2019 Regional Transmission Plan

Version 1.0

Document Revisions

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12/23/2019	1		Ping Yan, John Bernecker, Jameson Haesler, Rodolfo Romo, Phung Nguyen, Minnie Han, Craig Wolf, Yong Cheng, Hong Xiao
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Table of Contents

1. Executive Summary

The 2019 Regional Transmission Plan (RTP) is the result of a coordinated planning process performed by ERCOT with extensive review and input by NERC-registered Transmission Planners (TPs), Transmission Owners (TOs), and other stakeholders. The RTP addresses ERCOT System reliability and economic transmission needs for years 2021 through 2025. This report documents the results of the assessment, in part, to comply with the requirements of NERC Reliability Standards, ERCOT Nodal Protocols, and the ERCOT Planning Guide.

The reliability analysis was performed over a six-year planning horizon; years one through five representing the near-term horizon and year six representing the long-term horizon. The 2019 RTP assessed ERCOT's steady-state transmission needs under summer peak and off-peak conditions. In addition to the seasonal variations, the RTP also included various sensitivities to address uncertainty involved in the transmission planning process. The reliability analysis in the 2019 RTP included:

- Steady-state contingency analysis to identify criteria violations based on NERC Reliability Standards and ERCOT planning criteria.
- Short-circuit analysis to identify over-dutied circuit breakers in the near-term planning horizon.
- Cascading analysis to identify potential system cascading conditions.

Following the reliability assessment, ERCOT planners in collaboration with TPs developed Corrective Action Plans to address the reliability criteria violations identified in this assessment. These plans included but were not limited to, upgrades or addition of new transmission facilities and new constraint management plans.

The majority of planned improvements identified in the 2019 RTP are 138-kV and 345-kV upgrades. The projects identified as 345-kV upgrades consist of new substations, line additions, line upgrades, new 345/138-kV transformers, 345/138-kV transformer upgrades, and reactor additions. The majority of the projects were newly identified in the 2019 RTP.

The 2019 RTP identified the following noteworthy reliability projects:

- Hicks Switch to Alliance to Roanoke 345-kV line upgrades in Tarrant and Denton Counties.
- Lake Creek SES to Tradinghouse SES 345-kV line upgrade in McLennan County.
- Venus Switch to Navarro 345-kV line upgrade in Ellis and Navarro Counties.
- Seagoville Switch to Forney Switch 345-kV line upgrade in Dallas and Kaufman Counties.
- Forney Switch to Royse Switch 345-kV line upgrade in Rockwall and Kaufman Counties.
- Carrollton Northwest 345/138-kV transformer upgrade in Dallas County.
- New Resnik 345-kV station with two 345/138-kV transformers, and new 345-kV double-circuit line from Grissom to Angstrom, Angstrom to Resnik, and Resnik to Whitepoint in San Patricio

and Bee Counties. This project is a placeholder project for the AEPSC Corpus North Shore project that is currently under Regional Planning Group (RPG) review.

- Hutto 345/138-kV transformer addition in Williamson County.
- Quarry Field substation 345-kV addition in Winkler County. This project was also identified in the Delaware Basin Load Integration Study.

The 2019 RTP also included an economic assessment of the ERCOT transmission system for years 2021 and 2024. Through this assessment, ERCOT planners identified transmission congestion and tested various transmission upgrades to address this congestion in a cost-effective manner (as defined by ERCOT's economic planning criteria). Eight economic transmission improvement projects were evaluated in the 2019 RTP. Three of the eight solutions evaluated showed sufficient benefits to pass the ERCOT economic planning criteria. Most noteworthy of these projects was an accelerated timeline for the reconfiguration of the 138-kV network in the Jones Creek area in Brazoria County and the Whitepoint to STP 345-kV line loop-in to the Hillje 345-kV station in Wharton County.

The project completion years stated in the 2019 RTP Report were chosen to address reliability and economic needs in a timely manner. The TOs are expected to meet these project completion dates, but lead-times necessary to implement projects based on factors such as availability of construction clearances, the time required to receive regulatory or governmental approvals, equipment availability, land acquisition, and resource constraints may result in different project completion dates. The reliability projects stated in the RTP do not represent ERCOT's endorsement of the projects. Instead, they represent the suggested Corrective Action Plans for the reliability criteria violations identified under the system conditions studied in the RTP. The scope of projects identified in the RTP may change if further analyses by ERCOT or the TPs find better alternatives or a need for modifying the projects due to changes in expected generation, load forecasts, or other system conditions. TPs should perform studies to confirm the need with the latest system conditions, and develop applicable reliability projects to resolve any reliability criteria violations. For projects that are subject to ERCOT Nodal Protocols Section 3.11.4, Regional Planning Group Project Review Process, review shall be conducted in accordance with the process described therein. For a project that is under Regional Planning Group (RPG) review when the RTP is developed, a placeholder project will be used if the need is identified, however, it does not represent ERCOT's endorsement. Projects requiring RPG endorsement will be reviewed in future assessments (where sufficient lead-time exists), such as future RTPs, to ensure the identified system facilities are still needed.

The TOs will provide ERCOT additional details on project scope, project cost, and an implementation schedule with completion date(s) for each identified project. This information from the TOs may be provided through further RPG review and/or Transmission Project Information Tracking (TPIT) updates in accordance with ERCOT Planning Guide Section 6.4.1.

2. 2019 Regional Transmission Plan

This report documents the 2019 Regional Transmission Plan (RTP) assessment performed by ERCOT System Planning. It is intended, in part, to satisfy ERCOT's requirements under NERC Reliability Standards, ERCOT Nodal Protocols Section 3.11, and ERCOT Planning Guide Sections 3 and 4.

The RTP study is conducted annually for the entire ERCOT System. The 2019 RTP's near-term and long-term planning horizon analysis evaluated the reliability needs of the ERCOT transmission system for the years 2021, 2022, 2024, and 2025. As required by NERC Standard TPL-001-4, the 2019 RTP included a steady-state analysis of summer peak conditions for years 2021 (year 2), 2022 (year 3) and 2024 (year 5) and off-peak conditions for 2022 (year 3), and a short-circuit analysis of summer peak conditions for years 2022 (year 3) and 2024 (year 5). The 2019 RTP also included steady-state analyses for 2025 (year 6), representing the long-term planning horizon. The year six, or 2025, was selected based on the rationale that most of ERCOT transmission upgrades can be completed within five to six years from the date when the need is identified. In addition to analyzing the reliability needs of the system, the 2019 RTP also evaluated economic/efficiency needs of the ERCOT system for 2021 and 2024.

2.1. Stakeholder Involvement

The development of the RTP is a collaborative process. ERCOT worked with NERC-registered Transmission Planners (TPs), Transmission Owners (TOs), and other stakeholders to develop the input assumptions and the scope of technical studies that define the RTP. These assumptions are described in the RTP Scope and Process document and were presented to the stakeholder community at Regional Planning Group (RPG) meetings. The RTP Scope and Process document and input assumptions can be found in Appendices A, B, and C. Stakeholders were provided routine updates on the input assumptions and supporting analysis performed for the 2019 RTP study in the monthly RPG meetings. Feedback and comments from the RPG were incorporated into the RTP Scope and Process document.

The RPG is responsible for reviewing and providing comments on new transmission projects in the ERCOT Region. Per ERCOT Nodal Protocols Section 3.11.3, participation in the RPG is required of all Transmission Service Providers and is open to all Market Participants, consumers, other stakeholders, and Public Utility Commission of Texas (PUCT) Staff.

ERCOT worked with TPs, TOs, and other stakeholders to study the existing system, identify system upgrades and new transmission projects to ensure continued system reliability, and address projected system congestion.

2.2. Standards and Regulations

The RTP assessment was conducted based on requirements in NERC Reliability Standards, ERCOT Nodal Protocols, and the ERCOT Planning Guide.

ERCOT performed its steady-state reliability assessment in accordance with NERC Reliability Standard TPL-001-4, “Transmission System Planning Performance Requirements.” A portion of the RTP assessment also addressed some requirements from the FAC-002[1] reliability standard and the IRO-017[2] reliability standard.

ERCOT Nodal Protocols Section 3.10.8.4 (3) requires ERCOT to identify additional Transmission Elements that have a high probability of providing significant added economic efficiency to the ERCOT market through the use of Dynamic Ratings and request such Dynamic Ratings from the associated ERCOT Transmission Service Provider (TSP). This report identifies such Transmission Elements as part of its economic analysis. ERCOT Nodal Protocols Section 3.11.5 specifies the economic planning criteria used to evaluate the cost-effectiveness of projects in the RTP.

The RTP assessment adheres to ERCOT Planning Guide Section 3.1.1.2, which provides guidelines regarding completion of the RTP. This section requires that ERCOT complete and publish the final RTP report no later than December 31 each year. Additionally, ERCOT Planning Guide Section 4 and ERCOT Nodal Protocols Section 3.11.2 specify the transmission planning criteria to be used in the RTP assessment.

2.3. Confidentiality and Report Posting

The RTP report is shared with internal and external stakeholders. One redacted version of the RTP is created by removing, at a minimum, any confidential data such as the list of long lead time equipment. This report is shared with ERCOT stakeholders via the MIS Secure Area. A second, further redacted version of the RTP report is posted to the ERCOT public website.

[1] R4 from FAC-002
[2] R3 and R4 from IRO-017

3. 2019 Regional Transmission Plan Process

The RTP study process is described in Figure 1. The initial start cases to be used in the reliability analysis were prepared in the case-conditioning stage. The case conditioning step in the 2019 RTP also included the use of the “bounded-higher-of” methodology to determine appropriate weather zone load levels for the RTP study. The details of this methodology can be found in Planning Guide Section 3.1.7. Following case conditioning, a reliability analysis was conducted on the base case to determine the Corrective Action Plans needed to meet ERCOT and NERC reliability requirements. In addition to the base case, the 2019 RTP also included sensitivity cases, a short-circuit analysis, a cascade analysis, and a multiple element outage analysis as required by NERC Reliability Standard TPL-001-4. An economic analysis was also conducted to identify transmission projects that allow reliability criteria to be met at a lower total cost. The detailed scope, process, and input assumptions used in conducting both reliability and economic analyses are available in Appendices A, B, and C.

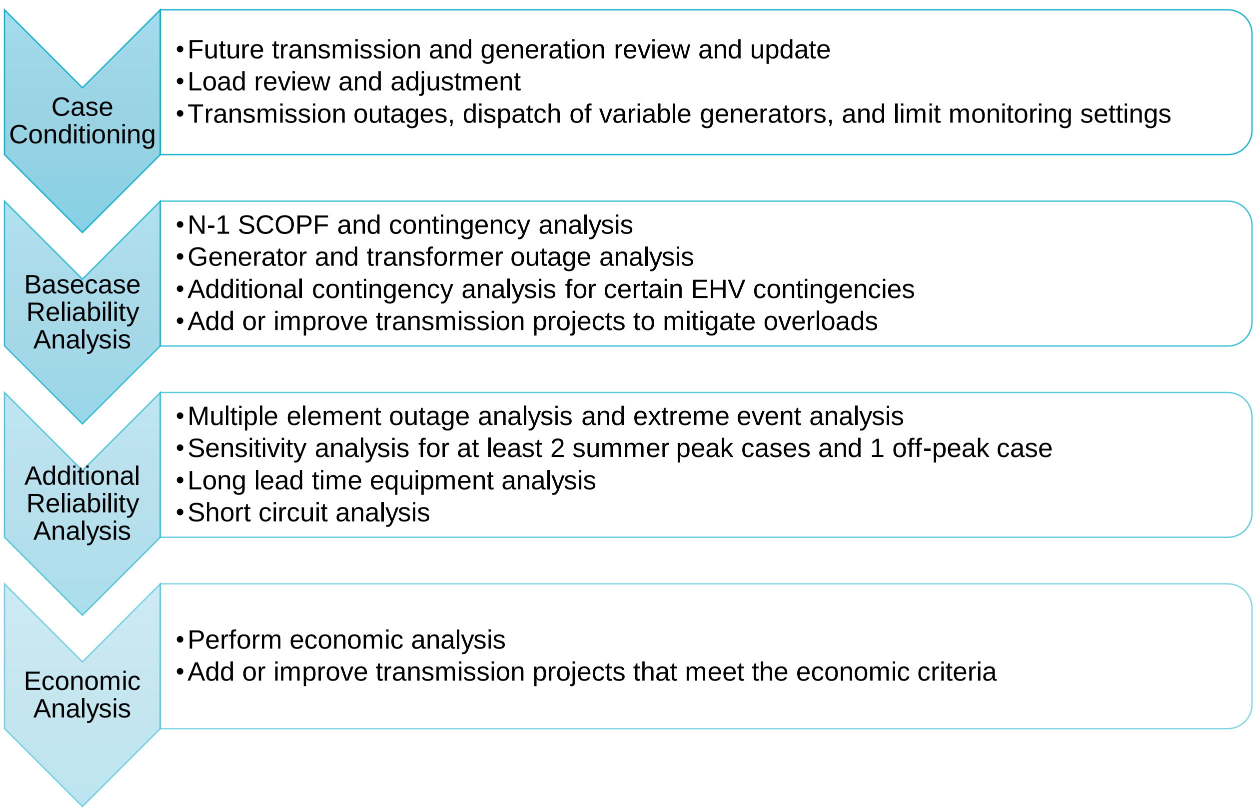

Figure 1: 2019 RTP Transmission Planning Process

ERCOT utilized the following software tools while performing the 2019 RTP:

- PSS/E version 33 was used to develop the conditioned cases.
- PowerWorld version 20 and 21 with Security Constrained Optimal Power Flow (SCOPF) and its SIMAUTO functionality were used to perform AC SCOPF analysis and to run generator and transformer outage analysis.
- PowerWorld version 20 and 21, and POM application suite version 2019 were used to screen critical contingencies while evaluating P3 (Generator outage) and P6-2 (Transformer outage) planning events.
- POM application suite version 2019 including Physical and Operational Margin (POM suite) – Optimal Mitigation Measures (OPM) and Potential Cascading Modes (PCM) were used to perform load shed analysis, multiple element outage analysis, and cascade analysis to identify critical events as candidates for detailed analysis in PowerWorld version 20 and 21.
- UPLAN version 10.4 was used to perform the security-constrained economic analysis.

3.1. Reliability Analysis

The reliability analysis in the 2019 RTP was focused on the steady-state portion of the NERC TPL-001-4 Standard and the ERCOT Planning Guide. The purpose of reliability analysis was to identify potential criteria violations and Corrective Action Plans that may be used to resolve them. The RTP analysis included Security Constrained Optimal Power Flow (SCOPF) to identify unresolvable constraints. Loading and voltage levels at BES elements were monitored for all NERC Planning Events, including Extreme Events. ERCOT staff developed Corrective Action Plans in collaboration with TPs to mitigate criteria violations following a contingency in accordance with the NERC and ERCOT performance requirements.

The 2019 RTP reliability analysis included the following studies:

- SCOPF: Security Constrained Optimal Power Flow (SCOPF) was used to perform basic power flow and Contingency Analysis (CA) for P0, P1, P2-1, and P7 contingencies. The SCOPF used generation cost data and other system constraints to give an optimal generation dispatch and unit commitment while maintaining the reliability of the system. In this analysis, the software simulated the removal of all elements of Protection System and other automatic controls following the contingency event.
- Contingency Analysis: Basic CA routines in the power flow software were used to test P2-2, P2-3, P2-4, P4, P5, and Extreme Event contingencies.
- Multiple Element Contingency Analysis: Planning events P3 and P6 involve a first and second level contingency analysis; such events were tested using multiple element contingency analysis. During this analysis, loss of elements due to first contingency was followed by

acceptable system adjustments, before testing the effect of the second contingency event. The list of acceptable system adjustments included system reconfiguration, changes in voltage schedule, and re-dispatch of generation. Other contingency events such as P4, P5, and Extreme Events, which involved simultaneous removal of multiple elements, were also analyzed. Extreme Events associated with the disruption of gas pipelines were also included.

- Cascading Analysis: Cascading analysis was conducted to test all Planning and Extreme Events where a facility may be loaded above its relay loadabilty rating prior to allowed load shed. In this analysis, the software simulated the removal of all elements of Protection System and other automatic controls following the contingency event. This included tripping of generators and transmission elements which were loaded beyond their relay loadability limits. These contingencies were screened to detect potential cascade events for more detailed analysis.
- Short Circuit Analysis: Impact of system changes such as transmission additions and upgrades, and generation additions on fault duties were evaluated under fault conditions via short-circuit analysis. The results of short-circuit analysis included the magnitude of short-circuit current and the source impedance associated with each fault. These results were communicated to the NERC Registered TOs and Generator Owners (GOs). TOs and GOs completed a review of study results, acknowledged the findings, and provided a list of over-dutied circuit breakers and Corrective Action Plans. In addition, TOs and GOs also confirmed the continued validity and implementation status of the facilities identified in the previous RTP.
- Long Lead Time Equipment Analysis: Per Requirement 2.1.5 of TPL-001-4, the impact of the possible unavailability of major transmission equipment with a lead time of one year or more was studied. The studies were performed with an initial condition of the identified long lead time equipment modeled as out of service, followed by P0, P1, and P2 contingency events. The list of long lead time equipment was developed based on TO feedback. The results of such analysis were communicated to the appropriate TOs.
- Sensitivity Analysis: ERCOT selected the summer peak conditions of 2021 and 2024 and off-peak conditions of 2022 for sensitivity analyses as required by Requirement 2.1.4 of the NERC TPL-001-4 Standard. ERCOT prepared the sensitivity cases by varying the following set of input assumptions:
    - Turn all wind and hydro units in the study region off (i.e., unavailable) in the 2021 and 2024 summer peak cases.
    - High-wind, low-load conditions for the off-peak case.

The sensitivity analyses were performed with all identified reliability solutions from the base case analysis to evaluate the effectiveness and robustness of the base case solutions under the stressed system conditions.

Corrective Action Plan Development

Per the ERCOT Planning Guide, reliability projects are those system improvements (projects) that are needed to meet NERC Reliability Standards or ERCOT planning criteria which could not otherwise be met by any possible re-dispatch of existing or planned generation. The software simulated the removal of all elements of the protection system and other automatic controls following the contingency event. This included the simulation of devices designed to provide steady-state control of electrical system quantities. These devices included equipment such as load tap changing transformers, phase-shifting transformers, switched capacitors and inductors. A list of potential Corrective Action Plans, or reliability projects, along with the corresponding limiting elements and contingencies was communicated to the appropriate TP and/or TO. TPs and TOs reviewed the initial list of reliability-driven projects for their technical feasibility and estimated the year of completion (taking into account necessary lead-times). In some cases, the TOs also provided project alternatives. In the instance that a project was not feasible in time, ERCOT designed a Constraint Management Plan to mitigate the criteria violations until the permanent Corrective Action Plan could be put in-service. These mitigation actions were developed in collaboration with TPs and further communicated to ERCOT Operations. Intermediate and final results were posted on the ERCOT MIS Secure Area and presented to stakeholders at regularly scheduled RPG meetings in order to solicit comments and suggestions.

System Operating Limit (SOL) Identification

The ERCOT SOL Methodology was used to determine if additional SOLs were needed in the planning horizon. Per the criteria, a new SOL was identified if results of the reliability analysis of the base case resulted in any of the following:

- Voltage instability (resulting in uncontrolled voltage collapse).
- Cascading or uncontrolled separation or islanding.
- Manual system adjustments in the planning horizon such as load shedding to prevent cascading or transient, dynamic, or voltage instability.

3.2. Economic Analysis

ERCOT staff conducted an economic analysis to identify system improvements that would allow ERCOT to meet NERC Reliability Standards and ERCOT planning criteria at a lower total cost (total system variable production cost plus carrying-cost of new projects) than the continued dispatch of higher cost generation.

To identify such efficiency-driven projects, ERCOT prepared a production cost model for years 2021 and 2024. This model was based on the ERCOT-developed load forecast, existing and planned generation (meeting the requirements of Planning Guide Section 6.9(1)), and the conditioned topology with newly identified reliability projects. The input information used in the start and final cases for economic analysis is provided as Appendix D and N. When applicable, predefined Remedial Action Schemes (RASs) were modeled in the case to relieve congested portions of the network. The list of

RASs modeled in the economic analysis section is documented in Appendix C. Following the production cost simulation, a list of all congested elements and binding contingencies was produced.

According to the economic planning criteria described in ERCOT Nodal Protocols Section 3.11.2(5), ERCOT recommends economic projects if the annual production cost savings exceed the first-year annual revenue requirement for the project. Based on the recent review of current market conditions, the first-year annual revenue requirement for a project was assumed to be 14% of the estimated project cost.

4. Findings from Reliability Analysis

4.1. Reliability Projects and CMPs

The primary purpose of the 2019 RTP reliability analysis was to identify ERCOT reliability criteria violations and potential Corrective Action Plans to resolve them. Overall, the base reliability analysis identified a need for fifty-six Corrective Action Plans. The detailed list of criteria violations and resulting Corrective Action Plans or reliability projects can be found in Appendix E. Figure 2 illustrates the geographic location of the identified Corrective Action Plans. The mapping between the reliability projects and the symbols in the map can be found in Appendix F.

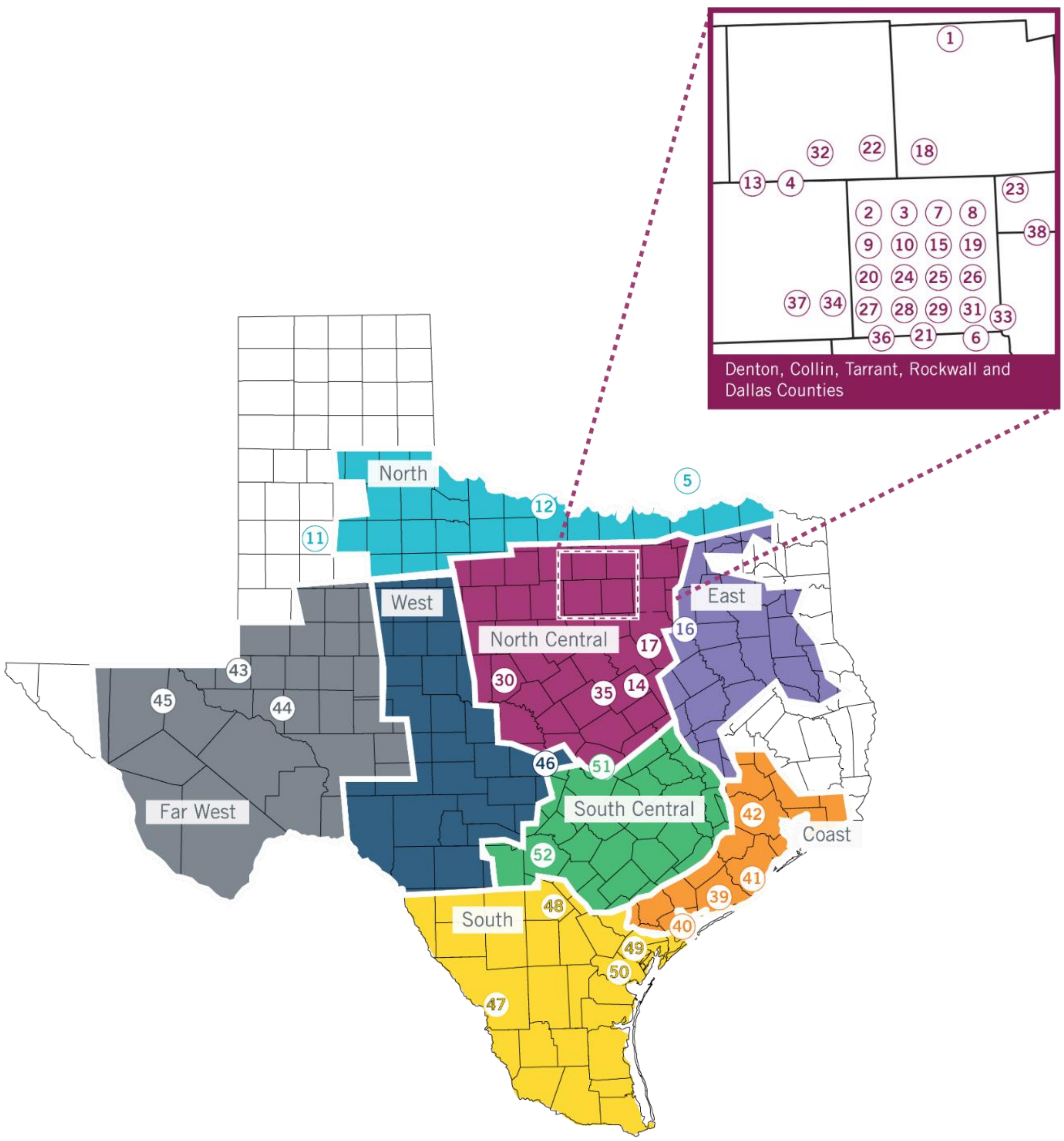

Figure 2: Geographic locations of Corrective Action Plans identified in the 2019 RTP

Figures 3 and 4 summarize the type of projects, their geographic locations, and voltage levels. Figure 5 distinguishes between projects that were newly identified in the 2019 RTP and projects that were identified in previous ERCOT planning studies or TSP studies.

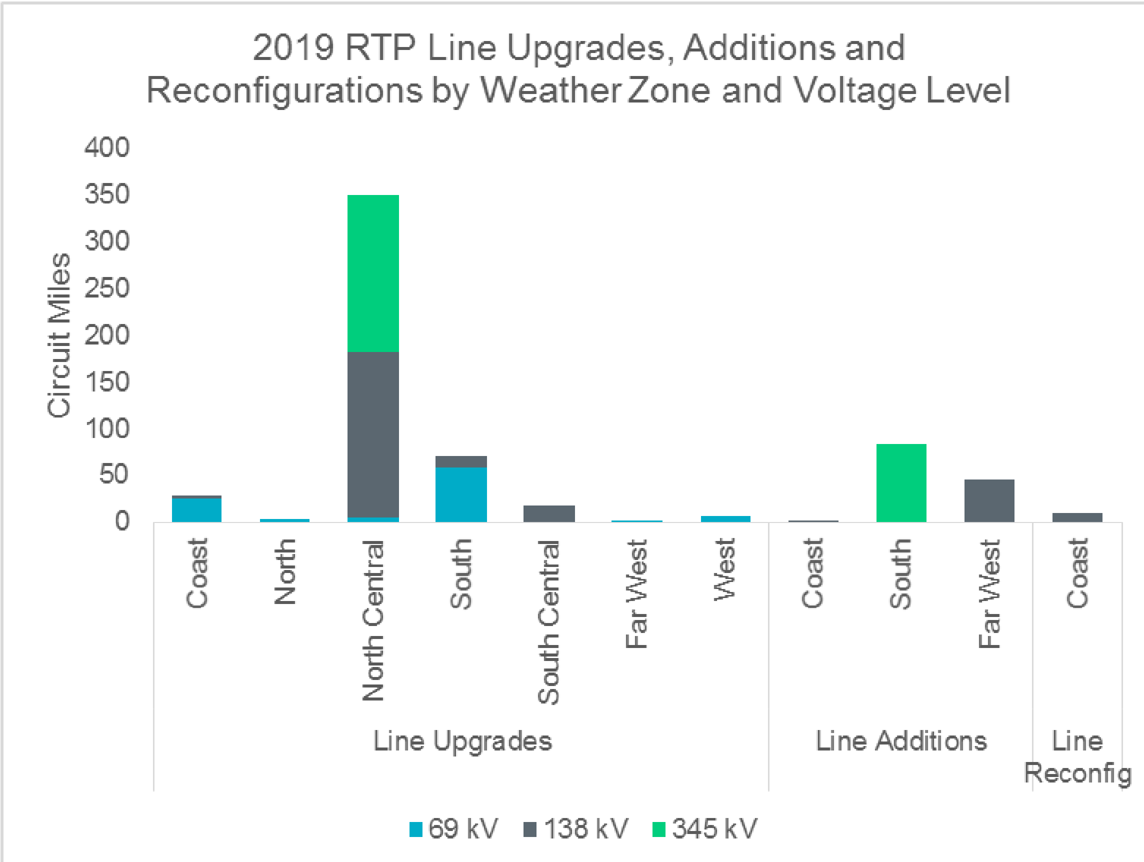

Figure 3: 2019 RTP transmission line project types by weather zone and voltage level

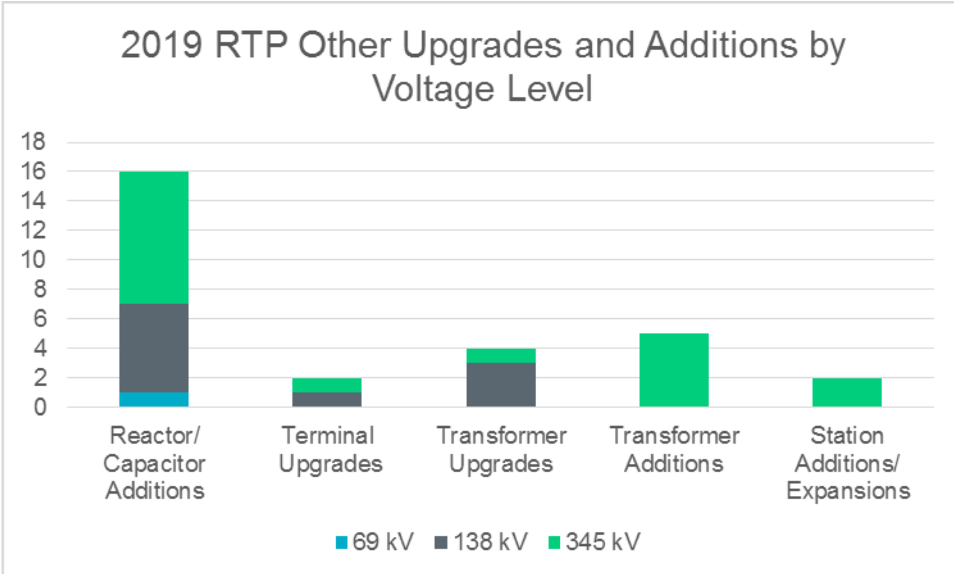

Figure 4: 2019 RTP other upgrades and additions by project type

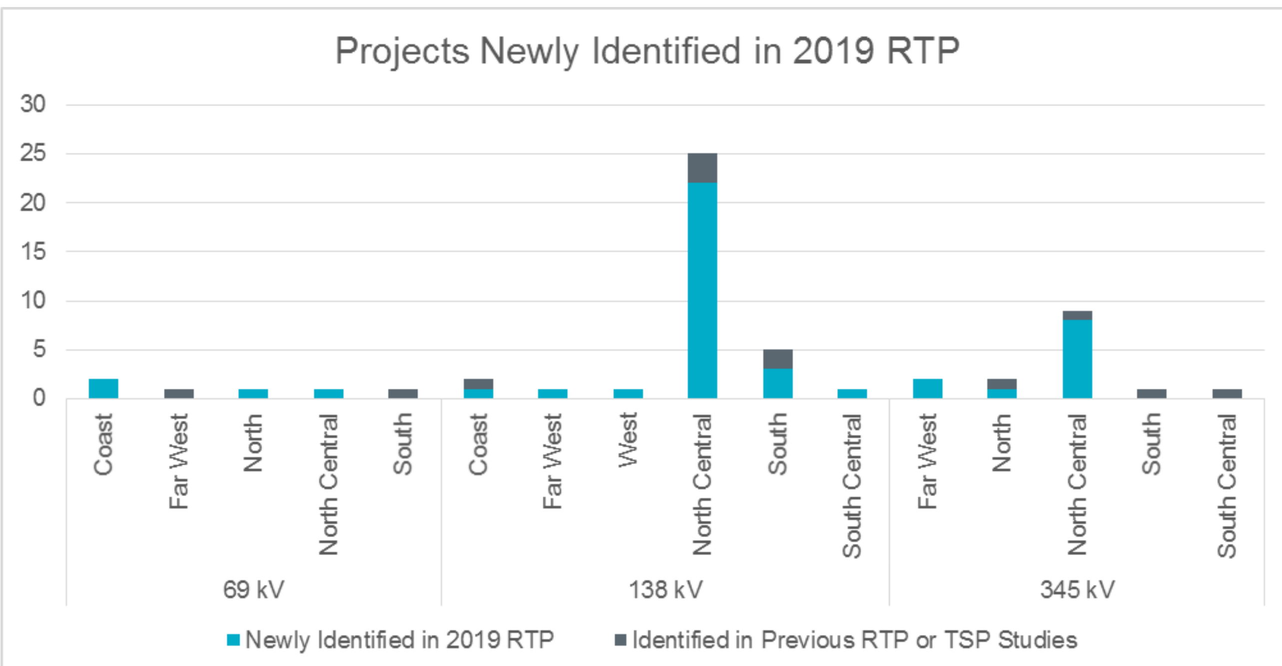

Figure 5: Projects newly identified in 2019 RTP versus projects previously identified

The Corrective Action Plans identified in the 2019 RTP included transmission upgrades that may not be completed prior to the need for the project due to lead-time challenges. ERCOT staff, in collaboration with TPs, identified five potential Constraint Management Plans (CMPs) as placeholder mitigating actions which will be reviewed in the operations planning horizon by ERCOT and TOs. The list and details of the CMPs identified in the 2019 RTP can be found in Appendix G.

Many reliability criteria violations could be mitigated by curtailing the DC tie exports on the DC ties with Mexico. Figure 6 below shows a breakdown of events that required DC Tie curtailment.

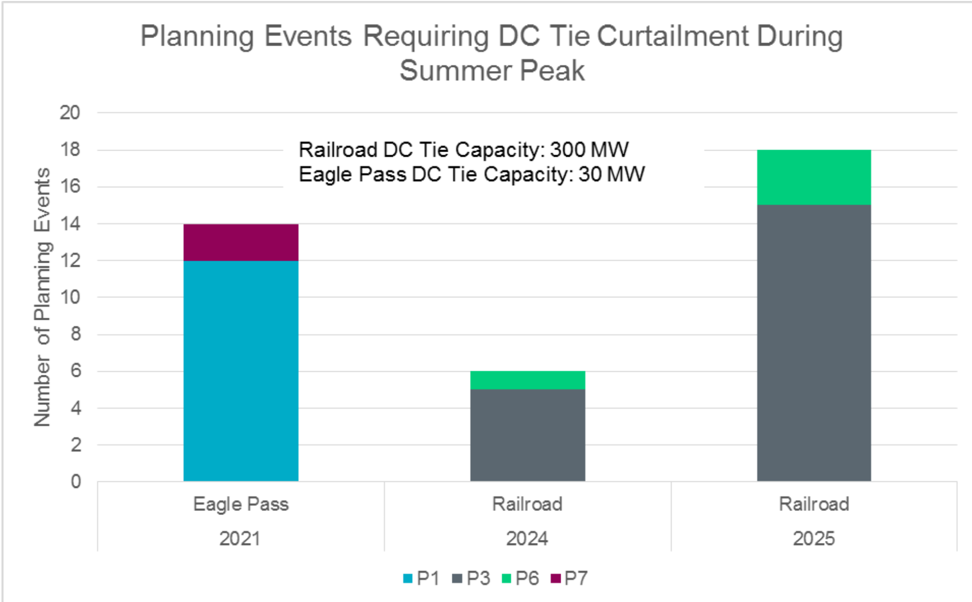

Figure 6: DC tie curtailments during summer peak in reliability analysis

In addition to this reliability analysis, a multiple element outage analysis was conducted for contingencies where non-consequential load shed was allowed per TPL-001-4 Table 1. This analysis consisted of 1) corrective action analysis, which identified mitigation measures (such as transformer tap setting changes, switching actions, generator re-dispatch, and load shed) to resolve any overloads and over/under voltage issues resulting from such contingencies; and 2) cascade analysis, which identified any contingencies that could result in potential cascade events.

Several Planning Events and Extreme Events were screened for detailed analysis. However, further investigation performed by ERCOT and affected TPs indicated none of the events resulted in cascading conditions. ERCOT also studied the loss of multiple generating stations due to the disruption of gas pipelines. The results of the multiple element outage analysis are documented in Appendix H. This appendix includes the list of critical contingencies identified as a result of this analysis and Corrective Action Plans or recommendations necessary to mitigate the impact of these contingencies. No new SOLs were identified in the 2019 RTP reliability analysis.

In addition to the above analysis, per ERCOT Planning Guide Section 3.1.1.2 (3), the 2019 RTP analysis also included development of a list of transmission facilities that were loaded above 95% of their applicable ratings under normal and contingency events (loss of single generating unit, transmission circuit, transformer, or common tower outage). This list is attached to the report as Appendix I.

4.2. Sensitivity Analysis

As indicated in Section 3.1, the impact of unavailability of wind and hydro generating units under summer peak conditions was evaluated in the 2021 and 2024 summer peak cases. For the 2022 off-peak conditions, ERCOT analyzed the system impact of the high-wind, low-load conditions.

The purpose of this portion of the study was to evaluate the effectiveness and robustness of the base case reliability projects under stressed system conditions.

In the high-wind, low-load sensitivity analysis, ERCOT maintained the wind penetration level close to 70%, excluded wind curtailment as a mitigation action, and studied the potential transmission solutions to facilitate the wind export from wind rich regions to load centers. Two new export paths were identified to greatly help the wind export from the North/West/Far West region to the east part of the system, and to improve export of the wind out from the Lower Rio Grande Valley (LRGV). Overall, ERCOT identified twenty-three additional transmission solutions, and the acceleration of two reliability/economic projects to facilitate the wind export in addition to acceptable mitigation actions such as voltage schedule changes, tap setting changes, and generation re-dispatch other than wind. The majority of the transmission solutions are located in the North Central and South Weather Zones. Since wind curtailment is a valid mitigation action in operations and in planning, the identified transmission solutions could serve as economic project candidates for further economic analysis, instead of being required for reliability purposes.

The unavailability of wind and hydro generating units in the summer peak cases greatly stressed the LRGV area, and ERCOT identified the potential need to have another import path into the LRGV. The wind export transmission solution for the LRGV identified in the high-wind, low-load sensitivity analysis was used to resolve the LRGV import issues as well. Overall, ERCOT identified nine additional transmission solutions, and the acceleration of one reliability project in addition to acceptable mitigation actions such as voltage schedule changes, tap setting changes, and generation re-dispatch. Six CMPs identified in the base cases and two additional CMPs were also needed for this sensitivity analysis.

A detailed list of system deficiencies and transmission improvements identified in the 2019 sensitivity analysis is provided in Appendix J.

4.3. Short Circuit Analysis

As indicated in Section 2.3, ERCOT conducted the short-circuit analysis for the 2022 and 2024 summer peak base cases with all reliability projects identified in the 2019 RTP and shared the results with TOs and GOs. TOs and GOs reviewed the fault duty information to identify buses with over-dutied breakers along with Corrective Action Plans.

Table 1 provides a summary of the results of the short-circuit analysis. These results indicate that short-circuit currents tend to increase as additional transmission elements are added or upgraded over the years. Based on the review and comments provided by TOs and GOs, eighteen buses were identified as having over-dutied breakers. The buses with over-dutied breakers and the resulting

Corrective Action Plans can be found in Appendix K, which also contains the study cases and details of the results.

Table 1: Summary of Short-circuit Analysis

Magnitude of Fault Current	Number of buses (3-phase fault)		Number of buses (single-line to ground fault)	
	2022	2024	2022	2024
Below 40 kA	4430	4455	4745	4773
40 kA ~ 60 kA	464	468	169	170
More than 60 kA	20	20	0	0

4.4. Long Lead Time Equipment Analysis

Upon ERCOT's request, the TOs provided a list of long lead time equipment based on their spare equipment strategy. All TO-provided, BES, long lead time equipment outages were studied to determine the impact of unavailability of such equipment for an extended period of time. This analysis was conducted on 2021, 2022, 2024, and 2025 summer peak conditions, along with 2022 off-peak conditions. Overall, twenty-four unique 345/138-kV transformers, eleven unique 345-kV reactive devices, one 138-kV reactive device, two 345-kV synchronous condensers and their transformers, and three tertiary connected shunts were identified as long lead time equipment. NERC category P0, P1, and P2 contingencies were studied. The results were shared with the respective TPs. The list of long lead time equipment and study results are attached in Appendix L.

5. Economic Projects

The 2019 RTP economic analysis was performed using production cost simulation runs for the years 2021 and 2024. The input assumptions and starting congestion for both years are presented in Appendix D. Figures 7 and 8 show the top constraints seen in 2021 and 2024, respectively. The size of each bubble represents the relative capacity of the congested element over the study period.

The 138-kV line from Jones Creek to Velasco experienced a significant amount of congestion in the 2021 case. This congestion was not seen in 2024 because the Jones Creek Copper Reconfiguration, which was identified as a reliability project for 2024, was included in the case. The project was tested in the 2021 economic case and it met the economic criteria. As such, ERCOT recommends that an earlier construction timeline be investigated for this project.

Like the Jones Creek to Velasco 138-kV line, the 345-kV line from WA Parish to Oasis was also congested in 2021, but not in 2024. This is due to the inclusion of the RPG-approved Bailey to Jones Creek project in the 2024 case. The Bailey to Jones Creek project is scheduled to be in-service in 2022.

The Big Brown to Jewett and Twin Oak to Jack Creek 345-kV lines were highly congested in both study years. This congestion is driven by high transfer of wind from North Texas down to Houston. Economic projects tested to relieve the congestion were unable to meet the economic criteria at this time. ERCOT will continue to monitor this congestion in future economic transmission planning assessments.

Similar to the 2018 RTP, significant congestion was seen in the Kendall area with the Kendall to Bergheim and Kendall to Cagnon 345-kV lines, the Bergheim 345/138-kV transformer, and the Kendall to Kerr 138-kV line being the most constraining elements. This congestion primarily results from increased wind and solar generation in the west and north regions of ERCOT. No long-term solution to resolve the congestion in this area met the economic planning criteria. The *2018 Dynamic Stability Assessment of High Penetration of Renewable Generation in the ERCOT Grid*[3] indicated that an additional transfer path between West Texas and Central Texas can be beneficial from a stability perspective. This and other long-term solutions to congestion in the Kendall area will be further evaluated in future economic transmission planning assessments as development of renewable generation in the west and north regions of ERCOT continues.

[3] Found at http://www.ercot.com/content/wcm/lists/144927/Dynamic_Stability_Assessment_of_High_Penetration_of_Renewable_Generation_in_the_ERCOT_Grid.pdf

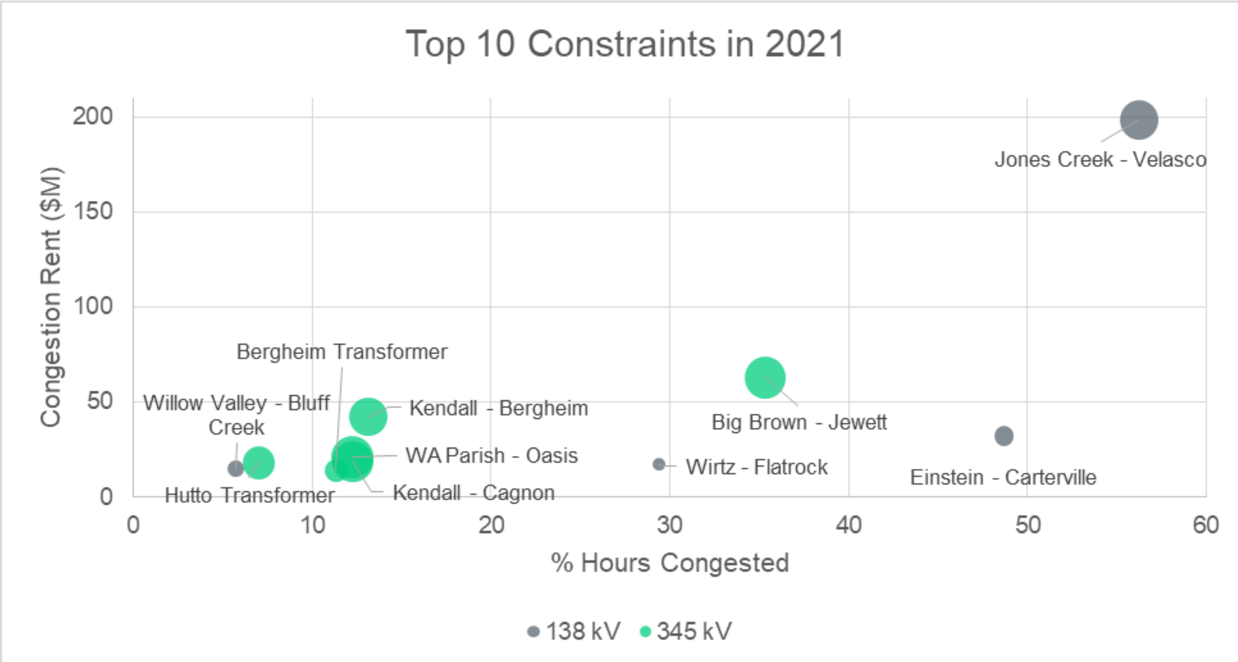

Figure 7: Top 10 Constraints in 2021

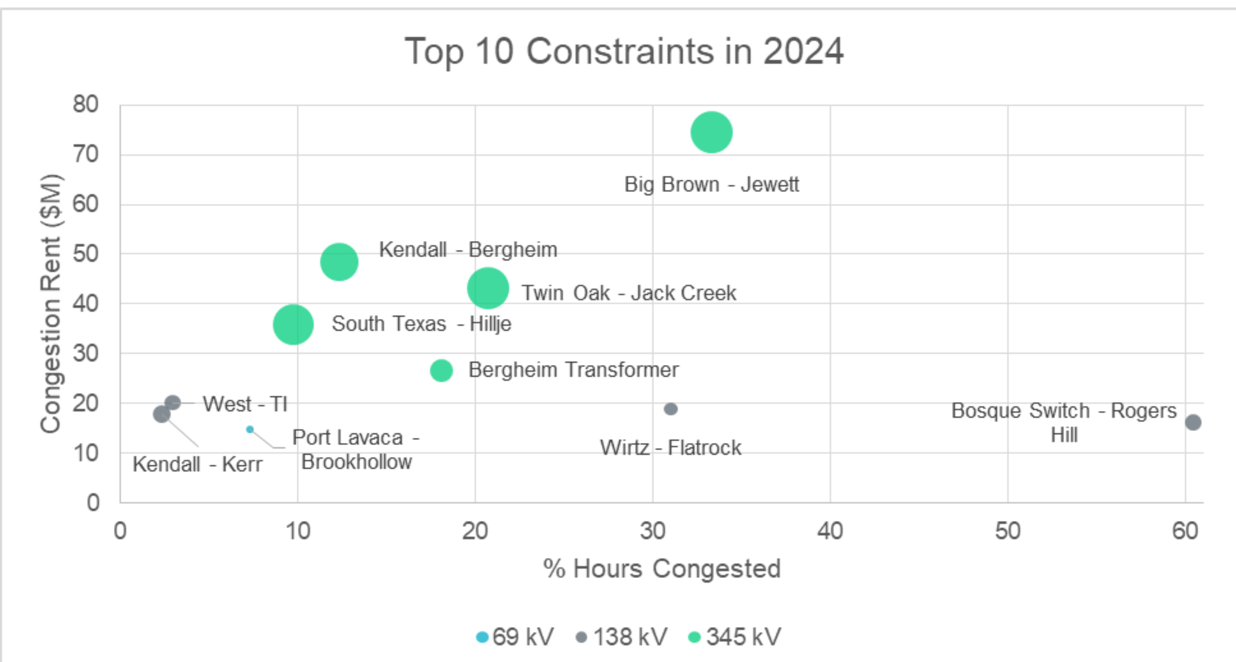

Figure 8: Top 10 Constraints in 2024

Eight economic transmission projects were evaluated in the 2019 RTP. Three of the eight solutions evaluated showed sufficient benefits to pass the ERCOT economic planning criteria. The previously mentioned Jones Creek Copper Reconfiguration project met the economic criteria, resulting in the in-service date for this reliability project being moved up from 2024 to 2021. The Brookhollow to Port

Lavaca 69-kV line upgrade also met the economic criteria to be accelerated from 2024 to 2021, but was not included in the final cases prior to 2024 because it is unlikely that this project can be in-service by 2021.

Another project of note is the Whitepoint to STP 345-kV line loop-in to the Hillje substation in Wharton County. This project helps address the congestion seen on the STP to Hillje 345-kV line in 2024. This option showed greater production cost savings than the Elm Creek to STP 345-kV line loop-in to Hillje project that was identified in the 2018 RTP. Further economic analysis is needed to determine the best long-term solution between these two options.

The full list and details of the economic projects tested in the 2019 RTP can be found in Appendix M. The input data and final congestion tables from the 2019 RTP can be found in Appendix N.

Finally, as required by ERCOT Nodal Protocols Section 3.10.8.4(3), ERCOT identified additional Transmission Elements that have a high probability of providing significant added economic efficiency to the ERCOT market through the use of dynamic ratings. Dynamic ratings for the identified elements (listed in Appendix O) have been requested from the associated TOs.

6. Appendices

Index	Description	Document	Access
A	RTP Scope and Process Document	Appendix_A_2019_RTP_Scope_and_Process_Final.pdf <file included in the public version>	Public
B	Input assumptions for the 2019 RTP reliability analysis	Appendix_B_2019_RTP_Reliability_Input_Assumptions.xlsx <file included in the public version>	Public
C	Input assumptions for the 2019 RTP economic analysis	Appendix_C_2019_RTP_Economic_Input_Assumptions.xlsx <file included in the public version>	Public
D	Economic analysis start case input and annual constraints	Appendix_D_2019_RTP_Economics_Start_Case_Inputs_Annual_Contraints.zip <file available in MIS Secure Area>	MIS Secure
E	Reliability Driven Projects	Appendix_E_2019_RTP_Reliability_Projects_Public.xlsx <file included in the public version>	Public
F	Project locations	Appendix_F_2019_RTP_Project_Locations.pdf <file included in the public version>	Public
G	Constraint Management Plans	Appendix_G_2019_RTP_ConstrainstManagementPlans.xlsx <file available in MIS Secure Area>	MIS Secure
H	Multiple element outage analysis	Appendix_H_2019_RTP_MultipleElementContingencyStudyReport.docx <file available in MIS Secure Area>	MIS Secure
I	Facilities loaded over 95%	Appendix_I_2019_RTP_95%_Exceedance_PG31123.xlsx <file available in MIS Secure Area>	MIS Secure
J	Sensitivity Analysis Results	Appendix_J_2019_RTP_Sensitivity_Projects.xlsx <file available in MIS Secure Area>	MIS Secure
K	Short circuit Analysis	Appendix_K_2019_RTP_ShortCircuitStudyCases_DetailedResults.docx <file available in MIS Secure Area>	MIS Secure
L	Long lead time equipment analysis	Appendix_L_2019_RTP_LongLeadTimeEquipment.docx (File is ERCOT-Confidential)	ERCOT Confidential
M	Economic projects evaluated	Appendix_M_2019_RTP_Economic_Projects_Public.xlsx <file included in the public version>	Public
N	Economic analysis final case input and annual constraints	Appendix_N_2019_RTP_Economics_Final_Case_Inputs_Annual_Contraints.zip <file available in MIS Secure Area>	MIS Secure
O	Transmission elements proposed to be dynamically rated	Appendix_O_2019_RTP_DynRating_NP3_10_8_4.xlsx <file available in MIS Secure Area>	MIS Secure