Do Red States Have a Comparative Advantage in Generating Green Power?

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Abstract

The passage of the 2022 Inflation Reduction Act will lead to a significant increase in US wind and solar power investment. Renewable power generation requires more land than fossil fuel fired power generation. The land that will be allocated to renewables depends on several demand side and supply side factors that include the land's renewable power potential, cost of acquisition, proximity to final power consumers, and local land use regulations. We find that Republican areas issue generation permits faster than progressive areas. We present evidence that rural Republican areas have a cost advantage for generating wind power; however, Democratic areas have sited more solar capacity. We use our statistical model to identify Republican Congressional districts that have the potential to scale up green power production.

I. Introduction

In 2021, the United States generated 21% of its electricity from renewable energy, with 9.2% from wind and 2.8% from solar.[1] To encourage utilities to purchase green power, state governments have ramped up their Renewable Portfolio Standards (RPS). In 2010, the average RPS was 3.16%, and as of 2021, this number has jumped to 10.7%. Such green mandates lead to greater investments in renewable power generation. The US seeks to expand green power supply, especially wind and solar, during a time when electricity demand is likely to rise as more people rely on electricity to power homes and vehicles (Davis, Fuchs, and Gertler 2014; Rapson 2014; Cicala 2022). The passage of the August 2022 Inflation Reduction Act creates a new set of incentives intending to accelerate the decarbonization of the nation's power sector (Bistline, Mehrotra, and Wolfram 2023).

A key challenge to renewable power generation is the land intensity of wind and solar power plants (Van Zalk and Behrens 2018). Based on our own estimates, each MW of utility-scale wind capacity currently takes 55.3 acres of land, and each MW of solar capacity takes 5.97 acres.[2] These are much higher than the land requirements for fossil fuel plants. Renewable power plants also differ from conventional ones in that wind and solar cannot be shipped across space. Green electricity must be generated locally in areas with high renewable potentials. While renewable power generation reduces the global externality of climate change, its spatial concentration in specific areas raises the likelihood of local NIMBYism against renewable project development (Stokes 2016). In 2022, 47 wind projects and 75 solar projects have been blocked by local governments across the US.[3]

As shown by Rappaport and Sachs (2003), the majority of the nation's population and an even larger share of the nation's earnings clusters close to the oceans. The sheer size of the US means that power generation can be sited on millions of other acres of land. Farmland represents

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[1] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

[2] See Section VIII for detailed discussions.
Hydropower is another source of renewable energy, but we do not study it in this paper because hydropower depends much more heavily on local geography than do solar and wind power. Also, most hydropower plants were sited decades ago. Since 2010, only 150 utility-scale hydropower plants have been built nationwide, while 870 utility-scale wind generators and 5028 solar generators have been built.

[3] https://robertbryce.com/renewable-rejection-database/
According to the EGRID data, 74 wind projects and 517 solar projects went online in 2021. This suggests a high block rate for wind projects.

over 900 million acres of land in the US (roughly 40% of the total area).[4] Some of this land could be converted into wind and solar farms if rural area residents do not engage in NIMBYism. Yet, in liberal states with high demand for green power, environmental lawsuits often slow land use projects.[5]

In this paper, we study whether Republican areas have an edge in siting land-intensive wind turbines and solar panels because they have fewer land use regulations, cheaper land, and more natural resources. Based on voting in the 2020 election, 83% of the land area of the United States featured counties whose vote share was over 50% for Donald Trump. In the areas with an above-median wind speed or solar radiation, 87.5% and 82% of the land area was in counties where a majority voted for Trump. Due to these natural advantages, for-profit developers of renewable power plants have an incentive to generate power in Republican areas. Interstate transmission capacity connects dispersed local renewable generators to coastal consumers of power. An example is the 730-mile Anschutz power line (currently under construction) that runs through the American West.[6]

We use a project-level dataset from the Berkeley Electricity Markets & Policy Lab to study the electricity generation permitting process. Generating capacity needs to wait in a queue to receive approval for commercial operation. This process is called interconnection, during which the regional regulators conduct a site study to evaluate the feasibility of the project. Developers can construct power plants only if their projects are approved (see the flowchart in Appendix 1 for details). The dataset we use provides information on 9400 renewable projects that applied for interconnection in the past two decades, including their capacity, status, and queue time. We document that the interconnection process is more streamlined in Red States than Blue States for land-intensive renewable projects.

We then explore the economic geography of the existing renewable capacity using a county panel dataset from years 2010 to 2021. We show that Republican counties feature lower population densities, lower land prices, and higher wind speeds. We also create a measure of each county's green market potential based on its neighboring states' RPS. This market potential grows faster in Republican counties. Consistent with these natural advantages, we find that Red States have

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[4] https://www.nass.usda.gov/Publications/Highlights/2019/2017Census_Farms_Farmland.pdf
[5] https://www.nytimes.com/2022/09/01/business/economy/california-nimbys-housing.html
[6] https://www.latimes.com/environment/story/2022-08-23/wyoming-clean-energy-california

installed more wind capacity. However, Blue states have built more solar farms, possibly due to solar panels' lower land intensity and states' solar incentives. Our results show that both a state's RPS and the RPS levels from neighboring states are correlated with a developer's decision to build wind and solar capacity.

Rural areas tend to elect Republican Congressional Representatives who have opposed past environmental protection legislation (Cragg et al. 2013). The expected windfall from green power generation could change future carbon mitigation politics. The price of local land in places with high renewable power potential is likely to be bid up as renewable power generators raise their bids for local land. This wealth effect for local landowners offers local jurisdictions greater property tax revenue (Kahn 2013). Increases in federal subsidies for green power could be increasingly attractive to rural landowners in places with wind and solar potential. We posit that the economic interests could swing some rural area residents toward accepting renewable energy. Gaining from the rise of green power, residents will lobby their Congressional Representatives to support more renewable energy subsidies (Peltzman 1984). Using our empirical models on the past pattern of renewable capacity deployments, we identify the subset of Red districts that we may be "Red/Green Swing districts."

This paper is organized as follows. In Section II, we introduce our main datasets. In Section III, we provide conceptual reasonings on why Republicans have an edge in generating green power and present graphical evidence. We then list our empirical hypotheses in Section IV. We study the green permitting process in Section V and the economic geography of the existing renewable capacity in Section VI. In Section VII, we identify the Republican congressional districts that may vote in favor of climate subsidies. In the concluding sections, we discuss the future land use of wind and solar power plants and point to the areas for future research.

II. Data

A. Generation permitting dataset

Developers need approval from regulators to construct and connect their generators to the grid (see Appendix 1). To study the generation permitting process, we use a comprehensive project-level dataset on interconnection application provided by the Berkeley Electricity Markets

& Policy Lab.[7] It includes roughly 15,000 utility-scale electricity projects that have applied for grid connection from 2000 to 2020. For each project, the dataset provides the project status (active, completed, or withdrawn), queue time, energy source, capacity, and location. We focus on the 2738 wind projects and the 6665 solar projects.

Based on each project's location, we merge in the respective county's votes for Trump in the 2020 presidential election, median home price, and farmland percentage.[8] Farmland percentage is the proportion of land occupied by farmland in each county. We calculate this using cross-sectional data in 2010 from Burke and Emerick (2016).

The final components of this dataset are the county-level wind and solar potentials. The wind potential refers to the wind speed 100 meters above the surface level, and the solar potential refers to the global horizontal irradiance (GHI). Counties with higher wind speed and higher solar radiance are more suitable for constructing wind and solar generating capacity. These environmental data are from the National Renewable Energy Laboratory (NREL) as GIS files. We overlay these files with county shape files to calculate the averages by county. The average county wind speed in the US is 6.9m/s.[9] The average GHI is 4.48 kWh/m^2/day. On the continental US, Arizona, Nevada, and California ranks top three based on solar potential.

B. Renewable installations dataset by county

To explore the economic geography of the installed green power plants, we compile a county/year dataset including the local wind and solar capacity, sociopolitical attributes, and environmental attributes. We calculate each county's green capacity in each year from 2010 to 2021 using data from the Environmental Protection Agency's EGRID database.[10] The EGRID dataset provides detailed information on each utility-scale electricity generator in the US, including

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[7] https://emp.lbl.gov/publications/queued-characteristics-power-plants
Data is collected from interconnection queues of all seven Regional Transmission Organizations (RTOs) in the US. The coverage areas represent more than 85% of the US electricity load. Alaska and Hawaii are excluded.
[8] We access the voting data from the MIT Election Data Science Lab: https://electionlab.mit.edu/data
We obtain the median home prices data from Zillow for each county in 2010: https://www.zillow.com/research/data/
[9] The minimum speed to power utility-scale wind turbines is 5.8m/s, and the average wind speed of 90.6% of counties meets this standard.
https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php
[10] https://www.epa.gov/egrid/download-data

the year built, energy source, capacity, and location. Using these generator data, we calculate the total wind capacity and total solar capacity by county/year.

We merge each state's RPS by year into our county panel.[11] Another dynamic variable in our county dataset is the annual out-of-state RPS market potential for each county. It is calculated using the formula for the market potential function (Hanson 2005). This variable captures the spatial cluster of nearby aggregate demand for a county's "exports" of green power. The out-of-state RPS potential for county j in year t is given by:

$$MP_{jt} = \sum_{k \in K} RPS_{kt} e^{-d_{jk}},$$ (1)

where K is a set of counties in a different state but with direct electricity transmission lines to county j, and d_{jk} is the distance (in 1000 miles) between county j and county k. This is a distance-weighted RPS from counties in nearby states. In 2021, the average out-of-state RPS market potential per county was 8.41 with a standard deviation of 7.65. Californian has an RPS of 33%. A market potential of 8.41 is roughly equivalent to having an average distance of 100 miles to 28 Californian counties. The RPS potential has a correlation of 0.185 with state RPS. The relatively low correlation indicates that many counties in states with low RPS are located close to states with high RPS.[12]

We merge in a few cross-sectional variables on county demographics and time-invariant environmental attributes. We obtain the county population, population density, and area data from the American Community Survey (ACS).[13] The county-level climate change belief data is provided by the Yale Climate Change Communication program.[14] We also include data on Republican votes, the county's farmland percentage, wind speed, and solar radiation.

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[11] https://emp.lbl.gov/projects/renewables-portfolio/

[12] We acknowledge this measure will overstate the RPS market potential because some states require utilities to purchase renewable electricity from within-state generators to fulfil RPS requirements.
We also create an alternative RPS potential by expanding K in equation (1) to all counties within 800 miles from county j (regardless of the availability of transmission capacity). This measure has a correlation of 0.723 with the one we use in our regressions.

[13] https://www.census.gov/programs-surveys/acs

[14] https://climatecommunication.yale.edu/visualizations-data/ycom-us/
Specifically, we use the percentage of population believing climate change is real in 2021 as the measure of each county's climate belief. This variable has an average value of 65.2%.

C. Congressional districts dataset

Based on the county/year panel, we create a dataset with the same variables by congressional district/year. The unit of analysis is a district in the 118th congress. Our main metric of a district's political affiliation is its congressmen's DW-NOMINATE score.[15] It is a continuous measure of politicians' ideology, where 1 is the most conservative and -1 is the most progressive. If a district has multiple representatives, we average these scores from all representatives. In the 118th congress, the average score of Democratic congressmen is -0.39, and that of Republicans is 0.52. We merge in DW-NOMINATE scores, population, and land area of each district in the 118th congress.

Some congressional districts span across multiple counties. To calculate their sociopolitical and environmental attributes, we weight all county attributes (from the county/year panel) by the area intersection factor to get the averages for each district.[16] The wind and solar capacity are the only exceptions. Instead of using the weighted average, we classify each green generator into a congressional district based on its longitude and latitude. We then calculate the total wind and solar capacity by district/year.

III. Supplying Green Power

A. Land requirements of renewable generation

Land is a key input in renewable power generation. Renewable generators have lower power density (defined as the electricity produced per unit of surface area) than conventional power plants, and solar panels occupy less land per unit of generation than wind turbines (Fthenakis and Kim 2009; Van Zalk and Behrens 2018). While a coal or gas power plant takes less than 1 acre per MW of capacity, our estimates suggest that for utility-scale projects, it currently takes 55 acres per MW of wind capacity and 6 acres per MW of solar capacity. Given the land intensity of renewable projects, especially wind, they have to be sited on large open land such as farmland and in regions with relatively cheap land prices.

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[15] https://voteview.com/data

[16] If 20% of land area of district A is in county i, 50% in county j, and 30% in county k, we weight the county attributes from county I, j, k with 2:5:3 to calculate the district attributes.

B. Local NIMBYism and land use constraints

Unlike fossil fuels, wind and solar power cannot be shipped across geography, which means renewable generators have to concentrate in regions with high local renewable potentials and available land. These areas tend to be in rural counties with a large share of farmland. Under the current technological constraints, most crops cannot be grown under solar panels or within an acre from the base of wind turbines. The opportunity costs of converting farmland into green power plants are the forgone agricultural profits. Local farmers disproportionally bear these costs and have an incentive to oppose renewable developments.[17] Stokes (2016) has found that widely-supported climate policies can fail when their benefits are dispersed but costs are concentrated on local communities. Residents also cite reasons such as declining property values and safety concerns to block local renewable projects (Gross 2020; Susskind et al. 2022).

Such NIMBYism is often bundled with more stringent land use regulations. For example, in California, the Williamson Act (a.k.a. California Land Conservation Act) provides property tax relief to landowners who agree to keep their land in agricultural or open space use. The act allows local governments to penalize landowners who convert land subject to Williamson Act contracts to non-agricultural uses, which is a significant disincentive for those who may be considering leasing or selling their land for renewable energy development.[18] Local regulations deter renewable developers from entering the market (Djankov et al. 2002; Mulligan and Shleifer 2005).

Despite a high RPS, expensive land and strict zoning codes could disincentivize profit-maximizing developers from building land-intensive renewable capacity in liberal states like California (Carley 2009). If transmission capacity is available, neighboring states such as Nevada and Utah may have an edge in generating green power and exporting it to California.[19] These states have cheaper land, fewer constraints on land use, and promising sun and wind potentials. However,

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[17] https://www.latimes.com/opinion/op-ed/la-oe-bryce-backlash-against-wind-energy-20170227-story.html
https://www.wsj.com/articles/solar-rollout-rouses-resistance-in-europes-countryside-11665234001
[18] https://www.sandiegocounty.gov/content/dam/sdc/pds/ceqa/Soitec-Documents/Final-EIR-Files/references/rtcref/ch2.5/2014-12-19_DOCSolarWhitePaper31111.pdf
[19] We acknowledge that interstate transmission is not always available, but in the case of California, there are several transmission lines connecting it to neighboring states.

the attempts to add transmission lines have also been met with political backlash when the lines just pass through the area without financially benefiting the residents (Gross 2020).

C. The spatial distribution of the existing green generators

In 2010, there were 38,783 MW of wind capacity and 582.4 MW of solar capacity in the US. These numbers have jumped to 133,408 MW and 61,683 MW respectively in 2021.[20] In this section, we present graphical evidence on the regional heterogeneity in wind and solar capacity deployment. Figure 1 shows the distribution of wind and solar capacity across congressional districts in 2021.

Districts with more conservative representatives (as measured by a higher DW-NOMINATE score (see Poole and Rosenthal 2001) are over-represented among wind generators. Many wind farms have been built in Texas and in the Mid-western states. By 2021, Texas had almost 35,000 MW of wind capacity, and the Midwest had over 52,000 MW. They jointly accounted for roughly two-thirds of the wind capacity in the US. Wind generators have been disproportionally built in Republican districts because these districts often feature high wind speed, low land prices, and fewer land use regulations such as zoning and limitations on the turbine height. These are favorable attributes that incentivize wind developers to enter the market, given that wind turbines are land intensive.

The deployment of solar capacity exhibits a different pattern. Solar farms are disproportionally located along the coastline. California had built 16,000 MW of solar capacity by 2021, roughly one-fourth of the national total. Texas, North Carolina, Nevada, Georgia, and Florida also rank high in solar capacity. Coastline states feature high daily solar radiation but tend to have high land prices. Solar farms occupy less space than wind facilities, and distributed solar panels can be installed on rooftops. Since solar farms use less land, solar developers are less responsive to the price of land per acre. The coastal liberal states face lower costs of building in solar capacity than wind capacity, so they ramp up solar to meet their ambitious RPS goals.

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[20] These only include projects in the EIA dataset, which are utility-scale projects with at least 5MW of capacity. In 2021, there was 3.9GW of residential solar capacity. By the data from NREL, approximately 3GW of community solar has been installed. As of now, utility-scale solar still accounts for more than 90% of the total solar capacity in the US.

In Figure 2, we create nonparametric plots of the total generating capacity and green power capacity per square mile with respect to the share of Republican votes in a county in the 2020 Presidential Election. An interesting pattern is that the total capacity density has a negative slope, but the green capacity density has an overall positive slope. Before the rapid development of renewable generations, due to losses of electricity during transmission, power plants locate closer to densely populated cities, which are often governed by Democrats.[21] The capacity density has been lower in Republican counties, where there are fewer people and lower electricity demand. This explains the negative slope of the capacity density curve in Figure 2(a).

However, green generators are more land-intensive than conventional coal or gas plants, and land prices in urban areas are high. Despite the higher power demand in cities, renewable power developers may be willing to site their generators farther from cities and bear more line losses because of the significantly lower land prices in rural areas. This could explain why we observe that green power capacity per square mile rises in counties with more Republican votes in Figure 2(b).

The renewable power capacity density drops when Republican votes go above 70%. There could be the local backlash against clean energy in highly conservative areas. When we disaggregate the density down into wind and solar respectively, the wind density has a positive slope until Republican votes reach 70%, whereas the solar curve has a negative slope. These results are consistent with Figure 1. Democrat areas have built in more solar panels but fewer wind turbines. These descriptive figures form the basis for our statistical analysis in the next sections.

IV. Empirical Hypotheses

In this section, we present our empirical hypotheses focused on the economic geography determinants of renewable power generation. We divide our hypotheses into the permit time, the site selection for projects, and the political implications of the growth of the green economy.

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[21] https://www.eia.gov/tools/faqs/faq.php?id=105&t=3
According to the EIA estimates, power losses average about 5% in the transmission and the distribution process. In long-distance transmissions, the losses are 8% to 14%.

Hypothesis I: Republican areas approve more green power projects and approve them faster than Democrat leaning areas.

A rising share of renewable electricity is produced by non-utility generators, who sell their power to local utilities in the electricity wholesale market.[22] To become commercially operable, these generators must receive approval from inspectors for interconnection to the grid. Congestion in interconnection queue is slowing down the nation's transition to renewable generation. As of 2021, more than 1000 GW of wind and solar generating capacity were waiting for interconnection access.[23] The completion rate of green projects has been low. Developers tend to withdraw their applications due to the unforeseen interconnection costs and the unpredictably long waiting time (Seel et al. 2023). Republican areas are more pro-business and have less stringent land use regulations (Holmes 1998). The lower level of "red tape" in Republican states gives them an edge in avoiding the land use uncertainty associated with NIMBYism in liberal states (Djankov et al. 2002; Mulligan and Shleifer 2005; Kahn 2011; Gyourko, Hartley, and Krimmel 2021). We thus hypothesize that the project withdrawal rate is lower in Red counties as they grant permissions faster.

Hypothesis II: Wind and solar power plants are more likely to locate and scale up in areas featuring lax land use regulations, cheap land prices, high wind and solar potential, and proximity to areas with ambitious RPS standards.

Consider a profit maximizing green power generator who must choose a single location with the United States for a contiguous set of solar panels or wind turbines. The firm is a price taker in the land market and the capital market. It must jointly choose a location and how many acres to "farm" for green power. The firm's cost of production is an increasing function of local NIMBYism, land prices, and the transmission distance to final consumers. It is a decreasing function of wind speed or solar radiation. Each unit of capacity can produce more power in regions with higher wind/solar potentials. The demand for renewable electricity is higher in urban areas with a high RPS. The firm will seek out a location to minimize its production cost while

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[22] https://www.c2es.org/content/renewable-energy/
[23] https://www.energy.gov/eere/analysis/queued-characteristics-power-plants-seeking-transmission-interconnection-end-2021

maximizing the demand for its product. The favorable factors listed above are more likely to exist in Red states. Our empirical work uses revealed preference methods to study the correlates of observed profit maximizing choices.

Hypothesis III: Renewable power subsidies provide an incentive for elected officials from rural Republican areas to cooperate with Democrats on enacting climate change mitigation legislation.

Previous studies have found that Republicans tend to support renewable energy due to financial benefits instead of concerns for climate change (Gustafson et al. 2020). Prior to the infrastructure packages that subsidize renewable developments, Republican representatives have consistently vote against carbon-pricing policies (Cragg et al. 2013). We hypothesize that rural Republican areas with high green power generation potential may become a new source of votes for green economy legislation going forward. Such votes would be due to economic and political interests (Peltzman 1984; Aklin and Urpelainen 2013). We identify the Republican districts with the highest propensity to vote in favor of renewable energy bills.

Together, these trace out the local dynamics of green power generation. We study the extensive margin (Hypotheses I and II), the intensive margin (Hypothesis II), and the political economy factors (Hypothesis III). We use datasets A, B, and C (see Section II) to test these three hypotheses respectively.

V. Understanding the Correlates of Permit Approval Times for Green Power Generation

In this section, we study the entry barriers in producing green power using interconnection data from the Berkeley Electricity Markets and Policy Lab. By the end of 2020, there were 4375 utility-scale wind and solar projects in the interconnection queue, 690 completed projects, and 4338 withdrawn projects. The high withdrawal rate of wind and solar projects is due to the uncertainties in interconnection costs and the unpredictable waiting time in the queue (Seel et al. 2023). We define the waiting time as the time since a project entered the queue (if it is still active). For completed projects, waiting time refers to the time it took from entering the queue to becoming

commercially operable.[24] Based on the completed renewable projects from 2000 to 2020, the median waiting time was 1563 days (4.28 years), and the 25th percentile was 875 days (2.4 years). We test whether local land use regulations are less stringent in Republican areas based on project withdrawal rates and the waiting time (Hypothesis I). We estimate the following linear probability model for a project i in the year 2020:

$$Y_i = \beta_0 + \beta_1 Votes\ for\ Republican + \beta_2'X_i + \delta_d + \varepsilon_i \tag{2}$$

In equation (2), Y is a withdrawn dummy or a waiting time dummy. The withdrawn dummy equals 1 if the project had withdrawn by December 31, 2020. This specification is estimate on all projects. The queue time dummy indicates whether the queue time exceeds a given time, which we set to two years when reporting results in Table 1.[25] This specification is estimated only on completed and active projects. The coefficient of interest is β_1. Votes for Republican refer to the percentage votes for Trump in the 2020 election in the project's county. We control for a vector of project attributes X, including its capacity, application year, farmland area percentage, home prices, and wind/solar potential in the county. The farmland variable captures the potential local reaction against renewables due to land conversions. We include census division fixed effects (δ_d). We estimate equation (2) using both the withdrawn dummy and the waiting time dummy separately for each energy source: wind, solar, and gas. If Republican areas approve electricity projects faster due to their lax land use regulations, we expect similar but numerically smaller results on gas projects because they are less land-intensive, especially in comparison to wind.

The results are shown in Table 1, where the dependent variable is the withdrawn dummy in odd columns and queue time dummy in even columns. We study wind and solar projects in the first four columns. In column (3), we find evidence that larger-scale solar projects are less likely to withdraw. This is due to the higher returns to waiting as larger projects generate more revenues and could benefit from the scale economies. The coefficient on project capacity is positive and statistically significant in column (4). This indicates that larger projects (if not withdrawn) need to

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[24] This is the time to secure an interconnection agreement plus the construction time. We include construction time because this is more policy-relevant because developers care about the entire duration from entering the queue to being able to commercially operate the project. See Appendix 1 for the flowchart of interconnection.

[25] We estimate the same specifications (dependent variable: I(wait>T years)) with T=1,3,4,5. Votes for Republican have a negative coefficient in all wind columns and is significant when T=4 and 5, but the coefficient is positive in solar columns and significant when T=5.

wait longer in the interconnection queue, as measured by the probability of waiting for more than two years.

In columns (1) to (3), the coefficient on Republican votes is negative and statistically significant. If a wind project is in a county whose Republican votes are 10% higher, the probability of waiting for at least two years decreases by 2.46%, and that of withdrawing drops by 2.52%. For solar projects, its withdrawal rate declines by 3% in a county with 10 percentage points higher Republican vote share, but we do not find statistically significant evidence that solar projects wait longer to be approved in liberal counties. This is likely a result of Blue states' supportive policy of solar installation and the relatively less land taken up by each solar panel. [26]   Solar panels are also less visible from far away than wind turbines and thus create less local NIMBYism.

The coefficient on the farmland percentage is positive and statistically significant in columns (1) and (3). In areas with more farmland, wind projects and solar projects tend to withdraw. Farmers have an incentive to block renewable projects because power plants could replace farmland and reduce crop yields. We also find that the withdrawal rate of wind projects is higher in counties with higher home prices. Given the land intensity of wind turbines, the cost of operating wind power plants is high in these regions. Column (1) also shows that wind projects are less likely to drop off the queue if the local wind speed is faster. Each unit of capacity can generate more power with a faster wind speed.

In our sample, there are 2773 active or completed projects in Blue districts and 2114 in Red districts. When the sample is limited to projects applying after 2015, the number is 2155 and 1939 respectively in Blue and Red districts. The proportions are similar when broken down to wind and solar projects respectively. Since the number of green projects seeking interconnection is not significantly higher in liberal districts, the longer queue time could not entirely be due to a project permitting congestion effect. By controlling for the application year, we rule out the possibility that projects in Blue districts have waited for longer because they applied earlier, when

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[26] Holmes (1998) documents that state policies have a significant effect on the location of manufacturers. Using a border pairs county panel sample, we test for differences in green power generation among pairs of counties where one county is in a liberal state and the adjacent county is located in a Right to Work state. We find that solar generators are more likely to be sited in the liberal county. There is no statistically significant evidence that the amount of wind capacity varies across the border. See Appendix 4 for a detailed discussion.

the interconnection process was under experimentation and featured longer waiting time.[27] These results suggest that the longer interconnection time in Blue districts arise from other local attributes such as the stringency of land use regulations (Kahn 2011; Gyourko, Hartley, and Krimmel 2021). Red districts have an advantage in producing green power because it is less costly for renewable generators to acquire land there.[28]

In columns (5) and (6), we test whether Republican areas are faster in approving gas projects as well. Based on the completed gas projects, the 25th percentile queue time is 477 days (1.31 years), and the median is 995 days (2.73 years). We find that gas projects in Republican areas are more likely to be approved within two years. The magnitude of the coefficient on Republican votes is smaller in column (6) than in column (2). This is expected as gas plants take up less land than wind turbines, which again suggests that Republican states feature less "red tape" and are thus favorable to installing land-intensive projects.

VI. Green Power Plant Site Selection and Power Generation

In the previous section, we have shown that electricity generation projects in Republican areas benefit from looser regulations. We now study the natural advantages of Republican counties. Using our panel dataset, we test whether Republican areas have lower population density, cheaper land prices, higher wind and solar potential, and higher RPS market potential than progressive areas. We estimate the following specifications for county i in state s (and year t if applicable):

$$Y_i = \beta_0 + \beta_1 Votes\ for\ Republican_i + \delta_s + \varepsilon_i \qquad (3a)$$

$$Y_{it} = \beta_0 + \beta_1' Votes\ for\ Republican_i * Year\ 2021_t + \varepsilon_{it} \qquad (3b)$$

In equation (3a), we estimate cross-sectional regressions on dependent variables including home prices in 2010, population density in 2020, wind speed, and solar radiation. We control for state

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[27] Based on all completed projects, wind projects proposed after 2010 are approved 27.3% faster than those prior to 2010, and solar projects are approved 20.2% faster.

[28] Developers do not know in advance the cost of development until local regulators conduct interconnection studies. If the application cost is low, they may have an incentive to submit multiple requests in a region as a form of price discovery, with the intent to only build one. One caveat is that we assume each developer only sends in a single request so that the project-level data is independent from each other. We will overestimate the negative effect of land use regulations on green permits if the higher withdrawal rate and the longer waiting time in progressive states are due to each developer sending in more requests.

fixed effects (δ_s) in this equation. In equation (3b), Y is a county/year variable and refers to state RPS or RPS market potential in neighboring states. To construct a state's RPS market potential, we use the formula given in equation (1). We estimate this equation on data in the year 2010 and 2021. We include Republican votes, the year 2021 dummy, and their interaction term to test whether RPS and RPS market potential grow faster in Red states. The standard errors are clustered by county. We weight all regressions by county area because larger counties have the potential to install more power plants.

The estimation results are reported in Table 2. We find that Republican areas feature a lower population density, a higher wind speed, and lower land prices. These are favorable conditions for land-intensive renewable power plants. These coefficients have similar significance levels and larger magnitudes when we do not include state fixed effects (not shown). We find no evidence that the solar radiation is higher in Red counties.

In the last two columns, we study how RPS and RPS market potential change over time. States such as Nevada and Utah are physically close to the nation's major green state (California). They could have a low RPS but a high RPS market potential. Compared to other state with a low RPS, they have a cost edge in generating green power, given the transmission costs of electricity and the line losses over long distances. In columns (5) and (6), we estimate a negative association between a state's RPS and its share of Republican voters, and RPS in liberal states rise faster. Yet, the growth rate of the market potential is higher in Republican areas, as indicated by the positive coefficient of the interaction term. A t-test on the coefficient of Republican votes and the interaction shows that Republican counties had significantly higher RPS potential in 2021.

Based on these findings on local attributes, we study the county level determinants of whether a given county has at least one green generator producing in a county and the total scale of production in that county. We study the association between these variables and county characteristics including political voting, RPS, market potential, land price, and natural environmental attributes (see Hypothesis II). Using our full panel data, we estimate the following specification for county i (in state k) in year t, for wind and solar respectively:

$$Y_{it} = \beta_0 + \beta_1 Trend_t * Republican_i + \beta_2 Republican_i + \beta_3' X_{it} + \delta_k + \gamma_t + \varepsilon_{it}. \quad (4)$$

In equation (4), Y is a dummy indicating whether a county has any wind or solar capacity in year t in the extensive margin columns. In the intensive margin columns, it refers to the logged

capacity or the share of total capacity that is wind or solar. X is a vector of county attributes, and the only time-variant variables in this vector are RPS and the RPS market potential (calculated using equation (1)). We include state fixed effects (δ_k) and year fixed effects (γ_t). State fixed effects control for each state's time-invariant environmental policies. Standard errors are clustered by state/year. The estimation results are shown in Table 3. The extensive margin estimations are reported in columns (1) and (4), and the intensive margin estimations are in columns (2), (3), (5), and (6).

Republican votes are significantly positive in all columns. In the baseline year 2010, Republicans had built in more wind and solar capacity, both on the extensive and intensive margins. Compared with recent years, environmental policies varied less across states before 2010.[29] We interpret this as the "business-as-usual" scenario in the absence of solar incentives. In this case, developers would locate land-intensive renewable power plants in counties that minimize the costs, which tend to be governed by Republicans.

The interaction term between Republican votes and the time trend is positive for wind but negative for solar. Over time, the gap in wind capacity keeps widening. Republicans have scaled up wind power plants, although they were not more likely to install wind turbines in new locations than Democrats. In counties with 10% more Republican votes, wind capacity increases 0.54% and 0.16% faster in columns (2) and (3) respectively. Yet, Democratic counties are taking over Republicans in producing solar power. A t-test of joint significance shows that Democratic areas featured significantly more solar capacity in the year 2021. A 10% increase in Republican votes is associated with a 2.3% and 0.1% slowdown in solar installations, as benchmarked by total solar capacity and the solar share respectively. These are consistent with the graphical evidence in Figures 1 and 2. Solar capacity is disproportionally installed in liberal counties as these counties provide more financial incentives[30] and the land intensity of solar panels is trending down (Van Zalk and Behrens 2018). Financial incentives reduce the cost of installing solar capacity in liberal states and thus attract more developers despite stricter land use regulations and higher land prices.

We find some evidence supporting Hypothesis II. Both wind and solar capacity tends to locate in areas with lower land prices and larger land areas, given its land-intensive nature. The

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[29] See Appendix 4 for detailed discussions.
[30] https://www.forbes.com/home-improvement/solar/solar-tax-credit-by-state/
This is also consistent with our analysis in Appendix 4.

magnitudes of the land prices' coefficients are larger in wind columns than in solar columns. Because wind turbines take up more space, investors' decisions are more responsive to land prices. Cheaper land prices give Republicans an edge in generating wind power. We also find that wind speed is significant in determining the extensive but not the intensive margin of wind capacity, and solar radiation raises developers' probability of installing and scaling up solar panels.

We interpret the climate belief variable and the county's population as proxies for the demand of green power. In counties with more climate believers, they are more likely to install wind turbines and scale up wind turbines and solar turbines. One possible reason is that residents in pro-climate areas voluntarily sacrifice some amenities to let developers install green power plants (Kotchen and Moore 2008). Population has positive coefficients in columns (1), (2), (4), (5) but negative coefficients when the dependent variable is the share of total capacity from wind/solar. More densely populated areas tend to have a larger share of brown capacity because electricity demand in these areas is more likely to exceed base load, which is increasingly met by renewable generation. Given this likelihood, populated areas have kept more fossil fuel capacity to fulfil the marginal demand during peak hours (Holland et al. 2022).

The coefficients of lagged RPS are significantly positive only in columns (4) and (5). Because we control for state fixed effects, the variations in RPS mainly come from liberal states that have increased RPS rapidly in recent years. As explained previously, these areas are more favorable for solar generation, so they install solar panels instead of wind turbines to meet the RPS goals. In columns (3) and (6), there is no evidence that RPS raises the share of renewable capacity. This result is consistent with the findings from Carley (2009). RPS market potential is significantly positive in columns (1) and (3). This supports our hypothesis that wind power may be generated in rural Republican areas and shipped to nearby liberal cities where demand for green electricity is higher. It is significantly negative in solar columns, which could be due to the limited variations of the market potential within states. When we exclude state fixed effect. RPS potential is significantly positive in columns (1) to (3) and insignificant in columns (4) to (6).[31]

VII. Could Rising Green Power Demand Affect Congressional Carbon Mitigation Politics?

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[31] As a robustness check, we estimate the models without California, Texas, or both. The coefficients have similar numerical values and significance levels as in Table 3.

Although no Republican members of Congress voted in favor of the August 2022 Inflation Reduction Act, this bill's emphasis on expanding renewable energy subsidies raises a new possibility. Republican representatives have revealed a strong antipathy towards carbon taxes, but many rural Republican representatives may support green subsidies if their districts gain financially from the growth of the green economy (Cragg et al. 2013; Gustafson et al. 2020).

For decades rural areas have been centers of energy and resource extraction. There is an extensive literature studying the effects of local energy booms on the labor market. Margo (1997) documents that wages rose significantly in California during the Gold Rush in the 19th century, and this has left the wages in California permanently higher. In contrast, using data from the pipeline construction in Alaska in the 1970s, Carrington (1996) find the local wage increase to be temporary. Studies on fracking also show the gas and oil extraction creates job opportunities, though at the expense of local amenities (Feyrer, Mansur, and Sacerdote 2017; Bartik et al. 2019).

A growing literature studies the effect of renewable energy on the local economy and politics. It remains an open question whether the areas that welcome green power production will experience a local economic boom. Brown et al. (2012) document an increase in local income and employment following the deployments of wind turbines. Lehr, Lutz, and Edler (2012) have found similar results in Germany. Once installed, these wind and solar farms create tax revenues that may be used to fund public projects to improve local quality of life (Kahn 2013). These investments have positive spillover effects on neighboring counties. However, once power plants have been built, most of the jobs are for maintenance. Jacobson, LaLonde, and Sullivan (1993) and Hanson (2023) document that the shutdown of coal plants negatively affects the local economy, as benchmarked by earnings and job counts. In some regions, renewable power plants have triggered electoral backlashes against governors responsible for these new installations (Stokes 2016). The logic from Peltzman (1984) suggests that local homeowners are more likely to support renewable plants if the green subsidies compensate them financially. We examine Hypothesis III in this section.

Figure 3 shows the trend of renewable capacity deployment from 2010 to 2021 in Blue versus Red states. We normalize each category of capacity by dividing it by the total green capacity in 2010 (roughly 40,000MW). From 2010 to 2021, the total green capacity has increased by a factor of five. Wind farms in Republican areas made up most of the renewable capacity in 2010

and still accounted for almost half of it by 2021. The figure also shows that the total wind capacity in Republican states is diverging from that in Democratic states, as we have documented that Republican states have an advantage in generating wind power. Solar farms contribute to approximately 30% of the total green capacity today. Although Blue states have more supportive policies toward solar installation, the difference in total solar capacity is relatively small between Blue and Red states.

Green subsidies will disproportionally benefit rural areas that have installed or will install large-scale renewable capacity. One concern is that Republicans might have saturated their cheap land with high wind speed or solar radiation. In Figure 4, using the sample of Republican districts, we calculate the average wind/solar potentials and the average land prices of the locations of renewable capacity each year. There is no evidence that new projects are built in places with lower potentials or higher land prices. This implies that diminishing returns have not kicked in. Green developers still have good land to choose from Republican districts, or they can expand the existing capacity.

There is plenty of open land in the American South and the West suitable to renewable developments. Figure 5 shows the renewable potential and the DW-NOMINATE scores of representatives from these districts. A score closer to 1 indicates the representative is more conservative. The size of the circles is proportional to the district's area. All four figures show that Republican districts have larger land areas. In the South, Republican districts tend to have higher wind speed and solar radiation than Democratic districts. In the West, liberal districts have more solar radiation on average, but there are a few large Republican districts with high wind and solar potentials such as the second district of New Mexico and the fourth district of Arizona. These are broadly consistent with the results on the natural advantages in Table 2.

Political science research emphasizes members of Congress seek to attract investment in their districts and lock in their policy preferences to insure against potential challengers (Aklin and Urpelainen 2013). The low carbon transition raises the possibility that Republican districts with green power potential can get larger subsidies in the future. When voters benefit financially from these subsidies, they are more likely to reelect the incumbent rather than an alternative candidate who is hostile to climate policies (Peltzman 1984). Republican congressmen thus have an incentive

to support green legislations if they perceive economic gains from doing so. In this section, we present some suggestive analysis that identifies this subset of Republican districts.

We identify the swing Republican districts using the representatives' DW-NOMINATE scores from the 118th congress and rank them using our model specified in column (2) of Table 3. We define swing districts as the Republican districts where the DW-NOMINATE score is at the lowest 10th percentile (i.e. below 0.33). We estimate the same linear model of the time trend, sociodemographic variables, and environmental attributes (see column (2) of Table 3 for the full variable list) using the district/year panel. The only exception is that we include region fixed effects instead of state fixed effects to allow more variations. We then extrapolate each district's total wind capacity in 2025 based on our results. This extrapolation relies on the assumptions that Republicans primarily have an edge in generating wind power (see Table 3) and have not used up the most suitable land for renewable generation (see Figure 4). We rank the 22 swing districts based on their predicted capacity from high to low. The ranking is reported in Table 4.

The districts at the top of the list tend to have larger land area, lower population density, and cheaper land prices. Roughly half of the swing districts have already installed wind capacity, and these districts have higher ranks than those that have not. The top district, the 23rd district of Texas, has built over 3000 MW of wind capacity so far, equivalent to 2% of the national wind capacity. Given the large capacity, this district will disproportionally benefit from renewable subsidies.

We recognize that districts with higher DW-NOMINATE scores may also vote against their ideologies and turn to support renewables. Among the districts that we predict to have an above-median wind capacity in 2025, 73.5% of them are governed by Republicans, including 13 of the 22 districts identified in Table 4. When weighted by area, Republican districts make up 83.7% of total area that would feature an above-median level of wind capacity.[32]

VIII. Future Land Use for Renewable Power Plants

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[32] Following the same approach, we repeat the analysis with solar capacity. Among the districts with an above-median predicted solar capacity, 72.6% are Republican (85.5% when weighted by area). 15 of the 22 swing Republican districts are in this subset.

A. Renewable power plant productivity growth

With our emphasis on economic geography, we have not addressed the macroeconomic issue of what will be the aggregate amount of United States land that will need to be set aside and devoted to green power to achieve US carbon mitigation goals. The land inputs needed per unit of green power are declining. With new techniques such as floating installation of solar panels, it might take as little as 0.3% of the Earth's land area to meet the global electricity demand (Victoria et al. 2021). Under such optimistic assumptions, the land demand from renewables will be lower than today's estimates.

The marginal cost of supplying green power drops if each acre of facility generates more power. Using data at turbine and farm level, we test whether the land use per MW of capacity is declining over time. We obtain the capacity, sweep area, height, and installation year of each turbine in the US from the USGS database.[33] This database provides the location of each turbine. We group them by wind farm and use GIS to sketch out the rough boundary of each farm (see Appendix 2). We then calculate the area of each farm.[34] In our sample, the median land use is 55.3 acres/MW. There is not a similar dataset on the area occupied by solar farms. From the EIA power plant dataset, we randomly sample 150 solar farms built before 2020 and with at least 5 MW of capacity. We locate them on Google Earth and calculate their area (see Appendix 3).[35] In our sample, the median area per MW is 5.97 acres.

We estimate the following specification for wind turbine or solar farm i:

$$\log (MW\ per\ acre_i) = \beta_0 + \beta_1 Trend + \beta' X_i + \varepsilon_i \qquad (5)$$

In equation (5), X is a vector of covariates including turbine count, swept area, and height when the dependent variable refers to wind productivity. In the wind farm regressions, we also include manufacturer fixed effects and state fixed effects. The latter controls for the state-level regulations

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[33] https://eerscmap.usgs.gov/uswtdb/

[34] The direct Impact area of each turbine turns out to be very small (as low as 1% of the total farm area), which means the wind farmland area mainly comes from the spacing between turbines. This 99% of land can still be used for farming. However, the land between turbines cannot be used for other purposes that may offer higher returns (e.g. residential housing). Republican areas have an advantage because they have large open land that allows sufficient separations between turbines. It is thus important to analyze the total area of wind farms instead of only the direct impact area.

https://css.umich.edu/publications/factsheets/energy/wind-energy-factsheet

[35] We limit the sample to solar farms built before 2021 because Google Earth has not updated information on most newly built solar farms. Among the 150 solar plants, we are able to calculate the area of 101 of them. We acknowledge there could be measurement errors in the area calculation.

such as turbine height limits. We estimate this equation both weighted and unweighted by total farm capacity. The results are reported in Table 5.

Columns (1) and (2) show a positive but insignificant time trend of the land use productivity of wind power. The significantly negative coefficient on the turbine count suggests a tradeoff between horizontality and verticality. A wind farm can produce the same amount of power using a few large turbines or many smaller ones that spread out across the land. In columns (3) and (4), we document solar generators are becoming more land-efficient over time. On each acre of land, 9.6% and 13.6% more capacity can be sited each year. This is consistent with existing evidence such as Van Zalk and Behrens (2018). The marginal cost of installing renewable power plants decline as their power density rises.

B. Green power generation on federal lands

In the presence of backlash against renewable installation on private lands, more green capacity will be sited on federal lands. Most of renewable projects have been developed on private lands, while federal lands are often leased to oil and gas companies. In 2021, 0.8% of the wind capacity (1.1GW) and 7.1% of the solar capacity (4.3GW) was located on public lands.[36] The federal government owns over 20% of the land in the US. The Biden Administration's push to ban oil and gas drillings has been met with political challenges. In exchange for the support for climate bills, the administration compromised to continue leasing federal lands to oil and gas developers.[37] The existing brown energy projects impose barriers of entry for renewable developers, especially when the generation costs are higher for green developers due to the requirement of more land and more expensive equipment.

On federal lands, there have been only ten counties that have sited wind projects and 59 counties that have sited solar plants. Compared to private lands, public lands have been less favorable to developers because developments on these lands often incur higher costs and undergo long permitting processes with high failure rates.[38] These developments are subject to close scrutiny from environmental regulators due to concerns for issues such as biodiversity

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[36] We use GIS to classify each green power plant into federal lands versus not based on their longitude and latitude.
[37] https://www.nytimes.com/2022/09/14/climate/louisiana-gulf-drilling-fishing.html
[38] http://eelp.law.harvard.edu/wp-content/uploads/PDaniels_EELP_Renewables-Siting_Final.pdf

preservation. The Biden Administration seeks to change this status quo and expedite the installation of green generators on public lands.[39]

In counties with more green NIMBYism, renewable capacity is more likely to be deployed on public lands. We calculate each county's proportion of federal lands and its proportion of green capacity located on federal lands. We rank them based on the ratio of the latter to the former. Out of the 66 counties with some green capacity on federal lands, 42 have a ratio greater than 1 (i.e. capacity disproportionally on federal lands). The negative correlation between this ratio and Republican votes (r=-0.26) is statistically significantly smaller than 0 at the 5% level. This suggests that there has been less local NIMBYism in Red counties so that more capacity could be sited on private lands.

A large proportion of public lands are in the American West including Nevada, Utah, and Idaho. Over 70% of the lands in these states are publicly owned. Because California has high demand for green electricity and given the backlash from rural Western states, developers would be incentivized to install green capacity on public lands in these states if the process was streamlined. Meanwhile, green subsidies may be needed to give green developers a cost advantage over the existing oil and gas drillers.

IX. Conclusion

The US transition away from fossil fuel fired power plants to generating power using renewable sources will change the nation's economic geography. Renewable farms are more land-intensive than conventional power plants. We document Republican counties are faster in granting renewable permits as they have less stricter zoning regulations. Republican counties have an edge in wind generation due to the cheaper land prices, lower population density, and higher wind speeds. Despite having added in more wind capacity, they underperform Democratic counties on solar installation because solar panels are less land-intensive and Blue states provide more incentives for solar developers.

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[39] He seeks to permit 25GW of renewable capacity on these lands by 2025.
https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/12/fact-sheet-biden-harris-administration-races-to-deploy-clean-energy-that-creates-jobs-and-lowers-costs/

The rural Red State areas gaining from the emerging green power boom creates the possibility of new low carbon political coalitions forming. Going forward, some rural Republican areas' elected officials may vote in favor of further increases in green power subsidies. We presented an empirical approach for identifying these districts.

The opportunity cost of green generation is the forgone agricultural profits that would have been gained from the same land. We find no evidence that the land intensity of wind turbines is decreasing, but solar farms occupy less land per MW over time. The opportunity cost can decline due to the developments of vertical turbines and agrivoltaic farming. Future research should study how these new technologies could transform the political economy of the green capacity deployment.

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Table 1

The Correlates of Green Power Permit Approval "Red Tape"

	(1)	(2)	(3)	(4)	(5)	(6)
	Wind		Solar		Gas	
	Withdrawn	I(wait>2 years)	Withdrawn	I(wait>2 years)	Withdrawn	I(wait>2 years)
log(Capacity)	0.00617	0.0143	-0.0199***	0.0170***	-0.00915	0.0204**
	(0.0109)	(0.00892)	(0.00601)	(0.00409)	(0.00860)	(0.00846)
Republican votes%	-0.246**	-0.252***	-0.301***	0.0437	-0.0881	-0.214*
	(0.121)	(0.0959)	(0.0660)	(0.0300)	(0.0908)	(0.121)
Farmland%	0.226*	0.152**	0.403***	0.0498	-0.0514	-0.223
	(0.135)	(0.0758)	(0.107)	(0.0467)	(0.222)	(0.317)
log(Home price)	0.118***	-0.0317	-0.000602	-0.0169	-0.0699**	-0.0833*
	(0.0395)	(0.0270)	(0.0181)	(0.0103)	(0.0348)	(0.0460)
log(Wind speed)	-0.336***	-0.0486				
	(0.118)	(0.0627)				
log(Solar radiation)			-0.207	-0.0350		
			(0.138)	(0.0405)		
Application year FE	Yes	Yes	Yes	Yes	Yes	Yes
Division FE	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Full	Not withdrawn	Full	Not withdrawn	Full	Not withdrawn
DV mean	0.604	0.757	0.397	0.368	0.6	0.583
Observations	2,104	760	5,919	3,520	1,771	700

Standard errors are clustered by county.

*** p<0.01, ** p<0.05, * p<0.1

Withdrawn is a dummy indicating whether the project has withdrawn from the queue. Wait refers to the time a project has been waiting in the queue (and hasn't withdrawn). For completed projects, it refers to the time between entering the queue and becoming commercially operable.

This table shows the estimation from equation (2).

Table 2

The Attributes of Republican Counties

	(1) log(Density)	(2) log(Wind speed)	(3) log(Radiation)	(4) log(Home prices)	(5) RPS	(6) log(RPS potential+1)
Republican	-4.811***	0.0619**	0.0181	-1.165***	-0.0796***	0.104
	(0.389)	(0.0254)	(0.0121)	(0.107)	(0.0151)	(0.129)
Year 2021					0.123***	0.555***
					(0.00864)	(0.0488)
Republican x Year 2021					-0.121***	0.317***
					(0.0122)	(0.0726)
State FE	Yes	Yes	Yes	Yes	No	No
Observations	3,112	3,078	3,098	2,852	6,226	6,212
R-squared	0.565	0.623	0.884	0.439	0.131	0.156

Standard errors are clustered by county. All regressions are weighted by county area.

*** p<0.01, ** p<0.05, * p<0.1

Republican refers the percentage votes for Trump in the 2020 presidential election. Year 2021 is a dummy variable. The dependent variables in the first four columns are from 2010 data. In the last two columns, RPS and RPS potential are data from 2010 and 2021 (the first and the last year in our full panel). RPS market potential is calculated using equation (1).

Columns (1) to (4) show the estimation from equation (3a), and columns (5) and (6) show that from equation (3b).

Table 3

The Attributes of Counties Generating Green Power

	(1)	(2)	(3)	(4)	(5)	(6)
		Wind			Solar	
	I(Wind>0)	log(Capacity+1)	Wind%	I(Solar>0)	log(Capacity+1)	Solar%
Republican votes	0.121***	0.610***	0.420***	0.146***	0.915***	0.136***
	(0.0277)	(0.134)	(0.0324)	(0.0377)	(0.117)	(0.0275)
Trend x Republican votes	0.00610	0.0543***	0.0154***	-0.0651***	-0.232***	-0.00941***
	(0.00390)	(0.0182)	(0.00376)	(0.00573)	(0.0182)	(0.00363)
Lagged RPS	0.0307	0.219	-0.0285	0.446**	1.101***	0.0177
	(0.0401)	(0.181)	(0.0328)	(0.176)	(0.404)	(0.0646)
log(Lagged RPS potential+1)	0.0227***	0.0483	0.0185***	-0.0427***	-0.262***	-0.0441***
	(0.00794)	(0.0387)	(0.00654)	(0.0157)	(0.0536)	(0.0122)
log(Home price)	-0.0778***	-0.348***	-0.0805***	-0.0449***	-0.206***	-0.00733
	(0.00696)	(0.0359)	(0.00740)	(0.00986)	(0.0359)	(0.00998)
log(Wind speed)	0.0579*	0.00424	0.0459			
	(0.0304)	(0.168)	(0.0316)			
log(Solar radiation)				0.915***	4.207***	0.431***
				(0.0955)	(0.474)	(0.0662)
Climate belief	0.00331***	0.0173***	0.0128***	-0.000193	0.000458	0.00690***
	(0.000611)	(0.00332)	(0.000813)	(0.000621)	(0.00170)	(0.000634)
log(Population)	0.0127***	0.0218*	-0.0313***	0.0648***	0.184***	-0.0267***
	(0.00256)	(0.0125)	(0.00296)	(0.00419)	(0.0168)	(0.00266)
log(Area)	0.0426***	0.204***	0.0142***	0.0252***	0.134***	0.00178
	(0.00561)	(0.0277)	(0.00349)	(0.00683)	(0.0215)	(0.00330)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Total capacity>0	Full	Full	Total Capacity>0
DV mean in 2021	0.159	43.5 (unlogged)	0.157	0.292	20.6 (unlogged)	0.171
Observations	29,904	29,904	18,834	30,108	30,108	19,036

Standard errors are clustered by state/year.

*** p<0.01, ** p<0.05, * p<0.1

The dependent variables of columns (1) and (4) are dummies indicating whether there is any wind/solar capacity in a county in a given year. The dependent variables of columns (3) and (6) are proportions of the total generating capacity that is wind/solar.

These results are estimated based on equation (4).

Table 4

Identifying Swing Republican Districts Featuring Wind Power Potential

State	District	Wind speed (m/s)	Home price ($10000)	Area (10000 mile^2)	Population density (per mile^2)	Wind capacity (MW)
TX	23	7.33	11.92	5.90	831.09	3321.4
NY	21	8.24	12.13	1.71	84.64	1233.3
CA	23	5.80	20.01	1.80	159.68	363.8
ID	2	6.20	16.14	4.36	157.03	974.4
IL	12	6.71	9.15	1.43	109.66	0
PA	15	6.85	11.51	1.31	87.04	159
WA	4	6.07	16.48	1.82	66.30	1350.9
OK	4	7.83	10.99	0.99	348.07	1337.3
IA	3	6.24	14.01	1.07	553.84	2813.4
CA	22	4.58	14.78	0.43	106.25	0
IA	1	6.33	13.23	1.10	164.95	428
FL	28	8.62	18.37	0.26	1248.73	0
FL	26	8.59	20.02	0.24	1055.42	0
OH	14	5.88	12.78	0.25	492.70	0
NJ	4	8.48	31.89	0.07	1063.01	0
NY	2	7.99	47.62	0.04	1736.10	0
AL	5	7.15	14.35	0.35	320.06	0
OH	10	5.36	10.93	0.10	908.40	0
CA	40	6.40	49.00	0.04	3670.68	0
PA	1	8.37	30.85	0.07	1138.44	0
NY	11	8.20	40.47	0.01	18427.13	0

The districts are ranked based on their predicted wind capacity in 2025.

Table 5

Productivity Time Trends for Wind Turbines and Solar Farms

	(1)	(2)	(1)	(2)
		Wind		Solar
			log(Capacity/Acre)	
Trend	0.00141	0.00118	0.0959**	0.136*
	(0.00201)	(0.00128)	(0.0454)	(0.0713)
log(Height)	-0.0972*	-0.0158		
	(0.0523)	(0.0381)		
log(Swept area)	0.00882	-0.00704		
	(0.0279)	(0.0180)		
log(Turbine count)	-0.0808***	-0.0770***		
	(0.0109)	(0.0103)		
Manufacturer FE	Yes	Yes	No	No
State FE	Yes	Yes	No	No
Weight	No	Total capacity	No	Total capacity
Observations	1,151	1,151	98	98
R-squared	0.404	0.381	0.031	0.071

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This table shows the estimation from equation (5).

The unit of analysis is a wind or solar farm. In the first two columns, we include all wind farms with at least three turbines and built between 2005 and 2021. In the last two columns, we include our randomly sampled wind farms built before 2021 and with at least 5MW of capacity.

Figure 1

Renewable Capacity by Congressional Districts

(a) Wind
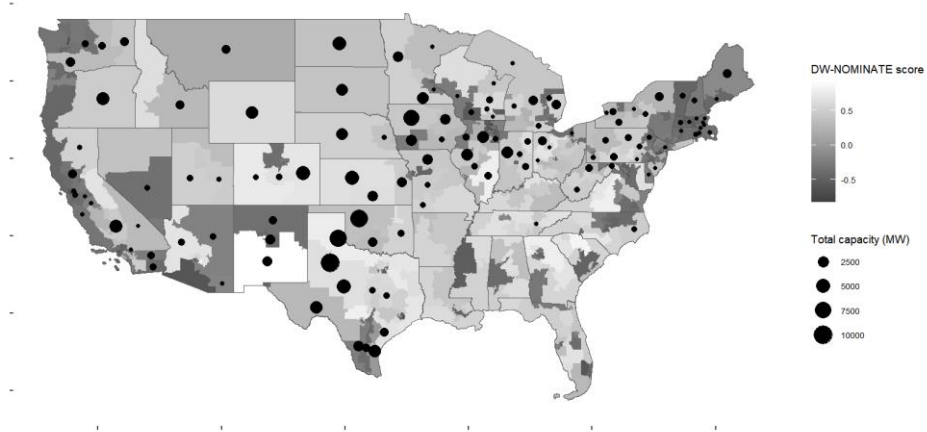
(b) Solar
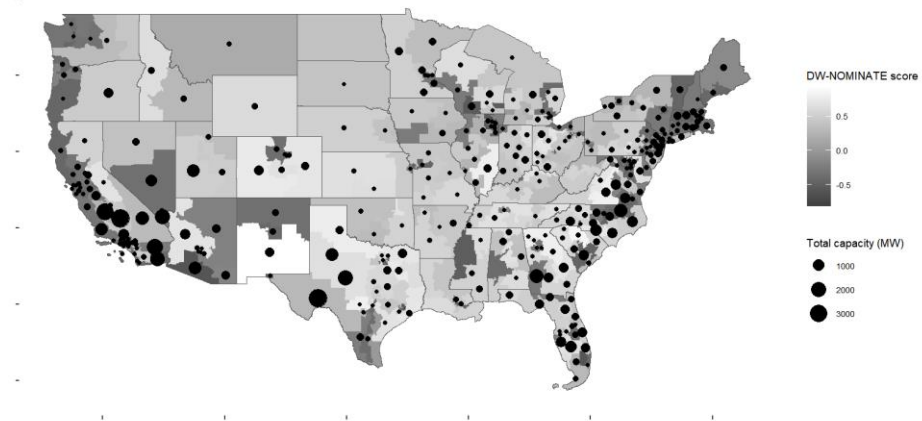
DW-NOMINATE is a continuous measure of political ideology, with -1 being the most progressive and 1 being the most conservative.

Each dot represents a congressional district with non-zero wind/solar capacity. The size of the dot is proportional to the total capacity within the district.
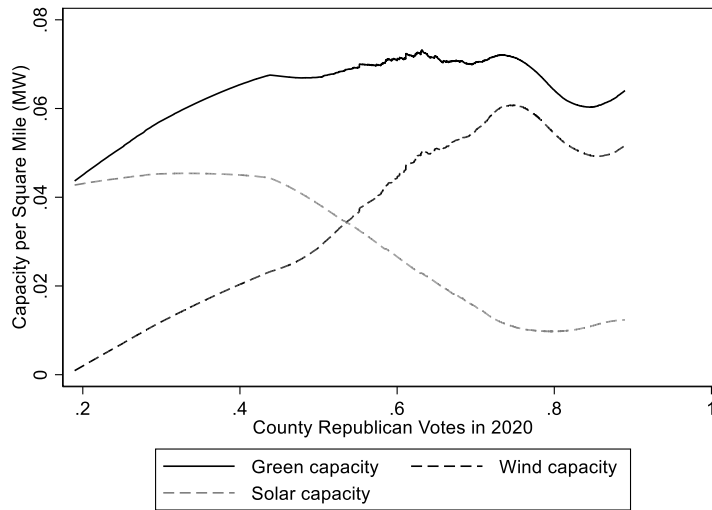
Figure 2

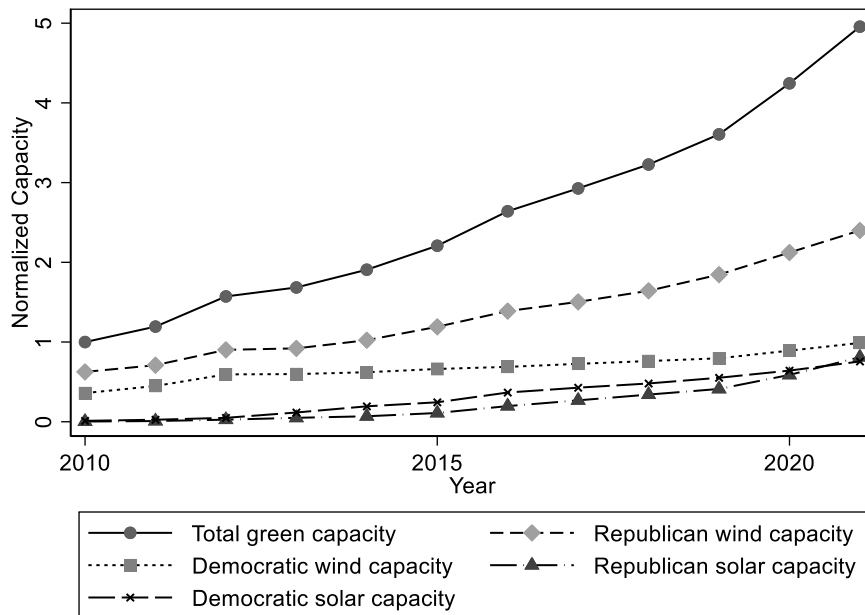## Electric Power Capacity and County Political Ideology

(a) Total capacity
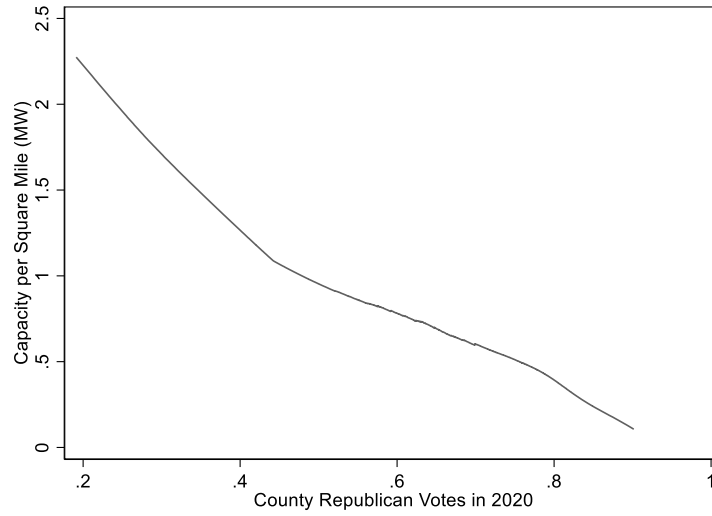
(b) Green capacity

We drop the top and bottom 1% of the Republican votes, which correspond to a vote of 89% and 19%.
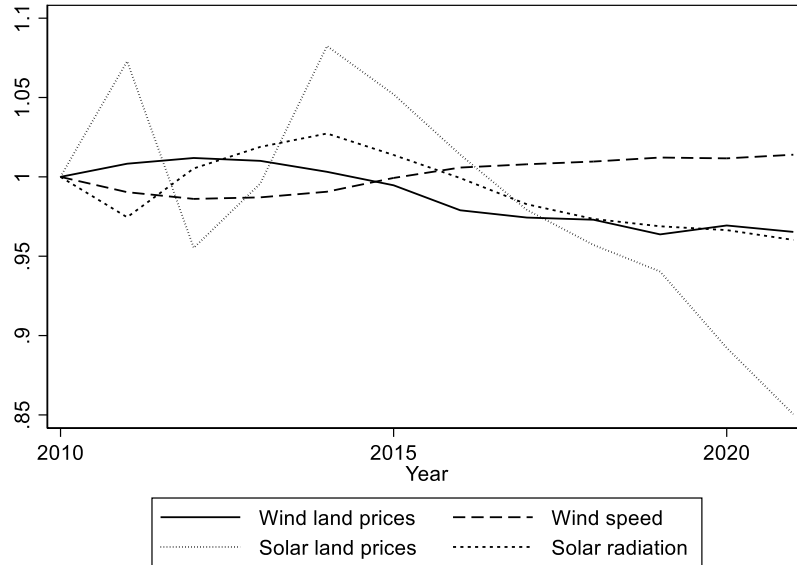
Figure 3

The Time Trend in Renewable Power Capacity

In this graph, all capacity is normalized by the total green capacity in 2010 (39365.4 MW). A state is defined as Republican if it voted for Trump in the 2016 presidential election.

Figure 4

Are There Diminishing Returns in Republican Districts?

We plot land prices weighted by wind and solar capacity respectively, wind speed weighted by wind capacity, and solar radiation weighted by solar capacity. We normalize each weighted average to its value in 2010. We restrict our sample to congressional districts governed by a Republican in the 118th congress.
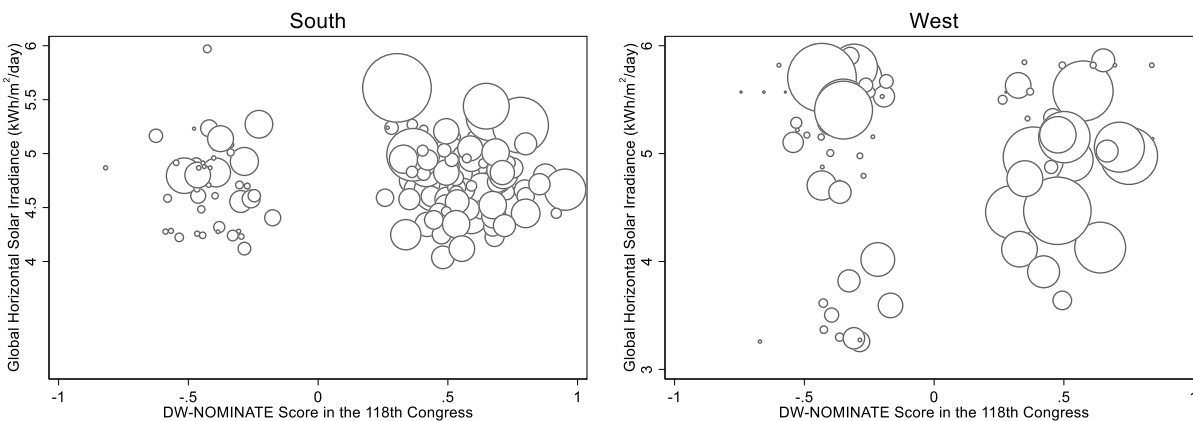
Figure 5

Congressional District Wind and Solar Potential
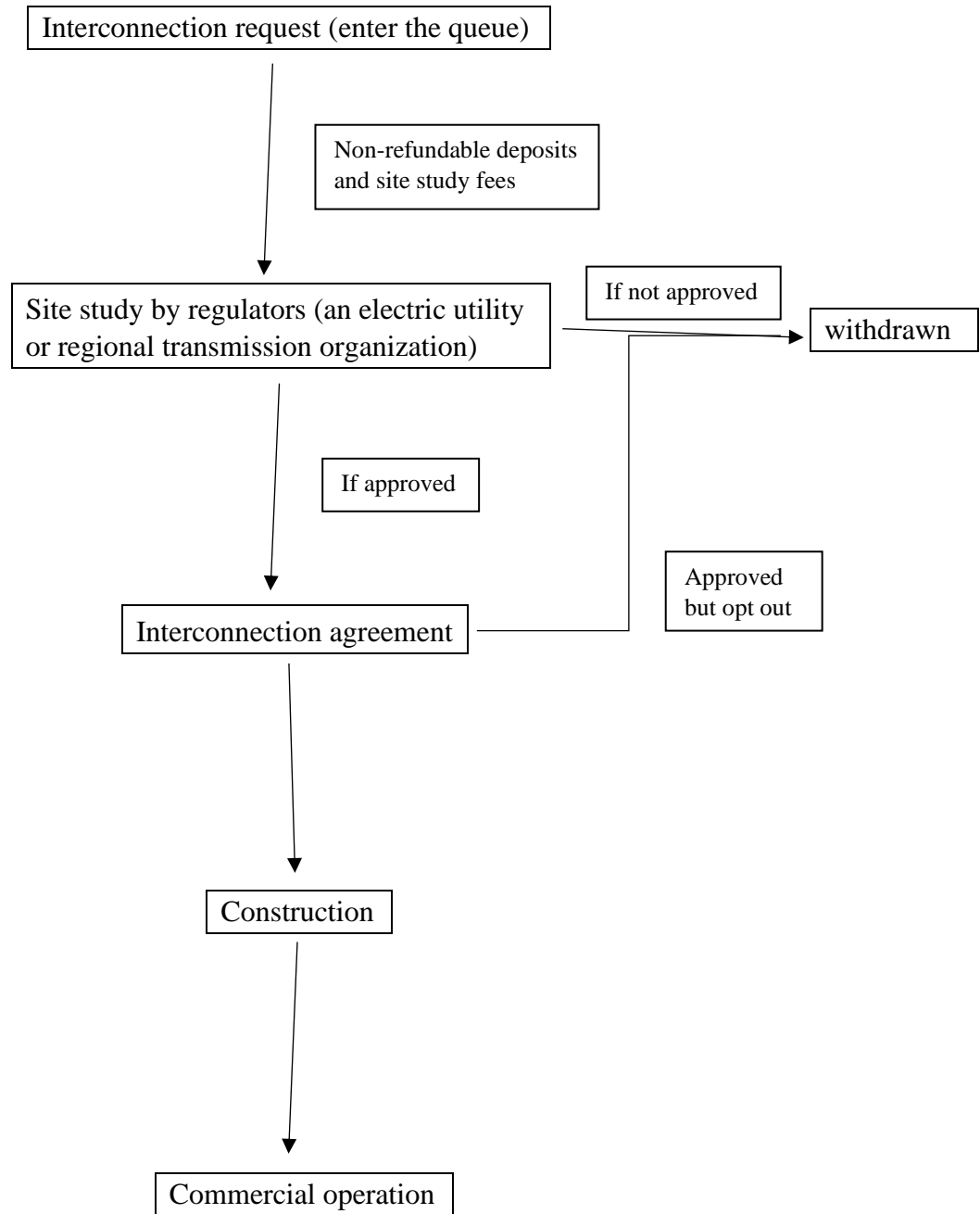
(a) Wind speed
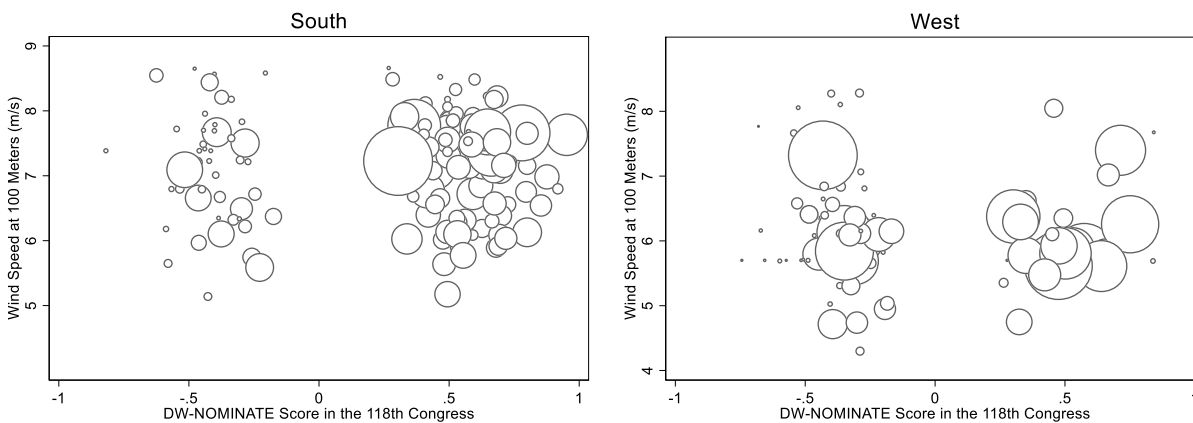
(b) Solar radiation

Each dot represents a congressional district in the 118th congress, and its size is proportional to its area. DW-NOMINATE score is a continuous measure of each district's representatives' political ideology. On a scale from -1 to 1, -1 is the most progressive, and 1 is the most conservative.
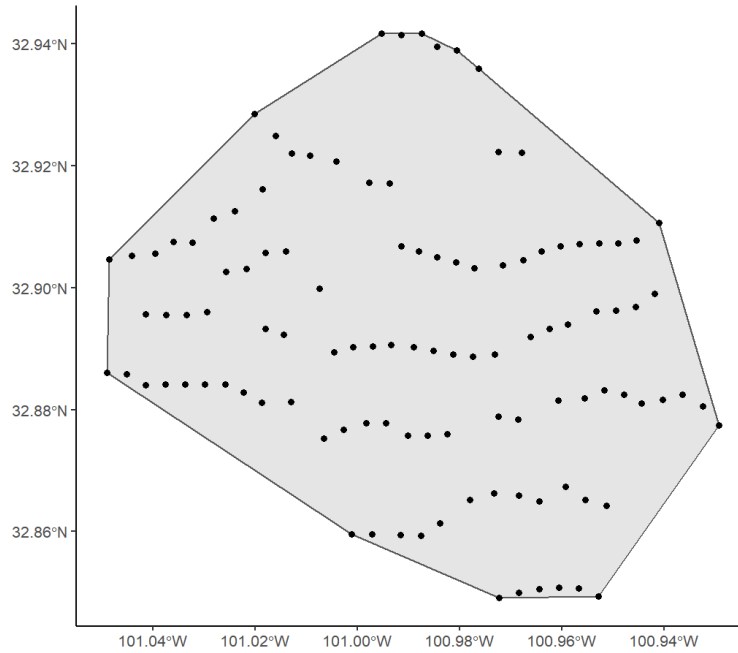
Appendix 1

Interconnection Study Process

Interconnection request (enter the queue)

Non-refundable deposits and site study fees

If not approved

Site study by regulators (an electric utility or regional transmission organization)

withdrawn

If approved

Approved but opt out

Interconnection agreement

Construction

Commercial operation

Appendix 2

Calculating the Wind Farm Area with the sf Package in R

We use the Amazon Wind Farm in Scurry County, Texas as an example. Each black dot in the figure below represents a wind turbine. The shaded area is generated by the st_convex_hull function, and we use the st_area function to calculate its area. We use this result as an approximation of the total wind farm area.
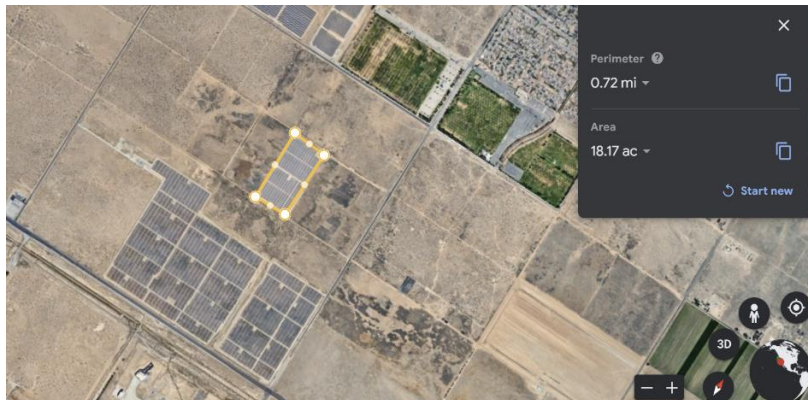
Appendix 3

Calculating the Solar Farm Area with Google Earth

(a) One single parcel

(b) Multiple widely separated parcels

Total area=154.61+18.17+59.15=231.93 acres.

(c) Rooftop

Total area is coded as 0.

Appendix 4

The Effect of State Policies on the Location of Green Power Plants

Using adjacent county pairs such that one county is located in one state and the other county is located in another state, we examine whether the more progressive county in the pair features more green power. We use the RTW dummy as a proxy for a conservative state. The unit of analysis is a county in the year 2021. A county can appear multiple times in this regression if it is adjacent to other counties that lie in another state. We run the following regression on county s in border pair i:

$$Y_{is} = \beta_0 + \beta_1 RTW_s + \beta_2'X_s + \delta_i + \varepsilon_{is}$$

where Y is a wind dummy or a solar dummy indicating whether there is any wind or solar capacity in the county by the year 2021, RTW is a dummy indicating whether county s is on the RTW side of the border, and X is a vector of county attributes including republican votes, home prices, land area, wind speed, and solar radiation. We include border pair fixed effects (δ_i) so that the results are based on the difference within each border pair. The standard errors are clustered by border pair.[40] The results are reported in the table next page.

In column (1), we find no evidence that the liberal and conservative side of the border differ with respect to their wind generation capacity. Neither the RTW dummy nor the Republican vote share is significant. The coefficient on land prices is negative and statically significant, consistent with results from Table 3. In column (2), the RTW dummy and Republican votes are significantly negative. When crossing from the liberal to the conservative side of the border, the probability of the county having solar capacity declines by 6.71%. This shows that solar incentives in liberal states are effective in attracting solar developers. Since solar panels are relatively less land-intensive, the cost premium of installing 1MW of capacity in liberal states is smaller for solar capacity than for wind capacity. The more generous solar incentive is thus likely to give liberal states a competitive advantage in sitting solar power plants.

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[40] There are 2764 border pairs in our sample. 996 have green capacity on one side but not the other. 1146 have none. 622 have green capacity on both sides.

We repeat our analysis using data from the year 2010. In columns (3) and (4), the RTW dummy is insignificant. This suggests that the solar advantages in Blue states are likely results of the supportive policies initiated in the past decade.

	(1)	(2)	(3)	(4)
	2021		2010	
	Wind	Solar	Wind	Solar
RTW	-0.0273	-0.0671**	-0.0157	0.00868
	(0.0219)	(0.0264)	(0.0161)	(0.00950)
Republican votes	-0.116	-0.396***	0.00276	-0.0676
	(0.0847)	(0.129)	(0.0578)	(0.0761)
log(Home prices)	-0.0614**	0.0593	-0.0229	-0.0174
	(0.0245)	(0.0389)	(0.0207)	(0.0138)
log(Area)	0.0742***	0.173***	0.0322***	0.112***
	(0.0156)	(0.0225)	(0.0110)	(0.0162)
log(Wind speed)	-0.00976		-0.0703	
	(0.258)		(0.200)	
log(Solar radiation)		-1.287		-0.750
		(1.095)		(0.513)
Observations	4,976	4,976	4,976	4,976
R-squared	0.726	0.665	0.702	0.591

Standard errors are clustered by border pairs.
*** p<0.01, ** p<0.05, * p<0.1

Wind and solar are two dummies indicating whether the county has any wind or solar capacity by 2021 or 2010.