Steady-State Power System Security Analysis with PowerWorld Simulator

S8: Security Analysis for a Generator Interconnection Study

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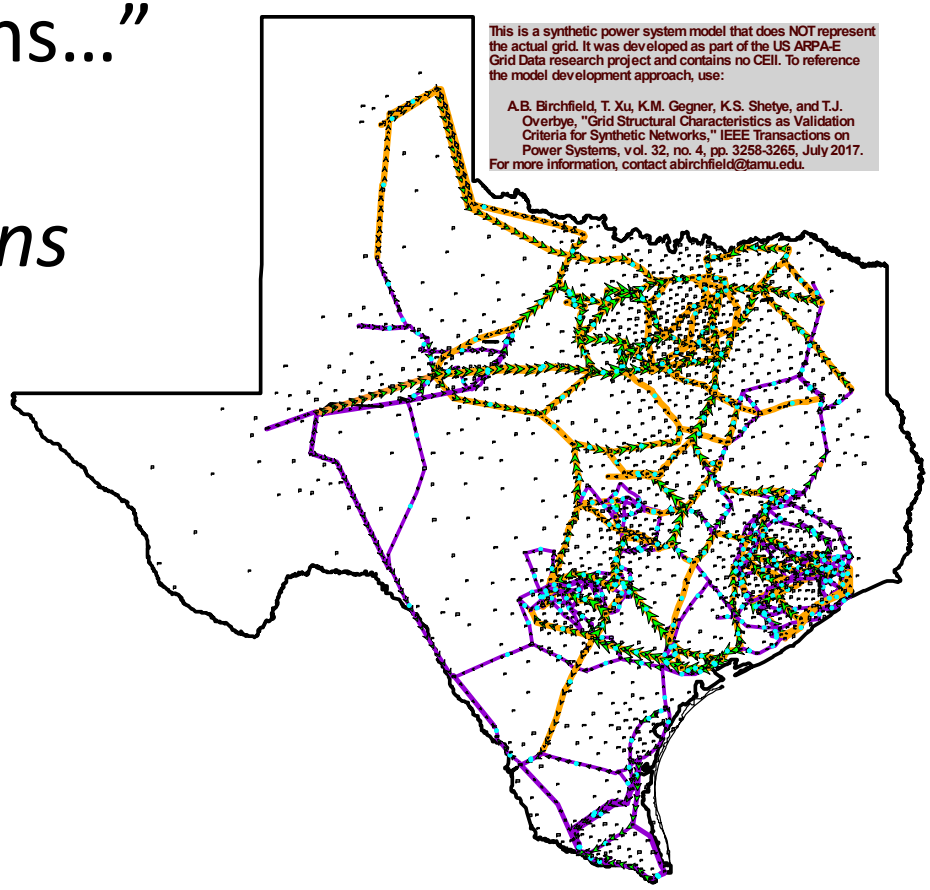
Generator Interconnection Study

- This session encompasses several types of analysis that might be performed as part of an interconnection study for a proposed generator
  - Contingency Analysis: Comparison of Contingent Overloads with and without proposed unit
  - PTDF: Visualize incremental flows from proposed unit
  - ATC: How much power can be delivered from proposed unit before overloads occur?
  - PVQV: How much power can be delivered from proposed unit before voltage becomes unacceptable or collapses?

Using Comparison of Two Sets of Contingency Results

- Open Case *ACTIVSg2000.pwb*
- In “Simulator Options…” check box *Prevent Controller Oscillations*

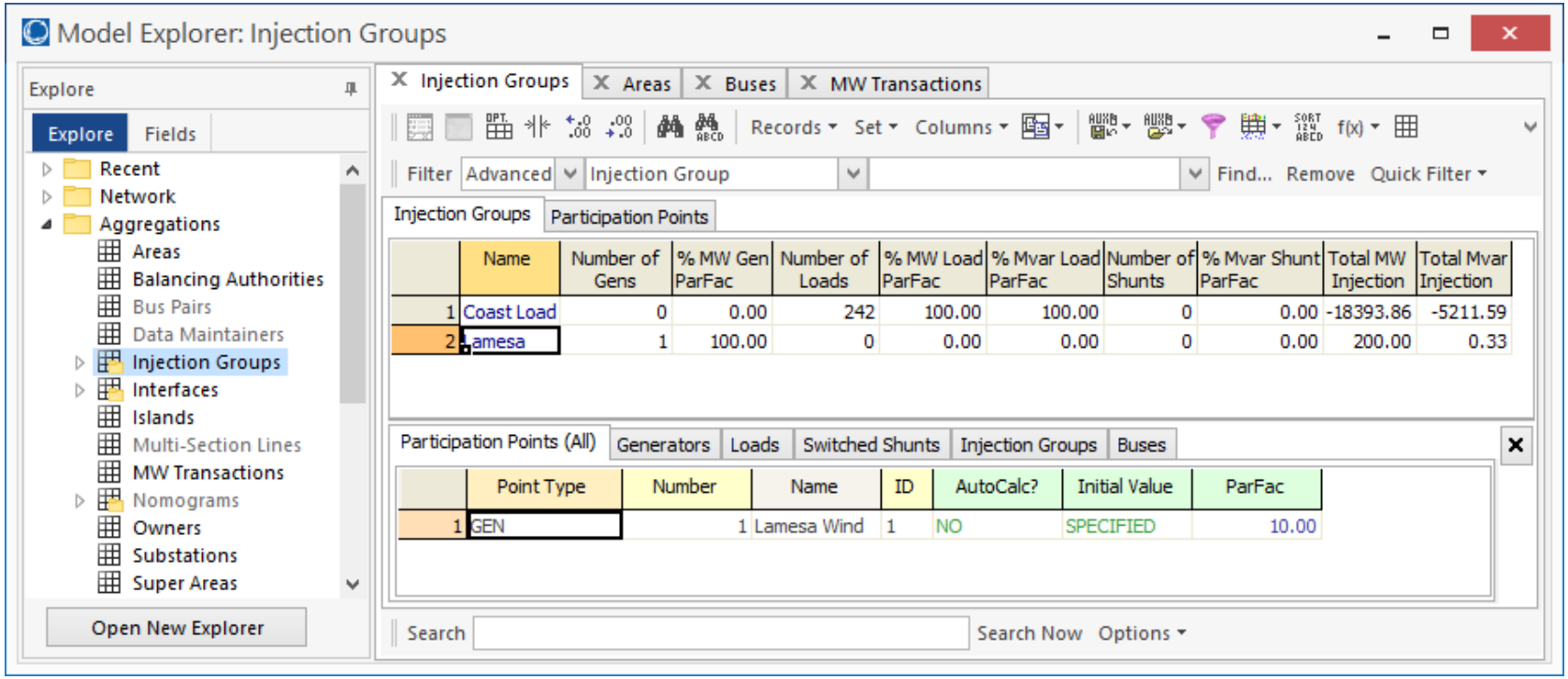


Model the Proposed Generator

- Interconnect at bus 1089 in Lamesa substation
  - New Bus 1 (Lamesa Wind): 34.50 kV, located in new area 10 (Lamesa), zone 1, and substation 54 (Lamesa)
  - New transformer to connect new bus 1 to existing bus 1089: R = 00024, X = 0.086, All Limits = 0
  - New Generator at Bus 1: 200 MW Max, regulate bus 1089 to 1.0 pu volt, -50 Mvar Min, 50 Mvar Max
- Add these elements manually or load *aux2020GeneratorInterconnect.aux*

Injection Groups

- Create injection groups to serve as sources and sinks for upcoming ATC and PV Analysis

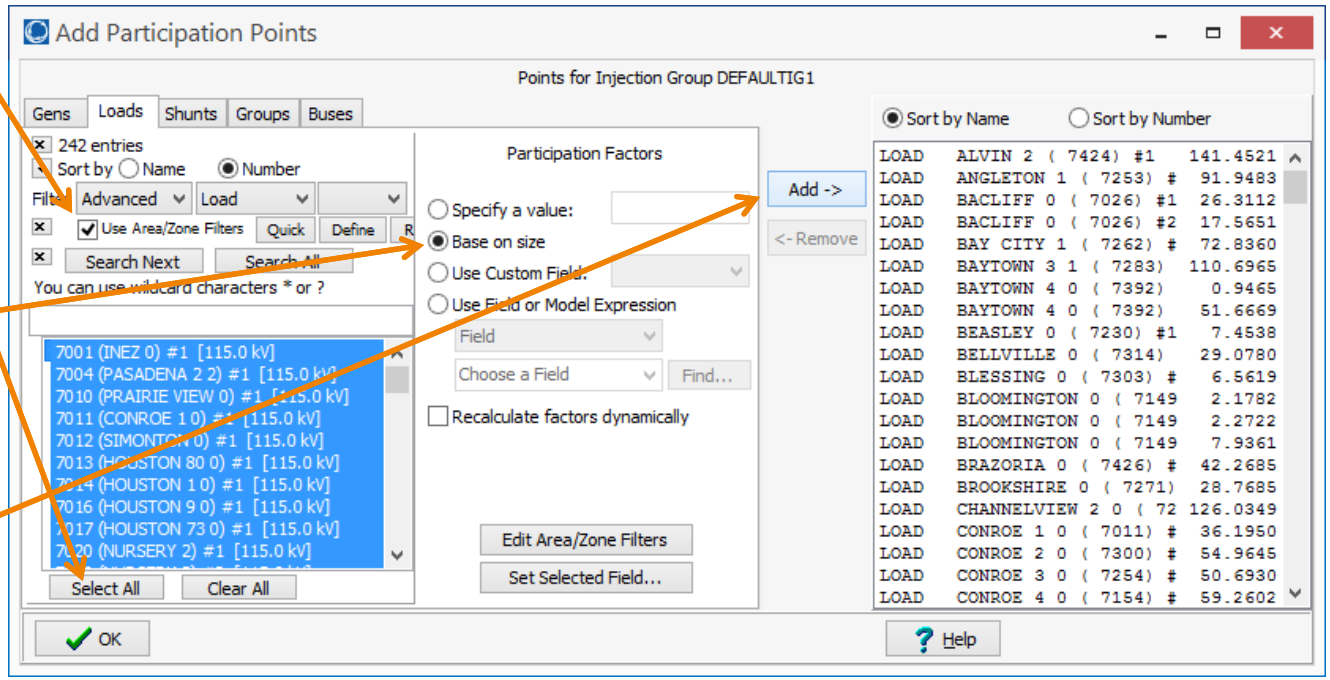


Injection Groups

- Group “Lamesa” contains only the new generator at Bus 1
- Group “Coast Load” contains all loads in Area 7 (Coast), with participation factors set to the size of the load
- Add these groups manually or load from *aux2030InjectionGroups.aux*

Injection Group “Coast Load”

- Use Area/Zone Filters and include only Area 7
- Select All
- Base on size
- Click **Add ->**

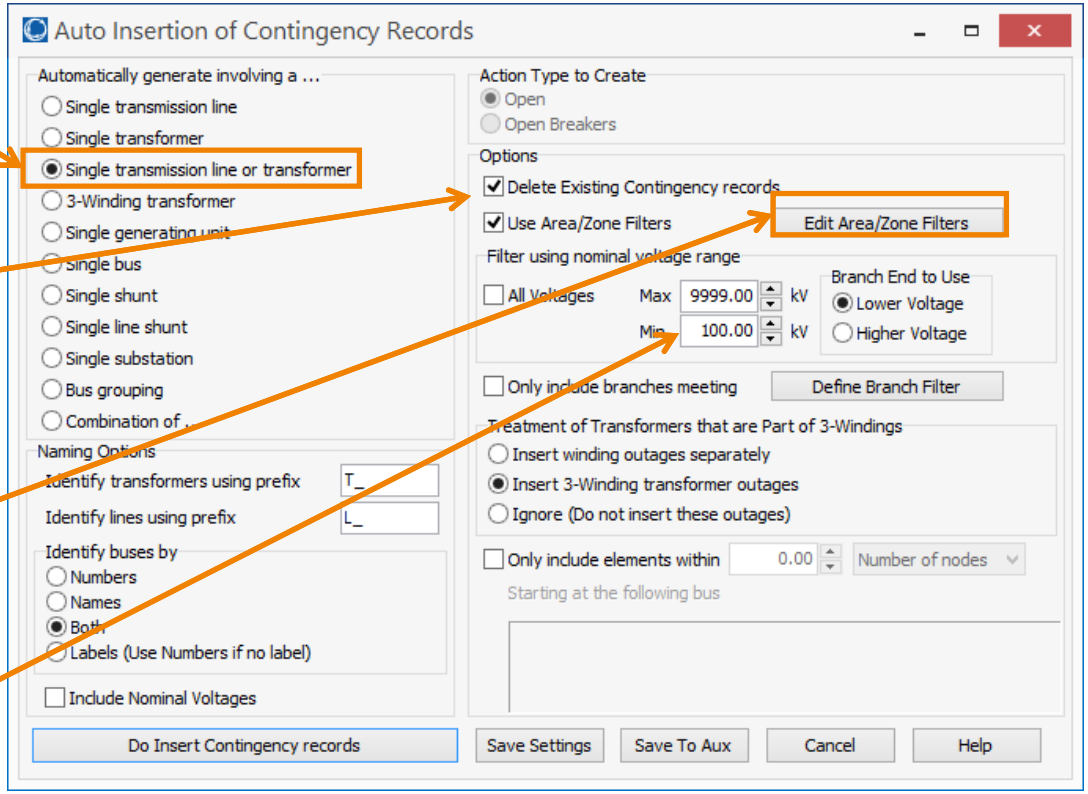


MW Control and AGC Settings

- Set Super Area “Texas” Off AGC
- Move System Slack to Bus 5262 in Area North Central (to allow control of Area 7, Coast)
- Set All Areas to Part. AGC except
  - Area 5 (North Central) to Off AGC
  - Area 7 (Coast) to IG Slack, with “Coast Load” as the injection group
- Set Unspec. MW Inter. = Int MW for all areas (to zero-out ACE)
- Perform manually or load *aux2040MWControl.aux*

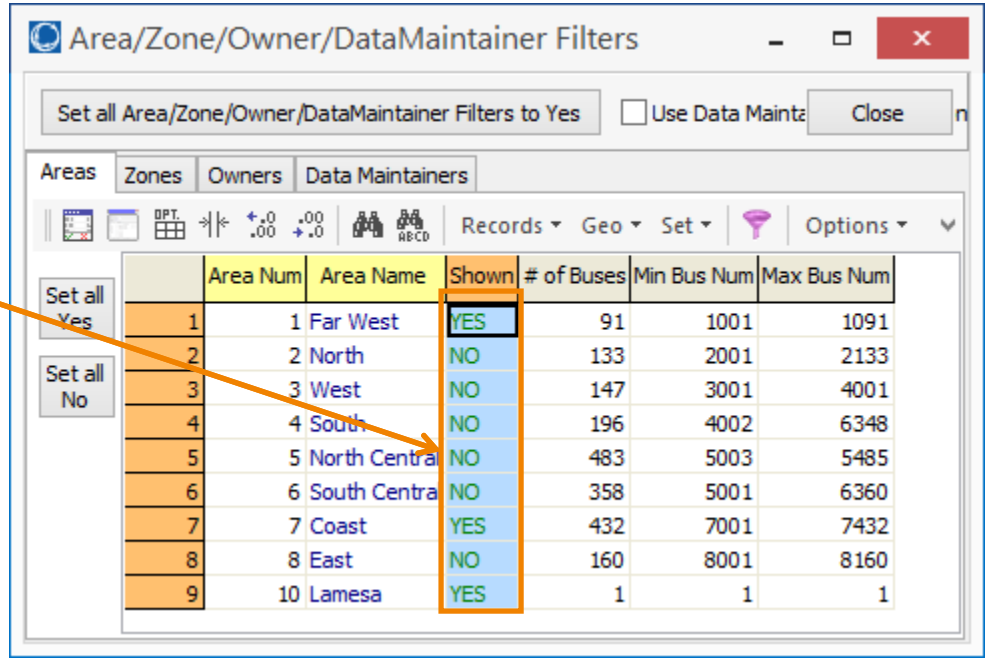
Setup Contingency Analysis

- Go to **Tools Ribbon Tab** and choose **Contingency Analysis**
- Click the **Auto Insert** button at the bottom of this dialog
- Choose **Single Transmission Line or Transformer**
- Choose **Delete Existing Contingency records**
- Click **Edit Area/Zone Filters** on this dialog
- Choose **100 kV Min**



Limit the Areas for which contingency area defined

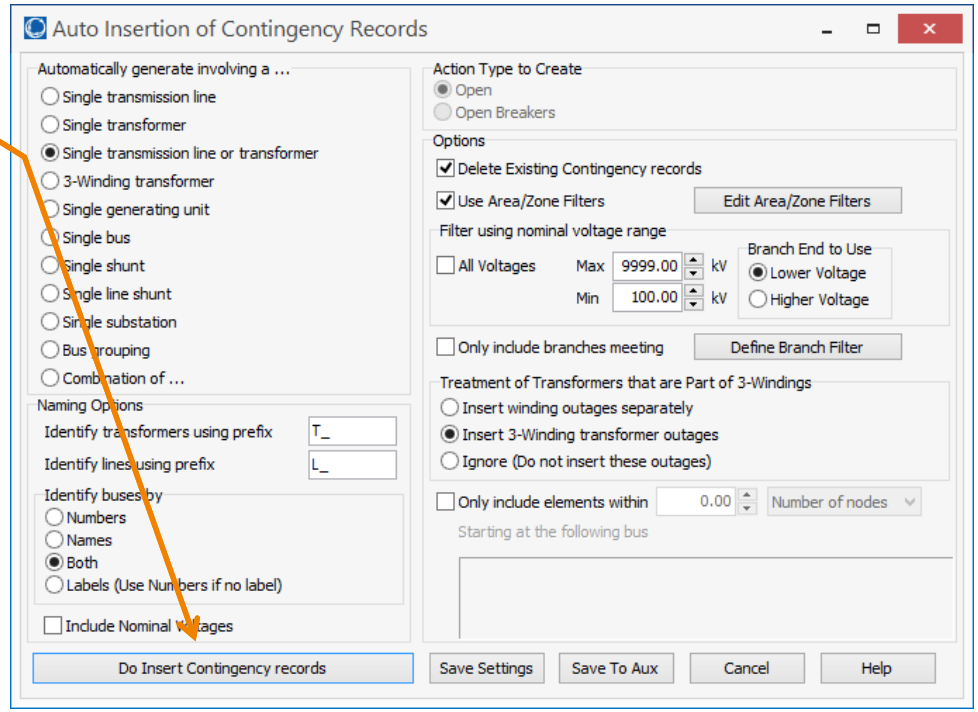
- Modify the Area/Zone Filters so that all areas are set to Shown = NO
- Then set the following 3 areas to YES
  - 1 (Far West)
  - 7 (Coast)
  - 10 (Lamesa)
- Click **Close**



	Area Num	Area Name	Shown	# of Buses	Min Bus Num	Max Bus Num
1	1	Far West	YES	91	1001	1091
2	2	North	NO	133	2001	2133
3	3	West	NO	147	3001	4001
4	4	South	NO	196	4002	6348
5	5	North Centra	NO	483	5003	5485
6	6	South Centra	NO	358	5001	6360
7	7	Coast	YES	432	7001	7432
8	8	East	NO	160	8001	8160
9	10	Lamesa	YES	1	1	1

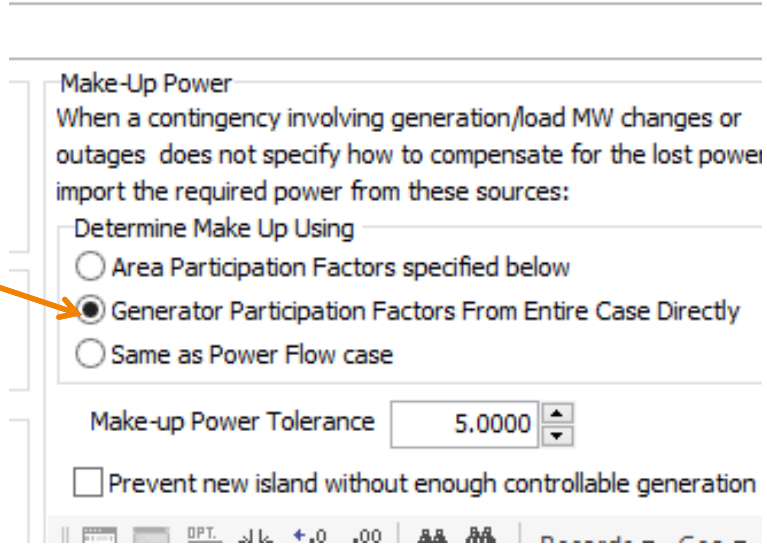
Insert the Contingencies

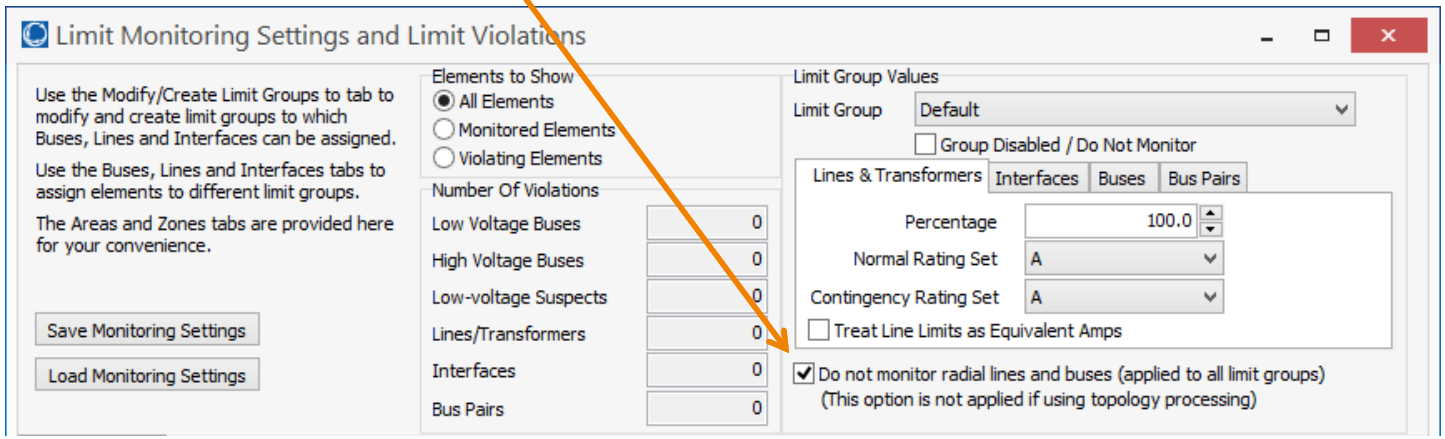
- Click **Do Insert Contingencies**
- A prompt will ask if you want to insert 968 contingencies and delete existing contingencies
  - Choose **Yes**



Setup Contingency Options

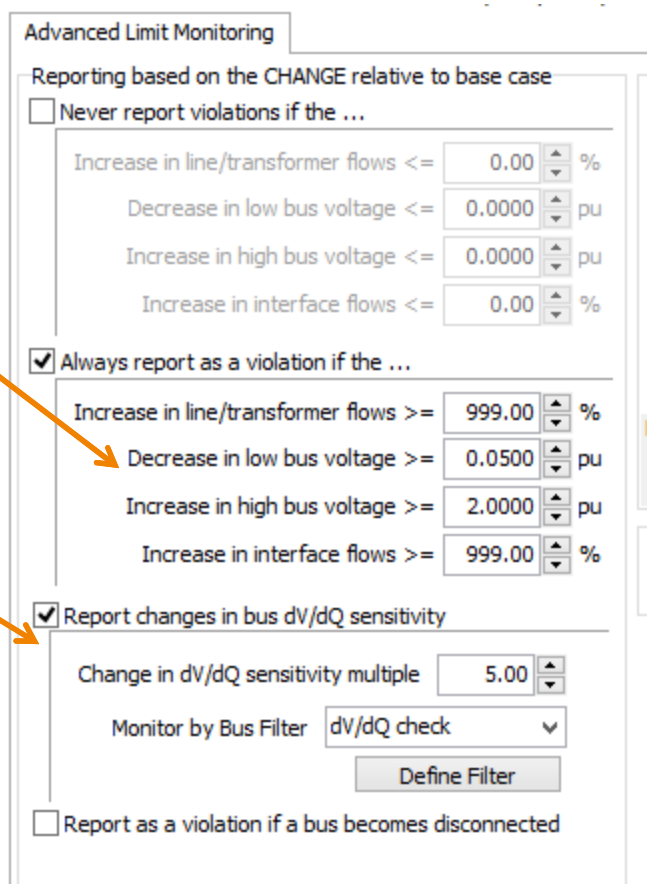
- Choose the **Options Tab**, and the **Modeling -> Basics** page
  - Set the Make-Up Power to **Generator Participation Factors from Entire Case Directly**
- Also open Limit Monitoring Settings
  - Ignore Radial Lines and Buses
  - Report Min kV = 100 for all Areas





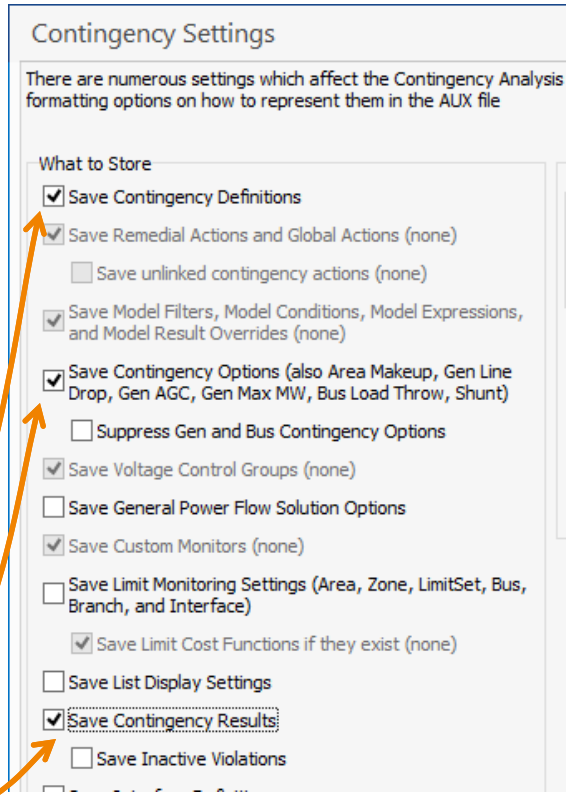
Advanced Limit Monitoring

- Always report as violations decrease in low bus voltage >= 0.05
- Report changes in bus dV/dQ sensitivity at least 5x greater than reference state, advanced filter on buses with >= 5 MW load in areas 1, 7, 10



Run the Contingencies

- Go back to the Contingencies Tab
  - Click **Start Run** Button
- We now have contingency analysis result for our base case.
  - Save these to compare to later
  - Click the **Save** Button at the bottom of the dialog
    - Save as file *LamesaCTGBase.aux*
    - On Dialog that appears check
      - Save Contingency Definitions
      - Save Contingency Options
      - Save Contingency Results

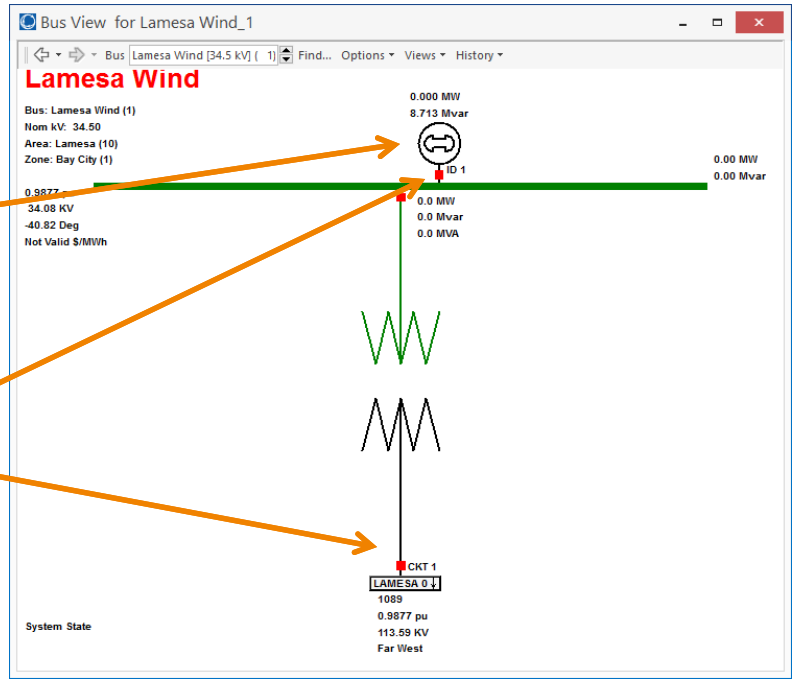


Build a Comparison Case

- Study the hypothetical new 200 MW generator at Lamesa
- Open Bus View Oneline and navigate to Bus 1

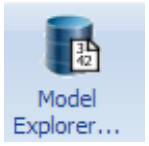
Here's our new generator

Close Breakers for Generator and collector transformer

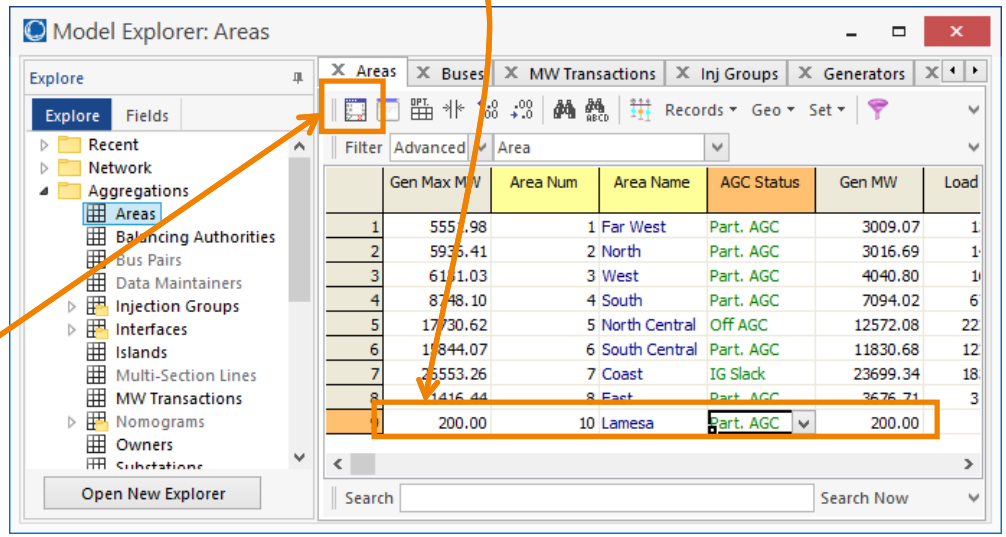


Create a Transfer from New Generator

- Generator bus is assigned to its own area number 10 (Lamesa)
- Open the Model Explorer

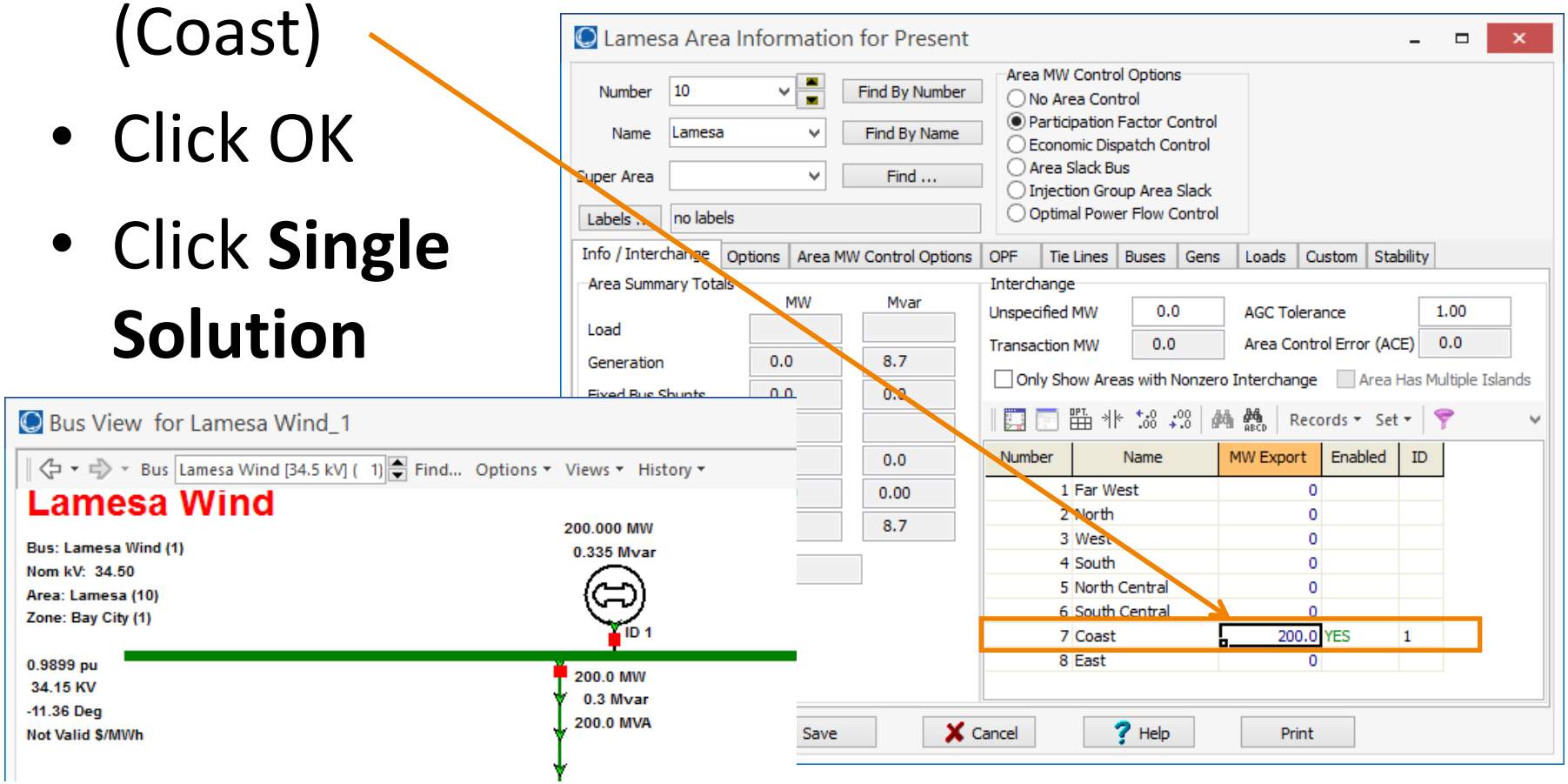


  - Choose **Aggregations\Areas**
  - Choose Area 10 (Lamesa)
  - Click the **Show Dialog** button



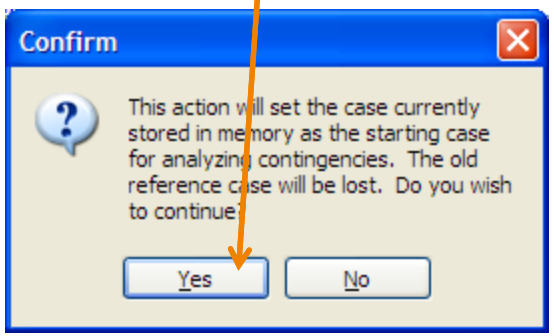
200 MW Transfer to Coast

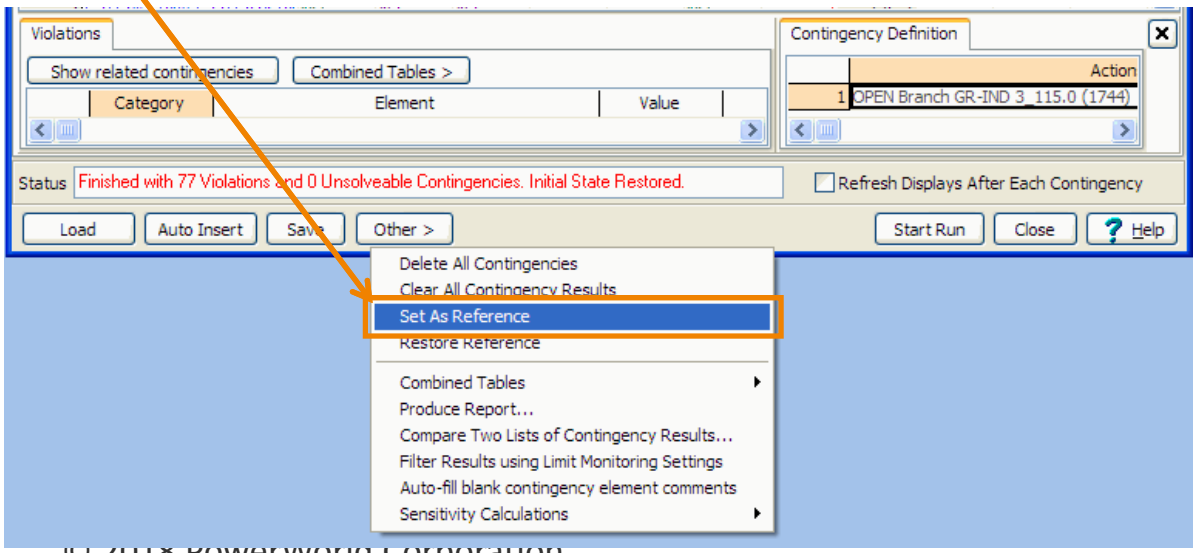
- Setup a 200 MW Export from Lamesa to Area 7 (Coast)
- Click OK
- Click **Single Solution**



Change the Reference State

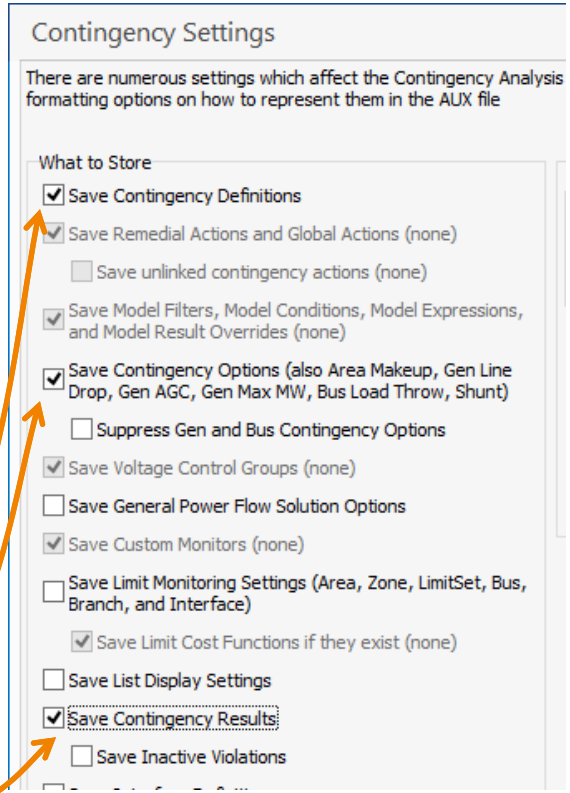
- Now Go to the Contingency Analysis Dialog again
- We have changed our system state now, but the contingency analysis tool still has the old “Reference State” stored
- We want to re-run the contingency analysis with the new 200 MW transfer included
- Choose **Other > Set As Reference**
- Click **Yes** on Dialog that appears





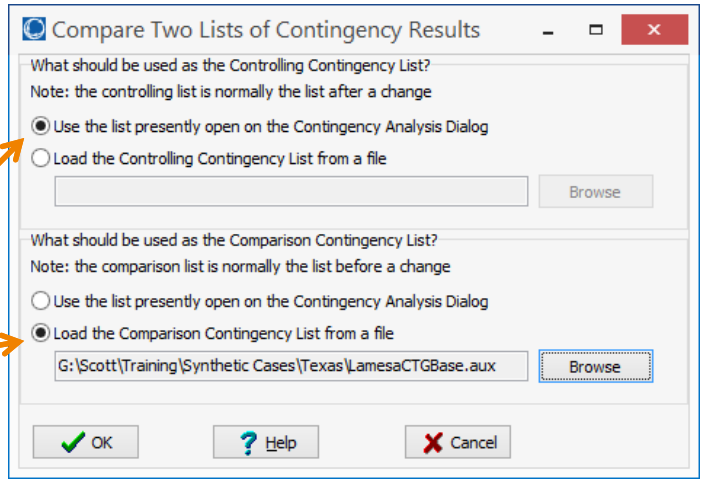
Run the Contingencies on the New Reference State

- Go back to the Contingencies Tab
  - Click **Start Run** Button
- We now have contingency analysis result for our reference case.
  - Save these to compare to later
  - Click the **Save** Button at the bottom of the dialog
    - Save as file *LamesaCTGTransfer.aux*
    - On Dialog that appears check
      - Save Contingency Definitions
      - Save Contingency Options
      - Save Contingency Results

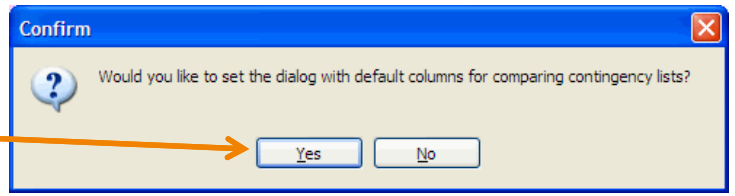


Compare the Results

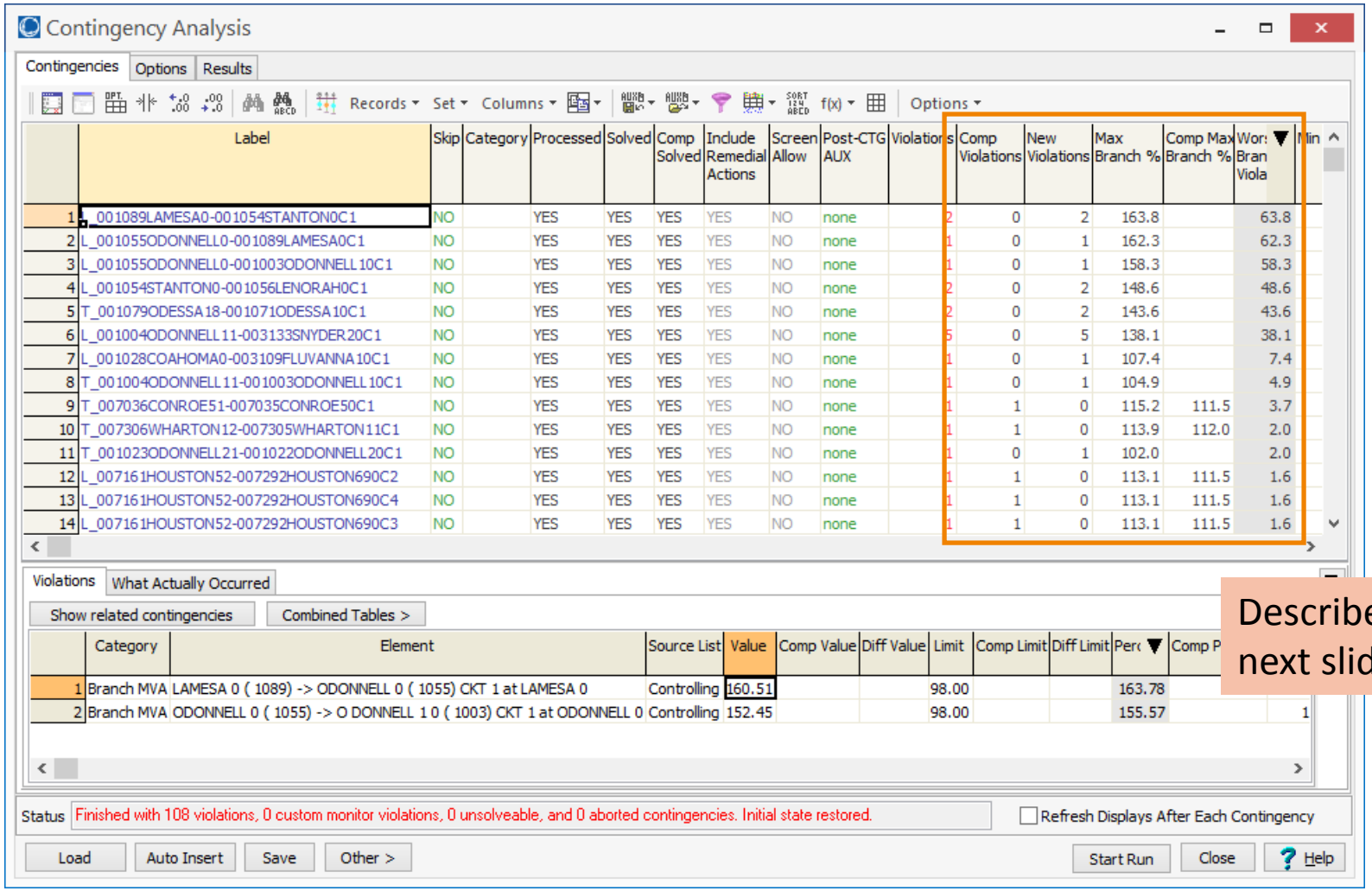
- Choose **Other > Compare Two Lists of Contingency Results…**
  - Choose Controlling List
    - *LamesaCTGTransfer.aux*
    - OR **Use the list presently open…**
  - Choose Comparison List
    - *LamesaCTGBase.aux*



- Click **OK**
  - This will import the two lists and do the comparison
- A dialog prompts for default columns for comparing contingency lists
  - Choose **Yes**



Comparison of Results By Contingency



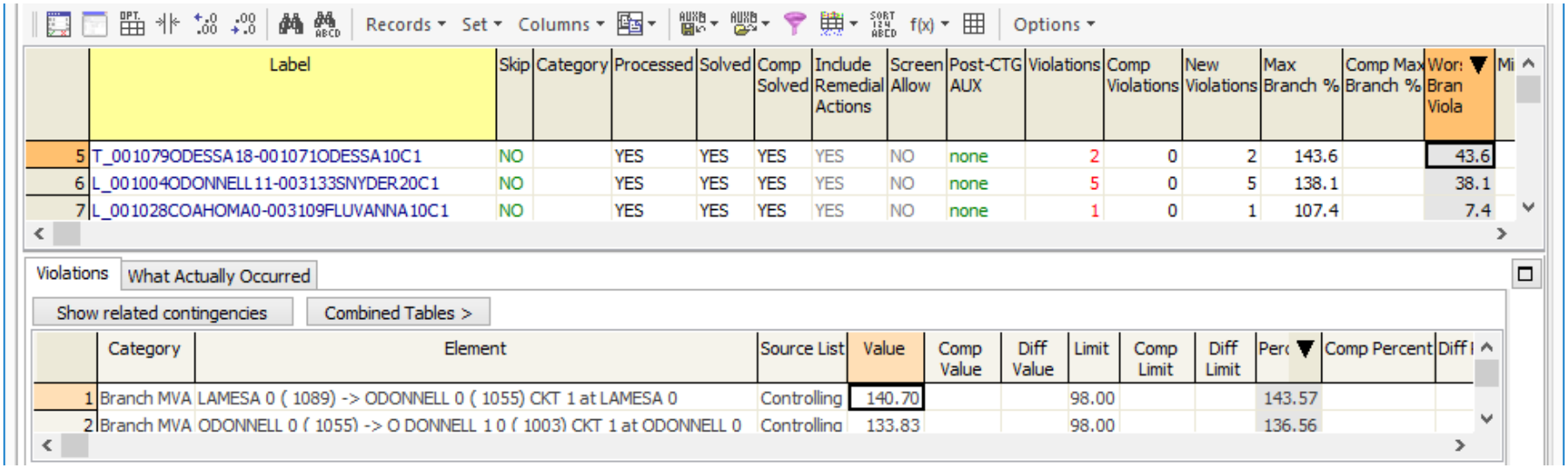
Described on the next slide

Comparison by Contingency: Explanation of Columns

- Max Branch %
  - Highest Branch % overload seen on any branch during this Contingency in the *Controlling* List
- Comp Max Branch %
  - Highest Branch % overload seen on any branch during this Contingency in the *Comparison* List
- Worst Branch Violation
  - Worst Branch Violation when comparing the *Controlling* List to the *Comparison* List
    - If the overload is in both the *Controlling* and *Comparison* List
      - Highest Difference it the % Branch violation
    - If an overload is in only the *Controlling* List then
      - % Branch - 100

Comparison by Contingency: Worst Branch Violation Example

- Go to Contingency: T_001079ODESSA18-001071ODESSA10C1



	Label	Skip	Category	Processed	Solved	Comp Solved	Include Remedial Actions	Screen Allow	Post-CTG AUX	Violations	Comp Violations	New Violations	Max Branch %	Comp Max Branch %	Wor: Bran Viola	Mi
5	T_001079ODESSA18-001071ODESSA10C1	NO		YES	YES	YES	YES	NO	none	2	0	2	143.6		43.6	
6	L_001004ODONNELL11-003133SNYDER20C1	NO		YES	YES	YES	YES	NO	none	5	0	5	138.1		38.1	
7	L_001028COAHOMA0-003109FLUVANNA10C1	NO		YES	YES	YES	YES	NO	none	1	0	1	107.4		7.4	

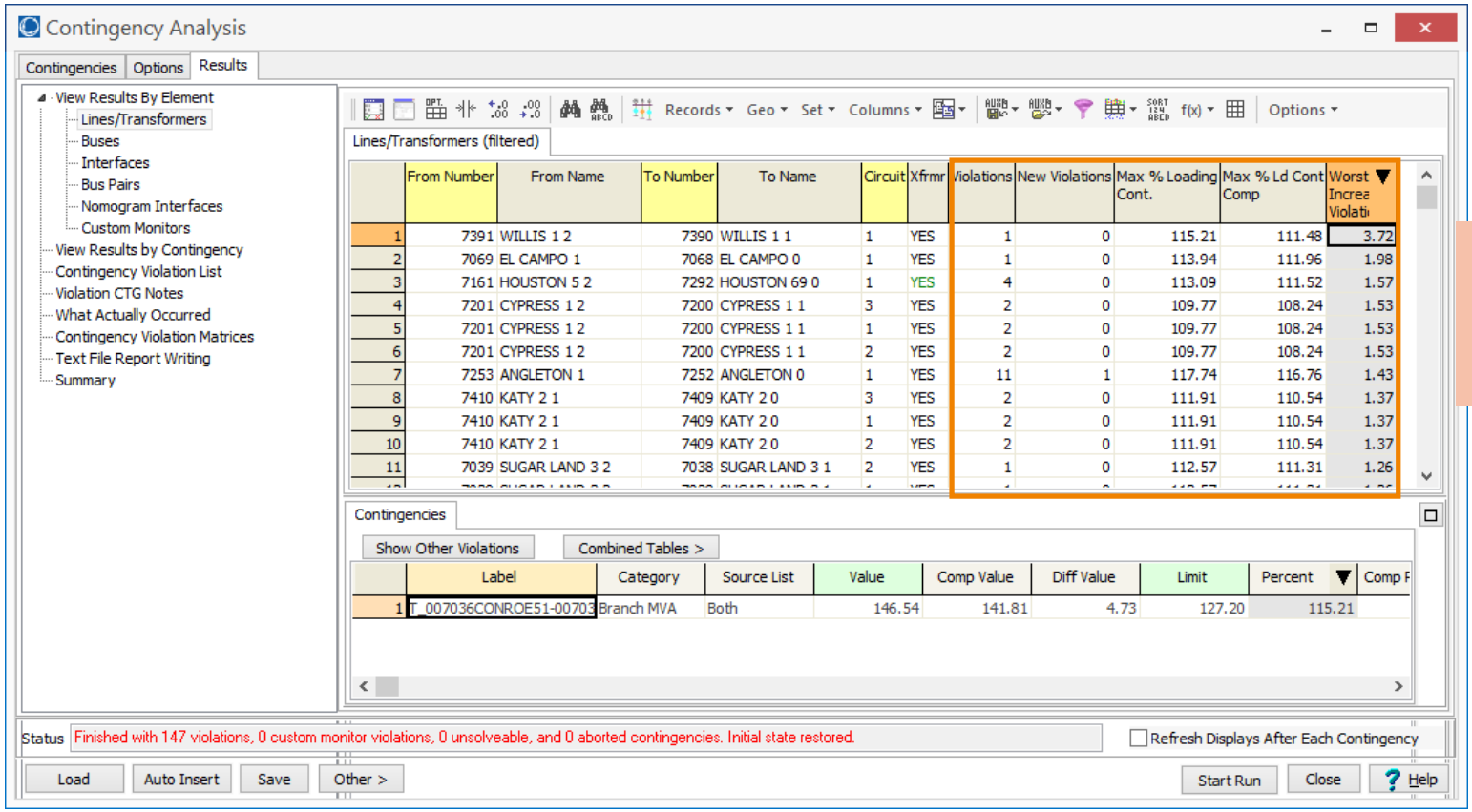
Violations | What Actually Occurred

Show related contingencies | Combined Tables >

	Category	Element	Source List	Value	Comp Value	Diff Value	Limit	Comp Limit	Diff Limit	Per	Comp Percent	Diff
1	Branch MVA	LAMESA 0 (1089) -> ODONNELL 0 (1055) CKT 1 at LAMESA 0	Controlling	140.70			98.00			143.57		
2	Branch MVA	ODONNELL 0 (1055) -> O DONNELL 1 0 (1003) CKT 1 at ODONNELL 0	Controllino	133.83			98.00			136.56		

  - LAMESA 0 – ODONNELL 0 went from no overload to 143.0%: treated as 43.0% for “Worst comparison
  - ODONNELL 0 – O DONNELL 1 0 went from no overload to 136.0%: treated as 36.0% for “Worst” comparison
  - Thus LAMESA 0 – ODONNELL 0 is considered the “Worst” with a value of 43.0%
- Similar comparisons are available for bus voltages

Comparison of Results By Element



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Comparison by Element: Explanation of Columns

- Max % Loading Cont.
  - Maximum % overload seen on this branch during any contingency in the *Controlling* List
- Max % Ld Cont Comp
  - Maximum % overload seen on this branch during any contingency in the *Comparison* List
- Worst Increase Violation
  - Worst Increase Violation when comparing the *Controlling* List to the *Comparison* List
    - If the overload is in both the *Controlling* and *Comparison* List
      - Highest Difference it the % Branch violation
    - If an overload is in only the *Controlling* List then
      - % Branch - 100

Comparison by Element: Worst Increase Violation Example

- Go to Branch: 7161 (HOUSTON 5 2) – 7292 (HOUSTON 69 0), CKT 1

Lines/Transformers (filtered)

	From Number	From Name	To Number	To Name	Circuit	Xfrmr	Violations	New Violations	Max % Loading Cont.	Max % Ld Cont Comp	Worst Increa Violati
1	7391	WILLIS 1 2	7390	WILLIS 1 1	1	YES	1	0	115.21	111.48	3.72
2	7069	EL CAMPO 1	7068	EL CAMPO 0	1	YES	1	0	113.94	111.96	1.98
3	7161	HOUSTON 5 2	7292	HOUSTON 69 0	1	YES	4	0	113.09	111.52	1.57
4	7201	CYPRESS 1 2	7200	CYPRESS 1 1	3	YES	2	0	109.77	108.24	1.53
5	7201	CYPRESS 1 2	7200	CYPRESS 1 1	1	YES	2	0	109.77	108.24	1.53

Contingencies

Show Other Violations | Combined Tables >

	Label	Category	Source List	Value	Comp Value	Diff Value	Limit	Per	Comp Percent	Diff Percent
1	L_007161HOUSTON52-007292HOUSTON690C2	Branch MVA	Both	250.05	246.57	3.48	221.10	113.09	111.52	1.57
2	L_007161HOUSTON52-007292HOUSTON690C3	Branch MVA	Both	250.05	246.57	3.48	221.10	113.09	111.52	1.57
3	L_007161HOUSTON52-007292HOUSTON690C4	Branch MVA	Both	250.05	246.57	3.48	221.10	113.09	111.52	1.57
4	L_007159HOUSTON50-007175SPRING70C1	Branch MVA	Both	228.96	226.59	2.36	221.10	103.55	102.48	1.07

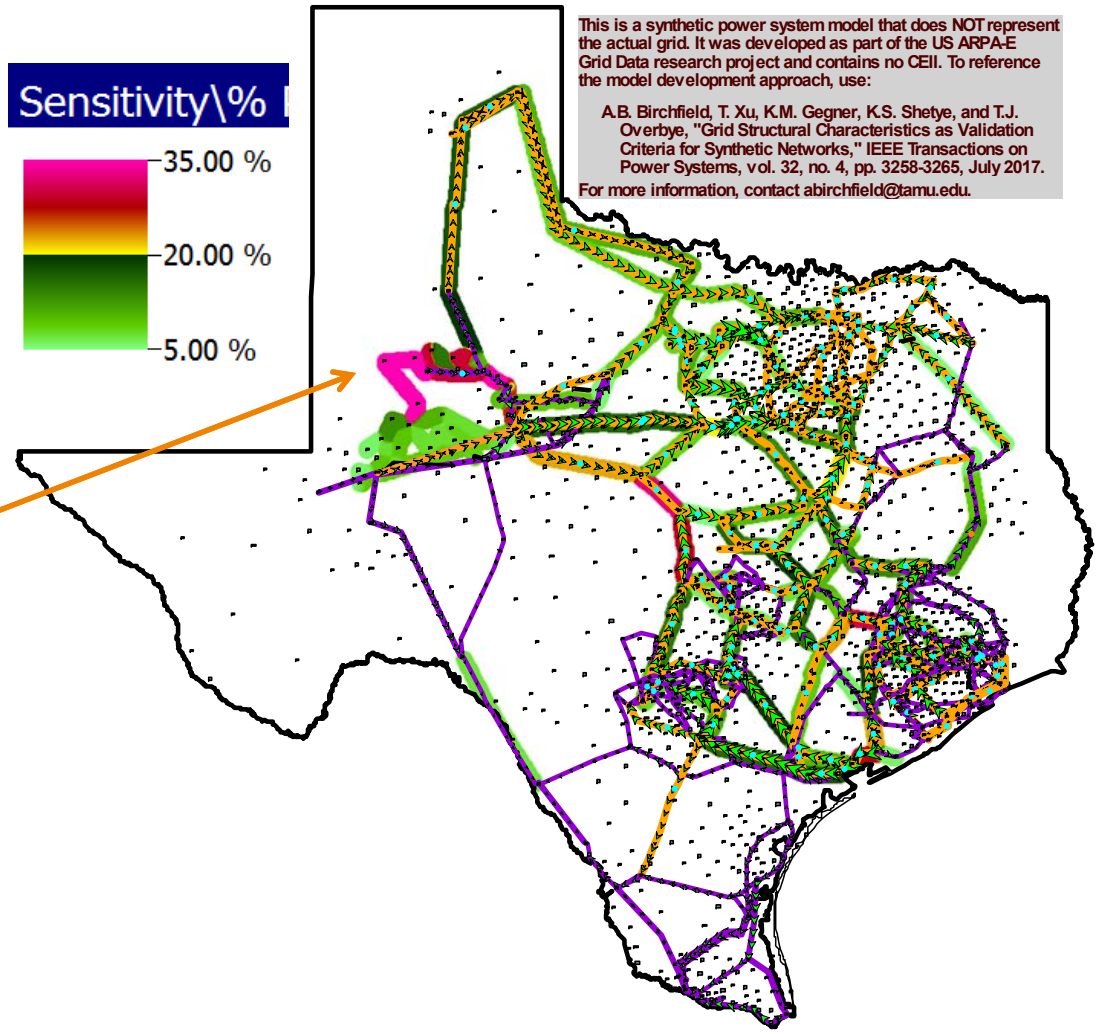
- For L_007161HOUSTON52-007292HOUSTON690C2 (and other parallel outages), went from 111.5% to 113.1%: treated as 1.6% for “Worst” comparison
- For L_007159HOUSTON50-007175SPRING70C1, went from 102.5% to 103.6%: treated as 1.1% for “Worst” comparison
- Contingency L_007161HOUSTON52-007292HOUSTON690C2 is considered “Worst” with a value of 1.6%

PTDF Calculation and Visualization

- Next, examine how incremental power from the proposed unit would flow through the system
- Shut off proposed unit by disabling transfer between area Lamesa and area Coast
- Open PTDF tool (Tools → Sensitivities → Power Transfer Distribution Factors)
- Choose Injection Goup “Lamesa” as Seller, Injection Group “Coast Load” as Buyer

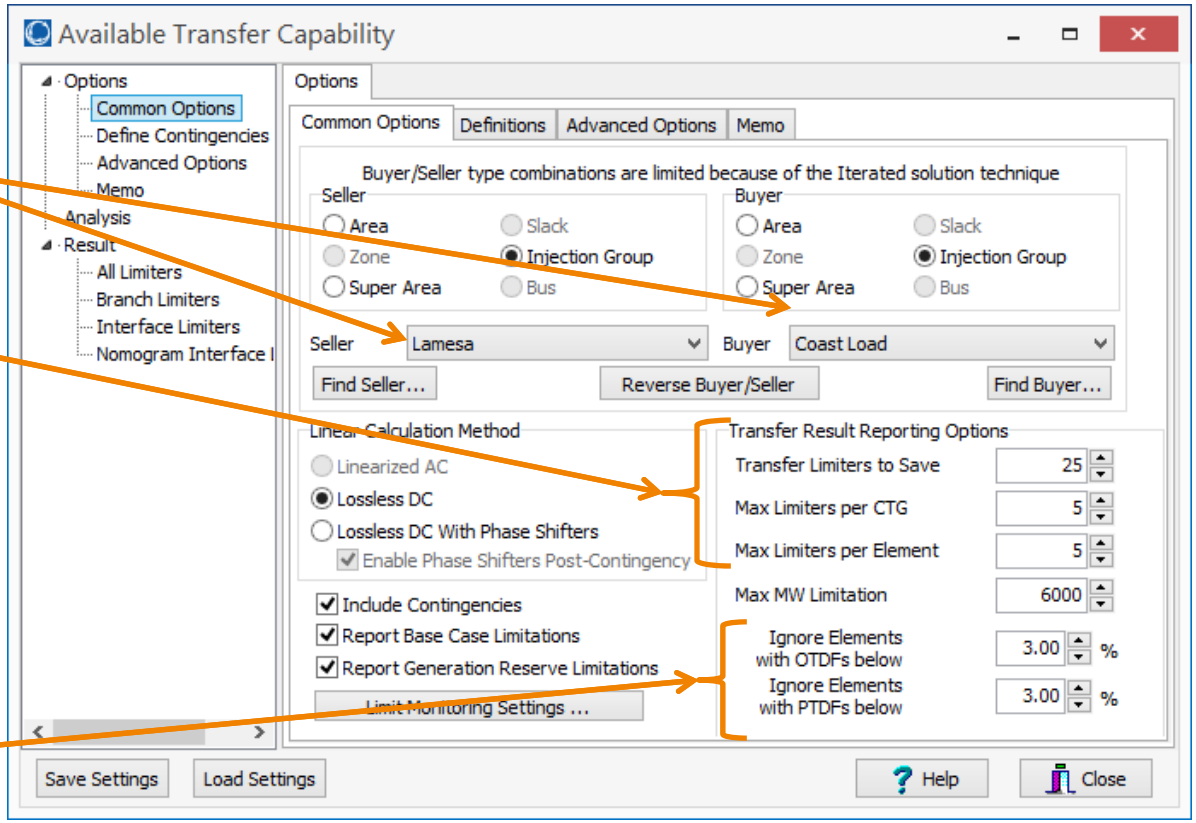
PTDF Visualization

- Color contour
- 5%-35% range
- Ignore zero values, below min
- Lamesa



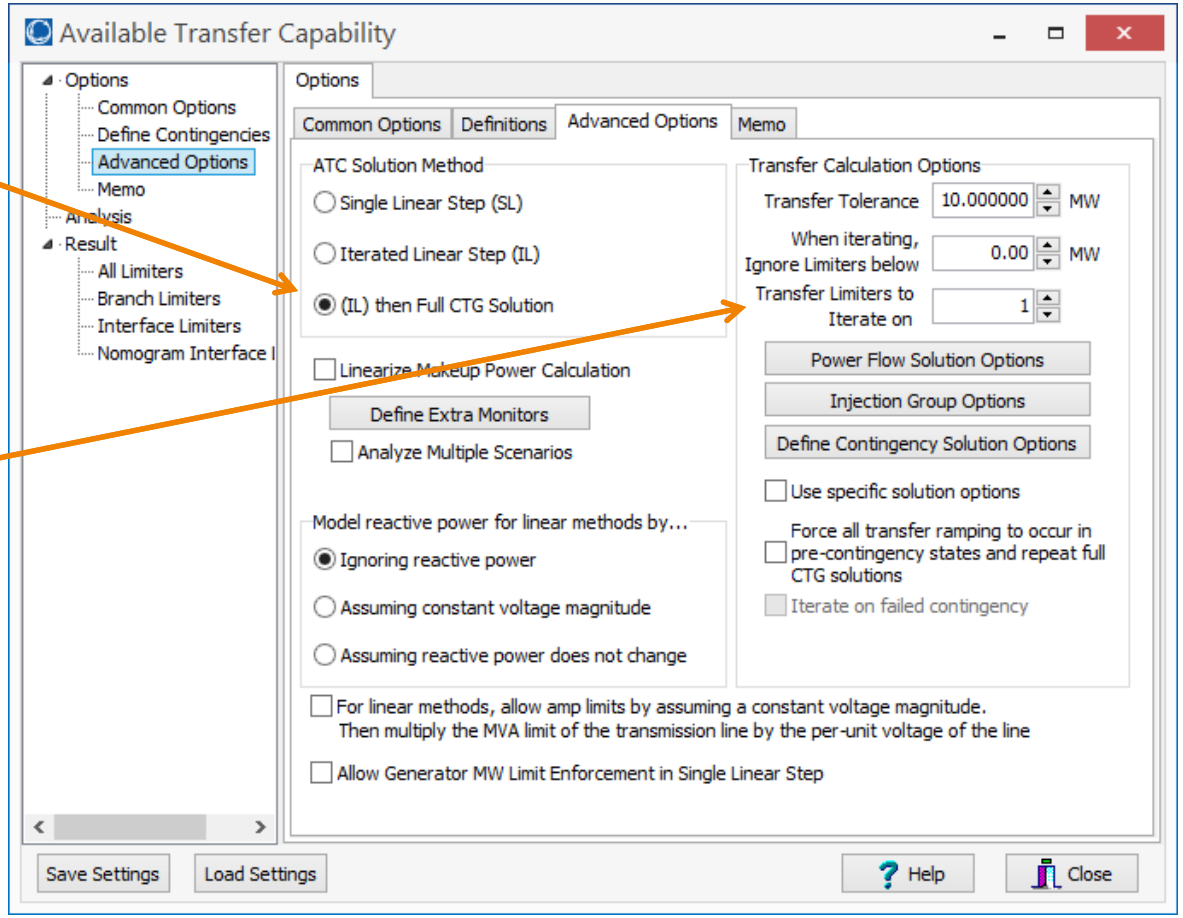
Available Transfer Capability

- Keep Seller and Buyer selections the same as PTDF
- Save 25 Limiters, 5 per CTG, 5 per element
- Ignore Elements with OTDF/PTDF below 3%



Available Transfer Capability

- Use (IL) then Full CTG Solution method
- Iterate on 1 Transfer Limiter



ATC Results

Overloads to remediate so proposed plant may be operated at full capacity without thermal security violations

Result

Records Set Columns Options

All Limiters | Branch Limiters | Interface Limiters | Nomogram Interface Limiters

	Trans Lim	Limiting Element	Limiting CTG	% OTDF	Pre-Trans Est	Limit Used
1	108.50	Line COAHOMA 0 (1028) TO FLUVANNA 1 0 (3109) CKT 1 [115.00 -	L_001004ODONNELL11-003133SNYDER20C1	53.67	245.75	250.00
2	123.08	Transformer FLUVANNA 2 1 (3097) TO FLUVANNA 2 0 (3096) CKT 1	L_001004ODONNELL11-003133SNYDER20C1	26.83	155.73	162.00
3	123.08	Transformer FLUVANNA 2 1 (3097) TO FLUVANNA 2 0 (3096) CKT 2	L_001004ODONNELL11-003133SNYDER20C1	26.83	155.73	162.00
4	124.48	Line LAMESA 0 (1089) TO STANTON 0 (1054) CKT 1 [115.00 - 115.0	L_001004ODONNELL11-003133SNYDER20C1	46.33	86.53	98.00
5	136.02	Line ODONNELL 0 (1055) TO LAMESA 0 (1089) CKT 1 [115.00 - 115.	T_001079ODESSA18-001071ODESSA10C1	-61.45	-75.69	-98.00
6	138.85	Line ODONNELL 0 (1055) TO LAMESA 0 (1089) CKT 1 [115.00 - 115.	L_001089LAMESA0-001054STANTON0C1	-100.00	-58.87	-98.00
7	139.05	Line LAMESA 0 (1089) TO STANTON 0 (1054) CKT 1 [115.00 - 115.0	L_001055ODONNELL0-001089LAMESA0C1	100.00	58.67	98.00
8	142.82	Line ODONNELL 0 (1055) TO O DONNELL 1 0 (1003) CKT 1 [115.00 -	T_001079ODESSA18-001071ODESSA10C1	61.45	71.52	98.00
9	143.03	Line ODONNELL 0 (1055) TO O DONNELL 1 0 (1003) CKT 1 [115.00 -	L_001089LAMESA0-001054STANTON0C1	100.00	54.69	98.00
10	143.03	Line LAMESA 0 (1089) TO STANTON 0 (1054) CKT 1 [115.00 - 115.0	L_001055ODONNELL0-001003ODONNELL10C1	100.00	54.69	98.00
11	151.72	Line FLUVANNA 1 0 (3109) TO FLUVANNA 2 1 (3097) CKT 1 [115.00	L_001004ODONNELL11-003133SNYDER20C1	53.67	312.09	340.00
12	155.67	Line ODONNELL 0 (1055) TO LAMESA 0 (1089) CKT 1 [115.00 - 115.	L_001054STANTON0-001056LENORAH0C1	-100.00	-42.05	-98.00
13	159.84	Line ODONNELL 0 (1055) TO O DONNELL 1 0 (1003) CKT 1 [115.00 -	L_001054STANTON0-001056LENORAH0C1	100.00	37.87	98.00
14	188.39	Line LAMESA 0 (1089) TO STANTON 0 (1054) CKT 1 [115.00 - 115.0	L_001028COAHOMA0-003109FLUVANNA10C1	46.12	57.10	98.00
15	195.76	Line LAMESA 0 (1089) TO STANTON 0 (1054) CKT 1 [115.00 - 115.0	T_001004ODONNELL11-001003ODONNELL10C1	46.33	53.50	98.00
16	199.59	Line ODONNELL 0 (1055) TO LAMESA 0 (1089) CKT 1 [115.00 - 115.	T_001023ODONNELL21-001022ODONNELL20C1	-59.97	-38.11	-98.00
17	200.00	InjectionGroup Lamesa	Base Case	0.00	0.00	0.00
18	204.61	Line ODONNELL 0 (1055) TO LAMESA 0 (1089) CKT 1 [115.00 - 115.	L_001056LENORAH0-001027MIDLAND20C1	-61.94	-33.04	-98.00
19	206.56	Line ODONNELL 0 (1055) TO O DONNELL 1 0 (1003) CKT 1 [115.00 -	T_001023ODONNELL21-001022ODONNELL20C1	59.97	33.93	98.00
20	206.87	Line STANTON 0 (1054) TO LENORAH 0 (1056) CKT 1 [115.00 - 115.	L_001055ODONNELL0-001089LAMESA0C1	100.00	41.85	149.00

ATC Automation

- The entire ATC process may be documented and automated in auxiliary files
- Re-open *ACTIVSg2000.pwb*
  - load *aux2000ATCMaster.aux*
  - results stored in *aux2090ATCResults.aux*
- Examine individual aux files (*aux20??*.aux*) for details

Voltage Analysis

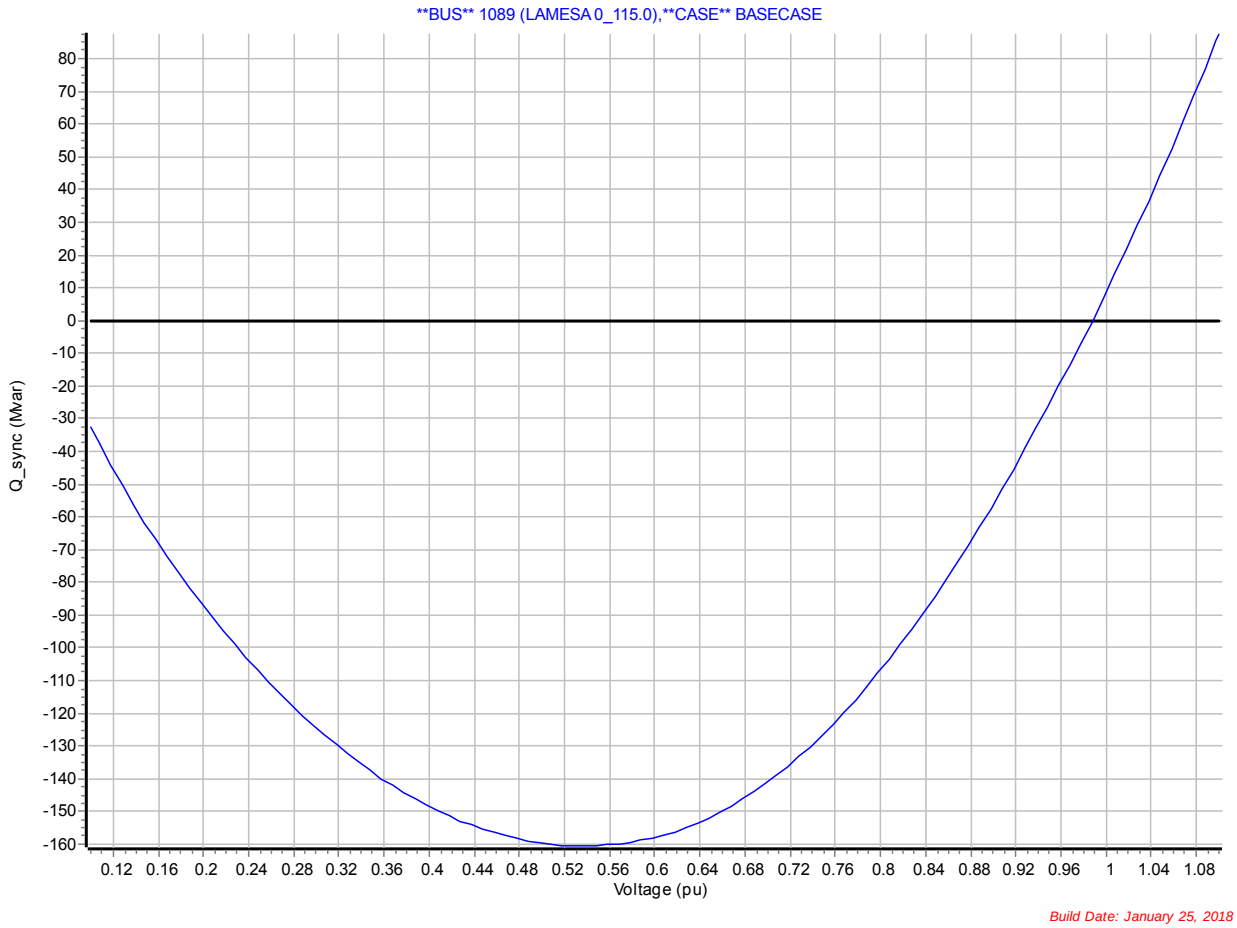
- Plot QV curves at point of interconnection
  - Compare Q margin with/without new unit
- PV analysis
  - Run on base case to identify contingencies that most limit the transfer
  - Run with short list of selected contingencies
- Run QV curves on buses and contingencies that cause most voltage problems

QV Curves at Interconnection Point

- Plot QV curves at bus 1089 (Lamesa 115 kV)
  - First, without proposed generator; then with
  - To quickly interconnect new generator
    - load *aux2000MasterInterconnectSetup.aux*
    - Close transformer between buses 1 and 1089 and generator
    - enable the transaction between area 10 and area 7
    - Solve the power flow
  - If reactive margin decreases with the new unit, then supplemental reactive support may be required
- QV Settings
  - Base case only: no contingencies
  - Disable all switched shunts, SVCs, LTCs, and phase shifters
  - Minimum pu voltage for constant power load = 0
  - May be loaded from *LouisianaGeneratorQVOptionsCough.aux*

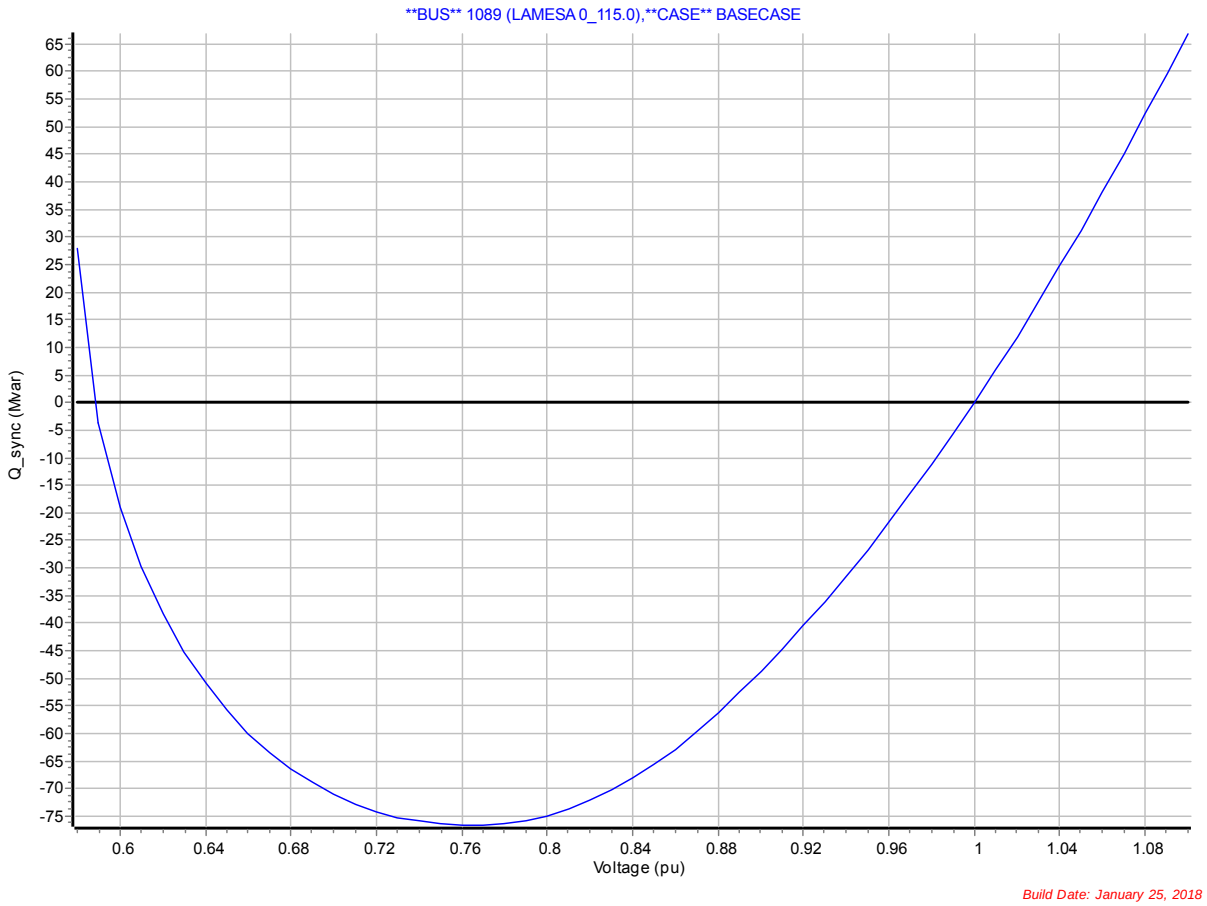
QV Curve without Proposed Unit

- Q margin = 161 MVar



QV Curve with Proposed Unit

- Q margin = 77 MVar, a decrease from the base case
- Additional reactive supply might be desirable

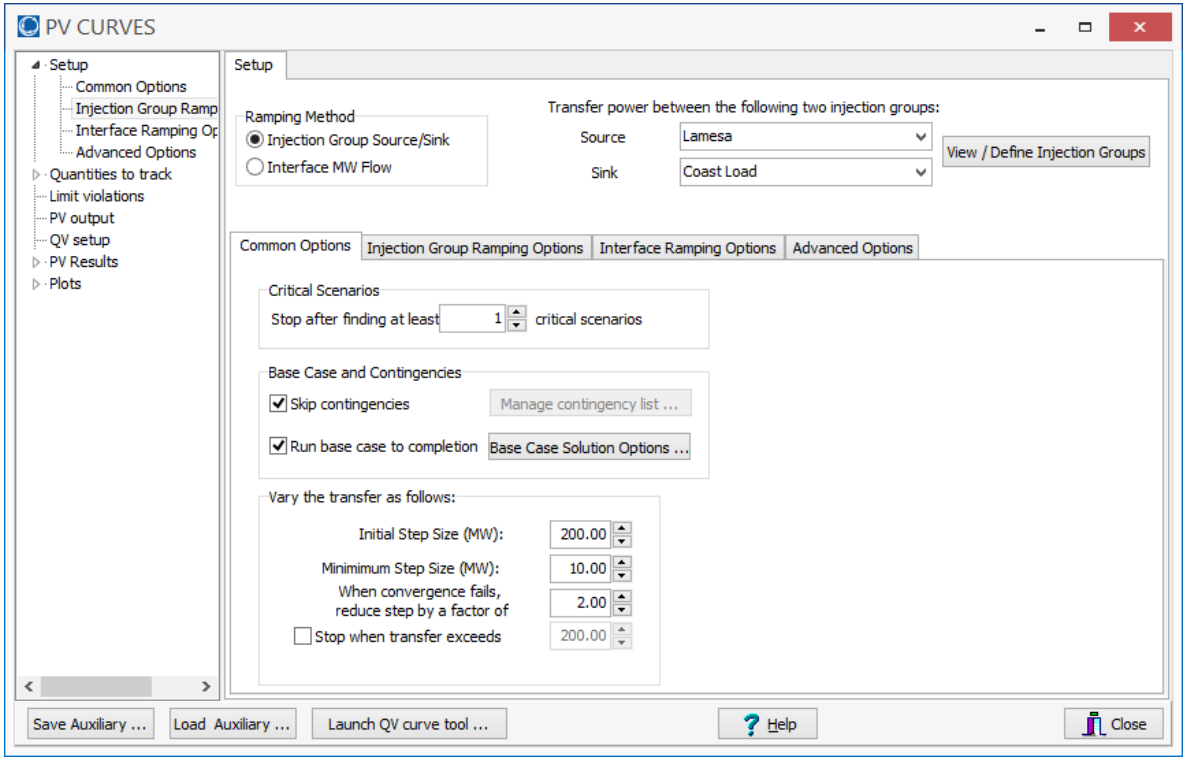


PV Study

- Examine the ability to transfer power from the proposed generator to loads in area 7
- Contingency screening process
  - Run PV on base case only (Skip Contingencies)
  - Repeat base case only, but stop when transfer gets to about 80% of the level of the nose point
  - Run contingency analysis on this state
  - Run PV with only those contingencies that failed at 80% transfer (these contingencies will likely fail earlier and become the most limiting)

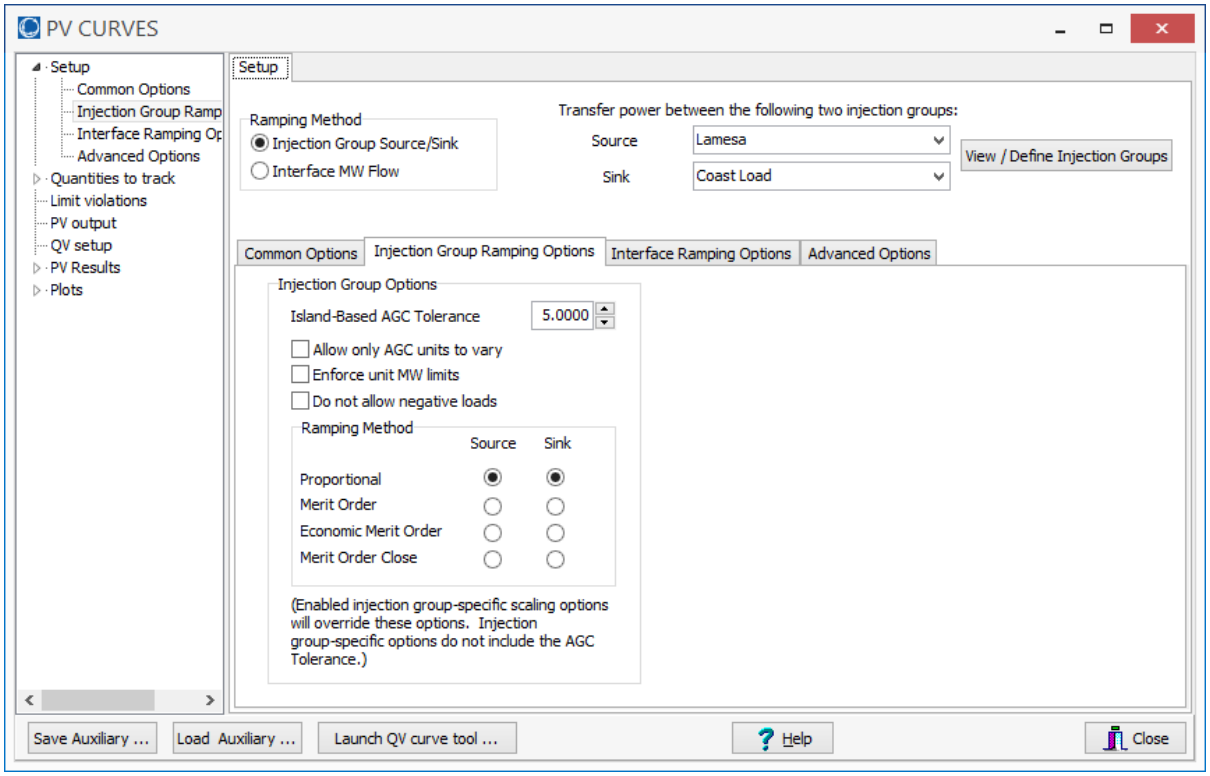
Base Case PV Study: Setup

- Source as Lamesa; sink as Coast Load
- Stop after 1 critical scenario
- Skip contingencies; Run base case to completion
- 200 MW Initial Step Size, 10 MW minimum



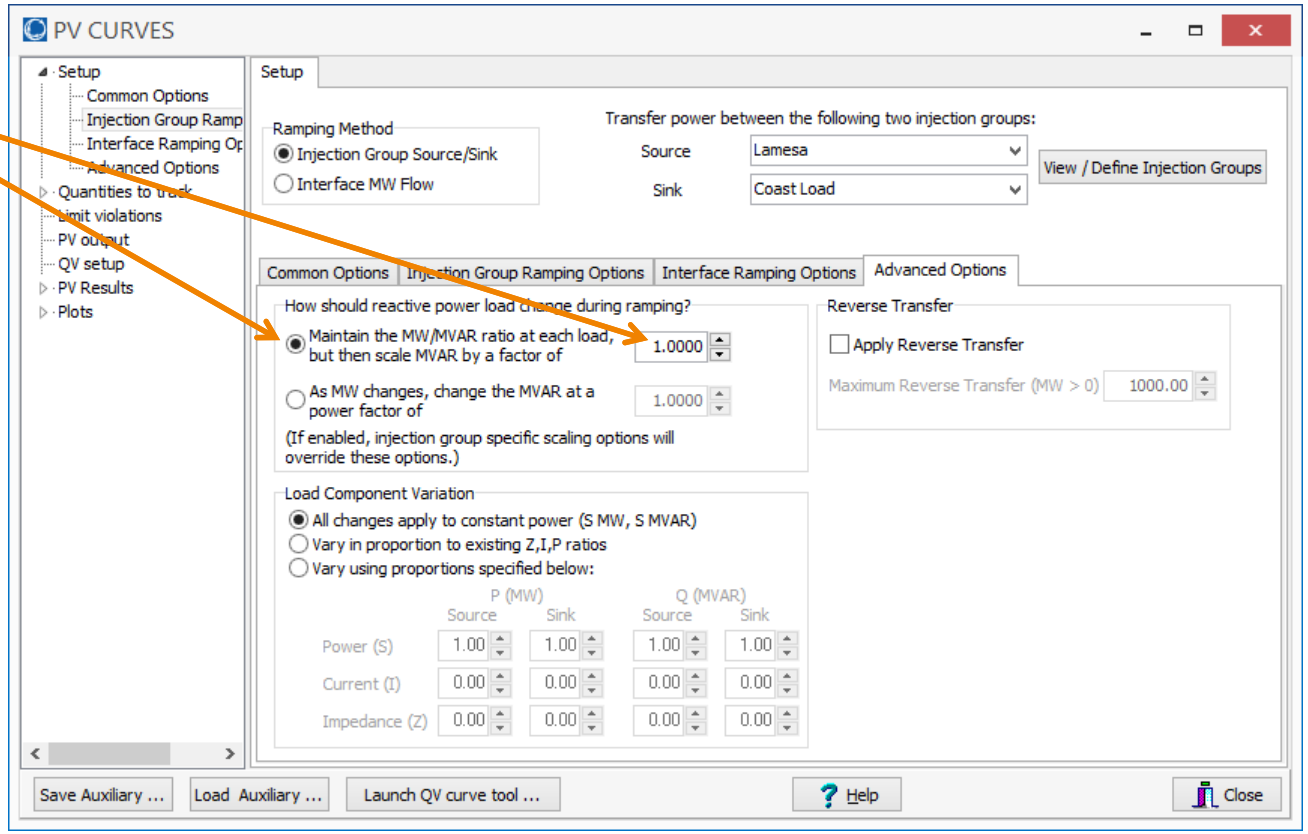
Base Case PV Study: Setup

- Do not Enforce unit MW limits (to identify nose point if beyond 200 MW capacity)



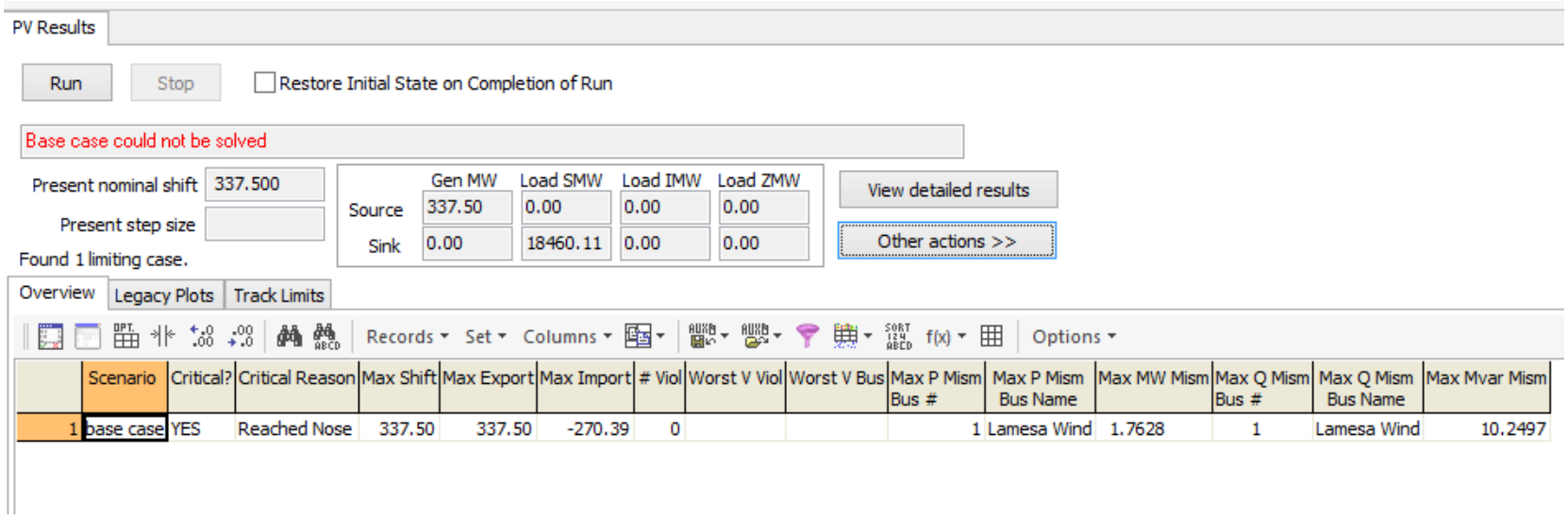
Base Case PV Study: Setup

- Scale load Mvar with MW



Run Base Case PV

- Nose occurs at 337.5 MW with no contingencies
- Click **Other actions >> Restore Initial State**



Contingency Analysis at 275 MW

- Enable Lamesa-Coast transaction and set to 275 MW
- Set reference to current state
- Remove Advanced Limit Monitoring options for faster processing
- 5 Unsolved contingencies
  - skip all but these and re-run PV analysis from zero
  - Optionally save these Contingency Label and Skip fields to an aux file for later use

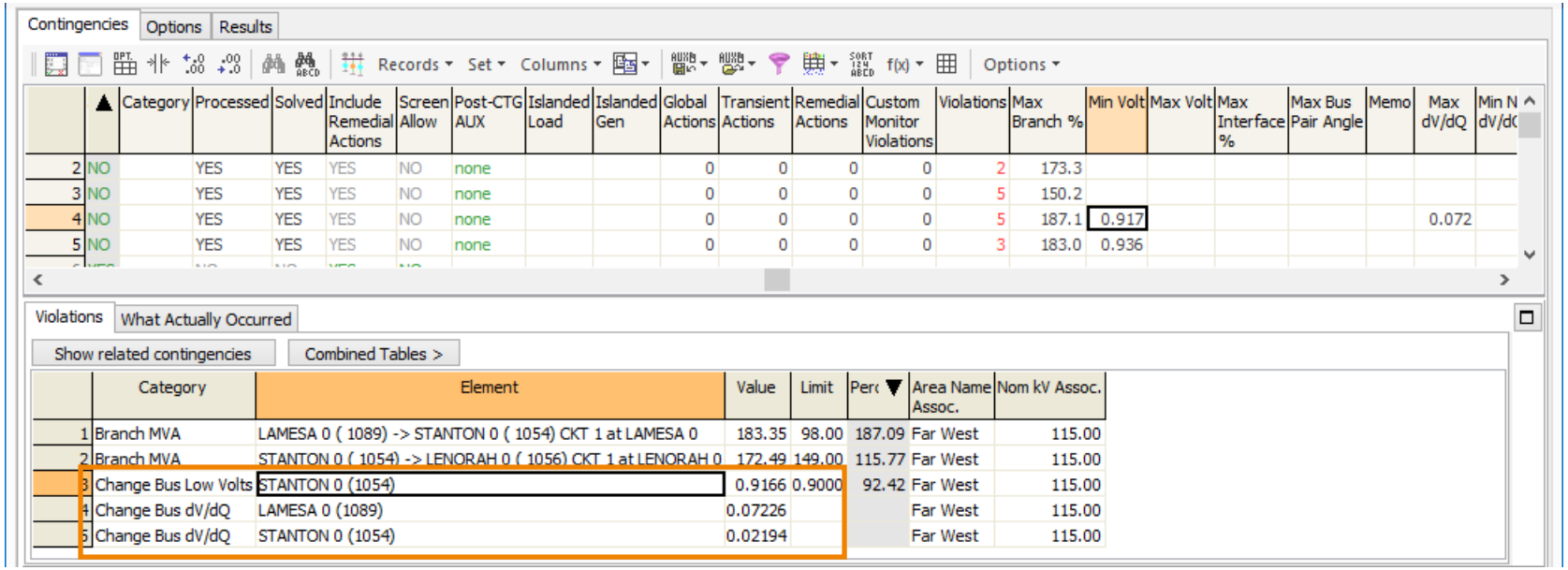
Contingencies | Options | Results

Records ▾ Set ▾ Columns ▾ Options ▾

	Label	Skip	Category	Processed	Sol ▲	Include Remedial Actions	Screen Allow	Post-CTG AUX	Islanded Load	Islanded Gen	Global Actions	Transient Actions	Remedial Actions	Custom Monitor Violations	Violations	Max Branch %	M
1	L_001089LAMESA0-001054STANTON0C1	NO		YES	NO	YES	NO	none			0	0	0	Unsolved	Unsolved		
2	L_001054STANTON0-001056LENORAH0C1	NO		YES	NO	YES	NO	none			0	0	0	Unsolved	Unsolved		
3	L_001004ODONNELL11-003133SNYDER20C1	NO		YES	NO	YES	NO	none			0	0	0	Unsolved	Unsolved		
4	L_001055ODONNELL0-001089LAMESA0C1	NO		YES	NO	YES	NO	none			0	0	0	Unsolved	Unsolved		
5	L_001055ODONNELL0-001003ODONNELL10C1	NO		YES	NO	YES	NO	none			0	0	0	Unsolved	Unsolved		
6	L_001010PRESIDIO10-001002PRESIDIO20C1	NO		YES	YES	YES	NO	none			0	0	0	0	3	126.1	
7	L_001002PRESIDIO20-001007VANHORN0C1	NO		YES	YES	YES	NO	none			0	0	0	0	3	126.2	

PV Analysis with Contingencies

- Identify several bus voltages to track
  - Try various values of Lamesa-Coast transaction between 225 MW and 250 MW
  - Solve 5 contingencies, reporting as violations decreases in low bus voltage and changes in dV/dQ sensitivity



	Category	Processed	Solved	Include Remedial Actions	Screen Allow	Post-CTG AUX	Islanded Load	Islanded Gen	Global Actions	Transient Actions	Remedial Actions	Custom Monitor Violations	Violations	Max Branch %	Min Volt	Max Volt	Max Interface %	Max Bus Pair Angle	Memo	Max dV/dQ	Min N dV/dQ
2	NO	YES	YES	YES	NO	none			0	0	0	0	2	173.3							
3	NO	YES	YES	YES	NO	none			0	0	0	0	5	150.2							
4	NO	YES	YES	YES	NO	none			0	0	0	0	5	187.1	0.917					0.072	
5	NO	YES	YES	YES	NO	none			0	0	0	0	3	183.0	0.936						

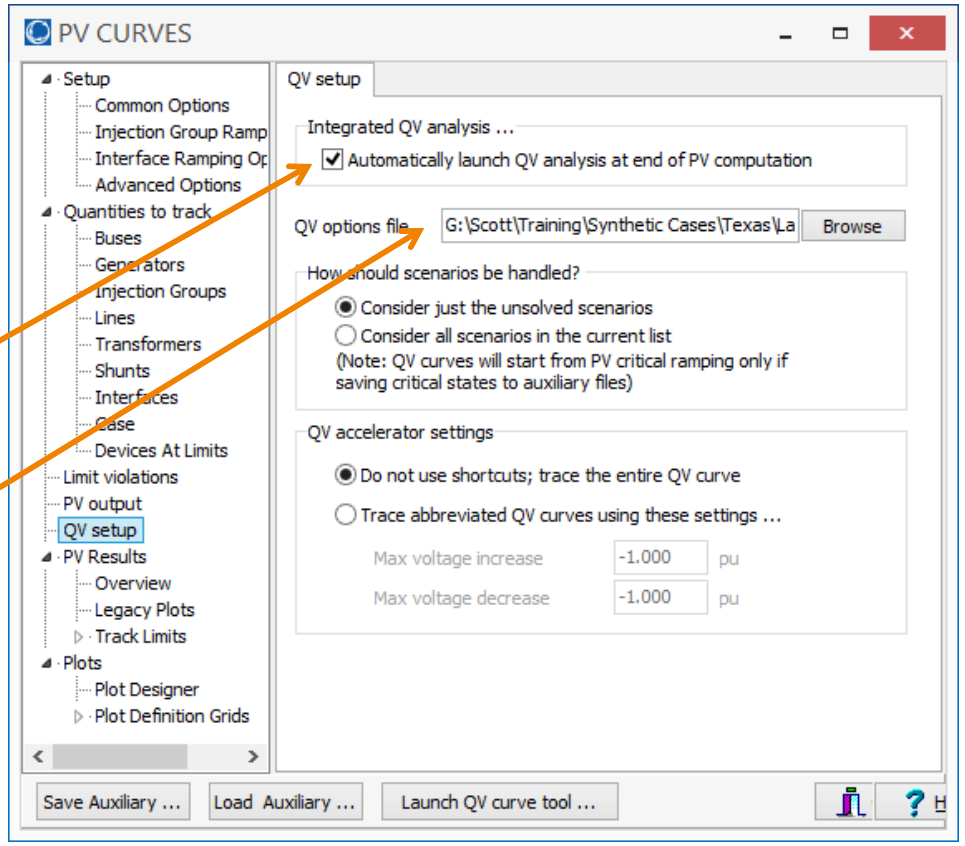
	Category	Element	Value	Limit	Perc	Area Name Assoc.	Nom kV Assoc.
1	Branch MVA	LAMESA 0 (1089) -> STANTON 0 (1054) CKT 1 at LAMESA 0	183.35	98.00	187.09	Far West	115.00
2	Branch MVA	STANTON 0 (1054) -> LENORAH 0 (1056) CKT 1 at LENORAH 0	172.49	149.00	115.77	Far West	115.00
3	Change Bus Low Volts	STANTON 0 (1054)	0.9166	0.9000	92.42	Far West	115.00
4	Change Bus dV/dQ	LAMESA 0 (1089)	0.07226			Far West	115.00
5	Change Bus dV/dQ	STANTON 0 (1054)	0.02194			Far West	115.00

PV Analysis with Contingencies

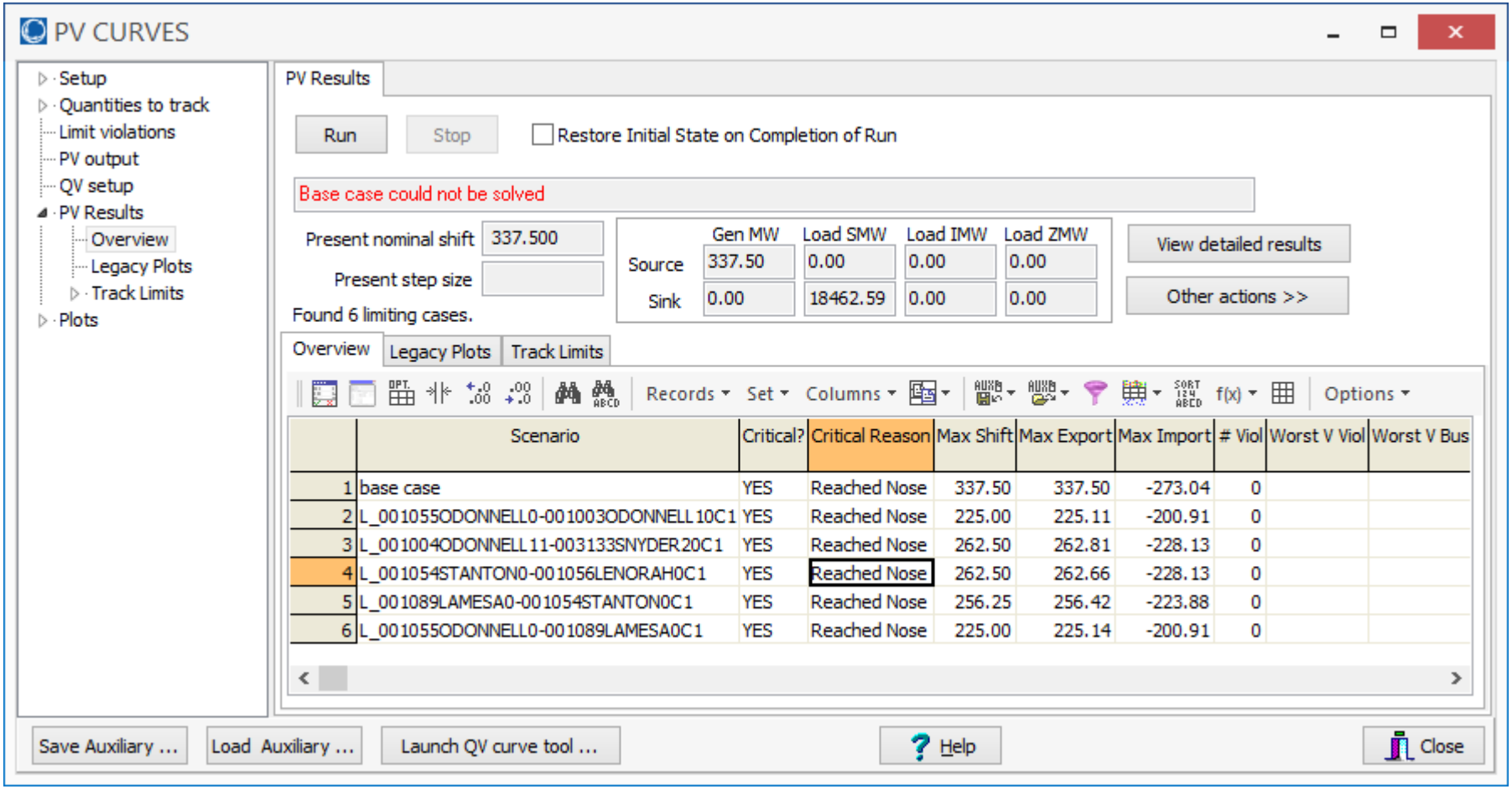
- Stop after 5 critical scenarios
- Initial Step 25 MW, Minimum Step 5 MW
- Track bus voltage at Lamesa and other vunerable buses:
  - 1022 O DONNELL 2 0
  - 1028 COAHOMA 0
  - 1054 STANTON 0
- Track MW and Mvar Reserve at Lamesa Wind
- Settings may be loaded from *LamesaPVOptions.aux*

Integrated QV Analysis

- Optionally select "Automatically launch QV analysis at end of PV computation" from *QV setup* tab
- Set "QV options file" to *LamesaIntegrated QVOptions.aux*

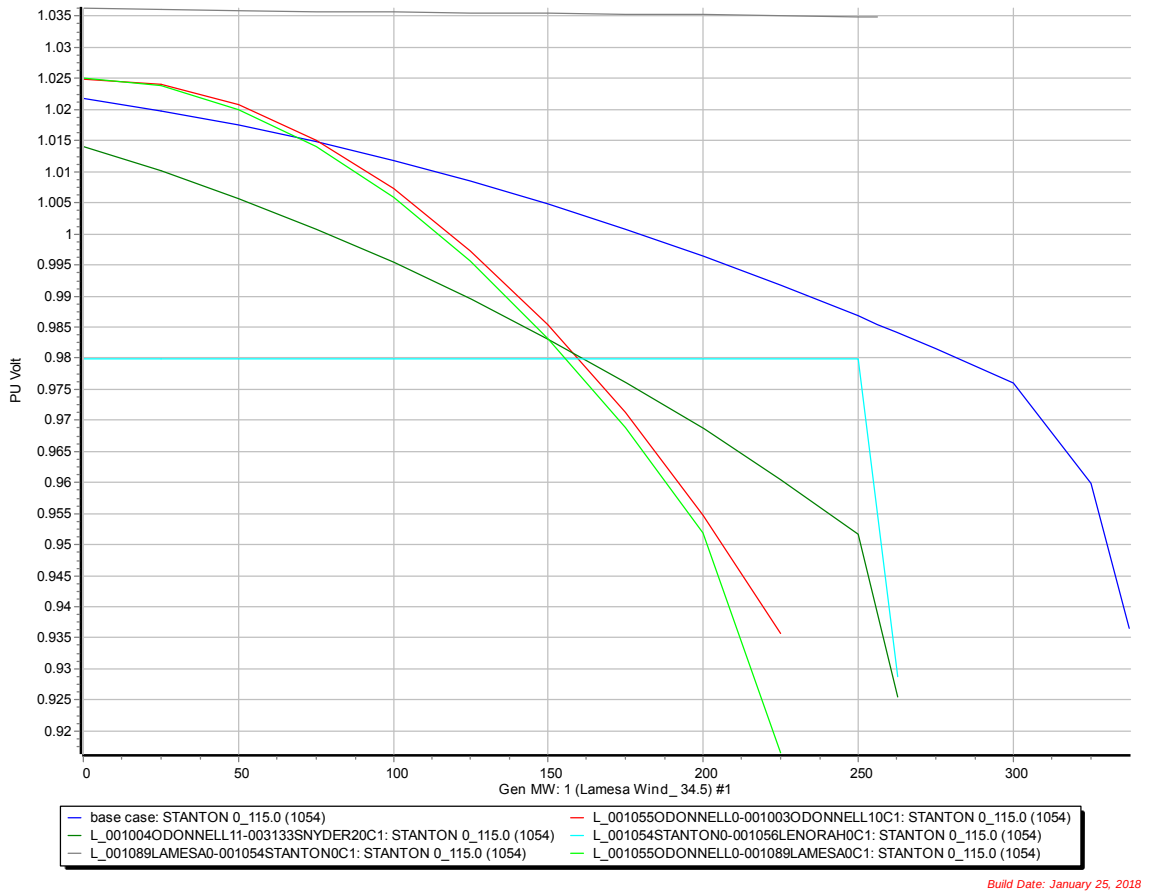


PV Results



PV Plot

- Bus Voltage vs. Generator Output

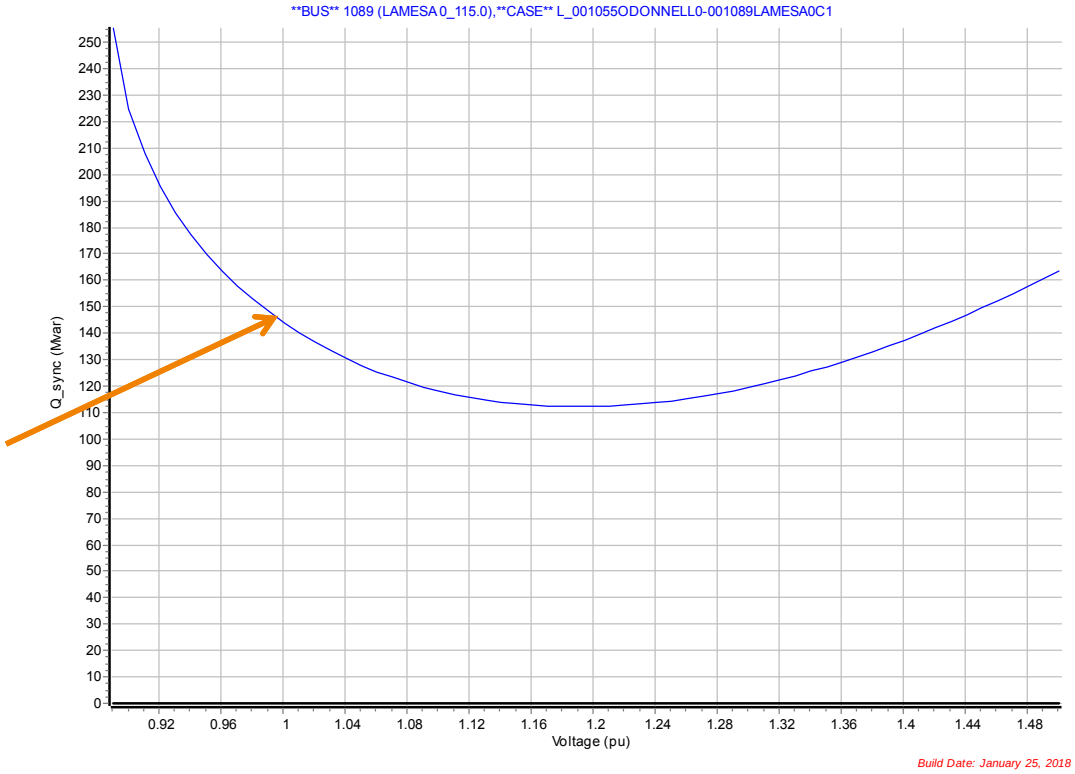


Summary

- Numerous thermal violations (ATC) caused by new interconnection at 200 MW
- Voltage margins also decrease significantly at 200 MW
- Major transmission upgrades likely needed to support this interconnection

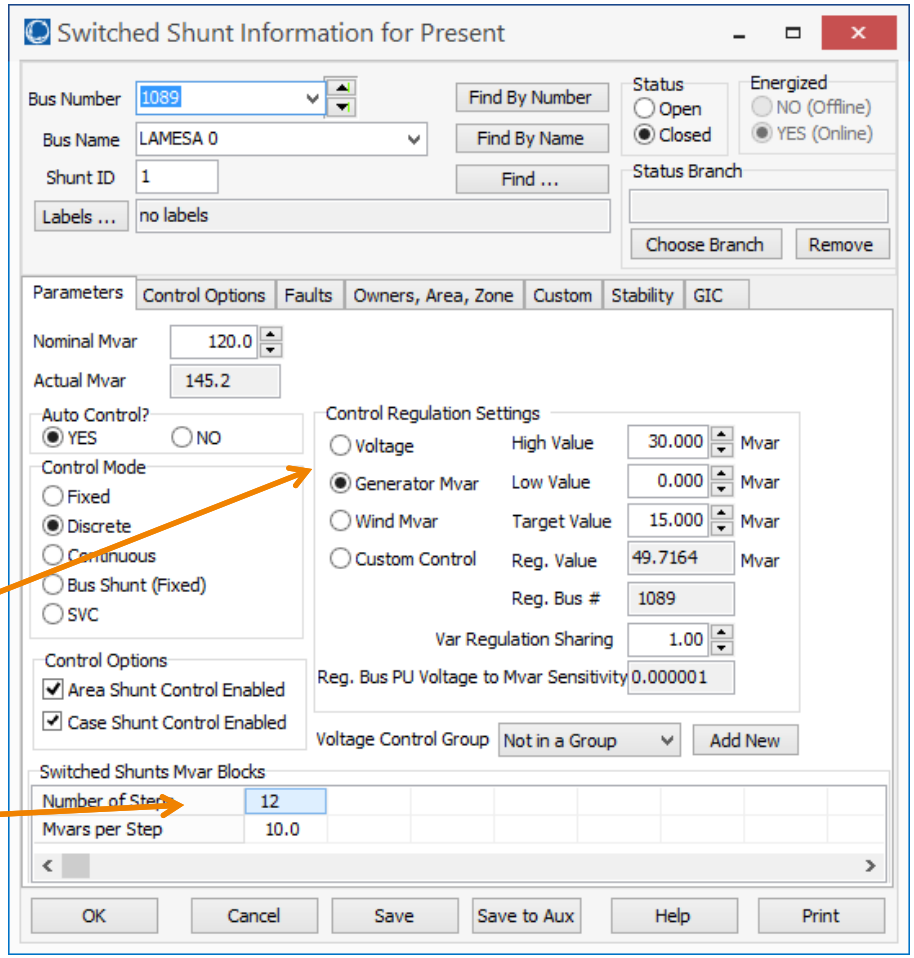
Optional Integrated QV Analysis

- Click “Launch QV curve tool…” button to run the QV analysis at Lamesa 115 kV bus
- QV curve for outage of O Donnell – Lamesa 115 kV line at 338 MW (base case nose)
  - Negative dV/dQ at 1.0 pu voltage!
  - Cannot support this transfer without transmission upgrades

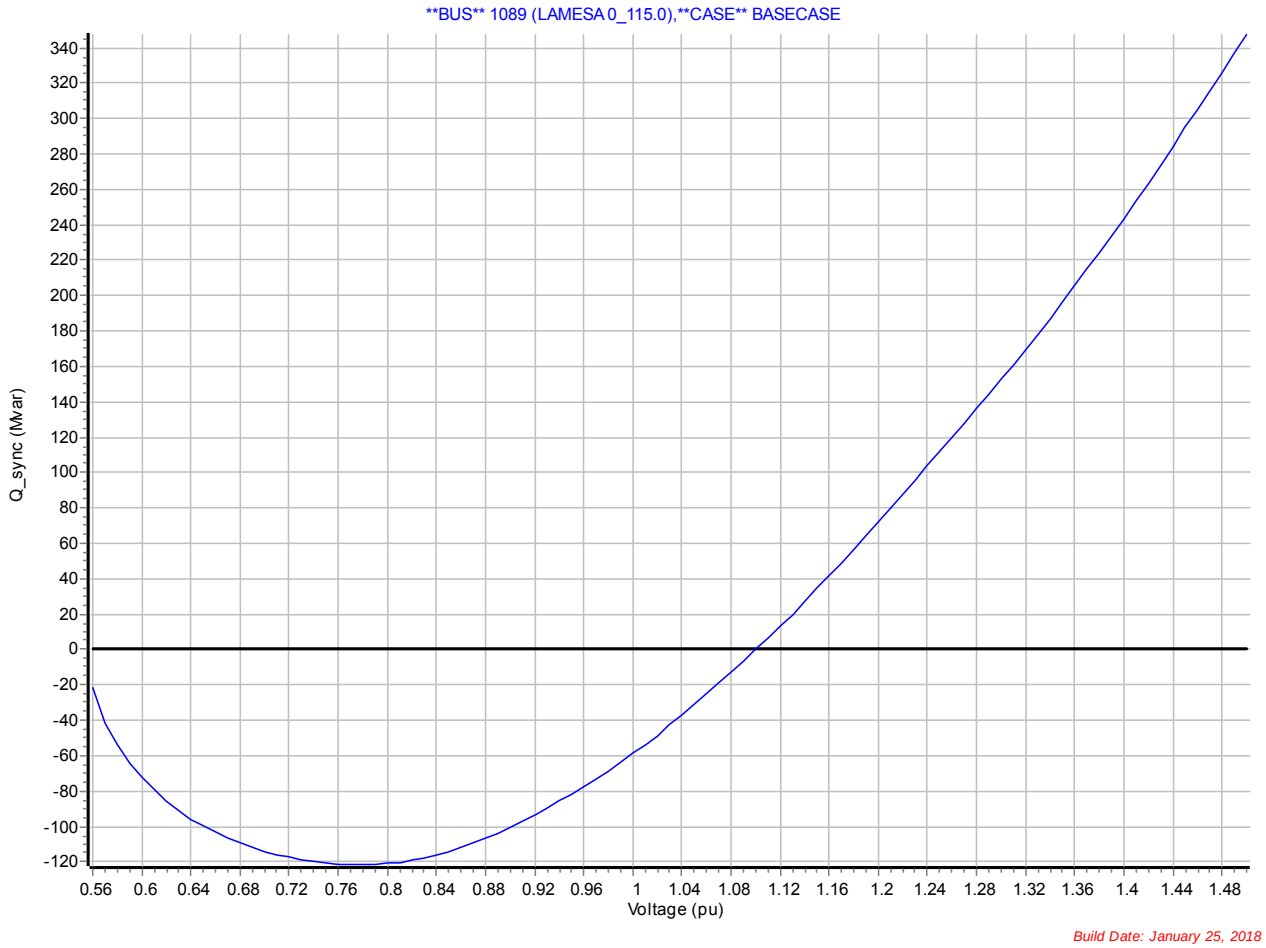


Repeat QV at 200 MW

- Choose “Start Over” from PV Analysis
- Set Generator to regulate to 1.1 pu for better voltage support
- Add 120 Mvar Switched Shunt capacity
  - Regulate Generator Mvar between 0 and 30 Mvar
  - 12 steps at 10 Mvar per step

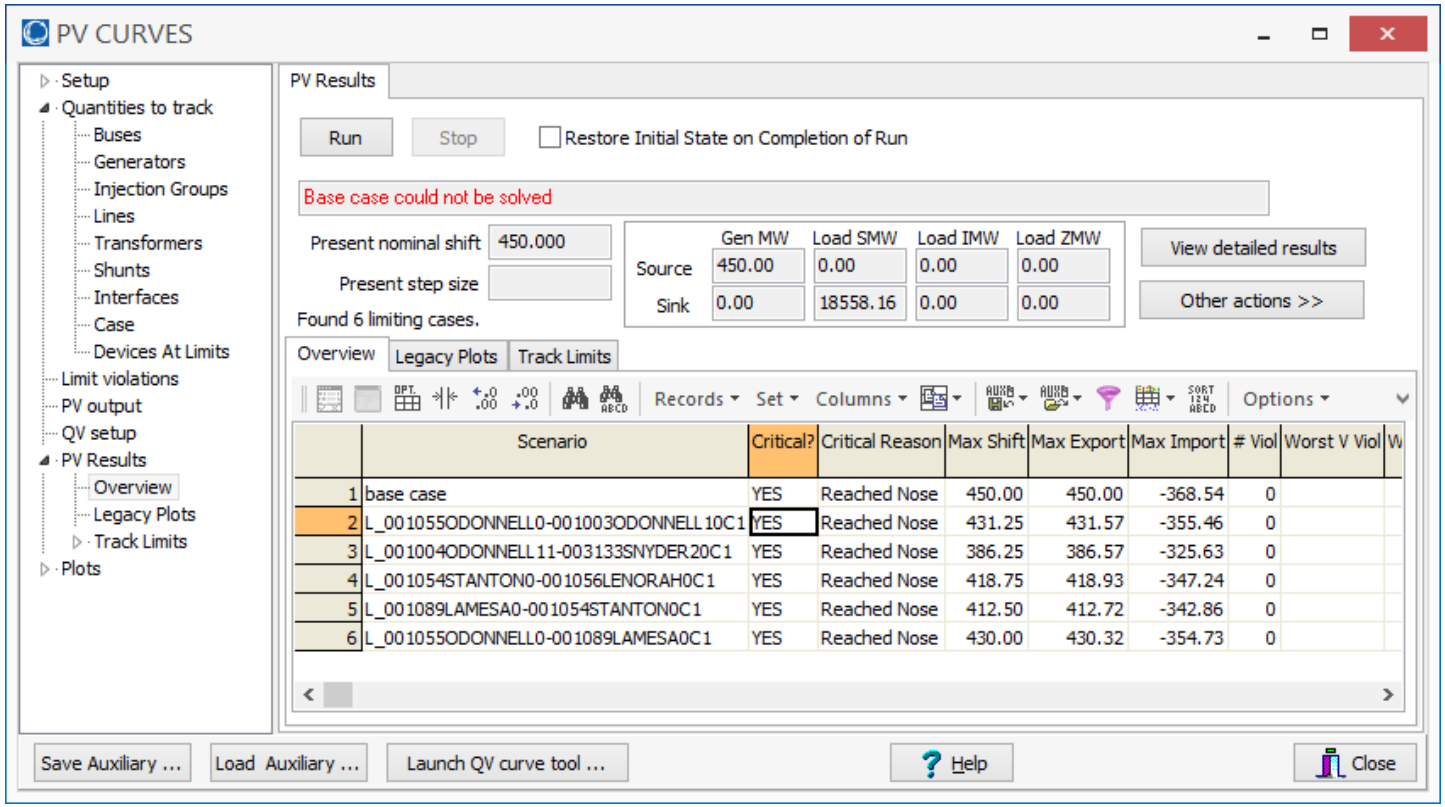


Slight Improvement to QV Margins



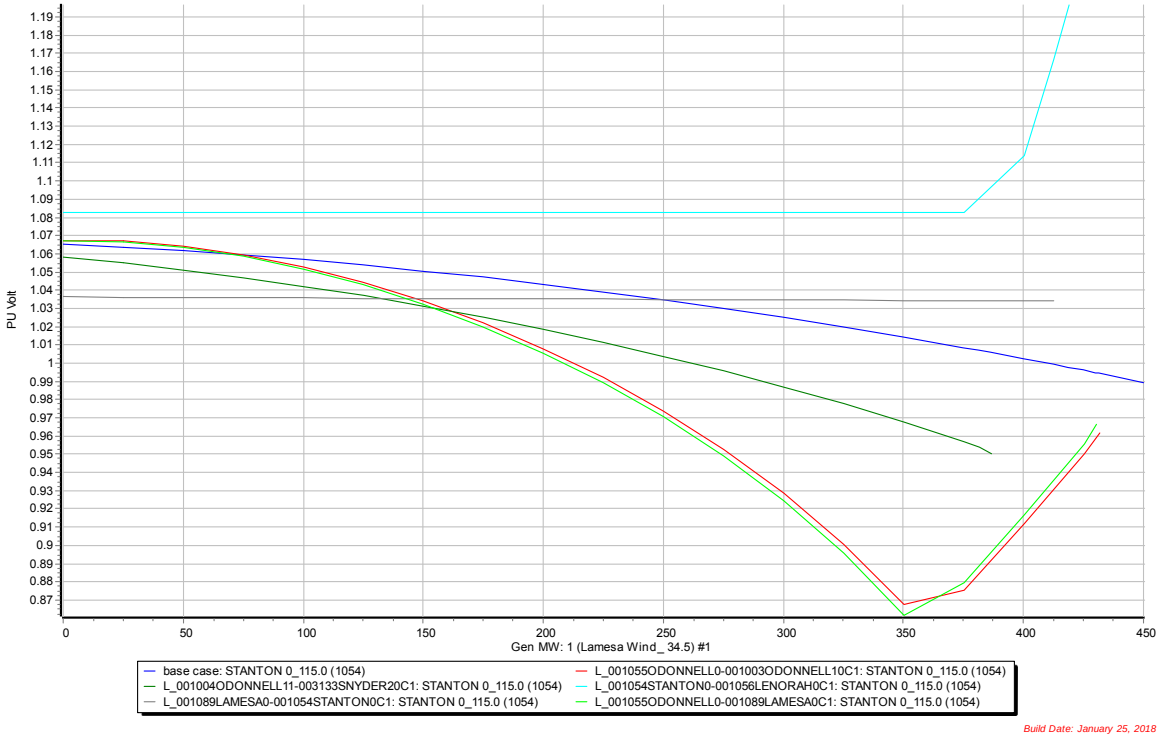
PV Analysis with Modifications

- Transfer capacity is improved for base case and all contingencies



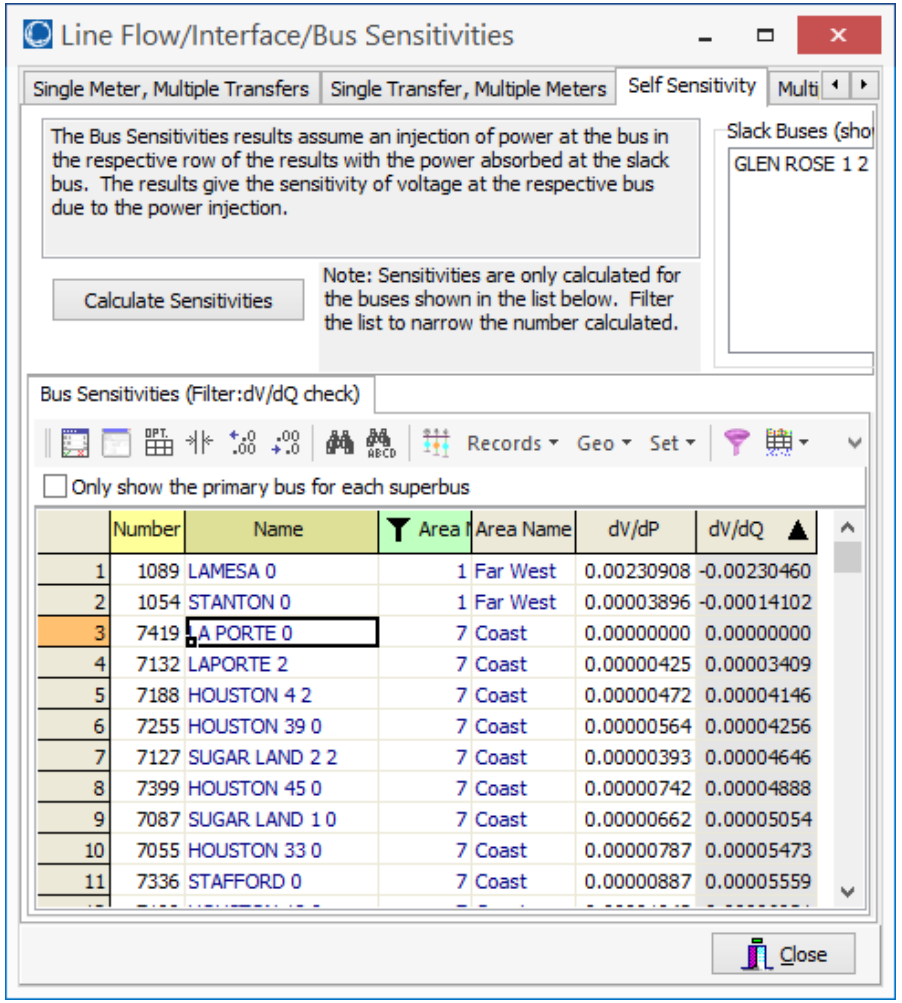
PV Analysis with Modifications

- dV/dQ appears negative near PV margin!
- Transmission upgrades still needed



dV/dQ Sensitivities

- 400 MW transfer
- O DONNELL 0 – O DONNELL 1 0, 115 kV out of service
- Negative dV/dQ at Lamesa and Stanton



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