Power System Operations and Control
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Module - 6
Lecture - 1
Additional Topics Relating to New Developments

Welcome to module six lecture number one and this module is devoted to the additional topics relating to the new developments. Now, we can see the developments in the electricity sector are tremendous from very beginning when the electricity was growing. Now, we have very mature and very complex system, where generation transmission and distribution all this sectors are grown to its situation level and there are some slight developments in the various sectors that will be discussed in this module. To start with, as we know that is the whole this electricity business or electricity industry can be divided into three broad categories; broad areas or you can say broad subgroups.

Those are generation transmission and distribution, so we will see in this lecture one that the developments from the generation side developments in the transmission side development in the distribution side. Also, we will see that development as whole in terms of operational structural changes that is the taken place in emerging power system. So, to see this development in your generation side, let us go and let us see these transparencies.

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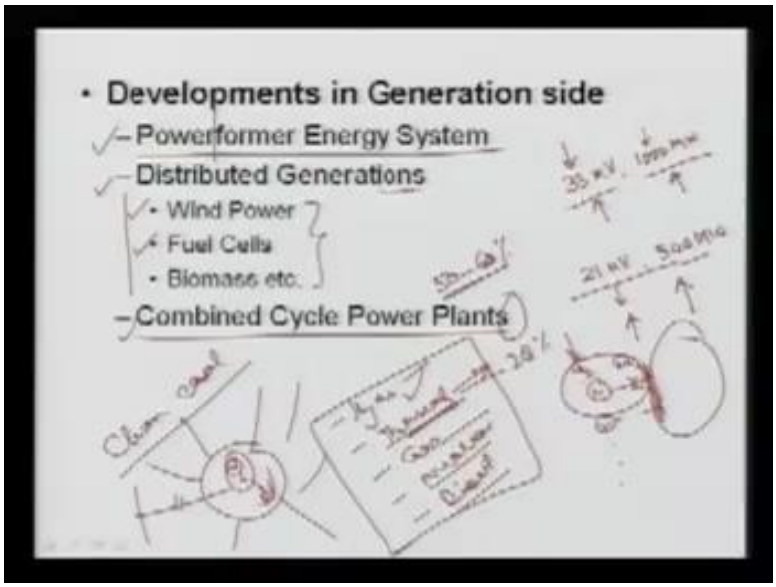

That is the developments in generation side; again the development in the generation means what are the various generations that we have right now? It is very important before going further new developments. Presently, we are having the power generations coming from your thermal power station, those are burning coal are even though those are burning sometimes your oil and gas also. So, we have you can say thermal power coal based power stations, basically called thermal power station. We have nuclear power stations, we are having gas based generation, we are having diesel based generation and of course we are also having hydro power generation using the hydro potential energy that we use in terms of generation of electricity.

So, these technologies are matured and there is very few development in these sectors. For example, in the coal based thermal power station, the development is related to that we are going for higher and higher size of unit generations because now we are having better and better cooling system. At the same time, we are having the better insulating material so that we can go for the higher voltage generation as well. So, presently in the generations in the all over the world, we are having the voltage generation of the station is 33 kV and they are generating power up to 1000 megawatt approximately unit. This is generated by one unit not by the one plant, one plant may have the several units.

For example, if this is your plant, where we are having several units they are connected with the gt here. Here, we are having another unit and it is connected by generating transformer and so on so forth. So, this is your one plant and that may have the several smaller in smaller units, so this we have the maximum generation level up to this 33 kV and also we are having this power generation this level. However, in India we have the maximum generation voltage level is 21 kV and the single unit that is the maximum power of the single unit is 500 megawatt that is installing the several other super thermal power stations.

So, we have the development from this side that we have the higher and higher voltage earlier these voltages were very low. Now, with the development of the various insulating materials and also based on the very fast and efficient cooling system, we were able to generate high power at the high voltage level. Now, although this is also almost same saturated and we are now going for the other types of genetic station, that is called non conventional. Although, these technologies are not so old, for example your wind fuel there is no, it is new. So, there is certain other type of power generation that is called

non conventional energy sources and they are not new, but their technologies keep on improving.

So, they will be new source of generation in future, so this is as I said in the generation level, the technology that we are having here right now. It is your hydropower, it is your thermal, it is your gas based, it is your nuclear based and also we are having the diesel based power generations. Now, you can see there is no doubt the various development from the even though thermal side as I said the voltage level of alternators has the power level is there. If you will see the development in the electrical mechanical side, I am just telling here the boilers, which we were using it was very conventional boiler.

Now, the people are going for the advanced technology in the boiler that is called fluidized based combustion techniques In that, what happens? The emission level is reduced and we can have the more efficiency, also we are going for the clean coal technology clean coal. What is this clean technology, there what we do? We try to wash the coals at the coal mandatory so that we should not transport the ash contents and then we can have the pure coal. So, its colorful value will be high and then we can have the high efficiency of the generation.

So, there is various developments small and small in each sector here in the hydro sectors thermal sectors gas sectors nuclear sectors and the diesel sector in the all the field electrical mechanical and the civil areas that is the future developments are there. Of course, it will see in the electrical side mostly it is saturated, so now we are going for the different technology here the voltage level we cannot go up to this level and the power generation is also limited to that because the cooling system. Another development here is the power former that is invented by ABB, the power former as we said is a power transformer plus generation means here if you are having the generators g.

Then, you are having the gt here then we are fitting this power to at the grid level and the system is connected here. Now, in this power former, what happens the gt requirement is eliminated and we are putting this generation higher? That means we are combining this transformer and this generation together, it is called power former, it is a trade name given by ABB. In this, we are just generating the generators at higher level we will see in the next few slides. In the distributed generation, the concept if we will see earlier we

had the concepts of the local generation means the loads and the generators were very close.

If in the first module, when I was discussing about the evolution of power system, I said the power generation and the loads were very close together. Then, there was some error and we went for the power generation at the remote places and we were connecting with the high voltage transmission line through the grid. It was reliable that you are going for more and more power generation, the pollution etcetera should be very away and also the energy sources they are away from the load centers. So, the power plants were built very near to the energy source level like hydro is very near to the hydro energy level, the thermal power station were very close to where the coals were available.

Now, again we are moving towards the again back period when there was local generation and it was fitting the local supply. So, the distributed generation concept comes in that way itself. Suppose you are having load in this area use load when you can have these generators here in this load centers itself and then you can fill the supply. Now, we can see, right now what we are doing we are taking the power from the different remote generations using the transmission network.

The major advantage of having this distributed generation are that we can avoid the T and D here, means this no transmission requirement which if we are going to filled here means requirement is reduced because your loads are keep on increasing. So, you have to keep on building the new transmission line, if you are building generators here, then you can provide the reliable supply you can reduce the T and D losses, you can reduce the T and D requirements. So, there are so many advantages, now the question why right now we are thinking various distributed generation. So, the distributed generations are the small amount of power generation near to the load centers.

Now, the technologies are development in this side, now we are having very efficient distributed generations and those can be built very near to the load center. For example, your combined cycle power plant here basically its combined cycle power plant is very efficient, the efficiency may be some time 50 to 60 percent However, we know the conventional power here, it is not more than 28 to 30 percent even though in ideal case it is less it is 28 to something 30 to 35 percent, but in the actually it is 24 percent in the

reality. So, now we are having the level of the efficiency and also they are very easily, they can install they can be very quickly started.

They can be very quickly set down and also the area required by these power plants is very small. Now, you can imagine the area requirement for the hydro power generation. The tremendous area requirement for the big thermal power station is very huge, but with the advent of this various the combined power cyclic plant we can put this power plant is very near to the load centers. We can have some space power plant also very smaller in area smaller amount we can put near to the load centers and it can provides various advantages as I mentioned here.

So, the distributed generations are the small amount of power generator and they are distributed in the network near to the load centers they are called distributed power generation. Again, the distributed power generations can be of different type it may be wind type wind power generation, it may be fuel cells, it may be bio based it may be solar it may be girdle. So, there is various types of non conventional energy sources those can be utilized even though many hydro micro hydro's plants can be also small hydro power plants may also come in the distributed generations sectors. So, let us see few here developments, first let us see the power transformer power former energy system.

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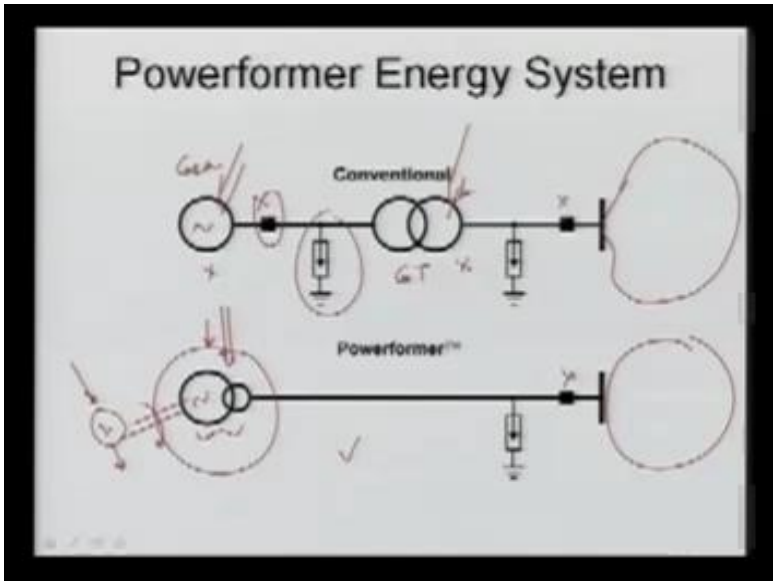

The power former energy system here as I said the conventional power generation here we have the generator this is your alternator. Now, we are having some lighting resister here protections here this is your circuit baker this is your circuit baker and this is your generating transformer and then we are feeding to the main grid system here. Now, what it is planned that this transfer, we can do something here we can increase this. So, we can go for direct levier connecting here and we are the feeding power to this. Now, we can say what are the savings, savings in terms of we can say we are save this circuit breaker requirement.

We have save this one and simply we require this circuit baker plus here we have save the generating transformers as well. So, there is a issues saving and therefore, we can even though reliability is also reduced. We can have the lesser space because you require the transformer here the bigger space and control etcetera for this transformer. Cost is reduced space is reduced reliability is issued so many advantage to go for this one. Now, the question what is this, what is the difference between these two? Earlier, we were using gt, now we are move to this power former means transformer alternator along with the transformer, means we can go for the higher voltage generation here, earlier it was not possible. Again, the technology here is not old means, this technology is based on the basic principle of magnetic field we will come to that point later.

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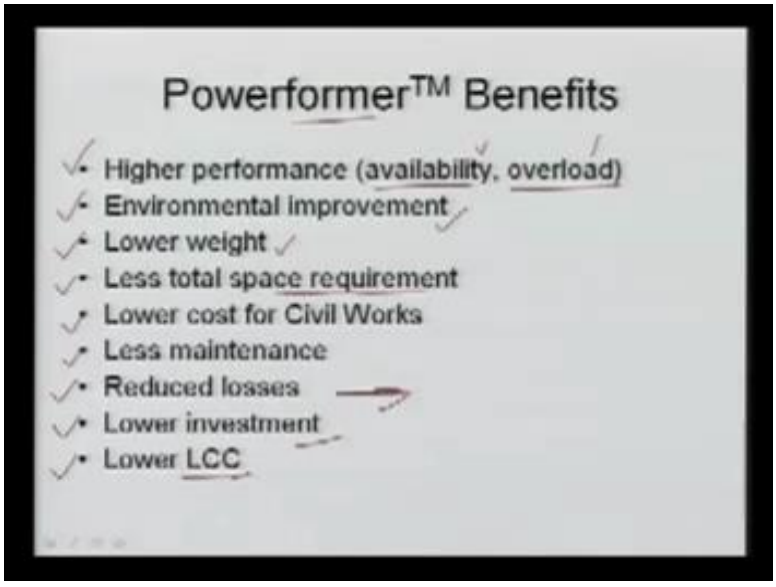

Now, let us see the various benefits of power former first the higher performance in terms of availability in terms of overload, means it performance if you are using the power former are you are using your generator and the generating transformer. Then, this power former is giving better performance compare to that in terms of availability in terms of over load why it is? So, the question here you can say there is some problem here in the transformer you generator will be you cannot generate you cannot feed the power here. So, whatever the problem here as well as here will arise it will be giving your reliability of the system.

So, if now here only this is the problematic we do not have the transformer, so the reliability here we have improved by reducing one equipment. If you have, keep on adding several equipments in the system the reliability of the system will keep on decreasing because it is related with the reliability. It is related with the probability related to the probability of the some problem in this transformer in a very equipment.

So, here it is more availability, now, in terms of overload I was telling, over load means here the overload of generators overload of transformer. How much we can over load a transformer you cannot exceed its capacity? Here, the overloading of alternators if you have the better cooling, you can overload these alternators up to 5 to 6 power, there is no problem. However no doubt there is overload capacity of a generator is decided by the turbine which is rotating here the rotating part.

So, the over load capability of this turbines are normally very less very less because if you are going for the more over load capability of turbine the cost of the same turbine will be very high. So, we it is better that if you have a overload capability here you can over load this alternators without any loss of problem. So, if just I said here, it will have the higher performance in terms of availability and in terms of overload. Another is your environmental improvement, what is the difference in the environmental, what you are going to do with this environment, now what happens here? We are going for the more space and more space, means more clearance more ground where you have to if you are the tresses etcetera, you have to cut there.

So, here means in terms of environment also it will be less of course the losses will be also less, so less heating will be there. So, over all you can have this your environment is also improvement is there lower weight of course weighting terms of weight of

transformer and the weight of alternator combined. Now, here we are removing the transformer now weight of a power former is always lesser. So, we are getting lower weight, of course if lower weight means it will be lower cost total capital cost we are talking.

So, lower weight lower capital cost, I am not talking about only civil works it is a capital cost of operators including your power former is cheaper compare to alternators plus transformer. Another is your less total space requirement as I said there is no transformer in the power former. So, the space requirement is minimized greatly and then we can have very compact power generations no doubt means you do not require the gt service station at all you can directly connect to the grid. So, this is the great improvement and so we require less space compare to the conventional generator and generating transformer combination lower cost of civil work.

Of course, if you are not requiring the transformer, so whole cost of the transformer foundation etcetera that will be minimized and then the total civil cost will be also less, less maintenance. So, whenever you are having minimum elements in a power system in any system, then it will have the less maintenance. So, in this case what is happening again we are not having the gt here, so the maintenance is only required for this one and earlier the maintenance here plus maintenance here where required.

So, though we can say the maintenance is also minimum, in this case compare to your conventional generating system reduce losses. Now, the loss earlier it was the loss related to here only the generator that is the power former. Earlier, it was the loss in the generator loss was also in the transformer, so the combine loss was more than the loss which we are having in the power former here, lower investment cost. Of course, the transformer cost is reduced, less cost is required, so the capital cost investment cost is reduced directly. Another is low lower life cycle cost; here LCC is life cycle cost means if you are going to see what the total period is where the cost is going. So, this cost is reducing. So, LCC will be also reduce means total life cost will be also reduced greatly.

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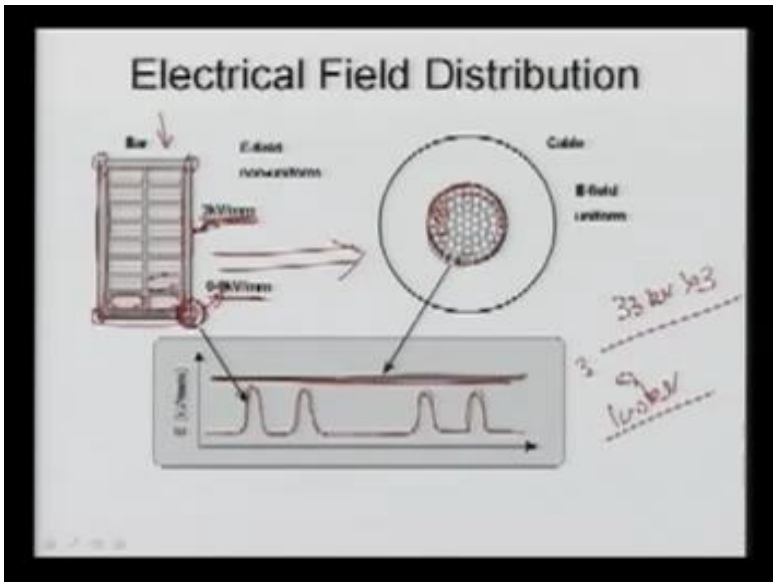

Now, let us think the theory behind that why we have achieve earlier we were not achieving. We know that the conventional system here we are having this is the slot, now we are putting the bars here this portion is your conductors, conductors rectangular bars we are just putting in the tax. So, these are basically the inserted and having the insulation in between. Now, you can see here why it was done because it was easy to manufacture it is easy to insert the bar inside the slots are this is the generation binding.

So, this is one slot where we are putting the bars for the binding purpose, so if we will see here the voltage gradient at this level at this point it is 3 kV per mm is there, but at this corner it is more than 2 to 3 times. So, always we know that the field at the sharp edges is higher than the than the other new form surface.

So, this is you can say new form surface these are the corners means sharp edges, so more fields are there here and that more fields means we have to have very good cooling because there will be more eddy current loss, then there may be possibility of part. Also, there is a possibility of the brake down of this insulation, so you can see the field here this variation of the field here it is very thick. You can see at the sharp edge it is this much and now we are having this value of this you can say, what is happening with this? We can say from moving from here this then you are having uniform then you are having again sharp edges at this.

So, this is the filled around this complete path, now if you are having let us suppose your circular conductor here, let us if you are having circular conductor here. Then, you can say the field you are having the uniform, now earlier the design was basically focus on that we have to design our complete insulation system for this voltage gradient. So, we were trying to see what the voltage gradient here is and whole system is designed on this one. So, our Everest field was less and then we were able to generate lower voltage, at the lower voltage, voltage will increase this will be again increase and then there will be insulation break down.

Now, for this capacity again 6 times if you are having circular the field gradient is uniform throughout the area. So, this we are knowing we know it very well the field around a circular path is uniform and less then the sharp edges. So, this is the case where now people are addressing transforming from here to here, so what they are doing? Instead of this rectangular bar, they are putting the cable of circular cross sections and then here you can say the small sections are here and then they are just inserting. So, we can have here effective circular radius and then we can have the inform field and then we can raise the voltage 3 times.

Now, earlier it is 9, now we can go for here three times its raise means if you are having 33 kV, now you can multiply by 3 to 4 times, now you are going in the 100 kV system. Now, if you are having 132 kV system, there is no need you can just increase again insulation. You can relay or you can increase and then you can directly feed to 132 kV systems, half generation there is no need of option transformer. So, in this technology basically it is nothing new, but we are using those old technologies and we found this power forma is very good and very useful for your future development.

That is already it is located at several locations outside the word and some commercial projects are also about to come in the future, now let us see the development in the generation side.

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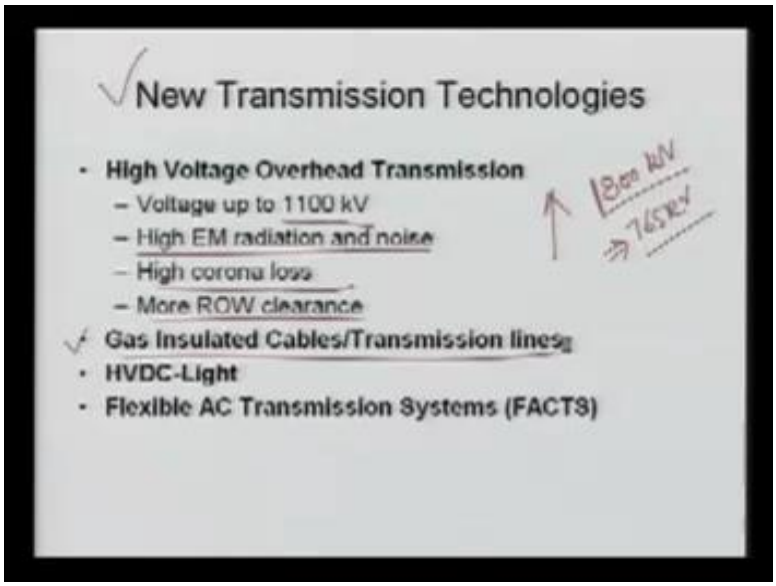

The new transmission technologies that are a high voltage what people are going again in the transmission side also we keep on increasing the voltage level and now we have ended with this 1,100 kilo volt system. If you are going for again further higher voltage system, what will happen? Then, there will be more radio and reference there will be more coronas and there is a more electromagnetic radiation. So, we have to go for more right of way means more path is required also you will have require more clearance the ground clearance so on and so forth. So, tower should be very high and it is very difficult to stick on it with possibility of the reliability is also less means reliability will be reduced the system.

So, that is why I said here the high EM radiation and noise high corona loss and more right of view clearance are required if you are keep on increasing the voltage. In India as I already mentioned that we are having the transmission line up to 800 kV. Basically, this 800 kV is insulation level, but the line will operate at 765 kilo volt system only. This line is presently operating at the 400 kV, but the future will add the transformer at this insulation level and we will operate those lines at the 800 kV so that we can transfer power very high at that time.

Another development in the transmission side, now people are thinking how many lines? If will see, it would go near to the any service station you will find so many lines are coming and going out at that point. If you measure, EM radiation will be very high and at

that EM radiation is sometime very hazardous to public because it may create so many diseases. So, the gas insulated cables and the transmission line are becoming popular.

These lines are popular is especially if you are having less space or there is no scope there is you are having limited space for moving the transmission lines. If you have, it is very congested area or there is some space etcetera. It is not possible to go for the towers designs etcetera, then we can go for the gas insulated cables and the transmission system, now let us see the gas insulated transmission system here.

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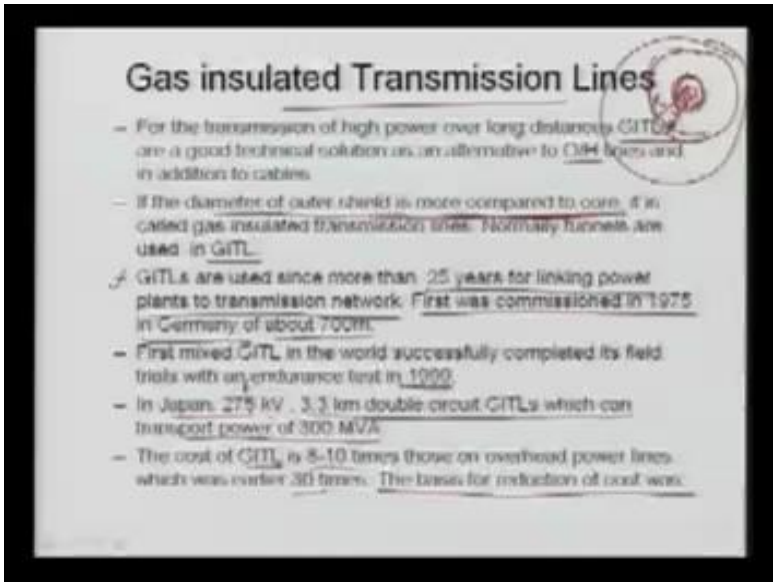

I will for the transmission of high power over long distance the gas insulated transmission lines are a good technical solution as an alternative to over head OH means over head lines an in addition to the k value. No doubt we are having the cables, but these cables are really limited by the voltage level. Already we are using the 400 kV grid insulation cable and it is using several country, but again the length are limited and again it is very expensive at the same times very difficult to you can say maintain another problems are occurring here. So, gas insulated transmission line may be alternative to your over head lines where you have limited supply, where there is no possibility that we can go for several lines.

If the diameter of outer side is more compare to the core, it is called gas insulated lines normally the internal are used at used in gas insulated transmission system. Here, what we are talking if the diameter of outer field is more compare to the core in a cable. Now,

question is, what is the difference between here the insulated transmission line and a cable? Cable, we know that here we are using a core and then we are having insulation here this is your let us suppose one core cable you are having. Normally, this is your r this is your capital R this ratio is not very high, means this core your this insulation is less and we go for the solid insulation some times.

Also, we go for the cables gas insulated, so this is the cable when this outer is not more than the radius of core, but in the gas insulated transmission line here this is very wide and your core is very small. I will show the example of this gas insulated cable, you can see this, what is happening?

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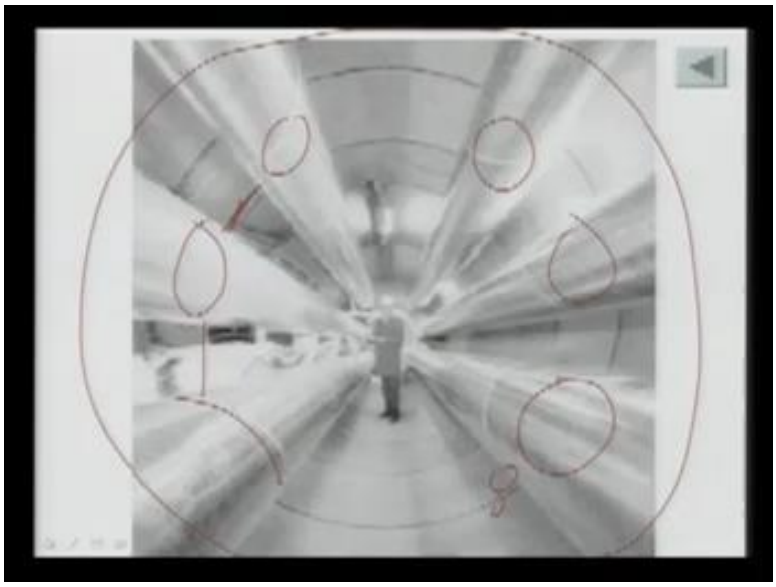

This, we are having the complete aluminum cell outside here and we are having the difference here you can say the pipes and they are basically for in the conductor three phase here we can also see here also we can see. So, three phases are going you can see a man is standing inside, so here inside we can fill the gas so that we can have with the high insulation requirement. So, here this is not air between the gaps here because in the air if the over head transmission line you are using the insulation between the two wires are air and air is the dualistic distance very less compare to this.

If you are using any insulating material insulating gas, so here we fill the gas and then we can have the very close the transmission lines and then it is just like a pipeline where we can fit all this three and these are basically hang with the insulators. Then, we can just

go for just like it is a pipe line, so as I said that the diameter of outer shield is more compare to the core, then it is called gas insulated transmission line. Otherwise, it is a gas insulated cables, gas insulated transmission lines are used since more than twenty five years for linking the power plants to the transmission network.

Basically, this is always it is used and it is already used for the lost twenty five years where we were using the power plant to connect the main grid, but it was the first was commission in 1975 in Germany about it was length was 700 meters. The first mixed GITL means the gas insulated transmission line in the world successfully completed its field trial with an endurance test in 1999. In Japan, we have the 275 kilo volt 3.3 kilo meter double circuit. The gas insulated transmission line this can transport about 300 mVA power, you can see this is 3.3 kilo meter gas insulated pipe is there where it is voltage rating is 275, it is very high value.

No doubt the cost of the gas insulated transmission line is very high, it is approximately 8 to 10 times those on the over head power lines which was earlier 30 times. So, with the development of new and new technology the cost of these the gas insulated transmission lines are reducing. Then, if it is sometimes it may be very power even the cost will be more, but you can imagine that there is no right of requirement there is no cutting of trees there. Again, it is a very reliable compare to the overhead lines, which is always expose to the environmental problems, so there is some lighting strokes and other required here, all the problems will be solved.

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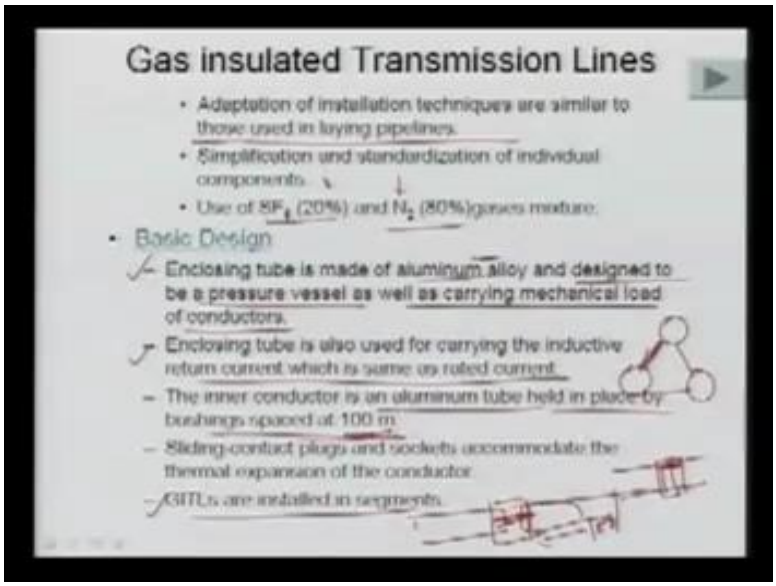

So, basis of reduction of cost was you can say the adaptation of installation of techniques is similar to those use in the lines pipeline. Now, the pipelines earlier it was very difficult because earlier people were digging the pipelines digging and then they were putting in the pipelines, but now going inside they keep in digging and putting the pipelines parallel. Then, it was very efficient and the cost of length is reduced tremendously the same time the simplification and extendarization of individual components are also trying to reduce the cost. Now, use of the sulphur flora, this sf 6, the 20 percent and end to gas mixture also reduce the cost.

Now, people are using nitrogen gas here 80 percent and the remaining this sf 6 gas 20 percent as I reduce the cost earlier only sf 6 was use which was very expensive. The basic design enclosing that here if you see the basic designer gas insulated transmission line that enclosing the tube is made of aluminum alloy. This tube we are the encloses that is aluminum alloy and design to be a pressure vessel as well as carrying the mechanical load of the conductor means this, which I am trying to sell here, the outside it is a aluminum alloy. It should be the load of this various cables supporting near disk insulator etcetera. So, it must be of that and also if you are putting the high pressure gas here that should also it should not burst.

We are using aluminum alloy because there will be some Eddy current over this here outside encloser. So, that will be also cool properly and then we can any way we can

minimize that. Now, here the enclosing tube is also used for carrying the inductive return current which is same as rated current because the current which are going here, we can use the encloses as the inductive current return and that is same as the rated current. So, we have to use the aluminum rather than normal cement or anything else. The inner conductor is an aluminum tube also now inside instead of wire, now we can go for the tube because if you are going for the tube, you can increase the radius and thereby you can reduce the corona.

Also, you can reduce the l you can also reduce you can increase the capacitance and you can search impedance load of the system can be increased tremendously. So, it is held in this space by the bushing is space in the 100 meter. You can see with this one we can put the core we can put the conductors even the 100 meter apart. However, in the overhead transmission line with several meters, it is not here is 100 meter, basically it is based the bushings means here 100 meter. This is your 100 meter between this two, no doubt the spacing between the conductor here we are using three conductors. Here, they are very close due to the how much insulated material you are using and they can be kept in this enclosed vessel.

The sliding contact plugs and the socket accommodates the thermal expansion of the conductor means we can have the some sliding conducts here the pipe is there. So, we can have some here sliding conducts here outside and it is here. So, this can be taking care expansion and contraction during the heating and non heating not the conductor. So, the GITLs means gas insulated transmission lines are installed in segments means here the pipe is this, then we can have another pipe and we can use sockets here, so it will be taking care of its transmission etcetera.

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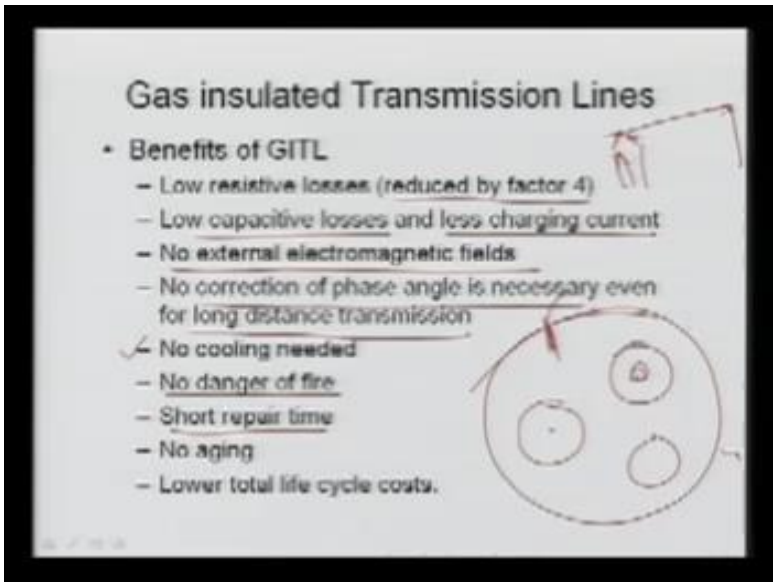

I have shown this diagram now you can see the benefits of gas insulated transmission lines are that it is low resistive loss it is providing and loss is reduced by factor 4, low capacity loss, less elective power charging of course. So, there is a less capacitive loss, no external electromagnetic fields, what happen, this you are having here the three conductors, let us suppose and this is circulated here. So, outside here it is a circular, so this is because you can see the field outside it will be 0. One current is going, one current is coming here, using your simple law, you will find the field outside is 0. So, no external electromagnetic field; however, in other it is not shown now no correction of phase angle is necessary even for long distance.

Here, the no correction of phase angle means if you are there is no displacement here in the phase angle. No cooling is needed here because gas itself is cool and loses are less. So, cooling is not required because here whatever the heat is dissertated this gas will be in conduct of ammonium and that will be coming out. No danger of fire is here is no fire at all because your gas is very prefers gas and it is a gas which is not inflammable it is not then there is no danger of fire. Here, you can repair very quickly the person can go inside we can correct it. Now, you can assume that if you are having the transmission line over transmission over head transmission line here and there is some problem.

So, you have to go at the transmission line and then you have to come on top and then you have to set down you have to maintain and then you have to go back here it is very

easily by looking by hand there is no need to go by riding on the tower. Aging is I said no aging here; it is not corroded because no atmospheric contents here are their it is a gas and it is a inner gas. So, here the corrosion etcetera, aging etcetera is very less and that is why the total here life cycle is minimized tremendously, voltage limit, thermal limit, high short circuit limit etcetera. That can be minimized with the fact, which already I have discussed in the previous two previous modules.

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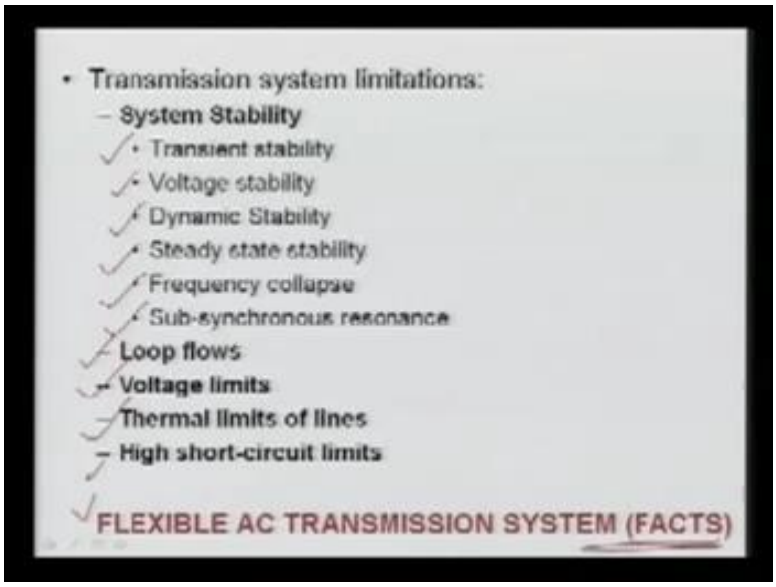

Now, in other way the development in the transmission side is your that is a your flexible AC transmission system, which already I have explained. It is solving several problems of conventional AC power system. Here, we had the various stability limits in such as a transient stability limit, voltage stability limit, dynamic stability limit, steady state, frequency collapse, sub synchronous resonance and also the various problems like loop flows. Again, we are having this power flow control which I have discussed that is your HVDC light.

In that HVDC light, here again HVDC light is a new development that is the improved version of HVDC. That also may come in the future and that is a new development which I have already discussed in the previous module when I was discussing the HVDC transmission systems.

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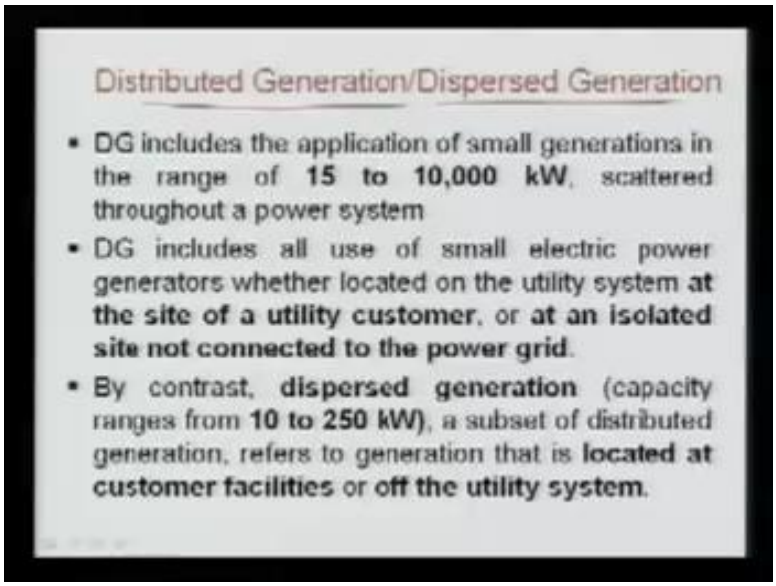

Now, let us go to see the distributed generations and the dispersed generation system. So, now let us see other development in the distributed generations and also dispersed generation. Here, the slightly difference normally people use the distributed generation very widely rather than dispersed generation. There is a minor difference between this distributed and dispersed generation, basically these generation no doubt they are used near to the load centers and they are distributed in nature. So, the DG that is the distributed generation includes the application of small generations in the range of 15 to 10 megawatt scattered throughout the power system especially near to the load center.

Dg includes all use of small electric power generators whether located on the utility systems at the site of utility customer or at an isolated site not connected to the grid power, means it can be near connected to the grid. It can be not connected to grid means it can be isolated and it can should supply power to the various customer. So, whether it is connected or not, if it is a small power generators and distributed throughout then it is called distributed generation by contrast the dispersed generation. Here, the capacity is range from 10 to 250 kilowatt, means this capacity is very small and subset of distributed generation here no doubt.

The distributed generation wide range its starting from 15 to 10, here it is 10 to 250 that is known as the distributed dispersed generators. It refers to the generation that is located

at the customer facilities and of the utility system, means it is near to the customer facility or of the utility system, it is aware from the utility system.

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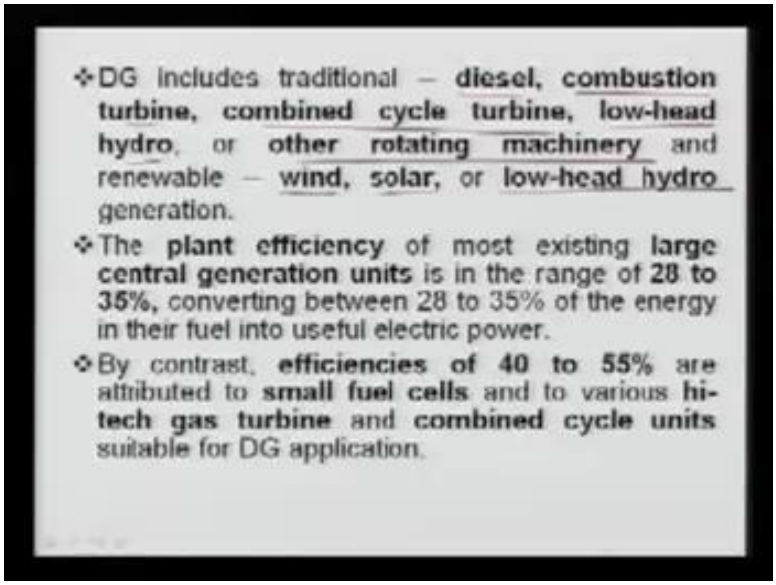

The DG includes the traditional diesel combustion turbines combined cycle turbines low head hydro and other rotation machine and the renewable like wind solar and the low head hydro generations The plant efficiency of most existing large central generation units in the range of 28 to 35 percent converting between the 28 of this energy in their fuel into the useful electric power. By contrast, the efficiency of 40 to 55 percent are attributed to small fuel cells and to various hi tech gas turbine and the combined cycle power unit suitable for DG application.

It means here we are using the high efficiency generating power station conventional or here having very small amount efficiency, it has almost developed that so that we can reduce the cost and we can supply power with minimum cost of generation or you can see cost of operation.

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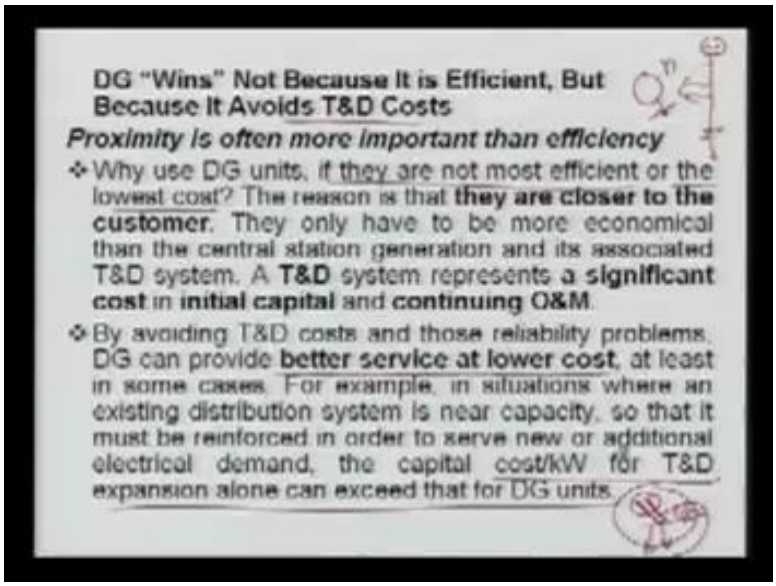

Now, DG means not because its efficiency not only efficiency, but because it avoids the T and D costs in the transmission distribution cost as well. The proximity is often more important than efficiency, why use DG units if they are not most efficient or lowest cost? Now, question why use the DG units if they are not most efficient or the lowest cost, means whether if they are not cheap or not efficient why we should use it? The reason is that they are closer to the customer they only have to be more economical than the centralization generator and its associated T and D system, T and D system represent the significant cost in the initial capital and the continuing O M.

So, even though if the let suppose your cost of your DG plus it is not efficient and more cost, but you can see that it is very near to the load center it is supplying power. Now, your load is here and then you have a generator here you have to add the cost of this transmission in this using system as well. So in that one it may be comparable and it is cheap option by avoiding the T and D cost and that reality problem the DG can provide the better service at the lower cost at least in some cases. For example, in the situations where an existing distribution system is near capacity so that it must be reinforced in order to serve new or additional electrical demand.

The capital cost per kilowatt of the T and D expansion alone can exceed the cost of those DG units. Here, I want to say that this here what happens, let us suppose your distribution system here.

Let us suppose situated here and this line which is coming, it is almost loaded to its full value. Now, if you are going to increase the load here, another connection here you have to go for another line. Then, the cost of this line will be very high not only this reinforcement may be other transmission line are also required to be added, but if you are putting here a one generating station here there is no requirement of T and D transmission distribution network.

So, thereby you are revising this and even though this is expensive the total effective value of putting this one if the cheaper option compare to taking the power from the gird term from the other forces. So, the DG's are the proximity is often more important than efficiency even though it is less efficient it is preferable and that is why people are going for the distributed generation.

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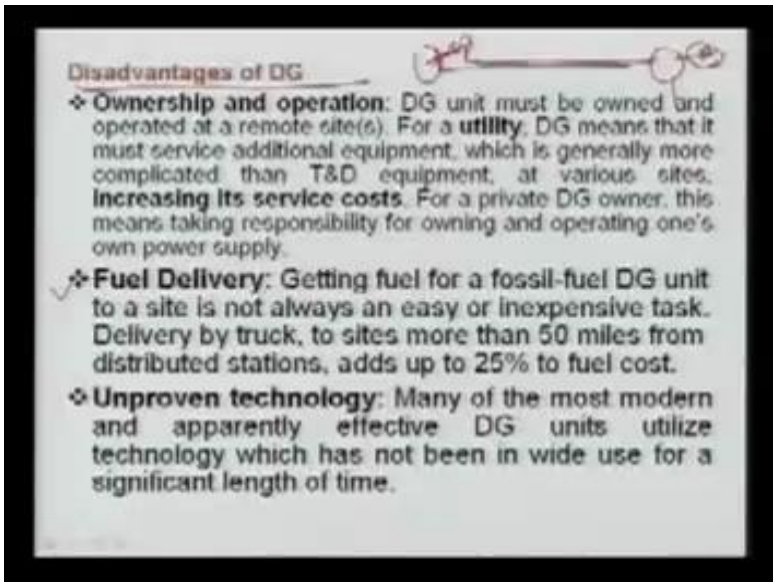

Again, this distributed generator is very important in the emerging power system, where the conventional operation means where the utilities were generating power transmitting and distributing the customer, now it is the different constant means that the different type of generating companies are there. They are competing to each other to sell power to the customer and that is why there is huge competition in this business as well. So, if we can have a large number of supplier's large number of genetic companies again we can have the more efficient free and fair electricity generation and the competition at that level.

So, the various advantages of DG units distributed systems are the ownership and operation. DG unit must be owned and operated at remote sites. For a utility, DG means that it must service additional equipment which is generally more complicated than the T and D equipment at the various sites. Increasing its service costs for a private DG owner this means taking responsibility for owning and operating once own power system. In other sense, here in terms of fuel delivery, the getting fuel for a fossil fuel DG unit to a site is not always an easy or inexpensive task delivery by truck to sites more than 50 miles from a distributed generation adds up to 25 percent of the fuel cost.

Also, there is unproven technology these are the disadvantage of DG just I am talking means the fuel delivery means suppose you are the fuel is near to the some coal mine and your DG load is here and you are going to generate power here. So, you have to transport this coal here and then you have to generate. Earlier, we were putting generator here and then we are putting the coal here and over the transmission line. So, sometimes it is very expensive to bring it here, but due to again new development it may be the cheaper option here unproven technology.

Many of the most modern and the apparently effective DG units utilize the technology which has not been in wide use for the significant length of time. It means that technology is not matured, but the technology of conventional power generations like thermal hydro nuclear and gas. That technology is matured and that power stations are running for more than 20, 25 years. In some cases, this is more than 60,70 years.

So, in the conventional generation the technology is the proven matured. Here, in the DG technology some of the technologies are not proven and still some R and D activities are on to improve the efficiency to mature the technology and to provide the reliability in some terms of generating units.

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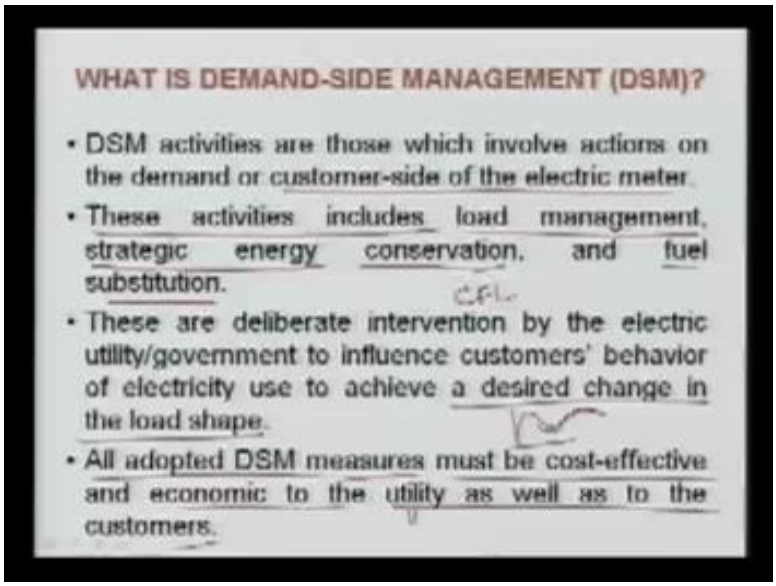

Now, let us see the distribution site what are the various development this generation is in we can include the distribution site development are in terms of generation development, but, that is the mixture of those. So, we can see the demand side the management question it arises what is the demand side management. What is the DSM programs and why it is needed? DSM activities are those which involve actions on the demand or customer side of the electric meter, means you can do something at the demand side or the customer side means both are same.

Then, it is known as the demand side management these activities include various activities that can be done on the customer side or demand side or load side the load management is strategic energy conservation and the fuel substitution. It means we can manage the load, I will just come to that point later what is the load management. So, we can manage this load we can go for the energy conservation and the example you can say people are using one of the example, means you can use the compact fluorescent lamp means 100 megawatt.

Your bulb can be replaced by a simple 8 or 13 watt cfi, so there is a huge energy saving load side management. So, energy conservation and the fuel substitution, means you can use electricity in terms of whatever you are using your gas and other thing. So, there is a fuel substitution is also possible to improve again always we are doing all the demand side management for the betterment for the customers.

These are the deliberate intervention by the electric utilities or government to influence the customers' behavior of electricity use. To achieve a desired change in the load shape means these are required so that we can change the load shape what is the load shape. Load that is varying and the system it is called load shape, we can change the loads shape for the various objective various requirements. All the adapted DSM measures must be cost effective and the economic to the utility as well as to the customer.

So, all the adapted DSM demand side managers must be cost effective, means it should not increase the cost. Effective idea is that you can reduce the cost you can improve the efficiency reliability of the system, so cost effective and economy both to the utility and the customers as well.

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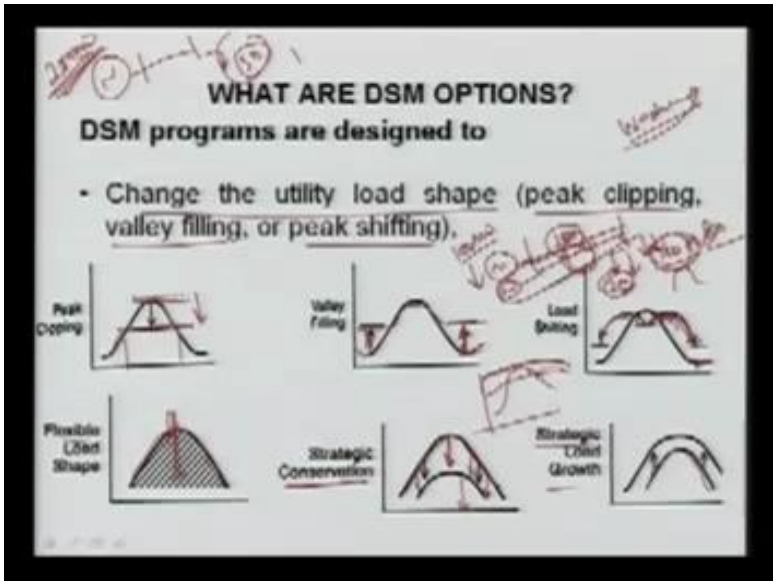

Now, what are the DSM options? The DSM programs are designed to change the utility load shape as I said in the load shape is your peak clipping valley filling or peak shifting. This peak clipping you can say the load on any particular utility let suppose like this. What he has to do? He has to have the generations up to meet this maximum demand plus which are margin and that may be peak may be occurring for the few hours. So, you can see in whole day there may be few hours are you may be sometimes in whole month or whole year that requirement is there. So, what you have to do? You have to put the generators for that meeting that capacity and that cost is very high and that generator is not utilized for full capacity for throughout the year.

So, that peak is very difficult to meet that and it will increase the cost of generation, but if any how we can just reduce this peak like this. Now, you can say this portion is quite for larger period and then you can say we can reduce the cost of total cost including capital cost etcetera that we will be in this. So, this is called peak clipping the idea here that we can reduce the total install capacity of the generating units also we require the transmission network for that providing power. So, it is a T and D requirement is also reduce significantly. So, here why reducing the peak it is very easy that we can total cost total effective cost per unit throughout the year it is reduced significantly.

Another is valley filling, you can say these are the valley filling here the people are not using, so what is that? That we can give incentive because during certain period your generation is very less your generators are likely loaded they are generating and you know if your generators are not loading to the full load its efficiency is less, cost of generation is more. So, during that period, if we can give some incentive, we can give something to the customer, please use this energy. Then, we can just lift this and we can have like this one and it is called your valley filling means we are just increasing the demand during the less demand period.

Another is your peak load shifting or sometimes called peak shifting, what we are doing instead of cutting here, we are doing something people are not generating we can ask the customer you can generate you can consume power during the periods. So, what we are doing we are shifting the peak, for example, the people who are using for washing purpose. There is no need to use the washing machine during the peak hours, they can use during the half peak hours and that can be done by let suppose we are offering that the price available during the here minimum generation minimum demand period is cheap. People automatically try to use their appliances during that period to save the cost of electricity.

So, this is basically one way that we can go for the load shifting into peak and shifted. So, again the total installed capacity of the generation also requirements are transmission distribution will be reduced significantly. Now, the flexible loads shape here this is your load shape, so we can have the flexibility in the load shape. Whenever this occurs, we can change that is the also one type of load shape change. Here, the conservation is one option means this is your normal peak demand, if you are going for the energy conservation.

You can reduce your curve to this value and then you can see there is a great advantage. There is a great achievement and then we can you can see here the cost of total not it is the energy conservation is saving money to the customer, but at the same time it is the saving money to the utility as well. For example, you can understand less about this is you are having the generator this is the transmission line. Here, you are having a load of 100 megawatt; this generator is also having 100 mega watt capacities this load is keep on changing no doubt. This transmission capacity is also 100 megawatt and then it is the supply no doubt.

Now, what is happening if you are doing some energy conservation? Here, let suppose your consumption is reduced to 80 megawatt, now the 20 megawatt load can be given together and other loads can be connected. So, whatever without changing this generation and transmission line that is 20 megawatt is same? So, this utility is not going to install new one, this utility is not going to built new transmission line and the same transmission line is working and it is power to other customers as well. If you are not doing the energy conservation, some 20 megawatt is increased; you have to go for on line you have to add another generator.

So, this cost will be added and this will be due to this cost now the total production cost total cost per unit including the capital cost etcetera that will increase in the cost of this customer as well as this customer will increase. So, if the saving is in two types, hence means it is a saving by yourselves you are consuming less and there is no edition of capital investment and that is why they issues use you can also saving. Another is load growth you can say your load is this, now you can ask the people you can give some incentive that people can generate more so that you can utilize your power properly.

For example you are having a generator, just install here and one line is left to here and your load is here 15 megawatts total loads of customer and you are having 2 mega watt unit here, what is happening? This generating unit is running at the 200 megawatt, 50 megawatt all the time, if this is your fixed demand, there by the efficiency of this is less and also use capital cost is put it here that is not applied properly. So, we can ask this here customer generate and then they can go for 200 megawatt so that we can have the more efficient power system and at the same time the total cost of operation will be reduced and then it will be saving to the utility as well the customer.

So, it is called load growth that we can do in such a fashion that instead of having this peak. We can ask that we can have a high voltage growth here and then we can operate our power system very efficiently.

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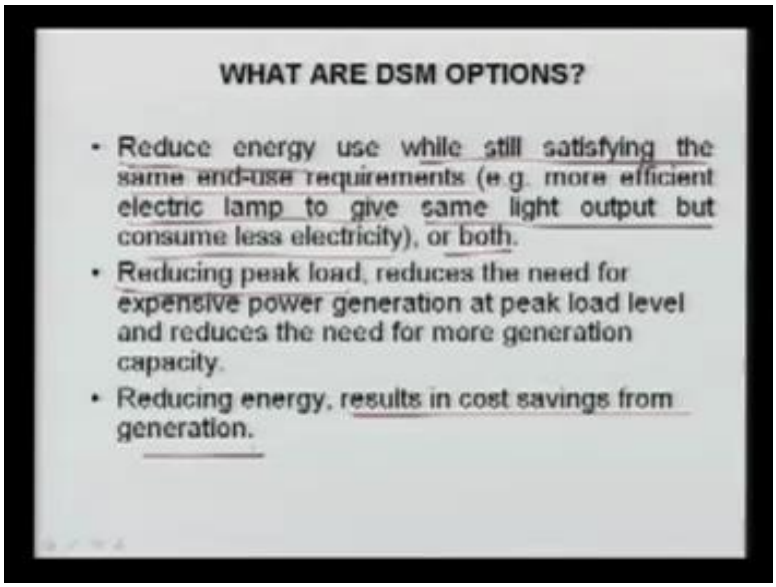

Now, question is what are the demand side options? The demand side options are basically reduced energy use while still satisfying the same end user requirement. Here, I am saying that we should not go for the load setting as we are doing right now in our country because we are having the limited generation limited resources. So, loads are more generation is less than we are going for. Here, you have to reduce the energy use while satisfying as I said is still satisfying the end user requirement. Requirement should not be just it should not be dark the requirement should be same, means more efficient electric lamp to give same light output, but they consume less electricity or both.

For example, just the placing 100 watt bulb by the 18 watt bulb that is your saving this is 70 here, 82 watt power, but the light this flux this light intensity is same. So, that is why it said the end use requirement should not suffer and it should be same and then it is called is one up that reducing energy requirement. Another ratio reducing peak load reduces the need for the expensive power generations at the peak load level and reduces the need for more generation capacity we require more capacity at that time. Also, it is reducing the energy results in the cost saving from the generation. So, if you are reducing the energy, then it will also reduce the cost saving at the same time.

So, there are various options are available in the power system and that we can discuss here. So, in this lecture although we are going to have one or two more lectures again, but, in this lecture you can see just we saw the various development in the generation side. In the generation side, we saw the development in the power former that includes your generator and generating transformer together. Also, we saw the various developments in terms of mechanical development. It means different type of turbine also very efficient cooling system that we have increase the voltage level also insulation level so that we can go from more power or voltage in the generating side.

Also, like the wireless improvement and also several other devices that we are taking place. Same time, you can see the various distributed generators they are also the technology keep on improving. We are expecting in the near future for the other type of renewal energy sources because the conventional energy sources, they consume the forcing fuels and that we are having limited. That keeps on going to exhausted so that we can use those conventional or non conventional energy sources for the generation of power and again there is lot of R and D works activities are going on.

In terms of transmission development, we saw that there is a HDVC light development gas insulated transmission line development also people are keep on increasing the voltage level to transform more and more power of the transmission line. Also, another addition to the flexible AC transmission system that we can control it surely; we can utilize the transmission network to its full capacity by installing the various new technologies, especially the flexible AC transmission system. One of those examples by that we can utilize the whole network resources to its maximum its full capacity rating and that is we are getting great advantage all of that.

In the distribution site, there is also there is the huge development in terms of basically demand side programs where we can see and already that the demand side programs are very useful for both utility as well as the customer perspective. We will see in the next lecture that what are the various the DSM options what are the categories for the DSM actions etcetera. We will see some examples for this promotional development and various methods, then we will go for these organizational changes what are the new changes that is occurring are taking place in the imaging power system.

Thank you.