TRANSMISSION CONGESTION COSTS RISE AGAIN IN U.S. RTOS

JULY 2023

Grid Strategies

RICHARD DOYING, MICHAEL GOGGIN,
AND ABBY SHERMAN,
GRID STRATEGIES LLC

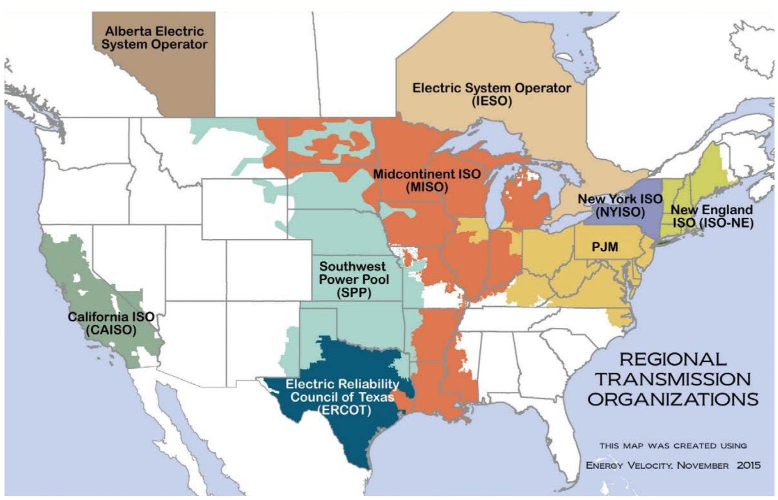
CONGESTION COSTS ROSE SIGNIFICANTLY IN 2022

Annual internal market congestion costs rose significantly in 2022, after nearly doubling from 2020 to 2021 across the Regional Transmission Organizations/Independent System Operators (RTOs/ISOs). ISOs and RTOs serve around 58% of U.S. electricity load[1]. Costs in RTO regions, apart from California ISO (CAISO), were **$12.1 billion**. Extrapolated to the rest of the U.S., including CAISO, congestion costs totaled **$20.8 billion**.

Congestion costs are incurred on the U.S. electric transmission grid when there is inadequate capacity to deliver the lowest-cost generation to load (consumers). Higher cost generation is dispatched instead, raising prices that are then charged to consumers. Various financial products exist that may partially or fully hedge congestion costs to individual loads (essentially providing insurance) and the associated risk, but the cost of congestion is ultimately paid by electricity customers.

All analysis not directly cited is based on the market monitor reports, linked in the appendix. CAISO has not published congestion data comparable to the other RTO regions for each year of the period analyzed in this report. CAISO has not yet released their 2022 market monitor report and is excluded from this edition.

FIGURE 1. *FERC — RTO/ISO Regions*



1 Peak loads for U.S. RTO/ISOs in 2022 (GW): ERCOT–80, ISO-NE–24.8, MISO-122, NYISO–31.2, PJM–150, SPP–53.4; peak load for the entire U.S.: 796 GW.

As shown in Table 1, total reported congestion costs increased by 100% from 2020 to 2021, and by about 56% from 2021 to 2022. 2022 congestion costs double the 2021 five-year average and *triple* the five-year averages from 2016 to 2019. This trend reflects the greater frequency and higher cost of thermal generators running in place of renewables curtailed due to inadequate transmission capacity, among other factors discussed on page 4.

TABLE 1. *Total Transmission Congestion Costs ($ millions) for RTOs from 2016–2022*

RTO	2016	2017	2018	2019	2020	2021	2022
ERCOT	497	976	1,260	1,260	1,400	2,100	2,800
ISO-NE	39	41	65	33	29	50	51
MISO	1,402	1,518	1,409	934	1,181	2,849	3,700
NYISO[2]	529	481	596	433	297	551	1,000
PJM	1,024	698	1,310	583	529	995	2,500
SPP	280	500	450	457	442	1,200	2,000
TOTAL	**3,771**	**4,214**	**5,090**	**3,700**	**3,878**	**7,745**	**12,051**

2 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.

Non-RTO regions do not have transparent congestion data, but if operating within the same wholesale context as RTOs, it can be assumed that congestion outside of these transparent markets is similar to congestion within them[3]. 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. Scaling the annual congestion costs totals from Table 2 approximates the nation-wide values shown below:

TABLE 2. *Estimated Congestion Costs for Entire U.S. ($ millions)*

2016	$6,501
2017	$7,266
2018	$8,776
2019	$6,379
2020	$6,686
2021	$13,353
2022	$20,777

The best way to reduce transmission congestion is to increase transmission capacity. However, very little of transmission spending is on new large-scale, high-voltage transmission lines. Yet, the need for new lines has only increased, largely due to (1) increased system vulnerability to the effects of extreme weather; (2) increasing electricity demand; (3) increasing customer demand of variable and clean energy that is often located far from the customer's location[4]. In addition, few U.S. utilities have adopted dynamic line ratings, advanced power flow control or topology optimization (together known as Grid Enhancing Technologies or GETs) to make more efficient use of existing grid infrastructure.

3 In the absence of a wholesale market, congestion costs would be measured as higher production costs and the distribution of those costs is a function of local retail ratemaking.

4 Zach Zimmerman and Rob Gramlich, "Transmission Planning and Development Regional Report Card", Grid Strategies LLC, 2023, https://gridstrategiesllc.com/wp-content/uploads/2023/06/ACEG_Transmission-Planning-and-Development-Report-Card.pdf.

ANALYSIS

Some regions, such as New England, may have relatively little internal congestion but there is significant congestion between New England with their neighbors, such as at the New York-New England interface.

Insufficient regional and interregional transmission capacity

Congestion is first and foremost an effect of insufficient transmission capacity. Congestion occurs when the cheapest generation cannot be delivered to customers, so higher-cost generation is dispatched instead, raising prices. Construction of new high-voltage transmission lines has significantly decreased since 2010 – the average installations going from 1700 miles from 2010-2015, to 645 miles from 2015-2020[5].

Fuel Prices

Every RTO region's market monitor report cited volatility in fuel prices, particularly for natural gas and coal, as a contributor to high congestion. The average cost of wholesale natural gas in the U.S. was the highest it had been since 2008 and increased by over 53% from 2021[6].

Transmission outages

SPP, NYISO, and ERCOT all cited transmission outages due to scheduled maintenance and/or upgrades as a major contributor to high congestion in 2022.

Extreme weather

Extreme weather events, notably Winter Storm Elliott in December of 2022, also contributed heavily to congestion in the U.S. RTOs. Winter Storm Elliott affected most of the continental U.S. from December 22-26th. MISO's market monitor report estimates that Winter Storm Elliott contributed to more than $350 million in congestion costs within just two days. PJM's market monitor report estimates that over 50% of the total congestion costs in December can be attributed to the winter storm alone.

Increases in electricity demand

The U.S. Department of Energy's (DOE) National Transmission Needs Study Draft found that to meet demand growth, almost all regions of the country will need to increase transmission capacity.[7] For instance, ERCOT's market monitor report stated that they broke the all-time peak demand record eleven times in the summer of 2022.

---

5 Jay Caspary, Rob Gramlich, Michael Goggin, and Julia Selker, "Fewer New Miles: The U.S. Transmission Grid in the 2010s", Grid Strategies LLC, 2022, https://gridprogress.files.wordpress.com/2022/09/grid-strategies_fewer-new-miles_final.pdf

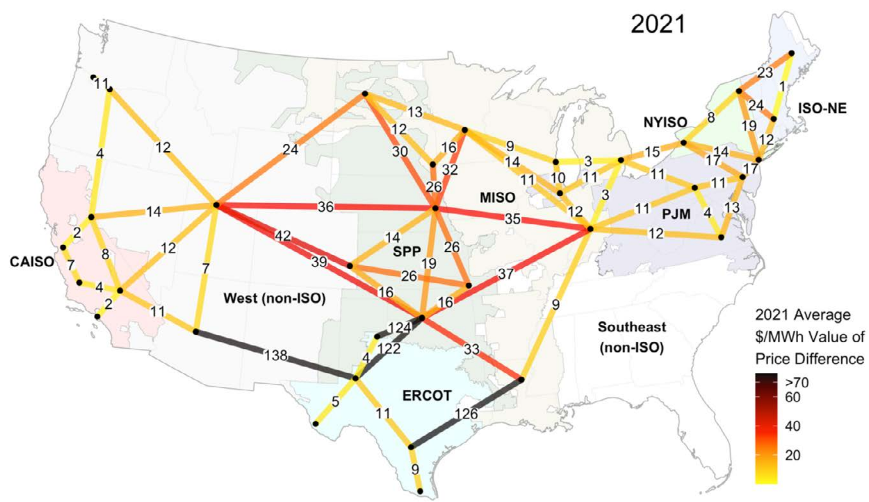
6 U.S. Energy Information Administration (EIA) (2023), "Average Cost of wholesale U.S. natural gas in 2022 highest since 2008", https://www.eia.gov/todayinenergy/detail.php?id=55119#:-:text=The%202022%20average%20Henry%20Hub,2000%2C%202003%2C%20and%202021.

7 U.S. Department of Energy (DOE) (2023), "National Transmission Needs Study", https://www.energy.gov/sites/default/files/2023-02/022423-DRAFTNeedsStudyforPublicComment.pdf

ACTUAL CONGESTION IS MUCH HIGHER THAN JUST THE INTERNAL RTO/ISO CONGESTION NUMBERS

A study by the Lawrence Berkeley National Laboratory (LBNL)[8] found that regional and interregional transmission links reduce congestion; and that interregional links have even greater value than regional links ($24/MWh vs. $11/MWh). LBNL estimates that only 5% of hours contribute to 50% of transmission's value, noting the outsized role that extreme weather events play in the value of transmission. The role that extreme weather events play in power outages and congestion will only continue to grow, as extreme weather events have increased 67% since 2000[9].

FIGURE 2. *LBNL — Marginal Value of Transmission in Relieving Congestion*



Greater transfer capability could have alleviated price spikes in electricity and saved lives during Winter Storm Uri in February of 2021. An analysis[10] found massive potential savings per gigawatt of transmission capacity between regions during Uri:

8 Lawrence Berkeley National Laboratory, "Empirical Estimates of Transmission Value using Locational Marginal Prices", https://eta-publications.lbl.gov/sites/default/files/lbnl-empirical_transmission_value_study-august_2022.pdf, slide 3

9 Climate Central, "Power OFF: Extreme Weather and Power Outages", https://www.climatecentral.org/climate-matters/power-outages

10 Michael Goggin, "Transmission Makes the Power System Resilient to Extreme Weather", Grid Strategies LLC, https://cleanenergygrid.org/wp-content/uploads/2021/09/GS_Resilient-Transmission_proof.pdf, pg. 11

FIGURE 3. *Savings per additional GW of transmission, February 12-20, 2021*

Receiving region – delivering region	Savings per GW of additional transmission capacity (millions of $)
ERCOT – TVA	$993
SPP South – PJM	$129
SPP South – MISO IL	$122
SPP South – TVA	$120
SPP S – MISO S (Entergy Texas)	$110
MISO S-N (Entergy Texas - IL)	$85
MISO S (Entergy Texas) – TVA	$82

The importance of the ability to transfer electricity between regions will only continue to grow as electricity demand, colder and hotter than normal seasonal temperatures continue to raise issues for grid infrastructure, and as the occurrence of extreme weather events continue to rise.

WHOSE RESPONSIBILITY IS MANAGING CONGESTION?

Unfortunately, in the U.S., the responsibility for reducing congestion on behalf of consumers is unclear. In other countries such as the UK, part of the grid operator's job is to reduce congestion, and they earn more or less money based on how well they do that. That is one reason why solutions such as Grid-Enhancing Technologies have been much more widely deployed in the UK.

In the U.S., transmission owners often consider reducing congestion cost to be outside of their responsibilities. RTO/ISOs minimize congestion on the existing regional transmission system through security constrained economic commitment and dispatch. RTO/ISOs also play a role in transmission expansion planning, but do not uniformly use regional transmission congestion cost reduction as a criteria when identifying potential new transmission. Moreover, RTO/ISO transmission planning does not consider opportunities to reduce interregional congestion cost.

State and federal regulators have an opportunity to assign responsibility for managing congestion.

SHORT, MEDIUM, AND LONG-TERM SOLUTIONS FOR CONGESTION

In the long-term, large-scale, high-voltage transmission lines are needed to address the causes and effects of congestion. However, major transmission projects can take more than a decade to develop. This is a lengthy time horizon to address an issue that needs to be resolved sooner rather than later.

In the short-term, solutions such as Grid-Enhancing Technologies (GETs) are able to increase transmission capacity on existing wires to relieve 40% of congestion or more in many cases[11]. In the medium term, reconductoring with advanced conductors involves replacing traditional steel and wire cores for conductors with carbon and/or composite cores on the same or new towers and on existing rights of way, allowing the lines to carry more capacity[12].

11 Tsuchida, Bruce T., Stephanie Ross, and Adam Bigelow, "Unlocking the Queue with Grid Enhancing Technologies: Case Study of the Southwest Power Pool", The Brattle Group, February 1, 2021, https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf.

12 Jay Caspary and Jesse Schneider, "Advanced Conductors on Existing Transmission Corridors to Accelerate Low-Cost Decarbonization", Grid Strategies LLC, March 2022, https://acore.org/wp-content/uploads/2022/03/Advanced_Conductors_to_Accelerate_Grid_Decarbonization.pdf.

APPENDIX A.

RTO/ISO MARKET MONITOR REPORTS

ISO-NE (2017), *2016 Annual Markets Report*, May 30, 2017, https://www.iso-ne.com/static-assets/documents/2017/05/annual_markets_report_2016.pdf

ISO-NE (2018), *2017 Annual Markets Report*, May 17, 2018, https://www.iso-ne.com/static-assets/documents/2018/05/2017-annual-markets-report.pdf.

ISO-NE (2019), *2018 Annual Markets Report*, May 23, 2018, https://www.iso-ne.com/static-assets/documents/2019/05/2018-annual-markets-report.pdf.

ISO-NE (2020), *2019 Annual Markets Report*, May 2020, https://www.iso-ne.com/static-assets/documents/2020/06/a6_2019_annual_markets_report.pdf

ISO-NE (2021), *2020 Annual Markets Report*, June 9, 2021, https://www.iso-ne.com/static-assets/documents/2021/06/2020-annual-markets-report.pdf

ISO-NE (2022), *2021 Annual Markets Report*, May 26, 2022, https://www.iso-ne.com/static-assets/documents/2022/05/2021-annual-markets-report.pdf

ISO-NE (2023), *2022 Annual Markets Report*, June 5, 2023, https://www.iso-ne.com/static-assets/documents/2023/06/2022-annual-markets-report.pdf.

Monitoring Analytics (2017), *State of the Market Report for PJM*, March 9, 2017, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2016/2016-som-pjm-volume2.pdf.

Monitoring Analytics (2018), *State of the Market Report for PJM*, March 8, 2018, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2017/2017-som-pjm-volume2.pdf

Monitoring Analytics (2019), *State of the Market Report for PJM*, March 14, 2019, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2018/2018-som-pjm-volume2.pdf.

Monitoring Analytics (2020), *State of the Market Report for PJM*, March 13, 2020, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2019/2019-som-pjm-volume2.pdf.

Monitoring Analytics (2021), *State of the Market Report for PJM*, March 11, 2021, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2020/2020-som-pjm-vol2.pdf, vol 2.

Monitoring Analytics (2022), *State of the Market Report for PJM*, March 10, 2022, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2021/2021-som-pjm-vol2.pdf, vol 2.

Monitoring Analytics (2023), *State of the Market Report for PJM*, March 9, 2023, https://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2022/2022-som-pjm-vol2.pdf.

Potomac Economics (2017), *2016 State of the Market Report for the ERCOT Electricity Markets*, May 2017, https://www.potomaceconomics.com/wp-content/uploads/2017/06/2016-ERCOT-State-of-the-Market-Report.pdf

Potomac Economics (2018), *2017 State of the Market Report for the ERCOT Electricity Markets*, May 2018, https://www.potomaceconomics.com/wp-content/uploads/2018/05/2017-State-of-the-Market-Report.pdf

Potomac Economics (2020), *2019 State of the Market Report for the ERCOT Electricity Markets*, May 2020, https://www.potomaceconomics.com/wp-content/uploads/2020/06/2019-State-of-the-Market-Report.pdf

Potomac Economics (2021), *2020 State of the Market Report for the ERCOT Electricity Markets*, May 2021, https://www.potomaceconomics.com/wp-content/uploads/2021/06/2020-ERCOT-State-of-the-Market-Report.pdf

Potomac Economics (2022), *2021 State of the Market Report for the ERCOT Electricity Markets*, May 2022, https://www.potomaceconomics.com/wp-content/uploads/2022/05/2021-State-of-the-Market-Report.pdf

Potomac Economics (2023), *2022 State of the Market Report for the ERCOT Electricity Markets*, May 2023, https://www.potomaceconomics.com/wp-content/uploads/2023/05/2022-State-of-the-Market-Report_Final_060623.pdf.

Potomac Economics (2017), *2016 State of the Market Report for the MISO Electricity Markets*, June 2017, https://www.potomaceconomics.com/wp-content/uploads/2017/06/2016-SOM_Report_Final_6-30-17.pdf

Potomac Economics (2018), *2017 State of the Market Report for the MISO Electricity Markets*, June 2018, https://www.potomaceconomics.com/wp-content/uploads/2018/07/2017-MISO-SOM_Report_6-26_Final.pdf

Potomac Economics (2019), *2018 State of the Market Report for the MISO Electricity Markets*, June 2019, https://www.potomaceconomics.com/wp-content/uploads/2019/06/2018-MISO-SOM_Report_Final2.pdf.

Potomac Economics (2020), *2019 State of the Market Report for the MISO Electricity Markets*, June 2020, https://www.potomaceconomics.com/wp-content/uploads/2020/06/2019-MISO-SOM_Report_Final_6-16-20r1.pdf

Potomac Economics (2021), *2020 State of the Market Report for the MISO Electricity Markets*, May 7, 2021, https://www.potomaceconomics.com/wp-content/uploads/2021/05/2020-MISO-SOM_Report_Body_Compiled_Final_rev-6-1-21.pdf

Potomac Economics (2022), *2021 State of the Market Report for the MISO Electricity Markets*, June, 2022, https://cdn.misoenergy.org/20220622%20Markets%20Committee%20of%20the%20BOD%20Item%2004%20IMM%20State%20of%20the%20Market%20Report625261.pdf

Potomac Economics (2023), *2022 State of the Market Report for the MISO Electricity Markets*, June 15, 2023, https://www.potomaceconomics.com/wp-content/uploads/2023/06/2022-MISO-SOM_Report_Body-Final.pdf.

Potomac Economics (2017), *2017 State of the Market Report for the New York ISO Electricity Markets*, May 2017, https://www.nyiso.com/documents/20142/2223763/2016-State-Of-The-Market-Report.pdf/2feb2a59-df4c-e967-0a53-6818458a3138

Potomac Economics (2018), *2017 State of the Market Report for the New York ISO Electricity Markets*, May 2018, https://www.potomaceconomics.com/wp-content/uploads/2018/06/NYISO-2017-SOM-Report-5-07-2018_final.pdf.

Potomac Economics (2019), *2018 State of the Market Report for the New York ISO Electricity Markets*, May 2019, https://www.nyiso.com/documents/20142/2223763/2016-State-Of-The-Market-Report.pdf/2feb2a59-df4c-e967-0a53-6818458a3138

Potomac Economics (2020), *2019 State of the Market Report for the New York ISO Electricity Markets*, May 2020, https://www.nyiso.com/documents/20142/2223763/NYISO-2019-SOM-Report-Full-Report-5-19-2020-final.pdf/bbe0a779-a2a8-4bf6-37bc-6a748b2d148e?t=1589915508638

Potomac Economics (2021), *2020 State of the Market Report for the New York ISO Markets*, May 2021, https://www.nyiso.com/documents/20142/2223763/NYISO-2020-SOM-Report-final-5-18-2021.pdf/c540fdc7-c45b-f93b-f165-12530be925c7

Potomac Economics (2022), *2021 State of the Market Report for the New York ISO Markets*, May 2022, https://www.nyiso.com/documents/20142/2223763/NYISO-2021-SOM-Full-Report-5-11-2022-final.pdf/5307870c-9b62-1720-1708-6b9c157211bb

SPP (2017), *State of the Market 2016*, August 10, 2017, https://www.spp.org/documents/53549/spp_mmu_asom_2016.pdf

SPP (2018), *State of the Market 2017*, May 8, 2018, https://www.spp.org/documents/57928/spp_mmu_asom_2017.pdf

SPP (2019), *State of the Market 2018*, May 15, 2019, https://www.spp.org/documents/59861/2018%20annual%20state%20of%20the%20market%20report.pdf

SPP (2020), *State of the Market 2019*, May 11, 2020, https://www.spp.org/documents/62150/2019%20annual%20state%20of%20the%20market%20report.pdf

SPP (2021), *State of the Market 2020*, August 12, 2021, https://www.spp.org/documents/65161/2020%20annual%20state%20of%20the%20market%20report.pdf

SPP (2022), *State of the Market 2021*, May 10, 2022, https://www.spp.org/documents/67104/2021%20annual%20state%20of%20the%20market%20report.pdf

SPP (2023), *State of the Market 2022*, May 15, 2023, https://www.spp.org/documents/69330/2022%20annual%20state%20of%20the%20market%20report.pdf.

APPENDIX B.
SOURCES FOR ANALYSIS NOT LINKED TO MARKET MONITOR REPORTS

Caspary, Jay, and Jesse Schneider. (2022). “Advanced Conductors on Existing Transmission Corridors to Accelerate Low Cost Decarbonization”, March 2022. https://acore.org/wp-content/uploads/2022/03/Advanced_Conductors_to_Accelerate_Grid_Decarbonization.pdf.

Caspary, Jay, Rob Gramlich, Michael Goggin, and Julia Selker. (2022). “Fewer New Miles: The U.S. Transmission Grid in the 2010s”, August 2022. https://gridprogress.files.wordpress.com/2022/09/grid-strategies_fewer-new-miles_final.pdf.

Climate Central. (2020). “Power OFF: Extreme Weather and Power Outages”. https://www.climatecentral.org/climate-matters/power-outages

Goggin, Michael. (2021). “Transmission Makes the Power System Resilient to Extreme Weather”. Grid Strategies LLC, July 2021. https://cleanenergygrid.org/wp-content/uploads/2021/09/GS_Resilient-Transmission_proof.pdf.

Millstein, Dev, Ryan H. Wiser, Will Gorman, Seongeun Jeong, James Hyungkwan Kim, and Amos Ancell. (2022). “Empirical Estimates of Transmission Value using Locational Marginal Prices”. Lawrence Berkeley National Laboratory, September 1, 2022. https://eta-publications.lbl.gov/sites/default/files/lbnl-empirical_transmission_value_study-august_2022.pdf.

Tsuchida, Bruce T., Stephanie Ross, and Adam Bigelow. (2021). “Unlocking the Queue with Grid Enhancing Technologies: Case Study of the Southwest Power Pool”, February 1, 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 (DOE). (2023). “National Transmission Needs Study: Draft for Public Comment”, February 2023. https://www.energy.gov/sites/default/files/2023-02/022423-DRAFTNeedsStudyforPublicComment.pdf.

U.S. Energy Information Administration (EIA). (2023). “Average cost of wholesale natural gas in 2022 highest since 2008”. January 9, 2023. https://www.eia.gov/todayinenergy/detail.php?id=55119#:~:text=The%202022%20average%20Henry%20Hub,2000%2C%202003%2C%20and%202021.

Zimmerman, Zach, and Rob Gramlich. (2023). “Transmission Planning and Development Regional Report Card”, Grid Strategies LLC, June 2023, https://gridstrategiesllc.com/wp-content/uploads/2023/06/ACEG_Transmission-Planning-and-Development-Report-Card.pdf.