



**Report on Existing and
Potential Electric System
Constraints and Needs**

December 2023

Key Takeaways

ERCOT implemented the Generator Revenue Reduction (GRR) test for economic project evaluation in 2023 and retained E3 to develop the **congestion cost savings test** economic criteria as required by SB1281. ERCOT is currently working on the Revision Requests to incorporate the recommended congestion cost savings test. ERCOT is also working on defining the resiliency criteria and performing the biennial **Grid Reliability Assessment** to assess the grid's reliability in **extreme weather scenarios**.

The ERCOT grid continues to evolve with increased thermal generation **retirement**, rapid growth in transmission-connected **wind**, **solar** and **energy storage** development, and distributed generation. ERCOT is critically evaluating planning processes and pursuing changes necessary to meet challenges associated with the **evolving grid**.

ERCOT sponsored a suite of Revision Requests to establish the registration, interconnection, and operational requirements for **Large Loads** to address their unique challenges and ensure their reliable interconnection to the grid. The Revision Requests are based on the experience with the interim Large Load interconnection process, analysis of operational events, and discussions at the Large Flexible Load Task Force (LTLTF).

Recent legislative changes require significant changes to identify regions with insufficient transmission capacity to serve existing and forecasted Load and develop a **reliability plan** for such regions including the **Permian Basin region**.



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About ERCOT Transmission Planning

ERCOT supervises and exercises comprehensive independent authority over the planning of transmission projects for the ERCOT system as outlined in the Public Utility Regulatory Act (PURA) and Public Utility Commission of Texas (PUCT) Substantive Rules. PUCT Substantive Rules further require ERCOT to evaluate and make a recommendation to the PUCT as to the need for any transmission facility over which ERCOT has comprehensive transmission planning authority.

ERCOT examines the need for proposed transmission projects based on ERCOT planning criteria and North American Electric Reliability Corporation (NERC) Reliability Standards. Once a project need has been identified, ERCOT evaluates project alternatives based on cost-effectiveness, long-term system needs, and other factors.

The ERCOT Protocols and Planning Guide describe the practices and procedures through which ERCOT meets its requirements related to system planning under PURA, PUCT Substantive Rules, and NERC Reliability Standards.

ERCOT annually performs a planning assessment of the transmission system that is primarily based on two sets of studies:

- The Regional Transmission Plan (RTP) addresses region-wide reliability and economic transmission needs and includes the recommendation of specific planned improvements to meet those needs for the upcoming six years. The public version of the 2023 RTP report is posted on the ERCOT website at: <https://www.ercot.com/gridinfo/planning>.
- Stability studies are performed to assess the angular stability, voltage stability, and frequency response of the ERCOT system. Due to the security-related sensitive nature of the information contained in these study reports, they are not published on the ERCOT website.

ERCOT also conducts the biennial Long-Term System Assessment (LTSA), which is completed in even-numbered years. The LTSA uses scenario-analysis techniques to assess the potential needs of the ERCOT system up to 15 years into the future. The role of the LTSA is to guide near-term planning decisions by providing a longer-term view of system reliability and economic needs. The 2022 LTSA report is posted on the ERCOT website at: <https://www.ercot.com/gridinfo/planning>.

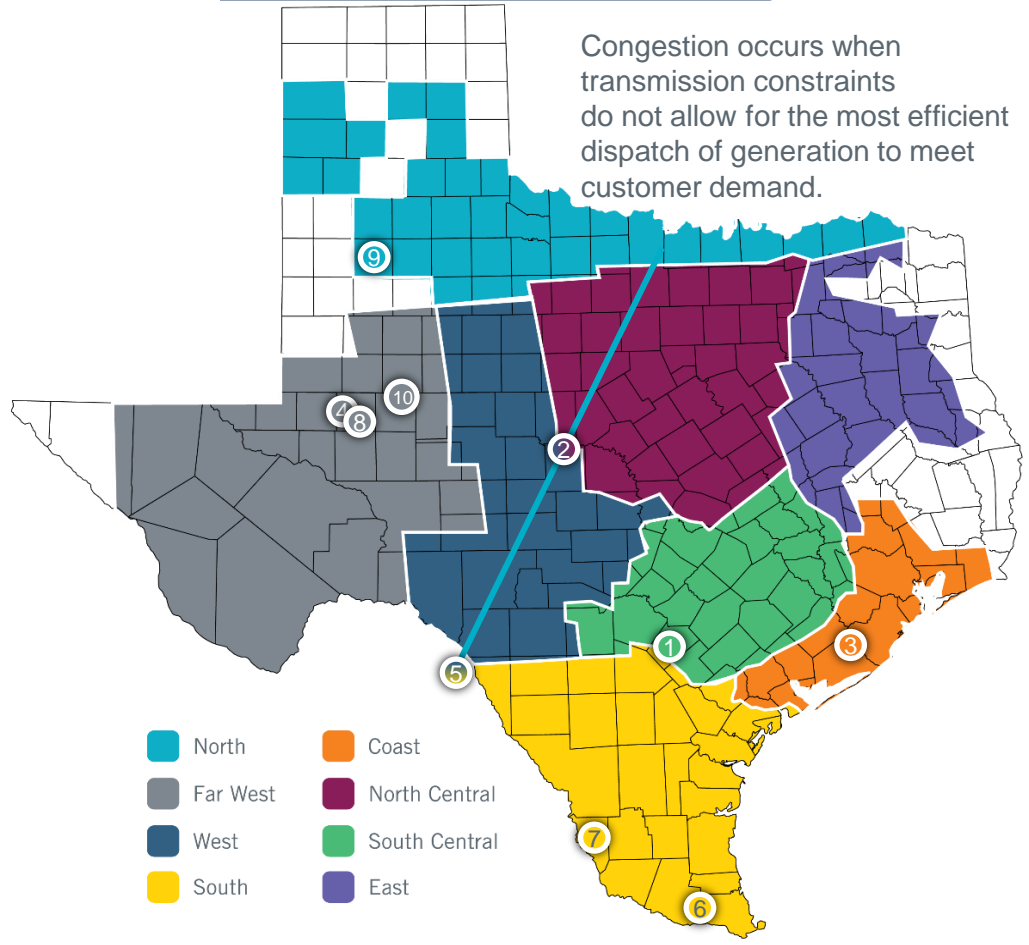
Map	Constraint	Congestion Rent*	Outage Related?
1	Pawnee Switching Station - Calaveras 345-kV Line	\$191M	
2	West Texas Export Interface	\$136M	
3	South Texas Project - WA Parish 345-kV Line	\$127M	Forced outage
4	Midessa South Switch 345/138-kV Transformer	\$89M	Planned outage
5	Hamilton Road - Maverick 138-kV Line	\$82M	Planned outage
6	Burns Sub - Rio Hondo 138-kV Line	\$69M	Planned outage
7	North Edinburg - Lobo Interface	\$64M	
8	Consavvy Switch - Cottonfield Sub 138-kV Line	\$62M	
9	Mackenzie Substation - Northeast Substation 115-kV Line	\$55M	Planned outage
10	Morgan Creek SES - Forest Creek and Sand Bluff Wind Farms 138-kV Line	\$55M	Planned outage

*Congestion rent indicates areas of the system where economic transmission projects may be beneficial. It is not an indication of whether a project to reduce specific congestion would or would not meet the ERCOT economic planning criteria.

Recent Constraints

Top 10 constraints on the ERCOT system

Oct. 2022 to Sept. 2023, based on real-time data



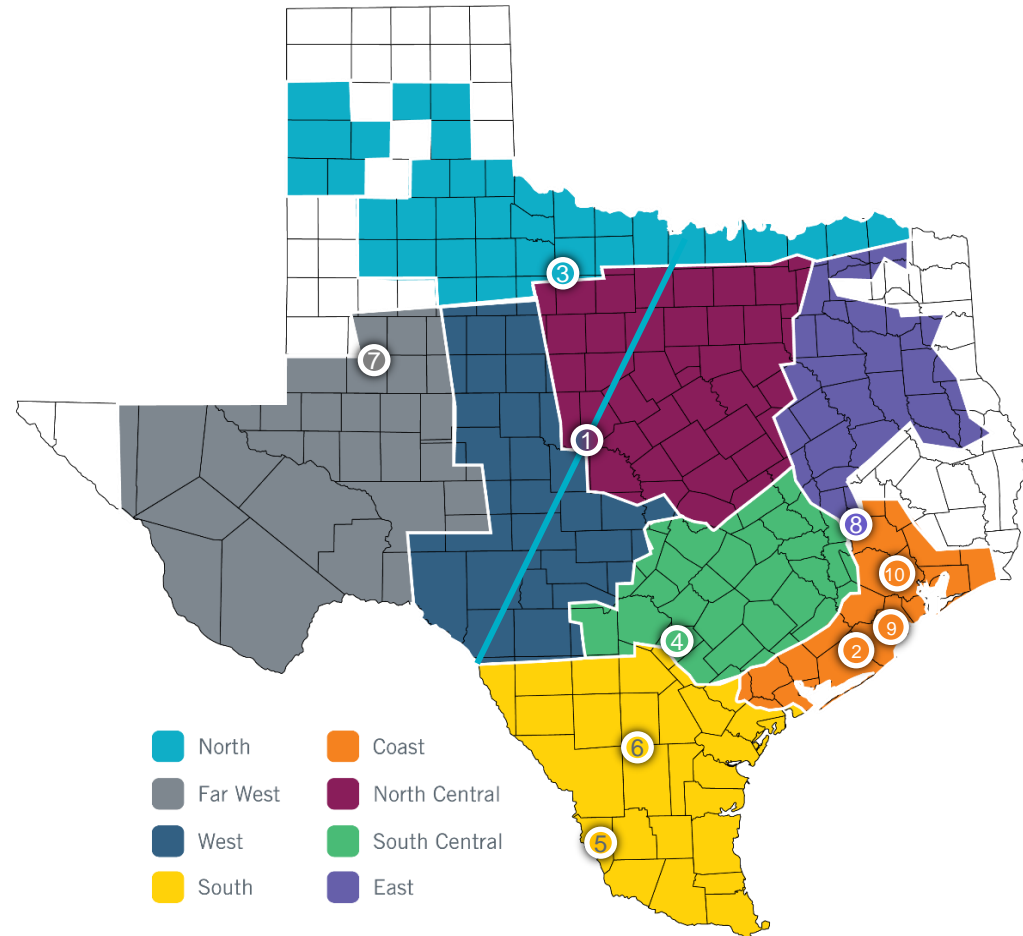
Map	Constraint	Congestion Rent*	
		2025	2028
1	West Texas Export Interface	\$149M	\$66M
2	South Texas Project - WA Parish 345-kV Line	\$53M	\$85M
3	Panhandle Interface	\$56M	\$56M
4	Pawnee Switching Station - Calaveras 345-kV Line	\$45M	\$26M
5	North Edinburg - Lobo Interface	\$52M	NA
6	Lon Hill - Whitepoint 345-kV Line	\$27M	\$17M
7	Farmland - Wett Long Draw 345-kV Line	\$14M	\$29M
8	North - Houston Interface	\$29M	\$7M
9	South Texas Project - Jones Creek 345-kV Line	\$13M	\$17M
10	Grant - Plaza 138-kV Line	\$23M	\$6M

*Congestion rent indicates areas of the system where economic transmission projects may be beneficial. It is not an indication of whether a project to reduce specific congestion would or would not meet the ERCOT economic planning criteria. Planned transmission outages were not included in the analysis.

Projected Constraints

Top 10 projected constraints on the ERCOT system for 2025 and 2028

Based on economic analysis conducted for the 2023 RTP



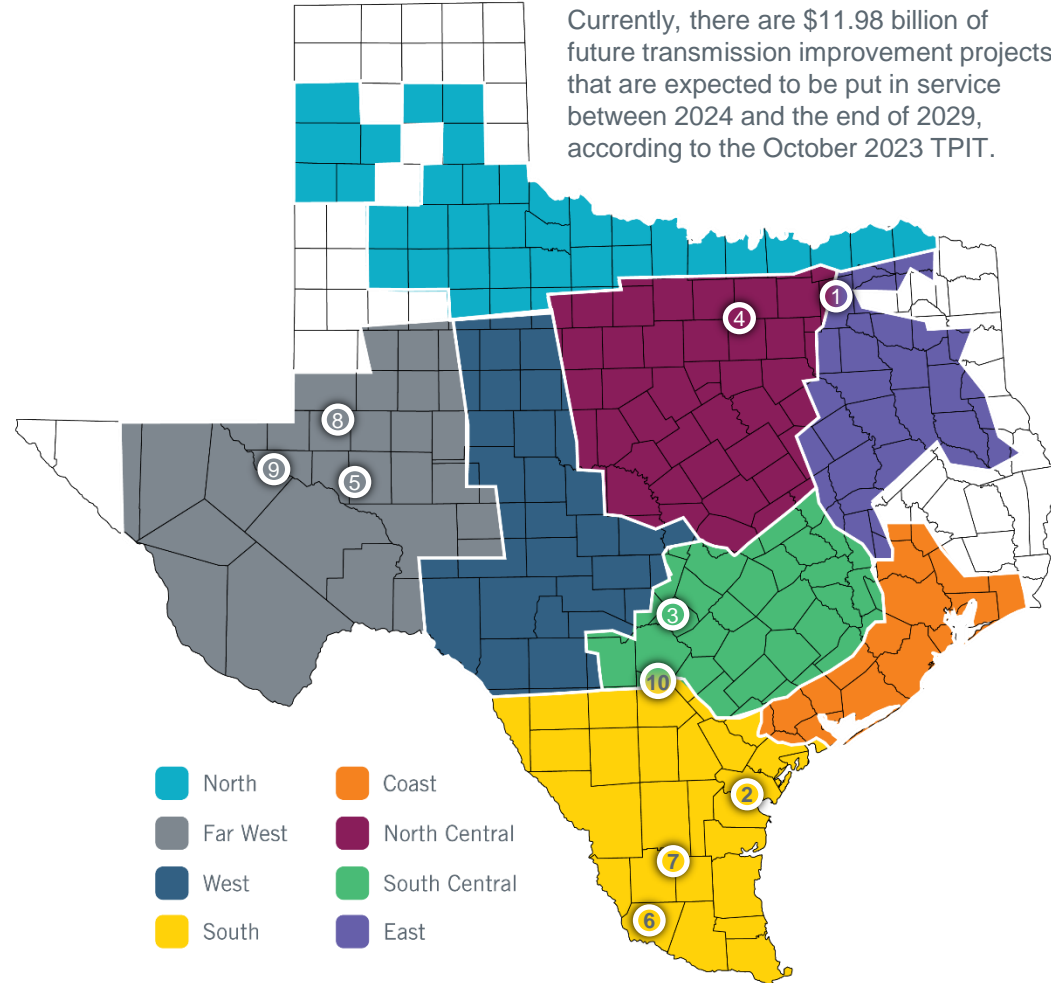
Planned Improvements

Top 10 significant improvements on the ERCOT system

Projects planned for completion within the next six years

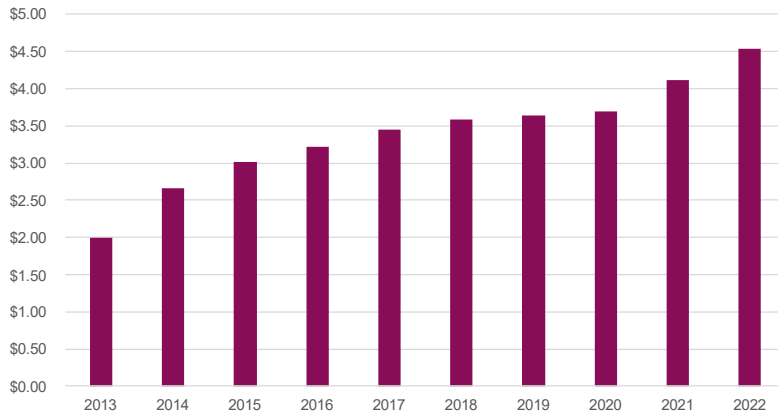
Map	Transmission Improvement	In-Service
1	Royse - Commerce 69-kV Line Conversion to 138 kV	2024
2	Corpus Christi North Shore Project	2024
3	Hays Energy - Kendall Corridor Transmission Line Rehabilitation Projects	2024, 2025
4	Roanoke Area Upgrades Project	2025
5	Bearkat - North McCamey - Sand Lake 345-kV Transmission Line Addition Project	2026
6	Second 345-kV Circuit from San Miguel - Palmito	2024
6	Loop La Palma into the North Edinburg - Palmito 345-kV Double-Circuit Line	2026
7	Lower Rio Grande Valley System Enhancement Project	2027
8	Synchronous Condenser Additions	2027
9	Silverleaf and Cowpen 345/138-kV Stations Project	2027
10	San Antonio South Reliability Project	2027

Currently, there are \$11.98 billion of future transmission improvement projects that are expected to be put in service between 2024 and the end of 2029, according to the October 2023 TPIT.



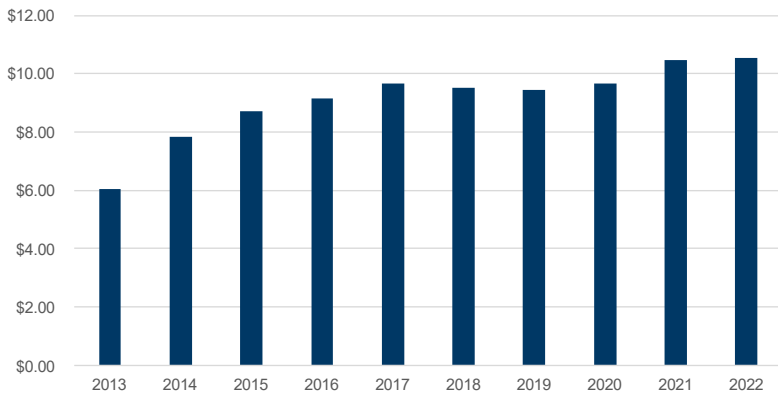
Transmission Cost Trend

ERCOT Annual Transmission Cost of Service
(\$ Billion)

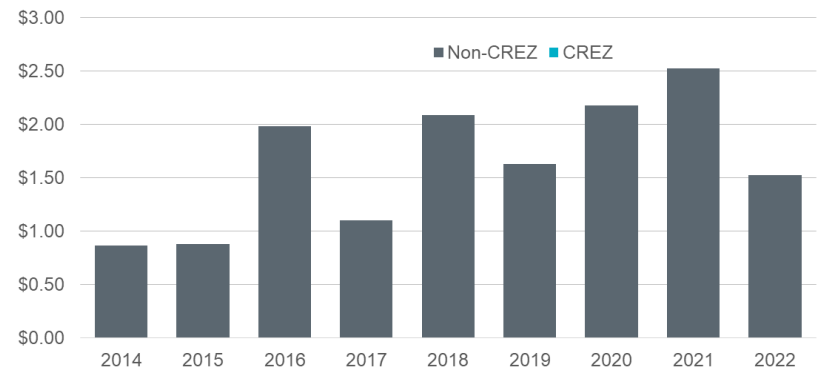


For the ERCOT region, the total Transmission Cost of Service¹ (TCOS), which reflects investment in transmission improvements, has increased in the past several years along with TCOS per MWh.²

ERCOT Annual Transmission Cost of Service
per Total MWh Energy Use
(\$)

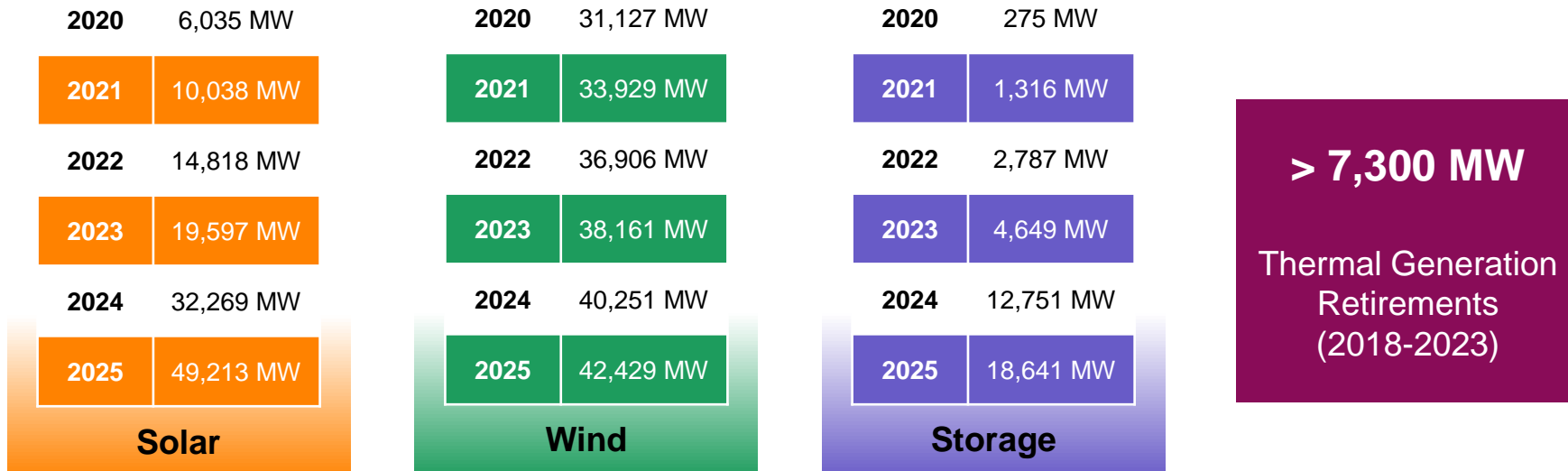


ERCOT Transmission Improvements by In-Service Year
(\$ Billion)



1. TCOS values are based on [ERCOT's Yearly Wholesale Transmission Service Charges](#) filed with Public Utility Commission of Texas
2. Total MWh Energy Use values are based on [ERCOT's Demand and Energy Report](#) published in ERCOT Market Information System (MIS)

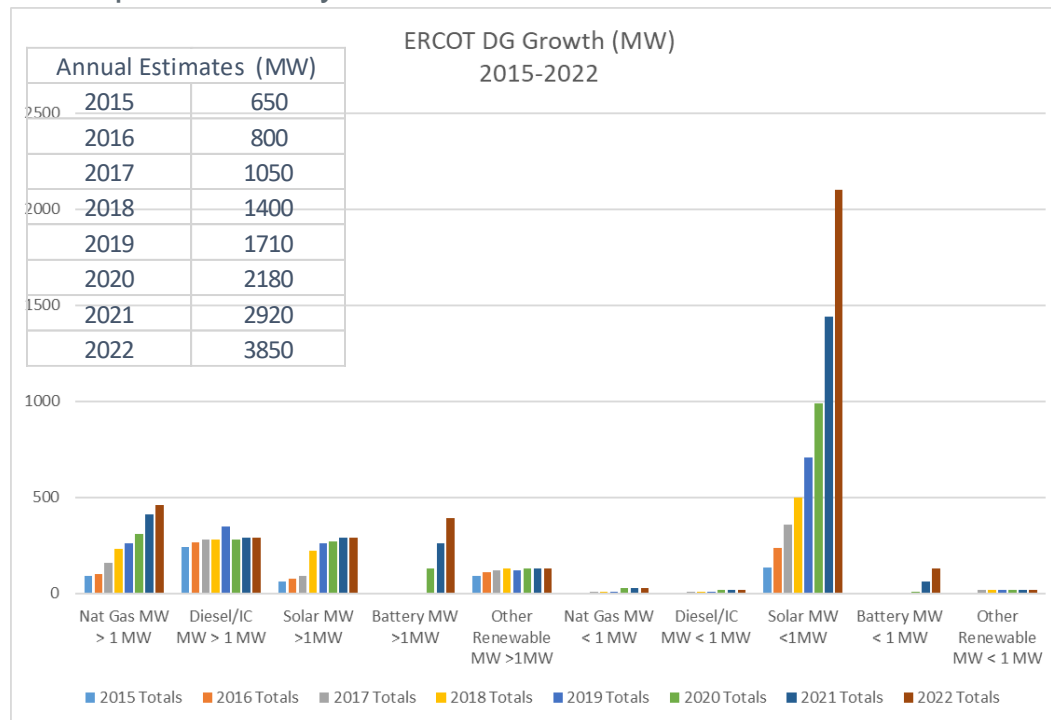
The Changing Grid – Generation



- ERCOT continues to experience a rapid shift in the type and location of generation available to serve demand.
- Robust growth of inverter-based resources (IBR) has continued. More than 62 GW of transmission-connected wind, solar, and battery energy storage capacity is expected to be installed by the end of 2023. Total IBR capacity has the potential to exceed 110 GW in 2025.
- Over 7,300 MW of coal and natural gas generation has retired since 2018.
- The change in generation mix has also resulted in increased distance between generation sites and demand centers. Retired coal and gas generation were closer to large cities, whereas the most abundant wind and solar resources tend to be in more distant locations.

The Changing Grid – Distributed Generation (DG)

- ERCOT continues to improve DG integration processes under increasing DG penetration.
 - Distribution Generation Resource (DGR) and Settlement Only Distribution Generator (SODG) modeling processes are largely finalized, and these facilities are explicitly included in the Steady State Working Group (SSWG) and Dynamics Working Group (DWG) cases.
 - Processes for collecting from Transmission Distribution Service Providers (TDSPs) and explicitly modeling aggregate unregistered DG (e.g., residential rooftop solar) are planned to be implemented in 2024.
 - Updated performance requirements for unregistered DG (IEEE 1547-2018) are expected to be implemented by PUC in 2024.

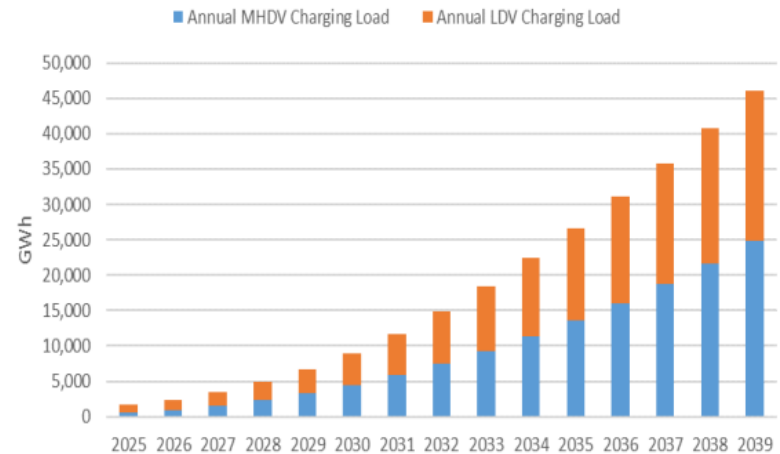
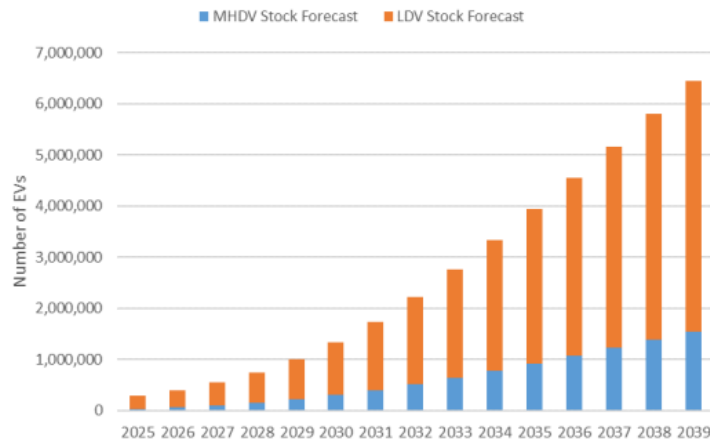
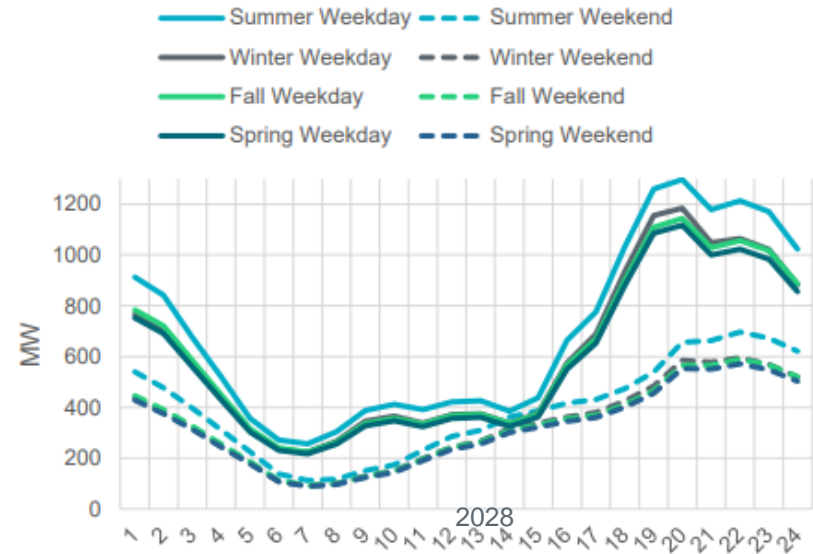


Projects are in progress at NERC to incorporate Distributed Energy Resources (DER) into relevant reliability standards (MOD-032, TPL-001, FAC-002) and SARs being proposed for others (MOD-031, PRC-006, EOP-004, EOP-005).

ERCOT participates in the NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG), which has published several Reliability Guidelines, White Papers, and Technical Reference documents to facilitate transmission planning, modeling, and analysis under increasing DER penetrations.

The Changing Grid – Electrical Vehicles (EV)

- The EV load impacts are incorporated into the ERCOT 2023 Regional Transmission Plan (RTP) and 2024 Long-Term System Assessment (LTSA) using the methodology developed by the Brattle Group.
- ERCOT plans to incorporate the EV load impacts in the 2024 Long-Term Load Forecast.
- ERCOT conducted training for the ERCOT TDSPs on the tool from the Brattle Group to facilitate collaboration on the anticipated growth of Medium Heavy Duty Vehicles (MHDV) and Light Duty Vehicles (LDV) in the ERCOT region.

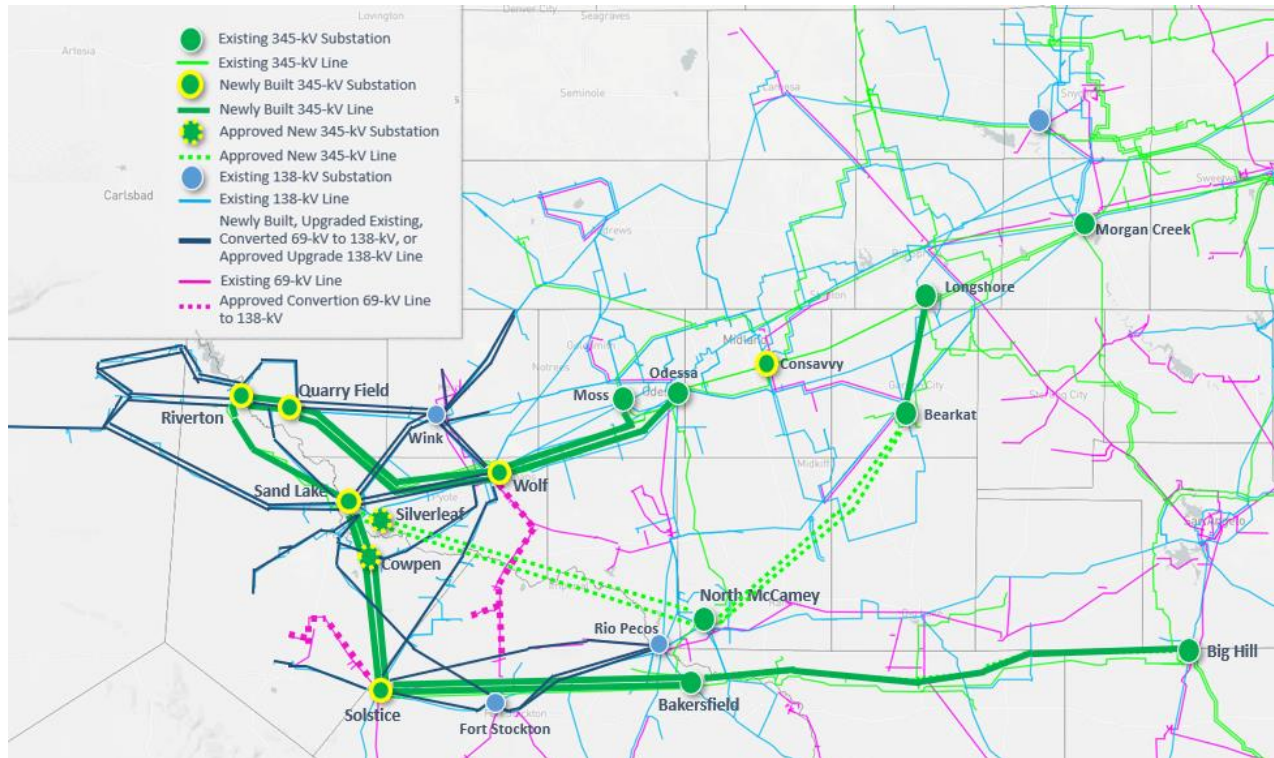


The Changing Grid – Demand in Permian Basin

- S&P Global [Permian Basin 2022 study](#) indicated that electrification in the Permian Basin is expected to increase compared with the 2019 study. The study projected the load demand in the Permian Basin to be 17.2 GW (ERCOT: 11.9 GW; SPP: 5.3 GW) by 2032 and reach 17.6 GW by 2040.
- ERCOT is working with the TDSPs serving the Permian Basin to develop transmission plans to interconnect the forecasted load in the area as required by House Bill 5066 (88th Legislature).
- In addition to the rapid growth in the oil and gas demand in the Permian Basin, significant amounts of Large Load are seeking interconnection in the area as well. In the 2023 RTP, the 2029 Far West weather zone load forecast is close to 15 GW. ERCOT performed independent reviews of multiple RPG projects and approved the following key projects in the past three years to reliably interconnect the forecasted load in the area:
 - Bakersfield – Big Hill 345-kV Second Circuit Addition Project (Stage 1)
 - Flat Iron – Barr Ranch – Pegasus South 138-kV Line Project
 - Consavvy 345/138-kV Switch Project
 - Lenorah Area 345/138-kV Project
 - Tesoro 345/138-kV Switch Project
 - Bearkat – North McCamey – Sand Lake 345-kV Transmission Line Addition Project (Stage 2)
 - Peck – Driver 138-kV Line Project
 - Stanton Loop South Dynamic Reactive Power Project
 - Silverleaf and Cowpen 345/138-kV Stations Project
 - West Texas Synchronous Condensers Project

The Changing Grid – Permian Basin Development

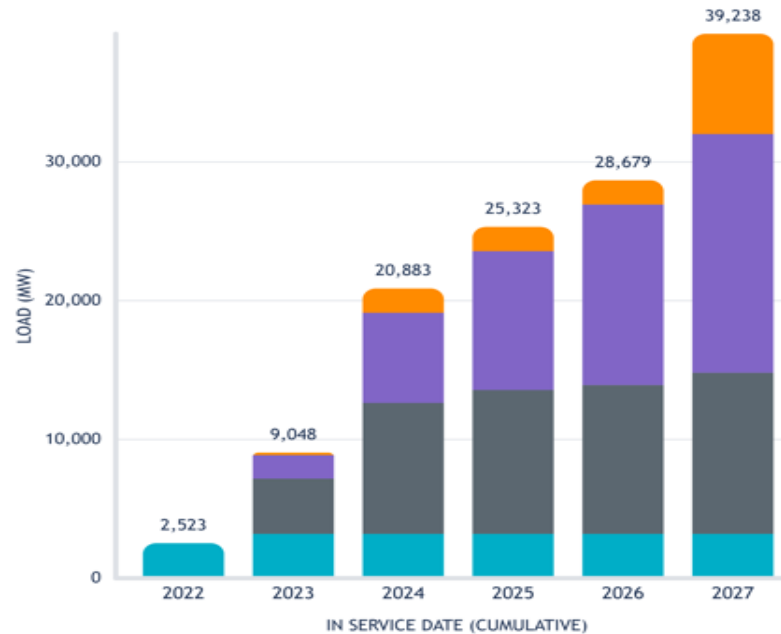
- Since 2014, there have been \$4.3 billion of approved projects in the Permian Basin area and \$1.2 billion of projects currently under review
 - 630 miles of 345-kV lines have been built
 - 330 miles of 345-kV lines have been approved for new build and over 430 miles of 345-kV lines are currently under ERCOT review
 - 2,500 miles of 138-kV upgrades are either already built, upgraded or converted along with approved future upgrades



The Changing Grid – Interconnection of Large Loads

- ERCOT continues to track nearly 40 GW of large load interconnection requests.
- 3,188 MW approved to energize since January 2022.
- Another 9,446 MW with proposed energization dates on or before December 31, 2024 have had planning studies reviewed and approved.
- The interim large load interconnection process, developed in 2022 to reliably integrate these load additions in a timely manner, continues to be used pending the approval of large load Revision Requests.
- ERCOT has proposed NPRR1191, PGRR111, and NOGRR256 to formalize the interconnection process for large loads and establish operational standards to maintain reliability.
- ERCOT continues to work with stakeholders to address the challenges associated with the unprecedented volume and characteristics of the current large load interconnection request.

Project Status	2022	2023	2024	2025	2026	2027
No Studies Submitted	-	180	1,750	1,750	1,750	7,219.5
Under ERCOT Review	-	1,695	6,499	10,013	13,013	17,213
Planning Studies Approved	-	3,985	9,446	10,372	10,728	11,617.5
Approved to Energize	2,523	3,188	3,188	3,188	3,188	3,188
Total (MW)	2,523	9,048	20,883	25,323	28,679	39,238



- Approved to Energize** – Projects that have received Approval to Energize from ERCOT Operations. NOTE: not all MWs in this category have been observed to be operational.
- Planning Studies Approved** – Projects that have received ERCOT approval of required interconnection studies. Any MWs that were not approved are reclassified as No Studies Submitted.
- Under ERCOT Review** – Projects that have studies under review by ERCOT.
- No Studies Submitted** – Projects that are tracked by ERCOT but that have not yet provided sufficient information for ERCOT to begin review. Additionally, MWs that were not approved by ERCOT after review of planning studies are included in this category until a path to interconnect these MWs is identified, or the customer cancels the interconnection request.



Implementation of New Economic Planning Criteria, PUC Substantive Rule 25.101 Amendments

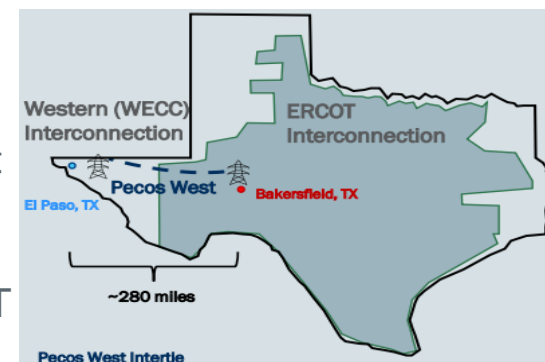
- Congestion cost savings test development for economic project evaluation
 - ERCOT implemented the Generator Revenue Reduction (GRR) test on an interim basis for economic project evaluation in 2023.
 - ERCOT retained Energy and Environmental Economic (E3) as an independent consultant for the development of the congestion cost savings test. E3 recommended the [System-Wide Gross Load Cost Test](#) as the best option for the rules and structure of the ERCOT market.
 - ERCOT in consultation with the PUC staff is working on submitting the needed Revision Requests to implement this new congestion cost savings test.
- Resiliency
 - ERCOT's first biennial Grid Reliability and Resiliency Assessment is anticipated to be completed by December 2024.
 - ERCOT is working on submitting Revision Requests to define the resiliency criteria.
 - Resiliency has been considered in ERCOT's independent review of Regional Planning Group project submissions.

Minimum Deliverability Criteria

- ERCOT established minimum deliverability criteria for reliability project evaluation in 2022.
 - The minimum deliverability criteria are intended to ensure that dispatchable Resources are not “bottled” from a reliability perspective. Establishing minimum deliverability criteria for dispatchable Resources will facilitate the identification of transmission needs to maintain reliability under system conditions with the potential for resource shortages.
 - ERCOT Board approved the [minimum deliverability criteria thresholds](#) in June 2022.
- The minimum deliverability criteria were implemented in the 2023 Regional Transmission Plan (RTP).
 - Additional system deficiencies were found under the minimum deliverability criteria.
 - Corrective Action Plans (CAPs) were developed to address the issues identified under the minimum deliverability criteria.

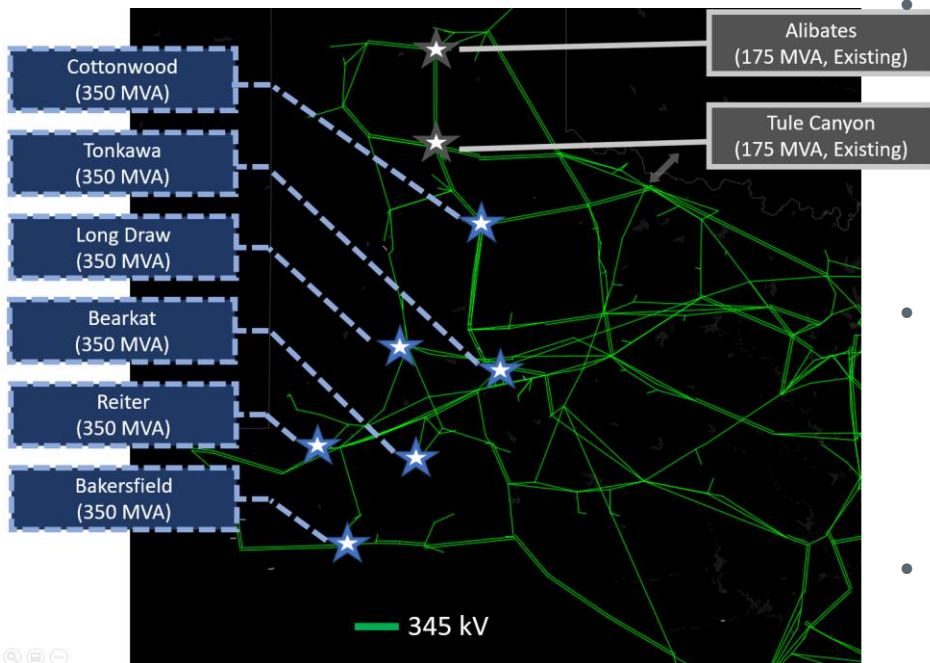
High Voltage Direct Current (HVDC) Transmission

- ERCOT currently has four asynchronous ties to other grids: two connections to the Eastern Interconnection with a total capacity of 820 MW, and two ties to the Mexican system with a total capacity of 400 MW. These ties allow ERCOT and the connecting grids to exchange power in emergencies and for entities to trade power between grids on a commercial basis.
- [Southern Spirit Transmission](#) has proposed building a 3,000 MW merchant tie between ERCOT and the Eastern Interconnection via a 320-mile HVDC line. ERCOT has materially completed its work on the directives assigned to ERCOT by the PUC in Project No. 46304. These include Directive 6 (determination regarding any needed transmission upgrades) and Directive 8 (determination regarding Primary Frequency Response and Voltage Support). This was formerly the 2,000 MW Southern Cross Transmission Project. Pattern Energy has requested ERCOT conduct a transmission interconnection study of the revised Southern Spirit Transmission project.
- In 2022, Grid United Texas submitted an application in PUC Docket No. 53758 seeking PUC approval of the [Pecos West Intertie](#), which is a proposed 280-mile, 1,500-MW HVDC transmission line with potential for expansion up to 3,000 MW, that would connect ERCOT to the Western Interconnection at El Paso by 2029.



Ongoing Efforts for Addressing Challenges Due to Inverter-Based Resources (IBRs)

- Significant prevalence of IBRs coupled with the absence of conventional synchronous Generation Resources can weaken the system and increase the likelihood of potential instability issues (e.g., Odessa events in 2021 and 2022).
- Several ongoing initiatives include IBR model review and updates (e.g., event analysis, approved PGRR085) and efforts to enhance the IBR model review process (e.g., PGRR109).



- As part of these ongoing initiatives, ERCOT has conducted assessments to identify necessary transmission reinforcements aimed at addressing operational challenges, fortifying system reliability, and reducing the likelihood of unexpected real-time events.
- As a result of [the assessment](#), ERCOT recommended six synchronous condensers with flywheels at the six 345 kV substations; Cottonwood, Tonkawa, Long Draw, Bearkat, Reiter, and Bakersfield.
- This synchronous condenser project received the endorsement of the ERCOT Board in December 2023 and is projected to be in-service in 2027.

Recent PUC Rule Changes and Initiatives

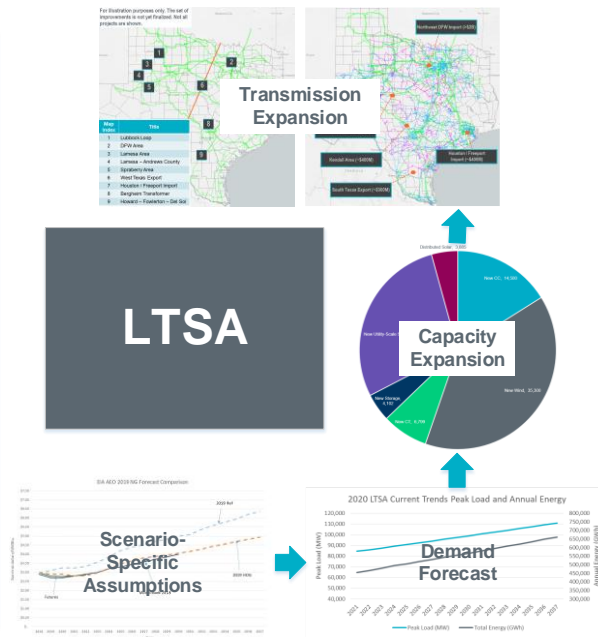
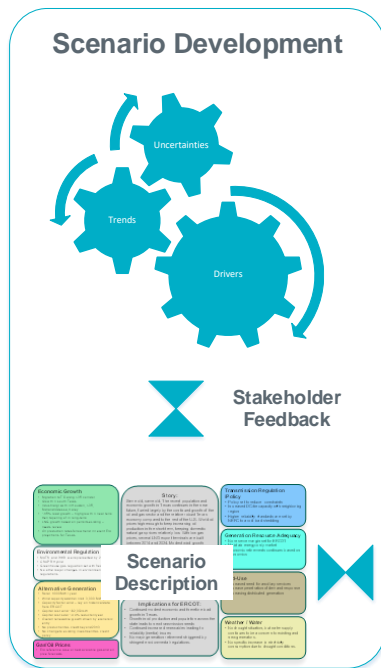
- In 2023, the Legislature enacted HB 5066 that, in part, required PUC to direct ERCOT to identify regions with insufficient transmission capacity to serve existing and forecasted Load and develop a reliability plan for such regions. ERCOT also must develop a reliability plan for the Permian Basin region, specifically. The PUC opened Project No. 55718 and interested parties are invited to file any studies or other reference materials relating to the reliability plan that will be developed for the Permian Basin region. In mid-December 2023, the PUC set a timeline and ordered ERCOT to develop this Permian reliability plan. Additionally, ERCOT is engaged in pending changes to the ERCOT Protocols and Planning Guide to reflect revisions the Legislature made (HB 5066) to Load seeking interconnection that the PUC considers when determining whether need exists in a certificate of convenience and necessity (CCN) amendment proceeding.
- PUC also adopted an updated version of Substantive Rule 25.55, regarding weather emergency preparedness, adding new summer weather preparedness requirements, and revising winter weather preparedness requirements.
- PUC has been working with ERCOT and its stakeholders to advance reforms to the Capacity, Demand and Reserves (CDR) and Monthly Outlook for Resource Adequacy (MORA) reports to provide a more comprehensive risk assessment of Generation Resource reliability under extreme weather scenarios and with the increased penetration of wind, solar, and Energy Storage Resources.
- ERCOT has been performing modeling studies to support legislative directive for PUC to develop a reliability standard for the ERCOT Region. Other studies being conducted to support reliability standard development include estimation of Value of Lost Load (VOLL) and Cost of New Entry (CONE).

Key Findings from the 2023 Transmission Planning Assessment

- With the retirement of conventional generation continuing, and the new and planned Generation Resources being mostly solar and battery energy storage, these rapid changes to the system will continue to bring additional challenges to the grid.
- The change in resource mix resulted in increased reliance on renewable generation to meet the higher system demand, which reduced the flexibility of resolving thermal overloads using generation redispatch and curtailment.
- Since renewable generation is typically located farther from the load centers, the 2023 RTP analysis found various major transmission pathways from the renewable-rich regions to the load centers needed existing system upgrades and/or additional new transmission pathways.
 - New 345-kV import paths from South Texas to Central Texas
 - Approximately 350 circuit miles of 345-kV line upgrade along the import path to Venus Switch towards the Dallas/Fort Worth metroplex from Lake Creek SES and Jewett
 - 345-kV upgrades and additions along the southwest Houston corridor
- Expected future generation will likely impact these needs and will be further evaluated in the 2024 RTP.

2024 Long-Term System Assessment (LTSA)

- ERCOT’s 2024 LTSA will analyze potential system needs through 2039.
- ERCOT analyzes different future scenarios in its long-term planning process to account for the inherent uncertainty of planning the transmission system beyond six years.



- 2024 LTSA ([Current Trends scenario](#)) will assume that between 2024 and 2039, the accumulated amount of retirement and added capacity will be 27,416 MW* and 71,671 MW**, respectively, and the total capacity in 2039 is 209,838 MW with more than 60% capacity from IBRs.
- Scenario development is currently underway.
- Transmission needs will be evaluated.

*10,987 MW of Coal, 10,766 MW of Gas Steam, 4,352 MW of CC and 1,206 MW of CT & IC

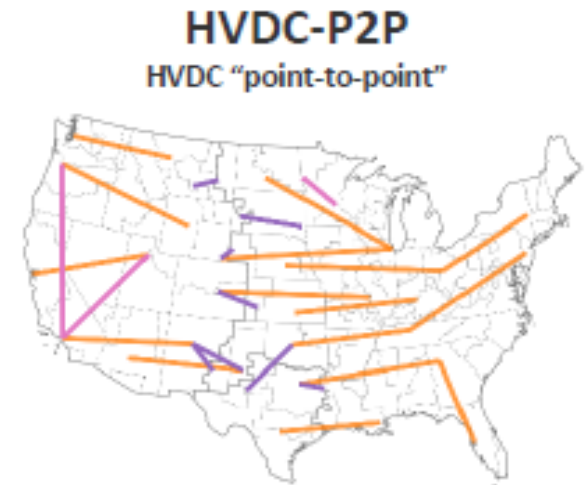
**17,100 MW of Wind, 22,217 MW of Solar, 14,079 MW of CC, 9,032 MW of Battery and 9,243 MW of CT & IC

National Transmission Planning Study

- Directed and executed by DOE, NREL, and PNNL (Jan 2022 to Dec 2023)
- Identify interregional and national strategies to accelerate cost-effective decarbonization while maintaining system reliability
- Inform regional and interregional transmission planning processes to discuss desired grid outcomes and address barriers to achieving them
- Results will help inform future DOE funding for transmission infrastructure support
- ERCOT has been monitoring the development and progress of this study

What the study will do

- Link several long-term and short-term power system models to test a number of transmission buildout scenarios
- Inform existing planning processes
- Test transmission options that lie outside current planning
- Provide a wide range of economic, reliability, and resilience indicators for each transmission scenario



Illustrative of one potential scenario. Scenarios will vary.

Contacts and Links

Contacts and Information

For general communications and queries, please submit an information request to: <https://www.ercot.com/about/contact/inforequest>

Media

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Links

ERCOT website: <https://www.ercot.com/>

Market Participants can access additional planning information on the Market Information System (MIS), which can be accessed through the “MIS LOG IN” link located at the top of the ERCOT website. A digital certificate is required to access to this area. Information available on the MIS includes a variety of data, procedures, reports, and maps for both operations and planning purposes, including the following planning-related information:

- Generation project interconnection information
- Regional Planning Group information
- Steady-state base cases