Life Cycle Assessment
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Lecture – 26
ISO 14040

Hello and welcome to the week 6 of the course. We are now in week 6; we have covered the material until week 5. So, in this particular week we will start with looking at this ISO 14040 terminology. Again we have covered this ISO kind of methodology in the past, but this is just a kind of a recap of the different technologies different; sorry terminologies that we have used. And we will go one by one; I will give you some examples of that as we make progress.

So, let us look at this terminology one by one. First one we talk about this life cycle inventory: we already spent quite a bit of time on LCI. So, what is LCI? Again this is more like a recap for you, now whatever you did in terms of part of week 3, 4, and 5 in terms of LCA methodology; at the beginning of this week six we are trying to recap so that things get fresh in your mind.

So, in terms of the LCI inventory we are looking at phases of LCA, involving the compilation and quantification of input and output. So, these are all the phases of LCA for products throughout its lifecycle. So, that is our LCI part- lifecycle inventory part.

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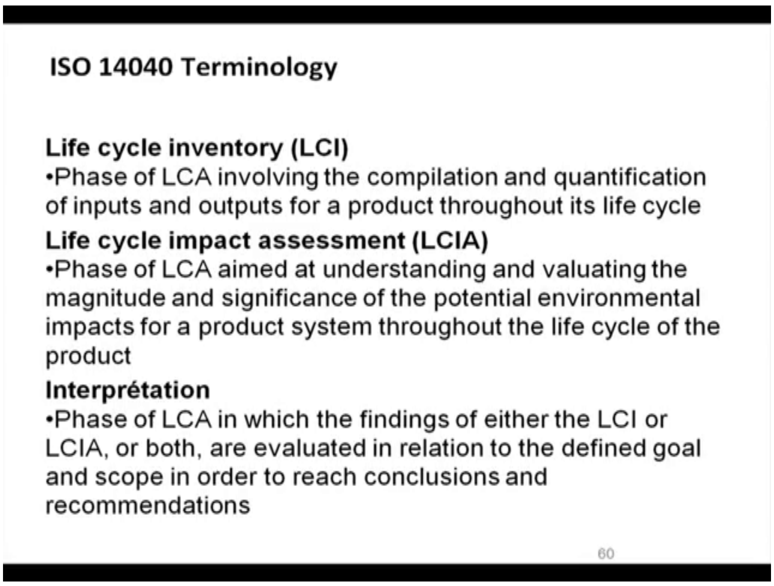

Then we already kind of looked at life cycle impact assessment which is the phases of LCA aimed at understanding and valuating the magnitude and significance of the potential environmental impact. So, that is phases of LCA. So, what we did in terms of LCI? Very simple, we looked at all the input and output, we made a big list, and we had several tables which you saw; so that is our LCI phase. Impact assessment, once we have the LCI data available we are trying to understand what are the impact categories associated with that and what kind of environmental or human health or ecosystem impact it will have. So, it is the phases of LCA aimed at understanding and valuating the magnitude and significance of potential environmental impact of the product system and throughout its lifecycle.

And just now we are in the previous module, last module of week five we look at the interpretation, which is the phase of LCA and which is the findings of either the LCI or LCIA or both or evaluated in relation to the defined goal and scope in order to reach conclusions and recommendation. So, all these different phases are important, but this is how they have been defined in l c; sorry ISO methodology. So, just wanted to kind of reemphasize on that by putting into this ISO definition, you already have gone through this stuff before. So, you should be familiar with that, but just again in terms of ISO how they define this different terminology.

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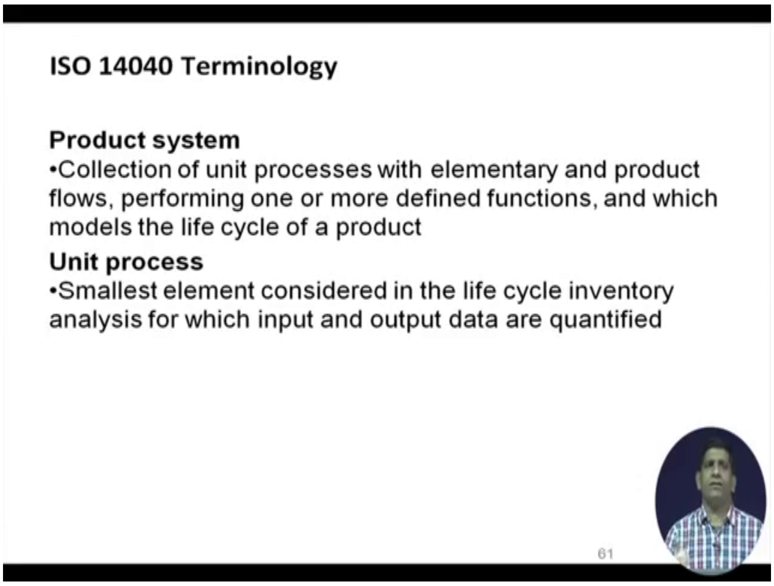

Then there are certain some other terminology like product system. What is the meaning of a product system? Here you have product system as it will tell that you have collections of unit process. You have different unit processes with elementary and product flow performing one or more defined function which models the lifecycle. So, you are looking at the entire product system. So, whatever is the unit process that goes into making that product; so compilation of all that is our product system.

Unit process is the smallest element considered in the life cycle inventory analysis. So, the smallest element that we see is the unit process for which we have the input and output data. So, the smallest element as part of the process chain for which input and output data are quantified that is your unit process. So, say there would be several unit processes in a product system. And for all of these unit processes we do the LCI- life cycle inventory. For all of this unit process when we collect this LCI data we look at its impact assessment. And for everything that we looked at the impact assessment we do the interpretation. So, they are all related to each other. Kind of it starts from unit process then to product system, then to LCI, then to LCIA, and then ultimately to interpretation and where you come up with your recommendation.

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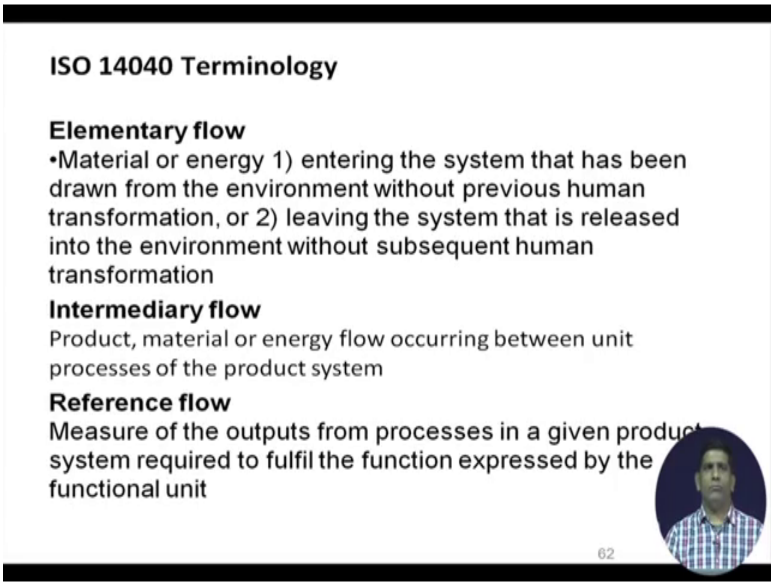

Some other terminology which we have seen earlier elementary flow, intermediary flow, reference flow; again these are ISO 14040 terminology, we have covered this material earlier as well. But just to give you what how the ISO defines it which is not different from what we did earlier this is just how the language is there. Because ISO methods are important is not it, we have to do LCA as per the ISO method. So, just give you familiarity with the ISO methodology.

So, in terms of the elementary flow, it is the elementary flow means you have whatever is like we have the material or energy flow. So, this is essentially we have the material coming in or the energy coming in when I say material we are talking about any like a material including water. So, that is water is there as well for most of the industrial process we need lots of water. So, it is the material or energy which is entering the system which has been drawn from the environment. So, for example when you go for material you are drawing it from the different minds or from the minds it will go to the metal like a smelting plant, from the smelting point will go the product; so as a very primary source or the different minds. So, it is materials entering the system that has been drawn from the environment without any previous human transformation. It is like a basic raw material we are talking about.

And then whatever is also that is our input to the system that is the input to the system. If you remember those boxes we had, where we had different types of input different type of output. Now the output is whatever the leaving systems into the environment without subsequent human transformation. So, these are very important, like when you are probably you are talking about these when we say without previous human transformation; that means these are the very basic raw material that you are collecting from the minds. So, you are collecting from the minds you have not made any changes to them. Once it goes to a smelting plant we start making changes to it. But here we are talking about the basic material just coming from Mother Nature in terms of the input parameter.

Similarly, in terms of the output parameters we are looking at the material or the energy that is leaving the system without subsequent human transformation. So, just to give you an example- say you had a industrial plant where we had certain industrial waste water discharge. Now industrial waste water industrial effluent, some places they call it industrial effluents, some places we call it industrial waste water it can be (Refer Time: 07:24) a pulp and paper industry or any sorts of industry where you have this some sort of industrial waste water coming in.

So, as per the rule, as per the environmental protection rules for in any country you will see that these industrial waste water before they are released into the surface water, whether we close to a lake or a river or any kind of creek or whatever be the source where they it is being the effluent goes away; it has to go through a treatment plant. And that is most of the very common name is used as effluent treatment plant, some places they may even call it industrial waste water treatment plant, because there is a different between waste; when we waste water treatment plant essentially we are talking about the municipal waste water. We do not municipal waste water is what waste water that is gets flushed in our toilet. So, that is predominantly those municipal waste water.

And those treatment plants are called STP, like a sewage treatment plant because that is a sewage material that is there. But on the other side when we have this industrial waste water we call them effluent treatment plant that is called ETP. So, when we are talking about this emissions going into the environment, so if you think about this water based emissions going into the environment we are saying that- without subsequent human transformation so what does that mean; that means, that after it has been treated- so your waste water from the industry as per law cannot be destroyed directly into the atmosphere, directly into the land, or to the water body. So, what you are doing? You are treating it in an ETP you are supposed to treat. So, as industry we are supposed to get the treatment done.

So, it will be taken to effluent treatment plant, effluent treatment plant will have different processes and other things involved to treated. And then the effluent of the sorry; the treated effluent from this effluent treatment plant will needs to be disposed in some sort of water body or may be potentially we use back into the system tube. So, if it is reused back into the system then again things are not going out, but part of it which is going out either in the water phase or in the semi solid phase because you may have some sludge as well which is produced as part of the ETP; so those things which will get disposed. And after you dispose it we are not going to do any changes to it. So, that is what they are talking about that without subsequent human transformation.

So, when both the cases elementary flow actually relates to the material and energy coming into the system or coming into the unit processes where, whatever is the material is coming in that has come directly from the nature without previous human transformation; whatever is the material going out is that going out after whatever treatment has been done, but after it has been released there is no further human intervention in terms of the transformation. So, that is probably if it was not clear in the previous module it helps you get clearer over here. So, that is what the elementary flow we are talking about.

Then we have intermediary flow. Intermediary flow, if you remember when we were going over the unit process concept we kind of talked about that as well. Here it is basically that is the interaction between the two different unit processes. So, for a product system as I said earlier you may have multiple unit process going on. So, in between the unit process there will be some flow. So, like input output from one particular unit process becomes pure output from one particular unit process becomes input to the next unit process. So, that is your intermediary flow.

Where things are; so we have the product, material or energy flow which is occurring between the unit process of the product system. So, it is not only, it is what is being interaction between the different unit processes within the system. So, nothing is coming from outside here, it is things how it is being used up within a particular system. So, that is your intermediary flow.

Then we also talk about a reference flow. Reference flow is based on measures the output from process in a given product system required to fulfill the function expressed by the functional unit. So, remember when we were doing that bulb example; bulb example we were looking at those bulb example we had a the function, we choose the function as lightning, we choose the functional unit as 700 luminous of light for 10000 hours. And then we said that for to achieve that particular function we need 10 bulbs of one type and 1 bulbs of the other type.

So, there our reference flow was those 10 bulbs of incandescent versus and 1 bulb of CFL we were comparing those two systems in that particular LCA exercise. So, that is the reference flow. The reference flow it is a major of the output from process in a given product system which is required to fulfill the function. So, the function in that our bulb example to required to fulfill to function of giving us 700 luminous of light for 10000 hours that we need a 10 bulbs of incandescent and 1 bulb of CFL, so that is where the functional unit was 700 luminous for 10000 hours. But to fulfill the functional unit we need a 10 bulb of incandescent and 1 bulb of CFL. So, that is 10 bulb of incandescent and for say product a, product c incandescent bulb and 1 bulb of CFL for our CFL system that would be called as the reference flow.

So, all the calculations that we did if you remember from that bulb exercise or based on those 10 bulbs and 1 bulb. So, that is how, I did not give you the detail calculation on the 1 bulb side we did a detailed calculation for incandescent bulb. For the CFL I just gave you just showed you the result. So, I hope that it was clear because for the benefit of time we did not, it is a same, and it is essentially the same way the calculation is done. But again just to I think I may have forgotten to mention that, but in the particular module but the calculation details calculation was never shown for CFL, we showed it for incandescent but the same method is used for CFL as well. But we did look at the results of both when we compared CFL and the incandescent bulb.

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ISO 14040 Terminology

Term	Example
Impact category	Climate change
LCI results	Amount of a greenhouse gas (GHG) per functional unit
Category indicator	Infrared radiative forcing (W/m^2)
Characterisation model	Baseline model of 100 years of the IPCC
Characterisation factor	Global warming potential for each GHG (kg CO_2 eq./kg gas)
Category indicator result	kg CO_2 eq. per functional unit
Category endpoints	Human health, ecosystems

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So, that is the reference flow; that is a concept of the reference flow. And then we have also has different impact categories. When we say impact categories there are different types of impact categories, you looked at the long list of impact categories climate change was one of them. We have acidification, eutrophication, and land use pattern, some I think there were some other stuff in there as well. So, this the impact there are different impact categories, so that is one example, one of the predominant one we keep on using is the climate change, so that is also is there.

Then there is a LCI result: in terms of the LCI results we always try to put them in the form of amount of a greenhouse gas for functional unit. So, we think we always put things as per functional unit so that we can compare the different systems. So, amount of greenhouse gas: most of the time the when we say it is mostly expressed in terms of CO 2 equivalent. So, it is the CO 2 equivalent which we use for our calculation. Then category indicators we had the infrared radiative forcing, that is one thing because of the climate change part of it we use the infrared radiative forcing which is the watt per meter square. So, that is one example that is category indicator we use.

In terms of model there is a IPCC model; that is the IPCC model as we know it based on the climate change that is the model most of our climate change calculations are based on. There are different kind of; if you remember from the table we had in one of the earlier module where you saw that different type of the contaminants or different types of emissions having based on their like a greenhouse gas impact potential for 20 years, 100 years, 200 years. So, we use 100 years for most of the times, so our base line model is of 100 years of the IPCC that is why we are had for one unit of methane if you (Refer Time: 16:30) to 24 units of CO 2.

Then characterization factor: characterization factor in terms of kg CO 2- global warming potential for each of the greenhouse gas that is how we will characterize them. That is kg CO 2 equivalent per kg of gas, as I was mentioned to you earlier. You can do a category indicator results. So, category indicator results from per kg of gas you will go to per functional unit. How much things are getting out in terms of the first functional units, so the kg CO 2 equivalent per functional unit, then category endpoints is human health impact, ecosystem impact and all that.

So, this is just an example: if the impact category is climate change how we mention, how we characterize, how we put this different results LCI category indicator characterization model. Similarly, if the impact category is something else we will do a different. Again the way the steps will be the same, but in terms of category indicator and characterization factor those may change a little bit, but for most of the characterization we express things as a CO 2 equivalent. So, that is what typically done.

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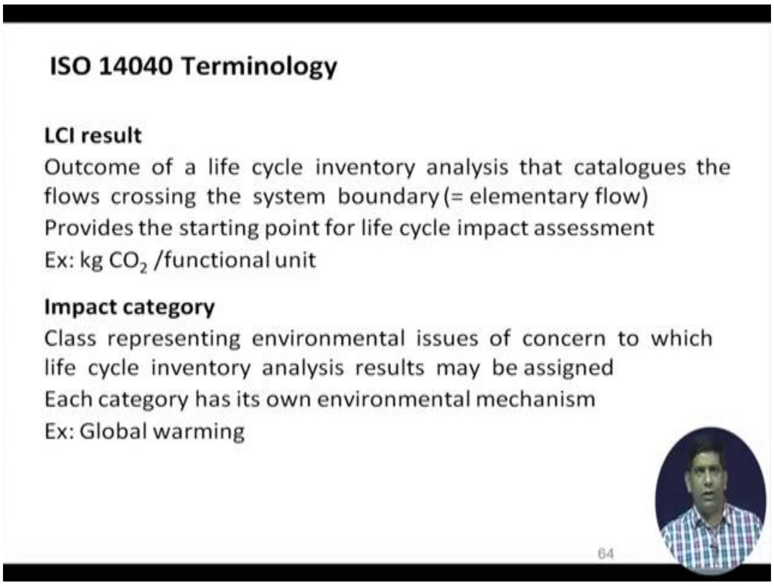

So, once you have that you will look at now in terms of the LCI results. LCI results are your outcome of lifecycle inventory analysis that catalog is the flow across the system boundary, so you look at the whole elementary flow. Then it provides the starting point of LCIA life cycle impact assessment. So, what is the in terms of an example is kg CO 2 per functional unit, because LCI as we have said earlier life cycle inventory is essentially like an accounting exercise.

Any accounting say if you look at a balance sheet, if you are familiar with balance sheets of company and when you look at any of the balance sheets towards the end of March, you will see many companies will be start producing their balance sheets, because for the yearly in terms of how much cells they made, how much expense they made, what are the different headings under which they with revenues were generated what are the different headings under which certain expenses were made. So, similarly here we are doing a life cycle inventory analysis, we are cataloging the flow across the system boundary. Elementary flows and those elementary flows are both input and output of the system. And taking that information is the basis of doing the life cycle impact assessment. And that is how much kg CO 2 equivalent per functional unit.

So, once for the impact assessment we need to know the impact categories. So, these are the class representing environmental issues of concern to which life cycle inventory analysis results may be a sign. So, we can have life cycle inventory results can be assigned to that. And each category has its own environmental mechanism. For example, if you look at the global warming, then you have the infrared, we look at for the global warming this was kind of a impact climate change and global warming. Here the category indicator was infrared radiative forcing, LCI results in amount of greenhouse gas; so in terms of global warming.

So, those were the different ways it is done. Again your impact some of these parameters will change. When we go for the land use we will put in a different way, but ultimately we will look at kg CO 2 equivalent per functional unit and then we look at some of these whatever is the endpoint. Probably we will have more endpoint, in fact in terms of for the ecosystem rather than human health. So, these are how things are kind of basically done in terms of LCI terminology.

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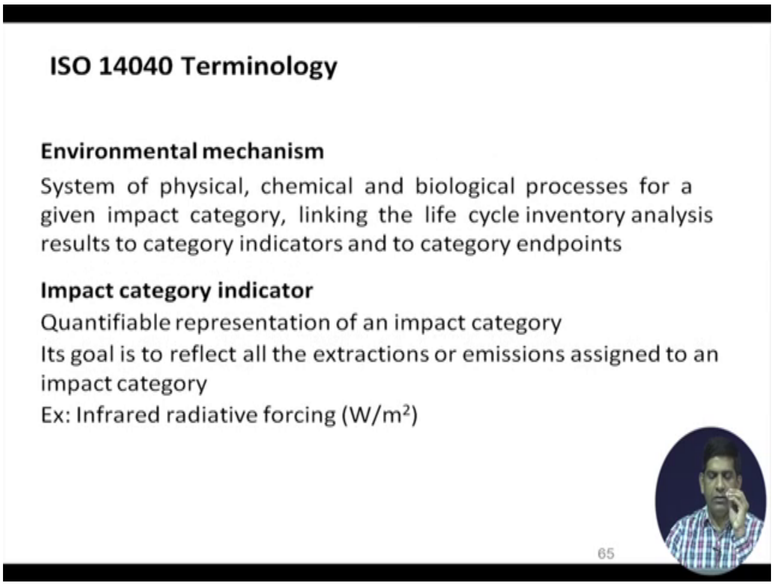

Some other terminology environmental mechanism, what are the physical chemical and biological process for a given impact category? And either related on in this particular week if not then definitely in the early next week we will look at some of this physical chemical and biological processes for certain environmental contaminant in the system. So, essentially we will kind of to a very quick look at fate and fate mechanism. Fate mechanism not that much on the transport mechanism, but mostly on fate mechanism of a chemicals, and how we kind of look, how that is important in terms of LCA exercise. So, we need to look at the environmental mechanism, because if you say- we say that this particular we will come up with our emissions from LCI inventory that this much of certain organic chemicals; a where b, c, d or inorganic chemicals inorganic compounds a, b, c, d, e these are being released into the environment.

Then the next question comes what happens when they comes out of the environment, what really impact it is going to have? Say if you had a scenario where you there is a industrial processes is out there where certain organic chemicals get released into the environment. Now the question comes this gets released, but whether what kind of impact this environment this particular chemical will have, what kind of impact categories we should choose. So, that is again the if you remember from the table there was a long list of impact categories, but which impact category is relevant for this particular chemical. So, that is where the environmental chemistry or the environmental like a (Refer Time: 21:57) even the interaction of that particular chemicals with the environmental media; whether it is being soil, whether it is being air, whether it is being water that comes in picture.

So, we will talk little bit about that in one of the lectures later on, where say if a environmental chemical sorry if it is an organic chemical gets released into the environment. So, you have a spill of that chemical or you had this like a effluent coming out of a industrial plant and just gets released into a soil on a surface soil or in a mix of a. Now, what will happen to this chemical? Will that chemical remain in the soil layer? Will the chemical volatilize and we will go into the atmosphere? And what will happen to the chemical whether it can travel through the ground, through the sub surface and then hit my ground water source.

So, we need to those kinds of answers. And if we cannot know those kinds of answers we cannot really find out what in terms of; like a when we look at the impact assessment in terms of what is the real impact. Whether if a chemical organic chemical gets released, but organic chemicals once it gets released most of the organic chemicals are volatile; but say if it is not a volatile compound, just for our discussion sake. If it is an the volatility is 0 there is no volatility of this compound. So, in the earth you can say which to make yourself more comfortable you can assume that it is an inorganic compound not an organic compound, because it is difficult to like a sometimes when we say that organic compound first thing comes in our mind that there will be a volatility factor involved in here.

But say if it is a inorganic compound, non-volatile. Now what will happen to this compound; whether it will stick to the soil, whether it will remain in first few inches of the soil, first few centimeters of the soil, or whether it will go into the sub surface and then it will go to the ground water. So, those things we need to look at. So, that is where things become important in terms of environmental mechanism. So, we have to look at this environmental mechanism we have to try to understand this physical chemical and biological process. And for a given impact categories then that will link and the link it to the lifecycle inventory analysis that will give us a results that will give us two category endpoints; what kind of endpoints we are looking at.

So, when we look at in terms of the indicator we impact at the and the other things impact category indicator that is a quantifiable representation of a impact categories. Goal is to reflect all the extractions or emissions, and then for climate change it is the infrared forcing that we look when that we use.

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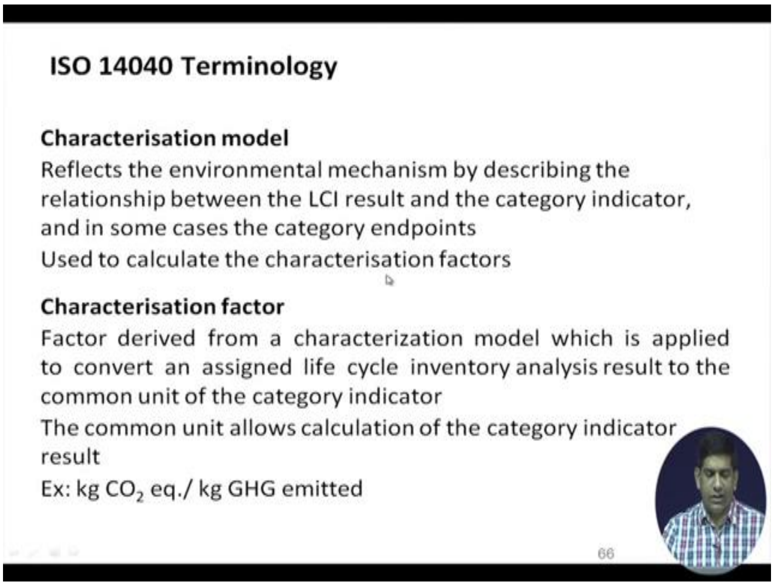

Then you look at your characterization model. Characterization model is what kind of model you are going to use, you can reflect the environmental mechanism by describing the relationship between the LCI results and the category indicator. And in some cases the category endpoint. You can calculate the characterization factor, in terms of what factor you need to use for that. And what is the characterization factor? It is the factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator. So, the common unit allows calculation of the category indicator results; for example what is kg CO 2 equivalent per kg of greenhouse gas emitted.

So, here if you remember for the methane we used a factor of 24, for nitrous oxide 298; that is the kg of greenhouse. So, how much is conversion factor. So, that is based on the characterization model that we used is based on the IPCC document that is kind of the base document that is being used in most of the LCA like a studies based on the I c a sorry; based on our IPCC document we come up with a characterization model. If we use 100 years the model and then characterization factor we get the numbers from that and that is how that is what typically gets used in the study.

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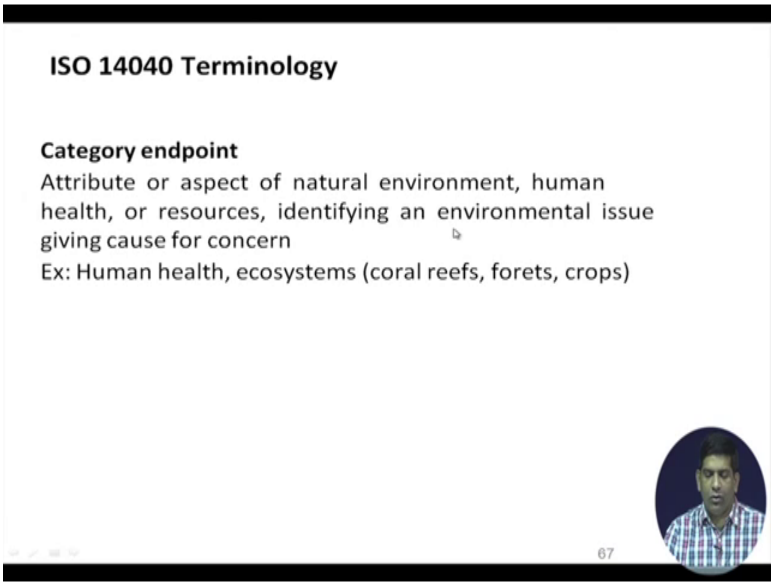

Then at the end you will have your category endpoint which is the attributable or aspect of natural environment, human health resource, identifying the environmental issues. For example, human health impact, ecosystem impact that could be coral, reefs, forests, crops, so that is the category endpoint of that particular type of impact that we are looking at.

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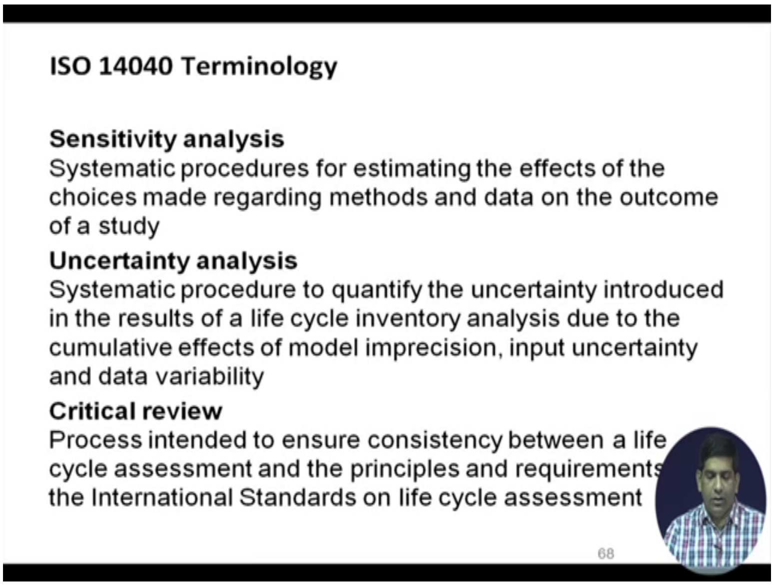

Then you can do sensitivity analysis, uncertainty analysis; so we kind of talk about that earlier as well, I am kind of not spend too much time on this one. Sensitivity analysis, we are trying to say whether what are the methods and like estimate the effects of choices made. So, if you have 5 parameters keep one four constant (Refer Time: 26:58) one and find out. Uncertainty gives you in terms of the model imprecision input we talked about that in earlier model data variability, model imprecision, inputs and uncertainty those things are there.

Critical review is once you have processes intended to consistency between a life cycle assessment and the principle and requirement of international standards on life cycles. So, you need to kind of make sure that whatever things we are doing as per the international practice. So, that is what it is kind of talked about in terms of the critical review of the entire material.

So, these are some of the ISO terminology. Again most of this material we kind of covered earlier. So, this was just to give you, again these definitions came directly from the ISO document. So, just to give you how the I have told you that you should try to get the 2006 copy of the ISO document, but just in case if you do not even have the copy you should be able to understand what are the different terminology that ISO uses, and if you get the ISO document that is several like several page document and here what we have provided is a summary of that.

So, I am not saying that you should not; actually I am encouraging you to get hold of that ISO document and look at it. And then once you read it if you cannot understand this particular video will help you understand that ISO document. But what if you need to other than ISO document you should also read other stuff.

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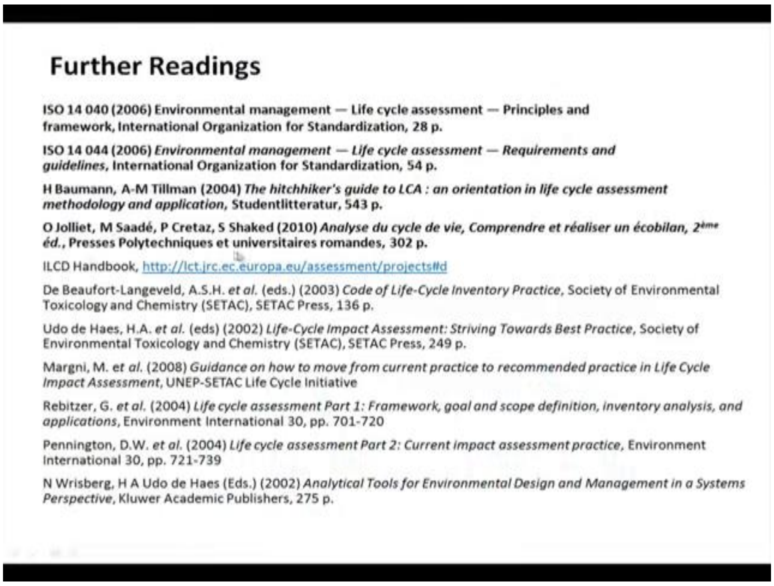

So, there are towards this particular where we have listed some sources, where you can get other information from different sources. And again some of this information, and this list is little bit older there are could be newer informations out there as well. But this is at least if you read this it will give you a good idea about how LCA procedure or LCI procedure that is how the LCA is done.

So, with this we kind of come to towards the end of this ISO methodology stuff. Now in the next module I will quickly give you what are the good points of an LCA. So, we have already told you that how the LCA needs to be done, how will you interpret the results, what are the different, what are the ISO methodology, ISO terminology and everything we have taken care of that. Now in the next module I will try to give you that if you are going to do a LCA exercise what are the good key points, kind of summary of the whole LCA methodology. What are the things like do's and do nots, I will give you we will try to go over that.

And then we will start looking at some of the other material in terms of many things that we talked about in this LCA methodology, we will try to explain them in more detail.

Like one thing if you remember we talked about in this environmental fate like a pollutant fate mechanism we will cover that kind of stuff in subsequent modules. So, with that let us wrap this particular module and then we will look at key points of a good LCA in the next module.

Thank you.