Strategies for Sustainable Design
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Lecture 23 & 24
Lifecycle Analysis Part A

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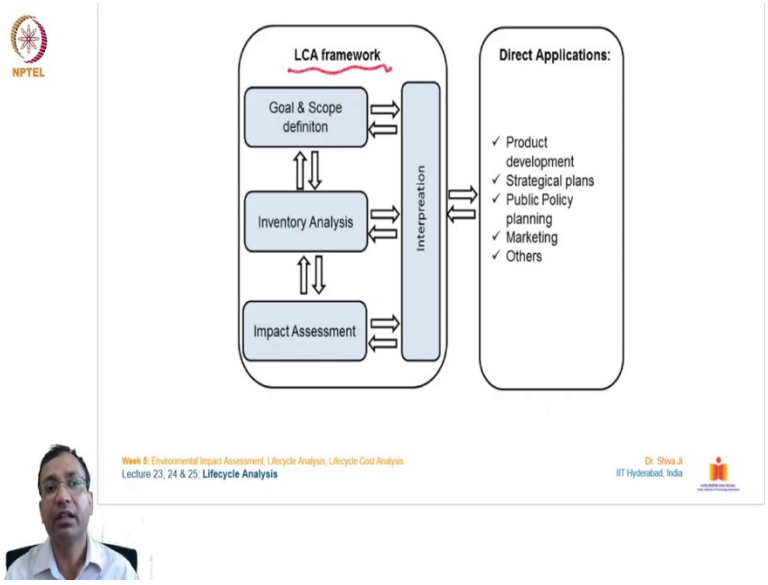

Hello everyone, today we will discuss about lifecycle analysis. So, what is the life cycle analysis? So, life cycle analysis is a process through which we analyze life of any product. So, what do we mean by life? For example, any living organism, any living being it gets a birth one day and it, it lives its life it consumes resources, it releases some a excretions and things and then it dies one day and it goes it, it gets disintegrated, gets decomposition goes back to the nature only.

So, similarly any product what we design today or we manufacture today so any project which we execute today any developmental project anything. So, that also gets its life one day it runs for it's a usable a lifetime and then it gets a degree of discarded once the age of it's a usability gets over. So, at that time it goes for a dismantling here, decomposition, degradation or whatever, depending upon it's a moleculer or a materialistic material a properties and things it gets or it comes to the end of it's life cycle.

So, that is entirely the basis of the very generic understanding of the life cycle analysis. So, let us see this illustration over here, this talks about kind of an interrelationship between different

activities and it talks about the interrelationship from an outsider a, it is a limit also. So, if you see the the first one a for any a such product, there must be a goal there must be some scope and usability of it.

So, based on that, it will go for inventory analysis based on that we go for an impact assessment and meanwhile, while carrying out all of these activities, it will keep on corresponding, it will keep on interacting with the other entities other stakeholders also. And as a direct application as a, a direct impact of it, it produces some sort of a some sort of, it satisfy usually some functions it fulfills some functions it fulfills is a purpose, it exerts some kind of impact. So, there will those are things which we list under are these are direct applications. So, for example, the product development, a strategist, statistical a plans public policy planning, marketing etc.

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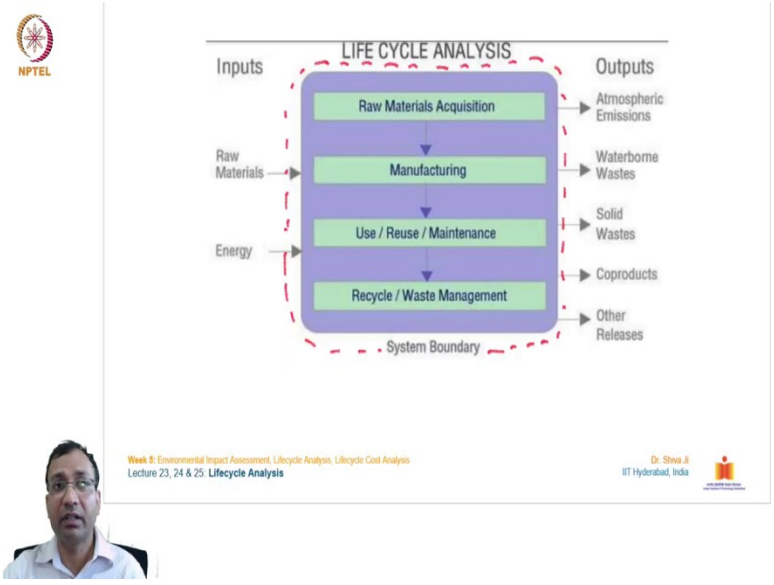

It will be more clear in this illustration over here if you see, so, this red boundary red this red dotted line is this system boundary off that particular for example, the product So, within that boundary, it now, acquires it sources the raw material, it goes for the manufacturing processes, it takes up the fabrication facility and in any sort of construction or the manufacturing or all of the including all, all, all varieties, whatever is needed for that particular item.

Then it goes for it is a usable life, it goes for a reusability and then it goes for even a normal a maintenance, depending upon the requirement for example, any building so, once a constructed,

we keep on maintaining it we keep on repairing of it, repairing it for any sorts of a faults which are coming up into in its functionality and it is a structure or in any of its component whether it is building services related things or anything.

And then it goes for the at the end of its a life cycle it goes for recycling, it goes for waste management and those activities the end of the life stage activities. So, out of this boundary of how these things take place they takes, it takes a lot of resources from the outside so they are in the form of a form of a raw material or even a finished product. And in form of the an energy. So, the energy is also one of the very important inputs what it receives and in turn as an output what it gives is the atmospheric emissions.

For example, all sorts of a CO2 and other GHG gases, and then it gives you a even a water based a pollutants, effluents, etc. Then it discharged is a solid waste also it gives is a solid waste also some, some metal based some waste or maybe some chemical compound waste based or maybe some even organic compounds our organic material based waste any sort of a gaseous liquid or a solid waste.

Then it gives a cool product also a byproduct also that this is all sorts of other these things also and there are some there are some other releases also as they are in the in the form of the other forms of energy. So, there are some more inputs, there are a the main component the main body of it, and then there are some outputs also. So, this is entirely kind of encompasses the overall life of any product. So, for example, we see our mobile phones, so, our mobile phones utilize the different sorts of metals, they utilize plastics. So, it uses a lot of resources, it consumes the n number of material and then it exerts some kind of impact.

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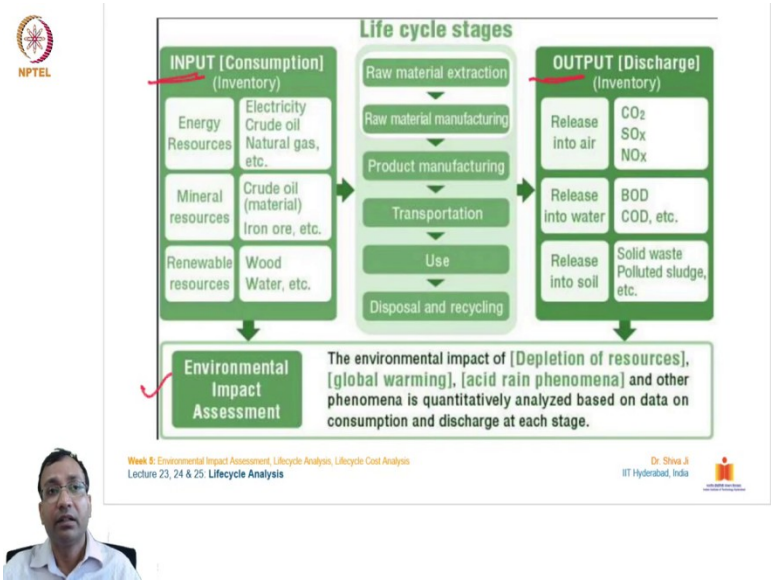

Let us understand this, from this, next slide over here. So, in the input to area if you see a conjunction as a little conjunction material for that unit over here. So, there are things energy is one of the major components utilized for as a, a resource an input resource material in the form of, a direct electricity or in the form of a crude oil natural gases.

So, these are all forms of, energy are they required for generating energy then it is required for mineral resources such as iron or different other types of a mineral based materials, ore based materials for, for bauxite is for aluminum industry and things that. Then there are a renewable resources which are also required to a certain extent such as a water, air sometimes a timber, wood, etc.

So, these are literally renewable resources or nature based resources, which are finite in number. So, these are also required for as a input material, then it goes for processing goes for extraction, the manufacturing, it goes for the processing part of it then it goes for a transportation from one place to another transportation of the raw material, then transportation of the finished material, there it goes for the uses part.

Those are the uses is the major part where the end user interacts with the product, consumes that product or lives with it, and it in turn, for depending upon the product, it provides select the maintenance it provides the energy it provides the repair and if it provides the other

consumption, a consuming materials as a raw materials for that product. For example, if an automobile is there, then it requires constantly the hydro if it is a a hydrocarbon based engine, then it requires a hydrocarbons to keep running.

So, those kinds of a raw materials are also the input materials are also needed for the main product of which we are analyzing. Then at the end of the life stages goes for the disposal and recycling. So, in the nutshell, this is the overall philosophy behind LCA, Life Cycle Analysis and is the output is releases, releases n number of a gaseous and liquid effluents then solid effluents and a solid waste material and things that.

And there if we compare if you compare with the Environmental Impact Assessments, so, there are some sorts of impacts on all of these 3 the stages of the LCA etc. So, if you see on the a bottom left side portion, so from there it starts exerting its impact. So, for example, if you are if we are extracting natural resources, if you are extracting hydrocarbons if you are extracting other a wood timber and if you are harvesting trees, etc.

So, there are some kind of an impact we are exerting on the ecosystem. And while it is a usage in it is a main lifetime period, if you are consuming even more resources. For example, I gave the example of automobile. So, there also it is, it is, it is exerting impact. And on the, wastage part if it is a discarded then how it is going to gets disposed in the nature.

So, whether there is any a recycling facility available to take care of this a waste product completely or it is going to generate some impact of through, it is a waste of material or through its entire a functional life it keeps on emitting gases. SOx, NOx gases and several other types of against this. So, they are all the kind of the outputs of the waste material or the discharges with which a product releases over it is a lifetime.

And in turn well we are all aware of the other an impacts which are happening at the a global level for example acid rains. For example, a global, global warming, warming itself and the depletion of resources the contamination of natural resources such as air, water and earth, noise pollution, light pollution. So, all of these activities sorts of things take place in and around a lifecycle of a product.

So, the intent of this course over here is to make you aware of, how these impacts are the different life stages can be handled. So, we will see some of the case studies and some of the lifecycle analyzes of the different types of the products and materials to understand the overall a mechanism, how it functions over the time?

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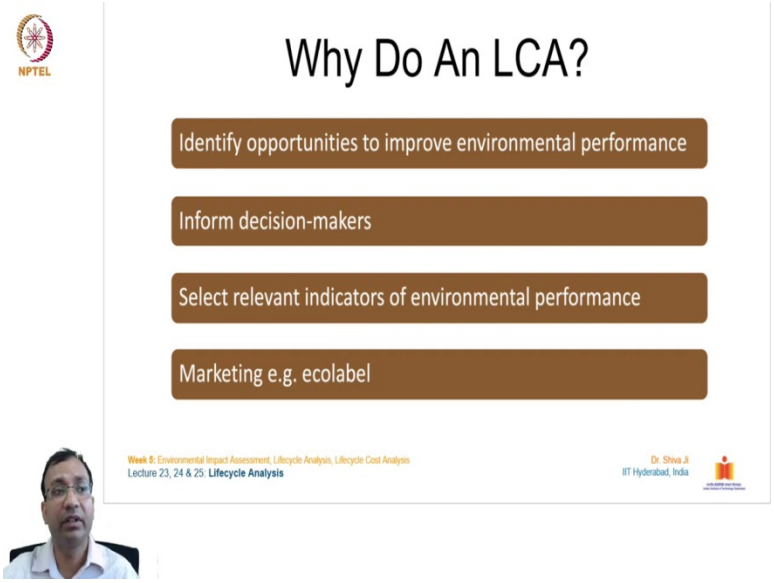

So, why do we need LCA? So, there are simple reasons, the first one is to identify the opportunity areas to improve the environmental performance of that particular product. Because we clearly saw the impacts are possible at any stages of the product lifecycle. So, we must be aware of what are those impacts? And how these are taking place? So, that we can we can minimize it, we can get rid of it, if it is possible completely.

So, we can at least work on it. The second is to take informed decisions. So, taking informed decisions is also a very important factor, because if some sort of repercussions come up later or some, some, some form of a discovery takes place later in the lifecycle of any product, then the there will be a very bad the progressions and after effects. So, we must take or undertake these LCA, LCA etc, for any a product, any newly proposed product, to understand and rectify the possible damages possible impacts this product can cause in its entire lifecycle.

And accordingly, we can take an informed decision. As we discussing the EIA lecture Environmental Impact Assessment chapter. So, Environmental Impact Assessments and these are LCA and these studies are mean for taking corrective measures, mean for informed decision making processes. So, that the overall process can be improved upon. Next one, it helps in selecting relevant indicators of environmental performance.

And lastly, well it helps even devising a certain sorts of a certain a types of a marketing strategies for example, an ecolabel is given over here So, ecolabel is marketing strategy. So, which advertises the responsible products which have been produced which have been properly taken care of through the EIA and LCA sorts of analysis, and they are the result of the, the analysis of such a studies and they are labeled as an ecolabel product.

So, they carry, some an optimum level of responsible behavior towards the ecology, and they are considered to be one of the good ones compared to the other normal products available in the market. Because they exert a comparatively a lesser impact than the generic products. So, such decisions can be taken care of, with the help of a analysis such as an LCA.

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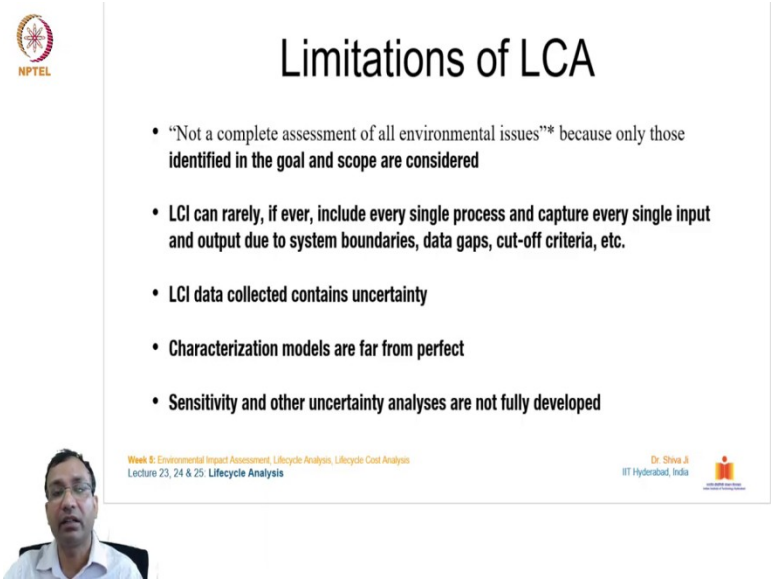

Well, there are some limitations also of LCA. Let us see, what are these limitations? So, well, LCA gives you a some glimpse of the lifecycle of a product, but it is not complete assessment of all environmental issues. Well, it does not talks about social issues. For example, it does not talks

about economical issues also of any a product, so there are some limitations for LCA and we must understand those limitations also so that we can take the informed decision properly.

Well, LCA, can rarely and if ever include every single process and capture every single input and output due to system boundaries, data gaps and cutoff criteria. So, there could be some limitations while, while undertaking that study itself whether the system boundary is a defined? Whether it is a known? All of the data is available? Whether the data is available in the a quantifiable format?

Because LCR analyze on the a quantifiable format only. See if there is some data which is subjective in nature that cannot be processed under LCA. Yeah, and there are some other issues such as a sensitivity issues, something a value system, based issues or something or maybe culture based issues. Those sorts of issues cannot be taken care of by an LCA.

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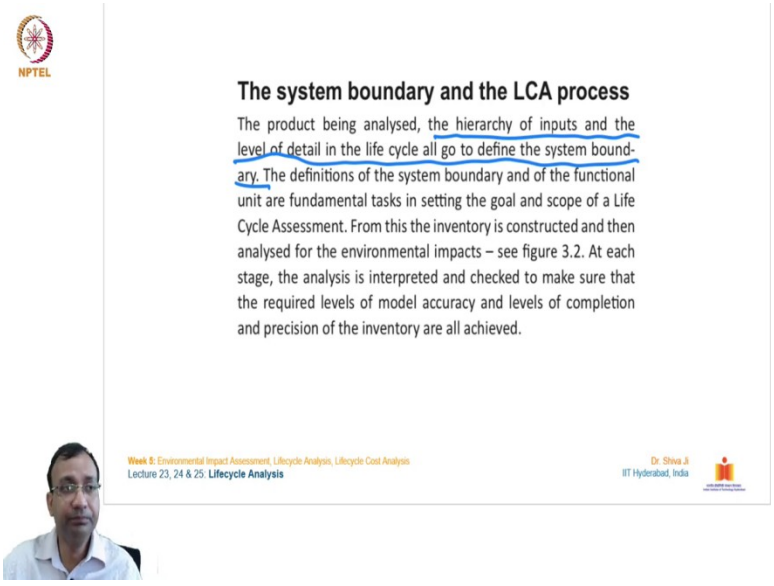

So, these are limitations. So, let us move to the a system boundary and try understanding the LCA process. So, the product been analyzed the hierarchy of inputs and the level of detail in the life cycle all go to define the system boundary. So, as it talks over here, the, the details in the life cycle analysis. So, for example, what are its reaches, what are the different our stakeholders, what are the activities happening between the different stakeholders, how it is behaving. So, all of this in a combined way, it becomes a system boundary for conducting LCA.

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Let us see this illustration over here, it gives an idea of how a typical there are the typical stages inside, lifecycle analysis of any product. So, you can see from here it starts with history with the process of a resource extraction and processing and it goes on with a design then it goes for the manufacturing and retailing then it goes for a distribution then it goes further like use then it goes for a once the end of life happens then it goes for the a collection back or the it goes for reuse recycling, energy recovery or disposal or even if it is a landing in the landfills.

If it is discarded in the simple outside our premises, so, all of those things. So, if you if you see, so, from source till the a manufacturing it is known as a cradle to gate. So, this is being the cradle from where it is getting it is a it is an elemental level from where we are starting to source these materials. For example, if it is our mineral ore, then the ore is the cradle of that metal which we are going to extract from that mineral that ore.

So, from these ore, these mines to this manufacturing unit this becomes a cradle to grave and from this place to the place of its distribution it becomes till the cradle to site then from cradle to grave. One it is it is recycled or reused or disposed of. And if it in its elemental form, it starts from here, it lists its life it dies and if it comes back to again to its elemental form, that is that concept we know it has a cradle to cradle.

For example, if any a natural a living being dies for example, any an animal or maybe even if a tree dies, it just fell into a forest and then it starts deteriorating and disintegrating and over period of time maybe in a year or two or in a 5, 10 years, it will vanish completely. So, mammoth structures such as a tree also is able to disintegrate and decompose into a such a at our elemental level that you cannot have found the traces of it once it is gone.

So, that is a concept of cradle to cradle. So, from wherever it started from a seed in the soil and then in germinated into a big tree and then it lives its life, it died and then it goes back again to the soil. So that is concept of a cradle to cradle. But if a man made a prototype of a human made product, if it is not reaching its cradle to cradle again after the usage, then there is the problem and this is problem of pollution which is happening. The resources are flying at the wrong places and that is causing the whole this phenomena of pollution.

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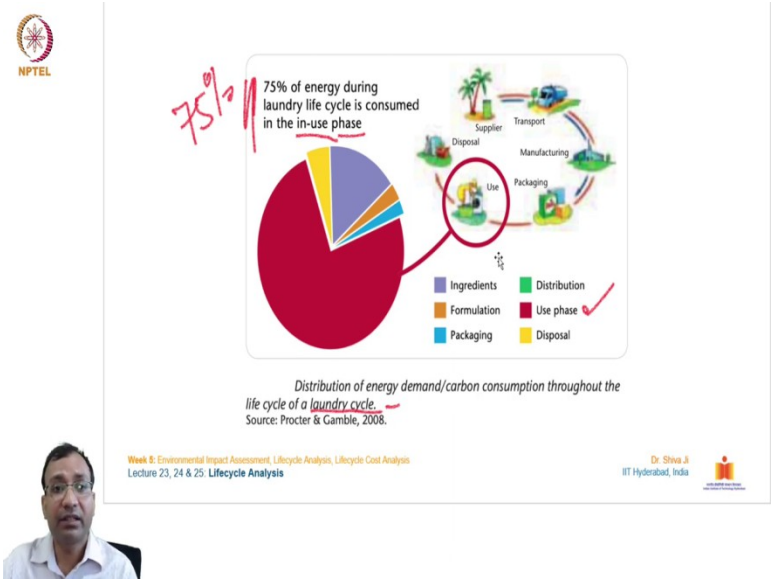

So, let us try understanding these LCA concept through different a case studies over here. So I have gathered a number of case studies from a different a manufacturing units different product types. So, we will try understanding it. So, here the example is for a laundry the cloth washing activity. So, here if you see the 75 percent of energy during laundry cycle, laundry life cycle is consumed in the in-use phase.

So, while it is being used at the, at the user facility, so, this is the place where it consumes a 75 percent of the energy of the entire lifecycle. So, if you see, it starts from a supplier go to a transport, manufacturing, packaging then usage, then disposal. So, this is the typical life cycle of a laundry. So, this is the place where it consumes the highest. So, what is the learning from this slide over here to this use phase a stage is a stage which consumes 75 percent of energy.

So, is there a way to minimize this volume of energy which is consumed by this unit. So, we can work on improving the efficiency of it, because this product or this appliance is going to be there for a number of years, a good number of years minimum 10 years, I think we can say a general a household washing machine or laundry unit lasts 10 to 15 years. So, 10 to 15 years for a product appliance is a long period of time and it is going to consume a huge volume of energy.

Even if it is like used maybe once per 2 days or so, so, how this energy consumption can be reduced? So, this could be the potential intervention area for you and me as a a designer, architect and engineer to work on it and create that the impression create that are lasting effort for minimizing the energy consumption part. So, this energy consumption on the a usage basis becomes focus in a such product.

So, this is the learning from here, we should conduct this LCA because this LCA gives us this analogy, a how much of an embodied energy how much of the usage energy how much of the at the end of the life cycle stays is going to create some kind of impact for example, resource consumption, energy consumption, etc etc.

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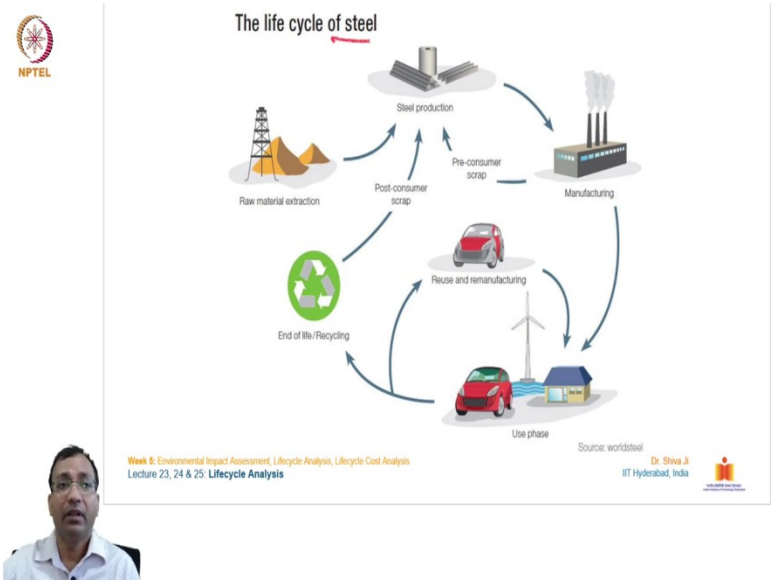

So, let us see for the our next example over here for a lifecycle of steel. So, if you see, steel is an such a material which is the which has become the backbone of our a today's growth and development activity. Without steel nothing is a possible if you see electricity generation. So, all our tools, equipments, all our transportation sector tools and equipments all our machineries all our even electronic gadgets in every level of buildings.

Almost every material starting from a small needle to the an airplane till the a biggest a manufacturing a units from the a hydrocarbon rigs. Every a machinery, every equipment uses some form of the steel. So, steel is the in the recent years has gained the most prominent if we go by the a metal sheet. So, steel is one of the best materials are very helpful materials, which is not very costly.

And it offers a plenty of workability offers machinability It is a adaptable while it is ductile, it is malleable, it is it can be drawn into shaped into n number of, shapes and volumes and structures it can be accosted into any forms we want. So, all our a combustion engines of the automobiles are also costed into a steel based alloys and different are using a different other metal also for it is a rigidity and strength.

So, there are n number of lucky users is if you look around your space right now, you will see a number of applications of steel. So, how the lifecycle of steel looks. So, this is a schematic

diagram which talks about it starts from the extraction of the raw material destruction of the old from the mines. There are a iron mined steel mines in the different places in our country streets of a Chhattisgarh and Jharkhand they are major in Orissa or these are the major supplier of a steel based iron, ores and minerals and from there it goes for the production unit.

From there they take out the metal part from that or and they start sending it for a fabrication and manufacturing for depending upon the requirement of the tools and equipments and whatever you have we need for. Then it goes for the usage phase for example, you can see over here the usage of steel in our building or uses of steel in even energy harvesting units for example windmill is given over there then it goes for a automobile all of those applications in different application it goes for.

Then it comes back again for a reusability for it is a remanufacturing or repurposing because steel is available highly recyclable material. Steel is one of the materials which any scrap dealer, any scrap buyer will pay you for and you can give it to him and it will again that piece of that scrap will come back to the factory and again it will go and get melt and it will again become a part of the some machine or some equipment.

So, steel is such a material which you can recycle for n number of times you can keep it a recycling for a longer number of times you can keep on a purifying it also on the smelting and melting processes. So, it offers a lot of a flexibility in terms of these sustainability parameters that we can keep on recycling this metal as for a very long period of time. So, the recovery efficiency in from this steel is very high and steel is always there is some price some good price you can get in the market.

So, it encourages the household people also to sell any any our equipment any a product which has some steel component to the scrap dealer and they get some value paid in turn. So, it helps, this this recyclability, this recovery capacity this recovery efficiency helps in increasing the recycling, increasing the potential for the recycling and even if it goes it is discarded in the a nature if it goes in the landfills.

So, what happens with the exposure to the air is for exposure to the water and moisture, it starts oxidizing, and then it starts breaking in it is an elemental form and it goes back again into the

nature in its elemental form. And maybe again, it can be recollected someday and can be put to use. So, steel offers a lot of flexibility and steel directly does not have any bad impacts during its usage period. Though there are emissions, extreme a volume of emissions come out while processing it. So, that is one of the disadvantages, but with all of these disadvantages, it offers a huge volume of opportunity and usability also and that is why steel is one of the most usable metals of this time.

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So, let us see how this gets a recycle. So, this illustration gives a clearer picture of the recycling part only of steel so once it gets in in the system from its raw material extraction, extraction etc Then it goes for the steel production then it goes for a usage then it comes back as a scrap then again it goes as a scrap in the steel production it gets refurbished under kind of recasted it to a new product itself.

Then again it goes for the it is a it is a usable usability it is a usage and it again last there for a several years and then again it goes for the recycling then again it comes to the factory. So, this is how the cycle of the steel as a metal as a material keeps on running. So, steel is one of the best materials as far as recycling process is concerned. But there are some consideration.

For example, if we maintain the purity of the material if the if we do not make it for example we discussed in the previous lectures, the alloys. The Alloys offer very high strength very high the

usability they can be used in a very a high stressful or tensile requirements or places of requirements such as avionics and all. But in the general life for example, or normal a 2 wheeler, which is not going to exceed speed of 100 kilometers a per hour.

So, there is there may not be any a particular need to use such a complex composites and alloys because at the time of the disposal of that motorbike, it is going to be really tough to take out those different materials, those metals from the alloy, and again reuse them. So, alloys are at the time of the usage, they offer immense strength and power, but at the same time in the, at the time of their disposal, they become very difficult to recycle also. So, we must take such decisions with the with the full, this consciousness what kind of applications are desired to that product.

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Let us go to the next this case example over here. So, this talks about buildings a whole life an emission, so, the focus over here is on the emissions. So, starting from the, it is an extraction from the top a green component you can see over here that is the starting point. So, we extract these in the form of raw materials, different materials, which are needed for the building. Well building consumes n number of materials and types of materials.

All sorts of material including steel cement stone, and the PVCs and the metals and wood, timber, plastics glasses. So, all sorts of materials are have actually found a place is somewhere in the a building industry, then it goes for the manufacturing, manufacturing units it gets

manufactured in the respective products. Then it goes for the transportation to the site and goes for the real execution of that building, then the once the building is completed, the building goes from the occupation and the main operational phase starts and it takes a longer period of time.

So, our building our normal buildings a lifetime ranges from a 30, 120 years. So, depending upon the application and the strength of the materials used in the construction of that building. So, after this extensive period of time, it goes for it is the end of the life and before that it keeps on carrying it is a maintenance and retrofitting and other repair activities also then the operation stays ends and then it goes for a demolition and or deconstruction.

At the stage of the demolition that rubble material, they are taken away from the site for an extraction and some of the bulk the concrete part that grit and cement part sand part goes for a landfill because the till now there are no efficient on the economics parameter. Systems available to recover the concrete part. So, there are still some researches and experimentations going on to deal with that, but the extracted metal parts and other components such as a glass etc, they go for recycling and this is how building the components of the building come to an end. So, during this period, you see the embodied emissions, they range from 20 to 50 percent of a building's a whole life emissions. So, this is this arrow mark you can see you can understand over there. So, that is the kind of impact building a normal building exerts.

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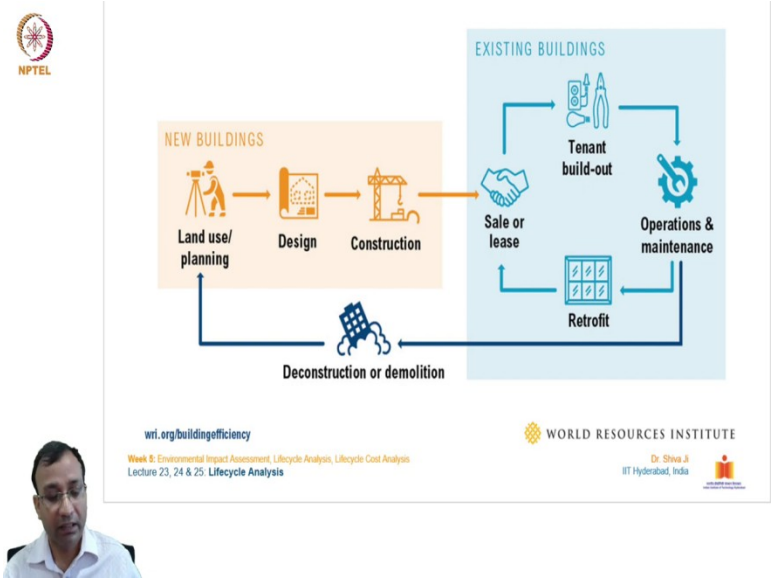

So, how it goes, you see this illustration over here. So, a new building comes up it goes a comes up with a concept stage then it goes for the design, construction, then in the blue shaded area if you see it goes for a sale leasing, it goes for a uses by this the occupants. Then it goes for a repair, maintenance, serviceability and all the retrofitting, etc. Then again goes for the deconstruction or demolition and then as again it. This is how the lifecycle of a building occurs, usually.

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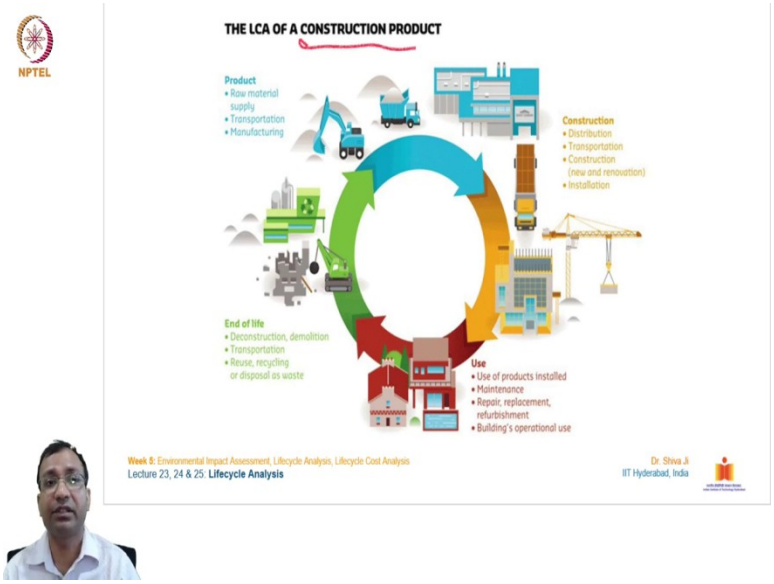

So, we will see that LCA of construction project in detail over here. So, you see that the product in the name of the products or raw material supply, transportation, manufacturing takes place then it goes from the construction phase to distribution, transportation, construction, new and renovation etc also whether it is a new building or a renovation of an old building. Installation, several sorts of installations take place.

Then in the usage period, the use of the product installed in the maintenance repair, replacement, refurbishment. So, these are any final activities which take place during a period of a lifetime of a building and at the end of the life. It goes for a demolition, reusing recycling disposal as a base material. So, this is how it goes to an end.

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How does a vehicle fares on the LCA parameter. So, if you see LCA based vehicle emissions regulatory focus, so, in this one when it goes for a raw material extraction, the material and powertrain and components manufacturing of that actual vehicle. Then it goes for the final vehicle is a manufactured. Because any may vehicle manufacturing company, it is likely that they may not be producing all components or all parts of that automobile and they may be taking help of several other a sub manufacturers and subcontractors who supply the components and parts of those, that automobile.