Non-ferrous Extractive Metallurgy

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Lecture No. # 38

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

Friends, I have delivered a good numbers of lectures on energy, and environment related issues or general interest, and also specific interest as regards to nonferrous metals production is concerned. I will deliver one more lecture, and that will be the end of this module number 9.

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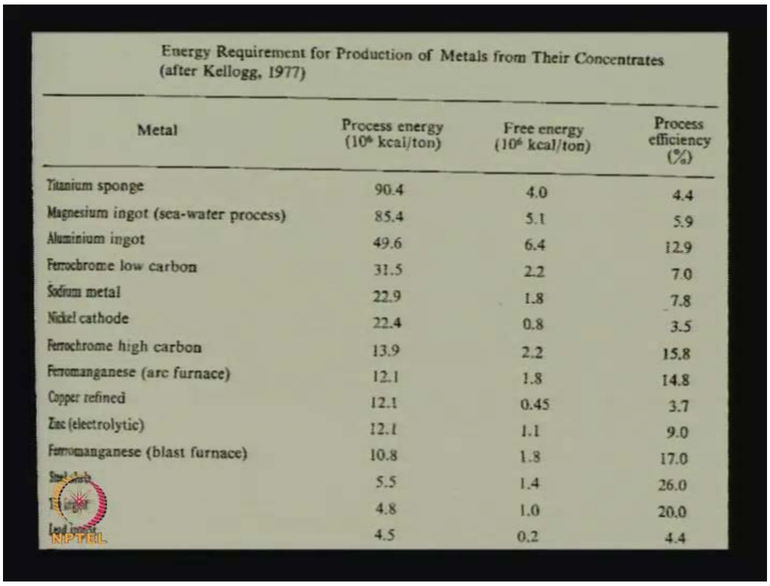

Energy Requirement for Production of Metals from Their Concentrates (after Kellogg, 1977)

Metal	Process energy (10^6 kcal/ton)	Free energy (10^6 kcal/ton)	Process efficiency (%)
Titanium sponge	90.4	4.0	4.4
Magnesium ingot (sea-water process)	85.4	5.1	5.9
Aluminium ingot	49.6	6.4	12.9
Ferrochrome low carbon	31.5	2.2	7.0
Sodium metal	22.9	1.8	7.8
Nickel cathode	22.4	0.8	3.5
Ferrochrome high carbon	13.9	2.2	15.8
Ferromanganese (arc furnace)	12.1	1.8	14.8
Copper refined	12.1	0.45	3.7
Zinc (electrolytic)	12.1	1.1	9.0
Ferromanganese (blast furnace)	10.8	1.8	17.0
Steel slab	5.5	1.4	26.0
[illegible] ingot	4.8	1.0	20.0
Lead ingot	4.5	0.2	4.4

And that actually would formally end, all the lectures I had to deliver for the course, but before I begin this last lecture, I would like to point out some mistakes that where there in a table I showed last time. Remember that, I showed a table where I compared process energy, and free energy for the production of various metals. I was trying to show that the actual energy you need in a process is much more than the free energy of formation of the compound. And the reasons are obvious had we if we had the pure combined with us we will need as much energy to decompose as the energy that was required for formation.

But we need much more, because very often we start with a low grade over, we go through concentration steps, we do many more things before you come to the final product from which we have to produce the metallic value. Now, the table I had shown had figures all jumbled up, and the you have to ignore that table I cannot delete it from the recordings, because that has already been recorded.

Please look at this table which makes things simpler. Here these are the products that we have produced in an industry, and I am showing here energy requirements for production of metals from their concentrates, and comparing with free energy. Actually I am leaving aside some very preliminary steps of mining etcetera, we just starting from a concentrate. You see the free energy for titanium dioxide would be only 4.0, but to make the titanium sponge, we will need so much more energy.

Similarly, for magnesium almost 16 times Aluminium in got see process energy, and theoretical energy that should decompose the mineral. Look at ferrochrome low carbon, sodium metal, nickel cathode, ferrochrome high carbon, ferromanganese, arc furnace, copper refine, wherever there is an electro chemical step coming. You will find the there will be difference between this, and this will be more etcetera, etcetera.

Only in the case of tin and lead, we find that the difference is not so much, because one does not need that much of energy to decompose to get lead or tin or steel from the concentrates, but the last column is significant. The process efficiencies as defined in terms of these two are very low in case of titanium sponge, magnesium, Aluminium, ferroalloys, like this nickel cathode its (( )) slightly higher in the case of steel, and tin. So, you get the idea that we have to spend energy in the initial steps, because (( )) decomposition.

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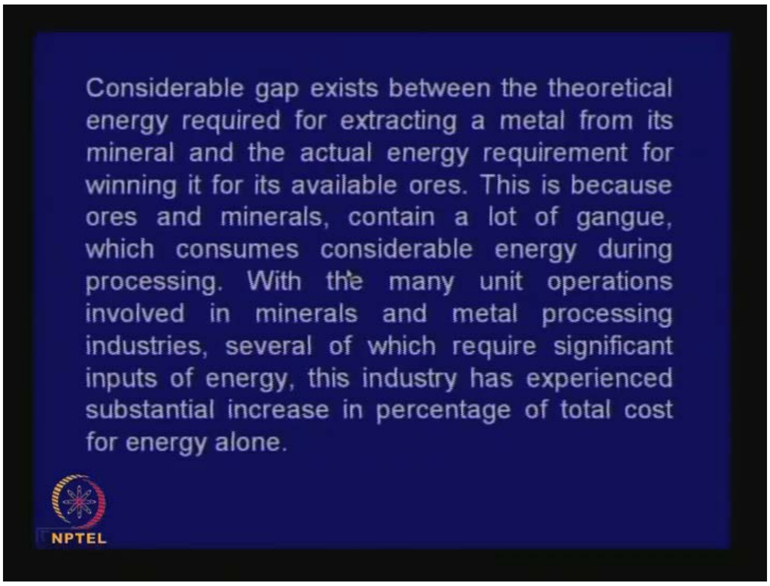

And this is what I said that considerable gap exist between the theoretical energy required for extracting metal from its mineral, and the actual energy required for winning it for its from its available ores. This is, because ores and minerals contain a lot of gangue which consumes considerable energy during processing with the many unit operations involved in minerals, and metal processing industry several of which require significant inputs of energy. This industry has experienced substantial increase in percentage of total cost of energy alone, and I had earlier mentioned that in the case of Aluminium 40 percent of the cost of the metal or even more is only the price of energy that has been used in the production of the metal.

Energy consumption, energy distribution for the that consumed for copper production I have shown, and again I want to emphasize that crushing and grinding takes enormous amount of energy 73.5 percent of the energy is going into crushing and grinding little less for flotation and filtration. And so, wherever there is a crushing or grinding involved you have to be very cautious.

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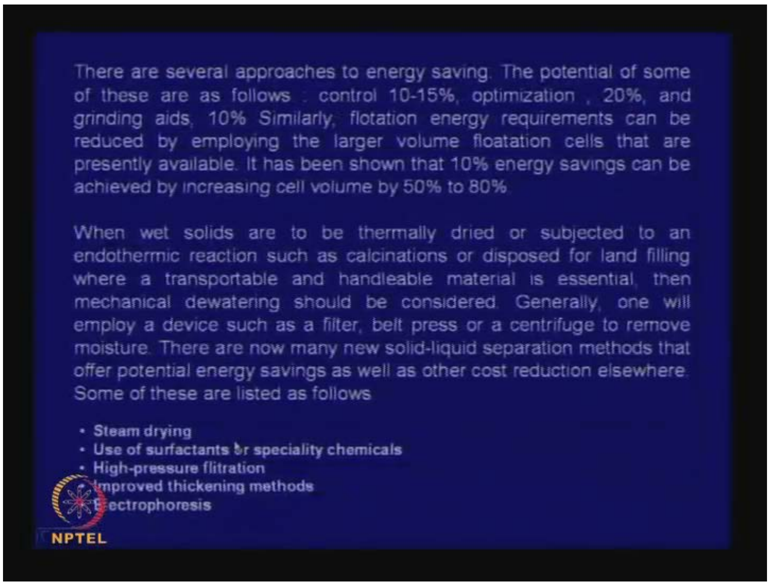

Now, there are several approaches to energy saving, and again this is a kind it is kind of repetition of what I had sent through control, through optimization, through grinding aids we can save energy; similarly through flotation cell enlargement if you have larger flotation cells, then also we will cut down on energy consumption during flotation. There is lot of energy required in drying, whenever we have wet solids, and there are now newer drawing techniques, newer methods of dewatering; these are all advances in technologies, and some of them have been listed.

Now, since I mentioned the subject of grinding which is which consumes enormous amount of energy; crushing and grinding has become very important disciplines for research to design new kind of crushers, and grinders which will take less energy. Then there are grinding, and crushing circuits means instead of taking the material and trying to grind grind it all the way to a finer sizes, there are now techniques that you partially do crushing, partial grinding take different fractions do them separately; again mix them intermediate all kinds of combinations, and these are called the comminution circuits, they have all been done. The whole idea is overall when you go from larger size particles to very fine size particles, we should not use excessive energy or at least you should use as low an energy as possible.

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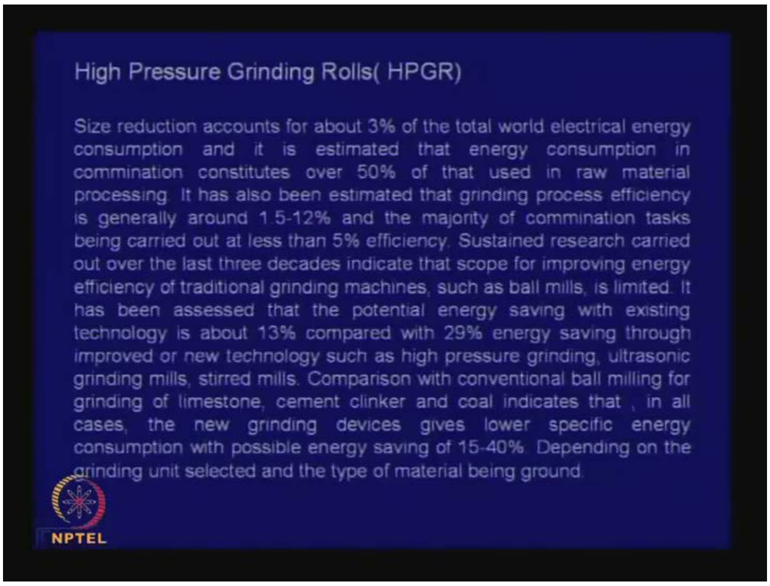

Now, to what extent this subject is important would be clear by the first statement. The size reduction in mineral industries accounts for about 3 percent of the total world electrical energy consumption.

Total worlds electrical energy consumption is so high, 3 percent of that is only being used in crushing and grinding of minerals. And it is estimated that the energy consumption in common comminution, it should be comminution constitutes over 50 percent of that used in raw material processing. It has also been estimated that grinding process efficiency is generally only 1.5 to 12 percent means rest of the energy is wasted as heat, and the majority of comminution tasks being carried out at less than 5 percent efficiency. Sustained research carried out over last 3 decades indicate, that scope for improving energy efficiency of traditional grinding machines such as ball mills is limited.

You know ball mill is a ball mill it it it is efficiency cannot be into so much, it has been estimated that the potential energy saving with existing technology is about 13 percent compared with 29 percent energy saving through improved or new technology, and one new technology is called high pressure grinding.

Where during grinding very high pressure is applied from both sides on to the particles being crushed or (( )). There are also ultrasonic grinding mills, where ultrasonic sound waves are used; there are stirred mills and comparison with conventional ball milling for grinding of limestone, cement clinker and coal indicates. That in all cases, the new grinding devices gives lower specific energy consumption with possible energy saving of 15 to 40 percent; the substantial amount of energy can be saved during grinding, if you use newer grinding techniques. Of course, it will depend on the grinding unit selected, and the time of material being ground obviously.

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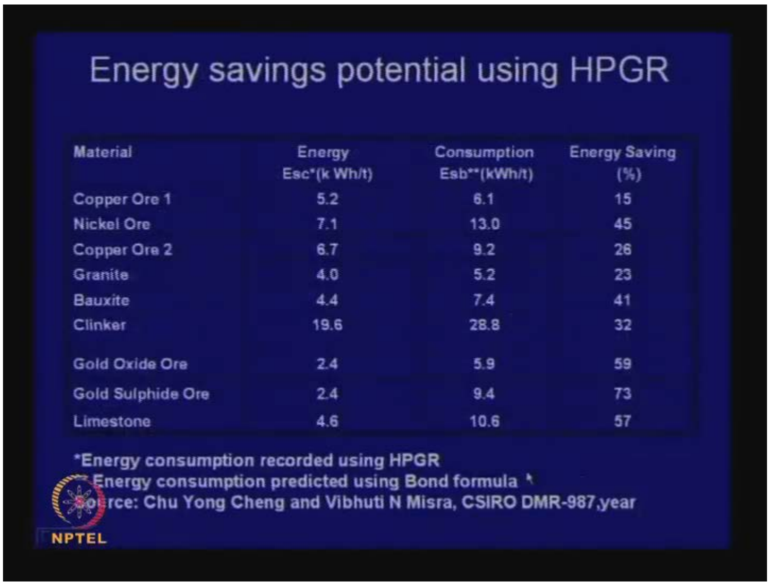

Now, the energy saving potential, when one uses this high pressure grinding roles. I I do not think I have a picture of that, but essentially you know whenever crushing or grinding is done; there are 2 roles through which the material to be crushed for grounding has to be passed. Generally the crushers are fixed, but in this case the crushers press on to the particles, which are going through the the space where they are being ground. That is why, and they are under high pressure. So, they will be called high pressure grinding rolls.

Now, this is the kind of energy saving that people have claimed, we can say 15 percent in copper ore grinding, 45 percent in the case of nickel ore, 26 percent in another kind of copper ore, granite 23, bauxite 41, clinker 32, gold oxide ores, gold suphide ores containing gold, limestone 57 percent. So, this is on the basis of energy consumption recorded using high pressure grinding roles in these units.

An energy consumption predicted using bond formula, you know one can calculate the theoretical energy energy requirements for crushing. So, the (( )) substances high pressure grinding roles, and other techniques must be used.

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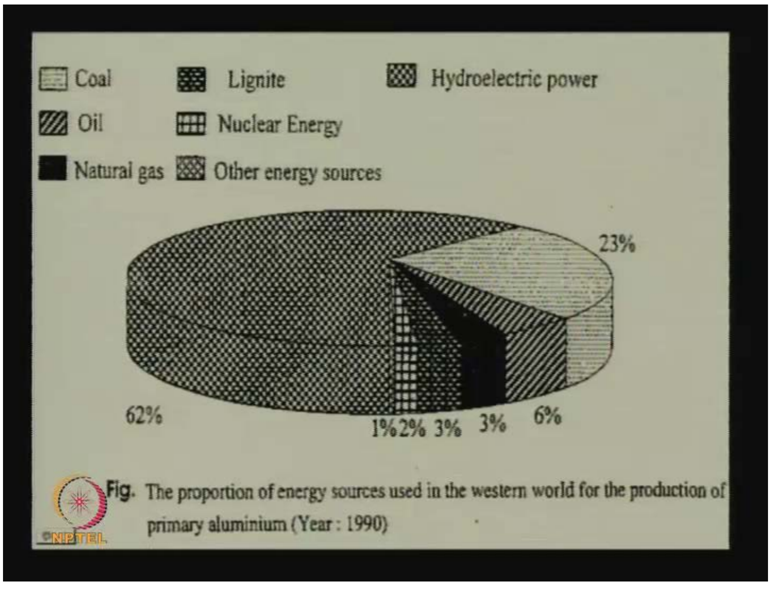

To go back a little, we will come back to the subject again, where is all this energy coming for nonferrous extractive metallurgy or or other industries. Since, we are talking about nonferrous extractive metallurgy talk about Aluminium which consumes the maximum amount of energy

Now, assume the western world, that energy for Aluminium extraction comes from a variety of sources. We talk about, what happens in India? First of all, you see thermal power plants will give 23 percent of the energy being consumed by Aluminium plants starting from bayer's process to smelters, but there are other sources – oil, natural gas, lignite, nuclear energy has come into picture also; small amount of nuclear energy is also supplying electricity to the grid from which electricity is being drawn by Aluminium plants. There are 1 or 2 other energy sources could be wind, could be solar it is not mentioned, but hydro electric power is what accounts for most of the energy being consumed by Aluminium industry 62 percent.

Why this is so, should be quite clear; that while it is very expensive to build dams, but once dams are built, the water that is stored can be released at the times needed for irrigation through channels, but the water that flows down through (( )) gates once you open the gates would also run generators that generate electricity; and generation cost is lowest, when we have a hydro electric power plan, because you do not need any raw materials there. The water that is stored has the potential energy that is converted to electrical energy through generators, when the water flows down.

Whereas in thermal power plants in need low materials, whether it is based on petroleum or natural gas you consume input materials. And you also give out CO 2, in this case nothing you have clean pure electricity that is coming from hydropower, and besides the need for Aluminium electrolysis so, so large that it is good to have a supply from hydropower. So, in every country many Aluminium plant's are near hydroelectric projects, we have one near hirakud dam, because but then we do not have that many dams to supply electricity to our Aluminium plants.

And many Aluminium smelters have their own captive power stations, like nalco in Bhubaneswar angul, and damanjodi; they have their own captive power plants. They meet their needs by generating power for themselves, if there is an excess they can give to the grid that goes for public consumption.

50 percent of the hydroelectric potential of India has been exploited, another 50 percent could be exploited; if we could go ahead, but the possibility looks very dim, because when we go for hydroelectric project, there are social costs. People will have to be displaced many roads, villages, ancient monuments, scenery they will have to be submerged. So, there is a problem associated and many people also say that dams have bad consequences over the over the long run, because it causes drop in the fertility of the soil, dams can cause earthquakes. So, there are all kinds of problems, I do not think India is going to have far too many dams.

We do not have this scope for far too much electricity from the hydro hydel projects, but India eventually can have more nuclear energy which can one day supply electricity to Aluminium smelters. We can also have to think of other things, alternate energy sources.

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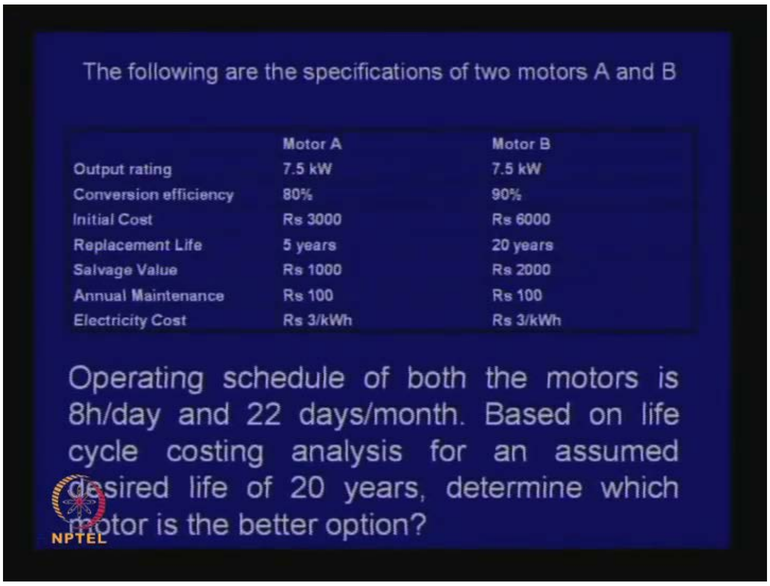

Now, let me now discuss some problems, and illustrations which would perhaps throw some light on the topics I had discussed in my earlier lectures. This would be related to life cycle analysis kind of thing, suppose that there are two kinds of motors A and B, and their specifications are given.

Both of the same capacity, but one has higher conversion efficiency, initial cost is also higher; it it it has a longer life 20 years for replacement whereas, the cheaper one every 5 years it has to be replaced. Salvage value is more for this, for this it is less annual maintenance is the same, electricity cost to run also is the same.

Now, operating schedule of both the motors is 8 hour day, and 22 days per month based on the life cycle cost analysis; for an assured desired life of 20 years determine which motor is best option, this is the problem. We have to look at the life cycle analysis, because we are talking about initial cost, then we are also talking about salvage value, when it is its life is over

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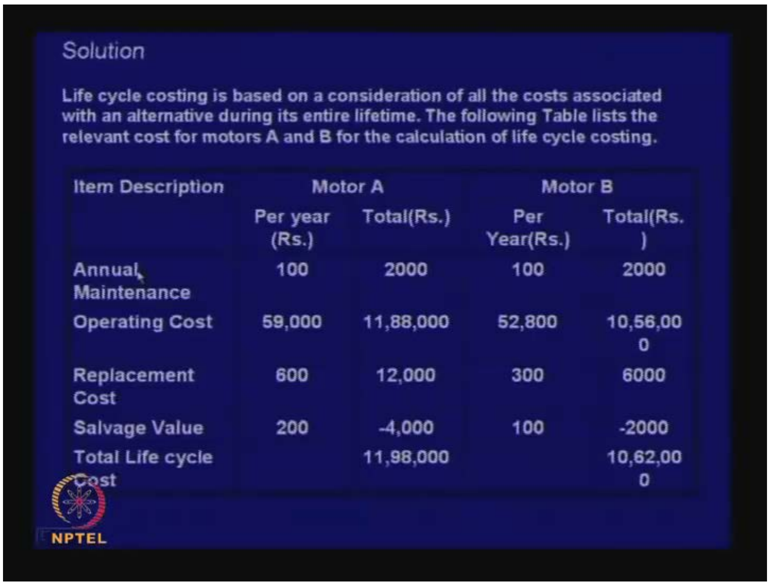

Item Description	Motor A		Motor B	
	Per year (Rs.)	Total(Rs.)	Per Year(Rs.)	Total(Rs.)
Annual Maintenance	100	2000	100	2000
Operating Cost	59,000	11,88,000	52,800	10,56,000
Replacement Cost	600	12,000	300	6000
Salvage Value	200	-4,000	100	-2000
Total Life cycle Cost		11,98,000		10,62,000

Now, we will solve this problem by doing life cycle analysis; the life cycle costing is based on a consideration of all costs associated with an alternative during its entire lifetime. The following table lists the relevant cost for motor A, and B for calculation of life cycle costing; the motor A, this is per year, and you get total for 20 years.

Annual maintenance this 20 years this much, operating cost annual this 20 years this, replacement cost annual this 20 years this, salvage value is so much, because its life is only so much. So, it has to be bought and this will be total life cycle cost is this.

For motor B on the other hand, we annual maintenance cost is the same; operating cost is bit lower, replacement cost is lower, because it last longer each unit. Salvage value is this much, and then on the whole total life cycle analyst will find this is costing less than this.

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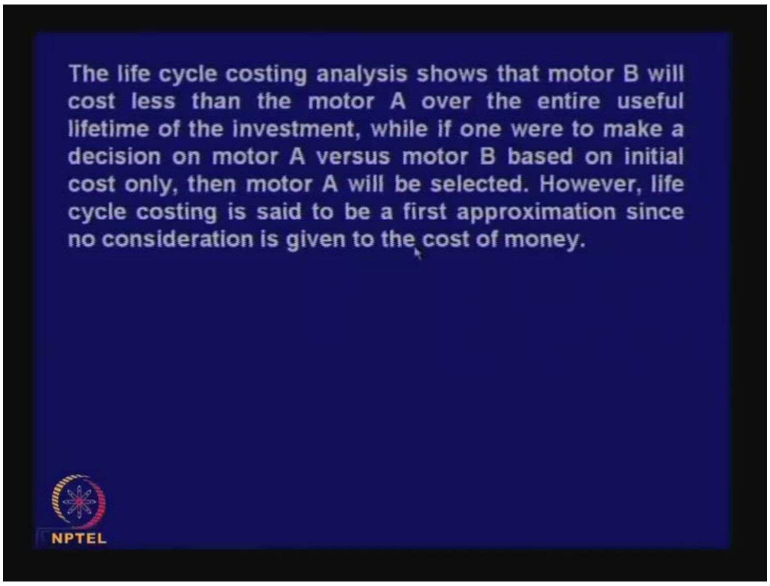

So, this is again an example of having a long term subjective horizon, it may cost initially little bit more motor B, but it on the long run it pays back.

So, the life cycle costing analysis show that motor B will cost less than motor A, over the entire useful life time of the investment. While if one where to make a decision on motor A versus motor B based on initial cost only, then motor A will be selected; however, life cycle costing is said to be a first approximation. Since, no considerations is given to cost of money. How the costing will change that we have not considered.

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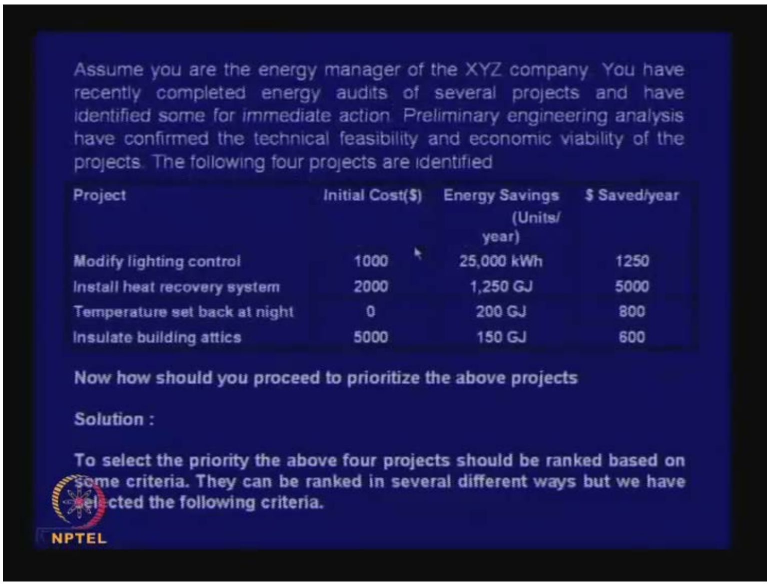

Now, let us come to another question. You assume that you are the energy manager of a company X,Y, Z, and you have recently completed energy audits of several projects, and you have identified some for immediate action. You have done the audit, now you are recommending some activities for action. Preliminary engineering analysis have confirmed the technical feasibility, and economic viability of the projects; that the project you have in mind can be done, the following 4 projects are identified.

We can think of to modify the lighting control which will initially cost 1000 dollars, energy saving per year will be this much, a dollar saved per year will be so much as compared to the present. Install heat recovery system that will cost something, it will save energy per year this much of dollar saved in will be per year. Temperature set back at night, that you say we will put the temperature back at night; it cost nothing initially, but you will save energy per year, you will save money insulate building attics, the roof we will insulate it will cost some money; there will be energy saving saved per year.

Now, how should you proceed to prioritize the above projects. Which one is more important? Which one is less important? That is the question. How do we analyze the solution to select the priority of the above 4 projects - above 4 project should be ranked based on some criteria. They can be ranked in several different ways, but we have to select the following criteria.

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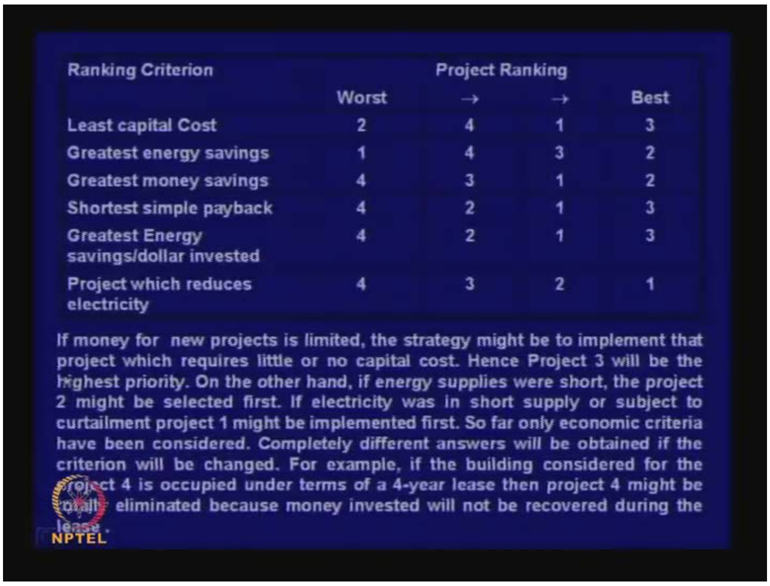

Ranking Criterion	Project Ranking			
	Worst	→	→	Best
Least capital Cost	2	4	1	3
Greatest energy savings	1	4	3	2
Greatest money savings	4	3	1	2
Shortest simple payback	4	2	1	3
Greatest Energy savings/dollar invested	4	2	1	3
Project which reduces electricity	4	3	2	1

If money for new projects is limited, the strategy might be to implement that project which requires little or no capital cost. Hence Project 3 will be the highest priority. On the other hand, if energy supplies were short, the project 2 might be selected first. If electricity was in short supply or subject to curtailment project 1 might be implemented first. So far only economic criteria have been considered. Completely different answers will be obtained if the criterion will be changed. For example, if the building considered for the project 4 is occupied under terms of a 4-year lease then project 4 might be totally eliminated because money invested will not be recovered during the lease.

The the various criteria are least capital cost, greatest energy savings, greatest money savings, shortest simple pay back, greatest energy saving per dollar invested, project which reduces electricity bills. And we give them some points that ranking criteria we give one here, yes now on on these criteria on project- ranking projects will be ranked based on this criteria like this.

Case number 2, we cover is a sorry. So, there are there are 4 options: 1, 2, 3, 4; number 2 will be the worst, number 4 option will be the best in terms of the initial cost; see this insulation costs very little. So, the project ranking will be like this, the best will be 3, then 1 then 4 and 2 in terms of least capital cost; if you refer to the table it will become very clear. In terms of greatest energy saving the ranking would be like this, best will be 2, 3 will be next phase, 4 will be 1, and so on and so forth.

So, we take the different criteria, and find out which is worst amongst the different operation options, and which is best in terms of these criteria. And the finally, we see that if money for new project is limited, the strategy might be to implement that project which requires little or no capital cost; hence project 3 will be will get the highest priority.

On the other hand if energy supplies were short, the project 2 might be selected first; if electricity was in short supply or subject to curtailment project one might be implemented first. So, for only economic criteria have been considered. Completely different answers will be obtained, if the criteria be changed; for example, if the building is considered for project 4 is occupied under terms of a 4 year lease, then project 4 might be totally eliminated, because money invested will not be recovered during the lease.

So, you see a a an industry has to operate under lot of practical considerations. So, what may be the best in theory may not find a ready application, you have to fix criteria whatever ideas are there for implementation, they have to be measured against this criteria keeping in mind all practical considerations.

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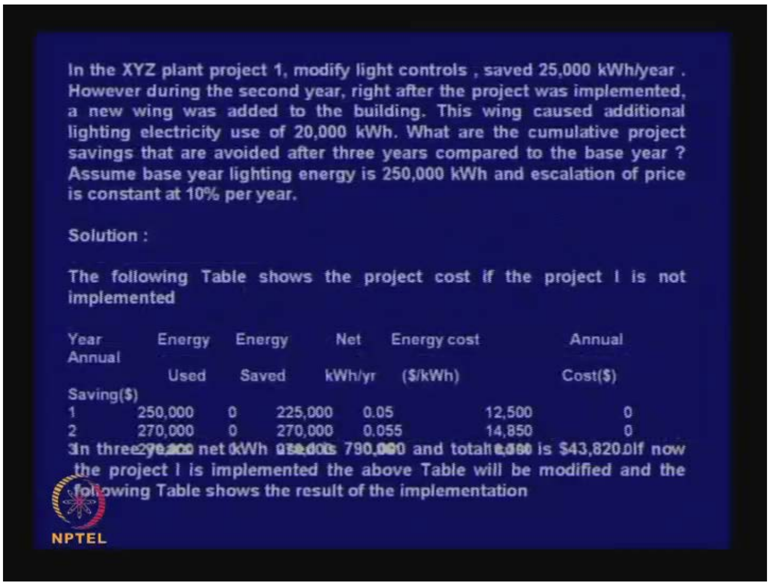

Now, we continue in the X, Y Z plant project one, modify light controls save 25000 kilowatt hour per year; however, during the second year right after the project was implemented, a new wing was added. Suppose a new room was added to the building, this will cost additional lighting electricity use of 20000 kilowatt hour. What are the cumulative project savings that are avoided after 3 years compared to the base year - assume base year lighting energy is 25, 12, 200, 50000 kilowatt hour, and escalation of price is constant at 10 percent per year. We are making things more difficult, I have given the calculations I will just read out you have to think about it do it for yourself.

The following table shows the project cost if the project one is not implemented. Here energy energy used energy saved, net energy cost annual cost; everything has been given in this table. First year, second year, in 3 years the net. So, much and total of this much is now the project one is implemented above table will be modified, and the following table shows the result of the implementation.

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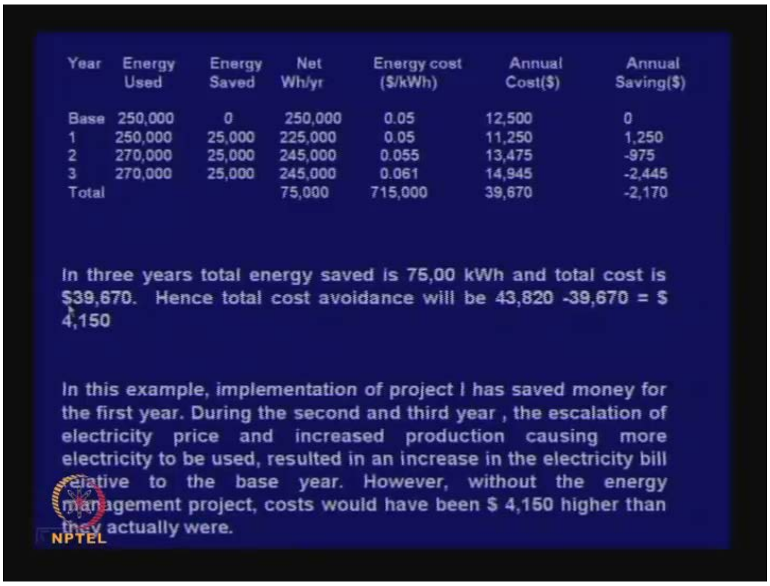

So, we have given all kinds of calculations, energy used this is the base here energy saved, net watt hour, energy cost, annul cost, annual saving which compared to base years – first, second, third year. Then total of what what is happening everywhere? So, in 3 years the total energy saved is 75, 7500 kilowatt and total cost is dollar 39670; hence total cost avoidance will be this, this, this.

So, we this is a kind of analysis industry has to do. In this example implementation of project one has saved money for the first year, during the second and third year the escalation electricity price, and increased production causing more electricity to be used resulted in an increase in the electricity bill relative to the base here.

However without the energy management project cost would have been so much higher than the actual environment. So, you think of implementation of new ideas with reference to priorities, criteria, realities, escalations, costs, everything etcetera, etcetera, etcetera. Certainly one would not think of bringing in a very expensive project which gives marginal advantages in a given period of time.

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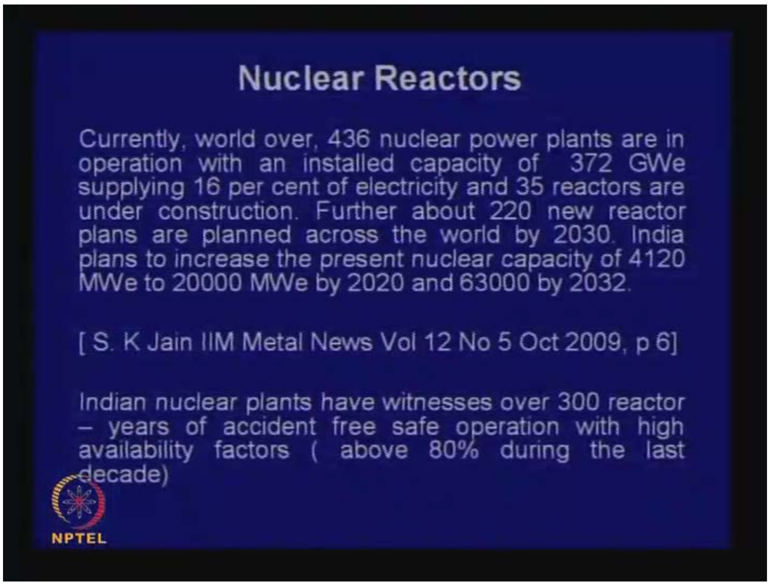

Now, I am coming towards the end of this module, and I like to discuss very briefly a topic which is becoming increasingly debatable in our country. And that is electricity from nuclear reactors. Some day we hope that nonferrous metals production, we will not (( )) depends so much on electricity from fossil fuels. Like petroleum, natural gas, and electricity from thermal power plants, which happens to be the fact of the matter today.

I given you one example, where one nonferrous industry is looking for an alternate source of energy, and that is the ferromanganese production units, manganese ore India limited with head office in Nagpur.

They are getting part of their energy requirements from wind energy. So, they are first of all saving use of coal, they are not using coal for part of that their requirements, and by not using coal, here they cut down on CO 2 emission, and because they have cut down on CO 2 emission, they are getting carbon credit.

And the money they have invested in setting up an alternate source of energy in terms of wind mills, they are equipping within a year year and half, and so they gradually want to expand the their involvement with wind energy.

Perhaps in near future many industries would look for alternate energy sources to gain carbon credit, get financial gain. And accordingly have cleaner operation not generate CO 2, their image will increase, but it will take time, because carbon is not used only as the form from thermal power plant producing, electricity and its coming no. Carbon as coke or coal also is directly used in some industries, like blast furnace operation depends on coke as a reducing agent for iron ore reduction.

Now, you cannot replace that by a form of electricity, you need coke straight away, and that is going to generate CO CO 2 from the top. In Aluminium smelters, the electrolytic process depends on use of carbon anodes on which the oxygen discharge forms CO, CO 2 and that goes out.

Now, you also need electricity to apply a voltage, and pass current. that electricity we can get from an alternate source. If you are getting a thermal power plants, we can get electricity from hydel plants, we can also get from nuclear power plants or we can get from solar energy or wind energy. But there is no substitute as of now for the carbon which is going being consumed as an anode, it is a consumable anode; the oxygen is constantly eating away carbon.

The cathode is not being eaten away. The cathode is finally, discharged. So, we cannot think of getting rid of all the carbon, but where carbon is been used in thermal power plants. We can think of eliminating that carbon, if you can for alternate energy sources, and I have given you some data to show. In many countries use of nuclear energy as well as other alternate sources of energy is growing. In France 80 percent of the country's energy needs is met by nuclear energy alone.

Even in many countries where there is a lot of oil, and coal say soviet Russia sorry European countries; there is substantial use of nuclear reactors. So, far china is not so much dependent on nuclear reactors, but they are also expanding their nuclear energy facility in a very big way.

India also has now planned to expand nuclear energy availabilities substantially, I think there are some figures I will show you, but in next 20 or 30 years they would perhaps like to make it 5 or 6 times, the present what we have is about 4 or 5 percent of energy need. Now, currently the world has over 436 nuclear power plants, the figure is as of October 2009.

This number may have gone up already, but as of october 2009, according to S K Jain who is a big man in our atomic energy establishment, 436 nuclear power plants were operating with an installed capacity of 372 giga watt, what is that you need sorry the unit I am not very clear about the unit. And it was supplying 16 percent of the electricity in in world world electricity consumption 16 percent is coming from nuclear reactors. 35 rectors are under construction , further about 220 new reactor plans plants are planned across the world by 20, 30.

So, by 20, 30 this number 436 will increase to 636 plus 35 almost 700 nuclear power plants all over the world. India plans to increase the present nuclear capacity of 4120 mega watt to 20000 which means 5 times by 20, 20 and 6 to 6 3000 by 20, 32. Now, there is another 22 years. In 22 years, we would like to increase it by almost 15 times that is a very tall order, and by in another 10 years we want to increase it by 5 times. So, there is not much time, in 10 years time it will increase by 5 times, and by in 20, 23 years time by 15 times, that is the plan.

Now, Indian nuclear plants have witnessed over 300 nuclear, 300 reactors years of accident free safe operation. You know how this is calculate? 300 reactor years means, if a reactor is operating for 9 of 2 years, it is 2 reactor year. So, taking into account all the reactors, and their duration as to how long they have been operating, we calculate reactor year operations.

Now, this is something India can claim with a lot of credit, but 300 reactor years of operation it could be one reactor operating for 300 years or 10 operating for 30 years, but we have many more than 10, as you know there has never been any accident anywhere. Now, lately there was something that happened in a reactor in the south that was not an accident, that was a man mischief created by some person, that is not an accident. So, the reactor operation that we have in India, we can consider safe and if the reactors we have also have high availability factors means 80 percent of the time, they were available for electricity generation.

Now, this is a very important parameter, that if we invest a lot of money into creating a facility for nuclear power generation that investment should not stay idle, which means you must be able to produce electricity all the time. In the case of nuclear power plants we cannot do all the time, it needs maintenance it needs many other things, but 80 percent of the time, they are able to produce in our country. At least during the last decade, this is what is claimed.

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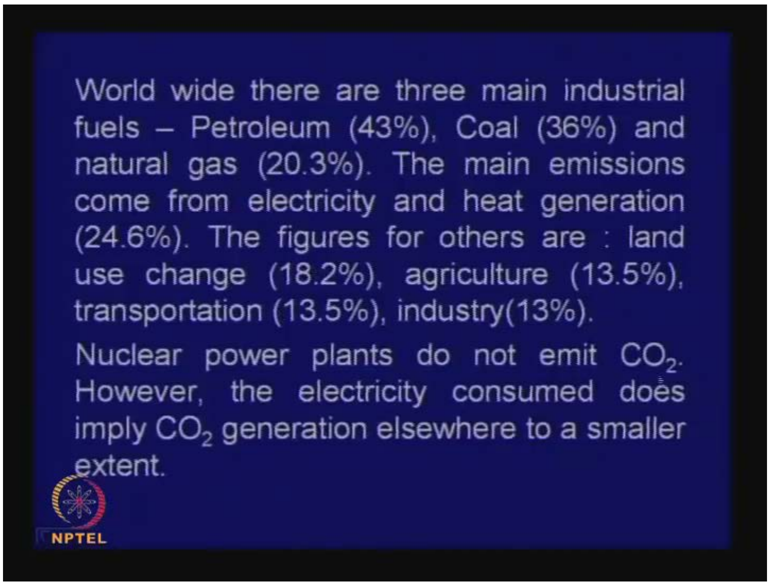

Now, worldwide there have been 3 main industrial fuels, in today world energy scenario 43 percent energy consumption is met by petroleum, coal needs 36 percent of the worlds energy needs natural gas need 20 percent; these are the 3 main ones, the rest are by the other sources including nuclear energy, and other things.

The main emission come from electricity, and heat generation 24.6 percent; the figures for others are land use change means, when your forests you have cut down forests - in brazil the amazon forest is disappearing very rapidly. When you do that, then the forest that was absorbing CO 2 is no longer there. So, that CO 2 will come out, we say that that figure will attributed to change in land use pattern.

Agriculture will account for some transportation, some industry 13 percent; now nuclear power plants do not emit any CO 2. I should not say it it is it is not associated with any CO 2, because people should know that when the nuclear power plants are operated, they also consume electricity. How they consume electricity, there all kinds of pumping of water, pumping of coolants, you have lighting, you have all kinds of things that is met by conventional electricity.

So, you do need electricity energy input in the nuclear power plant also, but some day it is may be possible that if it is operating all the time, it generates power generates electricity part of which is used for utilities and services; it may be possible, but as of now you need some amount of electricity to run the nuclear power. Actually, this has been a criticism, because there have been papers giving cost of nuclear power generation, as I said the cost of generation is the lowest for hydel power, because there no raw materials are required. You have the water reservoir, you let the water flow down, you generate electricity; there no inputs required.

The input required, the amount of material required for nuclear power generation is very small, no doubt about that, but you need input of energy to run the utilities, to run the machines, run pumps all kinds of things. So, there has to be an input of energy there, that we when we talking about process fuel equivalent, we we saw this in importance of looking at it holistically.

So, here nuclear power plant generate electricity surely, but they do also consume from the input and some electricity, that has to be kept in mind. That’s what I have mentioned; however, the electricity consumed does imply CO 2 generation elsewhere to a smaller extent; it is not very large, but to a small extent.

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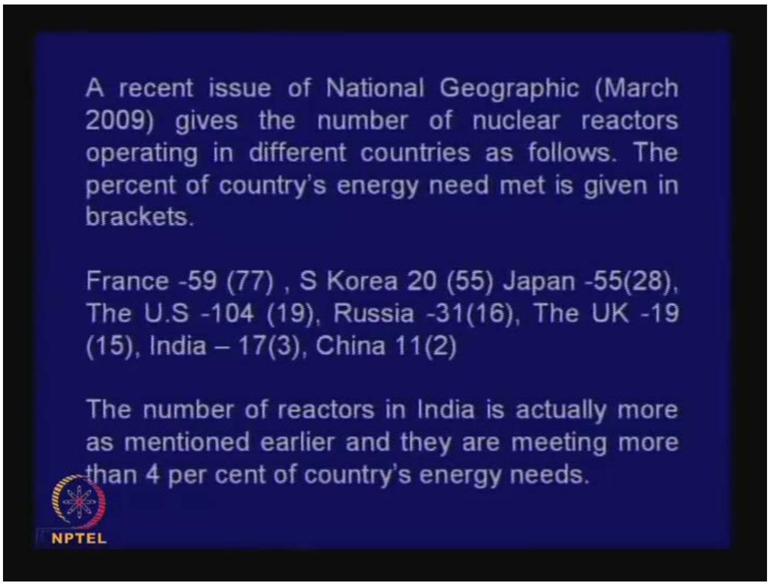

Now, a recent issue of national geography march 2009 gives the number of nuclear reactors operating in different countries as follows, and the percentage of countries present needs, energy need met is also given in brackets. Some of this figures may be contested, at least the figure for Indian I will tell you why? This is the very important country's need. France with 59 nuclear reactors meets 77 percent of the total energy need of the country; this is a remarkable example, and I told you earlier France does not have coal does not have petroleum, does not have natural gas. So, they took long ago, they took strides to be a nuclear power, and they have done that.

No other country can come anywhere near them, but look at South Korea which started late 22 nuclear reactors are meeting 55 percent of the country's needs. Japan we hardly talk about this, but Japan also has 55 nuclear reactors, 28 percent of country's need - energy need is coming from nuclear reactors.

Now obviously, the capacities of this nuclear reactors may not all be the same; that is why perhaps. Even if we have 17 nuclear reactors, we may not be producing as much electrical energy as 70 reactors in those countries are producing, but that is a different matter. In the US which is flushed with oil, and coal as rich; they have kept all their coal practically unutilized reserves, they trying to get it from the middle east.

They run 104 nuclear reactors getting 19 19 percent of their country's needs, and these are all very recent figures march 2009, in Russia; also Russia is a country which exports the largest amount of petroleum. They are even ahead of Saudi Arabia, they are so rich in oil, but they still they think there is wisdom in going for nuclear reactors. So, they have 31 reactors giving 16 percent of the country's needs.

Russia is unfortunately a country which has given a scale, because they had the chernobyl chernobyl disaster, which was a which was a very serious accident. And in that area people are still suffering, and they may suffer for generations Now, god forbid if something like that happens in our country? You should understand why one is bit hesitant about nuclear reactors in India, we are not very good in maintenance of any kind.

We are very good in creating things, but we are very poor in maintenance. You look at any building, specially buildings created by government, beautiful buildings we make then we do not know how to maintain it.

This is not so, in western world where whatever they create they maintain beautifully, and they look new and sometimes the look improves with time, because they are tuned towards maintenance requirement. That culture is not very good in India, and that is why many people tell that India has to be very cautious about nuclear plants, because we have to first train ourselves in maintenance, it is not that we cannot do that.

Today you go to any 5 start hotel in India, I am sure you must have (( )), and go to a government run guest house or a government run hotel you will see the stark difference how the maintenance is done in in 5 star hotels owned by private hands, because there is different kind of work ethics discipline, and command authority change operates. We have to bring in that kind of culture in nuclear plants. So, that they are maintained spick and span, if something has to be clean it has to be cleaned everyday. If something has to be tightened screws, they have to be checked every day. They are doing that in India. So, we have even in our government set up, institutions which are operating in a different level of maintenance, but we have to ensure that.

Now, coming back to this in UK- 19 reactors are giving 15 percent of energies needs country's. We have a good number17 reactors in India, but it is meeting only 3 percent of country needs. This figure quoted in national geographic may be low, I have heard a figure of 4, why is this so low? Obviously, it could be because of 2 reasons. May be the reactor capacities are low or secondly, it could be because our total energy requirement is so large.

Now, china with 11 reactors was behind India, and in terms of supply of energy needs only 2 percent, but things are changing they are going for a big expansion power. Now, here I have mentioned that, where the number of reactors India is actually more than as mentioned earlier, and they are meeting more than 4 percent of country's energy needs. Now, with that I complete module 9, and I tell you what happens now? I complete a discussions for the entire course, starting with general principles of extraction refining, then extraction of specific metals from sulphides, oxides, halides, talked about noble metals, talked about talked about secondary metals, talked about energy and environmental (( )).

Now, I have requested a friend of mine who's name is mister L Pugazhenthy to deliver 2 special lectures to you, mister Pugazhenthy whom we normally just call as pug is a very popular, person good speaker, he is executive director of India lead zinc development association is very knowledgeable in the area of nonferrous metals. And he was president of the Indian institute of metals last year, he is the going to deliver 2 lectures on non ferrous metals in India analyzing its true potential.

It will give an overview, he will tell you why it is important to study non ferrous extraction metallurgy, and what is its role in the economy of the county in the coming years. After those two lectures, I will take two lectures to review the entire course from the beginning till whatever that has been done so far. Thank you.