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Project Title:	21-SIT-01, SB100 Implementation Planning for SB100 Resource Build
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Description:	NREL Presentation: National Technical Potential Assessments-Data, Methods, and Outcomes
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National Technical Potential Assessments

Data, Methods, and Outcomes

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Senior Energy Researcher

March 13th, 2023

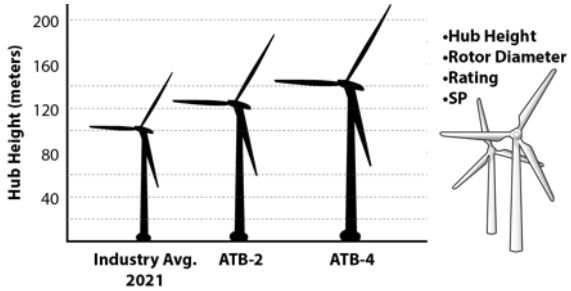
Photo from iStock-627281636

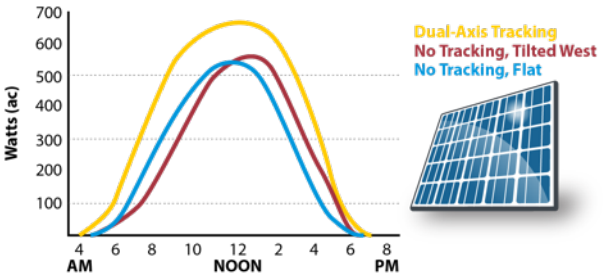
Data

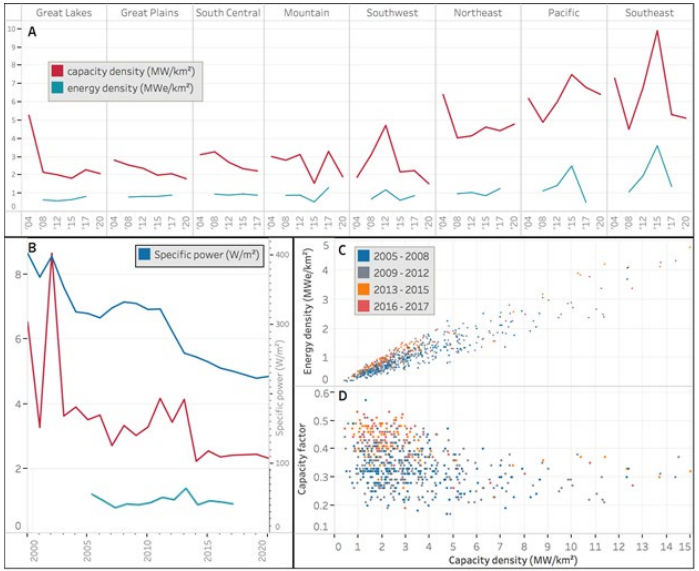
Data - Technology

Technical potential assessments stand at the intersection of multiple disciplines.

To accurately quantify potential, one must consider local siting constraints and the interaction with technology options – both present and future, and those interactions with wind, solar, or other resources.

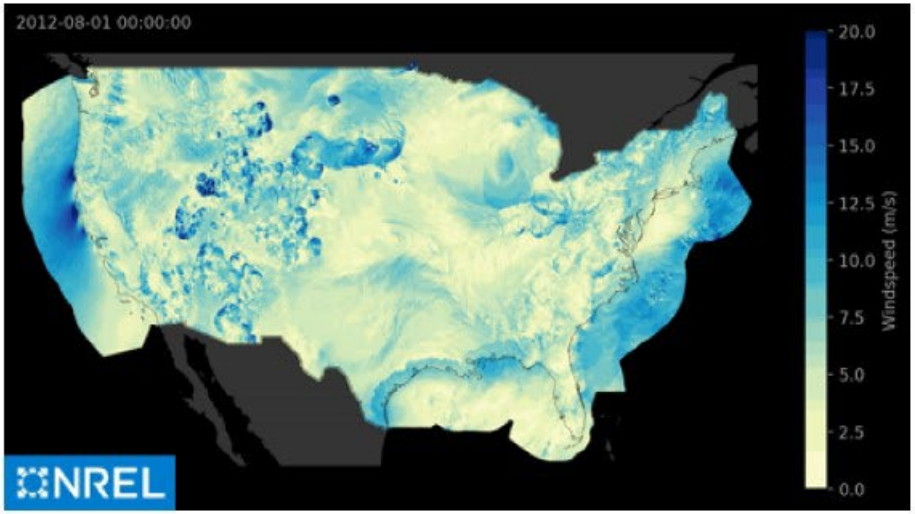






Data - Resource

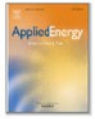
*Integrating super-resolved GCM data into NREL modeling ecosystems to understand impacts of climate change to resources and load. Represents a new frontier of research.



ELSEVIER

Applied Energy

Volume 151, 1 August 2015, Pages 355-366



The Wind Integration National Dataset (WIND) Toolkit

Caroline Draxl [a], Andrew Clifton [a], Bri-Mathias Hodge [a], Jim McCaa [b]

ELSEVIER

Renewable and Sustainable Energy Reviews

Volume 89, June 2018, Pages 51-60

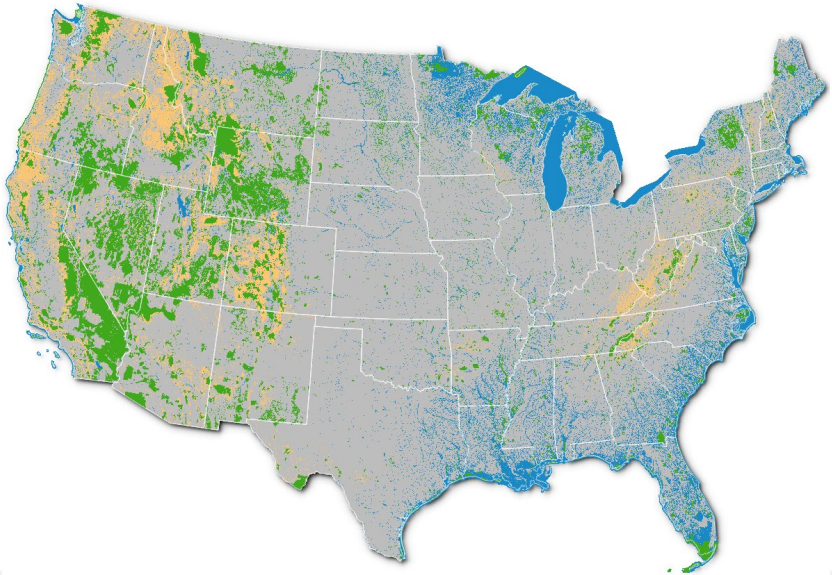
The National Solar Radiation Data Base (NSRDB)

Manajit Sengupta [a], Yu Xie [a], Anthony Lopez [b], Aron Habte [a], Galen Maclaurin [b], James Shelby [c]

Data - Environment

Environmental concerns around rangeland disturbance, species core habitat, public and private land conservation, and more are critical.

Data typically represent legally or administratively protected lands or lands with a regulatory hook that could prevent deployment or curtail generation.

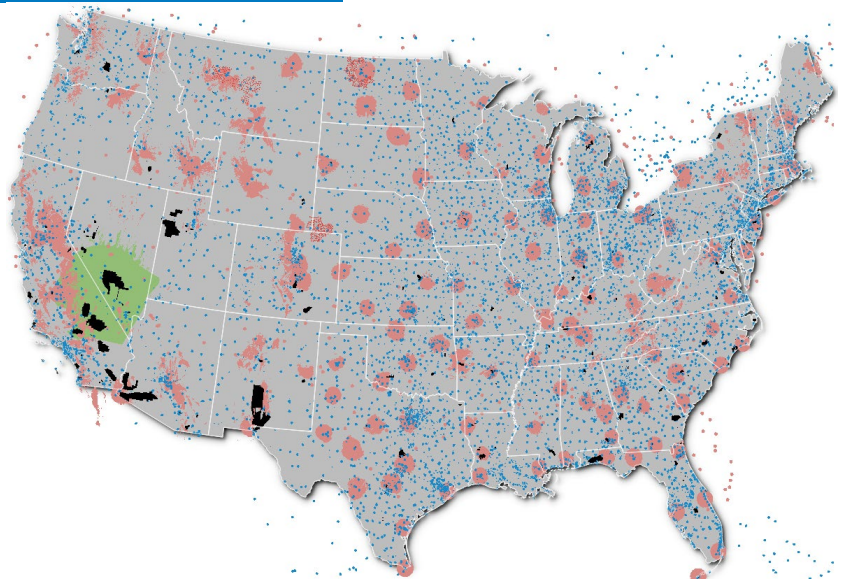


Example Dataset

Bat Hibernacula	Conservation Reserve Program (CRP)
ANL BLM Wind Exclusions	Water, Woody/Herbaceous Wetlands
	Bureau of Land Management Areas of Critical
Sage Grouse Core Habitat (federal land)	Environmental Concern
T&E Species Core Habitat (subset)	National Forest Service Inventoried Roadless Areas
USFWS NWI	NCED GAP 1, 2
American Farm Trust Conserved Farmlands	PAD-US GAP 1, 2
Nationally Significant Ag Lands	Slope Exclusion(s)
Big game migration corridors	Elevation & Mountainous Landforms

Data – Airspace

Airspace considerations including radar interference, airport proximity constraints, and military training routes can dictate final placement or height of a turbine.

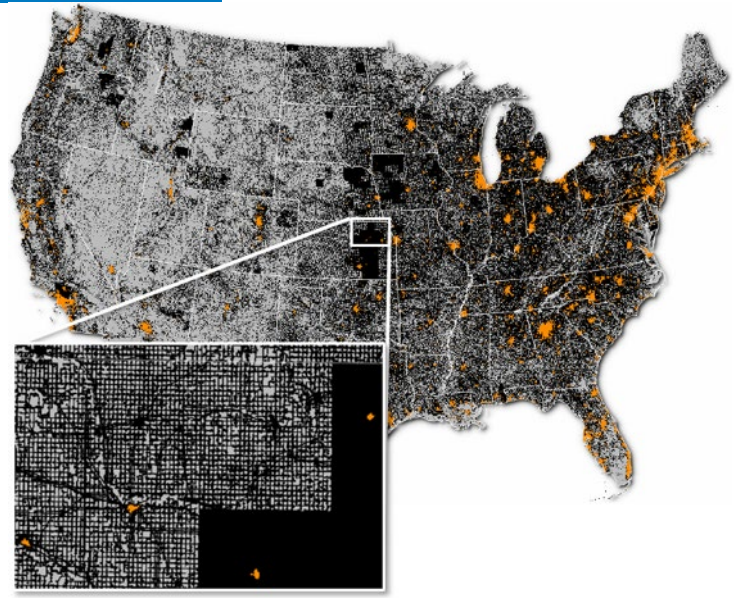


Example Datasets

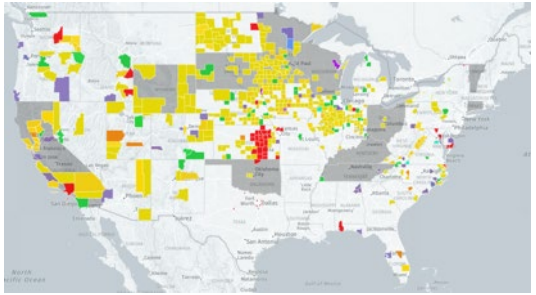
Airport Setbacks (variable)
Intercontinental Ballistic Missiles ICBMs
Risk of Adverse Impact on Military Operations and Readiness Area (RAIMORA)
DoD Lands
DoD Radar setbacks and line-of-site
NEXRAD setbacks and line-of-site

Data – Social / Regulatory landscape

Human infrastructure is a physical obstacle and is confounded by increasing number of siting ordinances, that dictate setbacks, sound limits, and more and are intrinsically linked with technology assumptions.

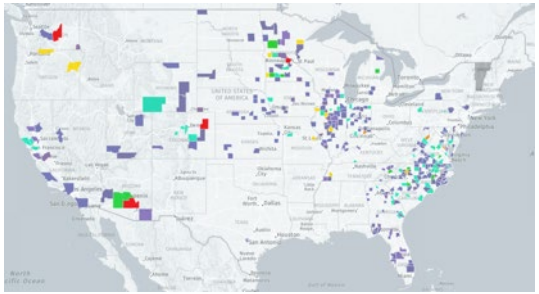


Wind Ordinances



https://data.openei.org/submissions/5733

Solar Ordinances

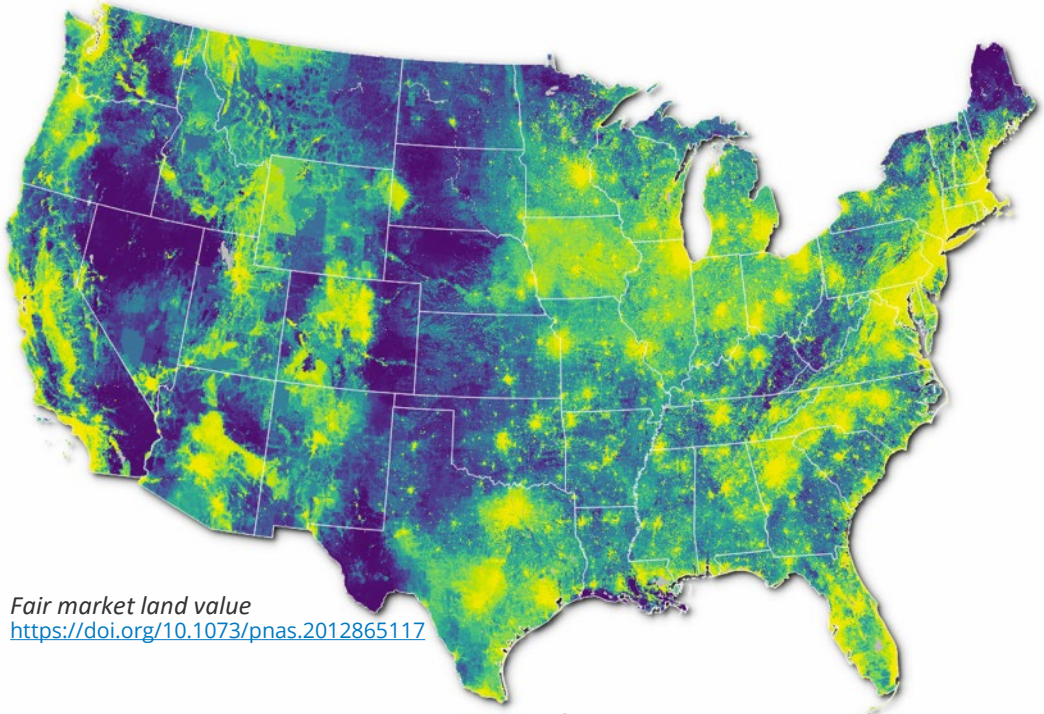


https://data.openei.org/submissions/5734

Example Datasets

Oil & Gas Wells
Oil & Gas Pipelines (ROW)
Water Setbacks
Existing Wind/solar facilities
Bans or Moratoriums
Height Limits
Rail Setbacks
Railroads
Road Setbacks
Structure Setbacks
Transmission Setbacks
Shadow Flicker
Sound Limits
Roads
Structures
Transmission (ROW)

Data - Land Characterizations



Fair market land value
https://doi.org/10.1073/pnas.2012865117

Siting is more than boolean exclusions. Quantifying the characteristics of remaining lands, especially those developed within our expansion models, helps to illuminate the potential scale of additive pressures. For example, roughly how many turbines might DoD expect to intersect military training routes?

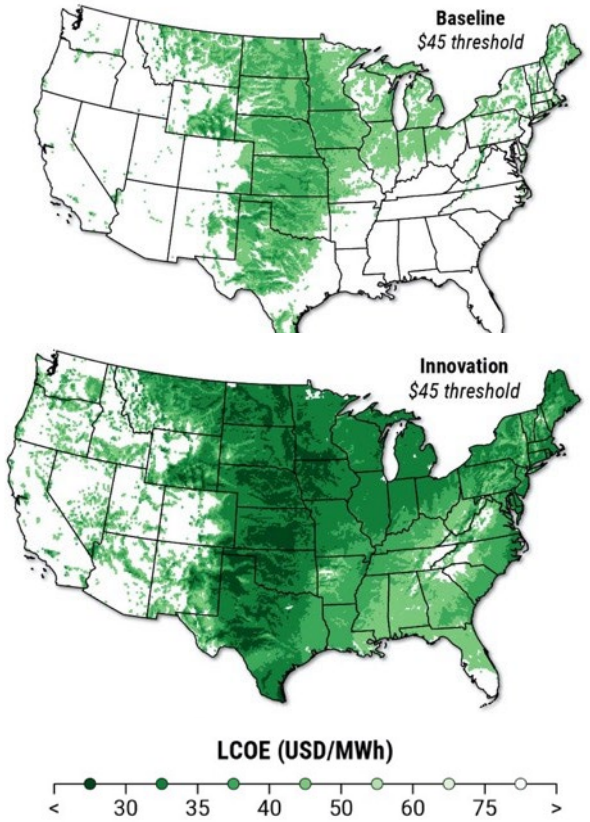
Example Datasets

TNC Key Wildlife Areas Wind
FWS Eagle Permit
T&E Bat species ranges (8 total)
Military Training Routes
Special Use Airspace
ANL BLM High Siting Sensitivity
ANL BLM Moderate Siting Sensitivity
National Land Cover Dataset (NLCD)
Sagebrush habitat
Wyoming Terrestrial Crucial Habitat
NCED GAP Status 3, 4
PAD-US GAP Status 3, 4
Federal land owenership
MLRC Tree Canopy
CDL Croplands
Gridded Population (Landscan)
USDA NASS Cash Rental Rates

USDA Census Data on Agricultural Land Value
CDC Social Vulnerability Index
TNC Resilient Lands
AFT Productivity, Versatility, Resiliancy (PVR)
AFT States best Ag Land
AFT Nationally Significant Agricultural Lands
Private Land Fair Market Value
TNC Key Wildlife Areas Solar

Data – Summary

Woven together, local siting constraints impose location dependent limits on deployment opportunities in many resource rich regions and illuminate the need for increased tailoring of power plants into the local social, ecological, and topographical context.

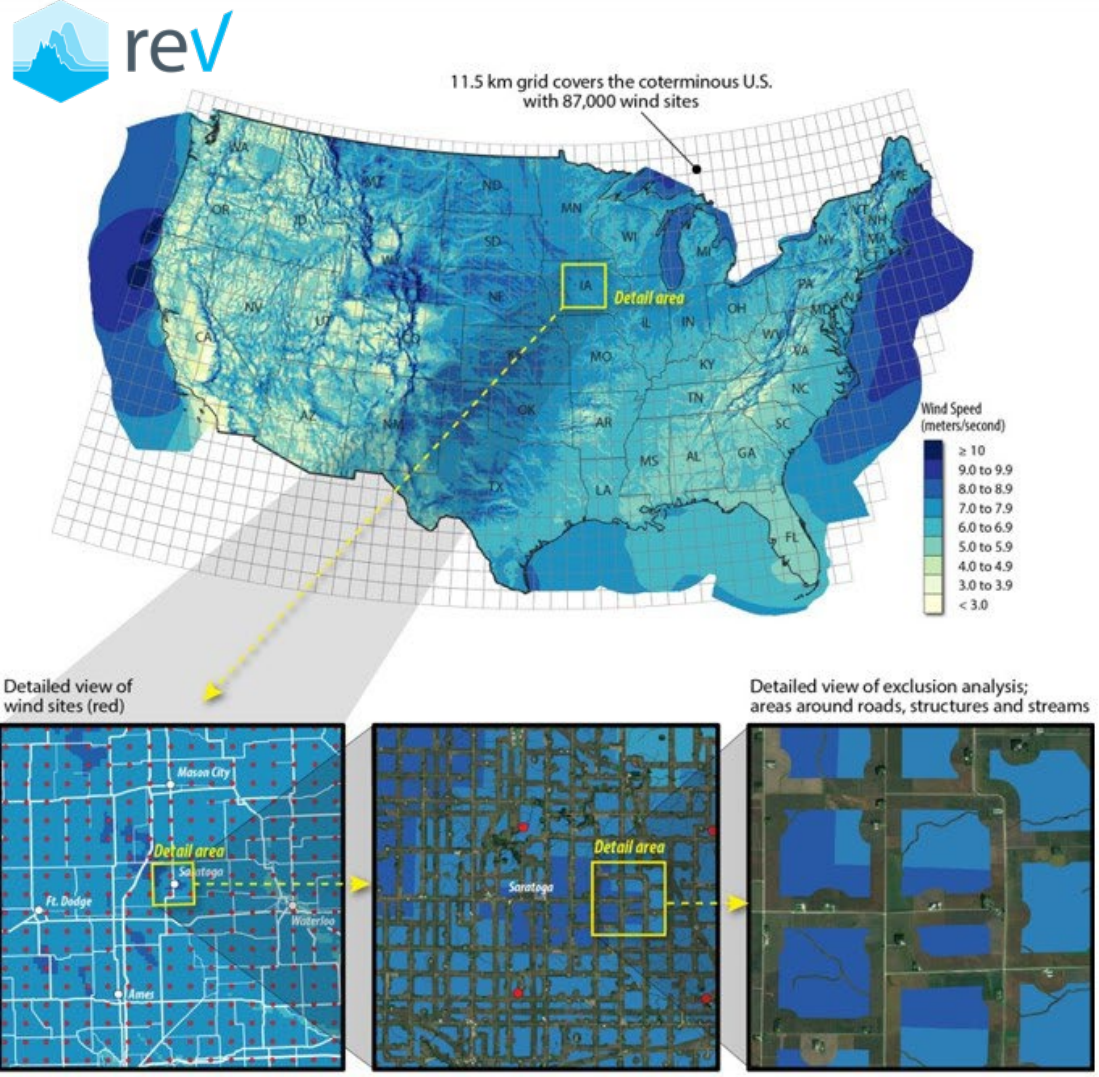


Areas highlighted in green meet an LCOE threshold of <$45/MWh. Demonstrating the geographic expansion and thus the value proposition of technology innovation pathways

Roberts et al., 2023. Exploring the Impact of Near-Term Innovations on the Technical Potential of Land-Based Wind Energy

Methods

A Best-In-Class Model for Estimating Renewable Energy Supply



Technologies Modeled

Land-based Wind

Offshore Wind

Rooftop PV

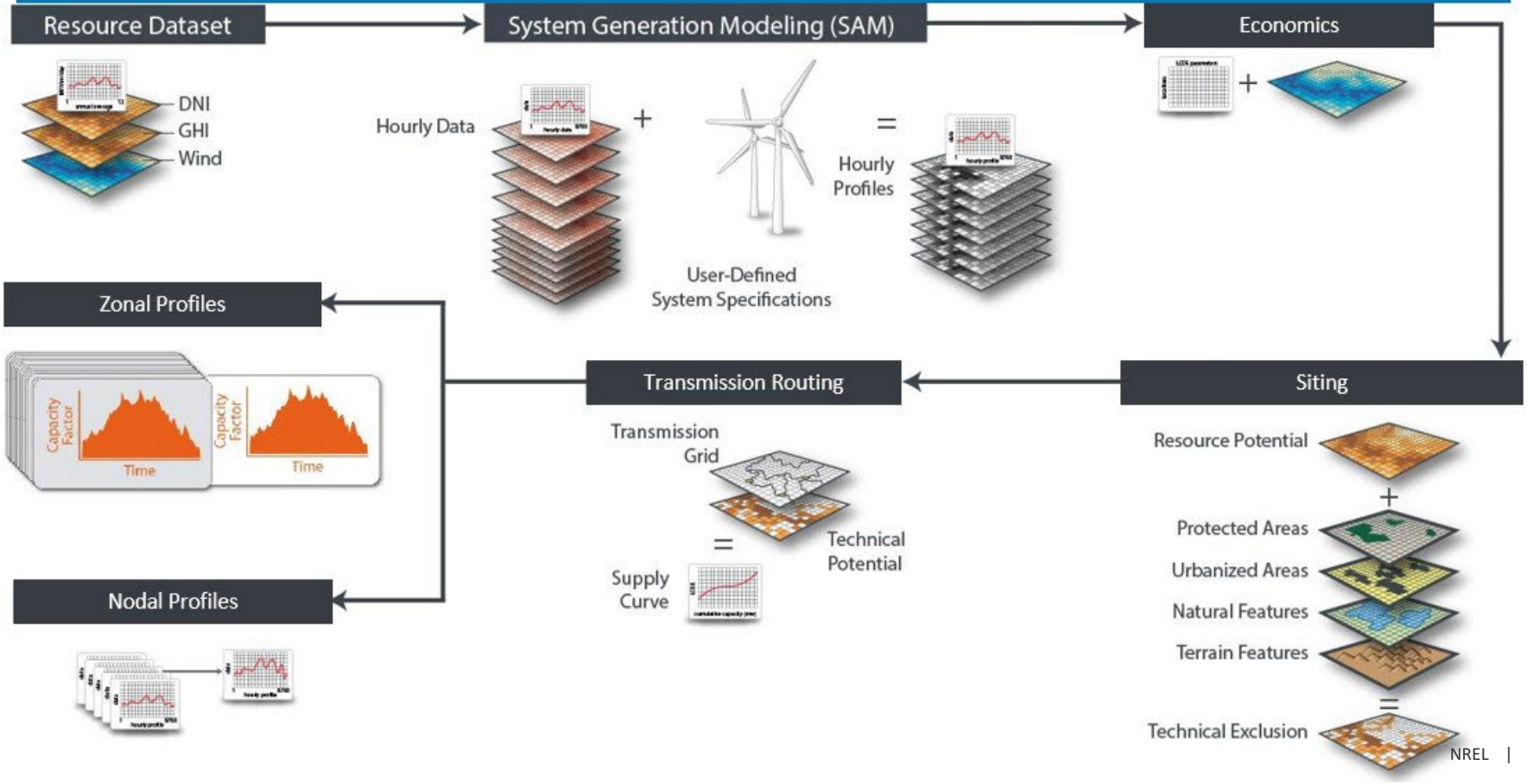
Utility-scale PV

Concentrating Solar Power

Geothermal

How does reV work?

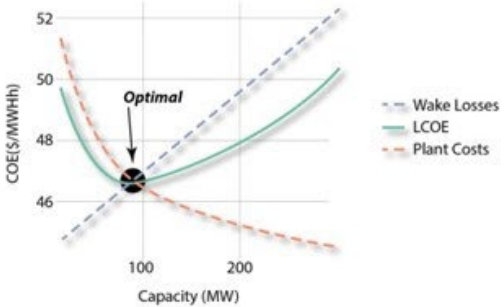
high performance computing software leveraging petabytes of data and computing billions of spatiotemporal calculations



Siting: Detail at Scale

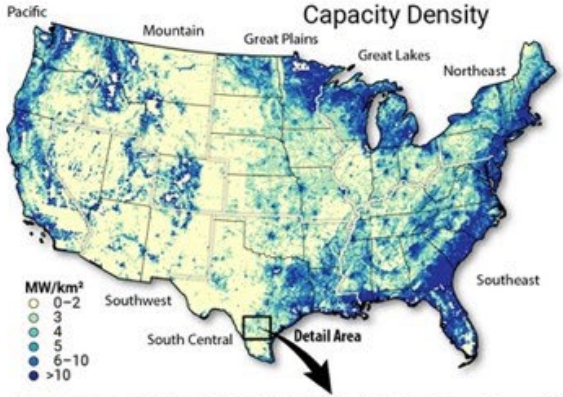
Spatial optimization of local wind plant designs – a novel advancement in technical potential assessments

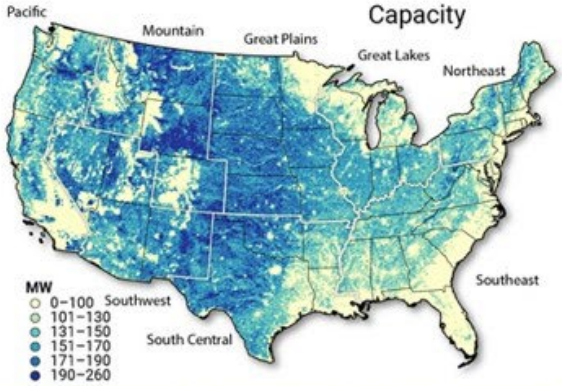
Approach accounts for the interactions between wind technology design, wind plant layout, and the vast array of regulatory, land use and infrastructure conflicts with wind development. Overcomes limitations with static or uniform capacity density assumptions.

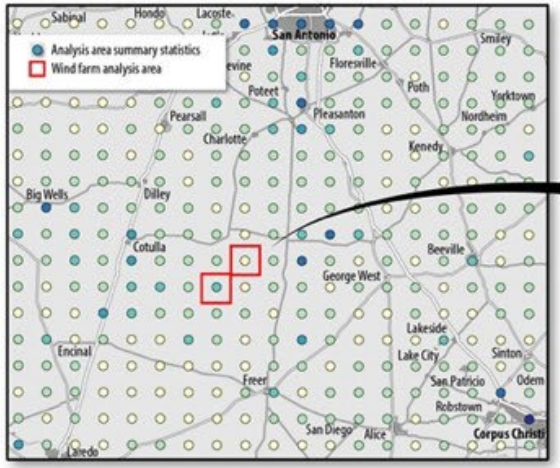


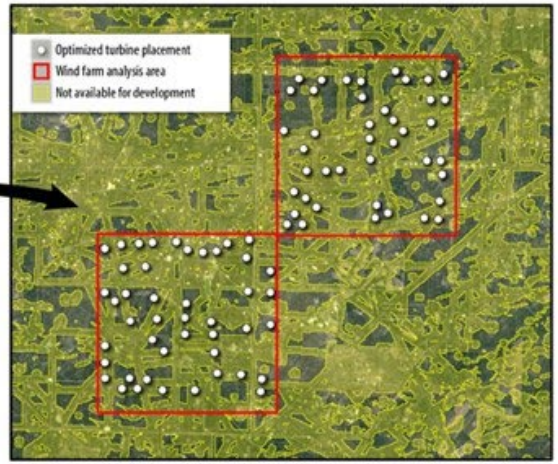
reV creates 67,000 development "sites" across the U.S., optimizing turbine placement (~3 million) considering technology design and cost, plant layout, and the vast array of regulatory, land-use, and infrastructure conflicts

Lopez et al., forthcoming









Siting Regimes

Philosophy & approach for a dynamic and evolving challenge

Open Access

least restrictive regime, applying only physical barriers and protected lands (e.g. national parks, conservation easements, etc.) that restrict development

Reference Access

moderate siting regime that balances siting considerations by utilizing, where feasible, best management practices to guide deployment potential

Limited Access

combination of the most stringent siting considerations of all scenarios that represents a plausible floor for available land

Transmission Routing

*Also modeling network upgrade requirements

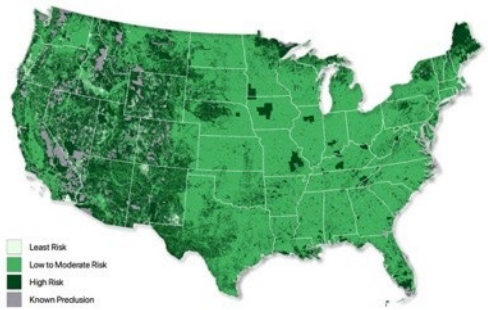
Regional voltage-based costs are selected based on the prospective wind (or solar) site size (MW) and routed to neighboring substations to estimate a cost of spur-transmission and point-of-interconnection.

Routing is guided by regional hard (component) and soft (land composition e.g., cropland vs suburban) costs. In addition, routes are guided by natural and cultural constraints and friction to avoid likely high mitigation cost areas.

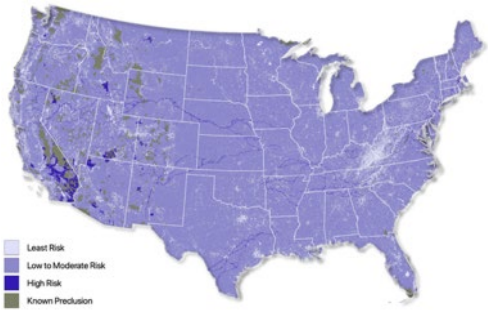
The routing routine is repeated for every reV site (~67,000 locations – land)

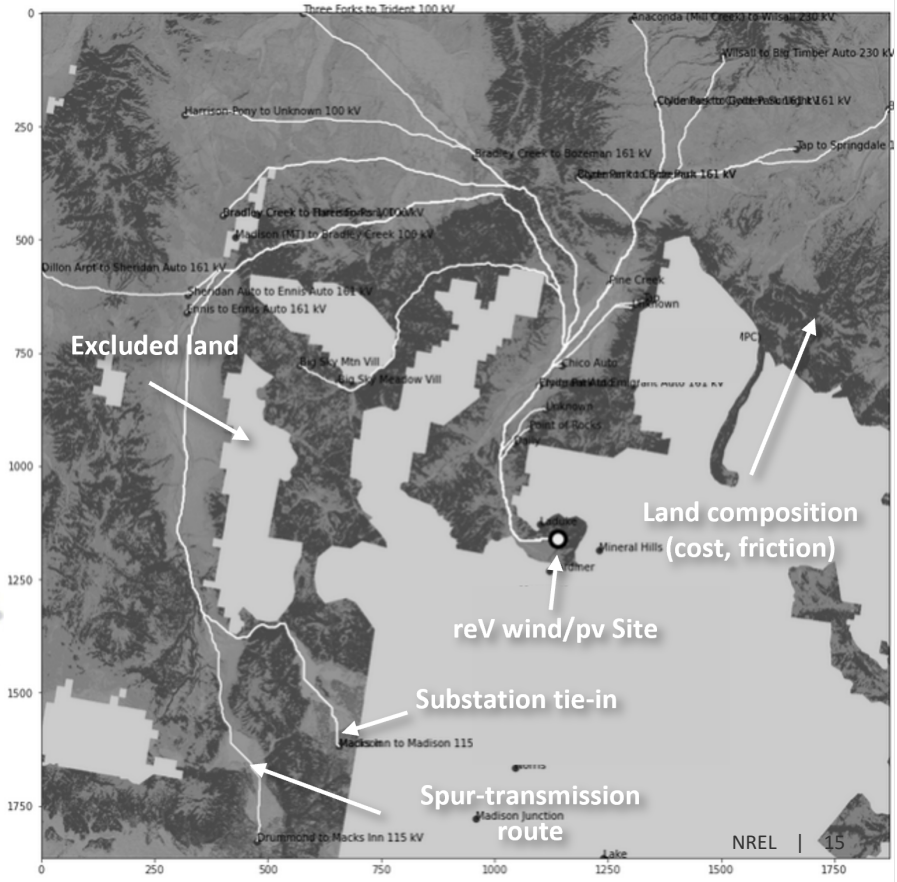
Extension of SWCA Environmental Consultants WECC Transmission Siting

Natural constraints

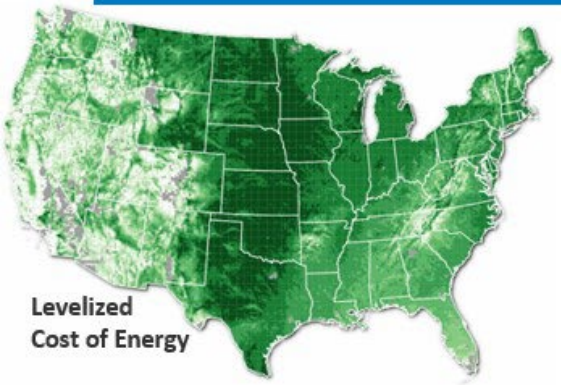


Cultural constraints

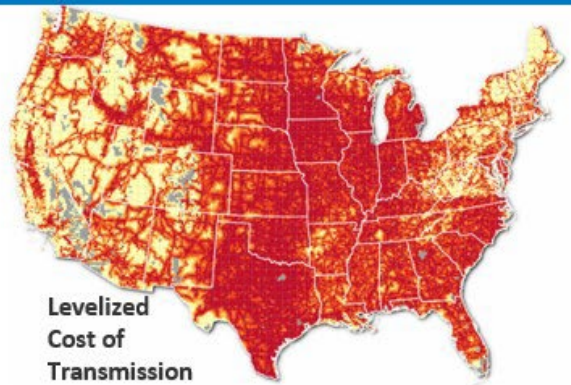




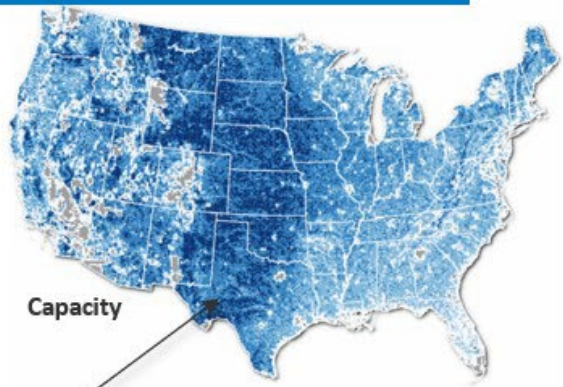
Bringing it All Together



Levelized Cost of Energy

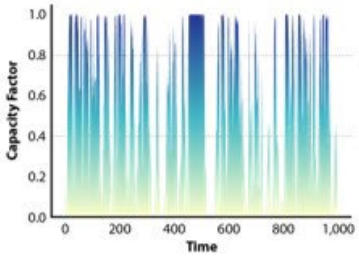


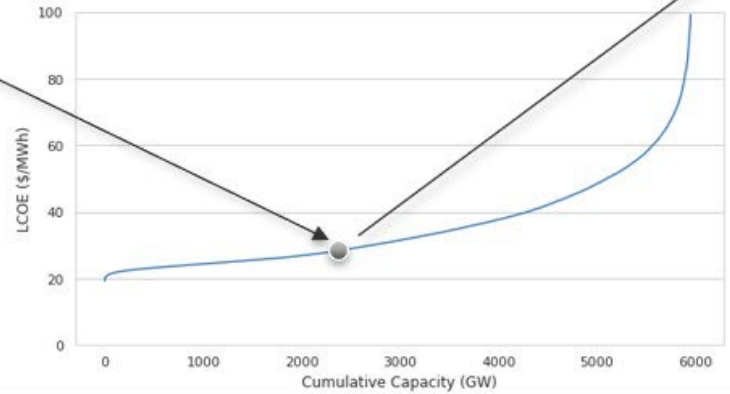
Levelized Cost of Transmission



Capacity

Supply Curve





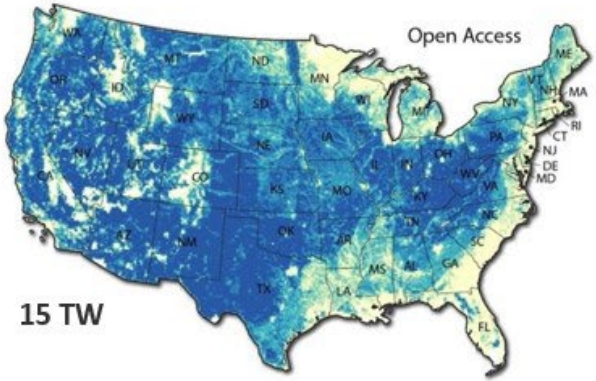
The supply curve graph is comprised of individual points, each with a geolocation and temporal profile, in addition to site costs, spur-line routing and costs, network upgrade paths and costs, and more

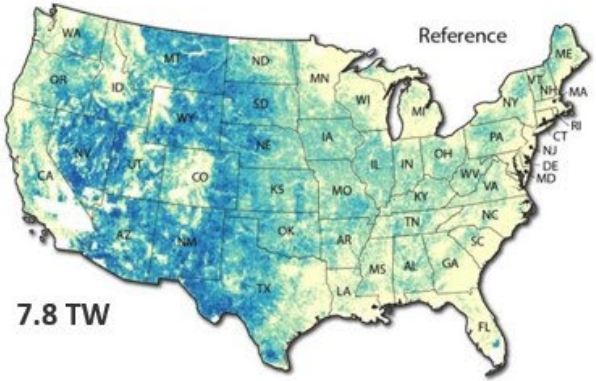
Given a set of assumptions, reV estimates the quantity, quality, and cost of VRE as well as its associated power profile

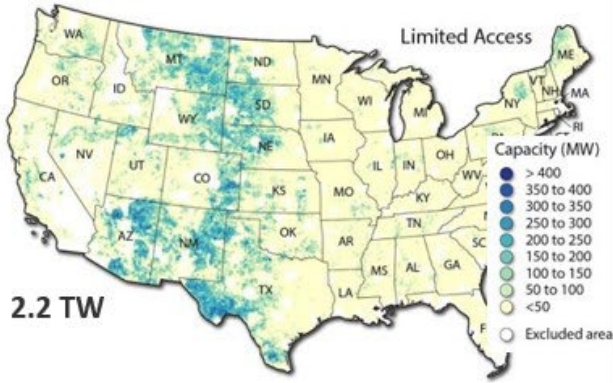
Outcomes

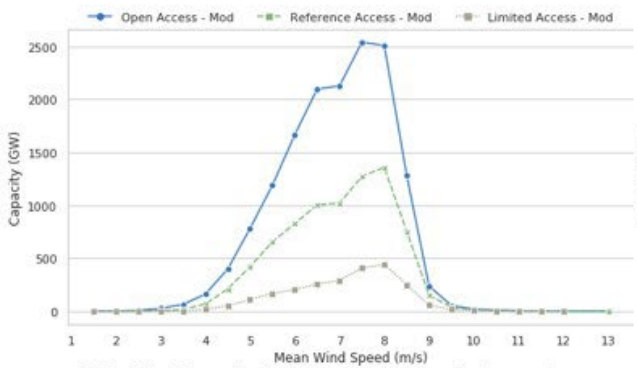
Influences of local siting on national wind potential

Below presents a previous study demonstrating a scenario-based framework for exploring composite siting constraints

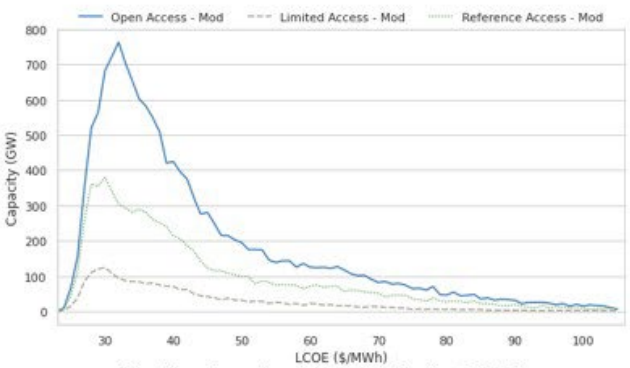




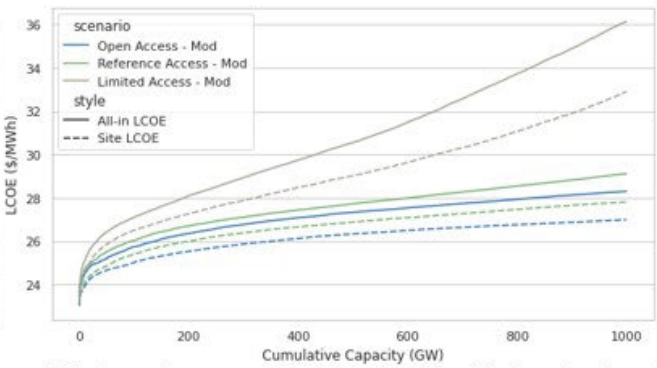




Distribution of wind capacity by wind speed



Distribution of wind capacity by LCOE



Wind supply curve and costs influenced by levelized cost of transmission

Lopez et al., 2021 https://doi.org/10.1016/j.energy.2021.120044

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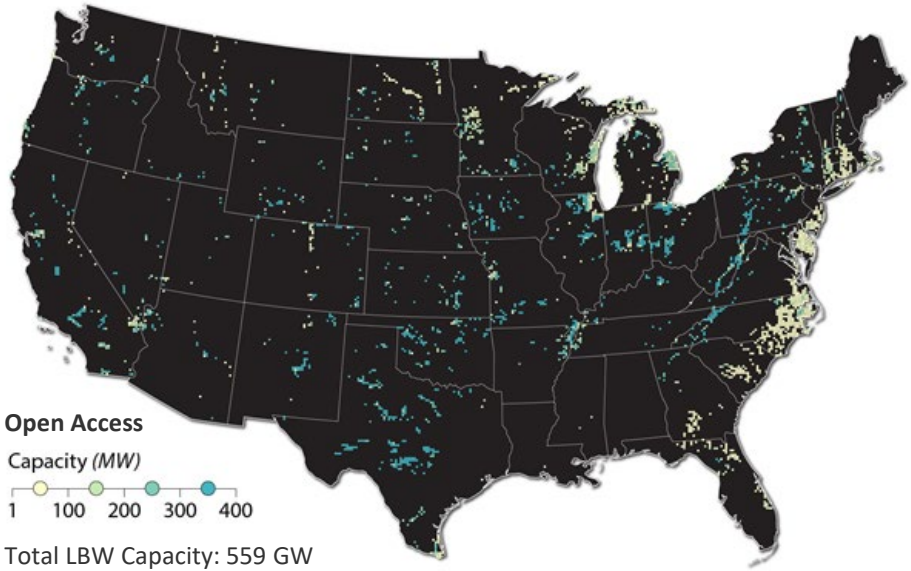
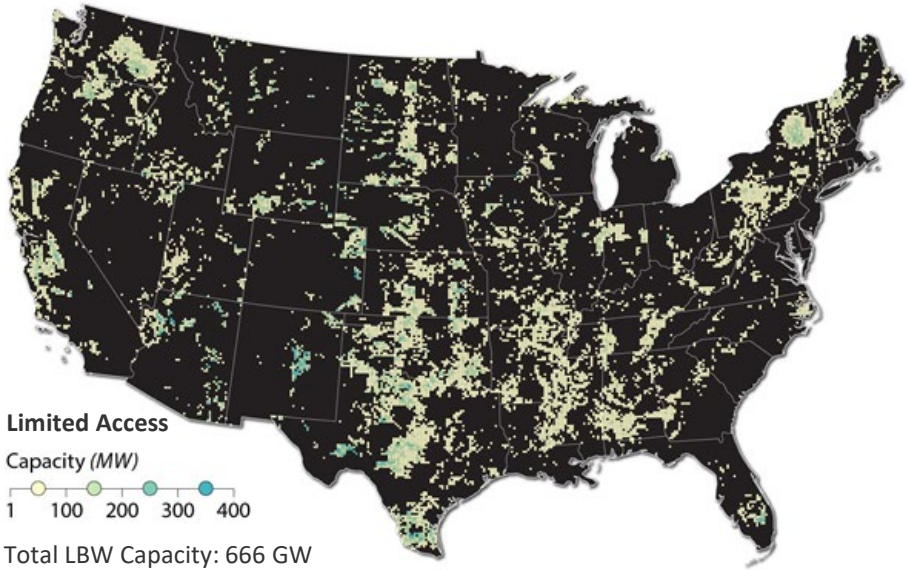
Local to National Implications

Local siting influences the pace, scale, and distribution of VRE deployment.

Wind capacity needed to reach 40% generation



Total LBW Capacity: 559 GW



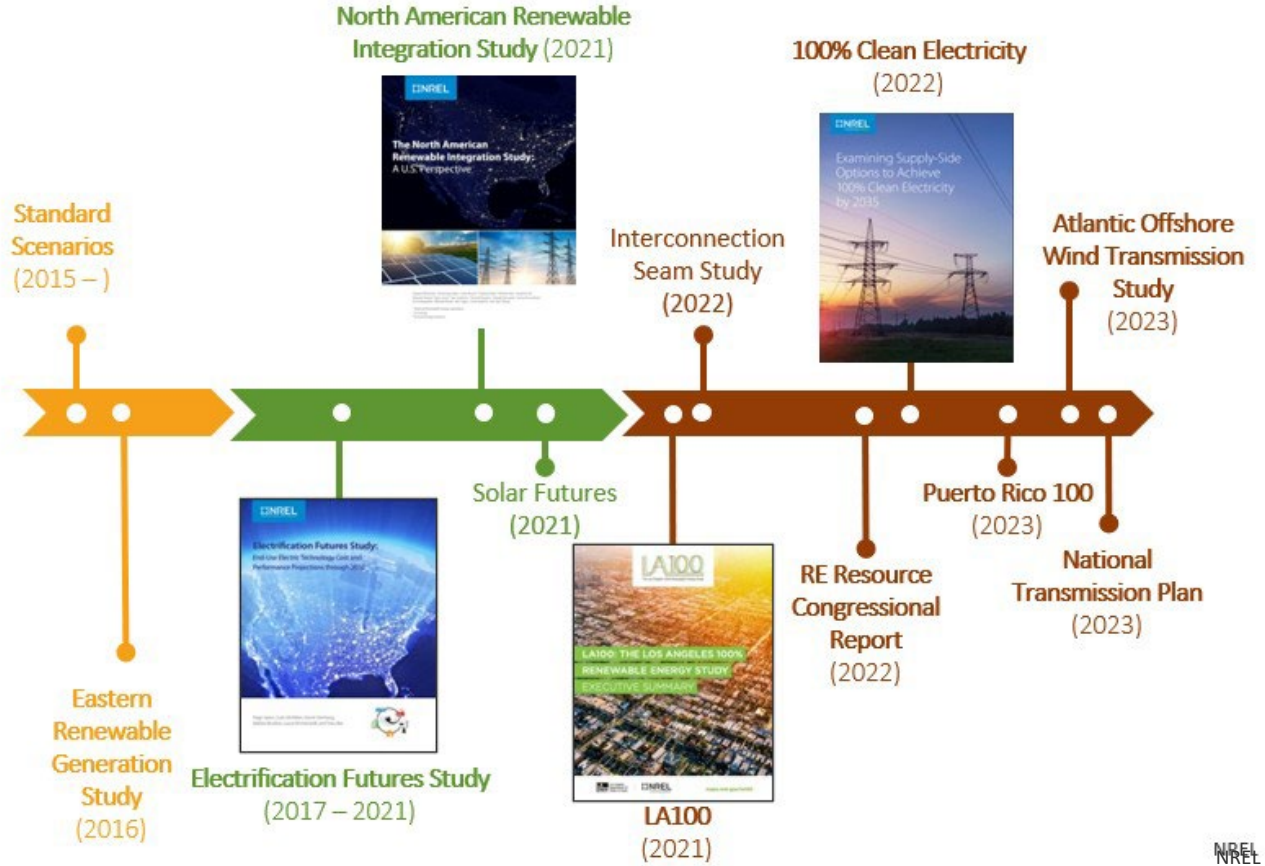
Total LBW Capacity: 666 GW

Mai et al., 2021 https://doi.org/10.1016/j.energy.2021.119998

Large Impact Studies

Technical potential estimates are foundational to these studies, providing the necessary resource and grid interconnection characterizations.

Ultimately, to understand decarbonization pathways, we must first define what's possible.



Thank you

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Contact: Anthony Lopez. Anthony.lopez@nrel.gov

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