Optimization of Day Ahead Distributed Intelligent Decision-Making for a Multi-Microgrid System

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***Abstract*— The aim of this paper is to schedule a day ahead operation of multiple grid connected microgrids using two stage optimization scheme. In the first stage, each microgrid forecasts its own load and determines shortage or surplus of power at each hour. In the second stage, power exchanges between microgrids and the utility grid is considered and the microgrids sell their excess energy or buy their shortage energy from the utility grid or other microgrids. Multi-layer feedforward perceptron method is used for forecasting electric loads. Also, stochastic programming is considered in order to account for the uncertainty of power produced by renewable generation units. It was found that by using this energy management method, the total costs of the system were decreased by 2.6%.**

***Index Terms*-- Bi-level stochastic programming, multiple microgrids, optimal energy management system**

I. Introduction

A microgrid consists of multiple energy resources including both renewable and non-renewable resources and usually it is grid connected to feed the loads of the distribution network. The context of microgrids has attracted researchers in the recent years because of the low cost of implementation and the fact that they have lower energy losses.

A number of studies in the area of microgrids include building a real time energy management system based on a hierarchical bi-level control scheme [1], building bidding strategies for microgrids using two-stage stochastic programming process [2], and minimization of energy losses of microgrids using plug in hybrid electric vehicles [3]. Reference [4] has presented a dispatching strategy of microgrids based on a hierarchical management in which the optimal model of microgrids is established for minimizing operation and environmental costs. In [5], an energy management model has been proposed based on a decentralized hierarchical architecture. The presented model is robust by considering the uncertainty of the renewable energy resources. However, no forecasting method is integrated with the model to complete day ahead energy management. In [6], a multi-level energy management system was designed for real-time operation of microgrids to enhance power quality factors. However, it has only considered dc microgrids. A multi-objective energy management scheme integrated with a pricing regime has been introduced in [7], which is not day ahead and the uncertainty of load and renewable resources is not considered. Other studies include optimizing microgrid energy management by using an advanced forecasting method for photovoltaic generation [8], designing an energy management system for microgrids based on cooperative model predictive control to maximize flexibility [9], managing microgrids to regulate voltage and frequency by using virtual droop control [10], and managing microgrids to achieve the maximum duration for supplying electricity during emergency conditions [11].

In this paper, a two stage energy management scheme is proposed for microgrids using forecasting methods and stochastic programming. In the first stage, the loads of the microgrids are forecasted using a multi-layer feedforward perceptron method, and the energy management system (EMS) of each microgrid manages microgrid resources to meet the forecasted load. In this stage, the lack and surplus energy of each microgrid is determined. In the second stage, the central energy management system (CEMS) manages and optimizes energy interactions between the microgrids and between microgrids and the utility grid to minimize the cost. The study conducted in this paper is a continuation of the work presented in [1] however it uses a faster method of day ahead optimization based on mixed integer linear programming to achieve global optimal solution for operation of microgrids while [1] uses optimization algorithms that may not lead to the global optimal operation point. Moreover, a forecasting technique is added to the optimization process which is a necessary part of day ahead scheduling of resources.

II. System Architecture

Fig. 1 shows the architecture of the system that is used in this study. As it can be seen from this figure, the operation of each microgrid is optimized by its own EMS in the first stage, and the overall operation of the system is optimized by the CEMS in the second stage. Each microgrid includes