Embracing Renewables – Overcoming Integration Challenges from Malaysia's Utility Perspective

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***Abstract*—Renewables have become the emerging source of energy. The sustainable and environmental friendly energy is rapidly becoming more pronounced to alleviate the damaging effects of burning hydrocarbon fuels. For some countries that heavily rely on imported fuels, harnessing the renewable resources helps to minimize the dependency on imported fuels that is susceptible to price volatility. This paper examines the challenges facing Tenaga Nasional Berhad in integrating Utility-Scale Solar PV. The discussion is centered on the function of Single Buyer Department as the dedicated power purchasing agency for Malaysia Electric Supply Industry (MESI). A review of the status of renewables in Malaysia and government policies that support the development of renewables is briefly discussed. The paper makes comparisons with countries with similar Electricity Supply Industry (ESI) structure. The paper subsequently suggests how the roles of Malaysia's Single Buyer can be further enhanced to support the country's renewables initiatives.**

***Index Terms*--Malaysia Electricity Supply Industry, renewables, Single Buyer, Utility-Scale Solar PV integration.**

I. INTRODUCTION

Malaysia is committed to promoting renewables in the energy sector. Apart from hydro potential in East Malaysia, the country receives abundant sunshine, hence solar radiation. The country's solar insolation per year ranges from 1400 to 1900kWh/m2/year at the average of about 1643kwh/m2/year with more than 10 sun hours per day [1]- [3]. As a testimony to Malaysia's commitment in advocating green energy, the country has rolled out several renewable energy policies and programs. At the same time, as the incumbent utility, Tenaga Nasional Berhad (TNB), particularly Single Buyer (SB), has been playing its part in supporting renewables. The tariff upward revision in the late 2013 has heightened the interest from public to generate electricity from solar resources to bring down their electricity bill. TNB therefore has to be one step ahead to embrace the change in Malaysia's generation landscape.

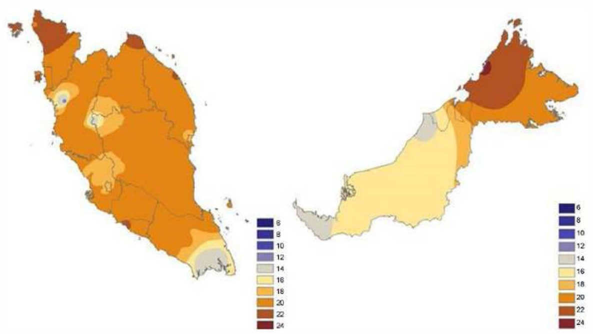

Figure 1. Annual average solar radiation (MJ/m2/day)

II. OBJECTIVE

This paper attempts to analyze the roles of Single Buyer in supporting the Utility-Scale Solar Photovoltaic (PV) generation. In doing so, the paper focuses on the challenges encountered by Single Buyer in discharging its duty. The absence of a proper regulatory framework and the Malaysian Grid Code (MGC)'s inadequate provisions for Utility-Scale Solar PV are identified as major barriers impeding a smooth integration of this type of generation. The paper subsequently looks at the on-going work to facilitate the integration of Utility-Scale Solar PV and finally proposes some recommendations to enhance the role of Single Buyer in anticipation of a higher penetration of Utility-Scale Solar PV.

III. SCOPE AND LIMITATION

Renewable potential in Malaysia is substantial, covering hydropower, biomass, biogas and Solar PV. This paper however focuses only on Utility-Scale Solar PV generation connected to the Peninsular Malaysia's transmission grid. Discussion is centered on the impact of the Utility-Scale Solar PV to the grid and to the function of Single Buyer particularly and to Malaysia Electric Supply Industry (MESI) in general.

IV. Overview of Malaysia's Power Sector

Malaysia Electricity Supply Industry (MESI) has been transformed from a vertically-integrated industry into a Managed Market Model (M3). Under M3, a ring-fenced Single Buyer is created and TNB business is regulated under Incentive Based Regulation (IBR) framework. Suruhanjaya Tenaga (ST) as the regulator has a direct supervision on the operations of Single Buyer (SB) to ensure compliance to the Single Buyer Rules (SBR) [4].

In the following section, the roles of Single Buyer are further elaborated particularly in the generation capacity planning and as the exclusive power purchaser.

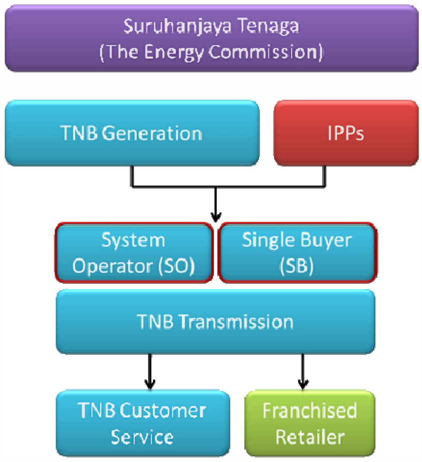

Figure 2. Malaysia ESI structure

V. Roles of Single Buyer

A. *Roles of Single Buyer in Generation Capacity Planning*

Under M3, there are essentially two distinct entities responsible for procuring new generation capacity, Single Buyer and Suruhanjaya Tenaga. Their specific functions are stated in the Single Buyer Rules (SBR), a set of rules that governs the operation of Single Buyer.

Single Buyer is responsible for the electricity demand forecast and the generation capacity planning while Suruhanjaya Tenaga is specifically tasked to acquire additional generation capacity identified earlier by Single Buyer [5].

The generation procurement process begins with the long-term electricity demand forecast as it fundamentally provides the information to decide on needs for future generation investment and the associated transmission reinforcements. The key assumptions used in conducting the demand forecast study include the economic and population growth, key industrial and commercial developments, and other important drivers such as the Government policies that could potentially impact the electricity growth in Peninsular Malaysia.

Based on the electricity demand projection, the following step is to conduct Generation Capacity Planning Study to decide on the timing and type of generation plants needed to meet the generation shortfall in the future. A reliability index, loss of load probability (LOLP) is used as the main criteria to evaluate the adequacy of generation supply to support the forecasted demand. Other factors, such as the operating reserve requirement, plant and fuel availability, plant retirement and project lead time are also considered as they certainly influence the outcome of the generation planning study.

In planning for the future generation plant up, only the conventional plants are being considered as the candidates. The obvious reason is that this type of plants, such as coal, gas thermal and hydro plants are dispatchable and able to provide a dependable capacity. A plant that is dispatchable and dependable means that it is controllable by the System Operator and can be switched on and off, depending on the economics, to meet the demand and to maintain the reliability of the network [6].

The Generation Capacity Planning Study conducted by Single Buyer identifies any generation shortfall in meeting the future demand. If new generation capacity is required, Suruhanjaya Tenaga (ST) will undertake the responsibility to contract for new capacity. The exercise begins with initiation of the tendering process, until the contract is awarded to the winning tenderer.

B. *Single Buyer As The Sole Power Purchasing Agency*

Single Buyer is the entity sanctioned by ST to be responsible for the management of electricity procurement and related services. Essentially, Single Buyer is entrusted to procure electricity from both the Independent Power Producers (IPPs) and TNB Generation and subsequently produce dispatch schedule. In performing its function, Single Buyer shall demonstrate transparency and impartiality at all times.

As outlined in the Single Buyer Rules, one of the fundamental roles of Single Buyer is to procure electricity to meet the demand on the least cost basis. To realize this role, Single Buyer shall produce Dispatch Schedules for day ahead, week ahead and three months ahead. These Dispatch Schedules shall be developed based on the Least Cost Dispatching Scheduling Methodology (LCDSM). The methodology specifies that the generating unit with the lowest marginal cost is to be dispatched first followed by the next lowest marginal cost unit until all demand is met. The Dispatch Schedules shall also be designed to ensure the security and reliability of electricity supply which includes adequate provisions for system security, operating reserve, transmission and generation constraints and fuel availability.

The underlying principle of LCDSM is to minimize the generation cost, subject to various constraints. Hence, the strategy is to select the cheapest possible combination of generating units to meet the demand at all times. This method does not discriminate between the types of plants to be dispatched. As long as the plant is cheap, it will be run first. LCDSM is consistent with the Least Cost Operation outlined in the Malaysian Grid Code (MGC) [7].

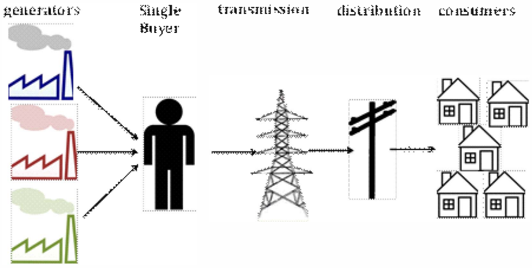

Figure 3. Single Buyer as the power purchasing agency

VI. STATUS OF RENEWABLES IN MALAYSIA

A. Development of Malaysia's Renewables Acts and Policies

Malaysia is committed to promoting renewables to be part of the electricity generation mix since the 8th Malaysia Plan in 2001. Recognizing renewables as the fifth fuel besides oil, gas, coal and hydro, the country has targeted five percent (5%) of total generation capacity to come from renewables by 2005, thereby reducing 70 million tons of CO_2 emission within 20 years [8]. The government's interest to develop solar energy was further manifested in the succeeding 9th Malaysia Plan in 2006, where 300MW of renewable capacity is targeted to be connected to the power utility-grid in Peninsular Malaysia [9]. In 2010, the introduction of National RE Policy and Action Plan (NREPAP) from the 10th Malaysia Plan has further encouraged the development of renewable in the country. In the longer term, NREPAP essentially aims to achieve thirteen percent (13%) share of renewable capacity by 2030 [10] .

Despite relentless initiatives to promote renewables for power sector, the response in terms of renewable development projects is slow [11]. Among the reasons identified for the sluggish response were 1) failure of renewable markets due to the monopsony power of the utility, 2) economical, financial and technological factors that constrains the market performance, 3) absence of proper regulatory framework, and 4) limited oversight to oversee the implementation problems [12]. Consequently, in 2011, the Parliament has passed Renewable Energy Act 2011 and Sustainable Energy Development Authority (SEDA) Act 2011 to spur the growth of renewables in a more aggressive manner. The renewable bill provides for the implementation of Feed-in Tariff (FiT) program, while the latter results in the establishment of SEDA Malaysia to oversee the implementation of FiT mechanism.

Moving forward, the ministry is drafting two more policies, namely the Net Energy Metering (NEM) and Utility-Scale Solar PV policies which are aimed to increase the share of renewables in the electricity generation.

Figure 4. Development of RE acts and policies in Malaysia

B. Renewable Programs in Malaysia

To support these policies, Malaysia has rolled out several renewables programs since 2001. Some of the programs are Small Renewable Energy Power Program (SREP) in 2001, Malaysian Building Integrated Photovoltaic Technology Application Project (MBPIV) in 2005 with the most recent being Feed-in Tariff (FiT) program.

FiT program was introduced following the enactment of RE Act 2011 and SEDA Act 2011 to encourage the public to generate electricity from renewable resources. Under the Malaysia's FiT mechanism, the utilities are obliged to purchase the electricity produced by the FiT Approval Holder at a fixed premium FiT rate [13]. Funding for this project comes from RE fund of which 1.6% additional charge is imposed on the customers' electricity bill. The renewable resources eligible for FiT program are biogas, biomass, small hydropower and Solar PV [14]. The program received an overwhelming response from the public, thanks to the premium FiT rate offered when it was first introduced in December 2011. To date, there is a total of 82,814.45 MWh of renewable generated under FiT program in 2014, resulting in CO_2 avoidance of 403,655.02 tons [15] [16] .

VII. BENCHMARKING WITH OTHER COUNTRIES WITH SIMILAR ESI STRCUTURE

To benchmark Malaysia's renewable development particularly a Utility-Scale Solar PV, it will be prudent to look at how other countries are treating their power generation from renewable resources. In this paper, the authors attempt to look at Jordan and Thailand as the ESI structure of these countries is similar to Peninsular Malaysia.

A. Jordan

The Jordanian ESI structure is somewhat similar to Malaysia ESI. National Electric Power Company (NEPCO) is a state-owned transmission company responsible for owning and managing the transmission network, power control, power purchase and sale and power exchange with bordering countries. The regulation of electricity industry is overseen by the Jordanian Electricity Regulatory Commission (ERC) [17] [18].

The effort to promote power generation from renewable in Jordan began as early as 1988. The recent past has seen rigorous initiatives by the government in terms of regulatory, financial and technical supports, alongside international agencies and foreign benefactor, to harness the renewable potential in power generation. Renewable is seen as the best and the cheapest alternative to mitigate the country's dependency on imported fuel coupled with the fact that the potential is enormous and yet to be tapped [19].

In the Jordan's Energy Strategy, the country aims to have ten percent (10%) of its energy mix from renewable sources by 2020. The renewable sources are to be made up of large scale power projects, consisting of 1200MW of wind energy, 600MW of solar energy and between 30MW to 50MW of waste-to energy facilities. As a way to attract investment, the government guarantees an entry into a power purchase agreement (PPA) to a successful developer. [20].

B. Thailand

Thailand ESI adopts a semi-unbundled structure termed "Enhanced Single Buyer Model". Electricity Generating Authority of Thailand (EGAT) is a state-owned entity with fifty percent (50%) share in generation and fully owns and operates the transmission network. The distribution systems are operated by the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA). The regulation of this sector is mandated to the Energy Regulatory Commission (ERC) [21].

Renewable energy in Thailand is seen as an alternative to ensure energy security and reduce reliance on imported fuels. The 15-Year Renewable Energy Development Plan (REDP 2008-2022) laid down clear policies and responsive plans that focus on increasing domestic alternative energy use to replace the fossil fuel imports. The REDP is targeting renewable to make up twenty percent (20%) share of final energy consumption in 2020. The superseding Alternative Energy Development Plan (AEDP 2012-2021 sets higher targets of renewable.

In terms of Solar PV, Thailand's FiT or popularly known as the Adder program has received overwhelming response predominantly from solar applicants. Implemented in the early 2007, the program has resulted in a 'speculated MW' rather than realizable projects. This has led the government to review its policy that impacted the whole renewable industry.

However, the lack of synergy between RE plans and Thailand's long term energy planning process hampers the development of renewables in the country [22].

VIII. Challenges in Integrating Utility-Scale Solar PV in Malaysia

Malaysia is expected to have its first Utility-Scale Solar PV in 2016. The 50MWac plant will be connected to the 132kV transmission network. To achieve the national renewable target, the country will definitely see many more Utility-Scale Solar PV plants in the coming years.

Unlike the conventional plant, the variability and intermittency of Solar PV generation brings new challenges in power system operation [23]. In addition, the country is yet to set a proper regulatory framework related to Utility-Scale Solar PV. At the same time, the Malaysian Grid Code (MGC) lacks the provisions for Utility-Scale Solar PV generation. All of these issues need to be addressed to ensure smooth integration of Utility-Scale Solar PV generation. This section deliberates further.

A. ASEAN and Malaysia RE target

Malaysia's RE plan has set a target of 2080MW of cumulative RE capacity by 2020 and 4000MW by 2030. Recently, ASEAN has set an RE target of thirty percent (30%) of installed capacity by 2020 for it member countries, translating into 9000MW of Malaysia's installed capacity. At the same time, ASEAN has also redefined large hydro as renewable, leaving about 5000MW to be realized through FiT and Solar PV generation [24].

According to SEDA Malaysia, FiT mechanism contributes about 1500MW of RE capacity of which the source of RE fund comes from 1.6% additional charge of TNB customers' electricity bill. To further expand FiT program requires additional RE fund, which means an increase in RE surcharges collected from the electricity bill. This may not seem palatable as the public will start questioning why they should pay more than what they consume. Therefore, for Malaysia to meet the national target of RE generation, Utility-Scale Solar PV and NEM become more favorable options.

B. Absence of Policy and Regulatory Framework for Utility-Scale Solar PV

Although several policies have been laid down for RE, the country has yet to establish a specific policy and regulatory framework for Utility-Scale Solar PV generation. A clear framework is a precursor to its smooth entry and is urgently required for Single Buyer to efficiently play its role. The policy and framework should among others include:

1) Implementation mechanism: SEDA reported that the application for Solar PV generation is overwhelming due to its easy and fast installation and relatively cheaper cost compared to other RE type applications. Thus, to be fair and transparent to all applicants, SEDA proposes that the Utility-Scale Solar PV is to be implemented through bidding mechanism. The policy should also determine the responsible agency to implement and oversee the bidding process and decide on the ownership of the plant, i.e. whether or not to allow for foreign and utility participation.

2) Size of plant: The policy should specify total generation capacity to be allowed for Utility-Scale Solar PV. A comprehensive study should be conducted to determine what is the appropriate penetration level for Malaysia to accommodate this intermittent energy. The study should also indicate the size allowed for each plant as well as the connection scheme to the grid, i.e. either to transmission or distribution grid.

3) Location and distance between Solar PV plant: Although Malaysia receives abundant sunshine during daytime, it is somewhat rare to have a full day with clear sky. With the isokeraunic level of 200 thunder days per year, the Malaysian sky is mostly covered by clouds, impacting solar radiation. For this reason, locating solar PV plant in one concentrated area will likely cause a sudden dip in the generation output when the cloud moves over the area. Therefore, to reduce intermittency, it is prudent to consider a minimum distance between solar PV plants.

The amount of sunshine received in Peninsular Malaysia is also characterized by a seasonal and spatial variation. The northen region receives more sunshine compared to the rest of the regions [25]. Thus, incentive should be given for the plants installed outside the northern region to create a more uniform distribution thoughout Peninsular Malaysia.

4) Generation forecast: Utility-Scale Solar PV generation is highly influenced by the weather condition. Therefore, it is mandatory for the plant owner to submit its generation forecast to minimize risks of deviation in daily generation dispatch.

C. Enhancement to Single Buyer Rules(SBR)

As mentioned in the preceding section, SBR is a set of rules that governs the operation of Single Buyer. SBR stipulates that the daily dispatching of generators shall follow the Least Cost Dispatching Scheduling Methodology (LCDSM). However, the existing SBR does not clearly specify how a renewable plant should be treated. Rather, SBR merely states that the generation from a renewable plant serves as one of the inputs to the Day Ahead Dispatch Schedule [26].

There are two possible scenarios to consider for Utility-Scale Solar PV in Malaysia; either the plant is treated as a Centrally Dispatched Generating Unit (CDGU) or the plant is treated as a deemed generation. In the first scenario, a CDGU plant is scheduled for dispatch according to LCDSM. Therefore, if the cost is higher than the system marginal cost, the plant is at a high risk of not being dispatched. Presently the price of Solar PV in Malaysia has not reached grid parity and therefore, will not be in favor of the Solar PV plant developer.

In the second scenario, the plant is treated as a deemed generation in which the plant must be dispatched whenever solar generation is available. That being the case, having a Utility-Scale Solar PV may pose economic and technical challenges. As a deemed generation, the plant is guaranteed to be dispatched despite being the most expensive plant, resulting in a less optimal overall generation cost.

Small penetration of Utility-Scale Solar PV may have a little impact on LCDSM dispatch since the intermittency can be compensated by the allocated spinning reserve. However, at a high penetration level, the existing spinning reserve will no longer be able to cater for a sudden drop in generation. This situation calls for more back-up generations to cover for larger variation, hence resulting in higher generation cost [27]. In this respect, SBR needs to be amended to clearly specify the treatment for Utility-Scale Solar PV plant.

D. Enhancement to Malaysian Grid Code (MGC)

The Malaysian Grid Code (MGC) is a document that outlines the development, maintenance and operation of the Peninsular Malaysia's Grid System. The MGC defines the principles governing the relationship between parties to the MGC, namely the Grid System Operator (GSO), Suruhanjaya Tenaga (ST), Grid Owner (GO), Single Buyer (SB) and all Users of the Grid System in Peninsular Malaysia [7]. The Grid System is defined as the TNB's transmission network with voltage level of 66kV and above.

The Utility-Scale Solar PV will be connected to the transmission network. Thus, like any other conventional plants, the Utility-Scale Solar PV plant has to fulfill the requirement of the MGC. However, the existing MGC lacks provisions for this type of intermittent generation.

In the MGC, a Centrally Dispatched Generating Unit (CDGU) is defined as a Generating Unit that is centrally dispatched by GSO. A CGDU is expected to fulfill a set of technical requirements to maintain security and integrity of the grid, among others, to provide spinning reserve, which can be delivered via primary response or secondary response. Moreover, a CDGU shall also be black start capable- a procedure necessary to recover from a total or partial blackout. A CDGU shall also be dispatched according to the least cost operation.

Clause CC6.4.1.1 of the MGC sets forth exceptions to the rule. The clause states that a Generating Unit with capacity of 50MW and less, hydro units and renewable energy plants that is not designed for frequency and voltage control are exempted from performance requirement usually expected from a CDGU. These exemptions have several implications on the treatment of Solar PV plant.

To begin with, any Solar PV plant with a capacity of 50MW and less is not expected to perform like a CDGU. This statement is also putting an exemption on Solar PV plant that is not designed for frequency and voltage control capability. However, the new generation of Solar PV inverters can fulfill similar technical requirements as the conventional plant. Therefore, to make exceptions for renewable plants will be at a cost to the operation of the grid system, especially when the penetration level becomes increasingly significant. This is because other conventional plants have to provide the ancillary services that a Solar PV plant cannot offer.

Based on these arguments, it is necessary to relook at the existing MGC to remove barriers and ambiguities that may otherwise impede a smooth integration of Utility-Scale Solar PV.

IX. ONGOING WORK

The first Utility-Scale Solar PV plant has made its debut in Peninsular Malaysia despite the absence of a clear policy and regulatory framework for this type of generation. Since then, the ministry and related agencies have doubled their effort to finalize the policy paper in anticipation of a growing number of Utility-Scale Solar PV plants. Suruhanjaya Tenaga is currently amending the MGC. At the same time, TNB and SB as the industry players are actively playing their part by assisting the policy makers in the formulation of the policy and framework for Utility-Scale Solar PV.

X. SUMMARY AND CONCLUSION

In anticipation of a high penetration of Utility-Scale Solar PV, Tenaga Nasional Berhad, specifically Single Buyer has to be well-prepared. High penetration of Utility-Scale Solar PV is likely to pose a new set of challenges to the operation of Single Buyer. Since Solar PV has not reached grid parity, Single Buyer is bound to buy the power generated from Utility-Scale Solar PV at a higher price and this contradicts with the principle of Least Cost Dispatching Scheduling Methodology.

High penetration of Utility-Scale Solar PV is also foreseen as a challenge to maintain a stable operation of the grid. Grid operators now have to deal with the inherent variability and intermittency of Solar PV. Moreover, the current Malaysian Grid Code (MGC)'s lack of provisions for Utility-Scale Solar PV will later cause a bigger problem to the operation of the grid.

Benchmarking with other jurisdictions, it is observed that a strong policy alongside government incentives are the key to drive the development of renewables. In terms of large-scale grid-connected RE generations, an attractive PPA is the way to entice investors to participate in power production from renewable.

Moving forward, it is necessary to enhance Single Buyer Rules and the Malaysian Grid Code in anticipation of a higher penetration of grid-connected renewable in Malaysia. This recommendation is critical to ensure continuous support on renewables from Single Buyer, particularly the Utility-Scale Solar PV, as well as to ensure efficient and fair treatment to the Single-Buyer Market Participants in view of a higher penetration of Utility-Scale Solar PV.

ACKNOWLEDGMENT

The authors of this paper would like to sincerely express their gratitude and appreciation to Tenaga Nasional Berhad for giving permission to publish this paper. The information presented and views expressed herein this paper are solely those of the authors and do not necessarily represent the views of TNB and/or the management and staffs of TNB.

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