Case Preparation for Studies

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SERC

Overview

Initial Case

Solution Parameters

Solve Settings

Basic Solution Check

Data Checks

TARA Studio

TARA

PUBLIC

Initial Case: Choosing the Right Format in PSSE

SAV Format

Use when the study needs a repeatable operating point.

Preserves fully converged voltages, angles, dispatch, flows, and control settings. This ensures engineers start the analysis from the exact same solved state, eliminating initialization discrepancies.

RAW Format

Use when sharing or editing the power-flow model.

Contains clean, plain-text network topology data rather than the converged system state. Best for cross-platform model transfer, manual parameter editing, and direct topology adjustments.

Key Takeaway: Use .SAV for repeatable analysis from a known solved case. Use .RAW for flexible model transfer, making sure to solve and validate the system state before comparing results.

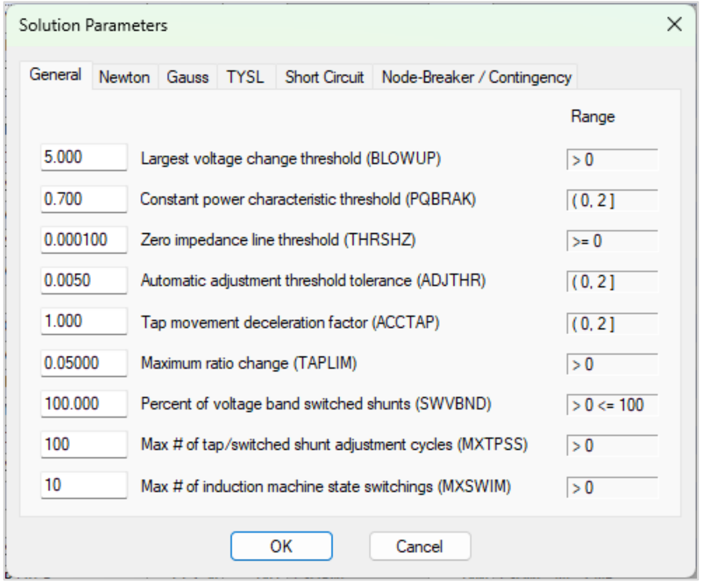
Solution Parameters in PSSE

Refer to the MMWG Manual on the ERAG website

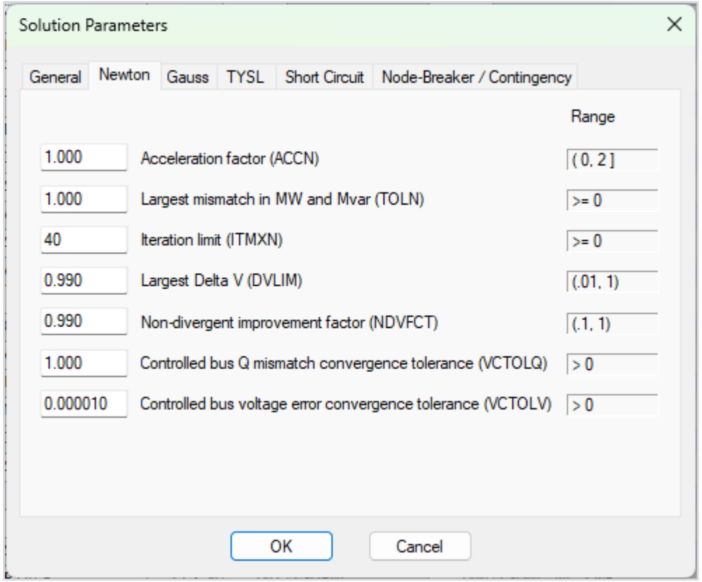
[ERAG | Eastern Interconnection | MMWG | Reliability Assessment]

Typical solution parameters settings utilized in the MMWG cases

General Solution Parameters



Newton Solution Parameters



Solve Settings: Area Interchange Control in PSSE

Tie Lines and Loads

Solves net interchange by factoring in both physical boundary tie lines and cross-area load assignments to correctly calculate Area Swing Bus generation.

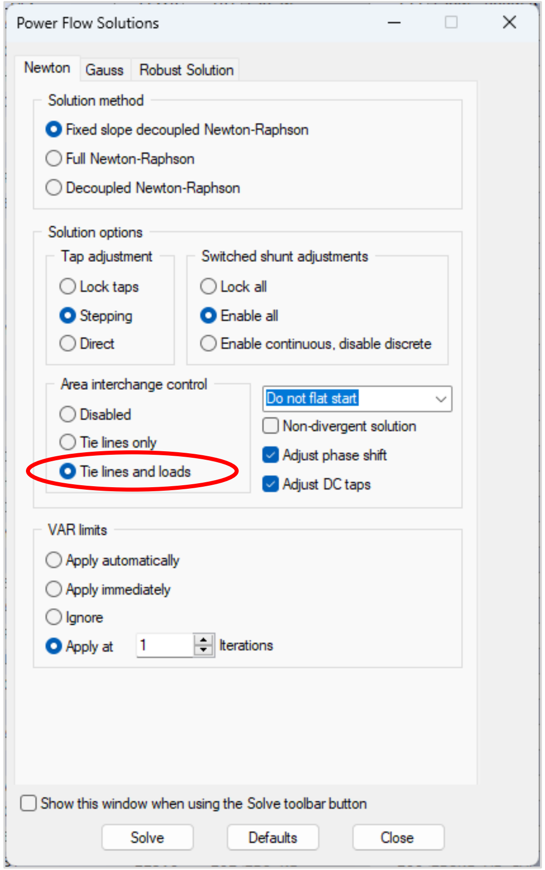
Used for creating cases

Disabled

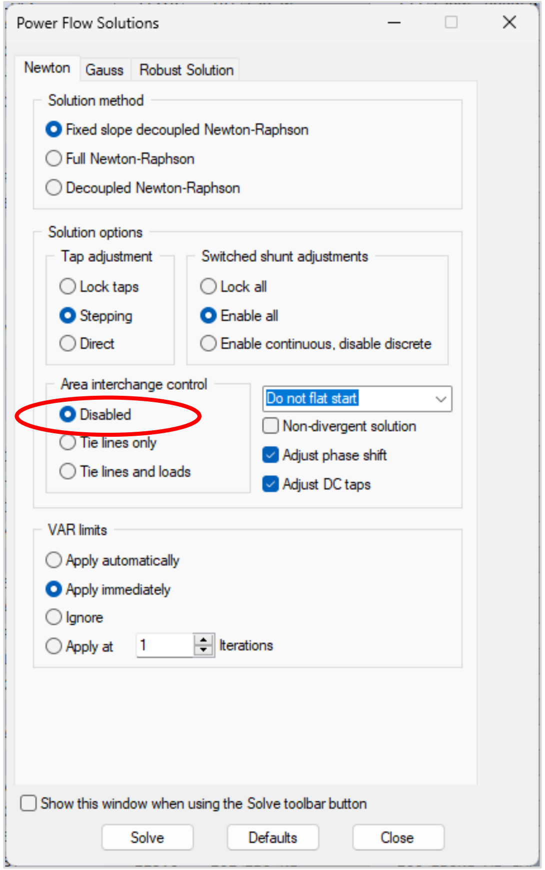
Suspends area interchange constraints, allowing the global swing bus to absorb mismatches and grid physics to dictate boundary line flows.

Used in transfer analysis

Tie Lines and Loads



Disabled



Solve Settings: VAR Limits in PSSE

Apply at 1 Iteration

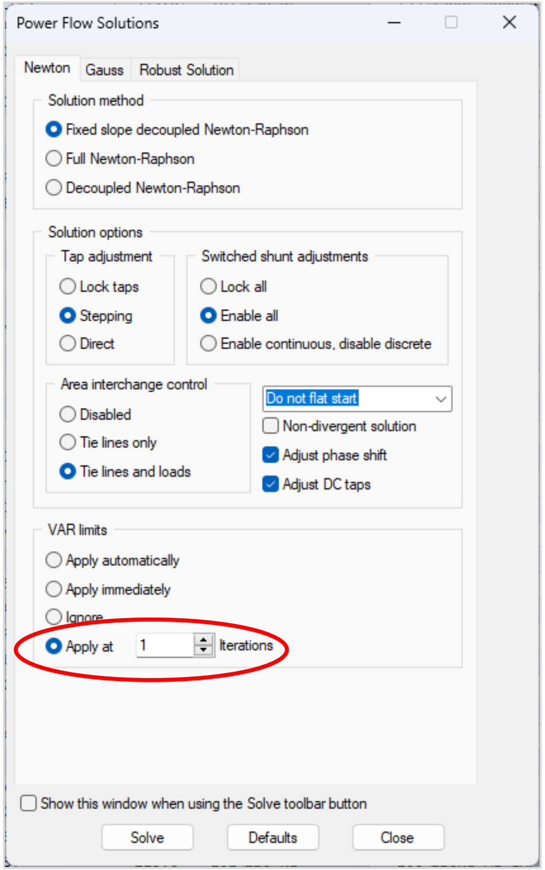
A standard setting for general power flow planning.

MMWG standard practice

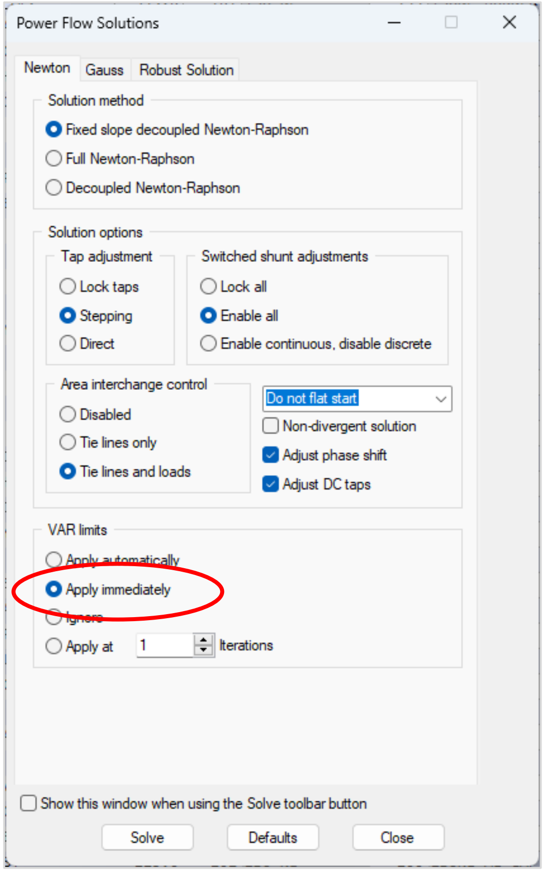
Apply Immediately

Use where the base case is already perfectly solved. Helps with processing automated scripts and analysis.

Apply at 1 Iteration

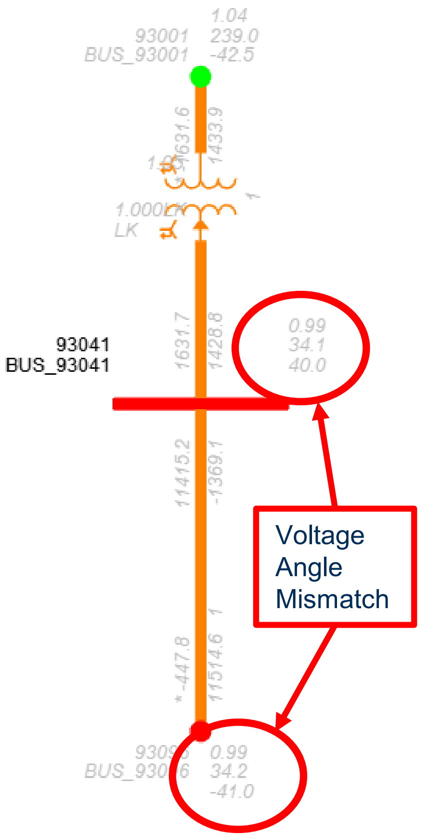


Apply Immediately



Solve: What to Look For?

One-Line Diagram



When a case solves, review the **iteration history** and the **system mismatch summary** to confirm convergence and locate problem buses.

Iteration Mismatch History

```
ITER      DELTAP      BUS            DELTAQ      BUS            DELTA/V/      BUS           DELTAANG      BUS
 0.0     130.4689(   93041        )  115.2604(   93096        )
                                                                 0.00000(               )  28.13038(   93041      )
 0.5     103.2894(   93048        )  112.6540(   93096        )
                                                                 0.99000(   93118       )   0.00000(              )

Blown up after 0 iterations
```

Worst Bus Mismatches

PSSE Python Command Line:
psspy.list(1,1,1,0)

```
   PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     MON, JUL 20 2026   8:15
2025 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA                       WORST
2026 SUMMER PEAK LOAD CASE, FINAL                                     MISMATCHES
```

BUS#-SCT X--	NAME --X	BASKV	MW	MVAR	MVA
93041	BUS_93041	34.500	-13046.89	-59.64	13047.02
93096	BUS_93096	34.500	486.95	-11526.04	11536.32
93001	BUS_93001	230.00	1592.85	-1430.41	2140.85
64447	BUS_64447	161.00	-0.10	-0.38	0.40
65455	BUS_65455	18.000	0.04	0.38	0.39
64448	BUS_64448	161.00	-0.09	-0.37	0.38
65456	BUS_65456	18.000	0.04	0.37	0.37
93119	BUS_93119	0.5750	-0.07	-0.36	0.36
64449	BUS_64449	161.00	-0.09	-0.34	0.36
65457	BUS_65457	18.000	0.04	0.34	0.35
63924	BUS_63924	161.00	0.18	-0.00	0.18
83530	BUS_83530	0.6900	-0.03	-0.13	0.13
82756	BUS_82756	345.00	0.02	0.13	0.13
3WNDTR		* BUS	0.10	-0.00	0.10
64062	BUS_64062	161.00	-0.09	0.05	0.10
61325	BUS_61325	138.00	-0.03	-0.09	0.09
61323	BUS_61323	138.00	-0.03	-0.09	0.09
61317	BUS_61317	13.800	0.01	0.09	0.09
61316	BUS_61316	13.800	0.01	0.09	0.09
93118	BUS_93118	0.5750	-0.02	-0.08	0.08
61327	BUS_61327	138.00	-0.02	-0.08	0.08
61319	BUS_61319	13.800	0.01	0.08	0.08
83517	BUS_83517	34.500	0.07	-0.00	0.07
61326	BUS_61326	138.00	0.06	-0.00	0.06
83523	BUS_83523	34.500	-0.05	0.00	0.05

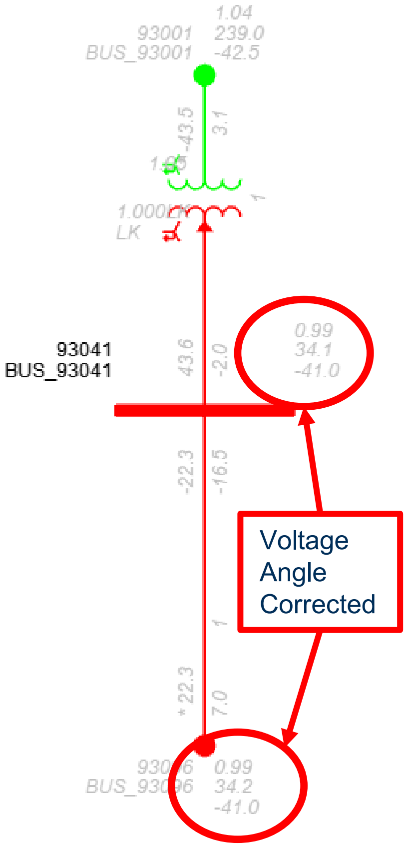
How to read it

- Iteration history lists the largest active (ΔP) and reactive (ΔQ) mismatches at each step.
- The summary ranks the buses with the worst remaining mismatches.
- Together they show where the solution is struggling to converge.

Solve: After Correction

Once the problem has been corrected, review the **iteration history** and the **system mismatch summary** to confirm convergence.

One-Line Diagram



Iteration Mismatch History

```
ITER     DELTAP      BUS            DELTAQ     BUS            DELTA/V/       BUS          DELTAANG       BUS
 0.0     0.0046(   93041      )    0.0038(   65455     )
                                   0.0044(   93001     )
                                                             0.00000(                )   0.00008(   93119       )
 0.5     0.0026(   93041      )    0.0040(   65455     )
                                   0.0044(   93001     )
                                                             0.00050(   93119        )   0.00000(               )
 1.0     0.0046(   93041      )    0.0116(   63924     )
                                                             0.00000(                )   0.00008(   93119       )
 1.5     0.0026(   93041      )    0.0118(   63924     )
                                                             0.00050(   93119        )   0.00000(               )
 2.0     0.0046(   93041      )    0.0038(   65455     )
                                   0.0044(   93001     )
```

Worst Bus Mismatches

PSSE Python Command Line:
psspy.list(1,1,1,0)

```
   PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     MON, JUL 20 2026   8:14
2025 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA                   WORST
2026 SUMMER PEAK LOAD CASE, FINAL                                  MISMATCHES
  BUS#-SCT X-- NAME --X BASKV       MW       MVAR       MVA
 93041     BUS_93041  34.500      0.46      -0.01      0.46
 93001     BUS_93001  230.00      0.06       0.44      0.44
 64447     BUS_64447  161.00     -0.10      -0.38      0.40
 93096     BUS_93096  34.500     -0.39       0.00      0.39
 65455     BUS_65455  18.000      0.04       0.38      0.39
 64448     BUS_64448  161.00     -0.09      -0.37      0.38
 65456     BUS_65456  18.000      0.04       0.37      0.37
 93119     BUS_93119  0.5750     -0.07      -0.36      0.36
 64449     BUS_64449  161.00     -0.09      -0.34      0.36
 65457     BUS_65457  18.000      0.04       0.34      0.35
 63924     BUS_63924  161.00      0.18      -0.00      0.18
 83530     BUS_83530  0.6900     -0.03      -0.13      0.13
 82756     BUS_82756  345.00      0.02       0.13      0.13
3WNDTR                 * BUS      0.10      -0.00      0.10
 64062     BUS_64062  161.00     -0.09       0.05      0.10
 61325     BUS_61325  138.00     -0.03      -0.09      0.09
 61323     BUS_61323  138.00     -0.03      -0.09      0.09
 61317     BUS_61317  13.800      0.01       0.09      0.09
 61316     BUS_61316  13.800      0.01       0.09      0.09
 93118     BUS_93118  0.5750     -0.02      -0.08      0.08
 61327     BUS_61327  138.00     -0.02      -0.08      0.08
 61319     BUS_61319  13.800      0.01       0.08      0.08
 83517     BUS_83517  34.500      0.07      -0.00      0.07
 61326     BUS_61326  138.00      0.06      -0.00      0.06
 83523     BUS_83523  34.500     -0.05       0.00      0.05
```

How to read it

- Iteration history lists the largest active (ΔP) and reactive (ΔQ) mismatches at each step.
- The summary ranks the buses with the worst remaining mismatches.
- Together they show where the solution is struggling to converge.

Data Check: PSSE Area Interchange

While in PSSE, check Area Interchange sums to zero.

PSSE Python Command Line: `psspy.area_2(0,1,1)`

Area Interchange Not Zero

X-- AREA --X	FROM GENE-RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	TO XFRMR MAGNE-TIZING	FROM CHARGING	TO LOSSES	-NET INTERCHANGE- TO TIE LINES	-NET INTERCHANGE- TO TIES + LOADS	DESIRED NET INT
1	1423.9	2.0	0.0	4163.9	15.3	0.0	4.8	18.0	0.0	24.1	-2800.2	-2800.2	-2800.0
CENTRAL	312.8	-1.2	0.0	1774.3	549.8	0.0	68.6	13.7	1072.7	326.0	-1348.0	-1348.0	
2	1528.0	0.0	10.6	3057.9	18.2	0.0	0.0	0.6	0.0	36.3	-1595.5	-1595.5	-1600.0
EAST	232.8	0.0	5.6	1072.5	-762.4	0.0	-0.0	2.6	812.9	815.5	-88.1	-88.1	
3	2990.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	131.5	2858.5	2858.5	2900.0
CENTRAL_DC	898.6	0.0	0.0	0.0	-3457.8	0.0	-0.0	4.6	0.0	2377.4	1974.5	1974.5	
4	321.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.8	279.2	279.2	0.0
EAST_COGEN1	142.3	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	0.0	142.3	0.0	0.0	
5	1479.0	5.0	1.1	513.1	0.0	0.0	0.0	0.5	0.0	32.2	937.0	937.0	900.0
WEST	36.3	-2.9	0.6	205.9	-1.3	0.0	-0.0	4.1	52.2	414.7	-538.4	-538.4	
6	321.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	321.0	321.0	300.0
EAST_COGEN2	142.3	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	0.0	142.3	0.0	0.0	
COLUMN	8063.5	7.0	11.6	7734.9	33.5	0.0	4.8	19.8	0.0	265.9	0.0	0.0	-300.0
TOTALS	1765.2	-4.1	6.2	3052.7	-3671.8	0.0	68.6	24.9	1937.8	4218.4	0.0	0.0	

Area Interchange Corrected

X-- AREA --X	FROM GENE-RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	TO XFRMR MAGNE-TIZING	FROM CHARGING	TO LOSSES	-NET INTERCHANGE- TO TIE LINES	-NET INTERCHANGE- TO TIES + LOADS	DESIRED NET INT
1	1423.9	2.0	0.0	4163.9	15.3	0.0	4.8	18.0	0.0	24.1	-2800.2	-2800.2	-2800.0
CENTRAL	312.8	-1.2	0.0	1774.3	549.8	0.0	68.6	13.7	1072.7	326.0	-1348.0	-1348.0	
2	1528.0	0.0	10.6	3057.9	18.2	0.0	0.0	0.6	0.0	36.3	-1595.5	-1595.5	-1600.0
EAST	232.8	0.0	5.6	1072.5	-762.4	0.0	-0.0	2.6	812.9	815.5	-88.1	-88.1	
3	2990.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	131.5	2858.5	2858.5	2900.0
CENTRAL_DC	898.6	0.0	0.0	0.0	-3457.8	0.0	-0.0	4.6	0.0	2377.4	1974.5	1974.5	
4	321.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.8	279.2	279.2	300.0
EAST_COGEN1	142.3	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	0.0	142.3	0.0	0.0	
5	1479.0	5.0	1.1	513.1	0.0	0.0	0.0	0.5	0.0	32.2	937.0	937.0	900.0
WEST	36.3	-2.9	0.6	205.9	-1.3	0.0	-0.0	4.1	52.2	414.7	-538.4	-538.4	
6	321.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	321.0	321.0	300.0
EAST_COGEN2	142.3	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	0.0	142.3	0.0	0.0	
COLUMN	8063.5	7.0	11.6	7734.9	33.5	0.0	4.8	19.8	0.0	265.9	0.0	0.0	0.0
TOTALS	1765.2	-4.1	6.2	3052.7	-3671.8	0.0	68.6	24.9	1937.8	4218.4	0.0	0.0	

MMWG: Power Flow Checker

- MMWG Representative has access to the PowerflowChecker.exe file
- Utilizes only .RAW files

All Power Flow Validation Checks			
3W High Resistance	Gen Reactive Power at Limit	Node Voltage Regulation	Small Voltage Band Trans.
3W Overloads	Gen Terminal Voltage	Non-positive RMPCT	Trans. Default R
3W Rating Errors	GTAP Out Of Range	Non-Zero Voltage Band Shunt	Trans. Default V
Area Without Slack Units	High Resistance Branches	Owner Out Of Range	Trans. IO Code
Blank Voltage Fields	Invalid Branch Owner	Parallel 2WXF Circulating Current	Trans. Max below Min
Branch Overloads	Invalid GEN Owner	Parallel 3WXF Circulating Current	Trans. Max or Min at 0
Bus Number Out Of Range	Invalid LOAD Owner	PARS	Trans. Voltage Checks
Bus Voltage	Invalid LOAD Zone	PGEN Outside Range	Trans. with suspect Impedance Correction Table
CNTB Errors	Large Rsource	Poor Load Power Factor	Unique Branch Name
Code 2 Buses Without Machines	Load Region Mismatch	Rating Errors	Unrealistic PMAX and PMIN
Duplicate Bus Names	Machines On Code 1 Buses	Read RAW Line with Differing KV	Unrealistic QMAX and QMIN
Gen MBASE	Missing Block 1 Steps	Read RAW Trans. Winding Voltage Mismatch	Zero Impedance ID
Gen Reactive Limit Power Factor	Multiple Swing Buses	Small Voltage Band Shunts	Zone Out Of Range

MMWG: Power Flow Checker

Minimum checks for studies:

- Area interchange balanced
- Swing buses in tolerance
- Generator P Gen ≤ P Max
- Generator Q Gen in tolerance
- No machines on code 1 buses
- Review overloaded branches ≥ 100kV
- Branch ratings: Rate B ≥ Rate A

MMWG: Power Flow Checker

Sample Rating Check

Area	Number	Name	kV	Area	Number	Name	kV	CKT	Type	Sample Case
100	11311	BUS_11311	230	100	11317	BUS_11317	230	1	Branch	Status: 1 Rating 1: 363.5 Rating 2: 0
100	11350	BUS_11350	161	100	11590	BUS_11590	161	1	Branch	Status: 1 Rating 1: 102.2 Rating 2: 0
100	11295	BUS_11295	230	100	11505	BUS_11505	161	1	2W Tran.	Status: 1 Rating 1: 66 Rating 2: 0
100	11296	BUS_11296	230	100	11528	BUS_11528	161	1	2W Tran.	Status: 1 Rating 1: 75 Rating 2: 0
200	13049	BUS_13049	230	200	13079	BUS_13079	230	1	Branch	Status: 1 Rating 1: 277.8 Rating 2: 0
300	87591	BUS_87591	345	300	88167	BUS_88167	345	1	Branch	Status: 0 Rating 1: 47 Rating 2: 0

MMWG: Power Flow Checker

Sample Branch Overload Check

Area	Number	Name	kV	Area	Number	Name	kV	CKT	Type	Sample Case
100	2849	BUS_2849	230	100	2851	BUS_2851	230	1	Branch	Flow: 455.539 Rating1: 438.2 Load1: 103.96 % Rating2: 438.2 Load2: 103.96 %
400	15677	BUS_15677	230	400	16920	BUS_16920	161	1	2W Tran.	Flow: 45.524 Rating1: 39 Load1: 116.73 % Rating2: 39 Load2: 116.73 %
400	15677	BUS_15677	230	400	16921	BUS_16921	161	1	2W Tran.	Flow: 45.525 Rating1: 39 Load1: 116.73 % Rating2: 39 Load2: 116.73 %
500	98256	BUS_98256	345	500	98257	BUS_98257	345	1	Branch	Flow: 204.935 Rating1: 169.3 Load1: 121.05 % Rating2: 254.2 Load2: 80.62 %

TARA Studio: Solve & Save

Optional step:

- Load RAW file in Tara Studio
- Solve in TARA Studio with Area Interchange set to: Tie lines and loads
- Solve several times getting the iterations down
- Save the RAW file for loading into TARA

Initial Solve

```
 Total Shunts: Continuous=611 Discrete=6426
Nit     P_Mism   #bus VoltMgn VltAngl    Q_Mism   #bus VoltMgn VltAngl arInterEr    AngChn    #bus VoltMgn VltAngl  VM_Chan    #bus VoltMgn VltAngl DeAccFc
 1p     -0.545   1569  1.0131  -1.088   425.000  15584  1.0145  -0.671     0.000 -0.00001 999947  1.0008  -1.578
 1q   7143.580  85333  1.0301  -0.931 38005.210  26374  1.0309  -2.162     0.000                                    0.05847   5839  1.0177  -1.378
 2p    136.102  15523  1.0386  -0.042    18.177   6076  0.9554  -1.843     0.000  0.28520   5870  1.0200  -1.036
 PARS summary: Total 10 PAR Viol. #contrFlows=79. At limit=1
 2q   -738.698  23640  0.9977  -1.524  2478.623  15523  1.0386  -0.042     0.000                                    0.12478  16197  1.0263  -0.590
 3p   -734.773  23640  0.9874  -1.524    19.372  15489  1.0366  -0.604     0.000 -0.28425   5871  1.0341  -1.349
 PARS summary: Total 18 PAR Viol. #contrFlows=78. At limit=2
 3q   -503.208  15822  0.9915   0.054-47146.480  15533  0.9817  -0.054     0.000                                   -0.18981  16197  1.2161  -0.590
 4p     56.545  15374  1.0440  -0.067    60.104  16197  1.2161  -0.590     0.000 -0.04890  80536  1.1025  -2.901
 PARS summary: Total 15 PAR Viol. #contrFlows=78. At limit=2
 4q    -47.078  80535  1.0919  -0.313  -133.239  85347  1.0000  -0.883     0.000                                    0.13402  15288  0.9800  -0.015
 5p    -46.105  15288  0.9800  -0.015   175.692  80535  1.1616  -0.313     0.000  0.05410  15288  0.9800   0.039
 5q     30.665  15517  1.0018  -0.000   300.803  15530  0.9969   0.005     0.000                                    0.15000  80535  1.0116  -0.336   0.929
 6p    -33.774  80535  1.0116  -0.336    12.198  80535  1.0116  -0.336     0.000  0.04930  80535  1.0116  -0.287
 6q    -11.541  80535  1.0116  -0.287    84.625  16197  1.1905  -0.590     0.000                                    0.03585  16197  1.1547  -0.590
 7p    -11.564  15517  1.0001   0.000    -7.044  16197  1.1547  -0.590     0.000 -0.01124  15288  1.0051   0.026
 TAPS summary: Total 1 TAP Adjusted #LowVolt=49 #HighVolt=43
 7q     -3.342  79479  1.0483  -0.221     9.668  16286  1.1496  -0.590     0.000                                    0.01550  79973  1.0503  -0.693
 Can't adjust dispatch by        0.5 MW for  63612 BUS_63612    13.8  358  806 .
 Can't adjust dispatch by       -0.5 MW for  75455 BUS_75455    25.0  403  403 .
 Can't adjust dispatch by        0.1 MW for  75304 BUS_75304    13.8  409  409 .
 8p      3.485  79479  1.0441  -0.221    -0.816  16197  1.1503  -0.590     0.000  0.00394  79973  1.0503  -0.689
 8q      1.522  79479  1.0441  -0.220     3.059  15288  1.0019   0.028     0.000                                    0.00544  15288  0.9964   0.028
 9p     -1.981  15288  0.9964   0.028     0.217  15288  0.9964   0.028     0.000  0.00219  15288  0.9964   0.030
 9q     -0.642 998266  0.9821  -0.376    -0.515  16286  1.1458  -0.590     0.000                                    0.00096  15311  0.9581   0.198
10p      0.445  15374  1.0279  -0.065     0.246  79975  1.0522  -0.207     0.000  0.00037  15311  0.9581   0.199
10q     -2.273  37911  1.0159  -0.943     0.422  37911  1.0159  -0.943     0.000                                   -0.00059  15288  0.9972   0.030
11p     -2.353  37911  1.0159  -0.943    -0.179  15286  1.0085   0.370     0.000  0.00037  95798  1.0078  -1.505
11q     -0.258  19455  1.0217  -1.270    -0.429  37911  1.0159  -0.943     0.000
```

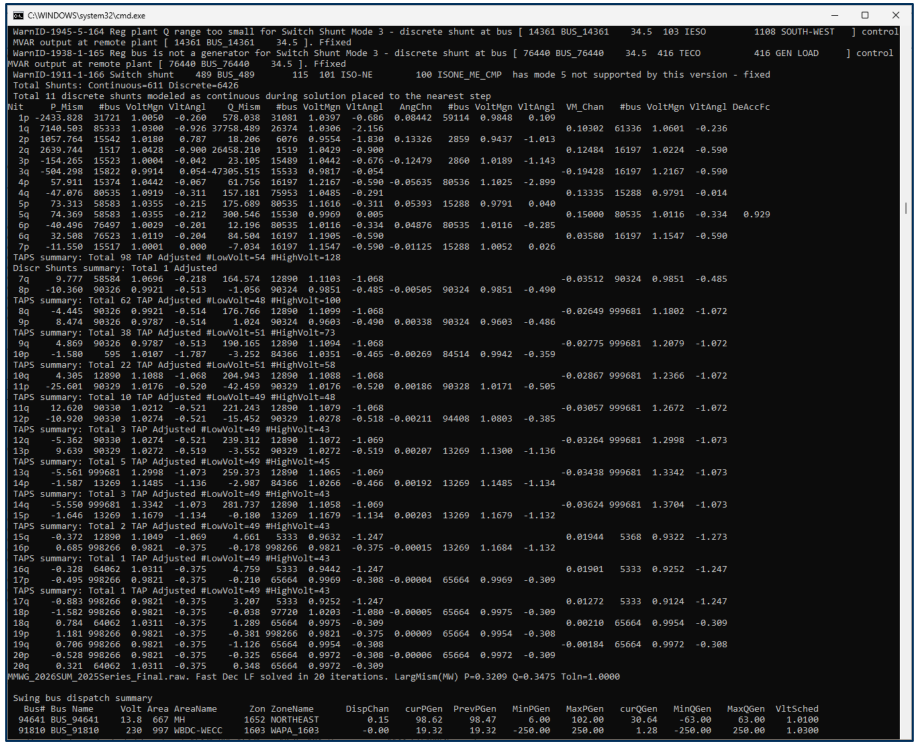
After Multiple Solves

```
Total Shunts: Continuous=611 Discrete=6426
Nit     P_Mism   #bus VoltMgn VltAngl    Q_Mism   #bus VoltMgn VltAngl arInterEr    AngChn    #bus VoltMgn VltAngl  VM_Chan    #bus VoltMgn VltAngl DeAccFc
 1p      0.130  61335  1.1292  -0.256    -0.173  61334  1.1251  -0.256     0.000 -0.00003  93273  1.0257  -0.289
 1q      0.085  91316  1.0014  -0.670    -0.240  61334  1.1251  -0.256     0.000                                   -0.00041  65664  0.9966  -0.310
Can't adjust dispatch by        0.5 MW for  63612 BUS_63612    13.8  358  806 .
Can't adjust dispatch by       -0.5 MW for  75455 BUS_75455    25.0  403  403 .
Can't adjust dispatch by        0.1 MW for  75304 BUS_75304    13.8  409  409 .
 2p     -0.285  91125  1.0250  -0.499    -0.006  84298  0.9919  -0.411     0.000 -0.00023  90425  1.0000  -0.954
 2q      0.182 996124  1.0011  -0.671     0.204  65664  0.9966  -0.310     0.000
```

TARA: Initial Solve When Loading PSSE RAW File

The **.RAW power-flow case** is imported and loaded into **TARA** to prepare the model for analysis.

TARA Command Window Log



What this shows

- The .RAW case is read in record by record.
- Buses, branches, and other elements build the TARA model.

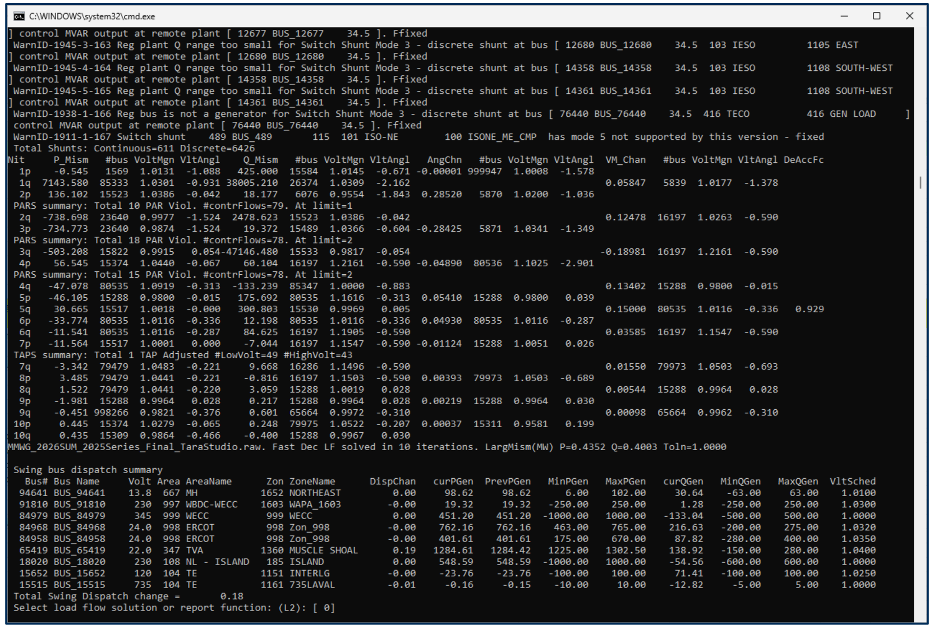
Why it matters

- Confirms the case imported cleanly before any studies run.
- Warnings listed here should be resolved before solving.

TARA: Initial Solve When Loading TARA Studio RAW File

The solved case from **TARA Studio** is loaded into **TARA** for contingency analysis.

TARA Command Window Log



What this shows

- The solved network is imported from TARA Studio.
- Each element is listed as the model is rebuilt.

Why it matters

- Verifies the solved model transferred without errors.
- Establishes the base case for contingency analysis.

TARA: Warning Summary

TARA warning summary after initial loading

WarnID	#Warn	Sever	Message	File
1906	1	2-error !	Continuous mode switched shunt with different Vmax and Vmin - shunt fixed	File Sample.raw
6160	20	2-error !	Transformer has high suspicious R/X ratio - make R smaller and X bigger to improve case convergence	File Sample.raw
6185	1	2-error !	Branch has extremely high R/X ratio - make R smaller and X bigger to improve case convergence	File Sample.raw
1200	9	1-info	Float Value out of range	File Sample.raw
1436	4	1-info	FACTS Device has mode online but no capability or it is unsupported mode or it has a data error.	File Sample.raw
1534	12	1-info	Incorrect voltage band width [Vband=0] with discrete switched shunt. Locked during shunt adjustments	File Sample.raw
1800	28	1-info	Bus defined as a generator bus but has no generators	
1830	2	1-info	PAR table used for LTC. Transformer impedance will not be adjusted with Tap ratio adjustments	
1831	2	1-info	LTC table used for PAR. PAR impedance will not be adjusted with PAR angle adjustments	
1923	2	1-info	Incorrect compounding resistance for two-terminal DC Line. Set RCom=RDc	
1925	1	1-info	Rectifier zero ALFMX or ALFMX<ALFMN for two-terminal DC Line	
1928	1	1-info	Inverter GAMMX<GAMMN for two-terminal DC Line	
1945	1	1-info	Reg plant Q range too small for discrete shunt controlling reactive power output of the plant at remote bus-fixed	
6155	1	1-info	Suspicious PAR has R=0 and small X. Increased X to improve flat start	
6159	8	1-info	Branch has high suspicious R/X ratio - make R smaller and X bigger to improve case convergence	File Sample.raw
1100	1	0-comment	Number of completed input files. See warnings details for # of lines read in	
1842	1	0-comment	Shutdown buses not connected to swing	
1878	81	0-comment	Transformer remote control bus is connected to its terminal via low impedance line - controlling terminal instead	
1911	1	0-comment	Switch shunt has mode not supported yet - fixed	

Severity Level: 1-info; 2-error; 3-potentially critical; 4-critical error

SERC

TARA: Warning Summary List

TARA warning list will provide more detail, file name and the line where the error was found

WarnID	SeverLvl	Message	File	Line
1906	2	752 Bus-752 continuous mode switched shunt with different Vmax [1.0450] and Vmin [1.0150] - shunt fixed.	File Sample.raw	400413
6160	2	2W Transformer [123 Bus-123 27.6 101 116 456 Bus-456 99.0 101 116] has high suspicious R/X ratio [11.55] > 10.00. R= 0.00578 X= 0.00050 Suggested R= 0.00500	File Sample.raw	398242
6185	2	Branch [12345 Bus-12345 69.0 233 268 23456 Bus-23456 69.0 233 268] has extremely high R/X ratio [173.00] > 100.00. R= 0.01730 X= 0.00010 Suggested R= 0.00100	File Sample.raw	198774
1200	1	machRSource Float Value 100000000.000000 is out of range [-999999.000000-9999999.000000]. Using default=0.000000	File Sample.raw	160454
1200	1	Float Value 34.500000 is out of range [0.000001-2.000000]. Using default=0.050000	File Sample.raw	399734
1436	1	FACTS Device has mode online but no capability or it is unsupported mode or it has a data error. [45 DVAR] Series link operating as a SSSC and shunt link is disabled by SHMX=0 and TRMX=0. Mode=1	File Sample.raw	399752
1534	1	Incorrect voltage band width [Vband=0] with discrete switched shunt at [500 Bus-500 69.0 235 289].	File Sample.raw	402412
1800	1	Bus 100 Bus-100 22.0 defined as a generator bus has no generators		
1830	1	PAR table 1 range [-60.00:60.00] used for LTC 667 Bus-667 260 Bus-260 1 with regul range [0.00:0.00]. change table# to zero		
1831	1	LTC table 88 range [1.00:1.00] used for PAR 703 Bus-703 665 Bus-665 1 with regul range [-120.00:120.00]		
1923	1	Compounding resistance(RComp)= 0.02500 > dc line resistance(RDC)= 0.00010 for two-terminal DC Line 31. Set RComp=RDc		
1923	1	Compounding resistance(RComp)= 0.02500 > dc line resistance(RDC)= 0.01000 for two-terminal DC Line 32. Set RComp=RDc		
1925	1	Rectifier ALFMX(0.31084) < ALFMN(0.38066) for two-terminal DC Line 11		
1928	1	Inverter has GAMMX(0.26494) < GAMMN(0.33475) for two-terminal DC Line 11		
1945	1	Reg plant Q range too small for Switch Shunt Mode 3 - discrete shunt at bus [660 Bus-660 680 XYZ] control MVAR output at remote plant [660 Bus-660]. Ffixed		
6155	1	Suspicious PAR [780 Bus-780 101 100 193 Bus-193 101 100] has R=0 and small X=0.00050 with Phase angle =30.000 Check data. Winding=1 Increased X to improve flat start		
6159	1	Branch [567 Bus-567 102 145 890 Bus-890 102 145] has high suspicious R/X ratio [20.00] > 10.00. R= 0.00020 X= 0.00001 Suggested R= 0.00010	File Sample.raw	183901
1100	0	Read in 408780 records from File [Sample.raw] (Lev=1)		
1842	0	Total shut down 2 buses not connected to swing. Total 109203 buses		
1878	0	Transformer [439 Bus-439 101 100 211 Bus-211] remotely controlled bus {416 Bus-416] connected to fromBus via ZIL - changed to control fromBus		
1911	0	Switch shunt 750 Bus-750 101 BCD 100 ABC has mode 5 not supported by this version - fixed		

Thank You

Steady State Contingency File Creation/Maintenance Process at ATC

PRESENTED BY:

Kerry Marinan P.E.

Principal Transmission Planning Engineer

August 6, 2026

Introducing ATC

- Wisconsin-based company
- Over 5 million electric consumers in service area
- Over 500 employees making sure you have the energy you need, when you need it

Topics:

- 1. How are steady state contingency files developed at ATC?
- 2. How are steady state contingency files maintained at ATC?
- 3. How are steady state contingency files confirmed for completeness and accuracy?

How are the System Planning models maintained and developed at ATC

System Planning Model Development

1. The ATC Planning model development/model maintenance process begins with the establishment of a reference model.

   a. The reference model is established once a year as the foundation from which all future year models are constructed from.
   b. The reference model is based on the August MISO Model on Demand base case model.
   c. All new future projects are written to work with the reference model and all projects that have been placed in service, prior to August, are archived.

2. Files to support the development of future models are updated and maintained. The following are a few of the key supporting files

   a. A master ATC bus number list with all of the ATC area assigned bus numbers is maintained.
      - All existing bus numbers are documented with their powerflow 12-character name, English or long name, EMS reference point and NERC generator EIA code as applicable.
      - Unused bus numbers are assigned to projects as they are developed with the project file/name referenced, so that there is no potential of multiple projects assigning the same bus number.
   b. Each future project file/Idev is named by “In-service date / geographic location / brief high-level description”.
      - This allows the files to be easily sorted by their planned in-service date, locate the general project area and identify the project type/description. (See the example file at the end of the presentation)

How are steady state contingency files maintained at ATC?

Steady State Contingency File Maintenance

- The ATC NERC TPL-001-5 steady state contingencies are maintained in spreadsheet form.
  - All as-built contingencies types are maintained on a separate spreadsheet tab and listed in order by voltage and substation or line name. Future contingency definitions are listed below the as-built definitions in order by decreasing voltage and alphabetically by substation or line name.
  - The names of future projects/Idevs that result in new contingencies or changes to existing contingencies are listed on a separate tab that allows for the enabling or disabling of selected future contingencies by entering the letter “P” for the project status.
  - An effective date for the model is entered and the master file filters out existing and future contingencies based on the effective date and the project status. Since future projects/Idevs are named with their in-service date, the date can be used to enable /disable future contingencies.
  - As-built and future contingencies are maintained on an ongoing basis.

Master Contingency File Example

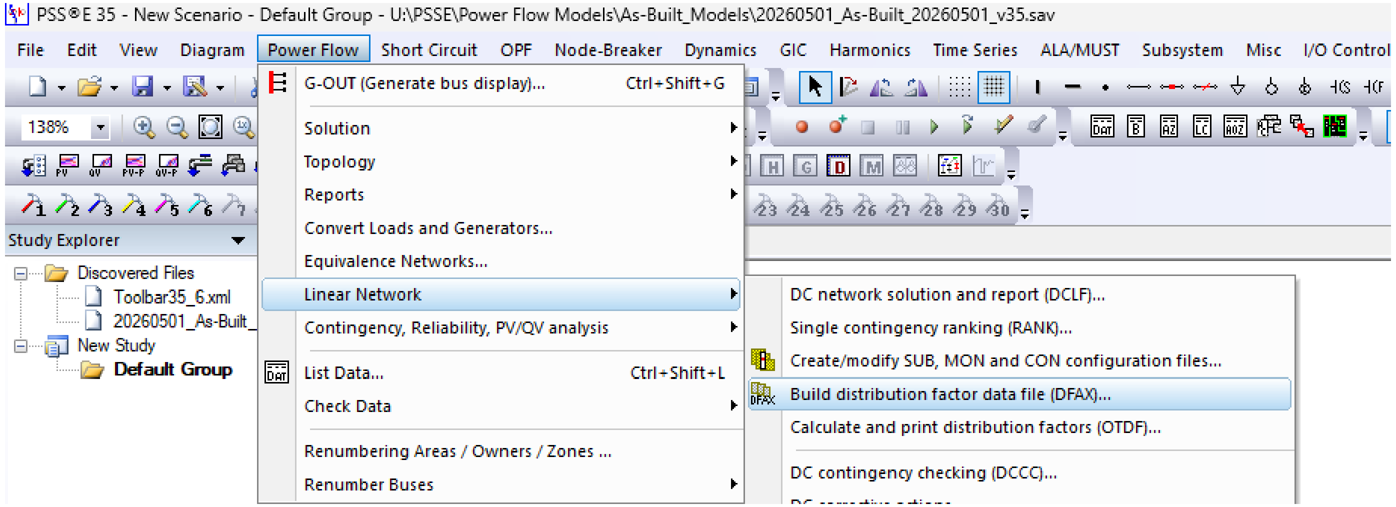
	Maintain this section with new Contingencies, project status changes and ISD changes							Output Contingency File
STATUS		20251201				"ES" Log	"LL" Log	Output:
ex	COM **					FALSE	TRUE	COM **
ex	COM ******* BEGIN EXISTING 69kV Contingencies *******					FALSE	TRUE	COM **
ex	COM **					FALSE	TRUE	COM **
ex						FALSE	TRUE	
RT	Contingency 'NB22:69:ATC:STG69:1'/3 / STAGECOACH 69 kV BUS SECTION 1 FAULT	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	Contingency 'NB22:69:ATC:STG69
RT	OPEN LINE FROM BUS 693889 TO BUS 698131 CKT 1 / Y-128 WALLY RD - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 693889 TO
RT	OPEN LINE FROM BUS 698130 TO BUS 698131 CKT 1 / Y-62 BLACK EARTH - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698130 TO
RT	OPEN LINE FROM BUS 698131 TO BUS 698686 CKT Z / Y-141 STAGECOACH - CROSS PLAINS 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698131 TO
RT	OPEN LINE FROM BUS 698131 TO BUS 698133 CKT 1 / 6927 STAGECOACH - TIMBERLANE TAP 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698131 TO
RT	End	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	End
ex	Contingency 'NB22:69:ATC:WTN69:1'/3 / WEST TOWNE 69 kV BUS SECTION 1 FAULT					FALSE	TRUE	Contingency 'NB22:69:ATC:WTN69
ex	OPEN LINE FROM BUS 698138 TO BUS 698167 CKT 1 / 6998 CROSS COUNTRY - WEST TOWNE 69					FALSE	TRUE	OPEN LINE FROM BUS 698138 TO
ex	OPEN LINE FROM BUS 698674 TO BUS 698167 CKT Z / WEST TOWN BUS TIE 69					FALSE	TRUE	OPEN LINE FROM BUS 698674 TO
ex	End					FALSE	TRUE	End
RT	Contingency 'NB22:69:ATC:W_MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM Contingency 'NB22:69:ATC:W
RT	OPEN LINE FROM BUS 698620 TO BUS 699658 CKT 1 / H-60 SPCT - WEST MARINETTE 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69862
RT	OPEN LINE FROM BUS 699659 TO BUS 699658 CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69965
RT	OPEN LINE FROM BUS 699658 TO BUS 698621 CKT 1 / Y-299 W MARINETTE - WELLS ST 69 (1 Mi UG)	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69965
RT	End	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM End
ex	COM **					FALSE	TRUE	COM **
ex	COM ******* BEGIN FUTURE 69 kV Contingencies *********					FALSE	TRUE	COM **
ex	COM **					FALSE	TRUE	COM **
f	Contingency 'NB22:69:ATC:STG69:1'/3 / STAGECOACH 69 kV BUS SECTION 1 FAULT	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM Contingency 'NB22:69:ATC:S
f	OPEN LINE FROM BUS 693889 TO BUS 698131 CKT 1 / Y-128 WALLY RD - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69388
f	OPEN LINE FROM BUS 698154 TO BUS 698131 CKT 1 / Y-62 BLACK EARTH TAP2- STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69815
f	OPEN LINE FROM BUS 698131 TO BUS 698686 CKT Z / Y-141 STAGECOACH - CROSS PLAINS 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69813
f	OPEN LINE FROM BUS 698131 TO BUS 698133 CKT 1 / 6927 STAGECOACH - TIMBERLANE TAP 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69813
f	End	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM End
i	Contingency 'NB22:69:ATC:W_MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM Contingency 'NB22:69:ATC:W
i	OPEN LINE FROM BUS 693621 TO BUS 699658 CKT 1 / H-60 KC PAPER - WEST MARINETTE 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69362
i	OPEN LINE FROM BUS 699659 TO BUS 699658 CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69965
i	OPEN LINE FROM BUS 699658 TO BUS 698621 CKT 1 / Y-299 W MARINETTE - WELLS ST 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69965
i	End	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM End
f	Contingency 'NB22:69:ATC:W_MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	Contingency 'NB22:69:ATC:W_MAR
f	OPEN LINE FROM BUS 699658 TO BUS 698626 CKT 1 / G-59 WEST MARINETTE - MENOMINEE 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699658 TO
f	OPEN LINE FROM BUS 699659 TO BUS 699658 CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699659 TO
f	OPEN LINE FROM BUS 699658 TO BUS 698621 CKT 1 / Y-299 W MARINETTE - WELLS ST 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699658 TO
f	End	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	End

DEMO

How are steady state contingency files confirmed for completeness and accuracy

Steady State Contingency File Error Checking

One method for testing contingencies for errors using PSSE is to build a Distribution Factor Data file (DFAX) using PSSE and a Subsystem and Monitored Element file.



The resultant errors will show up in the progress window.

No contingency events specified--contingency "P12:138:ATC:836:OCCRK-2:OAKVIEW:NLL" skipped

** Record 653: OPEN LINE FROM BUS 699198 TO BUS 699955 CKT 1 / 8241 PLYMOUTH#5 - SAUKVILLE 4 138
Bus not found: 699198

No contingency events specified--contingency "P12:138:ATC:X-181:SUN138:JOHNSTOWN:NLL" skipped

** Record 3970: OPEN LINE FROM BUS 699963 TO BUS 699950 CKT 1 / 4434 JOHNSTOWN - LAKEHEAD DELEVAN TAP 138
Bus not found: 699963

Steady State Contingency File Error Checking Cont.

Another method for testing contingencies for errors using TARA is to load the model, Subsystem and Monitored Element files and review the “Warn_List” tab for Warning IDs “3071”.

10	WarnInd	WarnID	SeverLvl	Message
286	276	3071	2	Contingency 136 P12:138:ATC:8241:PLYMOUTH#5:SAUKVL4:NLL was added with 1 error(s)
358	348	3071	2	Contingency 932 P12:138:ATC:4434:JOHNSTOWN:WHTWTR3:NLL was added with 1 error(s)

Steady State Contingency File Error Checking Cont.

ATC has developed an in-house tool that will read in all the various contingency files associated with the model and perform error checking on them. A RAW version of the PSSE model and the contingency files are required.

The tool checks the connections in each contingency to ensure the match with the model topology and if not, a report can be generated containing the contingency name and the element that has failed the mapping test.

The tool also checks for ATC area branches that are not included in any of the ATC category P1 contingencies and creates a CSV that can be opened/filterd and reviewed to ensure proper category P1 contingency coverage.

DEMO

Q&A

Contact info: kmarinan@atcllc.com

ATC

Energizing Your Future

Example Idev “20271115_Z1_T-D_Generic.idv”

```
VERSION 35
@!TEXT Author: kpm
@!TEXT
@!TEXT Project Name: New Generic 115 kV DIC
@!TEXT
@!TEXT           MTEP PID:#####, Target Appendix A in MTEP26
@!TEXT           LIRF:#####, PR:???????, ATC cost:$?????, FP:????, WO:?????
@!TEXT
@!TEXT Description:
@!TEXT           -Construct a new substation and install two new 115/24.9kV, 33/38 MVA transformers with circuit breakers for high-side protection.
@!TEXT           -Construct new 115kV loop through configuration at the new substation per ATC substation design standards.
@!TEXT           -Install bus-side line disconnect switches on each incoming line at the substation. Provisions shall be made for future line circuit breakers
@!TEXT            and line-side disconnect switches.
@!TEXT           -Install two line circuit breakers at the substation. Provisions shall be made for a future bus-tie circuit breaker.
@!TEXT           -Reroute the existing LINE1  Substation_A - Substation_B 115kV line and construct new double circuit 115kV transmission line (Approx. 0.3 miles)
@!TEXT            to the new substation.
@!TEXT           -Assumption: Cut LINE1 between structures 114 & 115 and construct 0.3 miles of double circuit 115 kV to the new GENERIC SS
@!TEXT
@!TEXT                                                                                                      Line Input Data            Calculated Values
@!TEXT  Segment          Description                 Line     Configuration                                    Phase Conductor          R        XL       BC
@!TEXT  From             To               #      Miles   kV      Type                                        Type/Size/#Cond/Strands  (p.u.)   (p.u.)   (p.u.)
@!TEXT  ------------     ---------        -----  -----   ----    -------------------------------- -------/----/-----/------- -------- -------- -------
@!TEXT  Substation_A     Generic Tap      LINE1a 1.15    115     From LTAP                        ACSR     795     1  26/7     0.00101 0.00679 0.00086
@!TEXT  Generic Tap      Generic SS       LINE1a 0.3     115     ATC-138-DC-BP(T-OHD-STR-250)     ACSR T2  477     1  26/7     0.00022 0.00152 0.00025
@!TEXT  ------------     ---------        -----  -----   ----    -------------------------------- -------/----/-----/------- -------- -------- -------
@!TEXT  Substation_A     Generic SS       LINE1a 1.45    115                                                                   0.00123 0.00831 0.00101
@!TEXT
@!TEXT  Substation_B     Generic Tap      LINE1b 1.89    115     From LTAP                        ACSR     795     1  26/7     0.00167 0.01093 0.00143
@!TEXT  Generic Tap      Generic SS       LINE1b 0.30    115     ATC-138-DC-BP(T-OHD-STR-250)     ACSR T2  477     1  26/7     0.00022 0.00152 0.00025
@!TEXT  ------------     ---------        -----  -----   ----    -------------------------------- -------/----/-----/------- -------- -------- -------
@!TEXT  Substation_B     Generic SS       LINE1b 2.19    115                                                                   0.00189 0.01245 0.00168
@!TEXT

BAT_LTAP,690008,690010,'1',0.6142,690009,'GENERIC SS  ',115.0    / Tap GENERIC SS into LINE1 about 61.42% of the way from Substation_A
BAT_BUS_CHNG_4,690009,0,,691,1999,690,,,, 1.05, 0.95,,,,;        / Set bus normal Vhi & Vlo per unit values
BAT_BRANCH_CHNG_3,690009,690010,'1',,,,,,,0.00123,0.00831,0.00101,,,,,1.45,,,,,205,279,,,,,,,,,,,'ATC:ATC:LINE1b:GENRC:SUB-B:115' / FN-FE-WN-WE-SPN-SPE = 228-292-243-304-220-291 MVA
BAT_BRANCH_CHNG_3,690009,690008,'1',,,,,,,0.00189,0.01245,0.00168,,,,,2.19,,,,,205,279,,,,,,,,,,,'ATC:ATC:LINE1a:GENRC:SUB-A:115' / FN-FE-WN-WE-SPN-SPE = 228-292-243-304-220-291 MVA

BAT_LOAD_DATA_6,698595,'1',1,696,1689,691,1,0,0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0," "  / GENERIC SS Load #1 placeholder
BAT_LOAD_DATA_6,698595,'2',1,696,1689,691,1,0,0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0," "  / GENERIC SS Load #2 placeholder
```

Steady State Contingency File Creation/Maintenance Process at ATC

PRESENTED BY:

Kerry Marinan P.E.

Principal Transmission Planning Engineer

August 6, 2026

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2. Files to support the development of future models are updated and maintained. The following are a few of the key supporting files

    a. A master ATC bus number list with all of the ATC area assigned bus numbers is maintained.
        - All existing bus numbers are documented with their powerflow 12-character name, English or long name, EMS reference point and NERC generator EIA code as applicable.
        - Unused bus numbers are assigned to projects as they are developed with the project file/name referenced, so that there is no potential of multiple projects assigning the same bus number.
    b. Each future project file/Idev is named by “In-service date / geographic location / brief high-level description”.
        - This allows the files to be easily sorted by their planned in-service date, locate the general project area and identify the project type/description. (See the example file at the end of the presentation)

How are steady state contingency files maintained at ATC?

Steady State Contingency File Maintenance

- The ATC NERC TPL-001-5 steady state contingencies are maintained in spreadsheet form.
  - All as-built contingencies types are maintained on a separate spreadsheet tab and listed in order by voltage and substation or line name. Future contingency definitions are listed below the as-built definitions in order by decreasing voltage and alphabetically by substation or line name.
  - The names of future projects/Idevs that result in new contingencies or changes to existing contingencies are listed on a separate tab that allows for the enabling or disabling of selected future contingencies by entering the letter “P” for the project status.
  - An effective date for the model is entered and the master file filters out existing and future contingencies based on the effective date and the project status. Since future projects/Idevs are named with their in-service date, the date can be used to enable /disable future contingencies.
  - As-built and future contingencies are maintained on an ongoing basis.

Master Contingency File Example

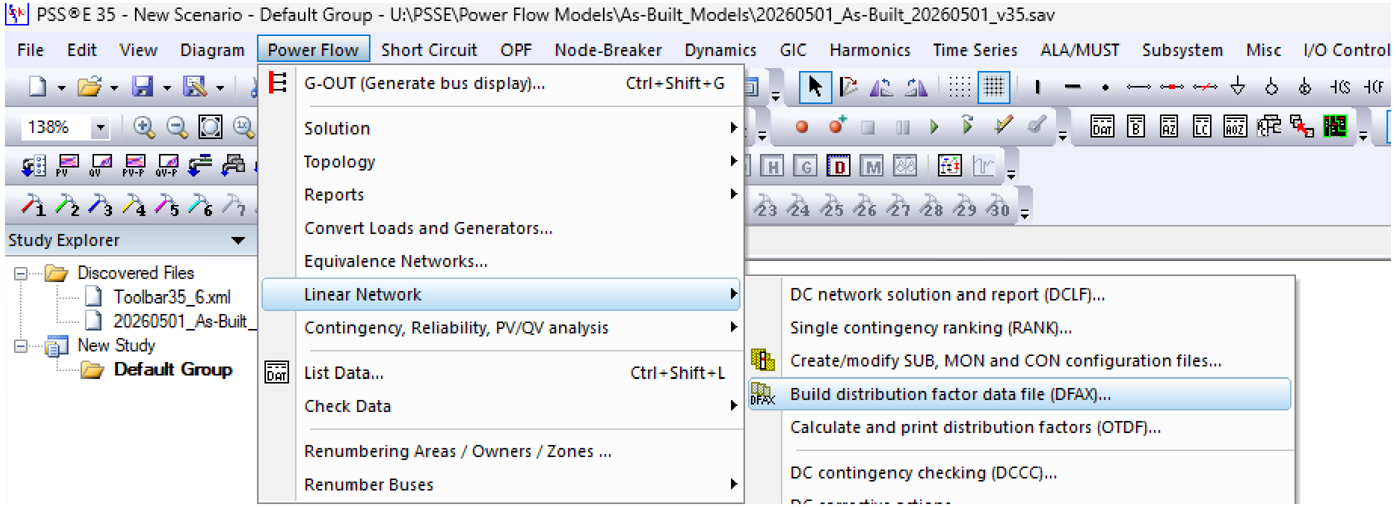
STATUS	Maintain this section with new Contingencies, project status changes and ISD changes	20251201				"ES" Log	"LL" Log	Output Contingency File Output:
ex	COM ***					FALSE	TRUE	COM **
ex	COM ******* BEGIN EXISTING 69kV Contingencies *******					FALSE	TRUE	COM **
ex	COM ***					FALSE	TRUE	COM **
ex						FALSE	TRUE	
RT	Contingency 'NB22:69:ATC:STG69:1'/3 / STAGECOACH 69 kV BUS SECTION 1 FAULT	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	Contingency 'NB22:69:ATC:STG69
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-128 WALLY RD - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 693889 TO
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-62 BLACK EARTH - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698130 TO
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 2 / Y-141 STAGECOACH - CROSS PLAINS 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698131 TO
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / 6927 STAGECOACH - TIMBERLANE TAP 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	OPEN LINE FROM BUS 698131 TO
RT	End	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	TRUE	End
ex	Contingency 'NB22:69:ATC:WTN69:1'/3 / WEST TOWNE 69 kV BUS SECTION 1 FAULT					FALSE	TRUE	Contingency 'NB22:69:ATC:WTN69
ex	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / 6998 CROSS COUNTRY - WEST TOWNE 69					FALSE	TRUE	OPEN LINE FROM BUS 698138 TO
ex	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 2 / WEST TOWN BUS TIE 69					FALSE	TRUE	OPEN LINE FROM BUS 698674 TO
ex	End					FALSE	TRUE	End
RT	Contingency 'NB22:69:ATC:W MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM Contingency 'NB22:69:ATC:W
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / H-60 SPCT - WEST MARINETTE 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69862
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69968
RT	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-299 W MARINETTE - WELLS ST 69 (1 Mi UG)	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 6996
RT	End	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rebuild.idv			FALSE	FALSE	COM End
ex	COM ***					FALSE	TRUE	COM **
ex	COM ******* BEGIN FUTURE 69 kV Contingencies *********					FALSE	TRUE	COM **
ex	COM ***					FALSE	TRUE	COM **
f	Contingency 'NB22:69:ATC:STG69:1'/3 / STAGECOACH 69 kV BUS SECTION 1 FAULT	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM Contingency 'NB22:69:ATC:S
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-128 WALLY RD - STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69388
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-62 BLACK EARTH TAP2- STAGECOACH 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69818
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 2 / Y-141 STAGECOACH - CROSS PLAINS 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69813
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / 6927 STAGECOACH - TIMBERLANE TAP 69	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM OPEN LINE FROM BUS 69813
f	End	P	20250601_Z3_T-D_BEEU_Black_Earth_2nd_Tap.idv			FALSE	FALSE	COM End
i	Contingency 'NB22:69:ATC:W_MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM Contingency 'NB22:69:ATC:W
i	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / H-60 KC PAPER - WEST MARINETTE 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69362
i	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69968
i	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-299 W MARINETTE - WELLS ST 69	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM OPEN LINE FROM BUS 69965
i	End	0	20240930_Z4_T-D_WPS_Scott Paper_SS_Rel	0	20251201_Z4_AM_WestMarinette_Tr	FALSE	FALSE	COM End
f	Contingency 'NB22:69:ATC:W MARINET:3'/4 / WEST MARINETTE 69 kV BUS SECTION 3 FAULT	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	Contingency 'NB22:69:ATC:W_MAR
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / G-59 WEST MARINETTE - MENOMINEE 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699658 TO
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / WEM-T1 W.MARNET - W.MARNET 138 - 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699659 TO
f	OPEN LINE FROM BUS XXXXX TO BUS XXXXX CKT 1 / Y-299 W MARINETTE - WELLS ST 69	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	OPEN LINE FROM BUS 699658 TO
f	End	0	20251201_Z4_AM_WestMarinette_Tr1_Replacement.idv			FALSE	TRUE	End

DEMO

How are steady state contingency files confirmed for completeness and accuracy

Steady State Contingency File Error Checking

One method for testing contingencies for errors using PSSE is to build a Distribution Factor Data file (DFAX) using PSSE and a Subsystem and Monitored Element file.



The resultant errors will show up in the progress window.

No contingency events specified--contingency "P12:138:ATC:836:OCCRK-2:OAKVIEW:NLL" skipped

** Record 653: OPEN LINE FROM BUS 699198 TO BUS **XXXXXX** CKT 1 / 8241 PLYMOUTH#5 - SAUKVILLE 4 138
Bus not found: 699198

No contingency events specified--contingency "P12:138:ATC:X-181:SUN138:JOHNSTOWN:NLL" skipped

** Record 3970: OPEN LINE FROM BUS 699963 TO BUS **XXXXXX** CKT 1 / 4434 JOHNSTOWN - LAKEHEAD DELEVAN TAP 138
Bus not found: 699963

Steady State Contingency File Error Checking Cont.

Another method for testing contingencies for errors using TARA is to load the model, Subsystem and Monitored Element files and review the “Warn_List” tab for Warning IDs “3071”.

10	WarnInd	WarnID	SeverLvl	Message	
286	276	3071	2	Contingency 136 P12:138:ATC:8241:PLYMOUTH#5:SAUKVL4:NLL	was added with 1 error(s)
358	348	3071	2	Contingency 932 P12:138:ATC:4434:JOHNSTOWN:WHTWTR3:NLL	was added with 1 error(s)

Steady State Contingency File Error Checking Cont.

ATC has developed an in-house tool that will read in all the various contingency files associated with the model and perform error checking on them. A RAW version of the PSSE model and the contingency files are required.

The tool checks the connections in each contingency to ensure the match with the model topology and if not, a report can be generated containing the contingency name and the element that has failed the mapping test.

The tool also checks for ATC area branches that are not included in any of the ATC category P1 contingencies and creates a CSV that can be opened/filterd and reviewed to ensure proper category P1 contingency coverage.

DEMO

Q&A

Contact info: kmarinan@atcllc.com

ATC

Energizing Your Future

Example Idev “20271115_Z1_T-D_Generic.idv”

```
VERSION 35
@!TEXT Author: kpm
@!TEXT
@!TEXT Project Name: New Generic 115 kV DIC
@!TEXT
@!TEXT          MTEP PID:#####, Target Appendix A in MTEP26
@!TEXT          LIRF:#####, PR:???????, ATC cost:$?????, FP:????, WO:?????
@!TEXT
@!TEXT Description:
@!TEXT          -Construct a new substation and install two new 115/24.9kV, 33/38 MVA transformers with circuit breakers for high-side protection.
@!TEXT          -Construct new 115kV loop through configuration at the new substation per ATC substation design standards.
@!TEXT          -Install bus-side line disconnect switches on each incoming line at the substation. Provisions shall be made for future line circuit breakers
@!TEXT           and line-side disconnect switches.
@!TEXT          -Install two line circuit breakers at the substation. Provisions shall be made for a future bus-tie circuit breaker.
@!TEXT          -Reroute the existing LINE1  Substation_A – Substation_B 115kV line and construct new double circuit 115kV transmission line (Approx. 0.3 miles)
@!TEXT           to the new substation.
@!TEXT          -Assumption: Cut LINE1 between structures 114 & 115 and construct 0.3 miles of double circuit 115 kV to the new GENERIC SS
@!TEXT
@!TEXT                                                                                                   Line Input Data            Calculated Values
@!TEXT  Segment          Description                      Line     Configuration                             Phase Conductor          R       XL       BC
@!TEXT  From             To               #      Miles     kV      Type                                    Type/Size/#Cond/Strands  (p.u.)   (p.u.)   (p.u.)
@!TEXT  -----------      ---------        -----  -----    ----    -------------------------------- -------/----/-----/-------  -------  -------  -------
@!TEXT  Substation_A     Generic Tap      LINE1a 1.15     115     From LTAP                        ACSR     795    1  26/7      0.00101 0.00679 0.00086
@!TEXT  Generic Tap      Generic SS       LINE1a 0.3      115     ATC-138-DC-BP(T-OHD-STR-250)     ACSR T2  477    1  26/7      0.00022 0.00152 0.00025
@!TEXT  -----------      ---------        -----  -----    ----    -------------------------------- -------/----/-----/-------  -------  -------  -------
@!TEXT  Substation_A     Generic SS       LINE1a 1.45     115                                                                   0.00123 0.00831 0.00101
@!TEXT
@!TEXT  Substation_B     Generic Tap      LINE1b 1.89     115     From LTAP                        ACSR     795    1  26/7      0.00167 0.01093 0.00143
@!TEXT  Generic Tap      Generic SS       LINE1b 0.30     115     ATC-138-DC-BP(T-OHD-STR-250)     ACSR T2  477    1  26/7      0.00022 0.00152 0.00025
@!TEXT  -----------      ---------        -----  -----    ----    -------------------------------- -------/----/-----/-------  -------  -------  -------
@!TEXT  Substation_B     Generic SS       LINE1b 2.19     115                                                                   0.00189 0.01245 0.00168
@!TEXT

BAT_LTAP,690008,690010,'1',0.6142,690009,'GENERIC SS  ',115.0    / Tap GENERIC SS into LINE1 about 61.42% of the way from Substation_A
BAT_BUS_CHNG_4,690009,0,,691,1999,690,,,, 1.05, 0.95,,,,;       / Set bus normal Vhi & Vlo per unit values
BAT_BRANCH_CHNG_3,690009,690010,'1',,,,,,,0.00123,0.00831,0.00101,,,,,1.45,,,,,205,279,,,,,,,,,,'ATC:ATC:LINE1b:GENRC:SUB-B:115' / FN-FE-WN-WE-SPN-SPE = 228-292-243-304-220-291 MVA
BAT_BRANCH_CHNG_3,690009,690008,'1',,,,,,,0.00189,0.01245,0.00168,,,,,2.19,,,,,205,279,,,,,,,,,,'ATC:ATC:LINE1a:GENRC:SUB-A:115' / FN-FE-WN-WE-SPN-SPE = 228-292-243-304-220-291 MVA

BAT_LOAD_DATA_6,698595,'1',1,696,1689,691,1,0,0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0," "  / GENERIC SS Load #1 placeholder
BAT_LOAD_DATA_6,698595,'2',1,696,1689,691,1,0,0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0," "  / GENERIC SS Load #2 placeholder
```

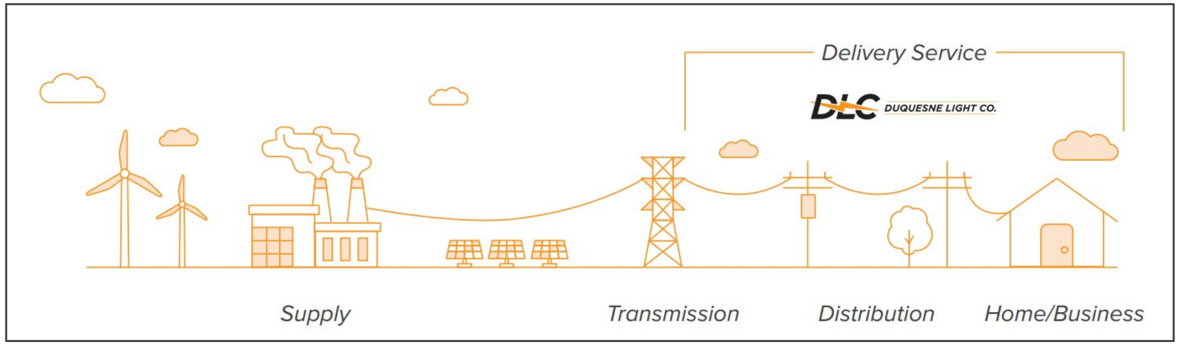
Contingency Presentation
2026 RF Planning Workshop

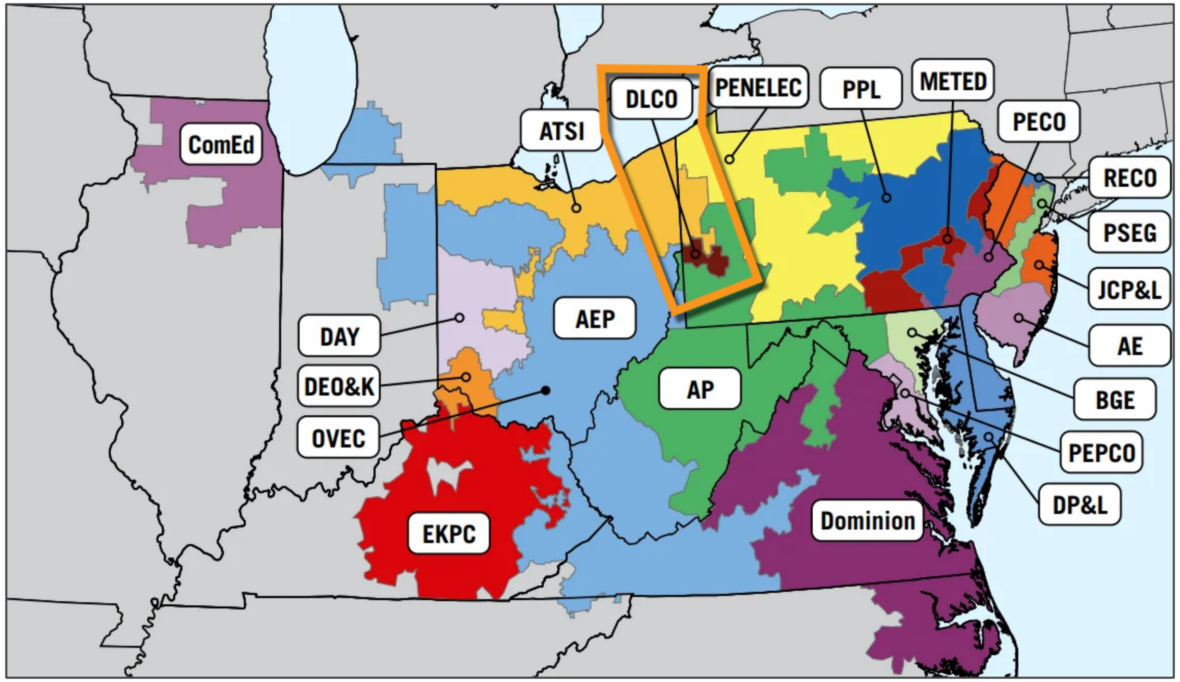
8/6/2026

Carter Leatherman
DLC Transmission Planning

Duquesne Light Company

Introduction





- Investor-owned Transmission and Distribution Utility in Southwestern PA
- Territory covers the City of Pittsburgh and nearby communities in Allegheny and Beaver Counties, 812 sq. miles in total
- ~600,000 customers
- ~150mi of 345kV & ~500mi of 138kV
- Peak load of ~2,700MW

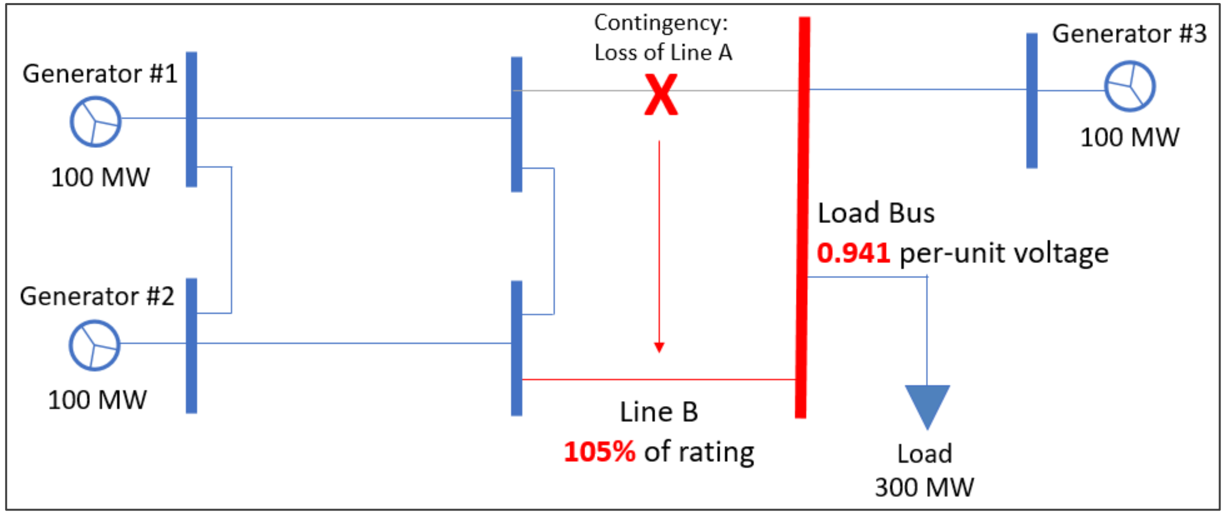
Outline

- Background of Contingency Data
- Process for internal studies
  - PJM contingency format
  - TARA Contingency Wizard
  - Project Contingency Files
  - Contingency file creation script
- Process for external contingency submission
  - Contingency database spreadsheet
  - Future improvements
  - Node Breaker
- Pain-points/quirks/discussion

Background

What Are Contingencies?

- Contingency Analysis simulates the power system's state/response after failures of individual components of the system → The system must not exceed its limits or initiate cascading failures, even under unexpected stress
- NERC Standard TPL-001-5 lays out categories of contingency events that must be simulated by planners.
  - Numbered P0-P7
- Recorded in a text file (.con) to instruct software (PSS/E, TARA, etc.) what actions to take.




```
CONTINGENCY “DLC_P12_LINE-A”
  OPEN BRANCH FROM BUS 123 TO BUS 456 CKT 1
END
```

- Because we have to study the loss of *any* BES circuit, generator, transformer, etc., there are *many* individual events to record in the contingency file.

TPL-001 Category Summary*

Category	Sub-Category	Description
P1	P11	Loss of a generator
	P12	Loss of a transmission circuit
	P13	Loss of a transformer
	P14	Loss of a shunt device
P2	P21	Opening of a line section without a fault
	P22	Bus section fault
	P23	Breaker fault (non-bus-tie breaker)
	P24	Breaker fault (bus-tie breaker)
P3		P11 followed by P11, P12, P13, or P14
P4		Fault plus stuck breaker (Only distinct from P23/P24 for dynamic analysis)
P5		Fault plus failure of non-redundant protection system
P6		P12, P13, or P14 followed by P12, P13, or P14
P7		Loss of two circuits that share a common structure for at least 1 mile

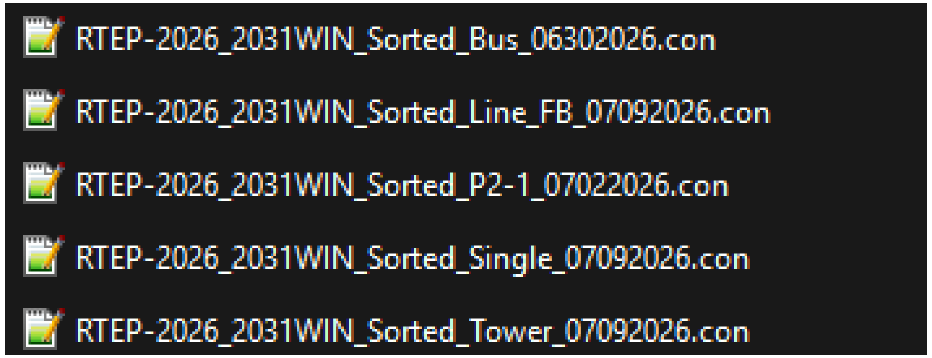
*Categories relating to HVDC lines omitted for brevity, as DLC has no HVDC facilities

Internal Study Process

PJM Contingency Format

- Breakdown into 6 different files based on NERC category:

PJM File Name	TPL-001-5 Contingencies
Single	P1 (All)
P_2-1	P2.1
Bus	P2.2
Line_FB	P2.3, P2.4 P4 (All)
P5	P5
Tower	P7(All)



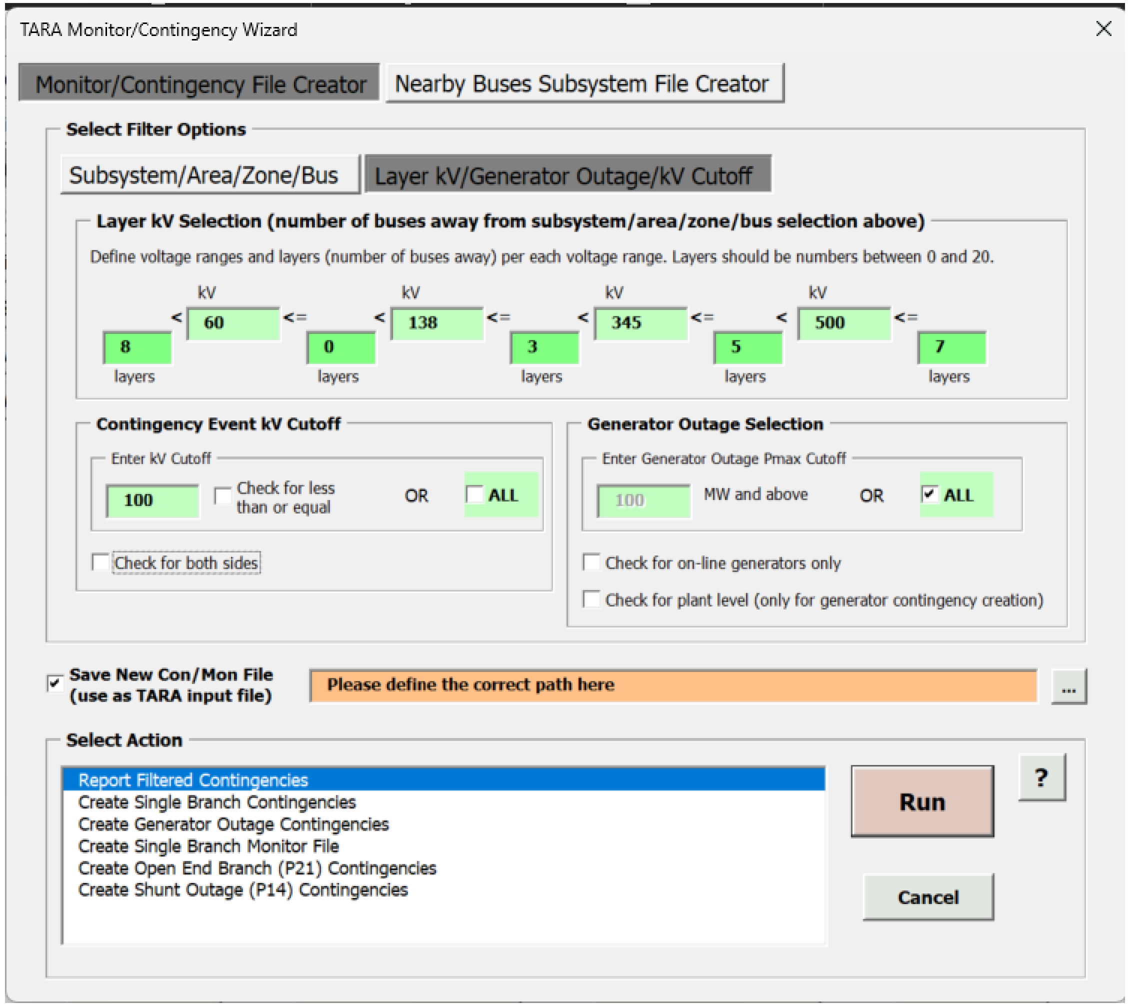
- P3 and P6 contingencies are made by combinations of P1 contingencies
- For steady-state applications, P23 and P24 cover all P4 contingencies
- Contingency name format:

[COMPANY]_[NERC-CATEGORY]_[EVENT-NAME]_SRT-[SUFFIX]

DLC_P12_Z-123_SRT-A

DLC_P24_DNTOWN-1-2_SRT-A

TARA Contingency Wizard Filter



- Running contingency analysis across a wide area is very time consuming. N-1-1 grows like N^2
- TARA Contingency Wizard filter excludes contingencies more than a certain # of buses away, variable cutoffs per kV level.
- We’re a small territory with no ties <138kV, but nearby connections to the regional backbone 500kV & 765kV systems
- Large generators (100s of MW) are modeled on GSU low side buses. Should not be excluded.
- No perfect way to include all those without including at least *some* unimportant contingencies
  - err on the side of bloating the contingency list rather than excluding possibly significant external events
- Achieves a reduction of ~10x in number of conts, while including all EHV within ~100miles of us
- Makes reviewing .con files for errors easier

DLC P1’s: ~100
PJM P1’s: ~13,000
Filtered P1’s: ~1,000

Contingency Preparation Scripts

Create individual files for projects, combine with starting contingency file, check for common contingency errors

- Draft .con files for each new project or solution
  - One for each PJM file type, per project
  - Include contingencies Added, Modified, or Removed by a project
    - Script recognizes `[REMOVED]` keyword in contingency name
- Compile ordered list of .con files
  - Start with “base” RTEP con file (typically filtered using TARA Cont Wizard)
  - Add project/solution con files in order
- Run contingency combiner script
  - Creates internal store (python dict) of contingencies (@dataclass objects)
  - Adds, modifies, or removes stored contingencies as specified by subsequent files
  - Outputs combined file reflecting internal state after all files are read
  - Also logs internal state and all changes made to internal state in JSON format
- Check for errors
  - TARA automatically runs a check on initial file ingest
  - PSS/E will skip any contingencies with unrecognized/erroneous instructions when running activity DFAX
    - Run DFAX at input file preparation time, parse PSSE progress output for “`contingency` […] `skipped`”, and tabulate results for review.

External Submission

Contingency Database

Current Method: Excel Spreadsheet

- Store lines of contingency file in excel spreadsheet rows, with columns to enable filtering by:
  - NERC category and sub-category
  - "In-service" and "retirement" dates
    - Make revisions of contingency with changes for various project states.

CONTINGENCY Description (Common I	Contingency Definition
DOWNTOWN-PENN HILLS Z-123	CONTINGENCY DLC_P12_Z-123
	OPEN BRANCH FROM BUS 123456 TO BUS 456789 CKT 1
	END

Comments	CONTINGENCY File to Export With Comments
/*DOWNTOWN-PENN HILLS Z-123	CONTINGENCY DLC_P12_Z-123 /*DOWNTOWN-PENN HILLS Z-123
/* 15DNTWN 138.0 - 15PNHILL 138.0 1	OPEN BRANCH FROM BUS 123456 TO BUS 456789 CKT 1 /* 15DNTWN 138.0 - 15PNHILL 138.0 1
	END

CONTINGENCY File to Export With Comments	Project ID	Out of Service Project ID	Start Date	End Date
CONTINGENCY DLC_P12_Z-123 /*DOWNTOWN-PENN HILLS Z-123		Lawrenceville	1/1/2023	12/31/2027
OPEN BRANCH FROM BUS 123456 TO BUS 456789 CKT 1 /* 15DNTWN 138.0 - 15PNHILL 138.0 1		Lawrenceville	1/1/2023	12/31/2027
END		Lawrenceville	1/1/2023	12/31/2027
CONTINGENCY DLC_P12_Z-123 /*DOWNTOWN-LAWRENCEVILLE Z-123	Lawrenceville		1/1/2028	
OPEN BRANCH FROM BUS 123456 TO BUS 789456 CKT 1 /* 15DNTWN 138.0 - 15LAWRNC 138.0 1	Lawrenceville		1/1/2028	
END	Lawrenceville		1/1/2028	
CONTINGENCY DLC_P12_Z-124 /*PENN HILLS-LAWRENCEVILLE Z-124	Lawrenceville		1/1/2028	
OPEN BRANCH FROM BUS 456789 TO BUS 789456 CKT 1 /* 15PNHILL 138.0 - 15LAWRNC 138.0 1	Lawrenceville		1/1/2028	
END	Lawrenceville		1/1/2028	

- Example: project looping in a line to a new substation. One contingency must be modified and another added. Old version is ended and new version starts on project ISD. Filter for required date.

Contingency Spreadsheet

Drawbacks and Future Improvements

- Creating new contingencies associated with projects is still a highly manual process.
  - Step through all lines, transformers, shunts, bus sections, breakers, and tower lines involved.
  - Check topology diagram for outaged branches/equipment for each fault
  - Use correct Bus and equipment IDs in written contingency definition
- Checks like bus-name lookup and error checking scripts speed up and clean up this work significantly
- Small number of projects reaching level of maturity to be submitted to PJM makes this a lighter burden and allows time for thorough review

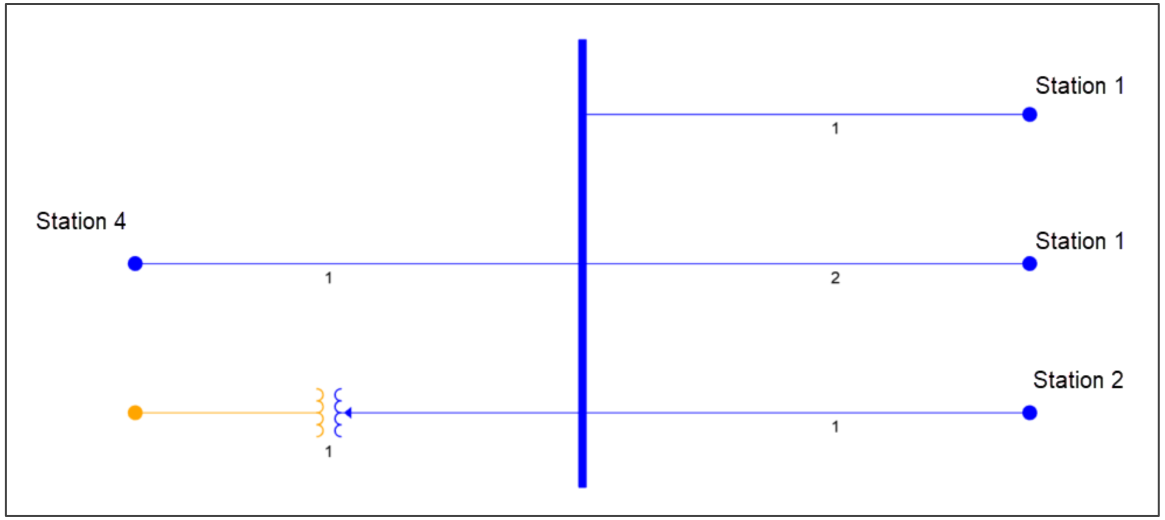
- Standardize syntax, avoiding variations of same instructions, avoid "**`open bus`**" instructions.
- Implement facility name lookup to further simplify validation of manual input
- Use formats suited to python/scripted processing (JSON, SQL?)
- General direction we want to move in:
  - specify underlying data (bus numbers, substation names, lines, breakers, etc.),
  - then automatically generate contingency text syntax from that underlying data, using lookup/reference to load flow case data, rather than storing manually-written instruction lines

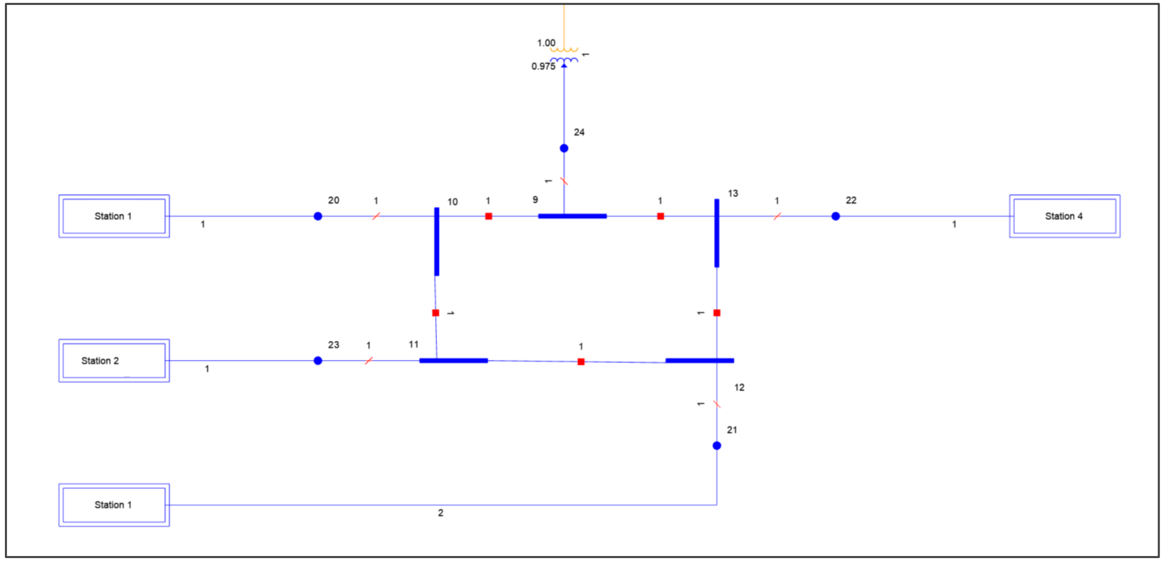
- End state of this…

Node Breaker

Full breaker topology of substations instead of single bus per voltage level, or “dummy” buses

- Bus Branch vs. Node Breaker





- Evaluate contingency topologies that split transmission buses
- Evaluate long-term outages that leave certain breakers open as a starting condition
- Enable automatic contingency specification using topology data → Ideally, development of new customer/sensitivity scenarios would only require development of new/proposed topology
- See EPRI “ARTS” Tool (NATF-NERC-EPRI Planning & Modeling Webinar 2024 Day 1)

https://www.epri.com/research/products/3002031027
https://restservice.epri.com/publicdownload/000000003002029385/0/Product

Node Breaker – Automatic Contingency Specification (PSS/E)

- `SINGLE ISOLATE BRANCH IN AREA [i]`
  - P12, P13
- `SINGLE ISOLATE BREAKER IN AREA [i]`
  - P23, P24
- `SINGLE OPEN TERMINAL IN AREA [i]`
  - P11, P14, P21
- Python for loop over “Bus Section” node IDs: `ISOLATE SUBSTATION [staid] NODE [nodid]`
  - P22

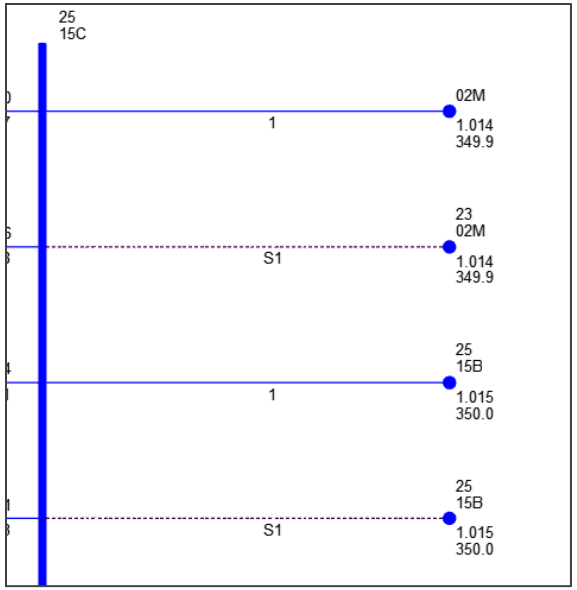
- Need additional data for:
  - P7: List of lines sharing structure for >1 mile
  - P5: Detailed data of non-redundant protection elements and results of failure
    - (Should never have to add to this data once compiled, only delete)

- In general, probably more flexible to develop scripting to process topology data into individual contingency events rather than use PSS/E Automatic Specification
  - `ISOLATE BRANCH […], ISOLATE MACHINE […], ISOLATE BREAKER […], ISOLATE […] NODE […]`

Edge Cases/Quirks

- PJM seasonal SRT-__ suffixes: Use project ISD filter to select contingencies which change over the future seasons in question
- TARA-only or MUST/ALA-only contingency instructions
  - `SET PRECONTRATING / SET POSTCONTRATING` for post-contingency ratings change.
    - We have a different approach:
      Separate “S1” branches with identical impedance, but single-breaker ratings (DBDB)

OPEN BRANCH FROM BUS [redacted]81 TO BUS [redacted]02 CKT 1
CLOSE BRANCH FROM BUS [redacted]81 TO BUS [redacted]02 CKT S1
OPEN BRANCH FROM BUS [redacted]02 TO BUS [redacted]36 CKT 1
CLOSE BRANCH FROM BUS [redacted]02 TO BUS [redacted]36 CKT S1
OPEN BRANCH FROM BUS [redacted]92 TO BUS [redacted]02 CKT 1
CLOSE BRANCH FROM BUS [redacted]92 TO BUS [redacted]02 CKT S1
OPEN BRANCH FROM BUS [redacted]02 TO BUS [redacted]31 CKT 1
CLOSE BRANCH FROM BUS [redacted]02 TO BUS [redacted]31 CKT S1



  - `OPENFROM / OPENTO` for P21 contingencies
  - These and other incompatible instructions cause PSS/E to skip → Our ingest of external contingencies from RTEP files now recognizes and comments out these instructions when preparing files for PSS/E

Questions & Discussion

- Any questions?

- Any experiences/challenges handling automation/validation of contingency creation?

- Any experiences/challenges in building node breaker models or system topology data for contingency specification?

Contingency Creation Process

Will Sayers – SPP Planning Coordinator Assessments

August 2026

Overall Process

- Auto Generated P1 Events
- Member & First Tier Contingencies
- P3 and P6 Contingency Creation

Auto Generated P1 Events

Auto Generated P1 Events

Standalone Python Script

Creates every possible P1 Event

Bus-Branch Model

Member & First Tier Contingencies

Member & First Tier Contingencies

SPP members & first tier entities submit contingencies each year

- P1, P2, P4, P5, P7, and Extreme Events

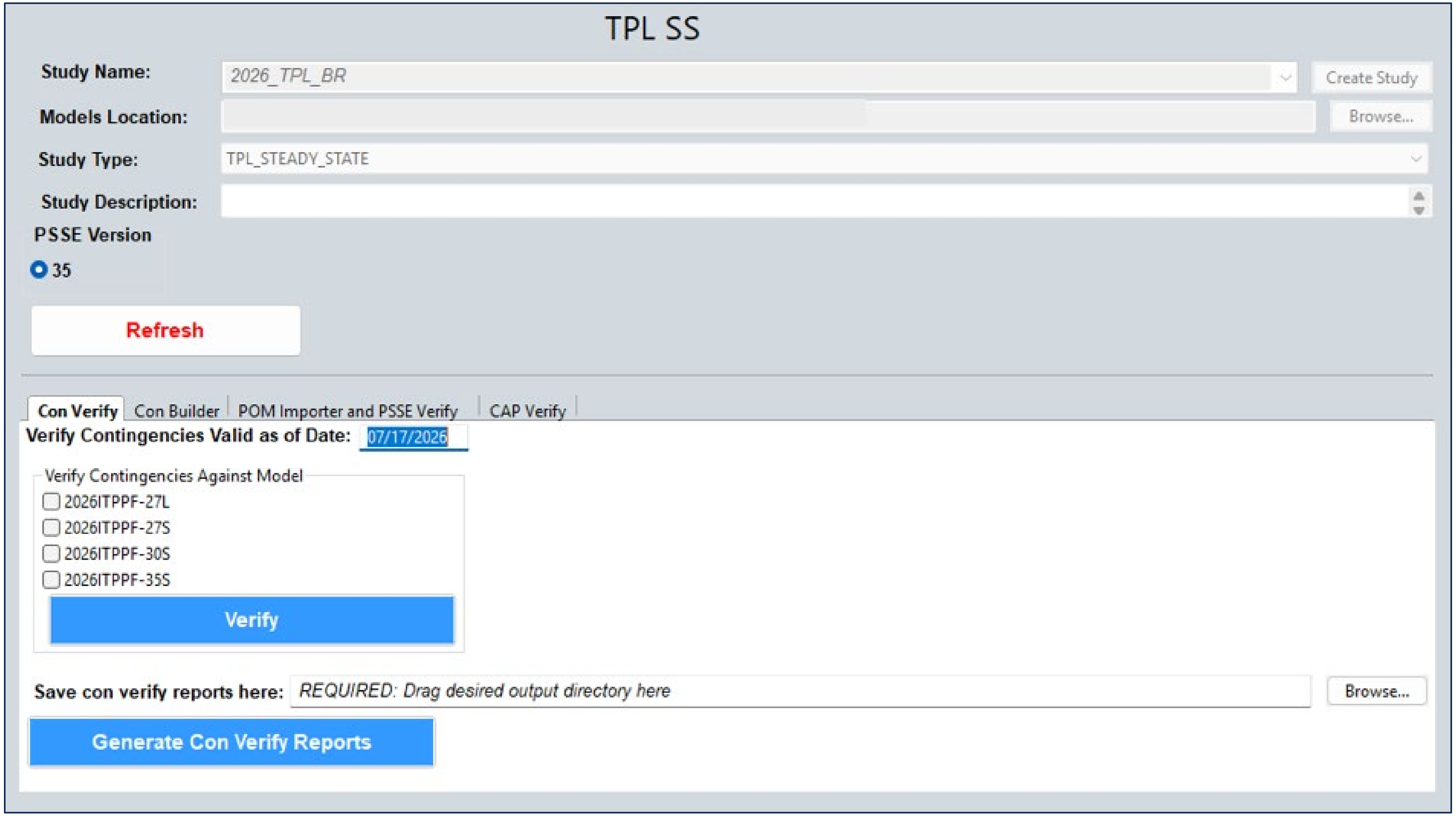
Each contingency is uploaded to a SQL database

Internal automation validates each contingency

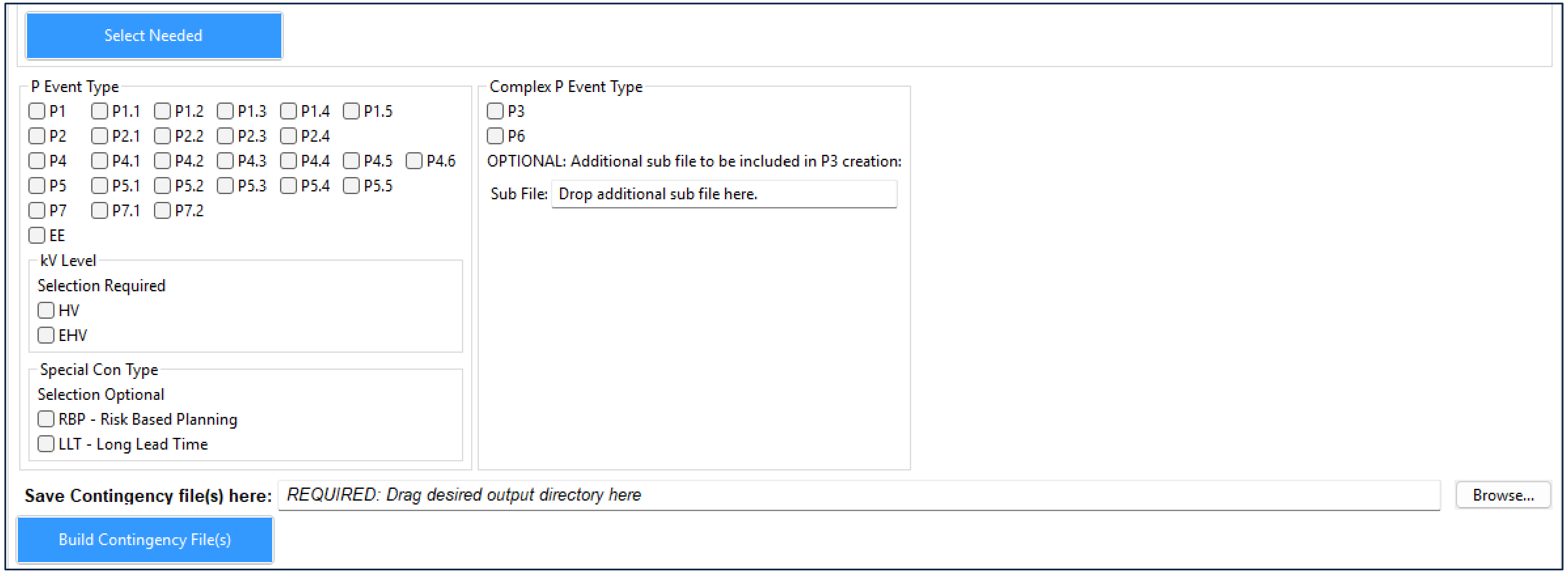
- For any assessment model, the contingency definitions are deemed valid or invalid

Reports are created for invalid contingencies to be reviewed for accuracy

Member & First Tier Contingencies



Member & First Tier Contingencies



P3 and P6 Contingency Creation

P3 Contingency Creation

Calculate Generator Shift Factor	Combine with Member Submitted P1.2 Events	Combine with Model Elements
• Each unit's shift factor is calculated using PSSE's MUST module	• Each generator with a GSF of 5% or greater is paired with a P1.2 Event within the same model area	• Each generator with a GSF of 5% or greater is paired with other N-1 elements within the same model area

P6 Contingency Creation

Member Submitted P1 Combinations

Each member submitted P1 event is paired with another P1 event within the same model zone

Auto Generated P6s

Using V&R Energy's POM software, P6s are created using model data for elements within the same model zone

Questions?

Contact

SPP Planning Coordinator

Please feel free to contact us at

planningcoordinator@spp.org !

FORWARD TOGETHER RELIABILITYFIRST

N-1 CONTINGENCY ANALYSIS

John Idzior, ReliabilityFirst

August 6, 2026

RELIABILITY FIRST

PURPOSE

We have a starting case with a topology, load, dispatch, and transaction schedule built in

We want to test various contingency scenarios, e.g.

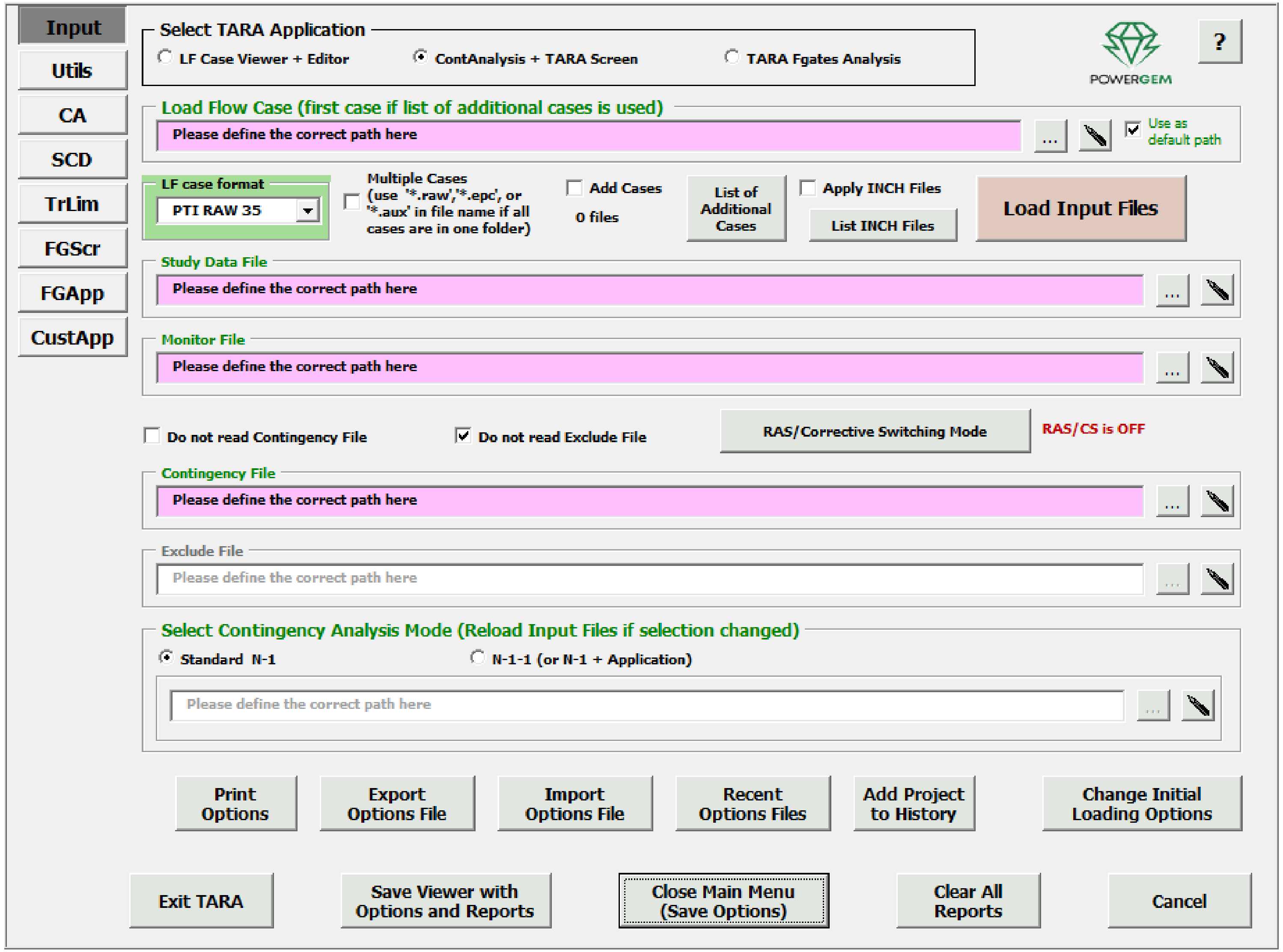
- Line or transformer fault
- Bus fault
- Line fault plus stuck breaker
- Define these in CON file

After applying the contingency, which branches and buses are affected?

- Standard practice is to limit the set of branches and buses in the case that are monitored. Don't monitor all branches in the entire case.
- Define which branches and buses to monitor for contingency impacts in the MON file

INPUT FILES

- Loadflow Case
- Subsystem File
- Monitor File
- Contingency File(s)
- Exclude File (Optional)
- RAS/CS File (Optional)
- INCH file (Optional)



N-1 ANALYSIS

AC Flow

- Apply a contingency and do AC solve
- Reports on thermal branch impacts, bus voltage impacts
- Iterative AC solution so non-convergence is a possibility

DC Flow

- AC solved upon initial loading, NOT doing a DC loadflow solve post contingency
- Compute contingency event distribution factors
- Estimate post-cont flow based on pre-contingency event MW multiplied by contingency event factor
- Will not match the exact AC flow, much faster than AC solving each contingency
- Thermal branch impacts only. Does NOT report bus voltage impacts or non-convergence

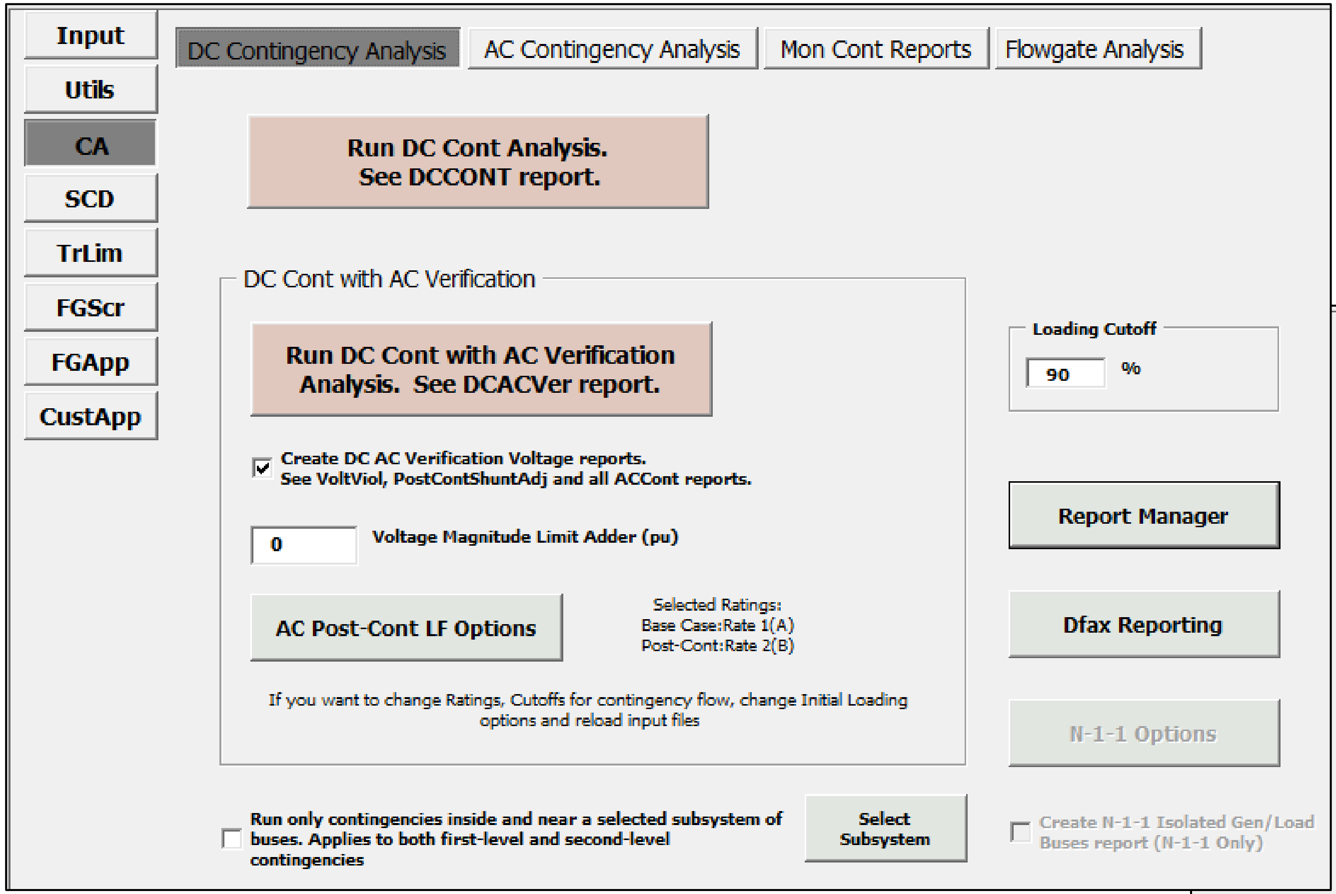
N-1 DC WITH AC VERIFICATION

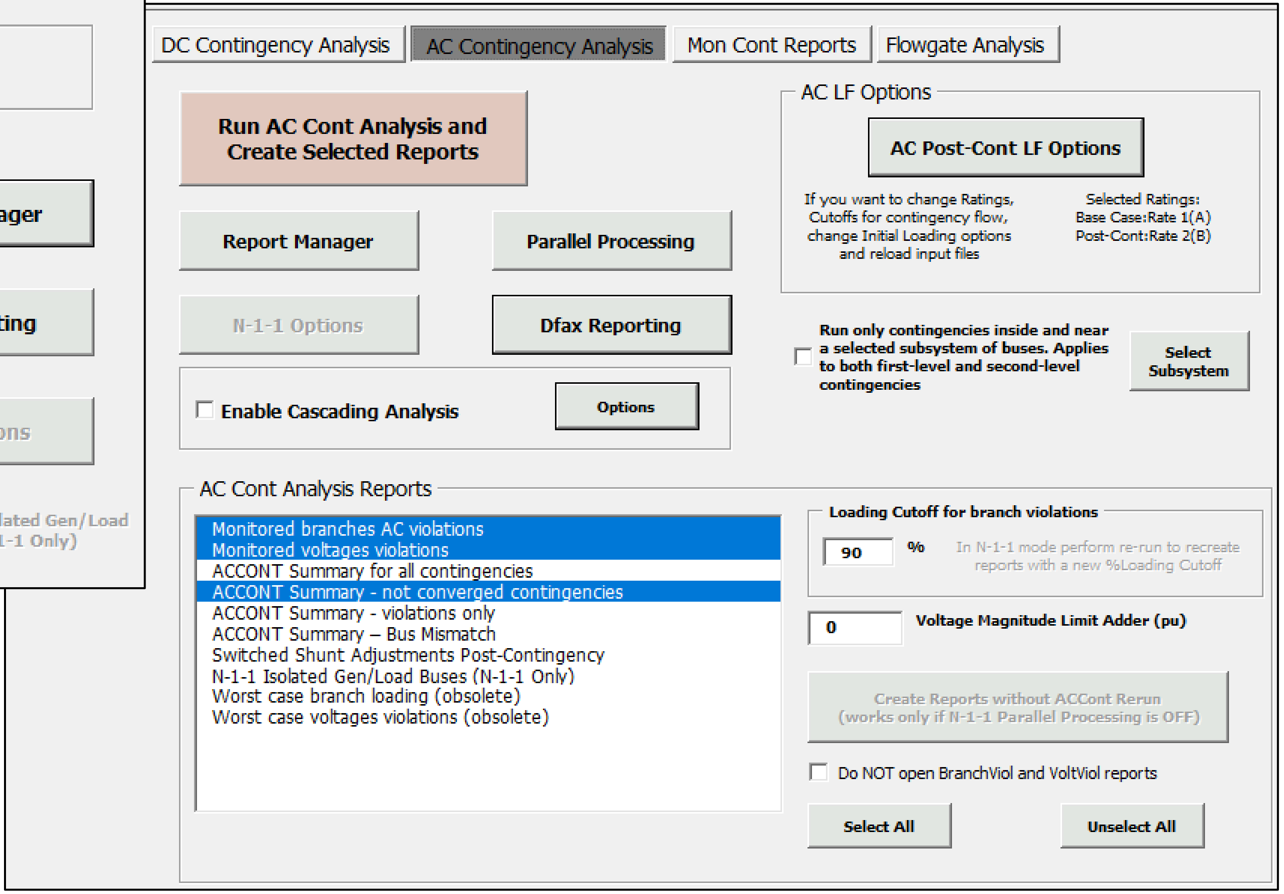
Identify contingencies that cause monitored branch loadings above value - such as 80-85%

- For these contingencies, do full post-contingency AC solve
  - Faster than full AC since number of AC solves is reduced

- Assuming that DC results are reasonably close to AC results, we should get a report very similar to the AC report
  - May not work well (or, at all) in instances of heavily overloaded systems, or other special circumstances

N-1 ANALYSIS


Input
Utils
CA
SCD
TrLim
FGScr
FGApp
CustApp
DC Contingency Analysis
AC Contingency Analysis
Mon Cont Reports
Flowgate Analysis
Run DC Cont Analysis.
See DCCONT report.
DC Cont with AC Verification
Run DC Cont with AC Verification Analysis. See DCACVer report.
Create DC AC Verification Voltage reports.
See VoltViol, PostContShuntAdj and all ACCont reports.
0
Voltage Magnitude Limit Adder (pu)
AC Post-Cont LF Options
Selected Ratings:
Base Case:Rate 1(A)
Post-Cont:Rate 2(B)
If you want to change Ratings, Cutoffs for contingency flow, change Initial Loading options and reload input files
Loading Cutoff
90
%
Report Manager
Dfax Reporting
N-1-1 Options
Run only contingencies inside and near a selected subsystem of buses. Applies to both first-level and second-level contingencies
Select Subsystem
Create N-1-1 Isolated Gen/Load Buses report (N-1-1 Only)


DC Contingency Analysis
AC Contingency Analysis
Mon Cont Reports
Flowgate Analysis
Run AC Cont Analysis and Create Selected Reports
Report Manager
Parallel Processing
N-1-1 Options
Dfax Reporting
Enable Cascading Analysis
Options
AC LF Options
AC Post-Cont LF Options
If you want to change Ratings, Cutoffs for contingency flow, change Initial Loading options and reload input files
Selected Ratings:
Base Case:Rate 1(A)
Post-Cont:Rate 2(B)
Run only contingencies inside and near a selected subsystem of buses. Applies to both first-level and second-level contingencies
Select Subsystem
AC Cont Analysis Reports
Monitored branches AC violations
Monitored voltages violations
ACCONT Summary for all contingencies
ACCONT Summary - not converged contingencies
ACCONT Summary - violations only
ACCONT Summary – Bus Mismatch
Switched Shunt Adjustments Post-Contingency
N-1-1 Isolated Gen/Load Buses (N-1-1 Only)
Worst case branch loading (obsolete)
Worst case voltages violations (obsolete)
Loading Cutoff for branch violations
90
%
In N-1-1 mode perform re-run to recreate reports with a new %Loading Cutoff
0
Voltage Magnitude Limit Adder (pu)
Create Reports without ACCont Rerun
(works only if N-1-1 Parallel Processing is OFF)
Do NOT open BranchViol and VoltViol reports
Select All
Unselect All

N-1 ANALYSIS OPTIONS

Ratings

- Select pre and post contingent rating set
- TARA does not monitor post-contingency flow if Rating is zero
- % loading cutoff for reporting

Repot Manager

- Branch Overloads/Voltage Reports
- Options to display data in results report

Other

- Initial loading solution parameters
- Parallel Processing
- AC Post Contingency solution options
- Multiple CONs impact monitored branch

RESULTS

1	POWER-GEM N-1 DC Monitored Facility Loadings[TARA Ver 2101.2.0.0 64-bit - Mon Oct 25 16:03:03 2021]											
2												
3	Loadflow Case: C:\files\TARA_v1902test\TrainingJuly2019\training.raw											
4	Study Data File: C:\files\TARA_v1902test\TrainingJuly2019\training.sub											
5	Contingency File: C:\files\TARA_v1902test\TrainingJuly2019\training.con (total 2415 contingencies)											
6	Monitor File: C:\files\TARA_v1902test\TrainingJuly2019\training.mon (90.0% loading cutoff)											
7	Exclude File: not provided											
8	Pre/Post Contingency PAR Adjustment: Adjusted/Fixed											
9												
10	Monitored Facility	monType	Fr Bus	Fr Name	To Bus	To Name	CKT	kVs	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name
11	45069 WHITE SULP~1 138 45058 MARLINTON 2 138 1	BES	45069	WHITE SULP~1	45058	MARLINTON 2	1	138	45	169	202.8	16262 WARM SPRIN~1
12	16272 WARM SPRIN~3 138 45058 MARLINTON 2 138 1	BES	16272	WARM SPRIN~3	45058	MARLINTON 2	1	138	15/45	176.5	211.8	16262 WARM SPRIN~1
13	16263 WARM SPRIN~4 138 16272 WARM SPRIN~3 138 1	BES	16263	WARM SPRIN~4	16272	WARM SPRIN~3	1	138	15	250	300	16262 WARM SPRIN~1
14	16297 FRONT ROYA~8 138 15069 FRONT ROYA~6 138 1	BES	16297	FRONT ROYA~8	15069	FRONT ROYA~6	1	138	15	175.8	211	16288 FRONT ROYA~7
15	45445 WEBSTER SP~2 69.0 45423 COWEN 4 69.0 1	NBES	45445	WEBSTER SP~2	45423	COWEN 4	1	69	45	62.5	75	16262 WARM SPRIN~1
16	15358 RICHMOND 7 3 138 16251 ASHLAND 7 2 138 1	BES	15358	RICHMOND 7 3	16251	ASHLAND 7 2	1	138	15	198.4	238.1	16250 ASHLAND 7 1
17	15069 FRONT ROYA~6 138 15066 FRONT ROYA~3 138 1	BES	15069	FRONT ROYA~6	15066	FRONT ROYA~3	1	138	15	195.8	235	16288 FRONT ROYA~7
18	45600 FRANKLIN ~22 69.0 45599 FRANKLIN ~21 138 1	BES	45600	FRANKLIN ~22	45599	FRANKLIN ~21	1	69/138	45	91.5	109.8	16262 WARM SPRIN~1
19	19237 HARTSVILL~24 138 19253 HARTSVILL~23 138 1	BES	19237	HARTSVILL~24	19253	HARTSVILL~23	1	138	19	250	300	19236 HARTSVILL~14
20	45424 CAMDEN ON ~1 69.0 45423 COWEN 4 69.0 1	NBES	45424	CAMDEN ON ~1	45423	COWEN 4	1	69	45	43.7	52.4	16262 WARM SPRIN~1
21	45445 WEBSTER SP~2 69.0 45444 WEBSTER SP~1 138 1	BES	45445	WEBSTER SP~2	45444	WEBSTER SP~1	1	69/138	45	77	92.4	16262 WARM SPRIN~1
22	45437 RICHWOOD 1 69.0 45424 CAMDEN ON ~1 69.0 1	NBES	45437	RICHWOOD 1	45424	CAMDEN ON ~1	1	69	45	43.8	52.6	16262 WARM SPRIN~1
23	45428 ROCK CAVE 2 69.0 45442 MILL CREEK~2 69.0 1	NBES	45428	ROCK CAVE 2	45442	MILL CREEK~2	1	69	45	67	80.4	16262 WARM SPRIN~1
24	45428 ROCK CAVE 2 69.0 45441 HUTTONSVIL~1 69.0 1	NBES	45428	ROCK CAVE 2	45441	HUTTONSVIL~1	1	69	45	72.2	86.6	16262 WARM SPRIN~1
25	45441 HUTTONSVIL~1 69.0 45048 ARBOVALE 1 69.0 1	NBES	45441	HUTTONSVIL~1	45048	ARBOVALE 1	1	69	45	75.7	90.8	16262 WARM SPRIN~1
26	16289 FRONT ROY~11 138 16297 FRONT ROYA~8 138 1	BES	16289	FRONT ROY~11	16297	FRONT ROYA~8	1	138	15	250	300	16288 FRONT ROYA~7
27	45069 WHITE SULP~1 138 15875 COVINGTON ~6 138 1	BES	45069	WHITE SULP~1	15875	COVINGTON ~6	1	138	45/15	173.6	208.3	16262 WARM SPRIN~1
28	16019 BREMO BLUF~6 138 16138 SCOTTSVILL~7 138 1	BES	16019	BREMO BLUF~6	16138	SCOTTSVILL~7	1	138	15	239.6	287.5	16227 NEW CANTON~3
29	16263 WARM SPRIN~4 138 16262 WARM SPRIN~1 500 1	BES	16263	WARM SPRIN~4	16262	WARM SPRIN~1	1	138/500	15	814.8	977.8	16262 WARM SPRIN~1
30	45382 RUPERT 1 1 69.0 45437 RICHWOOD 1 69.0 1	NBES	45382	RUPERT 1 1	45437	RICHWOOD 1	1	69	45	53.2	63.8	16262 WARM SPRIN~1

DCCONT | ConList | BranchFlows | VoltMonit | Warn_Sum | Warn_List | CaseSum | LogFile | ORA_OutList | ORA_OutSched | ORA_OutErrors | ORA ...

Public

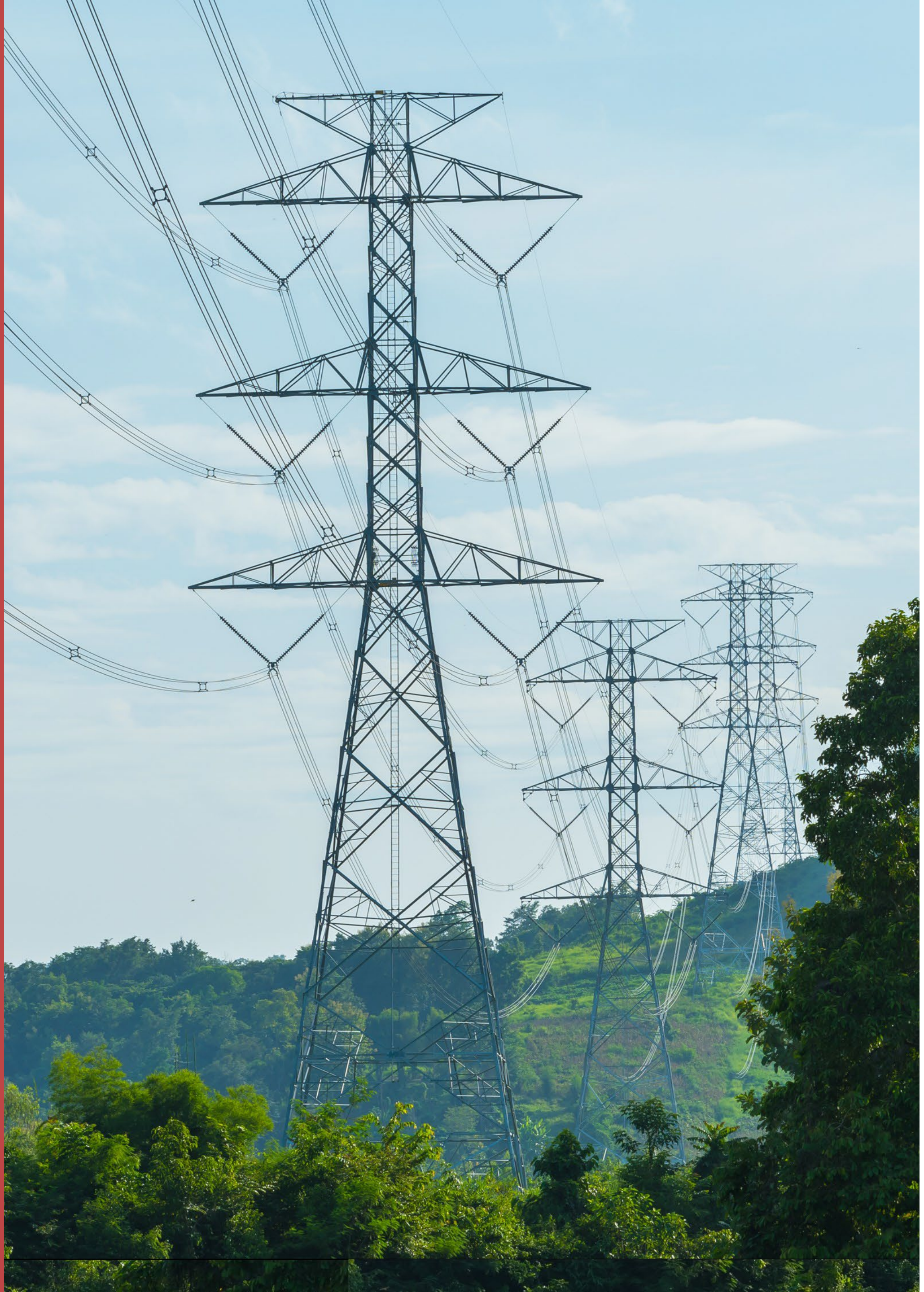
RESULTS

	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	021]												
5	es)												
10	To Name	CKT	kVs	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	ConType	Cont ID	Base Flow (MW)	Cont Flow (MW)	Final DC %Loading	Severity Rank
11	MARLINTON 2	1	138	45	169	202.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-26.4	-931.7	459.4	1
12	MARLINTON 2	1	138	15/45	176.5	211.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	37.1	942.4	444.94	1
13	WARM SPRIN~3	1	138	15	250	300	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	75.4	1255.8	418.6	1
14	FRONT ROYA~6	1	138	15	175.8	211	16288 FRONT ROYA~7 500 16299 FRONT ROY~10 500 1	Single	561	33.4	853.3	404.48	1
15	COWEN 4	1	69	45	62.5	75	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	26.5	301.6	402.14	1
16	ASHLAND 7 2	1	138	15	198.4	238.1	16250 ASHLAND 7 1 500 16259 ASHLAND 7 10 500 1	Single	550	-62	-937.7	393.87	1
17	FRONT ROYA~3	1	138	15	195.8	235	16288 FRONT ROYA~7 500 16299 FRONT ROY~10 500 1	Single	561	-7.5	812.4	345.76	1
18	FRANKLIN ~21	1	69/138	45	91.5	109.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	30	369	336.07	1
19	HARTSVILL~23	1	138	19	250	300	19236 HARTSVILL~14 345 19255 HARTSVILL~26 345 1	Single	751	164.2	991.1	330.38	1
20	COWEN 4	1	69	45	43.7	52.4	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-6.1	-172.2	328.31	1
21	WEBSTER SP~1	1	69/138	45	77	92.4	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-26.5	-301.6	326.42	1
22	CAMDEN ON ~1	1	69	45	43.8	52.6	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-3.6	-169.6	322.74	1
23	MILL CREEK~2	1	69	45	67	80.4	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	21.3	242.2	301.24	1
24	HUTTONSVIL~1	1	69	45	72.2	86.6	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-29	-249.9	288.43	1
25	ARBOVALE 1	1	69	45	75.7	90.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-38.3	-259.2	285.32	1
26	FRONT ROYA~8	1	138	15	250	300	16288 FRONT ROYA~7 500 16299 FRONT ROY~10 500 1	Single	561	33.4	853.3	284.43	1
27	COVINGTON ~6	1	138	45/15	173.6	208.3	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	2.1	543.1	260.69	1
28	SCOTTSVILL~7	1	138	15	239.6	287.5	16227 NEW CANTON~3 500 16232 NEW CANTON~8 500 1	Single	541	128.3	705.5	245.38	1
29	WARM SPRIN~1	1	138/500	15	814.8	977.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	-270	-2381.3	243.55	1
30	RICHWOOD 1	1	69	45	53.2	63.8	16262 WARM SPRIN~1 500 16271 WARM SPRIN~2 500 1	Single	555	1.7	-148.1	232.06	1

DCCONT | ConList | BranchFlows | VoltMonit | Warn_Sum | Warn_List | CaseSum | LogFile | ORA_OutList | ORA_OutSched | ORA_OutErrors | ORA ...

Live Demo

FORWARD TOGETHER RELIABILITYFIRST



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QUESTIONS & ANSWERS

John Idzior

john.idzior@rfirst.org

Power-Voltage Analysis: Continency Selection

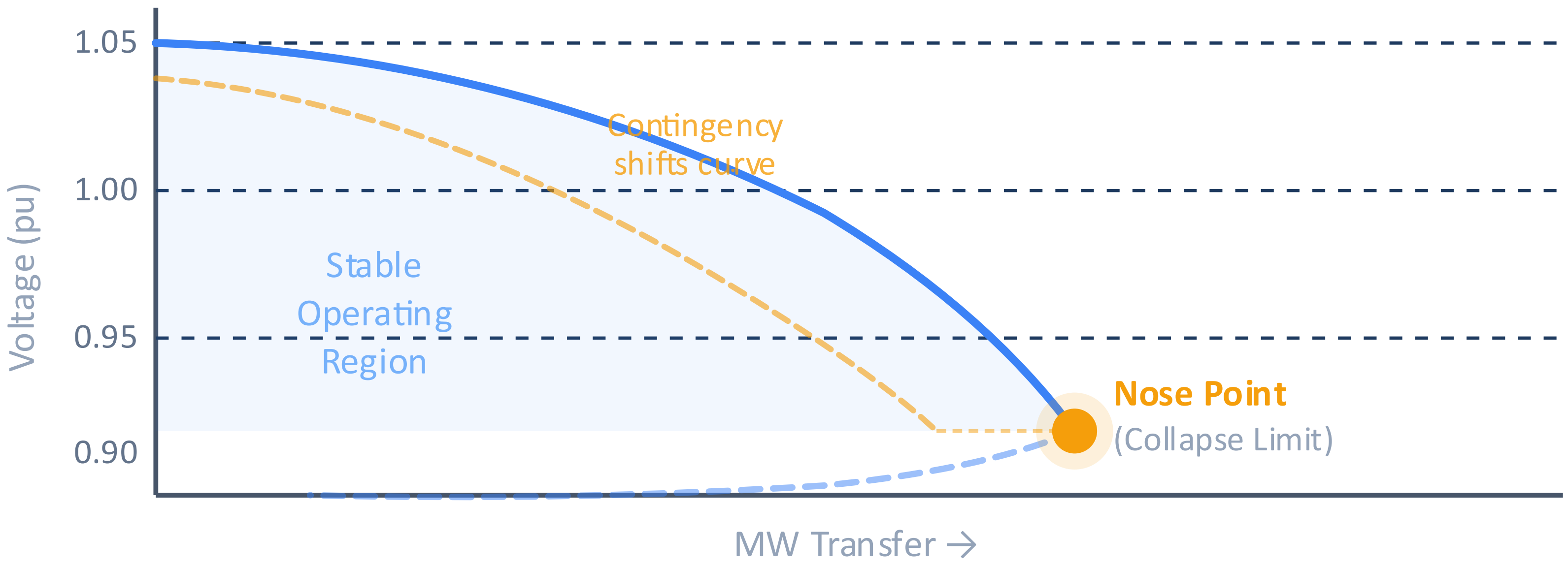
John Wiggins
Reliability Engineer

SERC

Agenda

- **PV Analysis**
  - Overview of voltage stability margins and why PV curves matter in transmission studies.
- **Why a Reduced Contingency List Is Essential**
  - Focusing computational effort on contingencies that meaningfully stress system voltage.
- **Contingency Selection Criteria**
  - Technical indicators of stressed conditions in both N-0 and N-1 cases.
- **Workflow & Automation**
  - A repeatable, traceable process for screening, combining .con files, and preparing PV-ready cases.

WHAT IS PV ANALYSIS?



- Voltage drops as MW transfer rises until it reaches the **nose point**, where the system can no longer support the load.
- The area ***before*** is the stable region.
- Every contingency shifts the curve - move the nose point and ***decreasing*** the stability margin

WHY A SMALLER CONTINGENCY LIST MATTERS

Steady State Contingency Analysis is Fast

- One Power Flow solution per contingency. Thousands of cases can run in **minutes**.

PV Analysis is Computational Heavy

- Each contingency requires **dozens of sequential power flow solutions** across a full transfer range. A complete N-1 list can take **hours or days**.

The Fix – Focus On Stressed Conditions

- Select contingencies by **voltage stress impact**, producing most critical contingency cases for PV.

Methodology & Automation Matters

- Smart screening makes PV analysis **practical at scale**, without sacrificing reliability or missing critical contingencies.

Contingency Selection
Stressed Voltage Conditions

Known Voltage Stability Conditions

- Known Voltage Stability Limits
- Defined Interconnection Reliability Operating Limits

Stressed Base Case Conditions

- Branches in proximity to low voltage buses
- Elements in proximity to poor numerical solutions
- Loss of reactive support
- Loss of Generation
- Branches with large angle separation

Stressed Contingency Conditions

- Non-converged contingency cases
- Contingencies resulting in low voltage across several buses
- Contingencies with a large voltage drop
- Contingencies resulting in branch overloads

Contingency Selection Workflow

Build Study Case

Build steady state case for the planned system state: stressed or normal operating conditions

Contingency Analysis – Thermal and Voltage

Perform power flow contingency analysis on your study case

Define Known Voltage Stability Contingencies

Create *.con* file with known voltage stability contingencies defined.

Contingency Selection: N-0 Case

Scan the steady state study case for stressed conditions. Create *.con* file based on methodology

Contingency Selection: Contingency Case

Scan the contingency analysis results. Create *.con* file based on contingencies indicating potential voltage stress

Combine Contingency Definition Files

Combine known voltage stability contingencies, and contingencies determined from the N-0 and Contingency Case.

Use reduced contingency list for PV Analysis

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Contingency Selection Workflow
Known Voltage Stability Limits

For N-1 studies on known IROL or voltage stability-limited paths, use the individual elements of the IROL or stability condition, organized by study region.

Verify at each study
- Confirm all listed elements are still in-service and reflect current topology per region

Update, don't rebuild
- Add new candidates when topology changes; remove retired elements with a logged justification

Log every change
- Record the reason: topology change, new equipment, planner judgment, or IROL redetermination

Flag IROL redeterminations separately
- A redetermined IROL requires full re-validation, not just an incremental update

Version control
- Label each cycle with date and study name so the file lineage is traceable across years

A well-maintained running list reduces build time at each study to a verification step, not a rebuild.

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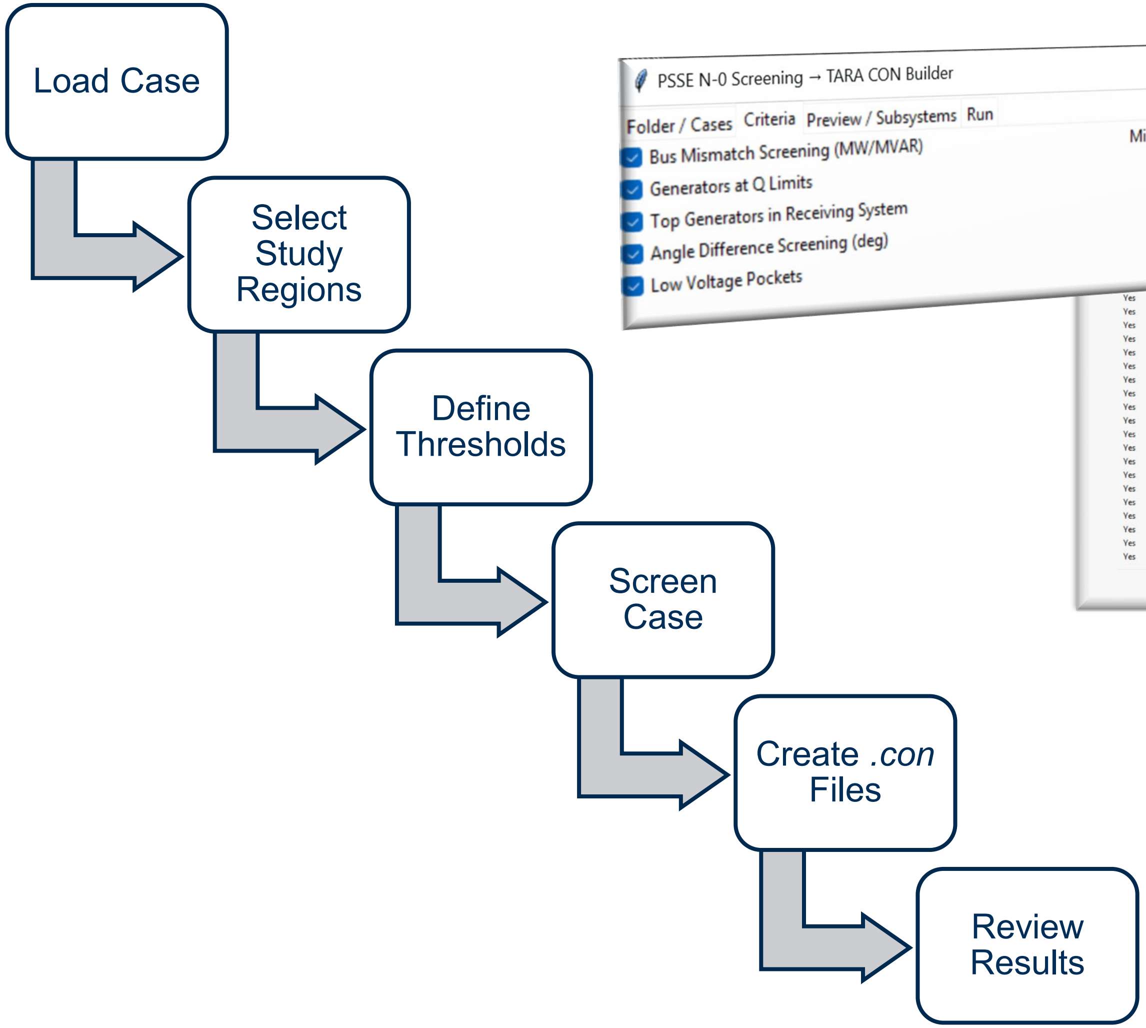
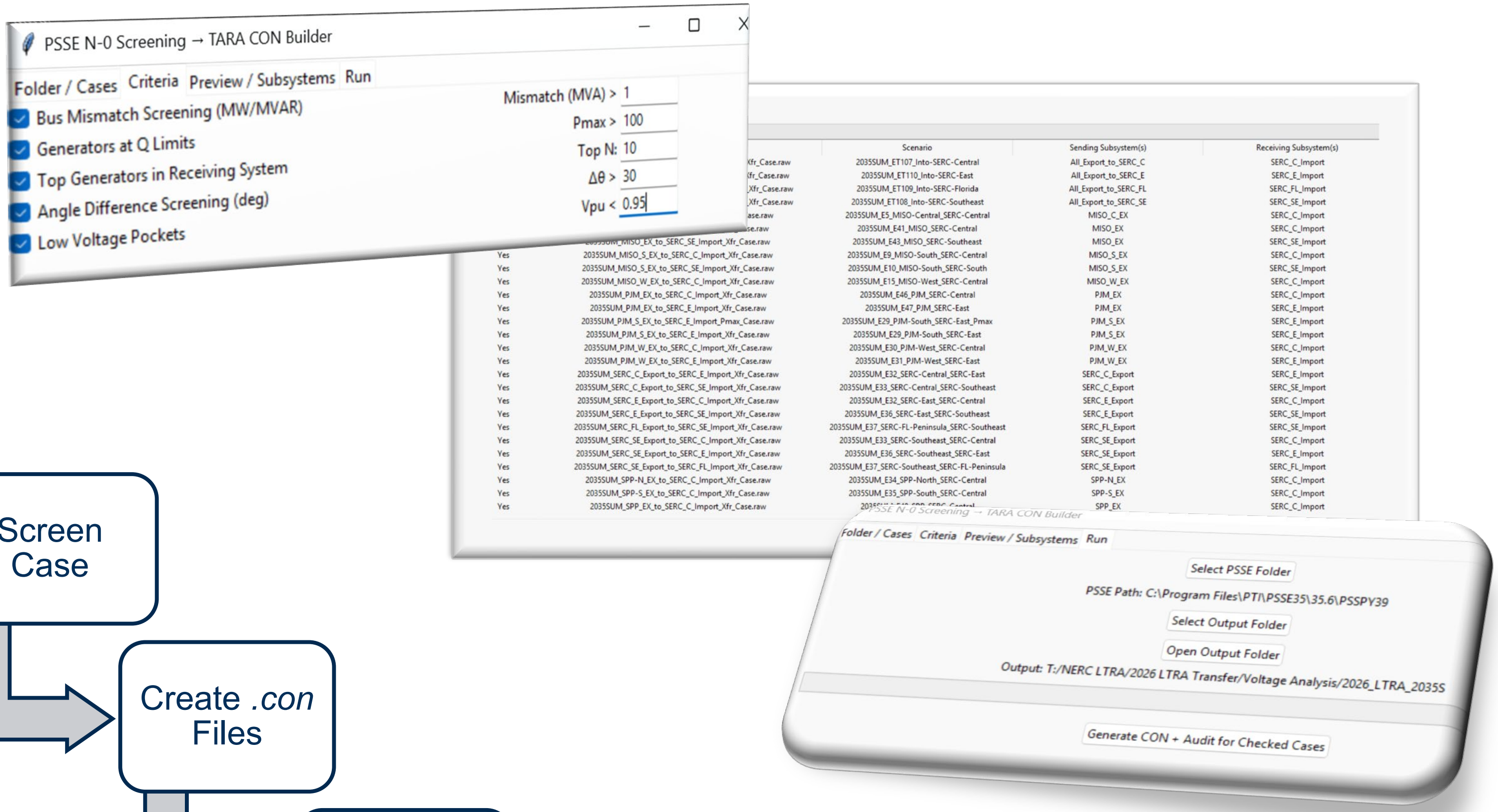
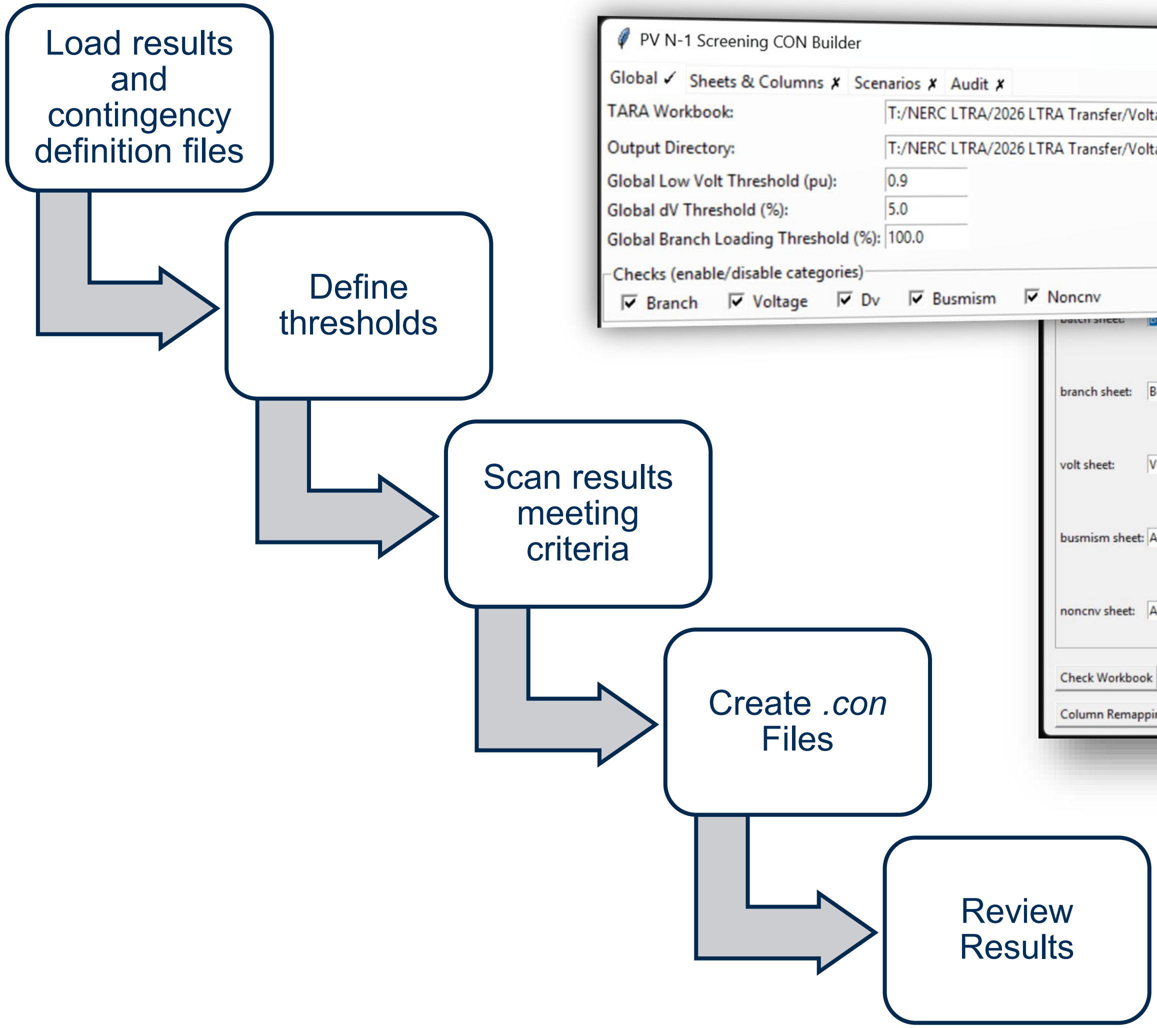
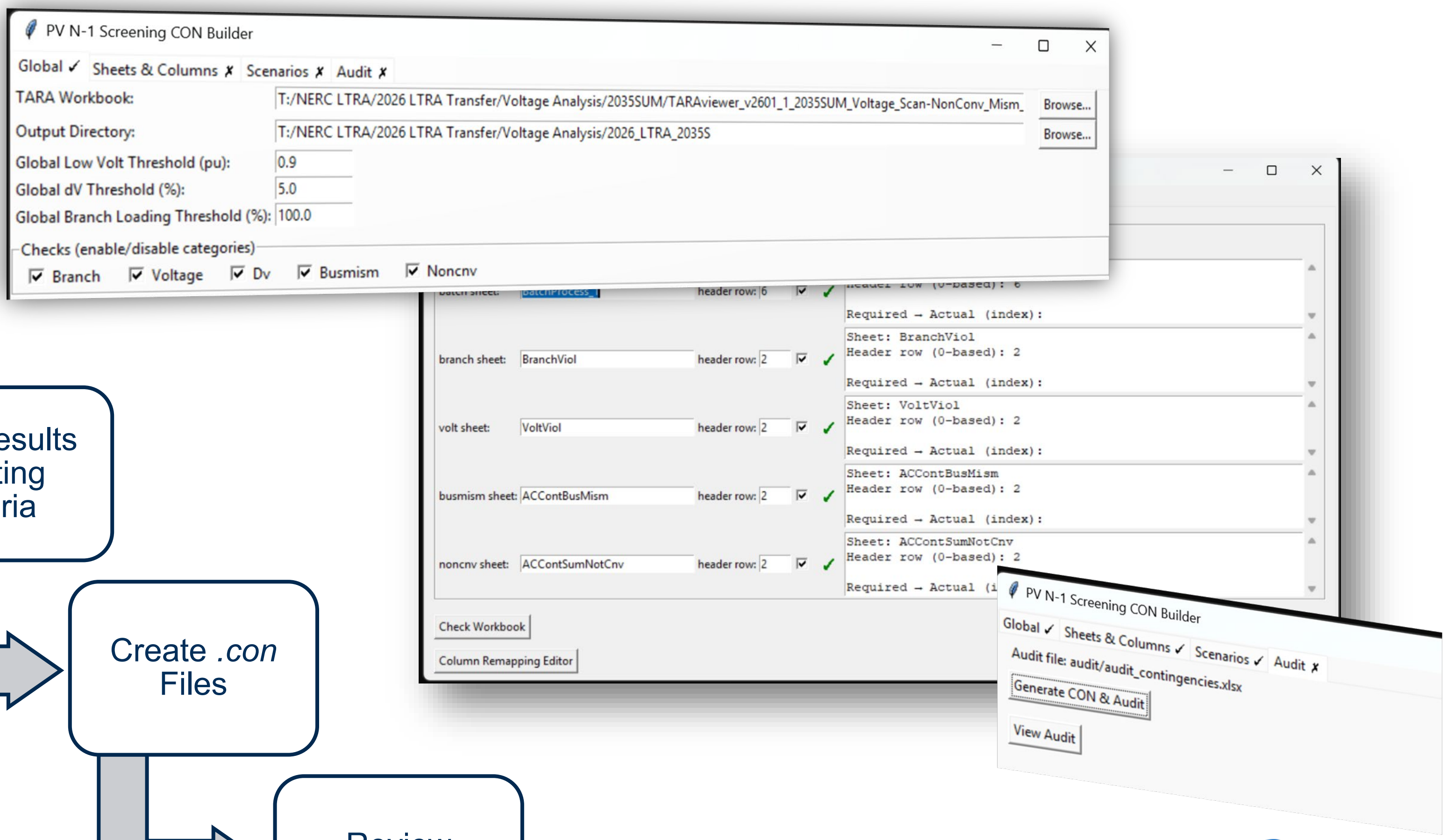
Contingency Selection Workflow
N-0 Screening





Contingency Selection Workflow
Contingency Screening





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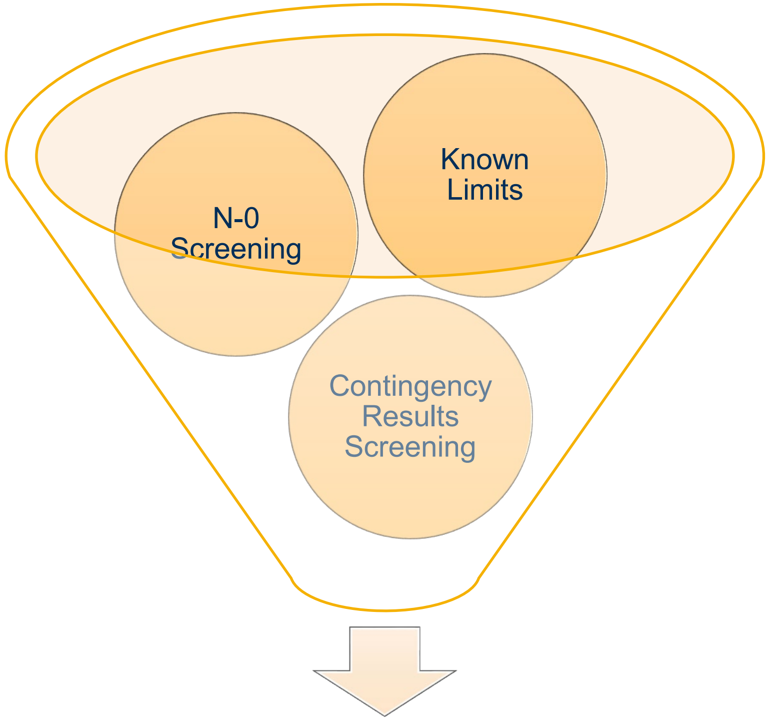
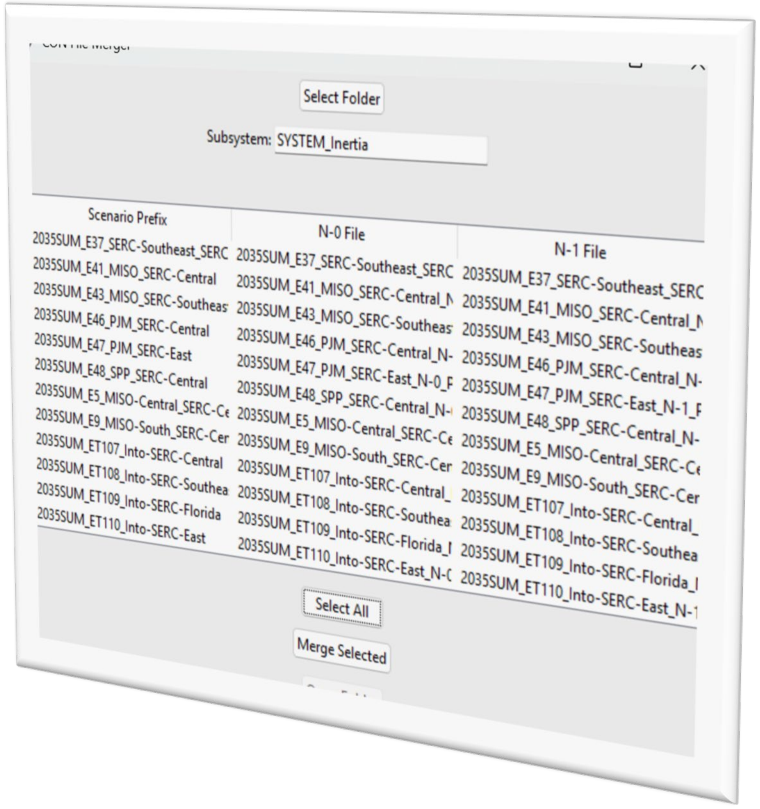
Contingency Selection Workflow
Combine .*Con* Files

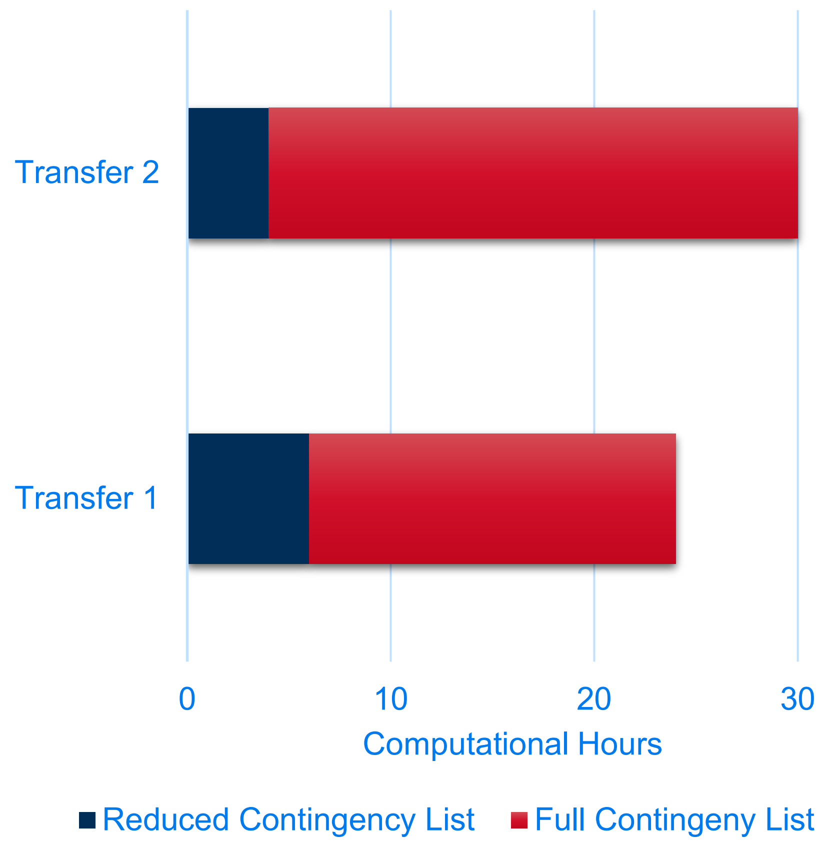


One *con* file ready for PV Analysis!



Summary

- PV analysis is a core component of a complete transmission reliability assessment.
- Technically justified screening criteria allow planners to focus PV studies on the contingencies that truly stress system voltage, reducing study durations.
- Repeatable workflows and automation improve efficiency, consistency, and defensibility across studies.



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FIRST CONTINGENCY INCREMENTAL TRANSFER CAPABILITY (FCITC)

John Idzior, ReliabilityFirst

August 6, 2026

RELIABILITY FIRST

PURPOSE

Primary objective of the transfer limit analysis is to identify transfer limits between power system areas

Use of transfer limit analysis

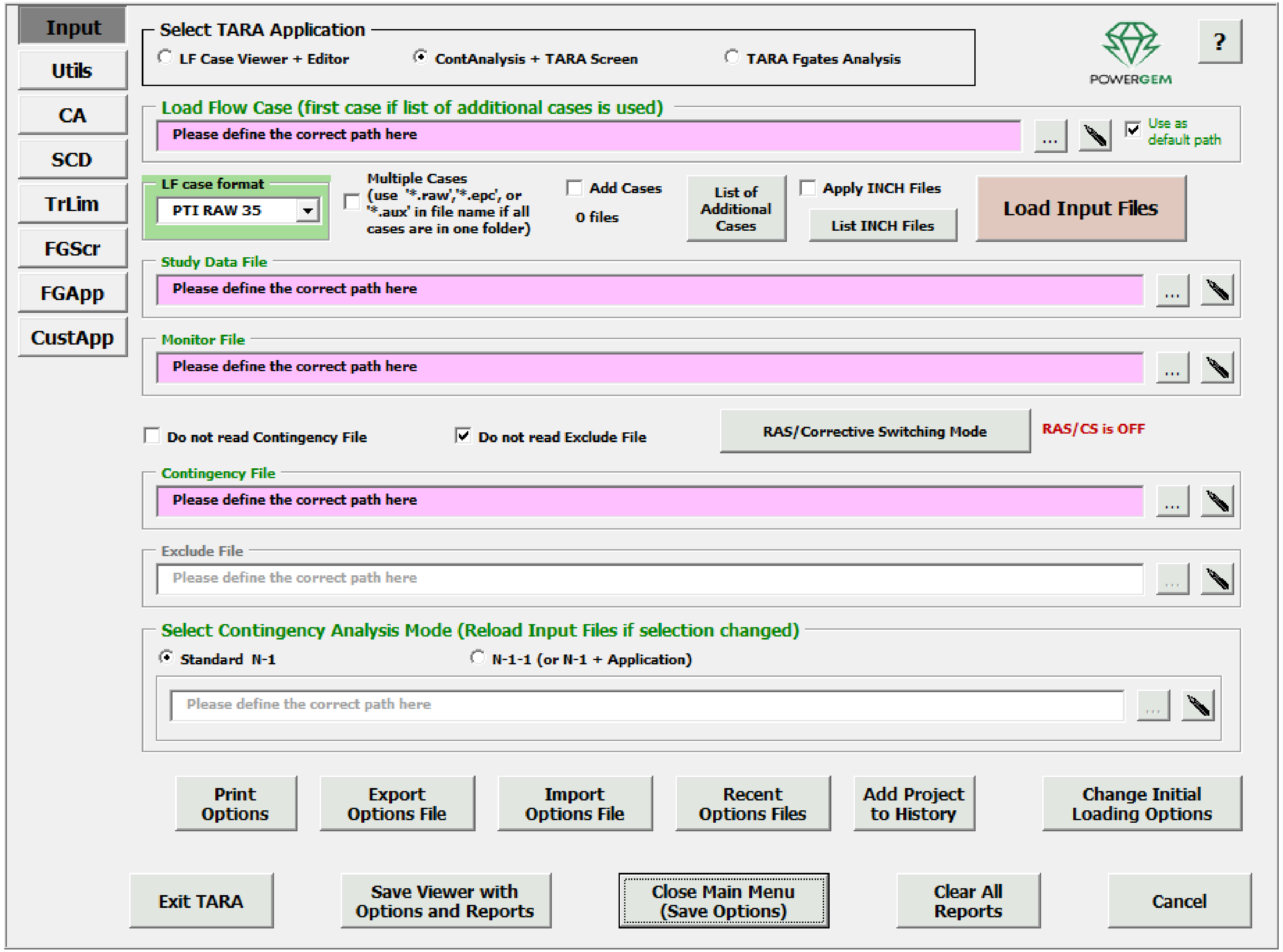
- Bottled generation or deliverability
- Must-run generation (load pocket)
- Evaluate Interfaces

TRANSFER PROCEDURE

- Scale up sending & Scale down receiving
- As transfer increases, keep track of MON/CON pairs that hit limit along the way
  - Only monitor pairs that have transfer Dfax above user-defined cutoff (pre- and/or post-cont)
- Will test up to user-defined max transfer amount
- Transfer continues even after generation runs out
  - For sanity check, check Subsystem Summary report for MW available
- For each mon/con pair that hits the limit, record amount of transfer required
- Select output using Report Manager

INPUT FILES

- Loadflow Case
- Subsystem File
- Monitor File
- Contingency File
- Exclude File (Optional)
- RAS/CS File (Optional)
- INCH file (Optional)



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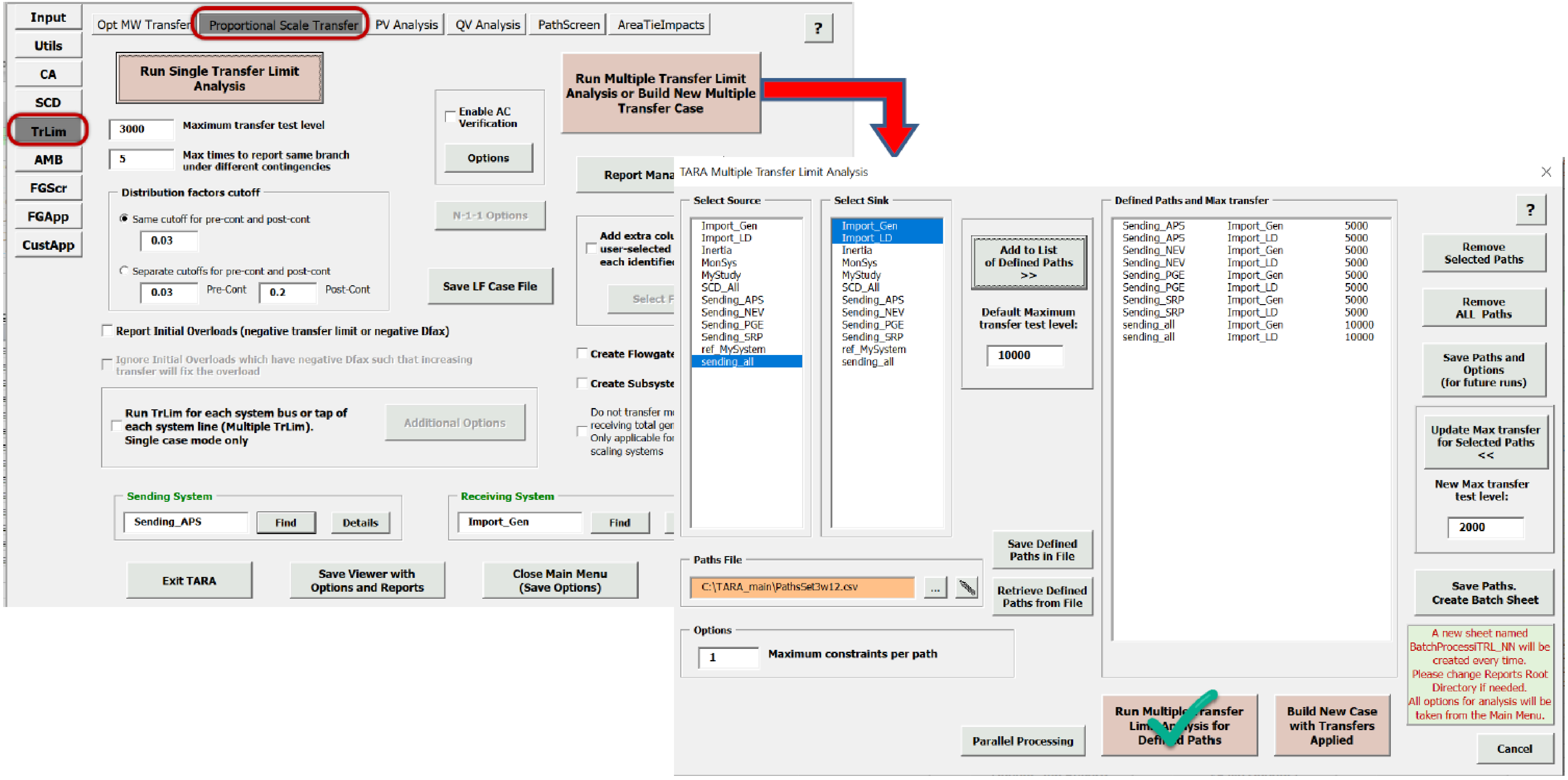
FCITC RESULTS

Significant factors that affect results

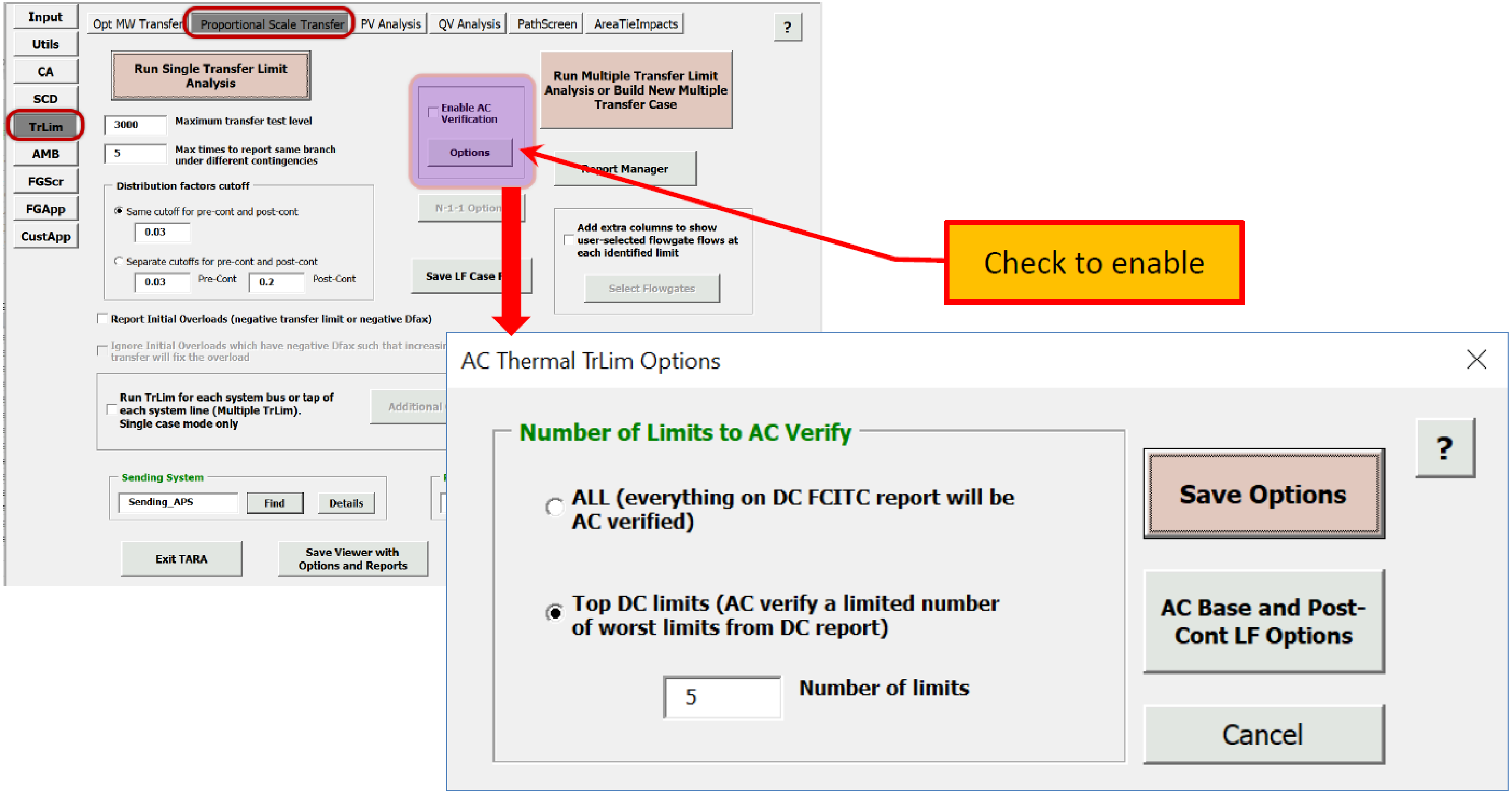
- Transfers built into the starting case
- Load levels and load profile
- Initial generation dispatch
- Participation factors defined by user

FCITC ANALYSIS



Public

AC VERIFY



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FCITC RESULTS

Send/Receive system names

Transfer level

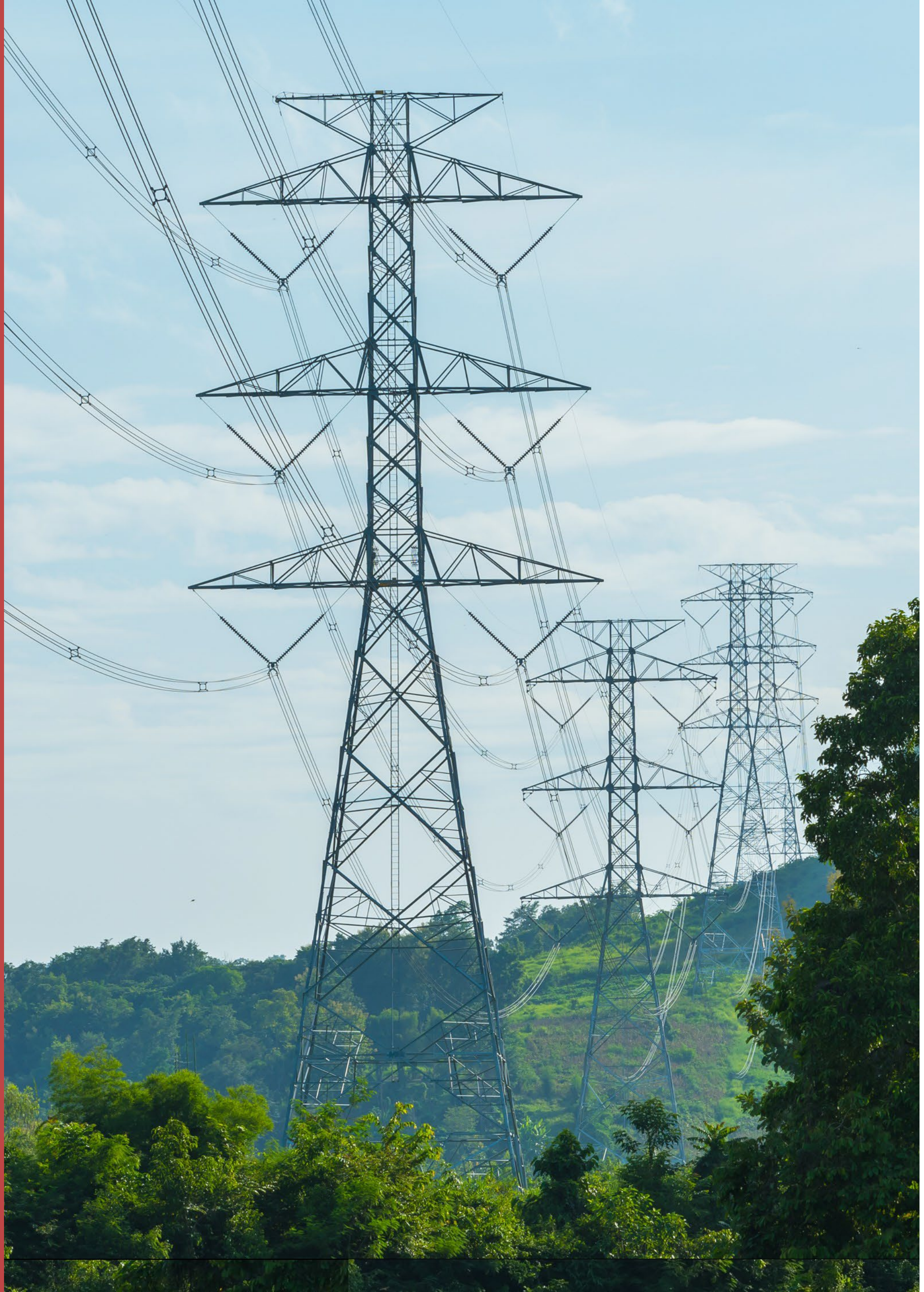
Distribution factors

Loadflow Case: C:\TARA_Training\training.epc
Study Data File: C:\TARA_Training\training.sub
Contingency File: C:\TARA_Training\training.con (total 809 contingencies)
Monitor File: C:\TARA_Training\training.mon
Exclude File: not provided
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed

Sending System	Receiving System	Monitored Facility	Are	TrLim	Dfax	Rate Bas	Rate Cont	Cont Name	Base Flow MW (No Transfe	Cont Flow MW (No Transf	DC %Loading (No Transf	HeadRoom
Sending_AE	Import_Gen	24374 REDBLUFF 500 29253 DVRS_RB_12	24	1281.7	0.14813	2598	2858	29255 DVRS_RB_22 500 24374 REDBLUFF	1501.3	2668.1	93.36	189.9
Sending_AE	Import_Gen	24374 REDBLUFF 500 29253 DVRS_RB_12	24	1296.7	0.14813	2598	2858	24801 DEVERS 500 29254 DVRS_RB_21	1501.3	2665.9	93.28	192.1
Sending_AE	Import_Gen	24374 REDBLUFF 500 29253 DVRS_RB_12	24	1296.7	0.14813	2598	2858	29254 DVRS_RB_21 500 29255 DVRS_RB_22	1501.3	2665.9	93.28	192.1
Sending_AE	Import_Gen	29252 DVRS_RB_11 500 24801 DEVERS	24	1301	0.14813	2598	2858	29255 DVRS_RB_22 500 24374 REDBLUFF	1498.4	2665.3	93.26	192.7
Sending_AE	Import_Gen	29252 DVRS_RB_11 500 24801 DEVERS	24	1315.9	0.14813	2598	2858	29254 DVRS_RB_21 500 29255 DVRS_RB_22	1498.4	2663.1	93.18	194.9
Sending_AE	Import_Gen	29252 DVRS_RB_11 500 24801 DEVERS	24	1315.9	0.14813	2598	2858	24801 DEVERS 500 29254 DVRS_RB_21	1498.4	2663.1	93.18	194.9
Sending_AE	Import_Gen	24374 REDBLUFF 500 29255 DVRS_RB_22	24	1632.8	0.14813	2598	2910	29253 DVRS_RB_12 500 24374 REDBLUFF	1501.3	2668.1	91.69	241.9
Sending_AE	Import_Gen	24374 REDBLUFF 500 29255 DVRS_RB_22	24	1647.7	0.14813	2598	2910	24801 DEVERS 500 29252 DVRS_RB_11	1501.3	2665.9	91.61	244.1
Sending_AE	Import_Gen	24374 REDBLUFF 500 29255 DVRS_RB_22	24	1647.7	0.14813	2598	2910	29252 DVRS_RB_11 500 29253 DVRS_RB_12	1501.3	2665.9	91.61	244.1
Sending_AE	Import_Gen	29254 DVRS_RB_21 500 24801 DEVERS	24	1652	0.14813	2598	2910	29253 DVRS_RB_12 500 24374 REDBLUFF	1498.4	2665.3	91.59	244.7
Sending_AE	Import_Gen	29254 DVRS_RB_21 500 24801 DEVERS	24	1667	0.14813	2598	2910	24801 DEVERS 500 29252 DVRS_RB_11	1498.4	2663.1	91.51	246.9
Sending_AE	Import_Gen	29254 DVRS_RB_21 500 24801 DEVERS	24	1667	0.14813	2598	2910	29252 DVRS_RB_11 500 29253 DVRS_RB_12	1498.4	2663.1	91.51	246.9
Sending_AE	Import_Gen	22472 MIGUELMP 500 22464 MIGUEL	22	2696.1	0.03254	1120	1329	22464 MIGUEL 230 22468 MIGUEL	718.4	1241.3	93.4	87.7
Sending_AE	Import_Gen	22468 MIGUEL 500 22472 MIGUELMP	22	2696.1	0.03254	1120	1329	22464 MIGUEL 230 22468 MIGUEL	718.4	1241.3	93.4	87.7
Sending_AE	Import_Gen	22468 MIGUEL 500 22464 MIGUEL	22	3510.1	0.03226	1120	1344	22464 MIGUEL 230 22472 MIGUELMP	695.4	1230.8	91.58	113.2
Sending_AE	Import_Gen	22468 MIGUEL 500 22464 MIGUEL	22	3510.1	0.03226	1120	1344	22468 MIGUEL 500 22472 MIGUELMP	695.4	1230.8	91.58	113.2

Mon / con pair for each transfer level

Live Demo



QUESTIONS & ANSWERS

John Idzior

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CASCADE ANALYSIS

Brian Hallett, ReliabilityFirst

August 6, 2026

RELIABILITY FIRST

PURPOSE

Cascade analysis evaluates how an initial component outage (N-1, N-1-1, etc.) can trigger a domino effect of overloads, line tripping, and widespread blackouts across the BES.

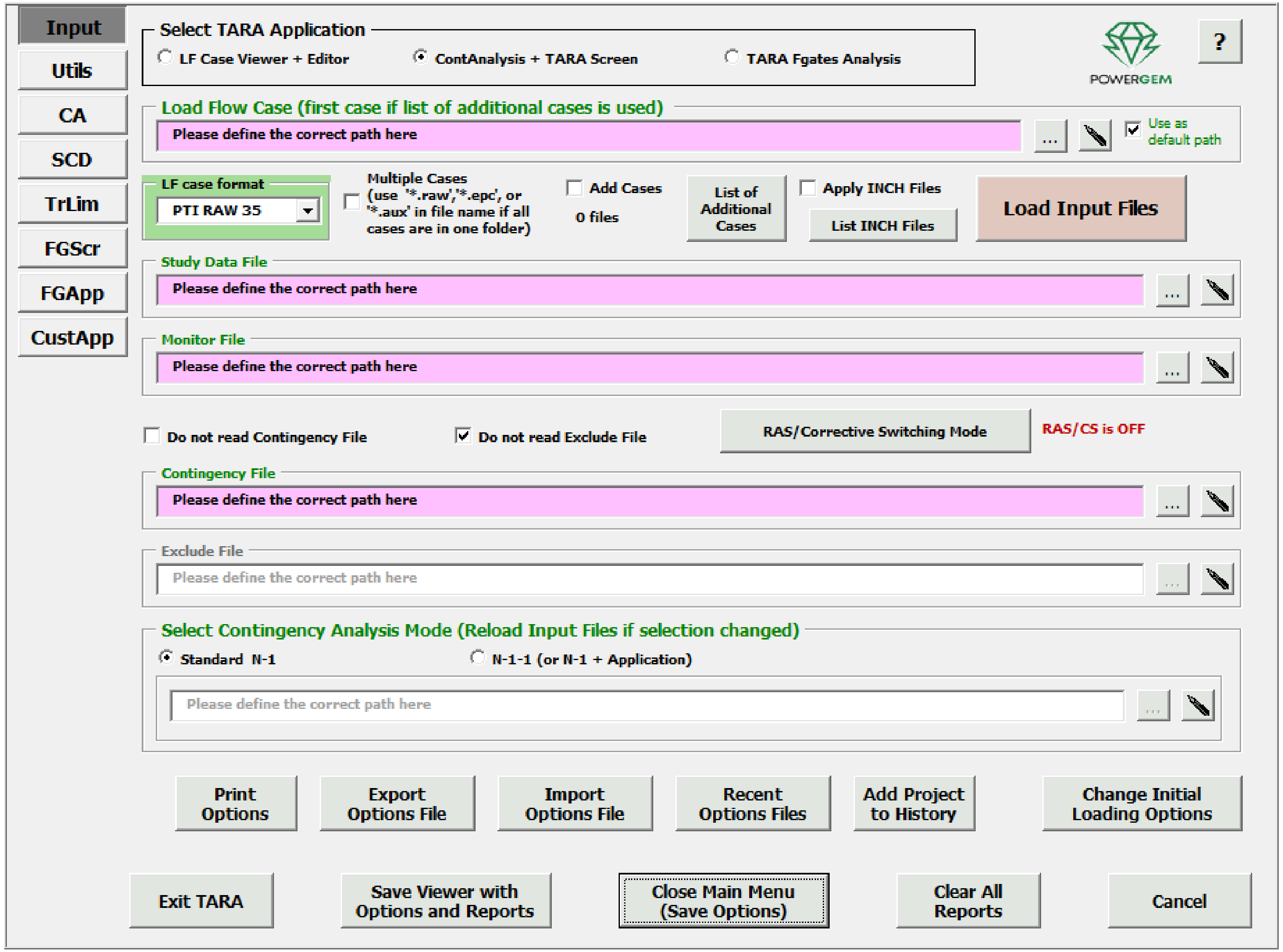
A cascade event that results in a non-convergence in steady-state analysis, may be an indicator of a potential stability concern that should be further investigated using dynamic analysis.

You may select different triggers and intermediate actions, e.g.

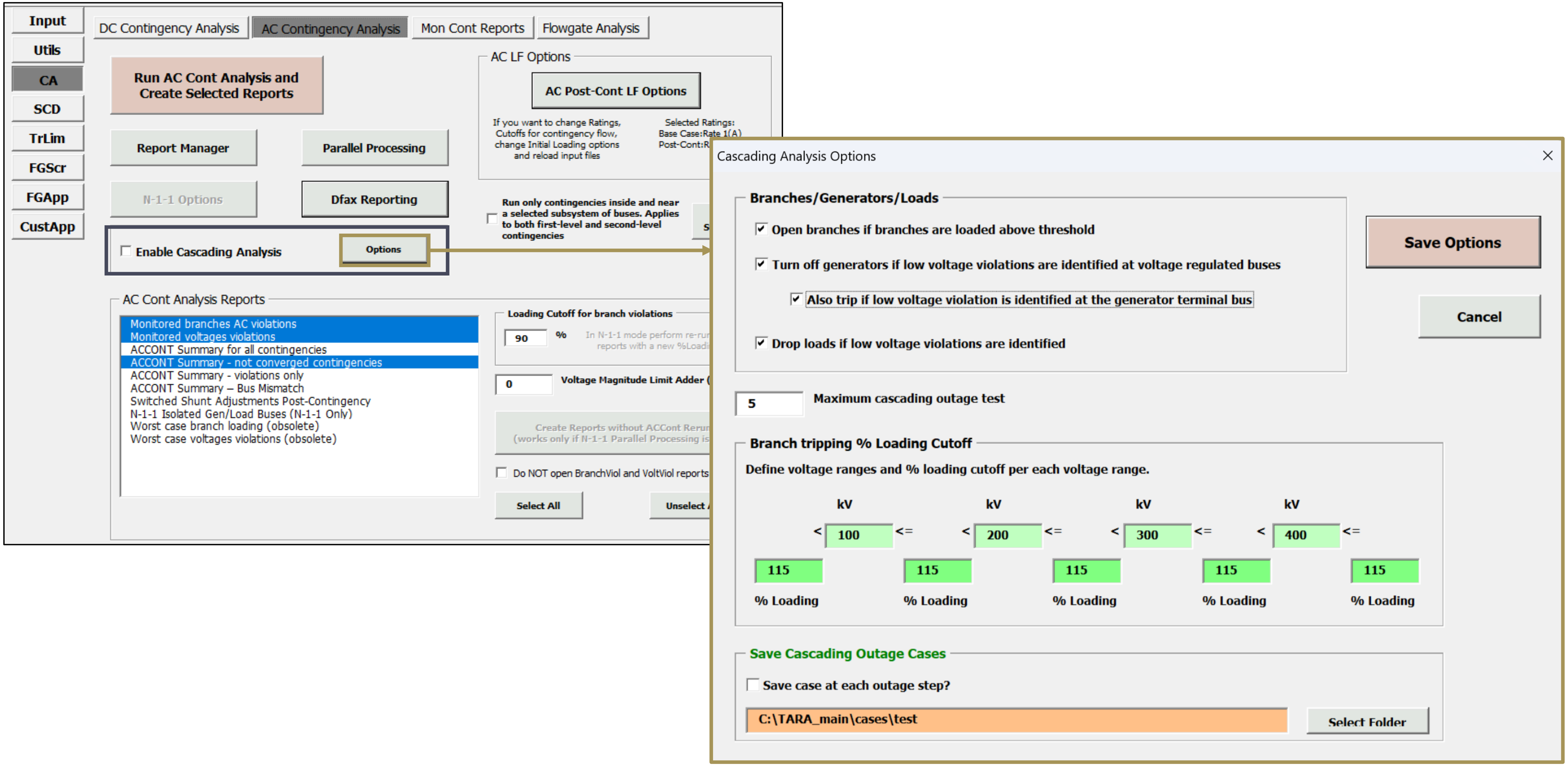
- Kick-off cascade for thermal overloads greater than 115%, or 125%
- Subsequent tripping of lines loaded above 100%, 115%, or 125%
- Trip generators below Vmin

INPUT FILES

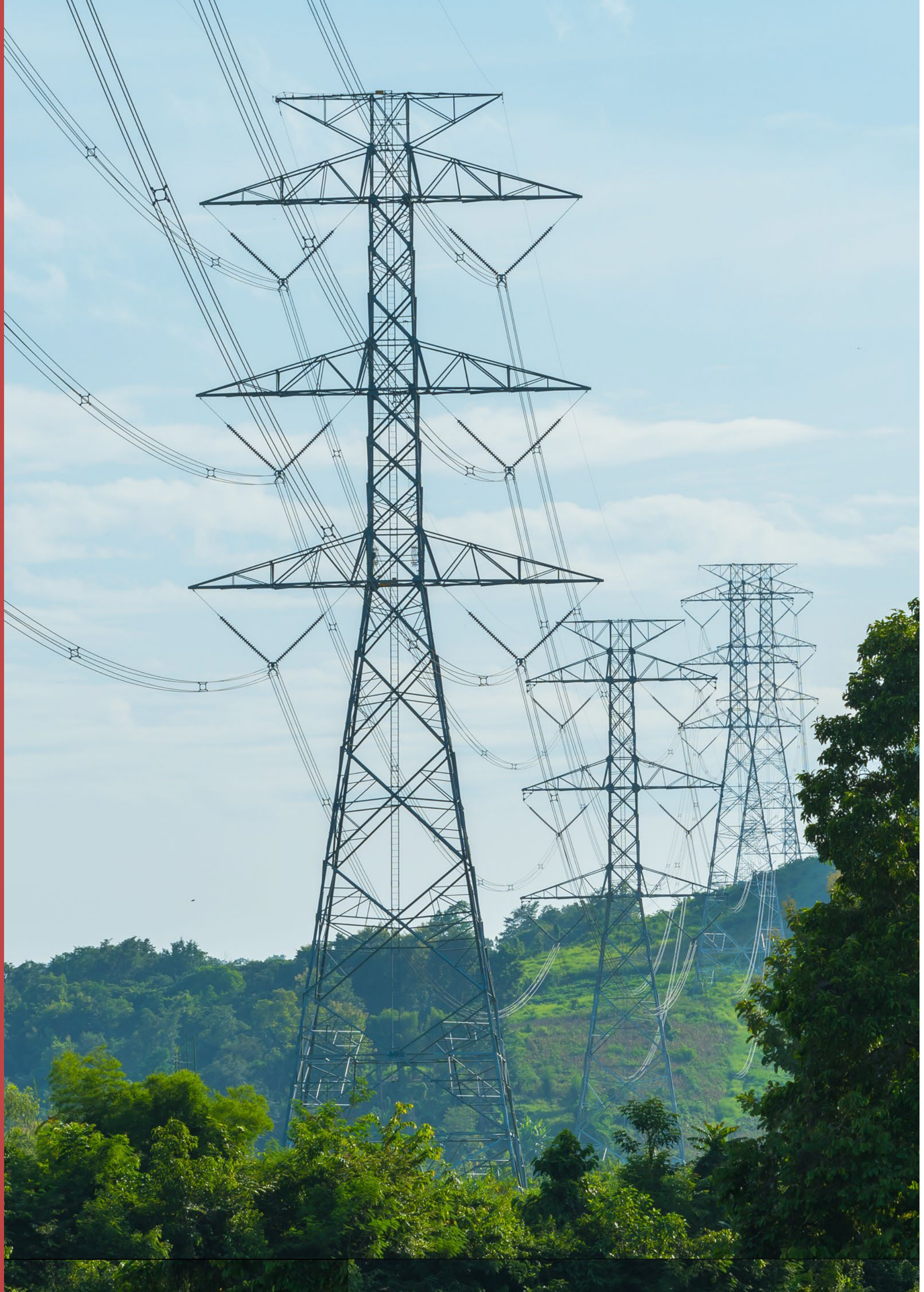
- Loadflow case(s)
- Subsystem file
- Monitor file
- Contingency file(s)
- Exclude file (optional)
- RAS/CS file (optional)
- INCH file (optional)



N-1 ANALYSIS > CASCADE



Live Demo



QUESTIONS & ANSWERS

Brian Hallett

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Public

FORWARD TOGETHER RELIABILITYFIRST

PV ANALYSIS

Brian Hallett, ReliabilityFirst

August 6, 2026

RELIABILITY FIRST

PURPOSE

PV can be a concern under heavy transfers, particularly into heavily loaded load pockets.

PV can be a good compliment to thermal transfer analysis, because some interfaces may be more limited by voltage decline than by thermal overload.

May want to test various contingency scenarios, e.g.

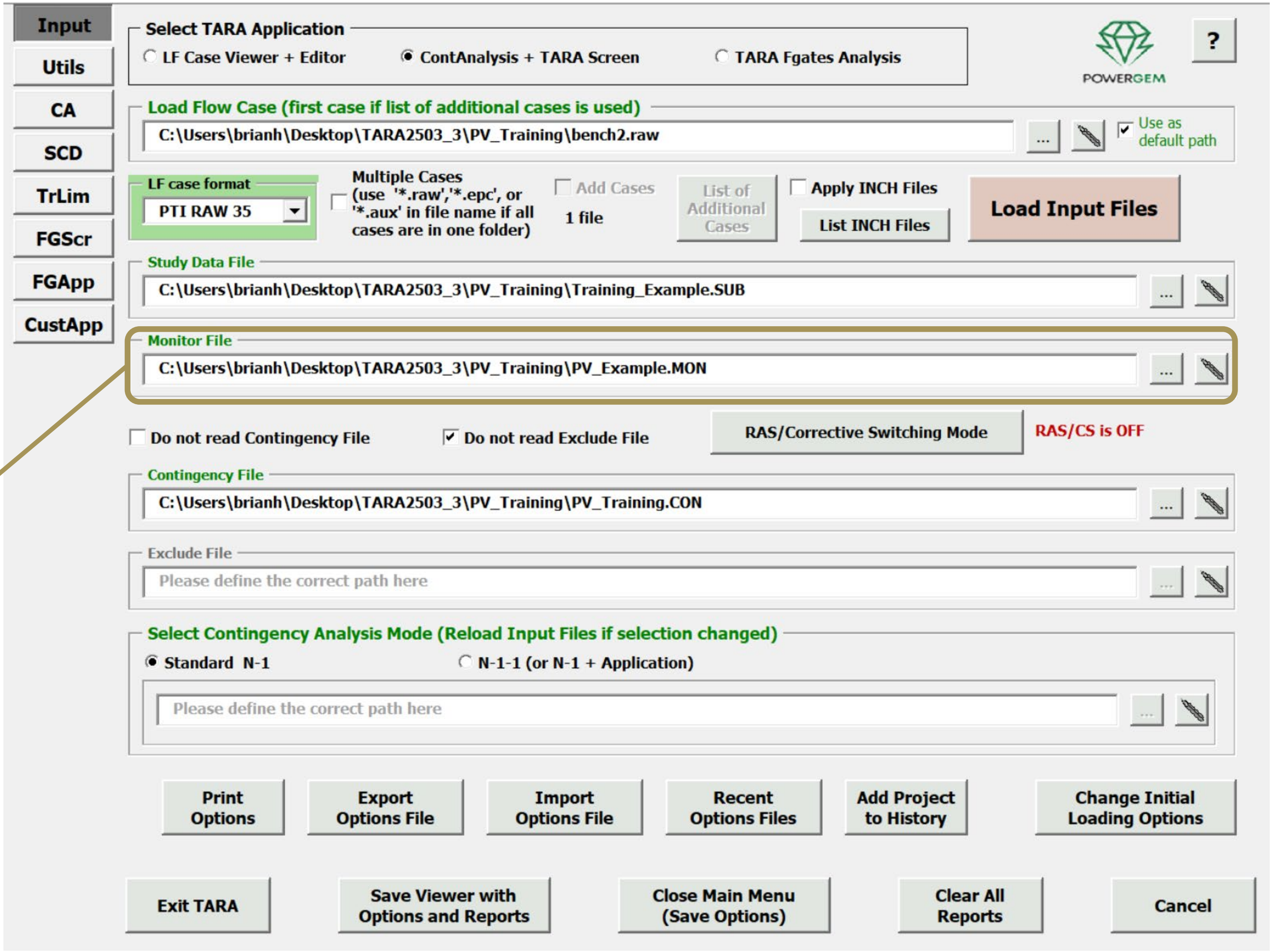
- Line outages
- Generator outages
- Combinations of line + generator outages

INPUT FILES

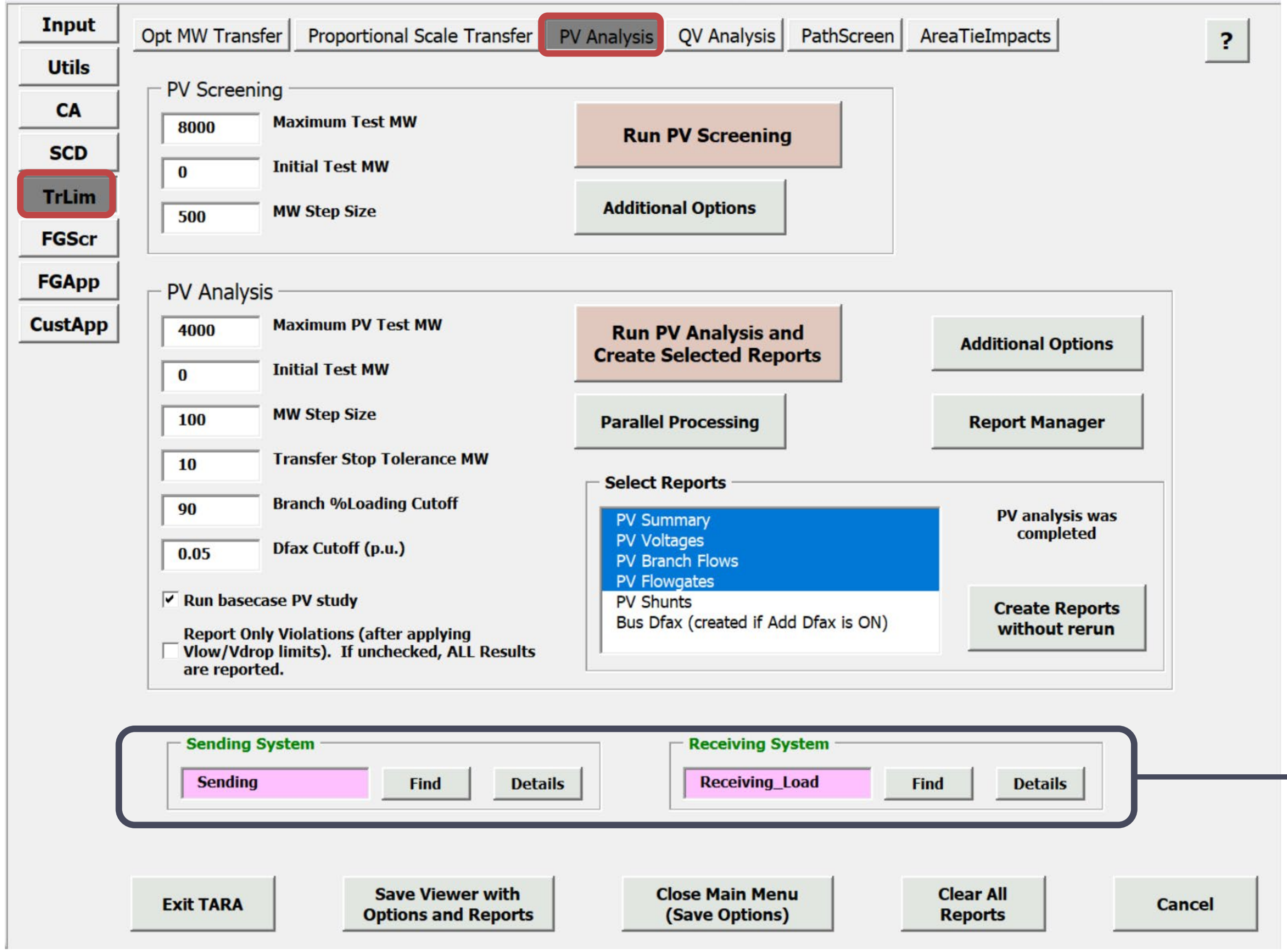
- Loadflow case(s)
- Subsystem file
  - ➢ Define 'Sending' System
  - ➢ Define 'Receiving' System
- Monitor file

```
COM Monitor file for PV Training Example

COM Monitor a flowgate - all the flows into the area based on tie-lines
monitor flowgate 1 "Area 4" rating 4000 MW
  monitor branch from bus 1280 to bus 1092 ckt  1
  monitor branch from bus 1280 to bus 1092 ckt  2
  monitor branch from bus 1282 to bus 1100 ckt  1
  monitor branch from bus 1283 to bus 1100 ckt  1
  monitor branch from bus 1270 to bus 1101 ckt  1
  monitor branch from bus 1803 to bus 1104 ckt  1
  monitor branch from bus 1306 to bus 1105 ckt  1
  monitor branch from bus 1307 to bus 1106 ckt  1
  monitor branch from bus 1314 to bus 1133 ckt  1
  monitor branch from bus 1314 to bus 1135 ckt  1
end


COM Monitor specific bus in the study area
monitor voltage range    bus  1183  0.90 1.03  /first attempt
  monitor bus 1183  / random bus in Area 4 with no generation
end
```

- Contingency file(s)

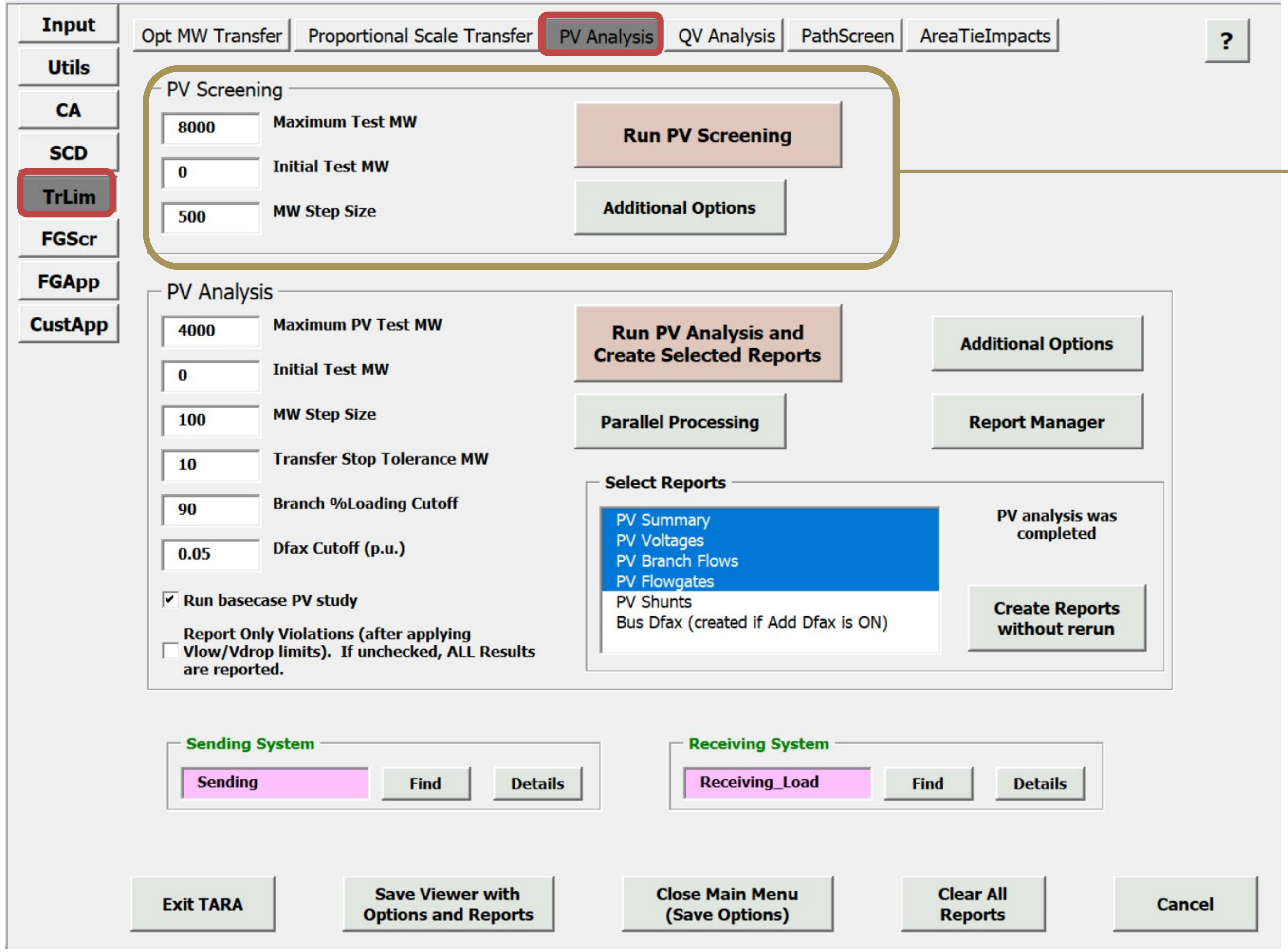


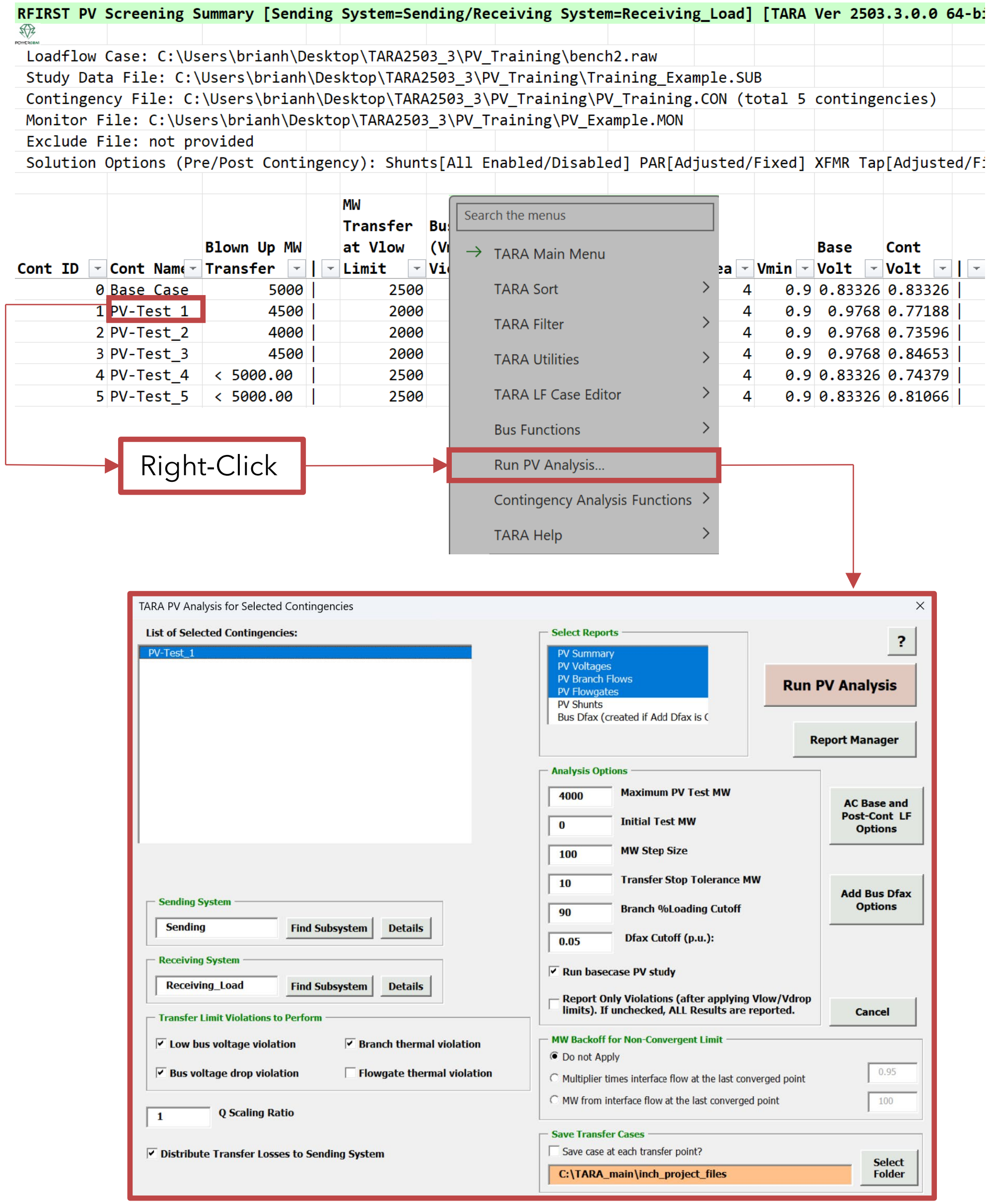
PV ANALYSIS



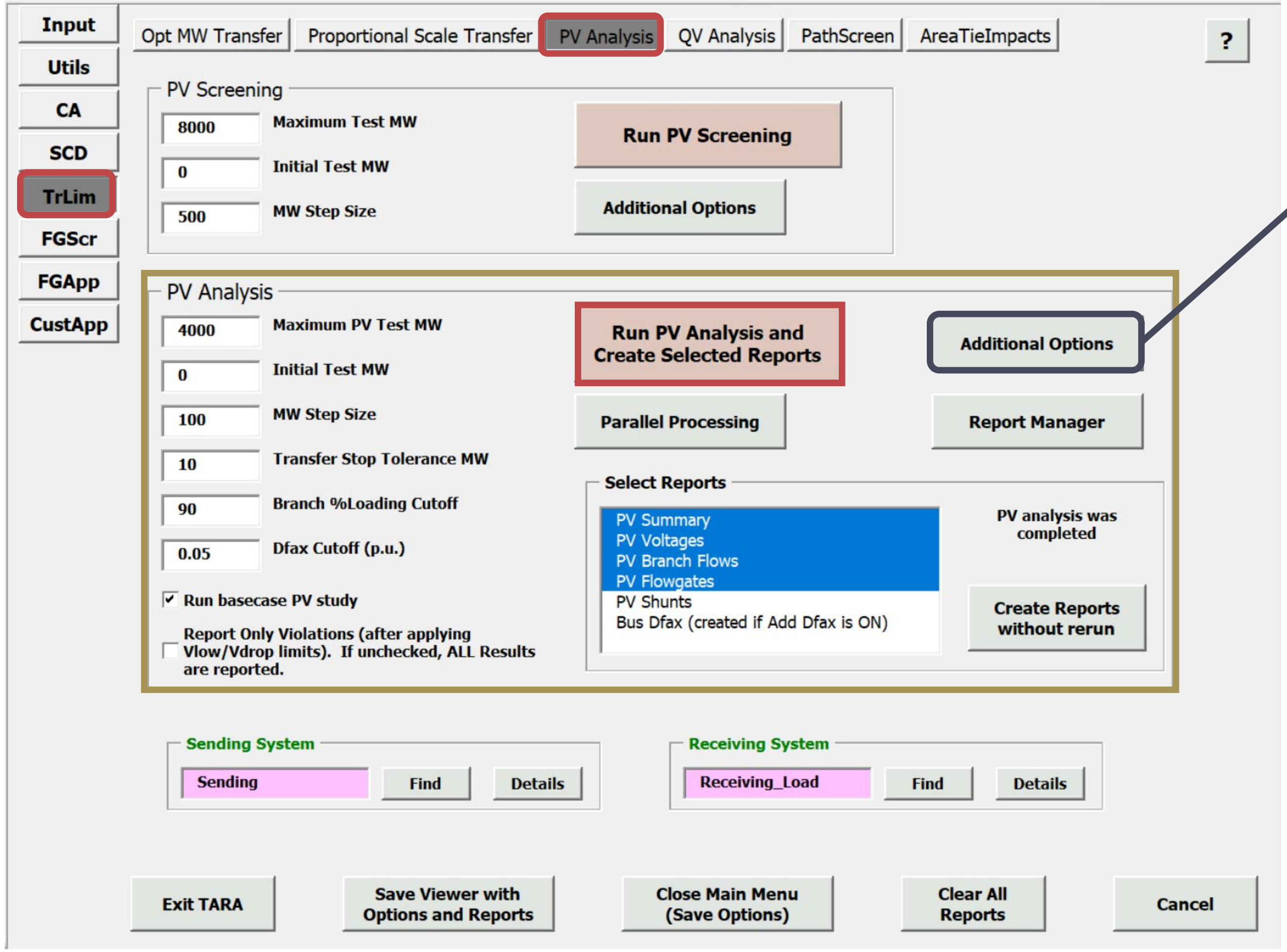

```
/File: Training_Examples.SUB
/Set-up Subsystems for PV Anaysis using generic PSSE sample case

Subsystem 'PV_Mon'
 Area 4
End

Subsystem 'Sending'
 Area 9
 Area 10
 Area 11
 Area 16
 Area 17
 Area 18
 Area 19
 Area 47
 scale all generation
End

/Sending areas are all West of the study area
/Total dispatched generation in these Areas = 39,870MW (PGen)
/Sample case has all Pmax set to 9999.9

Subsystem 'Receiving_Load'
 Area 4
 scale all load
End

/Receiving area load+losses = 3,899.95

Subsystem 'Receiving_Gen'
 Area 22
 Area 23
 Area 24
 Area 26
 scale all generation
End

/Receiving areas area all East of the study area
```

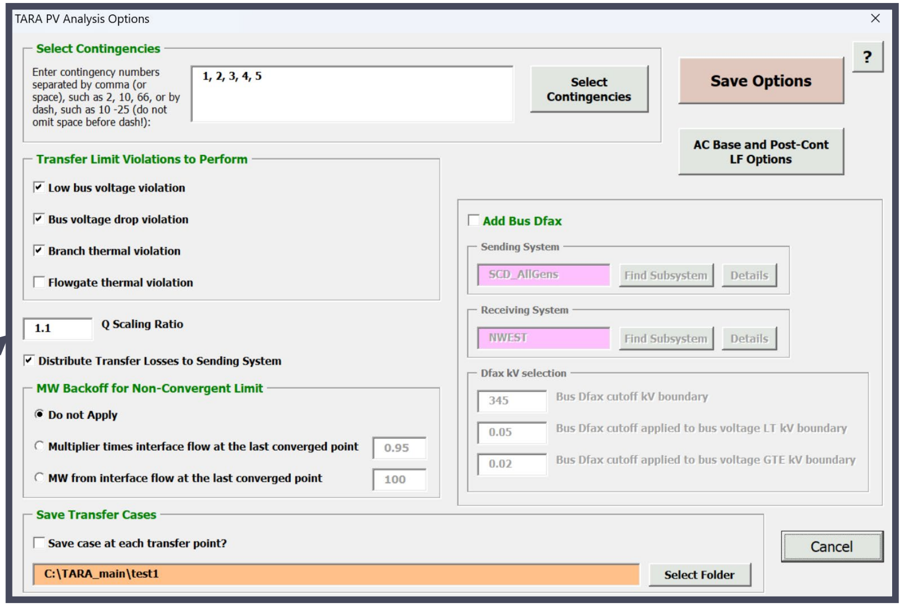
PV ANALYSIS


Input
Utils
CA
SCD
TrLim
FGScr
FGApp
CustApp
Opt MW Transfer
Proportional Scale Transfer
PV Analysis
QV Analysis
PathScreen
AreaTieImpacts
?
PV Screening
8000 Maximum Test MW
0 Initial Test MW
500 MW Step Size
Run PV Screening
Additional Options
PV Analysis
4000 Maximum PV Test MW
0 Initial Test MW
100 MW Step Size
10 Transfer Stop Tolerance MW
90 Branch %Loading Cutoff
0.05 Dfax Cutoff (p.u.)
Run basecase PV study
Report Only Violations (after applying Vlow/Vdrop limits). If unchecked, ALL Results are reported.
Run PV Analysis and Create Selected Reports
Additional Options
Parallel Processing
Report Manager
Select Reports
PV Summary
PV Voltages
PV Branch Flows
PV Flowgates
PV Shunts
Bus Dfax (created if Add Dfax is ON)
PV analysis was completed
Create Reports without rerun
Sending System
Sending
Find
Details
Receiving System
Receiving_Load
Find
Details
Exit TARA
Save Viewer with Options and Reports
Close Main Menu (Save Options)
Clear All Reports
Cancel


RFIRST PV Screening Summary [Sending System=Sending/Receiving System=Receiving_Load] [TARA Ver 2503.3.0.0 64-b
Loadflow Case: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\bench2.raw
Study Data File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\Training_Example.SUB
Contingency File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Training.CON (total 5 contingencies)
Monitor File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Example.MON
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Disabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/F
Cont ID | Cont Name | Blown Up MW Transfer | MW Transfer at Vlow Limit | Vmin | Base Volt | Cont Volt
0 Base Case 5000 2500 4 0.9 0.83326 0.83326
1 PV-Test_1 4500 2000 4 0.9 0.9768 0.77188
2 PV-Test_2 4000 2000 4 0.9 0.9768 0.73596
3 PV-Test_3 4500 2000 4 0.9 0.9768 0.84653
4 PV-Test_4 < 5000.00 2500 4 0.9 0.83326 0.74379
5 PV-Test_5 < 5000.00 2500 4 0.9 0.83326 0.81066
Search the menus
TARA Main Menu
TARA Sort
TARA Filter
TARA Utilities
TARA LF Case Editor
Bus Functions
Run PV Analysis...
Contingency Analysis Functions
TARA Help
Right-Click
TARA PV Analysis for Selected Contingencies
List of Selected Contingencies:
PV-Test_1
Select Reports
PV Summary
PV Voltages
PV Branch Flows
PV Flowgates
PV Shunts
Run PV Analysis
Report Manager
Analysis Options
4000 Maximum PV Test MW
0 Initial Test MW
100 MW Step Size
10 Transfer Stop Tolerance MW
90 Branch %Loading Cutoff
0.05 Dfax Cutoff (p.u.):
AC Base and Post-Cont LF Options
Add Bus Dfax Options
Run basecase PV study
Report Only Violations (after applying Vlow/Vdrop limits). If unchecked, ALL Results are reported.
Cancel
Sending System
Sending
Find Subsystem
Details
Receiving System
Receiving_Load
Find Subsystem
Details
Transfer Limit Violations to Perform
Low bus voltage violation
Branch thermal violation
Bus voltage drop violation
Flowgate thermal violation
1 Q Scaling Ratio
Distribute Transfer Losses to Sending System
MW Backoff for Non-Convergent Limit
Do not Apply
Multiplier times interface flow at the last converged point
MW from interface flow at the last converged point
Save Transfer Cases
Save case at each transfer point?
Select Folder
C:\TARA_main\inch_project_files

PV ANALYSIS


Input
Utils
CA
SCD
TrLim
FGScr
FGApp
CustApp
Opt MW Transfer
Proportional Scale Transfer
PV Analysis
QV Analysis
PathScreen
AreaTieImpacts
?
PV Screening
8000 Maximum Test MW
0 Initial Test MW
500 MW Step Size
Run PV Screening
Additional Options
PV Analysis
4000 Maximum PV Test MW
0 Initial Test MW
100 MW Step Size
10 Transfer Stop Tolerance MW
90 Branch %Loading Cutoff
0.05 Dfax Cutoff (p.u.)
Run basecase PV study
Report Only Violations (after applying Vlow/Vdrop limits). If unchecked, ALL Results are reported.
Run PV Analysis and Create Selected Reports
Additional Options
Parallel Processing
Report Manager
Select Reports
PV Summary
PV Voltages
PV Branch Flows
PV Flowgates
PV Shunts
Bus Dfax (created if Add Dfax is ON)
PV analysis was completed
Create Reports without rerun
Sending System
Sending
Find
Details
Receiving System
Receiving_Load
Find
Details
Exit TARA
Save Viewer with Options and Reports
Close Main Menu (Save Options)
Clear All Reports
Cancel


TARA PV Analysis Options
Select Contingencies
Enter contingency numbers separated by comma (or space), such as 2, 10, 66, or by dash, such as 10 -25 (do not omit space before dash!):
1, 2, 3, 4, 5
Select Contingencies
Save Options
?
AC Base and Post-Cont LF Options
Transfer Limit Violations to Perform
Low bus voltage violation
Bus voltage drop violation
Branch thermal violation
Flowgate thermal violation
1.1 Q Scaling Ratio
Distribute Transfer Losses to Sending System
MW Backoff for Non-Convergent Limit
Do not Apply
Multiplier times interface flow at the last converged point 0.95
MW from interface flow at the last converged point 100
Add Bus Dfax
Sending System
SCD_AllGens
Find Subsystem
Details
Receiving System
NWEST
Find Subsystem
Details
Dfax kV selection
345 Bus Dfax cutoff kV boundary
0.05 Bus Dfax cutoff applied to bus voltage LT kV boundary
0.02 Bus Dfax cutoff applied to bus voltage GTE kV boundary
Save Transfer Cases
Save case at each transfer point?
C:\TARA_main\test1
Select Folder
Cancel

PV RESULTS - SUMMARY

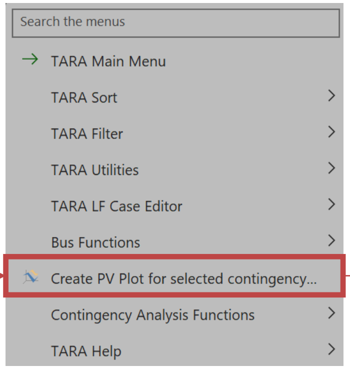
RFIRST PV Summary [TARA Ver 2503.3.0.0 64-bit - Thu Jul 30 09:39:31 2026]

Loadflow Case: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\bench2.raw
Study Data File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\Training_Example.SUB
Contingency File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Training.CON (total 5 contingencies)
Monitor File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Example.MON
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Disabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Fixed] Area Interchange [Disabled/Disabled]

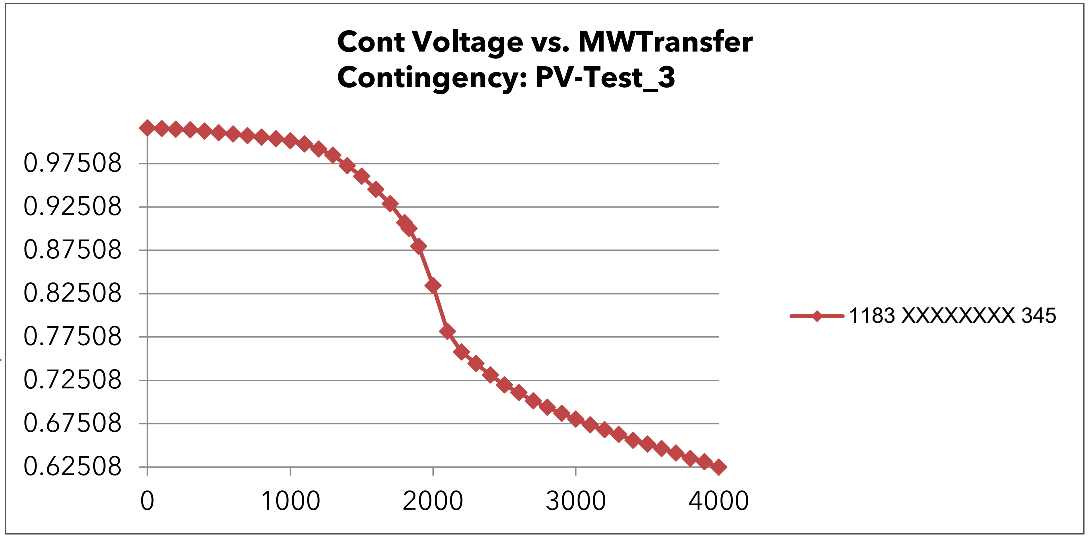
Sending System	Receiving System	Worst Limit Flag	Cont ID	Cont Name	Last Converged MW Transfer	|	FG Name (Last Converged	FGID	Ratin	Last Transfer Base MW	Last Transfer Cont MW	Last Transfer AC %Loading	Knee Fla	|	MW Transfer at Vlow Limit	Bus #(Vmag Vio)	Bus Nar	Base kV	Area	Vmin	Base Volt	Cont Volt	Limit Info	FG Baseflow at Vmag Violatio	FG Contflow at Vmag Violation
Sending	Receiving_Load	LTrans	0	Base Case	4000	|	Area 4	1	4000	2682.23	2682.23	115.4	Knee	|	2312.5	1183	XXXXXXXX	345	4	0.9	0.9	-	Found	2603.48	2603.48
Sending	Receiving_Load		1	PV-Test_1	4000	|	Area 4	1	4000	2682.23	3105.68	132	Knee	|	1656.25	1183	XXXXXXXX	345	4	0.9	0.9905	0.9004	Found	1908.94	3137.26
Sending	Receiving_Load	Vmag	2	PV-Test_2	4000	|	Area 4	1	4000	2682.23	2922.32	125.4	Knee	|	1506.25	1183	XXXXXXXX	345	4	0.9	0.9945	0.9004	Found	1754.52	2978.65
Sending	Receiving_Load		3	PV-Test_3	4000	|	Area 4	1	4000	2682.23	3313.55	137.7	Knee	|	1831.25	1183	XXXXXXXX	345	4	0.9	0.985	0.9002	Found	2089.77	3304.89
Sending	Receiving_Load		4	PV-Test_4	4000	|	Area 4	1	4000	2682.23	2294.69	103.3	Knee	|	2062.5	1183	XXXXXXXX	345	4	0.9	0.9597	0.9003	Found	2331.85	2353.61
Sending	Receiving_Load		5	PV-Test_5	4000	|	Area 4	1	4000	2682.23	2612.56	112.4		|	2406.25	1183	XXXXXXXX	345	4	0.9	0.858	0.8538	Within	2707.97	2706.15

PVcurves_test2 | PVScrSum | Warn_Sum | Warn_List | CaseSum | LogFile | PVcurves_test | PVSummary | PVVoltage | PVBranchFlow | PVFlowgate | PVShunt | BatchProcess_TrainingN1 | BatchProcess_TrainingN11 | +

Right Click



Plot Wizard



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PV RESULTS - VOLTAGE

RFIRST PV Voltage Result [TARA Ver 2503.3.0.0 64-bit - Thu Jul 30 09:39:31 2026]

Loadflow Case: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\bench2.raw
Study Data File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\Training_Example.SUB
Contingency File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Training.CON (total 5 contingencies)
Monitor File: C:\Users\brianh\Desktop\TARA2503_3\PV_Training\PV_Example.MON
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Disabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Fixed] Area Interchange [Disabled/Disabled]

Sending System	Receiving System	Worst Limit Flag	MW Transf	Bus #	Bus Name	Base kV	Area	Bus Type	Pgen	Pload	G Shunt	B Shunt	Min Volt Limit	Max Volt Limit	Cont Name	Cont ID	Base Volt	Cont Volt	%Vdrop
Sending	Receiving_Load		0	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.0164	1.01605	0.034
Sending	Receiving_Load		100	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01586	1.01538	0.048
Sending	Receiving_Load		200	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01532	1.0147	0.062
Sending	Receiving_Load		300	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01475	1.01319	0.156
Sending	Receiving_Load		400	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01409	1.01144	0.266
Sending	Receiving_Load		500	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01265	1.00977	0.287
Sending	Receiving_Load		600	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.01117	1.00801	0.315
Sending	Receiving_Load		700	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00965	1.0062	0.344
Sending	Receiving_Load		800	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00809	1.00409	0.4
Sending	Receiving_Load		900	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00649	1.00163	0.486
Sending	Receiving_Load		1000	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00486	0.99655	0.83
Sending	Receiving_Load		1100	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00318	0.99096	1.222
Sending	Receiving_Load		1200	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	1.00133	0.98182	1.951
Sending	Receiving_Load		1300	1183	XXXXXXXX	345	4	Load	0	5	0	0	0.9	1.03	PV-Test_1	1	0.99943	0.96791	3.152
Sending	Receiving_Load		1400	1183	XXXXXXXX	345	4	Load	0	5	0	0							
Sending	Receiving_Load		1500	1183	XXXXXXXX	345	4	Load	0	5	0	0							
Sending	Receiving_Load		1600	1183	XXXXXXXX	345	4	Load	0	5	0	0							

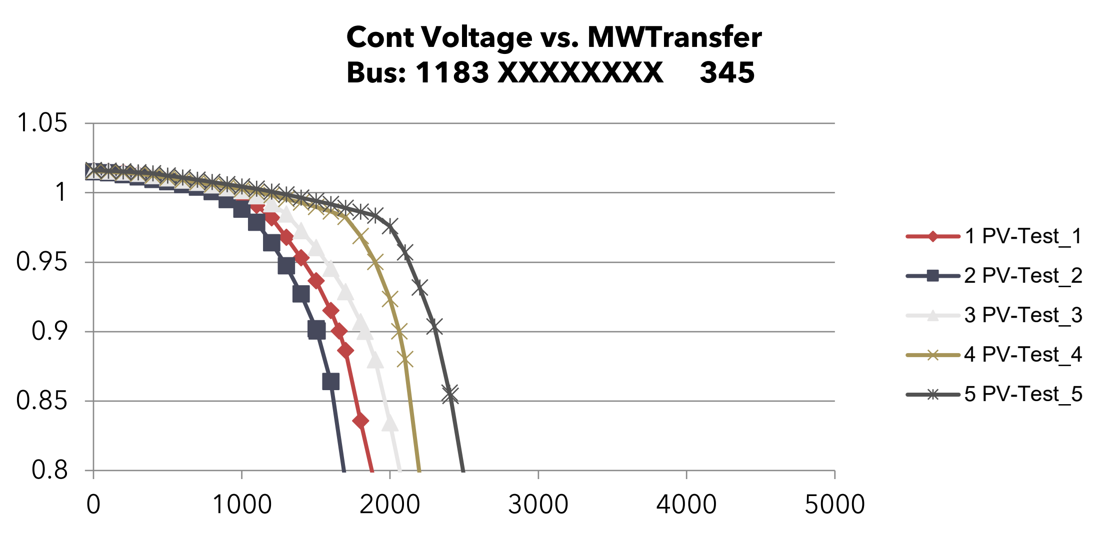
PVcurves_test2 | aseSum | LogFile | PVcurves_test | PVSummary | PVVoltage

Search the menus

- TARA Main Menu
- TARA Sort
- TARA Filter
- TARA Utilities
- TARA LF Case Editor
- Bus Functions
- Create PV Plot for selected contingency...
- Create PV Plot for selected bus...
- Contingency Analysis Functions
- TARA Help

Right Click

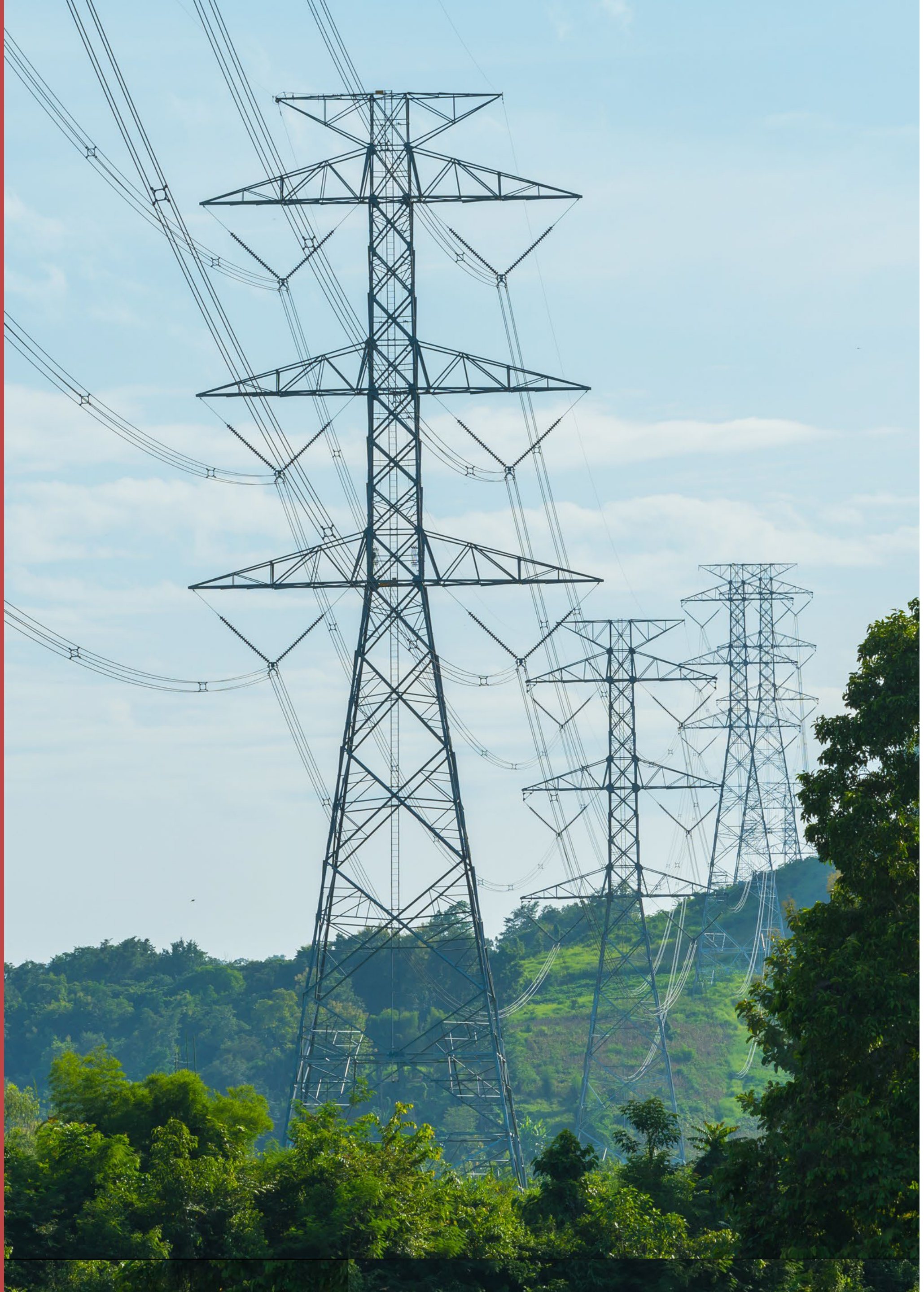
Plot Wizard



Live Demo

Public

FORWARD TOGETHER RELIABILITYFIRST



QUESTIONS & ANSWERS

Brian Hallett

brian.hallett@rfirst.org

Public

FORWARD TOGETHER RELIABILITYFIRST

QV ANALYSIS

John Idzior, ReliabilityFirst

August 6, 2026

RELIABILITY FIRST

PURPOSE

We have a starting case with a topology, load, dispatch, and transaction schedule built in

We want to identify voltage stability violations and reactive power margin for study buses under various loading and with different contingencies. Used to determine the location of the most effective reactive support and the size and type of reactive devices.

- Show Reactive margin at study bus
- Determine location, size and type of reactive device deeded
- Compare different sized Shunt devices

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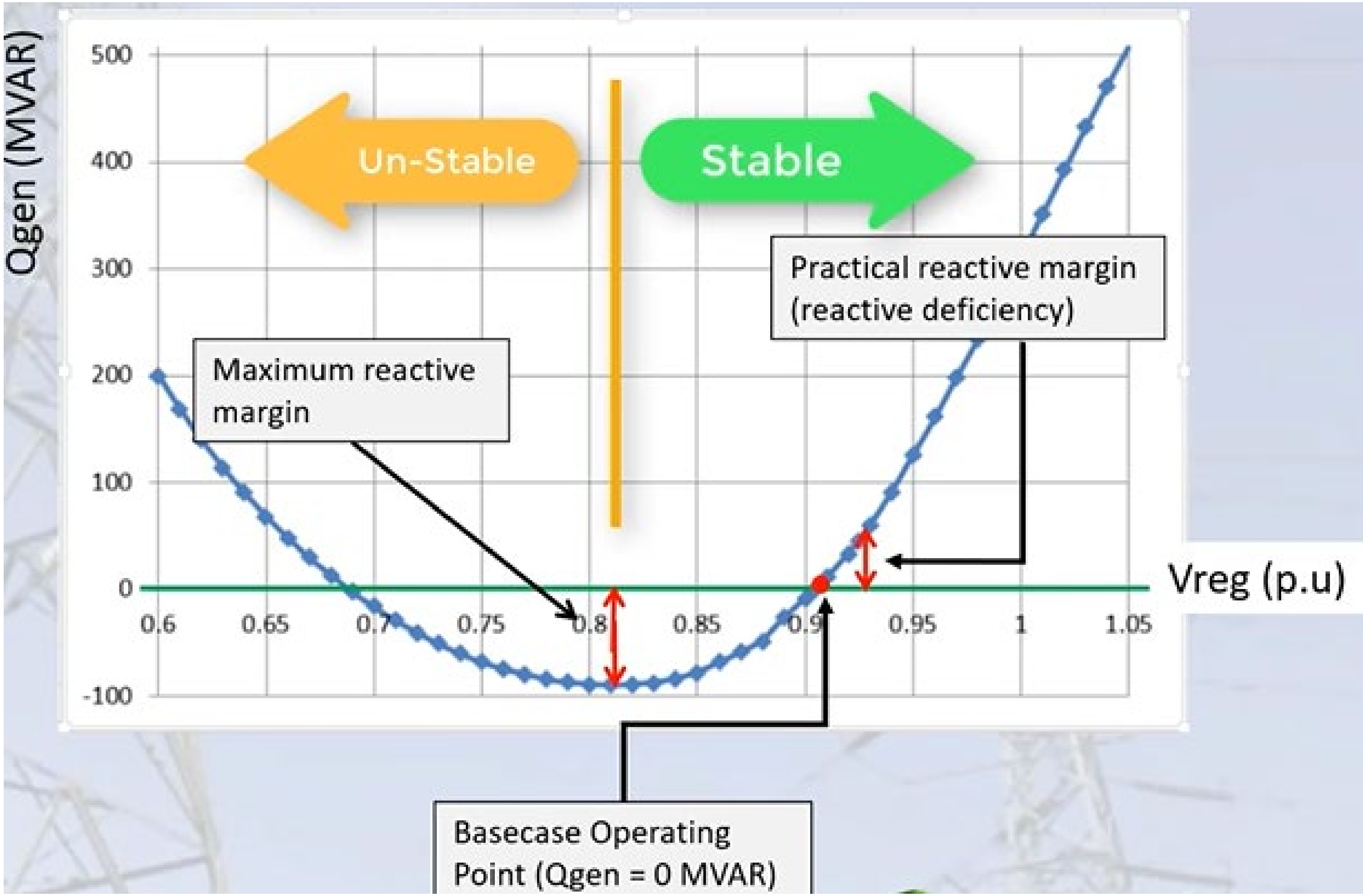
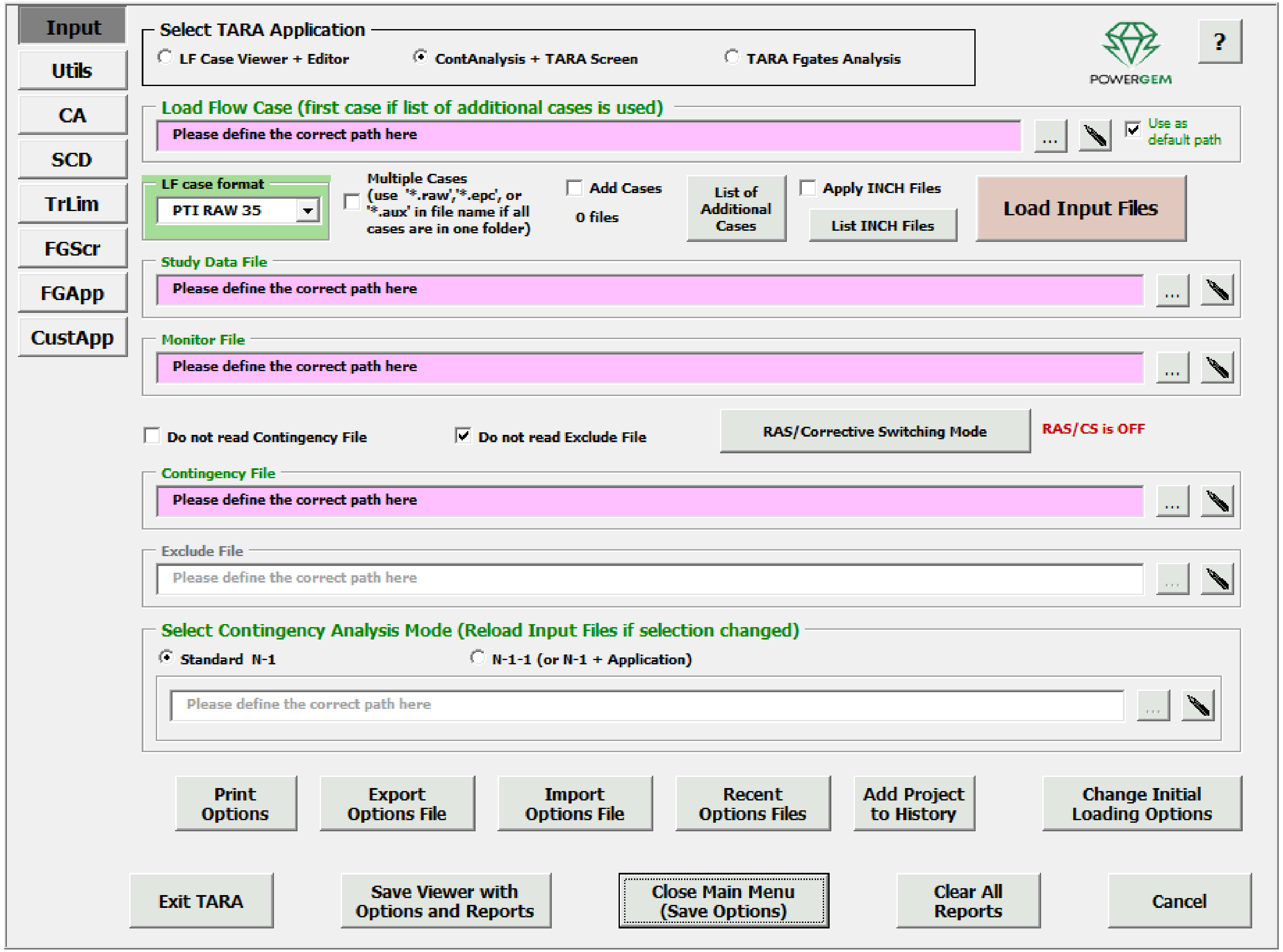
QV ANALYSIS



*Source: PowerGEM

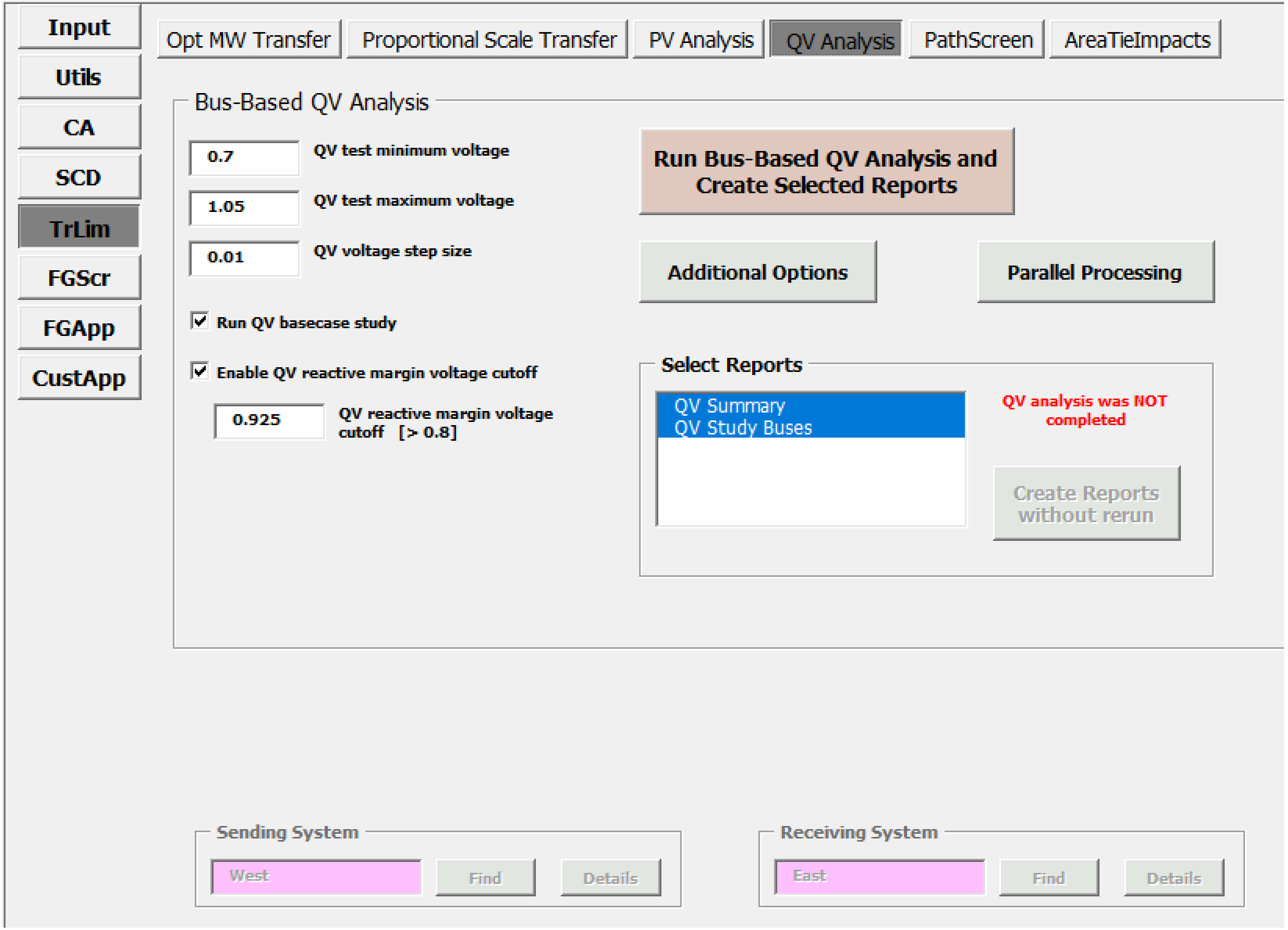
INPUT FILES

- Loadflow Case
- Contingency File
- Subsystem File*
- Monitor File*

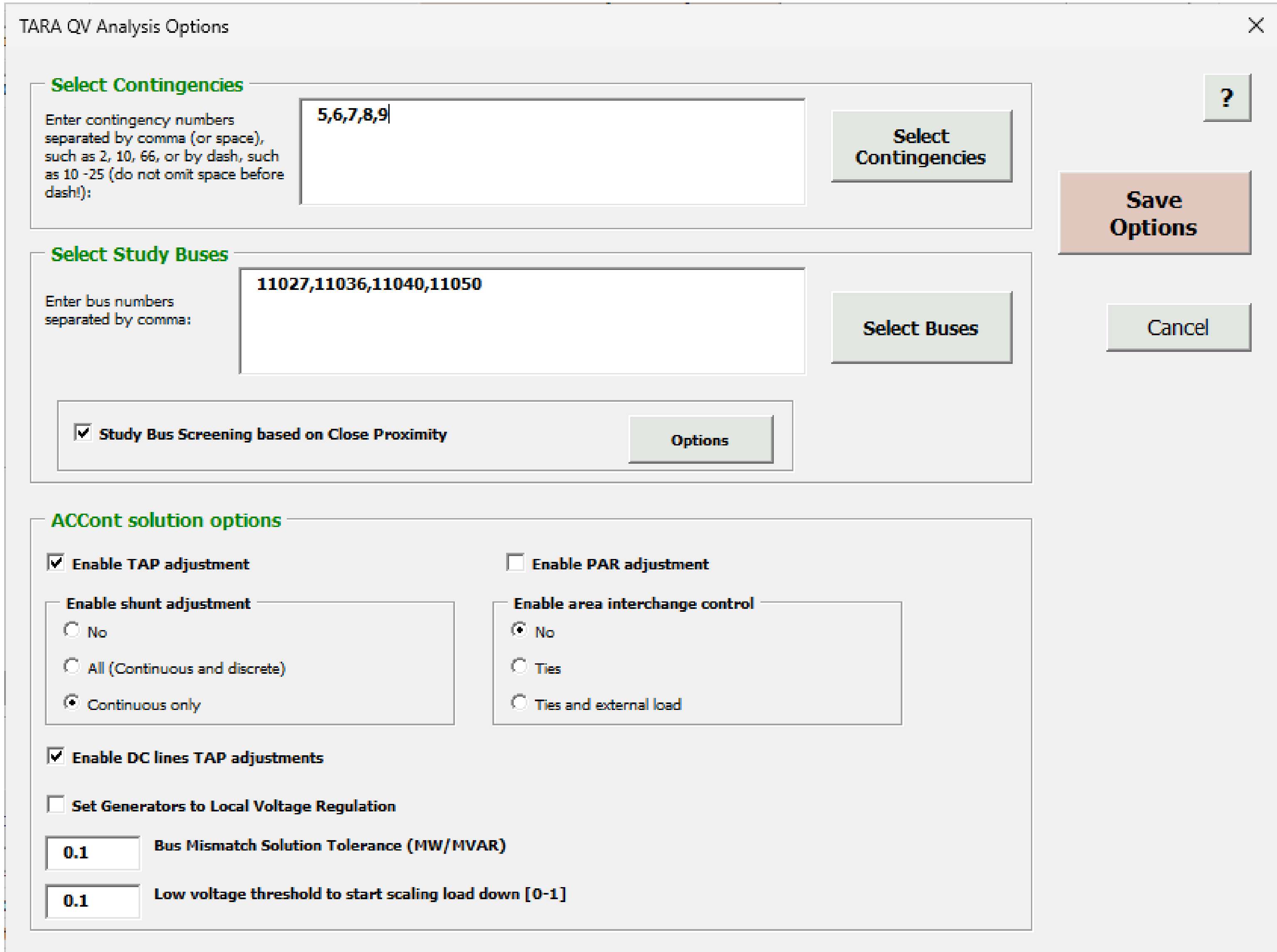


*Not used for analysis but necessary to load TARA

QV ANALYSIS


Input
Utils
CA
SCD
TrLim
FGScr
FGApp
CustApp
Opt MW Transfer
Proportional Scale Transfer
PV Analysis
QV Analysis
PathScreen
AreaTieImpacts
Bus-Based QV Analysis
0.7
QV test minimum voltage
1.05
QV test maximum voltage
0.01
QV voltage step size
Run QV basecase study
Enable QV reactive margin voltage cutoff
0.925
QV reactive margin voltage cutoff [> 0.8]
Run Bus-Based QV Analysis and Create Selected Reports
Additional Options
Parallel Processing
Select Reports
QV Summary
QV Study Buses
QV analysis was NOT completed
Create Reports without rerun
Sending System
West
Find
Details
Receiving System
East
Find
Details

QV ANALYSIS



TARA QV Analysis Options
Select Contingencies
Enter contingency numbers separated by comma (or space), such as 2, 10, 66, or by dash, such as 10 -25 (do not omit space before dash!):
5,6,7,8,9
Select Contingencies
?
Save Options
Select Study Buses
Enter bus numbers separated by comma:
11027,11036,11040,11050
Select Buses
Cancel
Study Bus Screening based on Close Proximity
Options
ACCont solution options
Enable TAP adjustment
Enable PAR adjustment
Enable shunt adjustment
No
All (Continuous and discrete)
Continuous only
Enable area interchange control
No
Ties
Ties and external load
Enable DC lines TAP adjustments
Set Generators to Local Voltage Regulation
0.1
Bus Mismatch Solution Tolerance (MW/MVAR)
0.1
Low voltage threshold to start scaling load down [0-1]

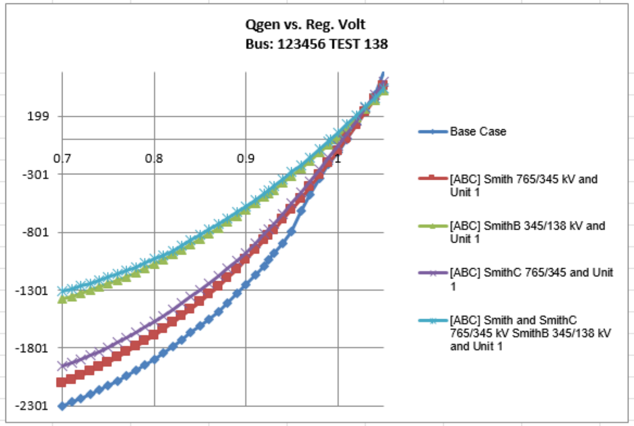
RESULTS

RFIRST QV Bus-Based Summary [TARA Ver 2502.2.0.0 64-bit - Mon Jul 27 15:00:20 2026]

Loadflow Case: C:\test\test.raw
Study Data File: C:\test\test.sub
Contingency File: C:\test\test.CON (total 4 contingencies)
Monitor File: C:\test\test.MON
Exclude File: not provided
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed

Bus #	Bus Name	Base kV	Area	Zone	Cont Name	Cont ID	Maximum Reactive Margin (MVAR)	Volt at Reactive Margin	Reactive Margin Rank	Base|Cont Volt W/O QV	Reactive Margin at VLimit (MVAR)	Low Volt Limit	Test Range Vlow	Test Range Vhigh
123546	TEST	138	123	1234	[ABC] Smith 765/345 kV and Unit 1	1	2107.95	0.7	1	1.009	829.8	0.925	0.7	1.05
123546	TEST	138	123	1234	Base Case	0	2300.7	0.7	2	1.0099	1044.1	0.925	0.7	1.05
123546	TEST	138	123	1234	[ABC] SmithB 345/138 kV and Unit 1	2	1377.26	0.7	1	0.9958	467.3	0.925	0.7	1.05
123546	TEST	138	123	1234	[ABC] SmithC									
123546	TEST	138	123	1234	[ABC] Smith									

Reg. Volt	Base Case	Reg. Volt	[ABC] Smith 765/345 kV and Unit 1	Reg. Volt	[ABC] SmithB 345/138 kV and Unit 1	Reg. Volt	[ABC] SmithC 765/345 kV and Unit 1	Reg. Volt	[ABC] Smith and SmithC 765/345 kV SmithB 345/138 kV and Unit 1
0.7	-2300.7	0.7	-2107.95	0.7	-1377.26	0.7	-1960.98	0.7	-1313.44
0.71	-2269.51	0.71	-2076.63	0.71	-1354.3	0.71	-1931.93	0.71	-1292.32
0.72	-2235.45	0.72	-2042.94	0.72	-1330.05	0.72	-1902.27	0.72	-1268.88
0.73	-2198.95	0.73	-2005.93	0.73	-1304.45	0.73	-1868.04	0.73	-1244.2
0.74	-2164.75	0.74	-1967.04	0.74	-1276.98	0.74	-1831.88	0.74	-1218.22
0.75	-2126.45	0.75	-1927.23	0.75	-1247.78	0.75	-1793.68	0.75	-1190.82
0.76	-2084.01	0.76	-1884.45	0.76	-1217.26	0.76	-1753.38	0.76	-1162.2
0.77	-2036.98	0.77	-1839.64	0.77	-1185.37	0.77	-1712.47	0.77	-1132.24
0.78	-1993.22	0.78	-1792.95	0.78	-1151.7	0.78	-1668.44	0.78	-1100.81
0.79	-1945.56	0.79	-1743.88	0.79	-1115.95	0.79	-1622.56	0.79	-1067.79
0.8	-1897.39	0.8	-1692.76	0.8	-1077.64	0.8	-1574.43	0.8	-1033.53
0.81	-1847.47	0.81	-1639.6	0.81	-1037.2	0.81	-1524.48	0.81	-997.86
0.82	-1786.51	0.82	-1584.47	0.82	-995.38	0.82	-1472.48	0.82	-960.25
0.83	-1731.35	0.83	-1527.09	0.83	-952.16	0.83	-1418.38	0.83	-918.57
0.84	-1671.55	0.84	-1467.65	0.84	-907.46	0.84	-1362.25	0.84	-874.32
0.85	-1612.41	0.85	-1404.28	0.85	-861.33	0.85	-1304.33	0.85	-828.64
0.86	-1551.11	0.86	-1338.73	0.86	-813.74	0.86	-1244.42	0.86	-781.53



Live Demo

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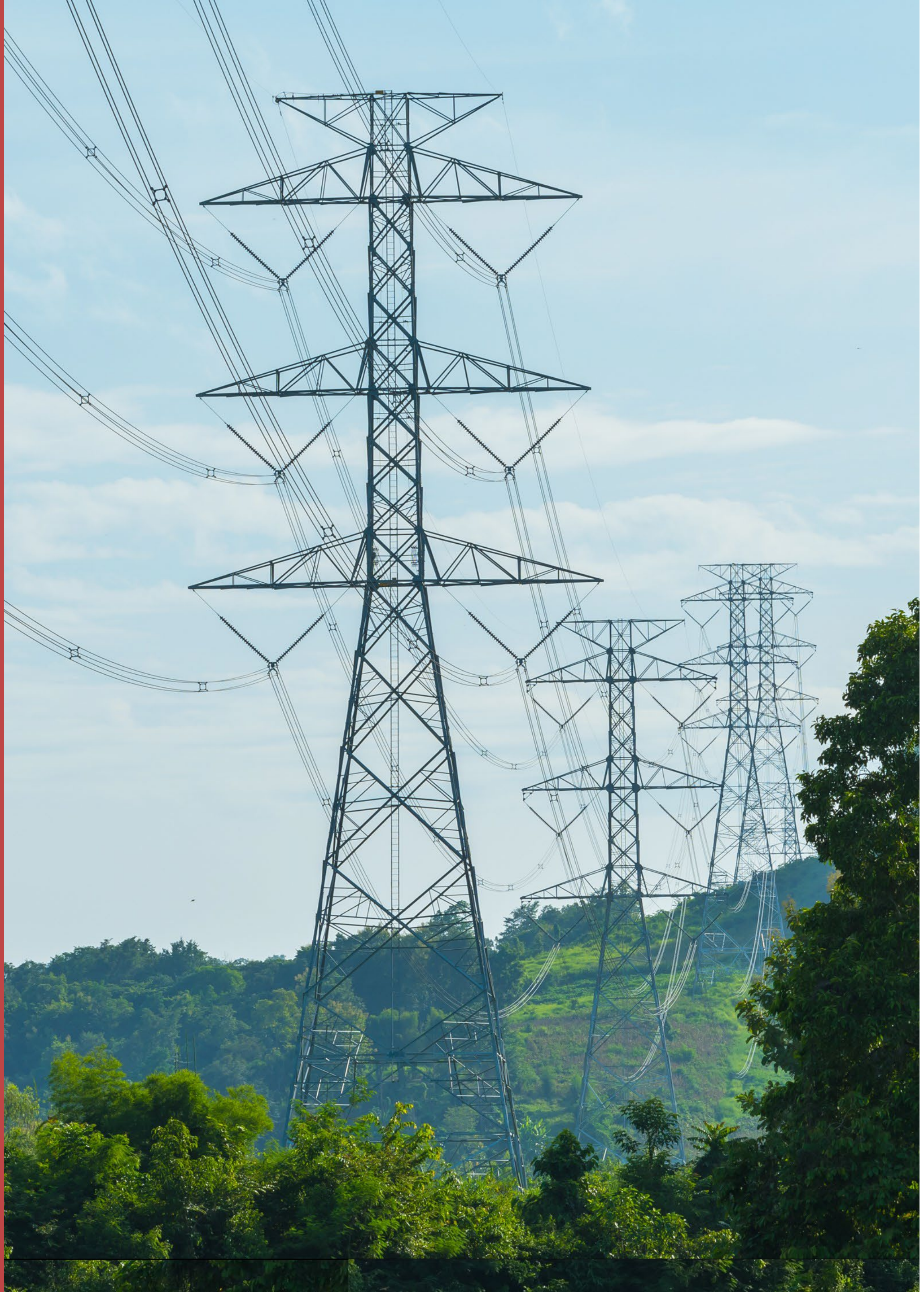


QUESTIONS & ANSWERS

John Idzior

john.idzior@rfirst.org

Dynamic Model In-Take Process

Ensuring model accuracy from design to final construction stages

Generator Modeling & Dynamic Studies, PJM

Importance of Dynamic Model

System dynamic behavior has become increasingly important to study, due to:

- **High penetration of inverter-based resources (IBRs),** which significantly changes system dynamics and stability characteristics
- **Growing interconnection of large data center loads,** resulting in increased load magnitude, load dynamics, and more complex grid interactions
- **Expanded deployment of HVDC and FACTS devices,** which play a critical role in supporting grid operation and improving system dynamic performance

These developments make accurate dynamic models more critical than ever, as they are fundamental to meaningful and reliable power system dynamic studies, and to the credibility of study results.

Challenges for Dynamic Model

Collecting and maintaining accurate dynamic models is not an easy task:

- **Dynamic model are constantly evolving:** Throughout the lifecycle of a generator or other dynamic device, models may change due to interconnection studies, as-built conditions, planned and unplanned equipment modifications, and model updates or corrections identified through MOD-026 and MOD-033 validation activities.
- **Dynamic models must support a wide range of studies, including interconnection, planning, operational, and event analysis applications:** While the models used for these studies may not always be identical due to differing objectives, assumptions, and study requirements, any differences should be technically justified, properly documented, and appropriate for the intended application. Regardless of the study type, the models should accurately represent plant behavior and maintain consistency with the actual facility configuration and performance.

Challenges for Dynamic Model

Collecting and maintaining accurate dynamic models is not an easy task:

- **Dynamic model changes occur simultaneously across multiple departments and processes:** As equipment modifications, model updates, validation activities, compliance requirements, and study efforts often occur in parallel, identifying/collecting the most accurate and up-to-date model becomes increasingly complex. Maintaining **a single source of truth** for dynamic models throughout the generator lifecycle is therefore a significant challenge, requiring strong governance, version control, and coordination among interconnection, planning, operations, and asset management teams.
- **Effective dynamic model governance is fundamental:** to maintaining model integrity, version control, traceability, and enterprise-wide accessibility, ensuring that reliable and up-to-date models are available for all study and operational needs.

Goals for Dynamic Analysis and Model

Goals for Dynamic Analysis and Model Change Control Process:

- **Ensure the dynamic model accurately represents the plant.** The dynamic model should faithfully reflect the equipment configuration, control systems, and electrical behavior of the generating facility or dynamic device throughout its lifecycle.
- **Maintain system reliability through dynamic security analysis.** Any proposed model or plant equipment change should undergo the necessary dynamic security assessments. If the change introduces reliability or security concerns, those issues must be resolved before the equipment change is implemented. This ensures that no model updates remain in an unstudied state and helps prevent unexpected operational impacts.
- **Approve model changes only after appropriate validation and studies.** Dynamic model updates should be released for operational, planning, or interconnection use only after completing the required validation, review, and study processes to confirm their accuracy and suitability.

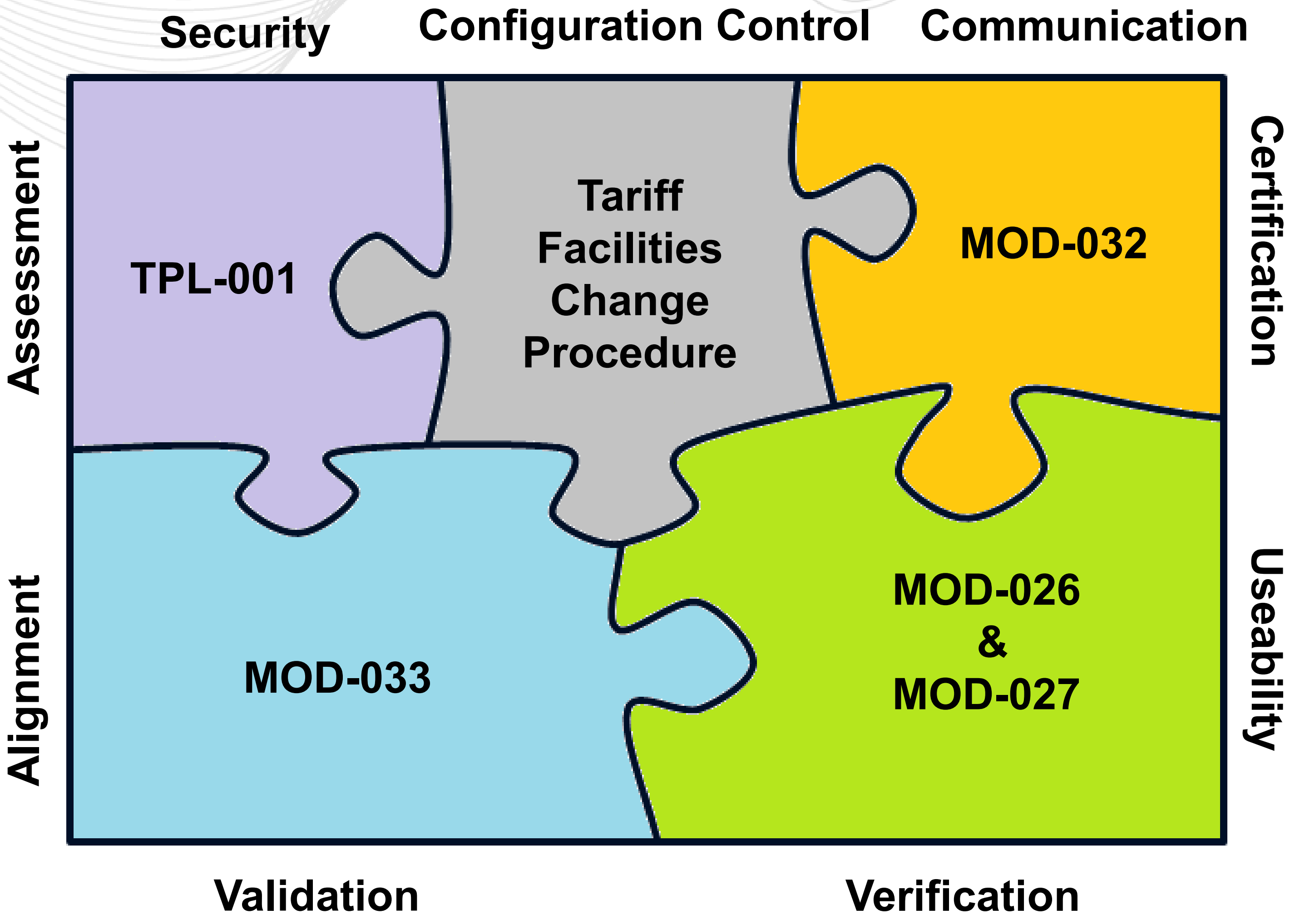
Goals for Dynamic Analysis and Model (cont.)

Goals for Dynamic Analysis and Model Change Control Process:

- **Keep the as-built model current.** Following the implementation of plant modifications, the Generator Owner (GO) should update and submit the corresponding as-built dynamic model to ensure the model remains consistent with the actual plant configuration.
- **Maintain a single source of truth for dynamic models.** A controlled model governance process should ensure that the most accurate, validated, and up-to-date model is readily identifiable and available for all applicable studies and analyses.
- **Integrate dynamic model management and security assessments into a common workflow for interconnection, planning, and operation**, ensuring that all dynamic models are properly reviewed, verified, validated, secured/approved, and maintained as reliable study-ready models throughout their lifecycle.

A Single Workflow for Dynamic Model and Security Analysis

Integrate dynamic model management and security assessments into a common workflow for interconnection, planning, and operation, ensuring that all dynamic models are properly reviewed, verified, validated, secured/approved, and maintained as reliable study-ready models throughout their lifecycle



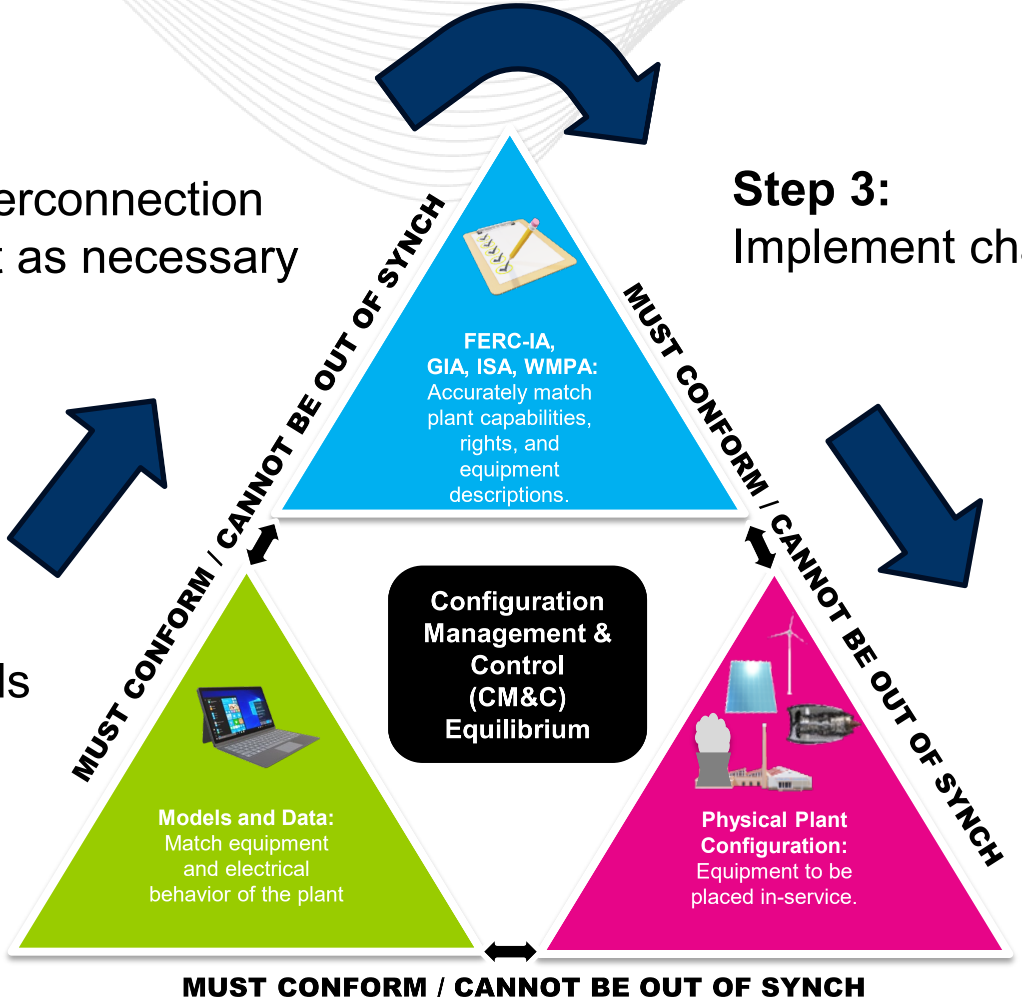
PJM Dynamic Analysis and Model Change Sequence

Step 2:
Update Interconnection Agreement as necessary

Step 3:
Implement change

Step 1:
GO submits proposed models
TP approves change

Step 4:
GO Submits As-Built Models
TP Approves



PJM Processes and Tools for Dynamic Model Management

- **Interconnection Study Process:** The interconnection study process serves as the initial entry point for dynamic models and may occur either during the development of a new generating facility or later in the lifecycle of an existing facility when significant upgrades or modifications are proposed. Dynamic models submitted through this process are used to evaluate system performance and reliability impacts associated with the proposed project.

- **As-Built within the Interconnection Study Process:** During the as-built phase, the dynamic model is verified to ensure that it accurately reflects the equipment, control systems, protection settings, and operating characteristics that have actually been implemented at the plant. This process establishes the baseline model representing the installed facility.

PJM Processes and Tools for Dynamic Model Management

- **Necessary Study Process:** The Necessary Study Process is intended for the post-commercial operation phase of a generating facility and supports dynamic model management throughout the remainder of the generator lifecycle. This process addresses changes that may affect the accuracy or applicability of the dynamic model, including:
  - Planned equipment modifications
  - Unplanned equipment modifications
  - Dynamic model corrections resulting from MOD 026 027 verification activities
  - Other plant or control system changes that may impact system performance
- **As-Built Verification within the Necessary Study Process:** As part of the Necessary Study Process, the dynamic model is verified against the actual plant implementation to ensure that it accurately reflects the installed equipment, control systems, settings, and operational characteristics. This verification establishes an updated as-built model that can be confidently used for operational, planning, and reliability studies.

PJM Processes and Tools for Dynamic Model Management

- **GenModel Window Process:** During the GenModel Window, dynamic models for all in-service generating units are posted for Generator Owner (GO) review and certification. If a GO identifies discrepancies between the posted model and the actual facility configuration or performance, the GO is required to submit model updates and corrections through the applicable MOD-026/MOD-027 processes.
- **MOD 026 027 Process:** Through the MOD 026 027 processes, GOs verify the accuracy of their generator excitation, turbine-governor, plant controller, and other applicable dynamic models. PJM then evaluates the submitted models to ensure they are usable and suitable for power system studies and reliability assessments.
- **MOD-033 (AGMV) Process:** During significant system events, dynamic model performance is validated against PMU through the Model Validation (AGMV) process. When model deficiencies are identified, PJM may require the GOs to investigate and update the model in accordance with MOD 026 027 R3 requirements, ensuring the model continues to accurately represent plant behavior and system response.

Under-Development PJM Tools for Dynamic Model Management:

- **Dynamic Model Management (Hierarchy) Database:** This database is currently under development to support dynamic model governance throughout the generator lifecycle. It will establish a model hierarchy, version control, and traceability framework to help users identify and select the appropriate dynamic model snapshot for interconnection, planning, and operational studies. The objective is to ensure that the correct model is used for each application while maintaining **a single source of truth** for all dynamic model data and revisions.

PJM Processes and Tools for Dynamic Model Management

Under-Development PJM Tools for Dynamic Model Management:

- **Dynamic Model Event Management Process:** This process is currently under development to support future MOD 033 dynamic model validation activities. Under this framework, GOs will provide plant PMU measurements and other relevant disturbance data following qualifying system events. The collected data will be used to compare simulated and actual plant responses, validate model performance, identify model deficiencies, and facilitate timely model updates to maintain model accuracy and study reliability. Once developed, this process will be integrated with the existing MOD 033 AGMV framework, creating a more streamlined and comprehensive model validation workflow.

PERFORMING A DYNAMIC ASSESSMENT IN PSS/E

Parimal Saraf, Principal Engineer, Engineering and System Performance, RF

Aug. 6, 2026

FORWARD TOGETHER RELIABILITYFIRST

RELIABILITY FIRST

OVERVIEW

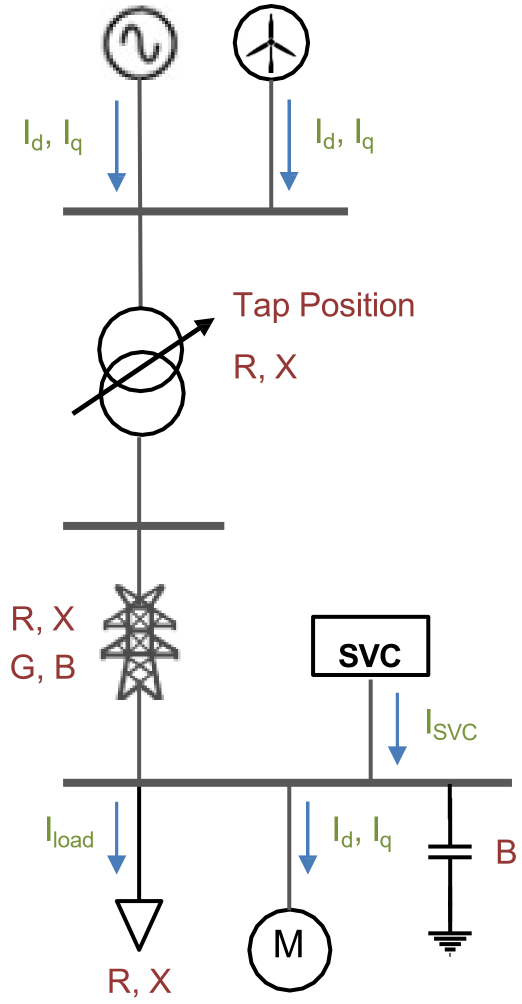
- BASICS OF DYNAMIC SIMULATION IN ELECTRIC GRIDS
- PERFORMING DYNAMIC SIMULATIONS IN PSS/E
- POST-PROCESSING THE OUTPUT FILES

BASICS OF DYNAMIC SIMULATION IN ELECTRIC GRIDS

REPRESENTATION OF DIFFERENT POWER SYSTEM ELEMENTS

- In dynamic simulations, the power and voltages in the power system change with respect to time
- Elements in the power system can be categorized as either passive or active elements depending on whether they can be represented as impedances (passive) or as dynamic current injections that can change over time or be controlled (active)

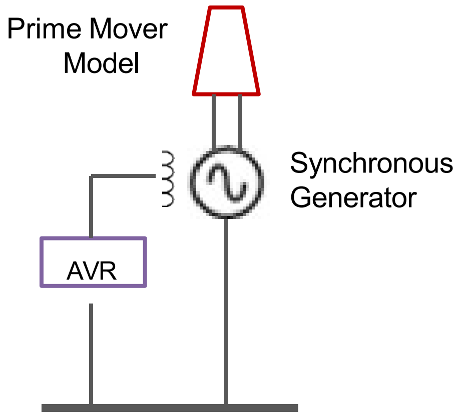
Element	Representation	Controllable	Dynamic RMS Model
Synchronous machine	Active	Yes	Stator magnetic and electrical equations, mechanical (swing) equation
Induction machine	Active	Yes (if generator)	Stator and rotor equations, mechanical load / prime mover equation
Converter-interfaced generation	Active	Yes	Voltage source behind impedance, controllable current injection
Transformer	Passive	Yes	Series / shunt impedances
Lines and cables	Passive	No	Series / shunt impedances
Shunt reactive plant	Passive	No	Shunt impedance
SVC / FACTS	Active	Yes	Either voltage source behind impedance or equivalent shunt impedance
Load	Passive or Active	No	Passive: shunt impedance Active: current injection behind shunt impedance

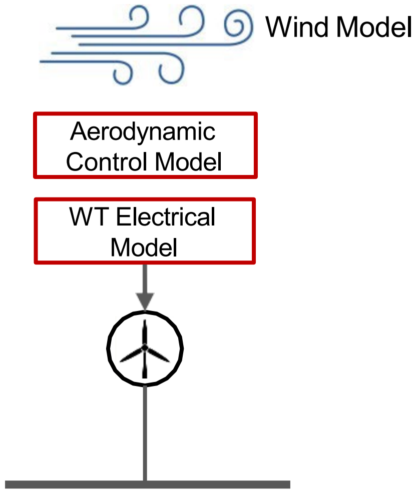


CONTROLS

- Power system elements such as synchronous machines, wind turbines, solar PV plants, SVCs and power transformers are "controllable" in the sense that their current injections in a dynamic simulation can be adjusted via a control system

- Controllers are represented by their own dynamic models





MATHEMATICAL REPRESENTATION

Differential equations: $\frac{d\boldsymbol{x}}{dt} = \boldsymbol{f}(\boldsymbol{x}, \boldsymbol{v})$

Algebraic equations: $\boldsymbol{0} = [Y]\boldsymbol{v} - \boldsymbol{i}(\boldsymbol{x}, \boldsymbol{v})$

$\boldsymbol{x}$ is a vector of state variables

$[Y]$ is the network nodal admittance matrix

$\boldsymbol{v}$ is a vector of nodal voltages (algebraic variables)

$\boldsymbol{i}$ is a vector of (net) nodal current injections

- The differential equations represent all the modeled system (RMS) dynamics, e.g., synchronous machines and their controllers (AVRs, governors, PSS, etc.), converter-based generation, SVC/FACTS devices, transformer tap control, etc.

- The algebraic equations represent the static (passive) elements of the network, e.g. line and cable impedances, fixed shunt and series reactive plant and loads. For a network with n nodes:

$$\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix} = \begin{bmatrix} Y_{11} & \cdots & Y_{1n} \\ \vdots & \ddots & \vdots \\ Y_{n1} & \cdots & Y_{nn} \end{bmatrix} \begin{bmatrix} v_1 \\ \vdots \\ v_n \end{bmatrix} - \begin{bmatrix} i_1 \\ \vdots \\ i_n \end{bmatrix}$$

- Except for very simple systems, a closed-form analytical solution for this DAE system is not possible and it must be solved using **numerical integration**.

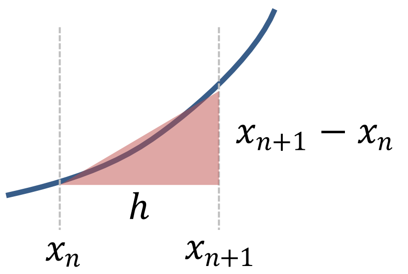
NUMERICAL INTEGRATION

Consider the first-order differential equation:

$$\frac{dx}{dt} = f(x,t)$$

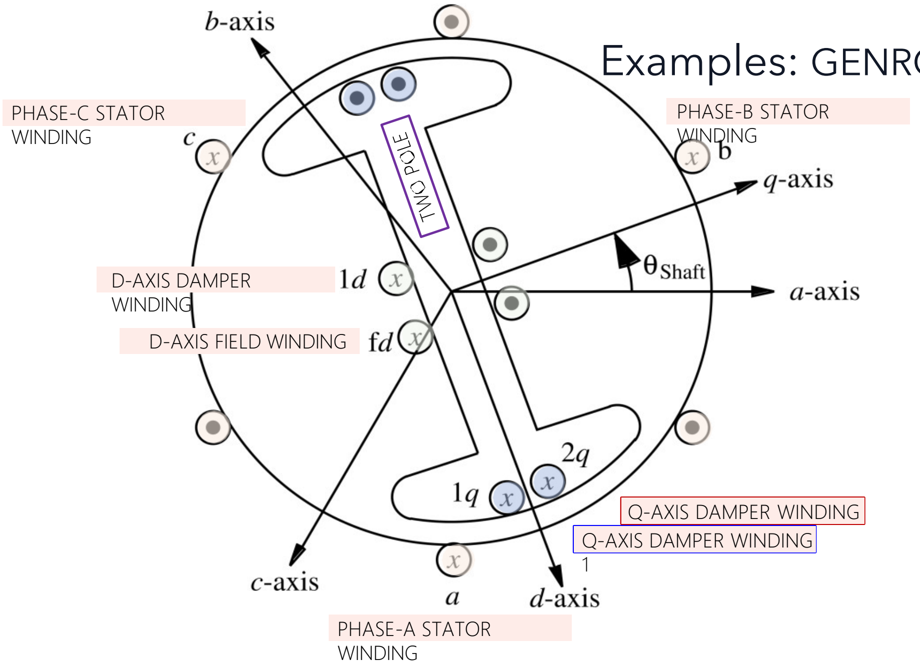
$$x_{n+1} = x_n + h * \frac{dx_n}{dt} = x_n + h * f(x_n, t_n)$$

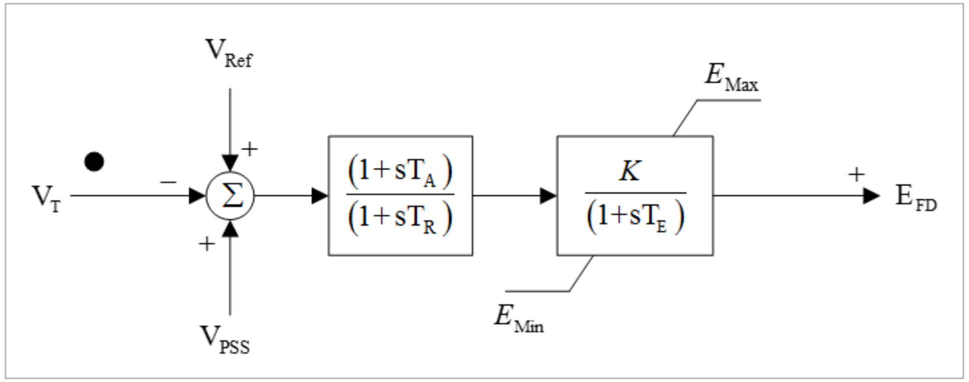
Time step



DYNAMIC MODELS

Examples: GENROU, GENROE





$$d\delta/dt = \omega_b(\omega - 1)$$

$$d\omega/dt = [P_m - P_e - D(\omega - 1)] / (2H)$$

$$dE'_q/dt = [E_{FD} - E'_q - (X_d - X'_d)I_d] / T'_{do}$$

$$dE'_d/dt = [-E'_d + (X_q - X'_q)I_q] / T'_{qo}$$

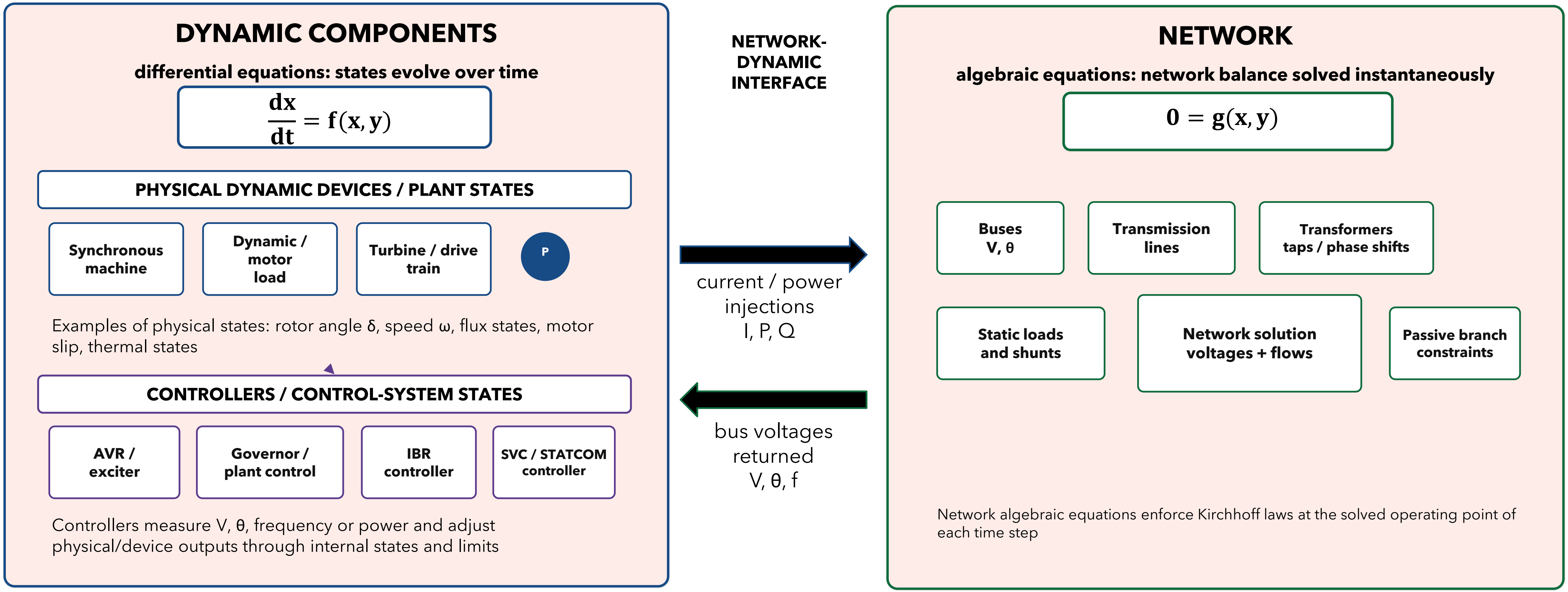
State variables associated with $= \delta, \omega, E'_q, E'_d$

$$dx_R/dt = [V_{ref} - V_T + V_{PSS} - x_R] / T_R$$

$$dE_{FD,u}/dt = [K \cdot V_A - E_{FD,u}] / T_E$$

Part of .dyr file

COUPLING BETWEEN DYNAMIC COMPONENTS AND NETWORK



At each simulation time step in PSS®E: dynamic states update → I / P / Q sent to network → network solved → V, θ returned → repeat

PERFORMING DYNAMIC SIMULATIONS IN PSS/E

PSS/E DYNAMIC SIMULATION FLOWCHART

.sav file
Solved power-flow case

CONG / CONL / ORDR / FACT / TYSL
Convert and prepare the network for dynamics

.cnv (converted case)
Network prepared for dynamic simulation

DLLs
User-defined model libraries

.dyr file
Dynamic model data

.snp (snapshot)
Assembled dynamic model state / snapshot

Initialization and Dynamic Simulation

Load .cnv + .snp + DLLs → Initialize states → Run flatstart/Apply disturbances → Run simulation → .out and .log files

ACTIVITIES CONG/CONL/ORDR/FACT/TYSL

CONG → **CONL** → **ORDR** → **FACT** → **TYSL**

- **CONG** — Convert generators

  Moves generators from power-flow injections toward dynamic-machine current-source interfaces.

- **CONL** — Convert loads

  Applies the selected dynamic load representation, often including voltage-dependent or impedance portions.

- **ORDR** — Order equations

  Reorders the sparse network equations for efficient repeated solution.

- **FACT** — Factorize matrix

  Prepares the network admittance matrix so voltages can be solved quickly many times.

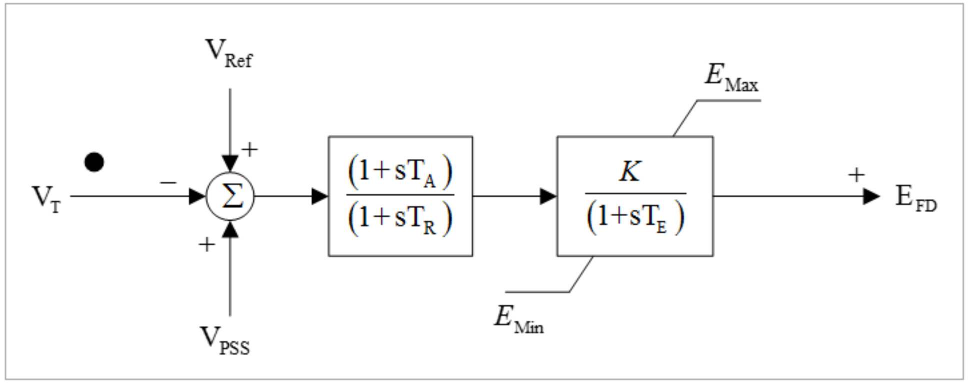
- **TYSL** — Switching solution

  Completes setup for transient-stability switching events such as faults and trips.

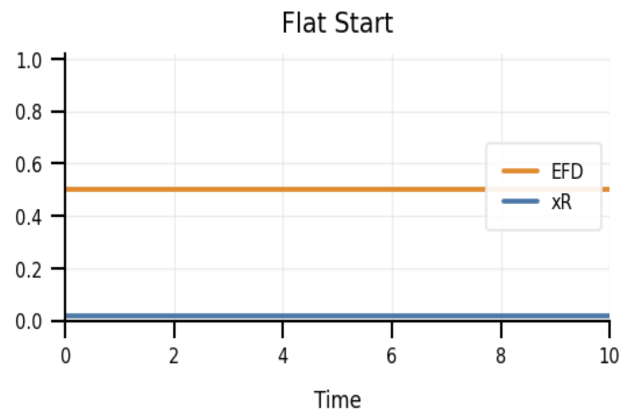
- CONG + CONL change device representation
- ORDR + FACT make the repeated voltage solution efficient
- TYSL prepares the network for fault/trip switching during the simulation
- PSS/E is now ready to repeatedly solve: $Y \cdot V = I$ while dynamic models update device currents and states

INITIALIZATION OF DYNAMIC MODELS

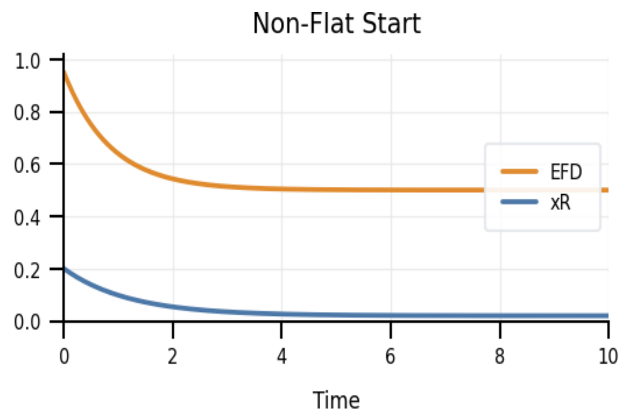
- It is good practice to check that your model flat starts by running the simulation without any disturbances / events and verifying that the outputs show no changes over time, i.e., are flat curves.



Flat Start



Non-Flat Start



DYNAMIC SIMULATION USING PSSPY API

1 **Read solved power flow**
psspy.case(...) then solve/check the case

2 **Convert network for dynamics**
psspy.cong(), conl(), ordr(), fact(), tysl()

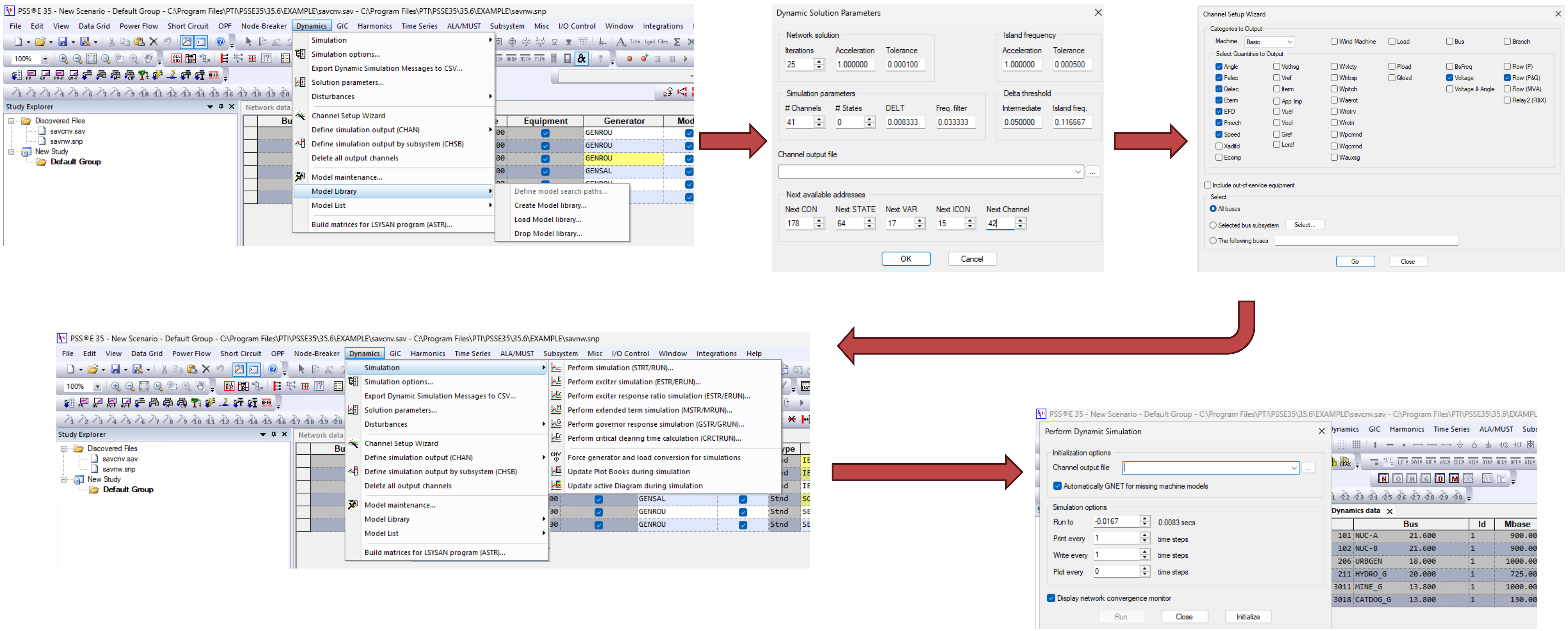
3 **Load user model libraries (DLLs)**
psspy.addmodellibrary(...) for DLLs; psspy.dyre_new(...) for DYR

4 **Save / restore assembled model data**
psspy.snap(...) and psspy.rstr(...)
.snp file also contains the dynamic solution parameters (psspy.dynamics_solution_param_2)

5 **Add channels and initialize states**
psspy.chsb and psspy.strt_2(...)

6 **Advance simulation and events**
psspy.run(...), dist_bus_fault(), dist_branch_trip(), dist_clear_fault()

DYNAMIC SIMULATION – PSS/E GUI



NOTES

- Any changes to power flow case such as adding a new transmission line or a generator should be made to .sav file and its corresponding dynamic data, if applicable, should be appended to the system .dyr file
- The following should be ensured before performing a dynamic simulation:
  - Converged power flow case (.sav)
  - No missing dynamic data corresponding to a dynamic device in the .dyr file
  - No missing DLLs as well as DLLs compatible with the working PSS/E version
  - Channels are added for monitoring
- If the simulation crashes midway after applying a disturbance, acceleration factor of network solution and/or simulation time step ("DELT") under the "Dynamic Solution Parameters" can be reduced for achieving numerical convergence

PYTHON SCRIPTS

Flatstart

```
import os, sys
import glob
from io import StringIO
work_dir = os.getcwd().replace('\\Events','')
sys.path.append(work_dir)
# Import required functions
_i = psspy.getdefaultint()
_f = psspy.getdefaultreal()
_s = psspy.getdefaultchar()

CNVFILE = work_dir + "\savcnv.sav"
SNPFILE = work_dir + "\savnw.snp"
LOGFILE = work_dir + r"\Outs+Logs\Outage_3005-3007.log"
OUTFILE = work_dir + r"\Outs+Logs\Outage_3005-3007.out"

psspy.progress_output(2,LOGFILE,[0,0])
psspy.prompt_output(2,LOGFILE,[0,0])

# Load snapshot
psspy.time(0)
psspy.case(CNVFILE)
psspy.rstr(SNPFILE)


# Load dynamic DLLs
dll_files = []
dir_list = os.listdir(work_dir)
for name in dir_list:
    ext = name.split('.')[-1]
    if ext == "dll" or ext == 'DLL':
        dll_files.append(name)

for dllfile in sorted(dll_files):
    dllerr = psspy.addmodellibrary('%s'%dllfile)
    if dllerr != 0:
        psspy.progress("ERROR: %s library NOT loaded\n "%dllfile)

study_areas = [1,2,5]
psspy.bsys(0, 1, [0.0, 999.0], len(study_areas), study_areas, 0, [], 0, [], 0, [])
psspy.chsb(0, 0, [-1, -1, -1, 1, 1, 0])
psspy.chsb(0, 0, [-1, -1, -1, 1, 13, 0])

# Print section start tags
psspy.progress('\n')
psspy.progress('\n BEGIN DYNAMICS SIMULATION :-')
psspy.set_relang(1, 206, '1')
psspy.dynamics_solution_param_2([150,_i,_i,_i,_i,_i,_i,_i],[ 0.5, 0.0001, 0.0041667,_f,_f,_f,_f,_f])

psspy.progress("\n Solution started")
ierr = psspy.strt_2([1, 0], OUTFILE)
psspy.run(1,10.0,11,11,9)

# Exit PSSE
psspy.stop_2()
```

Disturbance

```
import os, sys
import glob
from io import StringIO
work_dir = os.getcwd().replace('\\Events','')
sys.path.append(work_dir)
# Import required functions
_i = psspy.getdefaultint()
_f = psspy.getdefaultreal()
_s = psspy.getdefaultchar()

CNVFILE = work_dir + "\savcnv.sav"
SNPFILE = work_dir + "\savnw.snp"
LOGFILE = work_dir + r"\Outs+Logs\Outage_3005-3007.log"
OUTFILE = work_dir + r"\Outs+Logs\Outage_3005-3007.out"

psspy.progress_output(2,LOGFILE,[0,0])
psspy.prompt_output(2,LOGFILE,[0,0])

# Load snapshot
psspy.time(0)
psspy.case(CNVFILE)
psspy.rstr(SNPFILE)


# Load dynamic DLLs
dll_files = []
dir_list = os.listdir(work_dir)
for name in dir_list:
    ext = name.split('.')[-1]
    if ext == "dll" or ext == 'DLL':
        dll_files.append(name)

for dllfile in sorted(dll_files):
    dllerr = psspy.addmodellibrary('%s'%dllfile)
    if dllerr != 0:
        psspy.progress("ERROR: %s library NOT loaded\n "%dllfile)

study_areas = [1,2,5]
psspy.bsys(0, 1, [0.0, 999.0], len(study_areas), study_areas, 0, [], 0, [], 0, [])
psspy.chsb(0, 0, [-1, -1, -1, 1, 1, 0])
psspy.chsb(0, 0, [-1, -1, -1, 1, 13, 0])

# Print section start tags
psspy.progress('\n')
psspy.progress('\n BEGIN DYNAMICS SIMULATION :-')
psspy.set_relang(1, 206, '1')
psspy.dynamics_solution_param_2([150,_i,_i,_i,_i,_i,_i,_i],[ 0.5, 0.0001, 0.0041667,_f,_f,_f,_f,_f])

psspy.progress("\n Solution started")
ierr = psspy.strt_2([1, 0], OUTFILE)

psspy.run(1,0.5,11,11,9)
psspy.dist_bus_fault(3005,1,0,[0.0, -2E9])
psspy.run(1,0.56667,11,11,9)
psspy.dist_clear_fault(1)
psspy.dist_branch_trip(3005, 3007, '1')
psspy.run(1,10.0,11,11,9)

# Exit PSSE
psspy.stop_2()
```

RUNNING MULTIPLE DYNAMIC EVENTS

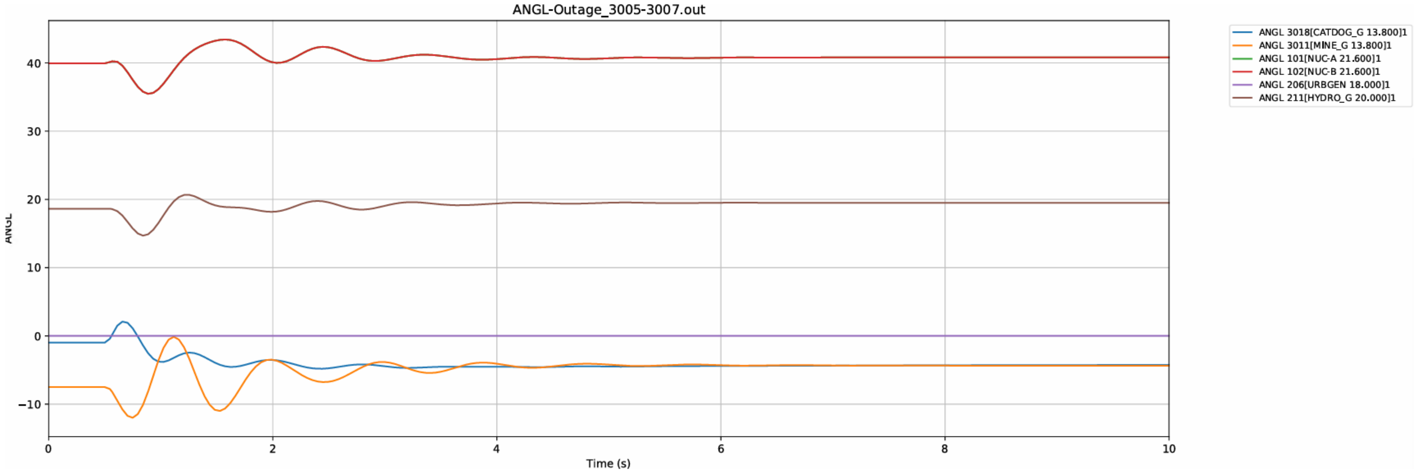
- Create multiple dynamic event files that can be automated to run sequentially using a batch (.bat) file

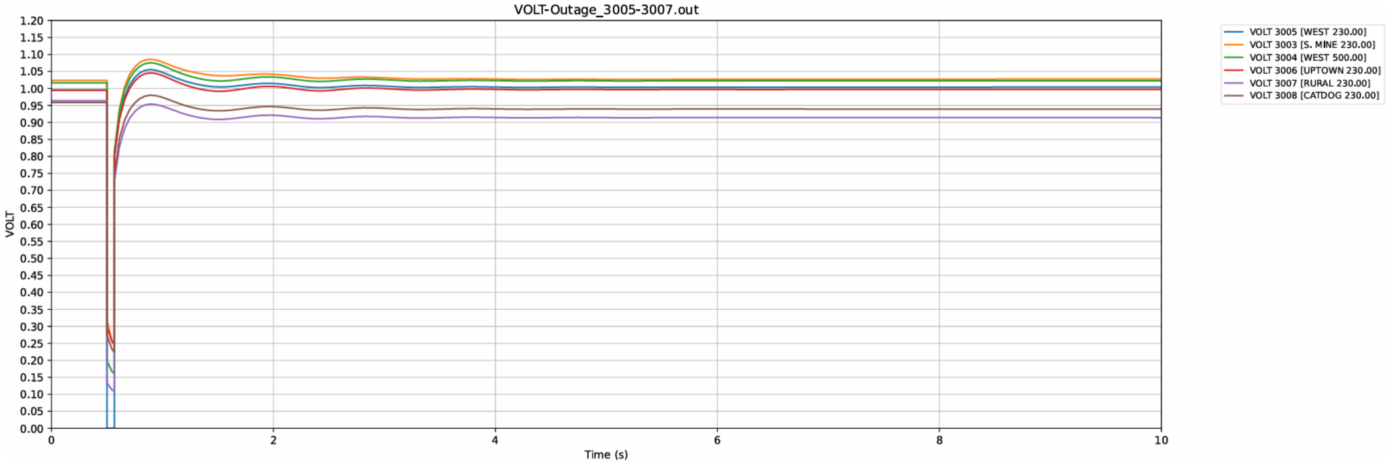
Name	Date modified	Type	Size
Outage_201-151	7/23/2026 6:22 PM	JetBrains PyChar...	2 KB
Outage_201-202	7/23/2026 6:21 PM	JetBrains PyChar...	2 KB
Outage_3005-3007	7/23/2026 6:14 PM	JetBrains PyChar...	2 KB

- The corresponding .out and .log files generated for each event can be saved in a different folder

- Each of these files can later be post-processed through automation scripts to identify any dynamic stability issues, if any

EXAMPLE DISTURBANCE



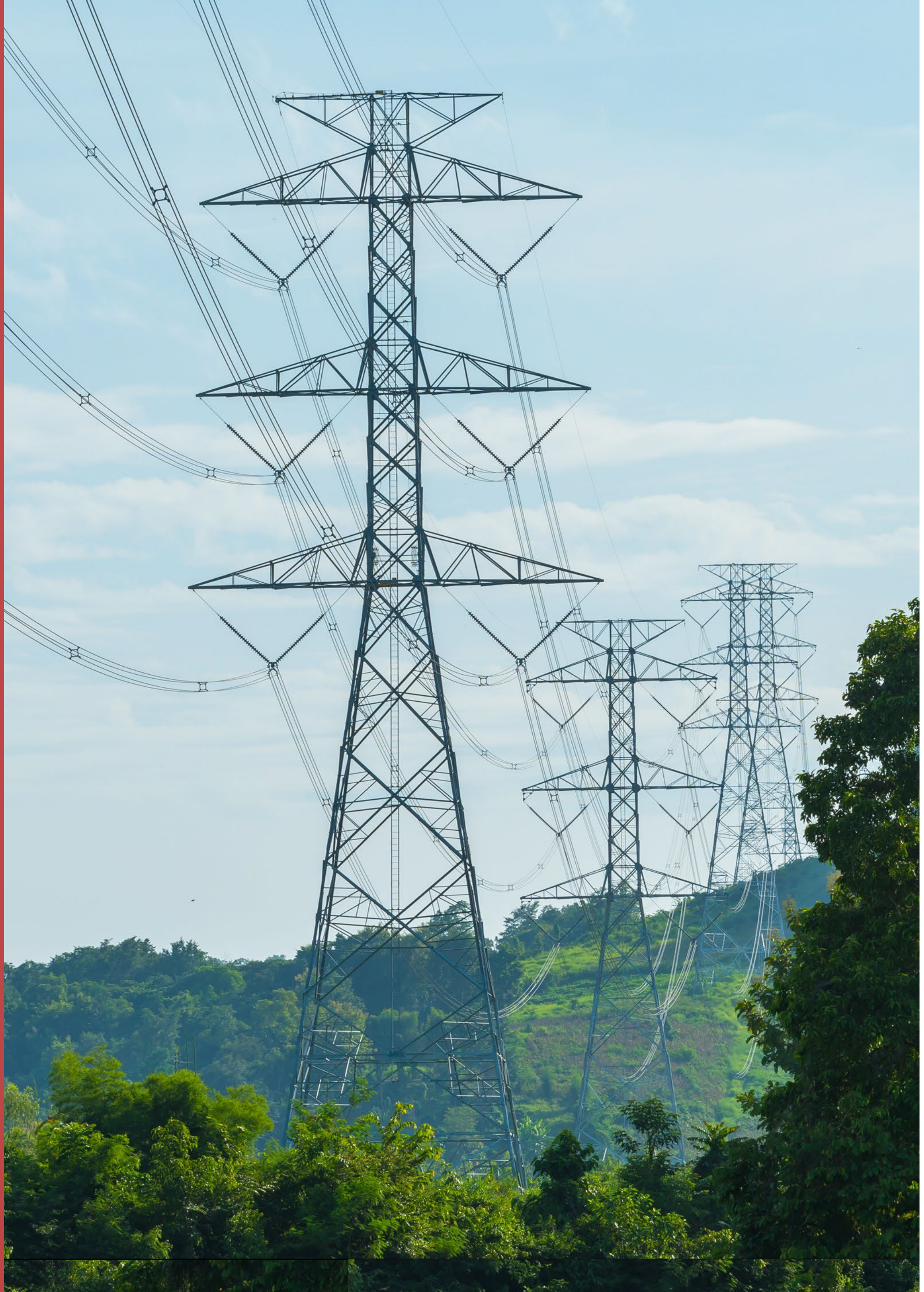


POSTPROCESSING THE OUTPUT FILES

POSTPROCESSING .OUT FILES

- Dyntools module, that's part of PSS/E dynamics package, reads PSS/E .out files and converts recorded channels into Python-accessible time-series data
- Enables one script to process many dynamic events automatically instead of reviewing each case manually
- Supports calculation of key metrics such as minimum voltage, frequency nadir, recovery time, settling time, and threshold violations
- Results can be ranked, flagged, plotted, and exported to Excel or CSV for consistent reporting

FORWARD TOGETHER RELIABILITYFIRST



QUESTIONS & ANSWERS

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