A MEHODOLOGY FOR TRANSFORMING INTO EXISTING DISTRIBUTION NETWORK INTO A SISTANABLE ATONOMOUS MICRO GRID

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Abstract

A distribution network with renewable and fossil-based resources can be operated as a micro-grid, in autonomous or no autonomous modes. Autonomous operation of a distribution network requires cautious planning. In this context, a detailed methodology to develop a sustainable autonomous micro-grid is presented in this paper. The proposed methodology suggests novel sizing and siting strategies for distributed generators and structural modifications for autonomous micro-grids. The optimal sites and corresponding sizes of renewable resources for autonomous operation are obtained using particle swarm optimization based techniques. The Particle Swarm Optimization (PSO) algorithm to solve the optimal network reconfiguration problem for power loss reduction. The PSO is a relatively new and powerful intelligence evolution method for solving optimization problems.Structural modifications based on ranking of buses have been attempted for improving the voltage profile of the system, resulting in reduction of real power distribution losses. The proposed methodology is adopted for a standard 33-bus distribution system to operate as an autonomous micro-grid. Results confirm the usefulness of the proposed approach in transforming an existing radial distribution network into an autonomous micro-grid.

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Keyword – *Power Loss Minimization, voltage Profile Improvement, micro grid, Distributed power generation, load flow, siting and sizing, particle swarm optimization.*

I. INTRODUCTION

1.1 Introduction

In modern power distribution systems, integrating small non-conventional generation sources has become attractive. These technologies have less environmental impact, easy sitting, high efficiency, enhanced system reliability and security, improved power quality, lower operating costs due to peak shaving, and relieved transmission and distribution congestion. The distributed generator (DG) units used are highly modular in structure as well as helpful in providing continuous power supply to the consumers. However, depending on the rating and location of DG units, there is also a possibility for voltage swell and an increase in losses. In this scenario, to exploit the complete potential of distributed generation, proper siting and sizing of DGs become important. This project, therefore, attempts to develop a sizing algorithm that transforms an existing distribution network to a sustainable autonomous system.[2]

Distributed generation (DG) is proving to be a viable alternative to conventional generation systems. With new technologies like micro turbines, fue.l cells, wind generators, solar cells, etc, getting cheaper their deployment into the grid will increase. Combined heat and power generation is one of the benefits of several DG technologies. Adding new components to a system should comply with better reliability and minimum costs.

Moreover there are several benefits from DGs both in terms of environmental and economic considerations. Micro grids are small DG based interconnected systems which will be easy to design, operate and sustain. Our vision of micro grid is that they not only network DGs with load points, but should also have the ability to operate in both grids connected and islanded modes. Micro grid architecture includes planning issues such as optimally designing the interconnections, sizing and siting the DG units to maximize reliability, reduce costs and improve security of the system. System planning based on reliability makes the system more robust and complies with the requirements of the consumers. System outage costs have been estimated which prove that an increase in system cost should be a compromise between the affordable price and the achieved reliability. [2]

There are many ways to integrate different AE power generation sources to form a hybrid system. The methods may be commonly categorized into three categories: dc-coupled, ac-coupled, and hybrid-coupled.

1.2 DC-Coupled Systems

In a dc-coupled configuration, shown in Fig.1 the different AE sources are connected to a dc bus through appropriate power electronic (PE) interfacing circuits. The dc sources may be connected to the dc bus directly if appropriate. If there are any dc loads, they can also be connected to the dc bus directly, or through dc/dc converters, to achieve appropriate dc voltage for the dc loads. The system can supply power to the ac loads (50 or 60 Hz), or be interfaced to a utility grid through an inverter, which can be designed and Controlled to allow bidirectional power flow

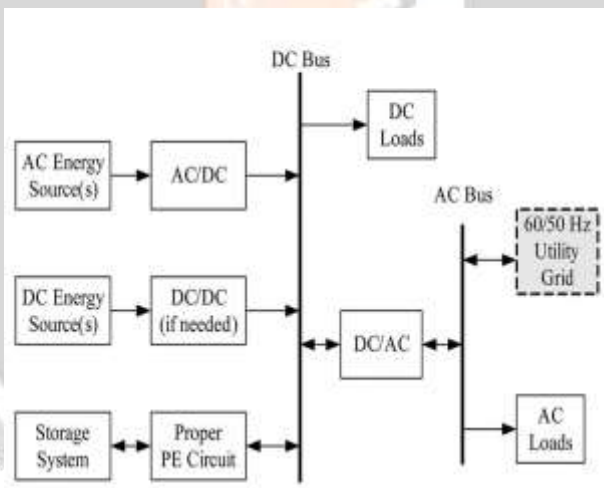


Fig. 1 Hybrid DC coupled circuits

1.3 **AC-Coupled Systems**

AC coupling can be divided into two subcategories: PFAC-coupled and HFAC-coupled systems. The schematic of a PFAC-coupled system is shown in Fig.2., where the different energy sources are integrated through their own power electronic interfacing circuits to a power frequency ac bus. Coupling inductors may also be needed between the power electronic circuits and the ac bus to achieve desired power flow management.

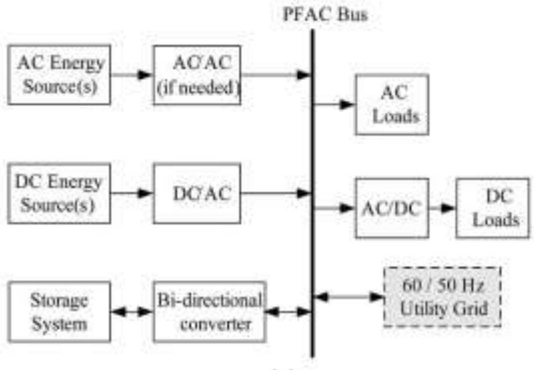


Figure.2. Schematic of ac-coupled

hybrid energy system:

1.4 Photovoltaic (PV) Systems

This system in large part is predicated on sunlight for power generation and a cell made from a doped silicon crystal is the key factor. A set of cells can shape a module or panel and several of those can be configured as an array in a photovoltaic device. Driven by green energy policies, photovoltaic farms are being adopted, thus increasing the penetration of photovoltaic arrays. This scenario was uneconomic solution because of the high installation cost and a relatively low power generation. Therefore, small scale distributed PV generation, with ratings ranging from 1 to 100 kW, has been viewed as a more economical solution for reliable power generation. The rating of the photovoltaic array is mostly in the range of 0.3 kW to a few MW. For the cause of supporting green electricity, the use of PV arrays faces major limits First are land costs as 0.25 ha is required to generate 150 kW of electrical energy. Second is climate as reliable operation is only obtained in sunny weather. The voltage fluctuations and harmonic distortion are typically associated with PV systems; however, these can be mitigated through internal controlled-reactive power sources.[4]

II Inverter-Based DG Unit

Typical DG units provide electrical power through conversion processes that can be classified as: high frequency such as micro-turbine generator, variable frequency such as wind turbine, and direct energy such as photovoltaic and fuel cell. An interfacing power electronic converter is required to convert the produced energy from DC to a constant voltage and frequency AC power source. This converter is usually called a Voltage Source Inverter (VSI) system and is the most functional block in the inverter-based DG unit. Figure 3.2 depicts the power circuit of the 3-phase VSI inverter-based DG unit and the associated control functions. The VSI system itself encompasses two main circuits with the first being the power circuit that includes three-leg VSI with an AC filter.

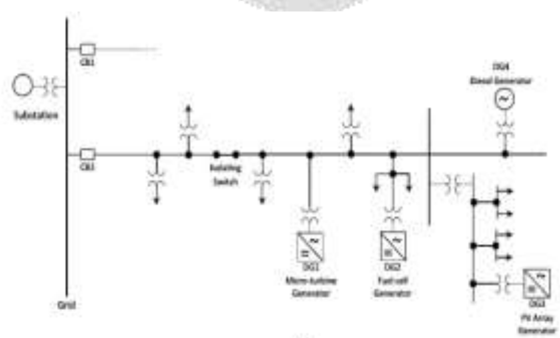


Fig. 3 Grid-connected mode

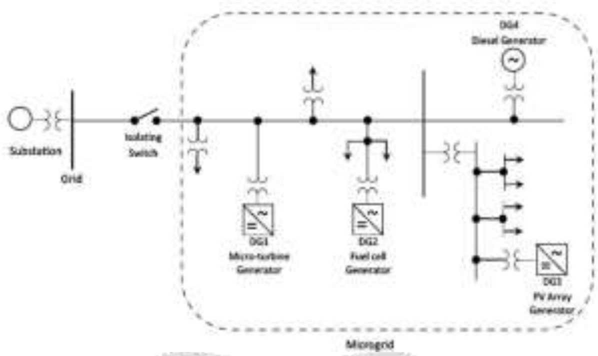


Figure 4 .An exam of the micro- grid: (a) Grid-connected mode.
(b) Micro-grid mode

The second is the control circuit that incorporates the VSI control loops that are designed to provide reliable operation. For example, in grid-linked mode, the voltage and frequency are set up by means of the grid which dominates the general system behaviour. In this case, the DG unit can be operated as a PQ generator, thus the control of the active and reactive power flows are largely required. Conversely, in the islanding mode, the device should offer regulated voltage and frequency or low power best might also arise. Therefore, voltage and frequency regulation must be considered as substantial control objectives, whereas power flow can be managed among the DG units provided they meet the total load demand. If not, the system has to undergo load shedding

III. Particle Swarm Optimization (PSO):

The PSO algorithm was proposed by Kennedy and eberhart in 1995. This algorithm simulates the social behaviour of the swarm such as schools of fish, flocks of birds, or swarm of bees where they find food together in a specific area. Therefore, this algorithm uses swam intelligence concept which can be defined as a collective behaviour of unsophisticated agents when they create coherent global functional patterns by interacting locally with their environment. In nature, the journey of the swarm of bees is the best example to understand the conception of the PSO approach. Imagine that this swarm searches to find higher concentration place of the flowers in the field. Initially, the swarm starts looking for the flowers in random locations and velocities with no prior knowledge about the field. At this stage, each bee can remember the locations of the most flowers, as well as knows the other locations of the abundance flowers which found by its neighbours. In that case, as shown in Figure 3.5.1 a, depending on the location of the most flowers that is personally pointed, and the location that is discovered and reported by the rest of the swarm bees, the hesitant bee accelerates in both directions, and alters its trajectory to move towards best position based on the social influence that dominates its decision.

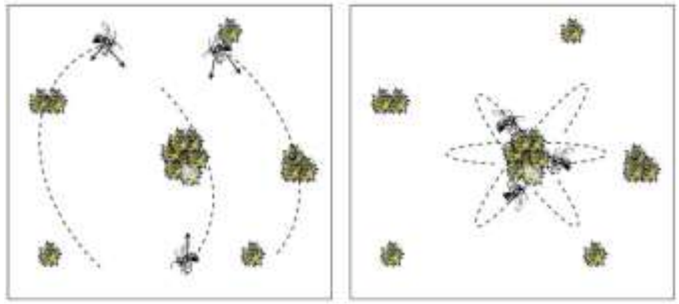


Figure 5: Bees search process in a field

(a) Bee search for location of Most Flower **(b) Bee attract to high flower Concentration area**

After this, a bee or swarm may discover new place with higher density flowers compared to previous one, so they move to modify their locations towards this new place. In like manner, when a place with more flowers is discovered by one bee later, the whole bees of the swarm draw towards this location in addition to their own personal detection. Consequently, after exploring the field and flying over the best density places, the bees are being pulled back towards them. They keep checking the location that they fly over in order to find the absolute best density of the flowers against the last encountered location. Eventually, the bees drive themselves into one position with the highest concentration of the flowers, and then all bees of the swarm gather around this point. .[3]

IV .PERFORMANCE ANALYSIS

The standard 33 bus distribution system with a demand, as shown in Table 1 .It has been adopted for the validation of the proposed methodology. The base voltage and base MVA chosen for the entire analysis are 11 kV and 100 MVA, respectively. The proposed 33 bus system as shown in fig 4.

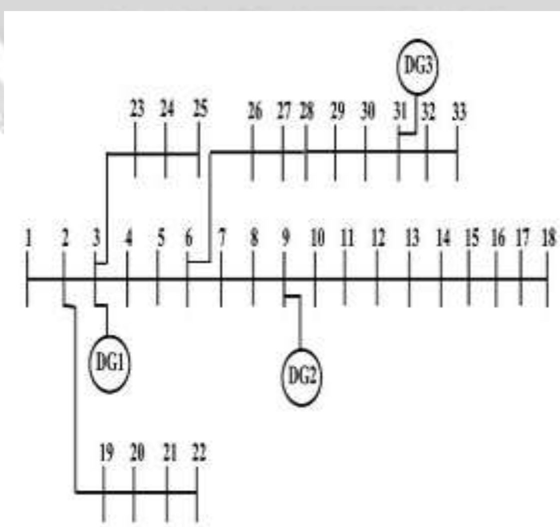


Figure.5. One line diagram of the autonomous micro-grid with optimally placed DG units

Sr No	Bus No	Load	
		Mw	Mvar
1	1	0.4	0.25
2	2	0.36	0.22
3	3	0.48	0.30
4	4	0.24	0.15
5	5	0.24	0.15
6	6	0.8	0.49
7	7	0.8	0.49
8	8	0.24	0.15
9	9	0.24	0.15
10	10	0.18	0.11
11	11	0.32	0.20
12	12	0.32	0.20
13	13	0.48	0.30
14	14	0.24	0.15
15	15	0.24	0.15
16	16	0.24	0.15
17	17	0.36	0.22
18	18	0.36	0.22
19	19	0.36	0.22
20	20	0.36	0.22
21	21	0.36	0.22
22	22	0.36	0.22
23	23	1.68	1.04
24	24	1.68	1.04
25	25	0.24	0.15
26	26	0.24	0.15
27	27	0.24	0.15
28	28	0.48	0.30
29	29	0.8	0.49
30	30	0.6	0.37
31	31	0.84	0.52
32	32	0.24	0.15

33	33	0.48	0.30

Table .1 Ranking of buses based on maximum Load of Real Power Demand

The real power losses in MVA and the cost of generation of the DGs in 0.1 million rupees have been normalized on a ten point scale using (1) and the variation of the losses and cost of power generation has been plotted against the number of DG units (i.e., for r=1 to 6) as Shown fig 6.

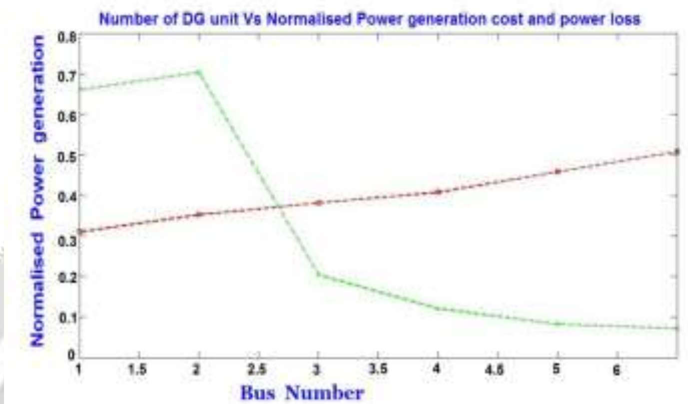
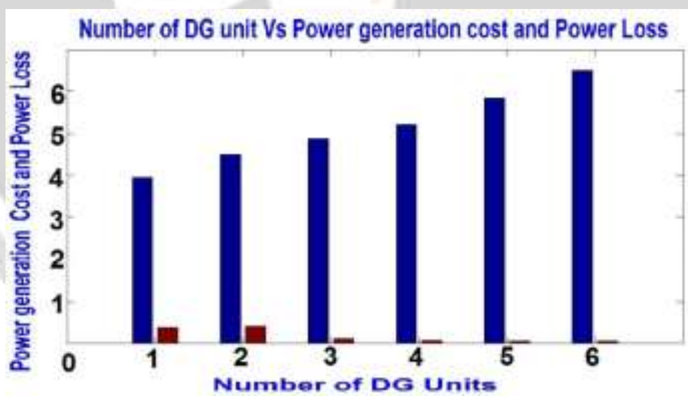


Fig 6 Variation in real power loss and generation cost against number of DG location in an autonomous micro-grid

It has been noticed that, for the standard 33 bus distribution system adopted for validation, the curves depicting the variation in the distribution system losses and the power generation cost are contradictory in nature and hence cut each other at three DG sites.



V. CONCLUSION AND FUTURE SCOPE

This project for the first time has proposed a comprehensive methodology for transforming an existing radial distribution system fed from a substation feeder to an autonomous micro-grid. A detailed objective function for converting an existing radial distribution network into an autonomous sustainable micro-grid has been formulated. New techniques for determining the number of units required, siting and sizing of thunits, and structure of the micro-grid have been developed. Two non-traditional optimization techniques have been employed separately for solving the sizing problem.

As a future scope of this work, ranking of buses based on power loadable limits can be attempted to investigate the effect of variations in the power loads upon the bus voltages. The PSO algorithm has been implemented for real-time self-tuning of the proposed power controller. This algorithm offered appropriate performance for finding the optimal control parameters required to reach the control objectives .Further studies can be made to device methods to reconfigure the system by incorporating both sectionalizing & Tie switches during disturbances in the Micro-grid.

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