Chapter 19
Three Scenarios in Microgrid to Solve Management Problem for Residential Application Using Genetic Algorithms

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ABSTRACT

This chapter discusses online management of the MicroGrid components. A major challenge for all power utilities is not only to satisfy the consumer demand for power, but to do so at minimal cost and low emissions. Any given power system can be comprised of multiple generating units each of which has its own characteristic operating parameters. The operating cost and emission level of these generators usually correlate proportionally with their outputs, therefore the challenge for power utilities is to balance the total load among generators that are running as efficiently as possible. One of the important applications of the MicroGrid (MG) units is the utilization of small-modular residential or commercial units for onsite service. Genetic Algorithms (GA) optimization is well-suited to solve the environmental/economic problem of the MG. The proposed problem is first formulated as a nonlinear constrained optimization problem. Prior to the optimization, system model components from real industrial data are constructed. The model takes into consideration the operation and maintenance costs as well as the reduction in NOx, SO2, and CO2 emissions. The optimization is aimed at minimizing the cost function of the system while constraining it to meet the customer demand and safety of the system. The results ensure the efficiency of the proposed approach to satisfy the load and to reduce the cost and the emissions in one single run.

INTRODUCTION

The need for more flexible electrical systems, changing regulatory and economic scenarios, energy savings and environmental impact are providing impetus to the development of MicroGrids (MGs), which are predicted to play an increasing role in the future power systems. One of the important applications of the MG units is the utilization of small-modular residential or commercial units for onsite service. The MG units can be chosen so that they satisfy the customers load demand at minimum cost all the time.

DOI: 10.4018/978-1-4666-4450-2.ch019

Recent developments in the electric utility industry are encouraging the entry of power generation and energy storage at the distribution level. Together, they are identified as Distributed Generation (DG) units. Several new technologies are being developed and marketed for distributed generation, with capacity ranges from a few kW to 100 MW. The DG includes microturbines, fuel cells, photovoltaic systems, wind energy systems, diesel engines, and gas turbines (Jenkins, 2010), (Chowdhury et. al, 2009).

The management of the MG units requires an accurate economic model to describe the operating cost taking into account the output power production. Such a model is discrete and nonlinear in nature; hence optimizations tools are needed to reduce the operating costs to a minimum level.

There are several potential economic benefits of microgrids are summarized as (Abu–Sharkh et al, 2006):

- Reduced transmission and distribution costs and energy losses.
- Potentially total higher energy efficiency.
- The small scale of individual investments reduces capital exposure and risk, by closely matching capacity increases to growth in demand.
- The low capital cost potentially enables low-cost entry into a competitive market.

This chapter assumes the MG is seeking to minimize total operating costs using Genetic Algorithm. MicroGrids could operate independently of the uppergrid, but they are usually assumed to be connected, through power electronics, to the uppergrid. The MG in this paper is assumed to be interconnected to the uppergrid, and can purchase some power from utility providers when the MG is insufficient to meet the load demand. There is a daily income to the MG when the generated power exceeds the load demand.

In the last scenario, it incorporates an explicit cost minimization criterion applied to the MG architecture. The formulation in this work seeks the best environmental/economical generation to satisfy the load demand and the constraints. The problem is decomposed into two stages, starting by building a system model, which is an important stage to understand the problem. The next stage is the application of the developed algorithm. The algorithm consists of determining at each iteration the optimal use of the resources available, such as wind speed, temperature, and irradiation as they are the inputs to the model. If the produced power from the wind turbine and the photovoltaic cell is less than the load demand, then the algorithm goes to the next stage which is the use of the other alternative sources according to the load and the objective function of each one.

The second objective of this chapter deals with solving the optimization problem considering several scenarios to explore the benefits of having optimal management of the MG. The study is based on minimizing the running costs. Then it is extended to cover a load demand scenario in the MG.

The optimization is aimed at minimizing the cost function of the system while constraining it to meet the costumer demand and safety of the system. The results demonstrate the efficiency of the proposed approach to satisfy the load and to reduce the cost and the emissions. The comparison with other techniques demonstrates the superiority of the proposed approach and confirms its potential to solve the problem.

Definition of Microgrids

The MicroGrid (MG) concept assumes a cluster of loads and microsources operating as a single controllable system that provides both power and heat to its local area. This concept provides a new paradigm for defining the operation of distributed generation (Lasseter 2001), (Lasseter, 2002). The MG study architecture is shown in Figure 1. It consists of a group of radial feeders, which could be part of a distribution system. There is a single

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