OPTIMIZATION OF MAXIMUM DEMAND OF ELECTRICAL ENERGY SYSTEM USING DISTRIBUTED GENERATION TECHNOLOGY

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To my beloved mother Hjh. Asia Abukar and
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ABSTRACT

Nowadays, the increasing of energy demand and its escalating cost has forced many companies and institutions looking solution for this problem. Electric customers have to pay a maximum demand charge in addition to the usual kWh consumption charge. The peak demand charge frequently stands a large portion of the total bill and it is based on only a period of 15 or 30 minutes registered during month/billing period. The increase of maximum demand due to the world economic development has created high concern from electric supply companies the need to supply that growth in the short period through the existing facilities. The aim of this research is to optimize maximum demand of electrical energy system using distributed generation technology. The selected case study is Universiti Teknologi Malaysia. In this research on-grid Distributed Generation system (DG) has been used to achieve optimum and minimum peak demand and power cost targets. The on-grid DG was based on Hybrid Power System (HPS) which combines power generated from renewable energy sources such as (PV arrays, wind turbine) and power purchased from grid utility. Micro power optimizer software (HOMER) has been used for the optimization and simulation processes. The results indicate that the maximum demand was reduced 16.5% while a potential cost savings of 14% has been achieved. A sensitivity analysis on resource availability and the system costs has been performed in order to explore how variations in average annual wind speed and solar radiation affect the current optimal system costs. Findings of this study will give a valuable contribution to UTM for analysis pertaining to the development of future optimization of peak demand of electrical energy system.

ABSTRAK

Dewasa ini, peningkatan permintaan tenaga dan kos yang semakin meningkat telah memaksa banyak syarikat dan institusi yang mencari penyelesaian untuk masalah ini. Pelanggan elektrik perlu membayar caj permintaan maksimum di samping caj penggunaan kWh biasa. Caj permintaan puncak kerap berdiri sebahagian besar daripada jumlah keseluruhan bil dan ia adalah berdasarkan hanya tempoh 15 atau 30 minit yang didaftarkan dalam tempoh bulan / bil. Peningkatan permintaan maksimum disebabkan oleh pembangunan ekonomi dunia telah mewujudkan kebimbangan yang tinggi daripada syarikat-syarikat bekalan elektrik keperluan untuk membekalkan pertumbuhan itu dalam tempoh yang singkat melalui kemudahan yang sedia ada. Tujuan penyelidikan ini adalah untuk mengoptimumkan permintaan maksimum sistem tenaga elektrik menggunakan tenaga teknologi penjanaan teragih. Kajian kes yang dipilih adalah Universiti Teknologi Malaysia. Dalam kajian ini berkaitan grid sistem Penjanaan Teragih (DG) telah digunakan untuk mencapai puncak permintaan optimum dan minimum dan sasaran kos kuasa. DG berkaitan grid berdasarkan Sistem Kuasa Hibrid (SBT) yang menggabungkan kuasanya dijana daripada Sumber Tenaga Diperbaharui seperti (Berbagai-bagai PV, Turbin Angin) dan kuasa yang dibeli daripada utiliti grid. Perisian pengoptimasi kuasa mikro (HOMER) telah digunakan untuk proses pengoptimuman dan simulasi. Keputusan menunjukkan bahawa permintaan maksimum dapat dikurangkan kapada 16.5% manakala potensi penjimatan kos sebanyak 14% telah dicapai. Satu analisis sensitiviti terhadap ketersediaan sumber dan kos sistem telah dijatankan untuk meneroka bagaimana peribataan dalam kelajuan angin purata tahunan dan radiasi solar menjejaskan kos sistem semasa yang optimum. Hasil kajian ini akan memberi sumbangan yang berharga kepada UTM untuk analisis yang berkaitan dengan pembangunan pengoptimuman permintaan puncak sistem tenaga elektrik masa depan.

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LIST OF ABBREVIATIONS

HVAC	Heating, Ventilating and Air-conditioning
UTM	Universiti Teknologi Malaysia
IEA	International Energy Agency
DSM	Demand-side Management
DR	Demand Response
TOU	Time of Use
kWh	Kilowatt hour
RM	Ringgit Malaysia
ICT	Information communication technology
MCD	Maximum contracted Demand
DM	Demand Management
AC	Air-conditioning
DDC	Direct Digital Control
PC	Personal Computer
TES	Thermal Energy Storage
TNB	Tenaga Nasional Berhad
KVA	kilo-volt Ampere
PF	Power Factor
GA	Genetic Algorithm
DRQT	Demand Response Quick Assessment Tool
DG	Distributed Generation
CHP	Combined Heat and Power
HPS	Hybrid Power System
PV	Photovoltaic Application
DEG	Distributed Energy Generation
HOMER	Hybrid Optimization Model of Renewable Energy

O&M	Operation and Maintenance
DC	Direct Current
COE	Cost Of Energy
NPC	Net Present Cost
ACF	Annual Capacity Factor

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CHAPTER 1

INTRODUCTION

1.1 Background

In the last decades, more and more stress is put on the electricity supply and infrastructure, on the other hand, electricity usage increased significantly. Demand peaks have to be generated and transmitted.

The peak demand charge frequently stands a large portion of the total bill and it is based on only a period of 15 or 30 minutes registered during month/billing period [1]. The increase of maximum demand due to the world economic development has created high concern from electric supply companies the need to supply that growth in the short period through the existing facilities or through future expansions [2].

As electricity cannot be economically stored on a large scale, it has to be produced at the same moment and in the same quantity that is actually requested and has to be transmitted instantaneously from the power generator to the user via transmission lines. Because of these special features, the electricity supply system has to be designed for the maximum expected demand [3].

As capacity addition is costly and can only be installed over a longer time frame (especially if a new power plant must be built), better load management at the user end helps to minimize peak demands on the utility infrastructure and improve the utilization of power plant capacity.

Demand optimization also is good for the planet. One study found that direct feedback on energy use and efficiency programs enabled by demand response solutions could save 50 billion kWh in electricity consumption and avoid the emission of 28 million metric tons of CO_2 in 2030—in the United States alone [4].

Researchers and practitioners have proposed a variety of solutions to reduce electricity consumption and curtail peak demand. This research deals with the issues of finding an acceptable strategy of reducing peak demand and, subsequently achieving potential cost savings.

1.2 Problem Statements

The world is gradually marching towards a severe energy crisis, what with an ever-increasing demand of energy overstepping its supply [5]. Limitations of energy resources in addition to environmental factors, requires the electric energy to be used more efficiently and more efficient power plants and transmission lines to be built.

Today's electricity prices on the wholesale market are volatile because they are determined by supply and demand, as well as by situations that depend on generation capacity, fuel prices, weather conditions, and demand fluctuations over time. On average, off-peak prices at night are 50 percent less than prices during the day. During demand peaks, prices can be many times greater than those of off-peak periods [6].

The increasing of maximum demand due to the development of new buildings and other equipments used has lead to an increasing of the electrical bill in UTM. In this year UTM has completed the construction of new educational buildings for faculty of electrical engineering, faculty of built environment etc. This means UTM electric energy consumption and also maximum demand will increase. Now UTM spends RM 20 million energy bills annually, whereas peak demand charges has a big contribution to the energy bills.

1.3 Objectives

The main objective of this research is to optimize maximum demand of electrical energy system using Distributed Generation Technology (DG) and reduce electricity bills; the selected case study is Universiti Teknologi Malaysia UTM.

1.4 Scope of the Research

In order to achieve the objectives of the project, some boundary or scope need to be specified. The scope of this research includes:

- Performing an optimization model on the proposed HPS in order to achieve optimum and minimum peak demand and power cost targets.
- Collecting historical data including electricity consumption, maximum demand and utility rate structure, wind and solar resources data.
- Using micro-power optimizer software (HOMER) for the optimization and simulation processes.
- Applying the proposed model on the selected case study to illustrate the applicability of the model.

1.5 Outline of the Research

This dissertation has five chapters; chapter 1 is the introduction and includes problem statements, objectives and scope of the research, followed by chapter 2 which is literature review related and useful to this research.

Chapter 3 covers the methodology of the research. The result and discussion were placed in chapter 4 and lastly chapter 5 provides the conclusion and recommendation for future work.

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