A Study on The Operating Characteristics of Microgrids

Suranjana Bharadwaj
Dept of Electrical Engineering
Girijananda Chowdhury Institute of Management and Technology, Assam

Abstract- *Micogrid is a comparatively new concept in power industry. It brings in autonomy in terms of generation and distribution of electrical energy in a small area. It also brings the added advantage of reliability, sustainability, security to an area which is already connected to the main grid. This paper does a detailed study of microgrids including its structure, functioning, challenges involved and the future scope with special attention to Indian power scenario.*

Keywords- energy, demand, utility, distributed generation, grid, islanding

I. INTRODUCTION

The ever increasing demand for energy, in today's world has become a challenge for the energy utility companies. This is result of a various socio-economic factors which may include increased use of electrical machinery in industries as well as agriculture, updated living standard of a certain section of the society utilizing more electrical devices which increases energy consumption, or simply because of the rise in population. Whatever may be the reason for this increased energy demand, this signifies the developing status of a nation and the authorities must be able to provide this to its people. By depending upon the traditional sources of energy generation and using the existing process of transmission and distribution, it has become nearly impossible day by day to cope up with this tremendous amount of load growth. As a solution to this crisis, researchers from around the world are trying for alternative sources of energy and that opens the huge opportunity for the renewable energy research sector.

The concept of microgrid comes as an alternative to the existing grid. It may co-exist with the traditional grid, and even operate independently. A microgrid is a modern power generation and distribution system where the generating sources lie very close to the load points. It is called "micro" considering its typically small size. Microgrids include distributed generation sources such as small hydro power (Run-off River), solar power, combined wind power, biomass, geo-thermal etc. The constructional features of a microgrid has both similarity and difference with a conventional grid. Similarity can be drawn on the basis that both the systems has generating sources, battery storage, control units and load points. But in case of microgrid the source lies close to the load and the requirement of complicated transmission system is omitted.

A microgrid mainly operates in two modes, one is the grid-integrated mode and the other one is the islanded mode. Although it may sound simple, successful operation of a microgrid and shifting from one mode to the other involves a lot of crucial steps. With the changeover from one mode to the other, the system should be capable enough to maintain the voltage and frequency imbalance that it undergoes. It is only possible when it possesses a robust and efficient control system which is able to sense any potential threat to the system and take the corrective measure. Full scale operation of microgrid is still not a reality, especially in countries like India, despite its several benefits. It is still done on experimental basis. Isolated grids are operating in some remote areas supplied by the renewable resources (mainly solar). The integration is not happening mainly due to some state policies. Researchers are now opting for the interconnected micro-grid which will give added stability to the system.

II. COMMON ARCHITECTURE

As the name suggests, microgrids are small units, generally less than 100kW that are flexible enough to operate with the grid in a synchronized manner and also can operate on its own. It may happen that some microgrids do not possess the necessary interfacing devices to be synchronized to the main grid and it is only operating in islanded mode. In such a case, we cannot draw 100% utilization from it.

The key components of a microgrid system can be divided into the following parts:

i) Energy sources
ii) Energy storage devices
iii) Control equipment
iv) Loads
v) Power electronic converters.

i) *Energy sources*

There are various types of possible sources present in a microgrid. The most commonly used is the PV system. Integrating PV to the grid increases the system performance. Combined heat and power plants (CHP) are an efficient way of utilizing the waste heat produced in industries and households. Fuel cells and Wind turbines are also coming up and contributing as alternate energy sources which are located near the load points.

ii) *Energy storage devices*

The energy produced by the mentioned energy sources needs to be stored efficiently so that it can be supplied to the loads whenever necessary. Hence a proper battery storage system is an integral part of the microgrid. For those sources generating DC, they will need a battery storage coupled with inverter so that this stored energy can be converted to AC as most of the loads run on AC. It is also necessary for connecting to the main grid after synchronization. Both AC coupled storage system and DC coupled storage systems are used as per convenience.

iii) *Control equipment*

A microgrid cascaded with so many different types of energy sources needs a robust controlling scheme for operating properly. Bringing all these micro generations under one voltage and frequency profile using different type of controllers while addressing the challenges of voltage imbalance or frequency fluctuation is a very difficult task. Both in islanded or grid connected mode, these control equipment play a crucial role in supplying quality power to the consumers. Power flow controllers are installed near the sources which regulate the power flowing out of the energy sources.

In case islanding is necessary control signals are sent to the specific circuit breaker to trip. Sensing devices like CT, PT, communication schemes like PLCC are also installed so as to make the system more responsive. An energy management scheme is provided which controls the power going out and coming in. A protection scheme is also there which will address faults occurring in the system. In case of internal faults, the faulty part must be isolated at the earliest which is possible if we have efficient sensing devices. In case of fault in the utility grid, microgrid should go into islanding mode.

iv) *Loads*

Loads play an important role in microgrid. The amount of load connected to a microgrid is not same at every point of time. The scheme of interconnection between microgrid and utility grid should be such that, at peak load hours, if the microgrid is unable to feed its own load, then the deficit amount can be supplied from the utility grid. On the other hand, at off peak hours when the microgrid has surplus power, it can feed the utility grid. Microgrid can play the role of a “back up grid” in case of emergency as it can supply to the utility grid in time of need. In this way the system becomes more reliable and flexible and complete blackout in certain areas due of fall of some big generating unit can be partially restored. One other important aspect is that the consumers can earn revenue in terms of energy saving by depending on the renewable sources.

v) *Power electronic converters.*

Power Electronics has become an integral part of modern power engineering. Using these converters power from one form can be converted to other form as per the voltage and frequency requirements. I covers a wide range of power levels starting from a few watts to several megawatts. The storage devices, the controllers and the renewable energy sources all use power electronic devices and converters now a days for faster and reliable performance. The DC power generated by the PV modules are converted to grid connectible AC through AC-DC voltage source inveters(VSI). The wind power generated by wind turbines is AC but it differs in magnitude and frequency from that required by the microgrid. So to bring it to usable level we use inverters in connection to batteries. In this way these converters play a huge role in operation of a microgrid.

III. ADVANTAGES AND DISADVANTAGES

As every system comes with its own merits and demerits, microgrid is also no difference. In fact the limitation of today leads to innovations of tomorrow. A whole lot of research are going on in this area and efforts are being made to minimize its drawbacks.

If we talk about the advantages, Microgrids offer flexibility in terms of depending on a single type of power generating source. We can changeover from one type of source to the other as per our need. System security and reliability increases to a great extent. If the main grid goes off, some loads can be fed through the microgrid. In this way blackouts can be avoided. Traditional energy sources like thermal plants or mega hydro plants has a lot of ill effects on environment. Replacing these with small, renewable sources helps keeping the environment safe reducing the emission of

harmful gases or the damage of biodiversity of an area. In certain cases, where the microgrid is capable enough to provide backup power to an area when the main grid goes off, there is no need of keeping other backup power arrangements like diesel generators which saves a lot of money. Traditional grid establishments requires a good amount of money in installing long transmission lines, power stations and the other supporting equipment. Since microgrids supply loads which lie very near to the generating points, hence the cost of transmission and also the power loss during transmission is greatly reduced and thus it gives an economical advantage over the traditional utility grid.

Although microgrid offers many advantages in terms of reliability of the services, low voltages generated by microgrids is not beneficial to be delivered to load points beyond a certain range. This is because it requires a lot of supporting mechanism and it increases the cost to large extent. From that point of view, microgrids are best suited for serving its local loads. Some strict protocols or rules must be followed by the microgrid to be able to connect it to the utility grid.

In countries like India, these protocols are sometimes very complex and therefore, the grid integration becomes a tedious task. From the economic point of view, anyone who installs a microgrid, his prime objective would be to lower his energy cost.

But, if the installation and other control equipment cost exceeds the amount to be payable to the utility in case all the loads need to be served from the utility grid, the it would be very difficult to realize the concept of microgrid in actual sense of the term.

IV. CHALLENGES FACED BY MICROGRID

The challenges that lie ahead for microgrid implementation is mainly of two type; economical and technical.

The prime benefit of installing a microgrid is related to providing reliable and quality power to its consumers. Using distributed generation with renewable energy resources, it tries to supply loads while maintaining the specific grid voltage and frequency. But, while doing so, it has to face a lot of challenges. One of the key issues regarding this is maintaining the balance between generation and load which keeps the frequency within the prescribed limit. The control of reactive power is also vital for maintaining the voltage levels. Since the microgrid consists of different types of renewable sources, each with its own generation levels, own frequency droop characteristics, hence it has become a very challenging task for the power engineers to bring them under one umbrella of voltage and frequency. Providing active and reactive power control equipment separately to each of the generation unit is practically not possible because installation cost increases to a large extent.

Realizing a fully developed microgrid with facility of both islanded and grid integrated mode, operating smoothly and providing quality power is the goal ahead for researchers in this area. The system should be equipped with such control mechanism that the changeover between these two modes become very smooth. Directional over-current relays are placed on each line to sense any type of fault and trip as necessary. While discussing the issue of microgrid, economic issues always prevail. If economic benefit is not there, how one will be interested in investing in the development of microgrid. This is one issue which is challenging the commissioning of microgrids to a large extent.

Moreover, microgrids are mostly owned by private firms and there has been a conflict of authority between these private firms and the utility grid. Another aspect is that, the renewable sources that we are using are not always available. The depend on weather, sunlight, speed of wind etc. These sources will be capable of providing an uninterrupted supply only if we combine them with large storage system. Most people find it troublesome dealing with these issues and they are satisfied with the conventional grid whose operations are simple and convenient for them. The government policies are putting thrust upon reaching the national grid to far remote areas. There is a very small portion of geographical area left where the grid is not arrived yet. Hence the so called remote locations, which are will solely depend upon microgrid are reducing day by day and even if it exists, there is lack of proper investment policies for putting a microgrid. This has turned out as a big challenge for the advocates of microgrid systems.

V. SCENARIO IN INDIA

The Government of India has been lately very serious about making electricity accessible to every remote corner of the country. The Prime Minister of India announced that by 2018, all households in India will have 24×7 access to electricity. Although efforts are being made to make this vision a reality, still, a considerable amount of area are yet to receive the access to national grid. Even if it has the access, load shedding is a major problem in these areas. The very first mention of microgrids was in the National Tariff Policy 2016. This policy advocates for providing a better space for investors to come and invest in microgrids in rural areas. The draft national policy on renewable energy based mini/micro-

grids was released by the Ministry of New and Renewable Energy (MNRE) in June 2016 that aims to create generation facilities up to 500 megawatts for over the next five years. In spite of these positive moves, un-interrupted electricity is still a distant dream for most of the villages in rural India. Instead of this what they get is 8 to 10 hours electricity with poor quality. Prime Minister Narendra Modi announced on 29April 2018 that his government has achieved 100% electrification of all villages in India with the last village of Leisang in Manipur being connected to the power grid. According to the government rules, a village is called electrified if 10% of the total number of households in the village have access to electricity. This means that a village will be called electrified even if 90% of its households do not have electricity. Efforts should be made to electrify those 90% households also. But the grim reality in this case is that mostly the power supply to our villages are looked after by the state electricity boards which are already going through huge revenue losses by supplying subsidized power to its agricultural and residential consumers. Further, the situation is worsened by the theft and pilferage of electricity.

In these cases, microgrids can be the best solution both for areas with no grid access at all and those which are not getting adequate amount of power. To address these issues a proper road-map is to be made. The government is already encouraging renewable generations. On April 2018, India's first industrial solar microgrid was commissioned in Gujarat by the multinational giant ABB. This will help in cutting down planned and unplanned power outages. Solar grids are already penetrating most of the rural areas. The need of the hour is of a proper accounting and defined policies for installation and operations of microgrids. A strategic protocol between the utility grid and microgrid should be such that the aim of providing reliable and quality power to every nook and corner of the country becomes a reality.

REFERENCES

[1] A. A. Salam, A. Mohamed and M. A.Hannan, "TECHNICAL CHALLENGES ON MICROGRIDS" in ARPN Journal of Engineering and Applied Sciences, vol.3, no. 6, ISSN 1819-6608, Dec 2008.

[2] Eklas Hossain, Ersan Kabalci, Ramazan Bayindir,Ronald Perez, "A COMPREHENSIVE STUDY ON MICROGRID TECHNOLOGY" in International Journal Of Renewable Energy Research, Ramazan Bayindir et al. ,Vol. 4, No. 4, 2014

[3] Rahul Tongia, " MICROGRIDS IN INDIA: MYTHS, MISUNDERSTANDINGS, AND THE NEED FOR PROPER ACCOUNTING" ,Brookings India IMPACT Series No. 022018. February 2018.

[4] Suranjana Bharadwaj, "A STUDY OF VARIOUS ISLANDING DETECTION METHODS IN MICROGRIDS",International Journal of Engineering Research & Technology (IJERT) , ISSN: 2278-0181.Vol. 7 Issue 06, June-2018

[5] Pavlos S. Georgilakis, Nikos D. Hatziargyriou, "OPTIMAL DISTRIBUTED GENERATION PLACEMENT IN POWER DISTRIBUTION NETWORKS: MODELS, METHODS, AND FUTURE RESEARCH", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 28, NO. 3, AUGUST 2013

[6] Johan Driesen, "DISTRIBUTED GENERATION: BENEFITS & ISSUES", ESAT/ELECTA, http://www.esat.kuleuven.be/electa

[7] S K Murthy Balijepalli, V & Khaparde, S.A. & Dobariya, C.V., "DEPLOYMENT OF MICROGRIDS IN INDIA", 1 - 7. 10.1109/PES.2010.5589956.

[8] Daniel Schnitzer, Deepa Shinde Lounsbury, Juan Pablo Carvallo, Ranjit Deshmukh, Jay Apt, and Daniel M. Kammen, "MICROGRIDS FOR RURAL ELECTRIFICATION:A CRITICAL REVIEW OF BEST PRACTICES BASED ON SEVEN CASE STUDIES", United Nations Foundation, January 2014

[9] Robert Lasseter, Abbas Akhil, Chris Marnay, John Stephens, Jeff Dagle, Ross Guttromson, A. Sakis Meliopoulous, Robert Yinger, and Joe Eto ,Consortium for Electric Reliability Technology Solutions White Paper on Integration of Distributed Energy Resources The MicroGrid Concept, Prepared for Transmission Reliability Program Office of Power Technologies Assistant Secretary for Energy Efficiency and Renewable Energy U.S. Department of Energy

[10] D. Mahinda Vilathgamuwa., L.P Chiang., L. Y. Wei, "Protection of microgrids during utility voltage sags", IEEE Trans Ind Electron. 53(5): 1427-36, 2006

[11] Meng Hui Wang, Mei-Ling Huang, Kang-Jian Liou, "ISLANDING DETECTION METHOD FOR GRID CONNECTED PHOTOVOLTAIC SYSTEMS", IET Renewable Power Generation

[12] Aziah Khamis HussainShareef Erdal Bizkevel Tamer Khatiba, "A REVIEW OF ISLANDING DETECTION TECHNIQUES FOR RENEWABLE DISTRIBUTED GENERATION SYSTEMS", Renewable And Sustainable Energy Reviews, Elsevier, Vol28, Dec 2013, pages: 483-493