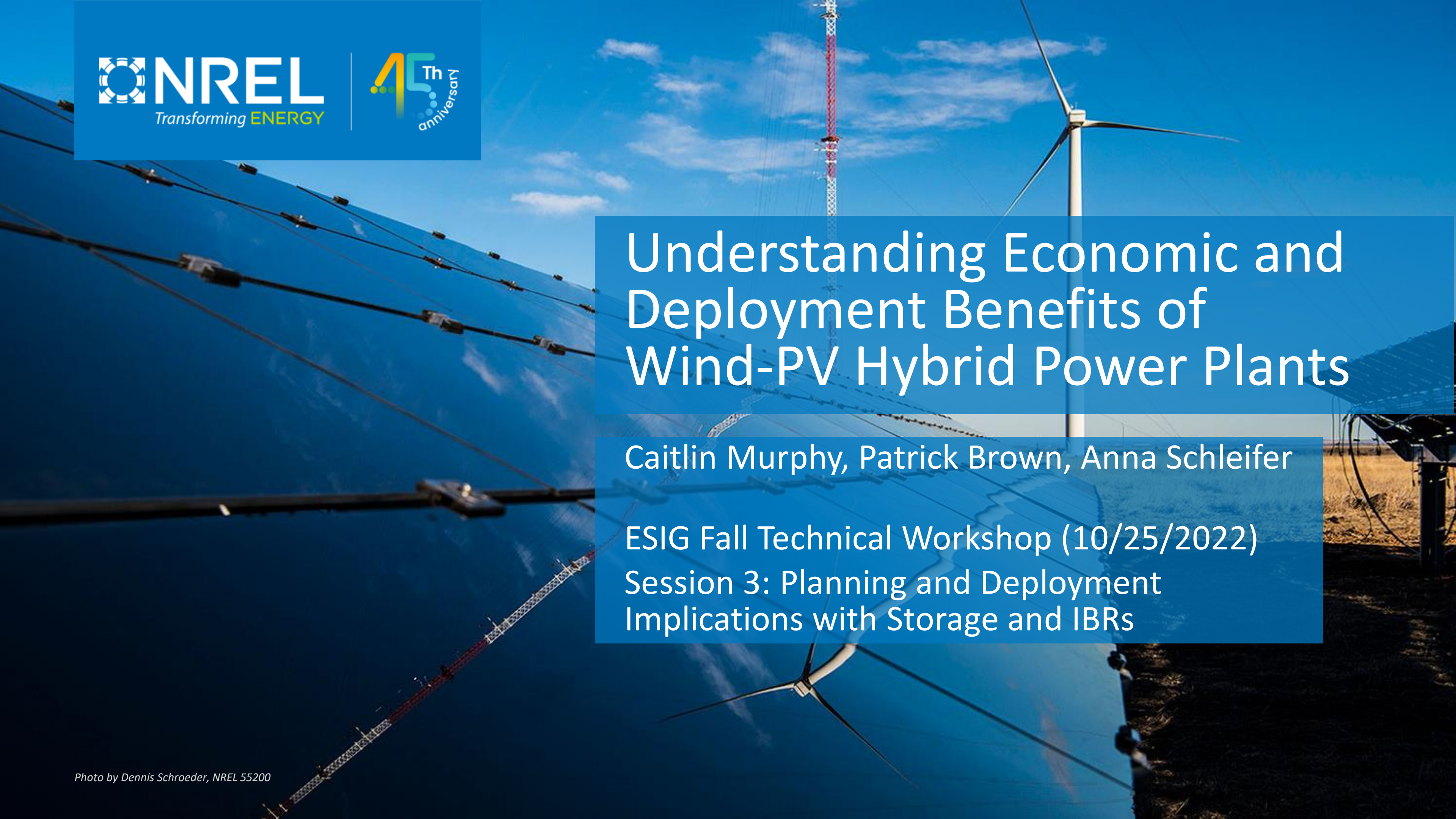


Understanding Economic and Deployment Benefits of Wind-PV Hybrid Power Plants

Caitlin Murphy, Patrick Brown, Anna Schleifer

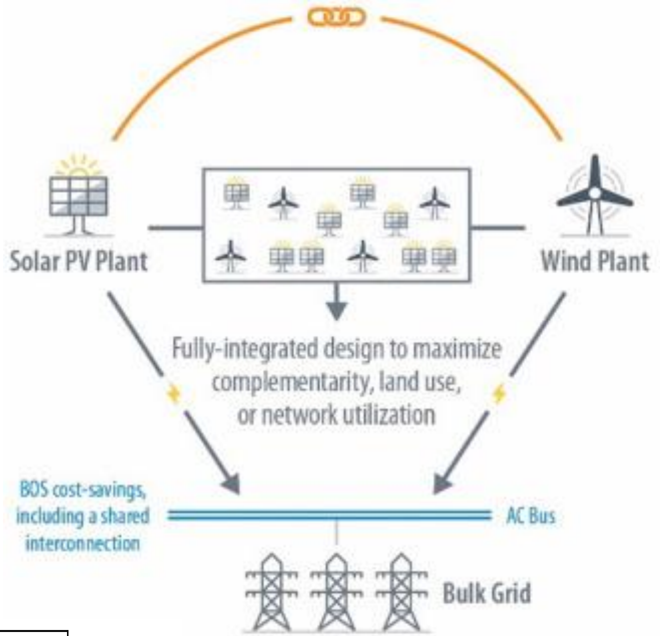
ESIG Fall Technical Workshop (10/25/2022)

Session 3: Planning and Deployment Implications with Storage and IBRs

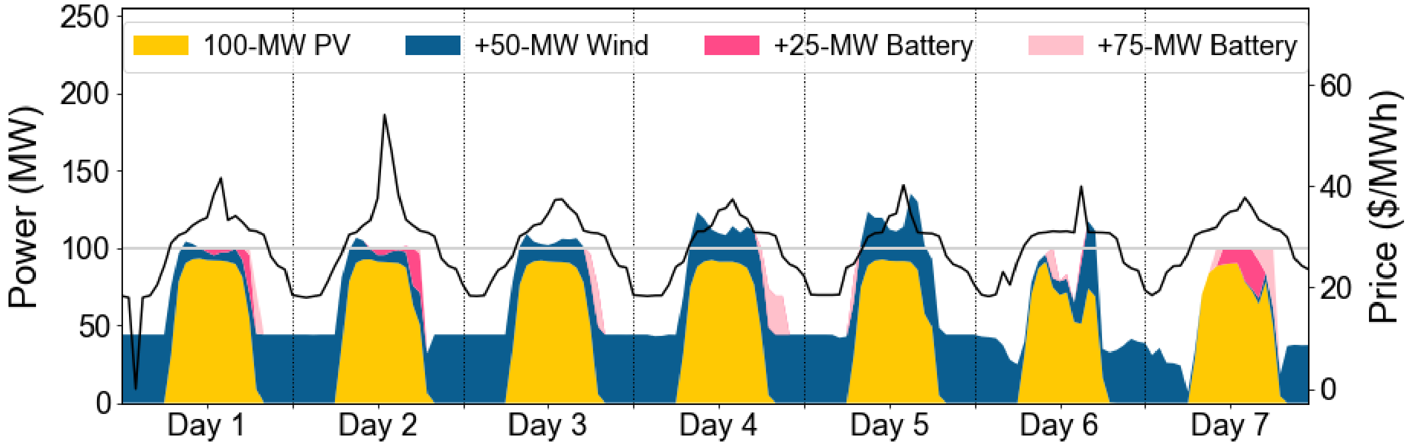
Photo by Dennis Schroeder, NREL 55200

Drivers of Wind-PV Hybrids

- **Shared balance of system costs** including shared spurline costs and potentially faster permitting/siting
- **Increased capacity factor** for hybrids that combine complementary resources (i.e., those whose generation profiles are anticorrelated, or out of sync)
- **Reduced variability**, which helps to facilitate VRE integration, increases dispatchability/reliability services with reduced storage requirements, and maximizes transmission utilization



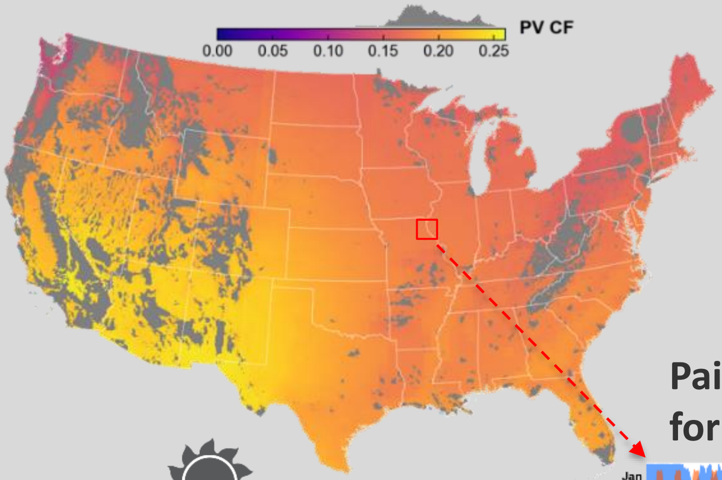
Murphy et al. (2021), https://doi.org/10.1016/j.rser.2021.110711

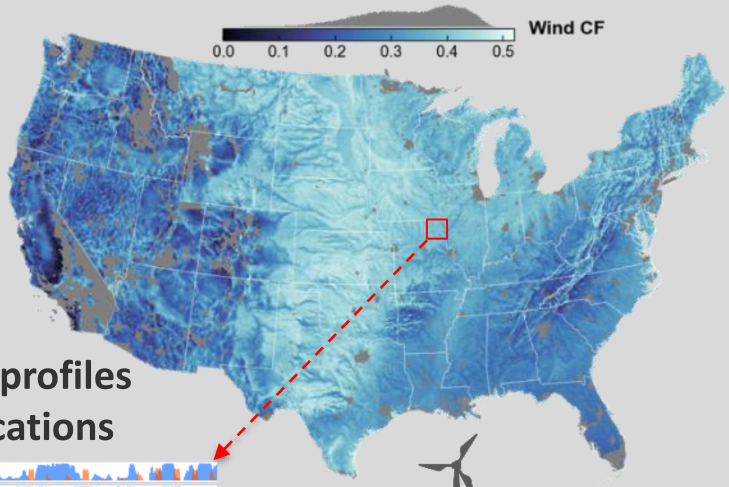


Schleifer et al., Frontiers in Energy Research, under review

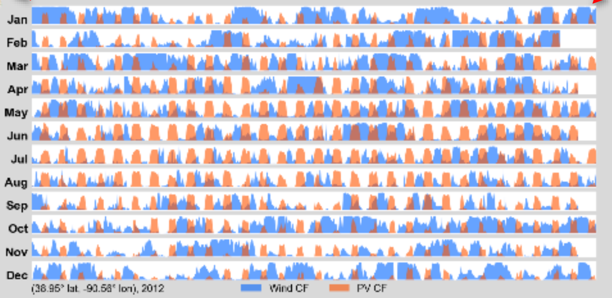
FlexPower Resource Assessment: A High-Resolution Dataset for Nationwide Evaluation of *Local Wind-PV Complementarity*

Hourly simulated power output for 2007-2013





Paired generation profiles for 1.76 million locations



PV System

- Monofacial 1-Axis Tracking
- Azimuth : 180 Degrees (due South)
- Inverter Efficiency: 96%
- Losses : 14.08%

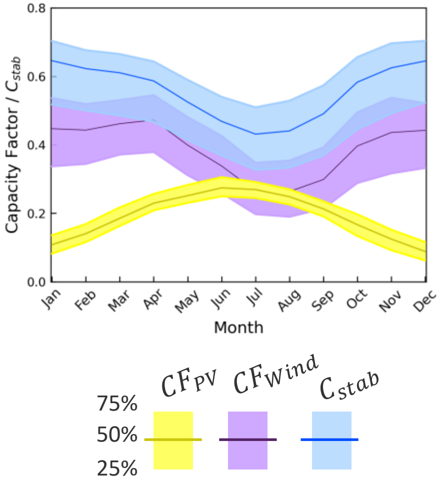
Wind 2030 Advanced

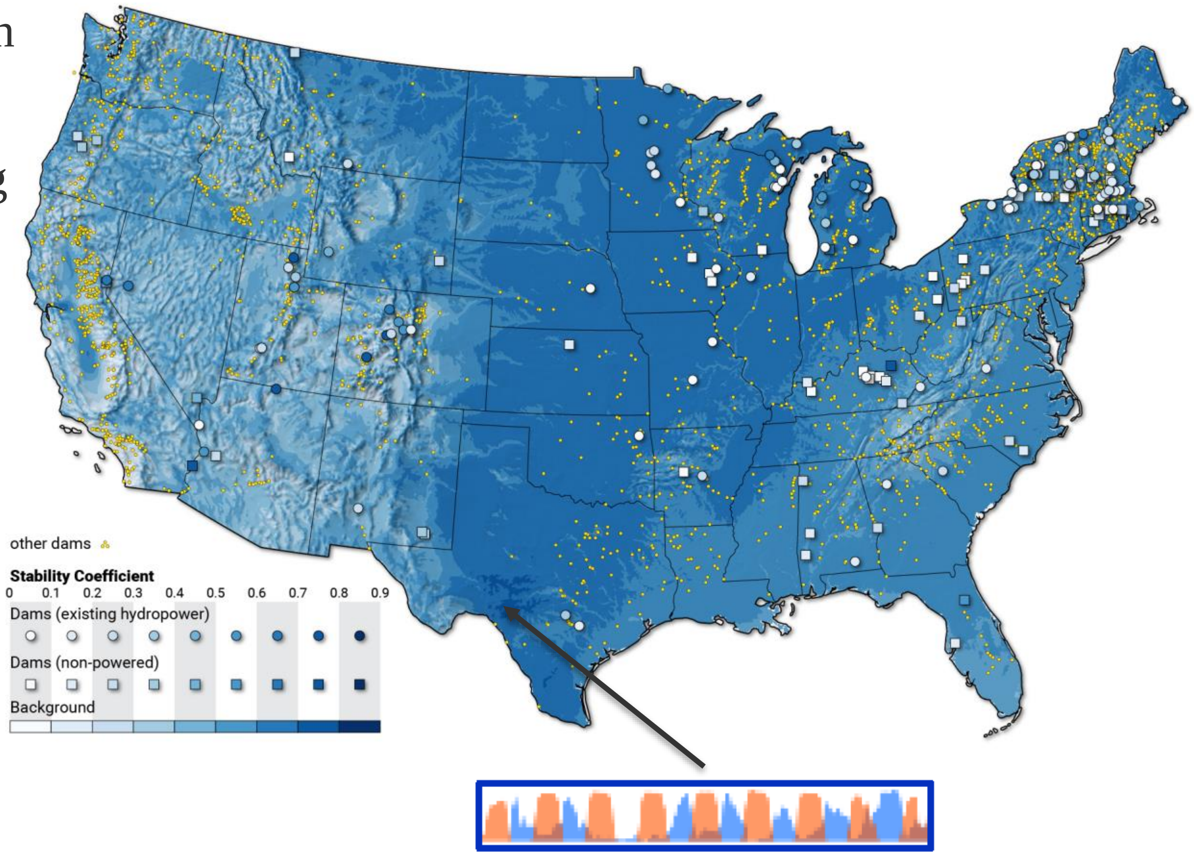
- Turbine Capacity: 7 MW
- Hub Height: 135m
- Rotor Diameter: 200m
- Losses: 9.4%

Wind-PV Complementarity is Found for Much of the Country

Wind offers the greatest stabilization benefits to colocated PV:

- In the wind belt and surrounding regions, the Central Valley of California, and the Northeast
- During winter months

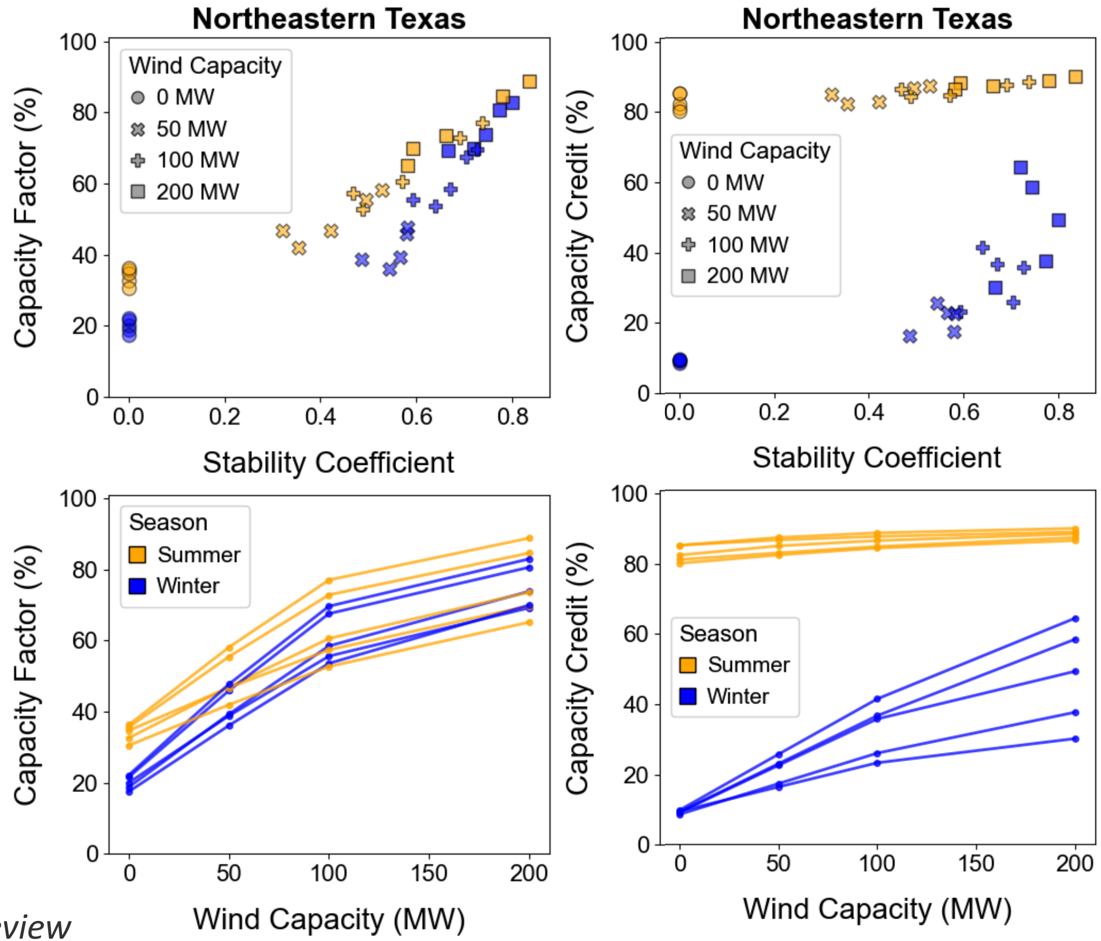




Harrison-Atlas et al., Renewable Energy, accepted

Wind-PV Hybrids: Complementarity and Performance

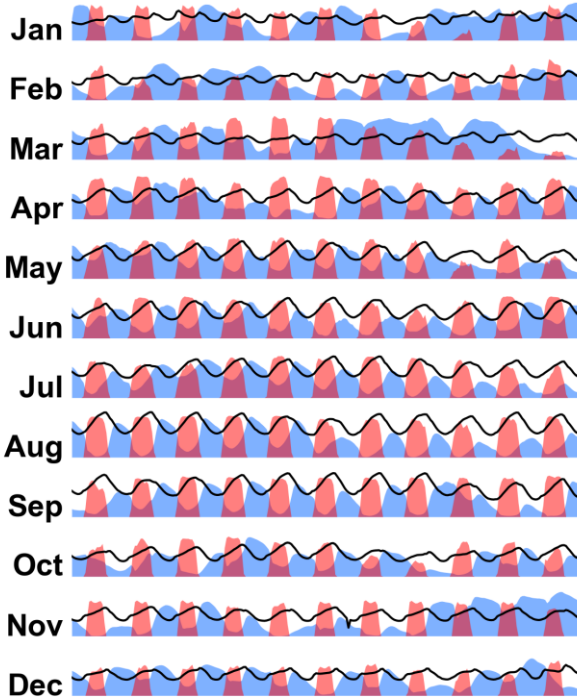
- Complementarity is a reliable indicator of capacity factor but is not as reliable for capacity credit
- Coupling complementary PV and wind resources allows for more effective utilization of interconnection capacity
- PV-wind hybrids can achieve capacity factors of 60–80%+ and capacity credits to close to 100%



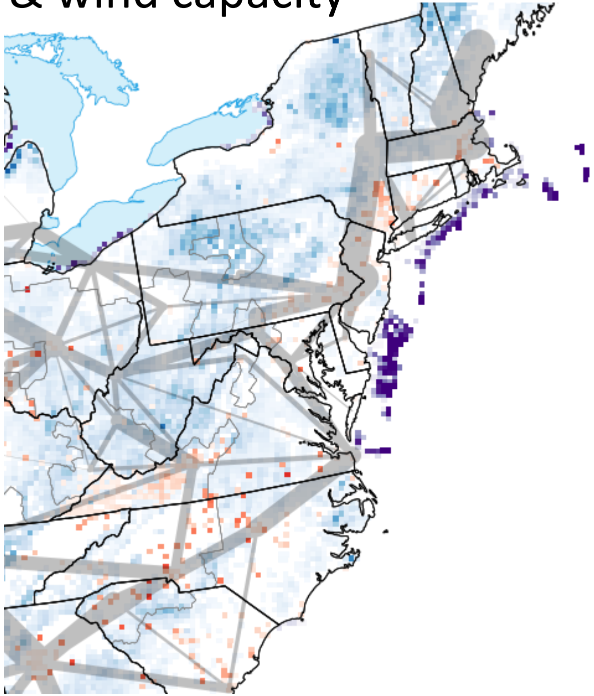
Schleifer et al., Frontiers in Energy Research, under review

Exploring Wind-PV Hybrid Deployment

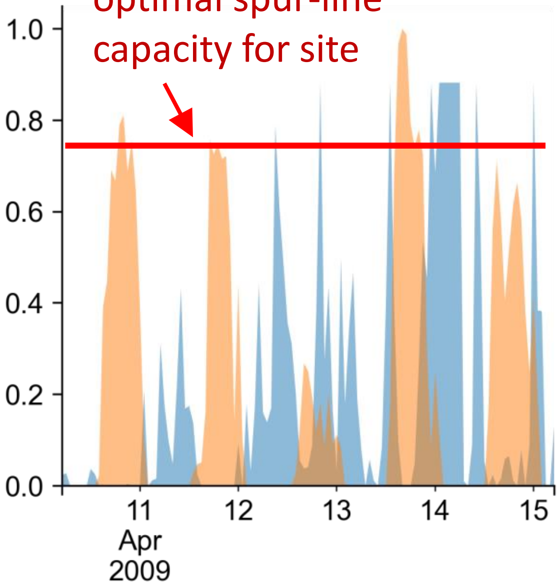
1. Hourly resolution for PV:wind complementarity



2. Individual-site-resolution for spur-line costs and PV & wind capacity



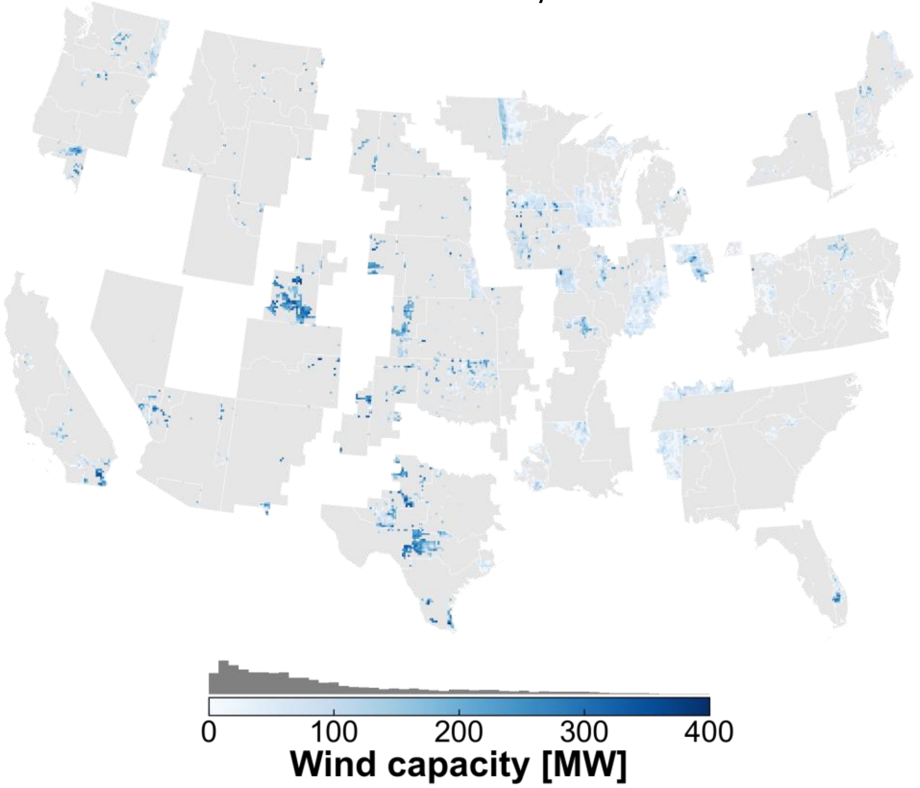
3. Site spur-line capacities optimized in ReEDS

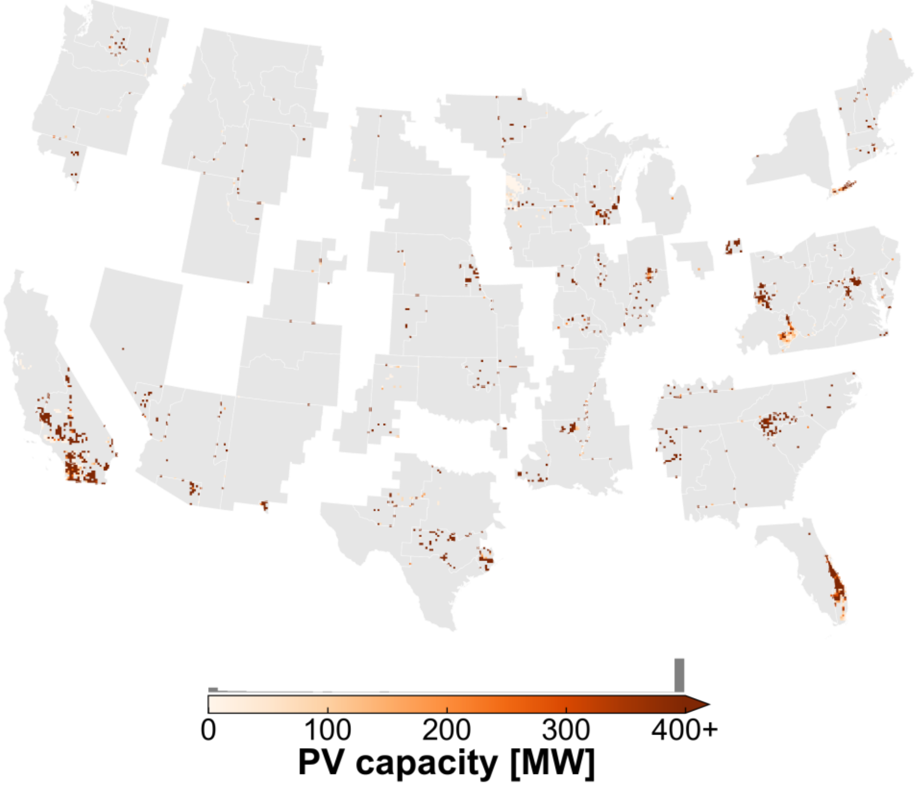


Brown et al. "Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States". In prep.

Wind and PV Deployment: No Hybrids

2040 zero-carbon systems

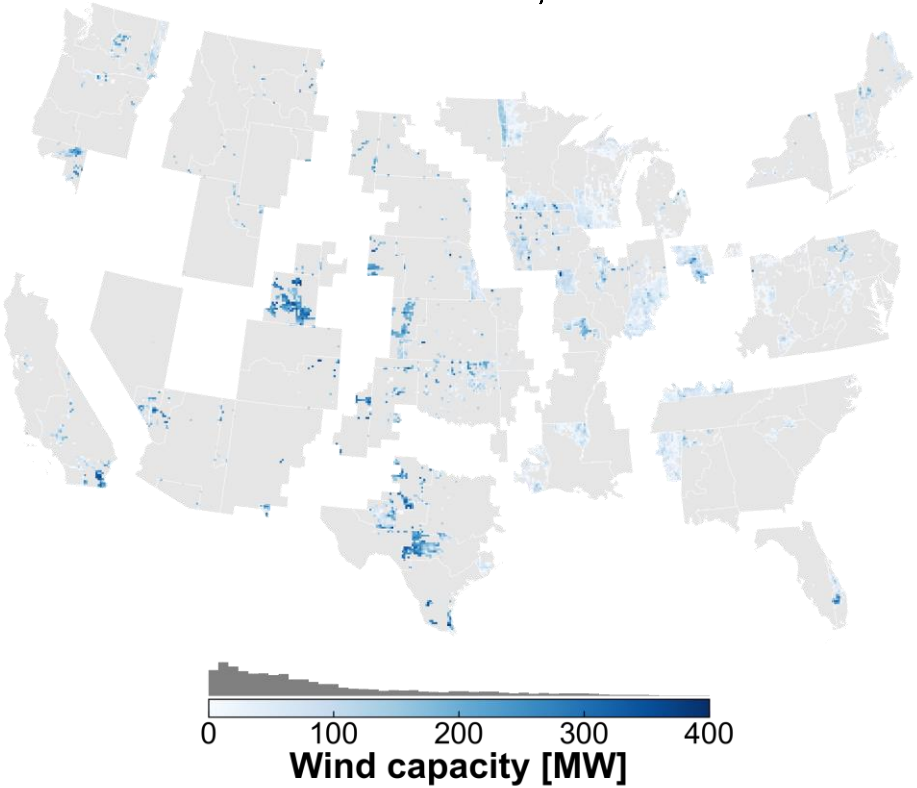


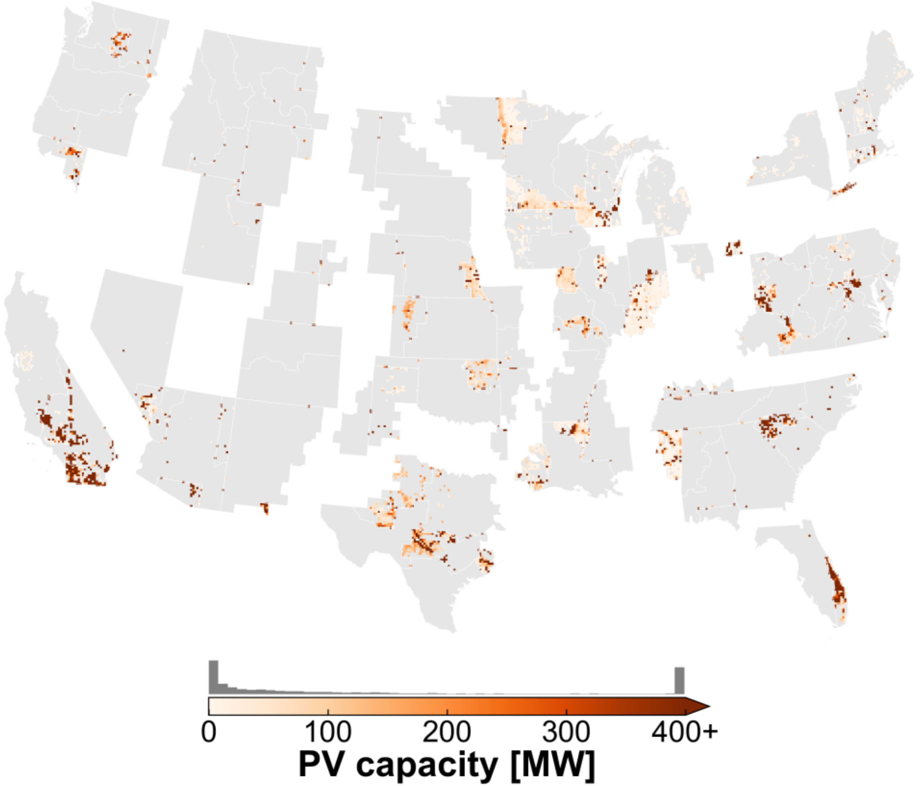


Brown et al. “Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States”. In prep.

Wind and PV Deployment: With Hybrids

2040 zero-carbon systems

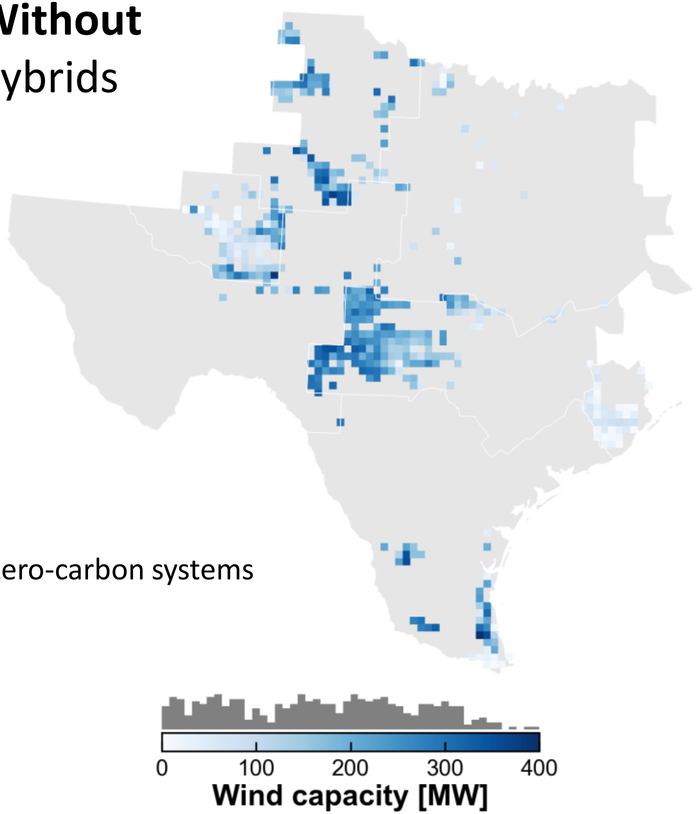




Brown et al. “Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States”. In prep.

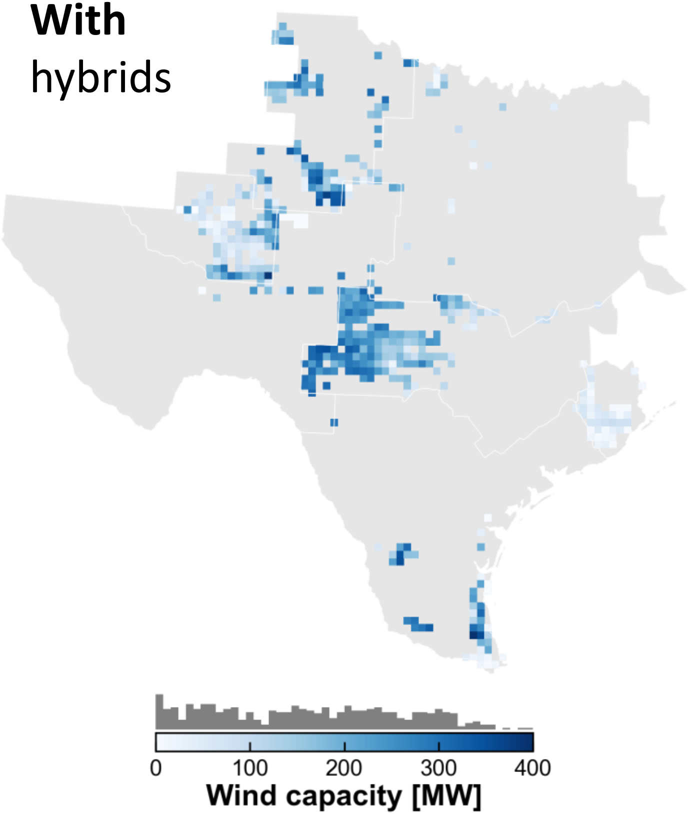
Wind Deployment in ERCOT: Minimal Shift with Hybridization

Without hybrids



2040 zero-carbon systems

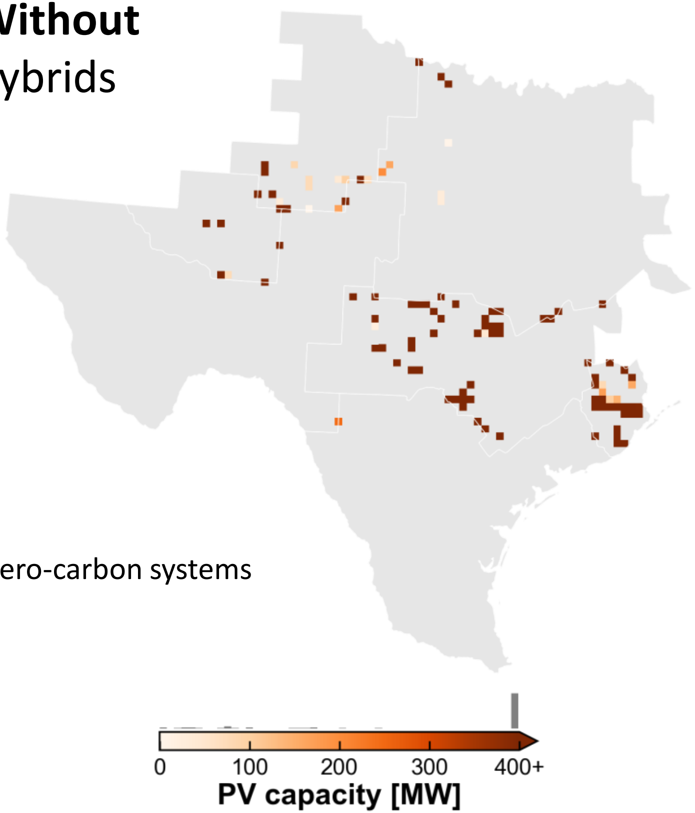
With hybrids



Brown et al. "Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States". In prep.

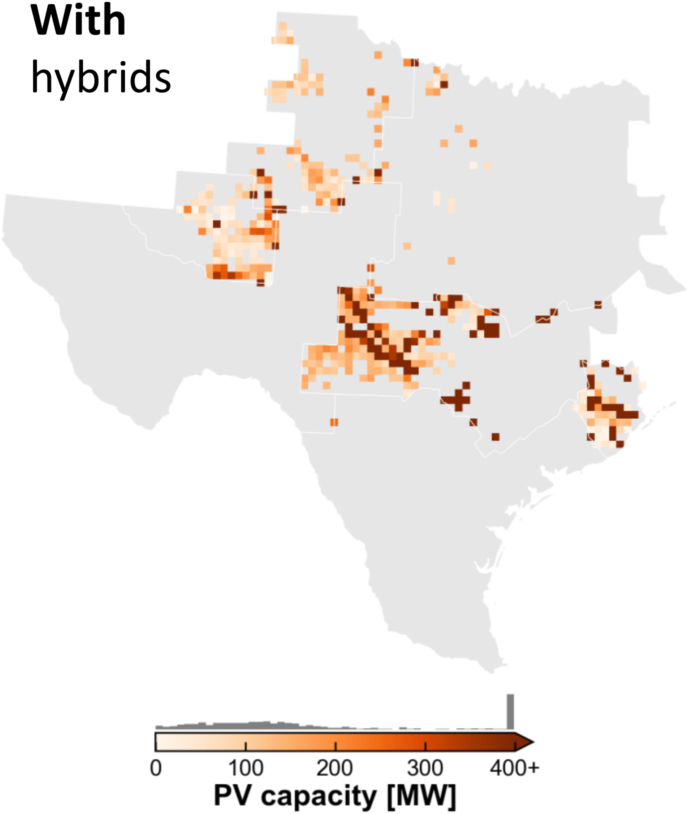
PV Deployment in ERCOT: Relocation to Wind Sites With Hybridization

Without hybrids



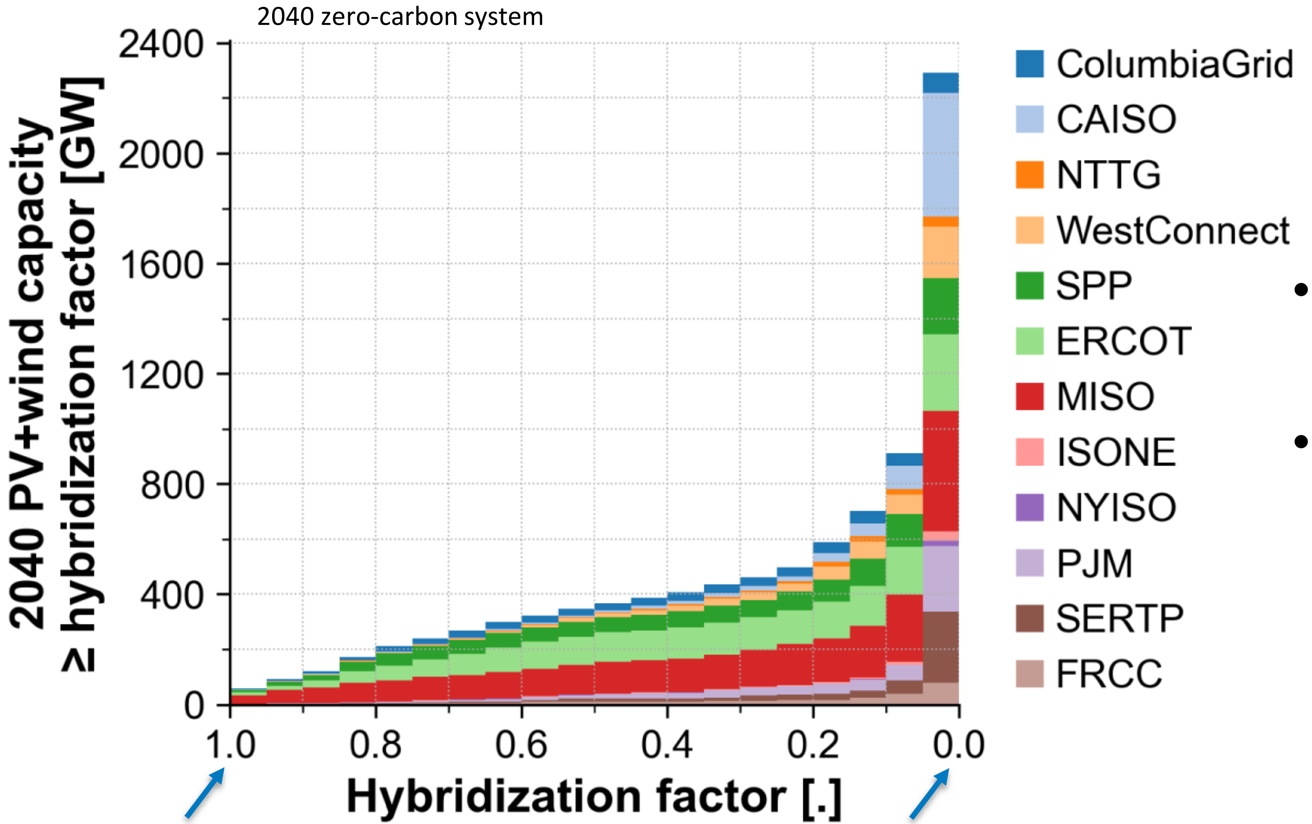
2040 zero-carbon systems

With hybrids



Brown et al. “Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States”. In prep.

How Much Hybrid Capacity is Deployed?



Wind-PV Hybrid with 1:1 Capacity Ratio

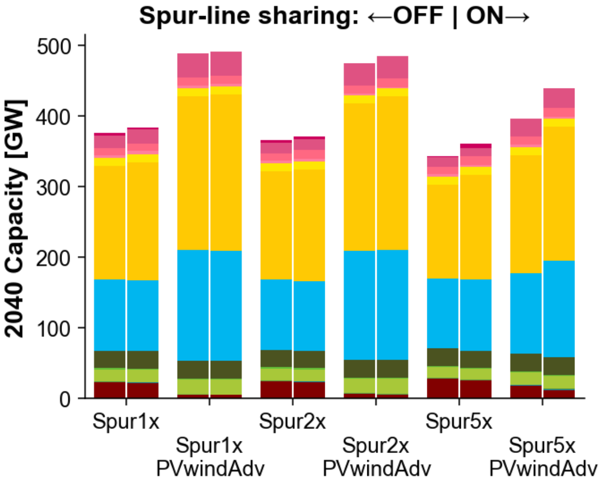
Wind-only or PV-only

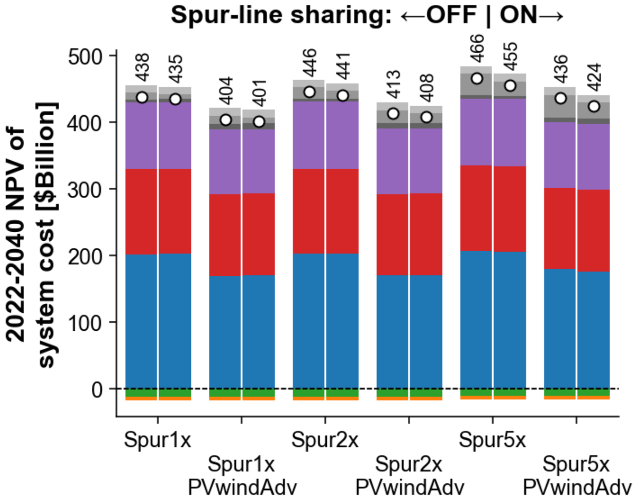
Brown et al. “Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States”. In prep.

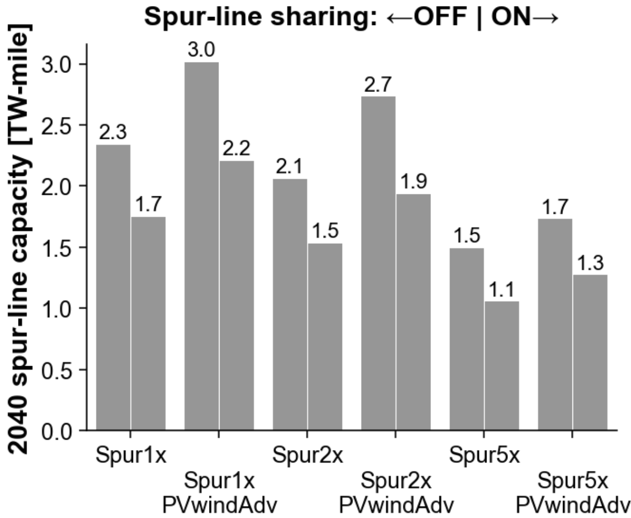
- Most PV/wind capacity is **not** hybridized
- Still a significant amount of hybrids: 195 GW of POI capacity = **348 GW of nameplate PV + wind** (versus 218 GW nameplate PV + wind at end of 2020)

What Value Does Hybridization Provide?

2040 zero-carbon ERCOT system







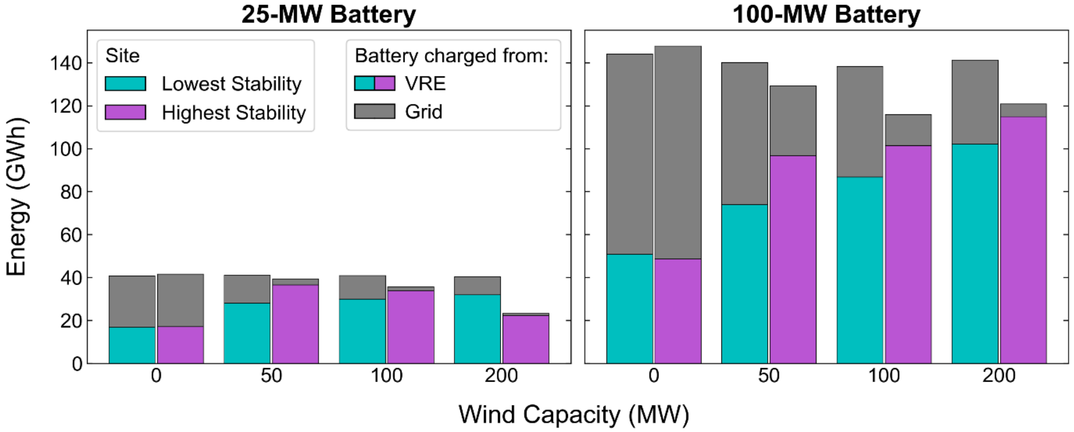
PV/wind deployment increases (but PV/wind cost matters more)

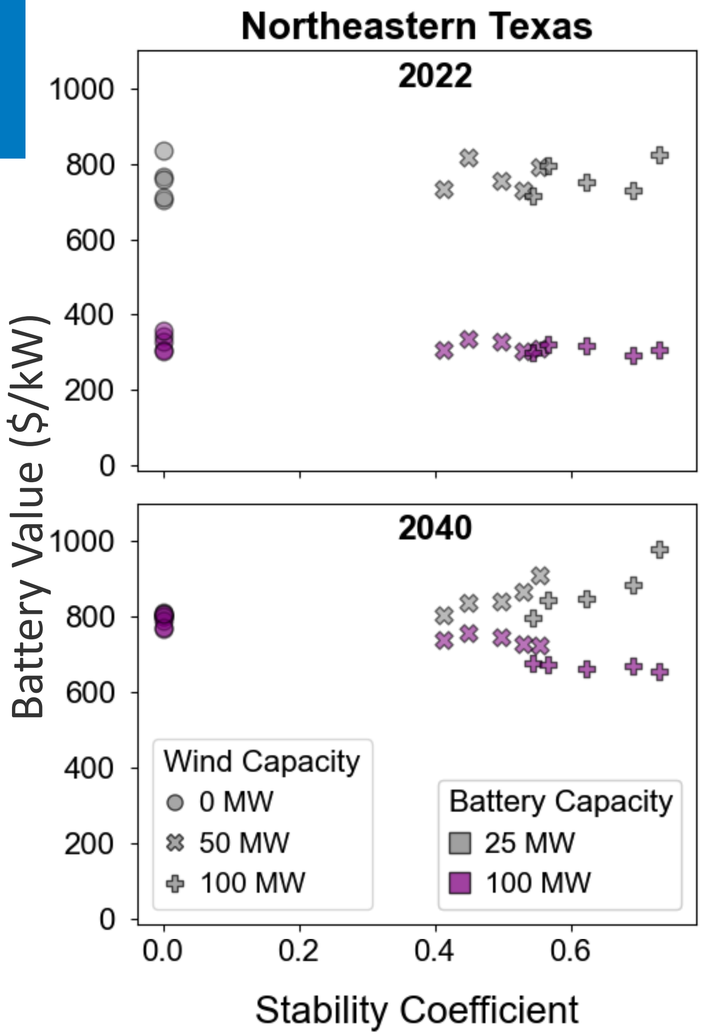
$2.5–12 billion in NPV of savings (0.6–2.8%) depending on spur-line and PV/wind cost assumptions

20–30% decrease in spur-line capacity [TW-miles]

Brown et al. “Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States”. In prep.

What's Next: Adding Storage





- In the near term, smaller batteries can provide comparable economic performance as larger batteries when coupled with complementary PV-wind systems
- Storage in a hybrid configuration charges primarily from coupled VRE resources (including clipped energy), and its utilization is reduced overall in regions with high complementarity

Schleifer et al., Frontiers in Energy Research, under review

Key Takeaways

- Decarbonization scenarios involving wind-PV hybrids achieve similar levels of VRE generation shares with reduced transmission interconnection; PV tends to relocate to wind sites
- Wind-PV hybrids that leverage *resource complementarity* involve increased capacity factors and transmission utilization, but the relationship between complementarity and capacity credit is more nuanced
- Optimal storage sizing in a hybrid configuration depends on the variability of the coupled generation source and the value of standalone VRE

Thank you!

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www.nrel.gov

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