RECEIVED
2016 APR 29 PM 1:56
PUBLIC UTILITY COMMISSION
FILING CLERK

SOAH DOCKET NO. 473-16-2751
PUC DOCKET NO. 45624

APPLICATION OF THE CITY OF GARLAND TO AMEND A CERTIFICATE OF CONVENIENCE AND NECESSITY FOR THE RUSK TO PANOLA DOUBLE-CIRCUIT 345-KV TRANSMISSION LINE IN RUSK AND PANOLA COUNTIES	§ § § § § § §	**STATE OFFICE OF ADMINISTRATIVE HEARINGS**

ERCOT'S RESPONSES TO COMMISSION STAFF'S FIRST REQUEST FOR INFORMATION TO ELECTRIC RELIABILITY COUNCIL OF TEXAS QUESTION NOS. STAFF 1-1 THROUGH STAFF 1-11

Electric Reliability Council of Texas, Inc. (ERCOT) provides the attached Responses to *Commission Staff's First Request for Information to Electric Reliability Council of Texas Staff RFI No. 1-1 through RFI No. 1-11*, filed on April 19, 2016. ERCOT's responses are due on April 29, 2016 and are therefore timely filed. ERCOT stipulates that all parties may treat these responses as if they were filed under oath.

Respectfully submitted,

/Chad V. Seely
Vice President and General Counsel
Texas Bar No. 24037466
(512) 225-7035 (Phone)
(512) 225-7079 (Fax)
chad.seely@ercot.com

Nathan Bigbee
Assistant General Counsel
Texas Bar No. 24036224
(512) 225-7093 (Phone)
(512) 225-7079 (Fax)
nathan.bigbee@ercot.com

Jennifer N. Littlefield
Corporate Counsel
Texas Bar No. 24074604
(512) 225-7179 (Phone)
(512) 225-7079 (Fax)
jennifer.littlefield@ercot.com

ERCOT
7620 Metro Center Drive
Austin, Texas 78744

ATTORNEYS FOR ELECTRIC
RELIABILITY COUNCIL OF TEXAS, INC.

CERTIFICATE OF SERVICE

I hereby certify that a copy of this document was served on all parties of record on April 29, 2016, by posting on the PUC Interchange in accordance with the provisions regarding service in SOAH Order No. 3 in this proceeding.

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

Staff 1-2 **If interconnected with the ERCOT transmission system, will the proposed Southern Cross Project qualify as the most severe single contingency on the ERCOT transmission system? If so, will additional Ancillary Services be necessary?**

Response:

Yes, the proposed Southern Cross Project will qualify as the most severe single contingency on the ERCOT transmission system, and ERCOT may need to procure additional Ancillary Services.

NERC Standard BAL-002-1 R3 requires ERCOT to maintain sufficient Contingency Reserve to cover the loss of the "most severe single contingency" (MSSC) in the ERCOT system. ERCOT's MSSC is currently1375 MW, which corresponds to the loss of one of the nuclear generators at South Texas Project (STP). As described in the application in this proceeding, the proposed Southern Cross Direct Current (DC) tie has an import capability of 2000 MW, which would establish a new supply-side MSSC for the ERCOT system. ERCOT meets its Contingency Reserve requirement by maintaining sufficient Physical Responsive Capability (PRC) through Responsive Reserve Service (RRS). Development of a larger MSCC would reduce the reliability margins that ERCOT is maintaining today which are above and beyond the minimum Contingency Reserve requirements. If it is necessary to maintain similar reliability margins, ERCOT will have to procure additional Ancillary Services.

The proposed Southern Cross Project would also establish a new most-severe single contingency on the demand side. The proposed DC tie's import and export limits are significantly higher than any of the existing DC ties. The export capability of 2100 MW in essence would have characteristics similar to that of a load of 2100 MW. Experiencing the loss of the DC tie while exporting 2100 MW would instantaneously send the grid frequency to a much higher value, although more detailed studies are needed to accurately estimate the peak post-contingency frequency under the expected range of system conditions. ERCOT currently does not have any Ancillary Services designed to address the high frequency events of such a large magnitude. If DC ties of such magnitude were to interconnect, ERCOT will need to investigate whether Primary Frequency Response (PFR) by the online generators coupled with the procurement of a substantially higher amount of Regulation Down service would be sufficient to moderate the frequency spike or whether it is necessary to design a new Ancillary Service that activates more quickly to return the frequency to normal bounds in order to reliably operate the grid.

PREPARER: Sandip Sharma

WITNESS: Dan Woodfin

Staff 1-3 **Has ERCOT identified any transmission upgrades that are necessary within ERCOT to facilitate imports and/or exports over the Southern Cross Project? If so, please provide a description of each transmission upgrade.**

Response:

No, ERCOT has not identified any projects that are necessary to facilitate imports and/or exports. However, ERCOT reviewed the Oncor reliability and interconnection studies that identified two sets of transmission upgrades that would allow imports and exports of 1500 MW and 3000 MW, respectively, over the Southern Cross Project. The Oncor study identifying such upgrades is attached.

PREPARER: Jeffrey Billo

WITNESS: Warren Lasher

Staff 1-4 **Please explain ramping limitation within the ERCOT transmission system and how interconnection of the proposed Southern Cross Project will interact with those ramp restrictions. What process exists for managing the ramping of flow through the Proposed Southern Cross Project?**

Response:

Generating units do not generally have the capability to change their output instantaneously, and different units change that output at different rates. In addition, the ramping capability of a particular generator may vary depending on its current operating conditions. Even the resources that are providing Ancillary Services take some period of time to respond to changes in system conditions. If the change in transfer over the DC tie exceeds the aggregate ability of the generating units on the ERCOT system to match that change, there will be an impact on system frequency until the change can be matched.

The OATI system used to schedule flows on the DC ties automatically builds in a ten-minute ramp each hour (i.e., the last five and the first five minutes of each hour) to accommodate the scheduled flows from one hour to the next. The tie operator then implements this schedule by adjusting the flows on the ties. These flows, including the ramping of the ties, are not controlled by ERCOT's market management tools. Consequently, other generators must be dispatched to address the impacts created by DC tie flows. In general, this means that the output of the generation on the ERCOT system must ramp at the same rate as the ramp of the DC tie transfer in order to maintain balance between generation and load in the ERCOT Interconnection and maintain frequency around 60 Hz. While this ten-minute ramp approach has generally not led to problems with the existing smaller ties, a new 2000 (or 2100) MW DC tie could create operational issues. If the DC tie is ramping from zero transfer in one hour to 2100 MW export in the next, then the other generation on ERCOT system must increase its output by 2100 MW within 10 minutes, which would exceed the ramping capability of the ERCOT system. Ramping from full import to full export (or vice versa), for a ramp of 4100 MW over 10 minutes, would certainly cause even greater problems. Given this elevated risk, ERCOT suggests that the DC tie schedules be integrated with market tools so that the ramping behavior of DC ties can be reliably managed. Extending the ramping period far beyond 10 minutes could also effectively achieve a ramp-rate limit on DC ties, but this would need to be addressed through a change to the OATI design.

PREPARER: Sandip Sharma

WITNESS: Dan Woodfin

Staff 1-5 **Please refer to the Direct Testimony of David Parquet at page 10, lines 3-12.**

a) **Does ERCOT agree that it will develop and execute a coordination agreement with the relevant Independent System Operator (ISO)/Regional Transmission Organization (RTO) / Balancing Authorities (BAs)?**
b) **If so, what issues need to be address in a coordination agreement?**
c) **What is the time frame for executing a coordination agreement?**

Response:

a) ERCOT agrees that it will need to develop a coordination agreement with the appropriate entity or entities. Whether such an agreement can be reached remains to be determined.

b) The coordination agreement is needed to address the following matters:
   - agreement to apply the NAESB standards governing DC tie interchanges (these standards otherwise only apply to FERC-jurisdictional public utilities per 18 C.F.R. § 38.1);
   - coordination and settlement of energy transfers during emergency conditions;
   - coordination and settlement of inadvertent energy transfers; and,
   - coordination of DC Tie outages.

   ERCOT's existing agreement with the Southwest Power Pool (SPP) incorporates by reference the ERCOT DC Tie Operations Procedure document, which provides the needed specificity on these matters. Whether these same terms would be included in an agreement with the counter-parties on the eastern end of the proposed Southern Cross Project remains to be determined.

c) This coordination agreement must be in place prior to energization of the DC tie. It is currently unclear where the eastern end of the DC line will be connected. That must be determined before it can be known what entities will need to be parties to the agreement(s). The identity of these entities and the NERC registration status of each such entity must be known before ERCOT can begin to work on the appropriate coordination agreements.

PREPARER: Stephen Solis

WITNESS: Dan Woodfin

Staff 1-6 **In regards to existing coordination agreements between ERCOT and other RTOs/ISOs/BAs, what is the process for operation of a DC tie line during an emergency situation?**

Response:

With respect to the current agreement between ERCOT and SPP, which incorporates the ERCOT DC Tie Operations Procedure document by reference, the Reliability Coordinator (RC) experiencing an emergency condition first notifies the other RC of the condition. If there are export flows on the DC tie for the RC with the emergency, that RC will seek to curtail the export flows by coordinating with the other RC to ensure that curtailing those exports will not create a reliability issue for the other RC. If the import capability is not being fully utilized, or after export flows have been curtailed, the RC with the emergency will then seek to maximize the import capability across the DC tie in coordination with the other RC.

PREPARER: Stephen Solis

WITNESS: Dan Woodfin

Staff 1-7 In the event of an emergency, what ability and authority would ERCOT have to manage power flows over the proposed Southern Cross Project to ensure reliability and quality of service?

Response:

As the NERC-designated Reliability Coordinator (RC) and Balancing Authority (BA) for the ERCOT region on one end of the DC tie, ERCOT would have the authority through the NERC Reliability Standards. Southern Cross Transmission LLC's (or any Affiliate) execution of the ERCOT Standard Form Market Participant Agreement would further formalize ERCOT's authority over the operation of the DC tie. In the event of any emergency, ERCOT would have the ability and authority under NERC Reliability Standards and ERCOT Protocols to direct the curtailment of any DC tie exports or to order the opening of the breaker connecting the DC tie to the ERCOT system so as to ensure reliability. However, these actions must be coordinated with the RC on the other end of the DC tie to avoid creating reliability issues for that RC.

Assuming that the DC tie operator is registered by NERC as a Transmission Operator (TOP) under the authority of ERCOT as the RC, ERCOT would, in the event of an emergency, have the ability and authority to direct the curtailment of any DC tie exports and to order the opening of the DC tie's breaker to ensure reliability and quality of service. Even under other NERC registration scenarios for the DC tie, ERCOT would still be the RC for the facilities used to connect the DC tie to the ERCOT system. These actions must be coordinated with the RC on the other side of the DC tie to avoid creating reliability issues for the other RC and to allow the DC tie to be available to provide import flows to assist with the emergency. However, it has not yet been determined whether Southern Cross (or any Affiliate) will be registered as a TOP, in which RC area the DC tie will be located, or which Regional Entity will register these facilities. So it is possible that an entity other than ERCOT will be the RC for the DC tie, in which case that RC would have the sole authority to curtail exports from ERCOT and to direct the opening of breakers to ensure reliability. In that case, ERCOT might need to modify its rules to reflect the authority of the other RC. See response to Staff 1-8.

PREPARER: Stephen Solis

WITNESS: Dan Woodfin

Staff 1-8 **Would ERCOT have the ability and authority to manage power flows across the proposed Southern Cross Project if any of the related equipment is located outside of Texas?**

Response:

Yes; the physical location of the DC tie should not inhibit ERCOT's role as the NERC-designated RC and BA for the synchronously connected ERCOT system, nor would it preclude ERCOT's application of its authority under the ERCOT Protocols, as further described in ERCOT's response to Staff 1-7.

Irrespective of whether ERCOT is determined to be the RC for the western converter station of the proposed Southern Cross Project, ERCOT could always disconnect the DC tie by opening a transmission breaker. However, this action would need to be coordinated with the RC on the other side of the DC tie and would prevent further usage of the DC Tie for import or export flows until the transmission breaker is closed back in.

PREPARER: Stephen Solis

WITNESS: Dan Woodfin

Staff 1-9 If it were necessary to shut off the proposed Southern Cross Project:

a) **Would ERCOT have the authority or ability to do so?**
b) **Would ERCOT need a physical/direct connection to accomplish this?**
c) **Would shutting off the proposed Southern Cross Project require Southern Cross to act? If so, is there a way to give control to ERCOT, the City of Garland, or Oncor Electric Delivery Company?**

Response:

a) Yes. NERC Reliability Standard IRO-001-1.1 R3 and R8 authorizes ERCOT to curtail any existing scheduled transaction that cannot be reliably accommodated.
b) As proposed, the Southern Cross Project would be interconnected directly with the ERCOT system, and so, if necessary, ERCOT would be able to instruct the Transmission Operator for the bus where the project interconnects to the ERCOT system to open any breakers needed to separate the DC tie from the ERCOT transmission system. If it were assumed that ERCOT were deemed to have no operational authority over the Southern Cross converter station in Louisiana (which ERCOT does not believe would be true), ERCOT would still have control over the facilities at the proposed substation in Texas, and could instruct the Transmission Operator to open the appropriate breakers at that substation if that were necessary to ensure system reliability. In either case, the Transmission Operator has the physical/direct ability to operate the equipment while ERCOT would issue instructions to the Transmission Operator consistent with currently utilized practices.
c) Under current procedures, if ERCOT identified a concern that required flows on a DC tie to be curtailed, ERCOT would first contact the tie operator to curtail the transactions on the DC tie (after contacting the appropriate RC/BA on the other end of the tie). If for some reason the tie operator did not respond to the ERCOT instruction, ERCOT would order the Transmission Operator for the proposed Panola substation (which ERCOT presumes will be Garland Power & Light) to open the breakers connecting the DC tie to the ERCOT system.

PREPARER: Stephen Solis

WITNESS: Dan Woodfin

Staff 1-10 If the proposed Southern Cross Project is built and interconnected to ERCOT, in what ways would it be more difficult to coordinate outages?

Response:

Outage coordination requires ERCOT to predict future system conditions—including DC tie imports or exports—with some measure of accuracy so that it can determine whether requested outages of generators and transmission elements can occur contemporaneously while maintaining system reliability. The expected availability of imports over DC ties may lead ERCOT to allow transmission outages in a particular area because the outages do not violate operational reliability criteria. If a DC tie ends up exporting instead, ERCOT may not have sufficient generation to meet system load or it could result in post-contingency transmission overloads that cannot be resolved by redispatch. The consequences may be that ERCOT has to curtail exports over the DC tie or withdraw approval of the outage. Conversely, if the DC tie is predicted to be exporting, then it will be modeled much like firm load and ERCOT will ensure that generation is available to meet the predicted demand. An incorrect prediction in this situation may also result in post-contingency transmission overloads that cannot be resolved by redispatch and require the DC tie transfer to be cut. With substantially larger DC ties, these problems become much more difficult, and ERCOT's margin of error in outage coordination increases substantially.

ERCOT will need to substantially expand its analytical capabilities to incorporate the proposed Southern Cross Project into outage coordination because the new tie will exponentially increase the contingency scenarios that must be studied and/or to improve predictions of likely future DC tie transfers. This will increase costs for ERCOT.

ERCOT will also need to consider how conservative to be when incorporating the proposed Southern Cross Project into outage schedule modeling. Being more conservative limits the number of potential outages that can be accommodated because ERCOT would need to plan for a wide swing from maximum export to maximum import capability of the Southern Cross DC tie at any given time. This is a difference of approximately 4,100 MW, assuming a maximum export of 2,100 MW, and a maximum import of 2,000 MW. On the other hand, if ERCOT were to take a less conservative approach and rely more heavily on expectations for future transfers, situations are more likely to arise for which ERCOT would need to cut the DC tie transfer or cancel previously approved outages.

PREPARER: Dan Woodfin

WITNESS: Dan Woodfin

Staff 1-11 In what ways would the addition of the proposed Southern Cross Project affect contingency models for the ERCOT transmission system?

Response:

The contingency loss of the proposed Southern Cross Project will need to be added to the contingency definition list that ERCOT operators and planners use to study system reliability, similar to the addition of a new transmission circuit or a new generation resource.

PREPARER: Jeffrey Billo

WITNESS: Warren Lasher

Southern Cross HVDC Tie Study Report

Oncor Electric Delivery Company LLC
System Planning
June 14, 2013

Executive Summary

Oncor was commissioned to perform a Steady State contingency analysis and a Transient Stability analysis to examine the impacts of an asynchronous high voltage direct current (HVDC) tie between ERCOT and SERC. The intent of the study was to determine the impact of the HVDC tie on thermal loading, system voltages and stability of the Oncor / ERCOT transmission system.

The study was performed for six different scenarios: a Benchmark Import case, a 1500 MW Import case, a 3000 MW Import case, a Benchmark Export case, a 1500 MW Export case and a 3000MW Export case, with all six cases having a generation profile prepared by ERCOT. All thermal, voltage and stability violations were addressed with multiple planning actions to ensure the reliability of the Oncor and ERCOT transmission system under contingency. Table 1 gives a comprehensive look at the amount of construction and upgrades necessary to connect the HVDC tie at the proposed levels.

Table 1 – Total New and Upgraded Equipment Required for Southern Cross Project

	IMPORT				EXPORT		
	Benchmark	1500 MW	3000 MW		Benchmark	1500 MW	3000 MW
New circuit miles	147 miles	147 miles	407 miles		0	0	147 miles
Upgrade circuit miles	23 miles	24 miles	293.9 miles		0	0	99.4 miles
Autotransformer	750 MVA	750 MVA	750 MVA		750 MVA	750 MVA	750 MVA
New Reactive	80 MVar	480 MVar	1200 MVar		0	640 MVar	1800 MVar
Series Reactor	2-ohm	2-ohm	2-ohm		0	0	0

Table 2 details the needed upgrades and construction necessary to resolve all thermal and voltage violations for each of the respective import/export cases. Electric power can be exported from ERCOT to SERC with a minimum amount of transmission upgrades, particularly at the lower level of generation export. However, the ability to import the same amount of power into ERCOT requires a much greater amount of construction of new lines, upgrades of existing lines and additions of shunt capacitors and a series reactor.

Table 3 details the need for various equipment and system protection actions to resolve all stability violations for each studied case. Because of the sensitivity of the transmission system in the area around where the HVDC tie will connect to the Oncor Transmission system, a new breaker switching scheme and two small dynamic reactive devices (DRDs) were needed to maintain stability on the 138 kV system. For this project two Static Var Compensators (SVCs) were evaluated and provided the necessary dynamic support.

TABLE 2 - Upgrades Needed to Alleviate Thermal and Voltage Issues

Ref. No	Transmission Line and Equipment	kV	Ckt	Length	Existing (MVA)	New 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	-	-	-

Notes 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)

TABLE 3 - Upgrades / Action Items Needed to Alleviate Stability Issues

				Action Items						
				IMPORT				EXPORT		
Ref. No	Transmission Line and Equipment	kV	Upgrade / Action Item	Benchmark	1500 MW	3000 MW		Benchmark	1500 MW	3000 MW
1	Crockett	69	+100 MVar SVC	Yes	Yes	Yes		Yes	Yes	Yes
2	Diboll	138	+80 MVar SVC	Yes	Yes	Yes		Yes	Yes	Yes
3	Crockett - Berea	138	Breaker Switching Scheme	Yes	Yes	Yes		Yes	Yes	Yes

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY

ONCOR

STEADY STATE ANALYSIS

1.0 STUDY PURPOSE

Southern Cross Transmission LLC submitted an interconnection request for an asynchronous high voltage direct current (HVDC) tie between the Electric Reliability Council Of Texas (ERCOT) transmission system and the Southeastern Electric Reliability Council (SERC) transmission system. This project consists of the construction of a proposed 345 kV Switching Station (Rusk Switch) in Rusk County Texas, an approximately 50-mile, double-circuit, 345 kV transmission line from Rusk Switch to the HVDC tie, currently proposed to be located in Louisiana.

The interconnection request was evaluated to determine the ability of the ERCOT transmission system to accommodate up to a 3000 MW import and export capacity of the Tie and identify any related reliability concerns. Oncor proposed to perform a Steady State contingency analysis and a Transient Stability analysis to examine the impacts of the HVDC tie on thermal loading, system voltages and stability of the Oncor transmission system. For this project there were six scenarios that were studied. These scenarios were:

1. A Benchmark Import case
2. A 1500 MW Import case with an 1500 MW power transfer from SERC into the ERCOT system
3. A 3000 MW Import case with an 3000 MW power transfer from SERC into the ERCOT system
4. A Benchmark Export case
5. A 1500 MW Export case with an 1500 MW power transfer from ERCOT into the SERC system
6. A 3000 MW Export case with an 3000 MW power transfer from ERCOT into the SERC system

2.0 ASSUMPTIONS

The Steady-State Study was performed with the following assumptions:

1. For Import into ERCOT from SERC

   - The project was studied with a 2015 Summer base case created and updated just prior to when the study commenced.

- ERCOT provided economic dispatch for the generation in each of the cases
    - Wind generation was dispatched as typical for summer cases
    - Generation in the Rusk County area was dispatched as
        - Martin Lake #1 – 805 MW
        - Martin Lake #2 – 810 MW
        - Martin Lake #3 – 810 MW
        - Tenaska Gateway – 846 MW
        - Stryker Creek #1 – 171 MW
        - Stryker Creek #2 – 502 MW
        - Aspen #1 – 50 MW
        - Nacogdoches #1 – 100 MW
- The Rusk County Switch was not modeled in the Benchmark case, but was modeled in the 1500 MW and 3000 MW cases.

2. For Export from ERCOT to SERC

- The project was studied with a 2015 Summer base case and scaling the load down to 41% of summer peak.
- ERCOT provided economic dispatch for the generation in each of the cases
    - Wind generation was modeled at CREZ build-out levels and dispatched at 80% of nameplate.
    - Generation in the Rusk County area was dispatched as
        - Martin Lake #1 – 805 MW
        - Martin Lake #2 – 810 MW
        - Martin Lake #3 – 0 MW
        - Tenaska Gateway – 0 MW
        - Stryker Creek #1 – 0 MW
        - Stryker Creek #2 – 0 MW
        - Aspen #1 – 50 MW
        - Nacogdoches #1 – 100 MW
- The Rusk County Switch was not modeled in the Benchmark case, but was modeled in the 1500 MW and 3000 MW cases.

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 32.1.1 was used for this study. The analysis examined the thermal and voltage violations observed in Oncor zones 130 through 148 for the 345 kV to 69 kV buses. 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.

2.1 Contingency Descriptions

The contingencies examined for this analysis are listed below:

- All "Special Contingencies" in the Southerncrossbasic.con file
- 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.

3.0 BASE CASE SYSTEM CONDITIONS

3.1 Oncor System Power Flow 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. Additionally, the shunt capacitor banks listed in Table 3.1-1 were added to allow the power flows to solve while Importing or Exporting 3000 MW of power.

Table 3.1-1
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 3.1-2 summarizes the Oncor system (Area 1) power flow conditions for the Import base cases and the final cases after adding the upgrades and eliminating the thermal and voltage violations.

Table 3.1-3 lists the Export base case and final power flow conditions. The only upgrade incorporated into the Export Benchmark and 1500 MW cases was the addition of the Collin 345/138 kV #2 Autotransformer. As mentioned earlier, the Export 3000 MW case required upgrades to allow all the contingencies to converge with an acceptable mismatch error and to eliminate any thermal or voltage violations that occurred.

Table 3.1-2
2015 Summer Import Cases

Case	Upgrades	Units	From Generation	To Load Area	To Bus Shunt	To GNE Bus	To Line Shunt	From Charging	To Loses	Net Interchange To Tie Lines	Net Interchange To Tie + Lines	Desired Net Int
Import Benchmark	Base	MW	29403.2	24466.7	0	0	0	0	676	4260.6	4260.6	0
		MVAR	2041.4	7049.1	-8573.2	0	0	6501	9735.4	331.2	331.2	
	Final	MW	29403.2	24466.7	0	0	0	0	650.9	4285.6	4285.6	0
		MVAR	1664.9	7049.1	-8570.5	0	0	6668.1	9534.1	230.3	320.3	
Import 1500 MW	Base	MW	30203.2	24466.7	0	0	0	0	883.4	4853.1	4853.1	0
		MVAR	3482.7	7049.1	-10023	0	0	6598.7	12823	231.5	231.5	
	Final	MW	30203.2	24466.7	0	0	0	0	830.4	4906.1	4906.1	0
		MVAR	2771.3	7049.1	-10183	0	0	6766.2	12422	250.1	250.1	
Import 3000 MW	Base	MW	30966.1	24466.7	0	0	0	0	1302.2	5197.1	5197.1	0
		MVAR	4692.1	7049.1	-13986	0	0	6611.1	17887	353.4	353.4	
	Final	MW	30966	24466.7	0	0	0	0	1118.6	5380.8	5380.8	0
		MVAR	3375.1	7049.1	-13452	0	0	7138.5	16485	433.1	433.1	

Table 3.1-3
2015 Summer Export Cases

Case	Upgrades	Units	From Generation	To Load Area	To Bus Shunt	To GNE Bus	To Line Shunt	From Charging	To Loses	Net Interchange To Tie Lines	Net Interchange To Tie + Lines	Desired Net Int
Export Benchmark	Base and Final	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	-227.1	
Export 1500 MW	Base and Final	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	-868.5	-868.5	
Export 3000 MW	Base	MW	10113.6	9508	0	0	0	0	556.2	49.5	49.5	0
		MVAR	1993	2739.3	-1817	0	0	6495.8	8509	-942.3	-924.3	
	Final	MW	10113.6	9508	0	0	0	0	550	55.7	55.7	0
		MVAR	1741.8	2739.3	-1973	0	0	6699.7	6699.7	-703.4	-703.4	

3.2 Major East Texas Line Loading

The following tables list the major East Texas line loading for Base Case conditions:

- Table 3.2-1: Major East Texas line loading in the Import Benchmark Case
- Table 3.2-2: Major East Texas line loading in the Import 1500 MW Case
- Table 3.2-3: Major East Texas line loading in the Import 3000 MW Case
- Table 3.2-4: Major East Texas line loading in the Export Benchmark Case
- Table 3.2-5: Major East Texas line loading in the Export 1500 MW Case
- Table 3.2-6: Major East Texas line loading in the Export 3000 MW Case

Table 3.2-1
Major East Texas Line Loading in the Import Benchmark Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base [1]		MEPPI Base		MEPPI Final	
						Rating [2] (MVA)	% FLOW	Rating [2] (MVA)	% FLOW	Rating [2] (MVA)	% FLOW
1	2478-3103-1	Royse South	Shamburger	345	81	1072	56	1072	55	1072	42
2	2437-3105-1	Forney	Elkton	345	92	1072	52	956[3]	51	1072	40
3	3116-3124-1	Mount Enterprise	Trindad 2	345	93	1072	48	1072	50	1072	40
4	3100-3103-1	Martin Lake	Shamburger	345	44	1631	47	1631	46	1631	37
5	3100-3102-1	Martin Lake	Tyler Grande	345	43	1631	44	1631	44	1631	36
6	3100-3105-1	Martin Lake	Elkton	345	48	1631	41	1631	41	1631	34
7	3109-3123-1	Stryker Creek SES	Trindad 1	345	69	1072	41	1072	44	1072	37
8	3100-3109-1	Martin Lake	Stryker Creek	345	41	1631	23	1631	23	1631	14
9	3100-3116-1	Martin Lake	Mount Enterprise	345	19	1631	8	1631	6	1631	9

1 Data Provided in the " *Southern Cross HVDC Tie Steady-State Study Report*"
2 Values were the same for Rating A, B, and C unless otherwise noted
3 The MVA rating of these lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C.

Table 3.2-2
Major East Texas Line Loading in the Import 1500 MW Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base [1]		MEPPI Base		MEPPI Final	
						Rating [2] (MVA)	% FLOW	Rating [2] (MVA)	% FLOW	Rating [2] (MVA)	% FLOW
1	2478-3103-1	Royse South	Shamburger	345	81	1072	78	1072	79	1072	61
2	3124-9997-1	Trinidad 2	Rusk County Switch	345	92	1072	77	1072	77	1072	64
3	3109-3123-1	Stryker Creek	Trinidad 1	345	69	1072	75	1072	77	1072	65
4	2437-3105-1	Forney	Elkton	345	92	1072	73	956[3]	74	1072	52
5	3100-3103-1	Martin Lake	Shamburger	345	44	1631	63	1631	62	1631	50
6	3100-3102-1	Martin Lake	Tyler Grande	345	43	1631	59	1631	59	1631	48
7	3100-3105-1	Martin Lake	Elkton	345	48	1631	55	1631	55	1631	45
8	3109-9997-1	Stryker Creek	Rusk County Switch	345	24	1631	50	1631	49	1631	35
9	3116-9997-1	Mount Enterprise	Rusk County Switch (Circuit 1)	345	1	1631	21	1631	22	1631	17
10	3116-9997-2	Mount Enterprise	Rusk County Switch (Circuit 2)	345	1	1631	30	1072	32	1072	24
11	3100-9997	Martin Lake	Rusk County Switch (Circuits 1 & 2)	345	18	1631	14	1631	15	1631	22

1 Data Provided in the " *Southern Cross HVDC Tie Steady-State Study Report*"
2 Values were the same for Rating A, B, and C unless otherwise noted
3 The MVA rating of this lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C.

Table 3.2-3
Major East Texas Line Loading in the Import 3000 MW Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base[1]		MEPPI Base		MEPPI Final	
						Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW
1	2478-3103-1	Royse South	Shamburger	345	81	1072	106	1072	101	1072	62
2	3124-9997-1	Trinidad 2	Rusk County Switch	345	92	1072	104	1072	106	1631	49
3	3109-3123-1	Stryker Creek	Trinidad 1	345	69	1072	106	1072	105	1631	49
4	2437-3105-1	Forney	Elkton	345	92	1072	101	956[3]	93	1072	52
5	3100-3103-1	Martin Lake	Shamburger	345	44	-	-	1631	76	1631	51
6	3100-3102-1	Martin Lake	Tyler Grande	345	43	-	-	1631	73	1631	47
7	3100-3105-1	Martin Lake	Elkton	345	48	-	-	1631	67	1631	43
8	3109-9997-1	Stryker Creek	Rusk County Switch	345	24	-	-	1631	69	2390	30
9	3116-9997-1	Mount Enterprise	Rusk County Switch (Circuit 2)	345	1	-	-	1631	20	1631	17
10	3116-9997-2	Mount Enterprise	Rusk County Switch (Circuit 1)	345	1	-	-	1072	30	1072	24
11	3100-9997-1	Martin Lake	Rusk County Switch (Circuits 1)	345	18	-	-	1631	36	1631	57

1 Data Provided in the "*Southern Cross HVDC Tie Steady-State Study Report*" by ONCOR
2 Values were the same for Rating A, B, and C unless otherwise noted
3 The MVA rating of this lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C.

Table 3.2-4
Major East Texas Line Loading in the Export Benchmark Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base[1]		MEPPI Base		MEPPI Final	
						Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW
1	2478-3103-1	Royse South	Shamburger	345	81	1072	22	1072	23	1072	23
2	2437-3105-1	Forney	Elkton	345	92	1072	25	956[3]	23	1072	21
3	3116-3124-1	Mount Enterprise	Trindad 2	345	93	1072	23	1072	22	1072	22
4	3100-3103-1	Martin Lake	Shamburger	345	44	1631	20	1631	20	1631	20
5	3100-3102-1	Martin Lake	Tyler Grande	345	43	1631	20	1631	22	1631	22
6	3100-3105-1	Martin Lake	Elkton	345	48	1631	21	1631	20	1631	20
7	3109-3123-1	Stryker Creek SES	Trindad 1	345	69	1072	22	1072	21	1072	21
8	3100-3109-1	Martin Lake	Stryker Creek	345	41	1631	19	1631	18	1631	18
9	3100-3116-1	Martin Lake	Mount Enterprise	345	19	1631	20	1631	18	1631	18

1 Data Provided in the " *Southern Cross HVDC Tie Steady-State Study Report*"

2 Values were the same for Rating A, B, and C unless otherwise noted

3 The MVA rating of this lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C.

Table 3.2-5
Major East Texas Line Loading in the Export 1500 MW Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base[1]		MEPPI Base		MEPPI Final	
						Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW
1	3100-9997	Martin Lake	Rusk County Switch (Circuits 1&2)	345	18	1631	40	1631	40	1631	40
2	2437-3105-1	Forney	Elkton	345	92	1072	12	956[3]	9	1072	8
3	3109-3123-1	Stryker Creek	Trinidad 1	345	69	1072	12	1072	13	1072	13
4	3100-3105-1	Martin Lake	Elkton	345	48	1631	10	1631	10	1631	10
5	3124-9997-1	Trinidad 2	Rusk County Switch	345	92	1072	10	1072	12	1072	12
6	3109-9997-1	Stryker Creek	Rusk County Switch	345	24	1631	9	1631	8	1631	8
7	3100-3103-1	Martin Lake	Tyler Grande	345	43	1631	6	1631	5	1631	5
8	3100-3103-1	Martin Lake	Shamburger	345	44	1631	6	1631	5	1631	5
9	2478-3103-1	Royse South	Shamburger	345	81	1072	3	1072	6	1072	6
10	3116-9997-1	Mount Enterprise	Rusk County Switch (Circuit 1)	345	1	1631	1	1631	1	1631	1
11	3116-9997-2	Mount Enterprise	Rusk County Switch (Circuit 2)	345	1	1631	1	1072	1	1072	2

1 Data Provided in the " *Southern Cross HVDC Tie Steady-State Study Report*"

2 Values were the same for Rating A, B, and C unless otherwise noted

3 The MVA rating of this lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C

Table 3.2-6
Major East Texas Line Loading in the Export 3000 MW Case

Ref. No.	To-From-CKT	To Bus	From Bus	Voltage (kV)	Length (Mi)	ONCOR Base[1]		MEPPI Base		MEPPI Final	
						Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW	Rating[2] (MVA)	% FLOW
1	3100-9997	Martin Lake	Rusk County Switch (Circuits 1&2)	345	18	1631	65	1631	65	1912	54
2	2437-3105-1	Forney	Elkton	345	92	1072	22	956[3]	24	1072	21
3	3109-3123-1	Stryker Creek	Trinidad 1	345	69	1072	48	1072	50	1072	19
4	3100-3105-1	Martin Lake	Elkton	345	48	1631	11	1631	14	1631	9
5	3124-9997-1	Trinidad 2	Rusk County Switch	345	92	1072	45	1072	48	1072	43
6	3109-9997-1	Stryker Creek	Rusk County Switch	345	24	1631	32	1631	34	1912	54
7	3100-3103-1	Martin Lake	Tyler Grande	345	43	1631	10	1631	12	1631	9
8	3100-3103-1	Martin Lake	Shamburger	345	44	1631	10	1631	12	1631	9
9	2478-3103-1	Royse South	Shamburger	345	81	1072	22	1072	25	1072	21
10	3116-9997-1	Mount Enterprise	Rusk County Switch (Circuits 1)	345	1	1631	18	1631	5	1631	3
11	3116-9997-2	Mount Enterprise	Rusk County Switch (Circuits 2)	345	1	1631	18	1072	7	1072	5

1 Data Provided in the "*Southern Cross HVDC Tie Steady-State Study Report*"

2 Values were the same for Rating A, B, and C unless otherwise noted

3 The MVA rating of this lines in PSSE was 956 MVA for Rating A and B and 1072 MVA for Rating C.

3.3 HVDC Model Parameters

The following figures show one-line diagrams of the Rusk County Switching Station 345 kV and the HVDC tie from the final cases with all the upgrades selected:

- Figure 3.3-1: One-line diagram of the Rusk County Switching Station 345 kV and the HVDC tie for the 1500 MW Import final case
- Figure 3.3-2: One-line diagram of the Rusk County Switching Station 345 kV and the HVDC tie for the 3000 MW Import final case
- Figure 3.3-3: One-line diagram of the Rusk County Switching Station 345 kV and the HVDC tie for the 1500 MW Export final case
- Figure 3.3-4: One-line diagram of the Rusk County Switching Station 345 kV and the HVDC tie for the 3000 MW Export final case

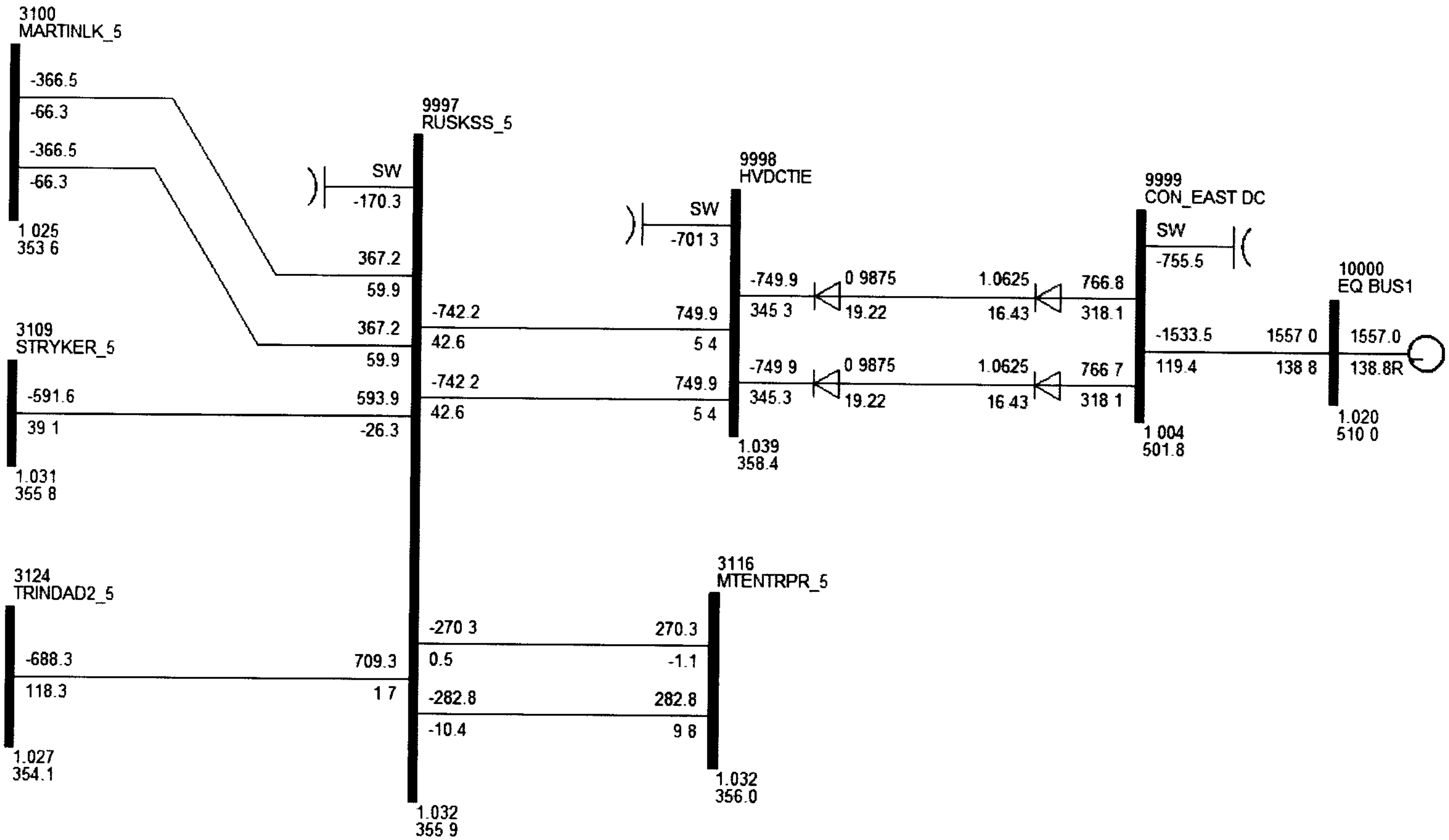

Figure 3.3-1: One-line diagram of the Rusk County 345 kV Switching Station and the HVDC tie for the 1500 MW Import final case.

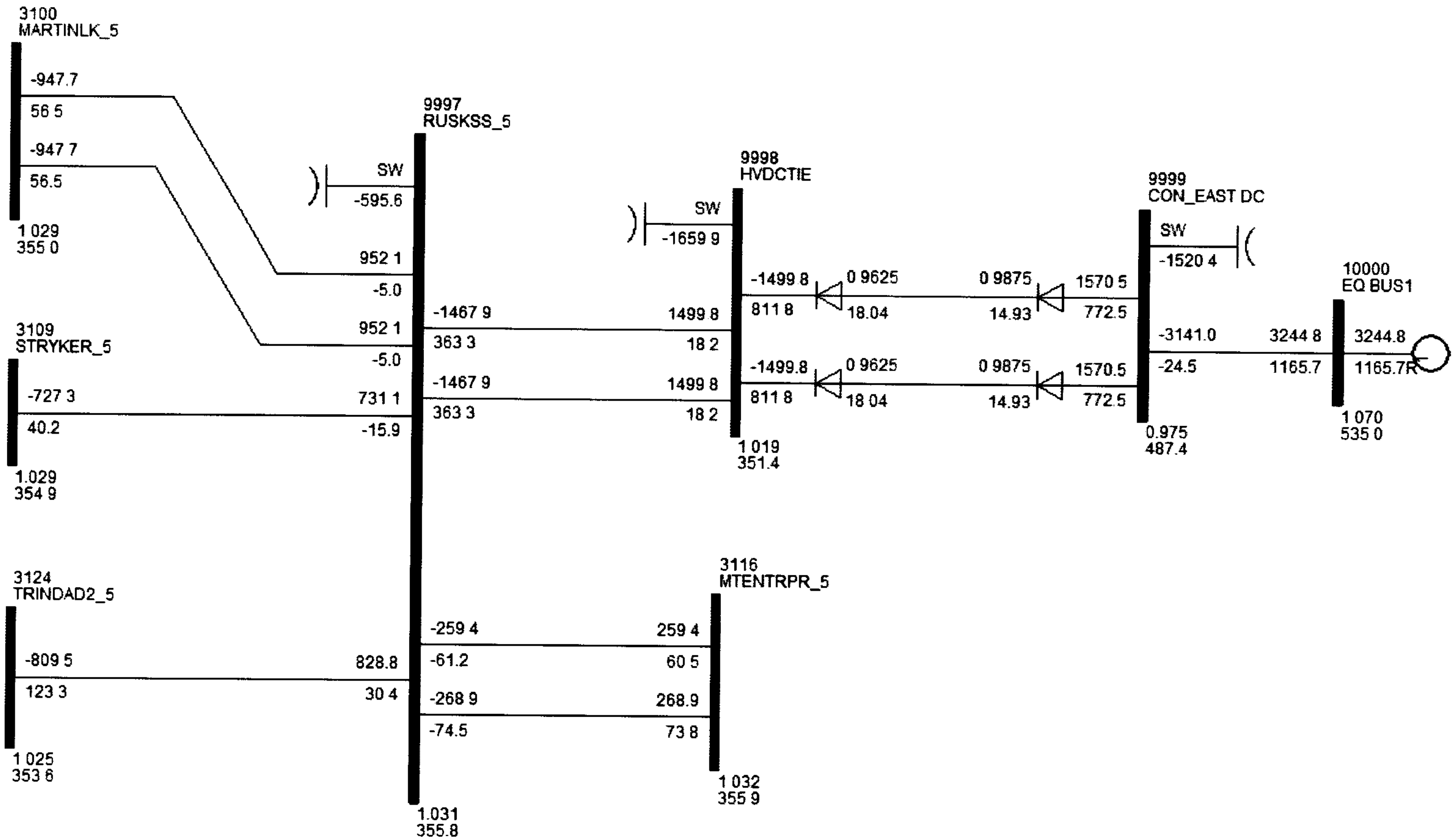

Figure 3.3-2: One-line diagram of the Rusk County 345 kV Switching Station and the HVDC tie for the 3000 MW Import final case.

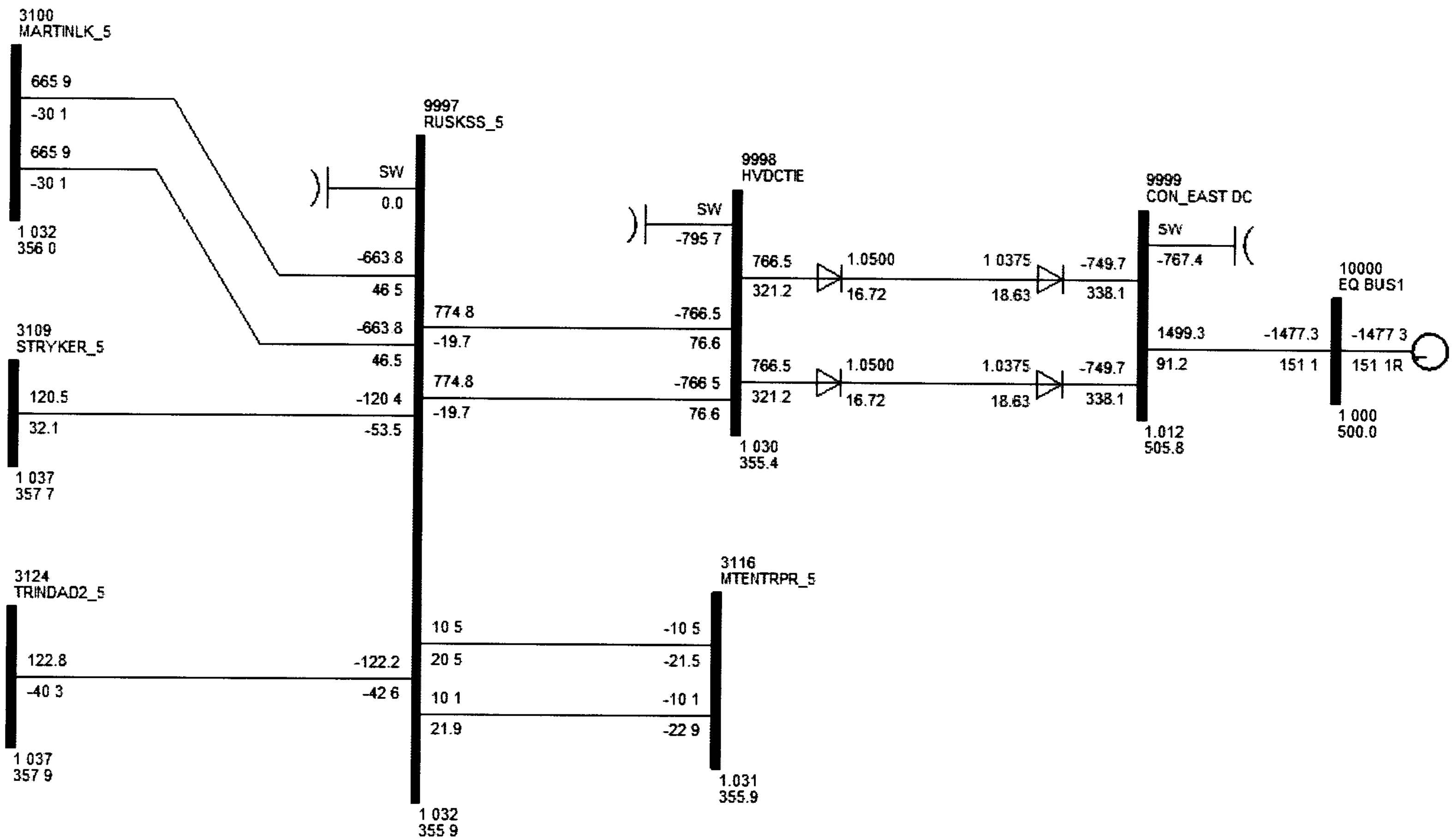

Figure 3.3-3: One-line diagram of the Rusk County 345 kV Switching Station and the HVDC tie for the 1500 MW Export final case.

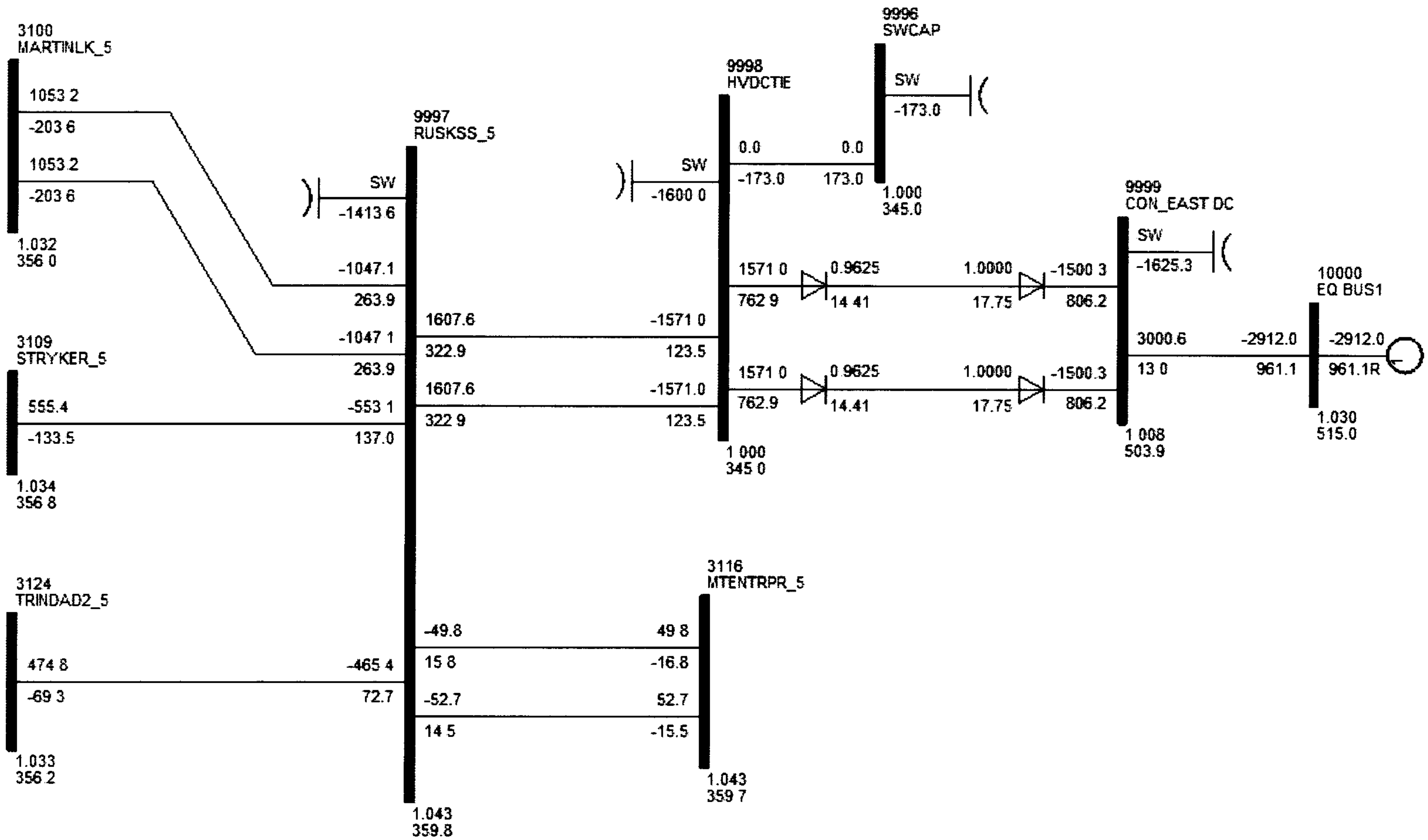

Figure 3.3-4: One-line diagram of the Rusk County 345 kV Switching Station and the HVDC tie for the 3000 MW Export final case.

Table 3.3-1 lists the model parameters for the HVDC model in PSSE for the Import cases. Table 3.3-2 lists the model parameters for the HVDC model in PSSE for the Export cases.

Table 3.3-1
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 3.3-2
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

4.0 RESULTS FOR THE STEADY STATE CONTINGENCY ANALYSIS

This section reports on the upgrades examined to eliminate the thermal and voltage violations in Zones 130 through 148 for 345 kV to 69 kV buses for the Benchmark, 1500 MW, and 3000 MW Import and Export case. Table 4.0-1 is a summary of new/upgraded transmission lines and transformers that were added to eliminate thermal violations.

Table 4.0-1
New/Upgraded Equipment Examined to Eliminate Thermal Violations

Ref. No.	Transmission Lines and Equipment	kV	CKT	Base Case [1] (MVA)	Length (miles)	New MVA Ratings for Transmisison Lines and Equipment [2]					
						Import			Export		
						Benchmark Line (MVA)	1500 MW Line (MVA)	3000 MW Line (MVA)	Benchmark Line (MVA)	1500 MW Line (MVA)	3000 MW Line (MVA)
1	Lufkin Switch to Nacogdoches SE (3117-3119)	345	1	N/A	23	1631	1631	1631	-	-	1631
2	Martin Lake to Royse North (3100-2461)	345	1	N/A	124	1631	1631	1631	-	-	1631
3	Martin Lake to Stryker (3100-3109)	345	1	1631 [3]	41	-	-	1631	-	-	1631
4	Martin Lake to Nararro (3100-68091)	345	1	N/A	130	-	-	1631	-	-	-
5	Martin Lake to Nararro (3100-68091)	345	2	N/A	130	-	-	1631	-	-	-
6	Trinidad to Styker (3123-3109)	345	1	1072	68 6	-	-	1631	-	-	-
7	Rusk to Trinidad (9997-3124)	345	1	1072	92	-	-	1631	-	-	-
8	Rusk to Stryker (9997-3109)	345	1	1631	23 4	-	-	2390	-	-	1912
9	Rusk to Martin Lake (9997-3100)	345	1	1631	17.5	-	-	-	-	-	1912
10	Rusk to Martin Lake (9997-3100)	345	2	1631	17 5	-	-	-	-	-	1912
11	Tyler Grande to Tyler G E. (3143-3213)	345	1	326	1	-	484	484	-	-	-
12	Dialville to Neches Pump (3160-3296)	138	1	214	15 5	-	-	326	-	-	-
13	Palestine South to Neches Pump (3271-3296)	138	1	214	9.5	-	-	326	-	-	-
14	Trinidad to Malakoff (3127-3276)	138	1	251	8.1	-	-	326	-	-	-
15	Forest Grove to Mabank Tap (3131-29266)	138	1	251	3.7	-	-	326	-	-	-
16	Malakoff to Mabank Tap (3276-29266)	138	1	251	3.7	-	-	326	-	-	-
17	Elkton to Tyler Southwest (3106-3139)	138	1	214	5	326	326	326	-	-	-
18	Tennyson Plano to Preston Meadows (2523-10010)	138	1	287	1	484	484	484	-	-	-
19	Flint to Jacksonville (3251-3253)	138	1	N/A	10.34	-	-	326	-	-	-
20	Collin to Northwest Carrolton (multiple branches)	138	2	N/A	17	326	326	326	-	-	-
21	Collin S E S Auto Transformer	345/138	2	N/A	N/A	Rating A = 700 MVA Rating B and C = 750 MVA					

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 Strker Creek 345 kV was modeled in the Import 3000 MW case

4.1 IMPORT CASES

New transmission lines were examined to determine their impacts on thermal overloading violations identified in the Import 1500 MW case. The base case 1500 MW Import thermal overloading results without any transmission line upgrades or additions modeled were compared to the 1500 MW Import case with one new transmission modeled at a time to determine the impact each upgrade had on the thermal overloading violations. Table 4.1-1 lists the results of the new transmission lines for the Import 1500 MW case on thermal overloads during contingency analysis for Base Case conditions (i.e., pre-upgrades).

ONCOR

Table 4.1-1
Summary of the Impact of New Transmission Lines for the Import 1500 MW Case on Thermal Overloads

Ref. No.	To	To Bus	kV	From	From Bus	kV	CK	Contingency	Import 1500 MW Base Case (No Upgrades)				Import 1500 MW Base Case + New Transmission Line Flow (%)[1,2]							
									Flow (MVA)	Flow (Amps)	Rate A/B	Flow (%)	Mount Enterprise to Nacogdoches 345 kV CKT 2	Lufkin Switch to Jewett Switch 345 kV CKT 1	Lufkin Switch to Nacogdoches SE 345 kV CKT 1	Martin Lake to Royse North 345 kV CKT 1	Martin Lake to Stryker Creek 345 kV CKT 1	Rusk County to Navarro 345 kV CKT 1	Lufkin Switch to Big Brown 345 kV CKT 1	Lufkin Switch to Nacogdoches SE 345 kV CK1 and Martin Lake to Royse North 345 kV CKT 1
1	2370	COLLINSS1_8	138	629	ROMANJUAREZ	138	1	PLTNAUSTRNCH	-348.21	346.59	326	106.32	105.80	105.72	-	-	-	-	-	-
2	3128	TRINIDAD_9	69	3239	ATHENS_9	69	1	FG-MABK-ATH	-35.00	35.94	32	112.30	112.12	102.61	111.85	-	110.82	-	105.19	-
3	2437	FRNY1_5	345	3105	ELKTON_5	345	1	SHAM-ROY-TY1	-876.77	999.04	956	104.50	100.36	-	-	-	-	-	-	-
4	3104	SHAMBRGR_8	138	3141	TYLERNW_8	138	1	SHAM-ROY-TY1	222.56	241.53	214	112.86	108.88	100.72	106.65	-	102.67	-	101.72	-
5	3123	TRINDAD1_5	345	3109	STRYKER_5	345	1	SHAM-ROY-TY1	-1038.42	1111.71	1072	103.70	-	-	-	-	-	-	-	-
6	9991	RUSKSS_5	345	3124	TRINDAD2_5	345	1	SHAM-ROY-TY1	1029.22	1110.02	1072	103.55	-	-	-	-	-	-	-	-
7	3160	DIALVILL_8	138	3296	NECHESRI_8	138	1	STRY-SMR-TRO	229.49	230.02	214	107.49	107.33	-	107.88	-	108.49	-	-	-
8	3271	PALSTNS_8	138	3296	NECHESRI_8	138	1	STRY-SMR-TRO	-221.96	226.77	214	105.97	105.81	-	106.36	-	106.97	-	-	-
9	3131	FOREGROV_8	138	29266	MABANKTAP	138	1	TDAD-TRICORN	256.95	259.12	251	103.23	103.14	100.14	103.06	-	103.04	-	102.63	-
10	3276	MALAKOFF_8	138	29266	MABANKTAP	138	1	TDAD-TRICORN	-256.90	259.06	251	103.21	103.11	100.12	103.04	-	103.02	-	102.61	-
11	3118	LUFKNSS_8	138	3340	LUFKIN_8	138	1	SOUTHCR3	-275.46	308.48	251	122.90	120.96	146.82	-	119.94	121.52	121.66	142.65	-
12	3119	NACOGDSE_5	345	3WNDTR	WND 1		1	SOUTHCR3	865.65	865.65	750	115.42	116.85	112.90	-	113.16	115.04	112.12	112.81	-
13	3120	NACOGDSE_8	138	3311	NACOSFA_8	138	1	SOUTHCR3	-249.13	266.17	214	124.38	122.12	103.10	-	120.43	124.27	116.44	105.36	-
14	3120	NACOGDSE_8	138	3315	NACOGSOU_8	138	1	SOUTHCR3	-294.81	315.72	249	126.80	124.76	128.94	-	122.43	125.86	120.84	127.65	-
15	3120	NACOGDSE_8	138	3319	HERTYNOR_8	138	1	SOUTHCR3	-272.59	304.12	214	142.11	139.99	145.21	-	137.02	141.00	135.26	143.60	-
16	3120	NACOGDSE_8	138	3WNDTR	WND 2		1	SOUTHCR3	834.75	834.75	750	111.30	112.52	110.87	-	110.88	111.20	110.97	110.87	-
17	3160	DIALVILL_8	138	3296	NECHESRI_8	138	1	SOUTHCR3	198.94	216.85	214	101.33	101.10	-	-	-	101.89	-	-	-
18	3301	GRESHRD_POI	138	3110	STRYKER_8	138	1	SOUTHCR3	246.45	262.61	186	141.19	139.60	115.73	-	135.21	140.84	129.90	118.38	-
19	3301	GRESHRD_POI	138	3304	GRESHRDSS	138	1	SOUTHCR3	102.07	108.77	100	108.77	107.09	102.35	100.91	103.46	107.98	100.27	102.44	-
20	3310	NACOGNOR_8	138	3311	NACOSFA_8	138	1	SOUTHCR3	-220.08	235.13	214	109.87	107.90	-	-	106.70	109.88	103.26	-	-
21	3314	NACOGSW_8	138	3315	NACOGSOU_8	138	1	SOUTHCR3	266.58	288.33	249	115.79	114.04	118.45	-	111.89	114.93	110.62	117.20	-
22	3314	NACOGSW_8	138	3316	NACOGST_8	138	1	SOUTHCR3	-253.55	274.73	249	110.33	108.69	113.37	-	106.75	109.51	105.71	112.14	-
23	3316	NACOGST_8	138	3340	LUFKIN_8	138	1	SOUTHCR3	253.53	274.71	186	147.69	145.49	151.76	-	142.91	146.60	141.51	150.12	-
24	2478	ROYSE_SS	345	3103	SHAMBRGR_5	345	1	FNYELK_TRISE	-1043.58	1193.61	1072	111.34	110.36	-	109.57	-	104.62	-	-	-
25	3106	ELKTON_8	138	3196	TYLERSWE_8	138	1	FNYELK_TRISE	174.15	192.45	186	103.47	102.93	-	102.48	-	-	-	-	-
26	2478	ROYSE_SS	345	3103	SHAMBRGR_5	345	1	FNY-ELKSEAG	-1009.82	1142.55	1072	106.58	105.67	-	104.92	-	100.78	-	-	-
27	3106	ELKTON_8	138	3196	TYLERSWE_8	138	1	FNY-ELKSEAG	170.91	187.26	186	100.68	100.21	-	-	-	-	-	-	-
28	2478	ROYSE_SS	345	3103	SHAMBRGR_5	345	1	FNY-ELKTRI	-1035.87	1184.49	1072	110.49	109.49	-	108.70	-	105.28	-	-	-
29	3106	ELKTON_8	138	3196	TYLERSWE_8	138	1	FNY-ELKTRI	173.76	192.10	186	103.28	102.74	-	102.29	-	100.17	-	-	-
30	3133	RICHLND2_5	345	3380	BIGBRN__5	345	1	WTML-TNDTRI	1159.45	1119.06	1052	106.37	106.37	-	107.33	-	108.32	-	-	-

1 The % flow results shown for the Import 1500 MW Base Case + New Transmission Line Column are not all of the thermal overloads violations observed for that case. These results only show how the new transmission lines were able to eliminate the thermal overloading violations from the Import 1500 MW Base Case and do not show any new violtions caused by the new lines.
2 "-" indicates the % flow is below 100%

The Lufkin Switch to Nacogdoches 345 kV #1, 23 mile long transmission line reduces the thermal overloading for the SOUTHCR3 double circuit 345 kV contingency from Rusk to Mt. Enterprise. The Martin Lake to Royse North 345 kV #1, 124 mile long transmission line reduces the thermal overloading for the thermal violations other than SOUTHCR3. These two transmission lines were chosen to be modeled together to eliminate thermal overloads observed in the Import 1500 MW base case.

4.1.1 Import Benchmark Case

Table 4.1-2 lists the number of thermal and voltage violations for the Import Benchmark case before making any upgrades to Oncor's system.

Table 4.1-2*
Summary of Thermal and Voltage Violations for Import Benchmark Case Before Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations
1	Special Contingencies	13	24
2	Single Circuit Area 1	11	176

*These violations occur before the SPS or manual switching operations have been implemented.

Table 4.1-3 lists the transmission lines and transformer upgrades selected for the Import Benchmark case. Table 4.1-4 lists the shunt capacitor bank upgrades examined for the Import Benchmark case at MURPHY1_8.

Table 4.1-3
Transmission Lines and Transformer Upgrades Selected for Import Benchmark 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 Upgrade
1	3117	Lufkin Switch	3119	Nacogdoches SE	345	1	1631	0.00074	0.00970	0.23455	23	New
2	3100	Martin Lake	2461	Royse North	345	1	1631	0.00401	0.05228	1.26451	124	New
3	3106	ELKTON_8	3139	TYLERWES_8	138	1	326	0.00181	0.01809	0.00598	5	Upgrade
4	2523	PL_TENNY_8	10010	PRSTMDWS_8	138	1	484	0.00013	0.00153	0.01976	2.64	Upgrade
5	Collin to Northwest Carrolton (multiple branches)				138	2	326	0.00036[1]	0.00362[1]	0.00120[1]	17	New
6	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.

Table 4.1-4
Shunt Capacitor Banks Examined for the Import Benchmark Case at MURPHY1_8 (bus 2696)

Ref. No.	Contingnecy	Binit (MVAR)	Bus Voltage (p.u.)
1	Base Case	-	1
2	BD-MURPMC	0	0.93
3		10	0.94
4		20	0.95
5		30	0.96
6		40	0.98
7		50	0.99
8		60	1
9		70	1.01
10		80	1.03
11		90	1.04

The BD-MURPMC contingency consists of the loss of the Ben Davis to Murphy 138 kV and Ben Davis to Parker-Maxwell Creek 138 kV transmission lines. This was the only contingency observed where voltage violations observed could not be solved by switching existing shunt capacitor banks or by changing transformer tap settings. The voltage violations for this contingency are eliminated if a shunt capacitor is added at MURPHY1_8 (bus #2696) and is sized between 10 to 90 MVAR. An 80 MVAR bank was chosen since it provides voltage support for the surrounding area.

The remaining voltage violations observed for the Import Benchmark case 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.

The Collin #2 345/138 kV autotransformer was observed overloading when the Collin #1 345/138 kV autotransformer was switched out and the transformer taps settings on Collin #2 were not at 1 p.u. on both sides. Series reactors were examined at the high side terminals of the Collin #2 345/138 kV autotransformer to eliminate the loading violations over 100% that were occurring. Table 4.1-5 lists the results of the series reactor's impacts on the Collin #2 345/138 kV autotransformer loading during the Import Benchmark case with the Collin #1 autotransformer out. It was determined that a 2-ohm series reactor would eliminate the thermal loading if the transformer taps were coordinated correctly.

Table 4.1-5
Series Reactor Impacts on the Collin 345/138 kV #2 Transformer Loading During the Import Benchmark Case with the Collin #1 Transformer Out

Ref. No.	Series Reactor (ohms)	Transformer Tap Settings (p.u.)		Loading (%)
		345 kV	138 kV	
1	2	1	1	88
2		0.924[1]	1[1]	99
3		0.9	1	105
4		0.879	1	109
5	3	1	1	86
6		0.924[1]	1[1]	96
7		0.9	1	101

1 These transformer tap settings were obtained by allowing the transformer taps to step.
The other tap settings were examined to see what other loading values could occur.

The 2-ohm series reactor, the transmission lines and transformer listed in Table 4.1-3, and the shunt capacitor bank upgrades were chosen to be modeled eliminating the thermal and voltage violations observed for the Import Benchmark case.

Refer to Table B-1 and Table B-4 in Appendix B for the list of loading violations and voltage violations, before implementing SPS or manual switching operations, for the Import Benchmark case for the "Special Contingencies" and the Single Circuit Area 1 Contingencies.

4.1.2 Import 1500 MW Case

Table 4.1-6 lists the number of thermal and voltage violations for the Import 1500 MW case before making any upgrades to Oncor's system.

Table 4.1-6*
Summary of Thermal and Voltage Violations for Import 1500 MW Case Before Any Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations
1	Special Contingencies	30	77
2	Single Circuit Area 1	41	224
3	Single and Double Circuits out of Rusk	16	39

*These violations occur before the SPS or manual switching operations have been implemented.

Table 4.1-7 lists the transmission lines and transformer upgrades selected for the Import 1500 MW case. Table 4.1-8 lists the shunt capacitor bank upgrades examined for the Import 1500 MW case at MURPHY1_8.

Table 4.1-7
Transmission Lines and Transformer Upgrades Selected for the Import 1500 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 Upgrade
1	3117	Lufkin Switch	3119	Nacogdoches SE	345	1	1631	0.00074	0.00970	0.23455	23	New
2	3100	Martin Lake	2461	Royse North	345	1	1631	0.00401	0.05228	1.26451	124	New
3	3106	ELKTON_8	3139	TYLERWES_8	138	1	326	0.00181	0.01809	0.00598	5	Upgrade
4	2523	PL_TENNY_8	10010	PRSTMDWS_8	138	1	484	0.00013	0.00153	0.01976	2.64	Upgrade
5	3143	TYLERGND_8	3213	TYLERGE_8	138	1	484	0.00005	0.00058	0.00748	1	Upgrade
6	Collins to Northwest Carrolton (multiple branches)				138	2	326	0.00036[1]	0.00362[1]	0.00120[1]	17	New
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.

Table 4.1-8
Shunt Capacitor Banks Examined for the Import 1500 MW Case at MURPHY1_8 (bus 2696)

Ref. No.	Contingnecy	Binit (MVAR)	Bus Voltage (p.u.)
1	Base Case	-	1
2	BD-MURPMC	0	0.93
3		10	0.94
4		20	0.95
5		30	0.96
6		40	0.98
7		50	0.99
8		60	1
9		70	1.02
10		80	1.03
11		90	1.04

BD-MURPMC was the only contingency observed where voltage violations observed could not be solved by switching existing shunt capacitor banks or by changing transformer tap settings. The voltage violations for this contingency are eliminated if a shunt capacitor is added at MURPHY1_8 (bus #2696) and is sized between 10 to 90 MVAR. An 80 MVAR bank was chosen since it provides voltage support for the surrounding area.

The remaining voltage violations observed for the Import 1500 MW case 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.

The Collin #2 345/138 kV autotransformer was observed overloading when the Collin #1 345/138 kV autotransformer was switched out and the transformer taps settings on Collin #2 were not at 1 p.u. on both sides. Series reactors were examined at the high side terminals of the Collin #2 345/138 kV autotransformer to eliminate the loading violations over 100% that were occurring. Table 4.1-9 lists the results of the series reactor's impacts on the Collin #2 345/138 kV autotransformer loading during the Import 1500 MW case with the Collin #1 autotransformer out. It was determined that a 2-ohm series reactor would eliminate the thermal loading if the transformer taps were coordinated correctly.

Table 4.1-9
Series Reactor Impacts on the Collin 345/138 kV #2 Transformer Loading During the Import 1500 MW Case with the Collin #1 Transformer Out

Ref. No.	Series Reactor (ohms)	Transformer Tap Settings (p.u.) 345 kV	Transformer Tap Settings (p.u.) 138 kV	Loading (%)
1	2	1	1	88
2		0.924[1]	1[1]	99
3		0.9	1	105
4		0.879	1	109
5	3	1	1	86
6		0.924[1]	1[1]	96
7		0.9	1	101

1 These transformer tap settings were obtained by allowing the transformer taps to step. The other tap settings were examined to see what other loading values could occur.

The two ohm series reactor, the transmission lines and transformer listed in Table 4.1-7, and the shunt capacitor bank upgrades were chosen to be modeled eliminating the thermal and voltage violations observed for the Import 1500 MW case.

Refer to Table B-5 and Table B-10 in Appendix B for the list of loading violations and voltage violations, before implementing SPS or manual switching operations, for the Import 1500 MW case for the "Special Contingencies," the Single Circuit Area 1 Contingencies, and the single and double circuit contingencies out of Rusk County 345 kV Switching Station.

4.1.3 Import 3000 MW Case

When the Import 3000 MW base case was examined for the steady state contingency analysis thermal and voltage violations were observed, however several of the single and double circuit contingency cases did not converge. Table 4.1-10 lists the number of thermal violations, voltage violations, and convergence errors for the Import 3000 MW case before making any upgrades to Oncor's system.

Table 4.1-10*
Summary of Thermal and Voltage Violations and Convergence Errors for the Import 3000 MW Case Before Any Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations	Number of Convergence Errors
1	Special Contingencies	16	42	17
2	Single Circuit Area 1	68	22	35
3	Single and Double Circuits out of Rusk	4	11	7

*These violations occur before the SPS or manual switching operations have been implemented.

Table 4.1-11 lists the single and double circuit contingencies from the Import 3000 MW cases that did not converge. The upgrades for the 3000 MW case were selected by first modeling the upgrades selected in the Import 1500 MW case. Additional upgrades were then made based on the contingencies that still had violations or did not converge. Table 4.1-12 lists the final lines and transformers added or upgraded to eliminate all violations. Table 4.1-13 lists the shunt capacitor bank upgrades examined for the Import 3000 MW case at MURPHY1_8.

Table 4.1-11
Summary of Single Circuit Contingencies from the Import 3000 MW Case With a Mismatch Greater Than One Before Making Any Upgrades

Ref. No.	Contingency Name	Contingency Description	Converged	Convergence State[1]
1	ALN*MON-RYS	OPEN BRANCH FROM BUS 2514 [ALLENSW2_5 345.00] TO BUS 1696 [MOSES1_T5 345.00] CKT 1 OPEN BRANCH FROM BUS 2513 [ALLENSW1_5 345.00] TO BUS 2461 [ROYSE_N5 345 00] CKT 1 OPEN BRANCH FROM BUS 1695 [MOSES_5 345.00] TO BUS 1696 [MOSES1_T5 345.00] CKT BC	FALSE	Blown up
2	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	FALSE	Blown up
3	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	FALSE	Blown up
4	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	FALSE	Blown up
5	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	FALSE	Blown up
6	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	FALSE	Blown up
7	STRY-SMR-TRO	OPEN BRANCH FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3112 [SMRFLDMT_8 138.00] CKT 1 OPEN BRANCH FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3147 [TROUPSS_8 138.00] CKT 1	FALSE	Blown up
8	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	FALSE	Blown up
9	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	FALSE	Blown up
10	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	FALSE	Blown up
11	SOUTHCR3	OPEN BRANCH FROM BUS 3116 [MTENTRPR_5 345.00] TO BUS 9997 [RUSKSS_5 345 00] CKT 1 OPEN BRANCH FROM BUS 3116 [MTENTRPR_5 345.00] TO BUS 9997 [RUSKSS_5 345.00] CKT 2	FALSE	Blown up
12	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	FALSE	Blown up
13	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	FALSE	Blown up
14	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	FALSE	Blown up
15	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	FALSE	Blown up
16	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	FALSE	Blown up
17	BIG_BRN-NAV	OPEN BRANCH FROM BUS 3380 [BIGBRN__5 345.00] TO BUS 68091 [NAVARRO 345.00] CKT 1 OPEN BRANCH FROM BUS 3380 [BIGBRN__5 345.00] TO BUS 68091 [NAVARRO 345.00] CKT 2	FALSE	Blown up

1 PSSE was set to solve using 100 iterations.

Table 4.1-11 (Continued)
Summary of Single Circuit Contingencies from the Import 3000 MW Case With a Mismatch Greater Than One Before Making Any Upgrades

Ref. No.	Contingency Name	Contingency Description	Converged	Convergence State[1]
18	OVRLOD 1	OPEN LINE FROM BUS 3358 [CENTVILL_8 138.00] TO BUS 3394 [JEWETTA_T_8 138.00] CKT 1	FALSE	Blown up
19	OVRLOD 2	OPEN LINE FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3103 [SHAMBRGR_5 345.00] CKT 1	FALSE	Blown up
20	OVRLOD 3	OPEN LINE FROM BUS 3355 [GRPLMGTA_8 138.00] TO BUS 3357 [PLSNTSPG_8 138.00] CKT 1	FALSE	Iteration limit exceeded
21	OVRLOD 4	OPEN LINE FROM BUS 3357 [PLSNTSPG_8 138.00] TO BUS 3358 [CENTVILL_8 138.00] CKT 1	FALSE	Iteration limit exceeded
22	OVRLOD 5	OPEN LINE FROM BUS 3354 [CROCKETT_8 138.00] TO BUS 3355 [GRPLMGTA_8 138.00] CKT 1	FALSE	Iteration limit exceeded
23	OVRLOD 6	OPEN LINE FROM BUS 2478 [ROYSE_S5 345.00] TO BUS 3103 [SHAMBRGR_5 345.00] CKT 1	FALSE	Blown up
24	OVRLOD 7	OPEN LINE FROM BUS 3109 [STRYKER_5 345.00] TO BUS 3123 [TRINDAD1_5 345.00] CKT 1	FALSE	Blown up
25	OVRLOD 8	OPEN LINE FROM BUS 2437 [FRNY1_5 345 00] TO BUS 3105 [ELKTON_5 345.00] CKT 1	FALSE	Blown up
26	OVRLOD 9	OPEN LINE FROM BUS 2432 [TRICRN1_5 345.00] TO BUS 3102 [TYLERGND_5 345.00] CKT 1	FALSE	Blown up
27	OVRLOD 10	OPEN LINE FROM BUS 3100 [MARTINLK_5 345 00] TO BUS 3102 [TYLERGND_5 345.00] CKT 1	FALSE	Blown up
28	OVRLOD 11	OPEN LINE FROM BUS 3100 [MARTINLK_5 345.00] TO BUS 3105 [ELKTON_5 345.00] CKT 1	FALSE	Blown up
29	OVRLOD 14	OPEN LINE FROM BUS 2432 [TRICRN1_5 345 00] TO BUS 3124 [TRINDAD2_5 345.00] CKT 1	FALSE	Blown up
30	OVRLOD 16	OPEN LINE FROM BUS 2427 [WATMLL_W5 345.00] TO BUS 3123 [TRINDAD1_5 345.00] CKT 1	FALSE	Blown up
31	OVRLOD 19	OPEN LINE FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3111 [STRYKERTA_8 138.00] CKT 1	FALSE	Blown up
32	OVRLOD 21	OPEN LINE FROM BUS 3111 [STRYKERTA_8 138.00] TO BUS 3160 [DIALVILL_8 138.00] CKT 1	FALSE	Blown up
33	OVRLOD 27	OPEN LINE FROM BUS 2428 [WATMLL_E5 345.00] TO BUS 2432 [TRICRN1_5 345.00] CKT 1	FALSE	Blown up
34	OVRLOD 38	OPEN LINE FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3112 [SMRFLDMT_8 138 00] CKT 1	FALSE	Blown up
35	OVRLOD 39	OPEN LINE FROM BUS 3112 [SMRFLDMT_8 138.00] TO BUS 3253 [JAXVLSW_8 138.00] CKT 1	FALSE	Blown up
36	OVRLOD 40	OPEN LINE FROM BUS 3116 [MTENTRPR_5 345.00] TO BUS 3119 [NACOGDSE_5 345.00] CKT 1	FALSE	Blown up
37	OVRLOD 41	OPEN LINE FROM BUS 3119 [NACOGDSE_5 345.00] TO BUS 3120 [NACOGDSE_8 138.00] TO BUS 3135	FALSE	Blown up
38	OVRLOD 56	OPEN LINE FROM BUS 3110 [STRYKER_8 138.00] TO BUS 3147 [TROUPSS_8 138.00] CKT 1	FALSE	Blown up
39	OVRLOD 75	OPEN LINE FROM BUS 3133 [RICHLND2_5 345.00] TO BUS 3380 [BIGBRN__5 345.00] CKT 1	FALSE	Blown up
40	OVRLOD 76	OPEN LINE FROM BUS 3147 [TROUPSS_8 138.00] TO BUS 3156 [WALNUT_POI 138.00] CKT 1	FALSE	Iteration limit exceeded
41	OVRLOD 77	OPEN LINE FROM BUS 3156 [WALNUT_POI 138.00] TO BUS 3227 [WHITEHSE_8 138.00] CKT 1	FALSE	Iteration limit exceeded
42	OVRLOD 178	OPEN LINE FROM BUS 3160 [DIALVILL_8 138.00] TO BUS 3296 [NECHESRI_8 138.00] CKT 1	FALSE	Blown up
43	OVRLOD 482	OPEN LINE FROM BUS 1431 [GRHAMSES1_8 138.00] TO BUS 1601 [GRAHAME_8 138.00] CKT 1	FALSE	Iteration limit exceeded
44	OVRLOD 517	OPEN LINE FROM BUS 1596 [GRAHAMSW_8 138.00] TO BUS 1601 [GRAHAME_8 138.00] CKT 1	FALSE	Iteration limit exceeded
45	OVRLOD 629	OPEN LINE FROM BUS 3271 [PALSTNS_8 138.00] TO BUS 3296 [NECHESRI_8 138.00] CKT 1	FALSE	Blown up
46	OVRLOD 782	OPEN LINE FROM BUS 1596 [GRAHAMSW_8 138.00] TO BUS 1599 [BARTON_8 138.00] CKT 1	FALSE	Iteration limit exceeded
47	OVRLOD 1913	OPEN LINE FROM BUS 3105 [ELKTON_5 345.00] TO BUS 3106 [ELKTON_8 138.00] TO BUS 29150 [El	FALSE	Blown up
48	OVRLOD 2037	OPEN LINE FROM BUS 3123 [TRINDAD1_5 345.00] TO BUS 3133 [RICHLND2_5 345 00] CKT 1	FALSE	Blown up
49	OVRLOD 2077	OPEN LINE FROM BUS 3124 [TRINDAD2_5 345.00] TO BUS 3134 [RICHLND1_5 345.00] CKT 1	FALSE	Blown up
50	UNIT 120101	REMOVE UNIT C1 FROM BUS 120101 [TGCCS_CT1 18 000]	FALSE	Blown up
51	UNIT 120102	REMOVE UNIT C2 FROM BUS 120102 [TGCCS_CT2 18 000]	FALSE	Blown up
52	UNIT 120103	REMOVE UNIT C3 FROM BUS 120103 [TGCCS_CT3 18.000]	FALSE	Blown up

1 PSSE was set to solve using 100 iterations

Table 4.1-12
Transmission Lines and Transformer Upgrades Selected for the Import 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	0.00070	0.00970	0.23450	23	New
2	3100	Martin Lake	2461	Royse North	345	1	1631	0.00401	0.05228	1.26452	124	New
3	3100	Martin Lake	3109	Stryker	345	1	1631	0.00132	0.01729	0.41811	41	New
4	3100	Martin Lake	68091	Navarro	345	1	1631	0.0042	0.05481	1.3257	130	New
5	3100	Martin Lake	68091	Navarro	345	2	1631	0.0042	0.05481	1.3257	130	New
6	3143	TYLERGND_8	3213	TYLERGE_8	345	1	484	0.00005	0.00058	0.00748	1	Upgraded
7	3123	Trinidad	3109	Stryker	345	1	1631	0.00222	0.02892	0.69956	68.6	Upgraded
8	9997	Rusk_5	3124	Trinidad2_5	345	1	1631	0.00297	0.03879	0.93819	92	Upgraded
9	9997	Rusk_5	3109	Stryker	345	1	2390	0.00076	0.00987	0.23863	23.4	Upgraded
10	3160	Dialvill-8	3296	Nechesri_8	138	1	326	0.00562	0.05609	0.01853	15.5	Upgraded
11	3106	ELKTON_8	3139	TYLERWES_8	138	1	326	0.00181	0.01809	0.00598	5	Upgraded
12	2523	PL_TENNY_8	10010	PRSTMDWS_8	138	1	484	0.00013	0.00153	0.01976	2.64	Upgraded
13	3271	PALSTNS_8	3296	NECHESRI_8	138	1	326	0.00344	0.03438	0.01136	9.5	Upgraded
14	3131	FOREGROV_8	29266	MABANKTAP	138	1	326	0.00134	0.01339	0.00416	3.7	Upgraded
15	3276	MALAKOFF_8	29266	MABANKTAP	138	1	326	0.00134	0.01339	0.00416	3.7	Upgraded
16	3127	TRINIDAD_8	3276	MALAKOFF_8	138	1	326	0.00294	0.02931	0.00911	8.1	Upgraded
17	3251	FLINTSUB_8	3253	JAXVLSW_8	138	1	326	0.00375	0.03741	0.01236	10.34	Upgraded
18	Collins to Northwest Carrolton (multiple branches)				138	2	326	0.00036[1]	0.00362[1]	0.00120[1]	17	New
19	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.

Table 4.1-13
Shunt Capacitor Banks Examined for the Import 3000 MW Case at MURPHY1_8 (bus 2696)

Ref. No.	Contingnecy	Binit (MVAR)	Bus Voltage (p.u.)
1	Base Case	-	1
2	BD-MURPMC	0	0 935
3		10	0.95
4		20	0.96
5		30	0.97
6		40	0 98
7		50	1
8		60	1
9		70	1.02
10		80	1.03
11		90	1.05

BD-MURPMC was the only contingency observed where voltage violations observed could not be solved by switching existing shunt capacitor banks or by changing transformer tap settings. The voltage violations for this contingency are eliminated if a shunt capacitor is added at MURPHY1_8 (bus #2696) and is sized between 10 to 90 MVAR. An 80 MVAR bank was chosen since it provides voltage support for the surrounding area.

The remaining voltage violations observed for the Import 3000 MW case 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.

The Collin #2 345/138 kV autotransformer was observed overloading when the Collin #1 345/138 kV autotransformer was switched out and the transformer taps settings on Collin #2 were not at 1 p.u. on both sides. Series reactors were examined at the high side terminals of the Collin #2 345/138 kV autotransformer to eliminate the loading violations over 100% that were occurring. Table 4.1-13 lists the results of the series reactor's impacts on the Collin #2 345/138 kV autotransformer loading during the Import 3000 MW case with the Collin #1 autotransformer out. It was determined that a 2-ohm series reactor would eliminate the thermal loading if the transformer taps were coordinated correctly.

Table 4.1-13
Series Reactor's Impacts on the Collin 345/138 kV #2 Transformer Loading During the Import 3000 MW Case with the Collin #1 Transformer Out

Ref. No.	Series Reactor (ohms)	Transformer Tap Settings (p.u.)[1]		Loading (%)
		345 kV	138 kV	
1	2	1	1	94
2		0.97[1]	1[1]	97
3		0.95	1	106
4	3	1	1	92
5		0.97[1]	1[1]	95
6		0.95	1	98

1 These transformer tap settings were obtained by allowing the transformer taps to step. The other tap settings were examined to see what other loading values could occur.

The two ohm series reactor, the transmission lines and transformer listed in Table 4.1-13, and the shunt capacitor bank upgrades were chosen to be modeled eliminating the thermal and voltage violations observed for the Import 3000 MW case.

Refer to Table B-11 and Table B-19 in Appendix B for the list of loading violations and voltage violations, before implementing SPS or manual switching operations, for the Import 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.

4.1.4 Summary

Table 4.1-14 lists the line and transformer upgrades required for the Benchmark, 1500 MW, and 3000 MW Import cases. In addition to these upgrades, a shunt capacitor located at the Murphy 138 kV bus and a 2-ohm series reactor located at the Collin #2 345/138 kV autotransformer eliminates all voltage and thermal violations observed for the Import case during the contingency analysis.

Table 4.1-14
Summary of New/Upgraded Equipment to Eliminate the Thermal Violations for the Import Cases

Ref. No.	Transmission Lines and Equipment	kV	CKT	Base Case[1] (MVA)	Length (miles)	New MVA Ratings for Transmisison Lines and Equipment for Import Cases[2]		
						Benchmark Line (MVA)	1500 MW Line (MVA)	3000 MW Line (MVA)
1	Lufkin Switch to Nacogdoches SE (3117-3119)	345	1	N/A	23	1631	1631	1631
2	Martin Lake to Royse North (3100-2461)	345	1	N/A	124	1631	1631	1631
3	Martin Lake to Stryker (3100-3109)	345	1	1631[3]	41	-	-	1631
4	Martin Lake to Nararro (3100-68091)	345	1	N/A	130	-	-	1631
5	Martin Lake to Nararro (3100-68091)	345	2	N/A	130	-	-	1631
6	Trinidad to Stryker (3123-3109)	345	1	1072	68.6	-	-	1631
7	Rusk to Trinidad (9997-3124)	345	1	1072	92	-	-	1631
8	Rusk to Stryker (9997-3109)	345	1	1631	23.4	-	-	2390
9	Rusk to Martin Lake (9997-3100)	345	1	1631	17.5	-	-	-
10	Rusk to Martin Lake (9997-3100)	345	2	1631	17.5	-	-	-
11	Tyler Grande to Tyler G.E. (3143-3213)	345	1	326	1	-	484	484
12	Dialville to Neches Pump (3160-3296)	138	1	214	15.5	-	-	326
13	Palestine South to Neches Pump (3271-3296)	138	1	214	9.5	-	-	326
14	Trinidad to Malakoff (3127-3276)	138	1	251	8.1	-	-	326
15	Forest Grove to Mabank Tap (3131-29266)	138	1	251	3.7	-	-	326
16	Malakoff to Mabank Tap (3276-29266)	138	1	251	3.7	-	-	326
17	Elkton to Tyler Southwest (3106-3139)	138	1	214	5	326	326	326
18	Tennyson Plano to Preston Meadows (2523-10010)	138	1	287	1	484	484	484
19	Flint to Jacksonville (3251-3253)	138	1	249	10.34	-	-	326
20	Collin to Northwest Carrolton (multiple branches)	138	2	N/A	17	326	326	326
21	Collin S.E.S. Auto Transformer	345/138	2	N/A	N/A	Rating A = 700 MVA, Rating B and C = 750 MVA		

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 line was modeled in the Import 3000 MW case.

4.2 EXPORT CASES

4.2.1 Export Benchmark Case

Table 4.2-1 lists the number of thermal and voltage violations for the Export Benchmark case before making any upgrades to Oncor's system.

Table 4.2-1*
Summary of Thermal and Voltage Violations for Export
Export Benchmark Case Before Any Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations
1	Special Contingencies	1	4
2	Single Circuit Area 1	1	84

*These violations occur before the SPS or manual switching operations have been implemented.

The only thermal violation for the Export Benchmark case was the Gresham Road POI to Gresham Road Switch 138 kV line (3301-3304) at 100.09% in the base case. This violation is due to the MW output of the NACPW_UNIT1 was set to 100 MW which is also the Pmax for this unit. Decreasing this generator below its Pmax rating eliminated this thermal violation for the Export Benchmark case.

The voltage violations observed for the Export Benchmark case 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.

The Collin #2 345/138 kV autotransformer was added to the Export Benchmark case because it was already a planned upgrade to the Oncor system. No additional transmission lines or upgrades were required to eliminate the thermal and voltage violations for the Export Benchmark case.

Refer to Table C-1 and Table C-4 in Appendix C for the list of loading violations and voltage violations, before implementing SPS or manual switching operations, for the Export Benchmark case for the "Special Contingencies" and the Single Circuit Area 1 Contingencies.

4.2.2 Export 1500 MW Case

Table 4.2-2 lists the number of thermal and voltage violations for the Export 1500 MW case before making any upgrades to Oncor's system.

Table 4.2-2*
Summary of Thermal and Voltage Violations for Export 1500 MW Case Before Any Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations
1	Special Contingencies	1	7
2	Single Circuit Area 1	1	88
3	Single and Double Circuits out of Rusk	1	1

*These violations occur before the SPS or manual switching operations have been implemented.

The only thermal violation for the Export Benchmark case was the Gresham Road POI to Gresham Road Switch 138 kV line at 100.31% in the base case. This violation is due to 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 eliminated this thermal violation for the Export 1500 MW case.

The voltage violations observed for the Export 1500 MW case were eliminated using SPS and manual switching operations such as switching open breakers, turning on/off shunt capacitor bank steps, or changing transformer tap ratios.

The Collin #2 345/138 kV autotransformer was added to the Export 1500 MW case because it was already a planned upgrade to the Oncor system. No additional transmission lines or upgrades were required to eliminate the thermal and voltage violations for the Export 1500 MW case.

Refer to Table C-5 and Table C-10 in Appendix C for the list of loading violations and voltage violations, before implementing SPS or manual switching operations, for the Export 1500 MW case for the "Special Contingencies," the Single Circuit Area 1 Contingencies, and the single and double circuit contingencies out of Rusk County 345 kV Switching Station.

One double circuit contingency would not solve for the 1500 MW case and is shown in Table 4.2-3. The case did not diverge but the solution was outside the mismatch tolerance. To solve this contingency 200 MVAR of the filter bank at the HVDC converter station was allowed to switch. This allowed the case to solve and no thermal or voltage violations were observed.

Table 4.2-3
List of Contingencies with a Mismatch Greater Than One for the Export 1500 MW Case

Ref. No.	Contingency Name	Contingency Description
1	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

4.2.3 Export 3000 MW Case

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. Table 4.2-4 lists the number of thermal and voltage violations for the Export 3000 MW case before making any upgrades to Oncor's system. Table 4.2-5 lists the single and double circuit contingencies from the Export 3000 MW case that did not converge. These contingencies were examined and then upgrades that were applied to the 3000 MW Import case were incorporated into the 3000 MW Export case to eliminate violations and help the cases converge.

Table 4.2-4*
Summary of Thermal and Voltage Violations for the Export 3000 MW Case Before Any Upgrades

Ref. No.	Contingency Set	Number of Thermal Violations	Number of Voltage Violations	Number of Convergence Errors
1	Special Contingencies	1	9	13
2	Single Circuit Area 1	1	108	17
3	Single and Double Circuits out of Rusk	1	0	2

*These violations occur before the SPS or manual switching operations have been implemented.

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.