Battery Charging Program
PowerWorld User Group Meeting

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Agenda

- Contributors
- Background
  - Need for Program Update
- Enhanced Battery Charging Program
  - Features
  - GUI / Results Snapshots
  - Benchmarking

Contributors – Thank You!

Name	Contribution(s)
Amos Ang	Team lead, coded core algorithm in Python, troubleshoot code identified by members, provided some training on use of Python and PowerWorld
Wesley Bellin	Code Tester
Justin Toledo	Code Tester/Benchmarking
Yun Han	Created the GSF* methodology, Directory/File error logs, Code Tester, Benchmarking
Xavier Sosa	Created the GSF methodology, set up the summary sheet templates, Code Tester/Benchmarking
Elijah Fernandez	Code Benchmarking
Lionel Olivares	Created the GSF methodology

*Generation Shift Factor(GSF)

Battery Charging Program Background

- Addresses issue that batteries need to be studied from an as-available perspective
- Discharge impacts was determined via the same generation interconnection process and upgrades associated with it
- Determine the charging schedule for the entire year so that it will not cause issues to the 66 or 115 kV SCE system. CAISO will not monitor and change the schedules of batteries with market because it is classified by FERC as a distribution system.
- 1st version of the program is written in collaboration with Jorge Chacon (Senior Manager) in the GE's PSLF EPCL
- Takes in an 8,760-hour profile from Re-Grid and converts it to 288-hour profile
- 8760-hour profile ->highest loading in month per hour->288-hour profile
  - 288-hour profile is a conservative assumption, and 8760-hour profile took too long to process in PSLF program
- Runs the power flow to re-dispatch the battery so that the monitored line will be 95% of the rating (normal or emergency)
- Base case used is one with the outage line already taken

Battery Charging Program Update Needed

- Update the program so that it can evaluate multiple batteries charging in the 66 or 115 kV network because many systems are getting more than one battery in these systems
- Previous tool was written to consider only one battery per system with one base case already having the outage taken
- Run manually for multiple batteries can take days for each sub-transmission system so automated version is needed
- Monitor voltages for the runs

Battery Charging Updated Program Features

- Program was revised from EPCL to Python
- Python code doesn't need to be edited (Users edit parameters in Excel)
- 8760-load profile can now have more than 15 loads per file(PSLF restriction)
- Process multiple batteries for multiple outage and monitored lines
- Able to run an 8760-load profile or a 288-load profile
- Uses one executable, no need to install Python for end users
- Base case doesn't need to have the outage line(s) taken out beforehand
- Dispatch batteries based on thermal limitations and monitors lowest voltage
- Multiple batteries are processed by the Generation Shift Factor algorithm developed in house
- Summary tables are exported to the Excel sheet with the settings to keep results in one file

Python Code Steps (meat of the program)

- After data is imported
- Take the first outage (if needed)
- Run PowerWorld and load 1st set of loads
- Calculate the generation shift factor (GSF) by:
  - Looking at the changes on the monitored element when battery one is turned off
  - The change in amps is divided by the size of the battery – this is the GSF
  - Repeat for other batteries
- Redispatch batteries if monitored element is above 95% of the rating
  - Redispatch first by turning off all the batteries and check the monitored element. Increment each battery by 1/GSF up to when the monitored element is at 95% of the rating
- Monitor the lowest voltage in the case
- Rinse and repeat for the next 287 or 8759 loads
- Output to starting Excel file results

Files and Attributes Needed to Run the Program

- Python code (Executable)
- 8760 Load Profile from Re-Grid File
  - Need to have unique bus number for each load in the system
- PowerWorld Simulator Base Case
  - Batteries are turned on
  - Batteries have a Pmin value greater than zero
  - “Monitored Element(s)” (line or transformer) need to have normal and emergency ratings
- Excel Sheet template
  - File names are entered correctly
  - Equipment is existing and correctly defined

Battery Charging Program Excel Snapshot

File Settings	
Base Case File Name	3Batteries_Rector_Aug.pwb
Base Case Path Location	C:\\work\\Battery_Charging\\
Profile File Name	2026_CPL.dat
Profile File Path Location	C:\\work\\Battery_Charging\\
Output File Name	(Option to remove if Excel output is sufficient)
Output File Path Location	(Option to remove if Excel output is sufficient)

Settings	
% Limit	95
Voltage Limit (p.u.)	0.95
System voltage (66 or 115 kV)	66
System Load / Swing Bus #	24235
Peak Start Time (0-23)	6
Peak End Time (0-23)	21
Profile Used 288 or 8760	288
Area (empty unless large case)	
Zone (empty unless large case)	

Battery Charging Program Excel Snapshot (cont.)

	Outage Element(s)				Monitored Element(s)			Rating Used
Set	From Bus #	To Bus #	CKTID		From Bus #	To Bus #	CKTID	1 for Normal; 2 for Emergency
1	24212	95153	2	Paired with	95133	95137	1	1
2	0	0	0	Paired with	95131	95115	1	2
3	1	1	1	Paired with				
4	2	2	2	Paired with				
5				Paired with				
6				Paired with				
7				Paired with				
8				Paired with				
9				Paired with				
10				Paired with				
11				Paired with				
12				Paired with				
13				Paired with				

Simulation Results

	Month	Hour	System Load	LineMW	LineMvar	LineAmps	LinePCT	Charging Batt 95116	Charging Batt 95154	Charging Batt 99028	Update System Load	New LineMW	New LineMvar	New LineAmps	New LinePCT	Low Bus	kV
0	Jan	0:00	594.97	58.24	11.18	507.39	93.55	55	120	80	594.97	58.24	11.18	507.39	93.55	95154	65.99985
1	Jan	1:00	583.13	57.74	10.72	502.49	92.65	55	120	80	583.13	57.74	10.72	502.49	92.65	95154	65.99986
2	Jan	2:00	574.95	57.63	10.46	501.16	92.4	55	120	80	574.95	57.63	10.46	501.16	92.4	95154	65.99986
3	Jan	3:00	572.4	57.6	10.39	500.73	92.32	55	120	80	572.4	57.6	10.39	500.73	92.32	95154	66.00053
4	Jan	4:00	576.3	57.71	10.51	501.89	92.54	55	120	80	576.3	57.71	10.51	501.89	92.54	95154	65.99986
5	Jan	5:00	590.72	57.98	10.91	504.83	93.08	55	120	80	590.72	57.98	10.91	504.83	93.08	95154	65.99985
202	Sept	10:00	928.14	72.09	26.14	657.99	121.32	22.7	171.7	80	953.69	56.09	20.6	515.12	94.98	95114	63.8828
203	Sept	11:00	984.11	73.21	28.61	675.17	124.49	21.2	157.9	80	991.14	55.56	21.81	515.14	94.98	95114	63.64027
204	Sept	12:00	1017.42	74.03	31.08	690.56	127.33	20.8	147.5	80	1010.61	55.28	22.44	515.17	94.99	95114	63.58849
205	Sept	13:00	1074.76	75.55	30.17	710.11	130.93	18.6	134.2	80	1047.63	54.57	23.89	515.11	94.98	95114	63.25842
206	Sept	14:00	1099.94	75.86	29.71	715.97	132.01	17.9	129.2	80	1065.27	54.18	24.69	515.15	94.98	95114	62.94634
207	Sept	15:00	1132.89	76.57	29.19	726	133.86	16.9	122.6	80	1087.76	53.84	25.34	515.17	94.99	95114	62.84218
208	Sept	16:00	1129.62	75.06	29.58	710.79	131.06	18.3	129.9	80	1096.17	53.7	25.54	514.92	94.94	95114	62.68192
209	Sept	17:00	1110.45	74.36	29.94	702.3	129.49	19	135.4	80	1085.61	53.88	25.26	515.18	94.99	95114	62.70154
241	Nov	1:00	598.24	60.16	12.3	525.27	96.85	47.4	180	80	659.1	58.79	12.49	514.57	94.88	95112	65.99912
242	Nov	2:00	589.6	59.82	11.97	521.88	96.22	48	180	80	651.07	58.82	12.37	514.59	94.88	99028	66
243	Nov	3:00	589.06	59.67	11.9	520.54	95.98	48.2	180	80	650.8	58.82	12.37	514.59	94.88	99028	66
244	Nov	4:00	594.91	59.64	12.05	520.49	95.97	48.2	180	80	656.7	58.78	12.53	514.56	94.87	99028	66
245	Nov	5:00	611.81	59.91	12.42	523.49	96.52	47.7	180	80	673.12	58.72	12.75	514.56	94.87	95112	65.99396
246	Nov	6:00	635.27	60.42	13.14	529.12	97.56	46.6	180	80	695.66	58.62	13.16	514.57	94.88	95112	65.98213

Battery Charging Updated Program Results Benchmarking

- Moorpark System (288 total results)
  - 264 battery charging results were within less than 1 MW difference for output of the battery being studied
  - 22 battery charging results were more than 1 MW (1 to 2.5 MW) due to different solution tolerances between programs
  - 2 didn't solve in PSLF but solved in PowerWorld
- Goleta System (288 total results)
  - 262 battery charging results were within less than 1 MW difference between the programs
  - 26 battery charging results were more than 1 MW difference and it is due to program staying below 95% of line loading

Battery Charging Updated Program Run Time Benchmarking