# ERCOT Independent Review of the AEPSC Valley Import Project (Laredo to Lower Rio Grande Valley 345 kV Project)

**Version 1.1**

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# Document Revisions

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# 1. Introduction

The Lower Rio Grande Valley (LRGV) area is located at the southernmost portion of the ERCOT region of Texas along the international border with Mexico. It includes the cities of Edinburg, McAllen, Harlingen, and Brownsville. The area has experienced high population and economic growth and consequently high electric load growth rates. Currently, the load is primarily served by local natural gas generation and power imports from the rest of the ERCOT system. The local generation consists of three combined cycle natural gas plants (~1592 MW total capacity) located on the west side of the LRGV, the Silas Ray plant (~116 MW total capacity) located on the east side of the LRGV in Brownsville, and the Falcon hydro-electric plant (~36 MW total capacity) located west of the LRGV area. Additionally, there is a 150 MW direct current tie with the Mexico CFE system located at the Railroad substation on the west side of the LRGV.

The LRGV area is able to import power via three 138 kV lines and two 345 kV lines. The two 345 kV lines are the Lon Hill-Nelson Sharpe-Ajo-Rio Hondo 345 kV line and the Lon Hill-North Edinburg 345 kV line. Both lines have up to 50% series compensation installed. Figure 1 shows the South Texas area of the ERCOT system including the LRGV.

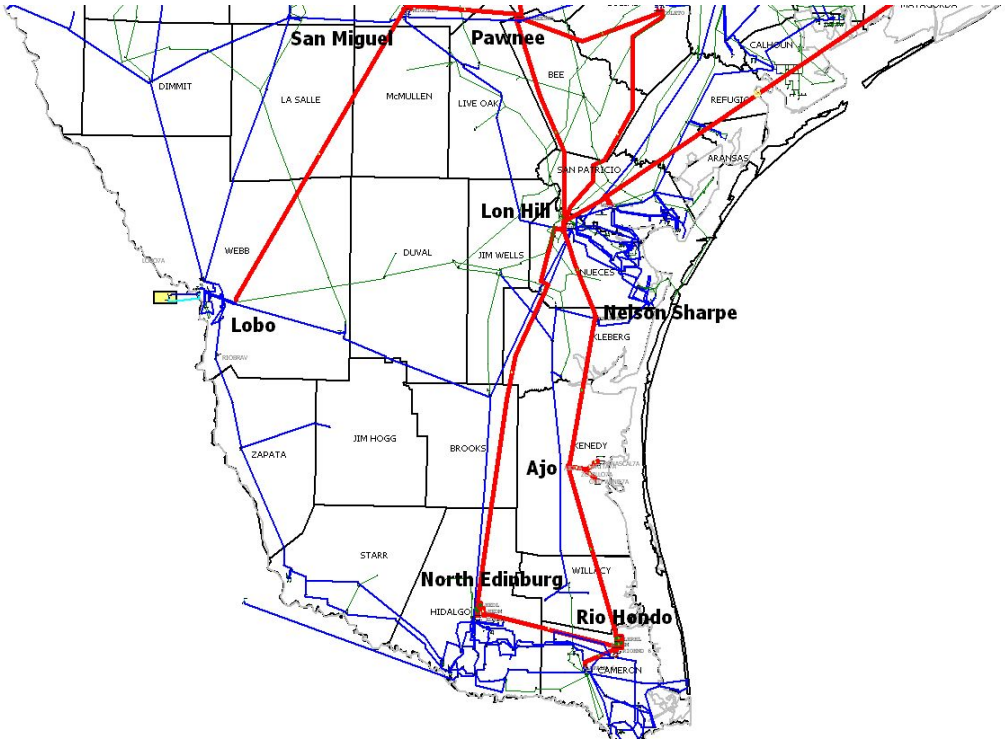


Figure 1: Map of South Texas and the Lower Rio Grande Valley

In order to provide transmission infrastructure that meets ERCOT reliability criteria and increases maintenance outage capability, American Electric Power Service Corporation (AEPSC) proposed the following improvements:

- Construct a new 148 mile, 345 kV transmission line from Lobo to Rio Bravo to Del Sol, a new 345 kV switching station on the west side of the LRGV, utilizing 2-954 ACSR conductor on double-circuit capable structures and a 24 ohm 3600 amp series capacitor on the Lobo 345 kV circuit;

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- Construct a new 15 mile (approximate), 345 kV transmission line from Del Sol to North Edinburg utilizing 2-954 ACSR conductor on double-circuit capable structures; and
- Construct a new 15 mile (approximate), 345 kV transmission line from Del Sol to Frontera utilizing 2-954 ACSR conductor on double-circuit capable structures.

The proposed project was also intended to meet future load growth needs in the Laredo area in addition to the needs in the LRGV. ERCOT analyzed the system needs and reviewed the proposed project along with several other alternative projects.

At the May 2011 Regional Planning Group (RPG) meeting AEPSC provided updated future year load forecasts for the LRGV and Laredo. For 2016 the 50$^{th}$ percentile summer peak forecast (50/50 forecast) is 2723 MW and 552 MW, respectively for the LRGV and Laredo. The 2016 90$^{th}$ percentile summer peak forecast (90/10 forecast) is 2803 MW and 573 MW, respectively for the LRGV and Laredo. It is assumed that there is a less than 10% chance that the load will exceed the 90/10 forecast. For 2020 the 50$^{th}$ percentile summer peak forecast (50/50 forecast) is 2944 MW and 589 MW, respectively for the LRGV and Laredo. The 2020 90$^{th}$ percentile summer peak forecast is 3030 MW and 611 MW, respectively for the LRGV and Laredo.

## 2. Study Approach

The Steady State Working Group (SSWG) 2016 summer peak base case (updated in April 2011) was evaluated to determine if there were any reliability criteria exceedances in the South Texas Region, generally the LRGV and Laredo areas.

Because there are two existing wind plants (Penescal and Gulf Wind) and two planned wind plant additions (Magic Valley Wind Project and Los Vientos) in the study area, one of the first tasks was to determine the appropriate assumption for wind plant dispatch. Historical data from 2010 for the Penescal, Gulf Wind, and Papalote Creek coastal wind plants was analyzed in order to establish the wind plant dispatch assumption.

The aggregate plant output as a percentage of capacity was analyzed for high load hours. High load hours were defined as when the ERCOT system load was greater than 60 GW. In 2010 there were 133 hours when the ERCOT system load exceeded 60 GW (1.5% of the hours of the year). During these 133 hours the lowest aggregate coastal wind plant output was 1% of capacity and the average was 37%. The 10$^{th}$ percentile output was 9% of capacity. There were 14 of the 133 hours (11%) when the aggregate output was less than 10% of capacity and 34 hours (26%) when the aggregate output was less than 20% of capacity.

Based on this data it was decided to set the dispatch of the wind plants in the area to 10% of their capacity for the study. This value was near the 10$^{th}$ percentile output for high load hours which, although conservative, seemed appropriate given the lack of history for coastal wind plant data and the low number of plants with operational history. Consideration was given to performing a sensitivity analysis with the area wind plants set to 0% or 1% capacity due to the worst case output experienced in 2010. However, the contingency loss of the largest natural gas unit in the area represented a larger MW loss than the wind plants, so it was decided not to perform this sensitivity.

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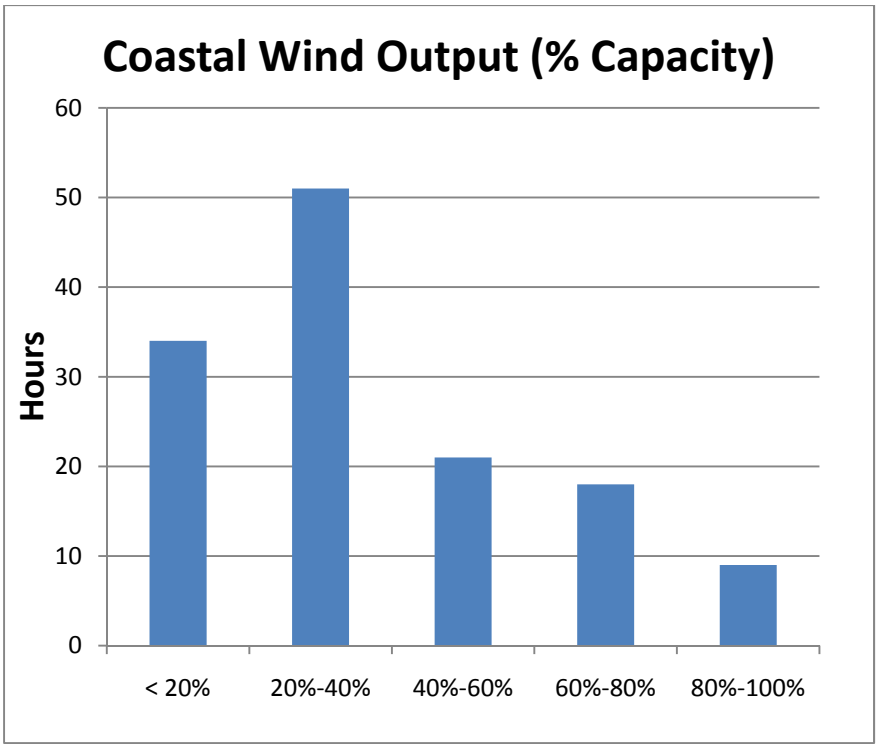


Figure 2: 2010 coastal wind output during high ERCOT system load hours

The Railroad DC tie was assumed to be set at zero export and import for the extent of this study. While both systems have supported emergency transactions and trade, and the DC tie is available for imports and exports, the purpose of this study is to ensure available import capacity to the LRGV from ERCOT without dependence on imports from CFE.

The SSWG 2016 summer peak base case was modified with the following changes to create the 2016 study case:

- The Lobo-Rio Bravo 345 kV line and associated facilities were removed from the model since this project is not RPG approved
- The dispatch of the Penescal, Gulf Wind, Magic Valley Wind Project and Los Vientos wind plants were set at 10% of their capacity
- Silas Ray Unit 5 (10 MW) was turned off in the model for the extent of the analysis because it was decided to not count on the availability of this unit to solve the local reliability constraints for the timeframe of this study due to its age (~60 years) and technology (small gas steam, non-reheat)
- All other generation in the LRGV was set at maximum output with the exception of the hydro powered units which were left at their base case output
- The tentative 250 MW load addition at Loma Alta in the Brownsville area, which had been included in the SSWG cases to reflect potential economic development activity at the Port of Brownsville, was removed from the study case
- The load in the LRGV was scaled to the 50/50 summer peak forecast (2723 MW)

It should be noted that a separate RPG review is underway (Sharyland and BPUB Cross Valley 345 kV Project) to consider the transmission upgrades needed to ensure that reliability criteria are satisfied

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for the Brownsville area, including consideration of the potential 250 MW load addition at Loma Alta. However, during the course of RPG review of this project, RPG members did not come to a consensus about the assumption to include the 250 MW load addition at Loma Alta. ERCOT will take these comments into consideration while performing the Independent Review of the Sharyland and BPUB Cross Valley 345 kV Project.

While there is some correlation between the review of the subject proposal (dealing primarily with the import of power into the LRGV) and the Sharyland and BPUB Cross Valley 345 kV Project, early analysis indicated that the review of the two projects could be effectively separated into two studies with two separate recommendations. A placeholder project (LaPalma to Loma Alta 345 kV line) was incorporated into the evaluation to account for any differences in cost that might be incurred across the various LRGV Import options considered in this review. Subsequently, the 250 MW load addition was removed from the study cases for this review and any additional transmission upgrades needed to support this load will be evaluated in ERCOT's Independent Review of the Sharyland and BPUB Cross Valley 345 kV Project.

The evaluation consisted of steady state voltage stability transfer analysis and AC contingency analysis and in accordance with NERC and ERCOT criteria. Several transmission improvement options were studied in order to resolve the reliability criteria exceedances found in the 2016 study case. Each option was evaluated based on its ability to meet the reliability criteria for both the 50/50 and 90/10 load forecasts. Generation solutions were not evaluated since ERCOT does not have the authority to propose generation additions.

In addition to ensuring that the transmission improvement options solve the reliability criteria exceedances in the 2016 study case, two sensitivities were evaluated:

1. N-1-1 (transmission) transfer capability
2. 2020 summer peak AC contingency analysis and steady state voltage stability

The N-1-1 sensitivity was studied in order to quantify the ability of the best alternatives to allow for maintenance outages. The 2020 summer peak analysis utilized the ERCOT DOE Long Term Study Task Force 2020 case. The case was modified to scale the load to 3030 MW in the LRGV area (not counting the 250 MW load at Loma Alta) and 611 MW in the Laredo area in order to match the 90/10 forecast for each of these areas. Additionally the case was modified by removing the Lobo-Rio Bravo 345 kV line and associated facilities, adding the Magic Valley Wind Project and Los Vientos wind plants which have signed interconnection agreements and turning off Silas Ray unit 5. The 2020 summer peak analysis was performed because the transmission improvement options studied were all high cost and must be designed with consideration for the long term needs of the area.

# 3. Study Case Evaluation

ERCOT performed a power flow AC contingency analysis using the PTI PSS/E software with the 2016 summer peak case to find reliability issues that exceeded both the NERC and ERCOT planning criteria. The results of the power flow analysis indicated that the loss of the largest generator[1] in the LRGV and a loss of Lon Hill-North Edinburg 345 kV line resulted in 128% overload (above the emergency rating) on the Ajo-Rio Hondo 345 kV line. The resulting overload cannot be relieved by redispatch of the generation in the LRGV area.

A transfer analysis was performed using Powertech VSAT software to determine steady state thermal and voltage stability LRGV load serving limits using the 2016 summer peak case. The VSAT transfer

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analysis was performed by scaling load in the LRGV valley area (sink) matched by an equal amount of generation scaling outside the LRGV area (source). VSAT performs AC contingency analysis at each incremental transfer level to identify the thermal and steady state voltage stability limits. The steady state voltage stability limits is defined as the non-convergence of power flow which is validated by modal analysis.

Based on the VSAT transfer analysis, it was determined that the thermal and voltage stability load serving capability for the LRGV for the loss of the largest generator[1] in the LRGV and a loss of Lon Hill-North Edinburg 345 kV line is 2345 MW and 2798 MW, respectively.

# 4. Description of Project Alternatives for Preliminary Analysis

Any new line must be geographically diverse from the two existing 345 kV lines that support the LRGV. The basis for this is twofold. First, both of the existing 345 kV lines run near the Texas Gulf Coast which make them susceptible to tropical storm and hurricane related forced outages. Also, both lines originate from the Lon Hill switching station in the Corpus Christi area which leaves the LRGV dependent upon one switching station for electrical service. While the loss of a substation is considered a Category D contingency for which some loss of load is allowed under the NERC TPL standards, it would not be rational to design such a contingency into the system during major system upgrades when there are reasonable alternative solutions. For these reasons it was decided that any new lines should not be sourced from the Lon Hill area, and that lines that were farther from the coast would be preferred. The one exception to this guideline is Option 9 which utilizes submarine cable, making it less prone to storm related outages.

Nine project alternatives were initially analyzed for solving the reliability criteria exceedances that were identified in the 2016 study case, including the project proposed by AEPSC. The nine project alternatives studied for the initial consideration are discussed below:

**Option 1** - AEPSC original proposal

- Construct a new 148 mile (approximate), 345 kV transmission line from Lobo to Rio Bravo to Del Sol, a new 345 kV switching station on the west side of the LRGV, utilizing 2-954 ACSR conductor on double-circuit capable structures and a 24 ohm 3600 amp series capacitor on the Lobo 345 kV circuit.
- Construct a new 15 mile (approximate), 345 kV transmission line from Del Sol to North Edinburg utilizing 2-954 ACSR conductor on double-circuit capable structures.
- Construct a new 15 mile (approximate), 345 kV transmission line from Del Sol to Frontera utilizing 2-954 ACSR conductor on double-circuit capable structures.

The total cost related to Option 1 is approximated to be $380 million.

[1] It was determined that the loss of a steam turbine in the particular LRGV combined cycle plant will result in the outage of the entire plant. The loss of generator is modeled as the loss of the all units in the plant.

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**Option 2**

- Option 1- AEPSC proposal with 600/750 MVA 345 kV, ± 48º Phase-shifting transformer, without series compensation, the Del Sol station and the Del Sol-Frontera 345 kV line

The total cost related to Option 2 is approximated to be $300 million.

**Option 3**

- Construct a new 145 mile (approximate), single circuit 345 kV line from Lobo to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 600/750 MVA 345 kV, ± 48º Phase-shifting transformer

The total cost related to Option 3 is approximated to be $255 million.

**Option 4**

- Construct a new 200 mile (approximate), single circuit 345 kV line from San Miguel to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 50% series compensation

The total cost related to Option 4 is approximated to be $365 million.

**Option 5**

- Construct a new 200 mile (approximate), single circuit 345 kV transmission line from Pawnee to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 50% series compensation

The total cost related to Option 5 is approximated to be $360 million.

**Option 6**

- Construct a new 220 mile (approximate) ± 400 kV 1,000 MW Biploar HVDC (classic) overhead line between the 345 kV Pawnee & 345 kV Loma Alta Stations
- Construct a new 345 kV Loma Alta Station with a 1,000 MW AC-DC Converter
- Expand the 345 kV STEC Pawnee Station with a 1,000 MW AC-DC Converter
- Add two 345/138kV 500 MVA autotransformers at Loma Alta, a new 14 mile 345 kV line from the existing 345 kV LaPalma station to the new 345 kV Loma Alta station

The total cost related to Option 6 is approximated to be $659 million.

**Option 7**

- Construct a new 200 mile (approximate) ± 400 kV 1,000 MW Biploar classic HVDC overhead line between the Pawnee & North Edinburg stations
- Expand the North Edinburg 345 kV Station with a 1,000 MW AC-DC Converter
- Expand the Pawnee Station 345 kV with a 1,000 MW AC-DC Converter

The total cost related to Option 7 is approximated to be $602 million.

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**Option 8**

- Construct a new 200 mile (approximate) ± 400 kV 1,000 MW Biploar classic HVDC overhead line between the Pawnee & Rio Hondo stations
- Expand the Rio Hondo 345 kV Station with a 1,000 MW AC-DC Converter
- Expand the Pawnee Station 345 kV with a 1,000 MW AC-DC Converter

The total cost related to Option 8 is approximated to be $602 million.

**Option 9**

- Expand the Barney Davis 138 kV Station with a 1,000 MW AC-DC Converter
- Construct a 345 kV bus at the Loma Alta station with a 1,000 MW AC-DC Converter
- Construct a new 150 mile (approximate) ± 320 kV 1,000 MW submarine DC cable between the Pawnee & Loma Alta Stations
- Construct a new 14 mile (approximate) 345 kV line from the existing 345 kV LaPalma station to new 345 kV Loma Alta station with two 345/138kV 500 MVA autotransformers at Loma Alta

The total cost related to Option 9 is approximated to be $944 million.

The VSAT transfer analysis was performed to determine the thermal and steady state voltage stability load serving limits for the LRGV using the 2016 summer peak case. The results of the 2016 transfer analysis results for the nine options are presented in the Figure 3. A 5% margin was included in the voltage stability study limits and no margins were applied for the thermal limits. The most limiting contingency for both the thermal and voltage stability for the all the options is the loss of the largest generator[1] in the LRGV and a loss of an additional 345 kV line serving the LRGV area.

All of the options except Options 1 and 4 appeared to meet the requirements for the LRGV in 2016. As noted in Section 5 below, AEPSC later provided a revised proposal based on Option 1 that met the 2016 requirements at a higher cost.

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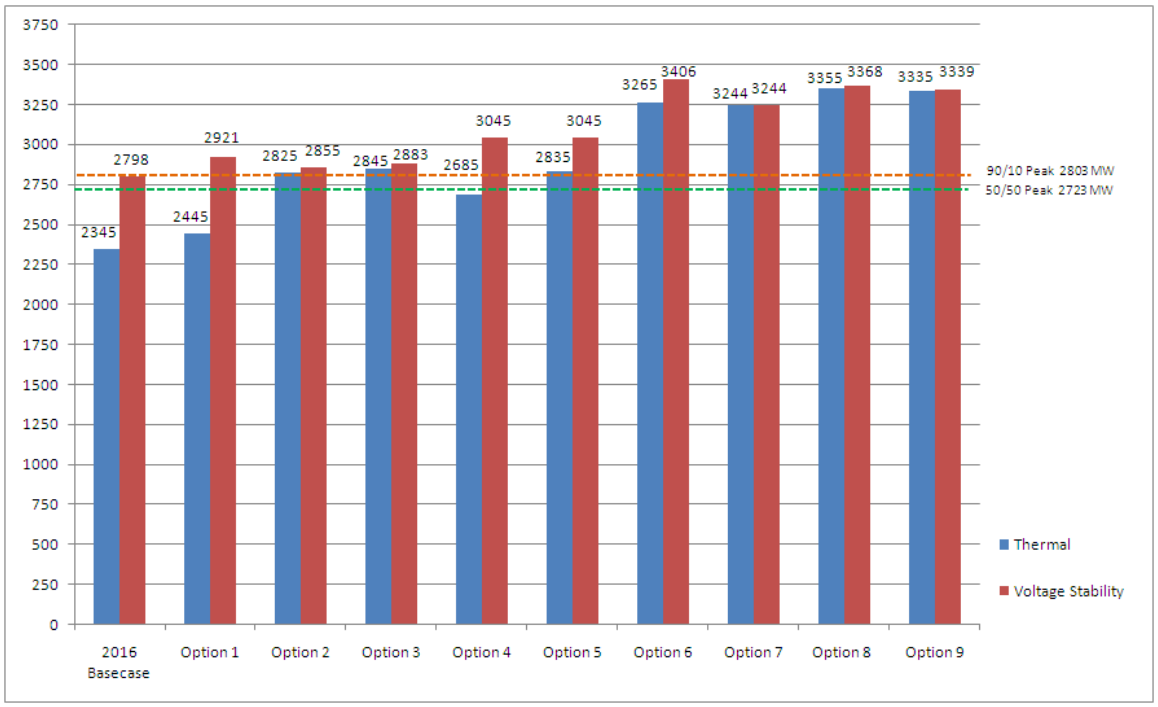


Figure 3: 2016 LRGV load serving capacity (MW)

The 2020 summer peak VSAT transfer analysis was used to further evaluate the above options to identify the additional system upgrades that would be needed for the long term needs of the area. The projected 90/10 load forecast for LRGV is 3030 MW (not counting the 250 MW load at Loma Alta). Based on the 2016 transfer analysis, the above options were further modified to include additional upgrades to meet the 2020 projected load forecast.

The eight project alternatives studied for the 2020 consideration are discussed below:

**Option 1A -** AEPSC original proposal + reconductor existing 345 kV lines

- Construct a new 163 mile (approximate), 345 kV transmission line from Lobo to Rio Bravo to North Edinburg, a new 345 kV switching station on the west side of the LRGV, utilizing 2-954 ACSR conductor on double-circuit capable structures and two 24 ohm 3600 amp series capacitors on the Lobo 345 kV circuit.
- Reconductor the existing Lon Hill-Nelson Sharpe-Ajo-Rio Hondo 345 kV line to 1988/2426 MVA normal/emergency rating
- Reconductor the existing Lon Hill-North Edinburg 345 kV line to 1988/2426 MVA normal/emergency rating
- Reconfiguration of the North Edinburg and Rio Hondo series capacitors such that the MVA rating is at least 2000 MVA and the compensation level is 25% of each respective circuit
- Construct a new 345 kV switching station (Caballo) on the Lon Hill-North Edinburg 345 kV, a new 25 mile, 345 kV transmission line from Caballo to Ajo utilizing 2-954 ACSR conductor on double-circuit capable structures.

The total cost related to Option 1A is approximated to be $535 million[2].

[2] Includes the $40 million ERCOT initial estimate for the Caballo to Ajo 345 kV

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**Option 3A**

- Construct a new 145 mile (approximate), single circuit 345 kV line from Lobo to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 600/750 MVA 345 kV, ± 48º Phase-shifting transformer
- Reconductor the existing Lon Hill-Nelson Sharpe-Ajo-Rio Hondo 345 kV line to 1988/2426 MVA normal/emergency rating
- Reconductor the existing Lon Hill-North Edinburg 345 kV line to 1988/2426 MVA normal/emergency rating
- Reconfiguration of the North Edinburg and Rio Hondo series capacitors such that the MVA rating is at least 2000 MVA and the compensation level is 25% of each respective circuit
- Construct a new 345 kV switching station (Caballo) on the Lon Hill-North Edinburg 345 kV, a new 25 mile (approximate), 345 kV transmission line from Caballo to Ajo utilizing 2-954 ACSR conductor on double-circuit capable structures.

The total cost related to Option 3A is approximated to be $475 million[2].

**Option 3_5**

- Construct a new 145 mile (approximate), single circuit 345 kV line from Lobo to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 600/750 MVA 345 kV, ± 48º Phase-shifting transformer
- Construct a new 200 mile (approximate), single circuit 345 kV transmission line from Pawnee to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures with 50% series compensation

The total cost related to Option 3_5 is approximated to be $615 million.

**Option 5D**

- Construct a new 200 mile (approximate), double circuit 345kV transmission line from Pawnee to North Edinburg, utilizing 2-954 ACSR with 50% series compensation

The total cost related to Option 5D is approximated to be $508 million.

**Option 6**

- Construct a new 220 mile (approximate) ± 400 kV 1,000 MW Bipolar HVDC (classic) overhead line between the 345 kV Pawnee & 345 kV Loma Alta Stations
- Construct a new 345 kV bus at the Loma Alta Station with a 1,000 MW AC-DC Converter
- Expand the 345 kV STEC Pawnee Station with a 1,000 MW AC-DC Converter
- Add two 345/138kV 500 MVA autotransformers at Loma Alta, a new 14 mile 345 kV line from the existing 345 kV LaPalma station to new 345 kV Loma Alta station

The total cost related to Option 6 is approximated to be $659 million.

**Option 7, Option 8 and Option 9 with no additional upgrades were considered for 2020**

The results of the 2020 transfer analysis results for the eight options are presented in the Figure 4. A 5% margin was included in the voltage stability study limits and no margins were applied for the thermal limits. The most limiting contingency for both the thermal and voltage stability for all of the

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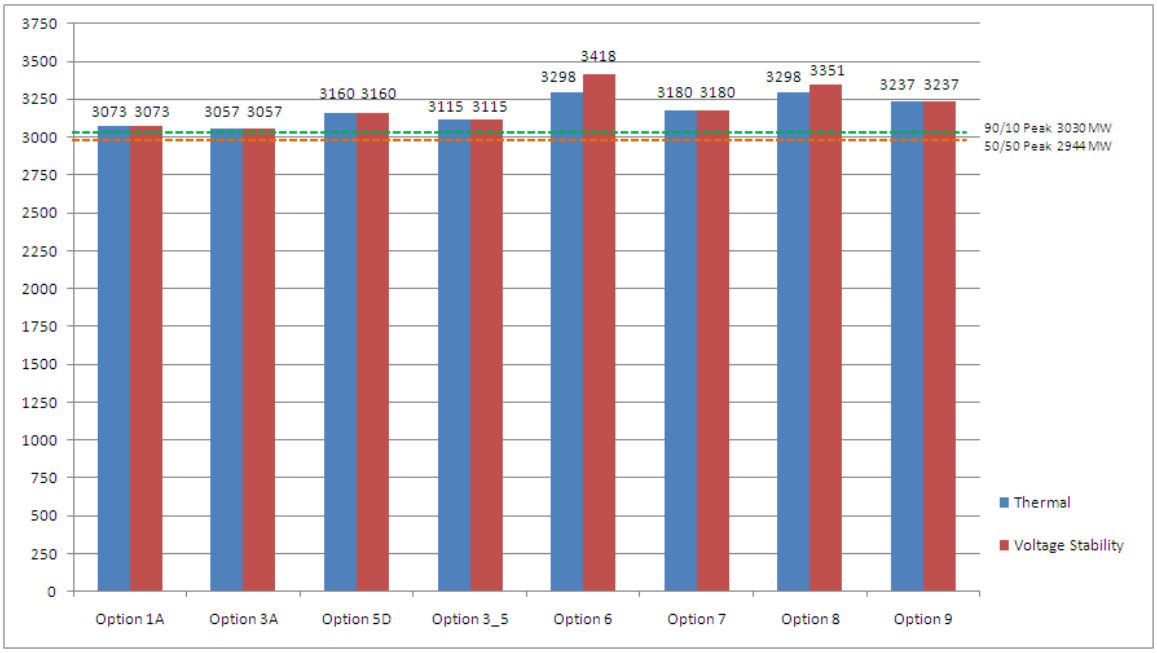
options is the loss of the largest generator1 in the LRGV and a loss of an additional 345 kV line serving the LRGV area.




Options 1A, 3A, 5D, 3_5, 7 and 9 are limited by voltage stability limits

Figure 4: 2020 LRGV load serving capacity (MW)

In addition to the LRGV load serving reliability issue, it was identified that there are additional load serving reliability issues in the Laredo and Brownsville area in the 2020 model.

**Laredo area reliability need in 2020:**

With a single contingency loss of the Gateway to University/North Laredo 138 kV double-circuit transmission line, the south Laredo area load will be served radially. This would result in a voltage stability problem in the area based on the projected 611 MW load in the Laredo area (2020 summer peak 90/10 forecast). A new source will be required in the south Laredo area, in order to provide the voltage support. One of the potential transmission improvements would be to construct a new Lobo to Rio Bravo 138 kV line. The Lobo-Rio Bravo 138 kV line is a preliminary solution to resolve the south Laredo area voltage issue and it has not been through RPG review. However, Option 1 would provide the capability to construct the additional Lobo-Rio Bravo 138 kV line by utilizing the open circuit on the proposed 345 kV line at an incremental cost of $20 million. For all the other options considered in the preliminary screening analysis, the estimated $50 million cost to construct a new Lobo to Rio Bravo 138kV line on new ROW will be added to the base project cost for comparison of the total 2020 projected project cost in order to allow for an equivalent comparison of the long-term costs of each option.

**Brownsville area reliability need in 2020:**

For the single contingency loss of the Rio Hondo to LaPalma 345 kV transmission line, the Rio Hondo-E. Rio Hondo-MVEC_Central 138 kV line serving the Brownsville area would overload in 2020. A new 345 kV source will be required in the Brownsville area, in order to relieve the 138 kV overload and serve the projected load in the Brownsville area. One of the potential transmission improvements would be to construct a new LaPalma to Loma Alta 345 kV line. The LaPalma to Loma Alta 345 kV line is a preliminary solution and it has not been through RPG review. However, Option 6 includes the construction of the new LaPalma-Loma Alta 345 kV line as part of the HVDC proposal.

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For all the other options considered in the preliminary screening analysis, the estimated $42 million cost to construct a new LaPalma-Loma Alta 345 kV line will be added to the base project cost for comparison of the total 2020 projected project cost in order to allow for an equivalent comparison of the long-term costs of each option.

Table 1 shows the estimated cost of the eight options considered for 2020. Based on the 2020 transfer analysis result and the estimated project cost of the eight options, Options 1A, 5D and 6 were selected for further considerations. The reasons for not considering the remaining options are highlighted below:

**Option 3A**: The load serving capability of option 3A was similar to 1A. Option 3A would require a phase shifting transformer on the new Lobo-North Edinburg 345kV line to meet the forecasted load serving capability in 2016. However, the phase shifter would not be needed in 2020 following the reconductor of the existing 345kV lines.

**Options 3_5**: The total project cost of option 3_5 to construct two new 345kV is significantly higher than options 1A or 5D. Also this option did not represent an increase in the load serving capability compared to Option 5D.

**Options 7 or 8**: Options 7 and 8 showed similar load serving capacity compared to Option 6. However, Option 6 had an added benefit in resolving some of the load serving issues in the Brownsville area in 2020.

**Options 9**: The project cost for the submarine DC cable was significantly higher compared to all of the other options and did not provide correspondingly higher benefits.

Table 1 shows the estimated cost of the eight options considered for 2020.

| Project Option | Base cost $ M | Reconductor existing 345 kV $ M | Caballo-Ajo 345 kV $ M | Lobo-Rio Bravo 138kV $ M | Loma Alta-LaPalma 345 kV $ M | Total cost $ M |
|---|---|---|---|---|---|---|
| Option 1A | 315 | 180[3] | 40[2] | 20 | 42 | 597 |
| Option 3A | 255 | 180[3] | 40[2] | 50 | 42 | 567 |
| Option 5D | 508 | - | - | 50 | 42 | 600 |
| Option 3_5 | 255+360 | - | - | 50 | 42 | 707 |
| Option 6 | 659 | - | - | 50 | - | 709 |
| Option 7 | 602 | - | - | 50 | 42 | 694 |
| Option 8 | 602 | - | - | 50 | 42 | 694 |
| Option 9 | 944 | - | - | 50 | - | 994 |

Table 1: Project cost estimate comparison for 2020

[3] The reconductor of the existing 345 kV lines shown here does not include additional cost for live-line reconductor as is included in later options because it is assumed that the lines could be taken out of service for this construction between 2016 and 2020 after the Lobo-North Edinburg line is placed in service

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# 5. Description of Project Alternatives for Final Consideration

Based on the preliminary analysis, Options 1A, 5D and 6 were selected for the final consideration. Option 1A was further modified to include the energized reconductor (live-line) of the existing LRGV 345 kV lines that would be completed by mid-2015. The reconductor of the existing 345 kV lines is necessary for this option to meet the reliability criteria by 2016. Since the existing lines cannot be taken out of service for extended times for construction until a third import source is constructed to the LRGV, AEPSC proposed a live-line reconductor where one phase is energized on temporary facilities to allow one phase at a time to be de-energized and the conductor replaced. This will allow the lines to be reconductored with minimal construction outages. The live-line reconductor is estimated to add $30 million to the total cost of reconductoring both lines.

**Option 1R** – Revised AEPSC proposal

- Construct a new 163 mile (approximate), single circuit 345 kV line from Lobo to Rio Bravo to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures, and two 24 ohm 3600 amp series capacitors on the Lobo 345 kV circuit (no additional substation equipment would be installed at Rio Bravo at this time but may be added in the future as needed to support the Laredo area needs)
- Energized reconducting (live-line) of the existing Lon Hill-Nelson Sharpe-Ajo-Rio Hondo 345 kV line to 1988/2426 MVA normal/emergency rating
- Energized reconducting (live-line) of the existing Lon Hill-North Edinburg 345 kV line to 1988/2426 MVA normal/emergency rating
- Reconfiguration of the North Edinburg and Rio Hondo series capacitors such that the MVA rating is at least 2000 MVA and the compensation level is 25% of each respective circuit

The total cost related to Option 1R is approximated to be $525 million.

The following additional upgrade was needed for 2020:

- Construct a new 345 kV switching station (Caballo) on the Lon Hill-North Edinburg 345kV, a new 25 mile (approximate), 345kV transmission line from Caballo to Ajo utilizing 2-954 ACSR conductor on double-circuit capable structures.

**Option 5D**

- Construct a new 200 mile (approximate), double circuit 345 kV transmission line from Pawnee to North Edinburg, utilizing 2-954 ACSR with 50% series compensation

The total cost related to Option 5D is approximated to be $508 million.

**Option 6**

- Construct a new 220 mile (approximate) ± 400 kV 1,000 MW Bipolar HVDC (classic) overhead line between the 345 kV Pawnee & 345 kV Loma Alta Stations
- Construct a new 345 kV bus at the Loma Alta Station with a 1,000 MW AC-DC Converter
- Expanded 345 kV STEC Pawnee Station with a 1,000 MW AC-DC Converter
- Two 345/138kV 500 MVA autotransformers at Loma Alta, a new 14 mile 345 kV line from the existing 345 kV LaPalma station to new 345 kV Loma Alta station

The total cost related to Option 6 is approximated to be $659 million.

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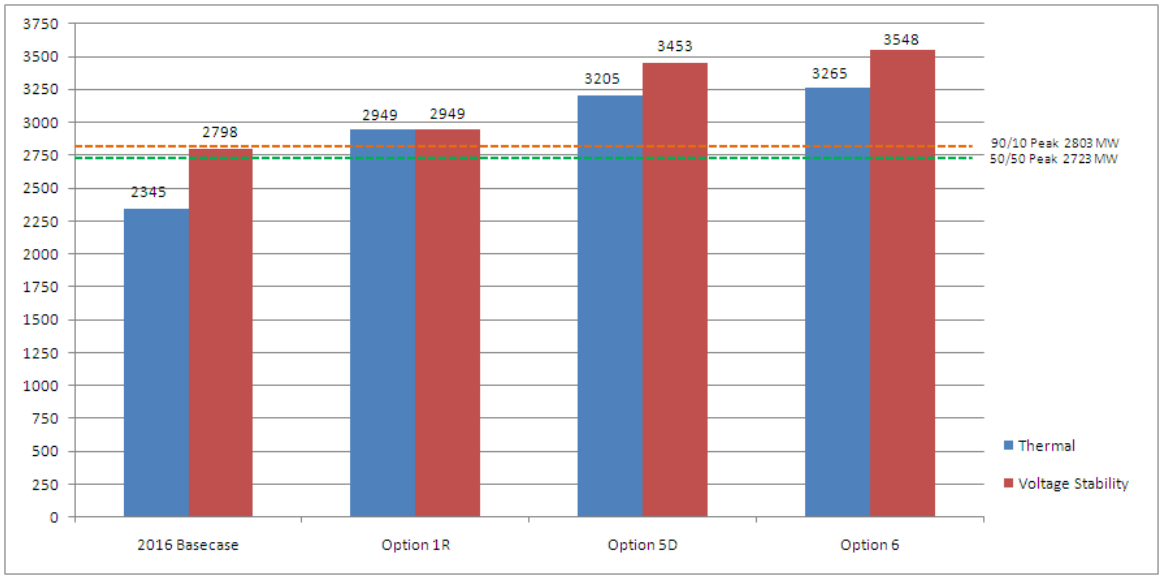
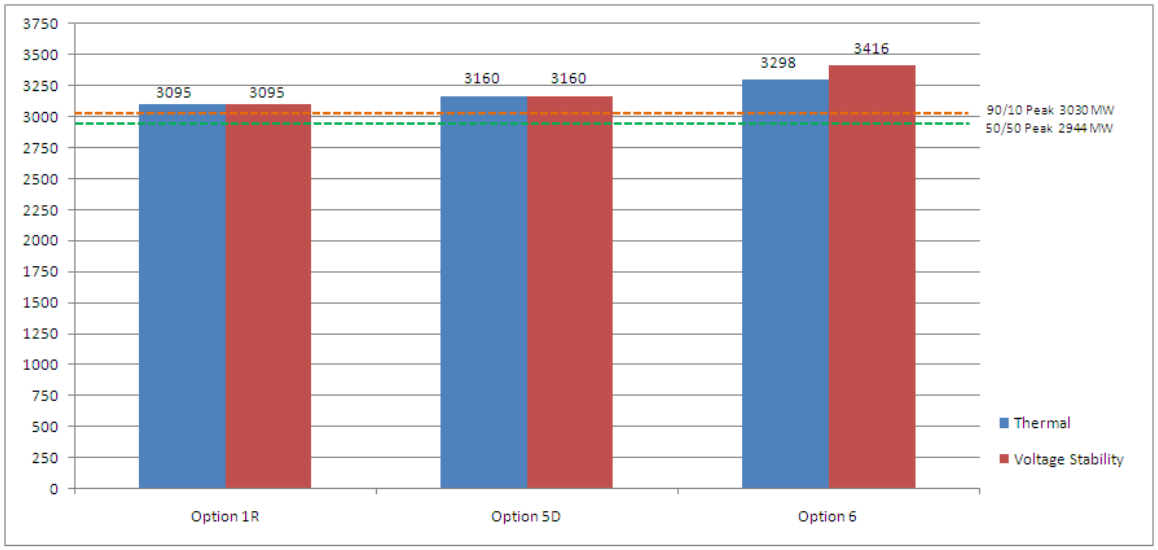
The results of the 2016 and 2020 transfer analysis for the final options are presented in Figures 5 and 6. A 5% margin was included in the voltage stability study limits and no margins were applied for the thermal limits. The most limiting contingency for both the thermal and voltage stability for the all the options is the loss of the largest generator[1] in the LRGV and a loss of an additional 345 kV line serving the LRGV area.




Option 1R is limited by voltage stability limits

Figure 5: 2016 LRGV load serving capacity (MW)




Options 1R, and 5D are limited by voltage stability limits

Figure 6: 2020 LRGV load serving capacity (MW)

**Additional transmission upgrades needed in 2016:**

A power flow AC contingency analysis was performed using PTI MUST software to identify additional transmission upgrades that would be required for the three options in 2016. Tables A1, A2 & A3 in Appendix A shows the thermal overloads for 2016 summer peak 50/50 forecast load level.

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The result compares the thermal overloads with and without the project options. Based on the results, it was determined that the Raymondville-Harlingen Switch 69 kV line needs to be upgraded for option 1R in 2016. For Option 5D, the Lon Hill-Smith-Edroy 69kV line and the Raymondville-Harlingen Switch 69 kV line will need to be upgraded in 2016. For Option 6, the Lon Hill-Smith-Edroy-Mathis 69 kV line and the Loma Alta-South Carbide 138 kV line will need to be upgraded in 2016.

**Maintenance Outage consideration:**

In the existing LRGV system, with only two 345 kV sources into the LRGV it is extremely difficult to take a maintenance or construction related outage of one of these lines because the contingency loss of the other would leave the LRGV with approximately 350 MW of import capability. Moreover, owners and operators of both generation resources and transmission assets must schedule maintenance and construction outages during two small windows in the spring and fall, respectively. Figure 7 shows the historical maximum daily peak as a percentage of the annual peak and the probability of the annual peak occurring for each day in a year. This limitation eliminated the option of removing one of the existing 345 kV lines from service for rebuild or reconstruction without building a third line to the LRGV area.

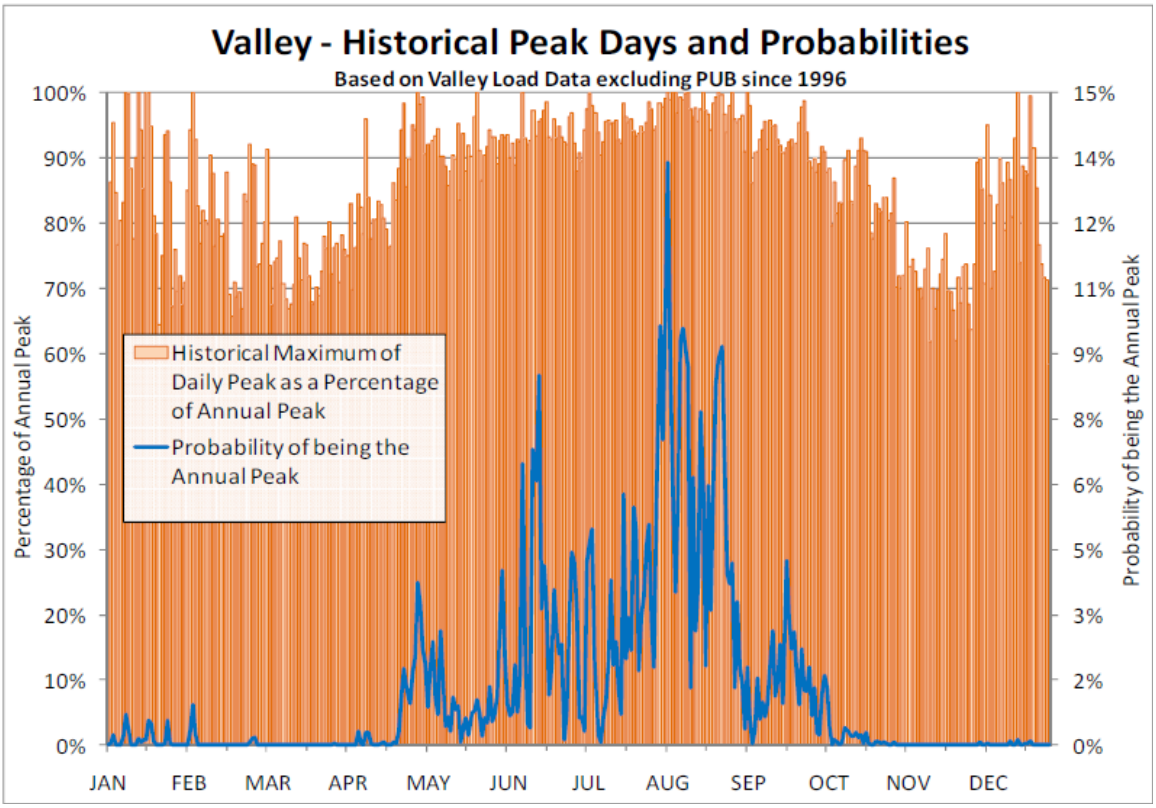


Figure 7: Distribution of Historical LRGV Peak Loads (courtesy of AEPSC)

The results of the n-1-1 transfer analysis for the final options are presented in the Figure 8. A 5% margin was included in the voltage stability study limits and no margins were applied for the thermal limits.

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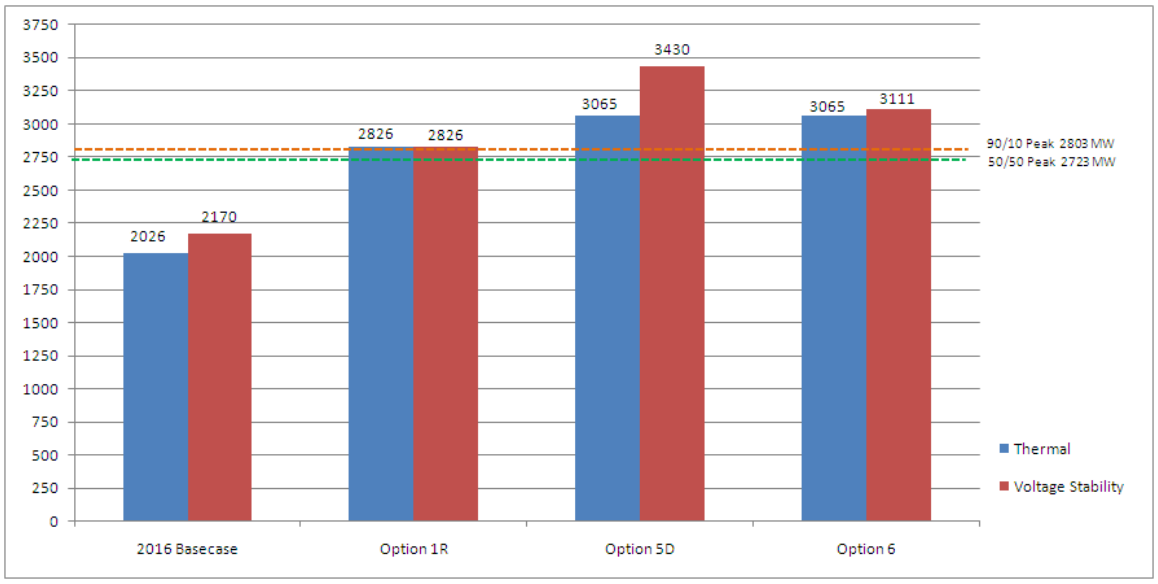


Figure 8: 2016 LRGV load serving capacity (MW) during maintenance outages

# 6. Conclusion

All three options met the reliability criteria for 2016. Several quantitative and qualitative criteria were evaluated in determining which alternative should be selected as the preferred option. These criteria are shown in Table 2. A discussion of some of the criteria considered follows.

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| | Option 1R | Option 5D | Option 6 |
|---|---|---|---|
| **Project cost in 2016** | $ 525 million | $ 508 million | $ 659 million |
| **2016 Thermal load serving capability (MW)** | 2949+ | 3205 | 3265 |
| **2016 Voltage stability load serving capability (MW)** | 2949 | 3453 | 3548 |
| **2016 Incremental LRGV load serving above 50/50 forecast (MW)** | 226 | 482 | 542 |
| **2016 Incremental LRGV load serving above 90/10 forecast (MW)** | 146 | 402 | 462 |
| **2016 N-1-1 (Maintenance outages) thermal load serving capability** | 2826+ | 3065 | 3065 |
| **2016 N-1-1 (Maintenance outages) voltage stability load serving capability** | 2826 | 3430 | 3111 |
| **Additional system upgrades needed in 2016** | Raymondville-Harlingen Switch 69 kV (18.1 miles) | Lon Hill-Smith-Edroy 69 kV (11.6 miles) and Raymondville-Harlingen Switch 69 kV (18.1 miles) | Lon Hill-Smith-Edroy-Mathis 69 kV (25.4 miles) and Loma Alta-South Carbide 138 kV (1.1 miles) |
| **Additional system upgrades needed in 2020** | Caballo-Ajo 345 kV ($ 40 million) | - | - |
| **Reliability Improvements needed for Laredo area beyond 2016** | Lobo-Rio Bravo 138kV ( $ 20 million ) | Lobo-Rio Bravo 138kV ( $ 50 million ) | Lobo-Rio Bravo 138kV ($ 50 million) |
| **Reliability Improvements needed for Brownsville area beyond 2016** | Loma Alta-LaPalma 345 kV ($ 42 million) | Loma Alta-LaPalma 345 kV ($ 42 million) | - |
| **Cost of total improvements through 2020 (Including Laredo and Brownsville improvements** | $627 million | $600 million | $709 million |
| **2020 Incremental LRGV load serving above 50/50 forecast (MW)** | 151 | 216 | 354 |
| **Geographical diversity of the new line** | Excellent | Good | Good |
| **Total new ROW required (2016/2020)** | ~163/~202 miles | ~200/~244 miles | ~234/~264 miles |
| **Rehabilitation of existing Lon Hill-Rio Hondo and Lon Hill-North Edinburg 345 kV lines** | Yes | No | No |
| **Infrastructure Improvement in the area of new generation interconnection projects** | Good | None | Fair |
| **Projected in-service date (estimation provider)** | 2016 (AEPSC) | 2017 (AEPSC) | 2016 (Sharyland) |

Table 2: Overall comparison of the final options

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Comparing the three options shows that each have their own strengths. While all three options meet the reliability criteria for 2016 forecasted loads, options 5D and 6 have a higher margin. However, with the final build out of the three options in 2020 the load serving capability is similar.

Option 6 has a slightly greater load serving capability, but the cost for Option 6 is significantly greater than Options 1R and 5D. Any local benefit that Option 6 may provide to the Brownsville area can likely be achieved with transmission improvements added to the other options at a lower overall cost than the cost premium of Option 6 (greater than $80 million in 2020). Thus, the additional advantages that Option 6 may provide to the east side of the LRGV and import capability do not justify the additional cost.

The choice between Options 1R and 5D is complex. Option 5D has a 3-4% lower overall cost, both in terms of the initial project build for 2016 and the longer term costs for the build out in 2020. Also, Option 5D has slightly more load serving capability than Option 1R. Given these small differences, it is important to consider other, less quantifiable costs and benefit differences between the options. Option 1R will require less new ROW, meaning that it will potentially have less impact on land owners and has the potential to be constructed quicker. AEPSC estimated that Option 1R could be completed by summer peak of 2016, but Option 5D may take until early 2017 for completion due to the longer ROW.

Option 1R also utilizes the western-most line analyzed in the study. This will provide greater geographic diversity from the existing 345 kV lines serving the LRGV which will lessen the chance of simultaneous forced outages from hurricanes and tropical storms.

Furthermore, Option 1R includes the rehabilitation of the existing Lon Hill-Nelson Sharpe-Ajo-Rio Hondo and Lon Hill-North Edinburg 345 kV lines. These lines, in particular, the Lon Hill-Nelson Sharpe-Ajo-Rio Hondo line, are currently in need of maintenance due to corrosion and age. However, as stated earlier, existing limitations make it difficult to take these lines out of service for maintenance without exposing the LRGV to reliability risks. The cost associated with the rehabilitation of these lines, while not explicitly included in this analysis, would be avoided if the lines were reconductored as part of Option 1R.

Additionally, the new Lobo-Rio Bravo-North Edinburg line and the reconductored Nelson Sharpe-Ajo-Rio Hondo line upgrade traverse areas that currently have a significant amount of new generation interconnection requests. As of July 2011 there were 860 MW of wind generation projects in the full interconnection study phase in Kleburg, Kenedy, Cameron, Hidalgo, Jim Hogg, and Webb counties. If some of this generation comes to fruition, Option 1R will provide infrastructure that will enable the connection and export of the power without the significant incremental cost that could be incurred under Option 5D.

Option 1R provides a second 345 kV source to the Laredo area. While the analysis performed in this study did not indicate a second 345 kV source was needed by 2020 under current load forecasts, other long-term studies have shown the need in the early 2020s.

Previously, it was stated that a potential 250 MW load at Loma Alta in Brownsville was not studied in the base analysis of this review. It should be noted that, as described, Option 1R does not provide the import capability necessary to meet the 2016 90/10 forecast if an additional 250 MW of load is added at Loma Alta (3053 MW total load). However, an analysis was performed to demonstrate that, with the addition of the LaPalma-Loma Alta 345 kV line, the acceleration of the Ajo-Caballo 345 kV line and the addition of approximately 200 MVAR of static shunt reactive devices in the Brownsville area would allow for the import capability necessary to serve this potential load addition. This analysis is intended to demonstrate that a reasonable solution exists, but it has not been optimized and is not

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recommended for endorsement at this time. Further upgrades may also be needed locally to serve this load addition.

While Option 5D provides slightly more import capability at a slightly lower cost, the other considerations support Option 1R. For the above stated reasons, Option 1R appears to be the best alternative for meeting the mid-term and future transmission needs of the LRGV.

The following facilities constitute the preferred option:

- Construct a new 163 mile (approximate), single circuit 345 kV line from Lobo to Rio Bravo to North Edinburg, utilizing 2-954 ACSR conductor on double-circuit capable structures, and two approximately 24 ohm 3600 amp series capacitors on the Lobo 345 kV circuit (no additional substation equipment would be installed at Rio Bravo at this time but may be added in the future as needed to support the Laredo area needs)
- Reconductor the existing Lon Hill-Nelson Sharpe-Ajo-Rio Hondo 345 kV line to 1988/2426 MVA normal/emergency rating as defined in modified proposal to achieve increased rating before peak of 2016
- Reconductor the existing Lon Hill-North Edinburg 345 kV line to 1988/2426 MVA normal/emergency rating as defined in modified proposal to achieve increased rating before peak of 2016
- Reconfiguration of the North Edinburg and Rio Hondo series capacitors such that the MVA rating is at least 2000 MVA and the compensation level is 25% of each respective circuit

This project is needed to ensure reliability for the LRGV. Because of the short timeframe necessary to complete project construction it is suggested that the project be deemed critical to reliability per PUCT Substantive Rule 25.101 (b)(3)(D).

Because the preferred option involves the addition of series capacitors near existing thermal generation units, follow-up studies will be performed by AEPSC to determine mitigation options for subsynchronous resonance interaction.

# 7. Designated Provider of Transmission Facilities

In accordance with the ERCOT RPG Planning Charter and Procedures Section 2.3.4, 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.

Both Electric Transmission Texas (ETT) and American Electric Power Texas Central Company (AEP TCC) own endpoints of the 345 kV transmission line from Lobo to Rio Bravo to North Edinburg listed in the project scope of this recommendation. Therefore, ERCOT designates ETT and AEP TCC as co-providers of the 345kV transmission line from Lobo to Rio Bravo to North Edinburg and associated series capacitor[4]. AEP Texas Central Company owns the existing 345kV lines and series capacitors listed in the project scope of this recommendation. Therefore, ERCOT designates AEP TCC as the provider for the reconductor of the existing 345kV transmission lines and reconfiguration of the North Edinburg and Rio Hondo series capacitors.

[4] ERCOT has been informed that AEP TCC has elected to delegate ETT and ETT has accepted delegation as the transmission provider of the Lobo to Rio Bravo to North Edinburg 345 kV transmission line and associated series capacitor.

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# Appendix A

Power flow results to identify additional transmission upgrades needed in 2016

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| Overloaded Element | Region | Nominal kV | Rating B (MVA) | % Overload | |
|---|---|---|---|---|---|
| | | | | Base | With Option1 |
| From LNHILL 6 (8455) to LHEDL (8905) 345 kV CKT 1 | AEP-TCC | 345 | 1176 | 128.9 | - |
| From LHRHL (8902) to AJO7A (80076) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 128.6 | - |
| From RIOHND 6 (8318) to LHRHM (8903) 345 kV CKT 17 | AEP-TCC | 345 | 1195 | 126.1 | - |
| From EDNBRG 6 (8383) to LHEDM (8901) 345 kV CKT 17 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHEDM (8901) to LHEDL (8905) 345 kV CKT 33 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHRHL (8902) to LHRHM (8903) 345 kV CKT 33 | AEP-TCC | 345 | 1195 | 126.1 | - |
| From AJO7A (80076) to SHARPE6 (85000) 345 KV CKT 1 | AEP-TCC | 345 | 1195 | 120.9 | - |
| From LNHILL 2 (8448) to RBSTN T2 (8884) 69 kV CKT 1 | AEP-TCC | 69 | 69 | 118.9 | 122 |
| From RIOHND 4 (8319) to ERIOHONDOSB8 (8764) 138 kV CKT 1 | STEP-TSP | 138 | 121 * | 107.7 | 108 |
| From CALALLENSUB9 (5626) to LNHILL 2 (8448) 69 kV CKT 1 | AEP-TCC | 69 | 106 | 106.9 | 108.5 |
| From LNHILL 6 (8455) to SHARPE6 (85000) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 106.5 | - |
| From LAPALM 4 (8314) to CAVAZOS4A (80229) 138 kV CKT 1 | AEP-TCC | 138 | 211 | 106.1 | 106.5 |
| From RAYVILE2 (8300) to RAYVL1-2 (8700) 69 kV CKT 1 | AEP-TCC | 69 | 38 | 102.8 | 125.6 |
| From LAPALM 4 (8314) to L.FRES 4 (8333) 138 kV CKT 1 | AEP-TCC | 138 | 226 | 102.1 | 102.5 |
| From LNHILL 2 (8448) to LNHILL 4 (8452) 138 kV CKT 1 | AEP-TCC | 138/69 TR | 91.3 | - | 101.8 |

Table A1: 2016 Thermal overloads with/without option 1R

| Overloaded Element | Region | Nominal kV | Rating B (MVA) | % Overload | |
|---|---|---|---|---|---|
| | | | | Base | with Option 5D |
| From LNHILL 6 (8455) to LHEDL (8905) 345 kV CKT 1 | AEP-TCC | 345 | 1176 | 128.9 | - |
| From LHRHL (8902) to AJO7A (80076) 345kV CKT 1 | AEP-TCC | 345 | 1195 | 128.6 | - |
| RIOHND 6 (8318) to LHRHM (8903) 345 kV CKT 17 | AEP-TCC | 345 | 1195 | 126.1 | - |
| EDNBRG 6 (8383) to LHEDM (8901) 345 kV CKT 17 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHEDM (8901) to LHEDL (8905) 345 kV CKT 33 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHRHL (8902) to LHRHM (8903) 345 kV CKT 33 | AEP-TCC | 345 | 1195 | 126.1 | - |
| From AJO7A (80076) to SHARPE6 (85000) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 120.9 | - |
| From LNHILL 2 (8448) to RBSTN T2 (8884) 69 kV CKT 1 | AEP-TCC | 69 | 69 | 118.9 | 121.3 |
| From COLETO 4 (8162) to KENDYSW4 (8186) 138 kV CKT 1 | AEP-TCC | 69 | 207 | 108.9 | 115.4 |
| From LNHILL 6 (8455) to NOPALITO7A (80382) 345 kV CKT 1 | AEP-TCC | 138 | 1011 | 108.2 | - |
| From RIOHND 4 (8319) to ERIOHONDOSB8 (8764) 138 kV CKT 1 | STEP-TSP | 138 | 121 * | 107.7 | 107.3 |
| From CALALLENSUB9 (5626) to LNHILL 2 (8448) 69 kV CKT 1 | AEP-TCC | 69 | 106 | 106.9 | 109.5 |
| From LNHILL 6 (8455) to SHARPE6 (85000) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 106.5 | - |
| From LAPALM 4 (8314) to CAVAZOS4A (80229) 138 kV CKT 1 | AEP-TCC | 138 | 211 | 106.1 | 106.7 |
| From RAYVILE2 (8300) to RAYVL1-2 (8700) 69 kV CKT 1 | AEP-TCC | 69 | 38 | 102.8 | 120.7 |
| From LAPALM 4 (8314) to L.FRES 4 (8333) 138 kV CKT 1 | AEP-TCC | 138 | 226 | 102.1 | 102.7 |
| From LNHILL 2 (8448) to LNHILL 4 (8452) 69/138 TR 1 | AEP-TCC | 138/69 TR | 91.3 | - | 104.4 |
| From LNHILL 2 (8448) to SMITH 2 (8866) 69 kV CKT 1 | AEP-TCC | 69 | 61 | - | 113.5 |
| From EDROY 2 (8408) to SMITH 2 (8866) 69 kV CKT 1 | AEP-TCC | 69 | 61 | - | 103.3 |

Table A2: 2016 Thermal overloads with/without option 5D

* Base case overload
Overload highlighted in green have projects identified in 5YTP

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| Overloaded Element | Region | Nominal kV | Rating B (MVA) | % Overload | |
|---|---|---|---|---|---|
| | | | | Base | with Option6 |
| From LNHILL 6 (8455) to LHEDL (8905) 345 kV CKT 1 | AEP-TCC | 345 | 1176 | 128.9 | - |
| From LHRHL (8902) to AJO7A (80076) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 128.6 | - |
| From RIOHND 6 (8318) to LHRHM (8903) 345 kV CKT 17 | AEP-TCC | 345 | 1195 | 126.1 | - |
| From EDNBRG 6 (8383) to LHEDM (8901) 345 kV CKT 17 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHEDM (8901) to LHEDL (8905) 345 kV CKT 33 | AEP-TCC | 345 | 1176 | 126.1 | - |
| From LHRHL (8902) to LHRHM (8903) 345 kV CKT 33 | AEP-TCC | 345 | 1195 | 126.1 | - |
| From AJO7A (80076) to SHARPE6 (85000) 345 KV CKT 1 | AEP-TCC | 345 | 1195 | 120.9 | - |
| From LNHILL 2 (8448) to RBSTN T2 (8884) 69 kV CKT 1 | AEP-TCC | 69 | 69 | 118.9 | 114.5 |
| From COLETO 4 (8162) to KENDYSW4 (8186) 138 kV CKT 1 | AEP-TCC | 138 | 207 | 108.9 | - |
| From LNHILL 6 (8455) to NOPALITO7A (80382) 345 kV CKT 1 | AEP-TCC | 345 | 1011 | 108.2 | - |
| From RIOHND 4 (8319) to ERIOHONDOSB8 (8764) 138 kV CKT 1 | STEP-TSP | 138 | 121 * | 107.7 | - |
| From CALALLENSUB9 (5626) to LNHILL 2 (8448) 69 kV CKT 1 | AEP-TCC | 69 | 106 | 106.9 | 102.6 |
| From LNHILL 6 (8455) to SHARPE6 (85000) 345 kV CKT 1 | AEP-TCC | 345 | 1195 | 106.5 | - |
| From LAPALM 4 (8314) to CAVAZOS4A (80229) 138 kV CKT 1 | AEP-TCC | 138 | 211 | 106.1 | - |
| From RAYVILE2 (8300) to RAYVL1-2 (8700) 69 kV CKT 1 | AEP-TCC | 69 | 38 | 102.8 | - |
| From LAPALM 4 (8314) to L.FRES 4 (8333) 138 kV CKT 1 | AEP-TCC | 138 | 226 | 102.1 | - |
| From PAWNEESW5 (5725) to LNHILL 6 (8455) 345 kV CKT 1 | AEP-TCC | 345 | 1011 | - | 101.8 |
| From LOMAALTA (5962) to CARB-VL4 (8337) 138 kV CKT 1 | AEP-TCC | 138 | 202 | - | 105 |
| From MATHIS 2 (8407) to EDROY 2 (8408) 69 kV CKT 1 | AEP-TCC | 69 | 61 | - | 103.5 |
| From EDROY 2 (8408) to SMITH 2 (8866) 69 kV CKT 1 | AEP-TCC | 69 | 61 | - | 108.6 |
| From LNHILL 2 (8448) to LNHILL 4 (8452) 138/69 TR 1 | AEP-TCC | 138/69 TR | 91.3 | - | 104.2 |
| From LNHILL 2 (8448) to SMITH 2 (8866) 69 kV CKT 1 | AEP-TCC | 69 | 61 | - | 118.8 |

Table A3: 2016 Thermal overloads with/without option 6

* Base case overload
Overload highlighted in green have projects identified in 5YTP

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