

# Revealing the Real Onshore Potential: A Socio-Technical Wind Atlas for the U.S.

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## Abstract

For the first time, we have developed a wind atlas to determine the onshore wind power potential of each U.S. state. Previously, Geographical Information System (GIS)-based wind atlases have been developed that include multiple parameters for identifying sites suitable for wind energy development. Such atlases contain data and exclusions for houses, roads, and protected areas. They also include restrictions for sensitive military and political land areas, terrain not suitable for wind power generation, national parks, and nature preserves. However, such atlases have yet to be developed for the U.S. or its individual states. The purpose of this study is to create a wind atlas to calculate the onshore wind power potential of each U.S. state, accounting thoroughly for exclusions. We also develop a GIS portal that can be used by stakeholders in the wind industry to plan future wind project developments and to reduce the uncertainty and risks in the early stage of site hunting. To accomplish these goals, we use Envision Energy's EnScope wind atlas tool. The tool accounts for Wind Resources Restrictions (social, environmental, and technical characteristics that can delay, impede, or stop wind power projects) Regulations (national and regional distance requirements to infrastructure, buildings, and protected areas) Wind Turbine Information (dimensions, footprint, and energy output of a modern onshore wind turbine) With the resulting atlas, we determine the maximum available land for developing wind energy in the U.S., the total wind energy potential in the U.S., and an indication of how that potential compares with what is needed to power the entire U.S. with wind's share of a 100% clean, renewable energy system for all energy purposes in 2050.

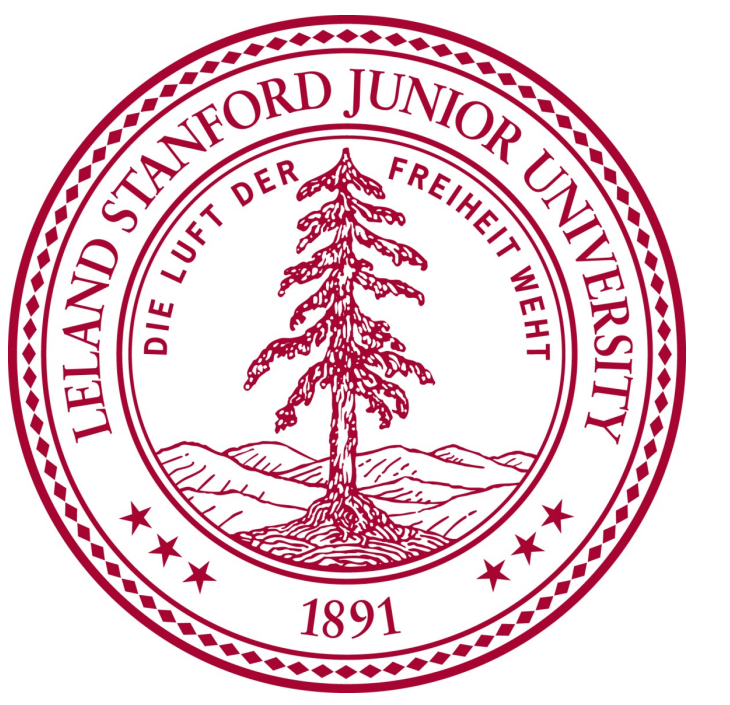
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## Background

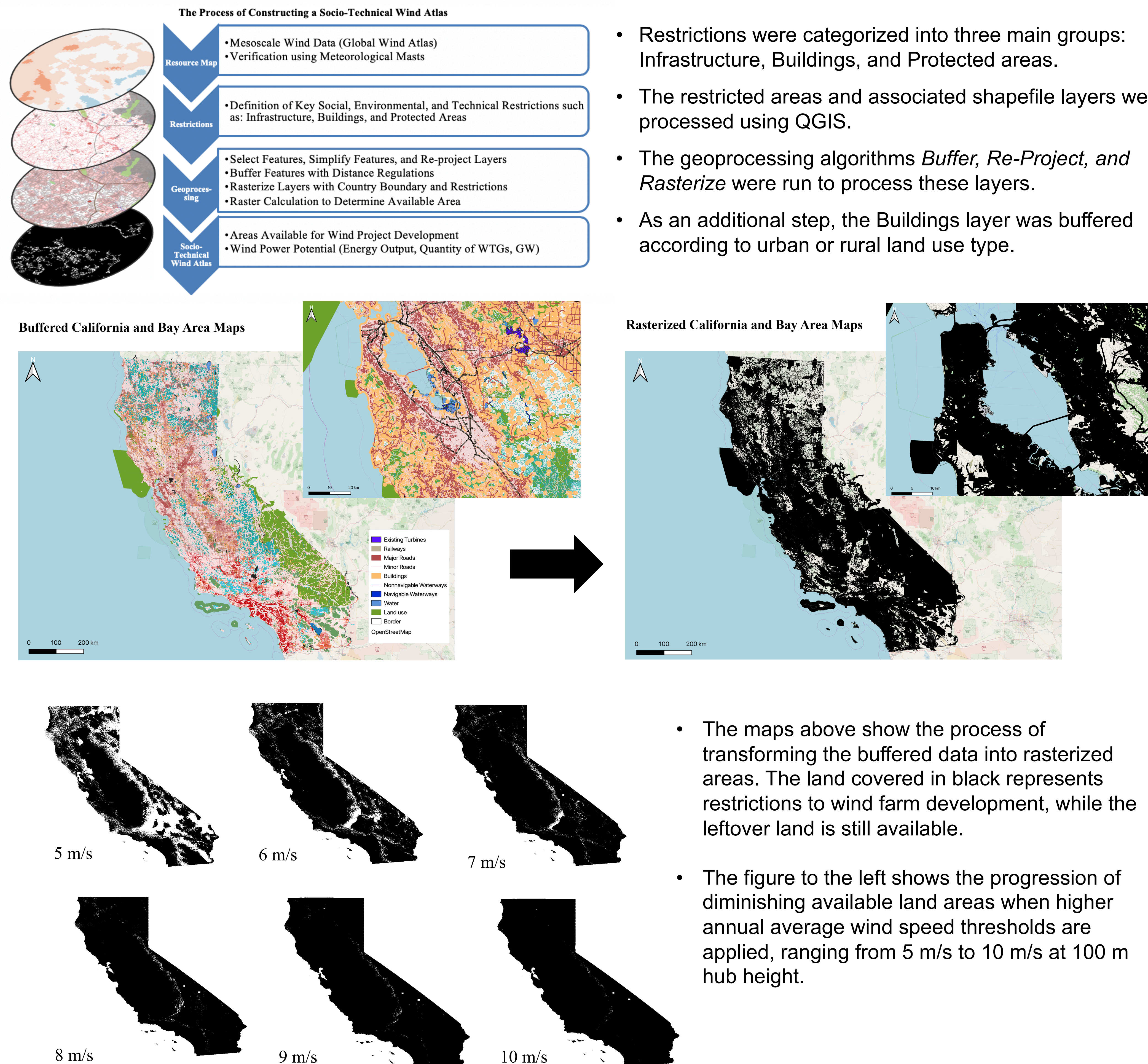
- The continuous development of onshore wind farms is an important feature of the U.S. transition towards an energy system powered by distributed renewables.
- This study simulates each state's potential for future onshore wind turbine installations.
- The study visualizes, via maps, all the national and regional socio-technical restrictions and regulations for wind project development using spatial analysis conducted through GIS.

## Objectives

- The U.S.-wide socio-technical wind atlas is the first of its kind, where the emphasis is on the restrictions and regulations for wind farm deployment, not solely on the wind resource itself.
- The methodological approach and application of open source data allows this study to be replicated for any country, which is why this will be developed into a global planning tool, reducing resources spent for greenfield development, increasing certainty in investment profiles, and assisting in national and international wind project planning.

## Results

## Methods & Process



## Conclusions

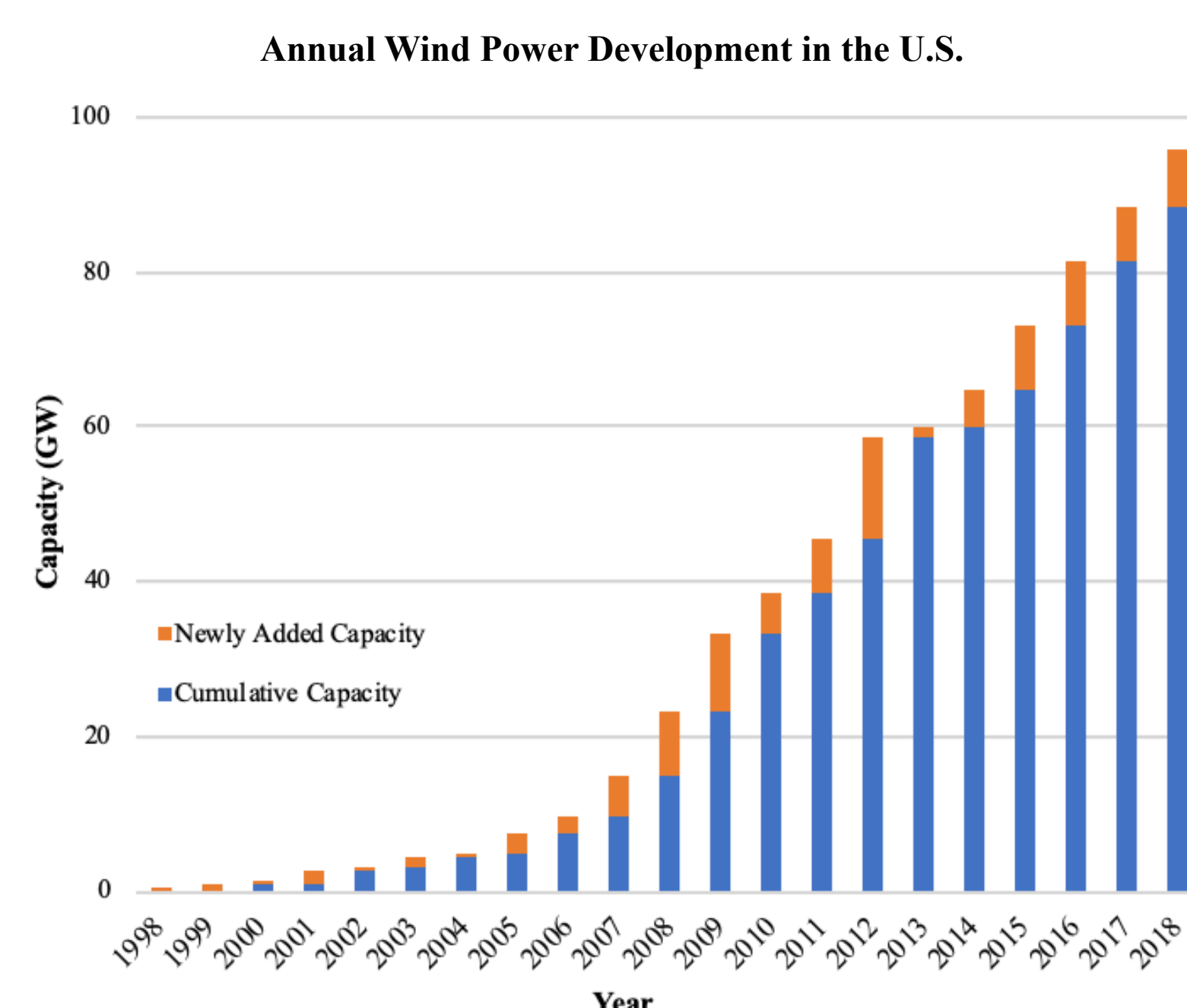
- This study offers a more rigorous, granular, multi-dimensional, and feasible assessment of the vast potential of future onshore wind project development in the U.S.
- This socio-technical wind atlas informs U.S. policymakers on the need for subsidies in states with available areas and low wind speeds, as well as collaboration opportunities and grid integrations.
- The individual high-resolution state maps will furthermore assist with the planning of future renewable energy systems, as states and regions will know where to invest more in wind, along with PV in the case of poor availability for wind project development.
- Examining the wind atlas, it becomes clear that wind turbine manufacturers are forced to innovate on solutions for areas with wind speeds below 6 m/s, as the spacing of such are enormous.

## Next Steps

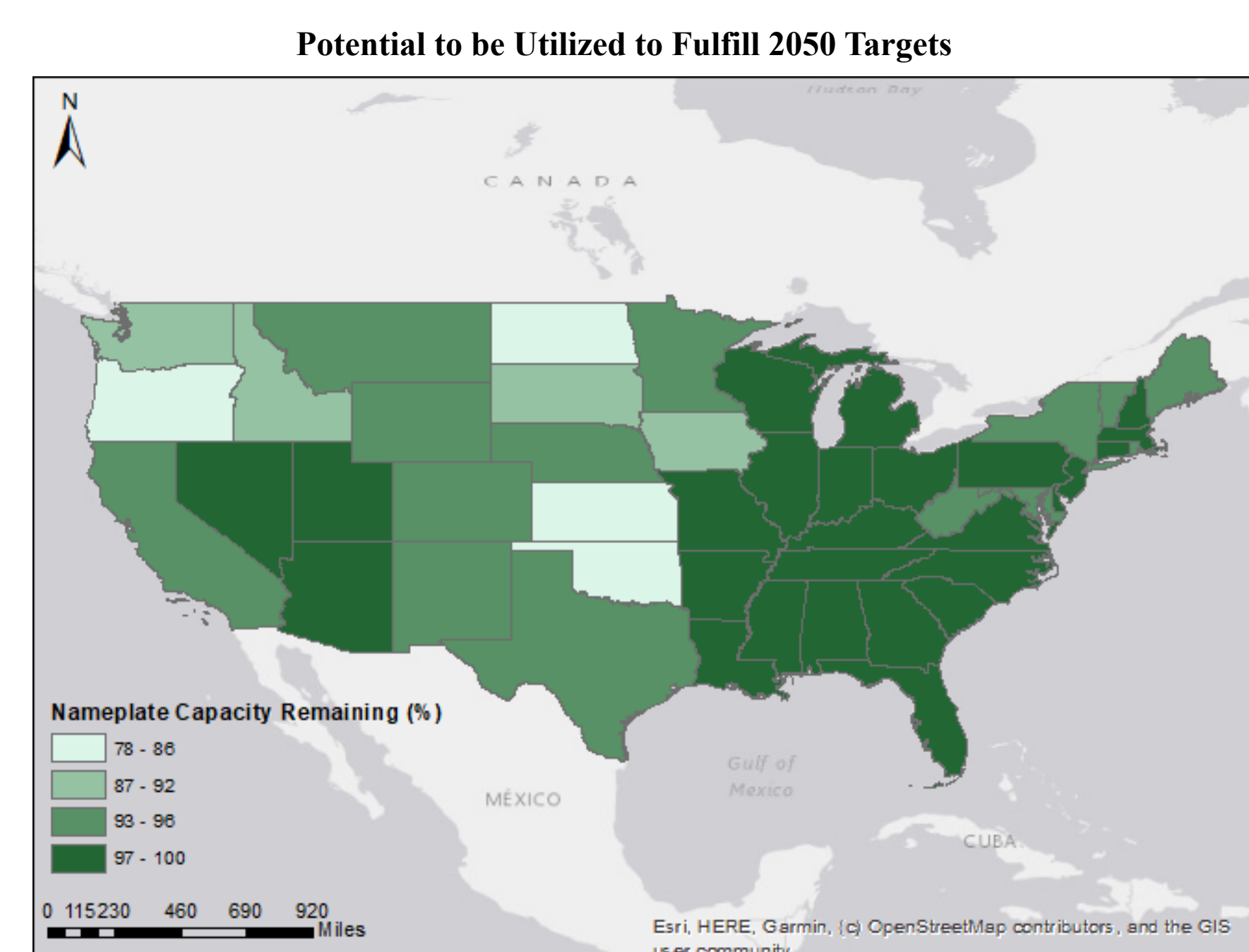
- Using mapped restrictions to quantify the land area leftover for wind farm development.
- Combining infrastructural and natural restrictions with economic wind potential to reveal the potential installed wind capacity.
- Comparing power density potential in different states.
- Conducting a similar analysis for offshore wind.

## References

- Enevoldsen, Peter, et al. "How Much Wind Power Potential Does Europe Have? Examining European Wind Power Potential with an Enhanced Socio-Technical Atlas." *Energy Policy*, vol. 132, Sept. 2019, pp. 1092–1100., doi:10.1016/j.enpol.2019.06.064.
- Jacobson, Mark Z., et al. "100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States." *Energy & Environmental Science*, vol. 8, no. 7, 2015, pp. 2093–2117., doi:10.1039/c5ee01283j.
- OpenStreetMap, Bing Maps, United States Wind Turbine Database, Global Wind Atlas



- The U.S. wind energy industry has experienced tremendous growth in the past decade (309% growth over the past 10 years).
- Repowering of existing capacity with more efficient turbines will reduce the amount of capacity needed to meet electricity demand in a period when total U.S. electricity demand growth is relatively flat.



- The U.S. has sufficient wind energy resources to meet and significantly exceed existing 2050 targets set by previous studies (The Solutions Project).
- The percentage of remaining nameplate capacity that can be installed represents the progress toward wind energy targets alone, ranging from 0.7-70% of total state energy demand.