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ABSTRACT

Deregulation of all commodities around the world has put onus on the power system operators to restructure the monopolistic structure and introduce competition in this sector. This is further being pushed by the advocators of open access market and supported financially by the World Bank.

This has resulted in the development of oligopolistic energy market with three basic structures e.g., Generation Companies (GENCOMs), Transmission Companies (TRANSCOMs) and Distribution Companies (DISCOMs). Generation sector has invited and attracted many investors to step small generation units of conventional or renewable energy sources that are competitive enough to take part and challenge the cost being offered by the traditional generating companies. The distribution sector or the retail sector purchases the power from the generation companies and supplies it to the customers making its own profit and is ultimately responsible for the customer satisfaction. For reaping the benefits of the economy of scale, transmission sector is placed under control of single entity, so it does not attract investors unlike the generation and distribution sector.

With the improvement of living and rapid industrialization, energy demand has increased rapidly. Power generation is the harbinger of economic growth and industrial development of any country. Indian power sector is facing challenges and despite significant growth in generation over the years, it has been suffering from shortages and supply constraints. With the increase in the level of global warming, renewable energy based distributed generators will increasingly play a dominant role in electricity production. More than 80,000 villages in the country are still to be electrified, with a significant number of such villages located in economically backward and difficult regions. With reference to the power and energy scenario, Government of India, has been promoting viable renewable energy technologies including wind, small hydro and solar power technologies. Renewable energy technologies based on Solar (Photovoltaic and Solar Thermal), Wind turbine generator, biomass, mini hydro along with the use of Fuel cell and Microturbine will gain considerable momentum in the near future. These renewable energy technologies are considered to offer sustainable energy alternatives to the world by serious environmental problems and volatile fossil fuel need. India is abundantly endowed with renewable energy resources like solar energy, wind energy, biomass and small hydro, widely distributed across the country and can be used as commercially viable technologies to generate power. In addition to this, renewable energy technologies also help in improving environmental issues.

To electrify remote and rural areas, it may be difficult as well as uneconomical to transmit power over long distances through transmission lines. On the contrary, single source DG, hybrid DG or microgrid are more favorable to electrify such areas. A microgrid consists of clusters of loads and distributed generators that operate as a single controllable system. The interconnection of the Distributed Generation (DG) to the utility grid through power electronic interface has raised concern about safe operation and protection of equipment's. Concept of microgrid supersedes all the advantages of single source DG and Hybrid DG. Many innovative techniques have been used for enhancing the performance and feasibility of microgrid in isolated or islanded mode and grid-connected mode. The common methods include the combination of different micro-sources along with converters and energy storage systems.

Different types of primary renewable energy sources are solar, wind, hydro power, biomass, geothermal and biofuels. Solar and wind are stochastically fluctuating and intermittent sources of energy. To make this power generation demand-oriented, energy storage is required. In general, energy storage systems are required when there is no exact correlation between demand and generation of power. Different types of energy storage systems include battery energy storage, pumped hydro storage, flywheel energy storage and supercapacitors. A hybrid power system consists of different types of micro-sources along with converters and energy storage systems.

Initially, in this thesis, various topologies of microgrid are analyzed for a location Aligarh in Uttar Pradesh, India and the feasibility of the proposed system has been tested by modeling an existing system. Hybrid Power Systems (HPS) such as Wind-Diesel, PV-Wind-Diesel along with proper converter and battery bank are modeled in HOMER (Hybrid Optimization Model for Electric Renewables). The feasibility of microgrid is justified with and without diesel generators. The HPS are connected in two different modes: (i) Isolated/ Islanded Mode and (ii) Grid Connected Mode. Economic feasibility study includes calculation of Cost of Energy (COE), Net Present Cost (NPC), Operating Cost (OC) and Carbon Dioxide (CO_2) emissions. Different combinations and ranges of micro-sources, converter and energy storage systems are taken into consideration for proposed method. Later on, A hybrid methodology is investigated to analyse reliability and techno- economic evaluation on various configurations of microgrid. The effect of addition and removal of DG units on the overall reliability of the system is analysed using Markov approach on MATLAB software. Various reliability levels of microgrid are considered i.e. two-level redundancy, three-level redundancy and four-level redundancy.

Further, an algorithm is proposed for optimal placement of DG and Distribution Static Compensator (DSTATCOM) in the network. The optimal size of DG and DSTATCOM is also evaluated using the proposed methodology. The aim behind optimal size and location of DG and DSTATCOM is voltage profile improvement and minimization of network losses.

Later, various possible power procurement strategies of a microgrid are analysed. The surplus or deficit power of a microgrid is sold and purchased via three options i.e. via DISCOM, via bilateral contracts and via power exchange. Based on this analysis, the most economical power procurement strategy is proposed for an assumed load, location and configuration of microgrid.

The present work is likely to address problems faced in design, feasibility, sizing of different components and techno-economic analysis. It also helps answering Greenhouse Gas (GHG) emissions and environmental issues and contribute significantly in microgrid operation and power system network. The different techniques developed will be particularly useful for the techno-economic analysis of any microgrid system. Furthermore, it also provides creative ideas for the implementation of the proposed scheme in practical application and design. Thus, this research work intends to establish and affirm the firm steps to achieve better technical, economical and environmental performance of microgrid using the proposed algorithms.