The Future Grid Needs Regulatory Reform, Major Transmission Expansion and Deployment of Advanced Technologies

Western Michigan IEEE Section Meeting
May 25, 2021

Jay Caspary

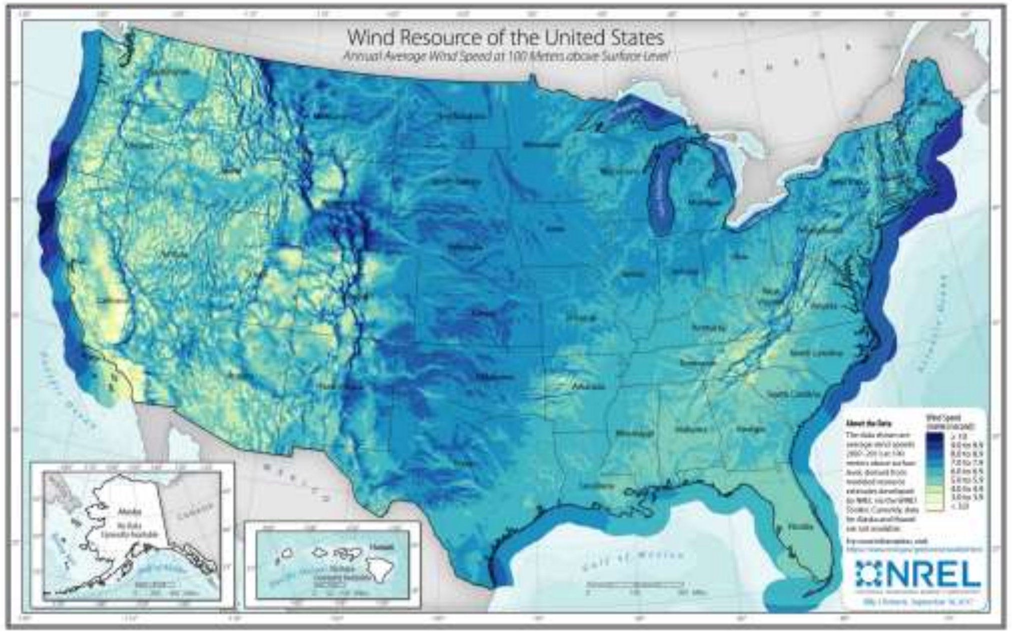
Grid Strategies LLC

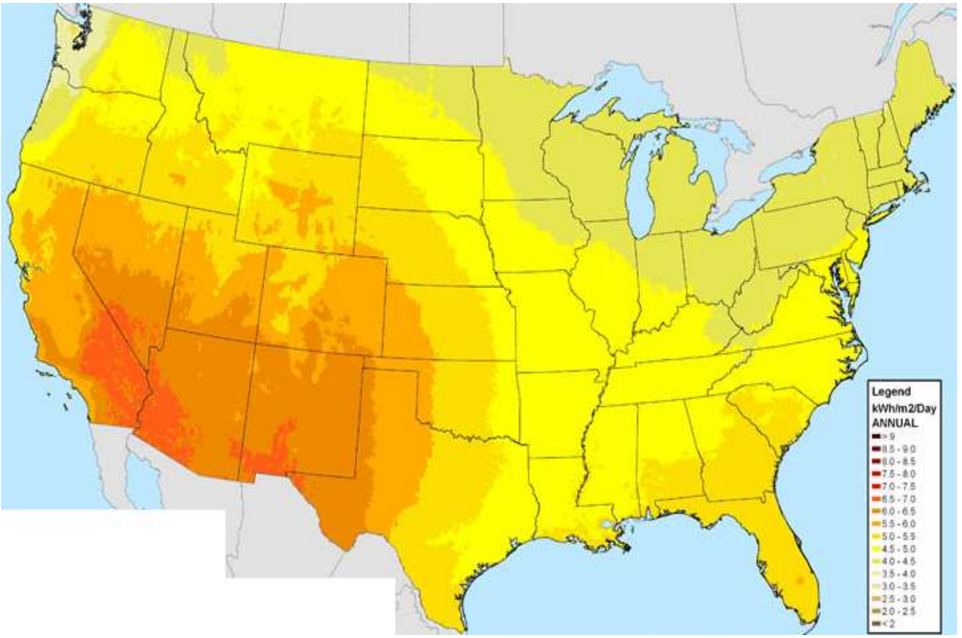
"To respond to the challenge of climate change, we need ambitious investments in our electrical grid. Solar, wind and other renewable energy sources are booming, moving us toward a carbon-free future. But we need a way to connect all this clean energy to our homes. Modernizing our outdated transmission network will create jobs, grow our economy – and allow responsibly sited, cleaner energy to thrive."

--Gina McCarthy, National Climate Advisor

Transmission and Renewable Energy
Inescapable physical properties

1. Best wind and solar far from load. 88% in 15 central states.
2. Regional exchange allows system balancing with higher penetration
3. Transmission supports weak parts of grid as generators retire, system inertia declines





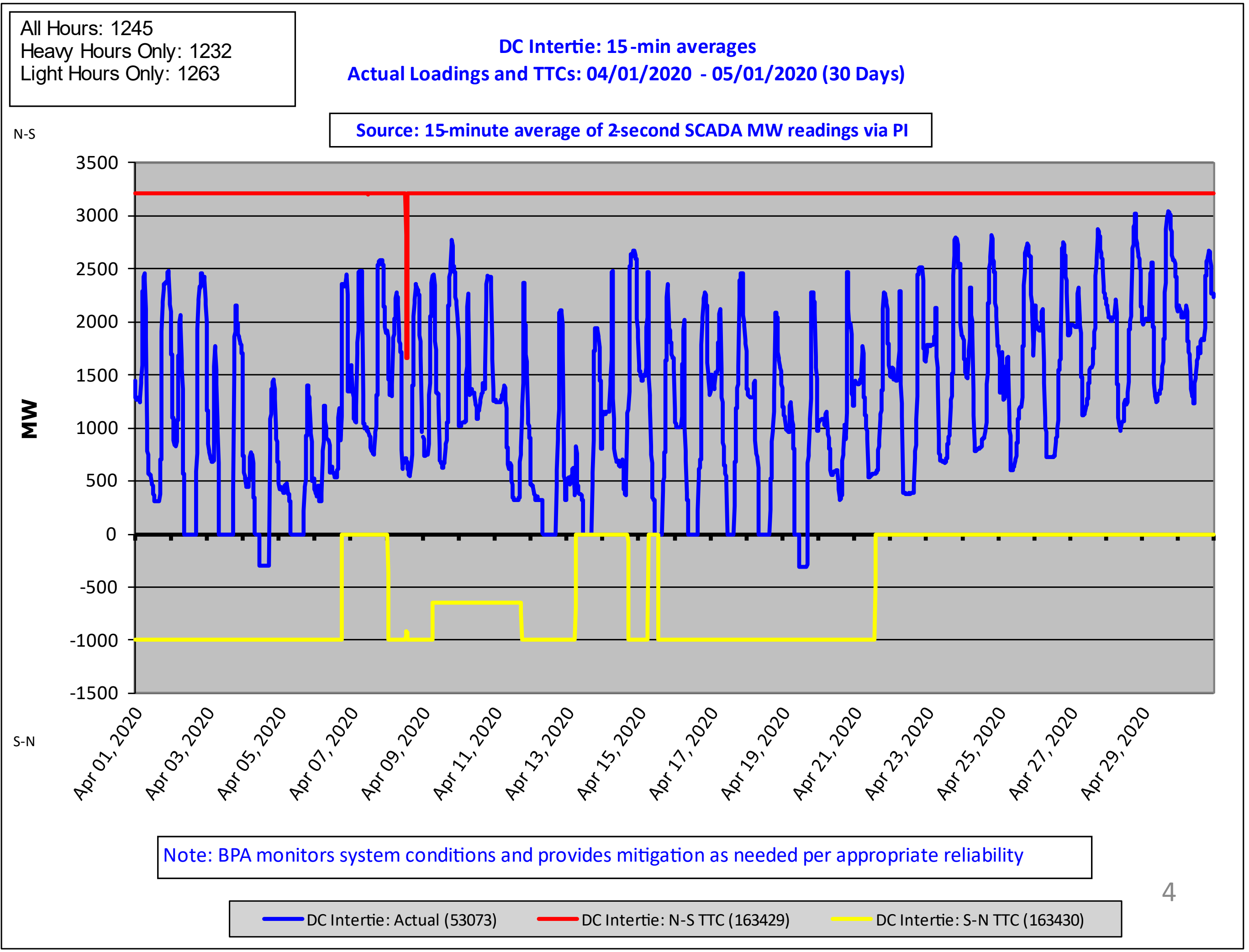
NREL Wind (left, 100m height) and Solar (right) Resource Maps

https://windexchange.energy.gov/maps-data/319 , https://www.nrel.gov/gis/images/map_pv_us_annual10km_dec2008.jpg

How High Penetration Renewable Systems Operate

10s of GWs move back and forth
Daily, seasonal patterns

Actual flows, Pacific DC Intertie



Modeled flows NREL Seam study

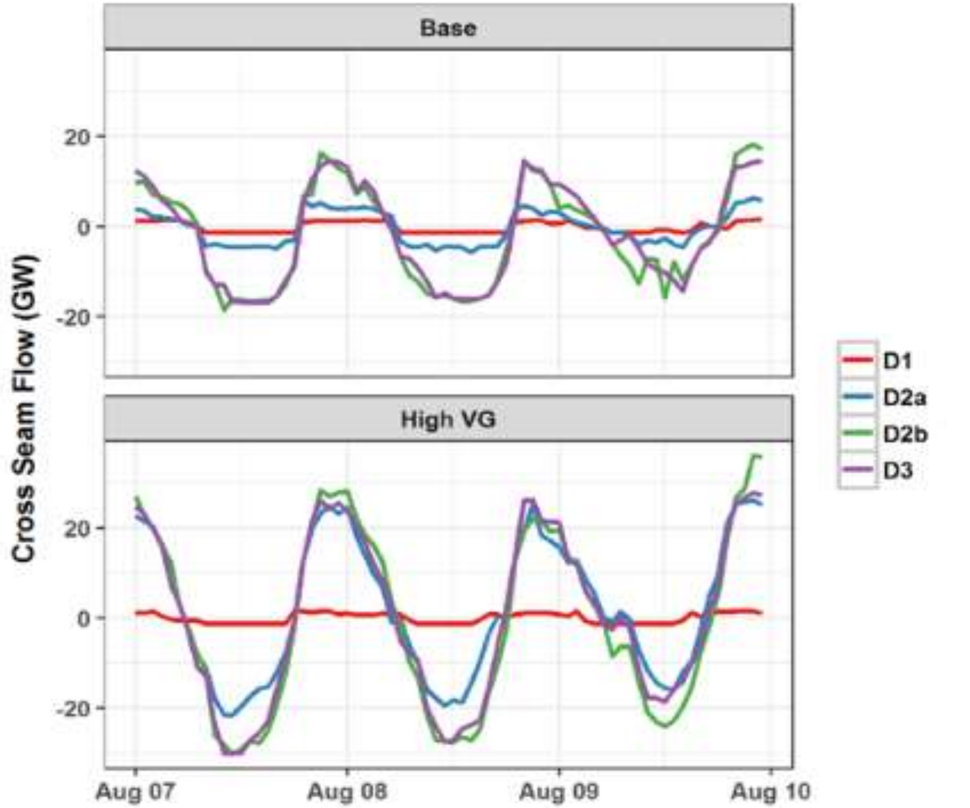
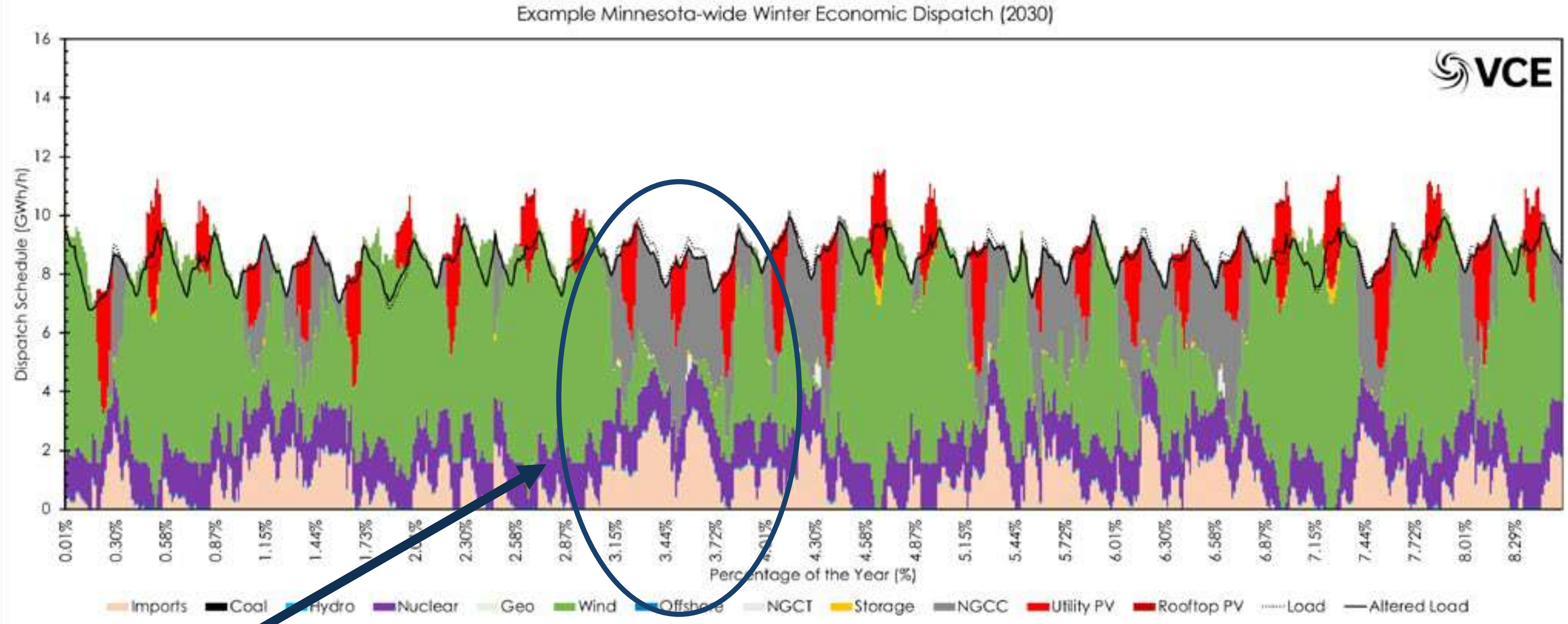


Fig. 3. Cross-seam transmission power flow (B2B and HVDC) during the coincident peak load period. A positive flow is a net export from the EI to the WI; a negative flow is a net import into the EI from the WI. Times are Eastern Standard Time.

Meeting demand in all hours in decarbonized system

Requires imports via transmission (beige) and flexible firm resources (gray)



- Multi-Day periods of low wind+solar, usually winter. Served by imports and firm resources.
- Source: Clack, VCE, Minnesota/Eastern Interconnection study. See also E3, EFI, VCE, Brattle, Jenkins/MIT et al., Gridlab/UC Berkeley, NREL, LBNL, IEA, ESIG, other studies

Transmission is #1 resilience measure

- NYISO: "[R]esiliency is closely linked to the importance of maintaining and expanding interregional interconnections, [and] the building out of a robust transmission system". https://elibrary.ferc.gov/eLibrary/filedownload?fileid=14838201

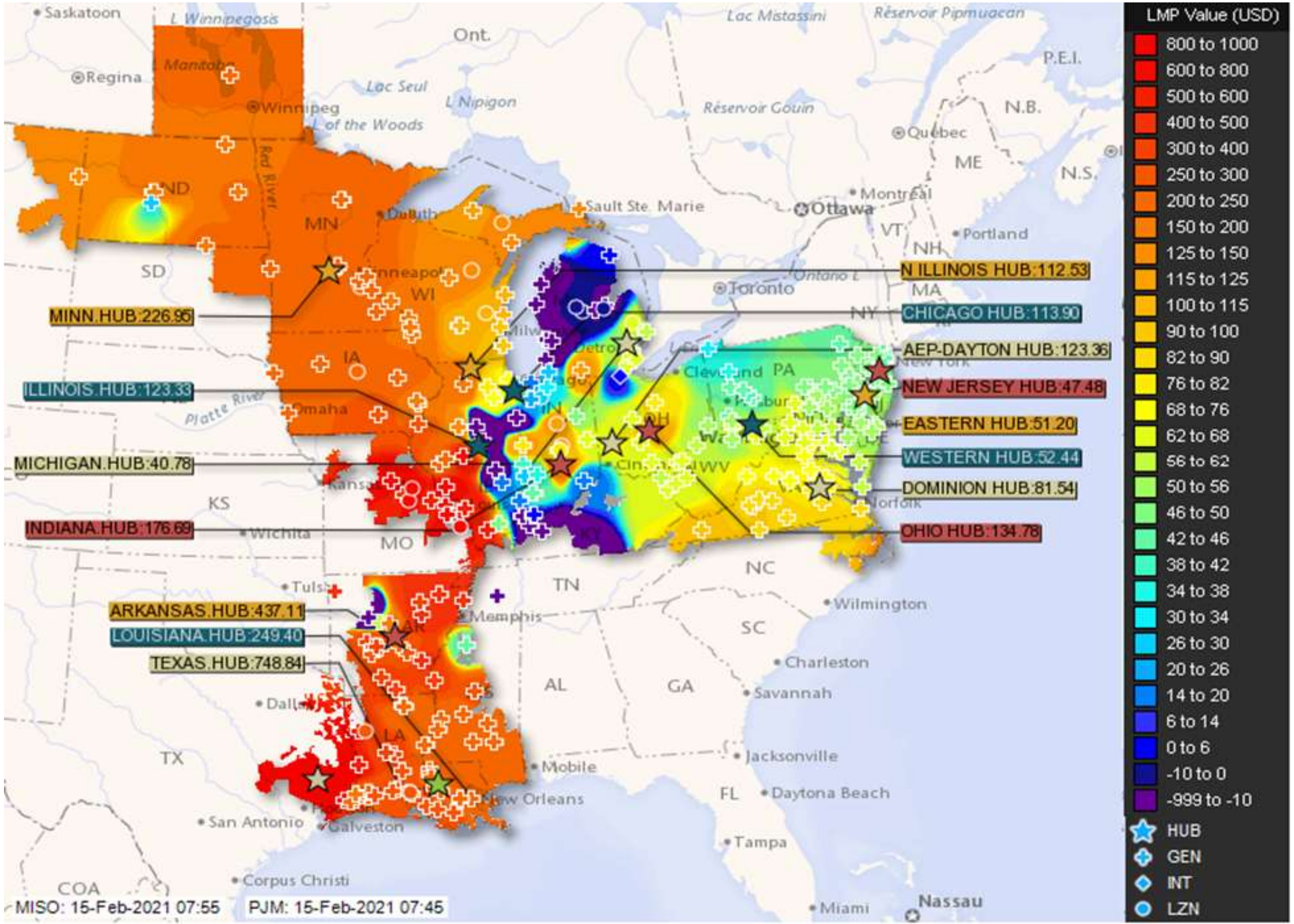
- ISO-NE: "The system's ability to withstand various transmission facility and generator contingencies and move power around without dependence on local resources under many operating conditions . . ., results in a grid that is, as defined by the Commission, resilient." https://elibrary.ferc.gov/eLibrary/filedownload?fileid=14837903

- National Academies of Sciences: "As the complexity and scale of the grid as a cyber-physical system continues to grow, there are opportunities to plan and design the system to reduce the criticality of individual components and to fail gracefully as opposed to catastrophically." https://www.nap.edu/login.php?record_id=24836

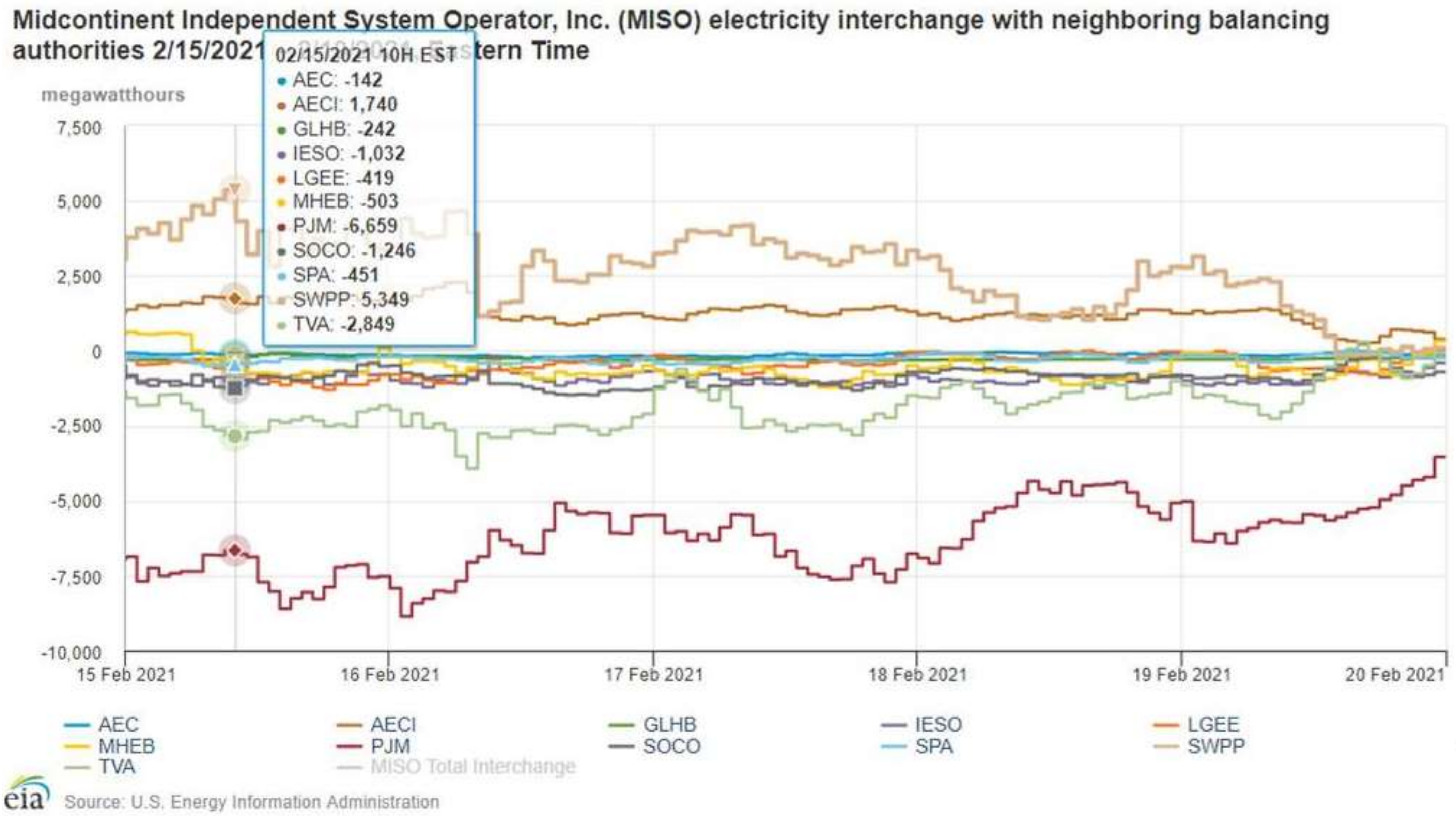
Interregional Transmission Kept the Lights On

in Winter Storm Uri Feb 2021

MISO imported 13 GW, ERCOT only 0.8 GW



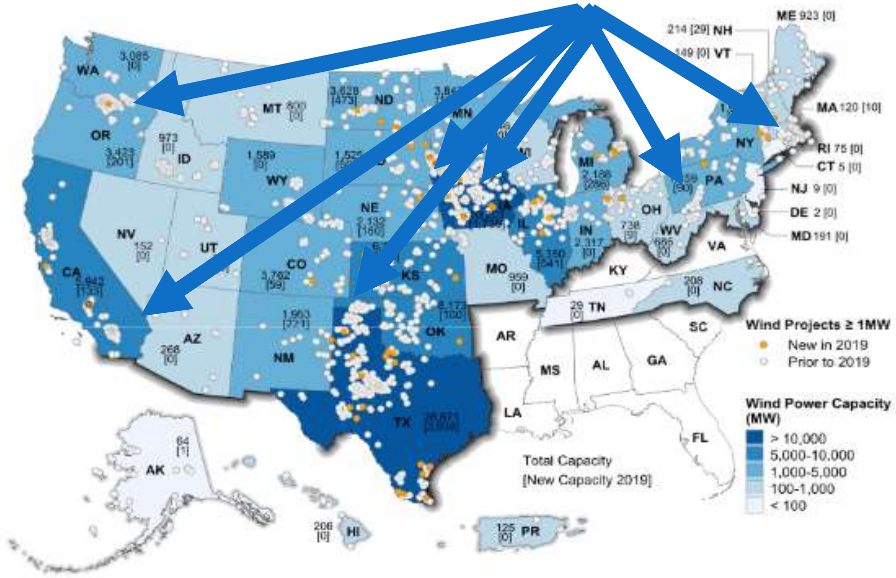
Power flowed from PJM to MISO to SPP



Generation is stuck in interconnection queues

- 734 GW of generation, 90% renewables stuck in queues, end of 2019

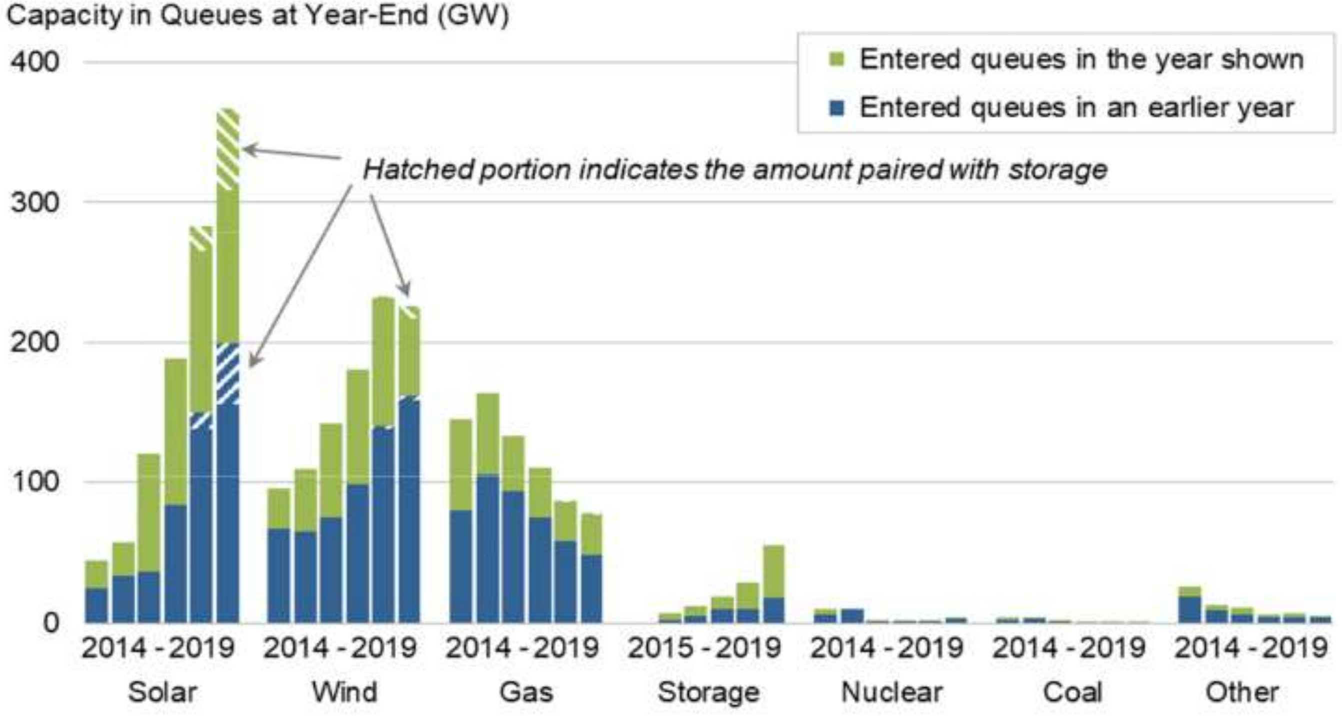
Resource Pockets



Note: Numbers within states represent MegaWatts of cumulative installed wind capacity and, in brackets, annual additions in 2019.

Source: AWEA WindIQ, Berkeley Lab

Wind Project Locations



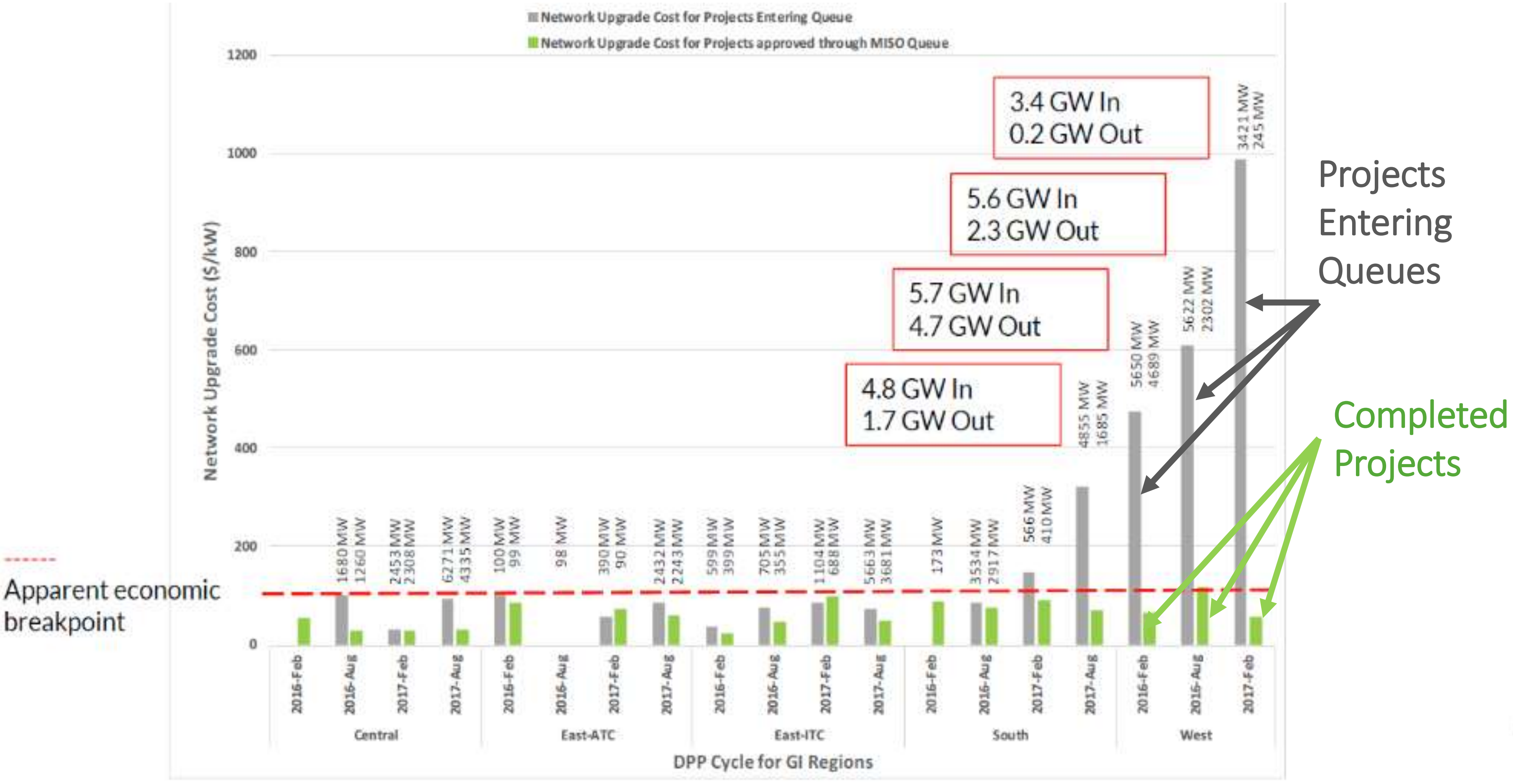
Source: Berkeley Lab review of interconnection queues

Note: Not all of this capacity will be built

Projects Entering Interconnection Queues

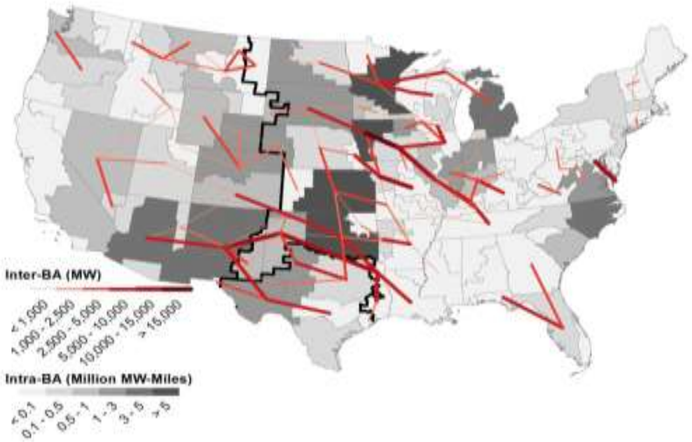
…resulting in massive network upgrade costs

Planning a HV network through an interconnection process is a bad idea



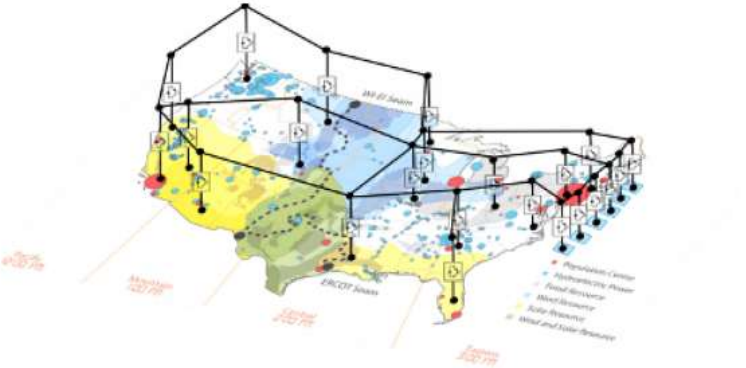
Goal: Enable 10s of GWs of power transfer

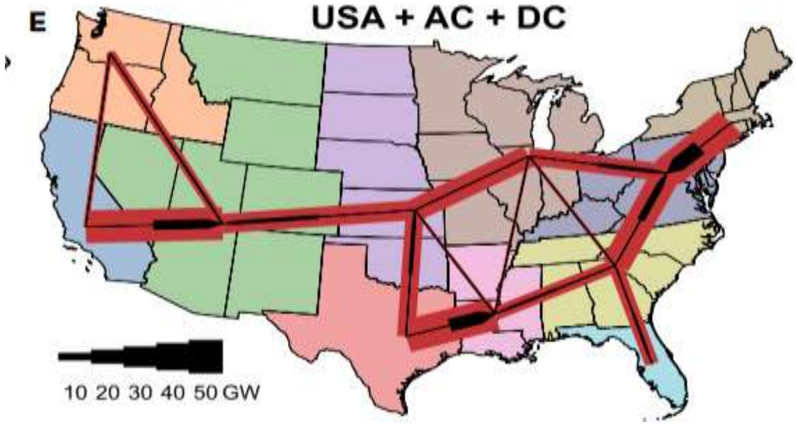
back and forth across and between regions



https://www.nrel.gov/analysis/re-futures.html

https://cleanenergygrid.org/wp-content/uploads/2020/10/Consumer-Employment-and-Environmental-Benefits-of-Transmission-Expansion-in-the-Eastern-U.S..pdf



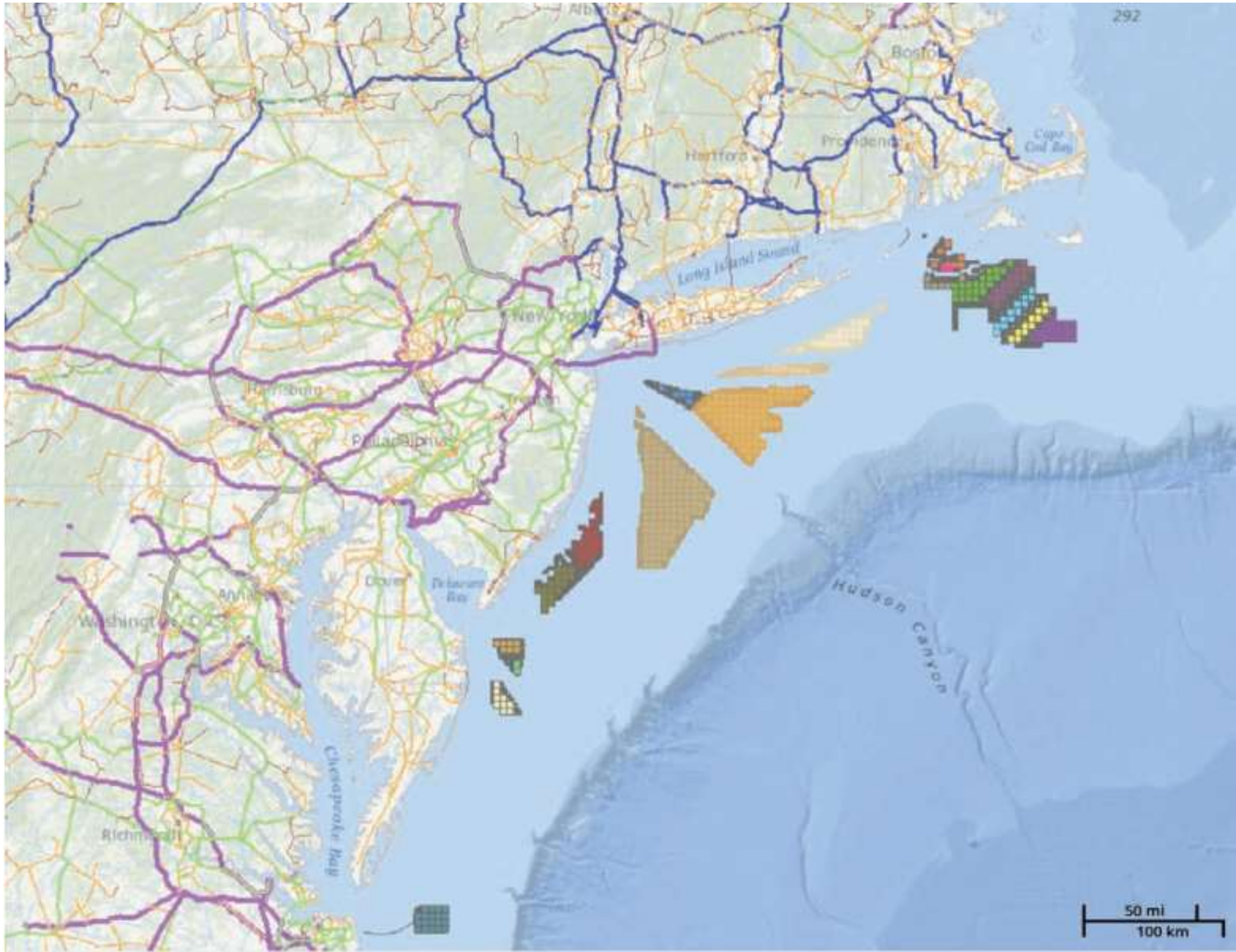


https://cleanenergygrid.org/wp-content/uploads/2020/11/Macro-Grids-in-the-Mainstream-1.pdf

https://www.cell.com/joule/fulltext/S2542-4351(20)30557-2

Offshore too!

- 30 GW in state plans
- Over 100 GW if the Northeast states decarbonize
- Provides diversity along West Coast as well
- High capacity value
- Transmission needed to efficiently access



First, get the most out of the existing grid

with Grid-Enhancing Technologies (GETs)

- GETs are VERY low cost, $0.5k - $25m
- GETs are deployable in MONTHS
- GETs are scalable
- GETs are modular
- GETs are mobile and re-deployable

- GET some GETs!

Grid-Enhancing Technologies

Advanced Power Flow Control

Dynamic Line Rating

Advanced Topology Control

www.watt-transmission.org

WATT Coalition Working for Advanced Transmission Technologies

Ampacimon LINDSEY LINEVISION newgrid SMART WIRES windsim

Transmission Plans Enabled ½ of US Wind Capacity

~110 GW installed in US

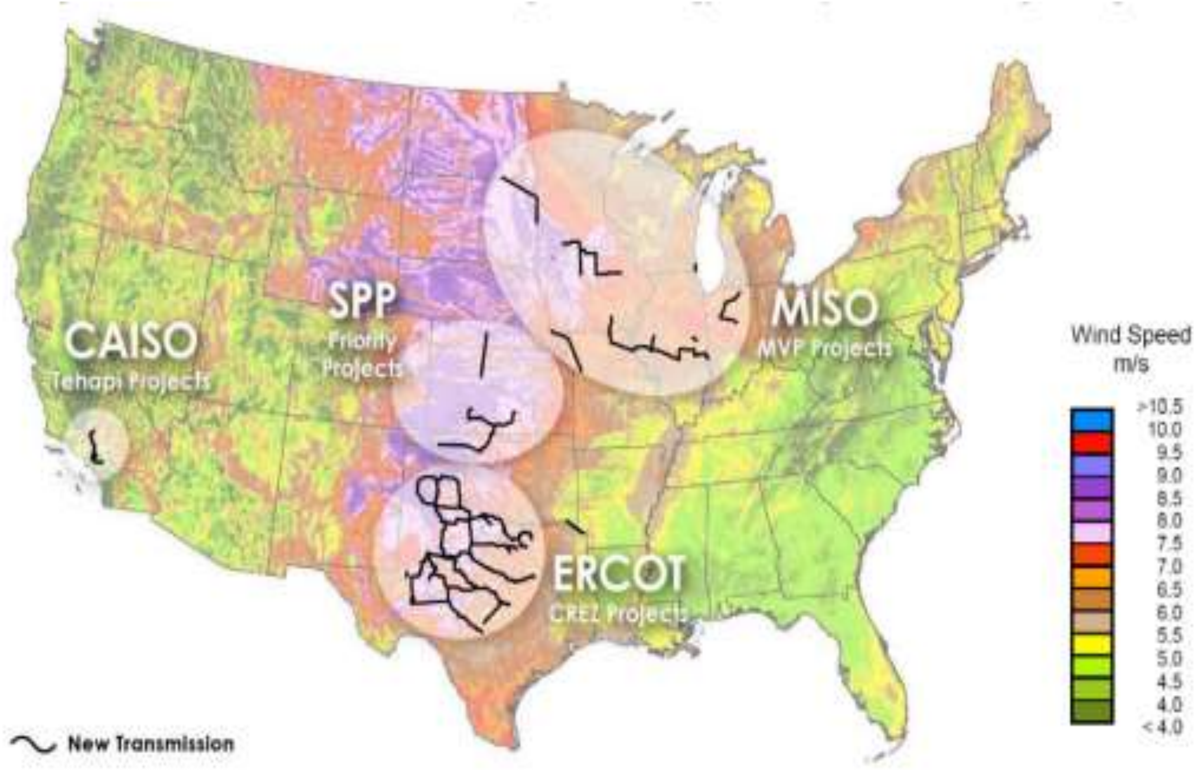
Transmission plan	Wind Capacity Enabled (GW)
Tehachapi CA	4.5
Texas CREZ	14.5
MISO MVP	14
SPP Priority Projects, Balanced Portfolio	6
CO+ME+NV+PAC+BPA	10
Total	49

Source: Grid Strategies estimates

BIG TRANSMISSION CAN BE BUILT!

Recent US Large-Scale Expansions

- MISO MVP, SPP priority projects, ERCOT CREZ
- 3:1 Benefit-Cost ratios
- Winning formula:
  - Pro-active multi-benefit planning
  - Broad, beneficiary pays allocation



Current transmission deficiencies

- Almost no inter-regional lines being planned
- Evolving resource mix, consumer demand, public policies, interconnection queues not being considered
- Competitive process can hinder as much as help development
- Narrow purpose planning reigns
- Reactive, not pro-active
- Grid-Enhancing Technologies ignored
- Deterministic
- Almost all transmission investment is local

- Report available here: https://cleanenergygrid.org/wp-content/uploads/2021/01/ACEG_Planning-for-the-Future1.pdf
- Full recording of webinar featuring all former FERC chairs going back 28 years here: https://cleanenergygrid.org/transmission-time-planning-future-fercs-opportunity-spur-cost-effective-transmission-infrastructure/

REPORT AUTHORS

Rob Gramlich and Jay Caspary

The authors thank Lauren Azar, Jennie Chen, Jenny Erwin, Miles Farmer, Michael Goggin, Bill Hogan, John Jimison, Paul L. Joskow, Alexandra Klass, Natalie McIntire, Ari Peskoe, Johannes Pfeifenberger, Pablo Ruiz, Jesse Schneider, Tyler Stoff, Gabe Tabak, Avi Zevin, and Devin McMackin for valuable contributions. Acknowledgment of their contributions does not imply endorsement of the recommendations.

REPORT SPONSORS

Commissioned by Americans for a Clean Energy Grid with support from the Macro Grid Initiative, a project of the American Council on Renewable Energy.

The time has come for the Federal Energy Regulatory Commission (FERC) to build on its previous orders and strengthen transmission planning through a new nationwide transmission planning and cost allocation rule.

- Policy Statement on Regional Transmission Groups (RTGs) (1993)
- Order No. 888 (1996)
- Order No. 2000 (1999)
- Order No. 890 (2007)
- Order No. 1000 (2011)
- Order No. ??? (2021?)

Recommendations for a New FERC Rule (1/3)

- A new comprehensive FERC planning rule should establish basic guidelines for transmission planning processes to ensure they meet future needs:
  - Require planning processes to rely upon the best available data and forecasting methodologies.
  - Require planning authorities to consider all of the benefits of transmission together.
  - Require transmission planning entities to evaluate all available solutions, including new physical infrastructure options and grid-enhancing technologies, within regional transmission plans to more efficiently serve customers.
  - Direct transmission planning entities to select a portfolio of solutions for each regional and interregional transmission plan that is likely to maximize aggregate net benefits.

Recommendations for a New FERC Rule (2/3)

- **Continue to adhere to the principle that transmission costs must be allocated in a manner roughly commensurate with benefits, while providing planning entities with flexibility in developing methodologies that adhere to this standard.**
  - Direct planning entities to allocate the costs of portfolios of projects as a group, rather than proceeding only on a project-by-project basis.
  - Provide that single metrics such as load flow analysis may not be the sole basis of cost allocation, instead directing planning entities to use methods that account for a broader range of benefits that projects bring the whole system.
  - Assign costs to loads whether or not their affiliated company remains in a Regional Transmission Organization (RTO).
  - Clarify that planning entities may allocate a portion of total costs in the future to generators and customers who utilize the new transmission infrastructure.

Recommendations for a New FERC Rule (3/3)

- **The Commission should ensure transmission investment is as cost-effective as possible.**
  - Ensure that local and end-of-life projects are more carefully evaluated as part of regional planning processes.
  - Ensure there is cost transparency and oversight of transmission costs and that public utility transmission providers are appropriately incented to pursue a more optimal mix of transmission solutions.
  - Consider targeted forms of performance-based rate making that can incent efficiency in project development.
  - Develop a more collaborative approach to transmission planning and ownership among utilities.
  - Ensure that interregional and possibly national transmission infrastructure is more seamlessly facilitated.

ESIG Transmission Planning for 100% Clean Energy

- ESIG held five transmission special sessions in Nov-Dec 2020 to convene over fifty electricity experts to examine transmission needs for 100% clean electricity goals
- Reviewed number of clean energy studies and their transmission plans
- Developed set of recommendations and macro grid concept
- https://www.esig.energy/transmission-planning-for-100-clean-electricity/

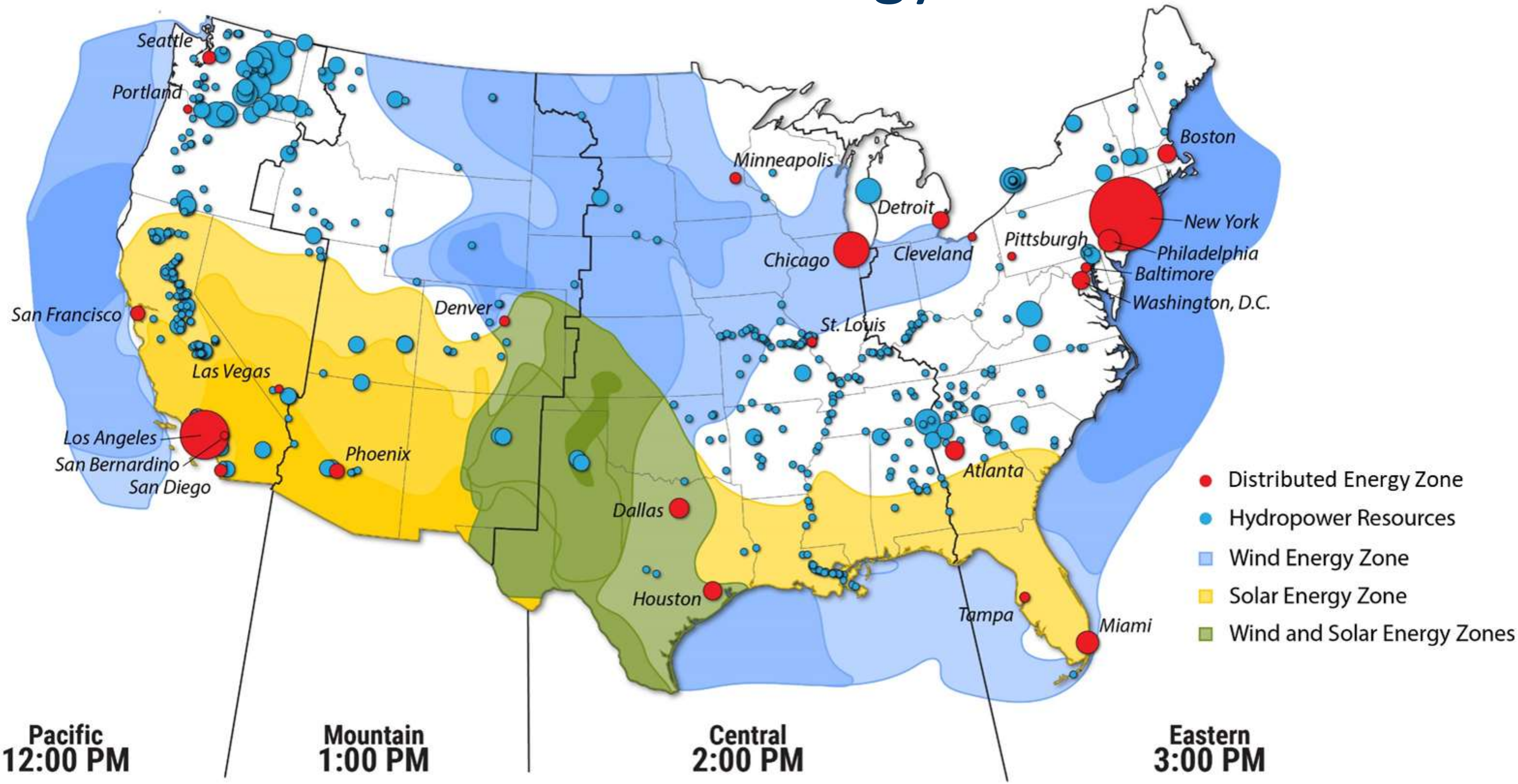
ESIG Recommendations

1. Create a national transmission planning authority
2. Identify renewable energy zones
3. Design a national macro grid

National Planning Process

- Conduct regular, on-going planning activities
- Include comprehensive engineering and economic analysis
- Leverage national and regional capabilities
- Include regional planners, utilities, and governments
- Result in the construction of multi-regional transmission

Renewable Energy Zones



Principles of a Macro Grid

- Connect regions with diverse load and generation profiles
- Have the smallest cost and footprint possible
- Take advantage of existing surplus transmission capability
- Be tightly integrated yet able to separate safely when necessary
- Have a network of transmission lines to minimize risk of failure
- Be built out in several stages

Stages of a Macro Grid

- Stage 1: Start with shovel ready projects that can grow
- Stage 2: Build reliable loops and collector systems
- Stage 3: Review, update, expand

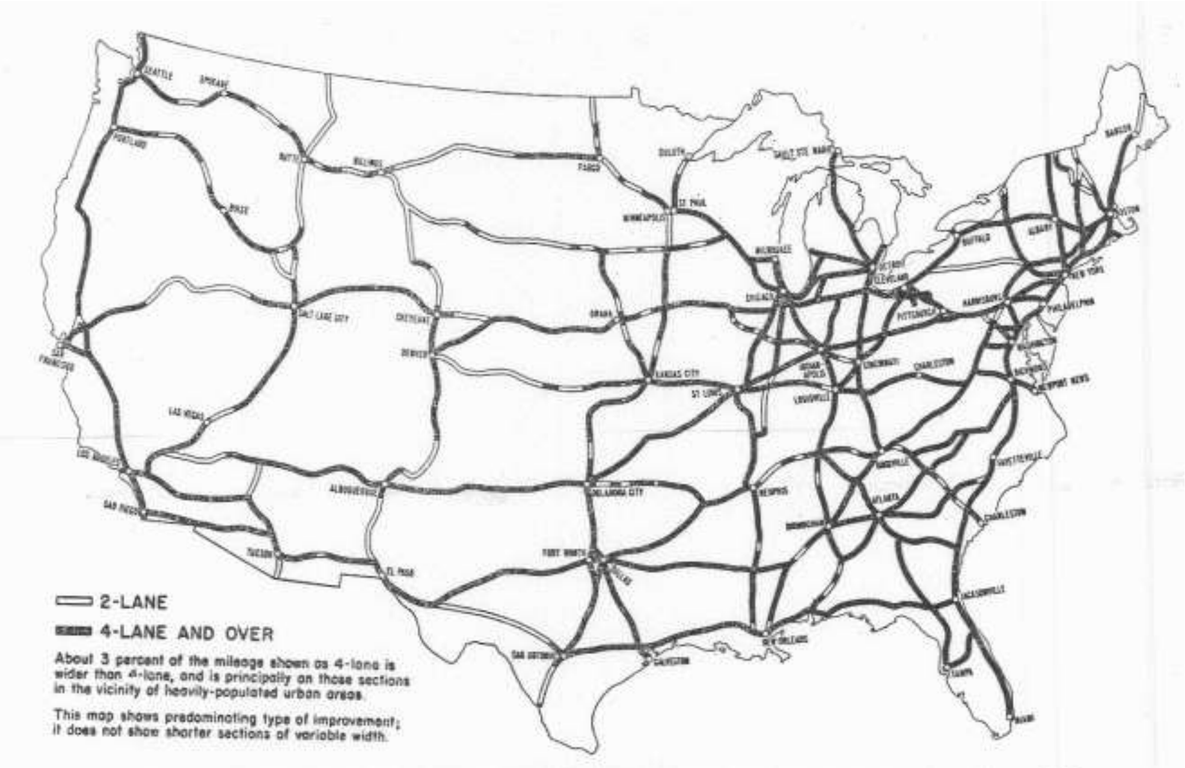
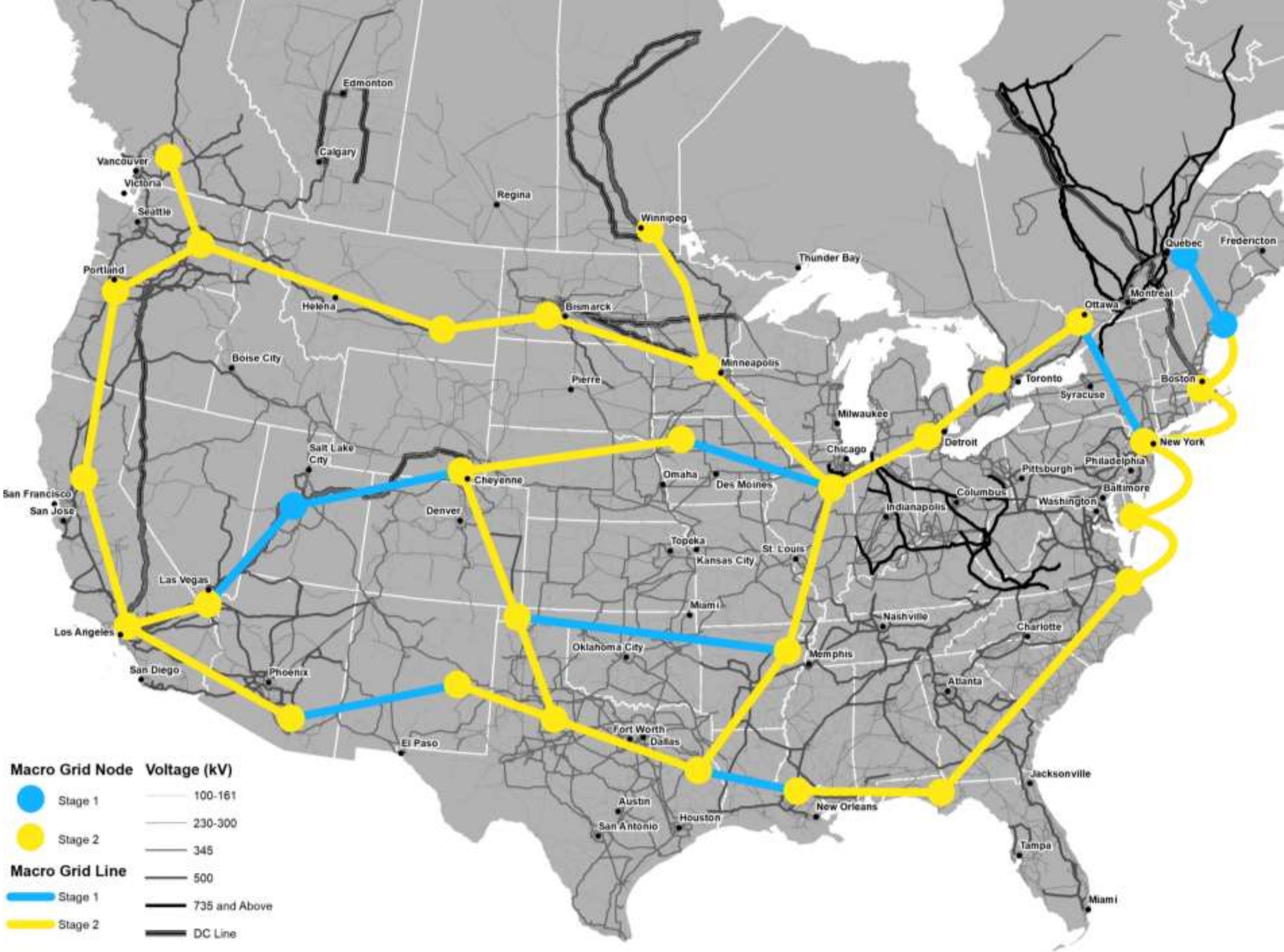


Figure 2.—Estimated status of improvement of the National System of Interstate Highways as to lane width, in 1965.

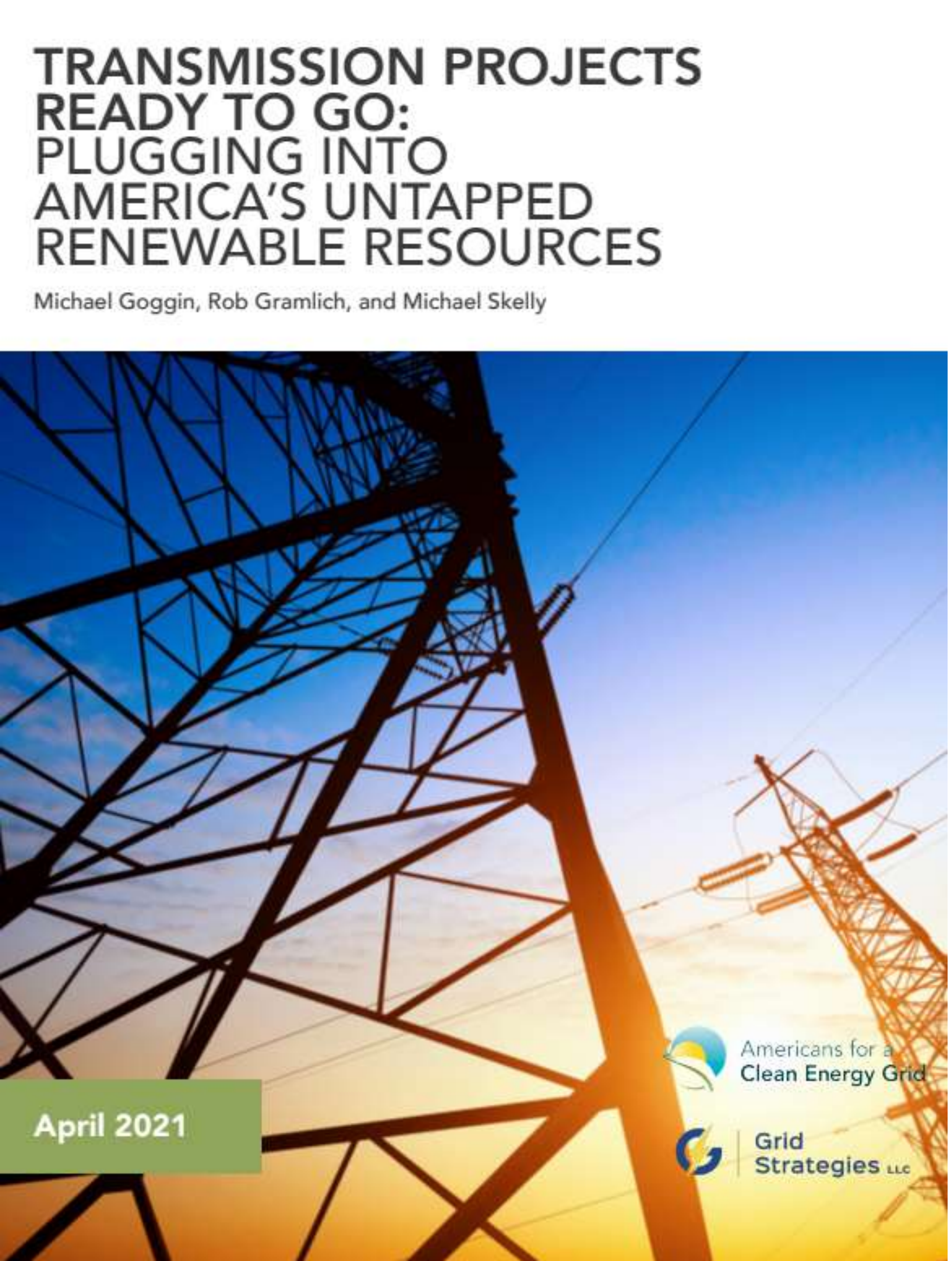
Original US Highway Map

We can’t build a macro grid overnight but that doesn’t mean we shouldn’t start today



ESIG Recommended Next Steps

- Start immediately
- Articulate the decarbonization vision and convene the major players
- Designate and authority
- Leverage national capabilities and industry expertise
- Provide seed funding for new transmission planning and financing



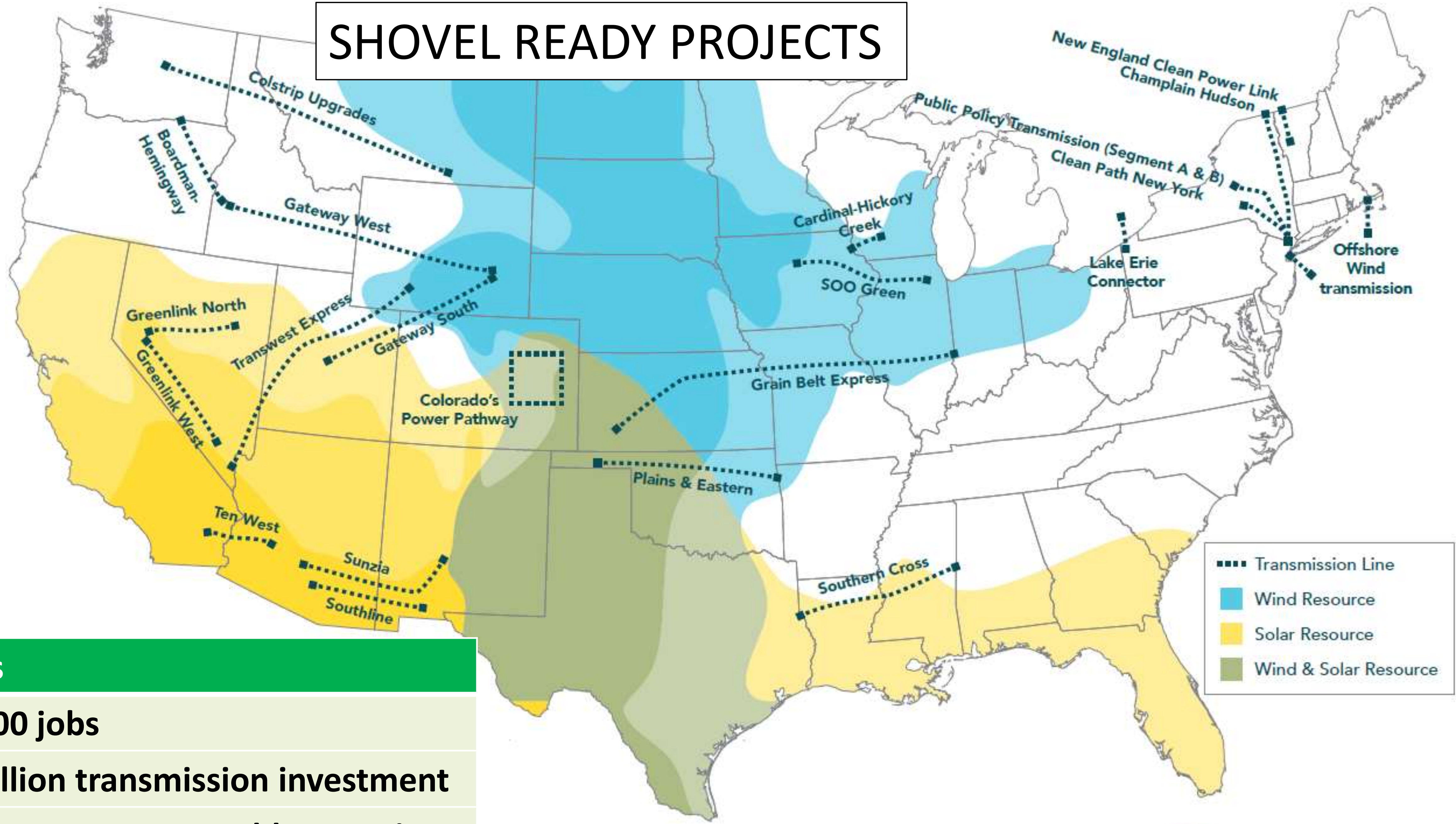
Projects Ready to Go

Produced by the Americans for Clean Energy Grid (ACEG) as part of the Macro Grid Initiative

Launch Event April 27, 2021 concurrent with White House *Fact Sheet: Biden Administration Advances Expansion & Modernization of the Electric Grid.* See https://whitehouse.gov/briefing-room/statements-releases/2021/04/27/fact-sheet-biden-administration-advances-expansion-modernization-of-the-electric-grid/

Projects Read to Go Report as well as recording of launch event is posted at https://cleanenergygrid.org/transmission-time-transmission-projects-ready-to-go/

SHOVEL READY PROJECTS



Benefits
1,240,000 jobs
$33.3 billion transmission investment
60,000 MW new renewable capacity

Americans for a Clean Energy Grid

Details of Projects Ready to Go (1 of 2)

Region	Project Name	Miles	kiloVolts	AC/DC	Costs ($B)
New England	NE Clean Power Link	150	320	DC	$1.600
New York	Clean Path New York Champlain Hudson Public Policy Transmission	265 330 100	320 300 345	DC DC AC	$1.500 $2.200 $1.230
Offshore	Multiple Projects	30	300	DC	$1.902
PJM	Lake Erie Connector	73	320	DC	$1.000
ERCOT - SE	Southern Cross	400	500	DC	$1.400
MISO	SOO Green Cardinal – Hickory Creek	350 100	525 345	DC AC	$2.500 $0.520
SPP	Grain Belt Express Plains & Eastern Oklahoma	780 400	600 600	DC DC	$2.300 $1.200

Details of Projects Ready to Go (2 of 2)

Region	Project Name	Miles	kiloVolts	AC/DC	Costs ($B)
West	TransWest Express	730	600	DC	$3.000
	Colorado's Power Pathway	560	345	AC	$1.700
	GreenLink North Nevada	235	525	AC	$0.810
	GreenLink West Nevada	351	525	AC	$1.608
	Gateway South	400	500	AC	$1.900
	Gateway West	1000	500	AC	$2.880
	Boardman to Hemingway	300	500	AC	$1.200
	Ten West	114	500	AC	$0.300
	Sunzia	515	500	AC,DC	$1.500
	Southline	240	345	AC	$0.800
	Colstrip Upgrades	500	500	AC	$0.227
TOTALS		**7,923**			**$33.278**

Unlocking the Queue with Grid-Enhancing Technologies

CASE STUDY OF THE SOUTHWEST POWER POOL
FINAL REPORT – PUBLIC VERSION

PRESENTED BY

T. Bruce Tsuchida

Stephanie Ross

Adam Bigelow

PREPARED FOR

WATT (Working for Advanced Transmission Technologies) Coalition

FEBRUARY 1, 2021

Brattle

ttps://watt-transmission.org/2021/02/22/unlocking-the-queue/

Issue at Hand

What are the roadblocks to integrating more renewables?

- Utilities and system operators have good understandings of the variability of renewable resources.
  - Wind became SPP's leading resource in 2020.
- Transmission availability is a major limiting factor.
  - Many renewable projects are locked up in the Generation Interconnection Queue.
  - There is a timing gap: renewables are developed (in months to years) much faster than transmission (in years to sometimes decades).
  - Utility-scale renewables are usually more cost efficient (on a $/MWh basis) compared to distributed resources.

Can Grid-Enhancing Technologies (GETs) help integrate more renewables?

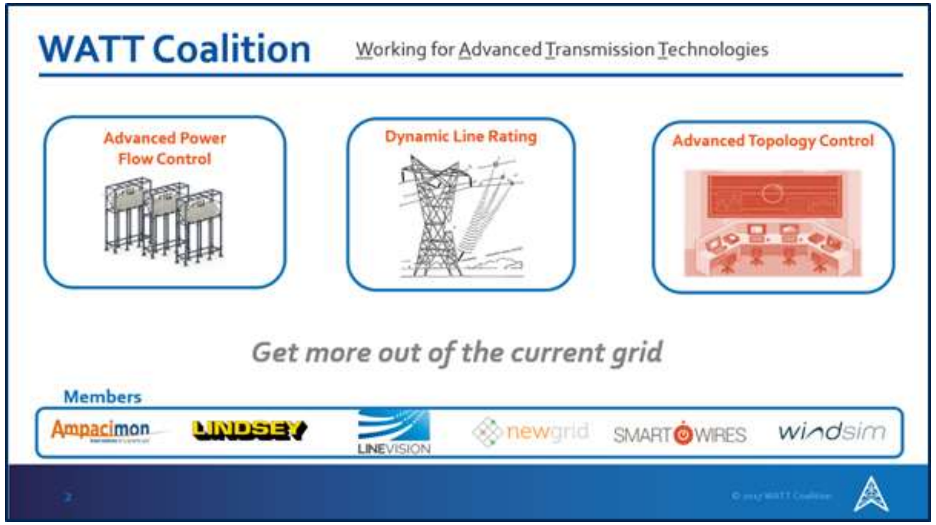
- GETs quickly and cost-effectively help maximize the capability of the existing transmission system

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Overview - 1/2

Goal: Analyze how much additional renewables can be added to the grid using Grid-Enhancing Technologies (GETs):

- GETs enhance transmission operations and planning.
- GETs complement building new transmission—they can bridge the timing gap until permanent expansion solutions can be put in place.
- While there are various types of GETs, this study focuses on the combined impact of the following three technologies:
  - **Advanced Power Flow Control**: Injects voltage in series with a facility to increase or decrease effective reactance, thereby pushing power off overloaded facilities or pulling power on to under-utilized facilities.
  - **Dynamic Line Ratings (DLR)**: Adjusts thermal ratings based on actual weather conditions including, at a minimum, ambient temperature and wind, in conjunction with real-time monitoring of resulting line behavior.
  - **Topology Optimization**: Automatically finds reconfiguration to re-route flow around congested or overloaded facilities while meeting reliability criteria.

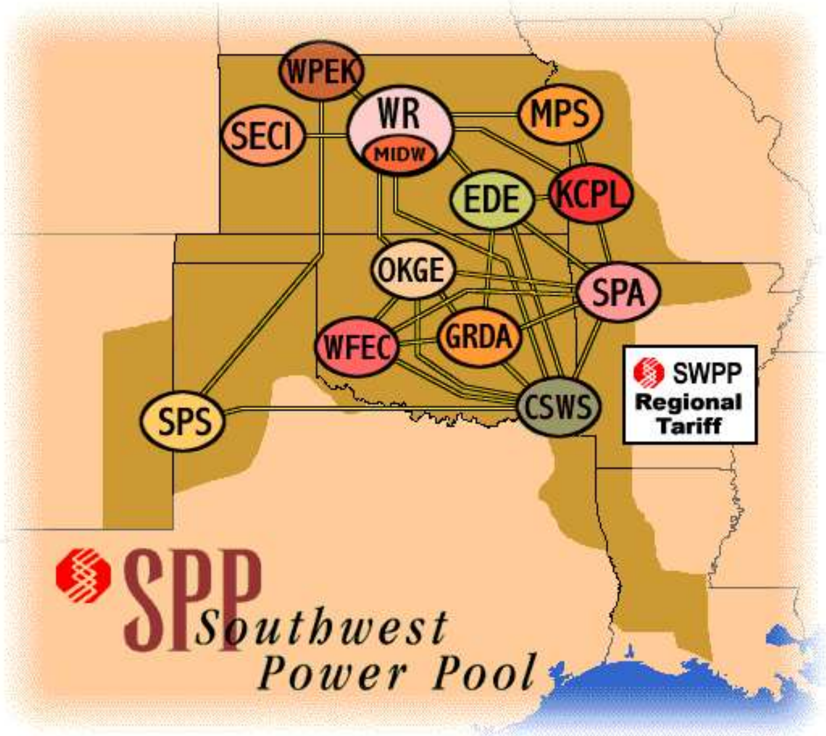


Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Overview - 2/2

Goal: Analyze how much additional renewables can be added to the grid using Grid-Enhancing Technologies (GETs):

- Use the Southwest Power Pool (SPP) grid (focused on Kansas and Oklahoma, looking at 2025) as an illustrative case study.
  - SPP Generation Interconnection Queue* (GI Queue) shows ~9 GW of renewable resources with an Interconnection Agreement (IA) executed in Kansas and Oklahoma.
  - SPP Integrated Transmission Planning (ITP) Reports** show high congestion.
- Results metrics for the combined (not for individual) three GETs include:
  - Renewables added (capacity [GW] and energy [GWh]).
  - Economic benefits (production costs, investments, jobs, etc.)
  - Carbon emissions reduction.



SPP figure from http://opsportal.spp.org/Images/SPPMap.gif
* SPP GI Queue as of September 28, 2020
** 2019 Integrated Transmission Planning (available at: https://spp.org/Documents/60937/2019%20ITP%20Report_v1.0.pdf) and Q3 2020 Quarterly Project Tracking Report (available at: https://www.spp.org/documents/62710/q3%202020%20qpt%20report%20draft.pdf)

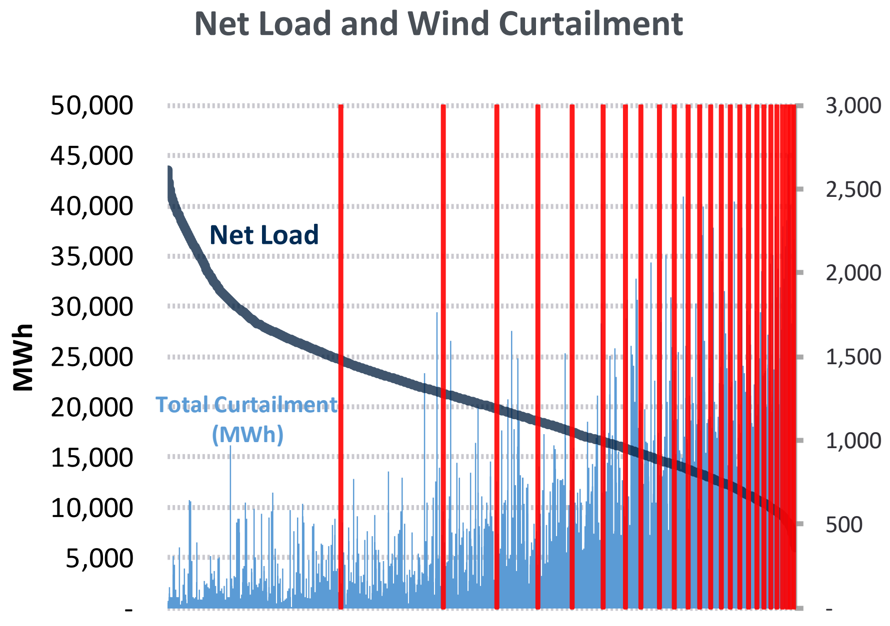
Study Approach - 1/2

Study purpose

- Quantify the benefits of **the three GETs combined** for integrating renewable resources (largely wind) using SPP as a test bed.

Analysis approach

- Select 24 representative historical power flow snapshots of SPP operations (2019 – 2020) that together reasonably represent a full year.
- Modify the snapshots to reflect new transmission upgrades, renewable projects from the GI queue, announced retirements, load change, etc.
- Find the maximum renewables amount (GW and GWh) that can be integrated under a business as usual scenario (Base Case) and then with GETs (With GETs Case), sequentially in the order of DLR, Topology Optimization, and Advanced Power Flow Control, by simulating the entire SPP system using the 24 power flow cases.
- Assess benefits of GETs including economic values (production costs, jobs, local benefits etc.) and carbon emissions reduction.



Areas between red line indicates the bins from which snapshots were selected, blue bars indicate curtailment of renewables. Each bin contains equal amounts of curtailment.

Study Approach - 2/2

Study purpose

- Quantify the benefits of **the three GETs combined** for integrating renewable resources (largely wind) using SPP as a test bed.

Finding the maximum amount of renewables that can be integrated

- Analysis is performed separately for the Base Case and With GETs Case for all 24 snapshots.
- Analysis is done using an iterative process:
  - Determine feasible reduction in thermal unit generation to accommodate additional renewable resources.
  - Dispatch wind and solar to their max output by running Security Constrained Optimal Power Flow (SCOPF).
  - Iteratively solve SCOPF (i.e., solve SCOPF, take out renewable projects with high curtailments, then resolve SCOPF, and repeat).
- Analysis assumes a 5% curtailment threshold for viability assessment (i.e., projects are viable if analysis indicates annual curtailments to be less than 5%).
  - Curtailment occurs largely for two reasons—transmission congestion (which the GETs will help solve) and minimum generation constraints of other generation resources.

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Results - 1/5

GETs enable more than twice the amount of additional new renewables to be integrated.

- Potential Renewables Considered: 9,430 MW
  - Based on queue projects with IA executed.
- Integrated Renewables (without further transmission upgrades)
  - Base Case: 2,580 MW
  - With GETs Case: 5,250 MW
  - Delta (With GETs Case – Base Case): 2,670 MW

RENEWABLE POTENTIAL ASSUMED FOR KANSAS AND OKLAHOMA

State	Wind	Solar	Total
Kansas	3,410	120	3,530
Oklahoma	5,760	140	5,900
Total	9,170	260	9,430

[Rounded to the nearest 10 MW]

~1.5 times the amount of wind SPP integrated in 2019 (1.8 GW).

ADDITIONAL RENEWABLES INTEGRATED

State	Base Case			With GETs Case			Delta (GETs - Base)		
	Wind	Solar	Total	Wind	Solar	Total	Wind	Solar	Total
Kansas	1,710	0	1,710	1,910	0	1,910	200	0	200
Oklahoma	770	100	870	3,200	140	3,340	2,430	40	2,470
Total	2,480	100	2,580	5,110	140	5,250	2,630	40	2,670

X2

[Rounded to the nearest 10 MW]

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Results - 2/5

GETs enable more than twice the amount of additional new renewables to be integrated.

- Additional renewables enabled by GETs: **2,670 MW / 8,776 GWh**.
  - 2,630 MW of **new wind** is assumed to produce over 8,640 GWh of energy per year.
  - 40 MW of **new solar** is assumed to produce about 60 GWh of energy per year.
  - GETs lower curtailment of **existing wind** by over 76,000 MWh per year.
- GETs installation cost is about $90 million.
  - Annual O&M costs is estimated to be around $10 million.
- GETs benefits (other than the value of additional renewables) include:

ANNUAL PRODUCTION COST SAVINGS
$175 million

ANNUAL REDUCED CARBON EMISSIONS
3 million tons

Additional Renewables enabled by GETs
2,670 MW / 8,776 GWh

LOCAL JOBS
650 long-term jobs and
11,300 short-term jobs

OTHER LOCAL BENEFITS
$15 million land lease and
$32 million tax revenues per year

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Results - 3/5

GETs enable more than twice the amount of additional new renewables to be integrated.

- Estimated annual production cost savings: **$175 million**.
  - Pay-back for GETs investment (~$90 million) is about half a year.
  - $175 million conservatively assumes $20/MWh savings for 8,776 GWh of energy.
  - $20/MWh is at the lower end of the generation cost of a new natural gas-fueled combined cycle plant or coal plant and lower than average 2019 LMP (both day-ahead and real-time).
- Estimated job benefits associated with the increased renewables (2,670 MW):
  - Over 11,300 direct short-term jobs (largely construction of renewables).
  - Over 650 direct long-term jobs for operation and maintenance of the renewable resources.
- Estimated carbon emissions reduction: **Over 3 million tons per year.**
  - Conservatively assumes the renewables replace carbon emissions from natural gas-fueled combined cycle plants.
  - Less efficient resources with higher heat rates and emission rates are more likely to be replaced.
- Other estimated benefits include:
  - Local benefits estimated to be over $32 million annual tax revenues and $15 million land lease revenues (based on literature research).

Study Results - 4/5

Key benefits of GETs for Kansas and Oklahoma

- Enable more than **twice** the amount of additional new renewables to be integrated.
  - This is 1.5x the amount of wind SPP integrated in 2019.
- Estimated annual production cost savings: $175 million.
  - Payback for GETs investment is about 0.5 years.
- Estimated carbon emissions reduction: Over 3 million tons per year.
- Over 11,300 direct short-term and 650 direct long-term jobs.
- Over $32 million annual tax revenues and $15 million land lease revenues.

Potential Nation-Wide Benefits

Extrapolating these results to a nation-wide level* indicate GETs to provide **annual benefits** in the range of:

+ Over **$5 billion** (~$5.3 billion) in production cost savings.
+ **$90 million tons** of reduced carbon emission (more than enough to offset **ALL NEW** automobiles sold in the U.S. a year).
+ About **$1.5 billion** in local benefits (local taxes and land lease revenues).
+ More than 330,000 short-term (only for first year) and nearly 20,000 long-term jobs.
+ Investment cost is $2.7 billion (only for first year). Ongoing costs would be around $300 million per year.

* EIA shows 2019 generation in Kansas and Oklahoma combined (136 TWh) was about 1/30 of the nationwide generation from utility-scale resources (4,100 TWh). EIA data, available at: https://www.eia.gov/electricity/state/kansas/, https://www.eia.gov/electricity/state/oklahoma/, and https://www.eia.gov/electricity/annual/html/epa_01_01.html

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Study Results - 5/5

GETs utilized in this study include:

- **Hardware solutions**: DLR on 56 lines and Advanced Power Flow Control on 8 locations.

Hardware Solutions by Voltage Level	345	230	161	138	115	69	Total
DLR*	10	3	11	22	3	7	56
Advanced Power Flow Control	3	0	4	1	0	0	8

- **Software solutions**: 204 unique Topology Optimization reconfigurations, averaging 13 per snapshot.**

Software Solutions by Voltage Level	345	230	161	138	115	69	Total
Lines	20	10	31	75	4	30	170
Substations	4	0	1	1	0	0	6
Transformers (high voltage terminal)	10	1	4	13	0	0	28

- Estimated costs for implementing the above GETs: ~$90 million.
  - Initial investment costs is estimated to be around $90 million.***
  - Ongoing costs of around $10 million per year.***

* Every DLR installation requires 15 to 30 sensors.

** Average actions represent the average number of actions that remain per case, not actions per hour. Based on other studies the average number of actions per hour is expected to be smaller, typically less than the number of topology changes due to planned outages.

*** Costs can vary project by project, and also on how the GETs service is provided—for example, Topology Optimization can be provided as a software subscription service to reduce the initial cost. We also assume utilities can incorporate these technologies without large costs.

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Table of Contents

Slides excerpted from full report, available at https://watt-transmission.org/2021/02/22/unlocking-the-queue/

Jay Caspary

Vice President

Grid Strategies LLC

jcaspary@gridstrategiesllc.com

(m) 501.951.3296