



2018 Regional Transmission Plan

Version 1.0

Document Revisions

| Date | Version | Description | Author(s) |
|------------|---------|---------------------------------------|--|
| 12/21/2018 | 1 | | Ping Yan, Jameson Haesler, Phung Nguyen, Rodolfo Romo, Lex Camargo, Minnie Han, Craig Wolf |
| | | | Reviewed by: Sandeep Borkar, Jeff Billo |
| 1/2/2019 | 1.1 | Corrected a hyperlink error on page 5 | Ping Yan |

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1. Executive Summary

The 2018 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 2020 through 2024. This report documents the results of the assessment, in part, to comply with the requirements of NERC Reliability Standards, ERCOT 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 2018 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 2018 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 2018 RTP are 138-kV and 345-kV upgrades. The projects identified as 345-kV upgrades consist of line additions, line upgrades, new 345/138-kV transformers and reactor/capacitor additions. Many of the transformer projects were identified in previous RTP or TP studies.

The 2018 RTP identified the following noteworthy reliability projects:

- New 345/138-kV transformer (second transformer) at McCree Station in Dallas County
- New 345/138-kV transformer at Saginaw Station in Tarrant County, and new 345-kV lines from Saginaw Station to Parker Switch Station and Hicks Switch Station
- New 345/138-kV transformer (second transformer) at Forney Station in Kaufman County
- New 345/138-kV transformer (second transformer) at Moss Station in Ector County
- Upgrade of the Norwood to Cedar Hill 345-kV line in Dallas County
- Upgrade of the Venus to Navarro 345-kV line in Ellis County

A 2017 NERC Single Point of Disruption (SPOD) study had identified four clusters of generators which could be impacted due to the disruption of the gas pipeline network in Texas. The 2018 RTP included a study of the impact of these extreme generation outages on the ERCOT grid.

Due to the projected high load growth in the Far West weather zone driven by the oil and gas development, ERCOT also performed a higher load sensitivity with West and Far West weather zone loads increased to the TP-submitted level in the 2020 and 2023 summer peak cases. For year 2020, an additional 545 MW of Far West load was added to the base case, and for year 2023, an additional 530 MW of Far West load was added to the base case. Additional Corrective Action Plans were identified with the higher load level studied for the West and Far West weather zones.

The 2018 RTP also included an economic assessment of the ERCOT transmission system for years 2020 and 2023. 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). Seven economic transmission improvement projects were evaluated in the 2018 RTP. Three of the seven solutions evaluated showed sufficient benefits to pass the ERCOT economic planning criteria. Most noteworthy of these projects was the upgrade of the Lewisville – Jones Street 138-kV line in Dallas-Fort Worth area in 2020 and the Elm Creek – STP 345-kV line loop-in at Hillje substation near the Houston area in 2023.

The project completion years stated in the 2018 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 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. Projects requiring Regional Planning Group (RPG) approval will be reviewed in future assessments (where sufficient lead-time exists), such as future Regional Transmission Plans, 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. 2018 Regional Transmission Plan

This report documents the 2018 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 Protocol Section 3.11 and ERCOT Planning Guide Sections 3 and 4.

The RTP study is conducted annually for the entire ERCOT System. The 2018 RTP's near-term planning horizon analysis evaluated the reliability needs of the ERCOT transmission system for the years 2020, 2021, 2023 and 2024. As required by NERC Standard TPL-001-4, the 2018 RTP included a steady-state analysis of summer peak conditions for years 2020 (year 2), 2021 (year 3) and 2023 (year 5) and off-peak conditions for 2021 (year 3), and a short-circuit analysis of summer peak conditions for years 2021 (year 3) and 2023 (year 5). The 2018 RTP also included steady-state analyses for 2024 (year 6), representing the long-term planning horizon. The year six, or 2024, 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 2018 RTP also evaluated economic/efficiency needs of the ERCOT system for 2020 and 2023.

2.1. Stakeholder Involvement

The development of the RTP is a collaborative process. ERCOT worked with NERC-registered Transmission Planners (TP), Transmission Owners (TO) 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 A1, A2 and A3. Stakeholders and the RPG were provided routine updates on the input assumptions and supporting analysis performed for the 2018 RTP study in the monthly RPG meetings held from January to May of 2018. 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 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 Protocols, and the ERCOT Planning Guide.

NERC Reliability Standards: 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-002¹ reliability standard and the IRO-017² reliability standard. ERCOT Protocols: ERCOT 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 Protocols Section 3.11.5 specifies the economic planning criteria used to evaluate the cost-effectiveness of projects in the RTP.

ERCOT Planning Guide: The RTP assessment adheres to ERCOT Planning Guide Section 3.1.1.2, which provides guidelines regarding completion of the RTP. This section also 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 Protocol 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. A 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 MIS Secure area. A redacted “public” version of the RTP report is created by removing, at a minimum, any system criteria violation information. This report is shared with the general public via ERCOT public website.

¹ R4 from FAC-002

² R3 and R4 from IRO-017

3. 2018 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 2018 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 2018 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 then 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 A1, A2 and A3.

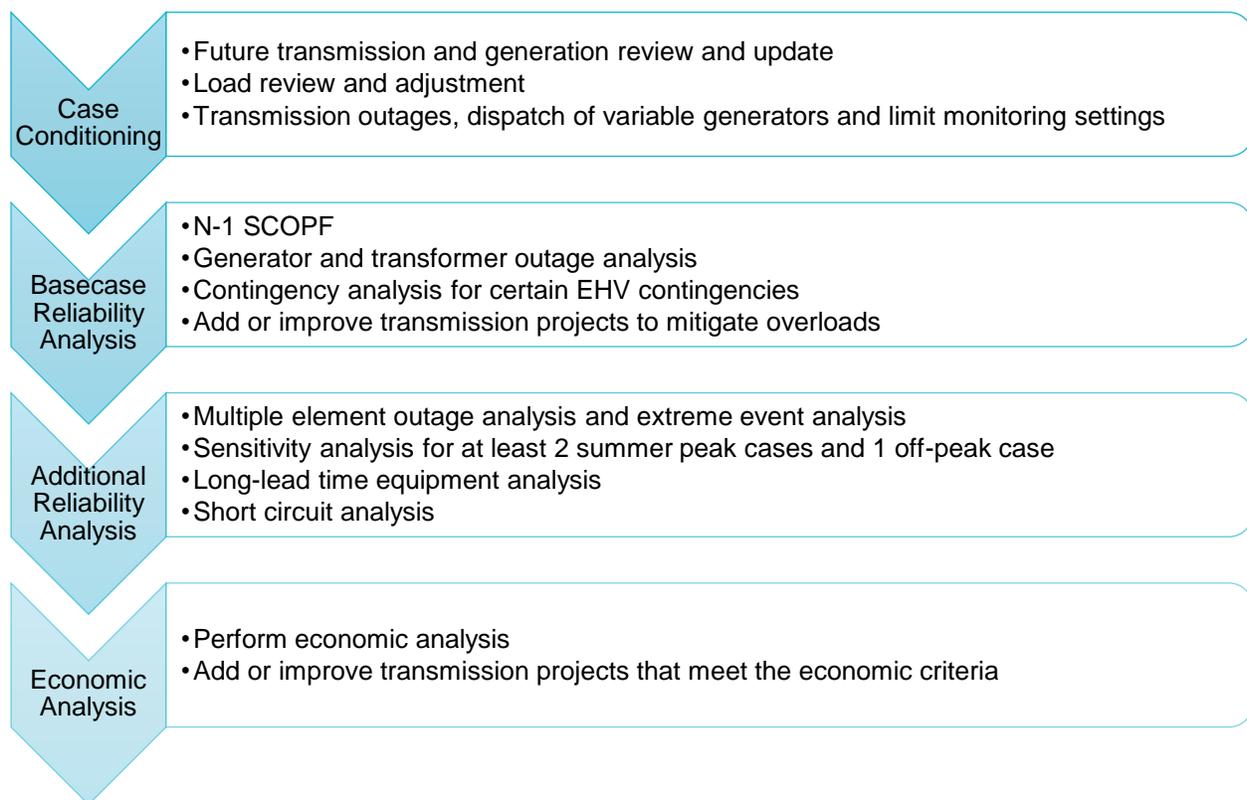


Figure 1: 2018 RTP Transmission Planning Process

ERCOT utilized the following software tools while performing the 2018 RTP:

- PSS/E version 33 was used to develop the conditioned cases and the AC reliability cases
- PowerWorld version 20 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.
- TARA version 1801/1702b and PowerWorld version 20 were used to screen critical contingencies while evaluating P3 (Generator outage) and P6-2 (Transformer outage) planning events.
- POM application suite version 2017/2018 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.
- UPLAN version 10.4 was used to perform the security-constrained economic analysis.

3.1. Reliability Analysis

The reliability analysis in the 2018 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 2018 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 was 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.

- **Cascading Analysis:** Cascading analysis was conducted to test all Planning and Extreme Events where a facility may be loaded above its relay loadability 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 (GO). 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 2020 and 2023 and off-peak conditions of 2021 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 and unavailable in the 2020 and 2023 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.

In anticipation of high load growth in the Far West weather zone driven by oil and gas development, the 2018 RTP also included a higher load sensitivity with West and Far West weather zone load increased to the TPs submitted level in the 2020 and 2023 summer peak cases. For year 2020, an additional 545 MW of Far West load and an additional 110 MW of West load were added to the base case, and for year 2023, an additional 530 MW of Far West load and an additional 105 MW of West load were added to the base case. The higher load sensitivity included a study of NERC P0, P1, P2-1, P7, P3, and P6-2 contingencies. The sensitivity analysis was 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 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 website 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; or
- 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 2020 and 2023. This model was based on the ERCOT-developed load forecast, existing and planned generation (meeting the requirements of Planning Guide Section 6.9), and the conditioned topology with the newly identified reliability projects. The input information used in the start and final cases for

economic analysis is provided as Appendix B. When applicable, predefined RAS's were modeled in the case to relieve congested portions of the network. The list of RAS's modeled in the economic analysis section is documented in Appendix A3. 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 Protocol 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 is assumed to be 14% of the total project cost.

4. Findings from Reliability Analysis

4.1. Reliability Projects and CMPs

The primary purpose of the 2018 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 thirty-eight Corrective Action Plans. The detailed list of criteria violations and resulting Corrective Action Plans or reliability projects can be found in Appendix C.

Figures 2 and 3 summarize the type of projects, their geographic locations, and voltage levels. Figure 4 also summarizes a list of projects that were newly identified in the 2018 RTP that were not identified in previous ERCOT planning studies. The project counts are based on transmission line segments, and may be part of longer breaker-to-breaker circuits. A detailed map of the ERCOT system with project locations can be found in Appendix D.

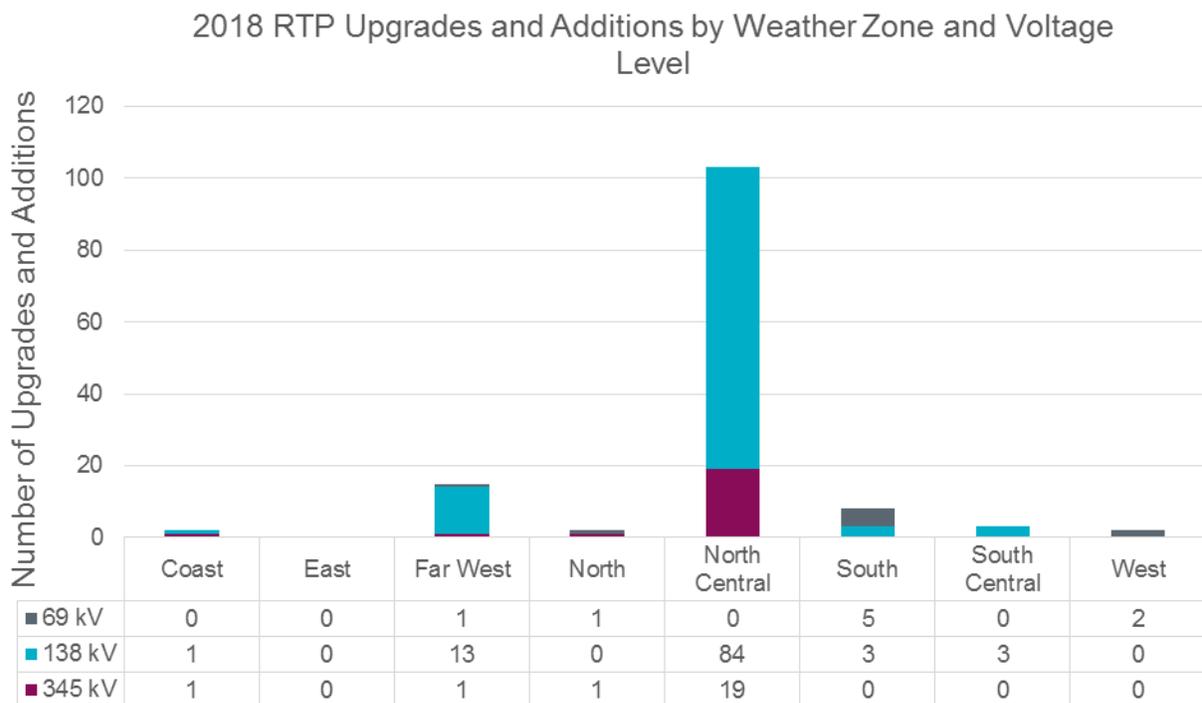


Figure 2: 2018 RTP upgrades and additions by weather zone and voltage level

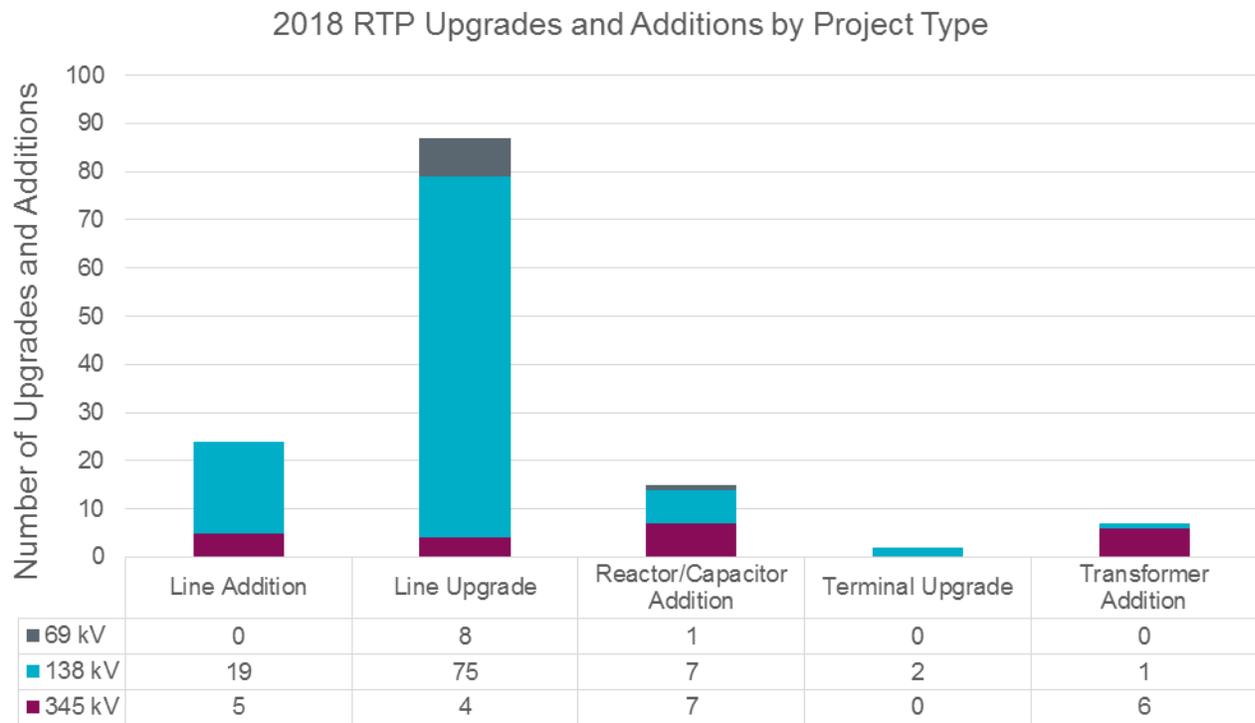


Figure 3: 2018 RTP upgrades and additions by project type

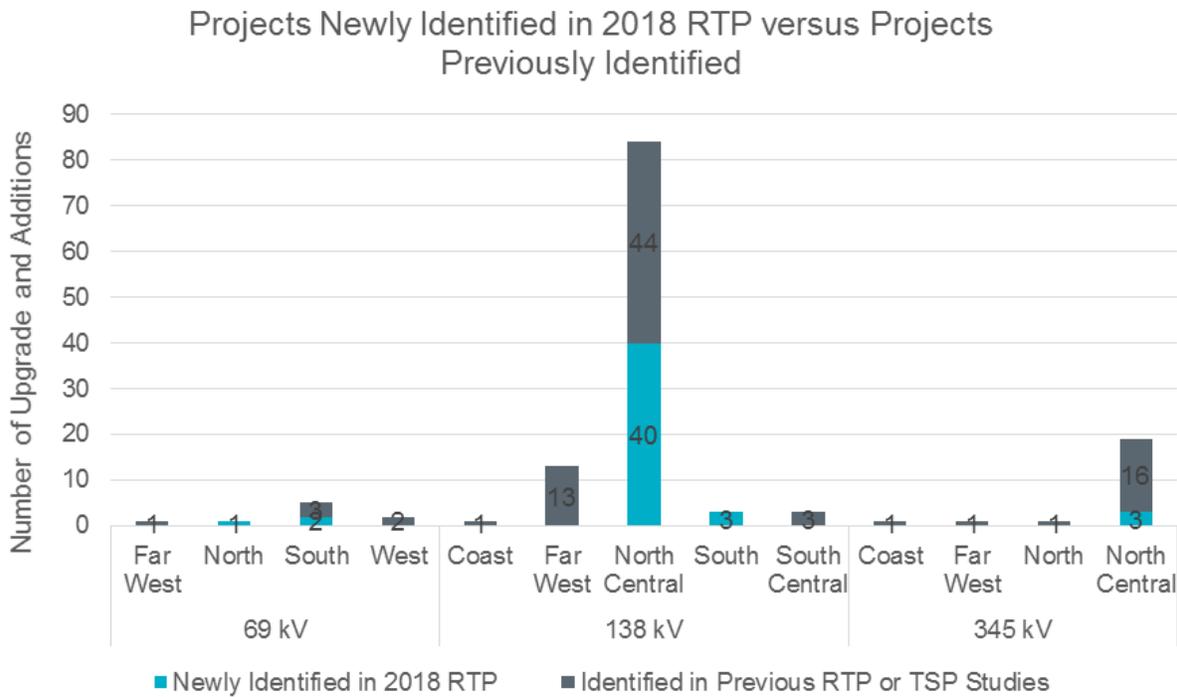


Figure 4: Projects newly identified in 2018 RTP versus projects previously identified

The Corrective Action Plans identified in the 2018 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 until they are reviewed in the operations planning horizon by ERCOT and TOs. The list and details of the CMPs identified in the 2018 RTP can be found in Appendix E.

Many reliability criteria violations could be mitigated by adjusting the DC tie dispatch on the DC ties with Mexico. ERCOT planning practices allow for DC tie dispatch changes under P3 and P6-2 conditions since they are considered to be manual system adjustments as prescribed in Table 1 of NERC TPL-001-4. However, there were some instances in 2020 and 2021 when DC tie exports had to be reduced to mitigate criteria violations resulting from P1 planning events. Figure 5 below shows a breakdown of events and the amount of export that can be sustained during the summer peak hour.

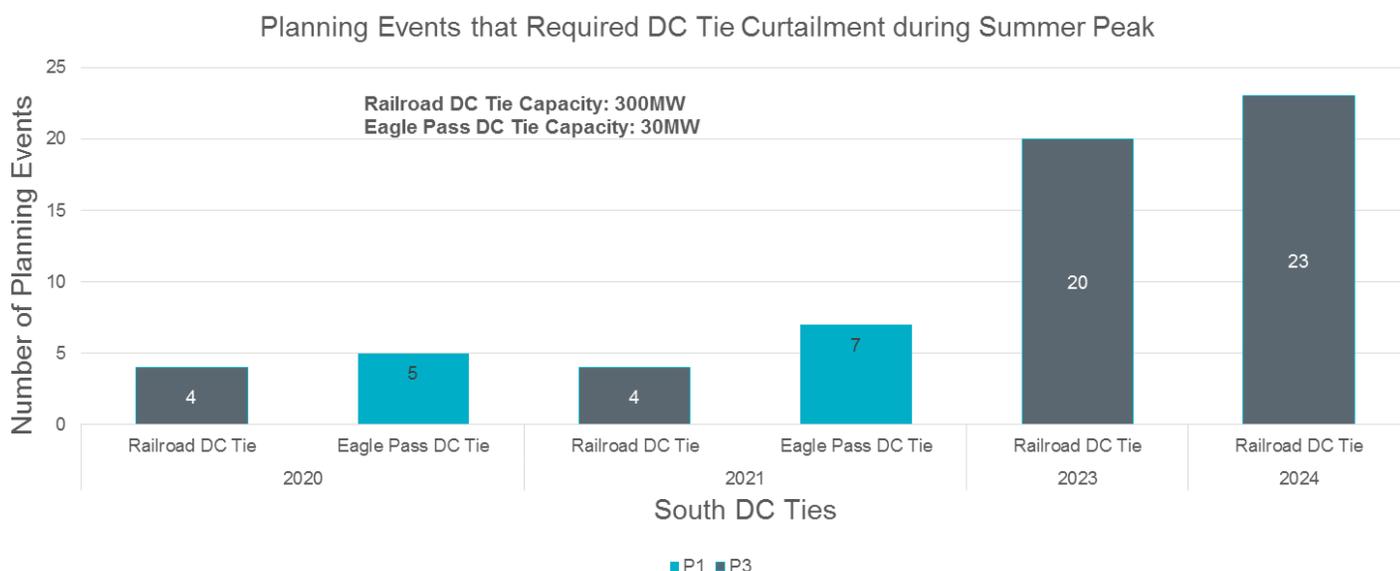


Figure 3: DC tie curtailments during summer peak in reliability analysis

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. A 2017 NERC Single Point of Disruption (SPOD) study had identified four clusters of generators which could be impacted due to the disruption of the gas pipeline network in Texas. ERCOT studied the loss of multiple generating stations due to the disruption of gas pipelines.

While the nature of the contingencies was extreme and involved significant loss of generation, any adverse impact, such as cascading, could be mitigated. Mitigation plans were communicated to and acknowledged by impacted TPs. The results of the multiple element outage analysis are documented in Appendix F. 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 2018 RTP reliability analysis.

In addition to the above analysis, per ERCOT Planning Guide Section 3.1.1.2 (3), the 2018 RTP analysis also included development of a list of transmission facilities that are 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 G.

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 2020 and 2023 summer peak cases. For the 2021 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. The sensitivity analysis identified the need for three additional upgrades and two additional CMPs in addition to acceptable mitigation actions such as voltage schedule changes, tap setting changes, and generation re-dispatch. Four CMPs identified in the base cases were also needed for the summer peak sensitivity studies but for different reliability constraints.

The West and Far West weather zones of the ERCOT region have seen rapid load growth in recent years. As a result, the ERCOT stakeholders expressed interest in studying the impact of continued oil and gas development in the region. Over the past 5 to 10 years, the Far West weather zone has seen a peak demand growth rate of around 7-8%. To capture the potential load growth, ERCOT performed a higher load sensitivity with West and Far West weather zone load increased to the TPs submitted level in the 2020 and 2023 summer peak cases. For year 2020, an additional 545 MW of Far West load and an additional 110 MW of West load were added to the base case, and for year 2023, an additional 530 MW of Far West load and an additional 105 MW of West load were added to the base case. The higher load sensitivity studied NERC P0, P1, P2-1, P7, P3, and P6-2 conditions. In order to resolve all the P0, P1, P2-1 and P7 contingency criteria violations, five new upgrades were needed in addition to acceptable system adjustments such as voltage schedule changes, tap setting changes, and generation re-dispatch. The completion of the Odessa to Moss portion of the Oncor Far West 2 RPG project will increase the existing Odessa to Moss 345-kV line rating to resolve certain N-1 contingency violations for 2020. For P3 and P6-2 conditions, criteria violations were seen in year 2020 alone. The Far West 2 project, which is planned to be in service by 2021 summer peak, eliminated the criteria violations in the model. As a result, load shedding was studied as a potential mitigation plan for P3 and P6-2 conditions for 2020.

A detailed list of system deficiencies and transmission improvements identified in the 2018 sensitivity analysis is provided in Appendix H.

4.3. Short-circuit analysis

As indicated in Section 2.3, ERCOT conducted the short-circuit analysis for the 2021 and 2023 summer peak base cases with all reliability projects identified in the 2018 RTP and shared the results with TOs and GOs. TOs and GOs reviewed the fault duty information to identify substations 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, twenty-four 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 I, 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) | |
|----------------------------|---------------------------------|------|---|------|
| | 2021 | 2023 | 2021 | 2023 |
| Below 40 kA | 4225 | 4240 | 4504 | 4517 |
| 40 kA ~ 60 kA | 450 | 450 | 190 | 189 |
| More than 60 kA | 24 | 28 | 5 | 12 |

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 2020, 2021, 2023 and 2024 summer peak conditions, along with 2021 off-peak conditions. Overall, twenty-five 345/138-kV transformers, three 345-kV reactors, one 138-kV reactor and two 345-kV synchronous condensers were identified as long lead-time equipment. NERC category P0, P1, and P2 contingencies were studied. The results were shared with the respective TPs. All the thermal overload and over/under voltage issues were associated with planning events that allow non-consequential load loss³. The list of long lead-time equipment and study results are attached in Appendix J.

³ ERCOT does not interpret NERC Reliability Standard TPL-001-4 to require Corrective Action Plans for violations identified in the long-lead-time equipment analysis. Nevertheless, ERCOT notes that even if Corrective Action Plans were required, none would be needed in this case because all of the violations identified in ERCOT's analysis were for planning events that permit non-consequential load loss to resolve them.

5. Economic Projects

The 2018 RTP economic analysis was performed using production cost simulation runs for the years 2020 and 2023. The input assumptions and starting congestion for both years are presented in Appendix B. Figures 6 and 7 show the top constraints seen in years 2020 and 2023. The size of each bubble represents the relative capacity of the congested element over the study period.

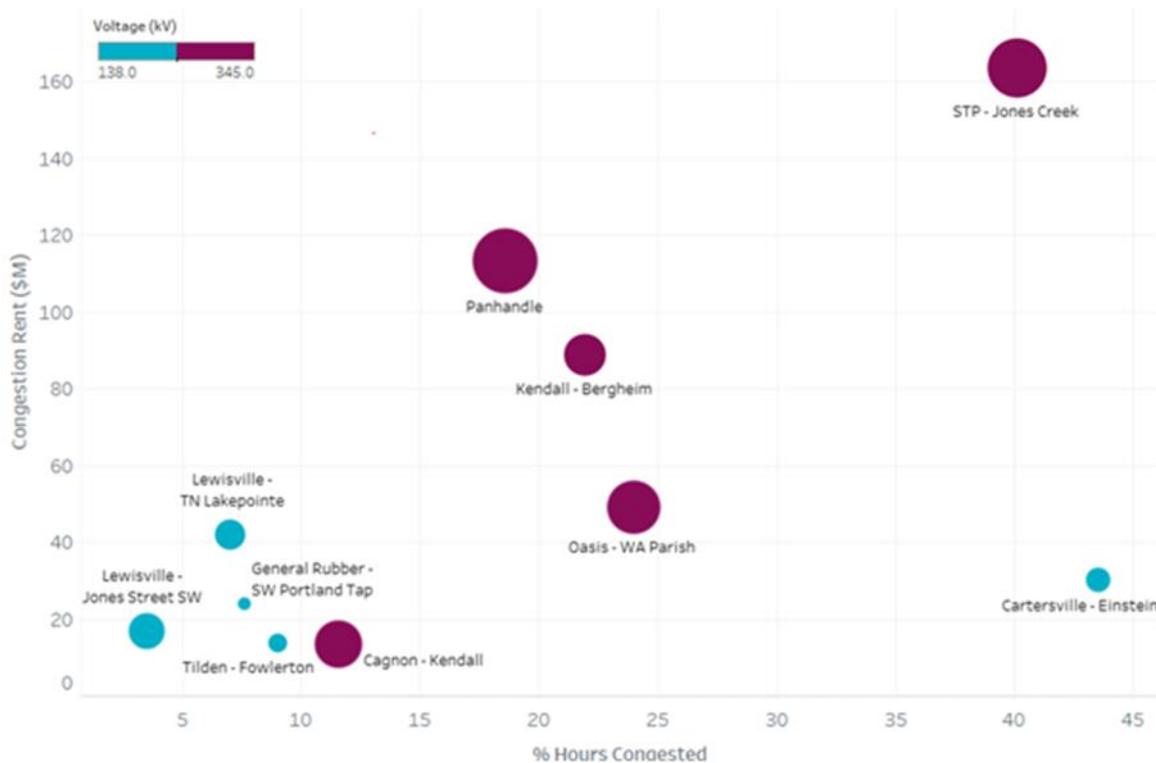


Figure 6: Top 10 Constraints in 2020

As seen in the charts, the Panhandle Interface in the North and 345-kV double-circuit lines from South Texas Project to Jones Creek in the Coast weather zone saw a significant amount of congestion in 2020. These constraints have seen consistent congestion over the past few planning assessments.

This first result is primarily driven by more wind generation connecting inside the Panhandle, a region which suffers from weak-grid conditions and resulting stability issues. The Panhandle area transmission upgrades to integrate Lubbock Power and Light loads were included in 2023, which resulted in an increase in the Panhandle Interface limits and lower congestion in 2023.

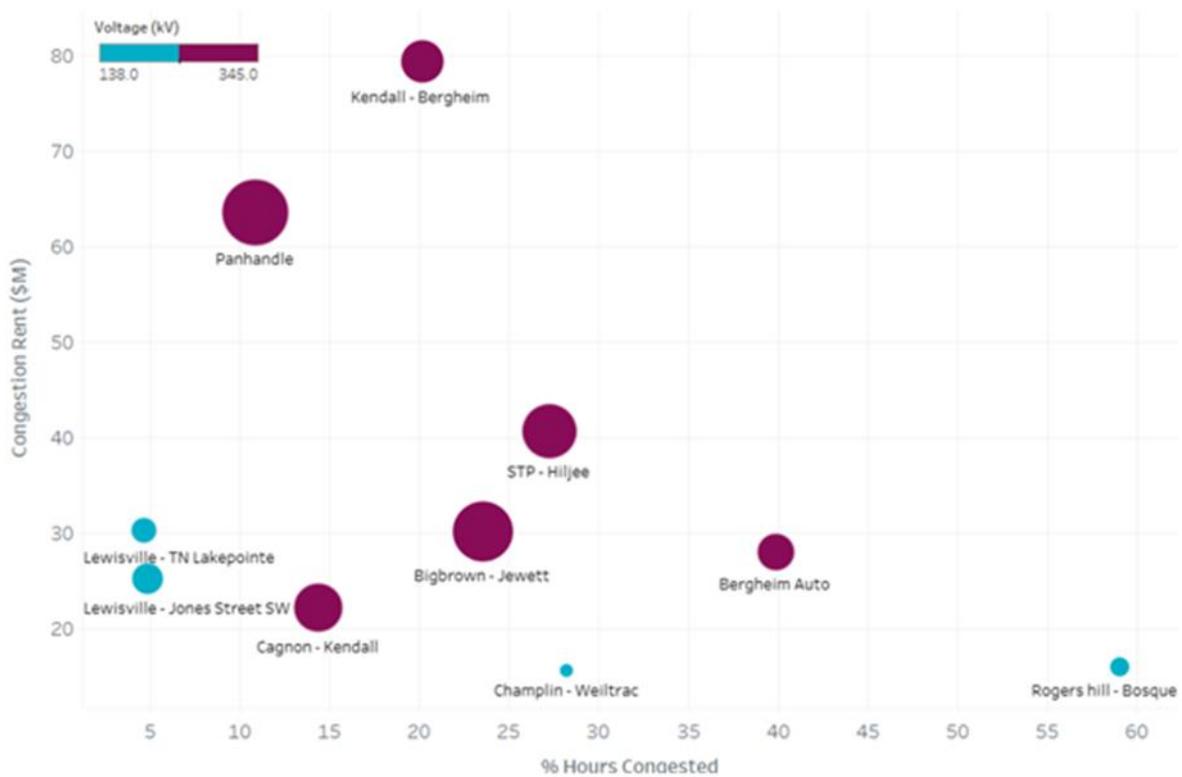


Figure 7: Top 10 Constraints in 2023

The STP to Jones Creek congestion saw a big increase primarily driven by additional industrial loads projected for the Freeport region. The recently approved Bailey – Jones Creek 345-kV project in Houston was also added to the 2023 case resulting in significant reduction in congestion rent for the STP-Jones Creek 345-kV lines.

In addition, high congestion was also seen on the Kendall – Cagnon and Kendall – Bergheim 345-kV circuits. This congestion primarily results from an increase in wind and solar generation in the west and north regions of ERCOT. While the projects evaluated to resolve the congestion in the Kendall area did not meet the economic criteria, they did demonstrate savings of \$20M-\$25M in 2020 and 2023. This area will continue to be evaluated in future economic transmission planning assessments as more renewable generation gets added to the west and north regions of ERCOT.

Seven economic transmission improvement projects were evaluated in the 2018 RTP. Three of the seven solutions evaluated showed sufficient benefits to pass the ERCOT economic planning criteria. Most noteworthy of these projects was the upgrade of the Lewisville – Jones Street 138-kV line in the Dallas-Fort Worth area. High congestion rents have been seen in real-time in the Dallas-Fort Worth area in recent years. The proposed Lewisville – Jones Street 138-kV line project should help mitigate congestion in the area.

In addition, the Elm Creek – STP 345-kV line loop-in to the Hilljee substation in Wharton County helps address the congestion seen on the STP – Hilljee 345 kV line in 2023. The list and details of the

economic projects tested in the 2018 RTP can be found in Appendix K. The input data and final congestion tables from the 2018 RTP can be found in Appendix L.

Finally, as required by ERCOT Protocol 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 M) have been requested from the associated TOs.

6. Appendices

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|-----------|---|--|--------------------|
| A1 | RTP Scope and Process Document | Appendix_A1_2018_RTP_Scope_and_Process_Final.pdf <file included in public version> | Public |
| A2 | Input assumptions for the 2018 RTP – addendum to the 2018 RTP Scope | Appendix_A2_2018_RTP_Input_Assumptions.xlsx <file included in public version> | Public |
| A3 | Input assumptions for the 2018 RTP economic analysis | Appendix_A3_2018_RTP_Economic_Input_Assumptions.xlsx <file included in public version> | Public |
| B | Economic analysis input information | Appendix_B_2018_RTP_Economics_Start_Case_Inputs_Annual_Constraints.zip <file available on MIS Secure> | MIS Secure |
| C | Reliability Driven Projects | Appendix_C_2018RTP_Reliability_Projects_public.xlsx <file included in public version> | Public |
| D | Project locations | Appendix_D_2018_RTP_Project_Locations.pdf <file included in public version> | Public |
| E | Constraint Management Plans | Appendix_E_2018RTP_ConstraintManagementPlans.xlsx <file available on MIS Secure> | MIS Secure |
| F | Multiple element outage analysis | Appendix_F_2018_RTP_MultipleElementContingencyStudyReport.docx <file available on MIS Secure> | MIS Secure |
| G | Facilities loaded over 95% | Appendix_G_2018_RTP_95%_Overload_PG31123.xlsx <file available on MIS Secure> | MIS Secure |
| H | Sensitivity Analysis Results | Appendix_H_2018RTP_Sensitivity_Projects.xlsx <file available on MIS Secure> | MIS Secure |
| I | Short-circuit Analysis | Appendix_I_2018RTP_ShortCircuitStudyCases_DetailedResults <file available on MIS Secure> | MIS Secure |
| J | Long lead-time equipment analysis | Appendix_J_2018RTP_LongLeadTimeEquipment.docx <File is ERCOT-Confidential> | ERCOT Confidential |
| K | Economic projects evaluated | Appendix_K_2018_RTP_Economic_Projects_public.xlsx <file included in public version> | Public |
| L | Annual Constraints from economic analysis | Appendix_L_2018_RTP_Economics_Final_Case_Inputs_Annual_Constraints.zip <file available on MIS Secure> | MIS Secure |
| M | Transmission elements proposed to be dynamically rated | Appendix_M_2018_RTP_DynRating_NP3_10_8_4.xlsx <file available on MIS Secure> | MIS Secure |