MINIMUM TECHNICAL REQUIREMENTS FOR INTERCONNECTION OF PHOTOVOLTAIC (PV) FACILITIES

The proponent shall comply with the following minimum technical requirements:

1. VOLTAGE RIDE-THROUGH:

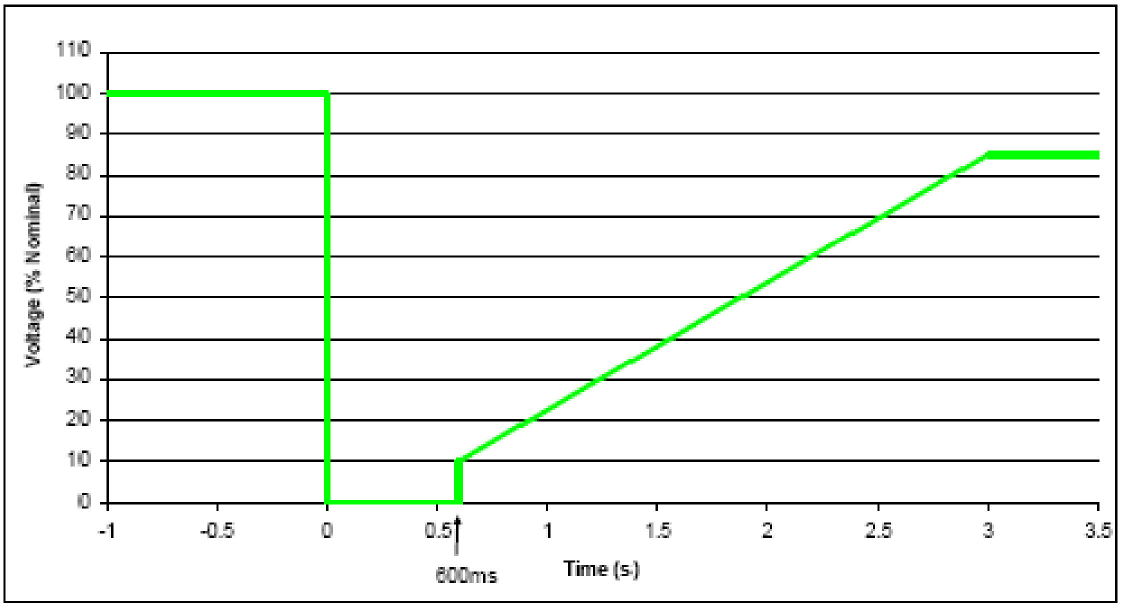

Figure 1 Low Voltage Ride-Through Requirements

a. PREPA's Low Voltage Ride-Through (LVRT) Requirements:

i. From Figure 1, PREPA requires all generation to remain online and be able to ride-through faults down to 0.0 per-unit (measured at the point of interconnection), for up to 600 ms.

ii. All generation remains online and operating during and after normally cleared faults on the point of interconnection, and

iii. All generation remains online and operating during backup-cleared faults on the point of interconnection.

b. PREPA's Overvoltage Ride-Through (OVRT) Requirements:

   i. PREPA requires all generation to remain online and able to ride-through overvoltage conditions specified by the following values:

Overvoltage (pu)	Minimum time to remain online (seconds)
1.4 – 1.25	1
1.25 – 1.15	3
1.15 or lower	indefinitely

2. Voltage Regulation System (VRS)

Constant voltage control shall be required. Photovoltaic System technologies in combination with Static Var Controls, such as Static Var Compensators (SVC), STATCOMs, DSTATCOMs are acceptable options to comply with this requirement. A complete description of the VRS control strategy should be submitted for evaluation.

a) Photovoltaic Facilities (PVF) must have a continuously-variable, continuously-acting, closed loop control VRS; i.e. an equivalent to the Automatic Voltage Regulator in conventional machines.

b) The VRS set-point must be adjustable by the PVF Operator following a PREPA System Controller dispatch. The set-point shall be adjustable between 95% to 105% of rated voltage at the POI.

c) The VRS shall operate only in a voltage set point control mode. Controllers such as Power Factor or constant VAR are not permitted.

d) The VRS shall be capable of adjustable Droop or adjustable gain. VRS that utilize Droop shall be adjustable from 0 to 10%.

e) The combined settings of Droop or gain are to achieve a steady-state voltage regulation of +/- 0.5% of the voltage controlled by the VRS.

f) The VRS shall be calibrated such that a change in reactive power will achieve 95% of its final value no later than 1 second following a step change in voltage. The change in reactive power should not cause excessive voltage excursions or overshoot.

g) The generator facility VRS must be in service at any time the PVF is electrically connected to the grid regardless of MW output from the PVF.

3. Reactive Power Capability and Minimum Power Factor Requirements

The total power factor range shall be from 0.85 lagging to 0.85 leading. The reactive power requirements provide flexibility for many types of technologies at the Renewable Energy Facility. The intent is that a PVF can ramp the reactive power from 0.85 lagging to 0.85 leading in a smooth continuous fashion.

The +/- 0.90 power factor range should be dynamic and continuous. This means that the PVF has to be able to respond to power system voltage fluctuations by continuously varying the reactive output of the plant within the specified limits. The previously established power factor dynamic range could be expanded if studies indicate that additional continuous, dynamic compensation is required. It is required that the PVF reactive capability meets +/- 0.85 Power Factor (PF) range based on the PVF Aggregated MW Output, which is the maximum MVAr capability corresponding to maximum MW Output. It is understood that positive (+) PF is where the PVF is producing MVAr and negative (-) PF is where the PVF is absorbing MVAr.

This requirement of MVAr capability at maximum output shall be sustained throughout the complete range of operation of the PVF as established by Figure 2.

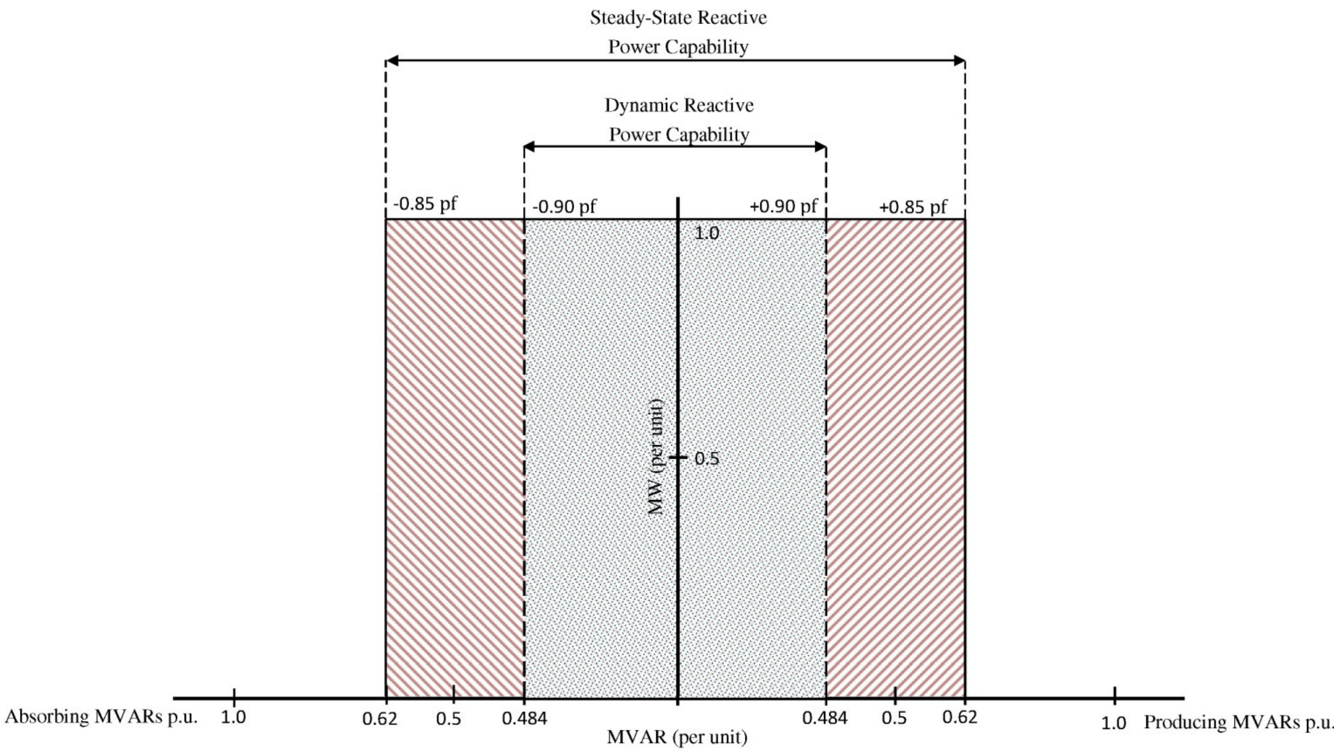

Figure 2 Reactive Power Capability Curve

4. Short Circuit Ratio (SCR) Requirements:

Short Circuit Ratio values (at the point of interconnection) under 5 shall not be permitted. The constructor shall be responsible for the installation of additional equipment, such as synchronous condensers, and controls necessary to comply with PREPA's minimum short circuit requirements.

5. Frequency Ride Through (FRT):

- 57.5 - 61.5 Hz No tripping (continuous)
- 61.5 - 62.5 Hz 30 sec
- 56.5 - 57.5 Hz 10 sec
- < 56.5 or > 62.5 Hz Instantaneous trip

6. Frequency Response/Regulation:

PV facility shall provide an immediate real power primary frequency response, proportional to frequency deviations from scheduled frequency, similar to governor response. The rate of real power response to frequency deviations shall be similar to or more responsive than the droop characteristic of 5% used by conventional generators. PV facility should have controls that provide both down-regulations and up-regulation reserves. PV technologies, in combination with energy storage systems such as BESS, flywheels, hybrid systems are acceptable options to comply with PREPA's frequency regulation requirements.

7. Ramp Rate Control:

Ramp Rate Control is required to smoothly transition from one output level to another. The PV facility shall be able to control the rate of change of power output during some circumstances, including but not limited to: (1) rate of increase of power, (2) rate of decrease of power, (3) rate of increase of power when a curtailment of power output is released; (4) rate of decrease in power when curtailment limit is engaged. A 10 % per minute rate (based on nameplate capacity) limitation shall be enforced. This limit applies both to the increase and decrease of power output.

8. Power Quality Requirements:

The developer shall address, in the design of their facilities potential sources and mitigation of power quality degradation prior to interconnection. Design considerations should include applicable standards including, but not limited to IEEE Standards 142, 519, 1100, 1159, and ANSI C84.1. Typical forms of power quality degradation include, but are not limited to voltage regulation, voltage unbalance, harmonic distortion, flicker, voltage sags/interruptions and transients.

9. Special Protection Schemes:

PV facility shall provide adequate technology and implement special protection schemes as established by PREPA in coordination with power management requirements.

10. General Interconnection Substation Configuration:

An interconnecting generation producer must interconnect at an existing PREPA substation. The configuration requirements of the interconnection depend on where the physical interconnection is to occur and the performance of the system with the proposed interconnection. The interconnection must conform, at a minimum, to the original designed configuration of the substation. PREPA, at its sole discretion, may consider different configurations due to physical limitations at the site.

11. Modeling and Validation

The Contractor shall submit to PREPA a Siemens - PTI certified PSS/E mathematical model and data related to the proposed PV facility. When referred to the PV facility model, this shall include but is not limited to PV inverters, transformers, collector systems, plant controllers, control systems and any other equipment necessary to properly model the PV facility for both steady-state and dynamic simulation modules. It is required that the Contractor submits both an aggregate and detailed version of the PV facility model.

The Contractor shall be required to submit user manuals for both the PV inverter and the PV Facility models. The mathematical models shall be fully compatible with the latest and future versions of PSS/E. It is preferred that the models are PSS/E standard models. In the case that the Contractor submits user written models, the Contractor shall be required to keep these models current with the future versions of the PSS/E program until such time that PSS/E has implemented a standard model. The Contractor shall submit to PREPA an official report from Siemens - PTI that validates and certifies the required mathematical models, including subsequent revisions. The data and PSS/E model shall also be updated and officially certified according to PREPA requirements when final field adjustments and parameters measurements and field tests are performed to the facility by the contractor. The mathematical model (either PSS/E standard or user written model) of the PV facility shall be officially certified by Siemens - PTI before a specific and validated PSS/E mathematical model of the complete PV facility be submitted to PREPA. The Contractor shall be responsible of submitting the official reports and certifications from Siemens – PTI, otherwise the mathematical model shall not be considered valid.

The Contractor shall be responsible to submit Siemens – PTI certified PSSE mathematical models of any kind of compensation devices (ie. SVC, STATCOMs, DSTATCOMs, BESS, etc.) used on the PV facility. It is preferred that the models are standard models provided with PSS/E. In the case that the Contractor submits user written models, the PV facility Contractor shall be required to keep these models current with the future versions of the PSS/E program until such time that PSS/E has implemented a standard model. In its final form, the mathematical model shall be able to simulate each of the required control and operational modes available for the compensation device and shall be compatible with the latest and future versions of PSSE. Final adjustments and parameters settings related with the control system commissioning process shall be incorporated to the PSSE mathematical model and tested accordingly by the PV facility Contractor and PREPA system study groups. The Contractor shall also perform on-site field tests for the identification, development, and validation of the dynamic mathematical models and parameters required by PREPA for any kind of compensation devices used at the PV facility. The mathematical models of the PV facility and its required compensation devices shall be officially certified by Siemens - PTI before a specific and validated PSS/E mathematical model of the complete PV facility be submitted to PREPA. The Contractor shall be responsible of submitting the official reports and certifications from Siemens – PTI, otherwise the mathematical models shall not be considered valid.

PV facility Owners that provide user written model(s) shall provide compiled code of the model and are responsible to maintain the user written model compatible with current and new releases of PSS/E until such time a standard model is provided. PREPA must be permitted by the PV facility Owner to make available PV Facility models if required to external consultants with an NDA in place.

12. Transient Mathematical Model

The Contractor shall be responsible of providing a detailed transient model of the PV facility and to show that it is capable of complying with PREPA's transient Minimum Technical Requirements.

13. Dynamic System Monitoring Equipment

The developer of the PV facility shall be required to provide and install a dynamic system monitoring equipment that conforms to PREPA's specifications.