AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electrical Power and Machines Engineering

Energy Management for Prosumers in Distribution Systems

A Thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy in Electrical Engineering (Electrical Power and Machines Engineering)

by

Nathalie Nazih Iskander Baskharoon

Master of Science in Electrical Engineering (Electrical Power and Machines Engineering) Faculty of Engineering, Ain Shams University, 2016

Supervised By

Prof. Tarek Saad Abdel-Salam

Assoc. Prof. Walid Aly Seif El-Islam El-khattam

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Examiners' Committee

Name and Affiliation	Signature
Prof. Noha Hany El Amary Professor in Electrical and Control Department, Vice-Director for African and Asian Affairs, Arab Academy for Science, Technology and Maritime Transport	.....
Prof. Hany Mohamed Hasanien Electrical Power and Machines , Ain Shams University	.....
Prof. Tarek Saad Abdel-Salam Electrical Power and Machines , Ain Shams University	.....

Date: ……/……../……

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Name and Affiliation	Signature
Prof. Tarek Saad Abdel-Salam Electrical Power and Machines , Ain Shams University	.....
Assoc. Prof. Walid Aly El-Khattam Electrical Power and Machines , Ain Shams University	.....

Date: ……/……../……

Statement

This thesis is submitted as a partial fulfillment of Doctor of Philosophy 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 a qualification at any other scientific entity.

Nathalie Nazih Iskander

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Date: ……/……../……

Researcher Data

Name	: Nathalie Nazih Iskander Baskharoon.
Date of birth	: The first of May 1990.
Place of birth	: Cairo, Egypt.
Last academic degree	: Master of Science.
Field of specialization	: Electrical Engineering.
University issued the degree	: Ain Shams University.
Date of issued degree	: 29th June 2016.
Current job	: Assistant Lecturer, Faculty of Engineering, The British University in Egypt (BUE).

Thesis Summary

In most countries, power utilities and distribution companies follow the electricity price that is tightly set by the government authority or energy regulator. However, competitive electricity market has many positive impacts on minimizing the price of energy and the services related to it. The main problem that faces the electricity market in Egypt nowadays is the high electricity prices. This problem arose after cutting the energy subsidies to reduce the burden on the government budget. Designing the energy market to overcome this challenge includes minimization of the overall cost of generation and reducing the shadow prices that highly impacts the consumers.

In this thesis, the international prices of the different types of fuel is considered. As the government plan is the full removal of subsidies in the energy market whether fuel or electricity. In this study, a transparent and open competitive market is attained. Vital goals are considered while planning the electricity market including; the supply-demand balance, reducing the power system losses and minimization of the congestion on the transmission lines. Two alternatives are proposed to study the electricity market. The proposed alternatives are compared with the traditional optimal power flow (OPF) analysis. These alternatives are applied to the Egyptian unified power network. Minimizing the overall electricity cost is done through optimizing the generation from the power plants available.

The first alternative represented the electricity market in Egypt as a regulated market. This market model is considered a monopoly market. It has utilities that owns the infrastructure, generation, transmission lines, meters and sells the electricity direct to the customer. Bottom-up modeling is applied to solve the objective function. The least priced power plants supplied the load demand with its full capacity. Some loads were placed away from the power plants with low cost of generation. This caused overloading of some transmission lines. Transmission system upgrading is applied by adding parallel circuits to the stressed transmission lines. This strategy showed positive impact on the shadow prices at the distribution level.

The second alternative proposed using the deregulated market while modeling the electricity market in Egypt. The deregulated electricity market allows market players to compete in buying and selling electricity through investing in the transmission lines and power plants. The retail suppliers buy the electricity from the generators owners and set prices for consumers Currently, the government allows the customers to invest in generating electricity using Renewable Energy Sources (RES), where a feed-in tariff and net metering system is proposed by the government to encourage the private sector. In this study, the Egyptian unified power network is divided into multiple regions. Every region has a different shadow price based on the load demand and the available power plants in this region. The clearing price of the market is set as the highest cost of generation of the power plants sharing in supplying the demand at this region. In this alternative, a proposal is implemented to introduce renewable energy power plants owned by the government at the distribution level. As a result, the generation is located near the load demand. There is no need to enhance the transmission system. Minimization of the shadow price is achieved using renewable energy power plants. As these power plants have low cost of electricity generation in comparison with the conventional power plants.

The two alternatives are examined technically and economically. Technically, both alternatives are more effective than the traditional optimal power flow analysis. Economic feasibility study is used to evaluate the two alternatives. Analysis shows that the photovoltaic PV power plants implementation is more effective than upgrading the transmission system. Simulation showed 63% savings in the overall cost of electricity generation. Photovoltaic PV power plants

make profit of 5.61 € per MWh generation. The PV power plants payback period is 54.4% of its lifetime.

Keywords:
Electricity Cost Minimization, Shadow Prices, Transmission System Upgrading, PV Power Plants, Solar Radiation Forecasting, Bottom-up Model, Optimal Power Flow, Economic Feasibility Study.

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