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Generation Revenue Enhancement in a Pool-Based Electricity Market with Capacity Payment: A Case Study of Malaysia's Electricity Supply Industry

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Abstract: The objective of this paper it to address the economic benefit in term of generation revenue for Malaysia electricity supply industry (MESI). Pool market model is recognized as a conceivable model to overcome the shortcomings of the single buyer market because this model is a safe option to be more competitive and transparent electricity supply industry. However, there are issues on the welfare of the generators involved and could invite a lot of rejections from the power producers if it is not properly executed. Therefore, this paper focuses on the pricing issue in pool market by extending the capacity payment mechanism in the single auction power pool in context of MESI. A case study is conducted for two bus test system in involving four generators around Peninsular Malaysia to illustrate the proposed model which introduce the base load sharing approach and minimum capacity payment involving the efficiency of the generators. An economic analysis is conducted to highlights the merits of the proposed model compared with other pool-based market model in term of generation revenue that will help in assisting in new policy setup and further research works to overcome this crisis.

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Keywords: Electricity Supply Industry (ESI), pool market, capacity payment, efficiency

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INTRODUCTION

Many have seen the compelling plans for the discount power market. It is accepted that the critical components of discount power market plans that function admirably are to initiate effective dispatch of generators, that give impetuses to generators to work productively and yield proficient costs for age benefits that upholds solid organization tasks [1]. An assortment of blemishes in discount "energy-just" power markets lead to generators acquiring net incomes that are lacking to help interest in a most minimal expense arrangement of creating limit and to fulfill shopper inclinations for dependability [2]. Fundamentally those that further develop evaluating when limit is completely used, helps in lessening the measure of the missing cash issue, however these progressions are ridiculous to improve the energy-just business sectors. Hypothetically, there are no extra components required because of effectiveness of energy-just business sectors, yet without legitimate plan, the energy-just market will experience the ill effects of genuine downsides.

A large portion of the executions of the limit installment approach have shown various downsides including limit installments are frequently fixed and don't mirror the common sufficiency of the age framework. Likewise, target techniques for building up the authoritative worth of the limit cost are for the most part absent or excessively oversimplified and the limit item to be traded for these installments is generally approximately characterized, where the item is typically characterized as far as the generator's "firm limit", which is regularly assessed through entirely questionable methods. Thus, installments coming about because of such strategies regularly don't really associate with genuine commitments of producing units to framework dependability and its capacity to convey energy during shortage. Along these lines, the proposition of another dependability installment instrument involves decency, motivating force similarity and market power moderation, where limit of each producing unit is paid by its compelling commitment to generally speaking framework unwavering quality [4]. The motivation behind these dependability installments is expected as an instrument to supplant the decent limit installment.

This paper proposes a clever age estimating approach for pool-based market model. The point of this examination study is to further develop the pool-based market model, which is valuable for Malaysian Electricity Supply Industry (MESI) to upgrade efficiency, to elevate contest to bring down costs, to expand client decision, to gather private venture, and to combine public finances. The proposed model presents the base age limit installment including the efficiency of the generator and base burden sharing methodologies. This market model could be applied as an elective power market model to carry on the MESI past arrangement toward rebuilding. Other than that, is to oblige a reasonable serious exchanging between power makers and every elaborate party, particularly to the Independent Power Producers (IPPs). The base age limit installment includes the efficiency of the generator is to teach the IPPs to offer and sell their power created at a lower cost, while the base burden sharing methodology assists with decreasing the market power activities and value fluctuations. A contextual analysis on comparison between the proposed model with other pool based models are directed to recognize which market model is predominant and could be some type of guide in helping new arrangements and further examination attempts to beat this emergency. In this examination, monetary investigation is acted as far as age income because of the valuing issue in pool model by broadening the limit installment instrument in the single closeout power pool and age sufficiency. This transmission flow imperatives in the examination are disregarded.

III. ELECTRICITY MARKET MODEL

The electricity trading arrangement available in deregulated structures such as single buyer market, pool market, bilateral contract, and hybrid/multilateral contract, which has its own distinct characteristic. In MESI, the current single buyer market is clearly biased towards the IPPs due to the capacity payment commitments stated in the PPA and is lacking in providing competition. Therefore, the pool market is highly recommended to replace the single buyer market with a pool market, some modifications were made to the pure pool market to make it compatible with MESI. An improvement in pool-based market was developed by adding properties to the pure pool market. On the other hand, it was too risky as the power producer's revenue remuneration is put on the line. The constraints in the pool market can be seen during both high and low electricity demand, where there is too high SMP during peak demand and no revenue during low demand.

Energy installment and limit installment in single purchaser model applied by MESI, bound under the Power Purchased Agreements (PPA) [5]. Tenaga Nasional Berhad (TNB) will just compensation the energy installment for the measure of the force use took from the Independent Power Producers (IPP). In the interim, the limit installment is the sum that TNB need to pay whether or not the created power is utilized or not [6]. The installation limit give additional income to the generator which are very little create income through the charges of energy cost. Notwithstanding, the energy cost is the key to the example dispatch, though just the less expensive generator or most minimal running expense generator ought to produce ability to fulfill load need.

The pool market model valuing plan comprises of uniform value which depends on the framework minimal cost and pay as offered which depends on the generator's energy bid cost [7]. The blend of framework negligible value (SMP), loss of burden likelihood (LOLP) and the worth of lost burden (VOLL) is the last value paid to the generators. As the unadulterated pool doesn't give limit installment to the generator, costly generators might open to misfortunes due to not being chosen to supply power during low burden interest,. The condition for pool bought value, PPP is just founded on the SMP [8].

In Australia, the power market depends on the energy just market plan. The pool is overseen by the Australian Energy Market Operator (AEMO) which issues dispatch directions to generators at five-minute stretches over time dependent on the offers generators have submitted in the offering system. The generators submit offers like clockwork. A dispatch value cost addresses the expense to supply the last megawatt of power to fulfill not really set in stone at regular intervals. The dispatch value applies to all generators planned into creation paying little heed to the level of their unique proposition [9]. The last not set in stone as the six dispatch costs are found the middle value of each half-hour to decide the spot cost. AEMO utilizes the spot cost as the reason for the settlement of monetary exchanges for all energy exchanged the National Electricity Market (NEM) [10]. An exchanging stretch the NEM is a half-hour time frame with generally 48 exchanging spans the market every day [11].

A. The Proposed Model

The proposed model introduces the methodologies of the base age limit installment system, and base burden request sharing including the effectiveness of the generators to teach the generators to apply low costs for power produced [10]. Hence, the IPPs can contribute capacity to the force buyer consistently [11-13]. From the everyday power request bend, the proposed model has separated the power interest into two regions, appeal region and low interest region. In this manner, to recognize the low and appeal regions, a line is drawn on the hourly power request bend at 80% of the pinnacle interest as the reference line [14]. The low interest region comprises of the hourly power interest beneath the 80% of the pinnacle request esteem. It will be exchanged through offering contests as in the pool market in addition to with the base age limit installment [15]. Be that as it may, the 80% reference line will isolate power interest in the high region into two sections; which are the power interest underneath the 80% reference line will be exchanged similarly among the base burden plants through request sharing methodology, and all IPPs will contend with one another to supply the excess interest nearby over the 80% reference line in pool market dependent on energy cost [16].

III. RESEACH METHOD

For contextual analysis, Figure 1 delineated the two transport frameworks to give a comprehension on the essential idea of the proposed approach to detail out the clarifications towards the exchanging pool based market model in term of the impact of burden variety towards the generator's income and all out age income. The investigation is directed at low burden interest (1500 MW), medium interest (3250 MW) and appeal (5000 MW) for four generators around Peninsular Malaysia which incorporate consolidate cycle gas turbine (CCGT) and warm plant type because of the productivity and cost presented by the generator. The boundaries; the accessible limit with regards to every generator in megawatt (MW), the limit cost in RM/kW/month, energy cost in RM/MWh and proficiency, as displayed in Table 1 are taken into accounts. Assessed values are being utilized because of money related qualities engaged with the investigation are secret and the transmission network is thought to be lossless.

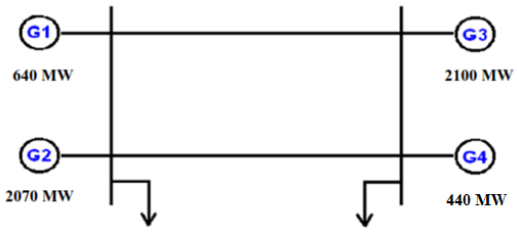

Figure 1. Four generators with two loads

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

Gen.	Plant Type	Available Capacity (MW)	Cap. Price (RM/MWh/h)	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	30000	200	43.64

IV. RESULT AND DISCUSSION

Figure 2 shows the age income for every generator, Gen 1 until Gen 4, addressed the IPPs associated with the offering rivalry during low, medium and popularity. The age income explains the installment got by the IPPs from the produced energy. In the meantime, in correlation, the market models address the various kinds of market model utilized. For single purchasers, during all interest, Gen 1 and Gen 2 got full installment from energy and limit installment. The proposed model, age income for Gen 1 and Gen 2 are expanded during low and medium interest because of progress in limit

installment which satisfy the necessity in term of generator's effectiveness and cost. Gen 1 and Gen 2 for pool and spot market models show a similar example during low and medium interest. In any case, the age income for the spot market marginally lower contrasted with pool model because of spot costs were taken from the normal of dispatch costs in thirty minutes. During low interest, for single purchaser model, the age income for Gen 3 kept on expanding contrasted with others market models. In the meantime, no income for Gen 3 and Gen 4 for pool and spot market models during low interest. Besides, too high SMP during top interest and no income during low interest shows the inadequacy of pool market model. During medium interest, Gen 3 shows that the pool and spot market models income expanded because of interest increment, which opens opportunities for costly generators to be chosen in the offering rivalry. The improvement in limit installment expanded the income for proposed market by 39.68% and 61.81%, separately contrasted with the pool and spot market models. The income for the proposed model diminished by 15.21% contrasted with pool model because of base burden sharing methodology and pool exchanging during appeal. Gen 4 is arranged as a costly generator and has no income during low and medium interest for pool and spot market models because of the example dispatch. It implies that the generators are positioned because of energy cost from the most reduced cost to the most exorbitant cost, where the least expensive generator ought to produce to satisfy need, coming about the costly generator to lose in the offering rivalry. In the meantime, there was no energy installment for Gen 4 in single purchaser model during low and medium interest. The income just come from the full limit installment, making the buyer bear the costs even there was no energy utilization during that second,. Notwithstanding, the proposed model figured out how to acquire income because of least age limit installment as pay to remain online when power was required. During appeal, the proposed model figured out how to get the income for the costly generator because of pool exchanging for the leftover interest from the base burden sharing.

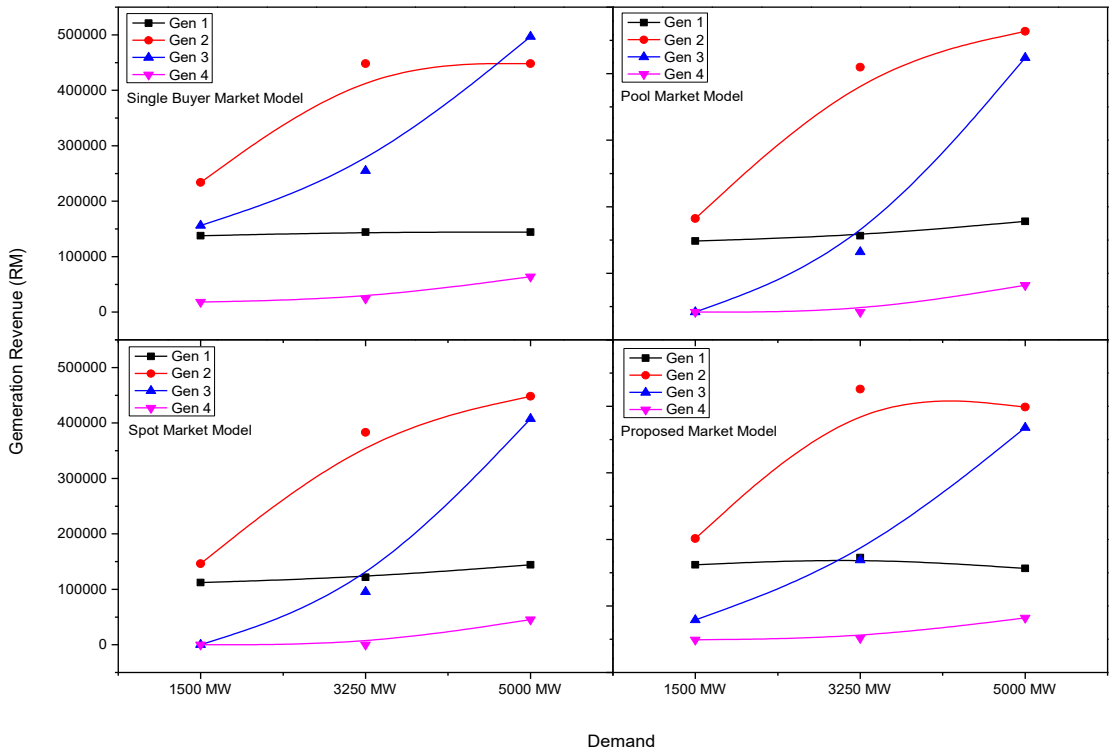

Figure 2. Comparison of Gen 1, Gen 2, Gen 3 and Gen 4 revenue for low, medium and high demand for each market models

Figure 3 delineates the examination of the all out generator's income for single purchaser, pool, spot market and the proposed models. For Gen 1 until Gen 4, single purchaser got the most elevated age income because of energy and limit installment. This happened despite the fact that a large portion of the Gen 3 and Gen 4 didn't get any energy installment during low and medium interest. Despite the fact that, spot market model has the similitude qualities to the pool model, however the income is marginally lower contrasted with the pool model because of spot costs paid for the energy utilized.. Under the pool model, the SMP is fluctuated because of interest of a specific period. Subsequently, the incomes for Gen 1 to Gen 3 are somewhat higher contrasted with the costly generator, Gen 4, as the generators were stacked from the least to the most exorbitant costs advertised. Thusly, the less expensive generators acquired more opportunities to win the offering rivalry, including during popularity where minimal expense generators got inordinate income because of high SMP. The generator's income for Gen 1 to Gen 3 of the proposed model is higher because of the base age limit installment and base burden sharing methodologies when contrasted with the spot market model. These adding properties decrease the income for the costly generators. Indeed that, the methodologies decrease the force of greater limit generators to guarantee a commendable age of income for all generators as a maker, and a commendable installment for the buyers. The proposed model ensures the advantage of all generators paying little heed to the variety of power interest and assists with instructing the generators to offer at less expensive costs for more income. The proficiency of the generator will restrict the limit installment as it depicts the genuine capacity and execution of the generator.

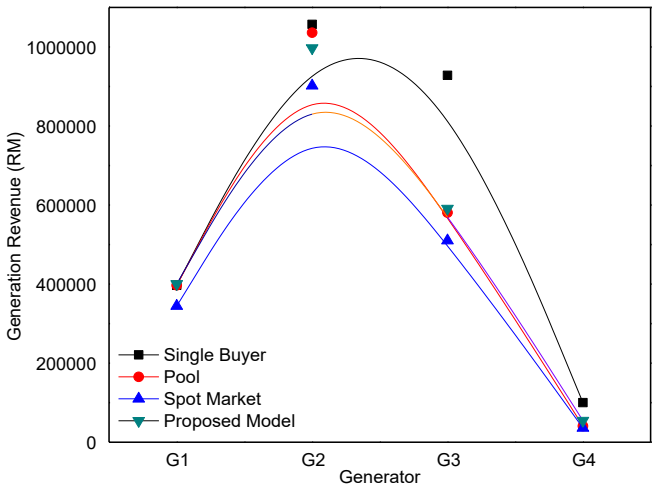

Figure 3: Comparison of total generator's revenue

Figure 4 shows the examination of absolute income age dependent on request as per the sorts of market models. For a wide range of interest, the single purchaser model produced the most pay contrasted with other market models. In the interim, the income for the proposed model during low interest was higher by 29.45 % contrasted with the pool market model because of the execution of least age limit installment. Nonetheless, the pool model shows the most elevated age income during top interest because of high SMP. In the mean time, the income for spot market model likewise surpassed the proposed model during top interest. This is on the grounds that when the interest expanded, the dispatch cost likewise expanded which affected the spot cost. Meanwhile, the age income for the proposed model is lower because of only one SMP tallied during base burden sharing. Subsequently, the complete age income for the proposed model improved by 0.54%, - 14% and 17.69% contrasted with the pool, spot market and single purchaser model, separately. During top interest, the income for the pool model is marginally higher contrasted with the single purchaser model because of high SMP. In any case, the income for the proposed model diminished more contrasted with the spot market because of the base burden sharing methodology coming about the decrease of market power works out. The decreased rates show the improvement in bringing down the interest installment. Contrasted with proposed model, despite the fact that, the pool and spot market models display extensive decreases in rates of age income, yet still can't guarantee sufficient pay for costly generators during low interest. The proposed model's base burden request sharing methodology guarantees that all IPPs has equivalent freedoms to take part in the exchanging and get income for their commitment in the hourly exchanging period barring the greatest cost generator.

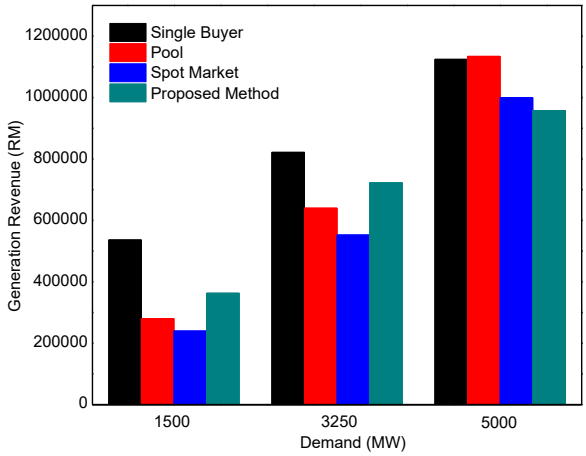

Figure 4: Comparison of total generation revenue based on demand

VI. CONCLUSIONS

In MESI. due to the availability of both capacity and energy payments, the generators had gained the largest revenue under the single buyer model. Furthermore, these generators still can obtain revenue even without any contribution to supply the load demand, yet does not provide any competition due to the long-term agreement. While. pool market model offers full competitive model, based on energy price

only and fully removed the capacity payment, reduces the revenue some of the generators quite significantly. Even though, the most expensive generators might not be able to get any revenue at all, but this approach will force the expensive generators to bid for the cheapest energy price most of the time, consequently will create competition. Therefore, MESI need to change the current market model used as it affect to various level of parties involved. The proposed model seems to be very effective as it gives the opportunity to all generators to participate not only in base load demand but also in peak load demand. The implementation of base load sharing approach in the proposed model able to reduce the market power exercises.

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