Power System Generation Transmission and Distribution

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Lecture No. # 04

Hydroelectric Power Generation

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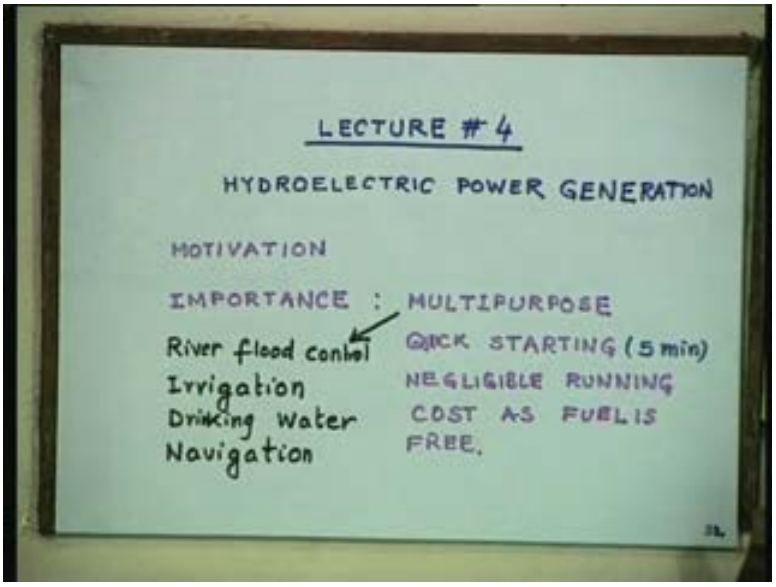

Today is the fourth lecture of this semester of this course. It is on hydro-electric power generation. We have seen in last three lecturers on how power system generation is important; what are the various conventional and non-conventional sources. We have talked in last lecture in detail about thermal power. Today is a turn of hydro. Why we should have hydro at all? Motivation, the motivation is we need generation; our load is always going ahead of generation. So, whatever generation is possible is welcome. Now, our potential hydro potential is 80,000 megawatt in the country.

In fact, if you can exploits the full potential there would not be any shortages. You may ask a question that why do not go ahead and do it. So, as to first remove shortages and do more progress more industrialization, the point is money. As I told you, you need 4 cores per megawatt and then there are other problems, which I will talk as we proceed in this lecture. The importance of hydro power station is it is multipurpose. It serves various objectives. It can control the flag, it can be used for irrigation; we need water for

irrigation, we are primarily an agriculture country. Drinking water is always a problem. In spite of 56 years after independence, we are not yet able to supply portable drinking water to all sections of societies, to all villages. There are still villages where they are to walk quite a long distance to fetch water for just to drink. Navigation, I am sure all of you know in India, it is very limited. Only from Bombay to Goa, there are ships, which go and then from Calcutta and Madras to Andaman Nicrobar. These are the only regular passenger ship service, which is I am aware of. Now, another beauty about hydropower plant is it is quick starting, unlike thermal power stations, where its takes 6 to 8 hours to start. You may ask me question why it is so important to have a quick starting.

Well, it is for peak load, it suddenly comes and then if you are not planned for it then you do know what to do. You can always start hydropower plant of appropriate capacity appropriate unit and in 5 minutes. In fact, the load it takes is 20 mega watts per minute. It is having a negligible running cost, as the fuel, which is water in this case is free; no charges for water.

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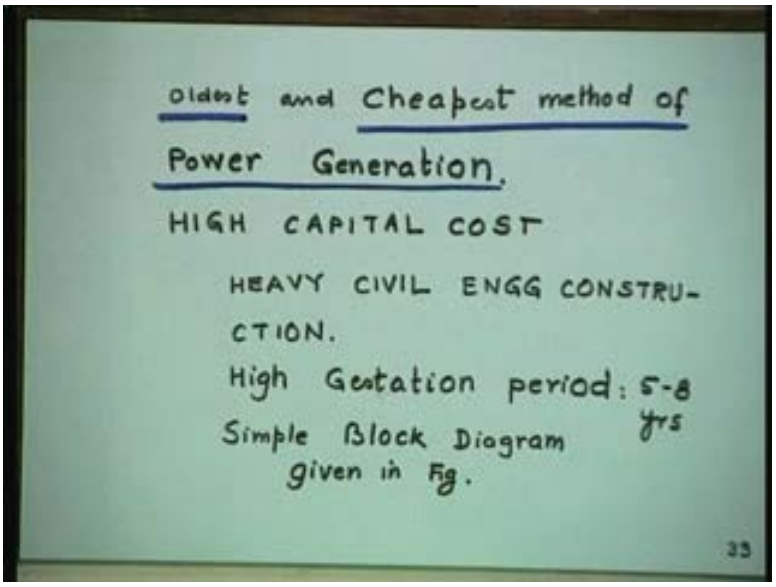

Well, let me also remind you, it is oldest and cheapest method of power generation. Even, as I told you in my introductory lectures, the first power plant that was installed in the country were hydro stations, almost, simultaneously in Darjeeling and in Saravathi River in Karnataka of 30 mega watt capacity. You cannot have all pluses in anything in life. It is always plus and minus; the minus thing here is in high capital cost and the land per mega watt is largest in this case; the land requirement. The minimum is nuclear you hardly need any land. Heavy civil engineering construction for the dam, reservoir and so

on and the gestation period is very high. It takes 5 to 8 years. In India, it may take up to 10 years. There are power plants which have not been yet completed in even more than 10 years. The Gujarat, the (( )) of the dam, in UP or Uttaranchal you know, Pauri Gharwal, still there are issues. Though only the village gets submerged, where do you replace the population? Give them alternative sites, which they have not yet done in few cases. Well, let me explain the working by a simple block diagram given in the figure.

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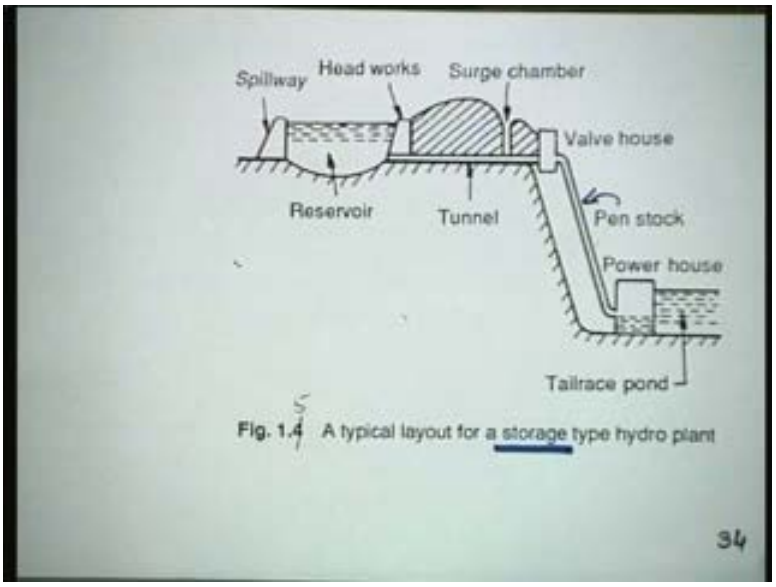

The figure is self explanatory. It is a typical layout for a storage type hydro plant. As we will see in next slide, there are different types of hydro power plants. We are more concerned about large power station. So, it is storage type. Why storage? You can control the output. This is the spillway, this is the head works, this is the reservoir, this is surge chamber, valve house, pen stock; this is pen stock, this is power house, this is tailrace pond and power is generated. This is tunnel. I am sure, you can go to Bhakra house and visit and see that it is our first big hydro power plant built in independent India, in 1956 and our first prime minister late Pundit Nehru, called it modern temple. As indeed, he called IITs also. These are the modern temples.

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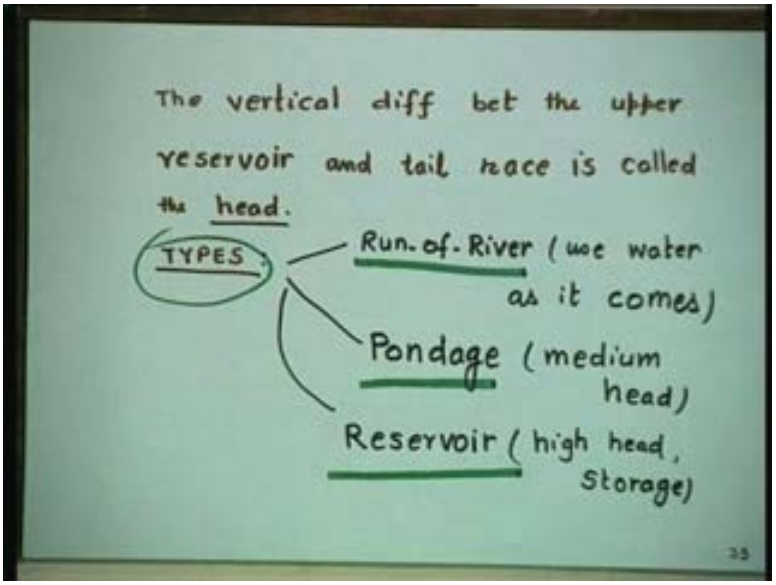

What is the head? Head is difference; vertical different that is between the upper reservoir and tail race; that is called head is a very important factor when you want to calculate the power generation by hydro power plant. I was just talking to you of different types of hydro power plant. What are the different types? There are three main types of hydro power plant in the world. Run of the river, I am surely you must have heard this things or might have read also in undergraduates, Pondage and Reservoir. We just talked about the reservoir. What is run of the river? It means use water as it comes, no harm, you have a grid; generate whatever power you can feed it to grid.

So, it is always welcome. Pondage is a medium head, water comes all the time, but you cannot store it. So, it is called pondage hydro power station and reservoir is of course of high head storage like a Bhakhra DVD system, you know and there are so many others in the country.

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What is the highest capacity hydro power plant in the world? It is in Brazil; 12000 megawatt. Our biggest is Bhakhra still, there is east wing 600 megawatt, west wing 600 megawatt, so total 1200 megawatt and since then we have not built another Bhakhra. Maybe, we are having shortage of money or whatever. What are the other types of hydro power plants? Cascaded, as the name indicates cascaded also, it is called as Series.

In this figure, you can see the upstream power plant is number one, downstream is number two. What is the advantage? The outflow of number one plant becomes the inflow to the second. Why not use the same water again and generate power. Now, we do have such series hydro power plants in Himanchal Pradesh, Jammu and Kashmir, Uttaranchal and northeast is full of water potential. Well, ladies and gentle men, there are two countries in the world where the hydro potential is tremendous. In Norway and Sweden, even Japan, Australia is 25 percent, in state of Tasmania, I do not know how many of familiar with Australia's geography. You know like Lanka, they have Tasmania State, away from the Maryland, Hobart being as capital.

If we are followers of cricket then must have seen that some test matches do take place in Hobart, which is close to New Zealand. Now, this cascaded power plants, if you model it. Naturally, if you go for, you are M.Tech students and if you take a project in hydro power plant, the operation of hydro power plant and it is an inter-disciplinary project in mechanical engineering, civil engineering, water resource engineering, and energy engineering environmental engineering. So, many can work in this area.

So, here to begin at tau, the times delay. Water which starts from plant one does not reach instantaneously to plant two. It takes certain time. And that time delay is tau. Tau, you are all familiar time constant. Whatever that that time delay is there, it can be a few days, few hours depending on the actual physical difference between the two power plants. Now, let us come to be another type of hydropower plant. They are called Tidal Power Plants.

All of you have must seen tides, at least movies and TV serials or whenever we visited Bombay, Madras, Calcutta, we do not have a sea in Delhi, but we know tides. Now, they have certain height. So, why not use that potential energy and generate power. Wherever possible the job of energy engineer that are going to be become is to generate power in as much minimum rupees per hour possible, producing as much minimum pollution or emission as you can, and making it as reliable as you can. These are the three golden rules that an energy engineer has to follow while generating power. Minimum cost, minimum pollution and good reliability, maximum reliability. I know it is an ideal situation. If you can have all the three; nothing like that, otherwise a combination. There are two important sites in our country called Bhavnagar, Gujarat, has been in news for right reasons are wrong reasons. All of you know about Gujarat. Now, lucky in Kutch area and second importance site in West Bengal, Diamond Harbor and that is Ganga Sagar.

Of course, so far we are not able to generate power; it still is making. I am sure soon this power plant will be completed and you start getting power out of them. Well, you may ask me a question like as said 12000 mega watt in Brazil, is the biggest hydro power plant. You may ask well me that what the biggest tidal power plant in the world is. This data is very important while appearing in interview and in IAS, engineering services, whatever, CAT, MAT or I do not know how many exams you may like to do in future. France is the country where on the river La Rance, the tidal height is 30 feet or 9.2 meters and flow is 18000 cumecs, meter cube per second. Earlier, the unit of cusecs in FPS system, now in SI system, it is cumecs. Now, we are going for different types of turbines.

I am sure that you must read about turbines in your mechanical engineering courses for thermal stations and so you must read about turbines in fuel dynamics, in civil engineering courses. There are three main types of turbines. You must have read the (( ))

diagonals and all those problems. I do not know how much of mechanical engineering you have read, how much of civil engineering you have read.

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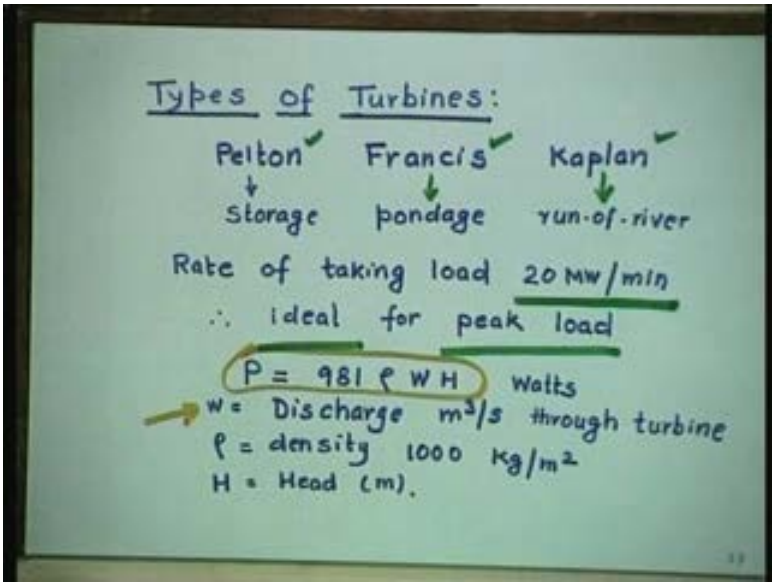

But in our days, we used to read lot of about them, and these three turbines are very important. Pelton, Francis and Kaplan; Pelton is suitable for of storage, and Francis is suitable for pondage, and Kaplan is suitable for run of the river. I have already talked about rate of taking load that is 20 megawatt per minute, some fifteen minutes back I was talking about this. Why hydro power plant is ideal for peak load? I have also answered this questions in the beginning itself. Quick start, it is quick five minutes, 20 megawatt per minute just now we have seen. What is the equation of power generation using hydro power? this is the equation; 981 is your value of g, rho is the density of water; 1000 kilogram per meter square, but used to be 1 gram per CC in CGS system, which everybody has forgotten now.

H is the head in meter. Now, this equation you need while calculating how much power has been generated with a given head, and other things are constant. If head varies the power generation varies. The discharge is another very important factor, which desires about power generation and by discharge, I means useful water discharge. There can be discharge through seepage that does not take part in power generation. There can be minimum discharge required to keep turbines running at no load. That is not giving you any power, but you need to have certain minimum, in order to go. Like in a thermal power plant, to keep the steam at particular temperature and pressure, we have to burn coal, so that you can take power as in when you need.

You cannot start from cold start all the time, as it is takes in 6 to 8 hours, like you are talking, you on your bike, you are in your car, and you are talking for a minute to someone, you normally do not switch off the engine. You think that you would just go. That is different matter; you may stand half an hour still talking. That is what Indian are known for their.

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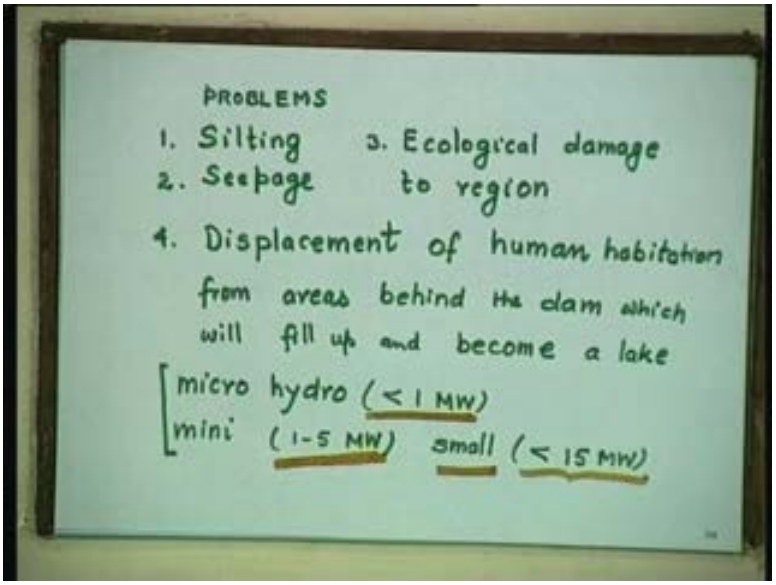

What are the problems with hydro power stations? Silting, Ecological damage, that is how this environmentalist, you must have heard of Bahugunas, Baba Amte, Arunthathi Roy, all these persons are very annoyed with anyone who would of hydro power. Do not think that nuclear power is only power where there is a controversy. Even hydro power and that why is this Narbada, the Pauri Gherwal; these hydro power station are not getting finished or not getting over. Seepage, I already talked about this. Seepage, you must have seen seepage in houses also, in the old construction. The main problem is displacement of human habitation from areas behind the dam, which will fill up and become a lake. If it becomes a lake, then how do you stay back there? That is what the Pohaddi villages is totally submersed in water and those guys needs alternative place to continue to live, to continue to lead a reasonable good life.

So far we were talking about the conventional hydro power plant. Since, you are a student of energy centre and you need to do more about non-conventional energy resources, renewable energy resources. Most of the resources are based on that, rather than electrical engineering or mechanical engineering. The micro hydro, pico hydro, mini hydro and small hydro become more important than large hydro. Pico hydro is few

watts, mini is 1 to 5, sorry, micro is less than 1 megawatt. 500 kilo watt, 750 kilo watt, 200 kilo watt and mini is 1 to 5 mega watt, and small is any things less than 15 mega watt. This is as per UN conventions, directives, norms. Our CEA has a different norms, Central Electricity Authority, which is right there in R.K.Puram sector one, which controls so many things in power sector.

Now, we have 5000 megawatt potential of just mini, micro, small power station. Again, China has taken a lead over us. They are having much more potential as well as install capacity in this category. we also have around 500 megawatt in a Himanchal Pradesh Haryana, Punjab, Uttaranchal, UP, in facts IIT Roorkee has two centers, where exclusively the work is going on in hydro. One is called alternative hydro center and another is called water resources development center. I do not know if you are aware of it. There are both run by MNES. MNES is ministry of non conventional energy resources. Some of you may be getting MES fellowships. Is there anybody getting? Are you aware of that? It is the only ministry, full-fledged ministry, in the world catering to non- conventional energy resources.

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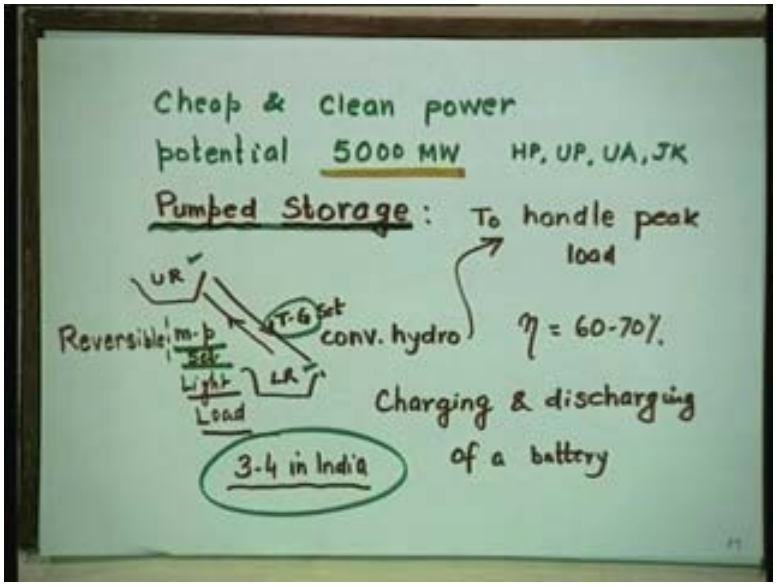

The potential is 5000 where as installed capacity, as I said as just now, is 500, just 10 percent. So, that is lot to do, miles to go, and that is why people like you will have great future now in energy sectors. Especially, with a passage of 2003 electricity energy act, you all will require it as auditors, as energy auditors. Now, energy audit is compulsory. I am sure there must be having one credit course on the energy audit, which is very important. If you do not have then go and attend in the evening, it is very important

course. Well there is other variety of hydro station. It is really multipurpose and multicolor.

It is called pumped storage, the only way to store energy in the big way. What we all aware of is battery; all of its storage of energy, electrical energy in form of battery. Your calculator, your torch, anything your radio, your television also runs on the battery, inverters needs the battery, but that is a small storage. If you want real big thing like 120 megawatt, 150 megawatt, you have to go for pumped storage power plants. What are another ways of storing energy? Compressed air, hydrogen etcetera, we will talk on them on some day; otherwise you may read them in some other courses as well. There are upper reservoir and lower reservoir like this. You have reversible set of motor and pump, turbines and generator. Same set of works as a motor and pump some time and turbines and generator.

So, if it is off-load period or light load period, when you do not need power, say it is a midnight. Most of the people are sleeping and most of the industries are not there because there is no much manufacturing activity. They are closed or the others do not have money and there are no requirements. Very few industries, which run round the clock and many industries are one shift, from 9 to 5 or 8 to 4 and whatever.

So, what happens in the night the load requirement is not same. Even the IIT, the night time loads requirements is much lower than the day time. Hardly, very few people work in labs. There are some people, computers, hostels and other employees; most of them sleep in night time. When it is a light load period then why not take this water in the lower reservoir to the top reservoir using motor pump set and keep it ready for peak period.

Then use this reservoir as normal conventional hydro power plant and same motor, pumps set works as a turbines generator and generates power; a beautiful arrangement. We have only two or three such power plants in the country, one in the Nagarjuna Sagar, near Hyderabad, Andhra Pradesh and another in Thalachur in Orissa. This is analogous to, similar to, parallel to, charging and discharging of the battery. Now, mobile is well known to everybody, you keep on charging, so that you use it next day for SMS, whatever film songs, FM, photograph, whatever use you want to put it depending on your pocket how much you permit and how much scholarships you are having.

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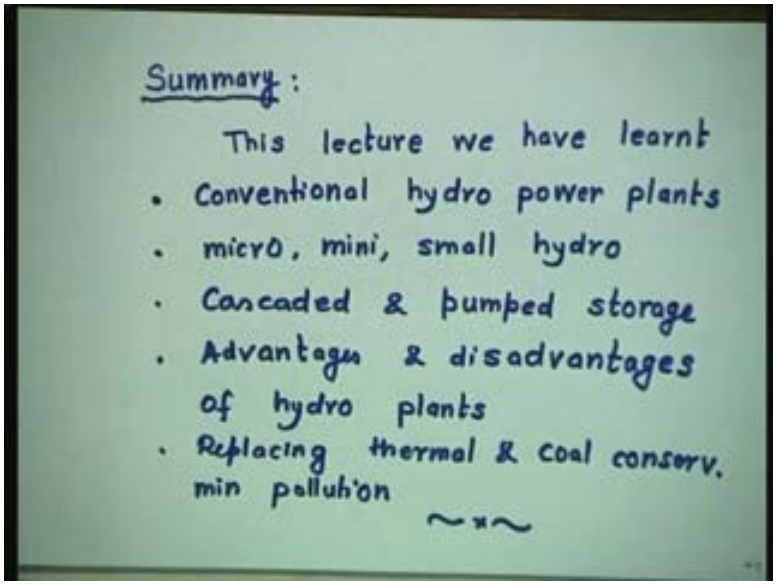

We have three or four in India, more are required. Well, what we have done let summarize it in this first half an hour of this lecture. We have learnt conventional hydro power plant, micro, mini and small. We have talked about cascaded hydro power plant. we talked about this storage, otherwise energy cannot be stored like water or gas; open a tap into you get water, open a nob to get a gas. So, this is magic, you have to generate energy as and when you need.

So, the only way store energy is in a big way is pump storage power plant. Advantages and disadvantages, we have talked like multipurpose, quick starting. The disadvantages is lot of money required and lot of land is required, then you have to convince the people, there are political implications, there are all this environmentalist are there, who will oppose, who can seat on fast and so on. Why it is required? Firstly, we have potential, great potential of 80000 megawatt. Why not use it? Why not tap it when do not have power or even shortage of power. America can afford not to spoil those rivers, because there have enough oil, enough coal and there demand is not going up, because everything practically in life they are doing in electrical energy.

So, where the demand can go up and population is not risings, otherwise you would not have so many immigrants. So, they are in happiest situation, we are not. Our install capacity must increase, as I said in the very first lecture. We need to add another one lakh in 10 years; we added to our account one lakh in 56 years and in another 10 years we wants to add, because we started with (( )) megawatt in 1947. Now, it is one lakh and five thousand, and we want to add another one lakh, we can well imagine how much

money is required, how much manpower is required, how many engineer, scientists working energy, environmental area will be required and above all the money will be required. Why you want to go for hydro? We want to replace thermal as much as possible and that is all the hydro-thermal scheduling is all about. This is a very important topic as an M.Tech project, mini project or major project. How you should do? There is full literature available for hydro thermal scheduling. How much of hydro we can use, so that we can save thermal, we replace thermal. Why, so that we can conserve coal and we have minimum pollution. If it is hydro, then there is no sulfur, then there is no carbon, no CO, there is no C O 2, there is no S O 2, there is nothing. Now, we come to our next topic that is nuclear power plant.

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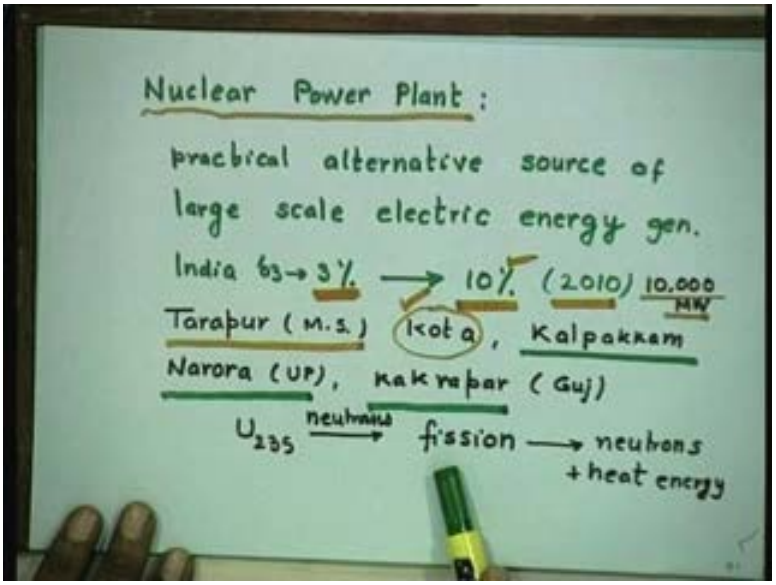

This is the third in the last type of conventional power plant. We have talked about thermal and we have talked about hydro just now and now will be talking about nuclear power plant. This is the practical alternative source of large scale electric energy generation. Why it is practical? It is already happening. Why it is alternative? It is alternative to thermal and hydro and if somehow you do not want hydro, if you do not have hydro or if you do not have coal, then nuclear is only choice. Well in India, even in 2003, we have just 3 percent of nuclear power generation. We want to make it, take it, to 10 percent.

We want so many things in life and it is not necessary we will achieve all of them. But it is no harm in having high aim, it is not failure, but low aim is a crime. We should aim high. So, our aim is 10 percent by 2010 and 10000 megawatt, which is roughly today

around 3000 megawatt. How does not nuclear power story start in India? With joint vision of Baba and Nehru, they thought why not use nuclear energy for peaceful purposes. Of course, Nehru was not there to see that first power station working, but it did initiate that Tarapur tramway, BARC is a prestigious institution and what is wrong with Tarapur? The fuel they used was or use is enriched uranium, and India does not have unfortunately this fuel; enrich uranium. Anything, we do not have what we do? We import and that is the only way to get it and import from where? From United States and our relationship with US; ladies and gentlemen, has been Monday Wednesday Friday good, Tuesday, Thursday, and Saturday are bad.

As and when we use to get bearing the Kennedy era, which lasted and now situation is different, because there is only one super power. I am talking about the 60s and 70s and 80s; those 30 years. So, if enrich uranium is not there, you cannot generate power, using Tarapur. So, what happen is we went to Kota. Kota is well known to all JEE (Refer Slide Time: 32:31) people and I am sure you are not come through JEE, because you are M.Tech students, but you know Kota is a large centre in the country to produce and get success in JEE. Kota is also or perhaps the only city in having all the three power plants, hydro, thermal power as well as nuclear. This is always asked in interviews.

So, Kota used the heavy water reactors and it was with the Canadians help. They have been problems there also. There has been leakage in heavy water etc. It has made headlines in past in newspapers. The third one is truly Indian. Be Indian, by Indian; Kalpakkam, it is close to Chennai, former Madras. It has research station as well, where the research is going fast (( )) technology. The fourth one is in Narora, near Aligarh, in UP. The fifth is Kakrapar; it is in Gujarat, in tiekadian Karnataka and so on. So, ten such places have been identified and lets hopes our this dream 2010 for 10 percent will be fulfilled, because of this nuclear power station coming up.

Let us explains briefly how it generates the power. U 235, the uranium, you known their atoms and bombarded with neutrons, creating fission process, which also generates neutrons and further this neutrons can be used. So, it is regenerative process and that is why the fuel required is very little and this generates the heat energy and hereafter you know what to do with the heat energy, produce steam at a particular temperature and pressure; turbines, generators, transformer grid, power is available. Released neutrons, there is a chain reaction as I was talking just now.

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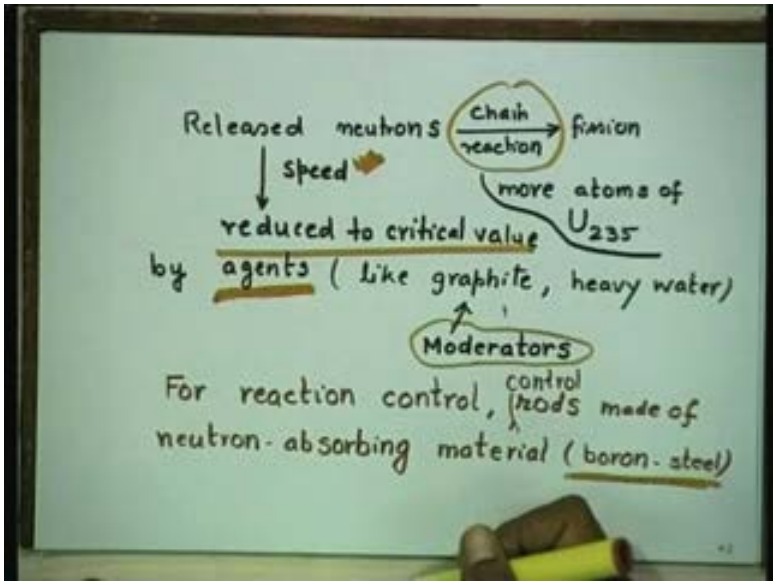

So, more fission, but can you control speed. Yes, we need to reduce the speed to a critical value. How do you achieve that? By using certain agents and what are these agents? The graphite, heavy water and they are called moderators. You must have seen in TV or anywhere, in any panel discussions, there is the moderator, so that you remain within in the subject. You do not talk some things which are irrelevant to that day to the topic.

So, here is the moderator, which sees that the speed does not go beyond certain critical value. What do you do? How do you control? For reaction control, the control rods made of neutron absorbing material are inserted in the reaction vessel, which is equivalent to the boiler here. There is no boiler here. Boron steel is one such material, which absorbs extra neutrons, so that the speed gets limited to a desire critical value. It would not allow it to pass, surpass or cross a certain value.

However, control is possible only within narrow range. It is not possible to have minus infinity to plus infinity, like you want the voltage to remain within the plus minus 5 percent. That is a different issue, in India it becomes plus minus infinity; voltage can as low as possible as 170 volt or it can go as 270 volt. A 60 watt bulb can behave like 100 watt bulbs in the night, when the voltage is very high or 25 watt in day time, in peak hour.

That is separate story and that is why we need a voltage stabilizers for whatever things you need to use, whether it is an AC, it is a fridge, whether it is a PC you need another

investments for 3 to 5000, in India, which is a poor country. Because, you are not able to control your voltage, it is free for all, but normally supposed to vary between plus and minus 5 percent. Here, also a control in possible only in within narrow range. What is the consequence of this? The consequence is nuclear power station can only be use as the base load station because variation is not possible. If it is generating 500 mega watts, it is 500 mega watts; all the time.

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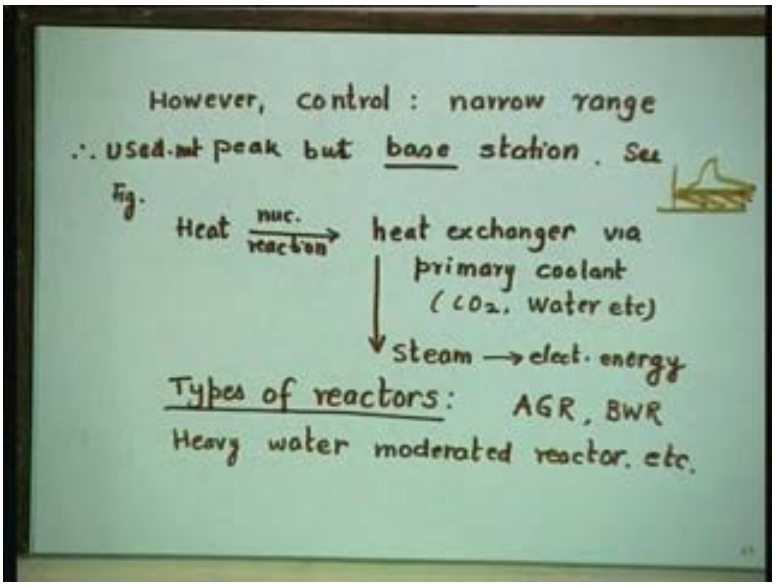

So, in order to use that 500 mega watt, I have shown that curve if you recall on very first day. So, this is the portion (Refer Slide Time: 38:17) this base load, which will be supplied by the nuclear power station. You have anyway other alternatives for peaking; peak load, gas station, hydro station, depending on how big is the peak. All peak shading technique are also there. I have given you five golden rules on how to flatten the load curves and make the load factor as close to one as possible. The ideal thing is step curve, u of t, whose Laplace is 1 by S. You must have read it in your controls system or mathematics or whatever. I will show you the figure; unfortunately they have to make it enlarge. I hope they will do that. Somehow, I could and I forgot to make it big one, otherwise I will bring it next time.

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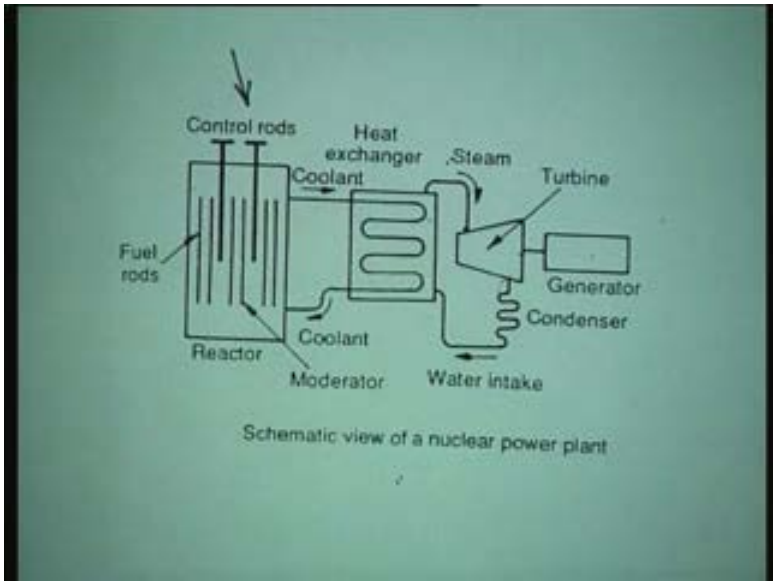

This is a reactor. Now, there are control rods and this controls rods and embedded in the reactors vessel. And these are the fuels rods and coolant goes back from here and comes backs. This is the heat exchanger and the steam; the water becomes a stream because of this heat and steam enters into the turbines here, goes here to generator and here is the condenser. It is similar to a thermal power plant; most part of this similar to the thermal power station, except the boiler parts, which is the reaction reactor here and reaction take place here in this vessel. This is the schematic view of the nuclear power plant.

Now, this heat in nuclear reaction, heat exchanger via the primary coolant, what are the coolants we use in nuclear power station? Either C O 2 or water and then there is a stream, which goes and produces electrical energy in normal conventional way. There is an advanced gas reactor and boiled water reactor. There are different types of reactors. I suggest and request you to go through the text books and read in details about various reactors, in case if it interests you. Heavy water moderator reactor is also there. So, they are several types of reactor and you can choose depending on the need.

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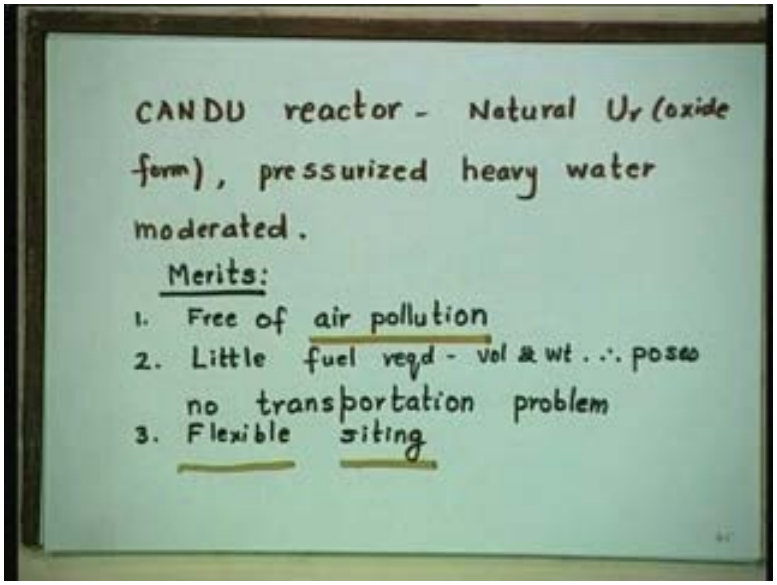

There is a CANDU reactor also. It is of Canadian design. It uses natural uranium in oxide form; pressurized heavy water moderated is used as a moderator. I told you already what a moderator is. What are the merits of the nuclear power station? It is totally devoid of any air pollution. There is no air pollution; no C O 2 gets into the sky, into the environment, no NOX, nothing. Very little fuel is required by volume as well as weight; therefore, it poses no transportation problem. You do not need railways; do not need wagons, not much money is spent on the transportation of the fuel.

Land per mega watt is very small and hence there are no siting problems. You can have a flexible siting. If it is thermal power plant, you have to see that it is not close to cities because of pollution or it should be close to mines. Like the Pithead power plants, of Singrolli, Korba, Chandrapur and so on. But nuclear power station siting is totally independent of all these considerations. It can be anywhere, but as I told you ladies and gentlemen that there can be only merits. There got to be certain demerits in whatever plant you are talking. So, what are the problems or demerits of this nuclear power station?

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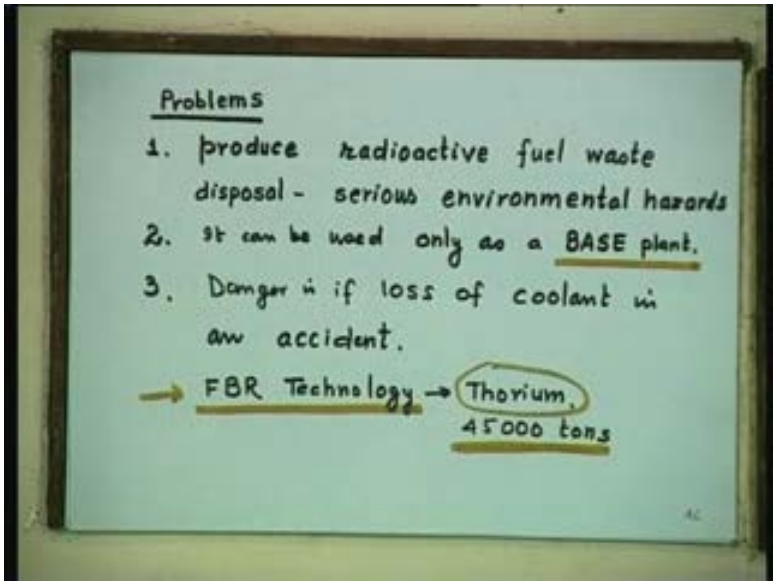

The biggest one, which we always talk, is radioactive fuel rays disposal. This is serious environmental hazard and it is said even when the nuclear power station has stopped working, we have declared it that it cannot be used anymore, in spite of using (( )) technology etcetera; the Indian technology, it is not working. Even then you need to guard it for another large number of years. If there is a radioactive leakage as indeed it happened in case of Three-mile Island, in 1960s or in terminal in 1986 that was in 1970s. Terminal was 1986; USSR, it was former USSR. Three-mile Island was in US.

The whole Europe was affected and you have to guard against that. It is not that there are no accidents when you walk, have you stopped walking? Not that there are any railway accident, in fact, it produces out of record in last two years, still we do not get tickets if we go to some places like Kolkata, Mumbai. Tickets are not available in good trains, in fast trains, like in Rajadhani. People do travel in air, though they have been some sabotage of some hostages, the terrorists' attacks, whatever, bird hit, tires not opening, several faults can develop and still do people travel in air.

Just because there have been two major accidents in last century, does not mean that you should not use nuclear power station. What is the important here is you have to be careful. In life you have to be always careful. There is a danger if there is a loss of coolant. In accident you can have a loss of coolant. Of course, that is also a sort of demerit that can only we use of a BASE plant, but in a grid operation and in inter connected operation that is not a demerit in the sense. There is another FBR technology coming, being developed in the country, fast breeder reactor, where we can use thorium

as a fuel. We have the largest deposit of thorium in the world of 45000 tones. Where is this thorium available? Anybody knows? It is in Kerala and Orissa; in the sand dunes of Kerala and Orissa.

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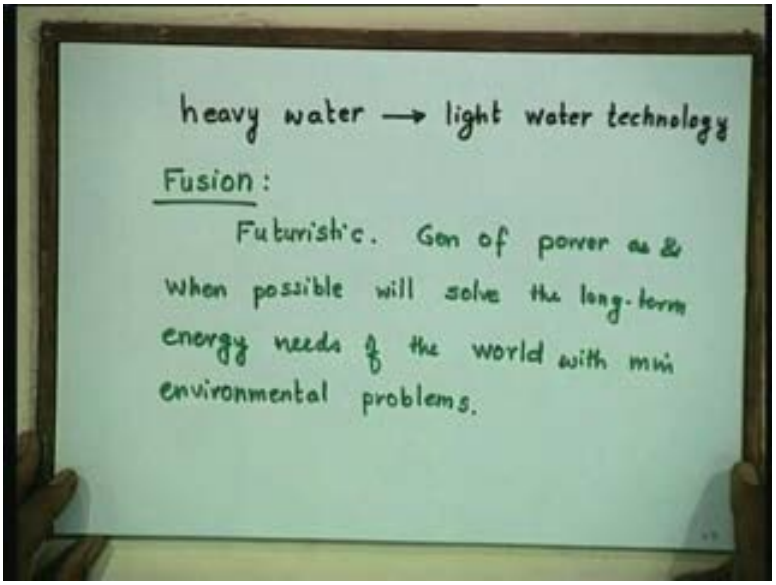

Instead of heavy water, now they are trying to use light water technology, which is cheaper and better. The progress is always go on and we always get better and better technology. What is fusion? So, far we have talking about fission like network analysis and network synthesis. So, fusion is futuristic. Why futuristic? Today there is no nuclear power plant based on fusion principle.

In fact, in 1989, a prime issue of a time magazine which there is a very famous magazine two American scientist claimed that there was achieved fusion, but later on it proved to be a cold one. Something, similar to our Ramar Pillay, who said the he, can have petrol from water and later on he was behind the bars, because he could not prove it. Generation of power as and when possible will solve all the long term energy needs of the world, if fusion becomes a success with hardly any environmental problems. Who knows that one day before 1969 July 23 rd, who know that we are going to moon and the human beings did walk on the moon on 23 rd July of 1969. Neil Armstrong and his one colleague, and one fellow was watching very closely sitting in the plane or whatever the space.

So, one day if fusion becomes a success, and then we do not need anything. Then there will be infinite energy available. We can use it. The main problem is how to control

fusion at that temperature. So, that is why the scientists are working and who knows fusion reactor may be available in 2010 or in any day.

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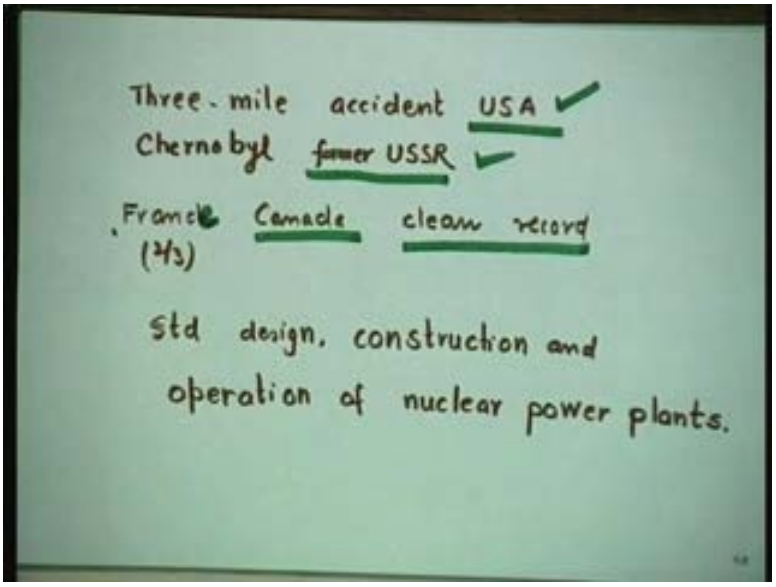

I already talked about the Three-mile accident in 1970s in USA, Chernobyl in former USSR in 1986. Yet, there are two countries in the world; France and Canada having a clean record. In fact, in France, the two-third of the power generated is by nuclear and there have been no Chernobyl, no Three-mile island; no accident. France is currently in news because of heat well, which normally we have been in India. Several thousand of people have already got affected and several have died also. Now, there is a need to do more research and development in standardizing the design, construction and operation of nuclear power plant. Why it is because we cannot have each nuclear power plant in different design like in US, Canada, France.

So, we need to have an Indian standard design, construction and operation, so that the spare parts required are minimal. We can order and they can be cheaper and if there is a larger demand, anything will become cheap. If demand is less then naturally it will be costly. If it is not made in-house in India, if you have to export it, sorry or import it naturally it will be costlier. Who knows we may export them also, India has been exporting power plant, BHEL has been doing that and NTPC is also doing that, consultancy all those things using information technology etc.

With this I think today we will finish. What we have done let us recapitulate. We talked about remaining two conventional plants namely hydro, nuclear and next lecture that is

on Friday, we will be talking on MSD, Geo-thermal that is on non-conventional resources, which will start, which are equally important, especially in far regions, hilly area, inaccessible area, where the grid has not reached. In India the grid has not reached everywhere. All villages are not yet been electrified. Only 85 percent has been electrified. So, in these 15 percent of villages, the only hope is renewable energy resources and well that is some time left for questions and answers and if you have any on the past lecture, I hope you solve those a five problems, which I gave you earlier on. It is there in the brown book and not in the blue book, as I said. So, any questions on the today lecture; anyone, any clarification, any suggestions, any doubt. If not then we will close.