Impacts of Spatial Resolution in a High-Fidelity Capacity Expansion Model: An ERCOT Case Study

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Motivation

- Meet the growing interest in regional impacts of the energy transition
- Allow users of NREL's Regional Energy Deployment System (ReEDS) to define unique focus areas
- Better represent the heterogeneity of variable renewable resources
- Better capture underlying transmission congestion
- Find opportunities for improvements in the ReEDS model
- Inform the types of studies suited for high-resolution representation

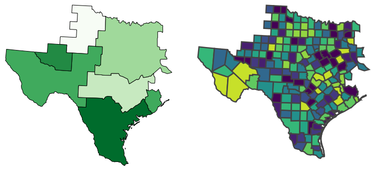

Figure 1. Maps illustrating The Electric Reliability Council of Texas (ERCOT) at balancing area (BA) (left) and county (right) resolutions.

Installed Capacity

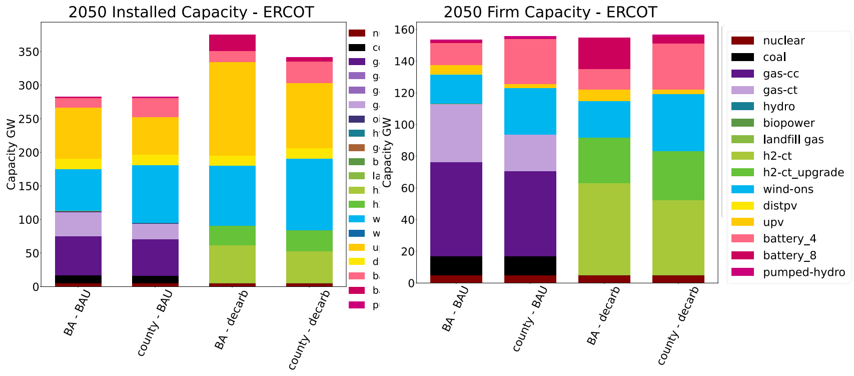

Figure 2. 2050 installed capacity (left) and firm capacity (right) in ERCOT.

BAU: Business as Usual; Decarb: Decarbonization (100% emissions reduction by 2035)

- Greater share of land-based wind in county-level solutions
- In the decarb scenarios, the county solutions has less installed capacity compared with the BA
  - Greater share of land-based wind which has a higher capacity factor than utility-scale PV (UPV)
  - Higher-resolution model allows higher quality renewable resources to be included as part of the least cost solution

Locational Shifts

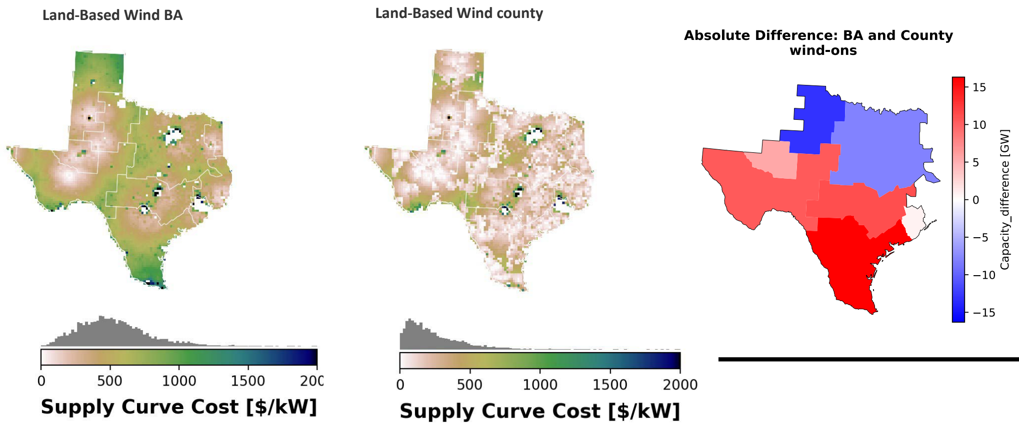

Figure 3. BA and county-level supply curve costs for land-based wind and absolute difference in installed land-based wind capacity in the county solution relative to the BA.

The exclusion of bulk network reinforcement costs in the county-level supply curves contributes to locational shifts in installed land-based wind capacity.

County solutions align land-based wind build-out with regions characterized by higher capacity credit values.

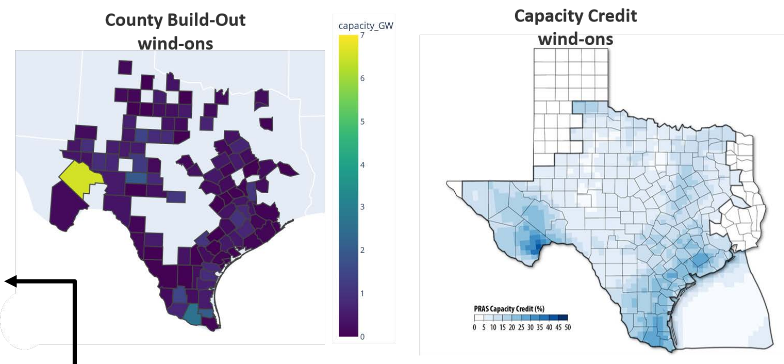

Figure 4. County-level land-based wind build out (left) and capacity credit values for land-based wind (right).

Curtailment

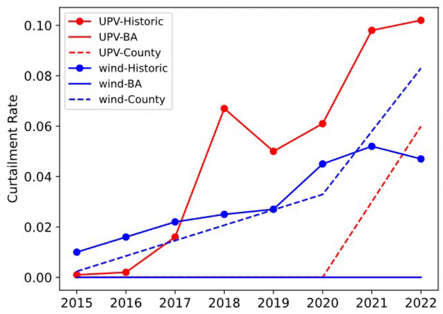

Figure 5. Curtailment rates across the ERCOT BAU and Decarb scenarios plotted with historic curtailment values.

- County-level results better capture curtailment in historic years
- BA-level model underestimates curtailment because ReEDS forces sufficient intrazonal transmission to be built to transfer wind/solar capacity to load centers

Runtime and System Costs

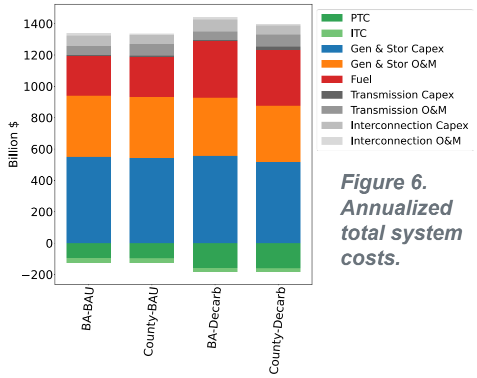

Figure 6. Annualized total system costs.

- Lower costs in county decarb results because less overall capacity is installed
  - High-potential and lower-cost resources are more accessible in the high-resolution representation
- Order of magnitude increase in number of model regions leads to at least an order of magnitude increase in runtime

Runtime (h)	BAU	Decarb
ERCOT County	0.63	0.64
ERCOT BA	0.05	0.07

Table 1. Impacts of spatial resolution on runtime.

Conclusions

- The relative competitiveness of wind and UPV is largely dependent on the underlying resource supply curves and transmission networks.
- Enhanced granularity of the resource supply curves enables the model to better identify areas with more valuable resources, both in terms of cost as well as capacity credit contribution.
- The higher-detail representation of available resources, coupled with the higher capacity factor of wind compared to UPV, ultimately results in less overall installed capacity across ERCOT and a geographic shift in the allocation of resources.
- Higher spatial resolution modeling leads to more opportunistic allocation of resources and an augmented valuation of resource adequacy contribution.
- The county solution offers more granular reporting at a substantial computational expense, therefore the value added must be evaluated on a case-by-case basis.

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