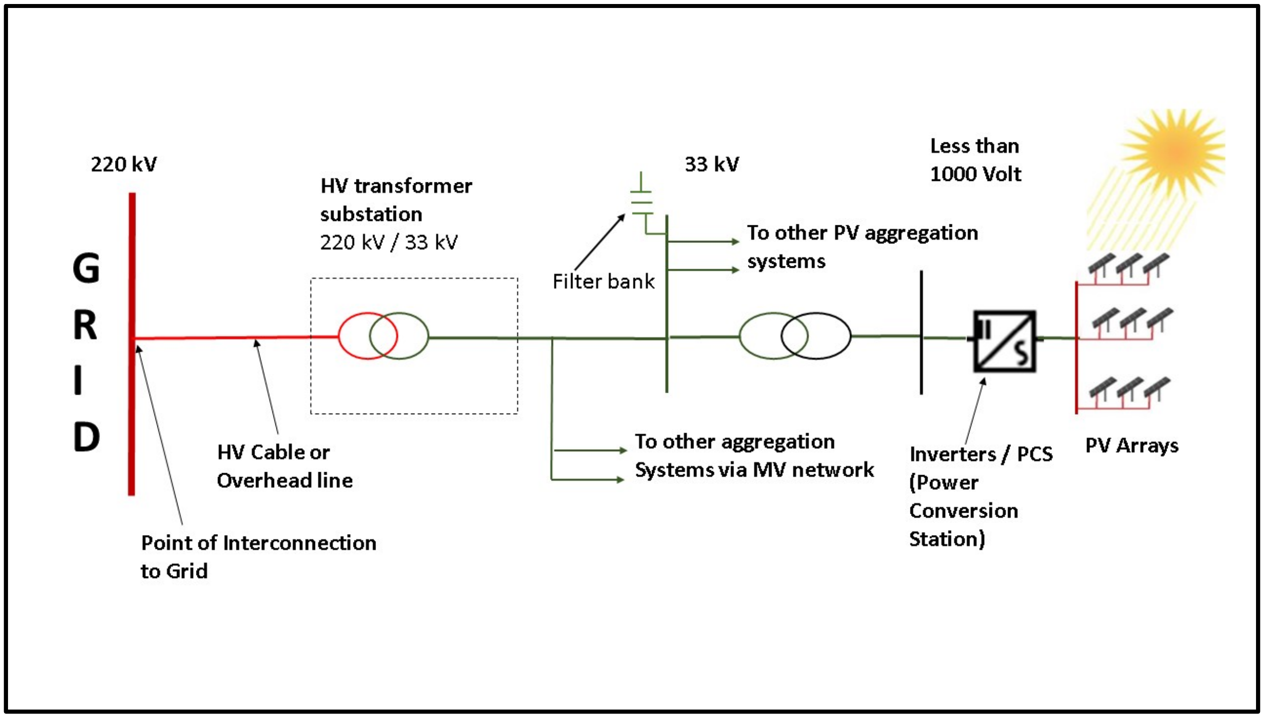
Annexure-I(D): Guidelines for Exchange of data for RMS modelling (Generic) of Solar Generating Stations

1. Models for Utility scale Solar generation farms:



In a typical utility scale solar farm / park, arrays of Solar PV panels connected to an inverter (Power Conditioning System / Power Conversion Station – PCS), which is stepped up to form part of the MV reticulation system (typically at 33 kV or less). A number of inverters are pooled and then stepped up to the voltage of 220 kV / 400 kV prior to connection to EHV grid. A Power Plant controllers (PPC) is usually installed at the point of interconnection to grid or the reticulation system. The PPC(s) control behavior of solar farms in accordance with mandates as per grid codes.

The dynamic components of a solar farm or park consists of the following elements (illustrated in picture below):

1. Generator or Converter
2. Electrical control including fault ride through
3. Power Plant Controller (PPC)
4. Energy storage (i.e. battery), if applicable

Depending on the nature of technology and usage of components at site ('As built'), the requirements for steady state and dynamic modelling evolves.

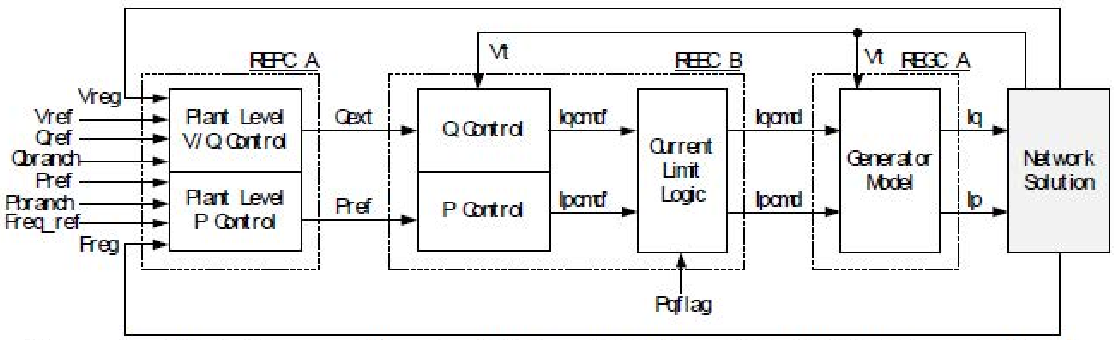


Figure 4 – Block Diagram Showing Different Modules of the WECC Generic Models

2. Generic models in PSS/E for modelling utility scale Solar PV and BESS installations:

Solar Technology	Generic model	Model Description
Utility Scale Solar PV	REGC	Renewable energy generator converter model
	REEC	Renewable energy controls model
	REPC	Renewable energy plant controller
Utility Scale Battery Energy Storage System (BESS)	REECCU	Electrical Control Model (To be used alongwith REGCA1 and REPCA1)

3. Details of models in PSS/E for modelling Solar plants / farms / parks:

Category	Parameter Description	Data
Inverter Details	Manufacturer, model number and product details	
	Year of commissioning	
	As found settings (obtained either from HMI or downloaded from controller in digital systems)	
Technology	• Grid following • Grid forming (viz. Assist in regulation of Voltage and Frequency) • Reactive power priority (Controls Pf or Voltage? Point of control?)	-
Single Line Diagram	Single line diagram of the solar farm showing number and location of inverters and PV arrays behind each inverter, cable run, transformers, feeders (including type of cables and electrical R,X,B parameters), and connection to transmission system Preferable : Electrical Single Line Diagram including details between PV-array to Inverters, Inverters to MV reticulation system, MV reticulation system till Point of Interconnection (POI) at EHV level (220 kV/400 kV)	
Capability	DC/AC ratio	
	Number of inverters	
	Panel type	
	Number of modules per string	
	Tracking in 0/1/2 axes	
	Capability diagram at nominal (STC) and typical temperature	
Controls	Does the solar farm have a PPC? If yes, whether PPC controls all or part of the inverters in Solar farm	
	What is the method of control – voltage regulation, power factor control, reactive power control?	
	Voltage control strategy (operating mode) • Controls MV bus • Controls HV bus • PF control • Q control	
	Is there a droop setting? • Voltage control • Frequency control	
	Is reactive power limited? Details thereof	
	Is active power limited below MPPT at high output? Details thereof	
	Temperature dependency details	
	Active power ramp rate limiters	
	Fault Ride Through (FRT) protocols and setpoints • LVRT • HVRT	
	Provide settings from controller	

Category	Parameter Description	Data
Reticulation System	Voltage of the reticulation system	
	Number of feeders	
	Cable schedules (lengths, cable size, conductor material, rating info)	
Inverter station transformer	Details of the turbine transformer, including vector group, impedance, and number of taps, tap position, tap ratio	
	Nameplate details	
Solar Farm step-up transformer	Details of the main solar farm step up transformer, including vector group, impedance, and tap position	
	Nameplate ; OLTC?	
	Controlled bus	
	Voltage setpoint	
	Dead band	
	Number of taps	
	Tap ratio range	
Connection Details	Voltage influence (maximum change etc)	
	Short circuit ratio (SCR)	
	· Min	
	· Max	
	Harmonic filters	
	STATCOM	
	Synchronous condensers	
	Battery Energy Storage System (if applicable)	
Power Plant Controller (PPC) Details	Does the solar farm have a PPC? If yes, whether PPC controls all or part of the inverters in solar farm	
	What is the method of control – voltage regulation, power factor control, reactive power control?	
	Voltage control strategy (operating mode) - Controls MV Bus - Controls HV Bus - PF control - Q control - Voltage control	
	Is there a droop setting? - Voltage control - Frequency Control - Is there line drop compensation?	
	Is reactive power limited?	
	Temperature dependency	
	Active power ramp rate limiters	
	FRT protocols and setpoints - LVRT - HVRT	
	Provide settings from controller.	

4. Generic Models for Utility Scale Solar-PV generation

Description of some generic models available in PSS/E Library are provided below:

Category	Parameter Description	Data
GENERATOR model		
Solar PV (REGCA1)	Tg, Converter time constant (s)	
	Rrpwr, Low Voltage Power Logic (LVPL) ramp rate limit (pu/s)	
	Brkpt, LVPL characteristic voltage 2 (pu)	
	Zerox, LVPL characteristic voltage 1 (pu)	
	Lvpl1, LVPL gain (pu)	
	Volim, Voltage limit (pu) for high voltage reactive current manage-	
	Lvpnt1, High voltage point for low voltage active current management (pu)	
	Lvpnt0, Low voltage point for low voltage active current management (pu)	
	Iolim, Current limit (pu) for high voltage reactive current management (specified as a negative value)	
	Tfltr, Voltage filter time constant for low voltage active current management (s)-	
	Khv, Overvoltage compensation gain used in the high voltage reactive current management	
	Iqrmax, Upper limit on rate of change for reactive current (pu)	
	Iqrmin, Lower limit on rate of change for reactive current (pu)	
	Accel, acceleration factor (0 < Accel <= 1)	
Electrical Control model		
Large Solar PV : (REECB1) [Refer Block Diagrams]	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp (s), Filter time constant for electrical power	

Category	Parameter Description	Data
Electrical Control model		
Large Solar PV : (REECB1) [Refer Block Diagrams]	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	

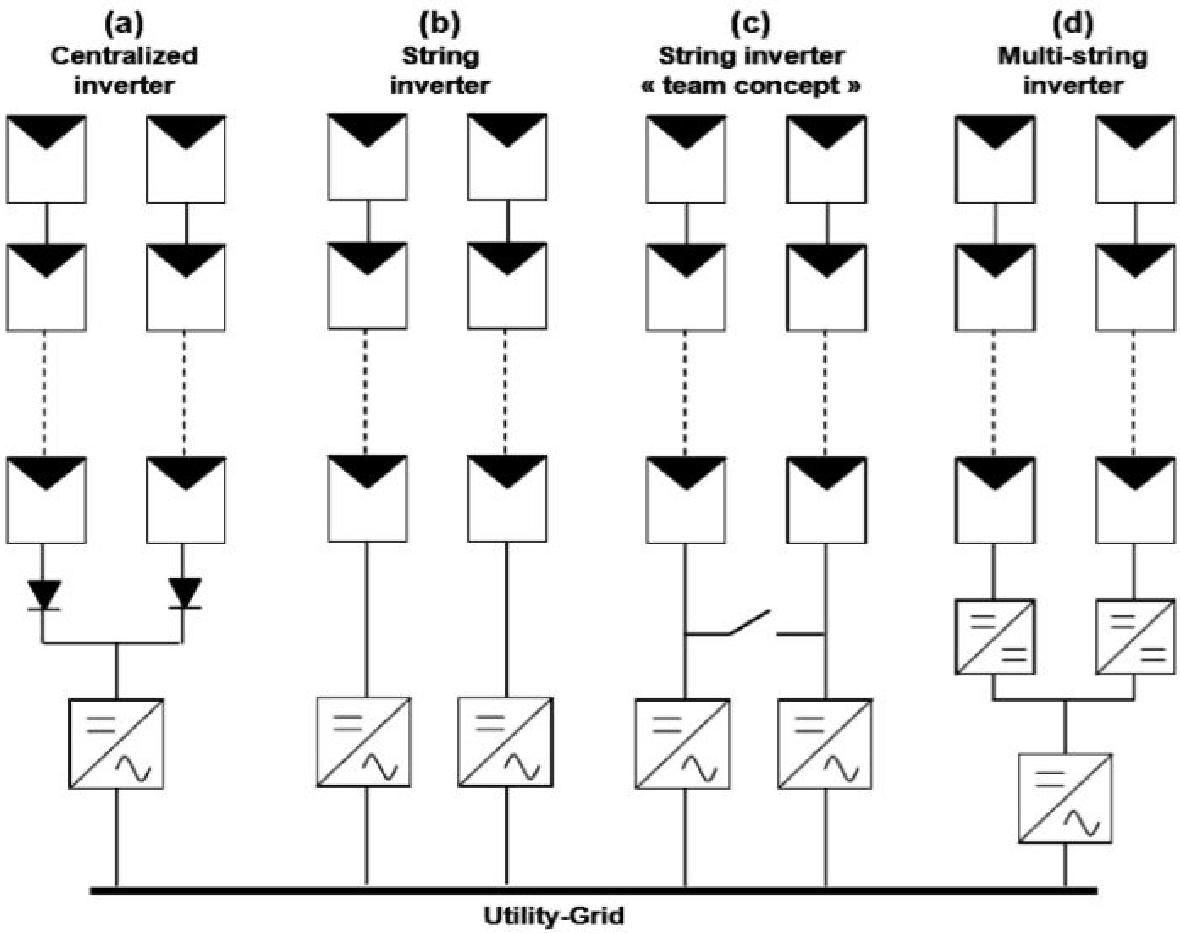
Category	Parameter Description	Data
Power Plant Controller (PPC) model		
Generic Power Plant Controller (PPC) model: (REPCA1)	Tfltr, Voltage or reactive power measurement filter time constant (s)	
	Kp, Reactive power PI control proportional gain (pu)	
	Ki, Reactive power PI control integral gain (pu)	
	Tft, Lead time constant (s)	
	Tfv, Lag time constant (s)	
	Vfrz, Voltage below which State s2 is frozen (pu)	
	Rc, Line drop compensation resistance (pu)	
	Xc, Line drop compensation reactance (pu)	
	Kc, Reactive current compensation gain (pu)	
	emax, upper limit on deadband output (pu)	
	emin, lower limit on deadband output (pu)	
	dbd1, lower threshold for reactive power control deadband (<=0)	
	dbd2, upper threshold for reactive power control deadband (>=0)	
	Qmax, Upper limit on output of V/Q control (pu)	
	Qmin, Lower limit on output of V/Q control (pu)	
	Kpg, Proportional gain for power control (pu)	
	Kig, Proportional gain for power control (pu)	
	Tp, Real power measurement filter time constant (s)	
	fdbd1, Deadband for frequency control, lower threshold (<=0)	
	Fdbd2, Deadband for frequency control, upper threshold (>=0)	
	femax, frequency error upper limit (pu)	
	femin, frequency error lower limit (pu)	
	Pmax, upper limit on power reference (pu)	
	Pmin, lower limit on power reference (pu)	
	Tg, Power Controller lag time constant (s)	
	Ddn, droop for over-frequency conditions (pu)	
	Dup, droop for under-frequency conditions (pu)	

Category	Parameter Description	Data
Electrical Control model : BESS		
Generic Electrical Control model for Utility Scale BESS: (REECCU1)	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp (s), Filter time constant for electrical power	
	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	
	Vq and Iq curve (Reactive Power V-I pair in p.u.) : 4 points	
	Vp and Ip curve (Active Power V-I pair in p.u.) : 4 points	
	T, battery discharge time (s) (<0)	
	SOCini (pu), Initial state of charge	
	SOCmax (pu), Maximum allowable state of charge	
	SOCmin (pu), Minimum allowable state of charge	

Note: SOCini represents the initial state of charge on the battery and is a user entered value. This is entered in pu; with 1 pu meaning that the batter is fully charged and 0 means the battery is completely discharged

Inverter Configurations:

Inverters within a Solar farm can be present in different configurations, as indicated below:



The data furnished must take into account the individual inverter configurations accordingly.

Document Revision History

Revision No.	Release Date	Prepared By*	Checked/Issued by*	Changes

**Mention organisation name, designation & contact details*

1) **General Information**

Name of the RE/BESS[1] plant : ……………………………………………………………………
RE/BESS Plant Capacity : ……………………………………………………………………
ISTS Connectivity Point (POI[2] Bus) Name : ……………………………………………………………………
Type of RE Plant (Wind, Solar, Hybrid, BESS) : ……………………………………………………………………
Name of RE plant Developer : ……………………………………………………………………
Name of the Consultant for Simulation Study : ……………………………………………………………………
Ambient Temperature Considered in Study : ……………………………………………………………………
Short circuit ratio (SCR) considered in Study : ……………………………………………………………………
Whether Study is Complete or Partial : ……………………………………………………………………

Part A: Plant Technical Details

2) **Technical Details**

i) **IBR[3] unit details for each make-**

Table 1: Details of IBR units in the plant

IBR Unit Details	
IBR unit type (WTG or Inverter)	
Model & Make	
No of IBR units	
Terminal Voltage	
Rated MVA	
Rated power (MW)	
Source Impedance (R, X[4])*	
Ambient temperature	
Qmax & Qmin limits (MVAR)	

**pu values on machine MVA base or %. Add columns in same table for different make IBR units in the plant.*

Include IBR unit (s) technical datasheets. Power curve, Derating curve, PQ capability curve at 0.95 pu, 1 pu & 1.05 pu voltage level & ambient temperature considered in the study.

[1] BESS- Battery Energy Storage System
[2] POI- Point of Interconnection – means a point on the grid, including a sub-station or a switchyard, where the interconnection is established between the facility of the requester and the grid
[3] IBR-Inverter based resource. An IBR unit can be the single solar inverter, single WTG or single BESS inverter.
[4] NERC's (North American Electric Reliability Corporation) following guidelines (page-36) may be referred for short circuit modelling guidelines https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_IBR_Interconnection_Requirements_Improvements.pdf#search=Reliability%5FGuideline%5FIBR%5FInterconnection%5FRequirements%5FImprovements%2Epdf

ii) **IBR unit transformer details-**

Table 2 Details of IBR transformers in the plant

IBR Unit Transformer Details	
Rating (MVA)	
Type (…………) of cooling	
Voltage Ratio (HV to LV)	
Vector Group	
Tap changer (OLTC* or other)	
Tap changer in LV side or HV side	
Total Number of taps	
Nominal Tap position	
Current Tap Position	
Impedances (r, x) in %	
Short circuit Impedance (r_0 , x_0)	
Whether IBR transformer is the part of IBR unit or separate?	

**OLTC-Online tap changing*

Include transformer data sheet and nameplate.

iii) **Power Transformer Details-**

Table 3 Details of Power transformers in the IBR plant

Power Transformer Details	
Rating (in MVA)	
Type	
Ratio (HV to LV)	
Vector Group	
Tap changer	
Tap changer (OLTC or other)	
Tap changer in LV side or HV side	
Total Number of taps	
Nominal Tap position	
Considered Tap Position	
Impedances (r,x) in %	
Short circuit Impedance (r_0 , x_0) in %	
Over load capacity (Loading at 110%, 120%, 130%, 140% & 150% with time) to be provided else include Overload capability in MVA vs time curve	

Include transformer data sheet and nameplate.

iv) **Conductor/Cable details-**

Table 4 Details of Collector system/reticulation system & EHV line details

Voltage (kV)	**From Bus**	**To Bus**	**Ckt ID**	**Length (kM)**	**Conductor Type**	**Positive***			**Zero***			**Ampacity (In Ampere, with specified AT & CT) ****	**MVA Rating**
						r_1	x_1	b_1	r_0	x_0	b_0		

**Positive & Zero Sequence impedance values in pu/ckt/km, **AT- Ambient temperature, CT-Conductor temperature.*

v) **Single line diagram (SLD) of the plant**

Single line diagram of the IBR plant showing number and location of IBR units, cable run, transformers, feeders (including type of cables and lengths), and connection to transmission system. Preferable: Electrical Single Line Diagram including details between individual IBR units and b/w IBR units and aggregation points. Include as Annexure.

vi) **Power Plant Controller (PPC) Details-**

Whether Only Master or Master with Slave PPC Configuration: Specify whether the plant having single or multiple PPC, If multiple PPCs then specify the details of master & slave PPC as below-

Master PPC OEM :
Master PPC Manual[5] :
Slave PPC-1 OEM (if applicable) :
Slave PPC-1 Manual :
Slave PPC-2 OEM (if applicable) :
Slave PPC-2 Manual :
Similarly specify for all the slave PPCs.
Specify Master PPC Control modes – Active, Reactive, frequency etc.
Specify the bus name/feeders where input to master PPC is taken for Voltage, Current, P, Q & frequency.
Specify the sampling rate of PPC input parameters measurement :
Specify whether line drop compensation is available in master PPC (Yes/No) : (whether it compensates collector system loss only or also includes EHV line loss)
Communication diagram for master/slave PPC control.

[5] Manual shall at least consist of PPC architecture, control strategies (voltage control, power factor, Q control & associated curves), configurable control & parameters, technical specification among other details

Part B: Simulation Model and Study Report Details

3) Wind/Solar/BESS/Hybrid Plant Simulation Models and Supporting Files: The simulation study report shall include the RMS & EMT model file names, supporting files, model setup procedure, model user guide, RMS & EMT software version, compiler version etc.

Type of Model	Description	File Names
RMS (Root Mean Square)	**IBR Unit Model**	
	Detailed Plant Model (including PPC model)	
	Equivalent[6] Plant Model (including PPC model)	
EMT (Electro Magnetic Transient)	**IBR Unit Model**	
	Equivalent Plant Model (including PPC model)	
	Power Quality Assessment Model	

Case preparation: Ensure line lengths, line & transformer rating (Rate-1 SIL, Rate-2 Thermal, Rate-3 110% of Thermal), short circuit parameters, Qmax & Qmin limits are updated in the model. Further, actual IBR unit bus name shall be same as OEM of the machine. Include **100 sec** flat run plot for P, Q, V at POI.

4) Simulation results showing the comparison of detailed plant model and equivalent model of the Wind/Solar farm/BESS/Hybrid - (Requirement is only for RMS model)

a) Steady state comparison of P, Q, V, I to be included at **POI**
b) Detailed v/s Equivalent model response comparison of P, Q, V & I at POI to be demonstrated for different tests like P control, Q control, Voltage control, LVRT, HVRT, frequency response control operation etc.

The error between the detailed v/s equivalent model response shall be within a tolerance band as specified by respective RLDC. Suitable measures shall be taken to minimized the error.

[6] **Recommended procedure for calculating the equivalent collector impedance -** E. Muljadi, S. Pasupulati, A. Ellis, D. Kosterev, "Method of Equivalencing for a Large Wind Power Plant with Multiple Turbine Representation", presented at the IEEE Power Engineering Society, General Meeting, Pittsburgh, PA, July 20-24, 2008.

Annexure-I (F) may also be referred for single generator equivalent model configuration.

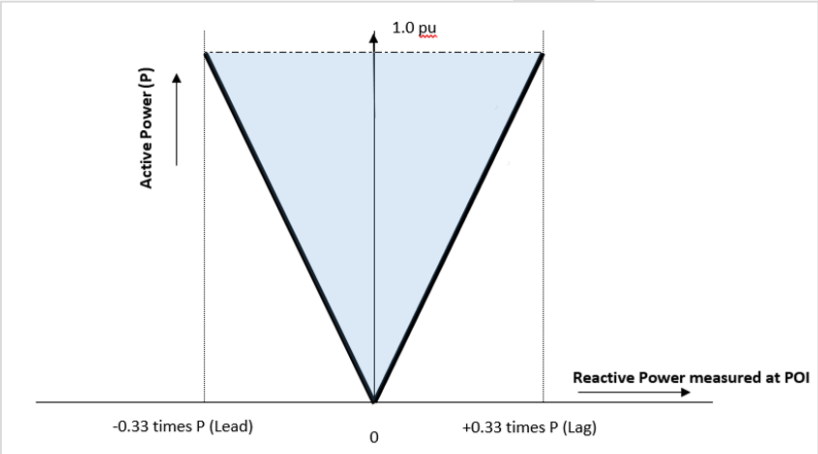
5) PQ Reactive Capability Curve plot of Wind/Solar Farm/BESS/Hybrid at POI -

a) Simulation study results/plots demonstrating PQ capability of the plant at **POI** for **0.95 pu, 1 pu & 1.05 pu voltage at POI** (factoring in specified ambient temperature) shall be included for following cases:

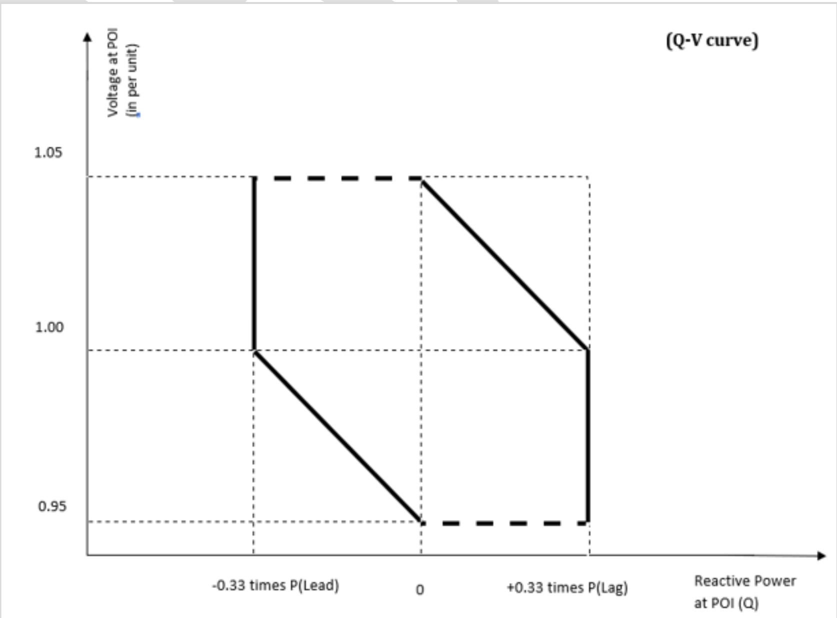
- Without any additional reactive power compensation[7]
- With additional reactive power compensation (if required for compliance of reactive power capability at POI)

  The study shall be carried out on both **detailed RMS and equivalent EMT model.**

- Generating station shall be able to deliver rated output at **POI** (at specified ambient temperature) for the above-mentioned conditions at least up to the capability shown in the PQ curve below:



- The voltage dependence of reactive power capability of RE Generator shall be governed as per the QV curve shown below:



7 **Additional dynamic Reactive Power Compensation devices** may include FACTS devices like STATCOMs additional inverter,SVG or any combination of such devices

- For all cases, the report shall include details of both active and reactive power exchange by generation pooling station with the grid at **point of interconnection (POI).**

6) Short circuit study results for 3-phase/ single phase fault at POI -
The short circuit contribution from the plant for different fault conditions **at POI** shall be tabulated.

7) Below mentioned tests shall be performed:

a) Power Quality[8] - The power quality study results **(at POI)** for the following shall be included:

i) Harmonics
ii) DC Current injection
iii) Flicker

b) LVRT Test - Plot of P, Q, Vac, Iac at POI and Plot of P, Q, Vac, Iac, Id, Iq, Vd,Vq at IBR terminal (for any one IBR of each make) shall be included for:

i) Case-1: 3-ph impedance fault at POI for 3 sec for voltage of 0.85 pu during fault
ii) Case-2: 3-ph impedance fault at POI for 1.65 sec for voltage of 0.5 pu during fault
iii) Case-3: 3-ph impedance fault at POI for 300 msec for voltage of 0.15 pu during fault
iv) Case-4: 1-ph fault at POI for 3 sec for voltage of 0.85 pu during fault
v) Case-5: 1-ph fault at POI for 1.65 sec for voltage of 0.5 pu during fault
vi) Case-6: 1-ph fault at POI for 300 msec for voltage of 0.15 pu during fault

- Above cases shall be simulated for **both full (100%) and partial (25% and 50%) active power dispatch.**
- Id, Iq, Vd and Vq are IBR output current and voltage along with reference in d-q frame. To be provided only in case of EMT model response.

- **LVRT settings** (including "K" factor), Response Time (ms) shall be mentioned in the study results.
- **Suitable margin** shall be incorporated in inverter level settings (through line drop compensation studies) to enable LVRT operation at specified voltage at POI.

c) HVRT Test - Plot of P, Q, Vac, Iac at POI and Plot of P, Q, Vac, Iac, Id, Iq, Vd,Vq at IBR terminal (for any one IBR of each make) shall be included for:

i) Case-1: 3-Phase voltage rise at POI is up to 1.2 pu for 2 sec
ii) Case-2: 3-Phase voltage rise at POI is up to 1.3 pu for 200 msec
iii) Case-3: 1-ph voltage rise at POI is up to 1.2 pu for 2 sec
iv) Case-4: 1-ph voltage rise at POI is up to 1.3 pu for 200 msec

- Above cases shall be simulated for **both full (100%) and partial (25% and 50%) active power dispatch.**
- Id, Iq, Vd and Vq are IBR output current and voltage along with reference in d-q frame. To be provided only in case of EMT model response.

- **HVRT settings** (including "K" factor), Response Time (ms) shall be mentioned in the study results.

[8] Power quality study is required to be carried out either in Detailed EMT model or in Power Quality Assessment model

- **Suitable margin** shall be incorporated in inverter level settings (through line drop compensation studies) to enable HVRT operation at specified voltage at **POI**.
- The Protection settings of 33 kV feeders, Generator PS & Dedicated Trans. Line shall be coordinated to enable HVRT compliance at **POI**. Same shall also be specified in the study results.

d) Operating Frequency Range [Frequency control flag (F_{flag}) set 0 in PPC model]

i) Case -1: Rated Active Power Generation in the frequency range of 49.5 – 50.5 Hz.

Plots of P, Q, V, f at **POI** demonstrating the ability of the plant to deliver rated active power in the frequency range of 49.5 – 50.5 Hz shall be included.

ii) Case -2: Capability to operate (stable operation) in the frequency range of 47.5 – 52 Hz.
Plot of P, Q, V, f at **POI** demonstrating the ability of the plant to operate in the frequency range of 47.5 to 52 Hz shall be included.

PPC control parameter setting shall also be specified for the above cases.

e) Frequency Response Test – Perform frequency response test with dead band of **±0.03 Hz** and droop of **both 3% and 6%** for the following cases:

i) Case-1: Step change/increase in grid frequency from 50 Hz to 50.5 Hz
ii) Case-2: Step change/decrease in grid frequency from 50 Hz to 49.5 Hz

Above cases shall be conducted for active power output of **10%, 50% and 100%** of rated active power.

PPC settings & plots of P, Q, V, f at POI shall be included for above mentioned cases.

f) Dynamic Reactive Power Support (DPRS) at POI - Perform dynamic reactive power test for the following control modes and cases:

i) Voltage Control Mode - Perform test for dead band & droop of 2%
   a) Case-1: Step increase in Voltage at **POI** from 1 pu to 1.05 pu
   b) Case-2: Step decrease in Voltage at **POI** from 1 pu to 0.95 pu

ii) Q Control Mode
   a) Case-1: Step change in Reactive Power (Q) injection at **POI** from 0 to 16.5% and subsequently to 33% of Active Power Output (P)
   b) Case-2: Step change in Reactive Power (Q) absorption at **POI** from 0 to 16.5% and subsequently to 33% of Active Power Output (P)

iii) Power factor control mode-
   a) Case-1: Step change in Power factor at **POI** from unity to +0.98 pf and subsequently to +0.95pf
   b) Case-2: Step change in Power factor at **POI** from unity to -0.98 pf and subsequently to -0.95pf

Above cases shall be conducted for active power output of **50% and 100%** of rated active power.
Plots of P, $Q_{desired}$, Q & V at **POI** along with IBR unit terminal voltage, P & Q shall be included.

g) **Ramping Capability -** Simulation test response demonstrating the rate of change of power output of the RE plant at a rate not more than +10% per minute shall be provided. The report shall include capability demonstration for both active power ramping up and ramping down scenario.

8) **Conclusion: This section shall clearly indicate the compliance status as below-**

S. No.	Simulation Test Description	Pass/Fail	Remarks
1.	Reactive Power Capability		
2.	Power Quality		
3.	Low Voltage Ride Through		
4.	High Voltage Ride Through		
5.	Operating Frequency Range		
6.	Frequency Response		
7.	Dynamic Reactive Power Support		
8.	Ramping Capability		

9) **Recommendation:**
Any parameter change, suggested setting to be kept in plant while commissioning shall be clearly indicated here like voltage, frequency, gain-parameters, Qmax, Qmin limits, active & reactive power ramp rates in IBR & PPC, droop, dead-band, polling rate coordination etc. or any other setting which require modification during commissioning.

10) **Guidelines for Simulation Studies –** The specified simulation tests shall be carried out on the simulation models mentioned below:

S. No.	Simulation Test Description	Simulation to be carried out on:
1.	Reactive Power Capability	Both - Detailed RMS and Equivalent EMT Model
2.	Power Quality	Detailed EMT / Power Quality Assessment Model
3.	Low Voltage Ride Through	Detailed and Equivalent RMS and Equivalent EMT Model
4.	High Voltage Ride Through	Detailed and Equivalent RMS and Equivalent EMT Model
5.	Operating Frequency Range	Both - Equivalent RMS and EMT Model
6.	Frequency Response	Both - Equivalent RMS and EMT Model
7.	Dynamic Reactive Power Support	Both - Equivalent RMS and EMT Model
8.	Ramping Capability	Both - Equivalent RMS and EMT Model

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