Assessment of the Economic Potential of Distributed Wind in Colorado, Minnesota, and New York

May 9, 2018

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NREL/PR-5000-71512

Introduction

Stakeholders in the small/distributed wind space **require access to better tools and data for more informed decisions** on high-impact topics, including project planning, policymaking, and funding allocation.

A major challenge in obtaining improved information is in the **identification of favorable sites**—namely, **the intersection of sufficient wind resource with economic parameters such as retail rates, incentives, and other policies.**

Research objective:

To understand the spatial variance of key distributed wind parameters and identify where they intersect to form pockets of favorable areas in Colorado, Minnesota, and New York.

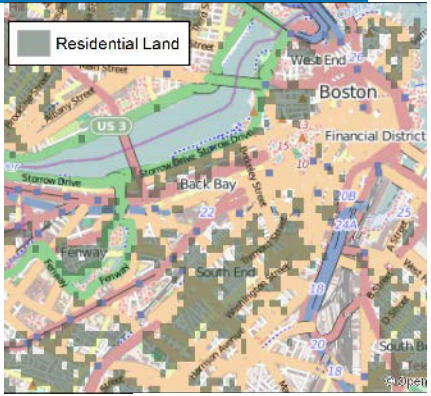
Modeling Approach

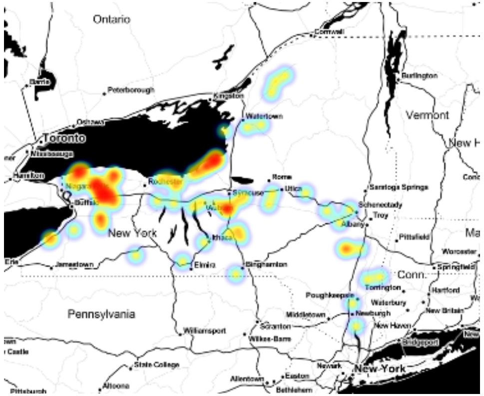
dWind: Distributed Wind Market Adoption Model

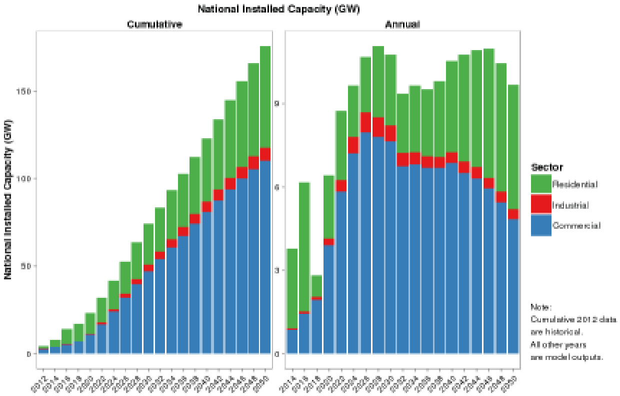
- **Forecasts adoption of behind-the-meter distributed wind** by sector in the continental United States through 2050

- **Agent-Based Model** simulates consumer decision-making

- **Incorporates detailed spatial data** to understand regional trends in distributed wind viability





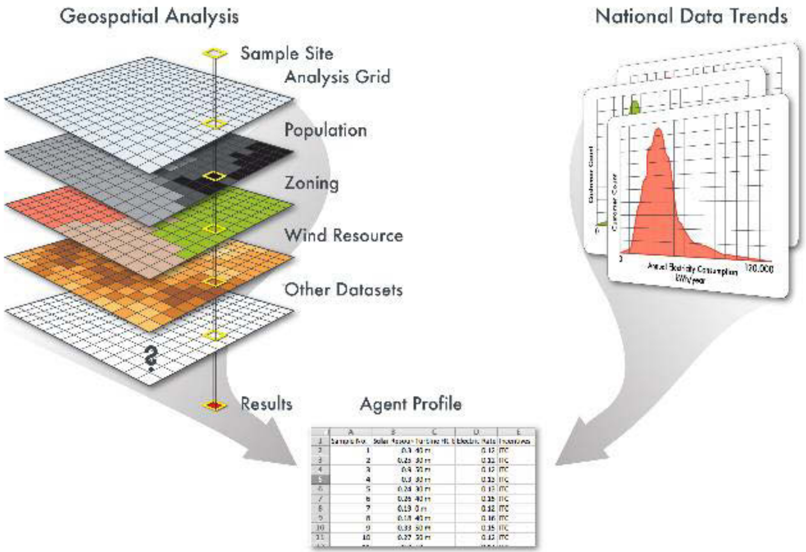


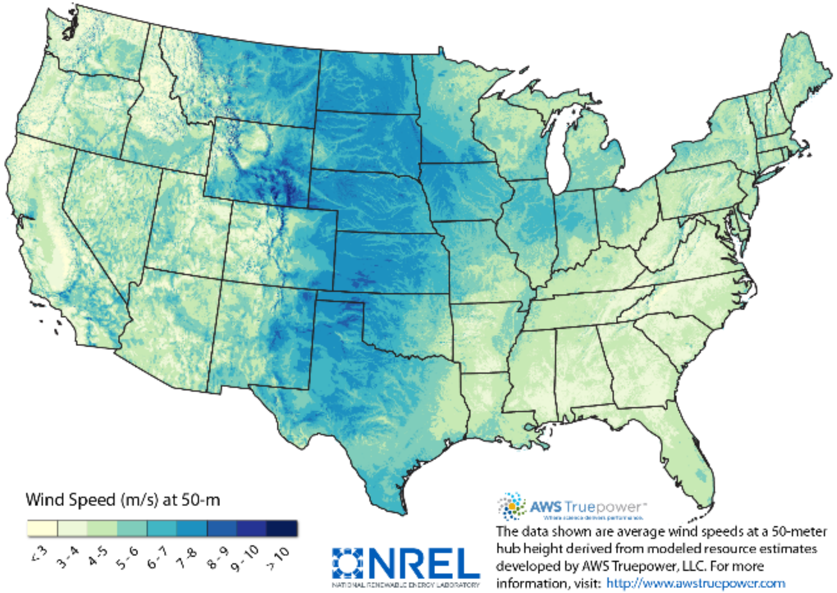
Top left: Evaluate adoption potential for each 200m² cell; Top right: Spatial focus permits regional predictions; Bottom: Results from BAU-Mid Costs Scenario in ITC Extension analysis

Modeling Approach

dWind: Use Spatial Data to Define Agents

Use the “pin-drop” method to create “agents” that are ***representative*** and ***comprehensive*** of the spatially resolved technical, economic, and market factors.





Wind speed at 50-meter hub height

Modeling Approach

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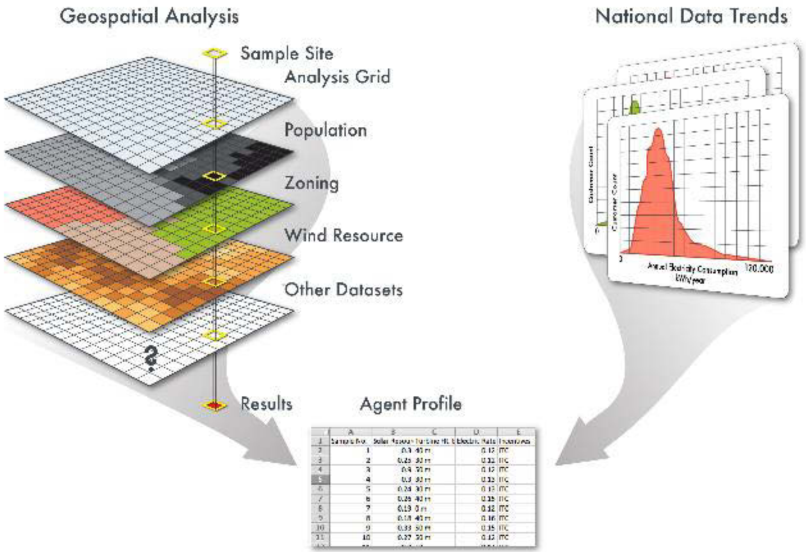

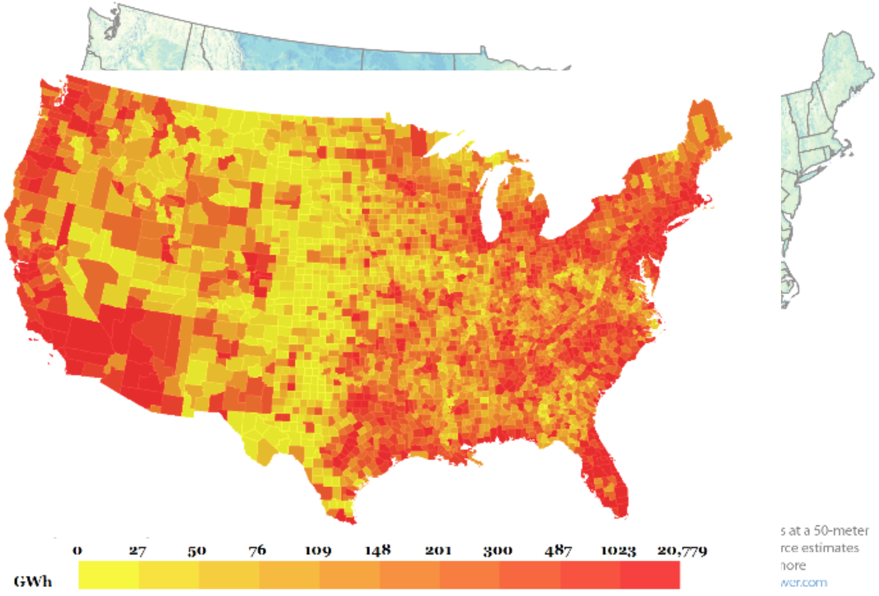

Residential sector annual aggregate load by county

Modeling Approach

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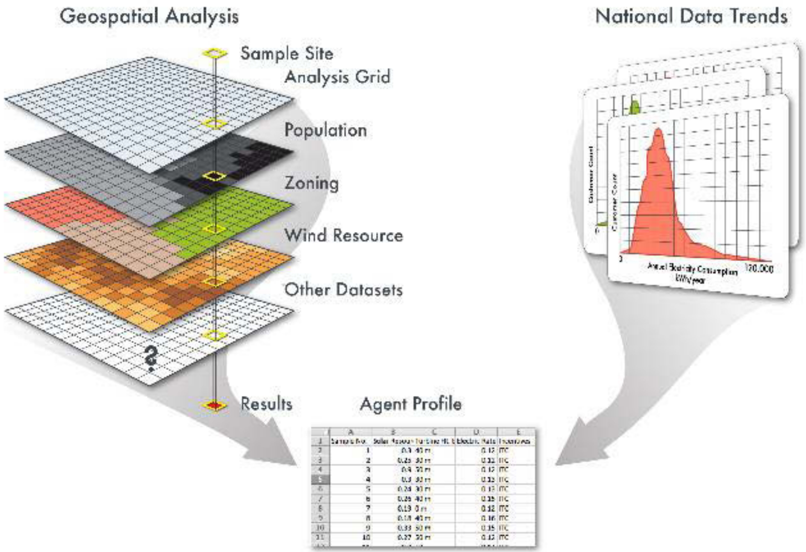
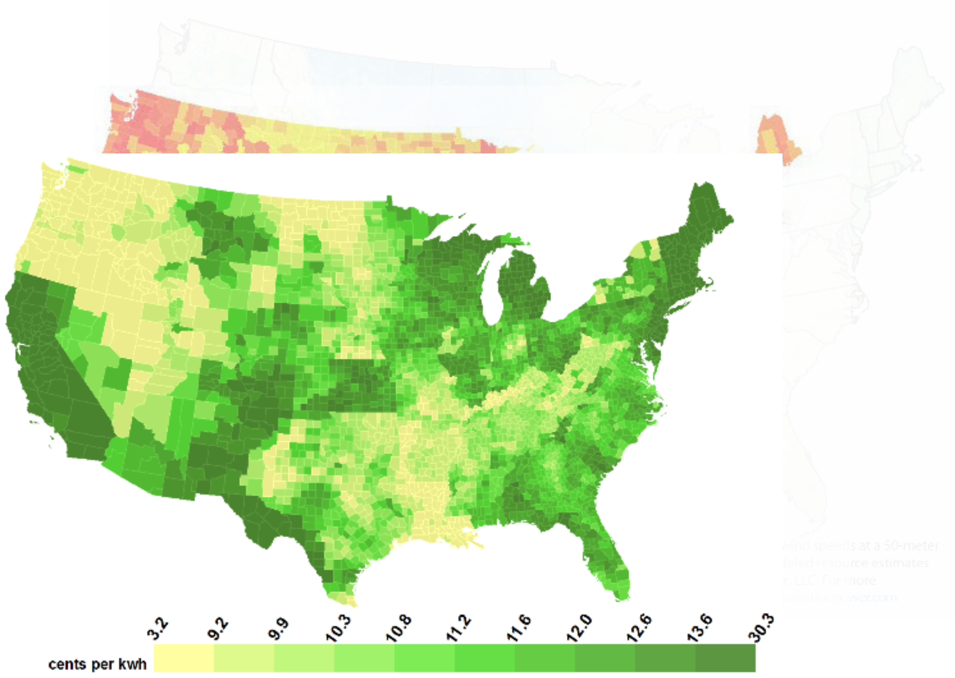




Residential sector annual average electricity rates

Scenario Analysis Framework

- Analysis is anchored by the **Reference Scenario**, which consists of central assumptions about several key variables:
  - *Capital costs*
    - Up to 45% reduction in capital cost by 2030, 70% reduction by 2050
  - *Operation and maintenance (O&M) costs*
    - 4% reduction in O&M cost by 2030, 10% reduction by 2050
  - *Technology performance*
    - Up to 25% increase in capacity factor by 2030, 55% increase by 2050
  - *Value of distributed generation*
    - Net metering expires as scheduled, excess generation valued at wholesale rate
  - *System financing and leasing costs*
    - Real weighted average cost of capital (WACC) of 5.4%
    - Leasing available in all states and sectors by 2020 using 7% real hurdle rate
  - *Turbine siting criteria*
    - System height setback factor of 1.1x
    - 12-m static rotor canopy clearance for areas with ≥ 10% canopy cover
- Single-variable sensitivity runs consist of changing above variables on an individual basis while holding all other variables constant at the Reference Scenario value.

Results

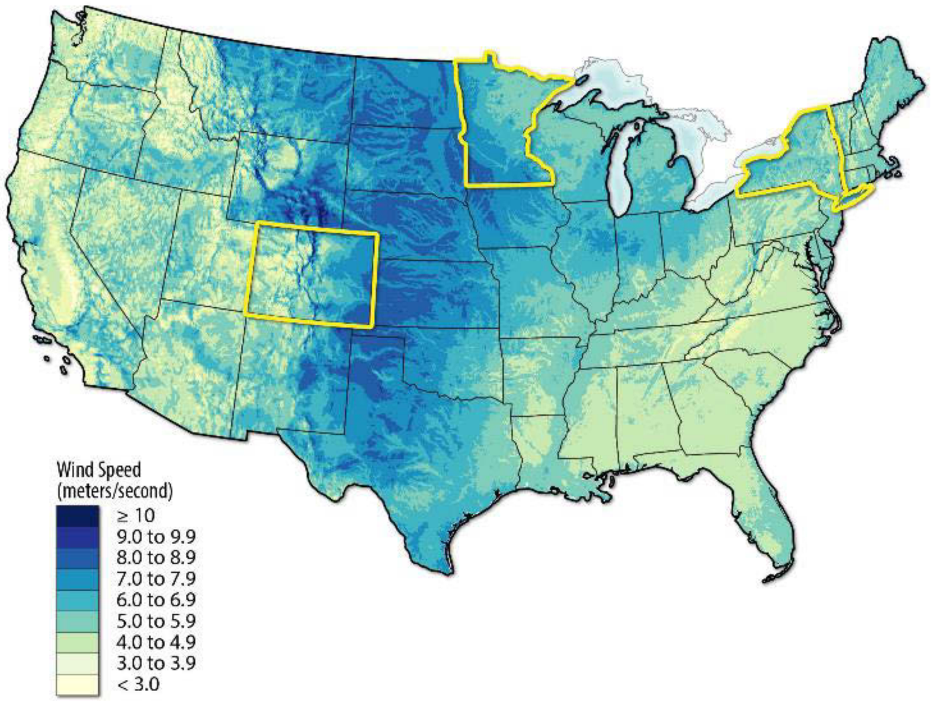
Modeling Metric – Economic Potential

- **Economic potential**: Defined as the amount of distributed wind capacity that could be deployed at a positive net present value (NPV).
  - Economic potential is driven by how costs (e.g., capital, O&M, and financing) measure up against potential revenue contributions (e.g., avoided retail electricity costs, financial incentives, and depreciation and interest deduction).
  - Though actual circumstances leading to turbine *adoption* may vary between customers, the *economic potential* metric provides a standardized assessment of when and where distributed wind investment would be a compelling economic decision.

Results

Intersection of Key Variables Inform Economic Viability

- Primary variables that inform economic potential estimates:
  - **Quality of wind resource**
    - Site-level wind resource is an important, though not an independently sufficient, component in determining economic viability.
  - **Amount of on-site electrical load**
    - Behind-the-meter wind is only deployed with sufficient on-site energy consumption.
    - Areas of high load often correlate with metropolitan centers.
  - **Availability of a particular site to interconnect a turbine**
    - Tree canopy and property setback factors dictate siting availability.
    - This analysis calculates siting availability as the percentage of all turbine configurations (23 unique combinations of turbine size and hub height) available for siting at a given location.



Average wind speed (m/s) at an 80-meter hub height

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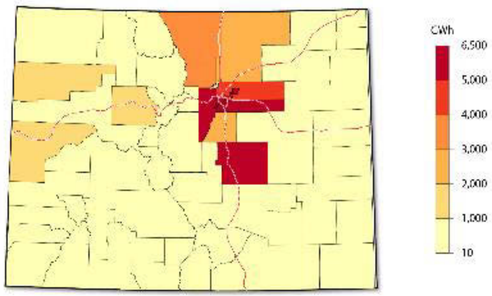

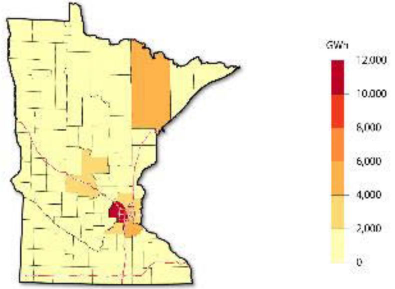

Electricity load (GWh) for all (residential, commercial, and industrial) customers in 2018

Results

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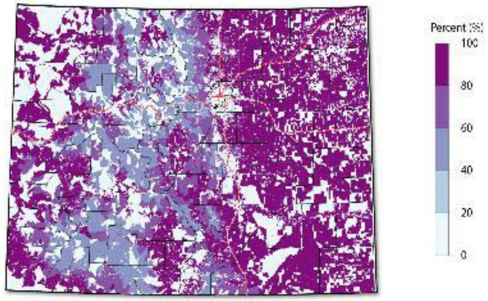
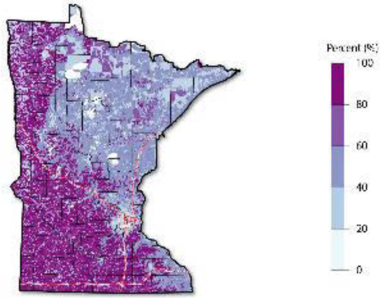
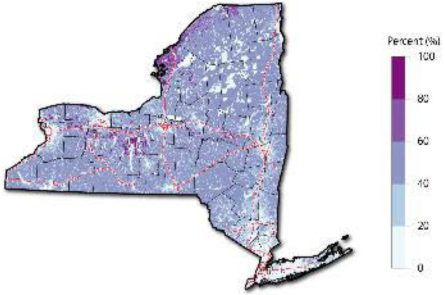




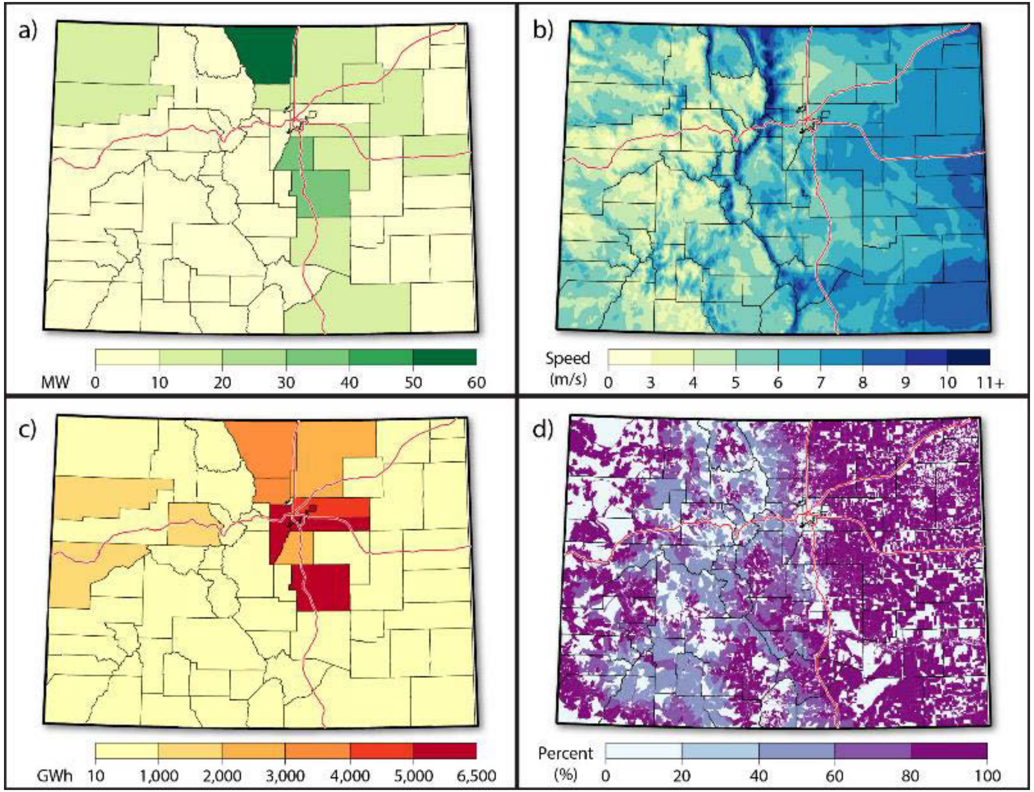


Favorability for siting availability represented by the proportion of total number of turbine configurations available for siting at each parcel

Colorado Results

Intersection of Key Variables Inform Economic Viability

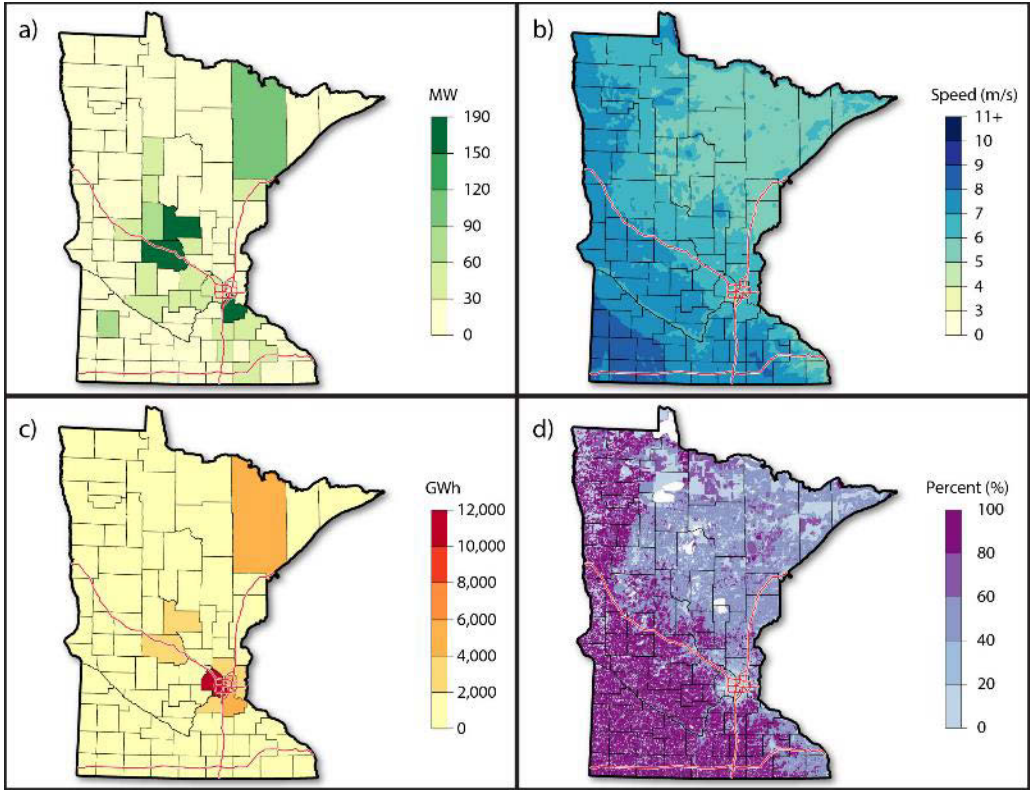
- **Colorado**
  - Front Range Urban Corridor and certain areas of Eastern Plains exhibit favorable conditions (a).
  - Variation in quality of wind resource (b) informs magnitude of economic potential statewide.
  - Electricity load (c) shows spatial distribution that favors areas of high population density (e.g., Front Range Urban Corridor).
  - Siting availability (d) limits opportunity in urban centers.



Minnesota Results

Intersection of Key Variables Inform Economic Viability

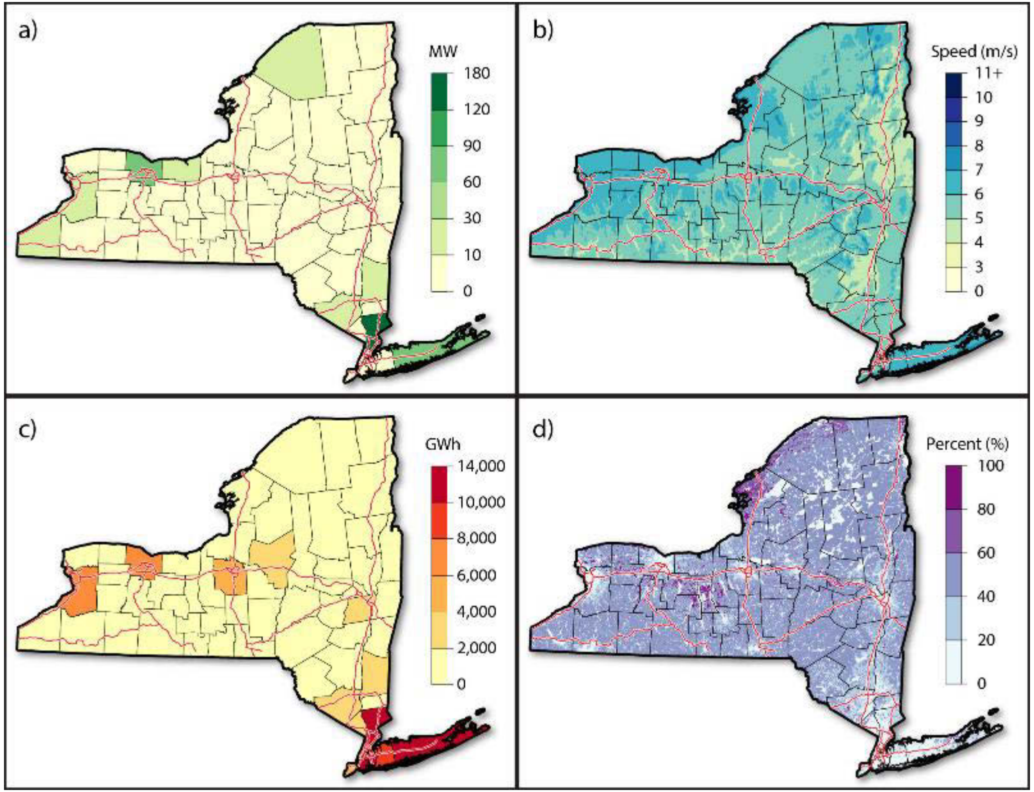
- **Minnesota**
  - High levels of potential observed for counties housing St. Cloud, Duluth, and the suburbs of the Twin Cities (a).
  - While wind resource (b) is highest in southern and western portions of state, lower levels of electrical consumption limit overall potential.
  - Areas of high load (c) correlate well with areas of high economic potential.
  - Despite poor siting availability in regions of high population density (d), spatial patterns and parcel sizes are sufficient to enable some penetration.



New York Results

Intersection of Key Variables Inform Economic Viability

- **New York**
  - High levels of potential are observed for counties that house population centers corresponding to Long Island, White Plains, Canton, Rochester, and Buffalo (a).
  - Generally strong wind resources (b) are exhibited statewide.
  - As in Colorado and Minnesota, areas of high load (c) correlate well with areas of high economic potential.
  - Though New York had the highest level of end-user load of the three states, lower siting availability (d) corresponding to areas of high population density limits the overall potential.



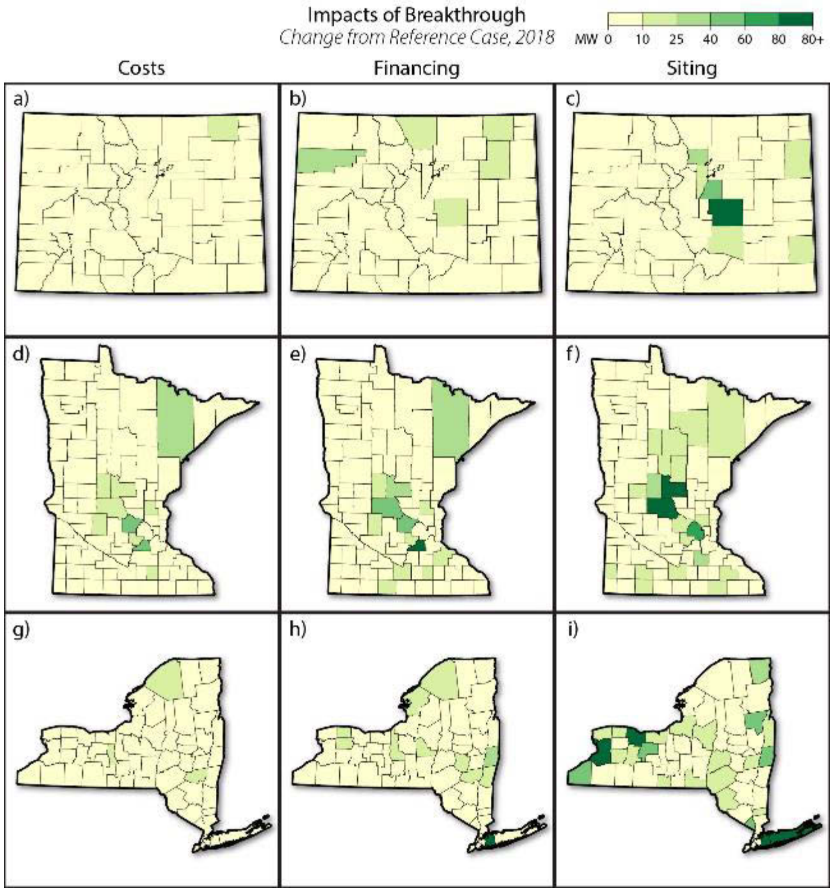
Results

Spatial Trends for Select Variable Sensitivities

- Reductions in capital and O&M costs appear to enhance already favorable areas in the **Breakthrough Costs** Scenario.

- The **Breakthrough Financing** Scenario shows weak trends in each state, perhaps boosting potential by alleviating capital-intensive nature of projects.

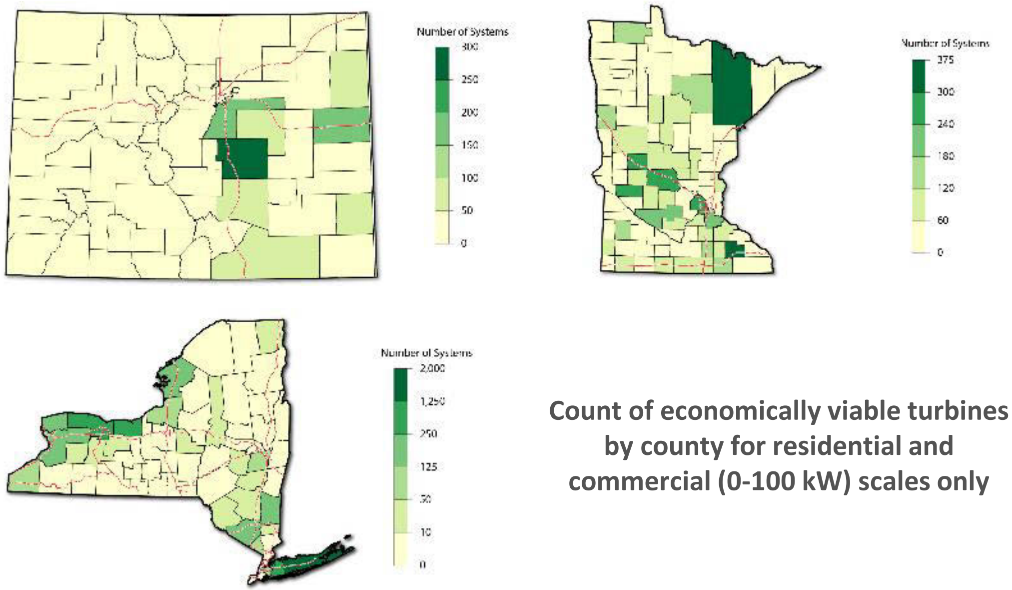
- Relaxing siting constraints in the **Breakthrough Siting** Scenario opened up more opportunities for distributed wind in areas of higher population density and therefore smaller parcels.



Results

Economic Viability for Residential and Commercial Scales (0-100 kW)

- **Economic viability by turbine count:** Defined as the aggregate number of sites in which a turbine can be sited at a positive NPV.
  - For the commercial and, especially, residential scale, the amount of **economic potential (MW) is incongruent with the actual number of systems** comprising this capacity potential.
- Economically viable turbines in the residential and commercial sectors cluster near **low-density urban centers and suburban areas**.
  - Load, siting, electricity prices, and other market factors still largely inform the economic viability by turbine count.
- However, while previous results closely followed spatial trends for load, **counts of residential and commercial class turbines illuminate pockets where conditions are more favorable.**
  - Indicates the role of siting availability in these turbine classes–**smaller turbine sizes can prosper (relative to larger turbine sizes) in areas where parcel size is limited.**



Count of economically viable turbines by county for residential and commercial (0-100 kW) scales only

Key Findings (1 of 2)

- The aggregated capacity totals for sites that can generate a positive NPV in 2018 are:
  - **360 MW** in Colorado
  - **1,950 MW** in Minnesota
  - **920 MW** in New York
- The aggregated system totals for residential and commercial scale turbines (0-100kW) in 2018 are:
  - **1,600 systems** in Colorado
  - **6,000 systems** in Minnesota
  - **4,950 systems** in New York

Key Findings (2 of 2)

- The greatest opportunity is seen in **low-density urban centers (e.g., industrial areas) and suburban and rural areas**; generally **agricultural, commercial, and industrial end-use customers** tend to offer the greatest near-term possibility for market expansion.
- Economic potential estimates are shown to be **highly sensitive to the nuances of retail rate structure and generation.**
- Access to **low-cost financing and reductions in capital costs** stand out as levers that can be used to **increase economic potential**, even as the former are broadly distributed spatially.
- Improvements in costs, siting, and other factors are not equally distributed across counties, for example:
  - Improvements to project siting in Colorado affect potential in suburban counties near Denver and the Eastern Plain
  - Improvements to project siting in New York and Minnesota have a more profound effect on the Residential turbine class and broader impacts throughout the state

This work was authored by Alliance for Sustainable Energy, LLC, the manager and operator of the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Wind Energy Technology Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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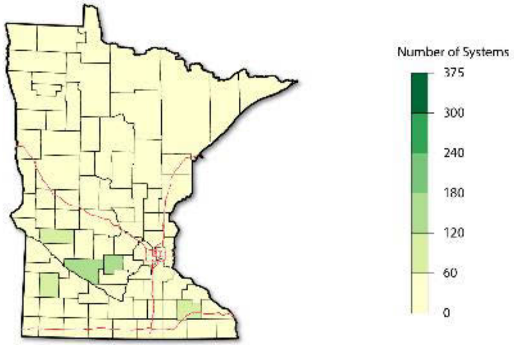
Additional Slides

Results

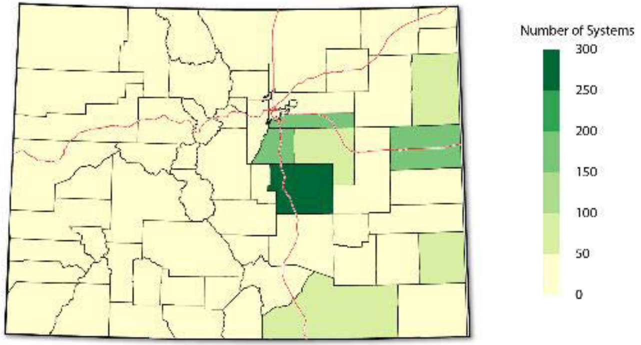
Economic Viability by Turbine Count for Residential Scale Only

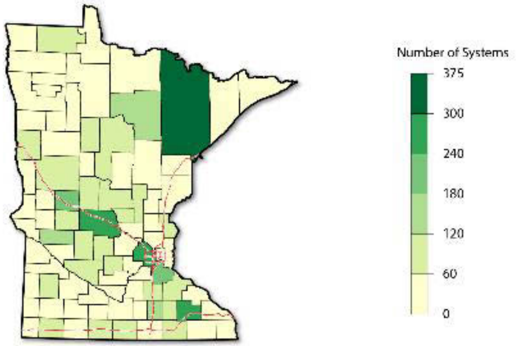


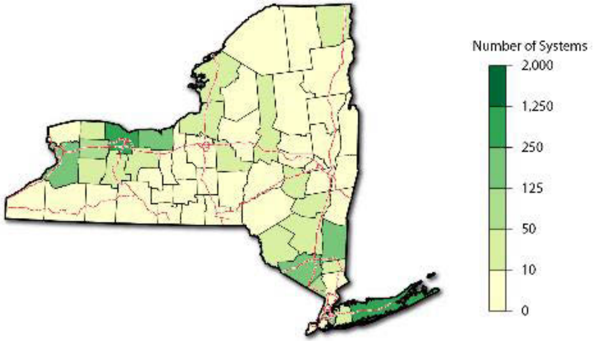
Count of economically viable turbines by county for residential (0-20 kW) scale only

Results

Economic Viability by Turbine Count for Commercial Scale Only



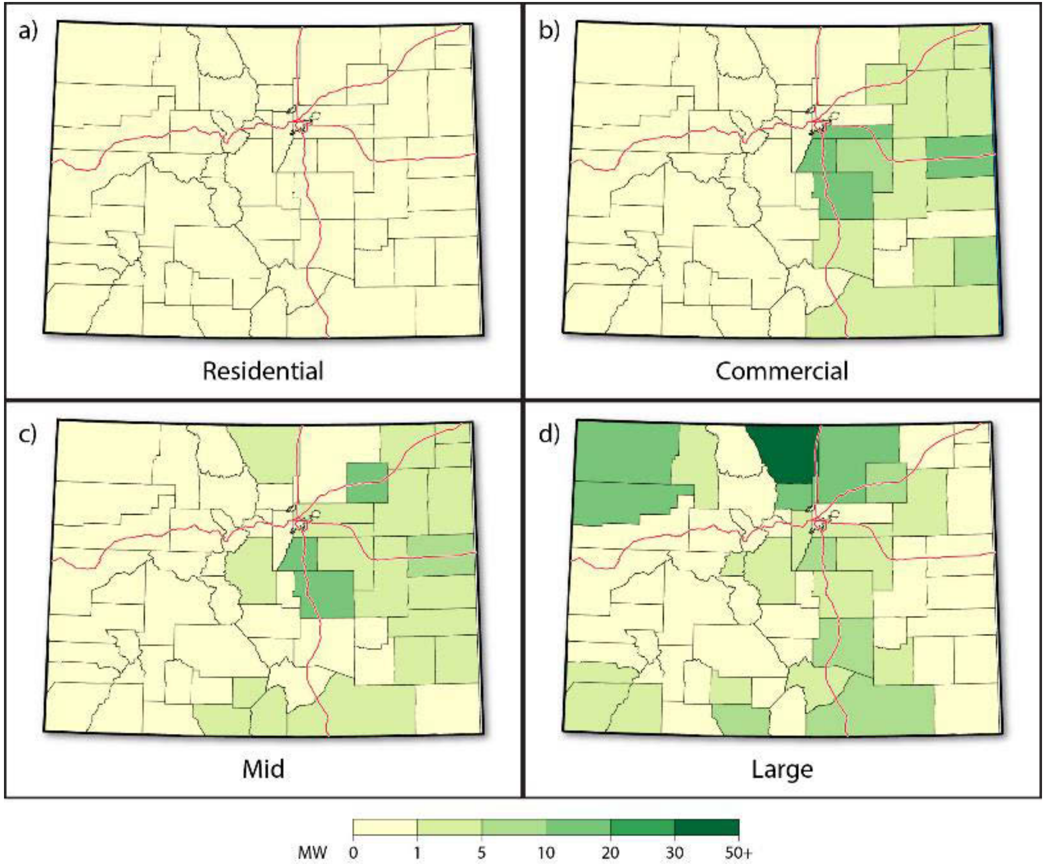




Count of economically viable turbines by county for commercial (21-100 kW) scale only

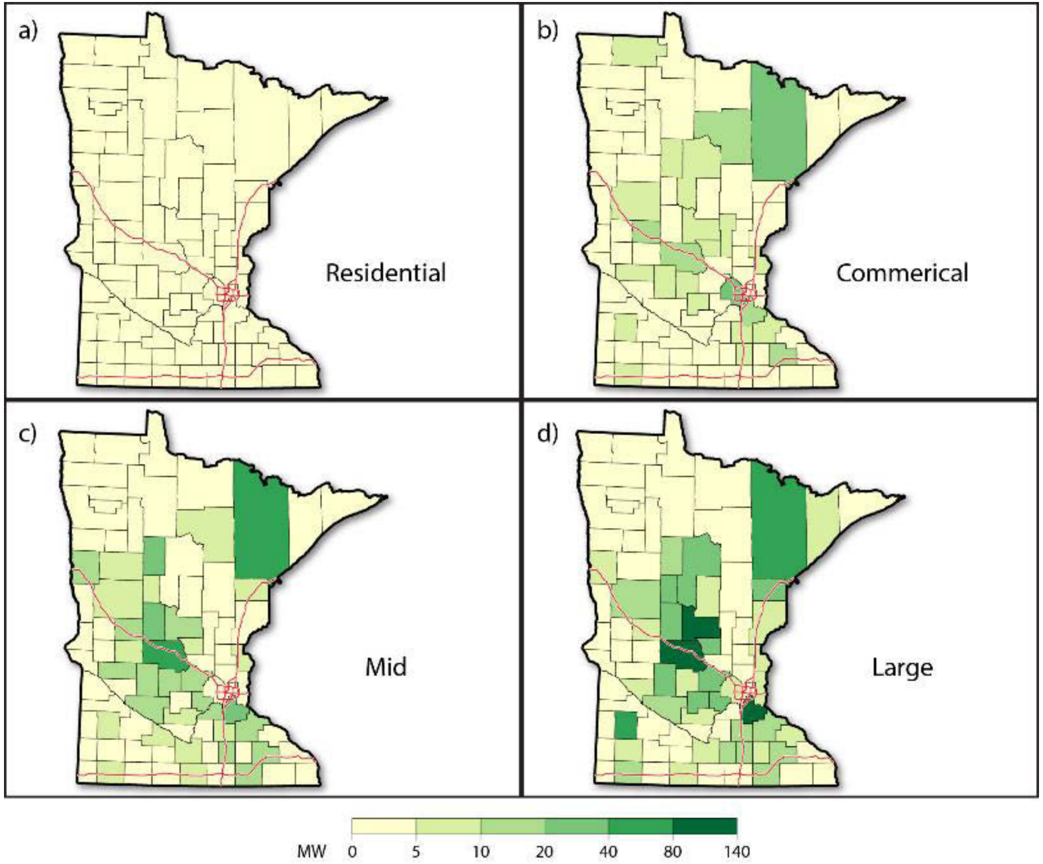
Colorado Results

Economic Potential (MW) by Turbine Class



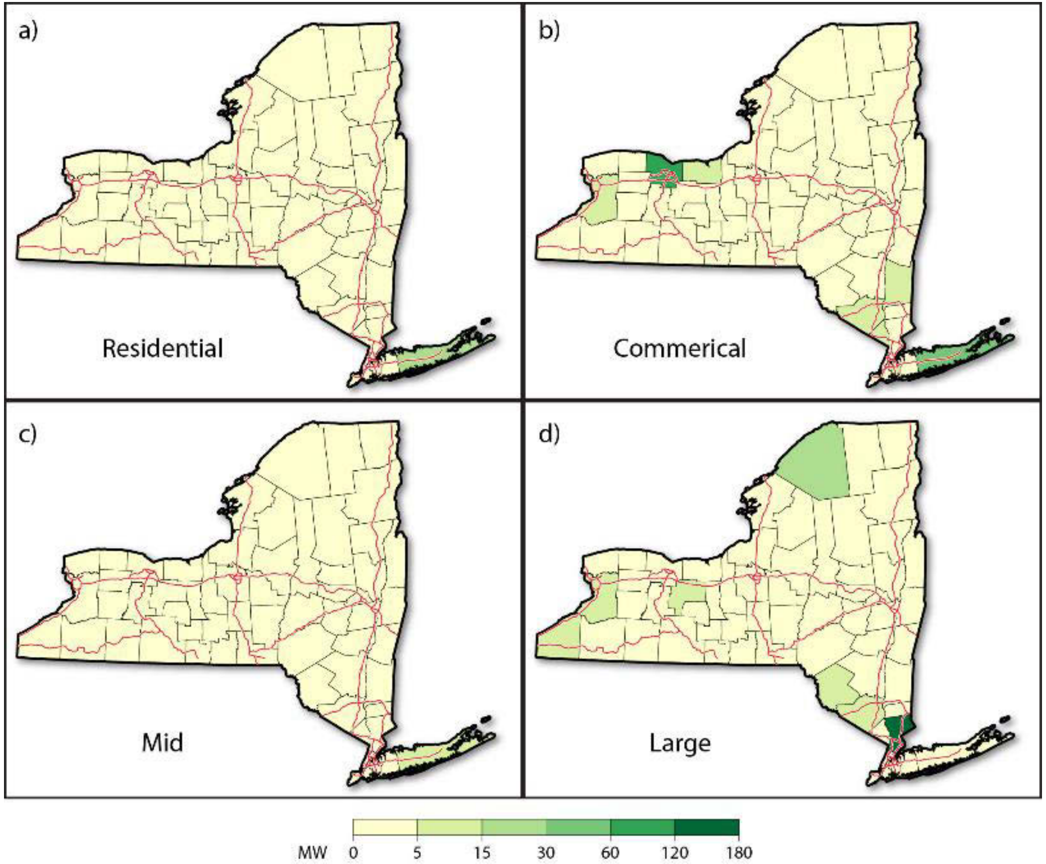
Minnesota Results

Economic Potential (MW) by Turbine Class

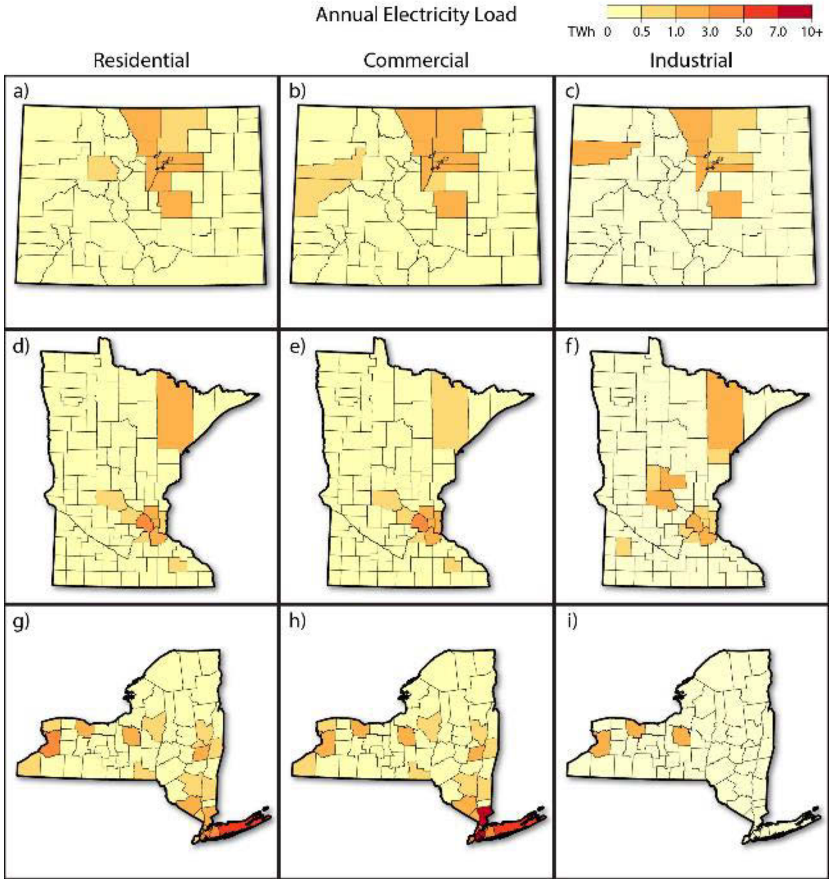


New York Results

Economic Potential (MW) by Turbine Class



Electricity Load by County and End-Use Sector



Additional Conclusions

- This study represents a detailed analysis of the economic potential for distributed wind energy systems by county for Colorado, Minnesota, and New York.
- Unique to this analysis is a thorough consideration of geospatial trends not previously explored in analyses of distributed generation technologies.
- Data layers given considerable attention in the study include:
  - Wind resource quality
  - On-site electrical load
  - Turbine siting availability.
- The intersection of these key variables (along with others such as applicable incentives, net-metering policies, retail rate structures) provide spatial visualizations that stakeholders in the distributed wind space can use to better understand the environment in which the technology could thrive and the challenges to be addressed to bolster its growth.