EXPLORING THE BILATERAL AND HYBRID MODEL IN DEREGULATED ELECTRICITY MARKET

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This piece of work is especially dedicated to my beloved husband, Tuan Mohd Faiz Bin Tuan Borhanuddin, my perfect parent, Mr. Mohd Yassin Bin Mohd Shariff and Mrs. Halimah Binti Saidin, my supportive in laws, Mr. Tuan Borhanuddin Bin Tuan Ismail and Mrs. Hayati Binti Ariffin, my precious siblings and to my adorable nephews and nieces. Thank you so much for all the unconditionally loves, never ending support and prayers throughout my journey in this final year Master's project. I love you.

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ABSTRACT

This thesis is reviewing all the outcomes towards the entire work that has been done for this Master's Project which is entitled 'Exploring the Bilateral and Hybrid Model for Deregulated market'. The outcome is about the background of the restructuring of Electricity Supply Industry (ESI) especially for Malaysia Electricity Supply Industry (MESI). Before the restructuring of the MESI, Tenaga Nasional Berhad, (TNB) was monopolized electricity market from generation, transmission, and distribution sector. It comes to the end when Independent Power Producer, (IPP) introduced by the Malaysian Government with the aim to avoid shortage and facilitate competitions among generators and the first IPP in Malaysia is YTL Corporation Sdn. Bhd. In 2001, the first of restructuring model was introduced is the Single Buyer Model and TNB is expected to be the single buyer in this model. From the literature review which has displayed the weakness of this model, this Master Project thus has proposed two other models in deregulated electricity market that can be applied for MESI which are the Bilateral Market Model and Hybrid Market Model in order to carry on the MESI previous plan towards restructuring. In this project, the proposed models are designed to carry out the power generation revenue for selected Independent Power Producers (IPPs) in Malaysia in order to accommodate a fair competitive trading between power producers and produce win-win situation to all involved market participants. The analysis from the results obtained in the proposed model illustrates guaranteed incomes for all selected IPPs, the pattern of the profits for each IPP and the factors that determines those incomes and profits. The obtained results also bring out the advantages and disadvantages from these market models to all involved parties including IPP, utility company which is TNB, government and the end users.

ABSTRAK

Tesis ini mengulas tentang kesemua hasil keseluruhan kerja yang telah dilakukan untuk Projek Sarjana ini yang bertajuk *'Exploring the Bilateral and* Hybrid *Model in Deregulated Electricity Market'.* Hasilnya adalah berkenaan tentang latar belakang penstrukturan semula Industi Bekalan Elektrik (ESI) terutamanya Industri Bekalan Elektrik Malaysia (MESI). Sebelum penstrukturan MESI, Tenaga Nasional Berhad (TNB) telah memonopoli pasaran elektrik daripada sector penjanaan, pemghantaran dan pembahagian. Ianya berakhir apabila Pengeluar Tenaga Bebas, IPP telah diperkenalkan oleh Kerajaan Malaysia dengan matlamat untuk mengelakkan kekurangan bekalan dan memudahkan persaingan antara para penjana dan IPP yang pertama di Malaysia adalah YTL Corporation Sdn. Bhd. Dalam tahun 2001, model pertama penstrukturan yang telah diperkenalkan ialah Model Pembeli Tunggal dan TNB dijangkakan untuk menjadi pembeli tunggal di dalam model ini.Daripada kajian literature yang telah memaparkan kelemahan pada model ini, maka Projek Sarjana ini telah mengusulkan dua model yang lain di dalam pasaran elektrik yang dikawal selia yang boleh diaplikasikan untuk MESI iaitu Model Pasaran *Bilateral* dan Model Pasaran *Hybrid* di dalam meneruskan rancangan MESI sebelum ini iaitu untuk menuju penstrukturan semula. Di dalam projek ini, model – model yang diusulkan direkabentuk untuk menghasilkan pendapatan penjana bagi Pengeluar – Pengeluar Tenaga Bebas (IPPs) di Malaysia dalam menampung persaingan perdagangan yang adil antara pengeluar – pengeluar tenaga dan menghasilkan situasi menang – menang kepada semua peserta pasaran yang terlibat. Analisis daripada keputusan – keputusan yang diperolehi menggambarkan jaminan pendapatan untuk kesemua IPP, corak dalam keuntungan bagi setiap IPP dan faktor – faktor yang menentukan pendapatan dan keuntungan tersebut. Keputusan yang diperolehi juga menunjukkan kelebihan dan kekurangan daripada model – model market

ini kepada semua parti yang terlibat termasuk IPP, syarikat utiliti, kerajaan dan juga pengguna akhir.

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INTRODUCTION

1.1 Overview of Deregulated Electricity Market

During the nineties decade, many electric utilities and power network companies world –wide have been forced to change their ways of doing business, from vertically integrated mechanisms to open market systems. The reasons have been many and have differed over regions and countries.

Among the developing countries, the main issues have been a high demand growth coupled with inefficient system management and irrational tariff policies, among others. This had affected the availability of financial resources to support investment in augmenting generation and transmission capacities. In such circumstances, many utilities were forced to restructure their power sector under pressure from international funding agencies. In developed countries, on the other hand, the driving force has been to provide customers with electricity at lower prices and to offer them a greater choice in purchasing economic energy.

This will be bringing to the definition of deregulated electricity market. In a regulated electricity market, a single company, normally referred to as a utility, owns the entire infrastructure which is the physical stuff that stores and distributes electricity, like transformers, poles, and wires. That same utility is also responsible for buying the electricity from electricity-generation companies, selling the electricity to consumer, and

distributing the electricity to home. Then, if the customers have a power outage or a broken transformer or need any other kind of service in a regulated electricity market, the utility company will take the responsibility for all of those issues. But customers cannot expect to get cheaper electricity, because the utility offers only one price.

However, in a deregulated electricity market, while the utility still owns all the infrastructure and is still responsible for distributing electricity to home, competing electricity providers are allowed to buy the electricity and sell it to the consumer directly. Then, if the customers have a power outage or a broken transformer in deregulated electricity market, the utility company which is still responsible for all of those issues would still be called by the customer. But the great thing is, the customer is able to choose to shop around and buy the power from any electricity retailer that does business in the market. This kind of market has being widely applied in those countries including Arizona, Arkansas, California, Connecticut, Delaware, Illinois, Maine, Maryland, Massachusetts, Michigan, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Texas, Virginia, and the District of Columbia.

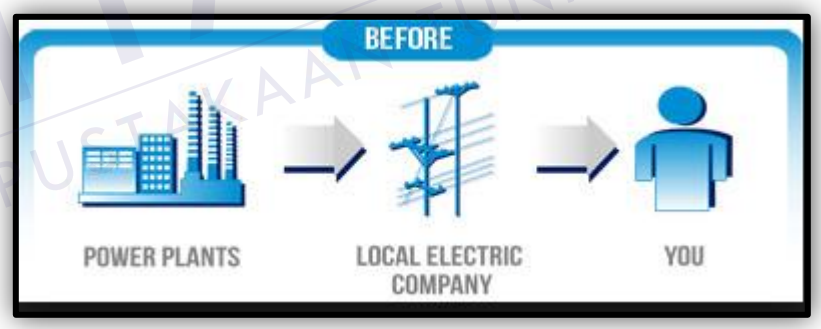

Figure 1.1: Regulated Electricity Market

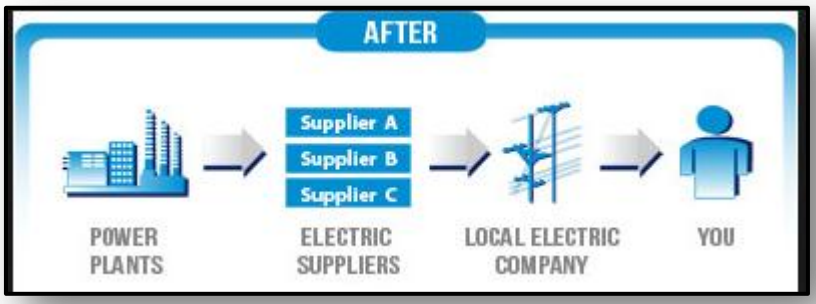

Figure 1.2: Deregulated Electricity Market

1.2 Electricity Trading Arrangements in Deregulated Structure

The trading arrangements in a model are the set of rules buyers and sellers (collectively, traders) have to follow when they make transactions [3]. The variable demand for electricity and the need for instantaneous response will mean that there will always be differences between trader contract for and actual generation and consumption. The market mechanism must account for these imbalance and see that they are pay for. Since all the power flows over a system according to the laws of physics, there is no way to tell whose power actually went to whom. There has to be a method of measuring and accounting for flows into and out of the network, or over interconnectors, if the transactions are to be invoiced and paid. There are many ways to do this, which vary in complexity with the number of traders who can use the network to make independent transactions. Prices for using delivery networks must give efficient location decisions and allow for the economic dispatch of plant.

There are several types of electricity trading arrangement that were applied in deregulated structure such as:

a) Single Buyer Model

b) Pool Market Model

c) Bilateral Market Model

d) Hybrid Market Model which combines the pool market model with other policies

The aim of this study is to identify both pro and cons for Bilateral Market Model and Hybrid Market Model besides analyzing the economic benefits among the players.

1.3 Problem statement

Since the millennium period starting in year 2000, world has started the new revolution of technology. Advanced countries like China, Japan and currently Korea keep competing among each other to offer the latest technologies to be commercialized to people all around the world. As this competition phenomenon increased, the major system being affected is obviously the electricity power. The electricity power demand keep growing as like linearly with the increasing of technology lifestyle by the millennium people. Consequently this will cause the major problem of the instability or chaos if the electricity power did not being structured, managed and traded well by the responsible parties. Thus, a perfect restructuring of electricity power market in power supply industry is highly needed.

Other than that, without the well-structured of the electricity power market, the responsible parties which are power generators as the power suppliers, the utility company as the customer, the government as the country ruler and finally the power consumers will having the risk of economics inefficiency and could suffered a massive profit erosion. The utility company and government are the most affected bodies by the inefficiency electricity market because as for the utility company, it has to pay to power generators for energy and capacity while the government has to cover the electricity subsidies for the consumers. This situation has occurred in Malaysia nowadays where the utility company (TNB) has to face the huge capacity price charged by the IPPs and the end users also have been affected by this situation with the increment of the electricity tariff. Hence, a research study has to be done as starting to overcome this problem and finally an effective policy must be bringing out to be applied to the electricity market. This policy conceived in any of electricity market models such as bilateral and hybrid model. Therefore, it is really important to dig out the pros and cons of these market models as they have their own policy that will determine the suitability and effectiveness of the electricity market.

1.4 Objectives

a. To study and observe the policies of selected electricity market models.
b. To study how to calculate the generation cost that been charged to the customer or power generation revenue according to each of the electricity market models.
c. To identify pros and cons for each electricity market models.

1.5 Scopes

a. The study is focusing on the operation and policies of the two electricity market models which are Bilateral and Hybrid Market Model.
b. The depth explanation on analysis and discussion is on the revenue calculation at power generation parts and the price that been charged to the customer for each electricity market models.
c. The calculation of the power generation revenue is done and review up to four selected IPPs busses in Malaysia.
d. The analysis of the power generation revenue is limited only for three types of load demand which are at low demand (1500MW), medium demand (4000MW) and high demand (5000MW).
e. The tool that used to review the results of power generation revenue for each generator for both electricity market models is by using Microsoft Excel.

1.6 Overview of the thesis

In Chapter 1, this project's thesis covered an explanation of the overview of deregulated electricity market, the electricity trading arrangements in deregulated structured, the problem statement, the objectives and finally the scopes for this entire Master's project. The overview of deregulated electricity market tells about the definition of the deregulated electricity market itself, the history behind it and the problem occurred that brings to the changing of the electricity market from vertically integrated mechanisms to open market systems. It also mentioned the example of countries that have been done

this changing. On the other hand, the electricity trading arrangements is explaining about several types of trading arrangements that were applied in deregulated structure. It shows the four main structures which are the single buyer model, pool market model, bilateral market model and hybrid market model. It also mentioned the aim of this project which is emphasizing on the bilateral market model and hybrid market model. Finally at the last of this chapter, it states about the problem statement that brings the relevancy to execute this project, the objectives that determine the direction of this project and the scopes that this project are covered.

Meanwhile in Chapter 2, this chapter covers all the literature review that relates to this Master's project. For the first half of this chapter explored the overview of restructuring of Electric Supply Industry (ESI), the Malaysia Electricity Supply Industry (MESI) and overview of market structures. The other half of this chapter is explaining details about the main two market structure models for this project and finally the overview of the Australian Electricity Market. For the first part of this chapter, the overview of ESI is reviewing about the exactly definition of restructuring process, how the progress towards restructuring and the positive effects behind it. Meanwhile for the MESI, it reviews the condition of electric supply industry in Malaysia and the current market model structure that being applied in this country which is the single buyer model. In the single buyer model, it reviews about the policies involved in the model and what types of payment that being set in this market model. Meanwhile, the second part of this chapter is explaining about the bilateral and hybrid market model which is the main aim for this project. The explanation of both market models is including the perspective of their definitions, structure, policies with ISO and how they been executed at the GENCO. Finally in the end of this chapter, the Australian country has been chosen as one of the example of outside country that applied different market model structure compare to Malaysia. The content in the example is showing the detail structure of National Electricity Market (NEM) of Australia that been applied pool market model in their country.

In the next chapter which is Chapter 3 is explaining about the methodology for the entire project. The methodology contains the view of the sources that being use to execute this project, flowchart of the project and the related mathematical equation to

get the power generation revenue of bilateral market model and hybrid market model. The flowchart of the project describes the flow from the beginning of the project which is the selection of the generators with their own capacity, the process to get the results depending on the two market structures and finally ending with the analysis for the entire results for power generation revenue. The part of power generation revenue of bilateral market and hybrid market model explains about the related mathematical equation to get the total revenue for each of the chosen IPP generators for this project. There are steps that have to be followed in those two market models in order to get the total revenue. As for the highlight, this project is using the real capacity of all IPPs in Malaysia in the calculation in order to relate to the real situation in this country and to show the effects of the two market models to the IPPs generator's revenue in Malaysia.

Next is the Chapter 4 showing the overall analysis of the entire obtained results for this project. This chapter is divided into five main sub chapters which are the overview of selected four generation power plant busses, the results of power generation revenue for bilateral market structures, the analysis of power generation revenue for bilateral market structures, the results of power generation revenue for hybrid market structures and finally the analysis of power generation revenue for hybrid market structures. This analysis chapter is explaining every detail of the results data that have been obtained in the final of this project. Every result data is displayed in the presentation of tables and bar charts and it showing the effects of those two market models to the generator's revenue in Malaysia. The analysis of bilateral and hybrid market model is divided into two sub chapters in order to ease the reading and understanding towards the analysis. The analysis for both market models is explaining the pattern of the power generation revenue, their relation with the current environment for market players in Malaysia and finally it lists out the advantages and disadvantages for each of the bilateral and hybrid market model.

Finally in the last chapter of this thesis which is Chapter 5 is the chapter of the conclusion and recommendation for the entire work in this Master's project. It summarizes and reflects every chapter in this Master project's thesis and gives the final conclusion and recommendation for the future work towards it.

1.7 Conclusion of Chapter 1

For Chapter 1, based on the problem statement stated and the overview regarding to the deregulated market also the electricity trading arrangement in deregulated structure, it can be conclude that this Master's project is relevant enough to be implemented. In the end of this project, all the objectives and scopes for this project has been executed and it can be conclude that the aim for this project has been successfully achieved.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Restructuring of Electricity Supply Industry (ESI)

Through the awareness of deregulated market, many utilities were heading to restructure their power sector under pressure from international funding agencies. Restructuring of the power industry will remove the monopoly in the generation sectors, and will introduce a competition at various levels wherever it is possible. Basically, the objectives of these restructuring are to enhance efficiency, to promote competition in order to lower costs, to increase customer choice, to assemble private investment, and to merge public finances. The tools of achieving these objectives are the introduction of competition which is supported by regulation and the encouragement of private participation. Changes in the ESI structure had introduced a number of electricity market models which is designed appropriately with its local condition. These market models are the single buyer model, the pool market model, the bilateral contract model and hybrid/multilateral model [3]. As for this master project case study, the depth discussion will be emphasis on the bilateral contract model and hybrid/multilateral model.

2.2 Malaysia Electricity Supply Industry (MESI)

Electricity first made its appearance in this country at the turn of the 20th century. In 1894, there were first two enterprising individuals installed an electric generator to operates their mines and marked the great beginning of the story of electricity in Malaysia. Until the mid-nineteen twenties, most generating plants were small and used a variety of fuel including low grade coal, local wood, charcoal and important oil as well as water power. As the rapid increase in electricity demands, the Central Electricity Board (CEB) was established on 1 September 1949. CEB became owner to 34 power stations with a generation capacity of 39.88 MW including a steam power station, hydroelectric power station, and diesel power station [6].

Then, on 22 June 1965, Central Electricity Board (CEB) was renamed as the National Electricity Board of the States of Malaya (NEB). The National Grid was one of the plans in full motion. The National Grid or Grid Nasional in Malay is the primary electricity transmission network linking the electricity generation, transmission, distribution and consumption in Malaysia. On 1 September 1990, NEB was replaced with Tenaga Nasional Berhad (TNB) and became a private company wholly-owned by the government. Its function includes generating, transmitting, and distributing electricity to consumers [6]. Government of Malaysia had allowed Independent Power Producers (IPP) to participate in the generation sector in addition to break the monopoly and encourage the competition. Since Malaysia Electricity Supply Industry (MESI) applied the single buyer model with TNB as the purchasing agency.

2.3 MESI towards Restructuring

Malaysia is currently undergoing reforming its electric supply industry into a more transparent, effective, and competitive power market. Therefore, in March 1998, government made a decision to establish an Independent Grid System Operator (IGSO) as part of 7th Malaysia Plan [19]. Objectives of restructuring are:

a) To promote efficiency in the utilization of financial and technical resources in the development and operations of the study.

b) To provide a level playing field for all players in the ESI.

c) To achieve competition electricity prices for all consumers.

The proposed MESI structure should include generation, transmission, distribution, retail, independent market operator (IMO), and a grid system operator (IGSO). The IMO is a new market administrator and long term planner who will be responsible for introduction competition into generation market and possibly the retail market. But, the target of operating the IMO by 1st January 2001 was not achieved.

In 2001, the first stage of restructuring model was introduced are Single Buyer Model which is to create a competition at the generation level. In this case, TNB is expected to be the single buyer at this stage. At the second stage, Multi Buyer Model was proposed to be operated in 2005 where it supposedly will enhance the wholesale market by introducing more than one buyer from the power market to provide customer. Nevertheless, this model was put on hold as other target was put on hold as well.

Before Malaysian Government was introduced Independent Power Producers (IPP), TNB was monopolized electricity market from generation, transmission, and distribution sector. It comes to the end when IPP introduced with the aim to avoid shortage and facilitate competitions among generators. The first IPP is an YTL Corporation Sdn. Bhd. which is own by Yeoh Tiong Lay and from time to time, many IPP have given an opportunity to supply the electricity [21]. Currently, there are 14 IPP that serve electricity throughout the Peninsular Malaysia via TNB with total install capacity 1414775.40 MW.

In 2001, Malaysian Electricity Supply Industry (MESI) has changed their electricity model from vertically integrated to the single buyer model due to the competitive environment in generation sector. In this model, TNB have an authority to choose which generator that success to supply their power output throughout Peninsular Malaysia based on demand that required by a consumers. Other than that, in 1998, MESI aims to establish an Independent Grid System Operator (IGSO) and Independent Market Operator (IMO) in 2001 but fails to do so [20]. In 2005, the plan move to establish a Multi Buyer Model, but it put on hold due to the effect of California' crisis and long term agreement bonded between the private power producers and TNB.

In this single buyer model, the IPPs will receive two payments which are energy payment and capacity payment. The differences between these two payments can be shown below at Table 2.1 [6].

Table 2.1: Differences between Energy Payment and Capacity Payment

Energy Payment	**Capacity Payment**
a) The value are different for one IPP to the other	a) Paid monthly based on each IPP's generation capacity
b) Price paid per unit of incremental output	b) To cover the capital and other fixed costs which are not covered by the energy price
c) Paid based on the utilization of the electricity per hour.	c) Unfair trading because the payment is made regardless of electricity usage
d) Required because the generators are paid for the works that they have done.	d) Fixed and TNB must pay regardless of the usage
G1 = PGi × CGi (3.1) Where, PGi = Available Capacity available by ith generator in MW CGi = Capacity Price for ith generator in RM/Mhr	GE1=PEGi × CEGi (3.2) Where, PEGi = Power Output generated by ith generator in MW CEGi = Energy Price ith generator in RM/MWh

2.4 Overview of Market Structures

2.4.1 Pool based market

A pool market is defined as a centralized market place that clears the market for buyers and sellers of electricity [1]. The market may be operated as a double auction or single auction. In a double auction system the market operator or the independent system operator (ISO) receives both sell bids (from Gencos) and buy bids (from Discos). The market price is obtained by stacking the supply bids in increasing order of prices and the demand bids in decreasing order of their prices, the intersection point determines the market clearing price [1]. In single auction only the sell bids are received and the price is determined by the highest accepted sell bid to intersect with the forecasted demand. The seller and buyer do not have any interaction in the pool market mechanism. Price

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