ENERGY AUDIT FOR THE UMP LIBRARY AND ENERGY EFFICIENCY PROJECT PROPOSAL

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JUDUL: **ENERGY AUDIT FOR THE UMP LIBRARY AND ENERGY EFFICIENCY PROJECT PROPOSAL**

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power System)"

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ENERGY AUDIT FOR THE UMP LIBRARY AND ENERGY EFFICIENCY PROJECT PROPOSAL

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power Systems)

Faculty of Electrical & Electronics Engineering
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NOVEMBER, 2008

I declare that this thesis entitled "*Energy Audit for the UMP Library and Energy Efficiency Project Proposal*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Author : **AHMAD SYAKIR BIN MOHAMAD**

Date : **17 NOVEMBER 2008**

Specially dedicated to
My beloved parents, siblings, fiancé
and all of my friends.

BEP still in memories..

Behold, thy Lord said to the angels: "I will create a vicegerent on earth." They said: "Wilt Thou place therein one who will make mischief therein and shed blood? Whilst we do celebrate Thy praise and glorify Thy holy (name)?" He said: "I know what ye know not."
(Al-Baqarah-30)

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ABSTRACT

Nowadays, people are more concerned about energy efficiency, energy consumption and conservations in buildings. Energy audit is considered as one of the comprehensive methods in checking the energy usage and wastage in buildings. This paper presents the preliminary study of energy audit that has been done in UMP library. In this study, energy audit and energy consumption data has been logged over a period of time by installing a data logger at the library main switch board. Based on the study, the actual implementation of energy efficiency programmed is done by installing capacitor bank at main switch board to improve the power factor, reduce the current consumption, voltage drop and electrical energy losses. Also reported in detail in this paper is the comparison study of energy usage and power variations over a period of time between existing and proposed techniques. From the analysis, it was found that the level of energy efficiency in building is inversely proportionate to the energy losses that occur; the higher the loss, the lower the efficiency. Energy efficient can be achieved by controlling the maximum demand and reducing energy losses by improving the power factor at the switch board. The simple pay back period calculation and formulation of the energy audit programmed for UMP library is also discussed in this paper. This paper also discuss about the improvement of lighting system efficient.

ABSTRAK

Pada masa kini, masyarakat sangat memikirkan tentang kecekapan tenaga, penggunaan tenaga dan pengekalan tenaga dalam bangunan-bangunan. Pengauditan tenaga adalah merupakan salah satu daripada kaedah-kaedah yang komprehensif untuk memeriksa kadar penggunaan dan pembaziran tenaga dalam sesebuah bangunan. Kajian ini membentangkan kajian awal mengenai pengauditan tenaga yang telah pun dipraktikkan di Perpustakaan Universiti Malaysia Pahang (UMP). Dalam kajian ini, data berkenaan pengauditan serta penggunaan tenaga telah dicatatkan sepanjang tempoh masa dengan memasang pencatat data pada papan suis utama di perpustaan. Berdasarkan kajian ini, perlaksanaan sebenar susunan aturcara kecekapan tenaga adalah dilakukan dengan memasang bank kapasitor pada papan suis utama untuk meningkatkan faktor kuasa, mengurangkan penggunaaan arus, voltan susut dan kehilangan tenaga elektrik. Dalam kertas ini juga dilaporkan secara terperinci berkenaan perbandingan kajian-kajian tentang penggunaan tenaga dan kepelbagaian kuasa sepanjang tempoh masa antara teknik yang sedia ada dengan teknik yang baru dicadangkan. Daripada analisa yang dibuat, telah didapati bahawa aras kecekapan tenaga dalam bangunan adalah berkadar songsang dengan kehilangan tenaga yang berlaku, iaitu semakin banyak kadar kehilangan, kecekapan semakin berkurang. Tenaga cekap dapat dicapai dengan mengawal keperluan maksimum dan mengurangkan kehilangan tenaga dengan meningkatkan faktor kuasa pada papan suis. Pengiraan tempoh bayaran semula yang mudah beserta aturcara perumusan pengauditan tenaga bagi Perpustakaan UMP turut dibincangkan dalam kertas ini. Kertas ini juga turut membincangkan mengenai penambahbaikan sistem nyalaan yang cekap.

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LIST OF ABBREVIATIONS

UMP	Universiti Malaysia Pahang
KUKTEM	Kolej Universiti Kejuruteraan Teknologi Malaysia
JPPH	*Jabatan Pembangunan dan Pengurusan Harta*
TNB	Tenaga Nasional Berhad
AC	Alternate Current
DC	Direct Current
MSB	Main Switch Board
LUX	I luminance Level
GUI	Graphical User Interface
VB	Visual Basic
SPP	Simple Payback Period
MD	Maximum Demand
V	Voltage
A	Ampere
Z	Impedance
W	Watt
kW / P	Kilo Watts / (Real Power)
kVA / S	Kilo VA / (Apparent Power)
kVAR / Q	Kilo VAR / (Reactive Power)
kWh	Kilo Watts per Hour
pf	Power factor
LED	Light Emitted Diode

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Energy efficiency program will bring great savings if planned and implemented correctly. It cannot be successfully carried out without the commitment from the top management. The top management should be informed about the current level of operating efficiency, additional saving potentials and resources needed to achieve it. Clearly defined and communicate with the top management by developing clear written goals and objectives will help to increase their understanding on efficient operation as part of management asset as well as reduces operating cost and maintain comfort [1]. A successful energy management plan should initiate with energy accounting or energy audit in order to record and track the progress of energy efficiency program.

Energy audit is a process of checking the way energy is used and identify areas where wastage can be minimize if not totally eradicate. Energy audit consists of several tasks which can be carried out depending on the type of audit and the function of audited facility. It started with review the historical data of energy consumption which can be compiled from the electricity bills. These data is important in order to understand the patterns of energy used and their trend. After obtaining the information on energy consumption, the next step is to set up an energy audit program. This program should start with site survey in order to obtain information on present energy used. The energy utilization such as running hours of

air-conditioning, lighting levels, locations of unnecessary air-conditioning and lighting due to unoccupied areas, temperature and humidity, chillers/pump scheduling and setting, efficiencies of equipments and machine and the areas of high energy consumption and the possibility to reduce consumption should be record for further analysis [2, 3].

The energy audit discussed in this paper will only focused in the UMP library building. It is carried out in aim of analyzing and identifying possible energy saving measures in the library, which can later be implemented for energy efficiency program in UMP. The UMP library inherits purpose-built factory building which is converted into the library building with some modifications to provide knowledge and information services to the campus community. No major conversions were done in the three phase electrical systems or design which contributes to energy inefficiency. Energy wasting practices are significant especially in the lighting, air-conditioning and mechanical ventilation system. Some of the equipments such as lighting system and air-conditioning split units are located at unoccupied an area which does not contribute to energy efficiency. The front view of UMP library is shown in Figure 1.1 while Figure1.2 shows the excessive lighting in UMP library building which was located at rack reference book.

Figure 1.1 Front view of UMP Library

Figure 1.2 Excessive lighting systems at rack reference book.

The energy audit has been done within a seven days time frame to obtain information of energy used in the UMP library in terms of KVA, KW and KVar which includes the current consumption, voltage and power factor. It has been found that inductive load which came from machines (i.e. Photostat machines) and air-conditioning units has result in low power factor in UMP library. This problem has been solved by installing a capacitor bank at the library main switch board for power factor correction which reduces current consumption. For further analysis of energy saving, the energy audit is continued for another seven days time frame to get the information of energy used in the building including the current consumption and corrected power factor after installation of capacitor bank.

1.2 Objectives of the project

The main goal of this engineering project is to propose energy efficiency project in (UMP Library). This proposal and designation is to reduce the energy consumption with engineering techniques and calculation method.

The objective of this project is:

i) To study and understand the energy audit of electricity energy consumption in UMP library.
ii) To propose the energy efficiency project for UMP library.
iii) To analyze the data before and after energy the implementation of energy efficiency proposal in UMP library.

1.3 Scopes of the project

There are several scopes of work for this project; study and identify how energy is being used in UMP library, how much, where and how energy is used and identifies energy saving opportunities. This project can be divided in two phase:

i) Phase I (PSM 1)
   a) Carry out overall energy audit for UMP library.
   b) Produce Energy Profile and Energy Saving Measure (analyze)

ii) Phase II (PSM 2)
   a) Propose energy efficiency project for UMP library.
   b) Implementation of Energy Saving Measures.

1.4 Thesis Outline

This thesis contains 5 chapter which is every chapter have its own purpose. After viewing the entire chapter in this thesis hopefully viewer can understand the whole system design for this project.

Chapter 1 contains of the introduction or the overview of this project, the problem statement of this project, the objectives of the project, the scopes of the project and the outline of this thesis for every chapter.

Chapter 2 contains all the literature review. This chapter will explain the information about the article that related to the project design and the research on energy efficiency that is done by other research. This chapter also describes the journals and others important information regarding this project.

Chapter 3 is chapter for the methodology of this project. This chapter will explain about the detail of the project. Its also includes the project progress that have block diagram, flow chart and also the explanation in detail about the project. The project explanation will be explained through block by block that refer to the block diagram.

Chapter 4 discusses the result and the analysis for this project. This chapter will explain on the results and analysis of the project. The analysis includes the existing system and the improved on proposed system. Both values will be compared to justify the theory.

Chapter 5 will explain the conclusion of the project. Its also includes the future recommendation of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain the literature study that is related to the project task. Besides that, this chapter will be important references to me when do the project. This chapter also includes the journal and the important information when do the research about the project. The information got from several sources such as websites, journals, books, magazines, handout and others.

2.2 A study on energy wasting

For industries that use air conditioning system for clean rooms, the total power consumption of all semiconductor plants exceeds 100 million kWh per year, with about 43% of this consumption to operate air conditioning facilities. This high power consumption is due to the requirement of the cleanliness kept for clean rooms, with extremely high power consumed to the air transferring power. They had developed the fan module unit (FMU) type air conditioning system to decrease the air transferring power, in overall vertical laminar flow type clean rooms. They installed this system in the latest semiconductor manufacturing plants. This air conditioning system has an improved FMU type fan, and considerably decreased running costs to about 53% of the recycle fan type. The air transferring power of this

FMU air conditioning system is 6.5W/CMM (m3/min). They also designed an air conditioning system without air conditioning ducts, which implemented saving energy, saving resources and maintenance savings, contributing to environmental protection [4].

One of the strategies to reduce energy wasting and electricity cost is by periodically reviewing schedules to ensure the equipment run only when needed, and by maximizing the use of a control system to operate the equipment and systems in an energy efficient manner while maintaining a comfortable and safe building environment.

2.3 Energy Audit

Energy audits are a systematic study or survey to identify how energy is being used in a building or a plant. It is also a useful procedure to find out the best options for energy conservation. Energy audits provide an analysis of the amount of energy consumed during a given period in the form of electricity, gas, fuel, oil or steam. Using that information, it is also possible to list how the energy was used according to the various processes in a plant or at the various outlets in a building. The next step in an energy audit then is to identify the potential for energy savings accurately [5].

Energy audit, similar to financial accounting process, is a process of examining an energy account, checking the way energy is used and identify areas where wastage can be minimized [6].

Energy audit cannot be successfully carried out without the commitment from the top management. Management must be firstly convinced of the necessity of implementing energy management and hence energy audit. The basic reasons are:

(i) Potential money returns

a) The probable energy and thus the cost saving after implementation.

(ii) Energy is expansive

a) Traditional energy resources, e.g. fossil fuel ,are diminishing,
b) There is a tendency of increasing unit cost for consuming electricity or other form of energy;

(iii) Probable destruction to environment

a) Burning of fossil fuel in power generation results in increase of CO_2, which contributes to global warming, etc.

2.3.1 Commencement of Energy Audit

Energy audit is started with a review of historical energy use. A set of 3 to 5 years historical data on energy consumption can be compiled from energy bills and plant records. From these data we can understand the past patterns of energy use and their trend. This is also a base reference for future comparison after the energy audit programmer is implemented.

It is often useful at this stage to compare the average energy use of the building being studied with other buildings with similar function and obtain some idea whether the building is apparent1y efficient or inefficient in the past few years [6].

2.4 The Site Surveys

After obtaining the information on historical energy use and on how much we spent for the past few years on energy, the next step is to set up an energy audit programmed. This programmed should be undertaken jointly by the Energy Manager and the building management or owners. This programmed should start with site surveys [6].

Site surveys are necessary to provide information on present energy use. They should be carried out to check and record the following:

(i) Energy sources
(ii) Energy utilization and
(iii) Energy control

2.4.1 Energy Sources

Different sources of energy supplying to the building should be recorded, whether they are in the form of electricity, gas, diesel oil, etc. Total energy cost of all inputs can subsequently be calculated in terms of a common unit, e.g. $/U<, so that their individual efficiencies can be compared.

Other related information should be checked and recorded, such as types of tariff being used; whether bulk tariff can be used and whether maximum demand can be cut down or power factor be improved.

2.4.2 Energy Utilization

Site surveys on energy utilization are more complicated and time-consuming. They may include the following [6]:

i) Running hours of air conditioning and length of pre-cool period.

ii) Internal comfort conditions, e.g. temperature, humidity, lighting levels.

iii) Locations of unnecessary air- conditioning and lighting, e.g. unoccupied areas.

iv) Chillers/pumps scheduling and setting.

v) Any energy efficient light fittings and control being used.

vi) Adequacy of insulation of the building fabrics, e.g. for curtain-wall buildings.

vii) Quantity of waste heat being discharged, e.g. incinerator flue, condenser heat, possibility of heat recovery.

viii) Efficiencies of individual equipment or machines.

ix) The areas of high energy consumption and the possibility to reduce consumption.

2.4.3 Energy Control

It records the ways the management has handled or controlled the energy use within the building.

Typical information required are the name of the person responsible for energy management, how and when energy consumption is reviewed, how often meter readings are taken, whether additional sub- meters are required, any energy forecast, comparison on energy consumption internally and/or externally, how well is the system operated and maintained, any energy efficiency improvement schemes in hand, whether employees are aware of the need for energy conservation, etc [6].

2.5 Energy Audit Programmer

Energy Audit Programmer is the next process for examining ways in which energy savings can be achieved, identifying all "energy management opportunities (EMO) and providing engineering and economic analysis for each EMO. Priorities

can be established, based on expected economic returns, capital cost input, pay back period and management preference, etc.

Energy Audit Programmer should be reviewed at least annually and shall typically comprise the following topics [6]:

i) Record Analysis

(a) Provide cost per unit of each kind of fuel consumed by the building and produce the Sankey diagram (a diagram showing the energy flow, to and from the building). Compare the energy consumption with previous periods and other buildings with similar function. Review existing records and check whether additional information is required.

ii) Environmental Conditions

(a) Review air-conditioning and lighting provisions and check whether they are unnecessarily provided.

iii) Electricity

(a) Review type of tariffs and check ways to reduce peak demands.

iv) Maintenance

(a) Review existing records, determine whether maintenance is adequate and consider how it can be improved.

v) Personnel

(a) Review energy conservation education campaign or propaganda and consider ways to further train and motivate employees.

vi) Capital Investment

(a) Review energy related capital projects and investigate economic life of major equipment.

Recommendations on EMOs with priority and their expected economic returns are then given to the management for consideration for subsequent implementation [6].

2.6 Energy Efficiency

Energy efficiency is appropriate as energy conservation, is an important aspect of Malaysia energy policy. Although Malaysia has resources such as oil gas, they are limited and delectable. There is a need to lessen dependence on these non-renewable sources of energy. Diversification into new and renewable sources of energy will require time and technological advances. Therefore available resources should be efficiently utilized; efforts in energy efficiency have to be pursued.

Energy efficiency is an area that could help significantly in the reduction of greenhouse gas production. Energy is lost at power stations before it is converted into electricity. More energy is lost during the transmission through power cables across the country. Yet more energy is wasted in homes and businesses through inefficient equipment and products as well as poor building designs. If zero energy was wasted, we would probably not be as worried about potential climate change [7].

2.6.1 Electrical Energy Efficiency

From the research by the Copper Development Center, in 2001, at United Kingdom, more than 8% of the total usage of electricity is probably wasted due to

the design of your equipment and the way it has been installed. Running equipment for longer than necessary is an addition to the energy wastes [8].

Electricity is the most expensive form of energy available-about 8 times the cost of coal of gas and 6 times the cost of gas- this expensive fuel must be used wisely. The average cost of industrial electricity in the United Kingdom has risen 13% in the last five years despite the very strict regulatory environment. In future, it many raise even faster [8].

Using high-efficiency motors, properly selected and installed, could save industry up to 300 million per year. A motor consumes electricity to the equivalent of its capital cost in just there weeks of continuous use- high efficient motors save money over the whole of their long life. Energy is lost in all cables. Using the minimum regulation size means greater losses and hotter running. Using larger sizes saves energy and costs less over the lifetime of the installation- the energy saved is worth many times the slightly increased cost of large cable [8].

2.7 Efficient and Effective Lighting

When the discussion talks about the need for lighting to be efficient and effective, some people think immediately of energy conservation. But efficient and effective is much more than that. Lighting has job to do and it must do it well. It’s not there for the benefit of the building but for the benefit of the occupants, and good lighting contributes directly to their efficiency and effectiveness. It also contributes to safety [9].

The principal purpose of lighting is to enable people to see. Unlike temperature and humidity, which must be controlled within fairly close limits for human comfort, lighting conditions can vary over an enormous range, and it’s essential to match the lighting standards to the type of work to be carried out. Poor

lighting contributes to accidents and more insidiously reduces the efficiency and effectiveness with which people work. It can decrease morale; increase staff turns over and be a casual factor in industrial action. Lighting in places of works, which is insufficient or unsuitable, directly contravenes the Health and Safety at Work etc [9].

Good lighting works well and uses energy efficiently. Efficient and effective lighting means ensuring that the correct lighting standards are provided both in terms of quantity and quality. It also means selecting the correct type of lightings system, using the most suitable lighting equipment, and controlling the hours of use. Effective lighting consists by maintaining the system in efficient working order [9].

The recommended luminance levels and guide for lighting design from Ministry of Energy, Telecommunication and Post Malaysia has been represented on Table 2.1. Reducing both installed power and time of use can minimize lighting energy consumption. Installed power should be minimized by the use of more efficient lamp/ballasting system luminaries. Efficacy ranges of available lamps are given in Table 2.2.

Table 2.1: Luminance Levels.

Task	Lux	Example
Lighting for infrequently used areas	20	Minimum service illumination
	50	Interior walkways and car parks
	100	Hotel bedrooms
Lighting for working interiors	200	Infrequent reading and writing
	350	General office, shops and stores; reading and writing
	500	Drawing office
Localized lighting for exacting tasks	750	Proof reading
	1000	Exacting drawing
	2000	Detailed and precise work

Table 2.2: Efficacy ranges of available lamps.

Type of lamp	Efficacy range (Lumens per watt)
Small fluorescent (7-25 W)	50-55
High pressure mercury fluorescent (50-2000W)	40-60
Hot cathode tubular fluorescent (4-125W)	45-95
Mercury halide (up to 10000W)	65-85
Low pressure sodium (18-200W)	100-180
High pressure sodium (50-1000W)	80-130

2.8 Energy Efficiency with Lighting

Lighting accounts for 20% to 25% of all electricity consumed in the United States. An average household dedicates 5% to 10% of its energy budget to lighting, while commercial establishments consume 20% to 30% of their total energy just for lighting. In a typical residential or commercial lighting installation, 50% or more of the energy is wasted by obsolete equipment, inadequate maintenance or inefficient use [10].

Saving lighting energy requires either reducing electricity consumed by the light source or reducing length of time the light source is on. This can be accomplished by [10]:

i) Lowering wattage, which involves replacing lamp or entire fixtures.

ii) Replacing the light source on-time, this means improving lighting controls and educating users to turn off unneeded lights.

iii) Using *daylighting*, which reduces energy consumption by replacing electric light with natural light.

iv) Performing simple maintenance, this preserves illumination and light quality and allows lower initial illumination levels.

2.9 Idea of Energy Efficient Concept

A comprehensive process for minimizing energy use and cost consists of ongoing involvement in the three fundamental components of energy management (see Figure: 2.1)

i) Efficient purchasing: This means purchasing energy at the lowest available unit cost
ii) Efficient operation: This requires operating the equipment that consume that energy as efficiency as possible.
iii) Efficient equipment: This entails upgrading or replaces existing equipment with more energy efficient version whenever it is cost effective.

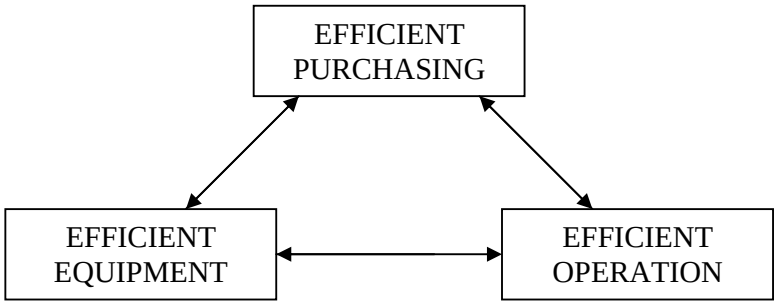


Figure 2.1 Three fundamental component of a comprehensive energy management process. Efficient operation has focus of this paper.

Efficient purchasing and efficient operation should be the basic day to day activities of an energy management program. It entails the ongoing application pf management skills and requires little or no capital expenditure to achieve their goals.

The third component, making capital improvements, should support the first two by altering or replacing existing equipment in order to reduce costs or improve equipment efficiency. Unlike the first two components, upgrading existing equipment usually requires substantial capital investment to achieve its goal.

Most energy-efficiency program concentrates their resources on equipment improvement first, when it would be more cost effective to begin with efficient purchasing and operation. In almost all facilities, the second component operating existing equipment as efficiently as possible is the least well understood and the most underdeveloped of the three. Ironically, this activity has a high potential for saving and requires little to no capital outlay [11].

2.10 Power Factor

Electrical power is composed of two components, Real power, and Reactive power. Real power, expressed in Kilowatts (KW), is power consumed in performing work such as producing heat, pumping fluids, moving elevators, producing light, etc. Reactive power, expressed as Kilovolt-Amperes Reactive (KVAR), is magnetizing power that is consumed in establishing and maintaining magnetic fields in induction machines such as transformers and motors.

Transformers and motors experience extremely high current flow upon start-up, known as in-rush current. Transformer and motor stator winding conductors represent a short circuit to current flow until the magnetic fields linking the primary and secondary windings for transformers, and the stator and rotor windings for

motors, are established. Once the magnetic fields are established in these machines, the current required to maintain the fields is substantially reduced [12].

The relationship between real and reactive power is modeled, along with Apparent Power, expressed in Kilovolt-Amperes (KVA), as the Power Triangle.

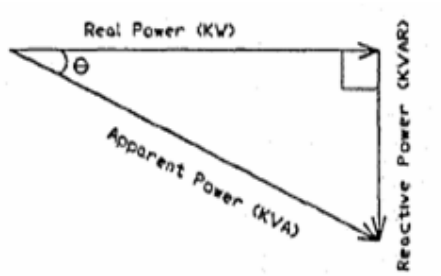


Figure 2.2 Power Triangle.

Real power and reactive power are *90"* out of phase and represent the two legs of the power triangle, while apparent power or the measurement of the composite real and reactive power, is the hypotenuse. Following the Pythagorean Theorem, apparent power, real power, and reactive power share the following relationship:

$$(KVA)^2 = (KW')^2 + (KVAR)^2 \tag{2.1}$$

The angle between real power and apparent power is the Power Factor Angle. The cosine of the power factor angle is Power Factor, expressed as a decimal or a percent, which can also be expressed as the ratio of real power to apparent power with the following relationship:

$$PF = cosine\ (\theta\ ) = \frac{KW}{KVA} \tag{2.2}$$

Power factor is significant because, as the ratio of real power to apparent power, it represents the efficiency of a given electrical distribution system. Low power factor indicates a relatively inefficient distribution system where a high percentage of electrical energy is allocated to establishing magnetic fields within induction equipment when compared to useful work gained in the form of real power.

In cases of low power factor, the customer maybe paying more to start and run motors and transformers at relatively low load levels than paying for useful production from the same motors and transformers. Likewise, the utility is supplying more energy to start and run motors and transformers at relatively low load levels than supplying power for the customer's ultimate purpose. Meanwhile, the electrical distribution system is carrying excessive reactive power relative to the: real power requirements of the load.

Conversely, high power factor indicates a relatively efficient distribution system where a minimal amount of electrical energy is to allocate to establishing and maintaining magnetic fields within equipment. In either case, the customer pays the utility for the energy supplied, whether that energy usage is advantageous to the customer in the form of an efficient, high power factor distribution system, or wasteful and costly to the customer in the form of an inefficient electrical system with low power factor [12].

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will explain about the detail of the project. Its also includes the project progress that have block diagram, flow chart and also the explanation in detail about the project. The project explanation will be explained through block by block that refer to the block diagram. (see Figure 3.1)

The objective of this chapter is to list the steps or the methodology to arrange how the auditing of energy consumption and examine the electrical energy efficiency at UMP Library was done. This is important to get the project accomplish. All the methodology will be followed to get the result in the work period. The methodology has been arranging on the first step before start the execution of the project.

The project has been divided into three categories to fulfill the thesis objective. Electricity analysis will be under energy auditing procedure for efficient operation. The tabulations show the energy consumption for the building.

Efficient Purchasing is about to replace the system in the building for energy efficiency. It consists to improve the power factor by correcting the reaction power and improve the power quality in the distribution of the building.

Efficient Equipment can make capital improvement. It will support the first two by altering and replacing existing equipment in order to save the electrical energy, to reduce cost or improve equipment efficiency.

3.2 Flow Chart of Energy Audit at UMP Library and Energy Efficiency Project Proposal

The flow chart of Energy Audit at UMP Library and Energy Efficiency Project Proposal can been seen in Figure 3.1.

For the first part, the objectives of this project were studied. The study is to audit the energy usage in this building and to determine the purpose and the useful for the future and also to our experience to survive after graduate. All the loads in the building also were been studied. In this procedure, an auditing for all the loads has been analyzed.

Then, all data for load in that particular building has been accumulate. This data will be getting from the process log the data that connect to the load. The power consumption auditing was done by using the data logger (*ELITE pro* power meter) and *elog 2004 software*. These equipments were used to measure the energy consumption such as voltage and current usage, the power factor (PF), real power (kW), apparent power (KVA) and reactive power (KVar) at each phase. Current clamp and voltage probes were connected to the load at each phase to measure the power consumption. The data was collected within seven days time frame during the semester break which is from 3rd (Tuesday) to 10th June 2008 (Tuesday). This data are very important to complete the objective for energy efficient program.

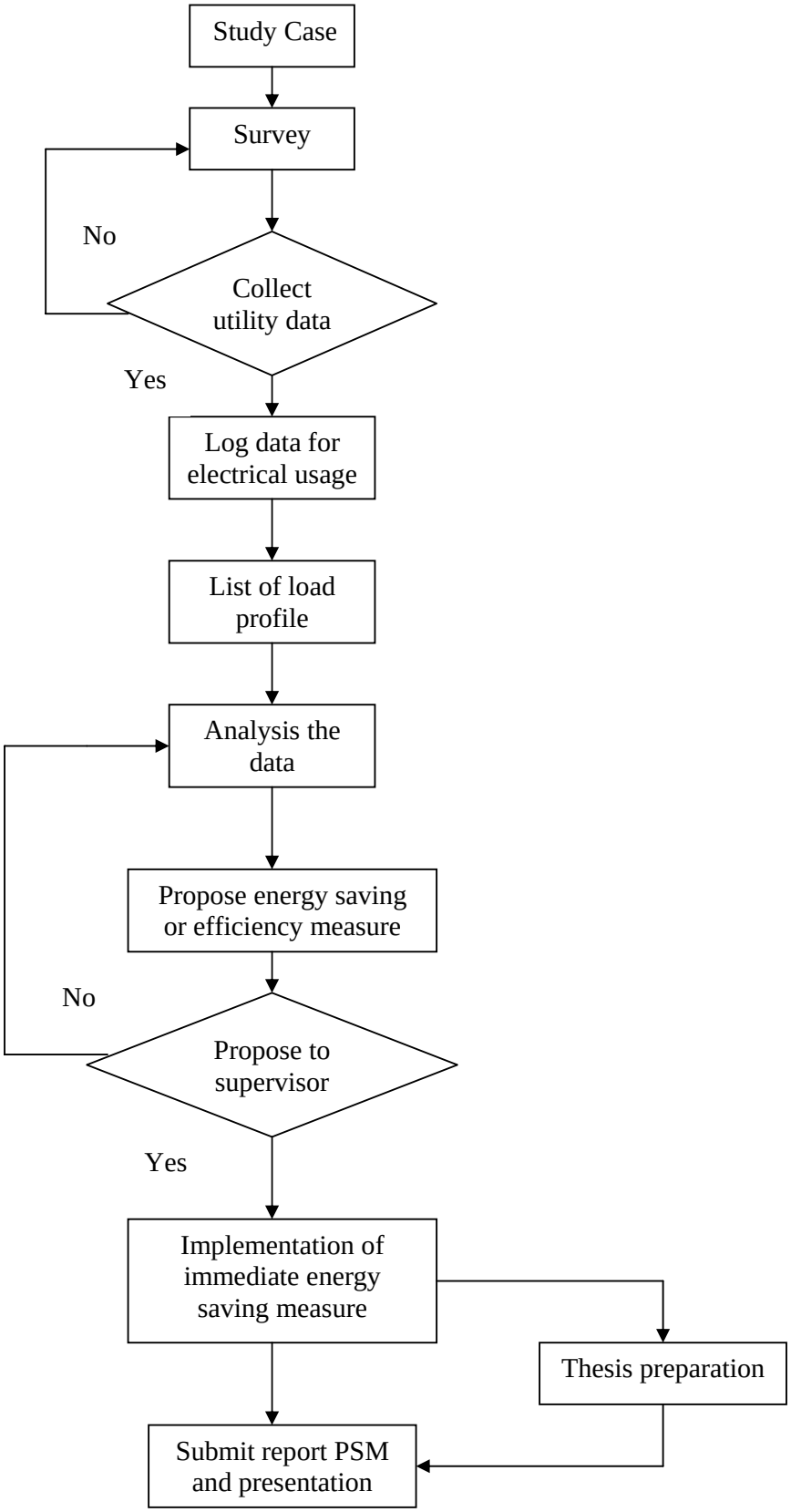


Figure 3.1 Flow chat of this project.

After than all data has been analyzed, the solution for energy efficiency will be given. The data from the reference, literature review and building loads will be analyze and come out with solution for energy efficiency. The solution depends on suitability on the system. Main goal is to save energy consumption and manage the energy to being used wisely and reduce the losses.

Based from the results obtained in the energy audit process at UMP library building, it was found that the power factor need to be improved since the power factor of the system during semester break is low for the period of 8a.m to 6p.m (office hour). This situation will become worst during semester season since the library operating hour is longer which is from 8a.m to 11p.m. The power factor needs to be corrected to prevent any internal electrical energy losses in the system as well as reduce current consumption thus increase energy efficiency. The power factor is corrected by installation of capacitor bank in parallel with the main supply. The reactive power correction is installed in order to get the desired power factor. The energy auditing in UMP library building after the installation of capacitor bank is done within seven days time frame which is from 11th June (Wednesday) to 18th June 2008 (Wednesday) during semester break.

Before that, the relamping of lighting system at UMP Library has also proposed to get the energy efficient. The information of energy efficient of lighting will get from the internet and other reference book.

Then, the design or modify the new system that used efficient techniques to save energy were develop except exchange the existing lighting system to proposed lighting system.. All retrofitting and cost installation has been recorded in the result to prove that the entire step are relevant and can be used for saving energy and reduce cost. Simple Payback Period will show the point of time to payback the investment for new installation of new efficient equipment. The simulation also been developed to examine the efficiency for the retrofitting and economic reason.

3.3 Selection of Building for Case Study

UMPLib is one of the IPTA University Libraries in Malaysia. Knowledge Management is a new approach for UMPLib (Universiti Malaysia Pahang, Library) to manage and utilize knowledge assets effectively. UMPLib provides information and knowledge services to campus community and relevant customers.

UMPLib emphasizes the management of tacit knowledge, though explicit knowledge is equally important. UMPLib also provides info structures facilities and resources that meet the requirements of academic programs and encourages knowledge sharing among UMP's community members.

As a knowledge management champion, UMPLib focuses its role in knowledge society and producing competent professionals in line with the UMP's vision and mission. Knowledge sharing will be nurtured by UMPLib to ensure that knowledge culture and learning organization is realized. UMPLib will continually strive to improve business and generate income through its services and products.

Figure 3.2 Front view of University Malaysia Pahang Library

Figure 3.3 Side view of University Malaysia Pahang Library

3.4 Auditing Procedure for Electrical Energy

The walk through tour with supervisor and technician in UMP Library has been organized with JPPH (*Jabatan Pembangunan dan Pengurusan Harta*). For electrical system in the building, JPPH of electrical unit technician will explain all the operation, according to the plan and schedule. JPPH technician also explain the function for each equipment in this building.

3.4.1 Power Consumption Auditing

The power consumption data for UMP Library was taken using the ELITE pro power meter and data logger elog 2004 software. This software can measured the energy consumption such as voltage and current usage, the power factor (PF), kiloWatt (kW), KVA and KVA. The power consumption data was collected within (seven days) time frame to obtain information of energy used in UMP Library. Then, the results of voltage, current (ampere), kiloWatt hour (kWh), KVA KVAR and

power factor were analyzed. The current clamp and voltage probes were connected to the load at each phase to measure current consumption. The data logger is shown in Figure 3.4 while the current clamping to the load is shown in Figure 3.5.

Figure 3.4 ELITE pro power meter

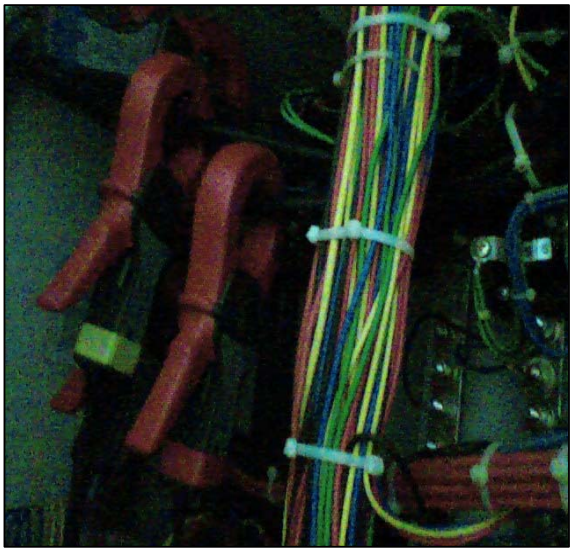


Figure 3.5 Clamping the three channel incomer at MSB

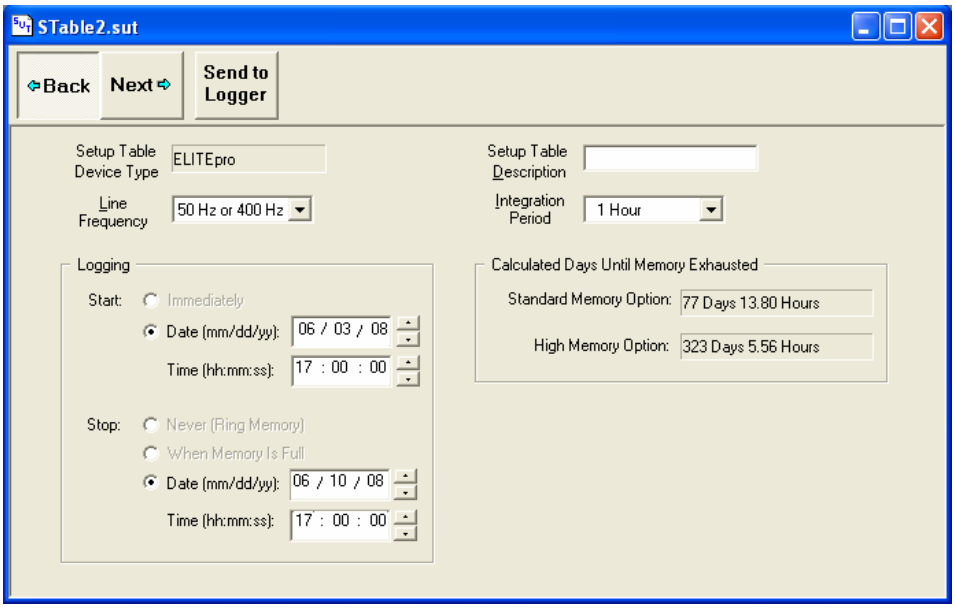


Figure 3.6 First step to log the data is creating a new setup table.

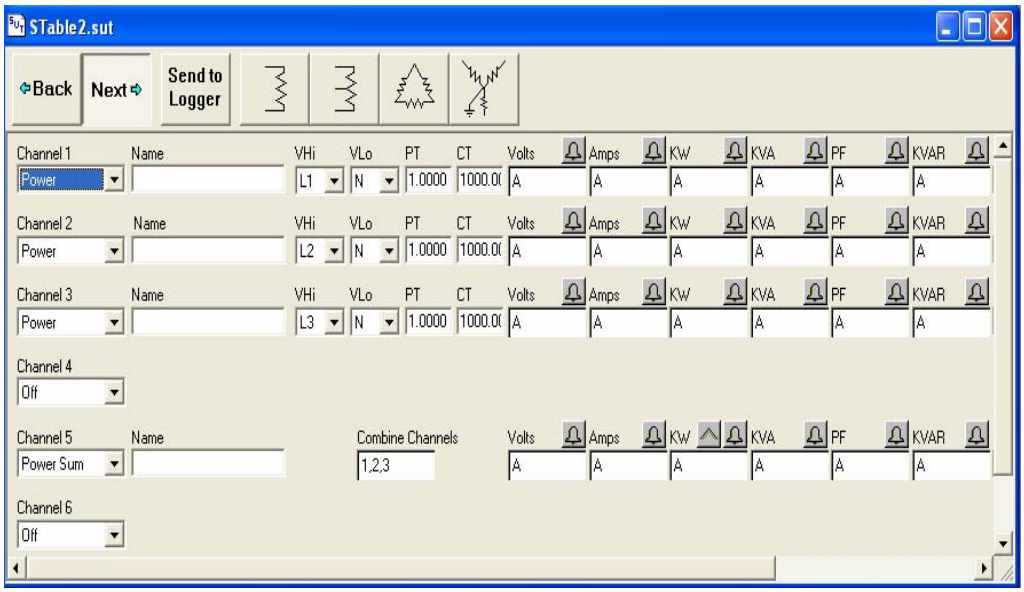


Figure 3.7 Second step, setup the channel parameter to measured.

Clamper was setup in wye type connected with the load. The wiring diagram as shown in Figure 3.8.

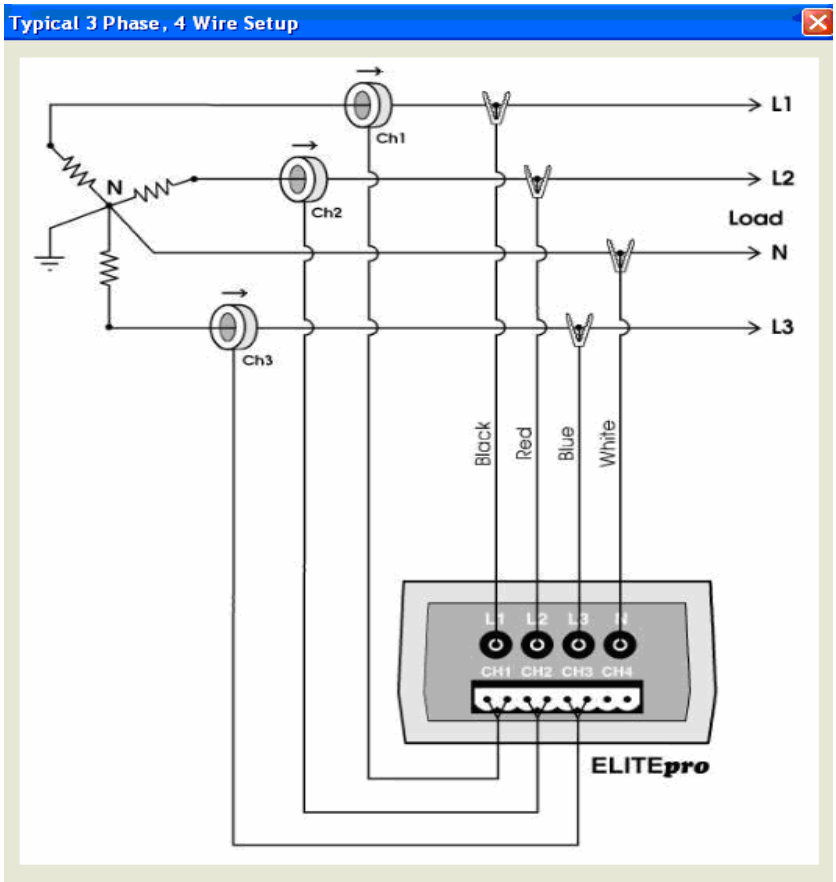


Figure 3.8 Three phases and four wires wye.

After clamping the wire cable, the elog 2004 software were simulated. Then, the result can be measured as shown in Figure 3.9.

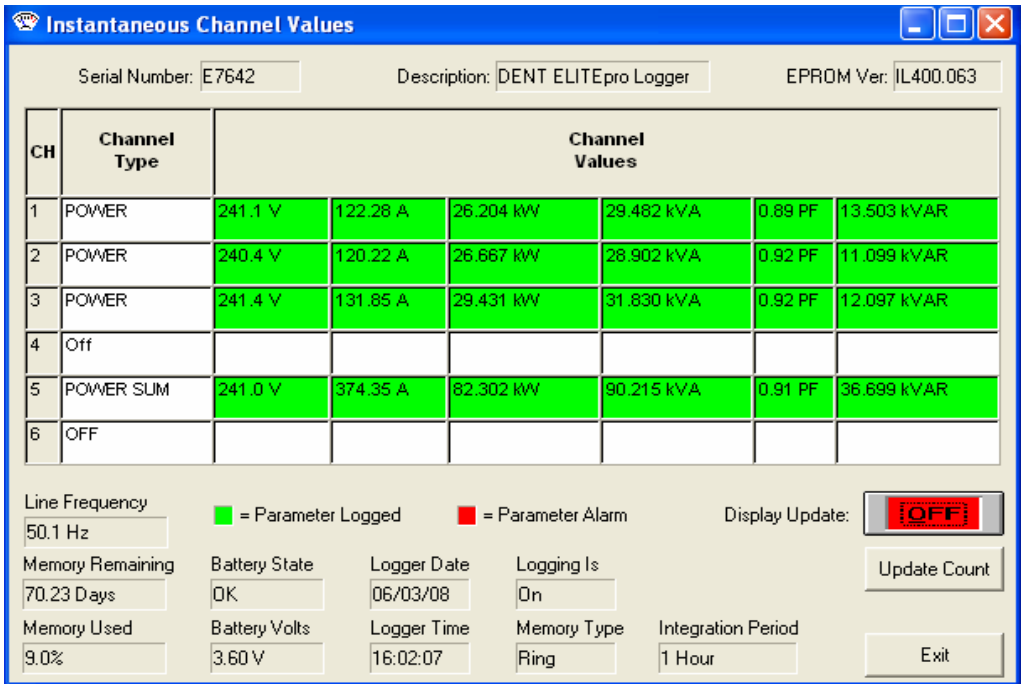


Figure 3.9 The results are measure in channel form.

This result can also be viewed in graph form as shown in Figure 3.10.

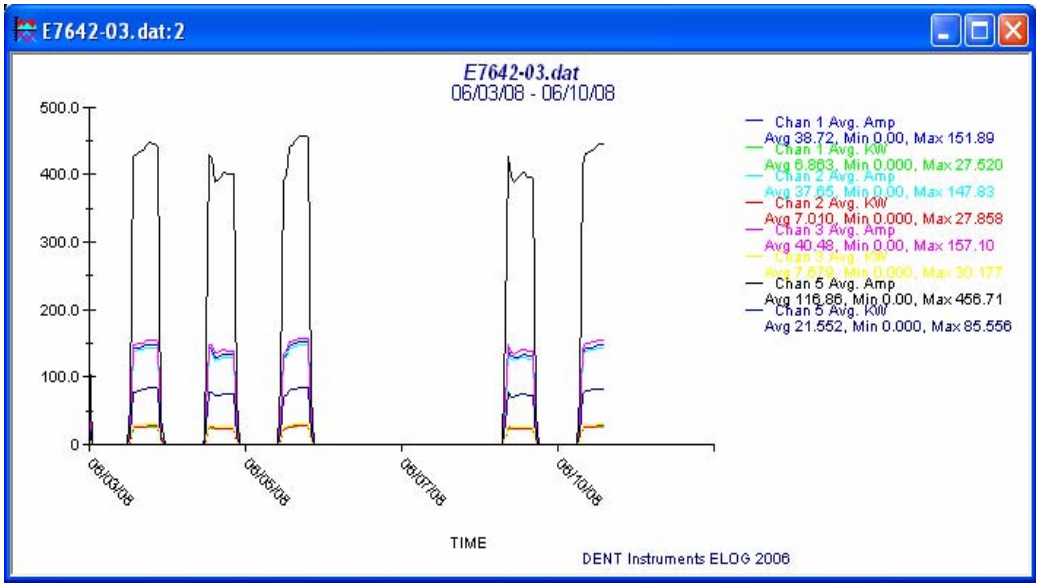


Figure 3.10 The result in graph form.

3.4.2 Power Factor Auditing

Power factor can be leading or lagging. For most applications, such as inductor motors and lamp ballast, it is lagging. For synchronous motor, it can be leading or lagging. Equipment with a leading power factor can sometimes offset equipment with lagging power factor, resulting in an overall system power factor nearer unity. With most equipment, such as induction motors and lamp ballasts, power factor is usually corrected by installing a bank of capacitors. The inductive of lamp ballast is 3.5µF. It is generally most effective to install the capacitors near the equipment responsible for the system's low power factor.

Based from the result obtained in the power consumption auditing process as discussed in sub chapter 3.4.1, it was found that the power factor needs to be improving since the power factor of the system is low during operation hour. The power factor needs to be connected by installing a capacitor bank in parallel with the main supply. The reactive power correction is installed to prevent any internal electrical losses in the system as well as to reduce current consumption and increase the energy efficiency.

The energy auditing in UMP library after installation of capacitor bank is done within 7 days time frame. The main switch board of the UMP library is shown in Figure 3.11. The installation of capacitor bank at the main switch board is shown in Figure 3.12.

Figure 3.11 The main switch board (MSB) at the UMP library.

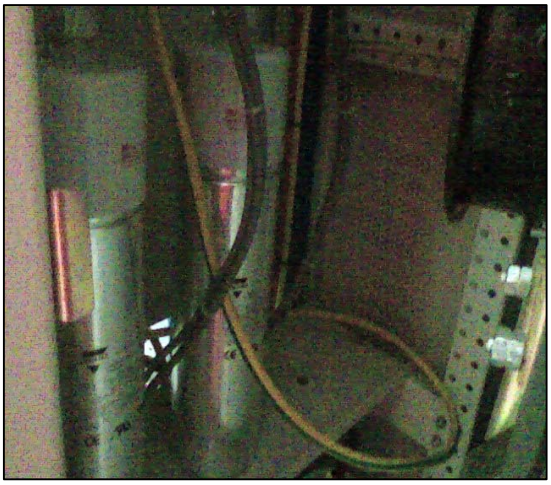


Figure 3.12 Installation of Capacitor Bank in UMP Library

3.5 Equipment Survey

These tasks were focus for two major equipments; air-conditioning and lighting system. Before surveying this equipment, the drawing and layout of equipment were got from JPPH (*Jabatan Pembangunan dan Pengurusan Harta*) electrical and mechanical unit. The drawing of lighting, were got from JPPH electrical unit and for the air-conditioning drawing; were take from JPPH mechanical unit.

3.5.1 Lighting Survey

There are many types of electrical items for lighting system in UMP Library. The lighting auditing process was conducted by surveying the system in UMP Library building. The description of the lighting property is enclosed in the Appendix 2. The study the lighting auditing is by study the layout of lamp in UMP Library using AutoCAD software. Fluorescent luminaries and down light are the most common lighting system installed in the all over the area building.

Most of the lamp is well efficient, but in certain place such as *Keluar* sign still use the fluorescent device. Compare to the market and new technologies the fluorescent can be change or use the Light Emitted Diode (LED) *Keluar* sign that more efficient and save 10 times energy that existing lamp. Another lamp at the lighting system at UMP Library is emergency lamp. Most of the lighting systems in UMP library are using magnetic ballast for the fluorescent lamp. The magnetic ballast can be changed to new technologies, electronic ballast in fluorescent lamp which gives more energy efficient.

3.6 Energy Conservation Recommendation

The recommendation for reinstalling, reschedule and retrofitting the equipment will be discuss in the Chapter 5. Energy auditing and simple calculation for brief the techniques and equipment with high-efficiency operation studied and will be proposed to the building. All the energy conservation method is proposed to save the consumption of electricity to reduce the monthly bill.

3.6.1 Simulation by Visual Basic 6.0

This simulation design for lighting retrofitting is done to compare and determine the existing lamp and the proposed system. This layout has been built using with software (Visual Basic 6.0).

3.6.1.1 Starting with Visual Basic

This procedure explains how to create a simple Simulink model. This model used as an example to compare the existing system and proposed system of lighting. A Simulink model has to be created before it can run a simulation.

For the first step, the Microsoft Visual Basic must be start. Usually, go to start menu > Programs > Microsoft Visual Studio > Microsoft Visual Basic 6.0' until the opening dialog windows appear as shown in Figure 3.13. Then, the icon of “Standard Exe” was selected before start the new project.

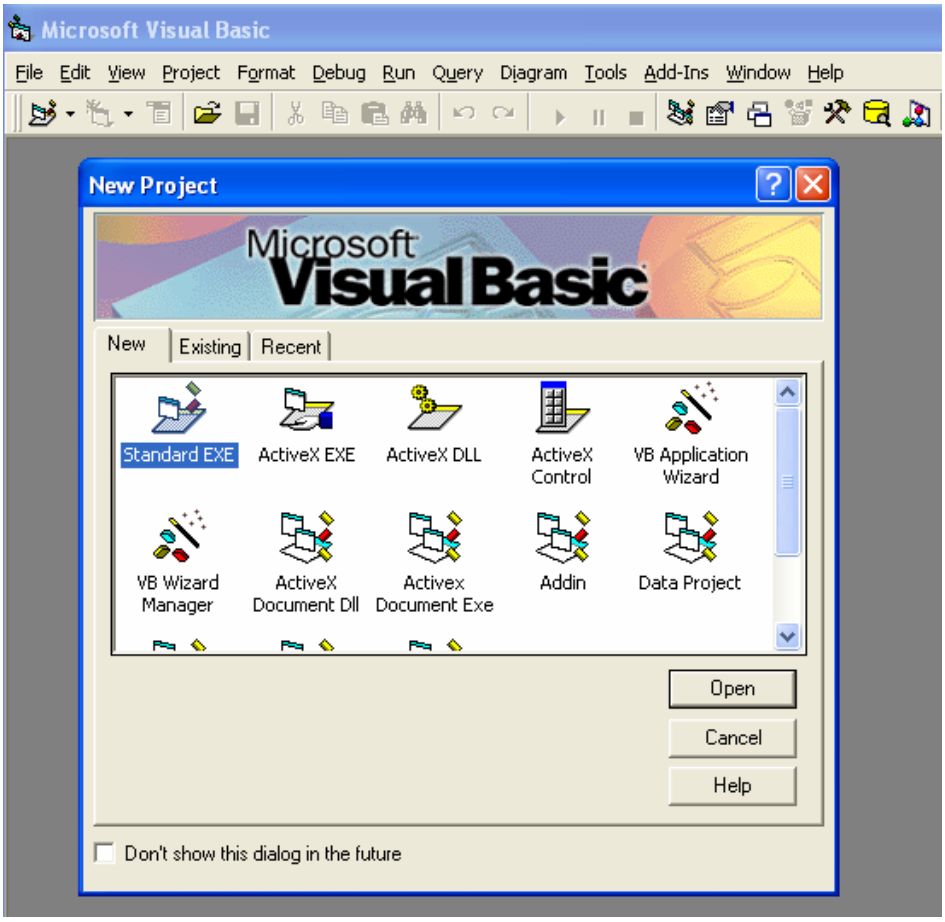


Figure 3.13 Opening dialog windows.

After the “Standard EXE” icon was click, then click "Open" button to start VB program.

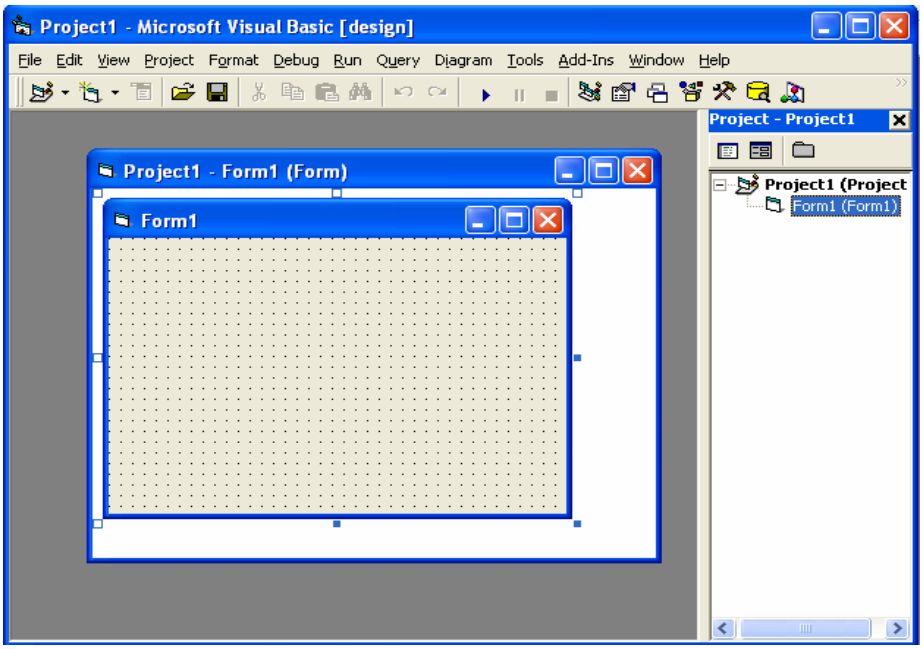
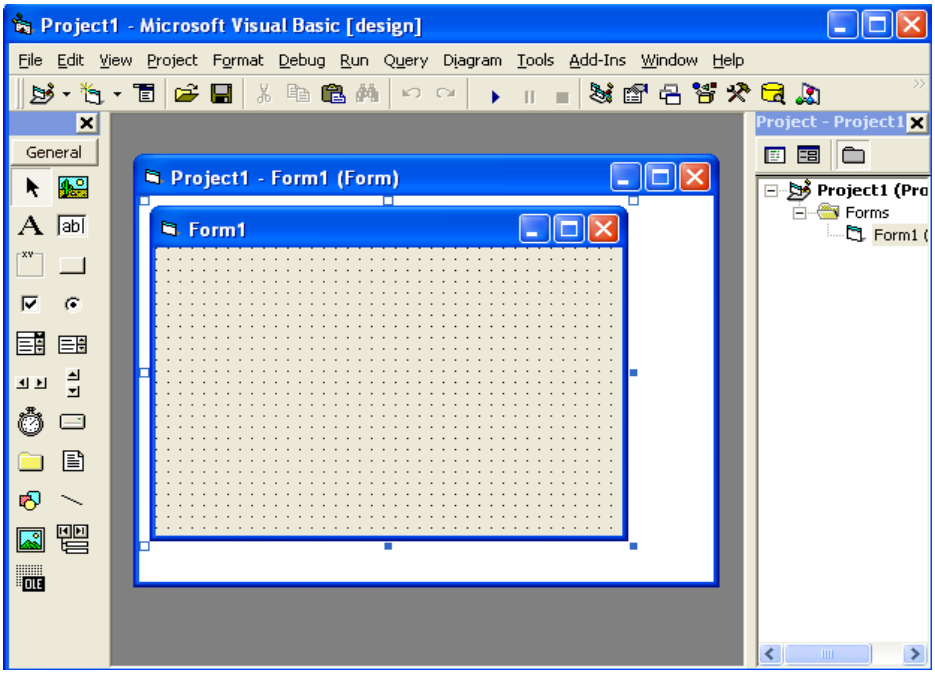


Figure 3.14 Form of project.

After the form windows appear as shown in Figure 3.14, the icon of view was clicked to get the toolbox.



. **Figure 3.15** The toolbox form.

After that, the icon of frame box was taken, and then, drag it to the form.

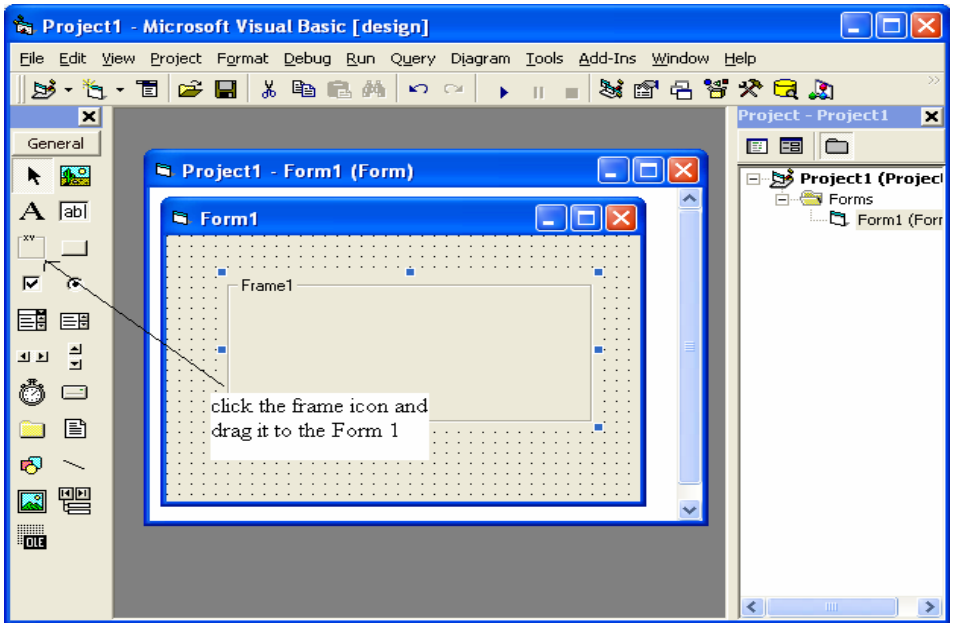


Figure 3.16 The view of frame in the form.

Then, the icon of textbox and label was clicked and dragged it into the frame.

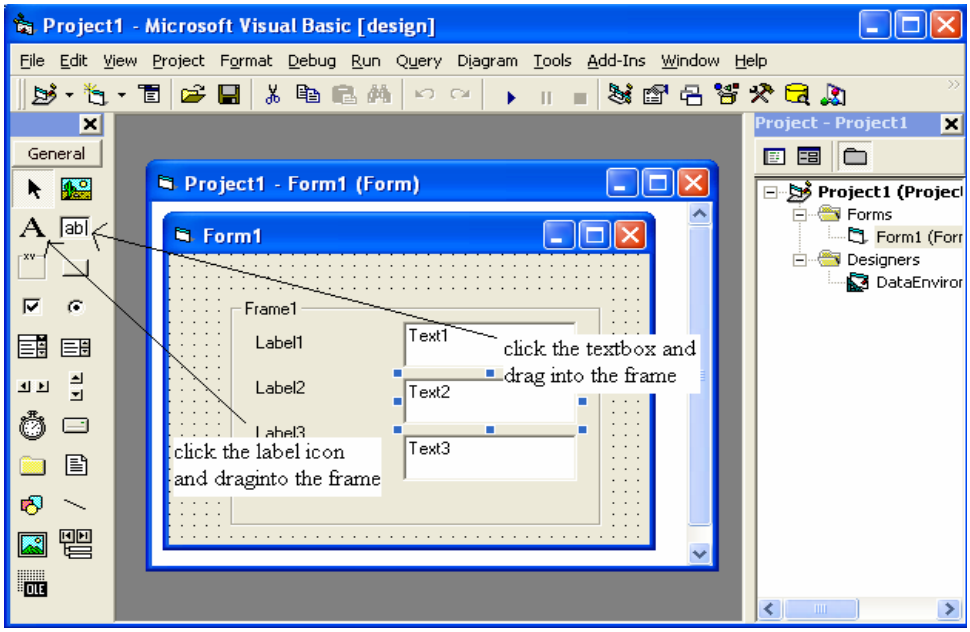


Figure 3.17 The textbox and label in the frame of project.

The properties window from the view icon was clicked to get the properties of frame.

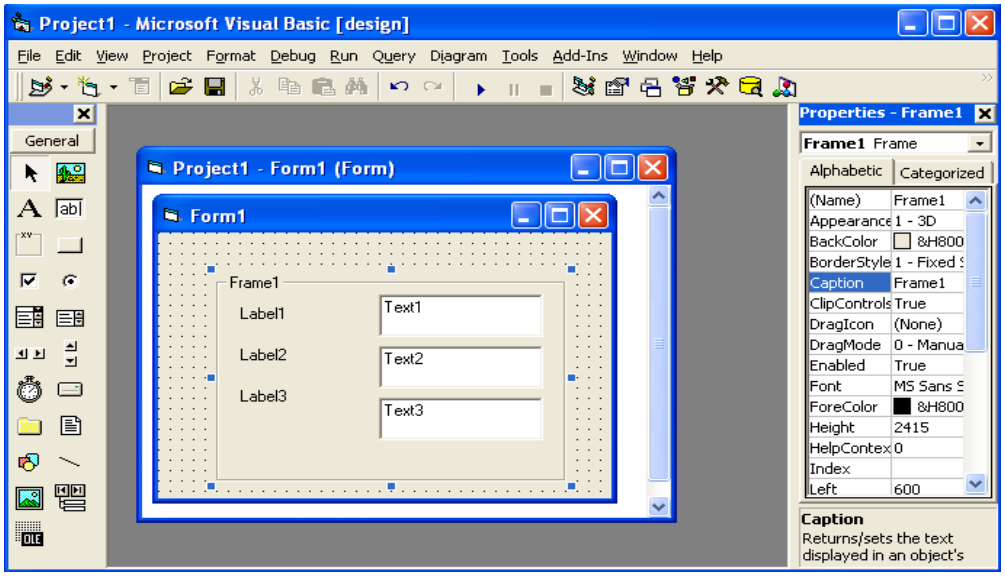


Figure 3.18 The properties of frame project.

Then all previous steps were repeated to build another frame. Then, the frame name was changed into the existing system for frame 1 and proposes system for frame 2.

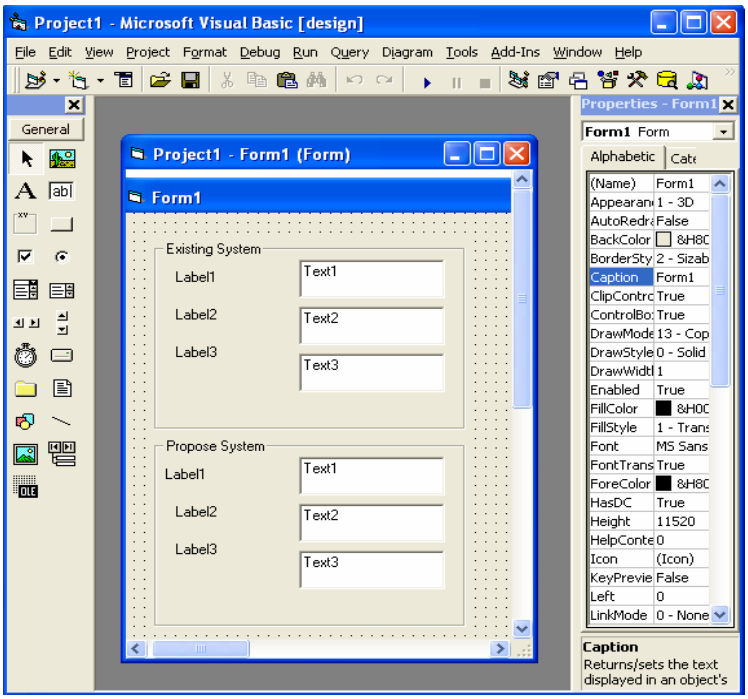


Figure 3.19 Frame of existing and propose lighting system.

Then, the icon of picture and font at the properties was clicked to select the form of background and the font size as shown in Figure 3.20.

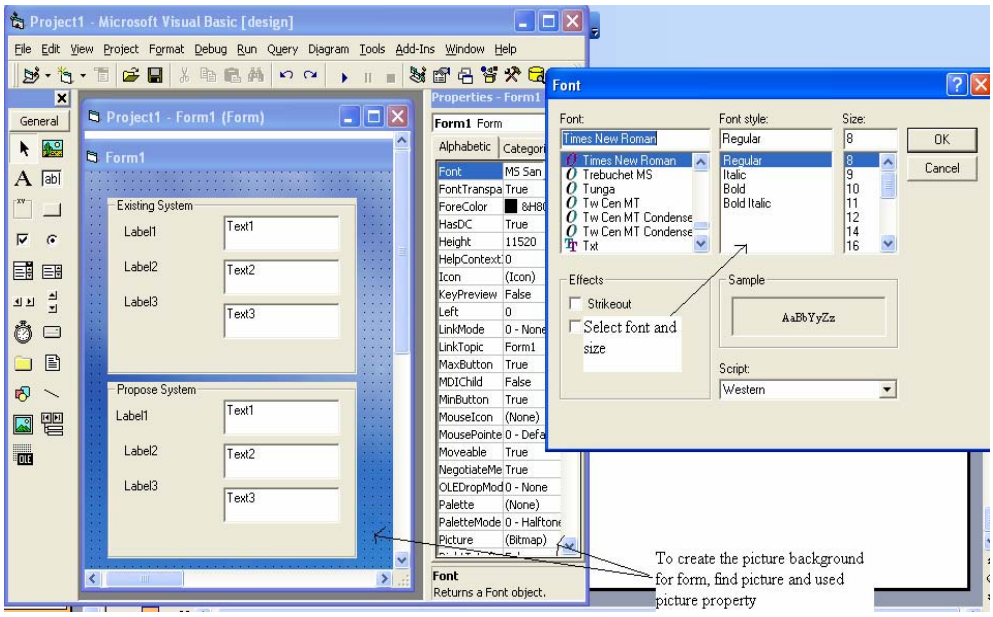


Figure 3.20 The background and types of font was selected on the project.

The icon label and textbox was clicked and dragged it into the frame as shown in Figure 3.21.

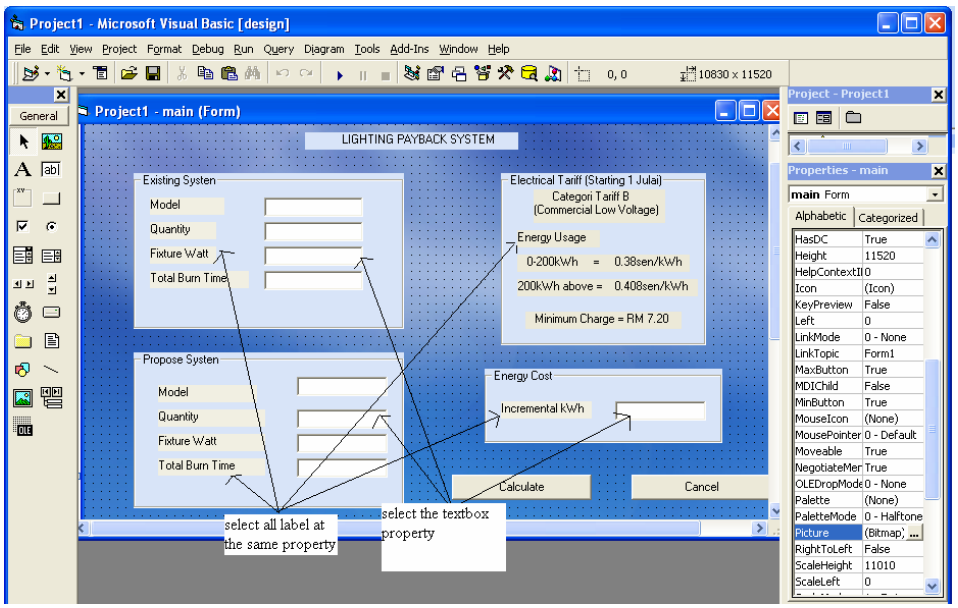


Figure 3.21 The label and textbox were selected.

After that, the frame icon was clicked and dragged it into the same form to build another frame. Then, the label and textbox icon were clicked and dragged into the new frame as shown in Figure 3.22.

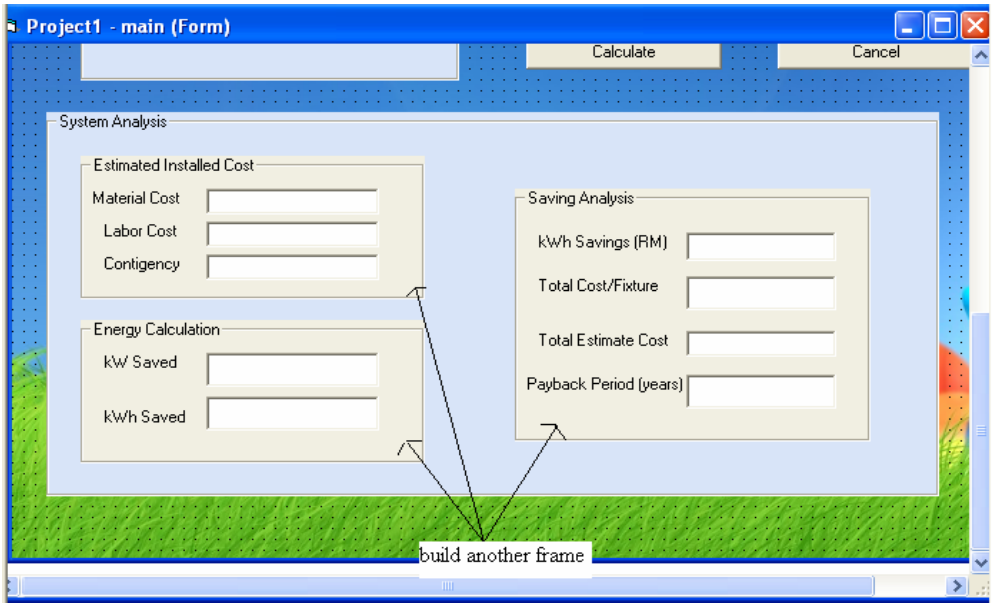


Figure 3.22 New frame was build at the same form.

Then, the coding was entering to complete the project. (see Appendix 4).

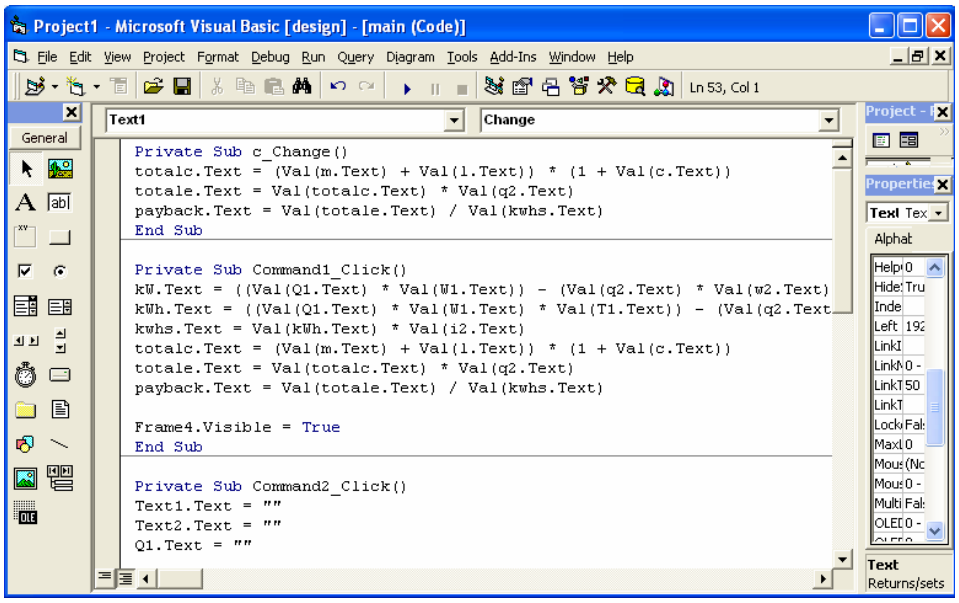


Figure 3.23 Part of coding.

3.6.2 Simple Payback Period

$$\text{Simple Payback Period} = \frac{Investment(RM)}{Saving(RM\ /\ years)} \tag{3.1}$$

This formula is to calculate the electrical energy saving with the period to pay back the investment for the reinstall or retrofit the new or high-efficiency equipment. The period of time need is use to give confidence to employees about the recommendation reliable or not.

3.7 Conclusion

To improve the power factor of energy consumption, the capacitor bank was installed at main switch board (MSB) at UMP Library. The relamping of lighting system has also discussed with exchange the magnetic ballast to electronics ballast to get the energy efficient of lighting at UMP Library.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter will explain about the result and analysis of the project. This chapter also explains the theory that adapted into the project. The analysis includes the measurement at actual value and also using elog 2004 software to the result.

4.2 Comparison Study of Energy Consumption at UMP Library

For further analysis of the result obtained, a comparison study of energy consumption before and after the installation of capacitor bank in the library MSB is discussed in detail. The results discussed in this paper will only focused on phase a (phase red) which connected to Channel 2 of the data logger. Since the system is balance under steady state condition, the results for phase b (phase yellow) and phase c (phase blue) indicate almost the same reading for voltage, current, power factor and power (S, P, Q) magnitude but in different angle of 120° between each phases.

4.2.1 Voltage Supply

The voltage supply came from TNB feeder is three phase (415V) with voltage fluctuation within 0.95 per-unit to 1.05 per-unit. The voltage of existing system and improved system (after reactive power correction) are shown in Figure 4.1 and Figure 4.2 respectively. The results for both existing and improved systems show that the voltage for phase b is almost 240V. For three phase system, the voltage is almost 415V under steady-state condition.

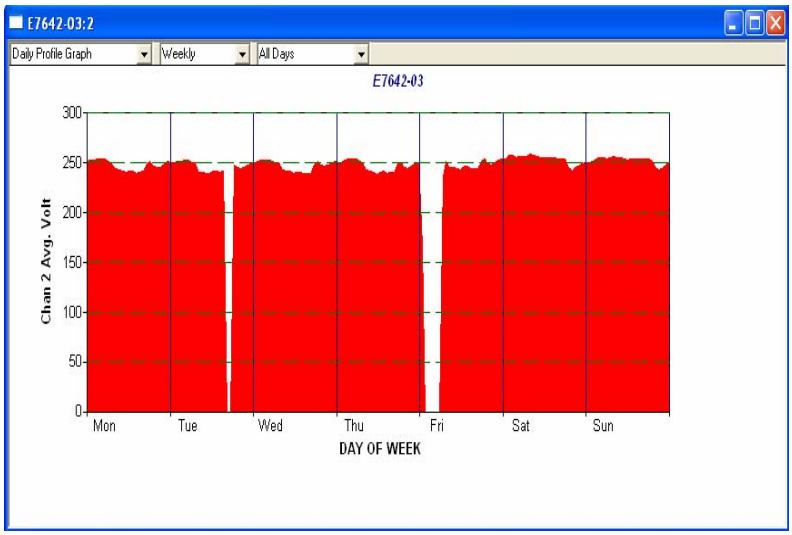


Figure 4.1 Average voltage for phase B (existing system).

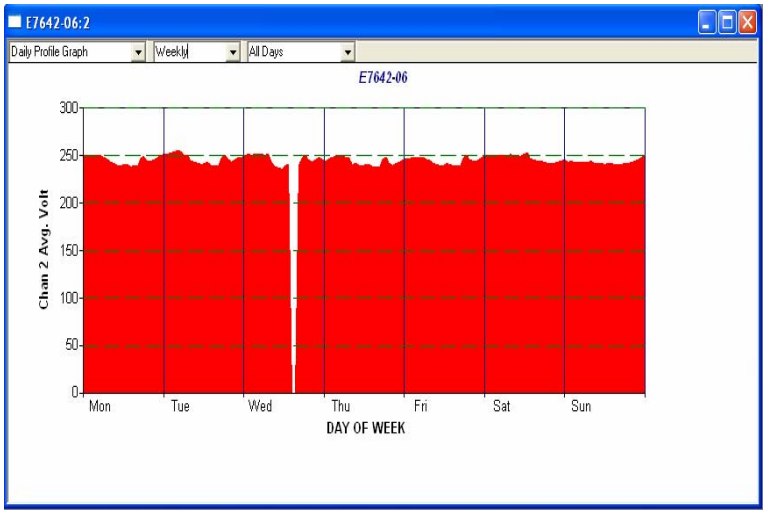


Figure 4.2 Average voltage for phase B (improved system).

4.2.2 Current consumption

The result of current consumption for existing and improved system is shown in Figure 4.3 and Figure 4.4 respectively. The maximum current logged at phase a before installation of capacitor bank is 147.83A. After power factor correction, the maximum current at phase a decrease to 124.00A. Low current consumption will reduce energy losses since energy losses is equivalent to I^2Z.

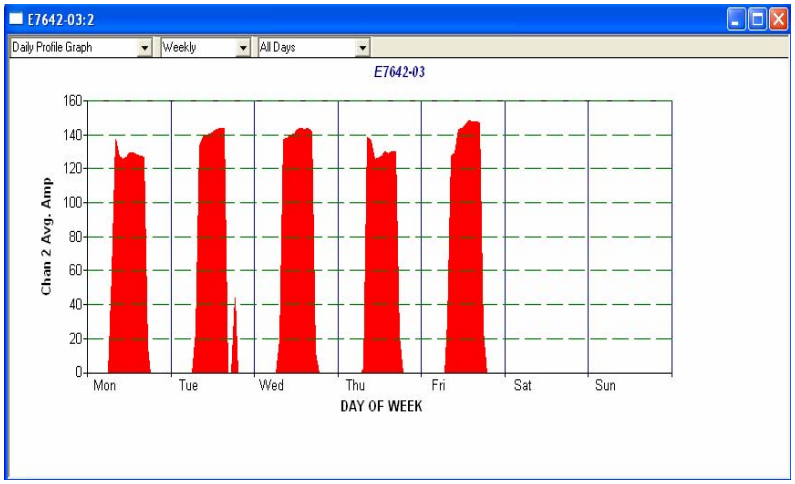


Figure 4.3 Current consumption for existing system.

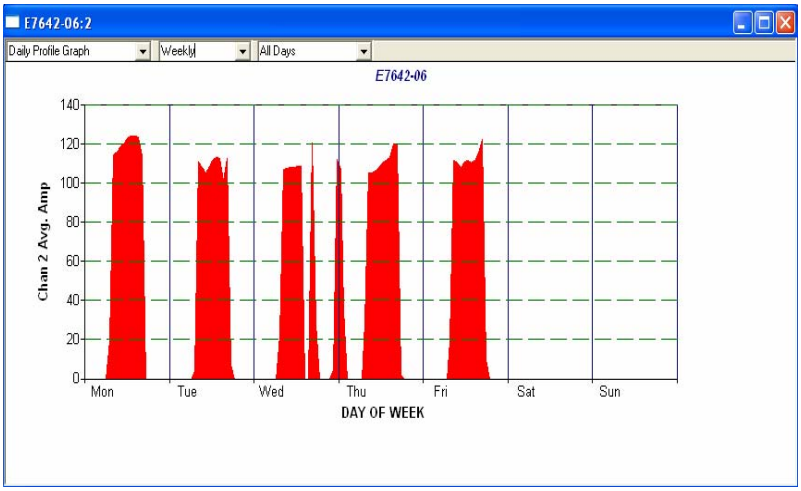


Figure 4.4: Current consumption of improved system.

4.2.3 Power factor

The result for power factor measurement is given in Figure 4.5 and Figure 4.6 for existing and proposed system respectively. The average power factor for existing system shown in Figure 4.5 was found to be 0.7 during office hour which is from 8a.m to 6p.m. During non-operating hour (from 6p.m to 8a.m) and public holiday the power factor increased to unity since no load is used. The low power factor during operating hour is due to high inductive load since most of the ac equipments in the library use induction motor which produce magnetic current and causes the current to lag the voltage.

This scenario will become worst during semester season since the library operating hour is longer while the electrical equipments run throughout the day until 11p.m at night which will increase the energy losses. The power factor needs to be improved by installing the capacitor bank in parallel with the main supply since the lowest power factor allowed by the utility (TNB) is 0.85.

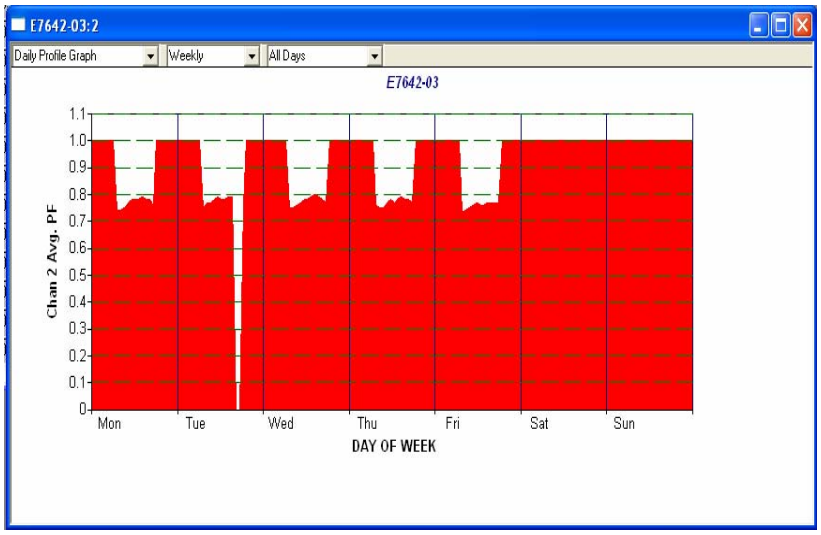


Figure 4.5 Power factor for existing system.

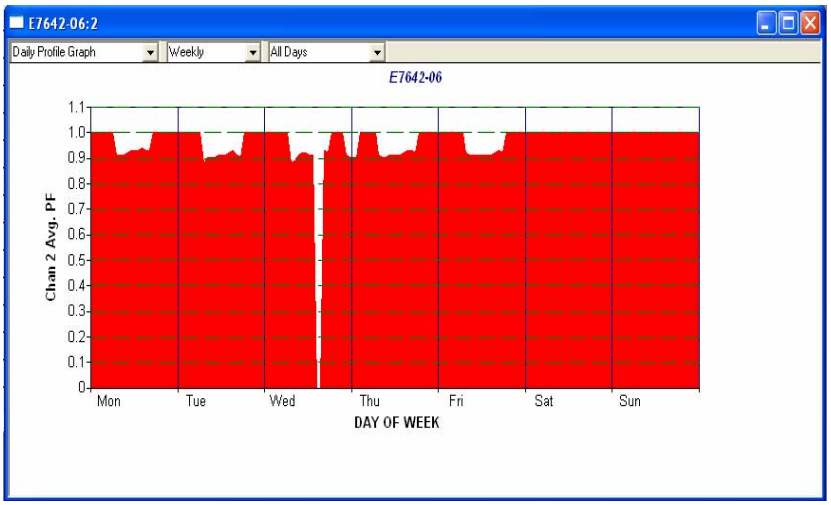


Figure 4.6 Power factor of improved system.

The average power factor during library operating hour after the installation of capacitor bank as shown in Figure 4.6 has been corrected to 0.9. This result shows that almost all the energy is used actively hence reduce energy losses as well as current consumption and voltage drop. The capacitor acts as a VAR generator, supplying magnetizing current for induction machines and reducing the reactive power requirement.

As a result, apparent power supplied by the utility will decrease, while the ratio of real power to apparent power, or power factor, increases toward unity. Improving the power factor will reduce both apparent and reactive power consumption. By reducing the apparent power, the capacity for generating, transmitting, and distributing real power will increase and the energy is efficiently used since the losses is reduces.

4.2.4 Apparent power (KVA)

Figure 4.7 and Figure 4.8 shows the KVA consumption for existing system and improved system respectively. Referring to Figure 4.7, the maximum KVA consumed during the seven day period is 36.374kVA. The maximum KVA has

reside to 29.609KVA after the capacitor bank installation which is depicted in Figure 4.8. This reduction means that the KVA has been reduced by approximately 16%.

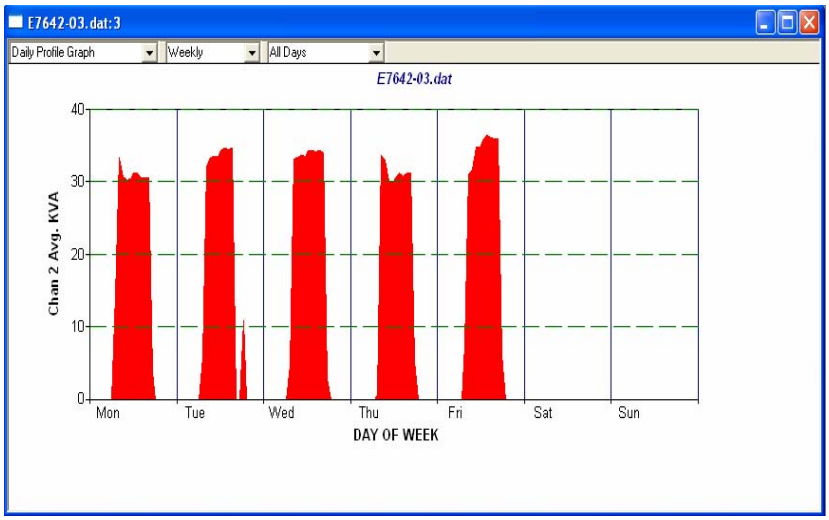


Figure 4.7 KVA consumption for existing system.

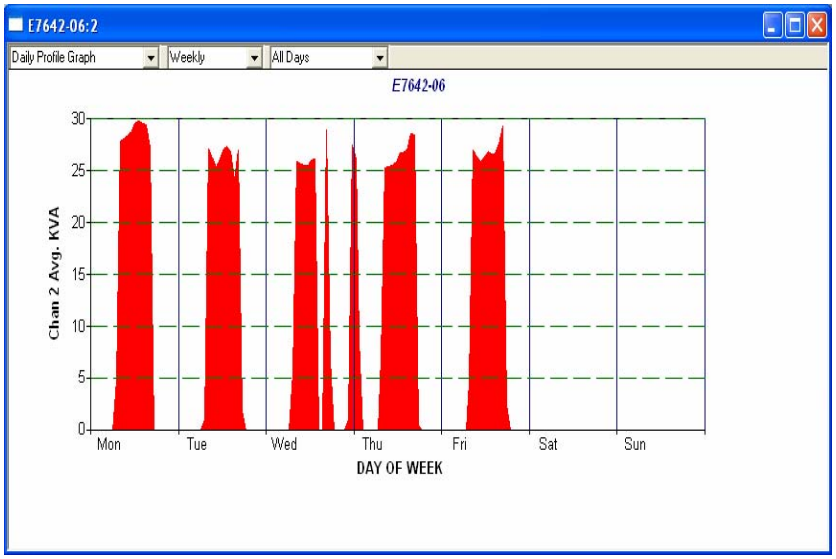


Figure 4.8 KVA consumption of improved system.

4.2.5 Real power (KW)

Figure 4.9 and Figure 4.10 shows the KW consumption for existing system and improved system respectively. Referring to Figure 4.9, the maximum KW consumed during the seven day period is 27.858 KW. The maximum KW has reside to 27.61 KW after the capacitor bank installation which is depicted in Figure 4.10. This reduction means that the KW has been reduced by approximately 1%.

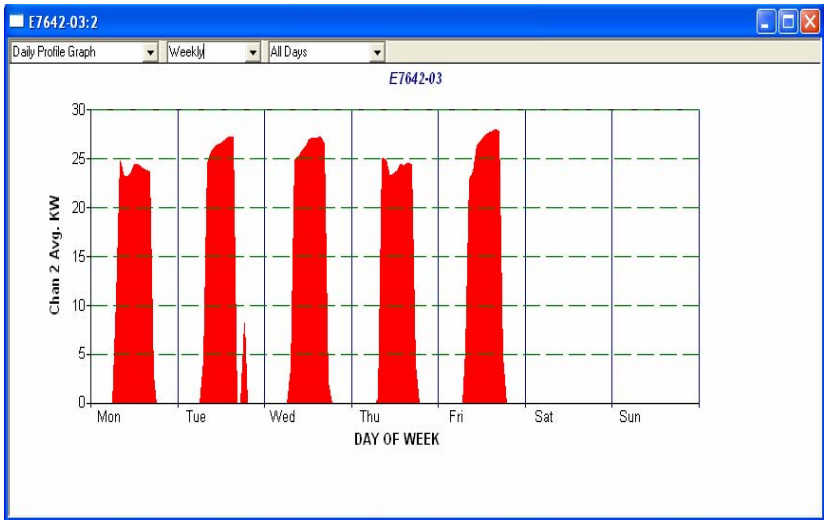


Figure 4.9 KW consumption for existing system.

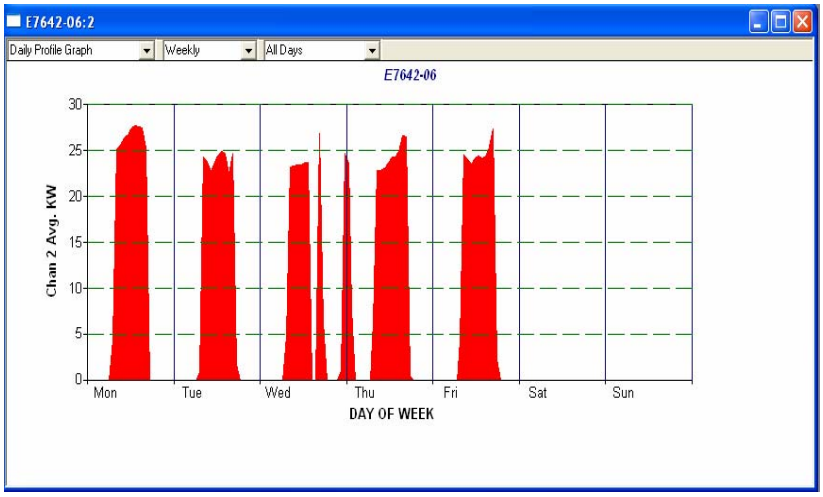


Figure 4.10 KW consumption of improved system.

4.2.6 Reactive power (KVar)

Figure 4.11 and Figure 4.12 shows the KVar consumption for existing system and improved system respectively. Referring to Figure 4.11, the maximum KVar consumed during the seven day period is 23.698 KVar. The maximum KVar has reside to 12.062 KVar after the capacitor bank installation which is depicted in Figure 4.12. This reduction means that the KVar has been reduced by approximately 49%.

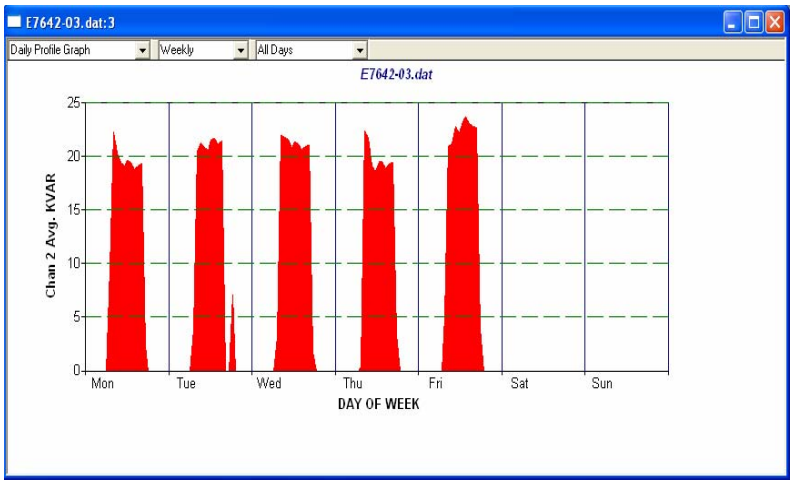


Figure 4.11 KVar consumption for existing system.

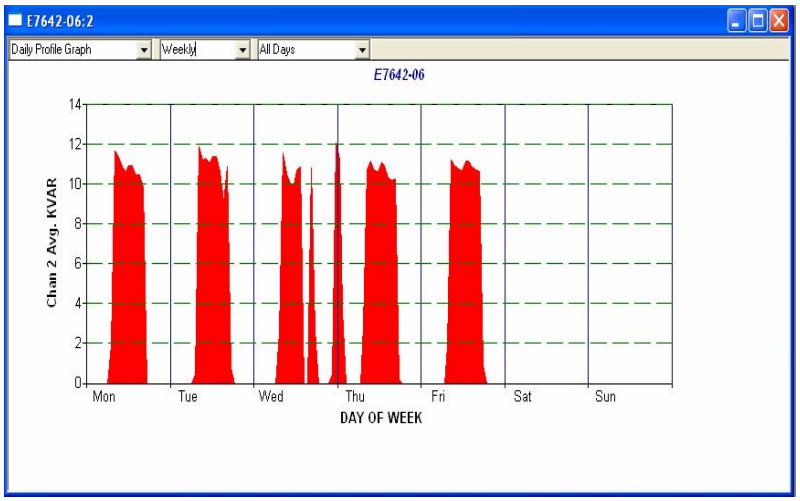


Figure 4.12 KVar consumption of improved system.

4.2.7 Summary of parameter measured

Table 4.1: Summary of differential between existing and improvement system.

Parameter	Without capacitor bank	With capacitor bank	Different
Voltage (V)	258.1	254.5	3.6V
Current (A)	147.83	124.00	23.83A
Kilowatt (kW)	27.858	27.610	0.248kW
PF	0.73	0.88	0.15pf
KVA	36.374	29.689	6.685kVA
KVAR	23.698	12.062	11.636Kvar
kWh	3621	3532	89kWh
kVAh	4745	3915	830kVAh
kVARh	3057	1675	1382kVARh

4.3 Power Factor Analysis

4.3.1 Installation and cost analysis

The kVAR capacitor bank that is installed in main switch board requires a correct calculation. The data of energy audit of existing system is needed in order to determine the value of capacitor bank per phase. From the analysis, the maximum demand for 0.7 power factor is 27.86Watt per phase with apparent power (S) 36.374kVA. The value of kVAR for existing system can be calculated based from power triangle. The kVar for existing system is 23.38kVAR. To bring power factor to 0.9, the new apparent power will be calculated using the formula given.

$$S = \frac{P}{\cos\theta} \tag{4.1}$$

Cos φ is power factor. The new apparent power per phase and calculated reactive power is 30.96kVA and 13.50kVar respectively. The value of kVar must be installed per phase is calculated by using Equation 4.2.

$$Q_{capacitor\ bank} = Q_{existing\ system} - Q_{proposed\ system} \tag{4.2}$$

From the result in Table 4.1;

Max demand, kW (P)	= 27.86 watt
Power factor	= 0.73
kVA (S)	= 36.374 kVA
kVar at pf 0.7	= $\sqrt{(36.374)^2 - (27.86)^2}$
	= 23.38kVar
To bring pf to 0.9,	
kVA	= P / pf
	= 27.86 / 0.9
	= 30.96kVA
At pf 0.9,	
kVar	= $\sqrt{S^2 - P^2}$
	= $\sqrt{(30.96)^2 - (27.86)^2}$
	= 13.50
So that, kVar capacitor	= $Q_{existing\ system} - Q_{improvement\ system}$
that must be installed/phase	= (23.38 - 13.50)
	= **9.88kVar**

Therefore, the reactive power need to be injected in the system per phase is 9.88kVar. Based from the calculation, the capacity of capacitor bank per phase that installed at the library MSB is 10kVar. The detail analysis is shown in Table 4.2.

Table 4.2: Improved systems with power factor correction for UMP Library main switch board (MSB)

Data	Existing system	Power factor correction	Improved system
Power factor	0.7	0.2	0.9
Reactive power, Q	23.38kVar	10kVar	13.50kVar
Apparent power, S	36.374kVA	-	30.96Kva
Real power, P	27.86Kw	-	27.61Kw

4.3.2 Power Factor Recommendation

The following energy savings has been calculated after the installation of capacitor bank at the library MSB.

Time use = 11 hours per day
Working days = 300 days per year
Time Usage per year = 3300

Maximum Demand = 1.732 X 0.9 X (Measured Apparent Power – Corrected Apparent Power)
= 1.732 X 0.9 X (36.374 – 30.96)
= 8.44kW

Cost Maximum Demand = Maximum Demand X MD Tariff X 12 month
= 8.44kW X RM 24.60 X 12
= RM 2491.49 / year

Total Usage (kWh) = 1.732 X 0.9 X (Measured Apparent Power – Corrected Apparent Power) X (time usage per year)
= 1.732 X 0.9 X (36.374 – 30.96) X 3300
= 27849.83kWh / year

Cost Energy Saving (RM) = Total Usage X Tariff TNB (cost 1 unit kWh)
= 27849.83kWh/year X RM 0.408
= RM 11362.73

So, total energy saving = Cost Energy Saving + Cost Maximum Demand
or replacement = RM (11362.73 + 2491.49)
= **RM 13854.22 / year**

Now, this calculation presents the analysis of power factor improvement from 0.73 to 0.90, which can save up to RM 13854.22 per year. This analysis show the requirement reactive power correction is 10kVAr.

4.3.3 Simple Payback Period (SPP)

The total cost of capacitor bank and installation is RM7500. The simple payback period for the implementation of capacitor bank is calculated by using Equation 4.3.

$$\text{Simple payback period, SPP} = \frac{\text{Investment(RM)}}{\text{Saving(RM/years)}} \tag{4.3}$$

= RM 7500 / (RM 13854.22 / year)
= 0.54 year
= **6 month 14 days**

From the observation, it shows that the payback period of installing the correction power about 6 month, which is less than one year. By improving the power factor correction, the total monthly cost could be cut down. This will definitely save much money and return period will be shorter since the new electricity tariff rate is introduced by TNB starting by August 2008.

The power factor desired will decrease depend of the operation. Even though it is recommended to install the correction power but the desired power factor are not durable and need to maintain in some period of time.

4.3.4 Discussion on Power Factor Correction in UMP Library building.

Developing a successful and effective energy efficiency program need an absolute understanding of present energy usage, facilities and equipment performances. This means that preliminary studies in the field of energy consuming in building and systems must be done first in order to obtain strategies and get the correct approach to implement energy efficiency program in UMP. This project is aimed to increased energy efficiency and reduces electricity energy losses by improving the power factor of the main supply in UMP building.

Based upon the data collected and result analysis, it is evidently that the total apparent power consumption at the library is reduced by approximately 19%. From the analysis, the return investment of installing the capacitor bank is found to be about 0.64 years, which is considered as a good achievement. It is believed that energy audit is one of the most comprehensive methods in achieving energy savings in buildings and thus reducing excessive energy consumption.

4.4 Lighting Retrofit

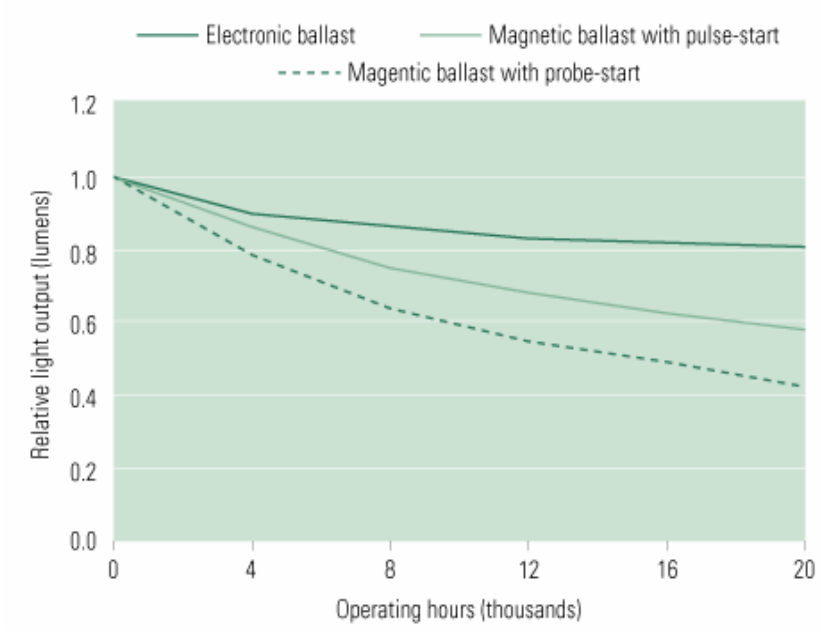
4.4.1 Relamping Fluorescent Lamp.

At UMP Library, the lighting system is use the magnetic ballast fluorescent lamp. The magnetic ballast is low efficient better electronic ballast. People nowadays are use the electronic ballast to reduce the current consumption because the electronic ballast can save energy compare the magnetic ballast.

Electronic ballasts have a number of other advantages over magnetic ballasts. Electronic high-frequency ballasts increase lamp-ballast efficacy, leading to increased energy efficiency and lower operating costs. Electronic ballasts operate lamps using electronic switching power supply circuits. In US, the electronic ballasts take incoming 60 Hz power (120 or 277 volts) and convert it to high-frequency AC (usually 20 to 40 kHz).

Electronic ballasts are more efficient than magnetic ballasts in converting input power to the proper lamp power, and their operating of fluorescent lamps at higher frequencies reduces end losses, resulting in an overall lamp-ballast system efficacy increase of 15% to 20%.

The light output of lamps driven by electronic ballasts also degrades more slowly over time, resulting in greater light output at the mean and end of the lamp's life (see Figure 4.13). This in turn enables systems with electronic ballasts to use fewer fixtures, or lower-wattage lamps, to provide the same output as systems with magnetic ballasts.



Source: E Source; data from Advance Transformer.

Figure 4.13 Electronic ballasts improve lumen maintenance.

Lamp output degrades more slowly with electronic ballasts than with magnetic ballasts. Output declines more rapidly on probe-start metal halide lamps operating on magnetic ballasts [14].

4.4.2 Observation / Perspective

This is a surprisingly complex issue with little good study data. Variations in electric rates, lighting equipment and labor cost, as well as advances in lighting technology have made previous rules of thumb on this issue in need of reevaluation. From the observation in UMP Library, there are three types lamp that most used.

i) Fluorescent Tube (Philips) 36W [Study and Office Area]
ii) Fluorescent Tube (Philips) 18W [Toilet]
iii) Downlight

The lighting properties and office luminaries at UMP Library can be see in Appendix 2, while the picture of lighting arranging in UMP Library can be see in the figure below.

Figure 4.14 Lighting arranging at private site study.

Figure 4.15 Lighting arranging at discussion area.

Figure 4.16 Lamp arranging at rack reference books.

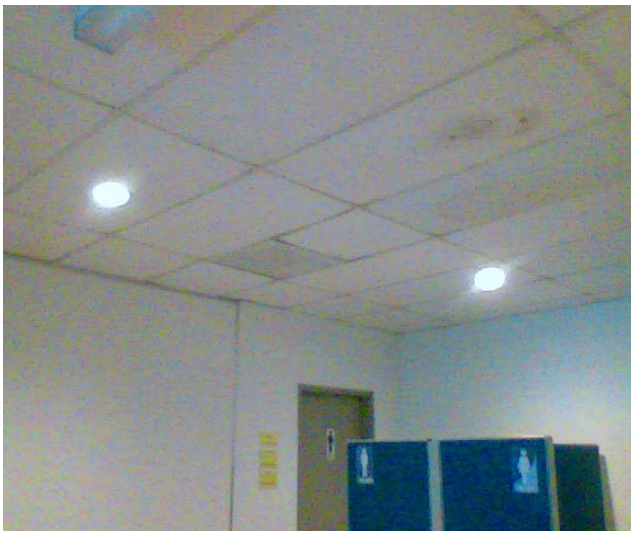


Figure 4.17 Downlight at UMP Library.

All calculation is derived from the same goals. The first goal is to define the existing conditions and the second goal is to define the proposed conditions. The following information must be gathered or guessed in order to arrive at an answer to the questions of economics.

Define the existing condition:

i) Fixture watts before retrofit.
ii) Quantity of fixtures.
iii) Hours of operation (burn time)

Define the proposed condition and economics

iv) Fixture watts before retrofit.
v) Hours of operation (burn time)
vi) Cost of retrofit.
vii) Incremental cost of electricity per kWh.
viii) Incremental cost of electricity per kW, demand.

4.4.3 Lighting Retrofitting Scheme Recommendation

From the observation, all the lighting property was under efficient equipment. The estimation and analysis for proposed and existing equipment has been developed by visual basic 6.0. The manual calculation and the formula are state below:

KW Saved = {[(Exist Quantity) X (Exist Watt)] - [(Propose Quantity) X (Propose Watts)]} / 1000 (4.4)

kWh Saved = {[(Exist Quantity) X (Exist Watt) X (Exist Hour)] - [(Propose Quantity) X (Propose Watt) X (Propose Hour)]}/1000 (4.5)

kWh Saving in (RM) = kWh Saved X Incremental $ / kWh (4.6)

Total Savings = kWh RM Saved + kW RM Saved (4.7)

Total per Fixture = (Material + Labor) X (1 + Contingency) (4.8)

Total Estimated Installed Cost = Total RM / Fixture X Proposed Quantity (4.9)

4.4.4 Simulation (Visual Basic 6.0)

This software gives the energy calculation for demand (kW) and total usage (kWh). Saving analysis will be given after the users fill the value of material cost, labor cost and contingency. Payback period also been given in last part of the software. All the command has been attach in the Appendix 4.

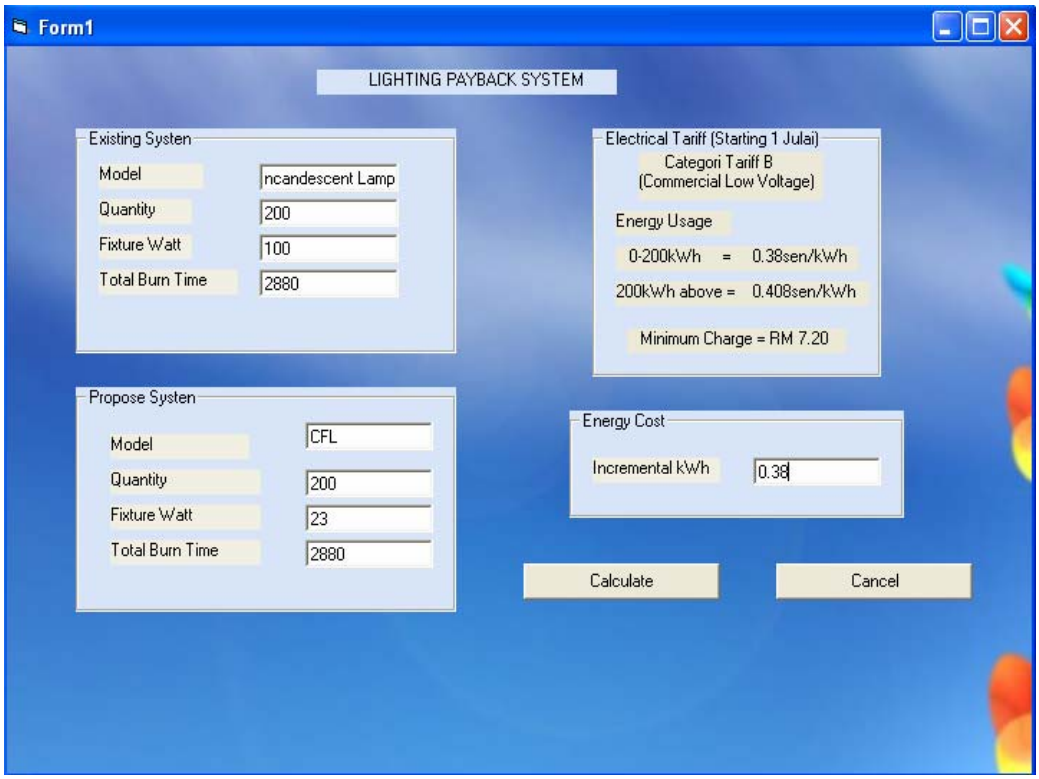


Figure 4.18 Simulation for exist and proposed new lighting equipment.

This layout is to compare and determine the existing lamp (incandescent lamp) and the proposed system (compact fluorescent lamp, CFL). This layout has been built up with software (Visual Basic). The incremental kW is the demand, and the incremental kWh is the total usage. In Malaysia, starting 1 July of 2008, the kW (unit of maximum demand) for the Tariff B is cost RM 24.60 and the kWh (total usage) is cost RM 0.38 for first 200kWh and RM 0.408 for another hours.

The maximum demand were measured at fully building in section B include PPA (*Pusat Perkhidmatan Akademik*) UMP, Treasurer Department, UMP Library, JHEPA (*Jabatan Hal Ehwal Pelajar*) UMP and UKP (*Unit Kesihatan Pelaj*ar) UMP.

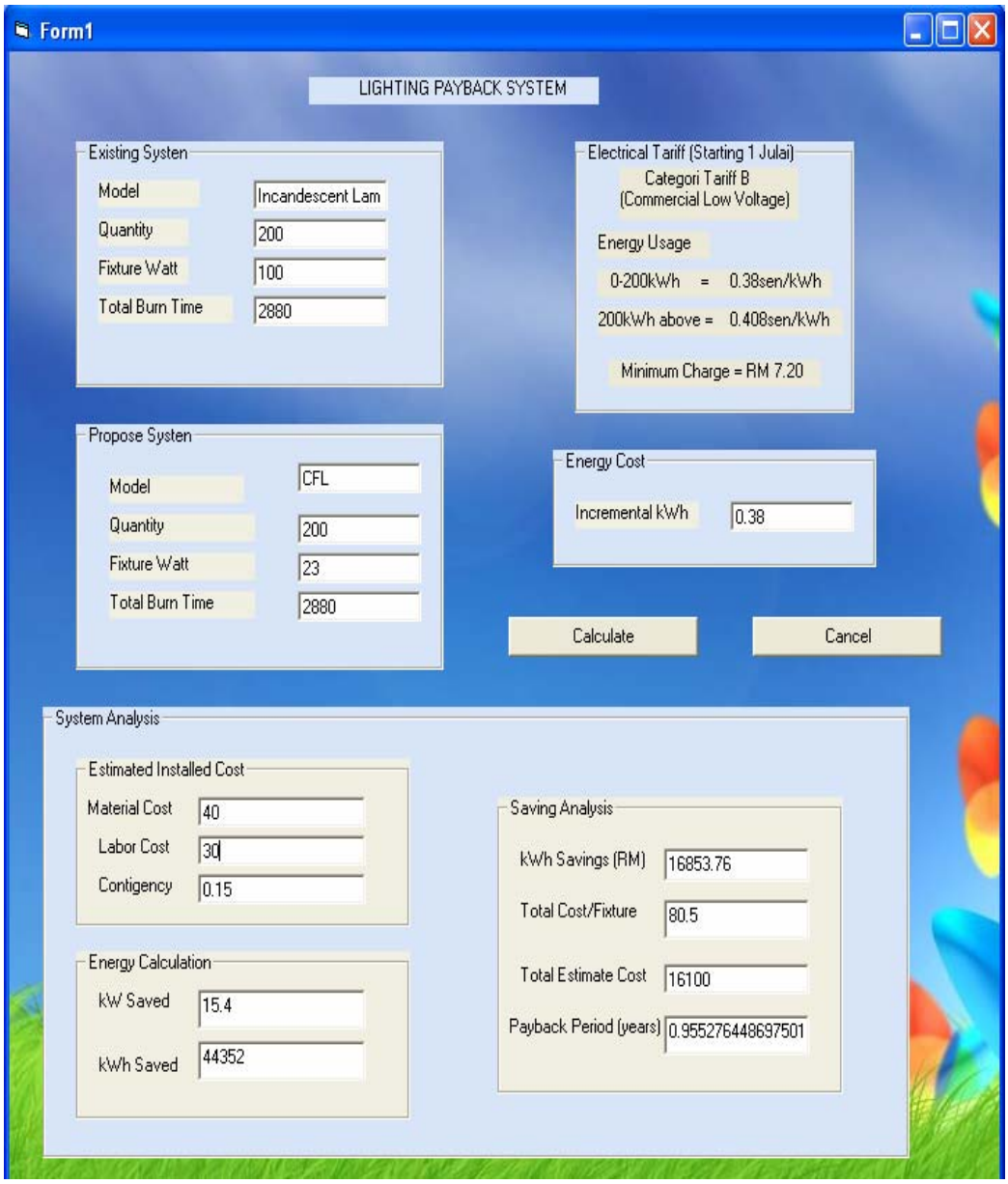


Figure 4.19 Result of the analysis between existing and proposed system.

4.4.5 Discussion on Lighting Retrofit.

Electronic ballasts for HID light sources offer various benefits over magnetic ballasts: greater efficiency, greater light and color stability, lower lumen

depreciation, better dimming options, faster warm-up and restrike times, less noise, elimination of flicker, and longer lamp life. However, they do carry a higher cost. To determine if electronic ballasts are a cost-effective solution, conduct a cost analysis that considers these five ballast/lamp parameters: ballast power, lumen maintenance (a measure of lamp light depreciation over time), lamp life, and end-of-life output. Other factors include the operational hours in a year, the cost of electricity, and the cost of the ballasts.

Systems with electronic ballasts currently cost significantly more than those with magnetic ballasts. However, energy savings can lead to a reasonable payback, depending on the application.

Table 4.3: Cost comparison electronic versus magnetic ballasts.

	Pulse-start lamp with magnetic ballast	Pulse-start lamp with electronic ballast
Lamp power (watts)	400	400
Ballast power (watts)	60	15
Initial output (lumens)	43,000	43,000
Lumen maintenance	0.65	0.70
End-of-life output (lumens)	27,950	30,100
Number of fixtures	100	93
Total output (lumens)	2,795,000	2,799,300
Annual operating time (hours)	6,000	6,000
Annual cost of electricity [a] ($)	22,080	18,526
Annual savings ($)	NA	3,554
Equipment cost/fixture ($)	135	335
Total equipment cost ($)	13,500	31,155
Cost difference ($)	NA	17,655
Simple payback (years)	NA	5

Notes: NA = not applicable.
a. Assumes energy cost of $0.08 per kilowatt-hour.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main purpose of this project is to save the consumption of electrical energy. The complete energy conservation technique and example for efficient operation has been reviewed in the literature review. The methodology of energy efficiency has been shown in chapter 3 was used to fulfill this final year project.

In chapter 4, it shows that the energy saving on the selected building load has also provided cost saving by implementing the recommended energy conservation techniques for the building loads. The comparison of energy saving tabulation between existing and propose technique has been derived. Simple payback periods have been show under all analysis for each topic. The simulation for lighting retrofitting and power factor improvement analysis has also been developed.

5.2 Future Recommendation.

The good management in operation system like an installation the capacitor bank and relamping the lighting system has better opportunity to save the budget for economic reason. The electric energy must be managed for efficient use not only for economic reason but also for reducing the pollutant. By implementing the saving technique, it brings the system more efficient.

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