ERCOT Delaware Basin Load Integration Study

Final

Document Revisions

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Executive Summary

ERCOT, with extensive review and input by Transmission Service Providers (TSPs) and stakeholders, performed the Delaware Basin Load Integration Study. This report describes potential reliability transmission needs to meet higher-than-forecasted electric demand driven by the oil and natural gas industry and the associated economic expansion in the Delaware Basin area located in the ERCOT Far West Weather Zone. The Delaware Basin area spans the following eight counties: Brewster, Culberson, Jeff Davis, Loving, Pecos, Reeves, Ward, and Winkler.

The Far West Weather Zone, especially the Delaware Basin area, has the highest peak demand growth rate in the ERCOT system in recent years. The historical load data from 2013 to 2019 showed that the average annual peak load growth rate of the Far West Weather Zone is approximately 11%, well above the ERCOT system-wide average.

Several planned transmission projects, including the Far West Texas Project (FWTP), Far West Texas Dynamic Reactive Devices (DRD), and Far West Texas Project 2 (FWTP2), endorsed by the ERCOT Board of Directors in 2017 and 2018, are expected to be sufficient to meet the current load forecast for the Far West Weather Zone through 2024. As the oil and gas load in the Delaware Basin area continues to develop, ensuring that the necessary transmission improvements are in place in time to accommodate the rapid load growth will continue to be a challenge. The nature of the industry is such that oil and gas customers are not able to accurately project their demand needs more than one or two years ahead of time while transmission improvements can take up to six years to complete planning studies, routing analysis (if needed), regulatory approvals, route acquisition (if needed), design, and construction.

The main purpose of the study is to identify potential reliability needs and cost-effective bulk power system upgrades, particularly long lead time transmission improvements, which may be necessary if the load in the Delaware Basin area increases at a rapid pace. ERCOT performed a steady state reliability analysis using a higher-than-forecasted (i.e. conceptual plus planned) load growth in the Delaware Basin area. The total load assumed in the study area was 5,372 MW, which is double the area load (2,688 MW) assumed in the ERCOT 2019 Regional Transmission Plan (RTP) for year 2024.

To address the reliability needs for the assumed total load, four short-listed long lead time transmission alternatives and a set of common transmission upgrades were identified to reliably serve the assumed load in the study area under both normal and contingency conditions. As a result, ERCOT identified a roadmap for the long lead time transmission upgrades (i.e. new 345-kV transmission lines) and the associated triggers in terms of the load level in the Delaware Basin area. As the common transmission upgrades and the upgrade of existing 345-kV lines are expected to require relatively less lead time, they were not considered in the roadmap development. Rather, they were assumed to be completed prior to first trigger level. Table E.1 lists the details of transmission additions associated with each stage.

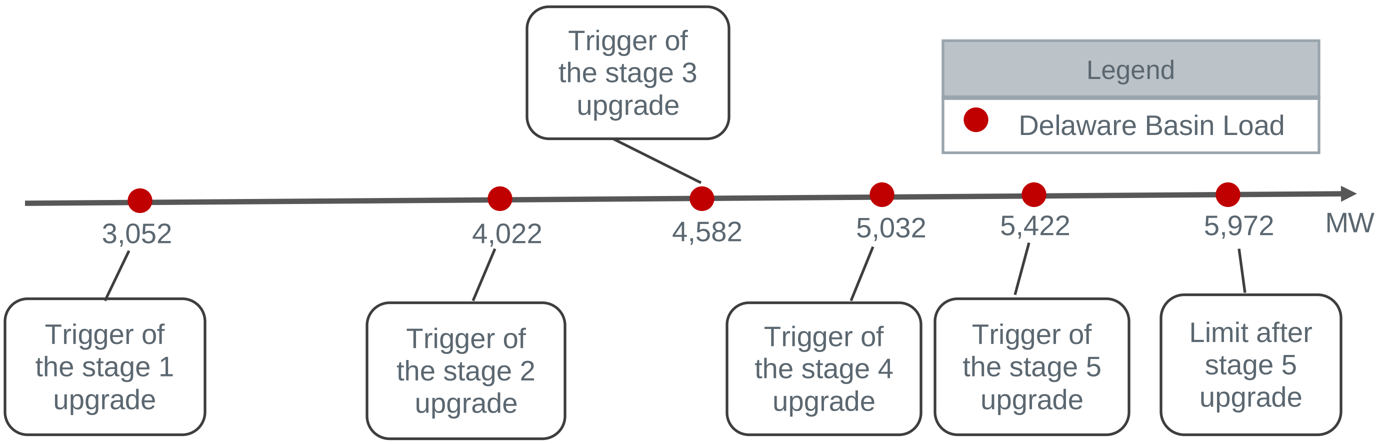

Figure E.1 Delaware Basin Transmission Upgrade Roadmap

Table E.1 Delaware Basin Transmission Upgrade Roadmap – Detailed Project List

Stage	Estimated Delaware Basin Load Level (MW)	Upgrade Element	Estimated Upgrade Cost ($M)	Trigger
1	3,052	Add a second circuit on the existing Big Hill - Bakersfield 345-kV line	69	Import Needs
2	4,022	A new Bearkat - North McCamey - Sand Lake double circuit 345-kV line	371	Import Needs
3	4,582	A new Riverton - Owl Hills single circuit 345-kV line	41	Culberson Loop Needs
4	5,032	Riverton - Sand Lake 138-kV to 345-kV conversion and a new Riverton - Sand Lake 138-kV line	56	Culberson Loop Needs
5	5,422	A new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	444	Import Needs

As noted above, all of the common transmission upgrades were included in the study while developing this roadmap. The addition of a second circuit on the existing structures of the Big Hill - Bakersfield 345-kV line, identified as Stage 1 upgrade, will be needed if the Delaware Basin load exceeds 3,052 MW. The Stage 2 upgrade, a new import path consisting of 345-kV circuits from Bearkat to North McCamey to Sand Lake, will be needed if the Delaware Basin load exceeds 4,022 MW. The Stage 2 upgrade is also expected to improve the existing Generic Transmission Constraints (GTCs) in the McCamey and Bearkat areas.

With Stage 1 and Stage 2 upgrades assumed in service, voltage instability was observed in the Culberson Loop when the Delaware Basin area load reaches 4,582 MW. Stage 3 and Stage 4 upgrades will be necessary to address the Culberson Loop voltage instability.

When the load in the Delaware Basin area exceeds 5,422 MW, the Delaware Basin area may need an additional new import path as shown in the Stage 5 upgrade.

Although the study year was 2024, it should not be assumed that all of the improvement projects are needed in 2024. The actual need for each project could be sooner or later than 2024 depending on the growth rate and location of the load in the Delaware Basin. Other factors that could affect the need for and timing of the upgrades include, but are not limited to, common transmission upgrade implementation, availability and dispatch of the generation in the study area, impedance of the new conductors, transmission upgrade cost estimates, and the results of dynamic stability analysis, which was not conducted as part of this study.

The TSPs and ERCOT will continue to study the Delaware Basin as part of their normal planning processes and recommend new transmission projects as necessary to address new customer interconnections, new generation development, and system needs.

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Disclaimer

It should be noted that the identified transmission improvements in this document are based on the assumptions used in this study. Assumptions that could change the results of this analysis include, but are not limited to, the following: actual load addition size, timing, and location; common transmission upgrade implementation; availability and dispatch of the generation in the study area; impedance of the new conductors; transmission upgrade cost estimates; and the results of dynamic stability analysis.

The primary focus of this study was to identify and to create a roadmap for long lead time transmission improvements, such as new extra high voltage transmission lines, to serve assumed conceptual and planned loads in the Delaware Basin study area. This study addressed transmission system thermal violations and steady state voltage stability issues identified during the analyses for the Far West Weather Zone.

A local reactive planning assessment was not completed as part of this study. The location and size of reactive devices were not optimized as part of this assessment.

1. Introduction

Over the past several years, the Far West Weather Zone, especially in the Delaware Basin area with significant oil and natural gas load, has had the highest peak demand growth rate in the ERCOT region. The average annual peak demand growth rate of the Far West Weather Zone was about 11% according to historic data between 2013 and 2019. The significant load growth rate was primarily driven by the oil and natural gas business development. Figure 1.1 shows the map of tectonic subdivision of the Delaware Basin area.

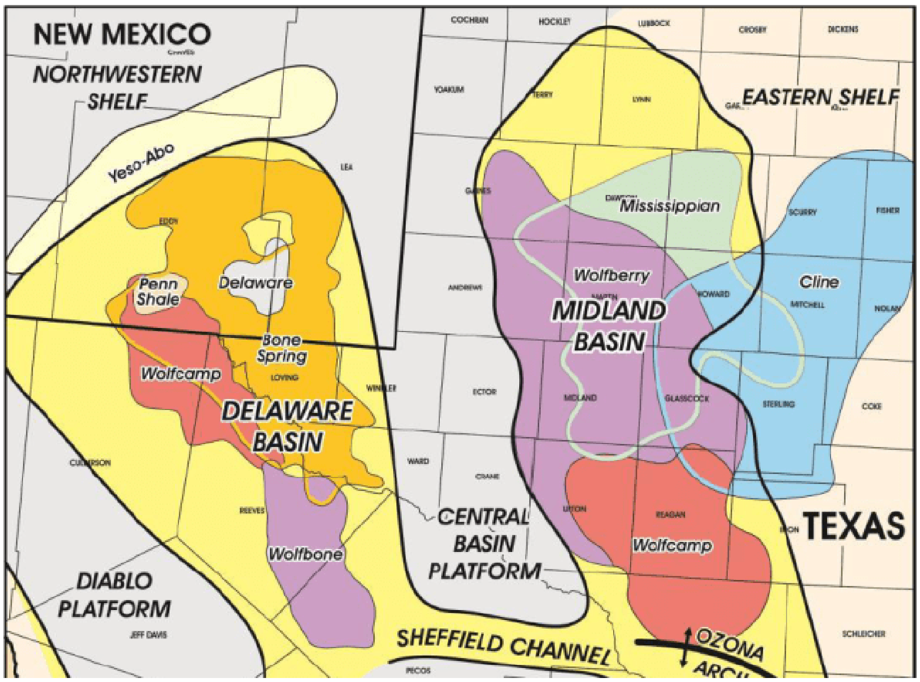

Figure 1.1 Map of Tectonic Subdivision of the Delaware Basin[1]

To accommodate the significant load growth and address the transmission needs in the area, the ERCOT Board endorsed the Far West Texas Project (FWTP), a Tier 1 transmission project in June 2017. In June 2018, the ERCOT Board endorsed the Far West Texas Dynamic Reactive Devices (DRD) Project and the Far West Texas Project 2 (FWTP2) to meet the projected contractually-confirmed load level in the Culberson Loop located in the Delaware Basin area. The FWTP, DRD, and FWTP2 projects, which include a new 345-kV double circuit transmission loop and multiple dynamic reactive devices, are scheduled to be completed by the end of 2020.

These projects along with other planned transmission upgrades are expected to be sufficient to meet the current forecasted load in the Delaware Basin area through 2024. However, if the load in the area develops faster than forecasted, it could outgrow the load serving capability of these planned upgrades. In addition, ensuring that the transmission improvements are in place in time to accommodate the rapid load growth will continue to be a challenge because the nature of the industry is such that oil and gas customers are not able to accurately project their demand needs more than one or two years ahead of time while transmission improvements can take up to six years to complete

[1] https://www.oilandgas360.com/ngl-energy-partners-adds-water-sources-for-oil-gas-operators-in-the-permian/

planning studies, routing analysis (if needed), regulatory approvals, route acquisition (if needed), design, and construction. Due to the nature of relatively short notice from the oil and gas customers providing financial commitment for new load additions, it is difficult to accurately forecast the load five years ahead during the typical planning studies.

Figure 1.2 shows the load comparison of five-year ahead load forecast in the ERCOT SSWG cases and actual historic load in the Delaware Basin area. In 2014, the projected 2019 summer peak demand in the SSWG case for the Delaware Basin area was 595 MW; the recorded peak demand in the Delaware Basin area in 2019 was 1,132 MW, which significantly exceeded the five-year out projected load from 2014. Figure 1.2 also shows substantial increase in the load forecast projected for year 2024. This is primarily due to a significant amount of conceptual loads added by TSPs to the Delaware Basin area.

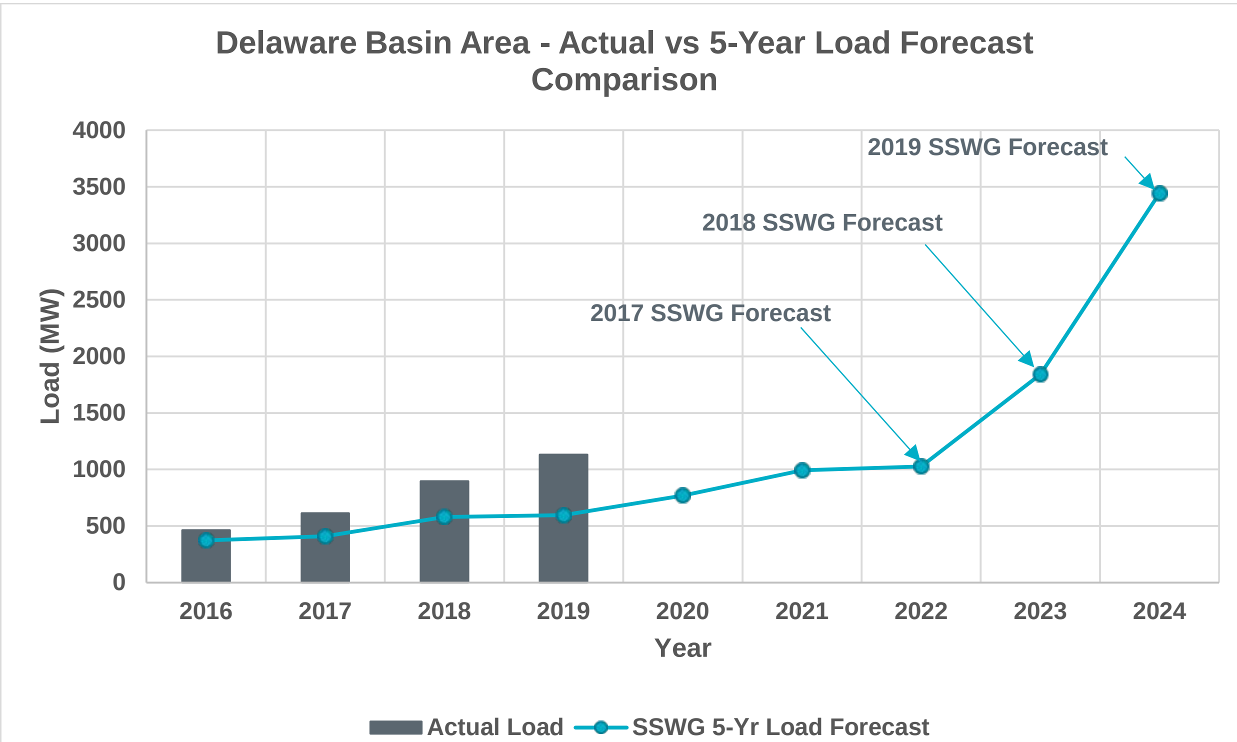

Figure 1.2 Actual and 5-year Load Forecast in the Delaware Basin Area

Given the challenges associated with uncertainties of the load growth in the Delaware Basin area, ERCOT initiated the Delaware Basin Load Integration Study to perform a reliability analysis for higher-than-forecasted load growth in the Delaware Basin area. ERCOT worked closely with TSPs and stakeholders throughout the study.

ERCOT performed steady state analyses using the updated case and identified both long-lead time transmission improvements and a set of common transmission upgrades to reliably serve the assumed load in this study. The common transmission upgrades include upgrading existing transmission facilities, adding new 138-kV transmission lines, and adding new reactive power devices. These common transmission upgrades were assumed to be in-service in the import path evaluation and the development of the long-lead-time-transmission-upgrade roadmap. It should be noted that these common transmission upgrades are expected to require relatively shorter lead time but will be highly dependent on the size and location of the new load additions. Additional studies such as dynamic stability analysis will need to be conducted to optimize the size, location and technology of the new reactive power devices identified as placeholders.

2. Criteria, Study Assumption and Methodology

The study criteria, assumptions, and methodology are described in this section.

2.1. Study Criteria and Monitored Area

The Delaware Basin area includes the following eight counties: Brewster, Culberson, Jeff Davis, Loving, Pecos, Reeves, Ward, and Winkler. Figure 2.1.1 shows the existing and planned 345-kV system map of the study area.

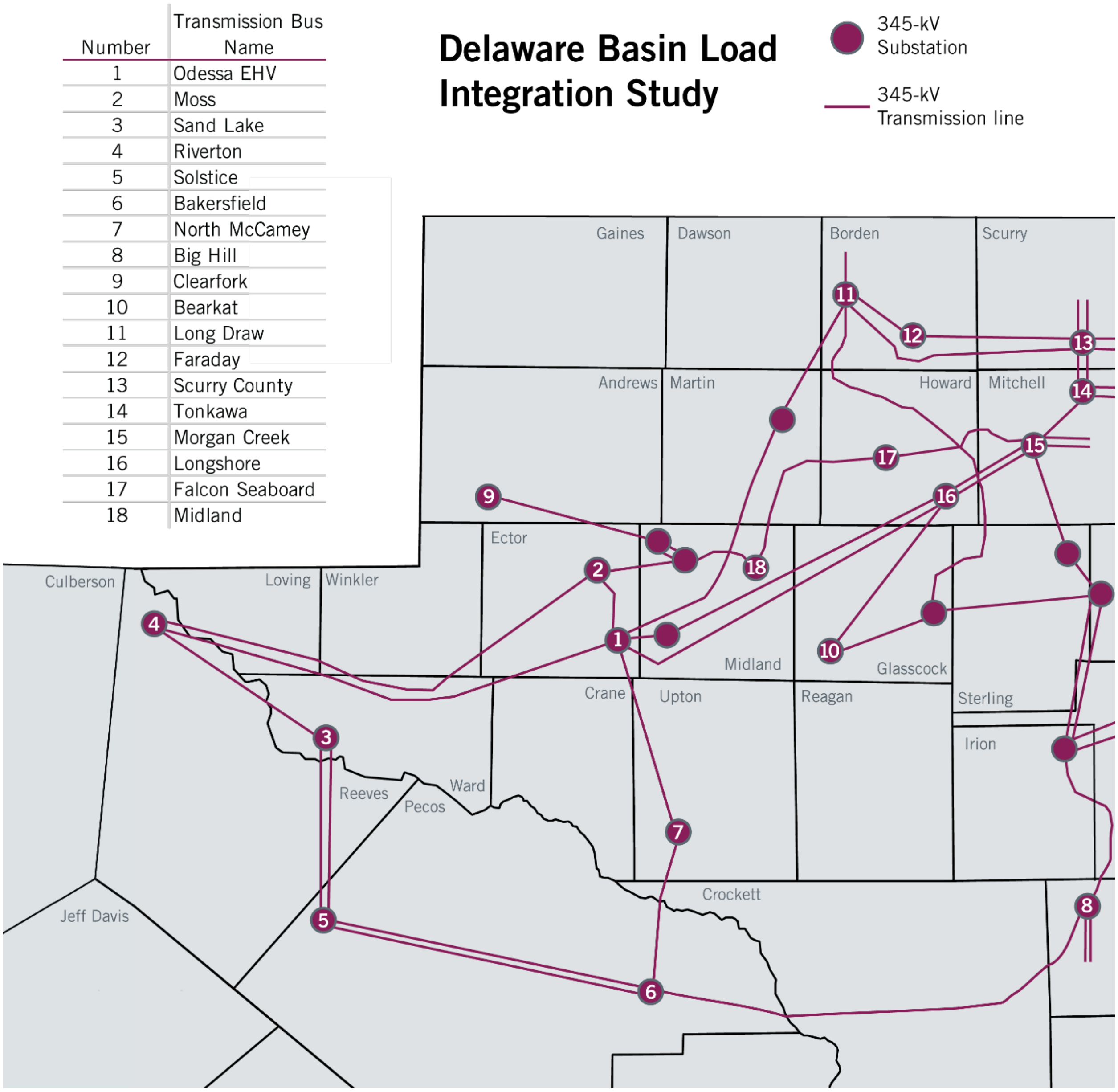

Figure 2.1.1 345-kV Transmission System Map of Study Area

The criteria applied for the AC power flow analyses were consistent with the requirements in the ERCOT Planning Guide 4.1.1.2 and the 2019 Regional Transmission Plan (RTP). As the main purpose of the study is to identify long lead time transmission improvements necessary to serve the assumed load in the study area, ERCOT mainly addressed identified transmission system thermal violations and steady state voltage stability issues in the Far West Weather Zone.

2.2. Study Assumption

2.2.1. Reliability Case

The following starting case was used in the study:

- The 2024 West/Far West (WFW) summer peak case from the 2018 RTP (posted in December 2018 on the ERCOT MIS site)

2.2.2. Study Case Loads

Initially, the Delaware Basin area loads in the starting case (i.e. 2018 RTP 2024 WFW case) were updated to match the area load with the load level (3,509 MW) in the February 2019 SSWG 2024 Summer Peak case as a significant amount of conceptual loads had already been added by TSPs to the Delaware Basin area in the February 2019 SSWG case.

Additionally, the Delaware Basin area loads were further updated by incorporating 1,863 MW of additional conceptual loads provided by the area TSPs (i.e. Oncor, AEP, TNMP, LCRA TSC, and GSEC) based on surveys of their high-use oil and gas customers to support this Delaware Basin Load Integration Study. The customers in the area supplied aggregated load information pertaining to size, schedule, type, and location for the year 2024 by assuming that there would be no capacity or schedule impediments to access electric service in the Delaware Basin. According to the TSPs, the types of the loads in the survey responses included, but were not limited to, the following: planned or projected new load, existing or new load with technology changes (e.g. conversion from self-serve generation to grid power), and load associated with uncompleted oil wells. The load survey samples included large customers that are expected to have a better load projection process and larger impact compared to smaller customers. ERCOT did not extrapolate the load levels provided by TSPs to attempt to account for the smaller customers that were not part of the survey. Using the aggregated load information from their customers, the TSPs established the 1,863 MW of additional conceptual loads projected for the year 2024.

As shown in Table 2.2.1, the load level modeled in this Delaware Basin Load Integration Study was approximately double the load in the same study area compared to the 2019 RTP.

Table 2.2.1 Delaware Basin Load Projection for Year 2024

2019 Regional Transmission Plan (based on Planning Guide Section 3.1.7)	2,688 MW
2019 February SSWG Case	3,509 MW
Delaware Basin Study (including higher than committed load)	5,372 MW

Figures 2.2.1 shows the distribution of the additional conceptual loads added to the study case in the Delaware Basin area.

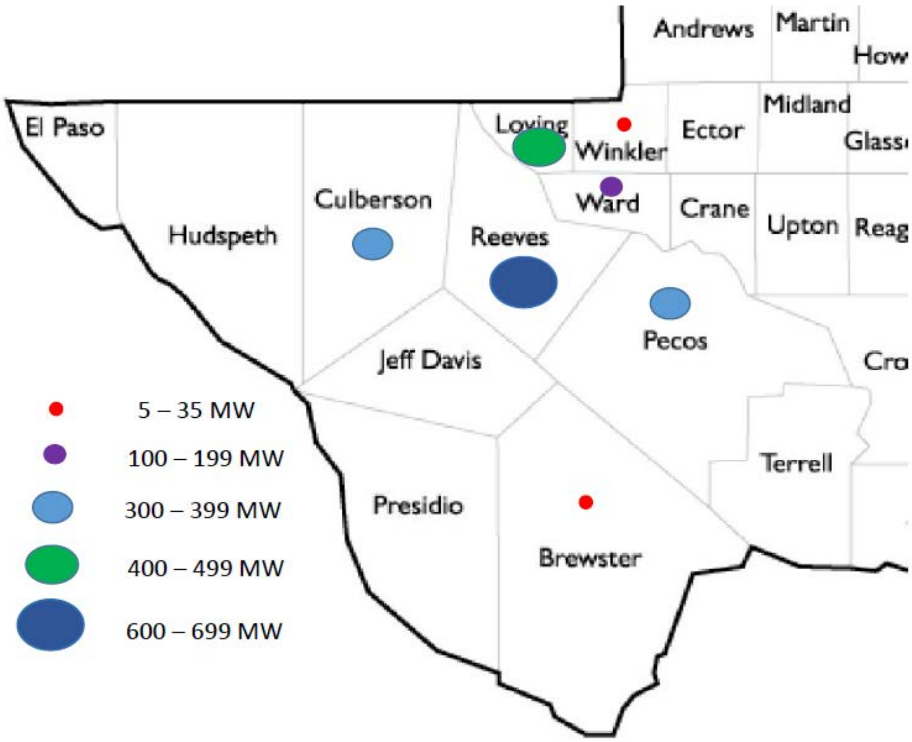

Figure 2.2.1 Distribution of Conceptual Loads Added to the System in the Delaware Basin Area

Figure 2.2.2 shows the load contour map of the total load in Delaware Basin area.

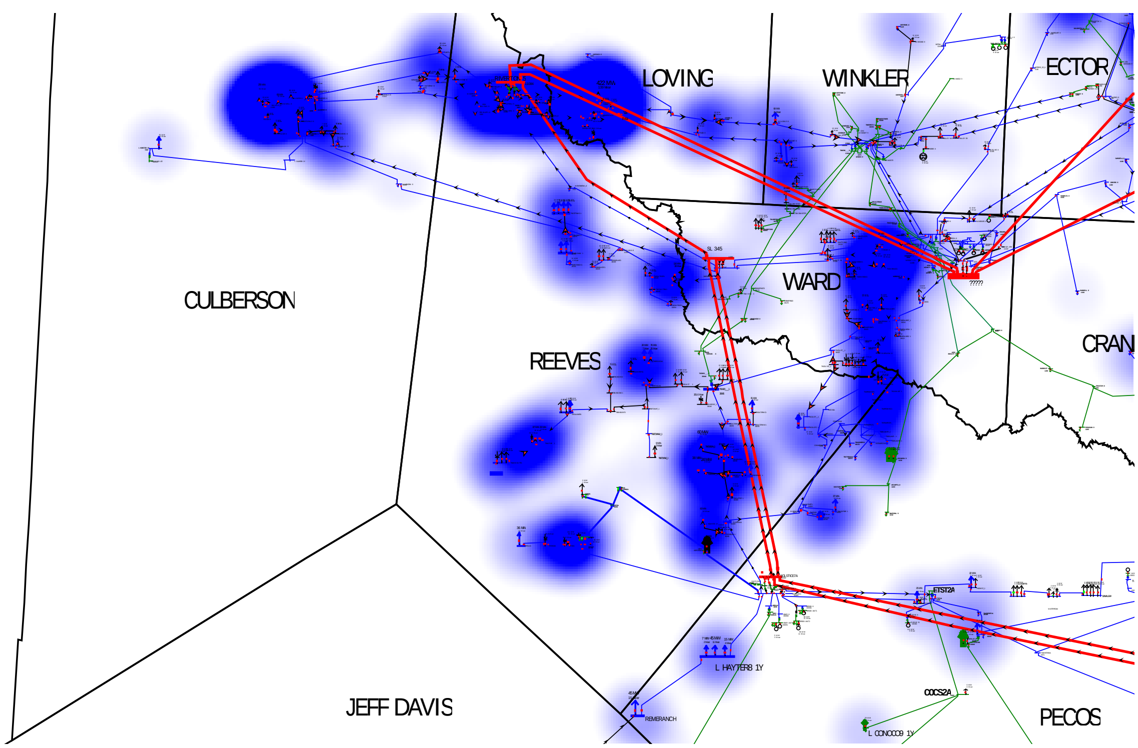

Figure 2.2.2 Load Contour Map of the Total Load in the Delaware Basin Area

2.2.3. Transmission Topology

The starting case was modified based on input from TSPs to include load additions and topological changes in the study area. TSPs provided upgrades and new circuits (if there were no existing transmission facilities in the area) necessary to interconnect the conceptual load additions.

2.2.4. Generation

Planned generators in the West and Far West weather zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2019 April Generation Interconnection Status report) were added to the study case. The added generators are listed in Table 2.2.2.

Table 2.2.2 Added Generators that Met Planning Guide Section 6.9 Conditions (2019 April GIS Report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
16INR0019	BlueBell Solar	30	SOL	Coke	West
17INR0067	Sweetwater 1 repower	0	WIN	Nolan	West
17INR0068	Sweetwater 2 repower	7	WIN	Nolan	West
17INR0069	Trent repower	6	WIN	Nolan	West
18INR0033	Oveja Wind	300	WIN	Irion	West
18INR0038	Barrow Ranch	160	WIN	Andrews	Far West
18INR0068	Loraine Windpark Phase III	100	WIN	Mitchell	West
19INR0029	Phoebe Solar	250	SOL	Winkler	Far West
19INR0083	Oberon Solar	180	SOL	Ector	Far West
19INR0099a	Kontiki 1 Wind (ERIK)	255	WIN	Glasscock	Far West
19INR0099b	Kontiki 2 Wind (ERNEST)	255	WIN	Glasscock	Far West
19INR0174	Elbow Creek repower	0	WIN	Howard	Far West
19INR0184	Oxy Solar	16	SOL	Ector	Far West
20INR0011	Ranchero Wind	300	WIN	Crockett	Far West
14INR0009	WKN Amadeus Wind	246	WIN	Fisher	West
18INR0055	Long Draw Solar	225	SOL	Borden	Far West
19INR0038	High Lonesome W	450	WIN	Crockett	Far West
19INR0080	Whitehorse Wind	419	WIN	Fisher	West
19INR0102	Queen Solar	400	SOL	Upton	Far West
19INR0163	Sage Draw Wind	338	WIN	Lynn	Far West
19INR0185	Lapetus Solar 2	100	SOL	Andrews	Far West
20INR0054	Taygete Solar	254	SOL	Pecos	Far West

Solar generation in the Delaware Basin area was turned off to represent a stressed system condition since the oil and natural gas loads are assumed to operate as constant loads throughout the day and night. The dispatch of solar and wind generation outside of the Delaware Basin area were consistent with the 2019 RTP methodology. Gibbons Creek Unit 1 (470 MW) was turned off as it was retired permanently in October 2019.

2.2.5. Capital Cost Estimates

Capital costs estimates of each transmission upgrade identified were provided by the TSP relevant to each upgrade. ERCOT used the cost estimates provided by the TSPs to calculate total project cost estimates for various project options. For new transmission lines requiring new right of way, ERCOT assumed a routing adder of 20% to the straight distance between two end points. The cost estimates described in this report only include the capital costs of the 345-kV transmission upgrades.

2.3. Study Methodology

ERCOT evaluated various types of transmission upgrades such as adding long lead time extra high voltage (EHV) transmission lines (e.g. new 345-kV lines) and new 138-kV lines. Table 2.3.1 shows the types of upgrades considered in this study.

Table 2.3.1 Types of Upgrades Considered in this Study

Types of Upgrades Considered	Comments
Long lead time Extra High Voltage circuits (e.g. new 345-kV lines)	**Main focus of the study**
Existing 345-kV line upgrades	Included in the analysis
New 138-kV lines	Included in the analysis, but not optimized
Existing 138-kV and 69-kV line upgrades	Included in the analysis, but not optimized
Voltage support devices, static and dynamic	Included in the analysis, but stability analysis was not performed to optimize

The graphic in Figure 2.3.1 shows the study process and methodology used in this study.

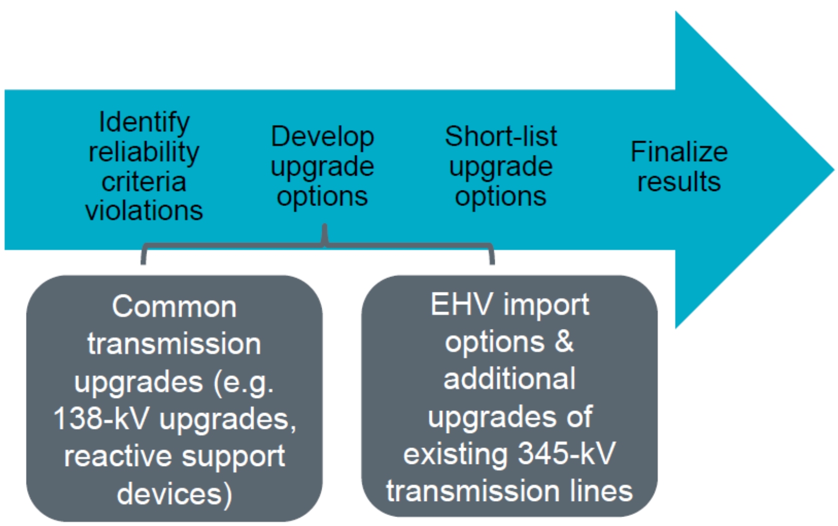

Figure 2.3.1 Study Process and Methodology

2.3.1. Tools

ERCOT utilized the following software tools for the Delaware Basin Load Integration Study:

- PowerWorld Simulator version 20 was used for SCOPF and steady state contingency and voltage stability analysis
- UPLAN version 10.4.0.22733 was used to perform security-constrained economic analysis

2.3.2. Contingencies

All of the NERC P1, P2-1, and P7 contingencies in the West and Far West weather zones were evaluated for the AC power flow analyses. ERCOT also evaluated G-1+N-1 and X-1+N-1 contingencies in the study area.

For the G-1+N-1 analyses, the following generator outages were considered to represent the most significant G-1 conditions in the study area:

- Permian Basin all five units (340 MW)
- Odessa Combined Cycle Train 1 (497 MW)

For the X-1+N-1 analyses, the following 345/138-kV transformers were considered to represent the most significant X-1 conditions for the study area:

- Riverton 345/138-kV transformer 1
- Sand Lake 345/138-kV transformer 1
- Wolf 345/138-kV transformer 1
- Quarry Field 345/138-kV transformer 1
- Solstice 345/138-kV transformer 1
- Megan 345/138-kV transformer 1

The oil and gas loads were assumed to be constant loads throughout the year. Because of this, it can be challenging to schedule maintenance outages of equipment without operating in a state such that the contingency of another facility causes thermal or voltage limit exceedances. To give due consideration for such operational flexibility and reliability in the study area, potential high impact maintenance outages which include major single-circuit 345-kV circuit and dynamic reactive devices in the Delaware Basin area were analyzed and are listed below.

- Odessa - Wolf 345-kV line
- Wolf - Quarry Field 345-kV circuit 1
- Faraday - Clearfork 345-kV circuit 1 (potential new line)
- Clearfork - Riverton 345-kV circuit 1 (potential new line)
- Bearkat - North McCamey 345-kV circuit 1 (potential new line)
- North McCamey - Megan 345-kV circuit 1 (potential new line)
- North McCamey - Sand Lake 345-kV circuit 1 (potential new line)
- Riverton - Sand Lake 345-kV circuit 1
- Solstice - Megan 345-kV circuit 1
- Megan - Sand Lake 345-kV circuit 1
- Bakersfield - Solstice 345-kV circuit 1
- Noelke - Bakersfield 345-kV line

- Queen Solar - North McCamey 345-kV line
- Rando DRD (250 Mvar)
- Horse Shoe DRD (250 Mvar)
- IH-20 SVC (190 Mvar)

3. Case Development for Long Lead Time Upgrade Identification

The existing and planned transmission system was not sufficient to serve the studied load of 5,372 MW in the Delaware Basin area. In fact, the study case demonstrated voltage instability under N-0 conditions. To identify the long lead time upgrades, which were the primary focus of the study, the reliability issues under N-0 that would be expected to be addressed through local transmission upgrades were first identified through the steps described in Appendix A. These transmission upgrades, summarized in Table 3.1, were necessary to address the voltage instability and thermal violations under N-0 condition. ERCOT also identified local transmission upgrades under N-1 in section 4. These transmission upgrades under N-0 and N-1 were collectively referred to as the common transmission upgrades. The full list of the common transmission upgrades is included in the Appendix B.

Table 3.1 Common Transmission Upgrades under N-0

Transmission Upgrades/Addition	Length (miles)	Normal and Emergency Ratings (RATE A/B) (MVA) Modeled in Study Case
Tap the new 345-kV Wolf station to the Odessa/Moss – Riverton 345-kV double-circuit lines and add two 345/138-kV transformers at Wolf station (TPIT 46094, Tier 3, Dec 2020)		750/750 (transformer Ratings)
Reactive device at Clearfork		300 Mvar
Reactive device at Riverton		300 Mvar
Reactive device at Wolf		300 Mvar
Reactive device at Barilla Draw		300 Mvar
Reactive device at Faulkner		300 Mvar
Reactive device at Coalson Draw (DRD)		250 Mvar
Capacitors at Owl Hills		110 Mvar
Convert 69-kV line Barrilla - Hoefs Road - Verhalen - Saragosa to 138-kV	33.8	483/483
Convert 69-kV line Yucca - Royalty - Coyanosa - Wolfcamp to 138-kV	46.9	614/614
Tap the Wolf - Riverton 345-kV double circuit at Quarry Field, and add two 345/138-kV transformer at Quarry Field station		750/750 (transformer Ratings)
Upgrade Quail Switch - Odessa EHV Switch 345-kV ckt 1	0.9	1521/1784
Upgrade the Solstice - Hayter - Remeranch 138-kV	15.7	614/614

Besides the common transmission upgrades, a placeholder project of a new single circuit 345-kV import path (Bearkat - Wolf - Sand Lake) was also added in the case development to address the voltage instability under N-0. This placeholder project will be evaluated and replaced by alternatives in section 4.

4. Initial Import Path Options

The study case development in Section 3 indicated that a new import path was needed to serve the assumed Delaware Basin load with solar generation offline in the area. ERCOT initially evaluated various import path options and the study results are summarized in this section.

4.1. Descriptions of the Initial Import Path Options

An initial set of import path options was developed by considering the following factors in the area: reliability criteria violations in the study case, potential generating capacity growth, the existing stability constraints (maintained in operations as Generic Transmission Constraints (GTCs)) in the region, and the ERCOT 2018 Long-Term System Assessment[2]. Table 4.1.1 summarizes the initial import path options. The maps of these ten initial Import path options are available in Appendix C.

Table 4.1.1 Descriptions of the Initial Import Options

Import Options	Estimated New Right of Way (ROW) (miles)	Cost Estimates ($M)
Option 1: add a second circuit on the existing Big Hill - Bakersfield - North McCamey - Odessa 345-kV line and a new North McCamey - Megan double circuit 345-kV line	78	311
Option 2: a new Faraday - Lamesa - Clearfork - Riverton single circuit 345-kV line	193	380
Option 3: a new Bearkat - North McCamey - Megan single circuit 345-kV line	149	278
Option 4: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	193	444
Option 5: a new Bearkat - North McCamey - Megan double circuit 345-kV line	149	343
Option 6: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV circuit	164	371
Option 7: a new Red Creek - North McCamey - Megan double circuit 345-kV circuit	216	490
Option 8: a new 1,200 MW HVDC line (VSC) from Abernathy to Riverton	240	906
Option 9: a new 1,200 MW HVDC line (VSC) from Howard Road to Bakersfield and a new double circuit 345-kV line from North McCamey to Megan	380	2,119
Option 10: a new single circuit 765-kV line from Howard Road to Bakersfield, two new 765/345-kV transformers at both Howard Road and Bakersfield stations, and a new double circuit 345-kV line from North McCamey to Megan	380	2,014

[2] https://mis.ercot.com/pps/tibco/mis/Pages/Grid+Information/Long+Term+Planning/

4.2. Results of Reliability Analysis for the Initial Import Path Options

4.2.1. Results of N-1 contingency analysis

Among the initial ten options evaluated, ERCOT found that five options did not meet the N-1 reliability criteria. The results of the study showed unsolved contingencies (i.e. potential voltage collapse) for Options 1, 2, 3, 7, and 8 at the assumed load of 5,372 MW in Delaware Basin area, and these five options alone were not evaluated further but were combined with other import path options for further evaluation.

Steady state voltage stability assessment under N-1 contingency conditions was conducted to estimate the load serving capability of the ten initial import path options and the results are summarized in Table 4.2.1. As an estimate, the load serving capability of each option was calculated by a 100 MW step change based on the assumed load of 5,372 MW under P1, P2-1, and P7 contingency events.

Table 4.2.1 Estimated Load Serving Capability of Ten Initial Import Options (NERC P1, P2-1 and P7)

Import Options	Estimated New ROW (miles)	Estimated Load Serving Capability (MW)
Option 1: add a second circuit on the existing Big Hill - Bakersfield - North McCamey - Odessa 345-kV line and a new North McCamey - Megan double circuit 345-kV line	78	~ 4,972
Option 2: a new Faraday - Lamesa - Clearfork - Riverton single circuit 345-kV line	193	~ 4,972
Option 3: a new Bearkat - North McCamey - Megan single circuit 345-kV line	149	~ 4,972
Option 4: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	193	~ 5,372
Option 5: a new Bearkat - North McCamey - Megan double circuit 345-kV line	149	~ 5,372
Option 6: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV circuit	164	~ 5,372
Option 7: a new Red Creek - North McCamey - Megan double circuit 345-kV circuit	216	~ 5,272
Option 8: a new 1,200 MW HVDC line (VSC) from Abernathy to Riverton	240	~ 5,272
Option 9: a new 1,200 MW HVDC line (VSC) from Howard Road to Bakersfield and a new double circuit 345-kV line from North McCamey to Megan	380	~ 5,472
Option 10: a new single circuit 765-kV line from Howard Road to Bakersfield, two new 765/345-kV transformers at both Howard Road and Bakersfield stations, and a new double circuit 345-kV line from North McCamey to Megan	380	~ 5,472

The results in Table 4.2.1 show that Options 4, 5, 6, 9, and 10 are capable of serving the assumed Delaware Basin load under N-1 conditions without voltage instability, and additional local transmission upgrades are needed to address the local N-1 steady state reliability criteria violations. These additional local transmission upgrades are listed in Table 4.2.2. As shown in the table, most of the upgrades are needed to serve the local load independent of the import options. The full list of the transmission upgrades are available in Appendix B.

Table 4.2.2 Additional Local Transmission Upgrades in the Initial Import Path Options

Transmission Upgrades	Estimated Length (miles)	Normal and Emergency Ratings (RATE A/B) (MVA) Modeled in Study Case	Import Options Requiring Local Upgrades
Build a new 345/138-kV Owl Hills station with two 345/138-kV transformers, and add a new single circuit 345-kV line from Riverton to Owl Hills station	20.3	750/750 (transformer Ratings) 2988/2988 (Line Ratings)	Common[3]
Tap the new Megan station to the Solstice - Sand Lake double circuit 345-kV line, and install two new 345/138-kV transformers at the new Megan station		750/750 (transformer Ratings)	Common
Build a new 138-kV line from Saragosa to Faulkner	18.0	614/614	Common
Rio Pecos to Fort Stockton Upgrade: Upgrade the 138-kV lines from Rio Pecos to Lynx to TNMP 16th St to Fort Stockton	74.6	483/483	Common
Convert the existing stations at Fort Stockton and Conoco Comp and Conoco Rgec 69-kV line to be 138-kV. Move the 138/69-kV transformer from Fort Stockton to Conoco Comp	25.1	614/614	Common
Build a new 138-kV line from Conoco Rgec to TNMP 16th street	22.0	483/483	Common
Build a new 138-kV line from Remeranch to Saragosa	26.5	483/483	Common
Upgrade the existing Morgan Creek - Tonkawa 345-kV line	21.3	1792/1792	Common
Upgrade the existing Morgan Creek - Longshore 345-kV line	36.5	1792/1792	Options 5 & 6
Upgrade the existing Midland East - Falcon Seaboard 345-kV line	48.4	1792/1792	Common
Upgrade the existing Saddleback - Salt Draw Tap 138-kV line	0.5	717/717	Option 5
Upgrade the existing Salt Draw Tap - IH20 138-kV line	4.9	717/717	Option 5
Build a new double circuit 138-kV line from the new Megan station to Saddleback	6.2	614/614	Common
Build a new double circuit 138-kV line from the new Megan station to Faulkner	24.2	614/614	Common
Upgrade the existing Morgan Creek - Falcon Seaboard 345-kV line	36.2	1792/1792	Options 9 & 10
Upgrade the existing Longshore - Midessa 345-kV line	48.0	1792/1792	Options 9 & 10
Upgrade the existing Midland East - Midland County NW 345-kV line	17.2	1792/1792	Option 10

[3] Common means the project is needed regardless of import options

4.2.2. Results of G-1+N-1, X-1+N-1, and N-1-1 contingency analysis

Import Options 4, 5, 6, 9, and 10 were further evaluated for G-1+N-1, X-1+N-1, and N-1-1. Tables 4.2.3 – 4.2.5 show the study results.

Table 4.2.3 Steady State Voltage Stability Analysis Results under G-1+N-1 for Options 4, 5, 6, 9, and 10

G-1 Scenario	Option 4	Option 5	Option 6	Option 9	Option 10
Permian Basin all five units	Voltage Collapse	Voltage Collapse	Voltage Collapse	Voltage Collapse	Voltage Collapse
Odessa Combined Cycle Train 1	No Voltage Collapse	No Voltage Collapse	No Voltage Collapse	No Voltage Collapse	No Voltage Collapse

Table 4.2.4 Largest Thermal Violations under X-1+N-1 for Options 4, 5, 6, 9, and 10

Element	Contingency	Option 4	Option 5	Option 6	Option 9	Option 10
Quarry Field 345/138-kV	Riverton - Quarry Field 345-kV double; Quarry Field 345/138-kV	< 100%	108.5%	104.7%	109.8%	108.2%
Riverton 345/138-kV	Owl Hill - Riverton 345-kV; Riverton 345/138-kV	100.4%	< 100%	< 100%	< 100%	< 100%
Megan 345/138-kV	Megan - Sand Lake 345-kV double; Megan 345/138-kV	< 100%	118.7%	< 100%	119.0%	120.7%
Wolf 345/138-kV	Wolf - Quarry Field 345-kV double; Wolf 345/138-kV	< 100%	107.8%	105.4%	111.0%	107.0%

Table 4.2.5 Steady State Voltage Stability Analysis Results under N-1-1 for Options 4, 5, 6, 9, and 10

	Option 4	Option 5	Option 6	Option 9	Option 10
N-1-1 Scenario	Voltage Collapse	Voltage Collapse	Voltage Collapse	Voltage Collapse	Voltage Collapse

As shown in Table 4.2.3 and Table 4.2.5, potential voltage collapse issues were observed for all five options under the G-1+N-1 and N-1-1 contingency conditions. As described in section 5, ERCOT further modified these import options to identify the additional upgrade needs to serve the assumed load in the Delaware Basin area. Option 10 which requires a new 765-kV line was not selected for the further evaluation as substantial new transmission additions will be required to satisfy the reliability criteria under the N-1-1 maintenance condition.

5. Modified Import Options

5.1. Description of the Modified Import Options

Twelve ERCOT modified Import Options based on the selected Import Options 4, 5, 6, and 9 and some of the transmission components in the initial ten import path options were developed to address the G-1+N-1 and N-1-1 reliability violations. These modified import options are referred as Options 4a, 4b, 4c, 4g, 5d, 5e, 5f, 6a, 6e, 6f, 6g, and 9e. Table 5.1.1 summarizes these twelve modified import options. The maps of these twelve options are provided in the Appendix B.

Table 5.1.1 Summary of the Twelve Modified Import Options

Options	Estimated New ROW (miles)	Cost Estimates[4] ($M)
Option 4a: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line, and add a second circuit on the existing Big Hill - Bakersfield - North McCamey -Odessa 345-kV line	193	573
Option 4b: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line, add a second circuit on the existing Big Hill - Bakersfield 345-kV line, and a new North McCamey - Megan double circuit 345-kV line	271	695
Option 4c: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line and a new Bearkat - North McCamey - Megan single circuit 345-kV line	342	722
Option 4g: a new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line, add a second circuit on the existing Big Hill - Bakersfield 345-kV line, convert the Sand Lake - Riverton 138-kV to 345-kV, and add a new 138-kV line from Sand Lake to Riverton	193	569
Option 5d: a new Bearkat - North McCamey - Megan double circuit 345-kV line, and a new Clearfork - Riverton double circuit 345-kV line	231	525
Option 5e: a new Bearkat - North McCamey - Megan double circuit 345-kV line, add a second circuit on the existing Big Hill - Bakersfield 345-kV line, and a new Clearfork - Riverton double circuit 345-kV line	231	594
Option 5f: a new Bearkat - North McCamey - Megan double circuit 345-kV line, and a new Faraday - Lamesa - Clearfork - Riverton single circuit 345-kV line	342	723
Option 6a: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV line, and add a second circuit on the existing Big Hill - Bakersfield - North McCamey - Odessa 345-kV line	164	440
Option 6e: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV line, add a second circuit on the existing the Big Hill - Bakersfield 345-kV line, and a new Clearfork - Riverton double circuit 345-kV line	246	622
Option 6f: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV line, and a new Faraday - Lamesa - Clearfork - Riverton single 345-kV line	357	751
Option 6g: a new Bearkat - North McCamey - Sand Lake double circuit 345-kV line, add a second circuit on the existing Big Hill - Bakersfield 345-	164	496

[4] Cost estimates do not include the local transmission upgrades.

kV line, convert the Sand Lake - Riverton 138-kV to 345-kV, and add a new 138-kV line from Sand Lake to Riverton		
Option 9e: add a new 1,200 MW HVDC line (VSC) from Howard Road to Bakersfield, a new North McCamey - Megan double circuit 345-kV line, add a second circuit on the existing Big Hill - Bakersfield 345-kV line, and a new Clearfork - Riverton double circuit 345-kV line	462	2,370

5.2. Results of Reliability Analysis for the Modified Import Options

ERCOT conducted the N-1-1 analysis for these twelve options. Table 5.2.1 shows the study results.

Table 5.2.1 Steady State N-1-1 Results for Options 4a, 4b, 4c, 4g, 5d, 5e, 5f, 6a, 6e, 6f, 6g, and 9e

Option 4a	Option 4b	Option 4c	Option 4g	Option 5d	Option 5e	Option 5f	Option 6a	Option 6e	Option 6f	Option 6g	Option 9e
Voltage Collapse	No Voltage Collapse	No Voltage Collapse	Voltage Collapse	Voltage Collapse	No Voltage Collapse	No Voltage Collapse	Voltage Collapse	No Voltage Collapse	No Voltage Collapse	No Voltage Collapse	No Voltage Collapse

Voltage collapse issues were observed in Options 4a, 4g, 5d, and 6a under the N-1-1 contingency condition. As a result, ERCOT performed additional studies for Options 4b, 4c, 5e, 5f, 6e, 6f, 6g, and 9e as no voltage collapses were observed under the N-1-1 contingency condition. Focusing on thermal violations, ERCOT evaluated these eight options under the N-1-1, X-1+N-1 and G-1+N-1 conditions. The results are summarized in Tables 5.2.2 – 5.2.4.

Table 5.2.2 Largest Thermal Violations under N-1-1 for Options 4b, 4c, 5e, 5f, 6e, 6f, 6g and 9e

Element	Miles	Option 4b	Option 4c	Option 5e	Option 5f	Option 6e	Option 6f	Option 6g	Option 9e
Morgan Creek - Falcon Seaboard 345-kV	36.2	< 100%	< 100%	105.0%	101.0%	104.0%	< 100%	< 100%	< 100%
Telephone Road - Clearfork 345-kV	32.8	< 100%	< 100%	103.6%	< 100%	102.7%	< 100%	< 100%	< 100%
Midland East - Midland County NW 345-kV	17.2	< 100%	< 100%	100.3%	< 100%	< 100%	< 100%	< 100%	103.3%
Odessa - Wolf 138-kV	44.4	< 100%	< 100%	< 100%	102.4%	< 100%	< 100%	107.6%	< 100%

Table 5.2.3 Largest Thermal Violations under X-1+N-1 for Options 4b, 4c, 5e, 5f, 6e, 6f, 6g, and 9e

Element	Option 4b	Option 4c	Option 5e	Option 5f	Option 6e	Option 6f	Option 6g	Option 9e
Quarry Field 345/138-kV	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%
Riverton 345/138-kV	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%
Megan 345/138-kV	< 100%	< 100%	114.2%	< 100%	< 100%	< 100%	< 100%	116.5%
Wolf 345/138-kV	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%

Table 5.2.4 Largest Thermal Violations under G-1+N-1 for Options 4b, 4c, 5e, 5f, 6e, 6f, 6g, and 9e

Element	Option 4b	Option 4c	Option 5e	Option 5f	Option 6e	Option 6f	Option 6g	Option 9e
Morgan Creek - Falcon Seaboard 345-kV	< 100%	< 100%	103.3%	< 100%	103.0%	< 100%	< 100%	< 100%
Telephone Road - Clearfork 345-kV	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	102.6%
Odessa - Wolf 138-kV	< 100%	< 100%	< 100%	< 100%	< 100%	< 100%	108.4%	< 100%

The N-1-1, G-1+N-1, and X-1+N-1 study results in Tables 5.2.2 – 5.2.4 indicate that Options 4b, 4c, 6f, and 6g performed the best among the options tested. There are no additional 345-kV thermal violations for Options 4b, 4c, 6f, and 6g under the N-1-1, G-1+N-1, or X-1+N-1 contingency conditions. Since the overload of the existing Odessa - Wolf 138-kV line was identified under N-1-1 condition in Option 6g, ERCOT included the upgrade of the overload existing 138-kV line as part of Option 6g during the further evaluation of the selected four short-listed options.

6. Short-listed Options

The results of the N-1-1, G-1+N-1, and X-1+N-1 analyses in Section 5 indicate that Options 4b, 4c, 6f, and 6g would provide the best performance among the eight selected modified options. For these four short-listed options, ERCOT conducted power transfer analysis, congestion analysis, and cost comparison.

6.1. Power Transfer Analysis

A power transfer analysis was conducted from a steady state voltage stability perspective for the four short-listed options. The load in the Delaware Basin area was proportionally increased, and NERC P1, P2-1, and P7 contingency events in the study area were tested to identify estimated maximum load serving capability. The results are listed in Table 6.1.1; all four short-listed options would be capable of serving a load level above the assumed Delaware Basin load.

Table 6.1.1 Power Transfer Analysis for Options 4b, 4c, 6f, and 6g

Option	Estimated New ROW (miles)	Estimated N-1 Load Serving Capability (MW)
4b	291	5,982
4c	362	6,062
6f	378	6,042
6g	185	5,772

6.2. Congestion Analysis

Although the Delaware Basin Load Integration Study was focused on reliability needs, ERCOT also conducted a congestion analysis to compare the relative performance of each of the short-listed options in terms of production cost savings.

The 2024 economic case built for the 2019 RTP was used as the starting case. The common 345-kV transmission upgrades together with the recently approved RPG projects in the Delaware Basin area were added to the starting case to create the study base case. The load in the congestion analysis remained the same as in the 2019 RTP. ERCOT then modeled each of the four short-listed import options and performed production cost simulations for the year 2024. 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 difference for each option.

As shown in Table 6.2.1, the results indicated that the annual production cost differences for Options 4b, 4c, and 6f were approximately $0.4 million, $3.1 million, and $3.1 million, respectively, when compared to Option 6g. The results indicated none of the options provided significantly better production cost savings than others. The study also indicated no significant change in system congestion on the ERCOT transmission grid for each short-listed option.

Table 6.2.1 Relative Annual Production Cost Differences (Referenced to Option 6g) in $ Million

Option	Option 4b	Option 4c	Option 6f	Option 6g
Relative Annual Production Cost Differences (referenced to Option 6g)	0.4	3.1	3.1	Reference

6.3. Cost Estimates

All four short-listed import options require some additional existing 345-kV transmission line upgrades. The cost estimate of each short-listed import option in Table 6.3 also includes the cost of upgrading the existing 345-kV lines. Since the main focus of this study was to identify cost-effective long lead time transmission improvements to reliably serve the assumed load, the costs of the transmission upgrades with voltage 138-kV and below were not considered in the cost comparison. Table 6.3.1 summarizes the cost estimates for the four short-listed options. Note all values are rough order magnitude (ROM) quality estimates and do not include uncertain factors that may be revealed during a more detailed routing study/CCN-level cost estimate (e.g. environmental/cultural components, etc.)

Table 6.3.1 Cost Estimates for the Short-Listed Options in $ Million

Option	Transmission Element	Cost Estimate ($M)	Total Cost Estimates ($M)
4b	A new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	444	753
	Add a 2nd circuit on the existing Big Hill - Bakersfield 345-kV line	69	
	A new North McCamey - Megan double circuit 345-kV line	182	
	A new Riverton - Owl Hills single circuit 345-kV line	41	
	Upgrade the existing 345-kV lines from Quail Switch to Odessa and from Morgan Creek to Tonkawa	17	
4c	A new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	444	816
	A new Bearkat - North McCamey - Sand Lake double circuit 345-kV line	278	
	A new Riverton - Owl Hills single circuit 345-kV line	41	
	Upgrade the existing 345-kV lines from Quail Switch to Odessa, from Morgan Creek to Tonkawa, and from Midland to Falcon Seaboard	53	
6f	A new Bearkat - North McCamey - Sand Lake double circuit 345-kV line	371	873
	A new Faraday - Lamesa - Clearfork - Riverton single circuit 345-kV line	380	
	A new Riverton - Owl Hills single circuit 345-kV line	41	
	Upgrade the existing 345-kV lines from Quail Switch to Odessa, from Morgan Creek to Tonkawa, from Midland to Falcon Seaboard, and from Morgan Creek to Longshore	81	
6g	A new Bearkat - North McCamey - Sand Lake double circuit 345-kV line	371	618
	Add a 2nd circuit on the existing Big Hill - Bakersfield 345-kV line	69	
	Sand Lake - Riverton 138-kV to 345-kV conversion and a new Sand Lake - Riverton 138-kV line	56	
	A new Riverton - Owl Hills single circuit 345-kV line	41	
	Upgrade the existing 345-kV lines from Quail Switch to Odessa, from Morgan Creek to Tonkawa, from Midland to Falcon Seaboard, and from Morgan Creek to Longshore	81	

7. Roadmap of Long Lead Time Upgrades

Based on the study results of the four short-listed import options described in Section 6 and the consideration of uncertainty of conceptual load growth in the Delaware Basin area, ERCOT developed a roadmap identifying different upgrade stages to accommodate the load growth in the Delaware Basin area. The transmission upgrades at each stage in the roadmap only include the long lead time transmission improvements (new 345-kV lines). As the upgrades of the existing 345-kV lines can be implemented in a relatively short time frame, they were not included in the roadmap development. The common 138-kV transmission upgrades and the reactive devices were also assumed to be in-service prior to Stage 1 to serve the local loads in the area.

Figure 7.1 shows the triggers of the transmission upgrades at each stage in terms of the load level in the Delaware Basin area. Table 7.1 lists the details of the transmission additions associated with each stage in the developed roadmap. The triggers and limits are based on either thermal or steady state voltage stability under the N-1, G-1+N-1, X-1+N-1, and N-1-1 contingency conditions.

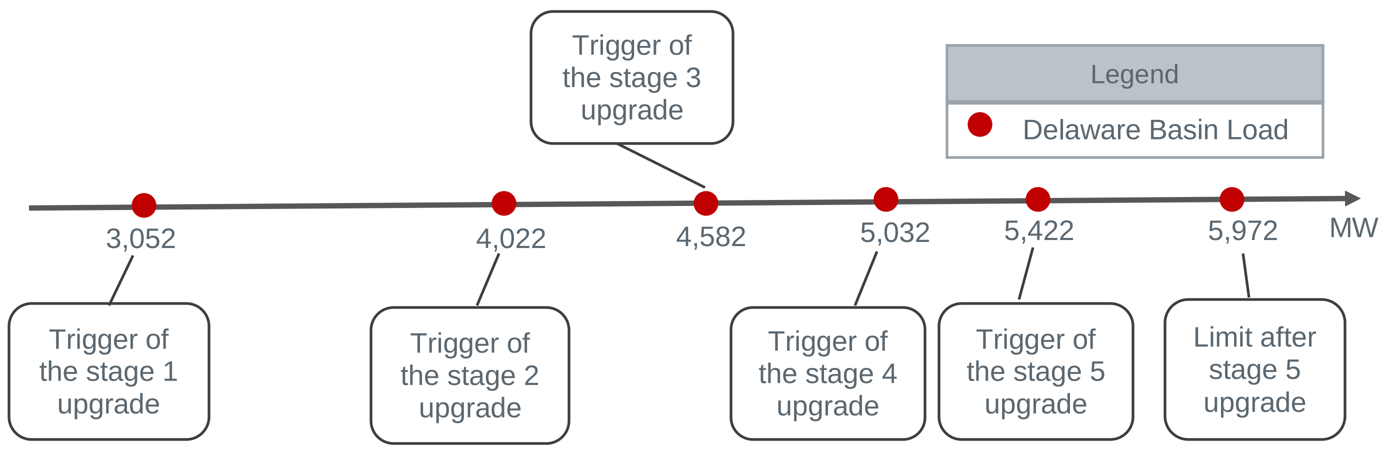

Figure 7.1 Delaware Basin Transmission Upgrade Roadmap

Table 7.1 Delaware Basin Transmission Upgrade Roadmap – Detailed Project List

Stage	Estimated Delaware Basin Load Level (MW)	Upgrade Element	Estimated Upgrade Cost ($M)	Trigger
1	3,052	Add a second circuit on the existing Big Hill - Bakersfield 345-kV line	69	Import Needs
2	4,022	A new Bearkat - North McCamey - Sand Lake double circuit 345-kV line	371	Import Needs
3	4,582	A new Riverton - Owl Hills single circuit 345-kV line	41	Culberson Loop Needs
4	5,032	Riverton - Sand Lake 138-kV to 345-kV conversion and a new Riverton - Sand Lake 138-kV line	56	Culberson Loop Needs
5	5,422	A new Faraday - Lamesa - Clearfork - Riverton double circuit 345-kV line	444	Import Needs

Figure 7.2 shows the existing and planned 345-kV system map of the study area together with the Stage 1 – Stage 5 transmission upgrades.

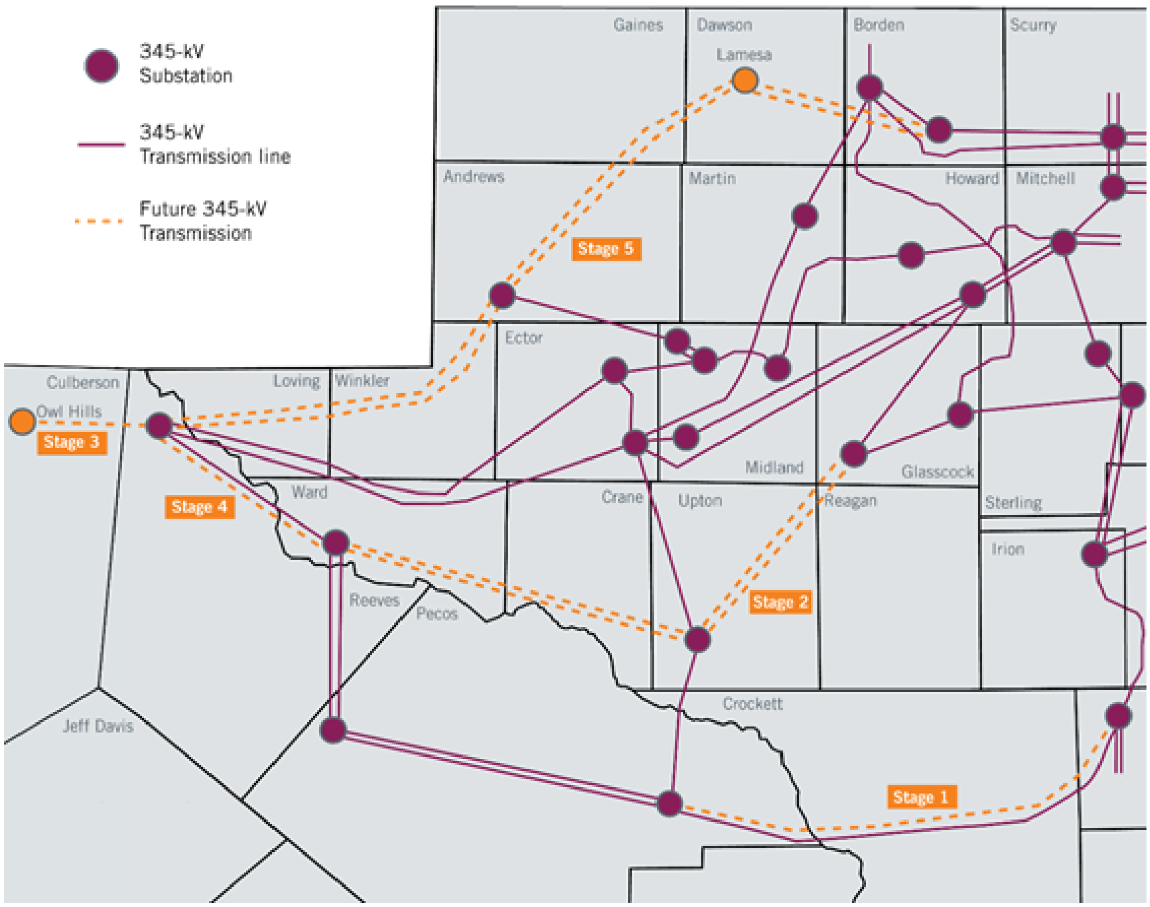

Figure 7.2 345-kV Transmission System Map of Study Area with Stage 1 – Stage 5 Upgrades

Although the study year was 2024, it should not be assumed that all of the improvement projects are needed in 2024. The actual need for each project could be sooner or later than 2024 depending on the growth rate and location of the load in the Delaware Basin. Other factors that could affect the need for and timing of the upgrades include, but are not limited to, common transmission upgrade implementation, availability and dispatch of the generation in the study area, impedance of the new conductors, transmission upgrade cost estimates, and the results of dynamic stability analysis, which was not conducted as part of this study.

7.1. Roadmap – Stage 1 Upgrade

Transmission overload is expected to occur under N-1-1 contingency condition when the Delaware Basin load level reaches 3,052 MW. The addition of the second circuit on the existing Big Hill - Bakersfield 345-kV line was identified as the stage 1 upgrade to address the transmission overload. The cost estimate of the Stage 1 upgrade is $69 million. With the stage 1 upgrade, the load serving capability in the Delaware Basin was estimated to increase to 4,022 MW.

In addition to benefiting the Delaware Basin area, this circuit would be expected to provide stability benefits for the export of wind and solar power out of the McCamey area and West Texas overall. As of November 2019, there were more than 3,500 MWs of generation connected in the Bakersfield and McCamey area, including approximately 2,400 MWs connected directly to the existing Big Hill - Bakersfield 345-kV line. Furthermore, there are existing stability constraints (managed in operations by the Bakersfield GTC and McCamey GTC). The addition of a second circuit on the Big Hill - Bakersfield 345-kV line would improve these stability constraints and lead to less congestion. ERCOT did not quantify these benefits as part of this study.

7.2. Roadmap – Stage 2 Upgrade

When the Delaware Basin load reaches 4,022 MW, additional transmission overload is expected to occur under G-1+N-1 contingency condition, which indicates the need for an additional import path. The addition of a new 345-kV double circuit line from Bearkat to North McCamey to Sand Lake was identified to address the transmission overload. The Stage 2 upgrade is estimated to cost $371 million, requiring approximately 164 miles of new right of way. With the Stage 2 upgrade, the load serving capability in the Delaware Basin area would increase to 4,582 MW.

The addition of a new 345-kV double circuit line from Bearkat to North McCamey to Sand Lake would also improve the existing stability constraints at Bakersfield and McCamey. ERCOT did not quantify these benefits as part of this study.

7.3. Roadmap – Stage 3 and Stage 4 Upgrades

Local voltage collapse issues under N-1 contingency conditions were observed when the area load reached 4,582 MW. The addition of a new 345-kV single circuit line from Riverton to Owl Hills was identified to address this local voltage collapse issue. The Stage 3 upgrade requires approximately 20 miles of new right of way and is estimated to cost $41 million.

When the Delaware Basin load reaches 5,032 MW, a different local voltage collapse was observed under N-1-1 contingency conditions. To address this additional local voltage collapse, ERCOT proposes the Stage 4 upgrade include the conversion of the Riverton - Sand Lake 138-kV line to 345-kV line and the addition of the new 138-kV line from Riverton to Sand Lake to serve the local load. The cost estimate of the Stage 4 upgrade is about $56 million.

The transmission upgrade identified in Stage 3 is to serve the projected load in the Owl Hills area along the Culberson loop. The need of this transmission upgrade is dependent on local load growth. Given the recent rapid load growth in the Owl Hills area, this transmission upgrade may need to be accelerated according to the TSP.

7.4. Roadmap – Stage 5 Upgrade

With the Stage 1 – Stage 4 upgrades assumed in place, the load serving capability in the Delaware Basin was found to increase to 5,422 MW. If the load in the Delaware Basin area reaches to 5,422 MW, another import path will be needed. A new Faraday - Lamesa - Clearfork - Riverton 345-kV double circuit line was identified as a placeholder import path option to further increase the load serving capability. The Stage 5 upgrade requires about 193 miles of new right of way and is estimated to cost $444 million. With the stage 5 upgrade, the load serving capability of the system in the Delaware

Basin area could reach 5,972 MW. The load serving capability may be further improved if additional reactive power support is implemented.

8. Conclusion

The purpose of the Delaware Basin Load Integration Study was to identify potential system constraints and transmission upgrade needs to potentially accommodate significant load growth in the Delaware Basin area. The results provide a roadmap for the long lead time transmission upgrades to the ERCOT stakeholders that include the upgrade needs and the associated triggers in terms of load level in the Delaware Basin area. In addition, a set of transmission upgrades will also be needed to address local issues and load connections in the area.

It should be noted that the identified improvements were based on the assumptions used in the steady state analysis in this study. Should these assumptions change, the results of this analysis will need to be updated which could yield a different set of transmission improvements or trigger points.

Figure 8.1 shows the load comparison of five-year ahead load forecast in the ERCOT SSWG cases and actual historic load in the Delaware Basin area together with the trigger points of the long lead time transmission upgrades identified in the roadmap.

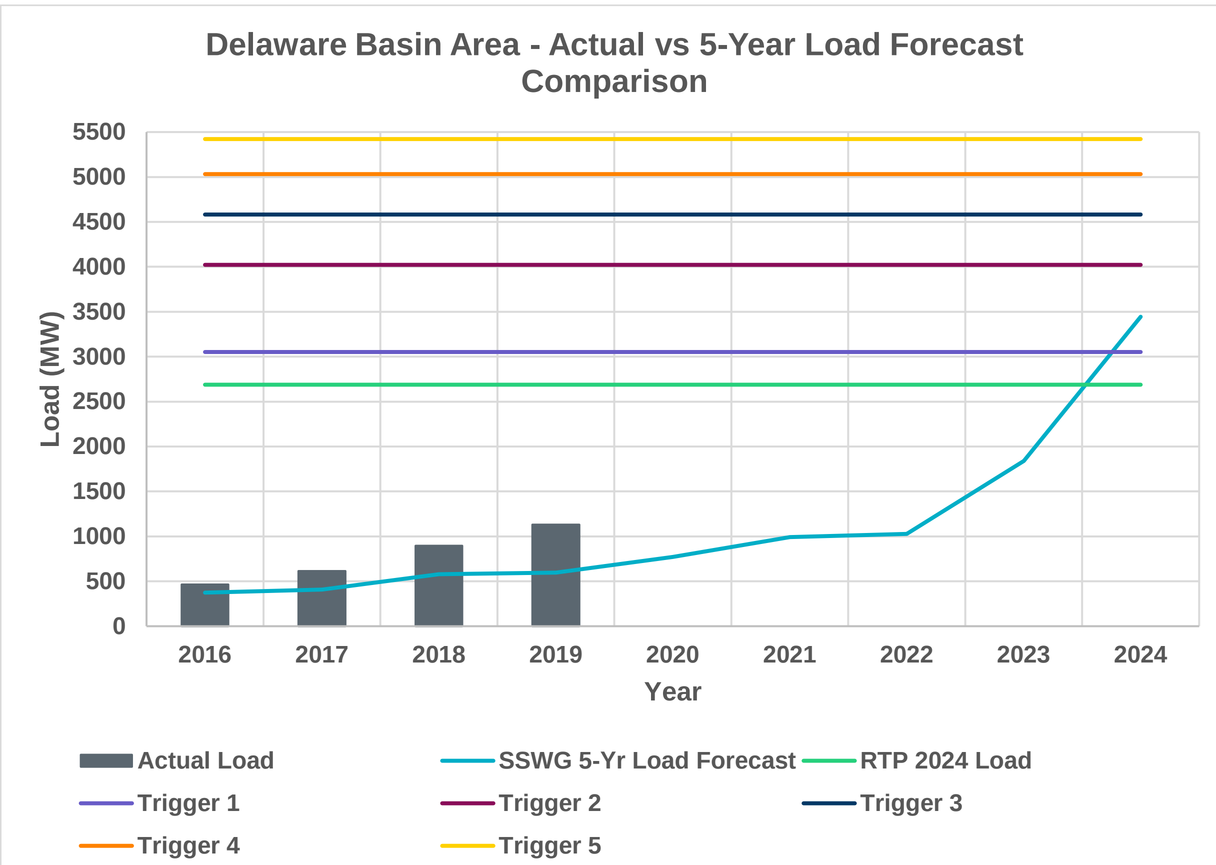

Figure 8.1 Actual and 5-year Load Forecast in the Delaware Basin Area

9. Appendix

9.1. Appendix A: Steps to Develop the Common Upgrades under N-0	Steps to develop the N-0 common up
9.2. Appendix B: List of Upgrades Identified in This Study	TransmissionUpgrades_DelawareBasinS
9.3. Appendix C: Options Diagrams	Appendix - Options Maps_v3.pdf