VARIABLE SPEED DRIVES AS ENERGY EFFICIENT STRATEGY IN PULP AND PAPER INDUSTRY

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DEDICATION

For my beloved mum,
my sister and my brother for their love and
encouragement.

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Bismillah-Hir Rahman-Nir-Rahim

Praise to Allah, Lord of the Universe, a praise that befits His might and suffices His Grace, Peace and blessing be upon His generous Messenger, His family and companions, for giving me the strength to complete this thesis.

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ABSTRACT

The industrial sector is the largest consumer of energy in Malaysia, matched by the transport sector. Like many developing countries, the industrial sector contributes significantly to the national growth, and this economic growth drives the high growth in energy demand. Therefore, the increase in energy cost recently has created a situation where it has become essential to develop alternative energy technologies as well as improve efficiency. In this case, energy efficiency means reducing environmental degradation and increasing sustainability as well as cost savings. This thesis focuses on the economic benefits that can be obtained by replacing mechanical flow control of pumps and fans with variable speed drive in industrial sector in Malaysia. Firstly, the different topologies of variable speed drive i.e. the rectifier topologies as well as the control of invertors with Pulse Width Modulation is discussed. In this project, case studies taken from the energy audit data is also reported. These case studies explain the economic benefits of variable speed drive on pumps in the pulp and pump industries. Based on the load profile before and after the installations, energy savings up to 21% can be obtained.

ABSTRAK

Sektor industri merupakan pengguna tenaga yang utama di Malaysia seiring dengan sektor pengangkutan. Seperti di negara-negara membangun yang lain, sektor industri menyumbang kepada pembangunan nasional dan ekonomi. Justeru itu, berlakunya peningkatan dalam jumlah penggunaan tenaga. Oleh itu, peningkatan dalam kos tenaga baru-baru ini telah memberi peluang untuk memperkenalkan teknologi baru untuk penjimatan tenaga. Cekap tenaga tidak hanya merujuk kepada pengurangan kepada pencemaran udara dan peningkatan daya tahan negara tetapi ia juga merujuk kepada penjimatan dalam kos tenaga yang digunakan. Tesis ini memberi fokus kepada faedah ekonomi yang boleh diperolehi dengan menggantikan sistem kawalan mekanikal yang menggunakan injap untuk mengawal pengaliran oleh pam dan kipas kepada sistem pemacu pelbagai halaju di dalam sektor industri di Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Malaysian Energy Scenario

Worldwide energy demand is projected to grow by over 50 percent in the next 20 years[1]. This trend is stimulated by the dynamics of current technological development. In the Asia Pacific region, rapid expansion has led to a large growth in demand for electricity. The Asia Pacific Energy Research Centre, (APERC) has forecasted that Southeast Asia itself will experience the fastest growth in electricity demand with an average of 7.8 percent per annum. Growth in electricity demand far outstrips the demand for other types of energy.

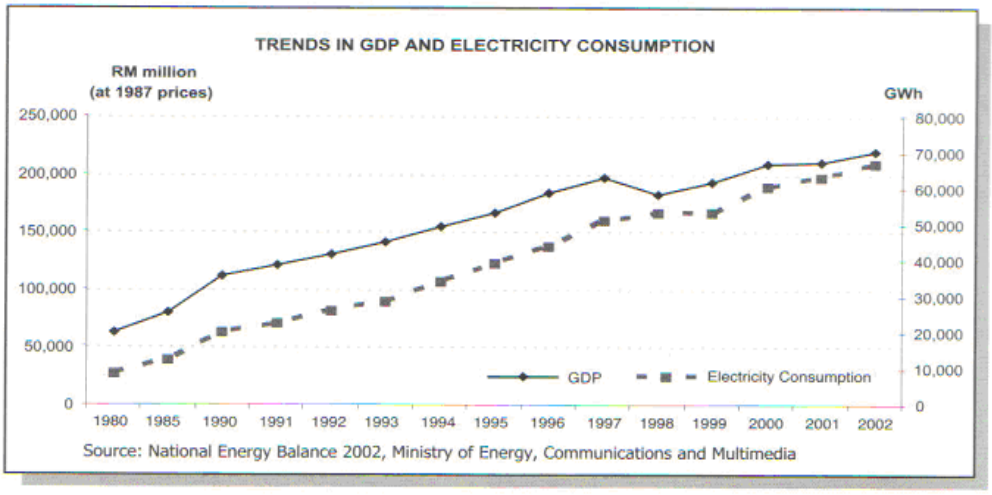

Figure 1.1 Trends in GDP and Electricity Consumption

[1] Centre for Strategic and International Studies (CSIS,1999)

1.1.1 Electricity Demand Trend

In Malaysia, the demand for electricity in 1980 was 8,682 GWh but in 2000 the demand for electricity rose sharply to 67,531 GWh (NEB 2002). This shows a growth rate of 9.8 percent per annum. Meanwhile, the Gross Domestic Product (GDP) growth rate for the same period expands at an annual average of 5.9 percent .By observing the growth rate for both electricity demand and GDP for Malaysia from 1980 to 2002, it can be easily deduced that the yearly growth rate for electricity consistently exceeds the yearly GDP growth.

During the early period of observation, it can be seen that the growth increases sharply each year. When Malaysia gained Independence in 1957, the country inherited a commodity based economy largely relying on rubber and tin. In the early 1980s, the former Prime Minister, Tun Dr Mahathir introduced the Look East Policy which uses Japan as a model for shifting the Malaysian economy from agricultural to industrial. The policy in essence pushed for heavy industries with several key projects including the national car project, iron and steel billets, boosting the refinery and petrochemicals industry, cement as well as pulp and paper industries. Obviously, each of the heavy industry requires a large amount of electrical energy in order to operate. As a result, this major push was the essential factor to the steep increase in demand for energy, particularly electricity in the early 1980s.

From the 1980s through to the mid 1990s, Malaysia experienced a diversified economy with sustained growth. The pattern of transformation for the Malaysian economy can be deduced the GDP contribution from each economic sector. The manufacturing sector, for example, grew from a mere 13.9 percent of the GDP to 30 percent in 2002.

1.1.2 Energy Intensity

When an economy grows, productivity improves for all inputs and the total amount of energy per unit GDP declines. This is the reason that there is an overall decline in energy intensity over time. Initially, as a country develops, the share of commercial energy increases at the expense of non-commercial energy, because the economic inputs, mostly labour and energy, are cheaper in the developing countries than in the developed countries. This will lead to an increase in commercial energy intensity before it flattens out. Eventually, once the economy matures, this intensity declines.

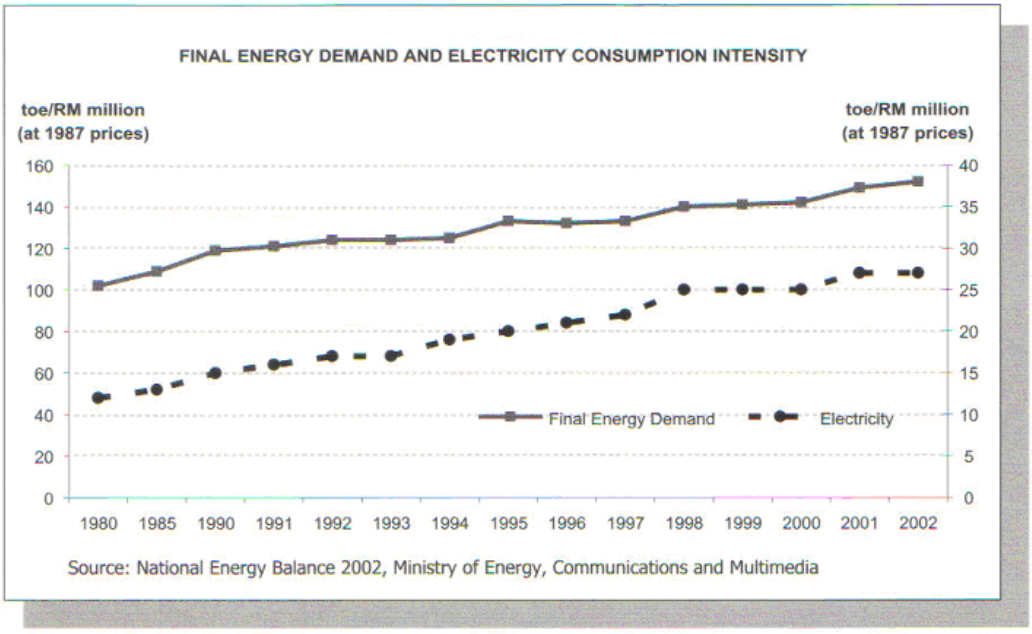

Figure 1.2 Final Energy Demand and Electricity Consumption Intensity

In Malaysia, as shown in Figure 1.2, the GDP intensity of energy demand increased from 102 tonnes of oil equivalent (toe)/RM million in 1980 to 152 toe/RM million in 2002. At the same time, the electricity intensity was seen to increase from 12 toe/RM in 1980 to 27 toe/RM in 2002, indicating an annual average growth rate of 3.8 percent. This should not be interpreted as evidence of decreasing technical efficiency in production, but more likely as a result of the shift in economic activity from labour-intensive to energy- and capital-intensive industries.

Furthermore, with the population rise and continuous improvement of living standards, an ongoing increase in energy consumption is unavoidable. The energy demand trend in Malaysia is predicted to grow continually until the Malaysia reaches the developed country status. Then, once the economy matures, it is foreseen that energy demand intensity will start to decline.

Hence, it is only natural that the Malaysian Government now considers the efficient and productive use of electricity as a key element in its planning for a sustainable national energy system. The choice stems from the desire to meet the efficient utilization and environment objectives of the National Energy Policy (NEP). In 1994, a number of studies were conducted by the Malaysian Government with technical assistance from the Asian Development Bank (ADB) to examine energy consumption patterns, the technologies used and the energy savings potential, particularly in the industrial sector. The studies have shown energy savings potential varying from 10% to 50%.

1.2 Problem Statement

In the industrial sector, motors consume a significant part of electrical energy. Electrical motors consume around 56% of the total consumed electrical energy and the induction motors alone accounts for 96%. [8] By concentrating solely on induction motors, the research further focuses on pumps, ventilators and air-compressors.

In many installations today, the pumps application are driven by a constant speed motor, and the output of the process is controlled by mechanical means, causing massive waste of energy. Fortunately, this application can be speed controlled and thus loss of energy can be reduced dramatically. [3]

Traditionally, the induction motor was operated directly from the grid, with almost constant shaft speed. With the development of power electronic converter in the

early seventies, induction motors could now be controlled by variable speed drives (VSD). This basically means that by inserting a converter between the motor and the electrical grid, it is possible to obtain a variable speed motor drive. Since the motor applications accounts for a large proportion of electrical energy consumption, VSD would contribute considerably in reducing energy consumption.

In conclusion, this thesis will focus on the area with the highest potential for energy reduction from the implementation of variable speed drive (VSD). Moreover, it will also concentrate on the amount of energy that could be saved through speed control applications and the economic benefits of the exercise.

1.3 Objectives

The objectives of this thesis are:

- To study and analyse the potential of implementing the energy efficiency measures in this case the variable speed drives in Malaysian Pulp and Paper Industries.
- To study a case on a sample of Pulp and Paper Industries

The raw data from energy audits conducted by Pusat Tenaga Malaysia, (PTM) were used in the case study to identify the potential of implementing energy efficiency options in terms statistical and engineering analysis methods.

1.4 Expected Benefits

These results obtained from this research would be used as a general guideline to similar industries when implementing energy efficiency (EE) measures. These measures can be executed by the industries based on their specific technical and economical preference.

The latest technology applied in variable speed drives (VSD) has also been selected and highlighted in this report. Although VSD technology is pretty recent, studies show that it can significantly reduce the amount of energy used to provide mass quantity of the end product. [3] Hence, the industries have the option of foregoing detailed investigations into VSD technology but instead focus their efforts towards energy efficiency through financial planning and investment strategy.

Furthermore, the general methodology suggested for VSD analysis in the later chapters of this report could be used as a broad guideline in determining an analysis scheme for implementation in the Malaysian Industries. The methodology provides the best tools for statistical, engineering and financial analysis. Analysis is extremely important in selecting the best EE option that fulfils the benefits and cost requirements.

For successful implementation of a new technology in industrial sector in Malaysia, it is recommended that EE plans includes tax incentives from government and financial support from international and local organization such as Malaysian Industrial Development Authority (MIDA), United Nation Industrial Development Organization (UNIDO), Ministry of Energy, Communication and Multimedia, Malaysia (KTKM), and local banks plans.

1.5 Thesis Outline

This report comprises of 7 chapters. Chapter 1 discusses the energy scenario in Malaysia as well as the electricity demand trend. The research objectives to be attained are also stated.

Chapter 2 goes on to discuss in detail the trend of energy efficiency in Malaysia, as well as the energy consumption in industrial sectors and the introduction to the energy audits

In Chapter 3, the theory of variable speed drive technology is explained. It describes the advantages and typical application of variable speed. Finally, the energy savings in the application

Chapter 4 describes the parameters for analysis and also the methods for analysis. The development of the Variable Speed Drive Potential Calculator is also explained. In Chapter 5, the energy scenario in pulp and paper industry is discusses.

Chapter 6 presents the results and analysis. Finally, Chapter 7 will summarizes the results and discussions from previous chapters and go on to propose further steps in integrating variable speed drive systems into other industrial sectors of the Malaysian economy.

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