ERCOT Independent Review of the AEPSC and Oncor Far West Texas Project

Version 1.0

Document Revisions

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1. Executive Summary

Over the past several years the load on the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop") and the load in the Barilla Junction area have experienced high load growth. Oncor has projected annual load growth rates as high as 11% over the next five years on the Culberson loop. Additionally, both areas, located in Far West Texas, have had an increase in requests for generator interconnections. Over 1,600 MW of solar resources are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020.

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Culberson loop area and the Barilla Junction area. The proposed project was estimated to cost $423 million and classified as a Tier 1 project. The proposed in-service date range for the FWTP was 2021-2022.

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region. ERCOT also performed sensitivity studies in compliance with the ERCOT Planning Guide.

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

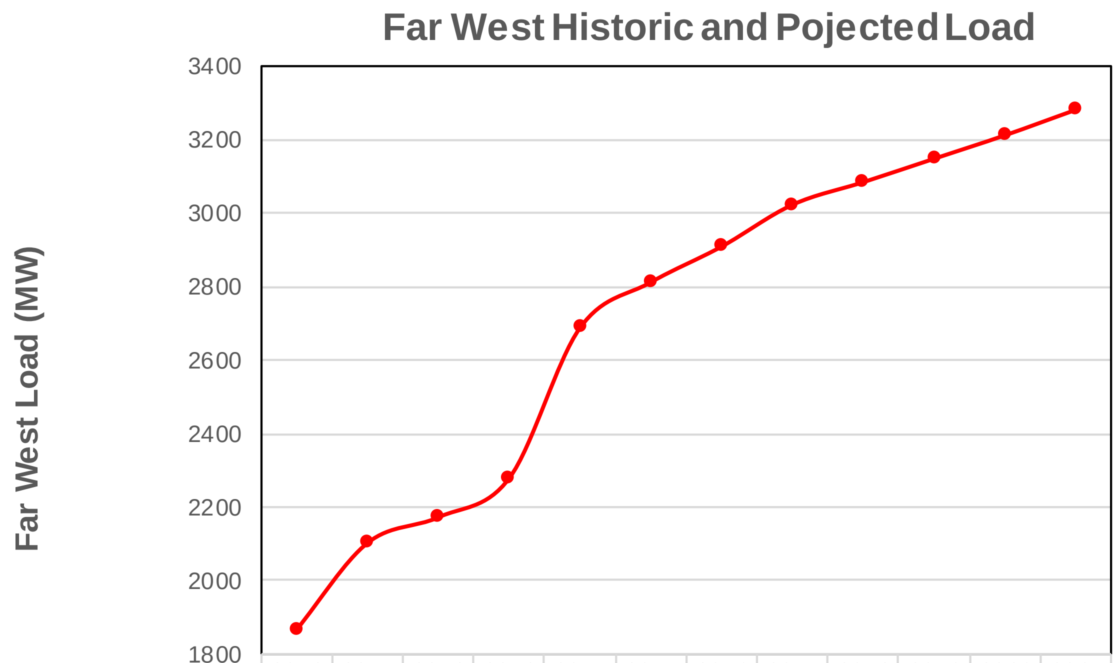
- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 85-mile, 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station, Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 68-mile, 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place

Although this option is not the exact configuration included in the FWTP proposal, it is a subset of that configuration with two autotransformer additions. ERCOT has determined that the alternative transmission expansion option, Option 2, will provide the most cost-effective configuration to meet the load forecast developed from contractual agreements. It will also allow a number of different possible expansion options that could augment the Far West Texas transmission grid load serving capability beyond the forecasts developed exclusively from committed load additions.

2. Introduction

Over the past several years the Far West Texas Weather Zone has experienced high load growth. Between 2010 and 2016 the average annual growth rate was roughly 8%. This strong growth rate was primarily driven by increases in oil and natural gas related demand. The most recent ERCOT 90th percentile summer non-coincident peak load forecast projects an average annual Far West Weather Zone growth rate of about 2.4% between 2016 and 2020.

Figure 2.1 shows historic and projected summer non-coincident peak load levels for the Far West Weather Zone.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Far-West Load (MW)	1867	2103	2172	2279	2688	2812	2909	3023	3084	3148	3212	3281
Growth (%)	7.4%	12.6%	3.3%	4.9%	18.0%	4.6%	3.5%	3.9%	2.0%	2.1%	2.0%	2.2%

Year

Figure 2.1: Far West Weather Zone historic peak load and ERCOT 90th percentile summer non-coincident peak load forecast

The Transmission Service Providers (TSPs) in the area including Oncor, TNMP and AEPSC have also identified high load growth rates concentrated in the Delaware Basin area. Oncor has projected annual load growth rates ranging as high as 11% over the next five years within a portion of the Far West Weather Zone, including Culberson, Reeves, Loving, Ward and Winkler Counties, based on committed customer load requests.

The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barilla Junction, Fort Stockton Plant, and Rio Pecos stations (“Barilla Junction area”) has seen increased load growth along with solar generation development. AEPSC has projected that the Barilla Junction area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barilla Junction 138 kV line alone. There are over 1,600 MW of solar resources that meet the conditions of Planning Guide Section 6.9 for inclusion in the base cases and that are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020. These generators are listed in Table 2.1.

Table 2.1 Solar Generation coming online in Pecos and Upton between 2016 and 2020

INR	Project Name	Fuel	Projected COD	Total Capacity	County
12INR0059b	Barilla Solar 1B	Solar	7/1/2016	7	Pecos
16INR0048	RE Rose Rock Solar	Solar	10/31/2016	160	Pecos
16INR0073	East Pecos Solar	Solar	12/1/2016	120	Pecos
16INR0065	Castle Gap Solar	Solar	1/11/2017	117	Upton
15INR0070_1	West Texas Solar	Solar	2/1/2017	110	Pecos
15INR0045	Riggins Solar	Solar	2/16/2017	150	Pecos
15INR0070_1b	Pearl Solar	Solar	4/28/2017	50	Pecos
16INR0065b	SP-TX-12-Phase B	Solar	8/15/2017	120	Upton
16INR0065a	Castle Gap Solar 2	Solar	9/6/2017	63	Upton
17INR0020a	RE Maplewood 2a Solar	Solar	10/1/2018	100	Pecos
16INR0114	Upton Solar	Solar	12/1/2018	102	Upton
15INR0059	Pecos Solar I	Solar	1/1/2019	108	Pecos
17INR0020b	RE Maplewood 2b Solar	Solar	5/16/2019	200	Pecos
17INR0020c	RE Maplewood 2c Solar	Solar	1/1/2020	100	Pecos
17INR0020d	RE Maplewood 2d Solar	Solar	7/15/2020	100	Pecos

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Barilla Junction area and the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop"). This project was estimated to cost $423 million and was classified as a Tier 1 project. Figure 2.2 shows the proposed FWTP. The major components of this project proposal were:

- A new 101-mile Odessa EHV – Riverton 345 kV line on a double circuit structure with a single circuit installed
- Expansion of the Riverton Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
- Expansion of the Solstice Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer
- A new 66-mile Riverton – Solstice 345 kV line on a double circuit structure with a single circuit installed
- A new 345 kV Lynx Switch Station with a 5-breaker 345 kV ring-bus arrangement and one 675 MVA, 345/138 kV autotransformer
- A new 59-mile Solstice – Lynx 345 kV Line on a double circuit structure with a single circuit installed
- A new 9-mile Lynx – Bakersfield 345 kV Line on a double circuit structure with a single circuit installed

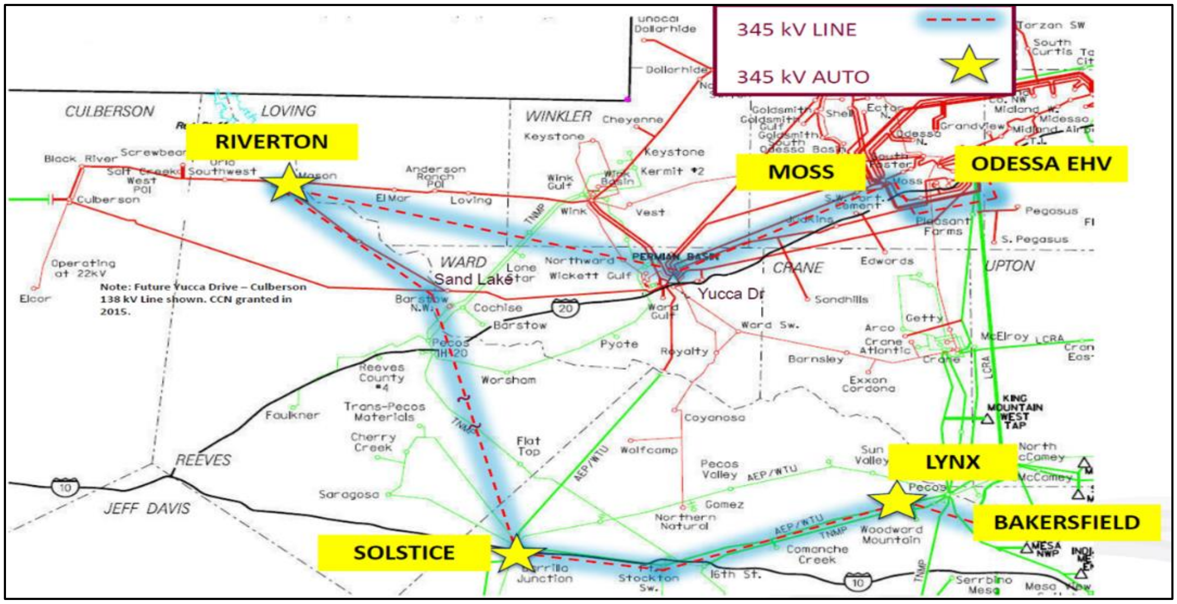


Figure 2.2: Proposed Far West Texas Project

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs in the Barilla Junction and Culberson loop areas and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region.

3. Study Assumption and Methodology

ERCOT performed studies under various system conditions to evaluate the system need and identify a cost-effective solution to meet those needs in the area. The assumptions and criteria used for this review are described in this section.

3.1. Study Assumption

The primary focus of this review are the Barilla Junction Area and Wink – Culberson – Yucca Drive loop transmission system.

Figure 3.1 shows the system map of the study area. The Barilla Junction and Culberson loop areas are highlighted in rectangles.

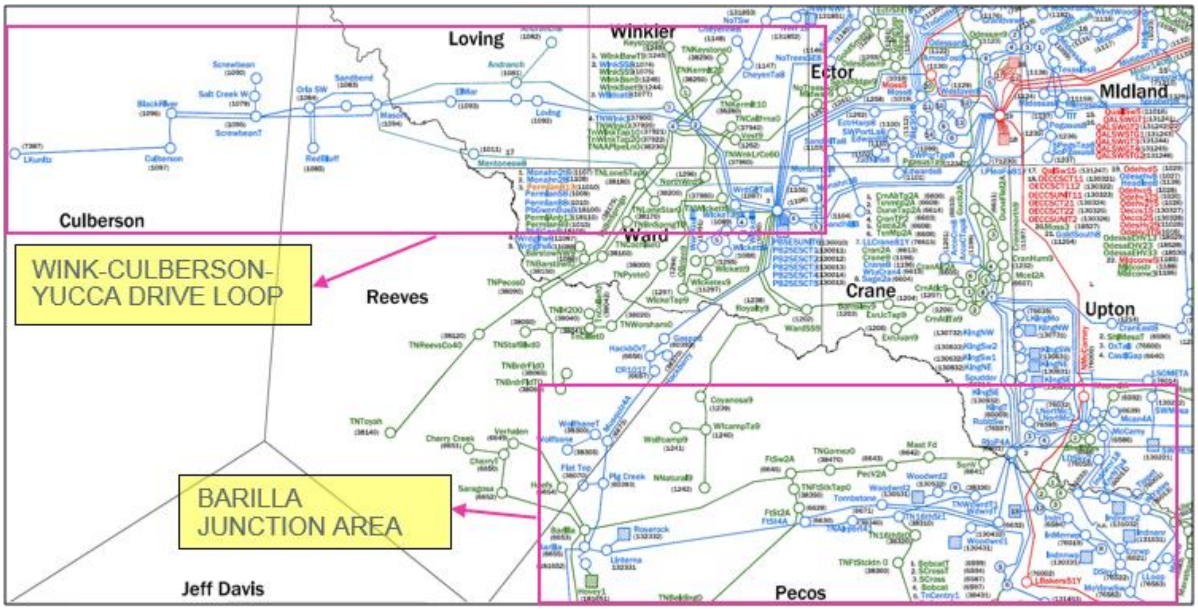


Figure 3.1: Transmission System Map of Study Area

3.1.1. Reliability Cases

The following starting cases were used in the study:

- The 2021 West/Far West (WFW) summer peak case from the 2016 RTP (based on the 2015 Steady State Working Group (SSWG) cases)
- The 2022 Dynamic Working Group summer peak flat start case

3.1.2. Transmission Topology

The starting case was modified based on input from AEPSC and Oncor to include topological changes, switched shunt additions and load additions in the study area. AEPSC provided system changes to the 138 kV line from Pig Creek to Yucca Drive via Gas Pad Tap. This section was upgraded to 966 MVA. The changes also included a switched shunt device at Hackberry Draw Tap 138 kV substation.

Oncor also provided topological updates to the Wink – Culberson – Yucca Drive loop. The changes included the new Riverton and Mentone substations, and a new Riverton-Mentone-Sand Lake 138 kV line along with other new buses and branches to accommodate new load additions in the Culberson loop. The changes also included a switched shunt added to the Whiting Oil 138 kV bus.

3.1.3. Study Case Loads and Potential Loads

The TSPs also provided data which increased the load in the Barilla Junction and Culberson loop areas. The original Oncor and AEPSC RPG submittal data included about 425 MW of load in the Culberson loop area and 511 MW in the Barilla Junction area by year 2021. These projections were later modified by Oncor to include additional confirmed load contracts for the Culberson loop during the ERCOT independent review. AEPSC also provided updated load information for the Barilla Junction area and some of the loads originally designated as conforming were modified to be non-conforming. After all the changes were incorporated the "Study Case" for 2021 had a total projected load of 533 MW along the Culberson loop and 511 MW of total load in the Barilla Junction area. Both AEPSC and Oncor met with ERCOT and shared information on the signed customer agreements and confirmed these proposed load additions.

Sensitivity cases were also created to reflect higher load projections from Oncor and AEPSC. These cases contained additional customer load requests that did not yet have firm commitment at the time of this independent review. To reflect this "Potential" load growth, the load was increased by 277 MW in the Culberson loop and 57 MW in the Barilla Junction area above the Study Case load. The total load in the Potential Load Case was approximately 810 MW and 568 MW in the Culberson loop and Barilla Junction area, respectively, for the Potential Load sensitivity.

3.1.4. Generation

Planned generators in the Far West and West Weather Zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2016 October Generation Interconnection Status report), which were not included in the RTP cases, were added. The added generators are listed in Table 3.1.

Key assumptions applied in this study include the following:

- Wind generation in West and Far West weather zones were set to have a maximum dispatch capability of 2.6% of their rated capacity. This assumption was in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[1].
- Solar generation was set at 70% of their rated capacity in accordance with the 2016 Regional Transmission Plan Study Scope and Process document.

Table 3.1 Added Generators That Met Planning Guide Section 6.9 Conditions (2016 October GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
16INR0023	BNB Lamesa Solar (Phase I)	102	Solar	Dawson	Far West
16INR0065a	Castle Gap Solar 2	63	Solar	Upton	Far West
17INR0020a	RE Maplewood 2a Solar	100	Solar	Pecos	Far West
17INR0020b	RE Maplewood 2b Solar	200	Solar	Pecos	Far West
17INR0020c	RE Maplewood 2c Solar	100	Solar	Pecos	Far West
17INR0020d	RE Maplewood 2d Solar	100	Solar	Pecos	Far West
15INR0061	Solaire Holman 1	50	Solar	Brewster	Far West

3.1.5. No Solar Scenarios

The Far West and West Weather Zones have a significant amount of solar generation, and the maximum output of solar generation modeled in the Study Case and the Potential Load Case was

[1] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

1,340 MW based on limiting the dispatch to about 70% of maximum capacity (maximum capacity was about 1,912 MW). To study system conditions when solar generation is not available, a 9:00 pm summer peak load condition case was created for both the Study Cases and Potential Load Cases. To create this “No Solar” peak condition, the load in the Far West Weather Zone was reduced by 6% based on a review of the historic Far West Weather Zone summer peak conditions from 2014-2016 at the time of peak and at 9:00 pm when the sun has set and solar generation output is expected to be near zero. Therefore, the load was scaled down in the Far West Weather Zone to reflect expected demand conditions at 9:00 pm for the “No Solar” scenarios.

3.1.6. Capital Cost Estimates

Capital costs estimates for transmission facilities were provided by Oncor, AEPSC and LCRA TSC. These cost were provided for individual transmission facilities and ERCOT used those values to calculate total project costs for various project options.

3.2. Criteria for Violations

All the violations identified in this report used the criteria described in this section.

All 100 kV and above busses, transmission lines, and transformers in the study region were monitored (excluding generator step-up transformers).

- Thermal violation
  - Use Rate A for Normal Conditions
  - Use Rate B for Emergency Conditions
- Voltage violation criteria
  - 0.95 < V pu < 1.05 Normal
  - 0.90 < V pu < 1.05 Emergency
  - Post Contingency voltage deviations
    - > 8% on non-radial load buses
- Voltage Stability Analysis
  - PV calculations for load transfer (Culberson loop)

3.3. Study Tools

ERCOT utilized the following software tools for the independent review of the Far West Texas Project:

- PSS/e version 33 was used to perform the dynamic stability analysis and to incorporate the TSP changes (idevs) in the initial steady-state case
- PowerWorld Simulator version 19 for SCOPF and steady state contingency analysis
- VSAT version 15 was used for voltage stability analysis
- UPLAN

4. Project Need

The need for a transmission improvement project was evaluated for the Study Case with both the base case and "No Solar" scenarios. The steady state analysis results showed transmission line overloading in the Barilla Junction area and voltage instability (unsolved contingencies) in the Culberson loop area under N–1 contingency analysis. The results of the steady state violations are summarized in Tables 4.1 – 4.4.

Table 4.1 2021 Thermal Overloading in the Study Region under N-1 Conditions

Element	Length (miles)	Study Case	No Solar Case
16th Street TNP to Woodward2 138 kV ckt 1	31.8	101%	115%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	106%
Rio Pecos to Woodward1 Tap 138 kV ckt 1	2.2	No Violation	106%
Tombstone to Woodward1 Tap 138 kV ckt 1	15.7	No Violation	106%

Table 4.2 2021 Unsolvable contingencies

#	Contingency (Category)	Study Case	No Solar Case
1	CEII	Unsolved	Unsolved

Table 4.3 2021 Voltage Violations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Salt Creek South Poi	138	0.873	0.893
Black River	138	0.878	0.896
Mentone SW	138	0.880	0.897
Mentcryo	138	0.885	0.898
Coalsndr	138	0.880	0.898
Sandlake	138	0.881	0.898
Sand Bend Poi	138	0.877	0.898
Culberson2	138	0.880	0.898
Orla Plant	138	0.865	0.899
Culberson	138	0.881	0.899
Culberson Wind Farm	138	0.881	0.899
Elmar	138	0.890	No Violation
Kunitz	138	0.883	No Violation
Mason (Oncor)	138	0.885	No Violation
Orla Southwest Poi	138	0.869	No Violation
Riverton	138	0.878	No Violation
Salt Creek West Poi	138	0.880	No Violation
Screwbean Tap	138	0.881	No Violation

Table 4.4 2021 Voltage Deviations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Kunitz	138	< 8%	9.2%
Mason (Oncor)	138	< 8%	8.7%
Orla Southwest Poi	138	< 8%	9.0%
Pig Creek Tap	138	< 8%	8.6%
Riverton	138	< 8%	8.8%
Salt Creek West Poi	138	< 8%	9.1 %
Screwbean Tap	138	< 8%	9.1%
Wolfbone Tap TNP	138	< 8%	10.0%
Woodward 1 Tap	138	< 8%	8.5%
Woodward 1	138	< 8%	8.5%

The unsolvable contingency identified in Table 4.2 and voltage violations listed in Table 4.4 indicated a local voltage stability challenge in the Culberson loop area. The detailed steady state results for the Study Case with and without solar can be found in the Appendix.

Figure 4.1 shows the thermal violations seen in the Study case.

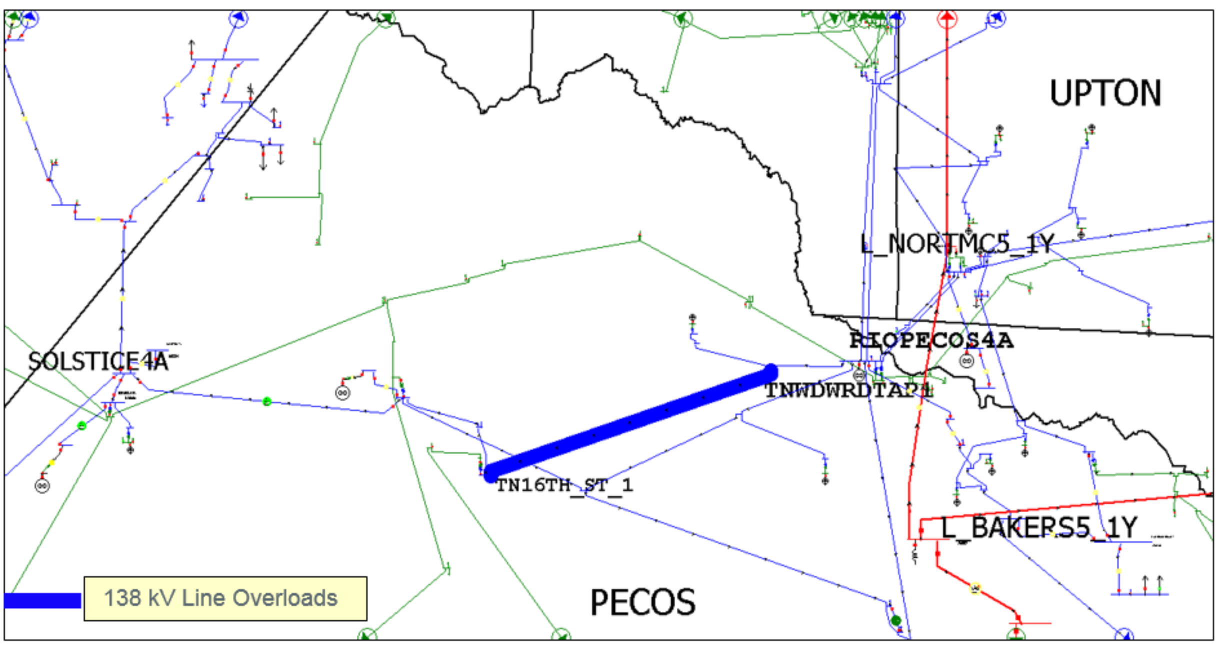


Figure 4.1: Study Case Thermal Violations in Study area

Figure 4.2 shows the voltage violations seen in the Study case.

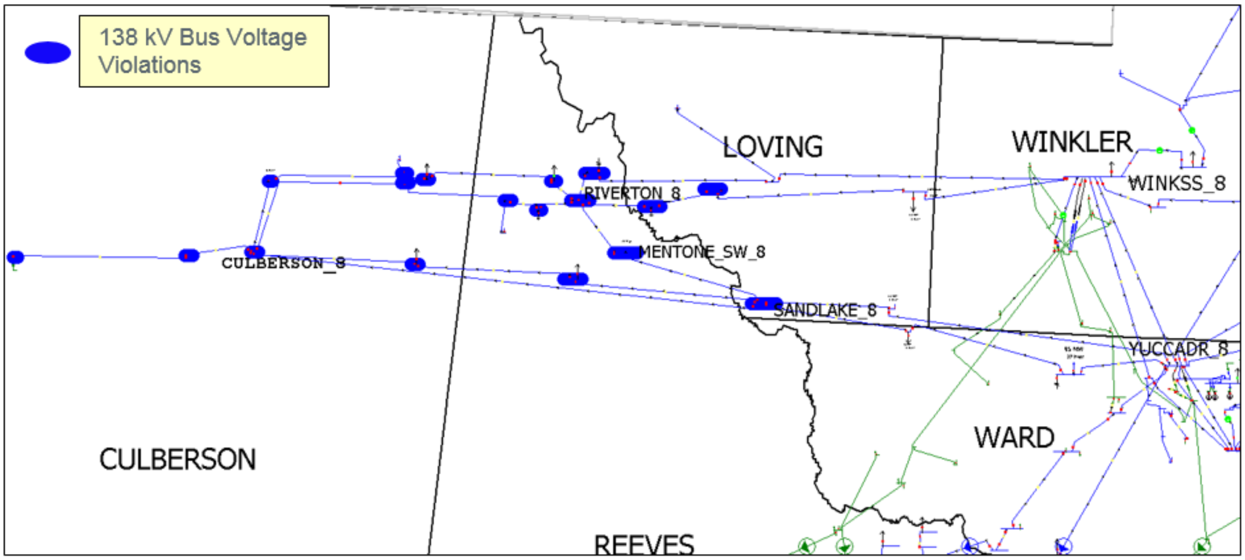


Figure 4.2: Study Case Voltage Violations in Study area

Figure 4.3 shows the thermal violations seen in the No Solar case.

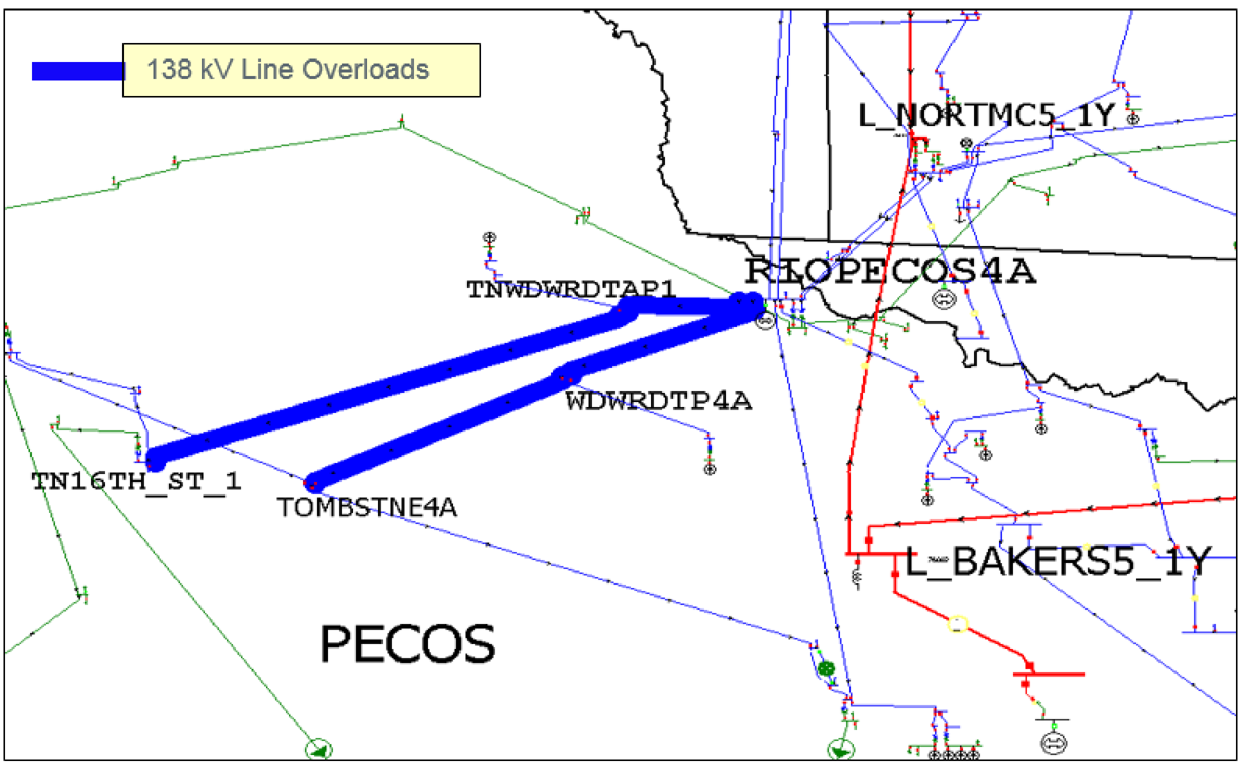


Figure 4.3: No Solar Case Thermal Violations in Study area

Figure 4.4 shows the voltage violations seen in the No Solar case.

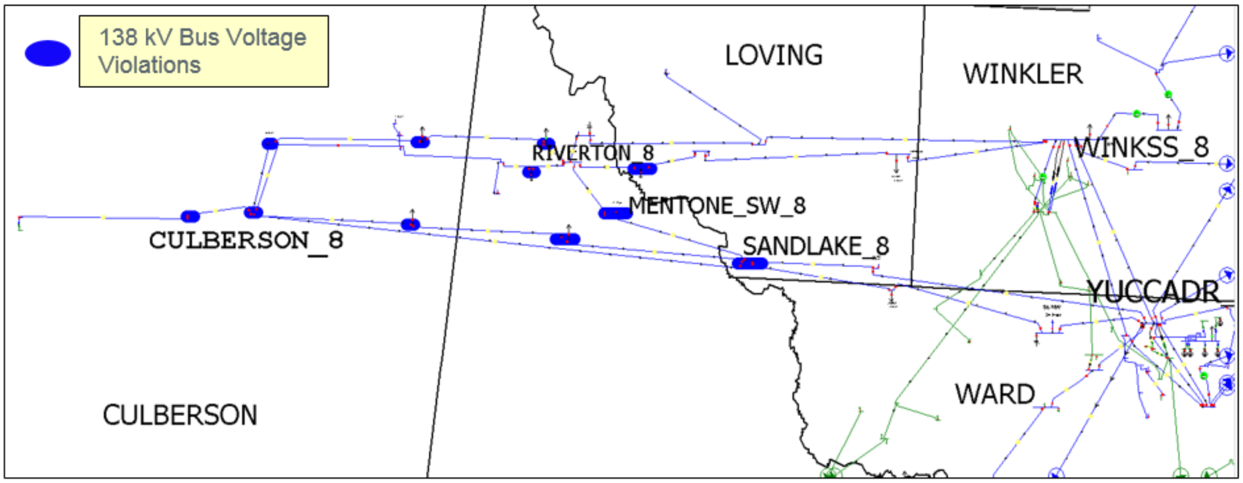


Figure 4.4: No Solar Case Voltage Violations in Study area

Both steady state and dynamic stability analyses identified reliability issues under the NERC and ERCOT reliability criteria.

5. Project Options

To address the reliability needs in the study area, ERCOT initially examined the FWTP proposal submitted by the TSPs in combination with nearly 40 alternatives.

5.1. Initial Options

An initial set of options (alternatives) was developed to address the identified reliability criteria violations for the Study Case while also considering an upgrade path to address potential needs in the future. This was accomplished by beginning with the simplest 138 kV expansion alternatives and then expanded to address performance violations. ERCOT also attempted to minimize the project cost. The ERCOT 2016 Long-Term System Assessment[2], which identified a long-term need for a project in the area, was also considered when developing the initial set of options.

The 40 alternatives could be described as variations of about 9 different transmission solutions, the variations created by using different 138 kV and 345 kV voltage class facilities; various termination points for new transmission lines; and various reactive compensation. Accordingly, diagrams of project options with cost estimates and a summary of reliability performance findings are provided in the Appendix for the 9 major transmission solutions.

Cost and reliability performance comparisons were used to narrow the 9 major solution options to the short-listed options discussed next. Generally, the short-listed options are also variations of the FWTP originally proposed by the TSPs.

5.2. Short-Listed Options

Among all the initial options, a final number of four options were studied further. The detailed description of the four short-list options are provided below and diagrams for these are included in the Appendix.

- **Option 1**
  - Install a new 200 MVAR Dynamic Synchronous Condenser at Mentone 138 kV substation
  - Install a new 200 MVAR Dynamic Synchronous Condenser at Culberson 138 kV substation
  - Construct a new approximately 85-mile 345 kV line operating at 138 kV on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV - Riverton 345 kV line operating at 138 kV.
  - Build a new McCamey – Fort Stockton 345 kV double circuit line operating at 138 kV (requiring approximately 47-miles of new Right of Way)
  - Build a new Pig Creek – Fort Stockton 345 kV single circuit line operating at 138 kV (requiring approximately 39-miles of new Right of Way)
  - Install a new 50 MVAR capacitor bank each at Mentone and Salt Creek 138 kV substations

[2] http://www.ercot.com/content/wcm/lists/89476/2016_Long_Term_System_Assessment_for_the_ERCOT_Region.pdf

- Install a new 18 MVAR capacitor bank each at Orla, Elmar, Loving and Alamito Creek 138 kV substation
- Install a new 3.6 MVAR capacitor bank Espy Wells 69 kV substation
- Install a new 10.8 MVAR capacitor bank at Shafter Goldmine 69 kV substation
- Install a new 7.2 MVAR capacitor bank at Sanderson TNP 69 kV substation

The total cost estimate for Option 1 is approximately $464 Million.

- **Option 2**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 2 is approximately $336 Million.

- **Option 3**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Expand the Sand Lake Switch Station to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 41-mile 345 kV line on double-circuit structures with one circuit in place, Sandlake – Solstice 345 kV single circuit line (requiring approximately 41 miles of new Right of Way).
  - Add a second circuit to the Riverton – Mentone – Sand Lake 345 kV to create a Riverton – Sand Lake 345 kV line on the existing Riverton – Mentone – Sandlake 345 kV line operating at 138 kV.

- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 3 is approximately $446 Million.

- **Option 4**
  - Option 4 is same as Option 3 with an additional new 200 MVAR Synchronous Condenser at Culberson 138 kV substation.

The total cost estimate for Option 4 is approximately $501 Million.

6. Steady-State Performance of Short-listed Options

To compare and contrast each of the options several analyses were performed. This Section discusses the performance of the four short-listed options under N-1 (NERC P1, P2-1 and P7) steady state contingency conditions for the studied scenarios.

Table 6.1 Steady State Reliability Assessment of All Final Options under N-1 (NERC P1, P2-1 and P7)

Load Level	Violation Type	Case	Option 1	Option 2	Option 3	Option 4
Study Case (533 MW in Culberson loop; 511 MW in Barilla Junction area)	Thermal	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
	Voltage	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
Potential Load Case (810 MW in Culberson loop; 568 MW in Barilla Junction area)	Thermal	With Solar	*Violations*	*Violations*	No Violations	No Violations
		No Solar	*Violations*	*Violations*	No Violations	No Violations
	Voltage	With Solar	No Violations	*Violations*	No Violations	No Violations
		No Solar	No Violations	*Violations*	No Violations	No Violations

The steady state results showed that all of the four options addressed the reliability needs in the Culberson loop and Barilla Junction area with Study Case load conditions. In the Potential Load scenario there were violations for Options 1 and 2. Option 3 and 4 showed no violations even under the Potential Load scenario. Option 3 had a voltage deviation of over 8% at Orla 138 kV substation in the Potential Loads case. It should be noted that there were some violations that were more severe in the cases that had solar generation than in the No Solar scenarios as these cases all reflected summer peak loading conditions while the No Solar cases had a slightly lower load level. A complete list of branch and voltage violations and the corresponding contingencies are provided in the Appendix.

7. Voltage Stability Analysis

A voltage stability analysis was conducted for the Culberson loop area for all short-listed options. The No Solar scenario represents the most stressed system condition from a voltage stability perspective and was therefore tested for all of the short-listed options. A Power-Voltage (PV) stability assessment was used to proportionally increase the load in the Culberson loop until a voltage collapse identified the maximum load serving capability for these options. The PV analysis included NERC P1, selected P6, and P7 contingency events. Table 7.1 shows the maximum load in the Culberson loop area to be reliably served as identified in the voltage stability analysis. All of the short-listed options provide more than a 10% voltage stability load margin when compared to the Study Case load level.

Table 7.1 Voltage Stability Assessment of All Final Options

Description	Option 1	Option 2	Option 3	Option 4
PV Results Culberson loop Load Served (MW)	917	717	917	1037

8. Economic Analysis

Although this RPG project is driven by reliability needs, ERCOT also conducted an economic analysis to compare the relative performance of each of the final options in terms of production cost savings.

The base case for this economic analysis used the 2022 economic case built for the 2016 RTP as the starting case. The topology changes and generation additions were similar to the steady state base case built. The load was modified to reflect the demand in the RPG proposal, but a 50/50 load scenario was used in ERCOT economic analysis, whereas the steady state analysis used a 90/10 load scenario. ERCOT modeled each of the four final options and performed production cost simulations for the year 2022. The annual production cost under each select option was compared to the option yielding the highest annual production cost in order to obtain a relative annual production cost saving for each option.

As shown in Table 8.1, the results indicates that Options 2 to 4 have over $6 million annual production cost savings compared to Option 1. This relative improvement in savings is due to the loss savings achieved by operating the new transmission lines at 345 kV. This apart, Options 2 to 4 showed no significant difference in congestion.

Table 8.1 Relative annual production cost savings (referenced to Option 1), in $ Million

Option	Option 1	Option 2	Option 3	Option 4
Relative Annual Production Cost Savings (referenced to Option 1)	-	6.2	6.6	6.6

9. Final Options Comparison

As shown in Table 9.1, a comparison of study results for the short-listed options shows that Option 2 met the system reliability criteria under the Study Case load conditions while deferring more than $100 million in capital expenditures when compared to the other options. Option 2 also resulted in lower system production costs when compared to Option 1 and was expected to provide an adequate voltage stability margin.

Although Option 2 did not meet the system reliability criteria for the Potential Load scenario, there are a number of different expansion options that can augment the load serving capability of Option 2 as the outlook for greater load and generation resources in this region becomes more certain. More specifically, as indicated by these studies, Option 3 or 4 are two possible options that could be constructed from Option 2 to meet applicable transmission planning criteria while serving significantly higher loads in this region. Option 2 also aligns with the long-term needs identified for the area in the 2016 Long-Term System Assessment.

Table 9.1 Options Comparison

Description	Option 1	Option 2	Option 3	Option 4
System Performance – Study Case	Met criteria	Met criteria	Met criteria	Met criteria
System Performance – Potential Load Case	Criteria not Met	Criteria not	Met criteria	Met criteria
Capital cost ($ Million)	464	336	446	501
PV Results Culberson Load Served (MW)	917	717	917	1037
Relative Production Cost Savings ($ Million)	-	6.2	6.6	6.6
Total System Loss Reduction (MW)	10.4	31.2	34.4	34.4
New Right of Way Required (Miles)	187	169	235	235

Additional studies were performed to verify that Option 2 will provide the most cost-effective configuration to meet the Study Case load conditions consistent with ERCOT Protocol and Planning Guide requirements.

9.1. Final Steady-State Performance Test

NERC P3, P6-1, P6-2 and P6-3 contingency analyses were performed under the Study Case load conditions with Option 2. This Option had no voltage collapse for these contingencies at the Study Case load level with both base case generation and with No Solar conditions applied.

Additionally, P2.2-2.3 (EHV), P4.1-P4.5 (EHV) and P5 (EHV) contingencies for the West and Far West Weather Zones were applied to Option 2 using the Study Case load levels with the base case generation and with No Solar conditions applied. There were no criteria violations found for Option 2 based on the conditions studied.

Figure 9.1 shows Option 2 applied to the study area.

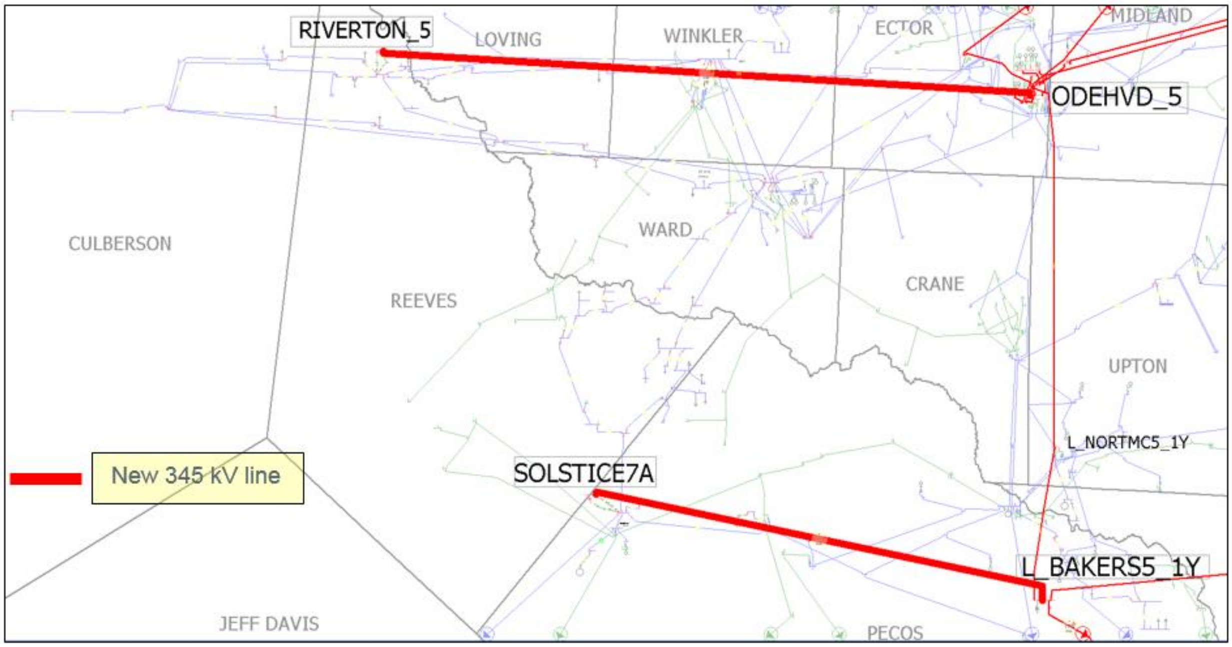


Figure 9.1: Option 2 applied to the Study area

9.2. Dynamic Performance

The majority of the loads in the study area were assumed to be oil and gas customers who employ voltage sensitive electric equipment in their operations. As indicated by the TSPs, heavy motor load was assumed to represent the load characteristic in the study area. The preferred Option 2 was tested using time domain dynamic stability simulations including a dynamic load model to quantify system stability.

It was assumed that if simulations indicated an acceptable (stable) system response following severe events and/or three-phase faults, the stability response would also be acceptable for the same events with single-line-to-ground (SLG) fault. If a potential stability issue was observed, the simulation was rerun with SLG faults to ensure a stable system response following a NERC planning events when applicable, thereby demonstrating compliance with NERC planning standards and ERCOT reliability criteria. Selected ERCOT transmission buses were monitored for frequency and voltage deviations. Nearby synchronous generating units were monitored for angular separation.

The limiting events identified in the PV analysis were studied in the dynamic simulation.

The dynamic event definitions included the removal of all elements that the protection system and other automatic controls are expected to disconnect for each event.

The dynamic simulation results showed that with Option 2 upgrades implemented the area of concern met the NERC and ERCOT reliability criteria. Detailed dynamic simulation results are presented in the Appendix.

10. Sensitivity Studies

Sensitivity studies were performed to ensure compliance with Planning Guide requirements.

10.1. Generation Sensitivity Analysis

ERCOT performed a generation sensitivity analysis based on Planning Guide Section 3.1.3(4) (a). Generator additions with signed Interconnection Agreements but that did not meet Planning Guide Section 6.9 conditions for inclusion in the base cases at the beginning of the study in the study region were added to the Study Case (based on the 2017 March Generator Interconnection Status report). In between the October 2016 Generator Interconnection Status and March 2017 Generator Interconnection Status reports there were another five units that met Planning Guide Section 6.9 conditions. These units were also added in this sensitivity study. Table 10.1.1 and 10.1.2 show all the generators that were added to the Study Case for this analysis.

Table 10.1.1 Generators Met Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West
15INR0064	BearKat Wind A	197	Wind	Glasscock	Far West
17INR0027	Dermott Wind 1	250	Wind	Scurry	West
15INR0064b	BearKat Wind B	163	Wind	Glasscock	Far West
17INR0027b	Coyote Wind	250	Wind	Scurry	West

Table 10.1.2 Generators with SGIA That Did Not Meet Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
13INR0023	Texas Clean C	240	Coal	Ector	Far West
16INR0010	FGE Texas 1	745	Gas	Mitchell	West
17INR0010	FGE Texas II	799	Gas	Mitchell	West
12INR0059c	Barilla Solar 2	21	Solar	Pecos	Far West
16INR0019	Capricorn Ridge Solar	100	Solar	Coke	West
16INR0023b	Lamesa Solar B (Phase II)	98	Solar	Dawson	Far West
12INR0060	Infinity Live Oak Wind	201	Wind	Schleicher	West
16INR0086	Cactus Flats Wind	150	Wind	Concho	West
13INR0020b	Rattlesnake W 2	158	Wind	Glasscock	Far West

The purpose of this generation sensitivity analysis was to evaluate the effect of the above mentioned generation units on the recommended transmission project. It was found that the Study Case violations did not entirely disappear with these additional generations. The violations seen for the Study Case with the generation units meeting Planning Guide Section 3.1.3(4) (a) criteria are summarized in Tables 10.2.1 – 10.2.4.

Table 10.2.1 Thermal Overloading in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Element	Length (miles)	Study Case	No Solar
16th Street TNP to Woodward2 138 kV ckt 1	31.8	No Violation	110%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	101%
Tombstone to Woodward1 Tap 138 kV ckt 1	15.7	No Violation	101%

Table 10.2.2 Unsolvable contingencies, With Generation meeting Planning Guide Section 3.1.3(4) (a)

#	Contingency (Category)	Study Case	No Solar
1	CEII	Unsolvable	Unsolvable

Table 10.2.3 Voltage Deviations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Wolfbone Tap TNP	138	< 8%	8.8%
Woodward 1 Tap	138	< 8%	8.7%
Woodward 1	138	< 8%	8.7%

Table 10.2.4 Voltage Violations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Sandlake	138	0.898	No Violation
Coalsndr	138	0.888	No Violation
Mentone SW	138	0.882	No Violation
Culberson2	138	0.881	No Violation
Screwbean Tap	138	0.878	No Violation
Kunitz	138	0.877	No Violation
Salt Creek West Poi	138	0.877	No Violation
Culberson Wind Farm	138	0.876	No Violation
Culberson	138	0.876	No Violation
Black River	138	0.871	0.899
Orla Southwest Poi	138	0.869	0.892
Riverton	138	0.869	0.896
Sand Bend Poi	138	0.867	0.895
Orla Plant	138	0.867	0.889
Salt Creek South Poi	138	0.864	0.892
Oxy Century TNP	138	No Violation	0.898
Wink TNP	138	No Violation	0.897

The above tables demonstrate the need for the transmission upgrades required to meet the NERC and ERCOT reliability criteria even with the additional generators in Tables 10.1.1 and 10.1.2. Full contingency results can be found in the Appendix.

Further analysis was performed testing these new sensitivity cases with Option 2 improvements applied. There were no criteria violations (under NERC P1, P2-1 and P7 events) seen for Option 2 with the generation sensitivity discussed in this section.

10.2. Load Scaling Impact Analysis

Planning Guide Section 3.1.3(4) (b) requires evaluation of the impact of various load scaling on the criteria violations seen in the study cases. As stated in Section 3.1.1, ERCOT used the 2021 West/Far West (WFW) summer peak case from the 2016 RTP for the steady state analysis. This case was created in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[3], which included load scaled down from the respective non-coincident peaks forecasted in the North, North Central, East, Coast, South, and South Central Weather Zones.

There were four 138 kV thermal violations seen in the steady state analysis as described in Section 4.1 of this report. Power Transfer Distribution Factors (PTDFs) were calculated using PowerWorld Simulator for these four lines using the Far West Weather Zone as the sink, and each of the other seven weather zones individually as the sources. It was found that no matter which other zones were scaled, the PTDFs for each of the lines remained very close. Therefore, ERCOT concluded that the load scaling applied in the cases did not affect the study results. The Appendix contains the PTDFs for each of the four lines under various transfers.

Because the voltage violations were observed at load serving buses, ERCOT assumed that the load scaling in the outside weather zones did not have a material impact on the observed need.

The case used in the dynamic stability portion of the analysis did not contain load scaling, therefore, the observed criteria violations were not affected by load scaling.

[3] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

11. Conclusion

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line.
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place.

12. Designated Provider of Transmission Facilities

In accordance with the ERCOT Nodal Protocols Section 3.11.4.8, ERCOT staff is to designate transmission providers for projects reviewed in the RPG. The default providers will be those that own the end points of the new projects. These providers can agree to provide or delegate the new facilities or inform ERCOT if they do not elect to provide them. If different providers own the two ends of the recommended projects, ERCOT will designate them as co-providers and they can decide between themselves what parts of the recommended projects they will each provide.

Oncor owns the Odessa EHV Switch Station and the planned Riverton Switch Station. Therefore, ERCOT designates Oncor as the designated provider for the 345 kV Odessa EHV Switch Station to Riverton Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Riverton Switch Station.

LCRA TSC owns the Bakersfield Station and AEP Texas owns the Solstice Switch Station. Therefore, ERCOT designates AEP Texas and LCRA TSC as the designated co-providers for the 345 kV Bakersfield Station to Solstice Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Solstice Switch Station.

13. Appendix

13.1. Base Case Violations – Steady State	BaseCaseViolations.xlsx
13.2. Options Diagrams	Options_Diagrams.pptx
13.3. Steady State Violations of Project Options	ProjectOptionsViolations.xlsx
13.4. Violations – Generation Sensitivity Analysis	GenerationSensitivityAnalysisViolations
13.5. Dynamic Analysis Results	CEII