Product Design and Manufacturing

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Lecture - 20c
Design for Environment (Part 1 of 2)

So, welcome back to the next lecture which is on Design for Environment, today there is a big push towards design for environment. Today what is happening in manufacturing people they slowly started talking about sustainable manufacturing so; that means, to say try to produce any object with minimum resources and try to do very minimum damage to mother earth. So, that is sustainability, whatever product we do that has to be sustainable for example, the plastic bags what we produced it was a; it was very handy it gave customer satisfaction, but today we realise that it is no more user friendly what has happened you are not able to bio degraded or dispose it.

Today people are started giving statistics saying that within 10 years from now we need another earth to dump all our plastic things and other materials which gets waste for example, electronic waste, rare earth material getting added to the soil. So, all those things are making big damage to mother earth. So, now, the topic of design for environmental is very important, initially we were talking about design for manufacturing then we slowly more towards design for assembly, but today we are talking about design for sustainability or design for environment it is a very important topic. So, let us keep discussing this topic in brief.

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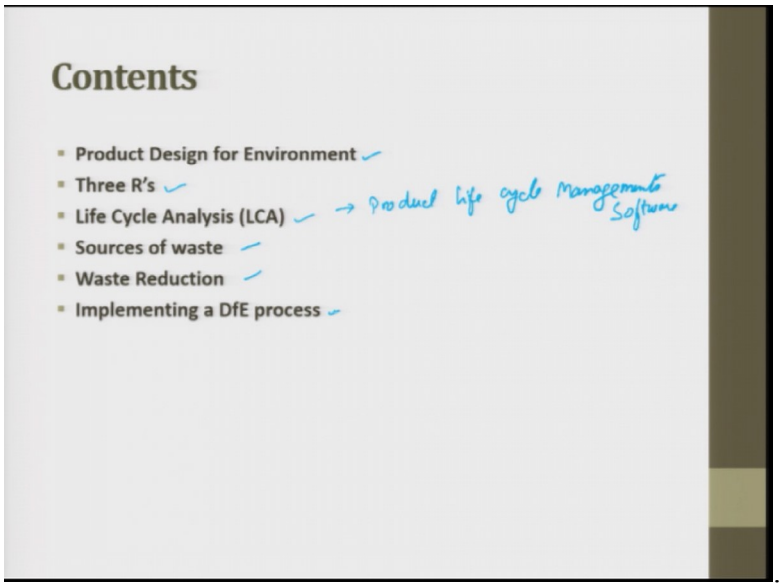

The content of the list lecture is going to be product design for environment, how are we going to develop design or products or packages which are user friendly to environment what are the three R's which have been talked about from school days till now, now this three R's have become four R's. Then Life Cycle Analysis LCA now this has become a part of all of the product lifecycle management softwares.

Softwares they are now making it part of their software for doing simulation and trying to do this analysis, life cycle analysis, then sources of waste, then waste reduction, then implementation of design for environmental process.

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Product design for environment; product design for the environment is very contemporary topic it is very important. Several researches all over the world are busy attempting to design products that minimise the impact on environment which I was telling to you. For example you take CNC machining or you take turning or you take grinding examples what we do in grinding we try to do machining operation and what we understand that when machining there is going to be a huge temperature rise.

In order to remove the temperature between the tool and workpiece we try to apply coolant, but we are also pretty sure the contact between the tool and the workpiece is going to be 100 percent or perfect. At that instant so, when we try to when we try to inject or when you try to apply coolant there it is not going to reach the contact zone exactly.

So, what we us what we do is we try to spread all around coolant of that cutting zone and what we argue saying that we try to extract heat from those positions. So, if you look at it many a times and many of the machining process we use flood coolant, this flood coolant is not serving it is true purpose, that is why people started talking about minimum quantity lubricants and so on and so forth. So, all this thing are to reduce the impact to environment because the coolant which gets converted into fumes that fumes are hazards to human operator, ok. It gets dispersed into the free atmosphere which is later going to be hazards for are for from the pollution point of view.

The present chapter or the present lecture is an atom to motivate young researcher's works to pursue in green product design.

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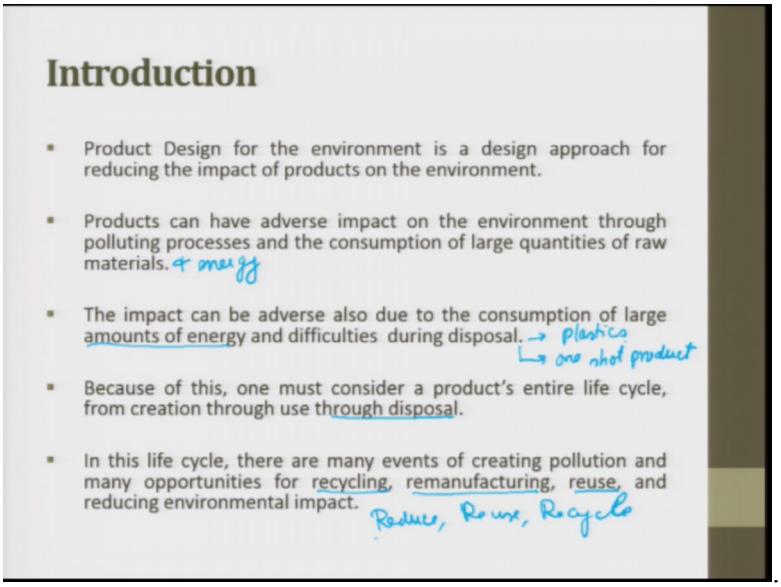

So, product design for environment is a design approach for producing the impact of the product to the environment. The products can have adverse impact on the environment through polluting processes and the consumption of a large quantity of raw material and energy. When we talk about sustainable manufacturing or manufacturing design for environment we try to also optimise the use of energy.

The impact can be adverse also due to the consumption of a large amount of energy and difficulty during disposal. For example the plastic chairs today are economical and very well accepted why because this products are one shot products; that means, to say from the pallet to the final chair it is done in one shot injection moulding process. Whereas, let us take the same there if it is made out of wood or if it is made out of steel there are several processes which has to go through and finally, you get the same output.

As far as the customer is concerned he only needs a product for setting if it is made out of metal, ceramic, plastic, steel, he is least bothered ok. So, now keep the customer into picture and then you see that cost which is going to be done and then look at a product or a material which can be quickly processed and you get the output so that is what is told about amount of energy and the difficulties during disposal.

Because of this, one must consider a product's entire life cycle, from creation through used through disposal. So, this plastic has only one problem today is disposal, you can quickly make it is a most economical thing it has a shorter lifetime of maybe 5 years or 6 years when it is exposed to sunlight. So, then on top of it when you have to disperse it these plastics are not degradable.

So, thermoplastics yes it can be at least recycled. So, people start doing it recycling and in the recycle also what happen every time when you just try to process the material loses it is strength and other properties so it is not like a origin material.

In this life cycle there are many elements of creating pollution and many opportunities for recycling, remanufacturing, recycling is different remanufacturing is different. So, recycling remanufacturing reuse see there is first something called as reduce we will see all the three R's reuse and recycle. When we talk about reduce you try to minimise the consumption for example, today we use lot of products which are 5 star rating for example, electronic devices let it be geyser, let it be refrigerator, let it be a air condition, we try to use 5 star because the energy consumption is quite less so, that is reducing the resources.

Next whatever we have reusing it, my elder son has a shirt and that shirt is still glossy and very good, but he has grown up to wear that shirt I could either transfer to my younger son or to a person whom I know and he reuses the same shirt, the shirt still has it is life and it can be used without doing any alteration so that is what is reuse. And the last one is recycle; recycle in the sense ,I take that shirt I tried to convert it into some other form and make a product for using for example, you have a jeans pant you can cut the jeans pant and try to make it into shorts that is also not recycle.

Recycle means you apply energy, you apply complete a new things and then try to develop a product it can be a same one similar one it can be a different product that is recycle. Reduce energy is produced, reuse there is no energy consumed in it, recycle there is an energy consumption it a. So, as far as possible we should try to reduce, then we will try to reuse, then we will try to go to recycle that is what is talked about.

In this life cycle there are many events of creating pollution and many opportunities for recycling, remanufacturing, reuse ,ok, remanufacturing is changing for example, scrap

which is coming out of machining operations can be converted into a billet for a low strength material application and reduce the environmental impact.

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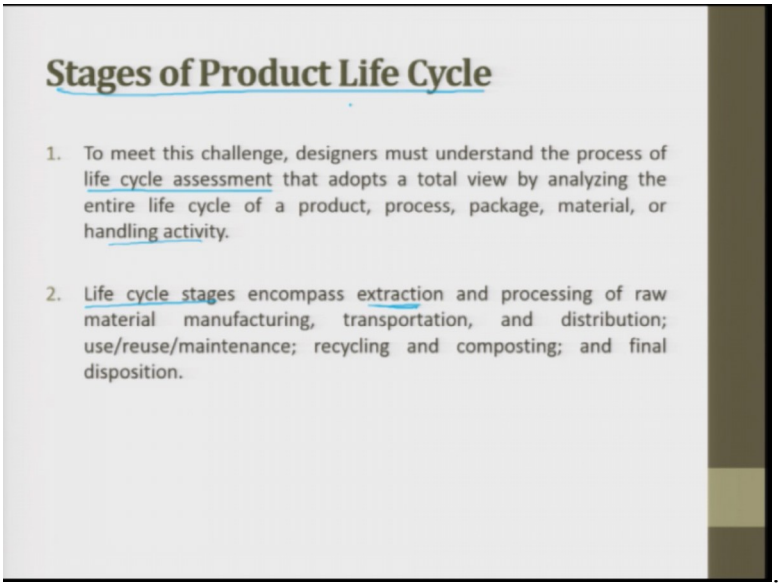

The stages of product life cycle is to meet this challenge designer must understand the process of life cycle assessment that adopts a total view by analysing the entire life cycle of a product, process, package, material and handling activities. So, when we try to think the take an example of thermoplastic bags plastic bags polythene bags, these polythene bags where never thought in totality. It was only thought of let us give a product to the customer so, that he is happy that is all, but they did not see.

After a while when the customer wants to throw this what will happen they did not think about it, because at that point of time there was a market pull then they needed a plastic bag, economical bag. So, that people can just walk into any shop any mall pick up a pick their commodities put it inside a plastic bag and come so that is what.

So, here they did not do the life cycle assessment properly it is not that was a mistake we are learning and in the process of evolution we also learn many new things as and when we grow, ok, you can take it as learning exercise rather than saying these are all not thought off right. So, to meet this challenge designer must understand the process of life cycle assessment that adopts you a total view by analysing the entire life cycle of your product process, package, material and handling activities.

Life cycle stages encompasses extraction which is a very high energy intensive process extraction and processing of raw material manufacturing, transportation and distribution use, reuse, maintenance, recycling and composting and finally, disposition it. So, all these things are different stages of product life cycle.

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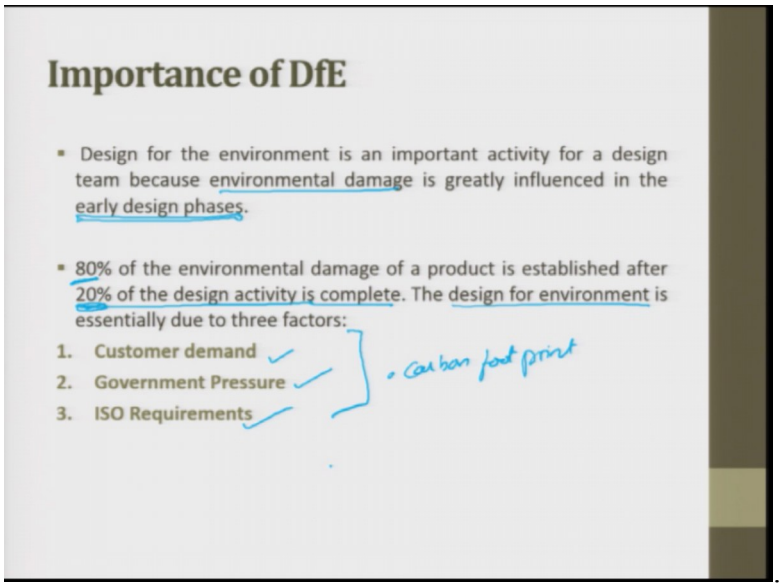

The importance of DfE, Design for Environment is an important activity for a design team because environmental damage is greatly influenced by the early design phase. So, at the early design even when we do concurrent engineering at the early stage itself you try to think about the product it is solution to the problem and because of this production what is it is influence on the environment? So, it has to be thought of in the early stage of design itself, 80 percent of the environmental damage of a product is established after 20 percent of the design activity is complete.

So, 80 percent of the environmental damage of a product is established after 20 percent of the design activity is complete. The design for environment is essentially due to 3 factors, customer demand design for environment customer demand, government pressure and ISO requirements. Today people are talking about carbon footprints right carbon footprints so; people are more worried about carbon footprints. So, people are now, there is a governmental pressure that is why every time you see new auto norms are coming into existence Bharat 4, Bharat 5, Bharat 6 and earlier it was then there were a lot of auto norms stringent auto norms have come into existence, ok.

Same with ISO requirements what happens in a tannery industry, what happens in paint industry, what happens in a pharmaceutical industry, what happens to the water after you use it for processing how do you disperse. So, all these things are now becoming very much stringent and it is required for any company to become international they are pushing very hard for design for environment.

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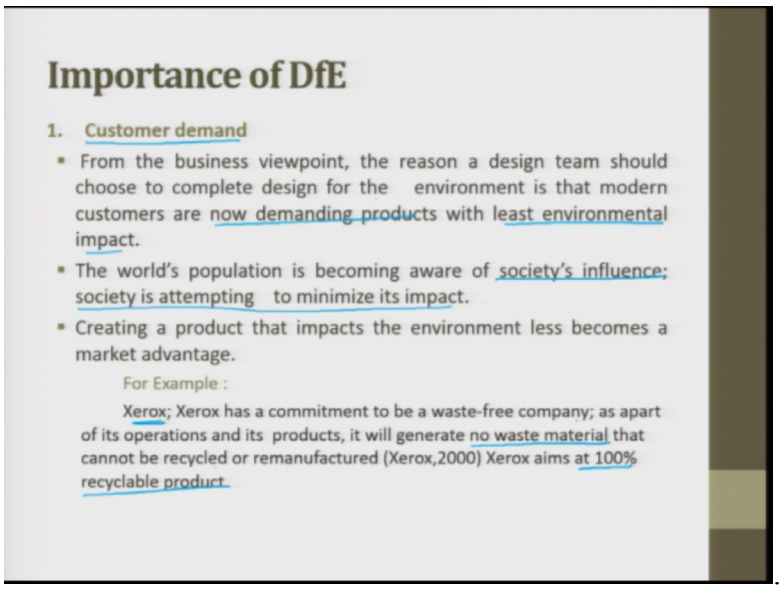

The customer demand, from the business viewpoint the reason a design team should choose to complete design for the environment is that modern customers are now demanding products with least environmental impact, now people are aware of it. So, people look for 5 star rating, people look even though the cost is little high they look for 5 star rating, people look for cars which do not which do not cause smoke out of it. So, they are going to electric cars right and people also look for a many products after the product life is over ,what happens for dispersal.

The world's population is becoming aware of the societies influence; society is attempting to minimise it is impact. Creating a product that impacts the environment less becomes a market advantage, today companies have started putting as there USP Unique Selling Point this design for environment.

Xerox has a committee to be a waste free company has committed to be a waste free company, as a part of it is operation and it is product, it will generate no waste material

that cannot be recycled or remanufactured, Xerox aims at 100 percent recyclable products ,ok.

When we talk about frugal engineering the one of the best examples of frugal engineering is making a new not incubator using car parts, ok. So, now, recycling of products is being 100 percent recycling is now been thought of in every product you buy in automobile every part is thought of 100 percent recycling. Thermo sets are removed and elastomers also are to some extent recyclable and all other parts are made of thermoplastic or it is made out of metals which are recyclables. So, 100 percent the automotive industry is also looking for recyclable products.

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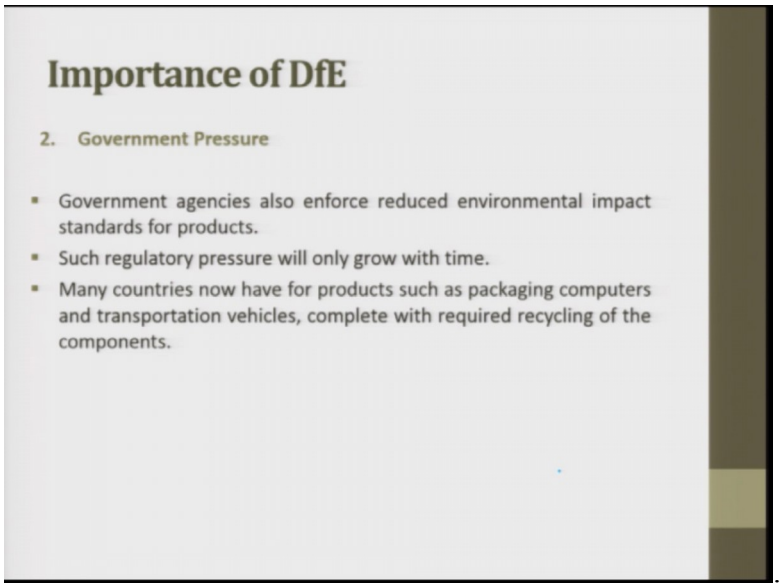

The government pressure government agencies also enforce reduce environmental impact standard for products. Such regulatory pressure will only grow with time this regulatory pressure will grow with time. Many company countries now have the product such as packaging computers and transportation vehicles, completely recycle components are being used.

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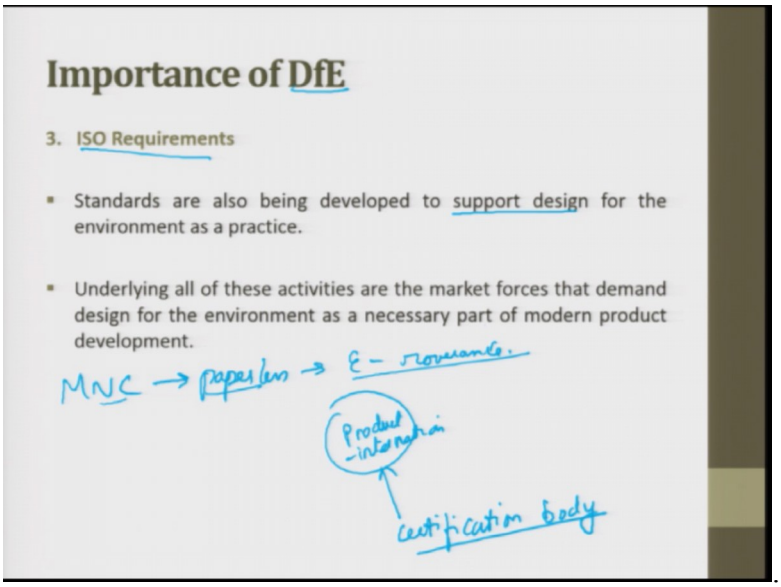

ISO requirements, today when one company has to make it are product international they look for a international certification body. So, ISO is one of the certification bodies, so, where as part of their certification they have also added this design for environment.

Standards are now being developed to support design for the environmental as a practice. Now, it has the support documents have come and the standards are doing established because we are also as said we are also evolving. So, the standards are also now only recently added.

Underlying all these activities are the market force that demand design for environment as a necessary part of modern product development, today lot of the multinational companies have gone for a paperless office or it is called as digital or it is called as e governance. So, electronic governance so, this is now moving towards paperless office. So, they have reduced the consumption of paper this has led to the reduction of tree cutting and the advantages there is a digital document which is always kept in the trawl in the in store or it is saved.

And second thing is the retrieval of these data's have become very fast and the correction of these data's have also become easy. So, now, this part is now added as part of ISO if any company wants to get an ISO certificate their product should follow design for environment and they should move towards the paperless factory. So, this is in turn putting lot of pressure on the companies and to meet out their requirements.

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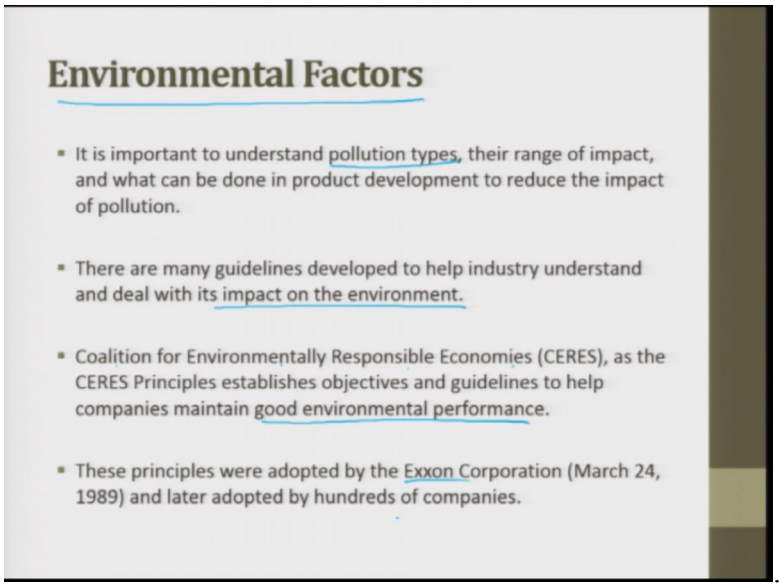

What are the environmental factors, it is important to understand pollution types, their range of impact and what can be done in product development to reduce their impact of pollution is one factor which is thought about. There are many guidelines develop to help industry understand and deal with the impact on environment. Coalition of Environmental Responsible Economies, as the CERES principle establishes objective and guidelines to help the companies maintain good environmental performance. These principles are adopted by Exxon cooperation and later adopted by hundreds of companies.

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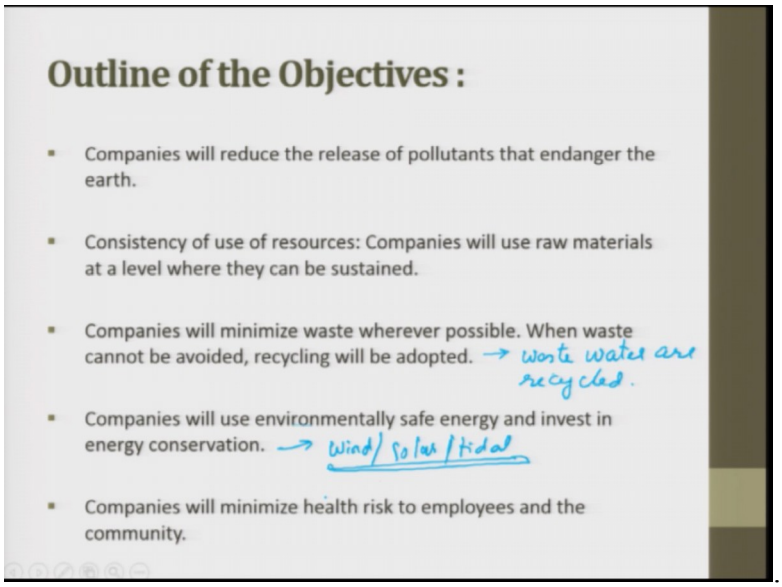

Outline of these objectives, company must reduce the release of pollutant that endangers the earth. Consistency of use of resources, companies might use raw materials at the level where they can be sustainable. Companies will minimise waste wherever possible. When waste cannot be avoided, recycling must be adopted. So ,waste water from big industries are getting recycled ,ok.

Companies will use environmental safe energy and invest in energy conservation. So, that is what we are looking for wind, solar, tidal, these are all non conventional energy sources, companies are requested to look for these things. And companies will minimise health risk to employees and their and the communities as part of this design for environment, the electric vehicles are part of now design for environment.

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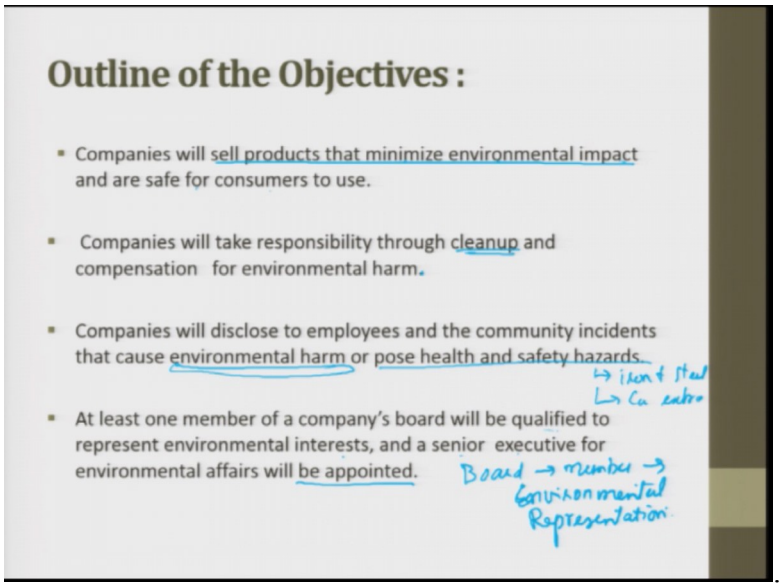

The companies will sell products that minimize environmental impact and are safe for consumers to use ok, sell products that in minimizes the environmental impact for example, plastic bags. Companies will take responsibility through cleanup and compensation for environmental harm now this has become a mandate. So, if the company gives a huge amount of packaging and is packaging materials are dispersed because they are these packaging material plays an important role in protecting the product from impact. For example, when you buy laptops it is packed in a carton box with lot of Styrofoam's there and that Styrofoam's are not reusable.

So, but these Styrofoam's have to be there because they come when while movement if there is a impact load the laptop has to take that. So, now, companies have decided they have produced so, much they have also now involved in cleaning up so much hm. And this is out now it is become a mandate of the company companies will disclose to employees and the community and the community incidents that causes environmental harm or pose health or safety hazards.

For example if you are running a iron and steel company or if you are running a copper extraction company. So, what happens is the, the companies responsibility is to tell the public near and dear staying close by the company that, this is what is the environmental impact is going to be made and this is how your health is going to get decorated.

So, if you are interested you stay here otherwise you look for a place apart from that and now companies also have taken the responsibility for example, lot of companies which are involved in energy production, they have also in now started getting involved in planting trees and making the place green and trying to clean up earth. So, these are some of the social responsibilities they are doing so, that they can try to keep the society happy.

At least one member of the company board will be qualified to represent environmental interest and senior executive for environmental affairs will be appointed. So, now, in all boards ,you see a member who is extremely conscious about environment, environmental representative, ok, he talks about the environmental impact of the company on the mother earth.

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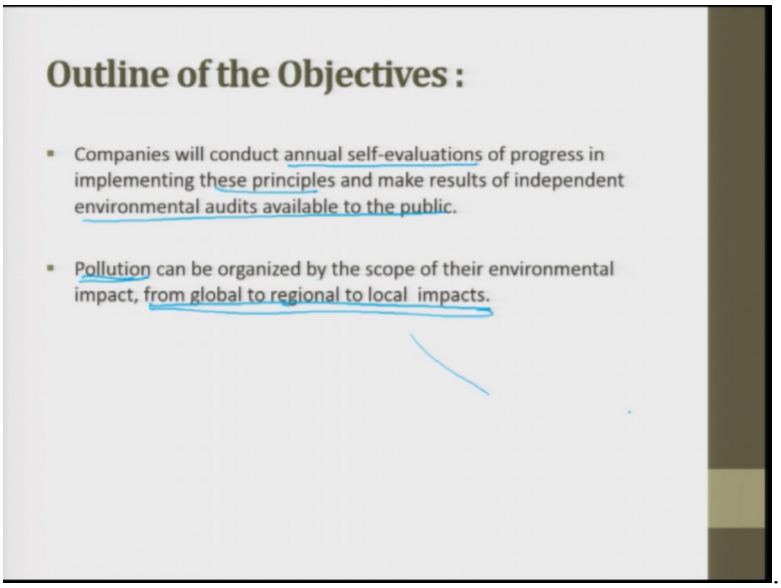

The companies will conduct annual self evaluation of progress in implementing these principles and make results independent of environmental audit available to the public. Pollutions can be organised by the scope of their environmental impact from global to regional unto local impacts. So, from global to local to regional to local these pollutions have a huge impact.

Suppose now in Delhi there is a huge set of pollution, the same pollution can also happen at Chennai or Mumbai or Calcutta, but the beauty of it is they have sea close by and the pollution moves or the fresh air there is a scope of coming whereas, in Delhi it is covered

by Himalayas at one side and the other side it is too far away it is having lot of land and the downward also it is having land. So, the fresh water the fresh air coming in is very difficult so, the pollution there is very dominating.

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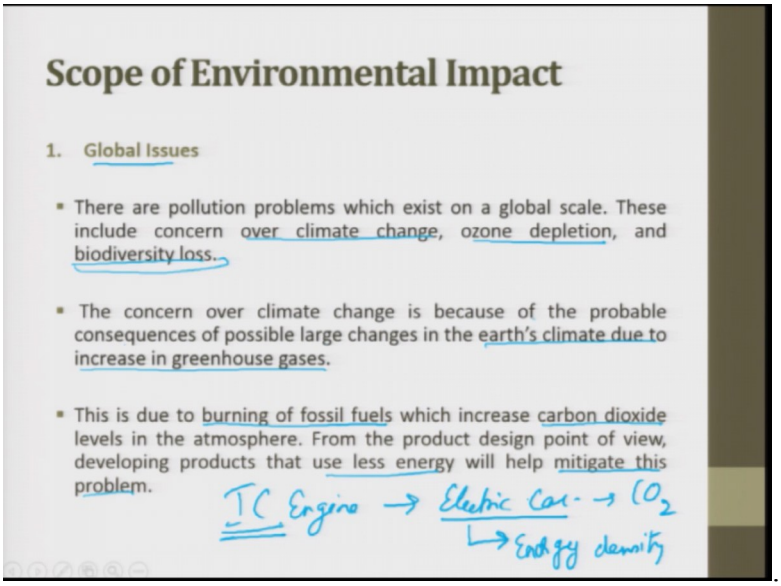

The global issues which are related there are pollution problems which exist on the global scale this includes concern over climatic change ozone depletion and biodiversity loss climatic change for example, the ice over the north zone is getting melted and if the ice or the north zone melts. So, the water level increases moment the water level increases there is always a possibility of a flood or a storm, because there is a imbalance in the water level. So, there is a climate change temperature increase temperature increase melting of ice melting of ice lot of water lot of water leading to flood or storm, ok.

Ozone depletion because we send so much of rockets here and there they peers the atmosphere and they go out. So, ozone depletion happens moment there is ozone depletion then there is lot of health problems which come into existence and since we disperse lot of waste into the sea ,ah, sea water and nuclear materials are dispersed in the sea there is the bio biodiversity is loss lot of small birds, fish and small animals die because the water is lost it is purity the atmosphere has lost it is purity.

When I was a young kid I used to play with lot of sparrows through rice here and there and these sparrows used to jump and eat and I used to have fun, today when I wanted to

do the demonstrate same thing to my son that I do not see sparrows in my vicinity itself people say because of the cell phone towers they get disturbed, second thing because of pollution also they get disturbed. And it is so surprising nowadays the place where I stay I do not see crows also. So, biodiversity is getting disturbed and there is a huge loss.

The concern over climatic changes because of the probable consequences of possible large change in the earth's climate due to increase in the greenhouse gases. This is due to burning of fossil fuels which increases carbon dioxide level in the atmosphere. From the product design point of view, developing products that uses less energy will help to mitigate this problem.

So, that is why from IC engine car we have gone to electric car electric vehicles and these electric vehicles CO 2 is not used and they are, but the only major challenge with this is energy density which people are now trying to work very hard in developing huge energy density so, that they can store energy and travel for a longer distance. I am sure keeping this environmental norm all these IC engines will slowly, slowly go away.

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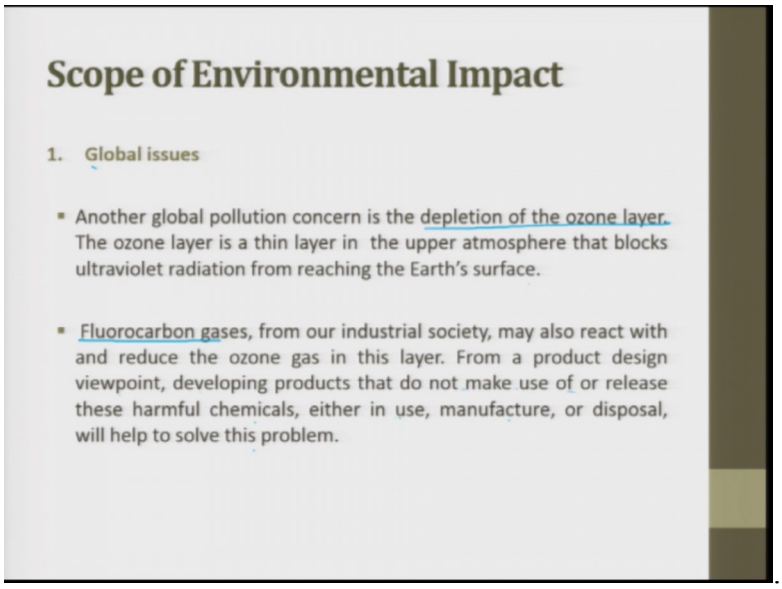

Another global pollution concern is the depletion of ozone layer. The ozone layer is a thin layer on the upper atmosphere that blocks the UV radiation from reaching the earth surface. Fluorocarbon gases from our industrial society may also react and reduce the ozone gas in this layer, from a product design view development products that do not

make use of release this harmful chemicals, either in use, manufacture or dispersal, will be used to solve this problem.

So, fluorocarbon gases were initially used as refrigerants now it is slowly removed in several places which was used in air condition, slowly it is removed such that they try to protect the ozone layer.

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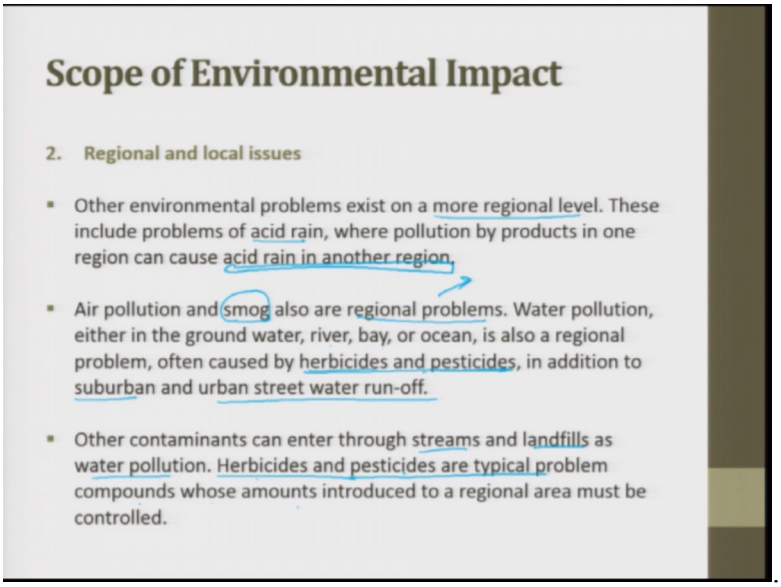

Regional and local issues, other environmental problem persist on the more regional level, these include problems of acid rain, when pollution by products in one region can cause acid rain in the another region. So, in a peak summer recently at Bhopal we could see there was a ice rain So, it was a peak summer and the rain whatever fall we had was full of ice. So, it was all change in the atmosphere we got this and the acid rains are something which happens because of pollution.

The air pollution and the smog also are regional problems. So, if you see that the trains planes are not able to take off trains are not able to reach and it creates a huge case in the transportation of the community. So, this come December, January, February in the North of India we have a huge problem because of the smog and air pollutions, the trains are not able to move traffic on the roads are not able to move. So, this leads to lot of pollution they are leads to lot of CO 2 and this CO 2 intern is in the atmosphere creating pollution.

So, air pollution and smog are all regional problems water pollution either in the groundwater, river, bay or ocean is also a regional problem often caused by herbicides and pesticides in addition to the sub urban and urban street water runoff. So, these are pesticides when we add to the farms and herbicides which is added they get mixed with the groundwater and the groundwater also many a times because of this chemicals which are getting used they leach away the soil and that is called as what leaching which is also a very big thing which is coming up today.

Other contaminants can enter through to streams and landfills as water pollution. Herbicides and pesticides are typical problem compounds whose amount introduces to the regional area must be controlled. So, today we talk about a major control of pesticides people are talking about organic farming and people are talking about precision agriculture where and which the use of this fertilizers used of this pesticides are controlled to a large extent, this in turn tries to reduce the pollution.

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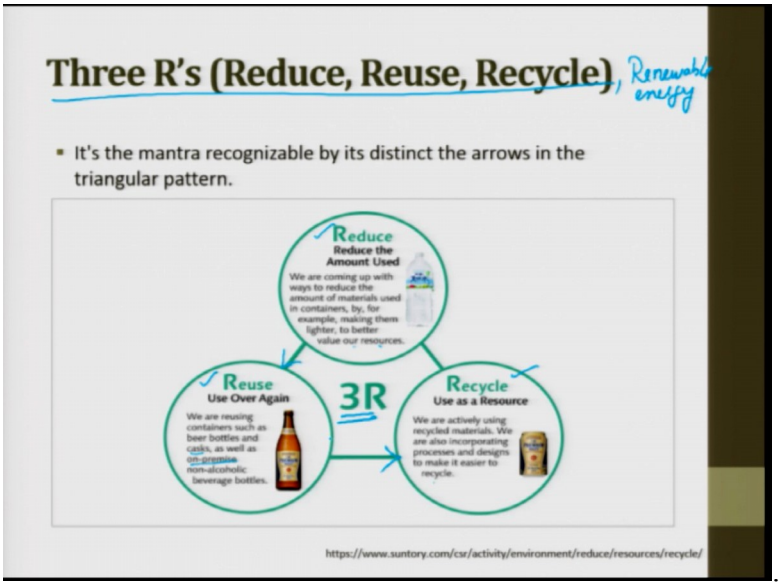

The 3 R's which we were talking about reduce, reuse, recycle, now it is also called as the energy is also talked about it is renewable energy,is also talk about these are the 4 R's which are talked about, it is the mantra recognisable by it is distinct the arrows in the triangle pattern. So, we have reduce, reduce the amount of use we are coming up with way to reduce the amount of water use the amount of materials used in the container buy. For example, making them lighter to better value our resources so, this is reduce.

Recycle is used as a resource we are actively using recycled materials, we are also incorporating processes and designs to make it easier for recycle. And reuse use over again we are reusing container such as beer bottles and cases as well as on premises non alcoholic beverage bottles. So, these are all the 3 R's reduce recycle and reuse or we can say reduce, reuse and recycle. So, 3 R's now renewable energy is added so, it becomes 4 R's.

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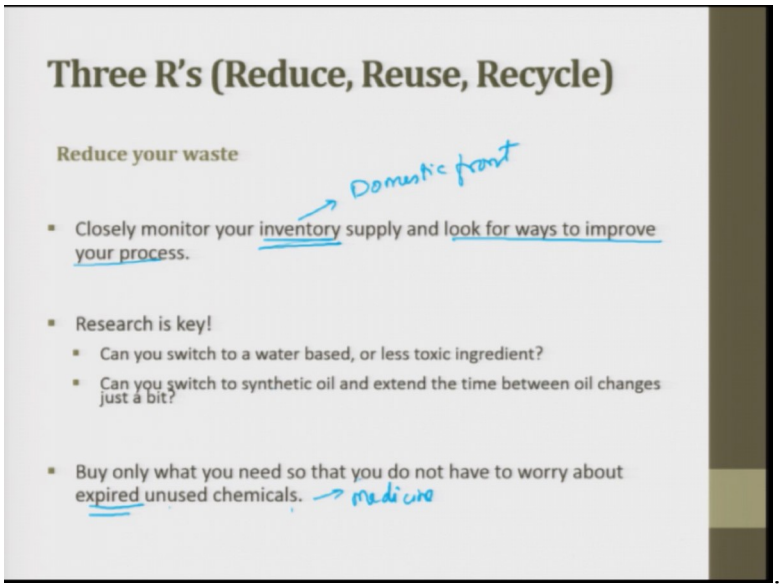

Reduce your waste closely monitor your inventory supply and look for the way to improve your process. Closely monitor your inventory supply you can try to do it in the domestic front closely monitor your inventory supply for example, we go to mall and then we pick up 3 soaps.

So, along with 3 soaps you get 1 soap free so, we buy for soaps and hardly our consumption rate is a family can consume only 1 soap a month. So, what has happened you have to closely monitor your inventory, because if you have more inventories you are going to consume more liberally or it might get wasted. So, closely monitor your inventory supply and look for a way to improve your process.

Research is the key, can you switch to water based or less toxic ingredient? Can you switch to synthetic oil and extend the time between oil changes just a bit? So, now, that is what earlier be used to have radiator, radiator was water cooler water cool now they are ingredients which are added synthetic ingredients which are added which makes it

sustainable and it is used for a longer time. Buy only what you need so that you do not have to worry about expired unused chemicals, this always happens for me in my house with medicine pharmaceutical.

So, when I go to shop I buy medicine and when I have cold I do not buy 1 tablet 2 tablet I buy an entire strip and over a of time of I do not consume it gets expired and it is waste. So, that is what we talk try to have tried you what you need so that you do not have to worry about what about the expiry of unused.

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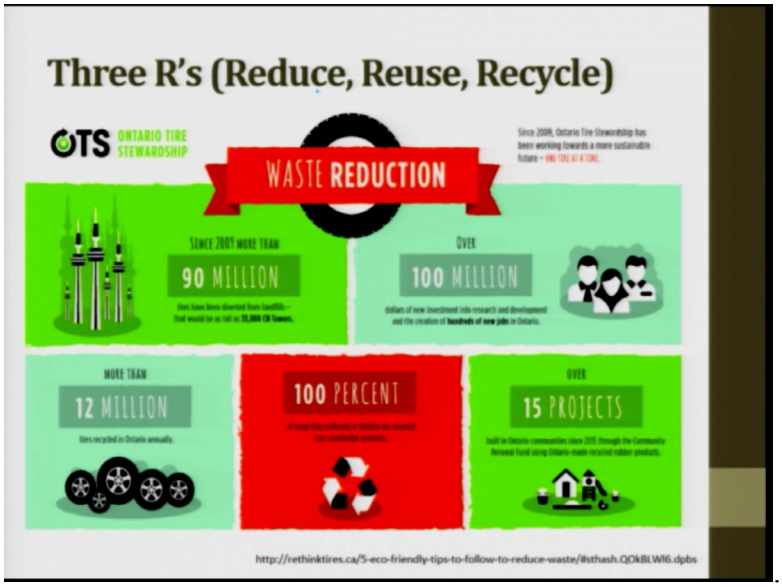

So, that 3 R's reduce, reuse, and recycle so, the waste reduction since 2009 more than 90 million tyres have been diverted from land filling that would be as tall as 33000 CR towers. So, so much has been used more than 90 million tyres have been diverted from landfills.

So, the other thing is over 100 million dollars of new investment into research and development and the creation of hundreds of new jobs in Ontario it is done for reducing the waste, 100 percent of scrap tyres collected on Ontario are recycled into sustainable products, more than 12 million tyres recycle in Ontario annually, over 15 projects built in Ontario community since 2015 through the community renewable fund users using Ontario made recycled rubber products. So, these are the things which government has taken countries have taken so, it is called as Ontario tyre towards shift. Since 2009

Ontario tyre towards shift has been working towards a more sustainable future 1 tyre at a time.

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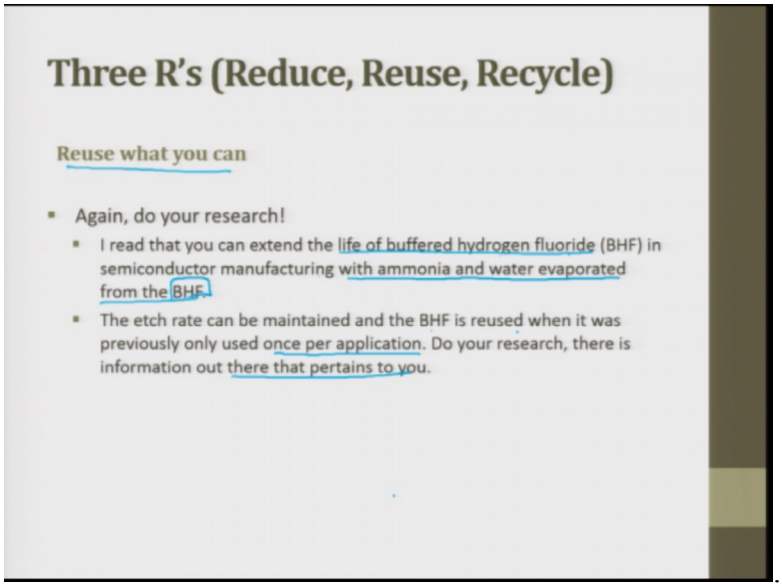

Reuse what you can again do your research I read that you can extend the life of Buffered Hydro Fluoride BHF in semiconductor manufacturing with ammonia and water evaporated from the BHF, extend the life of BHF in semiconductor with ammonia and water evaporated from the BHF. The etching rate can be maintained and the BHF is reused when it was previously only used once per application. Do your research, there is an information out that that pertaining to you. So, you can start looking for how do we work on this BHF and use it many times.

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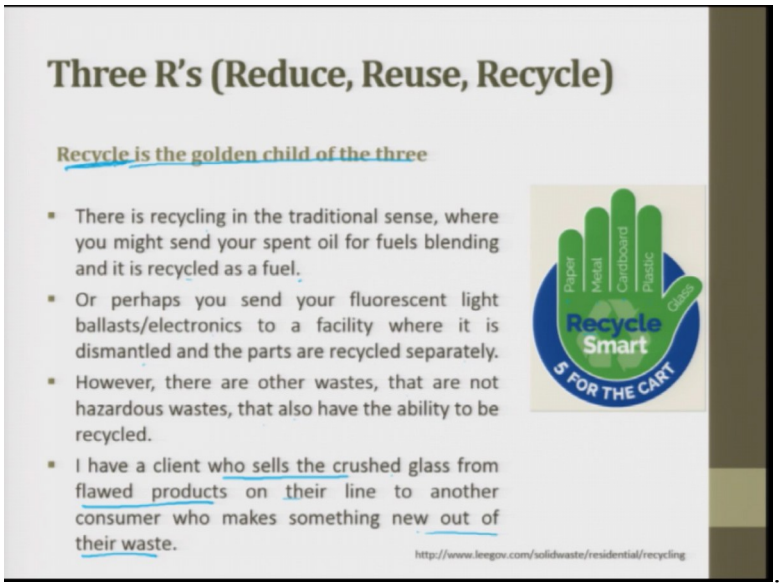

Recycle is the golden child of the 3 R. So, it is recycled smart paper, metal, cardboard, plastic glass, 5 for the cart. So, this is recycling in the traditional sense where you might send your spent oil for fuel blending and it is recycled as a fluid. On or perhaps you send your fluorescent light electronics to a facility where it is dismantled and the parts are recycle separately.

However, there are other wastes that are not hazardous waste that also has the ability of recycled. I have a client who sells the crushed glass from flawed products on their line to another consumer who makes something new out of their waste products so, this is all about recycling. Recycling is the golden child for of the three.

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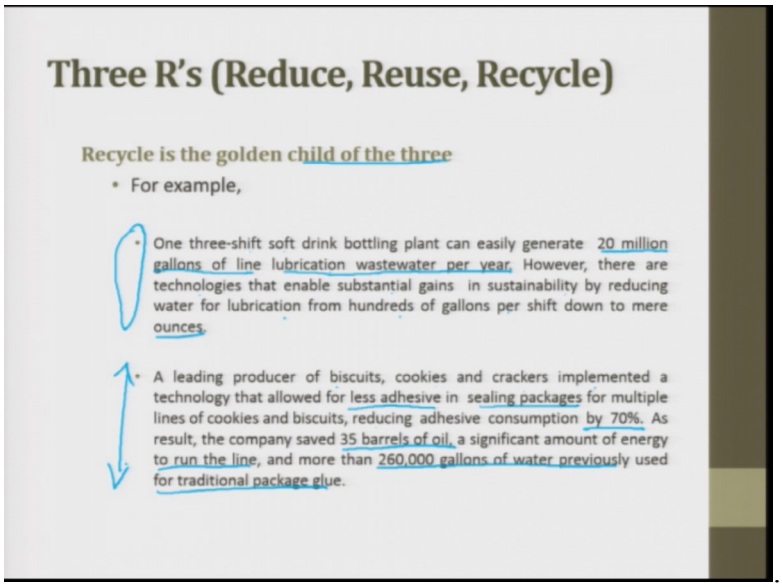

For example, one - three shift soft drink bottling plant can easily generate 20 million gallons of line lubrication waste water per year. However, there are technologies that enable sustainable games in sustainability by reducing the water for lubrication from hundred of gallons per shift down to merely ounce. So, people are worked on it and they are trying to reduce the 20 million gallons of line lubrication waste water per year to few ounces per day.

A leading producer of biscuits, cookies, crackers implemented a technology that allows less additive adhesive in ceiling package for multiple lines of cookies and biscuits reducing adhesive consumption by 70 percent. As result the company saved 35 barrels of oil, a significant amount of the energy to run the line and more than 260,000 gallons of water previously used for traditional packaging of glue. So, look at it so these are some of the examples where big companies across the globe awards started working.

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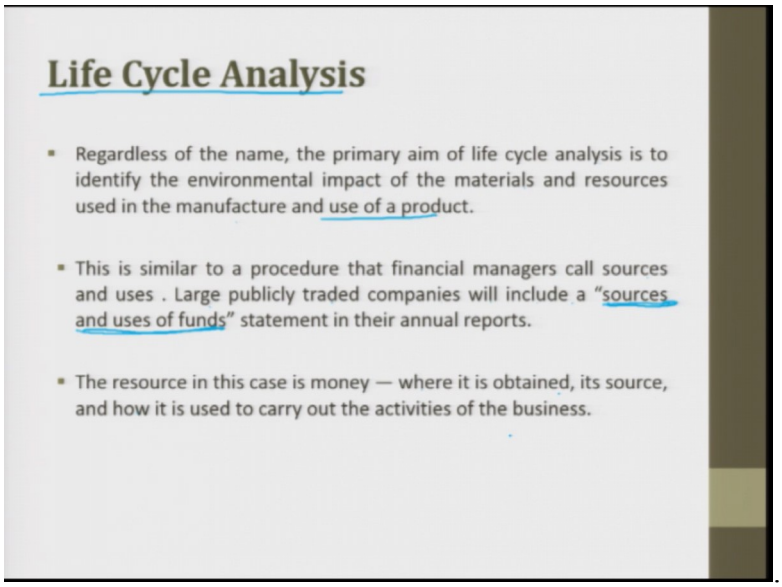

Now let us see life cycle analysis, regardless of the name the main aim of the life cycle analysis is to identify the environmental impact of the materials and resources used in manufacturing and use of a product. This is similar to the procedure that financial manager calls resources and uses. Large publicized trading companies will include a sources and uses of fund statement in their report. So, sources and uses of funds, the resources in this case is money where it is obtained, it is source and how it is used to carry out the activities of the business.

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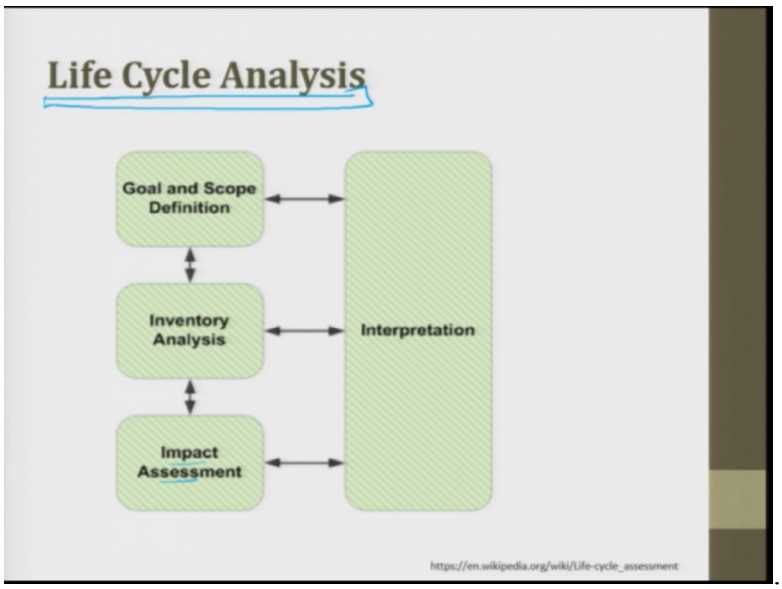

So, when we talk about life cycle analysis you have goal and scope definition and this is the interpretation, you have inventory analysis, you have impact analysis. So, all these things are part of life cycle analysis, goal and scope definition inventory analysis impact analysis and interpretation.

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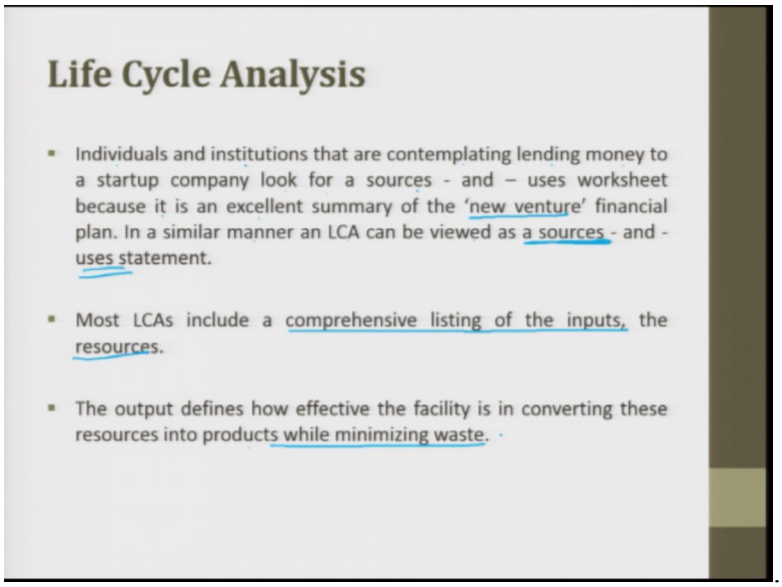

Life cycle assessment, individuals and institutions that are contemplating lending money to a startup company look for sources and uses the worksheet because it is an excellent summary of the new venture financial plan. In a similar manner and LCA can be viewed as a source and used statements. Most LCA life cycle assessment includes a comprehensive list of inputs and resources. The output defines how effectively the facility is in converting these resources into products while minimizing their waste.

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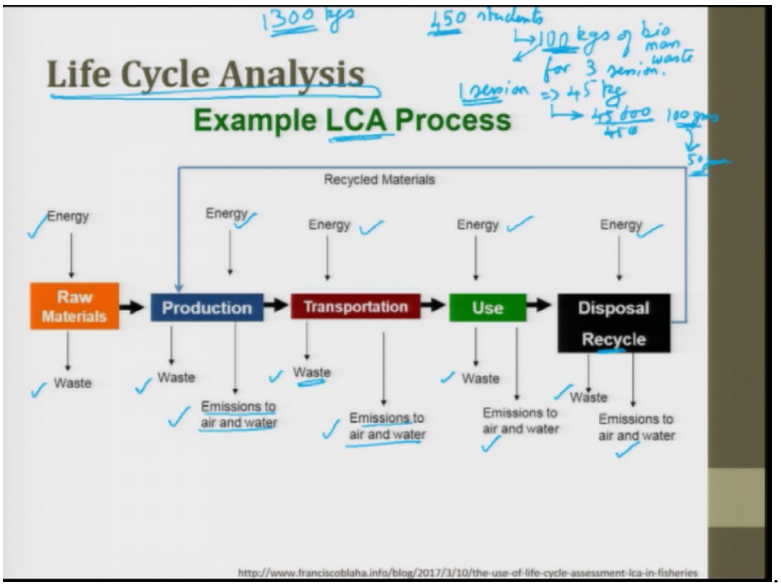

When you look at a simple life cycle analysis you can take raw material, food, you can take newspaper, you can take computer manufacturing, you can take food production; food production. I will tell you a very interesting case study which we recently did, in our institute where there are 450 students; 450 students they dine 3 times a day, everyday generate close to 90 kilos of biomass waste, can you believe? 90 kilos of biomass waste 450 students 90 kilos for simplicity sake let us make it 100 kilos just for calculation, is it a huge number, yes 100 kilos of waste which is a biomass waste we do, this can be while making Aloo, the peel of the Aloo while making some other Gajar you peel the from there and what is getting wasted in their plates put together is 100 kilos.

Now let us do a simple calculation, I divide this 100 and this is for waste for 3 sessions 3 sessions ok. So, then per session it is close to 33 kgs when I divide 33 kgs with this 450 students it boils down to maybe, let me do for just for calculation sake let me take it as 45 kgs ok. So, 45 kgs 450 students ok, it is 45 divided by 450 students I have converted into grams. So, this goes one this one goes so, every student generates 100 grams in one session and 100 grams is very typically your Cadburys weight or today's mobile phone weight. Do you think that a student wasting 100 grams of biomass is a big thing, no it is not big thing, but when you see in totality 100 kgs or 140 kgs it is big.

So, now what people are trying to say is try to reduce even this 100 grams to 50 grams and reduce this 100 kilos to 50 kilos. So, if you look at that this figure looks to be very

decent, but this figure is alarming and over a period of time if this is for a day, then think of for a month, then think of for a year and this is for one hostel you multiply it with 13 hostels. So, it is everyday we generate 1300 kilos of so, 1 ton of biomass we generate it is a huge waste.

So, now what we have are started doing is, we have started looking at can we reduce this by doing some pre-processing prior and trying to reduce the waste ok. So, this 1300 is per day so, you think of per month then per year you generate so much of waste. So, now, the life cycle analysis we started doing it and we have started relooking into the raw material so, here is a schematic diagram which is put for an example for LCA. So, first is raw material so, raw material we apply energy, it tries to convert the raw material into some usable format proceeds further and you also generate some amount of waste.

So, whatever raw material we process and we send it is a production again in the production what happens we generate waste and we also try to have emission of air and water is there, here also we try to apply energy. So, then after you produce you transport you apply energy, you generate waste and it also is doing emission of air and water waste is happening. Then we take it to the user, user applies energy again you try to generate waste and emission for air and water is done, then we take it to the dispersal and recycle again you apply energy waste and emission is done.

So, you see that so these it keeps on going when you try to recycle again it becomes in the production. So, this cycle keeps on going at every stage you see you apply energy and at every stage you see you generate waste and at every stage you see you generate emissions. Now this is what when we do this LCA life cycle analysis you have to reduce, reduce the waste, reduce the emission, reduce the energy, consumption that is what is LCA? LCA is life cycle analysis.

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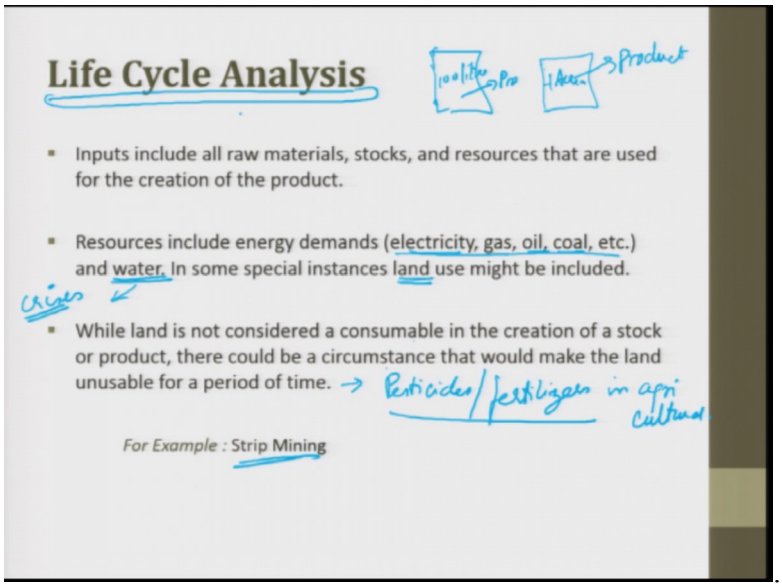

Life cycle analysis input includes all raw materials, stock, resources that are used for creation of a product you have to put all the inputs. So, here when you put the inputs you will also talk about the energy, you also will talk about energy the life of the material process disposal everything. You will try to talk resources include energy demands like electricity, gas, oil, coal etcetera and water. So, today apart from this is also becoming scarce this is also it getting into crisis.

Drinking water is a crisis, water for processing is a crisis in some special instance land use might be also included for resource land is also used when we start doing mining there are 2 types of mining, one is opened mining and other one is you do you do in the 3 dimensional mining. So, people are now trying to look from the open mining they are also trying to do deep mining. So, while land is not considered a consumable in the creation of a stock or a product there could be situations or circumstances that would make the land unusable after a period of time.

For example, this is talked about from the point of view of using pesticides or fertilizers in the agricultural land there we use or strip mining what we talk about. So, land is also becoming a major crisis today so, in the resources we that is why we are also talking today the life cycle analysis we are talking about precision agriculture. So, where in which the land productivity is improved water productivity is improved people talk about water productivity enhancement, land productivity and other.

In one acre of land what will be my production if I tried to take if this is one acre, the other way round what people talk is if 100 litres of water is used what is my production, because they try to talk about evaporation and other things. So, precision agriculture is something which is coming upon that is also getting integrated into life cycle analysis.

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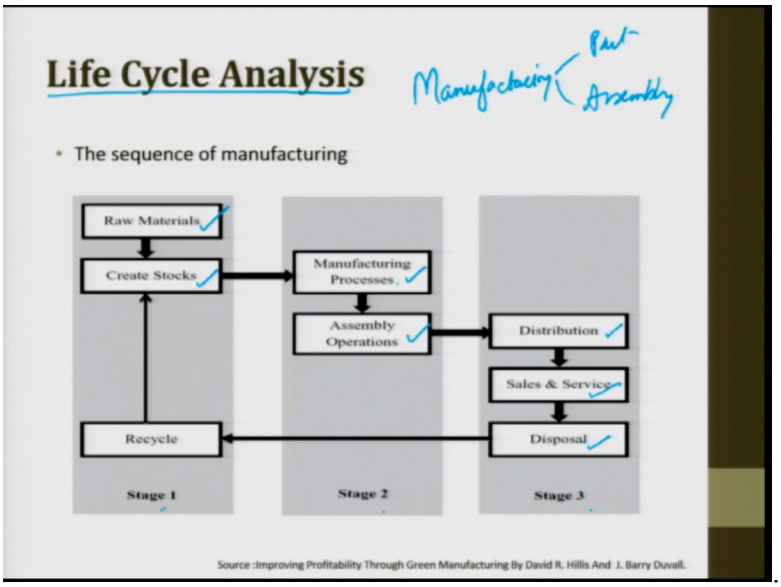

So, the sequence of when and, but here in this course we are more focused towards manufacturing when we talk about life cycle analysis keeping in sequence of manufacturing, raw material you create stocks and then you do a manufacturing process you do assembly. So, manufacturing is generally divided into two; one is producing a part, the other one is assembly.

So, raw material stock then what happens you try to produce a manufacturing process produce a part, then assembly, then assembly it will go into transportation then sales disposal and then what happens after they are trying to throw the product out then that gets disposed, it gets accumulated, it is gets recycle, it creates a stock. So, this is what we are trying to see, today when we buy a compressor when you buy a car they say the engine has 10 year warranty the compressor and a fridge has 7 year warranty, but if the fridge life is only 5 years, then what is the use of having that 7 years.

So, when we have a 7 year compressor it means to say at the end of 5th year you bring take the refrigerator to the particular company, they remove the compressor which has 7 years of warranty now they fit in into a new refrigerator where you buy. So, you do not

give a cost for the compressor so this is also life cycle analysis they do ,ok. So, it is divided into 3 stage manufacturing, then this is manufacturing, this is for primary manufacturing, secondary manufacturing and this is sales and service.

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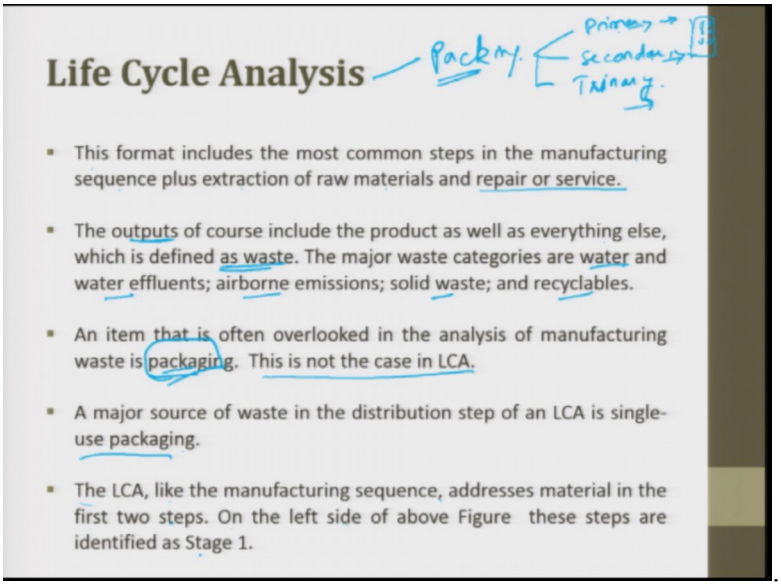

So, the format this format includes the most common step in manufacturing sequence plus extraction of raw materials and repair or service. The outputs of course, include the product as well as everything else, which is defined as waste the output is defined as waste. The major waste categories are water, water effluent, airborne emission, solid waste and recyclable. And item that is often overlooked in the analysis of manufacturing waste is packaging, we are least bothered about packaging, but now packaging is something which is more talked about in life cycle analysis.

Now, they do not talk about product alone they talk exclusively on packaging unit life cycle analysis, this is not the case in LCA, but today it is more focus towards that. A major source of waste in the distribution step of LCA is a single use packaging. So, when you when you look at it there are 3 types of packaging which is primary, next is secondary and the third one is tertiary or trinary.

So, primary means where the packaging material comes in contact with the product, the secondary means it can come it need not come or it comes in contact with top of the product for example, I try to buy a pharmaceutical item. So, in the pharmaceutical item that tablet comes in contact with the packaging that is primary. The next one is the tablet

along with the cover coming in contact with some material is called as secondary, all these tablet us getting packed and then while moving from one place to another is trinery. So, you have primary packaging, secondary packaging and trinary packaging, all these packaging's have to be reduced and you should think of applying life cycle analysis for packaging ,ok.

The most source of waste is the distribution system of an LCA is single use packaging, the LCA like the manufacturing sequence, addresses the material in the first 2 steps. On the left side of the above figure these steps are identified as stage 1 which we have discussed.

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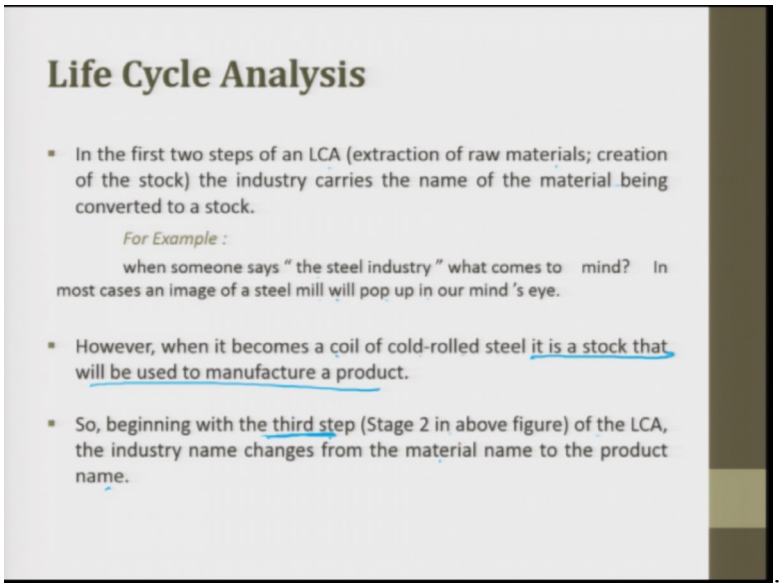

In the first 2 steps of LCA extraction of material and creation of stock is done, the industry carrying the name of the material being converted to a stock these are called as primary manufacturing industry. Example, when someone says a steel industry what comes to mind is the, in most cases and image of a steel mill will pop up in your in your eye even. However, when it becomes a coil of cold - rolled steel it is a stock that is used to manufacture a product. So, beginning with this third step stage 2 is above figure of an LCA the industry name changes from material name to a production. So, when you go to the third step we do not talk about steel, we talk about the product.

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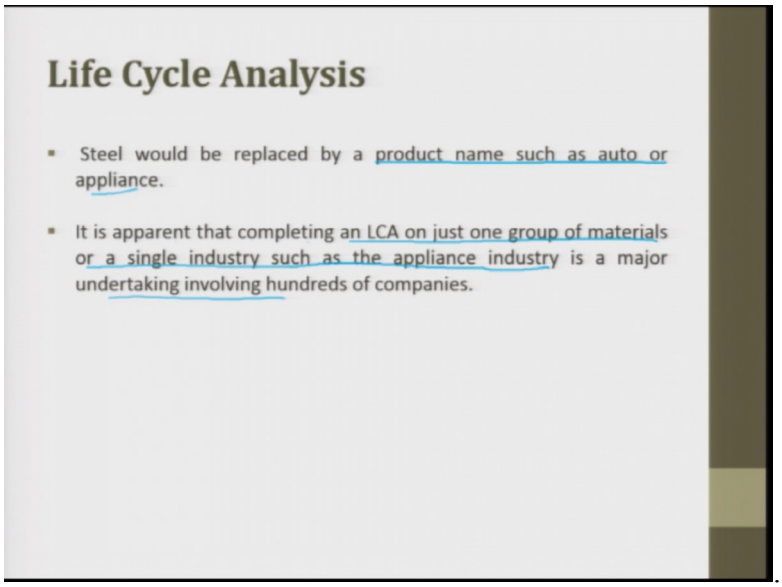

Steel is now replaced by a product name called as auto or appliance, it is apparent that completing an LCA on just one group of material or a single industry such as appliance industry is a major undertaking involved involving hundreds of companies. So, life cycle for everything is now added to software today and we look for the products.

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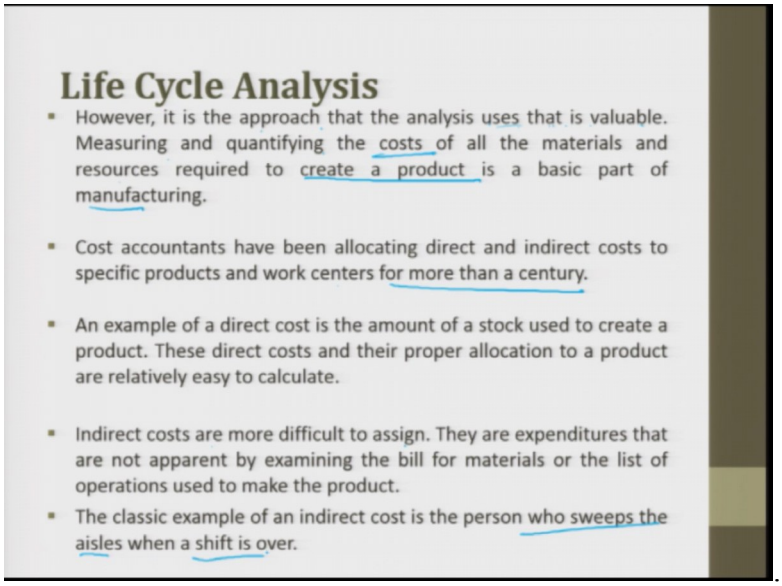

However, it is approach that the analysis use uses that is valuable it is the approach that the analysis is valuable, measuring and quantifying the costs of all the materials and resources requires to create a product is a basic of manufacturing. Cost accountants have

been allocating direct and indirect cost to specific products and work centres for more than a century. An example of direct cost is the amount of a stock used to create a product, indirect cost are more difficult to assign. The classic example of indirect costs is a person who sweeps the aisles when a shift is over.

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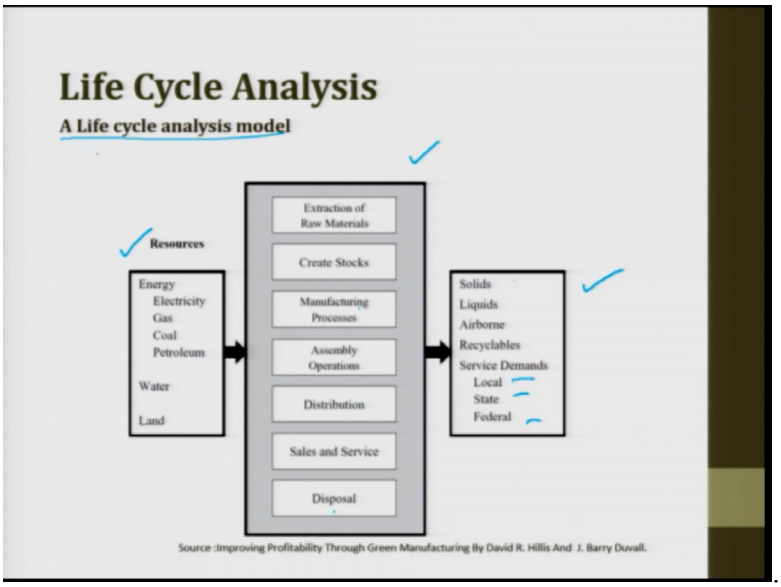

So, life cycle analysis model these are the resources, these are the stages of raw material and these are the by-products that is solid waste liquid waste, airborne, recyclable, service, demand, local state and federal and if you see that extraction of raw material, creation of stock, manufacturing process, assembly, distribution, sales and service and disposal all these things are now add up in the product life cycle analysis model.

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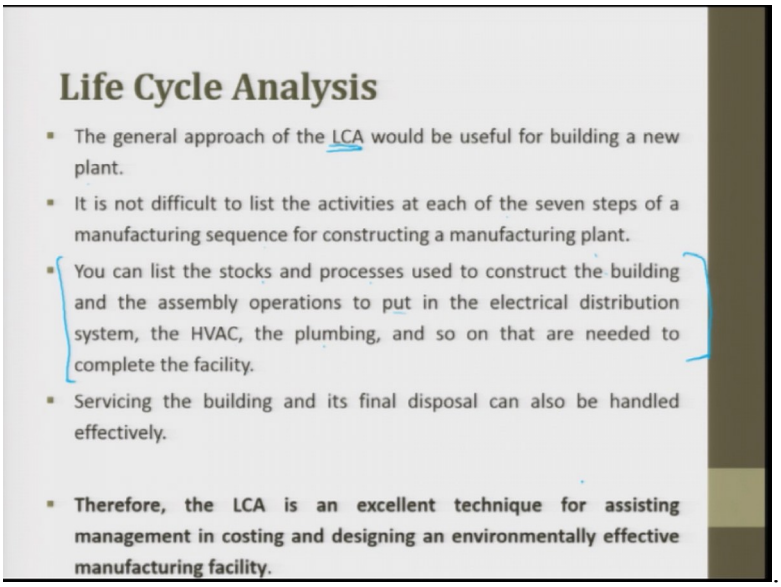

A general approach of LCA would be useful for building a new plant; it is not difficult to list the activities of each of the 7 steps of the manufacturing sequence for construction of manufacturing plant. You can list the 7, 1 2 3 4 5 6 7 and these are the 7 which are listed ok. You can list the stock and the process used to construct the building and the assembly operations to put in an electric distribution system, the HVAC the plumbing and so on that is needed for completing the facility. So, all these things are now thought of and added at the first stage.

Servicing the building and it is final disposal can also be handled effectively today. So, today we talk about something called as green building and where and which we allow the light to enter inside the building maximum light natural light to enter inside building and reduce the electricity cost and it is also thought of today from the cleaning point of view the building. So, not much of energy is applied for cleaning that is what is we talked about. Therefore, LCA is an excellent technique for assisting, management in costing and designing an environmental effective manufacturing facility. So, with this we stop.