carbon dioxide, I can actually emit 1 by 24 tons of methane. If my carbon dioxide is not my primary emission gas, it is methane, then I can do it.

If it is SF_6, then based on this comparison, compare using GWP, using the global warming potential, we can compare whichever gas that you are actually emitting as part of this. And some of these, okay, if you look into this, this is some example of carbon certificates. If we look into this one, this is a carbon offset certificate. You can see that, okay. So, there is one of them.

This is an offset certificate. This is also an offset certificate. This is an emission reduction, okay, certificate. There are multiple terms and names and standards that are being followed by people. But if you look into this, the green pop, it was in sometime in July 2012, 19 tons of carbon dioxide equivalents was offset or reduced as part of it.

So, this kind of certificates, it's actually the certificate that you see, these are in a way, these are permits. Once somebody evaluates and certifies it, that yes, you have the capability to do this or do something like that, or we have certified that you have reduced 19 tons of carbon dioxide equivalent. So that means you can go and emit a mass equivalence of 19 tons of carbon dioxide because the logic here is, it assures a zero-sum gain. Because the permit is, the permit zero-sum game, how is it assures that it is a zero-sum game? Because the sequestration activity has already occurred.

So, somebody has already done something, got the carbon dioxide, removed it away from the atmosphere. And hence, since you have already removed it, even if you go and emit the same quantity, it will turn out to be a zero-sum gain. There will be no effect on the total amount of carbon dioxide or carbon dioxide equivalents in the atmosphere as long as you are not emitting beyond what the offset certificate or the emission reduction certificate is awarding you. With this, we will take a quick break and then we will talk about the trading. How do you trade the carbon credits?

Because once you have a credit, then you can buy it, sell it, make money out of it. How do we do all of that? That's all part of the upcoming lecture in the following sessions. So, thank you very much for your patient hearing and we will get back quickly soon.

Thank you.