# Report on Existing and Potential Electric System Constraints and Needs
# December 2018

# Executive Summary

The annual Electric System Constraints and Needs report is provided by the Electric Reliability Council of Texas, Inc. (ERCOT) to identify and analyze existing and potential constraints on the transmission system. This report satisfies the annual reporting requirements of Public Utility Regulatory Act (PURA) Section 39.155(b) and a portion of the requirements of Public Utility Commission of Texas (PUCT) Substantive Rules 25.362(i)(2)(I) and 25.505(c).

The transmission system is used to transport power from generators to consumers. When consumers use more power in an area or when the generation fleet changes due to plant retirements or the addition of new resources, the transmission system may need to be upgraded to meet the altered system needs caused by these changes. Often, these upgrades are needed to meet statutory reliability criteria but can sometimes be required to meet the reliability criteria in a more efficient manner.

Insufficient investment in transmission can lead to reliability deficiencies and high congestion costs, which are ultimately borne by the consumers in terms of higher energy prices, and can impact external investment in new generation resources or end-use facilities, such as manufacturing plants. Energy prices in ERCOT have declined in recent years, as shown in Figure ES.1.

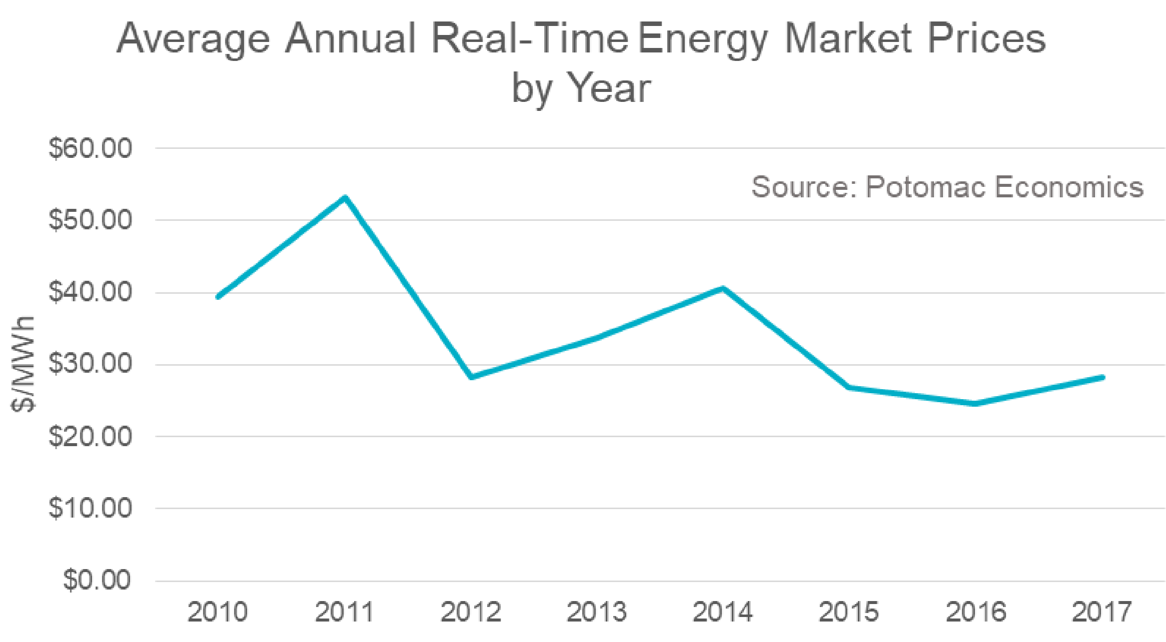


*Figure ES.1: Average Annual Real-Time Energy Market Prices by Year*

There are several factors that have likely contributed to the decrease in energy prices in ERCOT. One of those factors is an increase in wind generation, which has no fuel cost. Figure ES.2 shows the recent and projected increase in wind generation in ERCOT.

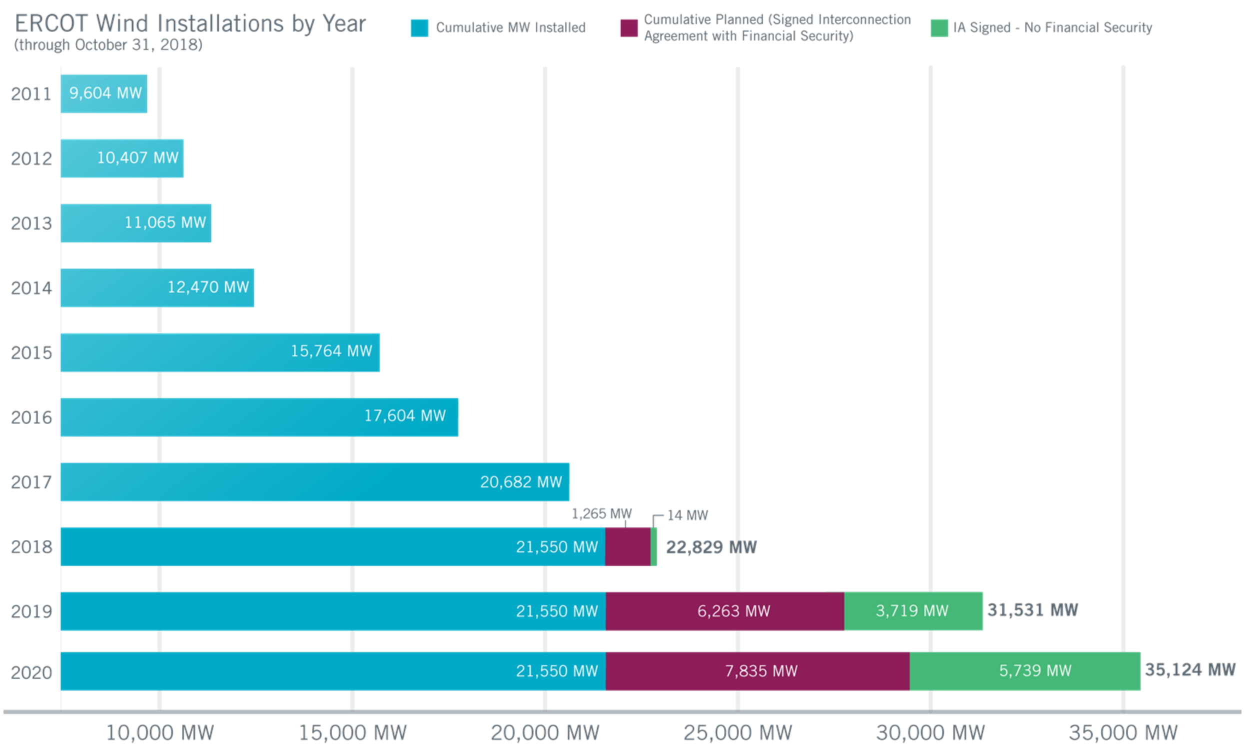


*Figure ES.2: Wind Generation Growth*

Nearly half of the total capacity of wind generation in ERCOT has been installed since the completion of the Competitive Renewable Energy Zone (CREZ) project at the end of 2013. The CREZ project, which cost more than $6 billion, included more than 3,500 miles of new 345 kV circuits to deliver power generated in West Texas to load centers in the eastern part of the state. Figure ES.3 shows the cost of all ERCOT transmission improvements by year.

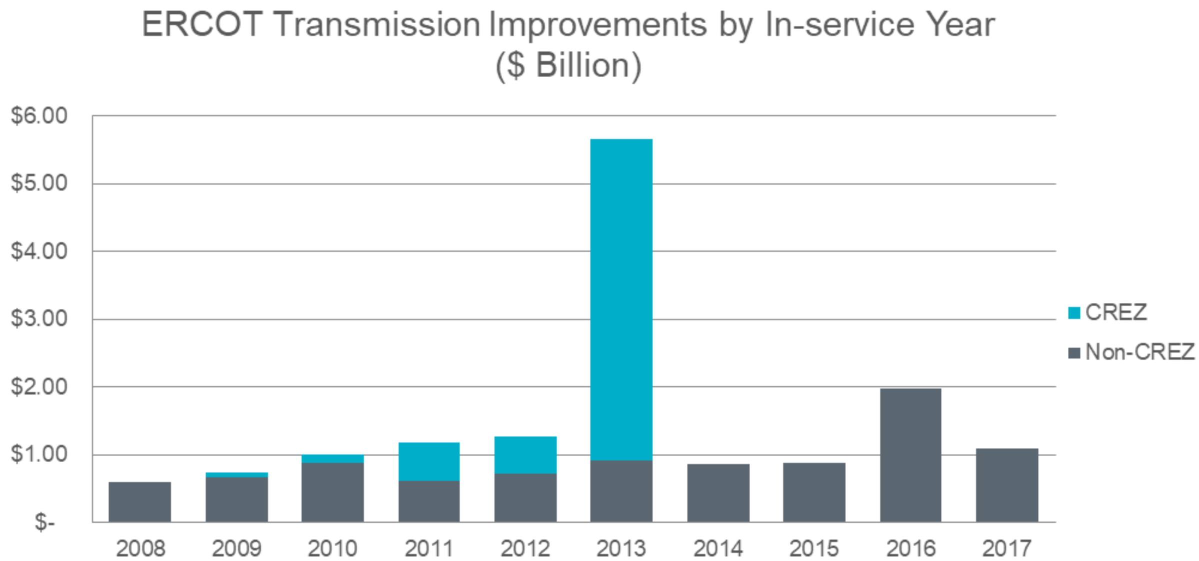


*Figure ES.3: Completed ERCOT Transmission Improvements by Year*

The growth in wind generation capacity in some areas has reached and exceeded the design capability of the CREZ transmission system. For example, dynamic stability and system strength considerations limit the reliable flow of power from the Panhandle to the rest of the ERCOT system due to the inverter-based design of the wind generation in the area and the remote nature of the Panhandle system. As a result, an export limit from the Panhandle region is necessary to maintain reliable operation. This export limit is applied to the sum of the power flows across the six circuits that connect the Panhandle region to the rest of the ERCOT system. The Panhandle Export Limit had the second highest amount of congestion rent on the ERCOT system in both 2017 and 2018. This congestion was exacerbated by several extended maintenance outages taken on Panhandle area transmission.

Two new transmission projects in the Panhandle went into service in 2018 to help relieve congestion in the area. Additionally, the 2021 planned integration of the Lubbock Power and Light system into ERCOT will include a new 345 kV path out of the Panhandle that will help alleviate congestion. However, as more generation is added in and near the Panhandle, the congestion is expected to continue. Furthermore, with the addition of a substantial amount of wind generation located just outside of the currently defined Panhandle area, ERCOT may have to change the way it manages the stability constraint in the area to maintain reliable operation.

The Bearkat area, in West Texas, is another area that has seen installed and planned wind generation capacity additions that are in excess of the CREZ-designed capability for the region. As the planned wind projects are completed, congestion will result from local transmission system limitations. ERCOT's economic planning criteria defines when a transmission project will be recommended to mitigate system congestion, specifically when the projected benefits of the project outweigh its expected cost. Based on this economic planning criteria, the ERCOT Board endorsed a new, approximately 27 mile

345 kV line from Bearkat to Longshore. This improvement, which will allow more low cost wind energy to reach the ERCOT market, is expected to be in service in 2022.

The continued growth of generation in the Panhandle and West Texas, from both wind and solar resources, is expected to cause congestion on the system in the future. In particular, the northwest side of the Dallas-Fort Worth area and northwest of San Antonio in the Kendall area are expected to see growing congestion over the next five years. ERCOT's long-term studies have identified cost-effective solutions to mitigate this congestion in the ten-year horizon. ERCOT and TSPs will continue to evaluate solutions for addressing the projected congestion.

Additionally, wind and solar resources, which use inverters to convert the energy they produce into electrical energy for the grid, interact with the grid in a fundamentally different way than conventional synchronous resources and actually rely on conventional synchronous resources in order to remain stable. As the resource mix shifts from conventional fossil fuel resources located near load centers to renewable, inverter-based resources located farther from load centers, ERCOT anticipates stability limits will be among the most limiting constraints on the transmission system.

ERCOT has also seen significant load growth and transmission expansion in the Far West weather zone over the last ten years that can be attributed to both natural gas and oil production in the Permian Basin. In fact, peak demand has more than doubled in the Far West weather zone since 2009. Figure ES.4 shows Permian Basin oil rig count information, which indicates rate of well and demand growth, by county as of October 2018. The graphic also shows the increase or decrease in rig counts since October 2017. In total, the Permian Basin added 79 oil rigs between October 2017 and October 2018.

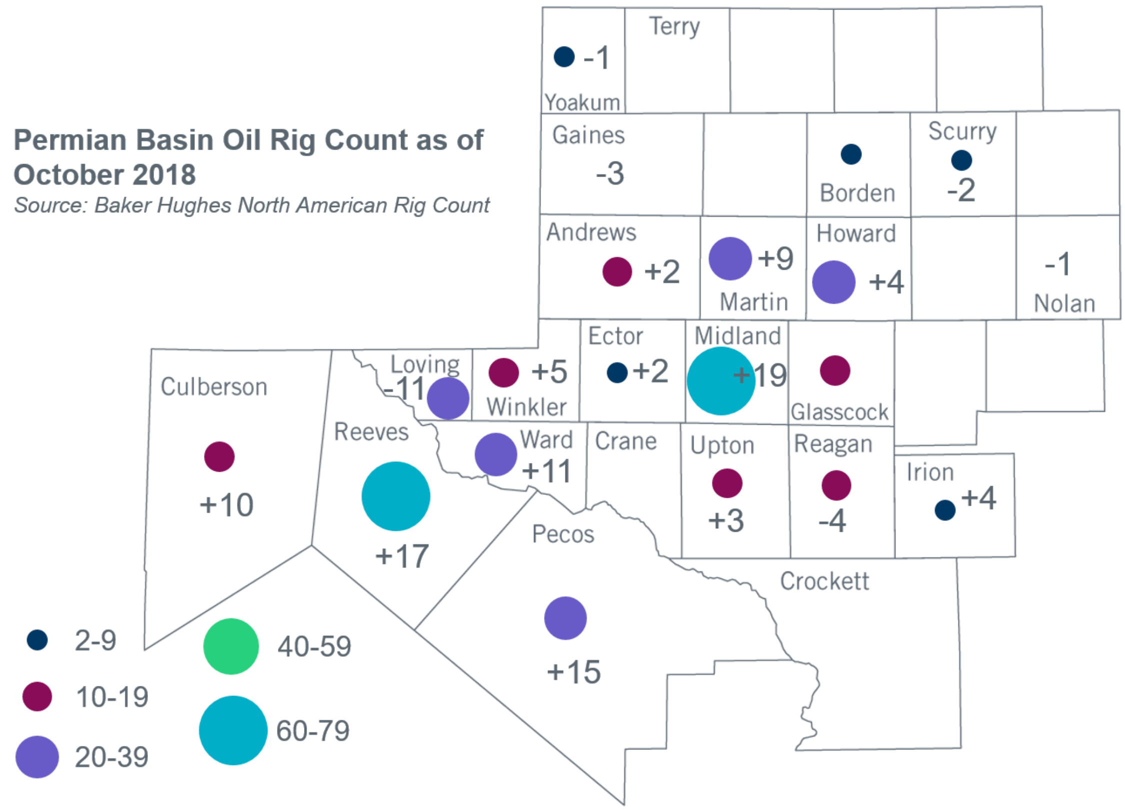


*Figure ES.4: Permian Basin Oil Rig Count and Annual Change by County*

This growth trend is expected to continue and has led to the planning of additional significant transmission improvements. Of the $3.90 billion of transmission improvements planned to be in service in 2019 and 2020 across the ERCOT system, $966 million are located within the Far West weather zone. Figure ES.5 shows the cost of transmission improvements, excluding CREZ projects, in the Far West weather zone from 2009 through 2017 and the estimated cost of planned transmission improvements in the Far West from 2018 through 2020. The investment in transmission to support natural gas production and the resulting increase in natural gas supply may be another factor in the decrease of ERCOT energy prices due to the corresponding decrease in natural gas prices.

Ensuring that the transmission improvements in the Far West region are in place in time to serve the load has been a challenge. This is because the nature of the industry is such that oil and gas customers are not able to accurately project their electricity needs more than one or two years ahead of time while transmission improvements can take two to six years to complete planning studies, routing analysis (if needed), regulatory approvals, route acquisition (if needed), design, and construction. As an example, congestion on the Yucca Drive-Gas Pad 138 kV line, which had the highest amount of congestion rent on the ERCOT system in 2018, was relieved by a transmission project that was endorsed by the ERCOT Board in 2016 but not put in service until late 2018. ERCOT has employed several strategies to address this challenge, but it is possible that short-term, high-impact constraints, like the Yucca Drive-Gas Pad 138 kV line, will occur in the future due to faster than expected load growth.

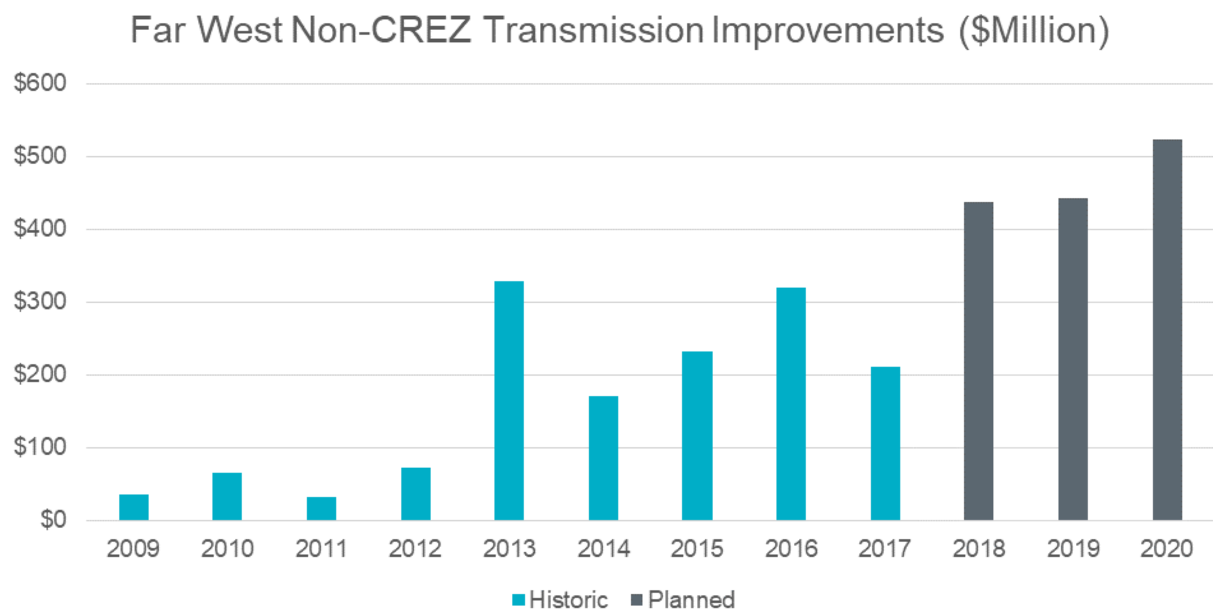


*Figure ES.5: Far West Weather Zone Transmission Improvements by Year*

One area that has seen a noteworthy decrease in congestion is the import of power into the Houston area from the north. Although North to Houston import congestion caused the third highest amount of congestion on the ERCOT system in 2018, of the $66.7 million in congestion rent, only $573,036 occurred after the Houston Import Project went into service in April. The Houston Import Project was endorsed as a reliability project by the ERCOT Board in 2014.

Recently, utilities either not currently connected to, or not fully connected to, the ERCOT grid have proposed switching all or parts of their systems into ERCOT. Currently, the Lubbock Power and Light (LP&L) system is served by the Southwest Power Pool (SPP) grid in the Eastern Interconnection. In 2015, LP&L expressed a desire to disconnect a majority of its system, including approximately 470 MW of load, from the SPP grid and connect it to the ERCOT grid. ERCOT conducted studies to support the PUCT approval of LP&L's request, which occurred in early 2018. The transition is expected to take place by June 2021 following the construction of the integration facilities, which include five new 345 kV lines, six 345/115 kV transformers, and several 115 kV lines.

Rayburn Country Electric Cooperative (RCEC), which currently has electrically separate facilities connected in both the ERCOT system and the Southwest Power Pool (SPP) system in the Eastern Interconnection, proposed moving their SPP facilities and customers into ERCOT. Similar to the LP&L request, ERCOT performed studies to support the PUCT approval of the transition. As of November 2018, the interested entities were engaged in settlement negotiations in regards to the details of the RCEC integration (PUCT Docket No. 48400).

ERCOT performs a biennial Long-Term System Assessment (LTSA) to assess the potential needs of the ERCOT system up to 15 years into the future. The role of the LTSA is to provide a roadmap for future transmission system expansion and identify long-term trends that should be considered in near-term planning. ERCOT studies different stakeholder-developed scenarios in its long-term planning process to account for the inherent uncertainty of planning the system beyond the next six years.

Stakeholders developed five different scenarios for the 2018 LTSA: Current Trends, High Economic Growth, High Renewable Penetration, High Renewable Cost, and Emerging Technology. ERCOT created a load forecast and performed generation expansion and retirement analysis for all five scenarios. ERCOT performed detailed transmission expansion analysis on the Current Trends scenario.

Based on the results of the analyses that went into the 2018 LTSA, ERCOT identified the following key findings:

- All five scenarios showed a significant amount of solar generation additions, ranging from a low of 3,900 megawatts (MW) to a high of 15,100 MW. Two scenarios showed some retirement of coal and gas generation. Higher amounts of wind and gas generation additions were also seen compared to previous LTSA studies.
- The scale of solar generation additions is dependent upon access to the solar-rich sites in the Far West Texas region.
- There may be generation capacity challenges during the summer in the hours ending 2000 to 2200 in scenarios with a large amount of solar generation.
- The Emerging Technology scenario, which reflected an assumed high adoption rate in the electrification of the transportation sector in Texas, showed a significant change in the load profile. For instance, the peak hour of the day shifted from hour ending 1700 to 2200 in the night and the magnitude of this peak was approximately 15% higher than conventional load. The load profile and generation expansion implications of the changing load shape in this scenario suggest that electric vehicle adoption and the resulting charging patterns should be monitored going forward.
- Expected continued generation additions in the Far West region will necessitate transmission improvements in the area to allow exports of solar and wind generation to ERCOT load centers. Specifically, new transmission lines between West Texas and San Antonio, and between the Far West and West weather zones were found to be economically viable in the long-term.

# Table of Contents

# Chapter 1. Introduction

The Electric Reliability Council of Texas (ERCOT), as the independent organization (IO) under the Public Utility Regulatory Act (PURA), is charged with nondiscriminatory coordination of market transactions, system-wide transmission planning and network reliability, and ensuring the reliability and adequacy of the regional electric network. The IO ensures access to the transmission system for all buyers and sellers of electricity on nondiscriminatory terms. In addition, ERCOT, as the North American Electric Reliability Corporation (NERC)-registered Planning Coordinator/ Planning Authority, is responsible for assessing the long-term reliability needs for the ERCOT region.

ERCOT supervises and exercises comprehensive independent authority over the planning of transmission projects for the ERCOT system as outlined in PURA and Public Utility Commission of Texas (PUCT) Substantive Rules. The PUCT Substantive Rules further indicate that the IO shall evaluate and make a recommendation to the PUCT as to the need for any transmission facility over which the IO has comprehensive transmission planning authority. ERCOT examines the need for proposed transmission projects based on ERCOT planning criteria and NERC Reliability Standards. Once a project need has been identified ERCOT evaluates project alternatives based on cost-effectiveness, long-term system needs and other factors.

Transmission planning (i.e., planning of facilities 60 kV and above) is a complex undertaking that requires significant work by, and coordination between, ERCOT, the Transmission Service Providers (TSP), and other stakeholders. ERCOT works directly with the TSPs and stakeholders through the Regional Planning Group (RPG). Each of these entities has responsibilities to ensure that appropriate transmission planning and implementation occurs.

The ERCOT Nodal Protocols and Planning Guide describe the practices and procedures through which ERCOT meets its requirements related to system planning under PURA, PUCT Substantive Rules, and NERC Reliability Standards.

# Chapter 2. ERCOT Transmission Planning

ERCOT annually performs a planning assessment of the transmission system that is primarily based on three sets of studies.

1. The Regional Transmission Plan (RTP) addresses region-wide reliability and economic transmission needs and includes the recommendation of specific planned improvements to meet those needs for the upcoming six years. The public version of the 2018 RTP report is posted on the ERCOT website at: http://www.ercot.com/news/presentations/.
2. The Long-Term System Assessment (LTSA) uses scenario-analysis techniques to assess the potential needs of the ERCOT system up to 15 years into the future. The role of the LTSA is to provide a roadmap for future transmission system expansion and identify long-term trends that should be considered in near-term planning. The biennial LTSA study is conducted in even-numbered years. The 2018 Long-Term System Assessment report is posted on the ERCOT website at: http://www.ercot.com/news/presentations/.
3. Stability studies are performed to assess the angular stability, voltage stability, and frequency response of the ERCOT system. Due to the security-related sensitive nature of the information contained in these study reports, they are not published on the ERCOT website.

These transmission planning studies are conducted using models that represent expected future transmission topology, demand, and generation. The models are tested against reliability and economic planning criteria per NERC Reliability Standards and the ERCOT Nodal Protocols and Planning Guide. When system simulations indicate a deficiency in meeting the criteria, a corrective action plan is developed; this corrective action plan typically includes a planned transmission improvement project. TSPs also perform studies to assess the reliability of their portions of the ERCOT system.

Transmission system improvements are built by TSPs and are paid for by consumers. During the twelve-month period from October 2017 through September 2018, TSPs completed $1.75 billion worth of transmission improvement projects. Figure 2.1 shows the cost of transmission improvements completed in ERCOT, by calendar year, from 2008 through 2017. The cost is separated by Competitive Renewable Energy Zone (CREZ)-related projects and non-CREZ-related projects. The improvement costs were notably higher than average in both 2013 and 2016. The reason that 2013 had higher than normal improvements is that most of the CREZ projects were placed in-service in that year. The 2016 total included two large projects located in the Lower Rio Grande Valley that accounted for approximately $649 million of the total.

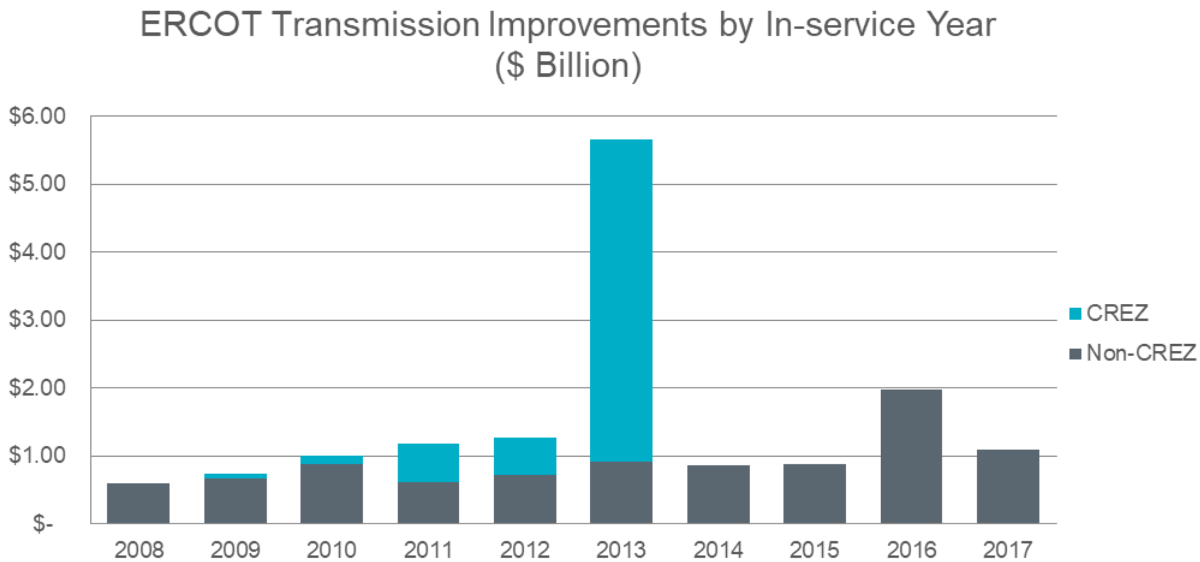


*Figure 2.1: Completed ERCOT Transmission Improvements by Year*

Funds expended by TSPs to construct new transmission improvement projects are added to their rate base, and they are repaid for the investment over the depreciated life of the project along with a rate of return on the project that is regulated by the PUCT. This repayment, as well as TSP overhead and maintenance, is summed annually and charged to consumers throughout ERCOT. This is known as the ERCOT Transmission Cost of Service (TCOS). Figure 2.2 shows the annual TCOS for 2008 through 2017. TCOS has increased over this time as the investment in transmission, most notably including CREZ, has outpaced transmission depreciation.

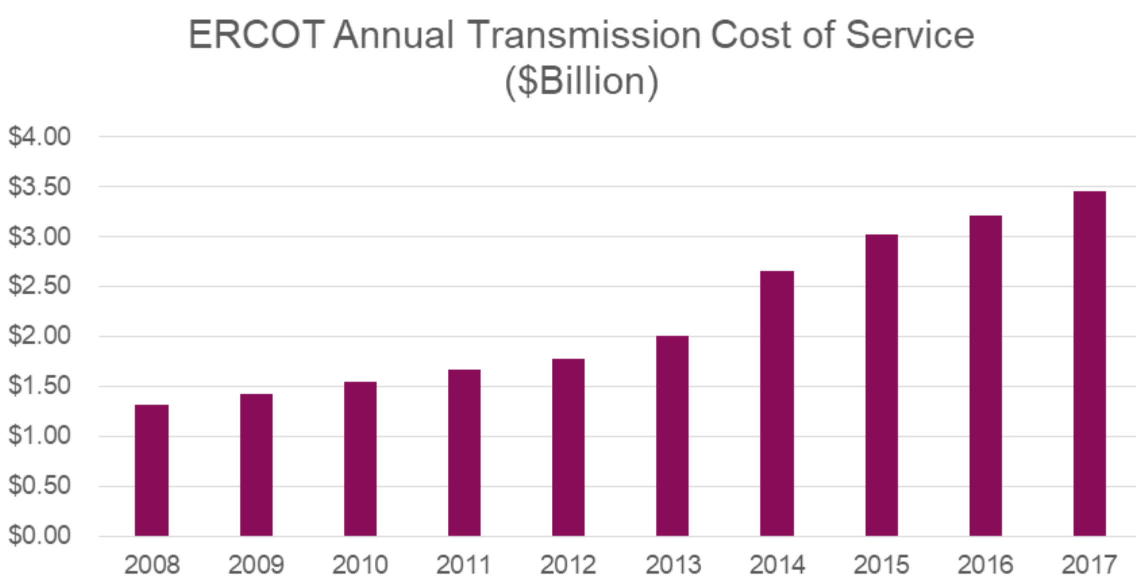


*Figure 2.2: ERCOT Annual Transmission Cost of Service*

Counterbalancing the increase in transmission costs in ERCOT has been a decrease in energy costs. There are a number of factors that have likely contributed to the decrease in energy costs in ERCOT in recent years, including lower natural gas prices and an increase in wind generation, which has no fuel costs. The investment in transmission has likely contributed, directly or indirectly, to both of these factors as transmission has supported the increase in demand related to natural gas production (see Chapter 4 for more information), and has allowed more wind generation to be delivered to the ERCOT market. Figure 2.3 shows the average annual real-time energy market price by year from 2010 through 2017.

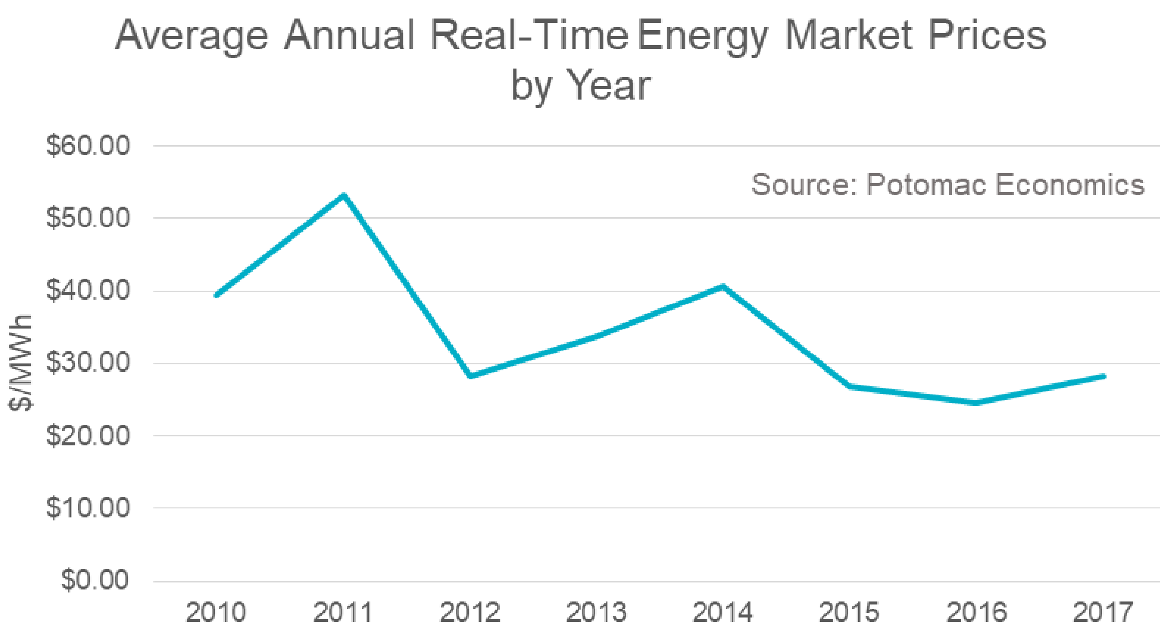


*Figure 2.3: Average Annual Real-Time Energy Market Prices by Year*

Transmission improvement projects that are estimated to cost more than $25 million or that require a Certificate of Convenience and Necessity (CCN) are reviewed by the RPG prior to implementation[1]. The RPG is a non-voting forum made up of ERCOT, TSPs, market participants, other stakeholders, and PUCT Staff. In 2018, $611.9 million of transmission improvement projects were reviewed and endorsed through the RPG process. Figure 2.4 shows the estimated cost of planned transmission projects by in-service year and separated by voltage class.

[1] Per ERCOT Protocol Section 3.11.4.3 certain projects are exempt from RPG review, such as projects to connect new generation or load customers.

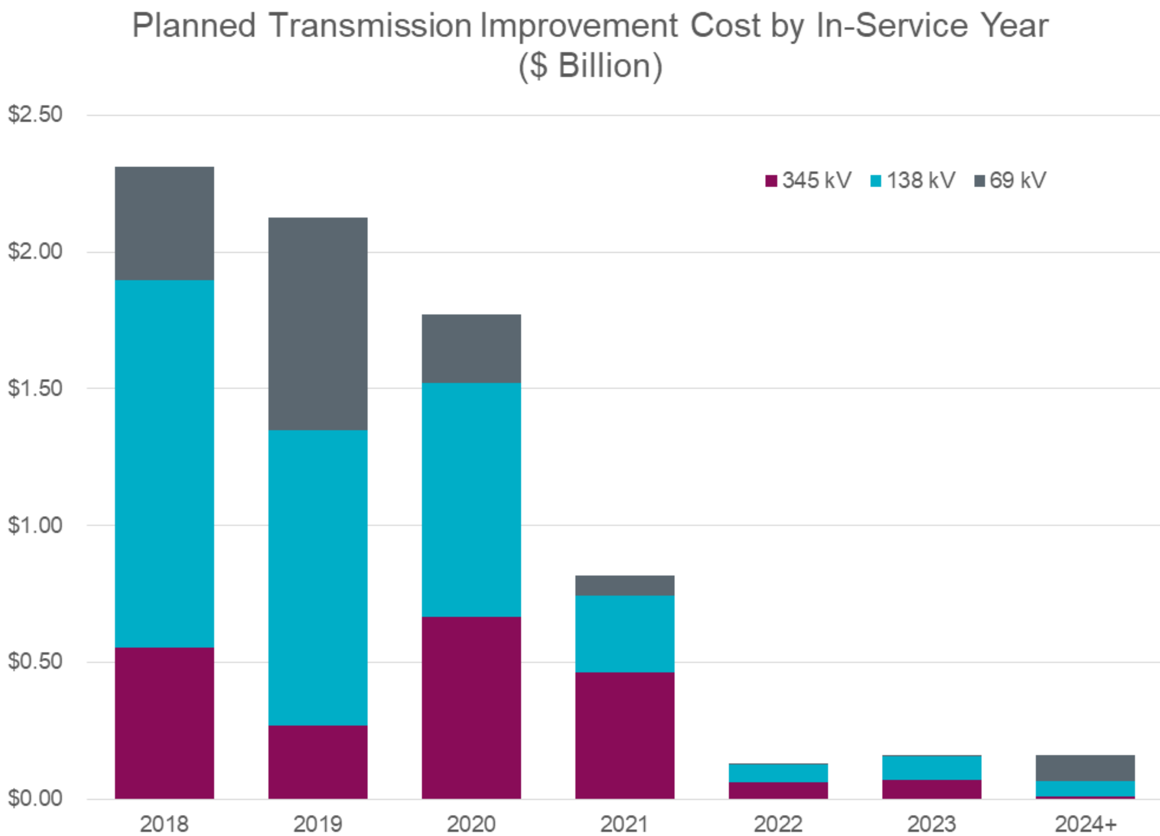


*Figure 2.4: Planned Transmission Improvements by Year*

A comprehensive list of recently completed and future transmission projects can be found in the Transmission Project Information Tracking (TPIT) report located at: http://www.ercot.com/gridinfo/sysplan/.

# Chapter 3. Recent Constraints

Congestion occurs when transmission constraints do not allow for the most efficient dispatch of generation to meet customer demand. Table 3.1 and Figure 3.1 show the top 15 congested constraints on the ERCOT system from October 2017 through September 2018, based on real-time data.

Table 3.1: 2018 Top 15 Congested Constraints on the ERCOT System

| Map Index | Constraint | Congestion Rent |
|---|---|---|
| **1** | Yucca Drive-Gas Pad 138 kV Line | $257,200,484 |
| **2** | Panhandle Export | $163,828,729 |
| **3** | North to Houston Import | $66,747,997 |
| **4** | Carrollton Northwest-Lakepoint 138 kV Line | $62,105,780 |
| **5** | Wagley Robertson-Blue Mound 138 kV Line | $57,301,063 |
| **6** | West-TI 138 kV Line | $43,121,143 |
| **7** | North Edinburg 345/138 kV Transformer | $40,192,145 |
| **8** | General Tire Switch-Southwestern Portland Tap 138 kV Line | $33,268,011 |
| **9** | Calaveras-Pawnee 345 kV Line | $23,187,230 |
| **10** | Scurry Chevron-Knapp 138 kV Line | $21,445,829 |
| **11** | Valley Import | $20,944,980 |
| **12** | Elm Creek-Skyline 345 kV Line | $20,631,858 |
| **13** | Linterna-Solstice 138 kV Line | $19,683,846 |
| **14** | Moore-Hondo Creek 138 kV Line | $16,828,493 |
| **15** | North McAllen-West McAllen 138 kV Line | $16,393,420 |

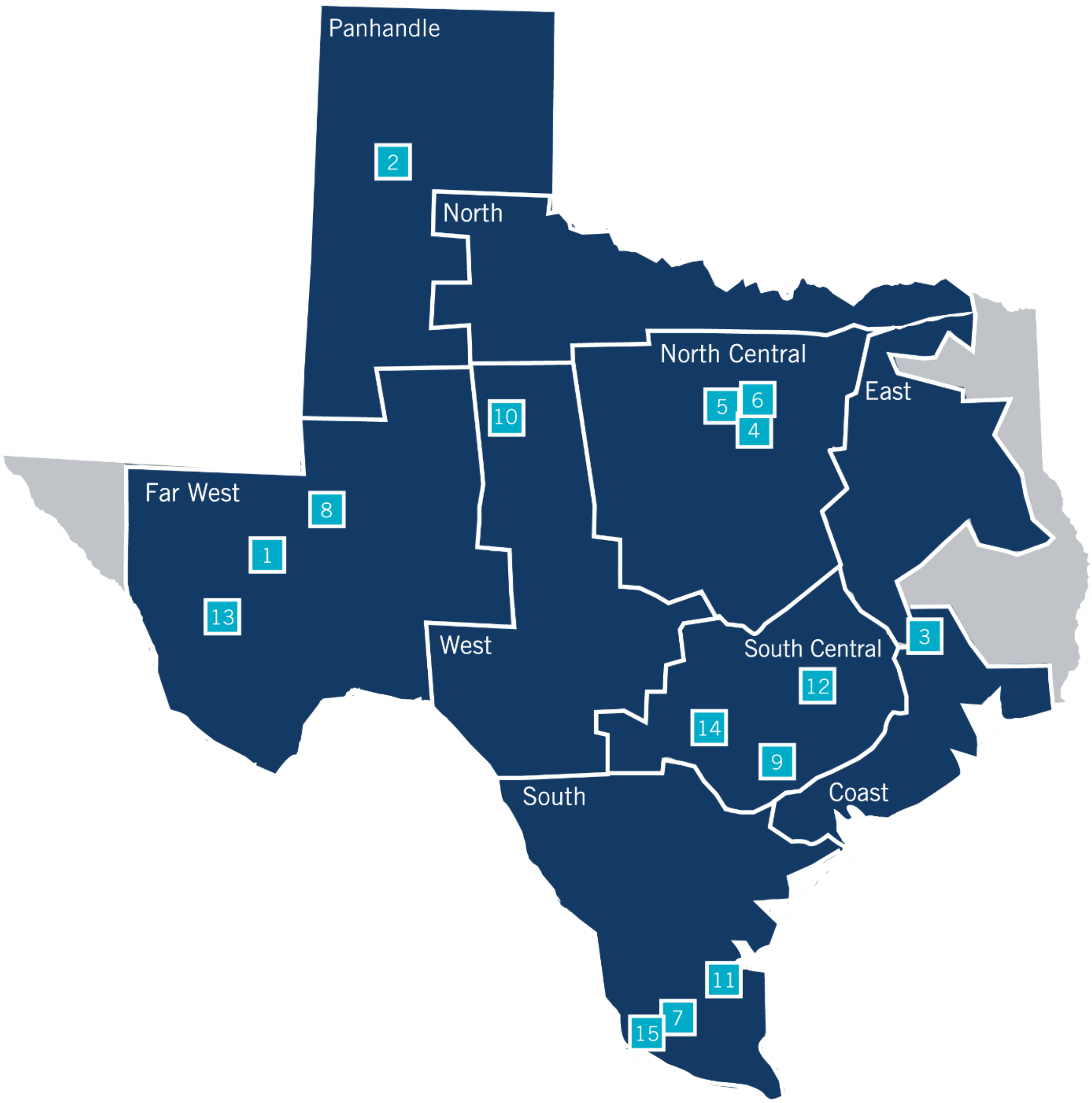


*Figure 3.1: Top 15 Congested Constraints*

The most significant congestion in ERCOT in 2018 was experienced on the Yucca Drive-Gas Pad 138 kV line in Far West Texas. This congestion was primarily due to significant load growth related to oil and natural gas activity in the area and the addition of solar generation in the south part of the area. This congestion was unique because the constraint would be active for high south-to-north power flows on the line during daylight hours when the solar resource was generating, and it would flip to being active for high north-to-south power flows during the nighttime when the solar resource was not generating. Planned transmission upgrades were placed in service in July 2018, after which the congestion did not occur. See Chapter 4 for more discussion on planned improvements for Far West Texas.

In August 2017, Hurricane Harvey made landfall in Texas and, among other things, caused damage to transmission lines in ERCOT. The forced outage of transmission lines caused congestion on the ERCOT system, including the Calaveras-Pawnee 345 kV line congestion. The Calaveras-Pawnee 345 kV line congestion persisted until May 2018 when some of the repairs were completed on damaged transmission lines.

The following sections detail other congestion experienced in ERCOT between October 2017 and September 2018.

### Panhandle Export

Dynamic stability and system strength considerations limit the reliable flow of power from the Panhandle to the rest of the ERCOT system due to the inverter-based design of the wind generation in the area and the remote nature of the Panhandle system. As a result, an export limit from the Panhandle region is necessary to maintain reliable operation. This export limit is applied to the sum of all power flows across the six circuits that connect the Panhandle region to the rest of the ERCOT system. The Panhandle Export Limit had the second highest amount of congestion rent on the ERCOT system in both 2017 and 2018. This congestion was exacerbated by extended maintenance outages taken on Panhandle area transmission.

The Panhandle region of the ERCOT grid is a prime location for wind generation development due to the favorable wind regime. In recent years, there has been a significant increase in the amount of new wind generation capacity in the Panhandle, both operating and future plants that are committed to construct. In addition, recently there has been an increase in new generation projects located near the Panhandle but outside of the existing Panhandle export constraint.

As of October 2018, there were 5,424 MW of existing and planned wind and solar generation located within the Panhandle and subject to the Panhandle export constraint and an additional 3,154 MW located adjacent to the Panhandle. Figure 3.2 shows the cumulative generation capacity by year in and adjacent to the Panhandle.

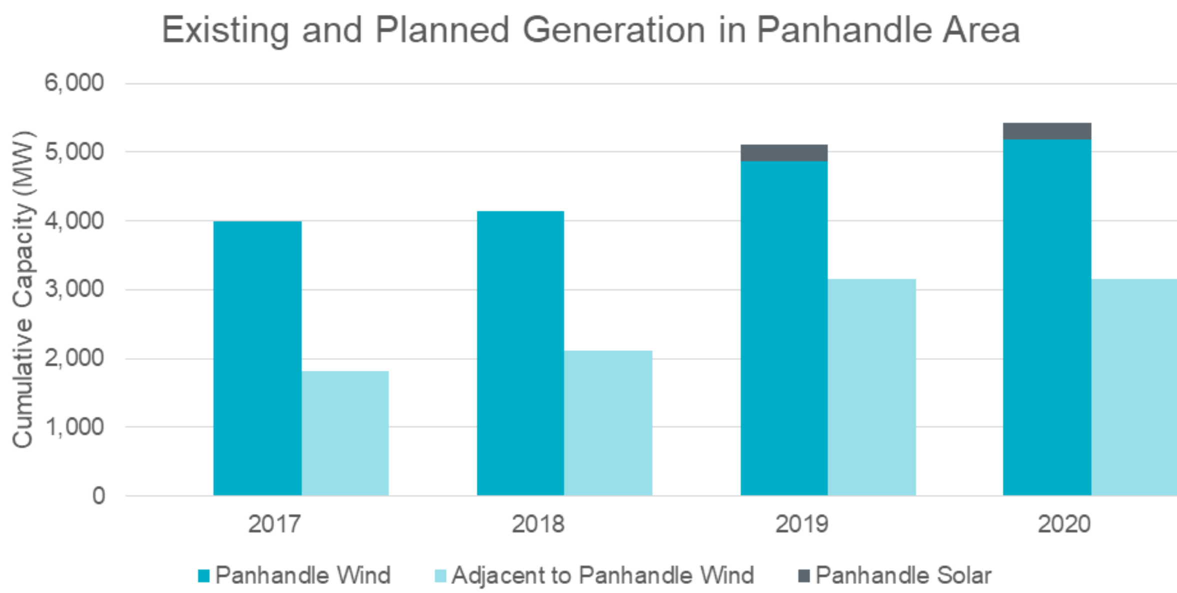


*Figure 3.2: Existing and Planned Generation in the Panhandle Area*

Additionally, as shown in Figure 3.3, approximately 16,990 MW of wind and solar generation is under study for future interconnection in or adjacent to the Panhandle. Of that total, 4,210 MW of wind and solar generation capacity in or adjacent to the Panhandle has a signed interconnection agreement but does not satisfy all of the requirements to be included in the transmission planning models.

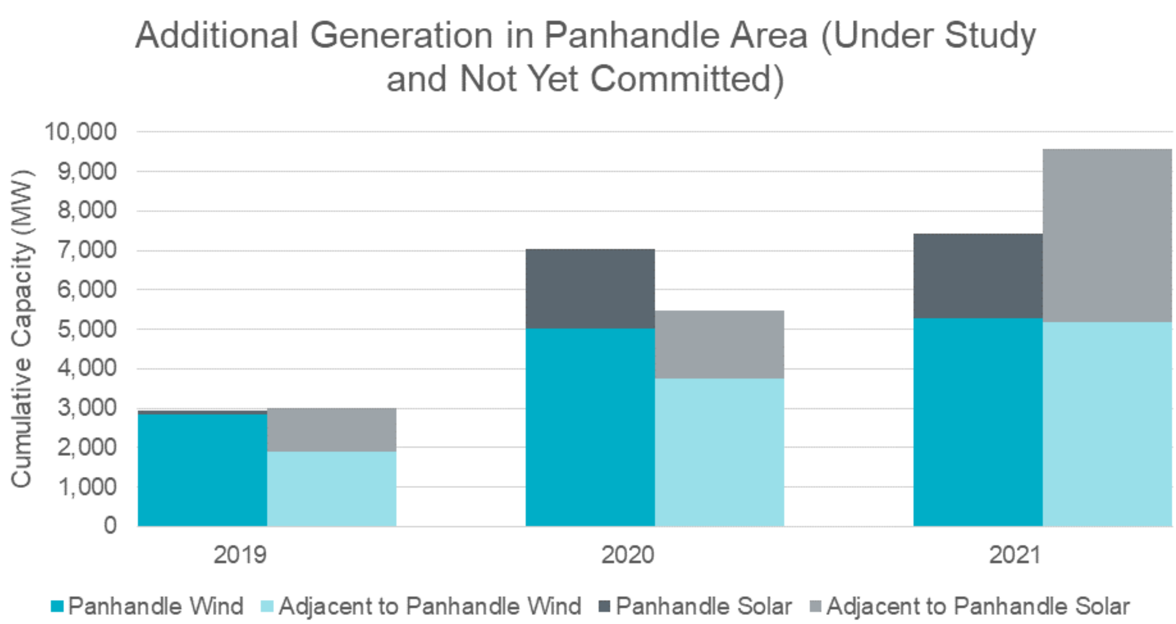


*Figure 3.3: Generation Under Study in the Panhandle Area*

Two Panhandle transmission improvements were implemented in 2018 to increase the Panhandle generation export capability, but they are not expect to eliminate the congestion in the area: (1) synchronous condenser installations at both the Alibates and Tule Canyon substations; and (2) a second 345 kV circuit connecting the Tule Canyon, Ogallala, Windmill, AJ Swope and Alibates substations.

This congestion is expected to increase over the next several years as additional generation is constructed in the area. ERCOT and TSPs are continuing to evaluate the Panhandle export capability from both operational and planning perspectives.

A Panhandle stability assessment[2] was completed in April 2018 to assess reliability in the Panhandle area. The assessment results indicated: (1) the planned integration of the Lubbock Power and Light system in 2021 (see Chapter 5), which will include additional 345 kV circuits connecting into the Panhandle and which will likely reduce transfers out of the area, improves Panhandle stability; and (2) as wind generation development continues to expand both in the Panhandle and adjacent to the Panhandle, the location of the Panhandle interface, i.e., the boundary that defines which generators are considered to be within the Panhandle and which are considered to be outside will become more difficult to determine. By mid-2019, ERCOT expects to complete a follow-up assessment to calculate the impact of the Lubbock Power and Light integration and additional generation development in the area across a range of scenarios. Figure 3.4 shows the Panhandle transmission system with the planned Lubbock Power and Light integration.

[2] http://www.ercot.com/content/wcm/lists/144927/Panhandle_and_South_Texas_Stability_and_System_Strength_Assessment_March....pdf

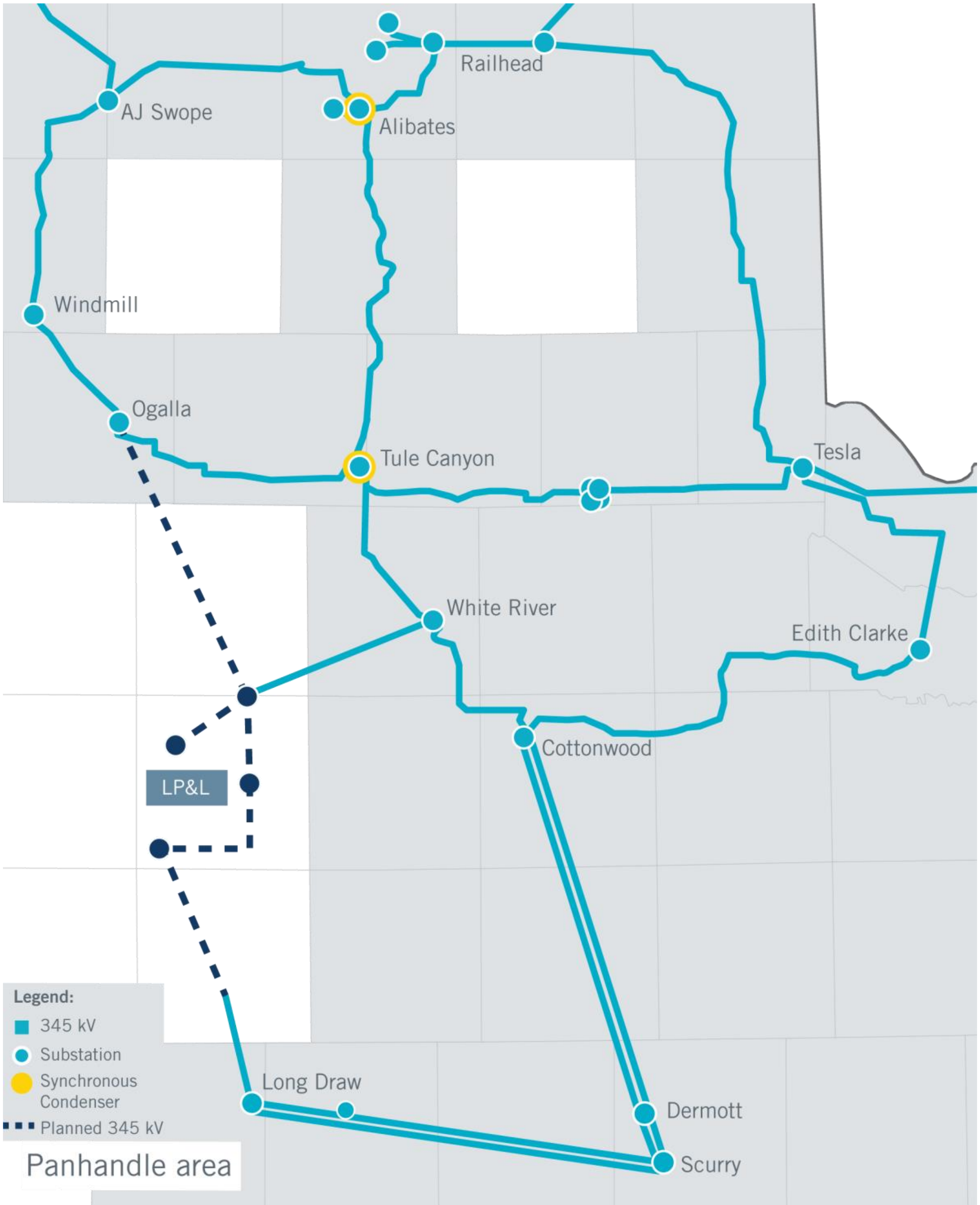


*Figure 3.4: Panhandle Area with Lubbock Power and Light Integration*

## Northwest Dallas-Fort Worth Area

As seen in Figure 3.5 below, the 345 kV Lewisville substation in Denton County and the 345 kV Hicks substation in Tarrant County act as a gateway for wind generation from the north and west wind regions of Texas into the Dallas-Fort Worth area. Under high-wind conditions coincident with higher Dallas-Fort Worth area demand, the 138 kV lines in the region realized high amounts of congestion rent in 2018 for the contingency loss of the Carrollton Northwest-Lewisville 345 kV double circuit line. The most notable congestion was seen on the Carrollton Northwest-Lakepoint 138 kV line with congestion rent of $62.1 million, and on the Wagley Robertson-Blue Mound 138 kV line with congestion rent of $57.3 million. In 2017 these transmission elements had a congestion rent of $25.8 million and $67.5 million, respectively.

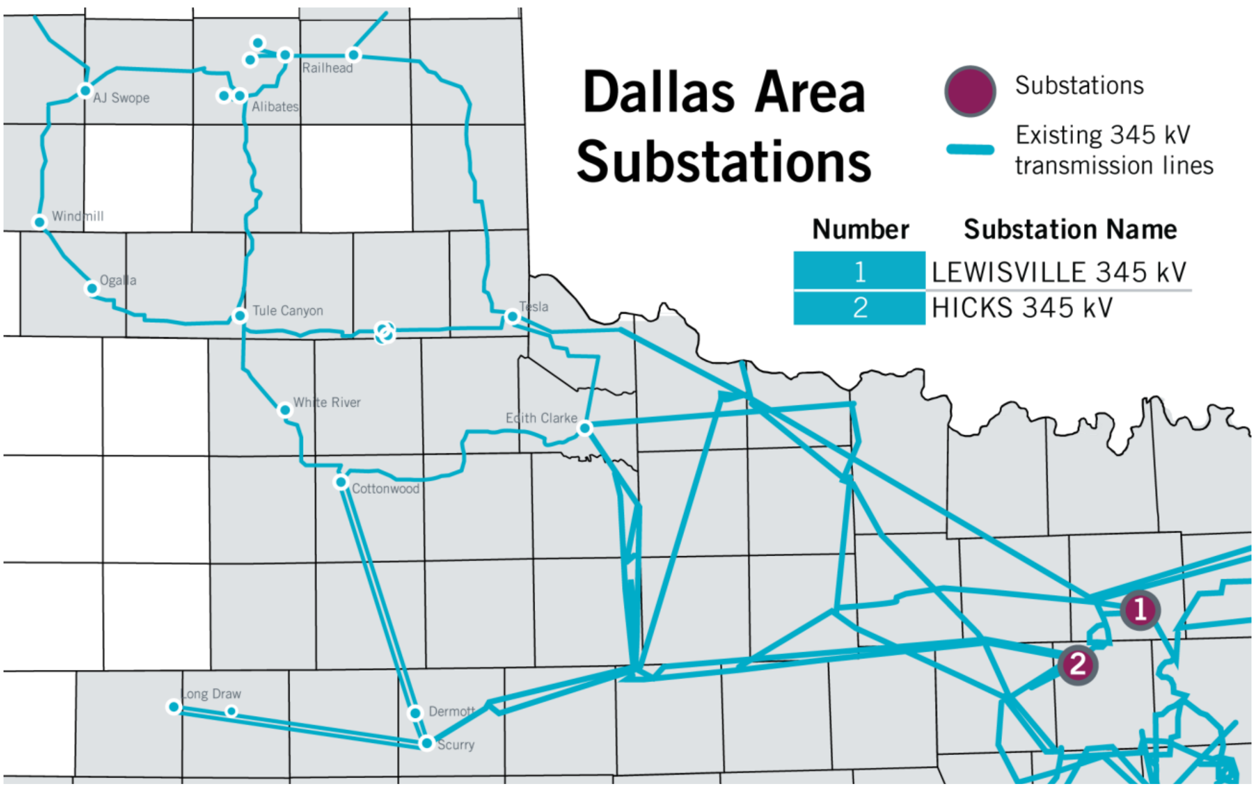


*Figure 3.5: Panhandle to Dallas-Fort Worth Area Transmission*

The increase in congestion can be attributed to various factors. The ERCOT system went through several changes that increased power flows into the Dallas-Fort Worth area from the west. First, the planned transmission improvements in the Panhandle area were completed in 2018 and helped release a larger portion of the Panhandle generation for export. In addition, the Panhandle region continued to see the addition of new wind generation (1,213 MW of new wind generation was energized in the Panhandle between October 2017 and September 2018). Much of the power from this generation flows from the Panhandle into the Dallas-Fort Worth area. Second, the recent coal generation retirements east and southeast of the region have further boosted the area's reliance on the wind generation from the northwest.

While the Wagley Robertson circuits continued to see high congestion in 2018, congestion has decreased due to some recently completed upgrades in the area. The upgrade of the existing Eagle Mountain-Wagley Robertson 138 kV line, which was placed in service in the summer of 2017 helped reduce the congestion rent in the region. Additionally, other upgrades planned in the area will potentially help relieve congestion on the Northwest Carrollton 138 kV circuits. These include the upgrade of the Carrollton Northwest-Lakepoint double-circuit 138 kV line and the upgrade of the Saginaw-Denton Avenue-Springdale 69 kV double circuit line to 138 kV operation.

The congestion in the northwest Dallas-Fort Worth area is expected to persist in the near future. ERCOT and TSP planners continue to evaluate potential solutions for this region as wind and solar generation additions in the Panhandle and west are expected to increase. Long-term studies have identified cost-effective solutions to resolve this expected congestion.

### Houston Import

The import of power into the Houston area from the north caused the third highest amount of congestion on the ERCOT system in 2018, totaling $66.7 million in congestion rent. However, from 2015 through 2017, North to Houston import congestion had the highest amount of congestion rent in ERCOT, and the 2018 amount is just 38% of the 2017 congestion rent ($174.3 million). The reason for the drop in North to Houston congestion is the completion of the Houston Import Project in April 2018. North to Houston congestion rent totaled just $573,036 from May 2018 through September 2018, after the Houston Import Project went into service. Figure 3.6 shows the North to Houston congestion rent since 2013.

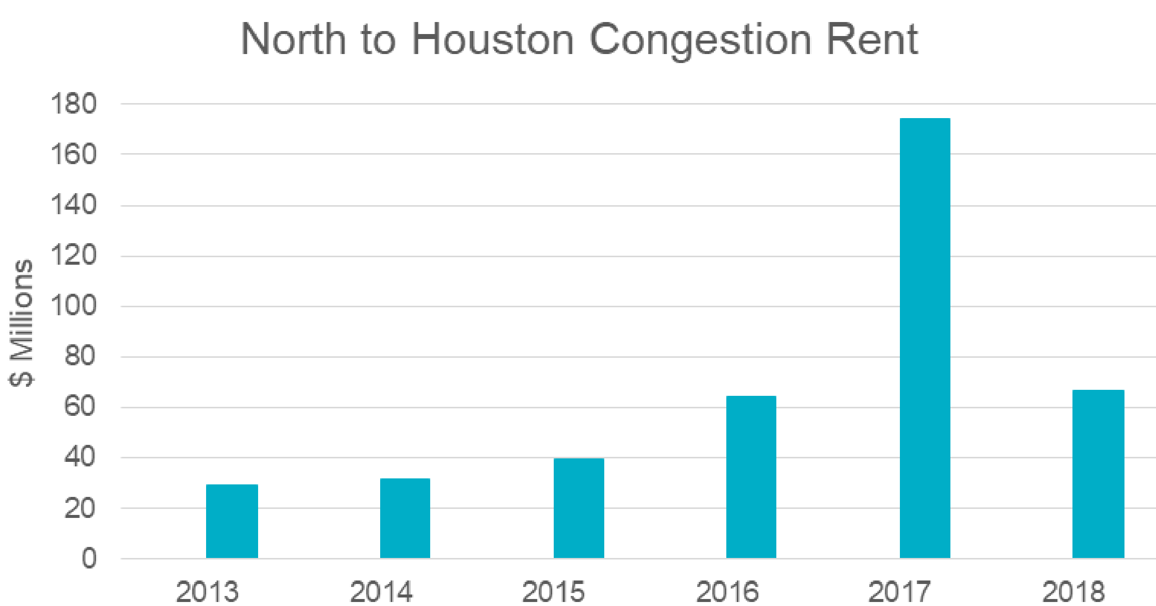


*Figure 3.6: North to Houston Congestion Rent by Year*

The customer demand in the Houston metropolitan area is currently served by generation in the area and power imported through 345 kV lines from the north and south. Much of the congestion in recent years can be attributed to the growth in demand and the retiring/mothballing of generation in the Houston area. The combination of these factors has resulted in increased imports of power from outside of the Houston area. Figure 3.7 shows the peak demand growth for the Coast Weather Zone, which primarily comprises the Houston area.

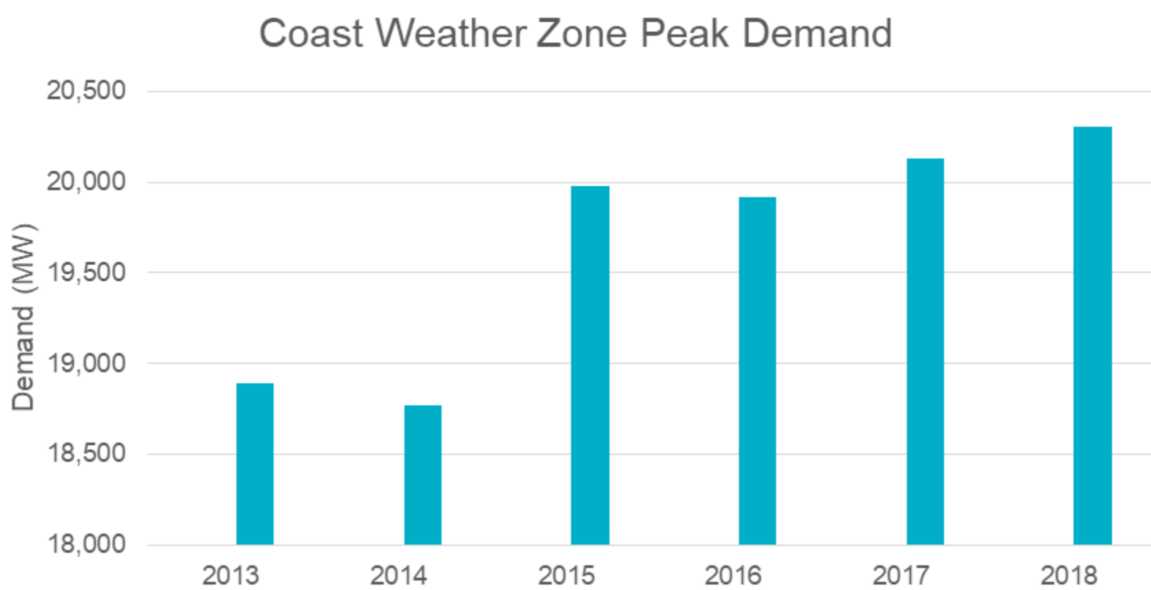


*Figure 3.7: Coast Weather Zone Peak Demand by Year*

To address the reliability need to import more power into the Houston area from the north, the ERCOT Board endorsed the need for the Houston Import Project in 2014. The project was completed in April 2018. Figure 3.8 shows the transmission lines associated with the project.


*Figure 3.8: Houston Import Project*

Figure 3.9 shows the flow duration curve for the summer hours for years 2015 through 2018. This data was compiled by taking the amount of power importing into the Houston area from the north for each hour in the months of June through August, and then sorting the values from highest to lowest. The results show that while 2017 summer had the highest amount of import on average, the highest flows were in 2018, after the completion of the Houston Import Project.

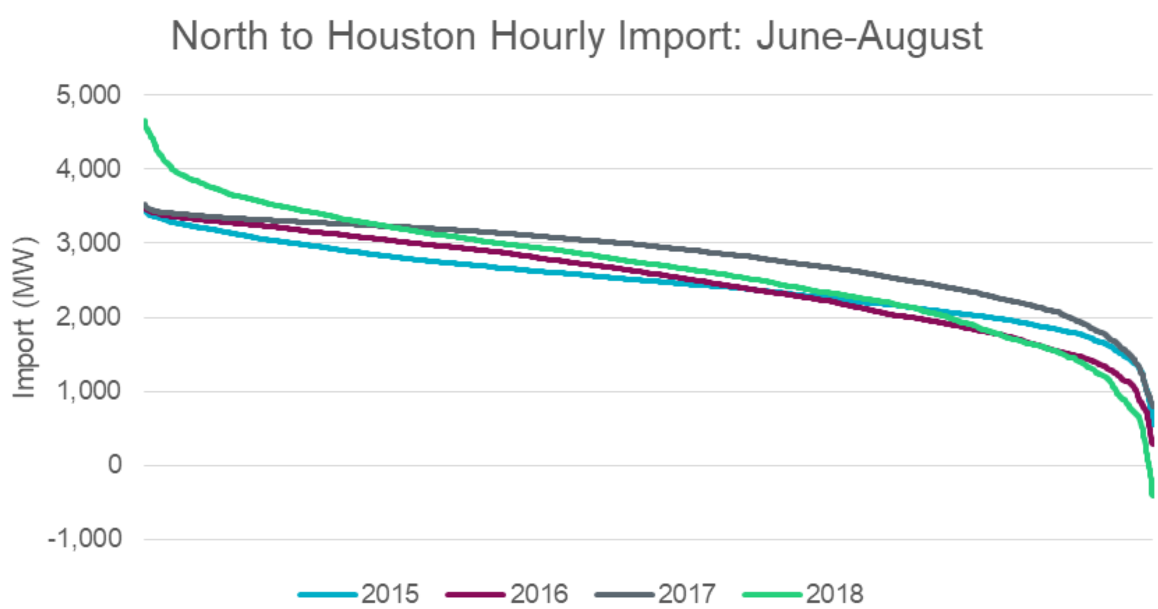


*Figure 3.9: North to Houston Summer Flow Duration Curve*

### Lower Rio Grande Valley

The Lower Rio Grande Valley (LRGV) experienced a significant amount of outage-related congestion in 2018. Congestion experienced on the North Edinburg 345/138 kV transformer and the North McAllen-West McAllen 138 kV line can be linked to generation and transmission outages in the area. The Hidalgo-Starr Transmission Project, which was endorsed by the ERCOT Board in June 2016 and is planned to go in service by 2020, is expected to help relieve congestion in the area when there are outages within the LRGV.

Congestion experienced on the Valley Import Limit mostly occurred due to the combination of load growth and outages on generation within the LRGV and/or the transmission circuits importing power into the LRGV. The LRGV Area Transmission Improvement Project, which was endorsed by the ERCOT Board in June 2016, is planned to go in service in December 2018. This project includes the installation of dynamic reactive support devices at the La Palma and Pharr 138 kV substations to improve voltage stability within the LRGV, which should reduce Valley Import congestion.

Load growth is expected to continue in the LRGV. Above and beyond the expected growth trend consistent with recent years, there are currently six liquefied natural gas

(LNG) plants that are being considered in the Port of Brownsville. These facilities typically consume a large amount of electric power. If all six were to be constructed, it could nearly double the electric demand in the LRGV. The addition of even one or two LNG facilities would likely require additional generation in the LRGV and/or a new transmission import line to serve the area. Further improvements will likely be required to meet the load growth if additional generation is not constructed in the area. Figure 3.10 shows a map of the area.

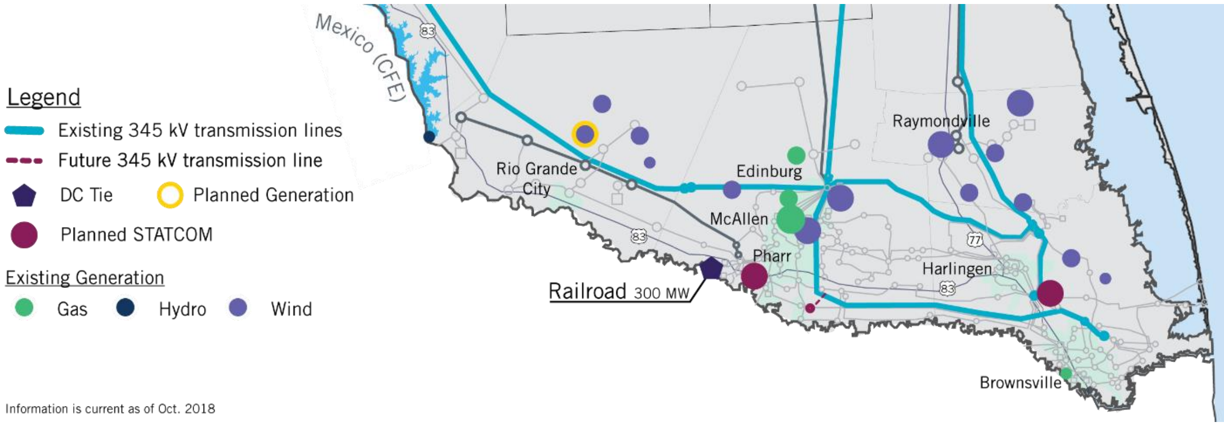


*Figure 3.10: Lower Rio Grande Valley System*

# Chapter 4. Planned Improvements

Currently, there are $5.73 billion of future transmission improvement projects that are expected to be put in service between 2019 and the end of 2024. Table 4.1 and Figure 4.1 show some of the significant improvements planned for completion within the next six years.

Table 4.1: Planned Transmission Improvement Projects

| Map Index | Transmission Improvement | In-Service Year |
|---|---|---|
| **1** | Add Horseshoe Draw Dynamic Reactive Device | 2019 |
| **2** | Add Zorn-Marion 345 kV Line | 2019 |
| **3** | Add IH-20 Dynamic Reactive Device | 2019 |
| **4** | Add Rondo Dynamic Reactive Device | 2019 |
| **5** | Add Leander-Round Rock 138 kV Line | 2019 |
| **6** | Upgrade Barilla Junction-Fort Stockton 69 kV Line | 2020 |
| **7** | Upgrade Crocket-Jewett 138 kV Line | 2020 |
| **8** | Upgrade Northwest Carrollton-Lewisville South 138 kV Line | 2020 |
| **9** | New Riverton-Odessa EHV/ Moss 345 kV Line | 2020 |
| **10** | New Sand Lake-Solstice 345 kV Line | 2020 |
| **11** | New Stewart Road 345 kV Station with 345/138 kV Transformer | 2020 |
| **12** | New Solstice-Bakersfield 345 kV Line | 2021 |
| **13** | New Bailey-Jones Creek 345 kV Line | 2022 |
| **14** | New Bearkat-Longshore 345 kV Line | 2022 |
| **15** | Upgrade Trinidad-Tricorner-Watermill 345 kV Line | 2023 |

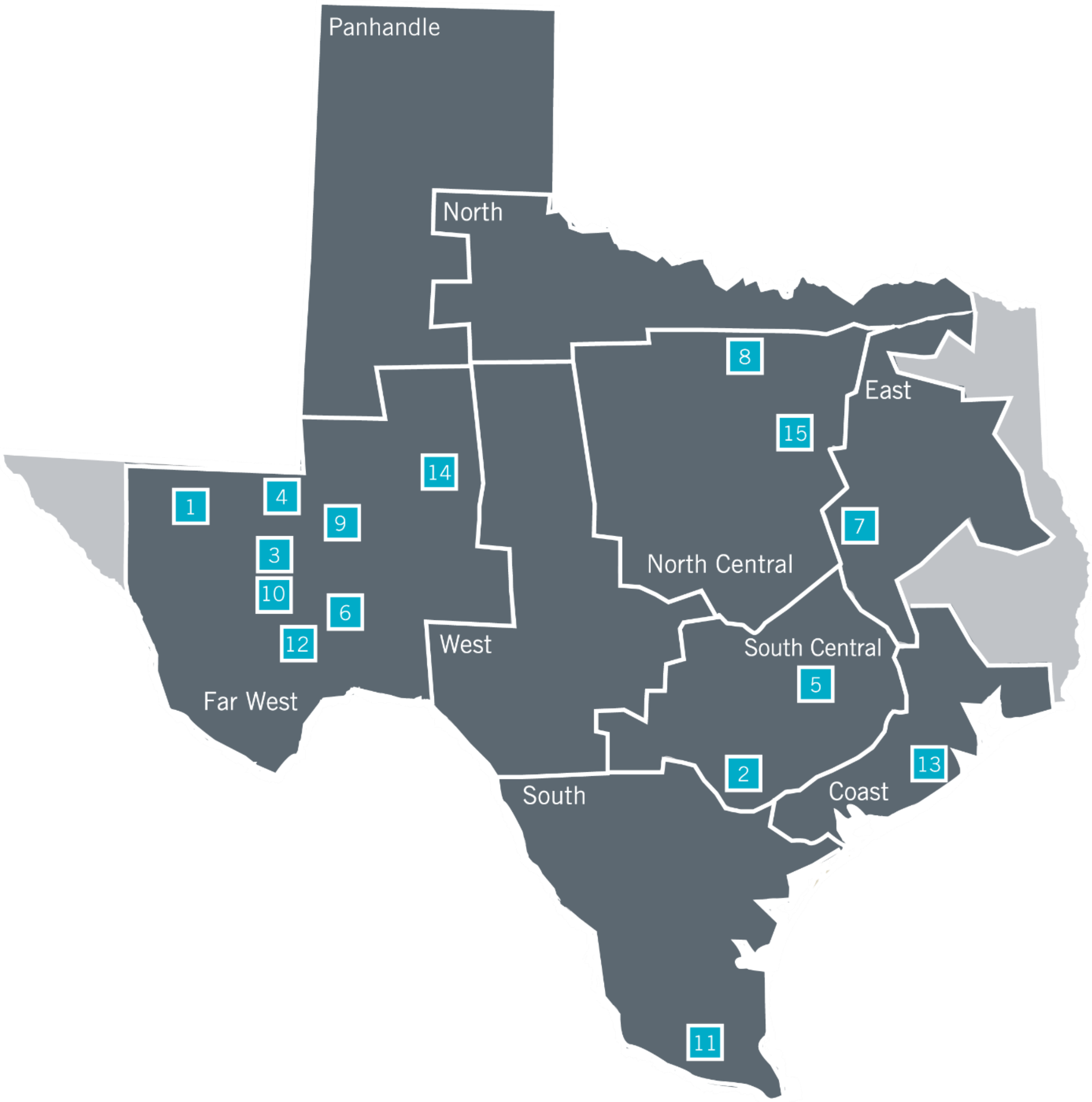


*Figure 4.1: Planned Transmission Improvement Projects*

## Far West

Ongoing and unprecedented load growth in the Far West weather zone over the last ten years has resulted in numerous transmission improvement projects in the area. This growth trend is expected to continue and has led to the planning of additional significant transmission improvements. Of the fifteen projects listed in Table 4.1, seven are located in the Far West weather zone. There are currently $3.90 billion of transmission improvements planned to be in service in 2019 and 2020 across the ERCOT system. Of those improvements, $966 million are located within the Far West weather zone. Figure 4.2 shows the cost of transmission improvements, excluding CREZ projects, in the Far

West weather zone from 2009 through 2017 and the estimated cost of planned transmission improvements in the Far West weather zone from 2018 through 2020.

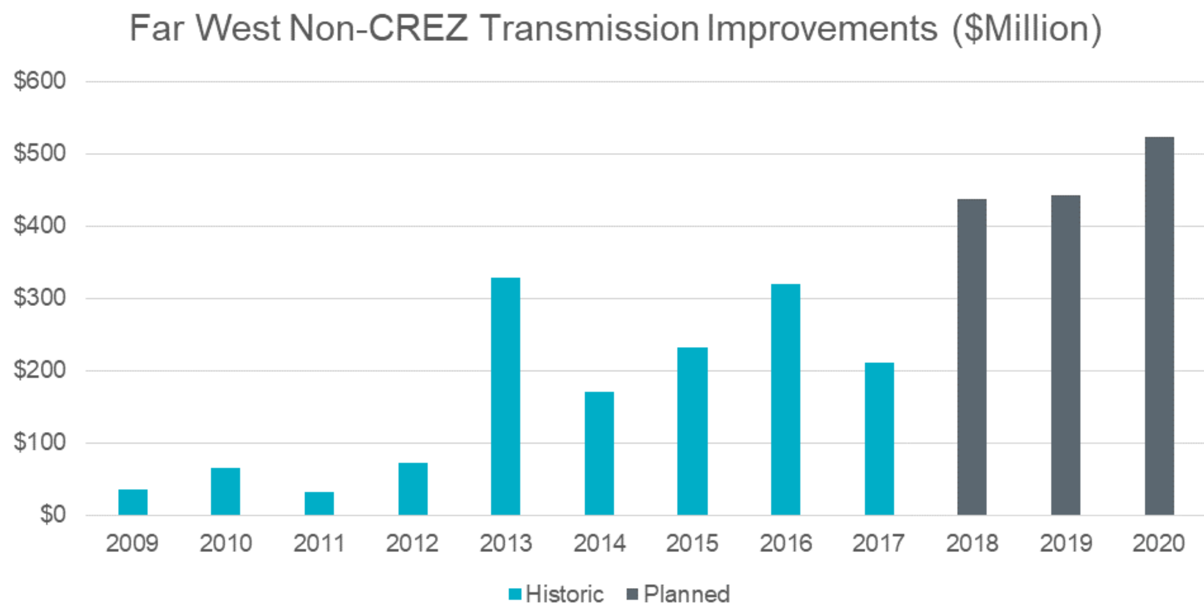


*Figure 4.2: Far West Weather Zone Transmission Improvements by Year*

Though the Far West weather zone accounted for less than 6% of the total energy demand in ERCOT in 2017 and has been among the smallest in terms of peak demand, it is the fastest growing region in ERCOT by percentage. The primary driver for the load growth is oil and gas industry development in the Permian Basin. Peak demand in the Far West weather zone grew by more than 15% between 2017 and 2018 and has more than doubled over the last decade. In contrast, ERCOT's system-wide peak demand growth rate has averaged approximately 1.7% over the last ten years. The ERCOT system peak demand grew 2,389 MW between 2016 and 2018, with the Far West weather zone accounting for 688 MW of that increase. Figure 4.3 shows the Far West weather zone peak demand since 2009.

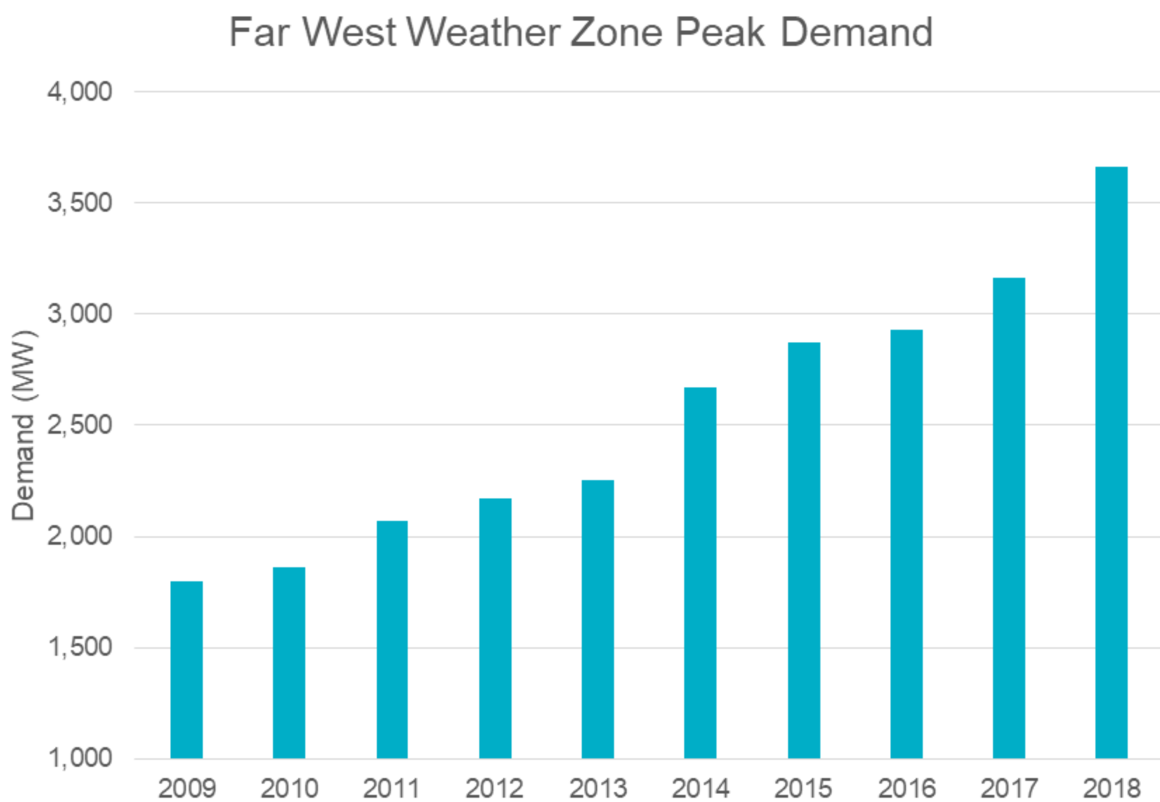


*Figure 4.3: Far West Weather Zone Peak Demand by Year*

Recent oil and gas industry activity in the Permian Basin has been concentrated in a few areas of intensive development. Figure 4.4 shows Permian Basin oil rig count information by county as of October 2018. The graphic also shows the increase or decrease in these rig counts since October 2017. In total, the Permian Basin added 79 oil rigs between October 2017 and October 2018. The rig count data indicates the rate of growth for the region since each oil rig represents new wells that are under development. Even if all oil rigs are removed from a county, it does not mean that the demand will be removed; rather it indicates that there is no more oil and gas growth in the county, though the demand is expected to continue for many years and even decades as the previously drilled wells remain operating. Conversely, if the rig count in a county increases, it indicates that the rate of growth is increasing in that area.

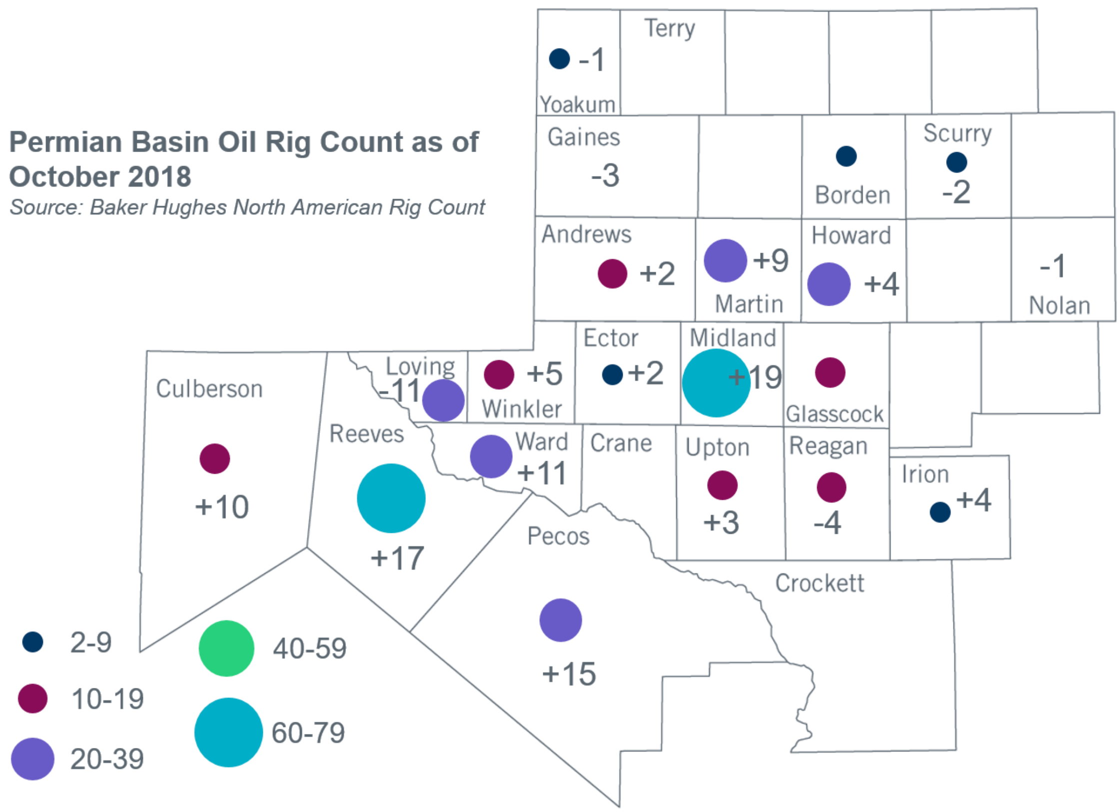


*Figure 4.4: Permian Basin Oil Rig Count and Annual Change by County*

The information in Figure 4.4 shows that most of the recent increase in Permian Basin oil and gas activity is concentrated in two sub-basins: 1) Delaware Basin (Culberson, Reeves, Loving, Ward, and Pecos Counties); and 2) Midland Basin (Midland, Martin, Howard, and Upton Counties). Due to previous transmission improvements that were put in place since 2012, the growth in the Midland Basin has not caused the need for additional transmission improvements. However, the load growth in the Delaware Basin, specifically the area known as the Culberson Loop, has caused the need for much of the planned transmission improvements in the Far West weather zone. This area has grown from experiencing a peak load of 22 MW in 2011 to exceeding 400 MW in 2018 and is expected to grow to over 1,000 MW by 2022. Figure 4.5 shows the planned transmission line additions in the Culberson Loop area.

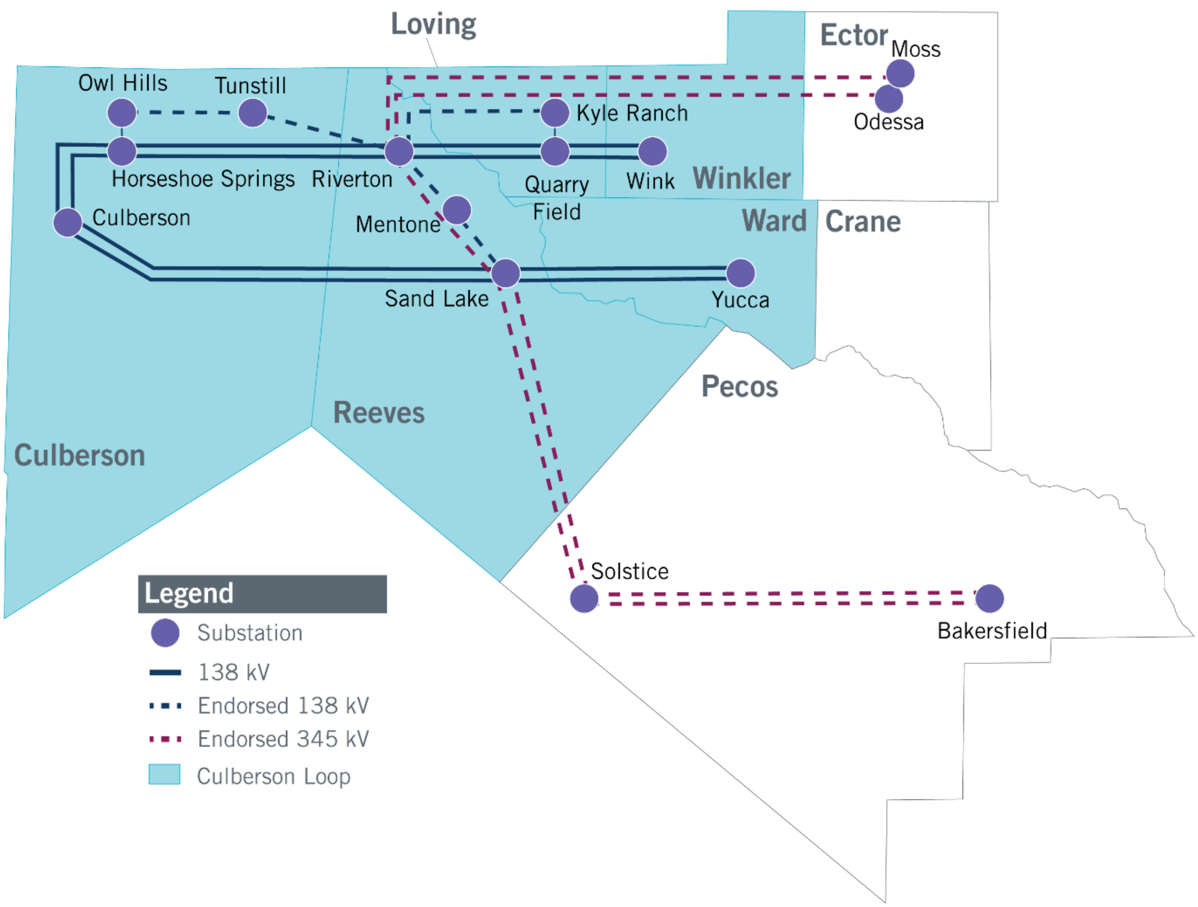


*Figure 4.5: Planned Transmission Lines in the Culberson Loop Area*

Ensuring that the necessary transmission improvements are in place in time to serve the growing load has been a challenge. This is 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 two to six years to complete planning studies, routing analysis (if needed), regulatory approvals, route acquisition (if needed), design, and construction. As an example, the transmission system of 2018 was largely planned between 2012 and 2015, but the Far West weather zone load forecast for 2018 increased substantially in 2016 and 2017. Figure 4.6 shows the change in the Culberson Loop load forecast over time.

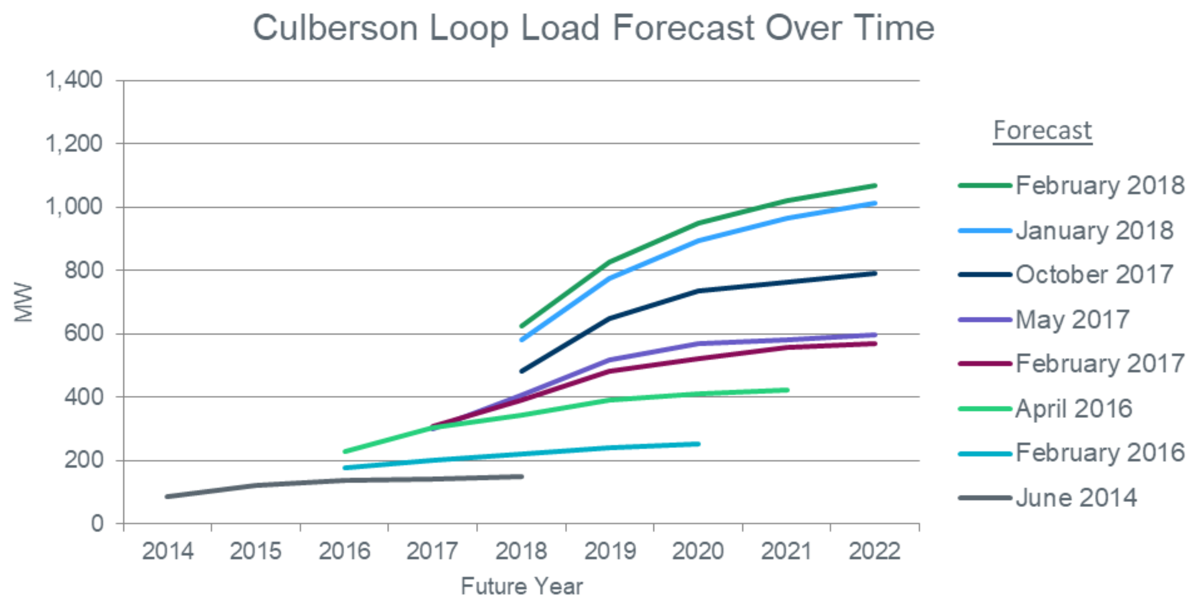


*Figure 4.6: Change in Culberson Loop Load Forecast Between 2014 and 2018*

When load grows faster than the transmission improvements can be put in place, it can result in congestion and reliability risks that system operators must manage. An example of this is the Yucca Drive-Gas Pad 138 kV line constraint, which had the highest amount of congestion rent on the ERCOT system in 2018 at $257,200,484. In October 2016, the ERCOT Board endorsed the Barilla Junction Area Improvement RPG Project, which included the planned rebuild of the Yucca Drive-Gas Pad 138 kV line. To meet the schedule of the rapidly developing load growth in the area and maintain reliable service to the customers during the upgrade, the TSP planned to perform the rebuild with the line energized by using temporary structures. Even with this plan, the load grew faster than anticipated which contributed to the high amount of congestion on this line until this and other improvements were put in service in the area (see Chapter 3 for more information).

To address the uncertainties regarding load growth in the Far West weather zone, ERCOT has employed several strategies. One strategy is designing expandability into the recommended transmission improvements, for instance, constructing a transmission tower to be double circuit capable if only one circuit is needed at the time and/or to be capable of operating at a higher voltage. As an example, in 2016 ERCOT recommended the Riverton-Sand Lake 138 kV line be constructed to have the capability to add a second circuit later and also be capable of 345 kV service, even though the identified need at the time was only for one 138 kV circuit. Nevertheless, in 2018 the need became apparent, and ERCOT recommended a Riverton-Sand Lake 345 kV circuit be added to the towers. Having the expandability designed in the beginning will allow the circuit to be put in place quicker – currently planned for 2020 – to meet the growing demand in the area. Other strategies include performing higher-than-expected load growth sensitivity studies, working closely with area TSPs to understand their projections of demand growth, and allowing TSPs more flexibility in their load forecasts used for transmission planning.

Even with these strategies in place, it is still possible that short-term, high-impact constraints, like the Yucca Drive-Gas Pad 138 kV line, will occur in the future due to faster than expected load growth. For example, there are several transmission improvements that are scheduled to be in service in the Culberson Loop area in 2019 to serve the load growth. However, if the load grows faster than anticipated it is possible that operators will have new reliability risks to manage in the spring of 2019, until the improvements are energized.

### Bearkat Area Project

As of November 2018, there were a total of 1,368 MW of wind generation capacity that was either connected to or planned to connect by 2021 to the Bearkat substation in Glasscock County. Limited existing transmission infrastructure in the Bearkat area (one 345 kV circuit and one 345/138 kV transformer) is expected to cause congestion for more than 50% of hours in a given year. This congestion will result in restrictions on the wind generation in the Bearkat area for the contingency loss of the 345 kV circuit.

In 2017, the TSP in the area proposed a transmission project to relieve the congestion. Upon the completion of ERCOT's independent review of the project, the ERCOT Board endorsed a new, approximately 27 mile 345 kV line from Bearkat to Longshore, based on ERCOT economic planning criteria. This improvement is expected to be in service in 2022 and will reduce congestion in the Bearkat area. Figure 4.7 shows a map of the area.

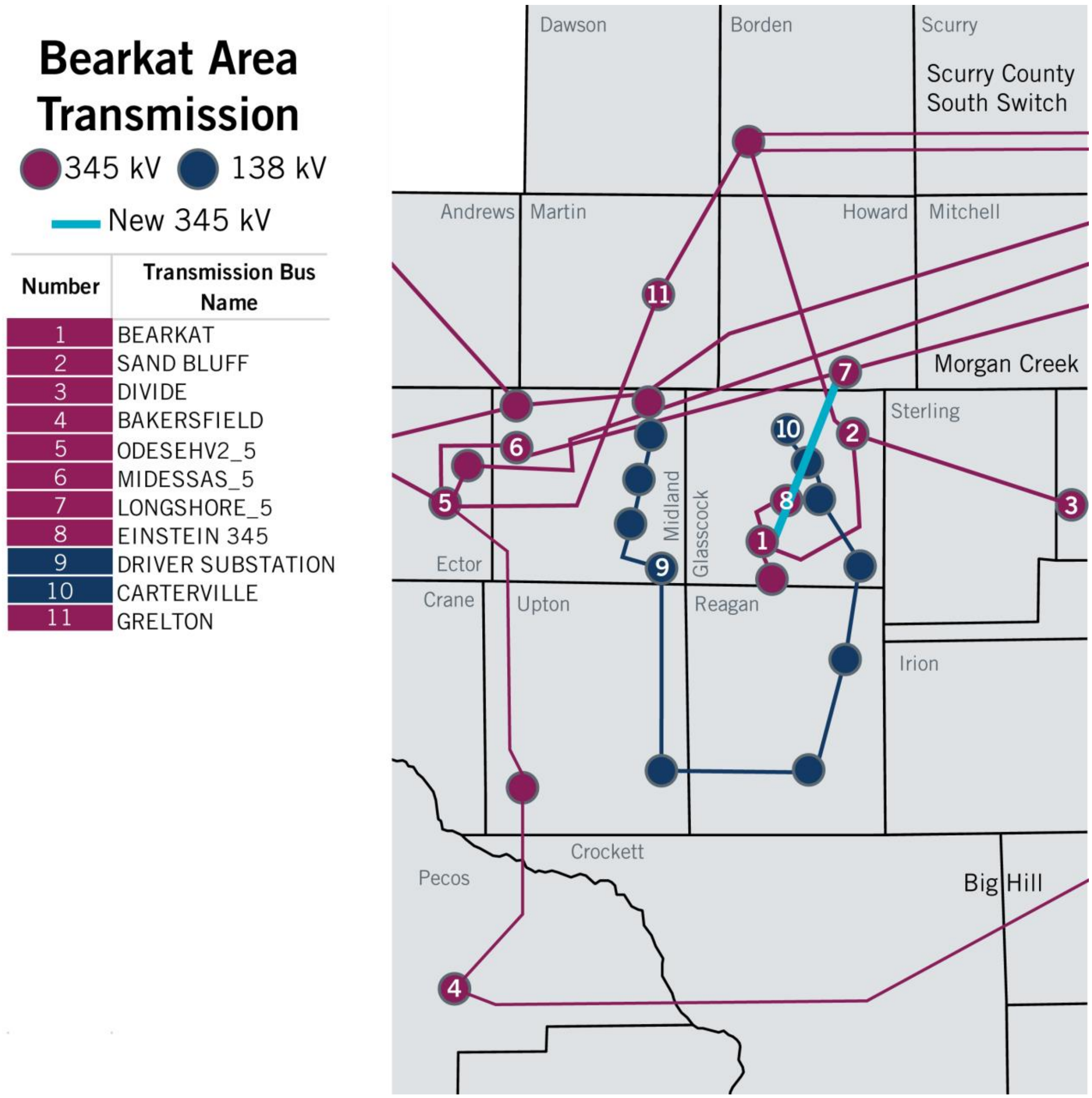


*Figure 4.7: Bearkat Area Transmission*

## Additional Reliability-Driven Planned Projects

Continued customer demand growth throughout the state is a key driver of the need for transmission improvements in the ERCOT region. The recently completed 2018 Regional Transmission Plan (RTP) identified 38 transmission projects needed to satisfy reliability planning criteria in the 2020 to 2024 timeframe, 22 of which were identified in prior planning studies. The projects included approximately 360 miles of transmission upgrades and 240 miles of new circuits. Figures 4.8 and 4.9 show the number of transmission improvements identified in the RTP by weather zone and type (a project may contain multiple improvements), respectively. More information on these projects can be found in the 2018 RTP report posted on the ERCOT Market Information System website.

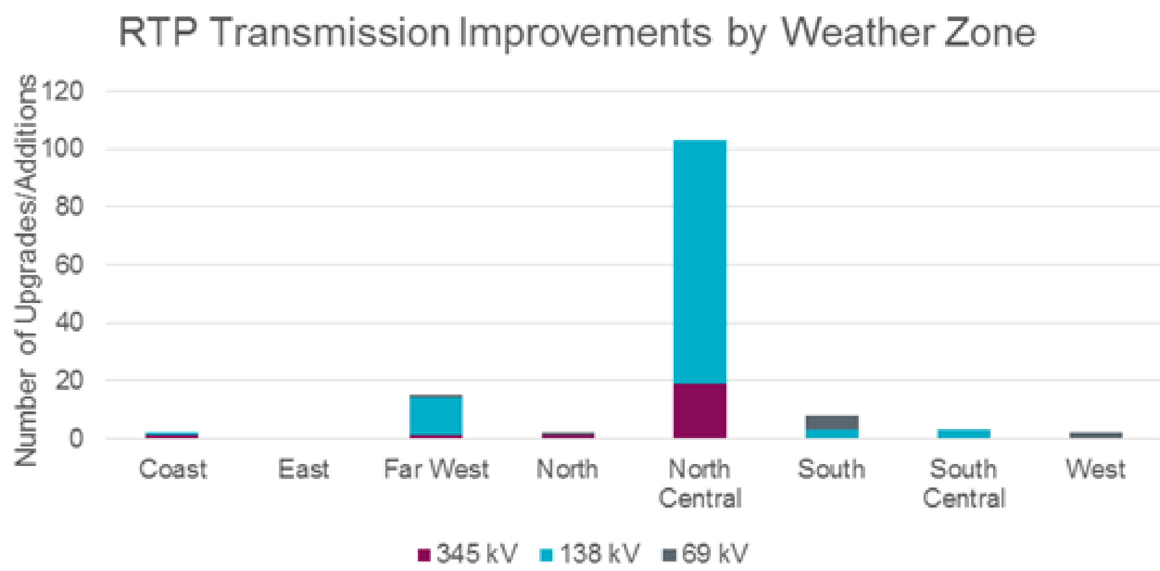


*Figure 4.8: RTP Transmission Improvements by Weather Zone*

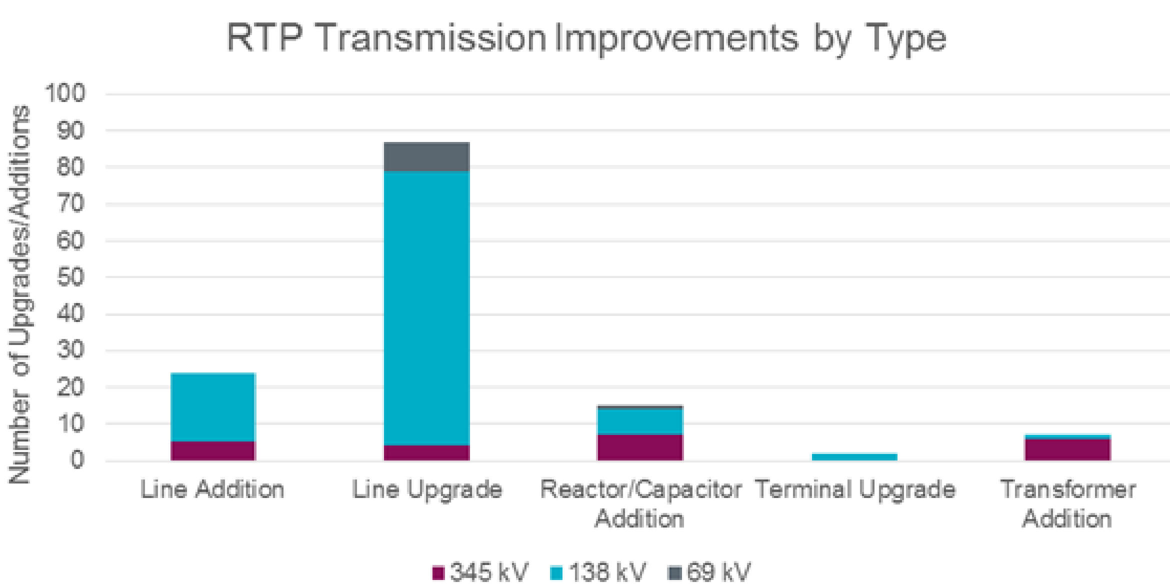


*Figure 4.9: RTP Transmission Improvements by Type*

# Chapter 5. Load Integration

Recently, utilities either not currently connected to, or not fully connected to, the ERCOT grid have proposed switching all or parts of their systems into ERCOT. Following is a brief description of the Lubbock Power and Light and Rayburn Country Electric Cooperative proposals.

## Lubbock Integration

Currently, the Lubbock Power and Light (LP&L) system is connected to the Southwest Power Pool (SPP) grid in the Eastern Interconnection. In 2015, LP&L expressed a desire to disconnect a majority of its system, including approximately 470 MW of load, from the SPP grid and connect it to the ERCOT grid. The PUCT asked ERCOT to perform an integration study for the LP&L system. Figure 5.1 shows the location of Lubbock relative to the ERCOT transmission system.

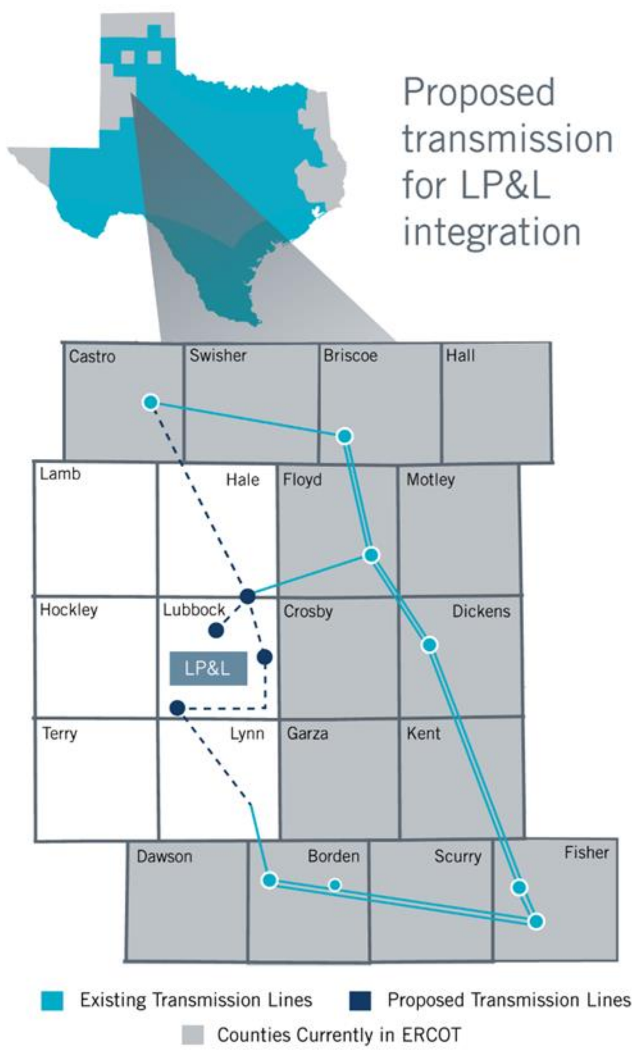


*Figure 5.1: LP&L Integration*

ERCOT's Lubbock Integration study focused on identifying the most cost-effective transmission facilities necessary to integrate the LP&L system into the ERCOT grid while meeting the applicable reliability standards. The study, which was completed in June 2016, included a recommendation for the transmission facilities ERCOT preferred should LP&L integrate into the ERCOT grid. The recommended transmission facilities were estimated to cost $364 million.

Following ERCOT's filing of the Lubbock Integration study, the PUCT asked ERCOT and SPP to perform a full impact analysis of the potential LP&L system move to ERCOT. ERCOT and SPP jointly created a study scope for the analysis and then separately performed the requisite studies. Both ERCOT and SPP filed their impact studies with the PUCT in June 2017; these studies are available online in PUCT Docket No. 47576.

In early 2018, the PUCT approved LP&L's request to move to ERCOT. The transition is expected to take place by June 2021 following the construction of the integration facilities, which include five new 345 kV lines, six 345/115 kV transformers, and several 115 kV lines.

### Rayburn Country Electric Cooperative Integration

Rayburn Country Electric Cooperative (RCEC) has a total peak load of about 1,000 MW. Most of this load is within the ERCOT system; however, approximately 190 MW is served from 138 kV transmission facilities within the Eastern Interconnection in the SPP region. The 190 MW load served from the Eastern Interconnection is located in Kaufman, Van Zandt, Henderson and Anderson Counties. RCEC is seeking to transfer this 190 MW load and most of the associated 138 kV transmission facilities from the Eastern Interconnection into ERCOT by December 2019 with the aim of having the entire RCEC load being served by ERCOT transmission facilities at the conclusion of this proposed transfer.

The PUCT asked ERCOT to perform an integration study for the RCEC load. ERCOT concluded its study and filed the study report with the PUCT in June 2017 (available in PUCT Project No. 47342). The PUCT also asked ERCOT and SPP to perform a full impact analysis of the potential move. ERCOT filed the impact analysis report with the PUCT in early 2018 (also available in PUCT Project No. 47342). As of November 2018, the interested entities were engaged in settlement negotiations in regards to the details of the RCEC integration (see PUCT Docket No. 48400).

# Chapter 6. Projected Constraints

## High Renewable Penetration Stability Constraints

Over the last 20 years, the ERCOT resource mix has shifted to include an increasing amount of renewable generation, primarily from wind generation resources. Recently, ERCOT has also begun to experience rapid growth in the amount of transmission-connected solar generation resources supplying energy. Figure 6.1 shows the change in ERCOT generation capacity, in terms of overall percentage, from the late 1990s to 2018.

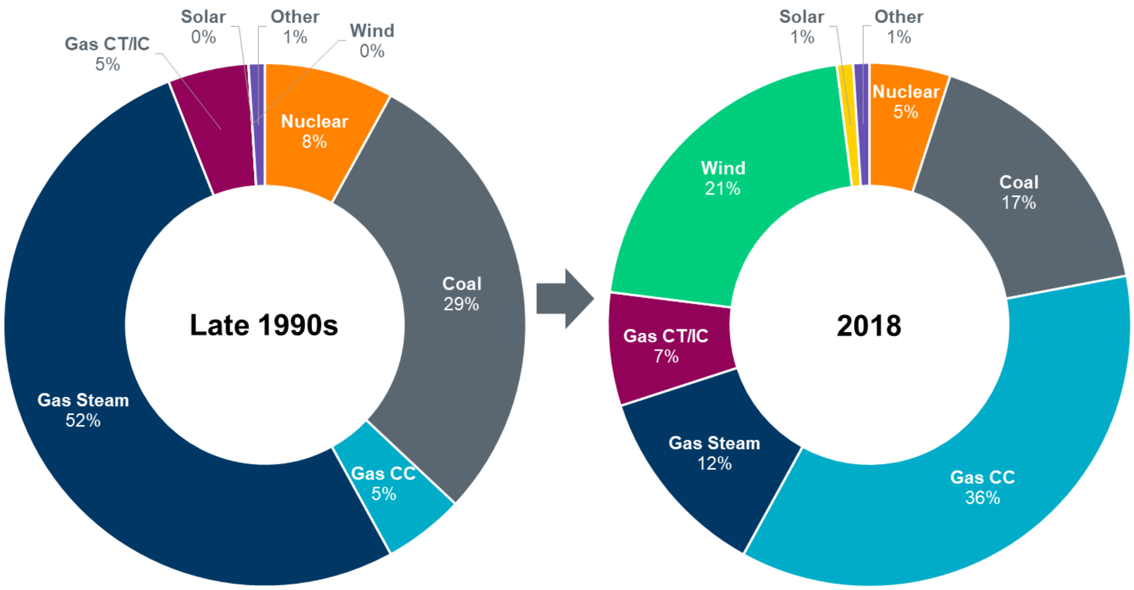


*Figure 6.1: Change in ERCOT Generation Capacity Mix*

Several indicators suggest the trend of increasing wind and solar resources in ERCOT will continue over at least the next 10 to 15 years. Of the proposed generation projects under study for interconnection as of October 2018, 86% of the capacity was for wind and solar resources. Figure 6.2 shows the mix of proposed new generation resource capacity under study.

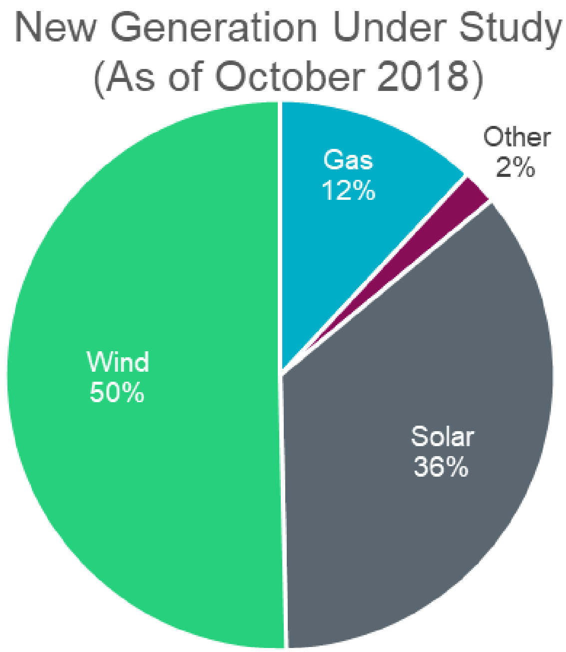


*Figure 6.2: New Generation Capacity Mix Under Study*

Another indicator that the amount of wind and solar resources will continue to increase on the ERCOT grid is that the results of the 2014, 2016, and, most recently, 2018 Long-Term System Assessments (LTSA) all show a significant amount of these resources being added over the next 10 to 15 years across a wide range of scenarios. As an example, the 2018 LTSA shows a range of 4,200 MW to 20,500 MW of wind and solar resources could be added to the ERCOT grid by 2033, depending on the scenario. See Chapter 7 for more information on the 2018 LTSA.

Wind and solar resources use inverters to convert the energy they produce into electrical energy for the grid. Inverter-based resources interact with the grid in a fundamentally different way than conventional synchronous resources and actually rely on conventional synchronous resources in order to operate reliably. Hence, the addition of more inverter-based resources has the compound effect of requiring more support from synchronous resources while at the same time displacing those synchronous resources.

Additionally, most wind and solar resources being added to the ERCOT grid are located in West Texas, whereas the resources they are displacing are primarily located in the eastern part of the state, closer to the major load centers. This has the effect of causing increased west-to-east power transfers across the state. While the CREZ project was constructed to facilitate these transfers, in several parts of the system power flows are reaching the limits of what the CREZ transmission lines were designed to carry. Nearly half of the total capacity of wind generation in ERCOT has been installed since the completion of the CREZ project at the end of 2013. Figures 6.3 and 6.4 show the recent and projected increase in wind and solar generation, respectively, in ERCOT.

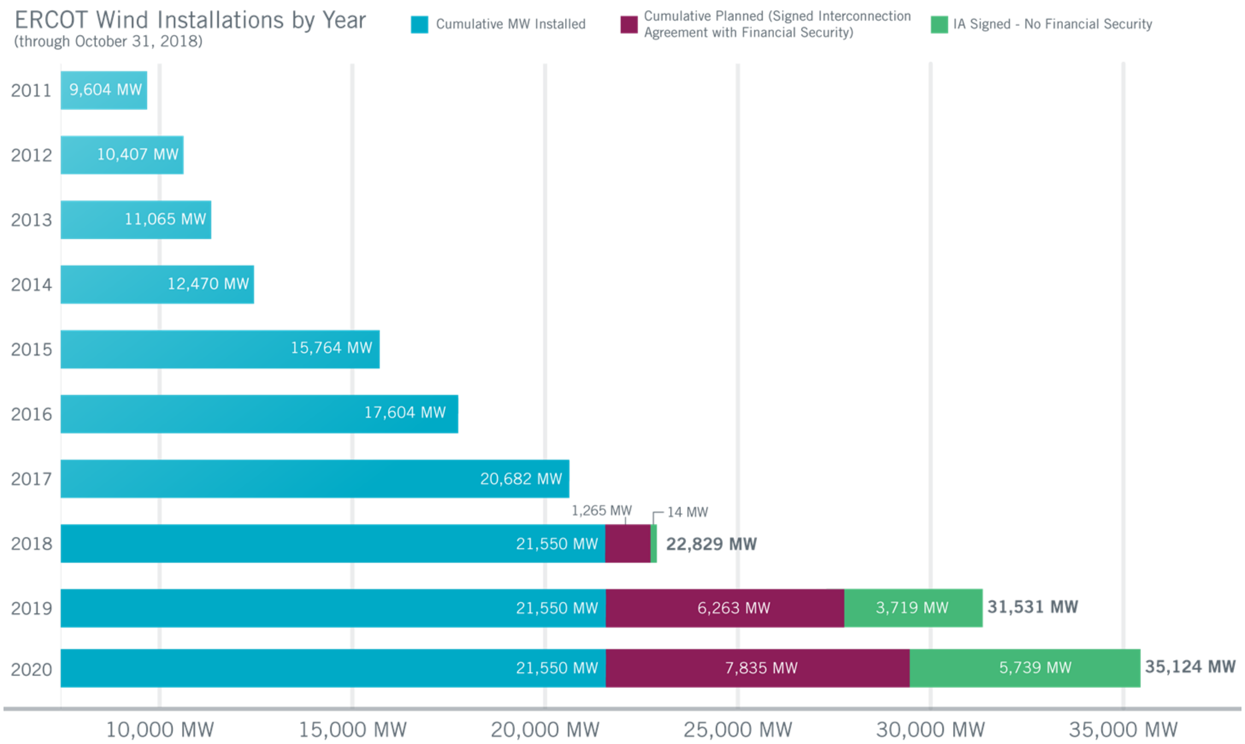


*Figure 6.3: Wind Generation Growth*

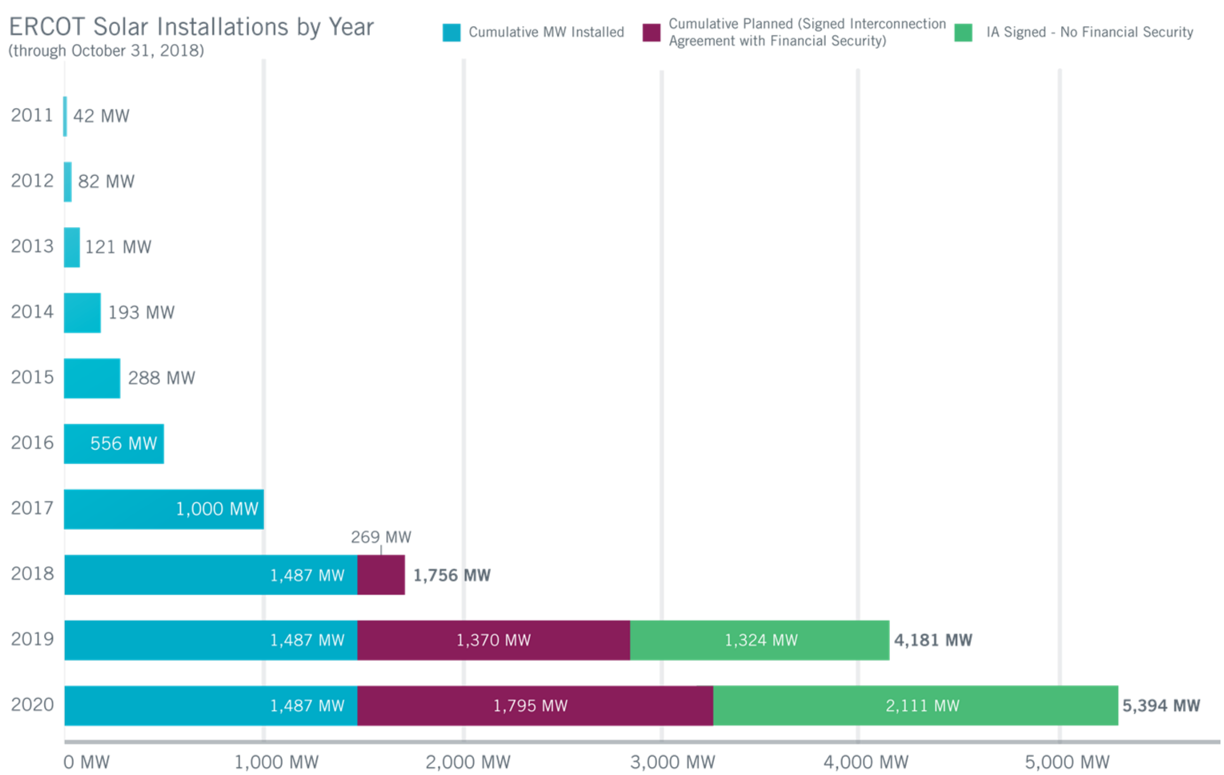


*Figure 6.4: Solar Generation Growth*

To understand potential future constraints on the grid, ERCOT completed a study in early 2018 analyzing a scenario in which 70% of the system load is supplied by wind and solar resources during off-peak conditions. To date, the highest instantaneous penetration of wind generation was 54%, which occurred in October 2017. The study demonstrated the need to perform detailed stability analyses when analyzing future system conditions involving high penetrations of inverter-based resources. The study also made recommendations regarding the modeling, performance, and system improvements that will be necessary to maintain a stable grid in the future, including the potential for a new transmission line between West and Central Texas. ERCOT will continue to analyze these issues and work to identify the most cost-effective solutions to address these challenges. The full report is posted on the ERCOT website at:
http://www.ercot.com/content/wcm/lists/144927/Dynamic_Stability_Assessment_of_High_Penetration_of_Renewable_Generation_in_the_ERCOT_Grid.pdf

Figure 6.5 illustrates the scenario analyzed in the study.

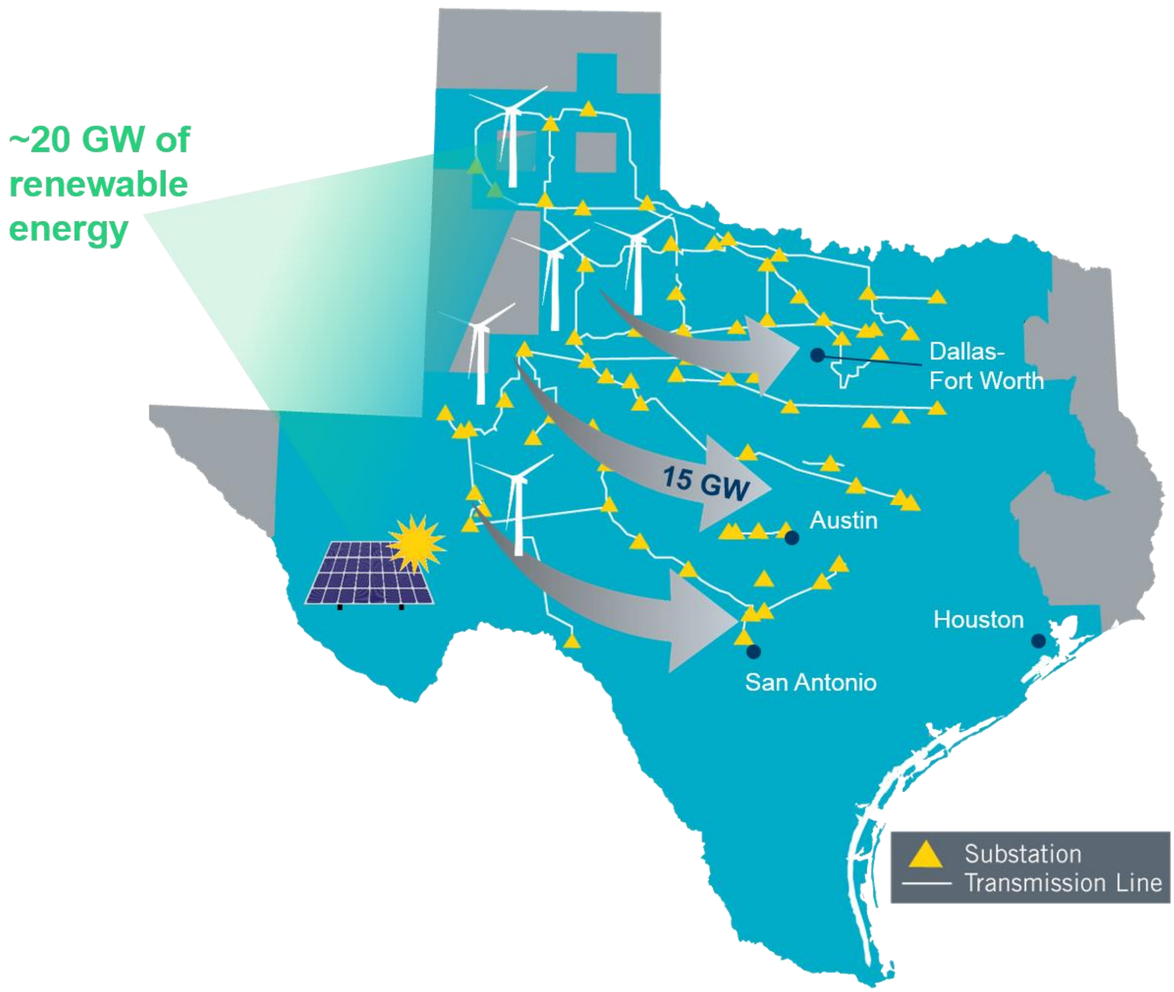


*Figure 6.5: Generation Transfer Overview in the High Renewable Penetration Study*

### 2020 and 2023 Projected Constraints

Future year constraints are also analyzed as part of the annual Regional Transmission Plan (RTP). Projects are identified to resolve the constraints expected to cause the most congestion on the system. If a project meets the economic planning criteria by sufficiently reducing overall system costs, it is included in the recommended project set. Often, however, the annualized capital cost of the project is greater than the expected system wide production cost savings. When this occurs, the project will not be constructed and the congestion will persist. Table 6.1 and Figure 6.6 show the constraints projected to be the most congested for 2020 and 2023 based on production-cost simulation modeling conducted as part of the 2018 RTP.

Table 6.1: List of Projected Constraints (2020, 2023)

| Map Index | Projected Constraining Element | 2020 Congestion | 2023 Congestion |
|---|---|---|---|
| 1 | South Texas Project-Jones Creek 345 kV Line | High | |
| 2 | Kendall-Bergheim 345 kV Line | High | High |
| 3 | Panhandle Export | High | High |
| 4 | Oasis-W. A. Parish 345 kV Line | High | |
| 5 | Big Brown-Jewett 345 kV Line | Medium | High |
| 6 | Cagnon-Kendall 345 kV Line | Medium | Medium |
| 7 | Carterville-Einstein Tap 138 kV Line | High | |
| 8 | Rogershill-Bosque Switch 138 kV Line | Low | Medium |
| 9 | Bergheim 345/138 kV Transformer | Low | High |
| 10 | DuPont Switch-Dupont PP1 138 kV Line | Low | Medium |
| 11 | General Tire Switch-Southwest Portland Tap 138 kV Line | Medium | |
| 12 | Tilden-Fowlerton 138 kV Line | Medium | Medium |
| 13 | Milo-Laredo VFT North 138 kV Line | Low | Medium |
| 14 | Wirtz-Flatrock 138 kV Line | Low | Low |
| 15 | Kingsville-Kleberg 138 kV Line | Low | Low |

**Legend** Low | Medium | High

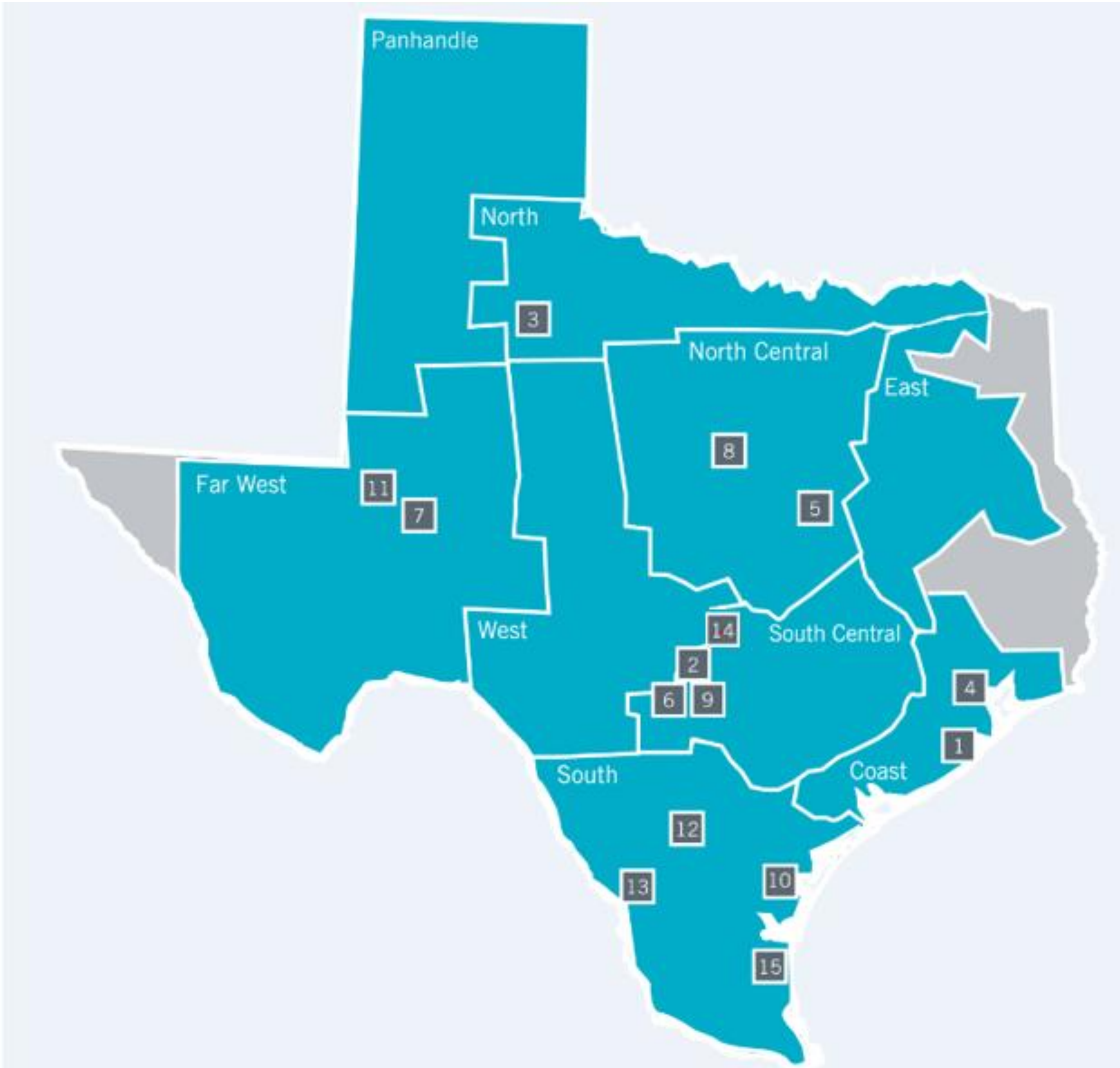


*Figure 6.6: Projected 2020 and 2023 Constraints*

# Chapter 7. Long-Term System Assessment

ERCOT's planning process covers several time horizons to identify and endorse new transmission investments. The near-term needs are assessed in the six-year planning horizon through the development of the Regional Transmission Plan (RTP). The Long-Term System Assessment (LTSA) provides an evaluation of the potential needs of ERCOT's extra-high voltage (345 kV) system in the 10- to 15-year planning horizon.

The LTSA guides the six-year planning process by providing a longer-term view of system reliability and economic needs. Whereas in the six-year planning horizon a small transmission improvement may appear to be sufficient, the LTSA planning horizon may reveal that a more extensive project could be required. A larger project may also be more cost-effective than multiple smaller projects — each being recommended in successive RTPs.

ERCOT studies different scenarios in its long-term planning process to account for the inherent uncertainty of planning the system beyond six years. The goal of using scenarios in the LTSA is to identify upgrades that are robust across a range of scenarios, or more economical than the upgrades that would be determined considering only near-term needs.

Stakeholders developed five different scenarios for the 2018 LTSA: Current Trends, High Economic Growth, High Renewable Penetration, High Renewable Cost, and Emerging Technology. Using the assumptions and guidelines set by stakeholders in the scenario descriptions, ERCOT prepared different load forecasts.

Planning for transmission 10 and 15 years in the future requires ERCOT to make assumptions regarding what types of new resources can be developed. ERCOT conducted generation expansion and retirement analysis for the five future scenarios using the guidelines set by stakeholders in the scenario descriptions. ERCOT performed detailed transmission expansion analysis on the Current Trends scenario.

Based on the results of the analyses that went into the 2018 LTSA, ERCOT made the following key findings:

- All five scenarios showed a significant amount of solar generation additions, ranging from a low of 3,900 megawatts (MW) to a high of 15,100 MW. Two scenarios showed some retirement of coal and gas generation. Higher amounts of wind and gas generation additions were also seen compared to previous LTSA studies.
- The scale of solar generation additions is dependent upon access to the solar-rich sites in the Far West Texas region.
- There may be generation capacity challenges during the summer in the hours ending 2000 to 2200 in scenarios with a large amount of solar generation.
- The Emerging Technology scenario, which reflected an assumed high adoption rate in the electrification of the transportation sector in Texas, showed a significant change in the load profile. For instance, the peak hour of the day shifted from hour

ending 1700 to 2200 in the night and the magnitude of this peak was also approximately 15% higher than conventional load. The load profile and generation expansion implications of the changing load shape in this scenario suggest that electric vehicle adoption and the resulting vehicle charging patterns should be monitored going forward.

- Expected continued generation additions in the Far West region will necessitate transmission improvements in the area to allow exports of solar and wind generation to ERCOT load centers. Specifically, new transmission lines between West Texas and San Antonio, and between the Far West and West weather zones were found to be economically viable.

In all five scenarios, a mix of solar, wind, and gas generation was added to the system to serve growing demand and replace retired capacity. Solar generation additions represented the largest resource capacity change on the system in three of the five scenarios. As seen in Figure 7.1, total utility-scale solar generation capacity additions ranged from 3,900 MW to 15,100 MW in the five scenarios. Conversely, two of the five scenarios had varying levels of coal and gas generation retirements.

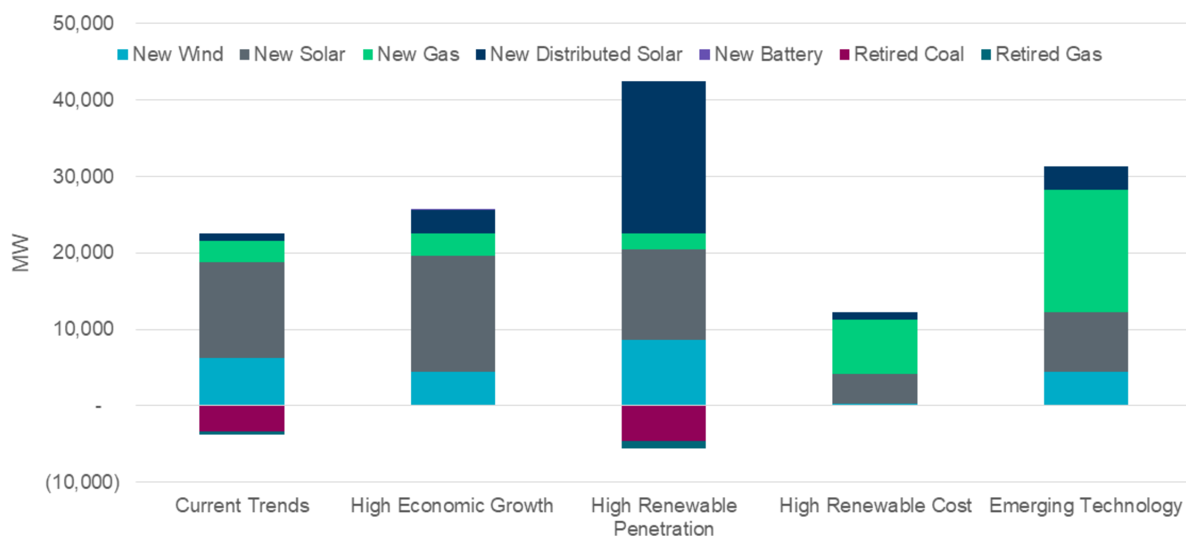


*Figure 7.1: LTSA Generation Capacity Additions and Retirements Across Scenarios*

The 2018 LTSA capacity expansion modeling results indicated a potential operational challenge due to capacity shortages in summer evenings when solar generation ramped down. This same potential generation capacity challenge was found in the 2016 LTSA modeling results. While the generation capacity shortage occurred in a relatively small number of hours, these modeling results indicate that conventional peaking generation units, such as combustion turbines, may not be able to recover investment costs to serve the evening peak demand. To meet this net peak demand requirement, other resources will need suitable ramping capabilities and be financially viable even though they could only be operated a limited number of hours each year.

In the Emerging Technology scenario, based on the assumed charging patterns and assumed high electric vehicle adoption in Texas, the total peak charging demand was estimated to be over 18,500 MW, occurring at midnight. Approximately 5,000 to 6,000 MW of charging demand was expected during hours ending 1600 to 1800. As a result of this increase in demand and changed load shape, the generation expansion model added approximately 9,000 MW more new generation capacity than in the Current Trends scenario. The Emerging Technology scenario also reflected fewer generation retirements than the Current Trends scenario. High charging demand primarily occurred at night when solar generation is not available. As a result, the Emerging Technology scenario had the most new gas generation among all scenarios studied.

One sensitivity case, in which electric vehicle adoption was assumed to be 50% of that in the Emerging Technology scenario, was developed to investigate the relationship between generation expansion results and adoption level of electric vehicles. Figure 7.2 shows the generation expansion model results for generation capacity additions by type and retirements for the Current Trends scenario, the Emerging Technology scenario, and the Emerging Technology scenario sensitivity case. The Emerging Technology scenario sensitivity case generation expansion results were approximately midway between the Current Trends and Emerging Technology scenario results in terms of gas and solar generation additions and generation retirements. Thus, the sensitivity showed a positive correlation between electric vehicle adoption and gas generation additions and generation retirements and a negative correlation with solar generation additions.

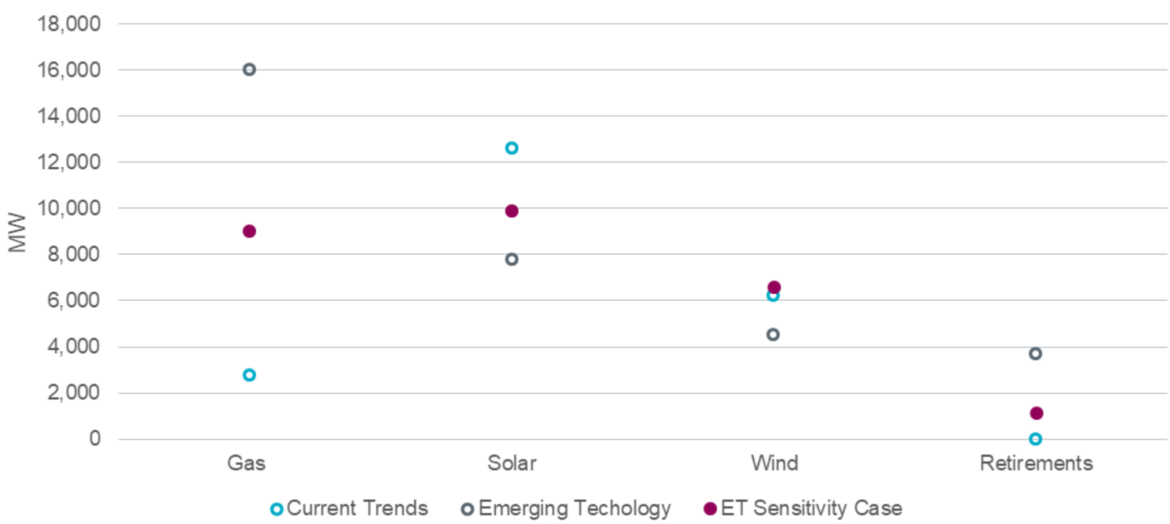


*Figure 7.2: Generation Capacity Additions by Type and Retirements for Current Trends, Emerging Technology, and Emerging Technology Sensitivity Scenarios*

The addition of solar generation in the western part of the state coupled with the retirement of coal and gas generation in the eastern part of the state could result in significant increases in west-to-east power flows on the transmission system. This outcome was noted in the results from the transmission expansion analysis.

The observed increase in west-to-east power flows resulted in the need for transmission system improvements including existing 345 kV line upgrades and new extra high voltage paths in order to reliably deliver power to the load centers. Figure 7.3 and Table 7.1 highlight some of the significant transmission improvements found to be needed in the Current Trends scenario.

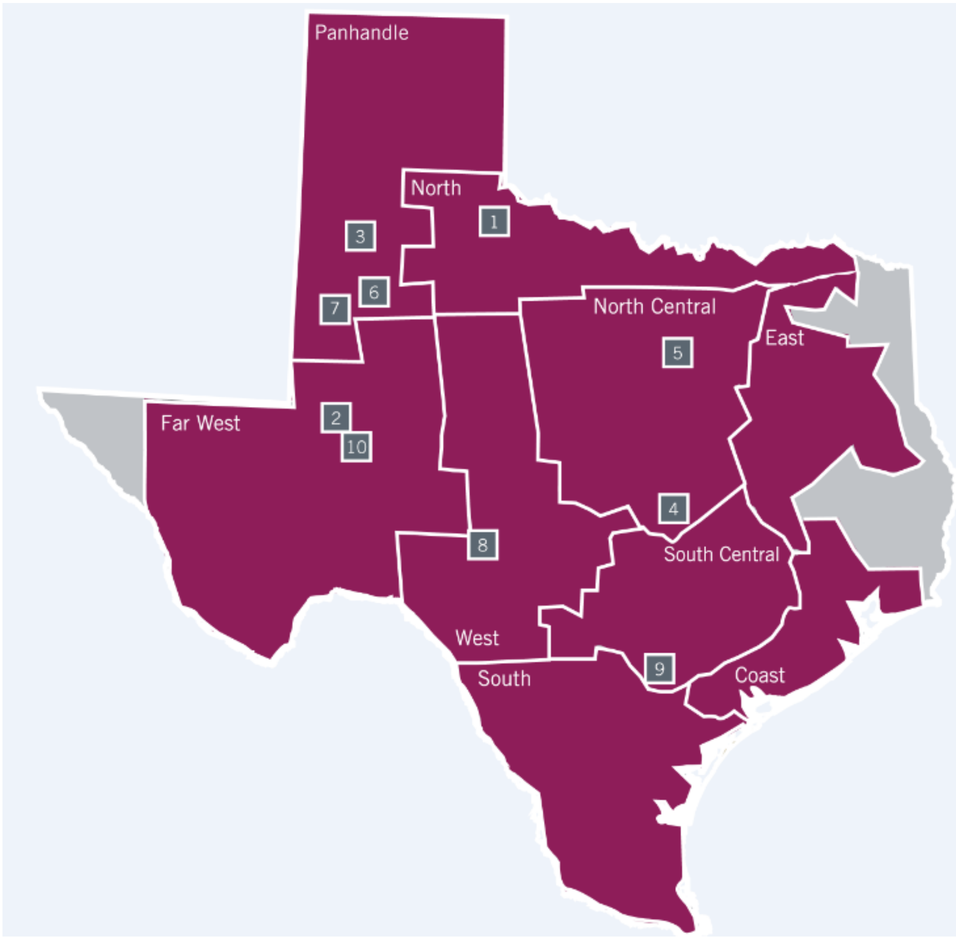


*Figure 7.3: Significant Transmission Improvements Identified for Current Trends Scenario*

Table 7.1: Current Trends Scenario Transmission Improvements

| Map Index | Transmission Improvement | In-Service Year |
|---|---|---|
| **1** | Add Oklaunion-Jacksboro 345 kV Line | 2028 |
| **2** | Add Odessa-Bearkat 345 kV Line | 2028 |
| **3** | Add Lubbock Loop 345 kV Line | 2028 |
| **4** | Add Northwest Austin Metro 345 kV Line and 345/138 kV Transformer | 2028 |
| **5** | Add Northwest Dallas-Fort Worth 345 kV Line | 2028 |
| **6** | Add Faraday-Morgan Creek 345 kV Line | 2028 |
| **7** | Add Long Draw-Dermott 345 kV Line | 2028 |
| **8** | Add West Texas to San Antonio 345 kV Line | 2028 |
| **9** | Upgrade Bergheim 345/138 kV Transformer | 2028 |
| **10** | Add Odessa EHV-Moss 345 kV Line | 2033 |

## Chapter 8. Southern Cross

ERCOT currently has five asynchronous ties to other grids: two connections to the Eastern Interconnection with a total capacity of 820 MW, and three ties to the Mexican system with a total capacity of 430 MW. These ties allow ERCOT and the connecting grids to exchange power in emergencies and for entities to trade power between the grids on a commercial basis.

Southern Cross Transmission has proposed building a 2,000 MW merchant tie between ERCOT and the Eastern Interconnection. The tie would connect into the existing ERCOT system in Rusk County and in the Eastern Interconnect would terminate in eastern Mississippi. Power would flow between terminals via an approximately 400-mile High Voltage Direct Current (HVDC) line. The developer expects to begin commercial operation in late 2023.

The PUCT has granted conditional approval for the facilities necessary to connect the Southern Cross project to ERCOT. However, due to the unique commercial nature and size of the tie, the PUCT has asked ERCOT to complete 14 directives to accommodate the project. The outcome of some of the directives may include changing ERCOT Bylaws, Protocols, or guides. ERCOT began working with stakeholders on these directives in 2017.

As part of the work on the PUCT directives, ERCOT is performing a transmission planning study to identify constraints, limitations, and transmission upgrades necessary to meet planning criteria with the Southern Cross project. ERCOT began this study in the third quarter of 2018 and expects to complete it in early 2019. ERCOT will share the results with stakeholders and the PUCT when complete.

# Chapter 9. Contacts and Links

## Contacts and Information

For general communications and queries, the public can submit a request for information at: http://www.ercot.com/about/contact/inforequest

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512-275-7432

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## Internet Links

ERCOT Home Page: http://www.ercot.com

Market Information System: https://mis.ercot.com/pps/tibco/mis
Users must obtain a digital certificate for access to this area. Folders in this area include data, procedures, reports and maps for both operations and planning purposes. Helpful information that can be found on this site includes the following:

- Generation Project Interconnection Information
- Regional Planning Group Information
- Steady-State Base Cases

# Chapter 10. Disclaimer

This report was prepared by the Electric Reliability Council of Texas (ERCOT) staff. It is intended to be a report of the status of the transmission system in the ERCOT region and ERCOT's recommendations to address transmission constraints. Transmission system planning is a continuous process. Conclusions reached in this report can change with the addition (or elimination) of plans for new generation, transmission facilities, equipment, or loads. Information on congestion costs presented herein is based on the most recent settlement calculations at the time of the development of this report. Future settlements as well as ERCOT Board of Directors and Public Utility Commission of Texas directives may change the figures presented herein.

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