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

Robert Huang and Matthew E. Kahn

University of Southern California

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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 such as the land's renewable power potential, cost of acquisition, proximity to final power consumers, and local land use regulations. We find that Republican areas are more likely to issue interconnection permits than progressive areas. We present evidence that rural Republican areas have a cost advantage in 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.

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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 power 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 increasing renewable power generation is the land intensity of wind and solar capacity (Van Zalk and Behrens 2018).[2] 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.[3] These land inputs are much greater than the land inputs for generating electricity using fossil fuels. 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 potential. 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.[4] Brooks and Liscow (2023) have found that backlash against infrastructure projects delays their completion and inflates their costs.

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

[2] 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] See Section VIII for detailed discussions.
MW stands for megawatt, which measures the rate at which electricity can be generated. When we say that a power plant has a capacity of 1 MW, it means that it is capable of producing 1 million watts of electrical power at any given moment.

[4] 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.

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. Mutually beneficial trade has occurred as the coastal people have purchased food from the American food belt and manufacturing goods from Southern manufacturing areas. On some level, trade in green energy represents another example of comparative advantage in a case where land prices vary across space. At the same time, the climate change challenge has raised political divisions that have not occurred in the case of producing food or manufacturing goods.

In this paper, we study whether Republican areas have an edge in siting utility-scale wind turbines and solar panels because they have fewer land use regulations, cheaper land, and more natural resources.[5] Based on voting in the 2020 election, 83% of the land area of the US 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. 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 (Davis, Hausman, and Rose 2023). 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 transmission organization (RTO) conducts 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). The dataset we use provides information on 8000 renewable projects that applied for interconnection between 2010 and 2020, including their capacity, status, queue

[5] Utility-scale wind and solar farms are more cost-efficient than rooftop solar due to economies of scale. Relying solely on rooftop solar may not be feasible to fully decarbonize the grid, as there may not be enough rooftops available.
https://www.latimes.com/environment/newsletter/2023-06-29/can-rooftop-solar-alone-solve-climate-change-heres-the-answer-boiling-point

[6] https://www.latimes.com/environment/story/2022-08-23/wyoming-clean-energy-california

time, and location. Most of the proposed capacity do not end up being built. We document that land-intensive renewable projects are less likely to withdraw from the queue in Republican areas.

We then explore the economic geography of the existing renewable capacity using a county panel dataset from 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. 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. We document that Red States have installed more wind capacity, but Blue states have built more solar farms. A border discontinuity analysis shows that solar generators are more likely to be sited on the liberal side of the border, and we interpret this as the result of policy incentives for solar in progressive states.

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 may be bid up as renewable power generators raise their bids for local land. This wealth effect for landowners offers local jurisdictions greater property tax revenue (Kahn 2013). Increases in federal subsidies for green power could be attractive to rural landowners in places with wind and solar generation 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 pattern of renewable capacity deployments, we identify the subset of Red districts that 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 Republican areas 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.

II. Data

A. 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.[7] The EGRID dataset provides detailed information on each utility-scale electricity generator in the US, including 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.[8] 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:

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

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. The lack of transmission capacity has led to renewables curtailment in local markets (i.e. supply>demand), which disincentivizes the construction of new generators (Davis, Hausman, and Rose 2023). We calculate the market potential using only county pairs with direct transmission lines. In 2021, the average RPS market potential per county was 8.41 with a standard deviation of 7.65. California has an RPS of 33%. A market potential of 8.41 is roughly equivalent to having an average distance of 100 miles to 28 counties in California (and all other nearby counties have zero RPS). The RPS potential has a

[7] https://www.epa.gov/egrid/download-data
[8] https://emp.lbl.gov/projects/renewables-portfolio/

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.[9]

We merge in variables on county demographics and time-invariant environmental attributes. We include data on votes for Trump in the 2020 presidential election and a Republican governor dummy indicating whether a state has a Republican governor in a given year.[10] Our data on median home prices in 2010 is from Zillow.[11] We obtain the county population, population density, and area data from the American Community Survey (ACS).[12] The county-level climate change belief data is provided by the Yale Climate Change Communication program.[13] These variables (except the governor dummy) are cross sectional.

The final component of this dataset is the county-level wind and solar potential. 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 favorable to siting green 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 6.75m/s.[14] 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. Generation permitting data

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

[9] We acknowledge this measure may overstate the RPS market potential because some states require utilities to purchase renewable electricity from within-state generators to fulfil RPS requirements.
[10] We access the voting data from the MIT Election Data Science Lab: https://electionlab.mit.edu/data
[11] https://www.zillow.com/research/data/
[12] https://www.census.gov/programs-surveys/acs
[13] 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.
[14] 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. The maximum speed below which wind turbines can safely operate is 22.5m/s, which is almost twice as high as the maximum county wind speed.
https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php

& Policy Lab.[15] It includes 1500 utility-scale wind projects and 6400 solar projects that have applied for grid connection from 2010 to 2020. For each project, the dataset provides the project status (active, completed, or withdrawn), queue time, energy source, capacity, and location. Based on each project's location, we merge in the respective county's demographic and environmental attributes from the county panel.

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.[16] 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.[17] 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 renewable capacity by district/year.

III. Supplying Green Power

A. Land requirements for renewable generation

[15] 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.

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

[17] 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.

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).[18] 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 (including the necessary spacing between wind turbines and solar panels). Given the land intensity of renewable projects, especially wind, they have to be sited on cheap, open land.

B. Local NIMBYism and land use constraints

Unlike fossil fuels, wind and solar power cannot be shipped, which means renewable generators have to concentrate in regions with high local renewable potential 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 include the forgone agricultural profits. Local farmers disproportionally bear these costs and have an incentive to oppose renewable developments.[19] Stokes (2016) has found that widely-supported climate policies can fail when their benefits are dispersed but costs are concentrated in 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 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 consider leasing or

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[18] Solar and wind power plants require more space compared to other forms of energy generation. However, they do not require any additional land for the extraction of energy. Coal-fired power plants heavily rely on mining operations to obtain fossil fuels, which necessitates a significant amount of land use. The power density calculations do not account for the land used to extract fossil fuels and may overestimate the power density for brown capacity.

[19] 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

selling their land for renewable energy development.[20] 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. These states have cheaper land, fewer constraints on land use, and promising sun and wind potentials. However, the attempts to add transmission lines have also been met with political backlash when the lines pass through the area without financially benefiting the residents (Gross 2020). For utilities subject to rate-of-return regulations, they tend to invest in excess capitals (Averch and Johnson 1962), which implies they prefer building their own power plants instead of purchasing power from other generators. This incentivizes them to block transmission projects (Davis, Hausman, and Rose 2023).

C. The spatial distribution of the existing renewable power 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.[21] 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

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[20] https://www.sandiegocounty.gov/content/dam/sdc/pds/ceqa/Soitec-Documents/Final-EIR-Files/references/rtcref/ch2.5/2014-12-19_DOCSolarWhitePaper31111.pdf

[21] 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.

disproportionally built in Republican districts because these districts often feature high wind speed, low land prices, and fewer regulations such as zoning and limitations on the turbine height. These are favorable attributes that incentivize wind developers to enter the market.

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. Facing lower costs of building in solar capacity than wind capacity, the coastal liberal states ramp up solar to meet their ambitious RPS goals.

In Figure 2, we create nonparametric plots of the total generating capacity and green power capacity per square mile with respect to each county's share of Republican votes and population density in 2020. An interesting pattern is that the total capacity density features a negative slope when plotted against Republican votes and a positive slope when plotted against population density, while the slope of the total green capacity has the opposite sign in both graphs. Before the ramp up of renewable generation, due to losses of electricity during transmission, power plants locate closer to densely populated cities, which are often governed by Democrats.[22] The capacity density has been lower in Republican counties, where there are fewer people and lower electricity demand.

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 and drops in counties with a lower population density (except in counties with very high Republican votes or very high/low population density). Total green capacity density starts to rise

[22] 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%.

again in the most densely populated areas as rooftop solar installations surge in cities such as Los Angeles and New York City.

The renewable power capacity density drops when Republican votes go above 70%. There could be local backlash against clean energy in highly conservative areas. These tend to be rural counties with the lowest population density, which can explain the positive slope of the green capacity density at low population density. When we plot the capacity density for wind and solar respectively, the wind density has a positive slope until Republican votes reach 70%, whereas the solar curve has a negative slope. 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.

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.[23] 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.[24] 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

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

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 within the US 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 supplying power 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 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 the financial benefits they offer (Gustafson et al. 2020). In the recent past, Republican representatives have consistently voted 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.

V. Understanding the Correlates of Permit Approval Rates 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. Among wind and solar projects proposed between 2010 and 2020, there were 4343 active projects in the queue, 374 completed projects, and 3144 withdrawn projects. To set up a commercially operable power plant, the developer first submits an interconnection request to the RTO, informing regulators the location, size, energy type, and other relevant characteristics of the project. The RTO then conducts site studies and grants an interconnection permit to the developer. The developer can construct the power plant after obtaining the permit. Details of this process are shown in Appendix 1.

In Table 1, we present the characteristics of the counties where developers applied to site their projects in. We compare the unweighted average of county attributes to the weighted ones (by wind capacity and solar capacity in the queue in 2020). Both wind and solar developers send more applications to counties with higher wind speeds/solar radiation, higher RPS, greater green market potential, lower population density, and less stringent land regulations.[25] Wind capacity tends to be proposed in Republican counties with cheap land, while solar capacity is disproportionally proposed in liberal areas. These descriptive results are consistent with hypothesis II.

Among all the applications, 48% withdrew before the end of 2020 (based on projects proposed between 2010 and 2020). The high withdrawal rate is due to the uncertainties in interconnection costs and the unpredictable waiting time (Seel et al. 2023). We study the heterogeneities in the approval rate and waiting time across counties. We define the waiting time as the time since a project entered the queue (if it is still active). For completed projects, waiting

[25] The land regulation index is from Gyourko, Hartley, and Krimmel (2021). Specifically, we use the Local Project Approval Index (LPAI). A higher value indicates more stringent regulations. One caveat is that this index is only available for 35% of the counties.

time refers to the time it took from entering the queue to becoming commercially operable.[26] Based on the completed projects in our sample, the median waiting time was 1482 days and 1448 days respectively for wind and solar, and the 25th percentile was 1007 and 701 respectively. We test whether Republican areas have higher project withdrawal rates and shorter waiting time (Hypothesis I). We estimate the following linear probability model for project i in the year 2020:

$$Y_i = \beta_0 + \beta_1{}'Republican_i + \beta_2{}'X_i + \delta_{rt} + \varepsilon_i \qquad (2)$$

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 estimated 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.[27] This specification is estimated only on completed and active projects. The coefficients of interest are the vector β_1. Republican is a vector including two variables: the percentage votes for Trump in the 2020 election in the project's county and a Republican governor dummy indicating whether the project's state had a Republican governor in the year it was proposed. We control for a vector of project attributes X, such as its capacity, its county's home prices, population density, and wind/solar potential. RTOs are responsible for permitting interconnection. We include RTO/application year fixed effects (δ_{rt}). They capture spatial and temporal factors such as the renewable production tax credits and the congestion in the queue at a given point of time. We estimate equation (2) separately for wind and solar. Standard errors are clustered by state.

The results are reported in Table 2, where the dependent variable is the withdrawn dummy in odd columns and queue time dummy in even columns. In columns (1) and (3), the coefficient on the Republican governor dummy is negative and statistically significant. In a state governed by a Republican, wind and solar projects are 7% and 11% less likely to withdraw. These represent relatively large reductions given the average withdrawal rate of 48%. As shown in column (3), Republican votes have a negative and statistically significant coefficient. Conditional on the party

[26] 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. Obtaining transmission access takes longer than constructing the plant.
[27] We estimate the same specifications (dependent variable: I(wait>T years)) with T=1,3,4,5. The coefficients on votes for Republican and the Republican governor dummy have similar significance levels as when T=2.

of the state governor, solar generators' withdrawal rates are lower in Red counties.[28] We attribute these differences to the stringency of land use regulations and local NIMBYism in liberal areas (Kahn 2011; Gyourko, Hartley, and Krimmel 2021). Such local oppositions can slow down the interconnection process by blocking the construction of the power plant itself or the transmission lines that connect the plant to the grid (Gross 2020; Davis, Hausman, and Rose 2023). Red states have an advantage in producing green power because it is less costly for renewable generators to acquire land there. That said, in columns (2) and (4), we find no evidence that Republican counties fast track renewable capacity that remain in the queue.

In column (2), we find that larger wind projects take longer time to connect to the grid, and counties with higher renewable market potentials approve wind projects faster. Column (3) shows that larger solar projects are less likely to withdraw, possibly due to the higher returns to waiting. Solar projects have higher withdrawal rates in states with high RPS. These states often feature stricter environmental regulations, which may lead to the rejection of renewable capacity due to concerns about its impact on biodiversity.[29]

VI. Green Power Plant Site Selection and Power Generation

A. 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):

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

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

[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.

[29] https://www.nationalgeographic.com/environment/article/activists-fear-biodiversity-threat-from-renewable-energy

In equation (3a), we estimate cross-sectional regressions using several different dependent variables, including home prices in 2010, population density in 2020, wind speed, and solar radiation. We control for state fixed effects (δ_s). In equation (3b), Y is a county/year variable and refers to state RPS or RPS market potential. 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.

We report the results in Table 3. We document 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 states 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 rises 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 coefficients of Republican votes and the interaction shows that Republican counties had significantly higher RPS potentials in 2021.

B. Renewable power incentives in Democratic counties

Although Republican areas possess natural attributes that are conducive to renewable energy generation, liberal areas have rolled out more financial support to accelerate the green transition.[30] These incentives can compensate the natural disadvantages of Blue counties and

[30] https://www.forbes.com/home-improvement/solar/solar-tax-credit-by-state/

determine renewable generators' location choices. 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 Right to Work (RTW) dummy as a proxy for a pro-business state. The unit of analysis is a county. 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, using cross sectional data from years 2010 and 2021 separately:

$$Y_{is} = \beta_0 + \beta_1 RTW_s + \beta_2{}' X_s + \delta_i + \varepsilon_{is} \tag{4}$$

where Y is a wind dummy or a solar dummy indicating whether there is any wind or solar capacity in the county, 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.[31] The results are reported in Table 4.

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 statistically significant. In column (2), the RTW dummy and Republican votes are negative and statistically significant. 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 represents a 20% drop relative to the mean probability of 31%, implying that solar incentives in liberal states are effective in attracting developers. Since solar panels are relatively less land-intensive, the cost premium of installing each unit of capacity in liberal states is smaller for solar than for wind. The more generous solar incentive is thus likely to give liberal states a competitive advantage in sitting solar power plants.

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 of Blue states are results of the policies initiated in this recent decade.

[31] 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.

C. Where is the existing renewable capacity?

Based on the previous findings, we study how the natural and policy advantages jointly affect the spatial distribution of the actual generating capacity. In this section, we model whether a given county has at least one green generator and its scale of production. 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:

$$Y_{it} = \beta_0 + \beta_1 Trend_t * Republican_i + \beta_2 Republican_i + \beta_3' X_{it} + \delta_k + \gamma_t + \varepsilon_{it} \quad (5)$$

In equation (5), 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 attributes (during the period we study) such as whether the electricity market is deregulated. Standard errors are clustered by state/year. The estimation results are shown in Table 5. 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 (see Table 4). 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 as estimated in columns (2) and (3) respectively. Yet, Democratic counties are taking over Republican areas 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. These are consistent with Figures 1 and 2. Solar capacity is disproportionally installed in liberal counties as these counties provide more fiscal incentives and as the land intensity of solar panels trends down (Van Zalk and Behrens 2018).[32]

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 their land-intensive nature. The 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. The table also shows that wind speed is significant in determining the extensive but not the intensive margin of wind capacity, and developers tend to install and scale up solar panels in places where solar radiation is higher.

We interpret the climate belief and the county's population as proxies for the demand of green power. In counties with more climate believers, developers are more likely to install green capacity. 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 the 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 on lagged RPS are positive and statistically significant in columns (4) and (5). Because we control for state fixed effects, the variations in RPS mainly come from liberal

[32] As a robustness check, we estimate the models without California, Texas, or both. We also replace state FE and year FE with state/year FE. In all cases, most coefficients have similar numerical values and significance levels as in Table 3.

states that have increased RPS rapidly in recent years. These areas are more favorable to 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 has a significantly positive coefficient 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. Its coefficient is significantly negative in solar columns, which could be due to the limited variations of the market potential within states.[33]

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

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. Using data from the pipeline construction in Alaska in the 1970s, Carrington (1996) find the local wage increase to be temporary. Studies on fracking 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. In the US, green jobs tend to locate in counties that have been offering more fossil fuel jobs (Curtis and Marinescu 2022). Once installed, wind and solar farms create tax

[33] When we exclude state fixed effect. RPS potential is significantly positive in columns (1) to (3) and insignificant in columns (4) to (6).

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 reduces local 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 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.

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 in the 118th congress. A score closer to 1 indicates the representative is more conservative. The size of the dots is proportional to the district's land 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.

Political science research emphasizes that members of Congress seek to attract investment in their districts (Aklin and Urpelainen 2013). The zero-carbon transition raises the possibility that Republican districts with green power potential can get larger subsidies in the future. When voters benefit from these subsidies, they are more likely to reelect the incumbent rather than vote for an alternative candidate who is hostile to the existing policy (Peltzman 1984; Aklin and Urpelainen 2013). This "lock-in" effect incentivizes Republican congressmen to support green legislations if they perceive economic and political 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 5. 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 5 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 and have not used up the ideal land for renewable generation (see Figure 4). We rank the 21 swing districts based on their predicted capacity from high to low in Table 6.

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 in Table 6. When weighted by area, Republican districts make up 83.7% of total area that would feature an above-median level of wind capacity by 2025.[34]

VIII. Future Land Use for Renewable Power Plants

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 US land that will need to be set aside for green capacity to achieve US carbon mitigation goals. The land inputs needed per unit of green power are declining. With new techniques such as floating 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.

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.[35] This database provides the location of each turbine. We group them by wind farm and sketch out the rough boundary of each farm (see Appendix 2). We then calculate the area of each farm.[36] 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 2021 and with at least 5 MW of capacity. We locate them on Google Earth and calculate their area (see Appendix 3).[37] In our sample, the median area per MW is 5.97 acres.

[34] 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 21 swing Republican districts are in this subset.

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

[36] 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

[37] 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

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

$$\log (MW\ per\ acre_i) = \beta_0 + \beta_1 Trend + \beta' X_i + \varepsilon_i \qquad (6)$$

In equation (6), X is a vector of covariates including turbine count, swept area, and height when the dependent variable is 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 such as turbine height limits. We estimate this equation both weighted and unweighted by total farm capacity. The results are reported in Table 7.

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. 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 declines as their power density rises and as local oppositions diminish (Brooks and Liscow 2023).

While only a tiny fraction of renewable capacity in the US is offshore today, more can be sited on the ocean going forward. Currently, 40GW of offshore wind capacity is waiting in the queue.[38] Such capacity features zero land cost, and there is no local backlash against these projects. Yet, the lack of stable transmission capacity poses a challenge to scaling up offshore renewable generation (Ali et al. 2021).

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 public lands are almost exclusively leased to oil and gas companies. In 2021, 0.8% of

there could be measurement errors in the calculation, but they are not systematically correlated with project attributes. These errors would thus not bias the productivity growth rate estimates.

[38] https://windexchange.energy.gov/markets/offshore

the wind capacity (1.1GW) and 7.1% of the solar capacity (4.3GW) was located on public lands.[39] The federal government owns over 20% of the land in the US. Federal lands feature high lease rates and additional fees based on energy production. Due to the land intensity of renewable projects, the cost premium for siting green capacity on federal lands is higher than that for brown capacity. To reduce barrier of entry, the BLM has proposed to cut the costs by 80% for wind and solar developers.[40]

Only ten counties have sited wind projects on federal lands, and 59 counties have sited solar farms. Compared to private lands, public lands have been less favorable to developers because developments on these lands often incur high costs and undergo long permitting processes with high failure rates.[41] These developments are subject to close scrutiny from environmental regulators due to concerns for issues such as biodiversity preservation. The Biden Administration seeks to change this status quo and expedite the installation of green generators on public lands.[42]

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.

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. We document renewable projects are more likely to be permitted in Republican counties. Red rural counties also have cheaper land,

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[39] We use GIS techniques to classify each green power plant into federal lands versus not based on their longitude and latitude.

[40] https://grist.org/climate-energy/the-feds-move-to-speed-up-development-of-wind-and-solar-on-public-land/

[41] http://eelp.law.harvard.edu/wp-content/uploads/PDaniels_EELP_Renewables-Siting_Final.pdf

[42] 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/

lower population density, and higher wind speeds. They have added in more wind capacity but underperform Democratic counties on solar installation because solar panels are less land-intensive and Blue states offer more incentives for solar developers.

The rural Red State areas gaining from the emerging green power boom creates the possibility of new low carbon political coalitions forming. In the future, 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.

In this paper, we do not explore the interdependency of developers' choices between building wind and solar capacity. Currently, wind contributes 45% of the total renewable electricity generation in the US, and solar only contributes 10%. The production tax credits for wind power will expire in 2024, while the investment tax credits for solar power will continue to be available.[43] Republican counties may switch from wind to solar as the PTC phases out and as Democratic counties saturate their optimal locations for solar panels.

Our paper focuses on the supply of renewable power, but the total necessary generating capacity also hinges upon the peak electricity demand. Intermittent renewables lead to resource adequacy challenges (Wolak 2022). The aggregate land use for electricity generation will increase if more backup capacity is needed. Future research can study the role of demand-side management tools such as dynamic electricity pricing in mitigating the “land rush” of renewable energy.

[43] https://www.eia.gov/todayinenergy/detail.php?id=46676

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Table 1

The Attributes of Counties with Proposed Wind and Solar Projects

	Unweighted	Weighted by wind capacity in the queue	Weighted by solar capacity in the queue
Wind speed	6.75	6.84	6.57
Solar radiation	4.48	4.51	4.82
Republican votes	64.97%	67.91%	61.30%
Median home price in 2010	133k	116k	133k
Land regulation index	2.50	2.43	2.40
Climate believers	65.26%	64.51%	66.41%
Population density	271.03	79.65	162.68
County area	1126.21	1460.46	2612.09
RPS	5.47%	7.75%	9.02%
Green market potential	9.57	11.25	8.74

In the second and third columns, capacity in the queue refers to the non-withdrawn and non-completed capacity by the end of 2020.

Table 2

The Correlates of Green Power Permit Approval "Red Tape"

	(1)	(2)	(3)	(4)
	Wind		Solar	
	Withdrawn	I(wait>two years)	Withdrawn	I(wait>two years)
Republican votes	-0.0193	-0.162	-0.125**	0.0272
	(0.169)	(0.115)	(0.0622)	(0.0311)
Republican governor	-0.0687**	0.00803	-0.108***	-0.00988
	(0.0325)	(0.0197)	(0.0284)	(0.0158)
log(Capacity)	0.0227	0.00784*	-0.0397***	0.0110
	(0.0155)	(0.00453)	(0.00984)	(0.00784)
State RPS	0.343	0.0714	0.603***	0.0373
	(0.492)	(0.232)	(0.224)	(0.0586)
log(RPS market potential)	0.0109	-0.0675***	-0.0136	-0.00333
	(0.0357)	(0.0131)	(0.0179)	(0.00437)
log(Home prices)	0.0227	-0.0327	-0.0162	-0.00235
	(0.0426)	(0.0223)	(0.0233)	(0.00861)
log(Population density)	0.0238	-0.000646	-0.00814	-0.00412
	(0.0218)	(0.0137)	(0.0101)	(0.00395)
log(Wind speed)	0.226	-0.0104		
	(0.144)	(0.0844)		
log(Solar radiation)			0.280	0.0436
			(0.262)	(0.0736)
RTO/year FE	Yes	Yes	Yes	Yes
DV mean	0.478	0.7	0.477	0.36
Observations	983	389	4,233	1,318

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

Withdrawn is a dummy indicating whether the project has withdrawn from the queue by the end of 2020. 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 3

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. 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 4

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

	(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
DV mean	0.15	0.309	0.068	0.04

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 had any wind or solar capacity in 2021 or 2010.

These results are estimated from equation (4).

Table 5

The Economic Geography of Wind and Solar Capacity

	(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. The lagged variables refer to their one-year lags.

These results are estimated from equation (5).

Table 6

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 by their predicted wind capacity in 2025.

Table 7

Productivity Time Trends for Wind Turbines and Solar Farms

	(1)	(2)	(3)	(4)
	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

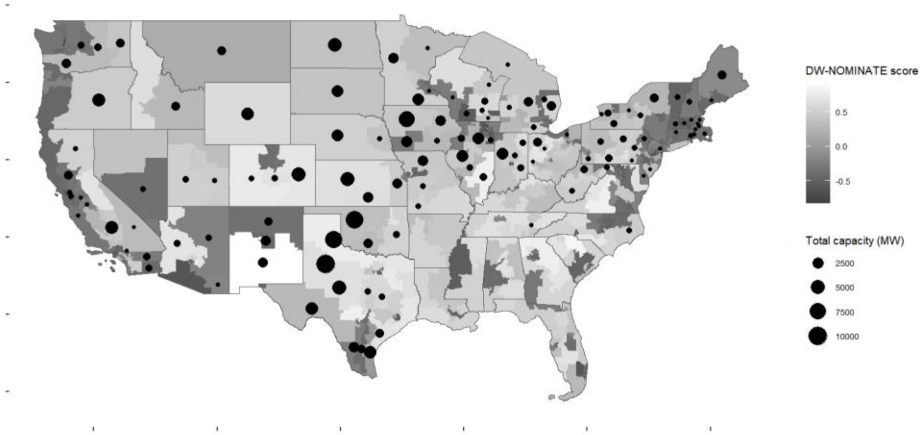
This table shows the estimation from equation (6).

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.

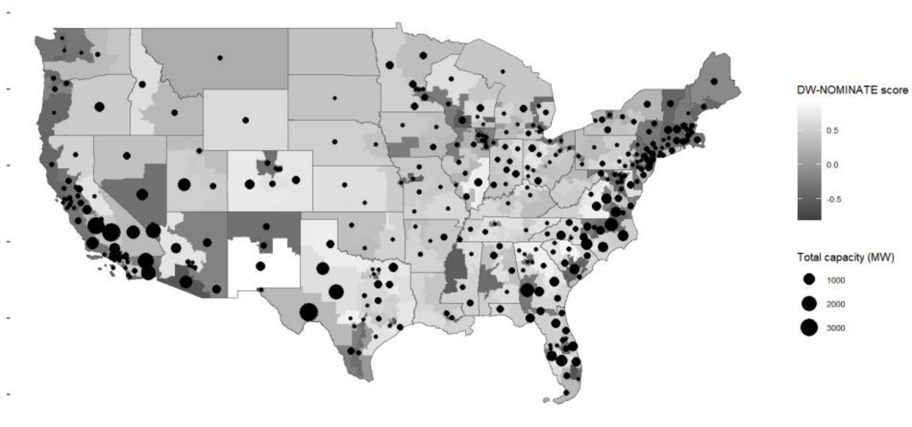
Figure 1

Renewable Capacity by Congressional Districts

(a) Wind



(b) Solar



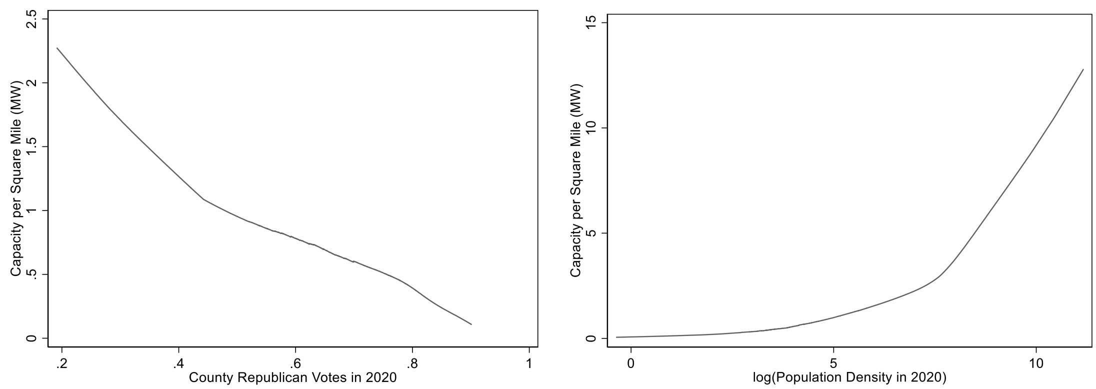
DW-NOMINATE is a continuous measure of political ideology, with -1 being the most progressive and 1 being the most conservative.

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.

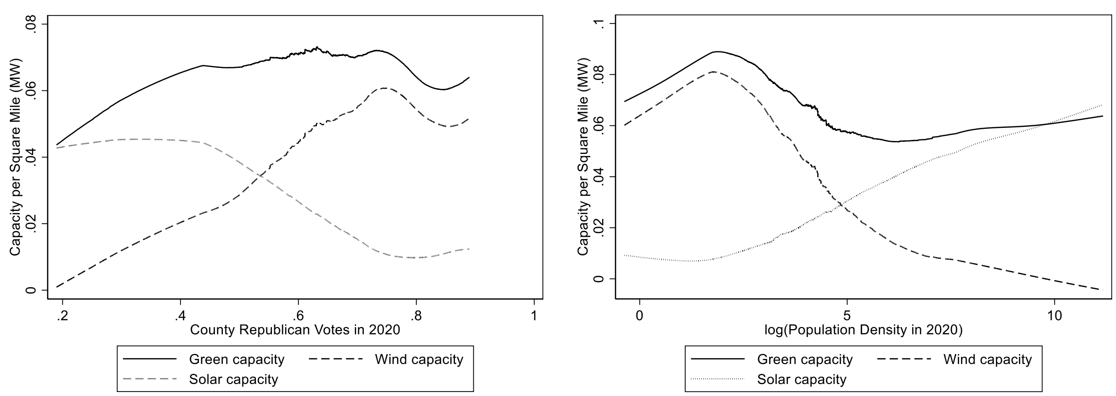
Figure 2

Power Plant Density and County Attributes

(a) Total capacity



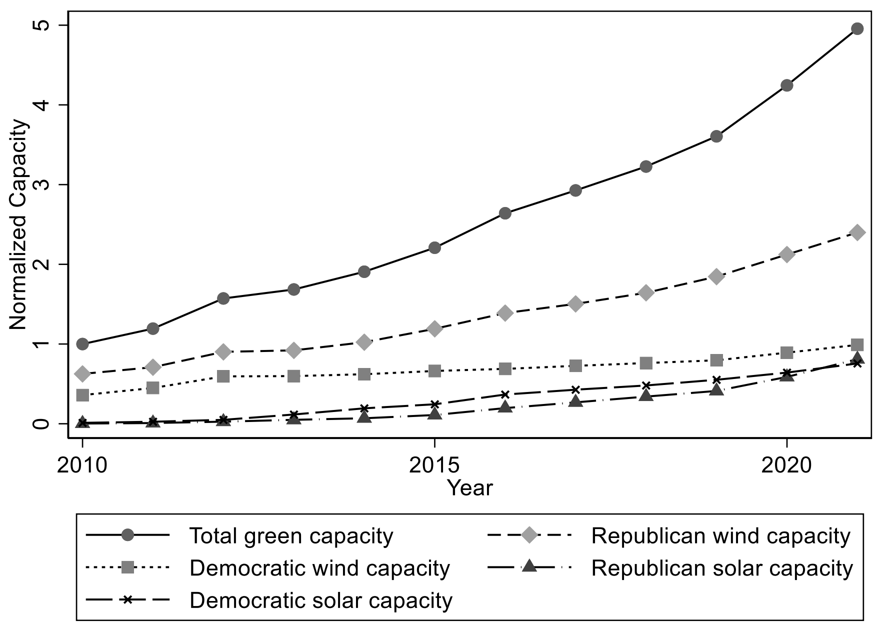
(b) Green capacity



When the explanatory variable is Republican votes, we drop the top and bottom 1% of the data, which correspond to a vote of 89% and 19%. When the explanatory variable is logged density, we drop the bottom 1%, which corresponds to 0.67 person/square mile.

Figure 3

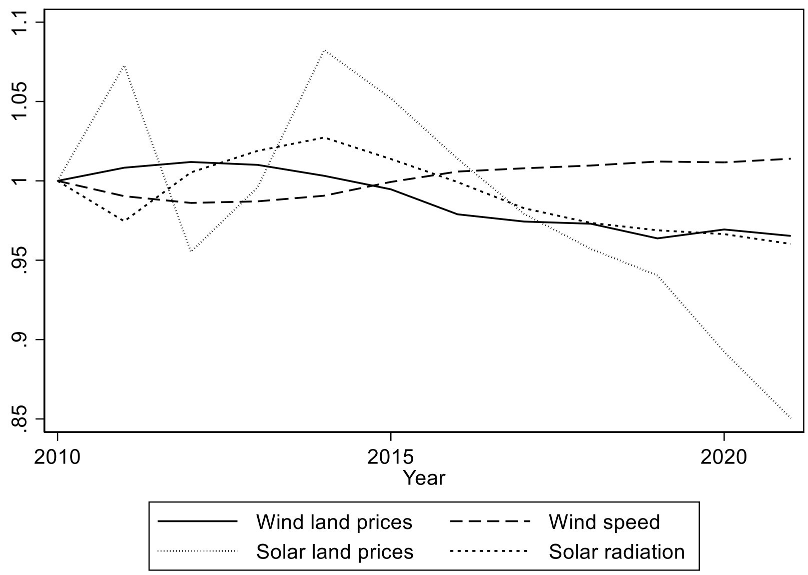
The Time Trend for Renewable Power Capacity



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?

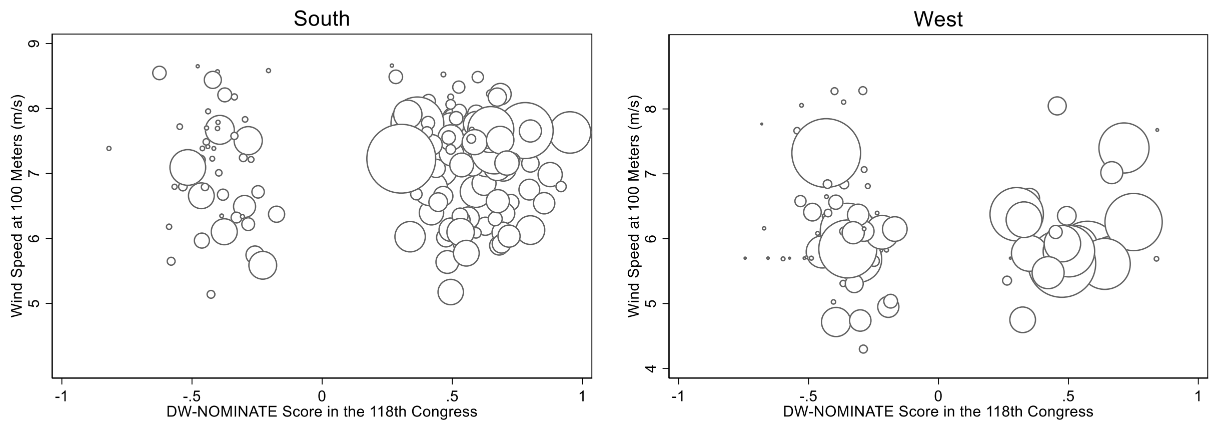


We plot land prices weighted by wind and solar capacity respectively, wind speed weighted by wind capacity, and solar radiation weighted by solar capacity. We normalize each weighted average to its value in 2010. We restrict our sample to congressional districts governed by a Republican in the 118th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

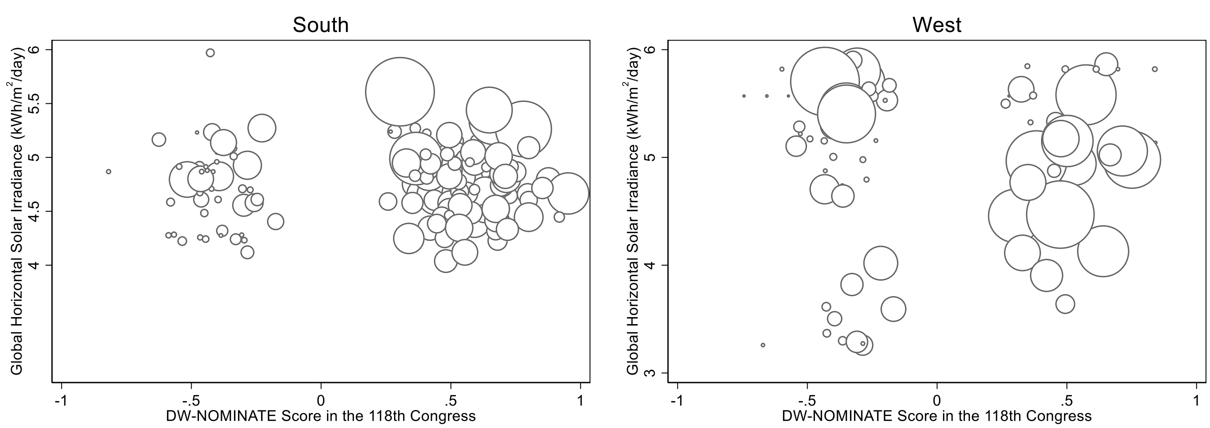
Figure 5

Wind and Solar Resources across Congressional Districts

(a) Wind speed



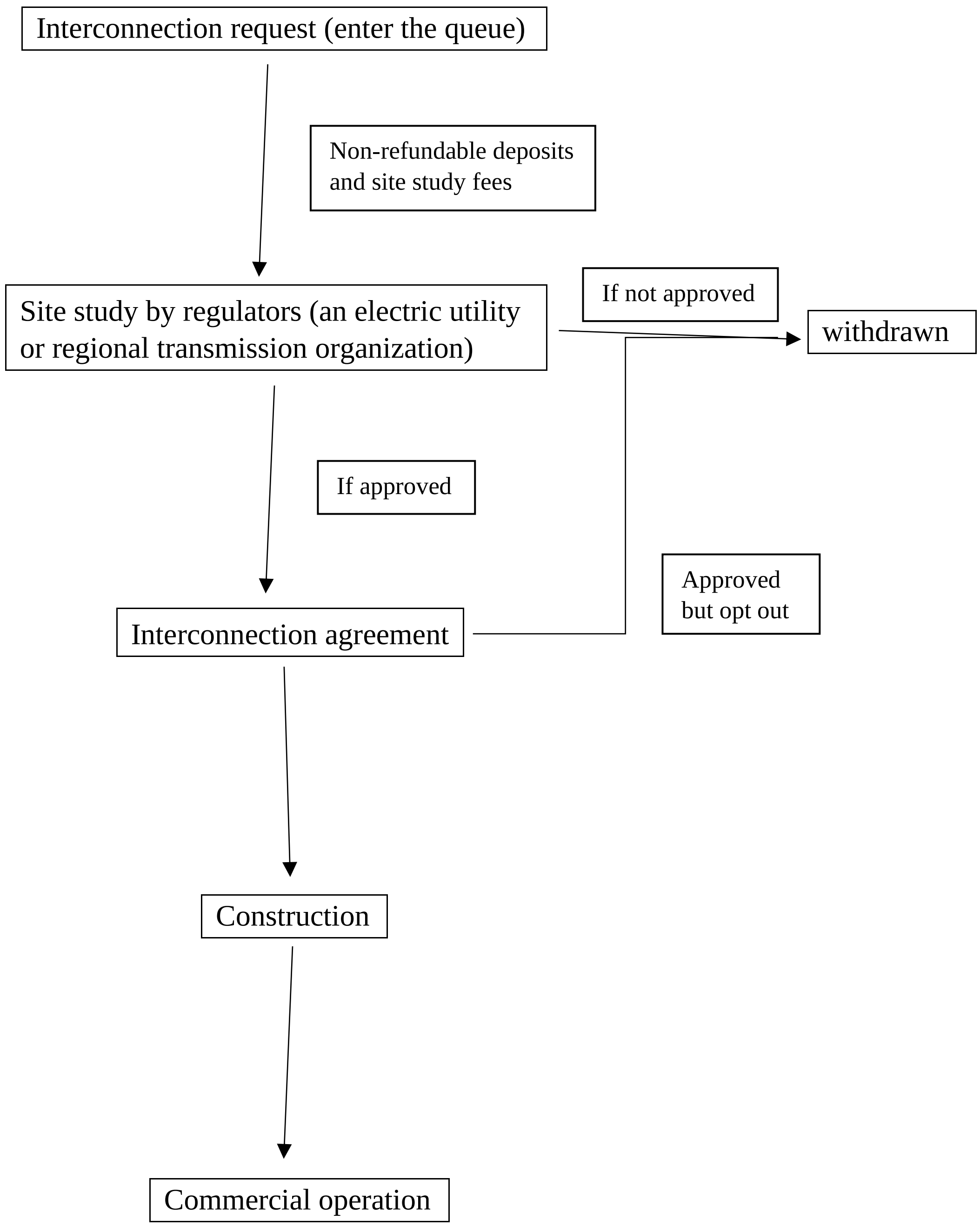
(b) Solar radiation



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

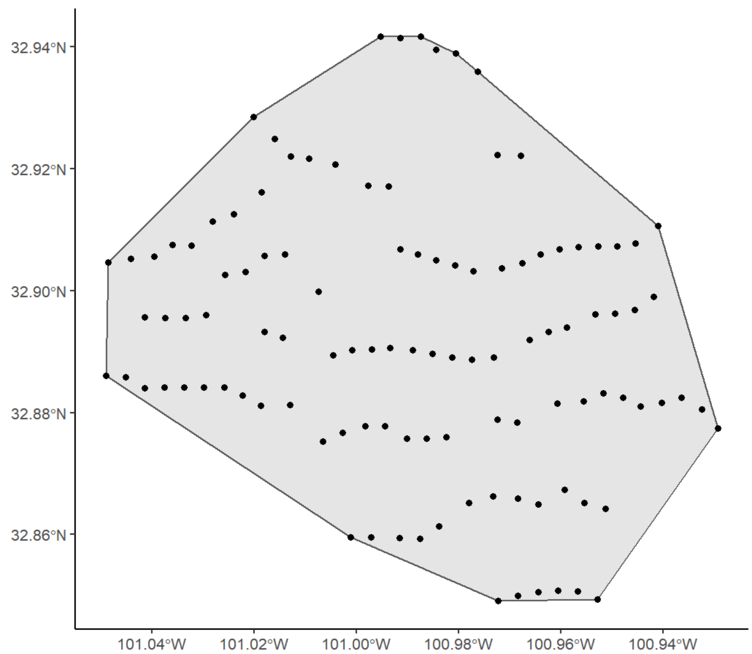
Interconnection Study Process



Appendix 2

Calculating the Area of Wind Farms

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.

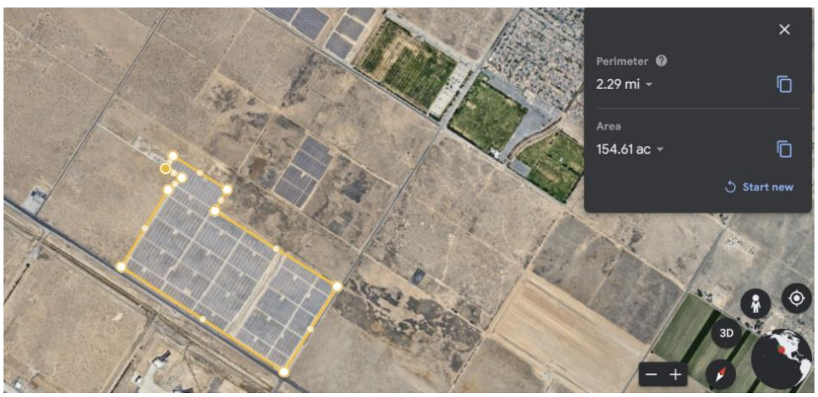


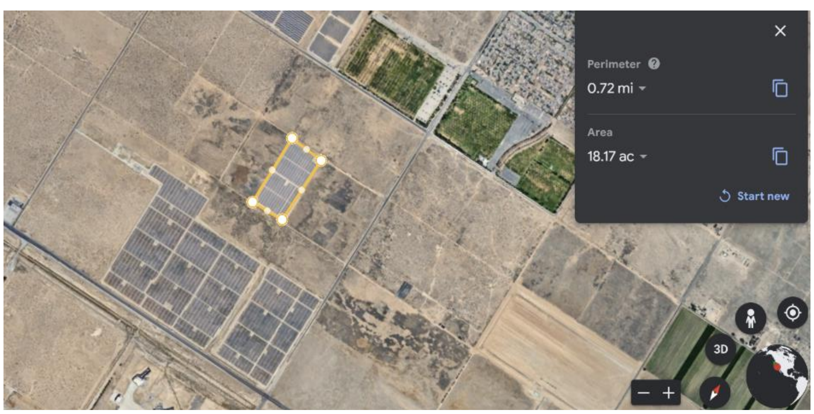
Appendix 3

Calculating the Area of Solar Farms

(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.