Abstract

With increased interest in clean and renewable energy sources, motivated by environmental and growing energy needs, the integration of distributed energy sources into the existing system is gaining importance. This integration has opened avenues for "local energy grids," termed as microgrid, that provides flexible and enhanced grid management. The microgrids have a dedicated control structure that can operate either in grid-connected or islanded/autonomous mode. The scope of this thesis is to address the optimal planning and operational concerns of AC islanded microgrid network, considering the uncertainty in its due course.

The uncertain nature of load demands and renewable generations are inherent by their nature, affecting the steady-state operation of microgrid. Various methods have been proposed for quantification of such uncertainties, depending on the randomness and problem under consideration. The objective of this thesis is to propose methodologies pertaining to optimal planning and operation considering uncertainties to ensure robust and secure operation of AC islanded microgrid. The relevant optimization problems are formulated related to economic, environment, and performance feasibility in droop regulated islanded microgrid.

The load demand and renewable generation uncertainties are characterized and propagated into the system model using different methods viz., scenario generation, point estimate, and hybrid approaches. The appropriate method is chosen and implemented depending on the context of problem formulation relevant to planning and operative perspective. The effect of renewable correlation on optimal operation of microgrid is also dealt with suitable transformations incorporated in uncertainty characterization. The formulated multi-objective optimization problems has been proposed to solve using the contemporary heuristic multi-objective ant lion optimization (MALO) algorithm with fuzzy normalization for droop parameters of dispatchable generators in the microgrid. The simulation studies demonstrate

how economic and environmental benefits, together with improved operational performance (enhanced loadability, reduced voltage variations etc.), can be achieved by optimal tuning of droop parameters in the microgrid.

At last, the stochastic optimal planning model of AC islanded microgrid is proposed with multi-energy demands viz., electrical, heating, and cooling loads. The optimal mix and sizing of multi-energy sources are solved concerning investment cost and emission-related objectives in uncertain load and correlated renewable generation environment. The simulation results demonstrate how obtained sizing can suffice the seasonal multi-energy demands.

Keywords: Islanded microgrid, uncertainty, droop control, optimal planning, costs, emissions, multi-objective optimization, multi-objective ant lion optimization (MALO).