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A STUDY OF ELECTRICITY MARKET MODELS IN THE RESTRUCTURED ELECTRICITY SUPPLY INDUSTRY

(KAJIAN TERHADAP BEBERAPA MODEL PASARAN ELEKTRIK DI DALAM PENSTRUKTURAN SEMULA INDUSTRI BEKALAN ELEKTRIK)

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TAJUK PROJEK : A STUDY OF ELECTRICITY MARKET MODELS IN THE RESTRUCTURED Y ELECTRICITY SUPPLY INDUSTRY

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ABSTRACT

In the new era of modernity, the competitive environment has spread widely into all sectors including the electricity market which began since 1980s. A number of market models have been introduced and each model was designed appropriately with its local condition. The selection of the model used depends on the justification determined by power utilities or regulatory policies taking into account the technical and economic aspect point of view. Looking forward to an opened and competitive electricity trading market, Malaysian Electricity Supply Industry (MESI) has aimed to restructure its current model to become a wholesale market model by taking the first step in 1992 through the introduction of the Independent Power Producers (IPPs). Since then MESI applies the Single Buyer Model which produces no transparent competition either on generation or demand side. Tenaga Nasional Berhad (TNB) is the only company that acts as the power off taker by all power producers and sells the energy to all relevant parties. The purpose of this research is to study in depth the restructuring of electricity supply industry and identifying the advantages and disadvantages for each electricity market models, i.e. existing single buyer, pool and bilateral market model. The economic benefits from the view point of power producers under these models were also analyzed. The findings can be used by the Energy Commission (EC) as a starting point in planning towards the next step of competitive environment. Besides, the current power authority (TNB) and other private investors may also use these findings for their own forecast on the system planning. A case study was carried out in order to compare the three market models in term of generation revenue by using the Matlab Simulation under the real load profiles for peninsular of Malaysia. The results showed that the single buyer is uncompetitive but is controllable as TNB monopolise the market. However, both pool and bilateral market models are able to provide a

competitive environment but creates higher risk as the energy price might fluctuate from time to time in practical. This shows that MESI should consider several policies if they plan to apply the alternative market models.

ABSTRAK

Dalam menuju ke era permodenan, persekitaran persaingan telah diaplikasi secara meluas di dalam pelbagai sektor termasuklah dalam model pasaran elektrik yang bermula sejak 1980an. Beberapa jenis pasaran model telah diperkenalkan dan direka berdasarkan penyesuaian keadaan tempatan. Pemilihan pasaran yang diaplikasi bergantung kepada justifikasi penguasaha tenaga dengan mengambil kira pengaruh dari sudut teknikal atau ekonomi. Industri Bekalan Elektrik Malaysia (MESI) telah merancang untuk mengaplikasi pasaran elektrik yang lebih terbuka, maka langkah pertama yang telah diambil iaitu melalui pengenalan kepada Penjana Kuasa Bebas (IPP). Sejak itu MESI mengaplikasikan model pembeli tunggal yang hakikatnya telah gagal untuk menyediakan persekitaran persaingan baik dari sudut pembekal atau keperluan semasa. Tenaga Nasional Berhad (TNB) merupakan satu-satunya syarikat di Malaysia yang membeli dan menjual tenaga kuasa elektrik kepada semua pihak. Tujuan kajian projek ini dijalankan adalah untuk mempelajari dan mengkaji dengan lebih mendalam tentang penstrukturan semula pasaran model and mengenalpasti kelebihan dan kekurangan bagi setiap jenis model seperti pembeli tunggal, pasaran berpusat dan pasaran bilateral. Kajian dari sudut kebaikan ekonomi bagi setiap model juga akan dianalisis. Hasil kajian ini boleh digunapakai oleh Suruhanjaya Tenaga (EC) sebagai satu titik permulaan dalam perancangan menuju ke pasaran persekitaran persaingan. Selain itu, pengusaha tenaga semasa (TNB) dan pelabur swasta boleh juga mengunapakai hasil kajian ini dalam perancangan mereka mengenai jangkaan sistem.Satu kajian telah dibuat untuk membandingkan ketiga-tiga model pasaran dari perspektif keuntungan kepada syarikat penjana elektrik dengan mengunakan simulasi MATLAB di bawah penggunaan profil beban bagi semenanjung Malaysia. Hasil menunjukkan model pembeli tunggal tidak dapat menyediakan pasaran persaingan

tetapi mampu dikawal kerana TNB menguasai keseluruhan pasaran. Manakala, kedua-dua pasaran pusat dan bilateral mampu menyediakan pasaran persaingan tetapi mengundang risiko yang tinggi kerana harga tenaga boleh berubah dari masa ke masa. Ini menunjukkan MESI sepatutnya mengambil kira beberapa polisi sekiranya mereka benar-benar merancang mengaplikasi model pasaran alternatif ini.

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LIST OF ABBREVIATIONS

EC	-	Energy Commission
IMO	-	Independent Market Operator
ISGO	-	Independent System Grid Operator
IPP	-	Independent Power Producer
MESI	-	Malaysia Electricity Supply Industry
PAB	-	Pay as Bid Scheme
PPA	-	Power Purchase Agreement
TNB	-	Tenaga Nasional Berhad Sdn. Bhd.
TNBD	-	Tenaga Nasional Berhad Distribution Sdn. Bhd.
TNBG	-	Tenaga Nasional Berhad Generation Sdn. Bhd.
UP	-	Uniform Price Scheme

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CHAPTER 1

INTRODUCTION

1.1 Overview of Electricity Supply Industry (ESI)

For almost a century, each sector in the electricity supply industry (ESI) which is generation, transmission and distribution were thought to be a natural monopoly. It is also has been vertically integrated within a utility and can be either, investor-owned and state-regulated or owned by the local municipality. But for Samuel Insull, the president of National Electric Light Association in 1890s, he had claimed that the business should be regulated at the state level [1]. During that period, consumers had no choice of buying the electrical energy except from the utility that held the monopoly for the supply of electricity in the area where these consumers were located. If the utilities were vertically integrated, this means that the utility generated the electrical energy, transmitted it from the power plants to the load centers and distributed it to individual consumers. In other cases, the utility from which consumers purchased electricity was responsible only for its sale and distribution local area. This distribution utility in turn had to purchase electrical energy from a generation and transmission utility that had a monopoly over a wider geographical area. Irrespective of ownership and the level of vertical integration, geographical monopolies were the norm.

In early 1980s, some economics started arguing that the monopoly status of electric utilities had removed the incentive to operate efficiently and encouraged unnecessary investments. They also argued that the cost of the mistakes that private utilities made should not be passed on to the consumers. Public utilities, on the other hand, were often too closely linked to the government. Politics could then interfere with good economics. For example, public utilities were treated as cash cows, and others were prevented from setting rates at level that reflects costs or were deprived of the capital that they needed for essential investments. However the status had remained the same until the expansion of transmission technology, which mainly for purposes of reliability had brought new possibilities for trade and competition.

Later on, the electricity supply industry (ESI) had undergone a major transition worldwide, as new technology and attitudes towards utilities is being developed and changed. 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.

Malaysia Electricity Supply Industry (MESI) on the other hand, had done the first step towards restructuring by encouraging private investors in producing electrical energy since 1992 following a nationwide power blackout and serious interruptions and rationing. Besides that, the introduction of Independent Power Producers (IPP) had aided TNB to overcome the electricity shortage issue and enlarge the electrical energy reserve margin. The competition is valid only in generation sector while the transmission and distribution sector are still with TNB. This electricity market model is also known as the single buyer model and since then, MESI had applied this market model. Currently, there are 14 IPPs in the Peninsular of Malaysia and the electrical energy is sold to the TNB on a fixed rate based on the power purchase agreement (PPA). This agreement which last for 21 years is signed between the TNB and IPP for the purpose of market risks protection. The restructuring is supported with the existence of Energy Commission (EC) which is an electrical regulator in Malaysia. EC is obliged to not only design the appropriate electricity market model but also to setup suitable policies and regulation related to electricity industry.

1.2 Objectives of the Study

The objectives of this study are:-

a) To study the electricity market models in restructured electricity supply industry
b) To identify pros/advantages and cons/disadvantages for each electricity market model
c) To analyze the economic benefits of these market models from the viewpoint of the power producers and consumers

1.3 Scope of Study

Changes in the electricity supply structure have led to various types of electricity market models such as Single Buyer Model, Pool Market model, Bilateral Contract Model and Hybrid/Multilateral Model. This study gives details on each market model but depth explanation was only given to Single Buyer Model and the Pool Market model. This is due to the facts that the existing Malaysia Electricity Supply Industry (MESI) is applying the Single Buyer Model. The nearest market model that could be applied without major changes to the electricity supply structure is the Pool Market Model. Examples of the application for these two market models will be analyzed and the results found thus will aid the design of Pool Market model. Nevertheless, some examples on the application of Bilateral Market Model also will be added in order to get some overview on the model's concept. The electricity trading that is being considered is only up to the transmission level. Consequently, the business is only between the generator as the seller and distributor as the buyer or customers without taking into account the end user.

1.4 Problem Statement

In 1992, following a nationwide power blackout and a series of interruptions and rationing caused the government to conduct an immediate assessment of the nation's power generation industry. As a result of rapid development of the national economy in the preceding years, it appeared the country was unable to cater for the parallel growth in demand for power. To narrow this widening gap, and under its successful privatization agenda, the Government identified the Independent Power Producer (IPP) model, whereby the capital-intensive development of new generation assets could be outsourced to the private sector. This became the initiative that would deliver the immediate national power security needed to maintain Growth Domestic Product (GDP) growth whilst not putting unnecessary pressure on Tenaga Nasional Berhad (TNB) resources.

The initial IPPs were awarded licenses to pursue the IPP model under power purchased agreements (PPAs) that would span periods of up to 21 years and govern how the IPP would construct, purchase and/or use of fuel, operate and sell energy produced. In this agreement, the power off taker which is TNB had agreed to pay to types of payment; energy and capacity payment. The energy payment is done based on the electricity consumed by TNB. Meanwhile, the capacity payment which is paid monthly regardless the usage performs two main roles. This type of payment provide extra revenue to the generator, to cover the capital and other fixed costs which are not covered by the energy price. It also provides incentives for generators to be available at times when the system needs generation capacity. As the power off taker TNB has to bear the high expenses and this has made TNB suffered massive profit erosion.

TNB is also hit by the increasing of fuel cost. The government is bearing the burden of rising cost due to the subsidies. But the IPPs are not sharing any of these burdens. When the demand getting slower, TNB could not sustain the capacity payment as it is fixed. As it stands, electricity tariff have gone up for the end users. Consequently, consumers also faced risks as they depend on current market situation. Therefore, a drastic action should be taken by designing some policies or any suggestion to come out before the market collapsed. A new market design is required so that the consumers pay reasonable price, TNB makes reasonable profit and IPPs as well. Perhaps this study can be some forms of help in assisting in new policy set out and further research works to overcome the crisis.

1.5 Methodology

In analyzing the economic benefits of the electricity market models applied for Malaysia Electricity Supply Industry (MESI), the following steps are undertaken:-

a) Conduct literature review on existing electricity market models
b) Analyze on the structure and operation for each market models
c) Identify the pros and cons of the market models
d) Formulate the mathematical equation representing the generation income and demand charge for each market models
e) Conduct comparative analysis among the market models using Matlab Simulation approach
f) Based on simulation results in (e), determine economic benefits among the trading parties

Figure 1.1 below shows the study's flowchart that explains the whole process for the study to accomplish its mission.

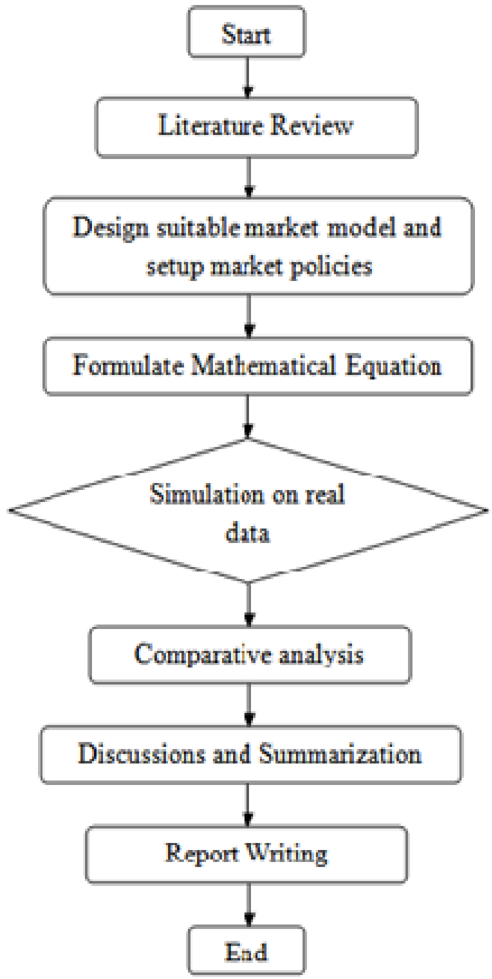


Figure 1.1 Study flowchart

1.6 Report Organization

Chapter 1 describes the overview of the study including the objective, the problem statement and methodology throughout the study. Meanwhile, Chapter 2 outlines the fundamental information on the restructuring of electricity supply industry (RESI) including a few example of the restructuring in advanced and developing countries. The structure of RESI also is being explained in this chapter.

Chapter 3 represents the depth explanation of current situation for Malaysia Electricity Supply Industry (MESI) which applied the single buyer model at this moment of time. It consists of the market players, types of payment, and related current issues. Other than that, this chapter also discussed the frame work that has been planned for Malaysia towards restructuring and the progress status.

A pool based market design for MESI is presented in Chapter 4. Two types of market settlement in pool market model which is one sided pool and two sided pool are being discussed in this chapter. Besides that, a hybrid model that able to overcome several issues arise throughout the process of applying the pool trading model are also included.

Meanwhile, Chapter 5 will briefly explain on another market design for MESI which is based on bilateral. The descriptions is not detail as in pool market model as the purpose of this chapter is just to give brief overview on the model if the model is expected to be applied in MESI. This is because the application bilateral market model requires major changes in the MESI structure compare to pool market model. Hence, it is impossible for a developing country like Malaysia to directly change its structure to wholesale concept as it requires high cost.

Chapter 6 explains about the case study conducted in order to compare all electricity market models which is single buyer, pool market model and bilateral market model in term of its generation revenue throughout the year. In this chapter, consequences of the application of new trading towards the market players can be examined. This is done by using the Matlab Simulation. Results of the simulation and analysis are discussed in Chapter 7. Finally, Chapter 8 concludes the study and suggests several future works that should be done.

CHAPTER 2

ELECTRICITY SUPPLY INDUSTRY RESTRUCTURING

2.1 Introduction

Since 1980s, the electricity supply industry (ESI) is undergoing a major transition worldwide, as new technology and attitudes towards utilities is being developed and changed. Other factors that contribute to the restructuring of ESI are changes in political and ideological attitudes, high tariffs, managerial inadequacy, global financial drives, the rise of environmentalism, and the shortage of public resources for investment in developing countries [2].

The revolution process of ESI comprises competition, restructuring, privatization and regulation. Basically, the objectives of these reforms 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 through the introduction of competition which is supported by regulation and the encouragement of private participation. An international approach for the design of the legal, regulatory, and institutional sector framework has come into view and it included the following:-

a) The privatization and restructuring of state-owned energy utilities
b) The separation of regulatory and operational functions, the creation of a proper regulatory framework, and the establishment of an independent regulator to protect consumer interests and promote competition
c) The vertical unbundling of the electricity industry into generation, transmission, distribution and trade (services)
d) The introduction of competition in generation and trade the regulation of monopolistic activities in transmission and distribution
e) The promotion of private participation in investment and management through privatization, concessions, and new entry
f) The reduction of subsidies and rebalancing of tariffs in order to bring prices in line with costs and to reduce market distortions

Electricity trading refers to any number of financial and/or physical transactions associated with the ultimate delivery of a host of desirable energy-related services and products to wholesale and, increasingly, retail customers. Power marketers, those engaged in such trade, however, need not own any generation, transmission or distribution facilities or assets. They rely on others for the physical delivery of the underlying services. Moreover, power marketers operate primarily as contractual intermediaries, usually between one or more generators and one or more customers.

Electricity market trading is quite different from other commodities because of the nature of electricity which cannot be stored, its availability must be instantaneous and absolute, as well as the technical complexities of the expertise, knowledge and planning capabilities that only power engineers can provide. For electricity market to perform successfully, two types of expertise must converge [3]:

a) A high level of technological expertise in the domain of power engineering, and

b) Financial and business expertise allowing market trading

2.2 Electricity Trading Worldwide

For regulators, the creation of trading exchanges can offer the chance to build a truly open and competitive market, guided by a global knowledge base of the successes and failures of other exchanges in other industries around the world. Energy exchanges enable the development of the wholesale business. In addition to the trading of physical quantities, ‘future’ markets are created making extensive use of financial products. Many exchanges offer multi-energy (i.e. electricity, gas, and oil) services, sometimes extending to other commodities as drivers as metal, pulp and paper.

The number and nature of players will evolve as the electricity market continues to open and the liquidity of exchanges increases. It is might be that electricity trading will occur increasingly over the internet in the coming years. There is a lot to be gained for all parties through these new markets. But it can be a complex process, and companies should evaluate participation in a trading exchange against the current market trends, the drivers in energy markets and the broader developments in financial and commodity trading.

Such considerations are unlikely to lessen the speed at which trading exchanges in the energy sector are growing. Instead, market forces, technology, and legislation will shape the new exchange landscape, creating an environment in which competition increases rapidly and consolidation occurs. It is vital that this shaping influence is allowed to continue, as for a market to successfully move to a deregulated mode, the basics such as maintaining an adequate balance of regional supply and demand must be established.

Across the world, competition in energy markets has driven the development of wholesale energy trading. There is an enormous variety in the speed and willingness of markets to deregulate, from country to country, and even from state to state. Many countries already have fully competitive and mature markets while other countries still do not plan to deregulate their gas and electricity industries.

2.3 Restructuring of ESI in Other Countries

The restructuring of ESI had occurred around the world ranging from the most advanced countries to the developing countries. Below are some of the restructuring that had occurred.

2.3.1 Electricity Trading in United Kingdom (UK)

In England and Wales before privatization had began, the electricity industry was a classic, vertically integrated, government-owned monopoly, seen at that time as the best way to provide a secure electricity supply. Consumers had no choice of supplier and had to buy electricity from their local regional electricity company (REC), so that price competition was not possible.

The UK is one of the pioneer countries in developing a free market electricity trading system. Initially market reform involved creating an Electricity Pool for England and Wales with a single wholesale electricity price. Producers sold to the Pool and licensed suppliers purchased electricity from the Pool. Pool participants were able to negotiate bilateral contracts. However, the Pool performances did not allow the development of full competition. On 27th March 2001, New Electricity Trading Arrangement (NETA) for England and Wales were launched. NETA provided new structure and rates for England and Wales electricity market. Under NETA there were major developments in which electricity is bought and sold, with major competition in generation and supply, with a wide range of new players competing in the liberalized energy market. The stated objectives of NETA are to benefit electricity consumers through lower electricity prices resulting from the efficiency of market economics. Promotion of competition in power generation and electricity supply, in order to use market forces to drive consumer costs down, was, and remains, a key objective of actions to liberalize and 'deregulate' electricity markets in the UK. The transactions taking place within the NETA markets are electricity price-quantity transactions on a half-hourly basis.

NETA is a wholesale market, comprising trading between generators and suppliers of electricity in England and Wales. Under NETA, bulk electricity is traded forward through bilateral contracts and on one or more power exchanges. NETA also provides central balancing mechanism, which do two things: they help the National Grid Company (NGC) to ensure that demand meets supply, second by second; and they sort out who owes what to whom for any surplus or shortfalls. The majority of trading (98 per cent in the first year) takes place in the forward contracts markets. A very small percentage of electricity traded (2 per cent in the first year) is subject to the balancing arrangements.

Under NETA the market provided through power exchanges replaces the previous Pool arrangement, allowing market players to trade electricity up to one day ahead of the requirement for physical delivery. The National Grid Company (NGC) operates as system operator for England and Wales, managing the HV transmission system and also providing all the technical and operational services normally demanded by the system to ensure its integrity including load forecasting, ensuring system security and stability, frequency control, and reactive power control. NGC acts on both a physical and a financial level through the balancing mechanism, selecting bids and offers for incremental or decremental supply of electricity in order to achieve physical balance between generation and demand.

However, in April 2005, the British Electricity Trading and Transmission Access (BETTA) arrangements were applied with new set of wholesale electricity trading and transmission arrangements. BETTA which supersedes the NETA has enable competition market in the Great Britain as it becomes an extension of the England and Wales market. BETTA intends to address this restriction on market development by introducing three new features [4]:

a) A common set of trading rules so that electricity can be traded freely across the UK
b) A common set of rules for access to and charging for the transmission network
c) A GB system operator, independent of generation and supply interests so that those who seek to use the system and access the market can be confident that the system operator has no incentives towards bias

Under BETTA, generators will have much more freedom on the one hand, but be much more accountable on the other. Any generator without a customer portfolio of its own will still have to sell its electricity into the network, but it will now be able to sell that power to any companies it chooses throughout England, Wales or Scotland. And it can sell that power at a price determined solely between buyer and seller, on a contract which can start and finish at times of its own choosing.

But BETTA also means that a generator will be bound to adhere to the terms of his contract in a much more closely-regulated manner. Any under-delivery or over delivery of power against a contract puts the generator in a position of 'imbalance'. This 'imbalance' can mean that the generator has to buy power from the market or sell power to the market to maintain a balanced position. These buy or sell prices are known as System Buy Price and System Sell Price and they can be quite punitive.

2.3.2 Electricity Trading in California

The pioneer California market provided the most severe challenge to competitive electricity market philosophy. Restructuring of the ESI of California took place in 1996, with the aim of bringing the benefits of competition to consumers. Prior to this regional utilities companies-investor-owned utilities (IOUs) provided monopoly supply and services. These former utilities now each provide a regulated distribution service in their areas, allowing direct access to third-party energy service suppliers; consumers now have a choice of electricity supplier.

When the new California electricity market structure took effect, the utilities had the prices for their consumers frozen at 10 per cent below the level at vesting in the expectation that costs and prices would fall. It was anticipated that consumer electricity prices set at this level would allow the utilities to recover the cost of investments that had been made before market liberalization stranded costs. An events unfolded, this proved to be entirely unfounded and resulted in the utilities business becoming non-viable.

The crisis in the California electricity markets resulted from a combination of factors [5].

a) Exceptionally high summer temperatures significantly increasing electricity peak demand
b) A lack of generating capacity in California and the West of America in relation to the strong growth of electrical demand following economics growth in California
c) A shortage of water resulting in relatively limited hydro-power import availability from the North West of America
d) An increase in gas prices for power generation compared with previous years
e) Exercise of market power by generators and other market players.
f) Environmental restraints on the construction of new generating plant and operation of existing plant
g) Weakness flaws in the design of the electricity market including limitations on forward contracting, fixed consumer prices, but variable wholesale electricity prices
h) Insufficient importance being given to power engineering expertise in design of market structures

Shortage of installed capacity or plant availability due to outages, maintenance, or generator market power, seems to have been a key driver for the California difficulties. Structural weakness in the design of the California market include restraints on consumer prices but free competition in the wholesale electricity prices and constraints on utilities to buy through a power exchange. These factors were major contributors to the problems of California electricity market. In order to ensure proper and reliable market trading it is imperative to ensure a technically viable and reliable system. Electricity markets demand technological expertise in power engineering plus a financial and business expertise that allows market trading.

The problems in California are not inherent problems with “deregulation,” but result from the way that California implemented its reforms, combined with a good deal of bad luck and ineffective government responses to its effects. Similar reforms in other countries and other regions of the United States have been more successful in achieving their goals.

2.3.3 Electricity Trading in India

Electricity reform process in India is already in action although at a slow pace [6]. Several state electricity board are being unbundled into three distinct corporations namely Generation, Transmission and distribution. The distribution system are being horizontally broken down into manageable Distribution Companies (Distco) with separate accountability and privatized for better efficiency in metering, billing and revenue collection. The system operation functions at the regional/national level can be with central transmission utility, while state transmission utilities may manage load dispatch centers in line with transmission system operator (TSO) concepts and these should not be allowed to have financial interest in the trading of power.

One power pool in each state managed by State Transmission Utilities (STUs) and one in regional basis Central Transmission Utilities (CTU) may be established. Regional Electricity Board (REBs) can assume the responsibility to operate the regional power exchanges. Since REBs are proposed for managing the power exchanges, certain important planning and operational functions should be transferred to the Regional Load Dispatch Centre (RLDCs). All the non-competitive old generators and old IPP having old contracts shall remain under regulatory control of the regulatory commissions and should supply power to the state power pools only at the regulated price. Information flow is one of the main concerns along with the Distribution Management System (DMS), which is presently at a very nascent stage. These must be properly addressed before adopting competition at retail level.

2.3.4 Electricity Trading in Korea

With a vertically integrated power system, the Korean utility provided the electricity successfully during the past decades with high economic development and high demand growth. And the productivity of the industry and price level was believed to be beyond the international average. Nevertheless, Korean electricity industry had a strong push for structure changes or restructuring [7]. As a matter of fact there was an evaluation works on the management of Korean Electrical Power Company (KEPCO) from July, 1994 to June, 1996 conducted by Korea Industry and Economy Research Institute and two accounting firms, from which a phase-in approach for the restructuring and privatization of the electric power industry was recommended. From June in 1997, a committee, named "Electric Power Industry Restructuring Committee", consisted 12 members of scholars, researchers, industry personnel and experts from related fields was formed to promote restructuring the electricity supply industry (ESI) in Korea. The major forces for the restructuring may be summarized as follows:

a) The economic crisis started at the end of 1997 leading the Government to initiate the fundamental reform of the industrial structure to improve the national productivity: The public industries such as electric utility were among the main targets of the reform.

b) International trend towards competitive electricity market recognizing the benefits of competition in the electricity supply industry: The international evidence in support of restructuring was compelling.

c) Potential inefficiencies in oversized KEPCO and public ownership: There has been general belief that public ownership and monopoly would eventually result in economic inefficiencies, which induced skepticism about the efficiency of KEPCO.

d) Steep increase of electricity demand requires additional 45,000 MW to be built by 2015.

e) Lack of capital due to retail price regulation: By 2015 investment and private or foreign funds of about 56 billion dollars or 7.5 billion dollars annually are required to build new power.

2.4 The structure of electricity supply industry (ESI)

There several models of structure that have been designed based on the region itself, but the four basic structure models of the electricity industry that have been widely adopted are [8]:

a) Model 1: Vertically Integrated Utility/Monopoly

b) Model 2: Single Buyer Model/Purchasing Agency

c) Model 3: Wholesale Competition

d) Model 4: Retail Competition

These model is seems to be the steps or process in order to achieve the ESI objectives and build a better structure. There are also country that tried to change the structure instantaneously but it require detailed design as complexity of the market model is proportional to the types of competition that being held.

2.4.1 Model 1: Vertically Integrated Utility

Model 1 indicates the most common electricity industry structure prior to deregulation. In this model, the utility controls and owns all or most of generation, transmission and distribution facilities within its region. It also performs a monopoly on selling electric power to consumers; hence there is no competition occurs and customers have no choice but to purchase electricity from their own local utility. The utility has full control and is responsible over all sectors of generation, transmission and distribution within its control area. The utility can be either publicly owned and not operated for profit, or has rates (prices) that are set by regulatory organizations.

Figure 2.1 (a) below indicates completely vertical integrated utilities which fully own generators (GenCo), transmission (TransCo and GridCo) and distribution (DistCo) sectors while for Figure 2.1 (b), the generations and transmission are handled by one utility which sell the energy to local monopoly distribution companies that could be one or more separate companies.

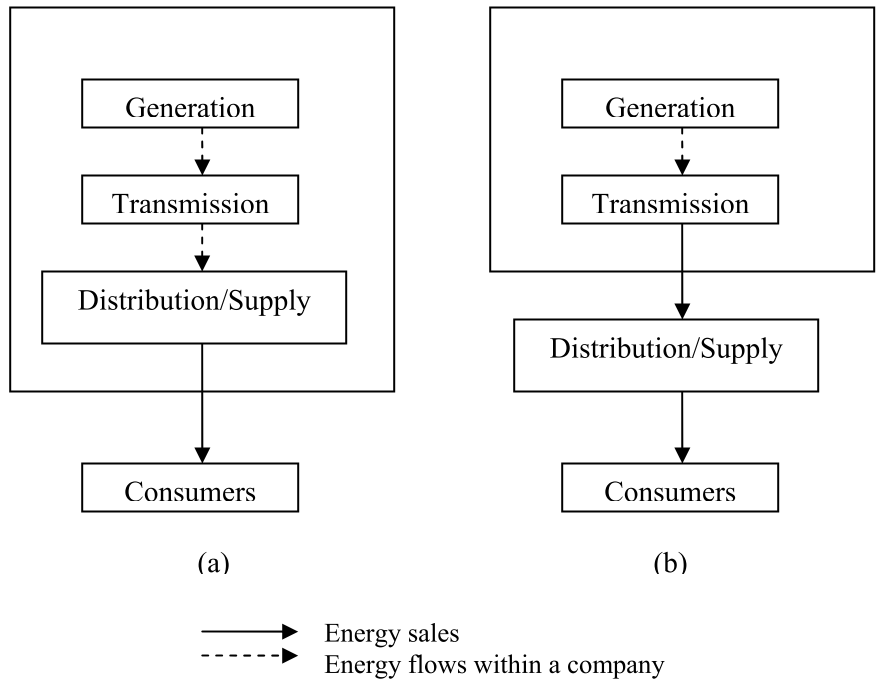


Figure 2.1 Vertically Integrated Utility (VIU)

2.4.2 Model 2: Single Buyer Model / Purchasing Agency

The single buyer model is being the first step toward the introduction of competition in the electricity supply industry. This model was first seen in developing countries in the 1990s. During that time, governments in several countries authorized private investors to construct power plants and be the independent power producers (IPPs). These IPPs is to generate electricity and sell it to the national power company so that there will be no shortage of electricity. This model allows the single buyer which is the purchasing agency, to choose a number of different generators to encourage competition in generation.

Some governments went further and split the national utility into generation, transmission and distribution companies, intending ultimately to turn over generation and distribution facilities to the private sector. Most decided to keep strategically important transmission and dispatch facilities in state hands, however, and awarded exclusive rights to the newly formed transmission and dispatch company and thus become the single buyer where it will purchase electricity from generators and sell it to distributors.

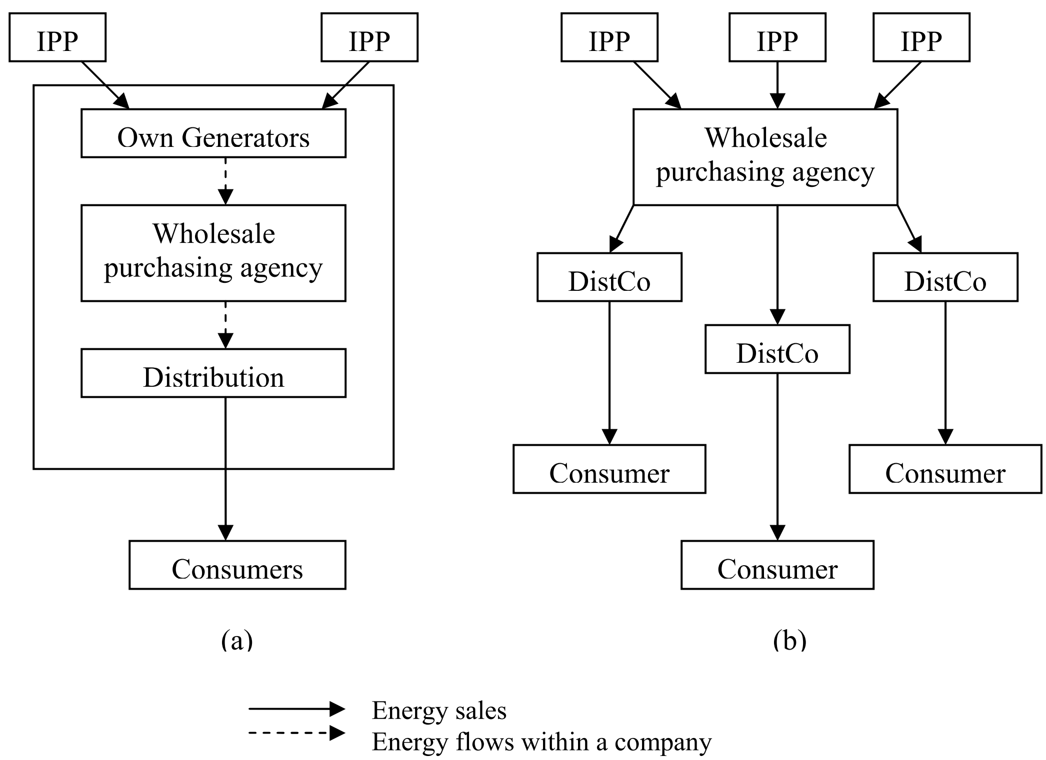


Figure 2.2 The single buyer model for electricity trading

Figure 2.2 (a) shows the integrated version of single buyer which competition only occurs at generation sector. Figure 2.2 (b) represent the disaggregated version and indicates further evolution of the model where the utility no longer owns any generation capacity and purchases all its energy from the IPPs. The distribution and retail activities are also disaggregated as DistCo purchase the energy consumed by their consumers from the wholesale purchasing agency. The rates set by the purchasing agency must be regulated because it has monopoly power over DistCo. This does not cover a cost reflective price but has the opportunity to introduce competition without extra expenses.

2.4.3 Model 3: Wholesale Competition

In this model, no central organization is responsible for the provision of electrical energy and the transmission network is open to all parties. DistCo purchase the electricity consumed by customer directly from generating companies. This allows generators to compete and sell their electricity directly to any distribution companies and brokers or offer it in a power exchange. In turn, the company collects payments from the generators and distribution companies for using their transmission facilities and services. These transactions take place in a wholesale market through two types of transaction; either pool trading or bilateral contract trading. The only functions that remain centralized are the operation of the spot market and the transmission network. Figure 2.3 depicted the wholesale competition model.

Distribution companies in this phase have the dual role of operating the distribution network and selling electricity. The latter role requires distribution companies to shop around and get the best deals from generators. This has prompted the growth of brokers and power exchanges, which can facilitate further competition. If necessary, distribution companies can also agree on long term contracts, which can stabilized the price of their electricity purchases. Wholesale competition can further liberalize the market and bring down wholesale electricity prices.

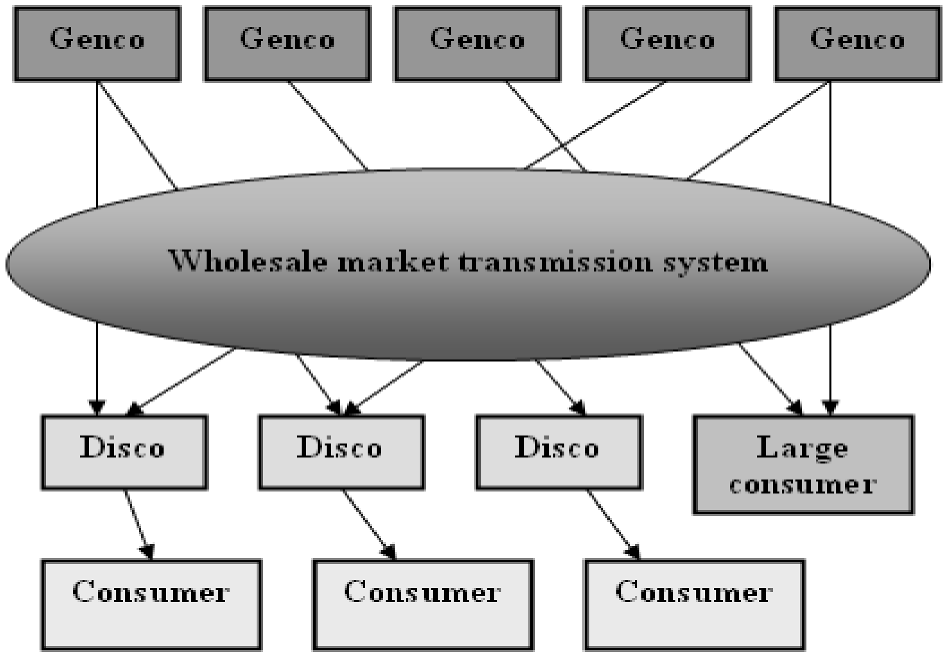


Figure 2.3 Wholesale Competition model

2.4.4 Model 4: Retail Competition

Figure 2.4 describes final form of competitive electricity market in whereby all consumers can choose their supplier. Because of the transaction costs, only the largest consumers choose to purchase energy directly on the wholesale market. Small and medium consumers purchase it from retailers, who in turn buy it in the wholesale market.

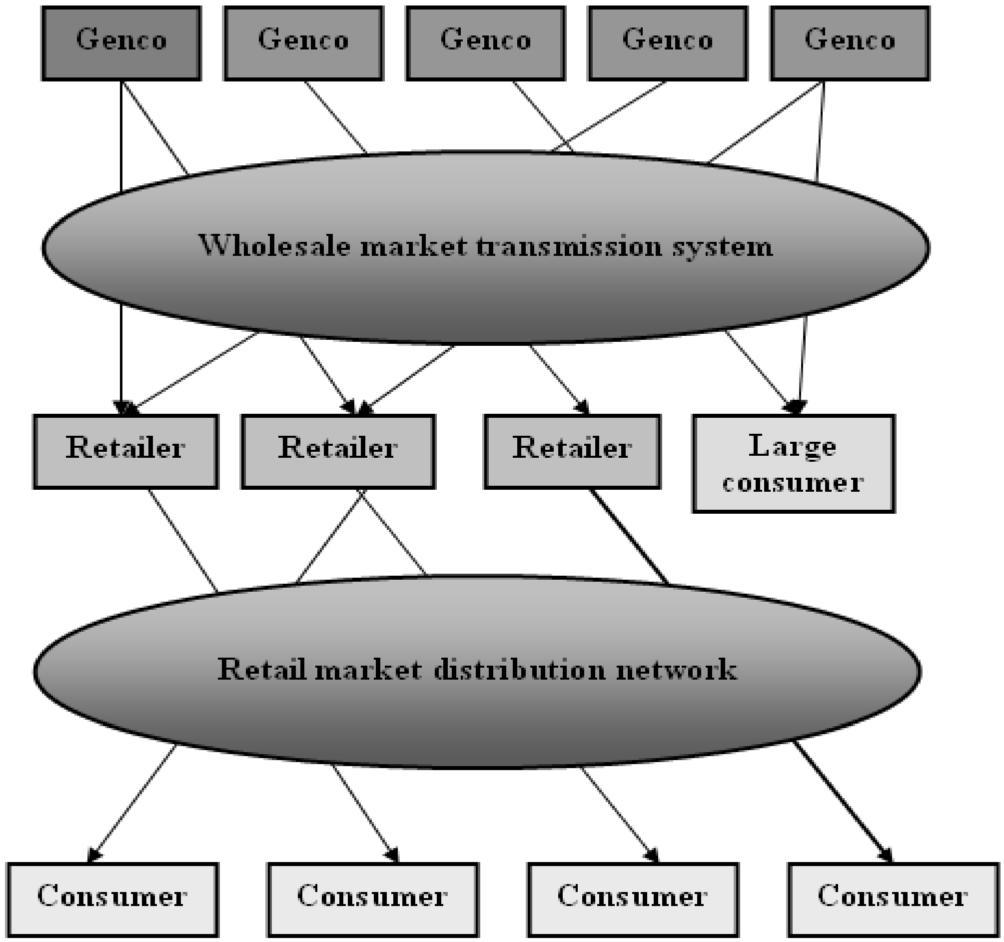


Figure 2.4 Retail Competition model of electricity market based

In this model, the activities at the distribution companies are separated from the retail activities because they no longer have a local monopoly for the supply of electrical energy in the area covered by their network. The only remaining monopoly functions are thus the provision and operation of the transmission and distribution network. The retail price no longer has to be regulated because small consumers can change retailer when they are offered a better price. From an economics perspective, this model is the most satisfactory because energy prices are set through market interactions. However, it requires considerable amounts of metering, communication and data processing. The cost of the transmission and distribution network is still charged to all their users as it is done on a regulated basis because these networks remain monopolies.

Table 2.1 below shows the summarization of important characteristic for each model. These models have quite different types of trading arrangements which require different sorts of contracting arrangements and have different regulatory requirements. These models also may require different ownership for the companied operating in the sector and have different implication for stranded assets. These dimensions do not define the models. The defining characteristic which distinguishes the models from each other is competition and choice.

Table 2.1: Structural Alternatives

Characteristic	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Definition	Monopoly at all levels	Competition in generation	Competition in generation and choice for Distcos	Competition in generation and choice for final consumers
Competition Generators	NO	YES	YES	YES
Choice for retailers	NO	NO	YES	YES
Choice for final consumers	NO	NO	NO	YES

2.5 Electricity Trading Arrangements

The trading arrangements in a model are the set of rules buyers and sellers (collectively, traders) have to follow when they make transactions [9]. 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. In Models 1 and 2, these decisions can be taken jointly with the decision to build plant, and there is no need for separate prices; but in Models 3 and 4, prices have to do the work of optimizing location and dispatch.

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 Contract Model

d) Multilateral trading which combines the pool and bilateral model

Malaysia is one of the developing countries that currently apply the single buyer model for their electricity trading arrangements. The aim of this study is to identify both pro and cons for each electricity market models besides analyzing the economic benefits among the players. Detail explanations regarding electricity trading arrangement will be covered in the first three models listed above. The single buyer model, pool market model and bilateral market model will be explained further later in Chapter 3, Chapter 4 and Chapter 5 respectively. No detail explanation on the multilateral trading model as it only combines of both pool and bilateral model features. Under this model, it is flexible that both sellers and buyers are option to choose trading through the pool or bilateral contract. The pool would serve all participants (buyers and sellers) who choose not to sign bilateral contracts. On the other hand, the participant who may acquires the economic equivalent of bilateral contracts if they do not take part in the pool system. This market model requires a power exchange (PX) involvement to act as an exchanger to balance supply and demand as well as running pool system.

2.6 The Economic Viewpoint of the Parties Involved

There are much different roles that GenCo, TransCo and DisCo play in single buyer, pool trading and bilateral contract models. The Table 2.2 set out the economic point of view of different parties in each market models in brief. The details economic viewpoint on these electricity market models in term of generation revenue will be explained in Chapter 6 and Chapter 7.

Table 2.2: The Economic Viewpoint of Parties Involved

<table>
<tr><th>Model</th><th>Single Buyer Model</th><th>Pool Trading Model</th><th>Bilateral Contract Model</th></tr>
<tr><td>GenCo</td><td>1. Power sold to GenCo is guaranteed through PPA
2. Long term PPA is attractive since the payment collection from purchasing agency is profitable. i.e. capacity payment and energy payment apply
3. Competition between GenCos is not intensive as in other models.</td><td>1. Power sold to PoolCo is based on merit order, the least generator will sell first in line
2. Only based on the energy price that have to reflects all the production costs
3. Create competition among generators as they will submit the lowest bid</td><td>1. Direct sells power to DisCo through the contract agreed by both parties
2. Only energy payment is apply, hence more competition between GenCo.
3. Bidding price based on the available capacity</td></tr>
<tr><td>TransCo</td><td>1. No access fee and the cost is covered by the purchasing agent</td><td colspan="2">1. Only provide power transmission and facilities maintenance services, and collect access fee from both GenCos and/or DisCos.</td></tr>
<tr><td>DisCo</td><td>1. Buy power from only one source, i.e. TransCo
2. The energy price is stable and therefore easier for end customers make investment decision. But the price is fixed</td><td>1. Buy power from Independent Market Operator
2. The energy price is uncontrollable. It based on the bid and offer by the market players</td><td>1. Freely negotiate with different GenCos to achieve the needs (e.g. price and delivery)
2. Have to consult with TransCo for delivery and the transaction is based on the lines security</td></tr>
</table>

CHAPTER 3

CURRENT ELECTRICITY MARKET IN MALAYSIA

3.1 Introduction

The history of electricity supply industry in Malaysia has started since as early as the year 1894 when the first electricity was generated by a private entity for its own consumption. In 1949, a national company named Central Electricity Board (CEB) was established which later changed its name to National Electricity Board (NEB). In a move to improve efficiency as well as to reduce the government's financial burden, the NEB had been corporatised and later privatized in 1990 under the name of Tenaga Nasional Berhad (TNB). Its core functions include generating, transmitting and distributing electricity to consumers. In its effort to break the monopoly and encourage competition, the government of Malaysia had allowed Independent Power Producers (IPPs) to participate in the generation sector and since then Malaysia Electricity Supply Industry (MESI) had applied the single buyer model with the TNB as the purchasing agency.

3.2 MESI towards Restructuring

Malaysia is currently undergoing reforming its electric supply industry into a more transparent, effective and competitive power market. In March 1998, the Government made the decision to establish an Independent Grid System Operator (IGSO) as part of the 7th Malaysian Plan and in the same year a decision was also made to revise the regulatory framework for the energy sector. These government driven initiatives can be summarized below:

a) Repeal the Electricity Act 1990 and enact the Electricity Act 2001
b) Enact the Energy Commission Act and the formation of the Energy Commission; and
c) Establish and operationalise the Independent Grid System Operator (IGSO) with core functions of long term generation and transmission planning market dispatch planning and settlement.

The restructuring of the MESI has been driven by a number of objectives. These objectives have been spelt out by the government and have been used as the guiding principle to evaluate and recommend a course of action.

a) To achieve transparency in the ESI
b) To promote efficiency in the utilization of financial and technical resources in the development and operations of the industry
c) To provide a level playing field for all players in the ESI
d) To achieve competitive electricity prices for all consumers

The proposed MESI structure would include generation, transmission, distribution, retail, an independent market operator (IMO) and a grid system operator

(IGSO) [10]. The IMO would be the new market administrator and long term planner who will be responsible for introduction competition into generation market initially and possibly the retail market. Nevertheless, the target of operating the IMO by 1st January 2001 was not achieved.

The first stage of the restructuring known as Stage I (Single Buyer Model) was succeeded to be operated in year 2001. This model is intended to create competition at the generation level via the establishment of a power pool with a Single Buyer of power from the market. TNB is expected to be the single buyer at this stage. Meanwhile, a Multi Buyer Model which is the Stage II, was proposed to be operated in year 2005 but was put on hold as other target was put on hold as well. This model supposedly will further enhance the wholesale market by introducing more than one buyer from the power market to provide for specific segments of customers. Table 3.1 shows the plan headed for the restructuring, the targeted year and the current status.

Table 3.1: MESI Planning Towards Restructuring

Year	**Planning**	**Status**
1992	The introduction of independent power producer	Done
1998	Establish an independent grid system operator (IGSO)	On Hold
2001	Operational date of the independent market operator (IMO)	On Hold
2001	Stage 1: Single Buyer Model -competition among generators	Done
2005	Stage 2: Multi Buyer Model / Wholesale market -competition among generators and distributors	On Hold

The monopoly status of Tenaga Nasional Berhad (TNB) in electricity industry comes to an end when the Malaysian Government decided to introduce Independent Power Producers (IPPs) in the generation sector with the aim of not only to avoid electricity shortage but also to facilitate competitions among generators. Yet, the TNB still conquers the electricity market in term of its transmission and distribution. YTL Corporation Sdn. Bhd. is the first IPP awarded the licence to construct gas-fired power and from time to time, new IPPs have been given the permission to supply the electricity. At this point of time, there are fourteen private producers that serve electricity throughout Peninsular Malaysia via TNB. The total installed capacity for these private power producers is reached up to 14775.40 MW.

Eventually, Malaysian Electricity Supply Industry (MESI) which was traditionally vertically integrated had moved to a single buyer model in 2001. In this model, TNB was the power purchasing agency which has the authority to choose a number of generators base on their energy bid price in order to supply the electricity for peninsular of Malaysia. This had created a competitive environment in the generation sector. MESI aims to establish an Independent Grid System Operator (IGSO) and Independent Market Operator (IMO) in 1998 and 2001 respectively but fails to do so. The plan to move on with the application of Multi Buyer Model in 2005 is being put on hold as other plans are being halted as well. These may due to the effect of California's Crisis and the long term agreement bonded between the private power producers and Tenaga Nasional Berhad (TNB).

3.3 Implementation of Single Buyer Model in MESI

The single buyer model first appeared in developing countries in the 1990s. In order to relieve capacity shortages while conserving scarce public resources, governments in several countries authorized private investors to construct power plants. The independent power producers (IPPs) have to generate electricity and sell it to the national power company or the power purchasing agency. IPPs sold their output through long term power purchase agreements (PPA) that consists of fixed capacity charges to protect investors from market risks.

The government of certain countries went further and split the national utility into generation, transmission, and distribution companies, intending ultimately to turn over generation and distribution facilities to the private sector. Most decided to keep strategically important transmission and dispatch facilities in state hands, however, and awarded exclusive rights to the newly formed transmission and dispatch company which will be the single buyer. The agency had to purchase electricity from generators and sell it to distributors. In theory, transmission and dispatch can be separated from the wholesale electricity trading monopoly. However, in practice, developing countries opting for the single buyer model kept these functions together to reduce transaction costs.

The single buyer model is implemented in MESI since 2001. In this model, the TNB plays the role as the power purchase agency which is obliged to buy the electricity generated by Tenaga Nasional Berhad Generation (TNBG) itself and the Independent Power Producers (IPPs). Although IPPs were introduced to provide competition in generation, the terms under which these IPPs were introduced did not affect real competition in generation. The PPAs between the IPPs and TNB as power off-taker provided for guaranteed return for the IPPs with very little risk borne by them over 21 years tenure. Most of PPAs are structured in such a way that they comprise of a two tariff which is capacity payment and energy payment portion. The detail terms included in this agreement will be explained further is next section.

The current structure of Malaysian Electricity Supply Industry (MESI) is depicted as in Figure 3.1[2]. It can be seen that all power producers can only sell their output to the TNB Transmission and Distribution and cannot directly go to the consumer's side. This means that the power producers do not have any other choice except depends on competition among each other. On the other hand, the TNB Transmission and Distribution has the authority to choose a number of generators that will supply the demand required by the consumers. The centralized electricity at power purchasing agency also can be purchased by local distributors before being distributed to the consumers.

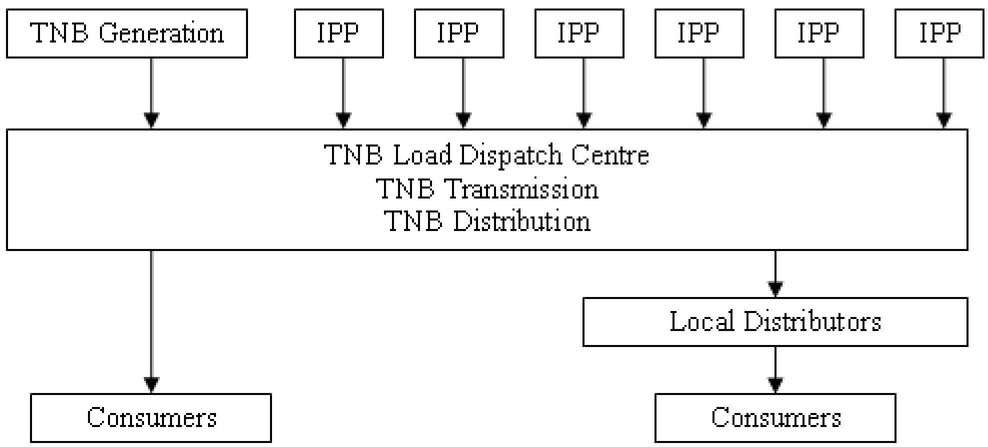


Figure 3.1: MESI structure; Single Buyer Model

3.3.1 Power Purchase Agreement (PPA)

A power purchase agreement (PPA) is a contract for the sale of energy, availability and other generation services from an independent power producer (IPP). It is normally developed between the owners of private power plants and the buyer of the electricity. Therefore, this agreement is widely being used in the single buyer model occupied competition in generation sector. The single buyer is the central purchasing agency, who may be the operator of a transmission grid performing the roles of dispatch and network control, or alternatively an integrated generating company. However, PPAs may also be used in more competitive systems such as wholesale competition and retail competition, for sales of electricity from a single IPP to an electricity wholesaler or aggregator. The wholesaler could combine purchases under a number of PPAs with spot purchases and sales, to assemble the volume of electricity required to service wholesale or retail contracts. PPAs may therefore be found in any system where it is possible to establish an IPP.

As Malaysia had introduced the private producers in generation sector, the PPA is being signed between the IPP and TNB as the purchasing agency. This agreement is valid for 21 years, whereby the usual range of this kind of agreement is between 15 to 20 years. A guaranteed return for IPPs with little risk is stated clearly in this agreement in order to encourage more private investors to participate. However, later on, the term in the PPA had created a problem to TNB. The basic information contains in this agreement are [11]:

a) Definitions
b) Purchase and sale of contracted capacity and energy (such as steam, hot water and/or chilled water in the case of cogeneration and trigeneration plants)
c) Operation of the power plant
d) Financing of the power plant
e) Guarantee of performances
f) Penalties
g) Payments (capacity payments which covers the capital costs of the generators and energy payments to cater for the variation of demand during plant operation)
h) Force majeure
i) Default and early termination
j) Miscellaneous

k) Term and conditions

The main economic elements of PPAs are the clauses relating to energy prices and payment for availability. However, this study will discussed the depth explanations on energy price, payment for availability, payment for ancillary and other terms and conditions [8]. This is because this thesis is focuses on the economic aspects from the perspective of the generators.

3.3.1.1 Energy Price

The energy price, in RM/MWh, is the price paid per unit of incremental output. The energy price is a key determinant of the pattern of dispatch. Ideally, generators should run in "merit-order", i.e. only the generators with the lowest running cost (i.e. variable costs per unit) should be generating to meet demand. If an IPP has a contract in which the energy price lies above its variable cost of output, the incentive for efficient dispatch is lost. The owner of IPP will want to run at all times, regardless the cost of other generators on the system and even if the IPP displaces other, cheaper generators. On the other hand, the dispatcher will be reluctant to dispatch the IPP except at times when the marginal cost of other generators is very high; the dispatcher may hold the IPP off the system, even when it represents a cheaper source than some generators who are currently on line.

For efficient dispatch, the dispatcher needs to know (and pay) the IPP's actual variable cost of generation. The energy price is therefore should be as close as possible to the costs of fuel burnt in generating 1MWh, plus some allowance for operation and maintenance costs which depend on the level of energy production. The dispatcher will then dispatch the IPP only when it is cheaper than other sources. The owner of the IPP will be indifferent to the pattern of dispatch, as it will have no bearing on total profits. However, since the IPP has no particular incentive to run, the IPP's earnings must be made partially conditional on availability, which will be explained later.

The energy price may take a simple form, i.e. just a single price per MWh. However, it is possible for the PPA to specify different prices for different stages of operation, e.g. a price per start-up, and a different price for different levels of output. Sometimes penalties are charged if generators fail to generate according to the instructions of the dispatcher, to encourage them to generate exactly as instructed.

Energy prices may be fixed, or set by a formula which includes separate terms for the cost of fuel and the assumed rate of conversion into electricity ("thermal efficiency"). It is usually possible to estimate the likely level of efficiency in combustion. However, the cost of fuel can vary widely. Fixing the unit cost of fuel in the PPA would expose the owner to risk, in the event that actual fuel costs rose. Whenever actual costs rose above this figure in the PPA, the IPP would make a loss on every kWh generated and its owners would be unwilling to let it be run at all.

One way to limit the risk is to include the actual purchase costs of the generator's fuel and its actual thermal efficiency. However, energy prices in PPAs do not usually reflect the full actual costs of generation incurred by the generator, since this rule would remove any incentive for the IPP to seek out lower cost fuels, or to increase efficiency of operation. Instead, energy prices in PPAs usually tied to the external, of fuel prices, thermal efficiency and other variable costs, which are not influenced by the decisions of the IPPs themselves. The owners of the IPP then have a profit incentive to operate more efficiently and to find cheaper fuel sources because, by doing so, they cut their costs but leave their revenues unchanged.

Indexing energy prices in this way provides a strong incentive for efficiency, but still imposes some risk on IPPs, since the index may fail to reflect some special factor which increases the IPP's fuel costs (such as an increase in local transportation costs). Some of fuel prices indices therefore include an allowance for the IPP's actual fuel costs, where they can be observed. The more heavily the index reflects the IPP's actual fuel costs, the lower the risk faced by the owners, but the weaker the incentive for the IPP's owners to minimize costs. The owner of the generator and the buyer of the generator's output therefore have to negotiate an index, which achieves an acceptable balance of risk and incentives.

For the conclusion, the energy price should cover the variable cost of output when requested by the dispatcher. This provides the information that the dispatcher needs to ensure an efficient dispatch. The price should therefore reflect as closely as possible the actual variable cost of generation, but should be tied to external indices of fuel prices to give the generator an incentive to minimize fuel (and other) costs.

3.3.1.2 Payments for availability

Availability payments in PPAs perform two main roles which are to:

a) Provide extra revenue to the generator, to cover the capital and other fixed costs which are not covered by the energy price per MWh

b) Provide incentives for generators to be available at times when the system needs generation capacity.

The second of these roles is particularly important for mid-merit and peak generators, which need to be available at specific times of the year, when the value of generation is particularly high. However, even base load generators need to be given representative signals about the value of their output to the system, to ensure that they time their maintenance outages to coincide with periods when the system is in surplus and the value of output is low.

The first step in negotiating availability payments is to agree a target level of availability in terms of a MW level and a number of hours per year. The target level of availability may be specified for the year in total. Next, the PPA must specify the fixed annual payment to be paid if the generator achieves the target of availability. The fixed annual payment would normally be expected to cover the non-variables of the generator, including a normal rate of profit. Finally, the contract must specify a system of availability bonuses and penalties for availability above or below the target level. These bonuses and penalties give the generator a continuous incentive to ensure that the generator capacity is maintained and available.

Availability payments are needed to cover the non-variable costs which are incurred to keep the generator available, whether or not the generator is required to produce energy. Each MWh of availability is worth the difference between the economic value of the generator's output and the incremental variable cost of its output. Ideally, the incentive for availability should reflect the actual economic value of energy on the system as a whole in any hour, but investors may prefer to limit their risk by defining contract availability payments which reflect prior estimates of the economic value.

3.3.1.3 Ancillary Services

As well as the energy price and payments for availability, a PPA should also contain clauses on the following matters, which sometimes referred to as “ancillary services”:

a) Performance of frequency control
b) Provision of short term reserve generation (spinning or standing)
c) Provision of voltage control (reactive power)
d) Payments for emergency generation (incremental output above normal levels, or “black starts” after a system outages)

The exact terms in these clauses will depend very much on conditions in each electricity system. Important considerations include, the cost providing the service; the value of the service to the system; and the ease with which output can be monitored. The terms of PPAs will also be affected by the terms implicit in any other technical agreements which impose obligations on generators or others. For example, all generators may have to provide frequency control as a condition of connecting to the network; further payment will not be required, unless the system operator wishes to encourage some generators to act more responsively than others.

3.3.1.4 Other terms and conditions

Finally, any PPA must include provision for a variety of other eventualities. A checklist of important technical issues might include:

a) Any constraints on the flexibility of operating the generator;

b) Procedures for maintenance scheduling;

c) Treatment of forced outages

In addition, the PPA must allow for adjustment of the terms in the light of unforeseen events caused by others. Apart from a general force majeure clause, a PPA would normally refer to:

a) Changes in the regulatory regime and any other documents (such as a grid code) which would materially affect the costs of the IPP;

b) The length of contract and conditions for contract termination;

c) Conditions for renegotiating the contract if any other conditions change.

If the sum of energy payments, availability payments and earnings from the sale of ancillary services is not enough to cover the costs of the generator, then the case for building it is rather weak. The sum of energy, availability and ancillary service payments represents the plant's total value to the system. If the payments do not cover the plant's costs, the plant is not economic. However, government policy may require some additional cost to be incurred, e.g. for environmental reasons, or to support generators who use domestic fuel, or to locate generators in a particular region. The additional cost should be added to the fixed charge, so that it does not distort decisions about availability and output.

In summary, negotiators must ensure that a PPA is designed in a way which encourages efficient operation and dispatch of the generator. Without the clear market price signals provided in a competitive system, this is a difficult task and many PPAs have been badly designed in ways which lead to gross inefficiency. However, the task is not impossible and examples of good PPAs are now found in a number of countries.

The benefits of designing PPAs efficiently have frequently been shown to justify the effort involved.

3.3.2 Installed Capacity and Generators Location

The current peninsular Malaysia Installed Capacity as shown in Table 3.2, where TNB owns 7 thermal plants, and 9 hydro power plants, while IPPs contribute more than 70 percent of the installed capacity with 14 power plants. The summarized of peninsular Malaysia installed capacity as shown in Table 3.3. The Figure 3.2 shows the location of these generators.

Table 3.2: List of individual TNB and IPP power plant

No	Power Plant	Owner TNB / IPP	Installed Capacity (MW)	Type of Plant
1.	Stesen Janakuasa Sultan Ismail, Paka	TNB	1006MW	CCGT
2.	Stesen Janakuasa Sultan Iskandar, Pasir Gudang	TNB	634MW	CCGT, OC, Thermal
3.	Stesen Janakuasa Tuanku Jaafar, Port Dickson	TNB	703MW	CCGT
4	Stesen Janakuasa Putrajaya, Serdang	TNB	577MW	OC
5	Stesen Janakuasa Gelugor	TNB	303MW	CCGT
6	Stesen Janakuasa Teluk Ewa	TNB	62MW	Thermal
7	Stesen Janakuasa Jmbtn Connaught	TNB	756MW	CCGT, OC, Thermal
8	Stesen Hidroelektrik Kenyir	TNB	4x100MW	Hydro
9	Stesen Hidroelektrik Pergau	TNB	4x150MW	Hydro

10	Stesen Hidroelektrik Temenggor	TNB	4x87MW	Hydro
11	Stesen Hidroelektrik Bersia	TNB	3x24MW	Hydro
12	Stesen Hidroelektrik Kenering	TNB	3x40MW	Hydro
13	Stesen Hidroelektrik Chenderoh	TNB	3x9MW,7MW	Hydro
14	Stesen Hidroelektrik Upper Piah	TNB	2x7.3MW	Hydro
15	Stesen Hidroelektrik Lower Piah	TNB	2x27MW	Hydro
16	Stesen-Stesen Hidroelektrik Cameron Highland: (a) JOR (b) WOH (c) Odak (d) Habu (e) Kg. Raja (f) Kg. Terla (g) Robinson Falls	TNB	 (a) 4x25MW (b) 3x50MW (c) 4.2MW (d) 5.5MW (e) 0.8MW (f) 0.5MW (g) 0.9MW	Hydro
17	YTL Power Generation Sdn. Bhd.	IPP	3x390MW	CCGT
18	Genting Sanyen Power Sdn. Bhd.	IPP	740MW	CCGT
19	Segari Energy Ventures Sdn. Bhd.	IPP	1303MW	CCGT
20	Port Dickson Power Sdn. Bhd.	IPP	4x109.1MW	OC
21	Powertek Berhad	IPP	4x108.5MW	OC
22	Pahlawan Power Sdn. Bhd.	IPP	322MW	CCGT
23	Panglima Power Sdn. Bhd.	IPP	720MW	CCGT
24	GB3 Sdn. Bhd.	IPP	640MW	CCGT
25	Teknologi Tenaga Perlis Consortium Sdn. Bhd.	IPP	650MW	CCGT
26	Prai Power Sdn. Bhd.	IPP	350MW	CCGT

27	Kapar Energy Ventures Sdn. Bhd.	IPP	2420MW	OC, Thermal
28	TNB Janamanjung Sdn. Bhd.	IPP	3x690MW	Thermal
29	Tanjung Bin Power Sdn. Bhd.	IPP	3x700MW	Thermal
30	Jimah Energy Ventures Sdn. Bhd.	IPP	2x700MW	Thermal

Table 3.3: Summarised of current Malaysia installed capacity (Peninsular)

Generators	**Capacity (MW)**
TNB Generators (7)	4041
TNB Hydro (9)	1904.50
Independent Power Producers (IPPs) (14)	14755.40
Total	**20700.90**

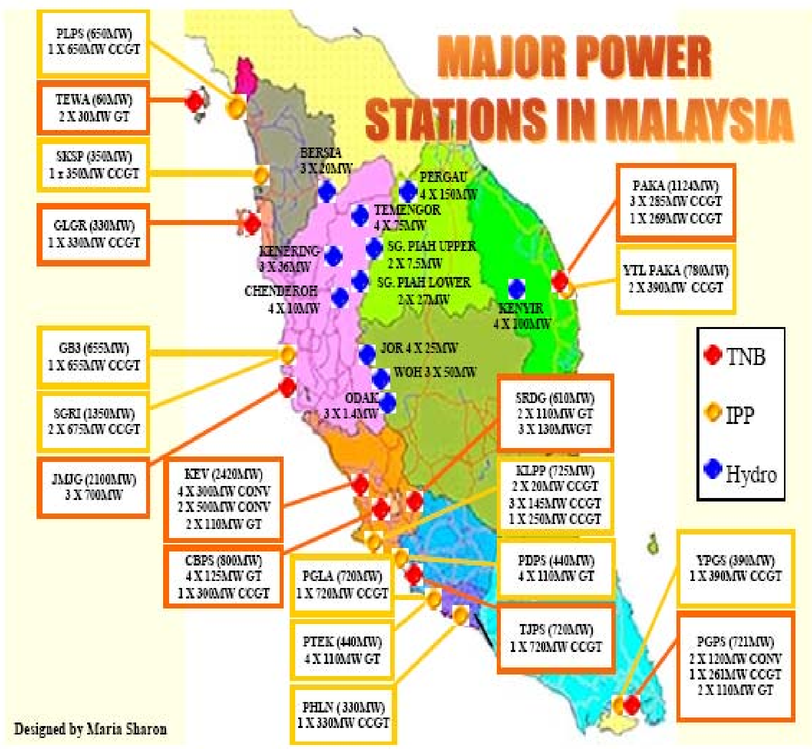


Figure 3.2: Generators Location in Peninsular Malaysia

3.3.3 Economic Aspect of Single Buyer Model

One of the objectives of restructuring is to promote a healthy competitive environment in the electricity trading. Trading in MESI, does not lead to transparent competition. This is due to the terms provided under the Power Purchase Agreement (PPA) between TNB and IPP. TNB acts as purchaser of the electricity while IPPs is the seller of electricity. In other words, TNB is a ready buyer of all generated electricity by IPPs and hence do not encourage transparent competition among the power producers. The IPPs has no choice to sell their output to other buyer except to TNB. This situation has reduced the opportunity for IPPs to supply directly to nearby industry and therefore, depend on assured single buyer, i.e. TNB for their revenues.

TNB is legally responsible to cater all payment contracted in the PPA. The profits of many IPPs were reaping at the expense of TNB which suffered of massive profit erosion as a result of it payouts to IPP. In single buyer model, each of private producers gain their revenue based on the two types of payments rated in PPA which are capacity payment and energy payment. As stated in previous section, the capacity payment (RM/kW/month) is to cover the capital and other fixed costs which are not covered by the energy price per kWh. Meanwhile, the energy payment is the price paid per unit of incremental output. Therefore the mathematical equation which represented these types of payment can be written as:

Capacity Payment for each generator,

$$G_i = \text{Available Capacity} \times \text{Capacity Price}$$

$$G_i = P_{Gi} \times C_{Gi} \tag{3.1}$$

Energy Payment for each generator,

$$G_{Ei} = \text{Power Output} \times \text{Energy Price}$$

$$G_{Ei} = P_{EGi} \times C_{EGi} \qquad (3.2)$$

All IPPs were paid monthly based on these payments, depending on the price rate in each agreement except for YTL Corporation Sdn. Bhd. where payment is being paid by using energy price rate. This is due to a special deal that was made whereby 80% of their installed capacity is being guaranteed to be bought by the TNB. All information regarding capacity and energy price rate for each IPPs are confidential. But, it is known that the duration of capacity price is the range of RM20/kW to RM40/kW and it depends on the type of generation for each power plant.

Actually, there is a different between these two payments. One can conclude that the capacity payment is an unfair trading since payment is made regardless of electricity usage. But for energy payment, it is required because the generators are paid for the works that they have done. The price of capacity payment is fixed and TNB must pay regardless the usage. Meanwhile, the price of energy payment is based on the utilization of electricity per hour. Notice that, each of IPPs used different types of fuel to generate electricity and thus gave TNB variation price for capacity and energy payment. In order to make the concept clear, let consider an example of generation revenue for Tanjung Bin power plant in an hour.

The installed capacity for Tanjung Bin power plant is 2100 MW. Let say the capacity price is RM 36/kW/month and energy price is RM200/MWh. For an hour, TNB used electricity has produced by Tanjung Bin about 1500 MW. For that particle of hour, TNB have to pay to Tanjung Bin;

The capacity payment paid to the Tanjung Bin power plant for that hour;

$$G_i = 2100\text{MW} \times \frac{\text{RM36}}{30 \times 24\text{kWh}} \times 1000 = \text{RM105000.00/h}$$

On the other hand, the energy payment paid to the Tanjung Bin power plant for that hour;

$$G_{Ei} = 1500\text{MW} \times \text{RM200/MWh} = \text{RM300 000.00/h}$$

Therefore, the total revenue that Tanjung Bin had obtained for that purposed of hour is the summation of capacity and energy payment is equal to **RM 405 000.00**. The TNB is the one who obliged to pay the amount.

From above example, it can be seen that the total generation revenue of all power producers involved in the single buyer model are able to be derived and the mathematical equation can be written as below:

$$G_T = G_1 + G_2 + ... + G_k \quad (3.3)$$

$$G_T = \sum_{i=1}^{k} G_i \quad (3.4)$$

$$G_i = (P_{Gi} \times C_{Gi}) + (P_{EGi} \times C_{EGi}) \quad (3.5)$$

Thus,

$$G_T = \sum_{i=1}^{k} [(P_{Gi} \times C_{Gi}) + (P_{EGi} \times C_{EGi})] \quad (3.6)$$

Where,

P_{Gi}	=	Power capacity available by ith generator in MW
C_{Gi}	=	Capacity Price for ith generator in RM/MWh
P_{EGi}	=	Power output generated by ith generator in MW

C_{EGi}	=	Energy price for ith generator in RM/MWh
k	=	Numbers of generators involved
G_T	=	Total generation income in RM/h

However, there are cases in the single buyer model where generators are only being paid using energy price without capacity price. Hence, during the analyzing process, capacity price is set to zero.

3.3.4 Example of a simple Case Study

A case study of four generators that supply three types of load demand is being used in order to detail out the explanations towards the trading in the single buyer model. Let us consider four generators G1, G2, G3 and G4 operating with the task of supplying two loads as shown in Figure 3.3. The three types of load demand included; the low demand which is 1500 MW; the medium demand which is 4000 MW and the high demand which is 5000 MW. Different types of demand are being used in order to see the effect of load variation towards the generator's revenue. The transmission network is assumed to lossless and it is pure operations of energy markets. Each generator details on installed capacity and the rate of capacity and energy price are listed in Table 3.4.

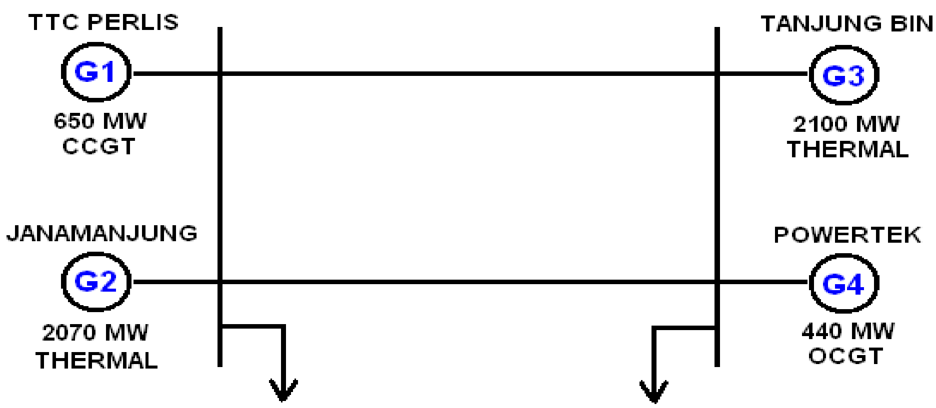


Figure 3.3: Four generators with two loads

Table 3.4: The detail information for each generator

Gen.	Available Capacity (MW)	Capacity Contribution Range (MW)	Capacity Price (RM/kW/month)	Energy Price (RM/MWh)
G1	650	1 - 650	36 000	120
G2	2070	651 - 2720	36 000	140
G3	2100	2721 - 4820	36 000	160
G4	440	4821- 5260	36 000	180

The Figure 3.4 shows the aggregated generation curve for the energy bidding process. The single buyer which is TNB will purchases power from the cheapest energy price according to the curve. Based on the capacity contribution range listed in Table 3.4, the numbers of generators that involved in supplying the three types of demand can be determined. At the demand of 1500 MW, only G1 and G2 are succeeded to sell their output, but G3 and G4 failed. Meanwhile during the demand of 4000 MW is required, the three cheaper generators are able to get the business. Only at demand of 5000 MW, all generators are able to contribute to the demand and being paid based on the energy price. The capacity payments are paid fixedly regardless the selling process.

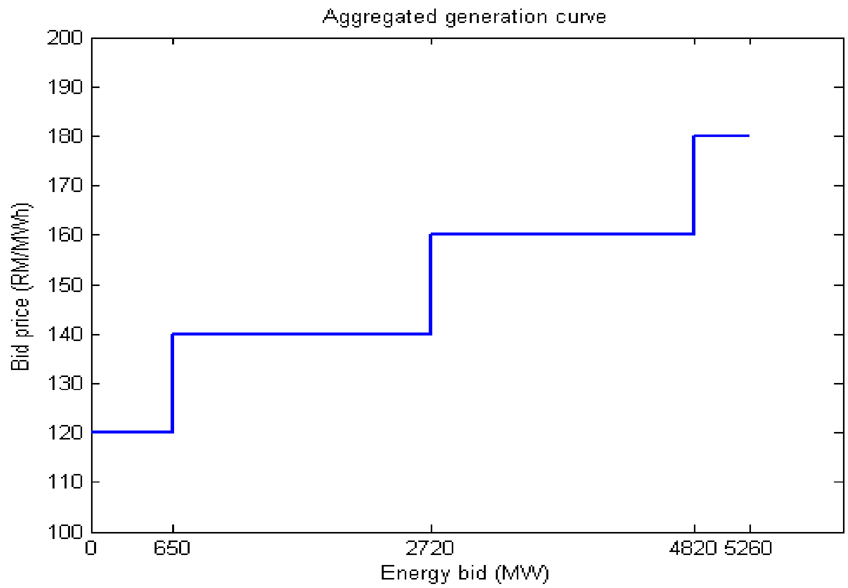


Figure 3.4: The aggregated generation curve

Based on the mathematical equation of generation revenue for single buyer model that consists of capacity and energy payment, the equation of 3.1, 3.2 and 3.5 are being used. The detail calculations of the generator revenue at the three types of demand are included in APPENDIX A. From the Figure 3.5, it can be observed that the most expensive energy price rate, G4 is unable to sell any power during low and medium demand. This means that the G4 only based on the capacity payment for its revenue during that moment of time. On the other hand, the cheapest generator which is the G1 manages to obtain both payments at all types of demand. This prove that the cheapest demand will be always chosen as the base load supplier meanwhile the expensive generators only can supply at peak hour load.

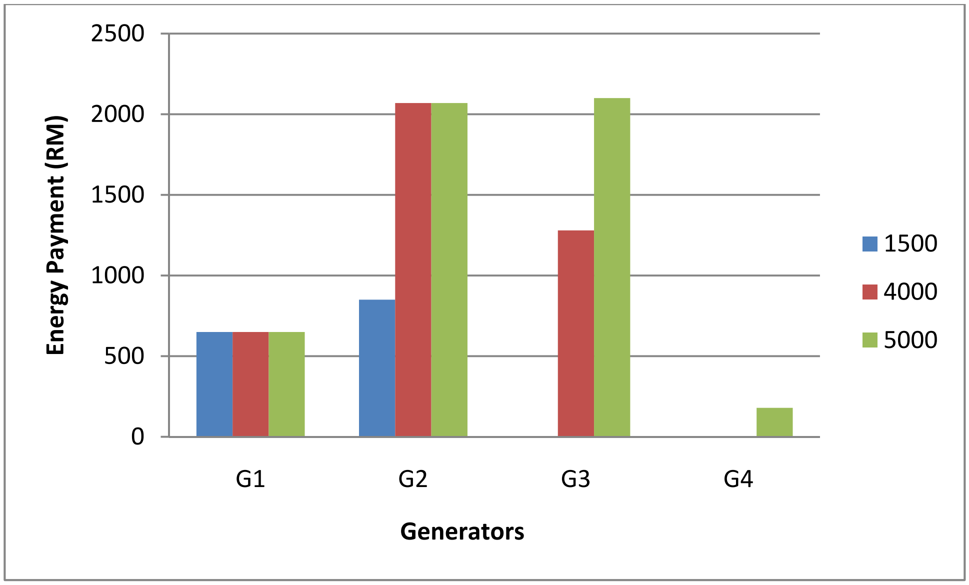


Figure 3.5: The energy payment obtained by each generator at different demand

Each generator's revenue prior to the types of demand is described in Figure 3.6. From the figure, an assumption of base load supplier will get the same amount of revenue throughout the day can be made. This is proven as the G1 manages to get the same revenue regardless the current demand. For G2, their revenue increased as the types of load change to medium and high load. On the other hand, the G3 had faced an incremental of revenue which is proportional to the incremental of current demand. As for G4, they get the lowest generation revenue compare to other generators. This can be seen in the Figure 3.7, whereby the total generation revenue of G4 for the three types of demand is the lowest among others. Meanwhile the intermediate price of generators which are the G2 and G3, get the first and second highest of total revenue. These figures might reflect the actual situation.

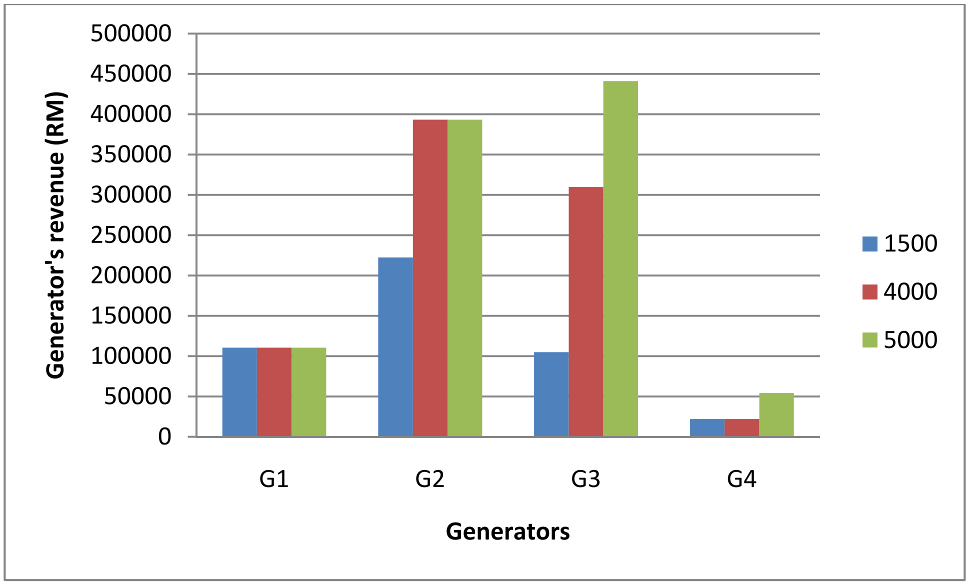


Figure 3.6: Each generator’s revenue at different demand

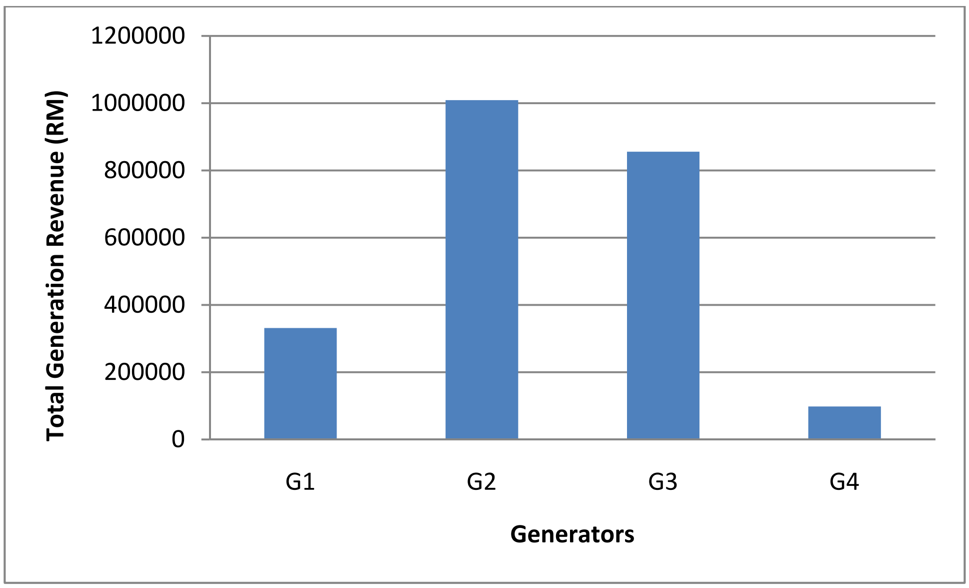


Figure 3.7: Total generator’s revenue for all types of demand

3.3.5 Related Current Issues [12]

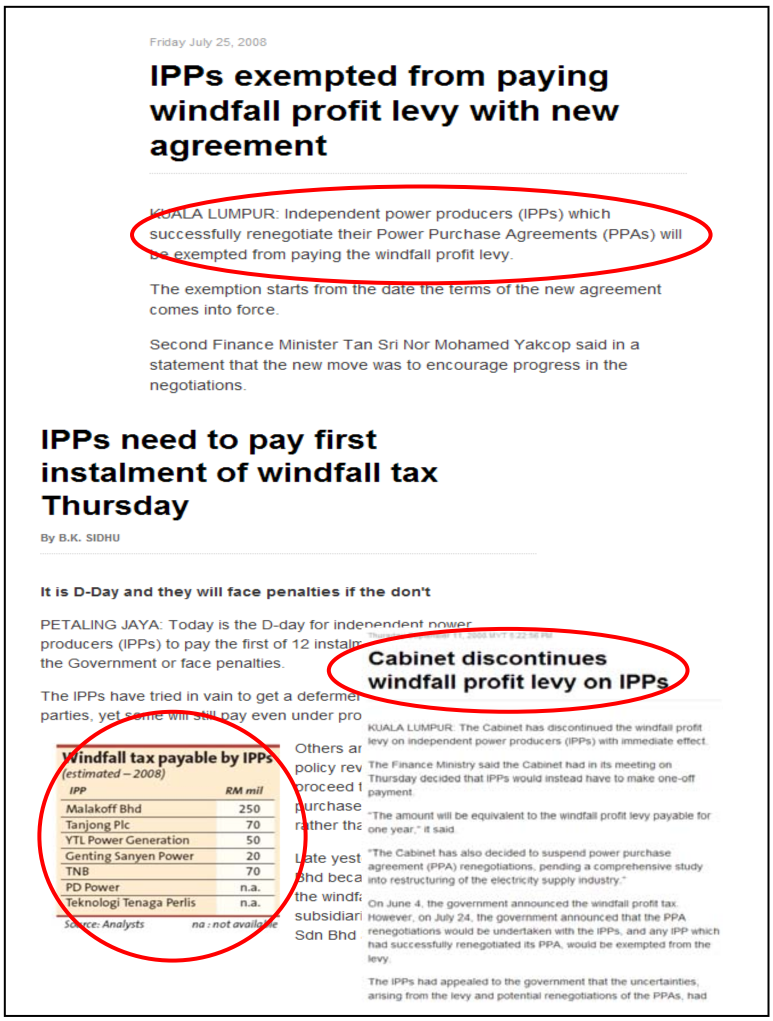
The tug of war between Tenaga Nasional Berhad Sdn. Bhd. and the independent power producer is as old as the privatization exercise of the country's power sector. It was the staggering financial crisis of the late 90s that brought to the surface the profits many of the IPPs were reaping at the expense of TNB which suffered massive profit erosion as a result of payouts to IPPs. Since then, the issue to renegotiate the IPPs have been widely debated and even pursued but of no avail. Energy Commission chairman even had mediated the talk between the TNB and IPPs but what had seemed promosing at the initial stages eventually turned stale mate. As it stands, electricity tariff have gone up for the end users. Tenaga Nasional is also hit by fuel cost. The government is bearing the burden of rising cost due to the subsidies. But IPPs are not sharing any of these burdens.

Recently, the assumption of these IPPs able to make big revenues has led the government to impose a windfall tax on IPPs without going through their financial position. The more to cut IPPs with a special windfall recently has drawn protest from Penjanabebas (an association of 14 IPPs). The windfall tax will be 30% of earnings before interest tax (EBIT) that is above the 9% threshold on return on asset (POA). Penjana bebas warned that the levy could effect their ability to meet their loan obligation.

The IPP issues bond to raise capital to finance its obligations. When the government implements windfall tax, rating agencies (RAM) review the rating based on their new cash flow positions. Number of them has a negative cash flow with the implementation of the new windfall tax. Due to the negative cash flow position, quite a number of IPPs rating has been downgraded. This has led the unhappiness among the

IPP because the windfall tax has caused the negative cash flow position of their company.

Later on, the government's move to impose a one year windfall tax payment and suspend the power purchase agreement (PPA) is positive for the independent power producers (IPPs). On 11th September 2008, the Cabinet said the government had discontinued the windfall profit levy on IPPs with immediate effect. IPPs would instead have to make one-off payment equivalent to the windfall profit levy payable for one year. Figure 3.8 shows some paper cuttings with regards to windfall tax.



Friday July 25, 2008

IPPs exempted from paying windfall profit levy with new agreement

KUALA LUMPUR: Independent power producers (IPPs) which successfully renegotiate their Power Purchase Agreements (PPAs) will be exempted from paying the windfall profit levy.

The exemption starts from the date the terms of the new agreement comes into force.

Second Finance Minister Tan Sri Nor Mohamed Yakcop said in a statement that the new move was to encourage progress in the negotiations.

IPPs need to pay first instalment of windfall tax Thursday

By B.K. SIDHU

It is D-Day and they will face penalties if the don't

PETALING JAYA: Today is the D-day for independent power producers (IPPs) to pay the first of 12 instalm the Government or face penalties.

The IPPs have tried in vain to get a defermen parties, yet some will still pay even under pro

Windfall tax payable by IPPs
(estimated – 2008)

IPP	RM mil
Malakoff Bhd	250
Tanjong Plc	70
YTL Power Generation	50
Genting Sanyen Power	20
TNB	70
PD Power	n.a.
Teknologi Tenaga Perlis	n.a.

Source: Analysts *na : not available*

Others ar policy rev proceed t purchase rather tha

Late yest Bhd beca the windfa subsidiari Sdn Bhd

Cabinet discontinues windfall profit levy on IPPs

KUALA LUMPUR: The Cabinet has discontinued the windfall profit levy on independent power producers (IPPs) with immediate effect.

The Finance Ministry said the Cabinet had in its meeting on Thursday decided that IPPs would instead have to make one-off payment.

"The amount will be equivalent to the windfall profit levy payable for one year," it said.

"The Cabinet has also decided to suspend power purchase agreement (PPA) renegotiations, pending a comprehensive study into restructuring of the electricity supply industry."

On June 4, the government announced the windfall profit tax. However, on July 24, the government announced that the PPA renegotiations would be undertaken with the IPPs, and any IPP which had successfully renegotiated its PPA, would be exempted from the levy.

The IPPs had appealed to the government that the uncertainties, arising from the levy and potential renegotiations of the PPAs, had

Figure 3.8: Paper cuttings regards to windfall tax issue

As for TNB, while it was unable to share the burden of rising coal cost with the IPPs, it is believed TNB would be compensated for the suspension of PPA negotiation with other forms of relief such as subsidy or tariff adjustment come in July 1, 2009 (the date for next review on pegged gas cost).

3.4 Advantages and Disadvantages of SBM

There several advantages and disadvantages in applying the single buyer model [13]. The popularity of the single buyer model is due to a number of technical, economic, and institutional factors, such as:

a) Single buyer model can facilitates the balancing between supply and demand in each seconds as it has the exclusive rights to buy and sell electricity

b) Single buyer model does not require third party access in transmission as there is no contractual arrangements for electricity to flow along the network

c) In Single buyer model, the sector ministry is obligated to fully decide on the investments in generation capacity, which is easier to cater

d) Single buyer model helps to maintain a unified wholesale electricity price, simplifying price regulation

e) Single buyer model makes it possible to shield financiers of generation projects from market risk and retail-level regulatory risk, reducing financing costs or making the investment commercially bankable

On the other hand, the major downside of the single buyer model is particularly in countries with weak or corrupt government and low payment discipline. The other disadvantages in applying the single buyer model are:

a) Government has the authority in made decision about adding generation capacity. Therefore, there has been an upward bias in the generation capacity procured under both the single-buyer and the IPP models which might invite corruptions
b) Power Purchase Agreements (PPA) that ensure the safety of investors had created a contingent liability for the government, which can undermine the government's creditworthiness and, ultimately, macroeconomic stability if it is unmanageable. This is regarding to the burden payment that have to be paid by the government
c) Under the single buyer model, wholesale electricity prices rise because fixed capacity charges must be spread over a shrinking volume of electricity purchases. When these high prices cannot be passed on to final consumers, taxpayers must bear the losses
d) Single buyer model hampers the development of cross-border electricity trade by leaving it to the single buyer, a state-owned company without a strong profit motive.
e) The single buyer model weakens the incentives for distributors to collect payments from customers
f) The single buyer model makes it so easy for governments to intervene in the dispatch of generators and the allocation of cash proceeds among them that few are able to resist the temptation
g) The single buyer model increases the likelihood that, under pressure from vested interests, governments will indefinitely delay the next step toward fully liberalized electricity markets

CHAPTER 4

A POOL BASED MARKET DESIGN FOR MESI

4.1 Introduction

As explained earlier in Chapter 3, the current model applied in MESI does not provide any transparent competition as it supposed to. Furthermore, TNB is contracted to pay the monthly capacity price to the IPP for a long term period. This chapter proposes a competitive market model which is based on the pool market model. This market model is the most suitable model to be applied based on MESI current structure and it is already drafted in the MESI plan towards restructuring.

The pool market model offers two types of market settlement which are single auction and double auction power pool. On the other hand, the pricing scheme which can be applied in the pool market model consists of two; i.e. uniform price which based on the system marginal price and pay as bid which is based on the generator's energy bid price. This study focus on the economic aspect from the perspective of the generators, the proposed model is being designed in order to overcome several disadvantages of the pure pool market.

4.2 Overview of Pool Market Model

In pool market model all energy supply is controlled and coordinated by a single pool operator who is normally known as independent market operator (IMO). There are two main sides of entities participating in the market, which are producers/supplier and customers/consumers. The IMO will consider the electricity bids and offers from these two entities to dispatch them in an economic manner depending on submitted bidding price and MW capacity [14]. This market model is depicted in Figure 4.1. The customers and suppliers do not interact to each other, but indirectly interact through the IMO. The IMO is responsible for both market settlement including scheduling and dispatch, and the transmission system management including transmission pricing and security aspects.

Basically, the pool market operation can be divided into two stages [8]. The first stage is called unconstrained dispatch and the second stage is called security constrained dispatch. During unconstrained dispatch, generators are placed in an ascending order according to their bid prices without considering any system constraints. A number of the least expensive generators are selected for dispatching to meet system predicted demands. The selected generators are called in-merit generators while the remaining generators are called out-merit generators. The bid price of the last dispatched generators determines the system marginal price (SMP). Next, the IMO evaluate if transmission constraint would occur under the unconstrained dispatch. If there is no constraint violation, the dispatch obtained from the unconstrained dispatch stage is executed. If there is constraint violation, the IMO would re-dispatch the generators using security constrained dispatch. This can cause some out-of merit generators are dispatched to replace in-merit generators. The cost of this action contributes to uplift charge and is added to energy price.

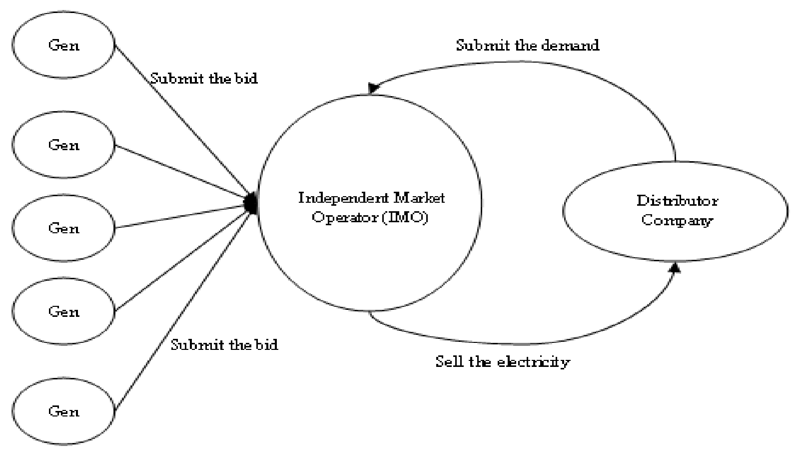


Figure 4.1: Electricity Trading; Pool Market Model

4.2.1 Pool Market Price Determination

The market clearing price represents the price of one additional MWh of energy and is therefore called the system marginal price or SMP. Generators are paid this SMP for every MWh that they produce, whereas consumers pay the SMP for every MWh that they consume, irrespective of the bids and offers that they submitted. In Pool system, there will be three prices involved. All generators and customers are obliged to follow these prices.

a) System Marginal Price (SMP)

This is the half hourly price derived from the offer price of the most expensive flexible generating unit scheduled in each half hour in the unconstrained schedule. This generating unit is known as the marginal set.

b) Pool Purchase Price (C_{PP})

This price includes the System Marginal Price and is the actual price paid to the generator which can be calculated by:

$$C_{PP} = \text{SMP (1-LOLP)} + \text{VOLL (LOLP)} \qquad (4.1)$$

Where,

LOLP is the Loss of Load Probability which is the probability of supply being lost by reason of the generation available being insufficient to meet demand. VOLL on the other hand, is the Value of Lost Load is the maximum price the supply of electricity demand is deemed to be worth. It is a value that is fixed annually.

c) Pool Selling Price (C_{SP})

An element called uplift is added to the Pool Purchase Price, to produce Pool Selling Price. Uplift reflects the difference between the cost of the Unconstrained Schedule and cost of on the day operation. PSP is calculated by:

$$C_{SP} = C_{PP} + Uplift \qquad (4.2)$$

$$C_{SP} = C_{PP} + \frac{SecurityCost}{TotalDemand} \qquad (4.3)$$

Where,

Uplift is the cost of providing ancillary services (AS) or other network operation. These ancillary services can include costs to procure MVAr, load following, maintenance services, black start capabilities. Other than that, the security cost relates with the contingencies during load dispatch.

4.2.2 Contracts for Difference in Pool Market

Producers and consumers of some commodities are sometimes obliged to trade solely through a centralized market. Since they are not allowed to enter into bilateral agreements, they do not have the option to use forward, future or option contracts to reduce their exposure to price risks. In such situations, parties often resort to contracts for difference that operate in parallel with the centralized market. In a contract for difference, the parties agree on a strike price and an amount of the commodity. They then take part in the centralized market like all other participants. Once trading on the centralized market is complete, the contract for difference is settled as follows [2]:

a) If the strike price agreed in the contract is higher than the centralized market price, the buyer pays the seller the difference between these two prices times the amount agreed in the contract.

b) If the strike price is lower than the market price, the seller pays the buyer the difference between these two prices times the agreed amount

A contract for difference thus insulates the parties from the price on the centralized market while allowing them to take part in this market. A contract for difference can be described as a combination of a call option and a put option with the same exercise price. Unless the market price is exactly equal to the strike price, one of these options will necessarily be exercised.

4.2.2.1 Example of Contract for Different (CFD)

Let us consider a case whereby the rules of the Malaysian electricity market insist that all participants must trade energy exclusively through the Power Pool. However, the Malaysia Aluminum Company (MALCo) and the Malakoff Power Company (MAPCo) have signed contract for difference for the delivery of 200MW on a continuous basis at a strike price of RM16/MWh. Three observations on the flow of power and the transaction between these companies are being done based on the following cases:

a) The pool price takes the following values: RM16/MWh, RM18/MWh and RM13/MWh.

b) During one hour the Malakoff Power Company is able to deliver only 50MWh and the pool price is RM18/MWh

c) During one hour the Malaysia Aluminum Company consumes only 100MWh and the pool price is RM13/MWh

Based on the contract for different concept explained previously, the three cases have been solved and summarized in Table 4.1. This table includes the flow of power and the transaction between these two companies.

Table 4.1: The power flow and the transaction for an hour

	C_{PP} (RM/MWh)	MAPCo	MALCo
a)	16	Produces 200 MW and Receives RM 3200 from the pool	Consumes 200 MW and Pays RM 3200 to the pool
	18	Produces 200 MW, Receives RM 3600 from the pool and Pays RM 400 to MALCo	Consumes 200 MW, Pays RM 3600 to the pool and Receives RM 400 from MAPCo
	13	Produces 200 MW, Receives RM 2600 from the pool and Receives RM 600 from MALCo	Consumes 200 MW, Pays RM 2600 to the pool and Pays RM 600 to MAPCo
b)	18	Produces 50 MW, Receives RM 900 from the pool and Pays RM 400 to MALCo	Consumes 200 MW, Pays RM 3600 to the pool and Receives RM 400 from MAPCo
c)	13	Produces 200 MWh, Receives RM 2600 from the pool and Receives RM 600 from MALCo	Consumes 100 MWh, Pays RM 1300 to the pool and Pays RM 600 to MAPCo

4.3 Market settlement strategies

In Pool, the structure can adopt any of the following two market settlement strategies. It could be either market settlement by maximization of social welfare or market settlement by minimization of consumer payment. The first market settlement strategy is more famous and yet it applied two types of auction which are Single Auction Power Pools and Double Auction Power Pools [15]. However, the adoption of any market settlement is based on the local conditions and the structure in electricity supply industry (ESI) of a country itself.

A first characteristic of a market settlement is the nature of supply and demand bids. Single auction power pools refer to strategies where only supply is based on bids and demand is estimated. Meanwhile, double auction power pool allows both supply and demand to be based on bids from participants. Commodities markets are usually organized according to the double auction. In short, the market settlement aggregates supply and demand bids and the intersection of the two curves defines the market price. However, in electricity markets demand participation may be difficult to obtain from a practical point of view. Most consumers of electricity have a low level of responsiveness to price increases. For this reason some market settlement uses estimates of demand rather than bids from consumers. This was formally the case in the United Kingdom pool. The pool estimated demand for each period based on historical records and this then allowed a pool price to be determined. Single auction are obviously not an ideal mechanism for determining optimal market prices. Their only justification is practical, when introducing market mechanisms, in particular during the start-up phase, they can be a good way to determine a market price, and however a lack of direct demand participation strongly limits the value of this.

4.3.1 Single Auction Power Pools

In this market settlement, the customers or distributor company can be assumed as one company only. The competition only valid among generator companies and customer does not know which generators those succeed to sell their output. The market structure for one sided pool is shown in Figure 4.2. The red lines indicate the electrical energy that flows from the generation to the distribution companies with the transaction is through a single pool operator.

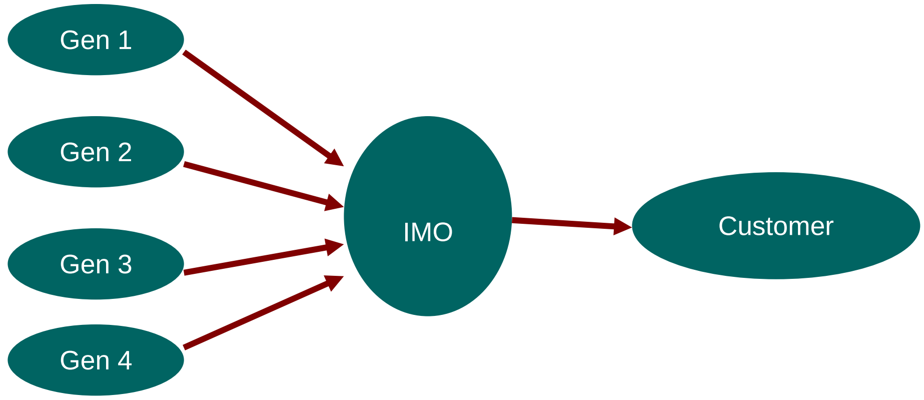


Figure 4.2: One sided pool market structure

Generator companies submit bids to supply a certain amount of electrical energy at a certain price for the period under consideration. These bids are ranked in order of increasing price. Meanwhile, the demand curve is predicted to be a vertical line at the value of the load forecast. The highest priced bid that intersects with the demand forecast determines the market price which applied for whole system as depicted in Figure 4.3. This arrangement is found in Australian system.

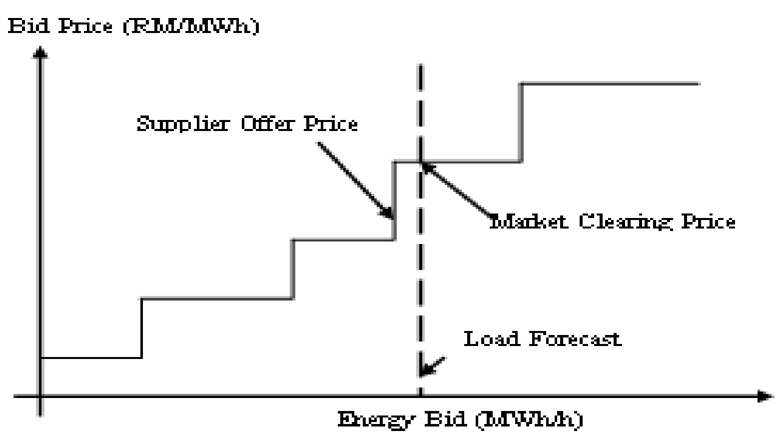


Figure 4.3: Market settlement in one sided pool

4.3.1.1 Application of Single Auction Power Pools in MESI

In single auction power pool, the market settlement only requires a distribution company or customer. Hence, it is easier for Malaysia Electricity Supply Industry (MESI) as the distribution and transmission industry is dominated by Tenaga Nasional Berhad Transmission and Distribution (TNBD) itself. At the moment, it is suggested that the TNB will act as the single pool operator. In this pool market the Tenaga Nasional Berhad Generation (TNBG) beside hydro power plants will get involved in the competition with other IPPs. The suggested single auction structure is shown in Figure 4.4. Red lines indicate the electricity energy that flows from the generation to the distribution companies.

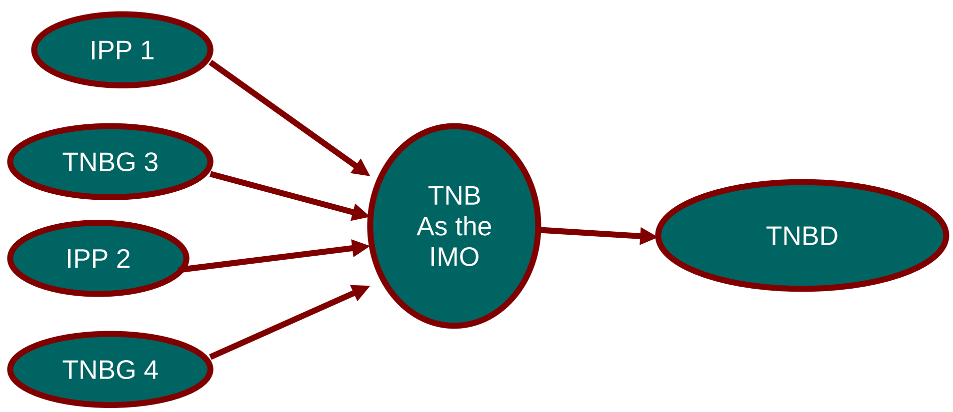


Figure 4.4: The structure of single auction power pool in MESI

First of all, the distributor company will announce the forecast load demand to the pool operator a day ahead before real time. Then, TNB as the single pool operator will start to receive the generators bid price and available capacity for that moment. This means that the bid price might be volatile from time to time depending on the demand and the current fuel cost. In spite of this, TNBG and IPPs will compete to bid the lowest bid price so that each of them manages to sell their output for particular hour.

The higher bid price will less the opportunity to get incomes. As the existing MESI structure is almost like single auction, hence, all design in this study is based on this market strategy.

4.3.2 Double Auction Power Pools

In this market settlement, there are several customers or more than one distributor companies. This is because the competition is not only valid among generator companies but also valid among the customers. However, each market participants does not know which generators and customers those succeed to sell and bought the electrical energy. The market structure for double auction power pool is shown in Figure 4.5. The red lines indicate the electrical energy that flows from generation to the distributor companies with the transaction through the single pool operator.

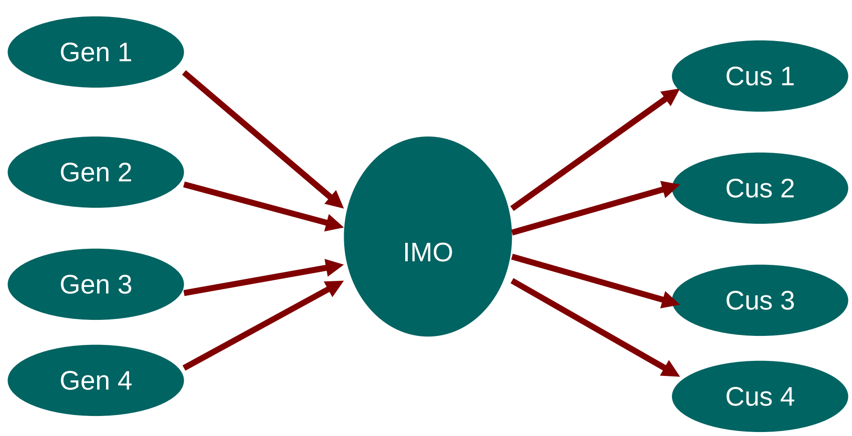


Figure 4.5: Double auction power pool market structure

In more sophisticated, the demand curve of the market can be established by asking buyers to submit offers specifying quantity and price and ranking these offers in decreasing order of price. The intersection of these constructed supply and demand curves represents the market equilibrium, refer Figure 4.6. All the bids submitted at a price lower than or equal to the market clearing price are accepted and generators are instructed to produce the amount of energy corresponding to their accepted bids. Similarly, all the offers submitted at a price greater than or equal to the market clearing price are accepted and the consumers are informed of the amount of energy that they are allowed to draw from the system. This market settlement strategy is used in New Zealand, California and NordPool (Norway, Sweeden, Finland, Denmark and Iceland) markets.

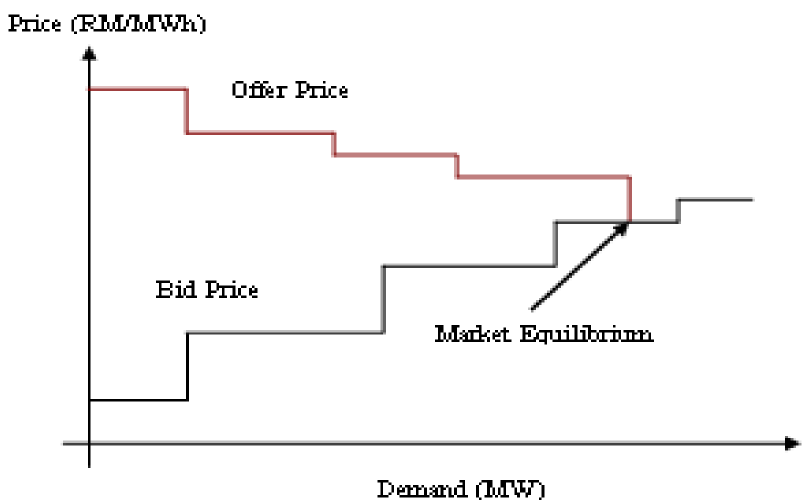


Figure 4.6: Market settlement in double auction power pool

4.3.2.1 Application of Double Auction Power Pools in MESI

This market settlement provides competition not only among the generators but also among the customers. To compete, the distribution company should be more than one. Therefore, it is suggested that private Distributor Companies (DistCo) beside TNBD are being introduced in MESI. It can be built based on region and this can reduce the effect of transmission loss as well. Figure 4.7 illustrates the double auction power pool structure that can be applied in MESI. Red lines indicate the electricity trading that flows from the generation to the distributors companies.

The supply side which is IPPs and TNBG submit their bid (the amount and associate price) for selling energy to the pool, while the demand side which is the TNBD and private distributor company submits their offer for buying energy from pool. The system price is obtained by stacking the supply bids in increasing order of their prices and demand bids in decreasing order of their prices. The system price and amount of energy cleared for trading is obtained from the intersection of these curves as explained previously.

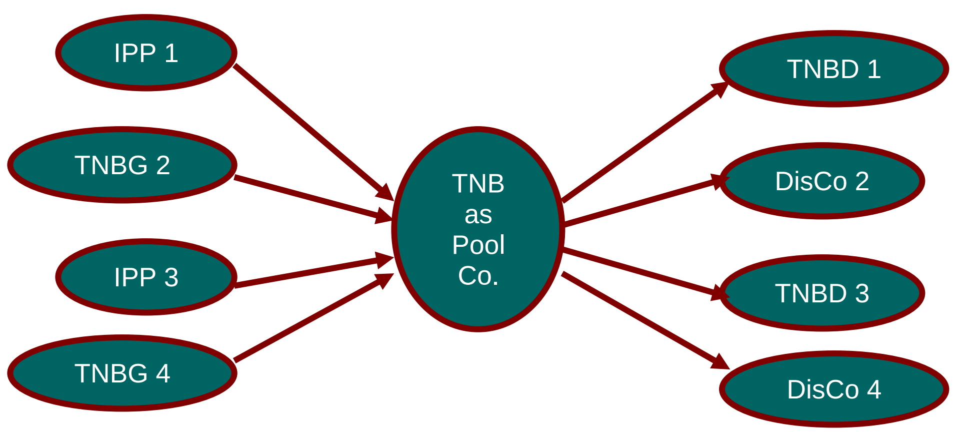


Figure 4.7: The structure of double auction power pool in MESI

As the structure and introduction of private distributor company is still far from MESI current structure, this market settlement is only in suggested model and will be not considered in the case study for the project. Perhaps that one day, the Malaysian Government will permit the introduction private distribution company in looking forwards for wholesale market model.

4.4 Pricing Scheme: Pay as Bid and Uniform Price

Uniform pricing scheme is one of the concepts in the pure pool market model before pay as bid scheme concept is being introduced due to some flaws occurred. The controversy over uniform pricing and pay as bid pricing centers on the distribution of the surplus and was first addressed in the United States with the treasury auction. Both of a theoretical and from an empirical point of view, definitive ranking of the uniform price scheme and pay as bid scheme is still an open question. In the uniform pricing scheme, all suppliers get paid the price of the system marginal price (SMP). Hence, all suppliers who bid lower prices get an extra profit called a surplus. In the same way all consumers who bid higher prices pay a lower price than the one they were willing to pay, this is called the consumer surplus, Figure 4.8 is being referred. The mathematical presentative of these two types of pricing scheme are shown in below sub section in order to detail out the effect of these scheme towards generators as the seller and customers as the buyer.

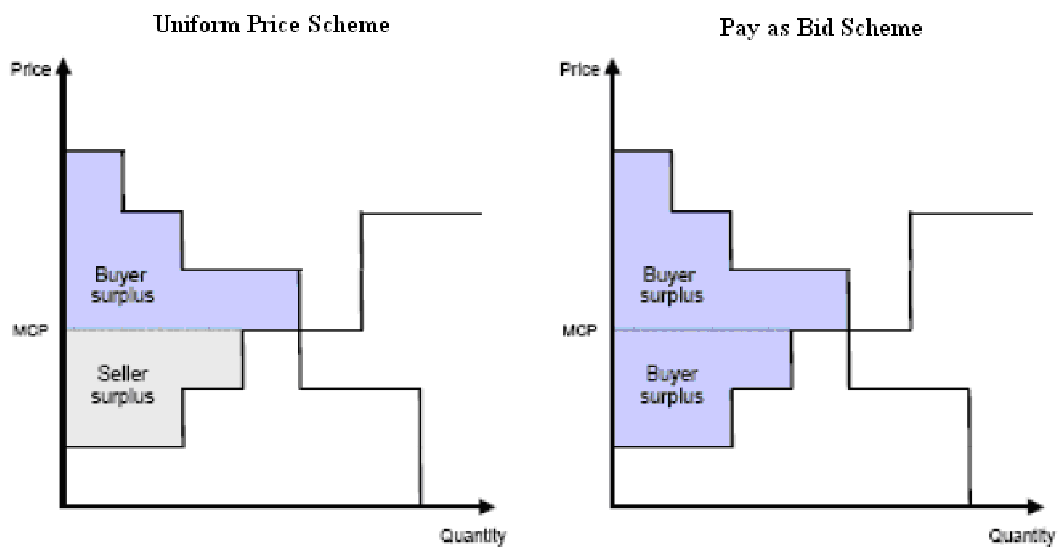


Figure 4.8: Distribution of surplus (assuming same bidding behaviours)

4.4.1 Uniform Price (UP) Scheme

In this pricing scheme, all generators are being paid based on the pool purchase price, C_{PP} which is effected by the system marginal price (SMP) regardless to their energy bid price. Therefore, the mathematical equation for each generator that being paid using the uniform scheme can be written as:

$$G_i = P_{Gi} \times C_{PP} \tag{4.4}$$

Let us consider a case of a power plant named Tanjung Bin, which has 2100MW for it installed capacity and their energy bid price is RM 150/MWh. Let say, for an hour, Tanjung Bin succeed to sell their output up to the maximum and the current pool purchase price is RM 250/MWh. For a uniform pricing scheme, the Tanjung Bin will be paid RM 250 for that hour regardless the energy bid price.

From a consumer point of view it might appear unfair that a supplier who is willing to supply at a price of RM 150/MWh receives the pool purchase price at RM250MWh. Because of this issue had arise, it has been suggested that pay as bid methodology, previously experimented with the United States Treasury's auction experiment, should be implemented in electricity markets to increase the consumer surplus and eliminate these "unfair profits". In a pay as bid scheme, suppliers get paid the price they bid.

4.4.2 Pay as Bid (PAB) Scheme

In this pricing scheme, the generators are being paid according to their energy bid price regardless the pool purchase price, $C_{PP.}$ Therefore, the mathematical equation for each generator that being paid using the pay as bid scheme can be written as:

$$G_{PaBi} = P_{GiPaB} \times C_{GiPaB} \qquad \textbf{(4.5)}$$

Let us consider the same case in section 4.4.1. For a pay as bid pricing scheme, the Tanjung Bin will be paid RM 150 for that hour instead of RM250.

Hence, from a generator point of view, the pay as bid scheme appears to be less attractive while it in theory it allows consumers to pay the right price. However in a pay as bid scheme in an imperfect market generators have a strong incentive to increase the level of their bids in order to ensure a minimum level of profit. Instead of submit bid price that reflects their marginal costs, suppliers will tend to bid what they think will be the market clearing price. Such behavior will lead to an increase in bids and will distort the system.

Marginal costs for some technology, and especially for base load plant, are almost zero (nuclear for instance). If players bid their true marginal costs they will not be able to recover their fixed costs. This will deter entry and involve less investment in base load power plants thus reducing the overall efficiency of the system. It can also be argued that from a supplier's point of view that pay as bid can also be implemented in the other way, i.e. consumers have to pay the price they were willing to pay.

In addition, pay as bid reduce transparency by creating many prices instead of one price in the marginal price system. It have shown that in some cases uniform price scheme are superior compare to pay as bid scheme in mitigating market power as they allow competitive arbitrageurs to outbid generators where generators may otherwise secure inter-connector capacity that amplifies their market power. Thus for all these reasons, marginal price appears as more suitable than pay-as-bid. Table 4.2 shows the comparison between Pay as Bid (PAB) scheme and Uniform Price (UP) in term of its advantages and disadvantages from the economic aspect point of view.

Table 4.2: The advantages and disadvantages for PAB and UP

	Pay as Bid (PAB)	Uniform Price (UP)
Advantages	- It can reduce the effect of market power exercise	- Seller with less bid price able to get extra incomes in high demand
Disadvantages	- Seller will not submit bid that reflect their marginal cost of production - The expensive generators cannot participate in low demand trading	- The amount of SMP is dependent on demand - Possibility in market power exercise - The expensive generators cannot participate in low demand

4.5 Economic Aspect of Pool Market Model

From previous equation of the generator revenue for each types of scheme, the mathematical equation that represents the total generation revenue for pool market model can be written as following. The mathematical equation for total generation revenue, G_T of pool market model with the uniform price scheme can be written as:

$$G_T = \sum_{i=1}^{k} G_i \tag{4.6}$$

From equation 4.1 and 4.4, the total generation revenue for this market model thus equal to,

$$G_T = \sum_{i=1}^{k} \left(P_{Gi} \times C_{PP} \right) \tag{4.7}$$

Where,

P_{Gi}	=	Power capacity available by ith generator to the pool in MW
C_{PP}	=	Pool Purchase Price in RM/MWh
k	=	Numbers of generators involved
G_T	=	Total generation income in RM/h

On the other hand, the mathematical equation that represents the total generation revenues, G_T of pool market model with the pay as bid scheme can be written as:

$$G_T = \sum_{i=1}^{k} G_{PaBi} \tag{4.8}$$

From equation 4.5, the total generation revenue for this market model thus equal to,

$$G_T = \sum_{i=1}^{k} \left(P_{GiPaB} \times C_{GiPaB} \right) \qquad (4.9)$$

Where,

P_{GiPaB}	=	Power capacity generated by ith generator to in MW
C_{GiPaB}	=	Bid Price for ith generation in RM/MWh
k	=	Numbers of generators involved
G_T	=	Total generation income in RM/h

4.5.1 Example of a Simple Case Study

The same example and data in the previous simple case study in Section 3.3.4 is being used in order to explain the difference between the pool market model with either uniform pricing and pay as bid pricing scheme. Only energy price rate will be taken into account as in pool trading model, the business is based on the competition among generators. Generators will submit their bid price (energy price) and only the least generators are able to sell their output. This situation can create competition among generators as each of them try to be the cheapest generators. As a result, the value of energy price will be not fixed as previous case study and the rate might be varies from time to time depending on the current market situation. Therefore, in this example, the value of capacity price has been included into the energy price in hourly basis so that the value will be more reasonable.

In order to detail out which generators that able to sell the output, a table which summarized the succeeded generators at all types of demand can be referred at Table 4.3. Note that, the numbers of generators that succeeded remain the same for all types of market, however, the major different are based on the amount of revenues that they obtained. Detail calculation for both uniform price and pay as bid scheme in this example can be referred to the APPENDIX B.

Table 4.3: Generators that succeeded is being ●

Gen	Low Demand	Medium Demand	High Demand
G1	●	●	●
G2	●	●	●
G3	-	●	●
G4	-	-	●

Figure 4.9 and Figure 4.10 describe the revenue obtained by each generator which is based on uniform price scheme and pay as bid scheme respectively. For both types of scheme, only the energy price is being considered and totally neglected the capacity price. It can be observed G4 unable for get any income at all for both low and medium demand. Meanwhile, the G3 manage to obtain an income for each types of load except for the low demand. This means that by applying pool market model which is based only on the energy price, the expensive generators will be unable to obtain revenues at low demand whereas this generator only get income during high demand.

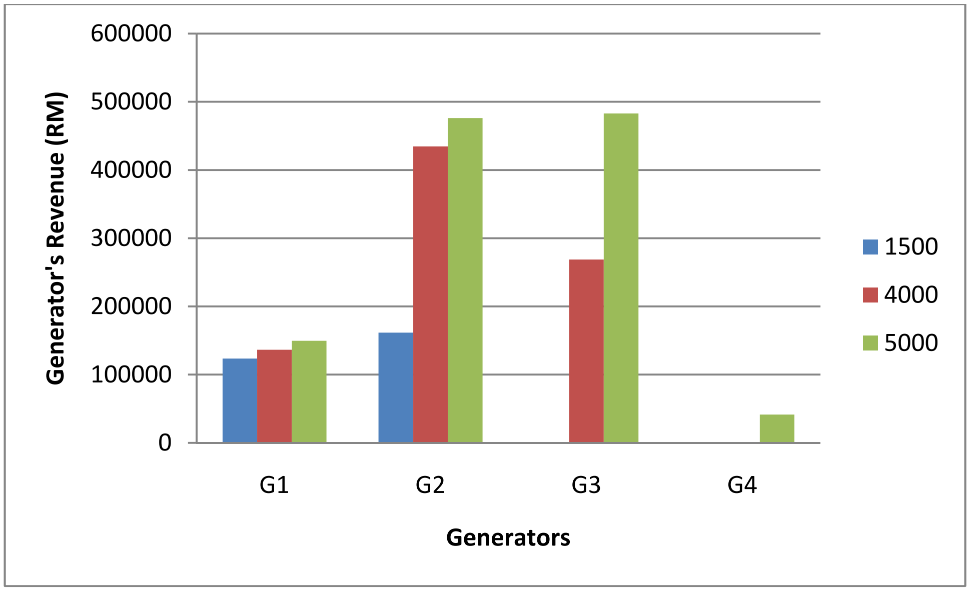


Figure 4.9: The generation revenues based on UP at different demand

From these figures, it can be seen that the amount of revenue that gain by generators for uniform price are higher than the amount of revenue that based on pay as bid scheme. This is because in pool market with uniform price, each succeeded generators will be paid based on the pool purchase price, which on the other hand varies with the demand. Meanwhile, the payment in pay as bid is based on each generators bid price.

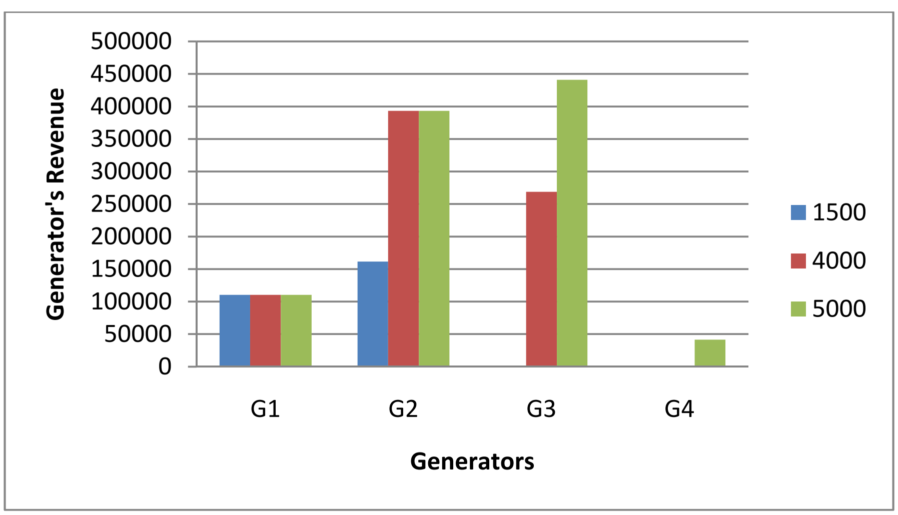


Figure 4.10: The generation revenues based on PAB at different demand

Figure 4.11 describes total generator's revenue for all types of demand. It shows that G2, as the second least energy price manage to obtain the highest revenue among the others. This is because the generators manage to sell their output most of the time and yet their bid price is more expensive compare to G1. On the other hand, G4 only manage to obtain the revenue during peak hours which will hurt their incomes.

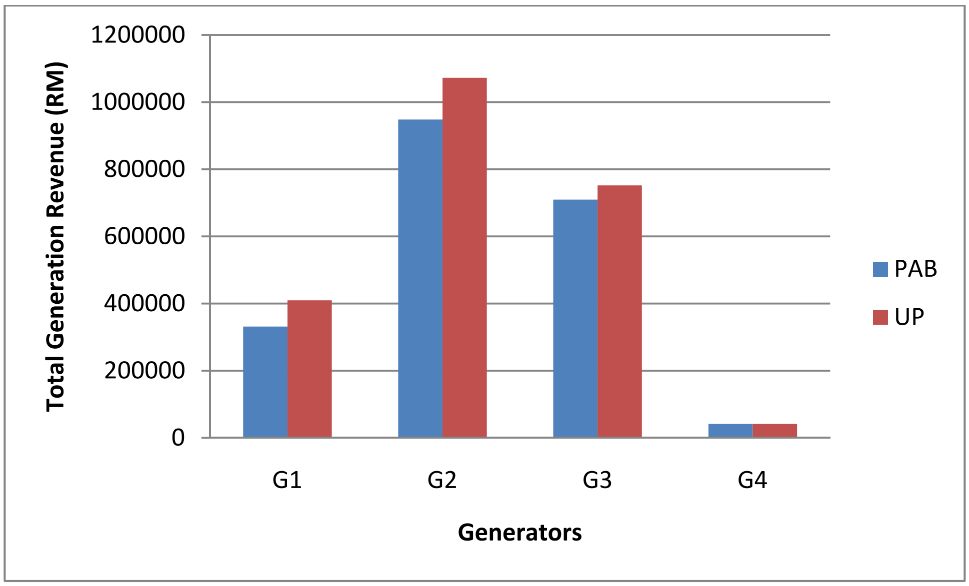


Figure 4.11: Total generator's revenues for all types of demand based on PAB and UP

4.6 Issue Arise due to Pool Market model

From the previous example, it can be seen that the pool market model can promote competition among the generators. However, it comes along with some problem and few issues. This is because the implementation of any types of market model is being influenced of the local condition of a country itself. Therefore, there are three main issues could be raised up when the pool trading model is applied in MESI, such as:-

a) Generators with higher energy bid price have less opportunity to sell their output. These expensive generators will not be able to contribute its capacity to demand most of the time especially during low demand. Because of there is no capacity payment, some generator will not obtained any revenue at certain hour.
b) TNB itself own different types of power plants and majority of these power plants are not so efficient due to ageing, this could increase the marginal cost of production and as a result the TNB have less opportunity to sell their output due to higher marginal price
c) There are possibilities of having market power exercise in pool trading model. For example, big power producers companies could monopoly the market by arranging several bidding strategies which may effect the stability of electricity market and rise up the market risks [1]

In order to overcome these issues and improve the pool market model, a hybrid trading model is being introduced. This proposed model consist of pool market model which supported by several market policies in order to accommodate a fair competitive trading and produce win-win situation to not only the TNB and the IPP but also to the customers. This is due to the fact that the consumers are affected from the market price. These market policies which can be regulated by the Energy Commission (EC) aim to reduce the exercise of market power and market risks.

4.6.1 Solution of issued; Suggested Market Policies

Energy Commission (EC) is a government body who is responsible to draft the regulation for MESI. One of the regulations that can be made is regarding the market policies which can overcome several issues arise when the pool market model is being applied in MESI. The suggested market policies that possible to be endorsed by the Energy Commission (EC) are written as follows.

a) Hydro power plants

Hydro power plants will not participate in the bidding process but it is given a special treatment [16]. In addition, hydro power plant usually are used for backup and to cater the peak load

b) Guaranteed revenues for base load demand

In order to ensure the participation of all power producers in selling their output throughout the day, the identified base load demand for each load profile will be shared among all power producers is being introduced. The concept is lesson learnt from competitive electricity market in Singapore [17]

c) Trading is only valid for high load demand

There is a very large variation in liquidity (the percentage of total consumption which is traded through the market) between different markets. This varies from 0 to 100 percent depending on the market structure. Markets such as in the Brazil and Czech traded the electricity up to 5% on the short term market while in Korea 100% is traded on the market. Meanwhile, in Australia 100% is traded on the market but in the order of 80% is covered by contracts for different. These figures are influenced by the market model in the countries [15]. Therefore, in the proposed model it is suggested that the electricity that will be traded and pass through the bidding process in pool market model is introduced only for high load demand.

d) The reduction of market power exercise

The market power exercise can be reduced as a part of their installed capacity has been used to supply the base load. This can reduce their ability to monopoly the pool market with certain bidding strategies. They also did not have the opportunity to play around with the market price as the system marginal price will be always at intermediate value. It is base on the electricity that being traded is only for peak load.

e) Application of pay as bid or uniform pricing scheme for the electricity trading

As there are two types of pricing scheme; i.e. uniform price and pay as bid scheme, the single pool operator may choose either one from these schemes which will enhance the benefit for each market participants

Finally, the proposed model which namely as hybrid model will be the combination the matter in b) and c). This proposed model is believed would be able to overcome the issues arise in pool market model. Each generator is being guaranteed to be able to obtain revenue at each hour. This also can be reduced the effect of market power exercise as the electricity is only being traded during high load demand.

4.7 Hybrid Model

Despite applying the pure pool market model, a hybrid model which includes the pool market model with several policies is believed to be the most significant market model for MESI. This hybrid market model provide competition environment which guaranteed revenue for each generator without taken into account the types of demand and the generator's energy bid price. This model also able to reduce the effect of market power exercise as the traded electricity will be only held during the high load demand. As a result, a market model which can provide win-win situation to all market participants including the end-consumers can be achieved. The end-consumers will pay a reasonable electricity tariff, the power producers will obtained reasonable profit as for TNB as well as IPP.

The hybrid model which combines the pure pool market and pro-rata base load profile has the following properties:

a) Base load demand

As mentioned in previous section, the base load sharing is being introduced in order to allow all generators will get their revenue regardless the current demand and their energy bid price. A pro-rata basis approach has been used in order to divide the base load fairly to all power producers. Note that, the portions of supply that obtain by each generator will proportional with their available capacity. This means that big generators will participate more in supplying the base load demand. Therefore, the mathematical equation that represents each generator's portion of supplying the base load demand can be written as;

$$P_{GiBL} = \frac{P_{Gi}}{\sum_{i=1}^{k} P_{Gi}} \times \text{Base Load Demand} \qquad (4.10)$$

As a result, all generators are able to sell their output regardless their energy bid price and the current demand. This has solved the problem whereby the generators with expensive bid price could not gain any revenue during low demand. In addition, it can reduce the effect of market power exercise which tries to manipulate the system marginal price in pool trading model. This is because a part of their capacity has been used to supply the base load; therefore this will reduce their ability to conquer the market. The mathematical equation for generator's revenue from the base load demand which is valid for both types of pricing scheme can be written as:

$$G_{iBL} = P_{GiBL} \times C_{GPaB} \tag{4.11}$$

Where,

P_{GiBL} = Power capacity generated under pro-rata basis for ith generator in MW

C_{GPaB} = Price based bid for ith generator in RM/MWh

b) High load demand

The remaining capacity from each generator is traded in the pure pool market model. As the remaining capacity for each generator is less, hence it is difficult for big generators to monopoly the market. Moreover, the system marginal price can be reduced due to less remaining demand required for the pool market model. The mathematical equation that will represent the generator's revenue from the high load demand is based on the types of pricing scheme that being used. If the uniform price scheme is being used, the mathematical equation for generator's revenue from the high load demand can be written as:

$$G_i = P_{Gi} \times C_{PP} \tag{4.12}$$

Where,

P_{Gi} = Remaining power capacity of ith generator; satisfy the pool demand in MW

C_{PP} = Pool Purchase Price in RM/MWh

Meanwhile, if the pay as bid scheme is being used, the mathematical equation for generator's revenue from the high load demand can be written as:

$$G_i = P_{Gi} \times C_{GiPaB} \qquad (4.13)$$

Where,

C_{GiPaB} = Price based bid for ith generator in RM/MWh

P_{Gi} = Remaining power capacity of ith generator; satisfy the pool demand in MW

Therefore, the mathematical equation for total generation revenue for the hybrid model with uniform price scheme is consists of equation for 4.11 for base load and 4.12 for high load demand will then produce an equation of:

$$G_T = \sum_{i=1}^{k} \left(P_{GiBL} \times C_{GPaB}\right) + \left(P_{Gi} \times C_{PP}\right) \qquad (4.14)$$

Where,

P_{GiBL} = Power capacity generated under pro-rata basis for ith generator in MW

P_{Gi} = Remaining power capacity of ith generator; satisfy the pool demand in MW

C_{PP} = Pool Purchase Price in RM/MWh

C_{GiPaB} = Price based bid for ith generator in RM/MWh

k = Numbers of generators involved

G_T = Total generation income in RM/h

On the other hand, the mathematical equation for total generation revenue for the hybrid model with pay as bid scheme which consists of equation 4.11 for base load and 4.13 for high load demand can be written as:

$$G_T = \sum_{i=1}^{k} \left(P_{GiBL} \times C_{GPaB}\right) + \left(P_{Gi} \times C_{GiPaB}\right) \qquad (4.15)$$

Where,

P_{GiBL}	=	Power capacity generated under pro-rata basis for ith generator in MW
C_{GiPaB}	=	Price based bid for ith generator in RM/MWh
P_{Gi}	=	Remaining power capacity of ith generator; satisfy the pool demand in MW
k	=	Numbers of generators involved
G_T	=	Total generation income in RM/h

The market policies and hybrid model are designed consequently in order to produce a fair market between the generators companies (TNB and IPP) and the distributor company as well as the end-consumers. With this model, the generations company manage to sell their output regardless the current demand as each of them contribute for the base load demand. Meanwhile, the customer can pay less for the remaining load demand as the system marginal price is getting lower. The proposed model which is designed for one sided pool market settlement is analyzed in the case study in Chapter 6.

4.7.1 Example of a simple case study

The same example and data in the previous case study in Section 3.3.4 is being used in order to prove the advantages of applying the hybrid model compare to pure pool trading model. Both pricing scheme are being used; i.e. uniform pricing and pay as bid pricing scheme. Same as example in pool trading model, only energy price rate will be taken into account as it is based on the competition among generators, this time the trading only valid during peak load. The value of energy price is assumed to remain the same both each types of load whereas in practical, the rate might be vary from time to time. The situation can create competition among generators as each of them try to be the least generators. The base load demand is identified as 1000MW for each types of load demand.

In this example, all generators able to contribute for the base load demand and their contribution prior the available capacity is listed in Table 4.4, equation of 4.10 is being used. This shows that each generator is guaranteed of its revenue and is proven in Figure 4.12, for uniform price scheme and Figure 4.13, for pay as bid scheme. Detail calculation for both uniform price and pay as bid scheme in this example can be referred to the APPENDIX C.

Table 4.4: Each generator's contribution for base and high load demand

Gen	Available Capacity	Base Load Demand	High Load Demand
G1	650	123.57	526.43
G2	2070	393.54	1676.46
G3	2100	399.24	1700.76
G4	440	83.65	356.35

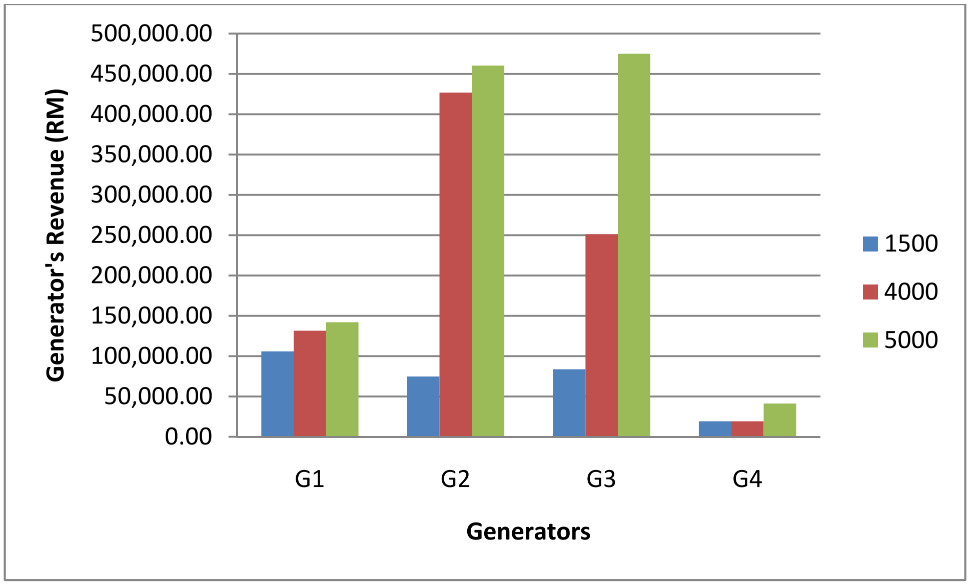


Figure 4.12: Each generator's revenue based on uniform price at different demand

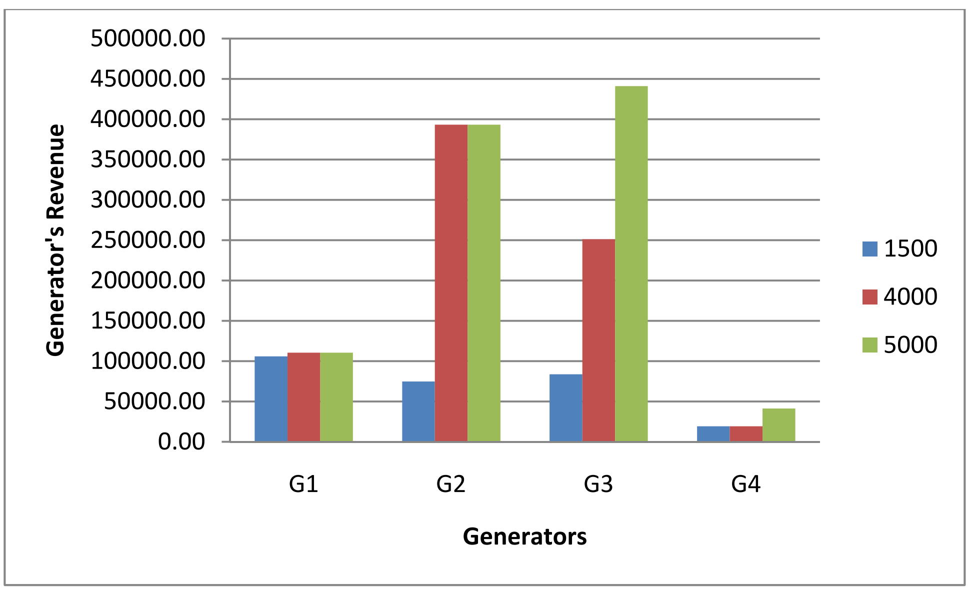


Figure 4.13: Each generator's revenue based on pay as bid at different demand

4.8 Types of Operating Pool Market

A pool can operate a day-ahead market (e.g. the former England and Wales Pool) or close to real time market (e.g. five minutes-ahead). There can also be a combination of several markets (day-ahead, intra-day and five minutes-ahead). Where a five-minutes-ahead market is operated, other sessions can still be run on the basis of non-firm offers and bids. Such sessions are used to create a forecast of the market prices as an indication for the market participants. Such price seeking sessions are based on non-firm offers and bids and are important to allow for non-dispatched demand side response in case of high market prices.

Day-ahead markets and real time markets are often confused since they are often regrouped under the term “spot market”. However, this thesis defined the spot market as the day ahead market, which can be organized bilaterally or/and on a marketplace. The real time market refers to real power balancing by the system operator. Due to the high transaction cost involved in bilateral day-ahead trading, the day-ahead market is usually organized on a marketplace. The real-time market or balancing market is always an organized market because it requires real time operation from the system operator to balance the system.

Since electricity consumption is difficult to predict and consumers can better estimate their consumption one day in advance than one year in advance the day ahead market allows participants to adjust their portfolio one day before delivery. When they are organized on marketplaces, day a head markets take the form of either power exchanges or power pool. Day-ahead markets contain four stages:

a) Participants submit bids

b) The marketplace determined the market price by accepting and rejecting bids

c) Transactions are settled

d) The results are transferred to the system operator in order to ensure physical delivery

The real-time market is used to price deviations in supply and demand from contract specifications. These deviations, intentional or unintentional, must be corrected by the system operator to ensure physical delivery. The real time market is used to price these deviations and to keep the system in balance; the system operator needs to be able to call in extra production at very short notice that is why the real time market must be centralized. Bilateral markets are too slow to handle very short term operations. Moreover beyond balancing the real time market provides two mains others ancillary services one, transmission security and two, efficient dispatch.

Consequently, day-ahead marketplaces and real-time marketplaces serve different purposes and are complementary. They represent the two main kinds of organized marketplaces in electricity. Their functioning is quite different and they should not be confused. This thesis however is based on day-ahead marketplaces.

4.9 Advantages and Disadvantages of Pool Market

The pool market model provides competitive environment for the electricity market players which satisfy the objective of restructuring the electricity supply industry (ESI). Nevertheless, this model has both advantages and disadvantages [18-19]. The general advantages in applying the pool market model are:

a) Contract for differences to hedge the risks from volatile pool prices for the producers and customer
b) Generation part of business benefits when the pool prices are high and the distribution part of business benefits when the pool prices are low

Meanwhile, there are several general disadvantages offers by the pool market model such as:-

a) The pool prices based on bid and offer prices which can be volatile from time to time
b) Requires balancing mechanism in order to avoid transmission congestion (with the consideration on generator that will ON/OFF), in term of reliability can match between supply and demand
c) Cost management and administration on this model based on market difference such as system cost and current infrastructure

CHAPTER 5

A BILATERAL BASED MARKET DESIGN FOR MESI

5.1 Introduction

A pool market model can be said as a kick-starter in moving forward towards creating a competitive environment in the electricity supply industry. As explained previously in Chapter 4, the generators in this market model will compete with each other by submitting the least cost in order to sell their production, and this might help in reducing the tariff rate to the end-user. An extra tremendous competitive environment is created under bilateral market model as each transaction is a direct negotiation between the generators and distributors without the existence of third party as practiced in the pool market model. Therefore, several bilateral electricity market model which is designed based on MESI under the current environment is included in this chapter in order to compare with the previous models and produce a dependable results.

The bilateral market model attracts buyers and sellers to choose different forms of bilateral trading or contracts depending on the amount of time available and the quantity to be traded. This study focus on the economic aspect from the perspective of the generators, the proposed model is being designed in order to overcome several disadvantages of the pure bilateral market models.

5.2 Overview of Bilateral Market Model

The bilateral is motivated by the concept that free market trading is the best way to achieve the competition in the electricity wholesale. This trading involves only two market participants; a buyer and a seller who makes the contracts. Usually the seller will be generators and buyers will be distributors companies and eligible consumers. The buyer takes full responsibility for acquiring all of the electricity required for their enterprise at the best prices that can be negotiated; seller have full responsibility for selling as much of their available energy as they can at the best prices that they can achieve. Participants enter into contracts without involvement, interference or facilitation from a third party. The electricity prices and transacted MW are decided by these participants not the system operator. Once the transactions are settled, the ISO need to be informed about the trade since ISO is responsible to ensure that the transactions do not endanger the system security as shown in Figure 5.1.

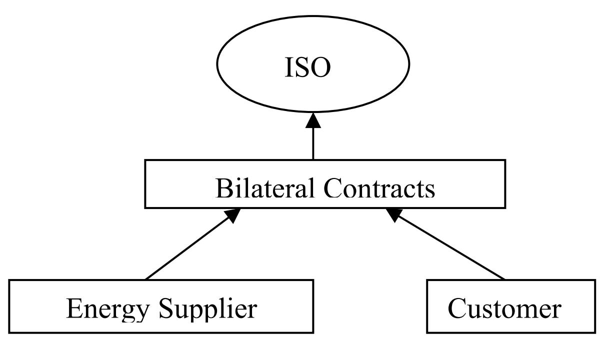


Figure 5.1: Bilateral Market Structure

The bilateral market model allows their customer/buyer to directly deal with generation company (GenCo) in energy purchasing, basically no other party is involved, of course both party can have contract more than one another. Unlike single buyer model, the transmission company (TransCo) no longer deal with energy buying and selling, hence no capacity payment is involved. It acts as a transmission facilities provider, and focus on facilitating the power flow between GenCo and customers, where customers can be distribution company (DisCo). In this phase GenCo pays the transmission charges to TransCo, and DisCo or customer pays similar charges to TransCo to access the transmission facilities and services.

Due to the fact that DisCo to be direct in negotiation with GenCo, it requires DisCo to search around and get the best deals from GenCo. This has prompted the growth of brokers and power exchanges, which can facilitate further competition. The bilateral contract can be very flexible, which can be either long or short term based on the price and delivery date that meet both parties' requirements.

The bilateral model contains an intermediate Power Exchange (PX) that balances the supply and demand since it is always unmatched. It creates an environment that both sellers and buyers can go to PX and compensate the contracts by purchasing or selling power in the exchanger. Under this model, economic dispatch is not applicable. Figure 5.2 shows the basic bilateral contract model. From this figure, it is clearly stated that GenCo are free to sell their output to any customer and pass through any TransCo by doing long term contracts. If it happen to be shortfall or over supply of power during the day as the load fluctuated, then the players will use the power exchange to balance out the supply and the demand.

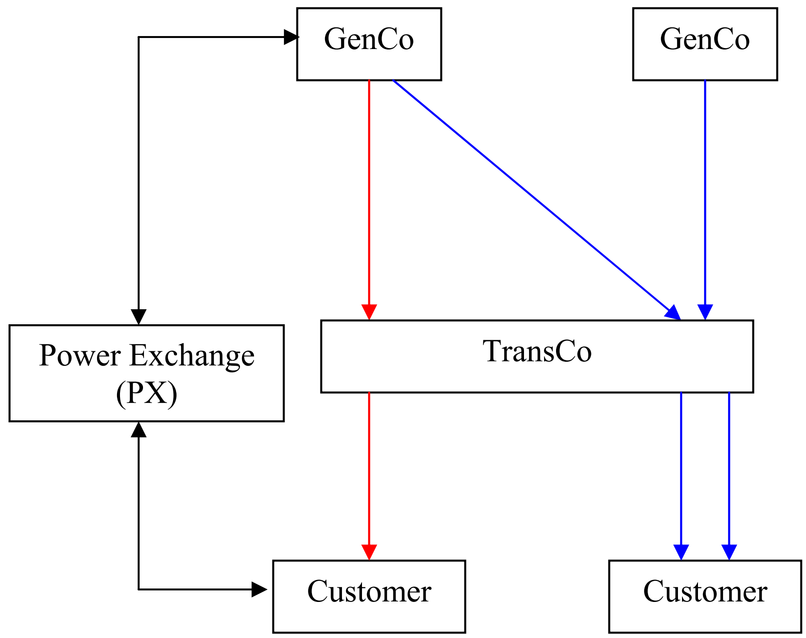


Figure 5.2: Basic Bilateral Contract Model

5.2.1 Market Settlement Strategies

Depending on the amount of time available and the quantity to be traded, buyers and sellers will resort to different forms of bilateral market model as stated below [8];

a) Customized long-term contracts

b) Trading “over the counter” (OTC):

c) Electronic trading

5.2.1.1 Customized long-term contracts

The terms of such contracts are flexible since the buyer and the seller are negotiated privately to meet the needs and objectives of both parties. They usually involve the sale of large amounts of power (hundreds or thousands of MW) over long periods of time (several months to several years). The large transaction costs associated with the negotiation of such contracts make them worthwhile only when the parties want to buy or sell large amount of energy.

5.2.1.2 Trading “over the counter” (OTC)

This transaction involves smaller amounts of energy to be delivered according to a standard profile, that is, a standardized definitions of how much energy should be delivered during different periods of the day and week. This form of trading has much lower transaction costs and is used by producers and consumers to refine their position as delivery time approaches. The word refine means if the generators short of supply power, they can buy the electricity in the market (in this situation the generators become buyer) and if the consumers had bought extra power, they can sell the electricity in the market (in this situation consumers become seller)

5.2.1.3 Electronic trading

Participants can either offers to buy energy and bids to sell energy directly in a computerized marketplace. All market participants can observe the quantity and prices submitted but do not know the identity of the party that submitted each bid or offer. The software that runs the exchange will check to see if there is a matching offer for the period of delivery of the bid each time a party enters a new bid. If it finds an offer whose price is greater than or equal to the price of the bid, a deal is automatically struck and the price and quantity are displayed for all participants to see. If no match is found, the new bid is added to the list of outstanding bids and will remain there until a matching offer is made or the bid is withdrawn or it lapses because the market closes for that period. A similar procedure is used if a new offer is entered in the system. This form of trading is extremely fast and cheap. A flurry of trading activity often takes place in the minutes and seconds before the closing of the market as generators and retailers fine-tune their position ahead of the delivery period

5.2.2 Characteristic of bilateral market model

According to the market settlement strategy, the essential characteristic of bilateral trading can be listed as below:

a) the price of each transaction is set independently by the parties involves, therefore, there is no “official” price

b) The details of negotiated long term contracts are usually kept private, some independent reporting services usually gather information about over-the-counter trading and publish summary information about the prices and quantities in a form that does not reveal the identity of the parties involved

c) this type of market reporting and the display of the last transaction arranged through electronic trading enhance the efficiency of the market by giving all participants a clearer idea of the state and the directions of the market

5.2.3 Example on bilateral market model

Malaysia Power trades in the Malaysian electricity market that operates on a bilateral basis. It owns the three generating units whose characteristics are given in the table below. To keep things simple, we have assumed that the marginal cost of these units is constant over their range of operation. Because of their large start-up cost, Malaysia Power tries to keep unit A synchronized to the system at all times and to produce as much as possible with unit B during the daytime. The start-up cost of unit C is assumed to be negligible.

Unit	**Type**	**P_{min}**	**P_{max}**	**MC**
		(MW)	**(MW)**	**(RM/MWh)**
A	Large Coal	100	500	10
B	Medium Coal	50	200	13
C	Gas Turbine	0	50	17

Let us focus on the contractual position of Malaysia Power for the period between 2.00 and 3.00 PM. on 11 June. The table below summarizes the relevant bilateral contracts.

Type	**Contract date**	**Identifier**	**Buyer**	**Seller**	**Amount**	**Price**
					(MWh)	**(RM/MWh)**
Long Term	10 Jan	LT1	Cheopo Energy	Malaysia Power	200	12.5
Long Term	7 Feb	LT2	Malaysia Steel	Malaysia Power	250	12.8
Future	3 Marc	FT1	Quality Electron	Malaysia Power	100	14.0
Future	7 Apr	FT2	Malaysia Power	Perfect Power	30	13.5
Future	10 May	FT3	Cheopo Energy	Malaysia Power	50	13.8

Note that Malaysia Power has taken advantage of the price fluctuations in the forward market to buy back at a profit some of the energy that it had sold. Toward midmorning on 11 June, Fiona, the trader on duty at Malaysia Power, must decide if she wants to adjust this position by trading on the screen-based Malaysian Power Exchange (MPeX). On the one hand, Malaysia Power has contracted to deliver 570 MWh and has a total production capacity of 750 MW available during that hour. On the other hand, her MPeX trading screen displays the following stacks of bids and offers:

11 June 2.00 pm to 3.00 pm	**Identifier**	**Amount (MWh)**	**Price (RM/MWh)**
Bids to sell energy	B5	20	17.50
	B4	25	16.30
	B3	20	14.40
	B2	10	13.90
	B1	25	13.70
Offers to buy energy	01	20	13.50
	02	30	13.30
	03	10	13.25
	04	30	12.80
	05	50	12.55

Based on her experience with this market, Fiona believes that it is unlikely that the offer prices will increase. Since she still has 130MW of spare capacity on unit B, she decides to grab offers 01, 02 and 03 before one of her competitors does. These offers are indeed profitable because their price is higher than the marginal cost of unit B. After completing these transactions, Fiona sends revised production instructions for this hour to the power plants. Unit A is to generate at rated power (500MW), while unit B is to set its output at 130MW and unit C is to remain on standby.

Shortly before the MPeX closes trading for the period between 2.00 pm and 3.00 pm, Fiona receives a phone call from the operator of plant B. He informs her that the plant has developed some unexpected mechanical problems. It will be able to remain on-line until the evening but will not be able to produce more than 80 MW. Fiona quickly realizes that this failure leaves Malaysia Power exposed and that she has three options:

a) Do nothing, leaving Malaysia Power short by 50 MWh that would have to be paid for at the spot market price
b) Make up this deficit by starting up unit C
c) Try to buy some replacement power on the MPeX.

Since the spot market prices have been rather erratic lately, Fiona is not very keen on remaining unbalanced. She therefore decides to see if she can buy energy on the MPeX for less than the marginal cost of unit C. Since she last traded on the MPeX, some bids have disappeared and new ones have been entered.

11 June 2.00 pm to 3.00 pm	**Identifier**	**Amount (MWh)**	**Price (RM/MWh)**
Bids to sell energy	B5	20	17.50
	B4	25	16.30
	B3	20	14.40
	B6	20	14.30
	B8	10	14.10
Offers to buy energy	04	30	12.80
	06	25	12.70
	05	50	12.55

Fiona immediately selects bids B8. B6 and B3 because they allow her to restore the contractual balance of the company for this trading period at a cost that is less than the cost of covering the deficit with unit C. On balance, when trading closes for this hour, Malaysia Power is committed to produce 580 MWh. Note that Fiona based all her decision on the incremental cost of producing energy.

Bilateral market introduces screen based trading, in the short term and balancing markets, to promote real-time price transparency and encourage independent price reporting as in other commodity futures markets. This has been beneficial for the participants. This model with bilateral contracts and a voluntary power exchange has been implemented in several European countries, with exchanges in the Netherlands (Amsterdam Power eXchange), France (Powernext), the Scandinavian countries (NordPool), Germany (EEX), Poland (PolPX) and Austria (EXAA). One can have several competing exchanges in one country, as was the case in Germany (EEX and LPX) and England (UKPX, APX, PowerEX and IPE).

5.3 Bilateral market model design for MESI

Bilateral market model is an open trading which incurs very high cost if MESI plan to apply the model. A lot of changes have to be done, especially on the structure. Current structure only allows private sectors in generation level, but with bilateral market model, we can see that TNB will not be able to monopolise the transmission and distribution sector as currently. There will be more distribution and transmission companies that can provide the services and the players are free to choose their own choice. However, this situation may occur in 50 years time in MESI, therefore a few bilateral market model design based on MESI under current environment is covered in this section.

5.3.1 Bilateral Market Model No.1

Few assumptions are made in order to make the design of the bilateral model become easier. The trading process is exactly the same as pool market model which is via bidding process but in this case they submit their bid price to the distributor company which is TNBD. All generators will try to submit the energy price rate as low as possible so that they manage to sell the output through the contract signed with the TNBD. There is no price scheme as exercise in pool market model, but generators will be paid based on their agreed price signed previously. Below are the details of the assumptions that are made and the model is represented as in Figure 5.3:

a) Only one distribution company is involved, assumed to be TNBD
b) All generators have to submit their energy bid price to TNBD
c) The dispatch selection is purely dependent on the agreement signed between distribution company and generators which are based on merit order list and the current load demand
d) The agreement also is based on the bid price submitted by generators
e) Exclude the capacity payment

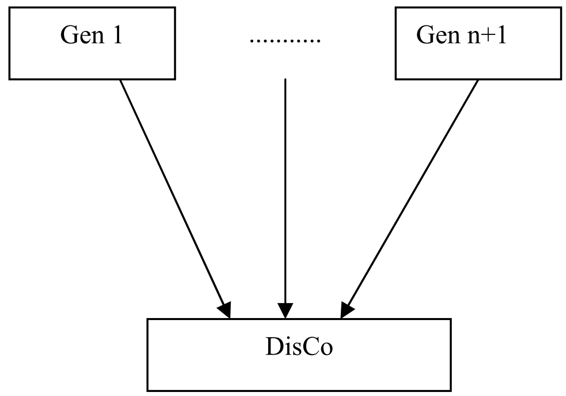


Figure 5.3: Bilateral Model No. 1

This model creates a real competitive market as each generator is competing for surviving due to the negligence of the capacity payment. Generators with higher energy bid price may face problem in selling their power all the time except during the load when it is at the peak. On the other hand, the distributor company is boundless to select the lowest energy bid price for energy trading. Without transmission losses being taken into account, it is assumed can effectively bring down energy tariff which is beneficial to the end users.

5.3.2 Bilateral Market Model No.2

In order to minimise the transmission losses, the distance between a generator and a distribution company shall be taken into account. In view of this, the distance between seller and buyer is a key factor that influences the energy price. Each generator is classified in regions depending on their location, where the load must be fulfilled by the generator in the same region. However, the demand may exceed the supply in some region as the load consumption is based on the activities done in that region. For example, more power needed for industrial area compare to rural area. Therefore, if the region is short of energy, the distribution company has to purchase from adjacent region generator companies. The assumptions are summary as follows:

a) Classified the generators in four regions, namely centre, southern, northern and eastern region. On the other hand, only one distribution company assigned to be in each region and total up to four distribution companies.

b) Load must be fulfilled by the generators in the same region. The distribution company is only allowed to purchase from adjacent region, if there is any particular case that shortfall within the region as it helps to reduce the transmission losses.

Figure 5.4 illustrates the generators and distribution companies classified in different regions, where they are free to negotiate among themselves but limited to be in the same region. They can only approach the other regions if the requirement cannot be fulfilled within the same region.

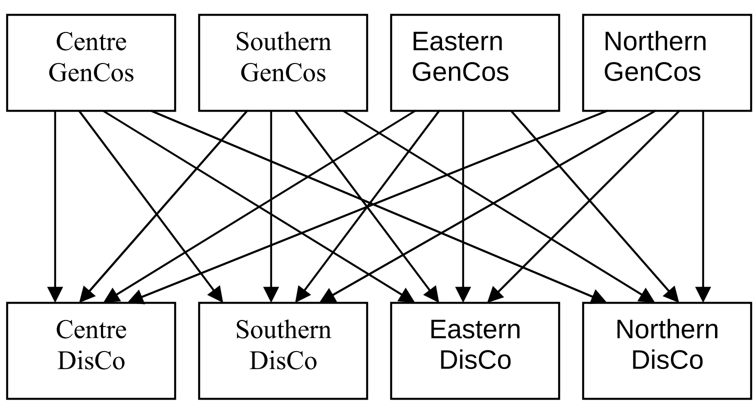


Figure 5.4: IPPs and DisCos differentiated in regions

Transmission charges can be minimized by applying this market model. The generators are obliged to sell their power to the local region's distribution company only except when there is surplus demand. Same issue as previous model, some of the generators with higher energy bid price in the region may face problem in selling their energy as cheaper generators will win the battle first. The other point to be noted is that the distribution company is limited to purchase power from local region's generators prior to adjacent regions. This may results higher energy bid price and as distribution company had no choice but to accept. Meanwhile, the distribution company in the regions that have energy shortage problem might have to purchase energy with higher bid price from other region which may increase the energy tariff to the end users. Therefore, it is suggested to set out more power plants in the energy shortages region.

5.3.3 Bilateral Market Model No.3

Similar to pool market model, there are several generators especially with the higher bid price that are found hard to survive. These generators only get an income during peak load; therefore the same concept of hybrid model as discussed in Chapter 4 is being suggested to overcome this issue. In this case study, the base load demand is being shared fairly within GenCos, and the other conditions are assumed to be the same as bilateral market model no.2. The assumptions made for this case study are summarised as below:

a) The concept of model no. 2 remains the same as in this model
b) Assumed that the bid price submitted by the IPPs is maintained
c) The portion of supply for the base load is by using the pro-rate concept

The generators will have a guaranteed minimum income as each of them has the opportunity to supply the base load regardless of their energy bid price. The remaining load demand is being traded through bidding process in their own regions.

5.3.4 Proposed bilateral market model for MESI

From the bilateral market model no.1, it was shown clearly that a significant amount of energy tariff is reduced however it is not practical since transmission losses are not taken into account. The bilateral market model no.2 take into account the transmission losses, and create a regional competition among generators in the market, however some of the generators may face the consequence of being closed down due to the higher energy bid price. Lastly, the bilateral market model no.3 may be able to help the generators by ensuring their survival in the competitive market.

Since the objective of restructuring is to propose a competitive market, bilateral market model no.3 is not recommended. To create a competitive market, bilateral market model no.1 and no.2 are possible to do so. However, the structure of bilateral market model no.1 is the nearest ones to the MESI existing structure compare to other models. Therefore, this model is being proposed to be applied in MESI. Details comparison and analysis of the proposed model and the existing ones can be observed in the next chapter.

5.4 Economic Aspect of Bilateral Market Model

In bilateral market model, there are two main sides of market participants who make the contracts namely generators and customers. The generators and customers can directly negotiate in the market place with their own selected entities without requiring to enter into pooling arrangement. It is believed that, bilateral implementation cost is cheaper and will benefit small generators since the deal is not based on ISO. In fact, domination is lesser in bilateral model which make it the best in modern electricity market. The mathematical equation of this model for generation income and demand charges can be written as per details:

For total generation income, G_T the formula is:

$$G_T = \sum_{i=1}^{k} (P_{Gi} \times C_{Gi}) \tag{5.1}$$

$$G_i = P_{Gi} \times C_{Gi} \tag{5.2}$$

Where,

P_{Gi}	=	Power capacity of *i*th generator; satisfy the demand
C_{Gi}	=	Bid Price offered by *i*th generator
k	=	Numbers of generators involved
G_T	=	Total generation income in RM/h

5.4.1 Example of a Simple Case Study

The same example and data in the previous simple case study in Section 3.3.4 and Section 4.5.1 are being used in order to give an overview of the proposed bilateral market model for MESI. Similarly as practiced in the pool market model, the business is based on the competition among generators. Generators will submit their energy bid price and only the least bid price generators are able to sell their output. This situation can create competition among generators as each of them try to be the least bid price generators. Same assumption as written in Section 4.5.1, as the energy bid price will include the capacity price in hourly basis. The numbers of succeeded generators that supply the load remains the same as previous chapter. Detail calculation for the proposed bilateral market model in this example can be referred to the APPENDIX D.

Figure 5.5 illustrates the revenue obtained by each generator in this bilateral market model. It can be observed G4 is unable to get any income at all for both low and medium demand. Meanwhile, the G3 manage to obtain an income for each types of load except for the low demand. This means that by applying bilateral market model which is based only on the energy price, the expensive generators will be unable to obtain revenues at low demand and only manage to get income during high demand.

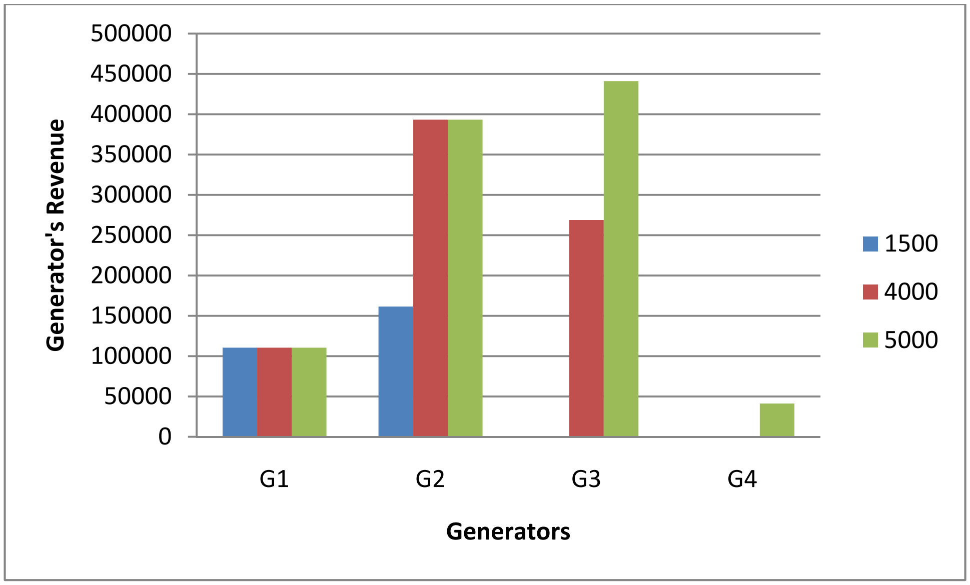


Figure 5.5: Each generation's revenues at different demand

5.5 Advantages and Disadvantages of Bilateral Market Model

Below are the listed advantages of the bilateral market model:

a) The ability of the government to intervene in the payment chain from consumers to generators is diminished

b) The government don't have the authority to decide about the new construction of power plant because it is based on private investor's decisions

c) Improve payment collection as the generators are been given the opportunities to choose their own reliable buyers.

d) The decisions on new capacity will be based on market

e) Better opportunities for cross border electricity trade

f) Market participants benefits more price transparency, no counter price risk with anonymous trading

On the other hand, the bilateral market model also occupies own disadvantages as listed follows:

a) The electricity production and consumption of sellers and buyers seldom match the contracted amounts. Hence, need balancing mechanisms which make trading becomes complicated.
b) Requires development of transmission access and pricing regime that reflects capacity constraints and loss factors in the high-voltage network.
c) Lead to suboptimal dispatch schedules
d) The lack of unified wholesale market price, such that the electricity price for small consumers depends on the power purchase contracts signed by their distributors
e) All bids and offer are firm such that the generator must deliver, and a consumer take delivery according to the contract which is very risky but the participants have the opportunity to trade in OTC

CHAPTER 6

CASE STUDY

6.1 Introduction

A case study is presented in this chapter which is purposely conducted in order to compare the generators revenue in Malaysia Electricity Supply Industry (MESI) under three selected market models, as follows; (i) Single Buyer Model, (ii) Pool Market Model with Uniform Price Scheme, (iii) Bilateral Market Model No. 1. The two new market models were chosen as the current structure of MESI is able to apply these models without major changes that can incur a large cost. With the intention to identify the effect of applying new market model in MESI towards the generators including TNBGs and IPPs, both existing and the two new market model will be analyzed by using the actual load profile in peninsular Malaysia. Several assumptions are made in order to reduce the complexity of the study.

This chapter begins with the comparison of the three selected market model based on the example of a simple case study which have been discussed in Chapter 3, Chapter 4 and Chapter 5 previously. It is intended to recap these models's characteristic as preceding comparisons are between the same types of market models. Next section will describe on the process of designing the market models by using MATLAB Simulation.

6.2 Comparison on the Selected Market Models

The comparison between the selected market models is based on the example of a simple case study discussed in Section 3.3.4, Section 4.5.1 and Section 5.4.1. This simple case study present four generators G1, G2, G3 and G4 that have to supply three types of load; i.e. 1500 MW (low demand), 4000 MW (medium demand) and 5000 MW (high demand). G1 until G4 is being stacked into merit order list where the energy bid price for G1 is the lowest among others and G4 is the most expensive.

In this simple case study only single buyer model consider the capacity payment besides energy payment as practiced currently in MESI. This means that each generator will receive a minimum income without considering the quantity of power sold. They will get additional energy payment if they manage to sell their power. Meanwhile, the pool and bilateral market model only consider the energy payment. Therefore, the generators will only obtain an income if they succeed to sell their power. Pool and bilateral market models encourage generators to compete in selling their power by submitting the least cost. This is because the power will be sold based on merit order, whereby, the lowest offer price generators will sell their power first, compare to the higher energy bid price. As a result, the generators with higher bid price will only make incomes during high demand.

In reality, the rate for energy bid price should reflects all cost and it will be much higher as compared to the energy price rate stated in the single buyer model. Considering this issue, the new energy bid price is being calculated which consist of the capacity price in hourly basis. The new energy bid price is used in the pool and bilateral market model. Basically, the concept of power selling for this three selected model is the same. All markets model were based on the merit order list and power selling depends on the current demand needed. The main difference is the price in single buyer model is being fixed as they are obliged to the PPA. But the price in pool market model may be volatile from time to time as it depends on the current market. On the other hand, the energy price for bilateral market model is based on the agreement made by the distributor and the generator company. In term of the flexibility of customer or the distributor, they are flexible if they enter the bilateral market model, compare to single buyer and pool market model.

In spite of this, each market model award different effects to the market players. But in this simple case study, the main intention is to observe the effect of applying these market models towards the generation revenue. This observation should reflect the electricity tariff endured by the end users. Figure 6.1, Figure 6.2, and Figure 6.3 illustrate the outcome due to the application the three market model during low, medium and high demand. Meanwhile, the total generation revenue for all types of demand is describes in Figure 6.4. Details calculation can be referred as in APPENDIX E.

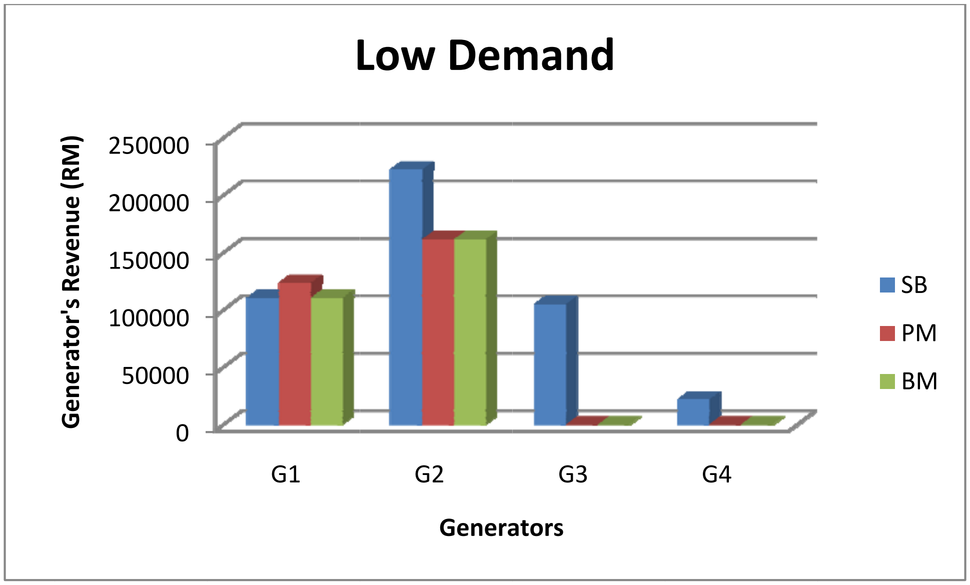


Figure 6.1: Each generator's revenues for during low demand

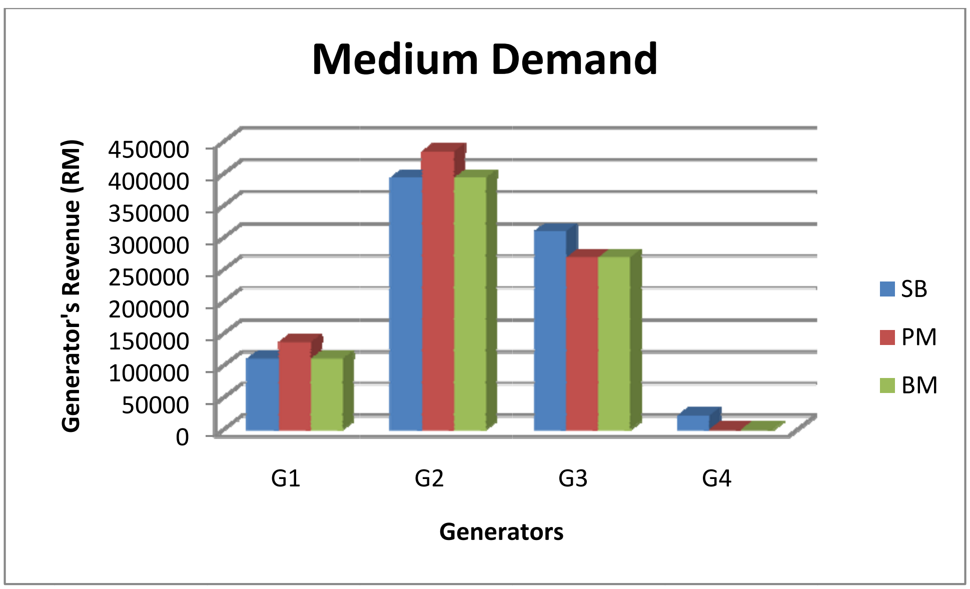


Figure 6.2: Each generator's revenues for during medium demand

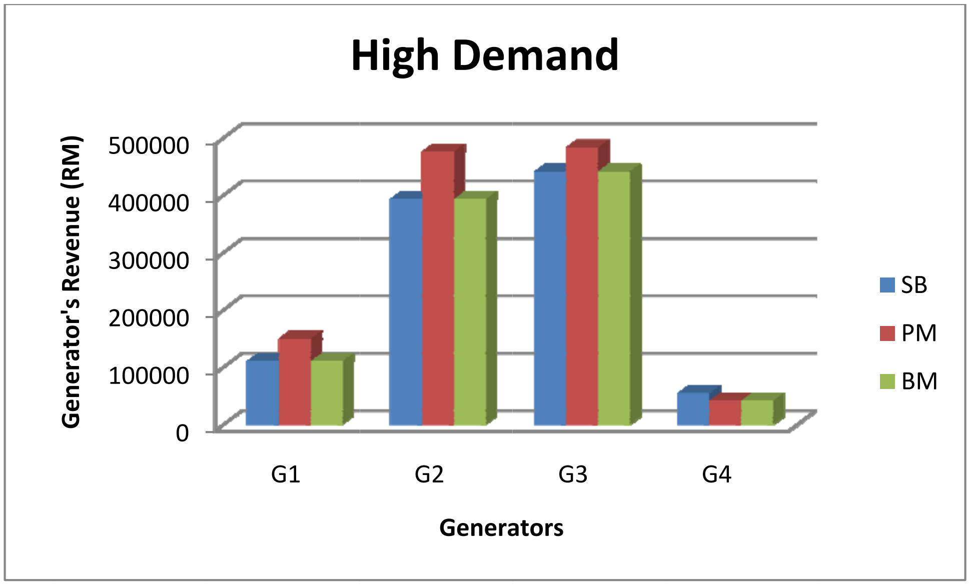


Figure 6.3: Each generator's revenues for during low demand

From the figures shown above, it can be seen that all generators obtained an incomes no matter what types of demand under single buyer market model. This is due to the capacity payments which are being paid for the availability of the power plant. Unlike system under pool and bilateral model, the generator with higher bid price, G3 and G4 are not able to generate any income at all during low demand. G3 get the opportunity to sell their power during medium and high load but G4 only obtained an income during high demand. This means that the income generated under single buyer model by the generators are safer. There are times where the generators gain more incomes under the new model compare to existing model, especially during medium and high demand. This may due to the uniform price scheme used in the pool market model, whereby cheaper generators also are being paid using the system marginal price.

Figure 6.4 shows that cheaper generators, G1 and G2 able to obtained higher revenue under pool market model compare to other two models. On the other side, the expensive generator G3 and G4 gain more incomes under existing model compare to the new ones. The bilateral market model is seems to be the cheapest cost endured by the customers among all models. However, this model is very complicated and creates higher risk compare to pool market model.

Figure 6.4: Total generator's revenues for all types of demand

6.3 Market Model Design

As mentioned earlier, there are three market models that are applied in this case study. These models will be analyzed and compared from the perspective of generation revenues. The design process starts with the formulation of mathematical equation for each market model. The previous mathematical equation which represents the total generation revenues for each of market model is being used. As the case study relates on the calculation of revenue for each hour, the MATLAB Simulation is being used to simplify the work. Listed below are mathematical equations of total generation revenue for each market model.

a) Single buyer model

$$G_T = \sum_{i=1}^{k} [(P_{Gi} \times C_{Gi}) + (P_{EGi} \times C_{EGi})]$$

b) Pool market with Uniform Price

$$G_T = \sum_{i=1}^{k} (P_{Gi} \times C_{PP})$$

c) Bilateral Market Model

$$G_T = \sum_{i=1}^{k} (P_{Gi} \times C_{Gi})$$

6.4 Load Demand Curve for Peninsular Malaysia

The hourly load demand curve for peninsular Malaysia is used in the case study as the load is heavier than load consumed in Sabah and Sarawak. Basically, there are four different types of load profile recorded and it differ with respect to time such as weekday load, Saturday load, Sunday Load and public holiday load. The load profile curve is shown in Figure 6.5 [20]. The details number for load profile for each hour in the four types of profile can be referred in APPENDIX F.

It is important to know the location of load demand, however this load profile curve does not illustrate the location of the load demand. This is because, in economic dispatch, there are two main factors that should be considered such as:

a) The marginal cost of production
b) The transmission losses

Therefore, without the information on the location of demand, the transmission losses could not be considered in the study. For example, if the highest load demand intensity i.e. Klang Valley, is being supplied by the nearest location of power plant, the effect of transmission line losses can be reduced. On the contrary, if the nearest generators could not supply, the cost of transmitting electrical energy will be higher due to losses.

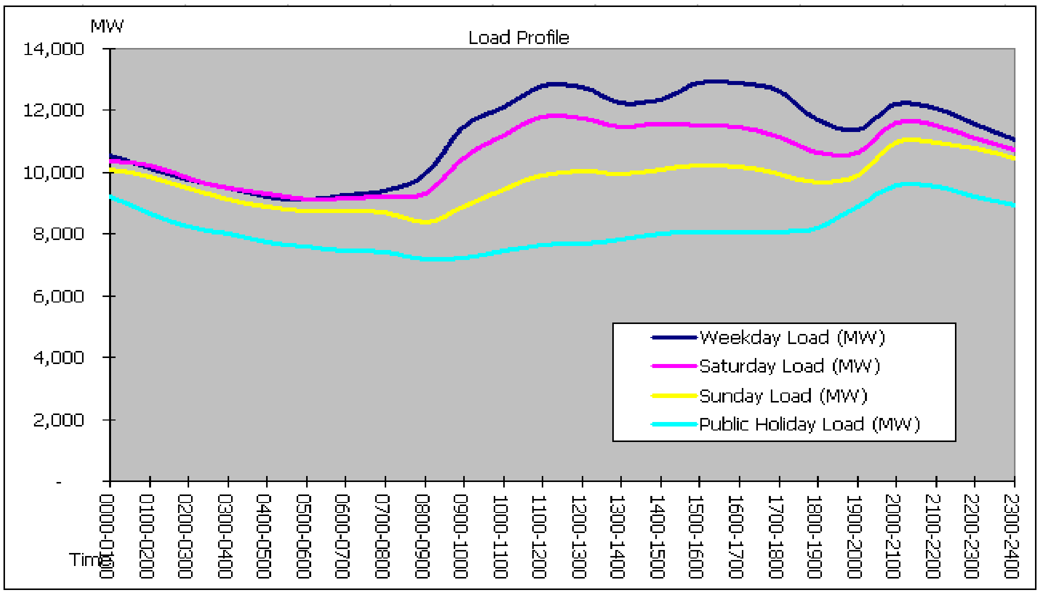


Figure 6.5: The peninsular load profile curves

6.5 Design Properties

The participants involved in this design model are limited to the 14 Independent Power Producers (IPP) which are bonded with power purchase agreement (PPA). This is because the fourteen IPPs are sufficient enough to supply the load consumed by the peninsular of Malaysia. There are many other power plants from TNBG side, but in this case study, they were neglected. This is because as proposed in the market policies, the hydro power plant will not involved in the bidding process. Meanwhile, other power plants owned by TNBG are neglected as the machine is not so efficient and thus the energy bid price might not reflect the actual values. Compare to IPP power plant which are not only new and apply the latest technology but also high in efficiency. The details of the IPPs that involved in this case study are simplified in Table 6.1. As mentioned previously, the private power producers will compete in pool and bilateral market model that used the current load profile as the base demand needed. Same concept applied to the existing model, whereby only the private power producers will supply the electrical energy.

The case study is applied on actual load profile of Peninsular Malaysia which is provided by the TNB. There are four type of load profile; Weekdays, Saturday, Sunday and Public Holiday Load Profile. These load profile is assumed to be fixed at the particular of hour for the whole year. Even though, the demand always fluctuated each day but the load profile illustrates the proximity to actual data.

In the single buyer model, the IPPs will receive two payments, which is capacity payment and energy payment. The capacity payment is being paid as long as the IPPs remain available to supply the energy and it is regardless the amount of energy transferred to the grid system. As for the energy payment, which values differ from one IPP to the other is being paid if only they able to sell their energy to the power agency (in this case is TNB). It is assumed that the generations are based on economic dispatch. i.e. the IPP with the least energy payment will be the first to generate followed by the IPP with the next least energy payment and so on until all load demands of that hour are met.

The one sided pool or single auction power pool is used in the market design as it is the nearest market model that suitable with MESI current structure. TNB will act as the pool operator meanwhile the market participants will be the power producers and TNBD. This kind of auction provides competition among generation side in supplying the electrical energy to fulfill the demand required. The bid price and capacity available for the IPPs are being stacked from the least price up to the highest to form a supply curve. The intersection between the supply curve and load curve during specific hour determines the system marginal price (SMP). This price is used as the energy rate for all energy transaction as only uniform price scheme is available in this case study. The trading is handled in hourly basis and the bid price is assumed to be fixed at each trading hour.

Bilateral market model possess three market strategies that depends on the amount of time available and the quantities to be traded. In order to simplify this model, it is assumed that distributor company, TNBD had signed the contract with IPPs based on merit order list and the current demand. In reality, there is no such thing as demand always match the supply, therefore power exchange is being used to balance out the deviation. However, this case assumed that all demand and supply is perfectly balance and match. IPPs are being paid based on their agreement signed with TNBD and the energy price rate depends on both side bargain made previously.

The design model in the case study is based on confidential data which could not be included in this thesis. The data consists of installed, capacity price and the energy bid price for each generator. Single buyer model used the same capacity and the energy price for each hour throughout the four types of load profile. But for both pool and bilateral market model, they used a rate of energy bid price that already considered the capacity price in hourly basis. The energy bid price in the pool and bilateral market model is assumed to be the same all the time. In actual situation, the rate might be differed from one another and the power producers might change their energy bid price depending on current market i.e. the fuel price or the forecast demand. Therefore, this case study may not produce a result with 100% accuracy, but as a preliminary observation, it is still acceptable.

All market models considered in this case study are the most simple concept as the main purpose of this chapter is to produce a result that describes the effect towards the generators in term of the revenue when MESI starts to apply new competitive market model. If MESI is seriously confirm in applying the new competitive market model, the hybrid model discussed previously may be used in next research study as the market model provide a win-win situation to all market players. However, the hybrid model is not considered in this case study.

Table 6.1: Lists of IPPs in Malaysia with their installed capacity and type of plant; Combine Circle Gas Turbine (CCGT), Open Cycle (OC) and Thermal (Coal)

No	Private Power Plant	Ins. Cap. (MW)	Type of Plant
1	Panglima Power Sdn. Bhd.	720.0	CCGT
2	Pahlawan Power Sdn. Bhd.	322.0	CCGT
3	GB3 Sdn. Bhd.	640.0	CCGT
4	Teknologi Tenaga Perlis Consortium Sdn. Bhd.	650.0	CCGT
5	Prai Power. Sdn. Bhd.	350.0	CCGT
6	Genting Sanyen Power Sdn. Bhd.	740.0	CCGT
7	Kapar Energy Ventures Sdn. Bhd.	2,420.0	OC, Thermal
8	Port Dickson Power Sdn. Bhd.	436.4	OC
9	Powertek Berhad	434.0	OC
10	YTL Power Generation Sdn Bhd	1,170.0	CCGT
11	TNB Janamanjung Sdn. Bhd.	2,070.0	Thermal
12	Segari Energy Ventures Sdn. Bhd.	1,400.0	CCGT
13	Jimah Energ Ventures Sdn. Bhd.	1,303.0	Thermal
14	Tanjung Bin Power Sdn. Bhd.	2,100.0	Thermal

With regard to the economic dispatch, this case study will only consider one factor which is the marginal cost of production. This means that the least energy bid price is able to sell their output first compared to the expensive generators. A healthy competitive environment can be developed as each power producers will not only try to submit the least bid price, but the bid price must be able to overcome their cost of production. Furthermore, all cases in this project will be unconstrained cases, whereby all power producers manage to transmit their electrical energy accordingly without facing transmission congestion problem.

Finally, the loss of load probability (LOLP) that is used in calculating the pool purchase price, C_{PP} is assumed to be zero. Therefore, the generation incomes for power producers reflect the demand charges set by customers. However, in the actual situation, usually the value of LOLP is never zero, but as the purpose of the project is only for introduction, the consideration is acceptable. As the LOLP become zero, the effect of value of loss load (VOLL) also is neglected whereas the value of VOLL for Malaysia is known as 1/365.

6.6 MATLAB Simulation [21]

All three market models are being designed in the MATLAB software in order to simplify the process of the analysis. The design starts with the flowchart for each market model. From the flowchart, a programming using C language is written in M-file to describe the flow that the MATLAB has to pass through, as shown in Figure 6.6.

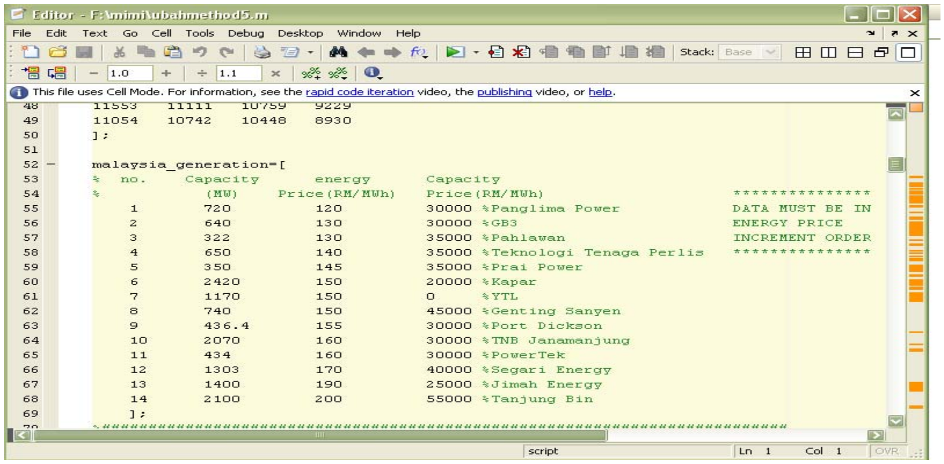


Figure 6.6: The M-file in the MATLAB Software

After the programming is completed, the file will be runned and at the command window, user has to select a load profile before the analysis is done; the selection is between weekday, Saturday, Sunday and public holiday load profile. Figure 6.7 describes the situation.

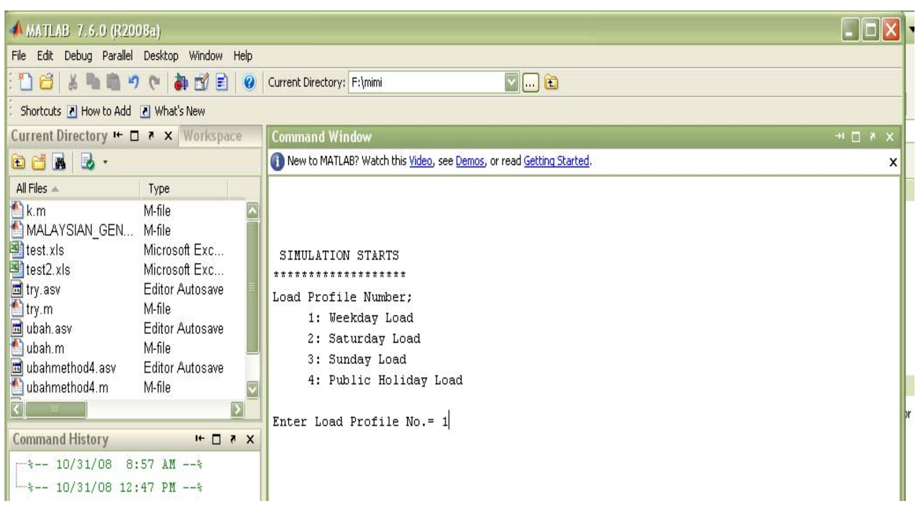
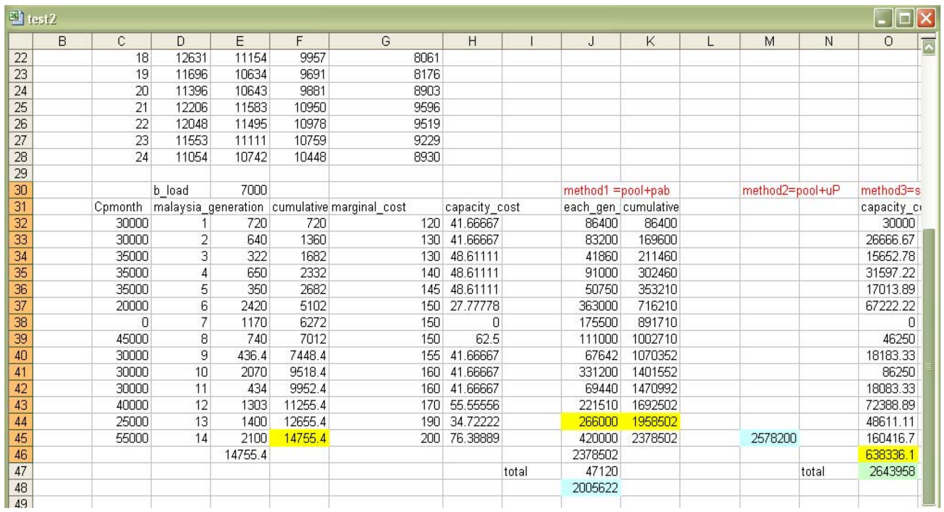


Figure 6.7: Enter Load Profile at the command window

Several results regarding the graph also are included in the programming, so that it is easier to compare the benefits between each market models. These can be seen in the Chapter 7. As a precaution, the answers are being verified by using Microsoft Office Excel. The data from the MATLAB simulation at hour 16 (4.00 p.m) is compared with the manual calculation in order to verify the answers as shown in Figure 6.8.



	B	C	D	E	F	G	H	I	J	K	L	M	N	O
22		18	12631	11154	9957	8061								
23		19	11696	10634	9691	8176								
24		20	11396	10643	9881	8903								
25		21	12206	11583	10950	9596								
26		22	12048	11495	10978	9519								
27		23	11553	11111	10759	9229								
28		24	11054	10742	10448	8930								
29														
30			b_load	7000					method1 =pool+pab			method2=pool+uP		method3=s
31		Cpmonth	malaysia_generation		cumulative	marginal_cost	capacity_cost		each_gen_	cumulative				capacity_c
32		30000	1	720	720	120	41.66667		86400	86400				30000
33		30000	2	640	1360	130	41.66667		83200	169600				26666.67
34		35000	3	322	1682	130	48.61111		41860	211460				15652.78
35		35000	4	650	2332	140	48.61111		91000	302460				31597.22
36		35000	5	350	2682	145	48.61111		50750	353210				17013.89
37		20000	6	2420	5102	150	27.77778		363000	716210				67222.22
38		0	7	1170	6272	150	0		175500	891710				0
39		45000	8	740	7012	150	62.5		111000	1002710				46250
40		30000	9	436.4	7448.4	155	41.66667		67642	1070352				18183.33
41		30000	10	2070	9518.4	160	41.66667		331200	1401552				86250
42		30000	11	434	9952.4	160	41.66667		69440	1470992				18083.33
43		40000	12	1303	11255.4	170	55.55556		221510	1692502				72388.89
44		25000	13	1400	12655.4	190	34.72222		266000	1958502				48611.11
45		55000	14	2100	14755.4	200	76.38889		420000	2378502		2578200		160416.7
46				14755.4					2378502					638336.1
47								total	47120				total	2643958
48									2005622					
49														

Figure 6.8: Verify the answer using Excel

CHAPTER 7

MATLAB SIMULATION RESULTS AND ANALYSIS

7.1 Introduction

This chapter presents the simulation results and analysis of the three market models in term of generation revenue. It provides generators scheduling details based on four types of load profile; i.e. weekday, Saturday, Sunday and public holiday. The total generation revenue for each market model is being compared weekly, monthly and annually in order to evaluate their economic aspects on the application of this model.

7.2 Case Study

For each type of market model, the same concept of stacked price is being used for each hour in each day as shown in Figure 7.1. The single buyer model used the stacked price in order to determine which generators succeed to obtain the energy payment besides capacity payment that is paid at a fixed amount every month upon their availability of the supply. Meanwhile, pool market model construct the staked price based on the energy bid price submitted by the generators. Usually, generators will submit different energy bid price for each hour based on the current market, but in this case study, the same staked is being used for each hour. As for bilateral market model, the generators with the least energy bid price which is shown in the stacked price are those who managed to sign the bilateral contract with TNBD.

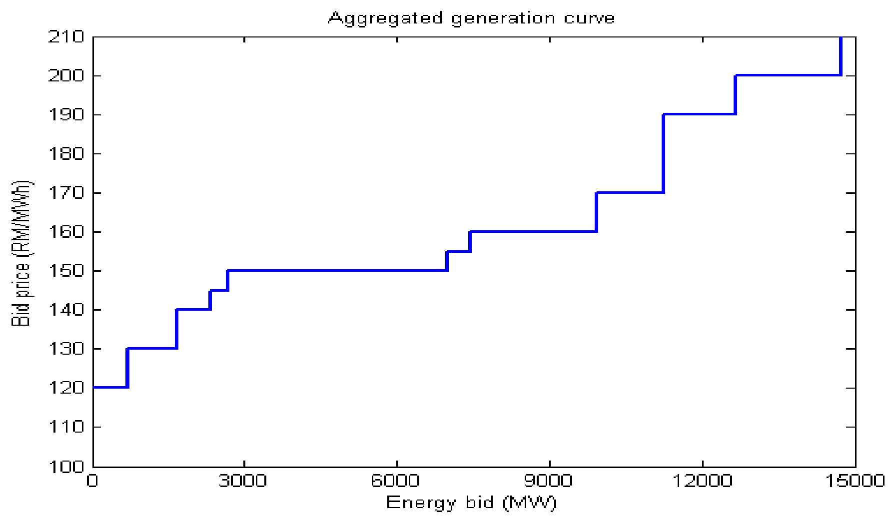


Figure 7.1: The stacked price

Bear in mind that both pool and bilateral market model used new energy bid price which consider the capacity price on hourly basis. Even though the energy price rate may not be the same as the exact rate, but it is expected that the energy bid price rate maybe higher in competitive environment than in the existing model. Moreover, the energy price may fluctuate from time to time and this may results uncertainty of generators revenue. Therefore, it is possible to presume that the pool market model is more expensive compare to single buyer model.

The capacity price for each independent power producer is shown graphically in Figure 7.2. Note that, the Gen 7 (YTL Corporation Sdn. Bhd) does not incur any capacity price. This is due to the fact that YTL has guaranteed to supply 80% of their installed capacity to the grid system as for the encouragement of the pioneer generations of IPP. Therefore, the PPA only includes energy payment and neglected the capacity payment. Nevertheless, this case study requires YTL to enter the bidding process as well as other generators but with the capacity payment remains zero. It is expected that YTL will gain less revenue under the new competitive market model if they did not revise current PPA.

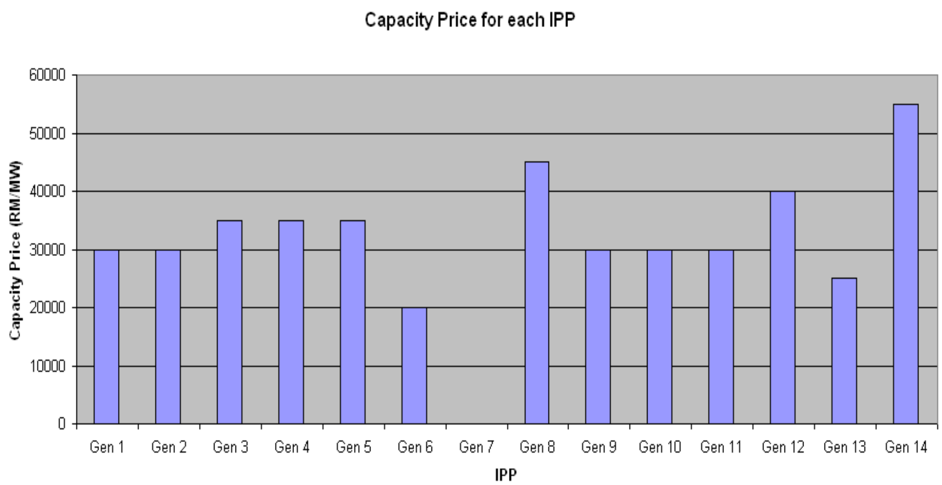


Figure 7.2: The capacity price for each IPP

7.3 Results Analysis and Discussion

The total generation revenues for each hour in a day and for each type of load profile; i.e. weekday, Saturday, Sunday, and public holidays are illustrated in Figure 7.3, Figure 7.4, Figure 7.5, and Figure 7.6 respectively. From these four figures, it can be observed that the total generation revenue for each hour is influenced by the current demand and the type of market model applied.

The single buyer model illustrates that the generators gain less income which means that the cost required by the end users is still reasonable compare with the other two market model. However, this situation only valid during the weekday and Saturday load profile but not for public holiday and Sunday. At this moment of time, the single buyer model is the most expensive compare to the other two models. This shows that single buyer may not be applicable during low load.

On the other hand, the generators are able to make maximum profits under the pool market model during peak load, (please refer to the generators revenue during weekday and Saturday load profile). This is due to the uniform price scheme used in this market model whereby, all generators that will be paid based on system marginal price regardless of their previous energy bid price. This system marginal rate is determined by intersection between the supply and demand. Therefore the rate will be high relatively when the current demand is high and at the point when the generators with least energy bid price will be able to maximize their profits. Market power exercise problem may result due to this as discussed in Chapter 4. Some policies controlled by the government may be suggested in order to overcome the problem.

Bilateral market model can be said as good from the perspective of end users as the cost seems to be cheaper at all load profile. This is due to the fact that each generator that signed the bilateral contract will be paid based on their agreed bid price which referred to their bid energy price. From the generators side, they may find aversion in applying this market model as the revenue will be less. But in reality, it is difficult to ensure that the supply matches the demand all the time and there will be a lot of changes in the MESI structure upon the application of this market model.

As mentioned previously, the generation revenue is based on the applied market model and the current demand needed at that point of time. There were several generators that obtain multiple gain of revenue under new competitive market model compare to the existing market model and vice versa. This shows that there should be a list of policy that are able to control the market price and construct the shape of returns or profits between all market players so that it will be in a win-win situation. The main important thing is that the energy tariff borne by end users is reasonable.

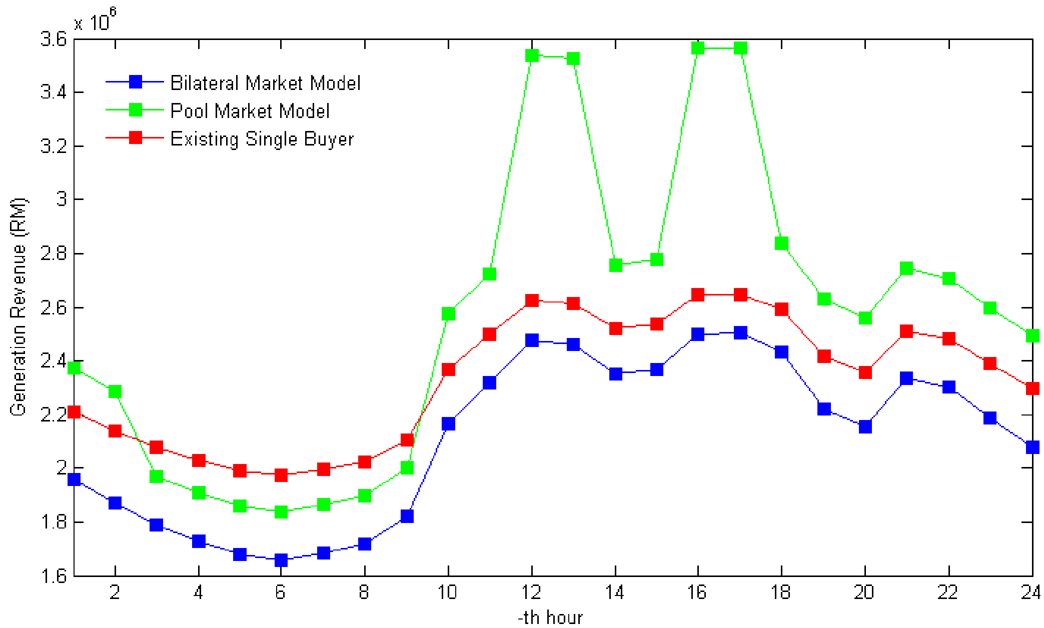


Figure 7.3: The total generation revenue at each hour; i.e. weekday load profile

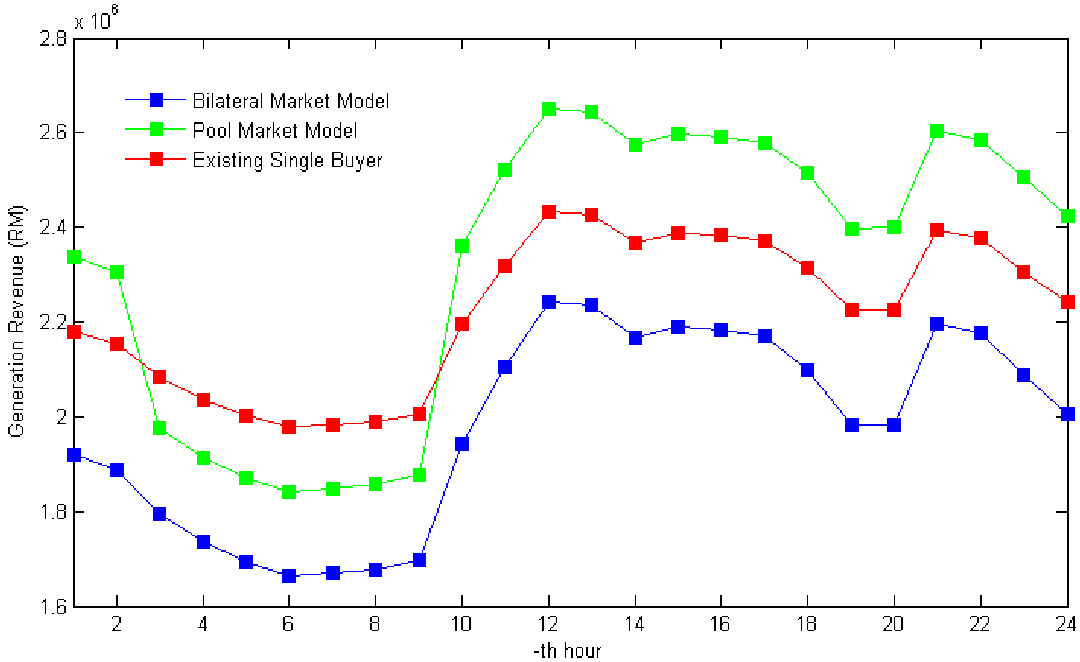


Figure 7.4: The total generation revenue at each hour; i.e. Saturday load profile

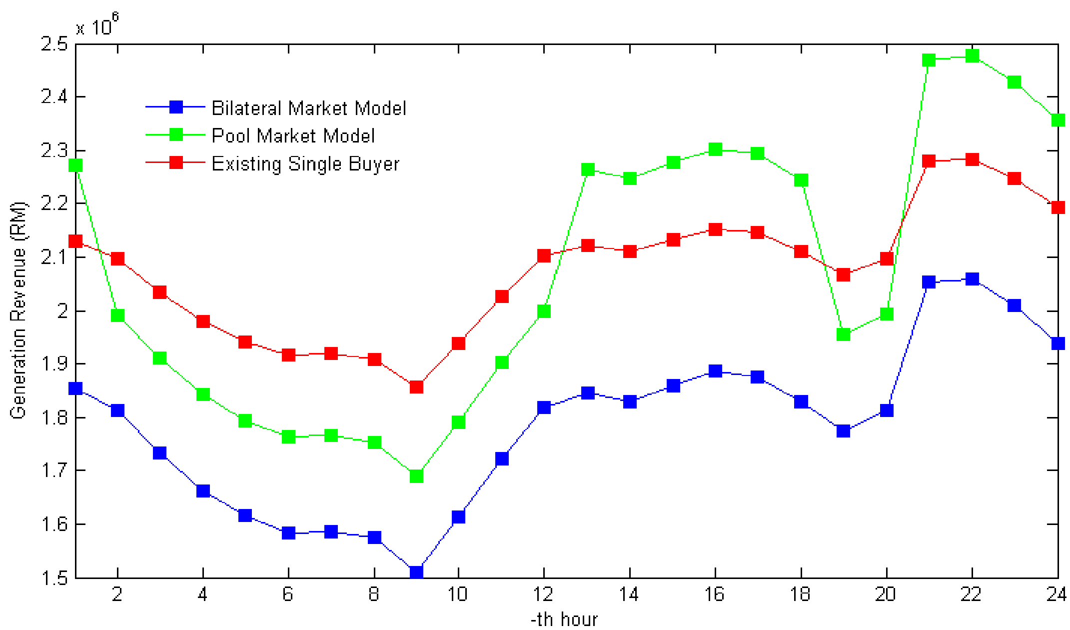


Figure 7.5: The total generation revenue at each hour; i.e. Sunday load profile

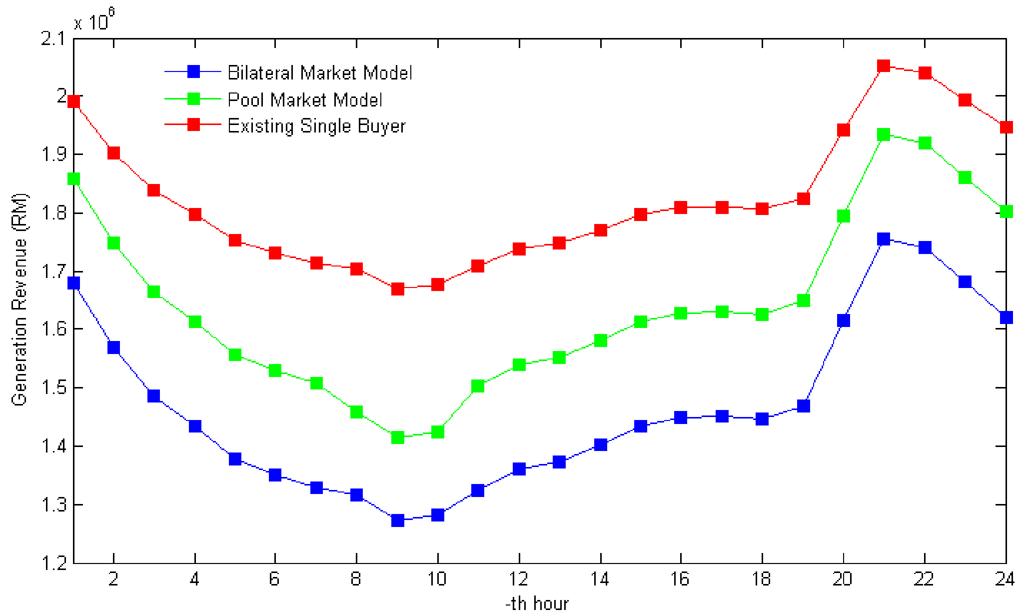


Figure 7.6: The total generation revenue at each hour; i.e. public holiday load profile

Meanwhile Figure 7.7, Figure 7.8, Figure 7.9 and Figure 7.10 illustrate the figure of each generator's revenue under the three market models for each types of load profile. The detail numbers of generation revenue for each market participant for each type of load profile can be seen in APPENDIX G. On the other hand the detail numbers of generation revenue for each IPP for weekly, monthly and annually basis are also tabulated in the same appendix.

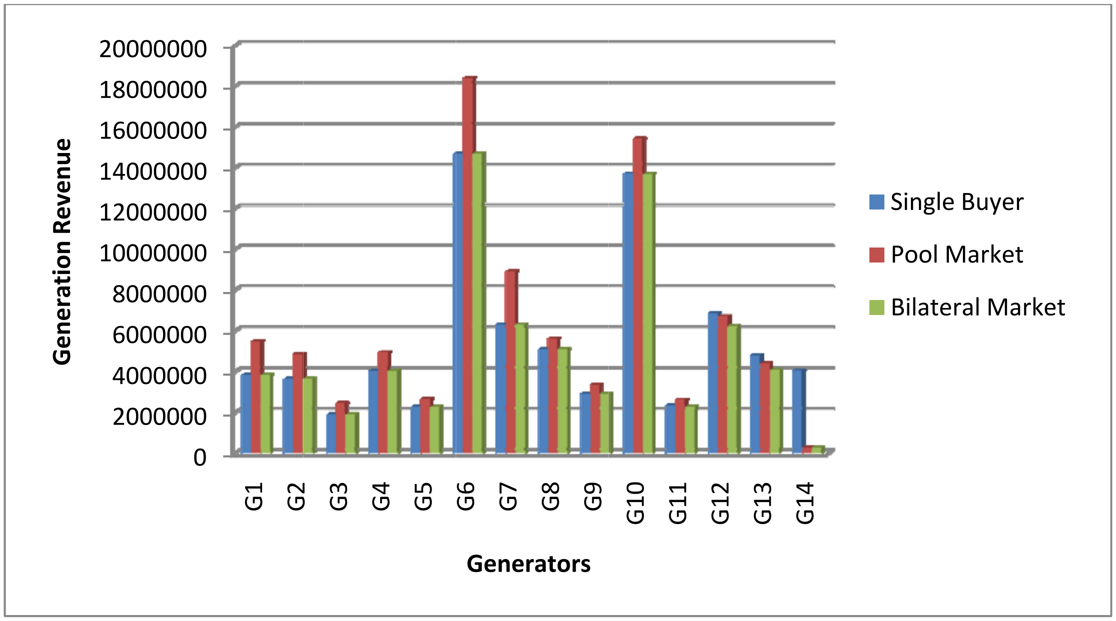


Figure 7.7: Each generators' revenues in a day; i.e. weekday load profile

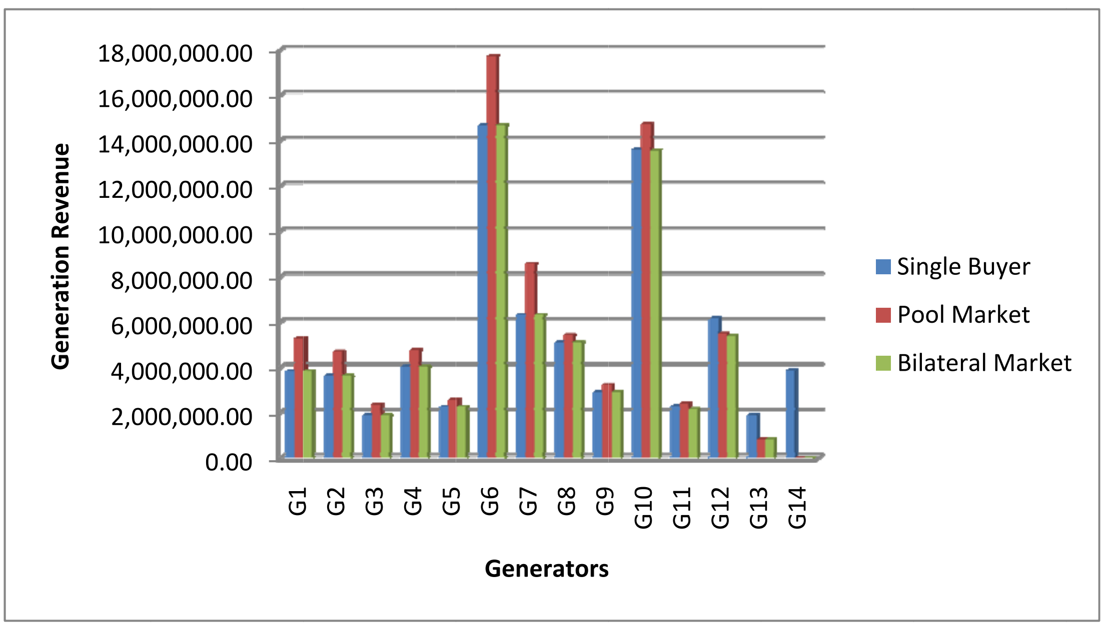


Figure 7.8: Each generators' revenues in a day; i.e. Saturday load profile

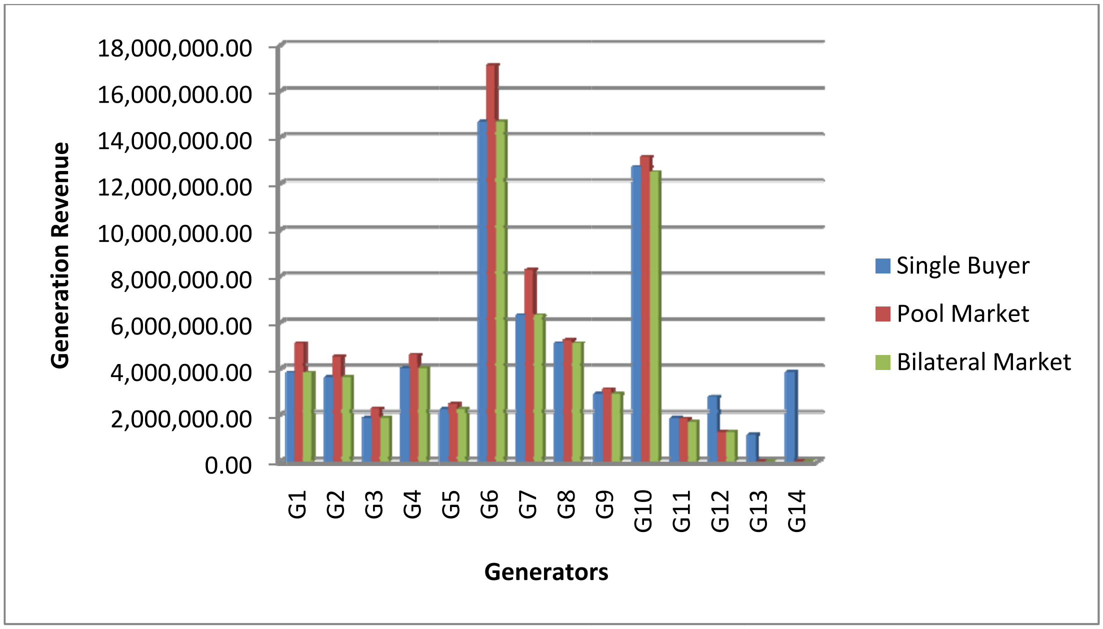


Figure 7.9: Each generators' revenues in a day; i.e. Sunday load profile

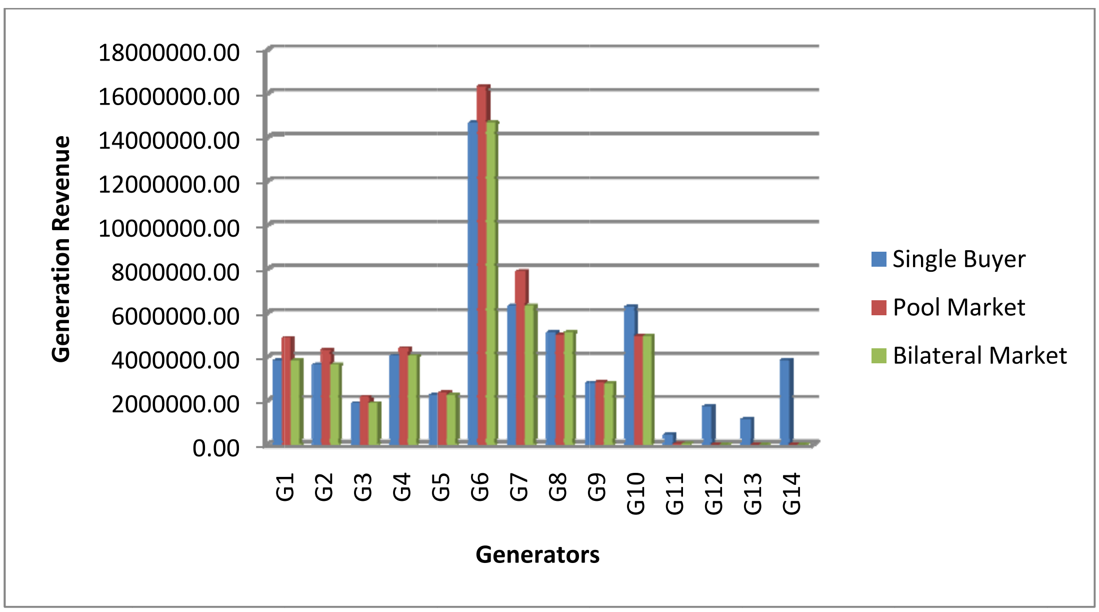


Figure 7.10: Each generator generators' revenues in a day; i.e. public holidays load profile

The generators will get different amount of revenue upon the application of new market model. New market model may provide a transparent competitive environment which is good to the market but it also cause a higher risk of uncertainty. This shows that it is very important to create an exact model that most suits with the MESI environment in order to reduce the percentage of expected risk, especially with regard to the energy price.

It can be observed that, the existing model has promised an incomes to the generators as all of them will get at least the capacity payment. Therefore, this market model does not influence much by the current demand except for generators that succeed to sell the energy, they will get extra incomes. As a result, generators do not have to work hard for gaining any incomes as long as they declare available, they will be paid through capacity payment. Nevertheless, this has show a discrepancy from the main intention of introducing the IPPs, which is to introduce a competitive environment among the generators sector.

Majority of the generators obtain extremely high revenue under the pool market model as they are being paid based on the system marginal price. Most of the time, the current demand touch the SMP of an average of RM 310.56 per MWh whereby the generators with cheaper energy price will get benefit from this. However, generators with the most expensive energy bid price will get less revenue especially during low peak hour as shown in Sunday and Public Holiday load profile. At this point of time, there are generators that are unable to get any revenue at all. This case can be observed as for Gen 6 that is able to obtain the highest generation revenue for all types of load profile upon the pool market model application. But as for Gen14, it does not gain any income under the same model during Sunday and public holiday.

The revenues under the bilateral market model do not differ much from the existing market model, except during low load. This may seem that bilateral is slightly like single buyer model with no capacity payment at all. But bear in mind that the structure of MESI have to be modified in order to provide all services needed under this model which has incur a very high of cost.

From the results, it can be seen that the pool and bilateral market model provide a fair trading as it is based on energy bid price only and totally neglected the capacity price. From the tables, it can be seen that the generation revenue for the two market model are sometimes less and higher compare to the existing model. TNB does not have to pay the capacity price anymore but have to be aware that the energy price would be extremely high.

The graph in Figure 7.7 shows that all generators' receive their revenues for each type of market model during weekday load profile; the models are single buyer, pool with uniform price, and bilateral market model. The Gen 6 and Gen10 are successful to supply the intermediate load demand and receive high revenue since they submitted medium bid price and moreover they have a huge installed capacity. The most expensive generator is Gen 14 receives the lowest revenue for pool market model as they depend on the peak load only.

Meanwhile during at low load (Saturdays, Sundays and Public Holidays), Gen 14 does not receives any revenue at all for pool market model. The tabulated table in Appendix G2, Appendix G3 and Appendix G4 in APPENDIX G show the zero number (in red). It can be observed that the expensive generators are unable to get any incomes at all during the low demand. Therefore, they only participate during peak load. But this is only valid for pool market model.

Payment scheme that is done through under bilateral market model which is paid as in the specified agreement is seem to be more economical compare to the uniform price scheme under pool market model. This is with the assumption that power producers will submit the same amount of energy bid price for both pool and bilateral market model. Nevertheless, in the real situation, for bilateral market model, the generators might not agree on a price that does not reflect to their marginal cost of production. They will try to estimate the system marginal price and submit their bid price around the prediction rate, so that they can earn more incomes. The uniform price on the other hand, might create market power exercise. For instance, a big generator company that has high installed capacity might conquer the pool market. Therefore, this will increase the market risk and distort the stability of market. The market demand curve, the auction mechanism and their interaction all have great influences on the market prices and the influence of market demand is more significant.

The economic benefits from the pool trading model and hybrid model are proven in this section. Table 7.1 illustrates the total generation income for all private power producers for each market model.

Table 7.1: The total generation revenue for each market model

	Single Buyer	Pool Market	Bilateral Market
Weekday	76,457,064.00	86,080,665.16	71,167,526.92
Week	521,831,478.00	577,440,428.85	482,575,967.25
Month	2,087,325,912.00	2,309,761,715.00	1,930,303,869.00
Annual	25,047,910,944.00	27,717,140,585.00	23,163,646,428.00

It can be seen that by changing the existing market model to the pool market model, TNB have to pay more, up to RM 10 million per week. This is due to the uniform price scheme used in the case study. With the application of some policy, this additional amount could be reduced and thus help TNB. Under the bilateral market model, TNB can save up to RM 5 million per week. However, the cost to prepare the application of this market model is very costly. Even though it requires less or more payment but these new market models has introduced a competitive environment in the generators level. The monthly revenue of some IPP, on the other hand will be reduced due to these changes. The reduction indicates the amount that TNB can save. Moreover, customers may be paying less for the electrical energy compare to the existing model.

CHAPTER 8

CONCLUSION AND FUTURE WORKS

8.1 Conclusion

The ongoing restructuring in electricity supply has led to the introduction of several market models in the industry. These include the single buyer model, pool market model, bilateral and multilateral market model. Malaysia has been under restructuring process and successfully unbundled the generation as well as distribution from transmission and it ceased the monopoly status of TNB in this field. IPPs were introduced to provide competition in the field of generation, however, the terms under which these IPPs did not reflect real competition in generation. In current Single Buyer Model, IPPs are making huge money due to capacity payment obliged by TNB, which ensure that the capital costs are covered. Therefore, this study outlines the outcome of the analysis on several electricity market models that has been done.

This study presented three out of the four market model that have been observed and analyzed namely the existing market model, pool and bilateral market model. The single buyer model in the case study found flawed, and uncompetitive. The current structure of power generation is not sustainable in the long run if we need to keep our electricity tariff at fairly competitive levels. Hence, with this proposed model, it provide as a vehicle for IPPs to put an effort to renegotiate the 21 years PPAs.

As it is today, we find that electricity tariff have gone up so much for the end-users. TNB is hit by higher fuel cost while the government is bearing the burden of rising cost due to the subsidies but the IPPs are not sharing any of these burdens.

Under the single buyer model, the generators had gained the largest revenue due to the existence of both capacity and energy payment. These generators still can obtain revenue even without any contribution to supply the load demand. This market does not provide any competition due to the long-term agreement; that simplify the electricity trading under one company which is TNB Transmission and Distribution.

The pool market model on the other hand, offers full competitive model and based on uniform price scheme. This model fully removed the capacity payment and therefore reduces the revenue some of the generators quite significantly. The most expensive generators might not be able to get any revenue at all and hence will force each of them to bid for the cheapest energy price most of the time and this will create competition. However, this pricing scheme has its own advantages and disadvantages. The application of any scheme should be monitored strictly to control the market price.

Both pool and bilateral market model are able to provide competition among IPPs. Bilateral model has also been proved that the ability of reducing energy tariff as shown in the case studied. However, these new market models can incur higher cost sometimes especially during high peak for example, pool market model. Therefore, it has to be regulated by Energy Commission (EC) to avoid the existence of market power exercise besides controlling the energy price submitted by the IPPs.

As a result, the generators will get reasonable profit, distributor company pay appropriate amount and end-consumers enjoyed low electricity tariff. Therefore, it is absolutely possible for MESI to apply the pool trading model as long as all market participants give full commitment and cooperation.

8.2 Future Works

For further future works, recommendations suggested for further investigations are on these following issues:

a) Include TNBG data in the analysis

In this case study, only fourteen IPPs are included in the case study and this does not reflect the actual situation in MESI. Therefore, with the TNBG data included in the analysis, the results reflect the actual situation.

b) Constrained case

In this case study, the transmission lines are violated to certain limits to cater for any (n-1) contingency. Thus generators must be redispatched so that these line contingency limits are not exceeded.

c) Bidding strategies

Bidding strategies are usually applied by the generators in order to maximize their profits. The information of these may help the TNBG to maximize their revenue

d) Market Power

There is possibility in having the market power exercise in this pool market model. There are many kind of market power exercise that are possible to occur. By knowing their tricks, the regulator can control the exercise.

e) Double auction in the pool market model

By doing further studies on possibility of applying the double auction power on MESI, we will be exposed more on the wholesale market model which is more competitive.

f) Consider a power exchange (PX) in bilateral market model

In a real bilateral trading market, besides GenCos submit a bid, DisCos are also required to submit an offer to buy energy from GenCos, it therefore forms an auction market. Due to the supply and demand are always unmatched, in other words, the system imbalance, an intermediate so called power exchanger (PX) is needed to set out an open market to balance the supply and demand second by second, further to develop a balancing mechanism. Therefore, it is suggested that a case study that consider the PX is done so that the analysis will be more accurate compare to the real ones.

g) Balancing mechanism

It is suggested also that further study is done in order to develop a balancing mechanism to solve the problems of imbalance and unmatched.

Above recommendations are relate with the application of pool market model, whereas to apply the pool market model in MESI will require major system to monitor the flow of power which are costly. As an alternative, capacity payment terms have to be studied so that the renegotiation on the capacity payment can be made.

REFERENCES

1. Steven Stoft. *Power System Economics Designing Markets for Electricity.* Wiley Interscience; 2003.
2. Dr Mohammad Yusri bin Hassan. *Teaching Module: Power System Control.* 1st edition. Faculty of Electrical Engineering, Universiti Teknologi Malaysia; 2006.
3. Hisham Khatib. *Economic evaluation of Projects in the Electricity Supply Industry.* The Institutional of Electrical Engineers; 2003.
4. www.smartestenergy.com, *BETTA goes Live in April 2005, but What Impact will it have on the Power Generation Sector in Scotland;* 25th May 2004.
5. Paul L. Joskow. *California Electricity Crisis.* NBER Working Paper Series; August 2001.
6. S.N. Singh. *Electric power Industry Restructuring: Present Scenario and Future Prospec.* IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies.pp 20-23; 2004.
7. J.K. Park. *Status and Perspective of Electric Power Industry in Korea.* IEEE; 2005.
8. Daniel Kirschen and Gorban Strbac. *Fundamental of Power System Economics.* John Wiley&Sons Ltd.; 2004.
9. Sally Hunt and Graham Shuttleworth. *Competition and Choice in Electricity.* John Wiley&Sons Ltd.; 2004.
10. Che Zurina Zainul Abidin and Azimah Abdul Aziz. *Restructuring of the Malaysian Electricity Supply Industry (MESI.* Tenaga Nasional Berhad. CEPSI; 2000.

11. www.wikipedia.com
12. Business Times Online (June-September 2008)
13. Laszlo Lovei.*The Single Buyer Model: A Dangerous Path toward Competitive Electricity Markets*. The World Bank Group; December, 2000.
14. Afrin Sultana .*Pool versus Bilateral Markets: A Global Overview*. Univesity of Waterloo, Canada; 16th August 2004.
15. Luiz Augusto Barroso, Teofilo H. Cavalcanti, Konrad Purchala and Paul Giesbertz. C*lassification of Electricity Market Models Worldwide*. IEEE; 2005.
16. *Long Term National Strategy for the Malaysian Energy Sector, ESI Restructuring*
17. G.K.Toh, H.B. Gooi, Y.S.Tsan and W.T.Kok. *Optimal Price Bidding Strategy for Competitive Electricity Market in Singapore*. IPEC; 2007.
18. Anuar bin Tamri. *Development of Electricity Market Modeling for Malaysia Electricity Supply Industry (MESI): Competitive Electricity Markets*. Faculty of Electrical Engineering. Universiti Teknologi Malaysia; 2006.
19. Norhafiza binti Mohamad. *Economic Analysis of Electricity Market Models in Restructured Electricity Supply Industry. Universiti Teknologi Malaysia; 2007.*
20. Tenaga Nasional Berhad Distribution Sdn. Bhd.
21. William J. Palm III. *Introduction To Matlab 7 For Engineers*. Mc Graw Hill International Edition; 2005.
22. The Economic Planning Unit. *Ninth Malaysia Plan 2006-2010*; Prime Minister Department, 2006.

APPENDIX A

Appendix A: Detail Data on example of single buyer model

Appendix A1: Generation Revenue at demand 1500 MW

Appendix A2: Generation Revenue at demand 4000 MW

Appendix A3: Generation Revenue at demand 5000 MW

Appendix A4: Total Generation Revenue for all types of demand

Appendix A1: Generation Revenue at demand 1500 MW

Gen.	Energy Payment (RM)	Capacity Payment (RM)	Total Payment (RM)
G1	78,000	32,500	110,500
G2	119,000	103,500	222,500
G3	0	105,000	105,000
G4	0	22,000	22,000

Appendix A2: Generation Revenue at demand 4000 MW

Gen.	Energy Payment (RM)	Capacity Payment (RM)	Total Payment (RM)
G1	78,000	32,500	110,500
G2	289,800	103,500	393,300
G3	204,800	105,000	309,800
G4	0	22,000	22,000

Appendix A3: Generation Revenue at demand 5000 MW

Gen.	Energy Payment (RM)	Capacity Payment (RM)	Total Payment (RM)
G1	78,000	32,500	110,500
G2	289,800	103,500	393,300
G3	336,000	105,000	441,000
G4	32,400	22,000	54,400

Appendix A4: Total Generation Revenue for all types of demand

Gen.	Gen revenue (RM) Demand at 1500	Gen revenue (RM) Demand at 4000	Gen revenue (RM) Demand at 5000	Total Gen. revenue (RM)
G1	110,500	110,500	110,500	331,500
G2	222,500	393,300	393,300	1,009,100
G3	105,000	309,800	441,000	855,800
G4	22,000	22,000	54,400	98,400

APPENDIX B

Appendix B: Detail Data on example of pool market model with uniform price and pay as bid scheme

Appendix B1: At demand 1500 MW (Uniform Price)

Appendix B2: At demand 4000 MW (Uniform Price)

Appendix B3: At demand 5000 MW (Uniform Price)

Appendix B4: At demand 1500 MW (Pay as Bid)

Appendix B5: At demand 4000 MW (Pay as Bid)

Appendix B6: At demand 5000 MW (Pay as Bid)

Appendix B8: Total Generation Revenue for all types of demand (PAB)

Appendix B8: Total Generation Revenue for all types of demand (PAB)

Appendix B1: At demand 1500 MW (Uniform Price)

Generator	SMP Payment (RM)	Total Payment (RM)
G1	123,500	123,500
G2	161,500	161,500
G3	0	0
G4	0	0

Appendix B2: At demand 4000 MW (Uniform Price)

Generator	SMP Payment (RM)	Total Payment (RM)
G1	136,500	136,500
G2	434,700	434,700
G3	268,800	268,800
G4	0	0

Appendix B3: At demand 5000 MW (Uniform Price)

Generator	SMP Payment (RM)	Total Payment (RM)
G1	149,500	149,500
G2	476,100	476,100
G3	483,000	483,000
G4	41,400	41,400

Appendix B4: At demand 1500 MW (Pay as Bid)

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	161,500	161,500
G3	0	0
G4	0	0

Appendix B5: At demand 4000 MW (Pay as Bid)

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	393,300	393,300
G3	268,800	268,800
G4	0	0

Appendix B6: At demand 5000 MW (Pay as Bid)

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	393,300	393,300
G3	441,000	441,000
G4	41,400	41,400

Appendix B7: Total Generation Revenue for all types of demand (UP)

Gen.	Gen revenue (RM) Demand at 1500	Gen revenue (RM) Demand at 4000	Gen revenue (RM) Demand at 5000	Total Gen. revenue (RM)
G1	123,500	136,500	149,500	409,500
G2	161,500	434,700	476,100	1,072,300
G3	0	268,800	483,000	751,800
G4	0	0	41,400	41,400

Appendix B8: Total Generation Revenue for all types of demand (PAB)

Gen.	Gen revenue (RM) Demand at 1500	Gen revenue (RM) Demand at 4000	Gen revenue (RM) Demand at 5000	Total Gen. revenue (RM)
G1	110,500	110,500	110,500	331,500
G2	161,500	393,300	393,300	948,100
G3	0	268,800	441,000	709,800
G4	0	0	41,400	41,400

APPENDIX C

Appendix C: Detail Data on example of hybrid market model with uniform price and pay as bid scheme

Appendix C1: At demand of 1500 MW (Hybrid and Uniform Price)
Appendix C2: At demand of 4000 MW (Hybrid and Uniform Price)
Appendix C3: At demand of 5000 MW (Hybrid and Uniform Price)
Appendix C4: At demand of 1500 MW (Hybrid and Pay as Bid)
Appendix C5: At demand of 4000 MW (Hybrid and Pay as Bid)
Appendix C6: At demand of 5000 MW (Hybrid and Pay as Bid)

Appendix C1: At demand of 1500 MW (Hybrid and Uniform Price)

Generator	Base Payment (RM)	SMP Payment (RM)	Total Payment (RM)
G1	21,007.60	85,000	106,007.60
G2	74,771.86	0	74,771.86
G3	83,840.60	0	83,840.60
G4	19,239.54	0	19,239.54

Appendix C2: At demand of 4000 MW (Hybrid and Uniform Price)

Generator	Base Payment (RM)	SMP Payment (RM)	Total Payment (RM)
G1	21,007.60	110,549.43	131,557.03
G2	74,771.86	352,057.41	426,829.28
G3	83,840.60	167,393.16	251,233.46
G4	19,239.54	0	19,239.54

Appendix C3: At demand of 5000 MW (Hybrid and Uniform Price)

Generator	Base Payment (RM)	SMP Payment (RM)	Total Payment (RM)
G1	21,007.60	121,077.95	142,085.55
G2	74,771.86	383,586.69	460,358.56
G3	83,840.60	391,174.90	475,015.21
G4	19,239.54	22,160.46	41,400.00

Appendix C4: At demand of 1500 MW (Hybrid and Pay as Bid)

Generator	Base Payment (RM)	Pay as Bid Payment (RM)	Total Payment (RM)
G1	21,007.60	85,000	106,007.60
G2	74,771.86	0	74,771.86
G3	83,840.60	0	83,840.60
G4	19,239.54	0	19,239.54

Appendix C5: At demand of 4000 MW (Hybrid and Pay as Bid)

Generator	Base Payment (RM)	Pay as Bid Payment (RM)	Total Payment (RM)
G1	21,007.60	89,492.40	110,500
G2	74,771.86	318,528.10	393,300
G3	83,840.60	167,393.20	251,233.46
G4	19,239.54	0	19,239.54

Appendix C6: At demand of 5000 MW (Hybrid and Pay as Bid)

Generator	Base Payment (RM)	Pay as Bid Payment (RM)	Total Payment (RM)
G1	21,007.60	89,492.40	110,500
G2	74,771.86	318,528.10	393,300
G3	83,840.60	357,159.70	441,000
G4	19,239.54	22,160.46	41,400

APPENDIX D

Appendix D: Detail Data on example of bilateral market model

Appendix D1: At demand 1500 MW

Appendix D2: At demand 4000 MW

Appendix D3: At demand 5000 MW

Appendix D1: At demand 1500 MW

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	161,500	161,500
G3	0	0
G4	0	0

Appendix D2: At demand 4000 MW

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	393,300	393,300
G3	268,800	268,800
G4	0	0

Appendix D3: At demand 5000 MW

Generator	Energy Payment (RM)	Total Payment (RM)
G1	110,500	110,500
G2	393,300	393,300
G3	441,000	441,000
G4	41,400	41,400

APPENDIX E

Appendix E: Detail Data on comparison of a simple case study for all market models

Appendix E1: Generator's revenue at demand 1500 MW

Appendix E2: Generator's revenue at demand 4000 MW

Appendix E3: Generator's revenue at demand 5000 MW

Appendix E4: Total generator's revenue at all demand

Appendix E1: Generator's revenue at demand 1500 MW

Generator	Single Buyer	Pool Market	Bilateral Market
G1	110,500	123,500	110,500
G2	222,500	161,500	161,500
G3	105,000	0	0
G4	22,000	0	0

Appendix E2: Generator's revenue at demand 4000 MW

Generator	Single Buyer	Pool Market	Bilateral Market
G1	110,500	136,500	110,500
G2	393,300	434,700	393,300
G3	309,800	268,800	268,800
G4	22,000	0	0

Appendix E3: Generator's revenue at demand 5000 MW

Generator	Single Buyer	Pool Market	Bilateral Market
G1	110,500	149,500	110,500
G2	393,300	476,100	393,300
G3	441,000	483,000	441,000
G4	54,400	41,400	41,400

Appendix E4: Total generator's revenue at all demand

Generator	Single Buyer	Pool Market	Bilateral Market
G1	331,500	409,500	331,500
G2	1,009,100	1,072,300	948,100
G3	855,800	751,800	709,800
G4	54,400	41,400	41,400

APPENDIX F

Appendix F: Load Profile of Peninsular Malaysia

Time	Weekday Load (MW)	Saturday Load (MW)	Sunday Load (MW)	Public Holiday Load (MW)
0000-0100	10,525	10,369	10,073	9,212
0100-0200	10,135	10,214	9,873	8,663
0200-0300	9,756	9,798	9,478	8,257
0300-0400	9,466	9,497	9,139	8,004
0400-0500	9,228	9,280	8,897	7,723
0500-0600	9,105	9,135	8,745	7,590
0600-0700	9,248	9,165	8,759	7,479
0700-0800	9,403	9,211	8,696	7,420
0800-0900	9,926	9,305	8,376	7,197
0900-1000	11,453	10,472	8,884	7,239
1000-1100	12,129	11,175	9,432	7,453
1100-1200	12,803	11,790	9,909	7,632
1200-1300	12,750	11,763	10,031	7,699
1300-1400	12,266	11,453	9,964	7,837
1400-1500	12,348	11,558	10,096	7,999
1500-1600	12,891	11,533	10,208	8,075
1600-1700	12,900	11,475	10,170	8,080
1700-1800	12,631	11,154	9,957	8,061
1800-1900	11,696	10,634	9,691	8,176
1900-2000	11,396	10,643	9,881	8,903
2000-2100	12,206	11,583	10,950	9,596
2100-2200	12,048	11,495	10,978	9,519
2200-2300	11,553	11,111	10,759	9,229
2300-2400	11,054	10,742	10,448	8,930

APPENDIX G

Appendix G: Detail Data on the simulations results on generation revenue

Appendix G1: Each generator revenue for each market model; i.e. weekday load profile

Appendix G2: Each generator revenue for each market model; i.e. Saturday load profile

Appendix G3: Each generator revenue for each market model; i.e. Sunday load profile

Appendix G4: Each generator revenue for each market model; i.e. Public Holiday load profile

Appendix G5: Total generator revenue for each IPP for each market model; i.e. in a week

Appendix G6: Total generator revenue for each IPP for each market model; i.e. in a month

Appendix G7: Total generator revenue for each IPP for each market model; i.e. in annual revenue

Appendix G1: Each generator revenue for each market model; i.e. weekday load profile

IPP	**Single Buyer**	**Pool Market**	**Bilateral Market**
	RM/day		
G1	3,830,400.00	5,476,413.60	3,830,458.00
G2	3,635,208.00	4,867,923.20	3,635,251.00
G3	1,882,632.00	2,449,173.86	1,882,618.00
G4	4,034,328.00	4,943,984.50	4,034,316.00
G5	2,256,336.00	2,662,145.50	2,256,324.00
G6	14,681,328.00	18,406,834.60	14,681,462.00
G7	6,318,000.00	8,899,172.10	6,318,000.00
G8	5,106,000.00	5,628,536.20	5,106,000.00
G9	2,921,592.00	3,346,697.20	2,921,635.00
G10	13,714,800.00	15,417,951.90	13,666,628.00
G11	2,357,832.00	2,625,052.42	2,257,867.00
G12	6,859,776.00	6,700,990.04	6,238,529.00
G13	4,796,424.00	4,389,305.92	4,071,954.00
G14	4,062,408.00	266,484.12	266,484.10

Appendix G2: Each generator revenue for each market model; i.e. Saturday load profile

IPP	Single Buyer	Pool Market	Bilateral Market
		RM/day	
G1	3,830,400.00	5,273,632.80	3,830,457.60
G2	3,635,208.00	4,687,673.60	3,635,251.20
G3	1,882,632.00	2,358,485.78	1,882,618.08
G4	4,034,328.00	4,760,918.50	4,034,316.00
G5	2,256,336.00	2,563,571.50	2,256,324.00
G6	14,681,328.00	17,725,265.80	14,681,462.40
G7	6,318,000.00	8,569,653.30	6,318,000.00
G8	5,106,000.00	5,420,122.60	5,106,000.00
G9	2,921,592.00	3,222,775.60	2,921,635.20
G10	13,623,840.00	14,728,204.17	13,559,875.47
G11	2,270,952.00	2,400,856.12	2,155,902.18
G12	6,157,506.00	5,478,730.88	5,383,247.04
G13	1,901,394.00	824,238.16	824,238.16
G14	3,850,008.00	**0.00**	**0.00**

Appendix G3: Each generator revenue for each market model; i.e. Sunday load profile

IPP	Single Buyer	Pool Market	Bilateral Market
	RM/Day		
G1	3,830,400.00	5,096,066.40	3,830,457.60
G2	3,635,208.00	4,529,836.80	3,635,251.20
G3	1,882,632.00	2,279,074.14	1,882,618.08
G4	4,034,328.00	4,600,615.50	4,034,316.00
G5	2,256,336.00	2,477,254.50	2,256,324.00
G6	14,681,328.00	17,128,445.40	14,681,462.40
G7	6,318,000.00	8,281,107.90	6,318,000.00
G8	5,106,000.00	5,237,623.80	5,106,000.00
G9	2,921,592.00	3,114,262.80	2,921,635.20
G10	12,723,120.00	13,160,593.26	12,502,767.96
G11	1,883,592.00	1,839,207.66	1,701,286.80
G12	2,787,426.00	1,278,886.08	1,278,886.08
G13	1,166,664.00	**0.00**	**0.00**
G14	3,850,008.00	**0.00**	**0.00**

Appendix G4: Each generator revenue for each market model; i.e. public holiday load profile

IPP	Single Buyer	Pool Market	Bilateral Market
	RM/Day		
G1	3,830,400.00	4,856,457.60	3,830,457.60
G2	3,635,208.00	4,316,851.20	3,635,251.20
G3	1,882,632.00	2,171,915.76	1,882,618.08
G4	4,034,328.00	4,384,302.00	4,034,316.00
G5	2,256,336.00	2,360,778.00	2,256,324.00
G6	14,681,328.00	16,323,093.60	14,681,462.40
G7	6,318,000.00	7,891,743.60	6,318,000.00
G8	5,106,000.00	4,991,359.20	5,106,000.00
G9	2,804,092.00	2,829,500.20	2,783,300.20
G10	6,282,240.00	4,943,590.17	4,943,590.17
G11	451,752.00	20,843.58	20,843.58
G12	1,737,336.00	0.00	0.00
G13	1,166,664.00	0.00	0.00
G14	3,850,008.00	0.00	0.00

Appendix G5: Total generator revenue for each IPP for each market model; i.e. in a week

IPP	Single Buyer	Pool Market	Bilateral Market
	RM/Week		
G1	26,812,800.00	37,751,767.20	26,813,203.20
G2	25,446,456.00	33,557,126.40	25,446,758.40
G3	13,178,424.00	16,883,429.22	13,178,326.56
G4	28,240,296.00	34,081,456.50	28,240,212.00
G5	15,794,352.00	18,351,553.50	15,794,268.00
G6	102,769,296.00	126,887,884.20	102,770,236.80
G7	44,226,000.00	61,346,621.70	44,226,000.00
G8	35,742,000.00	38,800,427.40	35,742,000.00
G9	20,451,144.00	23,070,524.40	20,451,446.40
G10	94,920,960.00	104,978,556.93	94,395,785.43
G11	15,943,704.00	17,365,325.88	15,146,522.58
G12	43,243,812.00	40,262,567.16	37,854,779.52
G13	27,050,178.00	22,770,767.76	21,184,007.76
G14	28,012,056.00	1,332,420.60	1,332,420.60
Total Gen Rev.	**521,831,478.00**	**577,440,428.85**	**482,575,967.25**

Appendix G6: Total generator revenue for each IPP for each market model; i.e. in a month

IPP	Single Buyer	Pool Market	Bilateral Market
	RM/month		
G1	107,251,200.00	151,007,068.80	107,252,812.80
G2	101,785,824.00	134,228,505.60	101,787,033.60
G3	52,713,696.00	67,533,716.88	52,713,306.24
G4	112,961,184.00	136,325,826.00	112,960,848.00
G5	63,177,408.00	73,406,214.00	63,177,072.00
G6	411,077,184.00	507,551,536.80	411,080,947.20
G7	176,904,000.00	245,386,486.80	176,904,000.00
G8	142,968,000.00	155,201,709.60	142,968,000.00
G9	81,804,576.00	92,282,097.60	81,805,785.60
G10	379,683,840.00	419,914,227.72	377,583,141.72
G11	63,774,816.00	69,461,303.52	60,586,090.32
G12	172,975,248.00	161,050,268.64	151,419,118.08
G13	108,200,712.00	91,083,071.04	84,736,031.04
G14	112,048,224.00	5,329,682.40	5,329,682.40
Total Gen Rev.	**2,087,325,912.00**	**2,309,761,715.40**	**1,930,303,869.00**

Appendix G7: Total generator revenue for each IPP for each market model; i.e. annual revenue

IPP	Single Buyer	Pool Market	Bilateral Market
	RM/year		
G1	1,287,014,400.00	1,812,084,825.60	1,287,033,753.60
G2	1,221,429,888.00	1,610,742,067.20	1,221,444,403.20
G3	632,564,352.00	810,404,602.56	632,559,674.88
G4	1,355,534,208.00	1,635,909,912.00	1,355,530,176.00
G5	758,128,896.00	880,874,568.00	758,124,864.00
G6	4,932,926,208.00	6,090,618,441.60	4,932,971,366.40
G7	2,122,848,000.00	2,944,637,841.60	2,122,848,000.00
G8	1,715,616,000.00	1,862,420,515.20	1,715,616,000.00
G9	981,654,912.00	1,107,385,171.20	981,669,427.20
G10	4,556,206,080.00	5,038,970,732.64	4,530,997,700.64
G11	765,297,792.00	833,535,642.24	727,033,083.84
G12	2,075,702,976.00	1,932,603,223.68	1,817,029,416.96
G13	1,298,408,544.00	1,092,996,852.48	1,016,832,372.48
G14	1,344,578,688.00	63,956,188.80	63,956,188.80
Total Gen Rev.	**25,047,910,944.00**	**27,717,140,584.80**	**23,163,646,428.00**