

The Economic Benefits of Generation Revenue Assessment in Pool-Based Market Model for Restructured Electricity Supply Industry

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Abstract. The electricity supply industry had undergo deregulation and restructuring toward becoming a more transparent and competitive electricity market environment. The pool market model is amongst the most preferred electricity market model. Even though it is a safe option to be more competitive and transparent electricity supply industry, there are issues on the welfare of the generators involved. This paper addresses the pricing issue in the pool market by extending the capacity payment mechanism in the single auction power pool. In the proposed model, the approach of minimum capacity payment involving the efficiency of the generators is introduced. A case study is conducted to illustrate the proposed model. An economic analysis is performed to highlight the merits of the proposed model with the pure pool in term of generation revenue.

1 Introduction

In the competitive electricity market, participation of generation companies and large consumers in bidding methodologies is for their own advantages. By strategically bidding, the electricity generating companies expect to maximize their profits and control the market price. Even though, they will suffer in great losses of market efficiency because their offers will deviate from the true marginal costs. Furthermore, incur much more payments from the consumers than really required. In order to achieve a maximum return, it is very important for the generation companies to formulate optimal bidding strategies with risk terminology before step into the electricity market, as the market clearing price (MCP) in this landscape is flexible [1]. The pool market model is a standout amongst the most preferred power market model actualized in many developing countries. Regardless of being the sensible and safe choice for a more competitive and straightforward power supply industry, there are issues on the welfare of the generators included. As reported by Zou et al. [2], which utilized of the analytical paradigm of economic mechanism design theory is to deduce and design a customized pool-based market mechanism, in order to fulfill three major properties; incentive compatibility, individual rationality, and payment cost minimization.

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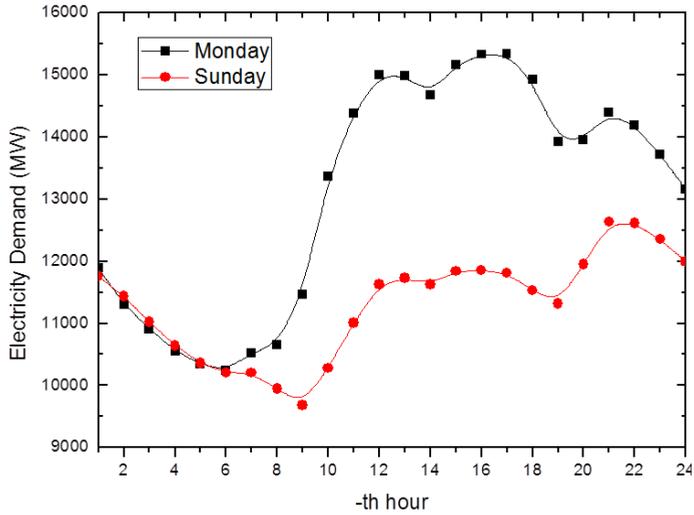
One of pool market model major benefits is that it provides a market for generators unable to sell their output via contract to a specific customer. This study is focusing on the economic aspect from the perspective of the generators. Therefore, the proposed model is being designed in order to overcome several disadvantages of the pure pool market such as price fluctuation and market power exercise.

2 Improvement of Pool Based Market Model for Malaysia Electricity Supply Industry (MESI)

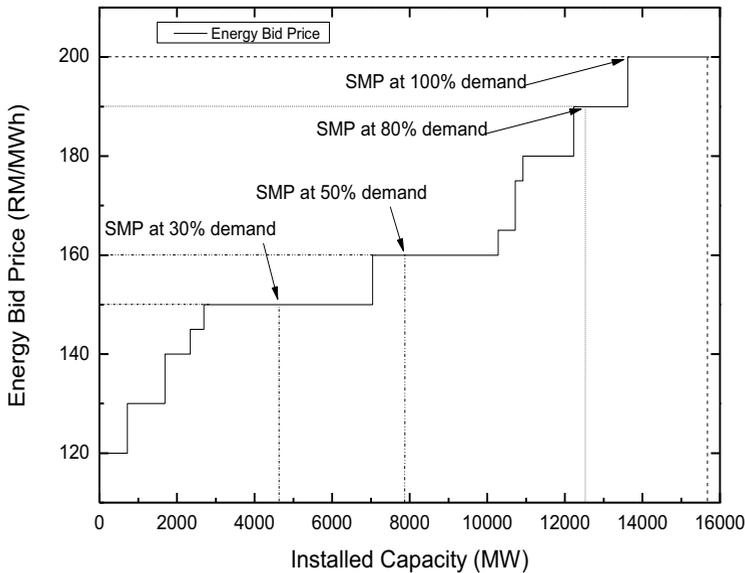
The reformed of single buyer is reinforced by implementation of competitive bidding, while the Incentive Based Regulation (IBR) will ensure the efficient operation [3]. Yet still single buyer model lack of competition due to long term of Power Purchase Agreements (PPAs). Nevertheless, there are few issues of introducing the pure pool market model such as price fluctuation and market power exercises. Thus, it is important to modify the existing pure pool model, so it can provide a fair market to supplier and user. It is reported at low load condition, the generators would gain more revenue under single buyer model compared to pool market model, whereas at high load demand, the generators would gain more revenue under pool market model [4]. Aifa [5] proposed an alternative electricity market model, hybrid model for MESI, which combines the pure pool market and pro-rata base load profile. In the meantime, Nuryasmin [6] proposed a minimum generation model that guaranteed income for all IPPs, and also generates profit for Tenaga Nasional Berhad (TNB). An improvement of hybrid model by Nurehan et. al [7,8] successfully overcomes the shortcomings of the pool market model, in the context of guaranteed revenue remuneration for the generator with the introduction of based load demand sharing approach known as hybrid model 1 (HM 1), and hybrid model 2 (HM 2). The introduction of the base load sharing is to ensure the expensive generator will get the remuneration, in order to overcome the problem in the pool market model. This is because there is no revenue during low electricity demand for the expensive generator. However, all these models did not consider on the efficiency, and the electricity price offered by generators during base load sharing. Furthermore, the base load power plants are designated based on their low cost generation, efficiency, and safety at rated output power levels.

3 Methodology of Proposed Market Model

Malaysia load profile curve in Fig. 1(a) is used to present the pure pool, HM 1, HM 2, and the proposed market model. Fig. 1(b) shows the aggregated generation curve and the system marginal price (SMP) at 30%, 50%, 80%, and 100% demand, which proven the pool market price is extremely high due to high SMP, during high electricity demand. Two load profile curves for Sunday, and Monday are used in this research. Assuming the generators bid the same price for the 24 hours, Table 1 shows the details of the sixteen generators selected around Malaysia. Instead of open cycle gas turbine (OCGT), only combine cycle gas turbine (CCGT) and thermal plant type are chosen due to the efficiency and price offered by the generator. This is because generation costs of OCGT are much higher, and the low load-factor of the peak-load services [9]. As the monetary values involved in this paper are confidential, estimated values in used instead.



(a)



(b)

Fig. 1. (a): Diagram of Malaysia load profile curves; (b): The aggregated generation curve and the SMP at 30%, 50%, 80%, and 100% demand.

This proposed model is an improvement of the pool based marketing model. It comprises of electricity demand sharing and capacity payment approaches, in order to educate the generators to apply low prices for electricity generated. Thus, Independent Power Producers (IPPs) can contribute power to the power purchaser at all times. In addition, the efficiency of the generators is taken into account. This proposed market model has categorized the electricity demand into two areas, identified as a high demand area and low demand area. The low and high demand areas are determined from the daily electricity demand curve, constructed using the demand forecasting data. A line is drawn on the

hourly electricity demand curve at 80% of the peak demand, which is used as the reference line to distinguish the low demand and high demand areas on the electricity demand curves. The electricity demand sharing is applied under high demand area. Meanwhile, the capacity payment is added for low demand area.

Table 1. Details on plant types, MW installed capacity, bid price, capacity price, and efficiency of 16 generators in Malaysia.

Gen	Plant Type	Installed Capacity (MW)	Energy/Bid Price (RM/MW/h)	Capacity Price (RM/MW/month)	Efficiency (%)
1	CCGT	720	120	30000	46.91
2	CCGT	640	130	30000	40.82
3	CCGT	334	130	35000	43.64
4	CCGT	650	140	35000	43.64
5	CCGT	350	145	35000	43.64
6	Thermal	2420	150	20000	39.03
7	CCGT	1170	150	30000	45.62
8	CCGT	762	150	45000	44.22
9	CCGT	1136	160	30000	40.74
10	Thermal	2100	160	30000	20.91
11	CCGT	440	165	35000	43.64
12	CCGT	100	175	35000	43.64
13	Thermal	100	175	30000	35.99
14	CCGT	1303	180	40000	42.09
15	Thermal	1400	190	25000	35.91
16	Thermal	2100	200	55000	25.82

3.1 The Low Demand Area.

The low demand area consists of the hourly electricity demand below the 80% of the peak demand value, and will be traded through bidding competition as in the pool market. Nevertheless, pool market cannot guarantee continuous remuneration for IPPs when the electricity demand is low. Consequently, numerous of high costs IPPs will experience low or even zero revenue during low demand period. Therefore, capacity payment with minimum generation is added during low electricity demand, in order to ensure continuous remuneration for all IPPs regardless their submitted energy bid prices and the fluctuating electricity demand. This minimum generation is based on the efficiency of the generator generates the electricity. Under the same bidding system as applied in the pool market model, the payment for power generated will depend on the SMP, which determined from the last IPPs being dispatched at that period of time. The purchasing price in low demand area, C_{PP} is paid to the IPPs for the power generated in an hour.

3.2 The High Demand Area.

The electricity demand under high demand area will be traded through demand sharing and bidding competition. The 80% reference line will separate electricity demand in the high area into two parts; i) the electricity demand below the 80% reference line will be traded equally among the IPPs through demand sharing approach, and ii) the IPPs will compete against each other to supply the remaining demand in the area above the 80% reference line. The distribution of the shared electricity demand depends on the IPPs available capacity. IPP with the highest capacity will have the biggest share of the sharing electricity

demand. The payment during electricity demand sharing will be determined by two factors; the SMP of the sharing demand and the amount of electricity demand shares of each IPP. C_{PP80} is the sharing price with the SMP value at the total shared demand (80% of peak electricity demand). The upper part of the high demand area will be put under bidding competition using the energy bid prices submitted by the IPPs. During this time, all IPP are involved, from the cheapest to the expensive generators.

4 Results and Discussion

In order to be selected in the generation dispatch, IPPs must win in the energy bidding. The IPPs with the lower energy bid price compared to the hourly SMP will be selected to fulfil the electricity demand for that hour. The SMP at 100% demand was RM200 followed by RM190, RM160 and RM150 at 80%, 50%, and 30% demand respectively. All participated IPPs in the electricity dispatch are paid according to the pool price which is determined from hourly SMP. In this case study, the power contribution is chosen at 80% from the peak demand for the load demand sharing, reducing the SMP to RM190. Consequently, the production cost of electricity will be lower, in order to control the price fluctuation during high demand. Therefore, the non-participated IPPs are exposed to the risk of losing their revenue, because only at 100% demand, all IPPs received the revenue. It means that, more IPPs will lose their revenue as the electricity demand keeps reducing. However, the IPPs revenue in the pool market continues to strike as the demand keeps increasing due to most IPPs are paid at a higher price compared to their own bid price. For example, IPP 1 is paid with RM190 for every MW power produced at 80% demand, which is RM70 higher compared to its initial bid price. Fig. 2 (a) and (b) illustrate the comparison of generator’s revenue on Sunday, and Monday respectively. The figures indicate that from low to middle price, the generators received the highest revenue under pure pool, but the revenue decreased for the expensive generator. This is because the generators were stacked from the lowest to the highest prices offered by generator. Furthermore, a cheaper generator will get the chance to win in the bidding competition. The generator’s revenue of the proposed model is increasing compared to HM 1 and HM 2 during low to medium price generator.

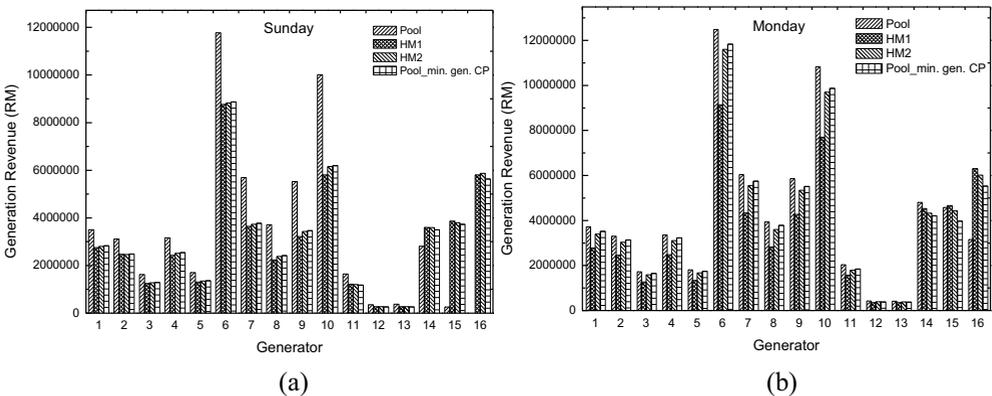
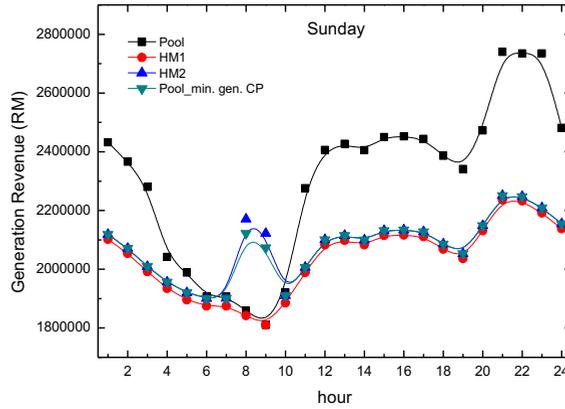


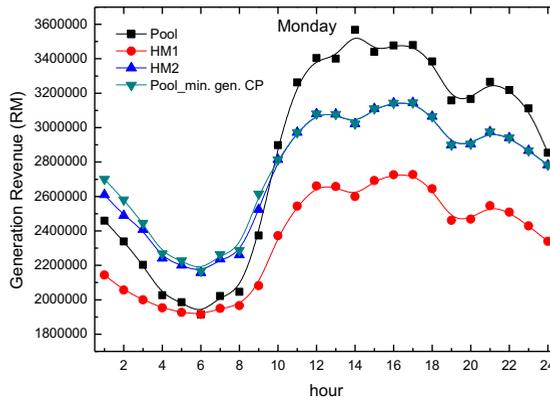
Fig. 2. (a) and (b): Comparison of generator’s revenue for Sunday and Monday.

It is reasonable to introduce minimum generation capacity payment based on the generator efficiency, instead of paying full capacity payment as compensation to the generators, because the possibility of expensive generators not selected in the bidding competition is high. Nonetheless, as a reward, this same type of capacity payment also will be given to the IPPs which have won in the bidding competition as an incentive, in order to

educate the IPPs to bid and sell their electricity produced at a lower price. For proposed method, the reduction of revenue for expensive generators does happen compared to HM 2, due to this change.



(a)



(b)

Fig. 3. (a) and (b): Comparison of hourly generation revenue for Sunday and Monday.

Fig. 3 (a) and (b) show the hourly generation revenue. HM 1 and pure pool model is the lowest and the highest revenue, respectively. For HM 2 and the proposed method, the revenue almost the same for the high demand. Meanwhile, revenue during low demand is slightly higher for the proposed method compared to HM 2, due to minimum generation capacity payment execution for participated and non-participated generator in the bidding competition.

5 Conclusion

Worldwide experience with the single buyer model has raised concern on how this model backfires due to poorly constructed such as lack of transparency and fairness, poor system planning and non-competitive. Several observers also voiced concerns over a profit-seeking single buyer, citing conflict of interest, duplication of cost and tariff hikes. Conversely, the pool market model offers full competitive model and based on uniform price scheme. The most expensive generators might not be able to get any revenue at all. Thus, will force each

of them to bid for the cheapest energy price most of the time, and this will create competition. The proposed model seems to be very effective. As it gives the opportunity more to the least cost generators to participate not only in base load demand, but also in peak load demand. However, minimum generation capacity payment also given as an incentive, and compensation for the least cost and expensive generator, which participate and lost in bidding competition respectively. As a result, it creates win-win situations between the generators as the seller and distributor as the buyer.

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