



Modeling Wind Deployment Potential

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Why model the power sector?

To provide an additional perspective of the power sector evolution by capturing a range of possible futures that consider a variety of driving factors, including:

- Vehicle electrification
- RE generator cost trajectories
- Other techno-economic & social considerations

We have started to explore varying land-use objectives and their potential impacts to the power sector evolution. We have not yet integrated wildlife minimization measures into our models.*

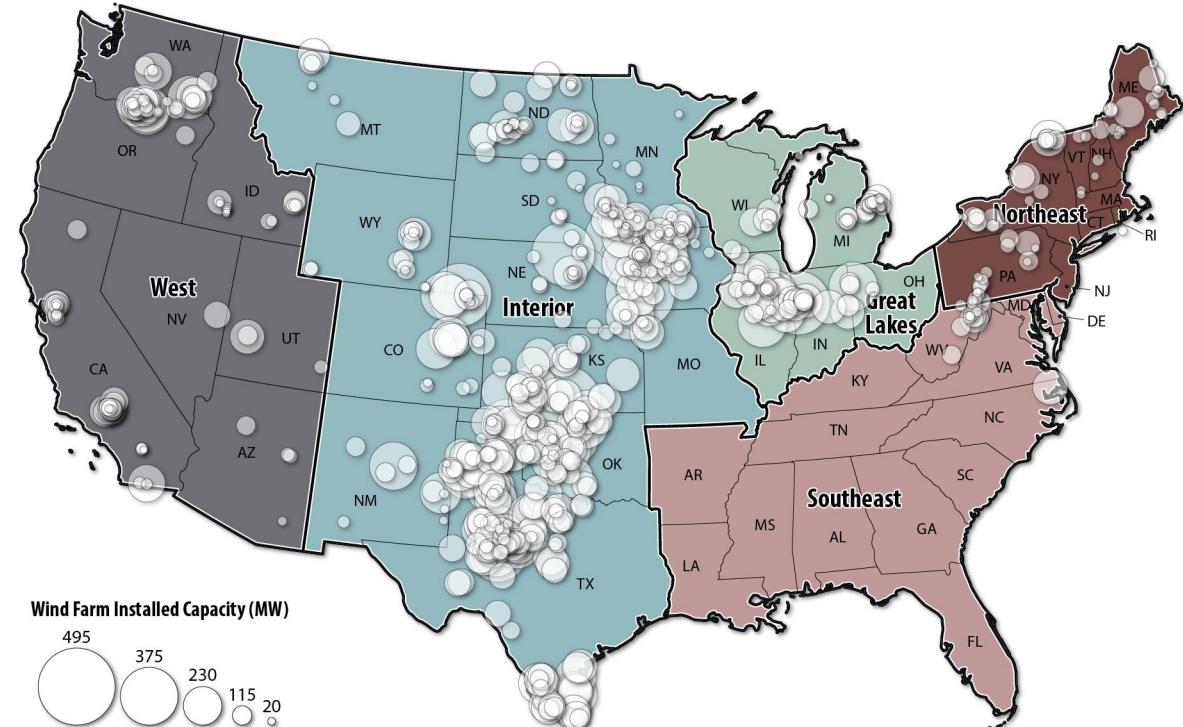
*Outside of excluding protected public lands and recorded conservation easements

Spatial Distribution & Footprint

The spatial extent of existing wind energy is ~38,000 km², or roughly the landmass of Massachusetts, Connecticut, and Delaware combined.

The spatial footprint (direct land-use) of existing wind energy is ~760-1,900 km², or roughly half the landmass of Rhode Island.

The vast majority of development has occurred on cultivated cropland (52%), grassland/herbaceous (22%), and shrub/scrub (14%)



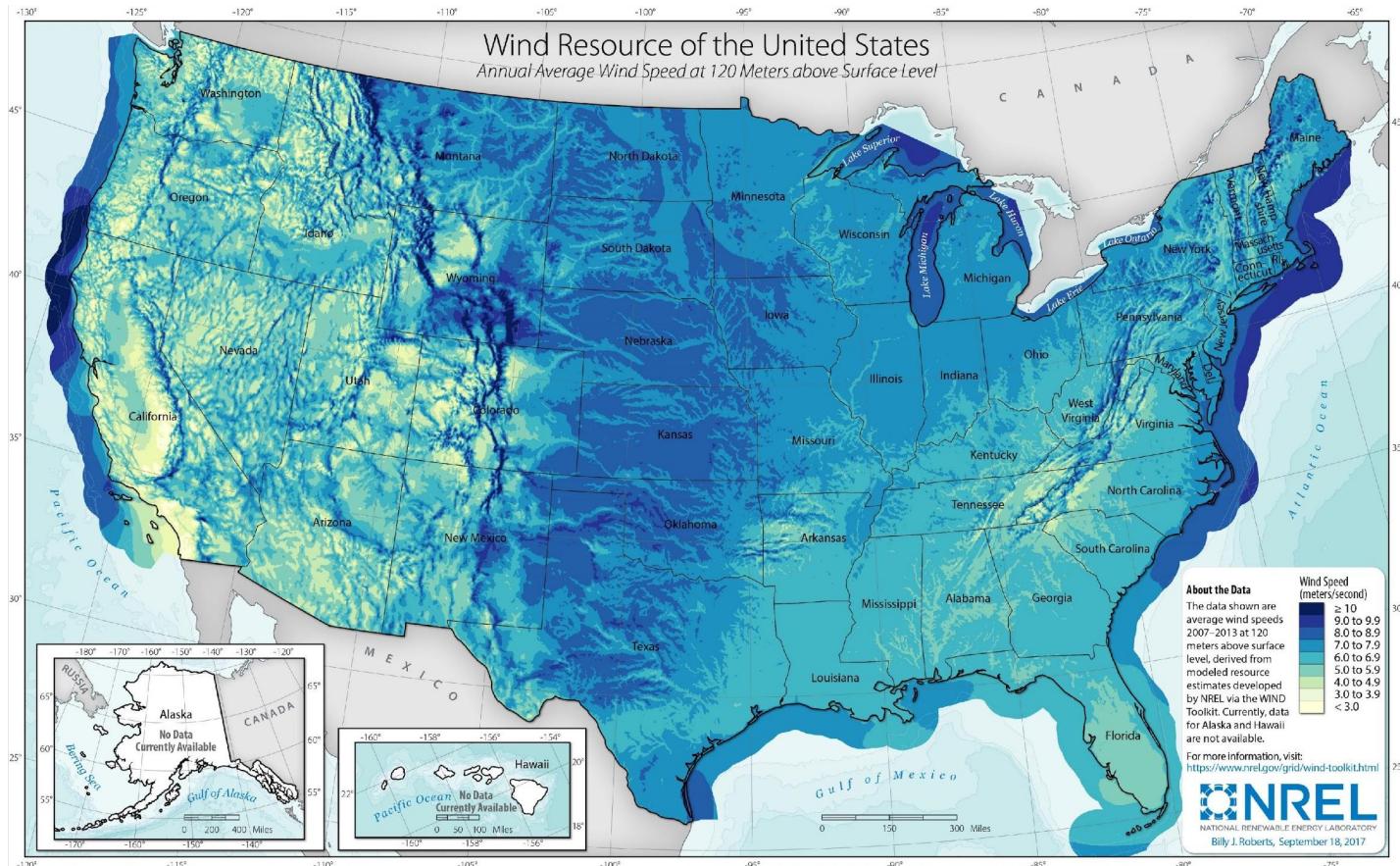
Preliminary Results - In Review

Modeling Future Deployment Potential

Two Key Models

reV - *Geospatial resource potential and cost characteristics*

ReEDS - *Simulating long-term build-out and operation of the US generation and transmission system*



reV - Renewable Energy Potential Model

Resolutions of a reV

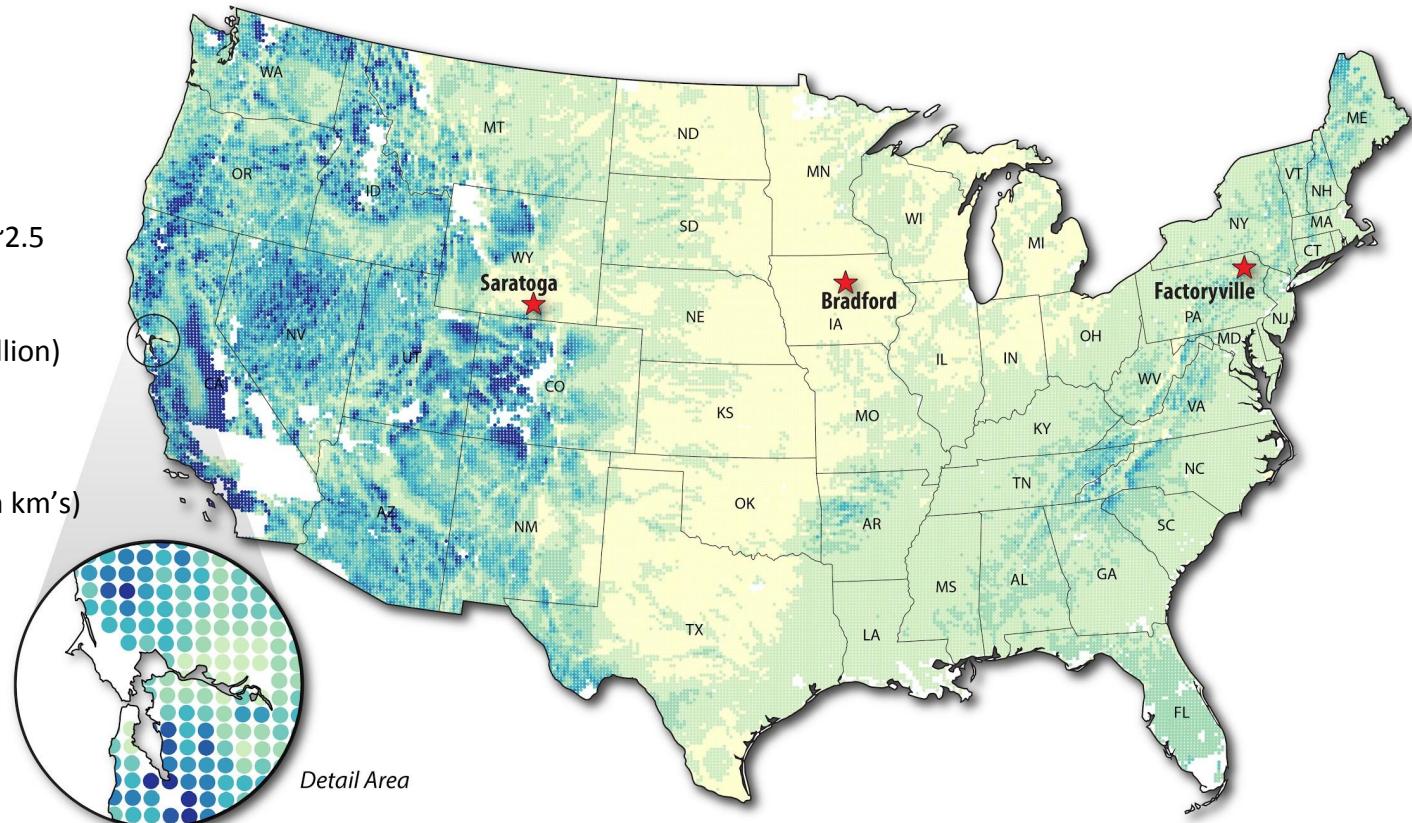
CONUS Geographic Scope

11.5 km “wind sites” (67,000)

2 km (hourly) wind resource (~2.5 million)

90 m land-use/cover (~960 million)

meter resolution for
buildings (~124 million) and
civil infrastructure (~11 million km's)

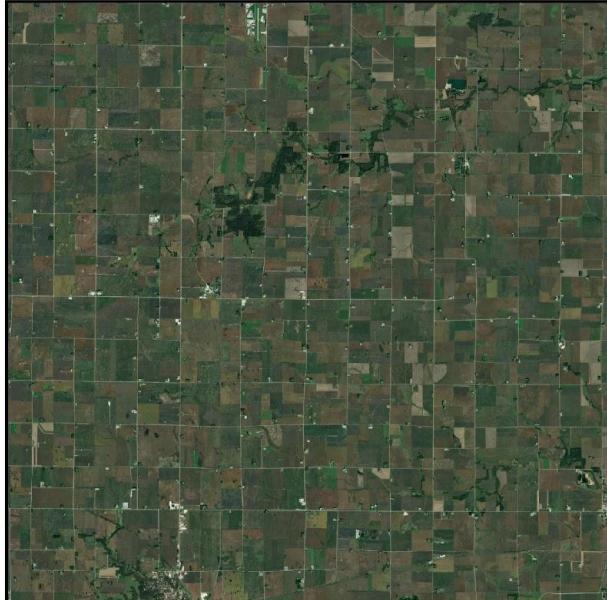


3 “Wind Sites” (analytical unit) of a supply curve

Wind Farm Analysis

11.5 km x 11.5 km Analysis Regions

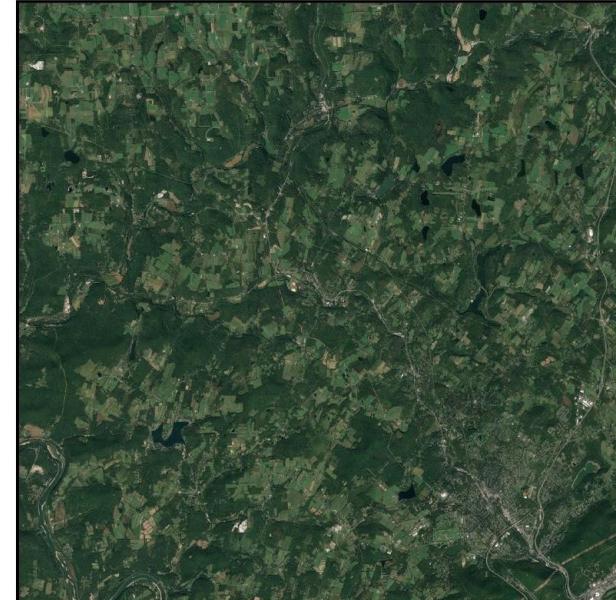
Bradford, Iowa



Saratoga, Wyoming



Factoryville, Pennsylvania



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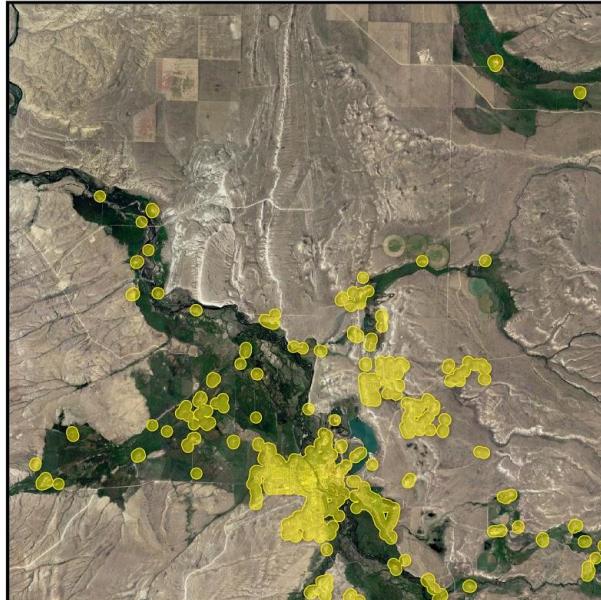
- Existing structures

infrastructure shown with 208 meter “no build” zones

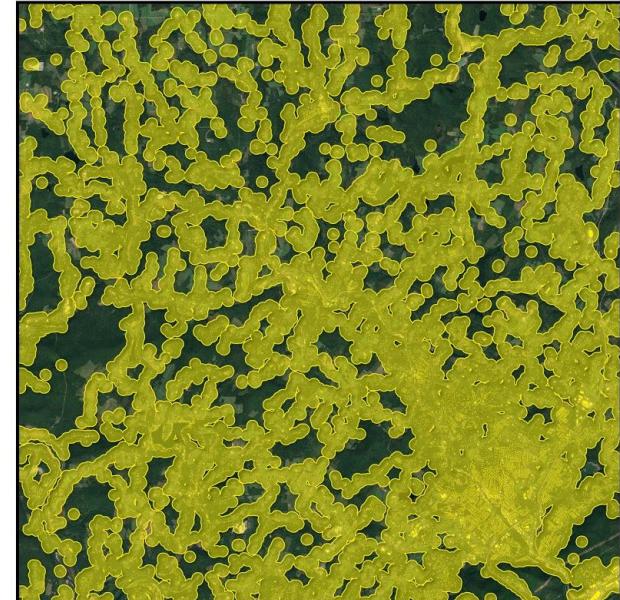
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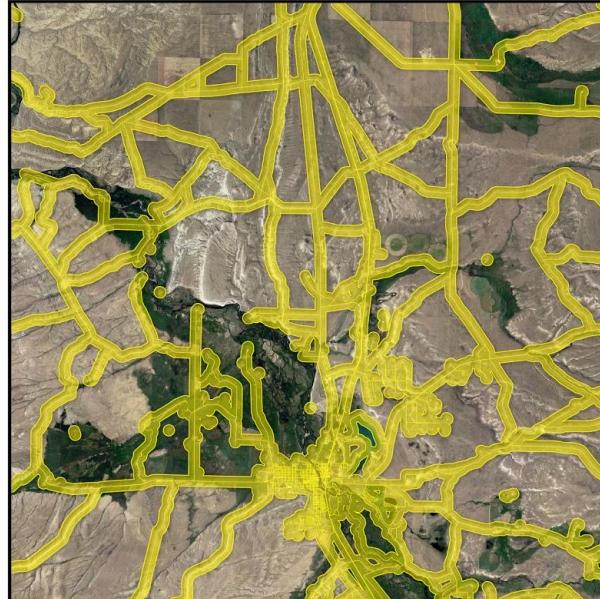
- Streets & railways

infrastructure shown with 208 meter “no build” zones

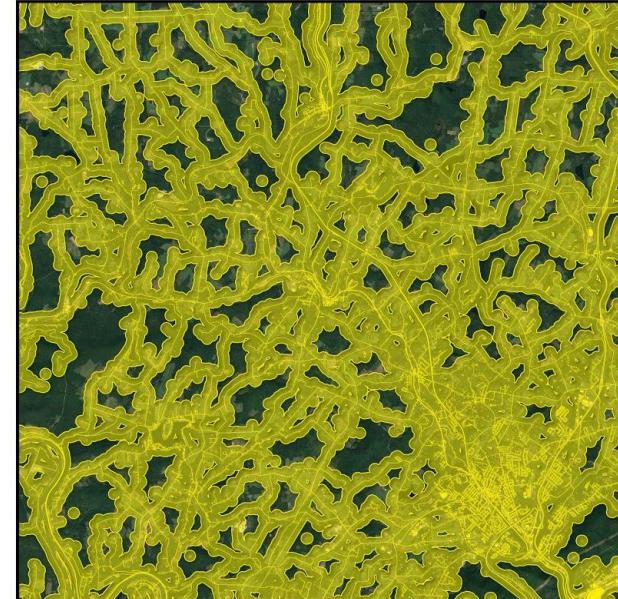
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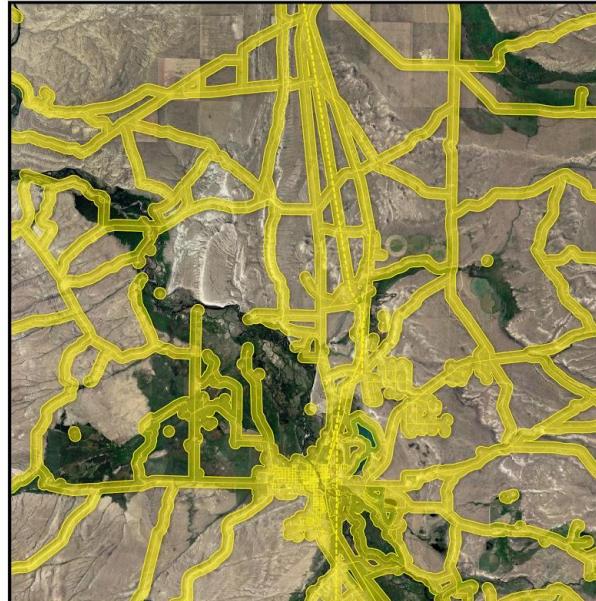
- Existing structures
- Streets & railways
- Transmission

infrastructure shown with 208 meter “no build” zones

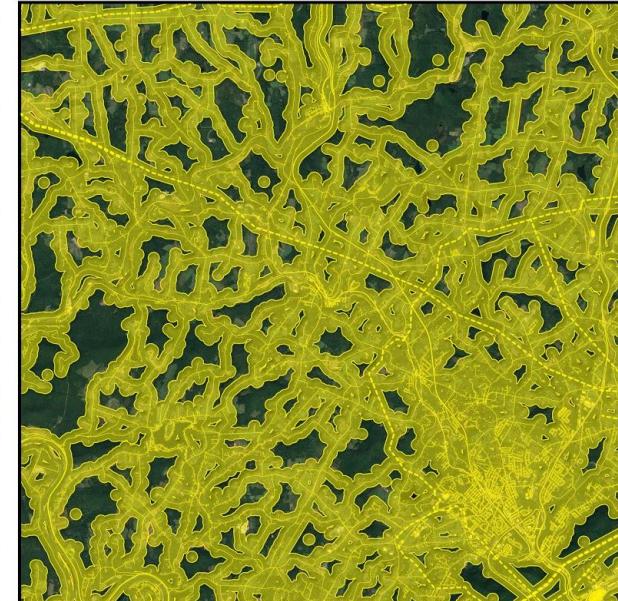
Bradford, Iowa



Saratoga, Wyoming



Factoryville, Pennsylvania



3 “Wind Sites” (analytical unit) of a supply curve

Wind Farm Analysis

- Existing structures
- Streets & railways
- Transmission
- Water bodies

infrastructure shown with 208 meter “no build” zones

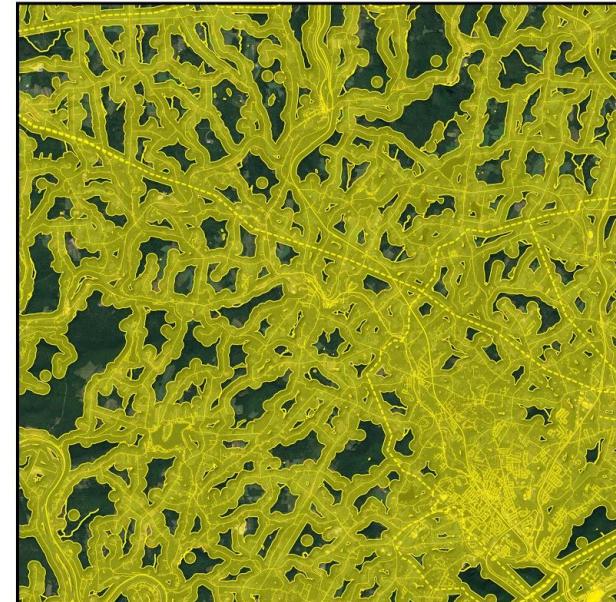
Bradford, Iowa



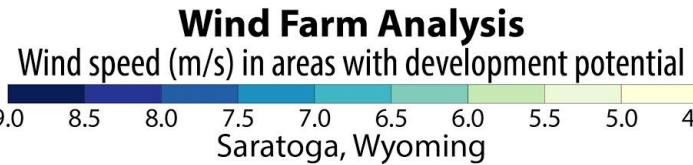
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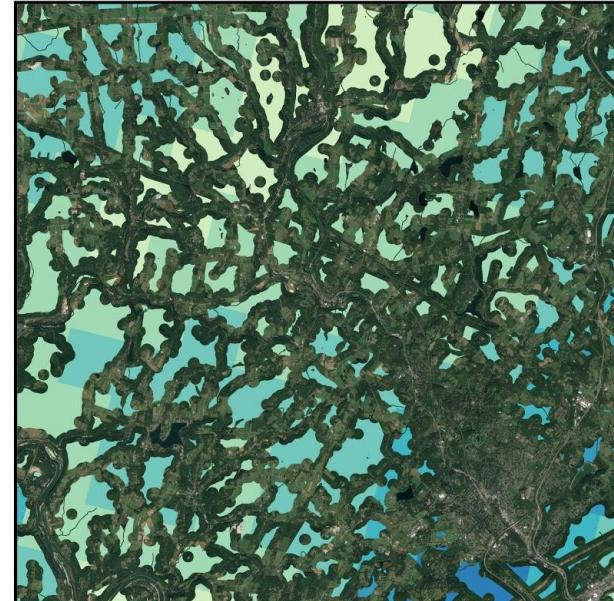


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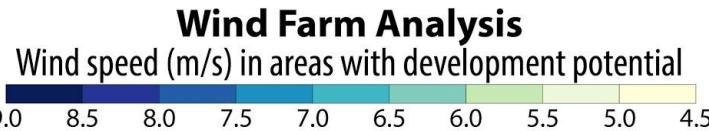
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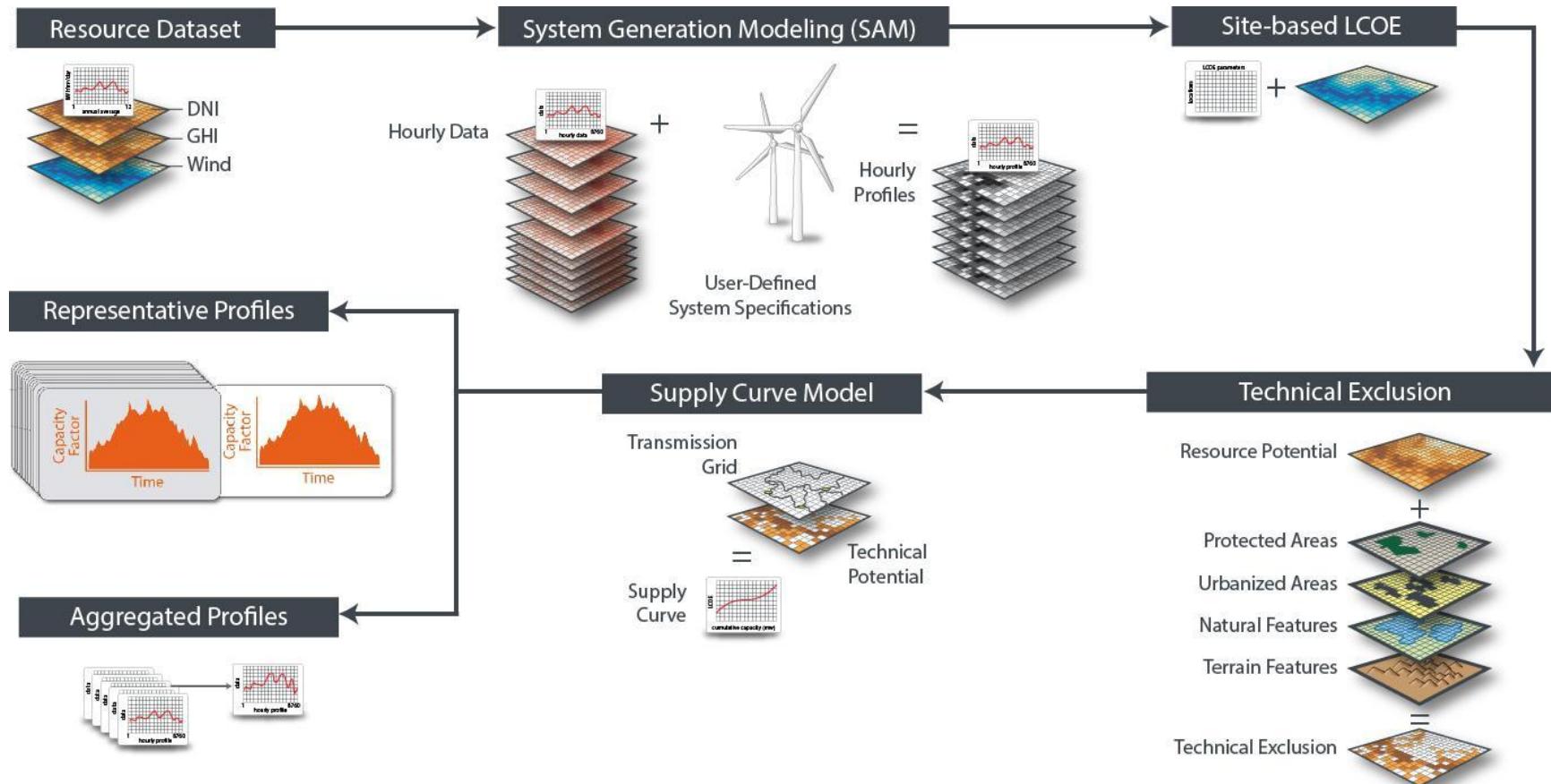


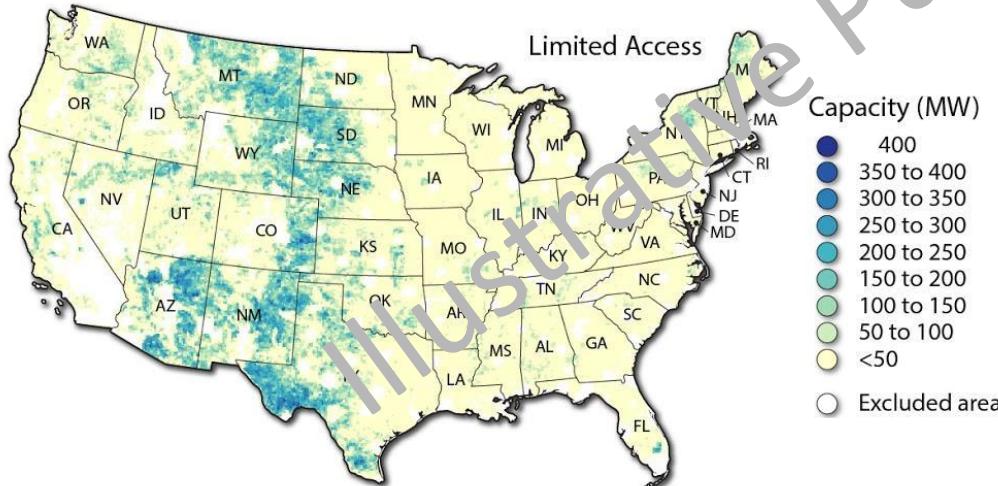
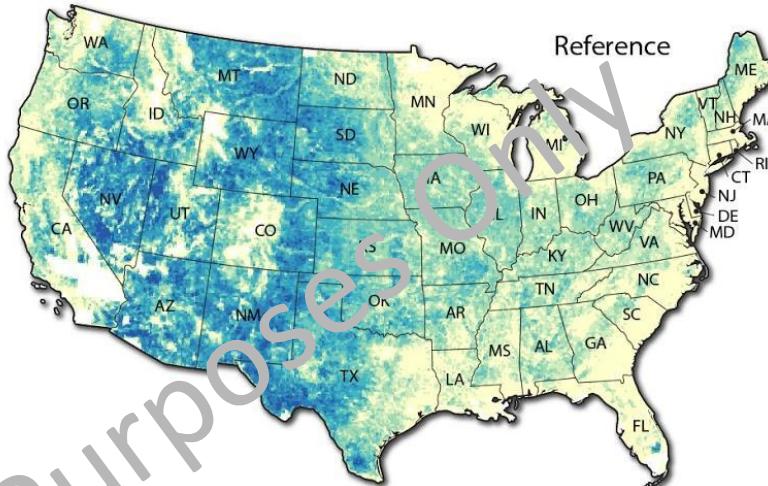
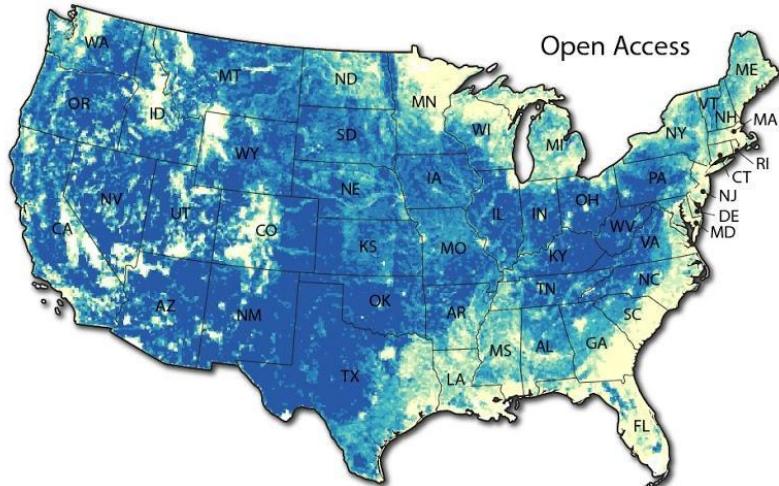
Detail Area

Wind Farm Summary:
*distance to interconnect
terrain complexity
land owner
wind speed
generation
land cover
capacity
LCOE
...*



Representation of wind energy resources using reV

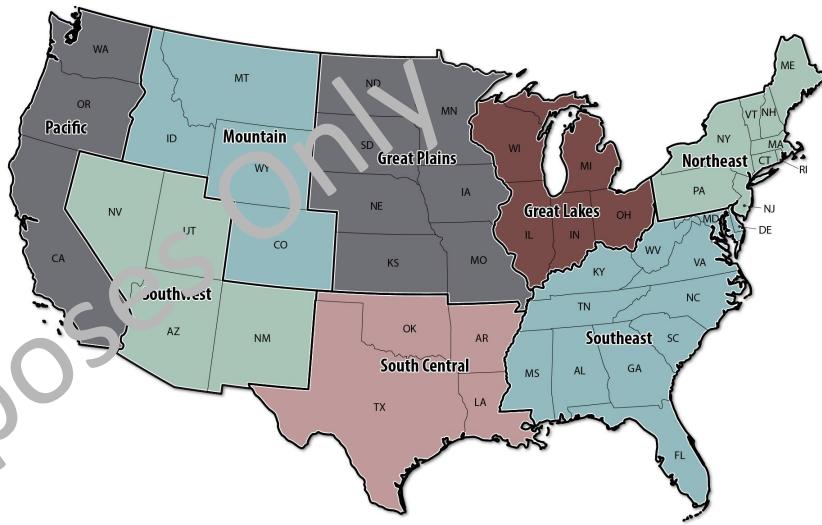
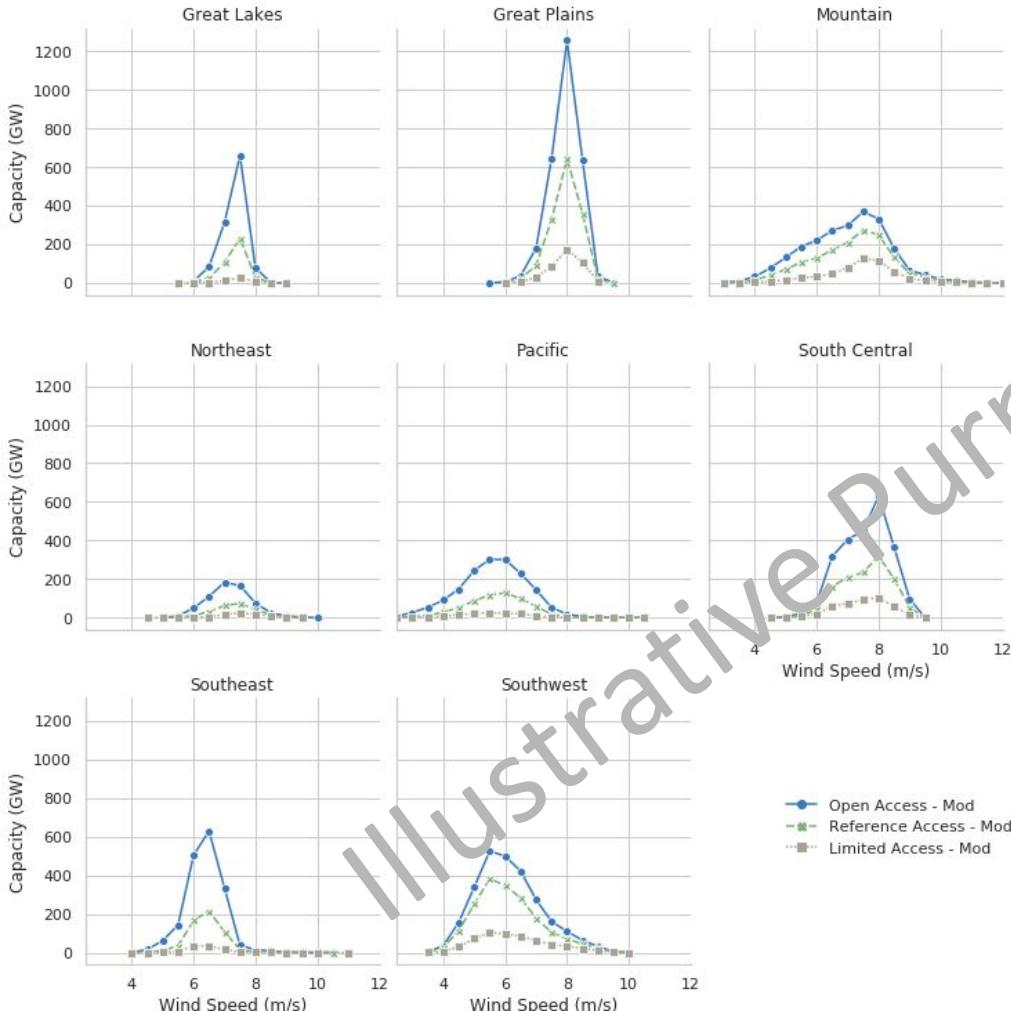




Spatial “exclusions” capture varying *siting constraints*

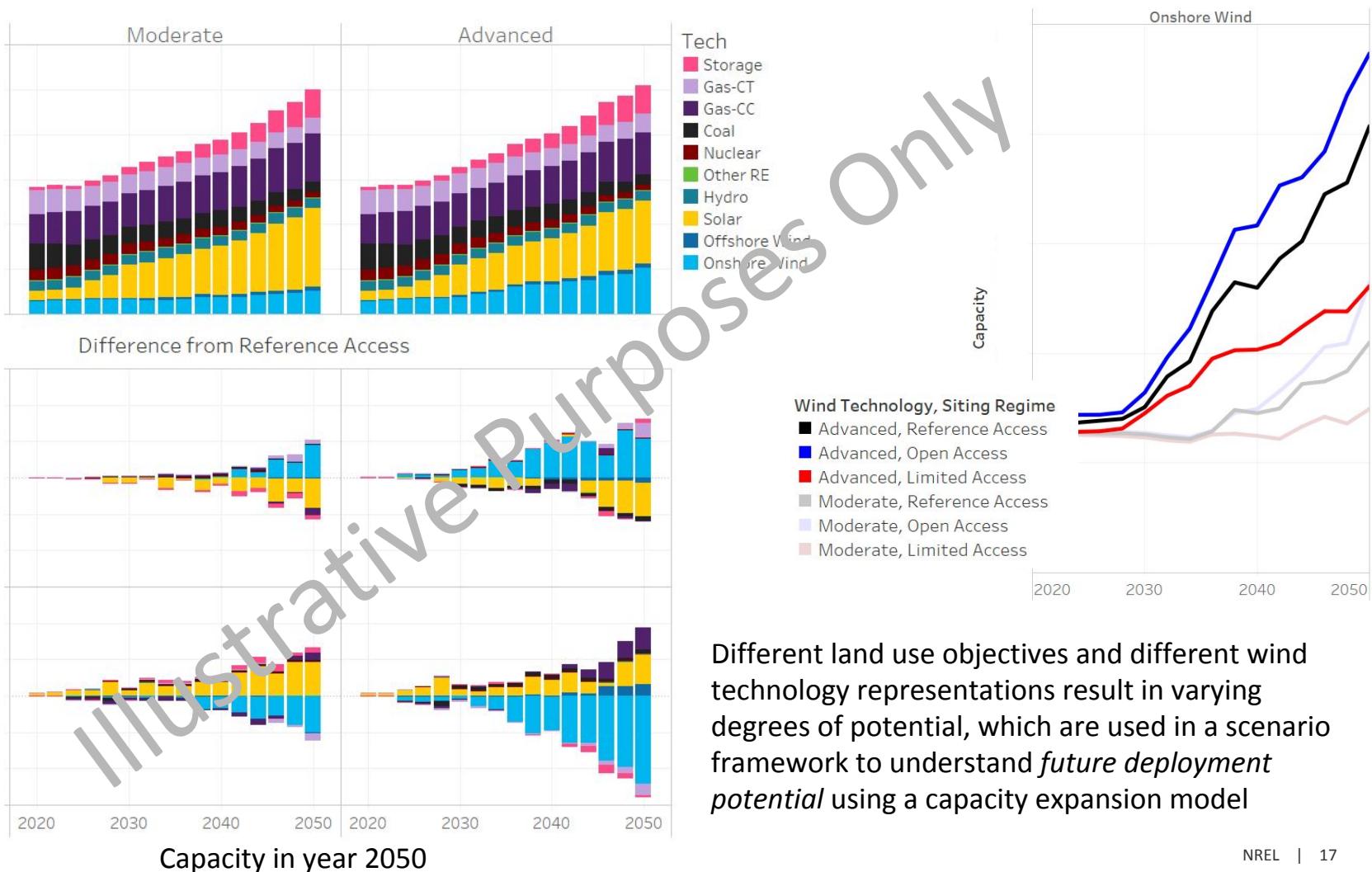
Siting constraints are not always additive, meaning constraints can be partially (or wholly) spatially coincident

Siting regimes (scenarios) capture combinations of constraints. In this case, increasing constraints represent *possible* additional challenges given setback ordinances, radar saturation, federal land development, etc.

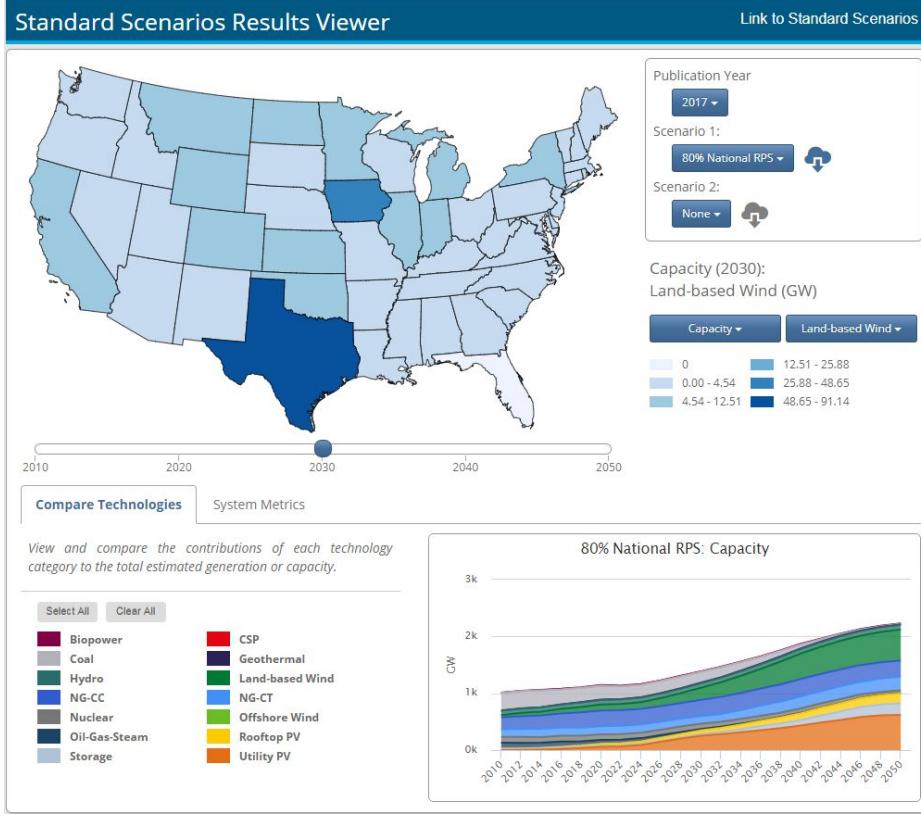


Wind resource quality varies spatially, and understanding how siting regimes intersect with wind quality is critical for the assessment of economic viability.

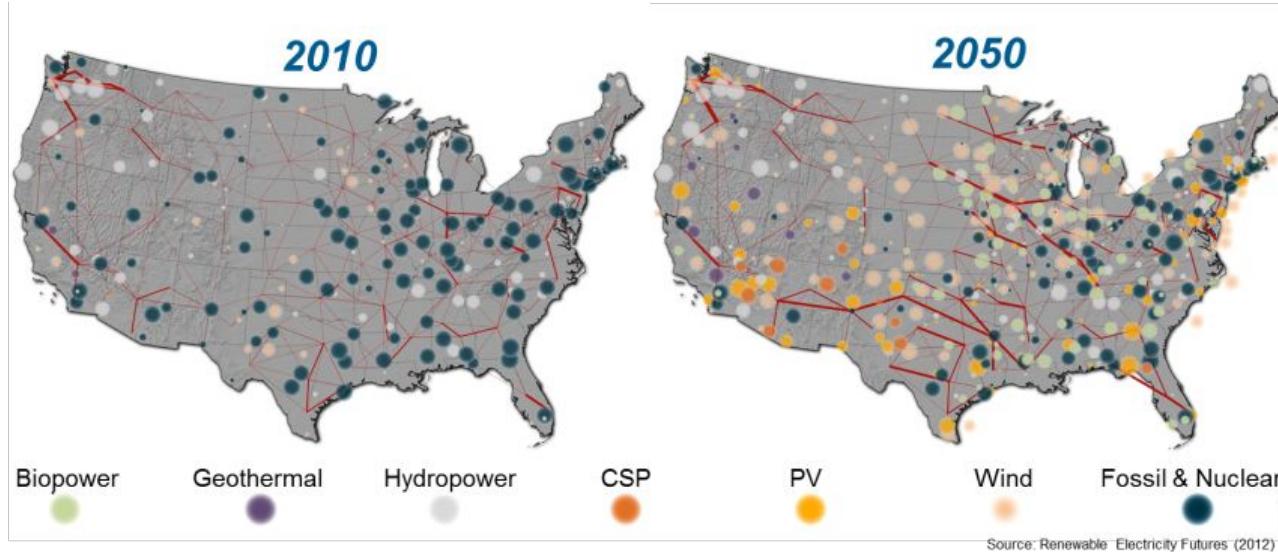
Ultimately, results represent a characterization of the developable quantity, quality, and cost of wind resources, that can be sorted to represent a “supply curve”.



A Best-In-Class Capacity Expansion Model

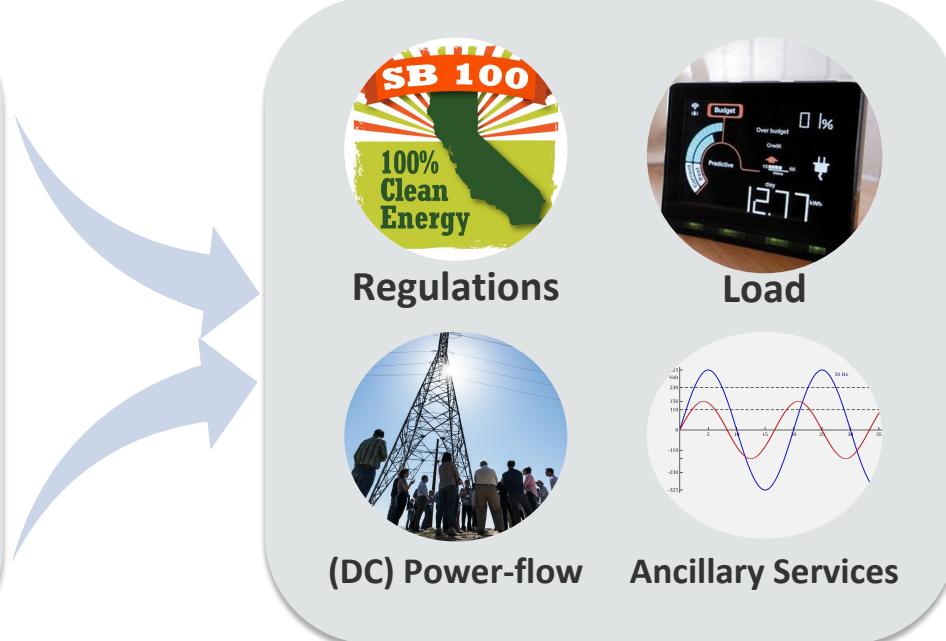
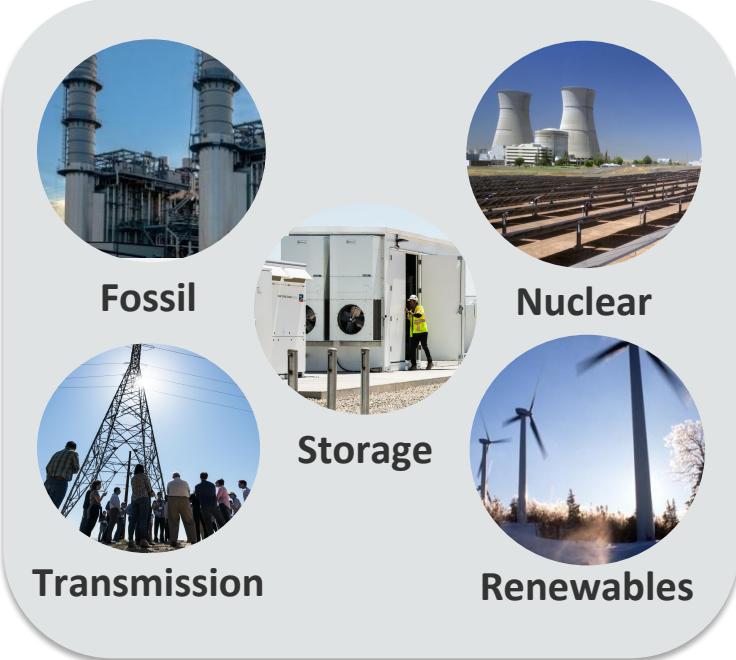


What does ReEDS do?

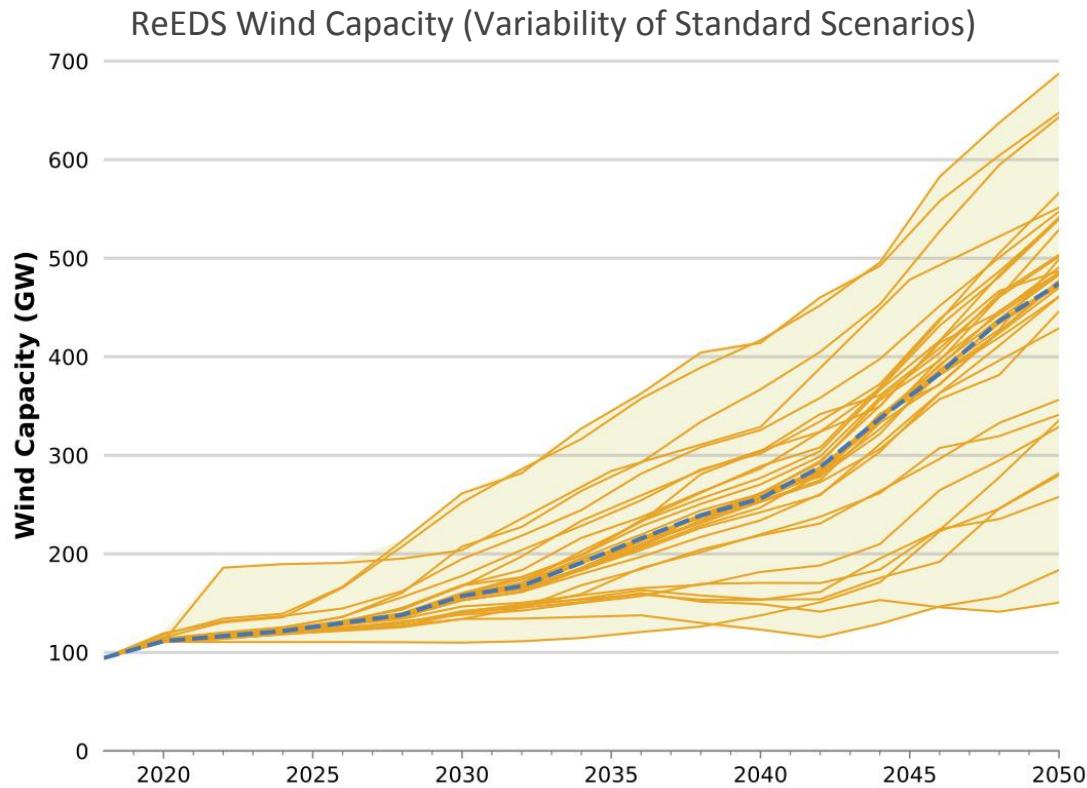


Simulates the evolution and operation of generation, transmission, and end-use demand

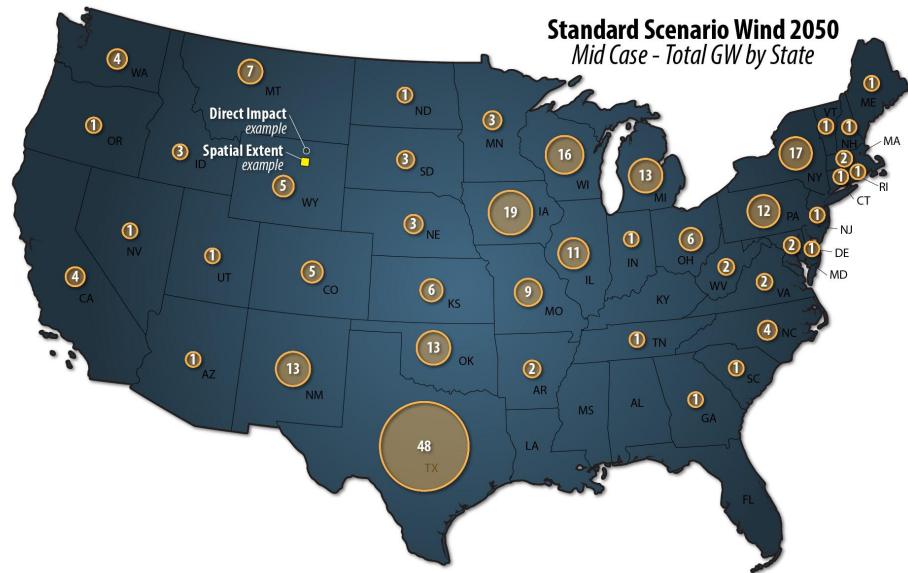
How does ReEDS really work



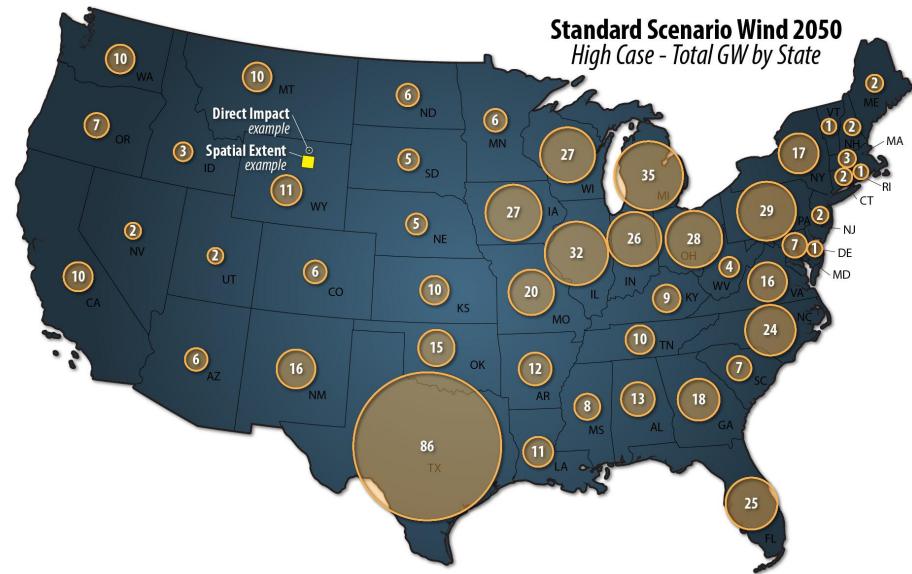
Exploration Through Scenarios



Future Deployment Magnitude



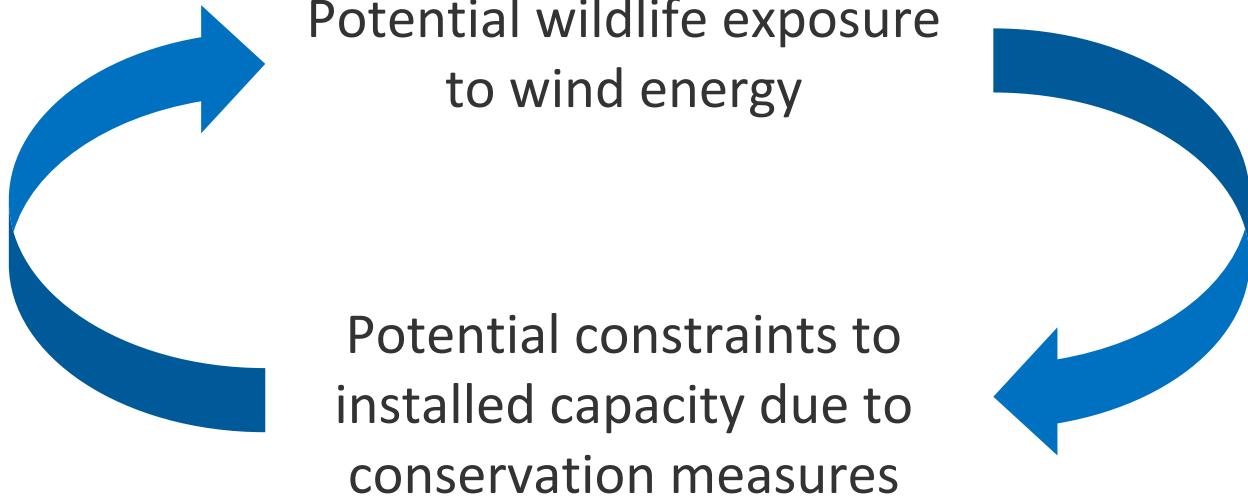
In total 232 GW of wind capacity representing 20% of total electricity capacity are expected in the mid-case. For Wyoming, this amounts to ~5 GW of capacity, which translates to roughly 1,666 km² (spatial extent) or 33 km² (direct land-use)



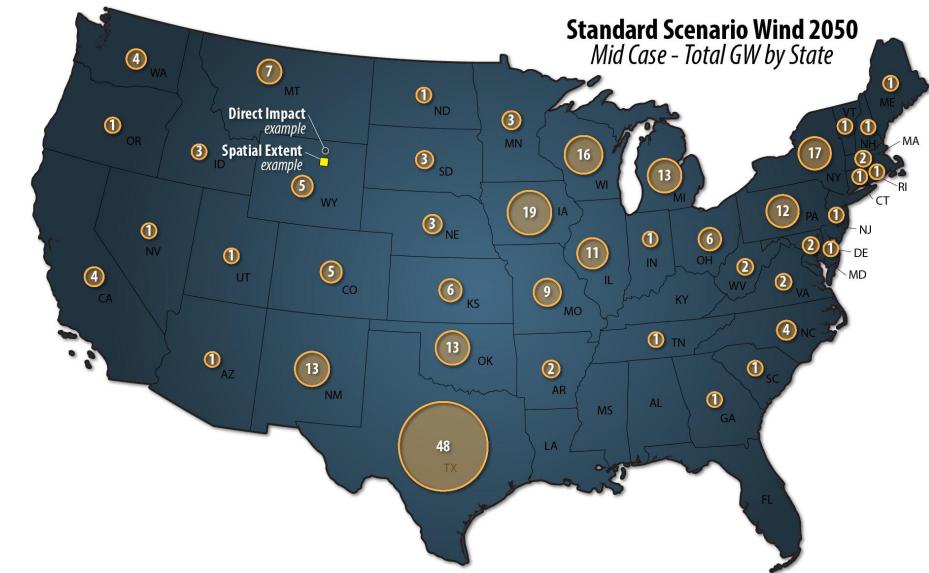
In total 633 GW of wind capacity representing 40% of total electricity capacity are expected in the high-case. For Wyoming, this amounts to ~11 GW of capacity, which translates to roughly 3,666 km² (spatial extent) or 73 km² (direct land-use)

Considerations

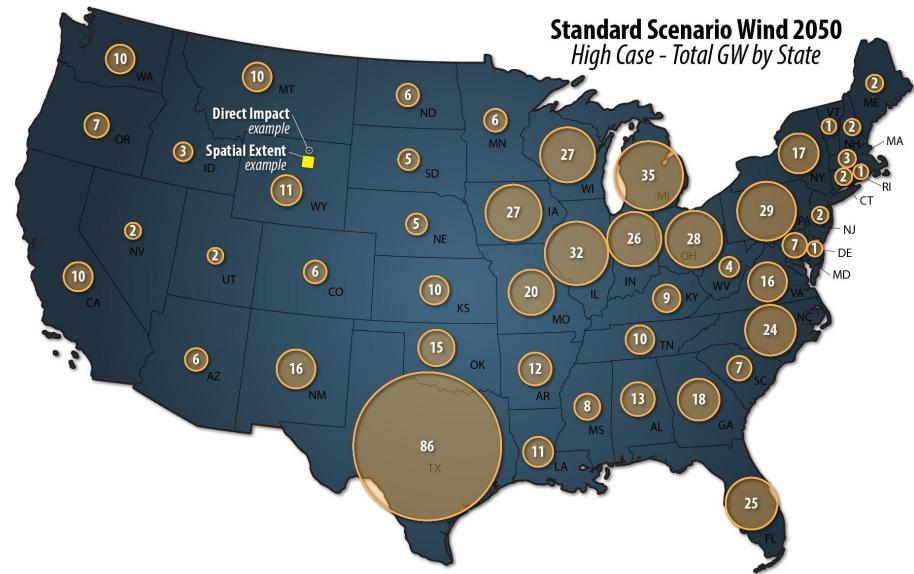
Utility of reV and ReEDs



Future Deployment Magnitude

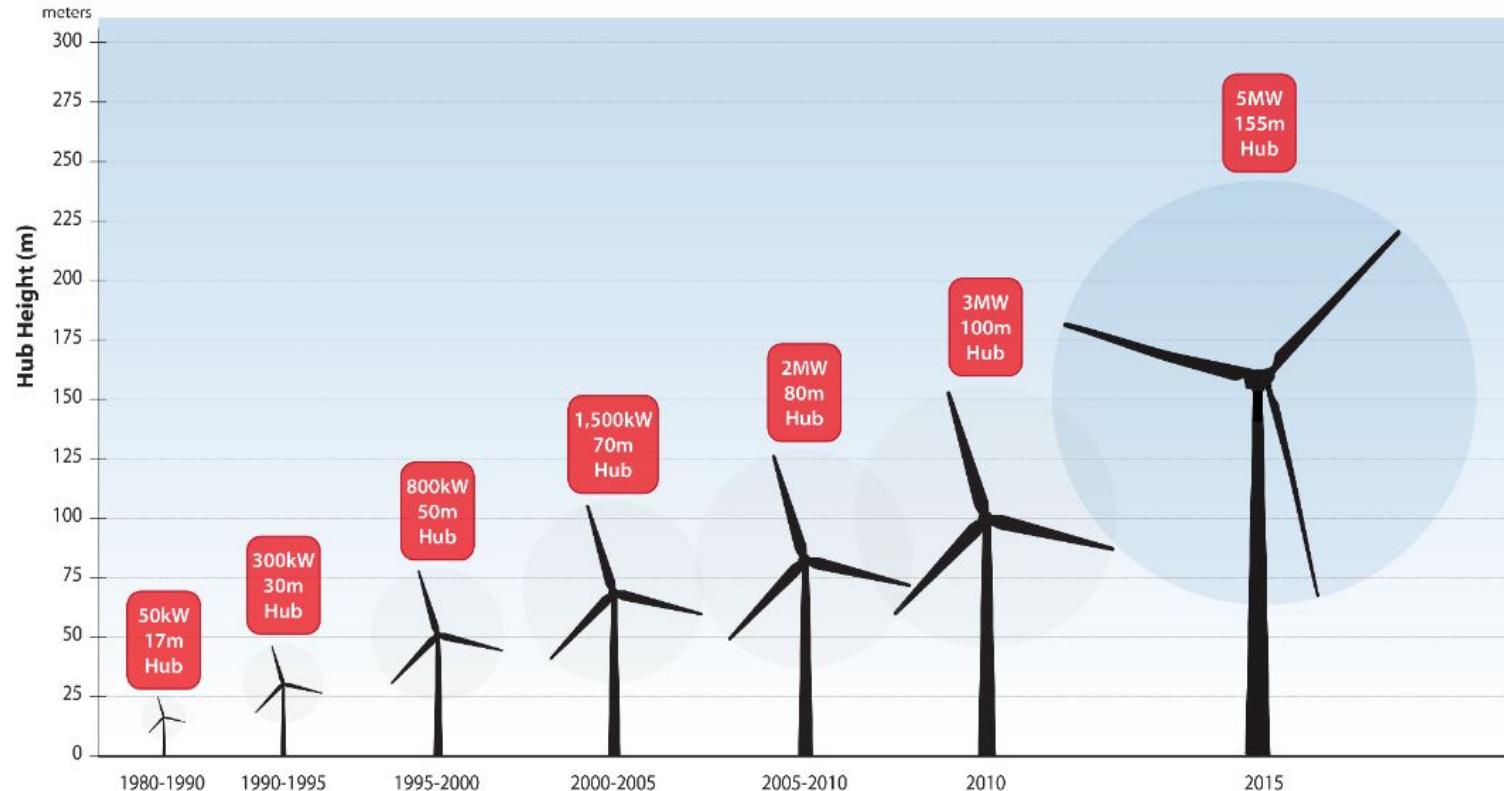


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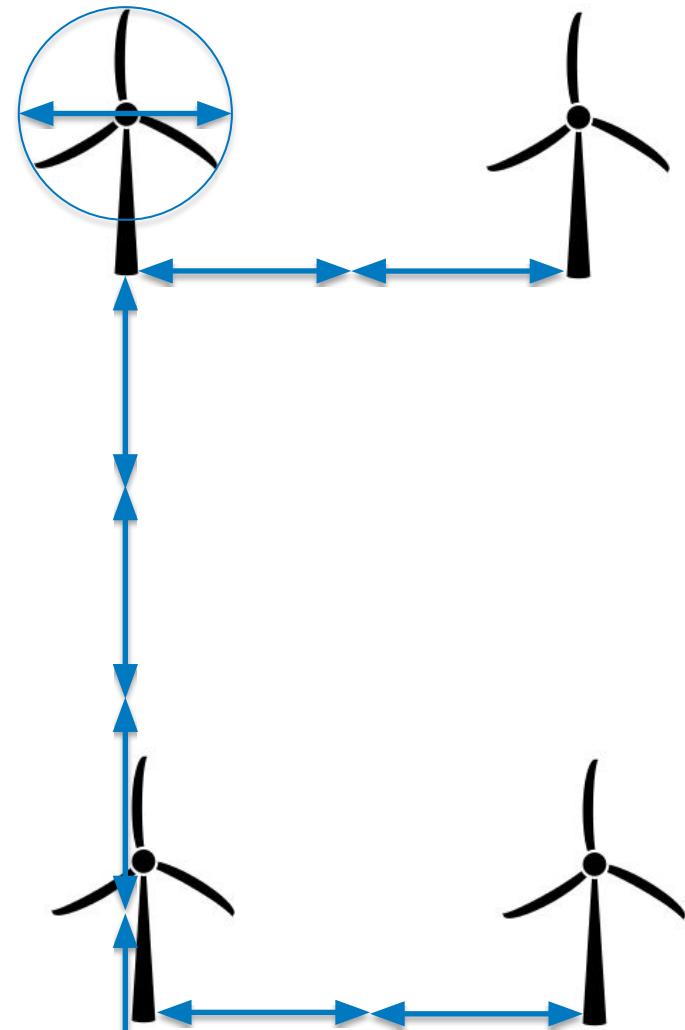
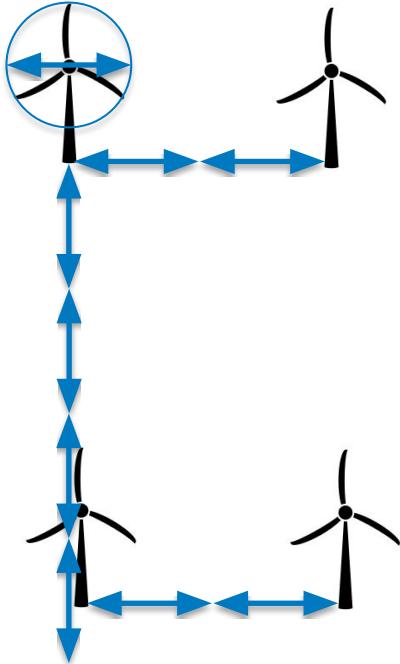


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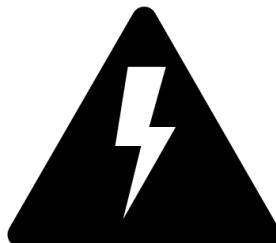
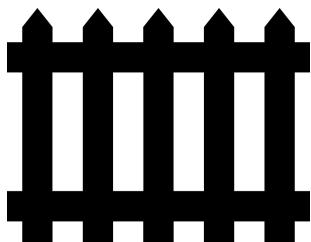
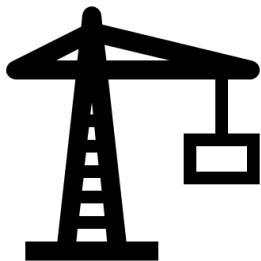
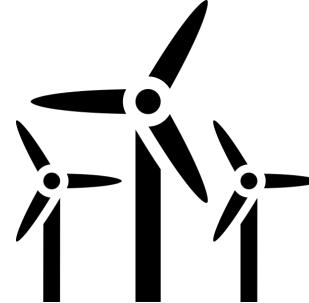
Wind Turbine Size Over Time



Spacing grows with turbines size



Wind energy is more than turbines



Pursuing Balanced Solutions

- As impact minimization measures are developed and advanced to cost-effectively reduce impact, it is also important to understand
 - How, these measures may affect wind energy deployment and generation
 - To what degree
 - How the effect varies across sites, technologies, and wind regimes
- Such analyses will support the pursuit of solutions that balance conservation needs and the responsible advancement of wind energy.

Resources

Publications

- [Renewable Electricity Futures](#)
- [Standard Scenarios](#)
- [The Renewable Energy Potential Model \(reV\) - Documentation](#)
- [U.S. Offshore Wind Energy Deployment Modeling](#)

Tools, Models, and Data

- [Standard Scenarios Data Viewer \(download ReEDS results\)](#)
- [The Renewable Energy Potential \(reV\) Model \(open-source model on Github\)](#)
- [WIND Toolkit \(download high-resolution wind time-series\)](#)
- [National Solar Radiation Database \(download high-resolution solar time-series\)](#)
- [Systems Advisor Model \(RE generator/cost model\)](#)
- [US Wind Turbine Database](#)
- [NREL ReEDS Model](#)

Thank You

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