DC Microgrid and Control System
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Lecture - 02
Concept of Microgrids

Welcome to our lectures on DC microgrid system. We shall discuss today the concept of the DC microgrid. This is our second lecture. So we shall give you, this will be our presentation layout today. That is introductions. Thereafter we shall see the different kind of microgrid structures.

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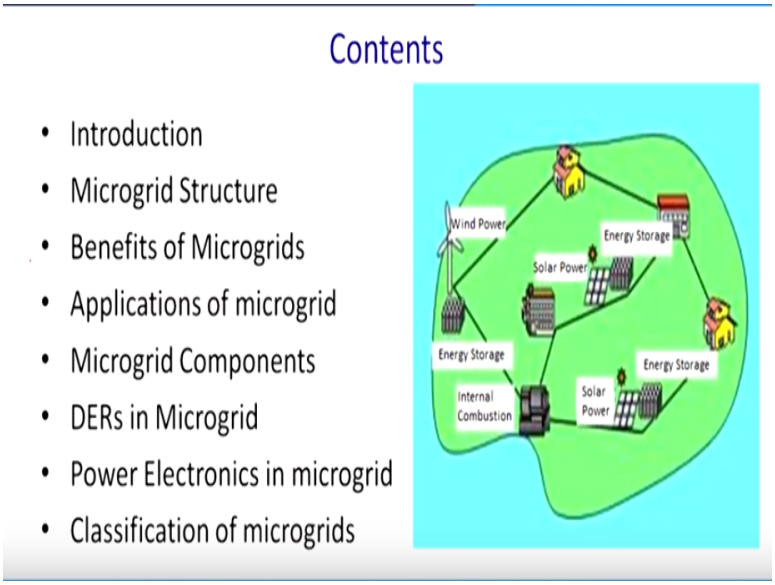

And then from this structures we shall discuss later the benefit of this actually benefit of microgrids. Then application of the microgrid. Then different entities that means the component of the microgrid. Then distributed energy resources of the microgrid and you will see that what are the different level of penetration of the power electronics in microgrids and then classifications of the microgrid.

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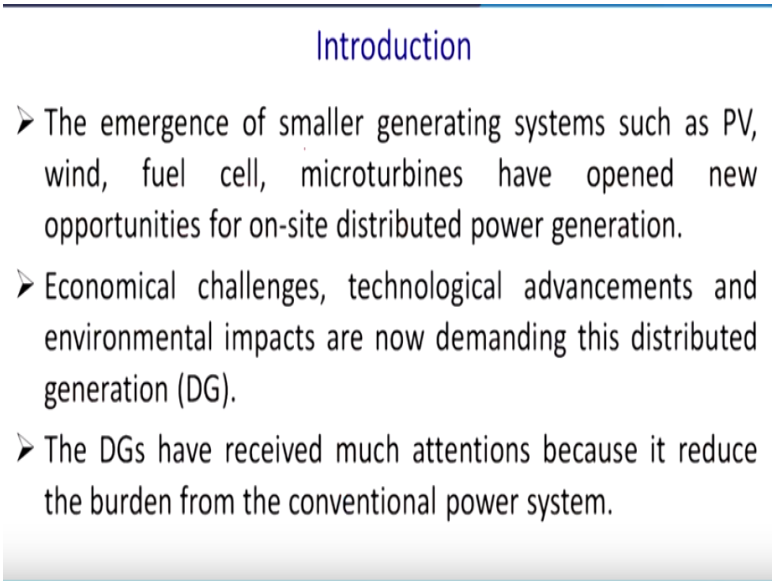

Now with the emergence of the smaller generating system such as solar PV, wind, fuel cell, microturbine have opened up the new opportunity for on-site distribution of the power generations. Because this generates power at the low level, lower level power as well as voltage. So no point of stepping up very high voltage level and transmit it. So for this reason we have a almost on-site installation and on-site consumptions.

It is something like the rural economy. So it grows the food in a village and it is consumed within a village. So it is a self sufficient village concept. But not the proposed you know. So we revisit the same kind of village concept in the microgrid. Thus economical challenges, technical advancement and environmental impacts are now demanding this distribution generation.

So self sustained microgrids and that can be a village. These DGs have received much attention. This is the distributor generations because it reduces the burden from the conventional power system that we require to have a monitor totally and dispatch the data. Huge data mining data processing and it is a total a centralized system and if something happens in a transmission line whole network will suffer.

There will be a huge revenue losses. So there are many disadvantage of the centralized power system. And thus we are gradually looking after the microgrid solutions.

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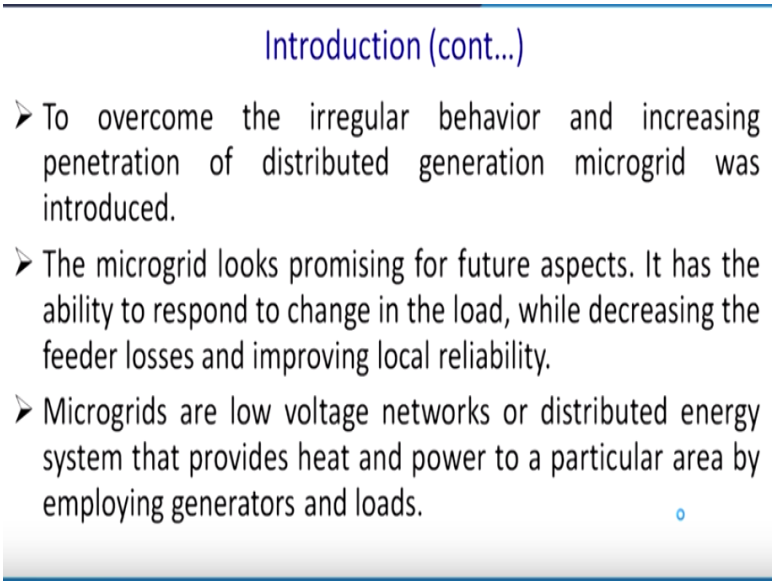

To overcome the irregular behavior and the increasing penetrations of the distribution generations, microgrid was introduced. Though it was started in USA, there is no problem but this problem is well suited to address huge number of villages and the rural electrification in India. For this season it has a huge significance in Indian context. So microgrid look promising for future aspects.

It has the ability to respond to the challenge in the load because power system has a traditional way of thinking that we have to meet the demand. So to continue to produce the large amount of power. But here philosophy is different. You require to spend energy as you have generated. The ability to respond change in the load while decreasing the feeder losses and improving the local reliability. So this is the one of the advantage.

So catastrophic failure and all those things will never occur here. Because there is a load and source mismatch, then only this kind of emissions comes into the picture and this should not be. Microgrids are low voltage network or distributed energy system can provide heat and power to a particular area employing generator and the load. Of course solar heating system can be the part of your microgrid.

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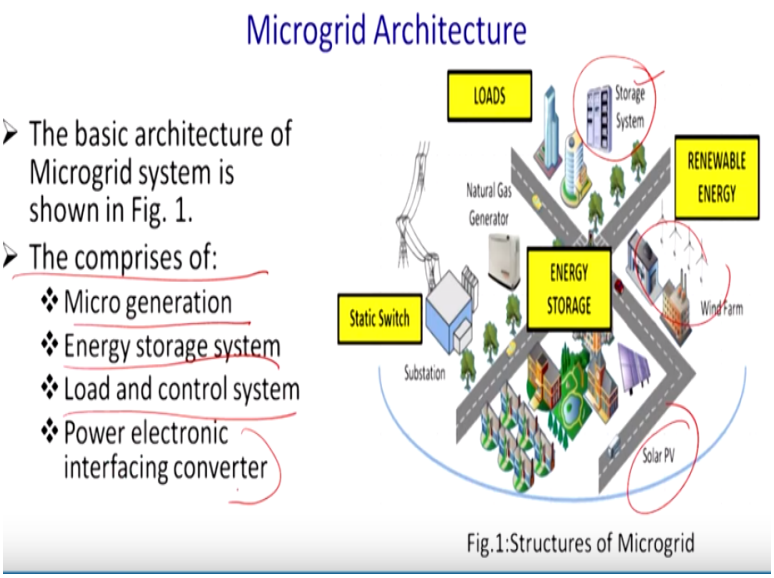

Fig.1:Structures of Microgrid

So this is one of the architectures of the structures of the DC microgrid. You have nowadays due to penetration of the digital datas you have a huge storage element and that require a DC system. You may have houses or malls. Then you may have a substations and you may have wind farm close to the seashore and you may have a rooftop or the car parking solar park. From there actually you can generate the energy.

And you will have a battery or any other storage element that will store the energy. So we have the basic architectures of the microgrid is shown in the figure No.1 and it comprises of micro generations. So these are micro generation. It may be generating 100 kilowatt or 200 kilowatt, something like that. And you will have a storage system since size of the storage is not very large.

And thereafter we have a load and the control system. We have to segregate the critical and the non critical load and accordingly actually tariff will be fixed. So for this reason we have a storage element that is basically a maybe a critical load and you may have the some lights for ornamental purpose that is non critical load you may switch it off.

So and thereafter power electronic interfacing converters because you may have a different load require different kind of voltage and frequency, maybe in case of the DC microgrid and if it is DC microgrid it may require a different kind of DC voltages. For this reason you require power electronics interface and converter. So this is the small structures of the microgrid.

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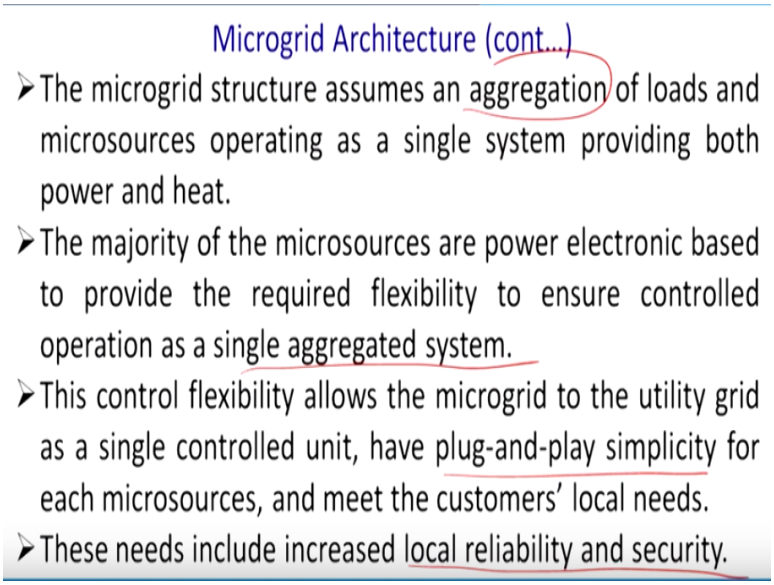

So let us discuss the architecture of the microgrid. Microgrid structure assume and aggregations of load and microsources operating in a single system providing both power and heat. And maybe for the winter countries it will be very useful to generate power for the room heating purposes or other applications. Majority of microsources are power electronic based to provide required flexibility to ensure control operation as a single aggregated system. So it will stand united as a one unity.

That means the aggregated system means. The control flexibility due to this power electronics it has a fast control mechanism. Control flexibility allows microgrid to the utility grid as a single controlled unit, have plug and play simplicity for microsources to meet the customer needs. So this is a one of the great aspects. You can switch it on and switch it off loads.

If you do not want to be connected to the grid, you switch it off and go to dilating mode. If you find that you do not have a load you may switch off your solar inverter and you can operate this way. The need include increasing local reliability and security. So you do not have to have, fiber securities are very big threats. So this kind of challenges is not there since you have a local reliability and security checks at local level.

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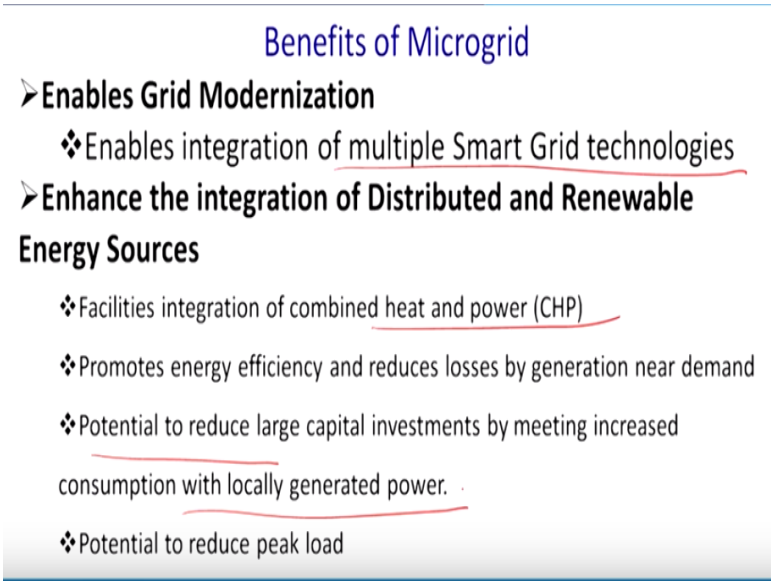

Enable grid modernization. Enable grid modernization of multiple smart grid technologies. Enhance the integration of distributed and renewable energy sources. Facilitates integrations of combined heat and power. So that is a quite modern concept. It is a concept of the green building where heating element can be incorporated with the power element.

Promotes energy efficiency, reduce loses by generations near demand and potential to reduce large capital investment because if you are setting up a large grid so you have to have a transmission line to be put, transformer to be put, stepping up stepping down, whole feeder to be put. So this is a huge investment. So for this reason potential to reduce large capital investment and it may not be meaningful if your consumers are quite low.

But you cannot deny to the access of the electricity to them. So for this reason this microgrid gives a huge opportunity to scale the upliftment of these people those who are denied electricity. And consumption with the thus what you do you have a solution consumption with locally generated power. You put a solar power plant at that village and you generate the power and feed that power in that locality, potential to reduce the peak load.

Because you may have a energy management system you have stored the storage element. So for this reason in evening maybe you may not take any power from the grid if it is a grid connected system in that way you can help to reduce the energy management system, peak power management.

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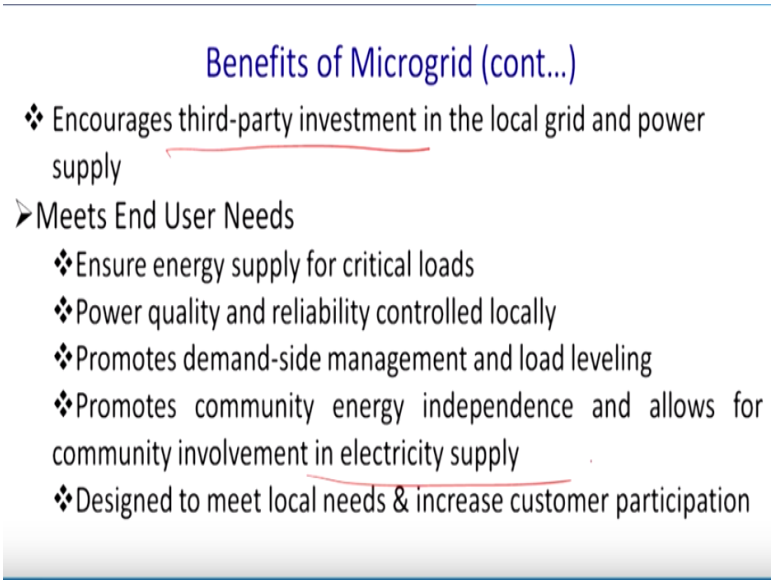

So benefits of the microgrid encourage third party investment in the local grid and the power supply because someone has to manage its architecture, its maintenance, its software and thus this is the scope of the third party investment. And that gives also the huge opportunity to the local youth. Meet user needs, so ensure energy supply for critical load. That is the one of the priority.

Power quality and reliability controlled locally. So it is not controlled centralized so where they will put this actually this power quality equipment like shunt active power filter or something that the local body does not have a say. So you can monitor and generate your own supply. Promotes demand-side management and load leveling like if you have less generations so accordingly you will have a, get rid of the useless load since it is a local level control. So you have a more synergy while doing it.

Promotes community energy independence. So that will help us to build a self-reliant villages. So we talk about the self-reliant villages now we can have a self-reliant power efficient villages and allows for community development in electricity supply and they also have a stake on those microgrid. So for this reason local body will have a more say and the control over it.

Designed to meet the local needs. So that is one of the aspect. Every village has some uniqueness. So you can address those uniqueness through this microgrids and increase the customer participations. Now application of the microgrid.

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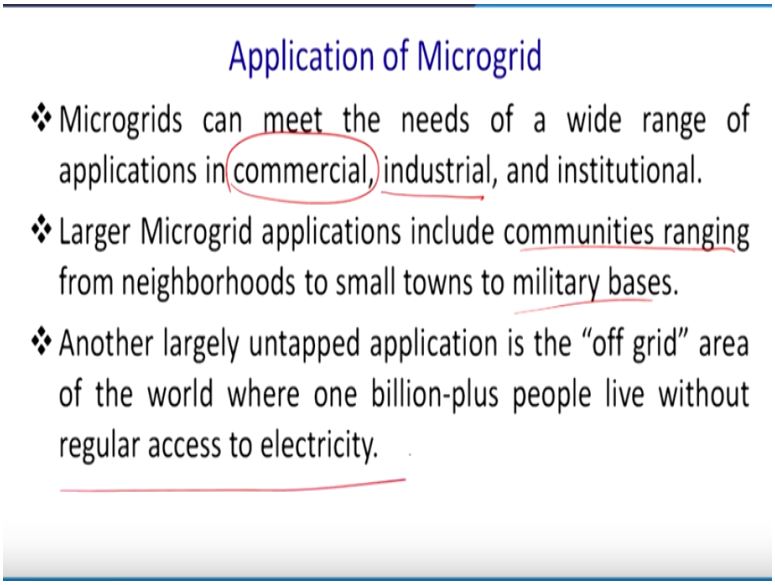

Microgrid can meet the need of the wide range of applications in commercial, industrial, and institutional as well also for the domestics. Commercial like you can think of one shopping, big shopping complex as an isolated entity and you can have a solar rooftop system and the car parking solar system and you may have a huge industrial house. They can put a solar system or wind and the institution like us we have around huge amount of solar institutions in almost all the roof tops in our institute.

So this can, all can be treated as the microgrid. Larger microgrid application include communities ranging from the neighborhood to the small town to the military bases. So these can be a small military bases where power reliability is an issue that will seek and establish a microgrid. Another largely untapped applications is the off grid area of the world where billion plus people lives without the regular access to the electricity.

So this is the great challenge and the access to the electricity and that can be achieved by the microgrid.

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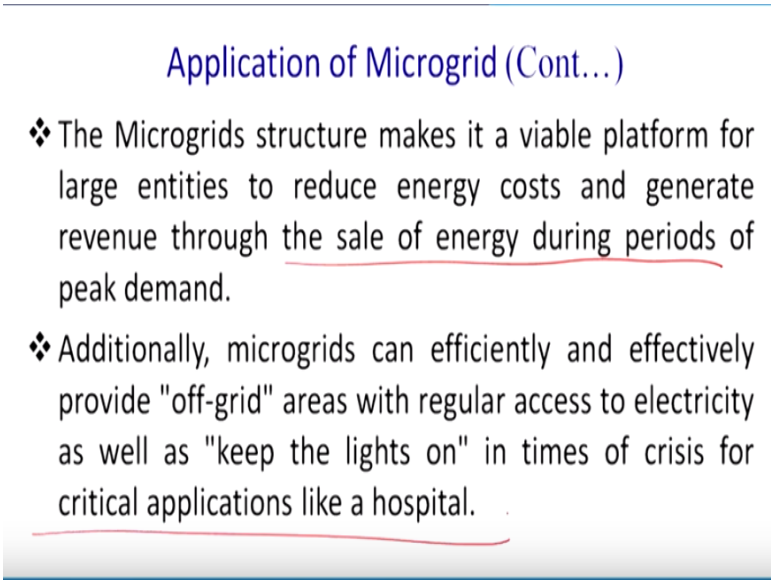

Microgrid structures makes it a viable platform for large entities to reduce energy costs and generate revenue through the sale of energy during the period of the peak demand. That is also one of the way to look at it. So once you store the energy and you sell it when you have a maximum power demand in the centralized system. Additional microgrid can efficiently and effectively provide off grid areas a regular access to the electricity.

That is what I was saying as well as keep the light on, on the time of crisis for the critical application like hospital or any other critical applications.

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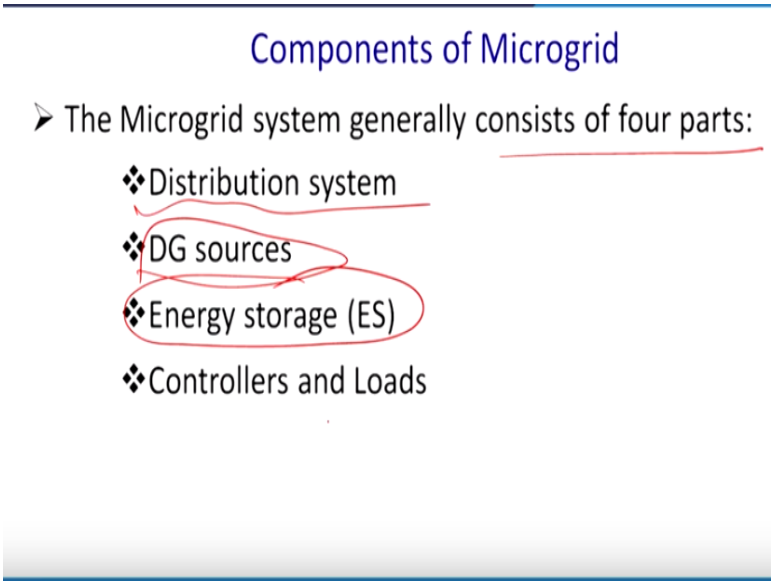

Now we have discussed in the previous class also microgrids are generally consisting of four parts. One is distributed system. So you have a ring kind of architecture or some kind of architecture where it is a distribution network. And you have a distributed generation, solar wind microturbine all those things and the storage elements or the

energy storage. These are batteries or other entities ultra capacitor and controller and the loads. Load accordingly will be switched on based on the available energy availability. So for this reason you require a controller to control the loads.

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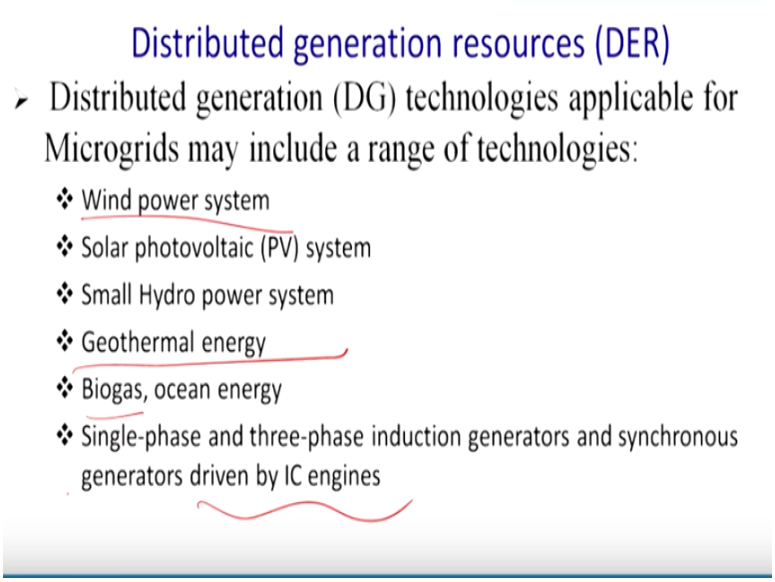

Distributed generation technologies applicable for microgrid may include a range of technologies because we have a wind farm thus we have a wind power system, solar photovoltaic system, small or micro hydro power system, geothermal energy, biogas ocean energy, single phase to three phase induction generator and synchronous generator driven by the IC engine. Sometime this is also used as a, these are basically the diesel generator. We are generally putting off this more gradually for the environmental issues.

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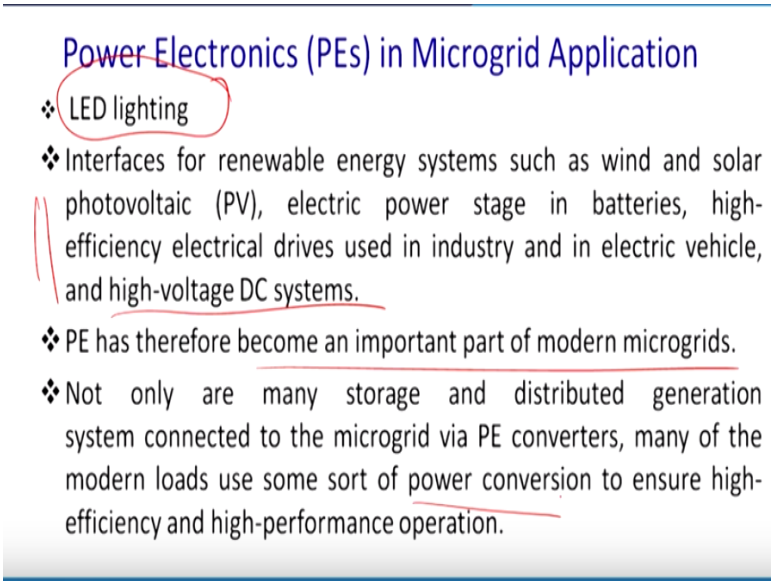

Power electronics microgrid application we have a very efficient lighting that is LED based lighting that will save our power consumption like anything. Interface for the

renewable energy systems such as wind and the solar photovoltaic, electric power stages in batteries, high-efficiency electrical drive used in industry and the electric vehicle and high voltage DC system. These are mostly the applications of your power electronics part.

You may have a electric vehicle charging scheme. You may have batteries to have a peak power management and you may have adjustable speed drive based lifts. So these are all part of the power electronics in microgrids. So PE has therefore become a important part of the modern microgrid for this reason.

Not only are the many storage and the distributed generations system connected to the microgrid wire, power electronics converters, many of the modern loads use some sort of the power conversion to ensure high efficiency and the high performance operation. Like your all the LED has to be provided by the LED driver. So it shall ensure the proper and you may want to have a dimming or you may have to have a increasing the lighting.

And you may have a smart lights like once the person goes then light will be switched on. Then once people is not there, to save the power consumption light may be off. And you may have a adjustable speed drive to control your centralized AC's. So these are few entities of the power electronics in modern microgrid.

But this is applicable in the institutional level, not in the (()) (20:19) level. So you may have a different kind of microgrid suiting different kind of requirement. If it is a industry, if it is a shopping complex it is a different kind of microgrid and if it is a village you have different kind of microgrid and different kind of load.

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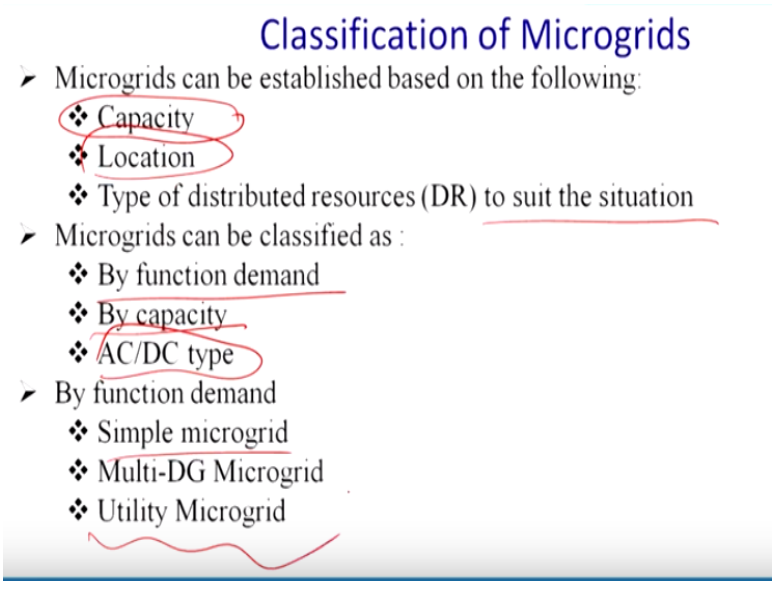

So microgrid can be classified based on this entities that is the capacity. So how much

capacity; 100 kilowatt, 10 kilowatt. These are the capacity. Based on that it can be categorized. And there are location. Whether it is a shopping mall, it is a commercial building, whether it is a industrial building, whether it is institution, whether it is a small village community. Based on that we can classify it.

Type of distributed resources or DR to suit the situation. So in a village we require different kind of scheme and in an industry we require different kind of scheme. So accordingly we shall design it. Microgrid can be classified best as by function demand. So how it will perform. So if how the load will pop up accordingly it will be. By its capacity to handle the power.

And whether it is a AC type microgrid, whether it is a DC type microgrid or it is a hybrid AC DC both, will be some part is AC some part is DC that is the hybrid microgrid. a somebody hybrid microgrid. And we shall later actually shift to the only the DC microgrid. Our course is on the DC microgrid. By function demand, simple microgrid. So you may have a one entity or two entities and one load.

So that constitute a very simple control logics and that is a simple microgrid. Multi distribution microgrid and you may have a utility microgrid. So these are the different kind of microgrid based on your classifications we can make it. Now let us see few things.

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Classification of Microgrids by capacity

Type	Capacity (MW)
Simple microgrid	< 2
Corporate microgrid	2 - 5
Feeder area microgrid	5 - 20
Substation area microgrid	> 20
Independent microgrid	Depending on loads on an island, a mountainous area or a village

Simple microgrid we generally have the capacity of below 2 megawatt. Later corporate microgrid mostly we may have a electronics complex something like that in Bangalore or Hyderabad. So they will have a small microgrid and this may have a capacity of 2 to 5 megawatt. Then feeder area microgrid is a quiet large some semi urban setup and is a quite a large energy it will cater. That is around 25 to 20 megawatt.

Substation area microgrid holds substations of around 20 megawatt power can be made microgrid. So that is called substation area microgrid. Independent microgrid this is you have a Sagar Island in West Bengal, it is a independent microgrid. Depending on the load on an island or a mountainous area or the villages you set a independent isolated microgrids. What is simple Microgrid?

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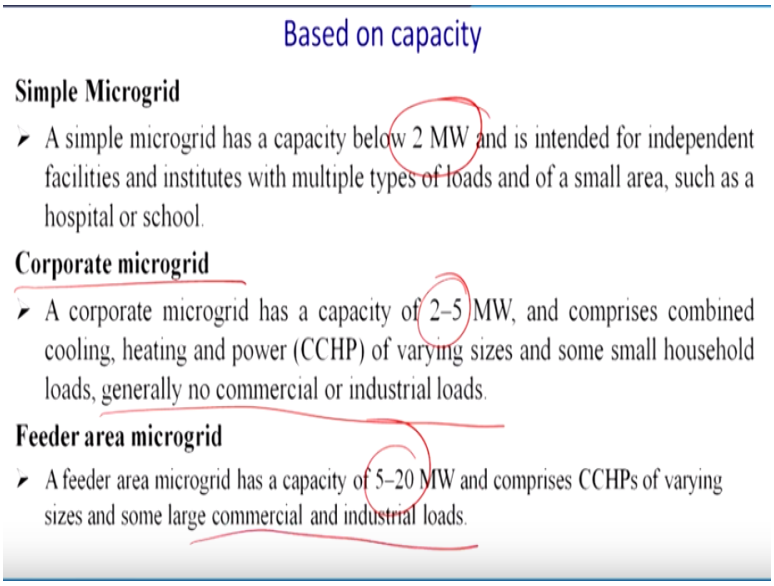

A simple microgrid has a capacity generally below 2 megawatt and intended for independent facilities and institutes with multiple type of loads and of a small area such as hospital, school, institute. These can be catered by the simple microgrid. Later corporate microgrid. Corporate microgrid has a capacity of 2 to 5 megawatt and comprise and combine cooling, heating power and varying size and small household loads generally. No commercial installation is being connected here.

So this is basically a corporate microgrid. Thereafter we will have a feeder area microgrid. The feeder area microgrid has a capacity of 5 to 10 megawatt comprises of CCHP size and a large commercial industrial load may be present here. And now next comes definitely the substation area microgrid.

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Based on Capacity (Cont...)

Substation area microgrid

- A substation area microgrid has a capacity above 20 MW and generally comprises common CCHPs and all nearby loads (including household, commercial, and industrial loads).
- The aforementioned microgrids are connected to common grids and therefore are collectively called grid-connected microgrid.

Independent microgrid

- An independent microgrid is mainly intended for remote off-grid areas such as an island, a mountainous area, or a village, and the distribution system of the main grid uses a diesel generator or other small units to meet the power demand of such areas.

Substation area microgrid has a capacity above 20 megawatt and generally comprises of the common CCHP and nearby load including household, commercial, and industrial loads. All can be put into the same segment. And aforementioned microgrids are connected to the common grids and therefore collectively called grid-connected microgrids. Generally these have huge capacity.

And last that is the independent microgrid, so independent microgrids are mainly intended to remote off grid areas such as islands, mountainous areas, villages and distributed system of the main grids, use a diesel generator or other small unit to meet the power demand of such areas.

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By AC/DC type

- Microgrids are classified into DC microgrid, AC microgrid, and AC/DC hybrid microgrid based on voltage and current types

DC Microgrid

In DC microgrid, DG, ES, and DC load are connected to a DC bus via a converter and the DC bus is connected to AC loads via an inverter to supply both DC and AC loads as shown in Fig.2.

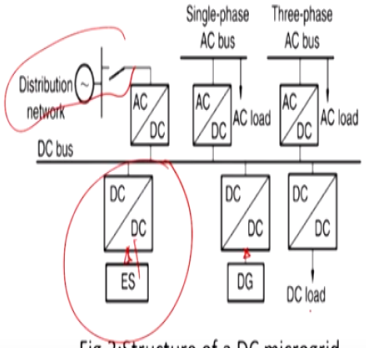

Fig.2:Structure of a DC microgrid

Now comes to the AC DC type microgrid. Microgrid are classified into DC microgrid, AC microgrid, AC DC hybrid microgrid. This is a DC microgrid. Our topic is on DC

microgrid. The DC microgrid where distributed generation and the storage element and the DC loads are connected and DC bus via converter and the DC bus is connected to the AC load via an inverter to supply the DC and AC load as shown in the figure.

See that actually this is the entry point of the grid. So it will connect a active rectifier. So for this reason what will happen, you will inject power with a good power quality. Thereafter you may have a single phase AC bus from there you rectify it, feed it here. That you may have a three phase bus and you can feed it here. And this is the DC bus and you may have a DC to DC converter to store the battery and it may be bidirectional.

Similarly it may be a distributor generation like solar and it may feeding to it and you may have a DC load. This power is unidirectional. This power is bidirectional and this power is also unidirectional considering that is a DC load. So this is the structures of the DC microgrid. Similarly you may have a AC microgrid.

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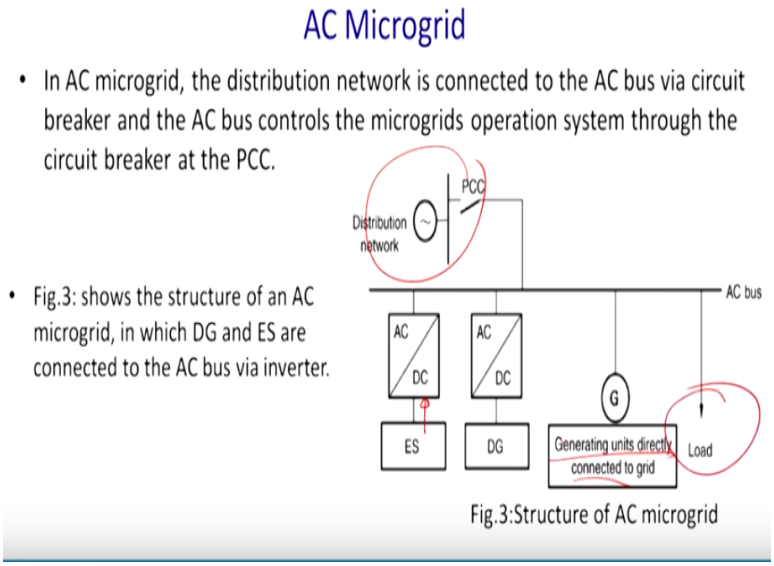

So AC microgrid distribution network is connected to the AC bus by the circuit breaker and the AC bus control, the microgrid operation system to the circuit breaker and PCC. So this is your entry point of it and you may have a battery storage element. So it is AC to DC. So it is bidirectional and you may have a DC distributed generation like solar.

So for this reason first you have a process received and you will convert into the AC and feed it to the bus and you may be actually connecting generating get directly connected to the rectifier or you may have a AC loads that can directly fit to the AC bus.

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AC/DC Microgrid

- An AC/DC hybrid microgrid is a microgrid consisting of an AC bus and a DC bus.

Fig.4: shows the structure of such a microgrid, in which the AC bus and DC bus allow for direct supply to AC loads and DC loads.

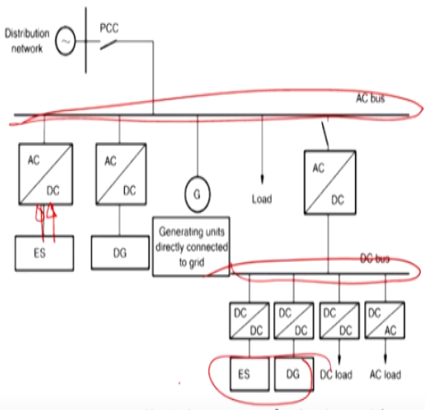

Fig.4:Structure of AC microgrid

And now you have a microgrid that is AC DC that is hybrid. Some portion is AC and some portion is DC, see that. Here you got a DC bus and here you got a AC bus and in between they are connected by the AC to DC and DC to AC bidirectional converter and for this reason this is called the microgrid. Power can enter for the distribution network and you can have a AC to DC converter and store the battery that is a bidirectional.

You may have a DC generator and that my feed to this AC grid and you may have a direct connections of the AC generator and you may have AC loads and similarly you can have a DC bus. From there you can have a power of it is actually DC, DC load and DC generator and they can interact via a AC to DC converter. This is the structures of the hybrid microgrid. Now thank you for your attention. We shall continue to our discussions on the DC microgrid in your next classes. Thank you.