ENHANCEMENTS TO THE REGULATORY FRAMEWORK FOR INTERMITTENT GENERATION SOURCES IN THE NATIONAL ELECTRICITY MARKET OF SINGAPORE

FINAL DETERMINATION PAPER

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FINAL DETERMINATION PAPER

1. Executive Summary

1.1. The Energy Market Authority ("EMA") embarked on a public consultation exercise on 28 October 2013 – 28 January 2014, to seek feedback on enhancements to the regulatory framework for Intermittent Generation Sources ("IGS").

1.2. IGS typically comprises of renewable generation such as solar and wind energy, where the power output is intermittent and cannot be controlled because it is dependent on the weather and environmental factors. Based on current technologies, solar generation offers the greatest deployment potential in Singapore. Solar energy also brings about multiple benefits. It is clean, generates no emissions and requires no fuel imports. Solar generation also takes place during the day, which coincides with the system peak demand in Singapore.

1.3. After careful consideration of the feedback received from solar industry players, electricity market licensees, companies and the public, the EMA is implementing the following key enhancements set out in this determination paper:

1.3.1. Clarified the licensing requirements for IGS;

1.3.2. Simplified the commissioning procedures for solar PV installations to connect to the grid, while ensuring safety;

1.3.3. Streamlined market participation and settlement to make it easier for IGS to receive payments for excess electricity exported into the grid; and

1.3.4. Streamlined the monitoring requirements for IGS.

1.4. It is also important to recognise the characteristics of IGS and its effects on the power system. For example, IGS output is intermittent as it fluctuates based on weather conditions, cloud cover and shadows. To manage the effects of intermittency, the EMA will adopt a "dynamic pathway" framework to ensure that there is sufficient reserves (or back-up) capacity in tandem with the growth in IGS capacity. There will be a further study on the reserves charging mechanism to recognise the intermittent nature of IGS, as there are trade-offs which need to be carefully considered. To this end, EMA will issue a second public consultation paper in Q4 2014 to seek industry feedback on the framework.

1.5. Moving forward, the EMA will continue to review the rules in consultation with stakeholders to ensure that the regulatory framework remains relevant as technologies and business models evolve.

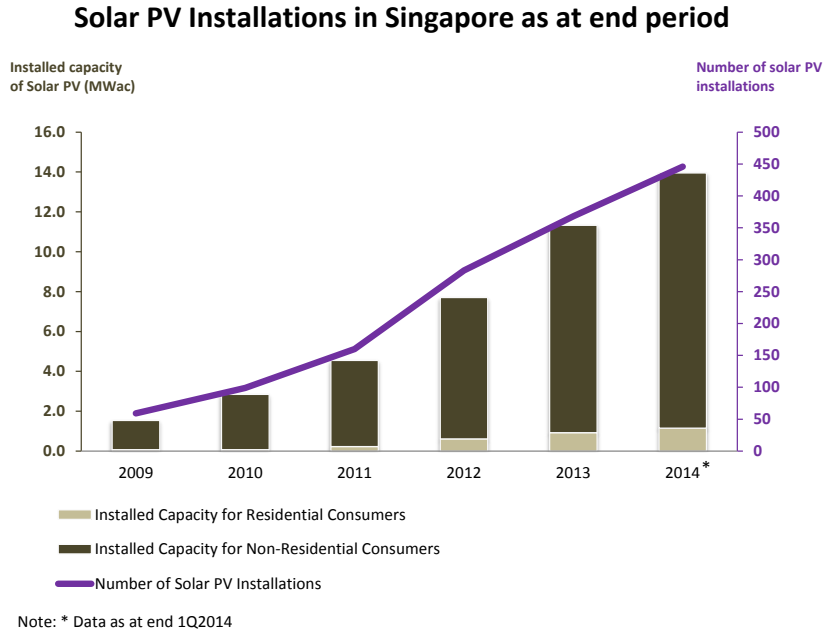
2. Background

2.1. An Intermittent Generation Source ("IGS") is defined as any source of energy that is non-dispatchable in the National Electricity Market of Singapore ("NEMS") because the power output cannot be controlled or varied at will. Examples of IGS include renewable sources of energy ("renewables") such as solar energy and wind energy[1].

2.2. Given Singapore's geophysical landscape, not all renewables can be harnessed for energy production. Of all the renewable options, solar energy has the greatest potential for Singapore. Solar generation also presents multiple benefits to Singapore's energy system. First, solar generation generates no emissions, thereby enhancing Singapore's environmental sustainability. Second, solar generation reduces our reliance on fuel imports. Third, solar generation occurs during the day, which coincides with the system peak demand in Singapore. This can in turn enhance Singapore's energy price competitiveness.

2.3. As of Q1 2014, the total grid-connected installed capacity of solar photovoltaic ("PV") is approximately 14 MWac. About 90% of the total solar PV installed capacity was installed by commercial and industrial consumers, while the remaining were installed on residential premises. Figure 1 shows the growth of the solar PV capacity in Singapore since 2009.

Figure 1: Trend in Solar PV Installations in Singapore from 2009 – Q1 2014[2]



[1] IGS integrated with technological solutions such as energy storage will no longer be classified as intermittent if they are dispatchable.

[2] An assumed conversion factor of 0.77 is used to convert solar PV capacity data from MWp to MWac.

2.4. On 28 October 2013, the EMA issued a consultation paper on the EMA's review of the regulatory framework for IGS, with the objective of maximising its potential when the technologies are commercially viable, while ensuring system security and stability. Through the consultation process, we received valuable inputs and suggestions from industry players and the public. In addition to the formal consultation process, the industry also presented the EMA with feedback from actual deployment cases.

3. Feedback from the Public Consultation Paper

Recap of the Consultation Paper

3.1. In the consultation paper, the EMA sought to identify and address the potential issues that an intermittent generator may face. This includes providing clarity on the licensing framework, the installation procedures as well as the electricity market participation and settlement process. In addition, the EMA had consulted on streamlining the market registration procedures to make it easier for consumers with small embedded IGS to be paid for excess energy injected into the grid.

3.2. The EMA also consulted on a "dynamic pathway" framework to facilitate the entry of IGS by having sufficient reserves to manage the intermittency of these sources, subject to the physical and technical limits of reserves availability in the power system. It involved the setting of two thresholds: the Intermittent Generation Threshold ("IGT") and the Intermittent Generation Limit ("IGL"). The IGT is the amount of IGS the system can accommodate based on the existing amount of reserves, which the EMA raised from 350 MWac to 600 MWac in October 2013. The IGL is the maximum IGS capacity based on the largest possible amount of available reserves in the system.

3.3. The consultation paper suggested having a reserves charging methodology to manage the intermittency effects of IGS. This is to ensure system security and stability as IGS deployment grows. The paper also explored the possibility of implementing an enhanced Demand Response ("DR") scheme for solar generation.

Summary of Feedback Received

3.4. The EMA's consultation closed on 28 January 2014 and 19 parties provided responses to the consultation paper (see Table 2). The respondents' feedback and the EMA's corresponding responses are detailed in the document titled "Response to Feedback on 'The Enhancements to the Regulatory Framework for Intermittent Generation Sources in the National Electricity Market of Singapore'" set out in Annex 1.

Table 2: List of Parties who have Responded to the EMA's Consultation Paper

Stakeholder Group	Parties that have responded
Solar Industry	• Joint submission by Sunseap, Ecosysinfra and YL Integrated • PV World • Singapore Electrical Contractors and Licensed Electrical Workers Associations ("SECA") • SolarGY • SunEdison • Sustainable Energy Association of Singapore ("SEAS")
Licensees	• CPvT Energy • Energy Market Company ("EMC")

	• Keppel Melimau Cogen • PacificLight • PowerSeraya • Senoko Energy • SP PowerGrid ("SPPG") • Tuas Power
Others	• Wartsila Singapore • Public (in personal capacity): Mr Ivan & Mr Dennis Gay

3.5. The solar industry recognised the importance of maintaining grid stability as solar deployment increases, and expressed support for the "dynamic pathway" approach (instead of a hard cap) to manage intermittency by procuring sufficient reserves in tandem with the growth of IGS capacity. On the pricing mechanism framework, the solar industry provided feedback that it should be kept simple to provide greater certainty over the cost factors for solar investments. In addition, as IGS output is inherently uncontrollable, it is difficult to implement the enhanced DR scheme using solar PV. Conventional generators have also raised concerns that the enhanced DR scheme could lead to an unlevel playing field.

3.6. On market participation process, the solar industry highlighted that it can be onerous for some contestable consumers with solar installations. For instance, the current market registration forms are geared towards conventional generation, and many of the details required are not relevant to solar PV installations.

3.7. On market settlement, the EMA received feedback that the default 'gross settlement' arrangement for solar generation participating in the market can result in price differences between the payment received for gross generation and the price paid to the consumer's retailer for gross consumption at the same premise. While alternative arrangements are available to address this, such measures are often not feasible given the typical profile and set-up of consumers with solar PV generation.

3.8. The EMA has taken into consideration all the views received. This determination paper covers key aspects of IGS deployment in Singapore, based on the proposals in the October 2013 consultation paper and further feedback from stakeholders. These include licensing, commissioning procedures, market participation and settlement, the dynamic pathway approach for IGS, monitoring requirements, as well as clarifications on metering requirements and grid charges for premises with IGS. More details are available in the subsequent sections.

4. Licensing Framework for Intermittent Generation Sources

4.1. This section clarifies the definition of the licensing threshold and requirements for IGS.

Licensing Framework

4.2. Under the current regulatory framework, any person who engages in the generation of electricity by means of a generating unit with a *name-plate rating of 1 MW or more but less than 10 MW,* and is connected to the power system, is required to hold a **wholesaler (generation) licence**. Any person who engages in the generation of electricity by means of a generating unit with a *name-plate rating of 10 MW or more*, is required to hold a **generation licence**. While the definition of "name-plate rating" is clear for conventional generation, the EMA has received feedback that the definition is less clear for some IGS technologies (e.g. solar PV) that have two capacity ratings– the Direct Current ("DC") and the Alternating Current ("AC") capacities.

4.3. Consistent with how the EMA treats conventional generation sources, the **aggregated AC capacity of IGS at the point of connection[3] to the grid** will be used to determine the threshold for licensing requirements. For solar PV systems, the **aggregated AC capacity of the inverters will be used**. In this paper's context, all references to 'IGS (installed) capacity' refer to the aggregate capacity at the AC inverters (i.e. MWac).

4.4. To link the definition of nameplate capacity to the licensing framework for electricity generation, if the aggregated AC capacity of the IGS at the point of connection is 1 MWac or more but less than 10 MWac, the **owner**[4] of the system will need to apply for a wholesaler (generation) licence from the EMA. If the aggregated AC capacity of the IGS at the point of connection is 10 MWac or more, the owner of the system will need to apply for a generation licence from the EMA. A summary of the licensing requirements is shown in Table 3.

[3] The point of connection refers to the point at which the AC output of the IGS facility is connected directly or indirectly to SP PowerAsset's ("SPPA") substation.

[4] In the case of a solar leasing model, the solar leasor will be deemed as the owner of the system.

Table 3: Summary of Licensing Requirements for Intermittent Generators

IGS (Installed) Capacity	Connected to the Power Grid?	Type of Licence[5]
Below 1 MWac	Yes	Exempted
	No	
1 MWac or more but less than 10 MWac	Yes	Wholesaler (Generation) Licence
	No	Exempted
10 MWac or more	Yes	Generation Licence
	No	

4.5. The EMA has received queries from the industry on whether there is a need for an electricity retail licence for intermittent generators who are interested to sell electricity to contestable consumers who are not located in the same premise. A retail licence is required in such cases.

[5] An Electrical Installation Licence is still required for the connection of all IGS.

5. Commissioning Procedures

5.1. This section highlights the streamlining of commissioning procedures for solar PV installations.

Streamlining of Commissioning Procedures for Solar PV Installations

5.2. Prior to the connection and operation of any IGS parallel to the grid, the Licensed Electrical Worker ("LEW") appointed by the owner is required to consult SPPG on the connection scheme and the relevant technical requirements. After SPPG verifies that all the technical requirements have been met, SPPG will proceed to "Turn On" the solar PV system and connect it to the grid.

5.3. The solar industry has provided specific feedback on the commissioning procedures:

5.3.1. From the initial consultation with SPPG to the final "Turn On", the process can take a substantive period of time; and

5.3.2. In some cases, the imposition of additional technical requirements for safety reasons, e.g. provision of external circuit breakers or inter-trip mechanisms for the solar PV installations, drive up costs and prolong the commissioning process. The industry players have asked if it is necessary for SPPG to impose the additional requirements.

5.4. The EMA has set up a joint Taskforce with SPPG to **review and enhance the existing commissioning procedures** for solar PV installations. The Taskforce will:

5.4.1. **Streamline the existing commissioning procedure** for solar PV installations.

5.4.2. **Review and update the existing technical requirements** for solar PV installations, to ensure the safety and quality of electricity supply.

5.5. For a start, the EMA has worked with SPPG to review the 'built-in' safety mechanisms within the inverters installed at solar PV installations. We have assessed that **where the 'built-in' safety mechanisms can meet the requisite standards, additional safety mechanisms will not be required**. We have also **reduced the commissioning procedures for solar PV installations from 27 working days to 7 working days, if all technical requirements are met**. The industry can contact the Taskforce through the EMA or SPPG to provide further feedback on streamlining the commissioning process.

5.6. The EMA has also received feedback that glare from solar PV panels could cause dis-amenities to neighbours and the surrounding environment. In Singapore's compact living environment, it is important to ensure that deployment of solar panels is done

properly without adversely affecting other residents. The EMA will monitor this issue and work with the relevant agencies to address the concerns.

Solar PV Registry

5.7. As part of the commissioning procedures, the LEWs appointed by solar PV owners are required to submit installation details, such as the name-plate capacity and installation location to SPPG. All details collected will be recorded in a **Solar PV Registry** maintained by SPPG. This is important for tracking the aggregate amount of solar installations and their corresponding locations for the purpose of ensuring power system stability, both at the localised level as well as the system level (refer to Section 7 on The "Dynamic Pathway" Approach for more details). LEWs will be **required to inform SPPG before they disconnect or retrofit any grid-connected solar PV systems**. This ensures that information in the Registry is up-to-date.

6. Market Participation and Market Settlement

6.1. This section sets out the enhanced market participation and settlement arrangements for (a) consumers with embedded IGS, and (b) standalone IGS. Embedded IGS refers to IGS generation installed principally to offset on-site consumption. Standalone IGS refers to IGS generation installed solely for selling electricity into the market.

Embedded IGS – Contestable Consumers ("CCs")

6.2. Streamlining the Market Registration Process

6.2.1. At present, CCs with embedded IGS are required to register with EMC as a market participant to receive payments for excess electricity sold into the grid.

6.2.2. However, the solar industry has provided feedback that this market registration process is an onerous requirement for consumers to receive payments for the relatively small amounts of excess electricity that they sell into the grid.

6.2.3. To address this concern, the EMA intends to streamline the market registration process for CCs with embedded IGS:

a) CCs with embedded IGS less than 1 MWac can choose not to register directly with EMC to be paid for excess electricity sold back to the grid. The EMA will introduce a new scheme to allow such consumers to **be paid the prevailing pool price through SPS as the central payment intermediary**[6]. Hence, they need not undergo the full market registration and participation process with EMC. This will be implemented in **Q1 2015** after the relevant system changes have been made.

b) CCs with embedded IGS that are 1 MWac and above will still be required to register directly with EMC to be paid for excess electricity sold back to the grid. For this group of consumers, the EMA has **streamlined the market registration procedures with immediate effect.** For example, the PSO data form has been reduced from 30 pages to 2 pages (refer to Annex 2). This will be implemented with immediate effect.

6.3. Allowing 'Net Settlement' for IGS

6.3.1. On market settlement, currently CCs receive payment for the **gross generation** from IGS, based on the prevailing nodal prices in each half hour period. At the same time, they also pay for the **gross consumption** of electricity. This is termed **'gross settlement'.** For a consumer buying electricity from a retailer, this can at times result

[6] SPS will act as a central intermediary, by aggregating output from IGS and registering them with EMC as a Pseudo Generator. SPS will pass through the payments from (and also charges by) EMC directly to the CCs.

in price differences between the price paid for gross consumption and the payments received for gross generation.

6.3.2. While 'gross settlement' is the default arrangement, there are existing mechanisms in place for CCs to effect 'net settlement'[7]. The mechanisms are:

a) **Price Neutralisation**[8]. For CCs with embedded IGS buying and selling electricity directly from the pool, they can enjoy 'net settlement' by way of price neutralisation and net treatment of non-reserves charges[9].

b) **Commercial arrangement with retailers**. For CCs with retail contracts, they can make commercial arrangements with their retailers to enjoy price neutralisation. This means that these consumers will be only charged for the net withdrawal from the grid, and/or receive payment for net injection into the grid.

c) **'Pseudo metering' arrangement**. CCs can work with SPS to use 'pseudo metering' to effect 'net settlement'. This is a back-end IT change and can be implemented if certain technical conditions are met. However, consumers cannot receive payment for excess electricity injected into the grid under this arrangement.

6.3.3. However, it may not be feasible for such consumers to make arrangements to effect net settlement for the energy component, particularly if they are small and already have existing retail contracts. First, small consumers are unlikely to buy electricity directly from the pool. Second, they may already have existing retail contracts and the retailers may not agree to alter the terms of their existing retail contracts to effect 'net settlement'. Third, such consumers may not meet the technical requirements to qualify for 'pseudo metering' arrangements.

6.3.4. To help these consumers, the **EMA will allow 'net settlement' for the energy component for IGS.** This is a reasonable approach since the output from IGS is not controllable.

6.3.5. The policy change is targeted at CCs with embedded IGS because NCCs already enjoy 'net settlement'; and 'net settlement' is not applicable to standalone IGS as they export all the electricity produced to the grid.

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[7] 'Net Settlement' means that consumers are either charged for their net consumption or paid for their net generation within each trading period.

[8] Price neutralisation refers to the equalisation of price differential between the electricity injection and withdrawal nodes using a credit/debit factor. The purpose is to allow embedded generators that generate electricity for its consumption to offset generation against their associated load, so that only excess generation at each node is paid at the respective energy price, or excess load is charged at (Uniform Singapore Energy Price ("USEP") + Hourly Energy Uplift Charge ("HEUC")) in the energy settlement.

[9] Non-reserves charges refer to the EMC fees, Power System Operator ("PSO") fees, Monthly Energy Uplift Charge ("MEUC") and Market Support Services ("MSS") fees.

6.3.6. Net settlement for energy component will be applied to all CCs with embedded IGS regardless of size and whether it registers through SPS or directly with EMC as a market participant. The 'net settlement' arrangement is not reversible, i.e. an IGS cannot opt out of this arrangement. For clarity, 'net settlement' will only apply to embedded IGS located within the same premise as the load (i.e. behind the same point of connection to the grid).

6.3.7. 'Net settlement' for IGS will be done within each half-hourly trading interval, on the basis that the value of the energy generated and consumed within each trading period is equivalent. CCs with embedded IGS will be charged or paid based on either:

a) **Net withdrawal** of electricity, when the total consumption exceeds generation from the embedded IGS in any half-hour period. For example, if total consumption is 100 kWh and IGS generation is 40 kWh, the consumer will be charged for a consumption of 60 kWh; or

b) **Net injection** of electricity, when the total generation from the embedded IGS exceeds on-site consumption in any half-hour period. For example, if total consumption is 50 kWh, and IGS generation is 90 kWh, the consumer will receive payment for 40 kWh.

6.3.8. 'Net settlement' of the energy component for all CCs with embedded IGS will be implemented in **Q1 2015**, after the relevant system changes have been made.

Embedded IGS – Non-Contestable Consumers ("NCCs")

6.4. NCCs with embedded IGS less than 1 MWac connected at the Low-Tension ("LT") **will continue to enjoy the "Simplified Credit Treatment".** Under this arrangement, such NCCs will be paid the energy component through SPS for export of excess electricity into the grid. The payment to such consumers is by way of a credit adjustment in their electricity bills, which essentially allows them to enjoy '**net settlement'** for their energy consumption. Such consumers are not required to register with EMC to receive payment.

6.5. Similarly, NCCs with embedded IGS less than 1 MWac connected at the High-Tension ("HT") and above will also be allowed the "Simplified Credit Treatment". This will be implemented at a later stage after SPS has made the necessary system changes.[10]

6.6. If a NCC installs an embedded IGS of 1 MWac and above (regardless of tension level the IGS is connected at), he will be required to register with EMC, consistent with existing market participation thresholds. These consumers will not be entitled to the "Simplified Credit Treatment", as the embedded IGS will be paid prevailing nodal prices for excess electricity sold into the grid. The EMA will implement 'net settlement'

[10] As an interim measure, such NCCs are required to register with EMC as a market participant to receive payment for their export.

for these NCCs, consistent with the treatment for CCs. This will take effect after SPS has made the necessary changes to its IT system.

Standalone IGS

6.7. Standalone IGS refers to those installations that do not offset internal load and inject all electricity generated into the grid. An example is a solar farm, which produces and sells electricity to other consumers by injecting all its output into the grid. We currently do not have such installations in Singapore.

6.8. Similar to other commercial generators, a standalone IGS will be required to register with EMC as a market participant to be paid the prevailing nodal price for the electricity sold back to the grid, less the applicable market charges.

Summary of Market Participation & Settlement for IGS

6.9. Tables 4 (a) and (b) summarise the key enhancements to the market participation and settlement for IGS. The detailed payment methodology for export and other applicable charges, including the numerical examples for illustration are explained in Annex 3. In addition, Annex 4 clarifies the required metering set-up and the applicable grid charges.

No Dispatch and Offer Submission Requirements for all IGS

6.10. The EMA recognises that the output of IGS is dependent on weather conditions and is non-controllable. Therefore, **all IGS will not be required to submit half-hourly offers and they will not be subject to dispatch by PSO**.

6.11. Instead, PSO will centrally forecast the aggregate output of all IGS in the system. The forecasted output of all IGS will be subtracted off the total system forecast demand. This lowers the forecasted system demand, and is analogous to incorporating the forecasted output as generation offered into the market. This method of centralised forecasting has the advantage of allowing the PSO to have a better overview of the aggregate output for the purpose of ensuring system security; as compared to individual IGS installations submitting output forecasts into the market (refer to Section 8 on PSO Monitoring Requirements for more details).

*Table 4(a): Summary of Enhancements to Market Participation & Settlement for **CCs** with Embedded IGS (enhancements in blue font)*

Tension Level	IGS capacity	Current Regime for CCs	Enhanced Regime for CCs
MARKET PARTICIPATION			
Low-Tension, and High-Tension and above	**Less than 1 MWac**	• Via registration with EMC as market participant	• **Via registration with SPS under Central Payment Intermediary Scheme; or** • Existing option to register with EMC as market participant remains (no change)
	Above 1 MWac	• Via registration with EMC as market participant	• Via registration with EMC as market participant (no change)
MARKET SETTLEMENT			
Low-Tension, and High-Tension and above	**Less than 1 MWac**	• Gross Settlement of the energy component; • Paid prevailing nodal price via EMC for export	• **Net Settlement of the energy component;** • **Paid prevailing pool price through SPS for export**
	Above 1 MWac	• Gross Settlement of the energy component; • Paid prevailing nodal price via EMC for export	• **Net Settlement of the energy component;** • Paid prevailing nodal price via EMC for export (no change)

*Table 4(b): Summary of Enhancements to Market Participation & Settlement for **NCCs** with Embedded IGS (enhancements in blue font)*

Tension Level	Capacity of IGS	Current Regime for NCCs	Enhanced Regime for NCCs
MARKET PARTICIPATION			
Low-Tension	**Less than 1 MWac**	• Via registration with SPS under "Simplified Credit Scheme"	• Via registration with SPS under "Simplified Credit Scheme" (no change)
	Above 1 MWac	• Via registration with EMC as market participant	• Via registration with EMC as market participant (no change)
High-Tension and Above	**Less than 1 MWac**	• Via registration with EMC as market participant	• **Via registration with SPS under "Simplified Credit Scheme"** *(to be implemented at later stage after SPS has made the necessary system changes)*
	Above 1 MWac	• Via registration with EMC as market participant	• Via registration with EMC as market participant (no change)
MARKET SETTLEMENT			
Low-Tension	**Less than 1 MWac**	• Net Settlement of the energy component; • Paid energy component of the tariff for export	• Net Settlement of the energy component (no change); • Paid energy component of the tariff for export (no change)
	Above 1 MWac	• Gross Settlement of the energy component; • Paid prevailing nodal price for export	• **Net Settlement of the energy component;** *(to be implemented at later stage after SPS has made the necessary system changes)* • Paid prevailing nodal price for export (no change)
High-Tension and Above	**Less than 1 MWac**	• Gross Settlement of the energy component; • Paid prevailing nodal price for export	• **Net Settlement of the energy component;** *(to be implemented at later stage after SPS has made the necessary system changes)* • **Paid energy component of the tariff for export** (to be implemented at later stage after SPS has made the necessary system changes)
	Above 1 MWac	• Gross Settlement of the energy component; • Paid prevailing nodal price for export	• **Net Settlement of the energy component;** *(to be implemented at later stage after SPS has made the necessary system changes)* • Paid prevailing nodal price for export (no change)

7. The "Dynamic Pathway" Approach

7.1. This section elaborates on the "dynamic pathway" approach proposed by the EMA, as well as the EMA's considerations on the pricing mechanisms to account for the intermittency and benefits brought about by IGS. This section also highlights the possible limitations of IGS deployment at the transmission and distribution level.

The "Dynamic Pathway" Approach

7.2. Given the intermittent nature of IGS, both regulation and spinning reserves are required to ensure system stability. For example, cloud cover or shadows may cause solar PV output to drop quickly, which requires the need for regulation and/or spinning reserves to make up for the shortfall. Without the corresponding reserves capacity as back-up, consumers are exposed to the risk of power disruptions and blackouts, which has happened in other countries with large amounts of intermittent sources.

7.3. In the consultation paper, the EMA considered two possible approaches to address the challenges of intermittency. First, a hard cap can be imposed on the total amount of IGS allowed in Singapore. This approach is straightforward but it will restrict the growth potential of IGS. Hence, the EMA's recommendation is to adopt the "**dynamic pathway" approach**, which is to manage intermittency by procuring sufficient reserves in tandem with the growth of IGS capacity. While this will still be subject to the physical/technical limit of reserves availability in the whole system, the "dynamic pathway" approach is more sustainable and allows for greater flexibility than a hard cap. It is also more equitable, as appropriate system costs can be shared amongst different generation sources.

7.4. During the consultation, respondents agreed that it was important to maintain grid stability as the deployment of IGS increases in Singapore. In addition, there was support for the EMA's proposal to move from a hard cap to the "dynamic pathway" approach, which consists of two thresholds illustrated in Figure 5. This also forms the broad construct for the mechanism to allocate reserves charges to manage intermittency, which will undergo further study and review.

7.5. **Intermittent Generation Threshold ("IGT")**

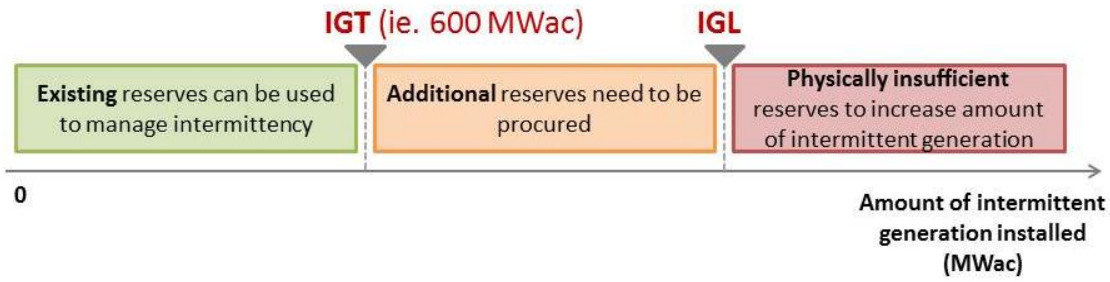
7.5.1. The first threshold is the **IGT** which is the amount of IGS that the system can accommodate based on the existing amount of reserves. This has been raised from 350 MWac to 600 MWac in October 2013. The IGT will be regularly reviewed, and could be further increased in future when there are enhancements in solar forecasting and methods to increase the amount of reserves available to Singapore's power system.

7.6. **Intermittent Generation Limit ("IGL")**

7.6.1. The second threshold is the **IGL** which is the total amount of IGS that the power system can support, based on the total amount of reserves capacity that can be called upon at any point in time. As there is a limit on the amount of reserves that can

be procured (given the total size of all the relevant facilities in the system that can provide reserves), the IGL will eventually be reached, where no further IGS capacity can be accommodated in the system. To go beyond the IGL, we will need to implement measures such as grid-level energy storage and increased interconnection with regional grids as it is not possible to further increase the amount of reserves in Singapore once IGL is reached.

Figure 5. Illustration of the "dynamic pathway" approach, IGT and IGL.



7.7. The EMA is currently reviewing both the IGT and IGL, which depend on factors such as system size, total reserves capacity available in the system and the geographical diversity of IGS.

Pricing Mechanisms for IGS

7.8. The consultation paper had proposed a pricing mechanism to recognise the intermittent nature of IGS, which requires back-up capacity from conventional generators to cater for output fluctuations. It was proposed that the aggregated output of all IGS be modelled as one pseudo generator for the purpose of assigning regulation and spinning reserves costs under the existing "modified runway model"[11]. Before IGT is reached, all intermittent generators will share the cost of reserves procured with other generation sources in the system. Beyond the IGT, more reserves will be required to manage the intermittency from the additional IGS capacity.

7.9. Several options on the allocation of reserve costs are being studied. For example, based on the 'causer-pays' principle, all the additional reserves procured can be charged to the incremental IGS capacity above the IGT. The downside of this approach is that it may deter investments beyond IGT. On the other hand, the costs of the additional reserves procured can be smeared across the entire base of IGS. However, this introduces uncertainty for early IGS entrants as their costs could increase when the total amount of IGS in the system exceeds the IGT. These are some of the challenges and trade-offs which require further study and consultation with stakeholders.

7.10. Besides the allocation of reserve costs, the EMA also explored the use of an enhanced DR scheme to recognise the benefits brought about by IGS. This was considered on the

[11] This model assigns a cost to each scheduled generation facility every half-hour period based on its generation output and its reliability measured by its probability of failure ("POF").

basis that solar energy is produced in the day, which typically coincides with the system peak demand.

7.11. **Assessment of respondents' feedback**

7.11.1. The industry has raised concerns that the proposed reserves charging mechanism may be too complex. The approach of charging reserves cost based on market prices which fluctuate every half-hour creates additional risks and uncertainty over the magnitude of the reserves cost, as investors are unable to predict the potential costs over the typical 20-year to 25-year lifespan of solar installations.

7.11.2. We understand the industry's preference for a pricing mechanism that is simple and can provide greater certainty. At the same time, the EMA needs to ensure that the reserves charging framework is fair to all generators and consumers, including future IGS owners. The EMA will conduct a further study and issue a **second public consultation paper in Q4 2014**, to seek industry feedback on the revised reserves charging framework.

7.11.3. For the enhanced DR scheme, EMA had received feedback from the industry that as IGS output is uncontrollable, it is difficult to implement the enhanced DR scheme using IGS. For example, a solar PV generator cannot respond to higher pool prices by raising its output because it cannot control the amount of electricity it produces. There were also concerns raised by conventional generators that the enhanced DR scheme could lead to an unlevel playing field. After careful consideration of the range of views provided, the **EMA has decided not to proceed with the enhanced DR scheme for IGS**.

Extension of Eligibility to Opt-Out of the Pricing Mechanism for IGS

7.12. The EMA has indicated that the pricing mechanism for IGS will only be applied to non-residential consumers (both CCs and NCCs), as such consumers are in a better position to manage the commercial risks of their investments. In addition, existing non-residential consumers who (a) have an existing embedded IGS installed prior to 1 January 2014; or (b) submit their application to SPPG before 1 January 2014 and with a commissioning date before 1 April 2014, will be given a one-off choice to opt out of the pricing mechanism.

7.13. The EMA has received feedback from the solar industry for the opt-out dates to be extended, as there may be projects in the pipeline that wish to opt-out but are unable to meet the deadline. Taking into further consideration that the pricing mechanism has yet to be finalised, the EMA informed the industry on the 28 March 2014 that the opt-out dates have been extended by 1 year. Specifically, non-residential consumers can choose to opt-out, if they meet the following revised criteria –

a) Installed their embedded IGS **prior to 1 January 2015** *(instead of 1 January 2014)*; **or**

b) Submitted their application to SPPG **before 1 January 2015** *(instead of 1 January 2014)* and with a commissioning date **before 1 April 2015** *(instead of 1 April 2014)*.

7.14. For eligible consumers who have chosen to opt-out, they will be subjected to the pricing mechanism (a) if they retrofit their IGS systems such that re-commissioning by SPPG would be required in the process; or (b) 25 years from the commissioning date of their existing IGS systems, whichever occurs earlier.

Localised Network Limit

7.15. While there are system-wide thresholds comprising the IGT and IGL, localised limits at specific geographical regions may exist. This can be due to the physical constraints of each network ring[12], where there is a limit to the amount of IGS it can support. Therefore, depending on the limit of the network ring in that area, the permissible capacity of IGS installations in each location may differ.

7.16. Parties who wish to invest in IGS should check with the EMA or SPPG on possible network constraints in their preferred locations, before making their investment decisions.

[12] The network ring refers to the connection of substations/nodes to form a network circuit.

8. PSO Monitoring Requirements

8.1. This section highlights the monitoring requirements for IGS with an installed capacity of 100 kWac and above in each premise. For consistency with the nomenclature used for monitoring of generation facilities in the NEMS Market Rules[13], premises with IGS will be termed Intermittent Generation Facilities ("IGFs") in this section.

Rationale

8.2. As mentioned in Section 7 on the "dynamic pathway" approach, one of the main challenges of deploying IGS is that it cannot deliver the desired output of electricity continuously, or as and when required. Changes in weather conditions such as solar irradiance and cloud cover can result in sudden power output fluctuations. In contrast, conventional generators can produce stable and controllable power output under normal operation.

8.3. With the expected increase in uptake of IGS in Singapore, the Power System Operator ("PSO") will need to manage the intermittent nature of such sources to ensure that the security and reliability of the power system is not compromised. For example, a moving cloud can cause a sudden drop in solar output. This means that PSO would need to activate back-up capacity from conventional generators to make up for this shortfall on a real-time basis. Importantly, PSO also needs to ensure that sufficient reserve capacity is available and online, ready to respond to sudden fluctuations in IGS output.

8.4. Hence, there is a need for PSO to implement real-time monitoring of IGFs. Currently, only about 10% of the existing solar PV in Singapore has installed capacities of 100 kWac and above. These solar PV are typically installed on commercial and industrial buildings with large rooftop. For residential consumers who install solar panels on their roofs, the typical size is less than 50 kWac. These consumers will not need to comply with the PSO monitoring requirements.

PSO Monitoring Requirements

8.5. PSO has carried out a review of IGF monitoring requirements, taking reference from Germany, which has one of the largest number of solar PV installations in the world. Even though Germany's solar PV installations are spread over large geographical areas (i.e. greater stability due to larger geographical diversity), it requires solar PV installations with capacity of 30 kWac and above to be centrally monitored.

[13] At present, monitoring requirements for generation facilities in the NEMS Market Rules are categorised into Generation Registered Facilities ("GRFs") and Generation Settlement Facilities ("GSFs").

8.6. Henceforth, PSO shall only require **IGFs with an installed capacity of 100 kWac and above** at each site/facility to provide PSO with the **Active Power** at (a) the point of connection to grid (i.e. service connection), and (b) at the AC-side of the IGF, sampled at **one-minute intervals.** The IGF owner shall transmit the data electronically every minute via secured File Transfer Protocol ("FTP") to PSO. Monitoring requirements for IGFs exceeding 10 MWac in installed capacity will be reviewed in future should there be any such installations.

8.7. Consistent with the regime for existing generators, the cost of setting up and maintaining the relevant infrastructure to fulfil the monitoring requirements will be borne by the IGF owner.

9. Summary of Enhancements

9.1. Taking into consideration all the feedback received from the various stakeholders, the EMA has reviewed and enhanced the regulatory framework for IGS in the NEMS. The enhancements, as summarised in Table 6, seek to maximise the potential of deploying IGS in Singapore, while safeguarding system stability and reliability.

9.2. Moving forward, the EMA will continue to review our rules in consultation with stakeholders, to ensure that the regulatory framework remains relevant as technologies and business models evolve.

Table 6: Summary of Enhancements

Features	Enhancements
Licensing Framework	**The EMA has clarified the licensing framework for IGS.** The aggregated AC capacity of IGS at the point of connection to the grid will be used to determine the threshold for licensing requirements. For solar PV panels, the aggregated AC capacity of the inverters at the point of connection will be used.
Commissioning Procedures	The EMA has **simplified the process for IGS to be connected to the grid**: ▪ The commissioning process for solar PV installations has been reduced from 27 working days to 7 working days. ▪ The EMA and SPPG have assessed that where the 'built-in' safety mechanisms within the inverters installed at solar PV installations can meet the requisite standards, additional safety mechanisms would not be needed. In addition, a Joint Taskforce has been set up to further streamline the commissioning procedures, as well as to review and update the relevant technical requirements.
Market Participation and Market Settlement	The EMA has **made it easier for IGS to receive payment when they export excess electricity into the grid**: ▪ The EMA will implement a new scheme in Q1 2015 to allow CCs with small embedded IGS to receive payment for excess electricity sold into the grid through SPS as the central payment intermediary. Hence, they no longer need to undergo the full market registration process with EMC. ▪ Furthermore, the EMA will allow "net settlement" of the energy component for all CCs and NCCs.
	The EMA recognises output from IGS is dependent on weather conditions and is not controllable. Hence, IGS, regardless of capacity, **will not be required to submit half-hourly price-quantities offer and will not be dispatched by PSO**.

Features	Enhancements
The "Dynamic Pathway" Approach	Instead of a hard cap, the **EMA will adopt a "dynamic pathway" approach to support further growth of IGS in Singapore**. This approach consists of two thresholds – IGT and IGL. The IGT has been raised from 350 MWac to 600 MWac on 28 October 2013. This threshold will be regularly reviewed, and could be further increased in future. The EMA is currently reviewing the IGL. As part of the "dynamic pathway" approach, the EMA intends to implement a reserves charging mechanism to recognise the intermittent nature of IGS. As this is an important issue where the trade-offs have to be carefully considered, the EMA will conduct a further in-depth study and issue a consultation paper in Q4 2014 to seek industry's feedback on the revised mechanism.
Monitoring Requirements	**PSO has reviewed and streamlined the monitoring requirements** - IGS with an installed capacity of 100 kWac and above at each site/facility will only need to provide PSO with Active Power data at one-minute intervals.

ANNEX 1: Response to Feedback

Response to Feedback on

Enhancements to the Regulatory Framework for Intermittent Generation Sources in the National Electricity Market of Singapore

(Attached Separately)

ANNEX 2: Revised PSO Data Form for IGF above 100 kWac

TABLE 15 - INTERMITTENT GENERATION FACILITY (PV) STANDING CAPABILITY DATA				
To be completed by Market Participant (with initial & company stamp on each page)				
Description of Data Submission (New / Revised / Removed):				
Name of Generation Facility:				
Maximum Generation Capacity*:				kW
Voltage Level of Connection Point to Grid:				66000 / 22000 / 6600 / 400 / 230 V
Facility's site address/Postal code:				
Total Internal Load Capacity:				kW
PV module				
Type of PV module:	(Monocrystalline / Polycrystalline / Amorphous / Others, please specify)			
Module Tilt Angle:				degrees
Module Azimuth Angle:				degrees
Drawing Submission			***Reference No***	
1. Detailed single-line drawing of the IGF showing connection arrangement of relevant PVs, numbers of inverters and switches.				
2. Schematic drawing of PV modules and inverters setup indicating total PV modules and total inverters capacity.				
Key Dates of Generation Facility				
Date Generating Facility is expected to synchronise to the power system.				
Date Generating Facility is expected to commence commercial operation.				
To be completed by PSO				
Name of 66/22kV substation connected to IGF:				
AGC B1 – B2 – B3:				
SCADA B1–B2–B3 (PV):				
Default Bus:				
Alternate Default Bus:				
Default Branch:				
SU Type:	*Dependent / Independent*			
Mapping Protocol:	*Include / Replace*			
Additional Information:				

*Maximum Generation Capacity (total installed capacity within the site) for Photovoltaic (PV) refers to the aggregated inverter capacity (AC) of each point of connection to the grid.

ANNEX 3: Clarifications on Market Settlement for IGS

1. This section clarifies the market settlement for CCs with IGS and standalone IGS.

Market Settlement for CCs with IGS

2. Table 7 provides an overview of the market settlement for CCs with IGS.

Table 7. Market settlement for CCs with Embedded IGS

Applicable Charges	Basis for Allocation	
	Generation	Load
Energy	**Net Settlement of energy component** ▪ **Net export**: Paid prevailing nodal price[14] ▪ **Net import**: Charged prevailing pool price (if buying directly from pool) or retail price (if buying from retailer)	
Reserves Charges		
Spinning Reserves	**To be determined** (To be updated based on EMA's Final Determination on the Pricing Mechanism Framework)	-
Regulation (ie. AFP)	**Min (5 MWh, total generation)** (May be subjected to update based on EMA's Final Determination on the Pricing Mechanism Framework)	**Gross consumption**
Non-Reserves Market Charges		
EMC Fees	**Net Export or Net Import**[15]	
PSO Fees	**Net Export or Net Import**[16]	
MSS Charge	-	**Net Import**

[14] For CCs with embedded IGS less than 1MWac, this refers to the generation weighted average nodal price. For CCs with embedded IGS 1MWac and above, this refers to the nodal price at the node at which the generation is located.

[15] For EMC fees, charges will be **zero** if there is no import or export of electricity (ie. gross generation equals to gross consumption).

[16] For PSO fees, charges will be **zero** if there is no import or export of electricity (ie. gross generation equals to gross consumption).

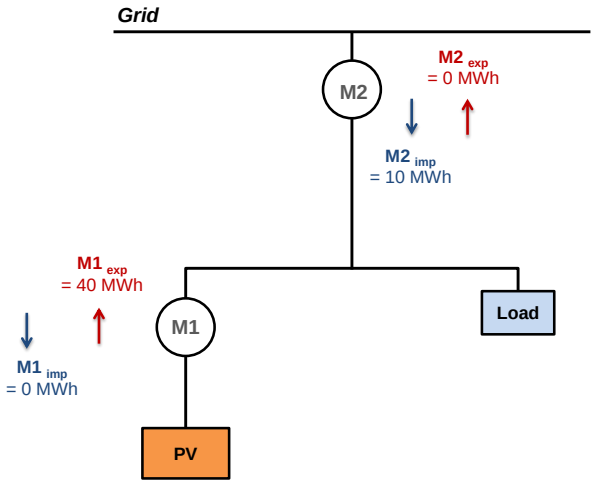
MEUC	-	**Net Import**
HEUC	-	**Net Import**
Grid Charges		
Use-of-System (UOS)	Not Applicable[17]	**Import channel**
Uncontracted Capacity Charge (High-Tension & Above Network only)		**Depending on type of backup required (Refer to Annex 4)**

[17] Grid charges are charged on consumption only.

3. Examples 1 and 2 below provide numerical illustrations of market settlement for CCs with embedded IGS, based on Table 7.

Example 1: Net Import (withdrawal) from Grid

Figure 8. Net Withdrawal of 10 units from grid



Example 1 : $M2_{export} < M2_{Import}$		
Item	**Formula**	**Qty (MWh)**
Gross Generation	**$M1_{net}$** = $M1_{exp}$ - $M1_{imp}$	40
Net Import[18]	**$M2_{net}$** = $M2_{imp}$ – $M2_{exp}$	10
Gross Consumption	**$M1_{net}$ + $M2_{net}$**	50

Applicable Payment / Charges	**Basis for Allocation**		
	Generation	**Load**	
		PV Consumer (Load that is self-generated)	**Retailer/MSSL** (Withdrawal from grid)
Energy	0	0	10
Reserves Charges			
Spinning Reserves	**To be Determined**	-	-
Regulation (ie. AFP)	5	40	10
Non-Reserves Market Charges			
EMC Fees	0	0	10
PSO Fees	0	0	10
MSS Charge	-	0	10

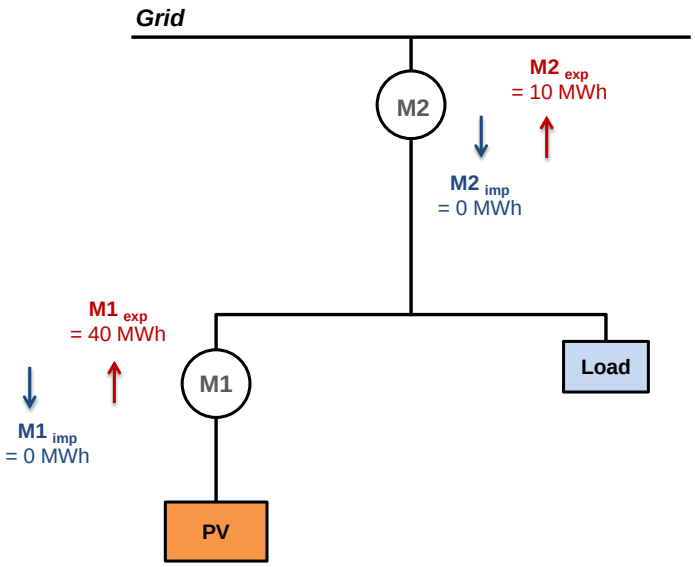
[18] Positive for net import; and negative for net injection

MEUC	-	0	10
HEUC	-	0	10
Grid Charges			
Use of System (UOS)	-	0	10[19]
Uncontracted Capacity Charge (High-Tension & Above Network only)	-	Depending on type of backup required (Refer to Annex 4)	

[19] Under a consolidated billing arrangement, the UOS is billed by the respective retailer (if on retail contract), or SPS (if buying directly from the wholesale electricity market through SPS).
Under split billing arrangement, the UOS is billed by SPS directly to the CC, while the energy component is billed by the retailer.
While consolidated billing arrangement is assumed in this example, the amount of UOS charged is the same regardless of the billing arrangement.

Example 2: Net Export (injection) into Grid

Figure 9. Net Injection of 10 units from grid



Example 2 : $M2_{exp} > M2_{Imp}$		
Item	**Formula**	**Qty (MWh)**
Gross Generation	**$M1_{net}$** = $M1_{exp}$ - $M1_{imp}$	40
Net Import[20]	**$M2_{net}$** = $M2_{imp}$ – $M2_{exp}$	-10
Gross Consumption	**$M1_{net}$ + $M2_{net}$**	30

Applicable Payment / Charges	**Basis for Allocation**		
	Generation	**Load**	
		PV Consumer (Load that is self-generated)	**Retailer/MSSL** (Withdrawal from grid)
Energy	10	0	0
Reserves Charges			
Spinning Reserves	**To be Determined**	-	-
Regulation (ie. AFP)	5	30	0
Non-Reserves Market Charges			
EMC Fees	10	0	0
PSO Fees	10	0	0

[20] Positive for net import; and negative for net injection

MSS Charge	-	0	0
MEUC	-	0	0
HEUC	-	0	0
Grid Charges			
Use of System (UOS)	-	0	0[21]
Uncontracted Capacity Charge (High-Tension & Above Network only)	-	Depending on type of backup required (Refer to Annex 4)	

[21] Under a consolidated billing arrangement, the UOS is billed by the respective retailer (if on retail contract), or SPS (if buying directly from the wholesale electricity market through SPS).
Under split billing arrangement, the UOS is billed by SPS directly to the CC, while the energy component is billed by the retailer.
While consolidated billing arrangement is assumed in this example, the amount of UOS charged is the same regardless of the billing arrangement.

Market Settlement for Standalone IGS

4. Table 10 provides an overview of the market settlement for standalone IGS.

Table 10. Market settlement for Standalone IGS

Applicable Charges	Basis for Allocation	
	Generation	Load
Energy	Gross Generation *paid the prevailing nodal price*	-
Reserves Charges		
Spinning Reserves	**To be determined** (To be updated based on the EMA's Final Determination on the Pricing Mechanism Framework)	-
Regulation (ie. AFP)	**Min (5 MWh, total generation)** (May be subjected to update based on the EMA's Final Determination on the Pricing Mechanism Framework)	-
Non-Reserves Market Charges		
EMC Fees	**Gross Generation**	-
PSO Fees	**Gross Generation**	-
MSS Charge	-	-
MEUC	-	-
HEUC	-	-
Grid Charges		
Use-of-System (UOS)	Not Applicable[22]	-
Uncontracted Capacity Charge (High-Tension & Above Network only)		-

[22] Grid charges are charged on consumption only.

ANNEX 4: Clarifications on Metering Requirements and Grid Charges

1. The EMA has received numerous queries on the metering arrangements and grid charges. This section **clarifies the existing metering requirements and grid charges** applicable to IGS.

Metering Set-up Requirements

2. For the purpose of market settlement, embedded IGS are required to fulfil the metering requirements and set-up as set out below.

Non-contestable Consumers

3. NCCs who apply to SPS for the "Simplified Credit Treatment" Scheme are required install a **bi-directional meter** to register the amount of electricity exported into the grid.

Contestable Consumers

4. CCs who (a) register with SPS for the Central Payment Intermediary Scheme or (b) register with EMC directly as a Market Participant to receive payment for their export, are required to **install revenue-class meters to measure**:

    a) **Total generation from IGS** [i.e. generation meter(s) – M1]; and

    b) **Net withdrawal from the grid** (i.e. consumption meter – M2). In order to register the amount of electricity exported into the grid, this meter needs to be bi-directional.

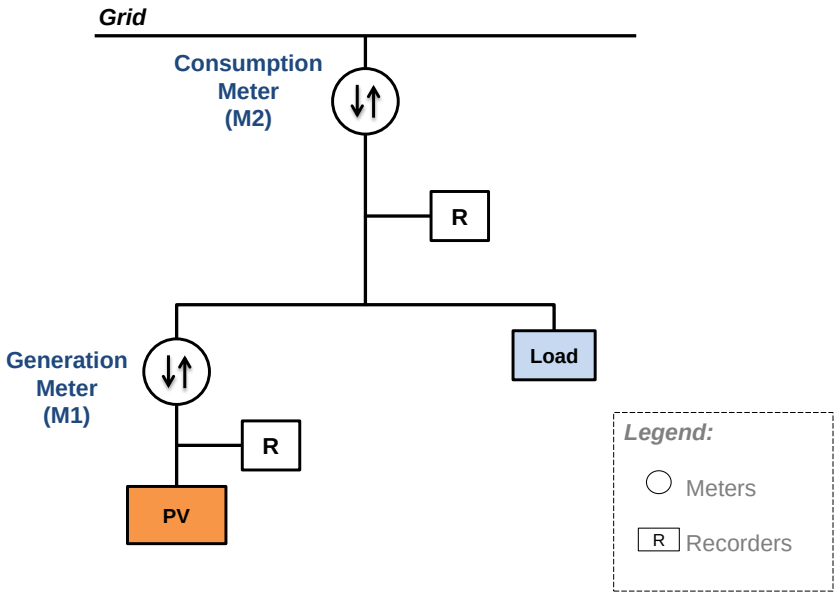
    This would be applicable for consumers connecting at all voltage levels (i.e. low-tension network as well as high-tension).

5. Figure 11 illustrates a simplified metering[23] set-up with one generation meter[24] and one consumption meter.

[23] Consumers may seek advice from SPPG on the actual metering set-up for their premise.

[24] Depending on the actual set-up at the consumer premise, there may be a need for multiple generation meters. For example, one generation meter would be required for each point of connection from the IGS to the consumers' load facilities.

Figure 11. Simplified Metering Set-up (with recorders to fulfil PSO monitoring requirements)



6. The solar industry has also sought clarifications on **whether there is a need to install an additional meter, called the summation meter**, for consumers with embedded IGS connected at the **high-tension and above network**[25]. The summation meter measures the total generation from the embedded IGS for the purpose of calculating if the consumer has exceeded its contracted capacity under the "Summation Scheme" – see sub-section on "Grid Charges" below for more information. The EMA would like to clarify that such consumers are required to install summation meter(s) in accordance with the requirements for the "Summation Scheme". **However, if generation meter(s) are already installed, consumers can choose to use the readings from their generation meter(s) for the purpose of the "Summation Scheme" (i.e. there is no need to install additional summation meters).** This is because the generation meter is a revenue-class meter which would already meet a more stringent set of requirements than the summation meter.

7. The meters are also required to meet the technical specifications stipulated in the relevant provisions of the Metering Code.

[25] This includes High Tension, Extra-High Tension and Ultra-High Tension.

Grid Charges

8. **Grid charges are paid by consumers**, not generators, for the grid infrastructure services provided to consumers' premises. Grid charges are paid to SP PowerAssets ("SPPA"), which is responsible for the operation and maintenance of the grid.

9. Hence, standalone IGS (ie. without embedded load and is connected directly to the grid) is not required to pay grid charges[26].

10. For consumers with embedded IGS, the applicable grid charges depend on the voltage level at which the consumer's load is connected to the grid.

Low-Tension ("LT") Network

11. LT consumers pay a **variable grid charge,** known as **UOS charge** based on the gross amount of electricity (in kWh) withdrawn from the grid.

12. For NCCs, the UOS charge is already incorporated in the regulated tariffs. For CCs, this will be billed by the respective retailer or SPS, depending on the billing arrangement.[27]

High-Tension ("HT") and Above Network

13. For HT and above consumers (both CCs and NCCs), the grid charge consists mainly of two components:

    a) Fixed component referred to as the **Contracted Capacity charge**, which is a monthly charge based on the Contracted Capacity (in kW) at each metered intake supply point. The rationale of a fixed component in the grid charge is to encourage consumers to declare their Contracted Capacity according to their load profile and to commit to the Contracted Capacity declared, given that SPPA's network investments are driven by capacity requirement. In the long term, this ensures efficient utilisation of network assets and help to lower grid charges; and

    b) Variable component referred to as the **UOS charge**, which is based on the amount of electricity (in kWh) withdrawn from the grid.

14. For more information on the prevailing grid charges, please refer to the "Transmission Service Rate Schedule", published by SPPG.[28]

[26] Nonetheless, there are charges associated with the connection of the IGS to the grid.

[27] Under a **consolidated** billing arrangement, the UOS is billed by the respective retailer (if on retail contract), or SPS (if buying directly from the wholesale electricity market through SPS). Under a **split** billing arrangement, the UOS is billed by SPS directly to the CC while the energy component is billed by the retailer.

15. **Depending on the type of backup supply required (i.e. full or partial backup),** consumers with embedded IGS located at the HT and above network can choose from one of the following three schemes - (a) **Summation Scheme**; (b) **Capped Capacity Scheme**; or (c) **Extended Capped Capacity Scheme**. For more information on each scheme, refer to SPPG's guide on "How to Apply for Electrical Connection"[29].

[28] The prevailing *Transmission Service Rate Schedule*, can be found on SPPG's website: http://www.singaporepower.com.sg/irj/portal?NavigationTarget=navurl://7d4c46d5b6cee8b3507d217d6988c05b&windowId=WID1397553311554

[29] SPPG's guide on How to Apply for Electrical Connection, can be found on SPPG's website: http://www.singaporepower.com.sg/irj/go/km/docs//wpccontent/Sites/SP%20PowerGrid/Site%20Content/Resources/documents/howtoapplyforelectconn.pdf