Life Cycle Assessment
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Lecture - 17
LCA – A Detailed Methodology (Contd.)

Welcome back. So, we will continue where we left in the previous module.

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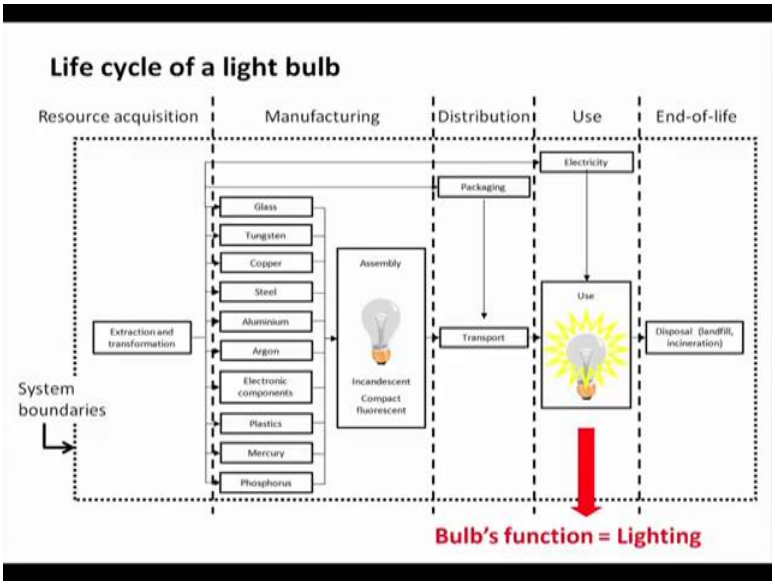

We were looking at this particular slide.

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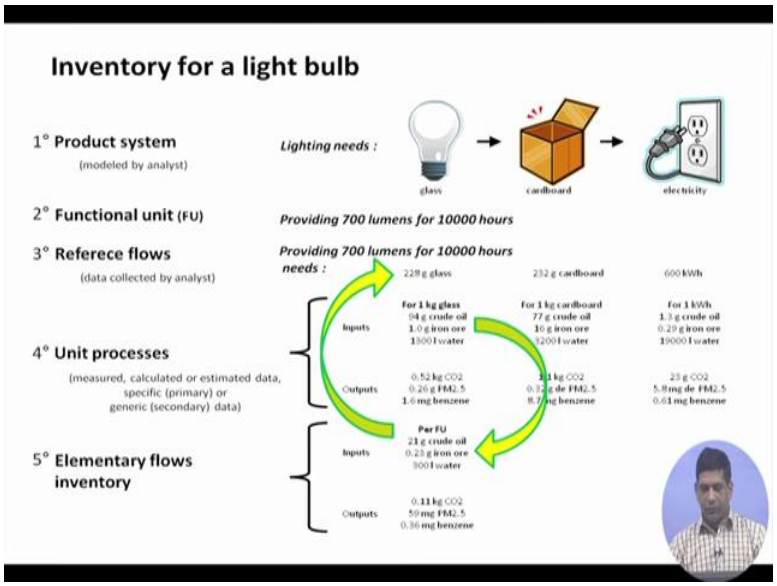

And if you remember we went we looked at this inventory of a light bulb at the last slide before towards the end of the last module. And then we were looking at how you can calculate you can go from 1 unit of the material 2 the reference flow we already did those calculations. So, that was kind of the end of the last module, so again just kind of quick recaps. So, this was the example because I will be continuing this example in terms of the life cycle impact as well as will look at the LCI, which we were we started preparing it in during the last module. And will also look at the impact statement as well as the interpretation coming out of this particular exercise.

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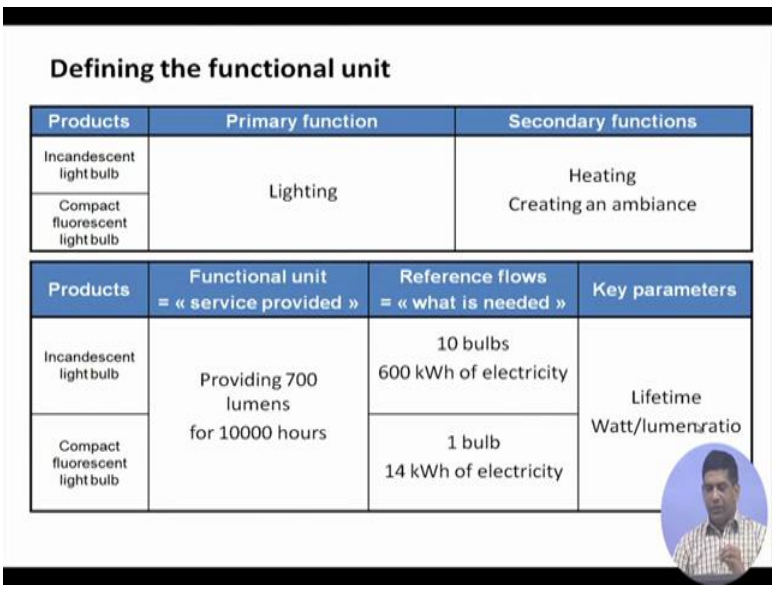

So, this was the problem we had this will we were trying to find out what is the life cycle analysis comparison between the incandescent light bulb and compact fluorescent light bulb. So, this 2 types of a then we also had this particular table. And I told you that you should try to have this table for each and every problem you work on this really helps. So, we looked at that function for both of them is lightning. I am going a little bit faster on that because we already covered it in the previous module just a recap primary function was the lighting the secondary function was the heating and or creating an ambience.

I told you that we will just focus on the lighting part we will not worry too much about the heating and creating an ambience in this particular example. We took the functional unit of 700 lumens and the reason we took that because it gives and for 10000 hours reason we did that because it gives a nice number of 10 bulbs and one bulbs for comparison and 10 bulbs at 60 watt becomes 600 kilowatts 60 kilowatt 600 kilowatt hours of electricity in one bulb for 14 kilowatt hour of an electricity key parameters for lifetime watt per lumen ratio.

So, we also looked at this was the last slide, we looked at just we need bulb cardboard electricity for the product system the functional unit we chose. We chose these 7 lumens for 10000 hours. As I said you can come up with any of these numbers it does not have to be 700 lumens for 10000 hours. The reason I took that because it gives me a nice one and 10, 1 bulb for one category and the 10 bulb for the other categories.

Then had the reference flow: reference flow is what is providing for 700 lumens for 10000 hours how much of a glass how much of card board what is the electricity we need, and this is for incandescent bulb. So, you need processes as the name suggests unit process. So, it will be for 1 unit. So, for 1 kg of glass these were the inputs these were the output we already discussed that. And we only taken 3 parameters, but they could be lot more there same thing for 1 kg of cardboard 1 kilowatt hour of electricity. Remember we talked about the water like a too much water is being used and emissions in terms of carbon dioxide a particulate matter as well as the benzene.

So, this is again this is not the complete list this is just an example list for us to work with. And for the complete list as we do in the real exercise, you will use you will be using database and from the database you can actually pull in for 1 kg of glass what are

the input required and what are the emissions coming out. So now, this is for 1 kg we need for 228 grams of glass. So, we can just do the math. So, per functional unit we have calculated that for if for 1 kg we need 90 for grams; so for 228 grams will need 21 gram of crude oils.

Similarly, you can calculate other stuff in terms of both input as well as the output same thing can be done for this. So, this was the last slide we looked in to the previous module now we will continue this example. So, as you can see we have lots of data just for assuming 3 parameters for input and 3 parameters for output. We are having just for this bulb and we have only taken glass cardboard and the electricity as you know. If you remember from the previous slide no glass was only one component there is some aluminum here, there is some phosphorus here there are there are lot of other components which goes into making this bulb as well.

So, the list will be 2 exhaustive. So, to take care of these kind of list, that is why we need the database is needed otherwise you have to be we spend a lot of time on the excel spreadsheet, and sometimes it will take forever say if you want to do, and this is am just talking about a bulb and if you think about doing for a plant. Say if you have to design I told you that in last around 2 years back like my research team me and my students we did a life cycle analysis for different waste management options for a city for a like I group of 3 cities actually they called a peel region which is near the near Toronto city in Ontario Canada; so just for the bulb if it takes so much of efforts.

So, think about that solid waste management system. So, in term you will have lots and lots of excel spread like you, will have multiple xl spreadsheet lots of data points are there in excel. And then if you are doing a masters or Ph.D. thesis based on that we it will take you forever to do it. So, that is what data base is are important.

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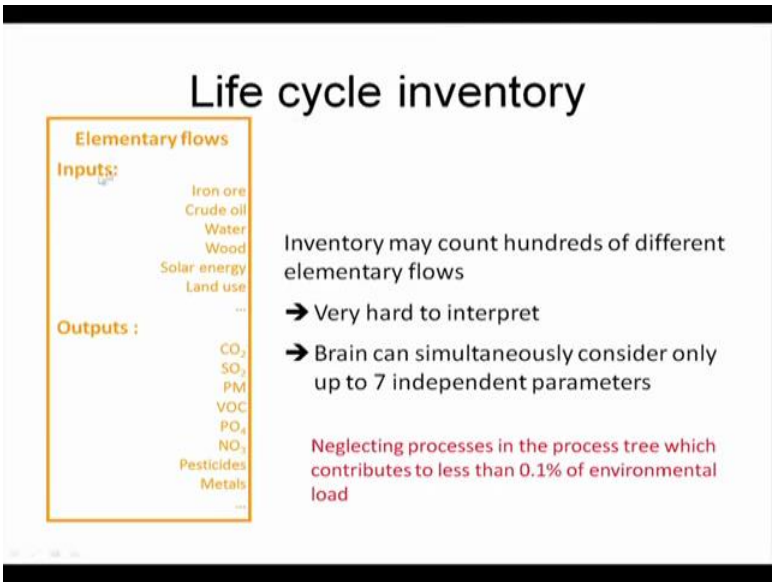

So, this is our elementary flow the input and output that you saw iron ore crude oil water wood solar energy land use, these are our input that is going into the system output coming out carbon dioxide, Sulphur oxide like socks particulate matter voices phosphate nitrate pesticides metals, and on the both top as well as bottom the dot that illustrates a there is much more there.

So, inventory may count hundreds of different elementary flows. So, it gets very hard to interpret because if you have so much data how to make sense of. So, much data our brain can also cannot really synthesize all these data together. So, it says it has been said that brain can simultaneously consider only up to 9 independent parameters sorry up to only 7 independent parameters. So, brain cannot take more than 7 independent parameters.

So, if you have huge data set it, becomes difficult for it we us for us to understand and for us to comprehend. So, for that matter what we do we neglect as you can see towards the end we neglect the process in the process tree which contributes to less than 0.1 percent of the environmental load. So, if you have less than 0.1 percent we do not include them. So, how will go about it? So, what we do is a quick LCA at the beginning kind of gets about quick in like we been in the experimental lab. See many times before you go for your big experimental design you run a quick dry we quick and dirty experiment we just to see whether it is really worth going for that big because when you

design an experimental plan it requires an effort. So, you may want to do a quick and dirty just quick test to find out yes it is going to work looks like there is a potential.

Similarly, here we do a quick LCA where we use several unit is as a black box you can say you can say. And then we see which is more which is creating more impact and then we focus on that anything which has an impact of less than 0.1 percent of the total environmental load, we can illuminate that because again that is a that is a drawback of doing of an LCA exercise, but see again many exercise you do an it, if there are some assumptions that you have to make there will some limitations.

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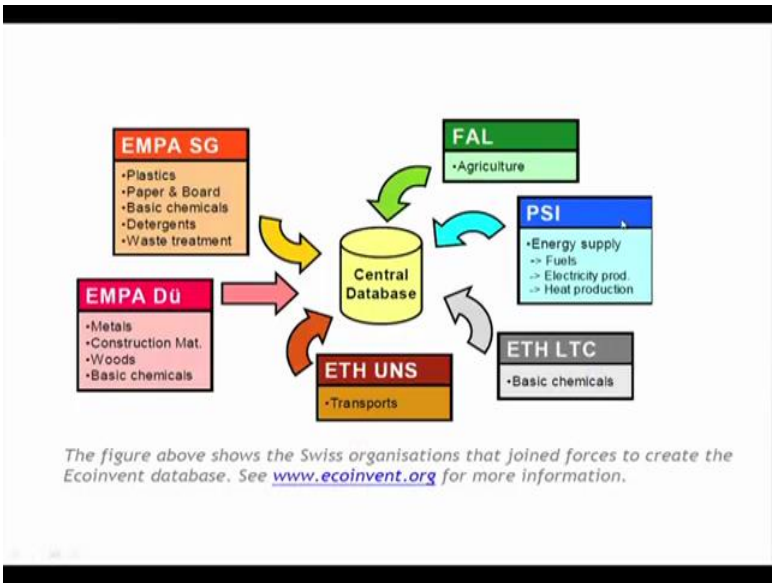

So, where this data gets coming from? So, this is one example of where the data is coming from. And since as most of if you are familiar with environmental industry or the environmental stuff working around the world, you know that most of the new initiatives in the environmental field actually start from the Western European countries. So, this LCA is not an exception. It is also within the same way it is as you can say the figure this figure shows a group of Swiss organization. So, the figure here you can see that there is a group of Swiss organization 1 2 3 4 5 6 here 6 of them we have listed. And the list keeps on growing and growing. So, what they have this is the Swiss organization that joint forces to create the ecoinvent database.

So, now ecoinvent is actually kind of a company, which is trying to collect data and from around the world. So, they started from the Western European countries, within the

Western European countries basically started from Switzerland. And from Switzerland as you can they took a theses 6 organizations, it one organization here I have the transport data this has basic chemicals data here. They have the energy supply data this one has agricultural data then some plastics paper, board, basic chemicals, detergents and metals construction material wood and basic chemicals.

So, there are some overlaps as well, so all these data that they have now. Now we would say data what would you mean by that? So, data means to make one. So, for example, making 1 liter of petrol or 1 kg of a steel or 1 ton of a steel or any unit you can think of sorry, any product or material you can think of a unit of that. So, to make 1 unit of that particular say 1 kg 1 kilowatt hour of electricity or 1 giga watt hour of electricity using coal base thermal power plant. Or using gas like a liquid natural gas or if you using for example, hydroelectric power or nuclear power or geothermal whatever solar power. So, for all these different energy sources to produce 1 unit of that energy, what are the different inputs that are needed in the system? So, if you think about the solar panel for example, solar panel it is, there is it is a solar panel is it is a physical thing. So, it is the certain material whatever may we need material to make them.

So, it does use some material and so what are those materials. So, to produce 1 kilo watt hour of electricity or giga watt hour of electricity using say solar panels, what how much material will be needed, what are those materials what are the basic kind of chemical composition of all those materials, and whether those materials are mind or whether what is the source of those materials what is the environmental foot print associated with getting those materials to make the solar panel, what are the waste coming out during the making of the solar panel when the solar panel is used how does it require any of the maintenance what kind of maintenance it requires what kind of service it requires and then also when it is disposed what happens to that materials.

So, all these things together; so that will be you say for 1 kilo watt hour 1 kilo watt of electricity from solar panel. We can calculate what are the different inputs and what are the different outputs. So, for these kind of data, for this particular central database this we have here in which is developed, now it is called ecoinvent ecoinvent has been developed taking into consideration the data that came from these 6 organizations first. And then the ecoinvent it is a like it is a company as I said earlier it is trying to develop it is own database. So, as I said as I told you in your previous module, that writes now we

are working with ecoinvent when I say we like myself my students. We are working on a project with ecoinvent to develop data in India.

So, once there are lot of other areas where they are working on this present focused is this present project of ecoinvent that we are associated with is focused on textile. So, it is a textile industry, how to collect the data in the textile industry interms of it is like it is what are the chemical release of from there, what are the different chemicals they use how much energy is required, how much water is required. So, we are collecting all that information from a textile industry in southern India.

So, that is and then we that there is a standard format in which it needs to be put together, so it is can be. So, it would be better to do. So, and then if you think about why, we need all these data again what is this LCA exercise. LCA exercise is a basically you are doing data compilation for all the input parameters all the output parameters. Now why we do data compilation, because we are interested into find out what are the environmental impact associated with any of these processes or product. So, that is the goal of doing this lifecycle analysis. So, the central database came initially from these 6 sources.

Now ecoinvent is trying to collect more data from different sources (Refer Time: 13:34) ecoinvent is one example there are other examples out there as well there is a and I have a list of some of those towards the end of other presentation where towards the end of the video probably you will see the different organizations, which are the data and some of these are free data free data means you we like you and me are already paying through the tax payers money or whoever is paying taxes and some of these are pay like for ecoinvent now is a paid service. So, you have to get the paid service. For non oecd countries of which India is a non oecd country you can get access to ecoinvent free of cost for educational purposes only.

So, for teaching risks and for student projects which is not funded through any other organization, we can use ecoinvent data base. So, that is available you can go to ecoinvent website and try to download that, but if you do not you can send me an email I can always help you to pin point in the right direction, but it is it is not that you go to ecoinvent web webpage and try to buy this product, there it will save for the non oecd countries including India, we can get access to this database without any charge just, but

that is only for educational purposes not for consulting not for industry only for educational purposes.

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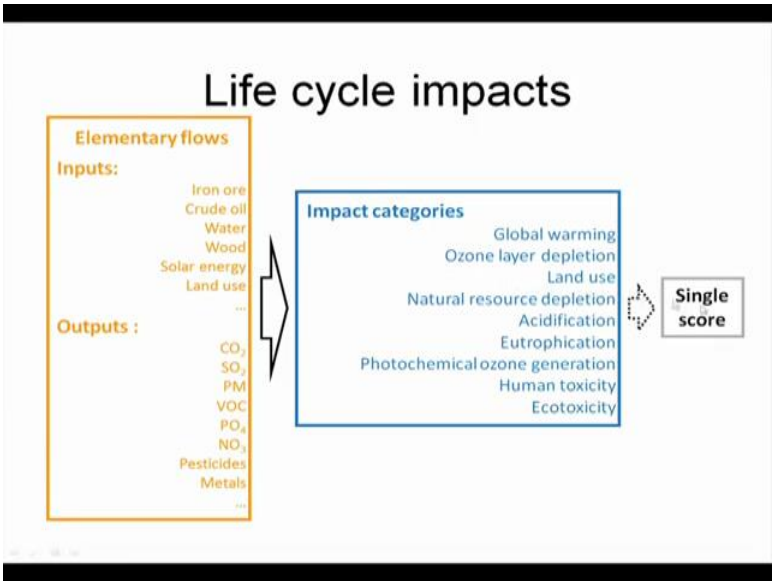

So, we had this elementary flow. This input and output what is going into the system what is coming out of. So, from this input and in output now we look what we have done. So, far we looked at the life cycle inventory part we looked at the inventory part now will look at the impact part. So, what is the interms of the impact? So, these are the input and output this was this is our LCI. This input and output that we have quantified that is the LCI day life cycle inventory this is what we call as life cycle inventory and we have done it for elementary flows. So, we looked at our unit flow from the data base or from and then we calculated for our, whatever we need for our particular example here we were looking at the bulb.

So, ultimately we are interested in the environmental impact. So, what kind of what kind of impact we are interested in. So, there are different impact categories out there. So, you can see over the list over here, global warming. Global warming is an it is a term used for climate change as well. So, it is a climate changes are a more general word and global warming is the word which is being used earlier. Now a day we mostly call it is a climate change. Because global warming it is a wrong impression warming seems to say that everything is getting heated up, but that is not the case the case is climate change when they say even when they say global warming, they are saying that the temperature at the

cooler places things are may be becoming cooler at the hotter, places things may become hotter or also we are seeing shift in the pattern places where it was does not used to rain it rains a lot the places where it used to rain quite a bit it is not raining.

So, that is all kind of comes under this climate change. Then that is one category one important category. Then we have ozone layer depletion because of release of these greenhouse gases we have this ozone layer why the ozone layer is important. Because the ozone layer helps us from getting exposed to the radiative like radiative rays that which if you like ultra violet rays which can have a negative impact on our bodies. So, we are getting a ozone layer this is like a acts as a protection layer.

So, change in land use because of a impact the could be change in land use. Natural resource depletion natural resources going down so that is another issue. Acidification, especially if it socks nocks you see here SO2NO3. So, socks and nocks that is the acid rain carbon dioxide also, lead to reduce reduction in in you in the ph. So, acidification is a problem. What is the problem with acidification because acidification will lead to say you must have heard about you may have heard about acid mine drainage?

So, acidification leads to what happens is, the lower acidification means lower pH lower pH means metals comes into solution many of these contaminates, which remains in in a precipitate form once the pH goes down it tends to come in solution. So, what does that mean, when it means in solution means if it is an after acidification if there is a rain fall, and our contaminated soil sediment whatever contaminated soil for example, mostly many times we here in that mine area as well. So, in those where we have these acidification happening our metals will get dissolved and next time when it rains it the metal will get into this rain water and can potentially go to the service water.

So, that is the problem with acidification. Then eutrophication if you are an environmental if you have taken any course in environmental science or engineering you probably must know eutrophication. Eutrophication is when you have the nitrate and phosphate getting in to a surface water where you have an algal bloom everything gets looks very green, but what happens is kind of covers a layer on top it does not let oxygen go into the deep water and that the species in deep water suffers for that; so and it also. So, that is the problem with the eutrophication.

Now, the photochemical ozone generation; that is another one for the photo chemical ozone generation human toxicity eco toxicity. So, all that there are different impact categories again, these are some of the impact categories this. These may not be the complete exhaustive list you may have to look at the complete exhaustive list. And for depending on where you are some of this impact categories may be of much more importance to you then the other. So, you need to be careful with that as well like what is which impact category is more important for depending on where you are. So, from there we come up with the single score as you can see over here. So, we come up with this impact category. So, that is your life cycle impact assessment and then we come to the single score.

Now, why single score? Again as I as I been telling you earlier as well you should always be worried you should always be asking question why we are doing this. So, why single score. Single scored because to help a common person understand the impact from any product or process. Say if you talk about all these different impact categories global warming ozone layer land use natural resources, and they may sound very technical very, but it is it is very difficult to quantify some very difficult to actually educate the common people with all these technical jargon associated with that like eutrophication or photochemical ozone say people who are not familiar with, this they get so much it like afraid of these they just do not want to even like learn about all that.

So, make things simpler like we do for say for example, Bombay stock exchange or national stock exchange or for that matter New York stock exchange any stock exchange they have a number. They have a single score and that single score tells you that whether the market is going up or market is going down. That is a Sensex is not it. We call it Sensex index. Sensex may be usually it is combination of 10000 companies and out of those 100 companies some may have done well on that day some may have done bad, but based on if the majorities have done well and then things have. So, looks prop up. So, then you see an increase in the BSC Sensex, if the majority has done poorly you see a decrease in the BSC Sensex.

So, similarly over here if you see a higher score than a bench score; that means, things are better in terms of the environmental impact. When if you look at a lower score then the bench score; that means, things are actually not that good from the environmental (Refer Time: 21:28) stand point. So, that is that the reason to have a single score. So, that

you can convey these to say politicians' policy makers or a bureaucrat who may not have that much of technical background, to explain them all you need something like a single score, with to like a to compare different product different processes.

So, that is the reason we do the single score. And not only in this particular life cycle analysis thing, this is also done for the water you know you here, what water quality index you here about air quality index. So, this water quality index air quality index, all those index are again based on single score to help at the layman understand the numbers the like an in a simple way the impact coming from a certain scenario.

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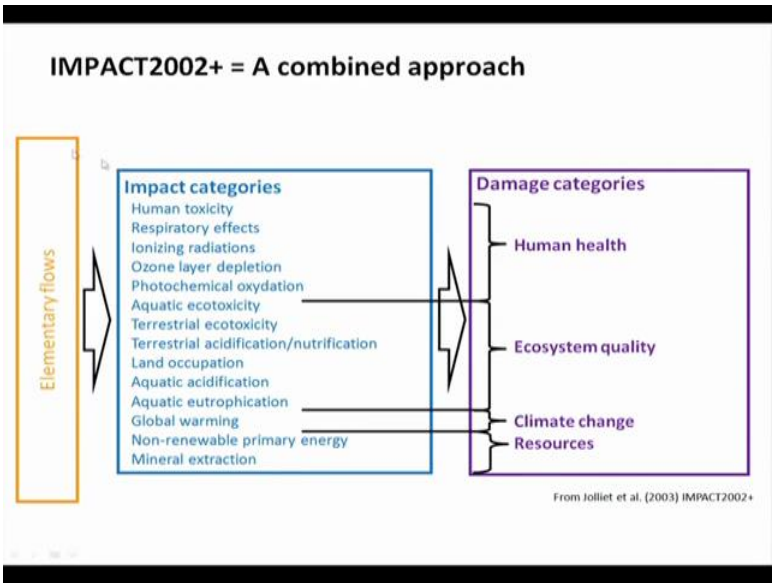

So, there are different approaches of going for the impact categories. So, you have your elementary flow. Elementary flow which was your elementary flow this input and output system. Then we have this impact category here. If you can see we have more list than what we had here. So, we have added some more some more list over here human toxicity, respiratory effect ionization, radiation, radiation photochemical, aquatic eco toxicity terrestrial eco.

So, there is a lot more things have been added to over here. And from these impact categories we go to what is known as the damage categories. Now what is damage categories is essentially you go in terms of for what kind of, what kind of damage we are going to see whether it is an impact on human health, whether it is impact on ecosystem quality, whether it is an impact on climate change or whether it is a resources. And for

that some of these impact here from the impact categories it does not mean that one will only go to one of this damage category, they may have a multiple relationship as well and in that case again we have to kind of do a weighted average in terms of we have to divide in in terms of allocate this percent to this category this percent to that category.

So, there are different impact categories and from the impact categories we have the damage categories. So, these are the major damage categories we kind of talk about human health ecosystem quality climate change and resources. And this is an approach which is called impact 2002 plus because that is this Jolliet et al in 2003. She came up with this this particular approach. So, this is one approach this is again. These are this is a popular approach. Now there is another one recipe 2009 which is an another approach used for going for impact category to the damage category, but again, but these are all different approaches. You can use the approach which you feel more comfortable with, but you need to justify why you are using that particular approach.

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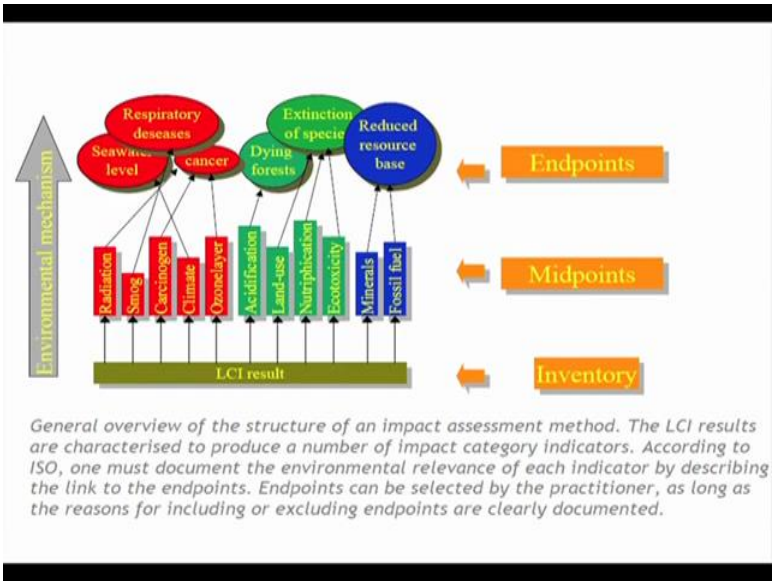

General overview of the structure of an impact assessment method. The LCI results are characterised to produce a number of impact category indicators. According to ISO, one must document the environmental relevance of each indicator by describing the link to the endpoints. Endpoints can be selected by the practitioner, as long as the reasons for including or excluding endpoints are clearly documented.

So, that is in terms of the different approaches. So, again we had this LCI result. So, that is one inventory result. That is an inventory result then you go to the midpoint is where you look at this impact radiation smog carcinogen climate ozone layer acidification. So, these are all the impacts that you look at interms of the midpoint and then you look at an end point in terms of end point, impact respiratory disease sea water level cancer dying forest extension of a species and reduced a resource base. So, these are all the end points

category out there. So, you go from LCI result to midpoint to end point and there is form midpoint to end point, when you go interms of their impact you need one of these methodology their recipe 2009 or impact 200 plus. So, those are some of the methodology at that you can use.

So, this is how in terms of impact assessment works LCI results it (Refer Time: 25:20) a produce a number of a category indicators. And according to ISO one must document the element relevance of each indicator, but describing the link to the end point end points can be selected by the practitioner as well as the reason for including or excluding end points are clearly documented.

So, it is basically you go from this LCI result that you get from remember we talked about that long table input and output of all the different unit is unit processes. Then you go to this midpoint and from midpoint you go to the end point.

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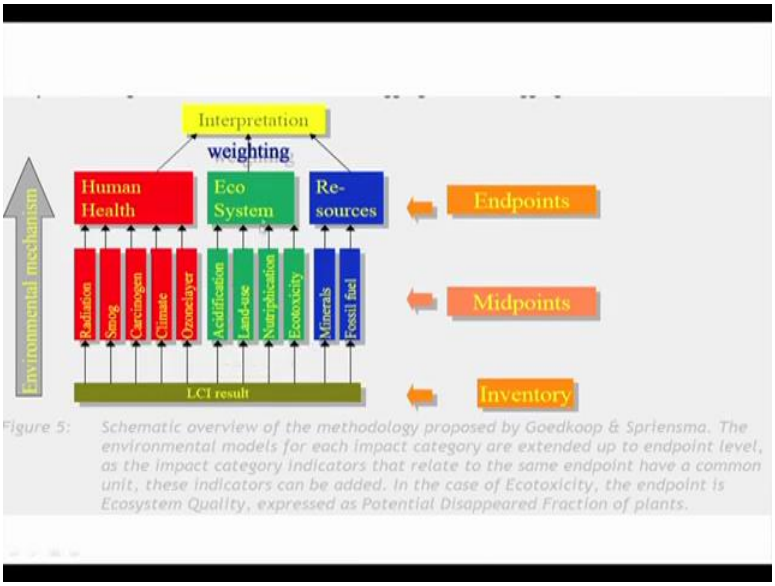

Figure 5: Schematic overview of the methodology proposed by Goedkoop & Spriensma. The environmental models for each impact category are extended up to endpoint level, as the impact category indicators that relate to the same endpoint have a common unit, these indicators can be added. In the case of Ecotoxicity, the endpoint is Ecosystem Quality, expressed as Potential Disappeared Fraction of plants.

And from this end point you go you do some waiting. Waiting again depends on what is the goal. What is the goal of this study what you want to what you want to achieve what is your focus?

So, schematic overview of the methodology; so you have it is an environmental model for each impact are extended up to end points. So, we look at the up to the end point level as an impact category human health ecosystem or resource base. And some impact

category may relate to the same end point there could be kind of cross as well. So, there could be some of these also related to ecosystem and some of these also relates to human health, but we need to we need to look at that like in in terms of overall like what are the different impacts that is coming out here.

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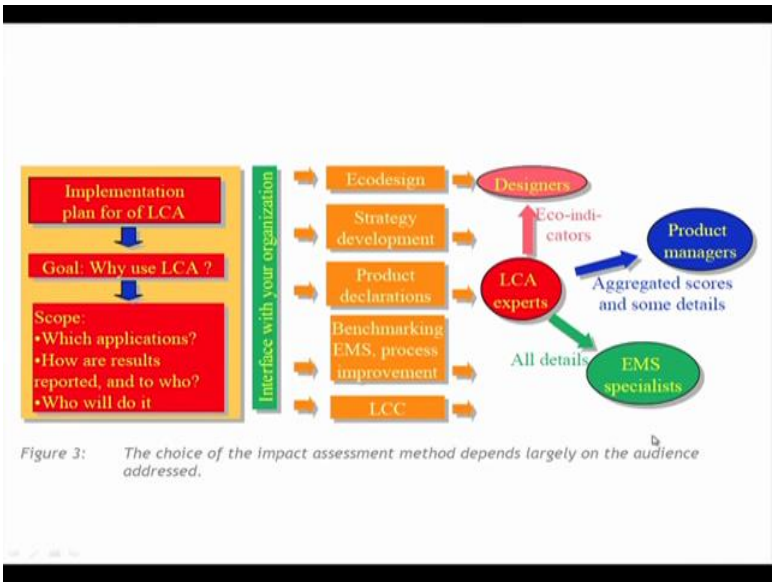

Figure 3: The choice of the impact assessment method depends largely on the audience addressed.

So, once you have this you can do some weighting and then you try to come up with interpretation in terms of which one is more important and how to go about that. So, what interms of the implementation plan of LCA, first of all goal is why use LCA you need to find out what is the use of LCA what is which application, how what who are the results reported whereas to who will be the person who is the audience, who will do it than your interference with your organization you try to talk with the organization people you come up with your eco-design you come up with strategy development product declaration benchmarking process life cycle costing.

Then keeping these things in mind in you come you approach your LCA experts either within the company or outside the company. Then you get the LCA exercise done, you take it to environmental management system is specialist for and then also product manager designers who will all be working on certain projects as well.

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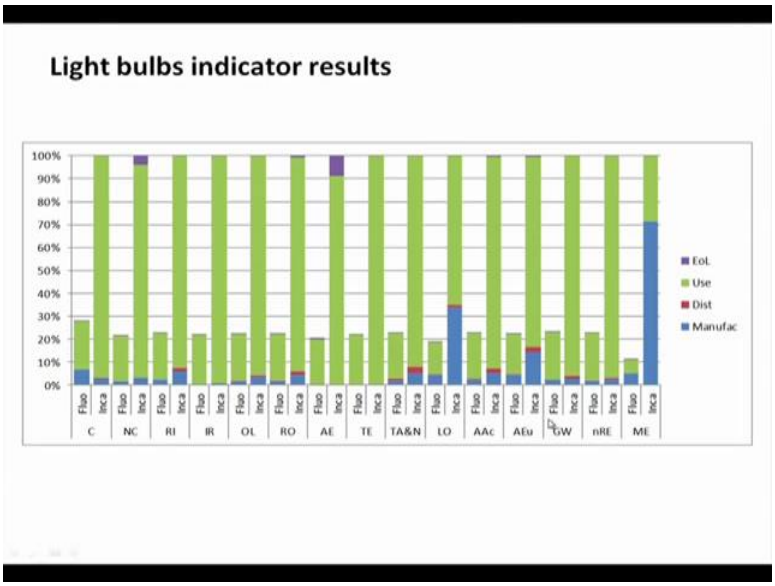

So, keeping all these like the end point coming out, you can communicate with all these different stake holders and to have a better design for that. So, let us kind of a stop over here for this particular module. So, what we did in terms of this module I kind of gave you a like an overview of how we go from life cycle inventory to impact and to interpretation. So, that is what we have in looking at. And then again it is very post the discussion board and we will be happy to answer those questions as well and do for do not forget to keep your weekly quiz. So, weekly quizzes are designed. So, that it helps you to like learn better.

So, with that let us close this particular video and then will get back again on the will continue with this exercise in the next module as well.

Thank you.