Product Engineering and Design Thinking
Prof. Prabir Sarkar
Department of Mechanical Engineering
Indian Institute of Technology, Ropar

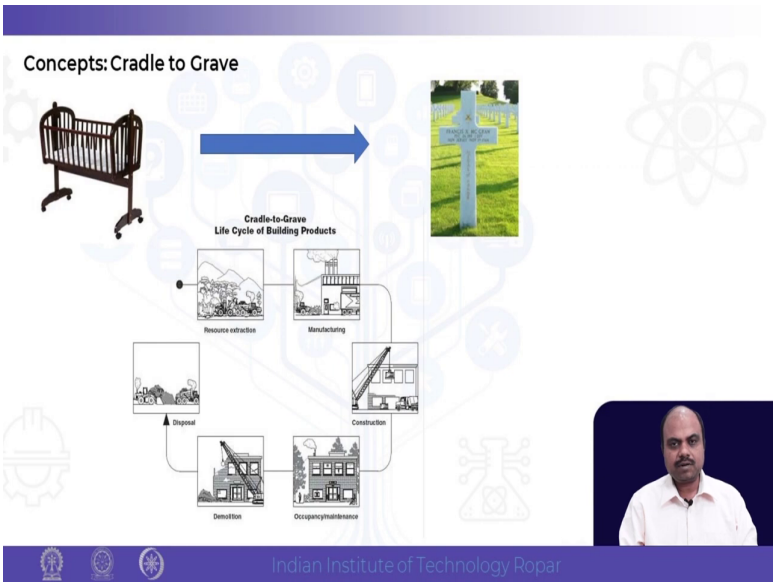
Module - 05
Embodiment Design and Eco-design
Lecture - 25
LCA and design thinking on LCA

(Refer Slide Time: 00:34)

(Refer Slide Time: 00:38)

In this lecture, we will be discussing about LCA in more depth Life-cycle assessment. But before we discuss about LCA, we need to understand some basic concept, one is this design for Cradle to cradle.

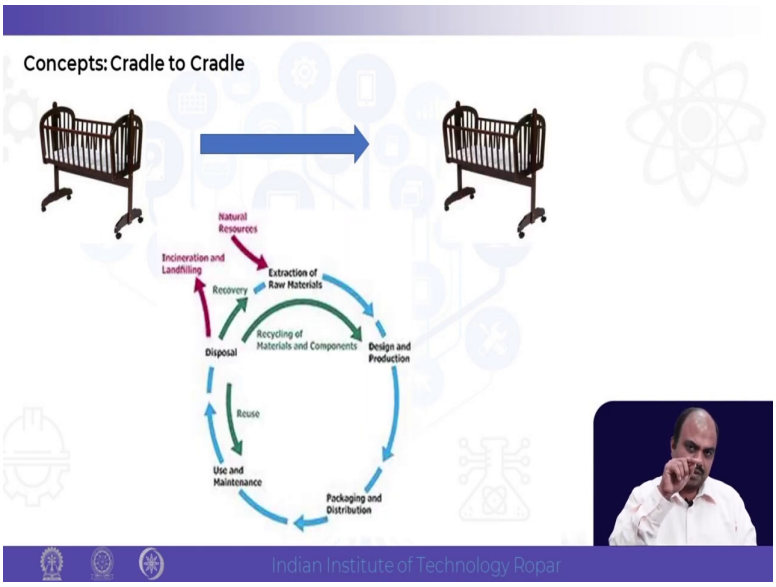
(Refer Slide Time: 00:45)



So even before that we need to understand what is mean by cradle to grave? So, in this image which you see here cradle as you know is when a child is born, we keep them in cradle. Grave is when somebody dies, we keep in the grave. Similarly, for material cycle also, the material is going to go through from the extraction to manufacturing, to construction, to usage and then disposal.

So, do you think cradle to grave is a good concept, is good idea or not? So, cradle to grave is equal to increase the amount of waste. So, we need to do something on this. That is why cradle to cradle is going to come, cradle to cradle is where?

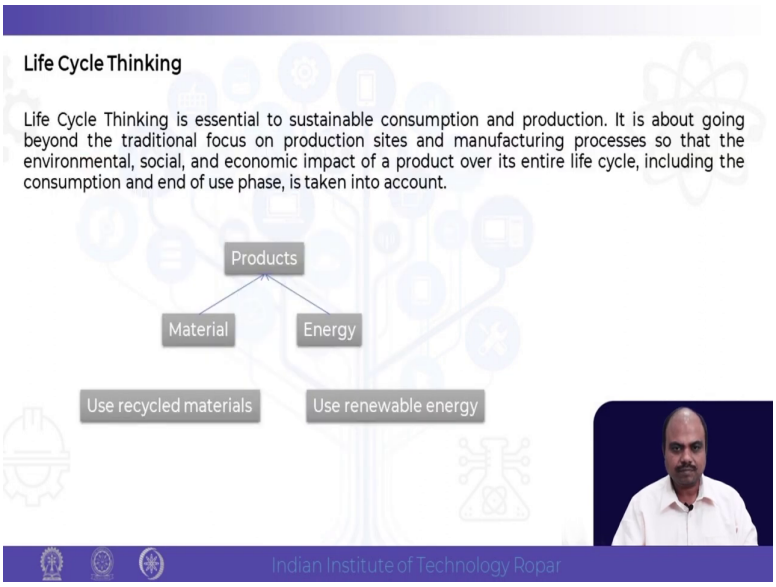
(Refer Slide Time: 02:01)



We are going to take the material and complete the cycle. So, while disposal or before even disposal, we are going to take care of so from the extraction, production, distribution, usage, we are going to either reuse. So, is going to go back to the usage part of it or part of it could be recycled material, which is going again to the manufacturing part of materials can be recovering.

That is, it is going as a ingredient for the raw materials. But unfortunately, there are there will be some part which is going to go for incineration landfill. That, if we can completely eliminate, then we can say, yes, we have achieved cradle to cradle.

(Refer Slide Time: 03:06)



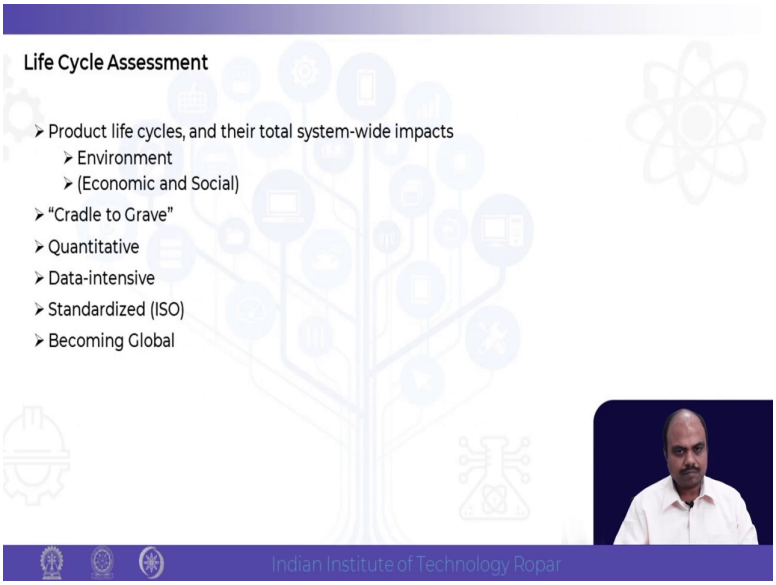
So, what is required for this? What is exactly we required for this achievement? If you want to achieve this, we need to start thinking in a different way. So, we need to think in a way which enables us to have cradle to cradle. That is life cycle thinking. You think about the entire life cycle of the product and see how we can achieve this cradle to cradle.

So, what is this life cycle thing? It is essentially to sustainable consumption and production, it enable us to sustainable consumption production. It is about going beyond the traditional focus on production sites, manufacturing; so, the environment, social and economical. So, we have already learned these three pillars of sustainability and this we need to think about the entire life cycle.

That is why in-product design is so important that we think about entire life cycle life cycle as a product, from the consumption, from the usage and take care. Something else, we need to

think of that products have materials and energy. So, we should use recycled materials and we should use renewable energy as much as possible.

(Refer Slide Time: 04:31)



So, product life cycle assessment either is LCA, where the originally LCA is basically from cradle to grave. Is the quantitative system or quantitative soft tool data intensive very much is standardization ISO fourteen thousand is related to the standard of LCA. Where, in ISO 1400 part of the ISO 1440 especially talks about LCA. It has already become global LCA.

(Refer Slide Time: 05:10)

Of course, there are some eco design strategies which is very which are very important like you know, you use of eco design strategies. Some of the recommendation for this are reduce use of material content of the product. So, how we can do that? Previously, if you see the engine of car, it is so heavy, it is not optimized. So later on, people optimize it, reduce it the weight. So, the material content is reduced.

If the material content is reduced, then what is going to happen? The car is lightweight, is going to use less fuel, is going to run faster. So, the material content of the product if it is reduced, then the material requirement for this manufacturing the material product is also going to reduce. Reduce energy content. So, how to reduce? There are again, if you see any car, previously it is not that efficient, lot of fuel is to burn.

Now, car with the same 1 liter of petrol, it can touch much longer. It can you can drive or one can drive or you can cover a longer distance. So, this is what it is about energy content and energy usage. Next thing is something important is try to design ideal product, where no product. So, ideally if you can eliminate the requirement of product itself, still the, if satisfy the need, then fine, you can go ahead with this one.

Then increase recycled material of the product percentage that is going to help. Design products for life and this is again important. Previously, 2-wheelers used to I mean previously our uncles and fore-father they use to. I mean, so these 2 have 2-wheeler, same 2-wheeler for 15, 20 years. Now, new 2-wheeler we are purchasing after 5 years, there are so many issues are there. So, these products are not designed for life.

If we, if a product is not performing, then people going to get frustrated and change the product, which should not happen. But having said that, it is not just about designer's problem, it is also about the problem of the technology. This is a mobile phone. If you see that mobile phones, there are certain people who are changing the modal of mobile phone very fast, because they wanted to get some one new, new things, new mobiles new stuff, which is not required.

However, there is certain, the, sometimes we are forced to change, take for example, when the service of 4G came, 3G mobile phones are not that useful. There are some issues were coming, people have to buy 4G mobile phone. So, that is called technical obsolescence. And second one is about product obsolescence. So, sometime we change the product.

So, if you have a product, which is having a longer lifetime and we ready to use, then this product will better, right. Next is eliminate unnecessary and unused and unnecessary product features. There are now many products are products are there, which is having many features, because people tend to buy a product when which is having more, more and more features.

We really need that. So, sometime we do not need products which are having so, many features so, many features we do not need. So, let us buy the products which are required,

satisfying our requirement. So, the designer is a responsible, just do not just try to sell a product, just because we have added more, more features, better that we focus on requirements.

Design for fast economic disassembly and major components prior to recycling. So, we need to do the another design strategy that when a design product is there, if we want to recycle, reuse, we have to dismantle, because product is made with multiple materials. So, if it difficult to dismantle is difficult to recycle, make it such a way, it is easy to do that.

(Refer Slide Time: 10:15)

Some other things are design products, compliant to standards and directives, RoHs, WEEE, REACH. So, restriction is hazardous substances, WEEE and REACH. So, there are some these products which we are going to design, it must be standard compliant, otherwise we cannot send this. So, these product it will take for example, any product will be electronic

products we make, computer, laptop, mobile phone, charger, all these things has electronic circuit.

And if you want to share this product in interest of market, even in national market, it has to basically adhere to some other standard, which are there already the market. RoHs, restriction of hazardous substances is one of the standards. WEEE w waste electrically electronic equipment that we have another standard. Reach are (Refer Time: 11:16) standard for chemicals.

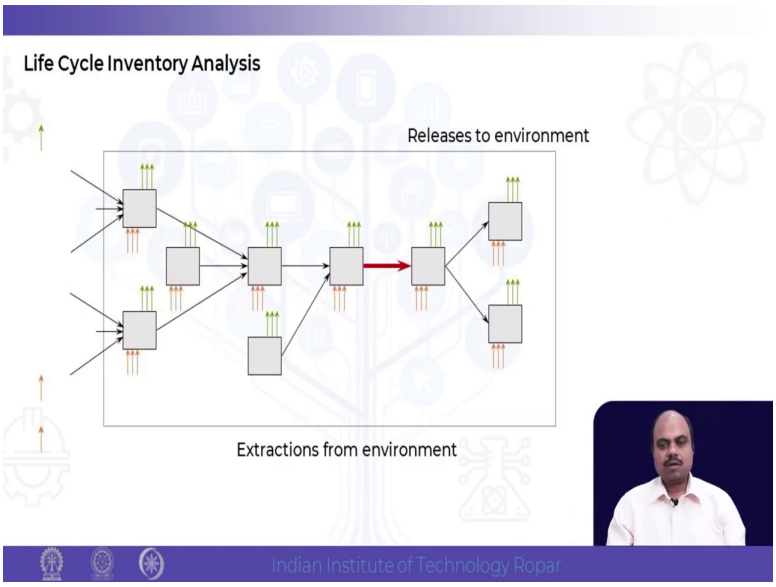
So, these standards need to be maintained very rigorously. Design products that could be used, reused, recycled and remanufactured, which means that when we are designing the product, we are not thinking about just usage, how the people are going to get satisfied? You know, that is the minimum thing, but apart from that how we can bring back this material back in the, make it a closed loop cycle. How can we reuse?

How can we re-manufacture? How can we recycle? Then LCA, we have to conduct life cycle assessment and where the opportunities to reduction that we can do and improve the ecological performance. Takeback is another thing, companies should be able to understand that products are often used for a service right, like previously the Boeing and airbus, they used to buy engines for their flights, for their aeroplane.

However, nowadays, many times they basically rent the engines. So, Pratt, and Whitney other, Gee, other companies, they are going to give engine service and their service maintenance and all this costs are being borne by the company. Same as often, we rent a car, right, for 566 days if you go somewhere, you rent a car. So, we do not need to always buy, we do not need to always buy things to use, sometimes we can rent it, right.

So, similarly, in the product, if somebody wanted to use it, if I design a product so, that it can be taken back by a company, then you will design the product very differently. Then, lease the product or sell the service that is I told long-term performance and end of life collection that has to be done in a better way.

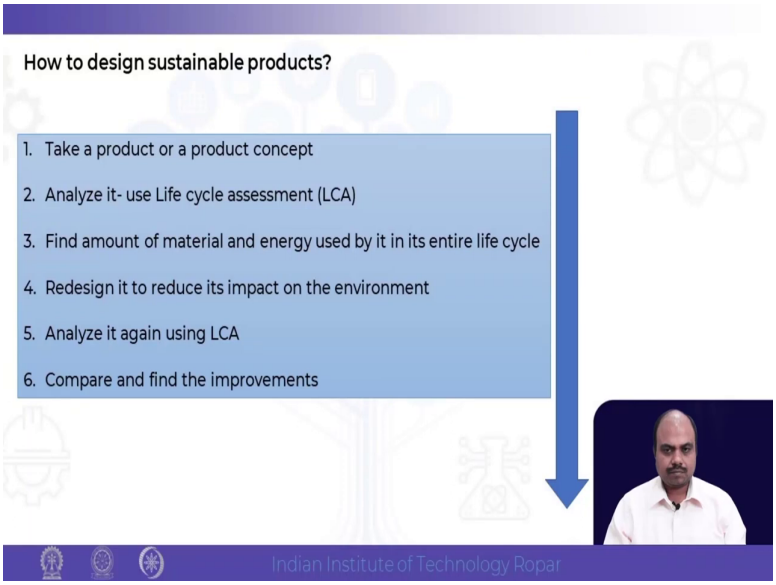
(Refer Slide Time: 13:17)



So, when you have the life cycle assessment, and life cycle inventory as analysis, if you take a black box, if you take a product, what are the inputs or which are which things are which are going while making their product? It is a (Refer Time: 13:34) generally it is product, material and energy and what is released to the atmospheric sometime it is waste, sometime its products, sometime its by-product and other things. So, this is we should, basic analysis, we should do input and output analysis.

(Refer Slide Time: 13:50)

(Refer Slide Time: 13:54)

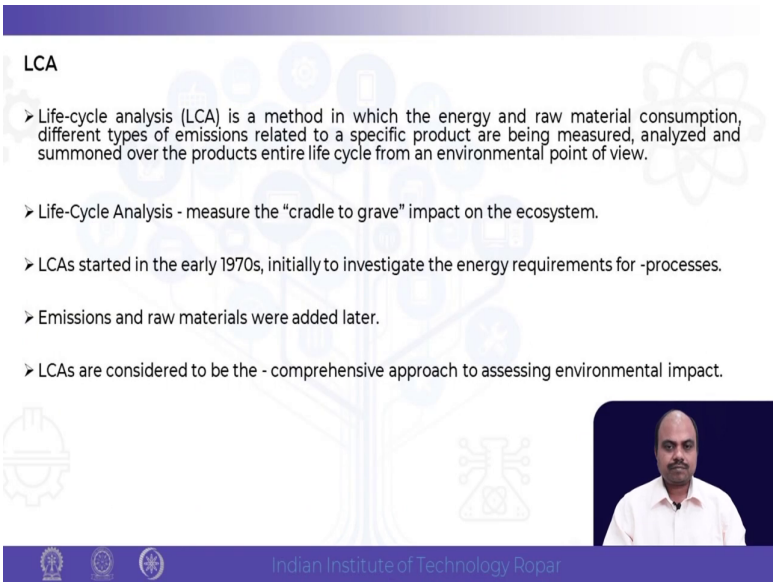


So, now, we are coming to sustainability and eco design. How to do sustainable product design? Take a product or a concept, select whichever you like for analysis, then analyze is to use life cycle assessment, find out the amount of material and usage during the entire life cycle and each and every phases, redesign it wherever you can see that lot of possibilities of reduction, analyze it again with the else here and then compare and do the improvement.

So, this is a good way of reducing the emissions, reducing the waste, reducing pollution. Emission means, not always the carbon dioxide emission or equivalent, the waste we are creating, that also is basically waste, that also is something which is undesirable.

(Refer Slide Time: 14:45)

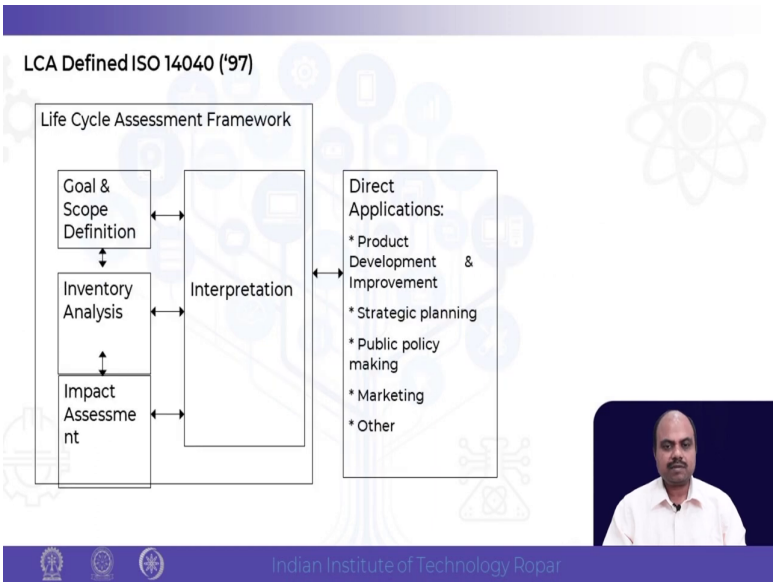
(Refer Slide Time: 14:49)



Now, we are going to go little bit of LCA. So, life cycle assessment is a method in which energy and raw material consumption and different types of emissions related to a specific product are being measured, analyzed and summoned over the entire life cycle product.

It is from cradle to cradle grave, grave concept and it started like in like kind of 1970s. Emissions and raw materials are were added later, and LCAs considered as the comprehensive analysis assessment of life cycle assessment.

(Refer Slide Time: 15:18)



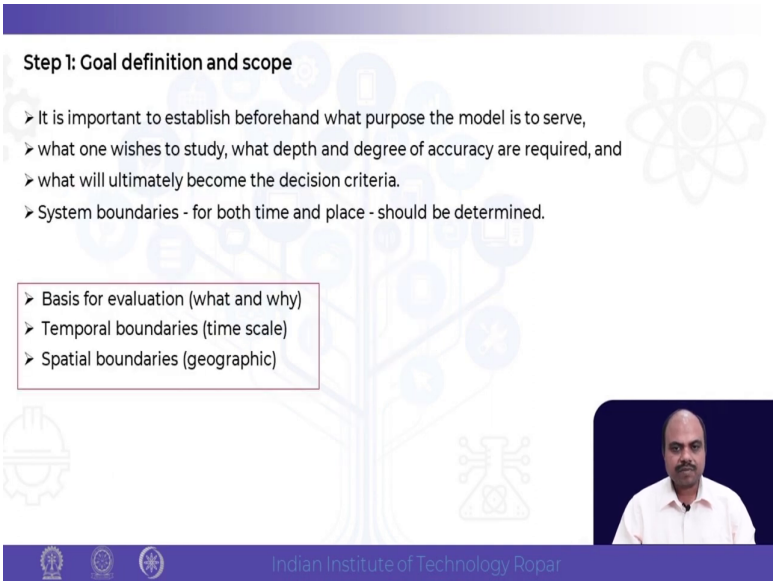
So, now, in this slide you see according to ISO 1440 standard, this is the framework for life cycle assessment framework. We start with goal and scope definition where you actually try to figure it out what exactly is scope, goal of this issue is, what is the goal of the problem and what exactly the problem we are going to address. Second is inventory analysis, inventory analysis where you will assess the entire life cycle of the product. Starting from the extraction raw materials to manufacturing, to design and is going on.

So, is what exactly is going on in the product and what exactly is coming out of the product. Then we goes to impact assessment. Impact assessment is for this you can convert it to CO 2 emission, CO 2 equivalent and various other assessment and you can use assessment criteria like assessment methodologies also. And this can be done either using manual way or you can use some kind of tools for this.

The interpretation which is going to go all the way around for the goal definition inventory analysis and impact assessment. This impact in interpretation is basically telling us how you going to interpret this analysis, what is your interpretation in terms of the expertise which somebody is having in LCA. So, what are the; what are the issues in this in this analysis in the results?

And direct applications of this is in product development, strategic planning, then product policy making, marketing and others. The wide range of applications of LCA which is there which are there.

(Refer Slide Time: 17:13)

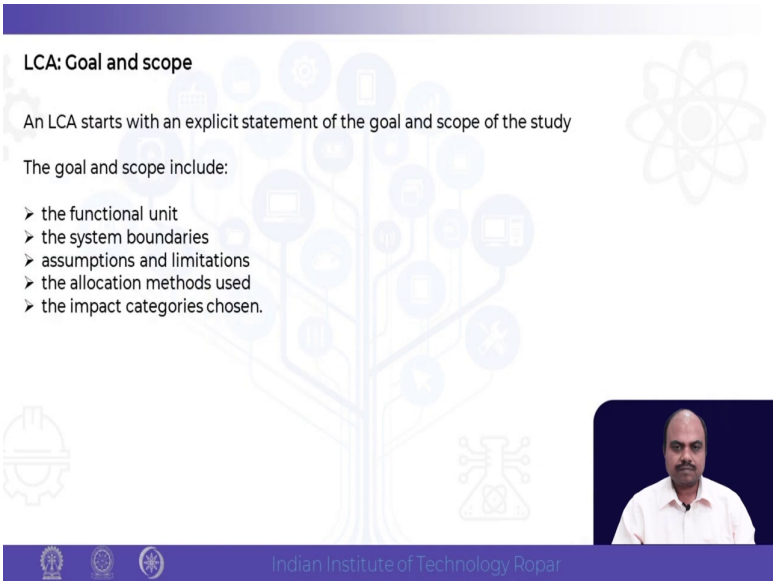


A little bit of description of this is goal and goal definition and scope, it importance established beforehand and the model is serve and when one wishes to study where the system boundaries. So, take for example, we are going to identify the pen. So, if you want to

do LCA pen, are you talking about only pen? Or you are talking about the machine which is required for the manufacturing of this pen or something else.

So, what is the system boundaries? So, what are the basic evaluation technique, what are the temporal boundaries? What is spatial boundaries, spatial boundaries, geometric geographic boundaries?

(Refer Slide Time: 17:55)

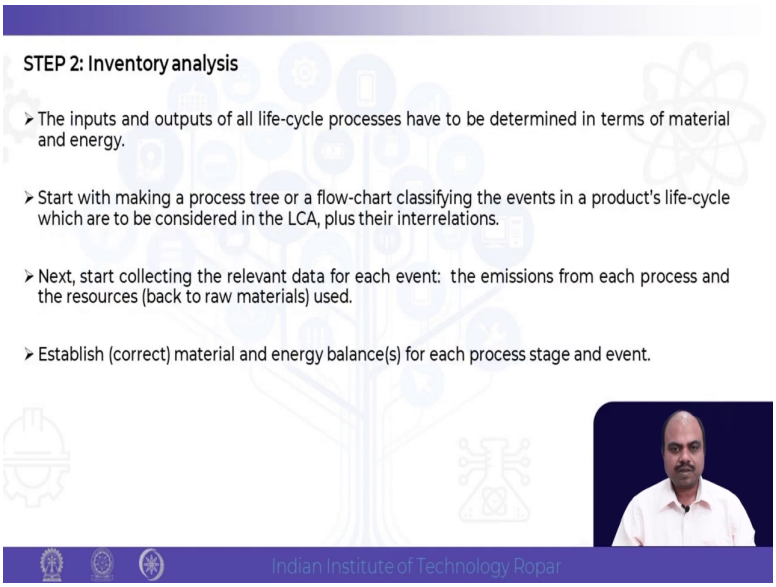


Next is goal and scope. here what is the functional unit? System boundaries, assumptions, limitations, allocation methods. So, allocation method is something like if you have same machine, same manufacturing base, same manufacturing room is being used to design sorry to manufacture two or three different components. Same machines are used to design to manufacture them.

Now, the emission caused by each of this machine had to be attributed or divided into such a way that it have some amount of emission added to the one product and similarly for others. Impact category chosen, are you talking about CO 2 emission only, are you talking about health issues, are you talking about. So, there are so, many ways in which you can measure the impact, which one you going to take.

So, there is no standardized method for method of this. But there are some methodologies which can be used for this.

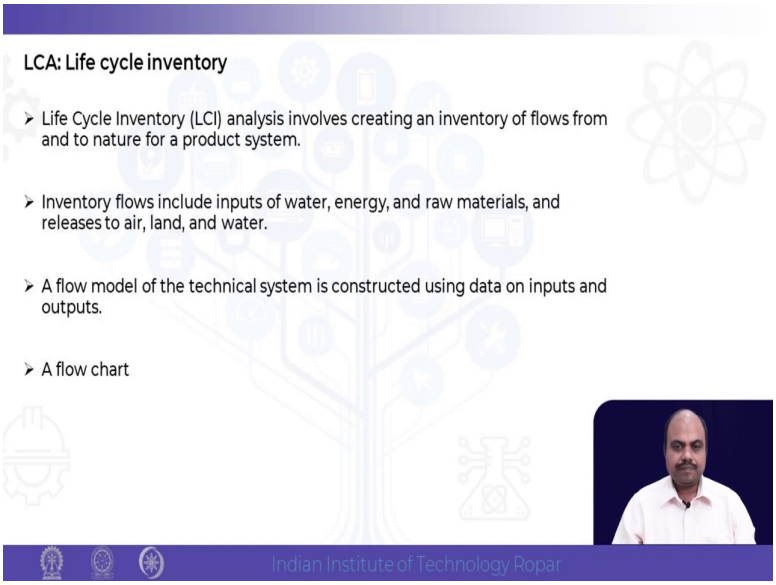
(Refer Slide Time: 19:07)



Inventory analysis, it is the input output analysis determined in terms of material energy. So, that is what I told that what are the things will be going inside and outside. Start making a

process tree, classify them, find out relationships, relevant data you analyze, take it, then establish the connection between the material and energy balances.

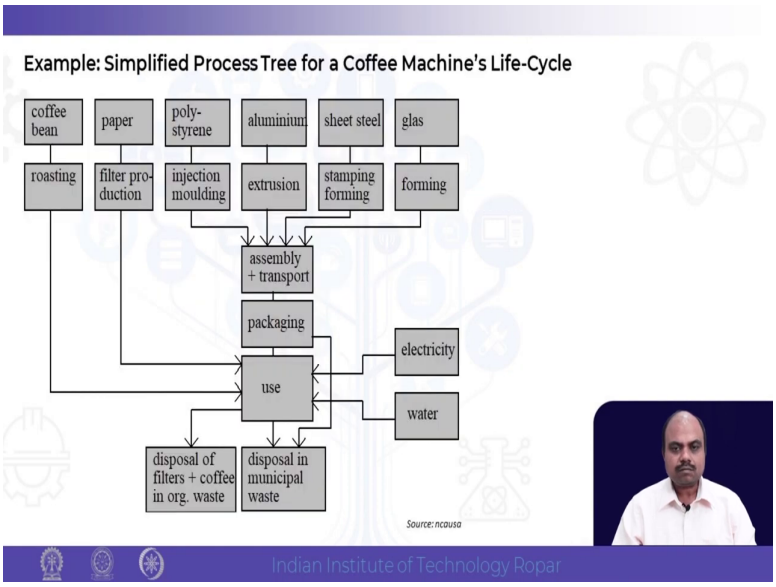
(Refer Slide Time: 19:39)



Next is LCA, where life cycle inventory analysis that is LCI, life cycle inventory analysis involving the inventory flow from and to the nature, what is going from the nature. What kind of material, at what stage, what energy and then what is going to the nature? In each and every life cycle, each and every phase of the product.

It could be water, it could be energy, raw materials released from the air, by the air to the air, land water and the flow model you make flow chart and put the values also that is very important amount.

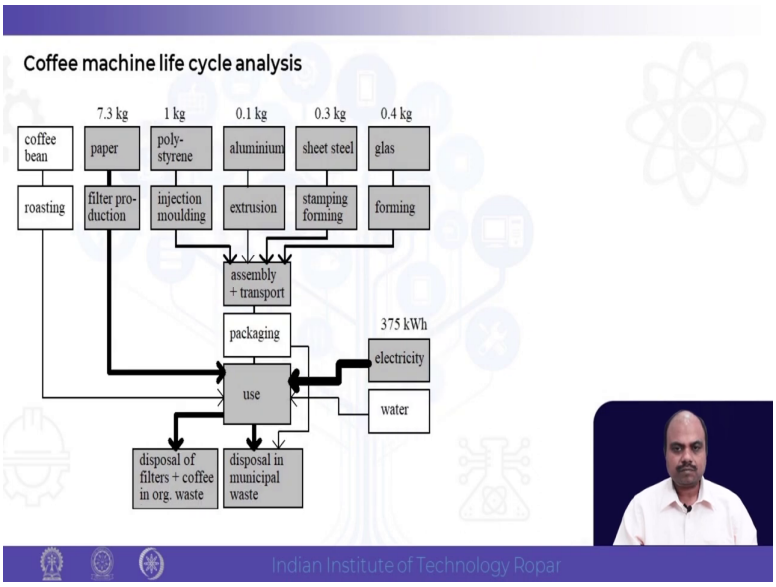
(Refer Slide Time: 20:26)



So, this is an example of you know simplified LCA, one of the example of LCA done on coffee machine. Coffee machine, if you see here, see that one coffee machine either where it will put water, filter paper, water and there is a bucket is also there that jug is there and the machine is going to heat the water and then add, there will be another place where you can put coffee, powder and it is going to heat the water, add the coffee and give it in the jug and then you can take the coffee.

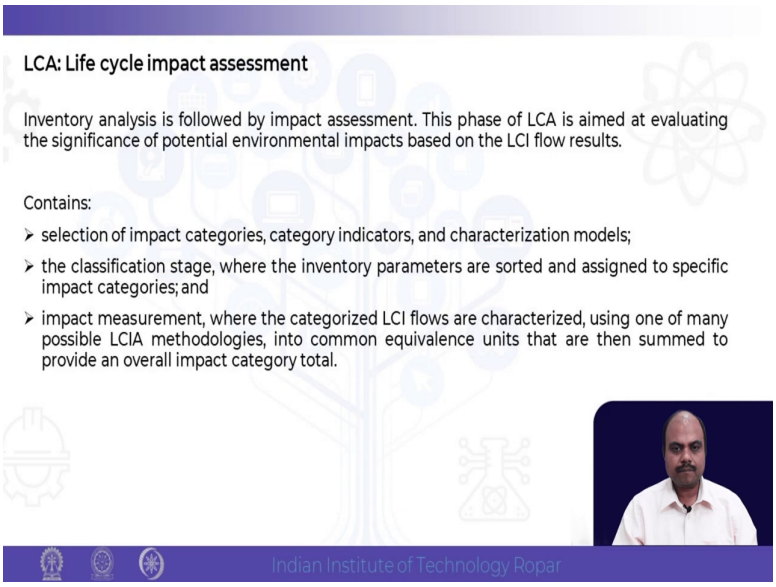
So, this block diagram is going to show showing how this, what kind of components are coffee bean, paper, poly styrene aluminium material is used and then is going to go and assembly and packaging usage after use so, this is the entire in short life cycle of the product coffee making. Coffee machine.

(Refer Slide Time: 21:33)



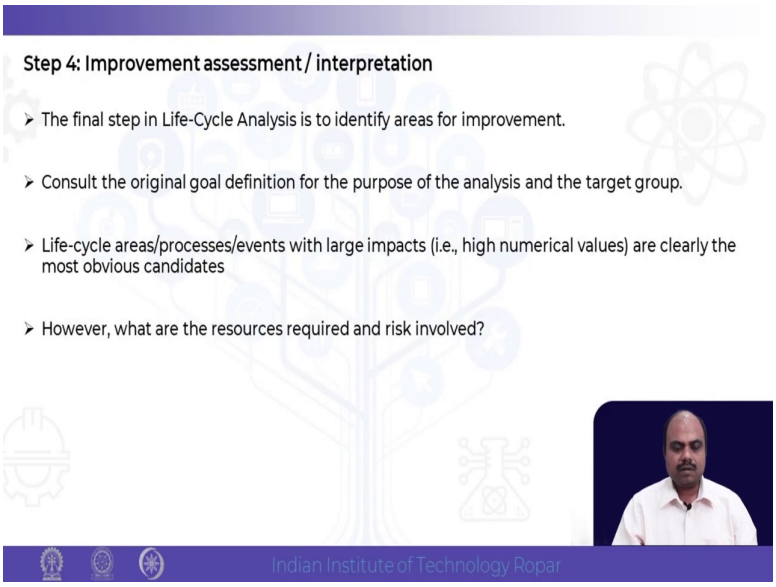
Then you put materials in terms of how much material is gained, seven 7.5 kg of paper is being added, 1 kg of poly styrene, 1 kg of aluminium and all these things each of this and also energy. This is very short version where more detail is of course, required and then you find out the electricity also how much is required.

(Refer Slide Time: 21:55)



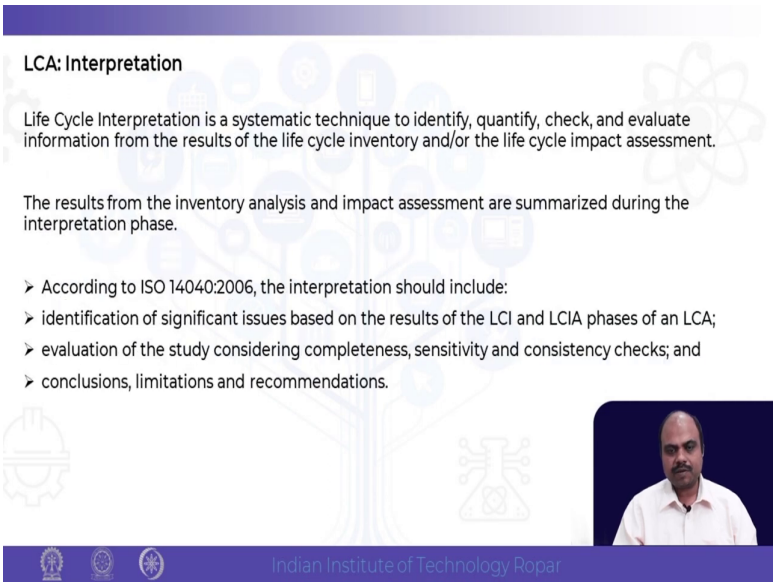
Then you put life cycle assessment, it contains impact categories, category indications, categories models, stages and impact measurements, LCA flow.

(Refer Slide Time: 22:19)



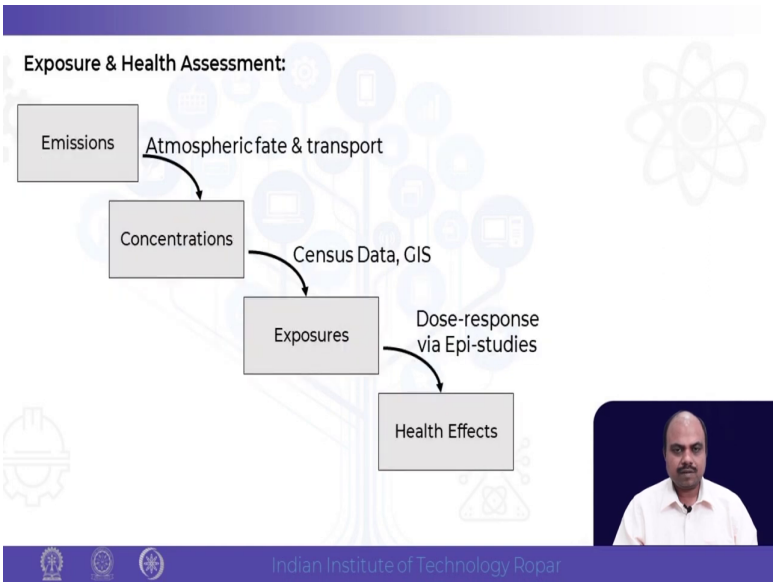
Then impact assessment, interpretation, final life cycle stage analysis stage analysis is done, original goal definition is done, then it is having high impact, larger impact and how these sources are required. This is all the same interpretation we are doing in these stages stage. Step.

(Refer Slide Time: 22:39)



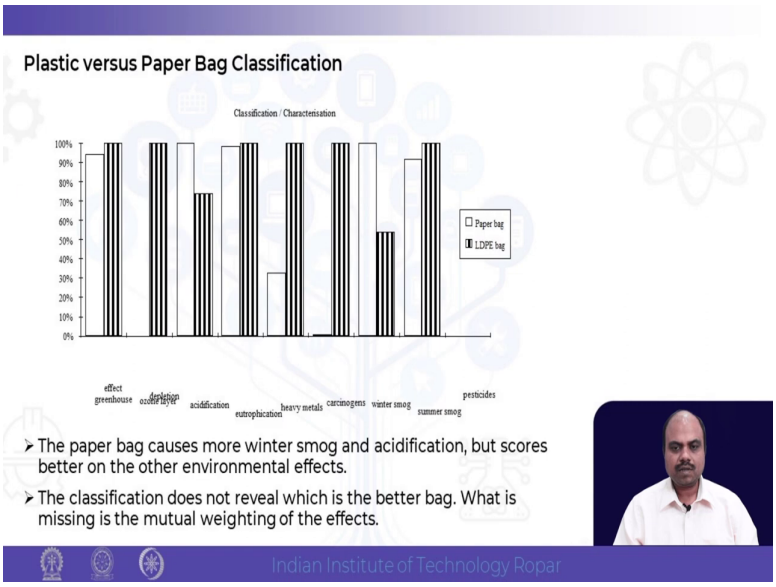
Then LCA. Interpretation is systematic technique to identify quality check and evaluate information. Here we are using ISO 1440, 2006 version new one also. It is with respect of LCI, LCA, we evaluate study and considering completeness, sensitivity, we can use consistency and then conclusion limitation and recommendation.

(Refer Slide Time: 23:08)



Now, here one thing I am going to ask that ok emissions are taking place. So, how this is related to human health? So, this slide is going to show is showing that emissions, it is adding to the atmosphere, concentration, like how much emission at what rate that we take. And then use census data. Census data means, one location how many people are there and GIS data. And then we have this kind of some kind of research has been done to map with respect to health effect.

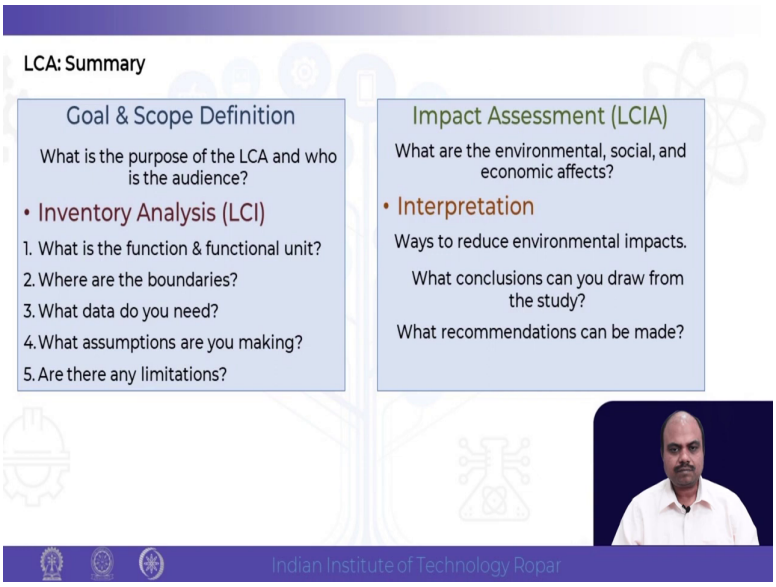
(Refer Slide Time: 23:48)



Now, typical example which you see here, paper bag and coffee bag, paper bag and plastic bag. Nowadays if you see and go to the market in any name of environmental sustainability, you will get a paper bag right and you feel that is good, plastic bags are many times eliminated. But these right thing to do or not think. If you want to use paper bag single time or plastic bag single time, then paper bags are better.

However, if you want to use multiple time, then of course, plastic bags are good right. So, this is analysis where it is having various effects on winter smog, acidize, other things and how they are performing with respect to each other. These analysis is done. You can do LCA and find out even there are different kinds of paper bags, there are different kinds of plastic bags. It is not that easy to just tell, this is better than that, which is not better. So, LCA is going to help us in understanding that.

(Refer Slide Time: 24:59)



So, summary of LCA, goal and scope definition, what is the purpose? Inventory analysis, functions, boundaries, limitations, interpretations, assessment first and then interpretations on the environment, all these things are summary of LCA.

(Refer Slide Time: 25:22)

See, LCA is a really difficult task. It require lot of data, lot of analysis. So, for smaller product, you can do it manually may be we have done, many times in research. However, for many other products, we need help. So, there are some software and very good software available with data initially for us data, European data. Now, it is lot of Indian data is also available.

So, this software is going to help in especially in the impact assessment from the emission to impact assessment finding out the values. Gabi is very well known, SimaPro is another well-known tool. then IDEMAT is another one, LCAiT team, EcoScan, IVAM, LCA Data, these are things which are can be used. So, first two are very important and very widely used. This energy of the software can be used for this.

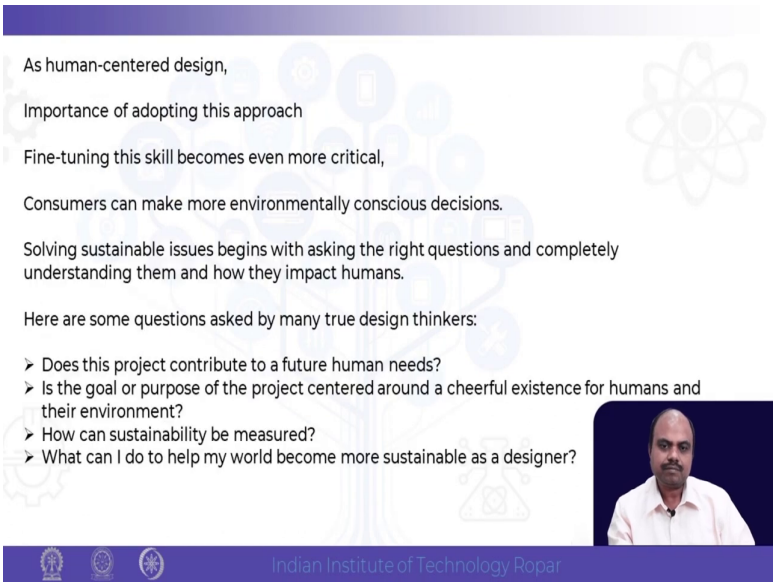
(Refer Slide Time: 26:21)

(Refer Slide Time: 26:36)

Now, design thinking. Design thinking can be extensively used in sustainability, to achieve sustainability. And here we are going to get a get little bit understanding of this. The design thinking is an innovative and creative approach that we have already know to solve most of the today's, most of the complex problem and sustainability, achieving sustainability and this is what is also regarded as a very complex problem with multi-dimensional problem.

So, design thinking aims to develop creative and user related ideas to find out resolutions and positive impact on the future. It is related to it is referred to as solution focused thinking. So, we means that asking the right questions, knowing about sustainability, sustainability cost, sustainable strategies and involving the stakeholders. So, all these things we have to understand and then we can use design thinking.

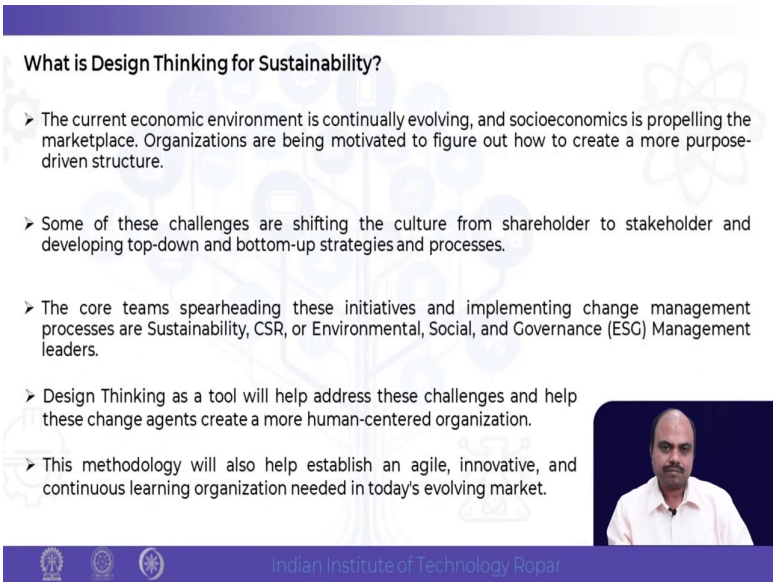
(Refer Slide Time: 27:29)



So, as human-centric design, it is important to adopt this approach, fine-tune and customer should be more environmental friendly decisions should be making, solving sustainable issues. And some of the questions we should be thinking, does this product contribute to the future human need, it is not just about making money by the company, is it really, is it useful to the customers?

So, is the goal and purpose for this (Refer Time: 28:11) does it make people happy and the environment? And how is sustainability in this, with respect to this particular design can be measured? And can I help people to be more sustainable?

(Refer Slide Time: 28:20)



So, what is design thinking for sustainability? It is a current environmental economical environment and continuously evolving and socio-economic in propelling the marketplace. Organization being motivated and he has a challenges to shift from one (Refer Time: 28:37) to top down and bottom up strategies and the governance leaders that is sustainability that is ES CSR and environmental social responsibility that we have to need to focus.

So, it helps a lot and involve the people especially designers for about to think sustainability in using design thinking approach.

Thank you.