Life Cycle Assessment
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Lecture - 25
LCA Interpretation

Hello, welcome back to the week fifth, this is the fifth week, and this is the last module of week five. And in this particular module, we will look at the LCA interpretation and we will also look at some of the ISO methods overview. So, if you remember, we started the LCA methodology few modules back, and then there we started with goal and scope definition, we looked at the function and functional unit, then we did the big LCI inventory lecture and then we also looked at the impact assessment. So, after doing all those steps, the last step as part of the LCA methodology is the interpretation.

So, in this particular module, we will look at the LCA interpretation, and then we also will go into ISO methods overview. Do not get confused, ISO methods overview when I say whatever we have done from goal and scope until this part in terms of impact assessment, what we will do in terms of interpretation, these all steps are as per ISO protocol. This when I say ISO method overview is I will just recap ISO methods and then give you some of the definitions which came from ISO just to get you familiarized with that ISO methods.

And again I will encourage you to download this ISO methodology document which is available if you as I said earlier you can go on Google and look at this ISO for 14040 for LCA. And you do not get the newest version newest version you will get only when you pay for it or if your library has an access for that. But you will get the old reversion which is not much different; it is for your learning purposes that should be fine. If you are doing a real LCA work for an industry or for a like a real project of course, you should buy the newest ISO methodology.

So, let us look at these slides for this particular module. We will start with LCA interpretation. So, when we say interpretation as the interpretation suggests we have to the information that we have collected so far. So, what information we have collected we looked at the goal and the scope then which has we selected a function functional unit for a particular function, then we did the LCI inventory and then we did the impact

assessment. For all these impact assessment, we had certain protocol and if you remember the protocols, we look at several of them and then recipe 2009 and impact 2002 plus that those two I suggested to be a good protocol to use for LCA impact assessment.

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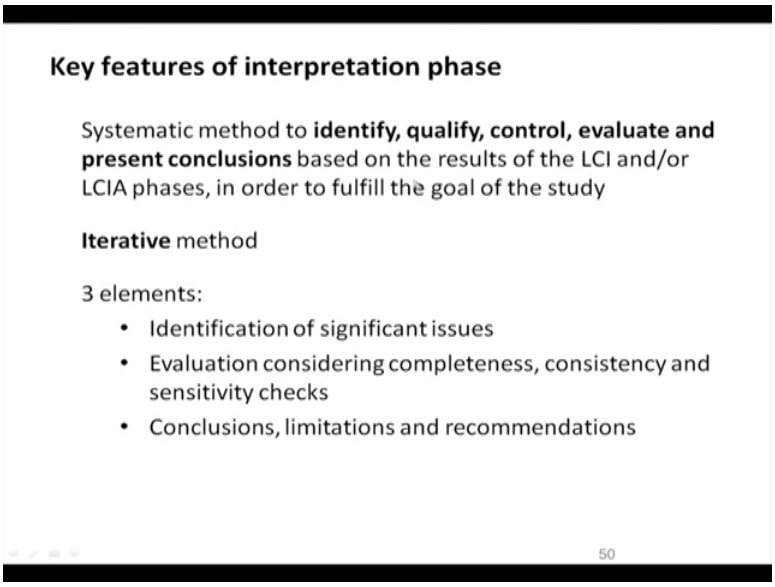

So, once you have the impact assessment information, we will go into the interpretation. So, in terms of interpretation, there are some key features of interpretation phase and we will look at some of these it is what is it, it is a systematic method, it is a systematic method to identify, qualify, control, evaluate and present conclusions. So, as the word interpretation suggest, we will have to interpret the data, interpret the information that we have collected. So, where the information we have collected, the information was based on the results of the LCI and or LCIA phases, so in order to fulfill the goal of the study.

So, again we started with a goal and a scope. So, to fulfill the goal and scope of the study, we did all the exercise in terms of the LCI inventory, LCIA in terms of the impact assessment and being done that now we are focused on how to interpret this information how what is how to make use of the information that we have collected. So that we can make either the process modification in terms of the better product or you can look for system modification, whatever is the interpretation whether the policy is going policy is going to help or we have to make certain changes in the policy. So, those kind of interpretation can be done and it is again it is an iterative method. When I say iterative

method means you would as you probably know from if you even if you do not know look at the dictionary for iteration in Oxford dictionary or whatever dictionary you have, iteration means you do it again and again. So, you do one round then you learn from it and then you may have to make certain changes, you may and then you do it again. So, it is a iterative method. And there are three elements three major elements there are other elements out there, but three major elements in terms of this interpretation phase.

One is we have to identify of significant issues. What are the significant issues that we have seen in terms of LCI inventory or LCIA - life cycle impact assessment, then we have to evaluate in terms of considering completeness, consistency and sensitivity checks. So, completeness means in terms of the data that we have collected is it a complete data is there certain data gaps which we did not have those data gaps how we will take care of those data gaps, so that is in terms of the completeness. Then the information has to be consistent, so that is the consistency.

Checks and sensitivity analysis which you have probably if you may have heard that term in other in mostly in environmental field and other fields as well. When we say sensitivity analysis is basically when you look at you have several parameters five parameters. For example, let us just stick with five parameters and then you look at say four parameters remains constant and then one parameter if I am change how the results changes. So, you can do that for each of the parameters keeping the other four constant and then you see that which one which parameter is more sensitive in terms of the result that we get, in terms of the impact assessment that you have found in terms of global warming, climate change, those acidification and all those different impact categories that we looked at.

So, once you do all the first two elements has taken care of then the third element is when you conclude. You will conclude the information that you collected you have to have you have to say there are certain limitations because any study when we did, there will be limitations data may not be complete. And there will be certain data which you calculated it was not a major data, it was not a primary data it was a secondary data. So, you have calculated the, you took the secondary data or you may have done some calculation based on theoretical formulation. So, those things, kind of gives us certain limitations of this study. So, we will talk about those.

And then ultimately finally, what we want we want some recommendation what because this whole exercise if you do not recommend something then that whole exercise does not mean anything. Because it has to be recommended in terms of say of you are doing a comparative LCA between product A versus product B or process A versus process B, you recommendation would be let the process A is better than process B or vice versa or whatever based on that you found. If you are doing a standalone LCA on a one particular product then your interpretation could be that your conclusion or sorry your recommendation could be that out of the several unit processes that goes into this particular product formulation, we can stick to say unit process C, D or whatever terms which has a biggest environmental footprint. So, we will try to reduce the environmental footprint of that particular process or which is in terms of the manufacturing of this particular product.

So, there are depending on the case by case basis, your recommendation will be different, but ultimately it is essentially means that you understand the impact assessment, first of all you do all the steps correctly goal scope function and functional unit, LCI inventory, impact assessment. And then you also realize the limitation as I said if you remember when we were looking at the benefits and drawbacks of an LCA, LCA is a modeling exercise. Any model those of you are familiar with environmental model or any model that you are trying to do, model has certain limitations, models are does not behave the way the natural environment will behave.

Natural environment usually has lot of complex stuff going on which it is very difficult to model even using mathematical equations or different techniques that we have. Our modeling techniques are getting better closer we can get to the natural environment better it is, but none of the model you will find which will hundred percent mimic the natural environment. So, there will be differentiation in there will be problems in terms of when we look at the model results and the natural results. So, natural means real life results. So, in terms of that that is also limitation. So, we need to kind of look at that aspect in picture. So, again this is a iterative method, you look at these three elements and you come up with a recommendation, then you based on what you found you may want to go back and look at interpretation again.

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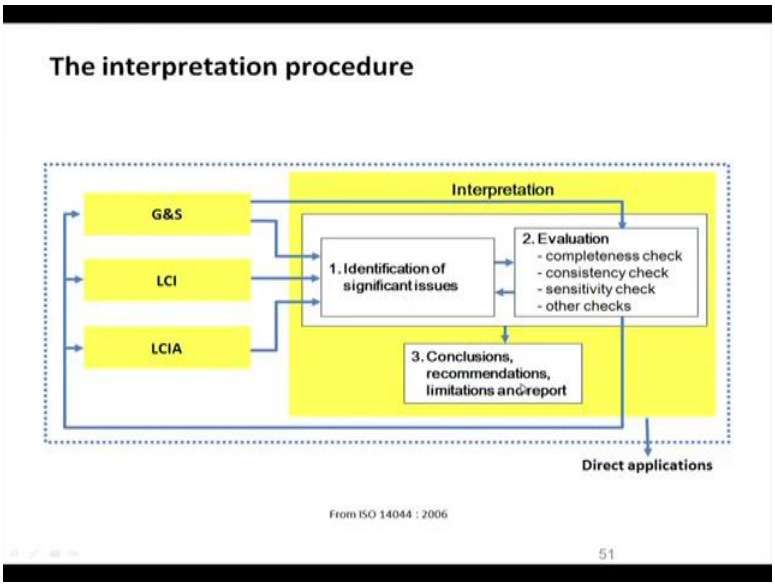

So, in terms of the interpretation procedure, so the here if you look at this three on the left hand side, we have the goal and scope, LCI, LCIA. So, once we complete these three exercise, we kind of go to interpretation phase which is the other right hand side you see the big yellow box; and within that we have certain white boxes in there. So, you take goal and scope information, LCI information and LCIA information, then you feed into your interpretation kind of steps and what you what you do you identify significant issues. Again this is a the same what you saw in the slide earlier, this is kind of a summary of that and it is from ISO document at 2006 document which was as I said is available online you can go through Google and try to find it.

So, it is identification of significant issues you try to identify, what are the significant issues out there in terms of goal and the scope, LCI, LCIA. Then you evaluate do completeness check; do your consistency check, sensitivity check or any other checks that is required. And you see the arrow is both sides, so based on this evaluation you may find some of the significant issues. Some of the significant issues you can find based on what you found in these three steps over here, but then when you are evaluating the final information that we have you may find some issues then you feed it back over here as well.

So, based on what you find in terms of your information, you come up with a conclusion, recommendation, limitations and report, so this is what you put it in there. In terms of

your evaluation that you did do in terms of completeness, consistency, sensitivity and other checks, you can feed this information back in your LCIA step, or LCI, step goal and scope step and so that is this is a kind of this will be the iteration going on. So, where you will feed this information back and then if you learn something new, you feed the new information in here again you do it couple of times to make yourself comfortable with that whichever. And then based on your final recommendation based on the whole exercise you go for the direct application.

And you will try to write it up in a simple language as much as possible, so that people are people get people understand. It should not be the direct application this conclusion, recommendation, limitations and that report there should be sections in there which is it is easy to understand for layman like as if it could somebody or something should be more nontechnical and then of course, you will have the technical information needed because the whole exercise acquaint with that. So, this is a interpretation procedure as per the ISO methodology.

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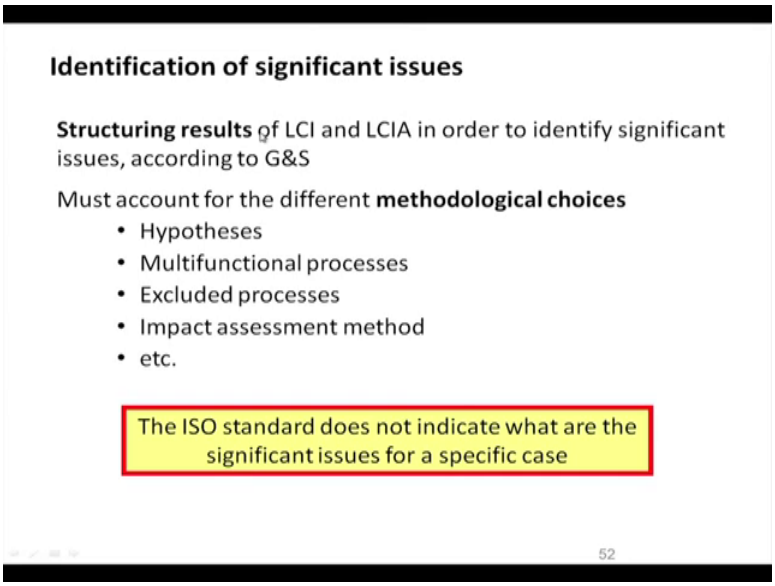

So, when we say identification of significant issues, let us you look at you try to structure results of LCI and LCIA life cycle inventory as well as the impact assessment in order to quantify significant issues including according to goal and scope. So, there are certain significant issues. So, here you must account for different methodological choices in terms of how will you go for like you have a hypotheses, and you try to see whether that

hypotheses is true or not. There are there are multifunctional processes. So, now how to when you have multifunctional processes, how you allocate your results to different functions and we look at some examples of how we can exclude certain processes especially if you are doing competitive LCA you can in fact, exclude certain processes if we have certain processes which does not have much environmental impact we can exclude those as well.

Then the this choice of impact assessment method the popular ones were recipe 2009 and impact 2002 plus, but there were several others as you saw in the previous module. So, there are in choice of impact assessment method we will also will have different results. So, those are also kind of needs to be taken care of and then there could be some other choices which we make. So, you need to look at in terms of issues associated with that.

So, ISO standard does not indicate what are the significant issues for a specific case for a specific case; and as a LCA practitioner or LCA professional, we will have to do that. ISO is just gives you a general overview because it cannot really do it, because it is for each and every LCA activity that is done it will have a unique set of issues associated with that that would be unit is which cannot be generalized. There are some general issues which we already kind of talked about in terms of look at your hypotheses look at the multifunctional, exclusion of certain process chosen choosing the method of impact assessment. So, those are generally stuff, but a specific stuff will depend from side to side and from case to case, so that is we need to look at more carefully.

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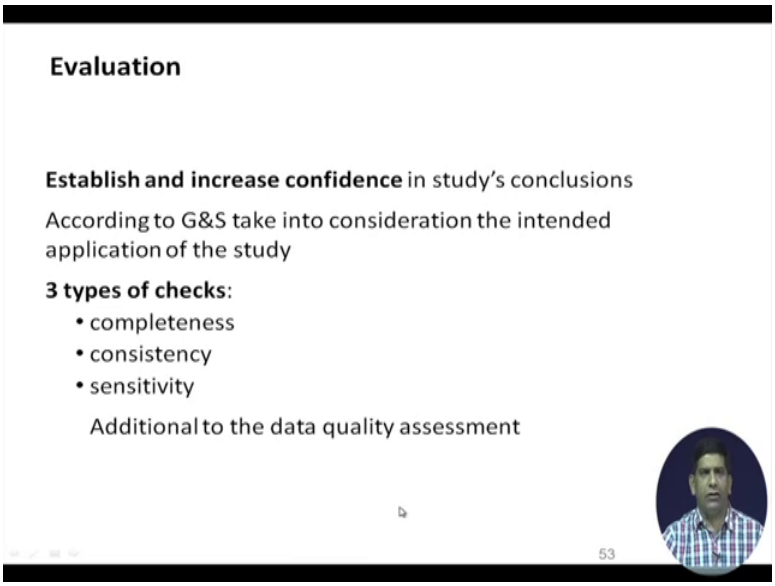

Evaluation, establishes increases confidence. We have to do three types of check that we talked about additional to the data quality assessment that this does not replace the data quality checks, which we talked about earlier. When you look at the quality assurance quality control you look at your replicates matrix spies, matrix spies duplicate and all that which we covered I think couple of weeks back in one of the module, so that would be there that is already there. But in addition to those you need also have to look at the completeness of data consistency of the data and sensitivity of the data. In terms of the completeness and consistency these are also part of q a q c, these are also part of the q a q c. So, when you do that you of course, do part of this already. Sensitivity is we normally not do it in a q a q c it is more like a it is basically to see how sensitive is certain parameters as opposed to other parameters for a particular scenario. So, according to goal and scope we look at we also look at the intended application of the study. So, if it is again how critical is this study that also is kind of we need to look at when we look at in terms of different types of checks associated with that.

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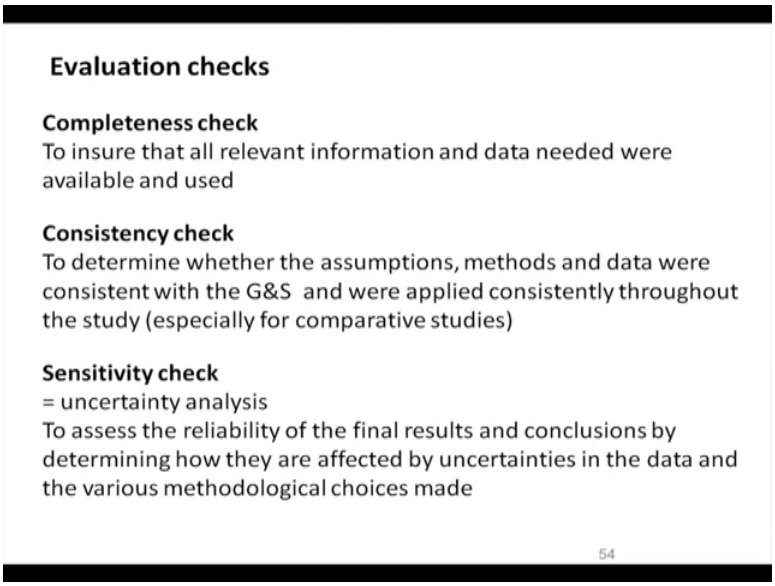

So, now what are these evaluation checks just to kind of go little bit further detail, so that you can because these things many times get little bit of little bit confusing when we say these, this is the completeness check, consistency check. So, what does what do they mean, so I thought I will just put few lines in one of those, so that it kind of gets you clear over there. Completeness means; that mean that all relevant information a data needed were available and used. So, whatever the information and data you wanted was available which in many cases will not be there. So, you will have to make certain assumptions you will have to make certain estimates.

So, you will make those whatever assumptions you made and whatever the gestimates you had to make you will list them and list them as a part of your limitations, because these were not available for you. And it is there is nothing wrong because you will if you kind of keep on waiting for getting each and every data needed to do an LCA exercise, probably especially if you use your PhD degree or like you are, so that will take forever. So, we have to get something done, learn from it and always we used to try to get improvement on that. But you do not anticipate that you will have all the data and all the information that is needed to do LCA when you start doing an LCA, 99.9 percent cases it will not be there unless you are just doing a lab based. Even in the lab based what there will be certain assumptions and estimates that you may have to make, so that is completeness.

Then consistency, so consistency check means you will determine whether the assumption methods and data were consistent with the goal and scope whatever was the goal and they are applied consistently throughout the study especially for competitive study. So, whatever assumption methods, and the data that we are used, they were consistent, and they were same kind of assumption, same kind of method same kind in terms of the data quality and all data quality checks you get, especially when we are trying to do comparative study. When you are say you are comparing product or some process and at the end of the day when you are interpret the results, you will say process x is better than process y or vice versa you have to be really careful that you both process x and y, product x and y were tested for their LCA activity on a similar scale or say similar yardsticks that would be a better word. You use a similar yardstick for both the process or both the product then only you can have a fair comparison.

So, as an LCA practitioner you need to be really careful you do not have some sort of biasness for one product versus the other, so that is why when we. When one when the product manufacturers do the LCA we are always little bit careful with their results we have to be really valuate their results in a minute detail, because there will be chances since they have their own benefits, so they are basically it is a conflict of interest. Say, if you have a LCA study done by if you are looking at one particular say I will again can go back to the cell phone, if you look at a Samsung cell phone or a Nokia cell phone Nokia is I think it is coming back now. But in terms of Samsung or any, any product we use a particular products, and then if the manufacturers have done the LCA study by themselves, then you need to be very careful to make sure that they have basically looked at all, they have followed the same methodology was they followed for the rivals product that they are comparing it with.

So, assumptions method data has to be consistent with the goal and scope. And they have to be applied consistently throughout the study, and it should be same for study A versus study B versus study say whatever different studies that you are going to compare together. So, then you have sensitivity check which we talked about a little bit it is a uncertainty analysis essentially to assess the reliability of the final results and conclusion by determining how they are affected by uncertainties in the data and the various methodological choices made.

So, here you usually what we do in terms of the sensitivity check is you keep if you have a five data like a data variable, you keep four constant and work with the fifth one and then try to change the conditions for fifth and see how the results get changed. And then we do it for all the different parameters, and to see which one actually came out to be more sensitive. So, since the reliability and how the reliability of the results in conclusion, so because all the data especially the data which shows lot of with a little change in the data you see change in final results and conclusion. So, for that particular data you need to make sure that the uncertainties in the data and the various methodology choices that were made were reasonable, and they were correct to the best of the knowledge and best of the available kind of tools and so that is where the sensitivity check comes in picture.

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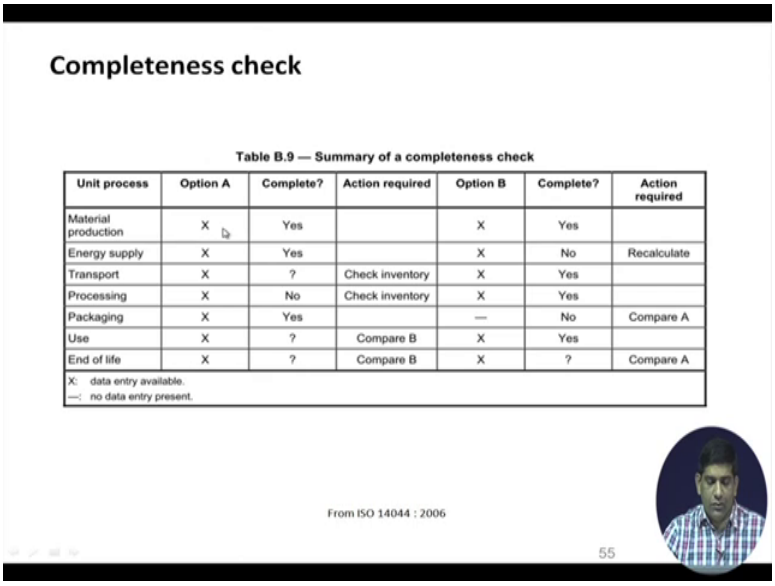

So, in terms of kind of when you do a completeness check you can use say table like this that is again coming from ISO document one example from there. So, you can somebody of a completeness check, how you do that you look at the say for example, different unit process here. Unit process has material production, energy supply, transport, processing, packaging use end of life. Now, you are comparing option A versus option B. Option A, x means the data entry is available, dash means the no data entry was present and of course, question mark means say it is a we are not sure. So, in terms of whether the data is complete or not.

So, in option A for unit process, so all for all these like material, energy supply, transport, processing, end of life you have the data entries available. Whether the data entry is complete you do the completeness check and you find that it is complete for material production, energy supply, not sure about transport, not complete about processing it is complete about packaging not sure about the use and end of life, so that is your use. And that is where the data is complete or not we need to we are not sure about that.

So, in terms of if it is not sure about this, you look at you check the inventory to see whether the inventory has all the data points. So, basically you know wait for the transportation based on your previous examples or you can look at some of the data from other sources where this transport data was collected, what kind of data is required in terms of the transportation and what data is available and what data is not available. So, you can check the inventory and try to find the data. And those data which is not available cannot be collected, you need to make some good estimate of that by using some theoretical or whatever information you have available.

Use and end of life because it says action is required because you have we have to compare the B, what B is doing. So, we need to kind of look at whether the data is available for B and then see whether we can compare and find out and. So, we can put the same in terms of the use and end of life, if it is a same product, we can put under same set of conditions for use and end of life to have fair comparison between the two. Same thing you can do for option B, here again material for all the data is available and other than packaging. So, packaging of the data is not available and if it is the similar product as product A, we use a similar we can compare with a like whatever is the information available for A we can use it for B, and do the comparison.

And again the completeness check can be done, wherever the completeness is not there in terms of energy supply it is not available or packaging it is not available. So, we can compare with the A part. For end of life the data was not sure, but in terms of whether it is a complete or not, it says compare with A, but here A it is also not available basically here you need to make some sort of estimate. We need to make some sort of decision based on some other works done for this or any other product. So, this is how you can go about doing a completeness check and this is again from ISO document. As I said earlier

we will be looking at this ISO document little bit more in detail, so that it gives you some idea about how different methodology which needs to be used.

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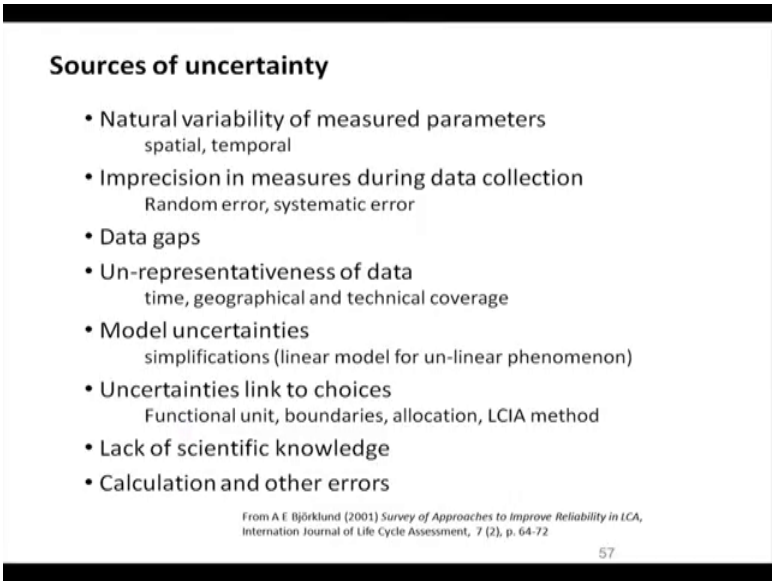

So, in terms of we if we look at the earlier we talked about there will be some uncertainty coming in. So, what is the sources of these uncertainties there are some natural variability of the measured parameters because the parameters were measured in a different settings, different lab, different people, so there are some variability will definitely come there. And there will be some variability in terms of the temporal. So, some data collected today, some data collected two years ago, different analytical instruments. So, this different type of lab settings, so that is you have some variability coming in from there.

There could be imprecision in measurement doing data collection. What is the imprecation imprecision means random error? Say for example, you are working in the lab and you are working with like a micro puppeteer, those of you are familiar with micro puppeteer, you are basically using it to drop have a drop of like one micrograms or two micrograms or three whatever at a microgram level or very low ml level. And then your phone rang or somebody just yelled your name for something and your forgot that whether you have really dropped four drops over there or three drops over there, and then it becomes a like or in between since you stop your puppetting you cut some air bubbles in there. So, those kind of problems comes where, these are random error which

will come in and whenever you are trying to do something manually we are not even the machines they are not 100 percent perfect in each of the scenario.

So, there will be some say if you are trying to add 1 ml of solution to something at one time you may end up adding 0.95 ml or other time you may add 1.05 ml, so because that is how the system is. And if you go for a machine, if it is a very good fancy machine which would be costly and mostly Japanese or German kind of a machine, it will give you 1, but again that it will not give you exactly 1.00000, but it would be 1.001, 1.004. So, which is essentially 1, but again there are some variability in there and that may if the data is sensitive if it is a sensitive information, so in that case, you will have sorry if it is a part of the sensitivity analysis if you find that this particular parameters is sensitive. So, even with a small fluctuation in data quality, you will see impact on results as well as the conclusion. So, those are some then there are some systematic error as well, they are like use lot of analytical instruments and other stuff. So, there will be some error which will come in there. There could be some data gaps data gaps means data is not available. So, what you can do if the data is not available you have to do some calculation for that.

Then unrepresentative, un-representativeness of data that means, time geographical and technical coverage and this is a very much relevant for a scenario like when we are trying to do something in Indian scenario or the scenario where we do not have the data collected. So, most of the data from these different databases that we looked at I showed you the world map where the different databases and different interpretation methods are coming from none were from this Indian sub continent of from India. So, what and even the databases are mostly from Western European countries some from US, US has some data, Canada is trying to have a database as well and. So, this equo invent database which is came out of Swiss - Switzerland, but is still trying to capture data from around the world. But it is still for most of the unit processes the data that we have in many of this database available in the market they are based on Western European countries or to certain extent US or like in other North American countries. So, that they do not have the data for Asian scenario, they have some, but it is still this is like a work in progress.

So, in that case what happens is you are it is a unrepresentative of data you have this data from western European countries from Germany or Denmark or wherever, and you are trying to use the data in Indian scenario, you and I know very well that scenario is way different. Because the way the industry is set up the way the labor is there labor in terms

of labor, we are more labor intensive; their processes are more machine intensive. So, there will be difference in the data that we get for this different, so that is your geographical problem.

Then technical coverage as well what kind of technology is being used for different data time in terms of when the data was collected, whether it is a new data, whether it was collected 4 years ago, 5 years ago and then because of the temporal variation your technology keeps on changing. So, especially for some areas like electronics and other things keep on moving very fast, so those are unrepresentation of data that say will be an issue in terms of the uncertainty.

Model we are we must know in times we make a linear model, we simplify the model just for our life. So, when you try to make something linear which essentially is not linear. So, you will of course, have some uncertainties coming in. So, and uncertainty linked to choices what kind of functional unit choice we make what kind of system. Boundary choice we make allocation of different functional unit LCI a method choice. So, these are all leads to some uncertainty.

So, many times we have lack of scientific knowledge we do not really know in terms of that that is certain processes exactly what is going on, but in that case we there will be some uncertainty from there as well, certain emissions or certain things will not get captured. Then calculation and other errors, there could be some calculation errors or other errors. So, these are some of the sources of uncertainty just to give you example and these came from a paper which was published in 2001 which is listed at the bottom. So, they had this information in terms of different stuff.

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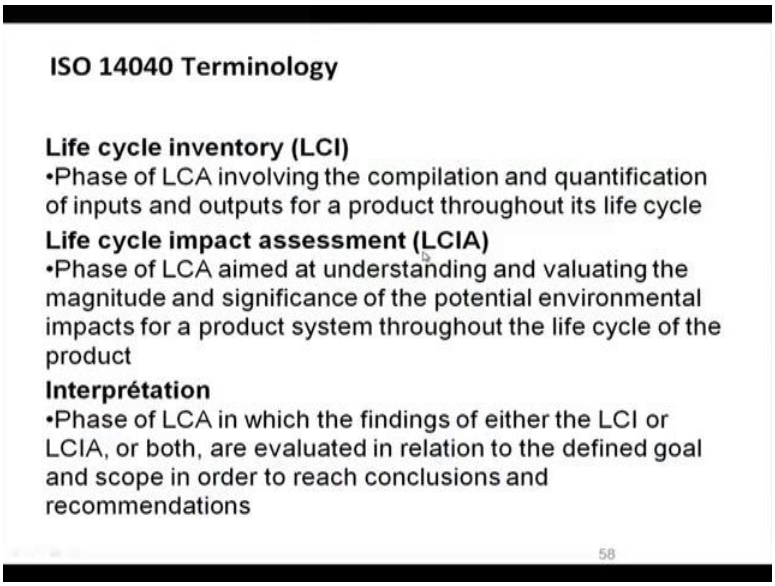

So, that is if you think about we have so far looked at how to interpret the LCI information, LCIA information, we talked about steps that goes into LCIA, sorry in terms of interpretation we also talked about the things are interrelated. So, many times when you interpret the information, you will decide that there are it really we are I am not reaching my goal, so I may have to refine the goal and change the goal. So, you go back and change the goal and scope and that will lead to changes in your function and function should be probably the same, but the functional unit you may want to change then LCIA needs to change, LCI will change and that will of course, LCIA will change and your interpretation will change. So, there could be certain interpretation associated with that.

And then we started looking at some of these specific when we talk about data in terms of uncertainty of the data your that we kind of look at completeness of the data, consistency check of the data, sensitivity check of the data in part of the evaluation and identification of the issues. So, how to do the completeness check we are again looked at this particular table this is again coming from ISO standard.

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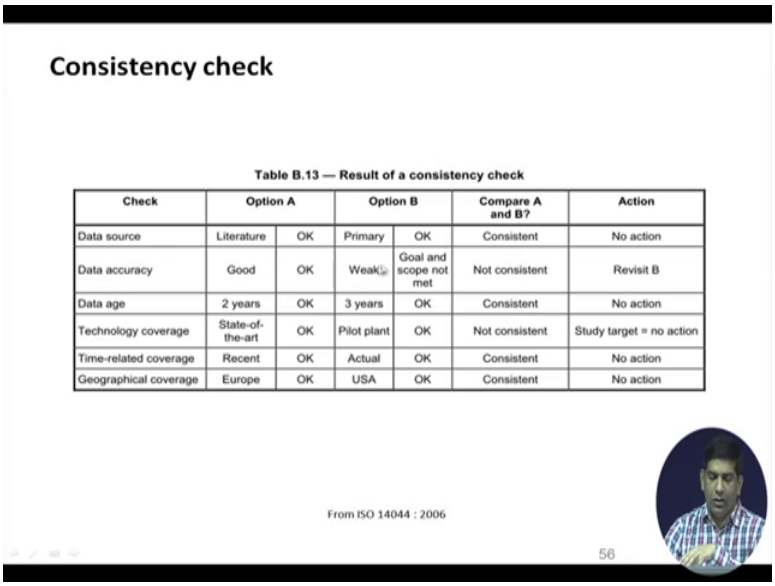

Check	Option A		Option B		Compare A and B?	Action
Data source	Literature	OK	Primary	OK	Consistent	No action
Data accuracy	Good	OK	Weak	Goal and scope not met	Not consistent	Revisit B
Data age	2 years	OK	3 years	OK	Consistent	No action
Technology coverage	State-of-the-art	OK	Pilot plant	OK	Not consistent	Study target = no action
Time-related coverage	Recent	OK	Actual	OK	Consistent	No action
Geographical coverage	Europe	OK	USA	OK	Consistent	No action

Then we can do similarly for consistency check, inter we can do completeness check as well as the consistency check. Consistency in terms of whether the data is coming from what is the data source, whether it is a primary data or from the secondary data and then compare A and B whether the primary and literature data is same if it is not it is a what is this not consistent. So, you may have to revisit. So, those things needs to be done in terms of the consistency check then we do look at sources of uncertainties, so that is what we have kind of covered in this particular module. So, we if you have already kind of did coverage of the entire ISO method sorry LCA methodology for any product or process including that for including when we do the interpretation of the results.

So, with that, we will try to kind of wrap up this particular module. So, I hope that with this you have a very good idea now how LCA is done, what are the different steps associated with LCA, and what are the things we need to be careful in terms of each and every step. So, next we will as I said earlier in this module, so in the next module, we will look at some of this ISO terminology, just to give you some ISO terminology and then we will carry forward into some other discussion including what are the key points of a good LCA, which would be there as well. So, thank you and keep watching and I will see you again in the next module.