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**ERCOT System Planning  
2016 Regional Transmission Plan  
Study Scope and Process**

## Document Revisions

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## 1. Introduction

The Regional Transmission Plan is the result of a coordinated planning process, performed by ERCOT Staff with extensive review and input by NERC registered Transmission Planners (TPs), Transmission Owners (TOs) and other stakeholders. This process addresses reliability and economic transmission needs for the six-year planning horizon. This process produces a region-wide reliability and economic study of the transmission system in accordance with NERC and ERCOT planning requirements over a six-year transmission planning horizon. Results of this process include recommendations for upgrading and improving the existing system and proposals for new transmission projects that ensure transmission system reliability and relieve significant anticipated transmission system congestion.

## 2. Scope

The 2016 RTP shall identify reliability needs and transmission upgrades and additions required to meet the system needs per criteria set in the ERCOT Planning Guide Sections 3 and 4 and NERC TPL-001-4 reliability standard.

The 2016 RTP will study the following reliability cases.

- Summer peak load cases for years 2018, 2019, 2021, and 2022.
- Minimum load case for the year 2019.
- At a minimum, one sensitivity case each for years 2018 and 2021 summer peak, and 2019 minimum load.

The 2016 RTP will also identify transmission projects that meet the ERCOT economic planning criteria as stated in the Protocol Section 3.11.2. Economic analysis will be conducted for years 2019 and 2022.

To the extent practicable, projects identified in the 2016 RTP will be based on consensus between ERCOT Planning and the NERC registered TPs with input from other market participants.

All stakeholder communication regarding the RTP will be conducted through the monthly Regional Planning Group (RPG) meetings and mailing lists. Start cases and results of the analysis will be available for review via ERCOT's MIS.

## 3. Input Assumptions

### 3.1 Transmission Topology

The Steady State Working Group (SSWG) summer peak cases for the years 2018, 2019, 2021, and 2022 will be used as start cases for reliability analysis. The SSWG minimum load case for the year 2019 will be used as the off-peak start case.

### 3.1.1 RPG Approved Projects

Per ERCOT Planning Guide Section 3.4.1.1, the starting base cases for the RTP are created by removing all Tier 1, 2, and 3 projects that have not undergone RPG Project Review from the most recent SSWG base cases. Projects receiving RPG acceptance concurrently with the RTP study will be reviewed for any material impact on the analysis. These and any other model corrections, submitted by the TPs shall be documented and included in the study cases.

### 3.1.2 Transmission and Generation Outages

All known generation or transmission facilities outages with duration of at least six months are assumed to be modeled in the SSWG base cases. The list of generator outages will include the mothballed units as documented in the current Capacity, Demands, and Reserves report. Outages on seasonally mothballed units will be included in the analysis of the minimum load study case.

### 3.1.3 FACTS Devices

A data request will be sent out to TOs to confirm the list of FACTS devices which are not available for steady-state voltage support. Such FACTS devices will be turned off for the RTP analysis since they are not expected to contribute during steady-state system conditions.

### 3.1.4 Ratings and Interface Limits

All System Operating Limits (SOLs), including Stability SOLs, shall be respected in accordance with the latest ERCOT System Operating Limit Methodology. All transmission lines and transformers (excluding generator step-up transformers) 60-kV and above shall be monitored for thermal overloads to ensure that they do not exceed their pre-contingency or post-contingency ratings. Dynamic ratings will be used for both the reliability and economic portions of the analysis. These ratings will be based on the 90<sup>th</sup> percentile<sup>1</sup> temperature as determined for the weather zone associated with the transmission element. The table below shows the 90<sup>th</sup> percentile temperatures used to derive the dynamic reliability rating.

**Table 3.1: 90<sup>th</sup> percentile temperatures used in the dynamic reliability ratings calculation**

Weather Zone	90 <sup>th</sup> -percentile temperature (°F)
Coast	102.4
East	106.2
Far West	110.4
North Central	108.4
North	109.0
South Central	105.5
South	104.0
West	107.3

<sup>1</sup> Calculated based on the most recent 30-year historical data of annual peak temperatures for each weather zone

For voltage analysis, all buses 100-kV and above shall be monitored to ensure that they do not exceed their pre-contingency and post-contingency limits. It will be noted in the report that Transmission Planner organizations may have different rating or voltage limit criteria than specified above. In addition to the voltage limits, 2016 RTP will also monitor the post-contingency voltage deviation for all buses 100-kV and above. This criterion is defined in the Planning Guide Section 4.1.1.4

Requirement 3.3.1 of TPL-001-4 requires automatic tripping of elements where relay loadability limits are exceeded. If such ratings are not available a default limit will be used. This default limit is determined to be the lower of 1) 115% of their emergency ratings and 2) 150% of normal ratings.

Appropriate Panhandle export interface limits, as identified by the latest planning studies, will be modeled in the economic cases if the total capacity of generation in the economic cases exceeds the interface limit.

### **3.1.5 Contingency Definitions**

The most current SSWG Contingency Database will be used to create the contingency set for the RTP analysis. All contingency categories P0-P7, including the extreme events conditions, will be studied in the 2016 RTP. A detailed list of definitions can be found in Table 1 of NERC TPL-001-4.

## **3.2 Generation**

### **3.2.1 Generation Additions and Retirements**

All existing generation plants are retained from the SSWG start cases. Future generation will be added to the SSWG start cases if requirements from Planning Guide Section 6.9 are met. However, if the future generation resource meets all requirements of Planning Guide Section 6.9 except all of the data required in the Resource Registration Glossary are not available as per Planning Guide Section 6.9(1)(a) then other sources such as Interconnection Agreements may be used to model these generators. The ERCOT Generation Interconnection Status (GIS) database will be used as a reference list containing the status of the future generation. Generation identified as retired or mothballed based on the most recent information available to ERCOT at the time of case building and analysis will be modeled as offline for appropriate cases.

### **3.2.2 Renewable Generation Dispatch**

Hydro-electric Generation Resources in the reliability cases are dispatched up to the Hydro Unit Capacity as defined in Protocol Section 3.2.6.2.2, Total Capacity Estimate. In the summer peak reliability cases, the wind plants will be dispatched based on the 15<sup>th</sup> percentile output from vendor supplied profiles sampled for the hours when ERCOT load is higher than the 95<sup>th</sup> percentile. The dispatch percentages resulting from this analysis are shown in Table 3.2. For the Off-Peak reliability case, the historical data of wind resources during the minimum load conditions will be analyzed to determine maximum wind dispatch output level.

**Table 3.2: Wind Dispatch in the 2016 RTP by weather zone**

Region	Coast	East	North Central	North	South	South Central	West	Far West
<b>Output</b>	N/A	N/A	1%	3%	10%	2%	3%	3%

Solar plants in the summer peak reliability cases will be dispatched at 70% of their rated capacity, based on analysis of vendor supplied solar curves similar to that described for wind generation. All solar generation in the minimum load reliability case will be modeled offline.

In economic analysis, an 8,760-hour profile will be used for hydro, wind, and solar units. Vendor supplied 8,760-hour profiles will be used for wind and solar, and historical dispatch will be used to create hydro 8,760-hour profiles.

### 3.2.3 Switchable Generation and Exceptions

Per ERCOT Protocol Section 16.5.4, upon receipt of a written notice, Switchable Generation Resource parameters used in the RTP cases will be updated to appropriately reflect the amount of switchable generation available to ERCOT for the study cases.

### 3.2.4 DC Ties

All of the existing DC ties (including those connecting to the *Comisión Federal de Electricidad* (CFE)) will be set based on the review of historical DC tie import/export information and any changes in the capacity of the DC ties.

The following table shows the DC tie dispatch for the reliability analysis in the summer and the min case.

**Table 3.2: DC tie dispatch in summer peak and MIN cases in 2016 RTP**

DC Tie	Summer peak dispatch	Min case dispatch
<b>Railroad</b>	300 MW export	0 MW
<b>South</b>	100 MW export	0 MW
<b>Laredo</b>	30 MW export	0 MW
<b>North</b>	220 MW import	0 MW
<b>East</b>	600 MW import	200 MW import

### 3.2.5 Reserve Requirements

The reliability analysis will be performed based on a reserve requirement of 2800 MW. In the economic analysis, generation dispatch will include 1,150 MW of responsive reserve requirements in addition to regulation requirements.

### 3.2.6 Fuel Price and Other Considerations

Wind and solar production cost will be \$0/MWh in the economic analysis. The natural gas price for the 2016 RTP will be based Energy Information Agency's (EIA) 2016 Annual Energy Outlook (AEO). While, no carbon tax will be considered in the 2016 RTP, the SO<sub>2</sub> emissions will be priced at \$10 per ton and NO<sub>x</sub> emissions are priced at \$100 per ton annually and \$200/ton seasonally.

ERCOT will also monitor the output of Dallas-Fort Worth area units that do not have Selective Catalytic Reduction (SCR) to ensure that they do not exceed their NO<sub>x</sub> emission restrictions.

### 3.3 Demand

The load in the RTP cases is organized and evaluated by weather zones. The RTP cases will be updated with the higher of either the aggregated weather zone load in the SSWG base cases or the ERCOT 90<sup>th</sup> percentile weather zone load forecast. The ERCOT 50<sup>th</sup> percentile load forecast, plus self-serve load, will be used for the economic portion of the analysis.

ERCOT will use the “scalable load” information from the SSWG cases to identify non-conforming loads to be used in the RTP cases. Non-conforming loads will be extracted from the weather zone load and will not vary on an hourly basis in the economic portion of the analysis. When loads are scaled in a weather zone, all loads, except those identified as non-conforming within the weather zone, will be scaled by the same percentage and the P/Q ratio at each load will be kept constant.

Load modeling changes (including shifting loads between substations) and corrections provided by TPs during the course of the analysis will be documented and included in the study cases.

### 3.4 Managing Imbalance in Cases

If there are not sufficient generation resources to meet the load, loss, and reserve requirements of the system, the following methods may be used.

- The base case may be split into multiple study regions. A study region may be a combination of multiple weather zones, such that the load inside the study region remains at the level determined as applicable for the RTP.
- The wind and solar generation output level for generators outside the study region may be increased to a higher value. However, this dispatch may not exceed the following maximums.
  - For a WGR, the maximum Dispatch level is the Seasonal Peak Average Wind Capacity as a Percent of Installed Capacity as defined in Protocol Section 3.2.6.2.2, Total Capacity Estimate.
  - For a PVGR, the maximum Dispatch level is the Solar Unit Capacity as defined in Protocol Section 3.2.6.2.2, Total Capacity Estimate.
- Load outside the study region, starting with the higher-of load levels, may be reduced until the load and reserve requirements are met.

## 4. The RTP Process and Method of Study

Figure 3.1 shows the RTP study process.



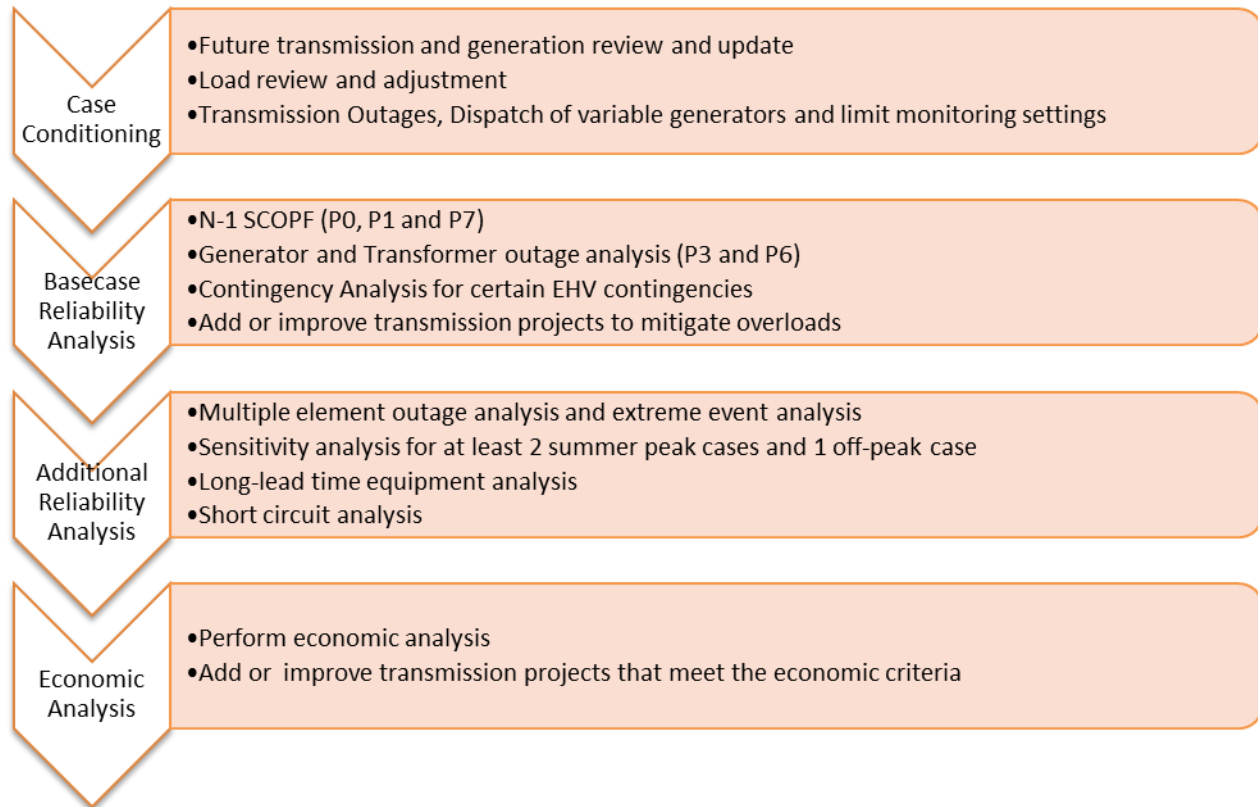


Figure 3.1: The Regional Transmission Plan Process

#### 4.1 Case Conditioning

A data request will be sent out to the TSPs to review and update information to be used in the 2016 RTP cases. This request will include, but will not be limited to, the following information.

- Review the list of FACTS devices which will not be used as voltage support devices.
- Review the list of Tier 1, 2, and 3 projects in Model-On-Demand (MOD) that have not completed RPG review.
- Review the list of future generation to be added or removed, as well as existing generation to be retired or mothballed from the 2016 RTP cases.
- List of generic equipment with long-lead time requirements in the TSP footprint. TPL-001-4 R2.1.5 defines the equipment to be studied in this analysis as having a lead time of one year or longer.

Following the response to the above data request, the SSWG start cases will be updated using the input assumptions discussed in this scope document. The summer peak and the minimum load cases will be prepared in this step. The reliability start cases created after case conditioning and resulting N-1 overloads will be shared with the stakeholders prior to reliability analysis.

#### 4.2 Reliability Analysis

PowerWorld SCOPF will be run to identify unresolvable constraints in the 2022 conditioned case. Corrective Action Plans will be studied in collaboration with TPs to find solutions to constraints under different contingency events per TPL-001-4 and ERCOT Planning Guide

Section 4. Loading on elements 60 kV and above will be monitored for P0, P1, P3, P6-2 (where the initial condition is the loss of a 345/138 kV transformer), and P7 events. It should be noted that manual system adjustment is allowed for P3 and P6 planning events. These system adjustments may include but are not limited to curtailment of DC tie flows, transmission configuration changes and re-dispatch of Generators if feasible. Loading on BES elements will be monitored for all other contingency events, including Extreme Events. Voltage violations for BES buses will be monitored for all contingency events, including Extreme Events. Corrective Action Plans will be developed per NERC and ERCOT reliability criteria.

Following a contingency where non-consequential load shed is an acceptable Corrective Action Plan, if the total load shed required to reduce the loading on elements below their 100% emergency rating is greater than 300 MW, ERCOT will investigate the need for a transmission improvement project. For an N-1-1 event, if the total load shed required after the first contingency, but prior to the second contingency, to prevent it from cascading is greater than 100 MW ERCOT will investigate the need for a transmission improvement project. When investigating the need for a transmission improvement project for either of these two conditions, ERCOT may decide to not recommend a project based on considering the likelihood and impact of the event occurrence and the cost and public impact of a transmission improvement project.

Once all reliability projects have been identified (i.e. no unresolvable constraints remain) projects will be reevaluated to determine if each project is needed. The above analysis will be repeated for other cases described in the scope section of this document.

#### 4.2.1 Cascading outage analysis

All contingency events where non-consequential load shed is allowed as a corrective action plan will be screened to detect potential cascade events for more detailed analysis. The screening to detect a cascade event will begin by simulation of events that may result in tripping of system elements as follows:

- Transmission facilities (100 kV and above) overloaded beyond their relay loadability limits (defined in section 3.1.4)
- Generator buses where voltage on the low or high side of the Generator Step Up (GSU) transformer are less than known or assumed minimum generator under-voltage trip limits
- Generator buses where voltage on the low or high side of the Generator Step Up (GSU) transformer exceed known or assumed maximum generator over-voltage trip limits
- Buses with known UVLS protection schemes where voltages go below the under-voltage triggering level

If an initiating event results in any one of the following conditions, the event will be selected as potential cascade event for more detailed analysis:

- The total load loss as a result of system cascading is greater than 6% of the total initial system load<sup>2</sup>

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<sup>2</sup> Based on Section 3.7 of the SOL Methodology for Operating and Planning Horizon

- The power flow does not converge - which may be a result of a potential voltage collapse condition, subject to additional confirmation

ERCOT may simplify the above tripping criteria and process further to more effectively identify cascading events.

The events identified as potential cascade conditions will be studied further in co-ordination with associated TPs. In the detailed analysis, an event will be defined as cascading if the total load loss as a result of system cascading is greater than 6% of the total initial system load. If power flow does not converge as a result of system cascading, ERCOT will conduct a voltage stability assessment. If the result of the assessment indicates system wide voltage stability issue, the event will also be defined as cascading. Appropriate corrective action plans will be developed in accordance with Table 1 of the NERC Reliability Standard TPL-001-4. Possible corrective measures, including potential mitigation plans, generator re-dispatch, and controlled load shed, or a transmission improvement project will be considered.

#### **4.2.2 LTSA Alignment**

Large projects (e.g., 345-kV) will be further evaluated using most recent Long-Term System Assessment (LTSA) cases to ensure project robustness and long-term effectiveness. Project concepts identified in the LTSA will be reviewed as an aid to identifying project recommendations that will provide long-term benefits either as part of a long-term plan for the development of the system or as an alternative to recommending a series of smaller incremental projects over time. Areas identified in the LTSA as requiring a significant number of system upgrades will be evaluated on a long-term basis if upgrade needs are identified in the area during the 2016 RTP analysis.

#### **4.2.3 Sensitivity Analysis**

NERC TPL-001-4 R2.1.4 requires transmission planners to study the impact of changes to basic assumptions via Sensitivity Analysis. For the 2016 RTP Summer Peak sensitivity cases, ERCOT will perform 'No-Wind-No-Hydro' sensitivity on base cases for years 2 and 5. The South/South Central and Coast/East study region will be studied by turning all Wind and Hydro Generation Resources in the South/South Central weather zones out of service in the corresponding base cases. Similarly, the North/North Central and West/Far West study region will be studied by turning all Wind and Hydro Generation Resources West/Far West/North/North Central zones out of service in the corresponding base cases. Similar 'No-Wind-No-Hydro' sensitivity will be performed on years 3 and 6, however, this analysis will be limited to only P0, P1 and P7 planning events.

For the 2016 RTP Off-Peak sensitivity case, ERCOT will perform 'High-Wind Low-Load' sensitivity on base case for year 3. ERCOT will review the historical data of coastal and non-coastal wind resources during the high wind conditions to determine the maximum dispatch level in all wind generation modeled in the minimum load case. The load level at each weather zone will also be determined by reviewing the historical data during the high wind conditions.

The sensitivity analysis will be performed with all reliability solutions identified from the base case analysis to evaluate the effectiveness and robustness of the base case solutions under the

stressed system conditions. For any new constraints found in the sensitivity analysis, ERCOT will identify potential corrective action plans which will be shared with stakeholders as a reference to guide analysis of future system conditions.

#### **4.2.4 Short Circuit Analysis**

ERCOT will perform a short circuit analysis based on three-phase to ground fault and single-line to ground (SLG) fault. The study will be conducted using the 2019 and 2021 summer peak reliability base cases with all projects identified in the 2016 RTP. All generators modeled in each case will be turned online except those determined in the 2016 RTP Scope (e.g. mothballed units or units with the notice of Suspension of Operations of a Generator Resource).

Faults will be tested at all BES buses (typically, 100 kV and above) and all point of interconnection (POI) buses associated with generators. For sequence impedance data required for the study, ERCOT will use the following assumptions and methodology.

- For transmission facilities in the RTP cases, positive sequence impedance will be based on the impedances in the RTP cases. Negative sequence impedance is identical to positive sequence impedance. For zero sequence impedance, the database built for ERCOT System Protection Working Group (SPWG) will be used. If zero sequence impedance data of a transmission line is not available, ERCOT may use a default value (typically, three times greater than positive sequence impedance). If zero sequence impedance of a transformer is not available in the SPWG database, ERCOT may use the data of similar transformer in the system or contact TSPs to obtain sequence impedances.
- For generators in the RTP cases, the database of SPWG will be used to obtain sequence impedance data. If the data of a generator is not available in the SPWG database, ERCOT may use either Resource Asset Registration Form (RARF) database or data of a similar generator in the system.
- Load level will be consistent with the RTP cases.

ERCOT will use PTI PSS/E software to conduct the short circuit study using the classical flat start (e.g. FLAT,CL in PSS/E) method for the conditioning of the pre-fault conditions.

The results of short circuit analysis will mainly include the magnitude of short circuit current and source impedance associated with each fault. Within 30 calendar days from ERCOT email notification sent to the NERG Registered TOs and GOs, TSPs and GOs complete the review of study results and provide a list of over-dutied circuit breaker and corrective action plans.

#### **4.3 Economic Analysis**

The final summer peak reliability cases for 2019 and 2022 are uploaded into UPLAN as the starting economic cases. The UPLAN database will be updated using input assumptions relevant to economic analysis discussed in this document. After completing a UPLAN run, the congestion in each case will be organized by its rank and shadow price. Economic projects will be studied in collaboration with the TPs for the highest congested elements. Once all economic projects have

been identified, a project-back-out analysis is performed to determine if each project is still economically justified when tested in combination with other economic projects. The final set of economic projects will be tested in the summer peak reliability case to ensure that the reliability case is still N-1 secure.

## 5. Deliverables

In the course of the analysis, the following information, at a minimum, will be shared with the stakeholders via MIS.

- Initial conditioned start cases and a list of binding constraints.
- Intermediate cases and binding constraints, and proposed reliability and economic projects as they become available.
- Steady-State AC base cases at yearly peak including all reliability and economic projects for each case.
  - Summer peak load cases for years 2018, 2019, 2021, and 2022
  - Minimum load case for the year 2019.
  - Each sensitivity case each for years 2018 and 2021 summer peak and 2019 minimum load.
- A final congestion table will be posted for each study year in the economic analysis.