POTENTIAL ELECTRICAL ENERGY SAVINGS IN DAIRY MANUFACTURING INDUSTRY OF MEDIUM ENTERPRISES

LEE YUN PHING

UNIVERSITI TEKNOLOGI MALAYSIA

POTENTIAL ELECTRICAL ENERGY SAVINGS IN DAIRY MANUFACTURING INDUSTRY OF MEDIUM ENTERPRISES

LEE YUN PHING

A project report submitted in partial fulfilment
of the requirements for the award of degree of
Master of Engineering (Electrical-Power)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2014

To my beloved family

ACKNOWLEDGEMENT

Firstly, I wish to thank my supervisor, Dr. Nor Asiah Muhamad, for her guidance, patience, and support which lead me to complete the thesis.

Secondly, I wish to thank Dutch Lady Milk Industries Bhd for allowing me to carry out case study.

Last but not least, I would like to express my gratitude to my family for their love and understanding.

ABSTRACT

The electrical energy consumption in dairy processing industry has been on the high side on present day. Over the years, many efforts on energy savings scheme have been carried out by government of Malaysia to highlight the sustainability of the energy supply. Dutch Lady Milk Industries Berhad has been facing high expenses issue on electricity bill. Many professional practices have been conducted on the equipment itself but not the management of electricity consumption. The purpose of this study is to achieve energy savings for the industry through management of electricity consumption. The analysis will be focused on the industry's load profile and operations. Theoretical results show the proposed programs: lighting re-lamping, on-site generation and solar photovoltaic system can have a potential annual savings of RM320,603.92 and ROI is only less than 3 years. This show that implementation of management in electricity consumption can help to reduce energy in dairy industry or medium enterprise sector.

ABSTRAK

Penggunaan tenaga elektrik di industri pemprosesan tenusu telah mencapai paras tinggi pada masa kini. Banyak skim telah dijalankan oleh kerajaan Malaysia untuk mengalakkan penjimatan kegunaan tenaga elektrik. Dutch Lady Milk Industries Berhad telah menghadapi isu perbelanjaan yang tinggi pada bil elektrik. Banyak peningkatan ke atas peralatan dan jentera telah dijalankan tetapi tiada langkah yang dilaksanakan dalam pengurusan penggunaan tenaga elektrik. Tujuan kajian ini adalah untuk mencapai penjimatan melalui pengurusan penggunaan tenaga elektrik. Analisis ini akan memberi tumpuan kepada jadual operasi dan profil beban industri ini dan ia menunjukkan program yang dicadangkan, iaitu menukar semula lampu, generasi tenaga elektrik di tapak dan sistem solar photovoltaic boleh mendapat potensi penjimatan sebanyak RM 320,603.92 setahun dan pulangan pelaburannya hanya kurang daripada 3 tahun. Ini menunjukkan bahawa pelaksanaan pengurusan penggunaan elektrik boleh membantu untuk mengurangkan penggunaan tenaga elektrik dalam industri tenusu atau sektor perusahaan sederhana.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

SME	-	Small and Medium Enterprise
GBI	-	Green Building Index
EE	-	Energy Efficiency
UHT	-	Ultra-High Temperature
HVAC	-	Heating, Ventilation and Air Conditioning
kW	-	Kilowatts
kWh	-	Kilowatts hour
ROI	-	Return on Investment
FiT	-	Feed-in Tariff
SEDA	-	Sustainable Energy Development Authority
kWp	-	Kilowatts Peak
PV	-	Photovoltaic
DPM	-	Digital Power Meter
MSB	-	Main Switchboard
EMSB	-	Emergency Main Switchboard
ATS	-	Auto Transfer Switch
AMF	-	Auto Main Failure

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Malaysian Small and Medium Enterprises (SMEs) participated mainly in five establishments such as services, manufacturing, agriculture, construction, mining and quarrying. According to Economic Census 2011 from Department Statistic Malaysia, majority of SMEs belong to services (90%), followed by manufacturing (5.9%) [1]. In manufacturing sector, SMEs involve predominantly in wearing apparel, food products, fabricated metal, printing and reproduction of recorded media. Food and beverage industry takes up 15.1% of manufacturing sector in 2011. The average energy consumption for food industry SME is 418.82GWh in 2011, equivalent to 15.1% of total energy consumption (2773.62GWh) in manufacturing sector; 0.390% of total electrical energy consumption (107330.05GWh) in whole Malaysia [2]. Based on the gathered statistics, electrical energy consumption for food industry alone is considerably high.

On the present day, electrical energy consumption has been snowballing in tremendous rate to fit in skyrocketed demand due to outgrowing of populations and industries. The electrical energy resources will eventually insufficient to support the required demand as electrical energy consumption is estimated to increase gradually in time.

Over the years, Government of Malaysia has formulated several policies and action plans to address energy concerns. The development of Energy policies in Malaysia started since 1975 with the introduction of National Petroleum Policy in 1975 with the three main objectives of ensuring sufficient and reliable supply of energy, promoting efficient utilization of energy and reducing the negative impact of energy production on the environment [3]. The National Green Technology Policy is framed in 2009 to introduce the strong promotion and public awareness of Green Technology and Green Building Index (GBI) [3]. Energy efficiency (EE) has been identified as one of the criteria to ensure sustainability of the energy supply since 7th Malaysian Plan (1996-2000) [3]. The key emphasis is to encourage the use of new and alternative energy sources as well as efficient utilization of energy. Therefore, the aim of this study is to save electrical energy and save cost through potential energy savings scheme and economical electrical energy usage in dairy processing industry.

1.1 Background of Study

According to the newest guidelines for SME definition [4], Dutch Lady Milk Industries Berhad belongs to medium enterprise under manufacturing category where the sales turnover is from RM15 million to not exceeding RM50 million or full-time employees from 75 to not exceeding 200. The industry is a manufacturer of dairy products in Malaysia that producing products for infants, growing up milk, UHT milk, pasteurized milk, sterilized milk, family powdered milk, low fat and 0% fat drinking yoghurt, and low fat yoghurt. Electricity is used throughout dairy processing to drive process motors, fans, pumps, and compressed air systems, as well as building lighting and Heating, Ventilation & Air Conditioning (HVAC) systems. In addition to these, one of the highest consumption of electricity in the dairy processing industry is cooling process, freezer and cold storage [5].

Two shifts are carried out daily in Dutch Lady's dairy processing plants where most operation is executed during on-peak hours (10.00am to 8.00pm) and the remaining is on off-peak hours (8.00pm to 10.00am). Currently, Dutch Lady Milk Industries Berhad applied for 11kV electrical supply and registered under TNB medium voltage peak or off-peak E2 special industrial tariff (E2s) where on-peak hours has higher rate of electric charges whereas lower rate for off-peak hours.

In average, Dutch Lady consumed total electricity of 1584967 kWh and maximum demand of 3300kW monthly. The estimated monthly electricity bill for Dutch Lady is calculated approximately to be RM 550,650.87 following TNB tariff rate E2s.

The electrical energy consumption for Dutch Lady is overwhelming that result in pricy payment. Hence, study on opportunities to reduce the consumption of electrical energy while maintaining or enhancing the production become an important aspect that need to be explored.

Electrical energy consumption can be minimized with the improvement in technology and energy management. In this paper, potential energy conservation and energy management opportunities will be analyzed and discussed at later stage.

1.2 Problem Statement

Dutch Lady Milk Industries Berhad has had many practices in appointing foreign consultants to enhance and improve the efficiencies of the machineries.

However, the consumption of overall electricity usage has not been justified to achieve economical and efficient usage of electrical energy.

In current situation, electricity bill for Dutch Lady Milk Industries Berhad is costly due to the operation of machineries. There are two factors that contribute to electricity charges. The first factor is the peak load of maximum demand in kilowatts (kW) per month. Secondly, the kilowatts hour (kWh) from all electrical equipment such as lighting, fan cooling unit, cold storage and other heavy machineries. Thus, the peak load of the maximum demand and the kWh has to be reduced to achieve the most economical and efficient electrical energy usage.

1.3 Objective

The aim of this paper is to achieve economical and efficient usage of electrical energy. In order to meet the aim, three significant objectives are required to be met beforehand. Our first objective is to fully understand existing designs of electrical distribution system, load profile and operations through site visits and energy audit.

Following objective is to identify potential opportunities in improvement of technology and energy management through thorough analysis on the load profile of the industry. The values and charts of electricity consumptions in load profile lead to potential opportunities in improving energy conservation and energy management.

Last but not least, the third objective is to analyze the feasibility and impact of the proposed solutions on existing system as well as the return on investment (ROI).

1.4 Scope of Studies

This section will discuss load profile and site map of Dutch Lady Milk Industries Berhad to shrink the scope of studies.

1.4.1 Load Profile

The information of peak of maximum demand, total electrical consumption for every main switchboard during on-peak hours and off-peak hours are obtained in load profile. With the help of GridVis tool, a graph of active power consumption from 11th September 2012 to 10th January 2014 is generated in Figure 1.1. The minimum demand is 215kW only whereas the peak demand is 3346kW. And the average is 2065kW. The rate of fluctuation of the electricity consumption is very high.

A histogram statistic in Figure 1.2 is generated from accumulated data showing the frequent rate of all range of consumed active power from September 2012 until January 2014. The occurrence rate of 3000kW is approximately 1600 times for 15 months. In another word, there is only four occurrence of breaching 3000kW threshold per day in average. Furthermore referring to Figure 1, there are days that never breached 3000kW threshold level at all.

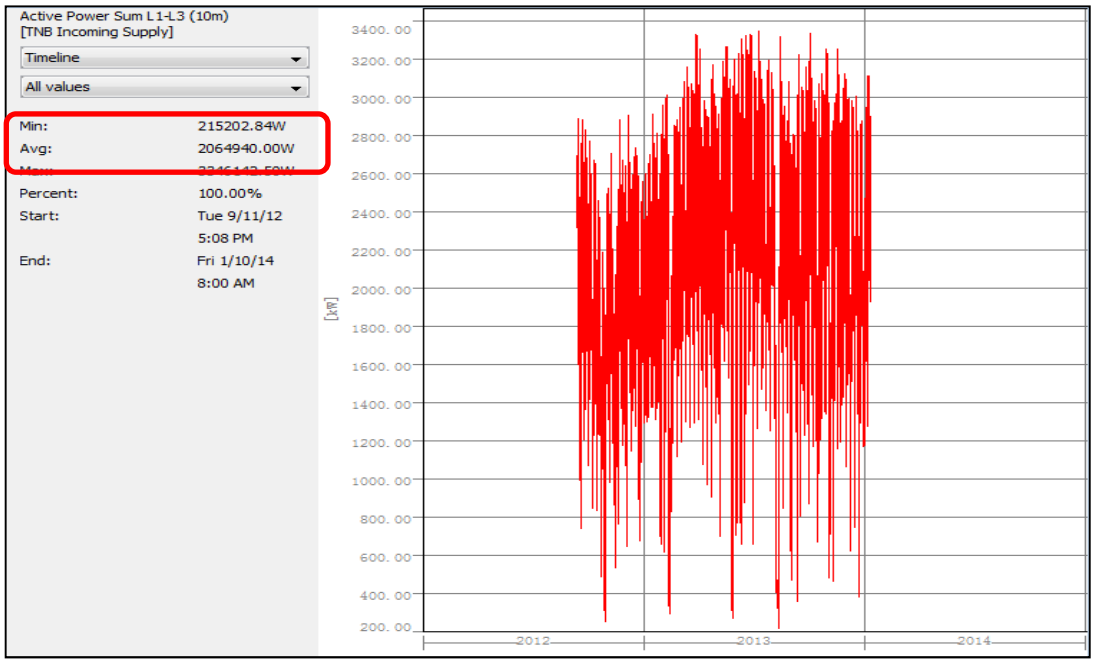

Figure 1.1 Load profile - active power (kW) graph

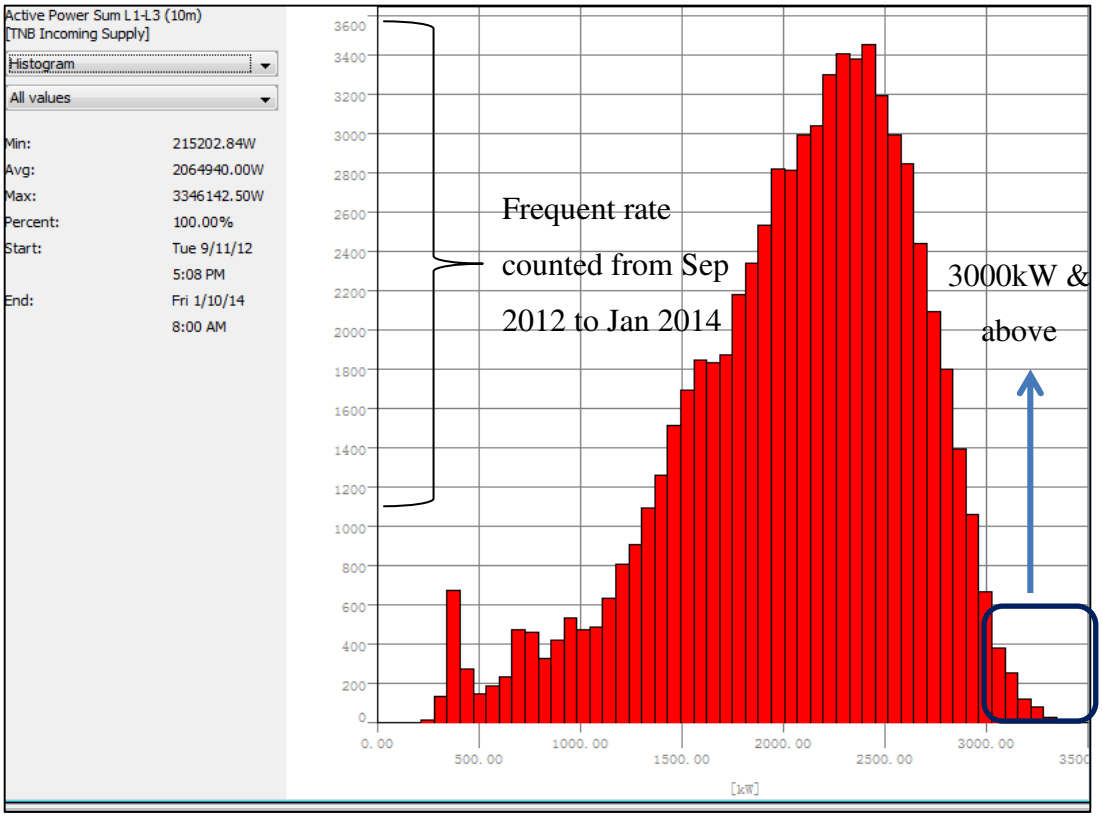

Figure 1.2 Active power frequent rate from Nov 2012 to Jan 2014 histogram statistics

1.4.2 Site Map

Figure 1.3 below shows the Dutch Lady Milk Industries site plan on Google Map.

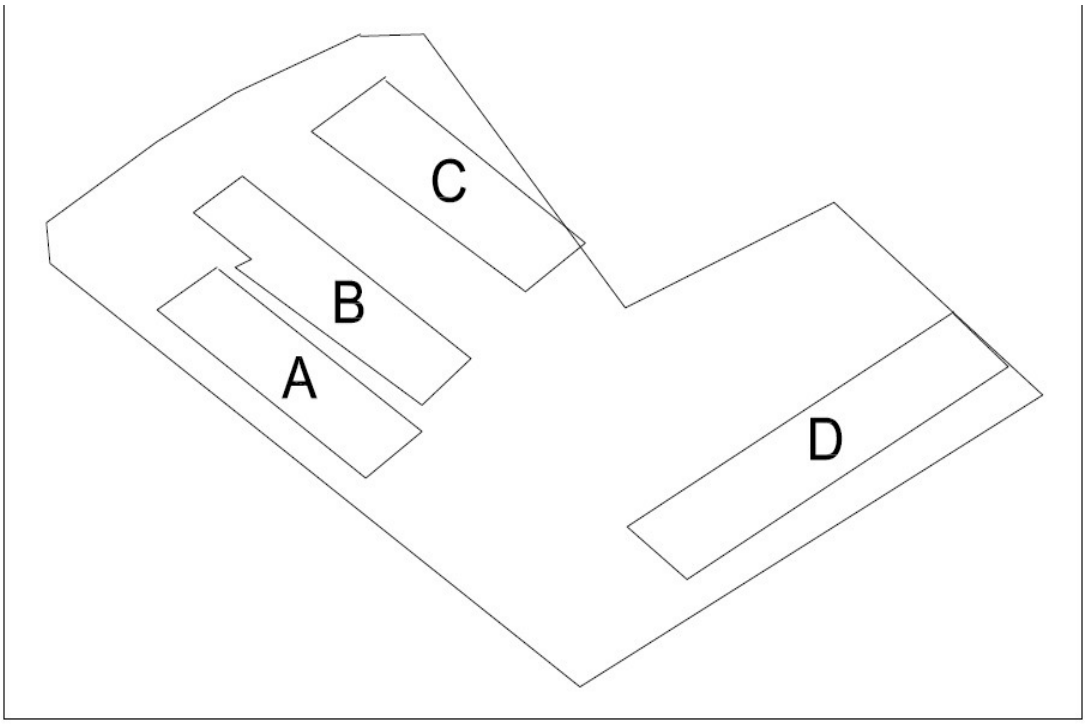

Figure 1.3 Dutch Lady Milk Industries site plan

Total of four buildings demarcated above are selected for case study as these buildings are relatively long in length and square geometry. The length and width of the buildings are calculated according to Google map scale (1cm equivalents to 33.33m if the image is printed in A4 paper). Table 1.1 shows the estimation of buildings size in length and area as per actual scale.

Table 1.1: Dutch Lady Milk Industries' buildings size

Building	**A**	**B**	**C**	**D**
Length (m) x Width (m)	116.67 x 33.33	126.67 x 55.00	113.33 x 40.00	36.67 x 170.00
Area (m^2)	3888.61	6966.85	4533.20	6233.90
Total Area (m^2)	21622.56			

There are 850 conventional high bay 250W lighting units with the interval distance of 5m from these four buildings. Table 1.2 below shows the electricity consumption cost in lighting according to TNB tariff E2s rate. Lighting system alone required approximately RM29,241.28 per month is relatively high.

Table 1.2: Electricity consumption cost in lighting system

Total number of lighting units	850.00
Total power (kW/month)	212.50
Total cost in maximum demand (RM/month)	6,991.25
Total cost in on-peak kWh (RM/month)	17,136.00
Total cost in off-peak kWh (RM/month)	5,114.03
Total electricity cost in lighting (RM/month)	**29,241.28**

1.4.3 Project Scope

1.4.3.1 Cap peak demand

From the observation in load profile, it showed the rate of fluctuation in electrical consumption is very high and the occurrence of maximum demand above 3000KW is low. So, there is a need to cap peak demand at 3000kW which can help to reduce the monthly maximum demand charge. The feasibility of capping maximum demand at 3000kW is to be determined.

1.4.3.2 Lighting

From the observation in site map, lighting itself consumed 212kW monthly or equivalent to RM 29,241.28 in electricity bill, which is considerably high. There is a need to investigate if existing lighting system is overdesigned and whether energy conservative light fitting are used.

1.4.3.3 Large roof areas

From the observation in site map, there is a huge roof area of 21622.56 m^2. The feasibility of implementation of solar photovoltaic (PV) system is to be determined.

1.5 Organization of Report

In general, this report consists of five main chapters; introduction, literature review, methodology, results analysis and discussion, and conclusion.

Chapter one reviews the general background of Dutch Lady Milk Industries Berhad in terms of electricity consumption and electricity cost. This chapter captures the crucial problem statements faced by the industry, leading to objectives and research scopes.

Chapter two discusses the literature review on the existing implemented solutions within the research scopes by others in food and beverage or dairy processing industry. This chapter is solely discussing on the technologies in lighting and solar PV system plus the energy management in improving efficient and economical electrical energy usage.

Chapter three provides a detail explanation on the solutions implementation methodology. The chapter starts with the step of process being carried out to propose energy and cost savings solutions. Later, it explains in depth on the strategies to implement or integrate to the industry system starting with lighting re-lamping, lighting zoning, relocation of electrical circuits, on-site generation and lastly solar PV.

Chapter four analyses and evaluates the simulation results on the proposed solutions. The evaluation of the simulation results is processed in the criteria of feasibility, profitability and ROI.

Chapter five concludes the finding of this research project and the most optimum solutions in improving efficient and economical electrical energy usage. Lastly, it includes further enhancements on the proposed solutions in future.

REFERENCES

[1] National SME Development Council, "Economic Census 2011: Profile of SMEs," National SME Development Council, 2011/12.

[2] National Energy Balance, Putrajaya: Suruhanjaya Tenaga (Energy Commission), 2011.

[3] Dr. Tan Ching Sin, "Sustainability Development Through Energy Efficieny Iniatives in Malaysia," p. 12, 2011.

[4] SME Corp. Malaysia, "Guideline For New SME Definition," *National SME Development Council,* p. 5, October 2013.

[5] Adrian Brush, Eric Masanet, Ernst Worrell, "Energy Efficient Improvement and Cost Saving Opportunities for the Diary Processing Industry," ENERGY STAR, Berkeley, October 2011.

[6] United States Department of Energy (DOE) (2006b), "Manufacturing Consumption of Energy 2006 Data Tables," Energy Information Association, Washington, D.C, 2006.

[7] The UNEP Working Group for Cleaner Production in the Food Industry, Eco-Efficiency for the Dairy Processing Industry, Southbank Victoria: Dairy Australia, August 2004, p. 153.

[8] A. Charest, "LED vs Fluorescent Lighting: An RSMeans life cycle cost comparison," 2013.

[9] R. S. S. Singh, "Low Power Passive Photovoltaic System Development to Assist Inconvenient Grid Connection Locations," *Energy and Power Engineering,* pp. 411-415, 2013.

[10] J. A. Quijera, "Integration of a solar thermal system in a dairy process," *Elsevier,* pp. 1843-1853, 2011.

[11] R. R.-I. Firdaus Muhammad-Sukki, "Feed-In Tariff for Solar PV in Malaysia: Financial Analysis and Public Perspective," in *The 5th International Power Engineering and Optimization Conference*, Selangor, 2011.

[12] S. H. A. Johari, "Feed-in Tariff (FiT) Concept to Promote the Usage of Renewable Energy in Malaysia," *International Journal of Energy and Power (IJEP),* vol. 2, no. 2, pp. 1-5, May 2013.

[13] D. M. T. Pavlovic, "Application Of Solar Cells Made Of Different Material In 1 MW PV Solar Plants In Banja Luka," *Renewable Energy Resources,* vol. II, no. 2, pp. 155-163, 2011.

[14] P. H. T. S. K. Chin Kim Gan, "System Performance Comparison Between Crystalline and Thin-Film Technologies under Different Installation Conditions," *IEEE Conference on Clean Energy and Technology (CEAT),* p. 6, 2013.

[15] V. S. D. P.Ravi Babu, "Mathematical modelling, ANN, Batteries and DSM Techniques applied to a Medium Scale Milk Industry," p. 7, 2009.

[16] Z. Popovic, "A Methodology for Reducing System Peak Load Through Load Management in Industries".

[17] K. V. S. K. B. V. S. R. P. Ravibabu, "Application of DSM Techniques and Renewable Energy Devises for Peak Load Management," p. 4, 2008.

[18] S. B. Standards Malaysia, Code of Practice On Energy Efficiency And Use Of Renewable Energy For Non-Residential Buildings (First Revision), MALAYSIAN STANDARD, 2007, p. 54.

[19] PAM & ACEM, *Design Reference Guide for Non-Residential Construction and Residential New Construction,* First Edition ed., vol. I, Green Building Index, 2009, p. 115.

[20] Solarworld, *Sunmodule.*

[21] Tenaga Nasional Berhad, "Tariff Rate Booklet," 2013.

[22] Tenaga Nasional Berhad, Tariff Rate in Malaysia, Malaysia, 2010.

[23] "Malaysian Petrol Products Historical Prices (RM/litre)," 14 February 2011. [Online].
Available: http://pricexa.blogspot.com/2011/02/petrol-product-historical-prices.html.

[24] D. L. T. Gee, "Handbook On The Malaysian Feed-In Tariff For The Promotion Of Renewable Energy," KeTTHA, 2011.