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A REVIEW PAPER ON POWER EXCHANGE AND TRADEWITH INCLUSION AND INTERCONNECTIONS OF MICROGRID

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ABSTRACT

This is a review paper discussing about the benefits of establishing an interconnections microgridsas weknow that for growing electric energy demand, there is a significant increase in the penetration of distributed generation (DG) to fulfill this increase in demand. Interconnecting DG to an existing distribution system provides various benefits to several entities as for example the owner, utility and the final user. Similar to conventional power systems, the energy management of distributed generation resources (DERs) is carried out to minimize the operation cost and maximize benefit of installation of DERS in microgrids. The short-term DER scheduling function for a power flow microgrids performing economic dispatch through optimal power flow simulation. Economic dispatch (ED) problem is one of the most important optimization issues in power system closely related to unit commitment .Providing bad solution for ED may affect generation negatively. Thus ED helps to allocate power demand among committed generators in economical manner.So, the objective remains to study for exchange & demand through optimal power flow strategy incorporating economic dispatch, trade process ideology, and draft market ideas for startup micro grid interconnected network so as work in deregulated electric power system.

Keywords: DER, Optimization, Microgrid, Power Energy, Interchange, Economic Dispatch, Unit Commitment.

I INTRODUCTION

A microgrid can be defined as a low-voltage distribution system to which small modular generation systems are to be connected. A microgrid consists of small generation systems and electrical loads through a low-voltage distribution network. In microgrid, we find small installation of the renewable energy sources that can fulfill the load demand. The microgrid can be installed for a village or a small town [2].The integration of distributed generators based on renewable energy resources (RER) and micro sources like photovoltaic system, wind turbine, microturbine using CHP system, fuel cell and batteries with storage facilities etc. has initiated more recent concept of microgrid which is considered as a cluster of interconnected distributed generators (DGs), loads and intermediate storage units that cooperate with each other to be collectively treated by the utility grid as a controllable load or generator towards

an evolutionary power solution for scarcity of fossil fuel in near future. The integration of microgrid with RER is evolving as an emerging power scenario for electric power generation, transmission & distribution. In this prospective, IEEE-P1547- 2003 is a benchmark model for interconnecting DERs with Conventional Electric Power System [3-4]. All these different types of renewable energy sources have one advantage that they produce less pollution and they are in abundance. Among all types of the renewable energy resources, the wind power is the most cost effective technique and the wind power generation is also increasing considerably as compared to photovoltaic cells and bio-gas plants. The advantage of the locally installed renewable sources is that they help to reduce the transmission losses. Microgrid can operated in both grid-connected and islanded-mode. It can be operated manually by switching off the loads when the main gridis disconnected and power generation is less than the demand or in case of external faults. We can improve the function of a microgrid by some computerized modeling at planning stage. As per the requirement of the customer it can be designed to meet his special needs and provide additional benefits, such as improved power quality and reliability, increased efficiency through co-generation and local voltage support [2]. The scopes of microgrid seem to be higher dependability of service, better quality of power supply, and better efficiency of energy use by utilizing the available waste heat from power generation systems too. The capacity to make use of renewable energy with modest pollution and potentially less costs is attractive and gains gradually more interests in many countries. Additionally, distributed generation can benefit the electric utility by decreasingovercrowding on the grid, reducing the need for new generation and transmission capacity, and offering supplementary services such as voltage support and demand response [1].
The schematic diagram of a typical microgrid is shown below in Fig. 1.1.

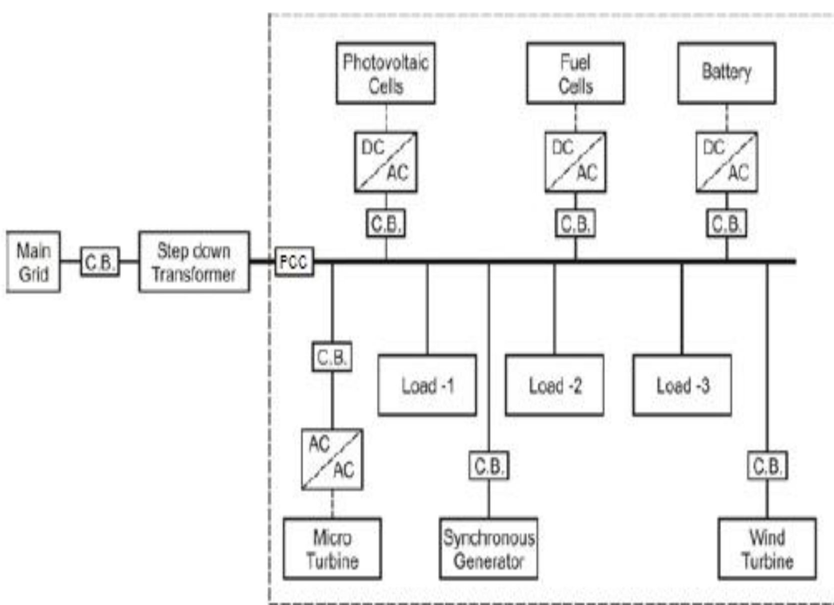

Fig. 1.1 Schematic Diagram of a Typical Microgrid

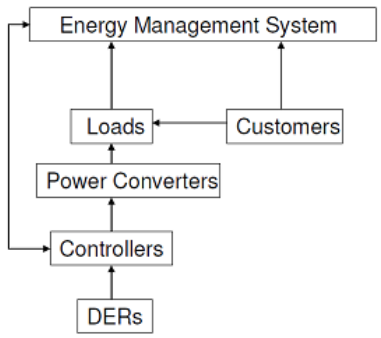

Fig 1.2. Microgrid key component

A micro-grid is a power system with distributed resources serving one or more customers that can operate as an independent electrical island with the bulk power system. Micro-grids may range in size from a tiny residential application involving the islanding of a single house up to small-city-size islands with 100 MW of total load. A micro grid is associated with a low voltage distribution power network and inherits small modular generation systems and loads that have certain coordinated functions to provide the solution to supply premium power to remote or specific area. [2]There are many possible configurations for micro grids, ranging from very small systems serving a single customer site up to very large systems that serve thousands of customers. This chapter investigates possible architectures for micro grids and discusses some of the factors that must be considered in the design of such systems.

A micro grid may take on many forms:

- Peak Electrical Load: 1 kW up to 100 MW
- Number of Customers Served: 1 to 50,000
- Type of customers: residential, commercial, or industrial
- Area served: from one house up to 10 square kilometers
- Part Time Micro grid - may be configured to switch between ―islanded‖ and ―non-islanded‖ operating modes based on the state of the bulk supply
- Full time Micro grid - always operates independently of the bulk supply
- AC or DC, Low voltage or high voltage architectures may be used
- Radial or networked designs with one or more generators

II DISTRIBUTED GENERATION

Distributed generation (DG) generates electricity on small scale close to end user of power. There are many economical, technical and environmental benefits of using DG. By suitable placement of DGs at optimal location with optimal size, benefits of DG can be maximizing. Optimization of DERs includes distribution generation (solar PV array, wind energy, hydro and biogas fuel generator) with battery backup to minimize cost function and increase reliability with security in power flow. So that each generating unit can deliver power efficiently fulfilling load requirement in particular area of grid as well area outside the grid. [1]Recently, distributed generation technologies have received much global attention; and fuelling this attention have been the possibilities of international agreements to reduce greenhouse gas emissions, electricity sector restructuring, high power reliability requirements for certain activities, and concern about easing transmission and distribution capacity bottlenecks and congestion, among others. Better, defined as any source of electric power of limited capacity, directly connected to the power system distribution network where it is consumed by the end users. Really DG is not a new concept in the evolution of electricity industry. DG can be powered by micro-turbines, combustion engines, fuel cells, wind turbines, geothermal, photovoltaic system, etc. DG takes place on two-levels: the local level and the end-point level. Local level power generation plants often include renewable energy technologies that are site specific, such as wind turbines, geothermal energy production, solar systems (photovoltaic and combustion),and some hydro-thermal plants.[3] For a more efficient and sustainable electric power system distributed energy resources (DER), such as small-scale renewable generation, storage technologies, and responsive loads, can potentially reduce greenhouse gas emissions and improve the efficiency of the power system. These DER showing a concept of DG explored organizing DER into micro grids to allow for greater integration of DER into the power system and electricity market operations. A micro grid is a subsection of a distribution system that consists of multiple DER that can operate both autonomously and in parallel with the main electricity grid. [4]

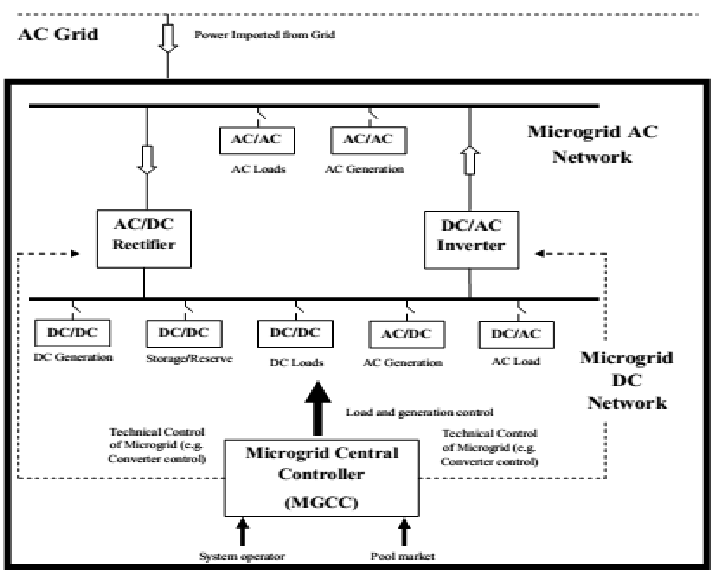

Figure.2.1 AC/DC Micro grid model showing power flows

Stand-alone and grid-connected operations of DERs help in generation augmentation, thereby improving overall power quality and reliability. Moreover, a deregulated environment and open access to the distribution network also provide greater opportunities for DG integration. In some countries, the fuel diversity offered by DG is considered valuable, while in some developing countries, the shortage of power is so acute that any form of generation is encouraged to meet the load demand.Inter utility transfer of energy can be done by Area Control Error to arrange sale of energy between interconnected system. AGC can be used to adjust utility generation in case two or more than two generation are operating in an area, and tie line flows can be used for transfer of energy.[7]

The interconnection of distributed generators (DGs) to the utility grid through power electronic converters has raised concern about proper load sharing between different DGs and the grid. Microgrid can generally be viewed as a cluster of distributed generators connected to the main utility grid, usually through voltage-source-converter (VSC) based interfaces. Concerning the interfacing of a microgrid to the utility system, it is important to achieve a proper load sharing by the DGs. A load sharing with minimal communication is the best in the distribution level as the network is complex, can be reconfigured and span over a large area.For a better performance of the DGs and more efficient power management system, it is important to achieve a control over the power flow between the grid and the microgrid. With a bidirectional control on the power flow, it is possible not only to specify exact amount of power supplied by the utility but also the fed back power from microgrid to utility during lesser power demand in the microgrid. With number of DGs and loads connected over a wide span of the microgrid, isolation between the grid and the microgrid will always ensure a safe operation. Any voltage or frequency fluctuation in the utility side has direct impact on the load voltage and power oscillation in the microgrid side.The isolation between the grid and microgrid not only ensures safe operation of load, it also prevents direct impact of load change or change in DG output voltage on the utility side. With their grid-interconnectivity advantages, advanced microgrids will improve system energy efficiency and reliability and provide enabling technologies for grid-independence to end-user sites. One popular definition that has been evolved and is used in multiple references is that a microgrid is a group of interconnected loads and distributed-energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. Further, an advanced microgrid can then be loosely defined as a dynamic microgrid. The value of microgrids to protect the nation's electrical grid from power outages is becoming increasingly important in the face of the increased frequency and intensity of events caused by severe weather. Advanced microgrids will serve to mitigate power disruption economic impacts.

III INTER-CONNECTED MICROGRIDS

Interconnection of different power generation is required to make the system more reliable, and a better system to operate at efficient cost whenever a load change is noticed it is taken care by suitable units in interconnection. If a unit is lost in one control area governing action from units in connected areas will take up to make up the load demand until the standing units are brought on back. Economics can be minimized in interconnected micro grid , for, e.g considering a 3 micro grid unit serving load if one of them may be generating power at less cost than other , then other utility when to buy next power for its Loads from the unit with low generation cost . Then it could increase the utility MG supplying to locally increase utility MG supplying power by benefit economically from selling power to other. On other hand, one MG may have surplus of power and may wish to sell it to an interconnected mg to fulfill their requirements on a long term firm supply basis a fair and equitable pricing to be decided and control center to be made in local area.

3.1 Need For The Inter-Connection of Areas

Earlier electric power systems were usually operated as individual units. But a need for the interconnection was realized due to the following reasons:

- There was a demand for larger bulk of power with increased reliability so there was interconnection of neighboring plants.
- It is also beneficial economically since fever machines are necessary as reserve for action at peak loads (reserve capacity) and also less machines are needed to be run without load to take care of sudden rise and fall in load(spinning reserve). For that reason, several generating units are connected with each other forming state, regional and national grids respectively. Also for the control of power flow in these grids the Load dispatch centers are needed.

Advantages of having Interconnected System:

- Reserve capacity is reduced and thus there is reduction in the installed capacity.
- For larger units the capital cost/kW is reduced. (In India a particular unit can hold up >500MW due to interconnection)
- Generators are used effectively.
- Generation is optimized so there is reduction in the installed capacity.
- The reliability of the system is increased.

The OPF formulation for the economic and reliable operation of the microgrids. Two formulations are considered, the first formulation considers a minimum cost scheduling of the microgrids and the second formulation considers a minimum cost and maximum reliability scheduling of the Micro grid where in both formulations the load is served using some combination of Micro grid AC generation, PV arrays, battery and power imported from the grid.

IV MICROGRID CENTRAL CONTROLLER

A microgrid central controller controls the load in the microgrid by proper managing the energy balance in the system. MGCC compares the total generation with the load demand in microgrid and some non-critical loads is shaded if load demand becomes higher than the generation. MGCC regulates the voltage and frequency to maintain system stability [5].

To supply various loads in microgrid, the different energy resources are integrated with the main grid, which makes the system complex. So for proper co-ordination of the energy sources there are a need of controller in microgrid for satisfactory operation. Microgrid central controller monitors the power generated by DGs and match up with the demand to maintain balance in the system. Microgrid central controller is needed to detect the power quality at PCC and so that it can decide whether to disconnect grid i.e. to initiate islanding mode. Resynchronization is done by central controller once the grid is restored by properly matching the voltage and frequency with that on the grid side.

So there is need for microgrid central controller for resynchronization purposes and islanding decisions reported in [5]. Microgrid central controller reduces the operational cost of microgrid for customers. As microgrid central controller fulfill the demand of the microgrid by using its own energy resources, so that it reduces the network congestion at time of peak demand when energy prices are high in open market.

4.1 Classification of MGCC

MGCC can be broadly classified in two types such as

- A.C Microgrid Central Controller
- D.C Microgrid Central Controller

AC MGCC (Alternating Current Microgrid Central Controller)

In AC grid, AC power sources and load are connected. To enable the connection of renewable based power generating sources with the present AC system, AC microgrid has been developed. By connecting microgrid directly to the AC grid investment cost lowers and structure is simple but with less reliability and lack of flexibility, therefore an interface is needed to be report.

DC MGCC (Direct Current Microgrid Central Controller)

In DC microgrid, DC power sources and loads are connected. The power supply connected with DC grid can be easily operated cooperatively, because they control only the DC- grid voltage. The most of alternative energy sources as well as energy storage devices produce and store electrical energy in DC. Thus the design of DC microgrid is fundamental if the DC loads and micro sources are to be easily be integrated on the network. The system cost and losses are reduced. The DC system also eliminates the use of multiple converters which reduce the system efficiency. Skin effect are absent in DC system and no reactive power forms. Efficiency of DC is 10-22% more than AC system. In DC microgrid, there is no need of voltage synchronization and effect of phase imbalance.

V PROBLEMS ASSOCIATED WITH INTERCONNECTIONOF MICRO GRID

5.1 Generation demand matching - Unit Commitment

In order to match the load demand, supply and generation it in=s necessary to study unit commitment issues and formulate unit commitment study for individual DER in micro grid Dg system. The UC problem determines a turn-on and turn-off schedule for a given combination of generating units, thus satisfying a set of dynamic operational constraints [10]

Methods used by utility companies for priority loads:

UCFunction:

- Reads minimum and maximum capacity of the production units
- Reads open market prices. The grid (open market) is considered as a “virtual”, large generator with maximum capacity determined by the congestion limit of the interconnection. Therefore the units taking part in the market are number of micro-sources

- Creates priority list sorted according to the differential cost of each unit – ratio of cost in maximum capacity to maximum capacity of each one of the micro-sources.
- The cheapest units are committed until the demand plus an amount of spinning reserve are covered. One of these units may be the grid. In our application, a 10 % spinning reserve of the requested load is assumed.

5.2 Economy energy evaluation- Economic load dispatch

Economy dispatch calculation for different micro grid DG units can be performed for better economy evaluation. Economic operation of existing decentralized schemes is also usually achieved by either tuning the droop characteristics of distributed generators (DGs) or prioritizing their dispatch order. For the latter, an earlier scheme has tried to prioritize the DG dispatch based on their no-load generation costs. Although the prioritization works well with some generation costs saved, its reliance on only the DG no-load generation costs does not allow it to operate well under certain conditions. ELD optimizes the operation cost for all scheduled generating units with respect to the load demands of customers.

ED function:

- Reads minimum and maximum capacity of the production units
- Reads open market prices. As above, the open market is considered as a "virtual" generator with maximum capacity the congestion limit of the interconnection
- Creates priority list sorted according to the differential cost of each micro-source (cost _ at _ max imum _ capacity − cost _ at _ min imum _ capacity) /(max imum _ capacity − min imum _ capacity) committed and the market.
- All units committed are dispatched at least at their technical minima.
- Active demand is dispatched to the committed units, according to the priority list, so that the active power demand is met.

Let us explain this by taking an example:

Consider two different cases having different unit commitment function and economic dispatch by the help of which we have concluded the result shown in graph:

Case I:

According to the prices of the market and the production cost, the MGCC tries to meet the active power demand. When the market prices are high, this usually means that there is peak demand at the whole grid. Due to the high prices, it is beneficial for the micro-sources to produce energy in order to minimize the Micro grid cost of operation. On the other hand, the micro-grid tries to maintain zero reactive power demand from the grid, if possible.

Case II:

The microgrid participates on the market by buying and selling active and reactive power from/to the grid. It is assumed that the micro grid serves its own needs, but it also participates in the market offering bids via an aggregator. The MGCC tries to maximize the value of the Micro grid, maximizing the gains from the power exchange with the grid

The MGCC is provided with:

- The market price for buying and selling active (A Ect/kWh) and reactive power (B Ect/kVarh) to the grid. The same prices apply to the consumers within the Microgrid.
- The active and reactive power demand, probably from a short-term forecasting tool.
- The maximum capacity allowed to be exchanged with the grid. This can be for example some contractual agreement of the Aggregator or the physical limit of the interconnection line to the grid.

Solution Methods

In order to optimize the operation of a power system two functions are required:
• Unit Commitment (UC) function, that determines which micro-sources will be committed at each time interval
• Economic Dispatch (ED) function, that determines the operating point (power) of each production unit (and load, if applicable).

Priority List

UC function:

In order to implement the “case II” policy, this function is slightly modified compared to the UC function in order to take into account the possibility of selling power to the grid.

The steps followed are:

- Maximum load for Unit Commitment is computed: It is the demand plus the capacity of the interconnection line plus an amount of spinning reserve.
- The differential cost of each of the micro-sources is computed and the values are placed in a priority list.
- The differential cost of the market price is computed and is placed in the above table.
- The elements of this list are sorted in ascending order.
- Micro-sources are committed until the grid is committed. The unit Commitment process stops, unless the power supplied by the grid is constrained by the interconnection line. In such a case, more expensive μ -sources than the open market prices are committed, so that the demand is met.

Negative values mean export to the grid. It can be seen that for a few hours a day active power is sold to the grid. These examples show that the cost reduction in the ideal citizen policy is greater than in the first case.

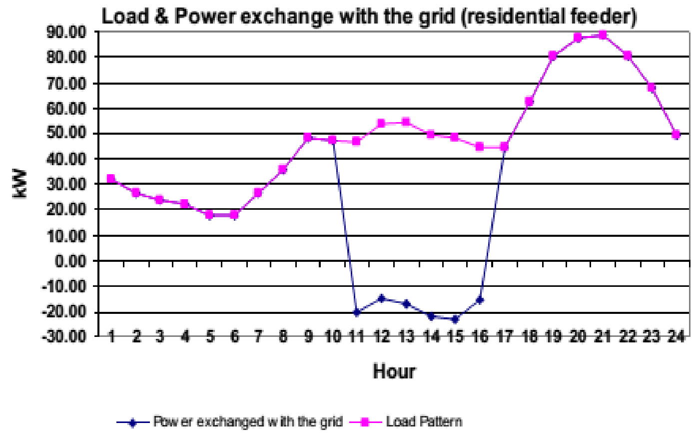

Figure 5.1: Load and power exchange for residential feeder

VI CONCLUSION

The study suggests that the significance of power trading is load management and also focus on microgrid electricity and power exchange, rising the scope of consumer side power generation and making electricity more reliable and economical. As India faces lots of difficulties during the supply of electricity, there are many regions which falls under the deficit region. In order to fill up that deficit gap, which have evolve the short term power market in the country and also to make reliability we have to introduce microgrids system so as to make consumer powerful and introduce private player in the market.

- As per CERC, Market Monitoring Cell, there is a huge difference between Generation and Demand. So for that reason short term power market is been introduced.
- As we know that long term PPA are not able to cater the demand in particular area and Also their utilities which have got power in excess ,there is a mismatch in the distribution sector where the case like there is a Deficit zone case and surplus zone case.
- So, for matching those deficit and surplus case, short term power market has been evolved.
- Demand and supply Gap mismatch to be reduced
- Enhance competition in the market by private generation using microgrids
- Promotes energy efficiency, having better load management
- Choice to consumer to purchase power and sell to & from anywhere in the country
- Risk Management i.e. trader mitigation where there is risk for both the seller and buyer i.e. The all financial transactions is seen by the trader which is a part of short term
- Load forecasting is done to know how much to buy power for selling it.
- DSM programmers were to provide cost- effective energy and capacity resources to help defer the need for new sources of power such as microgrids installed.

VII FUTURE SCOPE

This is a review study on power and energy interchange between microgrids sources integrated formed as a grid resources structure for better electric supply network reliability and integrity. Power trading for different load area by local area generation micro grid is discussed and can be shown by a case study. For this trading a generation side economic load dispatch and unit commitment aspects to be studied more clearly by formulating a model and making analysis using other software techniques.

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