ERCOT Southern Cross DC Tie Transmission Study

Version 1.0

Document Revisions

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Executive Summary

On May 23, 2017, the Public Utility Commission of Texas (PUCT) issued a Revised Order Creating and Scoping Project (the "Revised Order") in Project No. 46304, *Oversight Proceeding Regarding ERCOT Matters Arising out of 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)*.[1] The Revised Order contains fourteen directives to ERCOT related to the proposed interconnection of the Southern Cross Transmission (SCT) DC Tie Project[2] into the ERCOT grid. The SCT DC Tie is proposed to be a bidirectional DC Tie line which can support imports of up to 2,000 MW and exports of up to 2,100 MW.

This report memorializes the results of the study ERCOT performed to resolve Directive 6 in the Revised Order and also includes information that may be useful to resolution of the Voltage Support Service (VSS) issue raised in Directive 8.

- Directive 6 states: "ERCOT shall study and determine what transmission upgrades, if any, are necessary to manage congestion resulting from power flows over the Southern Cross DC tie, make any necessary revisions to its standards, guides, systems, and protocols as appropriate, and certify to the Commission when it has completed these actions."
- Directive 8 states: "ERCOT shall (a) study and determine whether Southern Cross Transmission or any other entity scheduling flows across the Southern Cross DC tie should be required to provide or procure voltage support service or primary frequency response, or their technical equivalents, (b) implement any necessary revisions to its standards, guides, systems, and protocols, as appropriate, and (c) certify to the Commission when it as completed these actions."

To address these Directives, in part, ERCOT conducted a transmission analysis to determine the ability of the transmission system in the area to support assumed imports and exports across the SCT DC Tie. Based on stakeholder input, ERCOT analyzed two primary conditions:

1. 350 MW SCT DC Tie import during summer peak conditions
2. 2,100 MW SCT DC Tie export during high wind, low load conditions

The results of the analysis showed that the transmission system was able to accommodate an import level of approximately 547 MW before thermal overloads were observed at summer peak for the conditions studied. Since this was greater than the assumed 350 MW summer peak import level, ERCOT did not analyze transmission upgrades that would allow for higher import levels. To manage

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[1] http://interchange.puc.texas.gov/Search/Documents?controlNumber=46304&itemNumber=4
[2] http://southerncrosstransmission.com/

this constraint in real time, ERCOT expects that it would need to redispatch generation in the area or else limit flows on the DC Tie if the actual import level exceeds the level analyzed in this study.

The results for the high wind, low load conditions showed that exports across the SCT DC Tie would be limited to 1,289 MW by voltage stability constraints under the studied conditions. Without system upgrades, ERCOT expects that SCT DC Tie would need to be limited or curtailed to manage these constraints. To achieve the assumed export level of 2,100 MW in the study, ERCOT identified two potential transmission system upgrades, Options A and B, which are described in Table E1. Table E2 provides a comparison summary of Options A and B.

Table E1: Upgrades Identified to Achieve Exports of 2,100 MW Under Studied Conditions

Option	Description	Cost Estimates ($M)	New Right-of-Way (Miles)
Option A	• 540 MVar dynamic reactive devices at 345 kV Rusk Substation • 525 MVar synchronous condenser capacity at 345 kV Panola Substation	$182 ~ 202	None
Option B	• A new Martin Lake to Panola 345 kV double-circuit line • 350 MVar synchronous condenser capacity at 345 kV Panola Substation	$185 ~ 205	~38 miles

Table E2: Comparison of the Upgrade Options

Items	Option A	Option B
SCT Export Limits	2,100 MW	2,100 MW
SCT Import Limits	~ 540 MW	~ 530 MW
Cost Estimates	$182 – 202 Million	$185 – 205 Million
Additional Right-of-Way Requirement	None	~38 miles
Short Circuit Ratio at Panola (1)	3.85	4.21
Operation Flexibility	--	Better

(1) The Short Circuit Ratio (SCR) calculations were based on the HWLL case with Unit1 in service at Martin Lake Station. For other operation conditions, the SCR number can vary from the values given in the table.

As proposed, the SCT DC Tie will utilize Line Commutated Converters (LCC) HVDC technology, which requires sufficient system strength (short circuit current) to operate properly. The actual design and controller settings were not made available to ERCOT at the time of this study; therefore, for purposes of this study ERCOT used a standard assumption that LCC HVDC equipment will require a Short Circuit Ration (SCR) of at least 3.0 to operate. Based on this assumption, the SCT DC Tie would not be able to operate at high import/export levels without system strength improvements. This limitation is in addition to the constraints identified in the aforementioned analysis. Hence, ERCOT determined that at least some of the dynamic reactive devices in Options A and B would need to be synchronous condensers to boost the system strength, as noted in the option descriptions.

ERCOT also performed a sensitivity analysis evaluating dynamic stability for full import and export conditions. The results of this analysis showed that the transmission system would experience angular instability at full SCT DC Tie import (2,000 MW). Therefore, while thermal constraints would be the most binding for imports, if those constraints were relieved, an angular stability limit would prevent full SCT DC Tie imports without additional transmission system upgrades. This angular stability limit could be managed in real time by curtailing the SCT DC Tie or by creating a Generic Transmission Constraint (GTC).

To resolve the identified angular stability constraint for full SCT DC Tie import, ERCOT's studies showed a new 345 kV transmission line between the eastern and central areas of the ERCOT region would need to be constructed. ERCOT identified multiple supplemental upgrade alternatives that would resolve this instability. However, additional reliability studies would be required to identify the optimal 345 kV line and address potential steady-state planning criteria violations.

Additionally, in order to provide information that may be useful to the resolution of the VSS issue raised in Directive 8 ERCOT reevaluated Options A and B to determine how they could be modified if the SCT DC Tie were required to provide VSS similar to the requirements of generators in ERCOT Protocol Section 3.15. Specifically, if the SCT DC Tie provided the equivalent of lagging and leading power factor of 0.95 reactive capability, fewer upgrades than those identified in Options A and B above would be needed to achieve full export capability under the studied conditions. The transmissions upgrades that would be needed under this scenario—labeled "Modified Option A" and "Modified Option B"—are described in Table E3.

Table E3: Upgrade Options Assuming VSS Requirement Per Directive 8

Option	Description	Cost Estimates ($M)	New Right-of-Way (Miles)
Modified Option A	480 MVar dynamic reactive devices at 345 kV Rusk Substation	$70 ~ 90	None
Modified Option B	A new Martin Lake to Panola 345 kV double circuit line	$102 ~ 123	~38 miles

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1. Introduction

On May 23, 2017, the Public Utility Commission of Texas (PUCT) issued a Revised Order Creating and Scoping Project (the "Revised Order") in Project No. 46304, *Oversight Proceeding Regarding ERCOT Matters Arising out of 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)*. The Revised Order contains fourteen directives related to the proposed interconnection of the Southern Cross Transmission (SCT) DC Tie Project[3] to the ERCOT grid. The SCT DC Tie is proposed to be a bidirectional, bipole DC Tie line which can support imports of up to 2,000 MW and exports of up to 2,100 MW.

This report memorializes the results of the study ERCOT performed to resolve Directive 6 in the Revised Order and also includes information that may be useful to resolution of the Voltage Support Service (VSS) issue raised in Directive 8.

- Directive 6 states, "ERCOT shall study and determine what transmission upgrades, if any, are necessary to manage congestion resulting from power flows over the Southern Cross DC tie, make any necessary revisions to its standards, guides, systems, and protocols as appropriate, and certify to the Commission when it has completed these actions."
- Directive 8 states, "ERCOT shall (a) study and determine whether Southern Cross Transmission or any other entity scheduling flows across the Southern Cross DC tie should be required to provide or procure voltage support service or primary frequency response, or their technical equivalents, (b) implement any necessary revisions to its standards, guides, systems, and protocols, as appropriate, and (c) certify to the Commission when it as completed these actions."

The proposed SCT DC Tie interconnection, as shown in Figure 1.1, includes a new 345 kV Rusk substation in Rusk County, Texas, that will be tapped into existing 345 kV transmission lines connecting Mt. Enterprise, Martin Lake, Stryker, and Trinidad substations, and a new 345 kV Panola substation in Panola County, Texas, on the Texas-Louisiana state line. The Panola substation will be connected to Rusk substation by a new 345 kV double-circuit transmission line and to the SCT DC Tie.

[3] http://southerncrosstransmission.com/

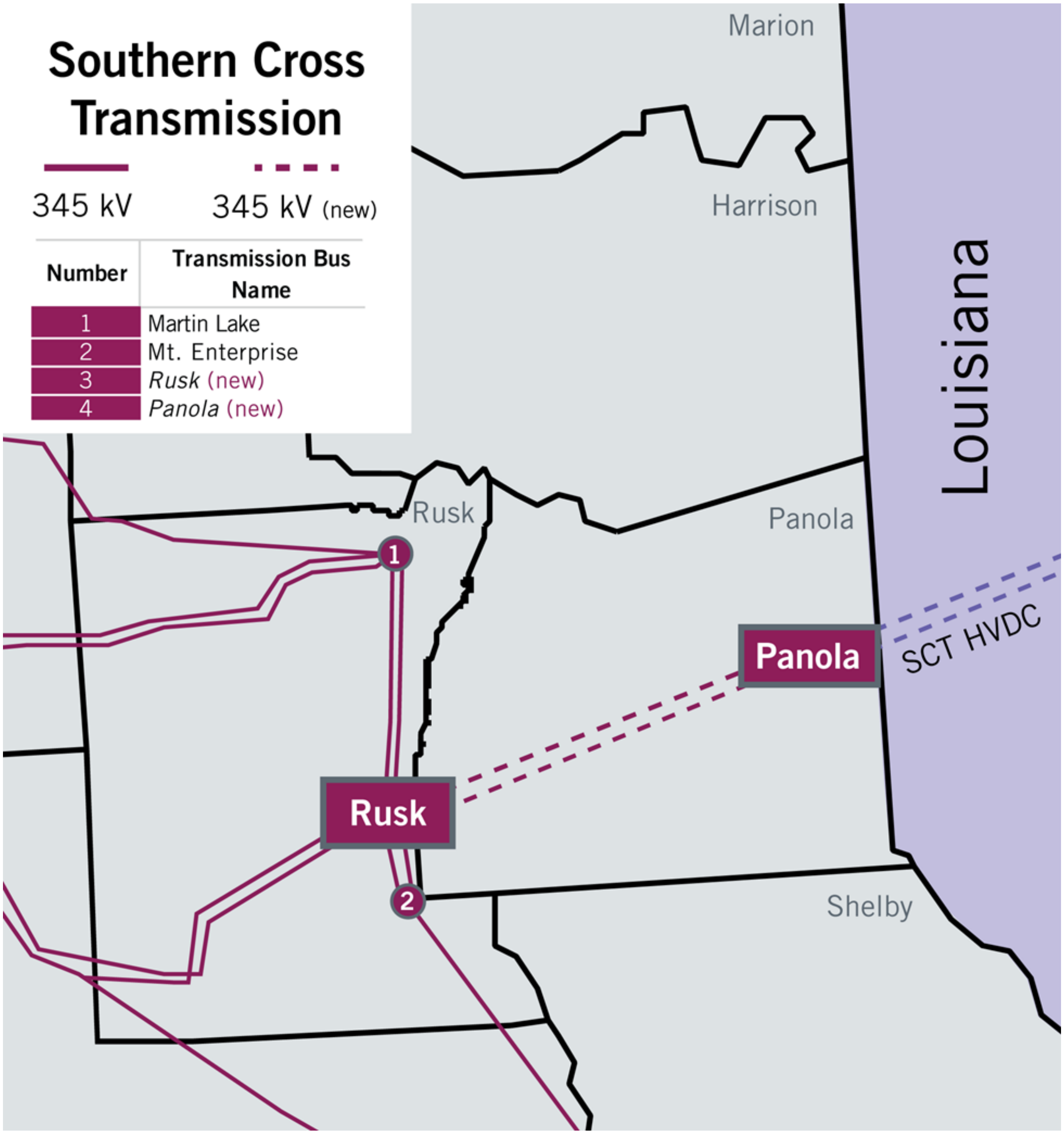

Figure 1.1: Proposed Interconnection of Southern Cross DC Tie

2. Southern Cross LCC HVDC Technology

The SCT DC Tie as proposed will utilize Line Commutated Converters (LCC) HVDC technology. This technology requires sufficient system strength (short circuit current) in order to operate properly. ERCOT's analysis showed that when generation in the area was offline, such as during high wind, low load conditions, the transmission system near the SCT DC Tie had relatively low short circuit currents. The SCT DC Tie modeling information, actual design and controller settings necessary to determine if the HVDC equipment would be able to operate under these conditions were not available at the time of this study. Therefore, ERCOT used a standard assumption that LCC HVDC equipment requires a Short Circuit Ration (SCR) of at least 3.0 to operate. Based on this assumption, the SCT DC Tie would not be able to operate at high import/export levels without system strength improvements.

LCC HVDC technology also requires dedicated local voltage support to maintain stable power transfers over the LCC HVDC system, and additional reactive devices are required to provide VSS for voltage control at the point of interconnection to the ERCOT Transmission Grid. Therefore, any capacitor banks provided within the overall SCT DC Tie model package were assumed to be available only to support transfers across the HVDC system and not for voltage support at the Panola substation. A unity power factor at the Panola substation was assumed for imports and exports for all scenarios studied, except the VSS scenario.

3. Assumptions, Criteria and Methodology

3.1. Assumptions

3.1.1. SCT Import and Export Levels

As required by Directive 5 in the Revised Order, ERCOT and stakeholders developed a set of import and export assumptions to be used in this analysis.[4] These assumptions are shown in Table 3.1.

Table 3.1: Southern Cross DC Tie Import/Export Study Scenarios

	System Condition	SCT Import/Export
Study Scenario (Steady State and Dynamic Stability)	Summer Peak	350 MW Import
	High Wind Low Load	2100 MW Export
Sensitivity Scenario (Dynamic Stability Only)	Summer Peak	2000 MW Import/ 2100 MW Export
	High Wind Low Load	2000 MW Import/ 2100 MW Export

3.1.2. Steady-State Study Cases

The 2018 Regional Transmission Planning (RTP) 2021 North/North Central (NNC) Summer Peak case (17SSWG_2021_SUM_NNC_10012018) and the 2018 RTP 2021 HWLL case (17SSWG_2021_MIN_U1_Final_10122017_Start_Case_v75_HWLL_v04) were used as the steady state base cases. The model for the SCT DC Tie was added to these two base cases according to the proposed interconnection.

The list of future generating units included in the study cases was updated in accordance with model-building requirements in ERCOT Planning Guide Section 6.9. The maximum dispatch for individual renewable generators was consistent with the 2018 RTP Study Scope and Process. Table 3.2 shows the list of proposed generators that were added to the study cases.

[4] See ERCOT Southern Cross Flow Assumptions presentation located here: http://www.ercot.com/calendar/2018/1/29/140231-PLWG

Table 3.2: Future Generating Units Added to North/North Central Study Region

GINR Reference Number	Project Name	County	Fuel	Capacity for Grid (MW)
18INR0070	Blue Summit II	Wilbarger	Wind	102
12INR0055	S_Hills Wind	Baylor	Wind	30
19INR0019	Foard City Wind	Foard	Wind	350

3.1.3. Dynamic Stability Study Cases

The 2018 ERCOT Dynamics Working Group (DWG) Future Year 2021 HWLL and 2020 Summer Peak (SP) flat start cases were used as the start cases to develop the stability study cases. The stability cases contained all existing and planned facilities in the study region, including reactive resources and control equipment.

The models of the transmission grid in the study region were reviewed and updated based on RPG approvals. The following changes were made to the start cases to create the SCT study cases:

- Remove the Crockett - Jewett 138 kV line upgrade (TPIT #4825)
- Remove the Nacogdoches Southeast- Herty North 345 kV line (TPIT #5467)
- Remove the Lufkin - Herty North 345 kV line (TPIT #5475)
- Remove the Shamburger North 345/138 kV substation (TPIT #5981)
- Add second circuit to SLU panhandle loop (TPIT #5180)
- Remove the Payne - Anna Switch 138 kV line upgrade (17TPIT0024)
- Remove the Navarro - Corsicana 69 kV line upgrade (TPIT #4274)
- Remove the Cresson - Rocky Creek 138 kV line (TPIT #4834)
- Remove the Liggett - Hackberry 138 kV double circuit line upgrade (TPIT #5490)
- Remove the Saginaw 345/138 kV transformer and new 345 kV line to Saginaw (TPIT #6273)
- Remove the Bell County - Gabriel 138 kV line upgrade (TPIT #4822)

3.2. Study Criteria

This section provides detail on the NERC and ERCOT Steady-state and Dynamics reliability criteria that were used to identify potential reliability violations.

3.2.1. Steady-State Criteria

For the reliability analysis, the following thermal and voltage limits were enforced:

- Rate A under pre-contingency conditions for transmission lines (60 kV and above) and for transformers with a low side voltage of 60 kV and above
- Rate B under post-contingency conditions for transmission lines (60 kV and above) and for transformers with a low side voltage of 60 kV and above
- 0.95 p.u. voltage under pre-contingency conditions for transmission buses (100 kV and above)
- 0.90 p.u. voltage under post-contingency conditions for transmission buses (100 kV and above)
- 1.05 p.u. voltage under pre- and post-contingency conditions for transmission buses (100 kV and above)
- Post-contingency voltage deviations
  - More than 8% on non-radial load-serving buses (100 kV and above)

The study region monitored for this study was the combined ERCOT North, North-Central, East and South Central weather zones and all facilities proposed to interconnect SCT DC Tie with ERCOT. Certain thermal and voltage violations that were within the South Central region but were physically and electrically remote from the 345 kV facilities proposed to interconnect SCT DC Tie with ERCOT were deemed unrelated and thus were ignored.

The following contingencies were simulated based on NERC TPL-001-4 and ERCOT Planning Criteria[5]:

- P0
- P1-1, P1-2, P1-3, P1-4, P1-5,
- P2-1, P2-2, P2-3 (All EHV only)
- P4-1, P4-2, P4-3, P4-4, P4-5 (All EHV only)
- P5-1, P5-2, P5-3, P5-4, P5-5 (All EHV only)
- P7-1, P7-2

Contingencies related to the proposed Southern Cross DC tie interconnection configuration were also included in the study.

3.2.2. Dynamic Criteria

The following system performance requirements were utilized to assess the dynamic performance of the preferred option:

- NERC TPL-001-4 Requirements
- ERCOT Planning Criteria

[5] http://www.ercot.com/content/wcm/current_guides/53526/04-070118.doc

Selected ERCOT transmission buses in the study region were monitored in dynamic simulations for frequency and voltage deviations. All generating units were monitored for angular separation. Relay actions recorded in the simulation log files were processed to summarize the operation of any relays that were included in the model (i.e. synchronous generators that were tripped due to machine angle swings in excess of 180 degrees, wind turbines tripped by voltage protection relays, etc.).

3.3. Study Methodology

The following describes steps that ERCOT took in this study:

- Step 1: Performed steady-state transfer analyses to evaluate import and export capabilities through the SCT DC Tie without any transmission upgrades from transmission circuit thermal limits and voltage stability perspectives
- Step 2: Identified transmission upgrades required to achieve Study Scenario conditions described in Table 3.1
- Step 3: Assessed system strength at Panola with transmission upgrades identified in Step 2 and identified improvements necessary to meet assumed SCR requirements while achieving Study Scenario conditions described in Table 3.1
- Step 4: Assessed dynamic stability with transmission upgrades identified in Step 3 and identified improvements necessary to satisfy dynamic performance criteria
- Step 5: Performed supplemental dynamics analyses in order to identify transmission upgrades necessary to achieve the Sensitivity Scenario conditions described in Table 3.1
- Step 6: Performed steady-state and dynamic stability assessments to provide insight into matters related to potential VSS requirement

4. Results of Study Scenario Analysis

4.1. Transfer Assessment

The initial generation dispatch in the study cases was set by Security Constrained Optimal Power Flow (SCOPF) with a 0 MW transfer to the SCT DC Tie. The source and sink defined in the transfer assessment were:

- Import assumption
  - A unity power factor power injection at the Panola bus as a source for imports
  - Adjusted generators outside of the study region as a sink for imports.
- Export assumption
  - A unity power factor power extraction at the Panola bus as a sink for exports
  - Adjusted load outside of the study region as a source for exports

The transfer assessments were based on a 2% Power Transfer Distribution Factor (PTDF) cut-off and a 2% Outage Transfer Distribution Factor (OTDF) cut-off to be consistent with real time procedures[6]. Thermal violations with PTDF or OTDF values less than 2% were deemed to be not caused by SCT DC Tie transfers. The generation dispatch in the study region was held constant in the transfer assessments. The transfer assessments were performed to evaluate if the study cases could meet the import/export Study Scenario conditions (described in Table 3.1) with no transmission upgrades. The results are shown in Table 4.1. A dynamic assessment was also conducted and identified no dynamic performance violations at the transfer levels listed in Table 4.1.

The results of the analysis showed that the transmission system was able to accommodate an import level of approximately 547 MW at summer peak for the conditions studied. Since this was greater than the assumed 350 MW summer peak import level, ERCOT did not analyze transmission upgrades that would allow for higher import levels. The limiting constraint was a thermal overload of a 138 kV line in East Texas. If the actual import level exceeds the level analyzed in this study in real time, ERCOT would likely need to redispatch generation in the area or else limit flows on the SCT DC Tie.

The results for the high wind, low load conditions showed that exports across the SCT DC Tie would be limited to 1,289 MW based on voltage stability constraints, under the conditions studied. Since the identified voltage stability constraint is local in nature, the only way to manage the constraint in real time would be to curtail SCT DC Tie exports, unless transmission system upgrades were implemented.

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[6] See Section 4 of the Transmission and Security Desk Operating Procedure Manual titled "Manage Transmission Congestion" found here: http://www.ercot.com/mktrules/guides/procedures

Table 4.1: Southern Cross DC Tie Import/Export Limits Under Studied Conditions

	Condition	Import/Export Limits
Study Scenario	Summer Peak	547 MW Import (1)
	High Wind Low Load	1,289 MW Export (2)

(1) Due to thermal restriction. No steady-state or dynamic violations up to 547 MW

(2) Due to voltage collapse. Voltage collapse assumed at 0.80 p.u. Voltage collapse at 1,289 MW.

4.2. Transmission Upgrades for Study Scenario Conditions

Approximately 20 options were evaluated to identify upgrades to accommodate 2,100 MW of exports under the high wind, low load conditions studied. Table 4.2 describes two short-listed options that met the Study Scenario conditions.

Table 4.2: Short-listed Options Required to Achieve Study Scenario Conditions

Option	Description
Option A	• 540 MVar dynamic reactive devices at 345 kV Rusk Substation • 525 MVar synchronous condenser capacity at 345 kV Panola Substation
Option B	• A new Martin Lake to Panola 345 kV double circuit line • 350 MVar synchronous condenser capacity at 345 kV Panola Substation

The synchronous condensers identified in both Options A and B were proposed to provide both dynamic reactive capability and system strength at Panola to ensure that the upgrade options met the assumed SCT DC Tie equipment SCR requirement. A dynamic assessment was also conducted for both short-listed options to ensure that no dynamic performance violations existed with the upgrades in place and under the Study Scenario conditions.

For Option A, the selection and implementation of the dynamic reactive devices at Rusk (SVC, STATCOM, or Synchronous Condenser) should be determined by the relevant Transmission Service Provider (TSP) and reviewed by ERCOT. Table 4.3 provides a comparison summary of the two short-listed options. The project cost estimates were provided by TSPs.

Table 4.3: Comparison of Short-listed Study Scenario Options

Items	Option A	Option B
SCT Export Limits	2,100 MW	2,100 MW
SCT Import Limits	~ 540 MW	~ 530 MW
Cost Estimates	$182 – 202 Million	$185 – 205 Million
Right-of-Way Requirement	No	~38 miles
Short Circuit Ratio at Panola (1)	(3.85)	(4.21)
Operational Flexibility	--	Better

(1) The SCR calculations were based on the HWLL case with Unit1 in service at Martin Lake Station. For other operation conditions, the SCR number can be variable from the values given in the table.

4.3. Transmission Upgrades for Sensitivity Scenario Conditions

ERCOT performed a sensitivity analysis evaluating only dynamic stability for full import and export conditions. The results of this analysis showed that the transmission system would experience angular instability at full SCT DC Tie import (2,000 MW). Therefore, while thermal constraints would be the most binding for imports, if those constraints were to be relieved, an angular stability limit would prevent full SCT DC Tie imports without additional transmission system upgrades. This angular stability limit could be managed in real time by curtailing the SCT DC Tie or by creating a Generic Transmission Constraint (GTC).

To get a high-level understanding of the amount of transmission system upgrades that would be needed to resolve the identified angular stability constraint for full SCT DC Tie import, ERCOT identified multiple supplemental upgrade alternatives. The results show a new 345 kV transmission path between the eastern and central areas of the ERCOT region would need to be constructed.

Table 4.4 describes four transmission upgrade options that were identified to supplement Option A or Option B to resolve the identified angular stability constraint. However, to achieve full import, additional reliability studies would be required to identify the recommended 345 kV line and address potential steady-state planning criteria violations. Table 4.5 provides a comparison summary of the identified four Sensitivity Scenario options.

Table 4.4: Supplemental Dynamic Upgrade Options [1]

Option	Description	Cost Estimate
Option D1	A new Rusk to Trinidad 345 kV single-circuit line on double-circuit structures	$ 189 – 229 Million
Option D2	A new Rusk to Forest Grove 345 kV single-circuit line on double-circuit structures	$ 161 – 195 Million
Option D3	A new Nacogdoches to Lufkin 345 kV single-circuit line on double-circuit structures A new Lufkin to Jewett 345 kV single-circuit line on double-circuit structures	$ 295 – 353 Million
Option D4	A new Nacogdoches to Herty North 345 kV single-circuit line on double-circuit structures A new Herty North to Lufkin 345 kV single-circuit line on double-circuit structures A new Lufkin to Jewett 345 kV single-circuit line on double-circuit structures	$ 301 – 360 Million

(1) The cost estimations for Options D1 and D3 were provided by TSP. The cost estimations for Options D2 and D4 were proportionally calculated based on the line lengths. The cost estimation for Option D4 did not count the upgrade cost for Herty North Station from 138 to 345kV.

Table 4.5: Comparison of Supplemental Dynamic Options

Items	Option D1	Option D2	Option D3	Option D4
Cost Estimates	$ 189 – 229 Million	$ 161 – 195 Million	$ 295 – 353 Million	$ 301 – 360 Million
Additional Right-of-Way Requirement	92 Miles	81 Miles	141 Miles	141 Miles

5. Voltage Support Services Evaluation

The transmission upgrades listed above in Table 4.2 are based on the SCT DC Tie model information provided to ERCOT. This model information showed that the SCT DC Tie, as currently proposed, would not provide support to the transmission system voltage levels.

To inform the VSS issue raised in Directive 8, Options A and B were reevaluated to determine how they could be modified if the SCT DC Tie were required to provide VSS similar to the requirements of generators under ERCOT Protocol Section 3.15. This analysis assumed the SCT DC Tie could provide the equivalent of lagging and leading power factor of 0.95 reactive capability, or 690 MVar (injecting or absorbing) for the 2,100 MW capacity, to support voltage on the ERCOT transmission system.

Under this scenario, it was assumed that the required 690 MVar of reactive capability would be achieved by the implementation of synchronous condensers for the assumed SCT DC Tie SCR need. Based on that assumption, the amount of upgrades identified in Options A and B could be reduced if SCT DC Tie were required to provide Voltage Support Service. The modified transmission options were labeled “Modified Option A” and “Modified Option B” and are described in Table 5.1. The cost estimates below reflect the cost of the residual transmission upgrades required and do not include the cost of synchronous condenser(s) that would provide the assumed 690 MVar reactive capability on the SCT DC Tie side of the point of interconnection.

Table 5.1: Options for Upgrades Required to Achieve Study Scenario Conditions, if SCT is Required to Provide Voltage Service Support

Option	Description	Cost Estimate
Modified Option A	480 MVar dynamic reactive devices at 345 kV Rusk Substation	\$70 - \$90 Million
Modified Option B	A new 38 mile double-circuit 345 kV line from Martin Lake to Panola	\$102 - \$123 Million

6. Conclusion

In presenting the results of this study, ERCOT makes no recommendation at this time regarding whether any transmission upgrades should be made to accommodate the SCT DC Tie because that determination is subject to further stakeholder discussion as part of the final resolution of Directive 6, Directive 8, and other Directives in the Revised Order. While ERCOT's study shows that SCT DC Tie can operate on a limited basis in ERCOT with existing transmission infrastructure, DC tie limits and/or other operational controls will likely be needed to manage the constraints observed in ERCOT's study. Alternatively, to the extent stakeholders may determine it prudent for transmission upgrades to be made to accommodate the full import/export capacity of the SCT DC Tie, this study has identified various transmission options for consideration and further discussion.