Smart Energy, Sustainable Future

DECISION PAPER

PROPOSED MODIFICATIONS TO THE TRANSMISSION CODE

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1 Introduction

1.1. The Transmission Code sets out the rights and obligations of the Transmission Licensee, together with the rights and obligations of users of the Transmission System. The Transmission Code also sets out the technical requirements to be met by those who seek to connect and operate installations on the Transmission System.

2 Proposed modifications to the Transmission Code

2.1. Pursuant to Section 1.6 of the Transmission Code, EMA had sought feedback on the proposed modifications to the Transmission Code to provide clarity and updates to the technical requirements of the Transmission Code relating to solar photovoltaic installations.

2.2. Feedback was received from 3 parties when the consultation closed on 19 May 2017. EMA has carefully considered the feedback and our responses are in Appendix 2.

3 EMA's Decision

3.1. Taking into account the feedback received, EMA has decided to modify the Transmission Code as set out in Appendix 1. The proposed modifications will come into effect on 12 October 2017.

Appendix 1

Proposed Modifications to the Transmission Code

Modification Ref. No.	Clause	Original Text	Modified Text	Reasons
TC/2017/1	6.12.7	Owners of solar photovoltaic installations with an installed capacity of 100 kWac or above at each site/facility which is connected to the grid, shall provide the Power System Operator with the following signals which is sampled and transmitted at 1 minute intervals. Detailed requirement shall be provided by the Power System Operator upon request. • Active Power (gross) at the AC-side of the solar photovoltaic installation.	~~Owners~~ *Connected person* with ~~of~~ solar photovoltaic system of ~~installations with an~~ installed capacity ~~of~~ equal to or exceeding 1MWac ~~100 kWac or above~~ at each site/facility ~~which is connected to the grid~~, shall provide the Power System Operator with the following signals ~~which is~~ sampled and transmitted at 1 minute intervals. ~~Detailed requirement shall be provided by the Power System Operator upon request.~~ • Active Power ~~(gross) at the AC-side of the solar photovoltaic installation.~~ ; and • Solar irradiance. Detailed requirements are stated in Section H4.3.	The proposed modification to the requirement is to reduce the regulatory burden for small solar PV systems with installed capacity below 1MWac. This is because the Power System Operator is now able to have fairly good estimates of the power output of these geographically dispersed small PV systems using solar irradiance measurements from various weather stations. To further improve accuracy of the PV output estimation and ensure good correlation with solar irradiance measurements, Power System Operator will require power output and solar irradiance measurements from the larger Solar PV systems i.e. 1MWac and above. This will enable it to calibrate and fine-tune power output estimations of the smaller PV systems so as to derive the near real-time estimated system total PV power output, and to constantly balance supply and demand of electricity.

Modification Ref. No.	Clause	Original Text	Modified Text	Reasons
TC/2017/2	H4.1	Substation and Switchhouse The status of the following equipment shall be provided: (f) Transformer taps (with the exception of 66/22kV transformers); (g) Solar global irradiance (applicable only to Transmission Licensee) that comply with the following minimum specifications. Transmission Licensee shall seek advice from the Power System Operator on the location of the transmission substation(s) for installation of Solar global irradiance measurement. • Irradiance range: 0 – 2000Wm^{-2}or better • Accuracy of direct output: >90% for clear sky • Directional response (for beam irradiance): +/- 20Wm2 • Response time to reach 95% response: < 30 seconds; and (h) Other quantities, as required.	Substation and Switchhouse ~~The~~ Status of the following equipment shall be provided: (f) Transformer taps (with the exception of 66/22kV transformers); and ~~(g) Solar global irradiance (applicable only to Transmission Licensee) that comply with the following minimum specifications. Transmission Licensee shall seek advice from the Power System Operator on the location of the transmission substation(s) for installation of Solar global irradiance measurement.~~ ~~• Irradiance range: 0 – 2000Wm-2 or better~~ ~~• Accuracy of direct output: >90% for clear sky~~ ~~• Directional response (for beam irradiance): +/- 20Wm2~~ ~~• Response time to reach 95% response: < 30 seconds; and~~ ~~(h)~~(g) Other ~~quantities~~ status, as required.	More appropriate to move H4.1(g) Solar global irradiance measurement requirement to section on 'measurements' in clause H4.1 instead of under 'status of equipment' in clause H4.1 (see TC/2017/3 below).

Modification Ref. No.	Clause	Original Text	Modified Text	Reasons
TC/2017/3	H4.1	Substation and Switchhouse The following measurements shall be provided: (f) Transformer taps (with the exception of 66/22 kV transformers); and (g) Other quantities, as required.	Substation and Switchhouse The following measurements shall be provided: (f) ~~Transformer taps (with the exception of 66/22 kV transformers)~~ Solar global irradiance (applicable only to Transmission Licensee) that comply with the minimum requirements as specified in Section H4.3(b). Transmission Licensee shall consult the Power System Operator on which transmission substation(s) require Solar global irradiance measurement device; and (g) Other ~~quantities~~ measurements, as required.	More appropriate to move H4.1 (g) Solar global irradiance measurement requirement under section on 'measurements' to replace the item (f) Transformer Taps which is already in the 'status' section.

Modification Ref. No.	Clause	Original Text	Modified Text	Reasons
TC/2017/4	H4.3	New section	Solar Photovoltaic System The following measurements shall be provided: (a) Active Power (gross) at the AC-side of the solar photovoltaic system; and (b) Solar irradiance from sensor installed in close proximity to the PV panels. The solar irradiance sensor shall comply with the following minimum specifications: • Irradiance range: 0 – 2000Wm^{-2} or better • Accuracy of direct power output: >90% for clear sky • Directional response (for beam irradiance): +/- 20Wm^{2} • Response time to reach 95% response: <30 seconds	To state measurements from solar photovoltaic system to be provided to the Power System Operator.

Appendix 2

EMA's Response to Public/Industry Feedback EMA's Response to Public/Industry Feedback

Modification Ref. No.	Clause	Public/Industry	Comments	EMA's Response
TC/2017/1 TC/2017/4	6.12.7 H4.3	Sunseap Leasing Pte Ltd	The output of a solar PV system does not only depend on the amount of solar irradiance present. The overall Performance Ratio of a PV system is highly dependent on other factors such as the design of the PV system, losses from shading, temperature, soiling etc. The cost to implement, operate and maintain the real-time Active Power reporting system per Power System Operator's requirements, is already very costly. The additional requirement to install and operate 1-minute irradiance data reporting to the Power System Operator will drive the overall PV system cost up even further. Moreover, there are already many research-grade weather stations deployed island-wide, and the research institutions already possess good capabilities to do PV system output forecasting using the data from these weather stations (most of which have pyranometers/irradiance sensors installed). There will be a duplicating of hardware and effort to analyze the data from these weather stations/irradiance sensors. We strongly suggest the Power System Operator retrieve real-time irradiance data from these existing research-grade weather stations directly, which are already evenly distributed across Singapore.	We note that there are existing weather stations being deployed by certain institutes for specific research projects. The Power System Operator (PSO) has been utilising the solar irradiance measurements from some of these weather stations to assess the feasibility of solar PV output estimation, especially for majority of the geographically dispersed and small solar PV installations, precisely to avoid imposing cost of reporting Active Power to PSO for these smaller solar PV installations. While there are promising results, there are insufficient numbers of weather stations to provide good coverage, and those from the Institutions may not be available in the longer term once they completed their research. In order to improve accuracy of the PV output estimation, PSO requires the PV power output and solar irradiance measurements from the larger solar PV systems (i.e. 1MWac and above) for better correlation and fine-tuning of the system-wide solar PV power output estimations. (For reference, in Germany, the requirement is for all solar installations with capacity of 30kWac & above.) This would further improve the accuracy for the real-time estimated total PV power output essential for balancing electricity supply and demand in real-time by the system operator. To minimise duplication of communication infrastructure, solar PV owners (of 1MWac and above) could leverage on the existing PV (Active Power data) communication system for sending of Solar Irradiance data.

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TC/2017/1	6.12.7	Energetix	Increasing the system capacity threshold that requires PSO reporting from 100kWac to 1MWac is a good idea, which the solar industry welcomes. However, the reporting requirement is still onerous for many systems that comprise multiple sub-systems with individual feed-in points, if each feed-in point needs its own set of meters. These meters are expensive. Three common reasons for multiple feed-in points on a building: 1) Economic: to reduce cabling costs, installers always seek to connect to the closest DB. Longer distances mean not only longer cables but also bigger diameter to contain I^2R losses. In an existing building it can also be very costly to lay trunking from one end to the other. 2) Capacity constraints: a 1MWac system at 3-phase 400V needs a 2'000A isolator, which is often not available. We typically have to split into 2 x 1'000A. 3) Load balance: many large buildings have two incoming supplies. To maximise self-consumption and minimise exports, we must split the PV between the two points in relation to the demand drawn from each.	By having only one meter installed at the largest subsystem, the reading send to PSO may not accurately represent the power output of the entire solar PV system, especially when shading happens at some of the subsystems. However, we are open to the suggestion (only install a single set of meters on the largest subsystem of any installation >1MWac, and the PV owner scales the readings according to total system size), provided it can be demonstrated that the arrangement can achieve the required accuracy of direct power output of >90% for the entire PV system at all time.

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			Thus it is very rare to escape with a single feed-in point for a 1MW+ system. We propose a practical solution, to install a single set of PSO meters on only the largest subsystem of any installation >1MWac, and scale the readings according to total system size. The difference between a scaled reading and a multi-metered reading is trivial, but the cost saving is significant, especially for smaller sub-systems.	
TC/2017/4	H4.3	Energetix	This looks only half-baked. The irradiance sensor is poorly specified, which risks leading to only partly useful information for PSO. It should specify installation orientation, location and maintenance: • Orientation should be horizontal and not plane-of-array or any other orientation. Otherwise data cannot be meaningfully compared between sites. • Location should maximise exposure to sunlight, avoiding any shade between the hours of 08:00 and 18:00 if possible. • Maintenance: the sensor should be cleaned at least every 6 months.	Thank you for your "Fully Baked" specifications. We will review separately your expert view on installation orientation, location, calibration and maintenance of irradiance sensors. However, we understand that solar irradiance sensor with irradiance range of 0-2000 W/m² is more commonly available in the market as compared to irradiance range of 0-1500 W/m². Specifying an irradiance range of 0-1500 W/m² will thus reduce the sensors available for installation owners to choose from. As such, we will continue to adopt an irradiance range of 0-2000 W/m².

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			How does PSO plan to ensure recalibration and minimise missing data? Relevant standards specify recalibration every 24 months, which requires sending the sensor to a certified lab, and results in missing data for several weeks. Why specify irradiance range of 0-2'000W/m² or better (presumably this means or greater)? The wider the range, the greater the percentage inaccuracies at lower irradiance levels that prevail in Singapore. Our weighted average daytime irradiance is around 300W/m², and the peak seldom reaches 1'400W/m². Better therefore to specify a range of 0-1'500W/m². But PSO will get more reliable data by delegating the installation, monitoring and maintenance of a network of irradiance sensors to a qualified single organisation, eg SERIS, who already operate >25 such sites around Singapore, in a synchronised network. They also make sure to recalibrate their sensors within every 24 months, per relevant standards.	
TC/2017/1 TC/2017/2 TC/2017/3 TC/2017/4	6.12.7 H4.1 H4.3	SP Group (SP) on behalf of SP PowerAssets Ltd	<u>Existing threshold of 100kWac should be maintained or lowered for system reliability and network security</u> The requirement for owners of solar PV system with an installed capacity of 100 kWac and above to provide signals to PSO was introduced on 12 Aug 2015. EMA has indicated, at the time of introduction of this requirement, that this information is required to monitor the power	The solar output estimation model is now able to have fairly good estimation of the solar PV output of these geographically dispersed small solar systems using solar irradiance measurements. As such, we are able to remove the requirement to provide active power data for small (below 1MWac) solar PV systems. Only solar PV system with an installed capacity of 1MWac and above will be required to provide Active Power

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			output to ensure that there is sufficient reserve capacity available in the system to respond to sudden fluctuations in solar PV output to maintain system reliability and security. In this consultation paper, EMA has not indicated that the monitoring of solar PV system with an installed capacity of 100 kWac and above is no longer required. Instead, EMA is suggesting the use of estimates (i.e. solar irradiance measurements from various weather stations) instead of actual data to monitor the power output of the smaller solar system i.e. 100 kWac to less than 1 MWac. Based on the consultation paper, it seems that the change is on the premise that the smaller PV systems will be geographically dispersed evenly. The requirement to provide signal of power output of PV should be retained at 100 KWac or further lowered to better enhance the capability of PSO and/or SPPA to maintain system reliability and security. With PV proliferation, many small PVs are expected to grow at the distribution level and become a sizable portion of generation capacity in the future. Currently, approximately 54% of the PVs installed in Singapore are < 100kWac. In the future, considering available residential rooftop	output and Solar Irradiance to PSO. This also reduce the regulatory burden to the connected person. As for SP's need of (1) PV power output and solar irradiance data to optimise network utilisation and (2) intervention to maintain grid stability in times of emergencies, we understand that SP will conduct a comprehensive study on its proposal to implement the monitoring and controlling of PVs at distribution level. We will separately work with SP on the study. With regard to SP's comment on alignment with "causer pay" principle, SP may wish to refer to the latest consultation paper by EMA on "Enhancements to the Regulatory Framework for Intermittent Generation", and submit your comments.

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			space, many of these PVs could be less than 100 kWac individually. Notwithstanding the increased intermittency, growing concentration of PV systems at the distribution level can cause localized over voltage situation. Therefore, there is a need to continuing monitoring PVs and in emergencies allow SPPA to intervene and influence PV operations. It is also prudent to impose these requirements now in order to develop a robust system for the future. EMA has stated that this change will lower the regulatory burden of small PV systems but has not elaborated on the details on the regulatory burden EMA is attempting to lower. If the regulatory burden relates to the cost of providing the information to PSO, we believe that this can be reduced via leveraging on technology instead of removing the requirement. <u>Need of PV power output and solar irradiance data to optimise network utilisation</u> SPPA should be granted access to the data for monitoring purposes. Real-time data can assist in planning to optimise utilization of network and PV connections whilst maintaining network stability. As such, we would like to propose that the Transmission Code be amended for the information to be sent to both PSO and SPPA.	

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			<u>Need of intervention to maintain grid stability in times of emergencies</u> PVs are currently required to automatically disconnect when frequency or voltage fluctuates beyond a prescribed band. A disturbance in the grid may disconnect multiple PVs. The simultaneous disconnection of multiple PVs can compound grid instability issues particularly when PVs share of generation is large. In response to this potential network disruption, Germany has allowed the grid operator to remotely limit power output of the PVs to maintain the grid stability. Similarly, SPPA as the national grid operator, should be delegated capability to tune down PV output to help stabilise the grid. In emergencies, the SPPA should have the ability to intervene and disconnect PVs. SPPA would like to work with EMA to develop a solution to encourage PVs deployment whilst maintaining grid stability, and for SPPA to actively manage the distribution network. <u>Alignment to "Causer Pay" Principle</u> The alignment of the causer pay principle and equitable cost allocation should be considered	

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			even as EMA and the electricity industry go about fine tuning the Transmission Code and industry practises. SPPA notes that network reinforcements (if any) arising from PVs are currently not paid by PV owners but by all remaining non-PV network consumers. SPPA submits that in situation of controlling output during instabilities or emergencies, the cost of instability should be placed on PVs.	