**Sustainability Through Green Manufacturing Systems: An Applied Approach**

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**Lecture - 09**
**Life Cycle Assessment Elements**

Good morning. Welcome back to the course Sustainability through Green Manufacturing and Applied Approach. So in week three, we are covering Life Cycle Assessment. So, in the last lecture I talked about various definitions of various kind of approach is people think of life cycle assessment. Like people think life cycle analysis and certain other terms terminologies that are associated with this one, that were life cycles stages and life cycle costing then product life cycle, product life, product lifecycle management all those things.

Now today I will talk about life cycle elements a Elements of Life Cycle Assessment, right.

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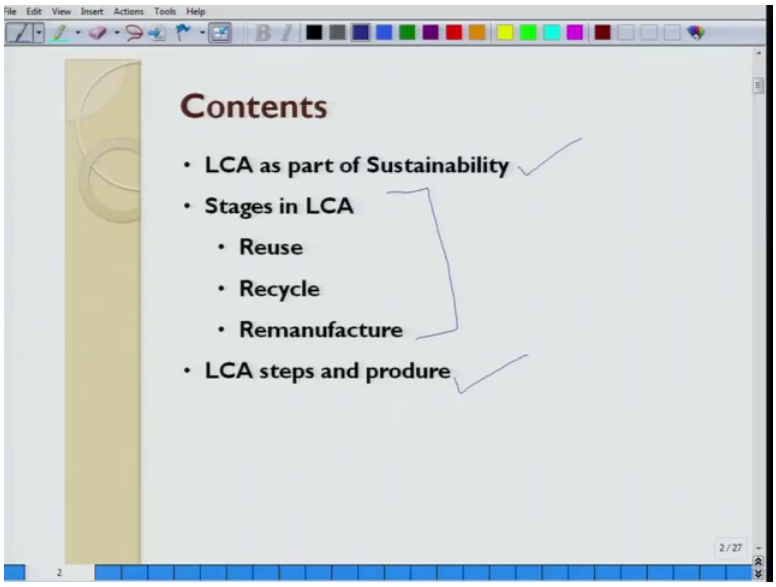


So, in this we will cover I will see as a part of sustainability. So, LCA is one of the tools to find final sustainable system right. So, what are other tools we will discuss later? So,

now, various stages in LCA would be discussed and steps how to conduct actual LCA life cycle assessment.

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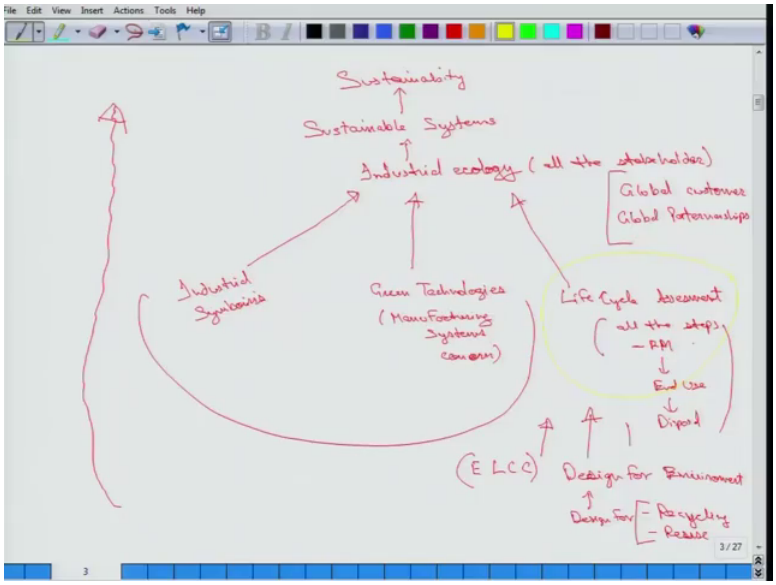


So, I will start here with co LCA is the related to sustainability. So, what I find here is we need to have a sustainable system right or may be sustainability, final sustainability through sustainable systems.

Now, sustainable systems would lead to sustainability; now and how these sustainable systems could be approach. If we look into the overall scenario for industry all the partners all the stakeholders need to participate in that. So, I put the term here industrial ecology right. Now that is industrial ecology all the stakeholders needs to be participated. So, in this case even the customer has to play very important role.

The customer does not have to be consider this own goals only, he has to be like think of like he is a global customer and global partnerships right. So, how could we get this industrial ecology? Like maybe industrial services symbiosis that is all in this working together to have a common kind of resource example in leather manufacturing industry in Kanpur, Kanpur is known as lather city of world.

So, we have a good number of lather manufacturing industries I would say we had that we had only a few a pioneer companies are working here now the companies are shifted to a neighboring state here now neighboring; neighboring cities only here. So, because

the pollution that was generated by lather industry was effecting the people, who are living around the gain river Ganges and wrong the banks of river Ganges and (Refer Time: 04:26) working together for a common goal like for they had a common effluent plant like 6 or 10 dries 6 to 10 dries would have a common effluent treatment plant and their create they will create the waste altogether.

And may in some industries people could use common resources or may be in if it is an industrial hub. If water is a common resource they can use a common pond for they use right that is industrial symbiosis then we have specifically in green manufacturing green technologies right. So, these green technologies are manufacturing concern manufacturing systems concern right. we will discuss about various green techniques or technologies some of those that could be used to improve our color right may we cannot go from black to green directly or if I say yes we can go one step ahead or maybe two step forward right.

So, another thing here is that we are talking now is life cycle assessment right, where in we consider all the steps that are involved from the very where in we consider all the steps starting from a raw material to end use and disposal we will discuss these in detail in this lecture only right. So, how could we obtain this life cycle assessment? So, this I will cover later. So, in this lecture we have more focus on life cycle assessment. So, what we have we have here designs for environment design for environment right.

Then we have life cycle costing and if I say life cycle costing that is the general life cycle costing which I covered in the last lecture taken example of purchasing of motorbike. Now I am more considered here about more bother here about environment thing. So, I will term here as environment life cycle costing ELCC right how environment comes into the play I will tell you right. So, a then design for environment involve design for recycling reuse right.

So, all the technical devices to production system to companies to economic sectors right all stakeholders participate into this to obtain this score right. So, what is life cycle assessment that we need to cover.

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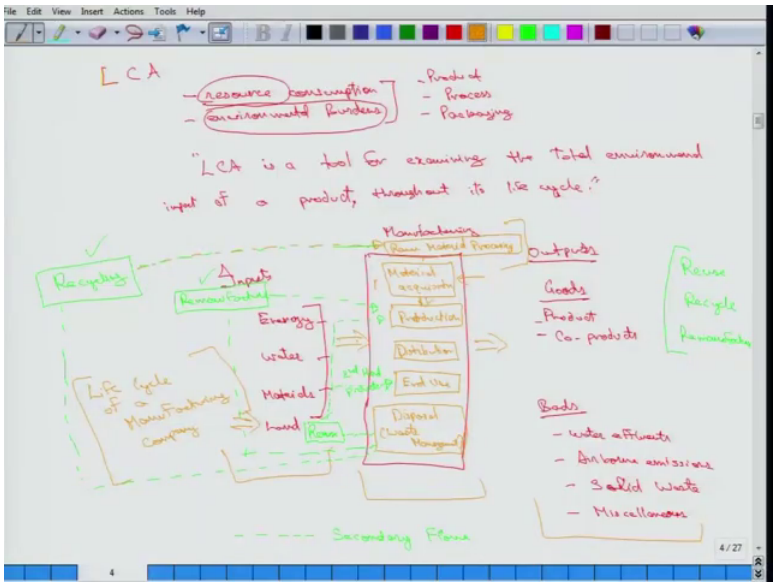


Now life cycle assessment LCA is an approach or is a I would say process to evaluate the resource consumption resource consumption and environmental burdens right which are associated with our product then process and packaging right or may be any activity like this, right.

So, LCA process the identification and quantification of energy and material uses that is resource consumption right and environmental releases across is all stages of occurs is all stages of life cycle; the assessment impact of these energy and material uses and releases to environment and the evaluation and implementation. So, life cycle assessment does an assessment of impact that all these stages regarding energy and material uses and releases to environment and evaluation and implementation of opportunities that affect the environment improvement needs to be there. So, I would like to say here that LCA is a tool for examining the total environmental impact of throughout its life cycle right.

That is from making in a factory then selling it in a store and uses it in a use it in in work place around at home and disposing it off right. So, what are elements of life cycle assessment here? So, elements of life cycle involve the inputs the processing and outputs at each stage we need to be aware we need to have assessment. So, what are elements here if you could recall, we had inputs that is energy water and materials I could put land here as well, but that is not always the case, but these resources are there in almost all the concerns then we have the process here manufacturing.

Where in we have material acquisition right, then is production or manufacturing then product distribution then and use of the product and disposal or I would right here in waste management. So, these are the inputs and we have outputs here outputs are what the goods and bads goods and maybe bads right goods are the product and sum co products, then we have bads here; bads here are water effluents, then airborne emissions and like all called of water air and solid waste right and maybe some miscellaneous waste right.

So, what does life cycle assessment tells us? While life cycle assessment needs assessment at all these stages all the data the embodied energy, the amount of water that is involved in here the materials is the material biodegradable is the material consumption low or high right than land is when I say land here, I would like to introduce a term life cycle of a manufacturing company. See when you see the manufacturing hubs you will find various companies those are closed there is a life cycle of a company as well from the very beginning like I will just took an example of the leather industry in Kanpur.

The companies those who acquired land and made the factory over there, now they are closed they need to shift to some other country because of some legal reasons and every company has a life cycle unless the industry or the factory keeps them updated with the forthcoming systems keep them re furnishing and to keep bringing the new technologies, it is very probable that it will vanish very soon. So, a very few com pioneer companies are left here in Kanpur like we have super tannery, like we companies those who manufacture world class manufacturing products. The companies those who manufacture a world class products like ractape bhugathi all these are manufactured in Kanpur only.

So, I will take an example of this in fourth coming lectures as well. So, what we have here is life cycle assessment I would like to put here terms like reuse the recycle and maybe remanufacture right. So, what is reuse? Reuse is like a I get a new car. So, I would like to change my car I like me after 5 years.

Now I will sell my car that would be (Refer Time: 17:19) used car used car in the like a the second hand car I will sell my car to the same company and get that replaced right they are basement offers available and another user who would like to spent a little less and would like to have an higher end car of the same kind what you would do for

example, a 8 lakh car if it is run for 5 years the replacement value like would talked in are life cycle costing the replacement value might be for 8 lakh or may be after 5 years 4 lakhs.

So, he can get that 4 lakhs car and reuse that this is one way of reuse customers keep on reuse things like a for example, also I have a fountain pen suppose a fountain pens I keep on refueling the ink in there. So, I am reusing that pen instead of use and throw things reusing the body component of the pen and just refilling the ink this is one way right another kind of reuse is the companies they take their product they use product or may be damaged or may not working product back like I will taken example of Ricoh here. Ricoh is a company that were manufactures stationary components or may be electronic equipment like printers then paper shredders and something like that.

So, what they do they take their product back from the customer, whenever the customer need to dispose at they some give them some disposable value right and they use some of the components in that. The plastics if it is a thermo plastic material they get it recycled and some of the gears that are made of out of composite materials they do not get deteriorate. So, they can reuse that in the new product, the metal parts also they can reuse which they it form that are good to go into a new product right or maybe they can use the components for repairing of and there after sale service for repairing of some other similar kind of products.

So, this is reuse. So, I will put. So, a reuse here that from disposal to end use. This end use customer this customer is changed here the customer I get for one was who was the first hand the market leaders which I have talked about in the product sales or may be in the product of customer who purchase the first hand on new product. Now in this case the end uses the customer who purchases like second hand products right and this reuse could also go into my production system like the example I just took right.

The next is remanufacture; I will put here remanufacture right remanufacture is from this disposal we go to manufacturing directly. So, when I say reuse, resue is using the components in the form they are like for example, some metallic components in the printers right and re manufacture is using the components by doing some processing on it for example, plastic could be could be recycled or some components might be some treatment or some kind of and may be in the like metal elements, the some of the

elements of the components some of the elements may be nuts and bolts may be some small screws need to be changed and they again put into their manufacturing that as well. So, that is re manufacture.

So, another thing that we can add here is, this is all coming from this disposal part that is recycling. So, this recycling would come into play when we include here in our process the raw material processing, as one of the comp one of the component of this body right. So, recycling would give you a new raw material for new not new, but recycled raw material that can be used. So, I put this raw material processing later here, I would like to say one thing in here that life cycle assessment may start from with a very extraction of material or maybe from the when we need factory we have considering of life cycle stages.

They only generally considered from the acquiring of material that is from purchasing from their supplier to end use this is what they consider where then it all depends from what kind of assessment you need to do you would like to do right. So, generally most of the concerns and most of companies takes into account the life cycle stages from this material acquisition only right material acquisition production. So, if I like read the flows here into primary and secondary.

So, this is my secondary flow in this green color, these are my secondary flow. So, this is my secondary flow and what is the primary flow of material? Primary flow of material is here flow material acquisition, to production, to distribution, to and use right.

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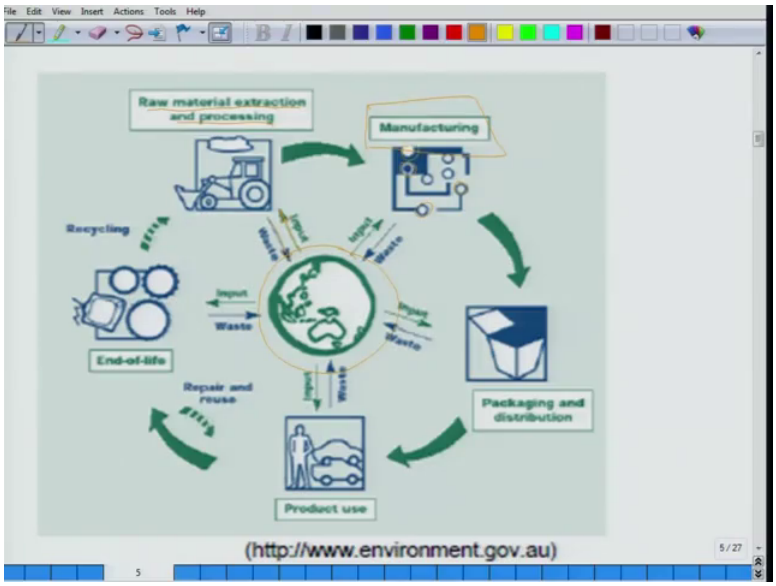


So, here I took a picture from a reference in that they have said this in mother nature is there, this mother nature has inputs into the system and waste is coming from the system right then we have raw material extraction and processing here from the very that part then manufacturing is there right in manufacturing we have all types of sections here in a factory right there are inputs and waste for coming out of fair yellow, then packaging and distribution is an important part here then and use by the customer.

Now, when customers think that end of life is there. So, he send it to end of life component here then sometimes the customers get it repaired and reuse that the thing and keep on re using the things were a longer time right. So, this end of life then repair and reuses there, then we have recycling of this components and the again go as a raw material into processing sessions these processing sessions.

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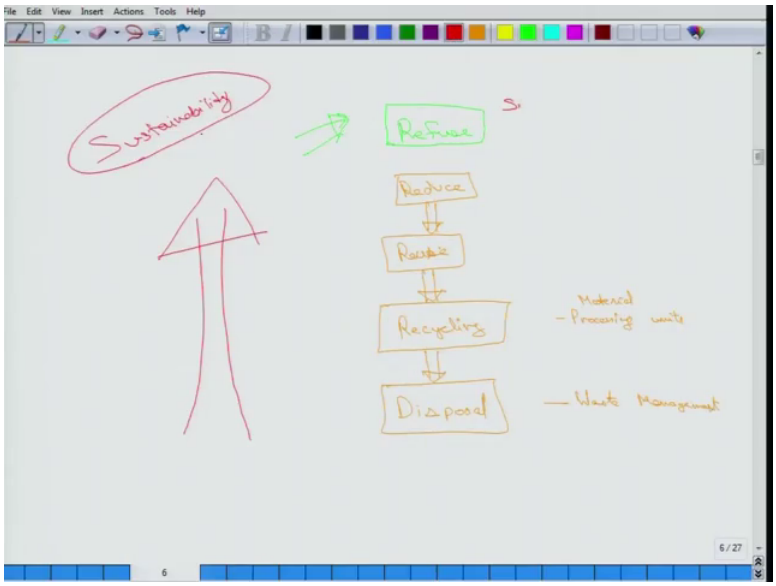


So, regarding reuse recycling re manufacturing disposal I will have to tell here that if for final thing what a product has to be disposed disposal right. So here in, we are like concerned for waste management.

That do we need to dump this into deep into the ground or maybe some products are like a dumped or sent deep into see as well those do not deteriorate or ocean or aquatic life for example, the ships at dumped deep into the sea after taking all the components that can be reused and some of the other big products like this these are dumped into the sea right. So, finally, disposal is there.

So, before disposal we could think of recycling, if not recycling then only we go to disposal right recycling is by processing units these are actually material processing units right. And before recycling we can think of reusing the product reuse if possible. So, what you might be noticing here is that, in this direction or sustainability is rising right assistant builder as in this direction.

So, before reuse we can even reduce the consumption consume less, people in western countries the consumption rate is quite high in comparison to that people who are in Asia or maybe in South Africa. So, standard of living or we can say the cost of length is also high that is always connected with that as well. So, the customers are being told by the people who are working in sustainable manufacturing concerns sustainability concerns that telling to reduce their consumption. So, I would like to say here I would put one

more word here refuse; refuse your usage, refuse your usage means not only to reduce for example, in IIT Kanpur we call it as a green campus.

We do not use automobiles over here all the students just use their bicycles this practice is very pertaining in some other universities 4 level university as well. So, this is refusing to use the product that effects my environment. So, this is where we can have sustainable world right this sustainability. So, during all these stages or manufacturing right 1 2 3 4 and 5 right there are some waste that is associated with this one. So, I would like to put some light into that right.

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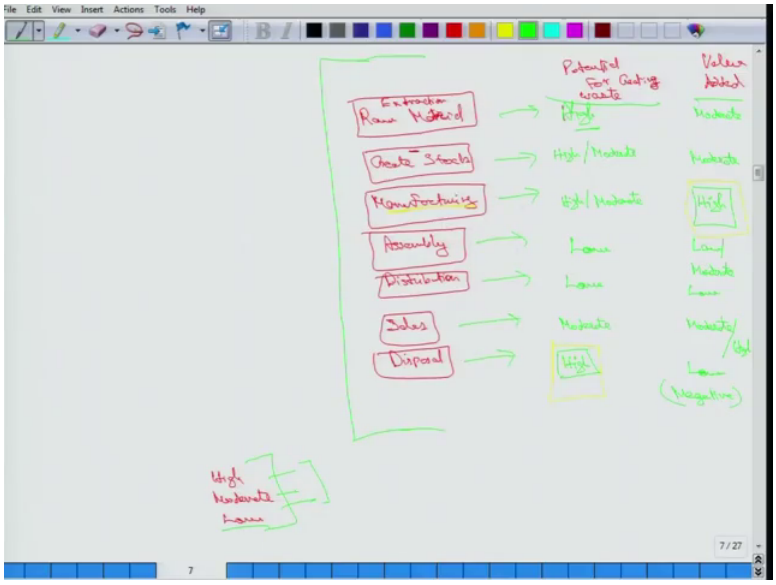


I will put these stages once again raw material then is creates stock, then is manufacturing, then maybe assembly, then distribution, sales and disposal. So, I have to put it in a way we discussed in the last lecture right for raw material we create stock and then manufacturing assembly sales and disposal. So, what is the comparative potential for creating waste right and what is the value added comparative.

So, if I put my scale as high moderate and low I would like to say here that during raw material processing that is this is the actually extraction before because it is, before this create stock. So, it this is extraction of raw material. So, what is the thing what is the potential of creating waste here? During extraction of raw material extraction metal there is has a huge weight associated with that. So, I will put high waste right. So, the waste is high here and the value added raw material is take potential of creating waste here is

high and value added is moderate, if I bring from these three quality parameters right for creating stock the waste that is produced is also high.

But it would be it is lesser than this raw material thing. So, I will put high or moderate and value added is again moderate right then for man in manufacturing, manufacturing essentially we know that predominantly manufacturing is main concern here. So, the value added would; obviously, be high because final product is produced here right. So, what is the waste that is crated? Waste and also that can be manufacturing high or moderate waste is created right and in assembly what is the waste that is created in assembly I would like say low.

In assembly whole in the parts are assembled not much waste is created right. So, here the waste that is carted is low and the value added is also may be low or moderate, it all depends what kinds of assemblies we have when in distribution, distribution is again low and low right. Sales and service sales and service what waste with the create sales and service is we all transportation is involved into that. So, carbon footprints are there while using trucks like. So, is the say here waste crated may be moderate right and value added is also moderate, I could even put high value here, but it is very less in comparison to this manufacturing here.

So, the highest value is this box here at this point manufacturing right then at disposal. So, what is the waste that is created during disposal low it is obviously very high. So, waste is high because everything the product finally, is disposed to the grounds right. So, at this box we have highest waste right and the value added is I could even put the though I have used these terms only here right. So, I need to I could only put low here, but I would like to put here maybe negative had I there had that scale here right.

So, during all these stages of or life cycle these kinds of weights are generated and these types of values are added. So, during life cycle assessment it needs to be kept in mind that manufacturing adds the highest value into the product right and disposal adds the highest waste has the highest potential to add to the waste right. So, next I would like to come to the procedure or steps for life cycle assessment. So, life cycle LCA steps.

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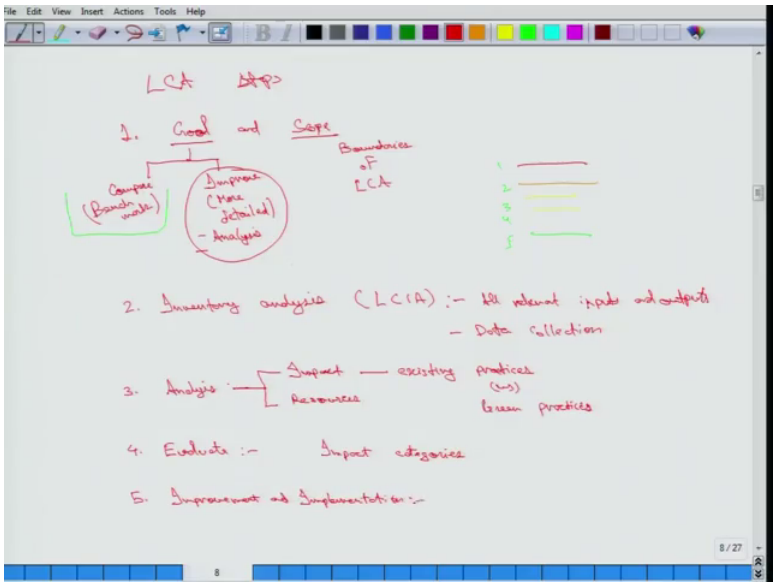


So, I would like to put here number 1 is we need to define our goal and scope right.

Here goal means what is the life cycle goal that do we need to only. So, by goal means we need to define that do you only have two compare with the existing competitors or taking considering getting computers and or all are pear level comp competitors right. So, or we need to improve as well so; obviously, this would be more detailed right and more analysis would be done here right analysis and here we only benchmark, benchmark are company right.

For example we just need to put the color that if green is the color that is (Refer Time: 37:27) need to paint our company. So, what is at what stage do we are from like very red then we have orange then we have various stages of yellow, and finally green. So, at what stage do we are right. So, this is need to be set here goal and scope. Scope here means the boundaries to boundaries of LCA like I discussed about this raw material processing do we need to start from raw material processing or do we need to start from the purchase or do we need to only concerned of the production here manufacturing, right.

Then next is inventory analysis. Inventory analysis is actually there is a term here LCIA life cycle inventory analysis. In that we do inventory analysis at all the stages from raw material work in progress and finish could inventory all the inventory analysis is done and that is a essential step in life cycle assessment here. So, we identify all relevant

inputs and outputs then data collection is there right then what we do is analysis; analysis of what of impact there is of impact resources right.

The impact analysis determining the relative environmental impacts of various available or existing practices versus green practices right then we needs to evaluate. Evaluate means classification of all the inventory and impact data, but we have into it table right into impact categories right then if the goal is this one improvement. We have 5 step as improvement and implementation right this includes all sensitivity analysis and validation of the practices which we have implemented, which we are trying to implement here. And the compact this is the similar kind of practices that are being there in the similar kind of practices that are available or the practices that we could develop to get into better situation.

With this I will conclude week 3 lecture 2 and in lecture 3 I will come up with more details of the steps of value analysis. And we will come up with the soft tools that are available to do value assessment as well in forth coming sessions.

Thank you.