

Battery Energy Storage Model Validation

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Together, Building
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BESS Model Validation

BESS should meet reliability requirements in both discharging and charging modes.

Power flow model

- MVA base is the sum of the individual MVA nameplate rating of the inverters
- Pmax is the maximum active power output from the equivalent generator to achieve contractual MW at POI
- Pmin is the maximum charging MW of BESS
- Meets ± 0.95 power factor requirement at the high side of the station transformer
- Base Load Flag (BL) = 0: provides both up and down frequency response
BL = 1 or 2 (NOT meet requirement)



BESS Model Validation

Dynamic model

Complete dynamic models should include models in below table.

Description	Model Name	Applicability Notes
Converter	regc_a	All IBR
Electrical control	reec_a	Type 3 and 4 WTG Solar PV DC-coupled BESS not charging from grid
	reec_c	Stand-alone BESS DC-coupled BESS charging from grid
Plant controller	repc_a	For single generator control
	repc_b	For multiple generator control
Ride-through protection	lhvrt	Voltage ride-through
	lhfrt	Frequency ride-through

Primary Frequency Response

	BL	frqflag	ddn	dup	fdbd1	fdbd2
Up and down regulation	0	1	>=20	>=20	[-0.0006,0)	(0, 0.0006]



BESS Model Validation

Dynamic model

Acceptable Reactive Control Settings

REEC			REPC	Notes	
pfflag	vflag	qflag	refflag	Mode	Meets Requirements
0	N/A	0	0	Plant Q	No
0	1	1	0	Plant Q and Local Q/V	Yes
0	N/A	0	1	Plant V	Yes
0	1	1	1	Plant V and Local Q/V	Yes
0	N/A	0	2	Plant PF	No
0	1	1	2	Plant PF and Local Q/V	Yes

CAISO requires IBR to provide reactive support in low voltage event:

pqflag should be 0 in reec model, i.e. Q-priority control. Ways to meet the requirement –

- a) Use voltage dip logic: vdip between 0 and 1.0 (typically 0.9), vup between 1.0 and ~1.2 (typically 1.1) and kqv \geq 2; or
- b) If voltage dip logic is disabled, qflag=1 and kvp \geq 2

Check VDL1 in reec model and make sure iq limit is at least 1.0 p.u. for low voltage.



BESS Model Validation

BESS will be tested at both max discharge and charge modes.

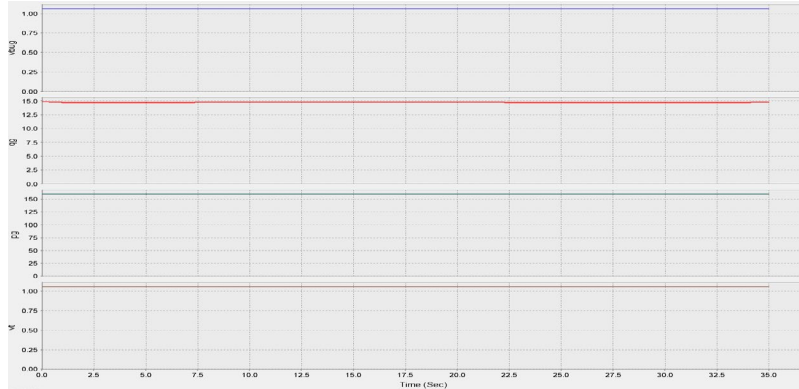
Flat run: 35 seconds.

Bump run:

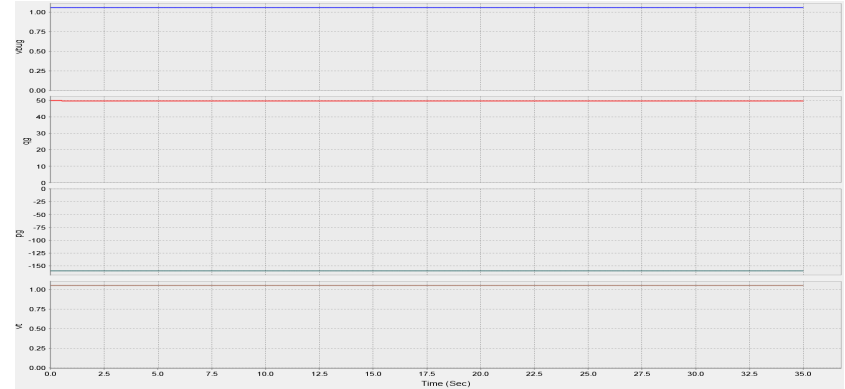
To avoid false tripping:

- 3 phase fault at the 500 kV bus closest to POI. Too close to the inverter terminal may cause numerical issue (voltage or frequency spike) and false tripping.
- Set LHFRT model to alarm only mode.

Discharging Flat Run



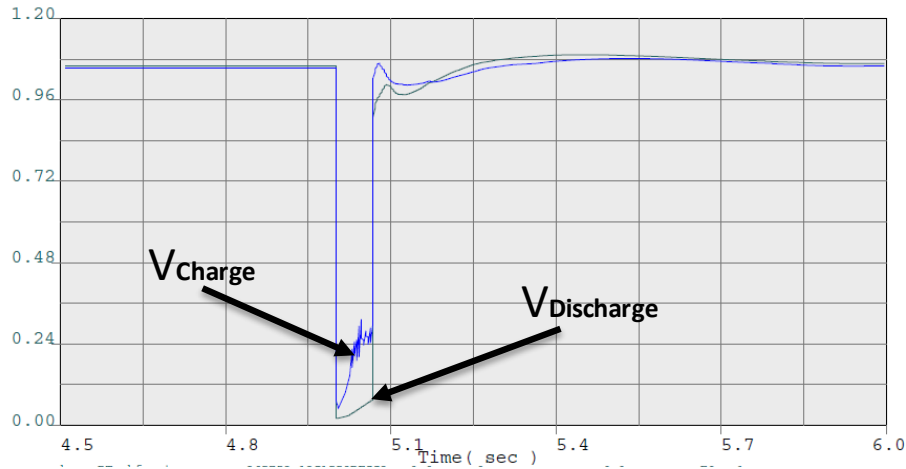
Charging Flat Run



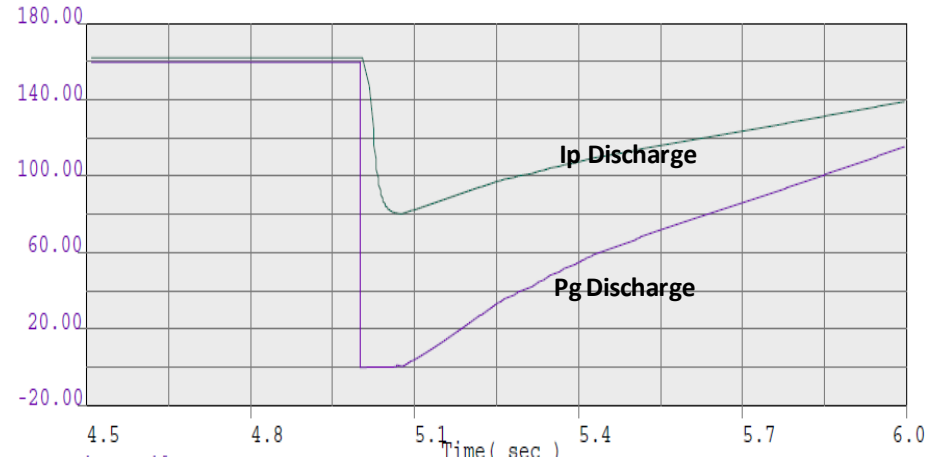


BESS Model Validation

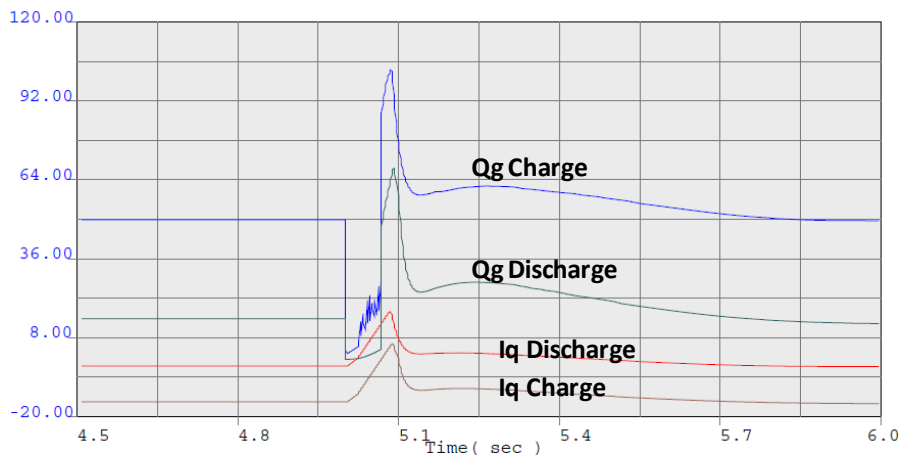
Discharging and Charging Terminal V



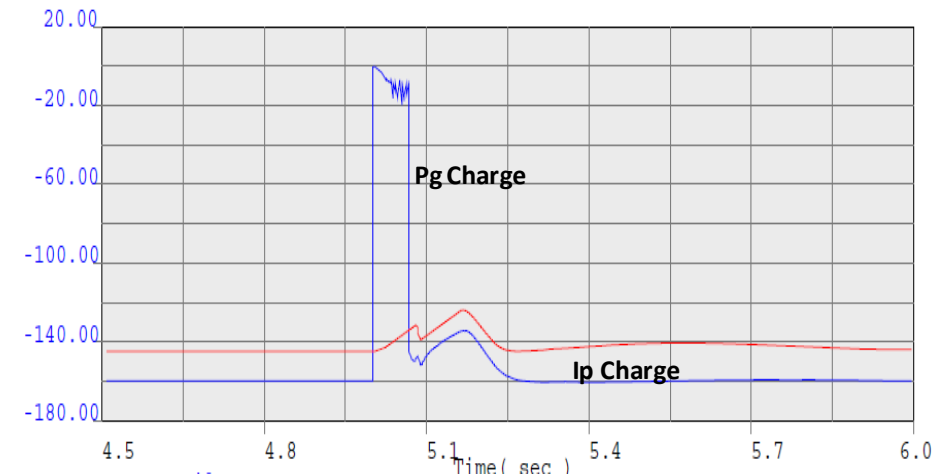
Discharging Pgen, Ip



Discharging and Charging Qgen, Iq



Charging Pgen, Ip





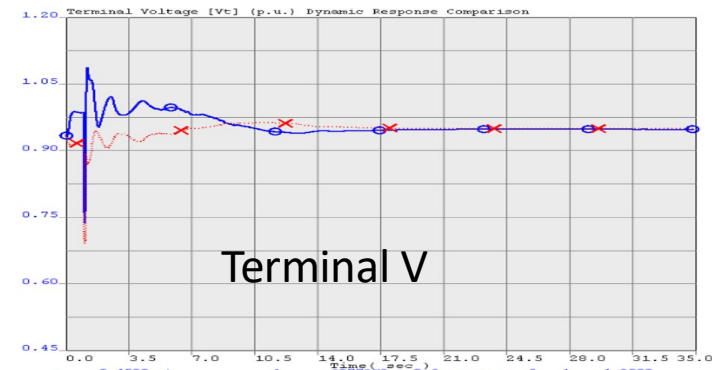
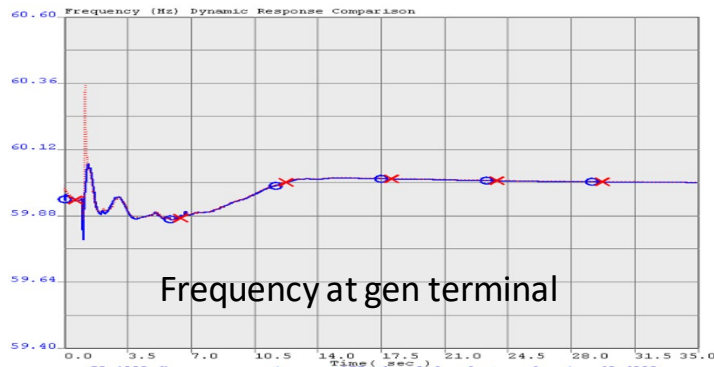
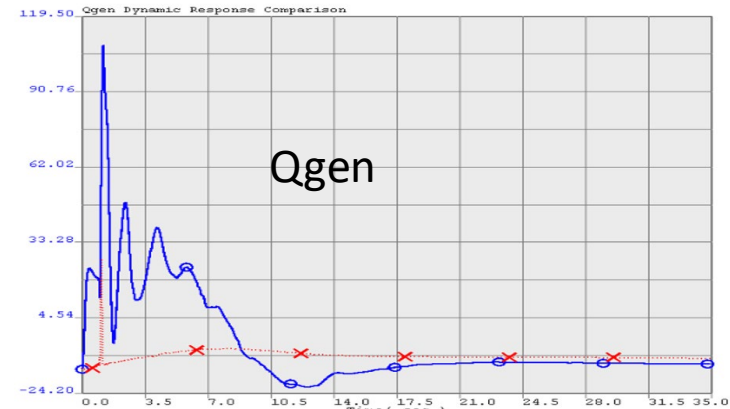
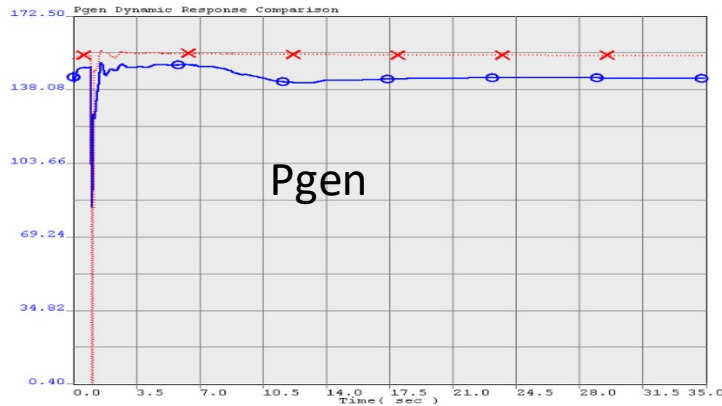
BESS Model Validation

PG&E current practice has a tool to generate lot comparison between Original and New models. It helps in trouble shooting to certain extend.

Solar PV MOD026 testing:

Blue: Original Plant V control, reec_a: "dbd1" -0.05 "dbd2" 0.05, "qmax" 1.0 "qmin" -1.0

Red: New Plant Q and Local Q/V, reec_a : "dbd1" -0.10 "dbd2" 0.10, "qmax" 0.53 "qmin" -0.53

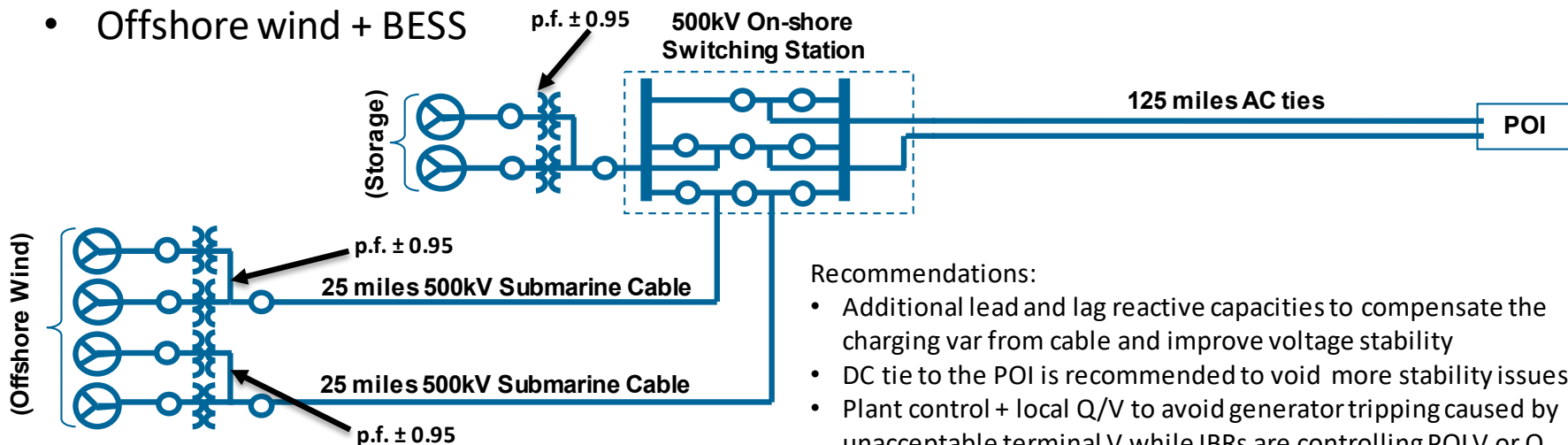


Hybrid Plant Validation

- Scenarios to be tested?

	Test Scenario			
BESS Pgen	Pmax	Pmin	Pmin	0
PV/Wind Pgen	0	0	Pmax	Pmax

- Offshore wind + BESS



Recommendations:

- Additional lead and lag reactive capacities to compensate the charging var from cable and improve voltage stability
- DC tie to the POI is recommended to void more stability issues
- Plant control + local Q/V to avoid generator tripping caused by unacceptable terminal V while IBRs are controlling POI V or Q