ERCOT Independent Review of the AEPSC and Oncor Barrilla Junction Area Improvement Project

Document Revisions

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1. Introduction

The oil and gas development in the Permian Basin in West Texas has introduced significant load growth in the Barrilla Junction Area, which is served by the following three 138 kV transmission lines:

- Barrilla Junction/Solstice to Permian Basin.
- Rio Pecos to Ft Stockton.
- Rio Pecos to 16th Street.

The load along the Barrilla Junction/Solstice to Permian Basin 138 kV transmission line is projected to reach 150 MW by 2020. The projected new incremental load together with the existing load will cause transmission planning criteria violations in the Barrilla Junction Area.

American Electric Power Service Corporation (AEPSC) and Oncor Electric Delivery (Oncor) submitted a Regional Planning Group (RPG) project in December 2015 to address the reliability issues in the Barrilla Junction Area. During the independent review, AEPSC submitted a supplemental report to address the dynamic issues in the area.

Based on this independent review, ERCOT concluded that new transmission reinforcement is needed to meet reliability criteria. ERCOT evaluated project alternatives to address the reliability needs and concluded the transmission project defined as Option B is the best solution. The detailed description of Option B is as follows.

- Rebuild the existing Barrilla Junction/Solstice to Permian Basin AEP-TNC/Oncor 138 kV transmission line (~54 miles).
- Install one new 100/-50 MVAR Static Var Compensator (SVC) at Hackberry Tap/Lotebush.

The estimated cost of the preferred project is approximately $77 million. The estimate may vary as the designated providers of the new transmission reinforcement perform more detailed cost analysis.

Figure 1.1 shows the system map of the study area. The highlighted Barrilla Junction/Solstice to Permian Basin 138 kV line is the focus of the study.

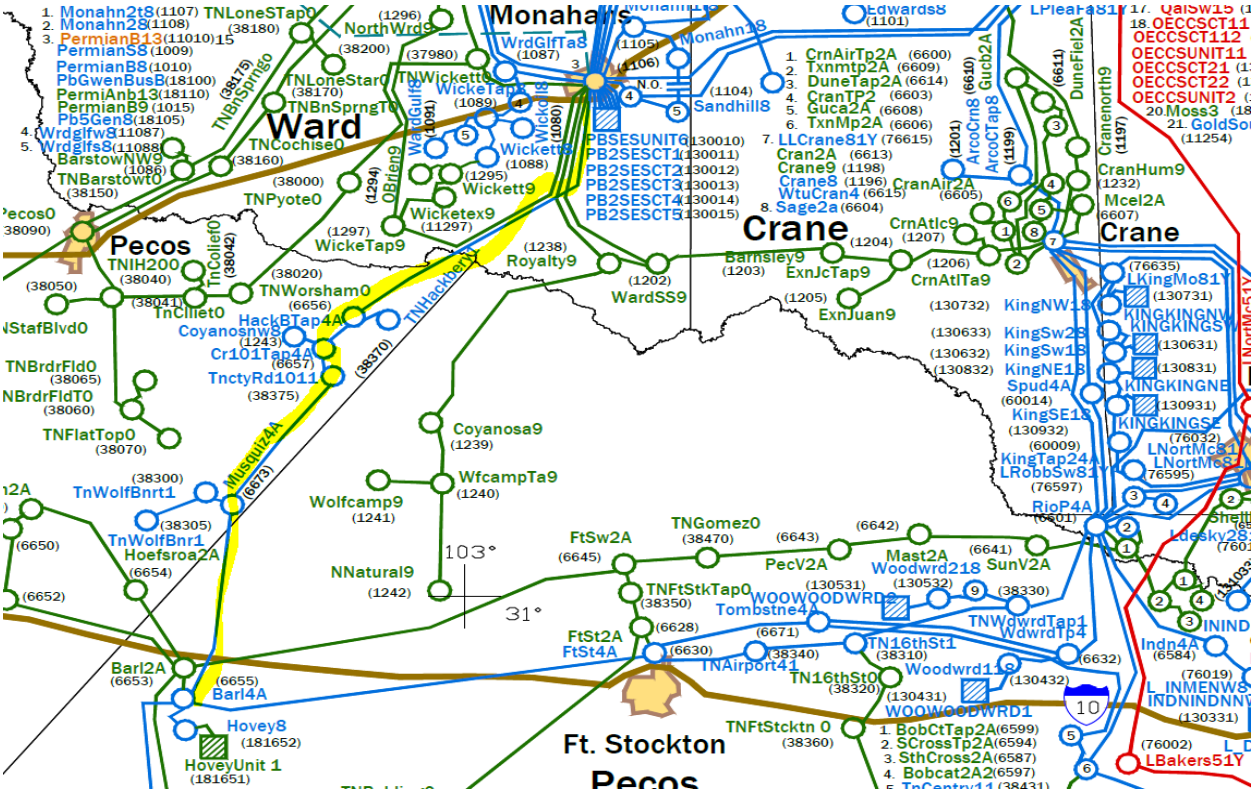


Figure 1.1: Transmission System Map of Study Area

2. Criteria, Study Assumption and Methodology

ERCOT performed studies to evaluate the reliability needs and to find a robust and cost-effective solution from both near-term and long-term transmission planning perspectives. The study criteria, assumptions and methodology for the ERCOT independent review are described in this section.

2.1. Study Region and Criteria

The primary focus of the study is the Barrilla Junction Area transmission system. The analysis of the system focused on the steady state thermal and voltage reliability of the ERCOT transmission system in the area of concern.

The criteria applied for the power flow analyses are consistent with the ERCOT Planning Guide Section 4.1.1.2 and the ERCOT 2016 Regional Transmission Plan (RTP). NERC TPL-001-4 contingency events (P0, P1, P2-1, P3, P6-2 and P7) were analyzed.

2.2. Study Assumption and Methodology

2.2.1. Study Base Cases

The following base case was used in the steady state 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 TNMP Line 69H rebuild and conversion project, and the Oncor Riverton-Sand Lake 138 kV upgrade project (currently under RPG review) were removed from the study case.

In the base case, the total load along the Barrilla Junction/Solstice to Permian Basin 138 kV line is approximately 98 MW. Based on the AEPSC and Oncor submission, the load along the line was modified to be 150 MW. A sensitivity study was also performed with a higher load forecast level based on information provided to ERCOT by AEPSC. The total load along the line is around 210 MW in the sensitivity study.

The following model updates and corrections were incorporated based on the feedback from AEPSC:

- Line limits and parameters correction for the Fort Stockton Switch to TNMP Fort Stockton Plant 69 kV line and the AEPSC Fort Stockton Plant to TNMP Fort Stockton plant 69 kV line.
- Rose Rock Solar and Hovey solar connection update (The Point of Interconnection was moved to Solstice instead of Barrilla Junction).

Generators in the Far West Weather Zone that met Planning Guide Section 6.9 conditions at the time of study, which were not included in the RTP cases, were added to the corresponding cases based on their Commercial Operation Date. The added generators are listed in Table 2.1.

Table 2.1: Generators Met Planning Guide Section 6.9 Requirements as of March 2016

GINR Number	Project Name	MW	Fuel	County	Weather Zone
16INR0065	Castle Gap Solar	117	Solar	Upton	Far West
16INR0065a	Castle Gap Solar 2	63	Solar	Upton	Far West

After the initial studies were completed, new updates were received in the area including both transmission network updates and new generators meeting Planning Guide Section 6.9 conditions. Additional sensitivity studies were performed incorporating those changes for the recommended option using the 2022 WFW summer peak case from the 2016 RTP to ensure no reliability violations in the study area. The added generators are listed in Table 2.2.

Table 2.2: Generators Met Planning Guide Section 6.9 Requirements as of June 10, 2016

GINR Number	Project Name	MW	Fuel	County	Weather Zone
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

2.2.2. Study Methodology

To evaluate the reliability needs, NERC TPL-001-4 contingency events P0, P1, P2-1, and P7 were analyzed for the 2021 WFW summer peak case in this study. ERCOT studies confirmed the reliability needs in the study region. More details of the reliability needs analysis can be found in Section 3.

ERCOT then studied three options based on analyzing the identified reliability issues and reviewing the RPG project submittal. More details of the three options can be

found in Section 4. In the option evaluation, NERC TPL-001-4 contingency events P0, P1, P2-1, P3, P6-2 and P7 were analyzed for the 2021 WFW summer peak case.

ERCOT also performed sensitivity analysis using the 2021 WFW summer peak case with increased load projection for all three options. More details of the sensitivity analysis can be found in Section 6.

Additional sensitivity studies were performed for the recommended option with the updated information in the area using the 2022 WFW summer peak case from the 2016 RTP.

In addition to comparing the system performance of each option, ERCOT also compared the cost estimates of the three options.

3. Project Need

ERCOT conducted a power flow analysis using the 2021 WFW summer peak study base case. The study results indicated transmission line overloading and bus voltage violations in the area under N-1 contingency conditions. The need analysis results are summarized in Table 3.1 and Table 3.2.

Table 3.1 Thermal Overload in the Study Region under N-1 Conditions

Branch	Length (miles)	N-1
Yucca Drive to Gas Pad 138 kV ckt 1	22.6	178%
Lotebush to Gas Pad 138 kV ckt 1	2.9	163%
Musquiz to Pig Creek 138 kV ckt 1	10.5	133%
Hackberry Tap to Lotebush 138 kV ckt 1	1.3	127%
Hackberry Tap to County Rd 101 138 kV ckt 1	1.5	118%
Musquiz to County Rd 101 138 kV ckt 1	3.2	103%

Table 3.2 Voltage Violations Identified in the Study Region under N-1 Conditions

Bus	kV	Limit (p.u.)	N-1
Hackberry Tap	138	0.92	0.77
Musquiz	138	0.92	0.78
County Rd 101	138	0.92	0.77
Solstice	138	0.92	0.90
Lotebush	138	0.92	0.77
Pig Creek	138	0.92	0.84
Gas Pad	138	0.92	0.76

Full contingency results can be found in the Appendix.

4. Project Options

ERCOT considered three options to resolve the identified criteria violations. The detailed description of the three options are listed below.

- **Option A**
  - Rebuild the existing Barrilla Junction/Solstice to Permian Basin AEP-TNC/Oncor 138 kV transmission line (~54 miles).
  - Install one new 100/-50 MVAR SVC at Hackberry Tap/Lotebush.
  - Install one new 100/-50 MVAR SVC at Ft. Stockton plant.

  The total cost estimate for Option 1 is approximately $94 million. The line costs assume that the Barrilla Junction/Solstice to Permian Basin 138 kV line will be rebuilt "energized". New Right of Way is not needed, but temporary supplemental Right of Way/easements are needed.
- **Option B**
  - Rebuild the existing Barrilla Junction/Solstice to Permian Basin AEP-TNC/Oncor 138 kV transmission line (~54 miles).
  - Install one new 100/-50 MVAR SVC at Hackberry Tap/Lotebush.

  The total cost estimate for Option 2 is approximately $77 million. The line costs assume that the Barrilla Junction/Solstice to Permian Basin 138 kV line will be rebuilt "energized". New Right of Way is not needed, but temporary supplemental Right of Way/easements are needed.
- **Option C**
  - Build a new ~50 miles 138 kV line from Rio Pecos to Musquiz.
  - Build a new ~26 miles 138 kV line from Permian Basin to Lotebush.
  - Install one new 100/-50 MVAR SVC at Hackberry Tap/Lotebush.

  The total cost estimate for Option 3 is approximately $90.8 million. Option C requires about approximately 76 miles of new Right of Way.

5. Option Comparison

In order to compare the three options, ERCOT performed the following contingency analysis.

- N-1 (NERC P1, P2-1 and P7), G-1+N-1(NERC P3) and X-1+N-1(NERC P6-2) analysis using the 2021 WFW summer peak case from the 2016 RTP.

All three options resolved the steady state reliability issues identified in the need analysis. However, for Option C, the Solstice to Pig Creek 138 kV line was loaded above 98% of its emergency rating (Rate B) under N-1 and X-1+N-1 conditions, and close to 100% of its emergency rating under G-1+N-1 condition. The summary of the results are listed in Table 5.1 to Table 5.3.

Table 5.1 Thermal Loadings in 2021 Summer Peak Case for all Options under N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	98.2%

Table 5.2 Thermal Loadings in 2021 Summer Peak Case for all Options under G-1+N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	99.9%

Table 5.3 Thermal Loadings in 2021 Summer Peak Case for all Options under X-1+N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	98.2%

While neither Option A nor Option B requires new Right of Way, Option C requires around 76 miles of new Right of Way.

Both Option A and Option B can achieve similar reliability improvement in the area but Option A requires the investment of another dynamic reactive device, which increased the cost by around $17 million. It should be noted that the Barrilla Junction/Solstice to Pig Creek section of the Barrilla Junction/Solstice to Permian Basin 138 kV line was recommended for upgrade as an economic project in the ERCOT 2015 Regional Transmission Plan [1].

The cost/new Right of Way comparison for the three options are summarized in Table 5.4. While all three upgrade options considered can address the reliability need in the study region, Option B is the most cost effective option with no new Right of Way requirement.

Table 5.4 Option Comparison

Option	Resolved Reliability Issues?	Cost	New Right of Way
A	Yes	$94M*	None**
B	Yes	$77M*	None**
C	Yes but with heavily loaded line	$90.8M	~76 miles of 138 kV lines

* The line costs assume that the Barrilla Junction /Solstice to Permian Basin 138 kV line will be rebuilt “energized”. The costs associated with the “energized” rebuild are included.

** New Right of Way is not needed. Temporary supplemental Right of Way / easements are needed.

6. Sensitivity Studies

6.1. Load growth sensitivity

ERCOT performed sensitivity studies with increased load forecast level based on potential load growth information provided by AEPSC. The 2021 WFW summer peak case was used with the load along the Barrilla Junction/Solstice to Permian Basin line increased from 150 MW to 210 MW. In the study, the following transmission projects that are currently under RPG review were added.

- The TNMP Line 69H rebuild and conversion project.
- The Oncor Riverton-Sand Lake 138 kV upgrade project.

The sensitivity studies showed that all three options resolved the steady state reliability issues identified in the need analysis. However, for Option C, several lines along the Barrilla Junction/Solstice to Permian Basin line were heavily loaded. The sensitivity analysis results were shown in Table 6.1 to Table 6.3.

Table 6.1 Thermal Loadings in 2021 Summer Peak Sensitivity Case for all Options under N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	98.1%
Musquiz to County Road 101 138 kV ckt 1	3.2	< 90%	<90%	99.4%

[1] http://www.ercot.com/content/news/presentations/2015/2015_Regional_Transmission_Plan_Report%20-%20Public.pdf

Table 6.2 Thermal Loadings in 2021 Summer Peak Sensitivity Case for all Options under G-1+N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	98.2%
Musquiz to County Road 101 138 kV ckt 1	3.2	< 90%	<90%	99.3%

Table 6.3 Thermal Loadings in 2021 Summer Peak Sensitivity Case for all Options under X-1+N-1

Branch	Length (miles)	Option A	Option B	Option C
Solstice to Pig Creek 138 kV ckt 1	13.0	< 90%	<90%	98.2%
Musquiz to County Road 101 138 kV ckt 1	3.2	< 90%	<90%	99.8%

6.2. Model update sensitivity

After the initial studies were completed, new updates were received in the area including both transmission network updates and new generators meeting Planning Guide Section 6.9 conditions for inclusion in the planning models. An additional sensitivity study was performed for the base case and the least cost option, Option B, incorporating those changes using the 2022 WFW summer peak case from the 2016 RTP to ensure no reliability violations in the study area. The following updates were incorporated into this sensitivity:

- Oncor Yucca Drive to Culberson transmission system updates.
- Oncor Wink to Culberson transmission system updates.
- TNMP WTN transmission system updates.
- New generators: RE Maplewood 2a Solar–100 MW, RE Maplewood 2b Solar–200 MW, RE Maplewood 2c Solar–100 MW and RE Maplewood 2d Solar–100 MW.

The results showed that the same reliability criteria violations occurred in the base case (with no improvement options) with the model updates. The results also showed that there are no reliability violations in the study area with Option B, and the loading on the Barrilla Junction/Solstice to Permian Basin 138 kV lines were under 90% of their emergency rating.

7. Consideration of Dynamic Reactive Device

The steady state analysis identified extreme low voltage violations (below 0.8 pu) in the area, listed in Table 3.2, under N-1 conditions. In addition, AEPSC submitted additional information regarding the need for dynamic device during the ERCOT independent review period. AEPSC also indicated that operating a single 100 Mvar shunt capacitor and/or reactor is not practical or feasible due to power quality, voltage flicker, and coordination concerns in the study region. Therefore, a dynamic reactive device is proposed to resolve the identified voltage violations.

The DWG NT2017 Summer Peak case, modified to include the Option B upgrades listed Section 4, was used to perform dynamic simulations. ERCOT tested the dynamic response of adding a 100 MVAR of synchronous condenser, static capacitors or a +100/-50 MVAR SVC. Pumps and Compressor loads were modeled using the dynamic composite load model provided by AEP, which included a representation of their dynamic load characteristics, including stall and trip features. Based on the provided load characteristics, a certain amount of load is likely to be disconnected due to its protection scheme during any nearby normally cleared three-phase faults.

ERCOT also conducted sensitivity studies varying the threshold voltage at which the motor load would trip (Under Voltage trip settings UV1 & UV2) to examine the impact of a different load trip setting on the system response. Relative to their value in the AEPSC load models (0.7 and 0.6 p.u),

UV1 was varied between 0.6 and 0.9 p.u. and UV2 was varied between 0.5 and 0.8 p.u., both, in increments of 0.05.

The simulation results indicated that there were reliability criteria violations according to ERCOT Planning Guide Section 4.1.1.5, Transient Voltage Response Criteria.

(1) For any operating condition in category P1 of the NERC Reliability Standard addressing Transmission System Planning Performance Requirements, voltage shall recover to 0.90 p.u. within five seconds after clearing the fault.

(2) For any operating condition in categories P2 through P7 of the NERC Reliability Standard addressing Transmission System Planning Performance Requirements, voltage shall recover to 0.90 p.u. within ten seconds after clearing the fault.

The study results show that one 100/-50 MVAR SVC or one 100 MVAR synchronous condenser at or near Hackberry Tap can provide sufficient dynamic response, eliminating the voltage violations (See dynamic plot 1 in the Appendix). The settings for UV1 and UV2 in the load model provided by AEPSC seem adequate for this type of study based on the sensitivity analysis showing that lower values of UV1 and UV2 degraded the voltage response while higher values produced faster and higher voltage response. (See dynamic plot 2 in Appendix).

In areas where there is a high penetration of inverter-based generation there is a stability concern associated with low system strength. To identify if there is a system strength concern for the Barilla Junction area ERCOT assessed the system strength need by reviewing the inverter-based generation development in the study region. According to the generation interconnection information as of September 12, 2016, most inverter-based generation projects (wind and solar) currently under study are not electrically close to the study region. The identified location of the dynamic reactive device (at or near Hackberry Tap) will address the voltage violations but may provide limited short circuit support to the area where most solar projects are projected to be implemented. Since the dynamic reactive needs of the area do not also include a need for improved system strength, SVC technology is preferred over synchronous condenser technology for this application. Therefore, one 100/-50 MVAR SVC is recommended to restore the post contingency voltage violation within acceptable voltage operating range.

8. Conclusion and Recommendation

Based on the independent review, ERCOT recommends Option B, which constitutes the most effective solution with the least cost and no new Right of Way requirement to meet the reliability need of the area:

- Rebuild the existing Barrilla Junction/Solstice to Permian Basin AEP-TNC/Oncor 138 kV transmission line (~54 miles).
- Install one +100/-50 MVAR SVC at Hackberry Tap/Lotebush.

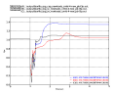
9. Designated Provider of Transmission Facilities

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.

ERCOT designates both AEPSC and Oncor as the providers for the rebuild of the Barrilla Junction/Solstice to Permian Basin 138 kV line. ERCOT designates AEPSC as the provider for the installation of the reactive power device at Hackberry Tap/Lotebush.

10. Appendix

AC Contingency Analysis Result of all the options (N-1, G-1+N-1, and X-1+N-1 analysis)	AC Contingency Analysis Results.xlsx
Dynamic plot 1 - cmld-4-new load model, three-phase fault & P1 contingency	
Dynamic plot 2 – Sensitivity run