Life Cycle Assessment
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Lecture – 21
Unit Process, Data and LCI Databases

Let us start looking at we are now in week 5. So, we have already covered four weeks' worth of material, we are now going into the second half of this course if you have, as I mentioned to you very early in the course this is a eight week course. So, we are in the fifth week now. So, in the fifth week we will start looking into where we have left at the end of fourth week, which was we were looking at this ISO methodology and different components of how to do LCA. So, let us look at kind of continue that I started if you remember from the last video that we had we were looking at unit processes.

So, let us continue looking at from the unit processes side, and then will continue and then will look at the other aspects in terms of the LCI database impact assessment and all that. So, in this particular module we will start looking at the unit process and data and LCI database.

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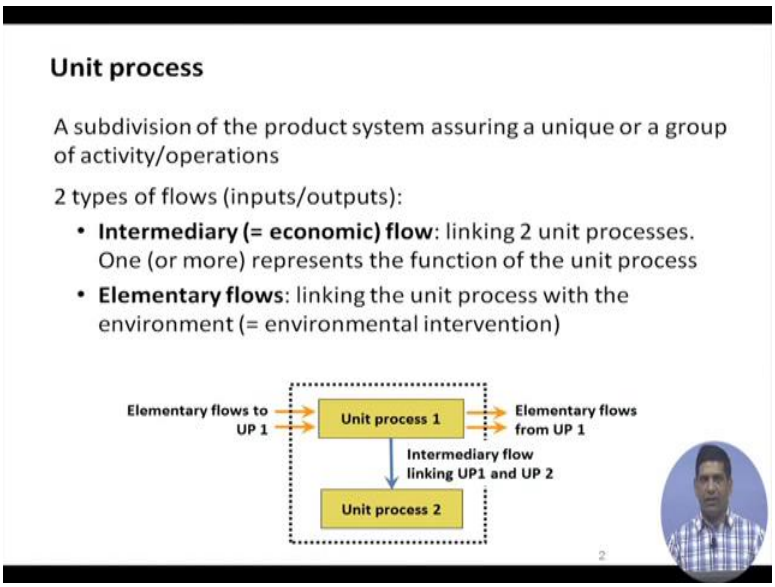

So, this was the last slide you saw towards the end of last module, where we looked at the unit if you remember we talked about this particular box which we were trying to cover; that you can have two types of unit processes there could be one unit process which is a intermediary flow, two types of flow not unit process actually; there is it two type of flow within between the unit processes. So, you what is unit process? It is a subdivision of the product system is assuring a unique or a group of activity or operation. So, it is a products we have a product system it is a subdivision of that, and it is a it gives us a unique or a group of activity happening there.

There could be two types of flows we looked into that when we say flows it is the input and output of the system, one we defined as intermediary flow which is where you the two unit processes are linked, linking 2 unit process 1 or more represents the function of the unit process and that then could be elementary flow. Elementary flow is where the unit process is linked with the environment. So, the top one here the unit process 1 has a elementary flow coming to unit process 1 elementary flow going out of unit process 1, and then unit process 1 and 2 is connected through the intermediary flow linking the unit process 1 and unit process 2.

So, this is how it is has been defined, this was the last slide will looked at towards the end of last week's materiel.

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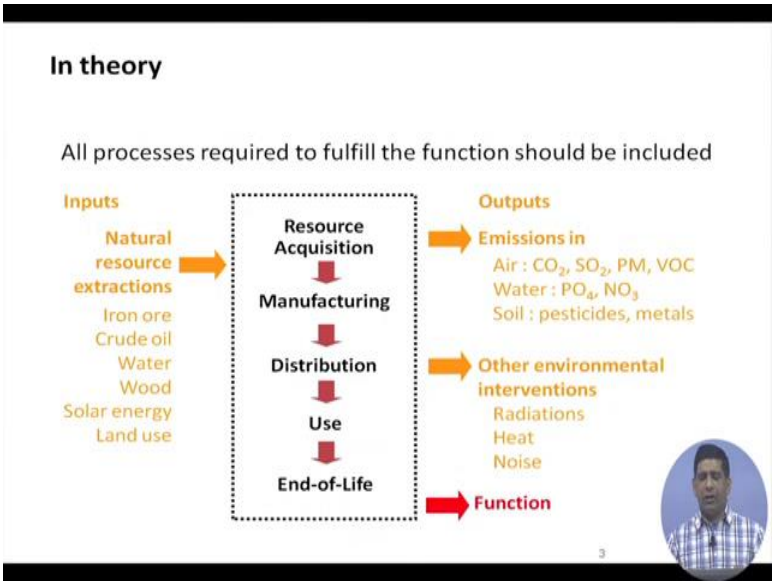

So, in theory, there are there will be all there will be lot of processes which will happen to achieve the function that we want to achieve. So, as you can see this is again the box came very similarly to what we had earlier we looked at in that our bulb exercise as well. So, for any of these life cycle analysis activity that we do, we have resource acquisition where things has to be acquired, where you are mining activities then manufacturing distribution use an end of life. So, this box kind of signifies cradle to grave, and for in this box if you look at any product this whole thing needs to happen for in terms of the products life cycle, and for and that is that product is giving us a function and we will use a functional unit to quantify all these inputs and outputs. So, the inputs again natural resource extraction, iron ore, crude oil, water wood, solar energy. So, these are our inputs outputs are emissions; air emissions, water emissions, soil emissions and also other environmental emission invent interventions and symptoms of radiation, heat, noise.

So, these are all outputs associated with that. So, in theory we have all process we required to fulfil the function we were we will take all the process which we require in terms of getting into the function of that particular product, and they include pretty much from cradle to grave if you take the cradle to grave concept it includes from resource acquisition all the way to end of life.

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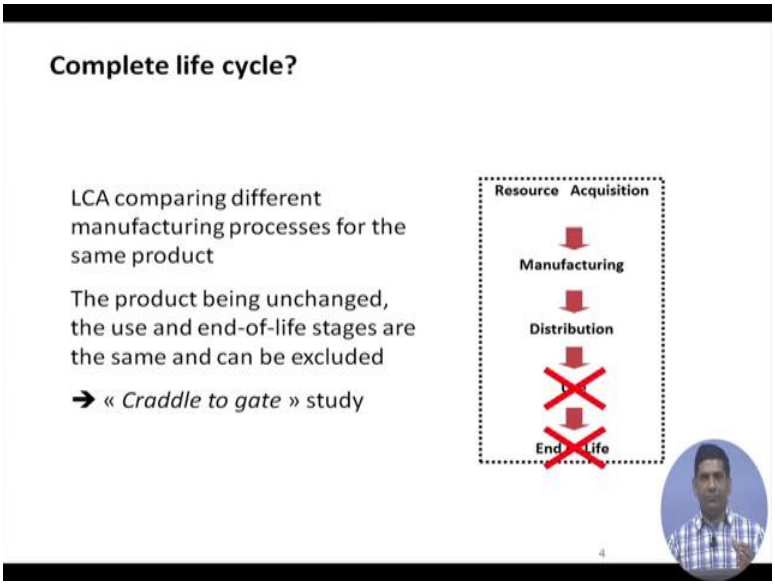

So, that is our complete life cycle; the previous box that you saw was a complete life cycle, but as I said earlier many times you may not to do complete life cycle, if you remember I talked about that say if you are running a company and you make a product then after the product leaves the boundary of your company, then you can make an argument that I do not have any control on that product anymore.

So, I do not really what happens to the product once it leaves my gate, I do not know it is because it depends on what kind of users I have some users may be environmental friendly they will take more care in terms of using the product, others may not care that much about environment and they may not take care of. So, they may use it in a way which has big bigger environmental footprint. So, we have to that part is as a company I have like a no control over that. So, one can make a argument and that is a very valid argument. So, in those kinds of scenarios where you do not really go all the way to the end, if you are doing all the resource acquisition if you look at this box again, if you just only doing resource acquisition, manufacturing distribution no use an end of life phase; so that is where we are just from the cradle.

So, this is a to the gate. So, as you can see here we are not taking the use phase and the end of life phase. So, that is there is no disposal or no recycling composting waste to

energy those things are not coming in here, so here the product being unchanged. So, LCA here different manufacturing process for the same product, the product being unchanged the use and end of life stages are the same and can be excluded.

So, if it is use and end of life can be excluded then it becomes a cradle to gate study. So, that is where you are only going from the cradle to the gate and you are not looking at the use phase or the disposal phase. If you look at some product especially where the disposal or the use phase is one of the dominating phase in terms of the environmental footprint, many product may come out to be much nicer; when I say nicer means from the environmental point of view, from a environmental point of view they comes they come out to be very good if you do a great cradle to gate study if we exclude the end of life or the use phase.

For example anything containing heavy metals say for example, if there is something containing lead or mercury we had electronics and all that. So, when this heavy metals it is a disposal part becomes very critical. Say if the things ends up in the landfill or in a dump like in India still we are way behind in the waste management system, we need to make a lot of improvement there all with the new push with [FL] mission and all that hopefully we will make progress in that area, but still we are we have to make a lot of progress and.

So, that is say right now most of the waste material in India is it is not managed, there are some good, good things happening in the country. So, I am a very optimistic person. So, if there are some really good things happening in the country in the waste management sector as well, those things needs to be kind of we need to learn from those and kind of replicate similar stuff elsewhere in the country, but majority of places in the country, majority of big cities or a small cities and towns they are struggling with waste management system.

So, anything with like a high heavy metal or like a lot of when I say high it is a higher concentration of heavy metal, or things which can has a potential to pollute the environment during the disposal in a big way. If you exclude the disposal phase in your life cycle analysis as in this particular example over here, if you exclude this end of life

they may come out to be much nicer, they will show up to be it is a very nice like a result, which may not be really true. Some of like mercury lamps or lead containing electronics those will be the cases where at their environmental footprint will come out to be much better if we exclude the disposal phase. So, we need to be careful with that.

So, that is why whenever you look a as I said if you are a young professional right now or a young student right now who will be working in this field in the environmental field for say next 30-40 years in as a career, or say if depend it does not matter where which should which area you will work, because these days this environmental impact is it needs to be looked at in every aspect; even if you are working for a company as a manager, say after you become an engineer or whatever and then you do an MBA degree and then you become a manager for a company, is still there also you have to things are so much interrelated now, you will either be look you have to look at some of these environmental footprint data or report.

So, you have to make sense of the report what these reports are, either you if you are a hard core environmental professional you will be producing this report. If you are working on the other side as a manager or even for a regulator or like a environmental regulator state pollution control board, central pollution control board, and all those different positions that you can end up or in the you MOEF for example,. So, there you will be looking at these reports.

So, when you look at this report you should be able to understand that report. So, when you look at this LCA report as I may have said earlier too, you should look at the system boundary very carefully whether it was a cradle to grave study or cradle to gate study. Something may look very good in cradle to gate, but when you do a cradle to grave study it may not look as good because of the impact that it will have especially during it is disposal phase in a waste energy plant or in a land fill and those scenarios. So, that is like a cradle to gate concept we kind of talked about that little bit earlier, but here it is a good and then it is a good like a example that we had to look at that as well.

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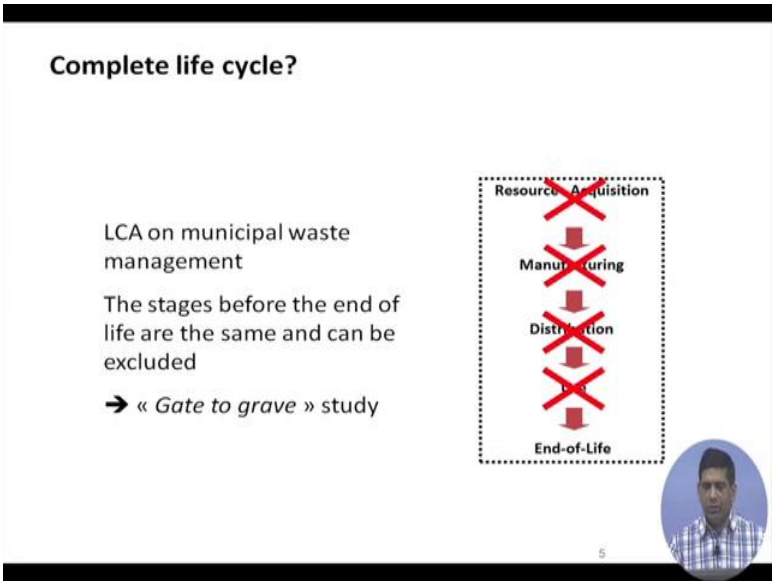

Then you may have something which is only when you look at only on the municipal say if you look at only look at the end of life. So, if you want to do a life cycle analysis only on the on the municipal waste management. So, if you are looking at the municipal waste management, we just talked about like [FL] mission the municipal solid waste, say for we are say like I am sitting here in Kharagpur. So, Kharagpur is a town in west Bengal with a it is a decent size town now in for example, in the town of Kharagpur they want to have a municipal solid waste management system.

So, when they want to have a municipal solid waste management system they can have different options to go for; they can go for a compost plant, they can go for a waste to energy plant, they can go for a landfill, I am talking about engineer landfill, maybe anaerobic digestion for the food waste, there are different options out there. So, for all these different options of course, which options to choose will depends on what is the waste composition, how much is the calorific value, how much is the biodegradable fraction and all that and will not go into that particular aspect that will be a separate course on municipal solid waste management, which probably will be offered later like later as well but not in this particular course.

So, we have in terms of if you if you are just if you are just focused on the end of life

weather composting say there are different options. I was giving you the example that in outskirts of Toronto, there are three small towns small from Indian contest pretty big from the Canadian contest, because everything with 6,00,000 population is considered very big over there. So, this Mississauga Brampton and there is another Caldon, this three together is called peel region.

So, we did a study like when I say we did a study like myself and my students we worked on a study for that peel region, where they had the different options; where like anaerobic digestion, landfill like a bioreactor landfill or a non bioreactor landfill, and then they are sending it to whatever is residual it is like actually it is like a that is landfill there is no residual here. And then you have a waste to energy plant bio like a compost waste to energy plant, and residual from both compost wastes to energy plant going to a landfill. So, there were there was three or four like four different options we had come up with, and then this four for this four different options we did a life cycle analysis and to see which option comes out to be better.

So, for all that we are not worried about resource acquisition manufacturing distribution or use phase, because this is common this waste material the waste material that is coming in it does not matter which were like it is a same thing, it is a waste material is coming because we are focusing only on end of life, we are looking at the end of life options we are looking at the waste disposal options. So, once the product is made waste, it does it is already the earlier part whether we go for composting, anaerobic digestion or landfill the previous impact remains the remains constant. So, when it was restored when it was made in a manufacturing plant, when it got sold, when people used it that particular aspect those things is the same.

So, since it is same we can ignore that part, because the environmental impact associated with those aspects is already is will be there whether we go for compost, or anaerobic digestion, or landfill or waste to energy plant it will be the same environmental impact. So, it is like saying that you have you a equation where you have a plus b plus c on one side, and the other side you have a plus b plus d. So, since a and b is common you can get rid of a and b and we just look at c and d. So, that similarly over here we have we can get rid of those factors which is common for very especially when you are doing the

comparative LCA.

So, for end of life here we have the stages before the end of life are the same, we can exclude that that is what we are talking about here, and that becomes gate to grave study. So, here we are just looking at gate to grave. So, there are different types of studies you can do, there are software's which actually specialises on working only for municipal solid waste management life cycle analysis, there is a like the software name is East-tech I think it was earlier it was east west, now it is called east steak or maybe vice versa earlier it was east west now it is called east tech, but this is this software is developed by technical university of Denmark, and they give this software free of cost to academic people and only thing is that you need to go and take a two weeks training in Denmark in Copenhagen, they can in outskirts of Copenhagen and that they will give you a software at the end of the course.

But they wanted to use the software properly, so that is why you need to take the core you need to take the training over there. In terms of training there is no charges only thing is that you have to get there that you have to pay for your ticket they arrange for your accommodation and everything. So, it is a pretty for academic people it is a nice kind of system it is a good software, last year we had a master student here working with me who use this software I did happened to take this training couple of years back, I do have a copy of this particular software; and that is it is focuses on waste management. So, it is the focus is on waste management as some of you if you have Goggled enough about me you know that my core area is on waste management.

So, that is how I led I am work from waste management I am moved to this life cycle analysis area. So, I do both waste management and life cycle analysis and if you think carefully there is a good relationship between the between the two as well, because when we talk about life cycle of material waste is a material too, somebody's waste it could be waste for you, but it could be material for somebody else. So, it has a value for other people. So, that is your cradle to gate study sorry gate to grave study which is focused on waste management system.

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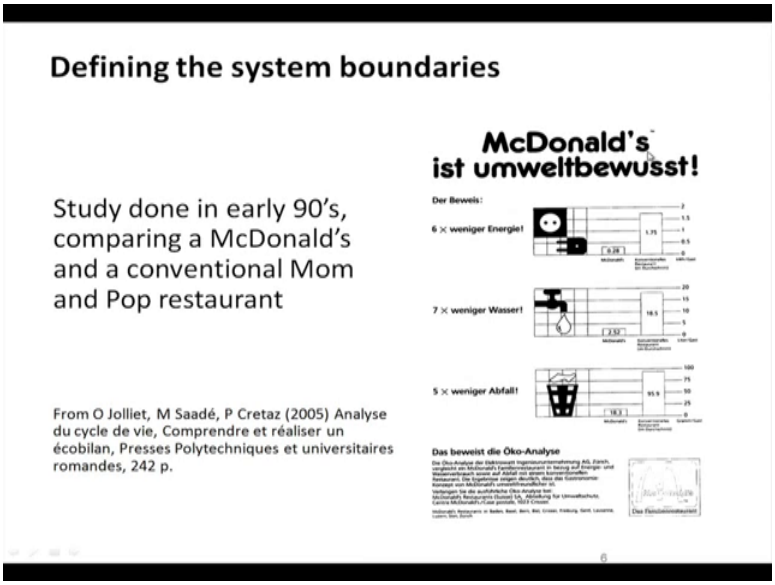

Now, we will look at some of these like look at this example on how you define the system boundary, and as I said you need to be always careful in terms of adding a proper definition in terms of system boundary, this particular has come from a French paper French report that is why you see some of these French language over here, but do not worry too much about that I have like it is a study done early in 90s, comparing a McDonald versus a conventional mom and pop restaurant.

So, again this some of this language is a western language. So, when we say McDonald everybody of us knows McDonald there is enough ad on TV now on McDonalds. So, you know even in India PP McDonald is a very popular place actually if you go to the western countries if you go to US or Europe and other places, most of the people actually do not like to go to McDonalds and Donald is considered a poor people's place for eating in America and other places. Here we a is still have craze for McDonald's and especially with this all kids because of those toys that they give, but here if you look at the comparing McDonald study was done in early nineties, and conventional mom and pop mum and pop restaurant means it is a conventional family restaurant.

So, it is a conventional restaurant where if you remember if you look at any of these big chain restaurants, they are these McDonalds or KFC or to the certain extent subway is a

bit different, but other there are other chains out there I do not remember right now, but this burger king for example,. So, these restaurants they do not they get semi cooked food from a centralised warehouse kind of place. So, they get semi cooked food and then they just do a the preparation over there.

So, there is no cutting of vegetables and all that happening, which happens in a conventional mom and pop restaurant. Mom and pop means a conventional family own restaurant where you walk in you give a order and then they cut the vegetables and prepare it for you sometimes, and then they give you the food if you are asking for something unique if there is something that they have made for that particular day, which they list anyway as a specials for the day or vegetable for the day if you buy that that is again that also produces lot of food waste over there.

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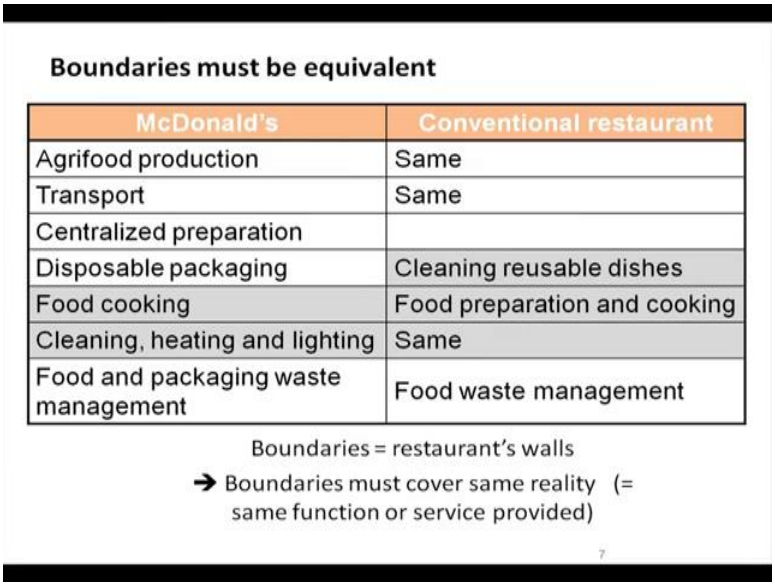

So, if you want to compare these two again the boundary system boundary has to be an equivalent, because that is where that is the critical if you are trying to compare these two systems MacDonald versus a mom and pop restaurant. So, both of them has a similar sub system boundaries. So, let us look at some let us look at this table to try to understand what I am trying to say over there. So, for both if you look at mine McDonald as well as the conventional restaurant, in terms of the agri food production in terms of the

production of the agricultural produce and from there to the food it is a same, it is a same whether you eat say if you are eating certain a veggie burger or a chicken burger whatever in a McDonald or a conventional restaurant, this stuff that needs to get to prepare that is the same.

So, agricultural aspect will remain the same and the product production of agricultural food processing little bit more or less the same; and there will be transportation involved in both cases: in the case of McDonalds as well in the case of conventional restaurant. Now in McDonald what is there they have a centralized preparation. So, they have a centralized preparation. So, here they do a centralized preparation so; that means, they do not do a lot of preparation in their individual store.

So, it preparation is done for example, in a city like Kolkata or say Delhi or other places they will have a centralized location depending on how many units they have on that particular city, sometimes even the food comes to this centralized location may not be in that city maybe in some other city pretty much we do have a subway at IIT Kharagpur campus over here, and subways most of the stuff actually comes from Kolkata to this particular subway because the centralised location where the food those all those salads and other things actually comes from Kolkata which gets they use it over here. So, that is why they do not produce much food they do not produce much food waste from the sense of like a preparation of food, they may produce food waste if people do not eat it, people do not take the whole sandwich and do not eat the whole sandwich and throw some away.

So, that food waste will be produced, but in terms of the preparation for example, the coverings of onions or when you leave the remove the skin of potato those kind of waste they will not produce and. So, they do not have to worry about that in Kharagpur, but they will worry about that one in Kolkata. So, that is that is why you need to be, but in the in case of conventional restaurant it will be; in terms of conventional restaurant there will be preparation being done. So, they will there is no centralized preparation the preparation they will have the raw vegetables there, and they will prepare right there. So, they will do produce those kind of waste. Why we are talking about that because that waste will have an environmental impact.

So, we need to be make sure that the when we calculate environmental impact it is we are including all the aspects and not give undue advantage to is to say McDonald or to conventional restaurant, then most of these McDonalds and these kind of a stores they have a disposable packaging. So, they have a disposable packaging, so they will produce a lot of waste from that for that, but if you look at conventional restaurant use they use reusable dishes. So, now, this reusable dishes those china dishes needs to be cleaned up. So, there will be detergent dishwasher liquid, hot water and those water needs to be used for that. So, there is those kind of aspects needs to be there. Food cooking there will be some food cooking in McDonald, but since it is a semi cooked kind of things which they get. So, cooking is usually it is mostly just the deep frying stuff, and or baking kind of the things they do. So, that is a little bit different, but they do a do some food cooking. In conventional restaurant they will do food preparation as well as cooking.

So, here they have food preparation as well as cooking now in terms of cleaning, heating and lightning it is the same in both the restaurants. So, that is a both are there and now it is if most of the people say for if most of the people are eating within the power within the McDonalds premises, among the many many this kind of restaurants like McDonalds or this fast food restaurants are it is pack and go as well like you do not eat sitting there, you eat and you basically take your stuff in a bag and just you walk out. So, you are not it is you are just carry your carrying the food not eating it you may be eating it is your car and later on when you find it find one trash can you junk the dump it over there.

So, although it was a waste generated because of McDonald, but it is being managed by some other sources McDonald is not managing it, but part of it nearly say even if you say 50, 60 percent people are eating it in house, there will be some packaging waste. And in conventional restaurant it will be mostly food waste you people throw away some stuff so that is it somewhere leftover food no packaging in here because that is in terms of food waste. So, now, if we think about the system boundary for this one, if we take the boundary as the restaurants wall if there a conventional restaurant or a McDonald restaurant, what is it really a fair kind of boundary and whether we are being unfair to something or the other that we needs to think about.

So, boundaries should cover same reality. So, they have the same function or the service

provided. So, now, for both McDonald as well as a conventional restaurant, we have to again choose a function and the functional unit remember we talked about that earlier. So, in terms of function of course, is to have the meal; now the functional unit we can say meal for 10 people, meal for 5 people, meal for 1 person something like that.

So, the average meal for a person for a month or for a day whatever we just we can choose that; and in that case say if you take the conventional restaurant which has to do some cleaning of reusable dishes, has to have a food preparation along with cooking, and then we will have food waste management. And for McDonald's we have we should include the aspects of centralised preparation, the proportion of centralised proportion preparation that is being done for this particular restaurant for serving that particular function. So, that is also important, it is to do that particular function we need to get that aspect cover over there. So, in terms of cooking again centralized preparation not only for preparation of say salads and other stuff or also for cooking, there is some centralized cooking done, there is a and then also we need to start of think about the packaging there is coming out from there.

So, we have to say we can take a function of serving the food, we can take a functional unit of say 30 hamburgers or 30 burgers or whatever is the most common food they sell, we can take that and compare between the two. So, again the boundaries must cover the same reality same function or the same services being provided, but you need to look at because situation may different in two restaurants or the two systems, I will should not say just the restaurant this is just an example of two different systems where the way the function is achieved is different because, but ultimately both are serving meal. So, that is, but the unit processes will be different in two different stuff. So, we need to be careful in terms of how to include those unit processes.

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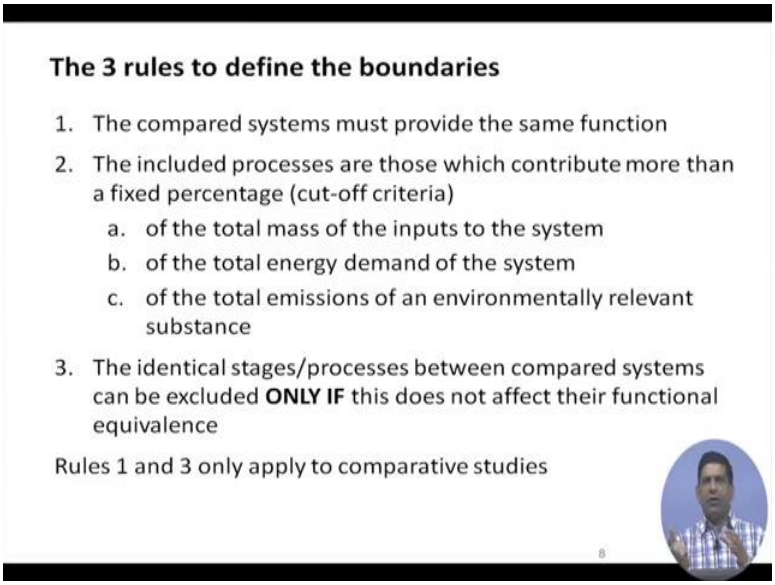

So, there are three rules to define the boundary; number one is the compared system must provide the same function. So, that is you it is provide the same function especially when we are say when we do the comparative studies, since most of this life cycle analysis is done comparative when you are trying to compare product a verses product b, or process a verses process b those kind of stuff. They included process are those which contribute more than a fixed percentage. So, there is a cut off criteria which we talked about earlier if you remember we said that more than 0.1 percent.

So, those processes are included which has some sort of a significant contribution, just to have a limit on number of processes included otherwise it gets too big of the total mass of the input to the system. So, that is of the total mass that is to the input to the system, the total energy demand of the system. So, we look at the total mass of the input total energy demand. So, we take a cut off criteria for that of the total emissions of an environmentally relevant substance. So, what are the total emissions coming out of that, so for that in all these criteria if the numbers are too small we can ignore that particular unit process?

Then the identically stage and process since identical stage and process will have the same impact on both the system and both the product, we can eliminate that. Again

because they have the since we are trying to compare the two if there is a certain aspect which is common in both a as well as b, we can take that certain aspect out because it will have the same impact, it will have the same unit of say CO2 emissions or whatever we are looking at. So, identically stages and process between the compared system can be excluded only if it does that does not affect their functional equivalents and I will give you another example of that letter on which will make it more clearer. So, if the function if they there they give the equivalent function even if we remove this particular process from both say product a and product b, but the function of that product does not change, we can take it off. So, again rule one and three applies only when we are doing a comparative study when we are comparing, but rule to apply even we are doing and a standalone LCA, both all the three rules applies in that case.

So, let us say in terms of. So, that is if you look at what we have looked about in terms of unit processes; we started with the unit processes in this particular video, and then we also talked about the system boundaries. There are unit processes there are unit processes could be linked to each other, again we have to be really careful in terms of what unit processes to include which some of them which is a very minimal impact can be excluded, unit processes which are common to two systems can be excluded, we have looked at cradle to grave, gate to grave or cradle to gate all the three kind of LCA scenarios. So, that is kind of and then we will continue to look at in terms of when you can especially the point three on the on this particular slide when we just looked at, with identical stage and process can be excluded. So, we will kind of look at the detail in the next video. So, I hope you are enjoying this again this is getting little bit of theoretical right now, but it just too kind of give you a big like understanding of the different components that goes into doing an LCA exercise.

So, I am trying to bring lot of examples through like some of the projects and the things that we have done. So, hopefully it will help you and keep learning from these videos and of course, if you have any questions feel free to put it on the discussion board, we will be happy to respond to any queries you have, our goal is to make you learn this life cycles. So, at the end of the course you should be able to do a life cycle analysis of any product or system on your own, that is our ultimate goal and let us work towards that goal.

Thank you.