Non-ferrous Extractive Metallurgy

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Lecture No. # 35

Energy and Environment Related Issues in Nonferrous Metals Production (Contd.

Well, friends, I have been defining a number of terms during course of my lectures and previously I have defined, what is waste, what is industrial waste. We have seen what is meant by pollution, what is meant by air pollution and in the last lecture, I introduced the term ecologically sustainable development.

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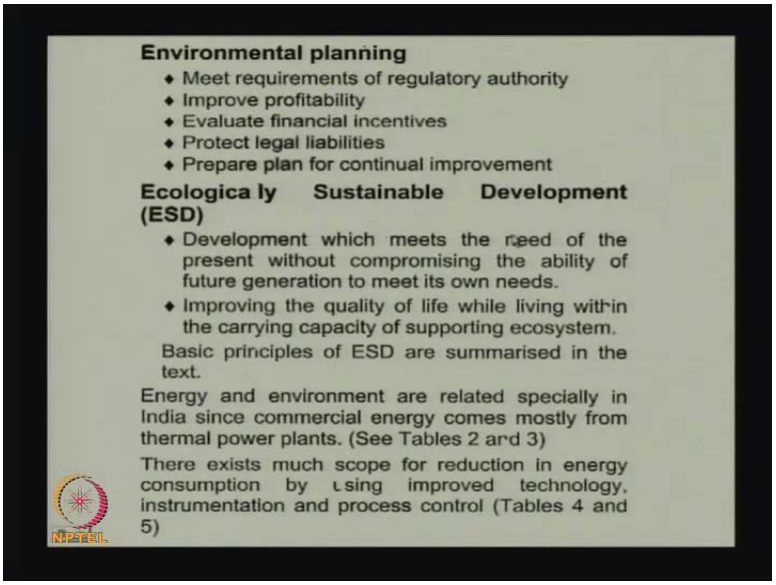

It is an extremely important idea. Whatever development we are talking about, has to be now ecologically sustainable development and the simple idea behind that is, we need to have development, which meets the need of the present generation without compromising the ability of the future generation to meet its own needs. And also improving the quality of life while living within the carrying capacity of the supporting ecosystem.

I have also given you the idea of what is carrying capacity. Any environment, natural environment can take pollution only up to a certain level and it has the inherent capacity to find remedial measures for it, but there is a limit beyond which it cannot do so.

Now, few years ago, when Doctor Murali Manohar Joshi was the education minister, HRD minister, he had talked about a term called sustainable consumption, means, he tried to say, that your consumption levels can be up to a certain limit beyond which it cannot be sustained. So, obviously, consumption can be sustained only if your development is sustained. The two terms are are related, but that term sustainable consumption has not caught on, at least in scientific circles, but there is a merit in it and maybe, I will refer to that little later, about sustainable consumption.

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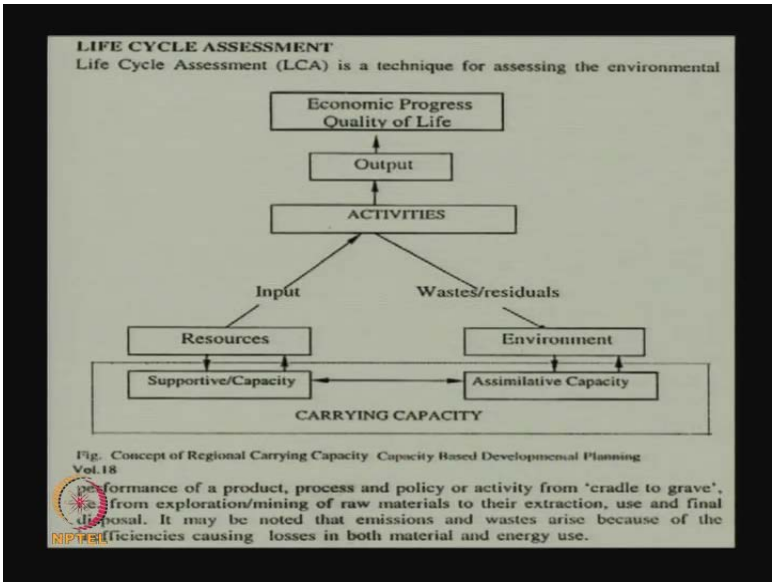

Now, regarding the carrying capacity let me mention one or two more things and that refers to what we call this diagram. You see, the economic progress, which actually attempts to improve the quality of life comes from, as I mentioned, availability of goods and services. So, from resources, that we have, there will be input, there will be activities, may be manufacturing activities, service activities; there will be an output and that will go towards quality of life. But these activities also generate wastes and residues, which will go to the environment.

So, from the resources we are generating goods and services as outputs for better quality of life, but during that process or making available goods and services or various activities, we necessarily generate wastes, that go into the environment.

Now, there is a supporting capacity for these resources. Some resources are renewable, some resources are not renewable. For example, suppose, we take out from the forests' timber for some activities, a timber based industry. Now, we know, there is a supportive capacity, that the forests continuously generate trees, the trees grow, they continuously generate timber, it has a supportive capacity. From a given forest you can take out periodically, certain amount of timber. If that amount of timber is also being generated, then you are matching the supporting capacity. If you take out more timber periodically, then during that periodicity not enough timber is being generated, then you have exceeded the supporting capacity of the supply source. So, there is a concept of supporting capacity, which should not be exceeded.

Unfortunately, some resources are not renewable, like if you have mines and from which you are taking out ores and minerals. The mines do not have the supporting capacity to replenish them; they cannot make their own ores and minerals. If we are taking out oil or coal, there is no supportive capacity to fill up the, the coal seams or the oil reserves. So, they are non-renewable resources, but in the case of renewable resources we have a supportive capacity.

More important is what happens to the environmental site. The environment is what has an assimilative capacity. If you reject wastes, which are below the assimilative capacity of the environment, then there is no problem, you have a sustainable development activity and it can go on. But if you are discarding to the environment wastes, which exceed the assimilative capacity, then you have a problem. Then, there is a mismatch between supportive capacity and assimilative capacity. So, this is the concept of regional carrying capacity and capacity based development planning.

Let us consider another term, it is called life cycle assessment, it is also very important term and it, it is also part of industrial metabolism. Lifecycle assessment or LCA is a technique for assessing the environmental performance of a product.

We are now going to see the performance of a product in relation to the environment or it can be the performance of a product, performance of a process and policy or any activity from cradle to grave, that is, from exploration and mining of raw materials to their extraction, use and final disposal; you have to consider the entire range from extraction to final disposal.

And it may be noted, that emission wastes arise because of benefits, because the efficiencies, inefficiency causing losses in both material and energy use. If there are losses in material and energy use, then you have a problem. Now, life cycle assessment, we will have to take into account from cradle to grave, I will come to that little later.

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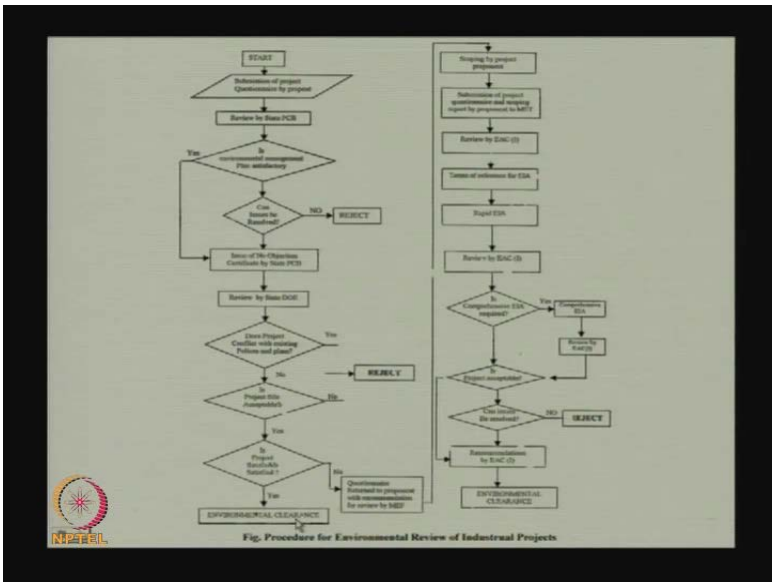

Fig. Procedure for Environmental Review of Industrial Projects

Now, let me see now, how the regulatory authorities today employ a procedure for environmental review of industrial projects. There was a time when, if an industrialist has, has, has the capital, he could buy land, he could buy machinery, he could hire people, he could set up an industry.

Nowadays, this is not possible because the government has regulatory bodies with people who are very well aware of the environmental issues, they would not like to support, if they can, things that are going to have adverse impacts on environment.

So, the entire procedure for approval of a project submitted is like this to start. The submission of project questionnaire, questionnaire by the one who gives the proposal,

first he has to fill up the questionnaires, giving answers to many questions of relevance to environment. This will be reviewed by pollution control board, they would try to find answer to this, is environment management plan satisfactory? If it is satisfactory, it will go to the next step, can issues, sorry, yes, then the question is, that there are many issues raised, can the issues be resolved if there are problems?

If there are no issues, if there are issues, that cannot be resolved, it is rejected. So, the, the board will first see, whether it is sound from environmental management point of view and if there are tricky issues, there are suggestions, as to how to solve them, then only it moves. In case there are no tricky issues and it is environmentally sound, this question is not arising, then it will go straight to yes, it will go to next step, where there will be issue of no objection certificate by the state pollution control board.

They will take into account what effect it has on the water body on the land, whether it has effect on the, on, on the surroundings, all kinds of things are there. Now, if there is no, then there is a no objection certificate from PCB and they will be reviewed by state PCB and they will raise the question, does the project conflict with existing policies and, and plans.

So, at every stage they will review, whether there is anything that contradicts the environmental plans the state has. If there is a no, it will be rejected; if it is yes, it will move. If it is no, then other questions come in, like if it is no, it is rejected, if it is yes, the question will be, is project site acceptable? The project may be, is the site acceptable? If it is yes, then is project thresholds satisfied all kinds of questions? It is only when yes, there will be an environmental clearance; if there is no somewhere, if it gets stopped, like questionnaire returned to the proponent with the recommendations for review by the board.

Sometimes it will reject straightaway, sometimes they have seen, that there can be suggestions, based on this you can improve, then it has to go back again and start all over again. Again it will be seen by the, the, those who submit the proposal, it will be submitted, project questionnaire and scoping report by proponent of MET.

Again, there will be a review, it will go to referee’s now. Then, there will be another review, review is the comprehensive environmental impact assessment required.

Sometimes you need an impact assessment, if it is yes, it will go for some more steps; if it is no, it will go straight.

The final question, is the project acceptable, can issues be resolved? If it is no, it will reject, there will be some recommendations and finally, there will be environmental clearance.

The idea of saying this is that our governments in every state have become far more careful now, that there are many steps in the review process. This thing is now being modified because in some of the review steps, they also bring in what we call, stake holders.

They might like to have a representative from the location where the project is proposed. They may have, may have to have representatives from, if it is a tribal area, representative of tribals to see what their views are. They might bring in NGos, which are active in, in opposing on environmental grounds projects. So, they are all stake holders and that is how the, the one has to proceed step by step very cautiously.

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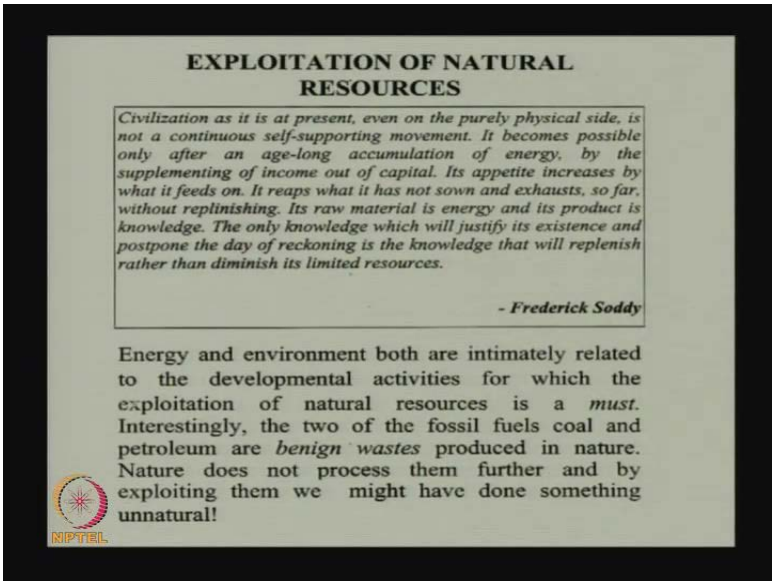

Now, at this stage, because essentially all developmental work depends on exploitation of natural resources, I would like to give you a very beautiful quotation by Frederick Soddy. The quotation is here.

Civilization as it is at present, even on the purely physical side, is not a continuous self-supporting movement. It becomes possible only after an age-long accumulation of energy, by the supplementing of income out of capital. Its appetite increases by what it feeds on. It reaps what it has not sown and exhausts, so far, without replenishing. Its raw material is energy and its product is knowledge. The only knowledge, which will justify its existence and postpone the day of reckoning, is the knowledge that will replenish rather than diminish, its limit, its limited resources.

Our resources are limited, so we need to have the wisdom to know not to diminish what we cannot replenish.

The other issue, that we have to keep in mind is not a quotation, I have written this, is that energy and environment both are intimately related to the development activities for which the exploitation of natural resources is a must; there is no, no alternative to this.

Interestingly the 2 of the fossil fuels, coal and petroleum, are benign wastes produced in nature. As I mentioned previously, nature does not process them further and by exploiting them, we might have done something unnatural. In nature, they are not processed further, nature leaves them as it is, but our civilization development starts where nature has stopped. So, maybe, we have done something very unnatural and when you go against nature, we might be fighting a losing battle.

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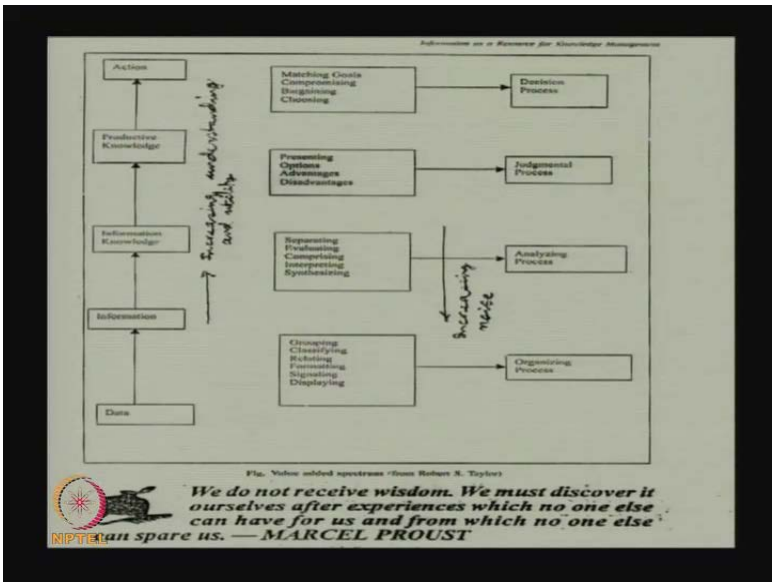

Now, here is something again philosophical, a soft subject, but I thought I will mention it. You know, we go through in our generation of knowledge and wisdom through the steps: data, data organized is information, information distilled is knowledge, knowledge further distilled and processed, it becomes productive knowledge that is wisdom, which tells us how to act.

So, from data to wisdom, we go through certain steps and which is characterized by increasingly indiscriminating a utility, or in increasing understanding and utility we need more understanding of data to have information, more understanding to make it into knowledge, more understanding to come into action for utilities.

Now, what does data involve? Grouping, classifying, relocating, formatting, signaling, displaying, this is an organizational step. As we go up we need separating, evaluating, compromising, comprising, interpreting, synthesizing. So, we are creating information out of this, it is an analytical process.

Then there is a judgmental process presenting, considering options, advantages, disadvantages. Then, there is a decision process matching goals, compromising, bargaining, choosing, there is increasing noise here. So, actually filtering out noise things, that we want to go towards less noise when we go for final action.

So, this you remember, it is a very complicated process, we need to be wise for sustainable development. And as he got wisdom, there is a very famous saying by Marcel Proust, that we do not receive wisdom, we must discover it ourselves after experiences, which no one else can have for us and from which no one else can spare us.

The knowledge we have today, our predecessors did not have. We cannot get the wisdom to solve the problems of today by looking at the texts available earlier, we have to find it for ourselves and if we do not, nobody will spare us.

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Now, let us become little more technical, leave aside philosophy. What is development? I repeat again, development is availability of goods and services for all sections of the population. There is a, recently a book has come out, made a name; it is called the bottom of the pyramid. You can have development, where the pyramid top is very high, but at the bottom of the pyramid, the people who are there, they, that forms the base. You cannot have a nation developed only at the top, not developed here.

We have some 5, more than 500 million below poverty line, we have 300 million illiterates, they are at the bottom of the pyramid, they have not seen the development. And development is not necessarily highways, flyovers, tall buildings, gadgets, consumer items, clubs, disco joints, pubs, swimming pools, shopping malls, automobiles, aeroplanes, these are important, but is also important are the goods and services made to the other sections.

Progress and development is demanded by the population, this needs more production, which needs energy. Progress generally leads to more pollution and all the Ps are related; you have the population, which means progress that needs production, production leads to pollution. The so called progress, if not monitored well, can lead to problems: poverty from unbalanced growth, petty pressure politics, pessimism, prediction of dooms day, all kinds of Ps.

Progress with peace and prosperity demands plans, prioritization, public participation, people's power, pragmatism. So, there are all kinds of Ps in this process.

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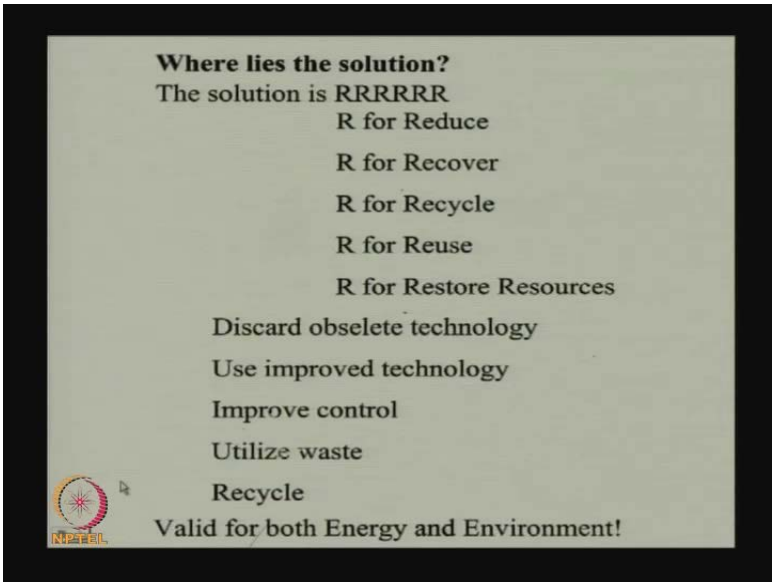

We know the problems, where is the solution? And these solutions will have to be kept in mind when we want to attack the problems of nonferrous metals industry from the points of view of energy and environment.

Lots of Rs will give us solution for all the Ps, R, R, R, R, R, R; R for reduce control industrial metabolism; cut down input of materials, then output of materials in terms of wastes will also be minimized.

One R for recover - recover as much as you can during the processing steps. One R for recycle, go for secondary metal production. R for reuse, you may not recycle the whole things, but try to see if there is something you have produced, that can, maybe, used. R for resource restore - resources, if you can, if you take out minerals from the mines, you may not be able to restore it, but you should not spoil the top soil, the over burden, that you can restore. If you are careful in planning things, take them aside, then put them back on the mines.

We need to discard obsolete technology, we need to use improved technology, we need to improve control, utilize waste, recycle; this is valid for both energy and environment.

A simple example, the copper industry at one time, when it was traditional, it had the traditional roasters, the reverberatory smelting, then converting in those steps, all kinds of heat were wasted because you went from one step to another. Lot of SO 2 were emitted about, which we had no solution. But when you brought in flash roasting, roasting, it combined roaster and smelter. Then, next step was continuous copper production where we cut down the stages. So, we cut down the total heat requirements, the whole processes was autogenous. Anyway, it, it was generating heat, it was used much better when there was one reactor and if all the SO 2 coming out were coming out in one stream, it could go for acid production.

Instead of little S O 2 and the roaster, some at the smelter stage, some at the converting stage, if everything happened in one reactor, things were much better. So, an improvement in technology helps out many of the problems. There are many such examples in nonferrous metallurgy.

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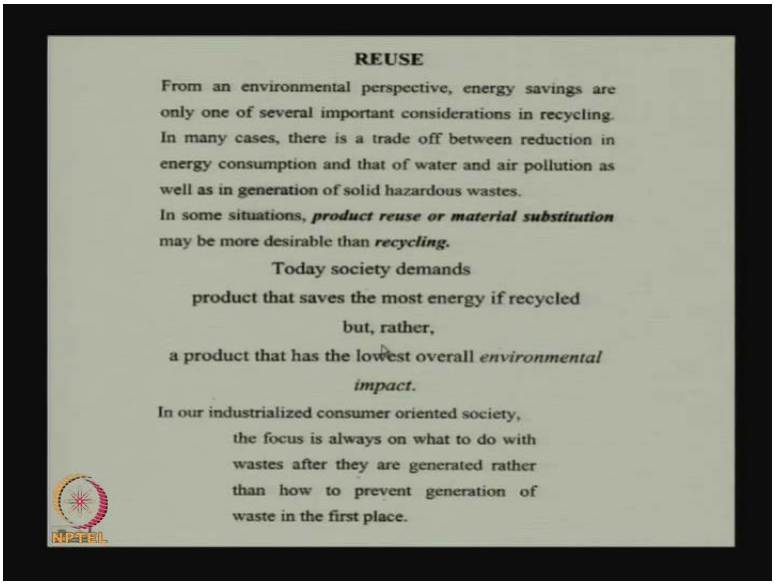

What we mean by the word reuse? From an environmental perspective, energy savings are only one of several important considerations in recycling. When we talk about reuse or recycling, our natural tendency is to always think in terms of materials being used, recycled or you know which is true in terms of energy also.

Energy that is coming out of in pyrometallurgical processes, can you use it? Instead of allowing to go into the atmosphere, can we trap that energy? Not only that, when you are discarding hot solids or hot liquids out of a reactor, there is a sensible heat in them. If we leave it into the environment, as it cools down, all the heat is dissipated lost and they are of no use, can we recapture that heat? There are technologies available for getting that sensible heat or if there is a gas coming out, which can be which can undergo combustion and give you more heat; that is even better.

Like the blast furnace gas, the CO that is in there, can it undergo combustion, give you more heat? It can, because blast furnace gas, it is not a very high calorific value gas, but it has calorific value and it is used in the plants in many sites.

Now, in many cases there is a tradeoff between reduction in energy consumption and that of water and air pollution, as well as, in generation of solid hazardous wastes. So, we often have to go for a compromise and tradeoff. For example, there is a tradeoff, that you can reduce energy consumption and that of water and air pollution and may be, allow little bit of solid hazardous waste, or we bring that down and use little more of these. So, this kind of a compromise, which is ultimately good for all, we have to go for…

In some situations, product reuse or material substitution may be more desirable than recycling. Maybe, recycling is not required, we will use the product of as it is reuse or we will have a material substitution. Today, society demands a product that saves the most energy for recycle. Today's society demands products that save the most energy, if recycled. But rather, I think product, that society demands, that is (( )) not the product, that saves the most energy recycled, but a product, that has the lowest overall environmental impact, what does it mean? I will give you some example.

In our industrial consumer oriented society, the focus is always on what we do with wastes after they are generated, rather than how to prevent generation of waste in the first place.

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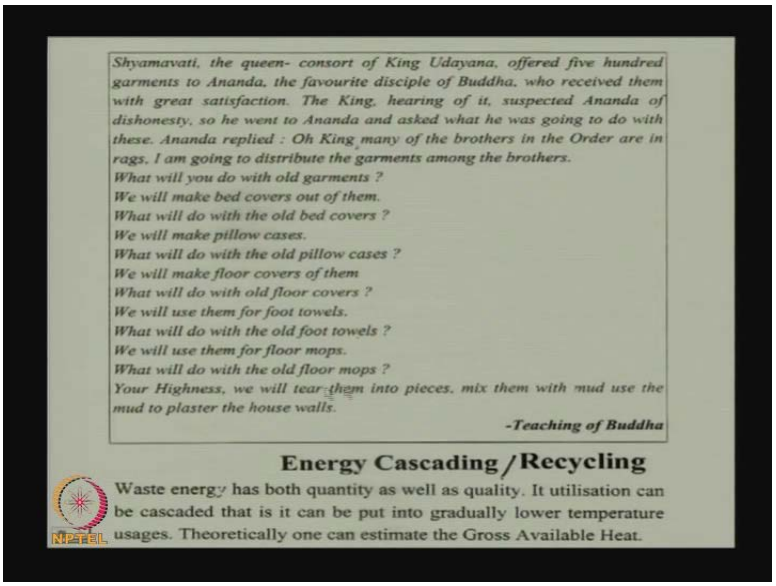

Let me give some examples. I think I have to explain this, before that I have a very nice quotation from Buddha about reuse, I will read it. Shyamavati, the queen consort of king Udayana offered 500 garments to Ananda, the favourite disciple of Buddha who received them with great satisfaction. The king hearing of it suspected Ananda of some dishonesty, that how can a monk be so satisfied with a gift of 500 garments.

So, he went to Ananda and asked what he was going to do with these? He said, oh king, many of the brothers in the order are in rags, I am going to distribute the garments amongst the brothers, brothers who do not have proper dresses, garments, they are wearing rags of now.

What will you do with the older garments, the king asked. We will make bed covers out of them. What will you do with the old bed covers? We will make pillow cases out of those bed covers. King asked Ananda, what will you do with the old pillow cases? We will make floor covers of them. What will you do with the old floor covers? We will use them for foot towels? What will you do with the old foot towels? We will use them for floor mops. What will you do with the old floor mops, the king asked. Your highness, we will tear them into pieces, mix them with mud, use the mud to plaster the house walls; house walls will be stiffer and better.

This is the about reuse; nothing is going to waste. The center philosophy of this quotation is to tell you, if we are smart, we will use everything because there is always a use, if only we know how to use that material.

Now, this is also a kind of cascading, that one thing goes into the other. Waste energy has both quantity as well as quality, you should know that. You may have a whole lot of energy coming, in, out, but if the temperature at which the gases containing that energy is low, according to the 2nd law of thermodynamics, it is very difficult to extract energy out of that, with simple example.

You can boil a cup of tea by using a candle because the candle has a flame, which has a temperature much higher than the boiling point of water and it can boil the water. But if you put a glass of water in this, in, in a, in a sea, the sea, the entire sea has lot of energy, but it does not have temperature, it cannot boil that tiny, the small amount of water in a cup, it cannot, because there is heat of great magnitude in the total sea, but the quality of heat is low, the temperature is low.

So, they are both important, we have to be very smart to see how to look at the quality of heat to find its application. You know, if you go to mines, in mines the coal often catches spontaneous fire, there are reasons why it does. So, so, the coal mines, the holes are often are flooded with water to keep the temperature cool.

They pump in water, the water comes out, it is fairly hot, it is 60, 70, 80 degrees. What is the use of that water, we have not pump. What we do in our country, you just throw it out. In a cold country where there is, there is the coal mine and they have to do the same thing, if the hot water coming out, they can find a use, they can put it on roads where there is snow. The snow will melt; the road will clear because the quality of heat in that water is good enough to melt snow, where the melting point is much lower.

In our case, the quality of water is of no use to us because we have not found a use for it yet. So, the utilization of waste energy can, can be cascaded, that it can be put to gradually lower temperature usages, like in the case of, I say cold country is, it is going to use for melting of this.

Now, suppose there is a hot gas coming out at 1000 degrees, it cannot be used to melt any metal or alloy, which requires temperature of 1100 degrees, but it can be used for an operation, where temperature requirement is less than 1000 degrees.

Obviously, the efficiency will depend on the temperature difference, utilization will be more efficient if the requirement of temperature is much lower than 1100 degree; there is a simple equation for that. But if you can find a gradually lowering levels of temperature requirements, then we call it cascading of energy. Theoretically, one can estimate the gross available heat and from that we can also calculate the efficiencies of such energy use.

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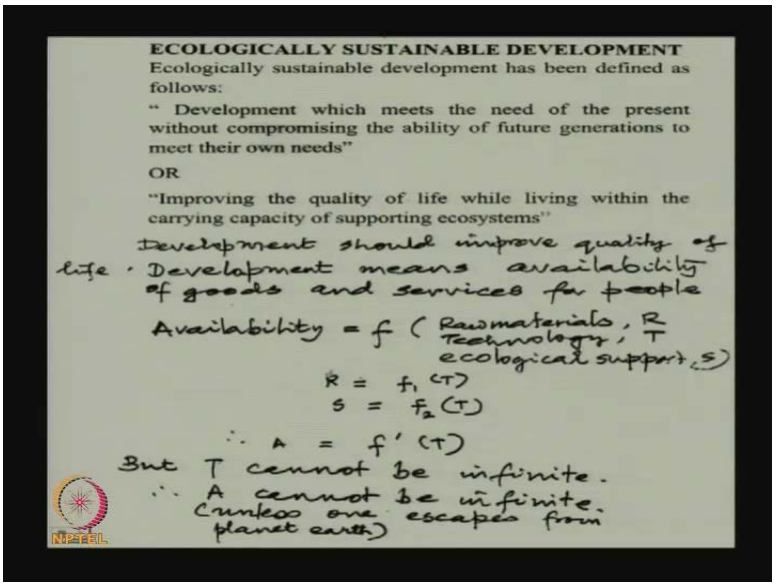

Now, let me say something again on ecologically sustainable development and some philosophical interpretation of that. The definition you have seen, development, which means, the need of the present generation without compromising ability of the future generation and another, improving the quality of life while living within the carrying capacity.

Now, if we define development as availability of goods and services, then it is a function of 3 things: raw materials R, technology T and ecological support carrying capacity or S. Now, these R resources very often are not finite, even though they may look finite. People say that R is very often a function of technology, what does it mean?

100 years ago, an ore body, a very poor grade, perhaps was not considered a resource. We did not have technology, but with improvement of technology, that ore body becomes an ore body from which we can get metallic values.

Today we do not consider sea water to be a resource of gold, but if technology improves, we will get a new resource of gold in the form of sea water.

So, people say, that the availability of resources are actually a function of technology and so is the ecological support. We find that we are creating environmental problems; we are not getting ecological support for a process. But suppose, we improve the technology, we know how to clean up the environment, how to handle the adverse impact, then we may be able to find, that yes, we can increase availability. So, eventually, what happens is, the resources actually are a function of technology; ecological support is also a function of technology.

So many people have argued that our development can continue availability of goods and services will go on increasing, because it is only a function of technology. As knowledge advances, as new technologies come, we will find newer and newer resources, they are they will never be exhausted. We will find newer and newer methods of finding solutions related to ecology if only we go on improving knowledge and technology. So, we do not have to worry.

So, many scientists even are divided now into 2 camps, one are the optimists and one are the pessimists. The optimist argue like this, that go on acquiring knowledge, go on advancing your technology, you can find solutions for all problems. There will be no dearth of resources; there will be no dearth of techniques to handle environmental problems.

But there are others who want to be more pragmatic, some of them are called pessimists. They say, look T cannot be infinite knowledge, cannot be infinite, you cannot go on increasing your knowledge and technology, there has to be a tapering off and it cannot go on increasing, you cannot keep on making available more and more goods and services like the capitalist philosophy.

I am not against capitalism, I am only against moderation. So, this relates to Doctor Murali Manohar Joshi's of sustainable consumption. At some point, you have to say, you should not or you cannot consume more than this, if you do it, it is not sustainable. You cannot get more and more knowledge, more and more technology even if you do. It will be diminishing return, the amount of efforts you have to put in for a marginal improvement would become more and more.

So, we are almost reaching a plateau. So, the advanced countries thought they can go on having more cars, more planes, bigger houses, everything, all that has landed us into a, into a crises today. And they are now deciding in Copenhagen, they will limit 2 percent average temperature rise of the planet and after 2020 it has to come down. And that means, huge reduction of the energy consumption in the advanced countries in relation to what they were doing 10 years ago. They have to not only consume less as of now, they have to go on reducing, so that goes to a level, which was 3 years ago.

The countries, which are developing, they are growing, their industries are growing, they, they were underdeveloped one time because of the developed countries, so they should be allowed to develop; they should be allowed to increase the CO 2 emission. But at a lower rate they argue that, so that eventually, per capita emission becomes everywhere the same.

Again, coming back to the center problem, you must understand, what are the issues that divide today as they divided in Copenhagen? The advanced countries are claiming do not go back to history all the time, you cannot reopen the issues as to why the Europeans went and settled in America or in Latin America, they cannot come back and give the land back to the natives; they said no, you cannot go back.

So, the underdeveloped countries argument, that we are underdeveloped because we were colonized, we were not allowed to be developed, our resources went for development of developed countries.

So, the developed countries have to accept, that as of now, the developing countries, which are struggling to develop, they should be allowed greater generation of CO 2, but of course, at lower rates because they must efforts, so that everything should be decided on per capita basis. Now, that is where the advanced countries are not agreeing.

He said, no we are all same under the sun, India is a country, China a country, actually if you go by the total emission, India has fairly large, 5th, highest is America, by far the highest, China 2nd. But if you go by per capita basis, I will give you the data later, USA is way above, India is very low. So, India has a right to increasing CO 2 emission, at least for some time, until we have come to a certain level.

But all this boils down to the concept of sustainable consumption, you have to cut down your consumption. So, now, in America there is talk of not using driers for drying clothes. They said, why not go in the fields like the Indians, do hang your clothes to dry on, on the, on the poles, on ropes on the poles, which means, they have to seriously think of going back to a simpler way of living.

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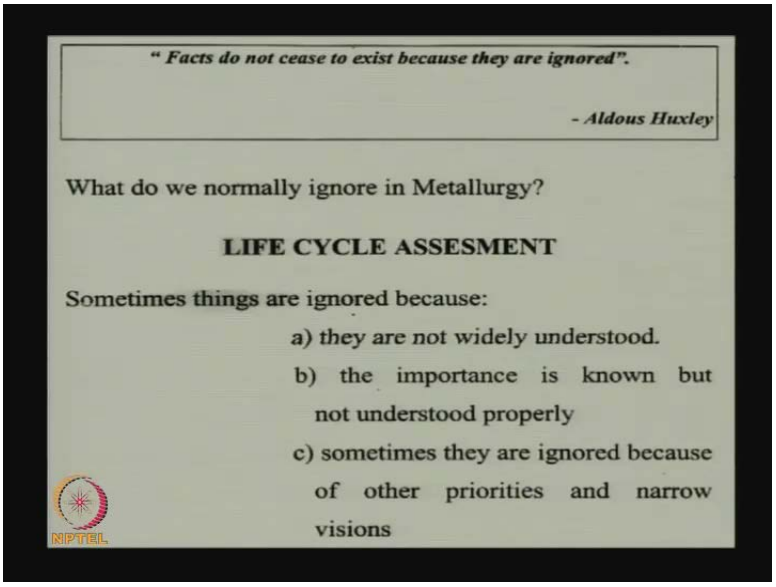

Now, I had mentioned this word life cycle assessment, normally we have been ignoring it in metallurgy or in the industries. Why do we ignore facts? Because they are not widely understood, the importance is known, but not understood properly. Sometimes facts are ignored because of other priorities and narrow visions.

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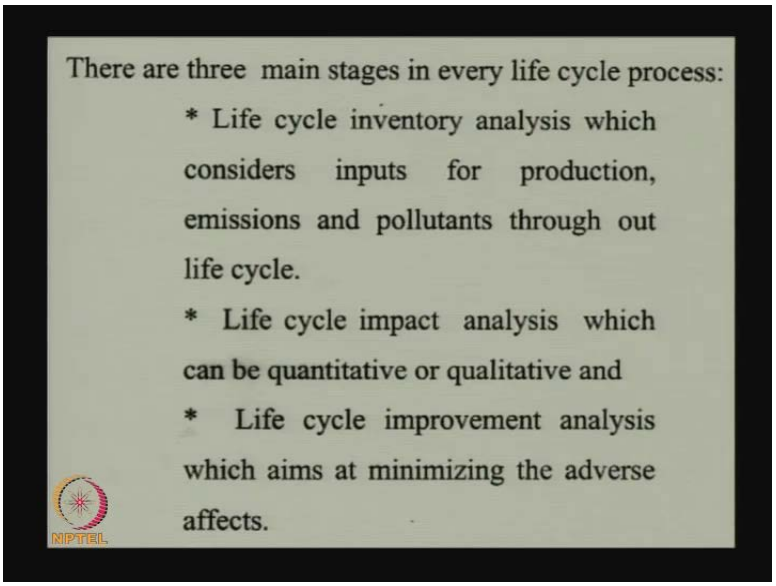

Now, there are 3 stages in every life cycle process. Again, life cycle, it means from cradle to grave, from when they think product or the process took birth and when it finally died. We have to think of the entire life and not just the production stage; that will be a very narrow way of looking at it.

Life cycle inventory analysis, which considers inputs for production, emission and pollutants throughout the life cycle, not just during the production. Life cycle impact analysis, which can be quantitative, it can be qualitative and there is life cycle involvement analysis, which aims at minimizing the adverse effects of that product or services all throughout the life, not only at the time of production.

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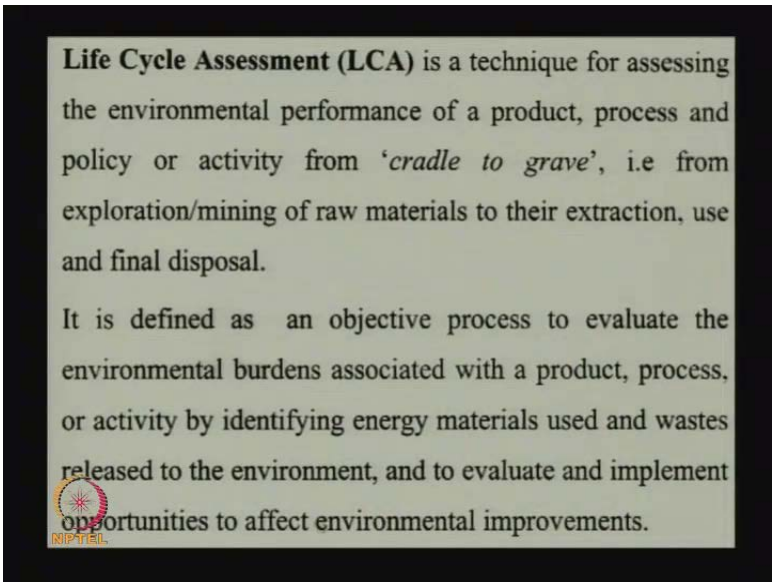

Life cycle assessment is a technique for assessing the environmental performance of a product, a process, policy or activity from cradle to grave, that is, from exploration mining of raw materials to their extraction, use and final disposal.

I am repeated what I had mentioned little while ago, it is defined as an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying energy materials used and wastes released to the environment and to evaluate and implement opportunities to affect environmental improvements. When you have created a product or given a service, it has an environmental impact even beyond when it started, that cannot be ignored, that is taken into account in life cycle analysis. There is a simple example.

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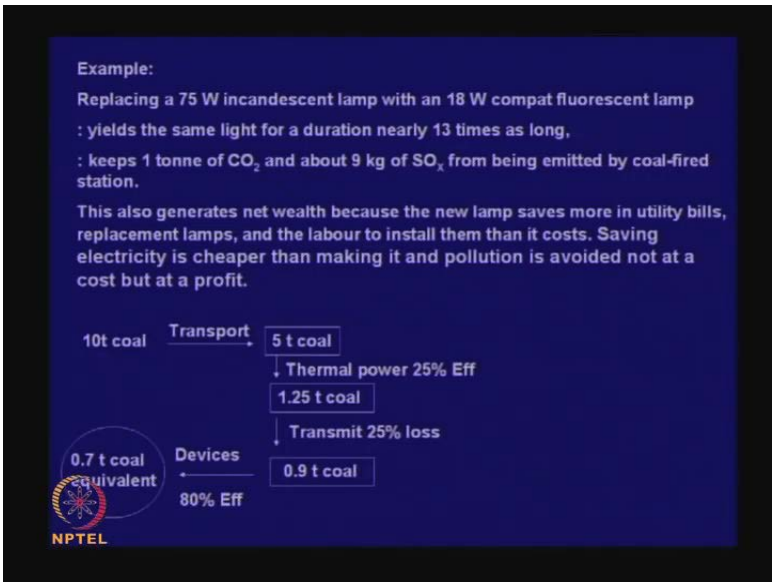

Replacing a 75 watt incandescent lamp with an 18 watt compact fluorescent lamp yields the same light for duration nearly 13 times as long it keeps one turn of CO 2 and about 9 kg of SO x from being emitted by coal-fired station because it is consuming less electricity.

This also generates net wealth because the new lamp saves more in utility bills and replacement lamps and the labour to install them than it costs. Saving electricity is cheaper than making it and pollution is avoided not at the cost, but at the profit.

Now, here we are talking about a long, longer subjective vision, different way I am looking at it. You might buy something at a higher price, at that time it cost you more, but look at its service throughout the life. I will have a better example later. How much it is costing in maintenance, in electricity bills and until it is finished. What was the overall cost during the whole life cycle? Cost, not only if there are electricity bills because it was consuming less electricity, overall how much CO 2 it has saved at the source.

So, these are unusual way of thinking, there use to be an advertisement in the TV where it shown, that to save electricity is to generate electricity or some, something to that effect, I do not know the exact wordings, but the meaning was, if you are saving it, actually you are creating it. Let me see look at it from another angle.

Suppose, in olden days, when we had coal-fired locomotives, you know, coal in our country is found in one corner, the eastern corner and that coal had to be transported all over the country. It is now done bit indirectly because from coal, electricity comes and then, that is gone all over the place, but suppose, we think of only coal being sent all over the country. Now, to transport 10 tons of coal all over the country, we will consume about 5 tons of coal. So, when you have delivered at different thermal power stations, you are ended up with only 5 tons of coal and when power is generated in thermal power plant, the efficiency if we assume 25 percent, you are left with actually 1.5 tons of coal, equivalent for that energy.

When you transmit through the lines, this 25 percent loss, sometimes it is 30 percent, 40 percent because there is theft, ideally should be less than 10, but assume 25 percent loss. So, what the energy you are getting in transmission lines is equivalent to only 0.9 ton of coal.

When it goes into devices, even if they are good, it, about 80 percent efficiency, the electricity you are using is equivalent to only .7 ton of coal, which has come from 10 ton of coal. Do you understand how many losses we have had in the steps?

So, if you save 10 percent electricity, here you save 10 percent coal at the source. So, the effect of saving is actually much larger than what we think.

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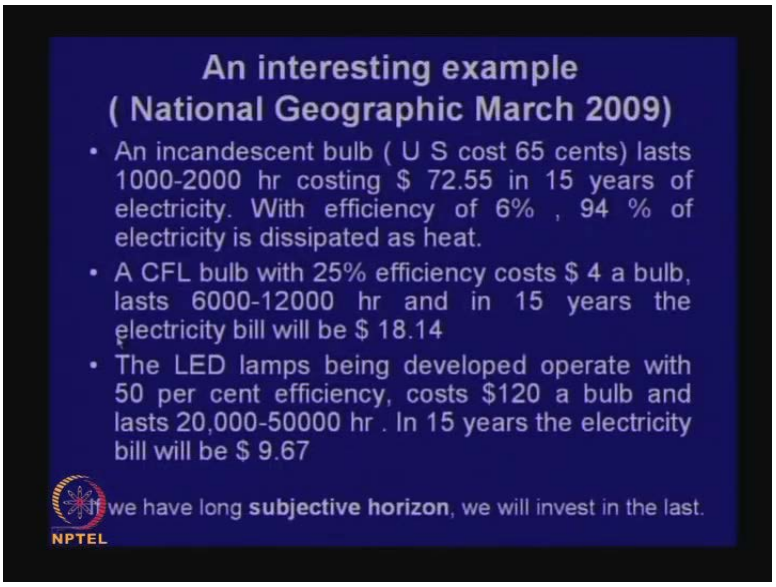

Now, coming back to that bulb example, I found a very nice example. You might wonder how this relates to nonferrous extracting metallurgy. These are the ideas, which can be implemented anywhere, including nonferrous extraction process, that is why, I want to emphasize.

Look at this interesting example from national geographic March 2009, an incandescent bulb, you know the olden bulbs, we used to have yellow lights. In the US, it costs 65 cents; in India it cost about 6 rupees. Its efficiency is only 6 percent 94 percent of the heat goes, 90 percent of the electricity goes into heat that is why it becomes. So, hot the bulb as well as the holder. Now, there it lasts thousand to 2000 hours and it will cost 72.55 percent dollars in 15 years of electricity. The electricity consumption is this because the efficiency is low, 94 percent will dissipated as heat.

Now, if you spend more money and spend 4, dollar 4 and buy a CFL bulb, which has 25 percent efficiency, it will last longer, 6000 to 12000 hour and in 15 years it will consume total electricity of 18.14. So, I took, you will be paying 3.5 dollars more when you buy it, but your electricity bill in 15 is going to come from 72.55 to18.14 . So, you see, if you have a longer subjective horizon, you know, the benefits you are getting.

Now, if you go to LED lamps, which are being developed now, they will operate at about 50 percent efficiency, they cost 120 dollars; a bulb last 20000 to 15000 hour in 15 years, the electricity cost will be 9.67.

So, in 15 years of course, it is marginally more expensive compared to others because to start it, you spend more money, but this money may come down with development and it last even longer. So, even advantage.

So, this is the kind of analysis we have to do for life cycle assessment and please remember, this which bulb in 15 years has emitted more CO 2. Obviously, the one which is operating at a much a lower efficiency on the whole it will be it will be consuming lot more electricity generating lot more CO. So, you have to look at things with a long subjective horizon.

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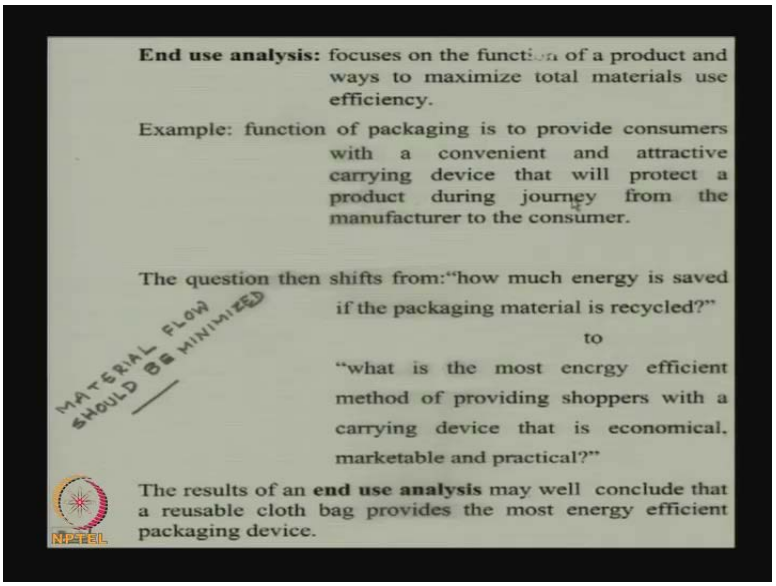

I will end this lecture by just mentioning the term end use analysis, which focuses on function of a product and ways to maximize total material use and efficiency, the kind of industrial metabolism, like you know, the function, you want a packaging material, what is the function to provide consumers with convenient and attractive carrying device, that will protect a product during journey from the manufacture to the consumer.

The question now shifts from how much energy saved if the packaging material is recycled. You do not stop at this that I have made a packaging and sent to the consumer, think of the end where it will be recycled.

So, the, the question now, how much energy saved if the packaging material is recycled, we shift to a question, what is the most energy efficient method of providing shoppers with a carrying device, that is economical, marketable and practical. The result of an end analysis may well conclude that a reusable cloth bag provides a most energy efficient packaging device.

So, think, think of things from different angles: how can we minimize material flow, how can in the total life cycle have the minimum impact on the environment? If you take into account all this then we talk about life cycle analysis.

So, now, during the last 3, 4 lectures, you have learnt many terms, many definitions and some explanations. We have talked about wastes, industrial waste, pollution, industrial

pollution, sustainable development, sustainable consumption, life cycle analysis, end use analysis.

Whatever I have said is perhaps can, can be said, can be explained better. But at least you know the terms and you can read up on them, learn more for yourself. You should be familiar with these terms because when you go to an industry, nonferrous industry, ferrous industry, wherever, these things should be in your mind. Because the concept we are discussing are all applicable in the manufacturing process, also for the metal extraction industry.

Thank you, we will continue with our discussions on issues related to energy and environment.