TRANSMISSION CONGESTION FOR 2024

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SECTION 1

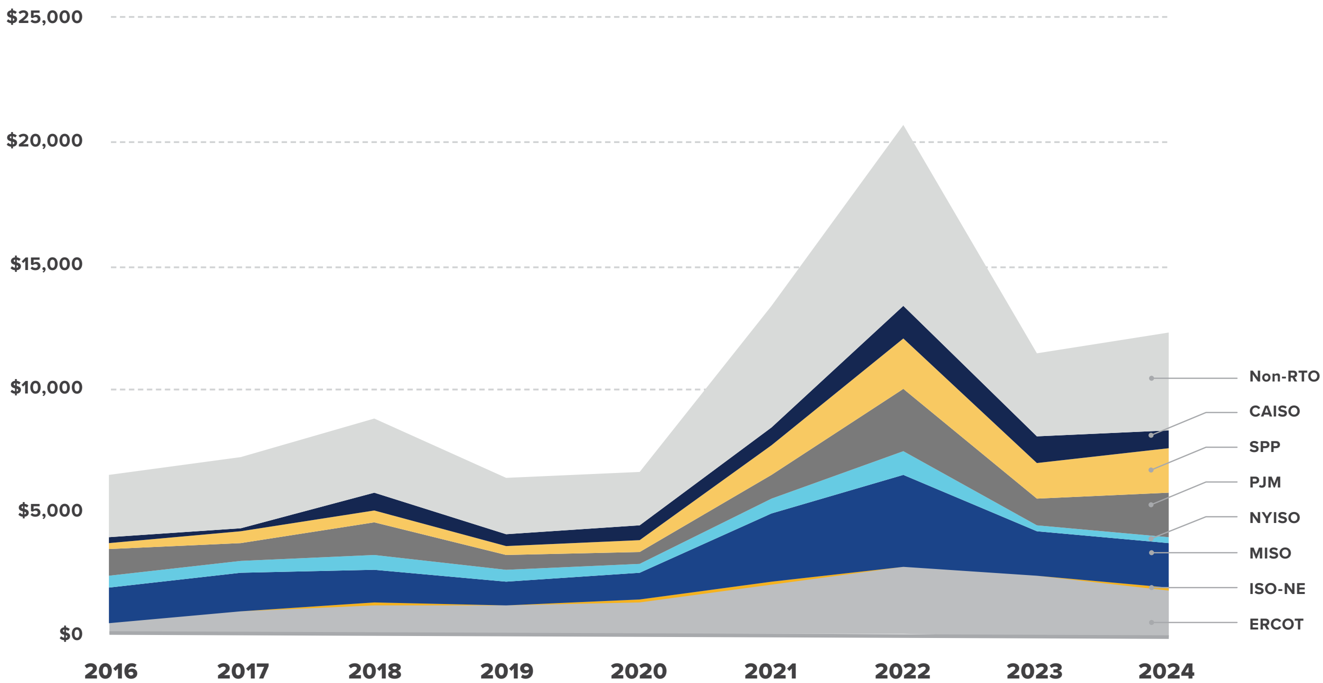
KEY FINDINGS

For four years, nationwide grid congestion costs have stayed well above $10 billion per year, surpassing $12 billion in 2024.[1] Before 2021, grid congestion costs had not exceeded $6-8 billion per year, but it is now apparent that $10-20 billion per year is not a spike or an outlier—rather, congestion at this scale is the new normal. These elevated costs demonstrate how inadequate transmission capacity raises power prices for customers, driven fundamentally by limited transmission expansion and exacerbated by rising electricity demand and extreme weather. These costs persist even as technologies like battery storage have stepped up to relieve congestion in certain regions. The grid's inability to freely move power remains a structural barrier that imposes substantial costs on consumers and impedes the reliability that comes with access to a more diverse generation portfolio.

1 While congestion costs are generally only transparent within regions with an organized wholesale market, meaning those with a regional transmission organization (RTO) or independent system operator (ISO), to estimate a national congestion cost figure that includes non-RTO/ISO regions, this report scales the known RTO/ISO congestion costs in Table B1 in the Appendix according to the peak load of the same regions when compared to total U.S. load.

FIGURE 1. Estimated transmission congestion costs for the contiguous U.S., scaled based on costs reported across all RTOs/ISOs, 2016-2024 ($M)

Estimated total transmission congestion costs in 2024 across the contiguous United States are slightly higher than those in 2023.[2]



Source: Market monitor reports; see appendix

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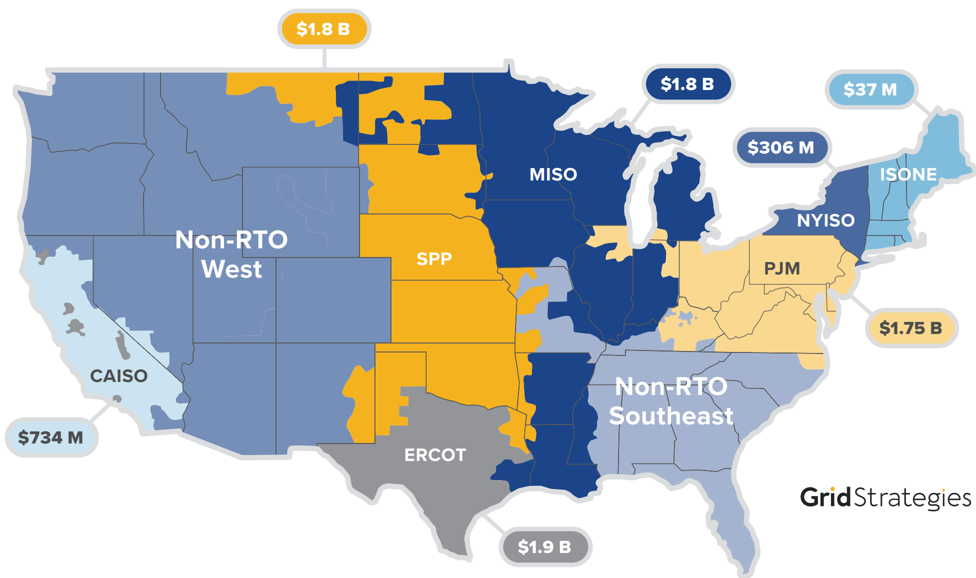
FIGURE 2. Transmission congestion costs by RTO/ISO, as reported by the internal and independent market monitors, 2024



2 Note that electricity congestion costs spiked in 2022, largely due to surging natural gas prices caused by the onset of the war in Ukraine.

About transmission congestion

When the grid cannot deliver the lowest-cost generation to load, more expensive generation is dispatched instead, raising prices. This cost is reported as "transmission congestion" in organized wholesale markets administered by RTOs/ISOs. While in some cases these costs can be hedged through financial instruments, they provide a measure of how inadequate transmission capacity raises power prices for customers. Grid congestion costs reveal where the system is constrained and can signal the need to build additional transmission infrastructure.

Note that the Federal Energy Regulatory Commission (FERC) requires transmission planners to conduct a robust evaluation of potential transmission projects, using multiple measures of the benefits of new transmission, before a transmission planner can move a project forward. One of those metrics is the value of new transmission for relieving costly congestion. This report focuses on congestion rents, which represent the difference in market prices between two locations multiplied by the amount of power flowing between them. Congestion rents are the most common—and often the only—metric reported by RTO/ISO market monitors for quantifying and comparing congestion across the grid. See additional discussion on congestion and the report methodology in the Appendix.

Non-RTO/ISO regions do not have transparent congestion data, but the factors that drive congestion in these regions are similar to RTO/ISO regions. If anything, non-RTO/ISO regions may experience even higher relative costs driven by grid constraints because non-RTO regions are not able to benefit from the operational scale, greater resource and load diversity, and regional transmission planning in the RTO/ISO regions. FERC has recognized this issue and proposed new data reporting requirements for non-RTO/ISO regions to increase transparency as part of its consideration of new rules around transmission line ratings.[3]

How expanding transmission capacity reduces congestion

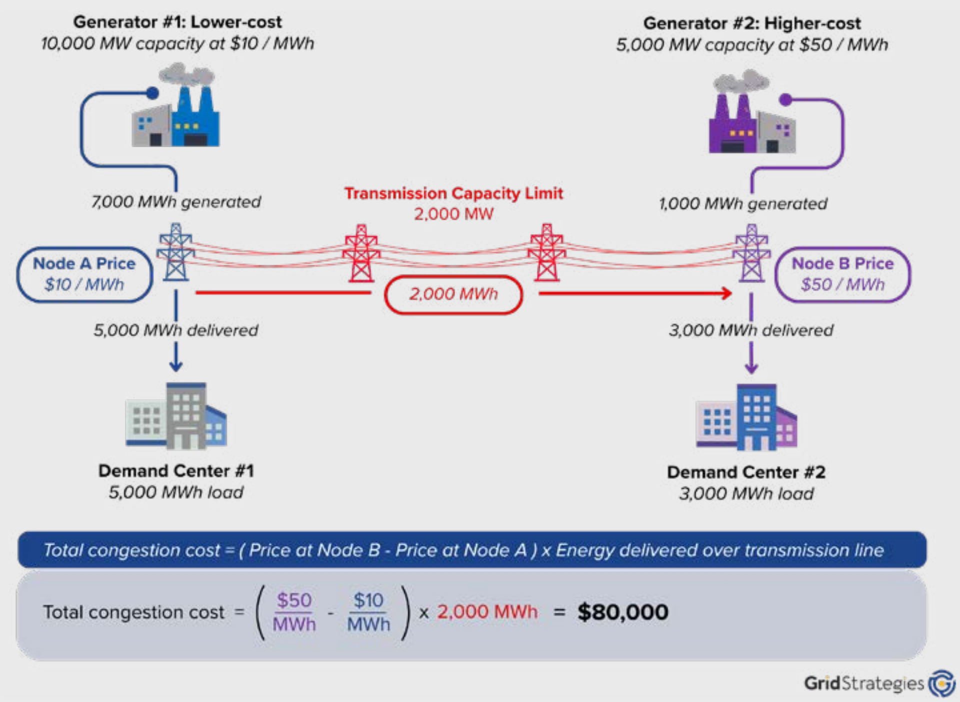
Congestion occurs when lower-cost generation cannot be fully delivered to load because transmission lines are operating at their physical or safety limits. When this happens, the line is said to be a binding constraint, and the system operator must dispatch higher-cost generation located within the constrained area to meet demand. This is called dispatching out of economic merit order, which is the order of pricing offers by all generators, from lowest to highest. The result is that the price of

3 *Implementation of Dynamic Line Ratings*, 187 FERC ¶ 61,201 (2024) (issuing an advance notice of proposed rulemaking (ANOPR) proposing potential reforms to enhance data reporting practices related to congestion in non-RTO/ISO regions, among other proposed reforms).

energy in the constrained area(s) is higher than in the unconstrained area. This idea is illustrated in the two figures below.

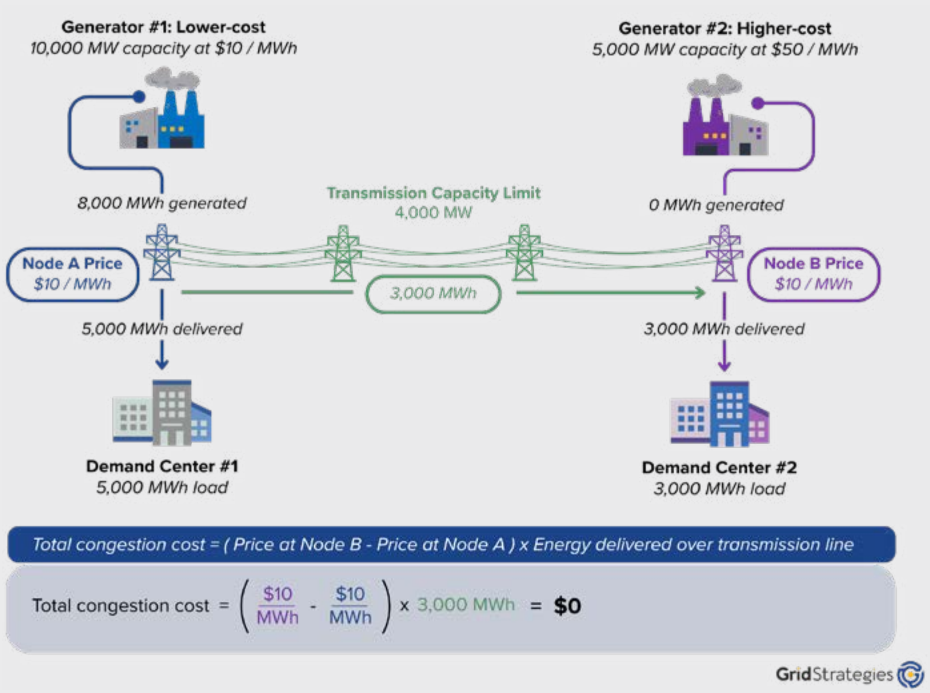
Assume an isolated, simplified system in Figure 3. The transmission line in red has a capacity limit of 2,000 MW. Generator #1 is the cheaper generator, producing energy at $10 / MWh, and can meet the entire load at Demand Center #1, resulting in a nodal price at Node A of $10 /MWh. However, Generator #1 cannot fully serve Demand Center #2, since the transmission line connecting the two can only carry 2,000 MW. The remaining load from Demand Center #2 must be met by Generator #2, which produces energy at $50 / MWh. As a result, the price of energy at Node B rises to $50 / MWh, even though part of this energy is imported from the lower-cost Generator #1. The congestion cost equals the price difference between the two nodes multiplied by the flow on the constrained line, which in this case is $80,000.

FIGURE 3. Limited transmission capacity constrains dispatch of lower-cost generation



Assume an isolated, simplified system in Figure 4. The transmission line in red has now doubled in capacity to 4,000 MW. This additional capacity allows Generator #1 to supply all energy needed to meet total system load from both demand centers. Because the line is no longer a binding constraint, the system can dispatch generation in merit order, and Generator #2 does not dispatch energy. The price of energy at both nodes is therefore $10 / MWh. With no price difference between nodes, the congestion cost falls to zero.

FIGURE 4. Additional transmission capacity allows for increased dispatch of lower-cost generation



Not measured: interregional congestion

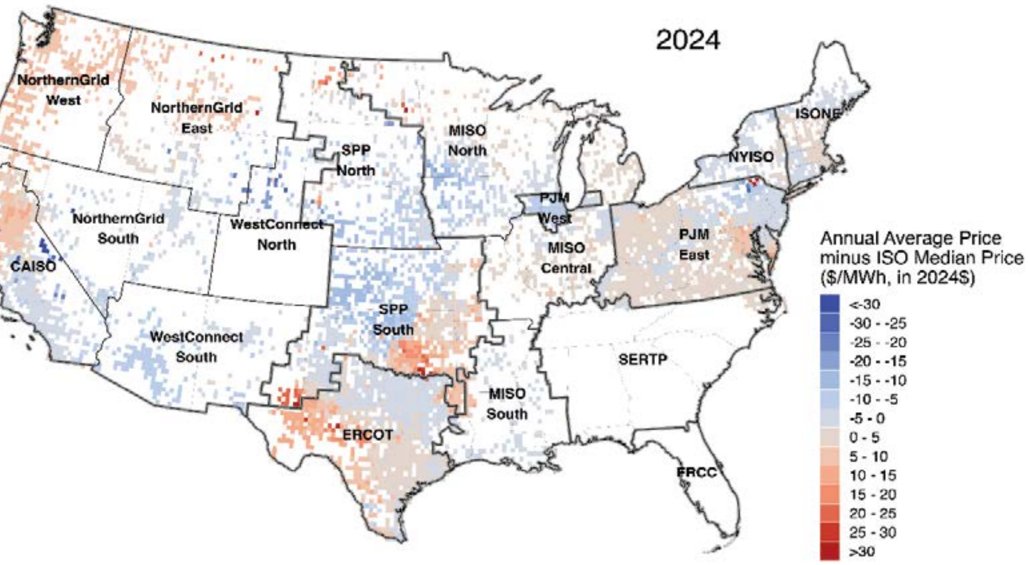
A study by the Lawrence Berkeley National Laboratory (LBNL) demonstrates that there is significant congestion cost between regions. Several interregional links have potential costs close to or above $20/MWh, or equivalently, $175 million per GW of transmission capacity per year.[4] These interregional costs are based on the difference in wholesale market energy prices between locations in two different regions, a measure akin to congestion cost within a regional market. Both measures reflect the additional cost to consumers of the inability to access lower-cost energy located farther away. The market monitor reports that this report collects and extrapolates for Figure 1 do not include reporting on price differences between regions. Therefore, this report's finding of $12 billion in annual congestion in 2024 is likely a very conservative value, since it does not include the cost of interregional transmission congestion. Additional transparency of data on interregional congestion would assist with a more precise estimate, similar to data in non-RTO/ISO regions.

4 Lawrence Berkeley National Laboratory, *Transmission Value in 2023* (Jul. 2024), at 1, https://emp.lbl.gov/publications/transmission-value-2023-market-data.

FIGURE 5. Average wholesale price of electricity relative to market median price, 2024 ($/MWh)[5]

The average wholesale price of electricity varies widely across the country. LBNL found that several interregional links—such as between ERCOT and the Southwest—have potential values close to or above $175 million per GW of transmission capacity per year.

Source: Lawrence Berkeley National Laboratory



Not measured: cost of transmission capacity needed for new generation

In many areas, it would be more efficient to plan and build both generation and transmission together. However, new generation is often developed independently, and the transmission needed to connect it is added later as a network upgrade to the existing system. Because these transmission upgrades are evaluated on a project-by-project basis rather than through a proactive, multi-value planning process that optimizes generation and transmission, their costs are often higher and less efficient than if transmission had been planned holistically.

Network upgrade costs are assigned to generators but are not captured in the congestion costs analyzed in this report. As a result, this report provides a conservative estimate of the total impacts of limited transmission capacity by excluding both the cost of these inefficient upgrades and the congestion impacts associated with transmission constraints.

5 Lawrence Berkeley National Laboratory, *Electric transmission value and its drivers in United States power markets* (Aug. 2025), at 5, https://emp.lbl.gov/publications/electric-transmission-value-and-0.

SECTION 2

DRIVERS OF CONGESTION PATTERNS

Limited transmission capacity

Transmission congestion stems from grid constraints that prevent electricity from flowing freely from where it is generated to where it is needed. In the Southwest Power Pool (SPP), the Market Monitoring Unit identifies several core causes of congestion, including limited transfer capability across the grid, as "historically, high-voltage connections between the west and east have been limited."[6]

SPP's transmission expansion in recent years has not kept pace with the scale and geographic distribution of generation development in the region, especially in the western portion of SPP's footprint. As a result, the southeastern area of the system has emerged as a persistent congestion hotspot. The SPP Market Monitoring Unit notes that record generation curtailments in 2024 were partly due to this regional imbalance between generation and the system's limited ability to efficiently move it to load centers.[7] SPP's transmission planning process has identified these as persistent limits that increase consumer costs and has approved record new transmission portfolios, in part, to address these constraints.

ISO New England (ISO-NE) has similarly found that transmission constraints in New England are limiting the grid's ability to deliver low-cost power to higher priced areas, especially from areas with new generation development. ISO-NE has significant generation resource opportunity in Maine but currently limited transmission capacity to deliver it into the rest of New England. This does not show up as congestion because the plants are not operating yet. The ISO-NE Internal Market Monitor notes that several high-capacity generators have come online in southwestern Connecticut in recent years, but constraints on the aging lower-voltage (115 kV) transmission system in that area can restrict the export of this power to the broader ISO-NE system. These constraints are especially acute when nearby transmission lines are out of service for maintenance or upgrades, making it difficult to fully utilize new generation capacity.[8]

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6 SPP Market Monitoring Unit, *State of the Market 2024* (May 2025), at 156, https://www.spp.org/documents/73953/2024_annual_state_of_the_market_report.pdf (hereinafter "SPP State of the Market Report").

7 *Id.* at 47.

8 ISO New England Internal Market Monitor, *2024 Annual Markets Report* (May 2025), at 196, https://www.iso-ne.com/static-assets/documents/100023/2024-annual-markets-report.pdf.

Extreme weather

Extreme weather remains a major cause of transmission congestion, stressing the grid and leading to high, localized price spikes. In the Midcontinent Independent System Operator (MISO), a significant share of total congestion costs in 2024 occurred during Winter Storm Heather in January, as cold temperatures and elevated heating demand coincided with generation and transmission outages, leading to a highly constrained system.[9]

MISO facilitated significant power exports and wheeling flows between PJM Interconnection (PJM), Ontario, and SPP throughout the storm. These large power flows created substantial congestion across the MISO system. At the same time, fuel supply issues and generator outages caused additional operational stress. Multiple natural gas pipelines imposed restrictions to manage competing demands for heating and electricity, leading to sharp volatility in natural gas prices. As natural gas prices spiked, electric system operators were forced to dispatch alternative, less efficient, and more expensive generation, further compounding congestion and cost pressures across the MISO grid.

As weather events become increasingly severe, more frequent, and unpredictable, departing from historical data and trends that previously guided system planning and operations, grid operators will face growing challenges with managing congestion as well as ensuring reliability during both winter and summer peak conditions that may coincide with these events.

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9 Potomac Economics, *2024 State of the Market Report for the MISO Electricity Markets* (Jun. 2025), at 50, https://cdn.misoenergy.org/2024%20State%20of%20the%20Market%20Report704622.pdf (hereinafter "MISO State of the Market Report").

Planned transmission and generation outages

Planned transmission outages significantly contributed to congestion across several regions in 2024. In New York City, congestion costs more than tripled from $15.7 million in 2023 to $52 million in 2024, largely driven by outages on key transmission lines.[10] On Long Island, congestion levels remained elevated for the second year in a row, with one of the two 345 kV transmission lines connecting upstate New York to Long Island out of service for approximately 200 days in each of 2023 and 2024.[11]

MISO similarly experienced significant congestion due to planned transmission outages. MISO currently evaluates planned generation and transmission outages based on reliability criteria, without considering potential economic impacts, such as congestion costs. As a result, the MISO Independent Market Monitor (IMM) has reported several instances where simultaneous generation and/or transmission outages in a given area have led to severe congestion—overlapping generation and transmission outages in 2024 drove $540 million in real-time congestion costs.[12] This accounted for 29% of real-time congestion costs in 2024.[13] According to the MISO IMM, this number may understate the effects of planned generation outages on congestion, as it does not include the effects of transmission outages that are scheduled at the same time. Accordingly, the IMM has urged MISO to pursue broader tariff authority, as approved by FERC to coordinate planned generation and transmission outages.[14]

ISO-NE's tariff provides authority to assess economic impacts when evaluating outage requests, which has proven an effective tool for ISO-NE to avoid unnecessary and costly congestion. However, most other RTOs/ISOs in the Eastern Interconnection, like MISO, lack this authority in their tariffs.

10 Potomac Economics, *2024 State of the Markets Report for the New York ISO Markets* (May 2025), at ii, https://www.potomaceconomics.com/wp-content/uploads/2025/05/NYISO-2024-SOM-Full-Report_5-14-2025-final.pdf (hereinafter, "NYISO State of the Market Report").

11 *Id.* at 63.

12 MISO State of the Market Report at 112.

13 *Id.* at X.

14 *Id.* at 72.

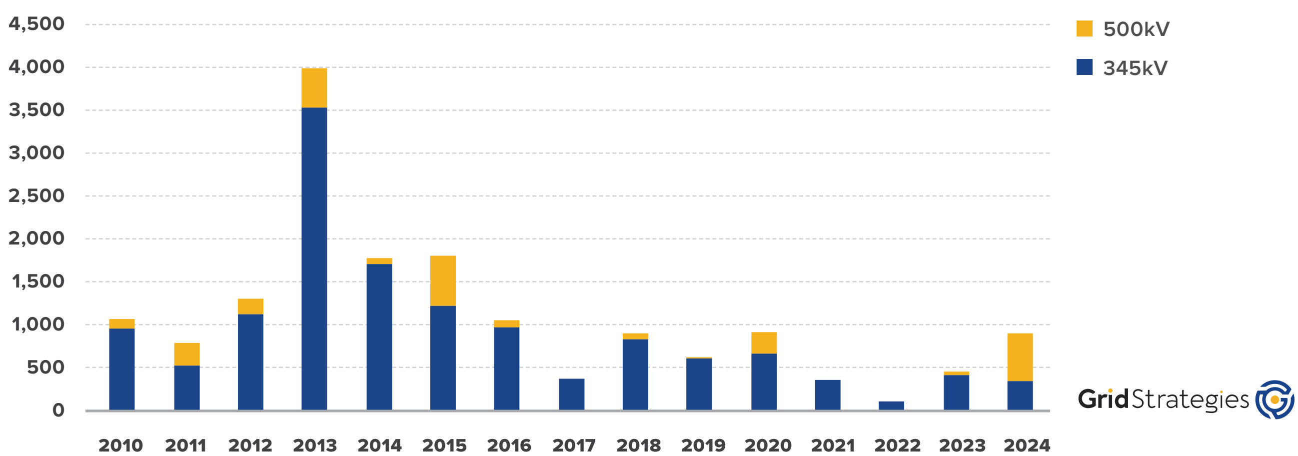
SECTION 3

MITIGATING CONGESTION

Expanding transmission capacity

Congestion is usually a symptom of insufficient transmission capacity. The U.S. Department of Energy's 2024 National Transmission Planning Study found that substantial expansion of both regional and interregional transmission is needed to help address congestion across nearly the entire country.[15] In 2024, only 888 miles of new high-voltage transmission were completed in the United States, far short of the approximately 5,000 miles each year needed to serve growing electricity demand.[16]

FIGURE 6. Miles of new 345 kV+ transmission lines built over the last 15 years, 2010-2024[17]



15 U.S. Department of Energy, *National Transmission Planning Study* (Oct. 2024), https://www.energy.gov/sites/default/files/2024-10/NationalTransmissionPlanningStudy-Chapter2.pdf.

16 Grid Strategies LLC, *Fewer New Miles: Strategic Industries Held Back by Slow Pace of Transmission* (Jul. 2025), https://cleanenergygrid.org/portfolio/report-fewer-new-miles-strategic-industries-held-back-by-slow-pace-of-transmission/.

17 *Id.* at 16.

The United States must invest in well-planned, high-voltage transmission, planned through proactive, scenario-based, multi-value processes to unlock the greatest savings to consumers. A leading example of this type of process is MISO's Long Range Transmission Planning (LRTP) process. The first portfolio planned through this process—Tranche 1—includes 18 transmission projects in the Midwest subregion, totaling more than 2,000 miles and $10.3 billion. These projects will deliver between $23.2-52.2 billion in net benefits over the next 20-40 years, according to MISO's estimates.[18] These benefits are likely under-stated because transmission planners often underestimate transmission benefits in initial planning studies, and ex-post assessments of consumer savings are often 20–40% higher than initially projected.[19]

Evidence shows that regional transmission planning can result in lower costs through new transmission that addresses specific, persistent patterns of congestion. New York has seen a 6% reduction in congestion since 2023, primarily due to the completion of the AC Transmission Segment A and Segment B projects, which increased transfer capability across the frequently congested Central-East and UPNY-SENY interfaces.[20] New York ISO (NYISO) planned these projects through its Public Policy Transmission Planning Process in coordination with the New York State Public Service Commission to meet a transmission need identified in 2015.[21] In SPP, 43 transmission projects were completed during 2024 that support the efficient transmission of energy across the footprint and provide relief for highly congested areas identified in SPP's regional transmission plan. One such project, Roundup-to-Kummer Ridge, was energized in December 2024 and will help reduce congestion in northwest North Dakota.[22]

Battery storage

Batteries are particularly well-suited to help resolve congestion, as they can reduce power flow over congested paths. The Electric Reliability Council of Texas (ERCOT) experienced a sharp reduction in congestion in 2024—down 20% from 2023 levels. According to the ERCOT IMM, this can be attributed to improved congestion management, particularly through the effective use of energy storage resources (i.e., batteries) in the real-time energy market. In ERCOT, 5 GW of battery capacity entered commercial operation in 2024,[23] bringing the total installed battery capacity on the ERCOT system up to 10 GW in total.[24]

Batteries can help resolve grid congestion by absorbing and storing electricity that cannot flow past a transmission bottleneck, delivering it later when the grid has more capacity to accommodate it. In this way, batteries allow low-cost power that would otherwise be curtailed to reach consumers, improving reliability and reducing overall system costs. Because they can act as both demand (i.e., when charging) and supply (i.e., when discharging), batteries are uniquely flexible tools for managing local transmission constraints.

18 MISO, *MTEP1 Report Addendum: Long Range Transmission Planning Tranche 1 Executive Summary* (June 2022), https://cdn.misoenergy.org/MTEP21%20Addendum-LRTP%20Tranche%201%20Report%20with%20Executive%20Summary625790.pdf.

19 Grid Strategies LLC, *Large-Scale Transmission Deployment Saves Consumers Money* (June 2025), at 2, https://gridstrategiesllc.com/wp-content/uploads/GS_Transmission-Deployment-Saves-Consumers-Money_vf.pdf.

20 NYISO State of the Market Report at 63.

21 NYISO, *AC Transmission Public Policy Transmission Projects* (May 10, 2019), at 7, https://www.nysrc.org/wp-content/uploads/2023/04/7.1.2-AC_Transmission_PPTN_NYSRC-EC_2019-05-Attachment-7.1.2.pdf.

22 SPP State of the Market Report at 160.

23 Potomac Economics, *2024 State of the Markets Report for the ERCOT Electricity Markets* (May 2025), at ii, https://www.potomaceconomics.com/wp-content/uploads/2025/06/2024-State-of-the-Market-Report.pdf (hereinafter, "ERCOT State of the Markets Report").

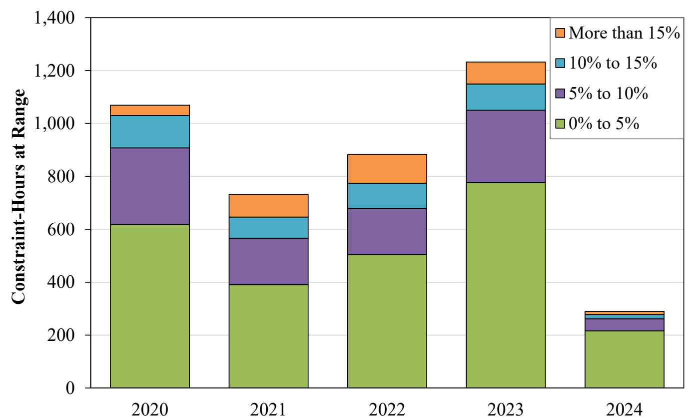
24 *Id.* at ix.

While batteries are an important tool in the congestion management toolkit, they are not a substitute for broader transmission expansion in reducing congestion, though. Despite the progress made in 2024, congestion has trended sharply upward in 2025, with the top 10 constraints in ERCOT reaching nearly $1.5 billion in the first half of the year.[25] For comparison, congestion in ERCOT for the entirety of 2024 was $1.9 billion.[26]

FIGURE 6. Overloaded distribution of violated constraints, 2020-2024

This figure from the ERCOT IMM shows that the overall rate of violated transmission constraints was down considerably in 2024 from prior years, with only 290 constraint-hours of violations compared to an average of 979 constraint-hours of violations for 2020-2023.

Source: Potomac Economics



Advanced Transmission Technologies

In addition to storage and proactive transmission planning, Grid Enhancing Technologies (GETs) (Dynamic Line Rating, Advanced Power Flow Control, and Transmission Topology Optimization) and High Performance Conductors (HPCs) (Composite Core Conductors and Superconductors)—together known as Advanced Transmission Technologies (ATTs)—can ease or eliminate congestion impacts while longer-term solutions are designed and implemented. GETs have near-term payoffs that complement new transmission infrastructure and support efficient operations in the long term even after transmission expansions are completed. GETs often unlock more than 20% additional capacity on existing infrastructure and can reduce congestion costs by 50%.[27] Studies show that GETs often pay for themselves in only six months to two years.[28] In some cases, the payback is even faster: PPL Electric Utilities installed Dynamic Line Rating (DLR) for under $1 million on three historically congested transmission lines and projected $23 million in annual congestion cost savings. Reconductoring transmission lines with HPCs can double or triple line capacity, all while using existing rights-of-

25 Potomac Economics, *ERCOT Wholesale Electricity Market Monthly Report* (July 2025), at 42, https://www.potomaceconomics.com/wp-content/uploads/2025/07/2025-06_Nodal_Monthly_Report.pdf.

26 ERCOT State of the Markets Report at ii.

27 The Brattle Group, *Building a Better Grid: How Grid Enhancing Technologies Complement Transmission Buildout* (Apr. 2023), https://www.brattle.com/wp-content/uploads/2023/04/Building-a-Better-Grid-How-Grid-Enhancing-Technologies-Complement-Transmission-Buildouts.pdf.

28 The Brattle Group, *Unlocking the Queue with Grid Enhancing Technologies* (Feb. 2021), https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf; U.S. Department of Energy, *Grid Enhancing Technologies: A Case Study on Ratepayer Impact* (Feb. 2022), https://www.energy.gov/sites/default/files/2022-04/Grid%20Enhancing%20Technologies%20-%20A%20Case%20Study%20on%20Ratepayer%20Impact%20-%20February%202022%20CLEAN%20as%20of%20032322.pdf.

way.[29,30] Connecting new large loads and the required generation to meet growing demand has the potential to create considerable new congestion on the grid. Reconductoring transmission lines with HPCs is a solution that allows grid operators to quickly alleviate congestion and meet system needs at a fraction of the time and cost of a new transmission line.

Transmission line ratings represent the maximum transfer capability of a transmission line—meaning the maximum amount of energy a line can transmit at any time—and can change based on real-time conditions, such as weather. FERC has taken action in recent years to require grid operators to use more accurate transmission line ratings.[31] The MISO IMM has explicitly recommended the increased use of DLR, recognizing that GETs "may enable large cost savings with little or no impact on reliability."[32] The PJM market monitor has also recommended that "the widespread adoption of Dynamic Line Ratings should be pursued," and that all PJM transmission owners should study the potential cost savings potential of GETs, implementing those that are cost-effective.[33] FERC is considering requiring the use of DLRs on congested transmission lines.[34] The MISO IMM also found that consistently applying ambient-adjusted ratings (AARs), as FERC recently required, could have saved $500 million in congestion costs across 2023 and 2024.[35] AARs capture extra headroom during cooler, windier periods when conductor capacity is higher than assumed under static line ratings methodologies. Use of AARs alone yields substantial savings, but using more advanced tools like DLRs, which also factor in wind speed, can deliver more than double the additive capacity on average[36] compared to AAR—providing even greater congestion relief for customers.

The MISO IMM also encourages adoption of "grid optimization" processes that redirect power flows to reduce congestion and improve outage coordination.[37] Topology Optimization software is a GET that can identify valuable transmission reconfigurations, such as opening a breaker to reroute power away from a constrained line. While transmission reconfigurations are most often used to address reliability issues, they are rarely deployed for economic purposes, despite their potential to relieve congestion quickly and affordably.[38] MISO's existing Reconfiguration Request Process is a promising step in this direction. In 2024, economic reconfigurations that MISO implemented under this process have already yielded over $100 million in market congestion cost savings, with one reconfiguration providing $57 million in market benefits.[39] ISO-NE has also identified reconfigurations using Topology

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29 Idaho National Laboratory, *A Guide to Case Studies of Grid Enhancing Technologies (Oct. 2022), at 11,* https://inl.gov/content/uploads/2023/03/A-Guide-to-Case-Studies-for-Grid-Enhancing-Technologies.pdf.

30 AMP Coalition, Grid Strategies LLC & ACORE, *Unlocking the Grid: A Playbook on High Performance Conductors for State and Regional Regulators and Policymakers* (Oct. 2024), https://acore.org/wp-content/uploads/2024/10/Unlocking-the-Grid-A-Playbook-on-High-Performance-Conductors-for-State-and-Regional-Regulators-and-Policymakers.pdf.

31 *Managing Transmission Line Ratings,* Order No. 881, 177 FERC ¶ 61,179 (2021) (requiring transmission providers to implement ambient-adjusted ratings and make other changes to transmission line ratings to improve their accuracy and transparency).

32 MISO State of the Market Report at 28.

33 Monitoring Analytics, *2024 State of the Market Report for PJM* (Mar. 2025), at 654 and 726, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2024/2024-som-pjm-sec12.pdf.

34 *See supra* n.3 (citing the FERC ANOPR on DLRs).

35 MISO State of the Market Report at 67.

36 K. Engel, J. Marmillo, M. Amini, H. Elyas, B. Enayati, *An Empirical Analysis of the Operational Efficiencies and Risks Associated with Static, Ambient Adjusted, and Dynamic Line Rating Methodologies* (Nov. 2021), at 2, https://cigre-usnc.org/wp-content/uploads/2021/11/An-Empirical-Analysis-of-the-Operational-Efficiencies-and-Risks-Associated-with-Line-Rating-Methodologies.pdf.

37 MISO State of the Market Report, at 28.

38 *Id.* at X.

39 NewGrid, *Ex-post Report 05/01-05/26: Rising – Bondville 138 kV flo Rising – Sidney 345 kV Congestion Mitigation (Sept. 2024), at 3,* https://cdn.misoenergy.org/RSC%20Revisions%20to%20MISOs%20Screening%20Criteria%20for%20Evaluating%20Economic%20Reconfiguration%20Requests%20(202408)_Alliant%20Energy649115.pdf.

Optimization software to relieve the impacts of planned outages, mitigating congested flows on the most limiting transmission constraints by 31% on average.[40] In July 2024, the Public Utility Commission of Texas established the Extended Action Plan (EAP) framework within ERCOT's Constraint Management Plan process to introduce a flexible and scalable approach to managing transmission congestion with topology reconfigurations.[41] In September 2025, SPP approved an Economic Topology Optimization process that allows market participants, such as generators and customers, to request evaluation of transmission reconfigurations to mitigate congestion.[42] This early leadership demonstrates the practical value of grid optimization as a congestion management tool, which can have an even greater impact through scaling and institutionalization of this process within all RTOs/ISOs.

To fully realize the benefits of ATTs, grid operators and utilities must invest in operational integration, including staffing, software upgrades, and real-time operational changes. As the MISO IMM concludes, "MISO will need to devote resources in the coming years to integrating such technologies into its operations and systems."[43]

SECTION 4

CONCLUSION

Grid congestion costs surpassed $12 billion in 2024 alone, with no sign of relief under current conditions. This marks the fourth consecutive year of congestion exceeding $10 billion, driven by rising electricity demand, limited transmission expansion, extreme weather, planned outages, and insufficient coordination of grid operations. While greater use of technologies like battery storage and ATTs has helped ease pressure in some regions, the grid's inability to move electricity freely to where it is needed, when it is needed, remains a major and costly constraint.

To reverse this trend, solutions must focus on expanding transmission capacity, deploying proven tools like ATTs, and modernizing grid operations to anticipate and mitigate congestion more effectively. Using solutions such as these will reduce the burden of transmission congestion on consumers and improve system reliability, ensuring a more secure and affordable electric grid for all Americans.

40 NewGrid, *Transmission Topology Optimization: A Software Grid Enhancing Technology, ISO-NE PAC Forum on Grid Enhancing Technologies* (Jun. 2025), at 6, https://www.iso-ne.com/static-assets/documents/100024/2025_06_18_gets_newgrid_materials.pdf.

41 ERCOT, *NPRR1198 Background*, accessed October 8, 2025, https://www.ercot.com/mktrules/issues/NPRR1198#background.

42 SPP Market Working Group Meeting, *Summary of Motion and Action Items* (Sept. 2025), at 8, https://www.spp.org/documents/74908/mwg%20minutes%2020250923-24.pdf

43 MISO State of the Market Report at 28.

APPENDIX A

ABOUT TRANSMISSION CONGESTION

Congestion rents offer insights that can guide transmission investment. Geographic differences in short-term marginal prices, reflected in congestion rents, result from physical constraints on the transmission system and the need to dispatch higher-cost local generation when lower-cost remote resources are undeliverable due to congestion. Those higher production costs are borne by consumers and are a direct measure the societal value of congestion.

Market data available from RTOs includes congestion rents, but not production costs incurred due to transmission congestion. Thus, congestion rents serve as a valuable available metric to assess congestion. Any other metric would be based on modeling rather than actual system and market data. Congestion rents are not a direct measure of the value of expanding a specific transmission element or path. Transmission expansion planning requires a holistic evaluation of the multiple reliability and economic benefits of new transmission.

Furthermore, high observed congestion costs do not always translate directly into higher costs borne by load. Consumers may be hedged against congestion through mechanisms such as Financial Transmission Rights (FTRs), Auction Revenue Rights (ARRs), or Congestion Revenue Rights (CRRs). These instruments redistribute congestion rents, potentially mitigating the direct cost impact on some market participants. Nevertheless, congestion rents remain an important indicator of the underlying physical and economic inefficiencies on the system that transmission expansion can alleviate.

APPENDIX B

RTO/ISO REGIONAL ANALYSIS

TABLE B1. Total congestion costs by RTO/ISO, 2016-2024 ($M)

	YEAR								
RTO/ISO	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
ERCOT	497	976	1,260	1,260	1,400	2,100	2,800	2,400	1,900
ISO-NE	39	41	65	33	29	50	51	32	37
MISO	1,402	1,518	1,409	934	1,181	2,849	3,700	1,800	1,800
NYISO[44]	529	481	596	433	297	551	1,000	311	306
PJM	1,024	698	1,310	583	529	995	2,500	1,068	1,754
SPP	280	500	450	457	442	1,200	2,000	1,400	1,800
CAISO[45]	197	138	745	451	605	760	1,323	1,049	734
TOTAL	**3,968**	**4,352**	**5,835**	**4,151**	**4,483**	**8,505**	**13,374**	**8,060**	**8,331**

TABLE B2. Estimated nationwide congestion costs, 2016-2024 ($M)

	YEAR								
Region	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
U.S.	6,501	7,266	8,776	6,379	6,686	13,353	20,777	11,488	12,295

44 NYISO's market monitor does not report both real-time and day-ahead congestion values in its annual state of the market report. These numbers are, therefore, based on day-ahead market congestion only.

45 CAISO does not have a region-specific congestion metric. However, DOE's National Transmission Needs Study used a proxy by combining Day Ahead Congestion with Real Time Congestion Imbalance Offset Charges as reported by CAISO's market monitor. *See* DOE 2023 Needs Study at 65. This report replicates DOE's method, using CAISO's Annual Reports on Market Issues and Performance for the relevant years.

APPENDIX C

INTERNAL AND INDEPENDENT MARKET MONITOR REPORTS CITED

Potomac Economics, *2024 State of the Market Report for the ERCOT Electricity Markets* (May 2025), https://www.potomaceconomics.com/wp-content/uploads/2025/06/2024-State-of-the-Market-Report.pdf.

ISO New England Inc. Internal Market Monitor, *2024 Annual Markets Report* (May 2025), https://www.iso-ne.com/static-assets/documents/100023/2024-annual-markets-report.pdf.

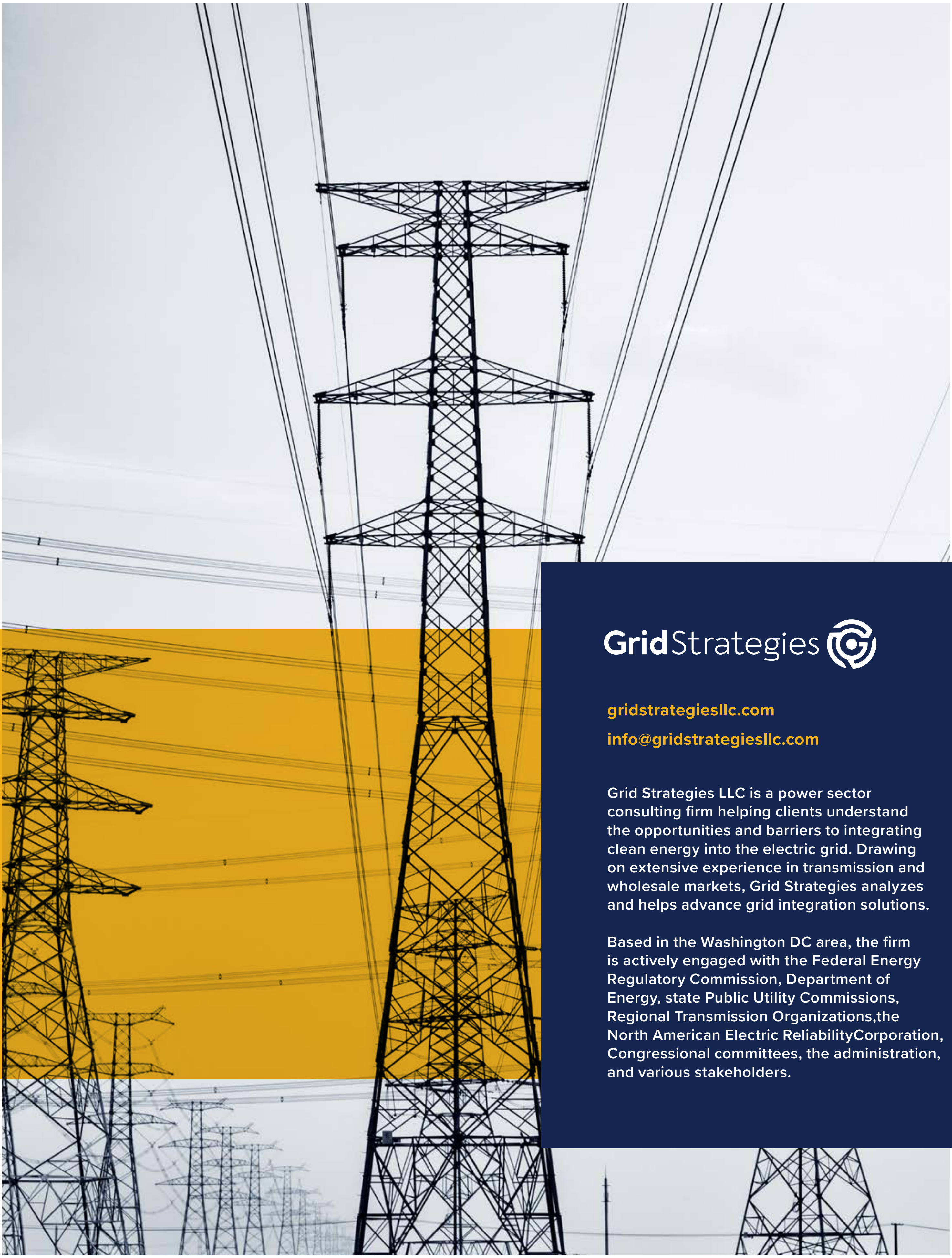
Potomac Economics, *2024 State of the Market Report for the MISO Electricity Markets* (June 2025), https://cdn.misoenergy.org/20250626%20Markets%20Committee%20of%20the%20BOD%20Item%2004%20State%20of%20the%20Market%20Report703831.pdf.

Potomac Economics, *2024 State of the Markets Report for the New York ISO Markets* (May 2025), https://www.potomaceconomics.com/wp-content/uploads/2025/05/NYISO-2024-SOM-Full-Report_5-14-2025-final.pdf.

Monitoring Analytics, *2024 State of the Market Report for PJM* (March 2025), https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2024/2024-som-pjm-vol1.pdf.

SPP Market Monitoring Unit, *State of the Market 2024* (May 2025), https://www.spp.org/documents/73953/2024_annual_state_of_the_market_report.pdf.

California ISO Department of Market Monitoring, *2024 Annual Report on Market Issues and Performance* (August 2025), https://www.caiso.com/documents/2024-annual-report-on-market-issues-and-performance-aug-07-2025.pdf.



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Grid Strategies LLC is a power sector consulting firm helping clients understand the opportunities and barriers to integrating clean energy into the electric grid. Drawing on extensive experience in transmission and wholesale markets, Grid Strategies analyzes and helps advance grid integration solutions.

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