Maldives Energy Authority

Guidelines on Technical Requirements for Photovoltaic Grid-connection

February 2013

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TECHNICAL REQUIREMENTS FOR GRID-CONNECTION

1 Electric System

1) Frequency

Rated frequency shall be 50Hz

2) Classifications of Interconnection

Basically, interconnection classification shall be selected in accordance with the following table. However the required classification might be changed due to capacity constraint of existing facilities or other technical issues examined by Grid Owner.

Table 2-1 Classifications of Interconnection

Rated Output of PV System (kW)	Breaker Capacity (A)	Interconnection Voltage
< 7	40A	LV (1Φ 230V)
7 - 35	63A	LV (3Φ 400V)
35 - 175	315A	LV (3Φ 400V)
175 >	—	MV (3Φ 11kV)

3) Electric System

The electric system of a power generation facilities shall be the same as the electric system of the grid to be connected except for the case specified in 4).

4) The electric system of a power generation facilities may be different from the electric system of a grid to be connected if one of the following conditions is satisfied.

(i) Capacity of a power generation facilities is very small compared to the maximum power usage so that an imbalance between phases actually causes no problems.

(ii) When connecting generation facilities of single-phase to a three-phase system a provision is made to stop inverters against phase imbalance.

2 Metering Method

The metering of PV system will be treated as follows.

Customers who install PV systems shall install a new meter (with protection for reverse rotation) to measure selling electricity beside of an existing buying meter (with protection for reverse rotation). The selling price shall be determined by Grid Owner in surplus power purchasing system.

Table 2-2 Metering method for Grid-connected PV system

<table>
<tr><th>Fig. No.</th><th>interconnection category</th><th>Procurement & Installation of meter</th><th>Type of meter</th><th>Installation point for meter</th><th>Boundary of properties and responsibility</th><th>Metering method</th></tr>
<tr><td rowspan="2">①</td><td>LV
1Φ(～40A)</td><td rowspan="3">Procurement: PV System owner

Installation: Grid Owner

Calibration: MEA accredited Organization</td><td rowspan="3">With protection for reverse rotation (MEA accredited products)</td><td rowspan="2">LV side (between existing meter and distribution board)</td><td rowspan="3">Primary side of meter or incoming cable terminal of MDB is boundary. The distribution lines side’s cables belong to Grid Owner. The meters belong to the customer but installation, removal and replacement without approval from Grid Owner are prohibited</td><td rowspan="3">An additional meter (with protection for reverse rotation) to measure selling electricity must be install beside an existing meter (with protection for reverse rotation)</td></tr>
<tr><td>LV
3Φ
(～63A)</td></tr>
<tr><td>②</td><td>LV
3Φ
(63～300A)</td></tr>
<tr><td>③</td><td>MV
(300A*～)</td><td>MV side of receiving transformer</td></tr>
</table>

* current at LV side

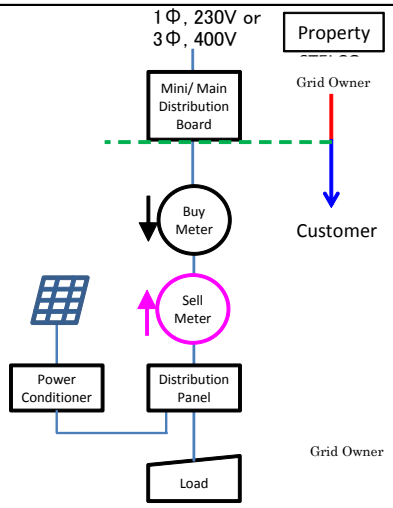
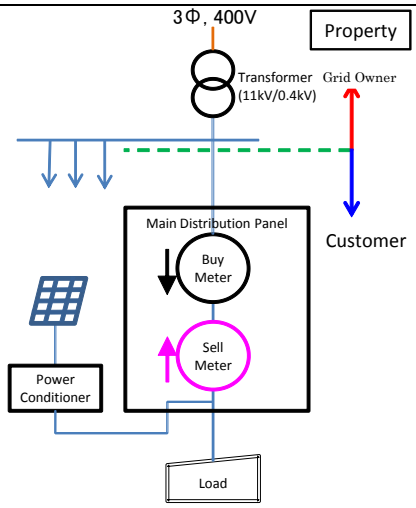
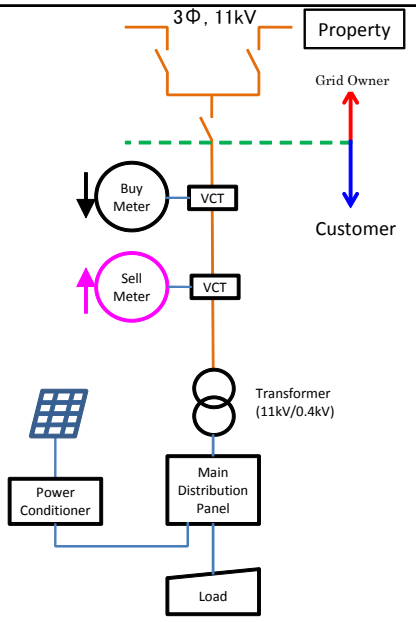
①	 1Φ, 230V or 3Φ, 400V Property Mini/ Main Distribution Board Grid Owner Buy Meter Customer Sell Meter Power Conditioner Distribution Panel Grid Owner Load
②	 3Φ, 400V Property Transformer (11kV/0.4kV) Grid Owner Customer Main Distribution Panel Buy Meter Sell Meter Power Conditioner Load
③	 3Φ, 11kV Property Grid Owner Buy Meter VCT Customer Sell Meter VCT Transformer (11kV/0.4kV) Power Conditioner Main Distribution Panel Load

Figure 2-1 Diagrams for metering of Grid-connected PV system

(except for Grid Owner Company's installation)

3 Power Factor

A power factor at a network connection point shall be considered as follows.

1) For a power factor at a network connection point in the case of no reverse power flow, 85% or over shall be considered basically adequate and shall not be viewed as a leading power factor from the system side (i.e. lagging power factor from the generation facilities side). However, for generation facilities without a reverse power flow and interconnected to a grid through inverters, it is difficult to let those generation facilities adjust reactive power in response to fluctuations of the total load of the Generation Facilities Installer and to change home appliance numbers aiming at adjustment of the power factor at network connection point. Therefore, a judgment shall be based on the operation power factor of the generation facility itself, and a lagging power factor of 95% or over viewed from the grid side shall be considered OK.

2) For a power factor at a network connection point in the case of a reverse power flow, 85% or over shall be considered basically adequate and shall not be viewed as a leading power factor from the grid side (i.e. lagging power factor from the generation facilities side) to prevent a voltage rise. However, the power factor at the network connection may not be 85% or over if any of the following conditions are met.

   (i) When unavoidable to prevent a voltage rise (power factor at network connection shall be controllable up to 80% in this case).

   (ii) When their rated output is small enough, based on actual connection with distribution lines, or when the load power factor is very close to 1 regardless of usage of the load, such as load of residential houses, and power factor at the network connection can be assumed to be adequate even if power generation facilities are connected (in this case, power factor of the generation facilities shall be 85% or over with reactive power control, and 95% or over without reactive power control).

4 Voltage Fluctuations

1) Provisions against normal voltage fluctuations

When power generation facilities are connected to a grid, voltage for low voltage customer should be kept within 230 ± 5.75 V for 230 V standard voltage and 400 V ± 10 V for 400 V standard voltage based on the Grid Owner's standard. If there is any concern that reverse

power flow from a Generation Facilities Installer can raise voltage of each point of a distribution line to deviate from the adequate value, the installer shall make provisions to maintain other customers at the adequate voltage. Considering impact to load equipments, it is desirable to keep voltages adequate even within the installer's premise. Especially when small output generation facilities are installed in an ordinary household, it shall be appropriate to define a voltage control point as the connection point since installer's knowledge on the electrical security may not be enough. But as decrease of generation power can be expected in this case due to the restriction of reverse flow from generation facilities when the grid voltage is close to the upper limit, the voltage control point can be moved to a leading-in pole provided that the supply voltage to other customers may not deviate from the adequate value. Though basic approach to prevent a voltage rise is to investigate per each connection from both sides of the conditions and the generation facilities conditions, it should be effective to standardize the actions in advance in view of reduction of discussion time and cost. If there is any concern that voltage at low voltage customers may deviate from adequate value (230 ± 5.75V, 400 ± 10V), then the Generation Facilities Installers shall make provisions to automatically adjust the voltage using a leading reactive power control function or an output control function. In case this is not enough, further provisions including increase capacity of the distribution lines shall be made.

2) Provisions against instantaneous voltage fluctuations

As an investigation of generation facilities connection, adequate instantaneous voltage drop during parallel-off of generation facilities shall be within 10% of the normal voltage (207 V shall be the lower limit for 230 V systems) since information equipments such as computers and OA equipments may be affected to stop by an instantaneous voltage drop of more than 10% of the rated voltage.

Under these assumptions, if self-commutated inverters are used, they shall have the capability to synchronize automatically. If externally-commutated inverters are used and the grid voltage may deviate more than 10% from the normal voltage due to instantaneous voltage drop during parallel-in, the Generation Facilities Installer shall provide current-limiting reactors. In case this is not enough, either increase of the distribution lines shall be taken or self-commutated inverters shall be used.

5 Protection Relays

1) Relay type

In order to prevent operation at outside of the adequate voltage or frequency, the following protection relays shall be equipped with the PV system.

Table 2-3 Protection relay list

Relay Type
Over-Voltage-Relay (OVR)
Under-Voltage-Relay (UVR)
Over-Frequency-Relay (OFR)
Under-Frequency-Relay (UFR)

In case that reverse power flow is prohibited, Reverse-Power-Relay (RPR) shall be installed.

2) Installation location of protection relay

Protection relays described in 1) shall be installed at a connection point or a point where fault can be detected. Here, a "point where fault can be detected" means specifically an outlet of a generation facilities, a communication bus between a connection point and a generation facilities, secondary side of the power receiving transformer.

3) Parallel-off point

In case protection equipment described in 1) works out, generation facilities shall be paralleled off at the either point of the following. Furthermore, upon parallel-off, electrical switches composed of semiconductors only are not basically usable since generation facilities should be mechanically isolated from the circuits and electrically insulated condition should be maintained.

(i) Power receiving breaker

(ii) Generator output breaker

(iii) Generator communication breaker

(iv) Bus communication breaker

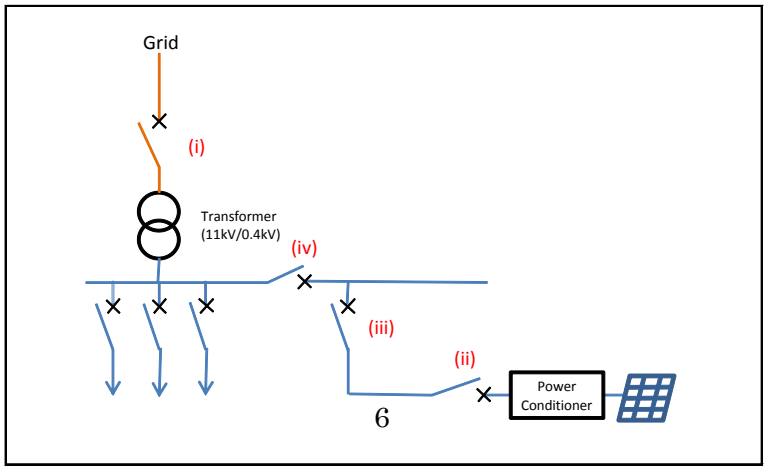


Figure 2-2 Parallel-off point

4) Phases of protection relay installation

Among relays in 1) above, under-frequency relays, over-frequency relays and reverse power relays shall be installed in a single phase. And under/over-voltage relays shall be installed in three phases.

6 Islanding Operation Detection

In case of a connection with a condition of reverse power flow, islanding operation detection shall be installed to prevent operation with balance between output capacity of generation facilities and the grid load. This is the reason why Grid Owner will not reclose the distribution line due to asynchronous between islanding generation system and the grid. The following table shows the type of islanding operation detection. The Generation Facilities Installer shall select one or more method from active type and one or more method from passive type.

Table 2-4 Type of islanding operation detection

Active type	Passive type
a) Frequency shift type	e) Power phase jump detection type
b) Active power fluctuation type	f) 3rd harmonic voltage rise detection type
c) Reactive power fluctuation type	g) Frequency change rate detection type
d) Load fluctuation type	

7 Automatic Recovering Function

If PV system has automatic recovering function after blackout, the function shall equip with a condition of receiving voltage confirmation to prevent the expansion of damage by unnecessary parallel-in.

8 Automatic Load Limiting and Power Generation Suppression

If dropout of generation facilities may cause overload to mainly connected power lines and transformers, the Generation Facilities Installer shall make provisions to automatically limit the loads or suppress the power generation.