Grid Strategies

Transmission Planning for PJM

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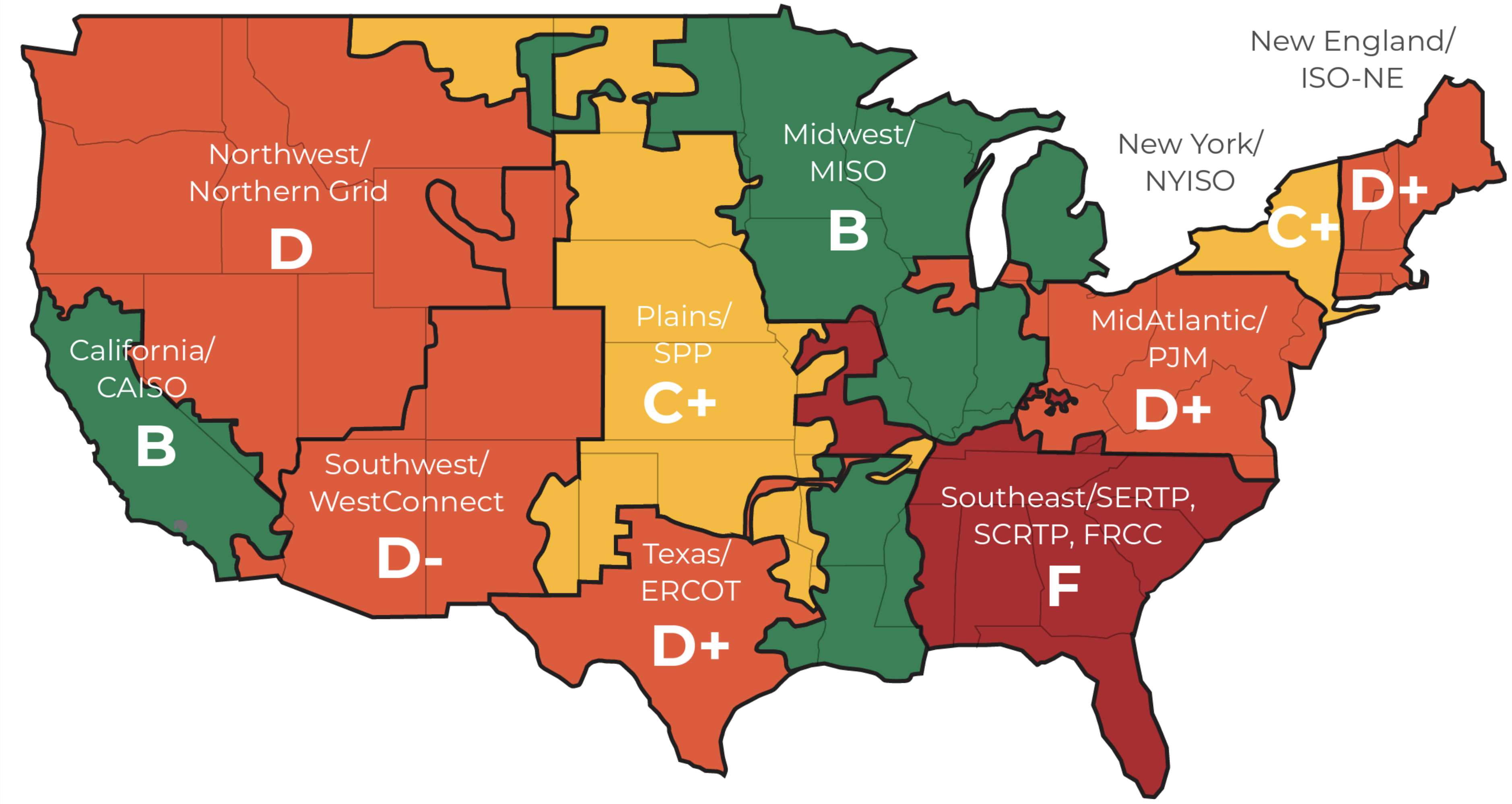
PJM Public Interest Organization User Group

National Transmission Planning Report Card: many low grades PJM Scores a D+ Overall



Transmission Planning Report Card—Grid Strategies & ACEG

Summary Grades

REGION	PLANNING METHODS AND BEST PRACTICES (65%)	TRANSMISSION LINES PLANNED AND TRANSMISSION MILES BUILT (20%)	TRANSMISSION CAPACITY AVAILABLE FOR NEW RESOURCES (7.5%)	CONGESTION (7.5%)	PERCENT	OVERALL GRADE
California/CAISO	A-	C	B-	C	85.8%	**B**
Mid-Atlantic/PJM	D	D	C+	B	67.5%	**D+**
Midwest/MISO	A-	B-	C+	C	86.0%	**B**
New England/ISO-NE	D+	D	F	A	68.0%	**D+**
New York/NYISO	B-	B	F	C	78.6%	**C+**
Northwest/ Northern Grid	F	C	B-	D	63.3%	**D**
Plains/SPP	C+	C	C-	C	77.5%	**C+**
Southeast/SERTP, SCRTP, FRCC	F	F	A-	D	51.9%	**F**
Southwest/WestConnect	F	B-	B-	D	62.3%	**D-**
Texas/ERCOT	D	C-	A	D	68.6%	**D+**

"The Mid-Atlantic region scored relatively low overall with a 'D+.' Most of its shortfall comes from planning methods because PJM has limited proactive, multi-value, scenario-based transmission planning. Instead, it takes a more siloed approach to planning"

Grading System

1. Graded regions, not entities (many parties involved and share credit/blame for regional planning)
2. Planning Methods and Best Practices
    a. Are regions using known transmission planning best practices (i.e. proactive, multi-value, portfolio-based, and scenario-based planning)?
3. Transmission Lines Planned and Miles Built
    a. Do regions have future proactive transmission development plans?
    b. Have regions been building new high-capacity transmission lines in recent years?
4. Transmission Capacity Available for New Resources
    a. Cost to interconnect new resources
    b. Completion rates for projects
    c. Time projects spend in interconnection queues
5. Congestion
    a. Regional load-adjusted congestion ($/MWh)

Planning Practice Grades

REGION	PROACTIVELY PLANNING GENERATION AND LOAD (10%)	SCENARIO BASED PLANNING (7.5%)	MULTI-VALUE PLANNING (10%)	PORTFOLIO PLANNING (7.5%)	INTERREGIONAL PLANNING (7.5%)	STAKEHOLDER ENGAGEMENT (10%)	CONSIDER ALL BUSINESS MODELS (5%)	GOVERNANCE (7.5%)	SCORE (OUT OF 65)	PLANNING GRADE (%)	PLANNING LETTER GRADE
California/CAISO	4	4	3	4	3	3	3	3	59	91%	A-
Mid-Atlantic/PJM	2	0	0	0	1	3	2	3	42	65%	D
Midwest/MISO	3	4	4	4	3	3	2	3	59	90%	A-
New England/ ISO-NE	2	1	0	1	0	3	2	3	44	67%	D+
New York/NYISO	3	3	3	3	0	3	3	3	52	80%	B-
Northwest/ Northern Grid	1	0	0	3	1	0	2	0	37	57%	F
Plains/SPP	2	2	3	2	2	3	2	3	52	79%	C+
Southeast/SERTP, SCRTP, FRCC	0	0	0	0	0	0	0	0	29	45%	F
Southwest/ WestConnect	2	0	0	0	0	0	2	1	35	54%	F
Texas/ERCOT	1	1	0	1	0	3	1	3	42	65%	D

"PJM does not conduct proactive generation and load forecasting and does not independently model retirements over its 15-year planning horizon. Thus, it fails on the most basic test of planning for the anticipated resource mix…PJM's planning process largely remains siloed into reliability, economic, and public policy planning."

Transmission Lines Planned and Built Grades

REGION	TOTAL SCORE (OUT OF 20%)	MILES BUILT AND PLANNED GRADE (%)	MILES BUILT AND PLANNED LETTER GRADE
California/CAISO	15.00	75%	C
Mid-Atlantic/PJM	13.00	65%	D
Midwest/MISO	16.00	80%	B-
New England/ISO-NE	13.00	65%	D
New York/NYISO	17.00	85%	B
Northwest/Northern Grid	15.00	75%	C
Plains/SPP	15.00	75%	C
Southeast/SERTP, SCRTP, FRCC	11.00	55%	F
Southwest/WestConnect	16.00	80%	B-
Texas/ERCOT	14.00	70%	C-

"The Mid-Atlantic region has little proactive transmission planned. Most of their trans- mission plans are driven by local projects proposed by Transmission Owners or projects needed to maintain reliability."

Capacity Available Grades

REGION	TOTAL SCORE (OUT OF 7.5%)	TRANSMISSION CAPACITY AVAILABLE FOR NEW RESOURCES GRADE (OUT OF 100%)	TRANSMISSION CAPACITY AVAILABLE FOR NEW RESOURCES LETTER GRADE
California/CAISO	6.13	82%	B-
Mid-Atlantic/PJM	5.88	78%	C+
Midwest/MISO	5.88	78%	C+
New England/ISO-NE	3.75	50%	F
New York/NYISO	3.75	50%	F
Northwest/Northern Grid	6.13	82%	B-
Plains/SPP	5.38	72%	C-
Southeast/SERTP, SCRTP, FRCC	6.75	90%	A-
Southwest/WestConnect	6.13	82%	B-
Texas/ERCOT	7.50	100%	A

"median current time spent in the [PJM] queue is almost four years, and interconnection costs are above $200 per kW."

Congestion costs rising in PJM

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**

https://gridstrategiesllc.com/wp-content/uploads/2023/07/GS_Transmission-Congestion-Costs-in-the-U.S.-RTOs1.pdf

Voluntary "market-based" transmission under-invests: economic consensus

Dr. William Hogan

"If there were no economies of scale and scope for transmission investment, electricity markets could follow the same competitive model for transmission where beneficiaries determine and pay for their own investments. Given the large economies of scale and scope, transmission is a natural monopoly and investment requires a central coordinator."

Dr. Paul Joskow

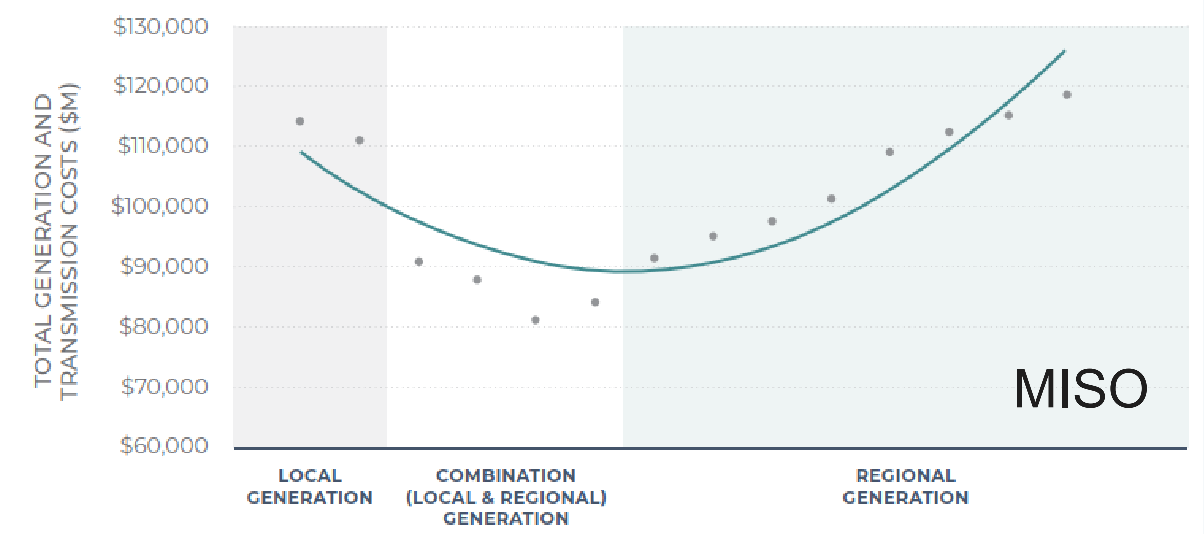
"There are numerous reasons why we should not expect "the market" to produce transmission enhancements that meet reasonable economic and reliability goals. Indeed, proceeding under the assumption that, at the present time, "the market" will provide needed transmission network enhancements is the road to ruin. There is abundant evidence that market forces are drawing tens of thousands of megawatts of new generating capacity into the system. There is no evidence that market forces are drawing significant quantities of entrepreneurial investments in new transmission capacity."

Dr. Frank Wolak

"Expansion of the transmission network typically increases the number of independent wholesale electricity suppliers that are able to compete to supply electricity at locations in the transmission network served by the upgrade...With the exception of the U.S., most countries re-structured at a time when they had significant excess transmission capacity, so the issue of how to expand the transmission network to serve the best interests of wholesale market participants has not yet become significant. In the U.S., determining how to expand the transmission network to serve the needs of wholesale market participants has been a major stumbling block to realizing the expected benefits of electricity industry re-structuring."

Economically sound transmission planning

- “Just and reasonable" has to mean <u>maximize net benefits</u>
  - Any other decision rule raises costs to consumers
  - Not least cost of transmission but least cost of delivered energy (generation + transmission)
  - Not benefit/cost ratio
- Dr. William Hogan: “A forward-looking cost-benefit analysis provides the gold standard for ensuring that transmission investments are efficient.”
- Overcome generator protectionism with strong independent planning



- Co-optimize transmission and generation

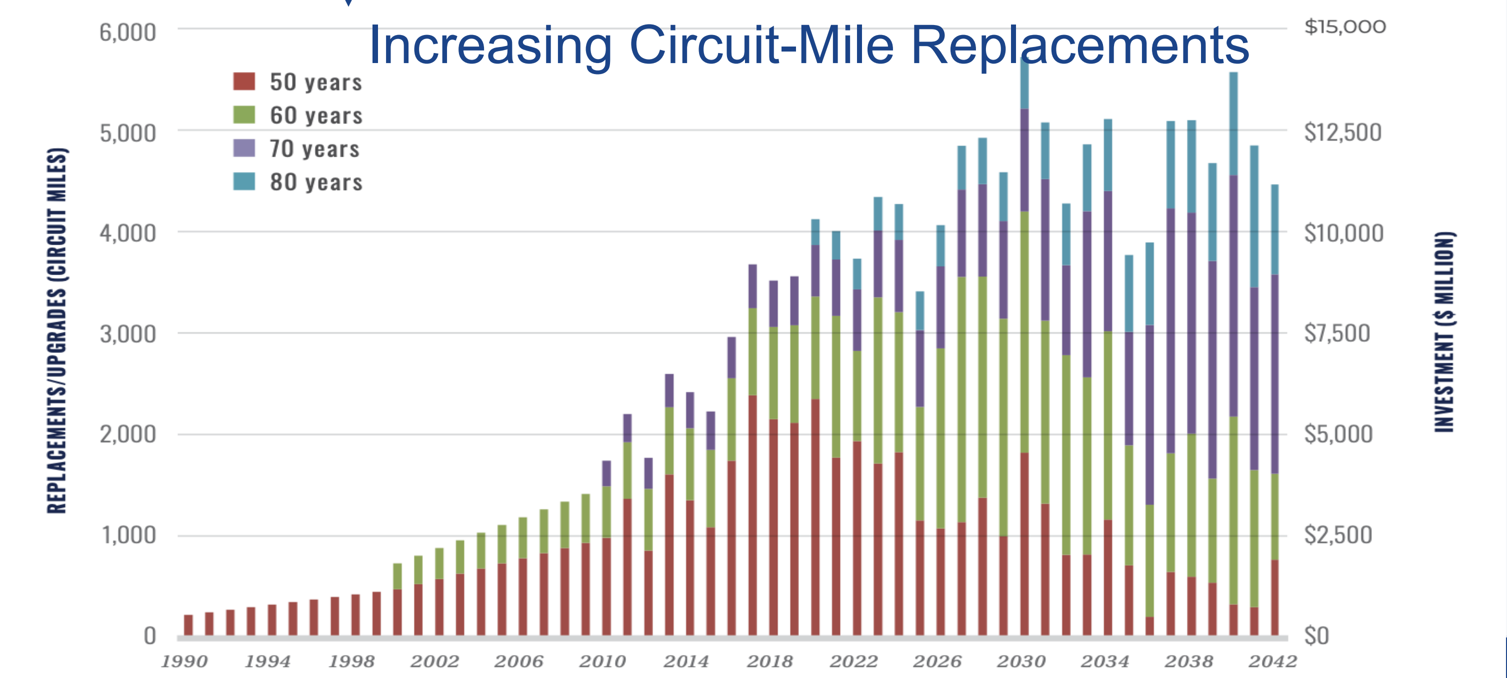
Other Ways to Deliver Power In Addition to New Lines on New Rights of Way Would Also Help Resolve Interconnection Challenges

High-Performance Conductors

- Replace aging wires
  - Composite core
  - Superconductors

Grid-Enhancing Technologies

- Power Flow Control
- Dynamic Line Ratings
- Topology Optimization



https://usea.org/sites/default/files/event-/AEPBoldTransmissionDescription11.13.2015.pdf

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Under-appreciated benefits of transmission

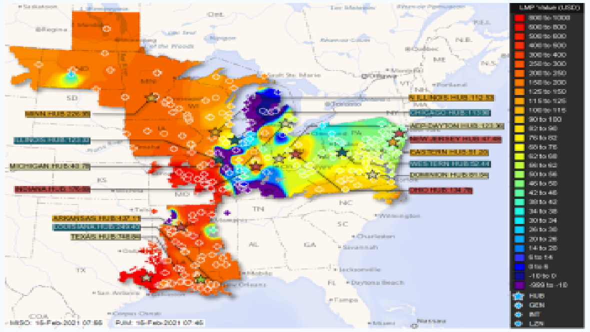
Capacity value

Greater ability to supply when power is scarce with regionally diverse portfolio.

Wind/hydro/geothermal/solar/storage complementarity

Congestion

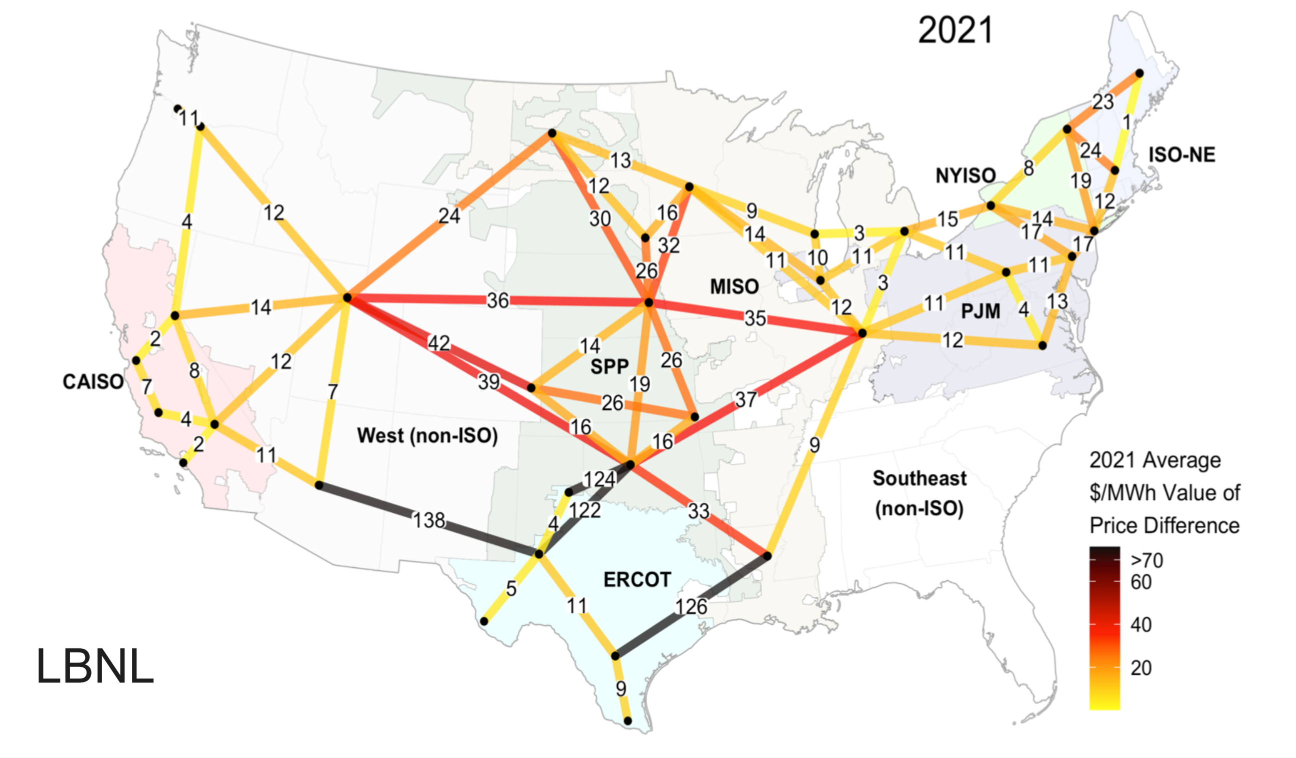
Production cost modeling always under-forecasts congestion, by a lot.



Reliability/resilience

50% of value in 5% of hours (LBNL)

Flows in both directions (winter storms Elliot, Uri, etc)



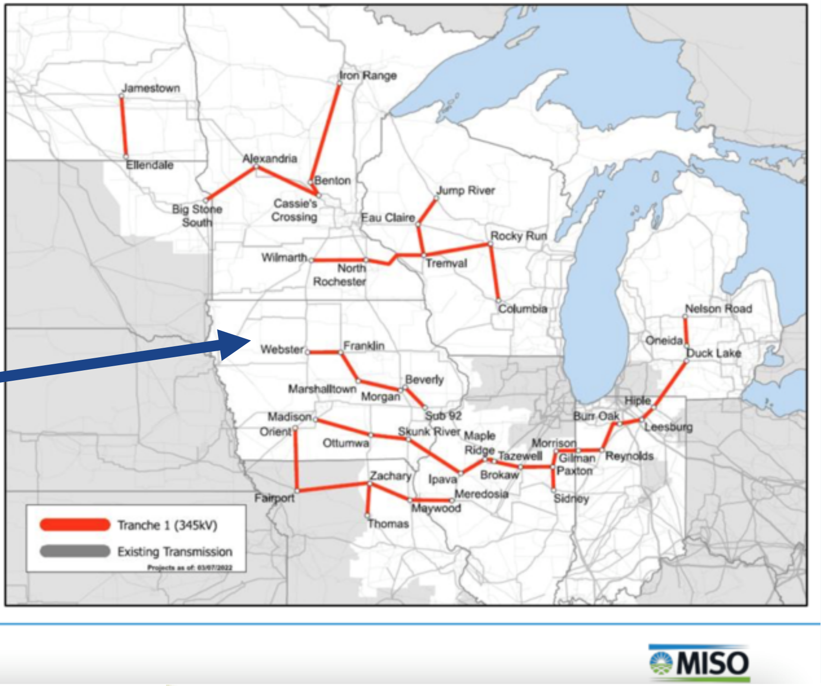
PJM's incremental approach costs consumers and fails to allocate costs to all beneficiaries

"Under PJM's current queue-based generation interconnection study process, the total costs of necessary onshore PJM network upgrades identified within individual PJM feasibility and system impact studies related to integrating 15.5 GW of offshore wind equals $6.4 billion. This results in PJM onshore network upgrade costs that adds over $400/kW to the cost of the offshore generation (including offshore transmission), or roughly 13% of offshore generation capital costs. By contrast, PJM's 2021 proactive region-wide study holistically evaluated onshore transmission investment needs to connect up to a cumulative 17 GW of offshore wind generation to its footprint (which reflects the offshore wind resource interconnection needs of multiple states' offshore wind plans). This proactive regional study estimated only $3.2 billion in PJM onshore network upgrade costs would be needed for interconnecting 17 GW of offshore wind generation—less than half the costs identified through the individual interconnection request studies. This reduces average interconnection costs to $188/kW-wind, which is only 45% of the over $400/kW cost associated with the current reactive, incremental interconnection study approach. In addition, the regional PJM study found that these identified $3.2 billion in onshore network upgrades result in substantial additional regional benefits in the form of congestion relief, customer load LMP reduction, and reduced renewable generation curtailments that would not be realized using reactive interconnection methods.

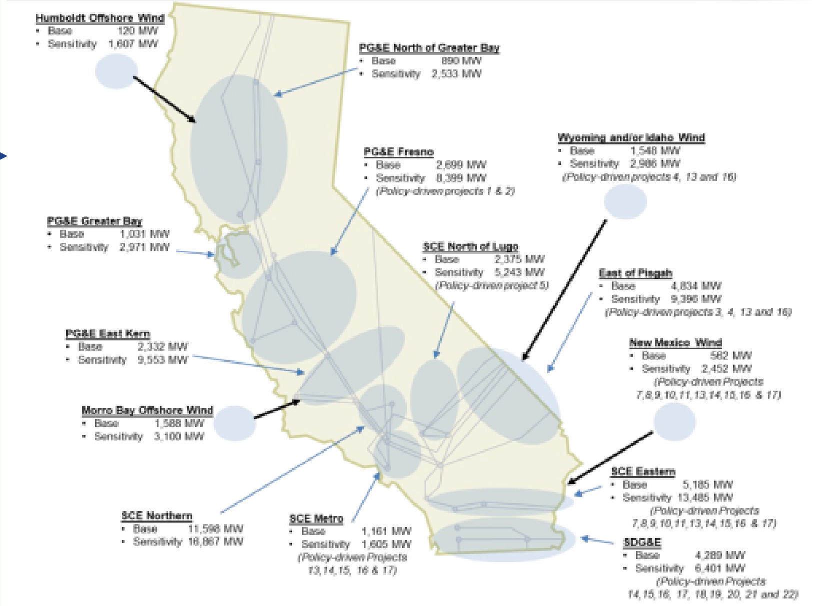
https://gridprogress.files.wordpress.com/2021/10/transmission-planning-for-the-21st-century-proven-practices-that-increase-value-and-reduce-costs-7.pdf

Recent examples of proactive transmission planning

- MISO Long Range Transmission Plan, Tranche 1
  - 53 GW of new renewables
  - ~$10 billion



- California ISO 2022-23 Transmission Plan
  - 4-7 GW of new power needed annually through 2032
  - 4.8 GW of out-of-state wind needed—helps resource adequacy
  - 45 projects
  - $7.3 billion



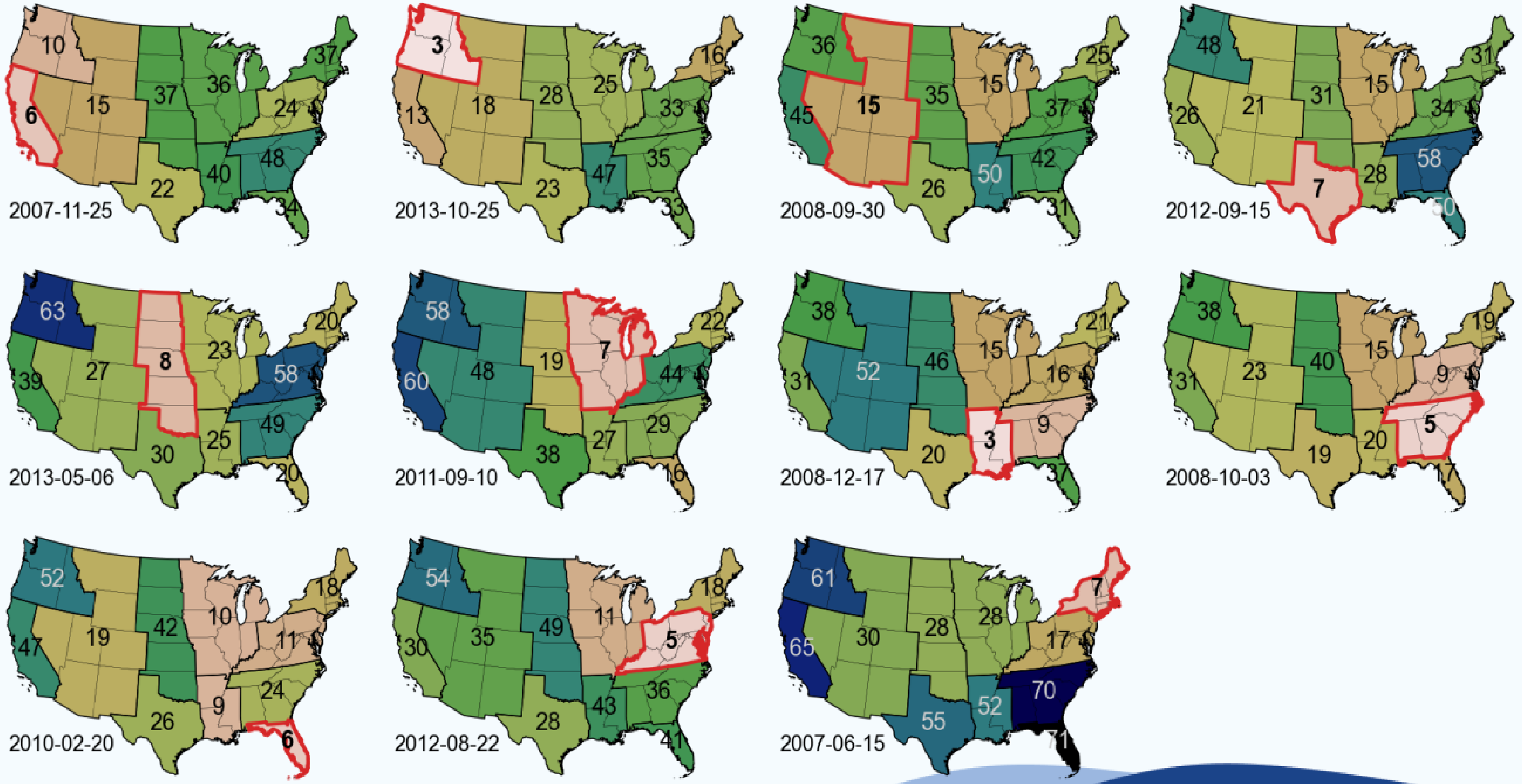
Renewables can contribute to resource adequacy and reduce costly generation reserve margins. Output is steady across wider areas

Take the least-windy day in each planning area from 2007–2013.

How windy are each of the other planning areas on that day?

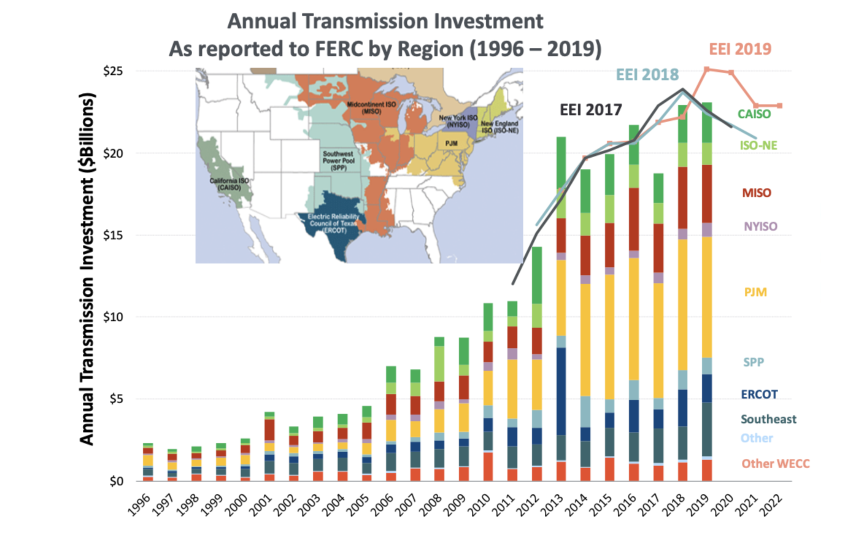
Single-day wind capacity factor [%] at top quintile of sites

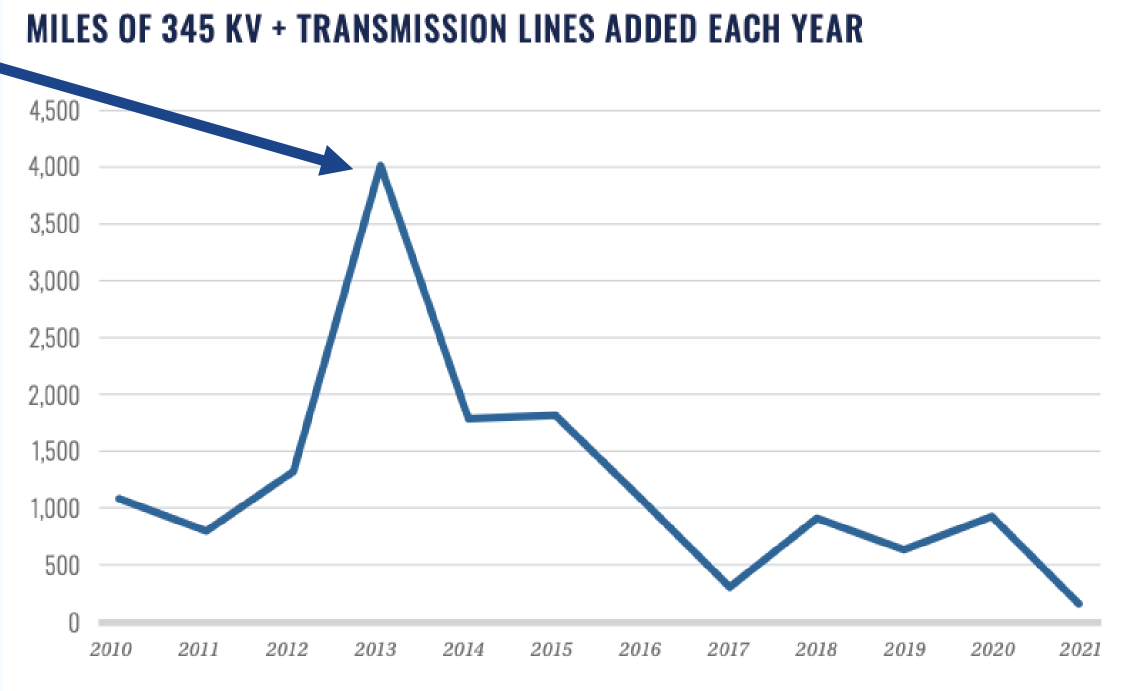
(Patrick Brown, MIT, NREL)



Not much long-distance transmission built recently

- Many miles of new transmission in 2013, then dropped to a trickle
- Investment rising but capacity not increasing—mostly replacing aging assets

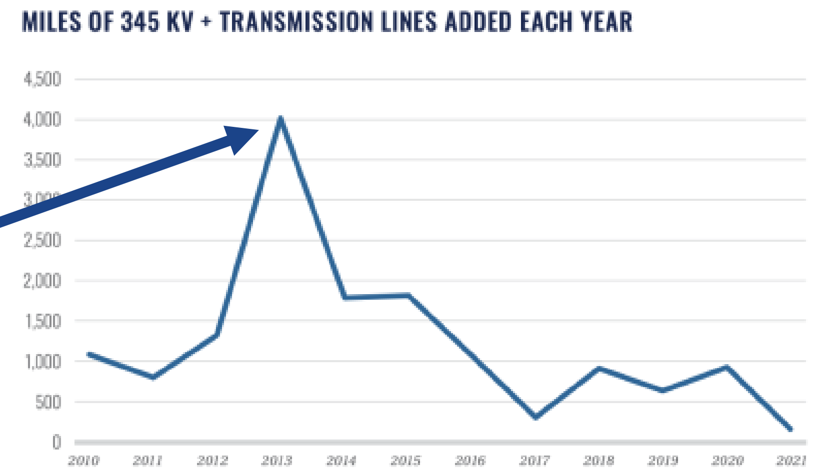




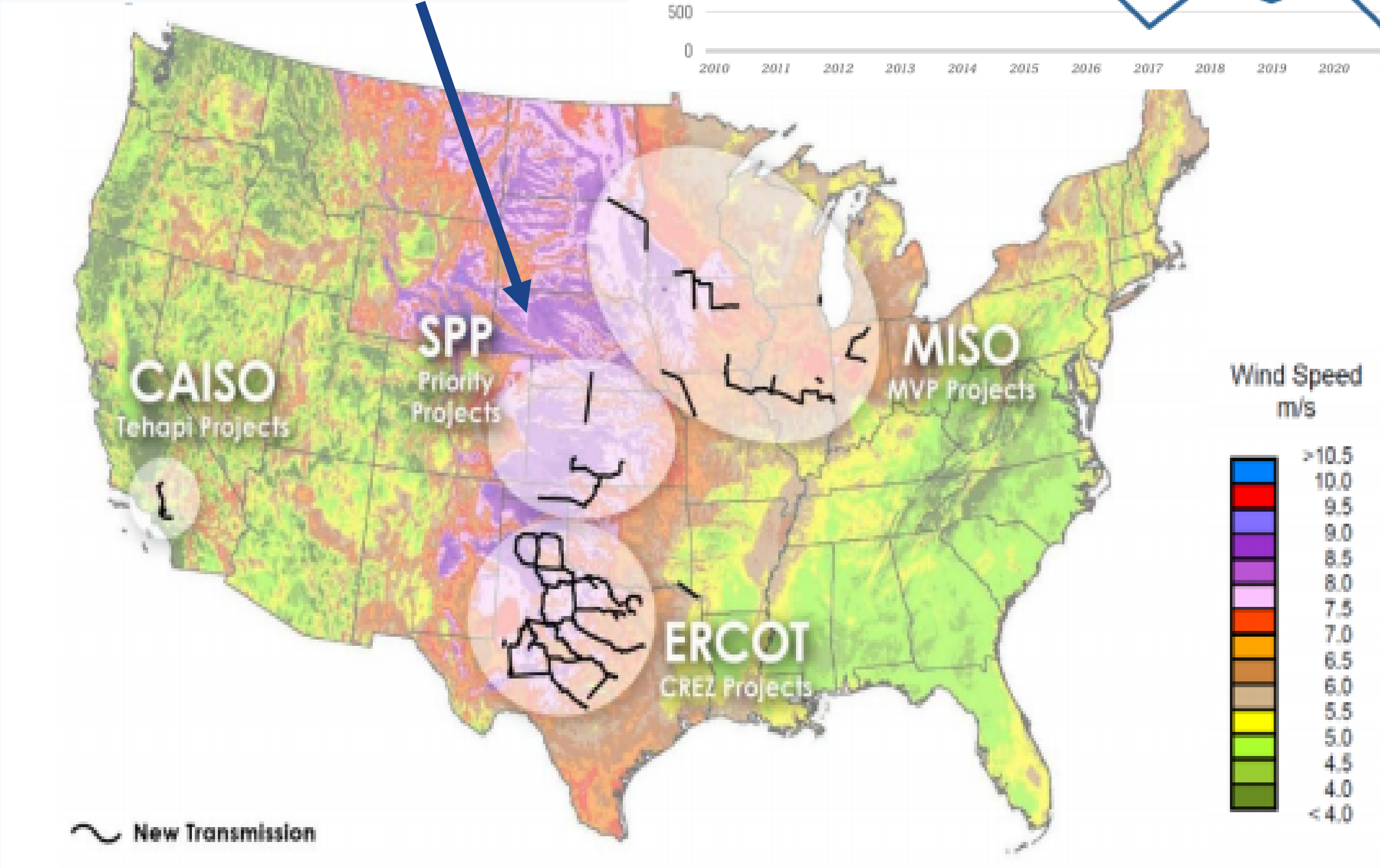
https://gridprogress.files.wordpress.com/2022/09/grid-strategies_fewer-new-miles_final.pdf

Big transmission CAN be built!
Address the 3 Ps

- **Planning**
  - Proactive, all electricity system benefits, probabilistic/scenario based, portfolio of network upgrades, all technology options, community engagement
- **Permitting**
  - Demonstration of benefits with credible regional authorities leads to high batting average
- **Paying**
  - Broad beneficiary pays cost allocation



2013 success



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