FORECASTING THE ENERGY DEMAND IN MALAYSIA USING GENETIC ALGORITHM

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I would like to thank my parents and sibling who always supported me by words and action and made this happen. Without their support and encouragement, none of this could happen. By dedicating this thesis to my family, I hope I can show only a small part of my gratitude to them.

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ABSTRACT

Energy is the building block of achieving sustainable socio-economic development and environmental goals of human development. Thus, each nation is keen on complete energy planning and management for the purpose of sustainable development. In Malaysia, statistics show that the energy consumption per capita from year 2000 as 1.26 ton of oil equivalent (toe)/person has increased steadily to 1.47 toe/person in 2010. One of the issues is establishing appropriate policy and managing the energy to support such a huge increase in energy demand. Two broad categories of energy management are supply-side and demand-side management. In recent decades, demand-side management has been on the focus for a number of reasons. One of the most important features of demand-side management is having a reliable outlook of the energy consumption in order to minimize the gap between the supply and demand of energy. In harmony with this need, the objectives of this study are to develop an energy demand model and forecast the entire energy demand of Malaysia. The model implements different macroeconomic indicators including gross domestic product (GDP), import and export statistics and population to estimate the total energy consumption in all sectors of Malaysia over a period of ten years. Through the review of literature and considering the current circumstances of the case study the most appropriate model and methodology to solve the problem is selected. The selected model is a causal regression model. The tool to solve this model is Genetic Algorithm (GA) and MATLAB software is used to develop and run the model. Finally, the results are compared with a similar study, a sensitivity analysis is done and it is discusses how the study has reached its objectives accordingly.

ABSTRAK

Tenaga merupakan asas pembentukan bagi mencapai pembangunan sosio-ekonomi dan alam sekitar yang mampan demi matlamat pembangunan manusia. Oleh itu, setiap negara berhasrat untuk menyempurnakan perancangan tenaga dan bidang pengurusan bagi tujuan pembangunan yang mampan. Di Malaysia, statistik telah menunjukkan bahawa penggunaan tenaga per kapita daripada 1.26 tan setara minyak / orang pada tahun 2000 telah meningkat dengan mantap kepada 1.47 tan setara minyak / orang pada tahun 2010. Salah satu isu adalah mewujudkan dasar yang bersesuaian dan menguruskan tenaga untuk menampung apa-apa peningkatan yang besar dalam permintaan tenaga. Terdapat dua jenis kategori yang dipakai secara meluas dalam bidang pengurusan tenaga iaitu, pengurusan berasaskan penawaran dan pengurusan bagi permintaan sampingan. Sejak kebelakangan ini, pengurusan berasaskan permintaan telah diberikan tumpuan demi beberapa sebab. Salah satu ciri yang paling penting bagi jenis pengurusan berasaskan permintaan adalah mempunyai prospek yang baik dalam penggunaan tenaga bagi mengurangkan jurang antara bekalan dan permintaan tenaga. Demi menampung keperluan secara harmoni, objektif kajian ini adalah untuk membangunkan sebuah model permintaan tenaga di samping meramal permintaan tenaga keseluruhan negara Malaysia. Model ini telah menggabungkan seberapa banyak penunjuk makroekonomi yang berlainan termasuk keluaran dalam negara kasar (KDNK), statistik import-eksport dan populasi untuk membuat anggaran bagi jumlah penggunaan tenaga yang meliputi semua sektor di negara Malaysia dalam tempoh sepuluh tahun. Suatu kajian kes model yang paling sesuai dan juga kaedah penyelesaian telah dipilih melalui kajian literatur dan pertimbangan semasa dengan teliti. Model yang dipilih adalah model regresi sebab dan akibat. Alat yang digunakan untuk membangunkan dan menjalankan model untuk menyelesaikan model ini adalah Algoritma Genetik (GA) dan perisian MATLAB. Akhir sekali, keputusannnya telah dibandingkan dengan kajian yang serupa dengan kajian model ini.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Energy is the building block of achieving sustainable socio-economic human development and environmental goals of human development. It also plays a key role in diminishing the poverty and increasing the standards of living. Widely, the per capita consumption of energy is typically employed as a gauge for measuring the economic development level in different countries.

Considering the ever-increasing demand of energy especially in developing nations, there has been a concern regarding the security and sustainability of the current generation and consumption rate and the profound effects of the consuming fossil fuels on the environment. Accordingly, recognizing the previous, present and future patterns of energy production and consumption is an integral part of meeting the final energy demand. In other words, to have a sustainable planning in energy production, there should be a high degree of knowledge in the past and current consumption rate and the outlook of energy demand. In order to understand the relationship between forecasting, planning and decision-making, see Figure 1.1.

The energy system covers both supply side and demand side operations. In the past decades when price energy was not expensive, supply sector was on the focus. Thus, the energy system was responsible for generating adequate supply to satisfy given demand. It was considered that supply sector is easily managed and influenced

(one reason perhaps was lower number of operations and actors engaged) than demand sector.

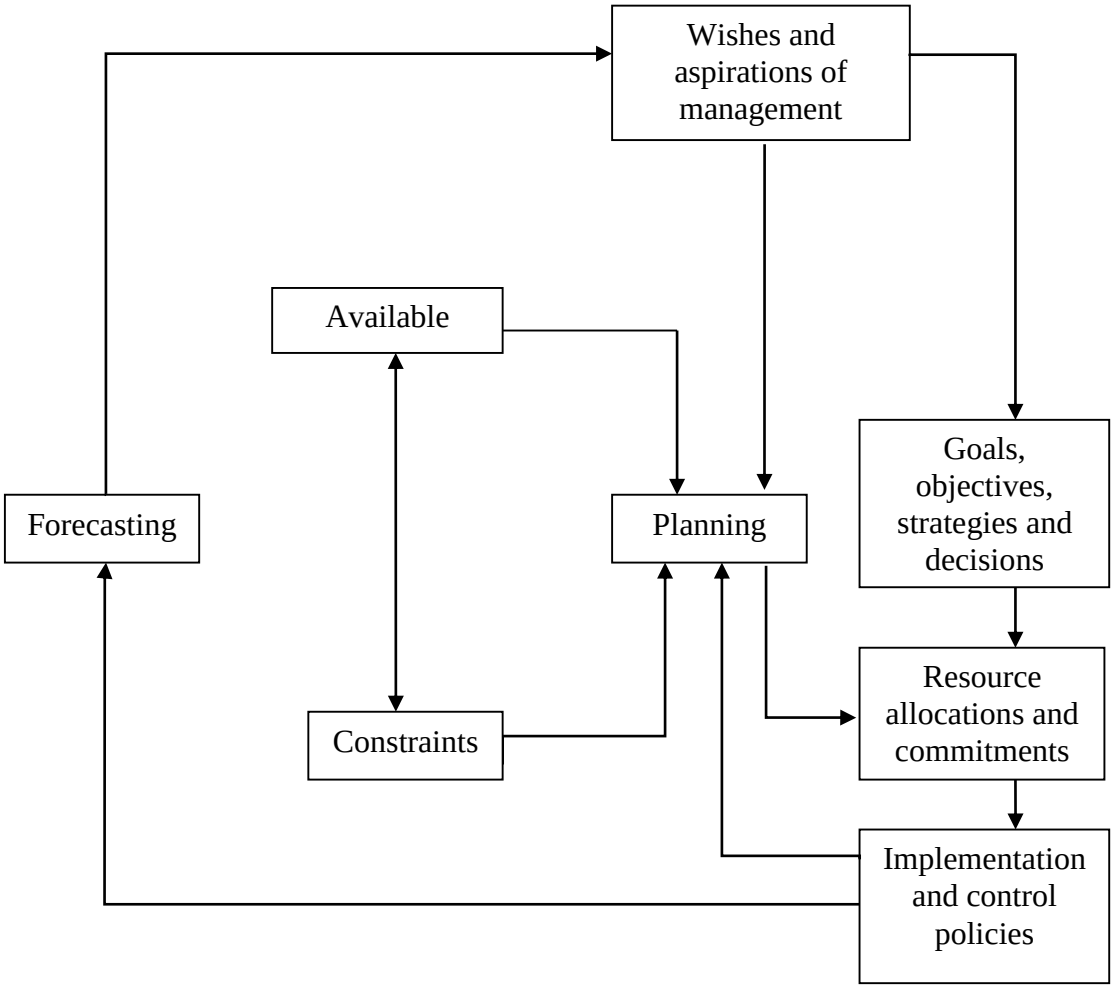

Figure 1.1 Linking Forecasting, Planning and Decision Making (Makridakis *et al.* 2008)

However, conflicts in the Middle East in the 1970s raised prices, made governments, policy makers and researchers to change the game plan and they reached the point that eliminating the demand-sector would not be an effectual approach of energy management.

Taking the importance of the energy in the nation development into account, Malaysian government has been reviewing its policy toward energy supply and demand management continuously (Rahman Mohamed & Lee, 2006). Statistics show that the energy consumption per capita from year 2000 as 1.26 Ton of oil equivalent-

/person(toe/person) has increased steadily to 1.47 toe/person in 2010 (Gan & Li, 2008). Malaysia is one of the developing countries that is experiencing huge growth in energy demand of all sectors. It also expected that there would be a very large growth in energy demand of Malaysia in the future, especially for primary energy sources like natural gas, oil and electricity.

Considering the growing energy demand in Malaysia, a significant challenge encountering the power industry would be to develop a sustainable and effective energy policy. In order to achieve this, one of the most important inputs is the future demand of energy. The 10th Malaysia Plan 2011-2015 asserts that during the period of the plan, fundamental structural changes should be done on new energy policy (Figure 1.2). It also encourages management to take initiatives in pricing, supply and demand side, which all require a new mechanism to assure optimum benefit.

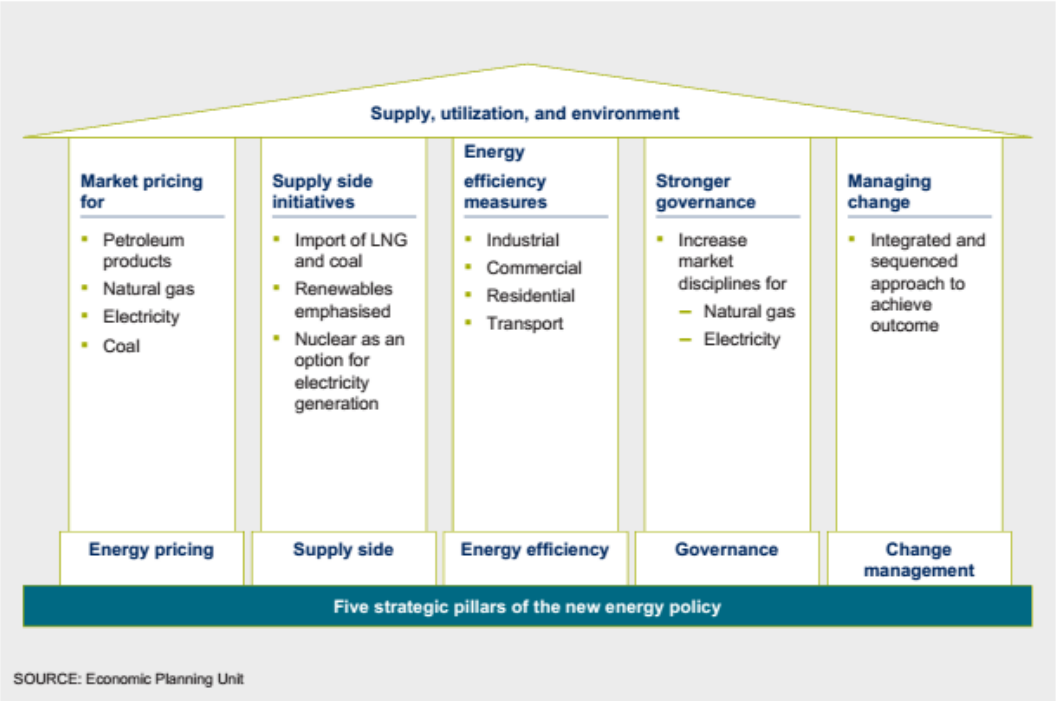

Figure 1.2 Five Strategic Pillars of the New Energy Policy (Adapted from 10th. Malaysia Plan 2011-2015, Prime Minister's Office of Malaysia)

Energy sector is an ever-changing environment that is susceptible to wrong decision-making and it consequently could undermine the performance of other sectors and even jeopardize the security of the nation. One of the disciplines that governments

need to deal with is to estimate the demand of energy consumption over the different courses of time. They also require an analysis of consumption, development and an assessment of pricing policy.

Energy planning just like other fields of planning requires a clear understanding of past, current and outlook of energy demand (Haldenbilen & Ceylan, 2005). One of the rigorous actions in energy planning is energy projection because of the high pace of economy development, technology growth, and government policies and other variables. Under such uncertain circumstances, the ripple effects of aforementioned factors could entirely deviate the figure from reality. Accordingly, forecasting the energy demand accurately is very critical for policy makers to allocate enough amounts of resources in order to meet the future demand.

From the global statistics, 85 percent increase of the global energy demand over the period of 2010-2014 will occur in developing countries outside the non-OECD (Organization for Economic Cooperation and Development). Energy demand of Malaysia is like other developing nations is mostly driven by rapid economic growth and ever-increasing population. On the contrary, OECD countries are already matured in energy consumption, considering the slower pace of economic growth and little population growth.

1.2 Problem Statement

Energy demand management tries to minimize the financial and environmental costs incurred by producing extra energy to meet the overestimated energy demand. It should also prevent undermining the security due to underestimating energy demand. To do so, it needs to minimize the gap between the energy demand and supply. Therefore, having a reliable outlook of the energy consumption is essential for policy makers to establish policies and make decisions in energy sector to minimize the gap between the supply and demand (Haldenbilen & Ceylan, 2005). The immediate result of having such a policy is reducing the costs and preserving the environment.

In addition to policy makers, there are some other groups such as researchers, energy suppliers, investors, power generation plants and end users who are interested in energy outlook. In different sources, including "World Energy Statistics" there are some statistics that show the future energy demand of different countries. Although the mentioned groups can use the data available in these sources, they also need to have a full understanding of the energy system to utilize that based on their own needs. For example, in some cases they need to extend the forecasting horizon or consider output of different scenarios based on their field of activities, which is impossible by just crunching the data provided by usually black-box processes. Considering these issues, having an appropriate model of the energy system is essential to forecast the energy demand, which in the case of Malaysia, there has not been any model available so far. One of the common methods, which has been used in the literature to project the energy demand, is developing the Genetic Algorithm. This study will used this approach to solve the problem.

The research gap of study is that all studies that have implemented GA to forecast energy demand in different nations or sectors have used the binary type of encoding for their algorithm. However, it seems that using binary GA is in conflict with the real space of the data in this arena. Thus, in order to improve the performance of algorithm and yield more accurate results this study wants to develop the algorithm based on the continuous encoding approach.

1.3 Research Objectives

Considering the mentioned problem, the objectives of this study are to:

- Develop an energy demand model for Malaysia
- Forecast the entire energy demand of Malaysia through implementing the proposed model on the basis of macroeconomic indicators
- Examine the sensitivity of the model toward the proposed indicators

1.4 Scope of the Study

This project is concerned with a causal estimating model, which is appropriate to forecast energy demand of Malaysia. The model implements different macroeconomic indicators including gross domestic product(GDP), import and export statistics and population to estimate the total energy consumption in all residential, industrial, agricultural and transportation sectors of Malaysia (covering Peninsular Malaysia, Sabah and Sarawak) over a period of ten years. MATLAB software would be used to achieve the optimum solution of the model.

1.5 Significance of Research

Energy is connected to industrial fabrication, agriculture, availability of hygienic water, education, health, and life quality. This study is an analytic method, which provides an outlook based upon the related data and the proposed model. The results of the study is important for energy pricing, energy system management, research and development, energy investment and contingency plan. It is also widely beneficial for interested parties such as energy suppliers, investors, power generation plants and end users.

1.5 Thesis Organization

Chapter one, covers an introduction and overview of energy demand forecasting. This chapter also discusses background of the study, statement of the problem, determining the objective and scope of the study and finally, contribution of the study on peoples' lives.

Chapter two includes the review of literature consisting of basic definitions regarding forecasting, energy demand management, energy models, and describing causal relationship. In final part of the chapter, different approaches of forecasting and

problem solving techniques are compared and finally, the appropriate model is selected.

Chapter three puts forward research framework and methodology, which provides guidelines on how this research will be conducted in order to reach its objectives.

In chapter four, the appropriate model and independent variables are selected based on the case study conditions. Subsequently, the different sources of data collection is introduced and summary of data required by the study is provided. Going forward, the process of developing the computer program is described in detail. Subsequently, the process of code verification and model validation are done and the performance of algorithm is compared with a similar case study in this chapter.

In chapter five, the result of the study is provided and findings are discussed. In order to investigate the effects of changing model parameters on optimal answer and final forecasted energy demand, a sensitivity analysis is done.

Finally, in chapter six the conclusion is drawn and future works are introduced as well.

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