Optimal Operation of a Microgrid in Presence of Distributed Energy Resources and Demand Response Programs

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Abstract:

In today's electric grid, due to demand growth, environmental issues and limited energy resources, distributed energy resources (DERs) application and demand-side management methods have received special attention. High penetration of DERs and implementation of demand response (DR) programs, especially in distribution networks, have affected several issues on these networks such as their control and operation. Although DERs can reduce the required network operation and planning costs, control and operation of a large number of DERs with different characteristics is a major challenge for the secure and efficient operation of power system. This challenge is introducing a new concept as microgrid which *is a MV/LV grid with embedded DERs interconnected with the upstream grid to exchange thesurplus or deficit of electrical power locally produced respect to the load.* Therefore, according to the key role of distribution networks in restructured environment, optimal energy management in this new environment requires considerable research. Due to these reasons, this thesis presents a comprehensive energy management framework for an active distribution network considering high penetration of distributed energy resources and demand response programs. In the proposed model, microgrid maximizes its profit by participating in energy and reserve markets and selling energy to its end-use customers; this is achieved by optimal scheduling of its internal resources during 24 hours time horizon. The proposed method can assess various DERs (both dispatchable and non-dispatchable units) along with their technical and economical constraints. It also considers distribution network security constraints, the possibility of power exchange with the neighboring microgrid, and uncertainties associated with renewable production and load pattern.

Also, a real-time pricing (RTP) in a smart grid environment is presented. Using the RTP, microgrid maximizes its profit considering customers' benefit. This pricing scheme could be used as an efficient tool to manage customers' energy consumption and distribution grid operation costs. Finally, a comprehensive model for energy management in an active distribution network in presence of DERs and proposed pricing scheme is presented in order to participate in energy and reserve markets. The proposed model is a mixed-integer nonlinear programming (MINLP) problem which is solved in GAMS software using DICOPT solver. A 32-bus distribution network including dispatchable generators, electric energy storage, wind turbine units, interruptible loads, and interties is used to evaluate the effectiveness and feasibility of the proposed method. Numerical studies show that by applying the proposed method, in comparison with fixed electricity price tariff, the distribution companies could increase the revenue of participants by modifying the consumption pattern. Also, they can operate the distributed energy sources in distribution network more efficiently

Keywords : Microgrid, Distributed energy sources, Energy management, Demand response, Real time electricity pricing.

[DOR: 20.1001.1.23222468.1391.1.3.8.4]
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Journal of Novel Researches on Electrical Power - Vol. 1-No. 3- winter 2012