Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

Optimal Allocation of Energy Storage Systems (ESS) for Load Management Applications

M.Sc. Thesis
By

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Submitted in partial fulfilment of the requirements for the M.Sc. degree in
Electrical Engineering

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STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the requirements of master of science degree in Electrical Engineering. The included work in this thesis has been carried out by the author at the department of electrical power and machines, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

The integration of distributed generation, especially the renewable energy-based ones, has led to a revolution in the use of distribution systems and the emergence of smart grid concepts. Smart grids facilitate the high penetration of renewable energy sources in order to achieve greater system reliability and efficiency. Energy storage systems (ESSs) are of the most promising techniques that can be used for achieving those goals. The capital and installation costs of energy storage systems are expensive and consequently, the utilities are very careful of integrating the energy storage devices in distribution systems because of the uncertainty of the cost benefits of these devices over their high costs. The research work in this thesis discusses the economic benefits of installing ESSs for distribution utilities; thus, the interest of integrating these ESSs in the power systems can be increased.

The first objective of this thesis is to introduce a new modeling strategy of wind-based renewable energy sources for planning purposes in distribution systems. This strategy is based on Monte Carlo Simulation method which considers the stochastic nature of the wind power through the correct determination of the appropriate cumulative distribution function. Monte Carlo Simulation technique is utilized for obtaining the most likelihood wind turbine output power at each hour at each season. The results of the proposed strategy are compared with another probabilistic model to show the effectiveness of the proposed algorithm. The proposed algorithm is tested using MATLAB environment and the results and comparisons show that the proposed modeling algorithm gives accurate results.

The second objective is to develop a comprehensive planning framework for allocating distributed storage (DS) units in distribution networks in order to achieve several benefits that include decreasing the cost of energy losses, deferring network upgrades, and making benefit of the price arbitrage. Moreover, the application of DS helps in shifting the peak demand into off-peak times, thus deferring the network upgrades. On the top of that, charging and discharging the DS units during off-peak and peak times, respectively, represent another benefit due to the price arbitrage between those different times. In this framework, the installation and maintenance costs of DS units are optimized with respect

to the economic value of the benefits mentioned above. The output of the planning framework is the optimal size and location of DS units to be installed by using Big Bang- Big Crunch and Grey Wolf optimization techniques, the optimal operation of DS at each load state and the load centers to be shed during contingencies.

Keywords: arbitrage benefit, distributed generators, energy storage systems, optimization.

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