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ENERGY MANAGEMENT AND OPERATIONAL PLANNING IN MICROGRIDs

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STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the requirements for M. Sc. 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

Electrical energy demand has been dramatically increased all over the world for the past decades. Renewable energy sources (RES), such as wind power, solar power, should be utilized to meet this tremendous energy demand shifting from reliance on the conventional energy sources based mainly on fossil fuels. A more recent concept exists for grouping a cluster of loads with RES distributed generators in a certain local area forming a Microgrid.

In this context, Microgrid is a key concept to transform the current power system to Smart Grid and realize the distributed control scheme on the power system operation. One of the main research areas in the smart grid is the energy management applications such as Load Management. The Load Management is one of the main important elements of energy conservation aimed at reducing energy consumption in smart grids. The term internationally used for Load Management is Demand Side Management (DSM), although there are similar terms such as Demand Response (DR). DR programs are widely implemented on the commercial and industrial side customers.

The problem addressed by this thesis in the Case Study Part-I is the insufficient awareness of residential side customers about the importance of DR and most of them have insufficient tools. Home energy management (HEM) system which is responsible for monitoring and managing the energy consumption of home appliances, is the most popular DR automation type for residential side customers. HEM system, provides many benefits such as reduction in peak demand, savings in the electricity bill and meeting the demand side requirements.

The case study Part-I includes two control approaches. Direct and indirect controls are applied as HEM systems. Load data is obtained from real sample household. Simulation results obtained from MATLAB/Simulink software demonstrate the effectiveness of the proposed approaches in demand reduction hence decreasing the electricity bill of customers.

In Case Study Part-II, the thesis focuses on the utilization of Renewable Energy Recourses (RES) as Distributed Generation (DG). DG as important part of the Smart Grid has flexible installation locations solving the problems of large/middle centralized power grids. Also, the usage of different energy sources (especially the RES) allows improving the efficiency and reliability of the Microgrid and reduces energy storage requirements compared to systems comprising only one single renewable energy source.

Among the various renewable sources of energy, the most popular sources are the solar and wind energy. Utilization of solar/wind energy became increasingly significant, attractive and cost-effective, since the oil crises of early 1970s. These sources as independent systems cannot provide continuous source of energy, as they are seasonal. Integrating wind and solar resources in a proper combination can overcome the drawbacks of their unpredictable nature and dependence on weather climatic changes. Hybrid Photovoltaic Wind Systems - HPWS can be beneficial in enhancing the economic and environmental sustainability of renewable energy systems. To use solar and wind energy resources more efficiently and economically; Optimal scheduling and sizing of HPWS plays an important role.

Marsa Matruh, Egypt is used as the site for Case Study Part-II to illustrate the effectiveness of the proposed algorithms. The objective is to optimally size a HPWS to supply a group of loads connected to the grid in order to reliably meet the demand requirements.

For the given location and for different scenarios, simulations for the proposed system are designed using MATLAB/Simulink software. The choice of various combinations of sizes of the solar PV arrays, wind turbines and units of the purchased electricity From/To grid is made based on the results obtained from GA and PSO optimization.

This thesis recommends the application of control approaches using HEM systems on residential side customers to achieve the maximum benefits by shifting/shedding the loads automatically and applying the incentive/price based schemes in order to encourage the residential side customers to use the DR programs, and also recommends the utilization of Hybrid PV/WT Grid Connected Systems to improve Microgrids efficiency and increase power system reliability.

Further researches on alternative methods or modifications of the existing approaches are to be worked out so as to achieve more cost and energy savings.

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