Ain Shams University

Faculty of Engineering

Electrical power and Machines Department

Demand Side Management with Renewable Energy Sources

By

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B.Sc. Electrical Engineering, Ain Shams University, 2012

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Electrical Engineering

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STATEMENT

This thesis is submitted as a partial fulfillment of M.Sc. degree in Electrical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

Ahmed Mokhtar Ibrahim Ahmed

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Ahmed Mokhtar Ibrahim Ahmed

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ABBREVIATIONS

DSM	Demand Side Management
CSU	Central Scheduling Unit
SG	Smart Grid
ANN	Artificial Neural Network
STLF	Short Term Load Forecasting
TOU	Time Of Use
CPP	Critical Peak Pricing
RTP	Real Time Pricing
LP	Linear Programming
GA	Genetic Algorithm
PSO	Particle Swarm Optimization
ACO	Ant Colony Optimization
EO	Evolutionary Optimization
EMC	Energy Management Controller
PAR	Peak to Average Ratio
ABC	Artificial Bee Colony
LPT	Load Priority Technique
CHP	Combined Heat and Power
DG	Distributed Generation
RMSE	Root Mean Square Error
MAPE	Mean Absolute Percent Error

Thesis Summary

A smart grid (SG) is an electrical network that manages electricity demand in an uninterruptible sustainable, reliable and economic manner. A smart grid uses smart net meters to overcome the weaknesses of conventional electrical grid. Demand Side Management (DSM) is a vital feature of SG to improve power efficiency, reduce the peak average load and minimize the cost.

One of the basic objectives of DSM is shifting load from peak hours to off-peak hours and reducing consumption during peak hours. Generally, a deregulated grid system is considered where the retailer purchases electricity from the electricity market to cover the end users' energy need. In this thesis, Demand Side Management (DSM) techniques (load shifting and Peak clipping) are used to maximize the profit for Retailer Company by reducing total power demand during peak demand periods and achieve an optimal daily load schedule using linear programming technique and Genetic Algorithm. This technique is implemented on the standard IEEE 33-bus radial network. Also, a short term Artificial Neural Network technique is used to get forecasted wind speed and forecasted users load for date 25-March-2018. The neural network here uses an actual hourly load data and an actual hourly wind speed data. Then the forecasted data is used in the optimization to get optimal daily load schedule to maximize the profit for Retailer Company. Then comparison between profit using linear programing and genetic algorithm are made. The optimized DSM succeeded to increase the profits of the company by around 4.5 times its previous profit using Linear Programing and around 2.5 times using Genetic Algorithm.

Keywords:

Demand-side management, load scheduling, linear programming, genetic algorithm, the Artificial Neural Network technique

CHAPTER ONE

INTRODUCTION

1.1 General

One of the important parts of the power system is the Distribution system. This distribution system connected the bulk generation with the customers. The proper planning of the system is very important challenge to meet the unstoppable increasing in demand.

DSM is described as the planning and monitoring of utility's activities designed to encourage customers to adapt their electricity consumption routines by considering the timing and the level of electricity demand. Thus, help the customers to use electricity more efficiently.

The load shapes which indicate the daily electricity demands of consumers between peak and off-peak times can be shown in Figure 1.1[1]. There are three DSM techniques i.e. load shifting (demand shifting from on peak hours to non-peak hours), Valley filling (increase load demand at off peak hours) and Peak clipping (reduce the peak demand) [2].

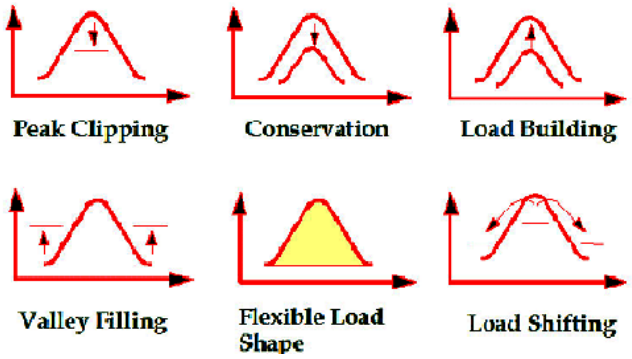

Figure 1.1 Classic strategies used for DSM.

Demand Side Management (DSM) is an important application that utilizes smart grid (SG) infrastructure to reduce the peak average load, improve energy efficiency and maximize profit. In future smart grids Central Scheduling Unit (CSU) should be used in all building, digital smart meters will be installed in all customers' flats that are equipped with digital and programmable control unit. Smart meter has communications with the CSU and vice versa as shown in Figure 1.2 [3-6]. Also, there is a distributed Energy Management Controller (EMC) unit in each user's smart meter.

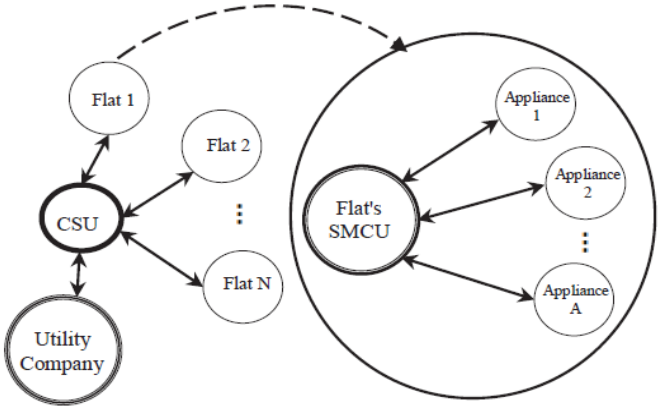

Figure 1.2 An assumed demand side management system.

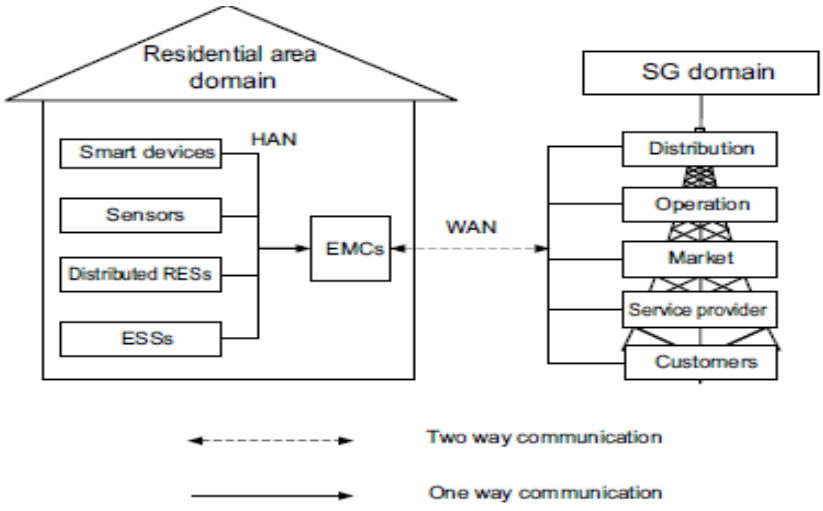

Figure 1.3 Domains of DSM.

As shown in Figure 1.3 [7] domains of DSM are residential area domain and SG domain. SG domain consists of distribution, operation, market, service provider and customers. A distributed Energy Management Controller is in residential area domain that connected to sensors and smart devices. All EMC units are connected to CSU so utility can control customer loads. Utility can shift customers load to off peak hours or clip customers load at peak hours taking into account users' preferences.

Optimization techniques are used to minimize the peak load, minimize cost considering user's individual preferences for the loads by setting priorities and preferred time intervals for load scheduling and Reduce PAR (Peak to Average Ratio).

1.2 DSM solutions and challenges:

I. Reduction in consumption:

Depend on customer's awareness to reduce their consumption to improve efficiency of equipment and process.

II. Shifting consumption from peak hours to valley hours:

In Demand Side Management (DSM) techniques the load is shifted from peak hours to off peak hours which results in financial benefit to residential customers. The optimization should reduce the total costs of the system. The flexible devices should be shifted to off peak period according to Load Priority Technique (LPT), considering user's individual preferences for the loads by setting priorities and preferred time intervals for load scheduling.