DC Microgrid and Control System
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Lecture - 24
Intelligent Microgrid Operation and Control (Continued)

Welcome to our lectures of the DC Microgrid and Control. We shall continue with our first part, that is the left out portion of the GA and the multiagent system. Then we shall talk about the energy management in the microgrid system. So let us see how much portion I can cover today.

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So that is the multiagent system we have will discussed. Thereafter MAD that is a multiagent systems, its application in the microgrid. Then we shall discuss about the energy management system and that that has some subpart, that is a load forecasting, weather forecasting, demand side management, state estimations, and the power flow module and the load leveling and the peak shifting. These are very important things in our, not only in microgrid but also the but also your normal applications, but also in a normal grid.

So let us continue with our portion of the GA, that is genetic algorithm, so which was left out in our previous lectures.

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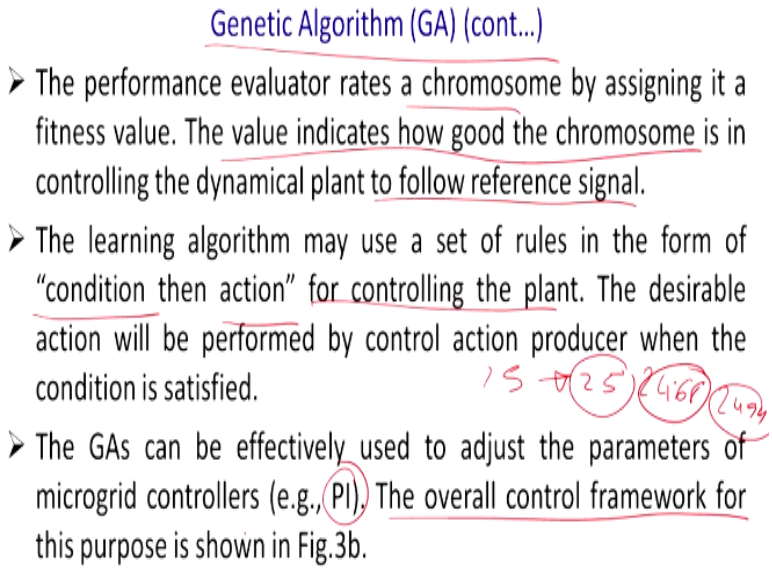

The performance evaluators rates the chromosome by assigning a fitness value. So you have to every chromosome will be tested, let us say you want to calculate this the square of the functions. So if you give 5, it should give you 25, so you will accept that 2% error may be. So if the value is 24.68, then it is not fitted with it, you reject that value. If the value is 24.99, you accept it, as simple as that. So that is the case. The value indicates how good the chromosome is in the controlling the dynamic plant to flow the reference signal.

So you will select those chromosomes only. The learning algorithm may use to set the rules in the form of the condition then actions. You had a FLC that is called if-then logic and here you have a condition then action. If this is the condition, then this is action, overshoot is more, then reduce the overshoot. If your settling time is high, reduce the settling time, increase again.

The controlling for controlling the plant, the desirable actions will be performed by control actions, control action producer when it is satisfied that is the fitness value, where your settling time you have achieved within this, you have got a peak overshoot within the 2%, fine, then you say that finish, and GA can be effectively used to adjust the parameter of the microgrid controller, for example P I. The overall control framework for this purpose is shown in Figure 3b, so that was in your previous slides.

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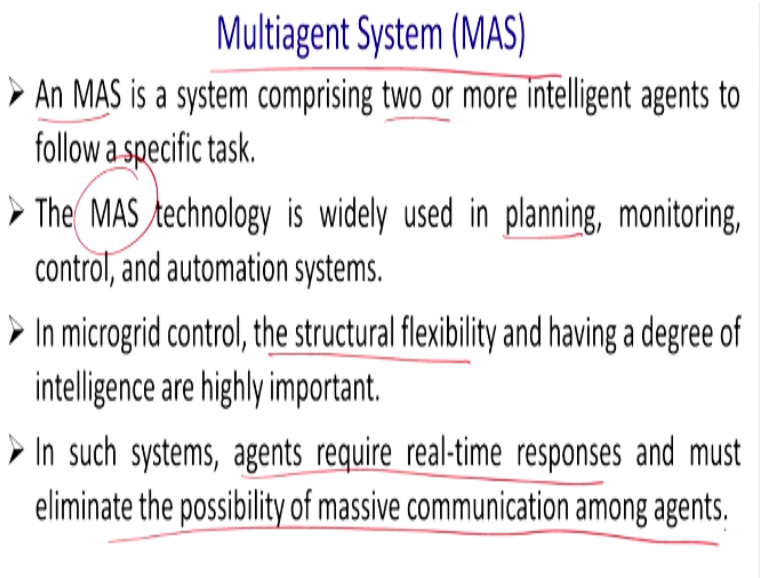

Now let us talk about the multiagent system. So the multiagent system, it is something very great amount of importance in our microgrid, DC microgrid or AC microgrid, because you have different stakeholders and the point one microgrid was a net consumer can be the net producers, so and this entity also the time dependent, it is not fixed. Today most of the houses are the consumers, but in case of the microgrid, they also sell us and they can have an energy storage element.

So it is a multiagent system and agent change their behavior, that is the one of the unique features of our microgrid. The MAS that is the abbreviation of the multiagent system, is compromising comprising the 2 or more intelligent agent followed by the specific task. The multiagent systems' technology is widely used in planning, monitoring, controlling, and automation system, so that is very useful for our modern way of living.

The micro in microgrid control, the structures structural flexibility, that means source can be turned into the load and vice versa that is a structural flexibility, and having a degree of intelligence are highly important. So you have to incorporate into the knowledge that yes this is possible. In such system, agents requires real responses and must eliminate the possibility of massive communication along the agents.

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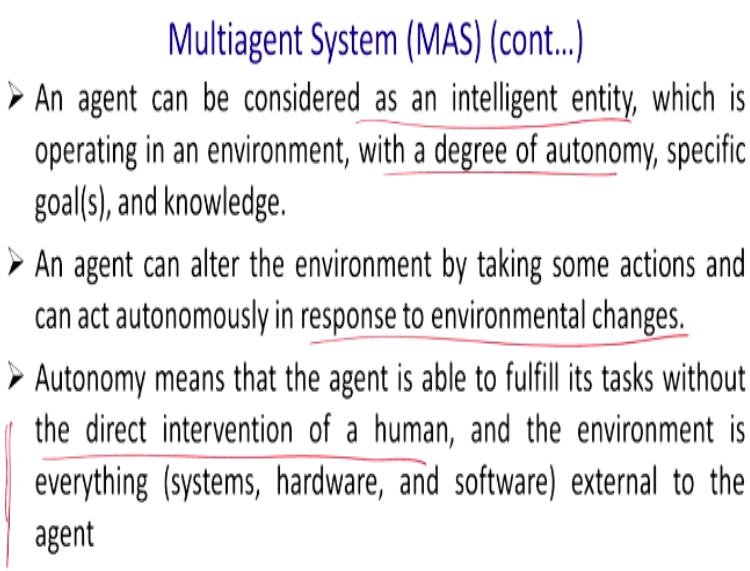

So an agent can be considered as an intelligent entity, which is operating in the environment with a degree of autonomy, specific goals, and knowledge. An agent can alter the environment by taking some actions and can autonomously in response to the environmental changes, so that is also possible. You got a you if you have a shortage of the production for the rainy day or something, then you may cut down the non-critical load intelligently.

Maybe you require an AC that is operating may be at 23 degree centigrade, without telling you smartly you know, it keeps the temperature maybe 26 degree centigrade and in that way, it saves a lot of power and that helps you to maintain the overall comfort level in a microgrid, that is also possible. The autonomy means that the agent is able to fulfill the task without the direct interventions of the human.

Of course, generally in the microgrid, there can be a super user, he or she can write off the intelligent control, but generally intervention is kept as less as possible and one person is given the responsibility only. So you don't have direct human intervention and smartly it can implement the control and the environ uh and the and the environment is everything, the system, hardware, software external to the agent. So that is something we have a multiagent system.

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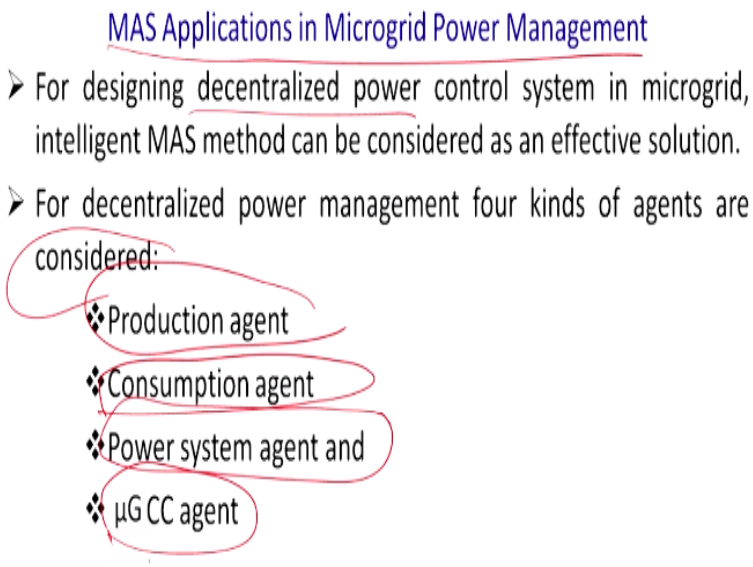

So MAS application in a microgrid power management, this is one of the very important topic to understand. For designing a decentralized power control system in the microgrid, intelligent my MAS method can be considered and is an effective solution also. For decentralized power management 4 kind of agents are considered. One is production agent, that is a solar plant, wind, you may have a fuel shell.

Consumption agent, mostly these are loads, but it can be a bidirectional also. Power system agent, that mean the active rectifier and all the ending point of this your grid, and MGCC agent. These all will be discussed in detail, that is basically microgrid current controller agent.

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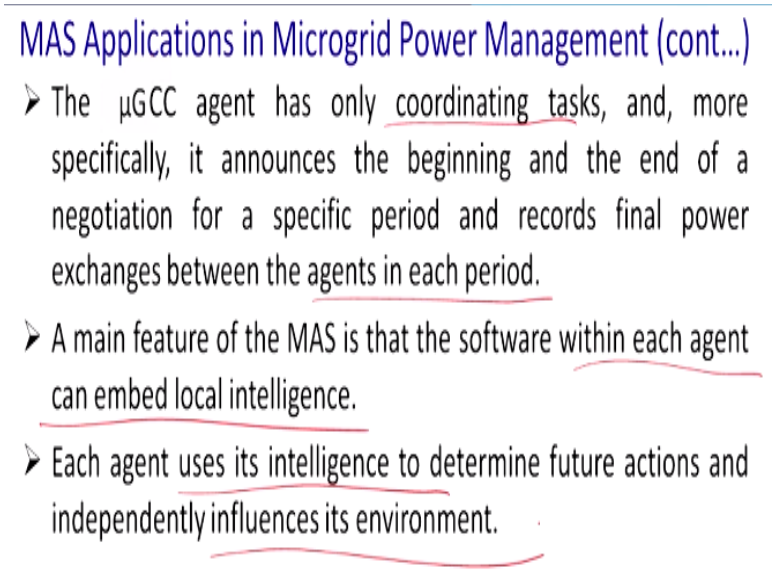

So microgrid controller that is agents has only coordinated tasks, generally it takes only the

coordinated task and more specifically it announces the beginning and the end of the negotiation for a specific period and records the final exchange of the power or any entities, most mostly power, between the agent in the each period. The main features of the MAS, that is the multiagent system, is that the software within the each agent can be embedded with the local intelligence.

So it can take its own decisions, it can you can put ANN or fuzzy logic controller within it and within our limitation, it can take its own decision to give you the optimal control. Each agent uses intelligence to determine the future actions and independently influence the total environment. So it is a critical load. If it finds that generation is more, then it may actually start the pending work which has been postponed because of the tariff was high. So this is something it can intelligently do that, you need not have to bother.

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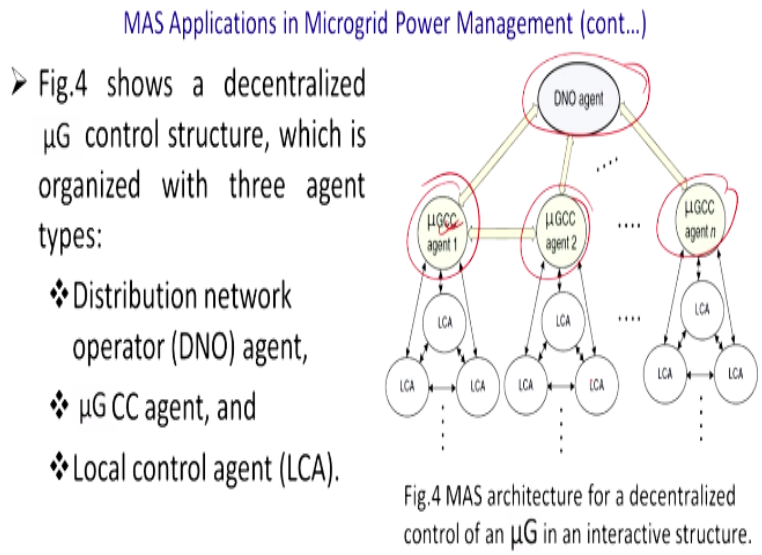

This is the overall pictorial diagram or the architectures of the decentralized control of the microgrid in the interactive structures. So this one is a microgrid, another microgrid, another microgrid, this is agent 1, agent 2, and agent 3, and in between you have a local control agent. This is named as LCA and so LCA can interact directly with a microgrid agent as well as it can interact among themselves.

If there is an energy surface of this microgrid, of course it can transfer energy and it can talk with each other to the PS and overall there is a DNO, that is called distribution network operator agent. This is the ultimate stakeholder of this all small microgrid and this will monitor and maybe dictate the terms sometime to monitor in a different way. This is the

centralized structures of the, decentralized structures of the microgrid in case of the MAS system.

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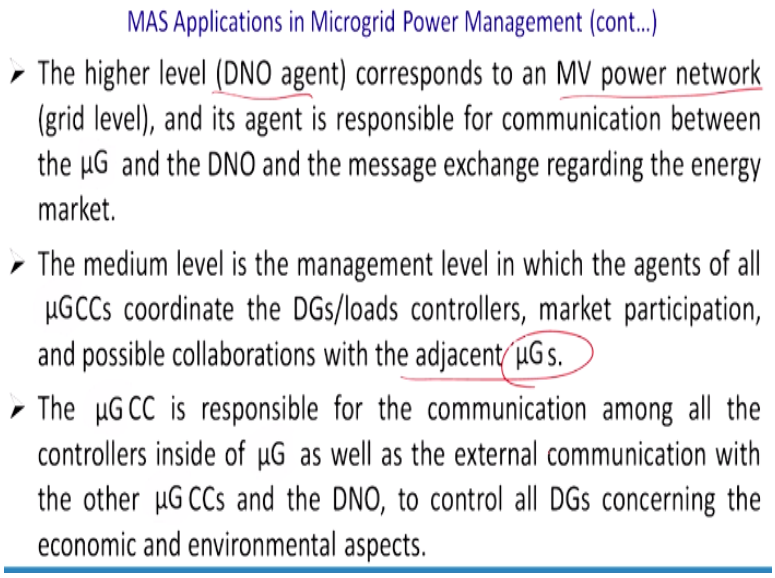

Now at the higher level, decision-making body is the DNO. The higher level that is DNO corresponds to an microgrid power network grid level, so maybe the grid and a micro all the small microgrid will interact to the DNO and its agent is responsible for communication between the microgrid and the DNO and the message exchange regarding the energy market. So whether your microgrid will sell the energy because of the excess power or take the energy when there is a demand in the microgrid, so that DNO will design and set the tariff accordingly.

The medium level management is a level in which the agents of all the microgrid coordinate with local generator or distributed generated, loads controller, market participation, and possible collaborations with the adjacent microgrid. The microgrid MGCC controller is responsible for the communication among all the controller inside the microgrid as well as the external communication with the other MGCC and dn ultimately with the DNO, that we have seen in this figure.

So ultimately, it can communicate also with another MGCC or with the DNO to control all distributed generators concerning the economic and the environmental aspects of the power dispatch.

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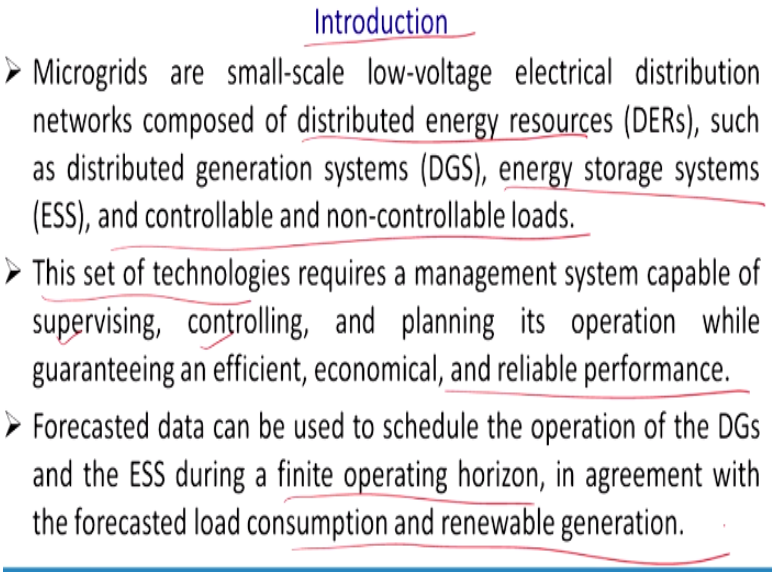

Now, now let us talk about another issue that is microgrids are small scale voltage electrical distribution network composed of distributed energy sources that we have told several times and such as distributed generation system, energy storage system, and controllable and the non-controllable loads or uncontrollable loads. Now we have to set or fix a technology to control all of them.

This sets of technologies requires a management system so this is a power management system of the microgrid, supervising, controlling, and planning, sometimes we require to plan because you know that in night there won't be any solar, so we require to increase the state of starch of the storage element that means our batteries to a some level, and accordingly you may once you in a day time, you may have to shed some kind of loads then and planning its operation while guaranteeing an efficient economical and the reliable performance.

So you should not have any power cuts, that is the requirement, and then what forecasted data can be used to schedule the operations of the distributed generations. When you have a forecasted data that solar will be this much of generations, wind will be this much of generations, and the ESS during the finite operations or finite operating horizons, and the mismatch will be fed into or taken from the storage element in agreement with the forecasted load consumptions with the renewable generation.

So, forecasting is one of the major part of the microgrid and we require to have a forecasting quite reliably, otherwise whole system can be messed up.

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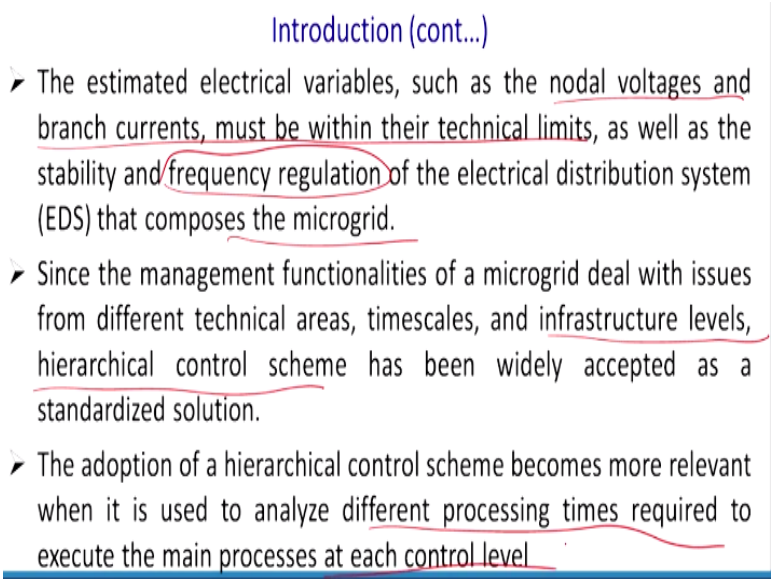

Now, the estimated electrical variables such as the nodal voltages and the branch current, must be within the technical limits. So, we generally apply the droop control in case of the DC microgrid, so how much amount of the droop will be allowed in case of the environmental changes that has to be in a technical limit as well as the stability and the frequency regulation if it is a AC microgrid of the electrical distribution systems that compose the microgrid.

Since the management functionalities of the microgrids deals with issues of the different technical areas, timescales, and also infrastructure level, so you may have timescale that is that has to be sustained for 1 hour and it may be 6 hour somewhere and also different kind of infrastructure, if it is a hospital, you got a lot of critical loads, and if it is a mall, then you have a very small amount of critical loads, mostly in lifts or you may have emergency lights up to some extent.

So, then infrastructure level also will take clause of your control system, and so we require, a hierarchical control scheme has been widely accepted as a standardized solutions, so who will control what, local control will be there some extent if it is a communication between two microgrid, so someone has to, they will talk with each other and upper level in DNO, there will be another hierarchy.

So, adoption of the hierarchical control schemes become more relevant, please note our different kind of control system, master-slave, peer-to-peer, and hierarchical control. So what we are saying in a multi MAS system, you got the hierarchical system that has to be that has

found to be advantageous and the control scheme becomes more relevant when it is used to analyze the different processing time were required to execute the main process at such control level.

For this reason, we require to cut autonomy in a peer-to-peer network and it cannot operate in a master setup mode because all the burden will be on the central system, and for this reason, we require to delegate the power, some will be taken by the local administration, something like that, and some will take another central level. So same way, we have a hierarchical protocol in case of your in case of your also the power management system for the microgrid.

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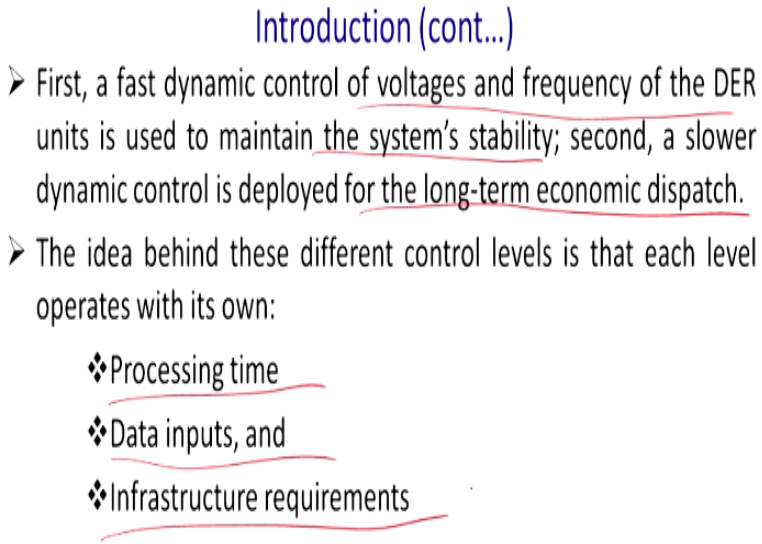

First, fast dynamic control of voltage and frequency of the DER unit is used to maintain the system stability, distributed energy resources that is that consists of the generations and the storage element , it will be used for maintaining the stability. The second, a slower dynamic control is deployed for the long-term economic dispatch. Then the idea behind these control levels is that each level operates within own.

So it depends on the processing time, you got a data inf inputs, and you got an infrastructure requirement, whether how many critical loads are there and how much power cut you can allow for the small interval of time, or how much you can allow to change over; these are the issues.

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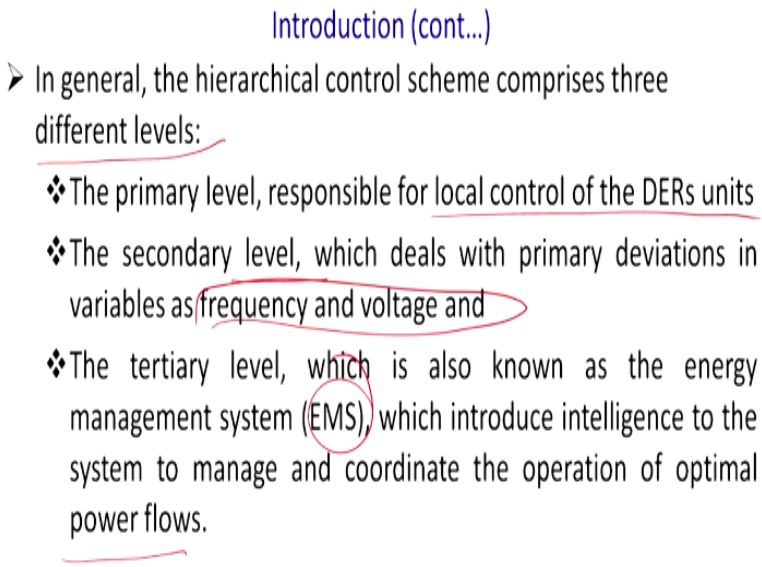

In general, the hierarchical control scheme comprises the 3 different levels. The primary level is responsible for local control of the energy, distributed energy resources. The second level generally, it deals with the primary deviations in the variable of the frequency and the voltage in micro, in AC microgrid this is the frequency and voltage, in DC microgrid it is the voltage and thus you got an advantage.

The tertiary level which also known as the energy management of management system, that is EMS, which introduced the intelligence to the system to manage and coordinate and coordinate the operation of optimal power flow between that different microgrid as well as the main grid, so that is called the tertiary level of control.

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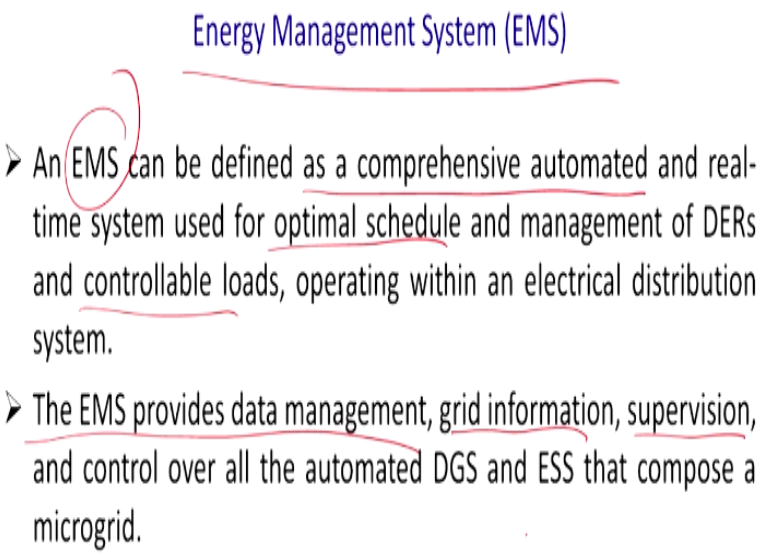

Now what we are talking about in much detail, that is the energy management system. It is a

holistic information based on forecasting, load shirring, load forecasting, weather forecasting, planning; all are the entities of the energy management system. So an EMS that is energy management system can be defined as comprehensive automated, no one does, no human being but you can employ the human beings right of options but it is generally automated.

And real-time system used for the optimal scheduling and management of the DERs and controllable loads, operating within the electrical distribution system. So there are uncontrollable load also, so that is something we require to understand which are the uncontrollable loads, and that also we require to take a purview of something in a controllable loads. The EMS provides the data management, grid formations, supervisions, and control over the automated DGs and ESS that compose a microgrid.

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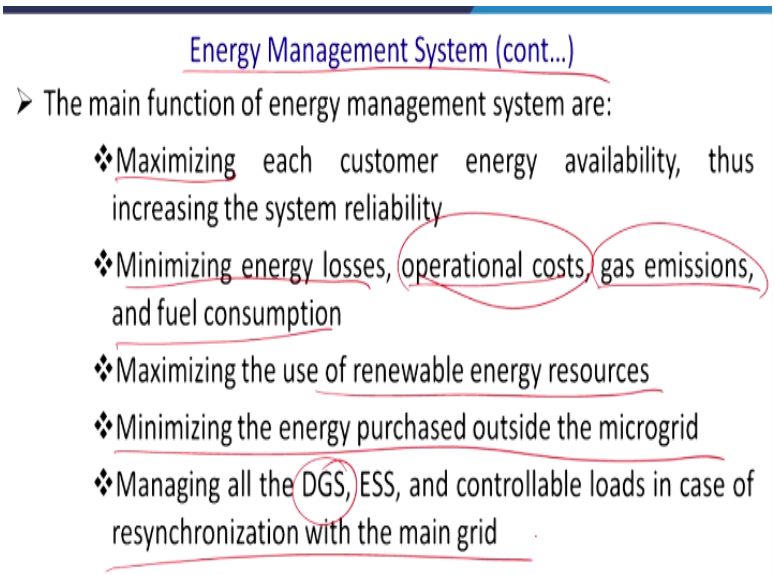

Now, let us talk about the energy management system and what are the entities and the scope of the energy management system. Thus main functions of the energy management systems are these are the follows. Maximize the each customer's energy availability and thus increasing the system reliability. So you are required to say no to the load shedding, and if you are saying this thing to the rural India, we see that what kind of achievement you are going to achieve where getting power was a challenge.

Minimizing energy losses, so we require to efficiently manage our energy so that transmission-distribution losses are being minimized and there are many issues, not only electrical issues, there are also issues related to the commercial aspect and that required to be also minimized; operational costs, gas emissions and the fuel consumption. If you have a

support of the DGs and that increases the cost, diesel generator not distributor generator, and that will emit and pollute your neighborhood and this is also a cause of concern.

Minimizing the issue of the renewable energy, maximizing the usage of the renewable energy and minimizing the use of the fuel-based power and also minimizing the energy purchase outside the microgrid, you try to cut your coat according to your cloth, so you require to spend the whatever you generate in your microgrid and try to have a least power demand from the main grid, and if you possible try to feed that power to the grid.

Managing all the distributed generations and the energy storage element and controllable load in case of the resynchronizations with the microgrid, that we have seen that we have a different kind of control mode, PQ control mode once you have connected to the grid-connected mode, once you have offline or the islanding mode, you are in a V/f control in case of the AC microgrid and also you may if it is a, we apply the droop control in case of the DC microgrid; those all manage.

Some portion of it can we have a droop control, some portion, the portion which you well to make it a DC microgrid, can be AC microgrid, and thus you go for the V/f control.

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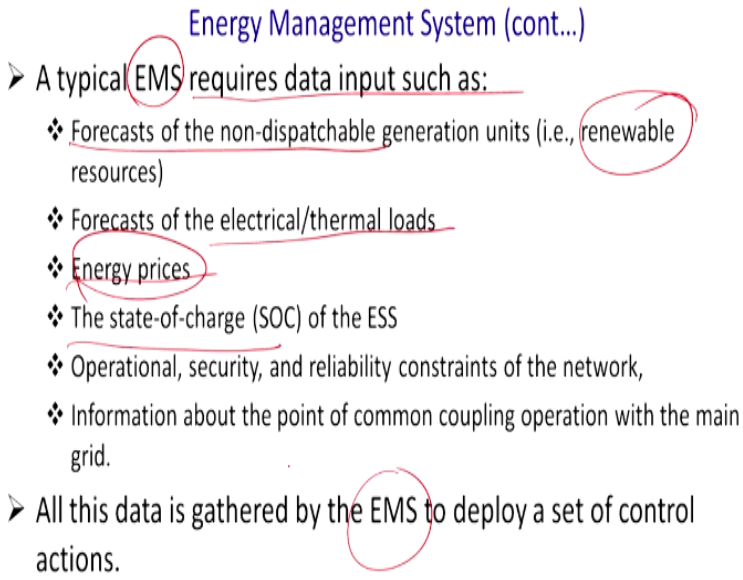

Now what are the typical applications of this energy management system that is EMS, require datas, we require lot of input data and require very fast processes, that is a too requirement and thus require huge amount of strand uses. First, forecast the non-dispatchable generator units, this is generate the renewable sources, how much solar will generate, how much wind

will generate, that you should have a data.

Forecast of the electrical and the thermal loads, thereafter energy pricing, unfortunately in India for the domestic purpose or pricing is same, we don't bother to actually and on more consumption even at the peak hours, but we required to have a dynamic energy pricing depending on the availability of the energy. The state of the charge of the storage element, if it is a battery.

Operational, security and the reliable constraint of the network, so whether it should not be hacked by the hackers or the terrorists so that all those problem may come up and mess up. Informations about the common coupling point at the main grid that also to be known. All the data is gathered by the EMS is deployed to set the control actions by the different kind of controller and mostly we prefer in this case hierarchical control.

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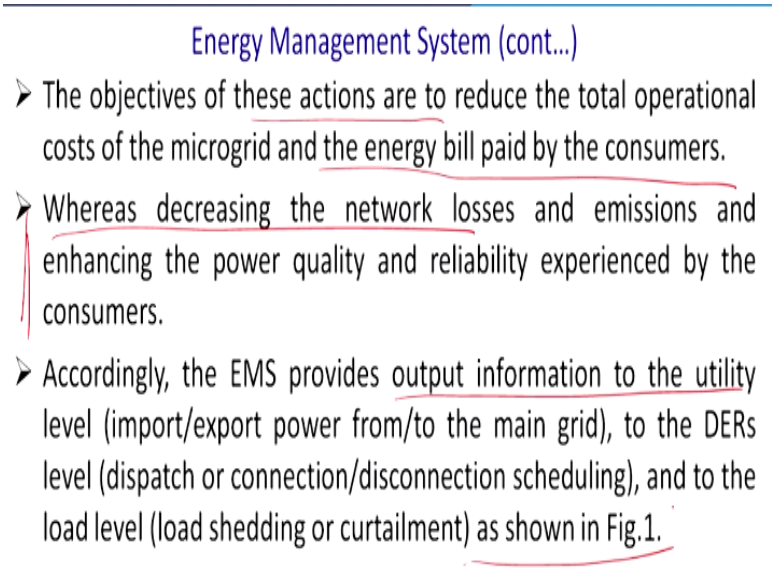

The objectives of these actions are to reduce the total operational costs of the microgrid and generate the bill that is paid by the customer that will be required to be minimized. So this is a multiobjective, you require the reliable power, and but also you req the consumer should pay less and you have a different kind of control level also, and thus what you require to do when he saved his money earned. Decreasing the network losses, emissions, and the enhancing power quality, reliability experienced by the consumers.

So you got a power anytime, it is not that you supply power when you have a surplus, it is very important you should able to supply power to the consumer when they require, and thus

this term is quite important. Accordingly, the EMS provide the output information to the utility level that is the import and exporter or the power purchaser, import and exporter power from the main grid the DES level, dispatch or the connection or disconnection scheduling and to the load level, the load shedding or the curtailment of the load.

These are the few aspects of the energy management system. We shall continue our some portion left out of the energy management system, then forecasting and other issues in the next class. Thank you for your attention.