Strategies for Sustainable Design
Professor Doctor Shiva Ji
Indian Institute of Technology, Hyderabad
Lecture 25
Lifecycle Analysis Part B

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So, in this example if we see this is a vehicle emission, so, this LCA analysis is done over here. So, materials are extracted and sourced from the lack of minerals, it goes for the chemical component manufacturing from the help of different other manufacturers and subcontractors then it the vehicle goes further it gets a final assembly and then it comes out in the market on the road. User buys it and then it goes for its regular consumption of its fuel.

So, on the fuel, it is going to run for the entire working life and that is where it starts consuming a lot of fuel depending upon its uses and there will be of course, the emission part of it. So, that this is such a product, this is a regular energy, fuel consumption and the emissions are going to be there as long as the product is in its use, and at the end of its life lifecycle it goes for recovery, extraction and recycling, disposal etc.

So, if you see here this the blue box is about the current vehicle emission regulatory focus, so, the focus over here is on the improving the emission part of it. So, if we focus on improving the emissions and you may have heard of the different Bharat Emission Stages. So, Bharat Emission

Stages 1, 2, 3, 4, 5. So, there are several stages and these stages, they laid out to the measurements.

They laid out the maximum permissible activity limit of the emissions of different activity compounds which come or come out of this the combustion engine from petrol and diesel and so, the these recommendation demand improvement from the manufacturing companies to improve upon the emission. So, you may have heard the, the fuel itself was refined several times to remove the compound of lead from this.

From the petrol and hydrocarbon based these are fuel and secondly, the energy efficiency of the engines were also optimized and then the fuel emission capacity was also for the threshold was usually raised high the bar was raised high and with every stage adoption, the efficiency here is the it is expected that the efficiency will improve by a significant leap. So, you may have heard from the Bharat Stage 3 the government of India plan to move to directly to Bharat Stage 5.

So, skipping the level of 4 so, that is a significant jump. So, this information was laid later years ago in advance to give it to the manufacturer, automobile sector the manufacturing companies, so, that they can prepare accordingly in the well in the time and from the later expected year of the, the, the implementation of our Bharat Stage 5 such vehicles were only allowed to as a road worthy.

So, this is a potential of conducting LCA analysis. So, that they help restructuring the re engineering the entire lifecycle of a problem of our products. So, even if you intervene at one stage of it, that is good enough to improve upon the like, maybe at least one after which you for example, here we are talking of talking about improving on the emission part of that automobiles for example, 4 wheeler cars.

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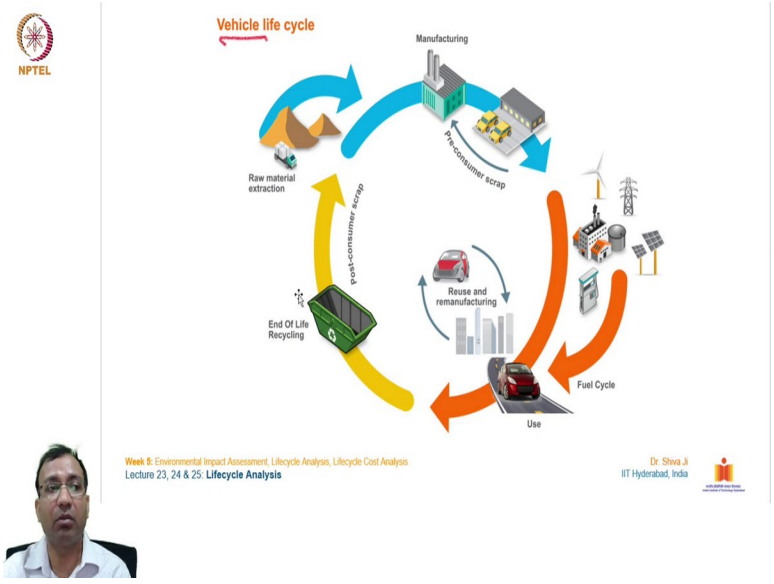

So, that is how the (())(04:02) decision for manufacturing of any product takes place. So, yeah, so, this is a schematic lifecycle of vehicle over here. So, that we have seen in the previous slide also the it goes from the source material to manufacturing then it uses then it is fuel consumption, then using manufacturing of the recycling and again it goes back. So, this is how things are moving. So, the exhaust the materials, the components, which cannot be recycled, they become the bottleneck in any labor such as this thing.

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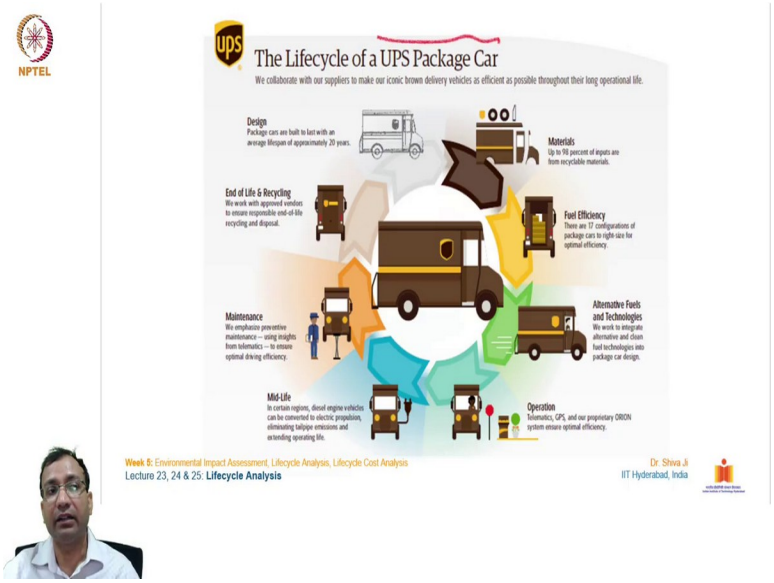

So, here you will have you will see lifecycle of like, courier companies package car, how do they do this thing. So, if you see from here from the design, so the package cars are built to last with an average lifespan of approximately 20 years. In India, a vehicle is designed for a general consumer vehicle like 4 wheelers or other personal vehicles. They are designed for a lifetime of for 15 years.

So, at the time of the registration maybe go for our vehicle registration to the registration authorities. So, they issue this roadworthy certificate that RC registration certificate which is generally valid for 15 years, so, after 15 years period between the vehicle becomes unroadworthy. So, here, if you see the vehicle itself is designed for the lifecycle of 20 years, which is good enough for commercial vehicle.

Because the technology also significantly changes in a span of 20 years. So, the amount of the materials what they have used over here, so up to 98 percent of the input materials, input materials are used on recyclable or recycled sources. So, that is responsible way of manufacturing such vehicles, which are specifically designed to serve one company one brand. So, there are it shows this is conscious effort.

So, we own the fuel, the fuel efficiency part if is there, there are 17 configurations of package cars to right size for the optimal, optimal efficacy. So, optimal those configure configuration, it depends on the volume and the weight, which this vehicle is going to carry, and the kind of terrain and the landscape on which it is going to, operate whether you are congested, the city we are talking about or are we talking about the countryside or are we talking about a very heavy vehicles or the medium heavy vehicles or maybe later goods vehicle.

So, depending upon this they have configured 17 configurations to fit in with the optimum engine capacity and chassis capacity. So, this is how the company has planned to bring in efficiency in this automobile unit. Next if you see they use alternative fuel and technologies also apart from depending upon the hydrocarbons-based ones these. The operations states that this company is well known for optimizing it is movement of these cars.

So, they always on the layout part from point 1 to point 2, they always they always follow the, the path of the least resistance that is why they keep on moving without crossing any taking left

turn the keyboard taking a right turns. So, this is I am in the context of the United States I am talking about and that is why you should be minimizing the number of red lights which may be installed in their path.

So, with the use of telematics with the use of GPS with the use of city layout, maps, etc, and the addresses on which the vehicle is going to deliver the goods This is how they plan the movement of that traffic and they keep on tracking the real time data of the traffic movement and volume on the certain centers. And that is how they drive the movement of this vehicle. In the mid life of this vehicle, they go for sometimes the changing in the this is converting it to electrical propulsion-based vehicle and so, some changes some retrofitting they carry out in the mid life of this vehicle also.

On the maintenance part if you see they emphasize on preventive maintenance rather than going for corrective measures. So, this is a very an efficient strategy once if, if number of fleet is the concern because there will be n number of vehicles to be taken care of by the respective drivers. So, it is always better to go for preventive measures to, to minimize the breakdowns and inefficiency in the operation stages.

In the end of the lifecycle, lifecycle stage, obviously they go for the approved agencies and approved vendors for responsible recycling, reusing and dispose, dismantling and disposal of the vehicle itself. So, this is a responsible way of going for vehicle design and this company has shown the way.

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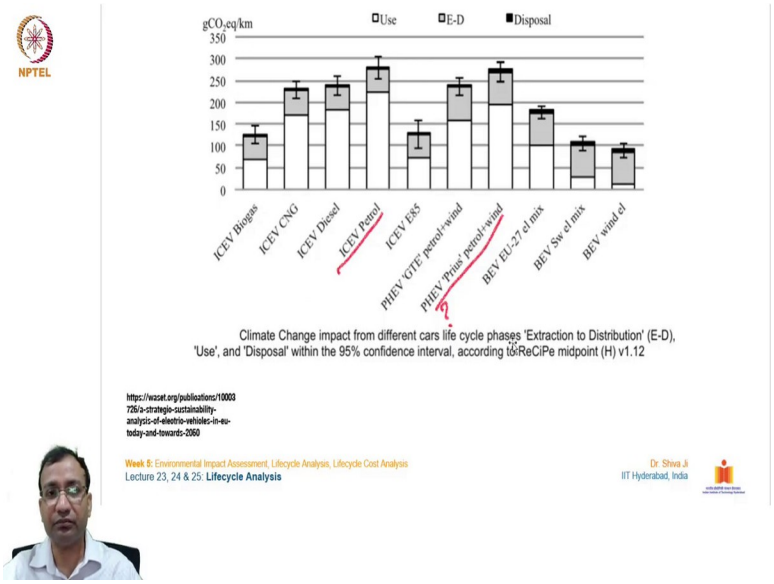

So, here if you see this actuary table this is talks about the climate change impact from different cards, the lifecycle phases from extraction to distribution, use and disposal within, 95 percent confidence interval. According to this, Recipe recipe make (())(09:53) an analytical analogy on which they have drawn this graph over here. So, see this petrol vehicle this has the in the highest this CO2 emission a contribution followed by this even this is a very famous model which came as a hybrid technology automobile in the some selected markets in the world. So, this is also one of the found to be the second highest contributed for the CO2 this thing.

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Similarly, if you see over here this is a LCA taken from this agency which talks about the LCA of wool. So, it goes from sourcing the raw material from the sheep, on the sheep farms. Then it goes for the lack of processing it uses certain amount of chemical certain amount of energy, water, other, other processing materials and agents then it goes for the transportation. It is distributed to the factories where the garments and woolen cloths are prepared and manufactured and from there again it goes to the market and then from there it goes to the user.

Then user, uses it for number of years for I would say usable time then again it goes at the end of the cycle, it goes back to the second nature. So, since this is a material, which is primarily taking from nature, wool, in itself is a natural yarn based material. But the chemical compounds and the treatments and the colors and these things add up to the hazardous component of this product.

So, we saw in the previous lecture sort of how the these coloring agents, how these pigments which are synthetic, which are manufactured from companies in the manufacturing units, they cause damages to the aquatic life and ecosystems. They pollute the water I say unit they spoil or they contaminate the topsoil of the places where their processing units are placed.

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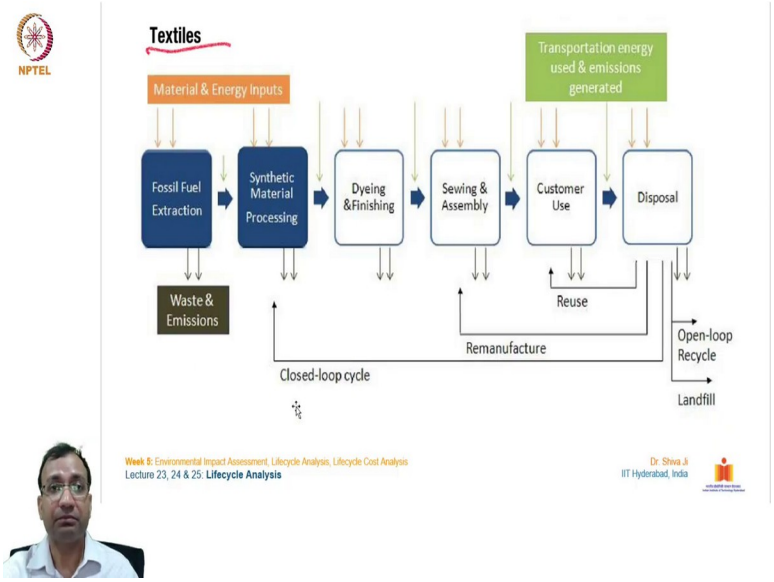

Let us move on to seeing the textile. So, the how the textiles works? If you see from starting up the material and energy inputs. So, it uses these things to extract the yarn and the fibers then it goes for processing of to making them into natural or synthetic fibers and then it goes for dyeing and finishing procedures then it goes for seeing an assembly you know preparing final garments, then it is sold to the customer from the markets.

So, there this transportation and other emissions are generated over there. Then it at the end after the end of its life cycle is goes further distribution disposal. So, from disposal if you see there are some, some of these arrows are going down to a different other life stages. So, from the first one, you see it goes for the lack of reusing So, so, for example, refurbishing the older garments or maybe selling it as a secondhand garment there are some markets in the some countries which sell secondhand used garments, and then it goes even for remanufacturing.

For example, the smaller pieces or the bigger pieces of the cloths can be turned into smaller pieces of the some maybe some garment or something that. Or maybe using the components of it buttons and zippers and things that, because they also form a huge bulk of this textile industry, then it goes to again, again if it goes to the this processing unit then it closes the cycle of it's life cycle and it becomes this.

But if there are some open loop recycling or if it ends up in the landfill, so that is worse part which could happen with this industry. So, this is where it gives generic lifestyle of these textile industry.

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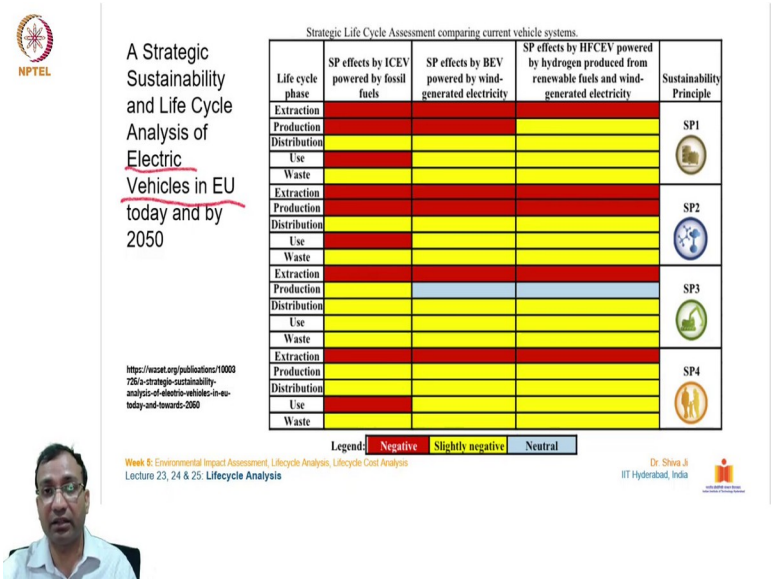

So, here we will see in this one progressing from the previous slides, our strategy gets you to sustainability and lifecycle analysis of electric, electrical, electric vehicle. So, this is a particularly taken from EU countries and what they project for year 2050. So, what are the strategic comparing and the factors what they have taken care of, each one. For the each of these components have lifecycle stage so into they are divided into 3 component.

So, having negative impact, having slightly negative impact and having neutral impact. So, based on that we will see So, for lifecycle phase for the extraction part. So, here they have taken if it is being taken from fossil fuel based sources then it is kept in the negative red area. If it is taken from BEV powered by wind generated energy even then it is kept in the red area negative area. If it is taken from the renewable fuels and fuels and wind energy generate electricity.

Even then it is taken into the negative area because extraction in itself as a process has a lot of impact on the surrounding and the ecosystem of any place. So, extraction as in principle has kept in the negative category only. In the production part if you see the these 2 are in the red, but the renewable resources if it is consuming energy from then it is taken into slightly negative area.

So, most of these areas are into red are either yellow whether it is distribution, use based extraction, production, distribution, use based extraction etc.

So, on these ones are the only neutral impact area what I see in the time of the production, if it uses renewable energy sources for his production and so, and it has divided onto principles of for sustainability principle 1, 2, 3, 4 and you can see over here, so, this is how they have bifurcated. So, I think such kind of strategies and such kind of analysis are very important for us to not just understand the ecological impact portion of any product, but to understand even the impacts on the economical aspects, understanding the impacts on the local social impacts also.

But majorly EIA and these LCA tools help for analyzing the environmental impacts, at least understanding the life stages and how the life stages of any product are going to have some sort of impacts and how we can improvise on them. So, this is a very interesting and useful tool in recent times, which was prepared. So, and we must learn it maybe for your own understanding, you can undertake some analysis of any household product, which you are familiar of, and you can understand, how, how it behaves at the different life stages of it is it is life cycle.

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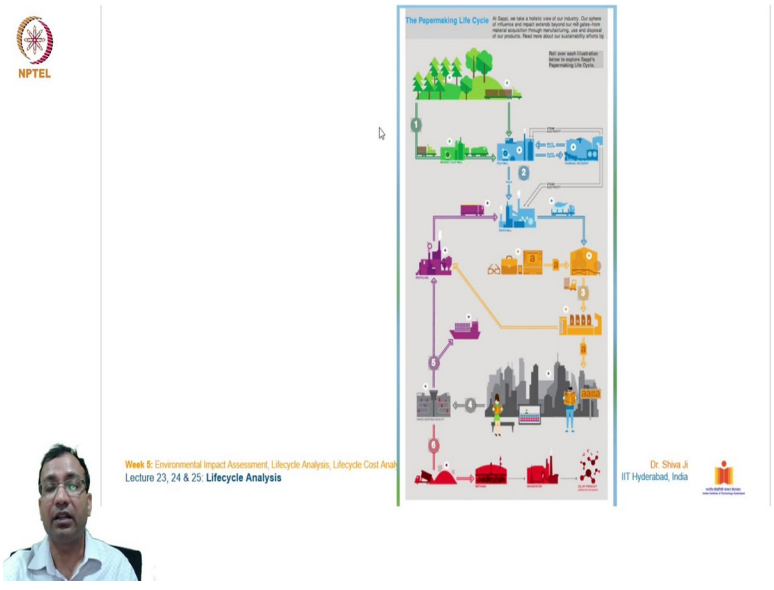

So, this slide talks about the papermaking life cycle. So, of course, paper industry paper and pulp industry is a highly intensive highly toxic industry also it consumes the primary resources of this planet, which are the trees. So, it consumes most of like, all of these mostly these papers are

made up of paper only. A very small amount of papers these days are used as recyclable material, because once a paper goes into processing.

So, depending upon its quality, and finishing what is given, it becomes a complex material, again, to take it back as a recycling unit, for example, I am talking about lamination which happens on the these papers. So, this lamination process, it installs a thin layer of plastic on this paper with the heat pressing method. And then at the end of the life cycle, that paper becomes very difficult to take these two components out because it uses adhesive also and then there are the recovery and the kind of the value the economic value.

Which is this paper this recovery is going to give is lesser than what it will, what will be give? Than what it will consume? So, that is why it becomes very difficult for the industry to recycle some of these materials also. And second, which is the most hazardous part of it, the kind of the pigments and the color which this paper industry uses to bring out these very shiny and nice and appealing looking prints on the paper. So, that also exerts a lot of impact on the ecology.

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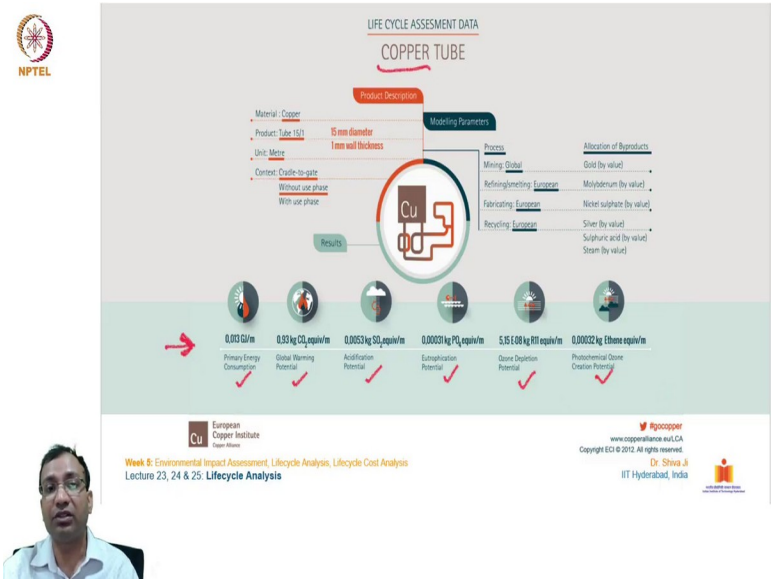

So, this slide talks about copper tube, how the copper tubes So, just for an example, what is taken over here is a copper tube of 15 mm, millimeter diameter with 1mm wall thickness. So, how they are used is that this thing, there are several stages shown over here the primary energy

consumption remains at this quantity then there is global warming potential how much it exerts in the terms of CO2 emission, then there is an acidification potential.

So, how much it carries and then it eutrophication potential then there is ozone depletion potential then there is photochemical ozone creation potential. So, there are several other types of after effects are also possible with these manufactured articles which we generally do not get to know in generic public life. But most of these materials have catastrophic resultants, catastrophic results.

So, as we can see over here our simple product our copper tube can have these many types of impacts, which are very, very crucial in the long run. So, imagine the volume of such products, which this world is producing across all the countries and the, the accumulated impact of all of that put together. So, how much it will become like.

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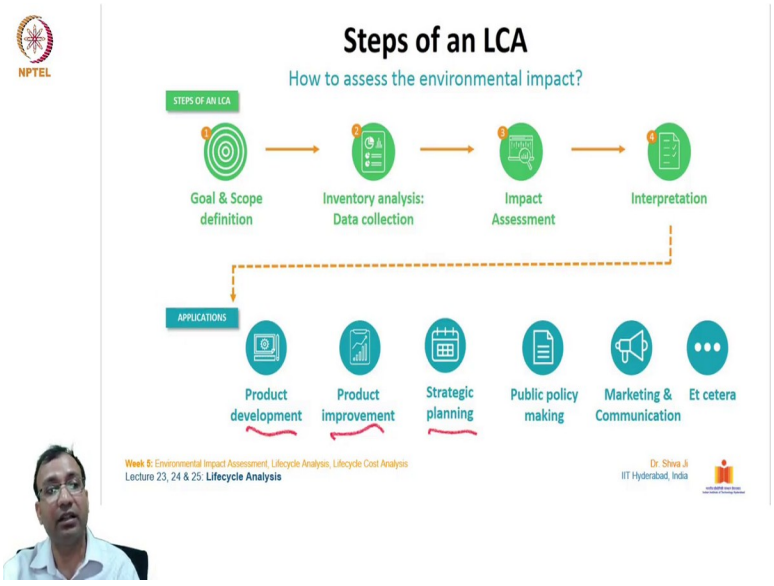

So, this is intent of talking about this course over here. Well, you may be having already some idea and some knowledge about LCA, but with the help of such case studies, my intent is to make you aware of how this LCA process is very important to be undertaking before going for fabrication and manufacturing of any product any item or even manufacturing simple objects, what kind of impacts they are going to create and what kind of resources they are going to consume.

So, a basic analogy of this LCA and impact assessment can give us intervention areas, which we can work it out in our the concept of stage in our design stage in our manufacturing stage to minimize the overall impact. So, you can see over here like, there could be these many different stages and we can use these knowledge for our product development, refined product development, a refined product improvement, strategic planning of that, even preparing policy, public policy.

Policies and rules and regulations what sort of material what sorts of threshold should be kept for controlling the pollution and the emissions. What kind of marketing and other communication materials should be prepared, etc, etc. So, there could be n number of application. Such tool such as LCA.

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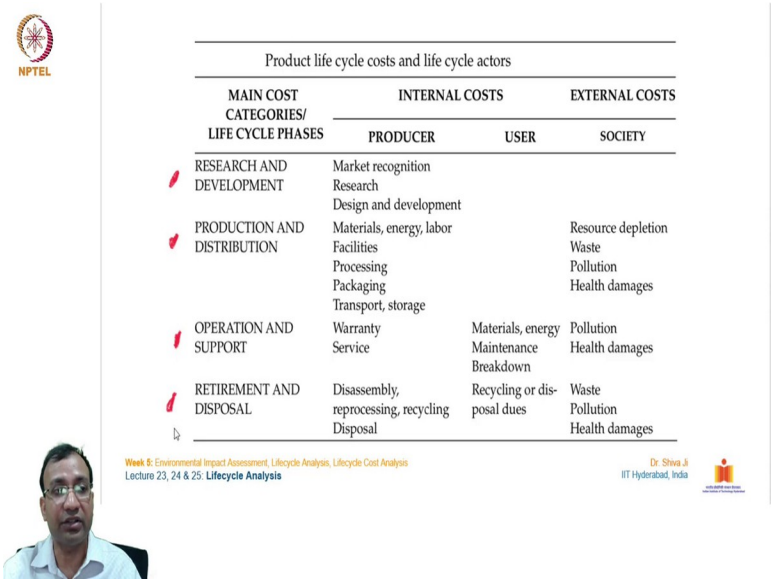

So, how this what are those different actors different stakeholders for calculating LCA of products? So, at a different or lifecycle stages research and development, so, the producer uses society, they play different roles foreign market recognition for the research and design and development for the distribution. And production phase the stakeholders who are related with the material supply, energy supply or energy production, labor facilities, processing packaging, transport storage.

So, these are important nodes while calculating the entire lifecycle of a product and where we can intervene to improve the entire to the lifecycle. Similarly, you can see some stakeholders and some, features over here also from the operation and support, we see warranty services, and from the retirement and disposal, we see disassembly, reprocessing recycling disposal, etc. Well, these are terms are repetitive, but it is very important for us to understand them in the order in order of their appearance, when they come? And how do they come? And how we can make our intervention?

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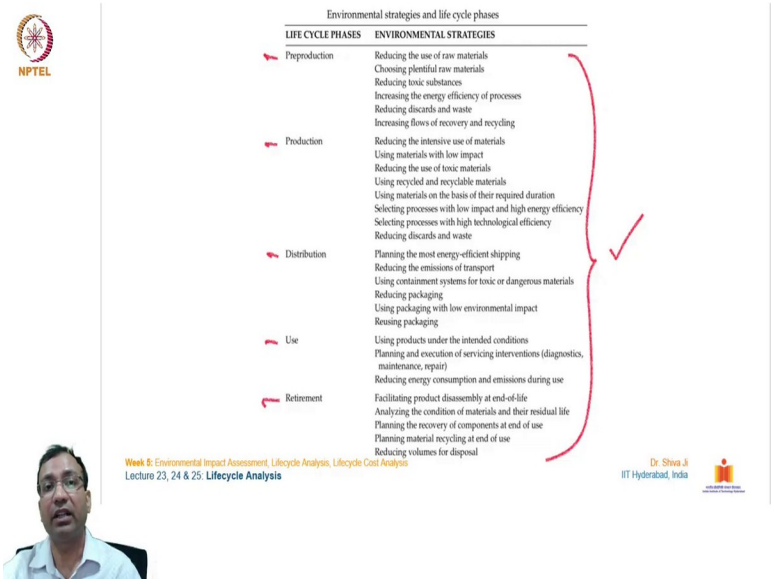

So, there could be several strategies or depending upon the lifecycle phases. This slide very important for you to note and understand you can make a note of the final strategies which are given on this particular slide over here and the pre production stage. We can go for are these many strategies which are reducing the use of the raw material, choosing the plentiful raw material, not the scarce material, we can go for reducing the toxic substances used in the product manufacturing.

We can go for increasing the energy efficiency of the process itself. We can go for reducing discarding and the waste. We can go for increasing flow of the recovery and recycling. So, these many things well, there could be even more, but at least these many you can note down for the pre production stage only with the help of which we can improve the LCA of any product. And at the production stage, you can go for reducing the intensity of use of the material so we can

minimize the use of the materials so, wear and tear and that is about how we can extend the longevity of that product.

We can go for using materials with the low impact. The materials which is for example, for construction the houses in the rural areas, it is traditional practice to go for mud constructions using timber using bamboo. But in the recent times in the post globalization era mostly the architecture in every country almost every city and town it is taking the similar a style of the architecture which is which is evolving.

So, there is no much difference between an architecture of one place to the other place. But if you see the vernacular architecture, so, the vernacular architecture evolves at that place, it carries that characteristic it carries those features, which are very very rooted to that particular place. So, those kind of characteristics being lost in this post in the industrialized era.

So, in the distribution also we can work for planning the most energy efficient shipping methods or distribution and transportation methods, we can go for reducing the emissions of the transport we can go for using containment system for toxic and dangerous materials reducing packaging, we can go for using packaging with low environmental impact if it is at all needed, we can go for reusing the packaging material because packaging also forms the one of the larger bulk of the waste material, which comes out of are these any packaged material.

So, the product goes for the consumption for the users for certain number of certain duration of time, but the packaging material gets thrown immediately once the product is delivered to the user. So, the packaging itself here is one sector where we can work for improvement. So, if you just focus on the packaging material and at the production stage of the packaging material. I pin pointedly if I go back and look at this life stage.

So, we can work for reducing the intense use of the material we can go for using the materials with the low impact we can go for reducing the usable or toxic materials. So, we should not use toxic color printing and inks in the on the packaging, we should not go for the very complicated treatment these days very fancy packets are available for even smaller things few number of chips and few number of biscuits.

And immediately the ones that the packet is bought by a customer the packet is thrown away. And the packet goes for very hard life or it is disposal and recovery because it becomes very difficult to recycle and reuse them. So, we can go for using materials on the basis of their required duration how much of life is expected out of that packaging material. So, it should be designed to last only a little more than that or maybe twice of that, not more than that because otherwise it is going to live there somewhere in the ecosystem.

And it will keep creating a trouble for the for the ecology. We can go for even selecting processes with the low impact and high energy efficiency we can go further with the high technological efficiency we can go for reducing discard and the waste. So, we can go for even behavioral changes also and the use case if you see using products under the intended conditions only planning and execution of servicing interventions for example, diagnostic maintenance, repair, etc.

We can go for reducing energy consumption and emission during the use itself because we saw in the automobile industry it becomes very critical and for a product chair or maybe a table the longevity becomes very important and the embodied energy becomes very important. Because that once that unit is bought once that furniture piece of furniture is bought by the consumer, the furniture is going to last for wider a duration of time.

So, the longer it serves the better it is. So, that is these kinds of these approaches may differ depending upon the these criticality for each product or the product category. So, depending upon that we can choose the intervention area and we can go for some strategies strong adopting suggested these is for the improvement. In the retirement stage if you see facilitating product disassembly at the end of the lesson.

This is what I was talking about with the context of alloys and other composite materials and compounds it becomes very difficult extremely difficult sometimes impossible, sometimes completely not practical or economical to disassemble or decompose them or disintegrate in them again into their different elemental and molecular forms, it becomes extremely difficult.

And so, we must choose our products in such a way that they are not that difficult at the end of the life stage. And again we can go for analyzing the condition of the materials and the residual life. We can go for planning the recovery of the competence at the end of the use, you can go for planning material recycling at the end of the use, you can go for reducing volume for the disposal. So, there are several, smaller smaller approaches and smaller strategies. Which can play a vital role in overall these control for the LCA.

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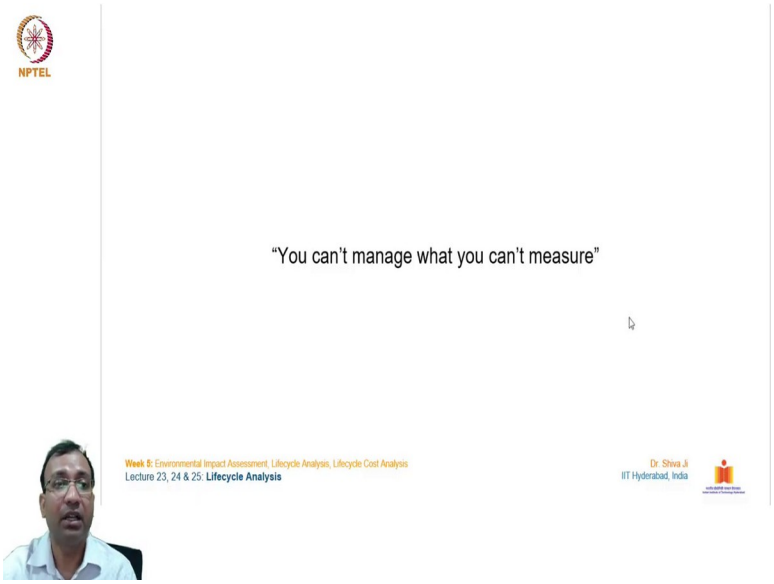

So, in LCA as we discussed in the previous slides, the things which we cannot measure they cannot be managed. So, this is one of the disadvantages in the LCA analysis. So, we must actually code or we must quantify the components and whatever the kind of numbers which are getting associated with them, so, that the some analysis can be made.

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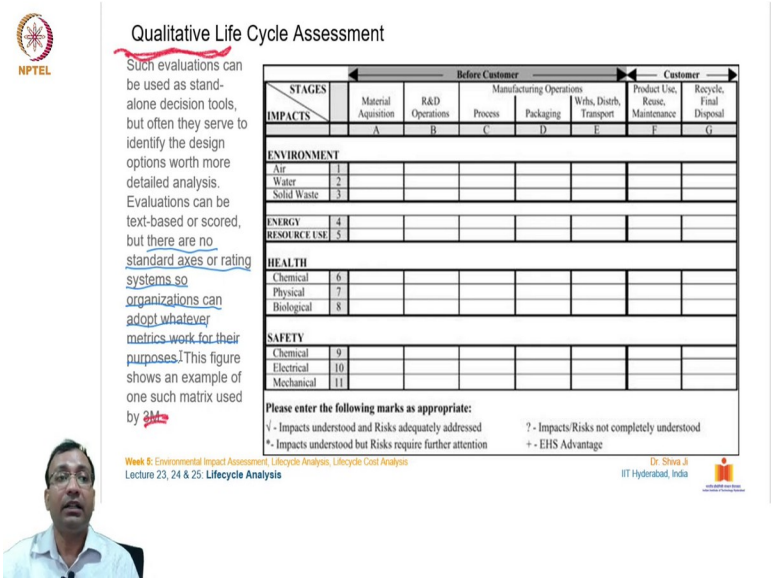

So, based on this some qualitative lifecycle assessments and some our quantitative lifecycle assessments are also made. So, we see over here like, this qualitative lifecycle assessment analogy is made. So, there is a, if you see there is like, there are no standard access or rating system. So, organizations can adopt whatever metrics work for their purpose. So, it depends on the product, it depends on the components which you are trying to analyze.

And it depends on the context in which you are analyzing which country which place which city you are talking about, from where you are sourcing, how far the resource places or how far the distribution places or how far it is going to get recycled and all this. So, it is very, very contextual also in the in these value if you see. So, these are some qualitative traits for the analysis. So, you are mostly you are free to choose and modify these standard tools. So, that that is why there are no is truly standard given tools for which can fit to every product or every category.

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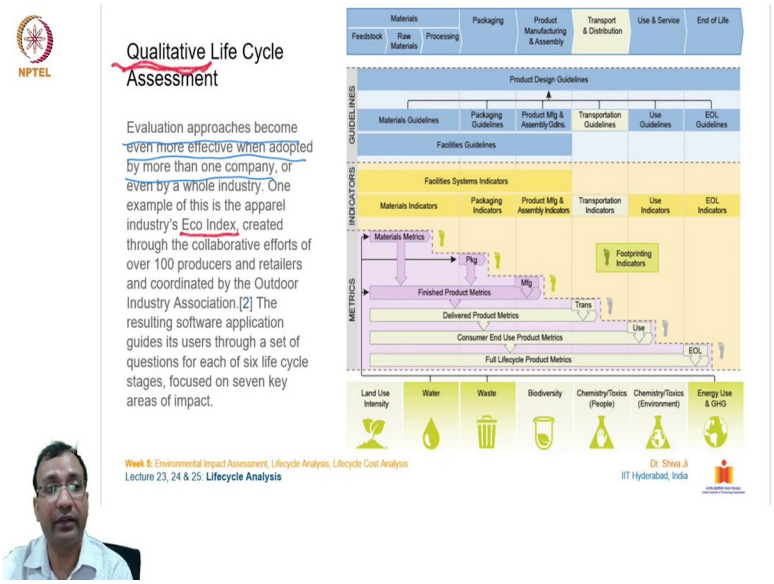

Let us, let us move on to this next slide. So, here also talks about evaluation approaches become even more effective when adopted by more than one company and all. So, of course, like, there are some approaches and if it is getting success and a different application different companies different organization. So, of course, the its acceptance will start increasing and one can claim that yes, this is one of the acceptable formats of analyzing lifecycle analysis of any product or something.

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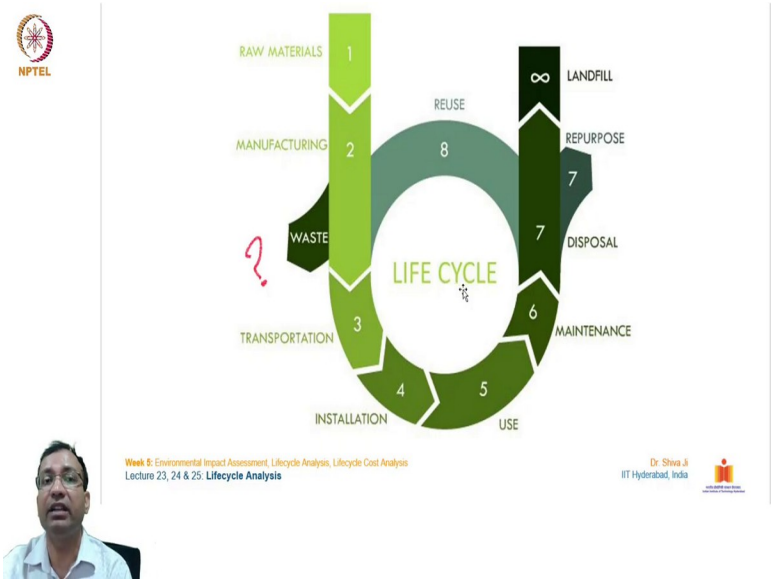

So, this circle which we have been seen for several times, so, this is questionable area, well in a lifestyle of all of these stages of a lifestyle of product everywhere you can find opportunities where you can intervene. So, you must keep this life stages in the mind and you keep thinking of whichever area you need to improvise.

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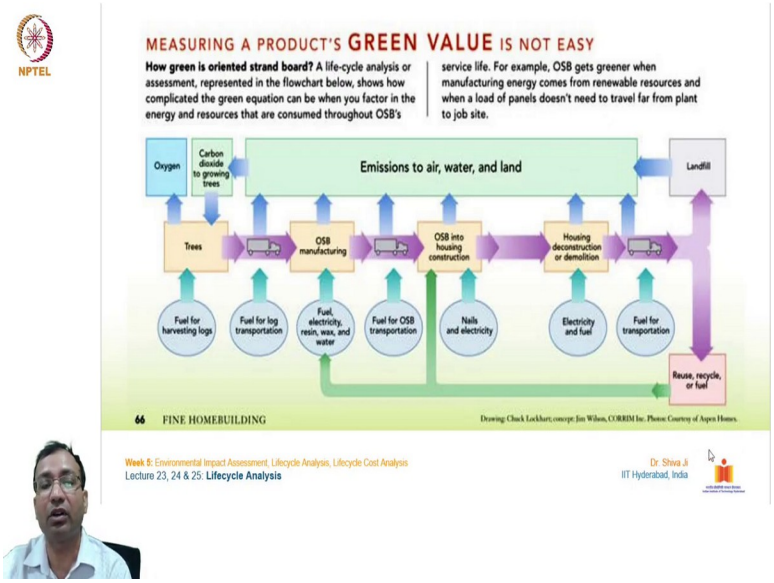

Whichever area you need to improve upon. So, all the products the green value the increasing the green value is the overall objective. Well, you can go for analyzing in breaking into several life stages several parts components and things and then overall in an overall sense, you will be able to draw some inferences.

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So, as we have seen some case studies this case study talks about supply chain of jeans. So, how this jeans material as a product as a material, it behaves in the ecosystem, how it exists in the ecosystem. So, of course jeans is mostly derived from cotton. So, the cotton industry and then there are some percentage of synthetic polymers also are used to add flexibility and stretchability and these are features.

So, based on the application how rugged and how fanciful and how the density of that the weave the density of the and how many number of plies. So, jeans comes into several applies also 1 layer ply, 2 layer ply even triple layer. So, depending upon literally this specification. So, the costing and the complexity increases. So, from the origin from the sourcing, then it goes further refining because cotton refining also and processing is an extension of the water extensive process and then it goes further transportation then is go for dying and other treatments what we have seen coloring etc.

Then it goes for transportation to the unit where it will be prepared into the ready garments, ready jeans units jeans pants or whatever and then it goes for the assembly then finishing you know then it goes to the labeling, packaging, etc, then with the transporting goods to the warehouse then again it takes to transportation. So, see n number of transportations are involved in any offer these are commercial value products.

So, this transportation sector in this contributes a lot a major factor for the indirect emissions are concerned. So, these indirect emissions are one of the very, very volumous come contributors for the overall impact of any product. And then from the retailers it goes for the to the end user and then from end user it goes for the disposal etc. And then there is again these strategies come at the end of this lifecycle enter reselling, reusing and recycling or refurbishing, etc, which we have discussed earlier. So, this is how jeans also was jeans is a very competitively a tougher and a stronger fabric a garment. So, usually it lasts longer. So, it saves all compared to other clothing material it saves on the longetivity part.

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For the food waste if you see here how the food waste works. We may have seen in our dining halls in the our institutions campuses or even restaurants, hotels etc. There is always certain percentages of food which are usually gets discarded when food is a very very costly material is not just the monetary cost of it which we pay from our pocket a food has a lot of cost and on the ecology.

A lot of cost on the lack of emissions a lot of cost on the transportation you know a lot of cost on the energy and resources and the effort which is being put up crop of wheat or paddy takes at least 6 months of cycle to produce and grow and then it reaches to the processing units then it reaches to the our homes when we buy then we prepare then we eat so it is a very long innocent a very extensive and energy consuming process. So, we must be responsible towards saving food.

Because on an average a huge percentage of this food just go waste by as a leftover from our plates.

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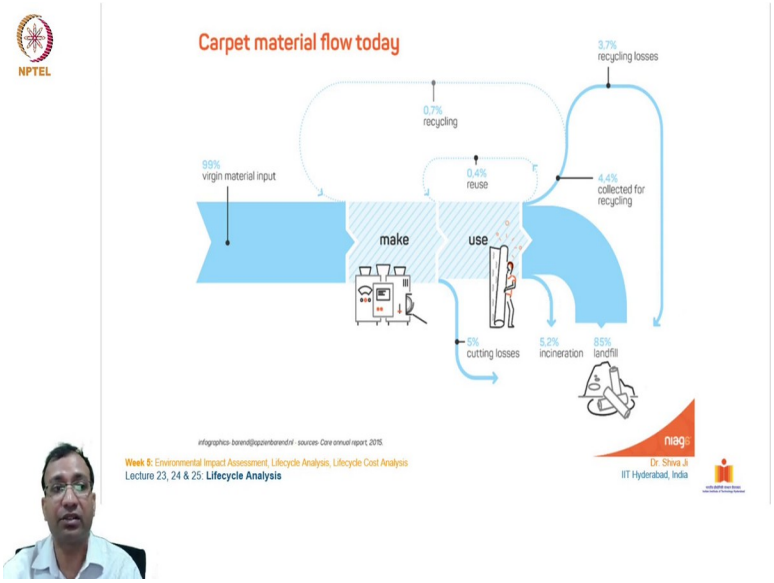

A certain company you can see over here has given a conscious effort to minimize the a waste is minimized the raw material or even the finished material from its life cycle and life cycle and they have tried to close the circle of their one of the products. So, that is why I have kept this slide at the end of this presentation. So that you can understand how one single companies' effort can make changes can bring changes to the overall impact.

So, here if you see this is generic flew of this carpet material. So, this is the normal for this is a generic flow into normal company. So, from the virgin material up to 99 percent it goes for making then it goes for uses, then there are some cutting and wastage losses, etc. From the stage it goes for again at the end of its lifecycle is usually goes into the all of such material goes into mostly landfills a very small amount of this material goes for the recycling and incineration, etc.

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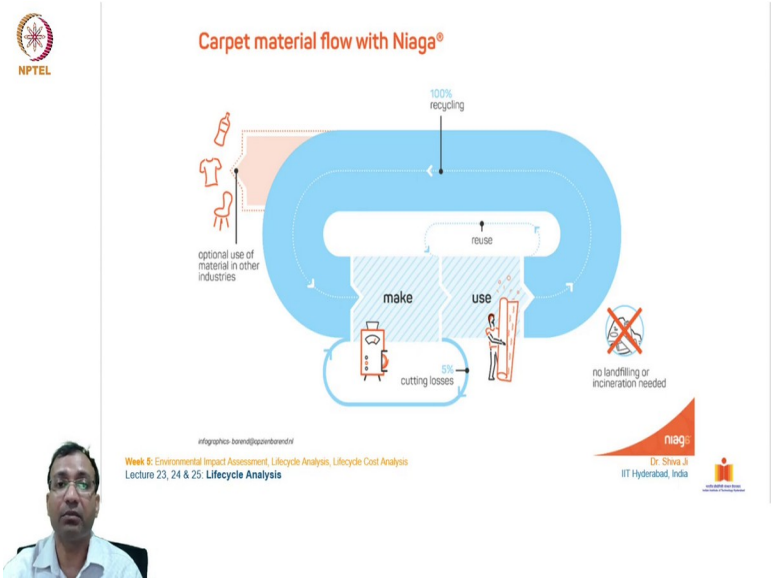

So, what this company did is to come up with a closed loop in their product life cycle. So, as you can see from here after the usage almost 95 percent of this a component they take it back as the in the recycling unit and even that of course, this is a cutting loss also of the little 5 percent. So, from 95 to 5 percent they are claiming the 100 percent recyclability they have achieved in their digital product lifecycle.

And at the end of it you can see if it is not getting refurbished as the same product then they are using it as an optional use as an optional material for other sorts of material. Yeah, as you can see over here. So, there is always extended use of the life lifecycle of this product or maybe refurbishing into or reusing into different ways. So, there are, we will discuss in the next lectures about these R's, several R's. there are 3 R's, 5 R's, 7 R's. So, we will discuss about these in detail in our upcoming lectures. So, I will keep it here for today. So, thank you all.