2023 TRANSMISSION CONGESTION REPORT

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Grid Strategies

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SECTION 1: ABSTRACT

Insufficient transmission grid capacity blocks the delivery of lowest-cost resources to consumers. The cost to consumers is measured through grid congestion. In the so-called "organized markets" where transmission congestion is transparently reported, total congestion costs in 2023 amounted to $8 billion. Scaled based on electricity demand, that number implies **$11.5 billion in congestion costs nationwide in 2023.** These costs are ultimately paid by consumers. The reduced delivery of low-cost generation, often renewables, also impedes clean energy goals and the reliability that comes with a more diverse generation portfolio.

About Transmission Congestion

Congestion costs are incurred on the U.S. electric transmission grid when there is inadequate transmission capacity to deliver the lowest-cost generation to load. Higher cost generation is dispatched instead, raising prices. For example, if a transmission line that delivers energy from a low-cost wind generator is at capacity, a higher-cost gas generator may be ramped up elsewhere to meet demand. Consumers must then pay these "congestion costs" that measure the difference between the actual cost of energy and least cost energy. Various financial products exist to manage congestion and the associated risk, but the cost of congestion is paid by customers.

Non-RTO regions do not have transparent congestion data, but one can assume that congestion outside of these transparent markets is similar to congestion within them.[1] The price transparency and generally more favorable transmission expansion policies in the RTO regions tend to reduce congestion in those areas relative to non-RTO regions. FERC has recognized this lack of transparency in its Advanced Notice of Proposed Rulemaking (ANOPR) on the Implementation of Dynamic Lines Ratings issued in June 2024; the ANOPR has proposed potential reforms to enhance data reporting practices related to congestion in non-RTO/ISO regions.[2]

Note that this report relies on congestion rents because that is the only metric reported by RTO and ISO market monitors**.** See more on the report methodology in the appendix.

[1] To estimate a national congestion cost figure that includes non-RTO regions, one can scale 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.

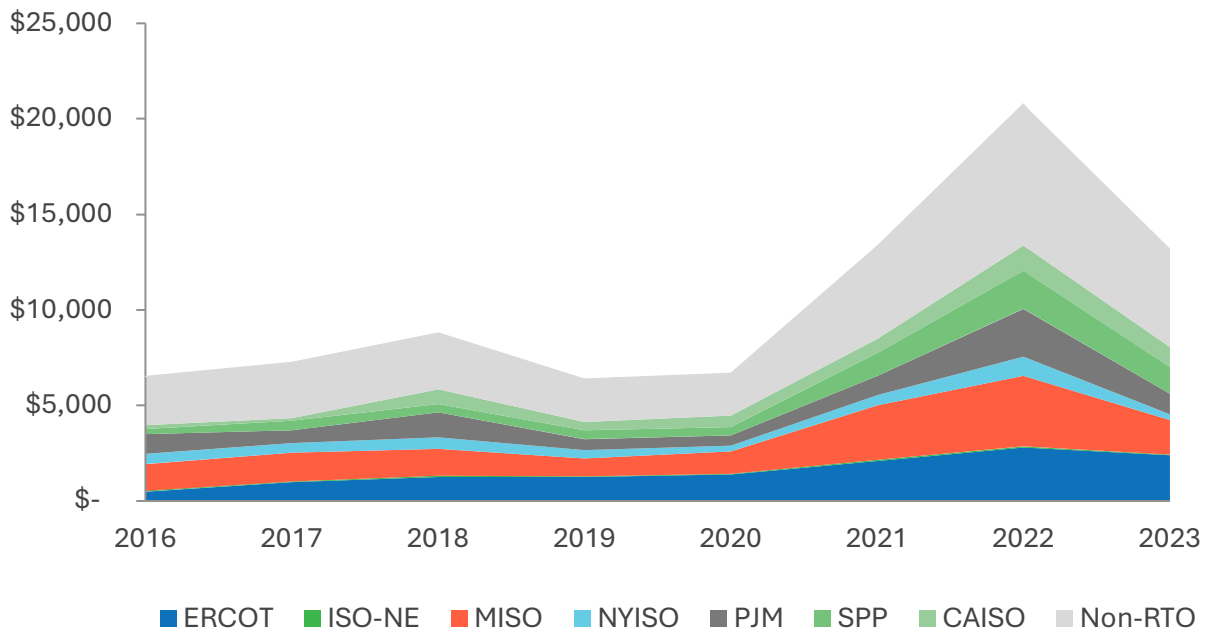
[2] Advanced Notice of Proposed Rulemaking, *Implementation of Dynamic Line Ratings,* 89 Fed. Reg. 57,707 (2024) (to be codified at 18 C.F.R. pt. 35).

SECTION 2: DATA ON 2023 CONGESTION

Total transmission congestion costs in 2023 were close to those in 2021 – the historic high before gas prices and extreme weather spiked costs in 2022. Despite volatility in commodity prices, congestion will likely rise because of the underlying trends of generation retirement and replacement without meaningful transmission expansion. Scaling the data provided by the RTOs to cover the entire country implies an **estimated $11.5 billion in nationwide congestion costs.**

Figure 1 *Total transmission congestion costs in 2023 across all RTOs and non-RTO regions are approximately equivalent to those in 2021. (values in the appendix)*

Estimated transmission congestion costs for the entire U.S., including costs reported across all RTOs, 2016-2023 ($M)



Source: 2023 Market Monitor Reports

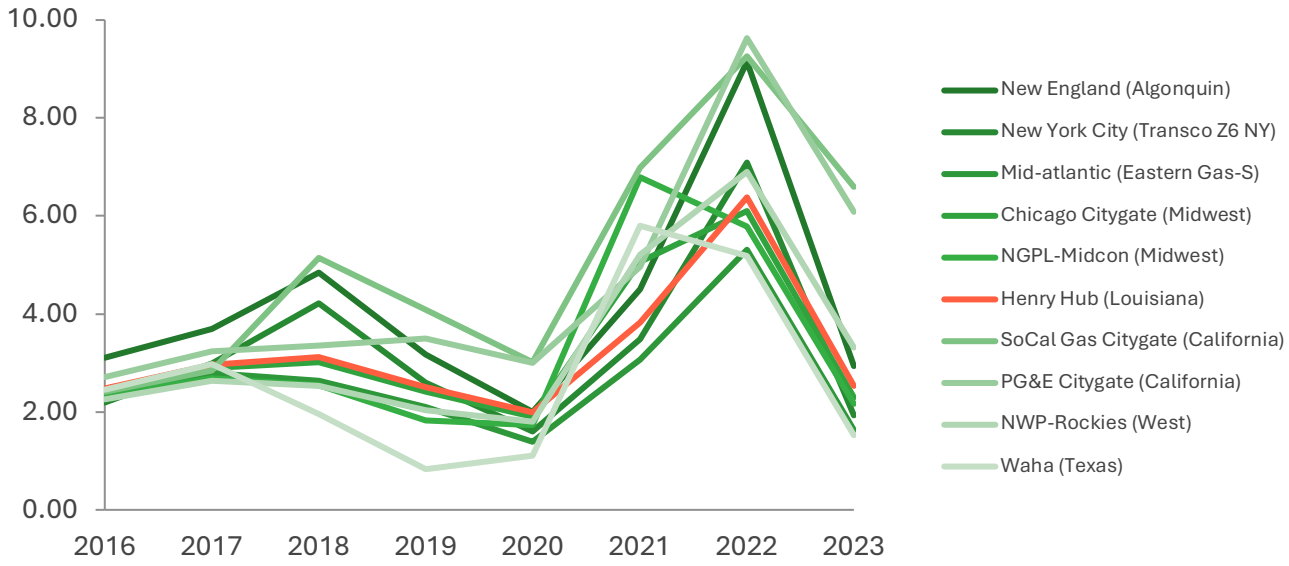
SECTION 3: FACTORS INFLUENCING CONGESTION COSTS

A. Changing Natural Gas Prices

The sharp decline in natural gas prices from 2022-2023 underpins the decline in transmission congestion costs over the same period.[3] Natural gas spot prices fell sharply by an average of 56% across all major trading hubs from 2022-2023**.** 2022 will likely be seen as a historic year for congestion due largely to the spike in natural gas prices caused by the war in Ukraine.[4] Summer 2022 saw the highest natural gas prices in real terms since November 2008.[5]

Figure 2 *Natural gas prices sharply declined across all major trading hubs from 2022-2023, including at the Henry Hub in Louisiana, considered the U.S. Benchmark for gas prices*

Average natural gas spot prices by trading hub, 2016-2023 ($/MMBtu)



Source: FERC State of the Markets Reports

[3] Changing congestion levels are correlated with changing natural gas prices, as gas-fired generation resources are generally those that are dispatched to manage transmission flows during periods of congestion.

[4] Federal Reserve Bank of St. Louis, The FRED Blog. *The Ukraine war's effects on U.S. commodity prices* (October 2023). https://fredblog.stlouisfed.org/2023/10/the-ukraine-wars-effects-on-us-commodity-prices/

[5] U.S. Energy Information Administration. *Energy commodity prices in 2022 showed effects of Russia's full-scale invasion of Ukraine* (January 2023). https://www.eia.gov/todayinenergy/detail.php?id=55059

B. Weather Variability

Extreme weather, which drove increased electricity load across regions in 2022, was less pronounced in 2023. Winter Storm Elliot in December 2022 contributed to more than $350 million in congestion costs across MISO in just two days. MISO provided extensive exports to neighboring regions that were struggling with reliability issues. These large and unusual exports, in combination with sweeping gas outages, caused severe congestion in MISO. The United States did not have a weather event with equivalent impact in 2023.

The 2023 FERC State of the Markets Report notes that total electricity consumption decreased across most RTOs/ISOs from 2022-2023, primarily due to milder weather. For example, electricity consumption in ISO-NE during January 2023 was 10% lower than the same time in 2022.[6] Only ERCOT saw an overall increase in system load in 2023, as hotter summer weather drove up consumption in the South and Central United States.[7] ERCOT's peak load hit a record 85.6 GW, which is 23% higher than the previous peak load record from 2018.[8]

C. The Energy Transition

As more new generation sources interconnect to the grid, congestion will increase unless transmission capacity expands to deliver this new generation to load. The Inflation Reduction Act (IRA) has driven significant growth in new renewables projects – 280 clean energy projects were announced across 44 US states in the IRA's first year alone.[9] While thousands of new projects await interconnection, the U.S. built only 55 miles of new high-voltage transmission capacity in 2023.[10] This lack of proactive investment in transmission expansion is slowing the energy transition. The DOE Transmission Needs Study found that regional and interregional transmission are needed to help address congestion across nearly

[6] FERC. *2023 State of the Markets* (March 2024), at 35. https://www.ferc.gov/news-events/news/presentation-report-2023-state-markets ("2023 State of the Markets")
[7] National Ocean and Atmospheric Administration, National Weather Service. *Exceptional Heat of Summer 2023, Lubbock TX* (2024). https://www.weather.gov/lub/events-2023-2023summer-heat
[8] Grid Strategies. *The Era of Flat Power Demand is Over* (December 2023), at 15. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf
[9] Goldman Sachs. *US Inflation Reduction Act is Driving Clean Energy Investment One Year In* (2023). https://www.gsam.com/content/gsam/sgp/en/individual/market-insights/gsam-insights/perspectives/2023/us-inflation-reduction-act-is-driving-clean-energy-investment-one-year-in
[10] Grid Strategies. *Fewer New Miles: The Transmission Grid in the 2020s* (July 2024), at 4. https://gridstrategiesllc.com/wp-content/uploads/Grid-Strategies_Fewer-New-Miles-2023.pdf

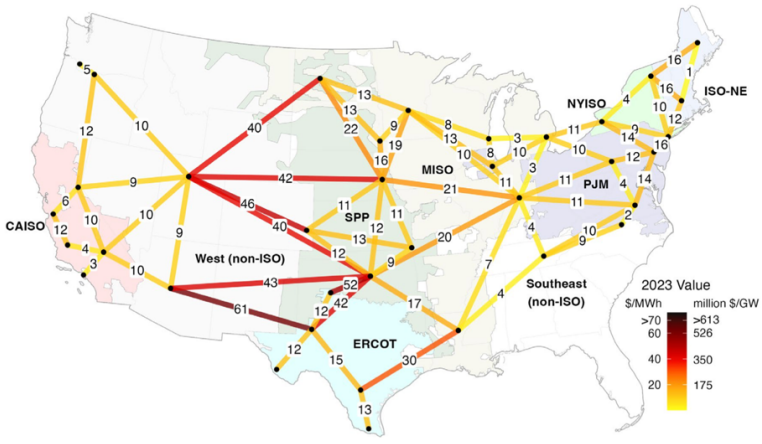
the whole country.[11] For example, 45% of all real-time congestion in MISO in 2023 resulted from lack of requisite transmission capacity needed to accommodate new wind resources. The transmission system is overdue for billions of dollars of investment to enable even greater renewable energy interconnection.

D. Not Measured: Interregional Congestion

A study by the Lawrence Berkeley National Laboratory (LBNL) demonstrates that there is significant value in transmission expansion between regions. Several interregional links have potential values close to or above $20/MWh, or equivalently, $175 million per GW of transmission capacity per year.[12] These values are based on the difference in wholesale-market energy prices between locations and can therefore serve as an analogue for congestion. While these findings by LBNL essentially reflect the value of transmission for interregional links, the market monitors do not measure or report on these values.

Figure 3 *Several interregional links have potential values close to or above $175 million per GW of transmission capacity per year. CREDIT: Lawrence Berkeley National Laboratory*

2023 transmission value across a set of selected links, $/MWh



Source: Lawrence Berkeley National Laboratory

[11] U.S. Department of Energy. *National Transmission Needs Study* (October 2023), at xi. https://www.energy.gov/sites/default/files/2023-12/National%20Transmission%20Needs%20Study%20-%20Final_2023.12.1.pdf

[12] Lawrence Berkeley National Laboratory. *Transmission Value in 2023* (July 2024), at 1. https://live-etabiblio.pantheonsite.io/sites/default/files/lbnl-transmissionvalue-techbrief-2023update-20230710_0.pdf

E. Emerging impacts: Load Growth

Load growth from new data centers and industrial facilities is an emerging driver of transmission congestion in PJM. Over the past year, PJM's 2028 forecast increased by 2% from 152.7 GW to 155.7 GW. Much of this load growth is expected to come from Loudon County in Northern Virginia, which hosts the largest data center market in the world.[13] Northern Virginia is served by Dominion Energy, which had the highest 2022 real-time LMP congestion component of all control zones in PJM at $16.57 per MWh.[14] This congestion indicates a further need for transmission expansion in PJM and is a trend that may arise in other areas of the country that have increasing load.

[13] Grid Strategies. *The Era of Flat Power Demand is Over* (December 2023), at 16. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf

[14] Monitoring Analytics. 2022 PJM State of the Market, Section 11: Congestion and Marginal Loss (2023), at 631. https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2022/2022-som-pjm-sec11.pdf

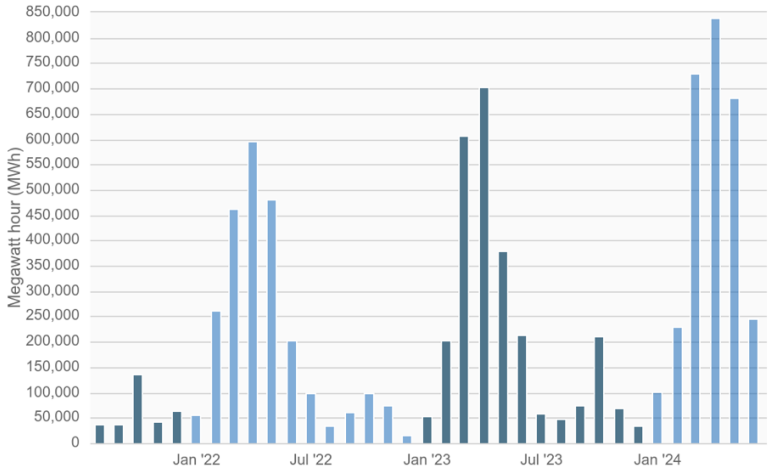
SECTION 4: IMPACTS OF CONGESTION

Customer Costs

Consumers lose millions of dollars when renewable resources with zero marginal cost cannot be fully utilized because of transmission congestion, requiring much more costly fueled resources to be used instead. Curtailment in the U.S. RTOs ranges from 3%-12%[15] of wind and solar production, and continues to grow in several markets. For example, wind and solar curtailments in CAISO have been increasing year-over-year, with a monthly record high in April 2024 of 800 MWh curtailed.[16] This means that wind and solar curtailments in CAISO averaged 12.78% of total wind and solar production over the course of the month. Curtailment remains volatile across the country and is a problem for generator economics. When cheap sources of new energy are curtailed, consumers lose money when thermal generators are spun up to meet demand.

Figure 4 *Wind and solar curtailments in CAISO have been increasing year-over-year for the last two years.*

Wind and Solar Curtailments in CAISO by month, 2022-2024 (MWh)



Source: CAISO

[15] In ERCOT, approximately 3% of total solar production and 4.2% of total wind production were curtailed to manage congestion in 2023.
[16] CAISO. *Managing the Evolving Grid* (July 2024). https://www.caiso.com/about/our-business/managing-the-evolving-grid

Slower clean energy deployment

Congestion also slows the development of new low-cost generation, as lines that are subject to congestion cannot accommodate electricity from new generation sources. Transmission capacity is not expanding fast enough to accommodate new sources of renewable generation being built. Interconnection for new generation is a slow process that can take 4-7 years from approval to completion. The number of interconnection requests nationwide climbed 16% in 2023 to reach 11,841.[17] Many of these projects are sources of renewable energy that would deliver much cheaper electricity to consumers when compared to thermal alternatives.

[17] *2023 State of the Markets*, at 45.

CONCLUSION

Expanding transmission capacity nationwide would save customers billions of dollars. Investments in proactive, multi-value, and scenario based regional transmission planning would have long term payoffs. One example is Texas' Competitive Renewable Energy Zone (CREZ) project, which was a $7 billion effort completed in 2013. After completion, CREZ interconnected 11.5 GW of new wind generation capacity and wind curtailment fell from a previous high of 17% to 0.5%.[18] Another example of long-term investment is MISO's Long Range Transmission Planning Tranche 1 Portfolio. The portfolio includes 18 transmission projects in the Midwest subregion, with more than 2,000 miles of transmission and a total investment of $10.3 billion. Projects in the Tranche 1 Portfolio are expected to deliver between $23.2-52.2 billion in net benefits over the next 20-40 years.[19] In addition to proactive planning, Grid Enhancing Technologies (GETs) can ease or eliminate congestion impacts while longer-term solutions are evaluated and implemented. GETs have near-term payoffs that complement new transmission infrastructure and provide longer-term efficient operations even after line upgrades are made. GETs often unlock more than 20% additional capacity on existing infrastructure and can reduce congestion costs by 50%.[20] Studies find that GETS often pay for themselves in only six months to two years.[21]

[18] ERCOT. *The Texas Competitive Renewable Energy Zone Process* (September 2017). https://cleanenergysolutions.org/sites/default/files/documents/jeff-billo_webinar-ercot-crez-process.pdf

[19] 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

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

[21] The Brattle Group. *Unlocking the Queue with Grid Enhancing Technologies* (February 2021). https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf and U.S. Department of Energy. *Grid Enhancing Technologies: A Case Study on Ratepayer Impact* (February 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

APPENDIX

Appendix A: About Transmission Congestion

The authors believe congestion rents offer a good approximation of societal congestion costs as the short-term marginal prices reflected in congestion rents should roughly approximate societal costs over the long term. Any other metric would be based on modeling rather than system data, introducing other types of imprecision. See more on the report methodology here.

Appendix B: ISO / RTO Regional Analysis

Table B1 **Total congestion costs by RTO,** 2016-2023 ($M)

	Year							
RTO	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
ERCOT	497	976	1,260	1,260	1,400	2,100	2,800	2,400
ISO-NE	39	41	65	33	29	50	51	32
MISO	1,402	1,518	1,409	934	1,181	2,849	3,700	1,800
NYISO[22]	529	481	596	433	297	551	1,000	311
PJM	1,024	698	1,310	583	529	995	2,500	1,068
SPP	280	500	450	457	442	1,200	2,000	1,400
CAISO[23]	197	138	745	451	605	760	1,323	1,049
TOTAL	**3968**	**4352**	**5835**	**4151**	**4483**	**8505**	**13374**	**8060**

Table B2 **Estimated nationwide congestion costs,** 2016-2023 ($M)

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

[22] NYISO does not report both real-time and day-ahead congestion values in their market monitor report. These numbers are based on day-ahead market congestion.

[23] California does not have a CAISO specific congestion metric. However, the DOE National Transmission Needs Study Draft used a proxy by combining Day Ahead Congestion with Real Time Congestion Imbalance Offset Charges as reported by CAISO's Market Monitor (see page 62 of the DOE Needs Study). This method was replicated for this report using CAISO's Annual State of the Market Monitor Reports.

Appendix C: Independent Market Monitor Reports cited

Potomac Economics. *2023 State of the Market Report for the ERCOT Electricity Markets* (May 2024). https://www.potomaceconomics.com/wp-content/uploads/2024/05/2023-State-of-the-Market-Report_Final.pdf

ISO New England Inc. Internal Market Monitor. *2023 Annual Markets Report* (May 2024). https://www.iso-ne.com/static-assets/documents/100011/2023-annual-markets-report.pdf

Potomac Economics. *2023 State of the Market Report for the MISO Electricity Markets* (June 2024). https://cdn.misoenergy.org/2023%20State%20of%20the%20Market%20Report636641.pdf

Potomac Economics. *2023 State of the Markets Report for the New York ISO Markets* (May 2024). https://www.potomaceconomics.com/wp-content/uploads/2024/05/NYISO-2023-SOM-Full-Report__5-13-2024-Final.pdf

Monitoring Analytics. *2023 State of the Market Report for PJM* (March 2024). https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2023/2023-som-pjm-vol2.pdf

SPP Market Monitoring Unit. *State of the Market 2023* (May 2024). https://www.spp.org/documents/71645/2023%20annual%20state%20of%20the%20market%20report%20v2.pdf

California ISO Department of Market Monitoring. *2023 Annual Report on Market Issues and Performance* (July 2024). https://www.caiso.com/documents/2023-annual-report-on-market-issues-and-performance.pdf