Transmission Planning for the Future

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Rob Gramlich

www.gridstrategiesllc.com

@RobGramlichDC

Grid Strategies LLC

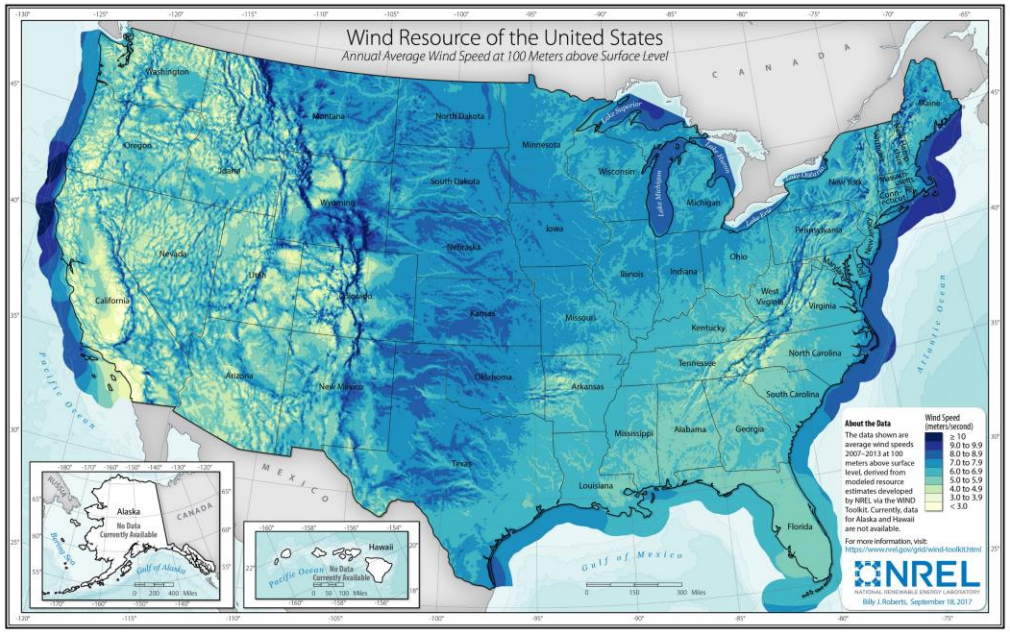
“To respond to the challenge of climate change, we need ambitious investments in our electrical grid. Solar, wind and other renewable energy sources are booming, moving us toward a carbon-free future. But we need a way to connect all this clean energy to our homes. Modernizing our outdated transmission network will create jobs, grow our economy – and allow responsibly sited, cleaner energy to thrive.”

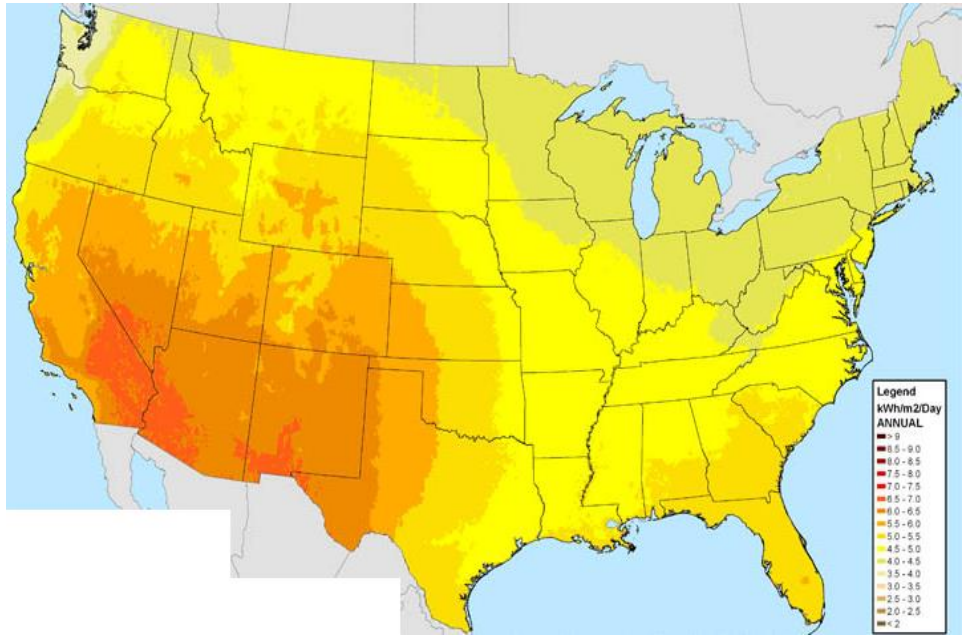
--Gina McCarthy, National Climate Advisor

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

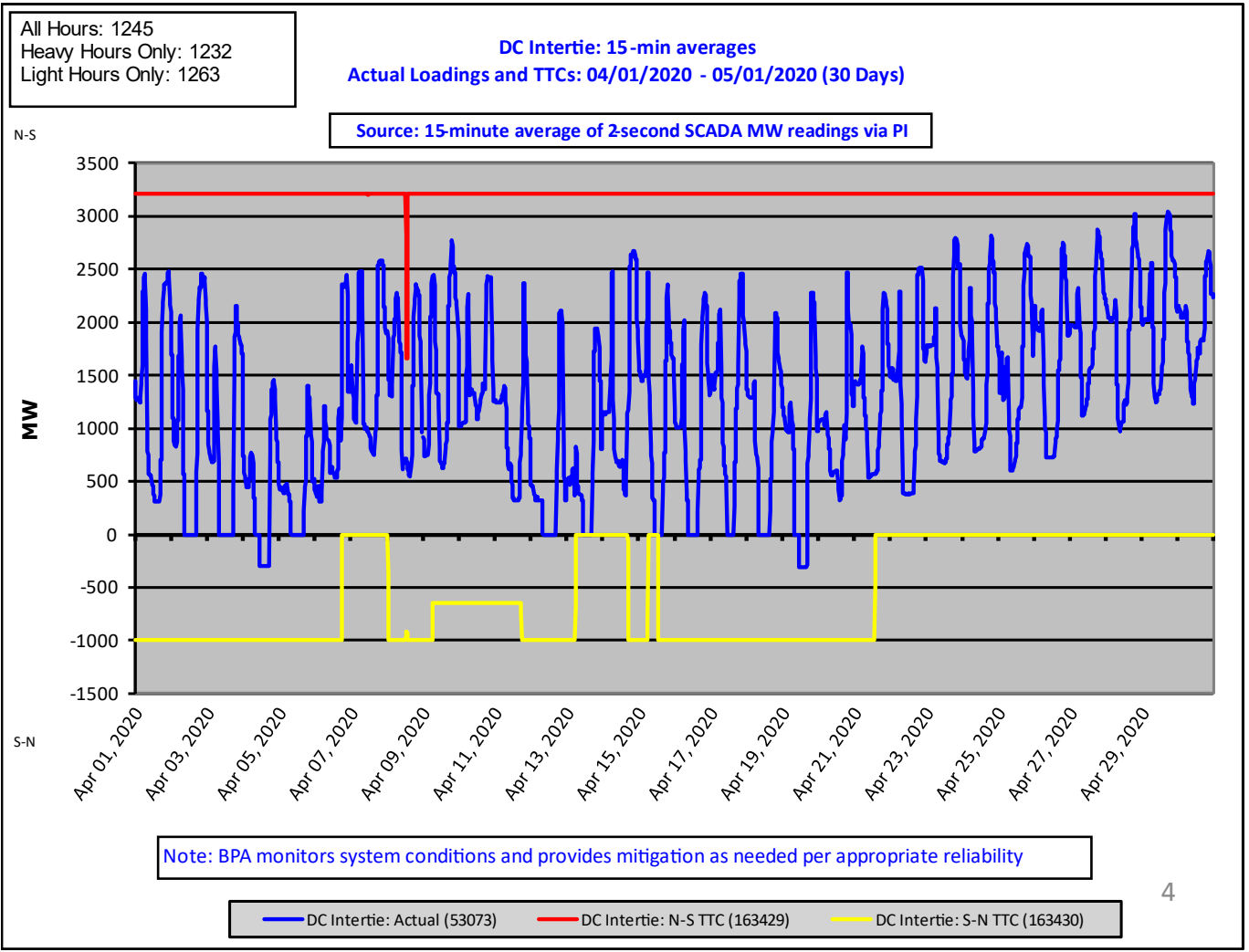
https://windexchange.energy.gov/maps-data/319 , https://www.nrel.gov/gis/images/map_pv_us_annual10km_dec2008.jpg

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

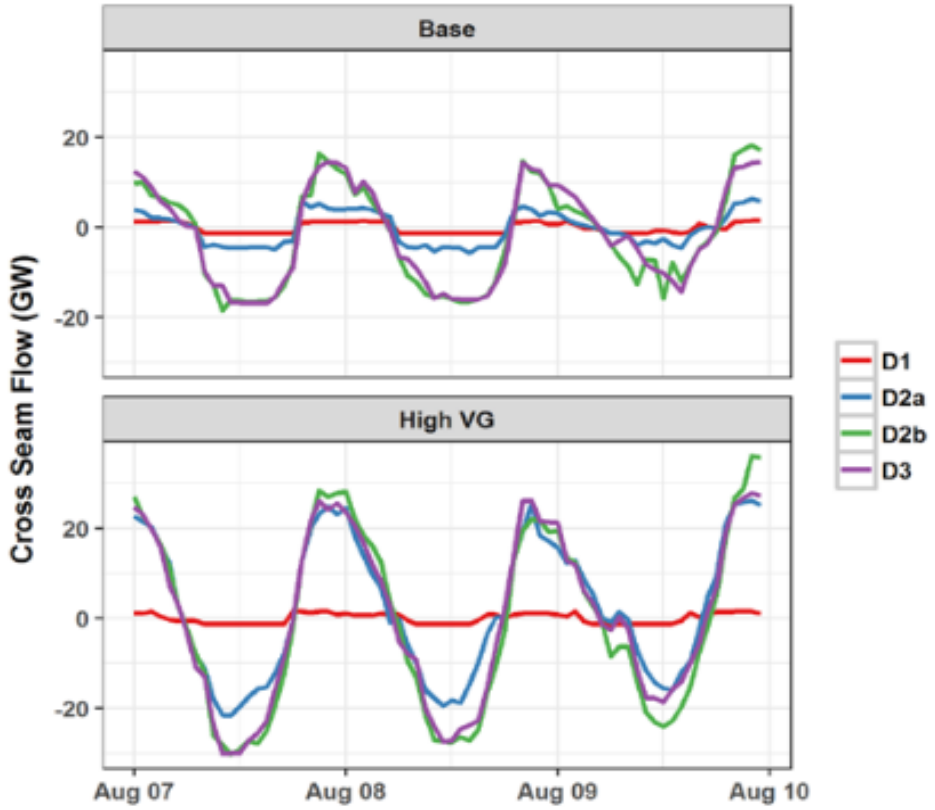
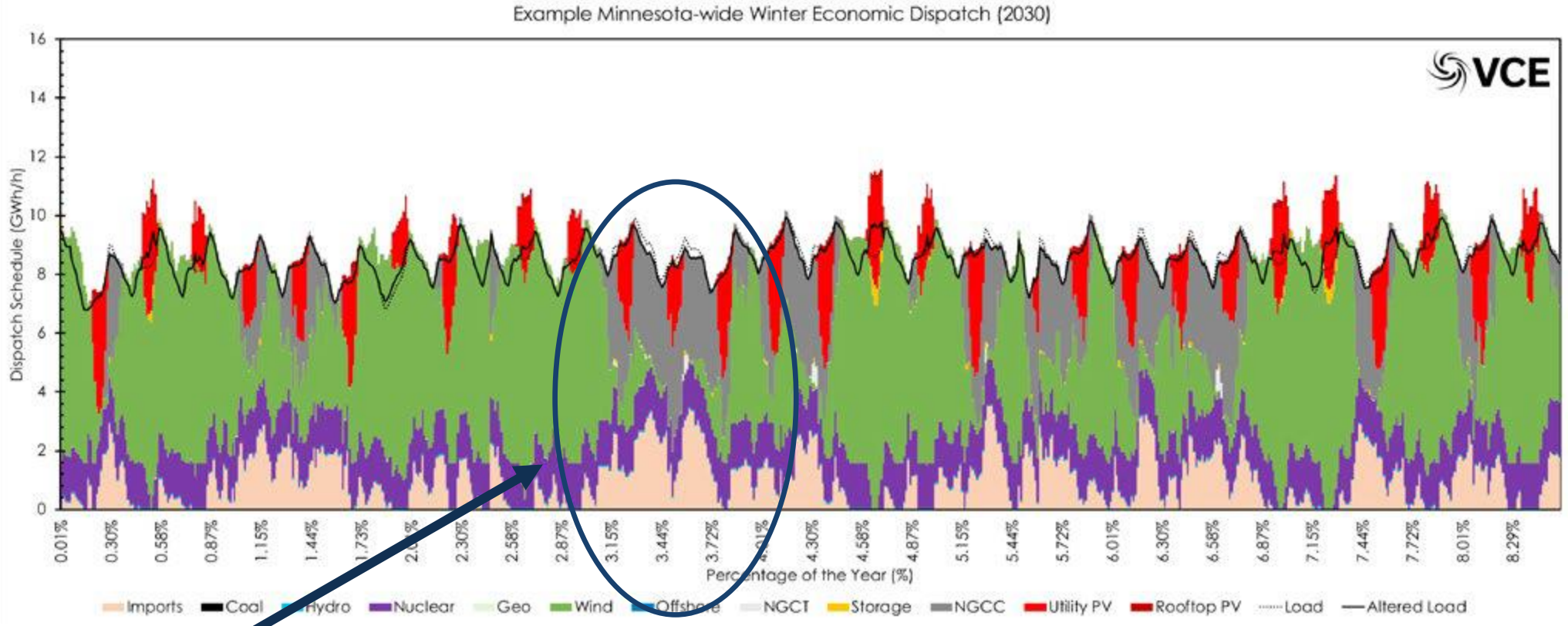


Fig. 3. Cross-seam transmission power flow (B2B and HVDC) during the coincident peak load period. A positive flow is a net export from the EI to the WI; a negative flow is a net import into the EI from the WI. Times are Eastern Standard Time.

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***

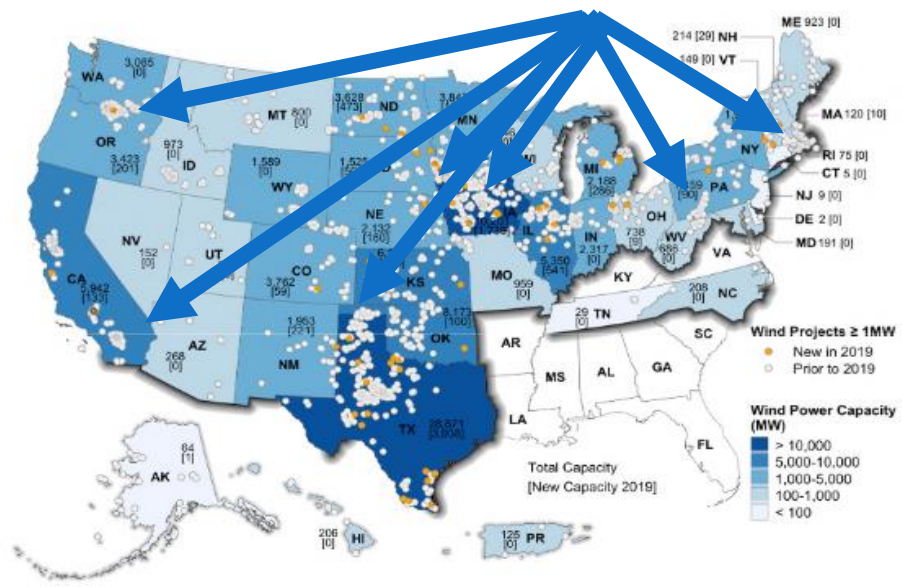
- ISO-NE: "The system's ability to withstand various transmission facility and generator contingencies and move power around without dependence on local resources under many operating conditions . . ., results in a grid that is, as defined by the Commission, resilient." ***https://elibrary.ferc.gov/eLibrary/filedownload?fileid=14837903***

- 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***

Generation is stuck in interconnection queues

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

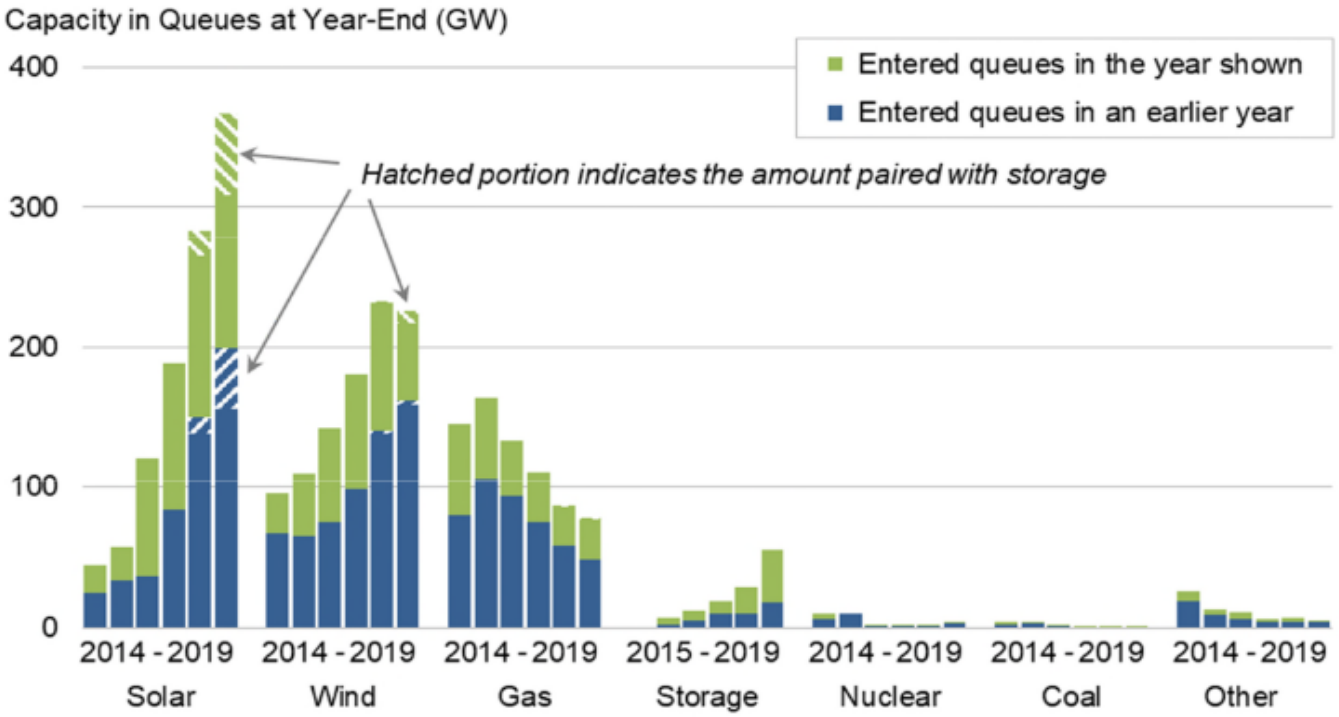
Resource Pockets



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



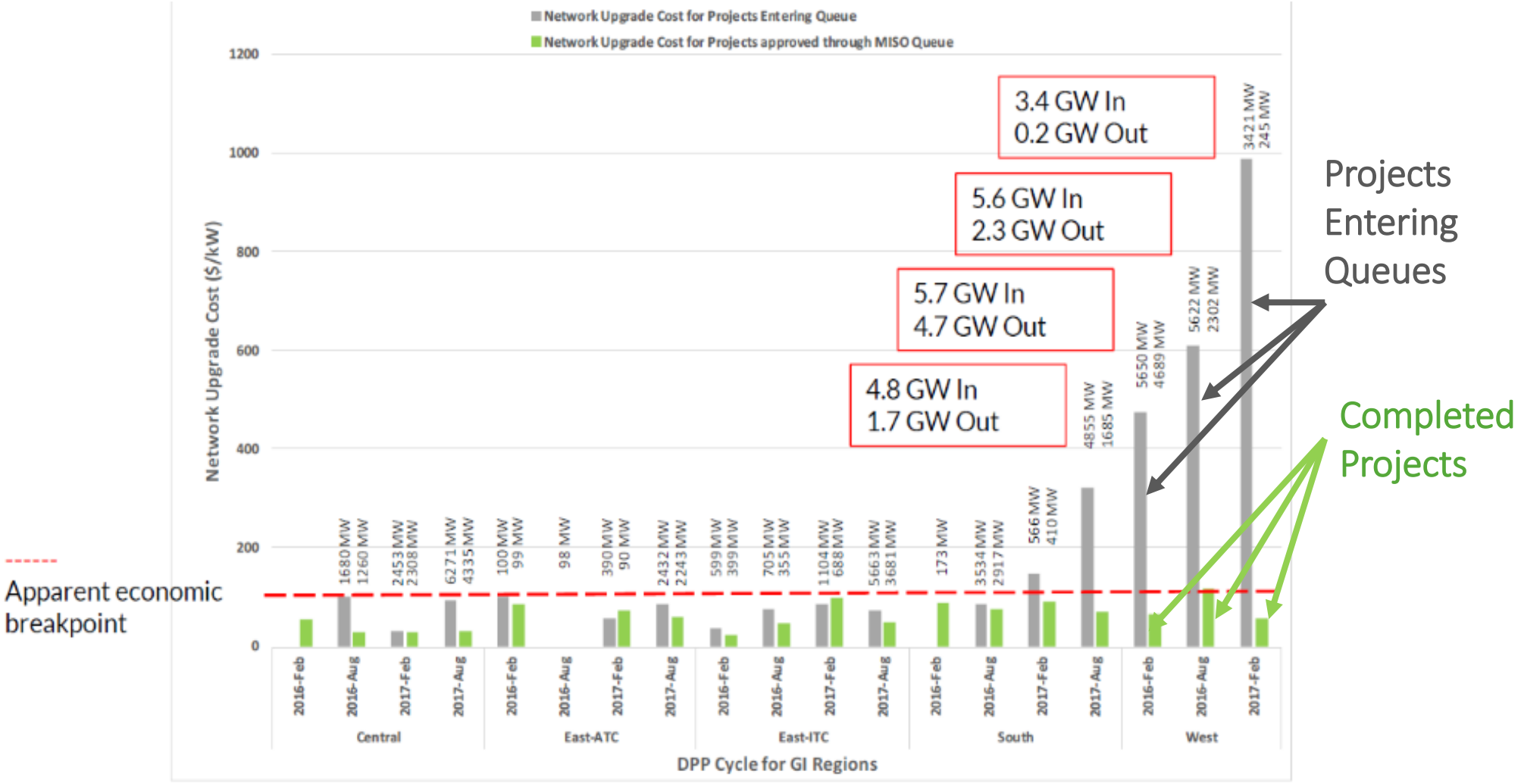
Source: Berkeley Lab review of interconnection queues

Note: Not all of this capacity will be built

Projects Entering Interconnection Queues

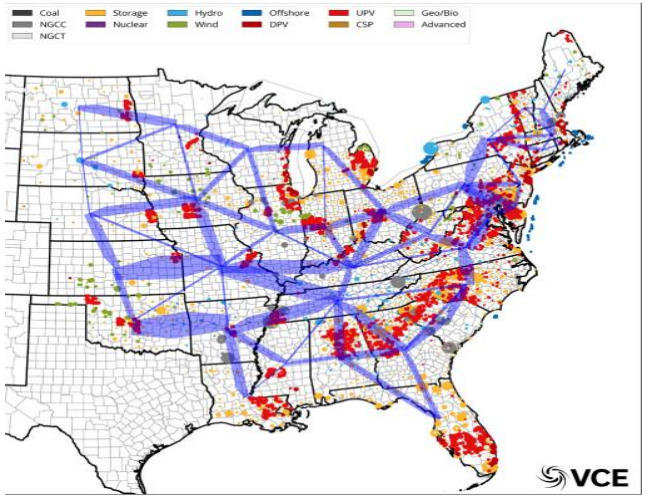
…resulting in massive network upgrade costs

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

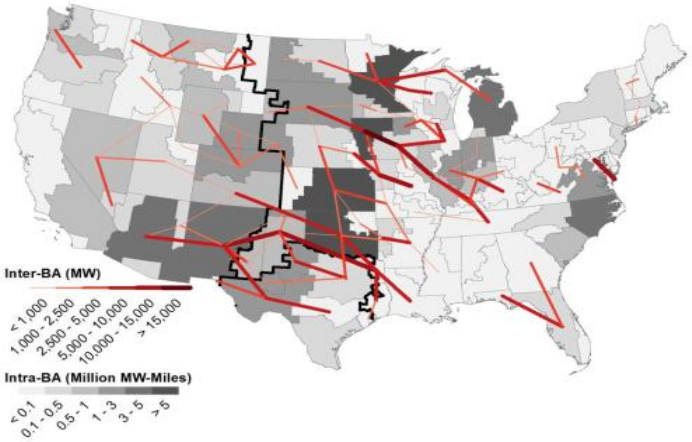


Goal: Enable 10s of GWs of power transfer

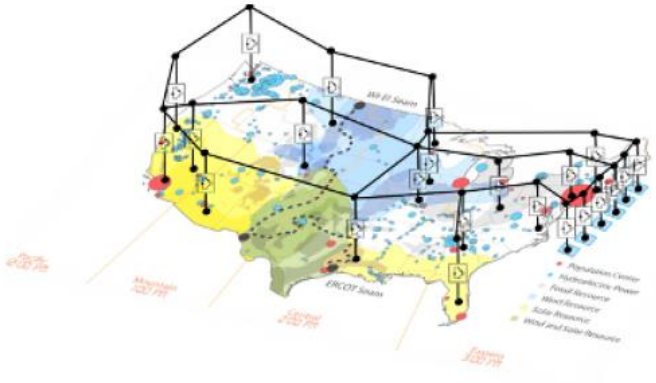
back and forth across and between regions



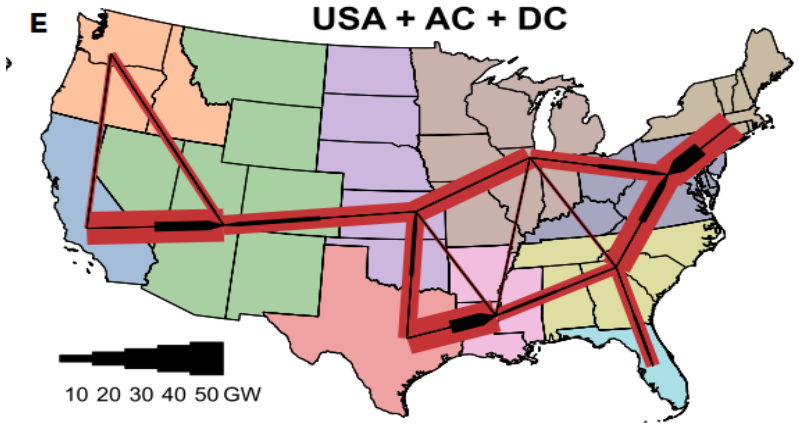
https://cleanenergygrid.org/wp-content/uploads/2020/10/Consumer-Employment-and-Environmental-Benefits-of-Transmission-Expansion-in-the-Eastern-U.S..pdf



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



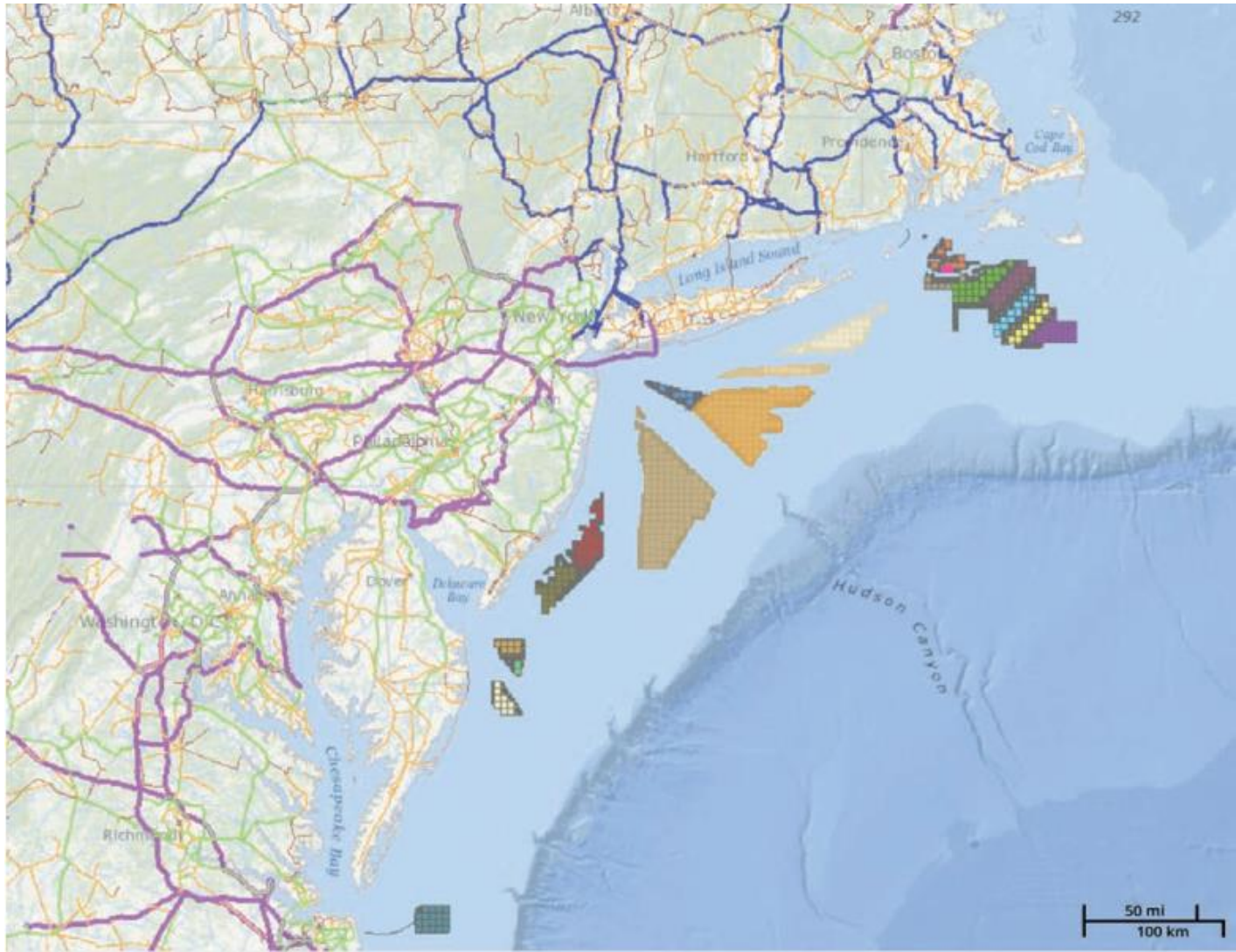
https://cleanenergygrid.org/wp-content/uploads/2020/11/Macro-Grids-in-the-Mainstream-1.pdf



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)

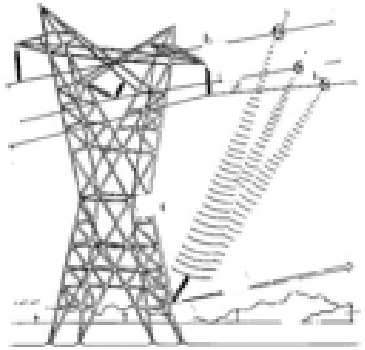
- GETs are VERY low cost, $0.5k - $25m
- GETs are deployable in MONTHS
- GETs are scalable
- GETs are modular
- GETs are mobile and re-deployable

- GET some GETs!

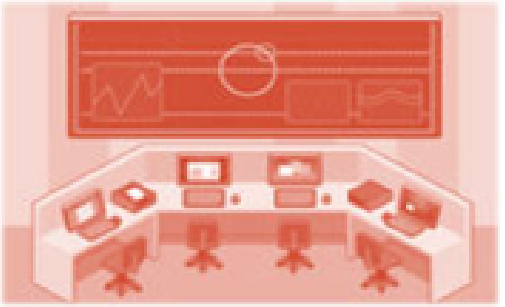
Grid-Enhancing Technologies

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

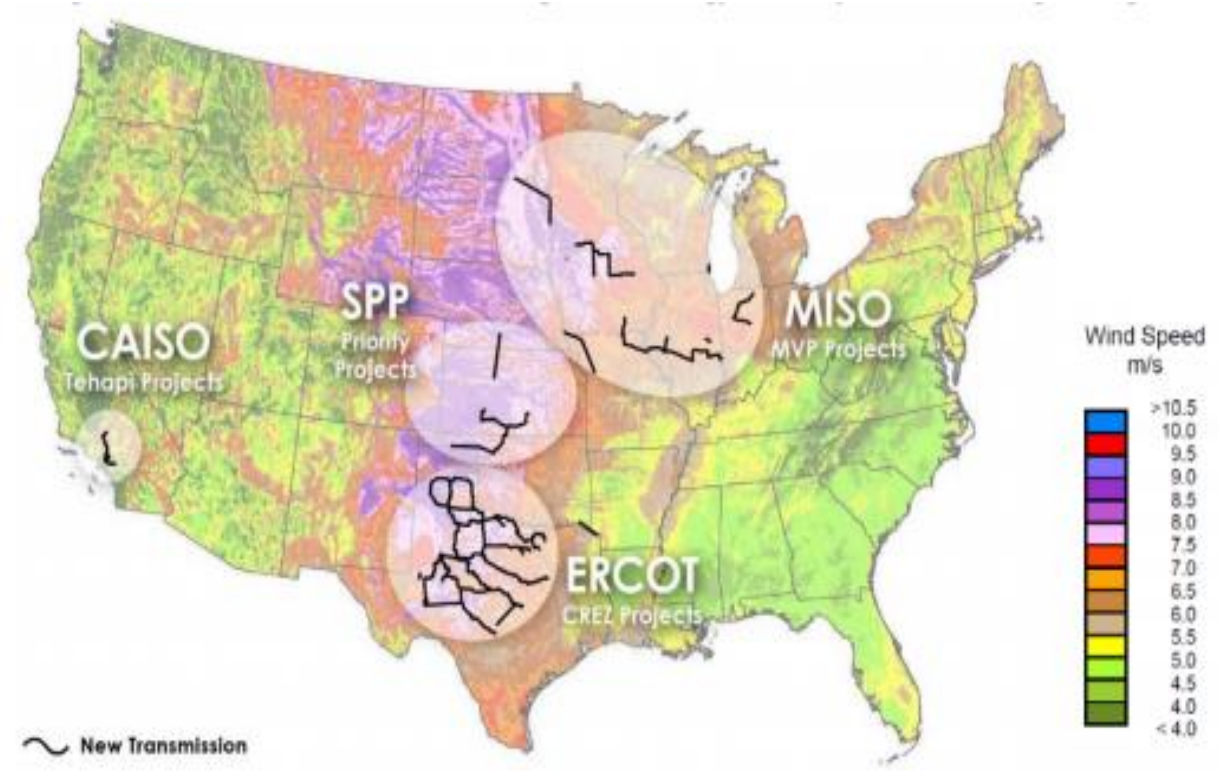
Transmission plan	Wind Capacity Enabled (GW)
Tehachapi CA	4.5
Texas CREZ	14.5
MISO MVP	14
SPP Priority Projects, Balanced Portfolio	6
CO+ME+NV+PAC+BPA	10
Total	49

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



FERC planning orders increasing regionalization

- 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?)

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

Next FERC Planning Order?

- Multi-benefit planning
- Public policies
- Utility resource plans
- Consumer resource plans
- Gen. interconnection queues
- Electrification estimates
- Carbon regulation estimates
- Multi-region RTO/process
- Congestion reduction
- Efficiencies across seams
- Resilience (low probability high impact scenarios)
- Scenarios and probabilities
- Grid operations as well as infrastructure
- Benefit-cost analysis