Report on Existing and Potential

Electric System Constraints and Needs

December 2015

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).

In 2015, the most significant constraint on the ERCOT System was related to the import of power into the Houston area from the north. From October 2014 through September 2015 this area has experienced over $39 million in congestion rent. Congestion in this area has been high for several years. In addition to the observed congestion, reliability studies have identified possible overloads in the next several years on transmission lines along this path. As shown in Figure ES.1, the Coast weather zone, which is primarily comprised of the Houston area, is the only zone in the ERCOT System to see a net decrease in generation since 2004. This means that the area has required increasing amounts of power to be imported from elsewhere in the ERCOT System. ERCOT has reviewed and endorsed a reliability-driven project to increase the import capability into the Houston area. The project, primarily consisting of new 345 kV transmission lines, is expected to be in-service by the summer of 2018.

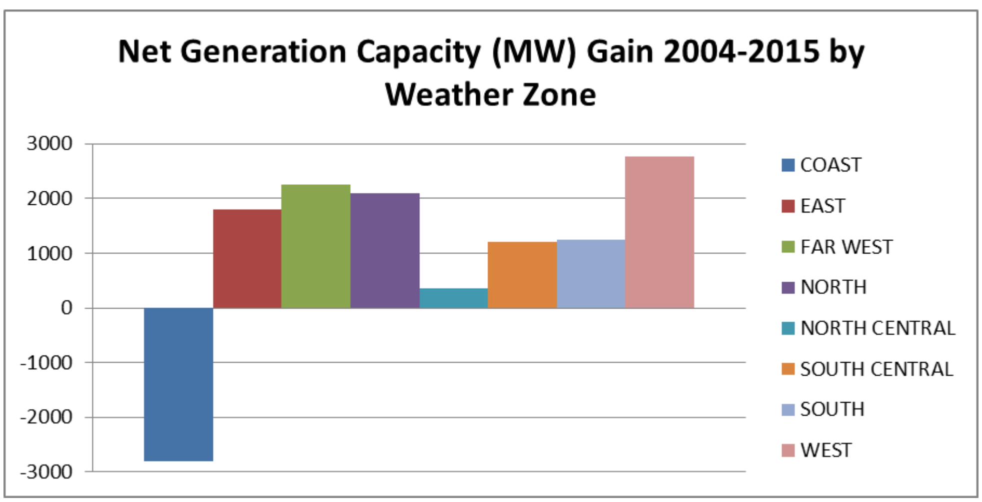

Figure ES.1: Net Change in Generation Capacity by Weather Zone (2004-2015)

The San Angelo area experienced high amounts of congestion in 2015 due to the outage of a transformer during an upgrade. This upgrade, which includes a new transformer, will improve the reliability of the system in the area moving forward.

Congestion due to oil- and gas-related activities in the Permian Basin in West Texas has been significantly reduced over the last several years due to the transmission improvements that have been implemented in the area. Permian Basin-related congestion accounted for only one of the top 15 constraints on the ERCOT System in 2015 compared to six in 2013 and three in 2014. Figure ES.2 shows the cost of transmission improvements (excluding Competitive Renewable Energy Zone projects) by weather zone in ERCOT since 2007. The Far West weather zone, which encompasses most of the Permian Basin's oil- and gas-related load, has seen a substantial increase in transmission investment over that time.

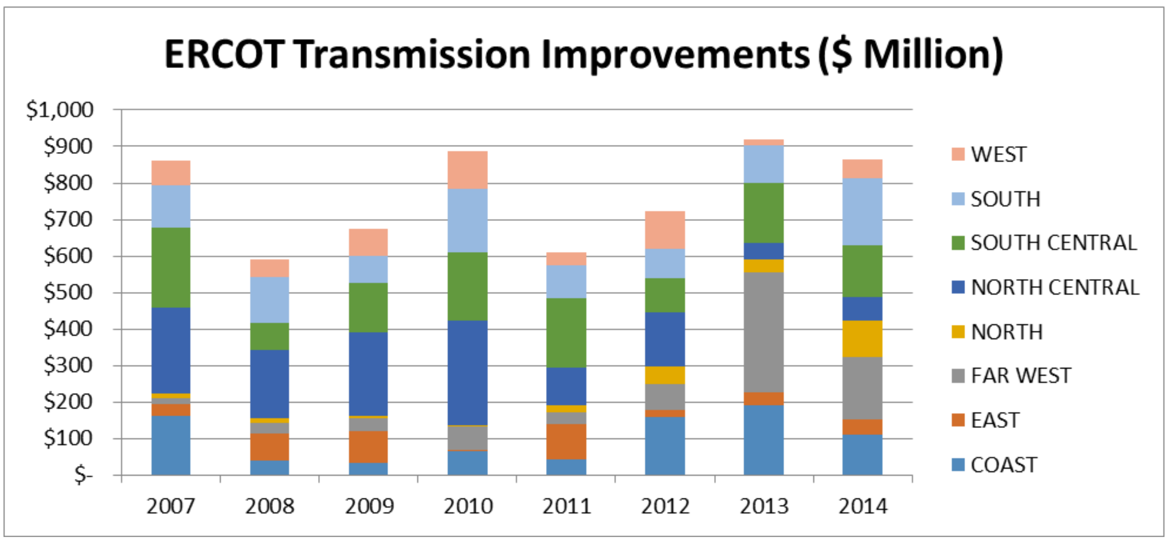

Figure ES.2: ERCOT (Non-CREZ) Transmission Improvements by Weather Zone and Year

In the Lower Rio Grande Valley (LRGV), a new 345 kV import line and the upgrade of the two existing 345 kV import lines are part of a project under construction to increase the overall import capability into the area by 2016. Additionally, a new 345 kV line that runs east-west across the LRGV is planned to meet reliability needs in and around the Brownsville area. ERCOT is currently evaluating the need for additional system improvements after 2016. This assessment is being driven by the recent announcement that one generation unit in the LRGV will be switched from serving ERCOT load to serving customers in the Mexico system. Potential needs for additional transmission may be deferred by several potential generation projects that are under study in the area.

Treatment of natural gas to form liquefied natural gas (LNG) is an energy-intensive process and the construction of such a facility can significantly increase the load already being served in an area. Several potential LNG facilities have been proposed across the United States, including many along the ERCOT Gulf Coast. The Freeport LNG liquefaction project and Cheniere's Corpus Christi Liquefaction facility were the first LNG export facilities within the ERCOT region to receive all necessary approvals to begin construction.

The Freeport LNG facility will be located on Quintana Island in Brazoria County and, at full production, will require 690 MW to serve its load. In 2015, ERCOT endorsed the Jones Creek project to meet the transmission needs of this project. The Cheniere facility, while having only slightly less LNG production capacity, will have a much lower electric power need because it will utilize different technology to drive its process needs and will require less extensive transmission upgrades. LNG exports from both facilities are expected to begin in 2018 and reach full output in 2019. Both projects are pursuing possible plant expansions and six additional LNG projects are exploring connection to the ERCOT grid in the Brownsville area.

A changing resource mix in ERCOT could lead to constraints in several areas. Wind generation development in the Panhandle will soon exceed the capability of the transmission system to export power out of the region. ERCOT is currently pursuing several upgrade solutions to this constraint, but congestion may persist if generation development continues. There are a substantial number of solar generation projects under study in Far West Texas. This area has a relatively weak transmission system and significant congestion could occur if a large amount of the solar generation under study moves forward with construction. ERCOT is planning to finalize a study of the region in 2016. Finally, the potential retirement of coal generation in ERCOT could lead to a considerable amount of local and regional reliability impacts on the transmission system.

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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 2015 RTP report is posted on the ERCOT Market Information System website.
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 identify 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 LTSA does not recommend the construction of specific system upgrades due to the degree of uncertainty associated with the amount and location of loads and resources in this timeframe. The biennial LTSA study is conducted in even-numbered years. The 2014 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 three 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 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 portion of the ERCOT System.

For analysis purposes, the ERCOT System is divided into eight regions, termed “weather zones,” developed based on overall consistency of weather patterns. Figure 2.1 depicts the location of these weather zones.

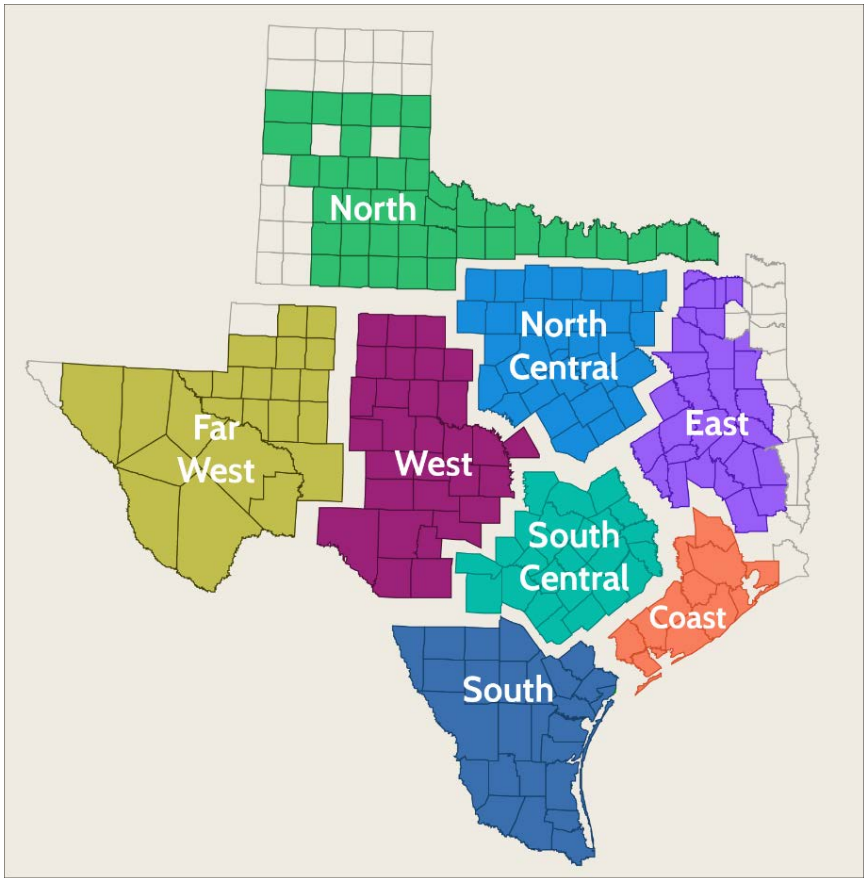

Figure 2.1: ERCOT Weather Zones

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 2015, $477.6 million of transmission improvement projects were reviewed and endorsed through the RPG process.

Transmission system improvements are built by TSPs and are paid for by consumers. During the twelve-month period from October 2014 through September 2015, TSPs completed $800.8 million worth of transmission improvement projects. Figure 2.2 shows the cost of transmission

[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.

improvements completed in ERCOT, by calendar year, from 2007 through 2014. The cost is divided by Competitive Renewable Energy Zone (CREZ)-related projects and non-CREZ-related projects.

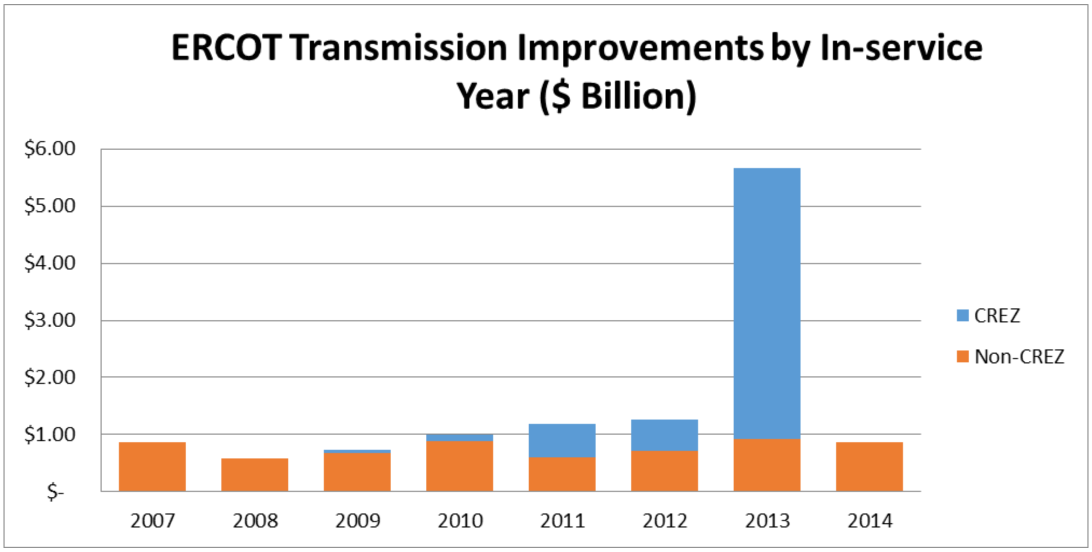

Figure 2.2: ERCOT Transmission Improvements by Year

Figure 2.3 further breaks down the non-CREZ-related improvements by weather zone. The data shows that the Far West weather zone has seen a significant increase in transmission investment since 2012, which can be attributed to oil- and gas-related upgrades.

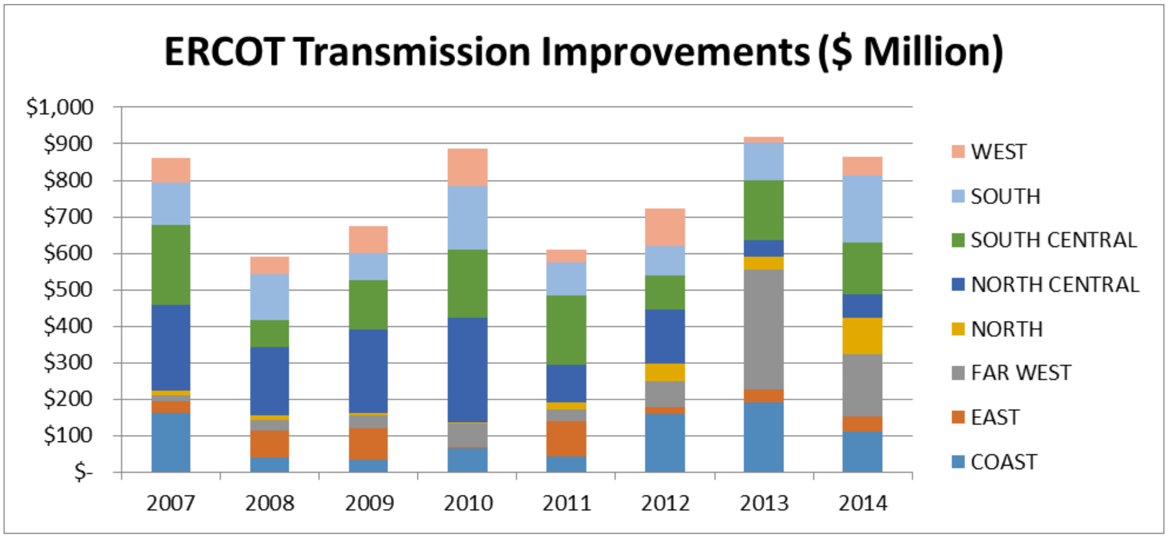

Figure 2.3: ERCOT (Non-CREZ) Transmission Improvements by Weather Zone and Year

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 limitations 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 2014 through September 2015, based on real-time data.

Table 3.1: 2015 Top 15 Congested Constraints on the ERCOT System

Map Index	Constraint	Congestion Rent
1	North to Houston Import	$39,316,039
2	Heights 138/69 kV transformer	$35,902,821
3	Rio Hondo-East Rio Hondo 138 kV line	$20,894,616
4	Harlingen Switch-Oleander 138 kV line	$19,245,752
5	Moss-Westover 138 kV line	$17,791,984
6	Hockley-Betka 138 kV line	$12,809,188
7	San Angelo College Hills 138/69 kV transformer	$12,124,531
8	La Palma-Villa Cavazos 138 kV line	$10,681,931
9	San Angelo Power 138/69 kV transformer	$10,622,923
10	Collin Switch 345/138 kV transformer	$9,098,021
11	Lon Hill-Smith 69 kV line	$8,504,021
12	Pflugerville-Gilleland Creek 138 kV line	$7,592,286
13	Cedar Hill-Mountain Creek 138 kV line	$7,469,997
14	Marion-Skyline 345 kV line	$7,358,307
15	East Levee-Reagan Street 138 kV line	$6,600,415

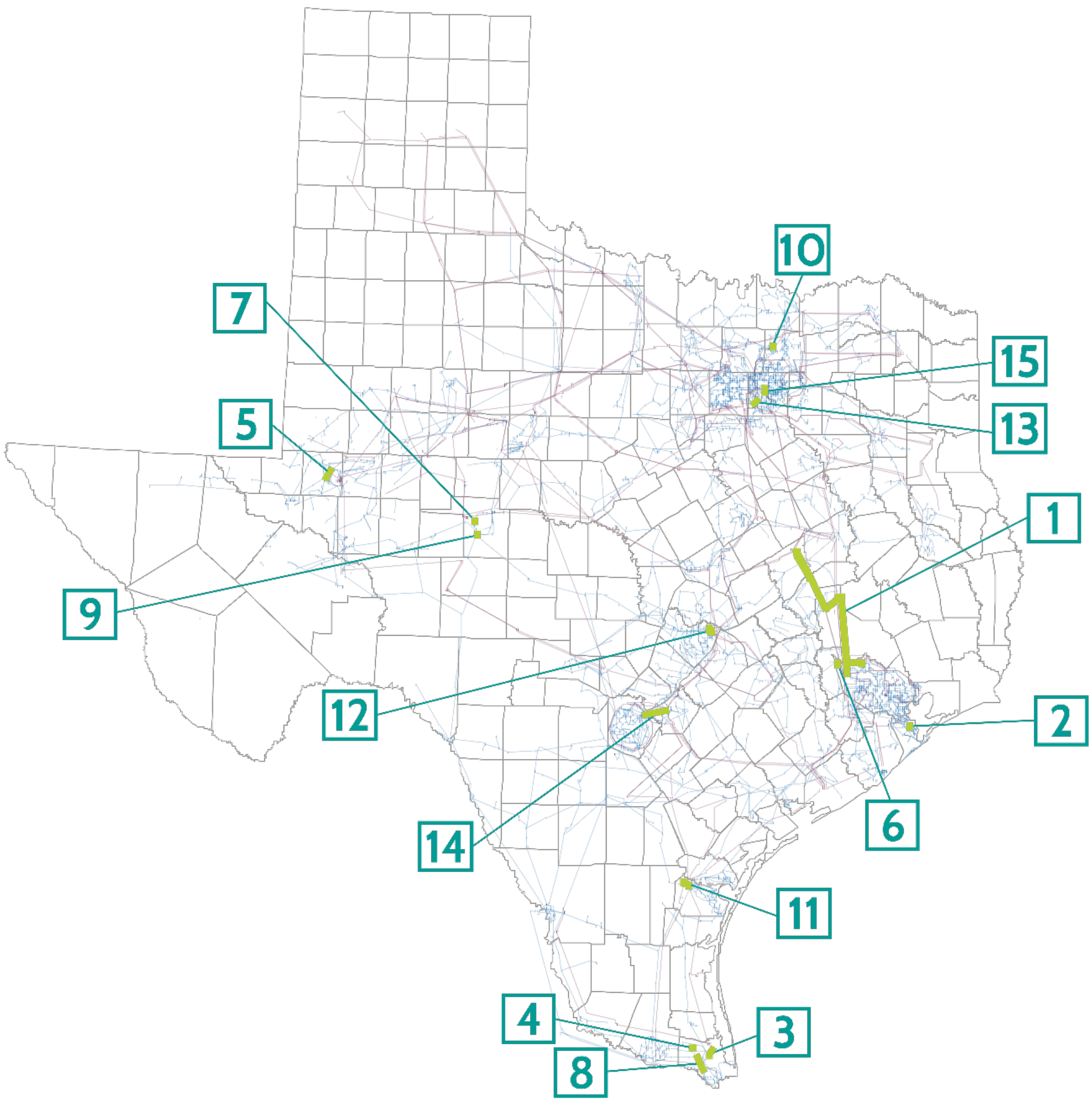

Figure 3.1: Map of 2015 Top 15 Congested Constraints on the ERCOT System

3.1 Houston Import

The import of power into the Houston area from the north caused the highest amount of congestion on the ERCOT System in 2015, totaling over $39 million in congestion rent. Multiple 345 kV lines coming into the area from the north experienced congestion, including the Twin Oak – Jack Creek 345 kV line, Singleton – Gibbons Creek 345 kV line, Gibbons Creek – Twin Oak 345 kV line, Singleton – Zenith 345 kV line, and the Singleton – Tomball 345 kV line. Additionally, the import of power to Houston from the North was constrained due to voltage stability limitations.

This voltage constraint is commonly referred to as the North to Houston stability limit. Congestion on these lines has been consistently high for several years. In addition to having the highest congestion rent in 2015, the North-Houston path experienced the fourth-highest congestion rent on the system in 2014 and the second-highest in 2013.

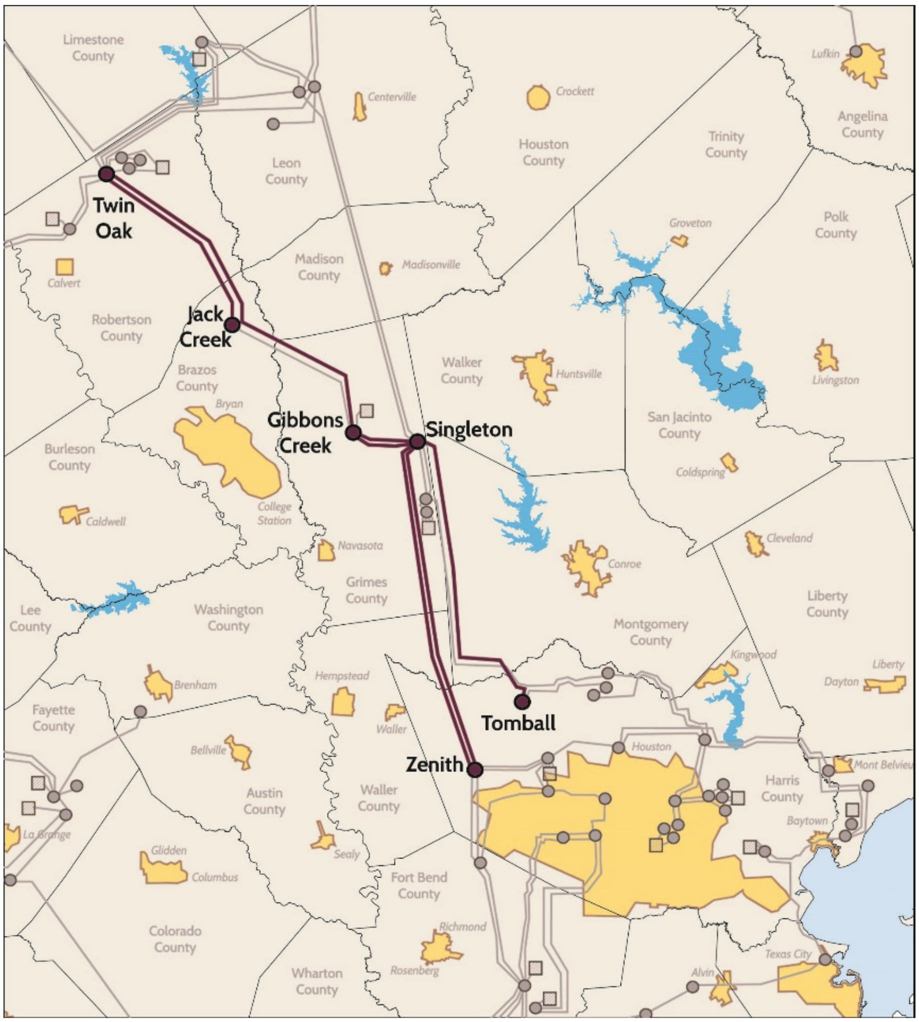

Figure 3.2: Houston Area 345 kV Congestion

The Houston metropolitan area is the second-largest load center in Texas, serving more than 25% of the entire load in the ERCOT System. Houston ranks fourth among U.S. cities in terms of population and nominal gross domestic product (GDP). With a nominal GDP of over $500 billion, Houston would rank 25th in the world if it were an independent country. In June 2015, there were more jobs in the Houston metropolitan area than in 35 individual U.S. states. Among U.S. ports, the Port of Houston has ranked first in import tonnage and second in total tonnage for 23 consecutive years.[2]

Houston, the "Energy Capital of the World," is expected to experience some negative economic impact due to the recent drop in oil prices. However, CenterPoint Energy, the primary transmission and distribution service provider in the Houston area, recently indicated that the number of residential customers on its system has historically not been correlated to oil prices. Their data shows that since 1980, residential customer growth has remained steady despite multiple spikes and dips in the price of oil.[3]

According to the Bureau of Economic Geology, approximately $24 billion of petrochemical and related large industrial projects are slated to come online along the ERCOT Gulf Coast between 2015 and 2018.[4] These projects, typically ranging from tens of megawatts to hundreds of megawatts, will add a significant amount of demand to the system. The addition of such large industrial facilities can represent future load growth that is not as easy to forecast when compared to residential and commercial customer classes.

The Coast weather zone, which primarily consists of the Houston area, is the only zone in the ERCOT System to have a net loss of generation capacity since 2004 (see Figure 4.3). This generation capacity loss plus the experienced and forecasted load growth has resulted in a significant increase in the amount of power being imported into the Houston area. 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. ERCOT conducted an independent review of the proposals and confirmed that there was a reliability need for additional imports into the Houston

[2] https://www.houston.org/assets/pdf/economy/Houston%20Facts_web.pdf
[3] http://files.shareholder.com/downloads/HOU/942334299x0x828290/813581C4-2267-4EAD-B5A0-E6D03DD67010/Q1_Slides_Final.pdf
[4] http://www.ercot.com/content/wcm/key_documents_lists/67259/GGulen_Oil_GasDevelopmentsinTexas_ERCOTLTSA071315.pdf

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 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 summer of 2018.

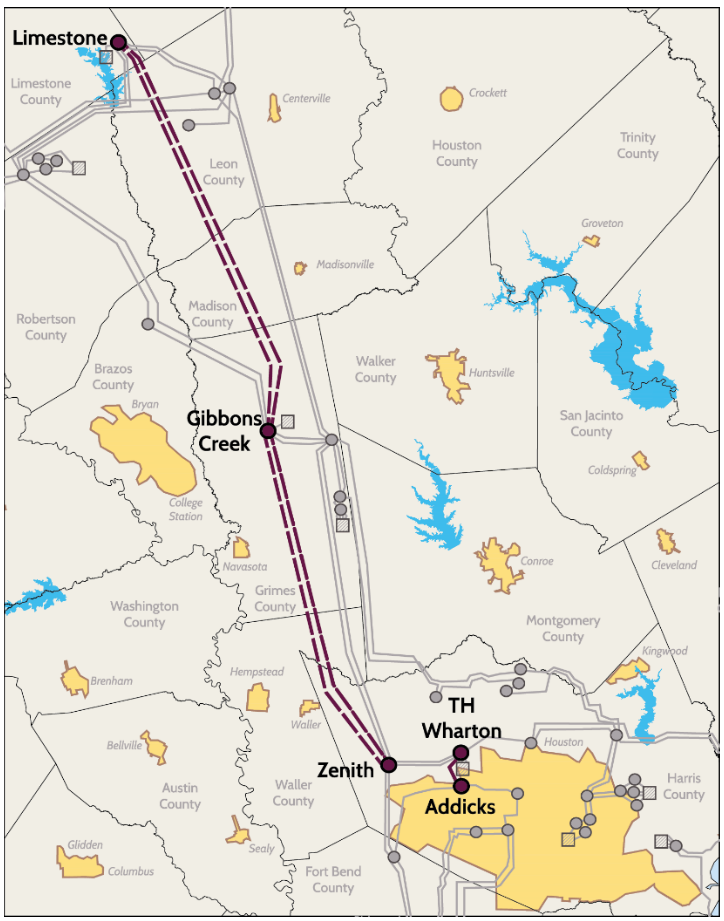

Figure 3.3: Houston Import Project Area

The 2015 RTP was conducted using more up-to-date assumptions than were used in the independent review of the Houston Import Project. Although the independent review indicated that the project was needed by 2018, a reliability criteria violation was found in the 2015 RTP for year 2016. However, it is unlikely that the project can be completed by 2016, and consequently, weather and outages could result in significant congestion costs on the import lines prior to completion. ERCOT operators 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. It should also be noted that the Freeport LNG project (discussed further in Section 4.3), which will add a sizable amount of load to the south side of the Houston area, was not included in the Houston Import Project analysis. At the time of the study, the Freeport project developer had not yet provided financial commitment to the TSP for the entire project. The addition of the Freeport LNG project would likely increase the need for the Houston Import Project.

3.2 San Angelo Congestion

The load in the San Angelo area, located in Tom Green County, is served by a 69 kV and 138 kV transmission system that includes four existing 138/69 kV transformers located at the San Angelo College Hills, San Angelo Power, San Angelo North, and San Angelo Concho substations. The peak demand in the San Angelo area is expected to reach approximately 290 MW by 2016. Almost half of the peak demand is served by the 69 kV transmission system through the four existing 138/69 kV transformers. The load in the area is expected to grow as shown in Table 3.2.

Table 3.2: Expected Peak Demand in San Angelo Area (source: 2015 RTP Cases)

2015 RTP Case	Expected peak demand served by 69 kV transmission (MW)	Expected peak demand served by 138 kV transmission (MW)	Total (MW)
2016	130	160	290
2018	133	167	300
2020	137	173	310

As shown previously in Table 3.1, one of the most congested areas on the system in 2015 was the area served by the 138/69 kV transformers at San Angelo College Hills and San Angelo Power (see Figure 3.4). The combined congestion rent on these transformers was greater than $22 million. The high congestion rent is the result of reduced capacity of area transformers due to the planned outage of the San Angelo Concho transformer. The Concho transformer has been out of service since February 2015, in order to construct the new 138/69 kV substation at Rusthill, which was put in-service in July. American Electric Power (AEP) built the Rusthill substation near the existing Concho substation in order to replace the Concho transformer with a new, larger transformer. Many outages were implemented to complete the substation construction, including re-terminating the 138 kV lines from Concho into Rusthill and replacing the existing Concho substation. The Rusthill 138/69 kV substation will improve the reliability of the system in the San Angelo area with the additional 138/69 kV transformer capacity (130 MVA). According to the ERCOT TPIT report, AEP is planning to replace the existing San Angelo North 138/69 kV transformer in 2018. The new transformer at Rusthill is expected to minimize the reliability and congestion impact when the San Angelo North transformer is replaced.

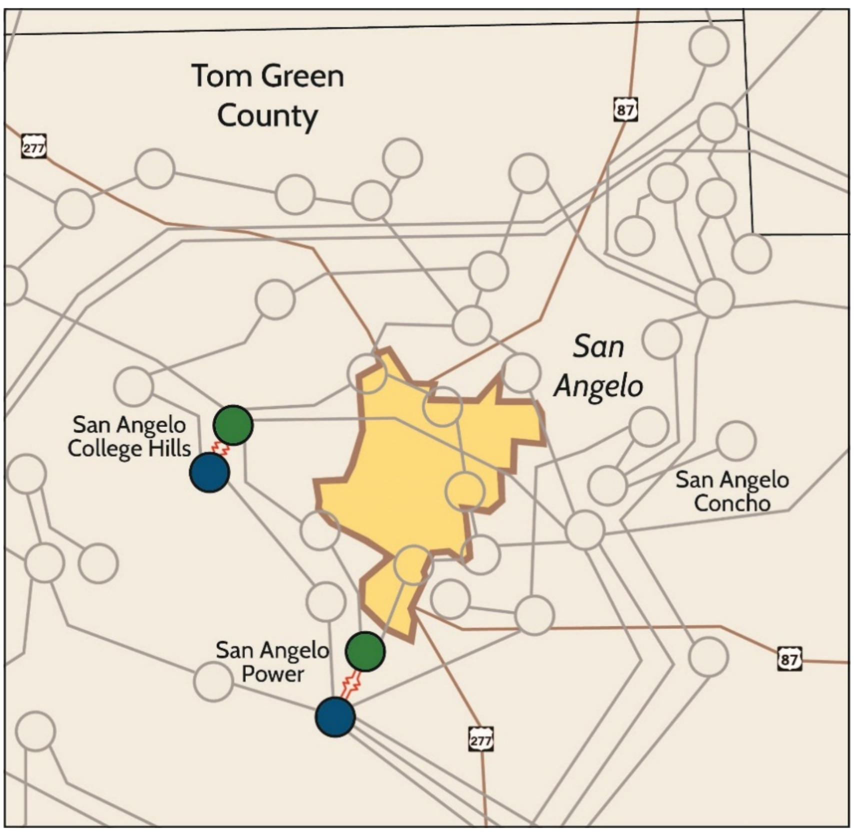

Figure 3.4: Congested Transformers in the San Angelo Area

3.3 West Texas Oil and Gas Load

Over the last several years the ERCOT System has experienced a significant amount of congestion in West Texas due to the growth in electric demand from the oil and natural gas industry and the associated economic expansion in residential and commercial developments in the Permian Basin area. However, from October 2014 through September 2015, only one of the top 15 constraints on the ERCOT System was located in Far West region of Texas (Moss Switch – Westover 138 kV line). In comparison, of the top 15 constraints in 2013, six were related to load in West Texas, and in 2014, three were related to West Texas needs. This improvement can be attributed to the implementation of several system improvement projects in that area.

Table 3.3 and Figure 3.5 show some of the significant West Texas transmission upgrade projects completed in the first half of 2015.

Table 3.3: Recently Completed West Texas Transmission Upgrades

Map ID	Project	Completion Date
1	Upgrade Midland Airport – Glenhaven 138 kV Line	May 15
2	Construct New Dermott Sw. Sta. – Ennis Creek Tap 138 kV Line	May 15
3	Upgrade Big Spring Switch – Big Spring West 138 kV Line	May 15
4	Install McDonald Road Sw. Sta. – Garden City East 138 kV Line	May 15
5	Replace Morgan Creek 138/69 kV Autotransformer	May 15
6	Upgrade Odessa North – Amoco South Foster – Westover 138 kV Line	May 15
7	Upgrade McDonald Road 138 kV Switching Station	May 15
8	Rebuild Holt 138 kV Switching Station as Double-Bus	May 15
9	Upgrade China Grove Switching Station Terminal Equipment	May 15
10	Construct New Andrews County South 345/138 kV Switching Station	May 15
11	Construct New Midland County Northwest 345/138 kV Switching Station	May 15
12	Upgrade North Andrews – Means 69 kV Line	May 15
13	Replace North Andrews 138/69 kV Autotransformers	May 15

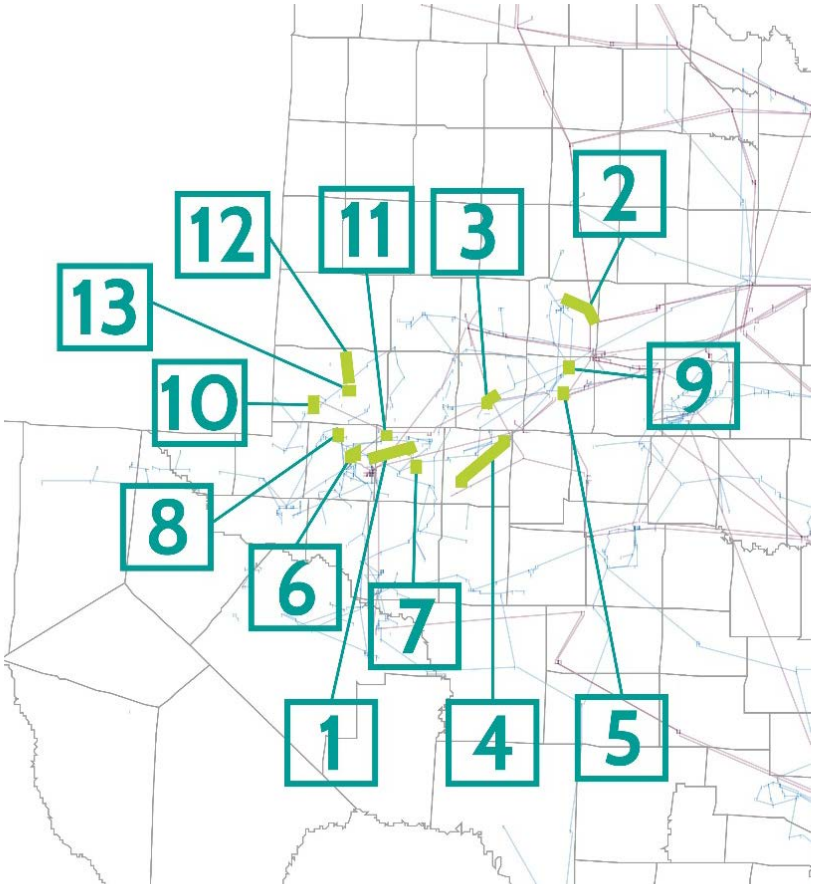

Figure 3.5: Recently Completed West Texas Transmission Upgrades

The load in West Texas continues to grow more quickly than in other parts of ERCOT. Despite the drop in oil prices, drilling activity in the Permian Basin continues. Peak demand in the Far West weather zone, which contains most of the Permian Basin, has increased at an average annual rate of 8.2% since 2009. Some of the growth in peak demand in 2014 can be attributed to the moving of load on the Sharyland Utilities system from the Eastern Interconnection to ERCOT. This transfer was completed in early 2014. Annual energy use in the Far West weather zone has experienced similar growth, increasing by an average annual rate of 9.9% from 2009 through 2014. Figures 3.6 and 3.7 show the Far West weather zone historical growth in peak demand and energy, respectively, since 2009.

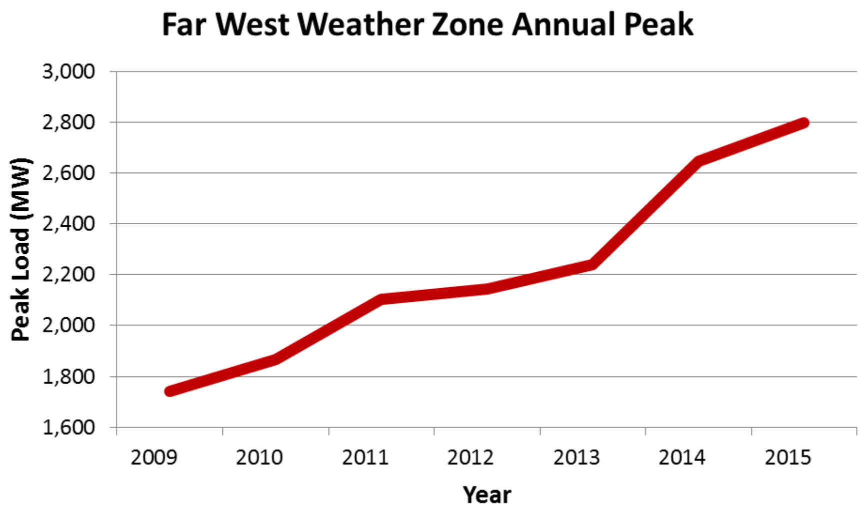

Figure 3.6: Far West Weather Zone Annual Peak Demand (2009-2015)

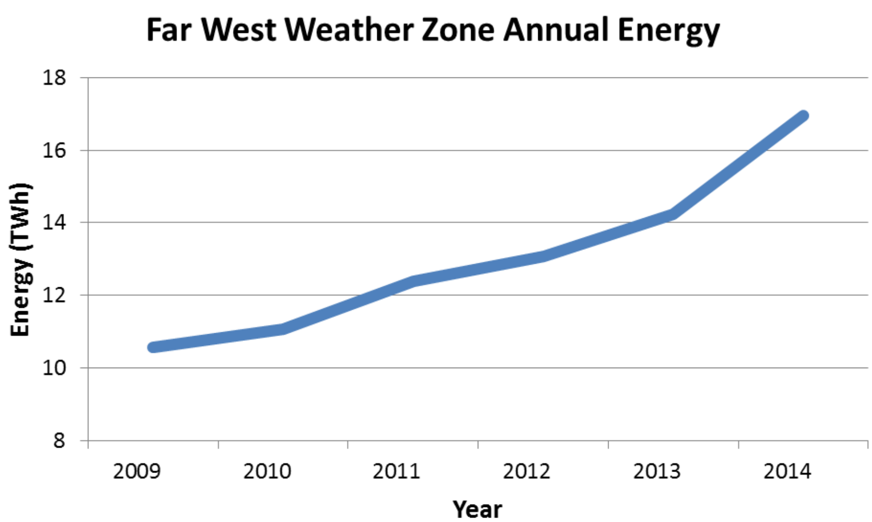

Figure 3.7: Far West Weather Zone Annual Energy (2009-2014)

Chapter 4. Planned Improvements

4.1 Historical Investments and Improvements

The need for transmission improvements is typically driven by increases in demand or changes in generation resources (both additions and retirements). Figure 4.1 shows the net change in weather zone peak demand between 2004 and 2015. The data shows that the two largest weather zones, Coast and North Central, had the largest net increase in peak demand. This result is to be expected since the two largest metropolitan areas in Texas—Houston and Dallas-Fort Worth—are located in these weather zones.

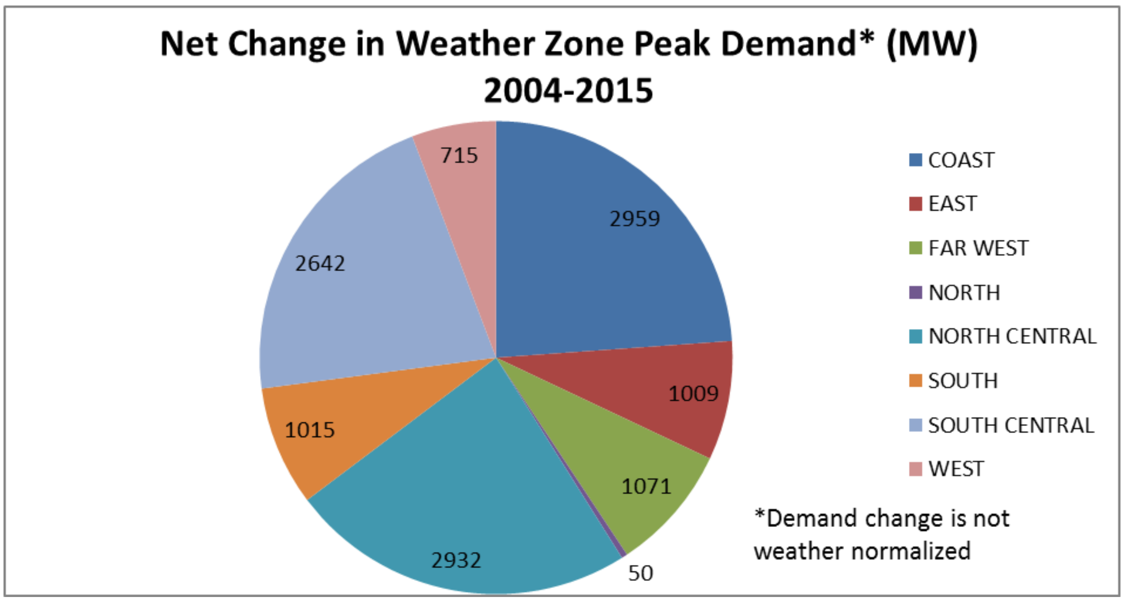

Figure 4.1: Net Change in Weather Zone Peak Demand (2004-2015)

Figure 4.2 shows the total growth percentage change in weather zone peak demand between 2004 and 2015. The chart shows that the Far West and West weather zones had the largest percentage increases in demand. This is most likely due to the increased demand from oil and natural gas activities in the Permian Basin. The Far West weather zone demand increase is also partially due to the aforementioned move of Sharyland Utilities load into the ERCOT System.

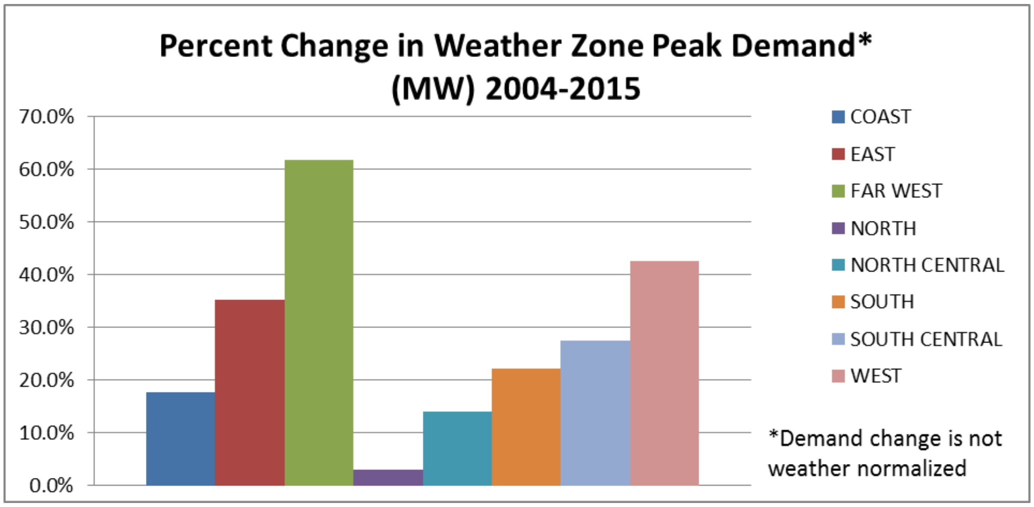

Figure 4.2: Percent Change in Weather Zone Peak Demand (2004-2015)

Figure 4.3 illustrates the net change in generation capacity by weather zone between 2004 and 2015. The chart indicates that all weather zones saw a net increase in generation capacity except for the Coast weather zone. The Coast weather zone, which is largely made up of the Houston area, saw a decrease of nearly 3,000 MW of generation capacity over this timeframe. The largest increases in generation capacity were seen in the West and Far West weather zones, which can be attributed to the wind generation additions in these zones. It should be noted that for purposes of this chart, wind generation was counted based on the nameplate capacity of the wind resources.

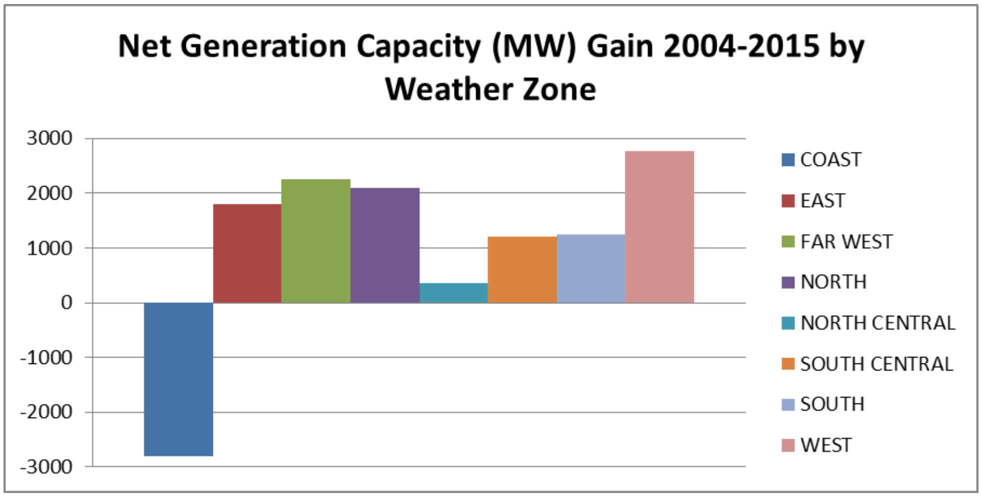

Figure 4.3: Net Change in Generation Capacity by Weather Zone (2004-2015)

Currently, there are $5.8 billion of future transmission improvement projects that are planned to be in service between 2016 and the end of 2021. Table 4.1 and Figure 4.4 show some of the significant improvements planned to be in-service within the next six years.

Table 4.1: Planned Transmission Improvement Projects

Map Index	Transmission Improvement	In-service Year
1	New Lobo – North Edinburg 345 kV line (Valley Import)	2016
2	New North Edinburg – Loma Alta 345 kV line (Cross Valley)	2016
3	Add Midessa South 345/138 kV transformer	2016
4	Add second Jewett 345/138 kV transformer	2016
5	Add second Jordan 345/138 kV transformer	2016
6	Add second Twin Buttes 345/138 kV transformer	2016
7	Add second Meadow 345/138 kV transformer	2016
8	New Fowlerton 345 kV station with 345/138 kV transformer	2017
9	New Jones Creek 345 kV station with two 345/138 kV transformers	2017
10	Upgrade McDonald Road – Garden City 138/69 kV line	2018
11	Houston Import Project	2018
12	Add second 345 kV circuit in the Panhandle loop	2018
13	Add synchronous condenser in the Panhandle loop	2018
14	Add Zorn – Marion 345 kV transmission line	2019
15	Add second Hicks 345/138 kV transformer	2020
16	Add Salado Switch 345/138 kV transformer	2021

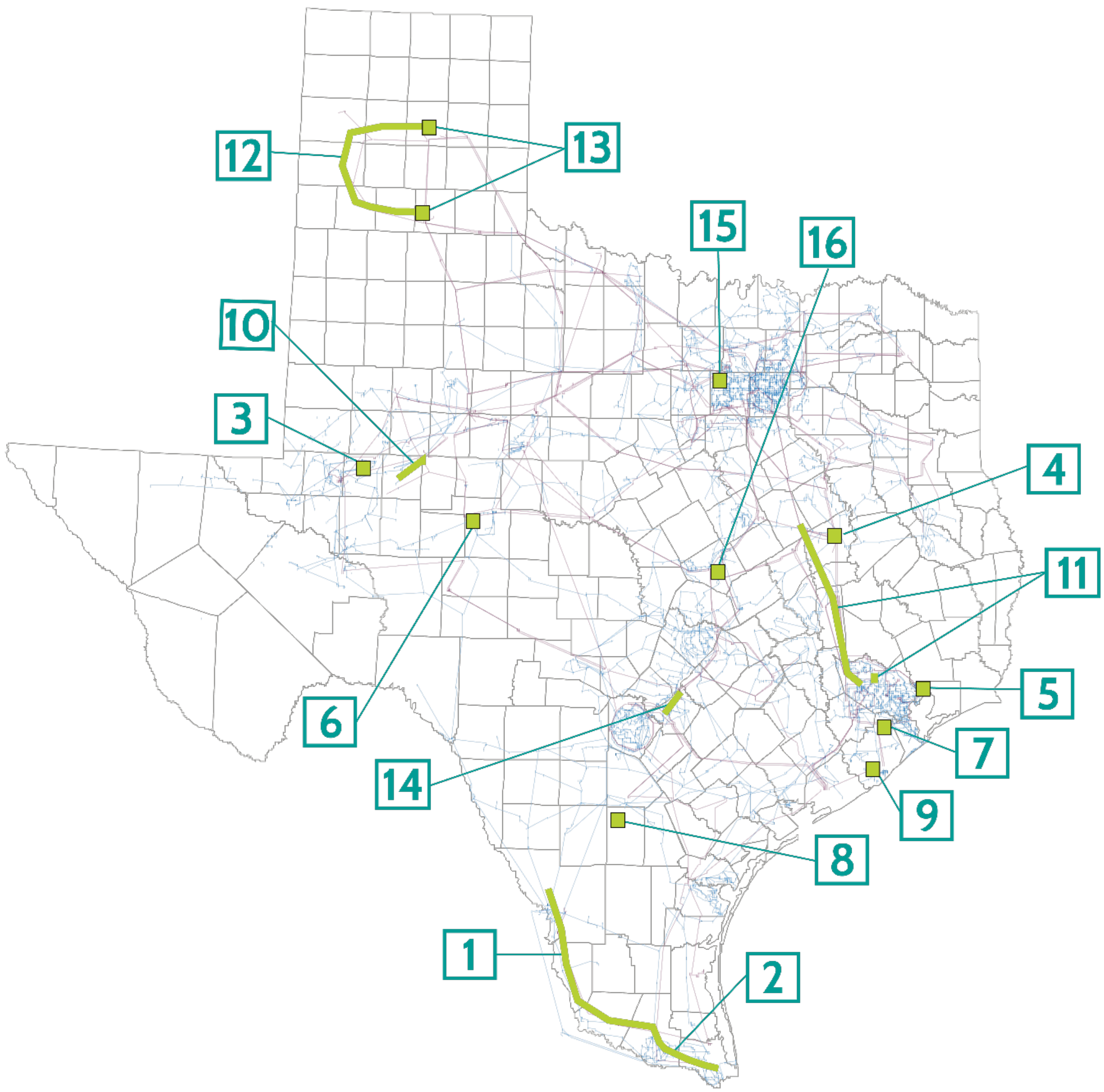

Figure 4.4: Planned Transmission Improvement Projects

4.2 Lower Rio Grande Valley

Currently, demand in the Lower Rio Grande Valley (LRGV) is supported by two existing 345 kV lines, three 138 kV lines, and approximately 1,700 MW of natural gas generation at four plants. The area also has hydroelectric and wind generation and an asynchronous tie with the Mexico system. Because the area is dependent on such a small number of resources, transmission and generation maintenance outages must be carefully planned in order to reliably serve the area. The area is vulnerable to contingency events that cause multiple pieces of equipment to be out of service at the same time due to equipment failure. Two transmission projects endorsed by the ERCOT Board of Directors in late 2011 and early 2012 will support the LRGV and are expected to be in-service by the summer of 2016. The first involves the construction of a new 345 kV line from the Lobo substation, near Laredo, to the North Edinburg substation. This new line will provide a third 345 kV import circuit into the LRGV. Additionally, the project includes upgrading both the existing 345 kV import lines. The second significant project includes a new 345 kV line 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. Figure 4.5 shows a map of the LRGV area transmission system.

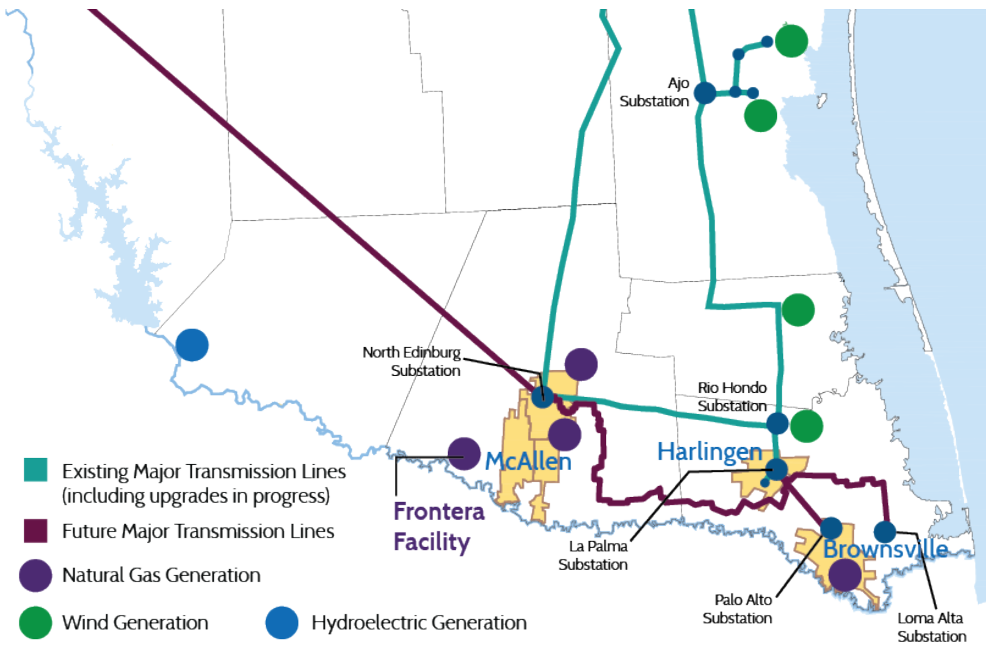

Figure 4.5: Map of Lower Rio Grande Valley

In July 2014, the owners of the Frontera generation plant, a 524 MW natural gas facility located on the west side of the LRGV, announced that they were planning to switch part of the facility (170 MW) out of the ERCOT market in 2015, and the entire facility (524 MW) starting in late 2016. Going forward, the plant will be generating electricity for the Mexico power system. ERCOT has concluded that the two planned 345 kV projects will largely relieve the reliability issues in 2016, but additional system improvements likely will be required sometime after 2016.

As of October 2015, the LRGV has one new natural gas plant (225 MW capacity) and several wind generation projects (more than 2000 MW capacity) with signed generation interconnection agreements (SGIA) and financial commitment. In addition, two new natural gas plants have SGIAs, but the developers have not yet provided financial commitment. Two transmission upgrade projects for the LRGV area have been submitted separately by TSPs to RPG to improve the reliability and import capability of the LRGV. ERCOT is currently conducting the independent review of these RPG projects and expects to complete the studies in 2016.

4.3 Liquefied Natural Gas Facilities

In February 2015, the ERCOT Board of Directors unanimously endorsed the Jones Creek project for a transmission upgrade to serve a load unlike any previously connected to the ERCOT System—a natural gas liquefaction and export facility. The production of liquefied natural gas (LNG) is an energy-intensive process and the construction of such a facility can significantly increase the load already being served in an area. Several potential LNG facilities have been proposed across the United States, including many along the ERCOT Gulf Coast. The Freeport LNG liquefaction project, which the Jones Creek upgrade will serve, and Cheniere's Corpus Christi liquefaction facility were the first LNG export facilities within the ERCOT region to receive all necessary approvals to begin construction.

The Freeport LNG facility will be located on Quintana Island in Brazoria County and, at full production, will require 690 MW to serve its load. The Cheniere facility, while having only slightly less LNG production capacity, will have a much lower electric power need because it uses different technology to drive its process needs and will require less extensive transmission upgrades. LNG exports from both facilities are expected to begin in 2018 and reach full output in 2019.

LNG facilities represent a type of load expansion that can dramatically impact local electric service. For instance, the Freeport area load is currently less than 80 MW. Adding the LNG liquefaction facility's 690 MW load will result a nearly ten-fold increase. This single project produced a significant need for additional electrical infrastructure in the Freeport area, and this need will be addressed by two projects that have been reviewed by the Regional Planning Group. The construction of LNG liquefaction facilities in other locations may have similar impacts. The Cheniere facility, which will use natural gas turbines instead of electric motors to drive the liquefaction compressors, will require much less power from the electric grid and more modest transmission upgrades or additions. However, future upgrades may be needed at each facility because both companies have begun the process for approval to expand the liquefaction and export capacity at their existing sites.

In addition to the two facilities under construction, six other projects have begun the LNG export project approval process. Developers have already applied to the Department of Energy (DOE) for licenses to export LNG from five of these proposed facilities. All six proposed facilities are located in the Brownsville area. Developers have begun the FERC pre-filing review process for three of these projects. Table 4.2 shows all LNG facilities in the ERCOT Gulf Coast region that have completed or begun the regulatory process for approval to liquefy and export natural gas. In addition to the almost 5 billion cubic feet per day (Bcf/d) of LNG authorized under current Freeport LNG and Cheniere approvals, the other proposed LNG facilities and expansions in the ERCOT region seek authority to export nearly an additional 13 Bcf/d. In total, companies across the Lower 48 States have filed export applications with the DOE for over 46 Bcf/d.[5] Figure 4.6 shows the general location of the approved and proposed LNG projects in the ERCOT system.

[5] Long Term Applications Received by DOE/FE to Export Domestically Produced LNG from the Lower-48 States, Department of Energy/Fossil Fuels Office, October 14, 2015.

Table 4.2: Proposed LNG Facilities in ERCOT

Company	Export Quantity (Bcf/d)	Free Trade Agreement Application[6]	Non-FTA Application[7]	Location
Freeport LNG	2.8	Approved	Approved (1.8 Bcf/d)	Freeport
Gulf Coast LNG Export	2.8	Approved	Under review	Brownsville
Cheniere Marketing and Corpus Christi Liquefaction	2.1	Approved	Approved	Ingleside
Eos LNG	1.6	Approved	Under review	Brownsville
Barca LNG	1.6	Approved	Under review	Brownsville
Annova LNG Common Infrastructure	0.94	Approved	n/a	Brownsville
Texas LNG Brownsville	0.55	Approved	Under review	Brownsville
Corpus Christi Liquefaction Expansion	1.41	Approved	Under review	Ingleside
Freeport LNG Expansion	0.9			Freeport
Rio Grande LNG	3.6			Brownsville
Total	**18.0**			

[6] Application to import or export natural gas to countries that have a Free Trade Agreement with the United States requiring national treatment for trade in natural gas. These applications are deemed to be in the public interest under Section 3(c) of the Natural Gas Act.
[7] Application to import or export natural gas to countries that do not have a Free Trade Agreement with the United States requiring national treatment for trade in natural gas. These applications are not deemed to be in the public interest under Section 3(c) of the Natural Gas Act and are subject to a public comment and review process to determine if the application is in the public interest.

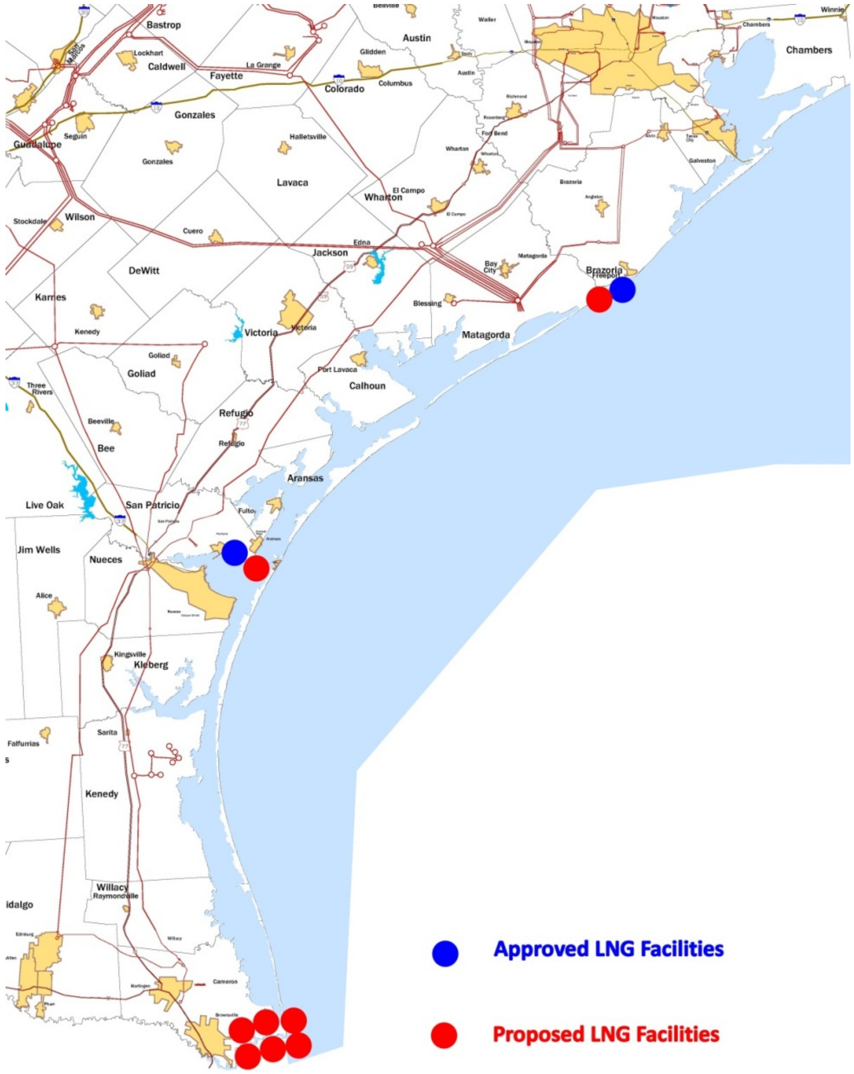

Figure 4.6: Approved and Proposed LNG Facilities in ERCOT

As with the facilities already under construction, the load impact of the proposed Brownsville facilities will depend on the technology chosen to drive the liquefaction compressors. Statements made in filings at FERC reveal the potential for significant load increases in the Brownville area. Texas LNG plans to use electric motors to drive its compression and therefore needs 240 MW of transmission capability.[8] The Annova facility also plans to use electric-driven compression and will have a 405 MW maximum load requirement.[9] The Rio Grande LNG Project currently plans to drive their liquefaction compressors using a pair of 300 MW natural gas turbines with electric helper motors, which would result in a minimal load impact.[10] However, Rio Grande LNG reported to FERC that they will also investigate grid-supplied power.[11] Each of these projects expects to begin operation in 2020, if approved. If these projects are approved and Rio Grande LNG elects to use grid-supplied power to serve its load, the projects could add over 600 MW of load in 2020 and another 600 MW in years to follow as subsequent phases of project development are completed. This rapid load increase could require significant transmission upgrades to meet customer needs and maintain reliability.

No specific information is publicly available about the power requirements of the Barca LNG, Eos LNG, and Gulf Coast LNG projects. None of these three Brownsville LNG projects have initiated the pre-filing process with FERC. However, these proposals—approximately 6 Bcf/d—will have large electric power requirements if they are constructed. Finally, another possible ERCOT-area LNG project could be developed in Galveston on Pelican Island. Next Decade, which is also proposing the Rio Grande LNG project, is exploring the feasibility of a 0.8 Bcf/d facility at that site. If approved and constructed, it is unlikely that any of these projects would be in service as soon as 2020. However, collectively, these projects could require significant power and associated transmission additions or upgrades.

4.4 San Antonio System Additions

The city of San Antonio, located in Bexar County, is the seventh most populous city in the United States and was among the top five fastest growing cities from 2000 to 2012.[12] Claritas projects the population of Bexar County to grow an additional 7.4% between 2015 and 2020.[13] Comal and

8 Texas LNG Draft Resource Report 1, Federal Energy Regulatory Commission, Oct 21, 2015.
9 Annova Draft Resource Report 1, Federal Energy Regulatory Commission, Sep 29, 2015.
10 Rio Grande Request to Initiate NEPA Pre-Filing Process, March 20, 2015.
11 Rio Grande Draft Resource Report 1, May 13, 2015.
12 http://www.citymayors.com/gratis/uscities_growth.html
13 http://www.sanantonioedf.com/living/demographics/

Hays counties, located north of Bexar County on the IH-35 corridor between Austin and San Antonio, are also expected to see significant growth.

The load in San Antonio is currently served by local generation, located near the southern edge of the county, and the 345 kV transmission loop connected to an inner 138 kV network. The bulk of the city's power needs are met by import paths from the Clear Springs, Zorn, and Elm Creek substations located in neighboring Guadalupe County (east of Bexar County) and the Kendall substation located in Kendall County (north of Bexar County).

In 2014, CPS Energy announced that the J.T. Deely coal-fired power plant, located in the southern part of Bexar County, will be retired at the end of 2018. With an output of approximately 850 MW, this plant currently represents nearly 20% of the generation capacity in Bexar County. The 2014 RTP identified that the combination of local demand growth and the retirement of J.T. Deely will result in reliability criteria violations on the transmission system from northeast Bexar County, extending into Comal and Hays Counties, unless significant improvements are constructed by 2019. Furthermore, in 2015, congestion rent on the 345 kV line between the Marion and Skyline substations was over $7.3 million (Table 3.1).

In June 2014, CPS Energy and LCRA Transmission Services Corporation submitted a project proposal to the RPG to address these violations. ERCOT conducted an independent review of the proposal and identified reliability criteria violations on several 345 kV and 138 kV lines and multiple transformers. In the independent review, ERCOT evaluated thirteen project alternatives to resolve the violations and endorsed approximately $86 million dollars of transmission upgrades to improve the transmission system supporting San Antonio before summer of 2019. The project strengthens the import path into Bexar County and mitigates the impact of contingencies, which are currently resulting in the high congestion costs mentioned above. The most noteworthy upgrades, as seen in Figure 4.7, are the construction of a new 18-mile 345 kV transmission line from Zorn to Marion substations, the addition of two 345/138 kV transformers at Clear Springs and Marion substations, and reconfiguration of the Hill Country—Elm Creek/Marion and Skyline—Marion/Elm Creek 345 kV double circuit lines.

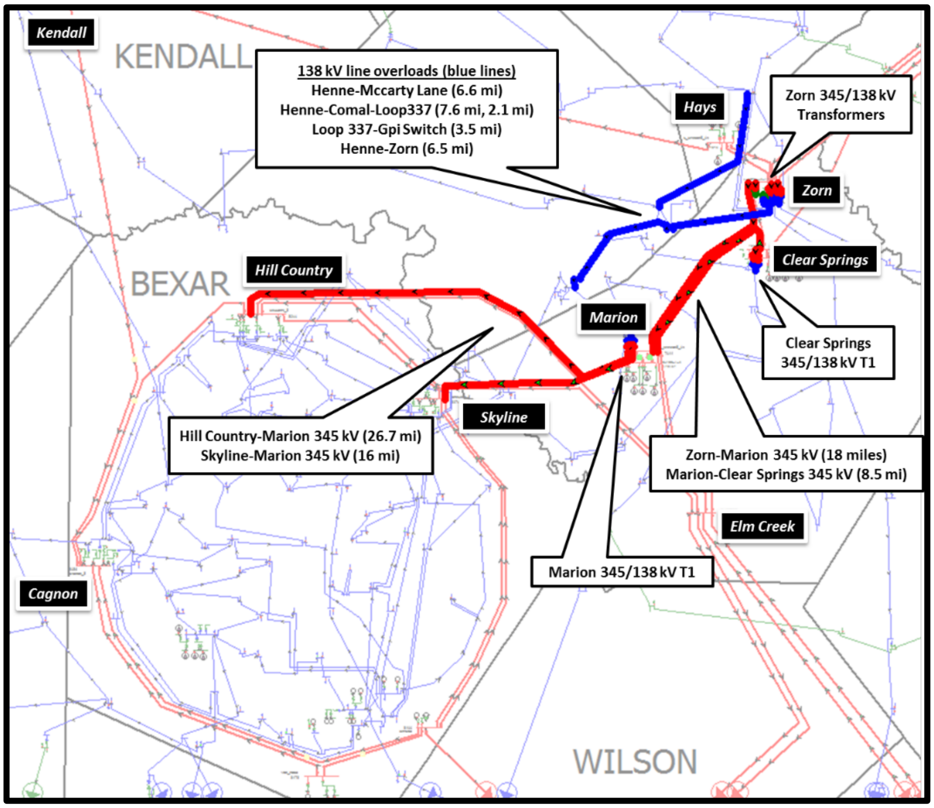

Figure 4.7: System Problems in the San Antonio Area

4.5 Additional Reliability-Driven Planned Projects

Continued growth of load throughout the state is a key driver for transmission improvements in the ERCOT Region. The recently completed 2015 Regional Transmission Plan (RTP) identified more than 60 projects needed to satisfy reliability planning criteria in the 2016 to 2021 timeframe. Twenty-one of these projects were previously identified in prior RTP studies for the ERCOT System. More information on these projects can be found in the 2015 RTP report posted on the ERCOT Market Information System website.

Chapter 5. Projected Constraints

5.1 Panhandle

The Panhandle region of the ERCOT grid, as seen in Figure 5.1, is a prime location for wind generation development. This development is accompanied by potential export limitations due to the operation of wind resources under weak grid conditions (as described in the April 2014 Panhandle Renewable Energy Zone Study Report[14]). As of September 9, 2015, 4,304 MW of wind capacity in the Panhandle satisfy the requirements of ERCOT Planning Guide Section 6.9 (PG 6.9), Addition of Proposed Generation Resources to the Planning Models. The total capacity of Panhandle wind resources with a SGIA exceeds 7,000 MW; another approximately 5,000 MW is under study for future interconnection in the region (see Figure 5.2).

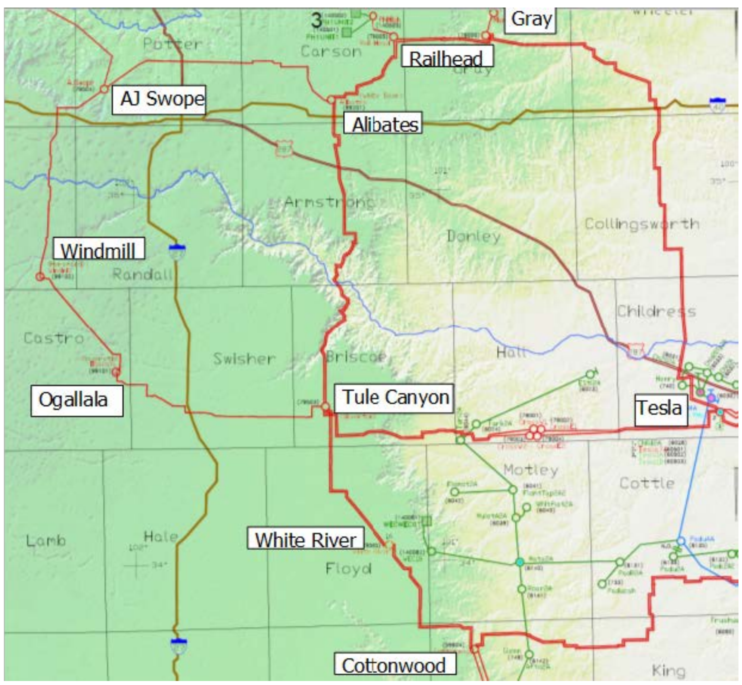

Figure 5.1: Panhandle Area Map

[14] Available at http://www.ercot.com/content/news/presentations/2014/Panhandle%20Renewable%20Energy%20Zone%20Study%20Report.pdf

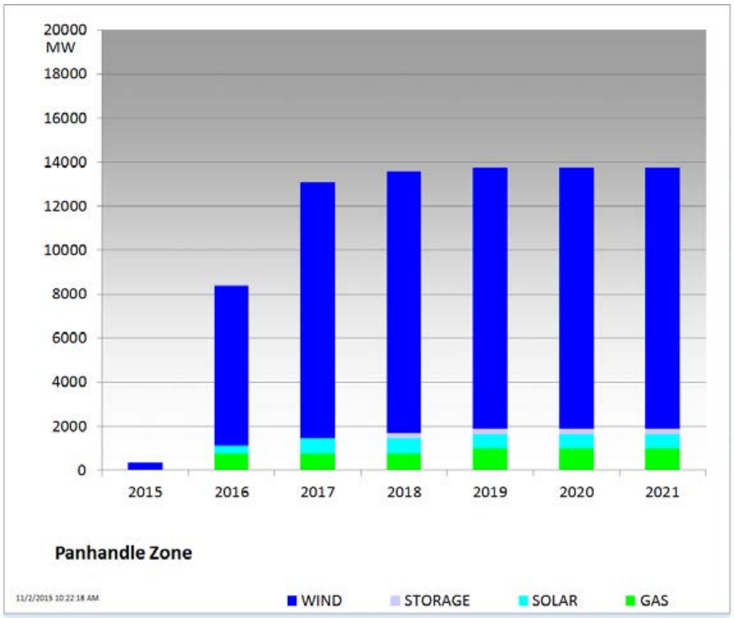

Figure 5.2: Panhandle Generation Under Study

Recognizing the challenges associated with connecting a large amount of wind generation in the Panhandle, ERCOT initiated the Panhandle study in early 2013. The purpose of the Panhandle study was to identify the potential system constraints and to identify possible future projects to increase the Panhandle export capability. ERCOT has continued to evaluate Panhandle export capability throughout 2014 and 2015 based on actual wind generation development patterns.

ERCOT recently confirmed the need for several transmission improvements to increase the Panhandle export capability. These include the installation of synchronous condensers at both Alibates and Tule Canyon, and the installation of a second 345-kV circuit on the Alibates-AJ Swope-Windmill-Ogallala-Tule Canyon transmission line which is under the Competitive Renewable Energy Zone (CREZ) Order, or PURA §39.904(g), per the PUCT Open meeting on September 24, 2015.

While the upgrades will increase Panhandle export capability, continued development of generation resources in the Panhandle will likely lead to further constraints. New transmission lines on new right of way (ROW) will be required to further increase export limits. These improvements will require significant wind generation development commitment in order to be justified per the ERCOT planning criteria requirements.

5.2 Solar Integration

The ERCOT system has seen a limited increase in operational utility-scale solar installation since 2010, as shown in Figure 5.3. By 2015, the total installed capacity had only increased from 15 MW to 193 MW. However, as of October 2015, approximately 9,300 MW of solar projects have been submitted through the ERCOT Generation Interconnection Request (GINR) process. Approximately 1,530 MW of solar projects in the GINR queue have SGIAs and are projected to be in service by 2017. In addition, a “stringent environment” scenario, developed for the 2014 LTSA, identified the potential for 16.5 GW of solar generation in ERCOT by 2029.

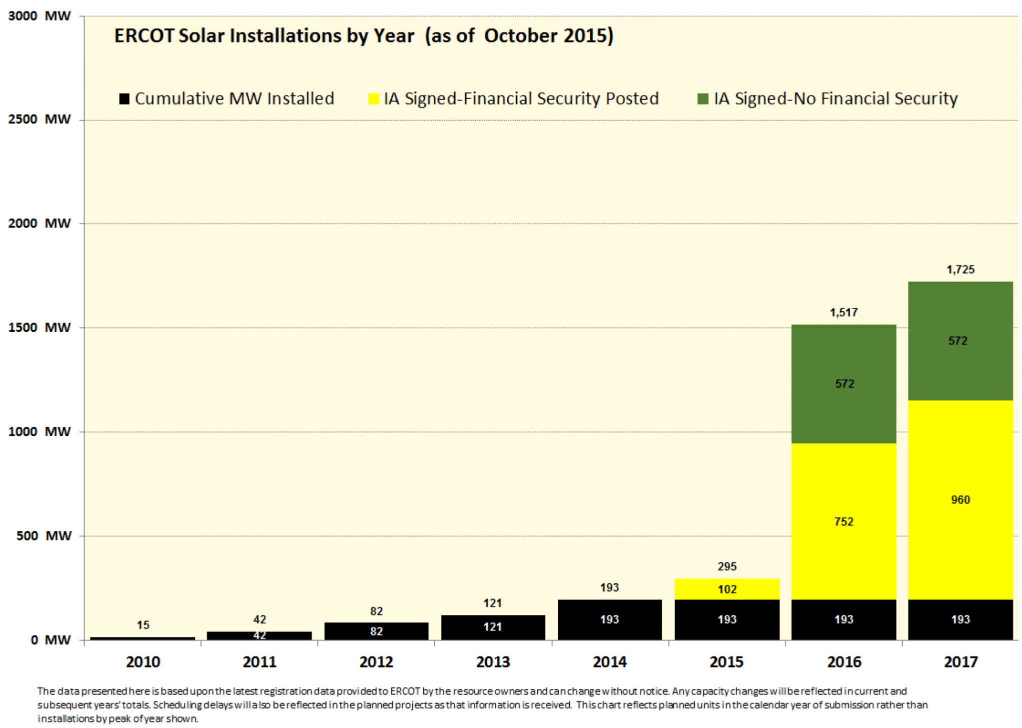

Figure 5.3: ERCOT Solar Installations by Year

Figure 5.4 shows the breakdown of the proposed solar GINR by weather zone. As shown, the majority of current GINR solar projects are located in the Far West weather zone, 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.

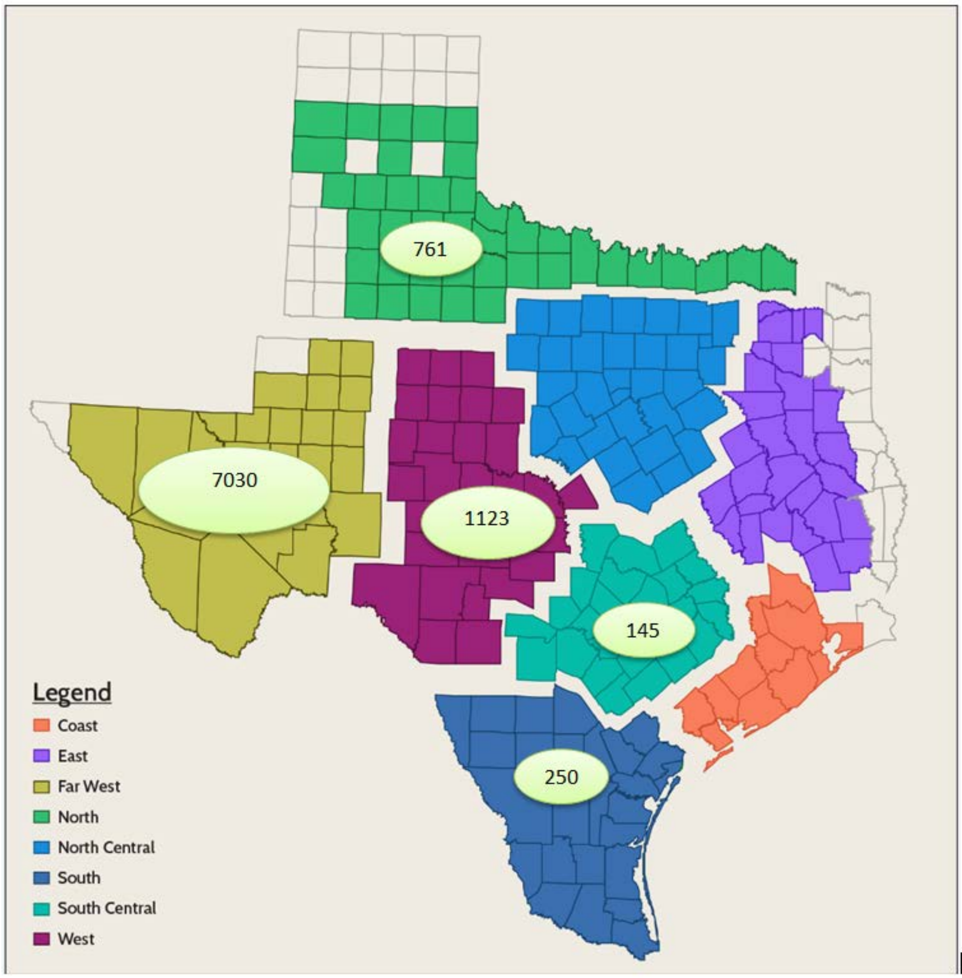

Figure 5.4: Solar Generation Interconnection Requests (MW) by Weather Zone

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 is 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 solar integration study is projected to be complete by the second quarter of 2016.

5.3 Generation Retirement, Regional Haze, Clean Power Plan

In August 2015, the U.S. Environmental Protection Agency (EPA) released the Clean Power Plan (CPP) final rule, which sets limits on carbon dioxide (CO_2) emissions from existing fossil fuel-fired power plants. Under the CPP final rule, Texas will be required to meet a final CO_2 emissions rate limit of 1,042 lb. CO_2/MWh (190 million tons of CO_2), on average, by 2030. EPA calculated these limits based on assumptions about coal plant efficiency improvements, increased production from natural gas combined-cycle units, and growth in generation from renewable resources. The final rule phases in these reductions over three compliance periods between 2022 and 2029, referred to as the "glidepath." Figure 5.5 shows the mass-based emissions limits for Texas published in the CPP final rule and the amount attributable to ERCOT based on the relative amount of load served in the ERCOT Region within Texas.

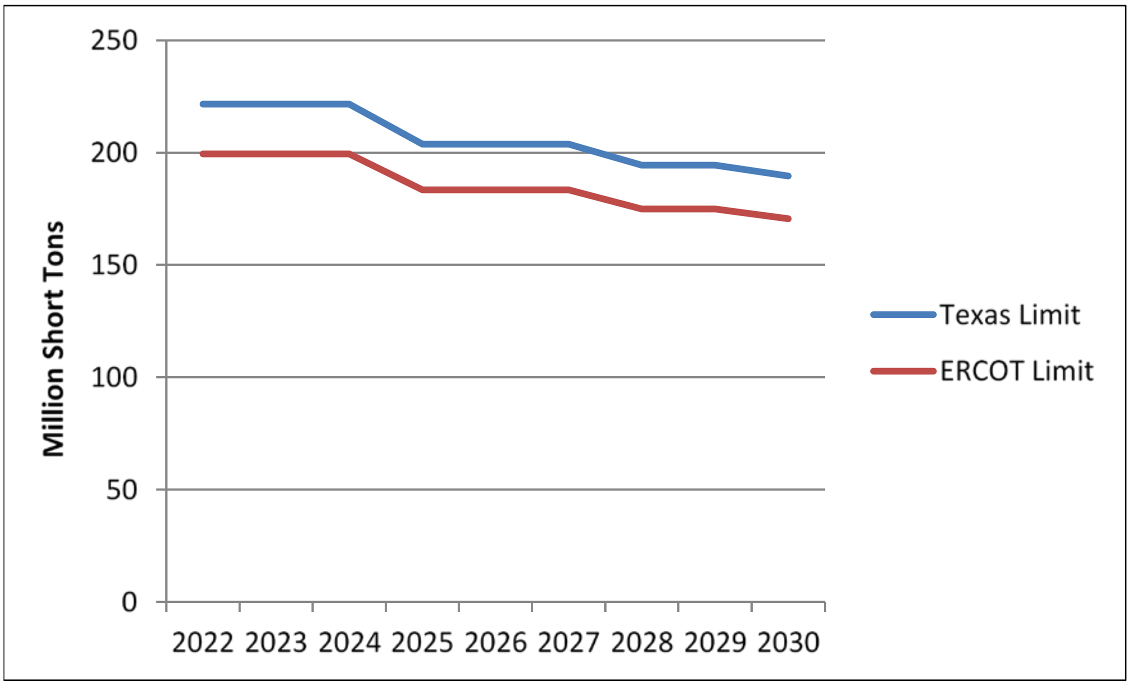

Figure 5.5: Carbon Dioxide Mass-Based Emissions Limits

In October 2015, ERCOT published an analysis of the potential impacts of compliance with the CPP final rule for the ERCOT Region's resource mix and grid reliability.[15] The analysis used

[15] Electric Reliability Council of Texas, Inc. *ERCOT Analysis of the Impacts of the Clean Power Plan – Final Rule Update*, October 2015. Available at: http://www.ercot.com/content/news/presentations/2015/ERCOT_Analysis_of_the_Impacts_of_the_Clean_Power_Plan-Final_.pdf.

stakeholder-vetted planning processes and methodologies consistent with ERCOT's regional LTSA studies. ERCOT modeled scenarios in which the CPP limits were achieved through a system CO_2 emissions constraint and a price per ton of CO_2, in comparison to a baseline. In addition to the CPP, the current requirements of the Cross-State Air Pollution Rule were included in all of the modeled scenarios, and EPA's proposed Regional Haze Federal Implementation Plan (FIP) for Texas was included in one of the modeled scenarios.[16]

Figure 5.6 summarizes the cumulative capacity additions and retirements by 2030 in the modeled scenarios. The results indicate that the CPP, by itself, will result in the retirement of at least 4,000 MW of coal generation capacity. When the impacts of the CPP are considered in combination with the requirements of EPA's proposed Regional Haze Federal Implementation Plan (FIP), there are additional unit retirements, many of which occur even before the start of CPP compliance in 2022. If ERCOT does not receive adequate notification of these retirements, and if multiple unit retirements occur within a short timeframe, there could be periods of reduced system resource adequacy and localized transmission reliability issues.

[16] In November 2014, EPA proposed a FIP disapproving portions of the Texas state implementation plan for Regional Haze, and setting SO_2 emissions limits for certain coal-fired units in Texas. EPA's proposed FIP would require seven coal-fired units in Texas to upgrade their existing scrubbers, and seven units (five of which are located in ERCOT) to install new scrubber retrofits.

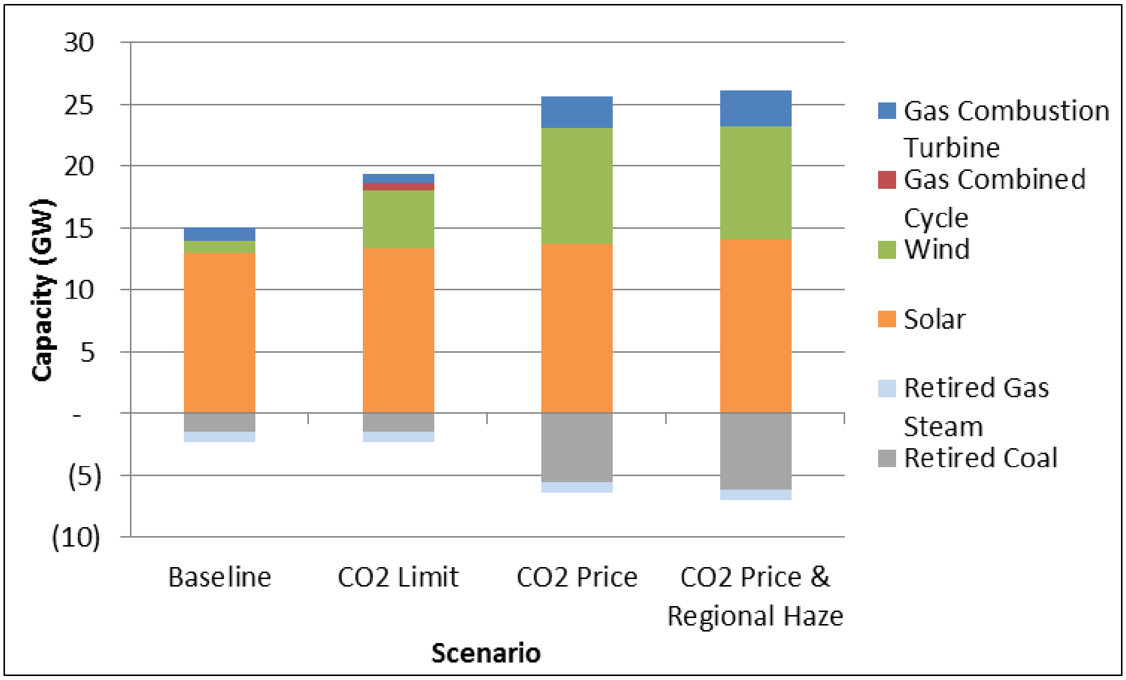

Figure 5.6: Capacity Additions and Retirements by 2030

ERCOT recently conducted a reliability analysis that evaluated potential retirement scenarios resulting from compliance with the proposed Regional Haze FIP.[17] The transmission impact study concluded that the retirement of coal-fired generation affected by the proposed Regional Haze FIP could have a significant local and regional impact on the reliability of the ERCOT transmission system. In one scenario that assumed the retirement of 4,200 MW of coal-fired capacity due to the proposed rule, comparable to the amount expected to retire due to the CPP alone, model results indicated that the following thermal capacities would be exceeded.

- 10 345 kV circuits (approximately 143 miles)
- 31 138 kV circuits (approximately 147 miles)
- 6 69 kV circuits (approximately 39 miles)
- 11 transformers

[17] Additional information on this study is available on ERCOT's Regional Planning Group (RPG) website at http://www.ercot.com/content/wcm/key_documents_lists/76860/Transmission_Impact_of_the_Regional_Haze_Environmental_Regulation__Oct_RPG.pdf.

The CPP study also predicted a sizeable amount of renewable capacity additions, due to the improving economics of these technologies as well as the impacts of regulating CO_2 emissions. If there is not sufficient ramping capability and operational reserves during periods of high renewable penetration, the need to maintain operational reliability could require the curtailment of renewable generation resources. The ability to curtail intermittent generation resources in real-time operations is a key backstop for maintaining the reliability of the system. This type of curtailment of renewable generation may be restricted if low CO2 generation is needed to achieve a system-wide emissions limit. Growth in renewable generation would also likely have a significant impact on transmission requirements.

5.4 2016 Reliability Constraints

When the annual Regional Transmission Plan is developed, there are usually a number of reliability needs identified where the projects designed to meet the needs will not yet be in-service when the reliability issue occurs. There are several reasons for this, the most common being faster-than-expected load growth and construction delays. Coordinating construction of multiple projects and equipment outages in the same area also affects the completion of projects.

When projects needed for reliability cannot be installed prior to need, the responsible TSPs and ERCOT work to design temporary operational solutions to resolve the reliability issue until the transmission project can be completed. Such operational solutions may include temporarily reconfiguring the system, running less efficient generation, or, in the worst case, establishing a procedure to shed load if an overload is expected to occur or actually occurs. While these actions ensure that reliability standards are upheld, they can often lead to substantial amounts of congestion on the system if generation redispatch is needed or is not sufficient.

The recently completed 2015 RTP identified the projected 2016 single contingency[18] reliability constraints (Table 5.1 and Figure 5.7) that will not have a transmission project in place to solve the constraint before it is expected to occur. Many of these constraints are located in the West

[18] For a list of 2016 reliability constraints caused by multiple outages see the 2015 Regional Transmission Plan Report.

Texas and Eagle Ford areas where demand has increased faster than previously anticipated. The remaining constraints are located in regions of North Texas.

Table 5.1: Projected 2016 Reliability Constraints

Index #	Transmission Element
1	Walnut Springs - Glen Rose 69 kV line
2	Hamilton County TNP - Jonesboro TNP 69 kV line
3	Hamilton-Maverick-Eagle Hydro Tap-Escondido-Eagle Pass City 138 kV lines
4	Kenedy Switch-Kenedy 138 kV line
5	San Miguel Tap -North Callahan 69 kV line
6	George West area buses
7	Pleasanton-Jourdanton and Big Foot-Pearsall 69 kV lines
8	Dilley Switch-Cotulla 69 kV line
9	Koch Up River 138/69 kV transformer
10	Bessel 138 kV bus
11	Cassava or Barnhart Phillips Tap-Yucca 69 kV line
12	TNMP 69 kV loop along Pecos, IH20, Flat Top and Wickett area
13	Uvalde-Montell-Campwood 69 kV lines
14	Mason-Katemcy 69 kV line and Fort Mason 138/69 kV transformer
15	Big Lake-Big Lake Phillips Tap 69 kV line

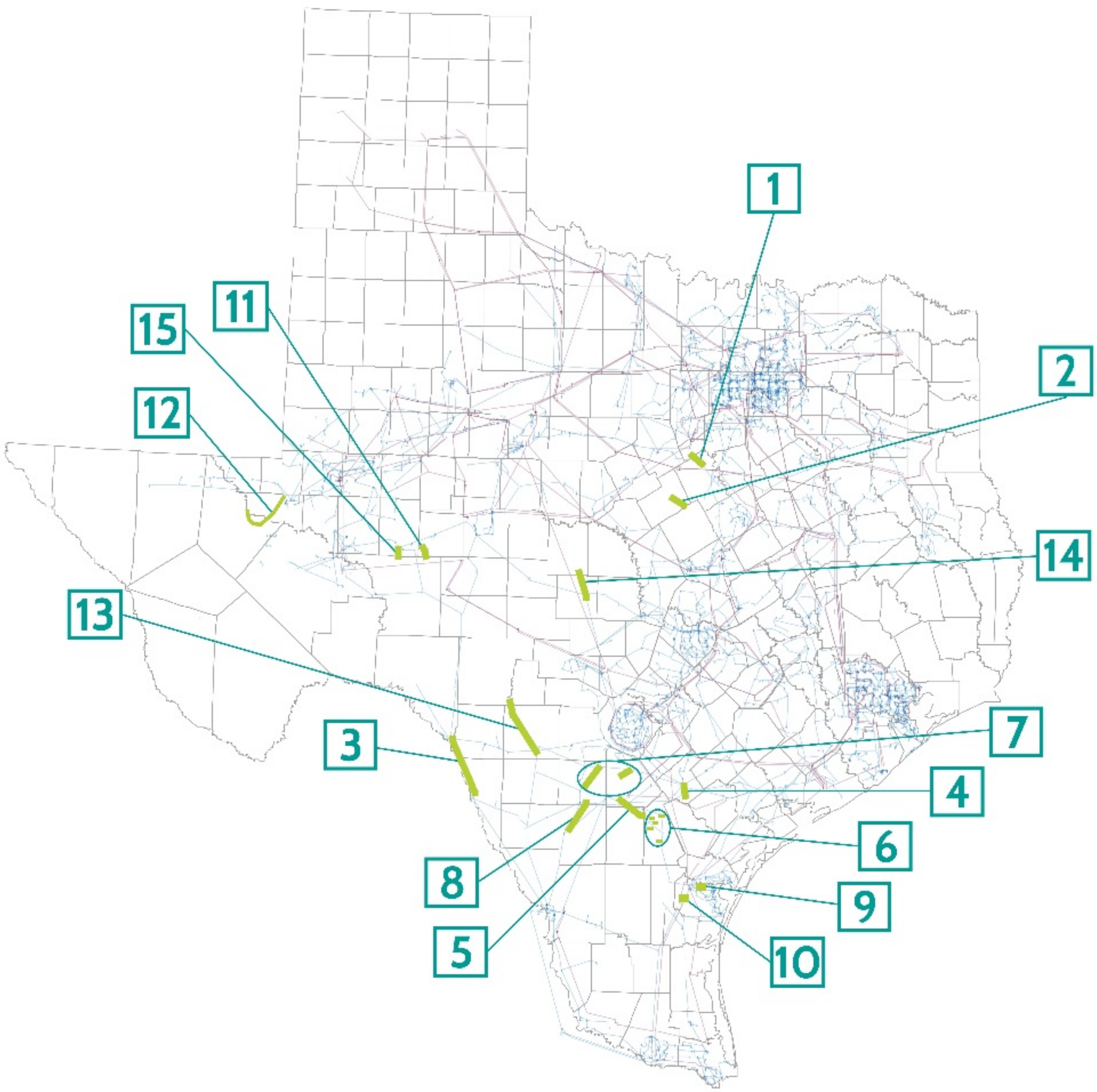

Figure 5.7: Projected 2016 Reliability Constraints

5.5 2018 and 2021 Projected Constraints

Future year constraints are also analyzed as part of the annual Regional Transmission Plan. 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 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 5.8 show the constraints projected to be the most congested for 2018 and 2021 based on model simulation in the 2015 RTP.

Table 5.2: List of Projected Most-Congested Constraints (2018-2021)

Index	Projected Constraining Element	2018 Congestion	2021 Congestion
1	Panhandle Interface	High	High
2	Cico – Comfort 138 kV line	Medium	High
3	Dupont Switch - Dupont PP1 (Ingleside) 138 kV line	Medium	High
4	TNMP Tie – Solstice 138 kV line	High	High
5	Cagnon – Kendall 345 kV line	Medium	High
6	Long Road - North Denton Interchange 138 kV line	Low	High
7	Goldthwaite - San Saba Switch 69 kV line	Medium	Medium
8	Escondido - Eagle Hydro 138 kV line	Medium	Medium
9	Rincon – Boniview 69 kV line	Medium	Medium
10	Hamilton Road – Maverick 138 kV line	Medium	Medium
11	Medina Lake - Pipe Creek 138 kV line		Medium
12	Wolfgang – Rotan 69 kV line	Medium	Medium
13	Leon Switch – Putnam 138 kV line	Medium	Low
14	Wirtz - Flat Rock 138 kV line	Medium	
15	Hicks Transformer 345/138 kV transformer	Medium	

Legend	High	Medium	Low

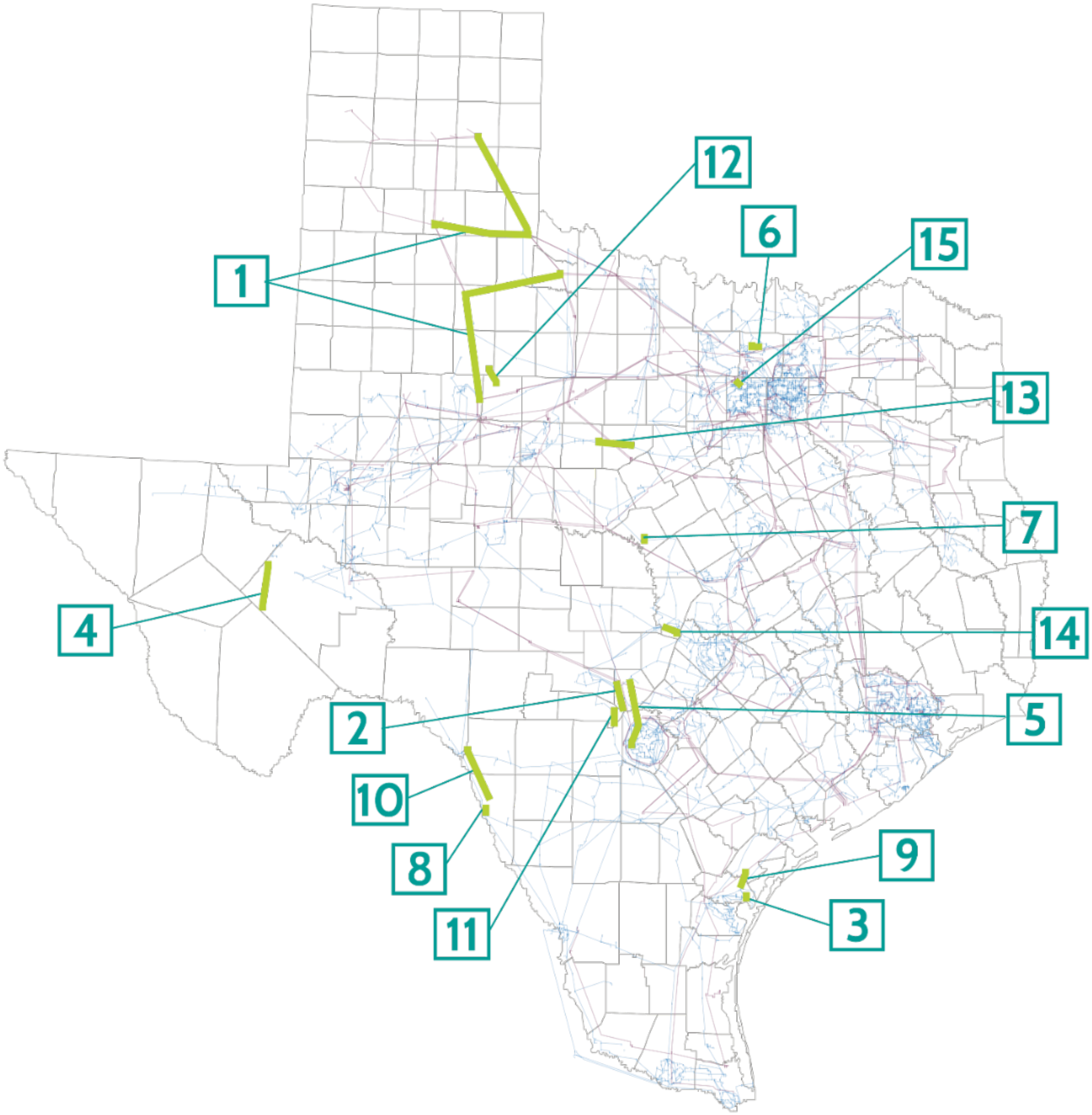

Figure 5.8: 2018-2021 Projected Most-Congested Constraints

Chapter 6. Contacts and Links

6.1 Contacts and Information

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

Media
Robbie Searcy
512-225-7213

Regulatory and Government Relations
Shelly Botkin
512-225-7177

6.2 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 7. 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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