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Analysis on single buyer market model and pool market model in deregulated electricity market

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Abstract

Since 2005, Malaysia Electricity Supply Industry (MESI) planned to shift its structure to a wholesale market model. Initially, the government introduced Independent Power Producers (IPPs), and since then, MESI has applied to a single buyer market model that continues till now. However, this model approach is lack of competition as it is supposed to. Therefore, this research presents conceptual analysis of a single buyer market model and the pool based market model. The purpose of this research is to address the economic benefits in term of generation revenue and demand payment in MESI. The research analysis consists of two bus test system in MESI involving four generators around Peninsular Malaysia considering existing single buyer model and pool based market model, i.e., pool model and spot market model. The results have shown that the pool market model ensures the intermediate value of total generation revenue and decreased the demand payment as it is proportional to the generation revenue. © 2024 Author(s).

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Analysis on Single Buyer Market Model and Pool Market Model in Deregulated Electricity Market

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Abstract. Since 2005, Malaysia Electricity Supply Industry (MESI) planned to shift its structure to a wholesale market model. Initially, the government introduced Independent Power Producers (IPPs), and since then, MESI has applied to a single buyer market model that continues till now. However, this model approach is lack of competition as it is supposed to. Therefore, this research presents conceptual analysis of a single buyer market model and the pool based market model. The purpose of this research is to address the economic benefits in term of generation revenue and demand payment in MESI. The research analysis consists of two bus test system in MESI involving four generators around Peninsular Malaysia considering existing single buyer model and pool based market model, i.e., pool model and spot market model. The results have shown that the pool market model ensures the intermediate value of total generation revenue and decreased the demand payment as it is proportional to the generation revenue.

1 Introduction

In the old days, vertically integrated utility (VIU) has dominated the electrical industry worldwide. Every part of the electricity supply industry (ESI) comprises generation, transmission, and distribution declared as the restraining infrastructure under the VIU. Figure 1 shows the flow of electricity through the ESI [1].

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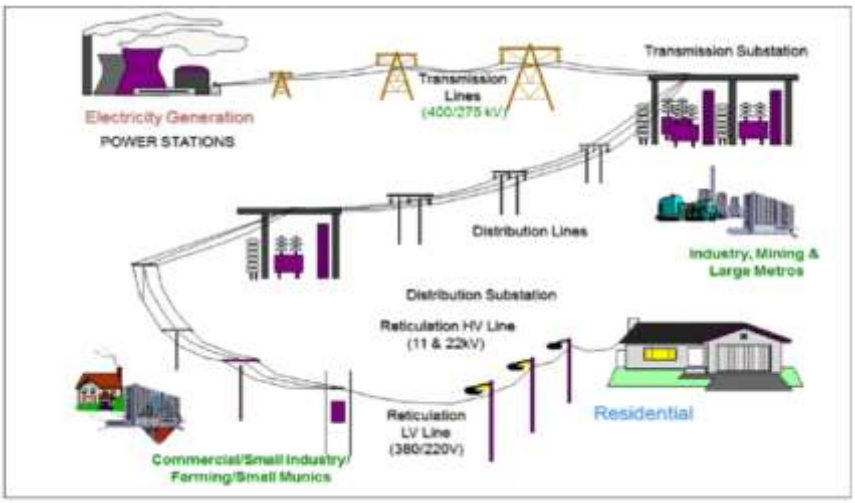

Fig. 1. Electricity Supply Industry [1]

The traditional structure of the electric utility produces several special features including low efficiency and disadvantages customer preferences. In the 1980s, ESI go through a major transformation worldwide as technology and consumer behaviours towards utility products changed due to the era of modernity [2]. This transformation also because of some economists have come to the conclusion that the exclusive control status of electrical company has eliminated the proper efficiency and encourage unnecessary investment [3]. In 1992, Malaysia Electrical Supply Industry (MESI) introduced Independent Power Producers (IPPs) in power generation site. Began in 2005, MESI planned to shift into a wholesale market model [3]. Figure 2 shows the MESI reformation [4].

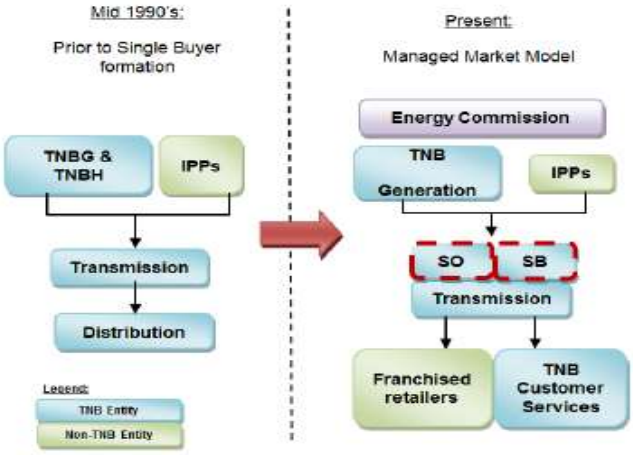

Fig. 2. MESI reformation [4]

The aim of this research is to improve the pool based market model which useful for MESI, in order to enhance efficiency and to promote competition in order to lower costs. Therefore, the objective of this paper is to identify which market model is superior between single buyer market model and pool based market model i.e., pool and spot market model, with analysis using two bus test system in MESI involving four generators around Peninsular Malaysia including combined cycle gas turbine (CCGT) and thermal power plants. Consequently, the findings can be applied in assisting and creating new policy set out for better electricity market model.

1.1 Single Buyer Market Model

Under the Power Purchase Agreement (PPA) that applied by MESI, consist two types of payments in single buyer market model which are energy payment and capacity payment. Energy payment is based on the electricity consumed by TNB. Meanwhile, the capacity was paid monthly regardless of the electricity usage which provides incentives for generators to be available at times when needed. Moreover, to provide extra revenue for generators to cover the capital and other fixed costs which are not covered by the energy payment [2,3]. Therefore, the equation which represents the total generation revenue of a single buyer market model can be written as [3]:

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

Where, P_{Gi} is the power capacity available by nth generator (MW), C_{Gi} is the capacity price for the nth generator (RM/MWh), P_{EGi} is the power output generated by nth generator (MW), C_{Egi} is the energy price for ith generator (RM/MWh), k is the number of generators involved and G_T is the total generation income (RM/h).

1.2 Pool Market Model

In pool market model, IPPs will offer or bid their energy prices to the energy purchaser. This energy prices will be arranged in stacked where the prices are range from the cheapest to the most expensive prices [5-6]. The pricing scheme of pool market model is divided into two forms; uniform price which refer the System Marginal Price (SMP) value and pay as bid is refer to generator's amount of energy bid price. SMP is calculated by considering the bid price of the most expensive generator to meet forecast demand. Equation 2 shows the mathematical equations of total generation revenue for the pool market model with uniform price [7]:

$$G_T = \sum_{n=1}^{k} (P_{Gi} \times C_{pp}) \tag{2}$$

1.3 Spot Market Model

Australia's electricity market referred to energy-only market design where spot market is managed by AEMO [8,9]. AEMO operates the electricity system to match both power supply and demand at the same time. Australian electricity market is different from other market where the spot electricity market is traded in a limited / constrained real-time spot market and its price are set to be fixed every 5 minutes by AEMO. This is based on the offer generator that have been submitted through bidding process every 5 minutes. In this process, dispatch price is also determined every 5 minutes. The dispatch price includes cost of generating the last megawatt of electricity in order to satisfied the demand, which does extend to all scheduled generators, irrespective of the amount of their original offer/bid. For every Australian National Electricity Market (NEM) region, the final price is calculated every half hour as the six transmission prices are on average from the 5-minute spot prices for each trading interval. Spot prices are used by AEMO as the basis for settling financial transactions for all energy exchanged in the NEM.

2 Conceptual Study of Single Buyer Market Model and Pool Based Market Model

The generation revenue model in MESI were tested using two bus systems as shown in Figure 3 for conceptual analysis. In this study, three type of load demand has been analysing; low load demand at 1500 MW, medium demand at 3250 MW and high load demand at 5000 MW. The parameters, the load demand curves, MW installed capacity data, energy prices, capacity prices, and generator efficiency as shown in Table 1 were used to evaluate the generator's revenue, total generation revenue and demand payment for single buyer, pool and spot market models. Demand payments is to analyse the amount the purchasers have to pay to the producers for the electricity generated in 24 hours. However, only a combine cycle gas turbine (CCGT) and thermal plant types are chosen due to the efficiency and price offered by the generator.

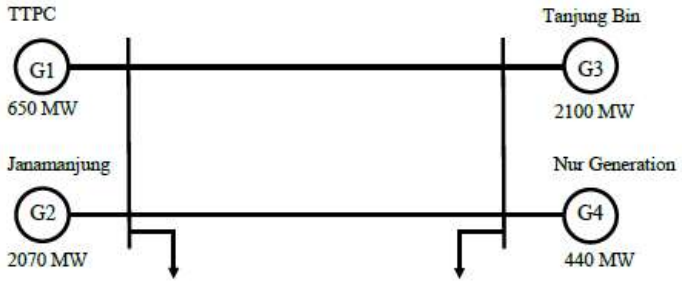

Fig. 3: Four generators with no loads.

Table 1: The details of each IPP in 2-bus system in Malaysia electricity system

Gen.	Plant Type	Capacity Available (MW)	Capacity Price (RM/MWh)	Energy Price (RM/MWh)	Efficiency, η (%)
G1	CCGT	650	35000	155	43.64
G2	Thermal	2070	30000	160	20.91
G3	Thermal	2100	55000	170	25.82
G4	CCGT	440	35000	200	43.64

3 Result and Discussions

Figure 4 shows that each of the generator received highest generation revenue from single buyer market model compared to pool and spot market model due to energy and capacity payment. Even though most of Generator 3 and Generator 4 did not receive any payment during low and medium demand due to energy bid and capacity price. The pool and spot market models show similar characteristic, where the generator's having low or no revenue during low and medium demand, while the revenue increased due to demand increase, which opens chances for expensive generators to be selected in the bidding competition. However, the pool model shows an increment of revenue due to high SMP during high demand.

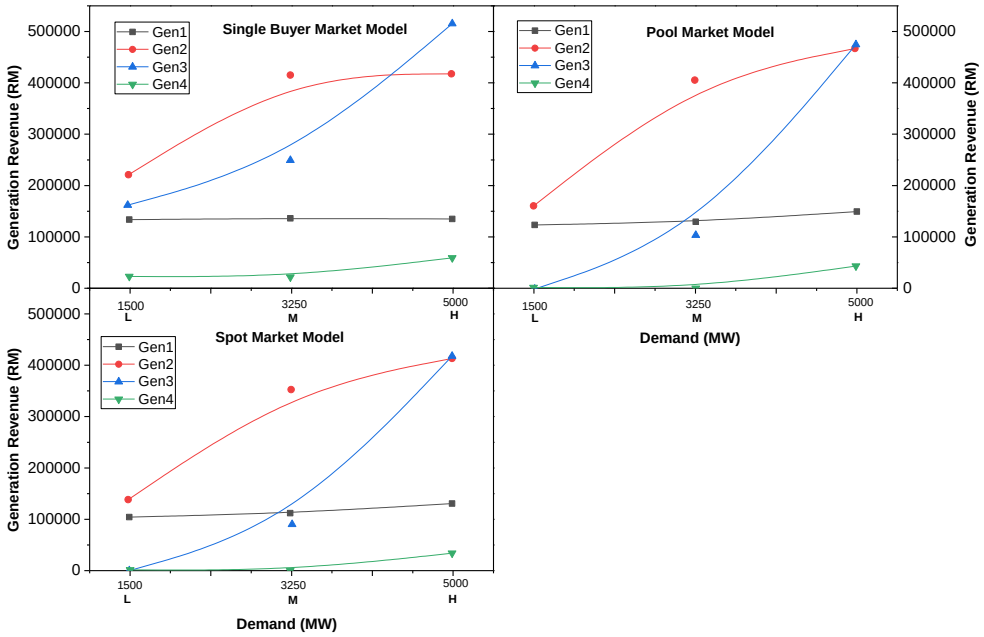

Fig. 4: The generation revenue for each generator during low, medium and high demand for Single Buyer, Pool and Spot Market Model

Figure 5 shows that single buyer market model received the highest total generation revenue compared to pool and spot market model. The total generation revenue of pool and spot market model are much lower compared to single buyer model due to no capacity payment applied for both market models.

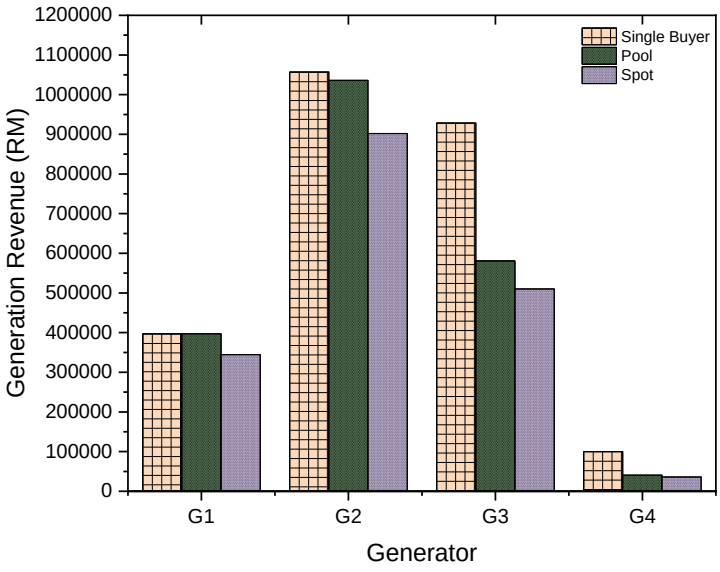

Fig. 5: Comparison of total generator's revenue according to market model

Figure 6 illustrates the comparison on demand payment based on total generation revenue. The purpose of comparison the demand payment is to analyse the amount of electricity produced to be paid to the power producers by the buyers. The calculation is observed by the single buyer is taken-into-account as a base. The demand payment for spot market model is the lowest compared to single buyer and pool market models, which benefit the energy buyer. However, the spot market model cannot guarantee any revenue for expensive generators during low demand.

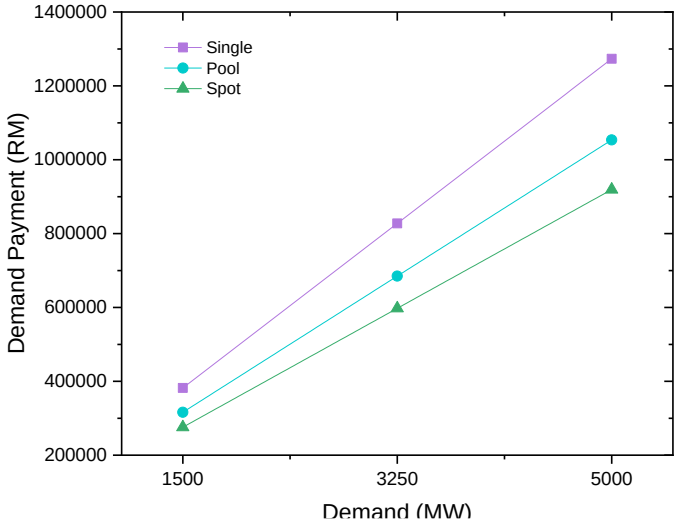

Fig. 6 : Comparison of total generation revenue based on demand

4 Conclusions

The generators had gained the largest revenue for the single buyer model, due to capacity and energy payment, where the generators obtain the revenue even without any contribution to supply the energy. Thus, this model does not provide any competition because the electricity trading only under one company which is TNB transmission and distribution. Overall, the pool and spot market models show similar characteristic The pool and spot market models may experience low or even zero revenue during low demand. However, the pool market model shows an increment of revenue during high demand due to high SMP. Obviously, this situation encourages power market exercises which is not good for the market, especially for the energy buyers. Even though the demand payment for spot market model is the lowest which benefit the energy buyer, this model cannot guarantee any revenue for expensive generators during low demand. Consequently, the pool market model still a full competitive model even without capacity payment, which reduces the revenue some of the generators quite significantly.

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