

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

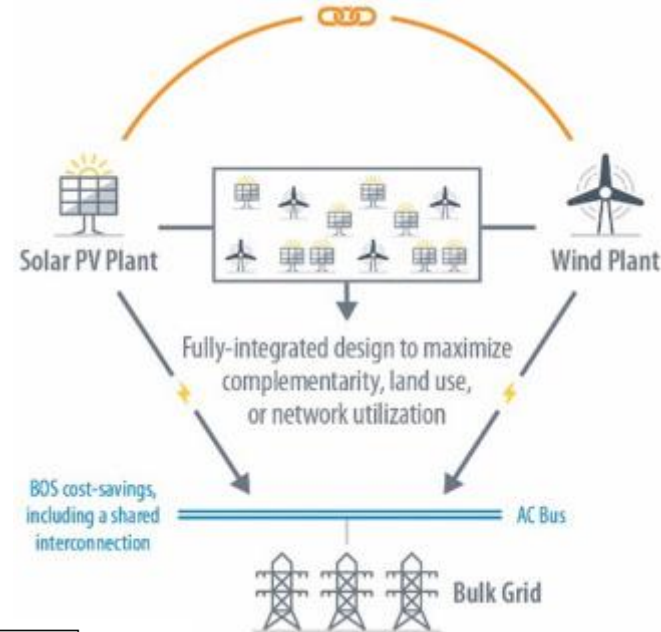
Caitlin Murphy, Patrick Brown, Anna Schleifer

ESIG Fall Technical Workshop (10/25/2022)

Session 3: Planning and Deployment
Implications with Storage and IBRs

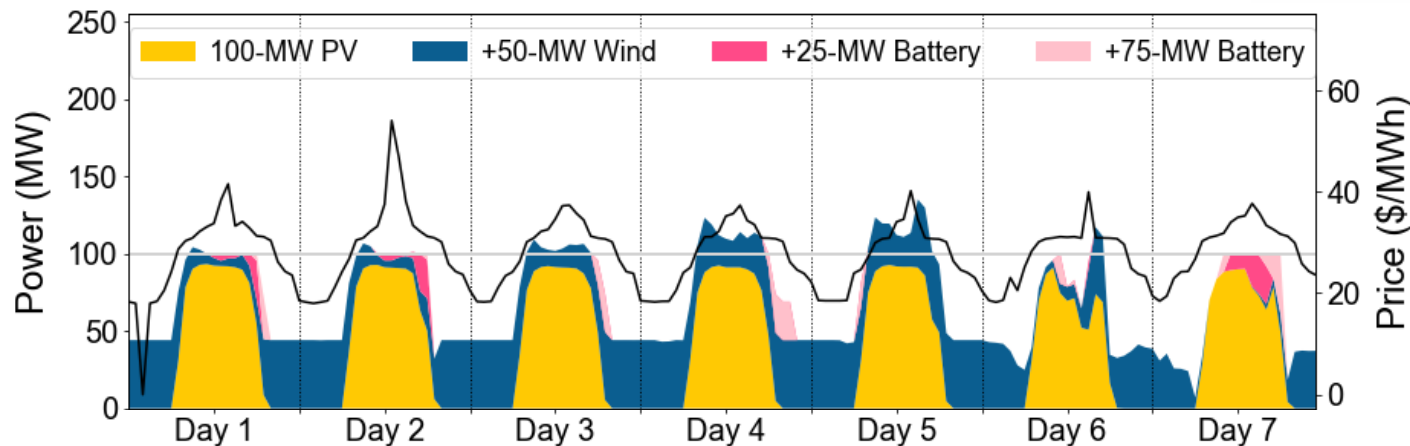
Drivers of Wind-PV Hybrids

- **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



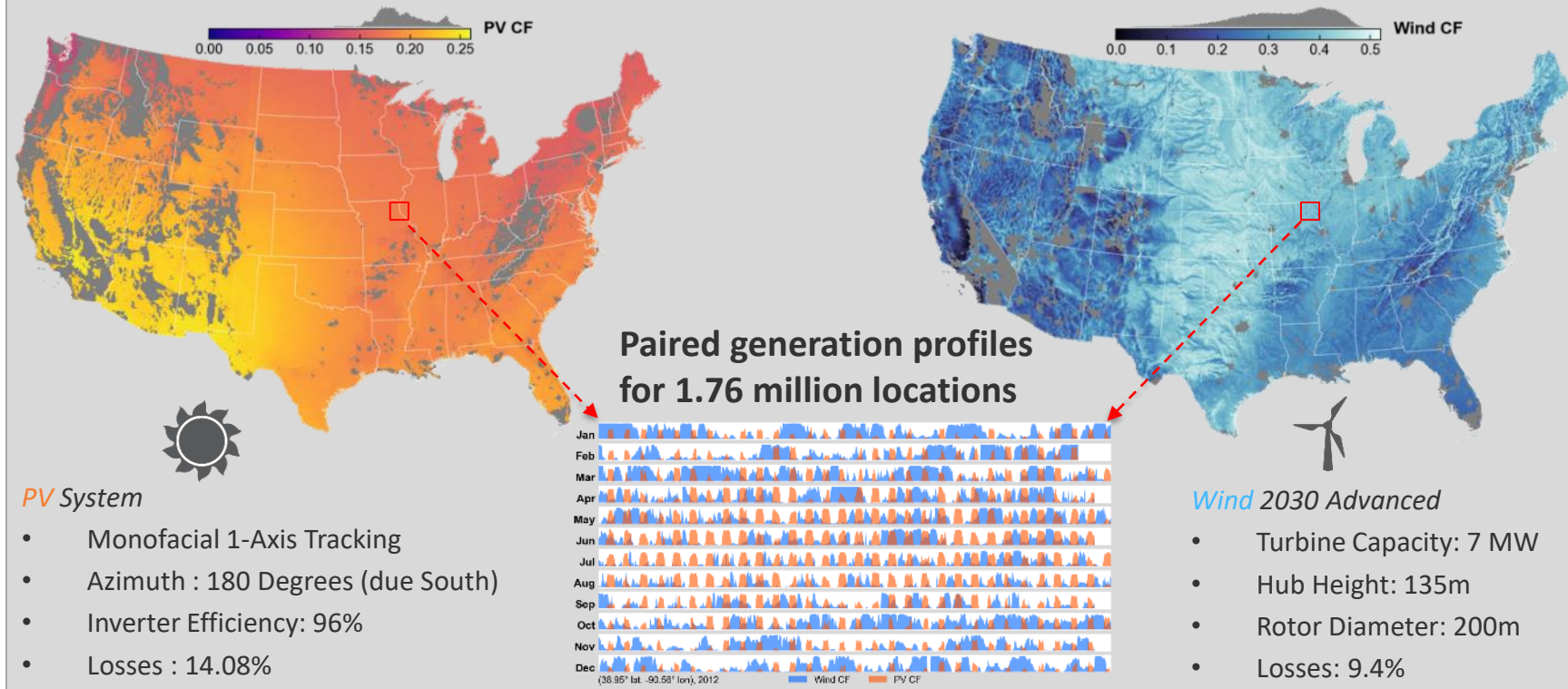
Murphy et al. (2021),
<https://doi.org/10.1016/j.rser.2021.110711>

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



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

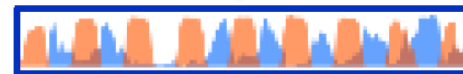
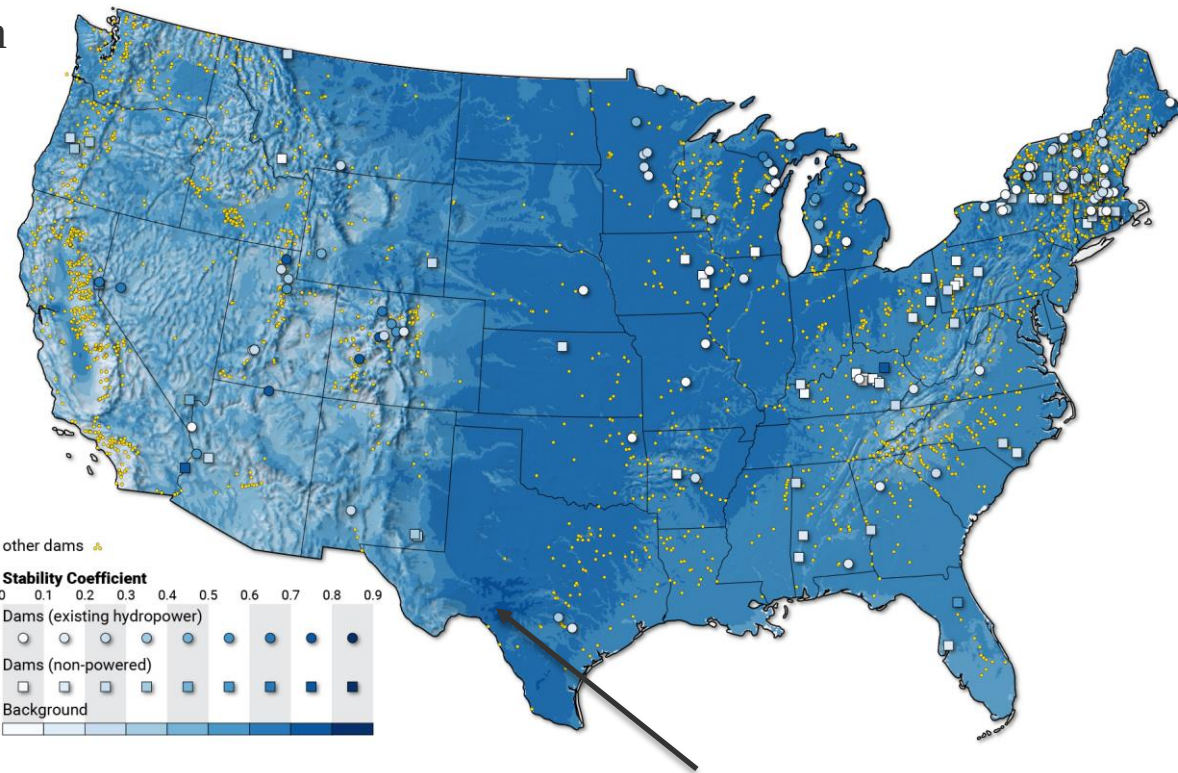
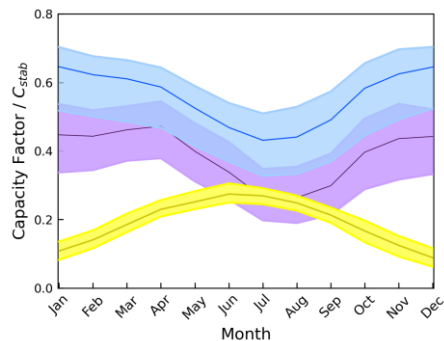
Hourly simulated power output for 2007-2013



Wind-PV Complementarity is Found for Much of the Country

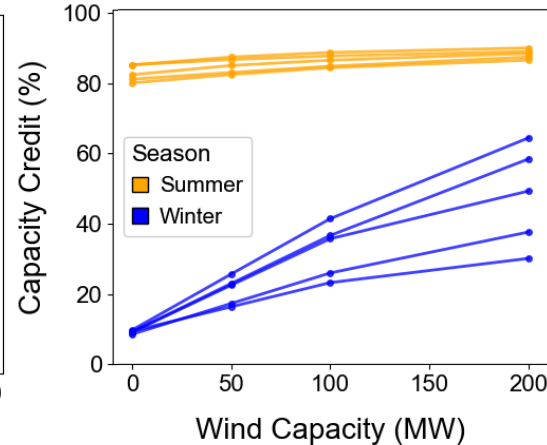
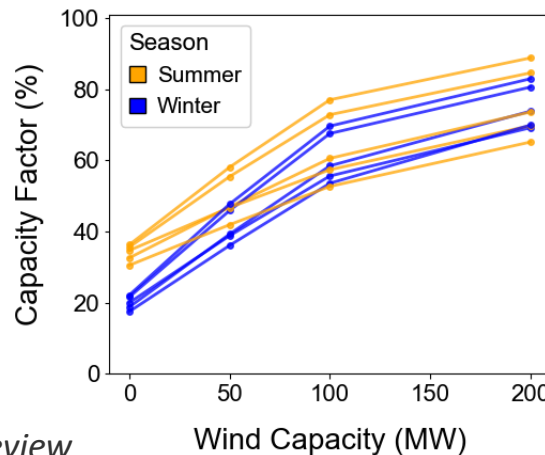
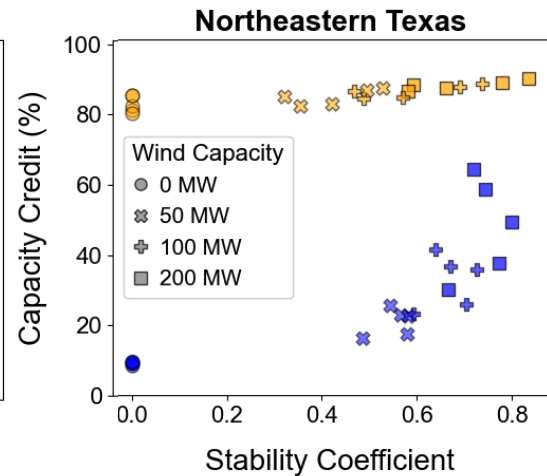
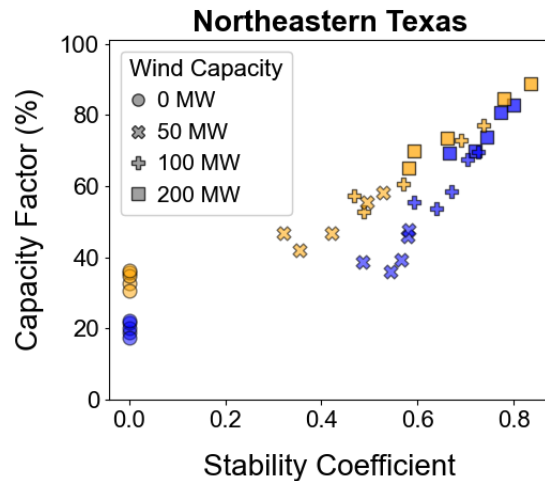
Wind offers the greatest stabilization benefits to colocated PV:

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



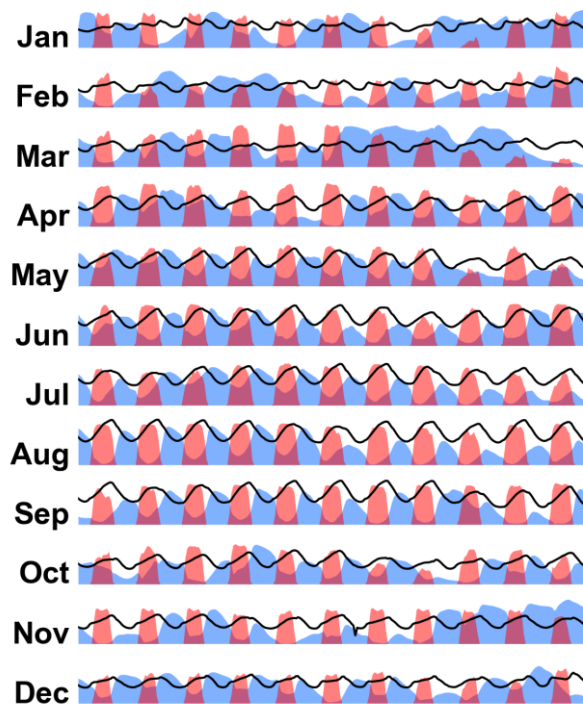
Wind-PV Hybrids: Complementarity and Performance

- 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%

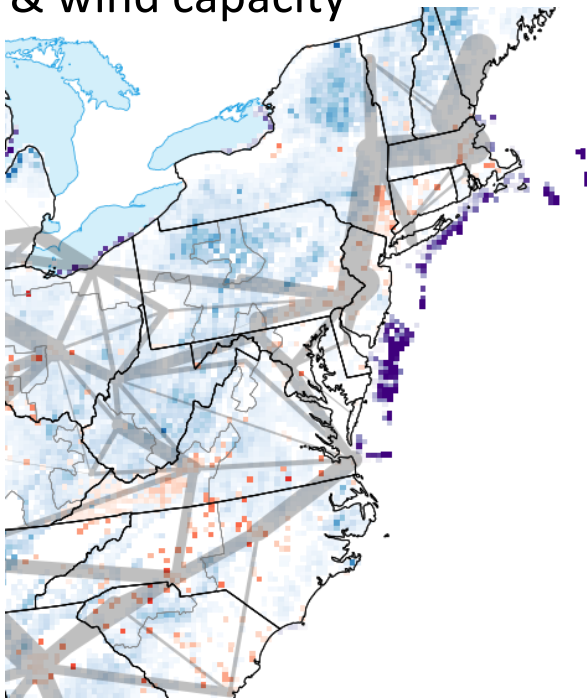


Exploring Wind-PV Hybrid Deployment

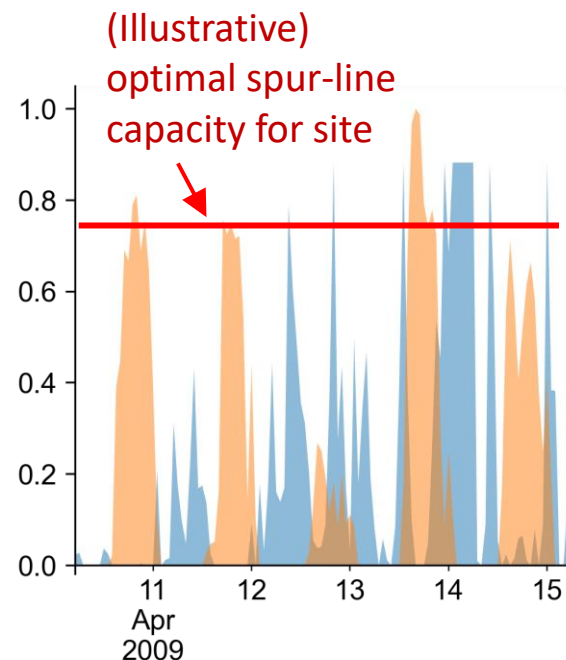
1. Hourly resolution for PV:wind complementarity



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



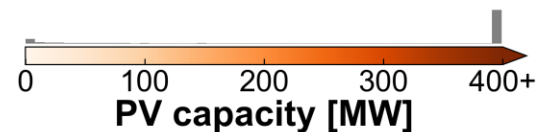
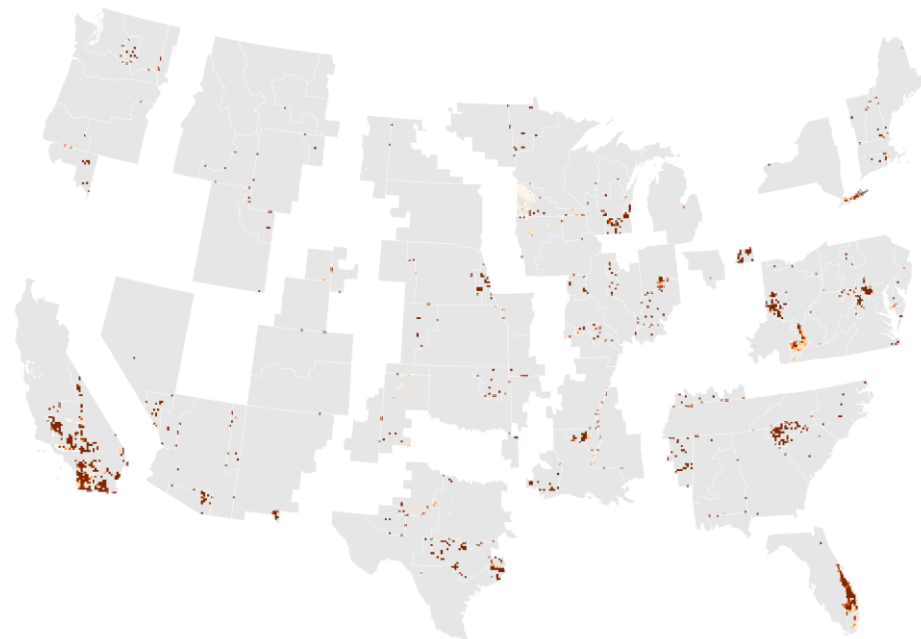
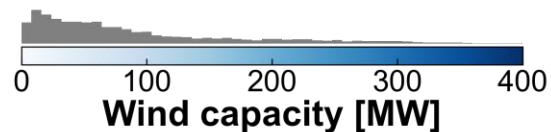
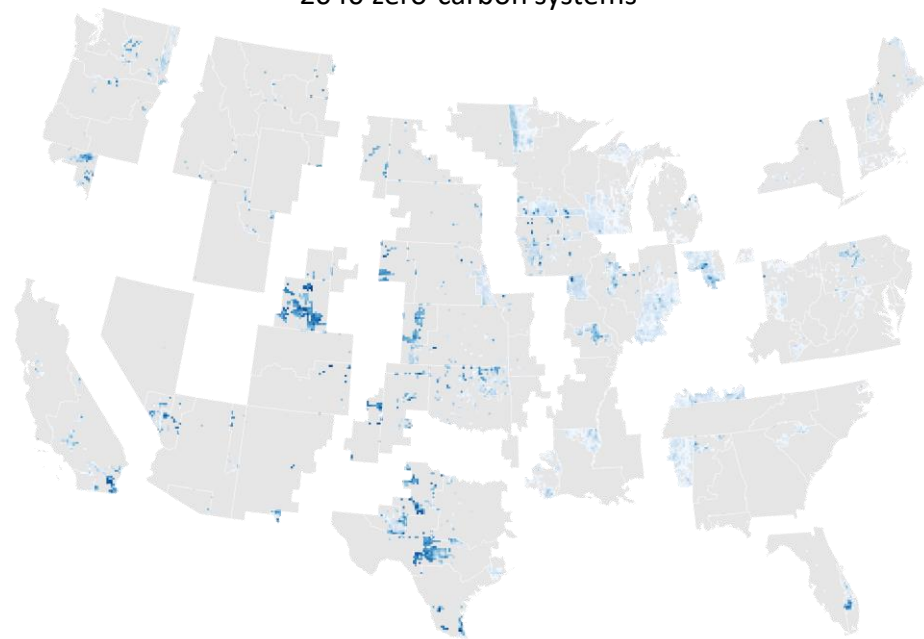
3. Site spur-line capacities optimized in ReEDS



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

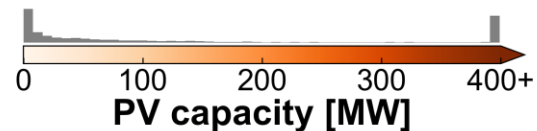
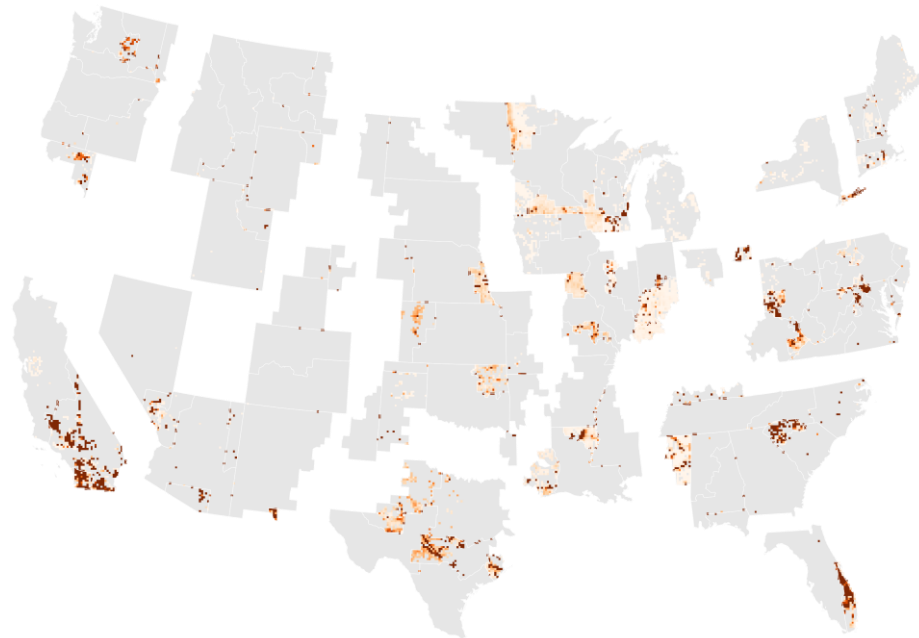
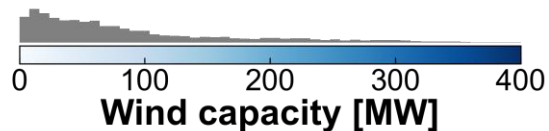
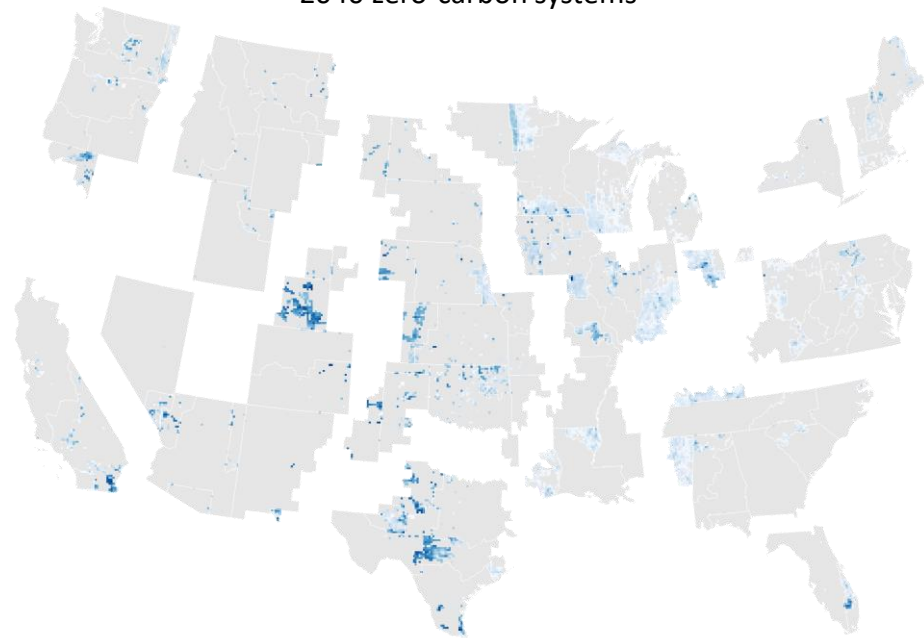
2040 zero-carbon systems



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

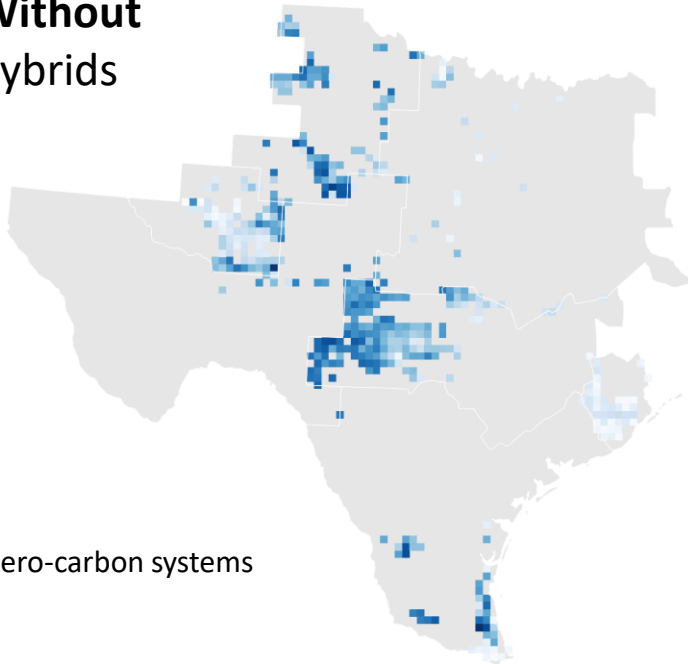
2040 zero-carbon systems



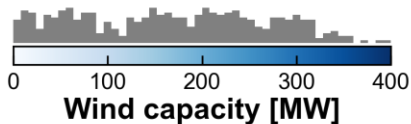
Brown et al. "Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States". In prep.

Wind Deployment in ERCOT: Minimal Shift with Hybridization

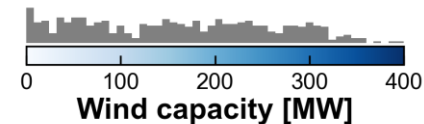
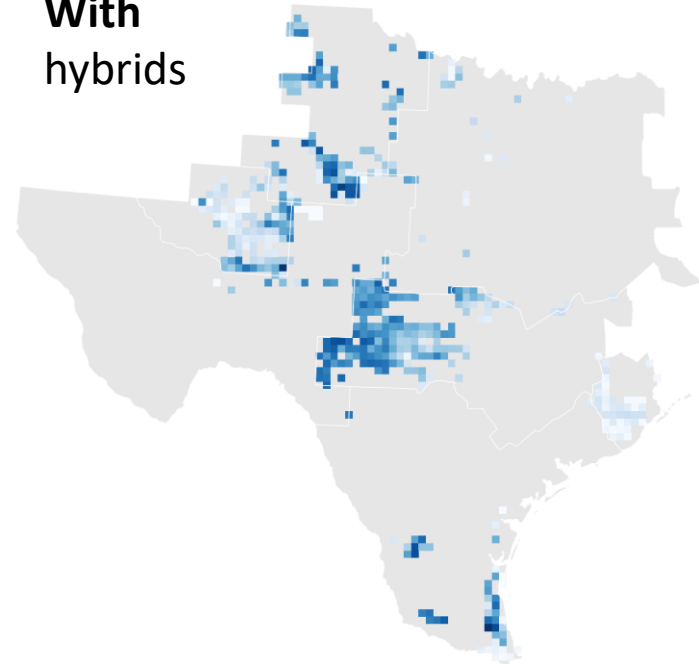
**Without
hybrids**



2040 zero-carbon systems

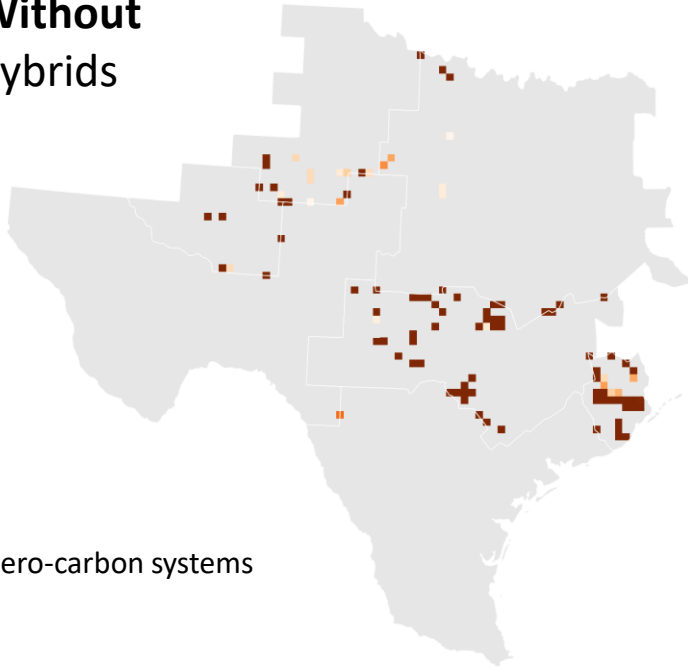


**With
hybrids**

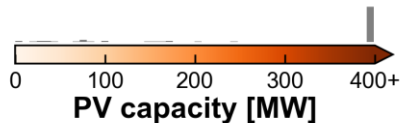


PV Deployment in ERCOT: Relocation to Wind Sites With Hybridization

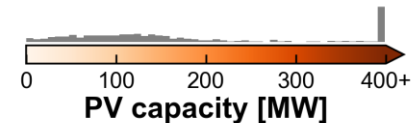
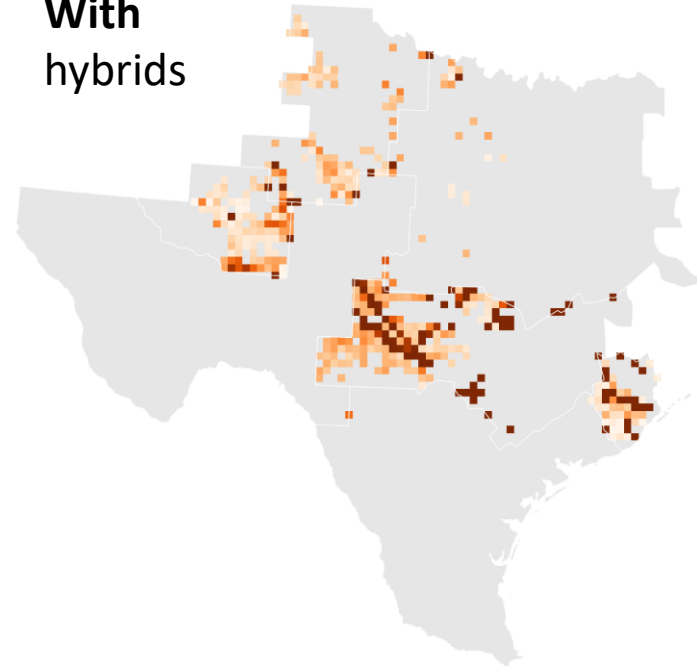
**Without
hybrids**



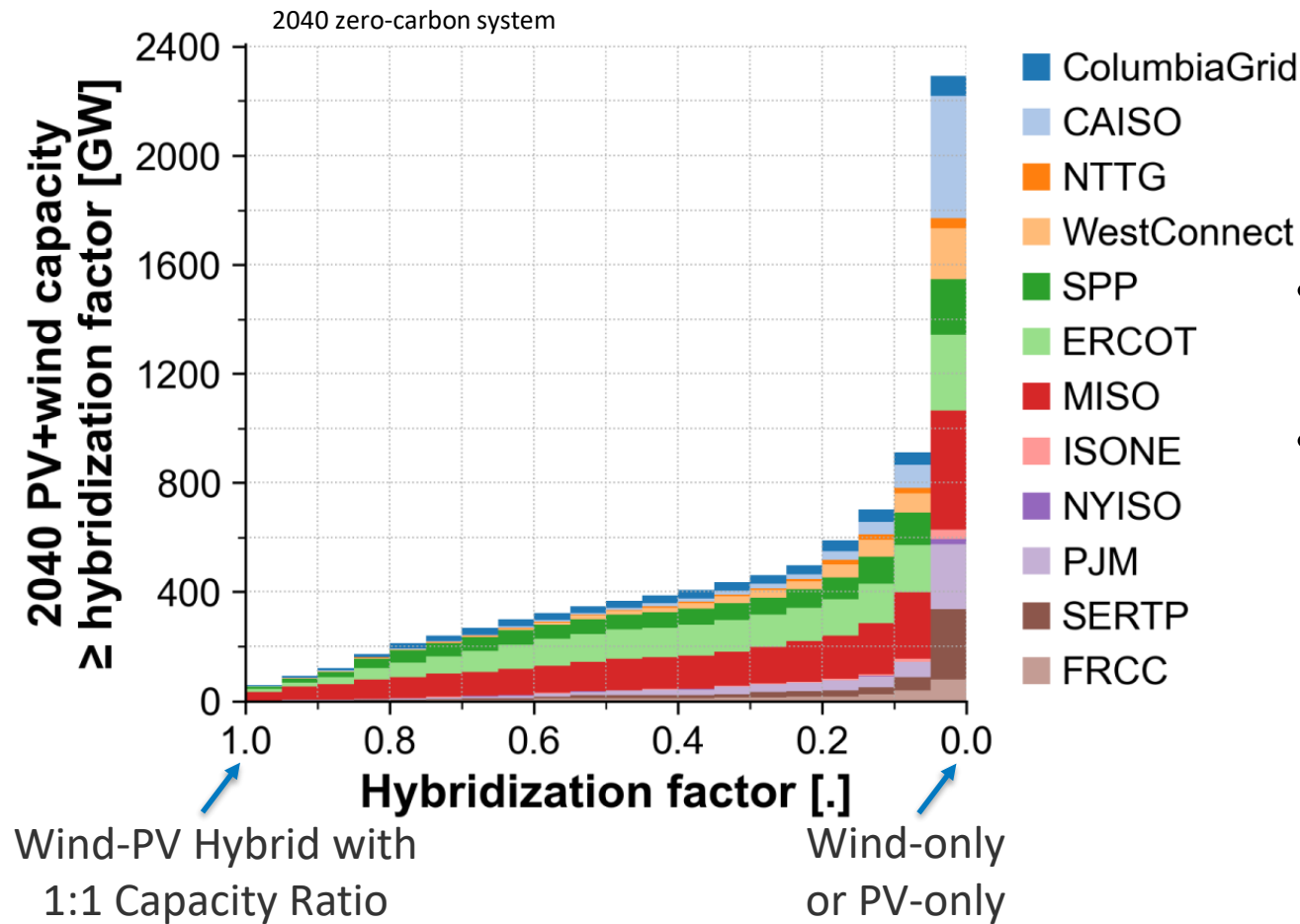
2040 zero-carbon systems



**With
hybrids**



How Much Hybrid Capacity is Deployed?

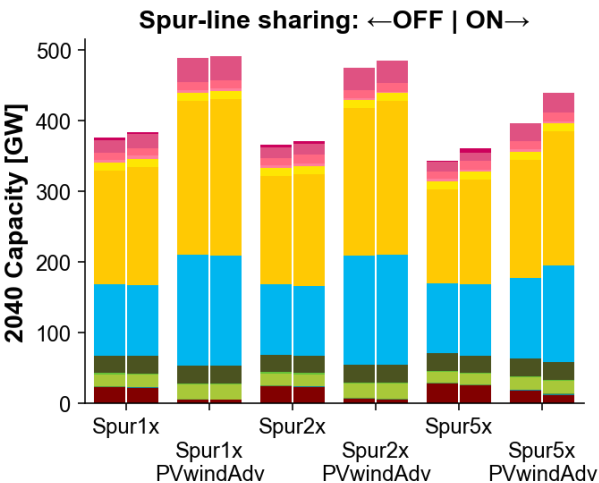


Brown et al. "Co-locating PV and wind to reduce interconnection costs in low-carbon power systems across the United States". In prep.

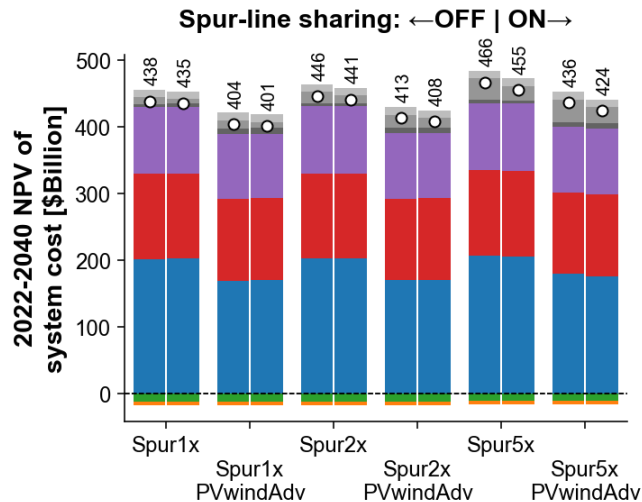
- Most PV/wind capacity is **not** hybridized
- Still a significant amount of hybrids: 195 GW of POI capacity = **348 GW of nameplate PV + wind** (versus 218 GW nameplate PV + wind at end of 2020)

What Value Does Hybridization Provide?

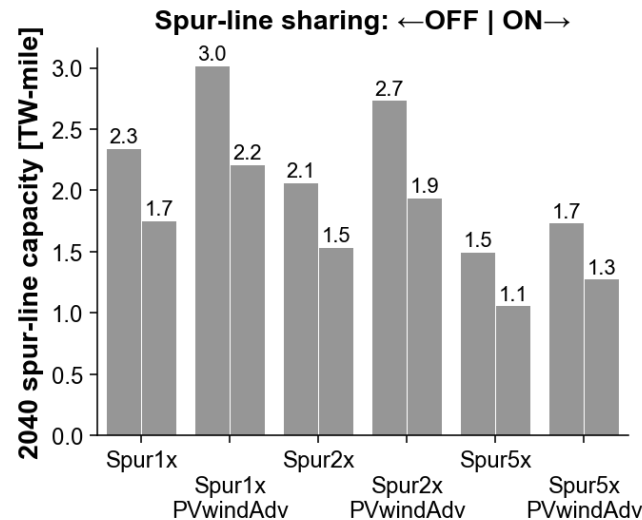
2040 zero-carbon ERCOT system



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

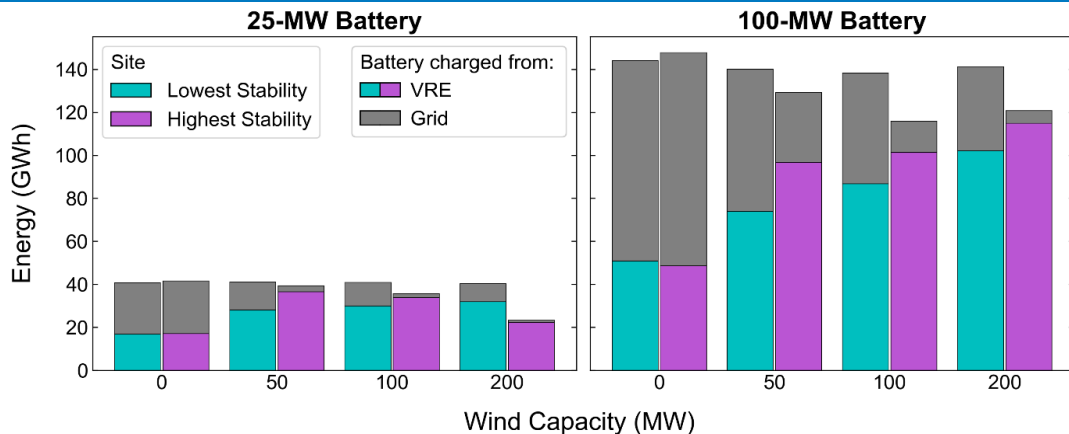


\$2.5–12 billion in NPV of savings (0.6–2.8%) depending on spur-line and PV/wind cost assumptions

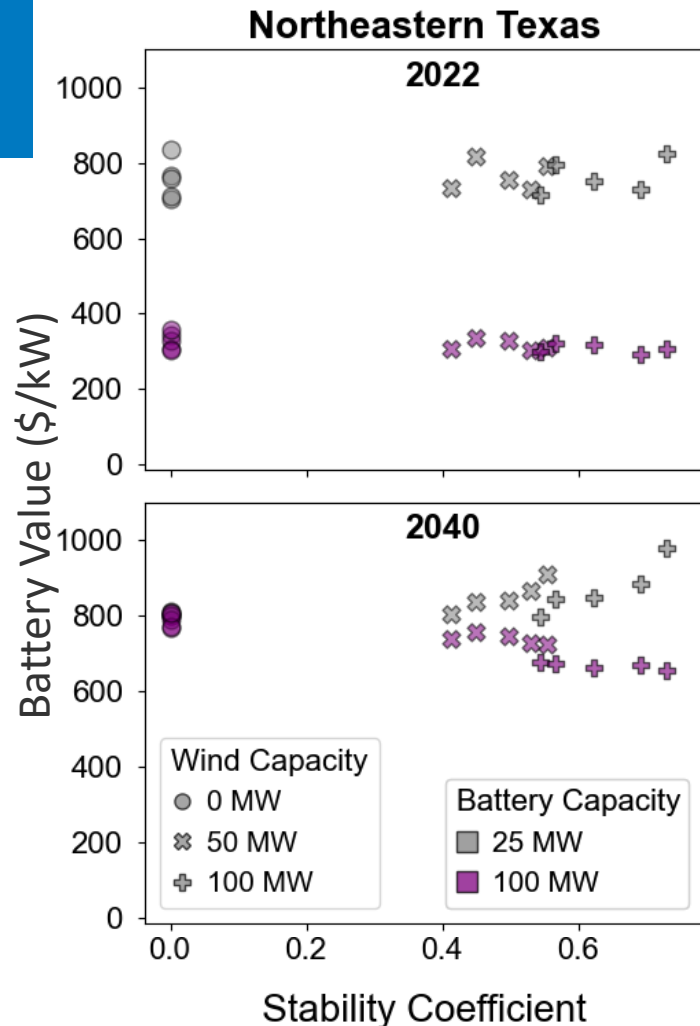


20–30% decrease in spur-line capacity [TW-miles]

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



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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