Chapter 6

Conclusions

6.1 General

The goal of integrating Distributed Generators (DGs) and storage devices is to improve distribution system management to operate the system in grid-connected mode or autonomous mode. The nonrenewable and renewable energy sources of smaller size installed at the distribution level are identified as Distributed Generators (DGs). Determining the right size DG at the right location for installation in the distribution system is still a problematic issue for power system engineers. In the case of renewable sources, the geographical area, source potential, and uncertain nature of renewable sources have necessitated a primary focus on DG penetration in distribution systems. The existing grid infrastructure capability, configuration, and load condition are key factors in accepting new resources in the Distribution system.

The new distribution system is expected to provide economic, technological, and environmental benefits within financial and ecological constraints. Therefore, an analysis of the availability of natural power sources and the optimum placement for renewable DG such as wind and solar has been addressed as part of the microgrid's fundamental planning. The intermittent nature of wind and solar power for the specified site has been evaluated for various values of statistical parameters. The probable average energy generation has been calculated, which has been used to design an optimization function for renewable DG placement and size. The optimal value of state and control variables for minimizing losses and the Levelized cost of renewable energy is crucial for stable power system operation. The metaheuristic optimization approaches such as Particle Swarm Optimisation (PSO) and LEVY PSO have been used in this study to identify the placement of hybrid DG for stable distribution system functioning in various scenarios.

The proposed work has been applied to IEEE-13 bus Distribution system. The backward-forward load flow has been utilized to compute nodal voltage and phase angle, branch current, and total network losses without placement of DG. The same parameters have been obtained after DG has been installed optimally. The optimized variables and optimum value of the fitness function have been obtained through the development of an optimization algorithm using LEVY PSO. In this case, node voltage and phase angle have been used as control variables. These control variables' maximum and minimum values have been set to industry standards. The network losses and injected power which are functions of these variables, branch current, and total network losses have been computed without taking into account load flow.

The main contribution of the thesis includes,

- Determination of wind unit model based on analysis of the Weibull probability distribution function. The estimation of the output power generation of wind unit has been carried out for the actual value of shape and scale parameter of pdf which has been obtained from historical data of specific site in Chapter-2.

- The process for determining the potential of solar electricity units per day on the specific site has been explored in chapter-3. The solar power generation model has been characterized as a beta probability distribution function, and hourly average energy generated by a given solar unit has been calculated. Historical data of town Cambay (seashore of Gujarat state) has been collected for analysis.

- The objective function has been created to obtain the technical benefits of integrating natural power distributed generators. Particle Swarm Optimization techniques have been run to resolve an optimization challenge. The work was conducted on the IEEE-13 node distribution system in Chapter-4

- The optimization problem which was created in Chapter-4 has been modified for the integration of renewable Distributed generators combined with a storage device in a microgrid. A levy flight PSO algorithm has been used to obtain the optimal value of variables and fulfill the objectives like minimum grid losses and the Levelised cost of energy generation and substation dependency.

The main purpose of this chapter is to highlight the key findings of the efforts made in this thesis and to give suggestions for future research in this field. Some of the key findings are highlighted in this section.

6.2 Summary of Important Findings

In chapter-2, the energy generation/day and power production/specific period has been computed in four ways.

1. Assume the fixed value of shape parameter- k by studying historical data of wind speed.

2. Choose Ray-leigh pdf means shape parameter- k =2.

3. Find the value of shape parameter- k for specific time slot/day by statical analysis of historical data of wind speed.

4. Consider power probability as per wind speed state and shape parameter- k has been calculated from wind statistics for one quarter.

Identical result has been obtained from method no:3 and 4. However, In the case of state-wise probability (method-4), the length of computational steps and time is less. From a research point of view, wind models with Shape parameter K=2 (Rayleigh) may not always be applicable to developing unique methods. As a result, a thorough analysis of wind speed and probable wind power has been carried out. This analysis has been used to plan the optimal installation, operation, and control of the power grid and scheduling of the power plant. This model is also useful for reducing estimation error in wind power forecasting and maximizing natural resource utilization in the power grid. The model which is discussed in chapter -2 is applied to plan summation of wind power resources with convectional DG in the microgrid.

The solar power generating model was established following a detailed analysis of the solar radiation at the chosen location-Town, Cambay, along the seaside of Gujarat state. The solar radiation potential has been evaluated using beta pdf, which is obtained on an hourly basis. The solar energy generation/day and solar power production/specific time period have been computed in two ways.

1. On the basis of hourly mean solar radiation.

2. hourly solar radiation is divided into four states.

When the state-by-state probability is taken into account, the estimation of average solar energy generated per hour in the first and second quarters is 25% greater. The probable energy produced per hour during quarter-3 is less than that produced by the preliminary technique. During the fourth quarter period, the average hourly energy generated by both the way is the same. The result of the estimation has been verified with the readily available solar power production tools.

The studies conducted in Chapter-4 reveal about Particle Swarm Optimization (PSO) for finding optimal summation of solar, wind, and microturbine in a microgrid. A microgrid power flow analysis with backward-forward load flow has been carried out to determine system losses, nodal voltage, and phase angle. The development of an optimal problem strategy for determining the placement and size of NPDG and microturbines in grid-connected microgrid has been presented in this chapter. The hourly average probable power generation of wind and solar units has been taken into account as the maximum power generation limit of that unit for the reliable operation of a distributed power system. In order to minimize losses and reliance on the main grid, the highest loaded node is the best optimum location for any DG having a maximum power generation limit. It has been proved that the PSO method is far better for getting the value of fitness function regarding optimal integration of renewable and nonrenewable DGs in a microgrid.

A novel approach, Levy flight Particle Swarm Optimization has been discussed in chapter-5 to solve the optimization problem of planning and operation of microgrid along with renewable and nonrenewable DGs. The fitness function has been developed by including DG Levelized energy costs, grid losses, system restrictions, and microgrid reliance on the main substation. The average G_best value has been obtained for the IEEE 13 bus distribution test system. Hence, Levy flight Particle Swarm Optimization provides the optimum value of the objective function.

6.3 Scope for Further Research

The following aspects are suggested for further research as a result of the analysis and investigations presented in this thesis.

(i) The findings in Chapters 2 and 3 were limited to the one chosen location. The idea can be analyzed for various sites near or off the coast. It can be used with a range of sizes and types of solar and wind power units.

(ii) The problem formulation can include voltage controller and AC/DC converter constraints. The same fitness function can be solved for real-time data of natural power supply or a variety of other situations not covered in this thesis.

(iii) In this study, the proposed strategy is applied to the IEEE-13 bus distribution system. The same can be tested on grid-connected commercial microgrid or residential microgrid. It can also be tested on an isolated microgrid.

(iv) In comparison to convectional PSO, the LEVY-PSO technique, which is explored and implemented in Chapter 5, is more efficient and faster. This method can be used to solve a wide range of optimization problems in order to address Smartgrid issues and identify solutions.