Power System Generation, Transmission and Distribution
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Lecture No. # 02
Structure of Power Systems

Today in the lecture number 2, we will be primarily on Structure of Power Systems, now all of you, are well aware what is power system. So, we have to slightly see in deeper in about its structure. Before we do that, we left last time about the diversity factor I think we have to come up to day light saving we have talked about it.

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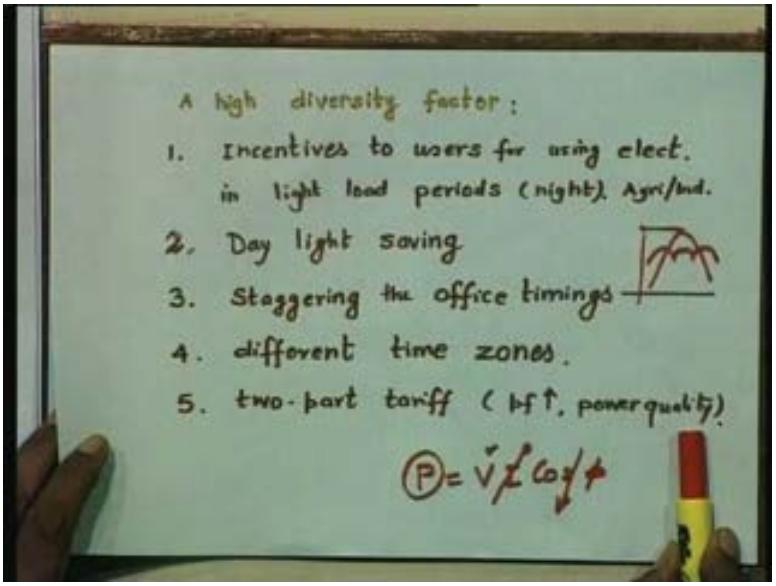

Now, staggering of the office timings, now what is staggering of office timing? Suppose, some offices start 8, some 9, some 10, it does happen in our country all offices do not start at 9'o clock. What is the advantage? The advantage is manifold for example, if you know that your office starts at say 11, why should you take bath at 6 you will I know get up leisurely take bath.

What has bath to do with your energy, because you will start your geyser, so you are using energy at different times; hence diversity factor will be help. Everybody in Delhi is not going to start his geyser or her geyser at a same time. So, as I said for every activity that you do, you need electric energy, preparing breakfast you need you know the toast

or sandwich maker or mixie or microwave or whatever? So, all these activities will take place at different times, because you have to get out of your house at different times.

Incidentally the bonus is ease of transportation system. Imagine, if whole 1 crore leaves their houses at same time, do you have that transportation system in place, the buses, you will not find any space, and there is no railway network as yet. So, it helps to ease the transportation problem at least you will get a space to stand in a bus; or even if you are taking your car out, you know there may not be a jam.

Different time zones, now what do you mean by different time zones? India is the country, where there is only Indian standard time right from Kanyakumari it will Jammu and your Somnath to Assam. But, please understand before partition, even Peshawar time was same as time as Delhi time. Now, Pakistan is half an hour behind and Bangladesh is half an hour ahead I hope all of you know this fact.

So, why not we divide the remaining part of the country what is India today into three parts. Let the western zone we have Pakistan timing, let the eastern zone have the Bangladesh timing, and the central zone today's Indian standard time; you may ask me questions, so what we happen, there may be more confusion, well confusion would not be there, because people will be understand.

Now, the bus is going to Lahore they suddenly adjust their clocks, moment the reach Lahore border. So, you will be adjusting your clock, moment you reach Ambala let us say the Ambala time zone changes. But, what is the advantage? The advantage is instead of having 1 peak, now you will have 3 peaks and smaller ones. So, you need not un necessarily have higher install capacity you can do away with that, you need not add any extra capacity and whatever capacity you have, that can be used more optimally. Because as you all know adding a mega watt needs 4 crores, transmitting that mega watt needs another 4 crores that is today's price. And where are crores in India, we do not we are a poor country we do not have money.

So, in order to avoid that capital investment, which government does not have; because by enlarge, most of the power systems in India is being controlled by government of India, there is hardly any private participation. Though, we desire we hope we request them please come in and invest money. But, you know the Indian power system

privatization started and ended with Enron, Enron he was a sad story like your Devdass. So, people do not want to repeat another Enron.

So, it is a basically the duty of the government to provide you power and they do not have money. So, why not use the existing power system optimally and there, these different time zones will definitely help us. And mind it as I said in the last lecture, all these measures do not need any money, they are free. If you declare tomorrow will timings will change as you pass Ambala or Kanpur, you do not have to pay anything, only thing you have to adjust your watches; as indeed you will go do it when you abroad, when you go to US you adjust your watches to New York time's, Delhi time would not be there.

Then, the last item in this category of high diversity factor is a two part tariff. What is tariff, when you go to hotel you ask what is a tariff what, how much it will cost you if you stay for night. So, similarly, the power you get in your home or industry or a commercial building, you to pay nothing is free. So, there is certain tariff and in India the most popular tariff is two part tariff. And two part tariff means, what? There is a charge for kilowatt there is charge for kilowatt hour as we will see after some time the equation exact equation.

You should have an incentive to have better power factor, why better power factor? If power factor is low, the P is equal VI cosine phi all of you know this equation, now power factor is low voltage being constant, the current will go up to get the same value of P this which mathematics everybody knows.

Current going up is not good, it is bad. Why it is bad? It will have more more losses I square r your conductor will get heat up, your insulation may melt it may fail. So, our aim should be to have as much higher power factor as possible. So, that is a part of power quality I am sure all of you must have learnt a topic called power quality, now it is very important topic in under graduate wherever you have done done your that the degree.

So, if power factor is high we say power quality is good. Another power quality issue is harmonics, which you must have heard about T H D Total you know Harmonic Distortion, which should be less than 5 percent; if you have done power electronics

course or drives course in your under graduate. Then I have two more factors given on this sheet, plant capacity factor, plant use factor.

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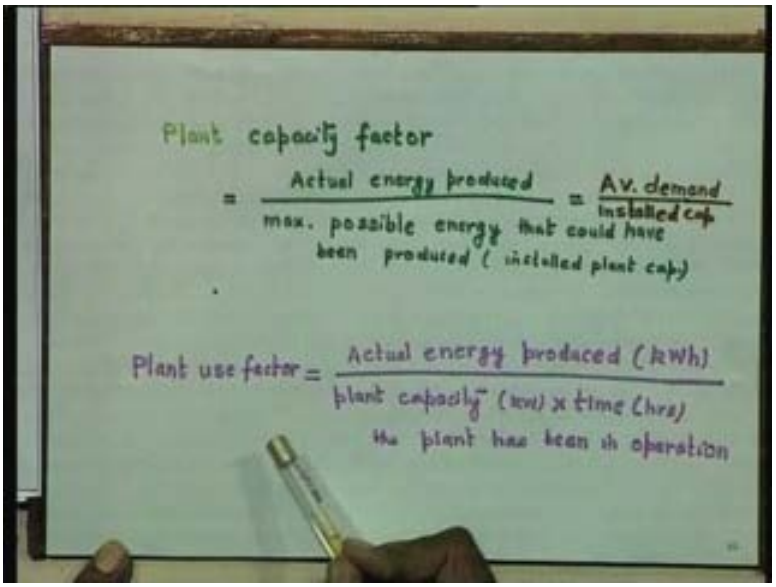

Now, these two factors are equally important as were the earlier two, the load factor and diversity factor. What does the plant capacity factor convey its nothing but, a ratio any factor is got to be a ratio, ratio of actual energy produced upon maximum possible energy that could have been produced. In fact, you also have a study factor, the actual studies carried out by you up on what you could have really done.

So, you should also try to use this factor in order to have better studies schedule or program. This is in short can be written as a average demand up on installed capacity. What is the use, if you have better plant capacity factor that means the existing plant you are using optimally, you are using in a better way. See, you purchase a book 400 rupees and if you do not open it through out the semester, you have wasted your 400 rupees if you get a scholarship; otherwise, you have wasted your 400 rupees of your parents or whose ever is supporting you.

Next is plant use factor, look the difference between the two factors they are not otherwise, I would not have written them twice. Plant use factor is nothing but, actual energy produced kilowatt hour upon plant capacity into time the plant has been in operation. This is a maximum possible energy, here actually what energy you could have generated, if you have used plant capacity. So, indirectly maintenance is involved in it,

indirectly how you are up keeping your power plant is your whole plant capacity available or there is a d rated. What is rated? 100 mega watt unit in never operated in 100 mega watt in India, it is rated to 80 mega watt; like, you people do not do your work to the best of your capability you always do less than that, that is a rating of yourself.

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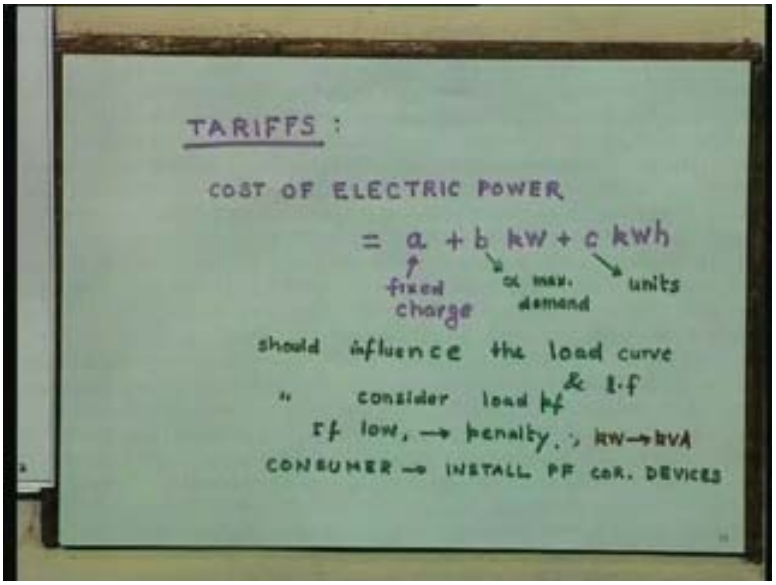

I was just talking about tariffs couple of minutes back the tariffs is back here, cost of electric power nothing is free, there is no free as they say in management. So, if you take a power otherwise it will be called theft, those of the person who use electricity without paying that is nothing but, a power theft.

In fact, in our country, theft is one of the highest 40 percent of the power is you know used are not paid for; and that is why T N D the part of your title of your course is renamed as theft and dacoity, not transmission and distribution, which is very unfortunate. And every person is trying to reduce this theft, power theft.

Now, the cost of electric power is given by a plus b kilowatt plus c kilowatt hour, what are a b c, this three are coefficients all of you have done enough mathematics to understand, what is coefficient; a is constant is a fixed charge like, telephone whether you make a single call or not, you have to pay that 250 rupees rent. And that is why people are going more and more for mobile phone, because there is no rent there, if it is a prepaid, they already cut whatever they want to cut. Plus b time's kilowatt, b is proportional to maximum demand, as c is the units actually consumed.

So, all of you must be paying electricity bill or your parents must be paying electricity bill at home. So, that bill will give you one is a fixed charge then depending on what is your connected load in your house; when you get connection, you have to declare what is your connected load, and then the actual energy consumed, which energy meter shows. Unfortunately in this country, all auto taxi meters are fast all energy meters are slow.

In fact, some of the energy meters run in opposite direction in night. So, that by the time morning is there, you are back to the starting point. Now, this should influence the load curve and load factor. Now, if load factor is low, there should be penalty on the consumer. How do you…? By replacing kilowatt to K V A; what is k v a kilowatt into cosine 5 power factor. So, rather having a kilowatt, let us have k v a and then, the consumer will be careful in having a better power, you will be forced to have a better power factor.

So, he has to install power factor corrective devises, this is what people do in energy audit, I am sure you must be doing that energy audit course. Have you are you doing there, evening people have a compulsory 1 unit energy audit course; and I request you to go and sit there. Because, there are some courses which are not there for the morning students which is bad?

So, you can go and nobody will say no, everybody is welcome please do that energy audit course. What is energy audit, you have to go and see in any any premises whether it is a factory, whether it is a building, whether it is a restaurant; how the energy is being consumed, in what energy is being consumed; is it being consumed rightly, is the bulb not required 100 watt in 50 watt will do, is it being even the house keeping measles to improve.

Then you know the energy c is to keep your things clean you do not have to wait for Diwali to clean your bulb. It can be cleaned regularly and will find the difference the lumens coming out will be much more than normally you get. So, this is what we do. You have to see the why voltage is coming down, why not we have a voltage stabilizer, the power factor.

How do you improve power factor, just by putting capacitances in shunt with load, the power factor will be go up. No doubt, there is a cost further capacity, there is a price to pay, but it is worth; because there is a something called payback period, you invest 10

rupees and that 10 rupees you will realized back in no time; and the payback period will be few days or months or at the most a year, it is worth. Other things are S V S etcetera Static Var System. fax I do not know how many of you know FACTS Flexible AC Transmission System. So, all these things are come here to have three in one.

They not only improve power factor, they improve efficiency and they improve the voltage control, voltage stability is you know achieved. What is the optimization problem here, what is problem here, what is the problem here, compensation how much where when, if you answer these three that is your R and D topic.

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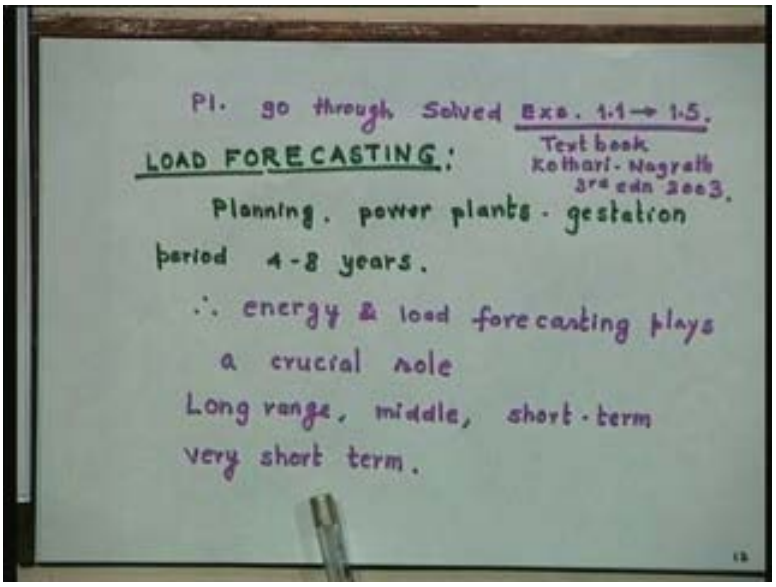

Now, there are five examples solved in the book 1.1 to 1.5, please go through these five examples. If you have any difficulty in understanding them, if necessary we will have a separate class for this, if not, because they are solved. you should how do you read a solved example, how do you solve a solved example, that is also an art; do not read it like a novel or a magazine, read the problem close the book try to solve it yourself, because we have already covered a theory.

The beauty is why do you why should you solve the solved this problems, you know exactly where you have gone wrong; in an unsolved problem, you would not be able to know where you have gone wrong, only thing you come to know is the answer is wrong. But, why answer is wrong it is not so easy to find out, you have to consult your colleague

who should be solving it independently. And if you do that same mistake, again there is a problem you never come to know where you have gone wrong.

So, the solved examples of very important, please go through them solve them yourself independently; and let me know whether you you have solved them or was the is there any difficulty you please let me know. What is load forecasting, it is a very important topic today. You must be seeing weather forecast every day whatever channel you may tune for I do not whether present day students at all see anything other than m TV and v TV. But, if you care to see any news channel, then there will be a weather forecast, even Doordarshan also shows 4 megacity temperatures, now a day they have started giving other city temperatures also.

Now, any planning will need this load forecast, you are planning a power system for 15 years hence, for the India of 2020 what should we know? We should know several factors, what we will be the population, what what will be the industrial scene, how much agriculture will be there, how much houses will use electricity.

Today only 85 percent villagers have been 15 percent are not. And these 15 percent are places in accessible places hilly areas, there is no grid there. So, are we able to take grid up to that point or not, we have to plan all these things. Power plants, once you know the load, then only you will go for power plant. How what do you do when you go for a market; suppose, your mother or father tells I will get you a shirt then you decide in your mind up to 500 rupees, then they take 1000 rupees in the packet and go. Of course now a days, there are debit card and credit card that is a separate story. So, you have to plan what you want to spend, before going to the market.

So, you are planning every time every day, right from getting up in the morning to sleepy. In fact, when you sleep, you must ask question to yourself, how was the day, was it past meaningfully or you have just wasted it. So, that next day should not be this same, that should be the you know aim of life.

So, once you know the load coming in 2020, then you can prepare for that load by planning power plants, because load is increasing exponentially, population is increasing exponentially in India. So, why should you have to plan power plant, there is something called gestation period. What is the gestation period? The total period required before a project is completed; where M Tech course gestation period is 2 years, Ph D gestation

period is normally 3 to 4 years, it all depends on you. Even in M Tech, your thesis is not complete it goes beyond 2 years.

So, a thermal power plant need 4 to 8 years, a hydro plant in India needs 10 years, a nuclear power plant needs 4 to 5 years. So, before you want to have a power plant, you have to start working finding capital looking for a fuel whether you have that much coal with you or water with you; building a dam, you must plan in advance, for that you need to know load, whether load is going to come or not, how do you know.

Energy and load forecasting plays a very crucial role. If your 5 years plans which the country makes a big role is played by this, the load forecasting and energy. Because, whatever you do, you need energy; all this computers will stop, if you do not have how much UPS you will use, and how long you will use. Even, this inverter so inverters which you use in houses, they cannot give you power for 12 hours, 18 hours, 24 hours, so they are only for short time.

How how many you know zones are there for planning? There is a long range, middle range, short term, very short term. And now like you must be planning for very short term, next 1 hour what you do after the class is over, then you plan for middle term the whole week, then you plan for again for the rest of the year, and then rest of the carrier very long term.

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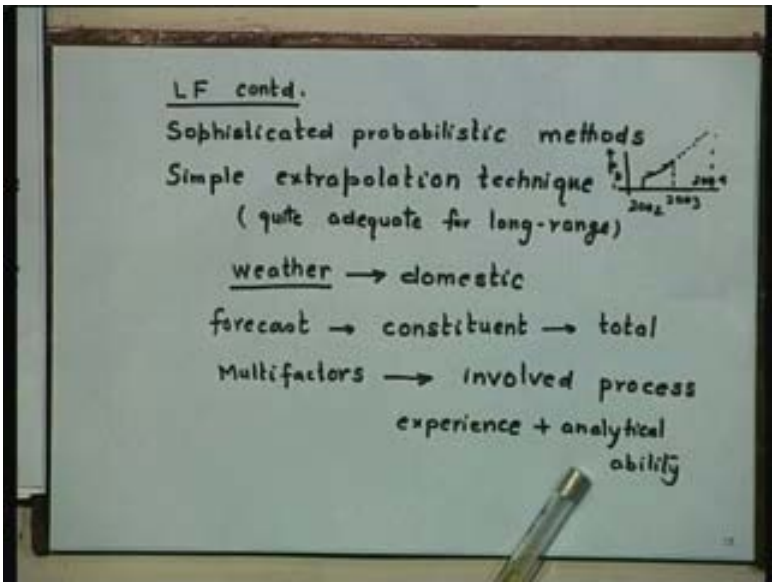

There are sophisticated probabilistic methods given in the literature. In fact, there are books written just on load forecasting and if you have time if you are free, you can go through the books, there are references given at the end of each chapter in the book; I do not know how much time you have, that you have to plan again.

Simple extrapolation technique is good enough for long range planning. For example, you have data up to 2003 august let us say. Now, if you want a data for 2004, what you do? Collect the data for 20 years plot a curve I am sure you must have read curve fitting techniques in your numerical analysis course; if you have not done the numerical analysis course, you can always read a by book by Hildebrand , , and so on, there are so many numerical analysis books.

Extrapolation technique is very easy you must be doing extrapolation when you have done your labs in your under graduate, open circuit test, short circuit test; especially if it is a straight line like short circuit test, you take three points and then you join in straight and that is extrapolation.

Weather normally affects a domestic load, and industrial load would not be affected that much by weather, whether it is running out side, whether there is a storm or snow storm; inside, if you are running a lath, lath is a being run. But, domestic load gets affected as it is small load of course, sigma is big, but individual house is a small load 3 kilowatt, 5 kilowatt depending on how rich you are, how many A C's you have fitted in your rooms.

So, the weather forecast is very important and the domestic load is sensitive to that. I am sure, you must have done sensitivity studies in so many courses in your curricular, how much sensitive, some people are more sensitive than others you know. So, why not forecast load in a constituent form totality; and then add it, forecast domestic load, forecast agriculture load, forecast commercial load, forecast industrial load and add them, that is much easier and much better and more accurate, rather than forecasting the total load in one go.

There are multi factors which affect forecasting. So, it is an involved process, it is not an easy process, there is whole department in planning commission dealing with forecasting. What is important experience, why do they ask for experience for a particular post, 5 years of industrial oblique, teaching oblique, R and D experience? Why why do they ask, because they know the experience person is better than a raw person; if

he is a raw person people will give him job or her job, but at a lower scale, lower grade, lower post, lecturer, assistance professor, associate professor and professor. And analytical ability should also be seen whether we can analyze things or not.

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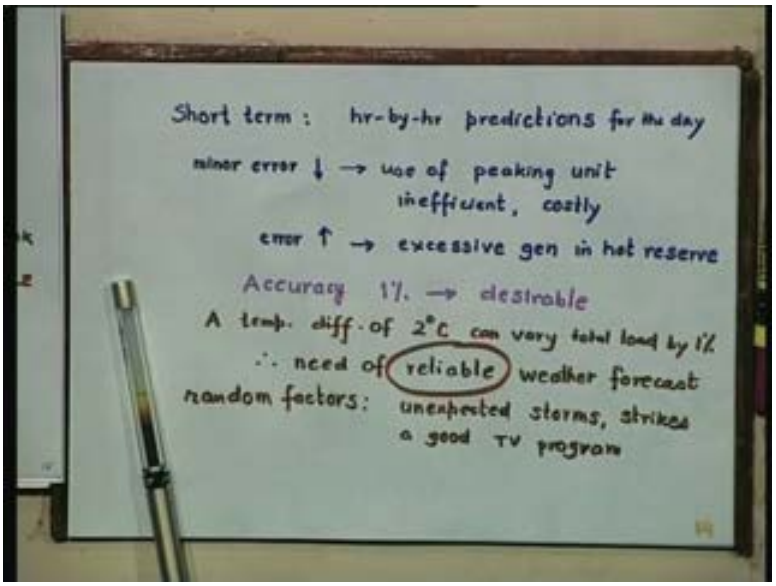

Short term is hour by hour predictions for the day I did mention you about the load dispatch centers in Katwaria Sarai do you remember? And I told you to go to your teacher or M Tech coordinator or head to arrange a visit there for all of you whole class not just this subset, because all of you are studying energy. There, they are doing this hour to hour prediction if it is now 11:31 what will be loaded 12, what will be loaded 1 pm. So, that there is a mid course correction, online monitoring and control, real time monitoring and control.

Every minute you have to monitor this system you know what is ICU, there the monitoring is every in 5 minutes, every 10 minutes that is ICU Intensive Care Unit, you are taking intensive care. If you have a minor error in your forecast, what will happen? You will have to use minor error in negative direction; that means instead of predicting 25 mega watt which is the correct value which will be coming at 12, you have predicted 20 by mistake; or may be a wrong model, may be a wrong input, output depends on input. If you do not work, how do you get a grade.

So, instead of 20 mega watt you have predicted you have got 25 mega watts, what will happen? You have to immediately start peeking unit which are inefficient and costly; all

peeking units are costly, that is why they are called peeking unit, which is not normally used. Wherever you have to go alone for some small job you take a scooter you do not carry your car or take your car, why? Car is costlier maneuver it, you cannot maneuver it on Delhi roads or Indian roads, it is easy to maneuver scooter; if scooter fellow can come right up to the red light, a car cannot do that, standing where he is standing.

So, you have to start inefficient and costly units if you have gone wrong in your forecast. Suppose, you have gone wrong on a higher side, you have predicted 30 mega watts, but actual load which comes is 25 mega watt, then what happens? Unnecessarily, you have planned for 30 mega watt excessive generation in hot reserve which you do not need. It is like that, you need 5 rupees and you are taken 500 rupee note in the market, why it may be pocketing; you may get or tempted to purchase something which you are not originally planned. But, you have taken 10 rupees and no card with you, you will come back you will not purchase that extra shirt, if you go to plaza or wherever.

So, accuracy of 1 percent is desirable. A temperature difference of 2 degree centigrade can vary total load by 1 percent, how? This point needs bit elaboration, suppose the weather forecast tomorrow 6th of August tomorrow, you say it will be 28 degree centigrade or let us say, 30 degree centigrade, though it is going to be 28 actual, but you have predicted 30. Now, 30 degree centigrade people start using fans. So, then you have calculated the how many fans will be use in Delhi, how many coolers will be used in Delhi, how many A C's will be started. But, if the temperature is 28 only which is quite ok, you at least do not need A C, you at least do not need cooler, may be fan with if it is free, office if somebody else is paying.

So, you know number let the fan be on, how does it matters, somebody else is paying. But, if it is 15 degree even if somebody has his paying, he would not keep your fan on. So, a difference of 2 degree centigrade can matter a lot at in such situation, where it can make lot of difference in making a decision whether the fan should be on or off. Look at the load how much change will be there in load forecast, just because your temperature, there was the error of 2 degree centigrade; think of the reverse, you plan for 30 degree it became 32 or 35; practically even will start his fan 35 degree centigrade, so again you have gone wrong.

So, a temperature difference of 2 degree centigrade can vary total load a 1 percent, so there is a need of reliable weather forecast; you cannot do a second job second grade job, you have to do a first grade job in exactly predicting of course with in that error of 1 percent. But, what is the problem, you are not a god after all you are a human being, even your software you are developed, it was also developed by human being, they are not been send by heaven hey take this software it will work, it may not work.

What are the random factors which affect your performance? Un expected storm otherwise, why anybody should die, if you can predict accurately that tomorrow there will be a railway accident nobody will go in that train. If you can predict there will be highjack of this plane do you think even the will go, everybody will apply for a casual leave or sudden sickness leave; unfortunately we do not know in advance many things in life.

If all those people who got divorce, do you think they were knowing when they got married, will be divorce otherwise, they would not have married. So, that is the life name of uncertainty. And hence, strikes you know the just few days back, British airways had a lighting strike on Heathrow airport thousands of passengers were they had to sleep on the floor, they were not having any dollars in their pockets; because, they were going to their near and dear ones in U S thinking that they will take care, they have purchased ticket anyway and the air gives you free food, free drinks, everything free. So, they are not prepared for this eventuality that there will be a sudden strike by British airways personnel and so all flights will be cancelled. It took them 24 to 48 hours to put them into alternative flights, because alternative flights are not really available, there are already booked.

A good TV program you are not planned for it, the talks are going on for live telecast you are not sure whether tomorrow the world cup or whatever foot ball, cricket will be telecast or not; there is bit of controversy on sponsorship or whatever you know the controversy of last world cup and suddenly they say, there is a telecast available.

So, everybody's is to his TV set. And who will plan for such so many TV set's on, you are not planned for it, so there will be problem. Same thing happened in 1982 when Prince Charles marriage with lady Diana who is no more was telecast throughout the world; and imagine how much power they must have planned extra power.

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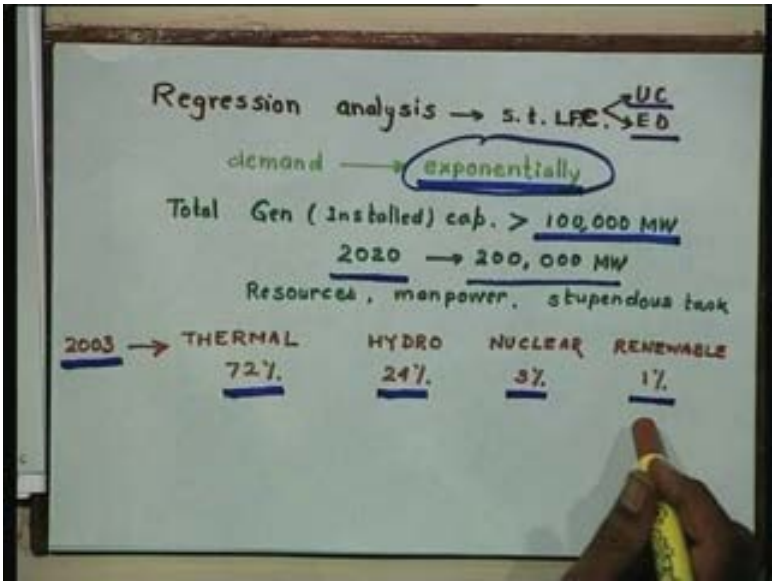

Regression analysis is another technique by which you can have a short term load forecast, why do you want short term load forecasting? There are problems called unit commitment and economic dispatch; I do know how many of you know what is unit commitment will be doing it in a next course in energy called power system planning ES 8 6 0, if I take or anybody takes he or she will be teaching UC and ED.

Unit commitment is which unit should be on or off, when a particular load comes tomorrow, some of you might have studied in you under graduate. It is given in our book in chapter 7 in case, those of you are not studied they can go through that chapter. Economic dispatch is how much units will share the load? So, that the total cost is minimum; say, 100 mega watt load is coming, should it be 50 50, 70 30, 80 20, 10 90, 0 100, 100 0 these are various possible combinations.

ED software will tell you how much each units should carry, how much units will be on or off; UC having made them on, how how they should share the load belongs to problem of ED. Now, both this problem need load, if load is not there; so, if bride and bride groom are not there, no marriage. So, if load is not there, no power system. So, you have to forecast the load.

So, that you can find out the solution to any power system problem, whether it is a faults studies, stability studies, security studies, reliability studies, economic dispatch, load flow, unit commitment name a problem; every problem need a input called load if load is

not there. Any job you go you ask sir what package will be there, how much I will get; when when they will say any question stand up and lady sir how much will be my package how much I will get can you not give me one more increment something like that.

Demand is increasing exponentially I have repeating this, this is the main problem. Total generation installed capacity today in the country has crossed 100,000 mega watt in 2000 ; the 100 th 100 100 crore baby was also born in 2000 in the hospital. And 101 this what you call as 100,000 mega watt 1 lakh we say, lakh and crores in outside world, they recognize only thousands, millions, billions, trillions.

You know when we started our journey what was our installed capacity in 47 when India got free India became free India got freedom just 1360 mega watt, 1360 mega watt; imagine from Peshawar to and Srinagar to Kanyakumari big country, 33 crore was the population one-third of today's population. The the installed capacity was just 1360 mega watt, I remember in my town we have all use to study using kerosene lamp, candles and so on, used to study use no electricity.

He is very prosperous person, he is a very wealthy person. What use to be for TV in 70's, people use to come to your house; can I come and have a Chitra? Sure, please come. So, he is to be very grateful to him, when used to give you opportunity to watch it, may be you are not born in 70's. Same thing happened to cable in 80's. Now, cable is there in every house hold, even, this is how things change time change.

Today, 1360 mega watt has become more than a lakh; yet, there are shortages, why? It is a story of a person who wanted to purchase ambassador in 1960, when ambassador is to cost 20,000 he was having only 15000, today it is 3 lakh he is still having only 2 lakh. So, the moral of the story is he could not purchase anything. So, we are improving non installed capacity, yet the total load is going faster and hence, what is happening? Every day we will have blackouts, brownouts, shortages.

In fact, if any day power does not go, we feel miserable something wrong today, why power is not gone, so we will so much use to it. 2020 estimate is this is going to be double that means whatever installed capacity added, from that 1886 to today 2003, same thing you have to add in another 15 years; task, not easy you need man power, you need

money, you need development of infrastructure, it will build dams, you have to build thermal power plants. So, tremendous task, you need resources, you need man power.

Today, 2003 is 100,000 mega watts, thermal is 72 percent. Thermal means oil gas coal largely coal in our country. Hydro is 24 percent, nuclear is 3 percent and then, renewable is 1 percent I hope the total is 100 you can just check. Hydro for the first time as gone below 25 percent, it use to be 50 50 in 60's when I was a student, 50 percent thermal, 50 percent hydro, thanks to buckram. Nehru called them modern temples, d v b eastern India so on, there was several hydro power plants in the country.

The first hydro power plant was build in Darjeeling 1898 followed by river in Bangalore same year, the capacity was 30 30 mega watt lot of water is fallen and . But, why this is going down and down, because of several reasons, 10 years; gestation period I told you, who can plan for 10 years when he do not know whether you are you have a stable government likely this government has been stable, but then how stable how much stable like; not like earlier days government when you have your own 300 MPS, it is totally dependent on so many factors and experiment.

So, where is a time to plan, every day you are answering for something, some issue, some this issue that issue, where are developmental issues. So, there is no money, there is no planning and thirdly, the the reason is equalogical and environmental issues. There are persons called Baba Amte, there all in strike whenever they want to reduce their weight they sit on strikes under strike; and that is why the hydro power plant is going on for last 15 years.

And the Narmada dam height they are not able to decide even after 10 years. What should be the height, do not you think it should have been decided before you start building the dam. It is like a analogy I can give you, you are invited a family for dinner after they arrived you form a committee what should be the menu, should be parota or a rotti or puri, why cannot you form this committee one day in advance in come to some conclusion not after the guests arrived.

So, in Narmada dam height should have been debated in public before you started planning for let or whatever it is well. The nuclear is also not going much ahead, because it is also in the world. Certain countries you cannot even pronounce the nuclear like it is

Germany, if you do that they will put you back in the flight to India, because there are problems I told you the 3 mile island; and what you to do the nuclear etcetera etcetera.

But mind it, there countries called France, Canada. In France, two-third of the power is generated by nuclear, no no 3 mile island; you do not take care you take precautions, people die on roads, have you stop walking on roads; there are car accidents, have you stop using cars; there are plain highjack's, plane crashes, . Do you get ticket for Bombay today in spite of 10 flights a day, no.

So, what you have to do is, you have to take the precautions we have be careful when you operate a nuclear power plant. The the answer is not close nuclear power, if you have a thorium largest deposit as I said 45000 tons, why do not you use it, it is your valuable resource. Renewable of course, the whole course, whole M tech is on renewable, so there are so many and experts in that building block 5 who will be talking in room number 344 on renewable. So, I will not talk much on that.

Structure of power systems we have come which was actually the topic of the day. State electricity board, all of you must be in some state and your state has a realistic board, there is a regional grid, there are 5 regional grids in the country.

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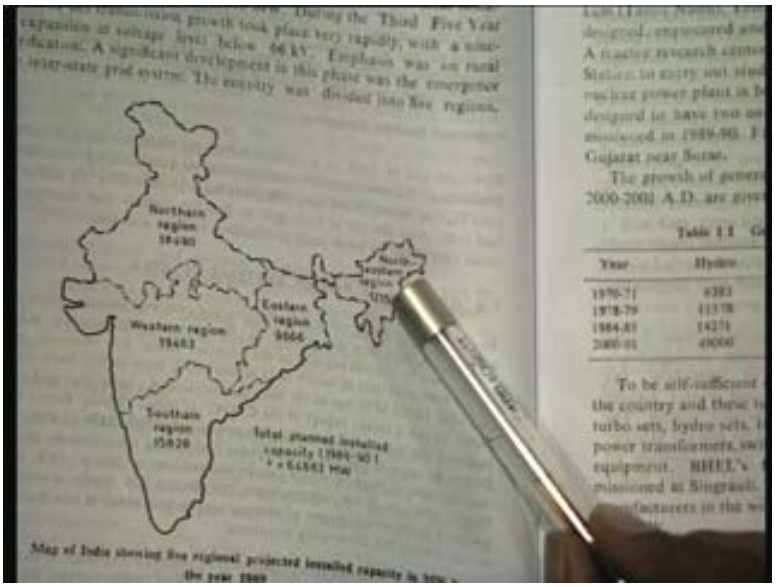

This is the map of our country N R E B, W R E B western zone western region, S R E B Southern Electricity Regional Grid or Board. Eastern region and north east is being

having special importance we have north east those states you know Arunachal Pradesh, Nagaland and so on. Why they are divided their country into 5 regions, so that at least they can be interconnected, and they can come to rescue of each other in case of demand.

So, each state electricity boards are interconnected n fact, this regions are also loosely interconnected. As I told you on very first day, HVDC line is connecting from Assam to South, so this is having a extra power and this extra power can be evacuated using HVDC link to the South. Now, we want to have a national grid. What is national grid, when this 5 regional grids will be strongly interconnected that will be a national grid.

Since 80 we are hearing that national grid will be soon in place, how soon it will be there I am not able to tell you, but one day yes and on that day, theoretically we should be able to transmit power from lake to Kanyakumari or to Assam Guwahati. In fact, we to have a grid, I am sure you know what is , our neighboring countries Bhutan, Nepal, Pakistan, Srilanka, Bangladesh; we have a connection Bangladesh, Pakistan was about to give us 2000 mega watt and the kargil happened, so we never got that. Nepal we do have some power plants build by us, and in return they do give us power. So, we do have a grid.

Whole of Europe is the international grid, the countries are like our like our states in fact, the Europe has really become 1 when the currency is 1, the parliament is 1, everything is 1; be our countries, south East Asia.

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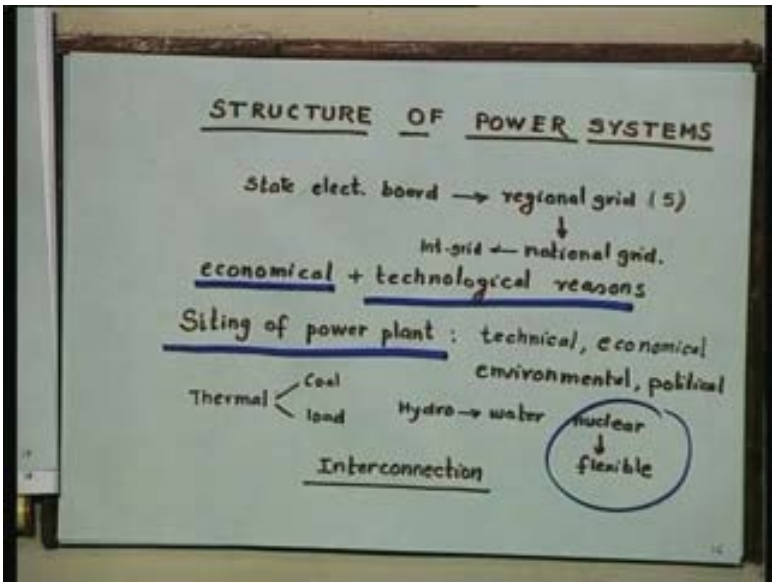

International grid, national grid, why should we have a grid, it is economical. If two of you purchase a book well, unless until tomorrow is and then there is a fight who should read first, unless until there are more than one books, but it is economical; or you have a common car 4 of you can go together. Technological reasons, it helps you; siting of a power plant is very important, there are technical, economical, environmental, and political factors, what is technical.

You should have a coal available there you should have water available there. The siting is more flexible for nuclear, because of fuel required is very little few kilo grams you can carry in your bag; not so coal, coal you have to transmit in . Power, the hydro is least flexible site selection, it will go where the water is, you to build dam there only. I already explained you thermal coal based and load based; interconnection, all these power system is interconnected, because you can get power from area to area, area to area depending on the time.

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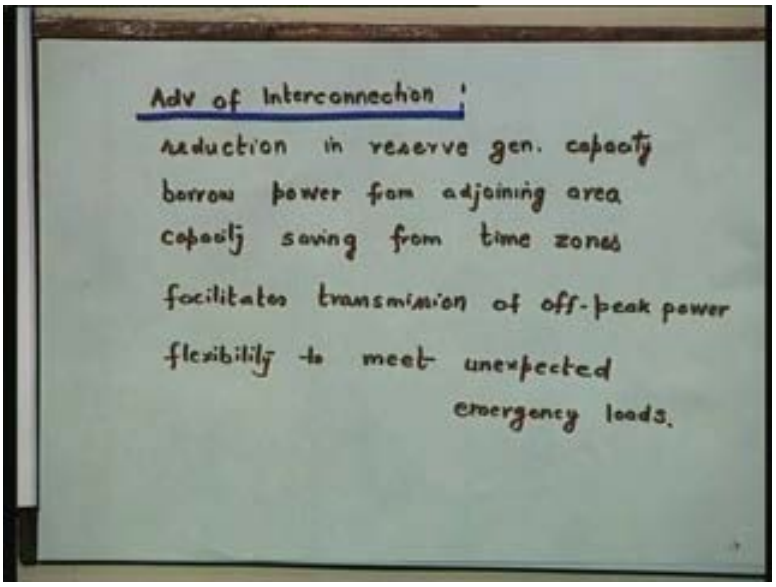

What are the advantages of interconnection? You are just talking about that, reduction in reserved generating capacity; each system did not have a reserve, because there is a common reserve, so you are saving money. Why, we go for the company goes for the same cars, Ford Hyundai or Ford Maruti. So, that you can keep common reserves, the minimum reserves or spare parts whatever you want to call it.

Borrow power from adjoining area. Capacity saving from time zones, time zone is not same in one region. So, as I explained you that, peak will come a different time; in north in winter all employees you know eat their lunch hour, lunch hour will be separated now; when it will be 1 clock for him, it will be 12:30 there. So, by the time, his lunch is over he will start. So, time zone will help you in capacity saving.

Facilitates transmission of off-peak power, some where it is off-peak some where it is peak you can transmit power from one end to another. Flexibility to meet unexpected emergency loads; if there is suddenly some load comes up in some region part of the region you can rush the power from another region. So, these are the advantages of having interconnected power systems.

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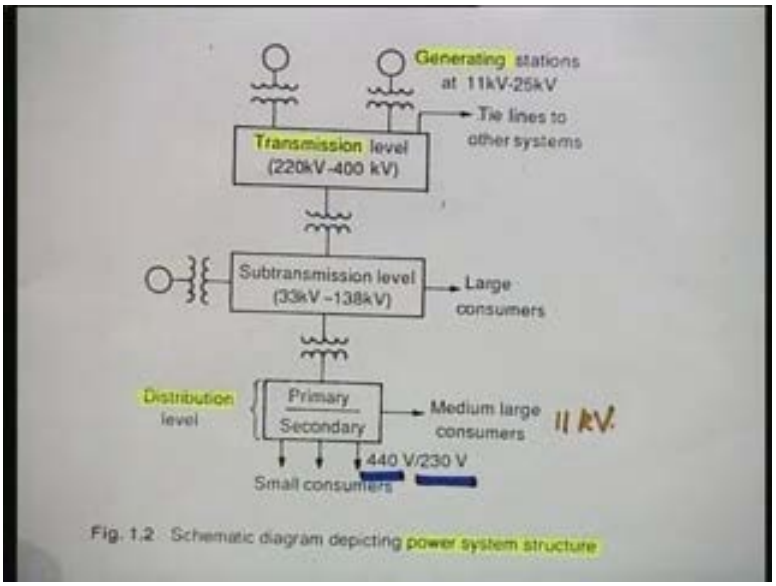

Now, this is the power systems structure, this is generation, this is transmission, this is sub transmission, this is distribution that is the name of our course; generation, transmission and distribution of electric power. Generating stations always generate the voltage 11 kV to 25 kV.

Now, some one of you can ask me question why not generated 400 kV, no need of transmission? We cannot, all of you have studied machines course in under graduate; there is problem of , is a problem of insulation, is a problem of material, you can go at most up to 25 kV. And hence, you need a transformer to step up the voltage, why? The transmission is cheaper at higher voltage.

In the fact, the bulk transmission is possible only when the voltage is higher. Because, it power transmission is proportional to V square. I told you that the other day, e v x into sine delta, delta is fixed 15 to 30 degrees for stability region, excess field fixed, once the transmission line is built and e and v are constant. So, they are equal. Assuming that, voltage drop is not much, voltage regulation is very good.

Higher the voltage, more power you will able to transmit. So, we cannot have transmission at a lower voltage, it has to be higher and higher; you have reached 400 kV level soon we want to be 765 or 800 kV. Then this sub transmission 33 kV 138 kV there are large consumers, you can have a generator here also to have an extra power fed into network, then again there is a transformer step down. Now, it would do not need any more is 400 kv, because we have reached the distribution level, because the action is only at a lower voltage, all loads need lower voltage.

So, the distribution level medium large consumers an 11 kV and a small consumers three phase 440, single phase 230 volts. So, this is the ladies and a gentleman is our class for today. And tomorrow we will continue with the same topic that is the structure and conventional power plants, that is what we are going to do tomorrow.

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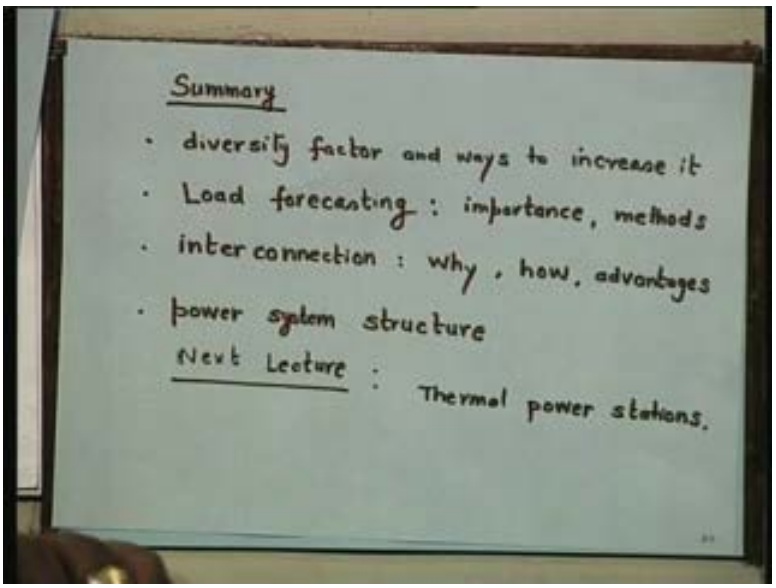

The next lecture is in thermal power stations, we have done diversity factor, load forecasting, interconnection and of course, power system structure. Any questions, any queries no yeah.

Higher the voltage lower the losses, because the current will go down; V I cosine pi as I told you, if V goes up, current comes down. Lower the current squared losses will be lowered, the conductor size will come down, the cost will come down; and there are better compensating devices to control voltage at higher voltage; facts in under graduate. That is right static.

Well HVDC transmission itself is a separate topic a books are written there. And naturally, whatever are there in ac system will be missing in dc system, but do not think it is perfect otherwise the whole ac transmission would have been substituted by dc transmission. There are problems, what are the problems? You need inverter and converter, a rectifier stations that means power electronics; once power electronics comes, harmonics comes of course, they are becoming cheaper and cheaper like your computers.

But, there are other limitations there is a, what distance, there is an ideal distance beyond below which it is not cheaper. In any case, we are going to have few lectures on HVDC transmission, so at that time perhaps you will be able to know more about it, not today. Today is that is this much is enough, but we do have a HVDC and there will be co existence we need ac, as well as HVDC.

And HVDC will continue to be a small percentage of ac, because you cannot just throw like what we did in computer you cannot do in power system, there you can go on 286, 386, 486, Pentium I upgrading; you cannot it is there it is a reality, you have to use it as long as it gives you power. Yeah any other question please, if no thank you very much.