De-carbonization and the US Power Sector

Harvard Electricity Policy Group
February 3, 2021

Rob Gramlich

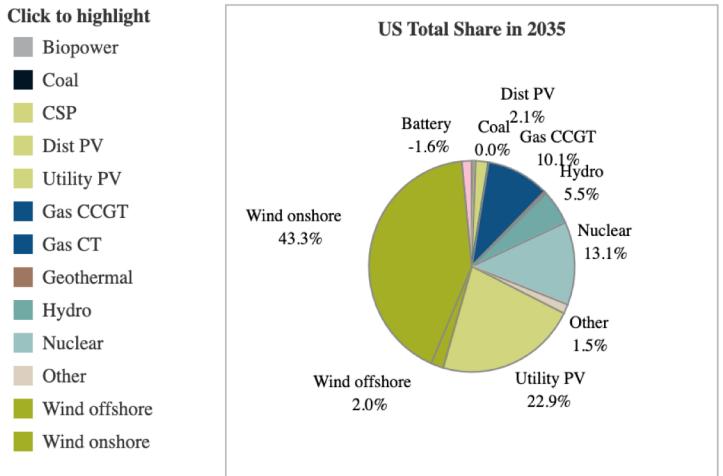
w/help from Michael Goggin

Grid Strategies LLC

90% carbon reduction w/existing tech

~70% of electricity from Renewables, electrify transportation and buildings

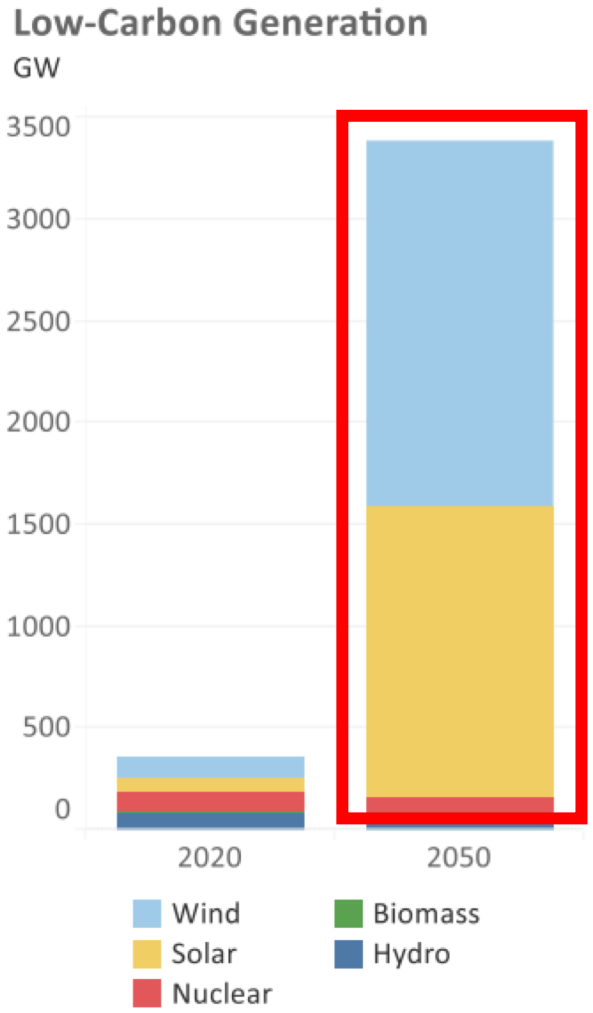
UC Berkeley/Gridlab 2035 report



Low Carbon Transition Strategies for the Midwest

80% Decarbonization by 2050

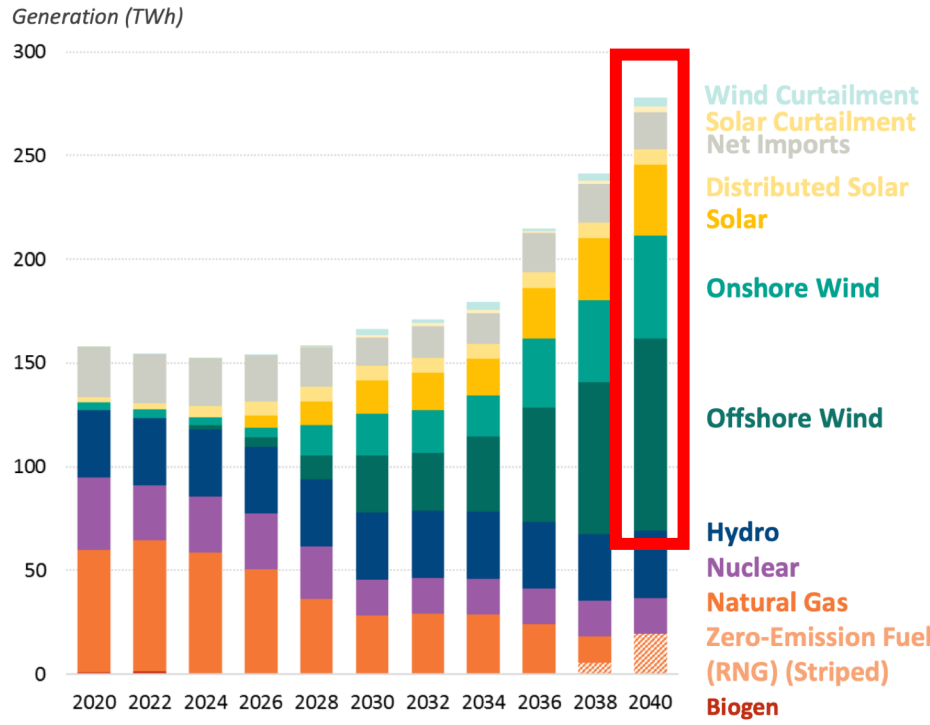
Evolved Energy Research



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

100% Decarbonization by 2040

The Brattle Group for NYISO

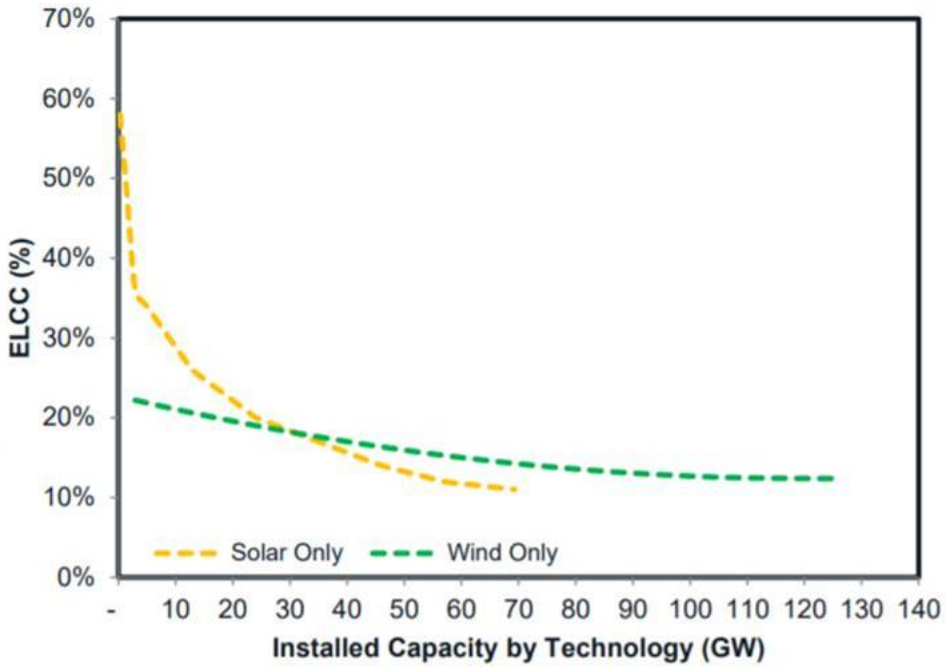


Balanced power portfolio: Renewables + storage + transmission + flex/firm resources

Each source fits a unique niche in the power system, they are not competing at high penetration levels…

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

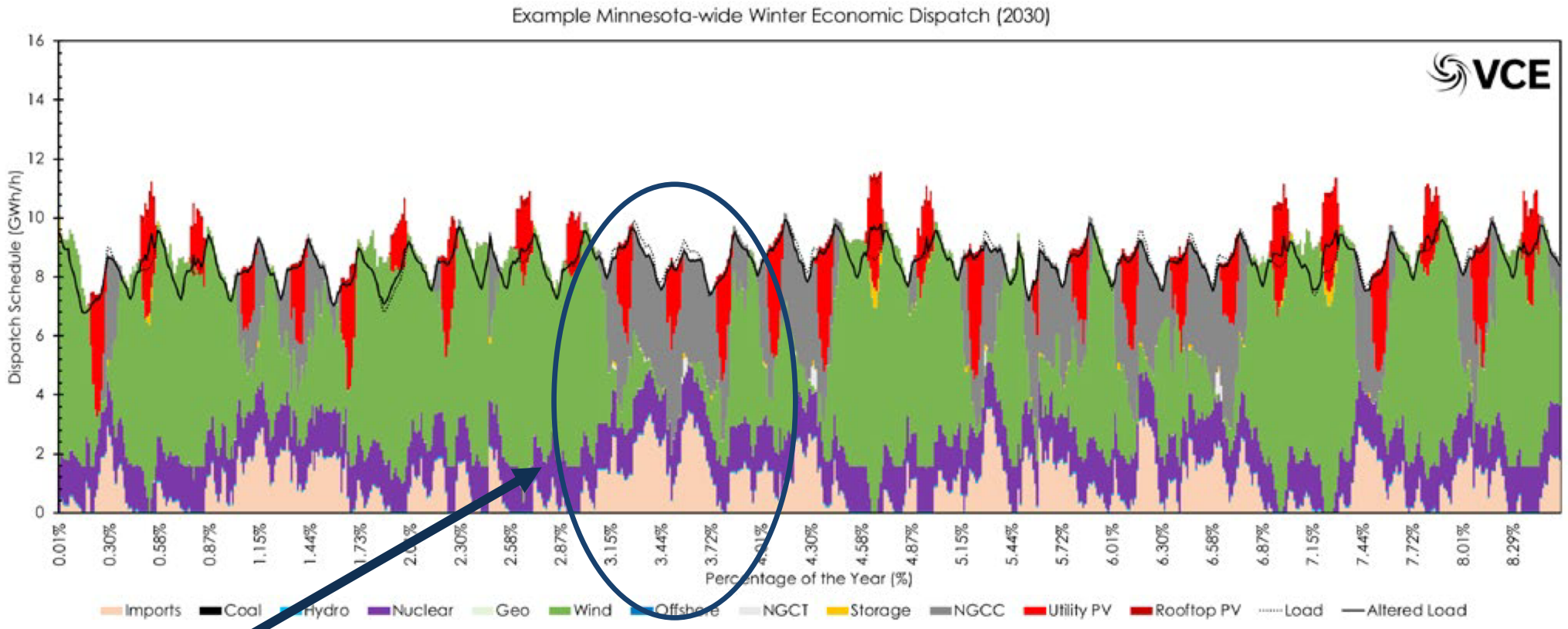
…because of the declining Effective Load Carrying Capability of each source as penetration increases



https://cdn.misoenergy.org/20180618%20RIIA%20Workshop430630.pdf

Transmission and flexible/firm sources needed

Imports via transmission (beige) and flexible firm resources (gray)



- Multi-Day periods of low wind+solar, usually winter.
- Source: Clack, VCE, Minnesota/Eastern Interconnection study. See also E3, EFI, Brattle, Jenkins, MIT EI, Princeton NZA, Gridlab/UC Berkeley, NREL, LBNL, IEA, ESIG, other studies

What policies?
Carbon tax is 1st best, no debate there

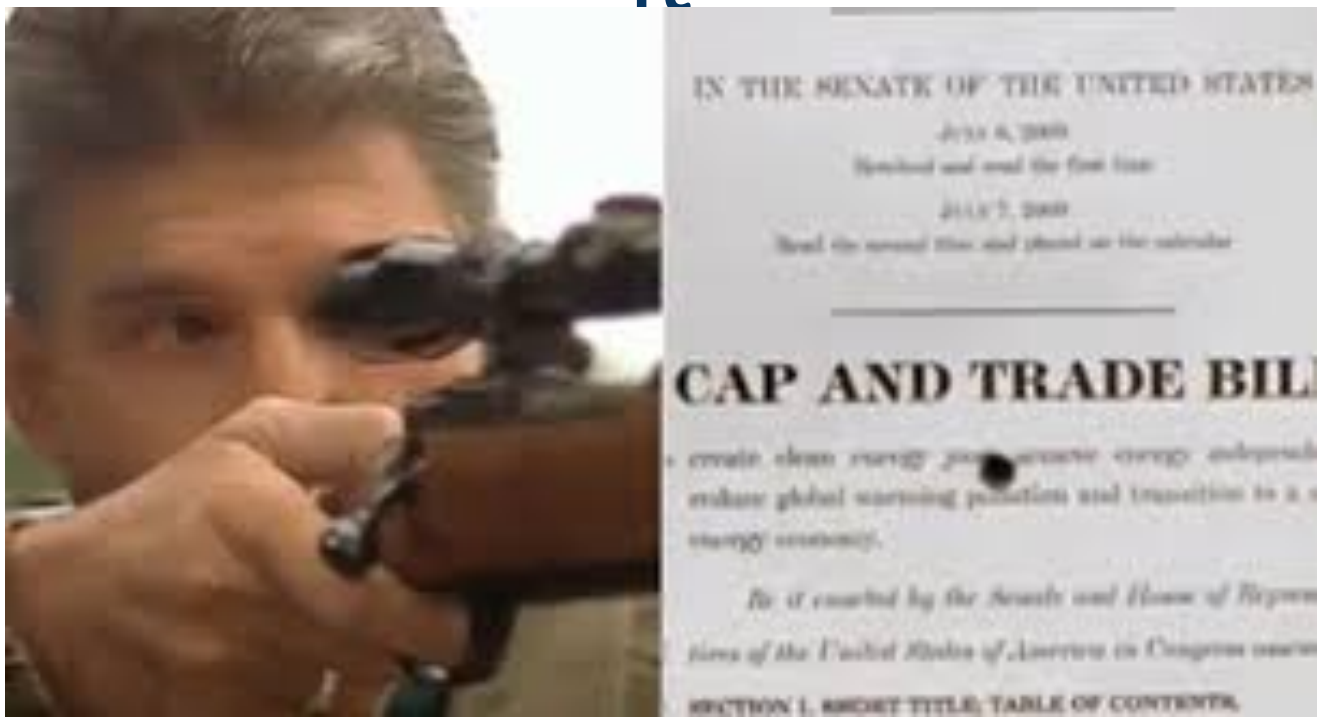
"We need to use the fiscal powers of government to correct marketplace distortions, rather than to create distortions…"

"We could reduce substantially environmental damages at much lower cost than through command-and-control regulations. At the same time, enough revenues would be collected to allow much more burdensome taxes to be reduced…"

"At present, our taxes on payrolls, incomes, and profits penalize the very activities that make the economy productive—work, savings, investment, and entrepreneurship…environmental charges discourage activities that make the economy less productive…"

"Because almost all economic activities use energy derived from fossil fuels, such reductions could be achieved most efficiently by taxing the carbon content of fuels…" Repetto, Dower, Gramlich (1993) https://gridprogress.files.wordpress.com/2018/10/pollution-and-energy-taxes-article-in-challenge1.pdf

But…it's Manchin's world, we're just living in it



- "I have repeatedly stressed the need for innovation, not elimination," Sen Manchin (D-WV)
- All 50 Democratic Senate votes are required to pass anything through Congress on taxes or spending, and 60 votes needed (10 R's) for energy policies
  - Trump beat Biden 69 to 30 in West Virginia
  - Senator Sinema, (D-AZ): Arizona 0.3% margin for Biden in '20, Trump won in '16
- Biden goals are just that, not policies. Supreme Court and Senate aren't going anywhere.

SO WHAT ARE WE GOING TO DO???

Which is more important, a livable planet or 1st best energy policy?
How to force reductions and move other major emitters towards binding commitments?

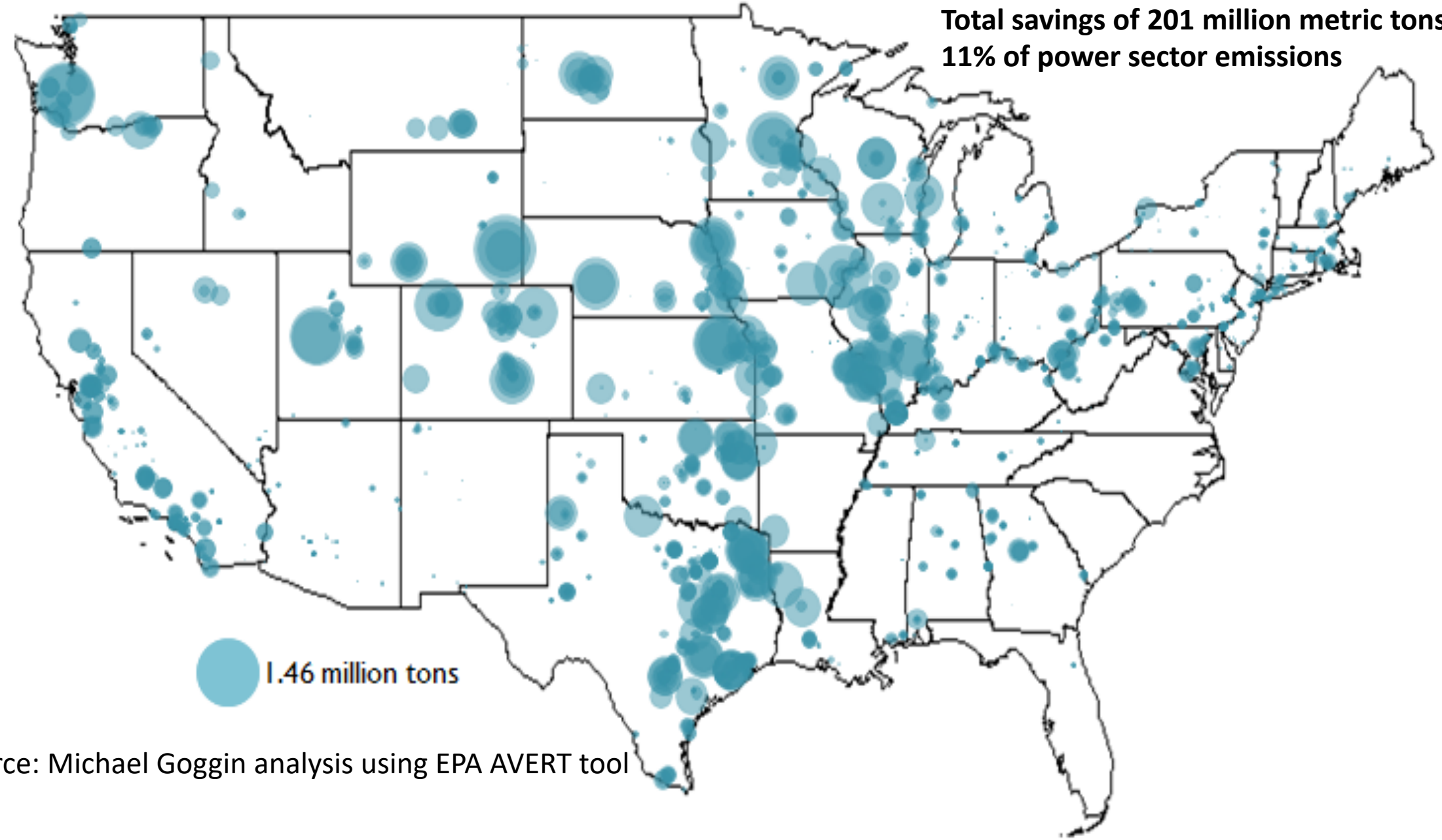
- Actual US policy options in 2021-22
  - EPA carbon regulation of power sector
    - Could be “mass based” only, and lead to carbon price
    - SCOTUS will likely reject but may as well try
  - Federal Clean Electricity Standard
    - 60 Senate votes will be hard to find than in 2009…
  - Vehicle emission standards
  - Energy efficiency standards
  - FERC transmission rule, federal financing for a macro grid
  - Tax credits for carbon free generation
    - Could be technology neutral
  - State policy, with feds allowing states to do more in all sectors

Pro-clean energy policies work

- Renewable Electricity Standards and tax credits have achieved massive renewable cost reductions by driving economies of scale.
- Renewable standards are giving way to Clean Energy Standards at the state (NM, WA, CA) and federal level (Smith bill).
  - Existing nukes, CCS, other sources being included, increasing competition
- CES/RPS politically popular at state and national level, making stronger policies politically feasible. 60 Senate votes possible, 30+ state policies.
- Can be as or more economically efficient than a carbon price, if a large share of carbon revenues are not used to reduce more distortionary taxes.
- Compared to a carbon price they are no less subjective. Discount rate is a value judgment, and dominates the determination of social cost of carbon.

Wind's CO_2 savings, by fossil generator

Total savings of 201 million metric tons of CO_2, 11% of power sector emissions

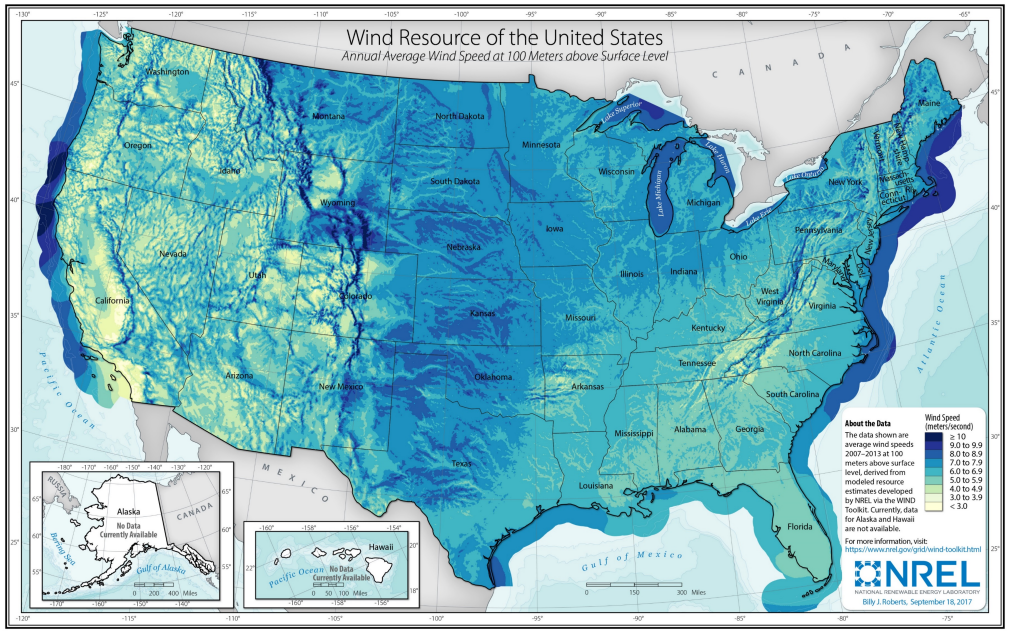


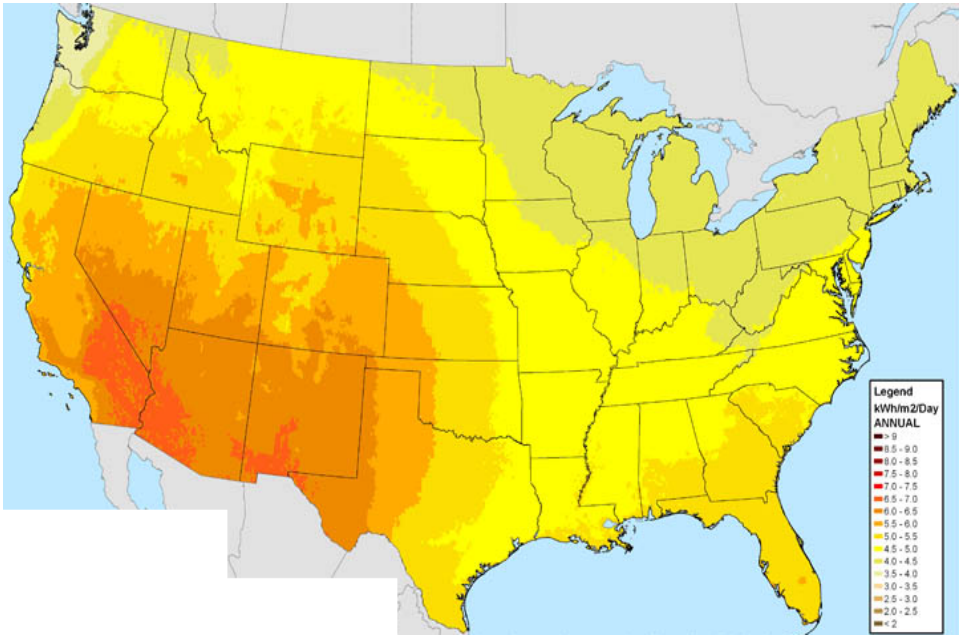
Source: Michael Goggin analysis using EPA AVERT tool

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





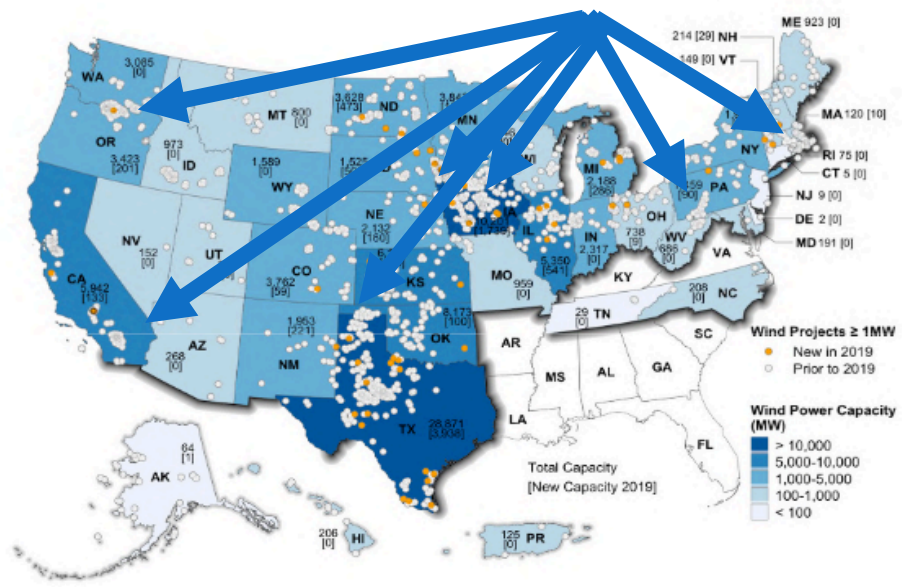
NREL Wind (left, 100m height) and Solar (right) Resource Maps

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

Generation is stuck in interconnection queues

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

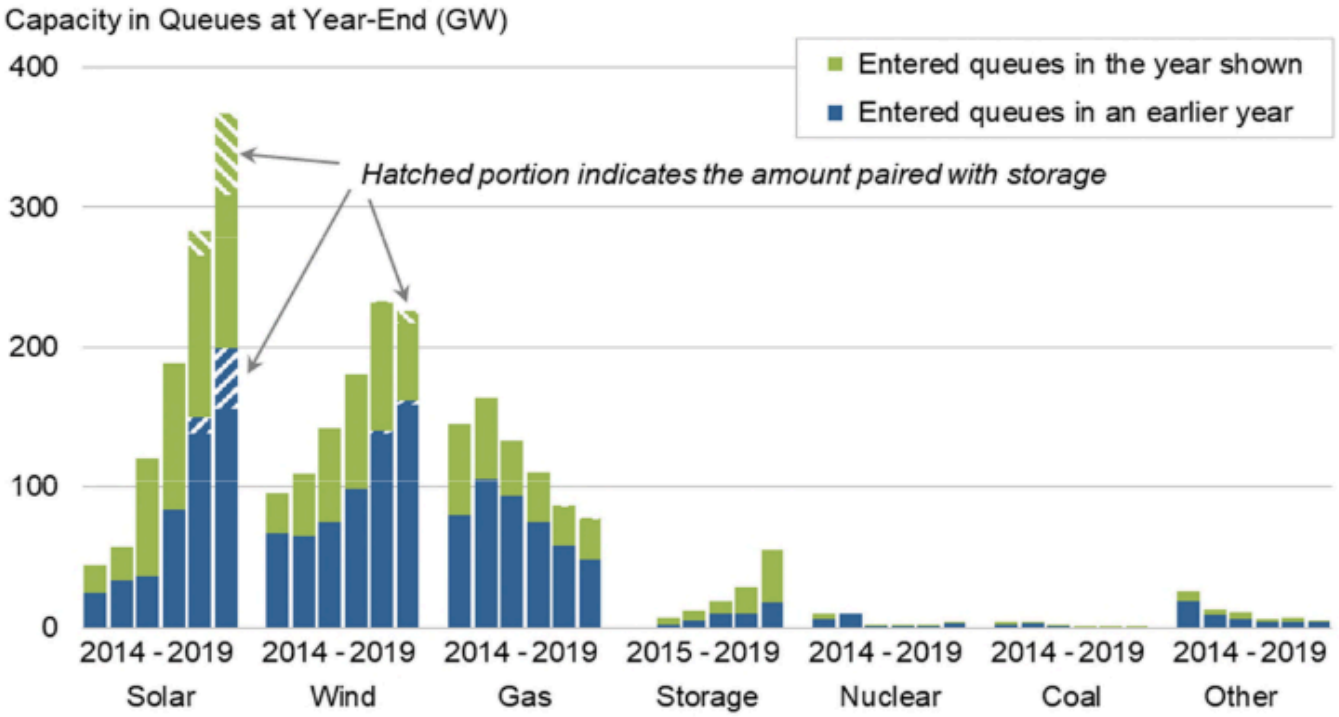
Resource Pockets



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



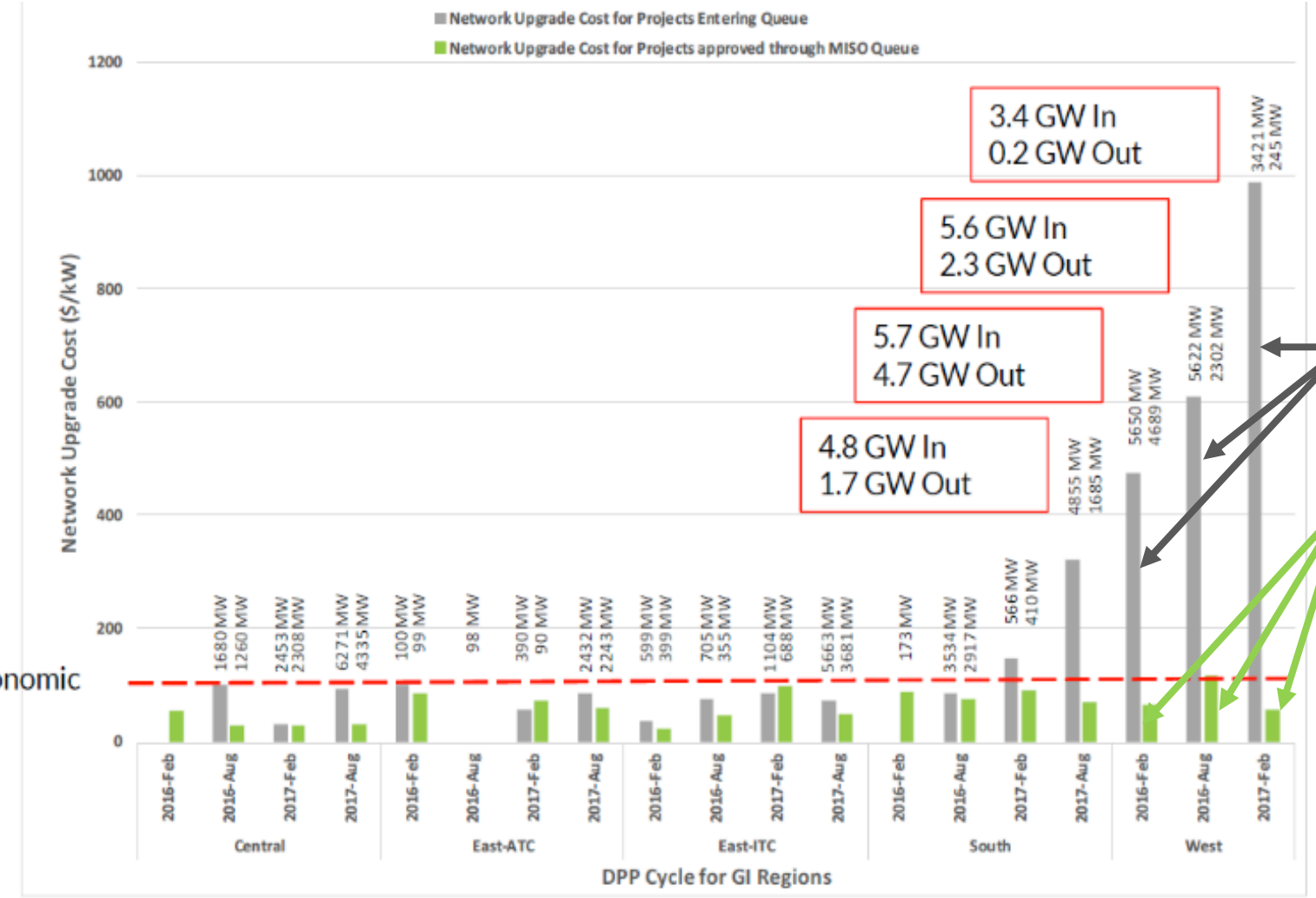
Source: Berkeley Lab review of interconnection queues

Note: Not all of this capacity will be built

Projects Entering Interconnection Queues

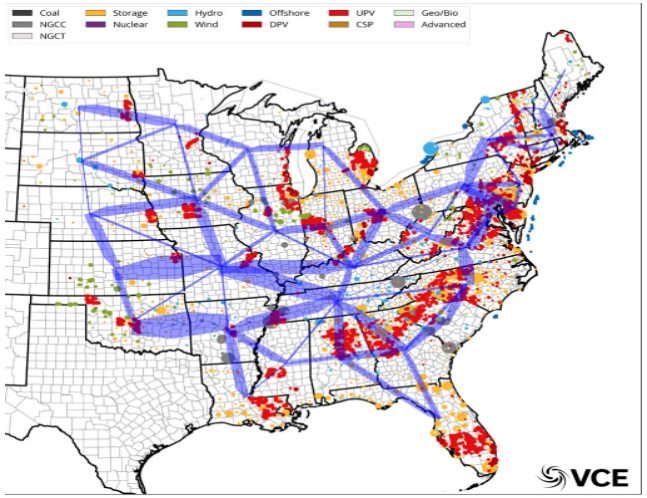
…resulting in massive network upgrade costs

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
2-3x increase in capacity needed



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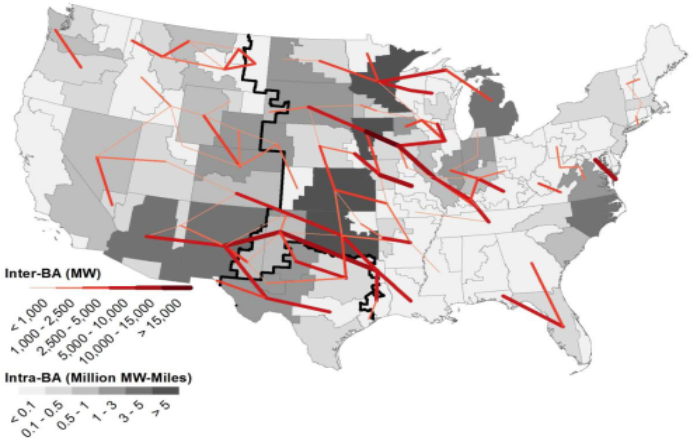
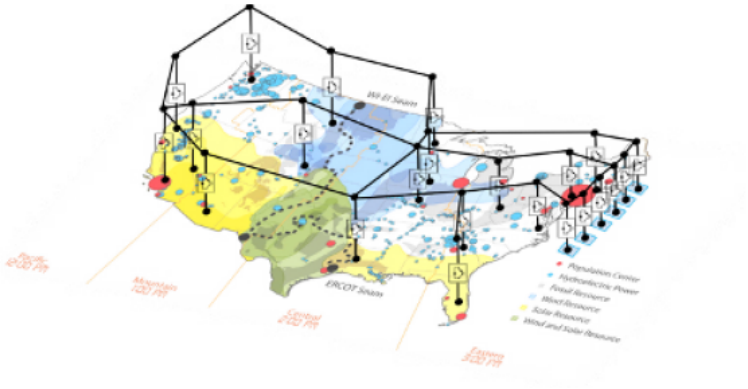


https://www.nrel.gov/analysis/re-futures.html



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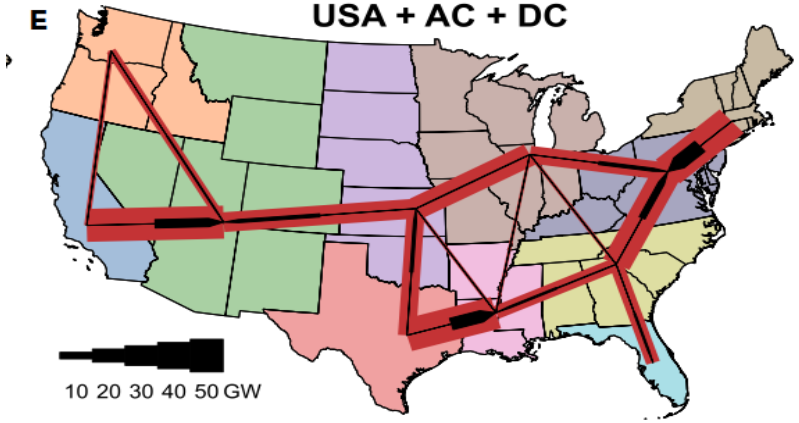
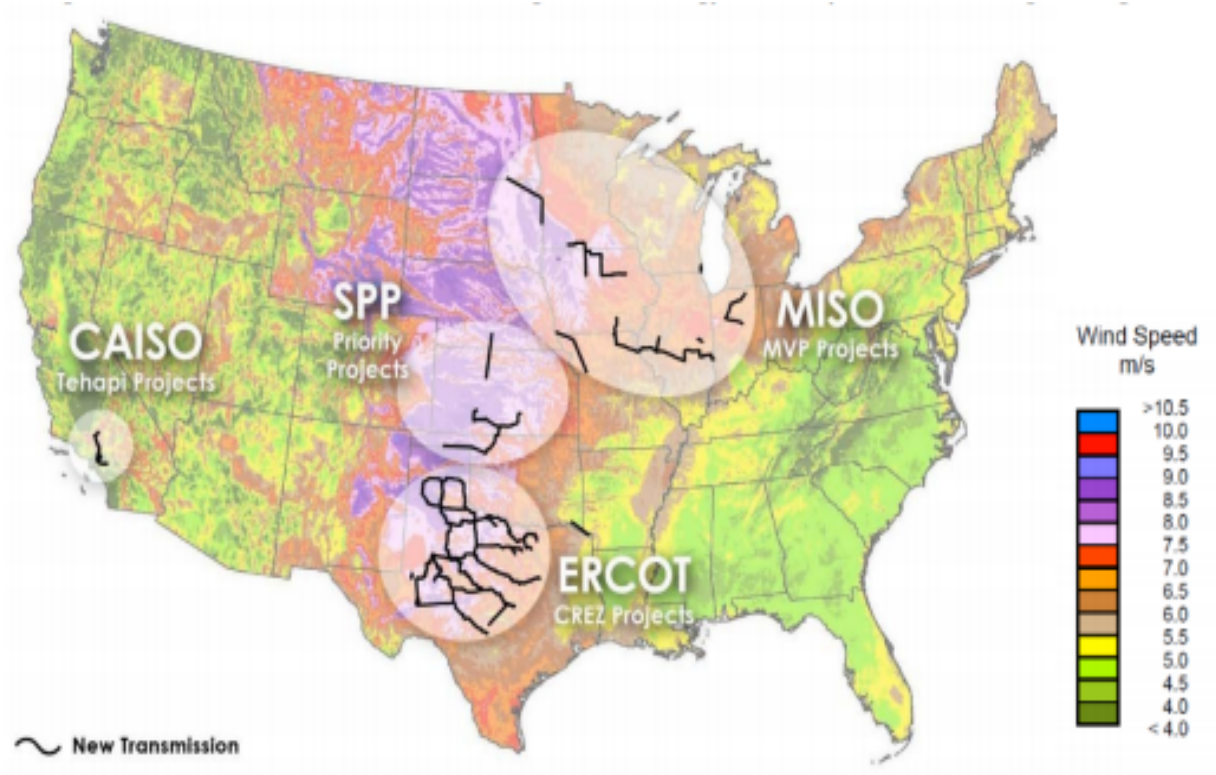


https://www.cell.com/joule/fulltext/S2542-4351(20)30557-2

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



Next FERC Planning Order?

Following Orders 888, 2000, 890, 1000

- 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

Efficient Market Structure and Design

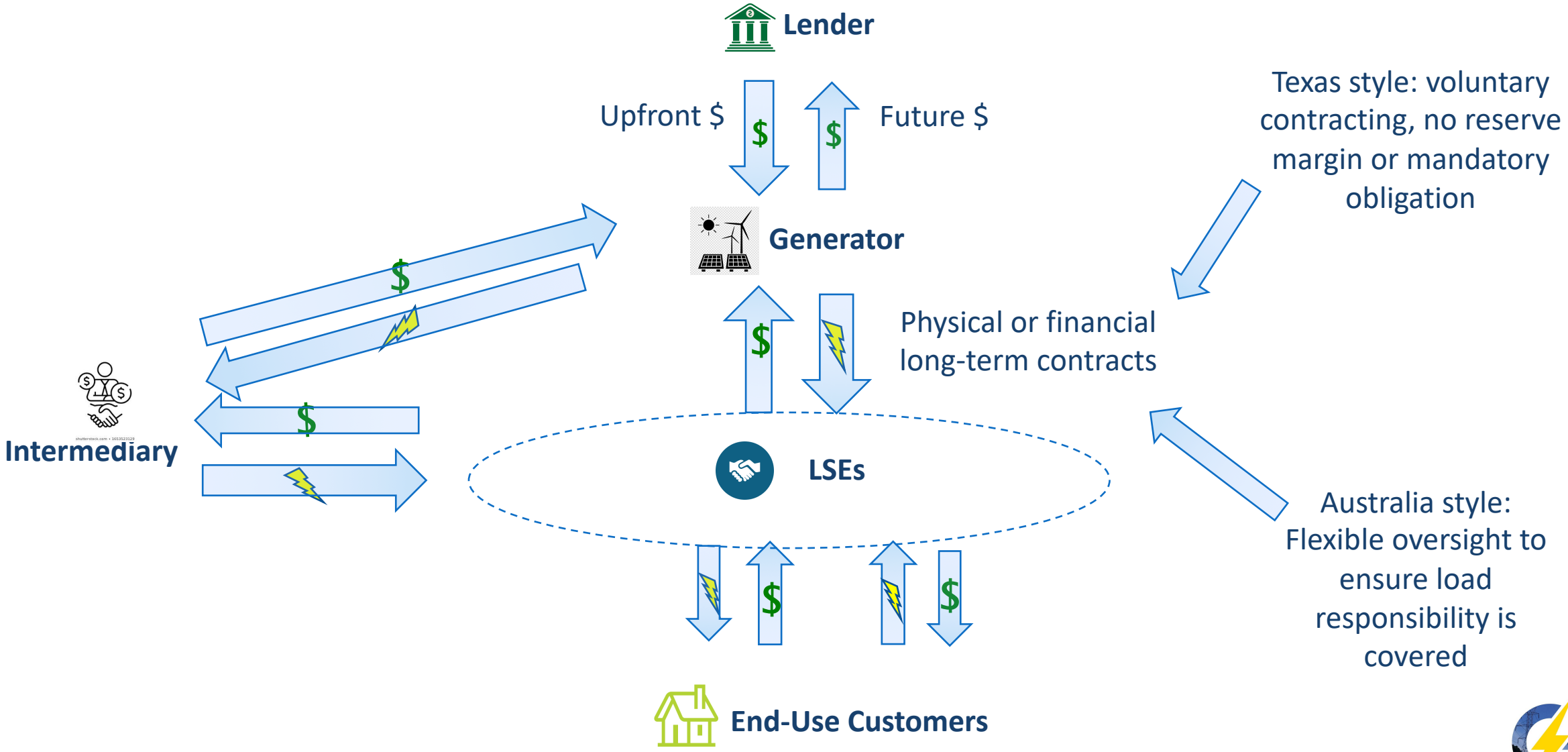
- CUSTOMERS (wholesale or direct access) Procure the types, quantity, term, of energy and risk management products
- RTO
  - balance power system with market mechanisms for energy and reliability services—bid-based SCED day ahead and real time, LMP, FTR, scarcity pricing
  - plan transmission for reliability and efficiency
- Competitive IPPs and marketers build projects, manage risks, sell products to customers including utilities, end-users, and the RTO
- Utilities own and operate T&D under regulation, no Generation
- Financial participants & marketers offer risk management products
- Environmental and energy policy makers internalize externalities

Energy adequacy and forward contracting

- Texas model works—voluntary contracting
  - Wholesale buyers have the incentive and ability to hedge
- Market failure in the other 13 states with retail competition
  - POLR distortion
  - Lack of creditworthy buyers
  - So, states should fix those
- Mandatory contracting not necessary but can work for those states that refuse to just fix their retail markets
  - RTO or states
  - Environmental attributes and energy, bundled or unbundled, at the discretion of states
  - Redefine physical metrics
  - Could be physical or financial (e.g., contract for differences)
  - Settled at physical spot market prices

Market-based (voluntary) investment structure

Achieves low generator financing cost



Market impact of CES and tax credits

- Negative marginal cost of carbon-free generation, affects bids
- Zero-emission resources almost never set the market clearing price
  - But may, if DR and transmission are done poorly
- Energy prices likely very low when renewable output high
  - Retail regulators should reflect wholesale supply/demand in retail rates. Will encourage alignment of consumption and prices
- High, scarcity-based prices during fast ramps and high net load
  - Encourages storage, DR, flexible sources