Report on Existing and Potential Electric System Constraints and Needs
December 2016

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 in the transmission system that pose reliability concerns or may increase costs to the electric power market and, ultimately, to Texas consumers. 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 Substantive Rules 25.362(i)(2)(I) and 25.505(c).

For the second straight year the most significant constraint on the ERCOT system was related to the import of power into the Houston area from the north. From October 2015 through September 2016 this constraint has experienced over $64 million in congestion rent. As seen in Figure ES.1, this congestion has been steadily increasing since 2012.

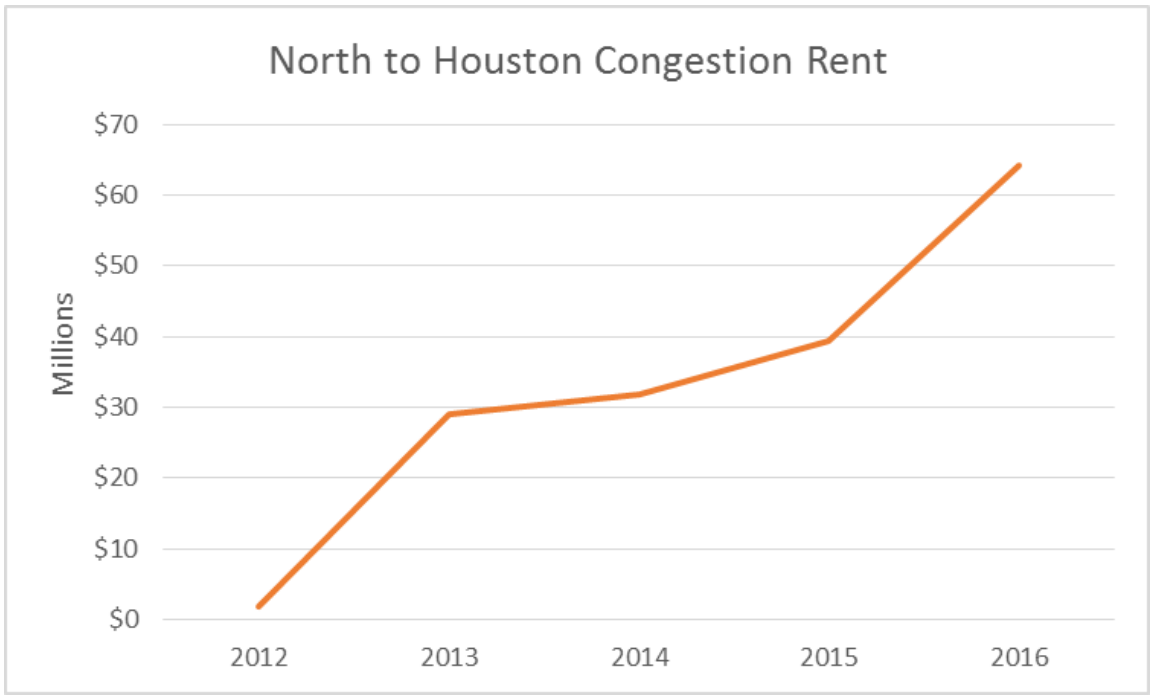

Figure ES.1: North to Houston Congestion Rent by Year

This trend is caused by the combination of load growth and aging and retiring generation in the Houston area. Together these factors have resulted in the increase of power imports into the area. Figure ES.2 shows the relative age of the generation fleet in the Houston area.

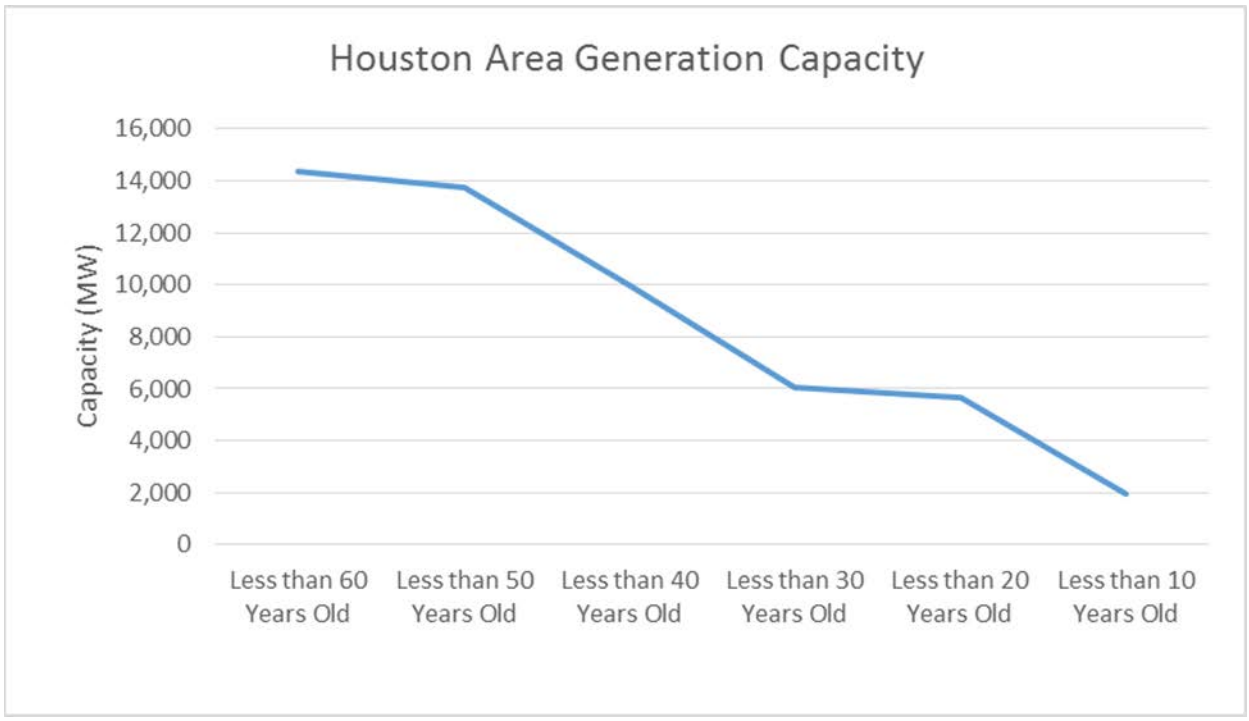

Figure ES.2: Aging Houston Area Generation Capacity

In 2016, the owner of the generation unit at the Greens Bayou plant in the Houston area submitted notice to ERCOT that they would like to retire the unit from the ERCOT market. ERCOT performed reliability analysis for Greens Bayou and found that without the unit there were reliability criteria violations for the 345 kV lines importing power into the area from the north under conditions where other generation units in the Houston area were out of service. Because of this result, ERCOT entered into a Reliability-Must-Run Agreement with the Greens Bayou unit. Fortunately, the generation outage conditions that would have led to the reliability issues did not occur over the summer of 2016 so ERCOT did not need to call on the Greens Bayou unit to run, but the RMR Agreement was in place in case those conditions did occur.

The long-term solution for relieving the constraints for the area is the Houston Import Project, which includes the construction of a new 345 kV import path from the north. This project was endorsed by the ERCOT Board of Directors in 2014 and is expected to be in-service by the summer of 2018.

The Panhandle represents another region of concern due to increasing congestion. Although the export constraint from this area had only the seventh highest amount of congestion rent in 2016, it is expected that it will have the highest amount of congestion in the future due to the increasing amount of generation being added in the area behind the export constraint. Figure ES.3 shows the amount of existing and planned generation in the Panhandle by year.

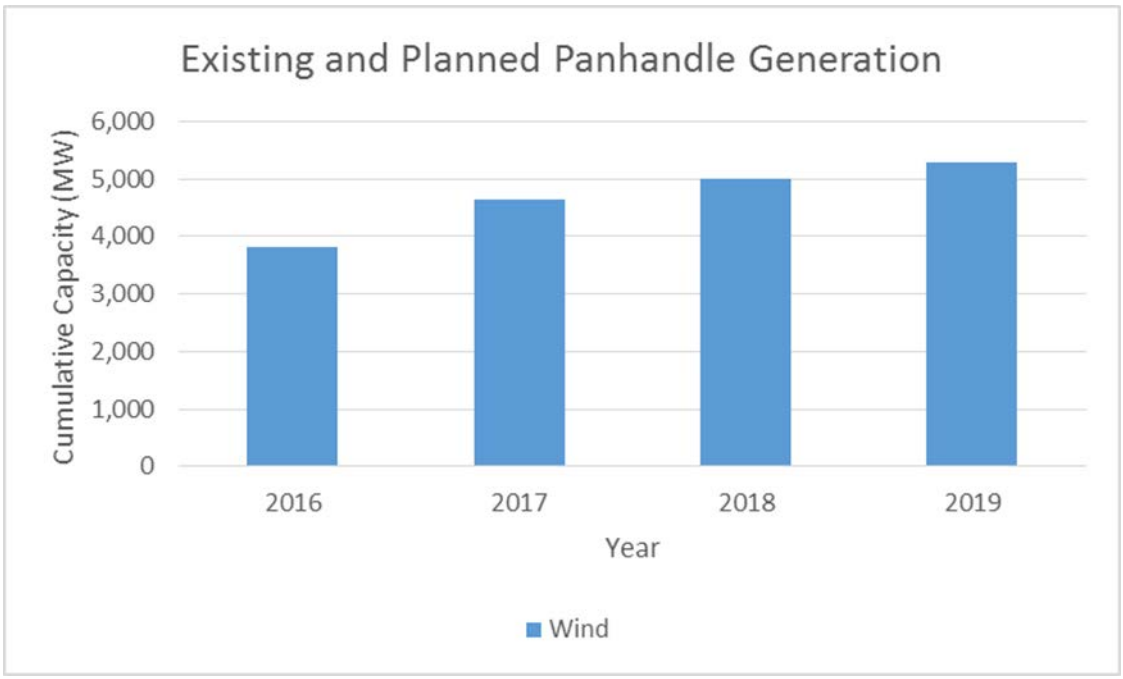

Figure ES.3: Cumulative Existing and Planned Panhandle Generation Capacity

In addition to the existing and planned Panhandle generation shown in Figure ES.3, there are another 11,850 MW of solar and wind generation under study in the interconnection queue.

To address this expected congestion there are two projects planned for the region. One will add two synchronous condensers; the second will add a second 345 kV circuit to an existing transmission line. Both projects, which are expected to be in-service by 2018, will lessen, but not eliminate, stability constraints associated with exporting a large amount of wind-generated power from the area. ERCOT is currently evaluating the need for additional transmission projects to allow greater Panhandle power exports.

For the first time in many years none of the top fifteen constraints on the ERCOT system were related to oil and gas demand growth from oil and gas customers in West Texas. However, load growth in the area remains strong as can be seen in Figure ES.4.

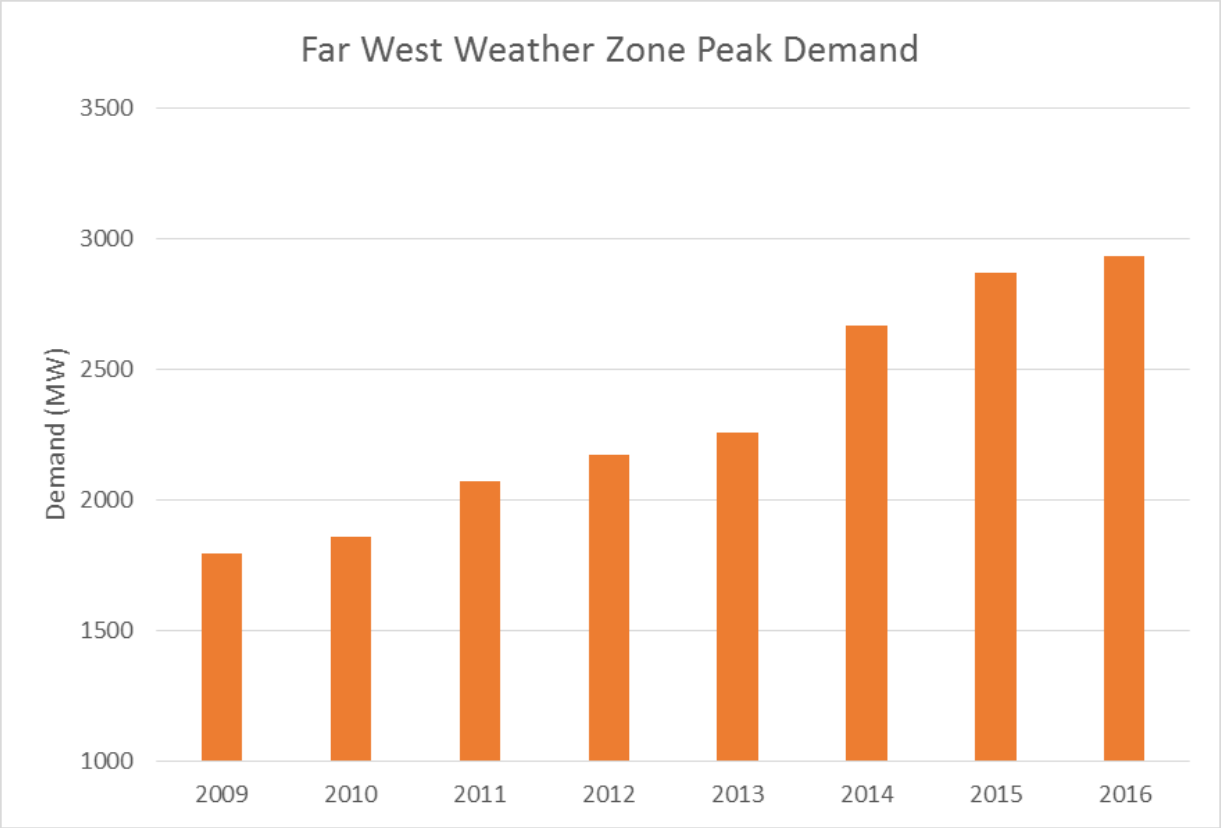

Figure ES.4: Far West Weather Zone Peak Demand Growth

ERCOT recently contracted with Energy Ventures Analysis (EVA) to evaluate the West Texas transmission planning process and also identify improvements to the planning process. EVA's significant findings included the observations that the Permian Basin drilling activity remains the strongest of all United States oil plays and that the Permian Basin, being a world class oil field, would quickly see a significant rebound in activity once oil prices recover.

In 2016, ERCOT and the Regional Planning Group reviewed and endorsed six major transmission projects related to oil and gas load growth. The estimated cost for these six projects exceeds $250 million. Additionally, ERCOT's review of the Far West Texas project (with an estimated cost of $423 million) is expected to be completed in 2017.

Electric Transmission Texas and Sharyland Utilities recently completed and energized more than $1.3 billion in improvements to the transmission system that delivers power into the Lower Rio Grande Valley (LRGV) area. These upgrades helped ERCOT effectively serve the region's record-high demand during the summer of 2016.

In 2016, ERCOT confirmed the need for two additional major transmission improvements for the LRGV, and the ERCOT Board of Directors endorsed both projects in June, 2016. These projects include the installation of two Static Var Compensators (SVC) to improve voltage stability, and a project that included several transformer and transmission circuit

improvements within the LRGV. Further improvements will likely be required to meet the load growth if additional generation is not constructed in the area.

Both the ERCOT generation interconnection queue and the 2016 Long-Term System Assessment (LTSA) point to a significant amount of utility-scale solar generation being added to the ERCOT system in the future. Although as of October 2016 there were only 398 MW of solar generation capacity on the ERCOT system, there were 11,700 MW under study. The LTSA analyzed eight different future scenarios. The results showed a range of 14,500 MW to 28,100 MW of solar resources could be added to the ERCOT system by 2031.

The best location from a solar resource standpoint is in Far West Texas. However, the power grid in this area is relatively weak. A substantial amount of transmission improvements will be required to move the solar generation to the load centers on the eastern part of the state or to get the power to the higher-capacity transmission lines constructed as part of the Competitive Renewable Energy Zones (CREZ) project. There is also a potential for a significant amount of local congestion until such improvements can be constructed.

Recently, there have been several developments relating to the system along the borders, or seams, of the ERCOT grid. Lubbock Power and Light has proposed to disconnect a majority of their system from the Eastern Interconnection and connect it to the ERCOT grid. Similarly, Rayburn Country Electric Cooperative has proposed moving the remainder of their load that is outside of the ERCOT system (currently connected to the Eastern Interconnection) into ERCOT. ERCOT is working with the Public Utility Commission of Texas (PUCT) to perform the necessary studies for these proposed transitions.

Additionally, there have been three significant proposals to construct more asynchronous (DC) tie capacity between ERCOT and grids in the Eastern Interconnection. These proposals are in various stages of study and development.

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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 in accordance with ERCOT and North American Electric Reliability Corporation (NERC) Reliability Standards. The IO ensures access to the transmission and distribution systems for all buyers and sellers of electricity on nondiscriminatory terms. In addition, ERCOT, as the NERC-registered Planning Coordinator/ Planning Authority, is responsible for assessing the longer-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 it has comprehensive transmission planning authority. In performing its evaluation of different transmission projects, ERCOT takes into consideration the need for and cost-effectiveness of proposed transmission projects in meeting the ERCOT planning criteria and NERC Reliability Standards.

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), stakeholders, and other market participants. ERCOT works directly with the TSPs, stakeholders, and market participants through the Regional Planning Group (RPG). Each of these entities has responsibilities to ensure that appropriate transmission planning and construction occurs.

The 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

Every year ERCOT performs a planning assessment of the transmission system. This assessment 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 2016 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. The LTSA identifies upgrades that provide benefits across a range of scenarios or might be more economic than the upgrades that would be determined considering only near-term needs in the RTP development. The biennial LTSA study is conducted in even-numbered years. The 2016 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 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 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 2015 through September 2016, TSPs completed $1.98 billion worth of transmission improvement projects, which is notably higher than previous years. The increase in transmission improvements is primarily due to the completion of two large projects located in the Lower Rio Grande Valley that accounted for approximately $649 million of the total (see Chapter 4 for more information on these two projects). Figure 2.1 shows the cost of transmission improvements completed in ERCOT, by calendar year, from 2007 through 2015. The cost is separated by Competitive Renewable Energy Zone (CREZ)-related projects and non-CREZ-related projects.

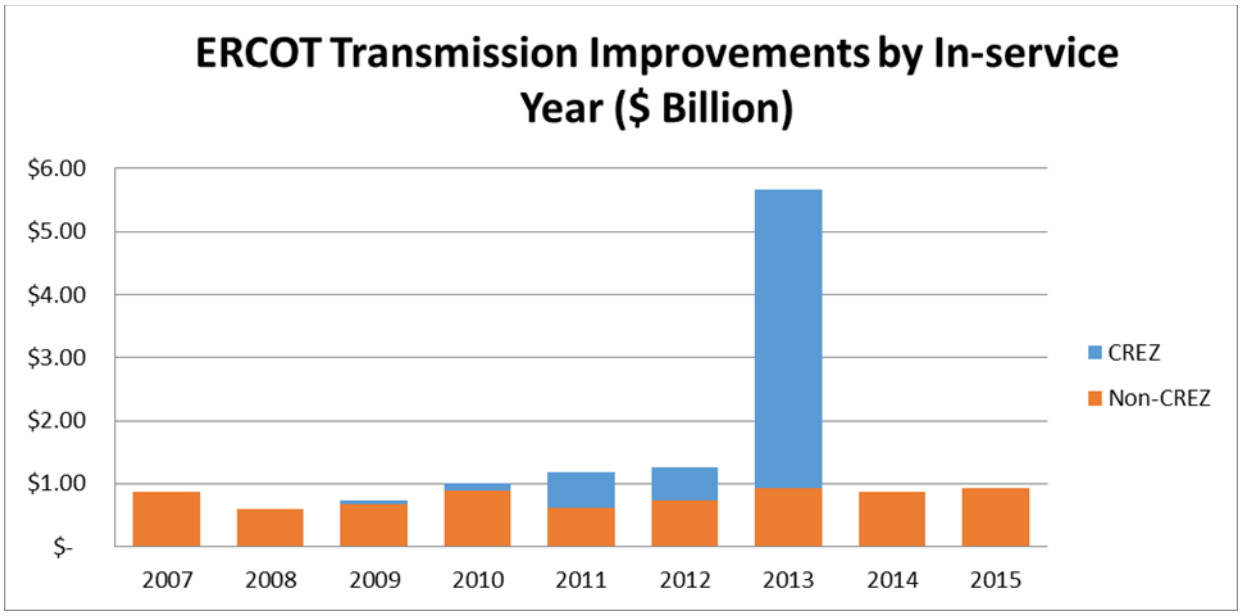

Figure 2.1: Completed ERCOT Transmission Improvements by Year

Transmission improvement projects that are estimated to cost more than $15 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 2016, $489.1 million of transmission improvement projects were reviewed and endorsed through the RPG process. Figure 2.2 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 certain projects are exempt from RPG review, such as projects to connect new generation or load customers.

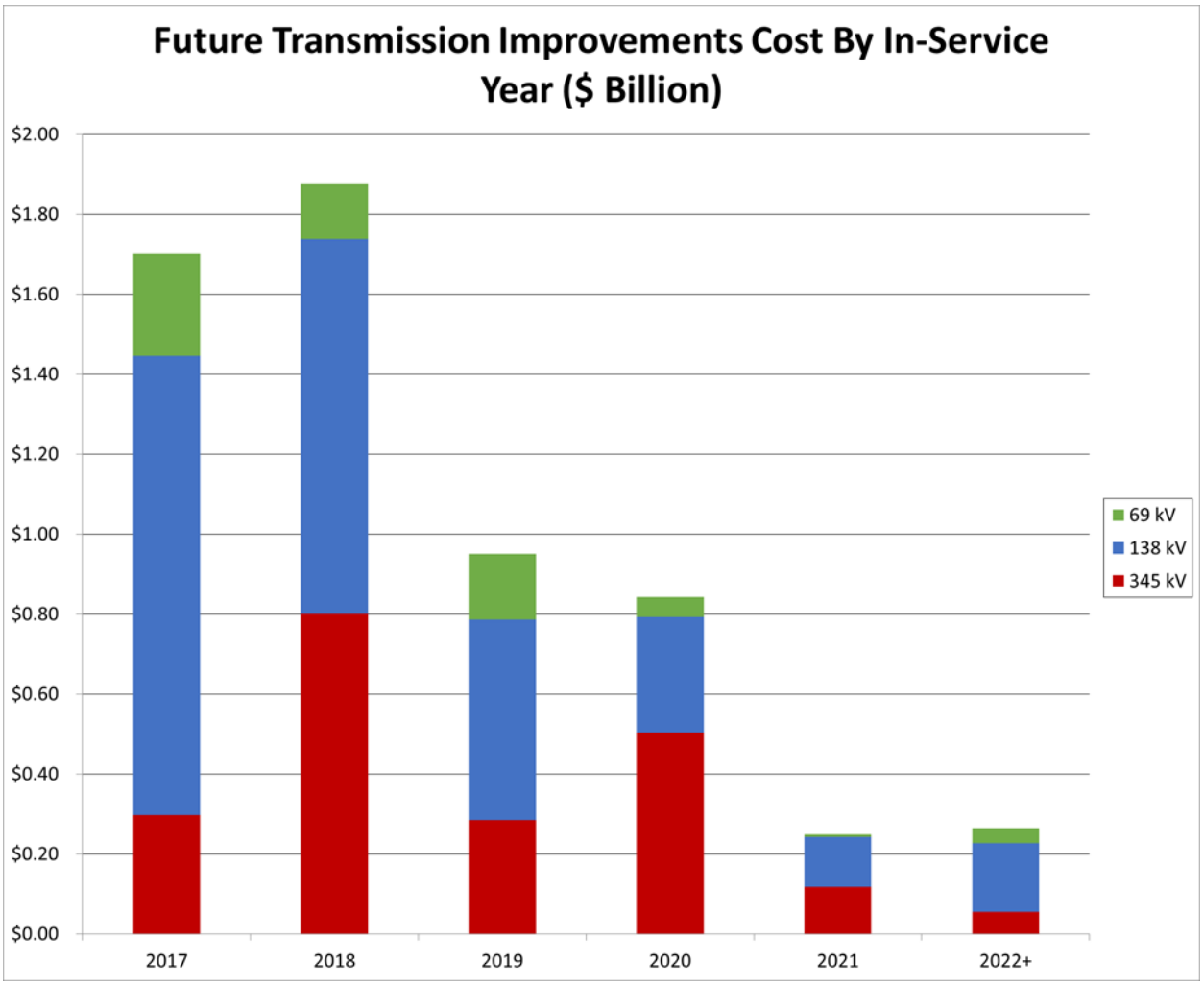

Figure 2.2: Planned Transmission Improvements by Year

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 2015 through September 2016, based on real-time data.

Table 3.1: 2016 Top 15 Congested Constraints on the ERCOT System

Map Index	Constraint	Congestion Rent
1	North to Houston Import	$64,141,507
2	Meadow 345/138 kV Transformer	$47,958,057
3	Fort Worth-West Denton 138 kV Line	$29,740,294
4	Loma Alta-Los Fresnos 138 kV Line	$26,946,998
5	Lower Rio Grande Valley Import Limit	$21,736,088
6	Morris Dido-Rosen Heights Tap 138 kV Line	$15,045,333
7	Panhandle Export Limit	$12,289,182
8	Morris Dido-Eagle Mountain 138 kV Line	$10,484,213
9	Carrollton Northwest-Lakepointe 138 kV Line	$10,437,559
10	Jim Christal-West Denton 138 kV Line	$10,434,358
11	Eagle Mountain 345/138 kV Transformer	$10,252,471
12	Javelina-Molina 138 kV Line	$9,644,364
13	Hockley-Betka 138 kV Line	$8,004,064
14	La Palma-Villa Cavazos 138 kV Line	$7,870,782
15	Bellaire-San Felipe 138 kV Line	$7,119,923

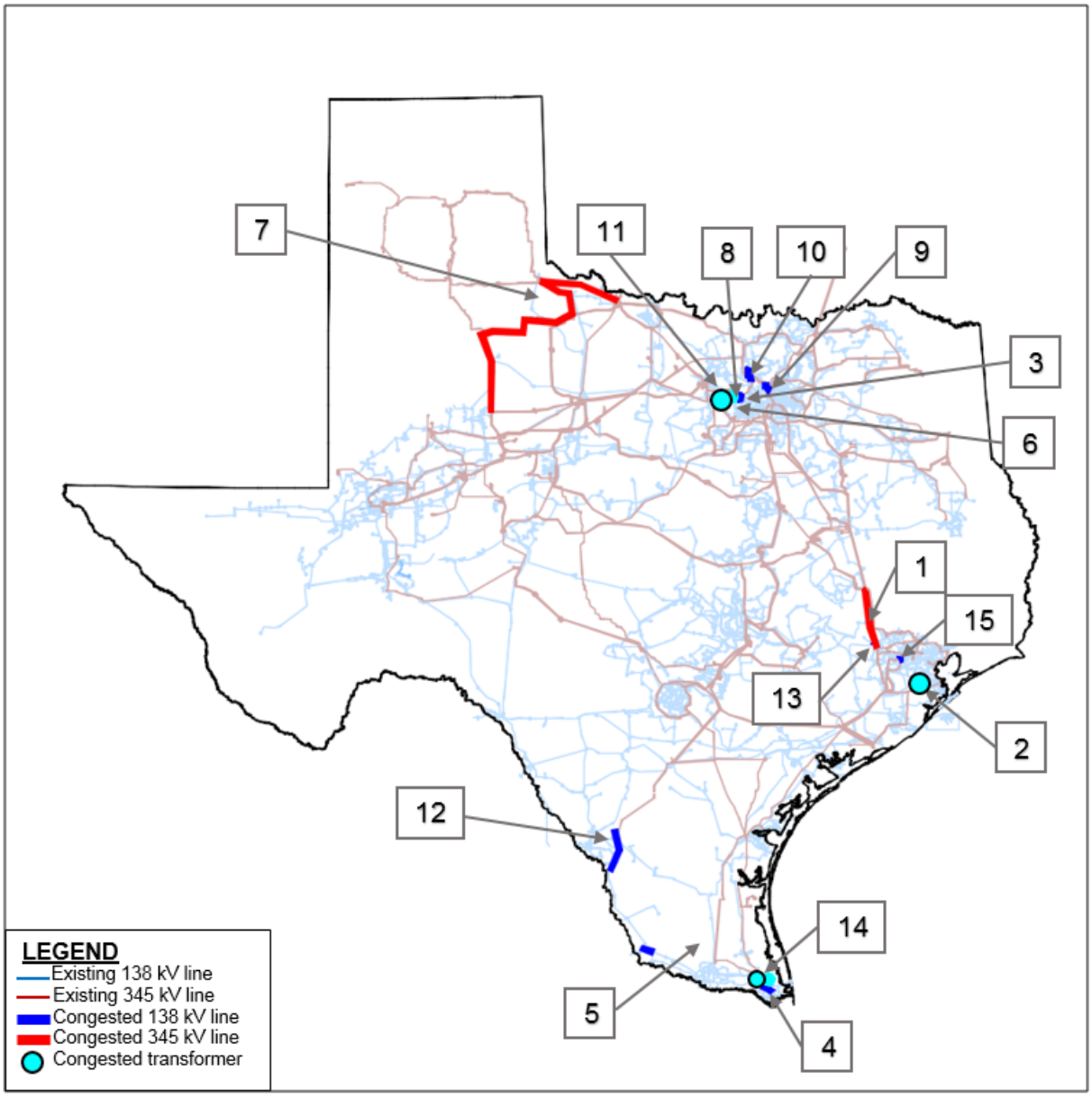

Figure 3.1: Top 15 Congested Constraints

Panhandle Export

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 committed to construction.

As of October 2016, 5,277 MW of wind generation capacity in the Panhandle met the requirements for inclusion in the transmission planning models (as per Planning Guide Section 6.9). Figure 3.2 shows the cumulative in-service capacity by year.

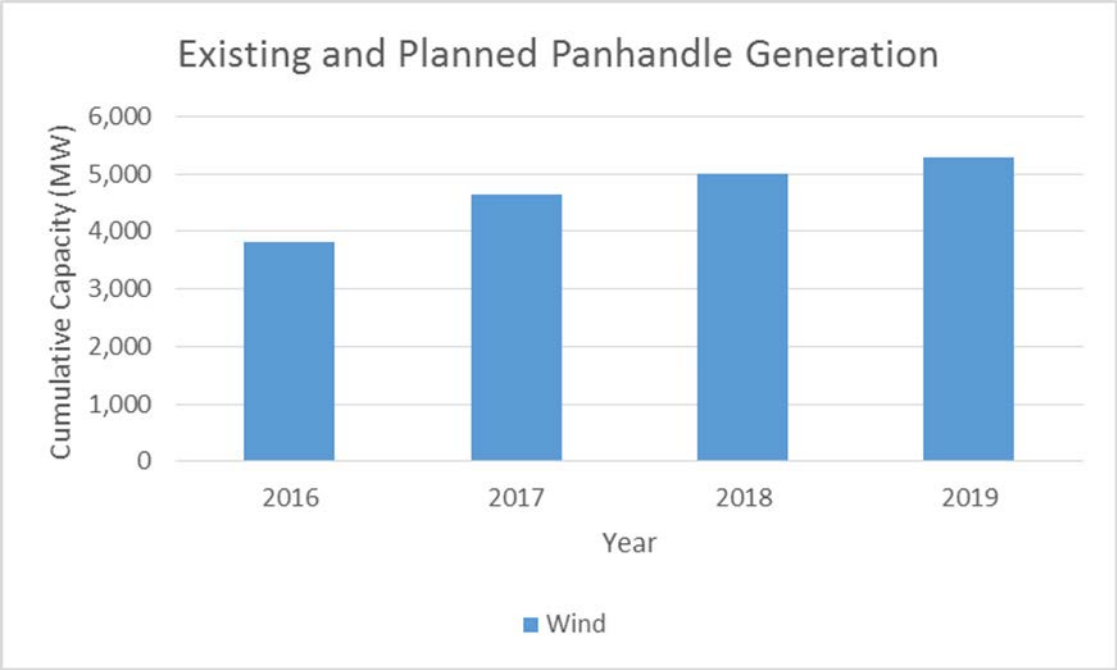

Figure 3.2: Cumulative Existing and Planned Panhandle Generation Capacity

Additionally, as shown in Figure 3.3, approximately 11,850 MW (including wind, solar, and storage resources) was under study for future interconnection in the Panhandle. Of that total, 4,250 MW of wind capacity in the Panhandle had a signed interconnection agreement but did not satisfy all of the requirements to be included in the transmission planning models.

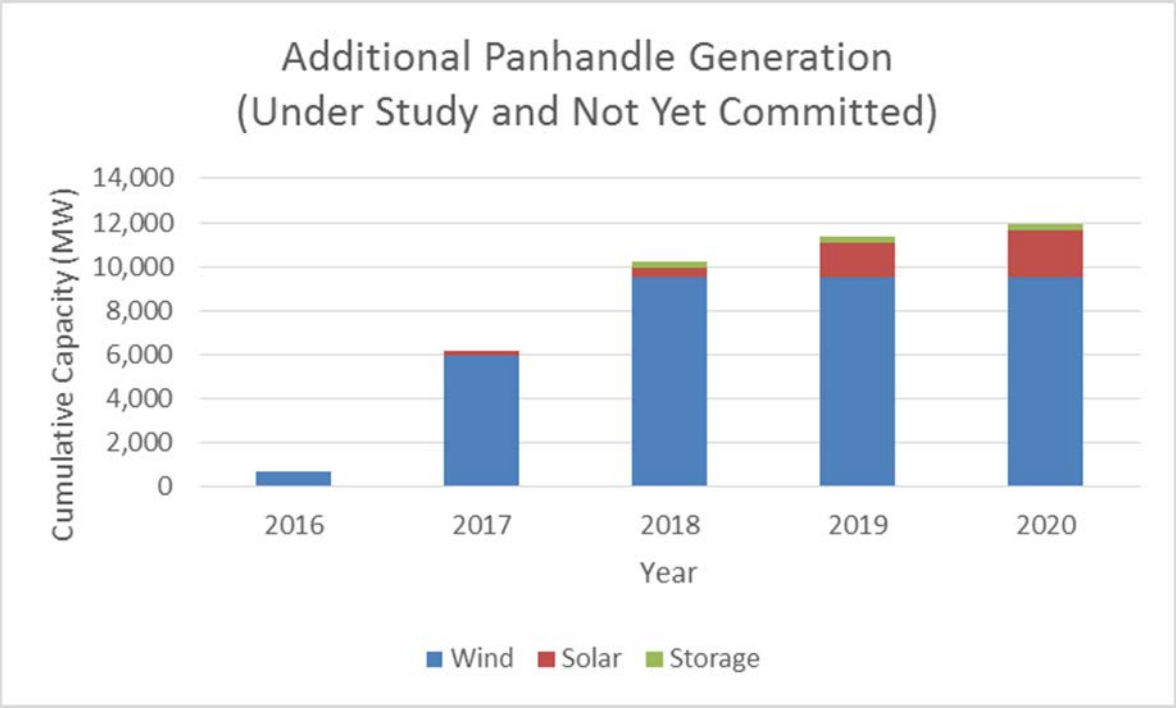

Figure 3.3: Panhandle Generation Under Study

Due to the power electronic-based design of wind generation and the remote nature of the Panhandle system, dynamic stability and system strength are reliability concerns for the area. As a result, an export limit from the Panhandle region is necessary in order to maintain reliable operation.

The constraint imposed by the Panhandle Export Limit had the seventh highest amount of congestion rent on the ERCOT system in 2016. As additional generation is constructed in the area this congestion is expected to increase.

Recognizing the existing constraints and projected renewable generation growth in the area, ERCOT continues to evaluate the Panhandle export capability. Two Panhandle transmission improvements are currently underway: (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. Both improvements are expected to be in service in 2018 and will increase the Panhandle generation export capability. However, these projects are not expected to eliminate the congestion in the area. Figure 3.4 illustrates the location of these improvements.

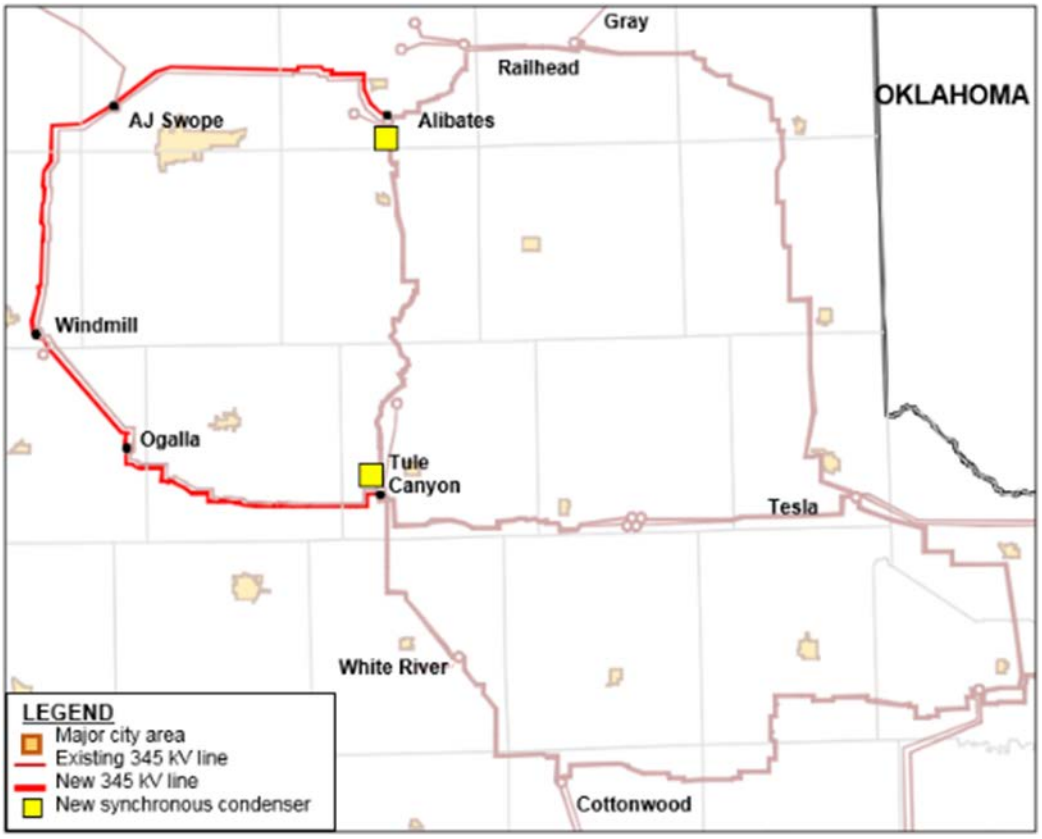

Figure 3.4: Panhandle Improvement Projects

In addition, the economic analysis ERCOT performed as part of the 2016 RTP identified the need to add a synchronous condenser at the Windmill substation to further improve the Panhandle export capability. However, continued development of generation resources in the Panhandle region will likely lead to further constraints. New transmission lines on new right-of-way (ROW) will likely be required to further increase export limits. In October 2016, Sharyland Utilities submitted a project for RPG review that includes constructing a new 345 kV line out of the Panhandle. ERCOT will perform an independent review of this proposal in 2017.

Houston Import

For the second year in a row the import of power into the Houston area from the north caused the highest amount of congestion on the ERCOT system. In 2016, north to Houston congestion totaled over $64 million, which is 34% higher than the next highest congested element. As seen in Figure 3.5, north to Houston congestion has been rapidly increasing over the last several years.

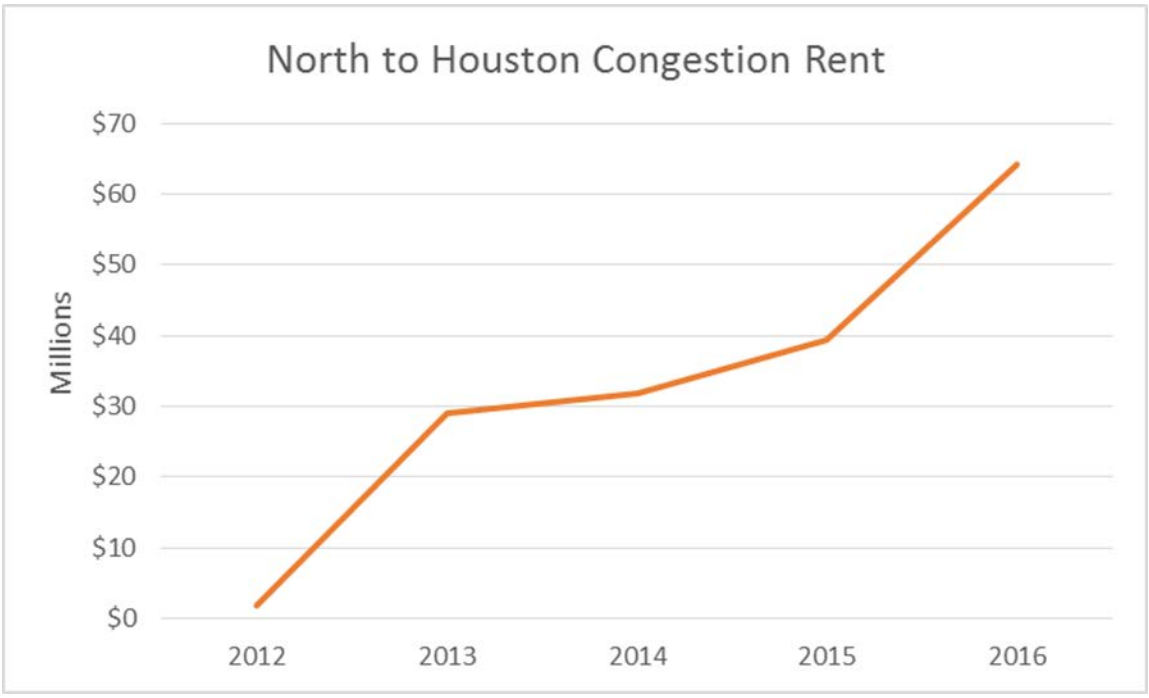

Figure 3.5: North to Houston Congestion Rent by Year

The load in the Houston metropolitan area is currently served by generation in the area and the power imported through 345 kV lines from the north and south. The increase in congestion rent can be attributed to the growth in demand and the retiring/ mothballing of generation in the Houston area. The combination of these factors causes increased imports of power from outside of the Houston area. Figure 3.6 shows the peak demand growth for the Coast weather zone, which is primarily comprised of the Houston area.

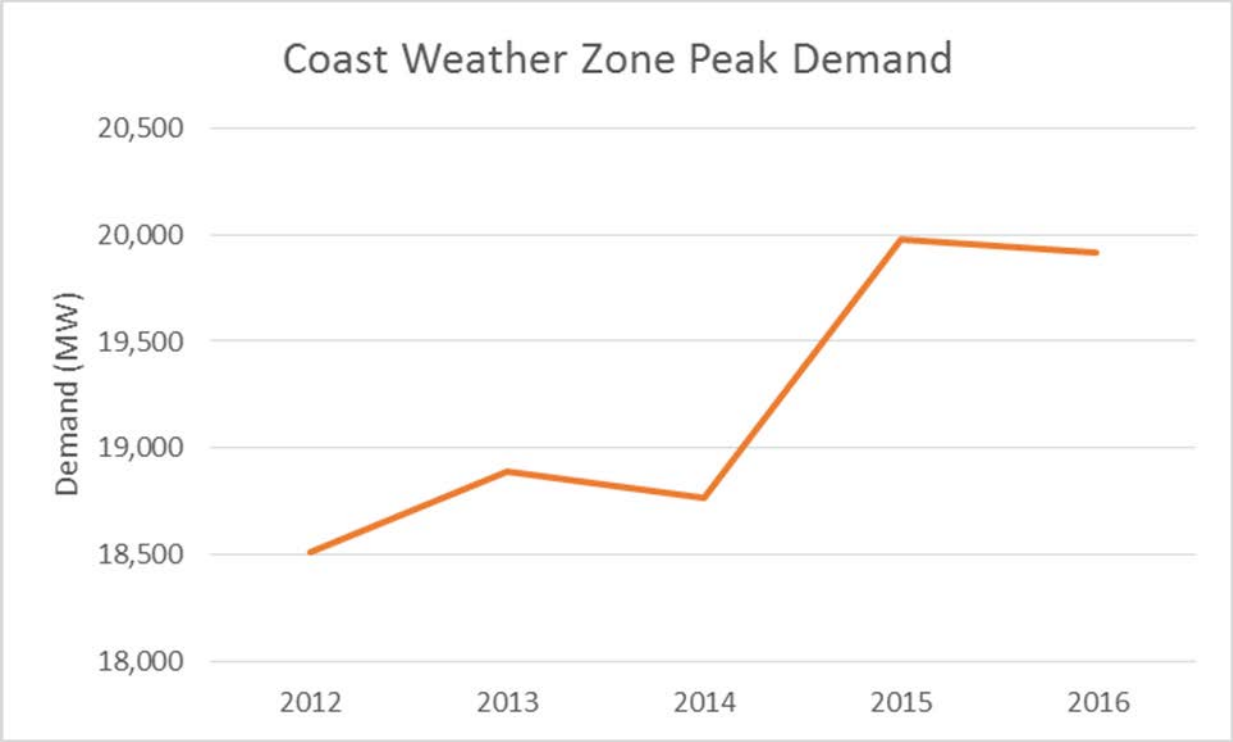

Figure 3.6: Coast Weather Zone Peak Demand by Year

In addition to normal load growth, the Freeport liquefied natural gas (LNG) export facility is expected to come online just to the south of the Houston area starting in 2018. At nearly 700 MW of peak demand, the Freeport LNG project is expected to increase Coast weather zone load by 3.5% by itself.

From a supply perspective, the generation in the Houston area is aging. In general, older generation units are less efficient and less reliable when compared to newer units. Older generation units tend to run less because they are not as economically competitive. As the ERCOT generation fleet becomes more reliant on rural, often renewable, resources and less on legacy fossil fuel generation located near the load centers, more power will be imported into the major load centers, as the Houston area is experiencing. Figure 3.7 shows the generation capacity of units in Harris, Chambers, and Fort Bend Counties, by age.

When a generation resource owner decides that a unit is no longer viable in the ERCOT market they must submit a Notice of Suspension of Operation (NSO) to ERCOT. ERCOT then performs a reliability analysis to determine if the generation unit is needed to maintain transmission system reliability. If it is, ERCOT will enter into what is known as a Reliability-Must-Run (RMR) Agreement with the owner, whereby ERCOT will pay to keep the generation unit running until an alternative solution to the reliability deficiency can be implemented.

In 2016, resource owners submitted NSOs for two generation units in the Houston area, specifically for Greens Bayou Unit 5 and the Clear Lake cogeneration plant. ERCOT performed the RMR reliability analysis for the Greens Bayou unit and found that without the unit there were reliability criteria violations for the 345 kV lines importing power into the area from the north under conditions where other generation units in the Houston area were out of service. Because of this ERCOT entered into an RMR Agreement with the owner of the Greens Bayou unit. Fortunately, the generation outage conditions that would have led to the modeled reliability issues did not occur over the summer of 2016 so ERCOT did not need to call on the Greens Bayou unit to run, but the RMR Agreement was in place in case those conditions did occur.

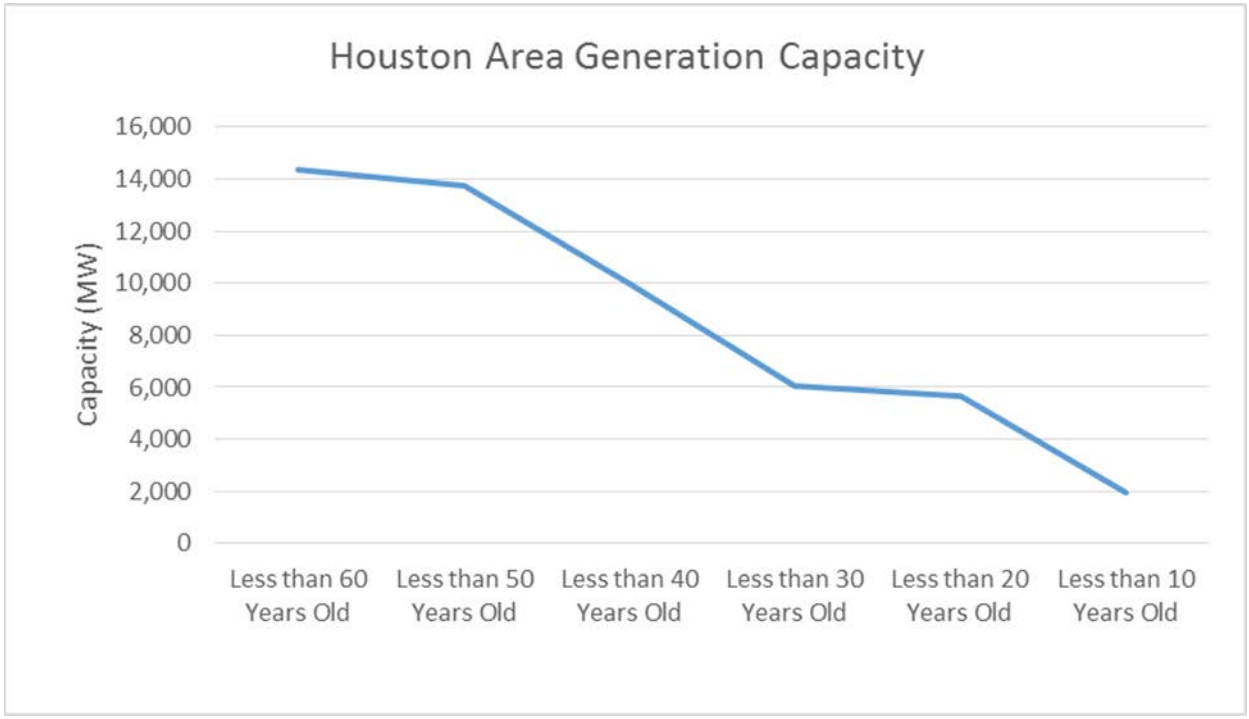

Figure 3.7: Aging Houston Area Generation Capacity

ERCOT also performed the RMR analysis for the Clear Lake plant but found that the generator did not have a material impact on any reliability issues. Therefore, ERCOT did not pursue an RMR Agreement with the owner of the Clear Lake plant.

Figure 3.8 shows the 345 kV lines that import power into the Houston area from the north and were congested in 2016.

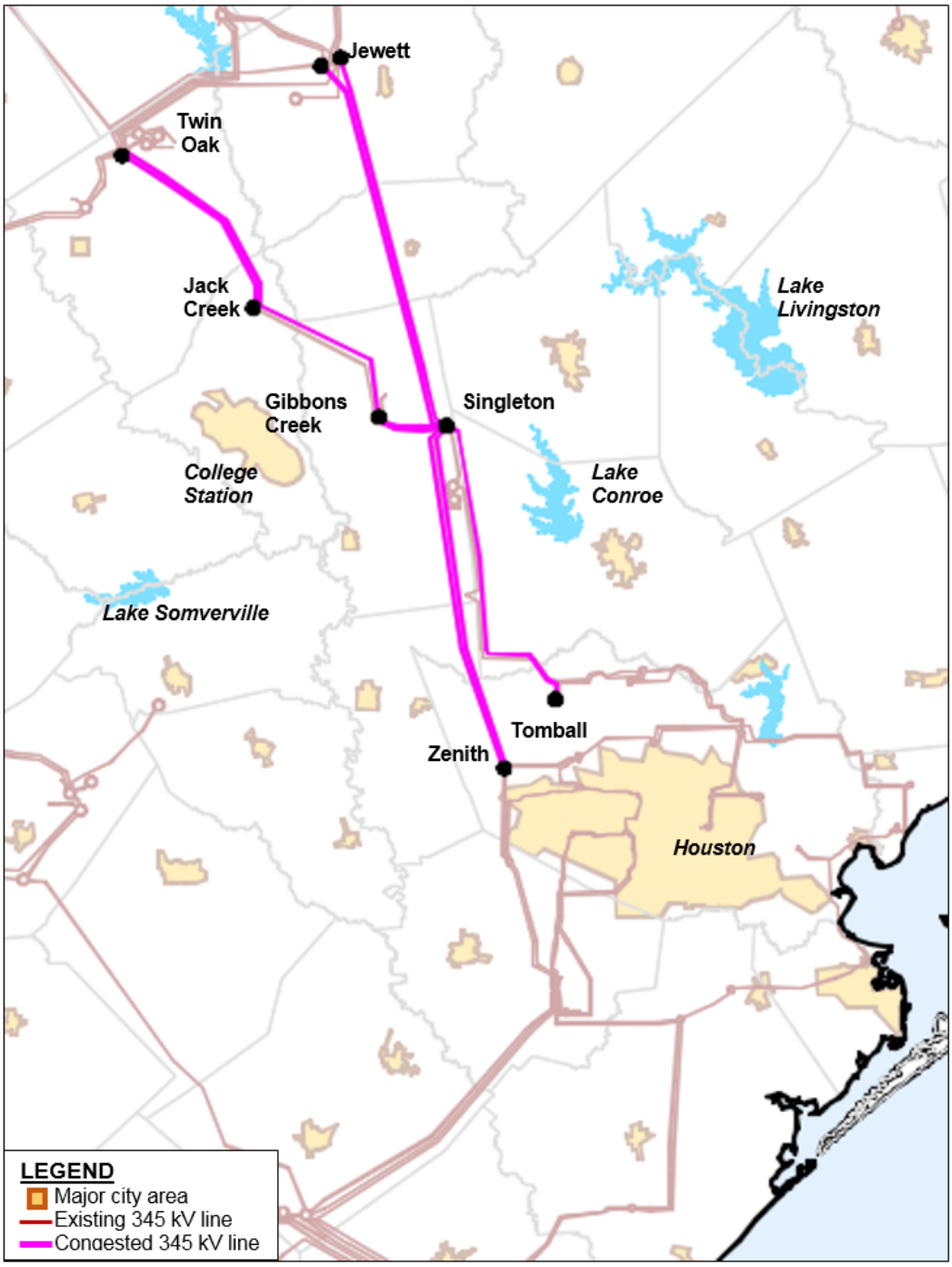

Figure 3.8: Congested North to Houston Import Lines

The 2006, 2008, 2010, and 2012 Long-Term System Assessments all identified a need to increase the import capability of the transmission system serving the Houston area. In the summer of 2013, ERCOT received three separate proposals for RPG review to construct a new 345 kV double circuit line into the Houston area. Each of the three proposals identified reliability criteria violations starting in 2018. Some of the reliability criteria violations were the same ones that led to ERCOT entering into the RMR

Agreement for the Greens Bayou unit in 2016. ERCOT conducted an independent review of the proposals and confirmed that there was a reliability need for additional imports into the Houston area. In addition to the base scenario, ERCOT conducted sensitivity analyses on three alternate scenarios based on stakeholder feedback. All of the sensitivity analyses showed a reliability need for a project.

ERCOT analyzed 21 options for solving the reliability criteria violations. To select the best long-term and most cost-effective option, ERCOT performed a variety of analyses. Based on these study results, in early 2014, ERCOT recommended the Houston Import Project, which involved the construction of a new 345 kV double circuit line from Limestone to Gibbons Creek, a new 345 kV double circuit line from Gibbons Creek to Zenith, and the upgrade of the TH Wharton to Addicks 345 kV line. The project is shown in Figure 3.9. The ERCOT Board of Directors endorsed the need for the project in April 2014, and deemed the new 345 kV double circuit lines as critical to reliability. The project is expected to be completed by the summer of 2018.

Recent RTPs have been conducted using more up-to-date load and generation information than were used in the independent review of the Houston Import Project. Although the independent review indicated that the project was needed by 2018, reliability criteria violations were found in the RTP to be possible as soon as 2016 or 2017. Since it is not expected that the project will be completed before the summer of 2018, weather conditions and system outages could result in significant congestion costs on the import lines prior to completion. ERCOT operators and the affected TSP will need to develop mitigation measures to ensure reliability for the system as a whole. These may include plans to shed load should certain contingencies occur on the system.

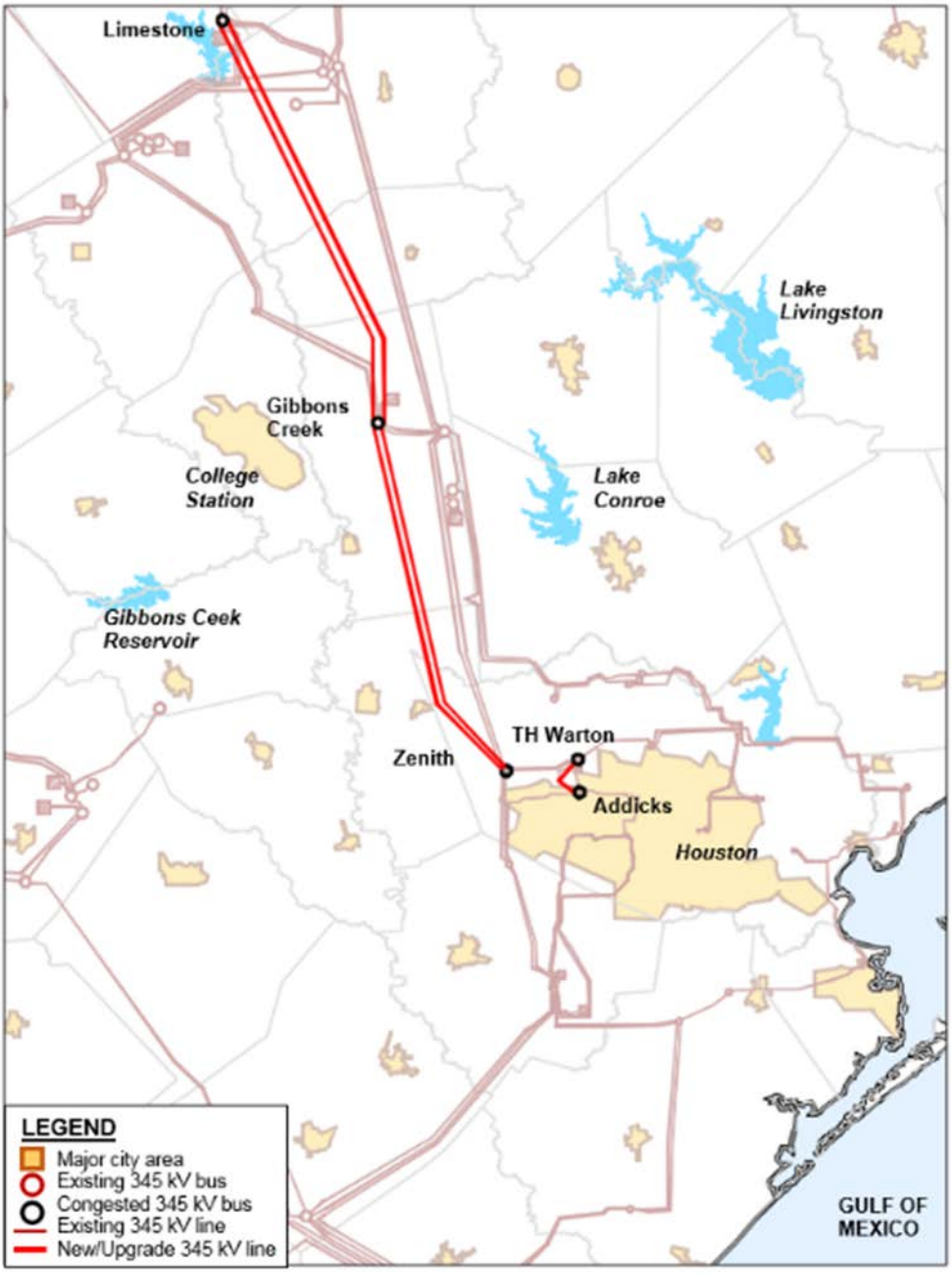

Figure 3.9: Houston Import Project

Meadow 345 kV Transformer Congestion

The Meadow substation, located on the south side of the Houston area near Alvin, has one 400 MVA 345/138 kV transformer which feeds the towns of Alvin, Highland, League City, and Dickinson. Apart from the transformer at Meadow, these cities are also served by three 345/138 kV transformers through the P. H. Robinson South substation. As seen in the Table 3.1 the Meadow 345 kV transformer experienced the second highest amount of congestion on the ERCOT system in 2016. This high congestion resulted from reduced transformer capacity in the area due to the failure of one of the three 345/138 kV transformers at the P. H. Robinson South Substation.

In order to relieve this congestion one of the 600 MVA transformers at the P. H. Robinson South substation was upgraded to 800 MVA and the 600 MVA new will be moved to the Meadow substation. This new transformer is expected to be in service by the summer of 2017. Figure 3.10 shows a map of the area and the location of the new transformer.

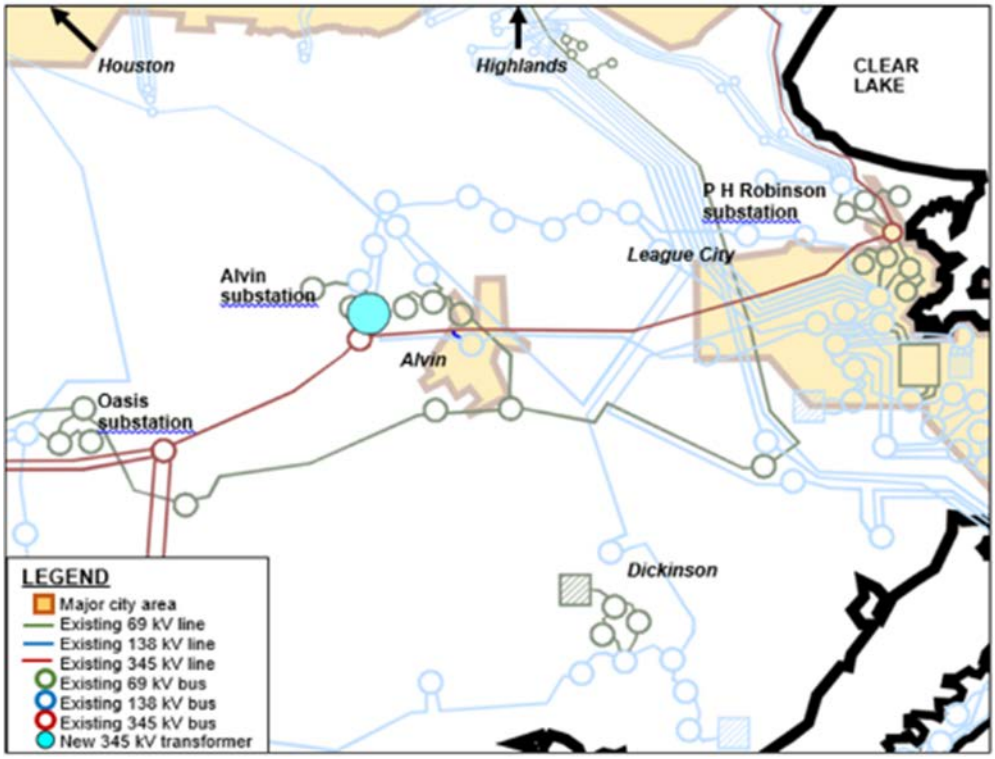

Figure 3.10: Meadow Substation Area

Denton Area Congestion

Transmission circuits connecting into the West Denton substation in the Denton County saw a large amount of congestion in 2016, accounting for the third and tenth highest congestion rent on the ERCOT system. This congestion was outage-driven resulting from construction outages associated with the project to reconfigure the Arco substation and add a new substation at Long Road to support new growth in this area. This project is expected to be completed by May of 2018.

Chapter 4. Planned Improvements

Currently, there are $5.75 billion of future transmission improvement projects that are expected to be put in service between 2017 and the end of 2022. 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	New Jones Creek 345 kV station with two 345/138 kV transformers	2017
2	Add second Zenith 345/138 kV transformer	2017
3	Add second Meadow 345/138 kV transformer	2017
4	Twin Buttes 345/138 kV transformer replacement	2017
5	Upgrade Mitchell Bend – Decordova 345 kV line	2017
6	Houston Import Project	2018
7	Add second Hicks 345/138 kV transformer	2018
8	Upgrade Mitchell Bend – Rocky Creek 345 kV line	2018
9	Add Alibates-Windmill-Tule Canyon 345 kV line second circuit	2018
10	Add synchronous condensers at Alibates and Tule Canyon	2018
11	Add SVCs at LaPalma and Pharr	2018
12	Upgrade Barilla Junction – Permian Basin 138 kV line	2019
13	Upgrade and conversion to 138 kV service of IH20 – Wickett line	2019
14	Add Zorn – Marion 345 kV line	2019
15	New Stewart Road 345 kV station with 345/138 kV transformer	2019
16	Add Riverton – Sand Lake 138 kV line	2020
17	New Fowlerton 345 kV station with 345/138 kV transformer	2022

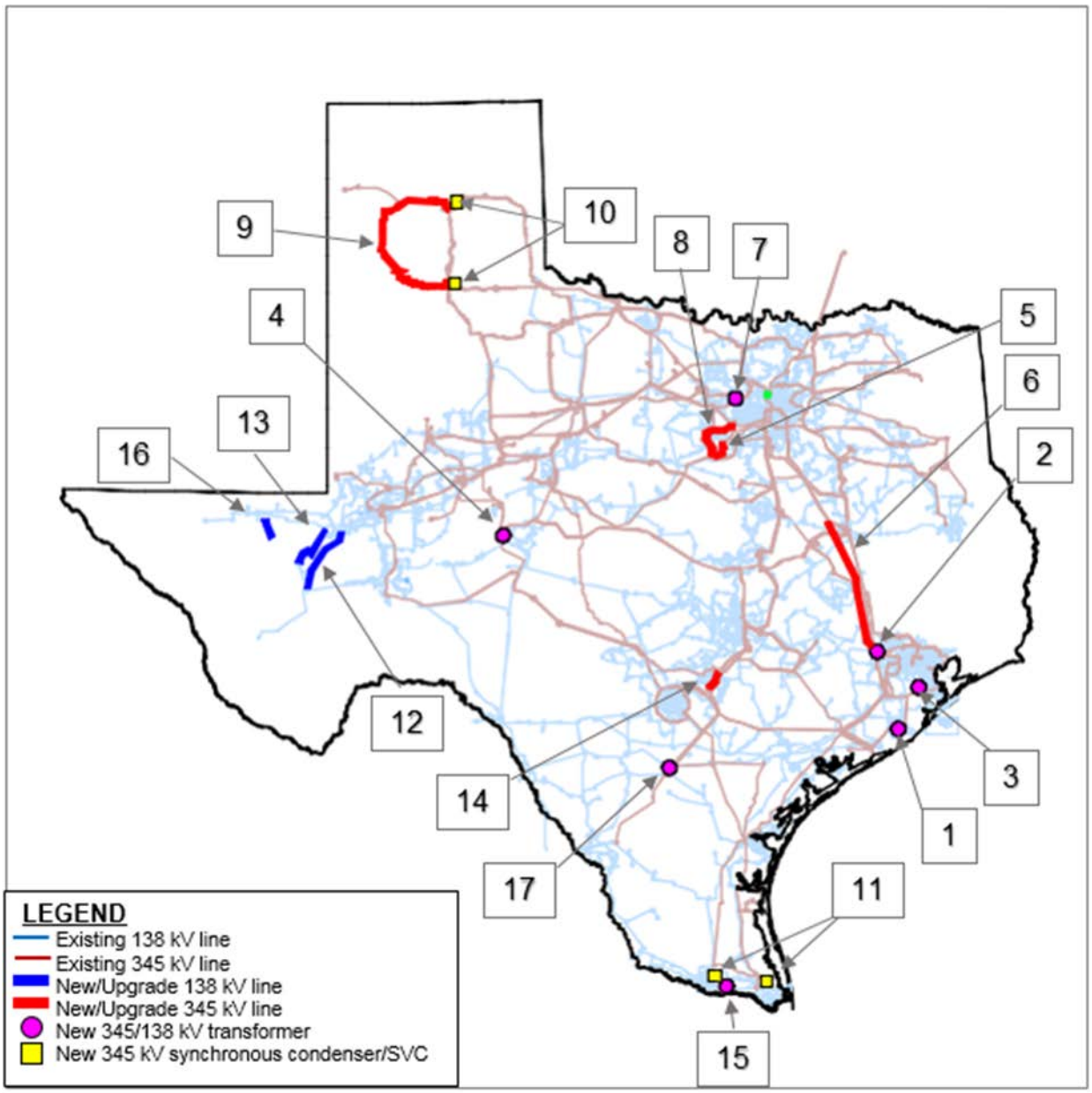

Figure 4.1: Planned Transmission Improvement Projects

West Texas Oil and Gas

In 2012, eight of the top fifteen congested transmission elements were in West Texas. Because of a number of transmission additions and upgrades, the amount of congestion in West Texas dropped significantly by 2016. Figures 4.2 show the Far West weather zone historical growth in peak demand from 2009 through 2016. This amount of load growth (as a percentage) exceeds that of the all the other weather zones in ERCOT and significantly exceeds the system-wide load growth of 1.6% per year observed during this same time period.

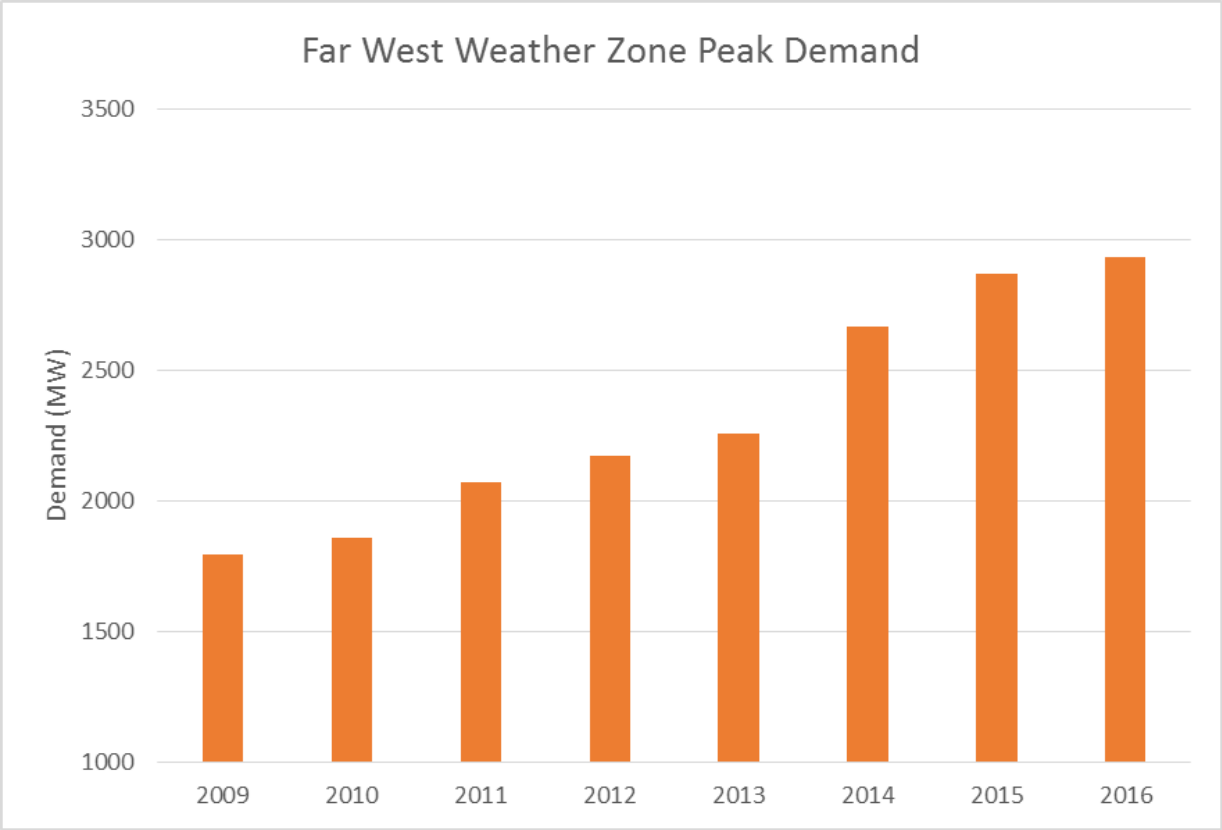

Figure 4.2: Far West Weather Zone Peak Demand Growth

In 2012 ERCOT completed a West Texas study and began identifying transmission facilities that might be required to serve the rapid load growth in this region. In early 2015, ERCOT began a process to update the 2012 study and continue the process of identifying specific transmission project required to stay ahead of rapid petroleum-related load growth in West Texas. As part of the study, ERCOT contracted Energy Venture Analysis Inc. (EVA) consultants to evaluate and to identify improvements to the West Texas transmission planning process.

The ERCOT study findings from the 2015 West Texas study indicates that there is a continued need for aging transmission lines in West Texas to be to be rebuilt and upgraded to higher capacity lines and operated at higher voltages to both improve voltage stability and reduce the risk of overloads. Also, the increasing presence of power electronics providing voltage control combined with the lack of adequate synchronous generation is increasing the risk of inadequate short-circuit currents and system strength-related grid reliability issues. These issues will need to be addressed in advance of future petroleum-related load growth in order to avoid future operational constraints in West Texas.

In June 2016, EVA completed its assessment of the West Texas planning process and presented a series of suggestions and recommendations on how the overall West Texas planning process could be improved. The EVA report notes that the Permian Basin is a world class field and is likely to be the second largest oil field in the world according to the Energy Information Administration (EIA).

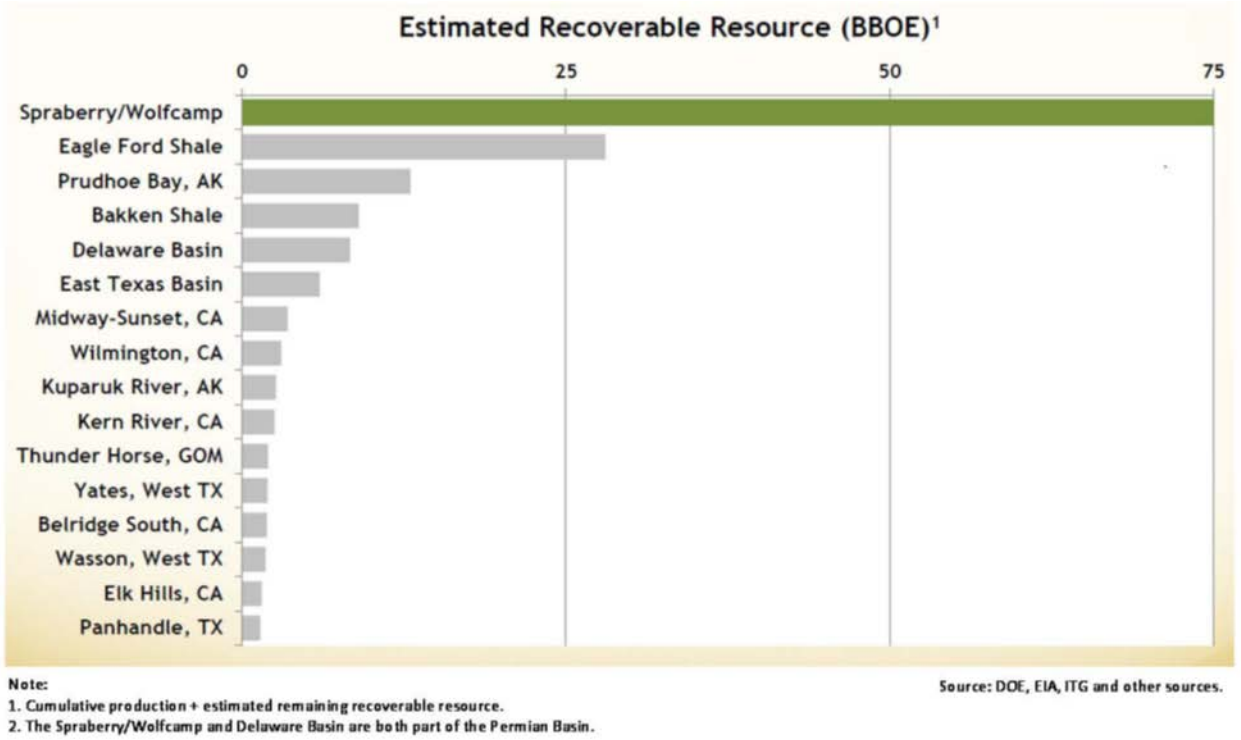

Figure 4.3: Comparison of the Resource Potential for Major U.S. Oil Fields

Even with the recent sharp decline in drilling activity, the total rig count in the Permian Basin recently exceeded the cumulative rig count for the next four largest U.S. tight oil/shale plays, as illustrated in Figure 4.4.

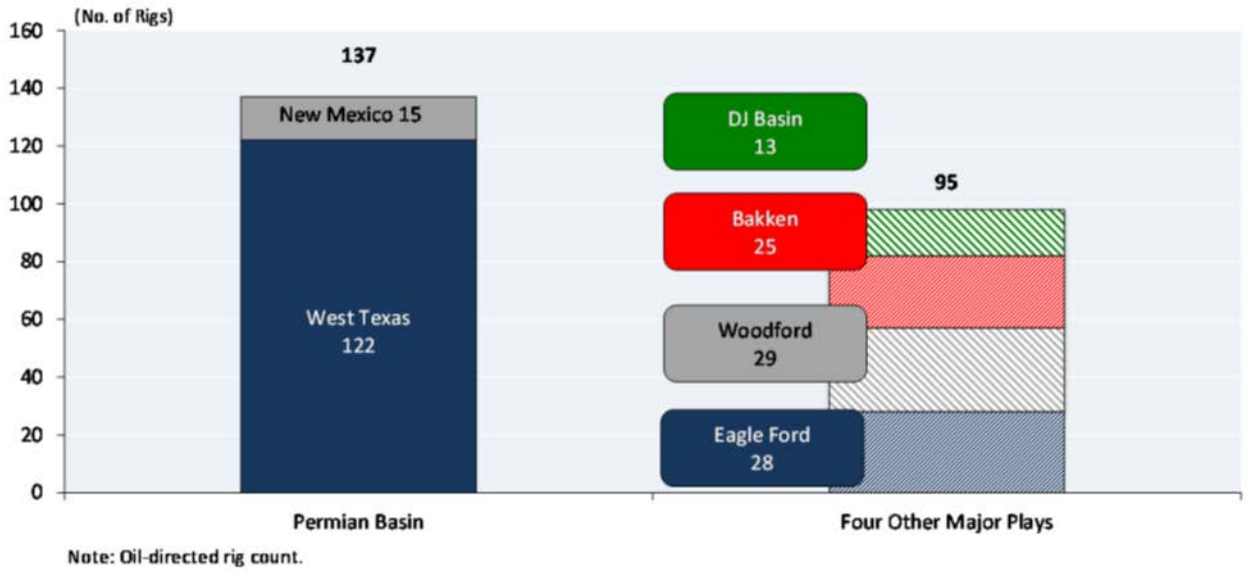

Figure 4.4: Permian Basin Rig Count May 2016

The EVA report also noted that once world oil prices recover, the West Texas drilling activity is expected to rebound significantly due to the size of the Permian Basin and the low average lead times associated with the Permian Basin oil production (i.e., the period from the final investment decision to product recovery).

ERCOT and the TDSPs are working closely with the oil producers to develop better capability to forecast the future load growth for West Texas and address future transmission infrastructure needs in the West Texas area. In 2016, ERCOT and the RPG evaluated and endorsed six major transmission projects related to oil and gas load growth in West Texas. Table 4.2 and Figure 4.5 provide more information on these projects.

Table 4.2: Major West Texas Projects Reviewed in 2016

Map Index	Transmission Improvement	Cost Estimate
1	Barilla Junction Area Improvement Project	$77.0 million
2	Line 69H Rebuild and 138 kV Conversion Project	$50.6 million
3	Riverton-Sand Lake Project	$40.2 million
4	Andrews County South – Holt – Andrews North Upgrade Project	$33.5 million
5	Katz to Tardis Transmission Project	$30.5 million
6	Salt Creek Project	$26.0 million

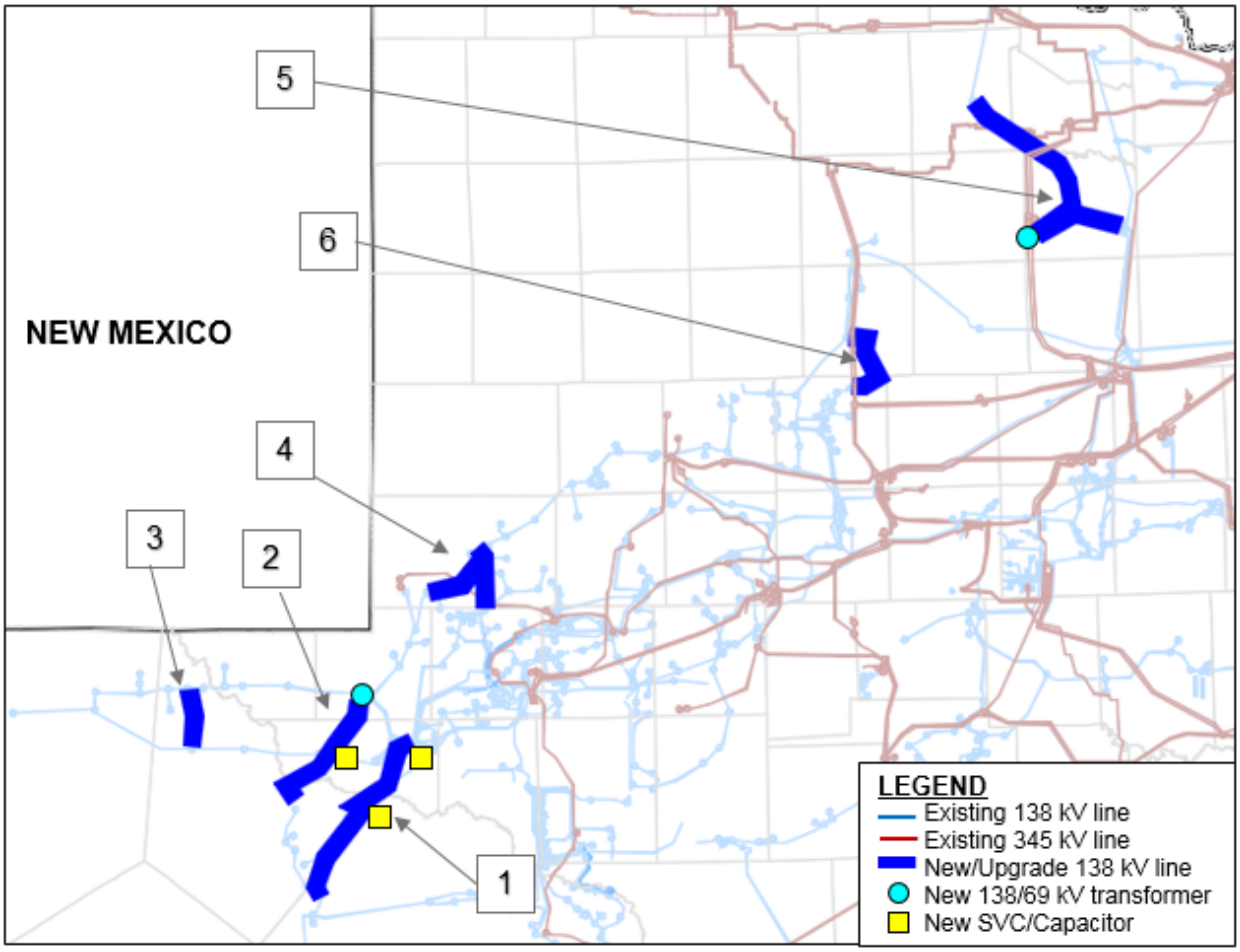

Figure 4.5: West Texas Projects Reviewed in 2016

Additionally, AEP and Oncor jointly submitted the Far West Transmission Project (with an estimated cost of $423 million) to the RPG in April 2016 to address the load growth and new generation projects in the area. ERCOT's evaluation of this project is expected to be completed in 2017.

Lower Rio Grande Valley

Electric Transmission Texas and Sharyland Utilities recently completed and energized more than $1.3 billion in improvements to the transmission system that delivers power into the Lower Rio Grande Valley (LRGV) area. Along with the upgrade of several existing circuits, the improvements include one additional 345 kV import circuit into the LRGV and one 345 kV circuit from the North Edinburg station, located on the west side of the LRGV, to the Loma Alta station, located on the east side of the LRGV. These upgrades helped ERCOT reliably serve the region's record-high demand during the summer of 2016. Figure 4.6 shows a map of the area.

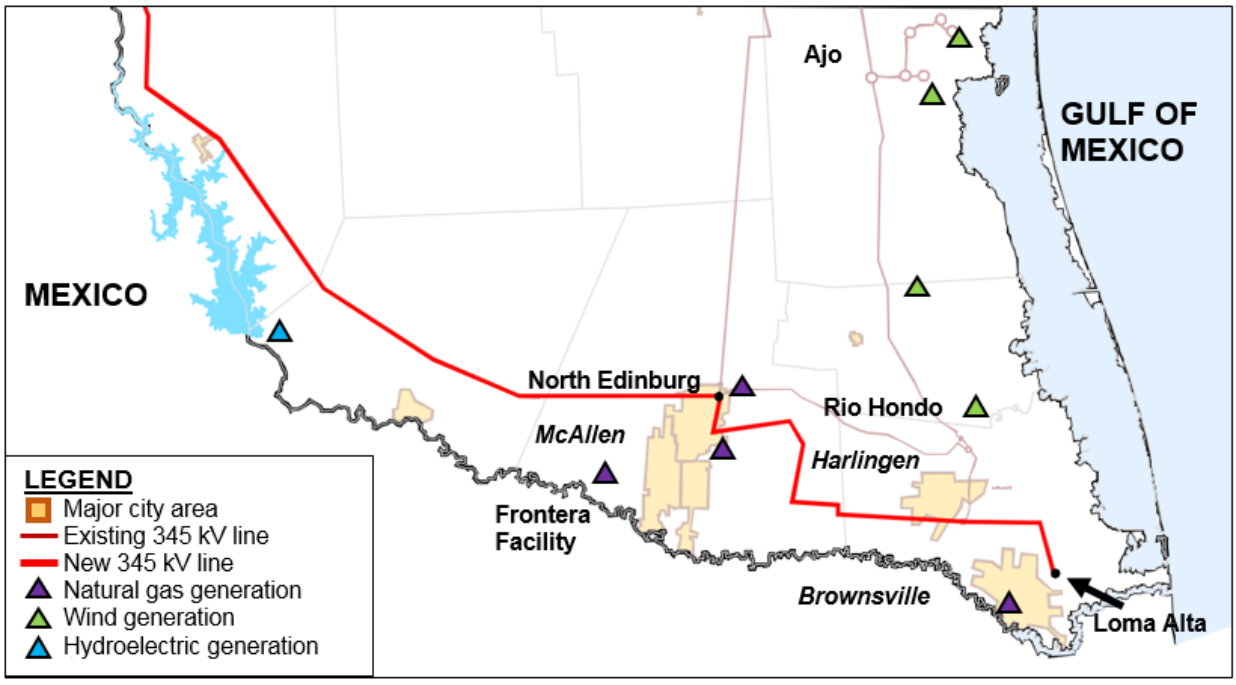

Figure 4.6: Lower Rio Grande Valley Area

In October 2016, a 524-megawatt (MW) power plant located in Mission, Texas, near the U.S. border with Mexico, discontinued service to the ERCOT grid. This generation resource, built in 1999-2000, originally was designed to be able to send power to both ERCOT and Mexico.

After receiving notification in 2014 that the plant owners planned to switch to Mexico, ERCOT studied the reliability impacts in the LRGV. Those studies indicated the system would continue to meet the NERC reliability standards in place at the time, but also identified potential reliability concerns when multiple generation or transmission resources were not operating during high-demand periods. The plant's owners agreed to continue serving the ERCOT grid until transmission improvements in progress at the time were completed and energized in 2016.

One new natural gas plant (225 MW capacity) is expected to start commercial operation in the ERCOT market by the end of 2016. As a result, the LRGV currently has approximately 1,470 MW of natural gas generation at four plants. As of October, 2016, there are more than 4,000 MW of existing or committed future wind capacity in or nearby the LRGV. Resource developers have signed interconnection agreements for two additional natural gas plants, but these developers have not yet provided financial commitment for necessary transmission improvements. Another approximately 2,400 MW of generation is under study for future interconnection in the region. The area also currently has hydroelectric resources and an asynchronous tie with the Mexico system.

In 2015, the RPG began to consider additional projects to improve the electric transmission grid serving the LRGV area. In 2016, ERCOT confirmed the need for two transmission improvements, and the ERCOT Board of Directors endorsed both projects in June, 2016. These projects include the installation of Static Var Compensators (SVC) at the La Palma and Pharr 138 kV substations to improve voltage stability, and a project that includes several transformer and transmission circuit improvements within the LRGV. Further improvements will likely be required to meet the load growth if additional generation is not constructed in the area.

Also, 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.

Additional Reliability-Driven Planned Projects

Continued customer demand growth throughout the state is a key driver for the need for transmission improvements in the ERCOT region. The recently completed 2016 Regional Transmission Plan (RTP) identified more than fifty projects needed to satisfy the reliability planning criteria in the 2017 to 2022 timeframe. Figure 4.7 below shows reliability projects identified in the 2016 RTP by voltage class and weather zone. Thirty-eight of these projects were previously identified in prior RTP studies. More information on these projects can be found in the 2016 RTP report posted on the ERCOT Market Information System website.

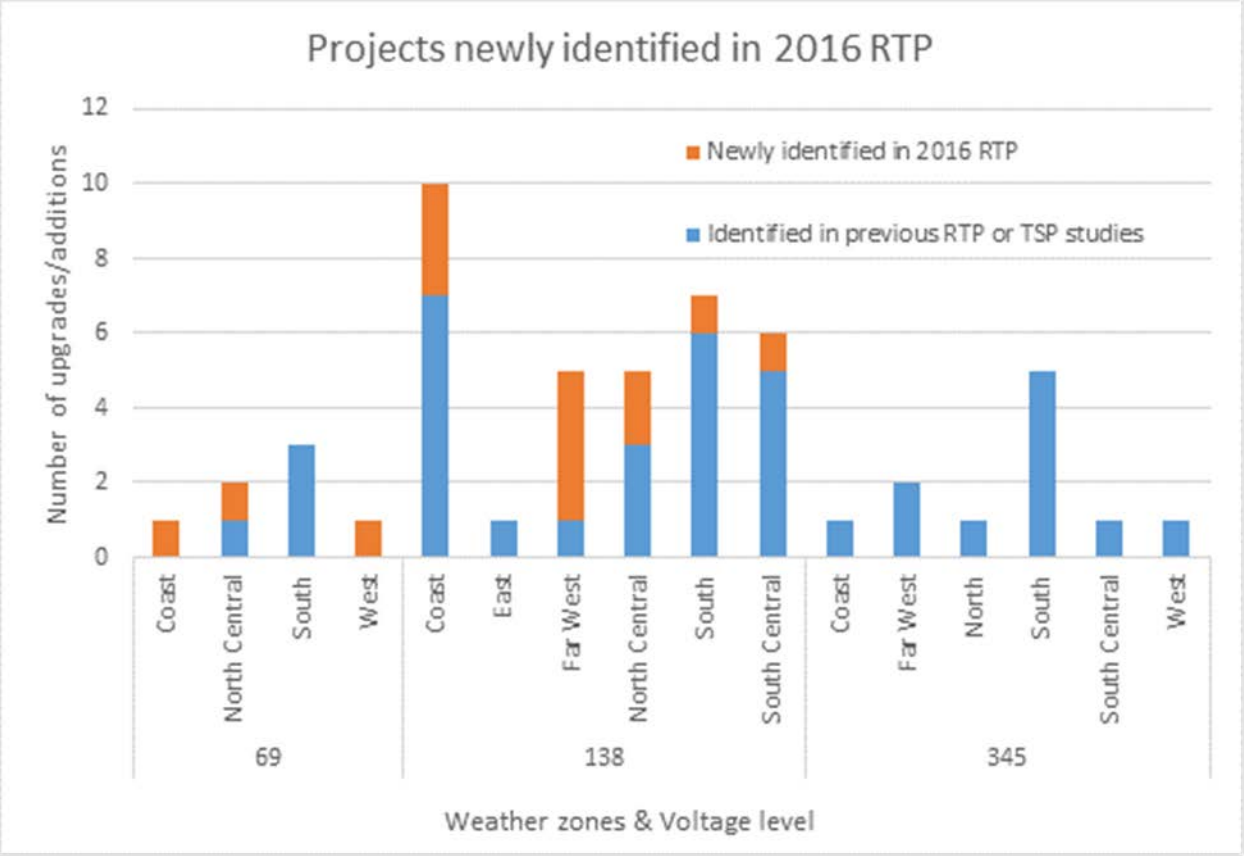

Figure 4.7: Regional Transmission Plan Reliability Projects

Chapter 5. Projected Constraints

Solar Generation Related Constraints

The ERCOT system has seen a limited increase in operational utility-scale solar installation since 2010, as shown in Figure 5.1. By 2016, the total installed capacity had only increased from 15 MW to 398 MW. However, as of October 2016, approximately 11.7 GW of solar projects are under study through the ERCOT generation interconnection request study process. Approximately 1,049 MW of solar projects in the study queue have interconnection agreements (IA) with posted financial security and are projected to be in service by the end of 2017. In addition, the 2016 Long-Term System Assessment (LTSA) generation expansion scenarios identified the potential for 14.5 GW to 28 GW of utility-scale solar generation in ERCOT by 2031.

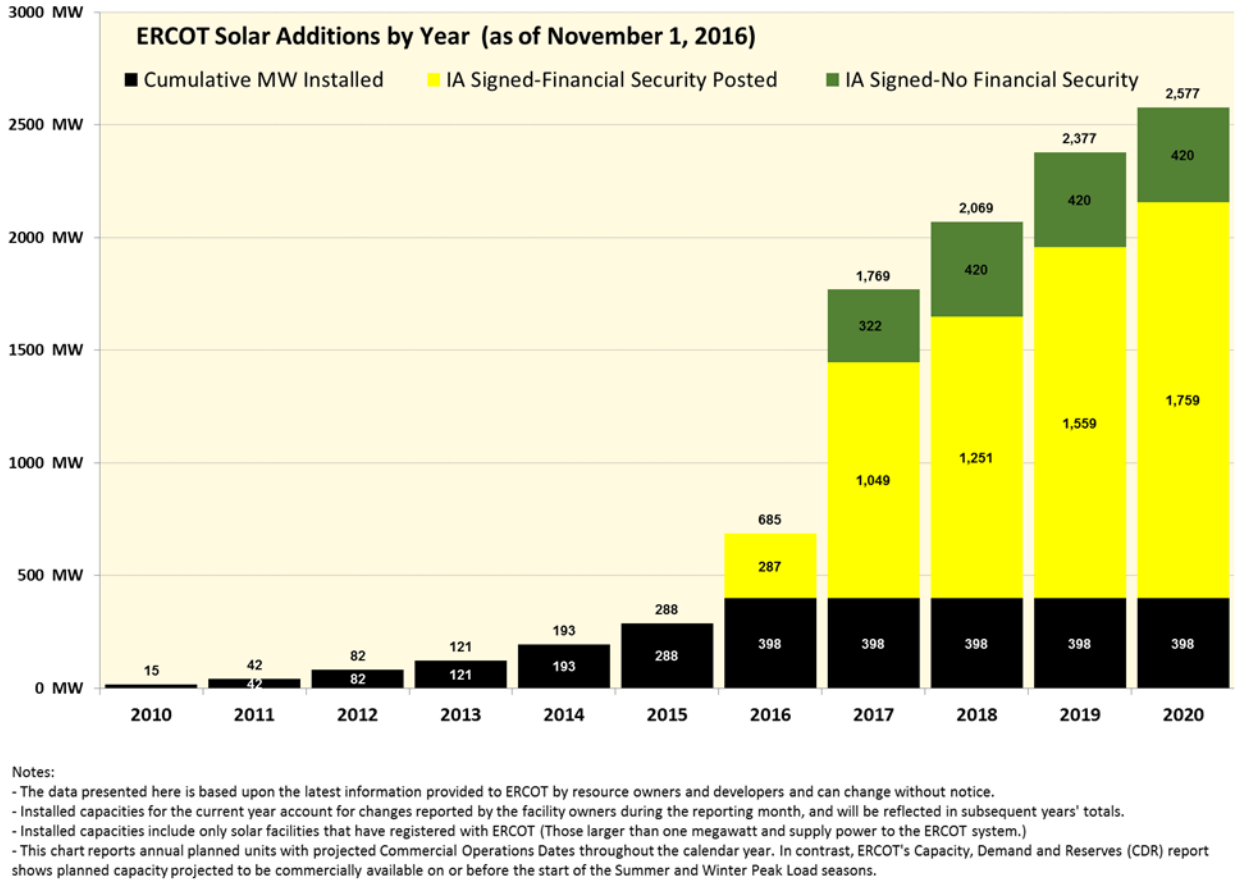

Figure 5.1: ERCOT Solar Installations by Year

Figure 5.2 shows the breakdown of the proposed solar in the study process by weather zone. As shown, the majority of proposed solar projects are located in the Far West weather zone, specifically in Pecos and Upton Counties, where the existing transmission system is relatively weak. Under weak grid conditions, a small variation of reactive support results in large voltage deviations, and in extreme cases, can lead to a voltage

collapse. All solar generation projects in the Far West weather zone are expected to be equipped with power electronic devices that will further weaken the local system strength due to limited short-circuit current contributions. Stability challenges and weak system strength are expected to result in significant constraints in exporting solar from the Far West.

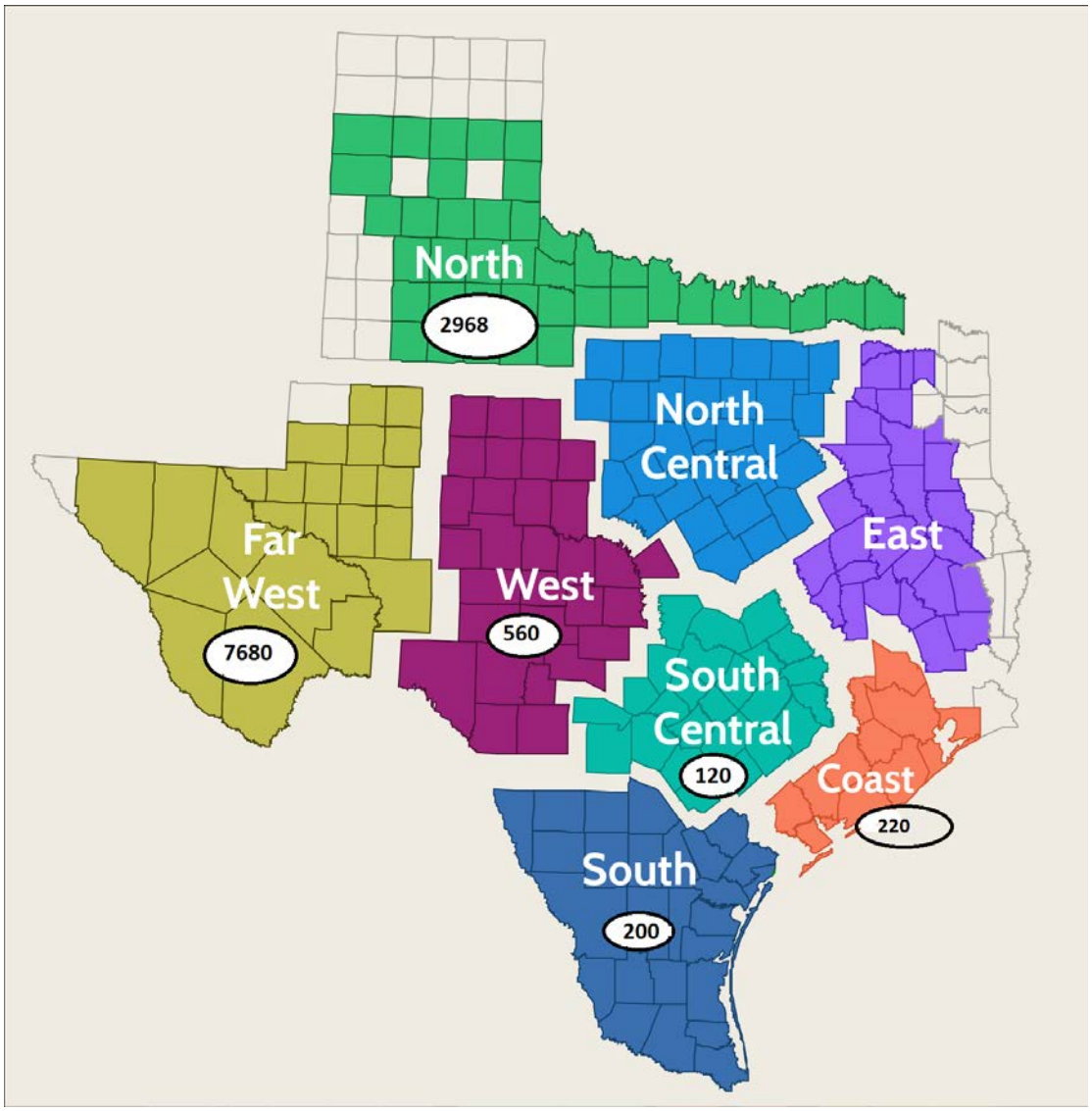

Figure 5.2: Solar Generation Interconnection Requests (MW) by Weather Zone

Recognizing the challenges associated with connecting a large amount of solar generation in the Far West weather zone, ERCOT initiated a solar integration study. The purpose of this study was to assess the impacts of the solar projects on ERCOT's current transmission system and get a high-level understanding of the needed transmission upgrades. The study was restricted to steady-state analysis and did not evaluate grid stability or economics.

The results of the study indicated the potential need for substantial expansion of the 345 kV network for even modest additions of generation in the Far West. The study also indicated that many proposed 69 kV solar generator interconnections may need to be shifted to 138 kV lines or substations.

The study results overlapped and aligned with some recent TSP studies to examine both load growth and generation interconnection requests in the area west and south of the Permian Basin. AEP SC and Oncor jointly submitted the Far West Transmission Plan (estimated to cost $423 million) to the RPG in April 2016, to address both load growth and generation interconnection in the area. The ERCOT independent review is expected to be completed in 2017.

Generation Retirement Due to Environmental Regulations

At the beginning of 2016 there were several U.S. Environmental Protection Agency (EPA) regulations that were expected to affect future electricity production and consumption in the ERCOT region. One of these rules was the Regional Haze Federal Implementation Plan (FIP) for Texas, which required specific coal-fired units to be retrofitted with new scrubbers or upgrades to existing scrubbers in order to reduce sulfur dioxide (SO_2) emissions. As shown in Figure 5.3, approximately 3,000 MW of coal capacity in ERCOT would be required to have new scrubbers by 2021, and 5,500 MW would be required to have upgraded scrubbers by 2019 under the rule.[2] In evaluating the potential market returns on these capital-intensive investments, the owners of the affected plants would also need to consider the impacts of other regulations such as the Clean Power Plan (CPP) and 2010 SO_2 National Ambient Air Quality Standard (NAAQS).

[2] Note that the Regional Haze FIP for Texas was stayed by the 5th Circuit of the U.S. Court of Appeals in July, 2016 and in November, 2016 the EPA voluntarily remanded the rule.

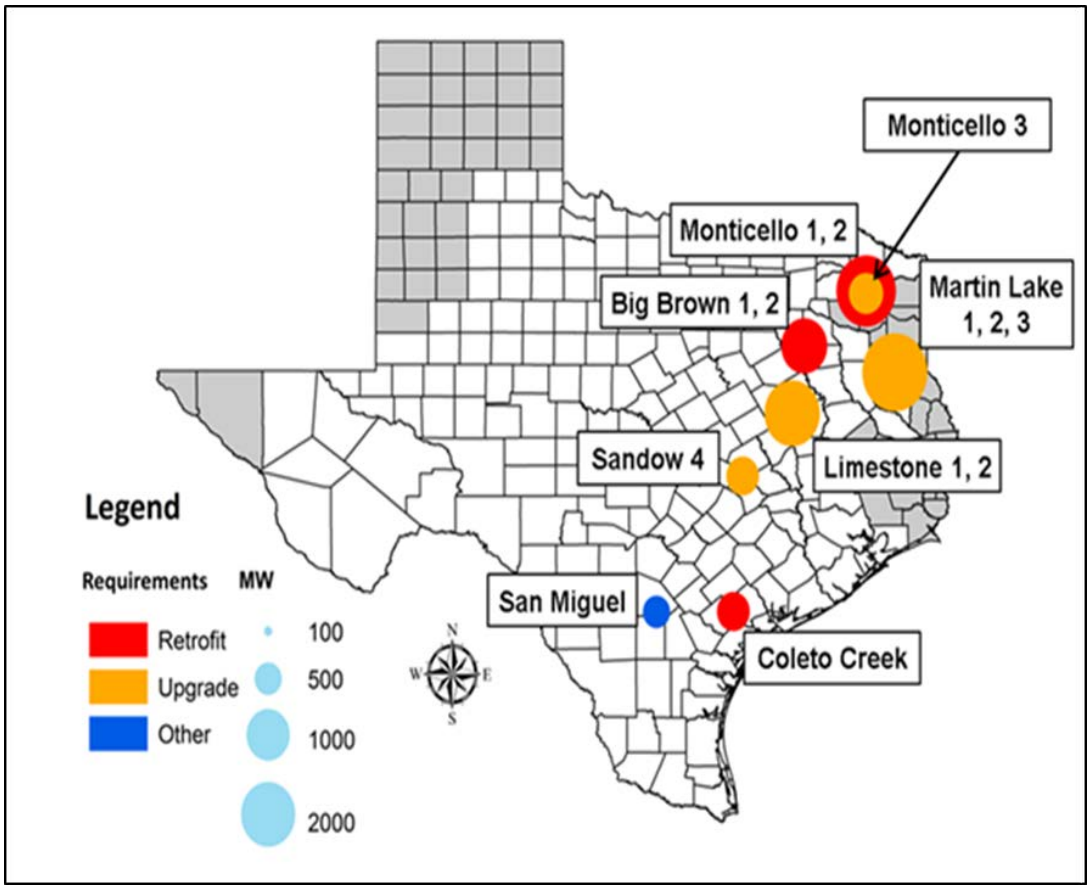

Figure 5.3: Regional Haze Affected Units in ERCOT

If the owners of these plants were to suspend operations, they would need to notify ERCOT at least 90 days before retiring or suspending operations of the generating unit. If multiple retirements occurred within a short timeframe, without early notice, loss of this capacity could result in localized grid reliability issues. In the ERCOT region, it takes at least five years for a new major transmission project to be planned, routed, approved and constructed. As such, in order for major transmission constraints to be addressed in a timely fashion, the need must be seen at least five years in advance. Even though the Regional Haze FIP has been remanded by the EPA, this regulation can serve as a proxy for any regulatory or market change that results in the suspension of operations of a significant amount of legacy coal generation within the 6-year planning horizon.

With these concerns in mind, ERCOT developed an environmental regulation scenario for conducting a transmission analysis during the 2016 Regional Transmission Plan (RTP). Assumptions about generation retirements were developed based on the requirements of the Regional Haze FIP and other pending environmental regulations. Specifically, the study assumed approximately 6 GW of generation retirements based on the following assumptions: 1) the retirement of the generation requiring new scrubbers under the Regional Haze FIP (Big Brown 1 and 2, Monticello 1 and 2, Coleto Creek) and 2) the retirement of the generation requiring upgrades of existing scrubbers under the

Regional Haze FIP if the generation is located in a county designated as being in non-attainment with the 2010 SO_2 National Ambient Air Quality Standard (NAAQS) (Martin Lake 1, 2 and 3, and Monticello 3).

These assumptions reflect one possible combination of unit retirements. It was intended to assess the transmission reliability implications of the retirement of multiple coal-fired units over a relatively short period of time, using known regulatory requirements to provide a scope for the analysis.

The scenario was developed using the year 2021 model from the 2016 RTP. To balance power supply and demand, ERCOT added new generation based on a review of the ERCOT Generation Interconnection Status (GIS) report and using the following approach: 1) any new generation that had committed to construct but were not included in the RTP start cases, and 2) any new conventional (with air permit), wind or solar units with an interconnection agreement that did not meet the requirements to be in the transmission planning models as specified in Planning Guide Section 6.9. Table 5.1 provides a summary of the total MW capacity from the new generation assumed in each weather zone.

Table 5.1: New Generation Assumed for the Scenario Analysis

MW Capacity for Grid	Coast	East	Far West	North	North Central	South	South Central	West
Gas	1073	1217	-	-	928	730	362	1598
Solar	-	-	834	201	-	-	-	100
Wind	-	-	-	1465	-	250	-	-
Total	**1073**	**1217**	**834**	**1666**	**928**	**980**	**362**	**1698**

The study results indicated the retirement of the resources would have significant impacts on the ERCOT grid, resulting in exceedances of thermal limitations primarily on the transmission system serving the load in the Dallas-Fort Worth area. A significant amount of transmission system improvements would likely be required to ensure transmission system reliability criteria are met even if a moderate amount of new resources were to be displaced around the region.

ERCOT identified thirteen projects that would be required to maintain reliability for the studied conditions. Eight of the thirteen projects involve the upgrade of existing 345 kV lines in and around the Dallas-Fort Worth area. In addition, the new generation assumed for this analysis is uncertain, and some of the included units are located around the major urban load centers. If the assumed new generation is not built in these specific locations there could be more severe impacts on the transmission system, as the inclusion of these units may have reduced the impacts of the assumed retirements. More details on this analysis can be found in the 2016 RTP report posted on the ERCOT Market Information System website.

Although both the Regional Haze FIP and the Clean Power Plan have been stayed by the Federal Courts, there are other regulations, including the recent 2010 SO_2 NAAQS designations and the proposed Best Available Retrofit Technology (BART) rule for Texas that may have an impact on coal capacity in ERCOT. In the coming years, resource owners will need to make decisions about their generation units that could result in reliability and transmission constraints. As new information becomes available, ERCOT will continue to analyze the impacts of regulatory developments that may affect the ability to provide reliable electricity to consumers in Texas.

2019 and 2022 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 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 5.2 and Figure 5.4 show the constraints projected to be the most congested for 2019 and 2022 based on model simulation in the 2016 RTP.

Table 5.2: List of Projected Constraints (2019, 2022)

Map Index	Projected Constraining Element	2019 Congestion	2022 Congestion
1	Panhandle Export		
2	South Texas Project – Jones Creek 345 kV line		
3	Oasis – W.A. Parish 345 kV line		
4	Cico – Comfort 138 kV line		
5	Long Road – North Denton Interchange 138 kV line		
6	Fort Stockton Plant – Airport 138 kV line		
7	Jones Street – Lakepointe 138 kV line		
8	16th Street – Woodward 138 kV line		
9	Raymondville – Las Pulgas 138 kV line		
10	Jack Creek – Twin Oak Switch 345 kV line		
11	Fayetteville 345/138 kV transformer		
12	Austrop – Sandow 345 kV line		
13	Bruni Substation 138/ 69 kV transformer		
14	Cagnon 345/138 kV transformer		
15	Fort Stockton – Barilla 69 kV line		
16	Reveille – Encinal 138 kV line		
17	Cagnon – Kendall 345 kV line		
	Legend	**None**	**Low** **High**

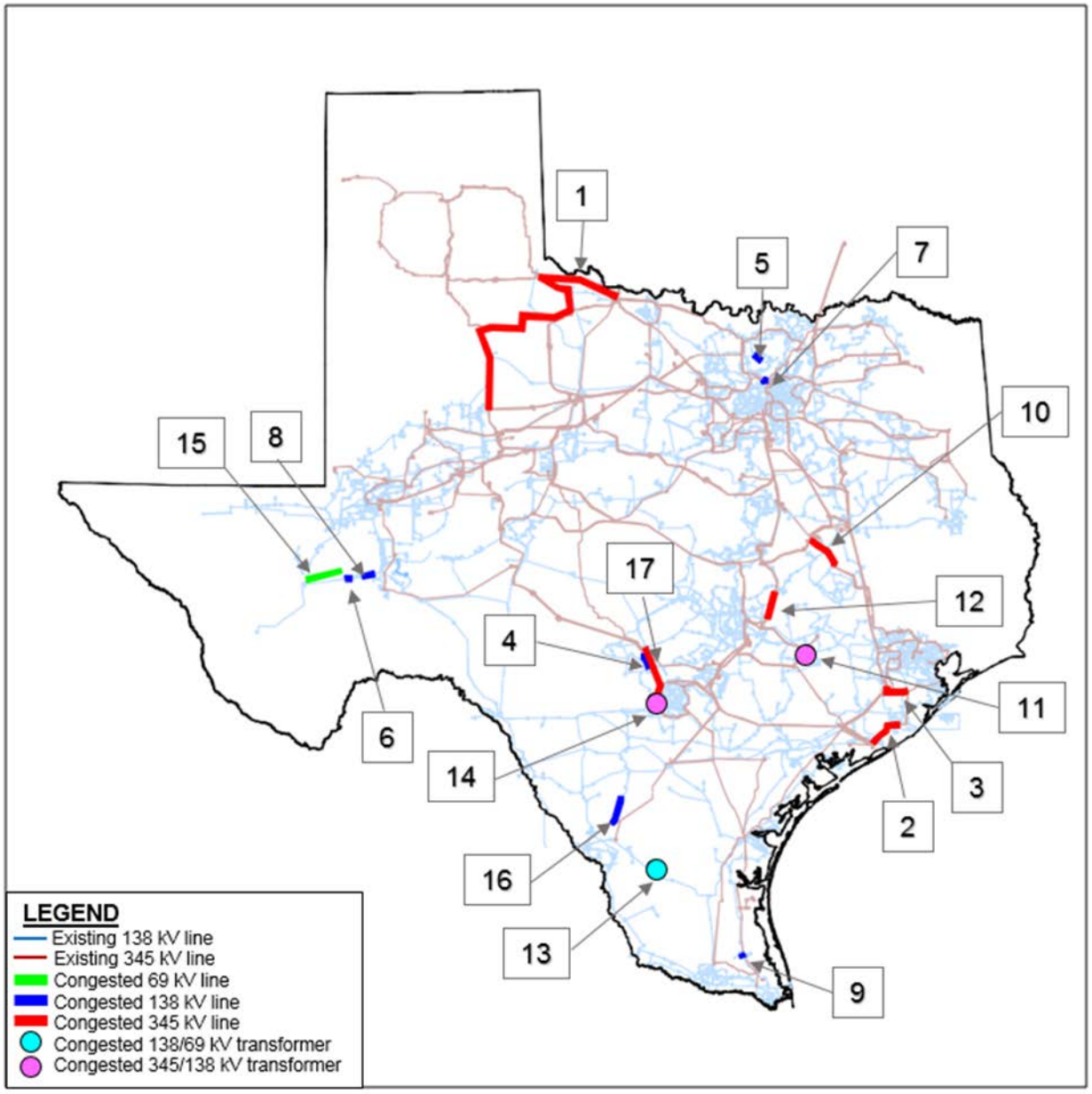

Figure 5.4: Projected 2019 and 2022 Constraints

Chapter 6. Seams Developments

Recently, there have been several developments along the borders, or seams, of the ERCOT grid. Following is a brief description of some of these activities.

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 their system 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 6.1 shows the location of Lubbock relative to the ERCOT transmission system.

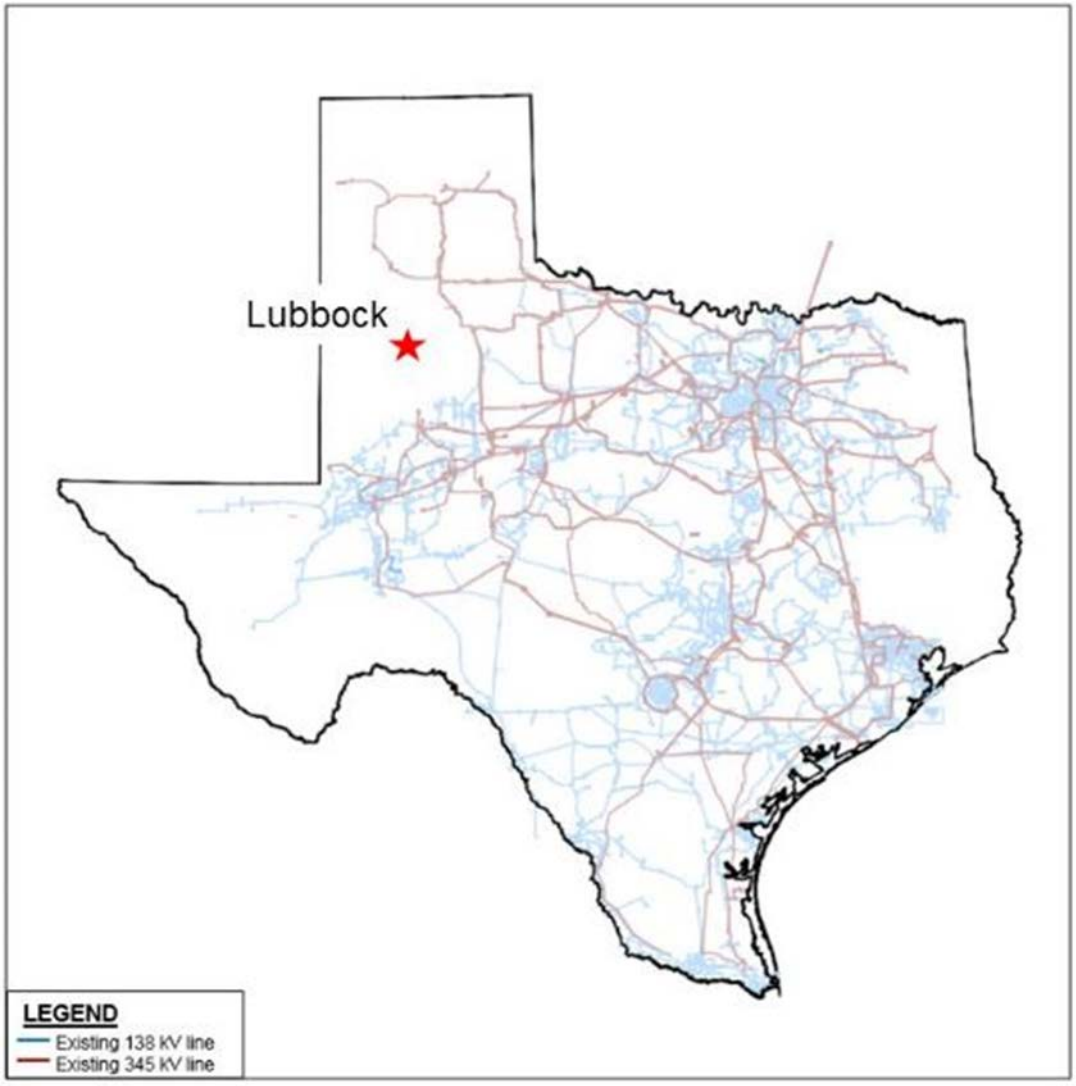

Figure 6.1: Lubbock and the ERCOT Transmission System

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 included over forty integration options.

ERCOT's preferred option included constructing 345 kV lines from the existing ERCOT grid to three separate interconnection points on the LP&L system. Though the preferred option was not the least expensive from a capital cost perspective at an estimated $364 million, the additional cost compared to the lowest cost option was justified due to the projected congestion relief it would provide for Panhandle generation exports. Compared to the planned Panhandle system, the preferred Lubbock integration option would increase the Panhandle export limit by approximately 500 MW. Additionally, the preferred option provided ample load growth capability for the LP&L system and aligned with ERCOT's previous long-range Panhandle transmission expansion plans.

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. This analysis is expected to be completed by the second quarter of 2017.

Rayburn County 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 of this load is served from 138 kV transmission facilities within the Eastern Interconnection. 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. RCEC and Lone Star Transmission performed a joint study and identified a preferred transmission interconnection option with an estimated cost of $38 million to integrate these facilities into the ERCOT grid.

The PUCT asked ERCOT to perform an integration study for the RCEC load. This study is expected to be completed in 2017.

DC Ties

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

Recently there have been several proposals to create new direct current (DC) ties between ERCOT and the Eastern Interconnection. As proposed, the Tres Amigas DC tie

would create a 1,500 MW connection between ERCOT and the Eastern Interconnection in the Panhandle. This project is currently under study.

The proposed Southern Cross merchant DC tie would be a 2,100 MW asynchronous tie between the Eastern Interconnection and ERCOT on the east side of the system, connecting into ERCOT in Rusk County. At the time of the publishing of this report the PUCT was considering the Certificate of Convenience and Necessity application for the portion of the project that is located in Texas.

In addition to these merchant DC ties, ERCOT is participating in a study with the Midcontinent Independent System Operator (MISO) in order to identify potential benefits from a new DC tie connecting the MISO grid in the Eastern Interconnection to the ERCOT grid. This study, which started in early 2016, did not begin with any assumed DC tie locations or size. The study is expected to be completed in 2017. Figure 6.3 illustrates the proposed DC tie connections.

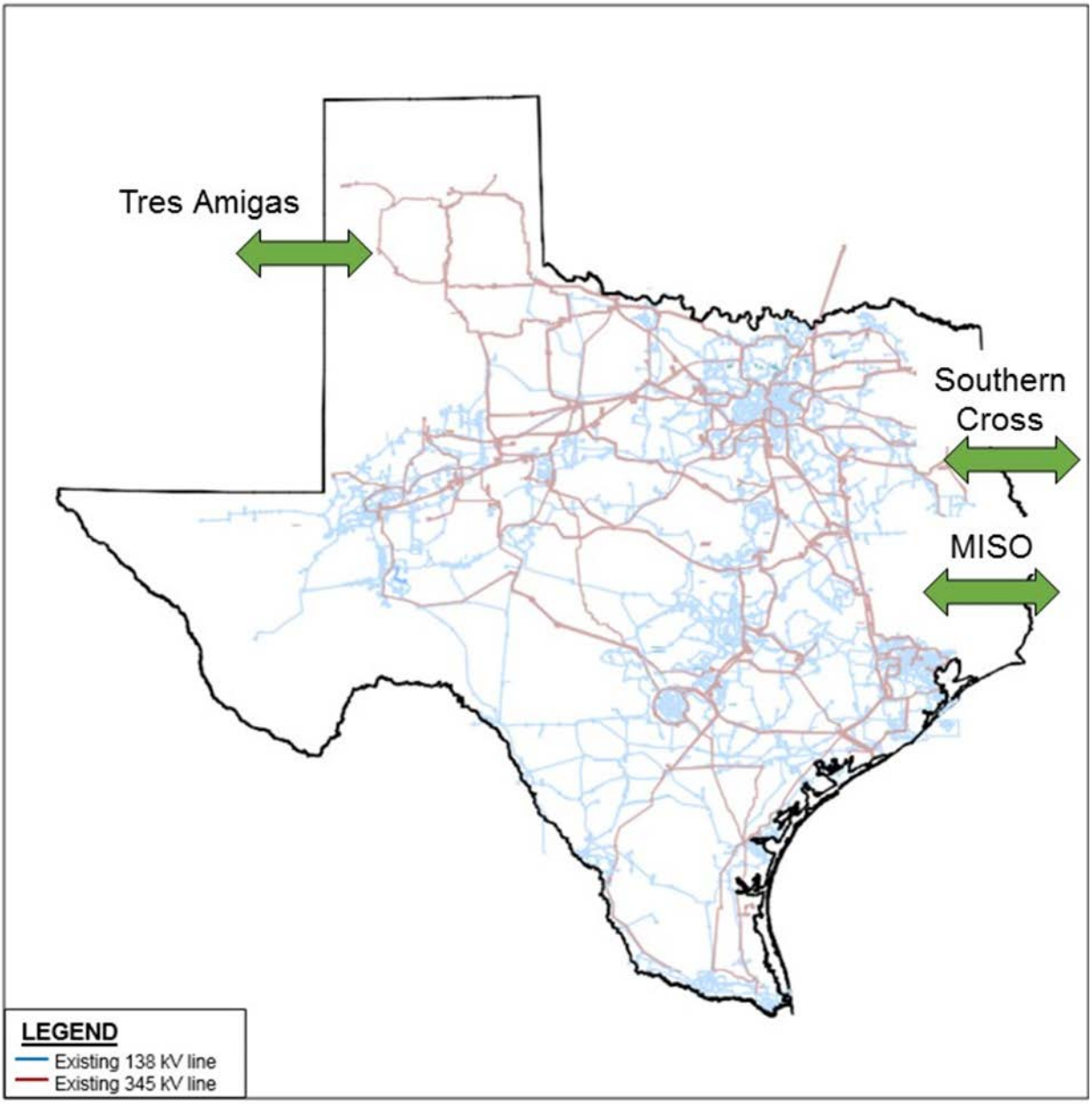

Figure 6.2: Proposed DC Ties to ERCOT

In 2016, the National Renewable Energy Lab (NREL) began the North American Renewable Integration Study (NARIS). The goal of this multi-national study is to examine how Canada, the United States, and Mexico can help each other meet renewable energy goals. Among other things, the study may include analyzing the benefits of increased DC tie capacity between ERCOT and Mexico, and potentially between ERCOT and the Eastern and Western Interconnections.

Chapter 7. Long Term System Assessment

The Long-Term System Assessment (LTSA) provides an evaluation of the potential needs of ERCOT's extra-high voltage (345 kV) system in the ten to fifteen-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 larger project could be required. A larger project may also be more cost-effective than multiple smaller projects—each being recommended in successive Regional Transmission Plans.

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

Members of the ERCOT RPG developed a set of eight different future scenarios through a series of stakeholder-driven scenario development workshops. Using the assumptions and guidelines set by stakeholders in the scenario descriptions, ERCOT prepared seven different load forecasts.

Planning for transmission ten and fifteen years in the future requires ERCOT to make assumptions regarding what types of new resources could be developed. ERCOT conducted generation expansion analysis for the eight stakeholder-developed scenarios using the guidelines set in the scenario descriptions.

ERCOT and stakeholders used the results from the load forecast and generation expansion analyses to select three of the eight scenarios for transmission planning analysis. The scenarios selected for transmission planning analysis were the Current Trends, High Energy Efficiency/ Distributed Generation, and Environmental Mandate scenarios.

The only scenario that showed load decreasing was the High Energy Efficiency/ Distributed Generation scenario, which assumed aggressive energy efficiency programs and a significant amount of distributed generation would be added in ERCOT. The expected strength of the Texas economy resulted in all other scenarios seeing moderate to strong load growth.

In all eight scenarios, solar generation additions by far represented the largest resource capacity change on the system. As seen in Figure 7.1, total solar generation capacity additions ranged from 14,500 MW to 28,100 MW in the eight scenarios. Conversely, all eight scenarios had varying levels of coal generation retirements, and seven of the eight scenarios had natural gas generation retirements. The retirement capacity by scenario is shown in Figure 7.2

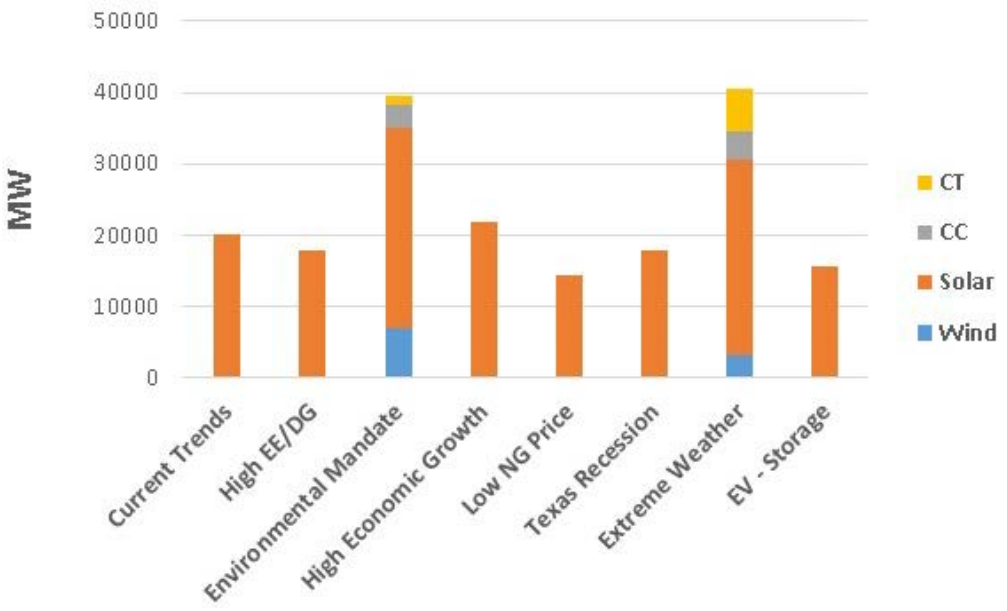

Figure 7.1: Capacity additions across all scenarios

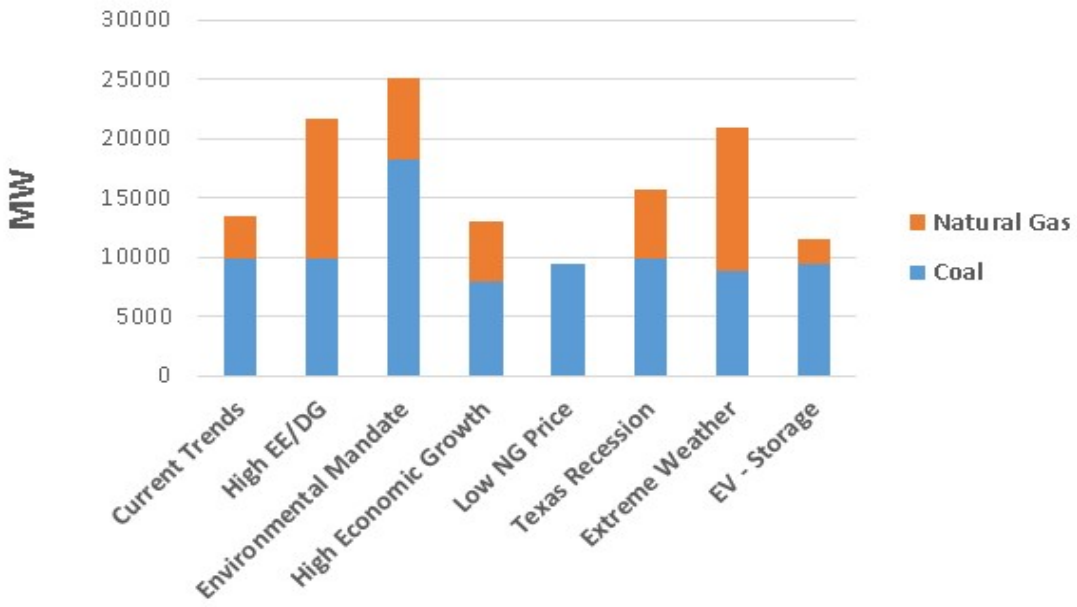

Figure 7.1: Generation retirements across all scenarios

One potential challenge identified in the study is the need for additional generation resources to offset the drop in solar production in late evening hours of the summer. With the amount of solar resources noted in many of the scenarios in this study, the loss of solar output in the late evening while air conditioning load remains high could lead to extreme system ramping conditions, or possibly insufficient generation capacity to serve load (especially on days when there is little to no wind generation output). On some days

the model simulation output indicated limited amounts of unserved energy. Figure 7.3 shows this potential result for a summer peak evening in 2031 from the Current Trends scenario. Results from this study indicate that if a significant amount of solar generation and/or additional wind generation is developed in ERCOT both resource adequacy and transmission planning studies will need to be adjusted to incorporate an assessment of system reliability under peak load and net peak load conditions.

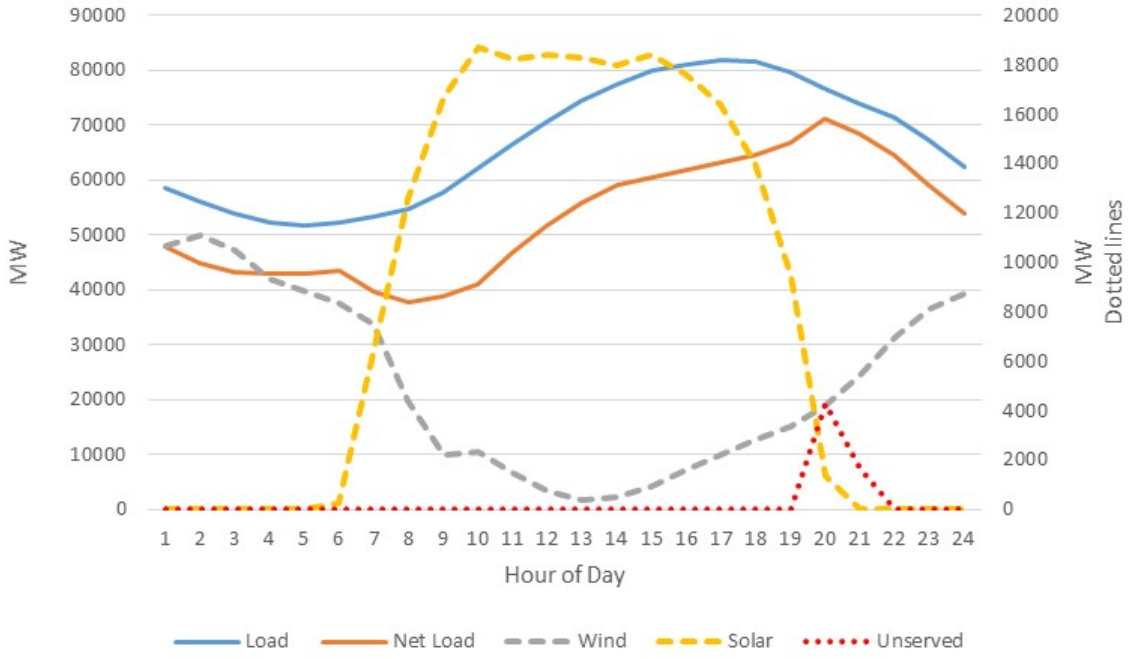

Figure 7.2: Net peak load challenge

The addition of solar generation in the western part of the state coupled with the retirement of coal and natural 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 all scenarios studied for transmission analysis. Figure 7.4 illustrates the change in generation capacity across the three scenarios that were used for the transmission analysis. The warm colors on the map indicate the location and magnitude of generation capacity that were added in a particular scenario, whereas the cool colors on the map show the loss of generation capacity on the system.

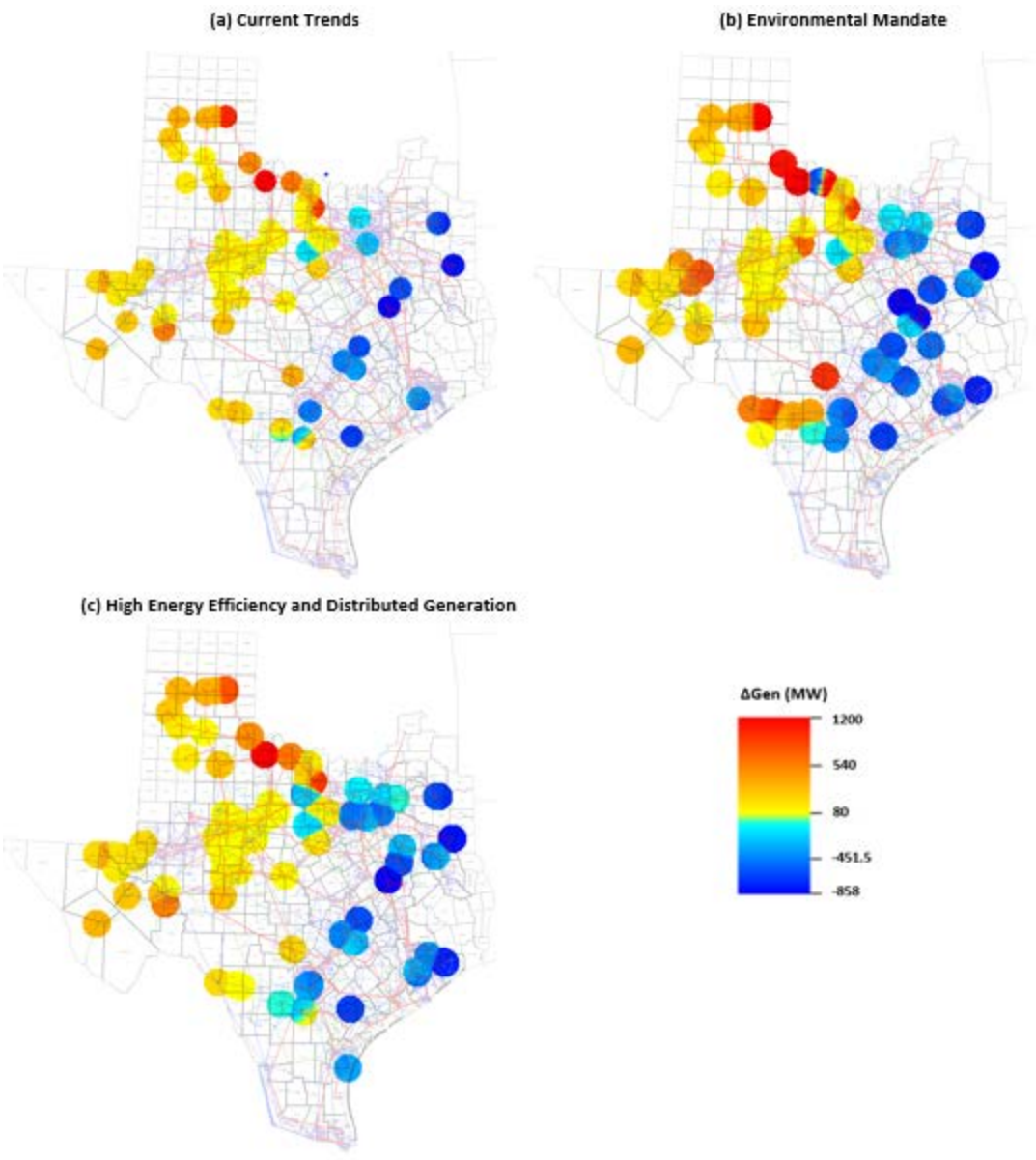

Figure 7.3: Change in generation capacity across different scenarios

The observed west-to-east power flows resulted in the need for transmission system improvements including existing 345 kV upgrades and new extra high voltage paths in order to reliably deliver power to the load centers. Even the High Energy Efficiency/ Distributed Generation scenario, which had a decreasing peak load, required substantial transmission improvements due to the increase in west-to-east power flows resulting from the change in generation mix. Figure 7.5 highlights some of the significant transmission improvements found to be needed in the Current Trends scenario.

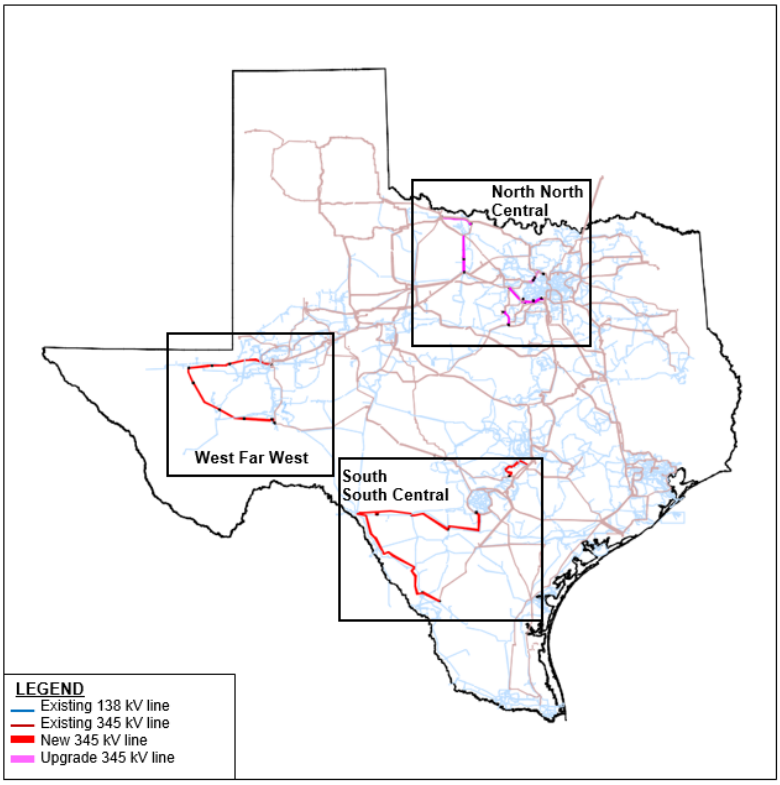

Figure 7.4: Transmission improvements in the Current Trends scenario

The Panhandle was found in all studied scenarios to have a significant amount of congestion due to generation additions in the region. Annual congestion rent in year 2031 ranged from $353 million to $866 million. ERCOT analyzed an additional export transmission path from the Panhandle and found that a new 345 kV line from the Ogallala substation to the Long Draw substation would meet the ERCOT economic criteria in the Environmental Mandate scenario. This finding was in line with the ERCOT 2014 Panhandle Study which identified a similar improvement as being necessary as generation capacity in the Panhandle increased.

The full 2016 LTSA report can be found on the ERCOT website:

http://www.ercot.com/news/presentations/

Chapter 8. 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

Media
Robbie Searcy
512-225-7213

Regulatory and Government Relations
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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
- System Protection Data

Chapter 9. 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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