Life Cycle Assessment
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Lecture - 02
Life Cycle Assessment

Welcome back.

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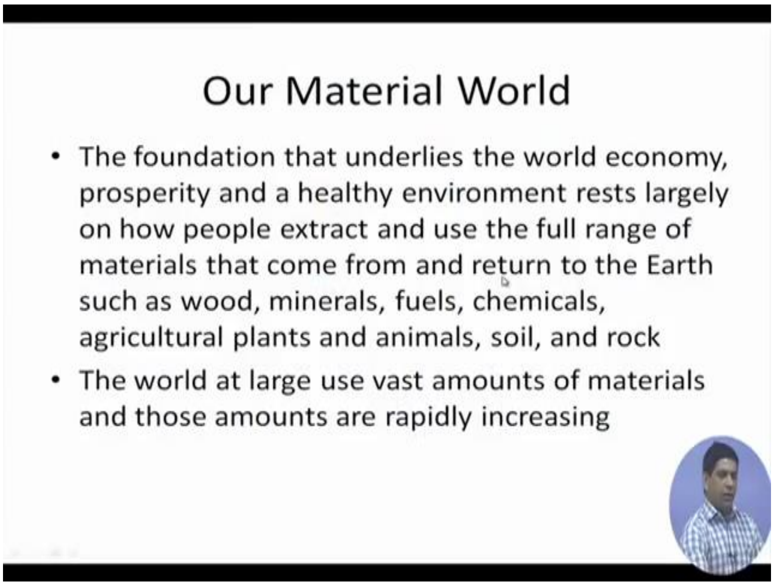

As we have been talking in the first video of this particular course, we had a overview of a basic concept of the sustainability, we will look at some of the energy demand issues. Now in this particular video we will focus on materials, because as I said earlier to make anything like- if you are an engineer we know that even, if you are non engineer you know that you that if you make anything you need material. So, the foundation of the world economy, it is a foundation that underlines the world economy its rest how people extract and use the full range of material that comes from the earth and also how we return it to earth. So, we need to return this material back to work so that the future generation can use it.

So, the world at large we use vast amount of material and as our affluence is going up, as our population is going up these amounts are also increasing. So, we are using lots of material, if we make more and more factories, more and more production, more and more demand then more and more material usage. We have to think about efficient use of those materials that is why I mean it better technology. And at the same time how to come up with the technology so that we can recycle these materials more, so we do not have to extract.

So, again materials are very important and we will look at how these materials are managed. Some of the examples of our wood mineral, fuels, chemicals, agricultural plants, soil, rock and all these are the different materials that we use.

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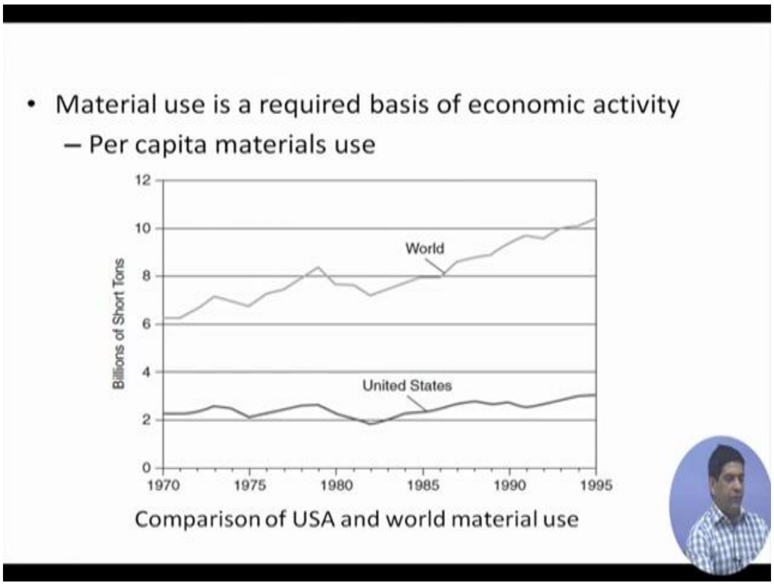

So, if you look at the world the usage of material this graph is a bit old, but even if you look at the graph it will probably keep on increasing; you will see even further increase in this graph kind going up. Because the per capita material used which is the billions of short ton; short ton means it is around 2000 pounds. Since the graph was generated in US, the US pounds and its 2000 pounds is short ton which is around 900 kg not 1000 kg. So, is per capita material used but that do not worry too much about the unit here, but what is what I am trying to say is the per capita material uses increasing over last several decades. And then things are even actually going up and up. With slightly you see this dips; dips are basically doing the period, so we have some sort of industrial recession either less demand.

So, if you look at if there is a new graphic available now you probably see a deep around 2008-2009 where we have a global recession, but otherwise the in on average things are just going up. The developed countries- you see more flat trajectory, because they have already kind of developed their demand is not going their population is also not increasing at the rate at which we see the population being increase in the developing countries especially in Asia and Africa. So, there is a lot of demand.

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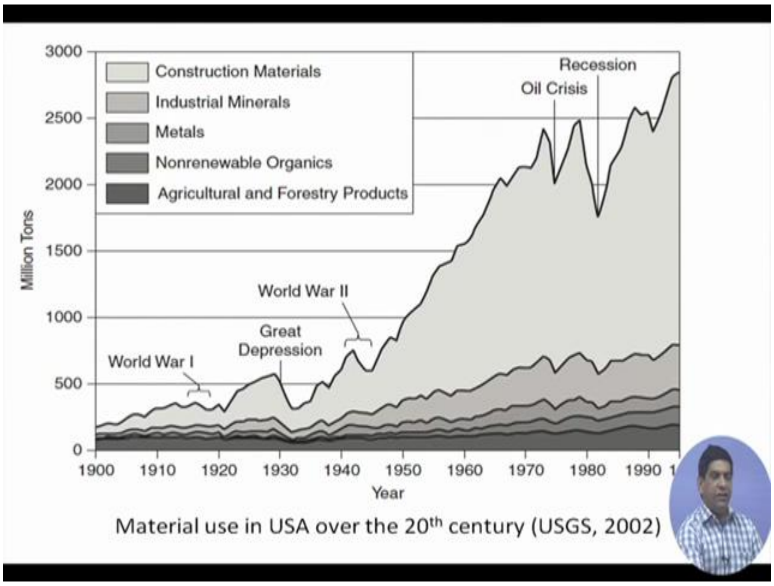

The message that I want to convey from this particular graph is there is a lot of demand, there is a material uses there and it is needed for all industrial activity. And on in the 20th Century; in the last century as you can see there is the different kind of material construction material, industrial material, metals, non-renewable organics, agriculture and forestry products. Say in terms of area the y axis is a million tons and the x axis is our years from the last century and the graph came from the USGS report.

So, if you look at there was a other than the great depression, you see that there is a continuous great depression oil crisis or recession you see. There is a trend of increase in demand, lot of demand in the agricultural sector and then the industrial mineral, metals and agricultural demand is there but not that high, but in construction and again if you think about in Indian contest; Government of India is pushing for housing for all right now. We want housing for all by 20-20 or 20-22 some I do not remember the exact year, but in next 10 years we have to build lots and lots of houses. If you really want the houses to be build.

And for those houses to build we need lots of construction material. We do not have that much sand available, if you really want to make all those concrete houses we need lot of sand lot of cement, India does not have that much sand. So, what that mean? That means, that we need to really manage whatever the construction material, we have in a more efficient way. And one of the aspects of that is how to recycle much about those construction materials, how to get this construction waste and demolition waste and recycle them so that they become usable.

And there we will talk later on as we have to be careful in terms of the environmental risk out of that, of course we need to look at the structural property, at the same time we need to look at the structure, environmental aspect. And we can look at the from a big picture life cycle perspective all these things really fit on. So, there is a lot of demand. And same thing you will see; these demands most of you see the graph for US. If you look at developing countries, somebody if you can after 2100, if somebody plots this graph for India China they will probably see something similar activity happening in India and China over this coming in this present century. We will probably more demand, because you have more population in here.

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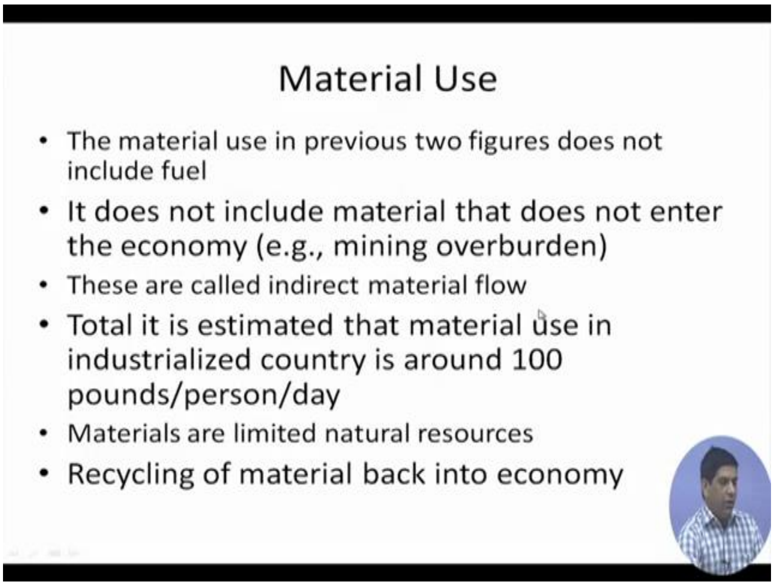

So, material use that you saw in the previous two figure it is not include fuel, so fuel is separate. It does not include material that does not in enter the economy; for example, the mining overburden, reproduce lots of mining overburden. These are called indirect material flow. The graphs what we had was the direct material flow. So, it is estimated that industrialized country its around 100 pounds per person per day, that much amounts of material. 100 pounds you are talking about nearly 45 kilogram. So, 45 to 50 kilogram per person per day is, what is needed material for developing all these different resources, different infrastructure activities.

But at the same time as I just said earlier materials are limited natural resources. So, we need to focus on recycling of this material back into the economy.

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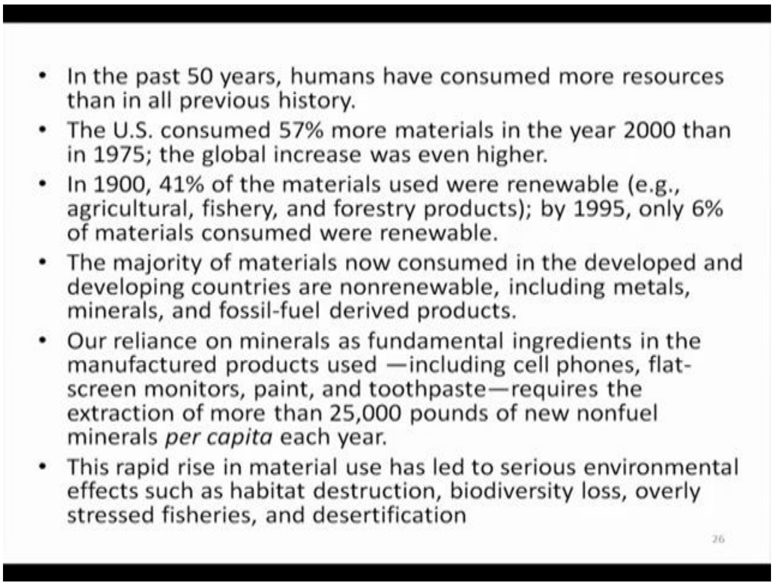

So, here in the past 50 years we have consumed more material then total material consumed by our human race since existence of the human race in the in this particular planet. I am pretty sure this next 50 years we will have probably similarly energy use of material if the material is available. It just for United States itself consume 57 percentage more materials in the year 2000 then in 1975; the global increases even higher; if you look at China or India you will see much more material usage, because this is based on the base year of 75. So, since in the early base years our material used was much less, we may even have more than 100 percent or 200 percentage increase.

In 1900s 41 percent of the material use was renewable. So, out of the all the material used 41 percent for renewable that agricultural, fisheries, forestry products. By 1995 it came down to only 6 percent and now probably to the much less. So, majority of materials today is being now consumed in developed and developing countries are non-renewable, including metals, minerals, fossil fuel, derived products.

And we rely on these minerals a lot, especially for some of these like newer products like cell phones, flat screen monitors, paints, toothpaste, all these materials they require nearly 20000 kgs of around 10000 to 12000 kgs of a non fuel minerals per capita is here that is around 25000 pounds. So, its rapid rise in material use, that is leading to lot of environmental impact on habitat, destruction, biodiversity loss, overly stress, fisheries, and desertification.

So, if you are wondering at the beginning of this lecture that why I am talking about this material, because everything is related. When you are trying to go for this material you are impacting environment. So, this whole life cycle analysis aspect is sustainability life cycle analysis is related to as I said earlier among the three pillars of sustainability life cycle focuses on environmental aspect. So, there is a source LCA but that is a different, this particular life cycle as we will discuss in this particular class is mostly focus on environmental.

And when you look at this environmental aspect for any particular product or process the use of material from this product and process is very important which does lead to this kind in terms of a habitat destruction biodiversity and all that.

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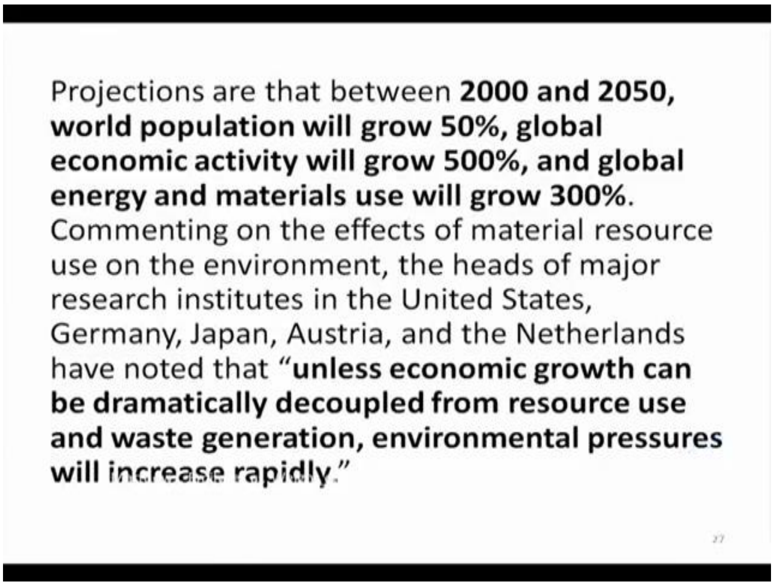

So, there is a projection that world population will grow 50 percent by 2050. So, whatever we had in with respect to 2000 in 50 years for population will grow by 50 percent. Global economic activity will grow up a 500 percent. And that will lead to global energy and materials used grow of 300 percent. So, think about that that is a big increase. If you look at some of the comments on the effect of material resource use an environment there are some of the research institutes in US, Japan, and Austria Netherlands; what they have come up with a conclusion that “unless we do a economic growth can be dramatically decoupled from resource use” which is you want to have economic growth, but not too much of the use of the research; but we said me too much use of the resources means too much not use of the too much of the newer resource whatever is the resource available we can recycle reuse within the system itself.

So, if we can decouple it from resource use and as well as a waste generation then we will have a lot of pressure on environmental issues and that will be in lots and lots of usage of life cycle analysis kind of tool. So, that is why life LCA tool, a person if know LCA from a job perspective, from their marketability perspective forward you go for a job interview many companies will have to do these kind of LCA exercise. Many companies started doing it, those who are not they have to do it, even the government agencies are looking at doing LCA now. Many European legislation and even in California and other places they are forcing people to go for this kind of regular exercise.

So, this will help you in your job if you have a understanding of this kind of exercise.

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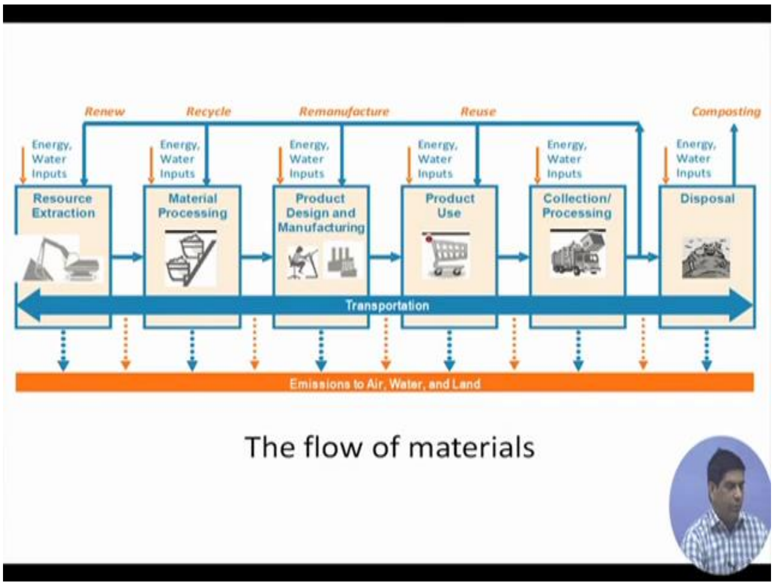

So, looking at this material, when you a material how it travels; this is the flow of material in a system. So, if you go from the left to right you start with the resource extraction where material resources you extract the resource and that are you are mining. And there you need lot of the arrows that you see on top these arrows on top is telling you the input coming into the system. And this dotted arrows at the bottom you see the emissions coming out of the system.

And in the middle those rectangular box is telling the different units different processes that is happening in as part of the material flow. And in between you see some of the reuse remanufacture recycle and at part of disposal part of it could goes to composting may go to the land flow.

So, if you start from the beginning; you have the resource extraction, from the resource extraction you go to the mat material processing which is your most famous metallurgy friends will do that for you. Then you go for product design and manufacturing, that will be will be designed and manufactured where most of the engineers come in picture. Then product is used where all of us comes in picture, that product will be used. Then it will go to the disposal, it has to be collected, processed, recycle back, and part of it would probably needs to be disposed as well.

So, for all of these units of course the transportation is involved from one to one process to another process whether within the plant or some time from one plant to another plant and the dotted lines at the back give you the emissions to air water and land. So, this whole concept is you are what is how the material flow. So, we have to watch these steps very closely to look at to where among these different activities when we see most of the environmental impact and you want to reduce those environmental impacts.

So, how will find out where the most of the environmental impact is after doing the LCA exercise.

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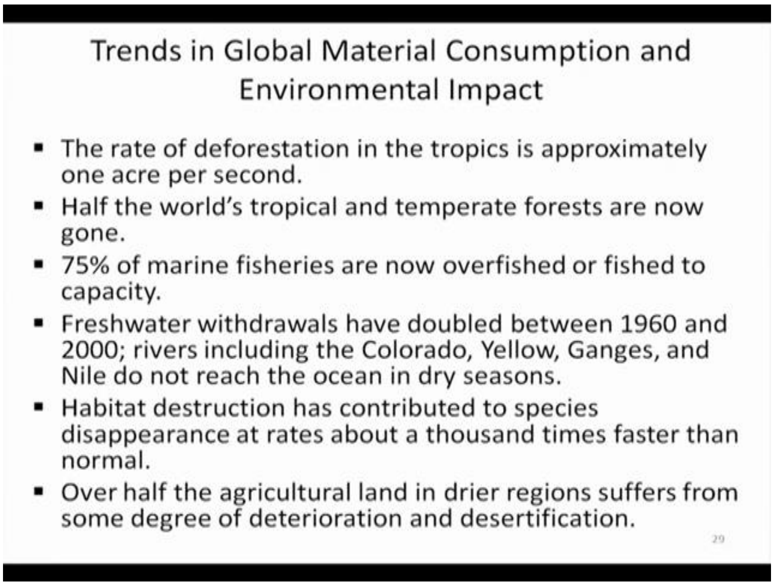

So, there is a rate of looking at the global material consumption and the environmental impact associated with that. We rate of deforestation is happening at a very faster rate one acre per second. Our half of worlds tropical temperature forest are now gone we do not see them. 75 percent of marine fisheries are now all overfished or over fished to fish to the capacity. Our marine life is also getting affected by the plastic pollution which will also talk about at some point in this class.

The face was a freshwater withdrawal has double between 1960s and 2000. If you think about in Indian context as well if you wherever you go in India our groundwater resource is getting depleted at a very alarming rate. The first if you had water at 30 feet, now you go upto 50, 60, 70 feet you do not see water. And many of these rivers are not reaching ocean in dry season that is and Nile even, Ganges, Colorado River, Yellow River, during the dry season you do not see them reaching the ocean.

There is a habitat destruction contributed to species disappearance at the rate which is about thousand time faster than normal. One half of the agricultural land is dry region is suffering from some degree of deterioration and desertification. So, the agricultural productivity is going down because of the usage of a lot of fertilizers and other causes associated with that.

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So, as you can see there is a substantial environmental impact which is coming up because of these different activities that is happening as part of the industrial or agricultural activities. So, another problem we have is, the concentration of most of these minerals when you mine like in your mining ore. Say today if you are mining for certain metals if you are getting 1 kg of the pure metal from 100 kg of those mineral ore; tomorrow like few years down the line few decades on the line you may have to 1000 tons will give you later, sorry 1 ton will give you a 1 kg see. So, you need to mine more and more, if you have to mine know that means more environmental emissions, that means more energy usage, and more energy used means more environmental emissions too and more water usage.

So, there is lot of these things are all interrelated. So, more amount of a material that have to be mined and processed is increasing at that increases environmental impact. Then we have lot of persistent, bioaccumulative, toxic chemicals can coming into the food chain between 1970 s and 2004 dodge 33 decades. The greenhouse gas emissions increase by 70 percent and this most of the global average temperature has is going up, because of the greenhouse gas, because of anthropogenic sources. And that includes extraction processing using disposal.

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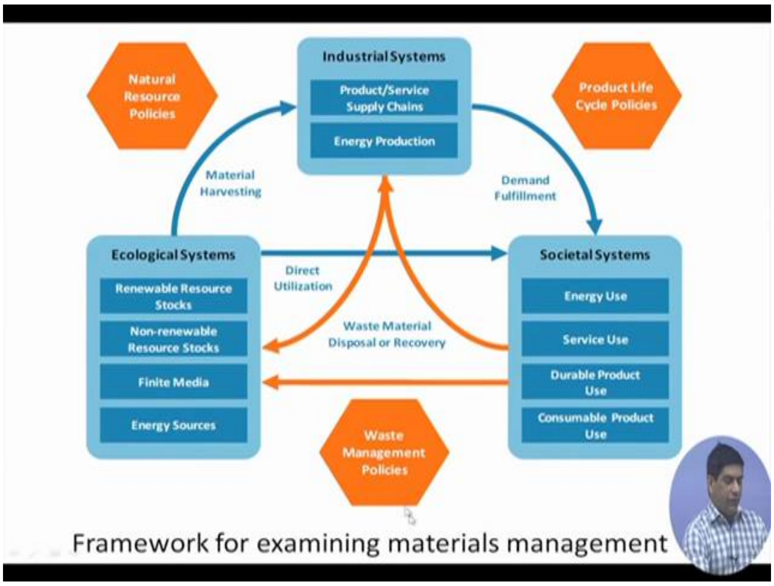

So, if you look at the exam materials management, if you look at how we can make an impact as how this LCA exercise will be useful. So, if you look at the natural resource you have to look at the natural resource policies, you look at the product life cycle policies, natural resource policies, product life cycle policies of the waste management policies. All the three this orange hexagon that you see this policy is can take into account some of this life cycle perspective. Try to improve the recycle, encourage recycling may give them some sort of incentive maybe some tax benefit.

So, those said that we can reuse the material. Sometimes it seems to be cheaper to just go for the virgin material then to recycle, but if you look at the long term cost, if you look at the environmental cost that is why I have this life cycle thinking comes in picture. Way you look at the long term impact you see that actually recycling is comes out to be much cheaper. There would be some situations where recycle does not, but most of the situation recycle comes to be much as a post to put in the middle and for in a waste energy plant.

So, once and then you have the ecological system, then you have a societal system, we have industrial system and these are all related. So, if you ecological system, renewable resource stalk, nonrenewable finite media, energy sources, society durable products, herbal product use, service use, energy usage, so there have industrial system, used in production server supply chain, energy production, material is being harvested from ecological system goes to industrial system- industrial system is actually full in the demand of the societal systems. So, everything is kind of related to one and another.

And this whole picture shows you the framework for examine how the material is getting managed. And this is very important in terms of when we look at things systems perspective rather than looking at just the ecological system separately, industrial separately, societal separately. What LCA exercise does, it helps us look at all the three systems into in totality so that we can make a better decision.

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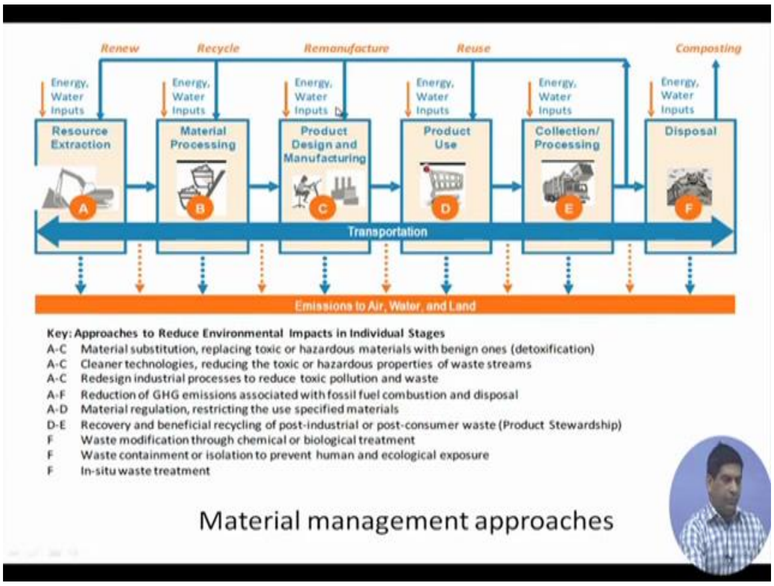

So, coming back to that particular graph if you look at these emissions, this sketch material management approaches. You see that here for A, B, C, D, E, F, where A to C is a material substitution we can do we can replace toxic and hazardous chemical with something say for one. We can use for cleaner technology, reduce toxin in hazardous properties, redesign industrial process so that produces less waste. Reduction of greenhouse gas material we can go for material regulation. And then part where you have a mostly waste modification you can do some treatment by street containment in say to a treatment.

So, all this will come into picture like how you can use some of these approaches. So, whatever you learn from your analysis you can apply over here. So, that is how what you are trying to say over here.

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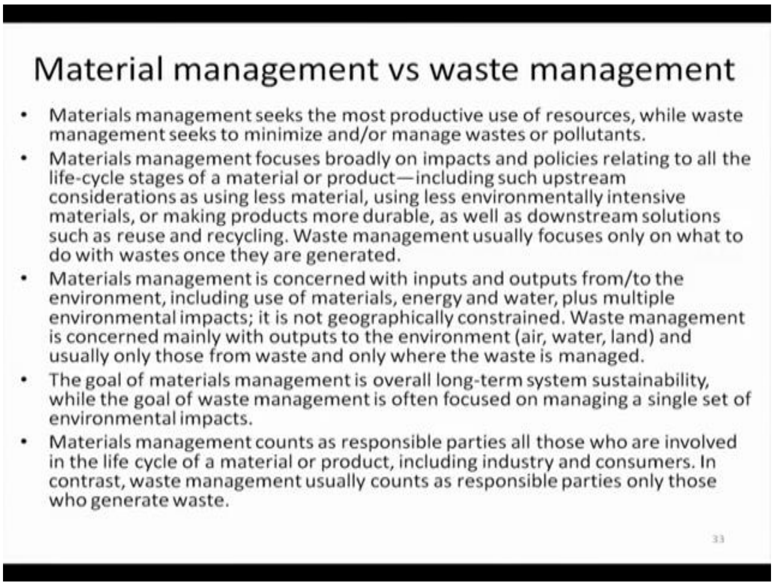

So, material at some point of time it becomes a waste, and then it goes to the waste management sector. So, material management seeks the more productive use of resource, but it is not useful any more it goes in to the waste management. Sector the waste management the goal is to minimize and manage waste of pollutants. Mmaterial management they broadly focus on impact and policies relate to whole life cycle of the product including upstream, use of using less material, use in less environmental intensive material, making products more durable.

So, material management and the waste management is interchangeable these days. You can have it is whatever was the waste earlier if you start recycling them that becomes a recycle material. So, many places in the world they do not call it waste management anymore they call it resource and recovery management or waste resource recovery of materials.

So, goal of material management is over the long term sustainability, while the goal of waste management is focused on managing a single set of environmental impact. So, when we look at the material management the waste management actually is part of that, and that comes into the whole life cycle of this particular material that we talked about.

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It is a broad concept there are lot of different countries and government and businesses are including different types of material policies. In European union has a sustainable materials management policy, then we have sustainable production and consumption that United Nations environmental program, then United Nation environment program another sustainable resource management.

Many times you hear 3 hours these days even 4 hours and 5 hours which is reduce reuse recycle now they are talking about recovery and sounds material resource; sounds material society that is in Japan. In EPA and others they call for design for environment, and then you hear the term green chemistry lean manufacturing, supply chain management, eco labeling green procurement zero waste. All these different concepts has the basic philosophy is the same; basic philosophy is to have better user material produce less waste so that less environmental impact. And LCA has a tool help us to quantify all those aspect.

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See if you look at the life cycle material approach for packaging which EPA; USEPA came up with, so you have your resource this is your life cycle. The orange the sketch that you see such kind of going through the life cycle aspect from cradle to grave; you start from a source extraction and then you go to end of life. Resource extraction, material processing, design manufacture, distribution retail, purchase and use, and your end of life.

So, for all these EPA was is working with materials manufacturers in and converters to reduce environmental impact in each of these processes to come up with the design for environment program. Where they try to encourage companies to go for more cleaner production. EPAs climate leaders and green supply network program assessed manufacturers with the reducing the green greenhouse and environmental impact. You are working with big companies like Walmart to improve the packaging. And even Amazon so that the package because the packaging waste is too much. They are also have a vehicle of policy now to reduce the vehicle emissions.

And with a sustainable packaging collision which is organization EPA is providing input to design in able to tell the consumers support end of life options, whether the packaging material can be recycled, whether it can be composted it or can it put in a waste to energy plant. So, those kinds of information are being provided to the consumer as well so that they can manage it in a better way.

So, many organizations around the world we do not say this much lot of activities in this line in India has not started this sentence it started much, but recently last year or I think early this year the government has set up a what is known as the Indian resource panel. So, there is Indian resource panel now which will look on policies like this where they will try to have a better or resource management in the country. So, we will also start calling it resource other than the waste management.

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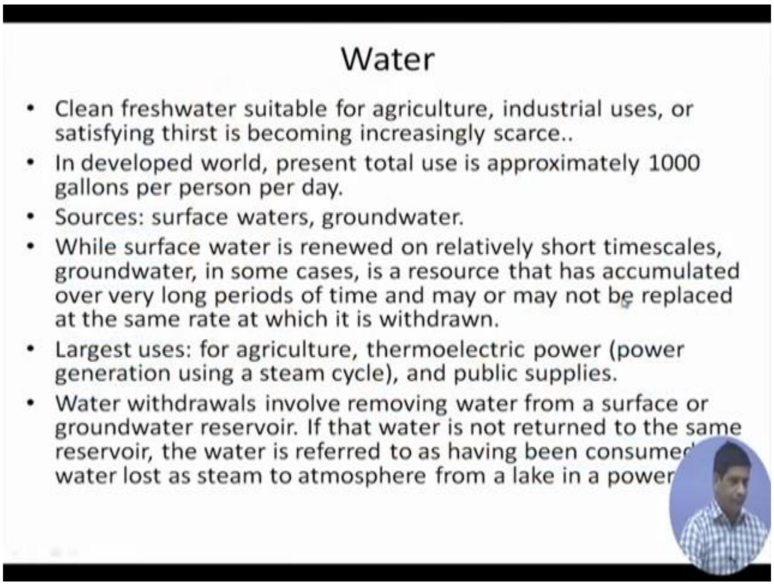

So, that in term of the material, and one of the materials or one of the other resources that goes into the water. And we need lots of water as you will see in subsequent lectures that water is very very important for any industrial activity. So, clean fresh water, it is a suitable for agricultural industrial use and its satisfying third trust. In developed world and combine uses around 1000 gallons per person per day and touching to every activity of the country like domestic industrial all the activities together; 1000 gallons- 1 gallon is around 3.8 liter can think about around 3800 liters per person per day, so close to 4000 liter per person per day. So if you have 40 liter per bucket, but we are talking about 10 buckets, so around 10 packets per person per day is what is the used.

Then we have sources are coming from surface water and groundwater, those are the major sources. Surface water does get renewed to and relatively short time scale, but the groundwater it takes a long time. So, what is happening in a country like India what you are saying right now we are extracting our groundwater is a much faster way then what the Mother Nature cannot replace it, and whatever was the groundwater recharge places those places have been now filled up high rise apartments there. We are making more and more areas to be concrete paved, so there be coming like impervious layer and that is creating reduction in opportunity for groundwater recharge. So, those are the problem why we have a lot of although we are extracting too much. In one hand we are extracting too much and at the same time we are not replenishing; we have actually hinder that the replacement of those groundwater recharge.

So, largest use in global including India is agricultural then thermoelectric power plant and public supply. And water withdrawal that is remove water from surface and groundwater, but if the water is not returned to the same reservoir the water is referred to having being consumed. So, water is lost as a steam or from a lake.

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So, there are some videos out there I will not play this video, but this particular I would encourage you to check out some of this video on how the different stuff is made, what are the sustainability stuff out of that, this particular website is called story of stuff dot com. They also have a YouTube site you can possibly want to go and check them out from there. And you can see a lot of videos associated with water usage, material usage, another aspect associated with like big picture sustainability.

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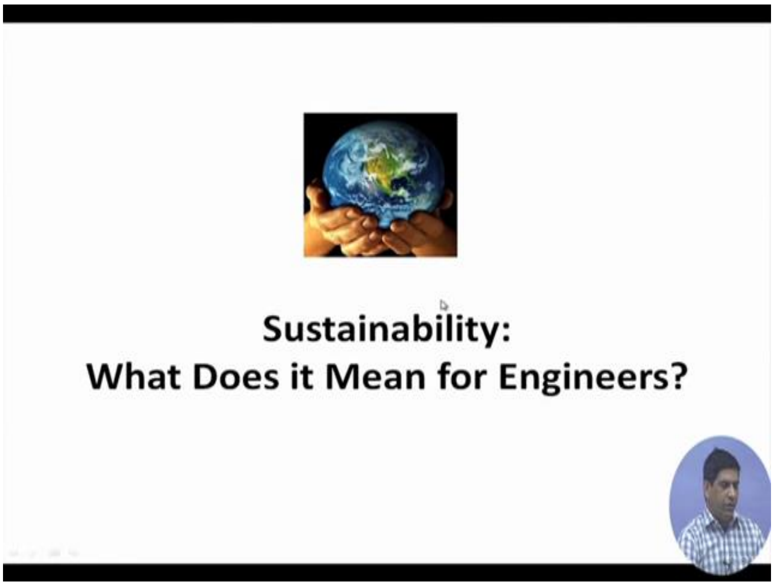

So, just the summarize we will have couple of slides here on. So, what we have talked so far, what is the sustainability and what does it mean for engineers.

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So, we have said that sustainability meets meeting society's present needs without compromising the ability of future, generation to meet their own needs. You saw that then humans are integral part of the natural world and the nature has to be preserved for our future generation.

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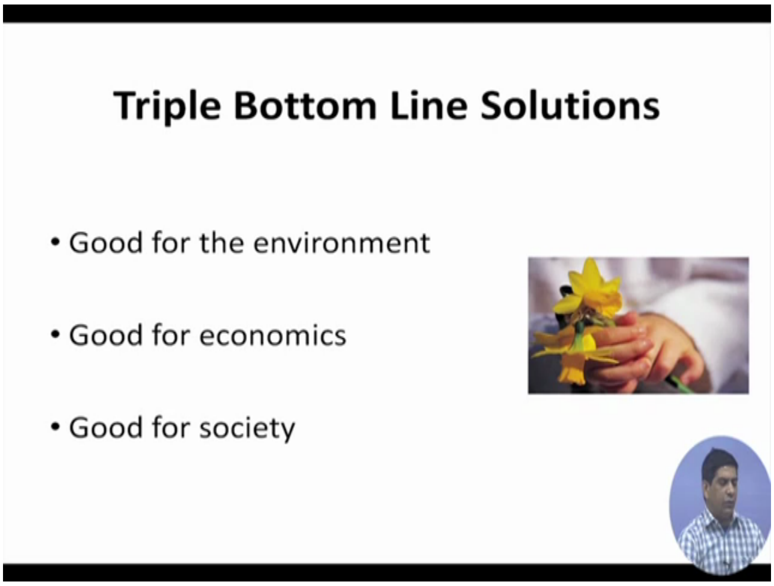

And most of these places we try to go for this triple bottom line solution, solution which is good for environment, good for economics and good for society. And many times is very difficult to find a solution if were good for all three. So, you have to have to kind of optimize it you have to optimize a solution which is can be used.

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And that is where you look at this whole life cycle or sustainability asked where you have the environmental protection and resource conservation at the same time economic prosperity and social welfare. So, this is all this kind of goes in picture.

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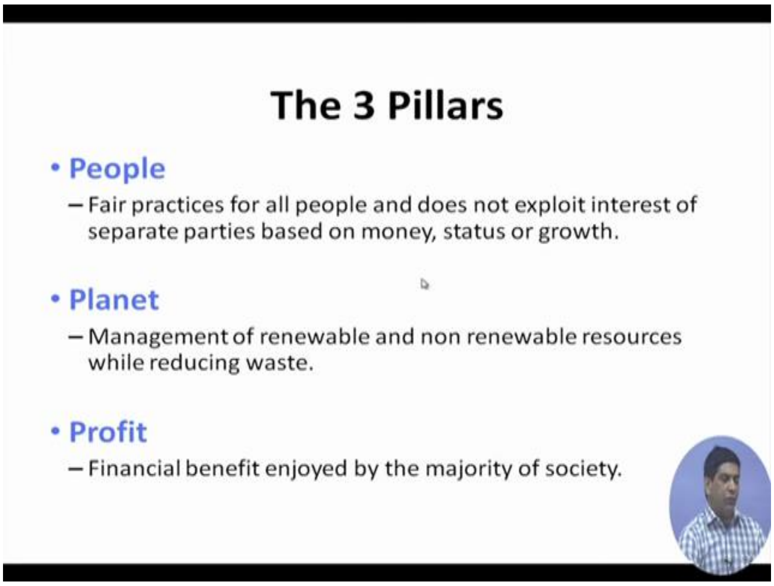

So, the three pillars is our people, planet and profit. So, that is your social, economic environmental economic. So, that your three like fair practice for all people does not explain to separate party is based on money status or growth. Planet that is a environmental management or renewable and nonrenewable sources, profit is financial benefit that is a economic aspect of that.

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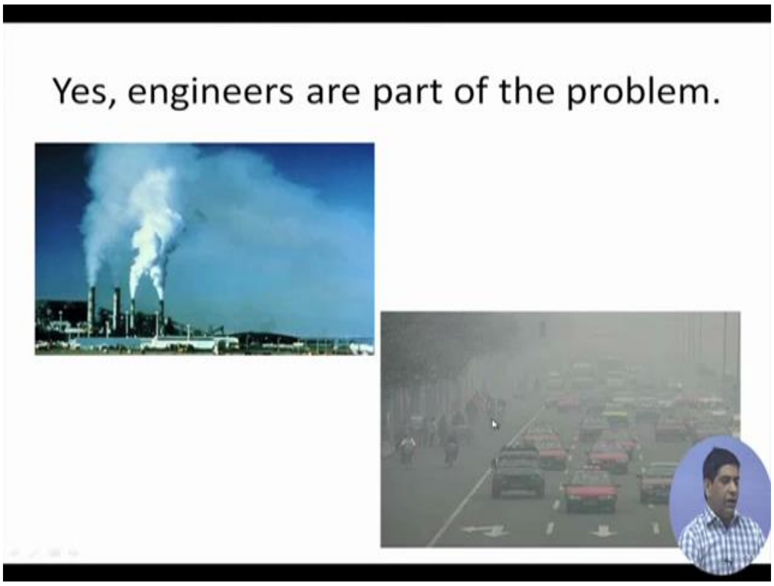

Engineers are part of the problem. We have created lot of issues, we have a lot of pollution Delhi, Beijing all the time all the access, but we are also part of the integral solution. So, what we have to come up with the solution to design all these different environmental protection systems and come up with products and processes which are more environmental friendly.

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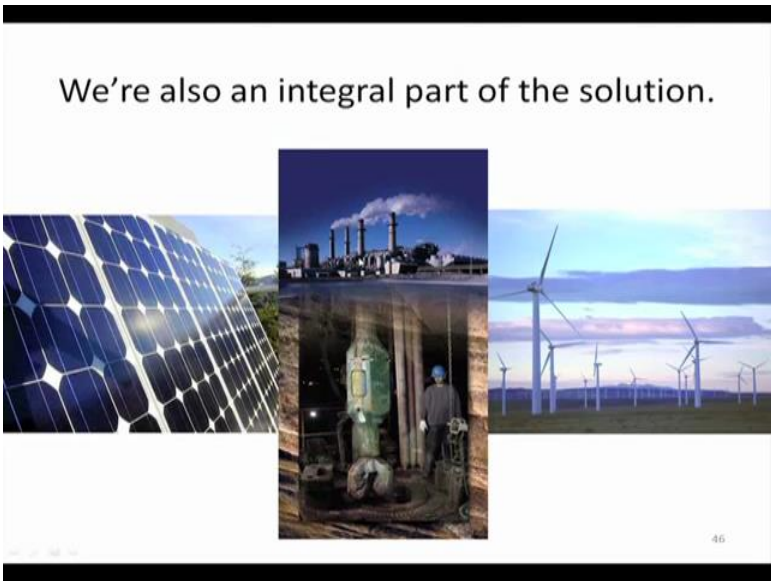

So, here you see the renewable energy and all that.

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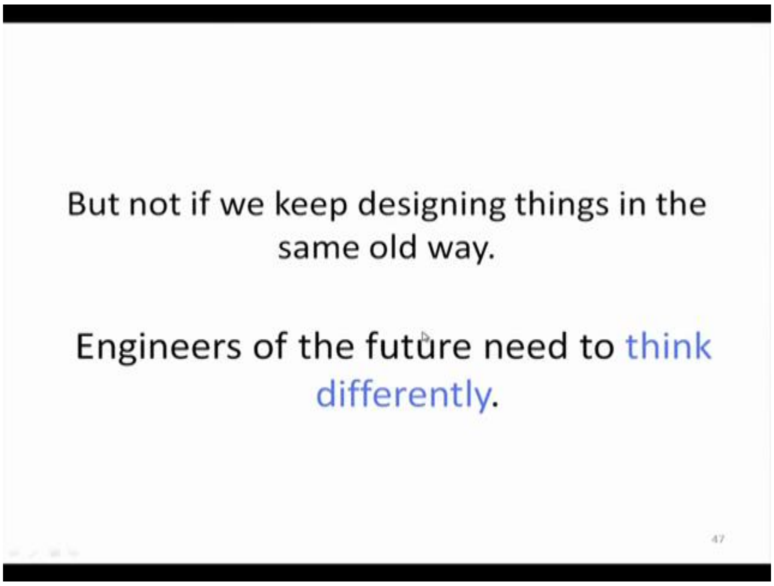

So, we will we cannot keep design in the things in the same way always; we have to start thinking differently. So, from next video on words we will start thinking that what are the things with that we need to start thinking differently, that probably we will start looking at in the second week. The first next week we will talk about the water; the water demand and all like this.

So, with this will conclude this particular a video which is your second module for the week one. And all again see you on for the third module.

Thank you.