

Survey of Micro grid Cost Reduction Techniques

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Abstract - The electricity consumption has increased to a huge amount in the recent years. Smart grid is an efficient, effective, reliable, two way electricity and information delivery from source to destination. Whenever there is a fault occurrence in main grid this fault also affects the micro grid. During optimal scheduling mechanism the operating cost of micro grid will be higher. The operating cost of micro grid will be less for a short span of time in islanding mode during the fault correction mechanism with the main grid. The operating cost will be higher after a short span of time when micro grid is operating in island mode during fault occurrence of main grid. In this paper the various operating cost procedures of micro grid are analyzed.

Key Words: Island mode, load scheduling, Distributed Energy Resources

1. INTRODUCTION

Smart grid is efficient, reliable and intelligent two way electricity and information delivery system from source to sink. The aim of smart grid is to make existing infrastructure more robust, reliable and efficient by using intelligent tools and technologies, encourage active demand side participation, enable better access to electricity, ensuring sustainability of supply through renewable integration, promoting green and clean environment and provide incentives for efficient production, transmission, distribution and consumption of electricity across the value chain of electricity. Distributed energy resources (DERs) is a small grid connected devices which is used for generation and storage purpose and it is located near the load centre. DER systems use renewable energy sources including bio mass, bio gas, solar power, wind power and geo thermal power. Distributed generation and storage enables collection of energy from many sources and may lower environmental impacts and improve security of supply. by means of an interface, DER systems can be managed and co-ordinate with a smart grid.

Micro grids are introduced not only to find out the needs of a large number of distributed energy resources in distribution system but also to find ongoing power, economics and to reduce the green house gas emission by making smarter power grids. Micro grid is a small scale power system with ability of supplying power to the end user in a reliable way and it can disconnect from the centralized grid and operate autonomously, provides a

distributed local intelligence for the power system to supply loads in a reliable and economic manner.

In power system operation and planning micro grids improve reliability by introducing self-healing at the local distribution network, reducing the power cut frequently, higher power quality by managing consumer demand, reduction in carbon emission by the conventional energy sources, reduction in the cost of distribution and transmission network by economic operation, provide energy efficiency by responding to real time market prices, reducing the total system expansion cost by industry investment on new generation and transmission facilities and providing a quick and efficient responder for supplying load in remote area. Environmental and economic benefits of using renewable energy include generating power that produces no green house gas emission from fossils fuels and reduces some types of air pollution, diversifying energy supply and reducing dependence on imported fuels. Micro grids are monitored by smart grid and load distribution is done economically [1].

Power is generated by means of natural energy source such as coal, oil, gas is called conventional energy source. The gas emitted during the operation increases the green house gas emissions and other environmental damage. In conventional source power is generated, transmitted and distributed to the consumers and amount chargeable for electricity is decided by the power supply distribution centre. Under fault condition, the fault is cleared by the both manual monitoring and manual restoration. If fault occurs in any one of the area it affect the whole network and causes blackout of the system. As the above problem needs to be solved we go for smart grid technology. DERs is used to supply power to the end users. Under fault condition the fault is cleared by self monitoring and self healing. There are various problems faced in traditional grid.

In traditional grid as demand is increased due to high population, increased in consumption of power, aging of infrastructure of the electrical components, increasing in green house gas emission and zero customer participation. The above mentioned factors are drawbacks in the traditional grid. The drawbacks are mainly due to the centralized nature of traditional grid so we go for decentralized nature of power generation with the help of smart grid. In smart grid there will be a smart control of energy transmission due to distributed energy resources. This improves the power quality of the grid and it is friendly

to the environment. In a summer day, the photovoltaic (PV) array supply more power and in a winter day, the wind turbine generates more power. If the day is neither sunny nor windy or if more power is needed, the fuel cell and micro turbine or main conventional supply can be used. The battery in a smart grid system allows excess power produced to be stored and it is used in good manner. In this way, it is expected that the smart grid could reduce emission level and could supply reliable energy in a variety of weather condition and load situation [5].

2. LITERATURE REVIEW

Amin Khodaei[1] proposed the Bender decomposition method. This method performs the islanding mode operation if fault occurs in the main grid. In island mode of operation, micro grid power is not sufficient to meet the demand in order to meet the demand then scheduling decision in the micro grid will be revised by revising generating units, energy storage system and adjustable load schedules. The islanding mode of micro grid operation is performed effectively for only one hour. More than one hour of operation slightly increase the micro grid total operating cost.

Ruilong Deng[2], proposed Dual decomposition and stochastic gradient method. This method performs to address the ever increasing load through appropriate scheduling i.e to shift the energy demand peak to off peak periods by pricing tariffs as incentive and without reducing the total power consumption. The drawbacks of its renewable generation intermittency are not taken as constraint.

Ruilong Deng[3] proposed Dual decomposition, a two level iterative algorithm and gradient projection. This algorithm performs the power provider release the price information one or several slot ahead and thus approach to residential energy consumption scheduling requires the capability of price prediction. If price prediction error occurs improve the performance to adjust the energy consumption schedule each time till the actual price information is achieved. The drawbacks of gradient projection method do not reveal the private information of power provider.

Amin Khodaei[4] proposed resiliency-oriented micro grid optimal scheduling model. This method is employed to account for uncertainties in load and generation forecasts and to find the worst case solution of the resilient operation problem by considering load and generation forecast uncertainties. A resiliency oriented optimal scheduling model was proposed and in this model a decomposition method is used to decouple the problem to a normal operation problem and resilient operation problem. Resilient operation problem is used when main grid supply is not available and the problem is solved using linear programming and normal operation problem is solved using mixed integer programming. For solving the worst case situation a robust optimization method is used. The

drawbacks are fault in the main grid is cleared and the supply will be restored in less than 7 hours from the time of incident.

S.X.Chen[5] proposed Jump and Shift method and it is used to minimize the total cost of the smart power system as well as minimize the total line loss. In this method, any nonlinear programming techniques such as the interior point method (IPM) and genetic algorithm can be used to solve the problems. The IPM is used because it is a very effective method to solve the multi-objective optimization problem via the jump and shift method. The drawback is the total computing time is 10.5 min for 112-bus power system. In future work performance can be improved.

Poria Hasanpor Divshali[6] proposed a Novel multi-stage method, which decouples this complicated optimization problem into three separate stages and tunes the droop parameters in short time so that the fuel consumption is minimized while all the constraints are satisfied. MATAB is used for solving the optimization using 'fmincon' function. The total computational time will be more when we use the voltage source converter based microgrids by including the constraints of real and reactive power max and min limit, stability margin, voltage and frequency regulation.

Carlos A.Hernandez - aramburo[7] proposed active power sharing with one dynamic droop characteristics. In this method communication infrastructure is used not only to minimize the running costs of the system but also to allow the co-ordination of power plants. Moreover the cost, constraint, penalty and availability functions make the optimal power setting for each plant a complex structure and this leads to the maximizing the financial benefits in a micro grid. The maintenance and management cost are not considered.

3. MICROGRID FUNDAMENTALS

3.1. Overview

Microgrid technology can efficiently combine the advantages of distributed generation, and also offer a new technical way for large scale application of grid-connected generation of new energy and renewable energy. Microgrid can not only improve the efficiency of energy cascade utilization, but also be used as an effective balancing of power grid and improve the reliability of power supply and power quality. It is one of the latest forward-looking research topics in the field of electrical engineering.

3.2 Microgrid Architecture

The electrical loads and micro sources are connected through a low voltage distribution network, while the heat loads and Combined heat and power (CHP) sources are connected to each other to minimize losses during power transmission. Two CHP micro sources, two non-CHP micro sources and two energy storage devices are connected to

three feeders in the micro grid. The micro grid is connected to the traditional grid through a point of common coupling (PCC) circuit breaker, CB4, which can be operated to connect or disconnect the entire micro grid from the traditional grid. The following Fig.1 illustrates the micro grid architecture.

In a normal condition, the micro grid is connected to the traditional grid so that exchange of power takes place. In abnormal condition i.e whenever there is fault in the traditional grid, CB4 is opened, so that the micro grid operates autonomously. In this situation, the micro sources are used to balance the loads in the micro grid. Suppose Feeder A and Feeder C have a higher electrical loads compared to the Feeder B connected loads. The micro grid can be operated in another kind of islanded mode by opening CB1 and CB3. In this case, micro sources which are connected to Feeders A and C feed power to the electrical loads connected to the Feeders A and C, while Feeder B is affected by disturbance. Moreover, the sectionalizing circuit breakers can be used to partition the micro grid for further reliability improvement.

The following figure 1 explains about the microgrid architecture. The micro sources can be operated in either a centralized manner or a decentralized manner. Centralized operation and control rely on a central controller (CC) and several micro source controllers (MCs) are used in the micro grid. Each MC is responsible for operation and control of each micro source. The information exchanges between the CC and MCs are established through a communication network such as field area network(FAN) or neighborhood area network(NAN).

3.3 Microgrid planning

The traditional grid is not able to meet the ever increasing demand due to high population and usage of battery electric vehicle. The micro grid concept is introduced near the distribution network to meet the demand. The operating cost of renewable energy source is less compared to the non-renewable energy source. Similar to the traditional grid, micro grid also have Load flow studies for planning purpose, Short circuit studies for designing the circuit breaker, unit Commitment, Economic dispatch, Energy Management System, Network Topology, Contingency analysis are carried out for successful operation. Micro grid is a small scale power system and its operation involves unit commitment and economic dispatch. Based upon the historical data available for the past year, estimate the load for the present day and decide which micro source should be committed at what time in such that the micro grid operating cost is minimized. Economic dispatch means allocation of power generation of each micro source in such away operating cost is less.

The objective of micro grid is to generate and transmit reliable power to the consumer in such away voltage and frequency should be within the permissible limit. Whenever there is a disturbance in the system there is a deviation in the voltage and frequency parameter. In order to bring the system in stable condition the active and reactive power generation by each micro source is adjusted based on its local measurements of system frequency and voltage. For instance, if system frequency increases, which means that more power is generated than used, so that all generators in the micro grid are accelerating, the power output of some or all of the generators need to be reduced.

3.4 Challenges in Microgrid

Due to integration of non conventional energy source and energy storage device, challenges arise in micro grid planning, operation and control. Due to variation in weather condition there will be change in the load demand and renewable power generation so it may deviate from forecasted values. The lithium-ion rechargeable battery provides a buffer against short term fluctuations in output from renewable energy sources such fluctuation can last for seconds or several minutes long. In order to address these challenges, stochastic modeling and optimization tools can be used for micro grid planning, operation and control.

The economics operation of micro grids are possible by shifting the energy demand from peak periods to off-peak periods or by decomposing the problem into a grid-connected operation as master problem and islanded operation as sub-problem or by reducing the industrial consumer cost. The services provided by the micro grids are reduction in aggregate technical and commercial loss occur in distribution network, power quality and grid security are improved. In terms of environmental aspects it will reduce the CO₂ emission and green house effect, Consumer participation in generating and transmitting energy. These

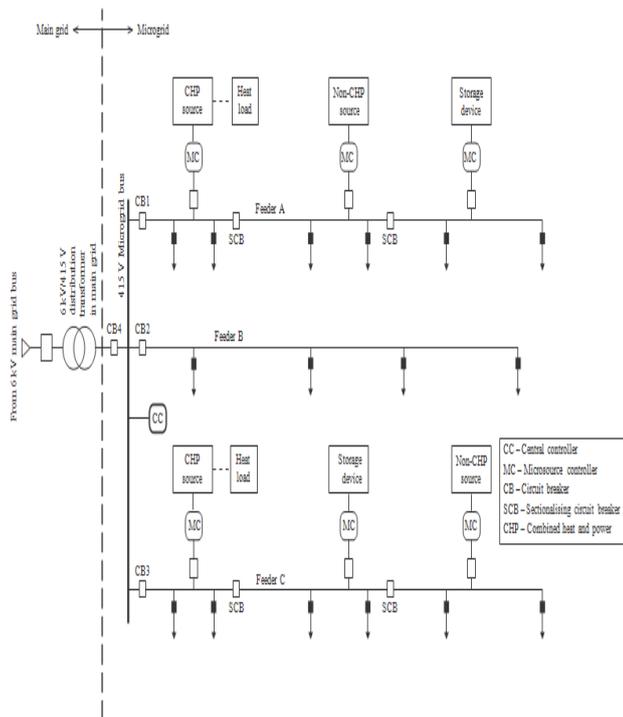


Fig – 1 : Microgrid Architecture

are the challenges in microgrid and various models are available for the solving the challenges in microgrid. The summarization of models used in solving the challenges are explained in next section.

4. MICROGRID MECHANISM

There are many models and mechanism available in micro grid for fuel cost reduction. There are two important models available in micro grid fuel cost reduction. They are stochastic model and resiliency oriented micro grid optimal scheduling model. They are explained as follows.

4.1. Stochastic model

There are much functionality in stochastic model. If we need to perform Trajectory of state evolution we use state evolution model. for utilization of pseudo measurements, spatial temporal model for renewable power generation we use state estimation technique and for spatial temporal model for renewable power generation ,load priority and system operation cycles with temporal correlation we use reliability analysis. There are many technique used in stochastic model for implementation aspects. The tools used are summarized in Table 1.

4.1. Resiliency oriented microgrid optimal scheduling model

This model is used to minimize the power mismatches between micro grid generation and load. The issue of uncertainty of micro grid scheduling can be solved using resiliency oriented microgrid optimal scheduling model. The functionalities and techniques are summarized in the following table.

Table – 1 : Microgrid Mechanism

Mechanism	Functionality	Technique
Stochastic model	State Evolution model	Stochastic hybrid system
	State estimation	Triangular factorization
		Belief propagation
	Reliability analysis	MCS with sequential sampling
		Markov chain analysis
MCS with simple random sampling		
Resiliency oriented micro grid optimal scheduling model	Worst case	Robust Optimization method
	Normal operation problem	Mixed Integer Programming
	Micro grid in island mode	Resilient Operation problem
	Decouple problem into normal operation problem	Decomposition method

The above table explains about the functionality and techniques in stochastic model and Resiliency oriented microgrid optimal scheduling model. Various techniques are used for implementation of functionality. Cost effectiveness will be final resultant using this techniques micro grid island mode functionality.

5. PROPOSED WORK

5.1. Overview

There are many challenges in economic , environmental and service factors of micro grid. There are many mechanism and factors available for cost reduction and scheduling algorithm of micro grid. Each mechanism can work up to extent effectively. We are introducing a model for reducing the total operating cost.

5.1. Total operating cost reduction

The aim is to minimize the microgrid total operating cost which includes the generation cost of local resources and cost of energy purchase from the traditional grid. By using Sheep Flock Heredity Model Algorithm(SFHMA)[10] the micro grid optimal scheduling problem is decomposed into a grid-connected mode and island model. The performance can be evaluated by generating the initial sequence, sub chromosome level inverse mutation process, global level cross over process, global level inverse mutation. Using the sheep flock heredity model the total operating cost can be reduced comparing with other mechanisms. We will be getting better efficiency comparing the existing techniques.

6. CONCLUSION

In this paper we have seen a overview of various fuel cost reduction techniques with micro grid architecture, planning and techniques available. We found that there are many challenges in the micro grid optimal scheduling problems with minimization of total operating cost. A multistage genetic operation can be performed to reduce the total operating cost. Sheep flock heredity algorithm can be used for reducing the total operating cost. There are many challenges in micro grid planning operation and control. Those challenges can also be solved to improve the total operating cost.

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