Harnessing the Power of the Sun ï Malaysiaôs Maiden Journey in Large-Scale Solar PV

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ABSTRACT

Malaysia continues implementing various policies and initiatives to combat climate change. During the 2015 Paris Climate Conference (COP 21), Malaysia reiterates its commitment in carbon reduction with the pledge to further reduce the greenhouse gas emission to forty-five percent (45%) by year 2030. On the energy front, deployment of renewable energy and energy efficiencies is seen as the key initiative in climate change mitigation. The countryôs effort in promoting renewables began in early 2001 with the enactment of five fuel policy that recognizes renewables as the fifth fuel. Numerous programs were rolled out to support this policy and subsequent other policies but responses received were rather lukewarm. Only ten (10) years later, the Feed-In Tariff (FiT) managed to spark overwhelming interest from the public and by far the most successful renewable program. The success of this program leads to a recent announcement by the government which approved for a 1000MW of Large-Scale Solar PV plant up. Dubbed LSS, the implementation of 1000MW of Solar PV will be in stages until 2020 with 200MW of initial plant up in Peninsular Malaysia and 50MW in the state of Sabah. This paper discusses the experience of Tenaga Nasional Berhad in assisting Suruhanjaya Tenaga, the Energy Commission of Malaysia, to formulate the Guidelines for Transmission-Connected LSS. In doing so, a brief review of the status renewables in Malaysia and government policies that supports the development of renewables is provided. The paper further deliberates the content of the Guidelines and finally suggests the way forward in facilitating the penetration of Large-Scale Solar PV to support the countryôs renewables initiatives.

KEYWORDS

Malaysia ESI, Renewables, Large-Scale Solar PV, transmission-connected

1. INTRODUCTION

Malaysia continues to implement various policies and initiatives to combat climate change. During the 2015 Paris Climate Conference (COP 21), Malaysia reiterates its commitment in carbon reduction with the pledge to further reduce the greenhouse gas emission to forty-five percent (45%) by year 2030 [1]. On the energy front, Malaysia is actively promoting the deployment of renewable energy (RE) in the energy mix to increase RE contribution whilst reducing the greenhouse gas emission in the effort to conserve the environment for future generation [2] .

Late 2015 saw the announcement by the Malaysian government to plant about 1,000MW of Large-Scale Solar PV (LSS) by 2020 to meet the Renewable target of 23% of the total generation capacity [3]. The 1000MW will be implemented in stages beginning 2017 with the first 200MW allocated for Peninsular Malaysia and 50MW for Sabah. The Energy Commission of Malaysia, Suruhanjaya Tenaga (ST) is tasked to conduct the competitive procurement of the energy for commissioning in 2018 onwards [4][1]. Subsequent to the news, ST established a working group consisting of members from Single Buyer (SB), Grid System Operator (GSO) and Grid Owner of Tenaga Nasional Berhad (TNB) and chaired by ST. The LSS Working Group is tasked to formulate a guideline for the integration of LSS to the transmission system.

2. OBJECTIVE

The objective of this paper is to share Malaysiaos experiences in formulating the guidelines for integration of Large-Scale Solar PV (LSS) into Peninsular Malaysia transmission system. In doing so, the paper looks into the technical and commercial considerations underpinning the formulation of the guidelines. The paper also suggests the way forward in facilitating the penetration of LSS to support the countryos renewables initiatives.

3. BACKGROUND ON MALAYSIA ELECTRICITY SUPPLY INDUSTRY

Malaysia Electricity Supply Industry (MESI) has undergone a transformation from a vertically-integrated utility model to a Managed Market Model. The Single Buyer and Grid System Operator are ring-fenced and TNB businesses are regulated under Incentive-Based Regulation (IBR) [5]. Suruhanjaya Tenaga has a direct supervision on the operation of Single Buyer. The reform initiatives seek to create a reliable, transparent, efficient and sustainable electricity industry in Malaysia [6].

[1] The government subsequently in January 2016 announced the approval of two (2) utility-scale solar PV on a fast-track basis for commissioning in 2017. Included in the announcement is the issuing of Request for Proposal (RFP) for 250MW plants this year for commissioning in 2017/18 onwards.

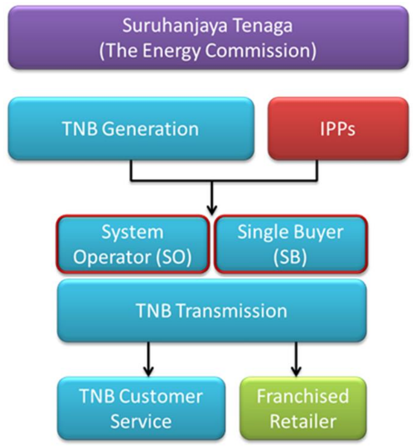

Figure 1: Structure of MESI

4. STATUS OF RENEWABLES IN MALAYSIA

The countryǿs effort in promoting renewables began in early 2001 with the enactment of five fuel policy that recognizes renewables as the fifth fuel. Numerous programs were rolled out to support this policy and subsequent other policies but responses received were rather lukewarm [7]. Only ten (10) years later, the Feed-In Tariff (FiT) program has managed to spark overwhelming interest from the public and by far the most successful renewable program owing to the attractive rates [8] .

5. LARGE-SCALE SOLAR PV

When it comes to the size of a Utility Scale Solar PV, there is no clear definition on the minimum threshold of a utility-scale project. A published academic paper [9] highlighted that the term utility scale has minimum limits from anywhere between twenty-five (25) kW to tens of megawatts. The National Renewable Energy Laboratory (NREL) caps the size to 5MW while International Renewable Energy Agency (IRENA) use the term without apparently defining it. However, one common denominator to qualify for a utility-scale is that the electricity from Solar PV plant is sold to the wholesale utility buyers through the grid instead of directly to the end-use customer for local consumption.

Suruhanjaya Tenaga defines a Large-Scale Solar PV as any Solar PV plant with a minimum size of 1MWac and a maximum of 50MWac and connected to either distribution or transmission grid in Peninsular Malaysia, Sabah or Labuan [10]. This definition, which is adopted in the Guidelines, forms the basis of all assumptions made in formulating the Guidelines.

Malaysiaǿs experience in Large-Scale Solar PV (LSS) is still at the infancy stage. The first mega scale Solar PV project in Malaysia is the 1MDBǿs 50MWac Solar PV plant in Kedah. The Power Purchase Agreement (PPA), signed between 1MDB and TNB in

April 2014, provides for 25 years of contract to sell 50MWac at transmission level. This pilot project is slated to be commissioned in 2017.

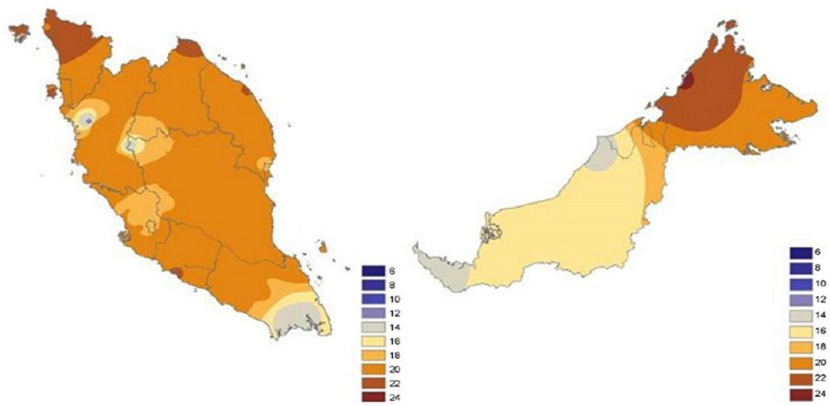

Figure 2: Malaysia Average Annual Solar Irradiance (MJ/m2/day)

6. GUIDELINES FOR LARGE-SCALE SOLAR PV

The Guidelines will be provided to the LSS developers during the Request for Proposal (RFP) stage. In essence, the Guidelines are aimed to guide the potential LSS developers seeking connection to the transmission system. The Guidelines were drafted based on prudent utility practices as well as lessons learnt from other jurisdictions. The Guidelines entail six (6) broad topics covering planning, operation and commercial aspect of LSS connected to the transmission grid. The content of the Guidelines is deliberated in the following subsections.

A. Connection to the Grid

This section describes the connection schemes allowed for connection to TNBȏs transmission grid. TNBȏs transmission grid or the Grid System is made up of 500kV and 275kV networks which act as the backbone and primarily used for bulk power transfer and the meshed 132kV network that links the backbone to the load centers.

In principle, the connection of the LSS plant to the Grid System can be made at any point of the network. However, to facilitate the integration of the first 200MW of LSS in Peninsular Malaysia, the following rules are imposed:

i. Voltage Level

Presumably, the power generated from LSS will be consumed locally, as such the connection to the Grid System is only allowed at 132kV level. Connection at this voltage level will also result in lower investment cost and ensure the reliability of the backbone is not compromised.

ii. Connection Scheme

The Guidelines identify two (2) possible connection schemes for the transmission-connected LSS; either to the existing substations or to the nearest existing transmission lines. The connection to the existing substation is permissible subject to the availability of the switchgear bay or space (if extension is required). For the connection to the nearest existing transmission lines, the LSS developer is required to construct a new fully switched switching station with a looped-in-looped out lines configuration into the switching station. Fig. 1 -2 below depicted such connection schemes.

Notwithstanding the above, the Grid Owner shall have the final say on the most appropriate connection points and voltage level based on the results of Power System Study.

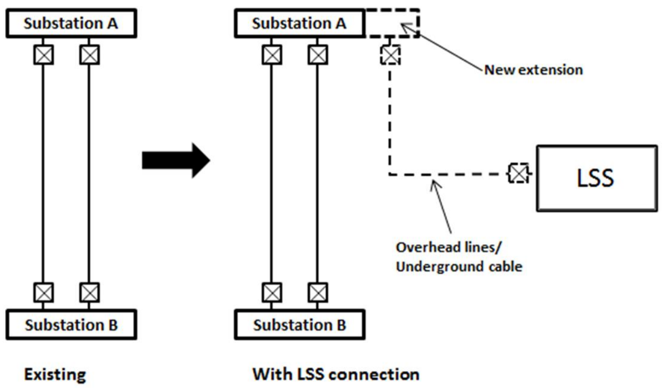

Figure 3: Connection to the Existing Substation

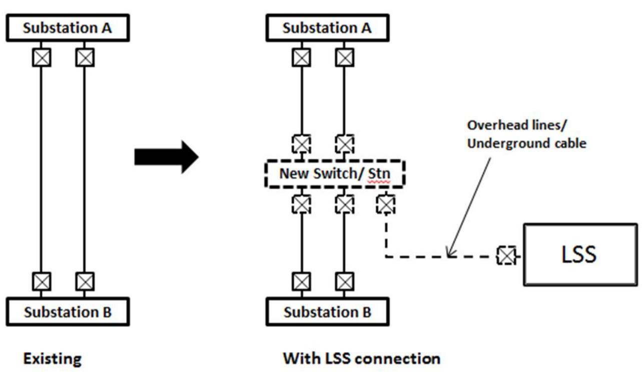

Figure 4: Connection to Nearest Existing Transmission Lines

iii. Scope of Interconnection Facilities & Asset Demarcation

For avoidance of doubt, the Guidelines clearly outline the scope of interconnection facilities and asset demarcation between TNB and the LSS developer. The LSS developer is fully responsible to acquire the land, obtain necessary permits from the relevant local authorities and undertake the design, construction, commission and testing of the interconnection facilities and the associated network reinforcement up to the Point of Common Coupling (PCC).

All costs associated with the connection of LSS to the Grid System shall be borne by the LSS developer.

iv. Potential Zonal Nodes for Grid Connection

Thirty-six (36) connection points or nodes were identified for the LSS connection to the Grid System. These nodes, which are spread throughout Peninsular Malaysia, were selected based on the following criteria:

(a) *Transmission adequacy* ï no reinforcement or upgrade of transmission network is required. The transmission network can accommodate up to 50MW of LSS injection without violation of security criteria.

(b) *Isolated network*- some of the nodes are located at rural area or from a spurred connection. This is to minimize the line losses since the LSS generation will be consumed by the local load.

(c) Non-congested network ï no nodes were selected from an already generation-rich area.

v. Nodal Factor

In the Guidelines, nodal factor is calculated for each identified node. Due to the physical characteristics of the transmission system, energy is lost as it is transmitted from generators to loads. Hence, additional generation must be dispatched to cover the losses [11]. Nodal factor, which captures the element of transmission losses associated with the LSS injected at that nodal point, is derived using the following formula:

$$\mu_{n=} \text{System Losses @ Nodal Point}^{n} \text{- System Losses @Reference Case}$$

Nodal factor^{n}= 1+[(μ_n- $\mu_{max)/}$Reference Case System Losses], where n= nodal point

Nodal factor, which is essentially a simplified version of nodal pricing, was formulated to assist ST in ranking and evaluating the bids for the LSS capacity.

B. Power System Study

Power System Study (PSS) is important to (a) identify the connection scheme and configurations for LSS plant to connect to the Grid System, (b) investigate the impact of this new interconnection to the Grid System and (c) assess the ability of the LSS to comply with the technical requirements as stipulated in the Malaysian Grid Code (MGC). The LSS developer is requested to conduct Power System Study (PSS) prior to making connection to the grid.

The PSS shall be conducted in two (2) stages,

i. Stage 1 of PSS shall employ generic models of Solar PV component to verify the impact on the Grid System based on the information of the PV plant known at point of time. The study report shall be submitted with the RFP submission

ii. Stage 2 of PSS shall be using actual model of Solar PV to provide indicative evidence of the LSS ability to comply with the MGC requirements. The study report shall be submitted six (6) months prior to the contracted COD.

The scope of PSS study shall include but not limited to power-flow analysis, contingency analysis, short circuit analysis, transient stability analysis, fault ride-through capability and reactive power requirement. The results of the PSS shall be benchmarked against relevant clauses in the MGC and TSRS.

C. Power Purchase Agreement (PPA)

Power Purchase Agreement (PPA) guarantees a generating company a long-term revenue stream through the sale of energy. Treated like an IPP, the successful LSS bidder shall enter into a Power Purchase Agreement with TNB as the off-taker. As such, the Guidelines correspondingly outlines the salient commercial terms of the LSS PPA.

Unlike other conventional generators, Solar PV output is inherently non-dispatchable. For this reason, the PPA for LSS is designed to be an energy-only PPA. The contract period of twenty-one (21) years makes the LSS projects attractive to the investors.

D. Operation of LSS

By and large, any grid-connected generator shall comply with the requirements of the Malaysian Grid Code (MGC) and the Transmission System Reliability Standard (TSRS). Compliance to the MGC and TSRS is vital to maintain the reliability of the Grid System. The latest MGC, which was revised in June 2015, makes sufficient provisions for the connection of an intermittent power source, termed Power Park Modules [12]. The following subsections provide the detail.

i. Dispatch of LSS

The LSS allowed for connection to the Grid System shall be between 30MW_{ac} and 50MW_{ac}. According to the MGC, any plant with capacity of 50MW and above, including a Power Park Module, shall be treated as a Centrally Dispatch Generating Unit (CDGU) and is expected to perform a number of technical requirements similar to any conventional plant. Below 50MW, the LSS shall be on self-dispatch up to its maximum output but still subject to GSOês discretion in order to maintain the security of the Grid System. In terms of dispatch, the LSS will receive a priority dispatch in which it will be dispatched first to meet the demand.

ii. Grid Requirement

The LSS shall be continuously connected to the Grid System except during a plant outage, transmission outage or system security reasons. To ensure the stability of the Grid System and prevent any power surge caused by a sudden injection of power, the LSS must be able to automatically and manually control the ramp rate and limit the real power delivered to the Grid System. Under emergency situation, the LSS shall be able to operate at reduced load or disconnect from the Grid System as instructed by the GSO.

iii. Telemetry & Weather Data Monitoring

To allow for monitoring of LSS plant output, The LSS shall install telemetry facility to the NLDC SCADA to enable monitoring of site data such as plant data and site weather data. For the same reason, the LSS owner shall install at least one (1) set of pyranometer for every 2MW of plant capacity at the appropriate locations within the site. In addition, at least one (1) set of full weather station shall be installed for every 10MW of plant capacity.

E. Dispatch Forecast

Solar PV generation is weather-dependent. In this respect, to minimize the risks of deviation in generation dispatch, the LSS owner are required to submit the generation forecast to assist Single Buyer and Grid System Operator in the planning, scheduling and grid operation.

Throughout the PPA term, the LSS owner shall submit the following generation profile (in MW) in 15 minutes interval:

i. Long term forecast- annual generation profile to Single Buyer

ii. Medium and short-term forecast- rolling four (4) months ahead, nine (9)-day ahead and day-ahead to Single Buyer

iii. Same day forecast- half-hourly basis for the remaining operation hours of the day to Grid System Operator.

7. CONCLUSION

The primary intention of the Guidelines is to provide necessary information to the prospective LSS developer seeking connection to the Grid System. At the same time, the Guidelines were designed to ensure that the integration of the variable generation source at large-scale does not jeopardize the reliability of the Grid System.

While the Guidelines were formulated after much deliberation, admittedly there are still rooms for improvement. With the emerging trend points toward higher deployment of Large-Scale Solar PV, the future work shall consider the inclusion of nodal pricing to send the right pricing signal to the generators whilst providing a tool to ST to evaluate the bid for capacity that is site-specific in a more transparent manner.

Transmission planning needs to evolve to better accommodate renewable generation. While the deterministic planning is still useful and relevant, it has become increasingly worthwhile to consider risk-based planning for long-term integration of renewable energy targets. Long term planning is subject to a number of uncertainties such as costs of new technology, introduction of a new regulation and other factors beyond the control of a transmission planner. These risks can be better addressed by a risk-based or trade-off scenario planning.

Nevertheless, for now this edition of Guidelines is sufficient to cover all bases to facilitate a smooth integration of Large-Scale Solar PV to the transmission grid.

ACKNOWLEDGEMENT

The authors of this paper would like to sincerely express their gratitude and appreciation to Tenaga Nasional Berhad and Suruhanjaya Tenaga 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 Tenaga Nasional Berhad and Suruhanjaya Tenaga and/or the management and staffs of Tenaga Nasional Berhad and Suruhanjaya Tenaga.

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