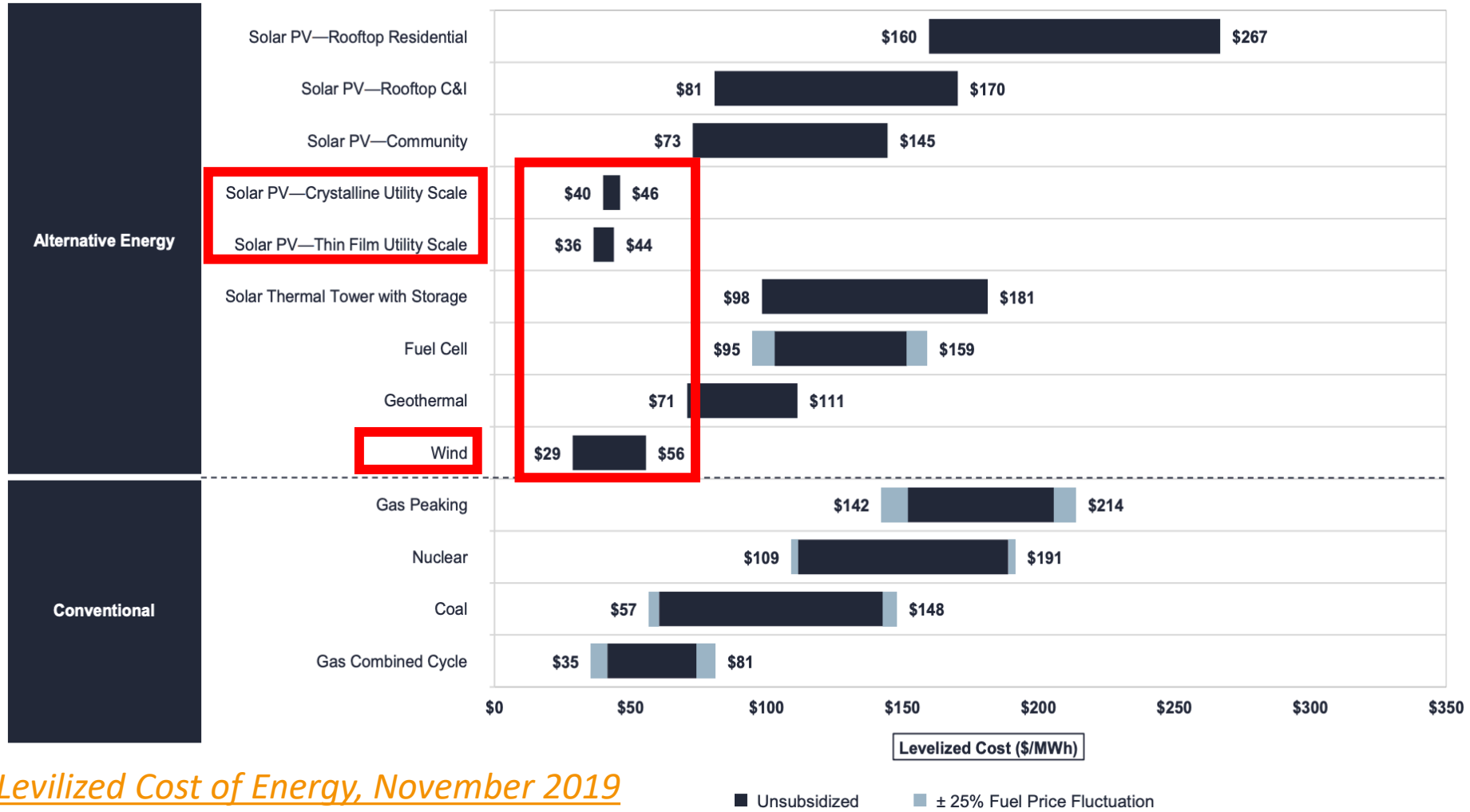
Connections to the future: Grid expansion and optimization

Rob Gramlich
November 2020

Large-scale renewable energy is cheapest generation technology



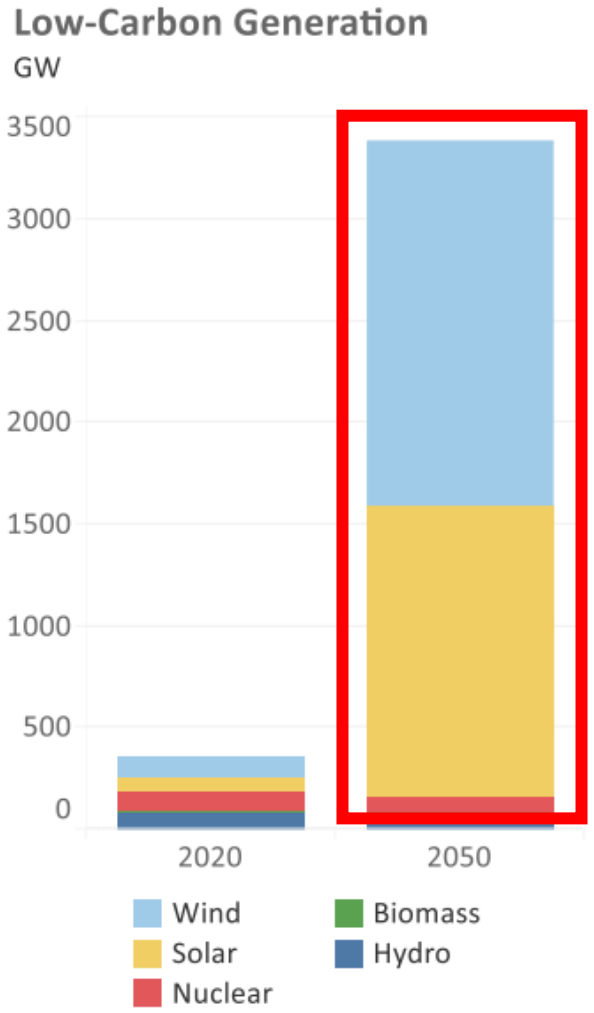
Lazard, Levilized Cost of Energy, November 2019

Wind and Solar Dominate Low-Cost, Low-Emission Models

Low Carbon Transition Strategies for the Midwest

80% Decarbonization by 2050

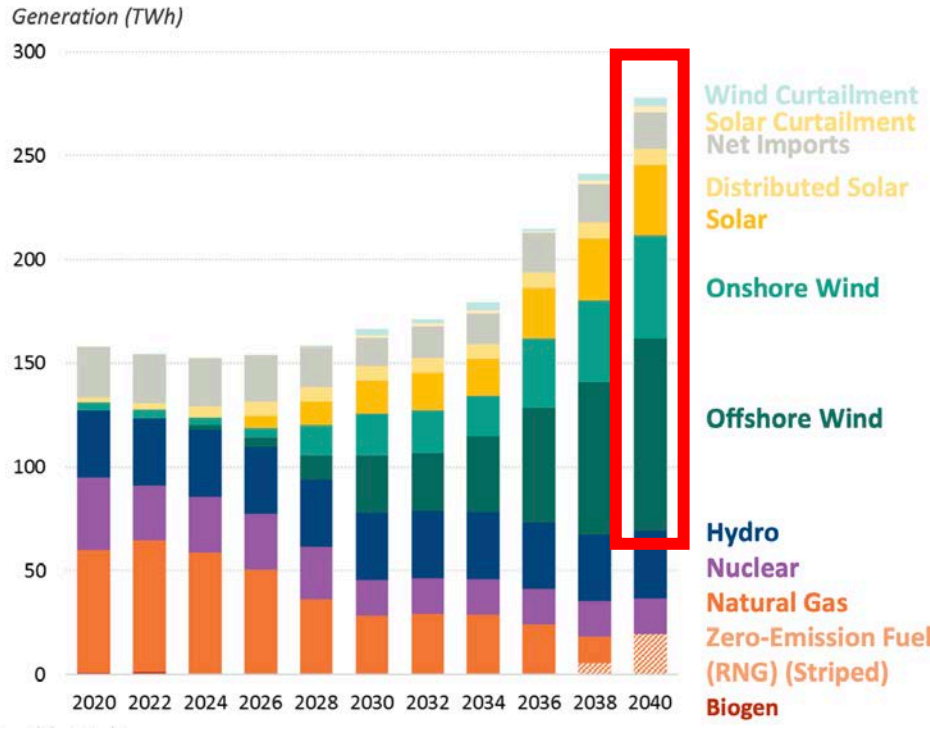
Evolved Energy Research



New York's Evolution To a Zero-Emission Power System

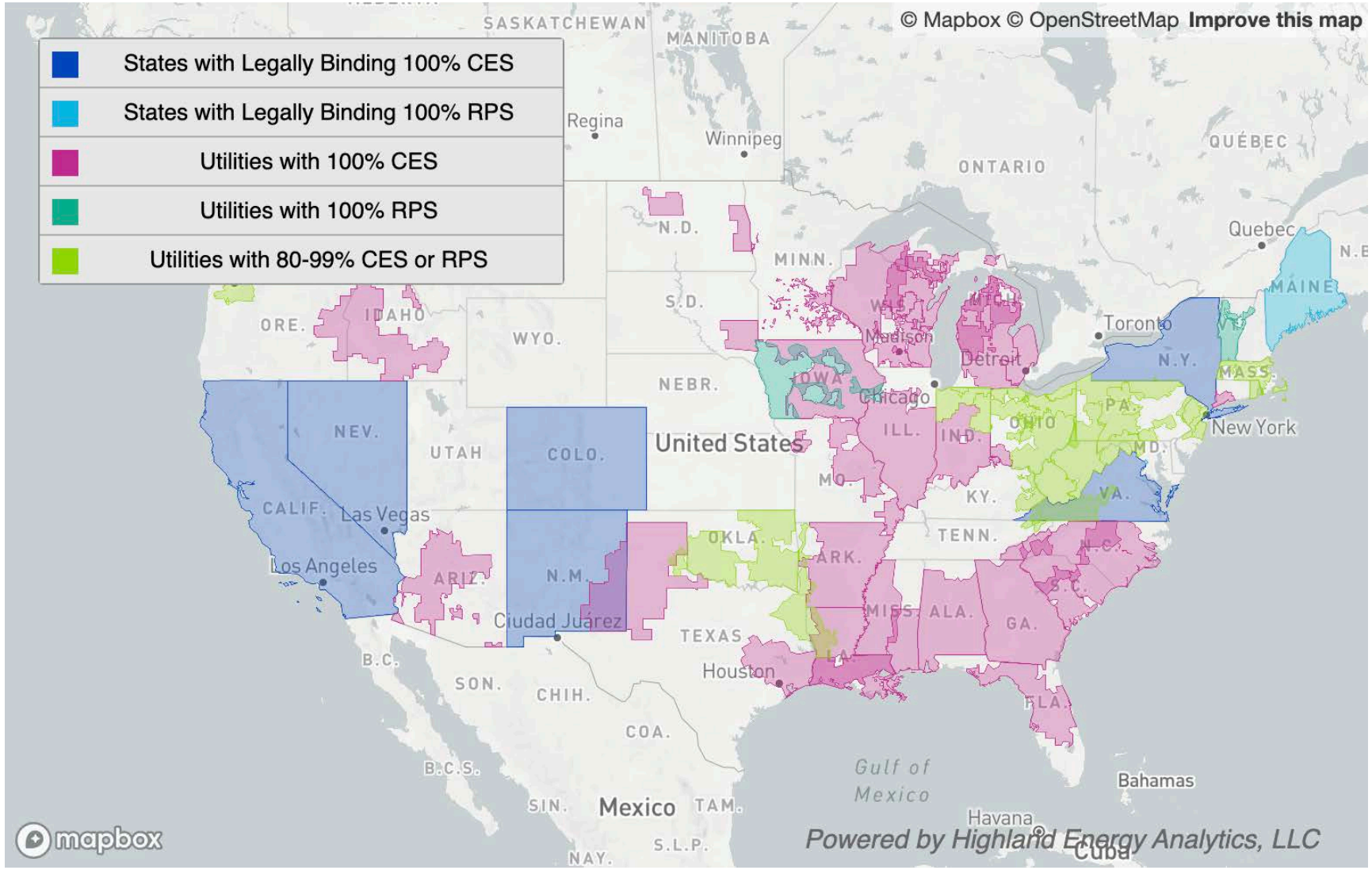
100% Decarbonization by 2040

The Brattle Group for NYISO



Massive Renewable Energy Demand from States, Consumers, Utilities

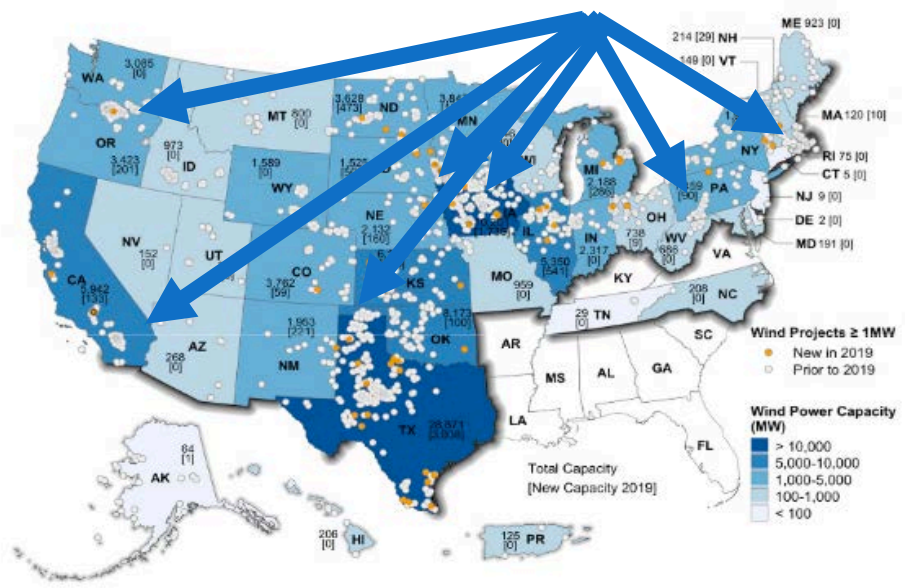
Clean Air Task Force, October 2020



But the supply is stuck in interconnection queues

- 168 GW of solar and 64 GW of wind projects entered interconnection queues in 2019

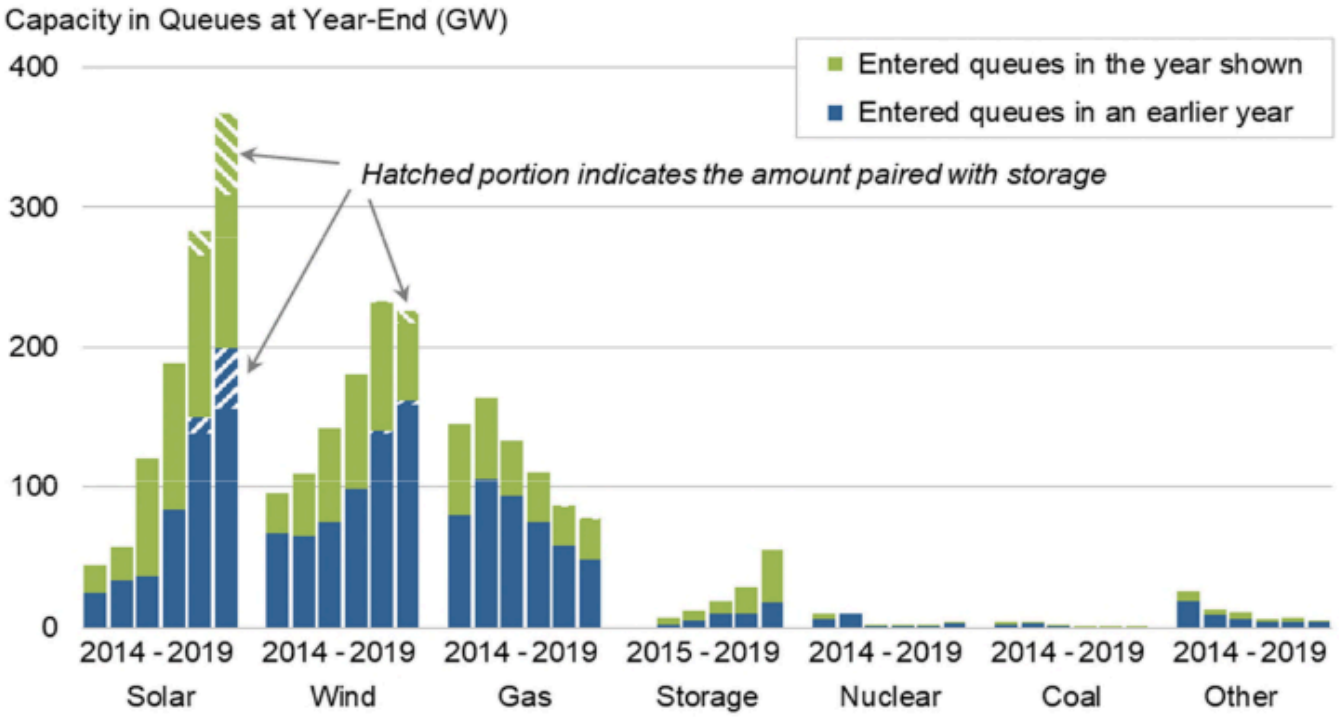
Resource Pockets



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



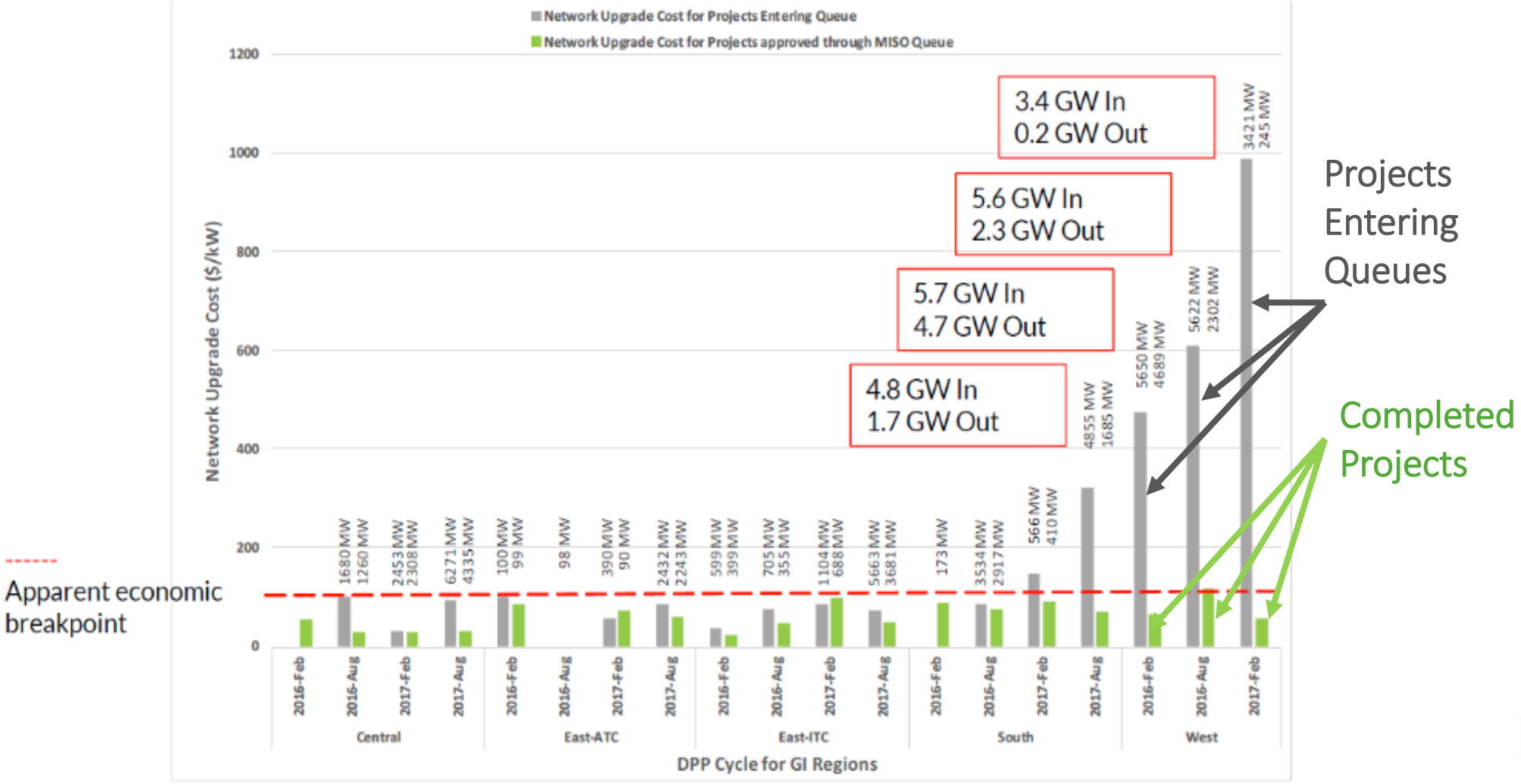
Source: Berkeley Lab review of interconnection queues

Note: Not all of this capacity will be built

Projects Entering Interconnection Queues

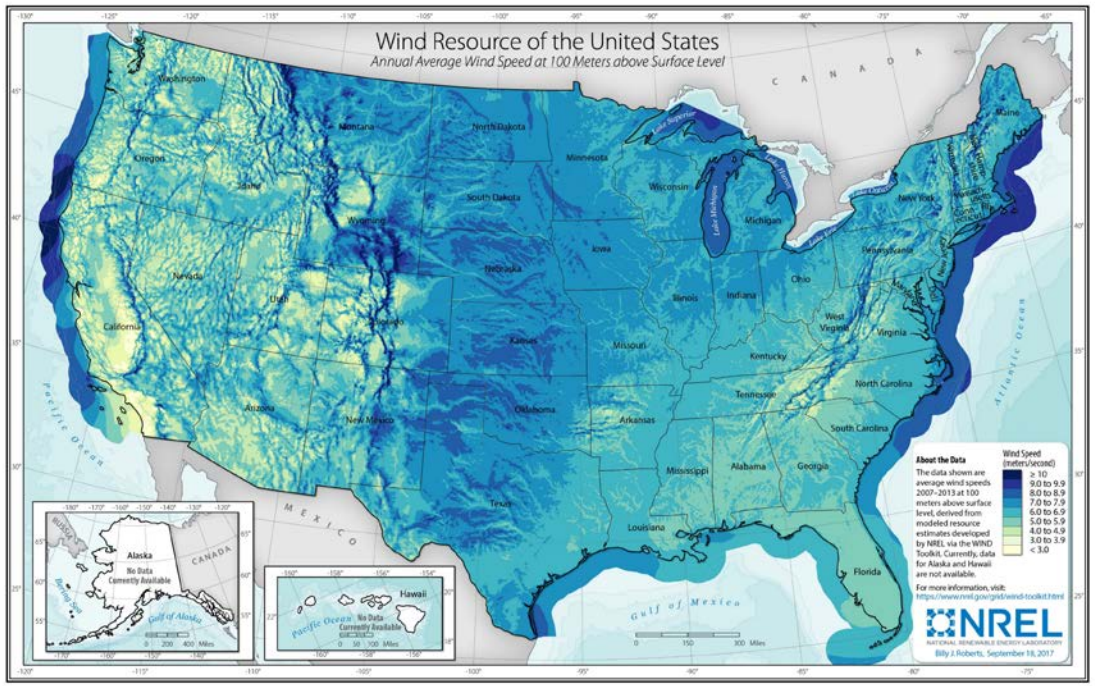
Resulting in massive network upgrade costs

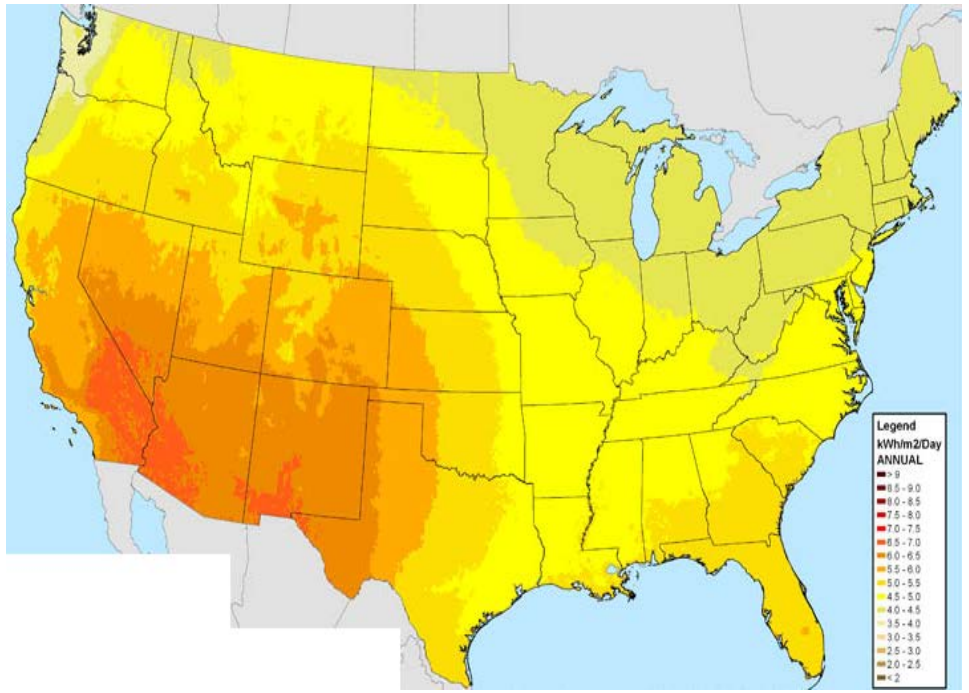
Planning a HV network through an interconnection process is a bad idea



Transmission enables renewable energy

1. Delivers best wind and solar to distant load
2. Allows regional system balancing (along with RTO energy markets)
3. Supports weak power systems as system inertia declines



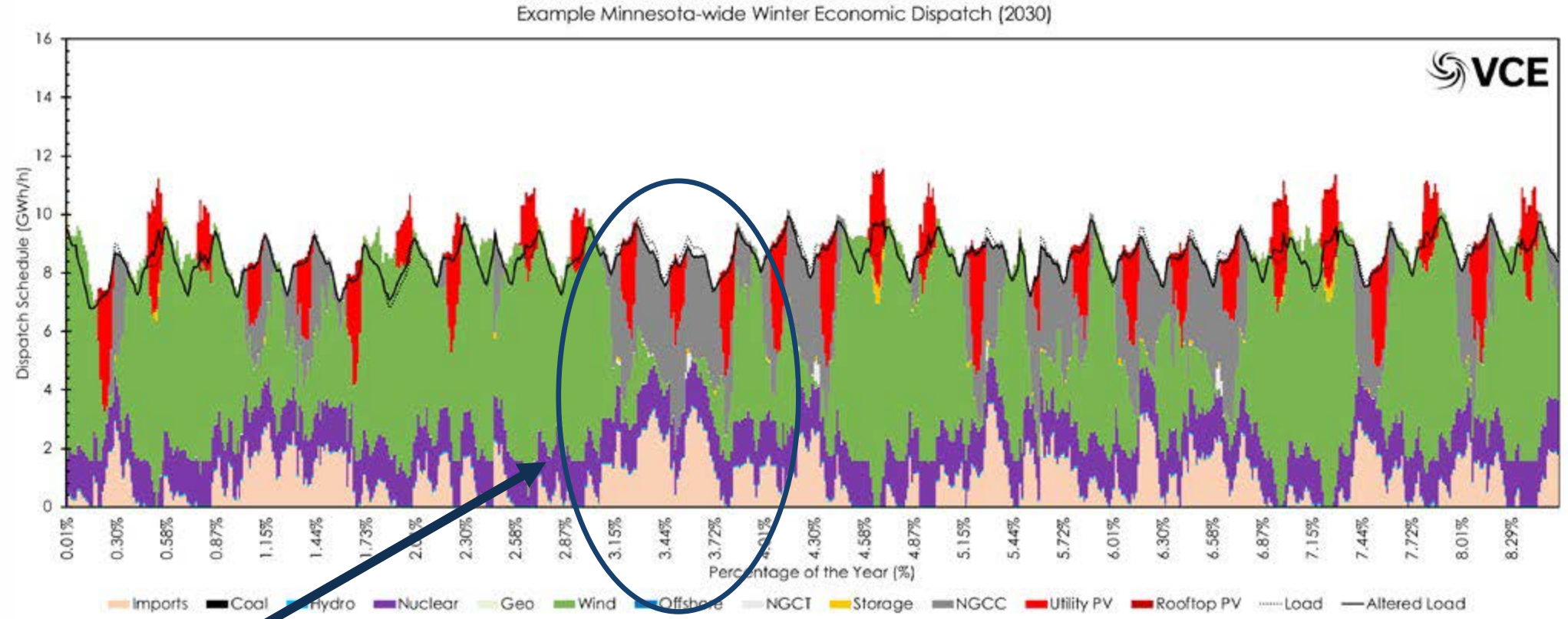


NREL Wind (left, 100m height) and Solar (right) Resource Maps

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

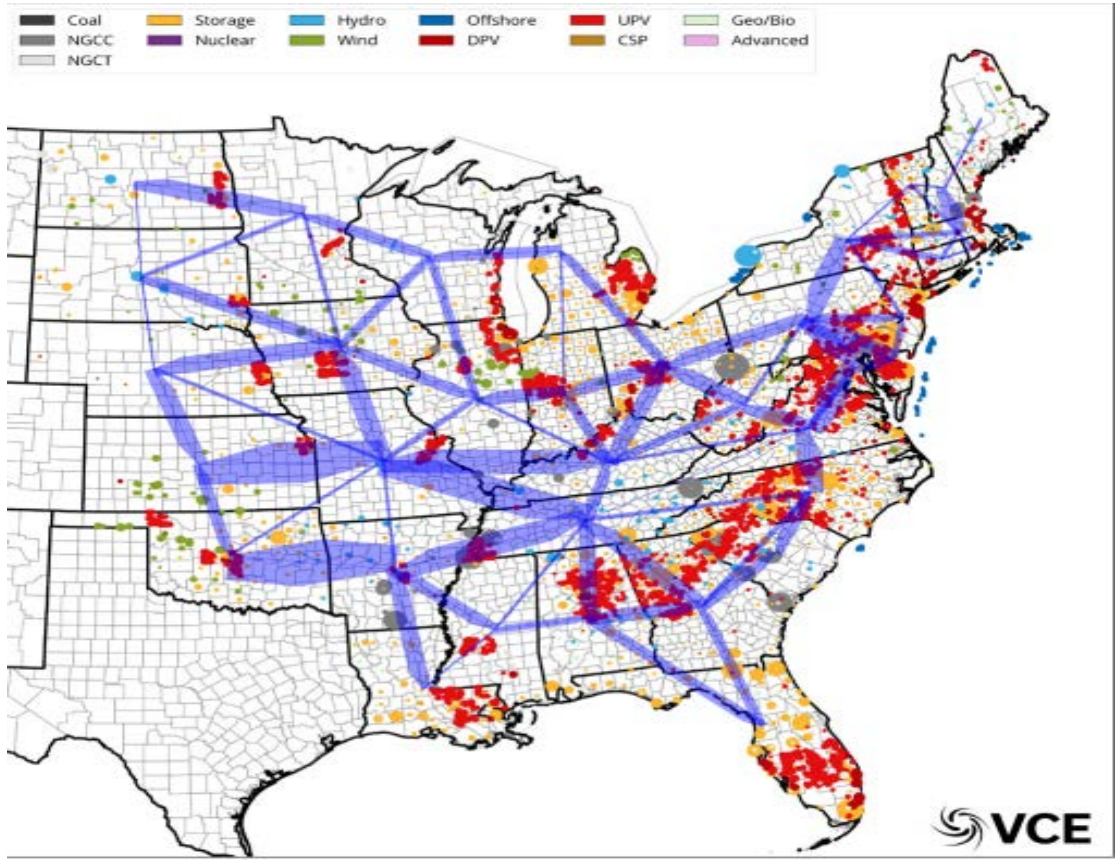
Year-round power with 90% lower emissions

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



- Multi-Day periods of low wind+solar, usually winter. Served by contracted 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

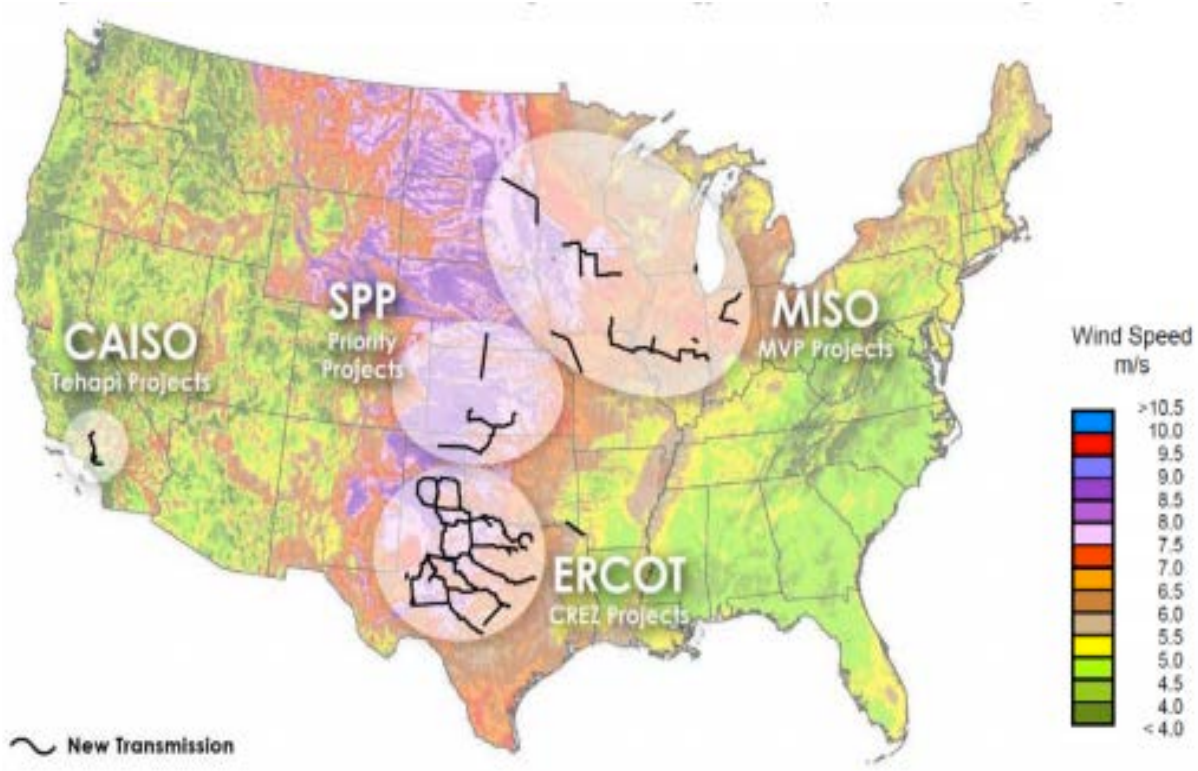
Goal: Enable 10s of GWs of power transfer



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

We know how to expand grid capacity

- It worked
  - 3:1 Benefit-Cost ratios
- Winning formula:
  - Pro-active multi-benefit planning
  - Broad, beneficiary pays allocation
- Takes time and $



First, get the most out of the existing grid

with Grid-Enhancing Technologies (GETs)

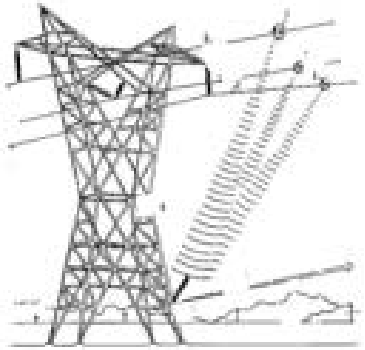
- GETs are VERY low cost, $0.5k - $25m
- GETs are deployable in MONTHS
- GETs are scalable
- GETs are modular
- GETs are mobile and re-deployable

- GET some GETs!

Grid-Enhancing Technologies

Advanced Power Flow Control

Dynamic Line Rating



Advanced Topology Control

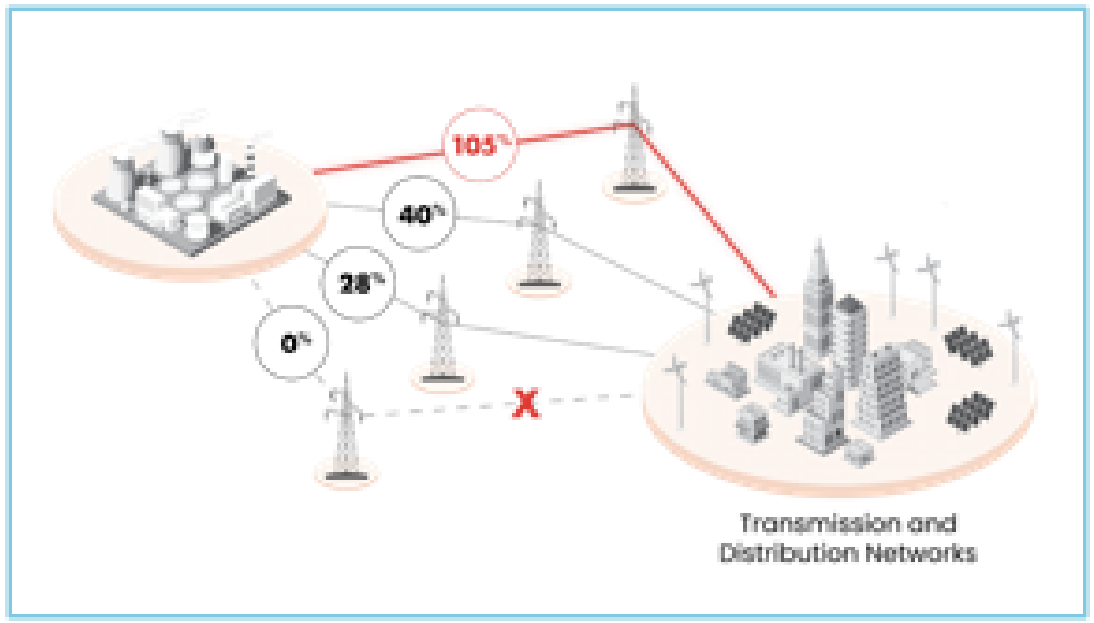
www.watt-transmission.org

WATT Coalition Working for Advanced Transmission Technologies

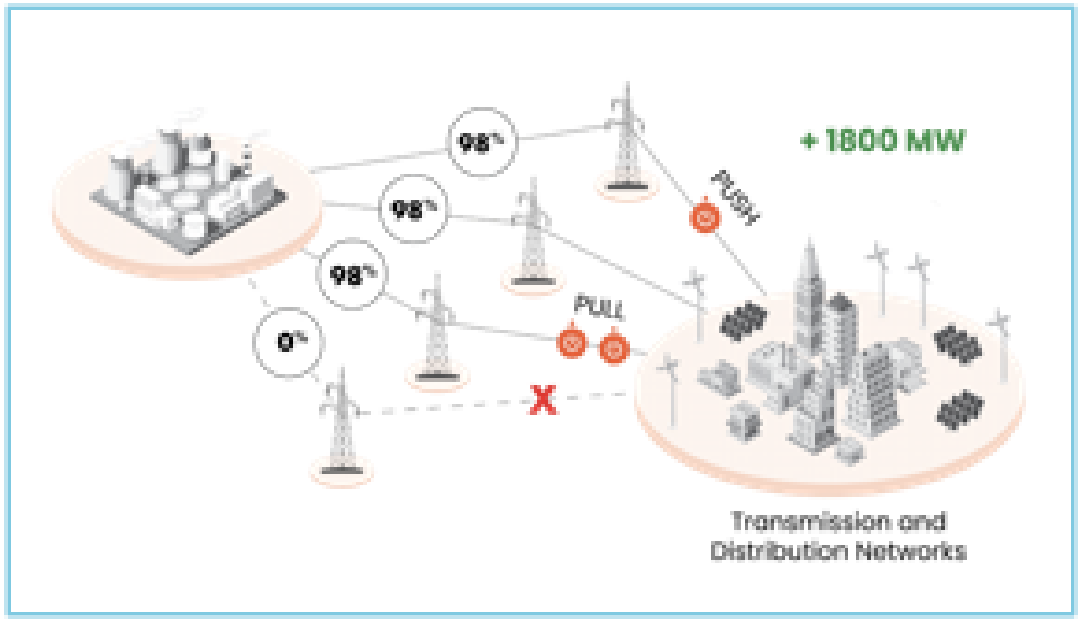
Ampacimon · LINDSEY · LINEVISION · newgrid · SMART WIRES · windsim

Power Flow Control to “Push” and “Pull” Power

Before



After



Power Flow Control Installation Methods

Tower-based

Ground-based

Mobile Units

Dynamic Line Rating

Increases capacity on existing transmission lines

- Wind and temperature affect line temperature which affects line capacity
- DLR based on actual monitored conditions rather than fixed worst-case assumptions

Improves reliability

- Provides forecasted ratings up to 48 hours ahead, and improves reliability by alerting operators to conditions such as clearance violations
- Estimates of increased capacity have been 40 percent, 30 to 70 percent, and 30 to 44 percent on three different tests
  - *US Department of Energy, Dynamic Line Rating Systems for Transmission Lines, April 2014*

We FORECAST these because they vary

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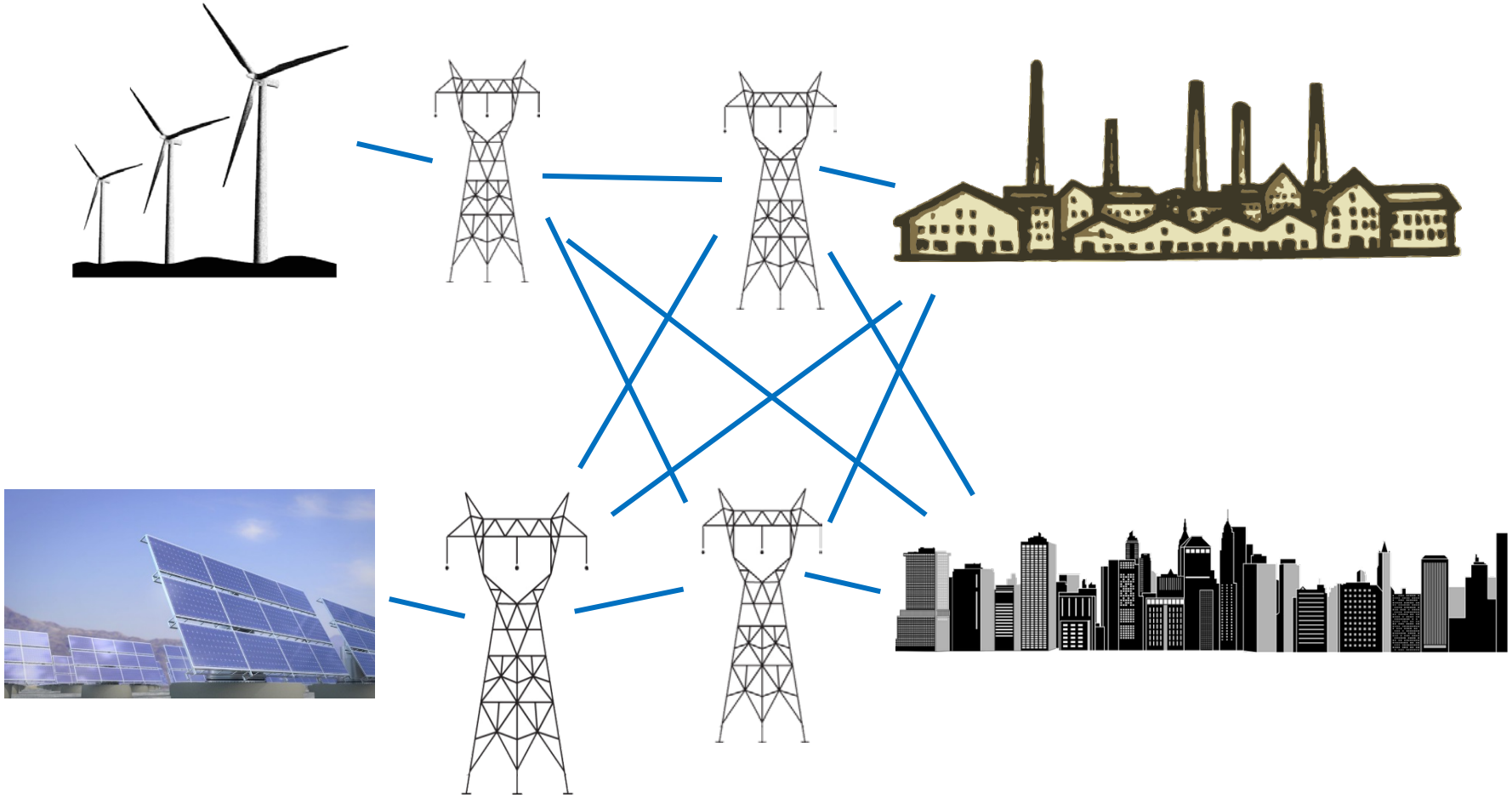

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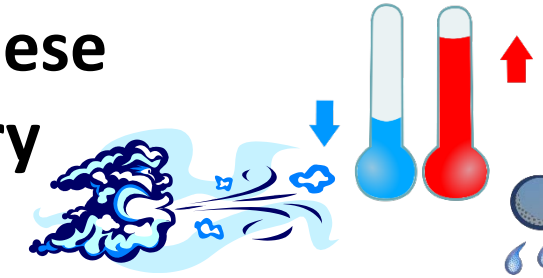

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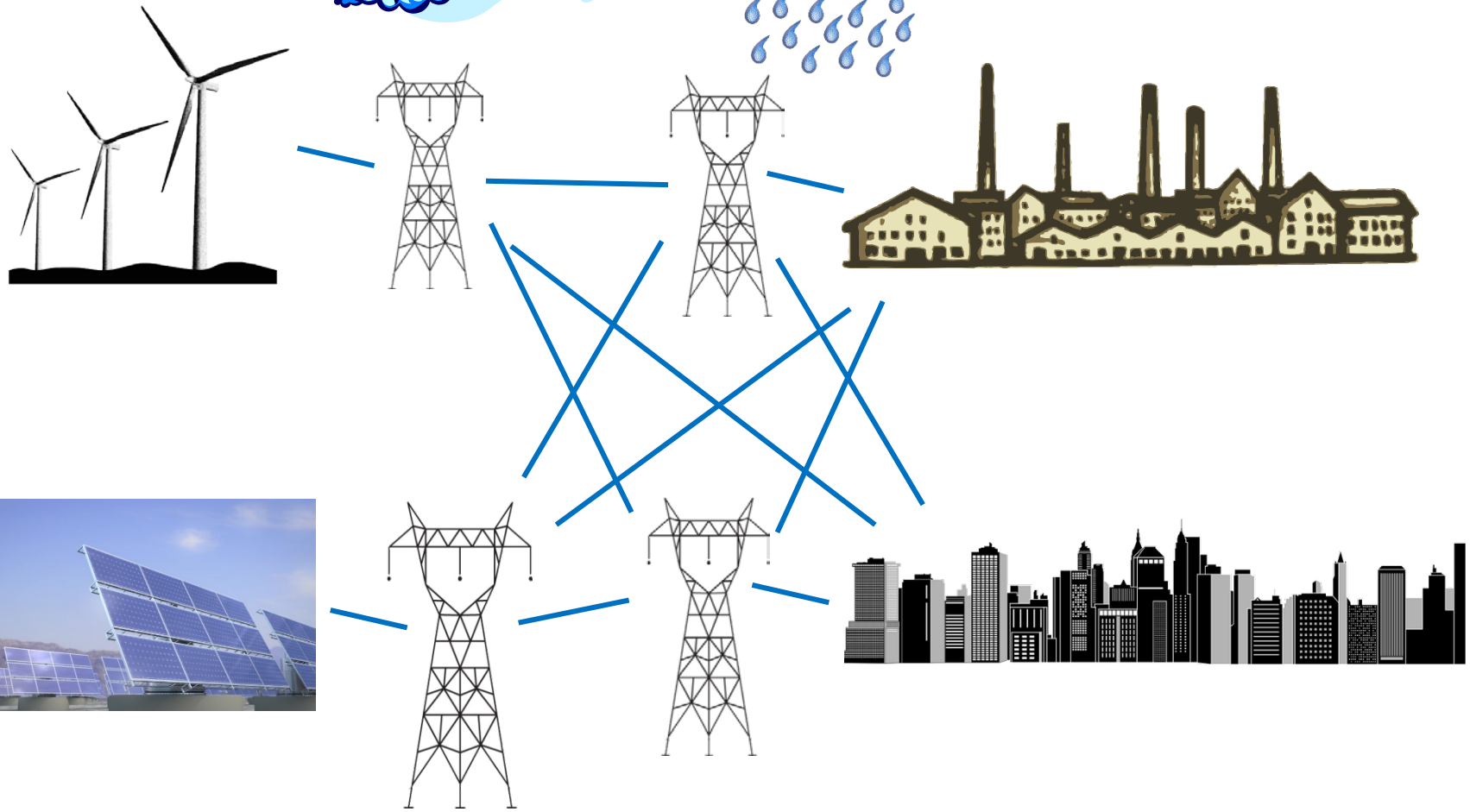

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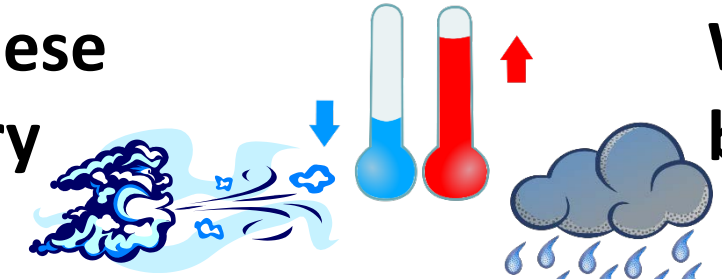

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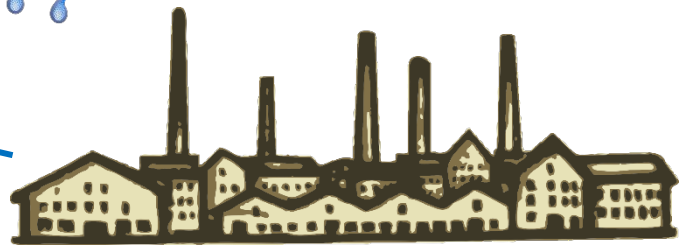


These vary too.

DLR on SPP lines

Figure 2: Transmission Capacity Forecast System Output showing 2- and 24-hour ahead forecasts

https://watt-transmission.org/resources/

Advanced Topology Control

Evenly distributes flow over the network

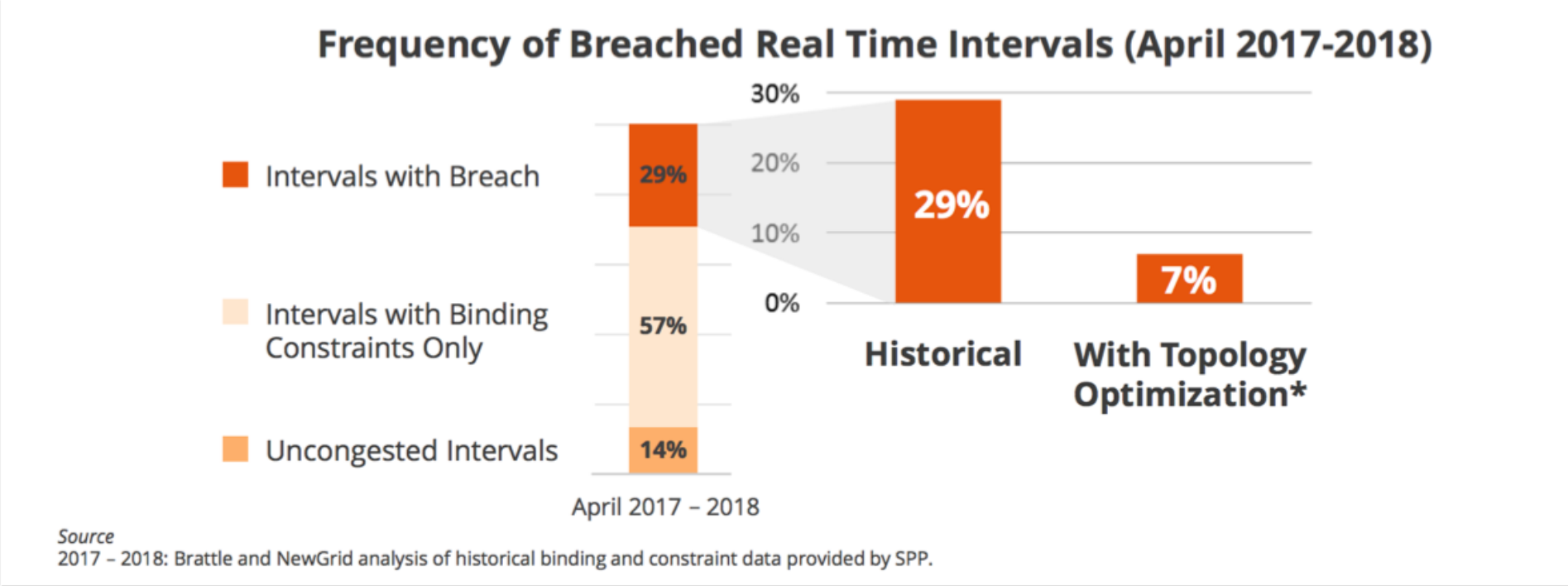
- A software technology that automatically identifies reconfigurations of the grid to route power flow around congested or overloaded transmission elements
- Reconfigurations are implemented through switching on/off existing high voltage circuit breakers
- Optimization increases the transfer capacity of the grid

Congestion and curtailment reduction

- Can reduce congestion by up to 50 percent and improve response to contingencies
- Can reduce renewable energy curtailment by up to 40 percent

Advanced Topology Control Breach Constraint Relief

Ability to reduce frequency of breached constraints at no cost

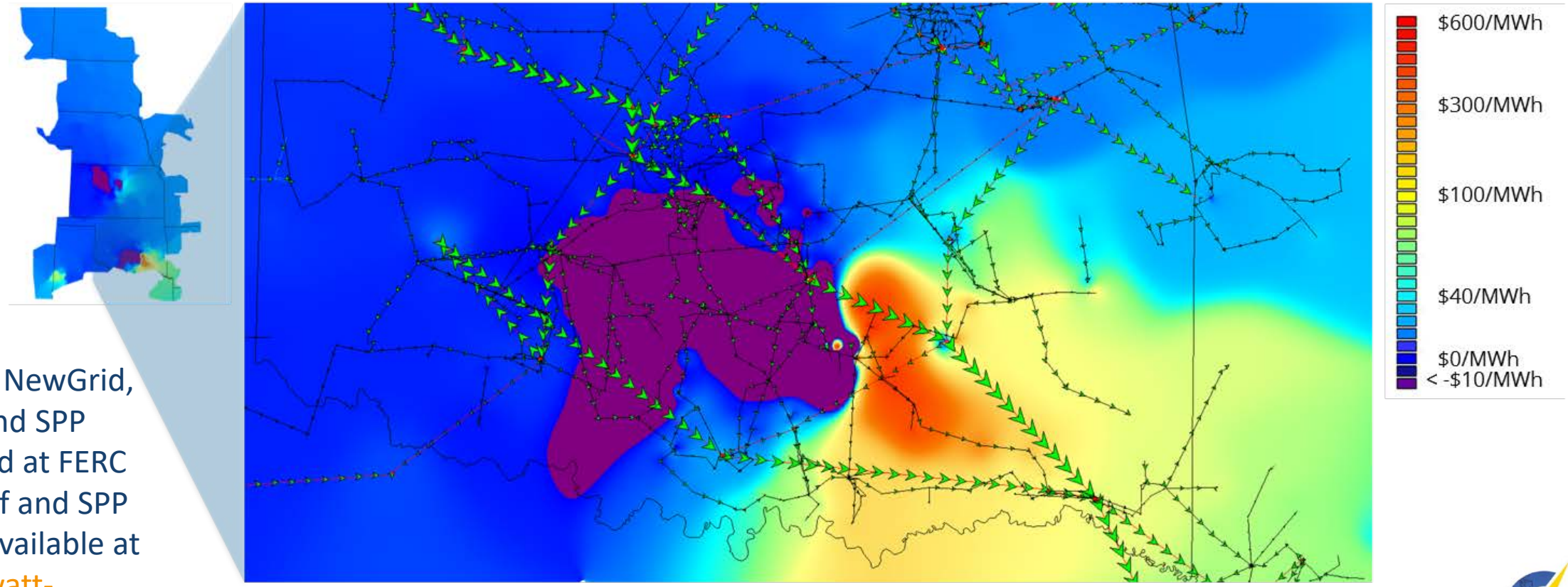


Source
2017 – 2018: Brattle and NewGrid analysis of historical binding and constraint data provided by SPP.

Topology Optimization in SPP: Before

Oklahoma, 3/10/18 8pm, 38% Wind Penetration in SPP

Historical Configuration: **Constraint Breach, High Congestion, Wind Curtailments**

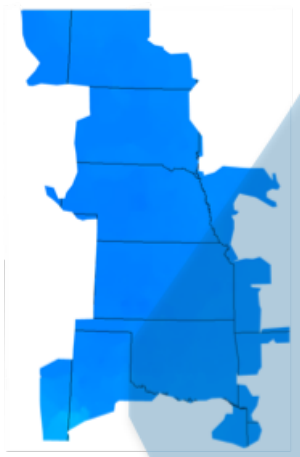


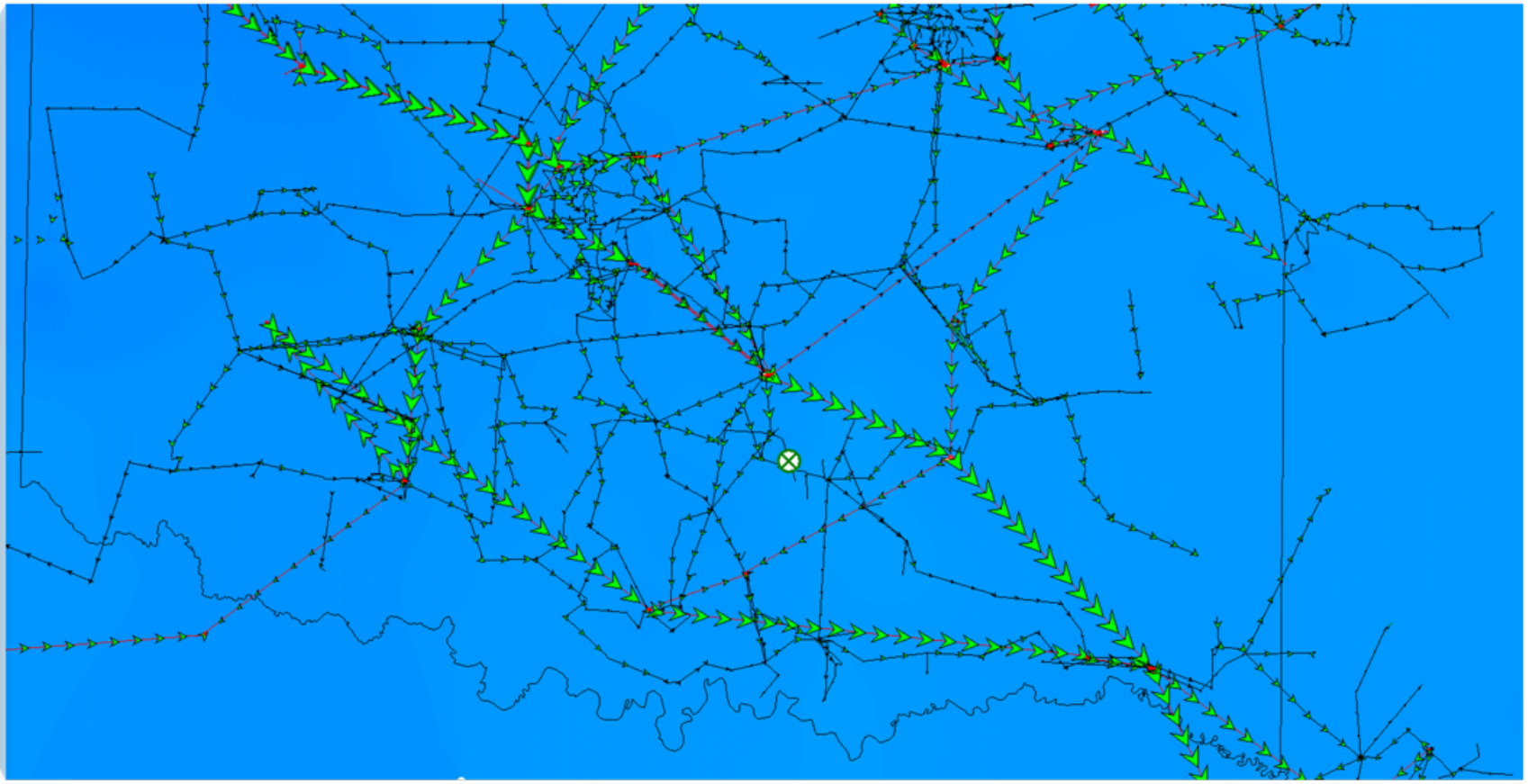
Paper by NewGrid, Brattle and SPP presented at FERC Tech Conf and SPP ORWG, available at https://watt-transmission.org/resources/

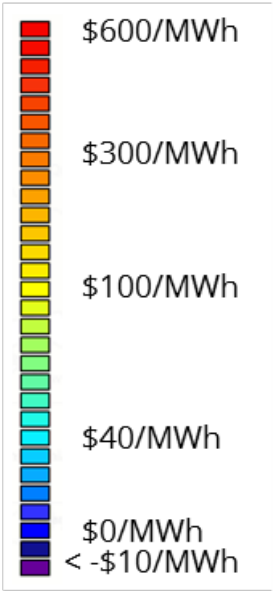
Topology Optimization in SPP: After

Oklahoma, 3/10/18 8pm, 38% Wind Penetration in SPP

Optimal Reconfiguration: **No Breach, Minimal Congestion, No Wind Curtailments**







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Barriers and solutions

to Grid-Enhancing Technologies

- **Awareness**
  - Many planners, utility executives, regulators, and stakeholders are unfamiliar with advanced transmission technologies and their benefits

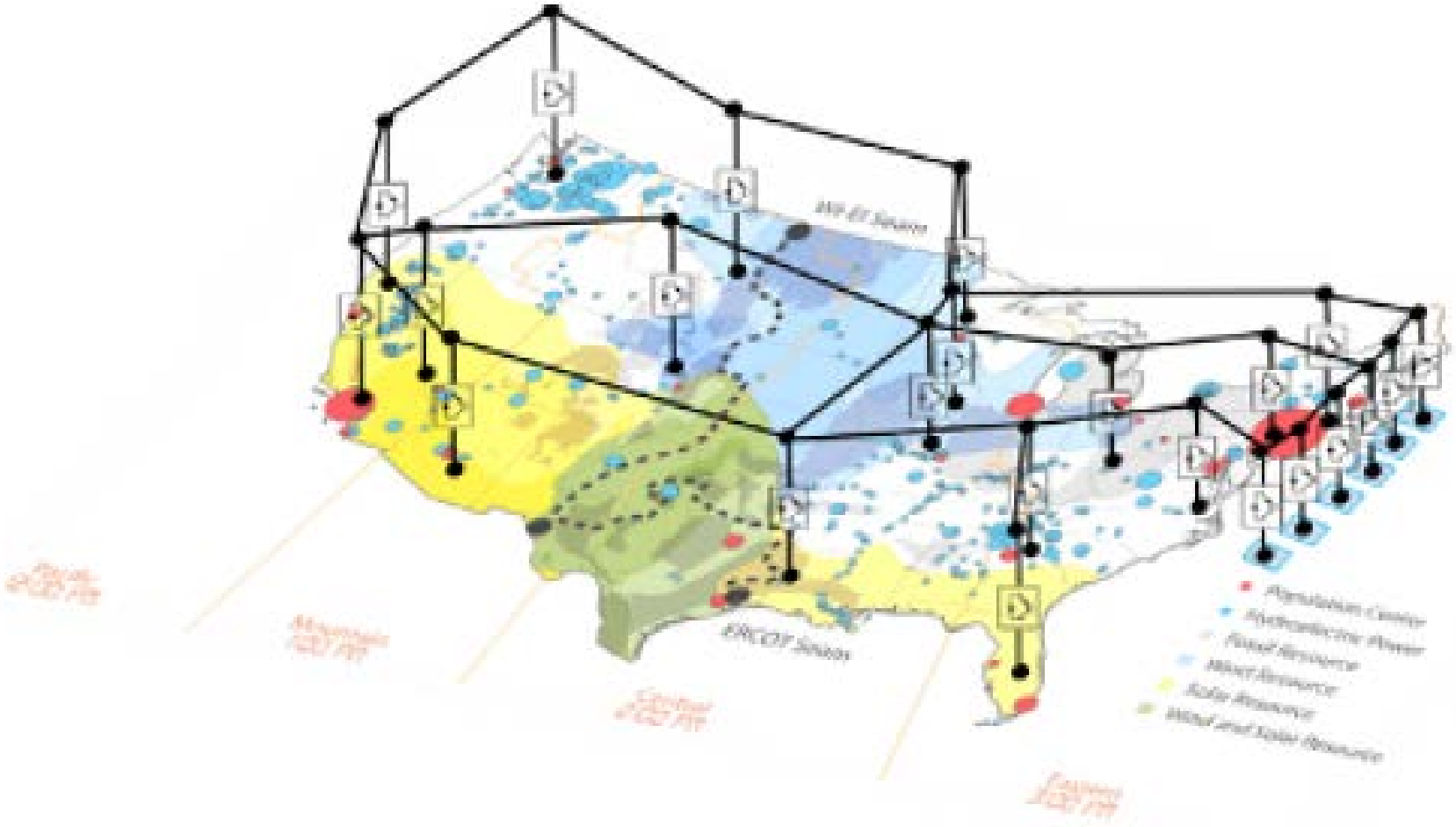
  ➔ Spread the word! (Thank you, MGA!)

- **No Incentive to Innovate**
  - Can’t be blamed for doing things the same way as usual
  - Lower returns on lower capital cost expenditures

  ➔ Carrots and sticks

Longer term goal: macro grid

Cross the seams



Federal transmission policy

- FERC
  - Planning rule?
    - Pro-active, multi-purpose
    - Incorporate future portfolio information
  - Re-align incentives for Grid-Enhancing Technology?
  - Line ratings rule
- DOE
  - Assist planning?
  - RD&D, deployment of Grid-Enhancing Technology?
- Congress
  - Infrastructure legislation? Help pay for the grid?