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DEMAND SIDE MANAGEMENT: ENERGY PROFILE OPTIMIZATION

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2017

" I hereby declare that I have read through this report entitle "Demand Side Management: Energy Profile Optimization " and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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Date : 2 JUNE 2017

DEMAND SIDE MANAGEMENT: ENERGY PROFILE OPTIMIZATION

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A report is submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

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JUNE 2017

I declare that this report entitle "Demand Side Management: Energy Profile Optimization" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in a candidature of any other degree.

Signature	: ....
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Date	: 2 JUNE 2016

BISMILLAHIRRAHMANIRAHIM

" In The Name of Allah, Most Gracious, Most Merciful"

For viewing,

Father and mother who is respected and loved,

MOHD AS'ARI BIN HAMZAH & MAMUNAH BT ABD RAHMAN

And supervisor, Faculty of Electrical Engineering Universiti Teknikal Malaysia Melaka, and do not forget also to my colleagues.

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Lastly, I would like to convey my gratitude to other people who directly or indirectly help me in this project and in process of finishing this report.

ABSTRACT

The energy growth for Malaysia is rapidly increasing as the country moving forward to be the one of the industrial revolution country. During the peak hours, the energy generated is more expensive than the off peak which rises the cost of generation. Due to that reason, Demand Side Management (DSM) through Demand Response (DR) technique is introduced to modify the demand profile by implementing different strategies of measures. The objective of this study is to optimize the energy profile for commercial sector as well as analyze the reduction of electricity cost by using the optimization technique. An Artificial Intelligence technique, which is Evolutionary Programming (EP) had been implemented to optimize the load profile of a commercial installation. Significant testing had been done while the proposed optimization technique shows the ability to reform the Maximum Demand from peak zone to off peak zone as to as reduce the electricity cost. The test results have been validated by using 4 cases which are conventional method for C1 ToU,C2 ToU, C1 EToU and C2 ETou tariff respectively. The impact of the EP has been analyzed while the performance of C1 and C2 EToU tariff indicate the optimum result of electricity cost for the medium voltage of installation. It is hope that the results from this study will benefits the engineer to rearrange the profile so that the demand side will enjoy significant reduction of electricity cost in the future.

ABSTRAK

Pertumbuhan tenaga di Malaysia semakin meningkat dengan pesat kerana Malaysia telah bergerak ke hadapan untuk menjadi salah satu yang terbaik dalam revolusi perindustrian. Pada waktu puncak, tenaga yang dihasilkan adalah lebih mahal daripada waktu biasa disebabkan oleh kos penjanaan yang tinggi. Oleh kerana itu, teknik DSM diperkenalkan untuk mengubah suai profil permintaan dengan melaksanakan strategi yang berbeza. Objektif kajian ini adalah untuk mengoptimumkan profil tenaga bagi sektor komersial dan untuk menganalisis pengurangan kos elektrik dengan menggunakan teknik pengoptimuman. Dalam kajian ini, teknik 'Artificial Intelligence', EP telah dilaksanakan untuk mengoptimumkan profil kuasa bagi sektor komersial. Ujian telah dilakukan untuk menunjukkan bahawa teknik pengoptimuman mampu untuk mengubah MD dari waktu puncak ke waktu biasa yang mana dapat mengurangkan kos tenaga. Keputusan ujian telah dilakukan dengan menggunakan 4 kes iaitu kaedah konvensional untuk C1 ToU, C2 ToU, C1 EToU dan C2 EToU tarif. Kesan EP telah dianalisis manakala tarif C1 dan C2 EToU menunjukkan kos optimum untuk bahagian pemasangan voltan rendah. Adalah diharapkan hasil kajian ini akan memberi manfaat kepada jurutera untuk menyusun semula profil supaya pengguna akan menikmati pengurangan kos elektrik secara ketara.

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LIST OF ABBREVIATIONS

2DPSO: 2 Dimensional Particle Swarm Optimization
ABC : Ant Bee Colony
ACO : Ant Colony Optimization
AI : Artificial Intelligence
BFA : Backtrack Free-path planning Algorithm
BFO : Bacterial Foraging Optimization
BPSO : Binary Particle Swarm Optimization
DR : Demand Response
DSM : Demand Side Management
EA : Evolutionary Algorithm
EP : Evolutionary Programming
ES : Evolutionary Strategy
EToU : Enhanced Time of Use
GA : Genetic Algorithm
GDP : Gross Domestic Product
IBR : Incentive Based Regulation
ICPT : Imbalance Cost Past Through
ILL : Incentives Load Limiting
ISO : Independent System Operator
MD : Maximum Demand
ORPP : Optimal Reactive Power Planning
PSO : Particle Swarm Optimization
RPP : Reactive Power Planning
RTO : Regional Transmission Organization
SIT : Special Industrial Tariff
TNB : Tenaga Nasional Berhad
ToU : Time of Use

CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter focused to the problem that drives the rest of the project. This chapter consist four parts which started with motivation that give an inspiration to the project followed by problem statement, objective of the project and scope of the project. The objective of this project is based on the problem stated in problem statement.

1.1 Motivation

In Peninsular Malaysia, the growing demand for electricity is driven by two main categories of the economy, the industrial and commercial sectors. For the forecast, Gross Domestic Product (GDP) growth rate for 2014 was estimated to increase from 5% to 5.3% with a bullish long-term economic projection of around 5%.

In terms of electricity sales, in 2015 an average growth rate of 2.4% was recorded. The largest customer is still the industrial sector with 42%. The commercial sector is not far behind at 35%, while the domestic sector is 21% and others comprising mining, public lighting and agriculture sectors are 2% bring up the rear. However, the commercial sector is projected to experienced higher growth and will be the largest customer, replacing the industrial sector by 2030.

Based on Figure 1.1, from the Malaysia Energy Statistics Handbook 2015 prepared by Energy Commission (ST), transportation, commercial and industrial sector are leading in their energy consumption.

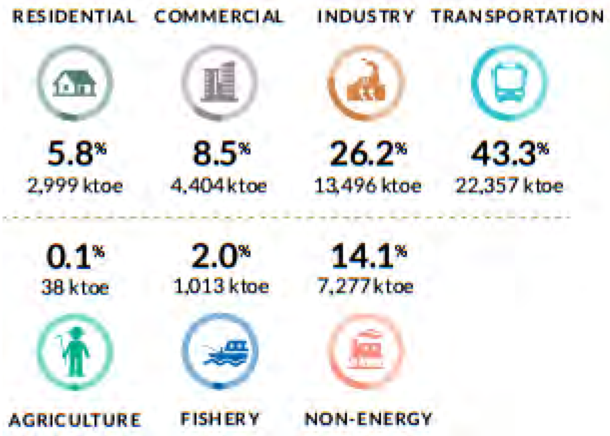

Figure 1.1: Energy consumption in every sector[1]

Sales are estimated to rise to 3.4% in 2016 and 3.8% the following year. Electricity generation is forecasted to reach 116, 813GWh in FY2015 and peak demand is estimated to reach 17, 461MW in the same year. This is a 560MW increase or 3.3% growth from that in the previous year[2].

Figure 1.2: Demand forecast (2005 – 2035)[2]

As the demand for electricity is expected to grow, the generation and transmission system needs to be further upgraded and expanded. Early 2014, the electricity tariff in Peninsular Malaysia is determined through the IBR framework and the ICPT mechanism. ICPT is a structure under the IBR context allowing the government to analyze the tariff every six months to consider changes in fuel and other generation expenses.

Beginning January 2016, Suruhanjaya Tenaga established a new type of tariff category which is Enhanced Time-of-Use tariff (EToU) for users. The EToU is formed as an alternative to demand side management initiatives. It inspires consumers to use electricity more cost-effectively by lessening their electricity consumption during peak hours and having more utilisation during off peak hours. Under the new EToU scheme, the peak time zone is reduced to 4 hours from the existing 14 hours and a new mid peak zone of 10 hours is introduced for energy and demand charges at rates lower than the current peak rates. Consumers will have more ethusiasm to consume electricity at the off-peak period due to lower tariff rates[2]. By using energy more competently, consumer can reduce their energy cost and utility itself can run at higher efficiency.

1.2 Problem Statement

In 2015, government had announced, the electricity tariff for domestic and industrial will be increased in 2016 because of the price of the coal is increasing. In this case, the production sector had no choice but to increase the price of their products. It will give a burden to a consumers, especially the low-income earners. When the electricity tariff increases in industrial sector, the food production, processing and retail cost will increase simultaneously.

Demand Side Management programs offers a great advantage on both utilities and end users such that after applying DSM programs, utilities did not need to build new power plants in order to meet the load and also for customers, their electricity bill is minimized[3].

As the Enhanced Time-of-Used tariff was introduced in line to demand response program, there are three time zones in a day/24 hours. The past research only focussed on overall load profile optimization rather than determining the zoning load shape profile optimization strategies. The impact of this action, the regular activities would be sacrificed by demand side as to as the total consumption was instantly reduced.

The load profile management serves as a monitoring tool in order to find the best strategies to implement DSM. Flattening the load profile behaviour of the customers load will maximize the use of the utilities generation capacity thus dropping the load factor. This usually done by altering some customer loads from peak loads hours to off-peak hours. On the other hand, off-peak load hours can also be improved to minimize the installation‘s load factor[4].

Energy consumption of any building is influenced by various internal and external factors. Trial and error processes as well as the experience of the energy analyzer are mostly used to determine the most of these factors. The established factors have a certain relationship to the energy consumption of a building, which needs to be established. However this process is a time consuming process. Due to that reason optimization technique by using AI is used to determine performance correlation between power consumption and energy cost. The advantage of using AI is that it is a computerized process and is therefore much less time consuming[5]. However, the implementation of AI contributes to many problems such as results were not accurate due to trapping problem on local and global process of bio-inspired algorithm. The example of them are PSO, ABC, ACO, BFO and etc.

Due to that reason the evolutionary algorithm (EA), would be the choice because of it accuracy in considering the convergence result while leads to achieve the optimum finding when it is hybrided with others optimization method. In this study, the conventional Evolutionary Programming is used to show the capability of the EA to find the best optimal solution for the load profile in communicating to commercial tariff ToU and EToU in order to find the objective function which is electricity cost optimization.

1.3 Objective

The objectives of this research are:

1. To differentiate between TOU and ETOU tariff scheme.
2. To optimize the energy profile for a commercial installation.
3. To analyze the reduction of electricity cost by using optimization technique.

1.4 Scope

The test data had been taken from a commercial installation. The load profile data for a year had been used to be a raw data for the Matlab initialization input.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter focused on the review of the project and review of the literature. The overall goals of this chapter is to establish the significance of the general field of study, then identify a part where a new contribution could be completed. This chapter critically evaluating the varoius methodologies used in this field so as to identify the suitable approach for this project.

2.1 Demand Side Management

Demand Side Management (DSM) means, the group of measures that urge the clients to utilize less energy during peak hours (stated by 1 in Figure 2.1) or if important utilize it when the load demands are lower, for example at night (stated by 2 in Figure 2.1) or on ends of the week[6].

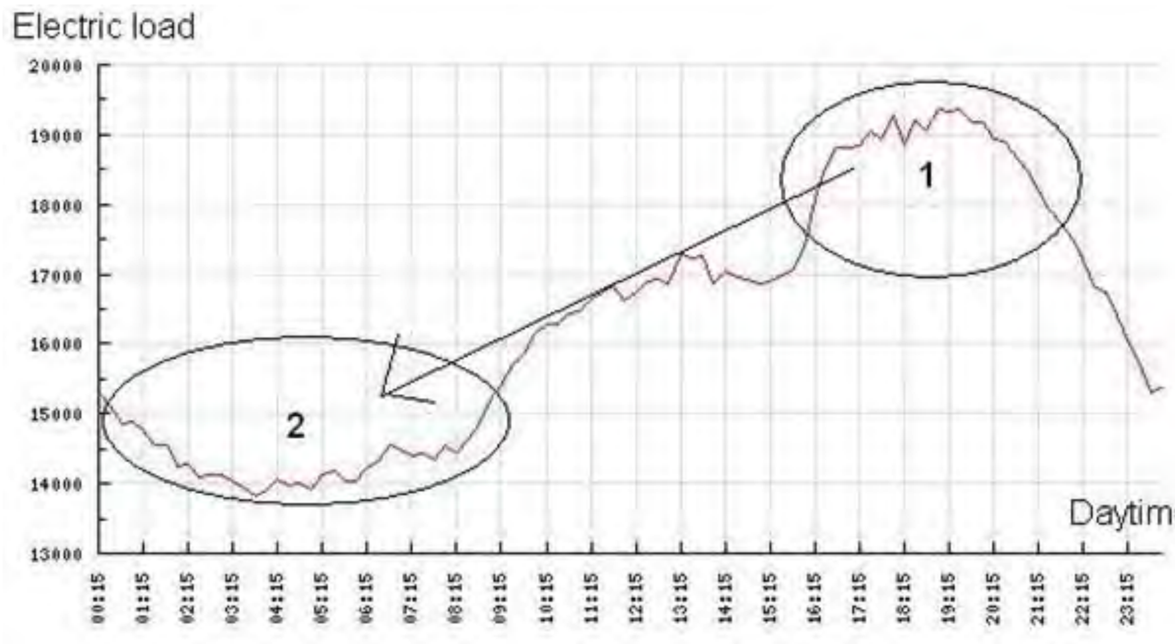

Figure 2.1: Demand Side Management[6]

The aims for Demand Side Management are:

1. Cost reduction – numerous DSM and energy effectiveness efforts have been presented with regards to incorporated asset arranging and lessening all out expenses for taking care of energy demand.
2. Ecological and social change – Energy proficiency and DSM might be sought after to accomplish ecological and community objectives by decreasing energy utilize, prompting to lessen greenhouse gas emissions.
3. Reliability and system matters – improving and deflecting issues in the power organize throughout diminishing interest in ways which look after framework dependability in the quick term and over the more drawn out term concede the constraint for organize growth.
4. Enhanced markets – Transient reactions to power economic situations (Demand Response), especially by reducing load during times of high market costs caused by reduced generation or system limit.

The inspiration driving the execution of DSM is clearly different for the individual social included. For service organizations, the diminishment or move of a client's energy request could mean staying away from deferrring building extra creating limit. In a few circumstances, this would prevent or defer energy costs rises that would otherwise be imposed on clients to help finance new investments in system capacity. For clients, DSM proposes the chance to diminish their energy charge over productivity and protection measures. For the situation of industrial clients, this would mean lower generation costs and a more focused item. For residential clients it implies that they would spare cash that could be spent on other family unit products[7].

There are five steps to implement Demand Side Management which started with load research. It consist of the study of load pattern of end-users, market survey, statistics survey and tariff rates. In load research it helps in figuring the significant maximum load users and also in the improvement of the load shape. Second step in implementing the DSM is by defining the load shape objective. The appropriate load shape among several is identified based on the result retrieved from the load research stage to reshape the load curve for maintaining the balance between power supply and demand. Fundamentally, there are six types of load-shape objective[8].

1. Peak Clipping: High demand periods are 'clipped' and the utility load is reduced during peak hours. It focuses on reducing highest demand.
2. Valley Filling: Low demand periods are filled by building off-peak capacities. It develops the system load factor by building the load in off-peak hours.
3. Load Shifting: It refers to shifting of the loads from peak demand periods to off-peak periods accomplishing the clipping and filling. But the clipping is different to shift in the overall demand of load is always present while in the case of clipping it is detached.
4. Strategic Conservation: Energy conservation programs aimed at reducing the whole energy consumption through reduction of electrical loads during all or most hours of the day.
5. Strategic Load Growth: Load shape modification that refers to a general increment in energy consumption during all or most hours of the day.
6. Flexible Load Shape: It involves making the load shape responsive to reliability conditions by developing specific programs to alter end-users energy consumption on required basis.

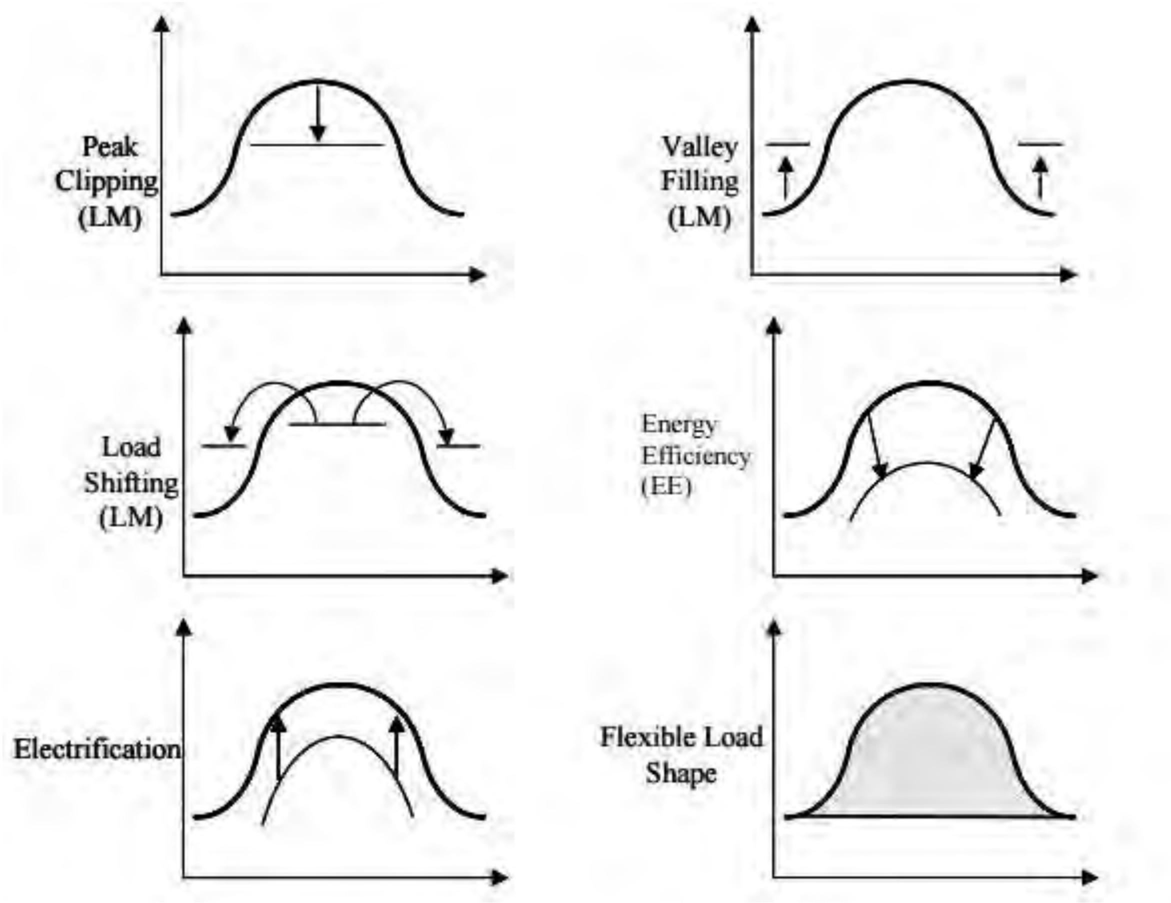

Figure 2.2: Six basic type of objective load-shapes[8]

Third step is asses program implementation strategies on the load shape objectives defined in step two, the implementation strategies for the DSM are assessed by identifying the end users applications and technology alternatives. A detailed benefit and cost analysis will also be carried out in this stage for both consumers and utilities.

The fourth step is implementation. This step involves the actual implementation of the programs designed to achieve the objectives of DSM so as to reshape the load curve in order to maintain a balance between supply and demand of electrical power.

And the last step is monitoring and evaluation. In this step, the implemented program is regularly monitored to ensure the effective and efficient adoption of DSM measures. The programs effectiveness is evaluated and compared with the DSM goals set to achieve by the utilities. Benefit and cost analysis is also done in this step to determine the actual benefits and cost incurred during the implementation process[8].

2.2 Demand Response

Demand response known as the alterations in electricity habit by end users from their regular consumption arrangements in response to changes in the charge of electricity over time. DR can be also known as the incentive outflows designed to persuade lower electricity use at times of high wholesale market charges or when system reliability is endangered. All intentional electricity utilization shape adjustments by end users that are planned to modify the scheduling, level of instant demand, or overall electricity utilization.

The advantages of DR program is divided in 3 categories which are participant, market-wide and reliability. For the consumers joining in DR programs can expect savings in electricity bills if they downgrade their electricity usage during peak periods. Meanwhile for the market-wide, an general electricity charge reduction is expected ultimately because of a more efficient usage of the available infrastructure, as an example the reduction of demand from high-priced electricity generating units. The cascaded effect of DR programs includes avoided or deferred need for distribution and transmission infrastructure implementations and upgrades.

Reliability advantages may be taken into consideration as one of the market wide advantages because they give an impact to all market participant. Through having a properly designed DR program, participant have the possibility to assist in lowering the chance of outages. Simultaneously and for this reason, participants are lowering their own risk of being uncover to forced outages and power interruption. On the other hand, the operator could have more alternatives and resources to maintain system reliability, thus reducing forced outages and their consequences.

Environmental benefits of DR programs are various and include better land utilization as a result of prevented new electricity infrastructure along with generation units and transmission/distribution lines[9].

2.2.1 Electricity Grid in Malaysia

In each nation, there is a standard framework known as National Grid System used to transmit power to everywhere throughout the nation. In Malaysia, there are three major parts