Life Cycle Assessment
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Lecture – 01
Life Cycle Assessment – Introductions

Hello everyone. Welcome to this course on Life Cycle Assessment. In this course we will be covering basics of a sustainability, sustainable engineering concepts, and also we will go over water demand, energy demand, water flow, energy requirement for different processes different environment, different industrial processes. And initially what I will do is I will give you background, some introduction and then we will give go individually in topics in more great detail.

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So, little bit background about myself. I am instructor for this course, this is a 20 hours course and I have B. Tech in Civil Engineering from IIT Kharagpur. Then I worked in industry for a little while, then I did my PhD, and I have worked as a research scientist. Then I have been teaching and doing research in the area of waste management sustainability, sustainable engineering, life cycle analysis for almost 7-8 years now.

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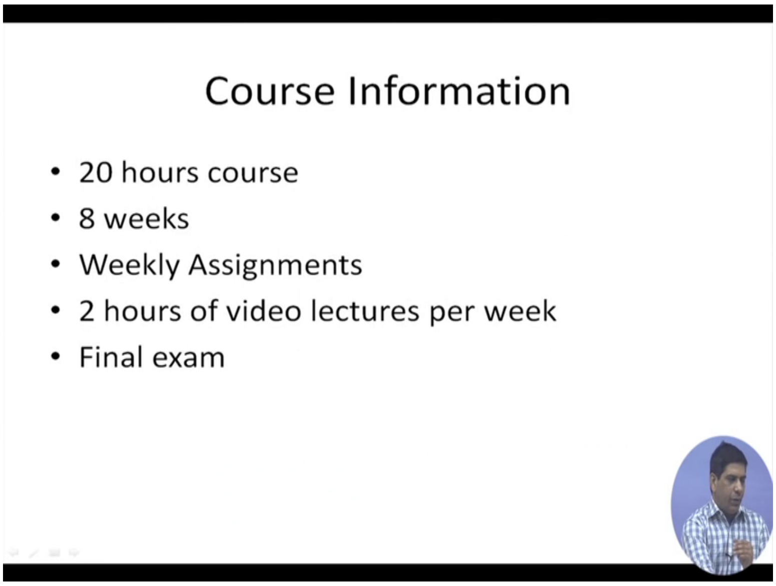

In this course just: it is a 20 hour course, we will have 8 weeks. At the end of each week there will be weekly assignments, we will have videos of 20 minutes, for every week we will have a 5 videos and an assignments. So, 2 hours of lecture videos per week and there will be a final exam at the end.

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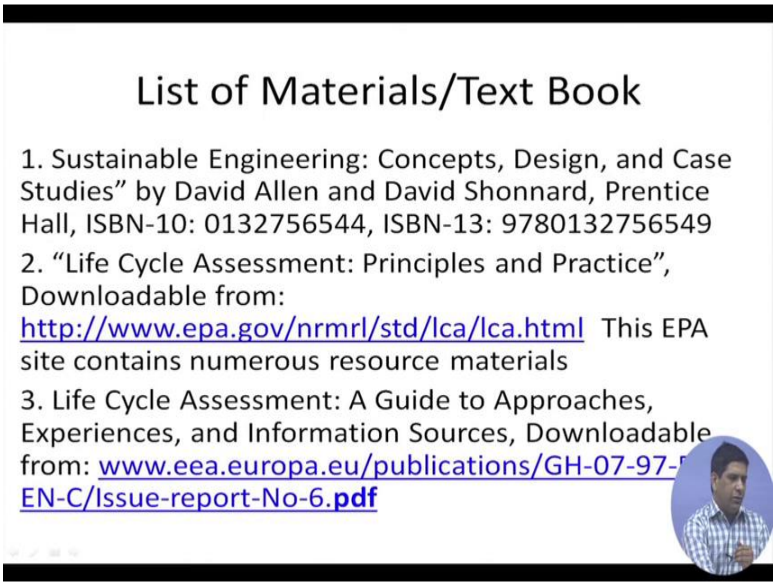

So, these are some of the materials and text books which we can find for this course. The first one goes over the Sustainable Engineering Basics; as you can see it is a concepts, design, and case studies on sustainable engineering by David Allen and David Stonnard, Prentice Hall, ISBN number is provided to you for if you want to purchase it you can get it from Amazon, Flipkart or any of those websites and also many of the text book many of the book stores will have it. And the second and third item is you can download they are freely available from the web. So, it is can be downloaded from there and we will be referring to the material from time to time in different lecture slides as we progress it to this course.

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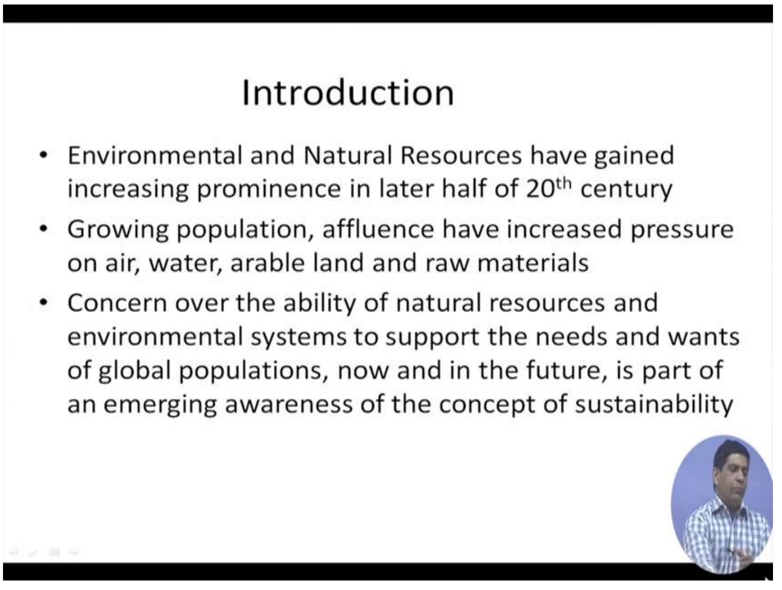

So, coming to the introduction: first of all in any course, first thing you need to understand is what is the importance of this course, why we need to, how this course was evolved, what is the need of the course, why people need to understand about these concepts? So, as the world is growing including our country India we are making progress, we are using more and more natural resources. And we are making a lot of a industrial activities, industrial plants are coming up. So, when all this things happens there is of course there will be depletion of natural resources, we need to at some particular point of time you need to start thinking about we cannot get newer natural resources anymore so we have to start recycling more and more.

So, we say there will be some environmental implications too, whenever you do any industrial activities you will produce certain emissions whether it is an air emission, water emissions, soil pollutions. Based on your previous environmental engineering courses or environmental science courses you know that these are very important like water air soil, these are very important part of our like how we interact with Mother Nature. So, keeping them clean, keeping them pure is a very important. And why this industrial activity is needed, there is a lot of demand our population is going up, we are right now more than 7 billion people Indian itself is a 1.2-1.3 billion; China again slightly more than India right now.

So, our populations are growing up. As the population is growing up at the same time affluence is also growing up. The affordability of the material, affordability of certain products; so if you remember 50-20 years ago having just one TV in the home was considered kind of luxury, I would say maybe in mid 80s and early 90s. But now if we go to a middle class house there will be multiple TVs. So, every bed room may have a separate TV, because its affordable now, based on the income of the people these cost of these electronics and cost of these many many products is not that high. So, people can buy those products.

So, when people able to buy those product what that means, that means is more and more demand for that product. So, with a more demand for the product with more products needs to be made. And when more products need to be made that means, more raw materials needs to be extracted, and they will be manufactured. So, there is a demand on raw materials. And there is a will be demand on water, because I show you a later on in one of the slides that water is one of the most essential item for any industrial activity; you need good water for any good plants, any production going on.

So, there will be a demand of all those, there would be water demand, there is a land demand for setting up all this factories, otherwise there will be a demand and also for mining activities, there would be a demand for a energy, because you need energy to do anything. And there would be emissions coming out, because whatever you can you produce energy there are emissions, when you make any plant. So, when you to make a plant or make products after the plant is commissioned that also have a lot of emissions coming out. So, that needs to be tackled. So, there would be air emissions, water missions, impact on land and of course demand for more and more raw materials.

So, what is happening is since the population is going up and we are using lots and lots of raw material, and we are creating lot of emissions going into the environment there is a concern that what will happen in the future. Whether we will have these resources available for our future generation, whether our grandchildren's would be able to enjoy the same level same lifestyle or they should enjoy on a better lifestyle than us; and for all that they also need natural resources. So, how to make the whole concept of the sustainability or the sustainable engineering is how to use the present material or present resources in a way so that our future generation can make use of that as well.

So, that is the whole awareness of that which is started around mid 80s with the United Nations some initiative. So, that whole awareness of that and the implementation of that in our day today life, when I say day today life means industrial practices and other practices. So, how to take care of today's demand at the same time make sure that the future demand is also made. And that is raise to the concept of what is known as the sustainability.

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So, sustainability: as this is a definition from the UN document which was the Brundtland Commission which first looked into this concept it meets the meaning of the sustainability the way it is defined is "development that meets the need of the present without compromising the ability of future generations to meet their own needs". So, as I said earlier we can meet today's need, but at the same time say our grandchildren, our children or great grandchildren should be able to meet their needs as well, so that resources should be available.

So, if you think about the items that were present on the periodic table, we cannot really destroy the material, we cannot create those material; the amounts of these materials are already given to us by Mother Nature. So, there is certain quantities of that, some are more some are less, the ones which are more we call them abundance. So, with that how we define is abundance of one element versus another element, iron is one of the most abundant elements, but most of the others are not. Many of the item that gets used in electronics for example, they are you hear the term rare earth metals; rare earth by the name itself if we just go back the English of it; rare means something which is not easily available, so it is there they are not abundant in Mother Nature. So, anything as I just said anything on the periodic table has certain quantity present in the Mother Nature. So, as we are using these quantities of course it will rain out at some point of time. So, those who are most abundant will rain out rain over may be 100 years or 1000 years, those who are less abundant will or the rare will run out much quicker.

So, how we can use this in a away so that our future generation can make use of this material as well. So, after we use it we should not make it in usable form, send it to a land or send to a certain place where you cannot use it anymore. So, this whole concept km is how to meet the need of the present without compromising the future, and this whole then the concept of sustainable engineering, green engineering, pollution prevention all these are interchangeable term to some extent they overlap with each other and they come under big picture umbrella of industrial ecology and all that. So, when you go for any of the sustainability activities as an engineer or as a practitioner you need to make sure that you measure the sustainability parameters.

So, how to measure the sustainability parameters there come as this concept of life cycle assessment which we will explain in this course as well.

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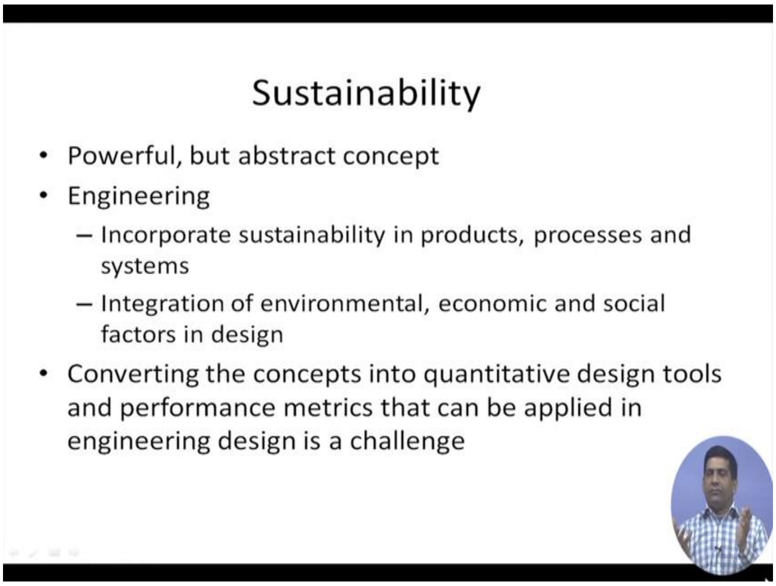

So, sustainability as I said it is a very powerful concept. As I was trying to explain you it is a very powerful, but it is a get abstract, but what is sustainable what is not sustainable. Many times when you talk to people regarding sustainable people get confused between sustainability versus durability those are two different things. Durability does not mean sustainability. It is a powerful concept, but as I explained earlier it is an abstract it many since its new it is relatively, so it is difficult to understand that.

And as a engineer or we as an engineering we want to incorporate the sustainability practices in our product, process, or systems. So, when you try to incorporate something you need to measure that, otherwise how will you incorporate? So, if you want to compare process a versus process b, so you need to have some sort of quantitative measurement so that you can compare this to say that process a is better than process b or they are equalizer or the vice versa.

So, for those incorporations we need to have some sort of a mathematical formulation and LCA- life cycle assessment helps in that mathematical formation. And when we talk about sustainability so far away I have been talking is mostly from the environmental stand point, but sustainability if you have looked at this particular concept it we will say it has three pillars. There are three pillars of sustainability: one is environmental and LCA does only the environmental parts, so not the way we do LCA there is a social LCA as well. And for there is an LCC- a life cycle costing assessment which is takes care of the economic part. So, there is a integration of the environmental, economic as well as the social factors in the design, that is the overall sustainability.

LCA; that we will we will be learning in this course will be focus mostly on the environmental part. We may touch a little bit on economic and social, but we will be focusing our main goal will be looking at the environmental side. Now we are trying to convert the concepts, this different concept into quantitative designed tool as a set. And then you look at some matrices so that you can apply an engineering design so that you can compare two different engineering designs.

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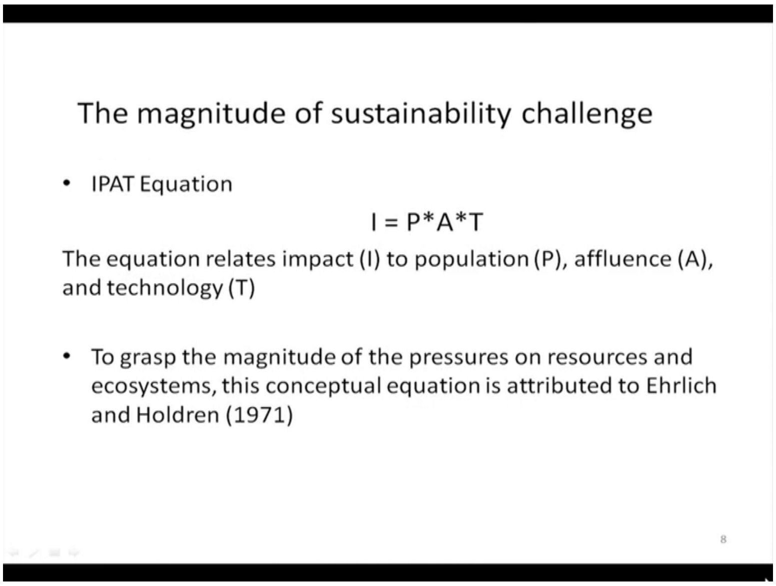

So, that is like a basic concept of where the sustainable engineering comes. And there is a magnitude of sustainability challenge. As I said very earlier today that our population is growing up, people’s affluence s going up to and technology is also keeps on improving. So, there is an equation which is presented its called IPAT equation. This IPAT equation is essentially where I is: what is the impact that is equals to the equation relates to the impact and with respect to the population multiplied by the affluence and the multiplied by the technologies. So, when we say multiplied by a approvence multiplied by a technology we need to put some numbers to that and we will get to yet in a minutes.

So, essentially it is the concept was developed to see; what is the magnitude of the pressure on resources on ecosystem. Our population is going up and on our affluence is also going up, and when we talk about technology we need to get more and more efficient technology. So, if we can have much better efficient technology which can take cares of the population increase say, if you have a 10 percent increase in population at the same time you make your process efficient by 19 to 15 percent the impact will be more or less the same, because now when we say increase in population we are talking about increase in demand.

As affluence part is as people are getting more and more affluence there will be more demand as well. So, whatever is the increase in p and a if we can take care of that to a increase by making our process more efficient that nullifies the pressure that is coming from p and a. If it is not, then we will have more and more pressure; when we say pressure essentially its pressure on natural resources, and also the emissions coming out in to the environment.

So, this concept was came into in by Ehrlich and Holdren in 1971; they came up with this equation.

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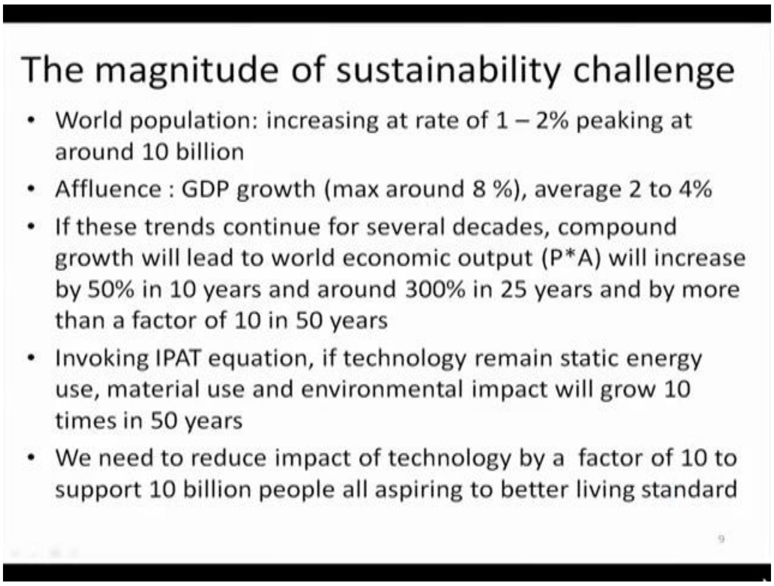

And to look at like in examples: so world population right now is increasing at going to 1 to 2 percent and it is said that around we will go up to around 10 billion and then we will pick and hopefully after that there will be no further increase the population will stabilized, but these are all based on some predictions. Then if you look at the affluence: affluence is related to the GDP growth and which is max around 8 percent, average is around 2 to 4 percent and that is the global average. Countries like developing countries like India, China that they are progressing as much higher level than most of the developed countries right now because they are already develops. So, they have a big base. So, our base is small, so our GDP growth comes out to be much bigger.

But if this trend continues for some time, if this trend continues for several decades so we have an increase in population, we have a increase in affluence. So, this will lead to a world more economic. So, world economic output needs to increase that will increase by around 50 percent in 10 years and maybe around 300 percent in 25 years. So, that is a more than a factor of 10 in 50 years. So, if you put the IPAT equation into this picture, if the technology does not change; so if the technology stays the same what we are looking at is the material use on the environmental impact will grow 10 times in 50 years, and we have seen that.

After the world war which was in mid 40s its 70 years before that we had the world war second world war after which the industrial revolution is started. So, that there are many areas especially in the developing countries the technology has not really gone in a much efficient way, we are a still using outdated technology, we are a still using things which is in a very outside crude way. If the technology remains static, so our energy used material used in environmental impact will grow 10 times. And our it is a its a we have more demand on the mother earth.

So, we need to reduce the impact. So, to reduce the impact by a factor of 10 to support 10 million people, it is because all they want to have a better living standard. So, we have to reduce the impact by a factor of 10 to support the growing population.

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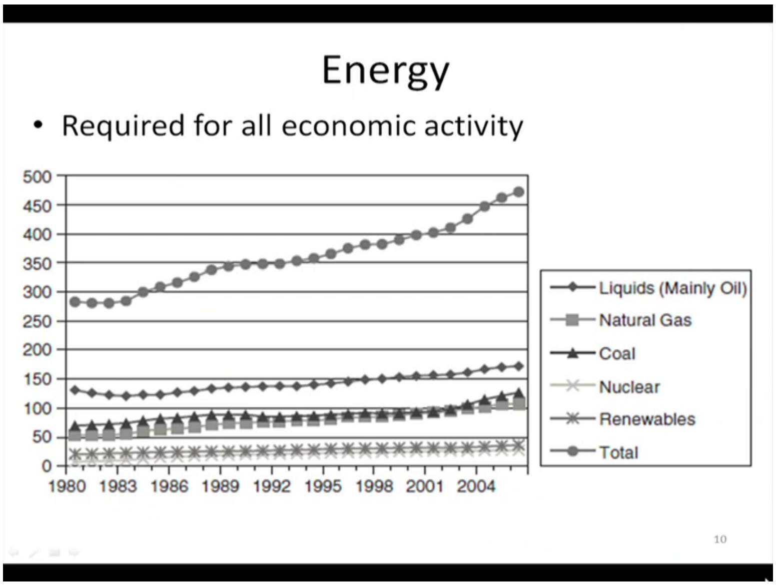

So, that is kind of a big picture of how like affluence and population increase is has an impact on natural resources requirement also an impact on how the environmental emissions will come out. Then if you look at for any of these industrial activities you require energy, without energy there cannot be any industrial activity. So, you need some form of energy.

And as you can see over last some 20-30 some years still there is a total energy demand which is the top graph you see the top line there are dotted with a with those circles, you see the energy is going up we need more and more energy come that is required. Then if you the different contribution that is coming out in terms of from different sources coal still produces; we still have a lot of coal energy which is the second line the triangle is your coal. And then be top of that is our natural gas: natural gas is a is more than the coal, then we have some supplies coming up from nuclear and renewable which is not that high, which is both of them at the bottom. So, that is coming out.

So, in terms of different supplies that is coming out coal is still in a country like India, we have more coal power coal dominates the energy makes. And we have been talking about that we will run out of this when the coal, natural gas or the oil these are all called fossil fuel. So, if you follow the newspaper, if you follow the different websites you hear from time to time that we will have more and more; we need to go for more and more renewable energy, we need to go for a more and more say solar power, solar does not renewable here potentially includes solar as well. And, so we need to have more and more solar power, we need to have more and more wind, geo thermal. So, those are considered as a renewable energy. But rather than the fossil fuel where your coal natural gas mainly oil this liquids they are they will run out, at some point of run out go for these alternative energy.

So, but the net cell here is we there is a lot of energy requirement and energy is need for a different activities. And you cannot have any industrial production without energy.

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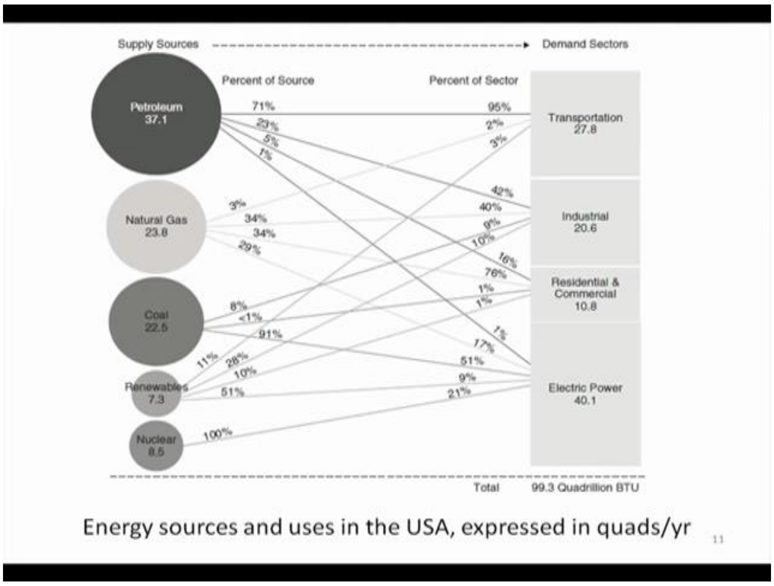

So, this is one example of a how then USA different energy sources; you see the petroleum which is number one in terms of supply, then natural gas coal renewable and nuclear; on the right hand you see the demand sector transportation sector has a highest demand then industrial, residential, electric power, sorry electrical power has a highest demand.

And you see that electrical power lot of electrical power is coming from nuclear, some from renewable, lot it coming from the coal, some natural gas. So, there is a different source which takes care of the supply. But many of these, if you look at the renewable that is only 7.3 percent; so a lot of it is going through the fossil fuel.

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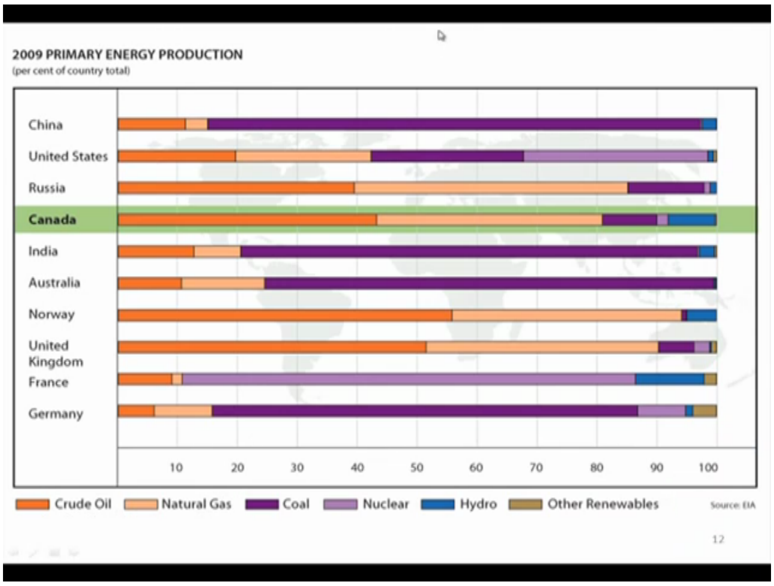

So, when you look at a primary energy production from the different countries. Here again China is that say at the bottom you can see the purple is our coal. And that is coal dominates in many of the developing countries and also like some other rich country as well Australia and then they use lot of call Germany has been using quite a bit of coal as well, but they are moving to many of this Western European countries of the developing countries they are now trying to move away from coal and go for rather form of energy or like a non fossil fuel energy.

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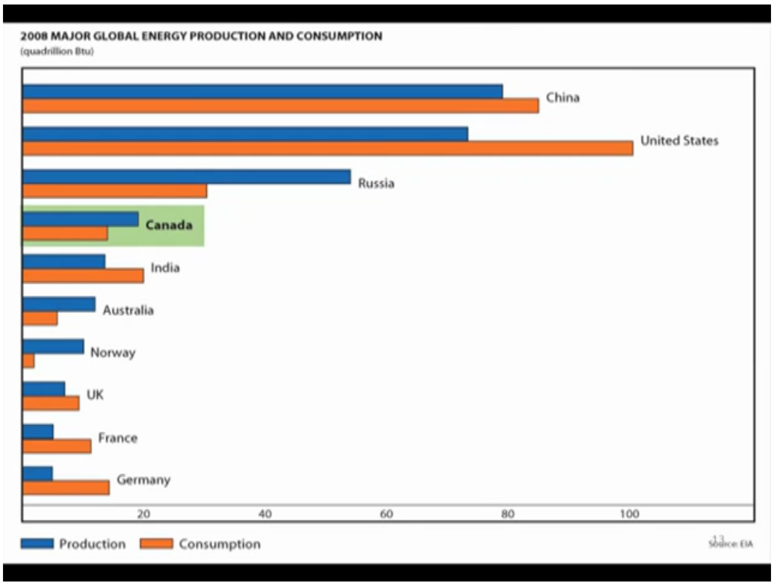

Again if you look at in terms of production and consumption: India is we are consuming more than what we produce so that is how we import. And same may holds true for China, US as well; US imports lot of energy some of the some of the countries which are can produce more energy than they consume includes Russia, Canada, Australia, Norway and those are the countries which are energy supplier they can export. Again these are 2008 data which came out in 2012 report. Present figure may change have the little bit from the big picture it will be almost the same.

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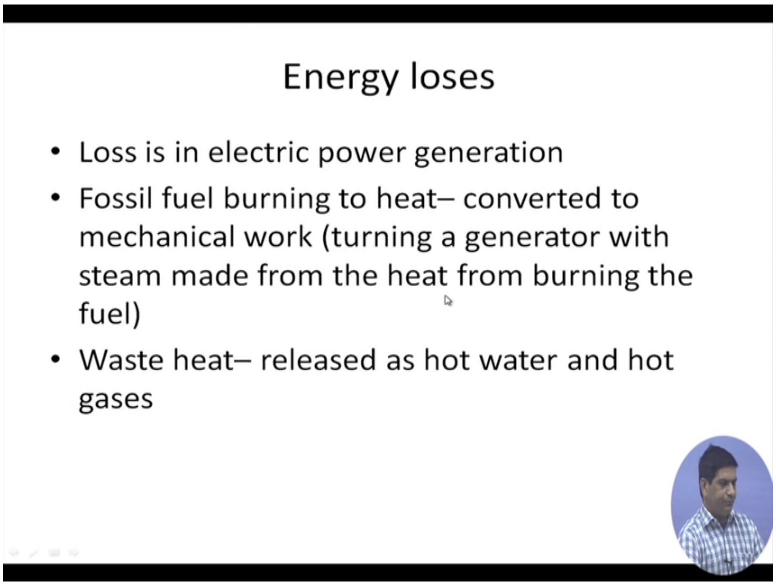

So, energy is important, but at the same time if country like India if there is a lot of energy loss; energy loss in electrical power generation and also lot of because of the our efficiency we will lose lot of energy in the waste heat are released at hot water and hot gases. When fossil fuel gets burnt to heat, converted to mechanical work and then this processor are not the deficients. And that is there is a loss electrical power generation at the same time there is a loss in electrical power transmission and there is lot of theft as well.

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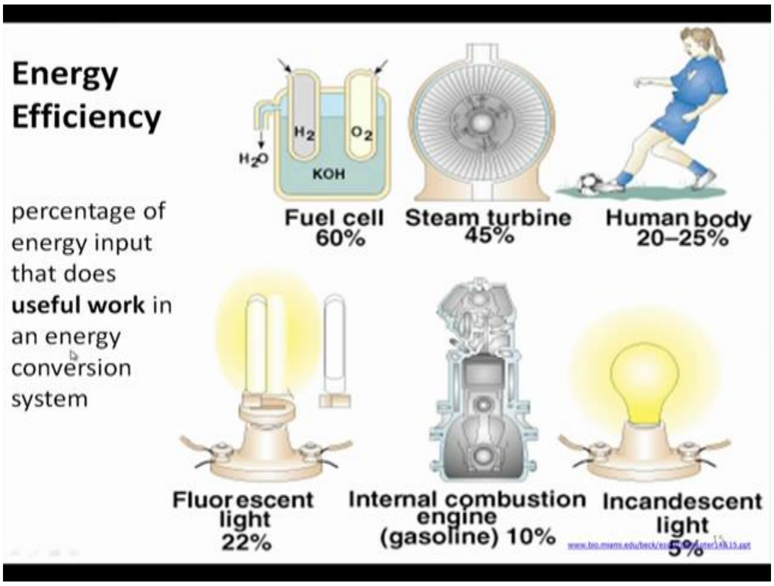

So, if you look at different stuff that we use, most of the time you see steam turbine or coal based thermal power plant they will produce steam and steam turbine is used for a energy its only 45 percent is energy efficient. So, again 55 percent of the energy is lost when we use a steam turbine. Fuel serves a 60 percent; so fuel cell is better, but microbial fuel cell or not any fuel cell technology they are much expensive. So, that is why they do not you do not see that might be used.

Fluorescent light that we use in our home is only 22 percent. Incandescent light the old bulb that we used to use is only 5 percent, internal combustion engine 10 percent, human body around 22 to 25 percent. So if you look at engineer there is a lot of the scope for us to improve this efficiency. So, if you improve this efficiency is of course, it will help in our sustainability goals.

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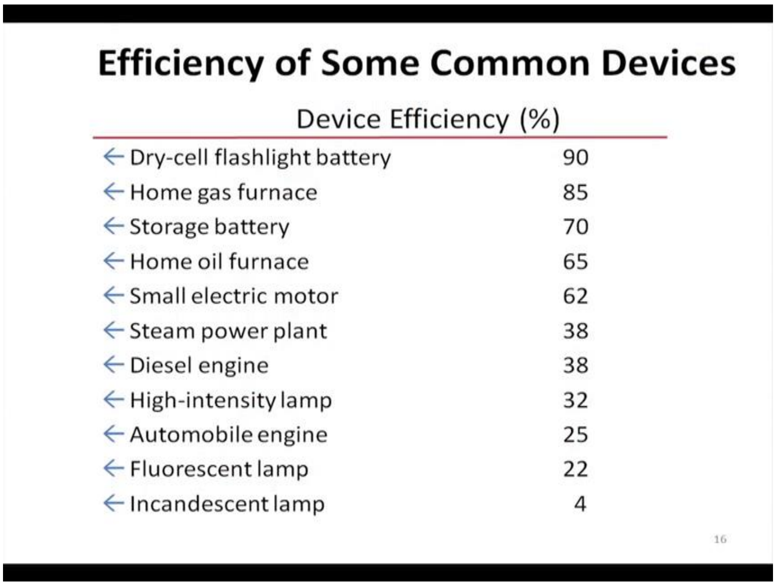

Efficiency of Some Common Devices

Device	Efficiency (%)
← Dry-cell flashlight battery	90
← Home gas furnace	85
← Storage battery	70
← Home oil furnace	65
← Small electric motor	62
← Steam power plant	38
← Diesel engine	38
← High-intensity lamp	32
← Automobile engine	25
← Fluorescent lamp	22
← Incandescent lamp	4

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And these are some of the other device efficiency you look at the dry cell battery 90 percent, home gas furnace 35 percent, storage battery is; home all home gas furnace is better than oil furnace then you have a small electrical model and you look at the incandescent lamp. So, as you can see for the different devices the intensity efficiency is very very kind of goes down, we have the efficiency goes down to a lower efficiency as you may progress.

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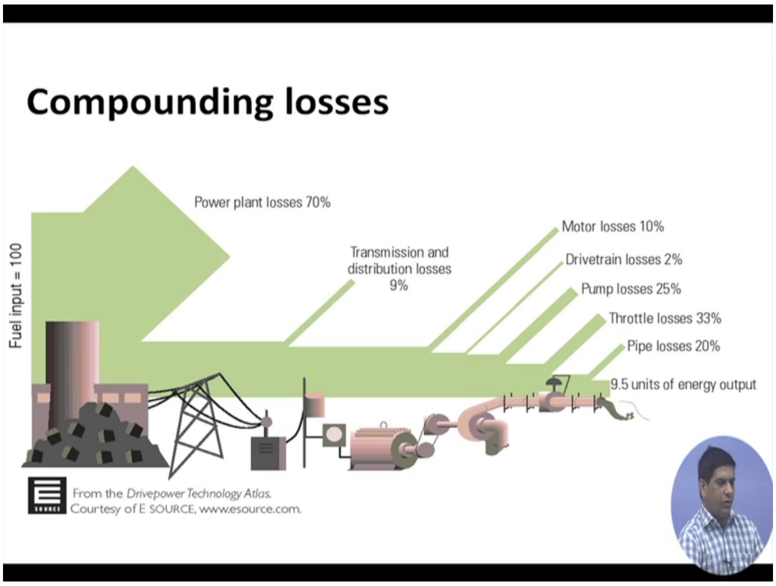

And then it its gets compounded: it gets compounded because we have full input of 100 at the beginning around 70 percent get lost in the power plant itself with all the processes happening in the power plant. Then there is a transmission and distribution loss, and then you have a motor loss, and drivetrain losses, pump losses, throttle loss, pipe loss. So, ultimately out of 100 unit only nearly 10 unit it is used up.

So, think about lot of opportunities as an engineer, not only electrical engineer but all sorts of engineering discipline has to kind of put their brain here to reduce all these losses and that will lead to a better our goal towards the sustainability.

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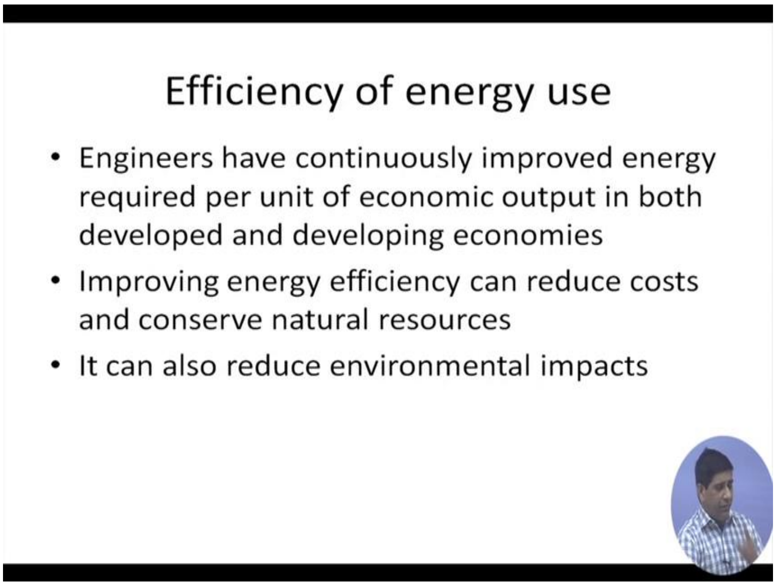

And we have to as an engineer we have continues to improve energy required for unit of economic output. And when we improve our energy that reduces cost and it can conserves natural resources. And when reduces conserved natural resources it also reduces on the environmental impact.

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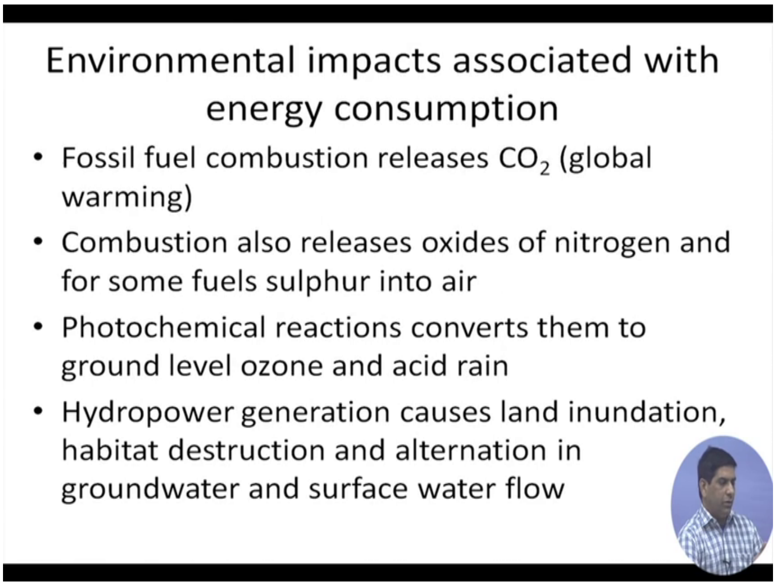

So, there are environmental impact is associated with the energy consumption. As I showed you earlier fossil fuel is still used a lot and that can be release carbon dioxide which is global warming. Gas combustion also releases oxides of nitrogen and some fuels, sulphur into the air.

So, photochemical reaction: they convert them into ground level ozone and acid rain. So, that is hydropower can cause land inundation its habitat destruction and alternation in groundwater and surface water flow. So, they are environmental impacts associated with this.

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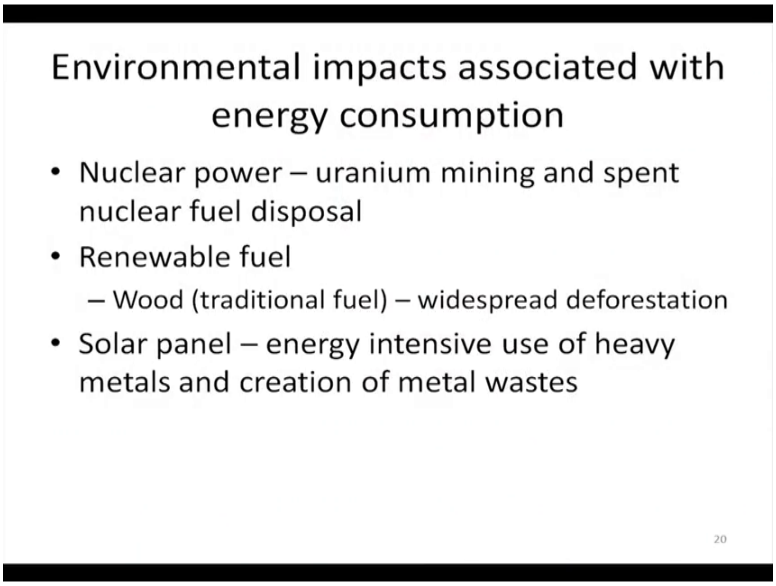

Nuclear power: the problem is how to manage in the; of course in the mining uranium mining as well as how to take care of the nuclear waste. Recently we have the tsunami in Japan and if you have followed the news we had big issues of a nuclear waste management. Renewable fuel in India contest also we have worried about nuclear fuel management that is one of the area where needs lot of attention. Renewable fuel: wood has been used as renewable fuel, but it is a lead to lot of widespread deforestation because we are using wood in a much faster rate than what forest can produce it for us.

Solar panels they are good in terms of; so energy, but if you look at from the big picture on life cycle there and there is a energy intensive use is there in the heavy metal and creation of the metal waste. So, to make the solar panel lot of energy is needed.

So, that is nut cell we have been talking about in. In terms of this particular course this is a life cycle assessment course this its where we will be looking at some of this what is the need. So, what I was trying to explain over the last 25 some minutes is to see why this course is needed. So, we need energy for everything, for our house also we need energy, from early morning too late evening, even during the night then the summer months you need your AC is going then, and also your fans going on. So, energy requirement is there and we have the resources requirement. So, energy, resource is needed for any of this industrial productivity.

For make there is a growing population, there is growing affluence, the affordability of different of the section of society is going up. Even if the Indian contest if you drive around go to the villages and other places also given you drive on the road you see these days you will see more motorbike than the manual bicycle that again kind of sources that we puts affordability have gone up people have kind of graduated from bicycle to motorcycle. And the people who used to drive motorcycle earlier has graduated to a small cars.

And for all of these there is a resource demand, there is a demand for energy, when the industrial production needs lots of water, there will be lot of waste produced, waste will come out in different form with either it will produce like a air pollution issues, water pollution issues. And like a soil: if you are if you look at the cotton industry and other industry if you are using lot of fertilizers well, if you are getting lot of a stuff from the agricultural field into your plan soap uses of multiple fertilizers different types of insecticide fungicides is also using having impact on the land quality the soil quality.

So, all these factors need to be incorporated when we are trying to look at a big picture impact. What happens is, so far if you look at any of the industrial process we have been taking a silos approach, when I say silos approach we will look only at one particular aspect or one particular unit we do not look at things in a big systems approach in the entirety.

So, this life cycle assessment is basically to forces us to look at in entirety. So, we need to look at from the cradle to grave and sometimes even from cradle to cradle which we will talk about later in this course. So, where we say even if we want to make a life and want to find out what is the environmental footprint of this particular product it is just a simple sketch pad. So, it makes of plastics, different material goes in there, could be different methods to uses in. So, we have to look at all the raw material that got to manufacture this, what was the environmental associate, impact associated with that, during use how we are going to use it, when we throw it away whether it is going to a land fill or a what about its energy plant and how this will be impact environment there.

So, all these factors needs to get to be incorporated and put together as one exercise and that exercise is your life cycle assessment exercise. As we will make progress in this course you will see several examples and it will get this concept most clearer and clear.

As the beginning we are trying to go over some of these basics of why this course is important as I said in the very beginning of the class today, you need a for any codes first thing you need to really understood really think about that why I am studying these course. Once this why factory is taken care of when you understand the why factor when that will help to develop interest in this particular course. And once you are interested you will learn the other part, you will be more interested to make progress.

So, with that we will try to wrap up this particular like a lecturer the first video lecture for the week one. And I will see you again for the second part of the half an hour video lecture.

Thank you.