Net Energy Metering Assessment Study (NEMAS) & Technical Requirement

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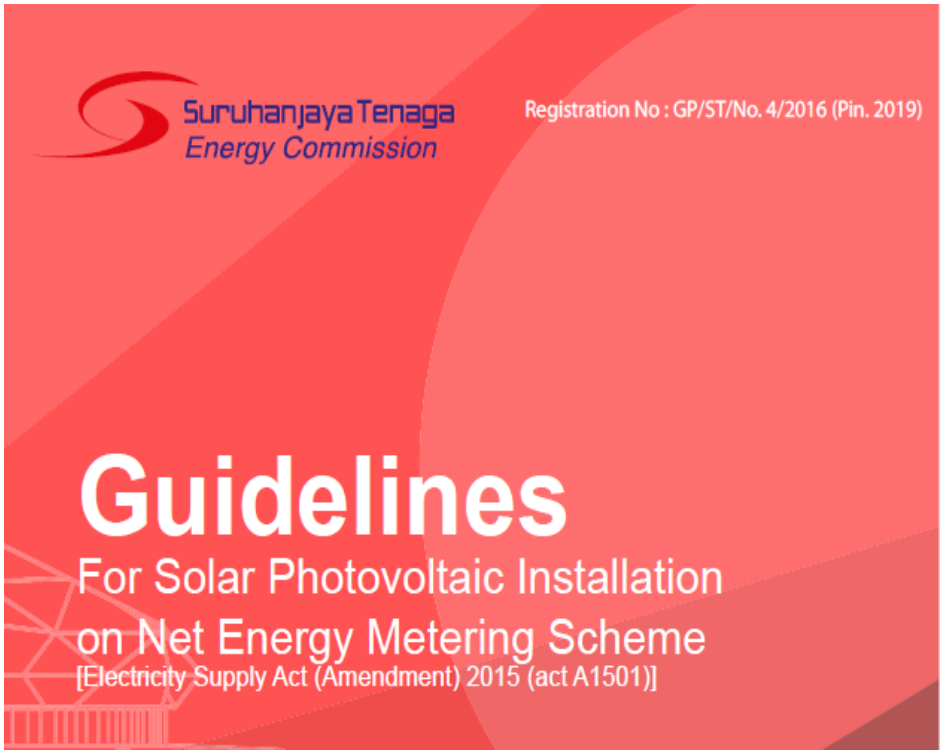
Main References



- **TNB support the initiatives by the Government to achieve 20% RE by 2025.**
- **With high penetration of RE, TNB to ensure connection of RE will not negatively impact the security, reliability, quality and safety of the existing supply to the consumers**

NEMAS and Technical Requirement

Capacity	Study	Technical Assessment
1 - 72kW	Self assessment (by Solar Service Provider)	a) Voltage profile & Penetration limit b) Physical check
> 72kW - 425kW	Load flow analysis (NEMAS)	c) Voltage regulation d) Penetration limit (60% CT / 75% MD) e) Power factor (above 0.85)
> 425kW	Load flow & short circuit analysis (NEMAS)	f) Fault level

Nominal Voltage	Steady state voltage limits
Low Voltage (230V / 400V)	-6%, +10%
Medium Voltage (11kV / 22kV / 33kV)	-5%, +5%

Nominal Voltage [kV]	Rated Voltage [kV]	Fault Current [kA]
33	36	25
22	24	20
11	12	20
0.4	1.0	31.5

Penetration Limit & Power Factor

b) Penetration limit

Average Maximum Demand / CT Rating	800/5 (554.26kWac)
Maximum Penetration Limit (60% of CT Ratio)	332.55kWac
The Proposed Capacity & Penetration	180.00 kWac @ 54.13%
Capacity Allowed	180.00 kWac

c) Voltage rise due to RE (Solar PV pf=1)

	Peak Load			Trough Load		
	Without RE (V)	With RE (V)	Variance (%)	Without RE (V)	With RE (V)	Variance (%)
PE Pasaraya Odyssey, Bkt Gambir	11220	11220	**0.000**	11220	11220	**0.000**
Consumer MSB	409	411	**0.489**	412	413	**0.243**
Inverter output	N/A	412	**N/A**	N/A	415	**N/A**

d) Power factor effect due to RE (Solar PV pf=1)

	Without RE (as per bill provided)	**With RE** (declared by the developer in form part 5(c))
Real Power, kWh	37,388 kWh	11,858 kWh
Reactive Power, kVARh	9,834 kVARh	9,834 kVARh
Power Factor, PF	**0.967**	**0.770**

Power Factor (PF)	Description
$PF \geq 0.85$	No charge
$0.75 < PF < 0.85$	For every different of 0.01, additional charge of 1.5% from monthly bill
$PF < 0.75$	For every different of 0.01, additional charge of 3% from monthly bill

Example:

Power Factor (PF) = 0.77;
0.85 – 0.77 = 0.08 / 0.01 = 8 units x 1.5% = 12%

Total PF surcharge = 12% of total bill

f) Power factor effect due to RE (Solar PV pf=0.967 lagging)

	Without RE (as per bill provided)	**With RE** (declared by the developer in form part 5(c))@47.42kVAR
Real Power, kWh	37,388 kWh	11,858 kWh
Reactive Power, kVARh	9,834 kVARh	3,108 kVARh
Power Factor, PF	**0.967**	**0.967**

Note;

- *Simulation is done at inverter power factor 0.967 lagging and consumer power factor is based on provided electricity bill.*
- *Consumer are advisable to run inverter at 0.967 lagging to ensure the electricity bill within the allowable limit power factor.*
- *Power factor **below 0.85** is subject to low power factor penalty.*

Impact of Distributed Generator (DG) on Fault Levels

1

Requirement based on Distribution Code

Clause 5.4.9 - Short Circuit Levels

- 5.4.9.1 - Distribution system shall be planned not to exceed 90% of the short circuit rating of the equipment (25kA@33kV and 20kA@11kV).
- 5.4.9.6 - The DG shall minimise its fault current contribution on reasonable request from Distributor.

2

Sources of fault current

- ✓ Sub-transmission grid connection
- ✓ Distributed Generation (DG) connected to distribution system

3

Impacts of DG on Fault Levels

- ✓ During fault, DG will contribute fault current to the system
- ✓ Total fault current < short time rating of the equipment
- ✓ Amount of fault current contribution depends on DG type and capacity

4

Risk if Fault Level > Equipment Ratings

- ✓ Health & Safety Risk to operation personnel, members of the public and the equipment.
- ✓ Equipment fail to operate correctly and may cause severe damage and supply interruptions

TNB has formularized 2 steps to encourage DG connection without impacting to fault current violation (DG capacity above 425kW)

Step 1: Connection of DG at identified Nodal Point

- TNB has identified **Nodal Point** for feasible connection of DG in the network.
- Number of Nodal Point will be revised from time to time
- Nodal Point is only applicable for DG capacity above 425kW

⊕ Faster and cheaper for DG Applicants

⊖ Location may not favorable to DG applicant

⊖ Increase fault current in the system

Step 2: Connection of DG at Non Nodal Point (DG applicant to minimize fault current contribution)

- **Non Nodal Point** is location point at which fault current almost reaching / reached 90% of short circuit rating
- With the installation of new DG plant, the fault current might increase beyond 90%.
- As per Distribution Code requirement, the DG applicant is required to minimize the fault current contribution

⊕ Provides flexibility to install DG Plants at any location

⊕ Zero/minimize additional system fault current

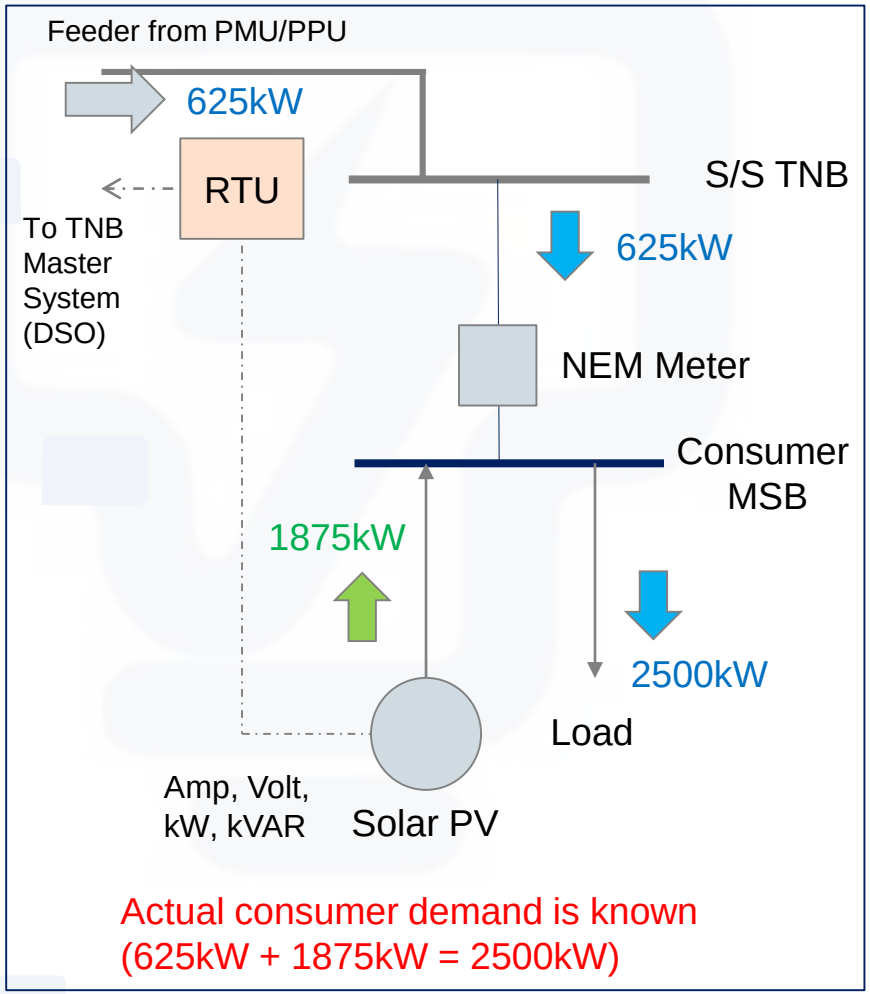
⊖ Higher Cost for DG Applicants

Other Main Technical Requirement

1. SCADA / Solar Monitoring is required for capacity 1MW and above
   - Solar generation output to link with TNB Regional Control Center / Distribution System Operator

2. To use solar inverter with smart functions (Smart Inverter)
   - Smart inverters are PV inverters that stay connected and provide additional functions to help actively support the grid - mainly voltage and frequency
   - Example - active and reactive power control

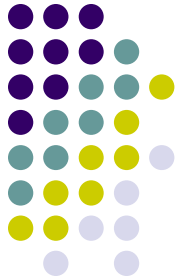
SCADA / Monitoring requirement for Solar Capacity 1MW and above



Existing System at TNB Substation	Scope
Substation equipped with SCADA system	Additional Communication Card
Substation not equipped with SCADA system	New SCADA system: Remote Terminal Unit (RTU), Battery Charger, Dual Sim Router (DSR)/ Modem 3G

- The SCADA system will be procured and installed by the customer based on TNB's specification and supervised by TNB
- The SCADA system will be handed over to TNB for operation and maintenance

Smart Inverter Functions



1. Anti-islanding with Grid Support Functions Enabled
2. Ride-Through Capability
   - Low/High Voltage
   - Low/High Frequency
3. Ramp Rates / Reconnect by Soft-Start
4. Reactive Power Control Functions
   - Dynamic Volt/VAr Mode
   - Fixed Power Factor
   - Reactive Power Control
   - Reactive Power Support Capability at Night (export/import) - optional
5. Active power control functions
   - Frequency-Watt
   - Volt-Watt
6. Data log/Memory Card for event logs
7. Remote Configurability / Scheduling / Shutdown / Power Reduction

THANK YOU