WECC

Underfrequency Load Shedding Review Group (UFLSRG) Report

Peter Mackin, Chair StS

July 17, 2018

Responsibilities

Charter:	Biennially review the Plan's consistency with the requirements of NERC Standard PRC-006.
	Review the submitted UFLS data for consistency and accuracy of modeling (annually per PRC-006).
	Conduct biennial simulations of the Plan to assess consistency with the performance requirements of NERC Standard PRC-006.
	Collaborate with all applicable entities to develop an annual report of the findings of the review and simulations.

Activities: Consistency with PRC-006

- WECC Plan:
  - For imbalances up to 25%
  - Arrest frequency decay before 58 Hz
  - Prevent frequency overshoot above 61 Hz
  - Restore frequency to 59.5 – 60.5 Hz

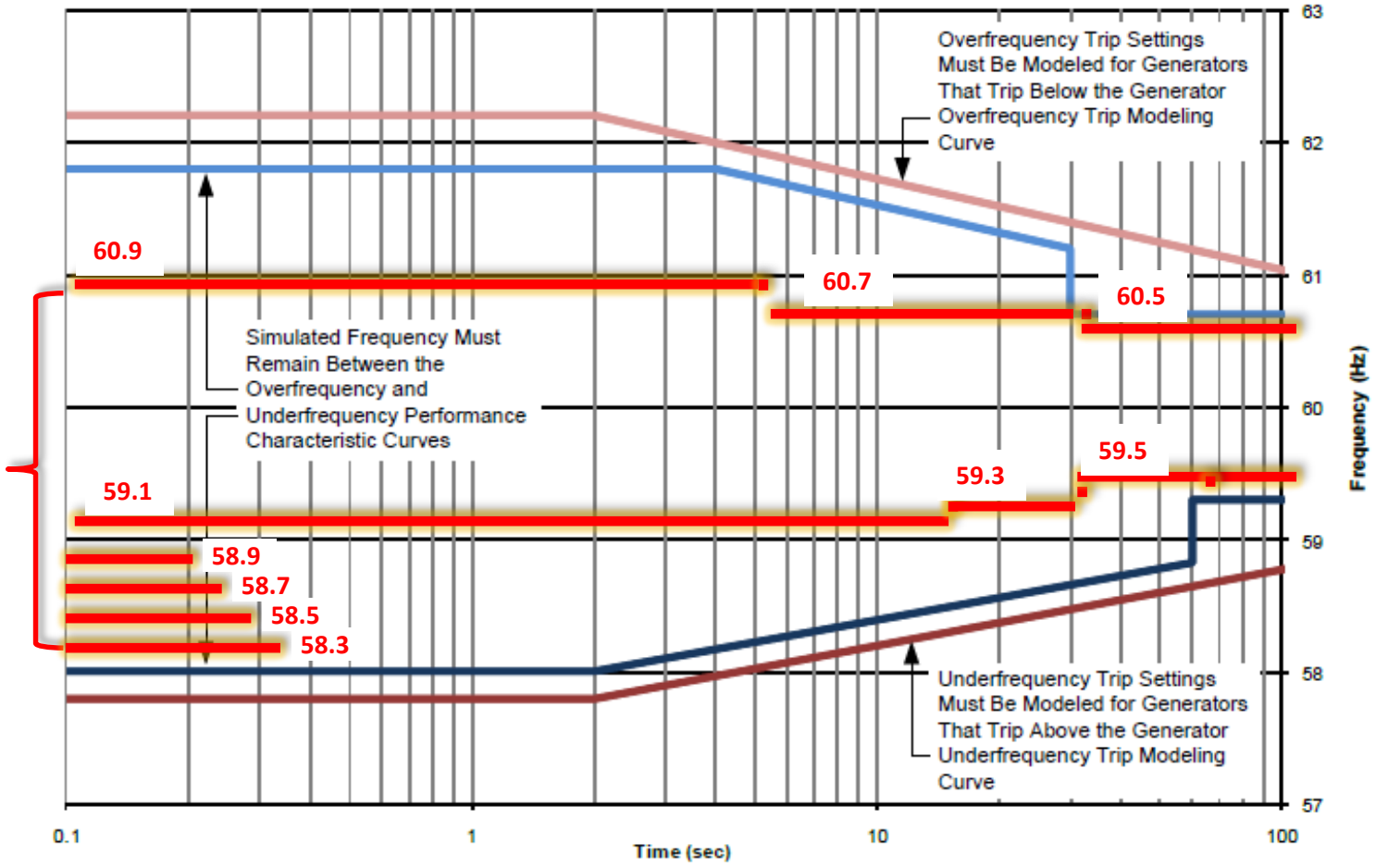
- PRC-006:
  - For imbalances up to 25%
  - Maintain frequency within performance curves

Overfrequency Performance Characteristic		
$t \leq 4$ s	4 s < t ≤ 30 s	t > 30 s
f = 61.8 Hz	f = -0.686log(t) + 62.21 Hz	f = 60.7 Hz

Underfrequency Performance Characteristic		
$t \leq 2$ s	2 s < t ≤ 60 s	t > 60 s
f = 58.0 Hz	f = 0.575log(t) + 57.83 Hz	f = 59.3 Hz

PRC-006 Performance Curves

WECC Plan 1a



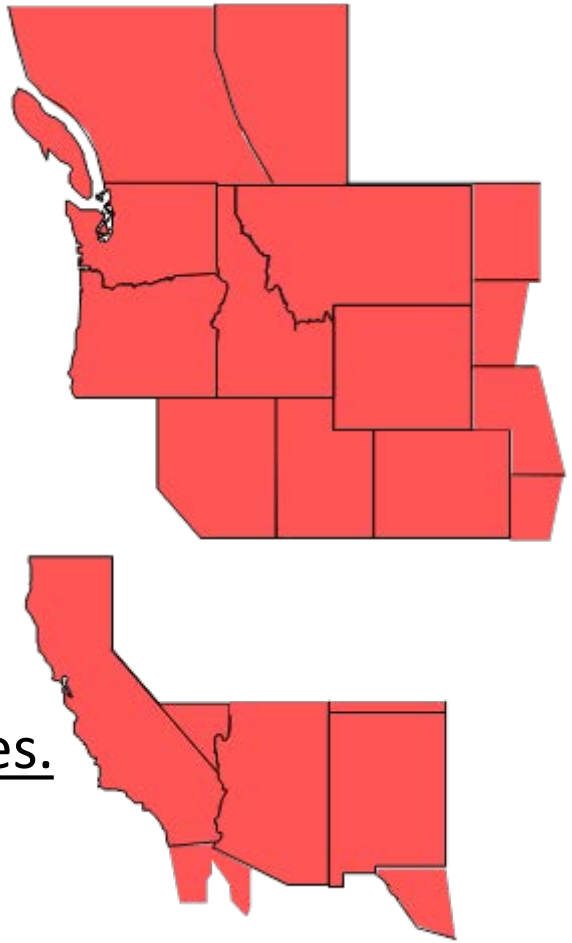
Conclusion: the WECC Plan is consistent with the requirements of PRC-006

Activities: Simulations

Three Island Scenarios.

(*2017HS post-separation MW shown)

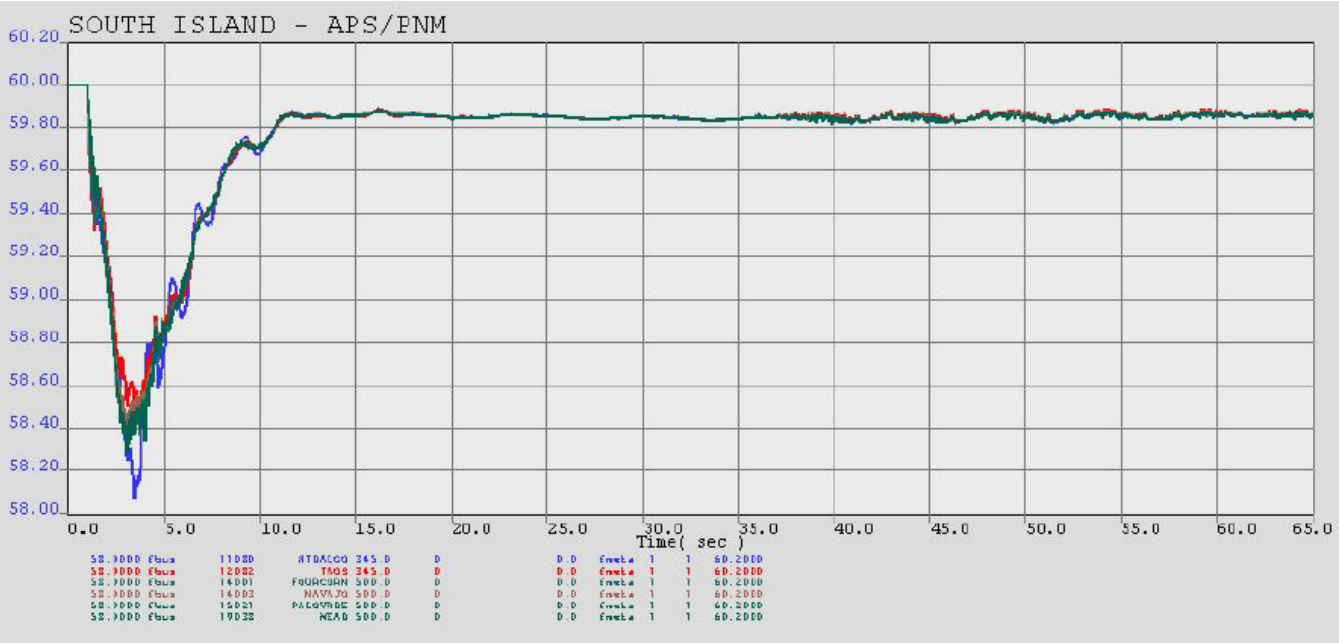
Island	Generation (MW)	Load (MW)	25% Imbalance (MW)
WECC	178,445	172,453	43,113
North*	83,052	80,369	19,661
South*	101,206	96,962	24,228



2017 Heavy Summer and Heavy Spring cases.

Results

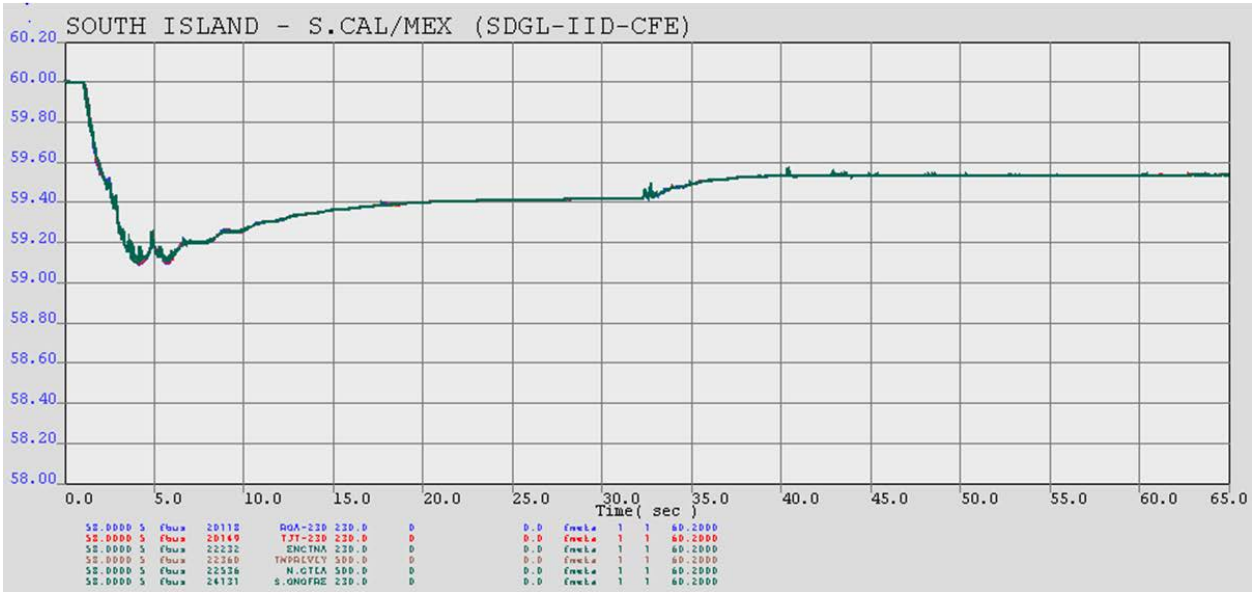
- Ignoring the effects of Distributed Generation (DG), the WECC Plan sufficiently arrested frequency decline following a 25 percent load and generation imbalance scenario.
- Frequency stabilized above 59.5 Hz in all simulations.



WECC Island Scenario – Arizona Region (south island busses) frequency performance for a 25 percent generation loss scenario in the heavy summer case for the WECC Island.

Results: Frequency Stalling

- Under frequency stalling.



Southern California / Mexico Region frequency following a 15 percent loss of generation. South Island scenario.

Activities: Simulations

Distributed Generation Sensitivity:

- WECC Island
- New CMPLDWG model
- Two sets of simulations.
- Everything held constant except:
  - DG tripping per IEEE 1547-2003, or
  - DG tripping per PRC-024

	Frequency below which DG starts to be tripped (Hz)	Frequency below which all DG is tripped (Hz)
DG: PRC-024	57.8	57.5
DG: IEEE 1547-2003	59.3	59

DG frequency protection simulations

Standard	Underfrequency Range (Hz)	Clearing Times (sec)
IEEE 1547-2003 (DG ≤ 30 kW)	< 59.3	0.16
IEEE 1547-2003 (DG > 30 kW)	≤ 59.8	0.16 - 300
	< 57.0	0.16
IEEE 1547a-2014	< 59.5	2 - 300
	< 57	0.16
PRC-024	≤ 59.4	180
	≤ 58.4	30
	≤ 57.8	7.5
	≤ 57.3	0.75
	≤ 57	inst.

DG frequency protection standards

Activities: Simulations

Distributed Generation Sensitivity:

- DG penetration levels: Northern Areas

Area Number	Area Name	Original Generation in WECC Island (MW)	Total Connected Load in WECC Island (MW)	DG Penetration (%)	DG Penetration (MW)
40	NORTHWEST	30,829	24,952	2%	499
50	B.C.HYDRO	11,480	8,028	1%	80
52	FORTISBC	613	779	1%	8
54	ALBERTA	10,745	10,909	1%	109
60	IDAHO	2,380	3,693	2%	74
62	MONTANA	3,067	1,870	2%	37
63	WAPA UGP	52	(45)	2%	(1)
64	SIERRA	2,411	2,270	5%	113
65	PACE	11,091	9,628	2%	193
70	PSCOLORADO	7,855	8,188	8%	655
73	WAPA R.M.	6,495	5,269	5%	263
North Island Sub-Total:		87,018	75,541	3%	2,031

Activities: Simulations

Distributed Generation Sensitivity:

- DG penetration levels: Southern Areas

Area Number	Area Name	Original Generation in WECC Island (MW)	Total Connected Load in WECC Island (MW)	DG Penetration (%)	DG Penetration (MW)
10	NEW MEXICO	3,180	2,856	10%	286
11	EL PASO	1,293	1,860	15%	279
14	ARIZONA	24,373	19,943	25%	4,986
18	NEVADA	6,252	6,449	15%	967
20	MEXICO-CFE	2,607	2,637	2%	53
21	IMPERIALCA	1,701	1,006	6%	60
22	SANDIEGO	4,648	4,657	20%	931
24	SOCALIF	14,661	22,963	20%	4,593
26	LADWP	4,867	6,746	25%	1,687
30	PG AND E	27,846	27,795	20%	5,559
South Island Sub-Total:		91,427	96,912	20%	19,400

Activities: Simulations

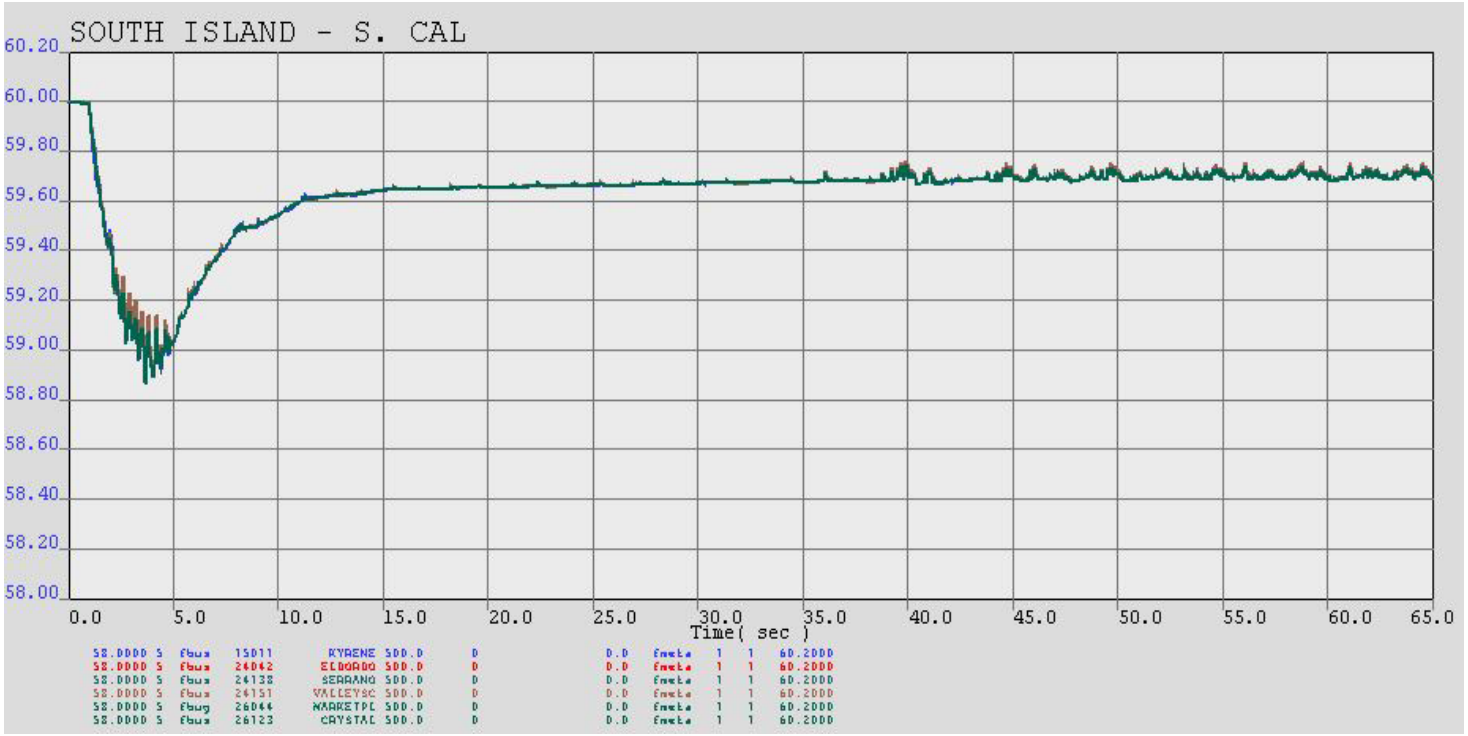
Distributed Generation Sensitivity:

- DG penetration levels: WECC Total

		Original Generation in WECC Island (MW)	Total Connected Load in WECC Island (MW)	DG Penetration (%)	DG Penetration (MW)
Total:		**178,445**	**172,453**	**12%**	**21,432**

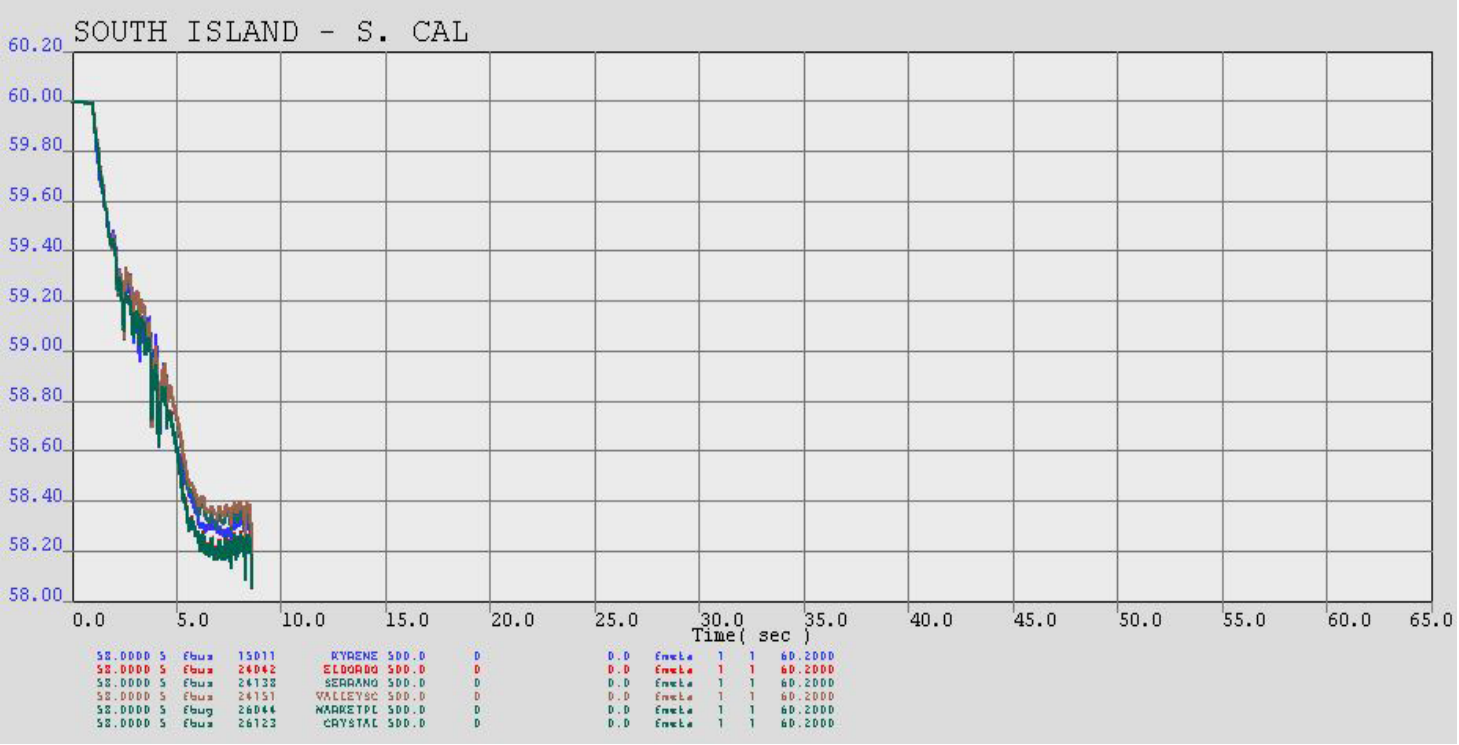
Results: Frequency Stalling

- 15% imbalance simulation with DG programmed to trip per PRC-024.



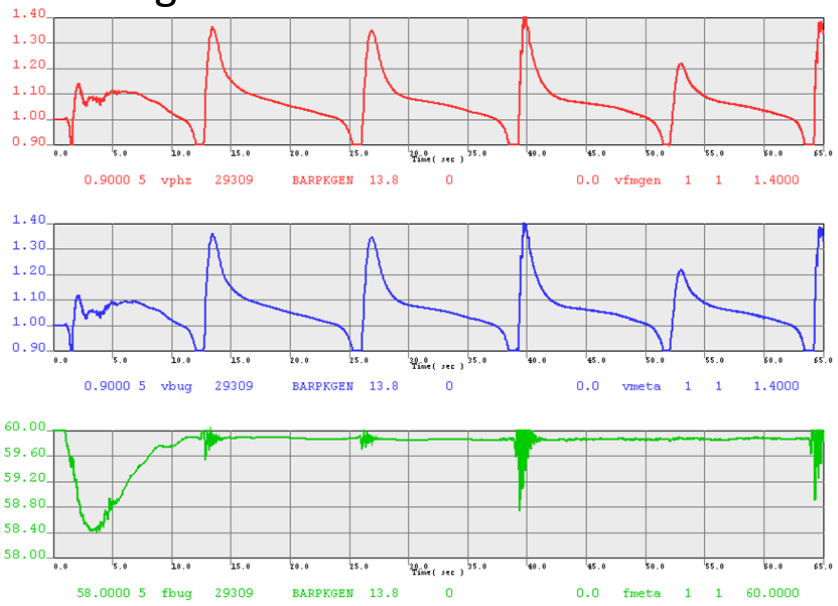
Results: DG Simulations

- 15% imbalance simulation with DG programmed to trip per IEEE 1547-2003.



Results: V/Hz

- PRC-006-2 D.B.3.3:
  - "Volts per Hz (V/Hz) shall not exceed 1.18 per unit for longer than two seconds cumulatively per simulated event, and shall not exceed 1.10 per unit for longer than 45 seconds cumulatively per simulated event at each generator bus and generator step-up transformer high-side bus associated with…"
- V/Hz was monitored in both the summer and spring cases
- A significant number of violations were attributed to incorrect model performance or capacitors remaining switched on.



Results: V/Hz

- In the end, there were still 53 V/Hz violations with no obvious mitigating factors.
- At this time, the analysis cannot demonstrate the system performs as required by PRC-006 D.B.3.3.

Recommendations

1. Continue vetting the UFLS Database.
2. Investigate noisy generator models (Appendix L).
3. Confirm the 80 capacitors that were assumed to trip when voltage exceeded 1.1 p.u. actually will.
4. Investigate the 53 unresolved V/Hz violations.
5. Validate the under frequency tripping performance of the CMPLDWG model.
6. Determine more accurate assumptions for DG penetration levels.
7. Study the operation of WECC RAS-1, including the impacts of high DG penetration levels.
8. Continue to incorporate the impacts of DG in the UFLS Plan studies.

Leadership

- Chair: Chris Pink, Tri-State G&T
  - February 2014 – present
- Vice Chair: Gary Keenan, Northwest Power Pool
  - April 2017 – present

- Previous Chair: Jerry Rust, Northwest Power Pool
  - 2008 - 2014

- Recommendation:
  - Recruit a new chair
    - Registered as a PC
    - Not from NWPP or TSGT

Questions?