

Power System Generation, Transmission and Distribution

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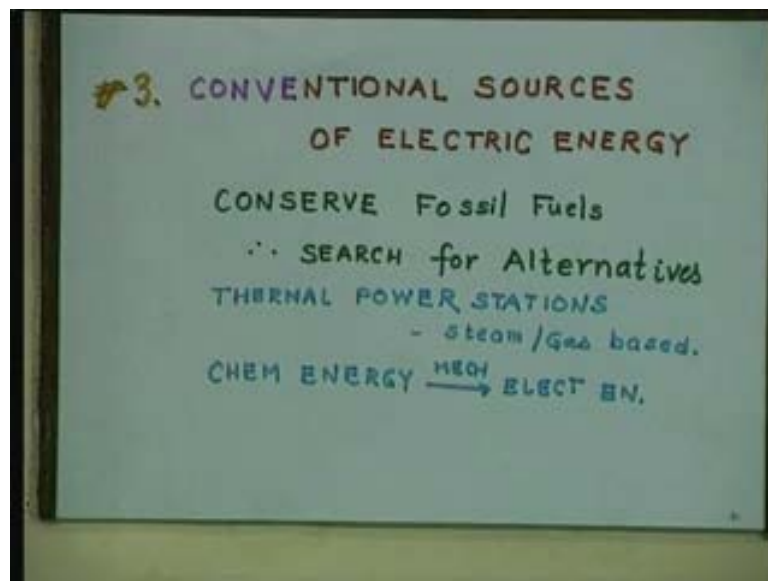
Centre for Energy Studies

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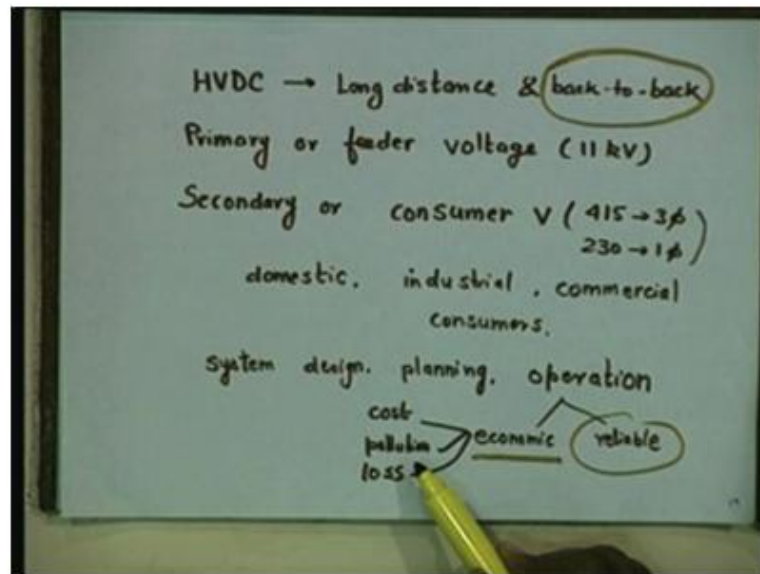
Conventional Sources of Electrical Energy

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Today is our third lecture; and the lecture is on conventional sources of electrical energy. And, yesterday we were taking about the transmission. I showed you a diagram for power system structure. Now, there someone asked me about HVDC.

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Now, HVDC can have two purposes; one is the long distance transmission, as I said north-east to south, another important application of HVDC throughout the world is back-to-back connection. Now, what is back-to-back? All of you know the France is having a frequency of 60 hertz, whereas England is having 50 hertz; that is why we are also having 50 hertz. Now, these two ac systems can be only connected by HVDC, because that is called asynchronous link, and this is also called as back-to-back connection, because you are connecting two neighboring ac systems we are connecting. So, this can be in the same building in fact, that why it is called back-to-back.

The advantage I already told you, you can connect two systems of different frequencies. Now, the primary, or feeder voltage is 11 kv in that figure, which I showed you the last time. And secondary or consumer voltage will be 415 volts for three phase connection, and 230 volt for domestic single phase. Now, you can have any consumer, you can have a domestic consumer, you can have an industrial consumer, you can have a commercial consumer, and each consumer will have its own requirement. And the electricity utility is obligated to supply the voltage of their choice; of course, they are free to take whatever tariff, they want to take.

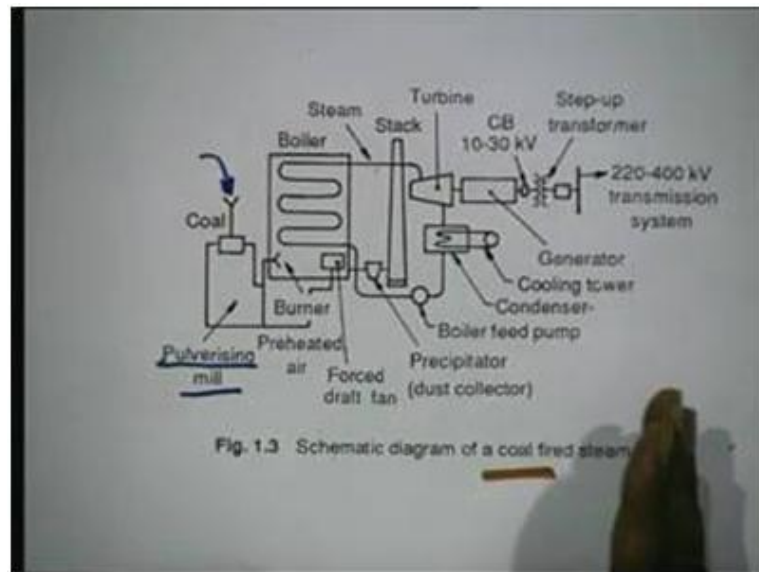
Now, system design planning and operation: This is the main three segments of any studies. You have to design a system; before design, obviously you have to plan a system; having plan and design a system, system must operate, otherwise what is the use

of that system? Any system, which is inoperative, you have definitely gone wrong somewhere, rather in designing or in planning. Now, when we want to operate, what is the main objective of any system engineer or planning engineer? The operation has got to be economic. So, all sudden done, we cannot short of forget about the cost whatever you do. And it has to be reliable. Now, reliability is as important as economic.

What is the use of power which is 10 paise per unit? But anytime you may have it, you may not have it. Based on such a power, which is highly unreliable, very cheap, I do not think any customer will purchase such a power. So, the power has got to be economic as well as reliable. Now, when you say economic, economic does not necessarily mean cost minimization. What is economic is minimum pollution, minimum loss. So, attributes to the economic need not be only cost. Any power generated by utility, which creates less pollution is more welcome than the power, which may be 10 paise cheaper, but it creates more pollution. So why people purchase petrol of higher price? If you go to any petrol station, you will find two types of petrol - premium and the normal. Premium is normally a rupee or 1.5 rupees costlier per liter, but I have seen many people preferring that, because the car runs efficiently, and give more mileage, further you create less pollution.

One car is not important, but sigmas of cars are definitely important for the pollution of a city. Loss, as you know, the loss also should be minimum. Now, when we talk of conventional sources of electrical energy, as I have been repeatedly telling you, they are only three conventional sources in the whole world. Thermal, that is coal, gas or oil; hydro is only water; and the third is nuclear, where only fission is possible. Fusion is not yet possible in practice. Fusion is only a theoretician's delight. You can go on producing papers; you can go on having PhD degrees; but in reality, so far we have not successful in producing power using fusion. One day yes, why not? But how far is that day? We really do not know. Now, when we talk of thermal power station, as I said, it is steam based or gas based. And chemical energy is converted to mechanical energy, which in turn is converted to electrical energy.

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Now, this figure, which is in front of you, is a schematic diagram of a coal fired steam plant; that means we use coal as a fuel. Coal has got to be pulverized first, so there is a pulverized mill. What is the meaning of pulverization? You make coal, convert coal into very fine particles. Why? Those of you have done mechanical engineering courses, perhaps all of you have done; you know that, the if it is further, you know fine, the value is better utilized, and you get better heat out of it. So, coal gets entry from here, in fact coal handling plant and ash handling plant, you might have studied in your power station practice course, where the best book is by McGraw-Hill; there are Indian books as well. Now, this coal when gets burned, there is a burner here; people have done PhDs on design of the burner in centre for major studies.

So, how to design burner, itself is a R&D topic. Now, of course we are not going to do that here, being in Master's course. Now this burner, we get a pre-heated here to help better combustion, better heat value, and then this is a boiler; and the water which comes here goes as a steam. Now, what particular pressure and temperature you want of steam? That is up to a designer and a planner. Super heated steam is always better, but at a cost. Everything that you want, you have to pay for it. Now, this steam passes through a turbine; I am sure you must have read about these turbines in your mechanical engineering course.

Now, this turbine converts the energy, which is coming in the form of a steam; and it becomes a prime over, and it runs your generator; this is a generator here. Now, what is this stack in-between? This stack is a particular device, which facilitates the the what you called the gaseous pollutants to go out, and disperse in the environment, in the atmosphere. I am sure all of you can immediately appreciate, higher the height of this stack or chimney as you call it, better it is. Why? You will get a wider area, so that it can dissipate over a larger and wider area.

So, whatever are the bad effects, ill effects of these gaseous pollutants, they are so diluted that nobody gets adversely affected to a larger extent. I will not say there will be no effect; there will always be an effect, but let that be minimum; there is some permissible value. Before we talk more about these gaseous pollutants, let me tell you about solid pollutants. What is the solid pollutant in the thermal power station? Ash. Why do you have ash? If you burn anything, naturally you are bound to get ash. Now unfortunately, the coal, Indian coal quality is not good, the ash content is 40 percent. Now, when you have a 40 percent ash, naturally you can well imagine, it will be deposited there. How do you collect it? By electro static precipitator; in some of the courses, they will definitely talk in detail about electro static precipitators. Again in PhD this is going on is this topic, Prof. Avinash Chandra must be teaching you, in whatever course he teaches, about electro static precipitators.

If you want to have an actual look at electro static precipitator, please go to Bhagalpur power station. Arrange a visit there, and see for yourself, how electro static precipitator works, and how it collects ash? Having collected ash, what do you want to do? You will dispose it. Where do you dispose it? So far, for most of the power plants, the ash is to be thrown in a nearby river, because you need water near every thermal power station. You be it , be it , you have Jamuna close by.

Now, this is of no good; throwing your dirty things in your backyard is no good, but it has been going on, and that is why the rivers have become polluted. So now, it is no longer permitted; and in fact, you utilize ash for something good. What is that? It is waste management. You use it for road filling, and land filling; you must have read, or seen on TV that Bombay city has some 3000 odd set of . Remember it is the financial capital of the country. All these things can be filled with these ashes, you can form

briskets, you can do so many things using ash. So, ash handling and utilization of ash itself, has become a very important project in our country, machine project.

Now, we come back to gaseous pollutants. What are gaseous pollutants that you have? All of you know chemistry so well; carbon, when it burns, anything that burns gets oxidized that is what we have taught in our first course in chemistry. Now, carbon when combining with oxygen becomes CO if the combustion is not perfect. If combustion is complete, it becomes CO₂. Well, nitrous oxide, when oxygen is already used in combustion, what is left is nitrogen. So, when nitrogen also combines with oxygen, it becomes NO_x - oxides of nitrogen. Then sulphur, luckily in Indian coal, sulphur content is low. Only in Assam coal, there is a bit of sulphur. But there are other countries in the world, where there is high sulphur content in coal, in that case SO₂, is also formed.

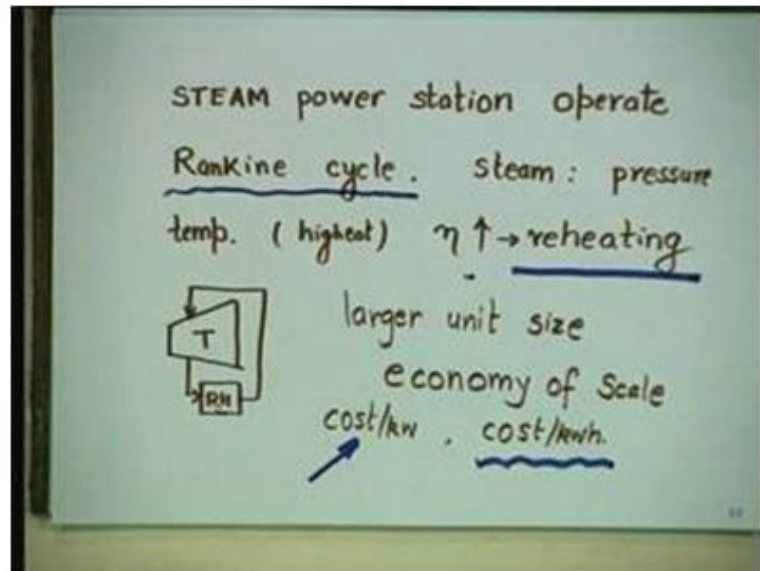
Now, all these gases, when they come out of the chimney or stack, they not only affect human health, but affect vegetation, affect buildings, and the story does not stop here; they have friendship with water vapor, which is always present in air. I am sure you must have done that experiment in physics, where a glass of water in outside you, find the drops of water, because that proves that the air has water vapor. So, when you combine with a water vapor in the atmosphere, acid is formed; sulphuric acid, nitric acid, or any acid is bad. And if it is formed in the large quantities, it starts coming back to the earth, and that is called 'acid rain'; you must have heard about acid rain; and this acid rain is very predominant in the western world, while India is no exception.

So, how to avoid it? For that, the US has passed 'clean air act' in 1970. We also passed that we have no problem in passing an act in Parliament; we have a democratic system, we have a parliament, and late Rajeev Gandhi, the Prime Minister of India, in 1986; you also passed a similar act called the 'clean air act'. Now, main problem in our country is not passing an act, but getting it implemented and that is the real part in it. So, again the US is revised its acts in early 90s. So, we also revised our act in the late 90s. If you really strictly adhere and follow this act, I am sure the pollution will be minimized by a large extent.

After this turbine, the steam passes through the cooling tower, you can get condensed; again water is fed back to the boiler by boiler feed pump. This precipitator is also showed here, which collects the dirt, the dust. Now, this steam runs, it is prime over, it

runs your generator, and power is generated. This is a circuit breaker, then there is a transformer, it steps up, and it goes to the transmission system, which at the moment is 400 kv, as I told you in our country.

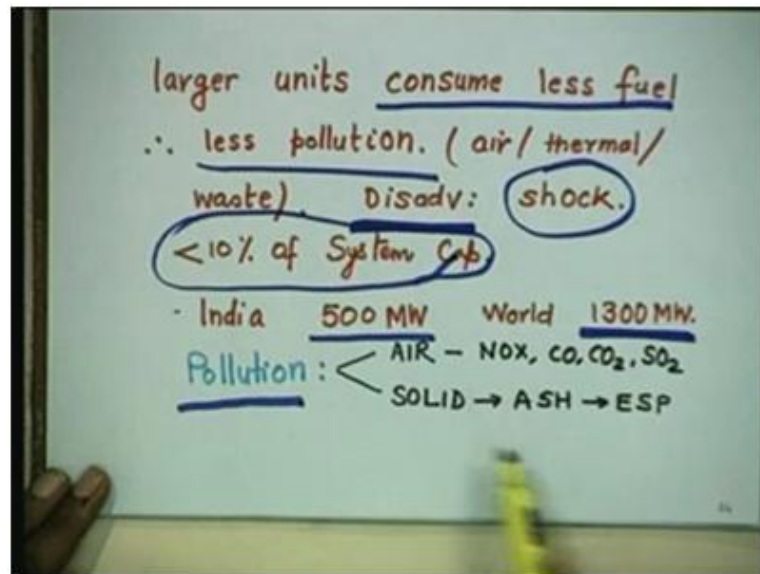
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So, this is in the brief, the story of how power is generated by coal, oil, and gas in a thermal power plant, or it is also called as 'steam power plant' because, you are generating steam. It operates at the Rankine cycle; I already talked about this; and Rankine cycle is a low efficiency cycle, which you must have learnt about in your mechanical engineering. Higher the steam temperature, higher the pressure, more the efficiency; and if you want to still increase the efficiency, instead of non-reheat turbine, use re-heat turbine. What is a re-heat turbine? Take out the steam from middle portion; have you reheated, bring it back again; of course, there is a cost. No advantage can be gained without payment, so cost of reheated, cost of the pipes, and it will increase the efficiency further.

Larger of the size of the unit, the better it is. Why? That is called 'economy of scale'. As I told you earlier, rather having 240 watt bulbs, it is better to have 100 watt bulb. It is cheaper, and it gives you more or less the same luminous. Cost per kilo watt decreases, if you move from 100 mega watt unit to 500 mega watt units. Similarly, cost per kilo volt hour also gets reduced, when you go from 100 mega watt to 500 mega watt units. And that is why in the whole world, the practice is to go for higher size units, larger size units.

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They also consume less fuel, the additional advantage. It is a fuel efficient. Once it consumes less fuel, the automatic advantage is less pollution, because, if you do not burn fuel, where is the question of pollution. By pollution, I mean all sorts of pollution air, thermal, waste. There cannot be anything in the world, which has only advantages, nothing, no so far nothing. So, what is the disadvantage in having large size units? As it is, we are having shortage of power all the time, everywhere; there was a time when Kerala used to be power surplus state. Now, there is no state practically in India, which is having extra power; that is one reason, why are we not going to go for national grid.

Barring north-east region, which I told you is having extra power; because if all are beggars, who is going to help whom? So, the grid has no advantage, because nowhere, if there is no surplus power and so who is going to help whom? Because everybody is in need of power. However, we definitely going to have a national grid one day, because there are certain hours in night, where definitely we have surplus a power, and if you can persuade, I told you those five golden rules to improve your load factor and diversity factor, where one day, you will be able to use that surplus power.

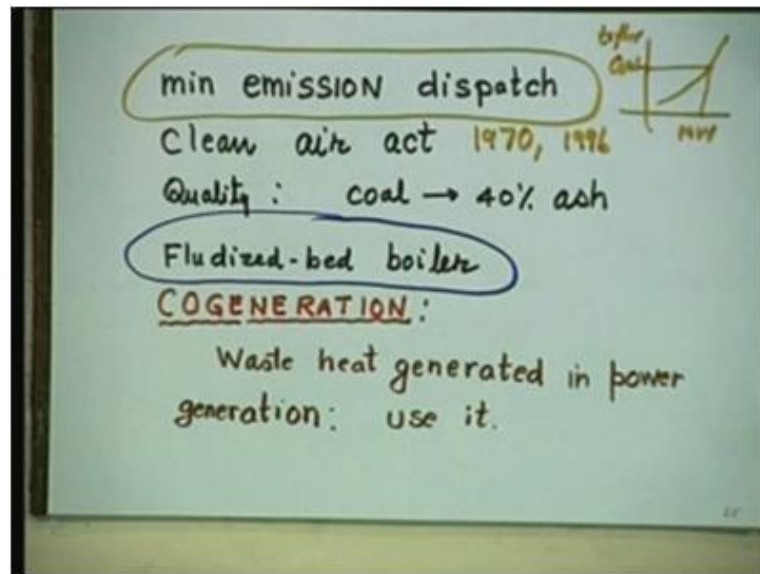
We were talking about this disadvantage of having larger size units, as it is, there are shortages, I told. And if one such 500 mega watt unit goes, goes means faulted and stops working, it is a big shock to the system. Suddenly 500 mega watt is not available; you can well imagine, how many industries will be derailed; how many people will not get

power. And as I said, in US, if Sun Micro system does not get power for one minute, they lose one billion dollars. Here, there is a question of 1 minute; for hours, there are no powers. And you can well imagine, how much loss, national loss, how much contribution towards GDP is withdrawn, the Gross domestic product.

But the golden rule is, it should be less than 10 percent of system capability, system capacity. If the system is of 2000 mega watts, we can afford to lose 1 unit of 200 mega watts. That is the minimum of this rule. You cannot afford to lose 500 mega watt out of 2000. Now, in India, the highest size of unit is 500 mega watt, which is called 'super thermal unit'. The first unit was imported from Germany - Siemens; and soon what is good in India is, we start duplicating, start manufacturing whatever we get from overseas; that capability we have; that may be, that is why we are called second largest scientific and technological man power, after US. In fact, US also, has lot of man power is Indian and Chinese.

Now world, the highest size size unit is 1300 mega watts. Why are we not able to go to there, because of shock one reason, and secondly money; 1 mega watt needs 4 crores, so 1300 mega watts will need what? 52,000 crores; from where, you bring it. Pollution, we have already talked just now, before five minutes; air - NOX, CO, CO₂, SO₂; solid, ash to be electric by electro static precipitator. There is another mechanism or way to reduce air pollution due to thermal power station. We are not talking about air pollution due to vehicles on the road; in fact, that is the culprit number one or villain number one, as far as pollution is concerned. But that is not our problem. There are other people, who take care of vehicular pollution, the CNG, and so on. And with CNG introduction, the pollution seen is definitely looking better.

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We are now, not that much bad as far as pollution is concerned. But let us come back to thermal power station pollution. Minimum Emission Dispatch; what do you understand by minimum emission dispatch? When we do economic operation of power systems, what do we do? We minimize cost versus mega watt. This is the curve, cost curve. And we see that we operate at that mega watt having minimal cost that is called economic dispatch. I talked about it while talking about the low forecasting; we need to look at forecasting for unit commitment as well as economic dispatches.

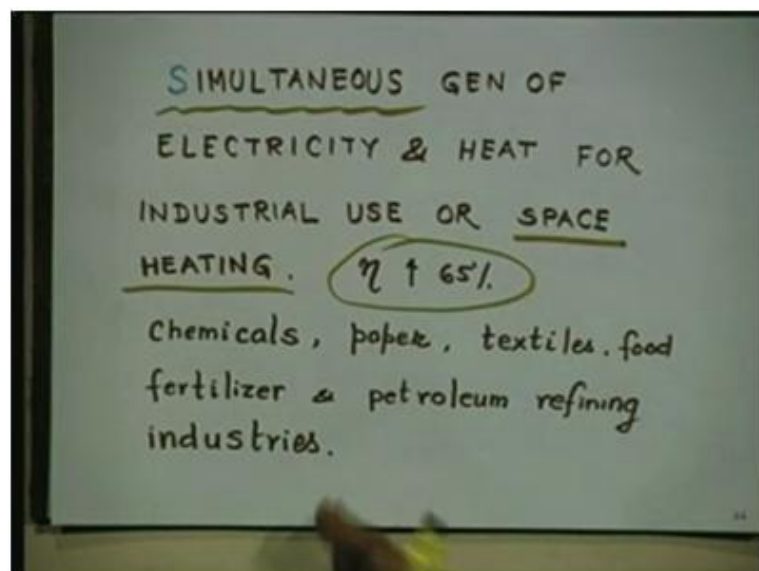
Now, instead of cost, we have tons per hour of NOX, CO, and CO₂. We minimize that, and forget about cost. This operation is called minimum emission dispatch. Clean air act, I already talked 1970 and 90s. Quality - bad, 40 percent ash. There is another important thing, which use, which if used will help us in reducing pollution and that is called Fluidized-bed boiler. Have you heard of it? This is a spatial boiler design; if used, it creates less pollution; of course, you have to pay for it. With this, we finish thermal power plant or steam power plant using coal as fuel, because you do not have oil, we have limited gas.

Co-generation is our next sub topic of today's lecture. What is co-generation? All of you know co-education. Some things two things being generated is called as the co-generation. Now here, the two things involved are steam and the electric power. You may ask me the question in this, hot country what to do with this steam? In cold

countries, France, Europe, part of US, major part of US. They need steam for building heating, commercial buildings, heating of commercial buildings; heating of any apartments, you use steam, steam heating. There is gas heating also, there is electric heating also, whichever is cheaper, people use.

In India, we do not need any heating. The winter is not that severe. If you ignore certain pockets like Kashmir, Sikkim, and hilly areas of UP, now Uttaranchal, or Madhya Pradesh, now there also hardly anybody uses centralized heating. That is a separate thing, if you have a stove or if you have a heater, or you know, that is a separate thing. But we do need steam in industry, if we go to any textile industry, you need steam. And that steam can be generated using co-generation principle, and you save money, and also the efficiency goes up. That is called using the waste heat. As I told you, waste management has become a big topic. So, waste heat generated, which you are otherwise leaving in a cooling pond, or cooling tower, why not use it other for heating buildings, or in whatever parts it is required, like Darjeeling or where ever. Or use it in industries where you need steam.

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Simultaneous generation of electricity and heat is called co-generation. If you generate them separately, that is not co-generation. If I have classes for girls separately, and boys separately, then it is called girls college like we have , , Kamala Nehru, and so on. I do not there is a girls engineering college also in the Delhi now, MIT - Mayila Institute of

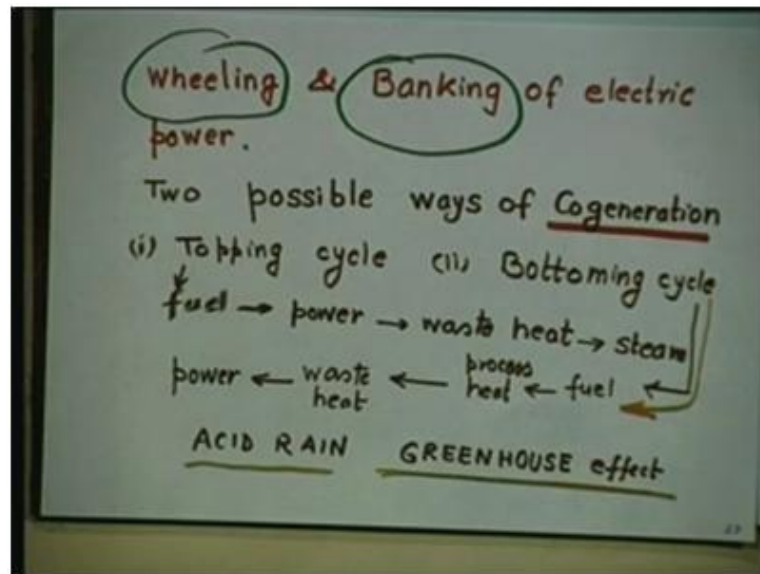
Technology it used to be called, now some Indhra Gandhi Institute of Technology. So, we can always generate power and steam separately, no problem. But if you have a simultaneous generation, then that is co-generation, for industrial use or space heating. We were just talking about space heating.

The efficiency becomes 65 percent; imagine that advantage from 40 percent to 65 percent. Which are the industries, where you need steam? Chemicals, paper, textile, I talked about textiles couple of minutes back, food fertilizer, petroleum refining industries. And if you have a captive power plant, what do you mean by captive power plant? The present energy bill passed in 2003, now allows you to generate your own power. Even IIT Delhi is thinking of generating its own power. We do have, in fact, a standby power. All the now have a standby power.

Now, we want to generate using gas, a 25 mega watt power plant in IIT campus, so that even houses will be supplied by that power plant, and so we need not pay money to DVB, or whatever generation companies, they are Tata, BSNL and so on. It is no longer , no longer DVB; now it is private power plants. When that will happen? I do not know; but there is a plan, there is thinking involved. AIM is going ahead with this plan, and the power line will Indraprastha gas station will gas line will pass through IIT, the Parliament road or outer ring road, as it is called; and we can also tap that gas, and start generating power; it is still in the planning stage. So, that is called 'captive power plant'.

Now you are captive audience, especially in this lecture, nobody can leave; that is captive audience. So, similarly, captive power plant is a power plant, where you are having your own, you are the owner. So, such power plants are needed in all industries. So, why not use the steam, which will also be generated along with power using these industries that is called co-generation.

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Now ladies and gentlemen, co-generation is of two types. Before we talk of those 2 types, let me introduce to you two important words used in power industries, using power systems; wheeling and banking. I am sure banking, all of you know banking. All of you must have opened your bank account after landing in this great campus; may be SBI, or Canara bank, you might have chosen; there is only two, not much of a choice. The two has enough, because someone says privatization only has meaning, if you have competition. If it is monopoly, it is worse than the government. So, we have two banks.

What is wheeling? People do not have much faith in government power. So what have they done? They have started 5, 6 industries together. As I said, it is highly capital intensive industry, the power industry. You need a lot of money. So 4, 5 industries together have combined, and installed a power plant, depending on their combined needs. So now they can withdraw power from that power plant to the need of that particular industry, and they have forgotten about government utility; they said no, thank you very much; we do not need any power.

Hindalco, you must heard have about Hindalco, the Birla factory of aluminum. They have their own power plant; not today, since ages which is self sufficient. That is called 'wheeling of power'. What is 'banking of power'? I have a power plant here, you may have a power plant in Gwalior, but I have an industry in Gwalior. So, I will take the power from you in Gwalior, and I give you power from here. So, it is banking or barter

system, or whatever you call it. It is not quite a barter system, but it is said as banking. Two possible ways of co-generation, I was talking about co-generation; topping cycle and bottoming cycle.

What is topping, and what is bottoming? When your main aim is to generate power, and your secondary, aim is to get steam that is called topping cycle. You have fuel, you use the fuel to generate power, then there is a waste heat, steam, and that steam can be used for any purpose, like space heating, industry and whatever. That is called topping cycle. What is bottoming cycle? Fuel; first aim is process heat; here textile industrialist, so you want steam first, forget about power; power will come later. Then if there is a waste heat, you generate power using that waste heat, whatever power you can get, and that is called bonus- the extra; because otherwise, you would have left this steam in the atmosphere, in the pond, in the cooling tower.

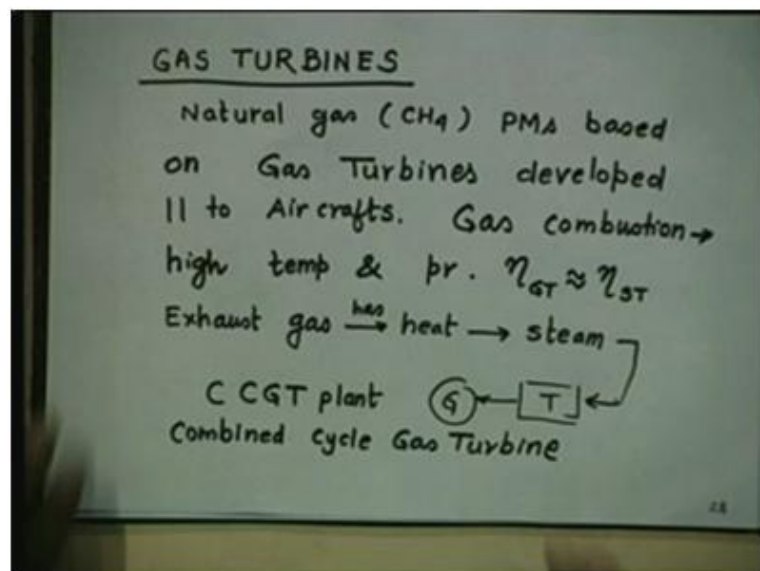
So why not use that to generate as much power as you can? Even in households, your mothers, you must have seen using last night's left over in making a new dish, I will not call it as waste; it is left over. So, you make another dish hot dish on that day. So, you do not have to throw that; everything is costly. As it is, it is considered bad to throw any the food article that is scarce. I already talked about acid rain, and green house effect. Green house effect is raising the temperature of the earth. Earth temperature is going up and up; thanks to all these industries, thanks to power generation, thanks to the so called progress you are making.

You have to have pollution, if you are generating something. A person like me, if I eat something, naturally I am adding calories; why like me? Anyone of you, if you eat anything, you are naturally adding calories. You cannot say, I want to eat, and yet I do not add calories; it is not possible. 0 calories perhaps water is the only thing, which has 0 calories. You may have low calorie diet, you may have a diet coke or something like that, low salts something; but you are definitely going to add salt, if you eat that low salt thing.

Similarly, whenever you generate power, whether it is a clean air act or whether it is a electro static precipitator, whether it is...Whatever equipment we use to minimize pollution. You can minimize; CNGL, we cannot make it dilute to 0 pollution city; it is impossible. When you will start your car, the pollution starts; you cannot say unless and

until, it is battery, I mean the electric car which we have a REVA, which we manufacture in Bangalore; but, how many people use that REVA? We do have electricity run bus from to Redfort; in fact, Prof., of IDDC is working very hard on that bus, which is run by electric power, naturally there is no pollution. But still you cannot say it will be 0, because in manufacturing those batteries, you have already created pollution elsewhere. So, do not think that solar energy has no pollution. Those cells they have not come from heaven, you have generated in Sai Baba, or somewhere like CEL, and in generating them, creating them, manufacturing them, you have already created pollution. Only thing is that you are not creating further pollution.

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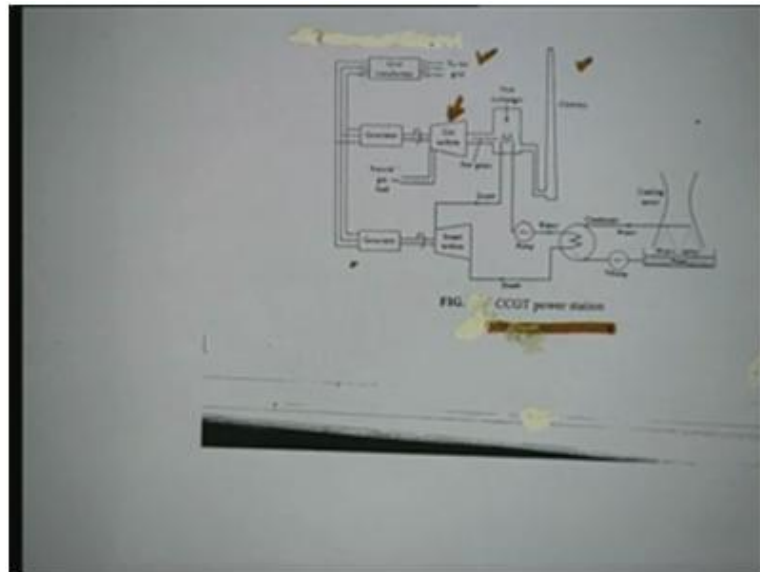


Gas turbines; natural gas, methane CH_4 formulas must be familiar to you, since all of you must have studied chemistry. You cannot come to engineering without studying physics, chemistry and math. The prime overs based... PMs means, not prime minister, it is prime prime overs based on gas turbines developed parallel to aircrafts. Imagine how much power that gas uses, when you use that fuel. Gas combustion, when having a higher temperature and higher pressure, efficiency of gas turbines is roughly same as efficiency of steam turbines.

Exhaust gas has heat, which will produce steam, turbine, and generation. We do have 6 gas turbines of 30 mega watt each in Rajghat power station. I am sure all of you must have heard about Rajghat, where there is a Samadhi of our Mahathma Gandhi, the father

of our nation. Now this is a separate gas turbine. Now, today is the era of hybrid combination, the man wants to achieve many things, which one go, that is why we have a dual degree program. You can have so many programs. You can do, you can get registered for dual degree in some universities in world. Combined... CCGT plant is what? It is Combined Cycle Gas Turbine plant. What is that? Let us see.

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I hope you will be able to see this figure; otherwise, you have to see in the book. This portion is, you know, the gas turbine. This is the generator attached to the gas turbine. This is heat exchanger. The gas runs to the generator, but the waste heat will be utilized here to produce steam, and that steam is taken to the steam turbine. And again we generate power to the generator; both these powers are combined straight to the grid. There is a chimney of course, here. There is water, there is a cooling tower here, there is a pump here, fed back again, the water goes back forms steam, comes back and the steam comes here; again you can use this steam as a co-generation, the third dimension you can add; but I do not want to add, and get it more complicated, because my aim is to explain you combined cycle of gas turbine power station.

Now, we do have 134 mega watt CCGT power station in the indraprastha power station. Again another assignment for you to go, rather than seeing Qutab Minar, Redfort and others, you must see road centre, Bhagalpur power station, in power station, Rajghat power station. This should be your Delhi tour, if you want to get a glimpse, because

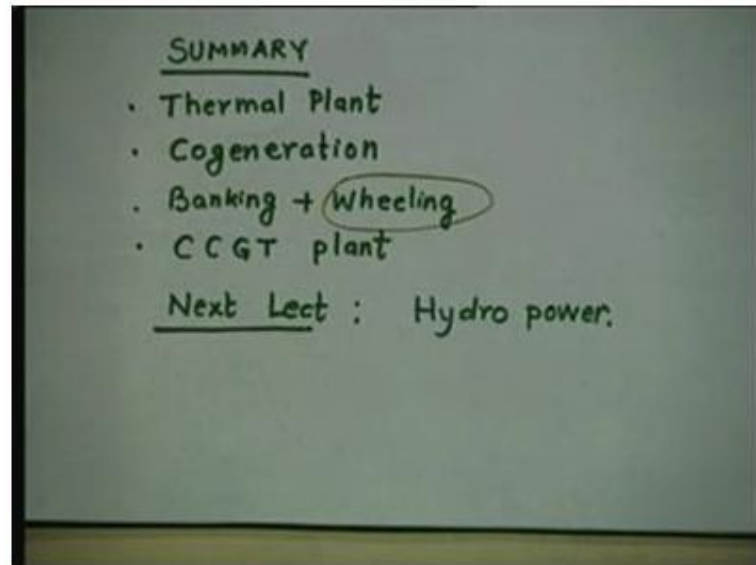
unfortunately, there is nothing called power system laboratory. Thus, the whole world is a power system laboratory. There are generators, there are transmission lines, there are distributions, there are substations; of course, we do have a substation. You can have a look at our ITT substation.

What is the importance of CCGT power plant? It is the fast starting; unlike thermal power plant which takes many hours, 2 to 6 hours to start, because the even if you have put coal, even if you have burned it, it takes times for steam to generate, and come to proper temperature and pressure . The process is like that. If you want to cook the dhal, even in a pressure cooker take a minimum time. There is no magic. Put a dhal, put a water, put a pressure cooker, 1 minute ready; no, not so far. Tomorrow I do not know.

So, certain things take time, and thermal power generation is one of those things. But hydro power is a quick start event. But here we are taking about CCGT. Hydro power is our next topic, on coming Tuesday; 2 to 3 minutes; whereas steam turbines takes 20 minutes, to start working. 10 percent overloads are allowed; and so, if there is a short emergency, not big emergency, then CCGT plant is very helpful. And I told you that you can always start a peaking unit, if you have gone wrong in your forecast. So your forecast is 20 mega watts and you get 25 mega watts, what do you do? You cannot start VVP. What do you do? You ask your load dispatch centre, fellow will ask the Indraprastha power station CCGT plants; hey, immediately start the 34 mega watt plant.

If your diesel is finished, petrol is finished; you have CNG; multi fuel injection nowadays, cars or buses or whatever. I do not know, I remember there is used to be LUNA, long back, which you can cycle, when the petrol is gone, it was so light, you can start cycling and you can reach your destination; may be more time. CO2 generation, ladies and gentlemen, is much lower here 55 percent. So, it is less polluting power plant. Peak demands; whenever there is a peak demand, because it is costlier, and we do not have gas, mind it. We have coal for 200 years as I said, hopefully. In Delhi we have one, this I already mention to you; 34 mega watt power plant.

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What have we done today? So far we have talked about thermal power plants. Please remember, we have 72 percent thermal power generation in this country. So, thermal power plant is very important for us. We have talked about co-generation. Especially in Gujarat, is there anybody from Gujarat? None. Sugarcane industry they generate, they earn more through co-generation, rather than sugarcane because that bagasse can be used for generating power. Banking and wheeling are two very important concepts.

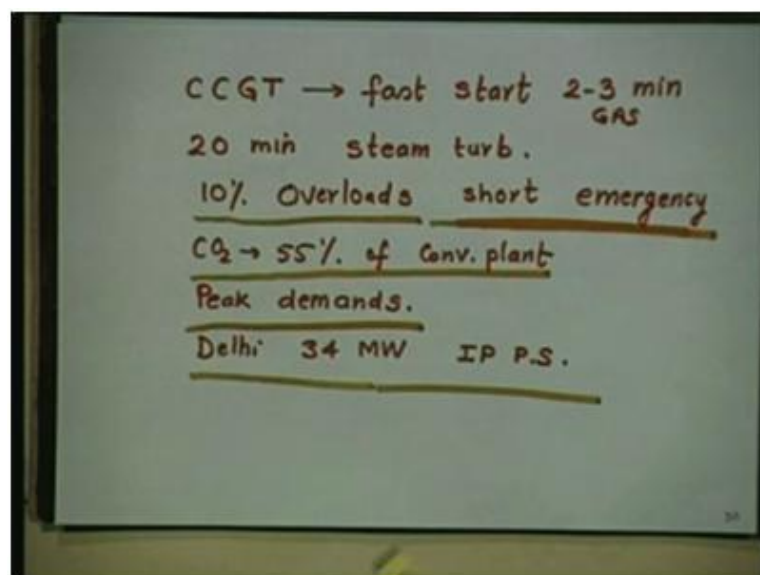
Let me give you another example of wheeling. In one of the Uttaranchal villages, Uttaranchal is the new state carved out of UP; of course, it was a backward area, there were no grid, but human beings were living there, I am talking about, where there are 25 households. Now, those 25 households also want their children to read under the lamp, they also want to watch a cable TV program of their choice, the news or all those serials, or whatever. How to watch that?

So, they got together, they had a meeting, and they said let us start a micro hydro power plant or mini hydro power plant. Why? Naturally water was flowing from a height to the bottom. So, there was a natural head, in civil engineering you must have read about hydro power plant. So, just put a water turbine, purchased from the market, whenever they must have gone to Darjeeling, Lucknow, or Delhi, and they started generating power. They created their own substation, own distribution network each house they took, and minimum requirements, a fan, lamp, tv, and fridge. This is not

that important in that Uttaranchal which is so cold, but if anybody wants to have, why not?

Whatever expenses come, there are hardly any expenses, there is free water of no cost, no coal, no gas, but still, whatever expenses came, they divide at the end of the month equally, because they are given equal connected load to everybody. And they are not dependent on NGO, and not dependent on government, and this story was telecasted on NDTV about a few months back. It is a success story, where they are not dependent on anybody. So, if there is any you know, problem with your hostel or something, if you yourself saw, rather than complaining and associating the warden, housemaster, dean or director, it is always good. So that is a success story of that village let me tell you, they are not literate people; they do not have degrees. They have never seen a university, they have never gone to a college, and yet they had enough IQ to do this.

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We are talked about CCGT plant. Our next lecture on coming Tuesday, same place, same time will be on hydro power. Now any questions please? I told you it is costlier, and we do not have gas as much as we like to have. So, it can be used only sparingly, whenever there is a peaking unit required, whenever there are short emergencies, and it will be again in combination with steam, not alone; so, that workout to be cheaper, because its efficiencies higher, almost the same as the s t, but the pollution level is low. But unfortunately we do not have gas then, even if you have gases, it is not only for power

generation. Same story as coal; coal is still used in some villages as fuel; coal is still required for shuttling services in steam locomotives.

So, there are so many other uses of coal, we have to see; like water, why there is a fight for water? Water is required for irrigation, some for navigation, some for power generation, and some for flood control. So, we do not have enough gas. Availability and cost, these are the two main problems, otherwise you could have many more gas power plants. But, we do have 6 units of 30 mega watt in Rajghat power station. As and when you visit Rajghat, you can have look at it. It is better if you go in a group, as an arranged visit. I think I can arrange in the minibus or something, you can go with your teacher; if nobody is coming I will come with you, there is no problem. Any other questions? To the industry? Well, you had to have a pipe line. Power plant has to be close to the industry, it cannot be far off; otherwise you have to pay for the pipelines, and that is why we are thinking of getting a gas pipeline from Iran, and it comes through Pakistan, it will be cheaper; if it does not come from Pakistan it will be costly; similarly, from Bangladesh side also. Well, this is not the answer your question. The answer to your question is it should be close to the industry. Normally, the owner of the industry also owns this power plant. So, it is free to have the selection of site, which will suit him.

Yes, please

So, I think with this, we finish our today's lecture. And please do solve those problems. See you on Tuesday. Thank you very much.