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Table 4.2-5
Summary of Single Circuit Contingencies from the Export 3000 MW Case With a Mismatch Greater Than One Before Any Upgrades

Ref. No.	Contingency Name	Contingency Description
1	MLAK_FRY_TRI	OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3102 [TYLERGND_5 345.00] CKT 1
2	MLAKE-SHAM	OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3103 [SHAMBRGR_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3103 [SHAMBRGR_5 345.00] TO BUS 3104 [SHAMBRGR_8 138.00] CKT 1
3	ML-EL_TG-TRI	OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3102 [TYLERGND_5 345.00] TO BUS 2432 [TRICRN1_5 345.00] CKT 1
4	RICHLND-TDAD	OPEN BRANCH FROM BUS 3123 [TRINDAD1_5 345.00] TO BUS 3133 [RICHLND2_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3124 [TRINDAD2_5 345.00] TO BUS 3134 [RICHLND1_5 345.00] CKT 1
5	SHAM-ROY-TY1	OPEN BRANCH FROM BUS 3103 [SHAMBRGR_5 345.00] TO BUS 2478 [ROYSE_S5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3104 [SHAMBRGR_8 138.00] TO BUS 3201 [LINDALE_8 138.00] CKT 1
6	TDAD-TRICORN	OPEN BRANCH FROM BUS 3123 [TRINDAD1_5 345.00] TO BUS 2427 [WATMLL_W5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3124 [TRINDAD2_5 345.00] TO BUS 2432 [TRICRN1_5 345.00] CKT 1
7	TLRG-ELK-FRN	OPEN BRANCH FROM BUS 3102 [TYLERGND_5 345.00] TO BUS 2432 [TRICRN1_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3105 [ELKTON_5 345.00] TO BUS 2437 [FRNY1_5 345.00] CKT 1
8	SOUTHCR2	OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 9997 [RUSKSS_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 9997 [RUSKSS_5 345.00] CKT 2
9	SOUTHCR6	OPEN BRANCH FROM BUS 9997 [RUSKSS_5 345.00] TO BUS 3109 [STRYKER_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 9997 [RUSKSS_5 345.00] TO BUS 3124 [TRINDAD2_5 345.00] CKT 1
10	FNYELK_TRISE	OPEN BRANCH FROM BUS 2437 [FRNY1_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 2432 [TRICRN1_5 345.00] TO BUS 2433 [SGVLSW1_5 345.00] CKT 1
11	FNY-ELKSEAG	OPEN BRANCH FROM BUS 2437 [FRNY1_5 345.00] TO BUS 2433 [SGVLSW1_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 2437 [FRNY1_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
12	FNY-ELKTRI	OPEN BRANCH FROM BUS 2437 [FRNY1_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 2437 [FRNY1_5 345.00] TO BUS 2433 [SGVLSW1_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 2433 [SGVLSW1_5 345.00] TO BUS 2432 [TRICRN1_5 345.00] CKT 1
13	BB-RICHLAND	OPEN BRANCH FROM BUS 3380 [BIGBRN__5 345.00] TO BUS 3134 [RICHLND1_5 345.00] CKT 1
		OPEN BRANCH FROM BUS 3380 [BIGBRN__5 345.00] TO BUS 3133 [RICHLND2_5 345.00] CKT 1
14	OVRLOD 2	OPEN LINE FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3103 [SHAMBRGR_5 345.00] CKT 1
15	OVRLOD 6	OPEN LINE FROM BUS 2478 [ROYSE_S5 345.00] TO BUS 3103 [SHAMBRGR_5 345.00] CKT 1
16	OVRLOD 7	OPEN LINE FROM BUS 3109 [STRYKER_5 345.00] TO BUS 3123 [TRINDAD1_5 345.00] CKT 1
17	OVRLOD 8	OPEN LINE FROM BUS 2437 [FRNY1_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
18	OVRLOD 9	OPEN LINE FROM BUS 2432 [TRICRN1_5 345.00] TO BUS 3102 [TYLERGND_5 345.00] CKT 1
19	OVRLOD 10	OPEN LINE FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3102 [TYLERGND_5 345.00] CKT 1
20	OVRLOD 11	OPEN LINE FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1
21	OVRLOD 13	OPEN LINE FROM BUS 3109 [STRYKER_5 345.00] TO BUS 3110 [STRYKER_8 138.00] TO BUS 3115 [STRYKER_3 13.200] CKT 1
22	OVRLOD 68	OPEN LINE FROM BUS 3109 [STRYKER_5 345.00] TO BUS 3117 [LUFKNSS_5 345.00] CKT 1
23	OVRLOD 85	OPEN LINE FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3301 [GRESHRD_POI 138.00] CKT 1
24	OVRLOD 216	OPEN LINE FROM BUS 3106 [ELKTON_8 138.00] TO BUS 3251 [FLINTSUB_8 138.00] CKT 1
25	OVRLOD 1913	OPEN LINE FROM BUS 3105 [ELKTON_5 345.00] TO BUS 3106 [ELKTON_8 138.00] TO BUS 29150 [ELKTON_3 13.200] CKT 1
26	OVRLOD 2037	OPEN LINE FROM BUS 3123 [TRINDAD1_5 345.00] TO BUS 3133 [RICHLND2_5 345.00] CKT 1
27	OVRLOD 2077	OPEN LINE FROM BUS 3124 [TRINDAD2_5 345.00] TO BUS 3134 [RICHLND1_5 345.00] CKT 1
28	UNIT 120041	REMOVE UNIT L1 FROM BUS 120041 [MLSES_UNIT1 20.000]
29	UNIT 120042	REMOVE UNIT L2 FROM BUS 120042 [MLSES_UNIT2 20.000]
30	UNIT 150111	REMOVE UNIT U1 FROM BUS 150111 [CPSES_UNIT1 22.000]
31	UNIT 150112	REMOVE UNIT U2 FROM BUS 150112 [CPSES_UNIT2 22.000]

Table 4.2-6 lists the transmission lines and transformer upgrades selected for the Export 3000 MW case. These upgrades eliminated the thermal overloads and allowed all the contingencies to solve except for the SouthCR2 contingency.

Table 4.2-6
Transmission Lines and Transformer Upgrades
Selected for the Export 3000 MW Case

Ref. No.	To	To Bus	From	From Bus	kV	CK	MVA	R (p.u.)	X (p.u.)	B (p.u.)	Length (miles)	New or Upgraded
1	3117	Lufkin Switch	3119	Nacogdoches SE	345	1	1631	0.00074	0.00970	0.23455	23	New
2	3100	Martin Lake	3109	Stryker	345	1	1631	0.00132	0.01729	0.41811	41	New
3	3100	Martin Lake	2461	Royse North	345	1	1631	0.00401	0.05228	1.26451	124	New
4	9991	RUSKSS_5	3109	Stryker	345	1	1912	0.00076	0.00969	0.23863	23.4	Upgraded
5	3100	Martin Lake	9991	RUSKSS_5	345	1	1912	0.00057	0.00738	0.17846	17.5	Upgraded
6	3100	Martin Lake	9991	RUSKSS_5	345	2	1912	0 00057	0.00738	0.17846	17.5	Upgraded
7	2370	COLLINSS1_8	2372	COLLINSS1_5	138/345	2	Rating A =700 MVA Rating B, C = 750 MVA					New

1 The units for these values are in (p.u./mile) not in (p.u.) as the rest of the impedance values in this table.

The double circuit contingency that would not solve for the 3000 MW Export case was the "SouthCR2" contingency, which is the loss of the Martin Lake to Rusk 345 kV double-circuit line. This same contingency was difficult to solve in the 1500 MW Export case. To solve this contingency it was necessary to model a 400 MVar continuously controlled shunt capacitor at the converter station in addition to the 1600 MVar of HVDC filters. This allowed the case to solve and no thermal or voltage violations were observed.

Refer to Table C-11 and Table C-16 in Appendix C for the list of loading violations and voltage violations, before implementing SPS or manual switching operations for the Export 3000 MW case for the "Special Contingencies," the Single Circuit Area 1 Contingencies, and the single and double circuit contingencies out of Rusk County Switching Station 345 kV.

4.2.4 Rusk to HVDC transmission lines

While the Rusk to HVDC Converter station transmission lines are not owned by Oncor, steady-state and stability analysis was performed on those lines to address any issues that may impact those lines or the transmission grid because of issues with the double-circuit line between Rusk County Switch and the HVDC Converter station.

The 1500 MW and 3000 MW Import and Export cases were examined with one of the two lines connecting the Rusk Switch to the HVDC converter station removed from service and the thermal loading on the remaining line and the voltages in the immediate area monitored for any possible problems. The cases used for this portion of the study contained all upgrades recommended in the original 1500 MW and 3000 MW analysis.

Table 4.2.7 lists the thermal loading observed on the remaining Rusk to HVDC converter station line with the other line out of service based on a 1631 MVA rating. As the table shows, when one line is removed from service there is the potential for the second line to overload. There were no other thermal overloads observed in the rest of the ONCOR system.

Table 4.2.7
Thermal Loading for Base and N-1 Conditions

Ref. No.	Case	Rate A/B (MVA)	Flow (%)	
			Base	N-1
1	Import 1500 MW	1631	46	90
2	Import 3000 MW	1631	93	195
3	Export 1500 MW	1631	48	103
4	Export 3000 MW	1631	97	186

Neither the Import nor Export 1500 MW cases had voltage violations for the N-1 or N-2 contingencies of the lines connecting Rusk 345 kV to the HVDC converter station.

The Import 3000 MW case had low voltage violations around Rusk and down to the Nacogdoches and Dibol/Lufkin areas during the N-1 contingencies. These low voltage violations were eliminated when the shunt capacitor at Rusk was increased to 600 Mvar and both 16.2 Mvar steps at Diboll were turned on. The only low voltage violation that remained was at the HVDC converter bus with its voltage being 0.55 p.u. The power flowing through the HVDC converter was 1649 MW after the capacitor adjustments were incorporated.

The Import 3000 MW case also had some high voltage violations during N-2 contingencies around Rusk and the 345 kV buses nearby. The high voltage violations were eliminated if the 400 Mvar, 345 kV capacitors at Rusk, the 240 Mvar, 345 kV capacitors at Shamburger, and the 160 Mvar, 345 kV capacitors at Tyler Grande were taken offline following the N-2 contingency.

The Export 3000 MW case during the N-1 contingencies did not have any voltage violations in the ERCOT system but the power flowing across the HVDC converter was reduced from 3000 MW to 2142 MW. The bus voltage at the HVDC bus decreased to 0.75 p.u. for the N-1 contingency.

The Export 3000 MW case had high voltage violations during the N-2 contingency that were eliminated when the shunt capacitor at Rusk was decreased to 450 Mvar.

4.2.5 Summary

The only thermal violation for the Export Benchmark and 1500 MW cases was the Gresham Road POI – Gresham Road Switch 138 kV line at just over 100%. This violation is caused because the MW output of the NACPW_ UNIT1 being set to 100 MW which is also the Pmax for this unit. Decreasing this generator below its Pmax rating eliminates this thermal violation for the Export Benchmark case.

The voltage violations observed for the Export Benchmark and 1500 MW cases were eliminated using SPS and manual switching operations such as switching bus tie breakers, turning on/off shunt capacitor banks, or changing transformer tap ratios.

One double circuit contingency would not solve for the 1500 MW or 3000 MW Export cases. This was the "SOUTHCR2" contingency, which is the loss of the Martin Lake to Rusk 345 kV double-circuit line. The case did not diverge but the solution was outside the mismatch tolerance.

To solve this contingency for the 1500 MW Export case a 200 MVar continuously controlled shunt capacitor was modeled at the converter station in addition to the 1600 MVar of HVDC filters. This allowed the case to solve and no thermal or voltage violations were observed.

When the Export 3000 MW base case was examined for the steady state contingency analysis only one thermal violation was observed, however several of the single and double circuit contingencies did not converge. These contingencies were examined and then upgrades were incorporated into the 3000 MW Export case to eliminate violations and help the cases converge. The upgrades listed in Table 4.2-8 for the 3000 MW Export case eliminated the thermal overloads and allowed all the contingencies to solve except for the SOUTHCR2 contingency.

To solve this contingency, SOUTHCR2, for the 3000 MW Export case it was necessary to model a 400 MVar continuously controlled shunt capacitor at the converter station in addition to the 1600 MVar of HVDC filters. This allowed the case to solve and no thermal or voltage violations were observed.

Table 4.2-8
Summary of Transmission Lines and Transformer Upgrades Selected for the Export 3000 MW Case

Ref. No.	Transmission Lines and Equipment	kV	CKT	Base Case[1] (MVA)	Length (miles)	New MVA Ratings for Transmisison Lines and Equipment for Export 3000 MW Case (MVA)[2]	New or Upgraded
1	Lufkin Switch to Nacogdoches SE (3117-3119)	345	1	N/A	23	1631	New
2	Martin Lake to Royse North (3100-2461)	345	1	N/A	124	1631	New
3	Martin Lake to Stryker (3100-3109)	345	1	1631[3]	41	1631	New
4	Rusk to Stryker (9997-3109)	345	1	1631	23.4	1912	Upgraded
5	Rusk to Martin Lake (9997-3100)	345	1	1631	17.5	1912	Upgraded
6	Rusk to Martin Lake (9997-3100)	345	2	1631	17.5	1912	Upgraded
7	Collin S.E.S. Auto Transformer	345/138	2	N/A	N/A	Rating A = 700 MVA, Rating B,C = 750 MVA	New

1 The Base Case (MVA) column shows either the current MVA rating for the transmission lines/transformer as modeled in the base cases or a N/A indicating that the branch does not exist in the base case and was selected as a new branch in certain cases.
2 The values provided in these column are the suggested MVA rating for the transmission lines/transformer to eliminate thermal loading violations during contingencies. If the cell contains a "-" then that line was not required to be upgraded/built for that case.
3 This line already exists in the Benchmark case before Rusk is modeled once Rusk is modeled in the 1500 MW and 3000 MW cases this line becomes Martin Lake to Rusk and Rusk to Stryker Creek The Martin Lake to Stryker Creek 345 kV was modeled in the Import 3000 MW case.

5.0 CONCLUSIONS FOR STEADY STATE ANALYSIS

5.1 Background and Objective

The objective of this analysis is to identify any system upgrades that would be required to maintain system reliability for the benchmark case and when importing or exporting 1500 MW or 3000 MW through the HVDC tie.

5.2 Approach

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 32.1.1 was used for this study. The thermal and voltage violations observed for the contingencies simulated were examined and upgrades were selected to eliminate the violations. Each case had upgrades selected to eliminate the thermal and voltage violations for that configuration. The upgraded Benchmark, 1500 MW and 3000 MW Import and Export cases were then used for the Transient Stability Analysis.

5.2.1 Metrics

The following metrics were used to flag thermal and voltage violations for the Steady State Contingency Analysis:

- Thermal Loading Violations: Any loading of branches and transformers greater than 100% of Rate B were flagged.
- Voltage Violations:
  - The 138 kV through 345 kV buses were flagged if the voltage was less than 0.95 p.u. or greater than 1.05 p.u.
  - The 69 kV buses were flagged if the voltages was less than 0.94 p.u. or greater than 1.05 p.u.
  - Voltage violations were also flagged if the bus voltage deviated by 5% (0.05 p.u.)

5.2.2 Contingency Descriptions

The contingencies examined for this analysis are listed below:

- All "Special Contingencies" in the Southerncrossbasic.con file which consisted of double-circuit lines sharing structures for more than ½ mile in the Oncor area, as well as other non-standard contingencies seen in the NERC Category B list.
- All Single-Circuit Contingencies in Area 1 examining branch, transformer, and generator outages
- All single-circuits out of Rusk County Switch 345 kV station
- All double-circuit contingencies out of Rusk County Switch, Stryker Creek, and Martin Lake 345 kV stations

Appendix A contains the complete lists of contingencies examined for the Steady State Contingency Analysis.

Note: Since the Rusk County Switch 345 kV station is not modeled in the Import or Export Benchmark Cases the single and double-circuit contingencies from Rusk County Switch station could not be simulated for the benchmark cases.

5.3 Conclusions for the Steady State Contingency Analysis

Table 5.4.-1 shows a summary of the new and upgraded transmission lines and transformers that were added to eliminate the thermal violations in Oncor Zones 130 through 148 for 345 kV to 69 kV buses for the Benchmark, 1500 MW, and 3000 MW Import and Export case.

There were some system voltage issues when contingencies of the double-circuit line between Rusk County Switch and the HVDC converter station were evaluated in the 3000 MW cases. However, the voltage issues were resolved with the existing capacitors or recommended capacitors installed due to this study.

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Table 5.4-1
Summary of New/Upgraded Equipment Examined to Eliminate the Thermal Violations

Ref. No	Transmission Line and Equipment	kV	Ckt	Length	Existing (MVA)	MVA Ratings for Upgraded Transmission Lines and Equipment [1] — IMPORT Benchmark (MVA)	IMPORT 1500 MW (MVA)	IMPORT 3000 MW (MVA)	EXPORT Benchmark (MVA)	EXPORT 1500 MW (MVA)	EXPORT 3000 MW (MVA)
1	Lufkin Switch - Nacogdoches SE	**345**	1	23	**NEW**	1631	1631	1631	-	-	1631
2	Martin Lake - Royse North	**345**	1	124	**NEW**	1631	1631	1631	-	-	1631
3	Martin Lake - Stryker Creek [2]	**345**	1	41	1631	-	-	1631	-	-	1631
4	Martin Lake - Navarro	**345**	1	130	**NEW**	-	-	1631	-	-	-
5	Martin Lake - Navarro	**345**	2	130	**NEW**	-	-	1631	-	-	-
6	Trinidad - Stryker Creek	**345**	1	68.6	1072	-	-	1631	-	-	-
7	Rusk - Trinidad	**345**	1	92	1072	-	-	1631	-	-	-
8	Rusk - Stryker Creek	**345**	1	23.4	1631	-	-	2390	-	-	1912
9	Rusk - Martin Lake	**345**	1	17.5	1631	-	-	-	-	-	1912
10	Rusk - Martin Lake	**345**	2	17.5	1631	-	-	-	-	-	1912
11	Tyler Grande - Tyler GE	**138**	1	1	326	-	484	484	-	-	-
12	Dialville - Neches Pump	**138**	1	15.5	214	-	-	326	-	-	-
13	Palestine South - Neches Pump	**138**	1	9.5	214	-	-	326	-	-	-
14	Trinidad - Malakoff	**138**	1	8.1	251	-	-	326	-	-	-
15	Forest Grove - Mabank Tap	**138**	1	3.7	251	-	-	326	-	-	-
16	Malakoff - Mabank Tap	**138**	1	3.7	251	-	-	326	-	-	-
17	Elkton - Tyler Southwest	**138**	1	5	214	326	326	326	-	-	-
18	Plano Tennyson - Preston Meadows	**138**	1	1	287	484	484	484	-	-	-
19	Flint - Jacksonville Switch	**138**	1	10.4	249	-	-	326	-	-	-
20	Collin - Northwest Carrollton (multiple branches)	**138**	1	17	-	326	326	326	-	-	-
	Elkton Switch Capacitors	**345**			**NEW**	-	-	320 MVar	-	240 MVar	320 MVar
	Rusk Switch Capacitors	**345**			**NEW**	-	400 MVar	560 MVar	-	400 MVar	1000 MVar
	Martin Lake Capacitors	**345**			**NEW**	-	-	240 MVar	-	-	240 MVar
	Nacogdoches Capacitors	**345**			**NEW**	-	-	-	-	-	240 MVar
	Murphy Capacitors	**138**			**NEW**	80 MVar	80 MVar	80 MVar	-	-	-
	Collin Switch 345/138 Autotransformer	**345/138**	2		**NEW**	750 MVA Autotransformer			750 MVA Autotransformer		
	Collin (series reactor for Autotransformer #2)	**345**			**NEW**	2 -ohm	2 -ohm	2 -ohm	-	-	-

<u>Notes</u>

1 - Values provided in columns are the upgraded MVA rating for the transmission lines and equipment to eliminate thermal loading violations during contingency. Cells with '_' require no upgrades.

2 - This line currently exists, before construction of the Rusk Switch. In the 1500 MW and 3000 MW cases this line becomes Martin Lake - Rusk and Rusk – Stryker Creek (Ref. Nos. 8 and 9)

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STABILITY ANALYSIS

6.0 OBJECTIVE

After performing the Steady State analysis of the impacts of the Southern Cross HVDC tie, a Transient Stability analysis was performed to determine the impact on the stability of the ONCOR System. The objective of the Transient Stability Analysis was to examine selected contingencies in the ONCOR area and evaluate the effect of the HVDC Tie on the system's ability to maintain acceptable voltages and the ability of existing generation to maintain stability and remain connected to the system.

7.0 BACKGROUND

A Steady State contingency analysis was performed prior to conducting the Transient Stability Analysis for the HVDC Tie. The objective was to identify system upgrades that would be required to maintain system reliability for the benchmark case and when importing or exporting 1500 MW or 3000 MW through the HVDC Tie. Upgrades were selected to eliminate the violations. Each case had upgrades selected to eliminate the thermal and voltage violations for that configuration. The upgraded Benchmark, 1500 MW and 3000 MW Import and Export cases were then used for the Transient Stability Analysis.

7.1 Base Case System Conditions

The original 1500 and 3000 MW Import and Export power flow cases had the HVDC system modeled as a generator. The generator absorbed or produced 1500 MW of power to achieve the Export and Import, respectively. The reactive limits of the generators were fixed at 0 MVars. To achieve the 3000 MW Export and Import cases the generator absorbed or produced 3000 MW of power, respectively. For the 3000 MW Export case the generator was supplying 500 MVars. For the 3000 MW Import case the generator was supplying 318.8 MVar. The equivalent generator was replaced with the PSSE two-terminal HVDC model using parameters provided by Southern Cross Transmission LLC . The Collin 345/138 kV #2 Autotransformer was added to all the cases since it is already a planned upgrade to the Oncor system. The shunt capacitor banks listed in Table 7.1-1 were added to the power flows to allow them to solve while importing or exporting 3000 MW of power.

Table 7.1-1
List of Additional Switched Shunt Capacitor Banks Added to the Import and Export 3000 MW Cases

Ref. No.	Bus Number	Bus Name	kV	Import 3000 MW		Export 3000 MW	
				Original Value*	New Value	Original Value*	New Value
				MVAR		MVAR	
1	3105	ELKTON 5	345	240	320	240	320
2	9997	RUSKSS 5	345	240	560	400	1000
3	3100	MLAKE	345	-	240	-	240
4	3119	Nacogdoches	345	-	-	-	240

Table 7.1-2 and 7.3-3 lists the model parameters and filter bank sizes used for the HVDC model in PSSE for the Import and Export cases, respectively.

Table 7.1-2
Model Parameters for the HVDC Model in PSSE for the Import Cases

Ref. No.	PSSE 2-Term DC Parameters	Import 1500 MW Case		Import 3000 MW Case	
		Rectifier	Inverter	Rectifier	Inverter
1	Max firing angle (degree)	17	20	17	20
2	Min firing angle (degree)	13	17	13	17
3	Bridges in Series	2	2	2	2
4	Primary base (kV)	500	345	500	345
5	Commutating Resistance (Ohms)	0	0	0	0
6	Commutating Reactance (Ohms)	6.837	6.837	6.837	6.837
7	Transformer Ratio (p.u.)	0.425	0.55	0.425	0.553
8	Tap Setting (p.u.)	1.0625	1	0.9875	0.9625
9	Max Tap Setting (p.u.)	1.1	1.1	1.1	1.1
10	Min Tap Setting (p.u.)	0.9	0.9	0.9	0.9
11	Tap Step (p.u.)	0.0125	0.0125	0.0125	0.0125
12	Setval (amps or p.u.)	1533.5	1533.5	3141	3141
13	Filter (Mvar)	750	650	1600	1600

Table 7.1-3
Model Parameters for the HVDC Model in PSSE for the Export Cases

Ref. No.	PSSE 2-Term DC Parameters	Export 1500 MW Case		Export 3000 MW Case	
		Rectifier	Inverter	Rectifier	Inverter
1	Max firing angle (degree)	17	20	17	20
2	Min firing angle (degree)	13	17	13	17
3	Bridges in Series	2	2	2	2
4	Primary base (kV)	345	500	345	500
5	Commutating Resistance (Ohms)	0	0	0	0
6	Commutating Reactance (Ohms)	6.837	6.837	6.837	6.837
7	Transformer Ratio (p.u.)	0.594	0.408	0.577	0.4
8	Tap Setting (p.u.)	1.0625	1.0375	0.9625	1
9	Max Tap Setting (p.u.)	1.1	1.1	1.1	1.1
10	Min Tap Setting (p.u.)	0.9	0.9	0.9	0.9
11	Tap Step (p.u.)	0.0125	0.0125	0.0125	0.0125
12	Setval (amps or p.u.)	1533	1533	3142	3142
13	Filter (Mvar)	750	750	1800	1600

8.0 APPROACH FOR THE TRANSIENT STABILITY ANALYSIS

8.1 Dynamics Case Development

The Siemens Power Technologies, Inc. Power System Simulation Program for Engineers (PSS/E) Version 32.1.1 was used for this study. Table 8.1-1 summarizes the Oncor area and total ERCOT power flow conditions for the Import cases after adding the upgrades identified in the Steady State Contingency Analysis compared to the power flow conditions after the cases were converted for dynamics using the ERCOT/ONCOR dynamic setup.

Table 8.1-1
2015 Summer Import Cases Before and After being Converted for Dynamics

Case	Before or After Converting	Upgrades	Units	From Generation	To Load Area Buses	To Bus Shunt	To GNE Bus Devices	To Line Shunt	From Charging	To Loses	Net Interchange		Desired Net Int
											To Tie Lines	To Tie + Lines	
Import Benchmark	Base Case Before Converting	Area 1	MW	29403.2	24466.7	0	0	0	0	650.9	4285.6	4285.6	0
		ONCOR	MVAR	1664.9	7049.1	-8571	0	0	6668.1	9534.1	320.3	320.3	
		Total	MW	79296.4	77679.2	0	0	0	0	1617.2	0	0	0
		Areas	MVAR	9943.2	19879.4	-16190	0	-1	17466.9	23721.8	0	0	
	Final Converted case	Area 1	MW	29436.9	24466.7	0	0	0	0	654.1	4316.1	4316.1	0
		ONCOR	MVAR	1018	7049.1	-8785	0	0	6888	9541.5	100.6	100.6	
		Total	MW	78344.7	76709.3	0	0	0	0	1635.4	0	0	0
		Areas	MVAR	9130.2	19794.7	-16621	0	-1	17898.5	23856	0	0	
Import 1500 MW	Base Case Before Converting	Area 1	MW	30203.2	24466.7	0	0	0	0	830.4	4906.1	4906.1	0
		ONCOR	MVAR	2771.3	7049.1	-10183	0	0	6766.2	12421.8	250.1	250.1	
		Total	MW	79488	77679.2	0	0	0	0	1808.8	0	0	0
		Areas	MVAR	11224.7	19879.4	-17855	0	-1	17561.7	26762.6	0	0	
	Final Converted case	Area 1	MW	30236.9	24466.7	0	0	0	0	833.6	4936.6	4936.6	0
		ONCOR	MVAR	2173.8	7049.1	-10339	0	0	6977.7	12465.4	-23.5	-23.5	
		Total	MW	78089.8	76249.2	0	0	0	0	1840.5	0	0	0
		Areas	MVAR	11064.4	19635.2	-18032	0	-1	17690.3	27153.3	0	0	
Import 3000 MW	Base Case Before Converting	Area 1	MW	30966	24466.7	0	0	0	0	1118.6	5380.8	5380.8	0
		ONCOR	MVAR	3375.1	7049.1	-13452	0	0	7138.5	16485.3	433.1	433.1	
		Total	MW	79785.7	77679.2	0	0	0	0	2106.5	0	0	0
		Areas	MVAR	11720.5	19879.4	-21113	0	-1	17950.8	30908.4	0	0	
	Final Converted case	Area 1	MW	31001.6	24466.7	0	0	0	0	1123.4	5411.5	5411.5	0
		ONCOR	MVAR	2729.5	7049.1	-13743	0	0	7341.8	16589.6	176	176	
		Total	MW	78389.4	76249.1	0	0	0	0	2140.3	0	0	0
		Areas	MVAR	11497.1	19635.2	-21426	0	-1	18056.9	31346.8	0	0	

Table 8.1-2 summarizes the Oncor area and total ERCOT power flow conditions for the Export cases after adding the upgrades identified in the Steady State Contingency Analysis compared to the power flow conditions after the cases were converted for dynamics using the ERCOT/ONCOR dynamic setup.

ONCOR

Table 8.1-2
2015 Summer Export Cases Before and After being Converted for Dynamics

Case	Before or After Converting	Upgrades	Units	From Generation	To Load Area Buses	To Bus Shunt	To GNE Bus Devices	To Line Shunt	From Charging	To Loses	Net Interchange		Desired Net Int
											To Tie Lines	To Tie + Lines	
Export Benchmark	Base Case Before Converting	Area 1 ONCOR	MW	11981.2	9508	0	0	0	0	249.7	2223.5	2223.5	0
			MVAR	924.9	2739.3	1510.9	0	0	6506.2	3458	-277.1	-277.1	
		Total Areas	MW	32678.2	31848.5	0	0	0	0	829.7	0	0	0
			MVAR	3400.9	7772.3	1881.4	0	-1	17328.9	11077 3	0	0	
	Final Converted case	Area 1 ONCOR	MW	8767.5	6291.2	0	0	0	0	252.9	2223.4	2223.4	0
			MVAR	912.9	2670 3	1504.6	0	0	6466.3	3512	-307 7	-307 7	
		Total Areas	MW	23741.1	22893.6	0	0	0	0	847 5	0	0	0
			MVAR	3302.3	7157 9	1834.3	0	0.4	16990.2	11299.9	0	0	
Export 1500 MW	Base Case Before Converting	Area 1 ONCOR	MW	11111.8	9508	0	0	0	0	305.1	1298.7	1298.7	0
			MVAR	1201.9	2739.3	743.3	0	0	6503	5090.7	-868.6	-868.6	
		Total Areas	MW	32763.1	31848.5	0	0	0	0	914.6	0	0	0
			MVAR	3792.7	7772.3	347.3	0	-1	17443.3	13117 6	0	0	
	Final Converted case	Area 1 ONCOR	MW	7897.5	6291 2	0	0	0	0	307.1	1299 2	1299.2	0
			MVAR	1128.2	2640.4	736.3	0	0	6464.5	5117 6	-900.5	-900.5	
		Total Areas	MW	23812.7	22883	0	0	0	0	929.6	0	0	0
			MVAR	3632 9	7137	299.7	0	0.4	17105.7	13302.7	0	0	
Export 3000 MW	Base Case Before Converting	Area 1 ONCOR	MW	10113.6	9508	0	0	0	0	549 1	56.6	56.6	0
			MVAR	2475.2	2739 3	-600.1	0	0	6692.9	8374 4	-1345.4	-1345 4	
		Total Areas	MW	33068.6	31848.5	0	0	0	0	1220.2	0	0	0
			MVAR	5212 3	7772 3	-2237	0	-1	17611 9	17290.1	0	0	
	Final Converted case	Area 1 ONCOR	MW	6900.3	6291.2	0	0	0	0	552.3	56.8	56.8	0
			MVAR	2385 7	2610 8	-626.5	0	0	6660.1	8467.8	-1405 5	-1405.5	
		Total Areas	MW	24070.8	22841.4	0	0	0	0	1229.3	0	0	0
			MVAR	4790.9	7144.5	-2493	0	0.4	17304.2	17443 4	0	0	

The 3000 MW Export case was difficult to convert for dynamics. The generation and load within the case was modified. Eventually it was necessary to model 2 SVCs to get the case converted for dynamics with acceptable performance. The capacitor dispatch around Rusk was modified and SVCs were modeled at Rusk 345 kV and at the HVDC inverter station. Both the Rusk SVC and the SVC at the inverter station were rated +400/-150 MVar. Table 8.1-3 lists the capacitors that were modified. The table shows the original dispatch for the cases, the dispatch determined by the Steady State Contingency Analysis (used as the starting point for the dynamic analysis), and the final dispatch required to get the case converted for dynamics.

Table 8.1-3
Capacitor Dispatch for the 3000 MW Export Case

Ref. No.	Bus Number	Bus Name	kV	Original Rating (MW)	Final Steady State Rating (MW)	Initial Dynamic Rating (MW)
1	3105	ELKTON_5	345	240	320	240
2	9997	RUSKSS_5	345	400	1000	450
3	3100	MLAKE	345	0	240	0
4	3119	NACOGDSE_5	345	0	240	0
5	9998	HVDCTIE	345	0	1800	2100

When preparing the 1500 MW and 3000 MW Import/Export cases the PSSE two terminal HVDC dynamic model CDC4 was added to the .dyr file using the parameters listed in Table 8.1-4 provided by Southern Cross Transmission LLC .

Table 8.1-4
CDC4 Dynamic Model Parameters Used for the HVDC Tie

CONs	Value	Description
J	5	ALFDY, minimum alpha for dynamics (degrees)
J+1	10	GAMDY, minimum gamma for dynamics (degrees)
J+2	0.01	TVDC, dc voltage transducer time constant (sec)
J+3	0.01	TIDC, dc current transducer time constant (sec)
J+4	0.15	VBLOCK, rectifier ac blocking voltage (p.u.)
J+5	0.9	VUNBL, rectifier ac unblocking voltage (p.u.)
J+6	0.01	TBLOCK, minimum blocking time (sec)
J+7	0	VBYPAS, inverter dc bypassing voltage (kV)
J+8	0.95	VUNBY, inverter ac unbypassing votlage (p.u.)
J+9	0.01	TBYPAS, minimum bypassing time (sec)
J+10	0	RSVOLT, minimum dc voltage following block (kV)
J+11	0	RSCUR, minimum dc current following block (amps)
J+12	3	VRAMP, voltage recovery rate (p.u./sec)
J+13	5	CRAMP, current recovery rate (p.u./sec)
J+14	320	C0, minimum current demand (amps)
J+15	175	V1, voltage limit point 1 (kV)
J+16	1500	C1, Current limit point 1 (amps); ≥C0
J+17	225	V2, voltage limit point 2 (kV)
J+18	3200	C2, current limit point 2 (amps)
J+19	325	V3, voltage limit point 3 (kV)
J+20	3500	C3, current limit point 3 (amps)
J+21	0.01	TCMODE, minimum time stays in switched mode (sec)

8.2 Fault Scenarios

The time domain fault scenarios were simulated with the system initially operating under steady state conditions. At 0.5 seconds, a 3-phase fault was applied and then normally cleared in 4 or 5 cycles. For cases with a stuck circuit breaker, a single-phase fault was applied, after the normal clearing time of 4 cycles one end of the transmission line was opened, it was then assumed that one pole of a circuit breaker sticks on the opposite end of the line resulting in the a single-phase fault that is then cleared by backup clearing 14 cycles after the original fault was applied. The simulation was then run out to 10.0 seconds.

Once the Benchmark, 1500 MW, and 3000 MW Import/Export cases were converted for dynamics a set of 179 contingencies were examined for the Benchmark cases and 192 contingencies were examined for the 1500 MW and 3000 MW cases. The Rusk County Switch 345 kV station was not modeled in the Benchmark case so the single and double circuit contingencies for that station were only examined for the 1500 MW and 3000 MW cases. The contingency list consisted of the following events:

- All single-circuits out of Rusk County Switch 345 kV and the following of particular interest:
  - Martin Lake – Tyler Grande
  - Shamburger – Royse
  - Tyler Grande – Tricorner
  - Martin Lake – Shamburger
  - Martin Lake – Elkton
  - Elkton – Forney
  - Rusk County – Stryker Creek
  - Stryker Creek – Trinidad
  - Rusk County – Trinidad
- All single-circuits in Oncor zones 143 through 147
- All double-circuits in Rusk County Switch, Stryker Creek, and Martin Lake 345 kV stations
- A stuck breaker at Martin Lake, Stryker Creek, and Trinidad (individually)
- Loss of one generating unit at Martin Lake, Stryker Creek, and Trinidad (individually)
- Trip of one Comanche Peak unit
- Loss of the bus with the most load in the DFW Metroplex

A complete list of the contingencies examined with a description of the faulted element, clearing times, and elements tripped is included in Appendix D.

8.3 System Performance Criteria

The following criteria, referenced from the document "ERCOT Transient Voltage Security Criteria Development (Part I)," Draft 3, dated September 9, 2003 were used to evaluate the performance of the system. Any bus exceeding the criteria was flagged for further investigation:

- The length of time the voltage took to recover after the fault had cleared was monitored. A delayed voltage warning exists if the time the voltage took to recover above 0.9 p.u. exceeded 1 second.
- Stability of the Oncor system after contingencies and system disturbances was monitored, both transient angular stability and oscillatory stability (damping).
- The post transient voltage was monitored. A voltage violation exists if the post transient voltage does not recover to 0.9 p.u. or recovers above 1.05 p.u.
- The number of generators to trip offline was also monitored.

ONCOR

No UVLS, UFLS, or voltage collapse is allowed for NERC Category A, B, and C contingencies.

8.3.1 Monitored Elements

For this analysis, buses in Zones 130 to 148, 71 × 345 kV buses were monitored and 227 × 138 kV buses were monitored. Additionally, the frequency, speed, terminal voltage, MW, and MVar output were monitored for the generators listed in Table 8.3-1.

Table 8.3-1
Generators Monitored for the Southern Cross Transient Stability Analysis

Bus #	Unit	Bus #	Unit
120021	[BBSES_UNIT1 18.000]L1	120115	[FREC_GT5 18.000]C4
120041	[MLSES_UNIT1 20.000]L1	120116	[FREC_ST6 18.000]C0
120042	[MLSES_UNIT2 20.000]L2	120141	[SCSES_UNIT1A13.800]N1
120043	[MLSES_UNIT3 20.000]L3	120142	[SCSES_UNIT2 19.000]N2
140064	[LPCCS_CT21 18.000]C4	120151	[TRSES_UNIT6 22.000]N6
140065	[LPCCS_CT22 18 000]C5	120161	[NACPW_UNIT1 13.800]R1
140066	[LPCCS_UNIT2 18.000]C0	140051	[TNSKA_GT1 13.800]C1
120031	[MNSES_UNIT1 18.000]L1	140052	[TNSKA_GT2 13.800]C2
120032	[MNSES_UNIT2 18.000]L2	140053	[TNSKA_STG 13.800]C0
120033	[MNSES_UNIT3 24 000]L3	140061	[LPCCS_CT11 18.000]C1
120101	[TGCCS_CT1 18.000]C1	140062	[LPCCS_CT12 18.000]C2
120102	[TGCCS_CT2 18 000]C2	140063	[LPCCS_UNIT1 18.000]C0
120103	[TGCCS_CT3 18.000]C3	140064	[LPCCS_CT21 18.000]C4
120104	[TGCCS_UNIT4 22.000]C0	140065	[LPCCS_CT22 18.000]C5
120111	[FREC_GT1 18.000]C1	140066	[LPCCS_UNIT2 18.000]C0
120112	[FREC_GT2 18.000]C2	150111	[CPSES_UNIT1 22.000]U1
120113	[FREC_ST3 18.000]C0	150112	[CPSES_UNIT2 22 000]U2
120114	[FREC_GT4 18.000]C3	150181	[FRNYPP_GT11 18.000]C1

A complete list of the channels monitored can be found in Appendix E.

9.0 RESULTS FOR THE TRANSIENT STABILITY ANALYSIS

9.1 Base Case Analysis

The Transient Stability Analysis examined 179 contingencies for the 2015 Import and Export Benchmark cases and 192 contingencies were examined for the 2015 Import and Export 1500 MW and 3000 MW cases. The results were tabulated and reported using the system performance criteria stated in Section 8.3. The upgrades required to eliminate the thermal and voltage violations identified in the Steady State Contingency Analysis were modeled in the base cases used for the Transient Stability Analysis.

9.1.1 Import Base Cases

Table 9.1-1 lists the results from the 2015 Summer Import Transient Stability Analysis from the original contingencies examined. The table shows that 19 of the contingencies examined either had voltage violations or went unstable. The 8 contingencies where instability occurred were all contingencies where a circuit breaker had a stuck pole resulting in backup clearing being required.

In general the contingencies resulted in more violations as the Import level was increased. The 1500 MW Import case had 6 contingencies with normal clearing that resulted in voltage violations. The 3000 MW Import case had 11 contingencies with normal clearing that resulted in voltage violations and 1 unstable stuck breaker contingency.

The 1 unstable stuck breaker contingency for the Import 3000 MW case was examined with the backup clearing times reduced from 14 cycles to 10 cycles, after the original fault was applied. The results for this contingency, with the reduced backup clearing time, indicated that there was no longer a stability concern and no violations occurred.

Table 9.1-2 lists the location and the type of voltage violations observed for the normal 3-phase clearing contingencies for the 2015 Summer Import case.

The first set of voltage violations were in the Royse\Shamburger\Martin Lake area where the post contingency voltage exceeded 1.05 p.u. at Shamburger if the Royse to Shamburger or the Martin Lake to Shamburger 345 kV lines were tripped (Cont. #2, 4, 16, and 17). The pre-contingency voltage was 1.046 p.u. and the post-contingency voltage settled to approximately 1.059 p.u. When these contingencies were re-examined with a lower initial voltage the resulting post-contingency voltage was acceptable. In addition there was a 240 MVar capacitor bank at Shamburger 345 kV that was in-service for these scenarios, if the capacitor bank is off pre-contingency or switched off post-contingency these overvoltages were eliminated.

The second set of contingencies with voltage violations was in the Pleasantville\Crocket 138 kV area (Cont. #18, 21, 22, and 24). When a 138 kV line between Jewett and Crockett is faulted and tripped several buses do not recover back above 0.9 p.u. within 1.0 second and several buses do not recover above 0.9 p.u. by the end of the 10.0 second simulation. For these contingencies if a +100 MVar SVC is located at the Crockett 69 kV bus, all the 138 kV bus voltages recover above 0.9 p.u. within the required time. Figure 9.1-1 shows a one-line diagram of the Pleasantville/Crockett area. Figure 9.1-2 shows a plot of the Crockett and Centerville 138 kV bus voltages during Cont. #18 with and without the SVC.

It was also observed that there was an open circuit on the 138 kV system between Crockett and Berea. Under contingency, when this circuit was closed within 1.0 second after the fault was cleared, all the voltage violations were eliminated and the 138 kV and 69 kV systems all returned to voltages above 0.9 p.u. without the need for an SVC. This would be a cheaper alternative to an SVC if it is possible to develop a relay scheme that would close this circuit when a fault is detected between the Jewett and Crockett 138 kV buses.

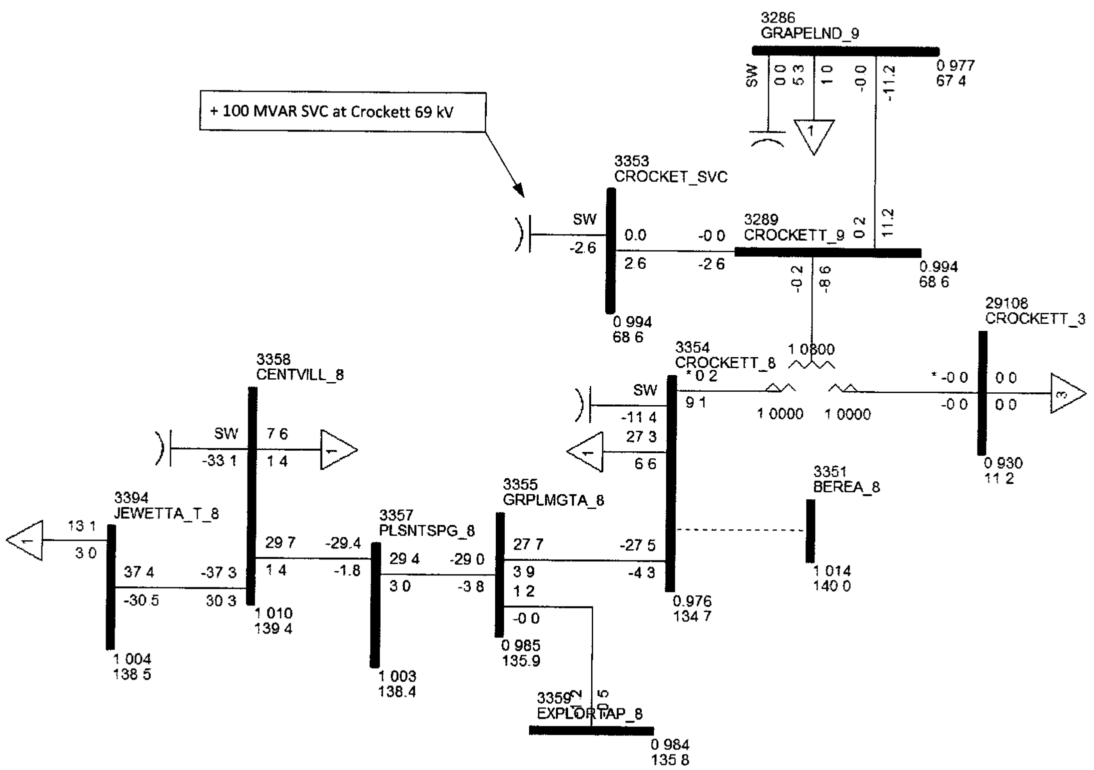


Figure 9.1-1. One-line diagram of the Pleasantville/Crockett area.

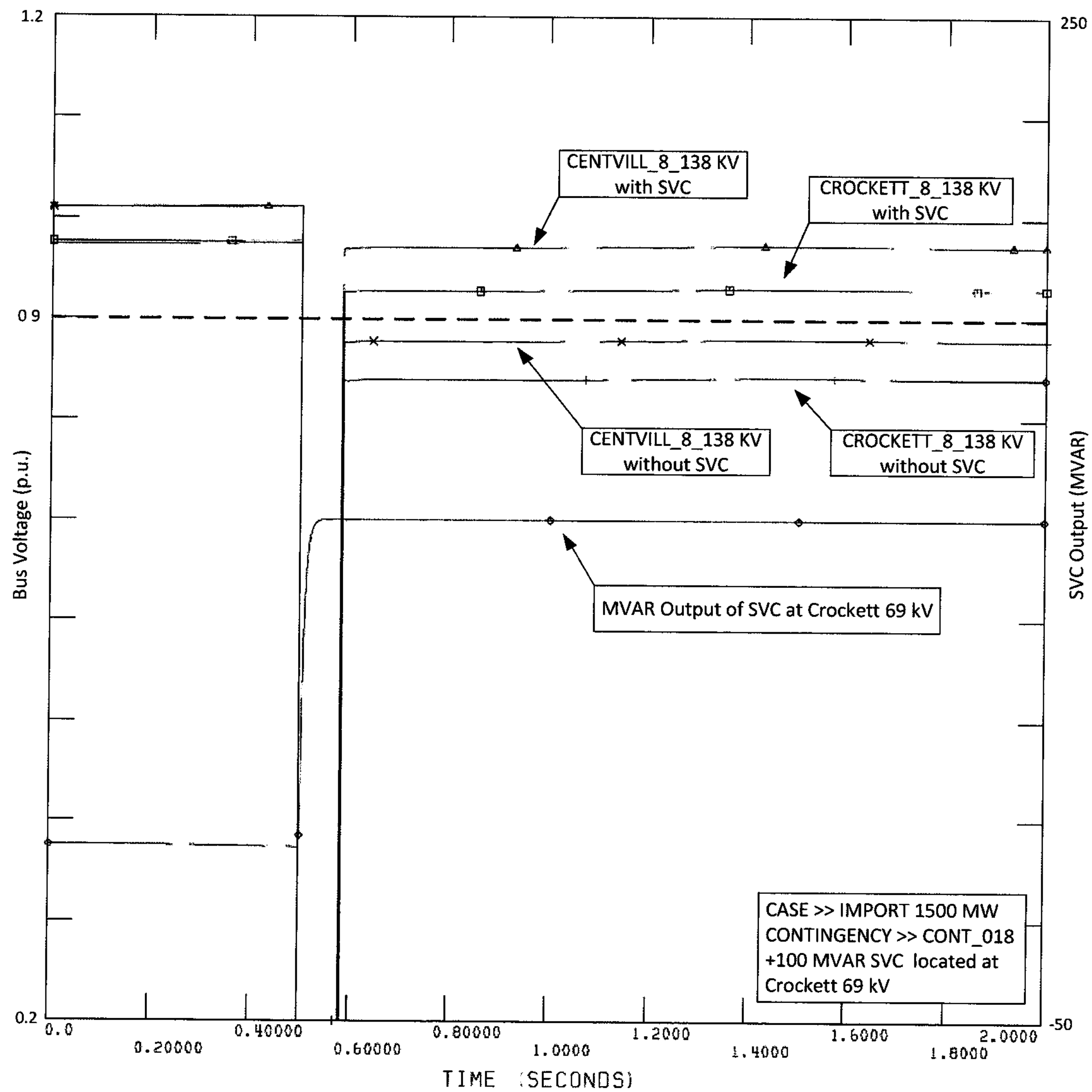


Figure 9.1-2. Plot of the Crockett and Centerville 138 kV bus voltages during Cont. #18 with and without the SVC.

The third set of contingencies with voltage violations is in the Diboll\Lufkin 138 kV area (Cont. #37, 49, and 95). When the 138 kV line between Lufkin and Diboll WTA is faulted and tripped, several buses do not recover back above 0.9 p.u. within 1.0 second and several buses do not recover above 0.9 p.u. by the end of the 10.0 second simulation. For these contingencies if a +80 MVar SVC is located at Diboll WTA the problem is alleviated and all voltages recover to within criteria. Figure 9.1-3 shows a one-line diagram of the Diboll\Lufkin 138 kV area. Figure

9.1-4 shows a plot of the Dibolet and Diboll 138 kV bus voltages during Cont. #37 with and without the SVC.

The stuck breaker contingencies will be examined in more detail in Section 9.2

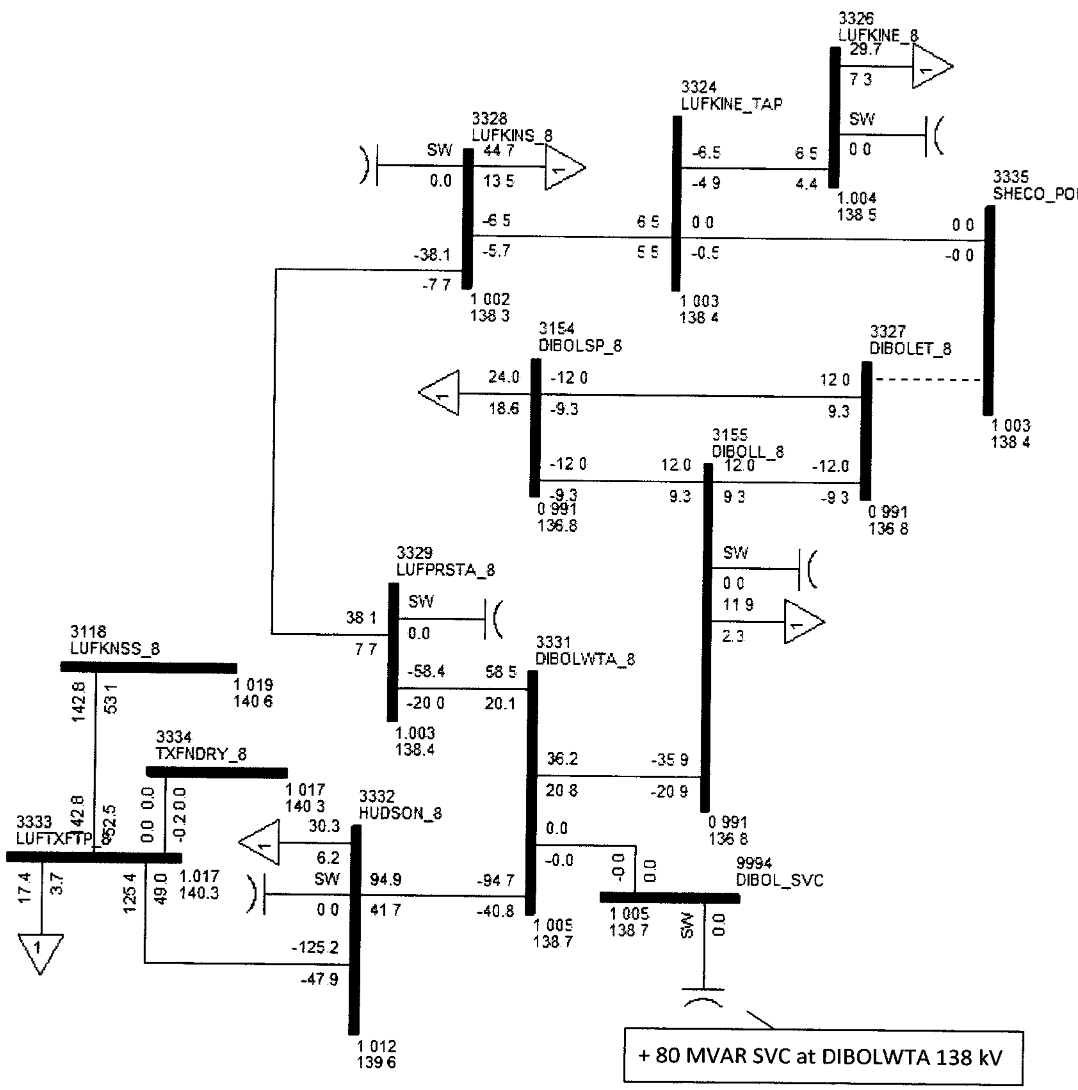


Figure 9.1-3. One-line diagram of the Diboll\Lufkin 138 kV area.

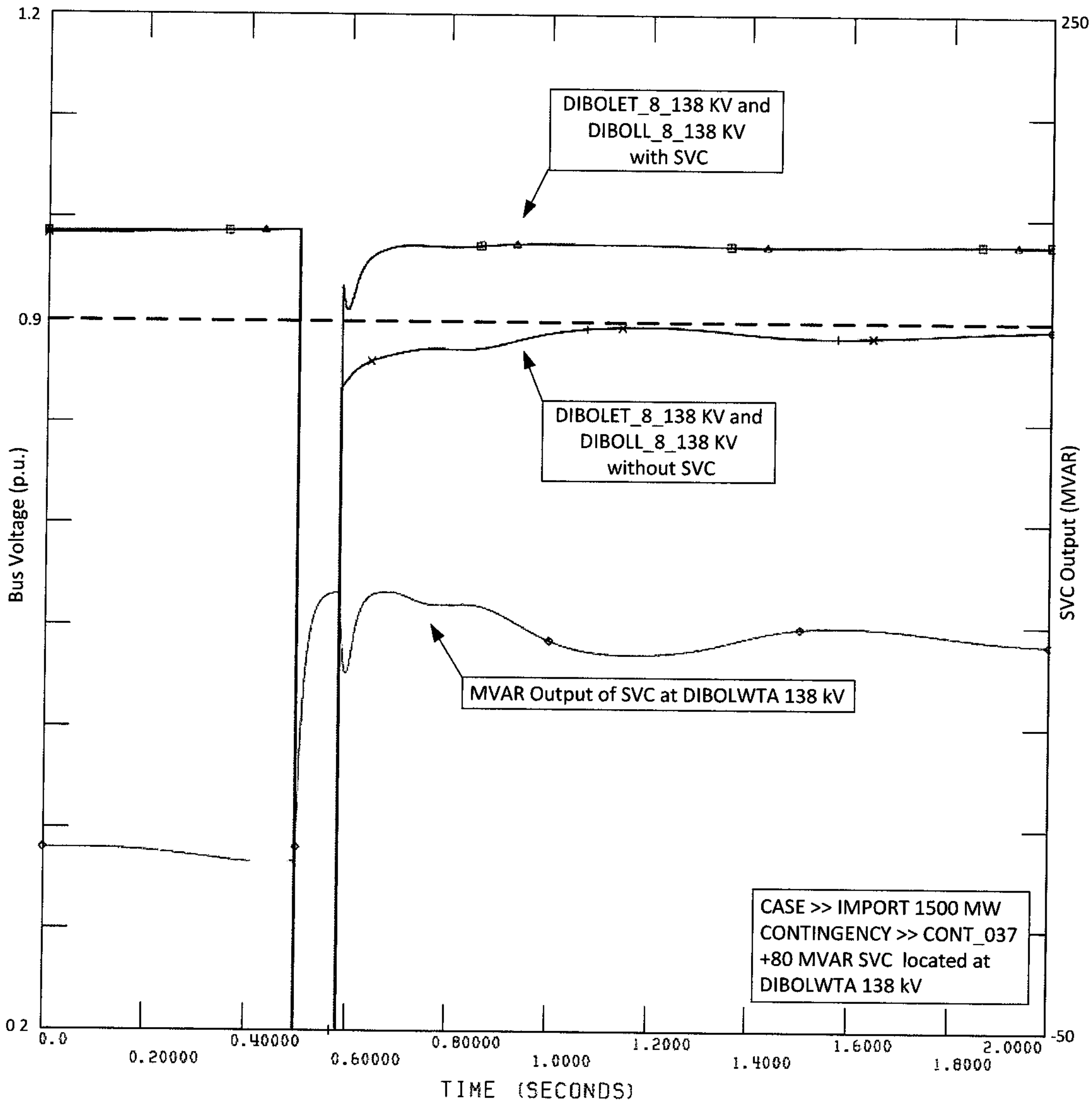


Figure 9.1-4. Plot of the Dibolet and Diboll 138 kV bus voltages during Cont. #37 with and without the SVC.

Table 9.1-1
Contingencies with Violations for the 2015 Summer Import Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Import - Benchmark		Import - 1500 MW		Import - 3000 MW	
				Number of Buses with Voltage Violations	Generators Trip Offline	Number of Buses with Voltage Violations	Generators Trip Offline	Number of Buses with Voltage Violations	Generators Trip Offline
1	CONT_002	SHAMBRGR_5 345KV BUS 3103 TO ROYSE_S5 345KV BUS 2478 CKT 1	Normal 3-PH	N/A	No	N/A	No	1	No
2	CONT_004	MARTINLK_5 345KV BUS 3100 TO SHAMBRGR_5 345KV BUS 3103 CKT 1	Normal 3-PH	N/A	No	N/A	No	1	No
3	CONT_016	MARTINLK_5 345 KV BUS 3100 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	No	N/A	No	1	No
4	CONT_017	ROYSE_S5 345 KV BUS 2478 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	No	N/A	No	1	No
5	CONT_018	CENTVILL_8 138 KV BUS 3358 TO JEWETTA_T_8 138 KV BUS 3394 CKT 1	Normal 3-PH	N/A	No	5	No	5	No
6	CONT_021	GRPLMGTA_8 138 KV BUS 3355 TO PLSNTSPG_8 138 KV BUS 3357 CKT 1	Normal 3-PH	N/A	No	3	No	3	No
7	CONT_022	PLSNTSPG_8 138 KV BUS 3357 TO CENTVILL_8 138 KV BUS 3358 CKT 1	Normal 3-PH	N/A	No	4	No	4	No
8	CONT_024	CROCKETT_8 138 KV BUS 3354 TO GRPLMGTA_8 138 KV BUS 3355 CKT 1	Normal 3-PH	N/A	No	1	No	1	No
9	CONT_037	LUFKNSS_8 138 KV BUS 3118 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	No	3	No	5	No
10	CONT_049	HUDSON_8 138 KV BUS 3332 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	No	2	No	2	No
11	CONT_095	DIBOLWTA_8 138 KV BUS 3331 TO HUDSON_8 138 KV BUS 3332 CKT 1	Normal 3-PH	N/A	No	N/A	No	2	No
12	CONT_188	MARTINLK 345 KV BUS TO SHAMBURGER 345 KV MARTINLK 345 KV BUS 3100 TO ELKTON 345 KV 3102 CKT 1 MARTINLK_5 345 KV BUS 3100 TO STRYKER_5 345 KV BUS 3109 CKT 1 MARTINLK_5 345 KV BUS 3100 TO MLSES_UNIT3 20.7KV BUS 120043 CKT 3 MLSES_UNIT 3 20.7 KV BUS 120043	Stuck Breaker	N/A	N/A	N/A	N/A	Unstable	Yes

N/A = Not Applicable

ONCOR

Table 9.1-2
Voltage Violations for the 2015 Summer Import Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Import - Benchmark Type of Voltage Violation	Import - 1500 MW Type of Voltage Violation	Import - 3000 MW Type of Voltage Violation
1	CONT_002	SHAMBRGR_5 345KV BUS 3103 TO ROYSE_S5 345KV BUS 2478 CKT 1	Normal 3-PH	N/A	N/A	#3103 SHAMBRGR_5_345 Final V > 1 05 p.u
2	CONT_004	MARTINLK_5 345KV BUS 3100 TO SHAMBRGR_5 345KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	#3103 SHAMBRGR_5_345 Final V > 1 05 p.u
3	CONT_016	MARTINLK_5 345 KV BUS 3100 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	#3103 SHAMBRGR_5_345 Final V > 1 05 p.u
4	CONT_017	ROYSE_S5 345 KV BUS 2478 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	#3103 SHAMBRGR_5_345 Final V > 1 05 p.u
5	CONT_018	CENTVILL_8 138 KV BUS 3358 TO JEWETTA_T_8 138 KV BUS 3394 CKT 1	Normal 3-PH	N/A	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3358 CENTVILL_8_138 #3359 EXPLORTAP_8_138 V recovery to 0.9 p.u > 1 sec Final V < 0.9 p.u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3358 CENTVILL_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u
6	CONT_021	GRPLMGTA_8 138 KV BUS 3355 TO PLSNTSPG_8 138 KV BUS 3357 CKT 1	Normal 3-PH	N/A	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u
7	CONT_022	PLSNTSPG_8 138 KV BUS 3357 TO CENTVILL_8 138 KV BUS 3358 CKT 1	Normal 3-PH	N/A	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u
8	CONT_024	CROCKETT_8 138 KV BUS 3354 TO GRPLMGTA_8 138 KV BUS 3355 CKT 1	Normal 3-PH	N/A	#3354 CROCKETT_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u Final V ~ 0 7 p.u	#3354 CROCKETT_8_138 V recovery to 0 9 p.u > 1 sec Final V < 0 9 p.u Final V ~ 0 7 p.u

N/A = Not Applicable

Table 9.1-2 Cont.
Voltage Violations for the 2015 Summer Import Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Import - Benchmark	Import - 1500 MW	Import - 3000 MW
				Type of Voltage Violation	Type of Voltage Violation	Type of Voltage Violation
9	CONT_037	LUFKNSS_8 138 KV BUS 3118 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	#3155 DIBOLL_8_138* #3327 DIBOLET_8_138* #3334 TXFNDRY_8_138 * V recovery to 0 9 p u > 1 sec Final V < 0.9 p.u.	#3155 DIBOLL_8_138* #3324 LUFKINE_TAP_138 #3327 DIBOLET_8_138* #3334 TXFNDRY_8_138* #3335 SHECO_POI_138 * V recovery to 0.9 p.u. > 1 sec Final V < 0 9 p.u.
10	CONT_049	HUDSON_8 138 KV BUS 3332 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	#3155 DIBOLL_8_138 #3327 DIBOLET_8_138 Final V < 0.9 p.u.	#3155 DIBOLL_8_138 #3327 DIBOLET_8_138 V recovery to 0 9 p.u. > 1 sec Final V < 0.9 p.u.
11	CONT_095	DIBOLWTA_8 138 KV BUS 3331 TO HUDSON_8 138 KV BUS 3332 CKT 1	Normal 3-PH	N/A	N/A	#3155 DIBOLL_8_138 #3327 DIBOLET_8_138 V recovery to 0 9 p.u. > 1 sec Final V < 0 9 p.u.

N/A = Not Applicable

9.1.2 Export Base Cases

Table 9.1-3 lists the results with concerns from the 2015 Summer Export Transient Stability Analysis from the 192 original contingencies examined. The table shows that 6 of the contingencies examined either had voltage violations or went unstable.

The Export cases had similar results with 4 contingencies with normal clearing times that resulted in voltage violations. The 1500 MW Export case had 2 unstable stuck breaker contingencies. Note the 3000 MW Export case had 2 × +400/-150 Mvar SVC's placed at Rusk 345 kV and the HVDC converter station at the initiation of the Transient Stability Analysis.

The 2 unstable stuck breaker contingencies (Cont. # 188 and 191) for the Export 1500 MW case were examined with the backup clearing time reduced from 14 cycles after the original fault was applied, to 10 cycles. These 2 contingencies remained stable with the 10 cycle backup clearing time and no voltage violations occurred. Oncor did receive confirmation from the System Protection department that these circuit breakers were modified to have a backup clearing time of 10 cycles.

Table 4.1-4 lists the location and the type of voltage violation observed for the normal 3 phase clearing contingencies for the 2015 Summer Export cases. The contingencies resulting in voltage violation were in the Pleasantville\Crocket 138 kV area (Cont. #18, 21, 22, and 24) and were also observed in the Import cases. When a line between JEWETTA_T_8 (#3394) and CROCKETT_8 (#3354) 138 kV is faulted and tripped several buses do not recover back above 0.9 p.u. within 1.0 second and several buses do not recover above 0.9 p.u. by the end of the 10.0 second simulation. For these contingencies if a +100 Mvar SVC is located at CROCKETT_9 (#3289) 69 kV all the 138 kV bus voltages recover above 0.9 p.u. within the required time.

Table 9.1-3
Contingencies with Violations for the 2015 Summer Export Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Export - Benchmark Pre-Upgrade		Export - 1500 MW		Export - 3000 MW	
				Number of Buses with Voltage Violations	Generators Trip Offline	Number of Buses with Voltage Violations	Generators Trip Offline	Number of Buses with Voltage Violations	Generators Trip Offline
1	CONT_018	CENTVILL_8 138 KV BUS 3358 TO JEWETTA_T_8 138 KV BUS 3394 CKT 1	Normal 3-PH	5	No	5	No	5	No
2	CONT_021	GRPLMGTA_8 138 KV BUS 3355 TO PLSNTSPG_8 138 KV BUS 3357 CKT 1	Normal 3-PH	3	No	3	No	3	No
3	CONT_022	PLSNTSPG_8 138 KV BUS 3357 TO CENTVILL_8 138 KV BUS 3358 CKT 1	Normal 3-PH	4	No	4	No	4	No
4	CONT_024	CROCKETT_8 138 KV BUS 3354 TO GRPLMGTA_8 138 KV BUS 3355 CKT 1	Normal 3-PH	1	No	1	No	1	No
5	CONT_188	MARTINLK 345 KV BUS TO SHAMBURGER 345 KV MARTINLK 345 KV BUS 3100 TO ELKTON 345 KV 3102 CKT 1 MARTINLK_5 345 KV BUS 3100 TO STRYKER_5 345 KV BUS 3109 CKT 1 MARTINLK_5 345 KV BUS 3100 TO MLSES_UNIT3 20 7KV BUS 120043 CKT 3 MLSES_UNIT 3 20.7 KV BUS 120043	Stuck Breaker	N/A	N/A	Unstable	Yes	N/A	N/A
6	CONT_191	MARTINLK 345 KV BUS 3100 TO TYLER 345 KV BUS MARTINLK_5 345 KV BUS 3100 TO ELKTON_5 345 KV BUS 3105 CKT 1 MARTINLK_5 345 KV BUS 3100 TO STRYKER_5 345 KV BUS 3109 CKT 1 MARTINLK_5 345 KV BUS 3100 TO MLSES_UNIT3 20.7KV BUS 120043 CKT 3 MLSES_UNIT 3 20.7 KV BUS 120043	Stuck Breaker	N/A	N/A	Unstable	Yes	N/A	N/A

N/A = Not Applicable

ONCOR

Table 9.1-4
Voltage Violations for the 2015 Summer Export Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Export - Benchmark Pre-Upgrade	Export - 1500 MW	Export - 3000 MW
				Type of Voltage Violation	Type of Voltage Violation	Type of Voltage Violation
1	CONT_018	CENTVILL_8 138 KV BUS 3358 TO JEWETTA_T_8 138 KV BUS 3394 CKT 1	Normal 3-PH	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3358 CENTVILL_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3358 CENTVILL_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3358 CENTVILL_8_138 #3359 EXPLORTAP_8_138 V recovery to 0.9 p u. > 1 sec Final V < 0 9 p u.
2	CONT_021	GRPLMGTA_8 138 KV BUS 3355 TO PLSNTSPG_8 138 KV BUS 3357 CKT 1	Normal 3-PH	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u
3	CONT_022	PLSNTSPG_8 138 KV BUS 3357 TO CENTVILL_8 138 KV BUS 3358 CKT 1	Normal 3-PH	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3359 EXPLORTAP_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u	#3354 CROCKETT_8_138 #3355 GRPLMGTA_8_138 #3357 PLSNTSPG_8_138 #3359 EXPLORTAP_8_138 V recovery to 0.9 p u. > 1 sec Final V < 0 9 p u.
4	CONT_024	CROCKETT_8 138 KV BUS 3354 TO GRPLMGTA_8 138 KV BUS 3355 CKT 1	Normal 3-PH	#3354 CROCKETT_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u Final V ~ 0 7 p u	#3354 CROCKETT_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u Final V ~ 0 7 p u	#3354 CROCKETT_8_138 V recovery to 0 9 p u. > 1 sec Final V < 0 9 p u Final V ~ 0 7 p u

9.1.3 Rusk to HVDC transmission lines

As stated in section 4.2.4 of this report, the Rusk to HVDC Converter station transmission lines are not owned by Oncor, however stability analysis was performed on those lines to address any issues that may impact those lines or the transmission grid because of issues with the double-circuit line between Rusk County Switch and the HVDC Converter station encountering a contingency.

For this part of the analysis a three-phase, line-to-ground fault was simulated at Rusk followed by the loss of each of the transmission lines connecting Rusk 345 kV to the HVDC converter station individually and as a pair (i.e. N-1 and N-2).

Results

The Import and Export 1500 MW cases had no voltage violations for the N-1 or N-2 contingencies and the ONCOR system remained stable.

The Import 3000 MW case had no voltage violations within the ERCOT system for the N-1 contingencies; however the power flow through the HVDC converter decreased from 3000 MW to approximately 2460 MW. The bus voltage at Rusk decreased to 1.0 p.u. and the bus voltage at the HVDC converter decreased to 0.81 p.u. Figure 9.2.1 shows the reduced power flow through the HVDC converter for the Import 3000 MW case for the N-1 contingency. Figure 9.2.2 shows the voltage plots for the Rusk and the HVDC converter station buses during the Import 3000 MW case for the N-1 contingency.

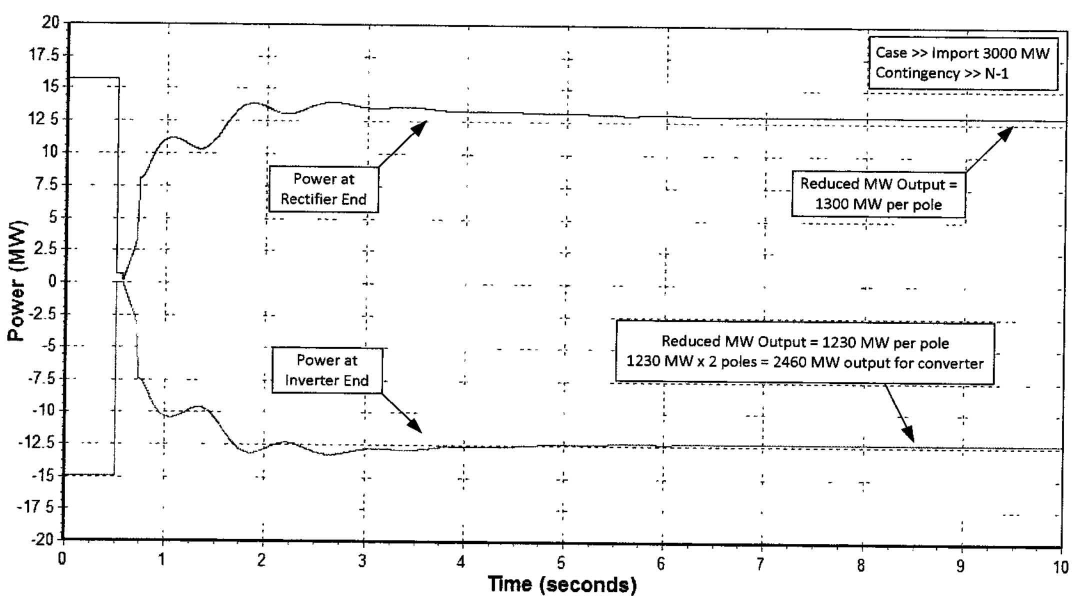


Figure 9.2.1. Plot of the reduced power flow through the HVDC converters for the Import 3000 MW case for the N-1 contingency. Note only 1 Pole shown.

The Import 3000 MW case did have post contingency voltages exceeding 1.05 p.u. following the N-2 contingency, (see Table 9.2.12). To reduce the voltages below 1.05 p.u. the amount of capacitance needed to be tripped at Rusk and neighboring stations was examined. Tripping the 560 Mvar shunt capacitor at Rusk and the 240 Mvar at Shamburger reduced the post-contingency voltages below 1.05 p.u. following the N-2 contingency.

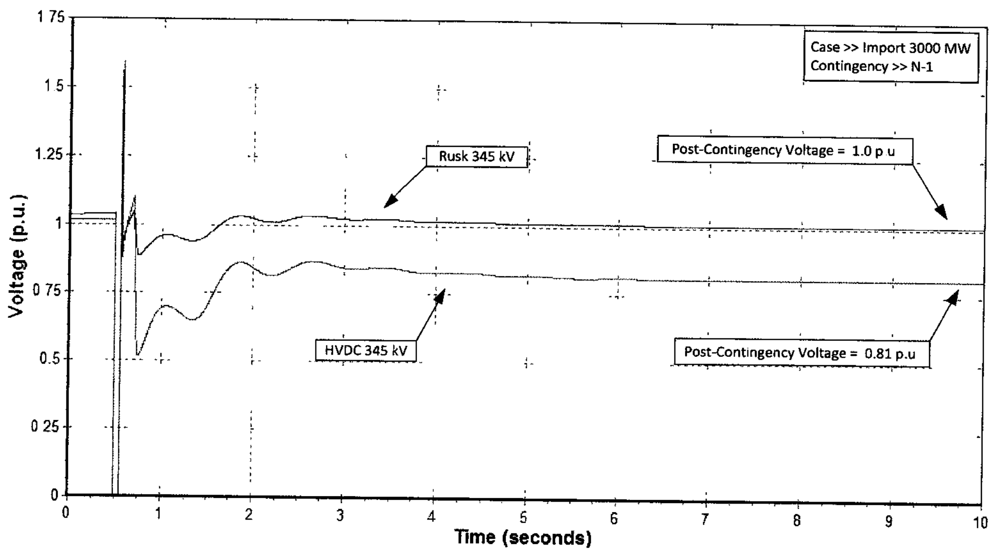


Figure 9.2.2. Voltage plots for the Rusk and HVDC converter station buses during the Import 3000 MW case for the N-1 contingency.

Table 9.2.12
List of the Post Contingency Voltages Exceeding 1.05 p.u. for the Import 3000 MW Case after the N-2 Contingency

		Sensitivity >>		Base Case No Shunt Capacitors Tripping	Tripping 560 MVAR Shunt Capacitor from Rusk 345 kV	Tripping 240 Mvar from Shambrgr 345 kV and 560 MVAR from Rusk 345 kV
Ref. No.	Bus No.	Bus Name	kV	Post-Contingency Voltage (p.u.)[1]		
1	9997	RUSK	345	1.07	1.05	-
2	3100	MARTIN LAKE	345	1.06	1.05	-
3	3102	TYLERGND	345	1.07	1 06	1.05
4	3103	SHAMBRGR	345	1.08	1.08	-
5	3105	ELKTON	345	1.06	1.05	-
6	3109	STRYKER	345	1.06	1.05	-
7	3116	MTENTRPR	345	1.07	1.05	-
8	3117	LUFKNSS	345	1.06	-	-
9	3119	NACOGDSE	345	1.06	-	-
10	3139	TYLERWES	138	1.07	1.06	-
11	3143	TYLERGND	138	1.05	-	-
12	3197	TYLERSW	138	1.07	1.06	1.05
13	3198	TYLRKLLY	138	1.07	1.06	1.05
14	3201	LINDALE	138	1 06	1.05	-
15	3238	ATHENS	138	1.05	1.05	-

1 " - " = The post-contingency voltage was below 1 05 p.u.

The Export 3000 MW case during an N-1 contingency had high voltages directly after the fault was cleared and interaction between the HVDC and SVCs was observed. The SVC dynamics models were then disabled with the continuously controlled capacitors left in the power flow. This prevented interactions between the SVC and HVDC, it was observed during the N-1 contingency that the power flow through the HVDC converter decreased from 3000 MW to approximately 2412 MW. The bus voltage at Rusk Switch decreased to 0.98 p.u. and the bus voltage at the HVDC converter decreased to 0.89 p.u.

The Export 3000 MW case during an N-2 contingency did have post contingency voltages exceeding 1.05 p.u. To reduce the voltages below 1.05 p.u. the amount of capacitance needing to be tripped at Rusk and neighboring stations was examined. Table 9.2.13 lists the post contingency voltages exceeding 1.05 p.u. for the Export 3000 MW case after the N-2 contingency.

The amount of capacitance needed to be tripped off-line to reduce the post-contingency voltage violations to 1.05 p.u., following the N-2 contingency, was examined. Tripping the 450 Mvar shunt capacitor at Rusk Switch and one 80 Mvar step at Elkton 345 kV bus reduced all post-contingency voltages below 1.05 p.u. following the N-2 contingency for the Export 3000 MW case.

Table 9.2.13
List of the Post Contingency Voltages Exceeding 1.05 p.u. for the Export 3000 MW Case after the N-2 Contingency

		Sensitivity >>		Base Case No Shunt Capacitors Tripping	Tripping 450 MVAR Shunt Capacitor from Rusk 345 kV +400/-150 MVAR at Rusk SVC	Tripping 450 Mvar from Rusk 345 kV and 1 X 80 MVAR STEP from Elkton 345 kV +400/-150 MVAR at Rusk SVC
Ref. No.	Bus No.	Bus Name	kV	Post-Contingency Voltage (p.u.)[1]		
1	9997	RUSK	345	1.06	-	-
2	3100	MARTIN LAKE	345	1.05	-	-
3	3102	TYLERGND	345	1.06	-	-
4	3105	ELKTON	345	1.07	1.06	-
5	3109	STRYKER	345	1.05	-	-
6	3116	MTENTRPR	345	1.06	-	-
7	3117	LUFKNSS	345	1.05	-	-
8	3119	NACOGDSE	345	1.05	-	-
9	3120	NACOGDSE	138	1.05	-	-
10	3312	CHIRENO_8	138	1.05	-	-

1 " - " = The post-contingency voltage was below 1.05 p.u.

10.0 SUMMARY FOR TRANSIENT STABILITY ANALYSIS

The Transient Stability Analysis examined 181 contingencies for the 2015 Import and Export Benchmark cases and 192 contingencies for the 2015 Import and Export 1500 MW and 3000 MW cases. The results were tabulated and reported using the system performance criteria from the document "ERCOT Transient Voltage Security Criteria Development (Part I)." The upgrades required to eliminate thermal and voltage violations identified in the Steady State Contingency Analysis were modeled in the cases used for the Transient Stability Analysis.

10.1 Base Cases Analysis

Table 10.1-1 shows the voltage violations and contingencies that went unstable for the 2015 Import and Export Benchmark, 1500 MW, and 3000 MW base cases. The contingencies where instability occurred were all contingencies where a circuit breaker had a stuck breaker resulting in backup clearing being required.

The first set of voltage violations involved the Royse\Shamburger\Martin Lake area where the post contingency voltage exceeded 1.05 p.u. at Shamburger if the Royse to Shamburger or the Martin Lake to Shamburger 345 kV lines were tripped (Cont. #2, 4, 16, and 17). When these cases were re-examined with a lower initial voltage the resulting post-contingency voltage was acceptable. In addition there was a 240 MVar capacitor bank at the Shamburger 345 kV bus that was in-service for these scenarios. If the capacitor bank is off pre-contingency or switched off post-contingency the overvoltages were eliminated.

The second set of contingencies with voltage violations was in the Pleasantville\Crockett area (Cont. #18, 21, 22, and 24). When a 138 kV line between Jewett and Crockett was faulted and tripped, several buses did not recover back above 0.9 p.u. within 1.0 second and several buses did not recover above 0.9 p.u. by the end of the 10.0 second simulation. For these contingencies if a +100 MVar SVC was located at the Crockett 69 kV bus then all the 138 kV bus voltages recovered above 0.9 p.u. within the required time.

It was also observed that there was an open circuit between the 138 kV buses Crockett and Berea. When this circuit was closed within 1.0 second, after the fault was cleared, all the voltage violations were eliminated and the 138 kV and 69 kV systems all returned to voltages above 0.9 p.u. without the need for an SVC.

The third set of contingencies with voltage violations was in the Diboll\Lufkin area (Cont. #37, 49, and 95). When a 138 kV line between Lufkin and Diboll WTA was faulted and tripped, several buses did not recover back above 0.9 p.u. within 1.0 second and several buses did not recover above 0.9 p.u. by the end of the 10.0 second simulation. For these contingencies if a +80 MVar SVC was located at the Diboll WTA 138 kV bus, the problem was alleviated and all voltages recovered to within criteria.

Two stuck breaker contingencies were identified that resulted in the system going unstable with a 14-cycle (Oncor typical 345 kV backup clearing time). These contingencies were re-examined with a 10-cycle backup clearing time and the system remained stable without voltage violations. Oncor System Protection confirmed that for these contingencies a 10-cycle backup time was what was actually in the field.

10.2 Conclusions for the Transient Stability Analysis

Two areas were identified that were susceptible to slow voltage recovery with the voltages not returning above 0.9 p.u. These two areas were the Pleasantville\Crockett area and the Diboll\Lufkin 138 kV area. It was shown that a +100 MVar SVC and a +80 MVar SVC, respectively, would alleviate the voltage violations and return the system voltages to a normal operating range.

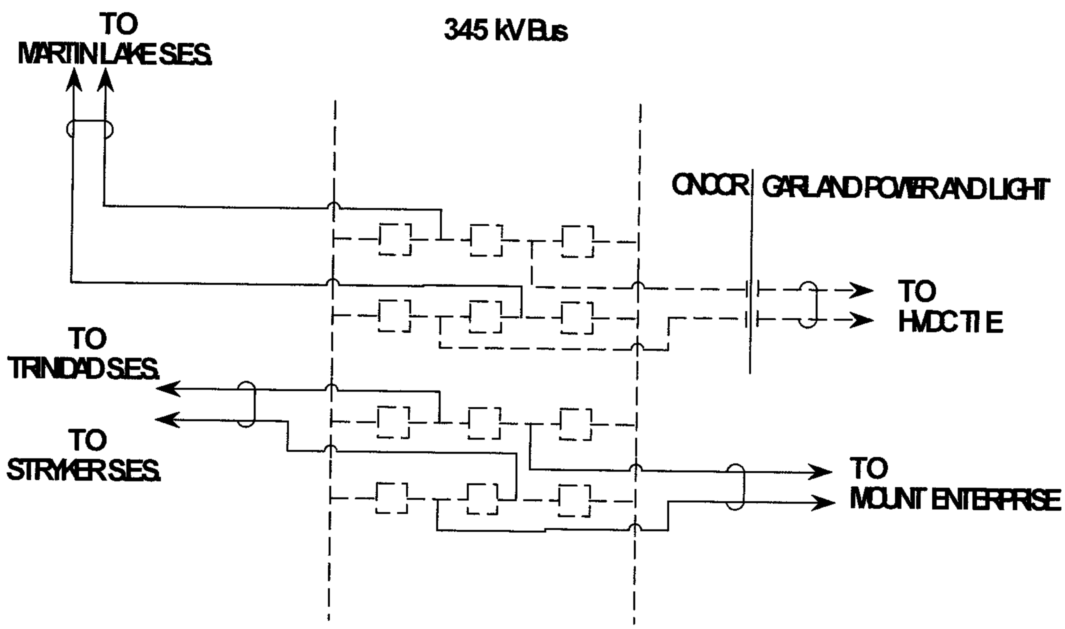
Table 10.1-1
Contingencies with Violations for the 2015 Summer Import and Export Benchmark, 1500 MW and 3000 MW Base Cases

Ref No	Contingency Case	Contingency Description	Type of Contingency	Import - Benchmark	Import - 1500 MW	Import - 3000 MW	Export - Benchmark	Export - 1500 MW	Export - 3000 MW
				Number of Buses with Voltage Violations					
1	CONT_002	SHAMBRGR_5 345KV BUS 3103 TO ROYSE_S5 345KV BUS 2478 CKT 1	Normal 3-PH	N/A	N/A	1	N/A	N/A	N/A
2	CONT_004	MARTINLK_5 345KV BUS 3100 TO SHAMBRGR_5 345KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	1	N/A	N/A	N/A
3	CONT_016	MARTINLK_5 345 KV BUS 3100 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	1	N/A	N/A	N/A
4	CONT_017	ROYSE_S5 345 KV BUS 2478 TO SHAMBRGR_5 345 KV BUS 3103 CKT 1	Normal 3-PH	N/A	N/A	1	N/A	N/A	N/A
5	CONT_018	CENTVILL_8 138 KV BUS 3358 TO JEWETTA_T_8 138 KV BUS 3394 CKT 1	Normal 3-PH	N/A	5	5	5	5	5
6	CONT_021	GRPLMGTA_8 138 KV BUS 3355 TO PLSNTSPG_8 138 KV BUS 3357 CKT 1	Normal 3-PH	N/A	3	3	3	3	3
7	CONT_022	PLSNTSPG_8 138 KV BUS 3357 TO CENTVILL_8 138 KV BUS 3358 CKT 1	Normal 3-PH	N/A	4	4	4	4	4
8	CONT_024	CROCKETT_8 138 KV BUS 3354 TO GRPLMGTA_8 138 KV BUS 3355 CKT 1	Normal 3-PH	N/A	1	1	1	1	1
9	CONT_037	LUFKNSS_8 138 KV BUS 3118 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	3	5	N/A	N/A	N/A
10	CONT_049	HUDSON_8 138 KV BUS 3332 TO LUFTXFTP_8 138 KV BUS 3333 CKT 1	Normal 3-PH	N/A	2	2	N/A	N/A	N/A
11	CONT_095	DIBOLWTA_8 138 KV BUS 3331 TO HUDSON_8 138 KV BUS 3332 CKT 1	Normal 3-PH	N/A	N/A	2	N/A	N/A	N/A

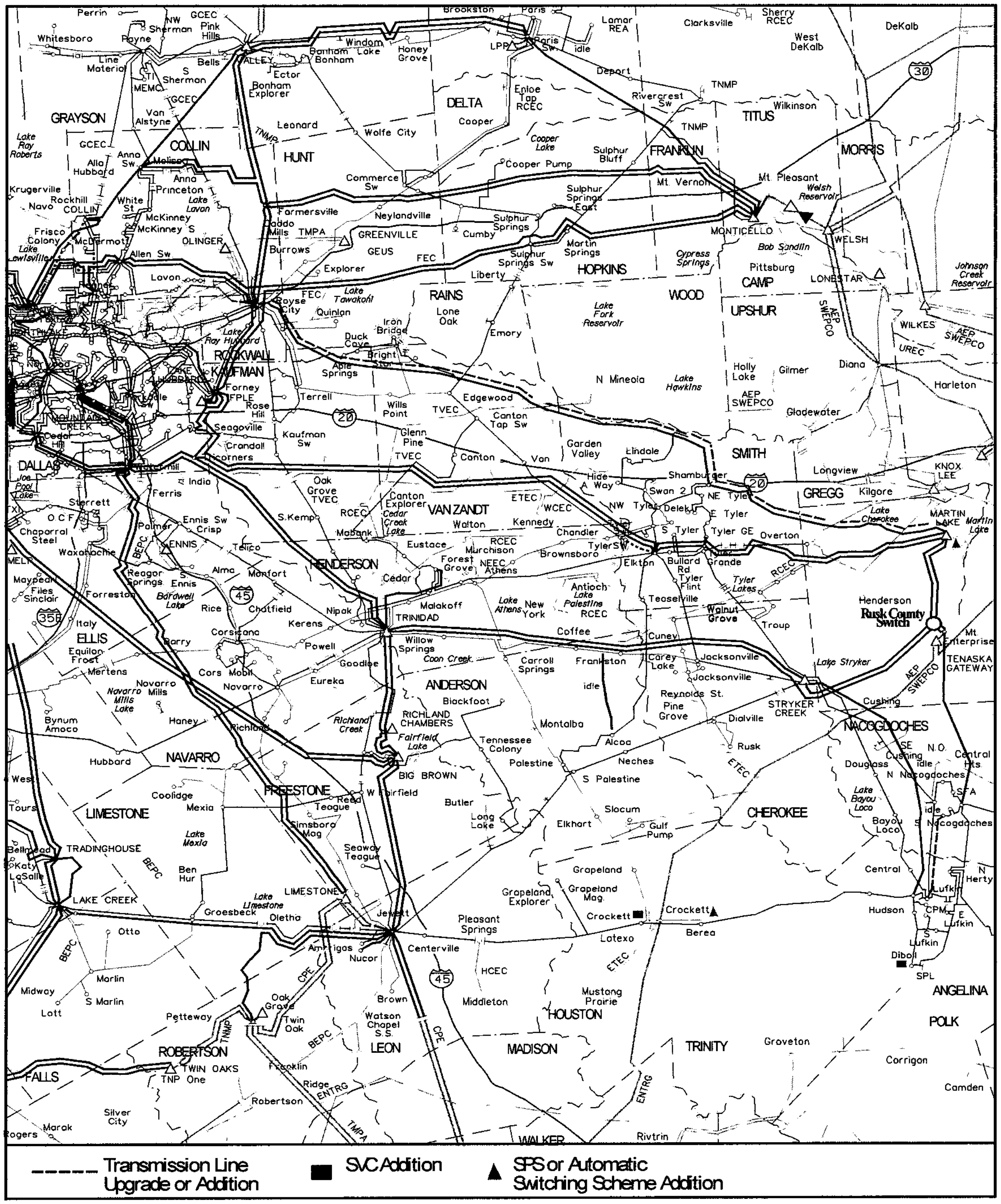
N/A = Not Applicable

APPENDICES

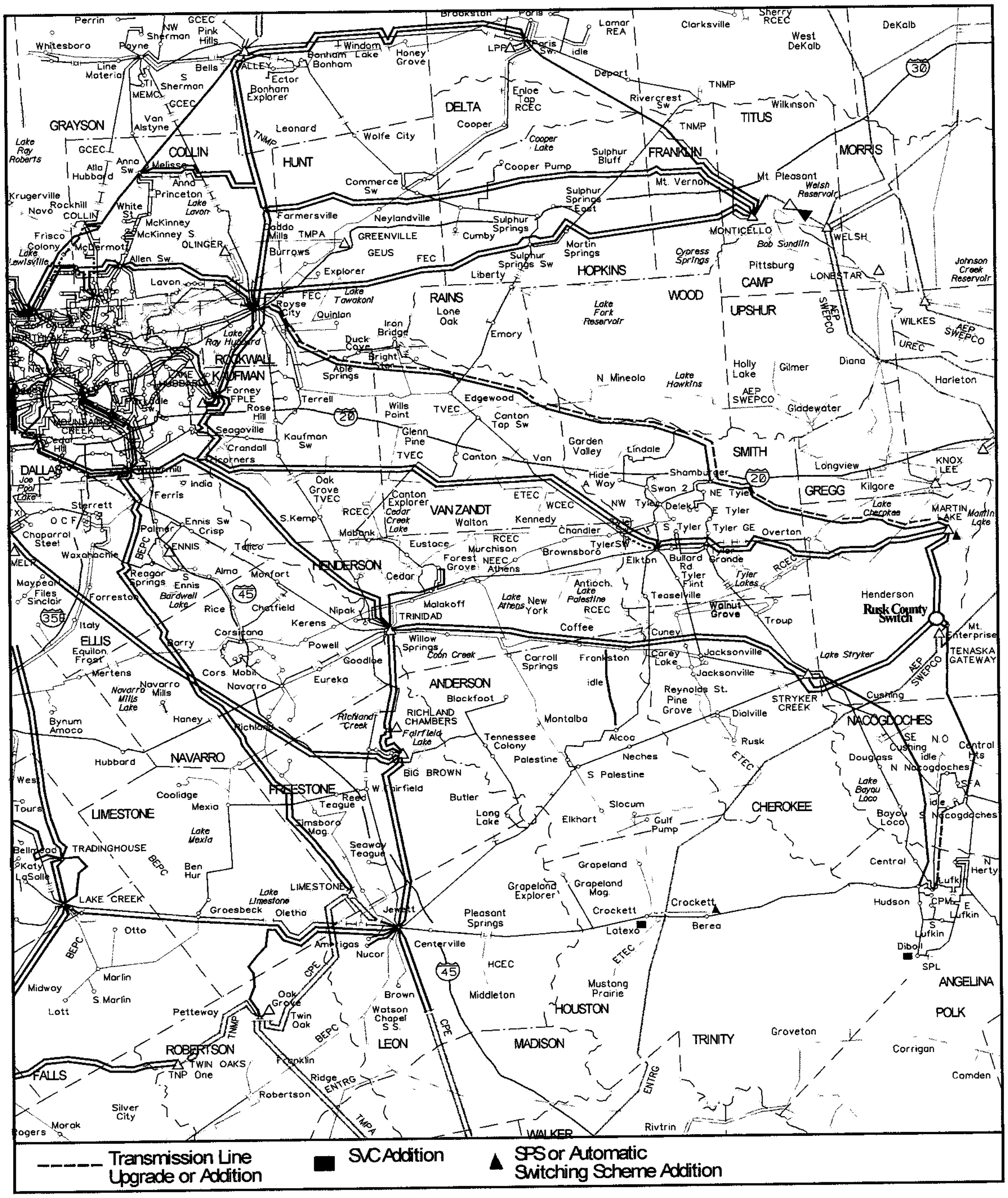
APPENDIX	APPENDIX FILE	DESCRIPTION
A	Appendix A_ONCOR_Southern_	Contingencies Examined in the Steady State Contingency Analysis for the Southern Cross HVDC Tie Analysis
B	Appendix B_ONCOR_Southern_	Results for the Import Benchmark, 1500 MW, and 3000 MW Cases Used to Select Upgrades
C	Appendix C_ONCOR_Southern_	Results for the Export Benchmark, 1500 MW, and 3000 MW Cases Used to Select Upgrades
D	Appendix D_ONCOR_Southern_	Contingencies Examined for the Transient Stability Analysis for the Southern Cross HVDC Tie Analysis
E	Appendix E_ONCOR_Southern_	Channels Monitored for the Transient Stability Analysis



Appendix F
Proposed Rusk County Switch One-Line

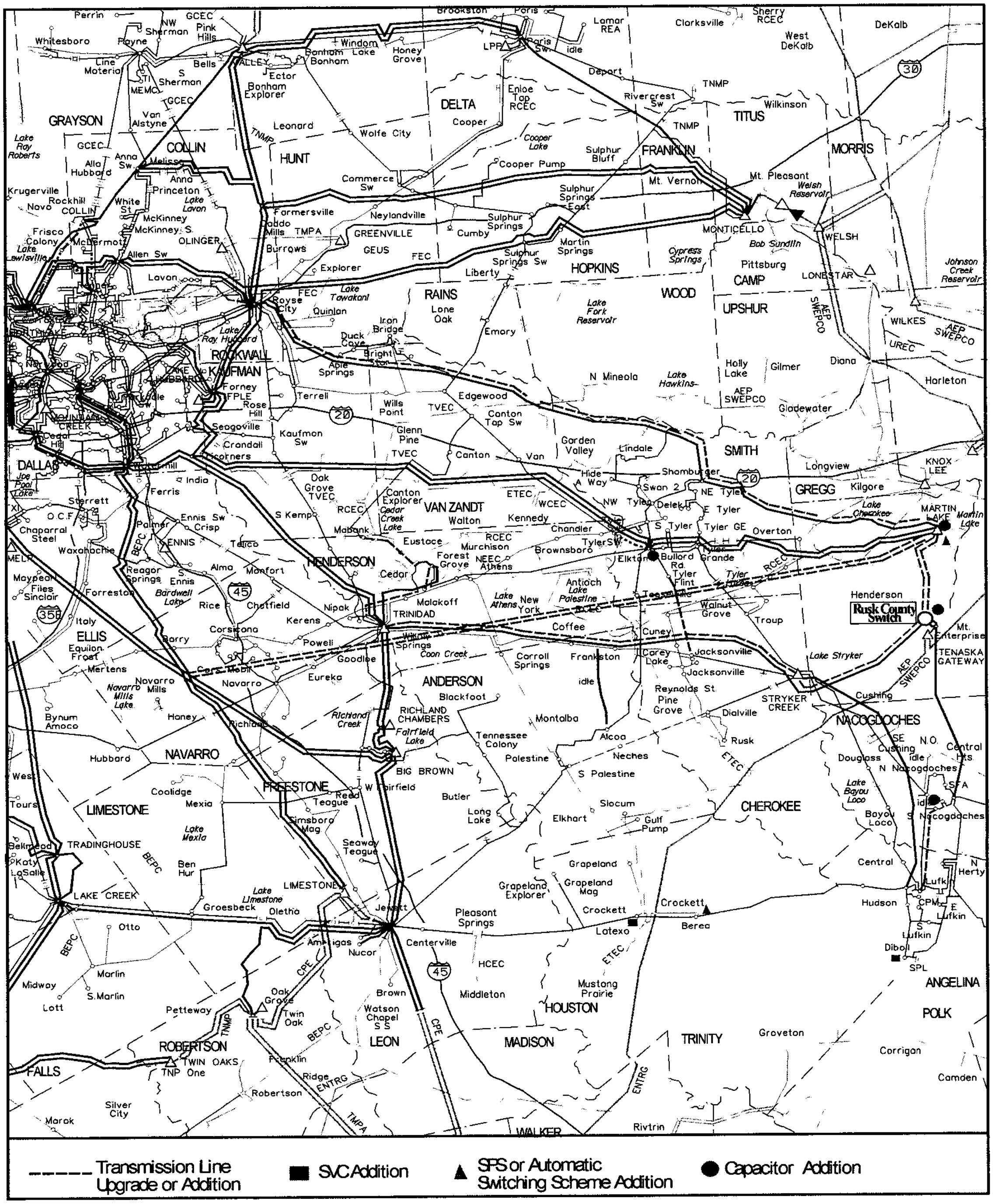


Appendix G
Benchmark Case Import/Export Upgrade Locations



Appendix H
1500 MW Case Import/Export Upgrade Locations

Oncor Electric Delivery – Proprietary and Confidential
Southern Cross HVDC Tie



Appendix I
3000 MW Case Import/Export Upgrade Locations

ERCOT'S RESPONSES TO COMMISSION STAFF'S FIRST REQUEST FOR INFORMATION TO THE ELECTRIC RELIABILITY COUNCIL OF TEXAS STAFF RFI NO. 1-1 THROUGH RFI NO. 1-11

Staff 1-1 **Has ERCOT undertaken or reviewed any reliability or interconnection studies related to the proposed Southern Cross Project? If so, does ERCOT believe that these studies are sufficient or are additional studies necessary?**

Response:

ERCOT has not undertaken its own studies but has reviewed the reliability/ interconnection studies related to the proposed Southern Cross Project performed by Oncor. ERCOT believes that these studies are sufficient to reliably interconnect the project.

PREPARER: Jeffrey Billo

WITNESS: Warren Lasher