Life Cycle Assessment
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Lecture - 27
Key Points of a Good LCA and Example LCA

As I said towards the end of the previous module we will look at key points of a good LCA. And I will go through this relatively quick, because I think we have covered enough material in terms of the LCA methodology. And to the discussion of each of those slides and different modules I have tried to give you a good idea about what should be goes into the good LCA exercise.

But again just a quick recap: this few slides you can use as a resource when you are trying to do some LCA activity. So, that was one of the reason what is that is also one of the motivation why to put these slides over there which you can whenever you are doing an LCA activity you can look at this slides and you kind of checks for each one of those. So, let us look at one by one.

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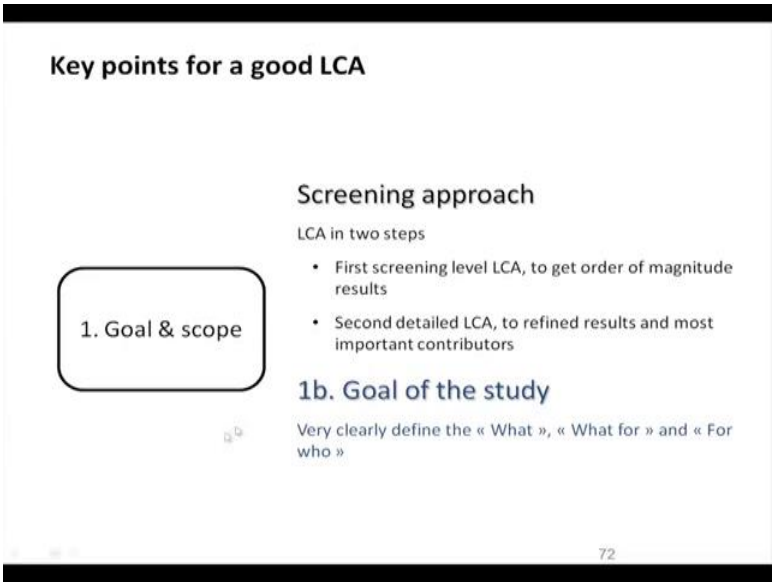

So, in terms of the key points for a good life cycle assessment exercise; first thing is as we as you know you have to have a screening approach. When we start with goal and scope that is our number 1. So, screening approach; if you remember in the beginning we said that when we do this LCA we do sometimes we do like we do in two steps, and the

first step we will do a screening level LCA and to get the order of magnitude results. There we do not go into nativity detail; we just do a screening level LCA. And what does that does it helps us to find out which are the processes which are having the bigger impact. And then we focus in the second detailed LCA we refine the results and focus on the most attributed contributors. The stuff does not contribute much we can ignore that, because as I said earlier, as you have seen earlier in terms of the inventory analysis, in terms of the different unit processes things can go like in big big big big tables. So, to avoid having so much of data to deal with we try to pick the data. And then what happens when we are looking at too much data, sometimes the important data gets ignored.

So, we are trying to focus on the important data for which we can get the results. So, that is a screening approach then you go for the goals of the study. We already talked about that goal is very clearly defined what for and for who.

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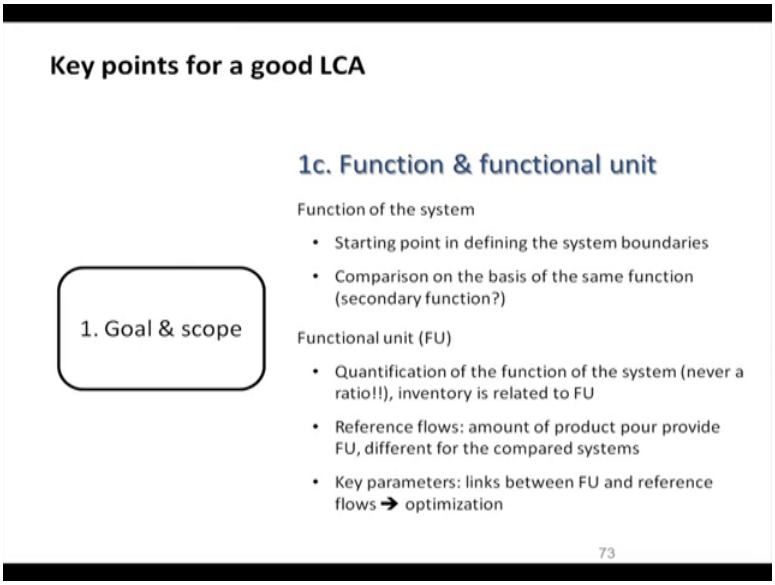

So, that is the goal of the study we looked at, then we found of the function and functional unit. You starting point of defining the system boundary, you have to have the function. And the comparison is the basis of the same function. Secondary function we have so far not got into that will; secondary functions for some initial LCA I would say you can just ignore the secondary function unless the secondary function is also

predominant as very close to the primary function then of course you have to do the allocation. But for most part for now let us just focus on the primary function part.

So, starting point in defining the system boundary we can do the comparison. Functional unit is the quantification of the function of the system, it is never a ratio it is a quantification of the function of the system. Inventory is related to functional unit, so we have the inventory we made the inventory related to functional unit you saw that example. Then we have the reference flow, we talked about that that is a amount of product provide per functional unit different compared system. Then we looked at the parameters in terms of the functional unit reference flow those optimization and all that.

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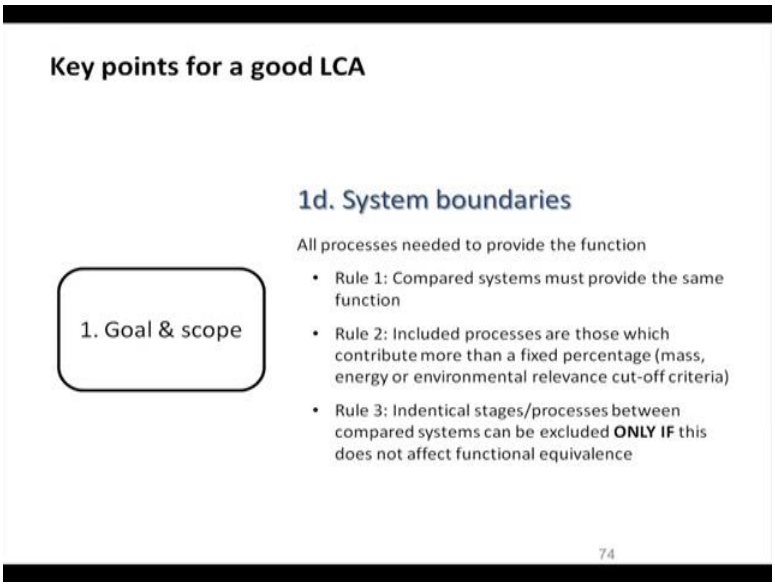

System boundary all process needs to provide the function. So, rule one is you compared system must provide the same function. So, when we look at the compared systems they should have the same function. And then you include the processes or those which contribute more than a fixed percentage; we talked about that 0.07 percent or something like that in one of the initial slides we had that. So, if it is more than a fixed percentage in terms of the mass energy or environmental release cut off criteria then we include it otherwise we do not include it, otherwise it gets too long.

And if there are identical stages processes between the compared systems we can exclude it only if it does not affect the functional equivalence. We talked about that remember that herbicide example; that herbicide a versus herbicide b. And we talked

about this particular case in much much detail. If you do not remember go back and look at that particular module that would be I think week 5 one of the first few module; first or second module I do not remember right now, but it was there in herbicide a versus herbicide b when we did that comparison. We can take a identical stage of processes of only if it does not affect the functional equivalence.

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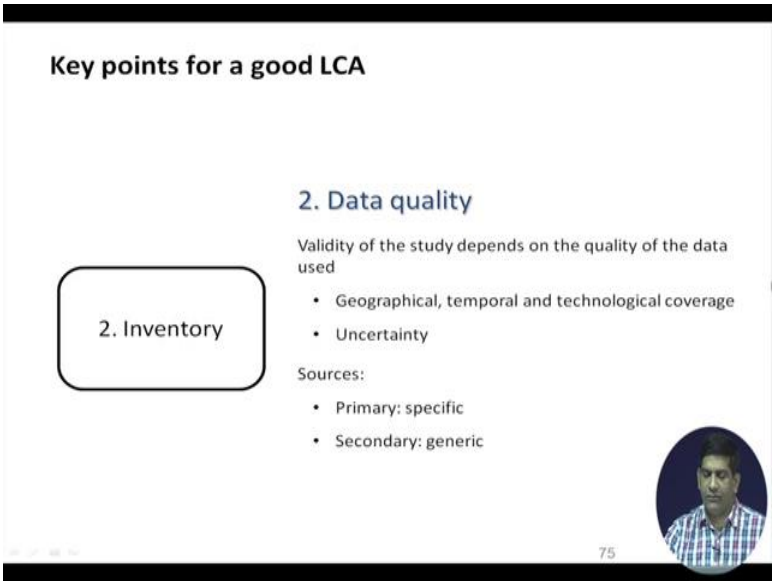

Data quality: we already talked about a lot about that, validity of the study depends on quality of data you have to have geographical, temporal, technological uncertainty, primary data, secondary data, so those things are important.

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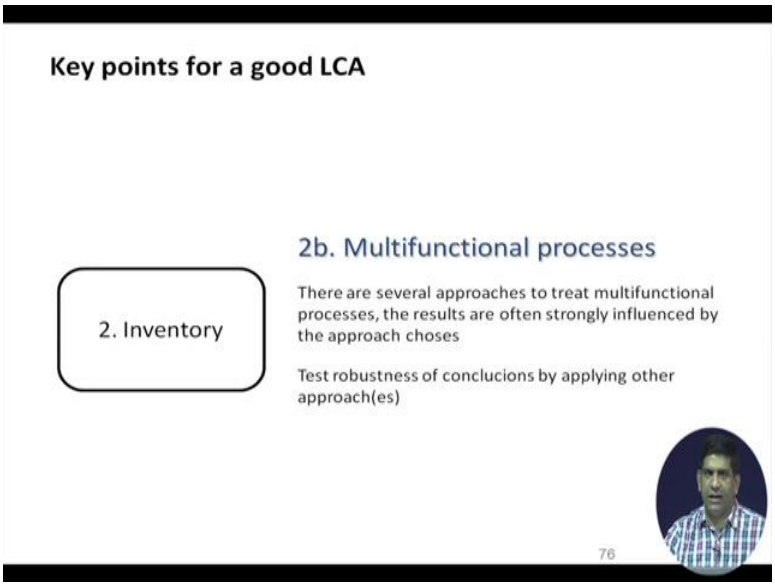

Multifunctional process: there are several approach to treat multifunctional process. The results are often strongly influenced by the approach chose. So, here you try to basically you have to do the location of different emissions as well as input as well as output for this multifunctional process.

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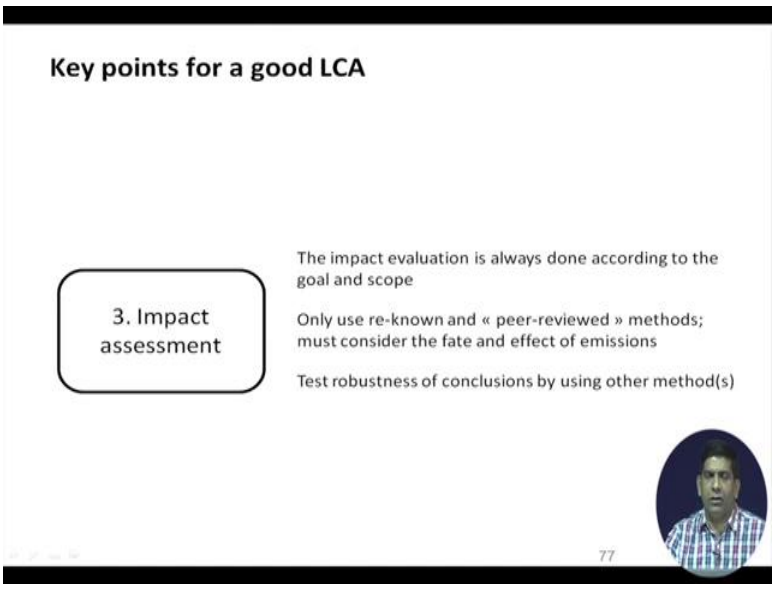

So, you check, do one approach and then you test the robustness of the conclusion by applying other approaches to see which approach, how the approach based on different approaches, how the conclusion changes. After you are done with inventory you go for

impact assessment. And it is done based on the goal and scope. Again there are different methods out there, we only use known and peer reviewed methods.

Right now impact 2002 plus and recipe 2009 those are the important, those are more common impact assessment method which is used you can use other methods as well, but then you should justify why which method you are using and what is the rational of using that particular method.

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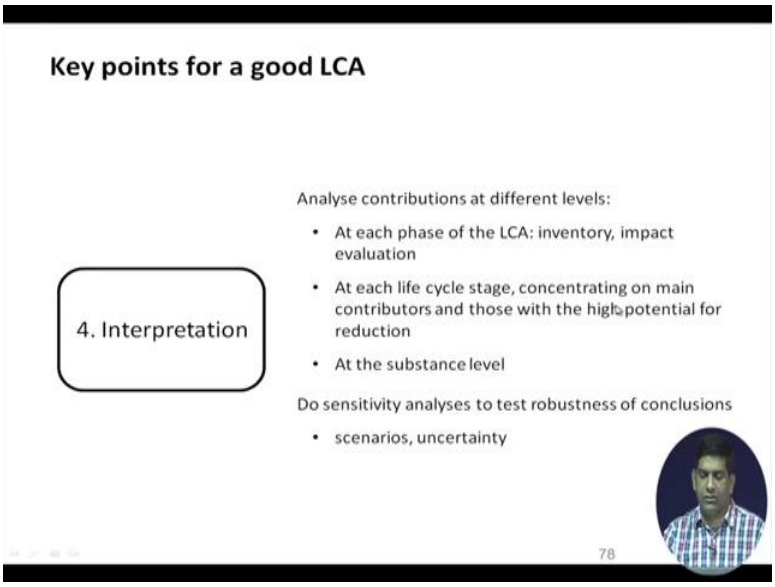

And then you many times you said try to compare one method versus the other in terms of that gives you the robustness of the conclusion as well. Then finally, interpretation we should look at analyzed contribution at different level, at each phase of LCA inventory impact evaluation, each life stage concentrative on main contributions and those with high potential at the substance level, do the sensitivity analysis to find out your stuff.

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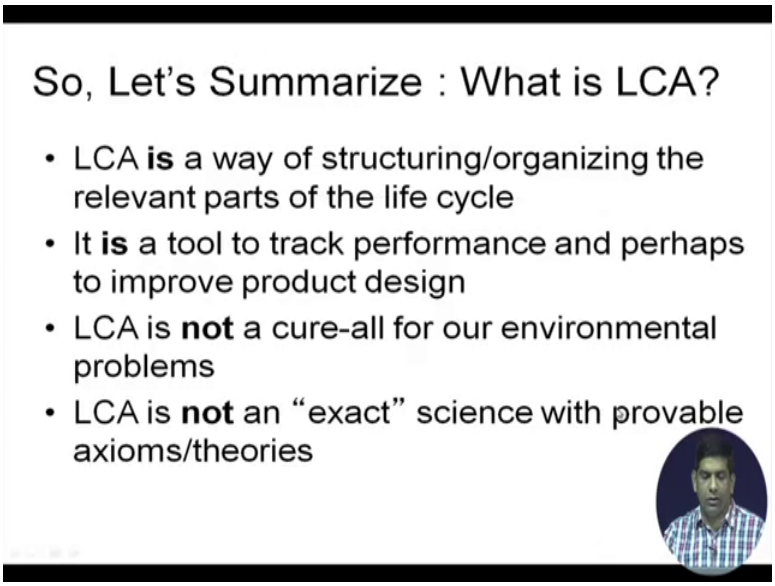

So, that is in terms of what was; like we can get summarize of I guess very quick summary few slides and that is in terms of key points of a good LCA. Again those slides could be a handy document for you later on, where you can whenever you do an LCA exercise you can go and check whether you are doing it correctly or not. So, that is to give you some idea and a kind of a ready reference.

So, in terms of LCA methodology or what is an LCA in terms of if you trying to summarize that although we are not at the end of the course yet, but we are in the sixth week, but whatever we have kind of covered so far if you it is always better to kind of in my view I like look; we always try to once we covered some detail it is always a good idea to kind of sit back and try to see the big picture. And then you go back and look at more detail that is, but do not forget the big picture because that is what its very very important. Many times what happens is especially those of you a masters of PhD student you get so much engrossed in your individual experiments as part of your thesis or part of the research project you do not really many times in the interview, in the your exams or presentations when we ask you the big picture questions you are not able to answer that.

Big picture means whatever research you are doing why you are doing that research. What new things you will learn from your research which will help your community. See most of you who are doing research projects in India or Abroad, wherever you are doing

it this research funding is coming from tax payers money. So, this tax payer people like you and I who are paying taxes or your parents or whoever is those pay taxes tax money is coming back to you as a research project. That is what funding for your masters stipend or a PhD stipend or your PhD DST project, DBT project whatever MOEF project that you might be working on.

So, you need to understand that whatever research you are doing should have some sort of benefit to the society, because the society is paying for it. So, you should not forget that. Especially for engineers I would say that since we are for engineers its true for anybody, but for engineers we should also basic science we have to do, but at the same time we have to show that how this basic science whatever we are developing is going to be implemented in the real field, and what changes this will bring.

So, what was not there which will be added by my PhD work or by my like a master's thesis work. So, you should always look at the big picture which students tend to forget and they get so much engrossed into the details in the mechanisms of certain equations, certain reactions, certain things happening; where those are very very important I am not saying those are not important those are important, because understanding of those is very very important. But at the same time why we are doing it, what we are going to get out of this and what benefit it will bring to the society which is not there, what new things we learn from this particular research project. Those things you need to really think about. And those are important questions that you will have to answer in any whether in your PhD exam, master's exam, or even during your job interviews they will ask you those kinds of question.

So, in terms of looking at the big picture which I said is important to look at, so let us summarize what we have learnt in terms of the LCA so far. So, what is an LCA? It is a way of structuring and organizing the relevant parts of the life cycle. So, it is a life cycle cradle to grave, cradle to get to grave and get to get. So, there are different types of life cycle we can look at. So, it is a way of structuring and organizing the relevant parts. So, when we say structuring and organizing with different unit processes that goes into that particular exercise. And it is a tool, again it is a tool; it is a tool to track performance and perhaps to improve product design.

So, we can use this tool to track the performance; performance in terms of environmental footprint, in terms of the environmental performance we can track. And also help in improving the product design to make it more environmental friendly. LCA is not a cure all for all our environmental problems. So, again it is a tool which we can use to understand things better, to understand things from a system perspective, but that does not mean that if you do LCA and that is if you do not do the follow up study associated; follow up task associated with this whatever we learnt, whatever is the recommendation as part of the life cycle interpretation. And if that thing is not followed up things does not change that is not going to do any benefit.

So, it is not a cure all for all our environmental problems. So, that is we need to be really careful. Many times what happens anything new comes everybody will do LCA say if LCA come is getting popular in India now you will see that even outside globally. Many studies they are doing LCA they are doing an sometimes I hear that oh these days publishing papers in LCA is much easier. I do not agree with that working in this area for few years now, it is not easy we have to really do a good LCA exercise to get it published in a good journal. Of course, there are lot of I would say journals are out there these days publishing any paper is not a problem, there are some journals which will charge you certain money and pay publish that paper. But to publish in good quality paper does not matter whether you are doing LCA whether you are doing some other research good quality research is important.

Again, it is not a cure all just do the LCA exercise you publish this paper and then that is it that is put it in our c b, but that is not getting implemented anywhere. And it is not an exact science with provable axioms or theory, it is not an exact science, it is a essentially is an accounting exercise we are trying to look at all the emissions input and output, we are trying to look at the big picture environmental footprint of any product or any process that is what LCA helps us do it.

So, that is kind of summarize of all this. And then we will look at some of more detail as we make progress, as we like make further progress in this particular course. And towards the end of course we will again try to summarize and then you some of these things will come up come up for discussion too. So, if you as just now we finished looking at an LCA methodology, so let us look at an example of how LCA. This is a real

example this was a product project done by master student working with me couple of years back.

So, this particular product it is an EnerPax and I will explain you what this product is there. We are trying to do a LCA of EnerPax from cradle to gate. So, this is an example let us walk through this example so that you see how this goal and scope function and functional unit and other things were used over here.

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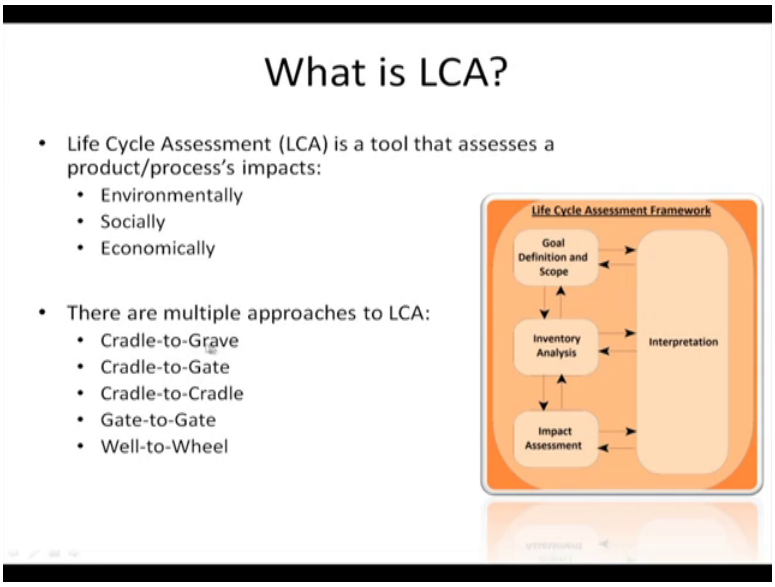

What is LCA you already know it, so we will kind of just skip that. There are multiple approaches to LCA you can do cradle to grave, cradle to gate, cradle to cradle; that is your whole life cycle, gate to gate well to wheel and we will talk about that later. So, it is a tool where you can look at the environmental, social, economical, but mostly we will focus on environmental aspect. And you already know about this life cycle assessment framework goal scope inventory impact and interpretation.

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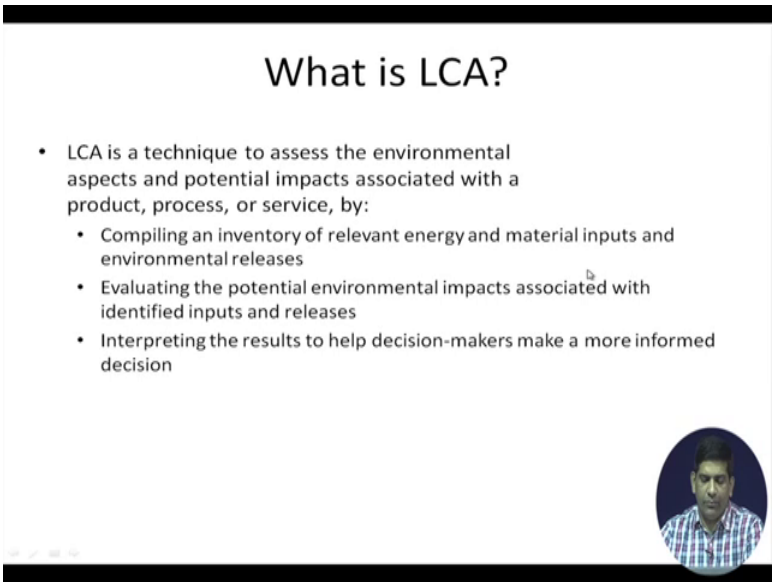

So, LCA is a technique to assess the environmental aspect, we already we compile inventory and relevant energy and material import. We will look at the potential environmental impact associated with inputs as well as release and interpret the data.

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So, we this project was done for a plant it is called a Dongara plant, that is a name of the company, it was just outskirts of like main Toronto area it is in Greater Toronto Area and it is in located in Vaughan which is in GTA Greater Toronto Area. And it processes

municipal solid waste from Greater Toronto Area and the regions of York, Durham and Peel.

So, when you say municipal solid waste in this particular area these are all areas of Ontario and South-West Ontario dominantly in that. So, they had most of this cities that have been listed over here they have three way collection system. When we say three way collection systems we are talking about municipal solid waste collection. So, they have recyclable collector separately wet waste going for a composting or anaerobic digestion wet waste food waste and other organic that is collected separately. And the third category is non-recyclables, non-compostables like non-biodegradable and I should not say bi because evens third category may have some biodegradable waste, but non compostable are going to anaerobic digestion non-recyclable that material is what this particular plant is processing.

And it is processing residential MSW as a Fitch talk to manufacture palletized fuel product. So, they are making some palletized fuel product and we did in LCA exercise, when I say we like my student actually did it under my supervision and we get those part of his masters work. And that is we made a full palletized fuel product to that came out of that.

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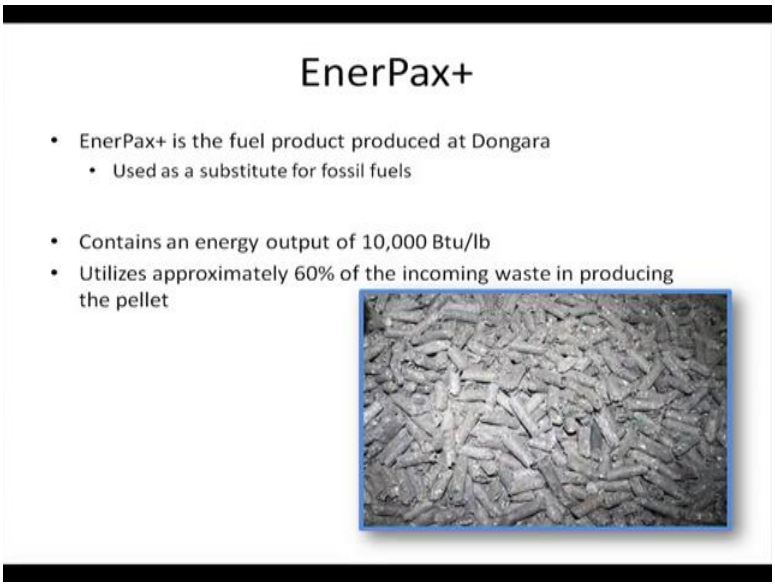

So, it is a fuel product produced in Dongara, you can see the picture over here this is how it looks like the smallest small pallets. And it contains an energy output of around 1000

Btu per palm. So, it is a lot, it is a good energy source. And around 60 percent of the incoming waste, since it is a non-recyclable non-biodegradable material; the material that we are coming to this Dongara plant not entire material had good calorific value. So, whatever goes in here should have a decent calorific value, then only you will have a good product.

So, that is a they had, but they should be they were able to utilize around 60 percent the rest 40 percent they were sending it to the waste energy plant which was nearby and either depending on whether the waste energy plant will take it or maybe it will go to the land fill which was so.

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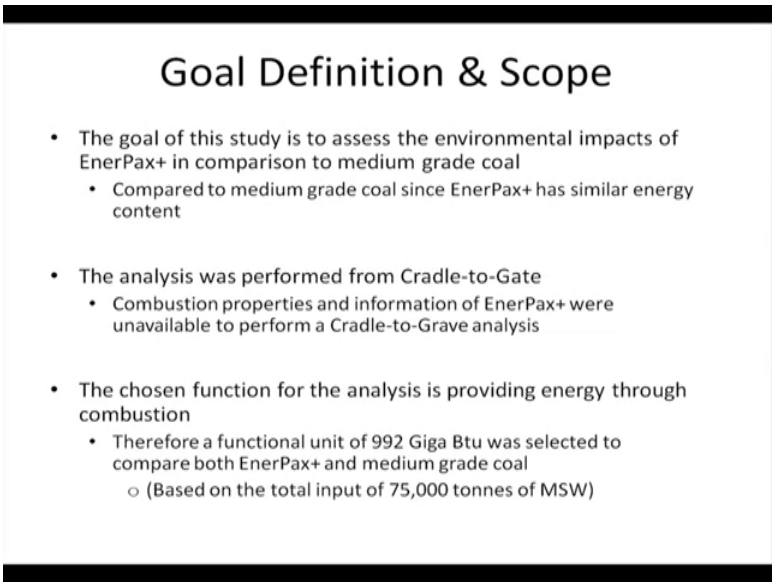

So what was the goal? Again the steps, so goal definition and scope: so the goal of this study was to see the environmental impact of this EnerPax in comparison of medium grade coal. Now here you need to understand the background behind this particular project. So, this was a project funded by this particular company and because this company wanted they were trying to apply to ministry of environment in Ontario to let their waste this particular product be used by coal based thermal power plant. So, these coal based thermal power plants were using this medium grade coal. So, that is why they wanted to compare with medium grade coal, because the medium grade coal is already used.

The reason this product is coming from waste, many countries around the world even the products making out of the waste material is considered almost as good as the waste material. So, unfortunately that is to certain extent is unfortunate, but that is how it is. So, there are the regulations in place right now. For example, if some when this particular project was done few years back and based on the regulation that was prevalent on that particular time in the province of Ontario in Canada what was there that if you have this product; if you are going to use these EnerPax pallets you are as good as a waste incinerateur. So, you and for waste incineration plant they have a stricter environmental control into stricter air pollution control system requirement as opposed to what is needed for like a coal based thermal power plant.

So, here we compare the medium grade coal, since EnerPax had similar energy content as well and that was being used in those coal based thermal power plant. The analysis will perform from cradle to gate. So, cradle was when this municipal solid waste coming that was to the plant. And to the gate once the EnerPax is going out in terms of plant as a product. So, the combustion property information of EnerPax was unable to perform cradle to grave analysis, so that is why we use cradle to gate. The chosen function for analysis is providing energy, is not it that is what both the cases we are providing energy through combustion.

Therefore, we choose a functional unit of 992 Giga Btu selected, and because that is get total input of around 75 tonnes of MSW. So, out of 75 tonnes of MSW we will get around 992 Giga Btu. So, that is what was chosen to compare both EnerPax as well as the medium grade core.

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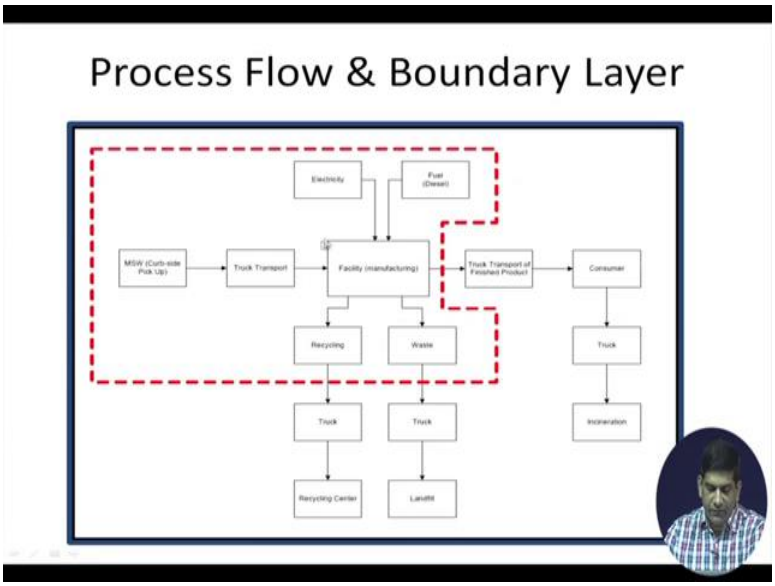

So, this was the process flow and the boundary layer. So, this is the MSW being picked in the cub side the truck transport goes to the facility in terms of the manufacturing. And there was some electricity, some fuel will come and then some recycling of the waste coming out, some of the waste will come out which will go to the land fill some of the recyclable can go again to the recycling center. And the product it goes to truck transport to consumer, and then we can go another truck to the incineration plant. So, these are. So, the red dotted line is what we have chosen for this process flow or the boundary layer for this particular hour stream.

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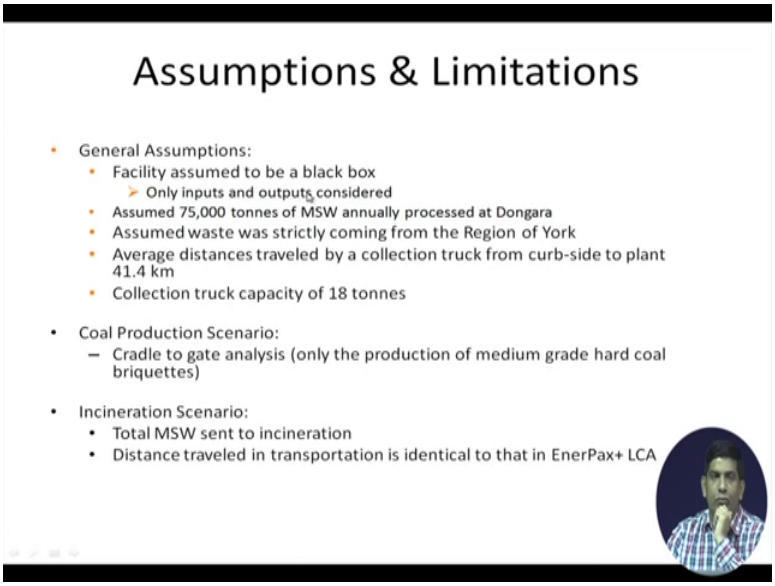

So, as I said there would be always certain assumptions and limitation. So, here the facility was assumed to be a black box, because only inputs and outputs considered. We did not had data for other details in terms of individual process like a material or energy input from individual process. So, we assume 75000 tonnes of MSW annually processed at Dongara. And then again assumed waste was strictly coming from region of York in terms of calculating the transportation requirement. Average distance travelled was 41.4 kilometer. Collection truck capacity is 18 tonnes.

So, think about that. You have to make certain assumption; we cannot really that is the nature of the exercise is such that you will have to make certain assumptions. And then if two different people are making different sets of assumptions results will be different, but then you need to make it more. As (Refer Time: 21:17) assumption you make you should have a strong basis for that. So, in that case it will be other people will have a if everybody follows that particular principle the assumptions will be similar.

So, coal production scenario like cradle to gate analysis for the coal as well, only the production of medium grade hard coal briquettes. So, here we assume the total MSW sent to incineration, distance travelled in transportation is identical to that in EnerPax plus LCA. So, we also looked at a incineration scenario that is part of that.

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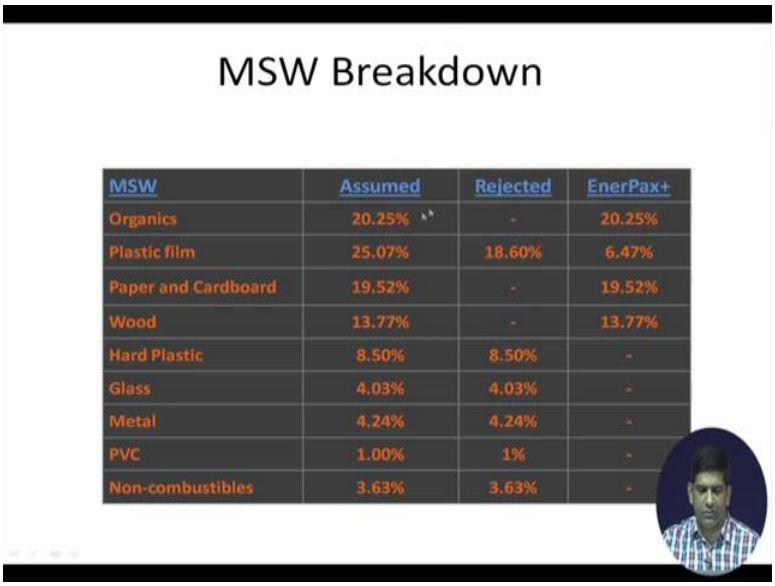

So, in terms of MSW breakdown these are the different percentages his organics plastic film, paper and cardboard, wood, hard plastic, glass metal, PVC, and non-combustible.

Although, it says this is what coming into the system and this was actually came from one of the study earlier done in terms of what is the percentages of the waste that comes in. And then out of that there are certain material gets rejected because it cannot be used and then list that is used in EnerPax the material and the other stuff which cannot be used it just goes off as a waste material either to recyclable. For example, glass, metal they can be recycle, even hard plastics, HDPE potentially be recycled. So but then EnerPax does not use that EnerPax only use part of these.

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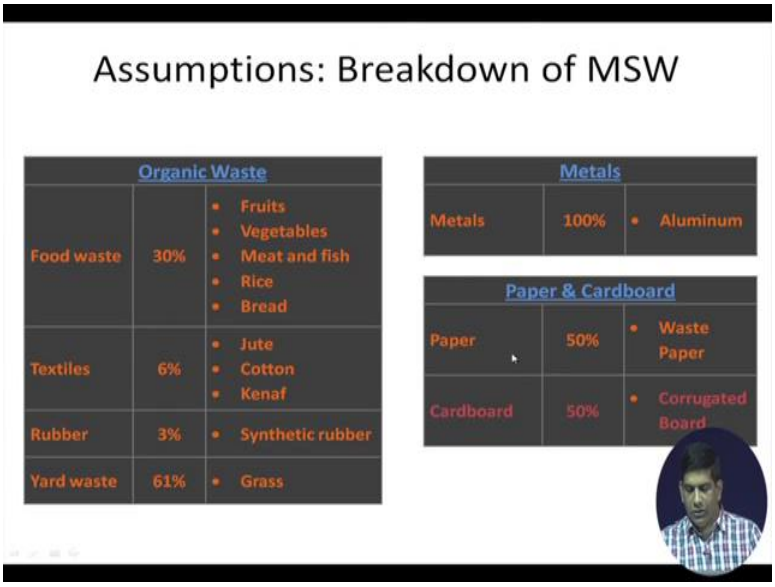

So, that is our; and what is there in the organic fraction of the waste we had some food waste stuff, textile, rubber, yard waste, some metals had aluminum paper and cardboard paper was there in terms of waste paper cardboard. So, those things were present in terms of what was there in terms of MSW breakdown.

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So, the rejected waste, plastic film, hard plastic some of this rejected waste could be recycled some will go into the land fill, so that is what. So, in terms of after doing this LCA exercise using EnerPax at Dongara, LCA scenario for coal, and LCA scenario for incineration.

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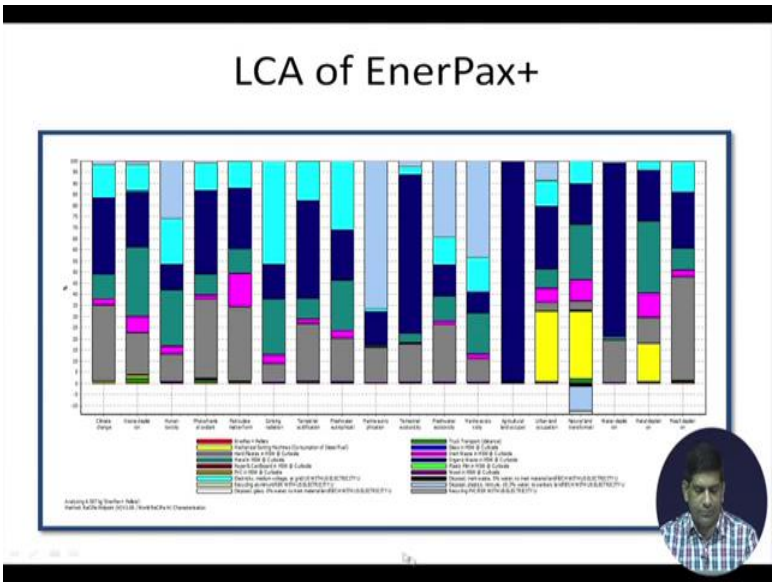

What we found and this kind of graph that you get from when you look at some of these data. Again coming from the SimaPro; SimaPro software this is what you get this kind of graph. So, here if you look at those categories; these again are as I said earlier will put will make 1 total comes out to be 100. And here you have different impact categories in terms of the climate change, ozone depletion, human toxicity, photochemical oxidation, particulate matter ionizing radiation, terrestrial acidification, fresh water marine terrestrial (Refer Time: 23:59). There are lot of others like fossil depletion, metal depletion, water depletion, all those things are there.

And these are some of stuff in terms of EnerPax per planet, mechanical shorting device, hard plastics in MSW, metals in MSW, so for different of the materials present you see those impact coming from the individual categories. So, if you look at the most predominant ones it is the truck transport, the truck transport is one of the main category that we see is a truck transport part. Again transport comes out to be the major contributed so in terms of the impact that is coming for all these different categories.

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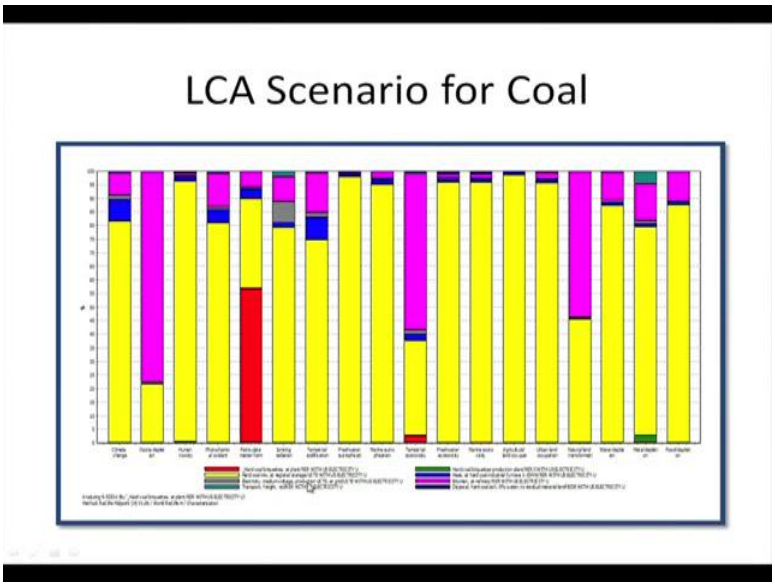

So, this was for EnerPax. Similarly if you go for the coal, again different activities associated with the coal. We have again the yellow which is our part coal mix that regional storage. So, that is comes out to be the dominating one. The pink one is the bitumen at refinery. So, those are because you need that for the transportation again for in terms of the coal production.

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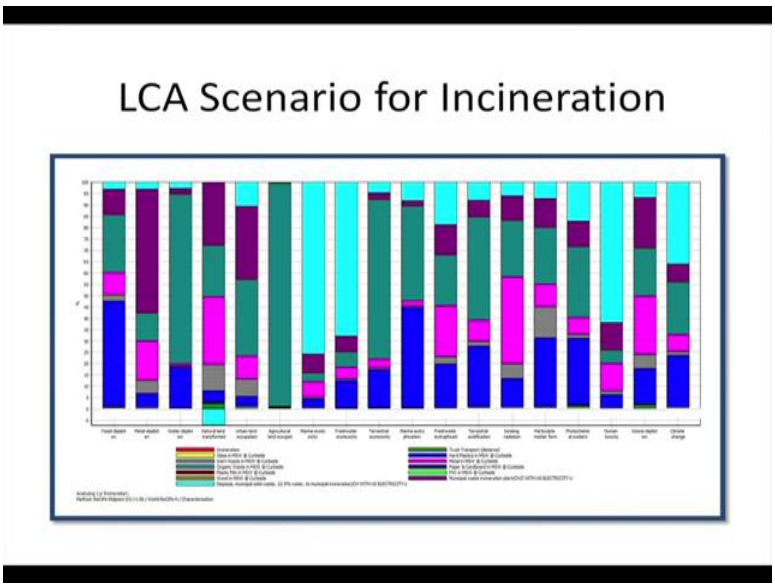

For incineration: here again we see our the light green colour seems to be dominating in many of them, it is our truck transport is very common that organic waste also its one of

the dominating criteria here. So, in terms of these are again different impact categories contributions towards different impact categories by different activities. So, that is what you are getting over there.

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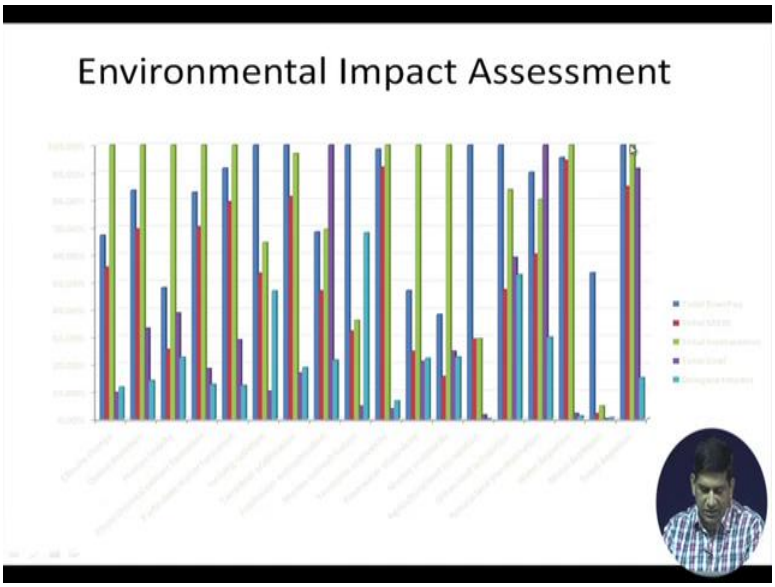

So, in terms of the environmental impact assessment if you look at the different criteria's we had I am sorry you cannot really probably read this slide very well, but I will just explain it. Again here for one here on the right hand side I have the legant for that, we have dark blue is the total EnerPax, the magenta colour is MSW, green is incineration, and then we have another like the purple is the total coal, and the light blue one which is the last column is the Dongara impact. So, that is in terms of what is the different impact coming in. And for the ones which has 100 percent we have; which has the highest one report them as 100 percent and the other values are with respect to those 100 percent. And at the bottom here are all the different impact categories, and here you see 0 to 100 percent.

So, if you look at these different categories the Dongara impact seems to be much low in terms of most of the impact categories. So, ones which is mostly high is the total incineration and in some cases we see total EnerPax is also pretty high as well. So, that is in terms of the environmental impact assessment.

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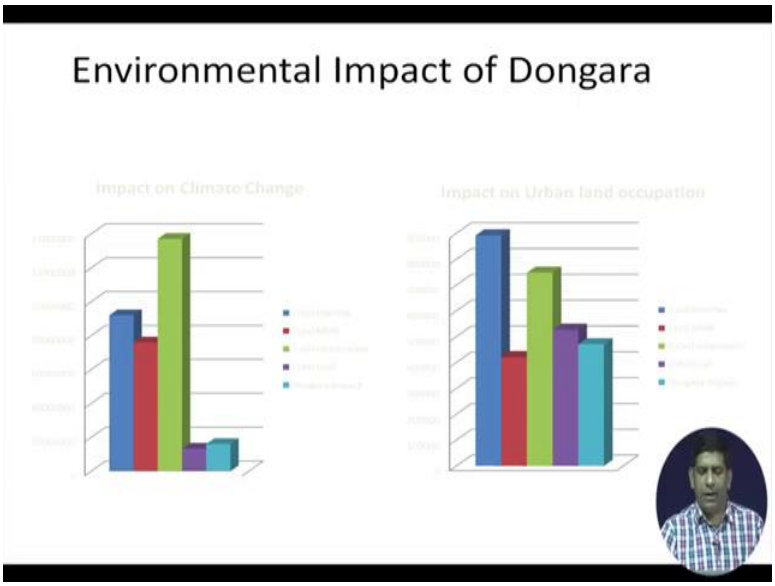

But if you look at the individually in terms of their impact; impact from climate change. So, incineration and coal is incineration is this part and we have Dongara is over here. Similarly, in terms of impact on urban land occupation again you see lot of impact on coming from other category as opposed to what we see from the Dongara.

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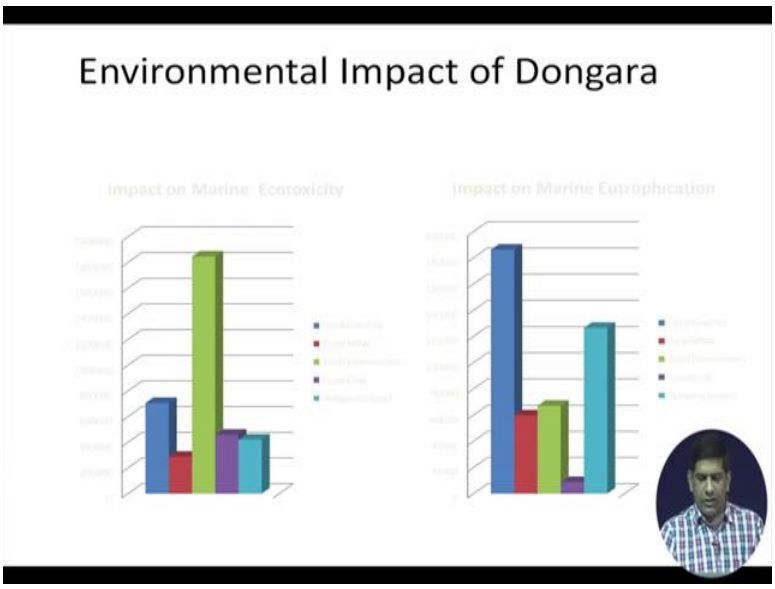

Impact on marine equitoxicity impact on marine eutrophication, so we can look at all these different impacts individually as well. So, what you saw in this particular graph over here was a combination of all different impacts together. Then in this these slides

we are looking at individually their impact. So, that is the individually how the impact is showing up. So, again for the different categories out there we can plot them up different categories.

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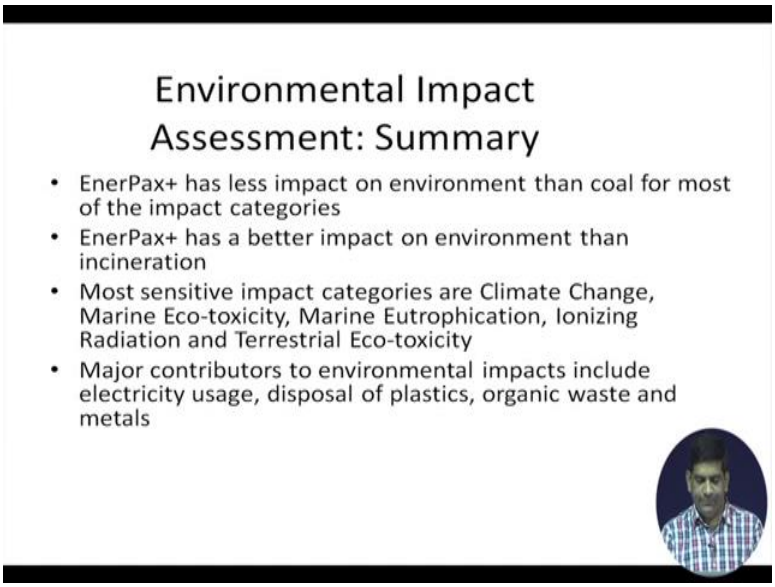

And, in terms of summary what we found at in this EnerPax the less impact on environment then coal or most of the impact categories, which was a better impact on environment then incineration. Most sensitive impact categories were climate change and the marine ecotoxicity marine, eutrophication, ionizing, radiation and terrestrial ecotoxicity. Major contribution where from electrical uses, disposal of plastics, organic waste and metal. So, these were the major contributed towards in terms of the environmental impact.

So, somehow we can come up with a better electricity uses, more electrical efficient technologies or if you can use better source of energy then our results will improve in terms of the environmental impact.

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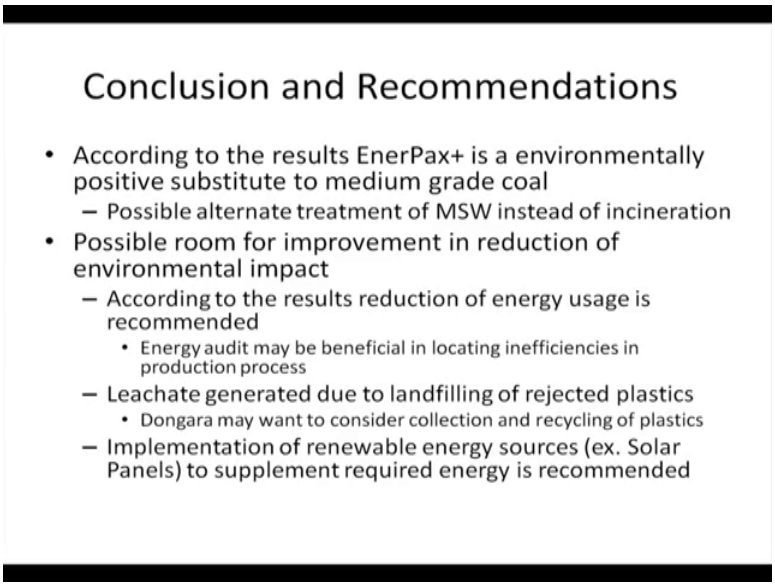

So, conclusions were EnerPax was found to be environmentally positive substitute for medium grade coal. Actually, it had a better it has lesser environmental footprint than medium grade coal and it is a possible alternative treatment of MSW instead of incineration. So, it even comes out better than the incineration plan. Of course, there are rule for improvement. So, according to the results we found the energy usage, reduction and energy usage if we can do that. Energy audit can be done to look at the inefficiency of the production process. So, that will be another thing can be done.

Leachate that is generated due to landfilling of rejected plastics, so Dongara may want to consider collection and recycle of plastic. If he can do the collection and recycling of plastic by the same plant that may help, because we do not have to send it to a long distance they can do it in the same campus within the same area. And if we can put some renewable energy sources like solar panel, so supplement the required energy this plant has a huge footprint. So, they can put some solar panels and then if you can use some of those solar panels for that.

So, that is kind of it is again give you an example of in terms of how this LCA activity is used in a practical sense. So, this was a practical problem where the company really wanted to do this LCA, so that they can took, they did take this results and presented it to m o ministry of environment and the student in myself were there with when we had the meeting with ministry of environment and then there were certain relaxations given to

the company. So, again if this is what you will do if you really want to use this LCA toward later on in your professional life this kind of scenarios will be where certain companies are trying to make some decision. And these LCA tools help them make the decision. Or there using this LCA tool to present their taste to a regulator the switch was the case over here. Where the regulator took the decision based on the data that was presented.

And since it was done at a university setting it was a master's thesis say university student and a faculty were involved they (Refer Time: 30:32) little bit of credibility to the steady in terms of non biasness and trying to have more independent study. So, that is an example. And then we will see lot of examples like this in the last week. Last week we will have lot of case studies associated with this on this LCA exercise.

So, with that we will close this particular module and then I will again see you in the next module.

Thank you.