South Plains Transmission Project

October 10, 2016

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Contents

1. Executive Summary

Sharyland has actively monitored the development and financial commitment of generation resources in the Panhandle region over the past year and, given the significant increase in wind generation resources since the last ERCOT independent assessment in the region, has prepared a comprehensive Panhandle region transmission assessment. Based on that assessment, on September 20, 2016, Sharyland presented nine transmission expansion options with the objective of increasing the Panhandle export limit. Those options are summarized in this report, and Sharyland recommends Option #3 (South Plains Transmission Project or "Project") as the preferred option to address the future needs of the Panhandle region.

The Project builds on other recent decisions concerning Panhandle transmission capacity. Based on the 2015 recommendation of the ERCOT independent assessment of the Panhandle region, at its September 24, 2015, Open Meeting the Public Utility Commission of Texas (PUCT) recommended the construction of the second 345 kV circuit on the Alibates – AJ Swope – Windmill – Ogallala – Tule Canyon (AAWOT) line under the CREZ Order (PURA §39.904(g)) and in the summer of 2016 approved a Certificate of Convenience and Necessity (CCN) for that project. Additionally, on December 8, 2015, the ERCOT Board of Directors approved the addition of two synchronous condensers, one each at Sharyland's 345 kV Alibates and Tule Canyon stations. The tender for the synchronous condenser has been awarded and the condensers, along with the construction of the AAWOT line, are on schedule to be completed by June of 2018. The estimated Panhandle export transfer capability with these project additions is 4,013 MW.[1]

ERCOT's recommendations for the addition of the second circuit and the synchronous condensers were economically justified per the ERCOT economic planning criteria.[2] These recommendations were based on ERCOT's independent assessment of the Panhandle region needs performed in September 2015, when the Panhandle Wind Generation Resources (WGR) capacity meeting Section 6.9 requirements of the ERCOT Planning Guide was approximately 4,305 MW. During the course of the last year, there has been a significant increase in the Panhandle capacity meeting Section 6.9 requirements, with a new total of WGR capacity of approximately 5,269 MW.

This Sharyland assessment of the Panhandle region spans system strength, power flow, dynamic stability, and production cost based economic assessments. Numerous transmission expansion options were investigated in the Sharyland studies with the objective of expanding the Panhandle export limit to accommodate the increases in generation capacity. At the August and September, 2016 ERCOT RPG meetings, Sharyland presented updates of the wind generation interconnection activity in the region, along with a study scope to review the addition of additional shunt reactive devices and new transmission paths to increase the Panhandle export transfer capability. Comments on the scope of work and transmission options were incorporated in the study plan.

[1] See ERCOT's Panhandle Export Update at the September 20, 2016 RPG Meeting: http://www.ercot.com/content/wcm/key_documents_lists/77742/Panhandle_Interface_Limit-Update_RPG_09202016.pptx

[2] See ERCOT Protocols Section 3.11.2

Sharyland recommends the South Plains Transmission Project as the preferred option to address the future needs of the Panhandle region. The Project includes the following three transmission additions:

- New 67.5 mile 345 kV (double circuit capable) Abernathy – Grassland single circuit line
- New 53.2 mile 345 kV (double circuit capable) Ogallala – Abernathy single circuit line
- One (1) 175 MVA synchronous condenser at Windmill (minimum short circuit contribution of 1606 A at the condenser terminals)

The South Plains Transmission Project provides the highest Panhandle export capability amongst all the options evaluated by Sharyland when taking both system strength and dynamic performance into account. Of note, this option meets the ERCOT economic planning criteria with or without the Lubbock Power & Light (LP&L) system integrated into ERCOT.[3] This project provides a new export path out of the Panhandle while striking an optimal balance between the system strength and dynamic performance of the region.

All the transmission additions comprising the South Plains Transmission Project align closely with the Stage 2 upgrades recommended for the Panhandle region by ERCOT in their April 2014 Panhandle Renewable Energy Zone (PREZ) study report[4] as well as ERCOT's recommended Option #4ow to integrate LP&L.

The capital cost estimate for the South Plains Transmission Project is estimated to be $251 Million. Assuming ERCOT endorsement by Q2, 2017, Sharyland estimates the project to be in service by the end of 2020. With the addition of the Project, the estimated Panhandle export transfer capability increases from 4,013 MW to 4,833 MW, and the South Plains Transmission Project satisfies the ERCOT economic planning criteria with annual production cost savings exceeding 15% of the capital cost of the Project.

[3] Details on the PUCT docket 45633 "Project to identify issues pertaining to LP&L proposal to become part of ERCOT" are posted at:
[http://interchange.puc.texas.gov/WebApp/Interchange/application/dbapps/filings/pgControl.asp?TXT_UTILITY_TYPE=A&TXT_CNTRL_NO=45633&TXT_ITEM_MATCH=1&TXT_ITEM_NO=&TXT_N_UTILITY=&TXT_N_FILE_PARTY=&TXT_DOC_TYPE=ALL&TXT_D_FROM=&TXT_D_TO=&TXT_NEW=trueAdd a link to the PUCT docket on the LP&L integration]

[4] See the Panhandle Renewable Energy Zone Study Report
http://www.ercot.com/content/news/presentations/2014/Panhandle%20Renewable%20Energy%20Zone%20Study%20Report.pdf

2. Introduction/Background

During the last year, there has been a significant increase in Panhandle capacity meeting ERCOT Planning Guide Section 6.9 requirements, with a new total of WGR capacity of approximately 5,269 MW. ERCOT's recommendations for the addition of the AAWOT second circuit and the synchronous condensers were based on ERCOT's independent assessment of the Panhandle region needs performed in September 2015, when the Panhandle WGR capacity meeting Section 6.9 requirements of the ERCOT Planning Guide was approximately 4,305 MW. Exhibit 2-1 depicts a comparison of the WGR capacity on each Panhandle station during the course of the past year.

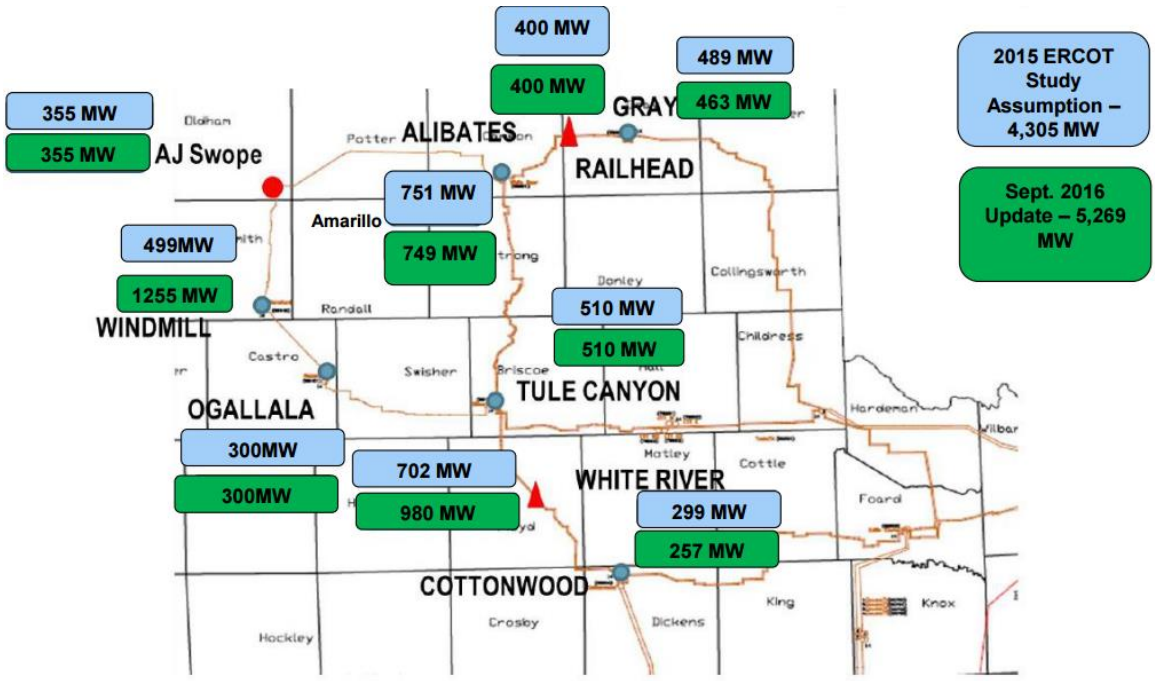


Exhibit 2-1: Panhandle WGR capacity meeting Section 6.9 requirements, ERCOT 2015 study vs. September 2016

Sharyland has been monitoring the development and financial commitment of generation resources in the Panhandle region over the past year. Given the magnitude of WGRs meeting Section 6.9 requirements of the ERCOT Planning Guide since the last ERCOT independent assessment in the region, Sharyland initiated a comprehensive Panhandle region assessment. The key objectives of the Panhandle assessment were as follows:

- Continue to update and refine the system strength, power flow, dynamic and economic assessment models
- Develop detailed transmission options to further increase the Panhandle export limit
    - Additional synchronous condensers
    - Additional dynamic reactive devices

    - Other shunt reactive devices
    - New transmission paths out of the panhandle
- Perform system strength and voltage stability assessment to identify Panhandle export limits associated with each option
- Perform economic evaluations to evaluate economically justifiable options
    - Evaluate sensitivity around LP&L integration for preferred options
    - Evaluate performance of preferred options with additional WGR capacity in the Panhandle (above those meeting Section 6.9 requirements)

This report provides a detailed discussion around the study/modeling assumptions, model benchmarking, system strength/dynamic/economic assessments and key observations.

3. Model Benchmarking

Given the significance of the economic analysis for this assessment, Sharyland benchmarked its economic model[5] with ERCOT's published results for previous studies in the Panhandle region. Specifically, the benchmarking effort comprised of aligning the modeling assumptions, wind generation congestion and curtailment patterns/observations between the Sharyland study economic model and those made by ERCOT in its 2015 Panhandle Transfer Capability Analysis study. A comprehensive ERCOT system model was utilized to perform hourly Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED) based production cost simulations to assess the economic performance under different system conditions. Transmission facilities 69 kV and above across ERCOT were monitored under contingency conditions and simulation algorithms capture the operation of phase shifters, Special Protection Schemes, DC Tie imports, voltage/stability limits, RMR operations and other key aspects of the ERCOT system. Exhibit 3-1 depicts the process overview associated with the economic assessment. Key areas of focus included:

- Natural gas prices
- Load profile development, mapping and forecast
- Generation expansion and renewable generation profiles
- Constraints/congestion mapping
- Changes in status of planned transmission upgrades

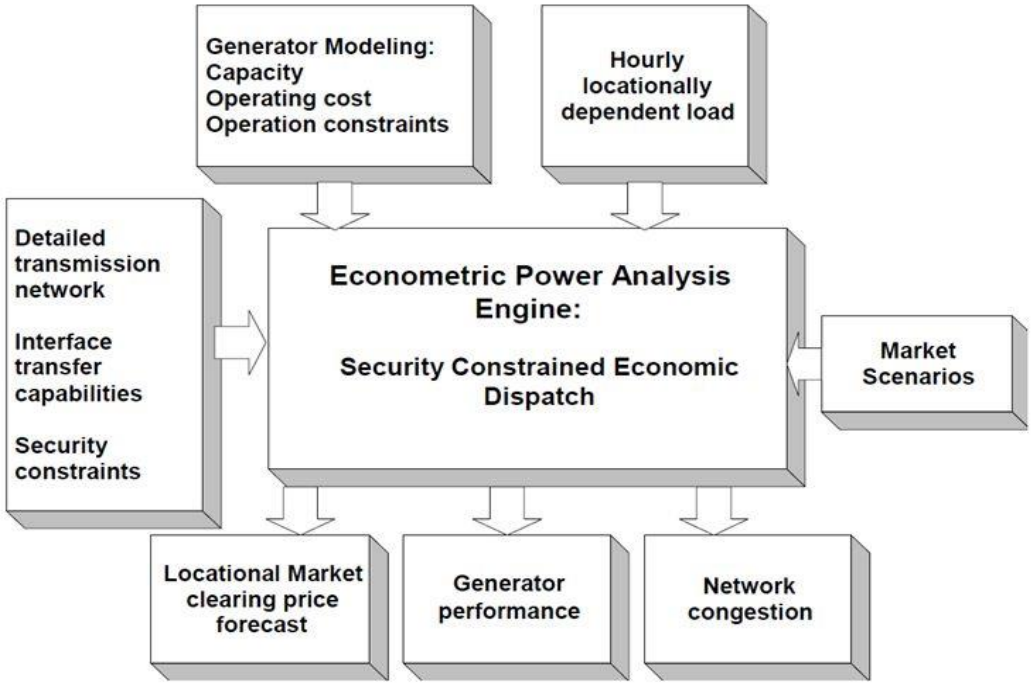


Exhibit 3-1: Process Overview, Transmission Congestion and Economic Assessment

[5] Sharyland utilized PWR Solutions' economic models for the assessment.

a. Generation Expansion Assumptions

All generation resources meeting Section 6.9 requirements of the ERCOT Planning Guide at the time of the ERCOT 2015 independent assessment were included and appropriately modeled for the benchmark. Specific focus was placed upon the wind generation levels in the Panhandle region and to align the same with those documented in the ERCOT 2015 study. Exhibit 3-2 depicts the total Wind Generation Resource (WGR) capacity (MW) in the Panhandle in the Sharyland benchmark model, which aligns closely with the ERCOT assumptions for the 2015 study. A combination of Net Capacity Factors (NCF) for the Panhandle region WGRs and the ERCOT utilized AWS True Wind profiles were utilized to derive the hourly profiles for individual WGRs in the Panhandle.

Station	Modeled MW
AJ Swope	355
Alibates	751
Cottonwood	299
Gray	289
Ogallala	0
Railhead	400
Tule Canyon	510
White River	500
Windmill	500
Grand Total	**3,604**

Exhibit 3-2 Panhandle Wind installed capacity (MW) by station – 2015 study

b. Load Modeling Assumptions

The 2015 ERCOT Regional Transmission Plan (RTP) assumptions for load forecast were utilized to update the hourly load profiles for the study model. Exhibit 3-3 shows a comparison between the 2015 ERCOT RTP based 2019 ERCOT load duration curve and the one used by Sharyland in their economic models. As is evident from the Exhibit 3-3, Sharyland's load assumptions align closely with those utilized by ERCOT for their assessment. Exhibit 3-4 depicts the ERCOT wide monthly demand peak and energy trend as utilized for the economic assessment consistent with the 2015 ERCOT RTP.

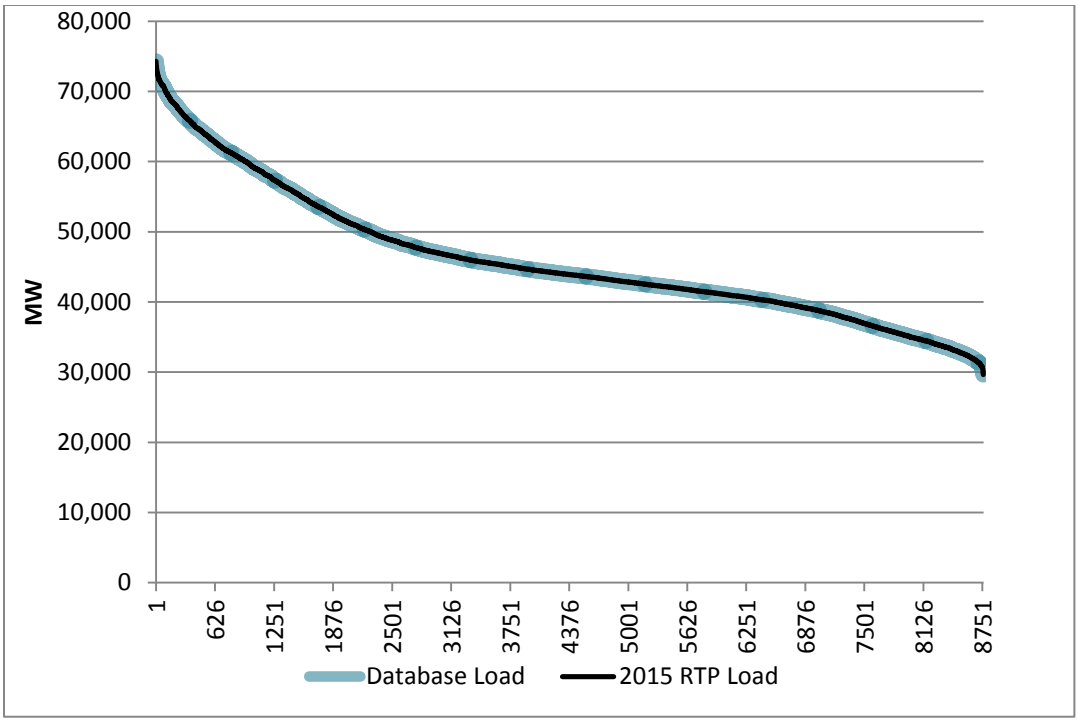


Exhibit 3-3: 2019 Hourly Load Duration Curve Comparison – ERCOT RTP vs Sharyland Study Database

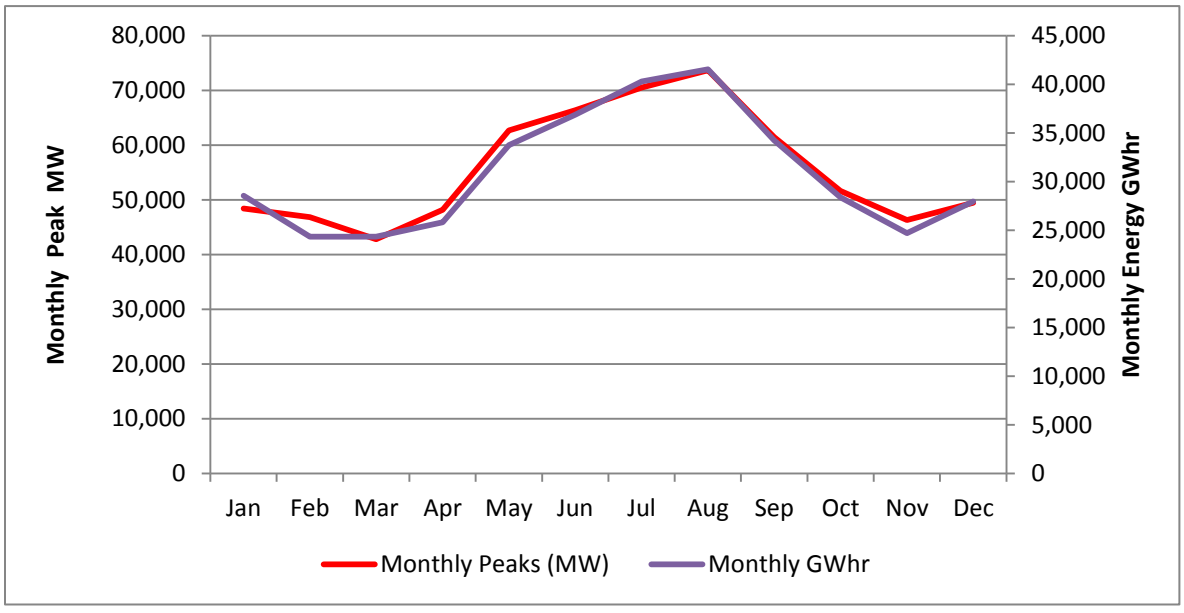


Exhibit 3-4: Monthly Peak and Energy Distribution

c. DC Tie Modeling Assumptions

Based on discussions with ERCOT, the ERCOT-SPP DC ties (North and East DC ties) were modeled as combined cycle units, while the ERCOT-CFE DC ties (Laredo, Railroad and Eagle Pass) were modeled as

loads given that the CFE DC ties are mostly exporting power from ERCOT. ERCOT load data was utilized to obtain the duration curves associated with the loads representing the CFE DC ties.

d. Natural Gas Prices

In line with ERCOT assumptions, Sharyland utilized the latest available natural gas prices' forecast from the EIA Annual Energy Outlook (AEO). The annual natural gas price forecast for 2019 was obtained and the NYMEX forward monthly prices were utilized to derive a shape for the monthly gas prices.

e. Transmission Additions

Transmission additions and planned transmission improvements were applied to the model based on the ERCOT Transmission Project and Information Tracking (TPIT) report from February 2016. Approved transmission additions and/or upgrades with expected in service dates prior to the study year were included in the economic model. Exhibit 3-5 provides a list of major transmission projects added to the economic model.

Key Transmission Projects	In-Service Year
New Lobo – North Edinburg 345 kV line (Valley Import)	2016
New North Edinburg – Palmito 345 kV line (Cross Valley)	2016
New Jones Creek 345 kV station with two 345/138 kV transformers	2017
Hill Country to Skyline - 345 kV 2nd Circuit	2016
Upgrade McDonald Road – Garden City 138/69 kV line	2018
345kV Houston Import Project	2018
Add second 345 kV circuit in the Panhandle loop	2018
Add synchronous condenser in the Panhandle loop	2018
Add Zorn – Marion 345 kV transmission line	2019

Exhibit 3-5: Key Transmission additions

f. Economic Model Benchmarking Results

In order to accurately benchmark its economic model, Sharyland evaluated the same scenarios studied by ERCOT in its 2015 independent assessment namely:

- Scenario 0 – No Panhandle transmission upgrades
- Scenario 1 – Only two (2) 150 MVA, 1050 Amp SCs at Alibates and Tule Canyon

- Scenario 2 – Only the second circuit on the Alibates – AJ Swope – Windmill – Ogallala – Tule Canyon section

Exhibit 3-6 depicts the summary results associated with the benchmarking efforts across all the three study scenarios. In addition to the Panhandle wind curtailment levels aligning very closely between the ERCOT and Sharyland results, the impact of each upgrade on the Panhandle curtailment levels as observed in the Sharyland model matches very closely to that documented by ERCOT. For instance, ERCOT results indicate a 3.12% reduction in the Panhandle wind curtailment levels by virtue of the addition of the synchronous condensers. The results obtained from the Sharyland model are indicative of a 3.3% reduction in the Panhandle wind curtailment levels for the same condition. The results from the benchmark effort demonstrate close alignment with the ERCOT models.

Scenario	Panhandle Wind Capacity (MW)	SCs at Alibates & Tule Canyon	Panhandle Second Circuit	% PH Wind Curtailment SU Model	Impact of Transmission Upgrades SU Model	% PH Wind Curtailment ERCOT	Impact of Transmission Upgrades ERCOT
Scenario 0	3,604	No	No	3.96%	**N/a**	3.65%	**N/a**
Scenario 1	3,604	Yes	No	0.84%	**3.12%**	0.35%	**3.30%**
Scenario 2	3,604	No	Yes	2.63%	**1.33%**	2.27%	**1.38%**

Exhibit 3-6: Sharyland and ERCOT Results Comparison

4. System Strength Assessment and Identification of Synchronous Condenser Locations

Panhandle system strength is estimated using a Weighted Short-Circuit Ratio (WSCR) metric[6]. ERCOT currently limits the Panhandle WGR dispatch such that the WSCR metric is above its target value of 1.5. Based on prior studies conducted by ERCOT and Sharyland, synchronous condensers are effective in increasing the value of WSCR and consequently the Panhandle export limit. ERCOT has endorsed the installation of two (2) synchronous condensers at Sharyland's Alibates and Tule Canyon stations. Further increase in system strength and Panhandle export limit may be achieved by installation of additional synchronous condensers. To that effect, Sharyland conducted a system strength assessment to identify the number and the optimal locations for any future synchronous condensers that may be installed on the Panhandle system.

Key aspects involved in development of short-circuit model for the WSCR based system strength assessment are summarized below:

- ERCOT system is modeled on the basis of the System Protection Working Group (SPWG) Future Year (FY) 2020 case
    - 2nd 345 kV circuit along the Alibates – AJ Swope – Windmill – Ogallala – Tule Canyon section is modeled in the SPWG case
    - One (1) 175MVA synchronous condenser each is added at the Alibates and Tule Canyon stations
    - Each synchronous condenser is modeled to provide a fault current of 1606A at the condenser terminals for a bolted 3-phase fault at its terminals
- Gas generation units in West Texas are kept offline (including the Antelope/Elk generation units at the 345kV Abernathy station)

Further, the latest Generation Interconnection Status (GIS) report (July 2016) available at the time of performing this study is utilized to identify all WGRs in the Panhandle that are currently meeting Section 6.9 requirements of the ERCOT Planning Guide. A total of 5,269MW of Panhandle WGR capacity is utilized for WSCR computation. Exhibit 4-1 depicts the WGR capacity that is utilized for WSCR computation at each identified 345kV station.

In order to determine optimal locations for synchronous condensers, two (2) additional 175MVAR units are incrementally added to the short-circuit case. Multiple scenarios are evaluated around all possible combinations of 345kV stations in the Panhandle transmission system that can be selected for locating the additional synchronous condensers. For each scenario, the Panhandle export limit that is required to achieve the minimum WSCR value of 1.5 is computed.

[6] ERCOT Panhandle Transfer Capability Analysis, September 8, 2015 (http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/42647_58_865838.PDF)

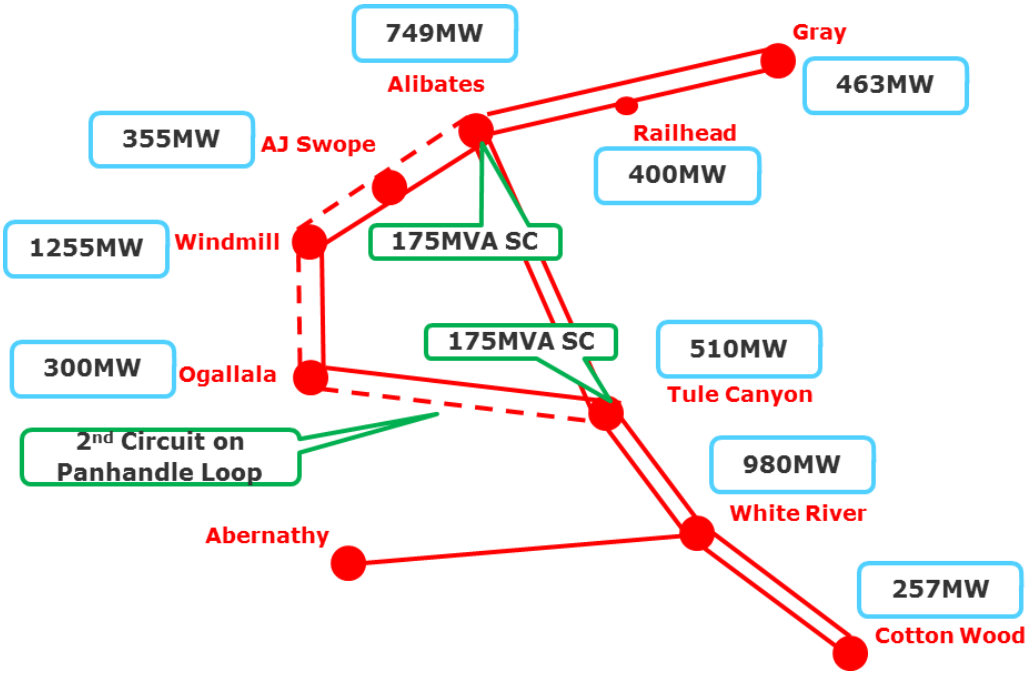


Exhibit 4-1: Panhandle WGR Capacity for Synchronous Condenser Location Assessment

Panhandle Export Limit for WSCR = 1.5									
New SC Location	Windmill	Alibates	Tule Canyon	White River	Gray	Cotton Wood	AJ Swope	Ogallala	Railhead
Windmill	4781	4734	4665	4674	4710	4574	4760	4738	4734
Alibates	--	4635	4586	4594	4618	4494	4685	4677	4640
Tule Canyon	--	--	4505	4518	4559	4418	4626	4604	4584
White River	--	--	--	4511	4566	4416	4635	4614	4592
Gray	--	--	--	--	4569	4465	4665	4652	4606
Cotton Wood	--	--	--	--	--	4308	4535	4515	4491
AJ Swope	--	--	--	--	--	--	4694	4709	4688
Ogallala	--	--	--	--	--	--	--	4665	4677
Railhead	--	--	--	--	--	--	--	--	4614

Exhibit 4-2: Synchronous Condenser Location Assessment – Result Summary

Exhibit 4-2 summarizes the key findings associated with the synchronous condenser location assessment. Locating both incremental synchronous condensers at the 345kV Windmill station is the most beneficial scenario from a WSCR perspective and results in the highest Panhandle export limit of 4,781 MW. This factor makes the 345kV Windmill station the optimal candidate from a WSCR perspective for the addition of new synchronous condensers. Sharyland utilized this key observation in developing additional transmission expansion options.

Lastly, Sharyland notes that the Panhandle export limits documented in Exhibit 4-2 are assumed to be solely determined based on system strength (i.e. WSCR) requirements. These export limits may also be influenced by dynamic stability issues in the Panhandle region. To that effect, there is a possibility that

the actual Panhandle export limits are lower than the system strength based limits depicted in Exhibit 4-2.

5. Transmission Option Development

Utilizing the ERCOT PREZ report and prior studies performed by Sharyland in the Panhandle region as a guide, Sharyland developed nine (9) transmission expansion options with the objective of increasing the Panhandle export limit. As stated above, the addition of synchronous condensers provides an increase in system strength (i.e. WSCR) based export limit, however, the export limit may also be impacted by other factors including dynamic stability in Panhandle region. The options recommended may need to include new transmission lines to resolve dynamic stability issues in the Panhandle region. Therefore, Sharyland utilized a combination of the following while developing transmission expansion options:

- Addition of synchronous condensers
- Addition of new transmission paths

As noted in the System Strength Assessment, if any of the options include addition of synchronous condensers, these are assumed to be located at the Windmill station. Exhibit 5-1 provides a definition for all nine (9) transmission expansion options. All new transmission line additions are assumed to be single circuit lines on double circuit capable towers. A 15% routing addition has been utilized for estimating the lengths for each of the transmission line additions. Detailed schematics and assumptions utilized to develop capital cost estimates are provided in Appendix A.

Option	Additional Synchronous Condensers (@175MVA each)	Transmission Additions/Upgrades	Capital Cost Estimate ($M)
1	2 SCs @ Windmill	None	69
2	2 SCs @ Windmill	345 kV Ogallala – Abernathy – Cottonwood line	273
3	1 SC @ Windmill	345 kV Ogallala – Abernathy – Grassland line	251
4	1 SC @ Windmill	345 kV Ogallala – Abernathy – Longdraw line	291
5	2 SCs @ Windmill	345 kV White River – Clear Crossing line	296
6	2 SCs @ Windmill	345 kV White River – Riley line	296
7	2 SCs @ Windmill + 1 SC each @ Tule Canyon and Alibates	None	131
8	1 SC @ Windmill	345 kV Ogallala – Abernathy line	133
9	1SC @ Windmill	345 kV Ogallala – Abernathy & White River – Cottonwood (on separate ROW)	189

Exhibit 5-1: Transmission Option Definitions

The following assumptions were utilized to develop planning level cost estimates for all the nine (9) transmission expansion options studied:

- The 345 kV single circuit (double circuit capable) line cost estimates are based on Sharyland's estimates from recent 345 kV constructions in the Panhandle region.
- A transmission line routing factor of 15% has been included to estimate the lengths associated with the AC transmission line options.
- Sharyland utilized the cost estimates derived from the recent tender process for the future synchronous condensers.
- The cost of station expansions has been accounted for based on estimates submitted for the LP&L integration study.

6. Transmission Option Assessment

Sharyland comprehensively evaluated all nine (9) transmission expansion options identified above. These evaluations encompassed system strength, power flow, dynamics and economic assessments. System strength (i.e. WSCR) based Panhandle export limits are computed for each option. These are compared with limits observed in dynamic evaluations. Finally, an economic assessment is conducted using the most restrictive Panhandle export limit for each option. Details associated with each evaluation are provided below.

a. System Strength Evaluation

Sharyland conducted a WSCR based system strength assessment for each of the nine (9) options. In line with the system strength assessment presented above, a Panhandle level WGR capacity of 5269MW is utilized for WSCR computation. Based on this capacity, the Panhandle export limit that is required to achieve a target WSCR of 1.5 is then computed. It is noteworthy that the Sharyland computed WSCR based Panhandle export limit for the base case (4,004 MW) aligns very closely with the 4,013 MW published by ERCOT during the September 20th RPG meeting.[7]

Option	Additional Synchronous Condensers (@175MVA each)	Transmission Upgrades	Panhandle Export Limit for WSCR = 1.5
Base Case			4,004
1	2 SCs @ Windmill	None	4,781
2	2 SCs @ Windmill	345 kV Ogallala – Abernathy – Cottonwood line	4,961
3	1 SC @ Windmill	345 kV Ogallala – Abernathy – Grassland line	4,833
4	1 SC @ Windmill	345 kV Ogallala – Abernathy – Longdraw line	4,831
5	2 SCs @ Windmill	345 kV White River – Clear Crossing line	4,948
6	2 SCs @ Windmill	345 kV White River – Riley line	4,932
7	2 SCs @ Windmill + 1 SC each @ Tule Canyon and Alibates	None	5,321
8	1 SC @ Windmill	345 kV Ogallala – Abernathy line	4,520
9	1SC @ Windmill	345 kV Ogallala – Abernathy & White River –Cottonwood (on separate ROW)	4,627

[7] See Panhandle Interface Limit Update RPG 09202016 provided by ERCOT http://www.ercot.com/content/wcm/key_documents_lists/77742/Panhandle_Interface_Limit-Update_RPG_09202016.pptx

Exhibit 6-1: Transmission Option Evaluation – System Strength (WSCR) Based Panhandle Export Limits

Key findings of the system strength evaluation are depicted in Exhibit 6-1, which are indicative of the following:

- Option#7 provides the highest Panhandle export limit of 5,321 MW from a system strength perspective. This option involves addition of four (4) synchronous condensers on the Panhandle transmission system. This option does not include addition of any new transmission lines. The synchronous condensers by themselves are observed to be effective in increasing the fault-current levels in the Panhandle region with corresponding improvement in WSCR and export limit. That being said, the Panhandle export limit for this option is expected to be limited by the results of the dynamic assessment due to the absence of a new export path out of the Panhandle.
- All options that include a new transmission path out of the Panhandle also perform well from a WSCR and export limit standpoint (Option#2 - #6). As expected, options that have a single 175MVA synchronous condenser have relatively lower export limits (e.g. Options #3 and #4). However, they offer significant improvement in the export limit compared to the base case.
- Lastly, Options #8 and #9 offer relatively low increase in the Panhandle export limit. Option #8 does not include a new transmission path out of the Panhandle export limit interface and therefore increase in export limit can be predominantly attributed to the addition of one (1) synchronous condenser at Windmill.

b. Dynamic Assessment

Sharyland also performed transient stability assessment to evaluate the performance of above mentioned nine (9) options from transient voltage and angle stability standpoint.

The ERCOT Dynamics Working Group (DWG) Future Year (FY) 2018 High Wind Light Load (HWLL) dynamic dataset was utilized as the starting dataset for the transient stability assessment. The following incremental changes and/or additions were made to arrive at the base study dataset:

- All WGRs meeting Section 6.9 requirements of the ERCOT planning guide in the Panhandle region (according to July 2016 ERCOT ROS report) not already included in the ERCOT posted dataset were incrementally modeled hence increasing the total panhandle wind capacity modeled in the study dataset to 5,269 MW.
- ERCOT gas units were scaled down to maintain the load and generation balance.
- The latest information associated with the turbines comprising the abovementioned WGRs available at the time of the study was utilized.
- For every transmission option, a corresponding study scenario was developed by incrementally integrating the transmission option into the base case.

Sharyland evaluated the performance of the Panhandle transmission system for all the ten (10) study datasets (base and study option datasets) for the following dynamic events:

- Three phase fault based normal clearing events for all Panhandle and nearby transmission facilities (P1 and P7 events)
- Single Line to Ground (S-L-G) fault based breaker failure events for all Panhandle and nearby transmission facilities (P4 events)
- Prior outage of transmission circuit followed by outage of another unrelated transmission circuit (P6 events)

Close to 100 dynamic events were utilized to evaluate the performance of study datasets from stability standpoint.

The following criteria were utilized to define stable transmission system performance for the dynamic events simulated for the transient stability assessment:

- All the generation units within and in the vicinity of the Panhandle region should be transiently stable except for units tripped for fault clearing, if any
- Voltage at BES elements within and in the vicinity of the Panhandle region should exhibit transient stability and acceptable transient voltage recovery
    - For P1 category events, voltage shall recover to 0.90 p.u. within five seconds after clearing the fault.
    - For P2 to P7 category events, voltage shall recover to 0.90 p.u. within ten seconds after clearing the fault.
- Loss of source should not exceed the ERCOT Responsive Reserve Service (RRS) i.e. 2,300 MW for any of the events simulated

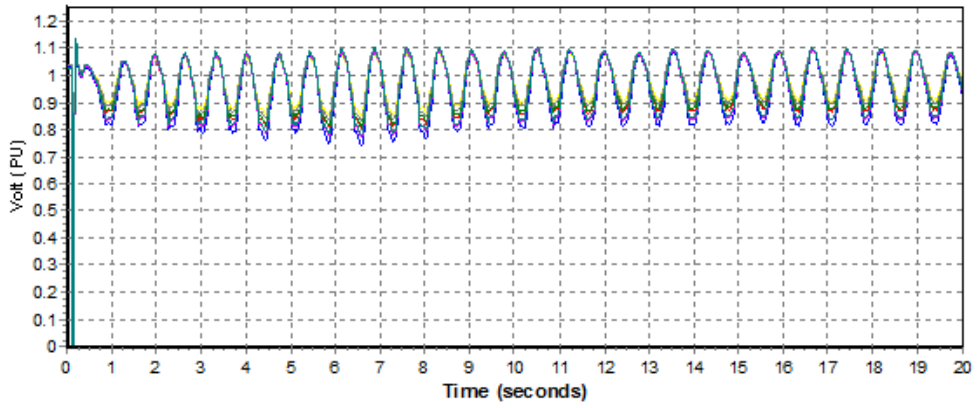
The following system responses would be considered unacceptable:

- Transiently unstable, with widespread system collapse
- Transiently stable, with un-damped or sustained power system oscillations
- Loss of source exceeding ERCOT RRS levels i.e. 2,300 MW

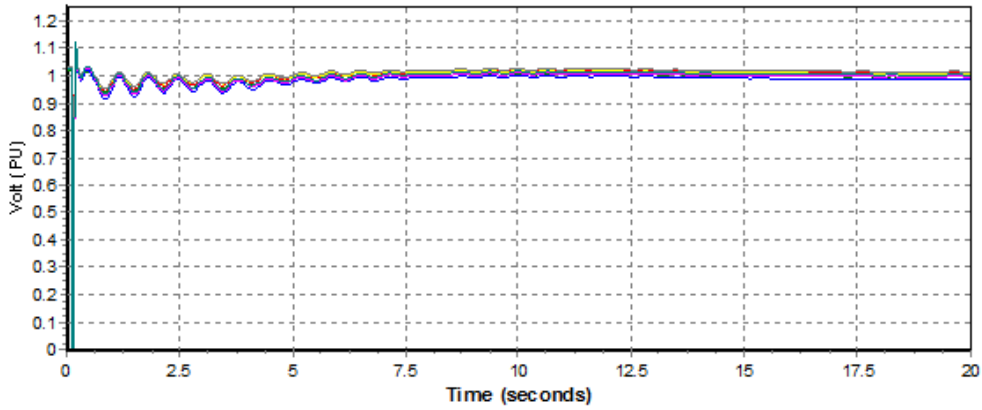
In addition to the above, specific focus was placed on observing any sustained or poorly damped voltage oscillations that could be potential manifestations of control/instability issues due to the weak system conditions in the Panhandle region.

Sharyland performed transient stability analysis by simulating the above discussed dynamic event categories on the study datasets. The study results were compared to the performance criteria to identify any unacceptable system response. In case of any unacceptable performance, the Panhandle wind export was reduced proportionally for all Panhandle generation resources to identify the Panhandle export limit in which no voltage and/or angle instability is observed. Any local wind generation limits within the Panhandle arising due to loss of transmission facilities within the Panhandle were also identified (if applicable for any transmission option).

Exhibit 6-3 provides a summary of the results of the transient stability assessment for the studied scenarios. Exhibit 6-2 provides a comparative analysis of the Panhandle system performance from a dynamic standpoint at two (2) different Panhandle export levels for transmission Option #1. Exhibit 6-2a depicts the Panhandle system performance at the WSCR based Panhandle export limit (4,781 MW) thereby clearly demonstrating unacceptable performance from a dynamic standpoint. To that extent the Panhandle export limit was required to be reduced to 4,204 MW for this transmission option to obtain acceptable dynamic performance as depicted in Exhibit 6-2b.



(a)



(b)

Exhibit 6-2: Panhandle Region 345KV Stations' voltage response for a critical dynamic event – Study Option #1 – (a) Panhandle export limited to WSR based limit of 4,781MW (b) Panhandle export limited to transient stability based limit of 4,204 MW

Option	Additional Synchronous Condensers (@175MVA each)	Transmission Upgrades	Dynamic Assessment Based Panhandle Export limit (MW)	
			Export Limit	Local Limits
Base Case			4,004	None
1	2 SCs @ Windmill	None	4,204	None
2	2 SCs @ Windmill	345 kV Ogallala – Abernathy – Cottonwood line	4,576	None
3	1 SC @ Windmill	345 kV Ogallala – Abernathy – Grassland line	4,986	Limit generation output at Windmill to 1,103 MW
4	1 SC @ Windmill	345 kV Ogallala – Abernathy – Longdraw line	4,984	Limit generation output at Windmill to 1,103 MW
5	2 SCs @ Windmill	345 kV White River – Clear Crossing line	4,470	None
6	2 SCs @ Windmill	345 kV White River – Riley line	4,450	None
7	2 SCs @ Windmill + 1 SC each @ Tule Canyon and Alibates	None	4,204	None
8	1 SC @ Windmill	345 kV Ogallala – Abernathy line	4,120	None
9	1SC @ Windmill	345 kV Ogallala – Abernathy & White River –Cottonwood (on separate ROW)	4,627	None

Exhibit 6-3: Transmission Option Evaluation – Dynamic Assessment Based Panhandle Export Limits

The results associated with the transient stability assessment when compared with the systems strength evaluation results are indicative of the following:

- The panhandle export limit as obtained by dynamic assessment seem more restrictive than the WSCR-screening based panhandle export limits especially for transmission options that do not offer a new export path out of the Panhandle
- Angular stability issues are observed in the absence of an additional export path out of Panhandle at export levels greater than 4,400 MW
- Transmission options that include a new export path out of the Panhandle exhibit a better balance between the WSCR based and the dynamic assessment based Panhandle export limit. This is clearly evident from the performance of Options #3, #4 and #9
- The SC only options (Options #1 and #7) are severely limited in terms of the Panhandle export capability from a dynamic standpoint
- Option #8 does not provide a significant benefit in terms of the Panhandle export capability since the Ogallala to Abernathy line segment comprising the option does not extend beyond the Panhandle export interface boundary

While the results of the system strength and dynamic assessment do provide clear indications towards better performing options (Options #3, #4 and #9) in terms of Panhandle export capability, Sharyland has evaluated all nine (9) transmission options from an economic perspective.

c. Economic Assessment

The future year 2019 economic model benchmarked with the modeling assumptions discussed above was utilized to evaluate the performance of the nine (9) transmission expansion options. The economic model was updated to reflect all Panhandle WGRs meeting Section 6.9 requirements of the ERCOT Planning Guide (5,269 MW). Transmission additions and/or upgrades associated with each transmission options were implemented in the economic model as appropriate.[8] The Panhandle export limit was implemented by defining the Panhandle interface consistent with ERCOT definitions and as defined below:

- 345 kV Tesla – Jim Treece/Riley double circuit
- 345 kV Tesla – Edith Clarke double circuit
- 345 kV Cottonwood – Dermott double circuit
- 345 kV Cottonwood – Edith Clarke double circuit

It is important to note that the Panhandle interface definition and limits were appropriately altered to reflect the addition of transmission facilities associated with each transmission option. The results of the system strength and dynamic assessment were utilized to identify the most limiting Panhandle export condition associated with each transmission option. Additionally, in line with ERCOT's operations practice, a 10% operational margin was utilized when implementing the Panhandle export limits for the purposes of the economic assessment (refer to Exhibit 6-4). Detailed 8,760 hour production cost based economic simulations were performed to evaluate the performance of each of the nine (9) transmission options and compare the same to the ERCOT economic performance criteria.

Per ERCOT's economic planning criteria, if the production cost savings of a transmission project is greater than the first year annual revenue requirement for a transmission project, calculated at 15% of the estimated capital cost of the project, then the project is deemed economically justified.

Exhibit 6-4 provides the summary results associated with the economic assessment for all the nine (9) transmission expansion options. Additionally, the system wide annual production cost (APC) savings accrued by virtue of each transmission option compared to the base case is also presented in Exhibit 6-4. Per the ERCOT economic planning criteria, the 15% annual revenue requirement in conjunction with the APC savings have been utilized to estimate the capital cost expected to be economically justified for each transmission option. Finally, the estimated capital cost expected to be economically justified for each option has been compared to the actual cost (Option Cost Estimate) associated with the option to comment on the economic feasibility of each of the nine (9) options studied. In other words, if the *Option Cost Estimate* for a particular option exceeds the *Capital Cost Justified for Transmission Investment* for that option, the option does not to meet the ERCOT economic planning criteria.

[8] The synchronous condenser additions in the Panhandle were not directly implemented rather the impact of the same on the Panhandle export limit was utilized to reflect the impact of the synchronous condenser.

Scenario ID	Panhandle Interface Limit			# Hours PH Binding	APC Savings ($M)	Capital Cost justified for Transmission Investment ($M)	Option Cost Estimate ($M)
	System Strength Limit	Stability Limit	Operational Limit (90% of Min of System Strength and Stability Limit)				
Base Case	4,004	4,004	3,604	2,318	NA	NA	NA
Option 1	4,781	4,204	3,784	2,038	12.3	82	69
Option 2	4,961	4,576	4,118	1,542	31	206.8	273
Option 3	4,833	4,986	4,350	1,162	40.5	269.9	251
Option 4	4,831	4,984	4,348	1,167	40.5	269.9	291
Option 5	4,948	4,470	4,023	1,681	25.7	171.6	296
Option 6	4,932	4,450	4,005	1,703	25.1	167.1	296
Option 7	5,321	4,204	3,784	2,038	12.3	82	131
Option 8	4,520	4,120	3,708	2,151	7.1	47.4	133
Option 9	4,627	4,627	4,164	1,467	33.2	221.1	189

Exhibit 6-4: Economic Analysis Results

The following key observations can be made from the results of the economic study depicted in Exhibit 6-4:

- Options #1, #3 and #9 meet the ERCOT economic planning criteria.
- While Options #3 and #4 are very similar in terms of composition and performance, Option #3 meets the ERCOT economic planning criteria while Option #4 doesn't. This is due to the additional cost associated with building approximately 30 miles of additional 345 kV line to Longdraw (Option #4) as opposed to terminating at Grassland (Option #3).
- Options #7 and #8 suffer in terms of economic performance due to limited Panhandle export capability stemming from the lack of an export path out of the Panhandle.
- Option #1 is economically justifiable despite limited improvements in Panhandle export capability due to the relatively lower cost of the SC only option. That said, the overall results of the study are indicative of one synchronous condenser coupled with an additional export path out of the Panhandle as an optimal and cost effective solution to the Panhandle export limitations.

7. Lubbock Power & Light (LP&L) Integration Sensitivity

The economic analysis showed that Options #1, #3 and #9 meet the ERCOT economic planning criteria based on their APC savings compared to the capital cost associated with the options. Sharyland conducted a sensitivity analysis to evaluate the performance of these options with the Lubbock Power & Light (LP&L) system integrated into ERCOT. Sharyland utilized the ERCOT recommended Option #4ow to integrate the LP&L system into the ERCOT grid[9]. This option is depicted in Exhibit 7-1.

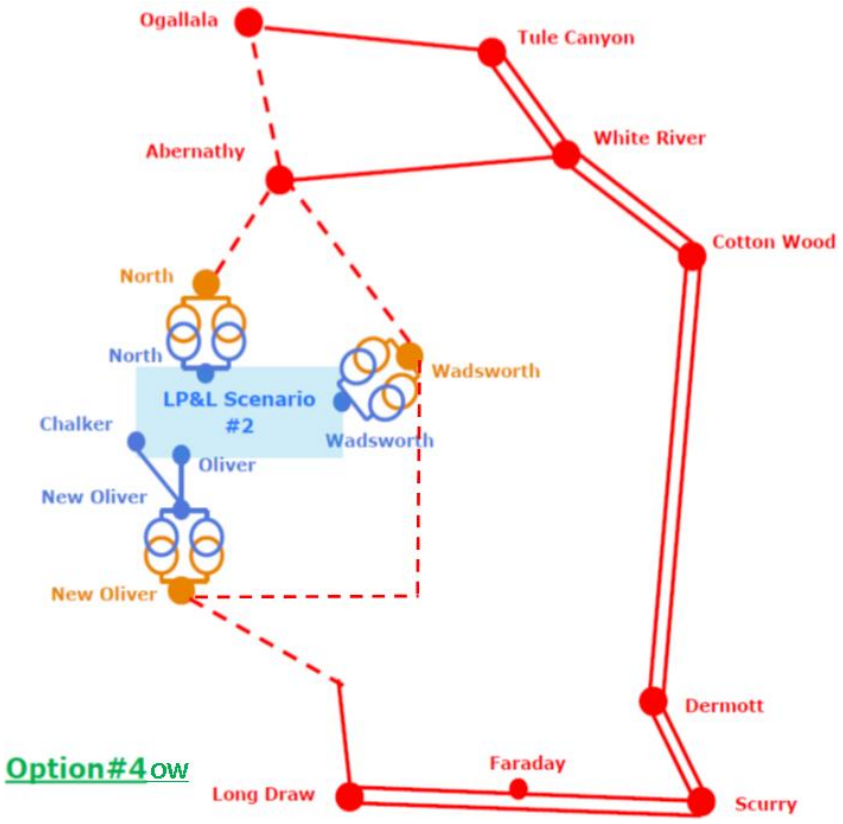


Exhibit 7-1: LP&L Integration via Option#4ow

It is important to note that Option #4ow,utilized for LP&L integration, already includes similar 345kV transmission lines that are a part of Option #3 except for the 345 kV Abernathy – North section. To that effect, implementation of Option #3 after LP&L has been integrated into ERCOT essentially amounts to addition of a single 175MVA synchronous condenser at the Windmill station. Options #1 and #3 will be similar post LP&L integration. The only difference between these two options is that Option#1 will

[9] Study of the Integration of the Lubbock Power & Light System into the ERCOT System, June 09, 2016 (http://www.ercot.com/content/wcm/key_documents_lists/76336/13_ERCOT_Lubbock_Load_Integration_Study.pdf)

include two (2) 175MVA synchronous condensers at Windmill. Detailed schematics for Options #1, #3 and #9 in presence of LP&L integration via Option #4ow are provided in Appendix B.

Sharyland reevaluated the Panhandle export limits from a system strength and dynamic stability perspective for Options #1, #3 and #9 in presence of LP&L integration solution. While conducting the system strength assessment, all gas generation units within the LP&L system are kept offline. The updated Panhandle export limits are utilized to perform economic simulations for evaluation of APC savings associated with the three (3) options. While conducting economic simulations, the Panhandle interface definition is appropriately modified to account for LP&L integration (Refer Exhibit 7-2). It is important to note that the Panhandle interface definition utilized by Sharyland post-Lubbock integration is consistent with that utilized by ERCOT in their LP&L integration study.

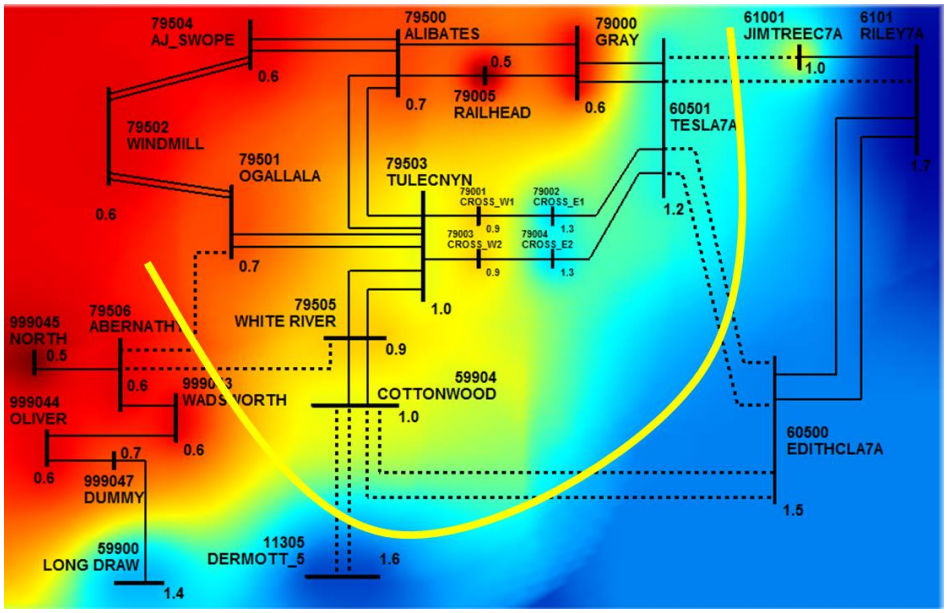


Exhibit 7-2: Panhandle Interface Definition with LP&L Integration (Option #4ow)

With LP&L Option 4OW Scenarios						
Scenario ID	Panhandle Interface Limit			APC Savings ($M)	Capital Cost for Transmission Investment ($M)	Option Cost Estimate ($M)
	System Strength Limit	Stability Limit	Operational Limit (90% of Min of System Strength and Stability Limit)			
Base Case	4,458	>4,458	4,012	NA	NA	NA
Option 1	5,191	4,941*	4,447	18.1	120.6	69
Option 3	4,838	4,941*	4,354	15	100	41
Option 9	4,931	>4,931	4,438	18.0	119.9	96.1

*LP&L lines observed to be congested

Exhibit 7-3: Economic Assessment with LP&L Integration (Option#4ow)

Exhibit 7-3 depicts the economic study results in presence of LP&L integration. It is important to note that the cost estimates associated with each option as depicted in Exhibit 7-3 represent costs incremental to the LP&L integration. Key observations associated with same are summarized below:

- All three (3) options are deemed to be economic based on APC savings listed in Exhibit 7-3 and their incremental capital costs post LP&L integration via Option #4ow.
- Options #1 and #3 offer similar performance in terms of transfer capability and APC savings.
- Option #3 has the lowest capital cost as it includes only one synchronous condenser.

8. Future Panhandle WGR Build-out Sensitivity

In addition to evaluating the impact of integrating LP&L into the ERCOT grid, Sharyland also performed a sensitivity around the increase in WGR Panhandle capacity beyond resources that currently meet Section 6.9 requirements of the ERCOT Planning Guide. The Panhandle WGR capacity was increased proportionately by ~13.9% (from the original 5,269 MW) resulting in a total Panhandle WGR capacity of 6,000 MW. No other changes were made to the economic model and/or assumptions as compared to the previous economic analysis. Note that the LP&L system integration into ERCOT was not modeled for this sensitivity.

The following study options were evaluated from an economic standpoint for this sensitivity:

- Base Case
- Option 3
- Option 9

No changes were made to the Panhandle export limits for the base option or the any of the other options evaluated for this sensitivity. Exhibit 8-1 depicts the summary results associated with the sensitivity analysis for the above options. The results associated with the same options for the base run have also been presented for comparative analysis purposes.

Scenario ID	System Strength Limit (MW)	Stability Limit	Operational Limit (90% of Min of System Strength and Stability Limit	APC Savings ($M)	Capital Cost for Transmission Investment ($M)	Estimate of Capital Cost for construction ($M)
Base Case	4,004	4,004	3,604	NA	NA	NA
Option 3	4,833	4,986	4,350	40.5	269.9	251
Option 9	4,627	4,627	4,164	33.2	221.1	189
Total PH WGR Capacity @ 6,000 MW (Increased by 13.9% w.r.t. base run)						
Base Case	4,004	4,004	3,604	NA	NA	NA
Option 3	4,833	4,986	4,350	58.3	388	251
Option 9	4,627	4,627	4,164	46	306.9	189

Exhibit 8-1: Summary Results, Future Panhandle Wind Build-Out Sensitivity

As evident from Exhibit 8-1, there is significant increase in the APC savings following the increase in the Panhandle WGR capacity to 6,000 MW. Based on the conditions studied, Option #3 exhibits $58.3M in APC savings for the sensitivity case in comparison to the $40.5M observed for the base run with 5,269 MW of Panhandle WGR capacity. The economic feasibility of Option #3 is significantly enhanced with the additional wind in the Panhandle region. While only WGR capacity meeting Section 6.9 requirements of the ERCOT Planning Guide can justify economic criteria recommendations, Option #3 provides for significant economic value should more wind locate in the region.

9. Recommendations

Based on the comprehensive analysis spanning system strength, power flow, dynamic performance, and production cost based economic assessments, Sharyland recommends the South Plains Transmission Project (Option #3) as the preferred option to address the future needs of the Panhandle region. The South Plains Transmission Project comprises of the following transmission additions and/or upgrades in the Panhandle region:

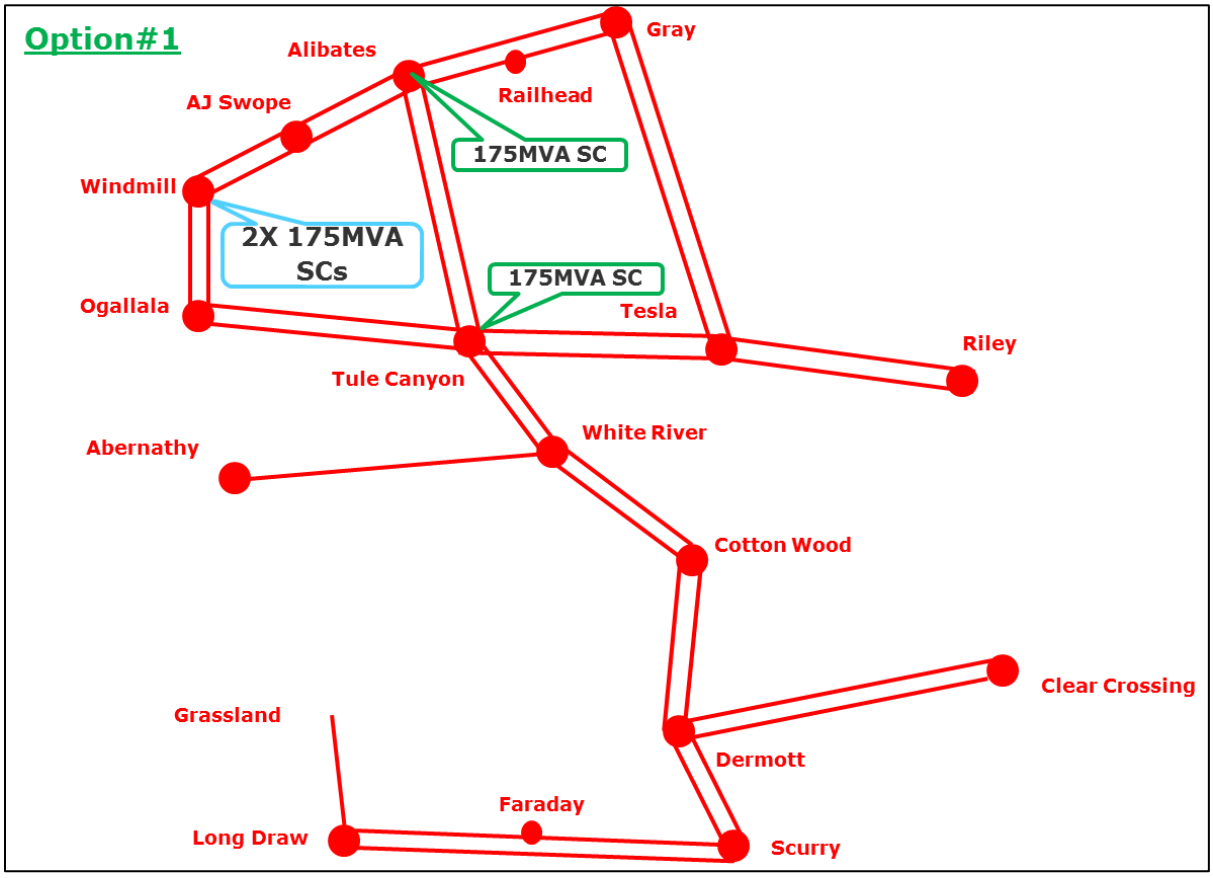
- New 67.5 mile 345 kV (double circuit capable) Abernathy – Grassland single circuit line
- New 53.2 mile 345 kV (double circuit capable) Ogallala – Abernathy single circuit line
- One (1) 175 MVA synchronous condenser at Windmill (minimum short circuit contribution of 1606 A at the condenser terminals)

The key factors associated with Sharyland's recommendation of the South Plains Transmission Project are as follows:

- The Project provides the highest Panhandle export capability amongst all the options evaluated by Sharyland when taking both system strength and dynamic performance into account.
- The Project meets the ERCOT economic planning criteria with and without the LP&L system integrated into ERCOT.
- The Project provides a new export path out of the Panhandle while striking an optimal balance between the system strength and dynamic performance of the Panhandle region in ERCOT.
- All the transmission additions and/or upgrades comprising the Project align closely with the Stage 2 upgrades recommended for the Panhandle region by ERCOT in their April 2014 PREZ study report.
- The 345 kV Ogallala – Abernathy – Grassland line section comprising the Project also aligns very closely with ERCOT's recommended Option #4ow to integrate the LP&L system if and when the same were to be approved.

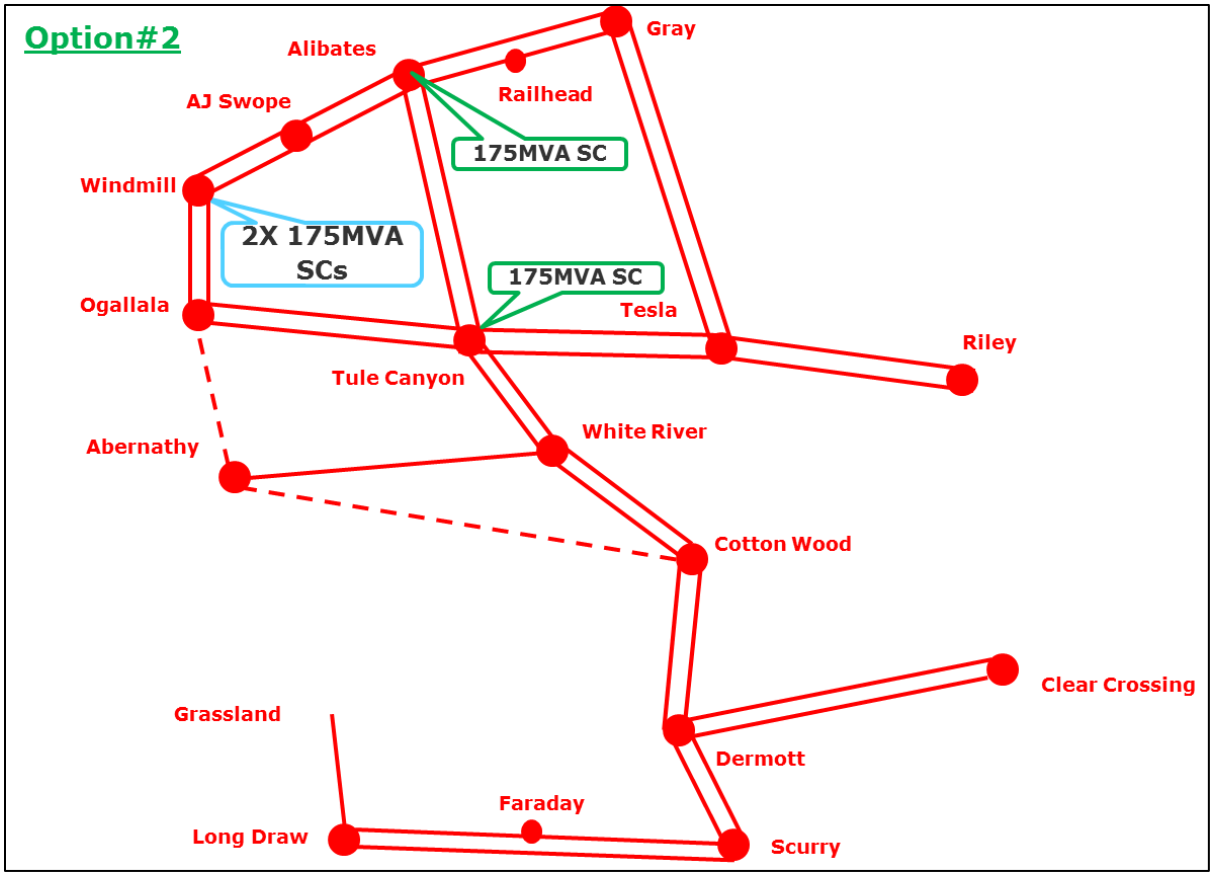
The capital cost estimate for the South Plains Transmission Project is estimated to be $251 M and Sharyland estimates the project to be in service by the end of 2020.

Appendix A – Transmission Option Schematics



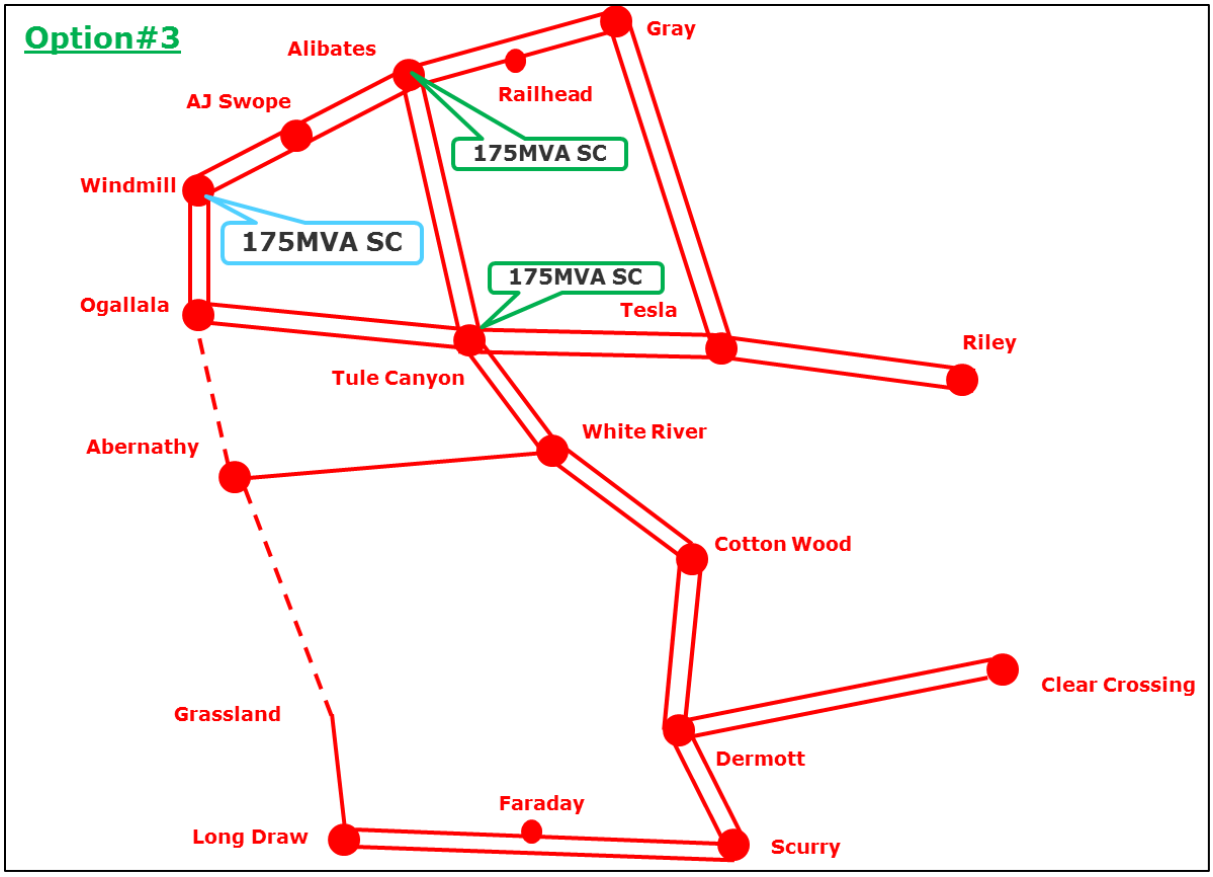
Option 1			
Item	Units	Cost/unit	Cost ($M)
175MVA Synchronous Condenser at Windmill (1606A)	2	34.5	69
Total			**69**

A1: Option #1 Schematic and Cost Estimates



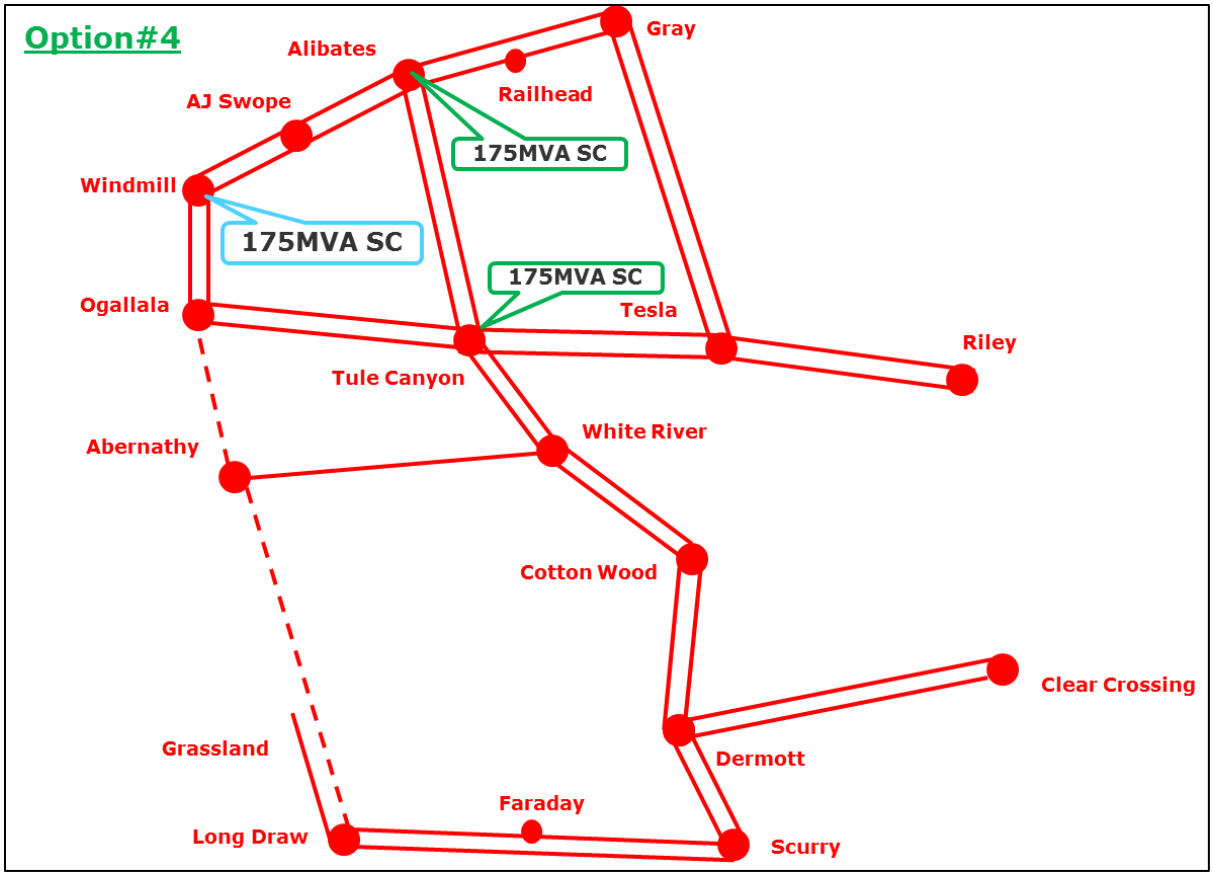
Option 2			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	2	34.5	69
Ogallala - Abernathy 345 kV line (SCKT on DCKT tower)	53.2	1.65	87.8
Abernathy - Cottonwood 345 kV line (SCKT on DCKT tower)	64.3	1.65	106.1
Ogallala Expansion 1 345 kV terminal	1	1.8	1.8
Abernathy Expansion 2 345 kV terminals	2	2.3	4.6
Cottonwood Expansion 1 345 kV terminal	1	4	4
Total			**273**

A2: Option #2 Schematic and Cost Estimates



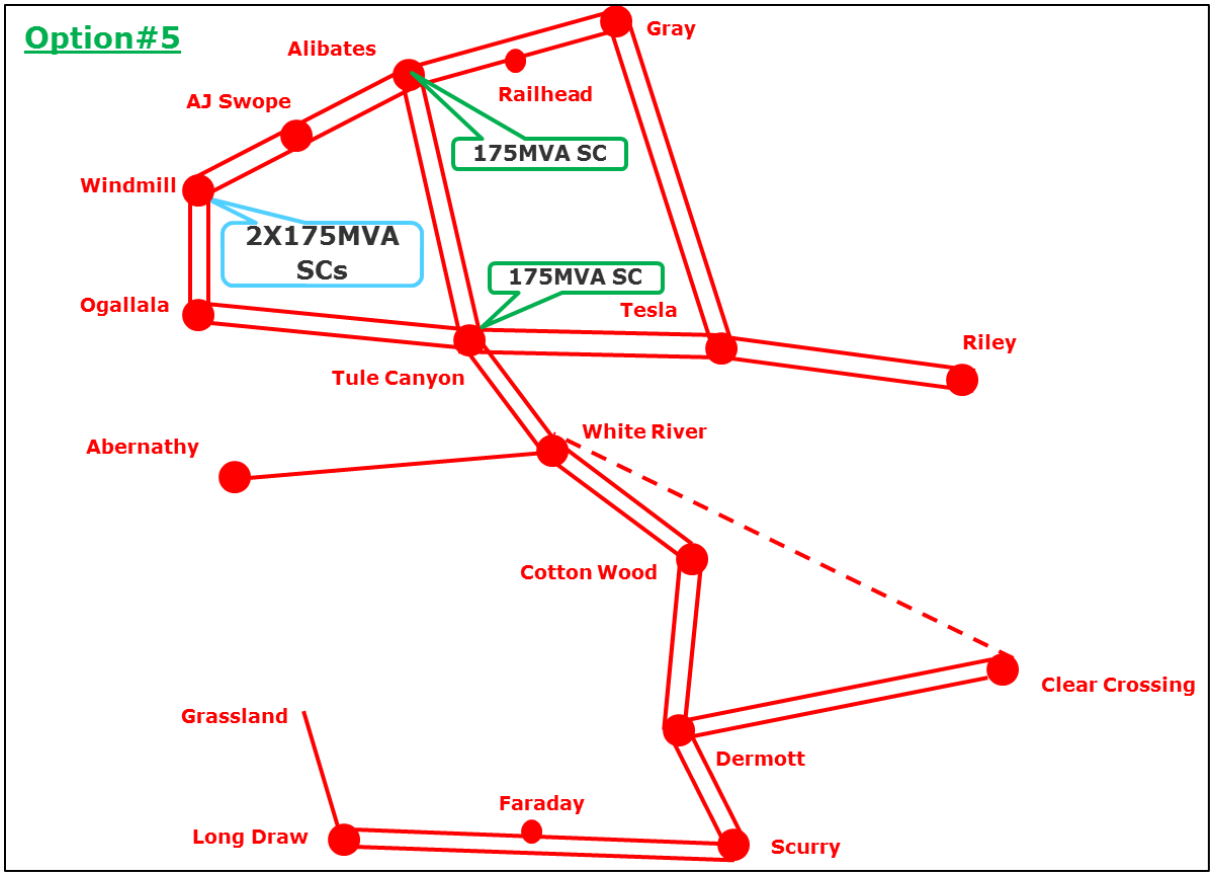
Option 3			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	1	41	41
Ogallala - Abernathy 345 kV line (SCK on DCKT tower)	53.2	1.65	88
Abernathy - Grassland 345 kV line (SCK on DCKT tower)	67.5	1.65	111
Ogallala Expansion 1 345 kV terminal	1	1.8	1.8
Abernathy Expansion 2 345 kV terminals	2	2.3	4.6
Longdraw Expansion 1 345 kV terminal	1	4	4
Total			**251**

A3: Option #3 Schematic and Cost Estimates



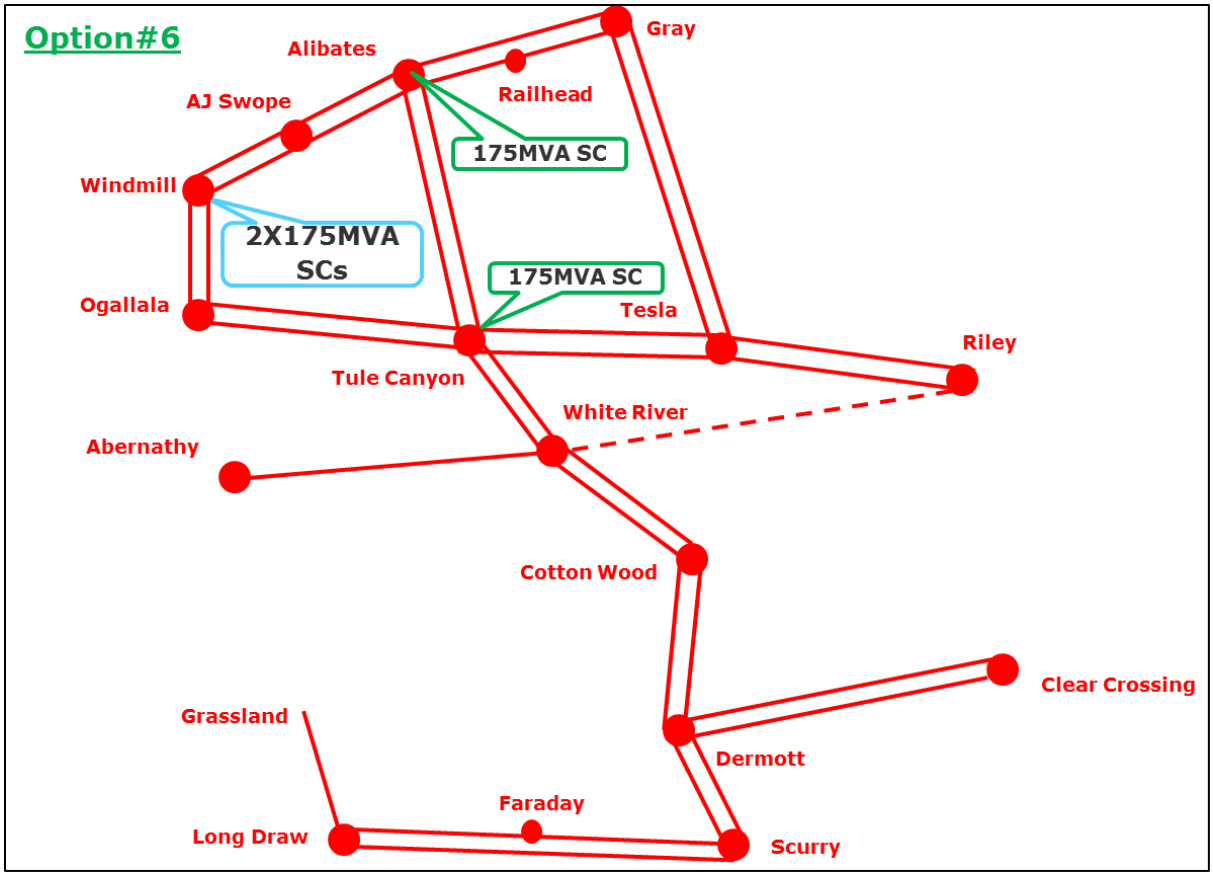
Option 4			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	1	41	41
Ogallala - Abernathy 345 kV line (SCK on DCKT tower)	53.2	1.65	88
Abernathy - Longdraw 345 kV line (SCK on DCKT tower)	92	1.65	152
Ogallala Expansion 1 345 kV terminal	1	1.8	1.8
Abernathy Expansion 2 345 kV terminals	2	2.3	4.6
Longdraw Expansion 1 345 kV terminal	1	4	4
Total			**291**

A4: Option #4 Schematic and Cost Estimates



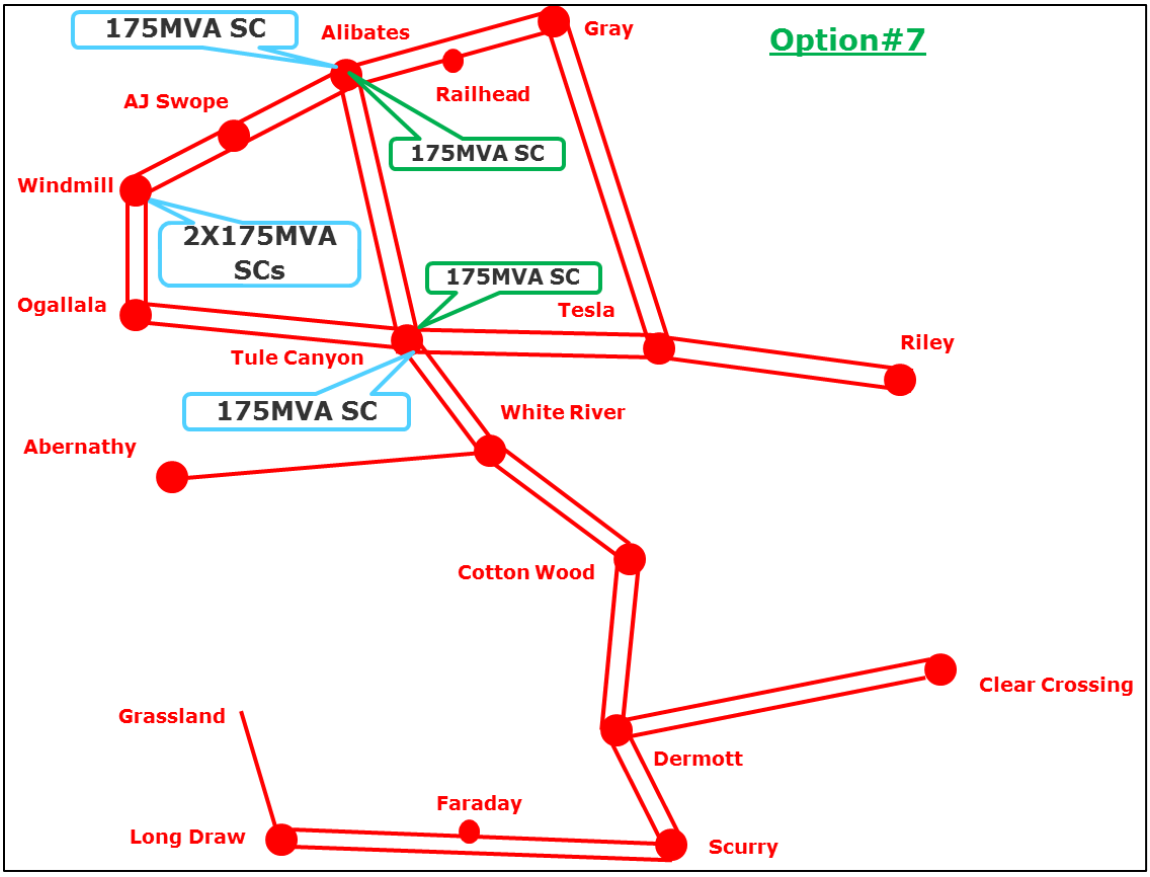
Option 5			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	2	34.5	69
White River - Clear Crossing 345 kV line (SCKT on DCKT tower)	134	1.65	221.1
White River Expansion 1 345 kV terminal	1	1.8	1.8
Clear Crossing Expansion 1 345 kV terminal	1	4	4
Total			**296**

A5: Option #5 Schematic and Cost Estimates



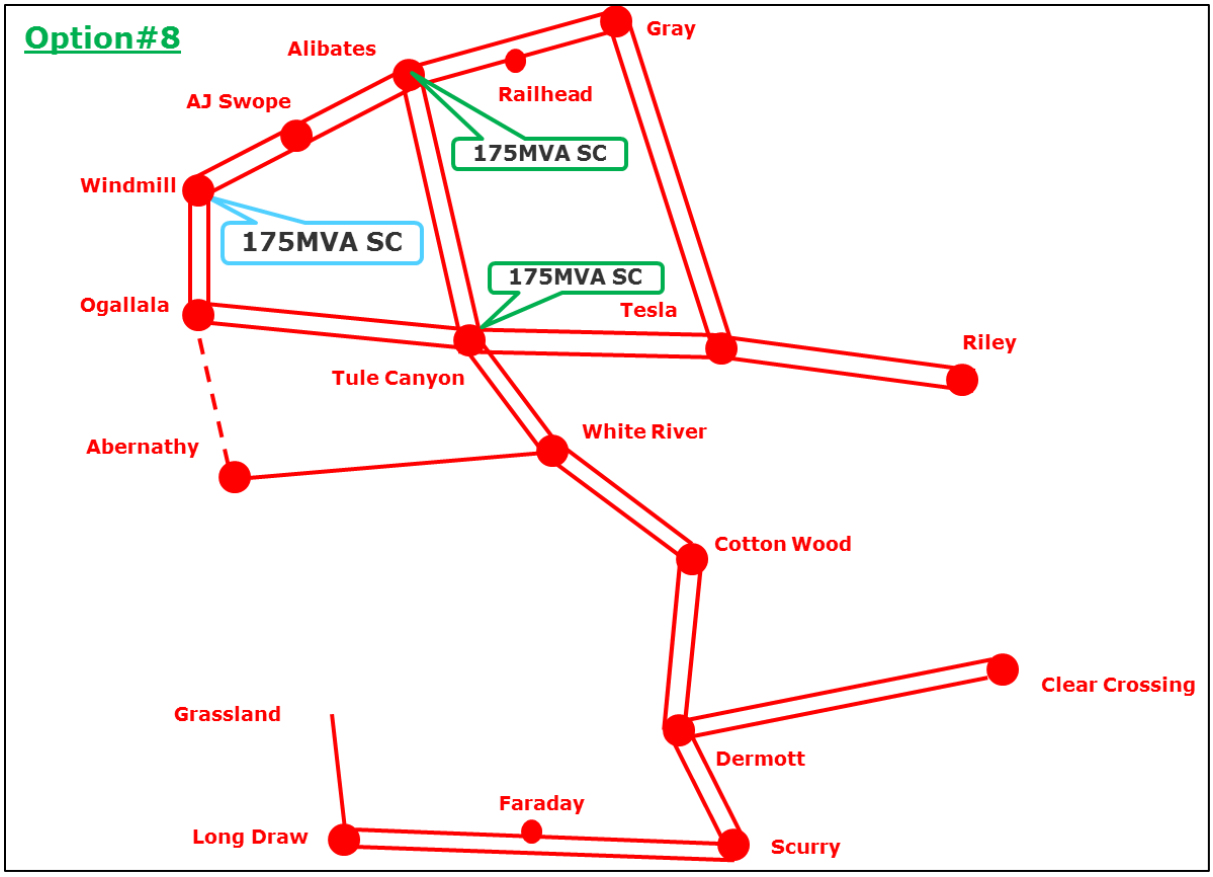
Option 6			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	2	34.5	69
White River - Riley 345 kV line (SCKT on DCKT tower)	134.2	1.65	221.4
White River Expansion 1 345 kV terminal	1	1.8	1.8
Riley Expansion 1 345 kV terminal	1	4	4
Total			**296**

A6: Option #6 Schematic and Cost Estimates



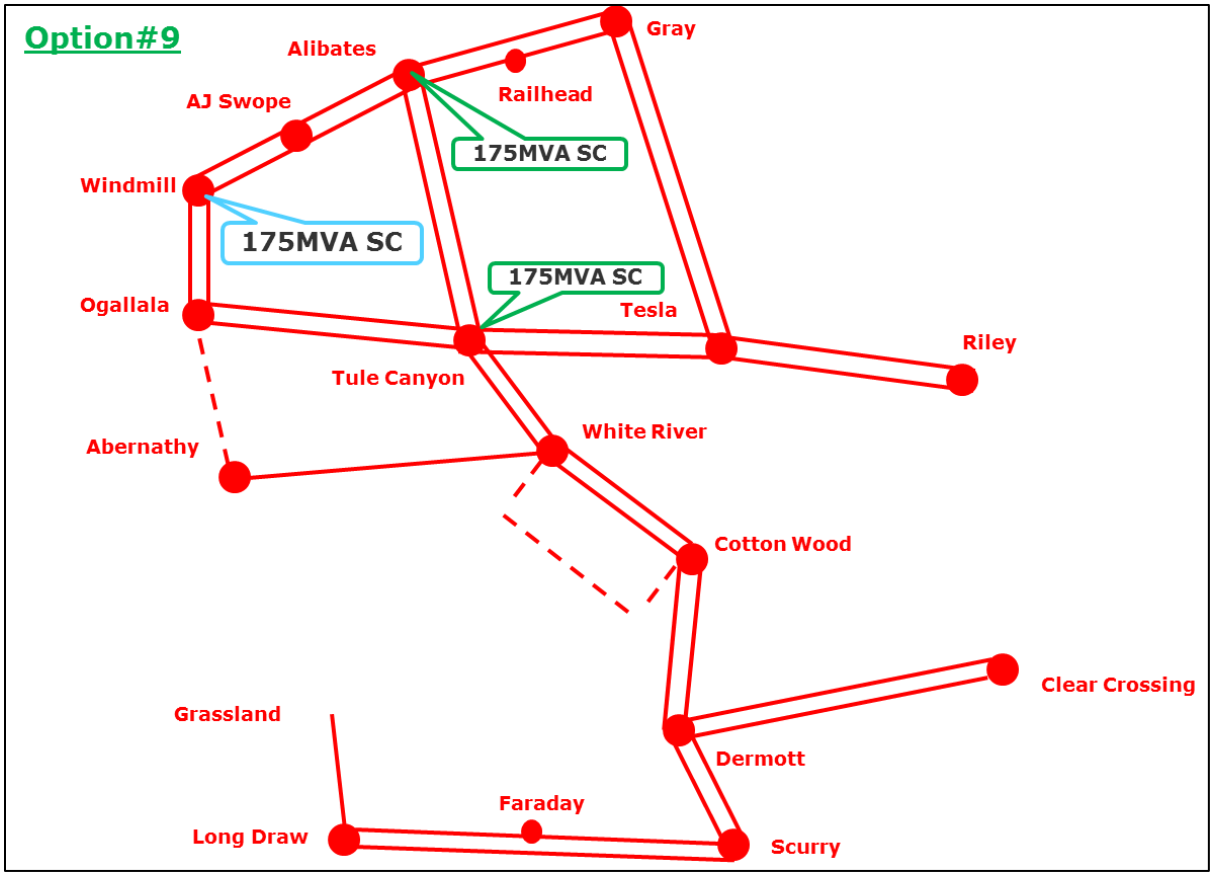
Option 7			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	2	34.5	69
175MVA Synchronous Condenser at Alibates (1606A)	1	31	31
175MVA Synchronous Condenser at Tule Canyon (1606A)	1	31	31
Total			**131**

A7: Option #7 Schematic and Cost Estimates



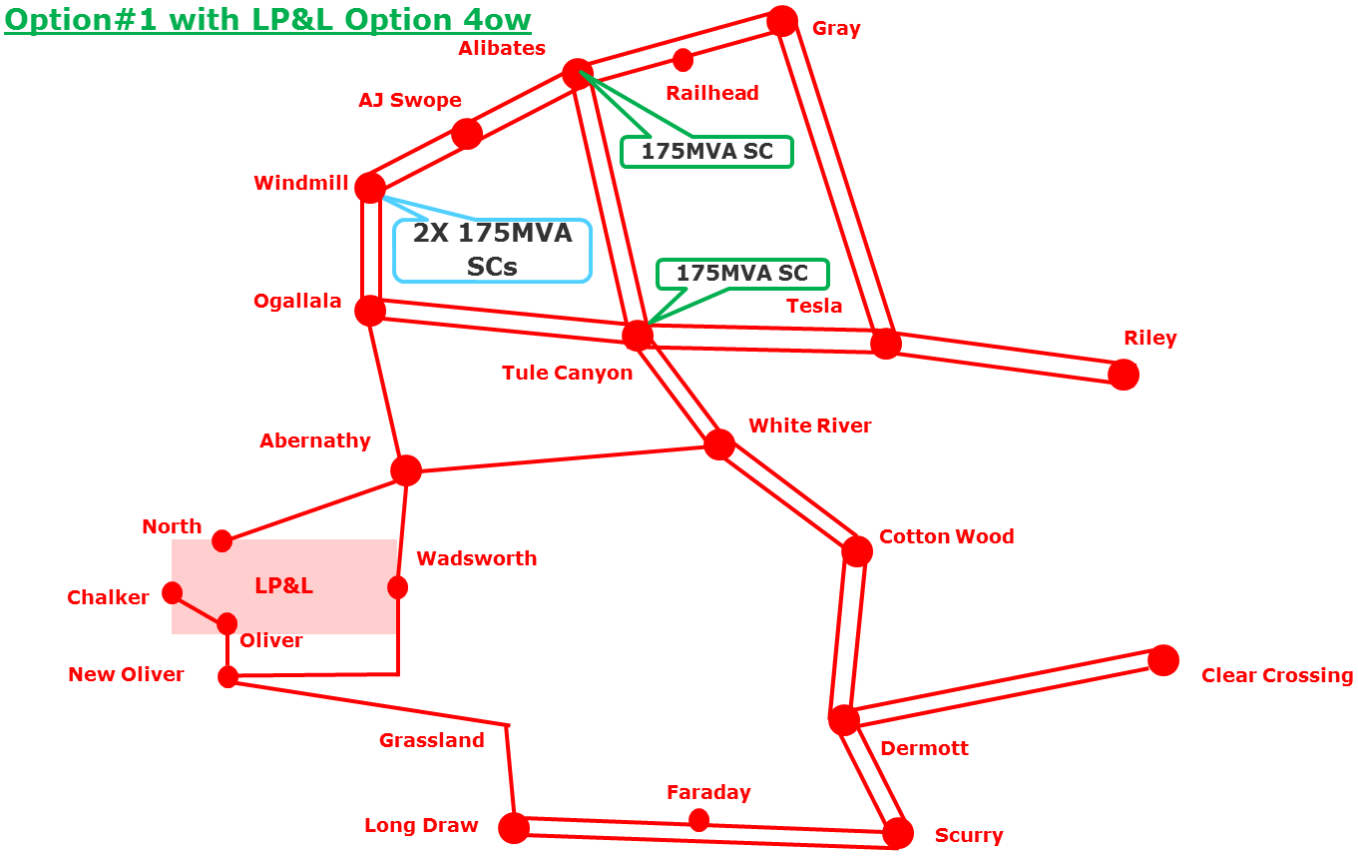
Option 8			
Item	Units	Cost/unit	Cost ($M)
175MVA Synchronous Condenser at Windmill (1606A)	1	41	41
Ogallala - Abernathy 345 kV line (SCKT on DCKT tower)	53.2	1.65	87.8
Ogallala Expansion 1 345 kV terminal	1	1.8	1.8
Abernathy Expansion 1 345 kV terminal	1	2.9	2.9
Total			**133**

A8: Option #8 Schematic and Cost Estimates

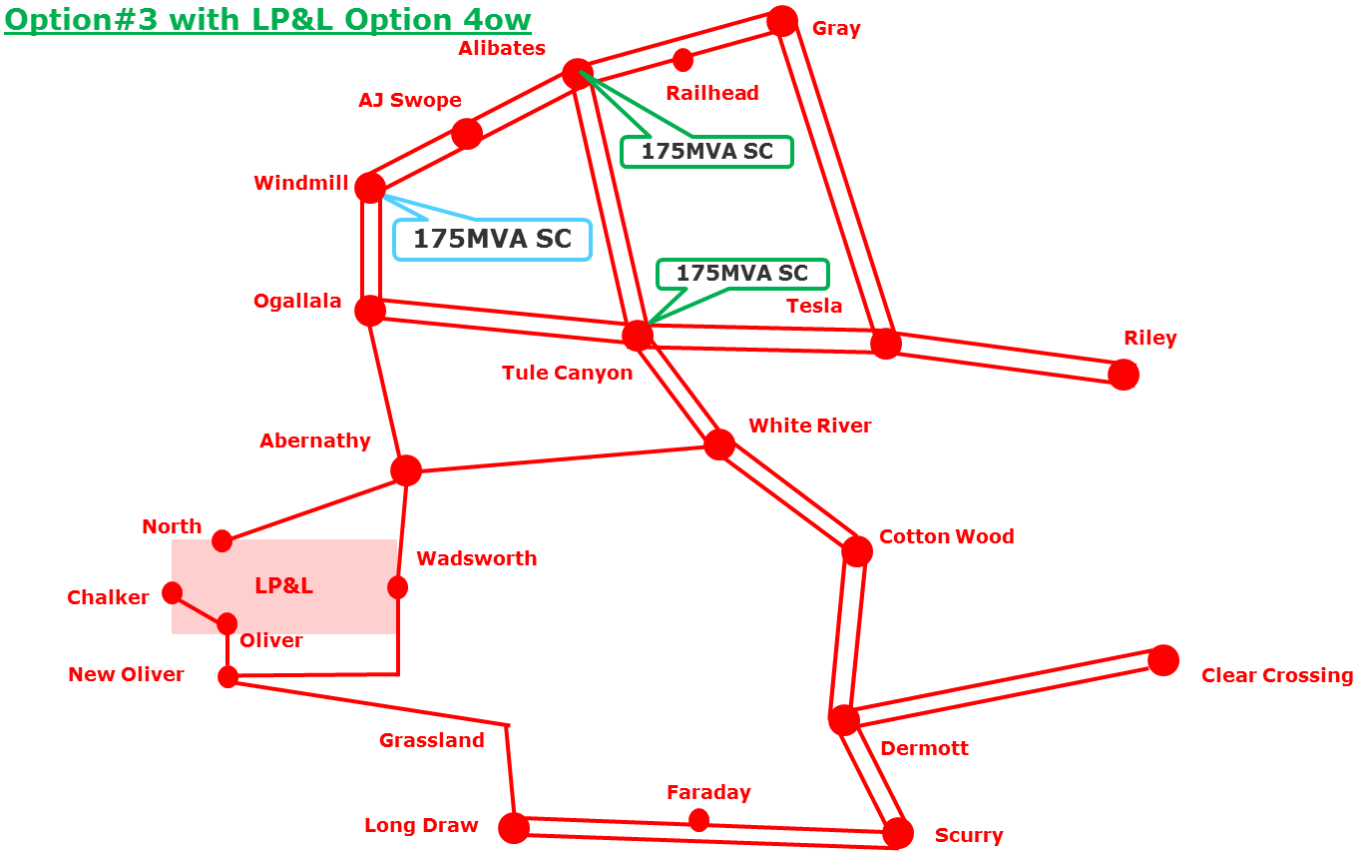


Option 9			
Item	**Units**	**Cost/unit**	**Cost ($M)**
175MVA Synchronous Condenser at Windmill (1606A)	1	41	41
Ogallala - Abernathy 345 kV line (SCK on DCKT tower)	53.2	1.65	87.8
White River - Cottonwood 345 kV line (SCK on DCKT tower)	29.9	1.65	49
Ogallala Expansion 1 345 kV terminal	1	1.8	1.8
Abernathy Expansion 1 345 kV terminal	1	2.9	2.9
White River Expansion 1 345 kV terminal	1	1.8	1.8
Cottonwood Expansion 1 345 kV terminal	1	4	4
Total			**189**

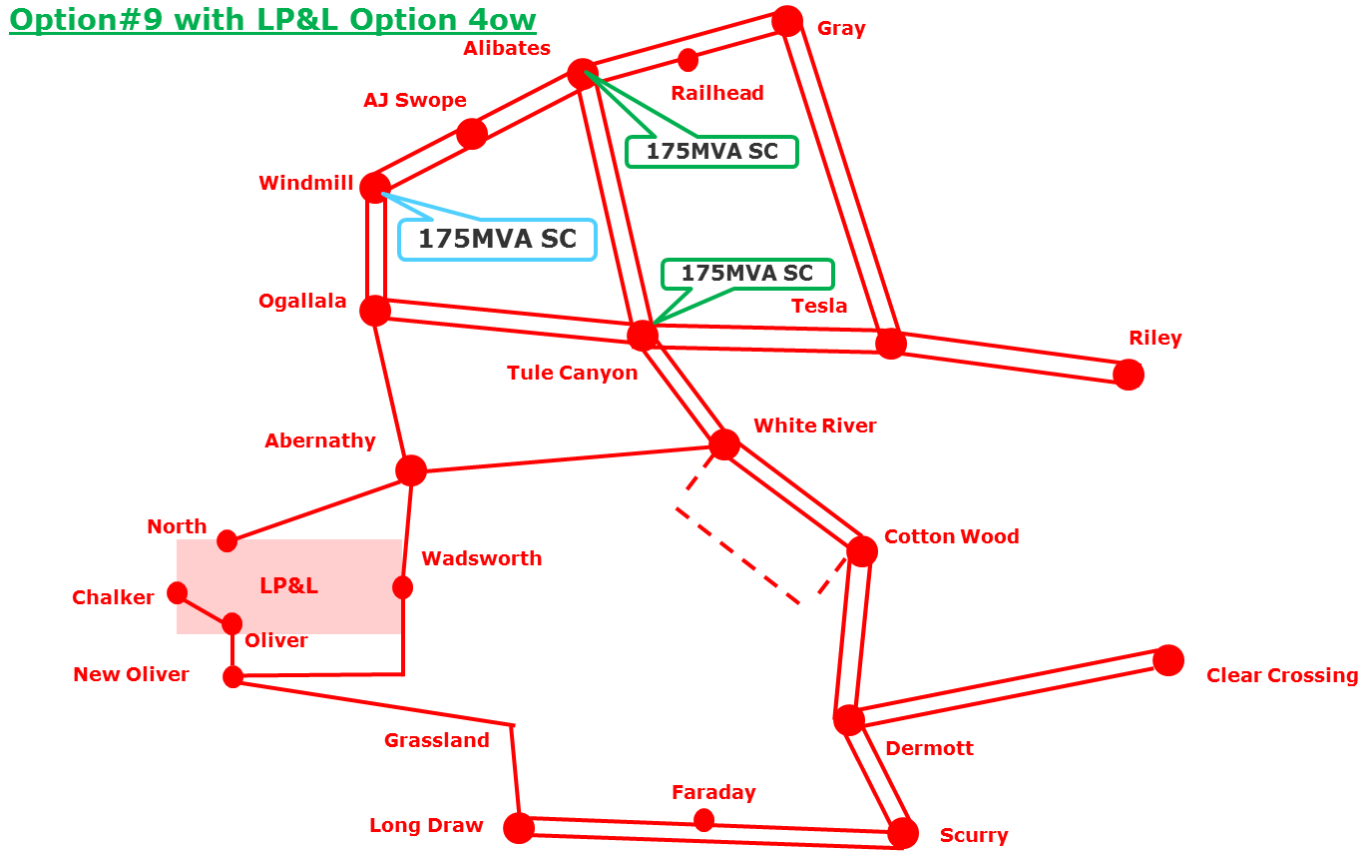
A9: Option #9 Schematic and Cost Estimates



A10: Option#1 with LP&L Option #4ow



A11: Option#3 with LP&L Option #4ow



A12: Option#9 with LP&L Option #4ow