

Power System Generation, Transmission and Distribution

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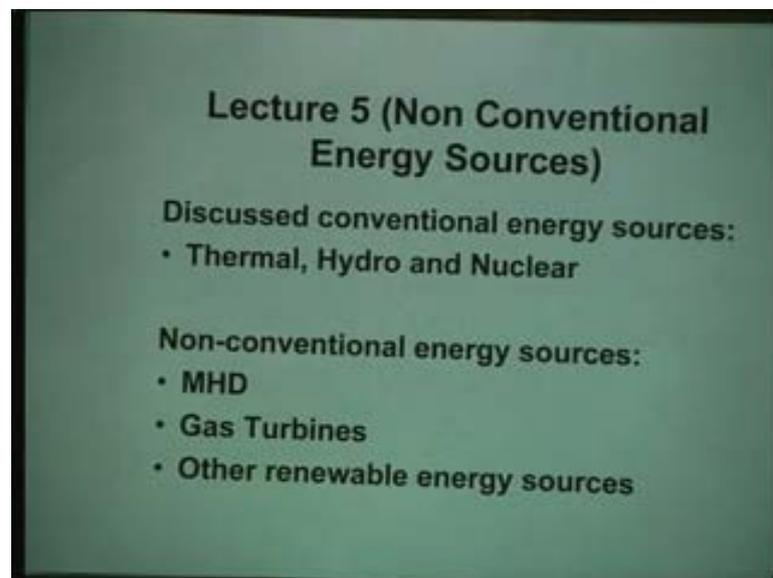
Department of Electrical Engineering

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Lecture No. # 05

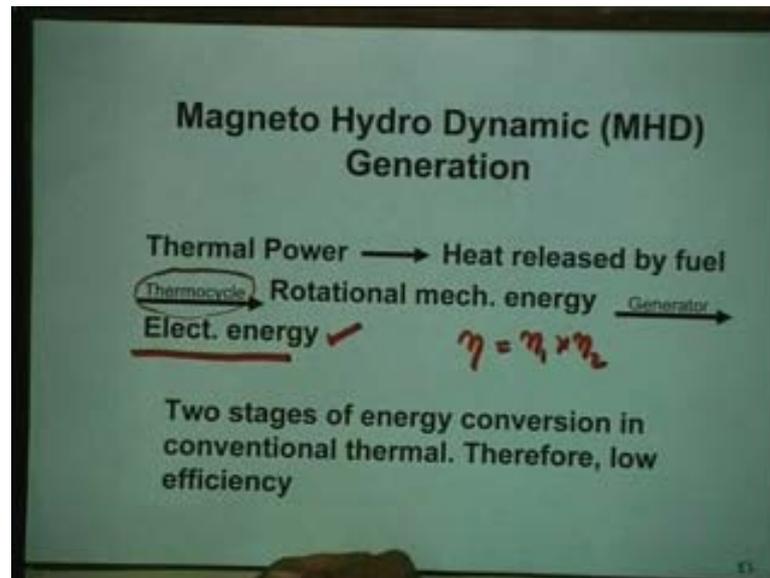
Non Conventional Energy Sources

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Today, we start the lecture 5; this is the non conventional energy sources, so far last four lectures, you for discussed various conventional sources of file; namely - thermal, hydro and nuclear. What are non-conventional sources? They are many as I said in the beginning in the earlier lectures. Today, we start with MHD. What is MHD? MHD stands for magneto hydro dynamic generator. Gas turbines and several other renewable energy sources virtual go cross them, as on when then time passes; of course, we will students of renewal energy center , you must be in detail, you will detail about them in the various other energy courses. However, we will have brief review of all the sources, the point primly with intention of how to generate electric power using them.

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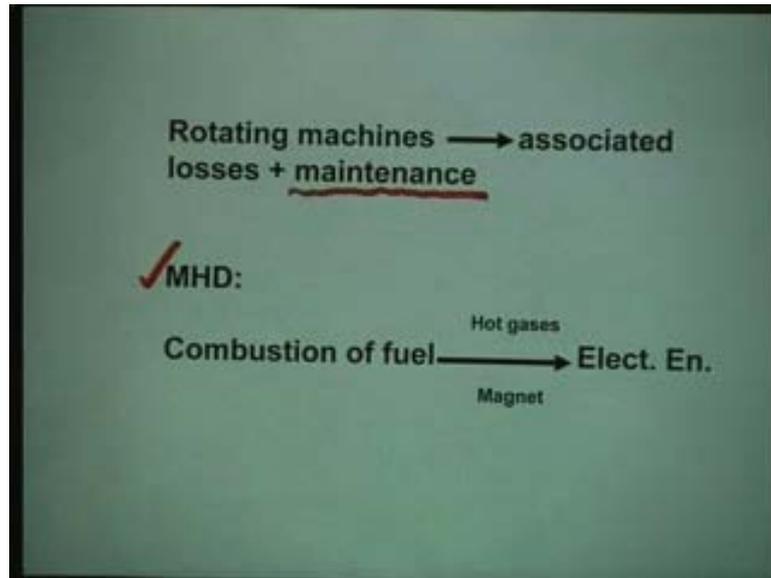


Let come to the magneto hydro dynamic generation. Now, what we are doing in conventional thermal power? We were releasing heat by fuel. Fuel can be natural gas, coal or oil; we were having thermo cycle, that is an rankine cycle or carnot cycle. And rotational mechanical energy, that is a prime over connectivity generator, an electric energy is to be generated. So, there are two conversions: chemical to mechanical and mechanical to electrical. All of your aware, that eta is equal to eta 1 into eta 2; naturally, the eta is to be lower of the two.

So, efficiency was in currently low, so two stages of energy conversion in conventional thermal. Therefore, was the low efficiency, the highest efficiency, we should can achieve in thermal park in the world; it is on forty percent. In India, it is not cross much beyond thirty for various reasons, that not going to them. The best manage government bar plant is Vijayawada, and best manage private bar plants is tatas, that is Bombay Tata electric company, and captive bar plan, it is Renu Sagar, that is the Hindalko (()) district.

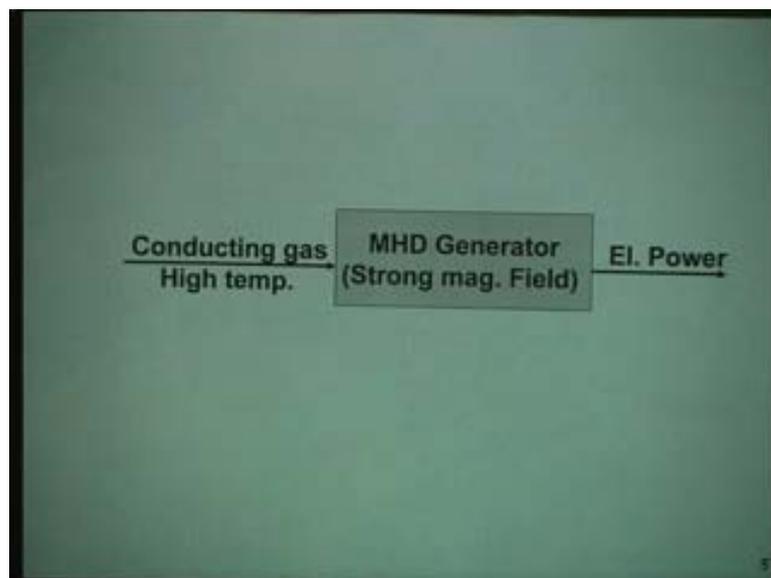
Now, district matter will change, that was old district. What is wrong with rotating machine? All of we have done being electrical engineering students electric machine courses, may be one, may be two, depending on which college, which university you have been, all these rotating machines have associated losses - the rotational losses, frictional losses, there are hysteresis losses, there are ion losses and so on, plus there maintenance losses.

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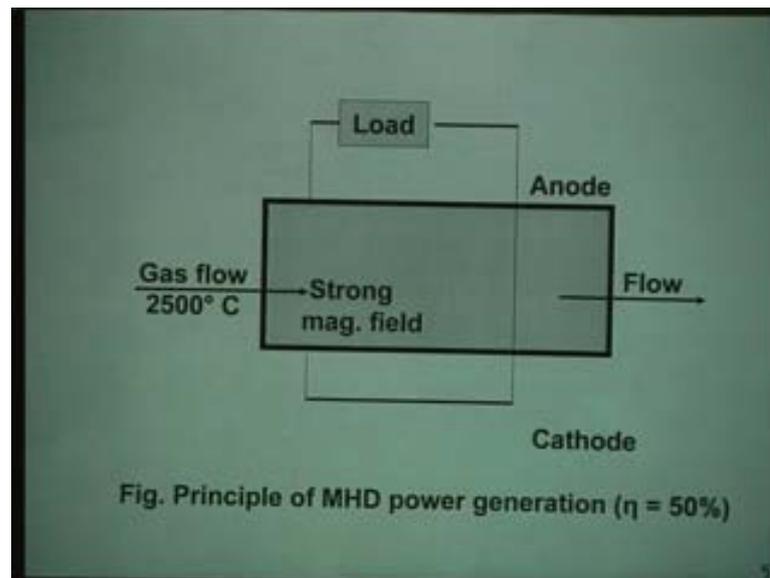
Anything which is moving, we need more maintenance. However, average said as MHD, everything is static. There is only one convergence fuel, there is compression of fuel, hot gases of form at very high temperature 2500 degree centigrade. And these gases pass through it re strong magnet, that generates elective bar. If you go to were energy center (()) MHD lab, they use to be big or the magnet 1.8 tesla; tesla is the nothing but labor per meter square, that magnets somehow is become now out of order; otherwise, to use to be magnet couple of years back in MHD lab.

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Whatever I now just said, it is written here. Conducting gas, MHD generator in is strong magnetic field and it generates electric power; here is schematic diagram explaining the principle of MHD; there are books on MHD. We do not have to read them, MHD enough.

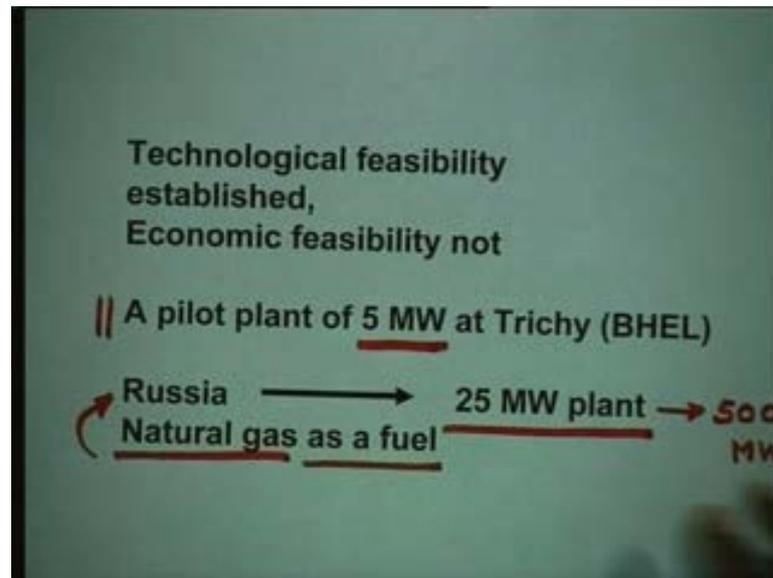
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Gas flow is said, the fuel can be again, anything can be coal, can be oil, can be anything at 2500 at a high temperature, all right, so that (()) take place. This is past in strong magnetic field plus minus anode cathode; there is the load directly supplies power to the load and to be the flow out, and these flow also has enough hot gases; why not use it? So, these can again the further used, may be as code generation form, may be as the combine a cycle plant. So, do not lose it to be atmosphere; this is further use, and that we will improve the efficiency of the whole plant, because it you are not wasty in anything; do not waste, it improves, it is even ecomicies; for example, if you have some sapatthis, I don't know what do we in hostels, in houses, is there again used as some dish and we don't there shows those things away.

Well, efficiency of around fifty percent, whereas just now talk about efficiency of thermal power station, which hasn't cross 40 percent anywhere in the world; even it so called modern technology, super heated extreme or reheated bind; I would explain you what is reheated bind; bring out the stream, pass it the reheated, again bring it bind; of course, any such thing we give have a ethadictional cost, cost as to be there well.

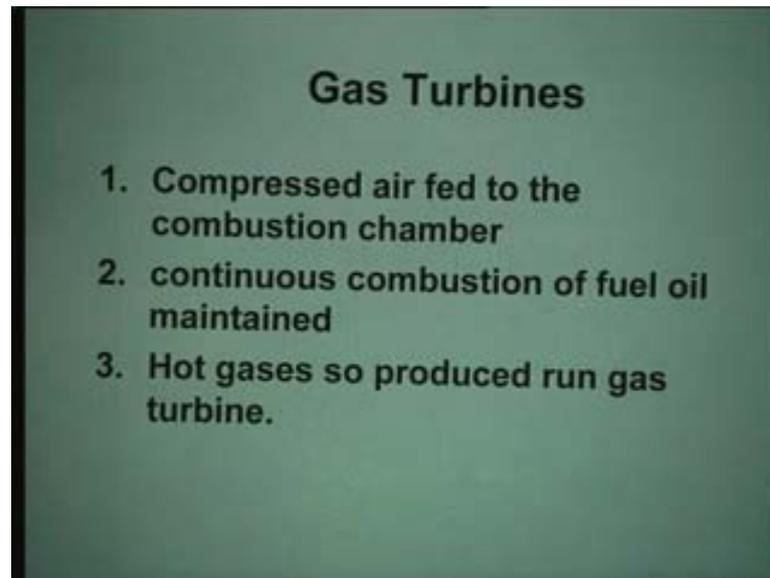
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So far, the status of MHD is research in the world; technological feasibility has long been established, there is no (()) that it works. Economic feasibility has not yet been established; that is why you hardly see MHD power plant anywhere. Why we were interested in MHD earlier on, because we had very good relationship with former Soviet Union – USSR, and they had a lot of interest, they helped us, they supplied a technology. They had 25 megawatt plant, using natural gas as a fuel in the Soviet Union – former Soviet Union – Russia. Now, they about to scale it up to 500 megawatt in early nineties and there was a collapse then power.

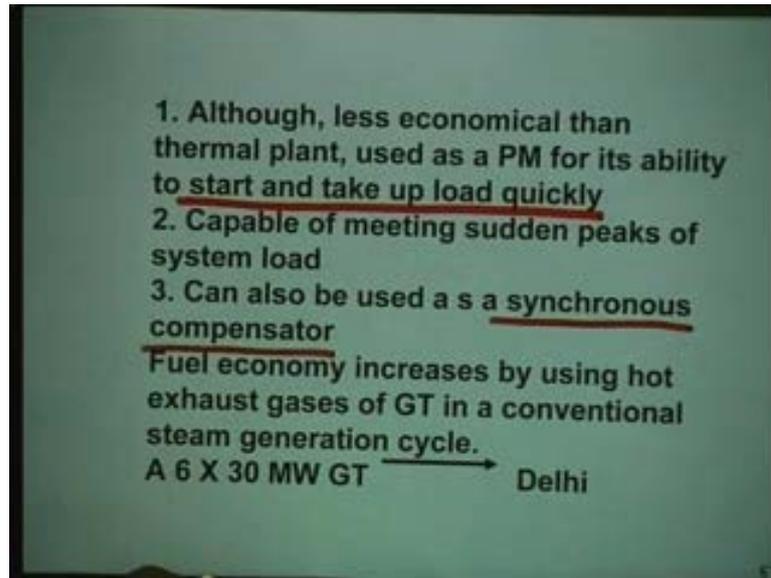
So, they could not do it, because they were doing something, we also did not in India Thiruchirappalli or Trichy as it is called. BHEL as established a 5 megawatts MHD power plant as seen in (()), but now it is not working, because it is not collapse there. So, we lost interest and moreover less like museum. If we visit Trichy, now so near was our MHD power plant, that is it. So, it is stop working, because there is no interest. There are other countries also where MHD research is going on like New Zealand, Japan, but not any significant power is generated anywhere in the world, only research papers, PhDs, design of a burner and so on.

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Now, we come to the next non conventional energy source, and that is gas turbines. What do we do in gas turbines? Compressed air fed to the combustion chamber; this is combustion chamber - continuous combustion of fuel oil is maintained. Hot gases so produced run gas turbine, something like wind, in some source run the turbine. If turbine is running at a prime over, generator will and power will be reduced as simple as that. Well, the efficiency of gas turbines is definitely lower than even thermal power. If it is forty, this is thirty; then, you may ask me question why you have it, then if this efficiency is even lower than the thermal power plant, which is as you to be a low efficiency power plant, why do we want have such as power plant at all?

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I give you thanks a within minute. As they said although less economical than thermal power plant, it is still uses the prime over - PM is prime over - for its ability to start and take load quickly. We are just turn in or given up the earlier lectures, like just hydro power plant may be held it as quick starting power - five minutes, but can you bring a hydro power plant your rescue for start duration peak load? You cannot go on establishing hydro power plant everywhere, just supply peak load.

So, gas turbine which is very handy, the land power kilometer kilo mega watt required is very small and it is not that costly; a gestation period is not that high, eight years or ten years; that is why gas turbines, though low efficiency is preferable, wherever you have to need the peak load for short duration; peak load means short duration. If it is for long duration, it become a normal load, how to we call it peak load? It is very much capable of meeting sudden peaks of system load; it is very quick sort. Can also be used as a synchronous compensator; what is synchronous compensator? Have you heard of synchronous compensator? You must read it synchronous compensation are in power system course in your fourth year; this is also called dynamic compensator.

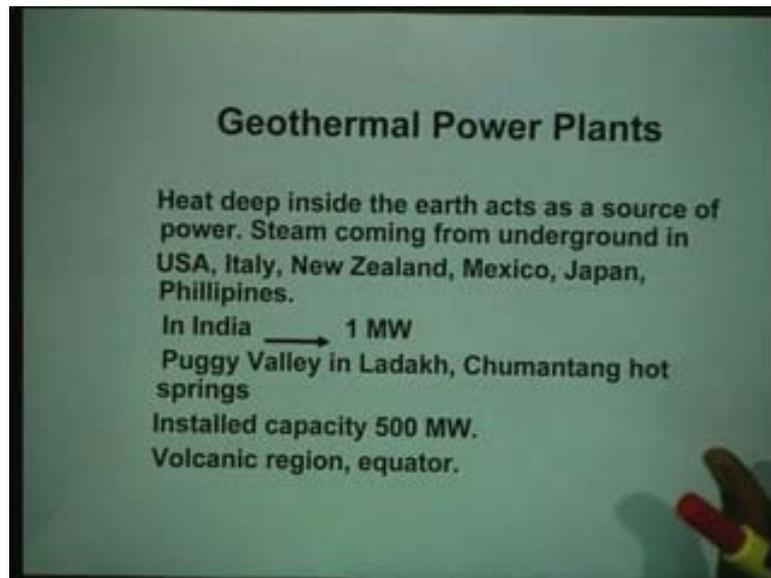
There are two types of compensation; compensation of what? It is not perfectly three in one; it is voltage, it is a power factor, it improve the efficiency also. So, what do you do? You put bank of capacitors, a bank of inductors across the load; you do not need both simultaneously. Either you need capacitors or you need inductors, why? Because either it

goes down or it goes up, it cannot be both simultaneously; either your inside to studio or your outside, only god can be (()). So, luckily we do not have low voltage or high voltage problem simultaneously in the same system, in the same point. Normally, India is you also know, we have a low voltage problem, because of the load being more than the generation.

So, there is the voltage sack; only ferranti effect, mr learn - under graduate, we have voltage at receiving an more than voltage at sending. Then, we need this bank of inductors to supply negative watts; other wise, normally we have to supply positive watts, that is you have to have a bank of capacities. This a static compensations; how what dynamic compensations? That is a synchronous motor running a load, this called dynamic, that sort of effort is also can be used using this gas turbines.

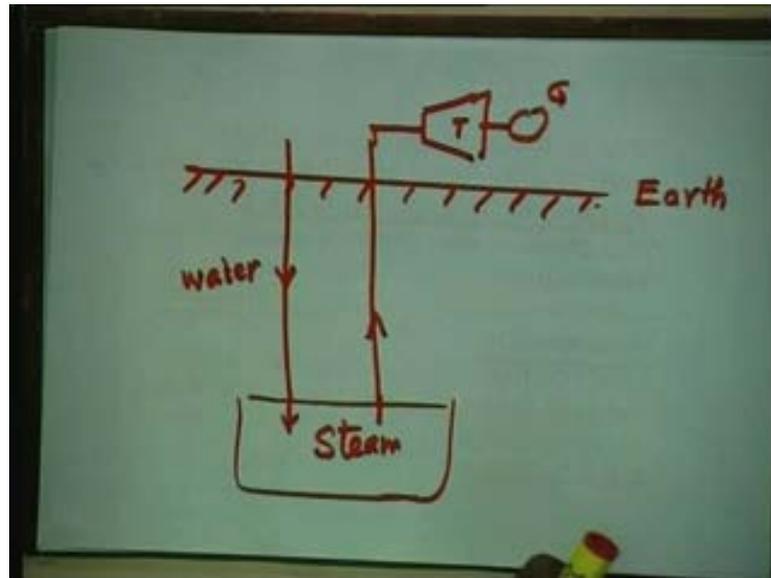
Fuel economy increases by using hot exhaust gases of GT in a conventional steam generation cycle; the item which has had in MHD also; anywhere where our (()) use it, that comes under west power generation also; do not use, do not, I mean, have any waste at all. Let waste be are primary source now, resource now and let the new material be the second, that is the iron which we are living. Well, Delhi, we have six such unit gas turbines of thirty mega watt, again which to request to you to go make visit, use your energy forum on, use whatever forum you want and take finite to go yourself; nobody finding your visit, and see in Rajikhat, you have these gas turbines. So, you must go see; it arrange three pansure, it will give you support; what do such thing? I told you so many things, go and see, like weather put them the power station, (()) and so on.

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Now, we come to the third non conversational energy source. Geothermal power, what is geothermal? All of us know there is heat inside the earth, all right. If you want to have taste of it, go to sonar, in arrange the picnic there; after (()), sixty seventy kilometers and there is a hot water is spring coming from the arc. People say all skin disease is can be cure if you go and have a bath there, whatever you applied. If you put rice there, in that water, its get cooks in your time. There is a tremendous amount of energy of level in the earth; heat deep inside in the earth acts as a source of power, why waste it? So, you should have it. Stream coming from underground in Japan, USA, Mexico, Newzealand, Australia, even India and Phillipines is been using generate power.

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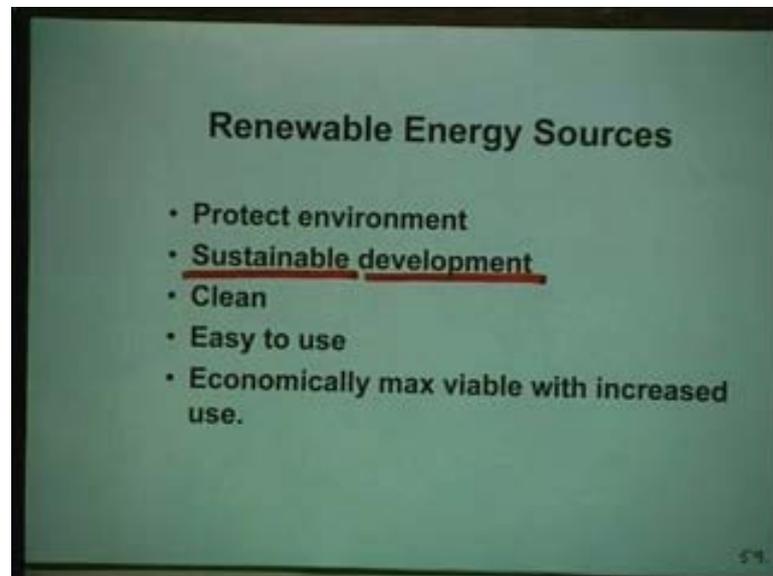
What do we do? This is your earth; this is how is your earth, have two pipes - long pipes - some it one pipe have it a water inside the earth. Here, it will get converted into steam, send back it to the earth, and use the steam directly in to the turbine, and then generator, so power is produced. It is only initial expenses; when you put this two long pipes, depending on what is your capacity your power station, how deep you should you go. I just a higher you go, cooler you feel **mr hurt this**. Similarly, lower you go, hotter you feel. In India also, we are very smart people, we are very intelligent people. Second, do not as for us intelligent; only thing is, brain only works, when it leaves in India, in US or Australia or UK, here it is an work so much.

So, we also have **1** megawatt geo thermal power station in Ladakh, place called puggy valley. Another such station is there in Chumantang, again Kashmir. Installed capacity throughout the world five hundred megawatt, but let me tell you ladies and gentle man, each megawatt counts, each rupee counts. If you respect rupee, hundred rupee will automatically will respect you, because is sigma important; do not thing is 1 rupee, save it, and then 1, **1, 1**, everyday, if you say became starting in whole year become 365. One rupee can be made ten rupees, one rupee ask is many be ten rupees; I am taking about my students is, there one rupee lot of many, specially in the volcanic regions, which is enough in the world, USA in Italy and several other places. Equator is definitely there, it passes through our Srilanka, there the heat is really good. Let me tell you geo thermal country, brutes to Newzealand; I was a Newzealand in last year, teaching they are

University in Crist church. This is tiny small country with just four million people, less than even pune or Nagpur population; there eight percent of power generation comes strong geo thermal and it is very economic.

Now, we come to renewal energy sources. So far we were talk about **non**, I mean, non conventional; renewal means is no fuel free and it gets generated automatically. Why it is important? Why should talk of renewal energy sources? Each products and wiremen, and wiremen becomes an very big issue. Now, in the world, there is the reo, conference in Japan, Toyoto and so on.

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Everybody talk about in practice the hardly do pressures rating to product the environment. In fact, there is competition going on, who is spoil most. Sustainable development is the word which all of us pronouns everyday every times, then become need of the hour. Any development has got to be sustainable, not only here will do well in minor one, you to do well in minor two, and here do well in major, or in between, whatever exercises are given or quizzes announced, unannounced, take home test, seminars, in our energy may be there are doing, within many departments, they have several components to keep you on your toes, do better in life; they have enough academic pressure.

So, they has to be sustainabled; you just can see 2003, 2004, I will work, and I take rest in 2004, 2005, no. This the energy, in energy area, sustainable development is only

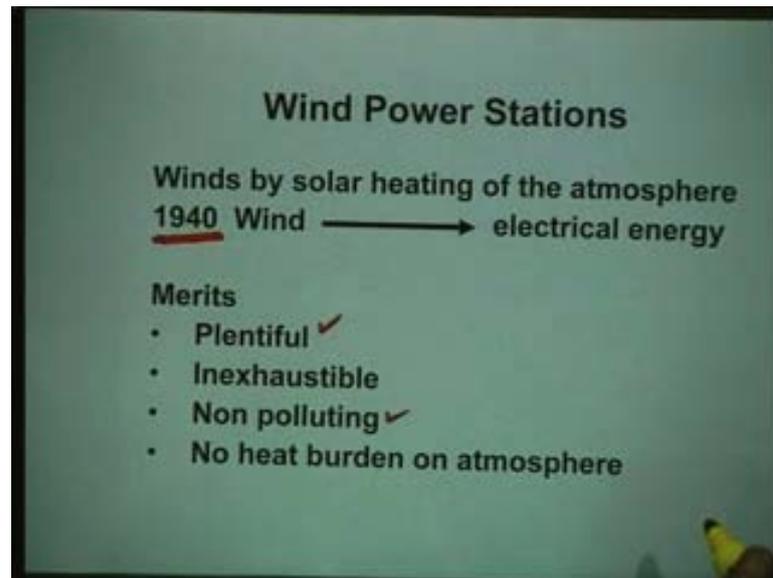
possible using renewable energy, while because everything is limited. The coal is for 200 years, and they said, we do say that it is continue for 200 years, because we find more and more places; exploration were (()) is there, yet I had told you availability versus affordability. As they said must it is called may be available, but it cannot afforded it. If even coal available, can we effort to bind it in discriminately? Why not leave it for our children and children's children as is our Indian Ethanes? We do everything for our family for our children.

So, leave coal also for our children, they will also need elective power. It is clean, the renewal energy source is clean, not dirty; easy to use, economically maximum viable with increase use. As usual go on increasing, it will become more and more available, because this is what the question is asked, when you talk of the even energy. What about cost? Anybody willing, they get up and say.

It is no good costly; conversional elective power, a cost is raisingand; non conversional energy power, cost is coming down. This was one rupee per unit as becomes four five rupees, that is, to be ten rupees, it is coming down with more and more use, and more and more RND, better and better technology, like example, PV better materials may we used. And then, development in power electronics, development in computers, have may it very cheap. Let us first talk about wind power station; I think after solar, may be when sun started, wind also started; I am in we cannot say which came earlier; it is one of the oldest source of energy.

If you go and see movies olden days, 16 centaury, 17 centaury, cinababha, rithanathi, these two go from one place to another. Mahatma Ghandi went to England to attend the round table conference in 1931 along with Gigugo lands, delegation in ship. Ship words in principle wind energy. Even if it is powered, because they checkout the route in such a way, that wind haves. The winds of course generated by solo heating of an mask; sun is the mother father of all energy sources. The sun is not there, you won't get their coal; if sun is not there, you won not get water; the hydro power, you won't get rains.

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1940 was the year when they started attempting, generating electric energy using wind. Why? what was the need? In fact there was no need as search. In fact, till 1970, nobody talk of energy conservation, nobody talk of energy management; thanks to those trees steep high kin all process in seventies, that is changed the whole scenario in the world.

Even US is so supreme power; of course, those they was another supreme power US is have. They got thread; one day they are all finished, and that is why the whole middle list party is there, just for why? Anything else? Otherwise will clear for enmities scan tree. They have petro dollars. Merits are, its area is plentiful, inexhaustible, to never finished, non polluting, there is no carbon, there is no Co₂, Ho₂, NOX, nothing. No heat burden on atmosphere, its not releasing in heat, like a thermal power plant, nuclear power plant, anything.

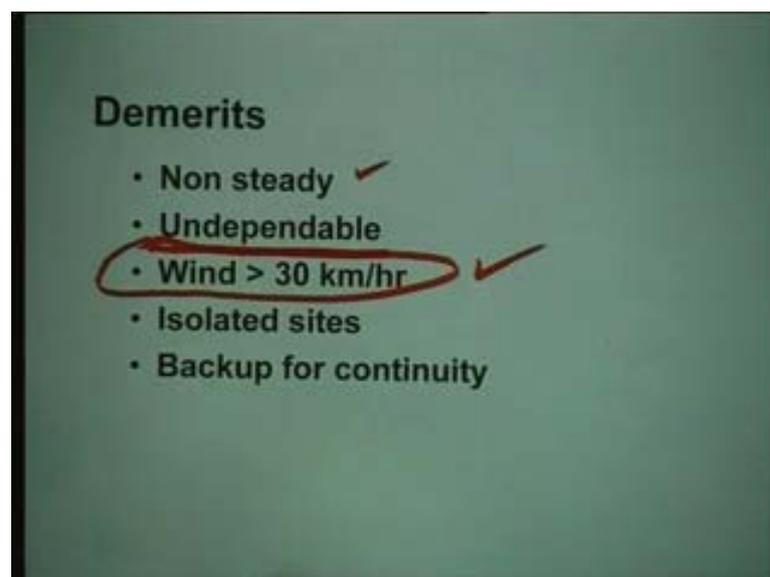
There is no green house effect; what is green house effect? The temperature of the earth is increasing every year; that is why this summer, France, the temperature has touch to the first time 100 degree paranite, I mean, though the talk of SI units and MKS unit, still in US, the temperature are shown in hundred degree fahrenheit, and the length is measured in miles. It cannot change into kilometers or centigrade; there if you see there the news, you find the temperature show in fahrenheit.

High eighty is I do not thing the centigrade; High eighty degree is centigrade is no body left, there all fahrenheit. So, hundred degree fahrenheit, that is about 37 or 38 degree

centigrade, which is nothing for us. In India, we have 48, 49. So, even in thirty eight degree, there is so sun is real very **very** harsh; that's why you need all sets of cream to avoid sun winds or even cancer - skin cancer. So, the sea level is also raised, and who knows one day there are already we were last quantified villages in Andhra, some was in the sea. And this continues, may be, you become in my age, then me not be Srilanka, then we not be Morasies, then we not be you know all under see; you know, stills there use to be srilanka here. Thanks to the green house effect, answer real thread, all small island nations may not be there.

If you discriminately go on perning goal, go on producing power, where repeatedly telling you there cannot be only plus points in anything, there has to be negative points. God has never made anything perfect; even when he came earth, suppose said, ram and Krishnan, they were also false with there; one fellow left his wife and other fellow life did is so many things, etc. What are the demerits in wind power stations? It is non study; it is there, it is not there. If you go for a morning walk, no, there is no evening today, no pointing is taken in morning walk. If those of you belong to villages, if there know the people use to sleep outside, for what, because the wind is going, the pure air of villages. If you sleep in Delhi, you may not find anything in the morning, when you get up.

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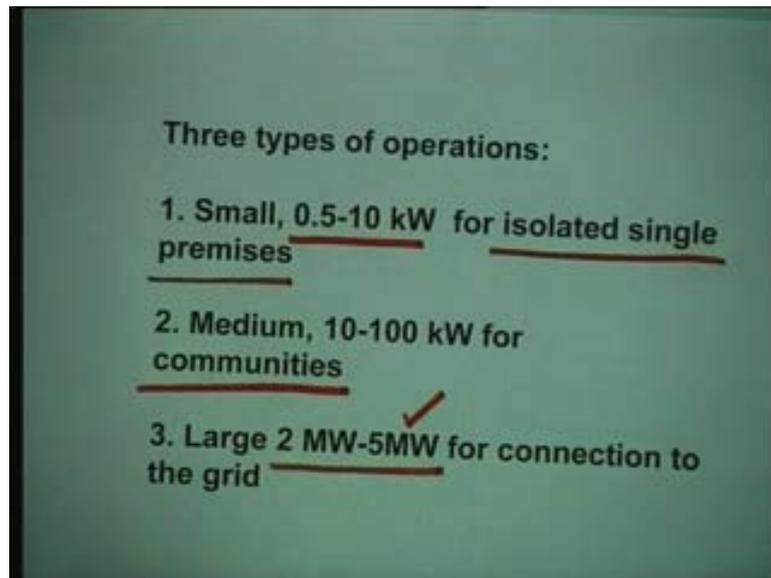
So, weather window, no way, nobody wants to outside and check your doors ten times for first sleeping, it is lock from inside or not. It is not only non-steady, it is

undependable; you cannot depend at 4 PM, I generate ten megawatt from wind and suppose wind is not there, she cannot just you have to have a ten byte arrangement. How are you do not get auto, you know, you will take 620 or 650 from hostel gate; you have to have alternative. So, you get out of your hostel room, well in advanced to catch you train, when you go to your home towns. When your wind is more than 30 kilometer per hour, then only it generates power; that's there is a minimum speed of wind which is required, if you want to generative power.

If it is lower and there, so there is a criticals like your excitation; some registers - critical registers is required. You must read in your machine course; then, they may sites are isolated. You not every were, backup for continuity, you have to have backup; this is the real prompt; like CNG bus, you have to **have** a diesel backup, this is the multifuel operation is required. Now, I think (()) is burden embarrassed, which can then both petrol and diesel. So, if you have petrol, use petrol; if you have diesel, use diesel.

Slowly, it will be four fuels: CNG, as thus the gas cylinders, and then fuel, petrol, diesel, and battery; whichever is economically depending on your, within city, the battery is ok; their something like a revakahar, which was show in IT company also. You are not there last year. Thus, the Bangalore pharmacy (()) at one stench go of the 65 kilometers, again you to recharge your batters. There are three types of operation in the wind power, what are they? Small – 0.5 to 10 kilowatt, something like mini, micro and small, hyper for isolated single premises.

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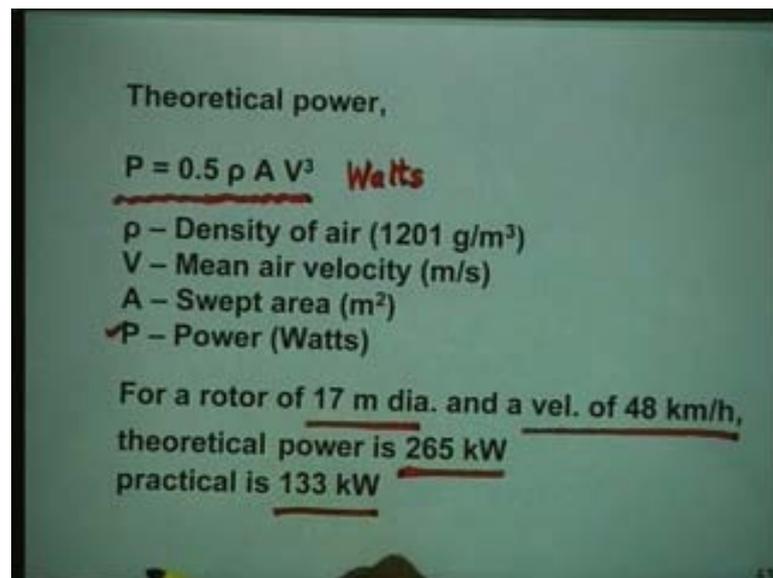


So, you living in a village in your field irrigation, sorry, agriculture, night sleep there, small house, small cottage isolated, nobody in your field, very big, several acres. Medium for communities: I give a example of the 25 houses in Utranchal village and started generic power - mini power - mini atom power station. Similarly, they could have operate power windows, but there is said wind, there is the problem, at least mini there was water is guarantee there, unless suddenly it is too cold and it is frozen.

So, only it that 1 month of 2 months, because more than 2 months, I don't think you have that is severe winter, where we what to that; dull lake get frozen when in 30 years, 40 year, you can run in car round in dull lake. In Kashmir, that happens very rarely; large 2 mega watt to 5 mega watt, please remember, 2 mega watt to 5 mega watt is large in renewable, which is the wind is very very small for a conventional power station, but it is large in wind, we have wind yet gone be on 5 mega watt wind power station; 10 mega watt is coming of course. For connection to the grid, then it is no longer works is an isolated wind power stations or is an autonomous wind power station, it works is the grid connected. Any renewal energy can more work in too modes: in is stand by mode, sorry, stand alone mode or autonomous mode or grid connected. Suppose there is lot of wind here, but unit do not need power here. I will still generated period to the grid; grid is always requiring power. So, we cannot money.

There are two types of wind turbines: horizontal axis and vertical axis. Horizontal axis is very popular, you will find most of the turbines use in the world are horizontal axis, but vertical axis has got certain advantages. So, IIT Delhi, in our center for an studies, we have to try it a PHD project of 12 lakhs, building a vertical axis wind turbine. You can see their behind our centers, behind block six, this big structure on vertical axis, wind turbine, wind power station, you may request of show you, how it is works, how it generates power, and how bulbs are lead. It is right there, here you do not go anywhere, unlike gas turbines, (()) thermal power station, whether poor, etcetera, just go and have a look at it. Another important is, it is a Denmark which first generate power using wind, followed by US; there are US, lot of wind forms are there, Germany, Spain, we are fifth in the world.

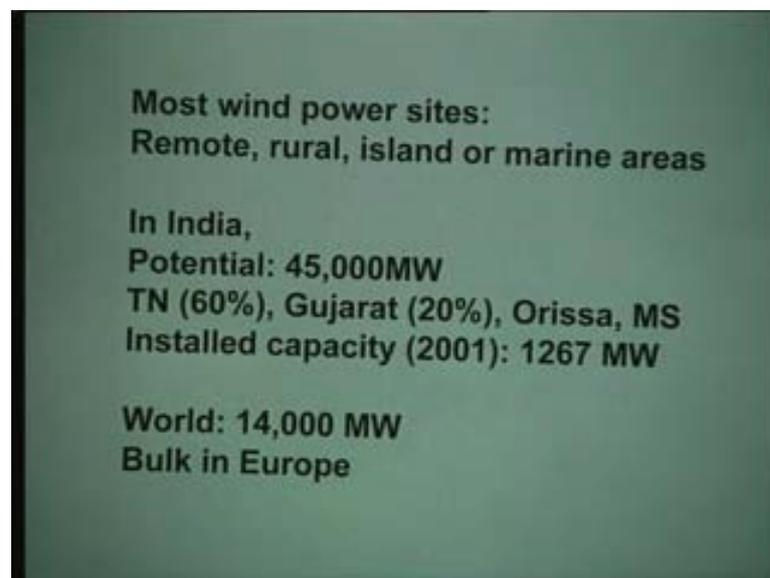
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Our total install capacity is 1200 megawatt; theoretical power, the power generation is given by these equation; P is equal to point 5 rho a V cube; of course, this is in watts. It is given in 0.5, 0.5 is 0.5, I do not an explain in 0.5; half rho is a density - density of air; it is 1201 grams per meter cube. V of course, it will with attitude; they are gets oxygen becomes less and less; that is why when you go the hill top, you carry oxygen, specially Mount Everest; V is not volume here, but mean air velocity in because English language has only 26 symbols.

So, they to use same symbols again and again for various purposes; V is voltage, V is volume, V is velocity and so on. For a rotor of 17 meter dia, and a velocity of 48 kilo meter per hour, a 30 you imagine how big rotor is 17 dia; that why these our wind structure is use. I do not know whether you seen it. And 265 kilo watt power it generated theoretical, but practically is just half, call efficiency 50 percent. Most of the wind power sites are remote; there won not be in the Bombay termini point wind power station; they will be join order problem issue, if you have in wind power station or in India gate.

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So, they got to be a remote in a rural environment, island, marine areas, and that is why most of the wind potential in India is on costal; Tamilnadu, Gujarat, Tamilnadu is 60 percent; it is huge success story. And Gujarat is gain 20 percent. If you visit Tamilnadu or Gujarat, do see this wind forms, use wind forms; Orissa, Maharashtra state, Rajasthan, there all coming up now, because whole countries divided in to 15 egroclamatic zones, and those states those areas which are coming in, you know, semi air it zone; there is institution on (()) a jodhpur that is the desert (()) less water per more wind; Rajasthan there is no wind problem, that is why every everything is done in the night time; it was cool, it was windy is quite comfortable.

Even most part of the year, install capacity as potential in India is 4500 mega watt, tremendous potential; if you can explode it, if you can tap it, how much we have in any far do so far, just twelve sixty seven mega watt as on 2001. You made another 1000

mega watts for two years, that is all. It will be 13, 6, 7. Now 2003, but I know authenticated; that is why I am giving you 2001 as given by MNES - ministerial nonconventional sources, because whenever the course data to be throw and should be correct. World potential, not potential, install capacity today is 1400 mega watt, which roughly 100 times India's. And bulk of these 1400 in Europe, naturally when as a three countries of higher of India, barring US, all of them all in Europe, Spain, Denmark and Germany.

Now, next time the course will talk of solar energy. Before you close this, let me tell you new trade, which is coming in renewal energy sources, that trade is roof talk. Earlier on, in there was know the fourth floor, now the fourth floor as come; before you came, it was only three floors in those teaching blocks; your energy is (()), you can very well see that fourth floor is not same that remaining three floor. Construction is light, because the on the you know foundation is not meant to have another floor. So, roof, we all always have a roof of level, and now days security reasons nobody goes and sleep on the roof; same thing, outside roof same thing, but you can have the power generation the roof, small wind power station. The research going on in IIT Delhi (()), how to generate wind power with small wind space? How small? Just five to six meters per second is small wind is up level all the time. So, what we are done?

So, we have developed which amplifies of wind space; there is wind tunnel here also incidentally. Lot of wind work is going on we applied on mechanism; what is this? Dynamics principle - floor dynamics, so if you happen to visit to applied mechanist department, you seen wind tunnel, you see how do feel about it. So, these wind small winds speed gets amplified to big one, that wind we lot of power; when it passes to wind to turbine, and then attach to generative generates power.

So, roof top power station are becoming very popular; you know ask me question what do we do that power; use that power to supply requirements of power that building. And if you have it still extra power, you feel it to grade, sell it and start on money or you can do banking and wheeling. What is banking and what is wheeling? I give you power here. You give me Guavalier, my factories in Guavalier, but I generate power in Delhi; I do not need power in Delhi, but you may be have in factory here, reading power and sell you power here. You may have a power station in Guavalier, you give me there wheeling, no power - no banking power. I give you today, tomorrow if I do not have,

then you give me that is banking. What do we bank? We put money today, when we have, and we withdraw, when we need.

So, that's is banking and wheeling of power, which has been as possible by renewable energy sources. And I think now all of you five minutes there, so I will ask you if have any question whatever we have done till today, include the today's lecture.

So, I am just not able to understand power generation (())

Well, logic is a read the of course, (()) must read the book, and we have not done in detail. Only logic is any (()) gas passed gas not a incised. When any what you call, fuel is put burnt and hot gases are formatted very high temperature, and it passes it magnetic fields it gets in incised. So, the...

Not magnetic is there?

It is a big magnet.

Negative energy is stored.

Yes, energy is naturally that the cure if the magnet, so that the magnet theorem cure also. So, that power when it plus anode is there and cathode is there, and the power can be, its like battery now. And the load as shows that the figure, and goes to the load; I different books on the imaginative, only imaginative in our library, I do not want to be read the whole book; I read just inductive chapter in case you want know more about MHD.

How the kinetic energy is converted to dynamic energy?

That's not say lot of air dynamic principle is what. In fact, that is the full course is going on, on wind in hydro, which I have finished just about fifteen minutes. Naturally, if you want more interested wind energy, again you have to consulted in colleagues you are right now undergoing that course; I hope you, but it is (()) a course title wind and hydro power, I am a right.

So, please there must be your friends; ask them same question and, but that much enough is given in the book also, but them if you want to details, you should be you have to go; that is another book also, we did not know what is that. In 1986, given in the my book is end of the references, you can read that book is or all alternatively you ask colleagues,

you undergoing its course; they **they** may whole semester - half the semester they may be only talk about wind.

Small details tell you read my another book - basic electrical engine; there are numerical also **(())** there, and that book is there in our central library - basic electrical engine. And there wind given **(())** in detail, not as small as power in book; you need you have seen our in basic electrical engine book.

Not...

That is power engine system basic, means, something like as smith, something like as rocking.

Not so thing used within; now, it is big one. So, there I devoted six pages on wind energy, unlike power book; there is only one page one and half page. And I am happy that more interested in, why, that is because of the time, we have four segments to cover: generation, transmission and distribution. It is not alone on generator; forget about alone wind, which has so is a target. All you have come to my office in second floor, and show you any other question, whatever you have done, whatever you not done. I do not think in reply in couple of minutes, whether you so many things which we do in which can our course on, when did have half course at this. Yes, anybody else? Done, we stop here.