# Examining County-Level Restrictions on Large-Scale Solar Development in the United States

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## Abstract

As large-scale solar project development in the United States has taken off over the past two decades, so too has opposition at the state and local level. Counties, which predominantly hold zoning and siting authority over solar development, have increasingly adopted restrictive ordinances that hinder or outright prevent further activity. Prior research has identified the significant negative effects of county-level ordinances on solar development capacity and investment, as well as a range of drivers behind individual-level opposition to large-scale solar. This paper builds on these findings by considering drivers of behavior at the county-level, studying county characteristics that may be informed by individual attitudes and their relationship to restrictive ordinance outcomes.

Using a cross-sectional model, common factors between restrictive counties are identified at a given point in time, with significant positive relationships identified between operational large-scale solar projects, pending large-scale solar projects, median home value, and restriction outcomes, as well as a negative relationship with population density. A panel fixed effects model is then applied to examine how changes in these and other factors relate to restrictiveness over time, finding positive relationships with operational large-scale solar capacity and population density, and an especially strong positive relationship with the restrictiveness of a county's direct neighbors. These findings provide econometric backing to anecdotal evidence from large-scale solar developers, including emerging concerns around diffusion of restrictive policies across county borders, and identify directions for industry-relevant research going forward.

**JEL classification:** Q42, Q48, R52, C23

**Keywords:** Large-Scale Solar Development, Community Opposition, Renewable Energy

## 1. Introduction

Demand for electric power is on the rise across the United States and the wider world: expected to grow by an average of 3.5% annually through the end of the decade, electricity usage will increase 2.5 times faster than overall energy consumption, putting pressure on developed countries that have seen relatively little load growth over the past 15 years (International Energy Agency, 2026). Beyond its environmental and public health benefits (Wiser et al., 2016), solar energy adoption is well positioned to meet this growing demand. Worldwide, solar is set to continue its rapid deployment, growing from 8% of global electricity supply in 2025 to 15% in 2030, surpassing wind by 2026 and hydropower by 2029 (International Energy Agency, 2026). Despite recent policy headwinds (Morgan & Jenull, 2025; Plumer & Elliott, 2026), “utility-scale” solar additions are expected to continue their rapid growth in the US, with 43 GW of projected additions in 2026, a 60% year-over-year increase (U.S. Energy Information Administration, 2026). As US power demand spikes – driven in part by the rapid buildout of data centers, the demand for which is projected to comprise up to 12% of all US electricity consumption by 2028 (Shehabi et al., 2024) – the relatively short 4-6 year project development life cycle of utility scale solar makes it an attractive source of supply (R. Nilson et al., 2024).

Solar energy writ large enjoys bipartisan favor in the United States: although support has declined slightly since 2020, 91% of surveyed Democrats and 61% of surveyed Republicans favor more solar power, and 60% of all surveyed adults say that “expanding wind and solar is a more important priority than expanding fossil fuels” (Kennedy et al., 2025). However, support for solar development in local communities is another story, with residents citing a litany of concerns about bringing solar development to their backyards (Bessette et al., 2024; Carlisle et al., 2015; Uebelhor et al., 2021). This “social gap” between generic and local development is well-documented in regards to wind power (Bell et al., 2013), and is increasingly acknowledged with respect to solar (Crawford et al., 2022).

Importantly, not all sources of solar energy are created equal. Solar photovoltaic installations can be roughly divided into three categories: rooftop solar sited on individual properties, community solar built on a single site and "subscribed" to by a pool of users, and utility-scale solar owned and operated by private companies. Utility-scale, or "large-scale" in the literature and for the purposes of this paper, solar (LSS) represents over two thirds of US installed capacity, a proportion that is set to continue growing in coming years (U.S. Energy Information Administration, 2023). Given their comparative scale, LSS projects require a greater spatial footprint and have a fundamentally different relationship with the public than rooftop or community solar. Perhaps unsurprisingly, LSS development has been found to be viewed more negatively by communities than other forms of solar, suggesting an even wider social gap for this type of facility (R. S. Nilson & Stedman, 2022).

As US installed solar capacity has taken off, growing from 1 GW in 2008 to 279 GW in 2026 (SEIA, 2026; SEIA Comms Team, 2024), the solar social gap has increasingly manifested in state and local restrictions on LSS development. In 2023, nearly as many counties moved to block solar development as received their first project, and as of 2024, 15% of US counties had effectively halted development of wind, LSS, or both within their borders (Weise & Bhat, 2024). Solar professionals list community opposition and local ordinances or zoning as two of the top three causes of project cancellations (along with grid interconnection), with over 80% of surveyed respondents expressing concern that community opposition will hamstring decarbonization goals (R. Nilson et al., 2024).

As solar development continues to grow in volume and geographic scope, county behavior will be a key determinant of its pace and success. Individual attitudes towards solar development are well-documented, albeit not entirely consistent. Rather, this paper explores counties as the population of interest, seeking to understand why some counties choose to adopt more explicit and severe restrictions on LSS development. Understanding these factors could prove valuable for future LSS activity, helping developers assess which counties are at greater risk of adopting restrictive ordinances, and enabling further growth of a key energy resource.

# 2. Background

## 2.1 Large-Scale Solar Development in the United States

LSS development is a complex, capital intensive, multi-year process with multiple potential points of failure. For the purposes of this paper, it is helpful to understand the history and fundamentals of large-scale, frequently referred to as "utility-scale," project development. Solar developers begin by selecting a site through a combination of desktop research and in-person visits, screening for a variety of factors including abundant solar resource, absence of complicating environmental factors, and available electric infrastructure for connection to the grid (Raboin, 2026). Once a suitable site is identified, developers move to gain "site control" through leasing or purchasing a parcel, which is often when local communities first become aware of a potential LSS project (R. Nilson et al., 2024). From there, developers begin an in-depth assessment of the site, including a range of environmental and geotechnical studies, and move on to conceptual and engineering design (Energy Transitions Initiative, U.S. Department of Energy, 2021).

The next major point of community engagement occurs during the permitting process, in which developers must apply for zoning approvals and use permits from the relevant authority. Depending on the project, this process can vary in complexity: some sites may warrant special consideration for endangered species, wetlands impacts, review under the National Environmental Policy Act, or a variety of other potential environmental and social factors. Only then can developers request interconnection to the grid, a process fraught with delays and uncertainty that in some power markets has taken up to eight years (Weeks et al., 2025). If LSS projects survive the interconnection queue, developers complete detailed engineering designs and look to secure financing and construction contracts, another months-long process.

Construction itself is then relatively quick, taking a project through to "Commercial Operation Date" (COD), where it can begin delivering power to the grid.

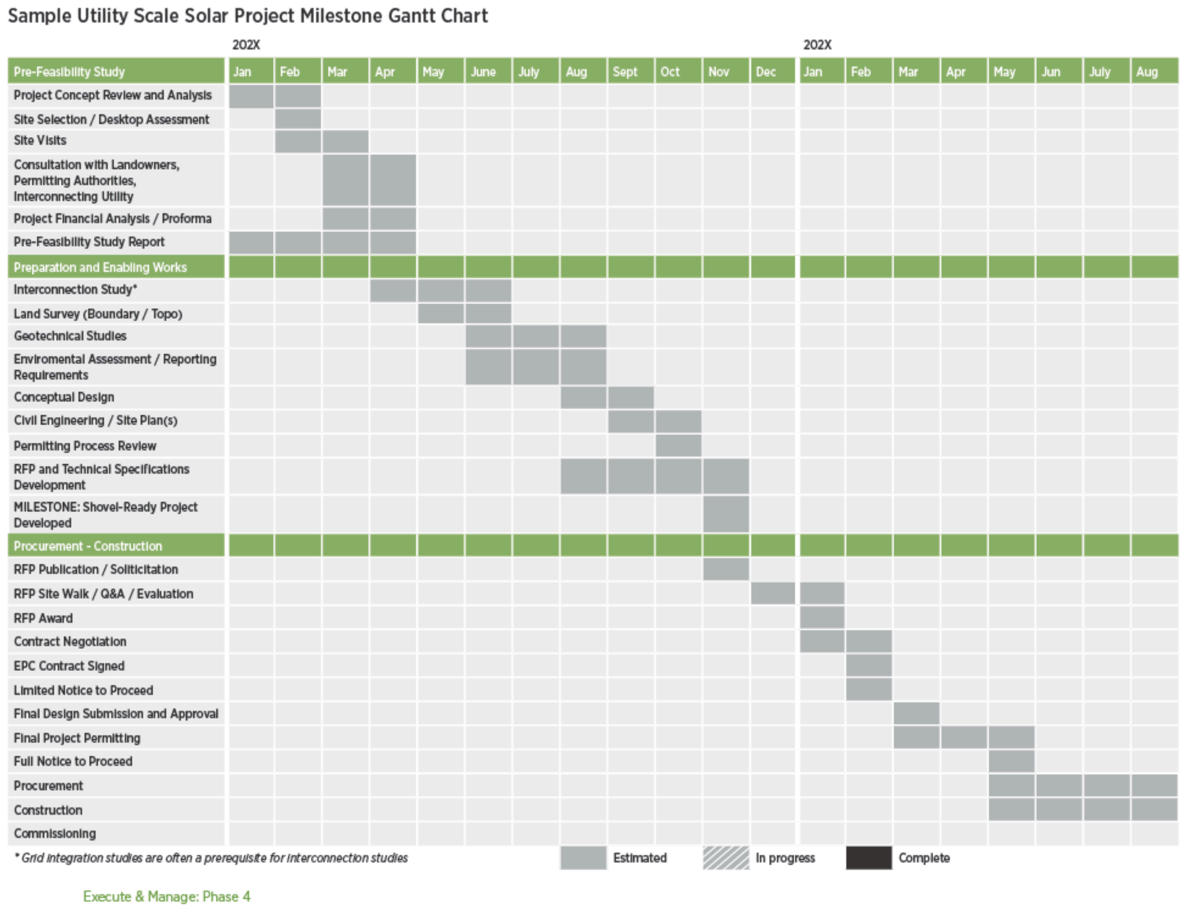


*Figure 1: Example LSS project development timeline from the Department of Energy's Office of Energy Efficiency and Renewable Energy, displaying the many stages of development and their potential timing (individual projects vary).*

LSS development at its current scale is a relatively recent phenomenon in the United States. Following the oil shock of the mid-1970s, Congress passed the Public Utility Regulatory Policies Act (PURPA) to support domestic energy efficiency and energy production in 1978. Among other provisions, PURPA directed utilities to purchase electricity from certain independent power producers (IPPs), who built and maintained "qualifying facilities" (QFs), including solar (Federal Energy Regulatory Commission, 2023). PURPA laid the groundwork for renewable development at scale, creating a guaranteed market for developers. Four years later, the first LSS project came online, with a total capacity of 1.1 MW (SEIA Comms Team, 2024). Even still, it took decades of research and development, supported by the Investment Tax Credit introduced in 2005, to drive down the cost of solar and enable the growth of the industry. The US reached 1 GW of installed capacity as recently as 2008, and has experienced exponential growth since then, adding ~43 GW of capacity in 2025 alone (Solar Energy Industries Association & Wood Mackenzie, 2026).

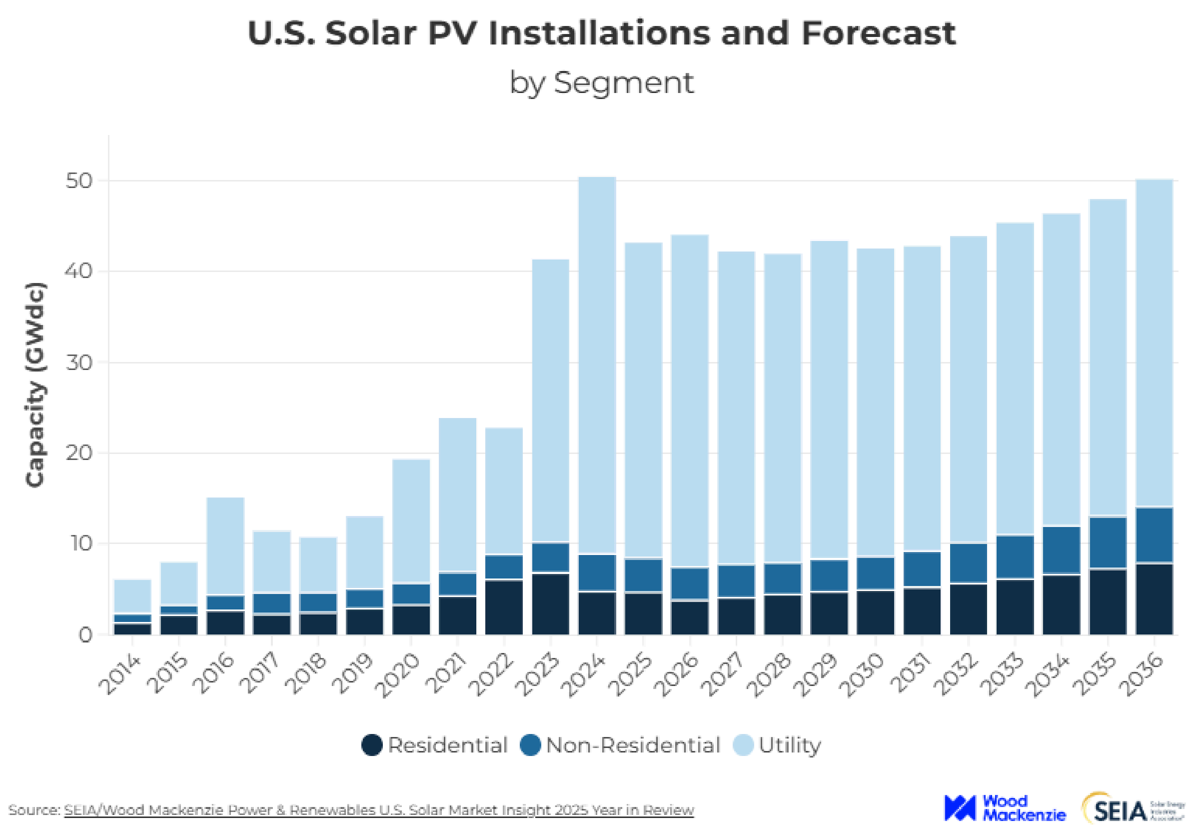


*Figure 2: Installed LSS capacity by year, historical through 2025 and projected for 2026 and beyond.*

Despite the industry's rapid growth, each individual LSS project is far from a sure thing. Each development stage represents a unique opportunity for failure, and even veteran renewable developers report cancelling at least a third of siting applications submitted in the past 5 years, and experiencing significant delays in half of all projects (R. Nilson et al., 2024). Of all the solar projects applying for interconnection between 2000 and 2018, only 10% of proposed capacity had been realized as of 2023, substantially less than for other energy resources (Rand et al., 2024).

**2.2 Local Opposition to Large-Scale Solar Development**

Although Americans largely approve of solar in general (Kennedy et al., 2025), opposition to LSS development at the community level is widespread and growing quickly. There are a range of documented reasons driving individuals and communities to become hostile towards LSS, from land use change to aesthetic concerns. These sentiments typically manifest either as backlash against a specific project, or in the use of zoning laws to restrict development activity. According to Columbia University's Sabin Center for Climate Change Law, which produces the nation's most comprehensive report of renewable opposition, "[b]y the end of 2024, at least 459 counties and municipalities across 44 states had adopted severe local restrictions on siting renewables," representing a 16% jump in just one year's time (Eisenson et al., 2025). This paper focuses on opposition codified through laws and ordinances, rather than opposition to specific projects.

Zoning is critical in the success or failure of LSS projects: without proper zoning, there is no legal basis for development. In the United States, zoning is largely a local matter, with over 40,000 local governments receiving delegated zoning power from their states (Nolon, 2015). States can fully delegate their zoning and siting authority to localities, delegate with contingent restrictions, or retain authority at the state level, with a clear majority of states opting for local control (Enterline et al., 2024). When states choose to delegate their zoning authority, there is evidence to suggest that this may empower LSS opponents, as local governments can be more directly held accountable by their constituencies (Hess et al., 2025). Counties and municipalities employ a range of restrictions on LSS development, from relatively minor setback requirements to outright bans (Appendix C contains a comprehensive list). Specific restrictions are not the only way of preventing development: by remaining silent on zoning for LSS, counties and municipalities that require explicit zoning standards for approval can also effectively block projects (Nolon, 2015).

# 3. Literature Review

## 3.1 Stated Reasons for Opposition to LSS Development

As renewable development and restrictive ordinances have increased, so has the body of work seeking to understand the sources and impacts of community opposition. Researchers have often sought to understand the reasons behind opposition to LSS development, with one study of the Midwestern US identifying aesthetic impact, decreased property values, reduction in agricultural lands, lack of positive local economic impacts, and assorted environmental issues as some of the most common concerns (Crawford et al., 2022). NIMBYism ("Not In My Back Yard"), while a convenient explanation for opposition, has been shown in one study of Southern California counties to be an oversimplification: opposition can be both informed and rational, although this is not always the case (Carlisle et al., 2015). Rural property values within half a mile of larger LSS projects, for example, were shown to suffer a 1.5% reduction compared to their peers, a common complaint among solar opponents (Elmallah et al., 2023). A national survey of resident attitudes around seven representative LSS sites also surfaced concerns about the development process itself, with residents feeling unaware or left out of proceedings, missing opportunities to provide feedback, lacking understanding about potential tax benefits, and feeling overwhelmed by the "sudden influx and needs of ex-local workers" to their communities (Bessette et al., 2024).

Public discourse around solar development has been shown to be complex, with many potential reasons to support or oppose further activity: one meta-analysis of articles mentioning solar identified as many as 20 relevant factors (Benetti et al., 2026). Among these, the following were most frequently identified as reasons for opposition: agricultural issues, power of energy companies, colonialism and extractivism, bureaucracy, finance, structure of electric power markets, and socio-economic impacts. A more narrowly scoped analysis within the Great Lakes region further demonstrated that narratives vary even around specific topics, such as "prime agricultural land," which along with several other issue areas has both positive and negative connotations within published articles: for example, concerns about loss of potential farmland versus interest in increased revenues from agrivoltaics (Uebelhor et al., 2021). A compiled list of potential reasons for opposition is provided in Appendix A.

### 3.2 Predictors of Opposition

Beyond broadly recognized reasons for opposition to renewable and LSS development, researchers have also attempted to identify predictors of opposition at the individual level, such as political leanings or socioeconomic status, with at times contradictory results across jurisdictions and time scales. One such study examined 1,184 wind energy projects across the US, demonstrating that opposition was more common for larger projects with taller, more numerous turbines, as well as those located in census tracts with higher White populations and lower Hispanic populations (Stokes et al., 2023). Interestingly, partisanship was not a significant predictor of wind project outcomes.

Turning to LSS, a survey of attitudes sampling from both the national population broadly and the Southwest specifically demonstrated that no demographic variables (race, education, age, urbanicity) were predictive of general support for solar development (Carlisle et al., 2015). However, when asked about LSS development in their county, both race and urbanicity became significant, with White respondents being more supportive and rural respondents being less supportive. Additionally, politically liberal respondents were more likely to support development in their counties, although this relationship was not demonstrated for development more generally.

Other studies have called into question the role of demographics in predicting local opposition. One survey of residents in upstate New York, for example, did not find a relationship between socio-demographic attributes, partisanship, or belief in climate change and opposition, but rather individual concerns around the impact of LSS development on the character and economic health of communities as driving factors (R. S. Nilson & Stedman, 2023). Another survey of Southern California residents found further evidence of less support for LSS developments nearby than for LSS in the US more generally, as well as a preference for LSS projects outside of residents' line of sight (Carlisle et al., 2016). Contrary to other work, this survey identified rural residents as more supportive of development than their suburban counterparts. For renewable energy development more broadly, a study based in Utah similarly found no significant relationship between urbanicity, education, political views, or religion and support for proximate activity (Larson & Krannich, 2016).

### 3.3 Impacts of Restrictive Ordinances

While consensus may not have emerged on what predicts individual opposition to local renewable and LSS development, the effects of restrictive ordinances have been clearly established. From a comprehensive national accounting of over 800 local solar ordinances, the impacts of which on available land were extrapolated and modeled, one study found that setbacks alone may be reducing available solar resources for development by up to 38% (Lopez et al., 2023). A more detailed investigation of agricultural lands in the Great Lakes region, surveying 2,474 solar ordinances at the county subdivision level, found that current zoning may have reduced LSS investment by 18% against the counterfactual without restrictive zoning ordinances (Owusu-Obeng et al., 2025). This study also sought to document the impact of "silent" ordinances, in which localities effectively prevent LSS development by not explicitly zoning for solar, finding that silence could be reducing available capacity by 31-59%.

Another nationwide survey found a significant relationship between types of ordinance and the odds of project cancellations, with counties implementing height restrictions realizing 5.7 times higher odds of experiencing at least one cancelled LSS project (Lee et al., 2026). Further, this survey identified counties that had yet to experience any LSS development, but had proactively adopted restrictive ordinances. These counties often shared borders with neighbors that had both experienced development and adopted ordinances, suggesting the possibility of "contagion," as has been demonstrated in utility-scale wind development (Lerner, 2022).

**3.4 Areas for Expansion**

Drivers of individual-level opposition to LSS development are well-documented, although existing literature is at times contradictory on what predicts hostile attitudes. The effects of restrictive county and municipal ordinances are clear, seriously hindering available LSS capacity and development outcomes. Existing research, however, has focused on the individual as the decision-making unit, rather than the county itself, and what may predict county-level behavior. Further, while private sector tools have sought to categorize jurisdictions as more or less friendly to LSS development, and made these findings available for purchase, the relative severity of county ordinances and what may predict these differences has yet to be studied. Through the application of econometric techniques, this paper seeks to identify the attributes of counties with more severe explicit restrictions on LSS development, with the goal of identifying relationships and their evolution over time.

# 4. Data

Based on current literature studying individual opposition (Bessette et al., 2024; Crawford et al., 2022), as well as public discourse around LSS development (Benetti et al., 2026; Uebelhor et al., 2021), a range of potential variables were identified which may contribute to the adoption of restrictive ordinances. As behavior has not previously been studied at the county level with respect to LSS restrictions, categories and variables of interest were also inferred from common reported points of failure in LSS development (R. Nilson et al., 2024). In total, 25 variables were assessed across six categories: Restrictive Ordinances, Socio-Demographics, Solar Development Pressure, Political Environment, Economic Structure, and Utility Structure. Using a combination of conceptual analysis and statistical techniques, variables with high multicollinearity or whose effects were better captured by other indicators were systematically eliminated, yielding 10 variables for the final specification. Six additional demographic controls beyond these 10 are used in robustness checks, which are available in Appendix B. Only complete county-year pairs are considered, resulting in slight variations in the number of counties considered between specifications.

### 4.1 Restrictive Ordinances

Data on county-level restrictions was accessed through the National Laboratory of the Rockies' Open Energy Data Initiative, which produces a comprehensive accounting of state and local zoning ordinances in the United States (Lopez et al., 2022). This data set was manually compiled from publicly available information, and as such may not capture every existing ordinance, but serves as an accepted baseline for ordinance-based research at the county level (Lopez et al., 2023). Of the 838 ordinances in the original data set, only 176 had years associated with their enactment. An additional 622 ordinances were able to be dated by reviewing publicly available zoning codes; however, these public records rarely track the evolution of ordinances over time, allowing only one enactment date to be assigned to each ordinance.

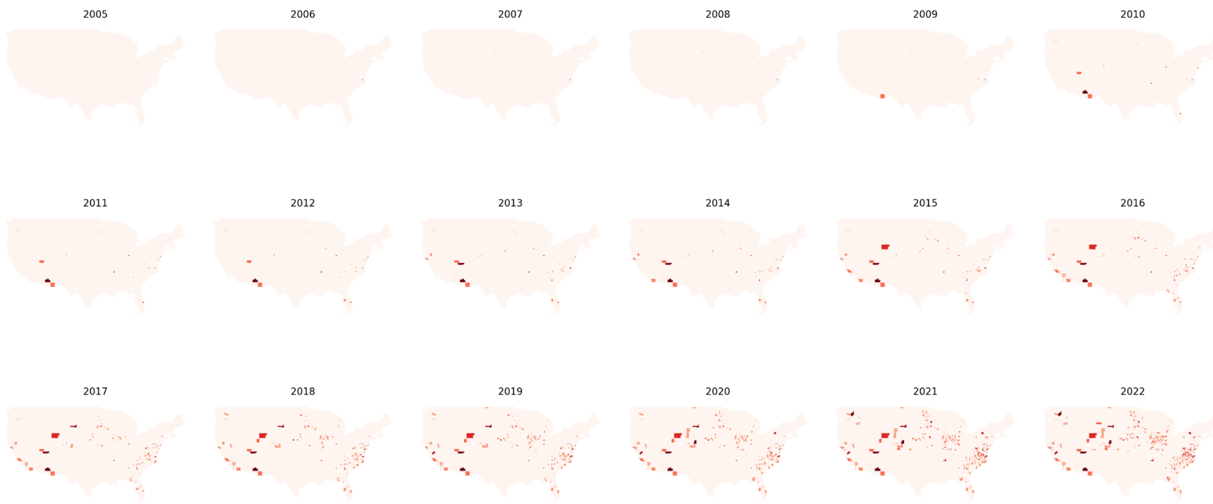


*Figure 3: County-level restrictive ordinances on LSS development by year, 2005-2022*

To operationalize this data, a unified restrictiveness score was then created for each county in each year from 2005 through 2022. Ordinance types were collapsed into the following major categories, reformatted to use consistent units, and normalized within each category for each county-year pair. For example, a setback requirement of 30.48 meters from the property line in Luzerne County, Pennsylvania, receives a normalized score of 0.19, relative to a maximum observed property line setback of 152.4 meters and a minimum of 1 meter across the entire data set.

*Table 1: Restrictive Ordinance Categories and Weightings*

| Type | Description | Units | Category | Weighting |
|---|---|---|---|---|
| Ban | Prohibition on LSS development | N/A | N/A | N/A |
| Coverage* | Maximum percent of lot covered | Percent | Site-based | 0.05 |
| Density** | Minimum spacing between solar panels | Meters | Site-based | 0.05 |
| Maximum Height* | Maximum array height | Meters | Height | 0.2 |
| Maximum Size* | Maximum lot size | Acres | Site-based | 0.05 |

| | | | | |
|---|---|---|---|---|
| Minimum Size** | Minimum installation size | Acres | Site-based | 0.05 |
| Noise* | Maximum allowed decibel level | dBA | Site-based | 0.05 |
| Setback – Highway** | Distance from highways | Meters | Landscape | 0.15 |
| Setback – Property** | Distance from property lines | Meters | Site-based | 0.05 |
| Setback – Road** | Distance from roads | Meters | Landscape | 0.15 |
| Setback – Waters** | Distance from waters and wetlands | Meters | Landscape | 0.15 |
| Setback – Structures** | Distance from structures | Meters | Landscape | 0.05 |

* denotes ordinances for which lower values are more restrictive (inverse normalization is used), ** denotes ordinances for which higher values are more restrictive.

Previous work has classified ordinances into site-based, landscape-feature setbacks, and height ordinances, finding statistically significant differences in effects on project cancellations between these categories (Lee et al., 2026). Drawing on this method, these categories were weighted by their expected contribution to LSS outcomes, based on the associated increase in cancellations found in previous research. Using these weights, a severity score was then constructed for each county-year pair. As more ordinances are added or "stacked" within the same county, the difficulty of development increases nonlinearly, which is not fully captured by the severity score. To account for this, a combined score was calculated as follows, where $\{1,...,K\}$ are the ordinance types, $s_i$ is the severity score, and $w_i$ are the category weights. The parameter λ represents the interaction of multiple restrictions: when λ is 0, there is no compounding or "stacking" effect, and when λ is 1, stacking is maximized, such that each restriction is considered to be fully independent and binding. A middle ground choice of 0.4 for the baseline specification represents a moderate degree of compounding across multiple restrictions. The α parameter determines how much weight is given to the severity score and how much weight is given to the stacking score: when α is 0, only stacking is considered, and when α is 1, only severity is considered. Similarly, a middle ground choice of 0.6 is used for the baseline.

$$Combined\ score = \alpha \sum_{i=1}^{K} w_i s_i + (1 - \alpha)\left[1 - \prod_{i=1}^{K}(1 - \lambda s_i)\right]$$

This combined score was then rescaled between 0 and 0.95, in which 0 represents no restrictions and 1 represents a complete ban, providing a scaled combined score for all county-year pairs. The maximum scaled combined score with counties not experiencing a full ban is capped at 0.95, to capture the step-up from a county with highly restrictive but still permissible ordinances to one with full prohibitions. Robustness checks with various values for parameters λ and α are available in Appendix B.

To investigate potential diffusion or "contagion" of ordinances between counties that share borders, which has been inferred from findings in recent research (Lee et al., 2026), a measure was constructed to capture the restrictiveness of neighboring counties, for each county-year pair. Using the US Census Bureau's County Adjacency File, borders were identified, and a weighted average score was constructed for each county based on the combined scores of its neighbors and the length of shared borders (U.S. Census Bureau, 2025a).

In some cases, when counties are "silent" on LSS zoning, this can also hinder development (Lee et al., 2026; Nolon, 2015). As such, minimal "restrictions" such as a one meter setback may actually be a sign that a county is attempting to encourage solar development, and should be scored as less restrictive than a county with no ordinances. To investigate this possibility, an alternate scoring measure was constructed, categorizing scores below the fifth percentile as negative. For example, a county with only a one meter setback receiving a restrictiveness score of 0.02 would instead receive a score of -0.02, while a county above the fifth percentile of restrictive ordinances would still receive a positive score. Full robustness checks using this variable are available in Appendix B.

Finally, the Open Energy Data Initiative has recently released an updated, 2025 version of its solar zoning ordinance database, produced with the help of large language models and at a greater degree of granularity than the 2022 edition (Castelão et al., 2025). Due to its very recent release, information not being available through 2025 for many predictors, and changes in format between the 2022 and 2025 editions, it was not possible to include this new data in the core specification. However, a first pass through the new edition, normalizing modified ordinance categories, was used to construct a roughly equivalent scaled combined score for 2025. Regressions based on this 2025 score are available in Appendix D.

### 4.2 Socio-Demographics

Demographic data at the county level was retrieved from the US Census Bureau's American Community Survey 5-Year Data, covering 2009-2024, via Python script using the publicly available API (U.S. Census Bureau, 2026). For the purposes of this paper, only data from 2009 through 2022 was used. Population density per square mile was calculated using Table B01003 and the US Census Bureau's Gazetteer Files, which provide county size (U.S. Census Bureau, 2025b). Demographic variables included in this study are selected based on prior use and significant results in studies of individual-level opposition to LSS development. Source tables for each variable are listed below.

*Table 2: ACS 5-Year Sources for Socio-Demographic Variables*

| Variable | Description | Source Table |
|---|---|---|
| Median Age | Median age of population | B01002 |
| % Hispanic | % Hispanic population | B03002 |
| % White | % White, non-Hispanic population | B03002 |
| % Female | % Female population | B01001 |
| % Bachelor's | % population with bachelor's degree or higher | S1501 |

| | | |
|---|---|---|
| Total Population | Total population | B01003 |

### 4.3 Solar Development Pressure

Cumulative capacity of operational LSS facilities, measured in megawatts, was collected from the US Energy Information Administration's Form EIA-860, which collects generator-level data on US power plants (U.S. Energy Information Administration, 2025a). Total LSS capacity entered into the interconnection queue was taken from the annual "Queued Up" report published by Lawrence Berkeley National Laboratory's Energy Technologies Area (Rand et al., 2025). Solar and solar + battery projects were included. Residential rooftop solar capacity data was taken from the "U.S. Distributed Solar and Storage" dataset, also maintained by the Energy Technologies Area (Barbose et al., 2025), and merged to the county level using the US Department of Housing and Urban Development Office of Policy Development and Research's "HUD-USPS ZIP Crosswalk Files" (U.S. Department of Housing and Urban Development, 2023). Counties typically adopt LSS restrictions in response to development pressure, proactively to forward renewable objectives, or potentially after observing restrictions enacted by their neighbors (Eisenson et al., 2025; Lee et al., 2026). As such, indicators of increasing solar development are relevant to include.

### 4.4 Political Environment

Vote share by party, a measure of political ideology, is calculated from the Massachusetts Institute of Technology's Election Data and Science Lab, specifically county-level presidential election returns (MIT Election Data and Science Lab, 2026). Given the multicollinearity of Republican and Democrat vote share, Republican vote share is used. Turnout data is calculated using total votes from the MIT data, divided by the Citizen Voting Age Population reported by the US Census Bureau in the American Community Survey in Table B05003 (U.S. Census Bureau, 2026). Political ideology and partisanship have previously been observed to be relevant to local LSS support or opposition, as well as to support for solar more generally (Carlisle et al., 2015; Kennedy et al., 2025). Voter turnout may be indicative of a county's political efficacy and ability to act on ideology.

**4.5 Economic Structure**

Average annual employment level in NAICS 11 (Agriculture, forestry, fishing and hunting) professions, intended to represent agricultural and related activity, was calculated from the US Bureau of Labor Statistics' Quarterly Census of Employment and Wages (U.S. Bureau of Labor Statistics, 2023). Disruption to agricultural land and practices has previously been studied as a source for opposition, making it relevant to include (Crawford et al., 2022). Employment data is taken from the Bureau of Labor Statistics' Local Area Unemployment Statistics and examined on an annual average basis (U.S. Bureau of Labor Statistics, 2025). LSS projects carry direct benefits in terms of employment opportunities, although involved workers may not always be local, and can also provide economic benefits through various tax structures (Gold & Mills, 2021). Median rent, income, and home values are similarly retrieved from US Census Bureau's American Community Survey 5-Year Data, with individual source tables listed below (U.S. Census Bureau, 2026). Property values have previously been demonstrated to be impacted by LSS development in specific cases, and median income and rent are also relevant markers of a county's economic structure (Elmallah et al., 2023).

*Table 3: ACS 5-Year Sources for Economic Structure Variables*

| Variable | Description | Source Table |
| --- | --- | --- |
| Median Household Income | Median household income, adjusted for inflation | B19013 |
| Median Home Value | Median home value, adjusted for inflation | B25077 |

| | | |
|---|---|---|
| Median Rent | Median gross rent, adjusted for inflation | B25064 |

Debt per pupil is taken from the National Center for Education Statistics' "Elementary/Secondary Information System" and mapped to counties using its "School District Geographic Relationship Files" (National Center for Education Statics, 2022, 2025). Long term debt outstanding at the end of the fiscal year across enrolled students is used, excluding adult education students. As LSS developers may contribute to local services through "Payments in Lieu of Taxes" (PILOTs), fiscal stress may increase the value proposition of an LSS project.

**4.6 Utility Structure**

Weighted average residential electricity price was collected from the US Energy Information Administration's Form EIA-861, which surveys US electric utilities for a range of information, including revenues, service territories, and quantity of electricity sold (U.S. Energy Information Administration, 2025b). Together, this information was used to construct the realized residential electricity price faced by the customers of each utility, weighted by sales volume into that county. For the purpose of simplicity, bundled sales were used, and only observed rates were included. Using this same data, the percent of each county's sales volume served by an investor-owned utility, as opposed to a public or municipal utility or electric cooperative, was also calculated. Electricity prices and utility structure have been consistently cited as relevant in LSS discourse.

**4.7 Summary Statistics**

*Table 4: Descriptions of Variables*

| Variable | Description | Cat. | Source |
|---|---|---|---|
| Scaled Combined Score | Constructed restrictiveness score | RO | NLR OEDI |
| Neighbor Restrictions | Weighted average of restriction scores of neighboring counties, by length of shared border | RO | NLR OEDI |

| | | | |
|---|---|---|---|
| Invert 5th Percentile | Scaled combined scores greater than 0 and less than 5th percentile of restrictiveness are negative | RO | Calculation |
| Invert 10th Percentile | Scaled combined scores greater than 0 and less than 10th percentile of restrictiveness are negative | RO | Calculation |
| 2025 Score | Proxy Scaled Combined Score constructed using 2025 data | RO | NLR OEDI |
| Population Density† | People per square mile | SD | Census Bureau |
| Median Age | Median age of population | SD | Census Bureau |
| % Hispanic | % Hispanic population | SD | Census Bureau |
| % White | % White, non-Hispanic population | SD | Census Bureau |
| % Female | % Female population | SD | Census Bureau |
| % Bachelor's | % population with bachelor's degree or higher | SD | Census Bureau |
| Total Population† | Total population | SD | Census Bureau |
| Operational LSS Capacity† | Cumulative LSS projects in operation (MW) | SDP | EIA |
| LSS in Interconnection Queue† | LSS capacity in interconnection queue (MW) | SDP | LBNL |
| Rooftop Solar Capacity† | Cumulative residential rooftop solar capacity (kW) | SDP | LBNL |
| Republican Vote Share | Percent Republican presidential vote share in last election | PE | MIT |
| Voter Turnout | Percent voters compared to Citizen Voting Age Population | PE | MIT |
| Median Household Income† | Median household income, adjusted for inflation | ES | Census Bureau |
| Median Home Value† | Median home value, adjusted for inflation | ES | Census Bureau |
| Agricultural Employment Level† | Average level of employment in NAICS 11 fields | ES | BLS |
| % Unemployment | % of population unemployed | ES | BLS |
| Median Rent† | Median gross rent, adjusted for inflation | ES | Census Bureau |
| Debt Per Pupil† | Long term debt outstanding at end of fiscal year per students | ES | NCES |
| Residential Electricity Price | Realized residential electricity price, $/kWh | US | EIA |
| Share IOU | Share of sales volume served by investor-owned utility | US | EIA |

† denotes logarithmic transformation to reduce right-skewness. Categories are Restrictive Ordinances (RO), Socio-Demographics (SD), Solar Development Pressure (SDP), Political Environment (PE), Economic Structure (ES), and Utility Structure (US). Variables constructed solely for robustness checks of λ and α are not listed here.

*Table 5: Summary Statistics of Variables*

| Variable | Obs. | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| Scaled Combined Score | 39,050 | 0.0119 | 0.0744 | 0 | 1 |
| Neighbor Restrictions | 39,050 | 0.0122 | 0.043 | 0 | 0.59 |
| Invert 5th Percentile | 39,050 | 0.0119 | 0.0744 | -0.02 | 1 |
| Invert 10th Percentile | 39,050 | 0.0118 | 0.0744 | -0.04 | 1 |
| 2025 Score | 2,973 | 0.0780 | 0.1995 | 0 | 1 |
| Population Density† | 39,050 | 3.8143 | 1.6922 | -1.5141 | 11.207 |
| Median Age | 39,050 | 40.9569 | 5.2224 | 21.5 | 68.3 |
| % Hispanic | 39,050 | 0.0892 | 0.1356 | 0 | 0.99 |
| % White | 39,050 | 0.7739 | 0.1954 | 0.01 | 1 |
| % Female | 39,050 | 0.4996 | 0.0229 | 0.19 | 0.59 |
| % Bachelor's | 39,050 | 0.2073 | 0.0942 | 0.01 | 0.768 |
| Total Population† | 39,050 | 10.310 | 1.4507 | 5.3891 | 16.129 |
| Operational LSS Capacity† | 39,050 | 0.4151 | 1.114 | 0 | 8.3642 |
| LSS in Interconnection Queue† | 39,050 | 0.6685 | 1.731 | 0 | 9.0417 |
| Rooftop Solar Capacity† | 39,050 | 1.6737 | 2.902 | 0 | 14.193 |
| Republican Vote Share | 39,050 | 0.6154 | 0.1528 | 0.04 | 0.96 |
| Voter Turnout | 39,050 | 0.5861 | 0.0992 | 0.02 | 1 |
| Median Household Income† | 39,050 | 10.786 | 0.2633 | 9.8507 | 12.046 |
| Median Home Value† | 39,050 | 11.937 | 0.4622 | 10.147 | 14.181 |
| Agricultural Employment Level† | 39,050 | 2.5275 | 2.5793 | 0 | 10.975 |
| % Unemployment | 39,050 | 0.0597 | 0.0279 | 0.011 | 0.291 |
| Median Rent† | 39,050 | 6.7346 | 0.2481 | 4.8276 | 7.9407 |
| Debt Per Pupil† | 39,050 | 7.6756 | 2.6782 | 0 | 13.5016 |
| Residential Electricity Price | 39,050 | 0.1184 | 0.0259 | 0.03 | 0.43 |
| Share IOU | 39,050 | 0.7528 | 0.3645 | 0 | 1 |

† denotes logarithmic transformation to reduce right-skewness. Variables constructed for robustness checks of λ and α are not listed here.

# 5. Methods

From the broader set of variables considered in the previous section, a combination of conceptual and econometric techniques are used to select the most relevant for the final specifications. Relationships between selected variables and restrictive ordinance outcomes are then examined through multiple lenses, seeking to capture the various ways in which county characteristics may influence LSS restriction outcomes. As several data sets are available only starting in 2009 or 2010, and the OEDI restrictive ordinance data set ends in 2022, a sample period of 2010 through 2022 is used. This is consistent with both the relatively small volume of development and restrictive ordinances prior to 2010 and the rapid acceleration of LSS development thereafter.

First, a cross-sectional OLS model examines variation between counties in the most recent modeled year, 2022, looking to identify common characteristics of counties with restrictions. Next, a lagged cross-sectional OLS model considers how past county characteristics predict restriction outcomes over the long term, using 2010 conditions and 2022 outcomes. Then, a first-differences specification of the panel model examines the change in both characteristics and restrictiveness between 2010 and 2022. Finally, a full panel fixed effects model considers within-county variation over time for each year between 2010 and 2022, a specification that is likely most relevant to LSS developers and other interested parties.

## 5.1 Variable Selection

To address multicollinearity between studied variables, both pairwise correlations and variance inflation factors (VIFs) were computed. When highly correlated variables were found that captured similar underlying concepts, those with the strongest conceptual justification or empirical performance were retained. To measure population pressure and urbanicity, Population

Density was retained while Total Population was not, as Population Density accounts more accurately for variations in county size. Median Rent, Median Home Value, and Median Income are all closely correlated: as the literature contains established impacts of LSS development on property values, as well as evidence that residents are highly concerned about property value impacts, Median Home Value is retained (Crawford et al., 2022; Elmallah et al., 2023). Rooftop Solar Capacity was also correlated with Median Home Value, and as the literature demonstrates that rooftop, community, and utility-scale solar are understood by residents as separate categories, was not retained (R. S. Nilson & Stedman, 2022).

Conceptually, Debt Per Pupil was also not retained, as the link between LSS development and municipal funding, especially for education versus other priorities like emergency response, is tenuous. % Unemployment is a shorter-term measure whose variation is more related to broader macroeconomic trends than structural differences between counties, and was determined not to be the best measure of economic conditions. Finally, socio-demographic and political environment variables including Median Age, % Hispanic, % White, % Female, % Bachelor's, and Republican Vote Share, which are frequently employed as controls in related literature, were categorized as further controls for robustness checks, as their inclusion or exclusion had very minimal effect on coefficients, statistical significance, or $R^2$ values. Further information regarding robustness checks is available in Appendix B.

*Table 6: Variables in Final Specifications*

| **Variable** | **Description** | **Cat.** | **Source** |
|---|---|---|---|
| Scaled Combined Score | Constructed restrictiveness score | RO | NLR OEDI |
| Neighbor Restrictions | Weighted average of restriction scores of neighboring counties, by length of shared border | RO | NLR OEDI |
| Population Density† | People per square mile | SD | Census Bureau |
| Operational LSS | Cumulative LSS projects in operation (MW) | SDP | EIA |

| | | | |
|---|---|---|---|
| Capacity† | | | |
| LSS in Interconnection Queue* | LSS capacity in interconnection queue (MW) | SDP | LBNL |
| Voter Turnout | Percent voters compared to Citizen Voting Age Population | PE | MIT |
| Median Home Value† | Median home value, adjusted for inflation | ES | Census Bureau |
| Agricultural Employment Level† | Average level of employment in NAICS 11 fields | ES | BLS |
| Residential Electricity Price | Realized residential electricity price, $/kWh | US | EIA |
| Share IOU | Share of sales volume served by investor-owned utility | US | EIA |
| Median Age‡ | Median age of population | SD | Census Bureau |
| % Hispanic‡ | % Hispanic population | SD | Census Bureau |
| % White‡ | % White, non-Hispanic population | SD | Census Bureau |
| % Female‡ | % Female population | SD | Census Bureau |
| % Bachelor's‡ | % population with bachelor's degree or higher | SD | Census Bureau |
| Republican Vote Share‡ | Percent Republican presidential vote share in last election | PE | MIT |

† denotes logarithmic transformation to reduce right-skewness. Categories are Restrictive Ordinances (RO), Socio-Demographics (SD), Solar Development Pressure (SDP), Political Environment (PE), Economic Structure (ES), and Utility Structure (US). ‡ denotes demographic controls.

### 5.2 Cross-Sectional Model

The cross-sectional model investigates potential common characteristics between counties that had adopted more restrictive LSS ordinances in 2022, the final modeled year. The dependent variable in this model, as well as in the other models and specifications, is Scaled Combined Score, representing the relative severity of a county's restrictions. This model seeks to determine if there are factors that, as of 2022, are indicative of a county being more likely to have adopted more severe LSS development restrictions.

$$ScaledCombinedScore_{i,2022} = \beta_1 NeighborRestrictions_{i,2022} + \beta_2 log(PopulationDensity_{i,2022})$$

$$+ \beta_3 log(OperationalLSSCapacity_{i,2022})$$
$$+ \beta_4 log(LSSinInterconnectionQueue_{i,2022})$$
$$+ \beta_5 Turnout_{i,2022}$$
$$+ \beta_6 log(MedianHomeValue_{i,2022})$$
$$+ \beta_7 log(AgriculturalEmploymentLevel_{i,2022})$$
$$+ \beta_8 ResidentialElectricityPrice_{i,2022}$$
$$+ \beta_9 ShareIOU_{i,2022}$$
$$+ \gamma_s + \varepsilon_i$$

Counties are represented by $i$, states are represented by $s$, state fixed effects are represented by $\gamma_s$, and the error term is $\varepsilon_i$. State fixed effects are included to control for unobserved differences between states, including policy choices regarding renewable energy along with decisions on siting and zoning authority. Standard errors are clustered by state to account for correlated shocks across counties within the same state.

**5.3 Lagged Cross-Sectional Model**

The lagged cross-sectional model uses 2010 values for predictors, and 2022 values for Scaled Combined Score, to examine whether baseline characteristics at the beginning of the period are related to restrictiveness outcomes at the end of the period.

$$ScaledCombinedScore_{i,2022} = \beta_1 NeighborRestrictions_{i,2010}$$
$$+ \beta_2 log(PopulationDensity_{i,2010})$$
$$+ \beta_3 log(OperationalLSSCapacity_{i,2010})$$
$$+ \beta_4 log(LSSinInterconnectionQueue_{i,2010})$$
$$+ \beta_5 Turnout_{i,2010}$$
$$+ \beta_6 log(MedianHomeValue_{i,2010})$$

$$+ \beta_7 log(AgriculturalEmploymentLevel_{i,2010})$$
$$+ \beta_8 ResidentialElectricityPrice_{i,2010}$$
$$+ \beta_9 ShareIOU_{i,2010}$$
$$+ \gamma_s + \varepsilon_i$$

As before, counties are represented by $i$, states are represented by $s$, state fixed effects are represented by $\gamma_s$, and the error term is $\varepsilon_i$. State fixed effects are again included to control for unobserved differences between states, and standard errors are clustered to account for correlated shocks across counties within states.

**5.4 First-Differences Specification**

The first-differences specification looks to understand the relationship that changes in county characteristics have with changes in restrictiveness, both from the beginning to the end of the sample period. This specification is focused on how within-county changes over time may potentially impact restrictiveness outcomes.

$$\Delta ScaledCombinedScore_i = \quad \beta_1 \Delta NeighborRestrictions_i$$
$$+ \beta_2 \Delta log(PopulationDensity_i)$$
$$+ \beta_3 \Delta log(OperationalLSSCapacity_i)$$
$$+ \beta_4 \Delta log(LSSinInterconnectionQueue_i)$$
$$+ \beta_5 \Delta Turnout_i$$
$$+ \beta_6 \Delta log(MedianHomeValue_i)$$
$$+ \beta_7 \Delta log(AgriculturalEmploymentLevel_i)$$
$$+ \beta_8 \Delta ResidentialElectricityPrice_i$$
$$+ \beta_9 \Delta ShareIOU_i$$
$$+ \varepsilon_i$$

where $\Delta X_i = X_{i,2022} - X_{i,2010}$

Counties are represented by $i$, states are represented by $s$, the error term is $\varepsilon_i$, and differences are calculated between 2010 and 2022 values. Fixed effects are accounted for via differencing, and standard errors are again clustered to account for correlated shocks across counties within states.

**5.5 Panel Fixed Effects Model**

The final specification is a panel fixed effects model using annual data from 2010 to 2022. County fixed effects are included to control for time-invariant differences across counties, and year fixed effects control for shocks experienced by all counties in a given year, such as national policy changes or macroeconomic events.

$$
\begin{aligned}
ScaledCombinedScore_{it} = \quad & \beta_1 NeighborRestrictions_{it} \\
& + \beta_2 log(PopulationDensity_{it}) \\
& + \beta_3 log(OperationalLSSCapacity_{it}) \\
& + \beta_4 log(LSSinInterconnectionQueue_{it}) \\
& + \beta_5 Turnout_{it} \\
& + \beta_6 log(MedianHomeValue_{it}) \\
& + \beta_7 log(AgriculturalEmploymentLevel_{it}) \\
& + \beta_8 ResidentialElectricityPrice_{it} \\
& + \beta_9 ShareIOU_{it} \\
& + \gamma_i + \delta_t + \varepsilon_{it}
\end{aligned}
$$

Counties are represented by $i$, years are represented by $t$, county fixed effects are represented by $\gamma_i$, and year fixed effects are represented by $\delta_t$. Standard errors are similarly clustered at the state level to account for correlated shocks across counties within the same state.

# 6. Results

## 6.1 Summary of Findings

*Table 8: Comparison of Regression Coefficients Across Model Specifications*

| Variable | Cross-Sectional | Lagged Cross-Sectional | First-Differences | Panel Fixed Effects |
|---|---|---|---|---|
| Neighbor Restrictions | 0.059 | 0.324 | 0.304*** | 0.213*** |
| Log Population Density | -0.006** | -0.003 | 0.051*** | 0.044** |
| Log Operational LSS Capacity | 0.007** | -0.13 | 0.007** | 0.006** |
| Log LSS in Interconnection Queue | 0.005*** | 0.009** | 0.003* | 0.001 |
| Voter Turnout | 0.011 | 0.022 | 0.091* | 0.039 |
| Log Median Home Value | 0.030*** | 0.017* | -0.038* | -0.021* |
| Log Agricultural Employment Level | -0.001 | 0.000 | -0.001 | -0.000 |
| Residential Electricity Price | 0.136 | -0.012 | 0.003 | 0.033 |
| Share IOU | -0.004 | -0.001 | -0.025 | -0.018 |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

Effect sizes are calculated as the product of each predictor's coefficient and its standard deviation, the full results and methodology of which can be found in Appendix D. For interpretability, effect sizes are further standardized as a percent of the standard deviation of Scaled Combined Score within each specification. All effect sizes are reported in this section on a relative basis to effect sizes of other predictors, as the specific meaning of each effect size changes across specifications.

## 6.2 Cross-Sectional Model

*Table 9: Regression Results from Cross-Sectional Model, 2022 Scores and Variables*

| Variable | Coefficient | Standard Error | t-Statistic |
|---|---|---|---|
| Neighbor Restrictions | 0.059 | 0.080 | 0.74 |

| | | | |
|---|---|---|---|
| Log Population Density | -0.006** | 0.003 | -2.17 |
| Log Operational LSS Capacity | 0.007** | 0.003 | 2.64 |
| Log LSS in Interconnection Queue | 0.005*** | 0.002 | 3.05 |
| Voter Turnout | 0.011 | 0.023 | 0.49 |
| Log Median Home Value | 0.030*** | 0.008 | 3.79 |
| Log Agricultural Employment Level | -0.001 | 0.001 | -0.82 |
| Residential Electricity Price | 0.136 | 0.155 | 0.88 |
| Share IOU | -0.004 | 0.008 | -0.058 |
| **Model Statistics** | | | |
| Observations | 2,973 | | |
| R-squared | 0.139 | | |
| State Fixed Effects | Yes | | |
| Year Fixed Effects | No | | |
| Clustered Standard Errors | State | | |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

The cross-sectional specification examines key characteristics of counties in the final studied year, and their potential relationship to restriction outcomes in that year, providing a "snapshot" of the LSS development and restriction landscape in 2022. As state policy environments differ greatly at any one point in time, it is helpful to include state fixed effects, focusing this specification on cross-county, within-state variation. Operational LSS Capacity, LSS in Interconnection Queue, and Median Home Value are all found to have a statistically significant, positive effect on restrictiveness, with substantial effect sizes. This suggests that counties with higher levels of LSS activity in 2022, both realized and pending, are more likely to have adopted more restrictive ordinances, potentially due to greater exposure to LSS in general. Additionally, counties with higher median home values, which also proxy for other markers of a county's economic health, appear more likely to have more restrictive zoning laws. It is possible this is motivated by a desire to “protect” property values on the part of homeowners, which has some grounding in the literature. Finally, Population Density is found to have a statistically significant, negative effect, suggesting that higher population density or more urban environments are less likely to be restrictive in 2022, with a similarly substantial effect size.

### 6.3 Lagged Cross-Sectional Model

*Table 10: Regression Results from Lagged Cross-Sectional Model, 2022 Scores and 2010 Variables*

| **Variable** | **Coefficient** | **Standard Error** | **t-Statistic** |
|---|---|---|---|
| Neighbor Restrictions | 0.324 | 0.399 | 0.81 |
| Log Population Density | -0.003 | 0.003 | -1.07 |
| Log Operational LSS Capacity | -0.013 | 0.010 | -1.29 |
| Log LSS in Interconnection Queue | 0.009** | 0.004 | 2.31 |
| Voter Turnout | 0.022 | 0.033 | 0.68 |
| Log Median Home Value | 0.017* | 0.009 | 1.98 |
| Log Agricultural Employment Level | 0.000 | 0.001 | 0.35 |
| Residential Electricity Price | -0.012 | 0.144 | -0.08 |
| Share IOU | -0.001 | 0.007 | -0.20 |
| **Model Statistics** | | | |
| Observations | 2,926 | | |
| R-squared | 0.123 | | |
| State Fixed Effects | Yes | | |
| Year Fixed Effects | No | | |
| Clustered Standard Errors | State | | |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

The lagged cross-sectional model looks instead at a county’s key characteristics in 2010, and seeks to determine if those values are related to restrictiveness outcomes in 2022. State fixed effects are similarly included, as policy environments varied between states in 2010 as well. It is important to note that in 2010, relatively little LSS development had occurred, so this specification is arguably the weakest among those studied. Only LSS in Interconnection Queue and Median Home Value have any statistical significance, and both have a moderate, positive effect on restrictiveness in 2022, with smaller effect sizes than in the Cross-Sectional specification. This suggests that counties which were early to experience LSS development, as well as those with higher property values, in 2010 were more likely to adopt more restrictive ordinances by 2022.

### 6.4 First-Differences Specification

*Table 11: Regression Results from First-Differences Specification, Change from 2010 to 2022 Scores and Variables*

| Variable | Coefficient | Standard Error | t-Statistic |
|---|---|---|---|
| Δ Neighbor Restrictions | 0.304*** | 0.061 | 4.94 |
| Δ Log Population Density | 0.051*** | 0.16 | 3.23 |
| Δ Log Operational LSS Capacity | 0.007** | 0.003 | 2.21 |
| Δ Log LSS in Interconnection Queue | 0.003* | 0.002 | 1.87 |
| Δ Voter Turnout | 0.091* | 0.048 | 1.91 |
| Δ Log Median Home Value | -0.038* | 0.24 | -1.59 |
| Δ Log Agricultural Employment Level | -0.001 | 0.001 | -1.27 |
| Δ Residential Electricity Price | 0.003 | 0.172 | 0.02 |
| Δ Share IOU | -0.025 | 0.021 | -1.20 |
| **Model Statistics** | | | |
| Observations | 2,926 | | |
| R-squared | 0.066 | | |
| State Fixed Effects | No | | |
| Year Fixed Effects | No | | |
| Clustered Standard Errors | State | | |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

The first-differences specification considers the relationship between the change in county characteristics from 2010 to 2022, and the change in restrictiveness outcomes from 2010 to 2022. As differencing removes fixed effects, state and year fixed effects are not included. Operational LSS Capacity and LSS in Interconnection Queue are both found to be statistically significant, with moderate to substantial, positive effects on restrictiveness, suggesting that counties in which LSS development pressure increased between 2010 and 2022 were more likely to also increase the restrictiveness of their ordinances during that time. Population Density and Voter Turnout similarly had significant, positive effects on restrictiveness, with more moderate effect sizes. Interestingly, Median Home Value had a borderline significant, moderate negative effect on restrictiveness, suggesting that counties that experienced an increase in property values saw a decrease in restrictiveness. Most notably, the change in restrictiveness of a county's neighbors had a highly statistically significant, highly substantial positive effect on a county's own restrictiveness. This supports the idea of "diffusion" of restrictive policies observed in utility-scale wind development, and anecdotally observed in recent studies of LSS (Lee et al., 2026).

### 6.5 Panel Fixed Effects Model

*Table 12: Regression Results from Panel Fixed Effects Model, Annual from 2010 to 2022*

| Variable | Coefficient | Standard Error | t-Statistic |
|---|---|---|---|
| Neighbor Restrictions | 0.213*** | 0.061 | 3.48 |
| Log Population Density | 0.044** | 0.016 | 2.83 |
| Log Operational LSS Capacity | 0.006** | 0.002 | 2.85 |
| Log LSS in Interconnection Queue | 0.001 | 0.001 | 1.33 |
| Voter Turnout | 0.039 | 0.026 | 1.49 |
| Log Median Home Value | -0.021* | 0.012 | -1.79 |
| Log Agricultural Employment Level | -0.000 | 0.000 | -1.44 |

| | | | |
|---|---|---|---|
| Residential Electricity Price | 0.033 | 0.096 | 0.35 |
| Share IOU | -0.018 | 0.014 | -1.28 |
| **Model Statistics** | | | |
| Observations | 39,050 | | |
| Groups (counties) | 3,066 | | |
| R-squared (within) | 0.067 | | |
| County Fixed Effects | Yes | | |
| Year Fixed Effects | Yes | | |
| Clustered Standard Errors | State | | |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01

The panel fixed effects model represents the strongest and most useful empirical framework, exploring within-county variation over time and its relationship to restrictiveness outcomes. Both county and year fixed effects are included, controlling for within-county, time-invariant unobserved characteristics, as well as temporal shocks common to all counties. Therefore, results capture the relationship between changes in county characteristics and restrictiveness within the same county over time. Operational LSS Capacity remains statistically significant, with a moderate, positive effect size, although LSS in Interconnection Queue does not, suggesting that changes in realized LSS development are related to changes in restrictiveness. Population Density is similarly significant, with a positive effect on restrictiveness, indicating that increases in population density are related to increases in restriction outcomes. Voter Turnout is no longer observed to be statistically significant. Median Home Value is similarly observed to be slightly statistically significant, with a fairly small negative effect size, suggesting that increases in property value are related to decreases in restrictiveness. This appears to contradict findings in the literature of concern around LSS development and its perceived negative impact on property values, although it is also possible that Median Home Value is picking up other economic characteristics of counties that are not being observed. Finally, Neighbor Restrictions remains highly significant, with a positive effect size that remains by far the largest observed. This further suggests that as neighboring counties increase their restrictiveness, a county's own restrictiveness is likely to increase as well, supporting the idea of "contagion" across county borders.

**6.6 Robustness Checks**

Three robustness checks were performed across all four specifications. Full comparison tables of independent variable coefficients from these models are available in Appendix B. First, an alternative specification including six demographic variables was assessed against all four core specifications. The magnitude and significance of all coefficients except for those on Median Home Value remained relatively unchanged across all specifications. Variations in significance level for Median Home Value were observed only in the Lagged Cross-Sectional and First-Differences specifications, and even then, changes were minimal.

Second, it is possible that counties choosing not to implement any ordinances regarding LSS development, and thus receiving a score of 0, are actually more restrictive than counties with a minimal set of ordinances, which would receive a very low restrictiveness score. In some counties,  the absence of zoning laws for a particular use case has the same functional effect as a prohibition on that use case. To account for this possibility, all specifications were checked using Invert 5th Percentile as the dependent variable, rather than Scaled Combined Score. All coefficient estimates were stable across this specification, and no change in significance levels was observed.

Third, a sensitivity analysis was conducted for the two key parameters in Scaled Combined Score, $\lambda$ and $\alpha$, which as described earlier determine the weight given to compounding ordinances and the balance between compounding and severity, respectively. Three potential values were assessed for each parameter, yielding nine variations on Scaled Combined Score, all of which were used as checks for robustness across all specifications, with further details available in Appendix B. In all cases, coefficient estimates were almost entirely unchanged in magnitude and significance level. Finally, for all four specifications and three robustness categories, explanatory power as measured by R-squared values was also highly consistent, with 0.01 as the greatest observed difference between the R-squared value of a core specification and its robustness checks. Across all model specifications and robustness checks, the estimated relationships remain stable in sign, magnitude, and significance, implying that the results are not sensitive to alternative controls, silent ordinances, or parameter choices in restrictiveness score construction.

# 7. Discussion

## 7.1 Analysis and Relevance of Findings

Across all specifications, Agricultural Employment Level, Residential Electricity Price, and Share IOU are not found to be statistically significant, suggesting that these factors do not contribute directly to a county's behavior around restrictive ordinances, either contemporaneously or over time. Although concerns about impacts on agricultural operations, electricity prices, and utility structure or power of energy companies are regularly cited in the literature around individual reasons for opposition (Benetti et al., 2026; Crawford et al., 2022; Uebelhor et al., 2021), these attitudes do not appear to be directly tied to county-level restriction outcomes.

Turnout among the citizen voting age population is found to have borderline significance only in the First-Differences specification, and to not be statistically significant in the other three specifications. Political ideology, as captured by Republican Vote Share, is similarly not found to be significant in any specification, suggesting that while individual views on solar development may manifest along party lines, partisanship is not a key factor in county-level decisions on LSS development (Kennedy et al., 2025).

Population Density, which serves for a proxy for urbanicity, is significant at the five percent significance level with a substantial negative effect size in the Cross-Sectional specification, not significant in the Lagged Cross-Sectional specification, and significant at the one percent significance level in the First-Differences and Panel Fixed Effects specifications with a moderate, positive effect size. These results indicate that in 2022, counties with greater population density than their peers were more likely to have slightly lower restrictiveness scores, but that over time, an increase in population density was related to greater restrictiveness.

Broadly, this is in line with findings that urban residents are more supportive of LSS development than their rural counterparts (Carlisle et al., 2015), while simultaneously suggesting that increasing population pressure may contribute to county-level opposition to LSS.

Median Home Value is positively related to restrictiveness in the Cross-Sectional and Lagged Cross-Sectional specifications, at the one and ten percent significance levels, respectively, meaning that counties with higher property values in both 2010 and 2022 are predicted to have more severe restrictions in 2022. Impact on property values is regularly cited in the literature as an individual-level concern towards LSS development (Crawford et al., 2022; Elmallah et al., 2023). However, Median Home Value is significantly negatively related to restrictiveness in both the First-Differences and Panel Fixed Effects specifications at the ten percent significance level, indicating that counties experiencing a rise in property values over time are less likely to have adopted severe restrictions during that time. As Median Home Value also functions as a broader marker of a county's economic structure that is correlated with characteristics such as education level and median income, these results bear further investigation.

Operational LSS Capacity is positively related to restrictiveness at the five percent significance level across all specifications except for the Lagged Cross-Sectional, in which the effect is negative and not statistically significant. However, this specification may be misleading, as relatively little LSS development had been completed by 2010. These results suggest that counties with greater installed LSS capacity in 2022 are more likely to have severe restrictions, and that increases in LSS development over time are similarly positively related to restrictiveness. This supports the conventional wisdom that as LSS development increases, counties are further exposed to the idea and more likely to adopt restrictions (Eisenson et al., 2025).

LSS in Interconnection Queue, which represents pending LSS development, is positively related to restrictiveness at the one percent significance level in the Cross-Sectional specification, the five percent level in the Lagged Cross-Sectional specification, and the ten percent level in the First-Differences specification. This indicates that counties with greater development pressure in 2022 are more likely to have restrictive ordinances, and that greater development pressure in 2010 also relates to greater restrictiveness in 2022, even where installed capacity in 2010 does not. However, LSS in Interconnection Queue was not statistically significant in the Panel Fixed Effects Model, implying that this relationship is not significant on a year-to-year basis, while realized capacity is.

Neighbor Restrictions, which represent a weighted average by border length of neighbor restrictiveness, had by far the largest effect size, and was positively related to a county's own restrictiveness at the one percent significance level in the First-Differences and Panel Fixed Effects Model. This suggests that as a county's neighbors become more restrictive over time, that county is also likely to become more restrictive, a highly relevant finding for LSS developers that corroborates anecdotal observations in LSS and documented research in utility-scale wind.

Models that consider changes over time, especially the Panel Fixed Effects specification, are most relevant for LSS developers and proponents, who seek to understand relationships between counties today, but most importantly how those county behavior changes over time. This paper's core finding of ordinance diffusion across borders may be useful in informing future development decisions. In fact, private companies like Transect seeking to aid LSS developers are actively developing and deploying their own models for community sentiment and opposition, including “contagion” between restrictive counties.

### 7.2 Limitations

Although these findings are robust across several specifications, there are also significant limitations to this paper that can be improved upon in future work. For one, the restrictiveness score used in these specifications considers the presence of any restriction to be an increase in severity, even mild ordinances that are meant to enable LSS development. Meanwhile, counties with no solar ordinances are considered to be the least restrictive, even though “silent” ordinances can hinder or fully prohibit LSS activity. Robustness checks for silent ordinances seek to address this, but a greater degree of granularity in ordinance data would be useful in capturing the intention behind enacted policies.

Additionally, the ordinance data set used is only available at the county level, while county subdivisions, townships, and other localities frequently retain their own zoning authority and may also enact restrictive policies. In Texas, for example, counties are largely permissive of LSS development, while municipalities are more strict (Eisenson et al., 2025). In reality, LSS zoning and development decisions occur at a hyper-local level, which has only recently been studied in depth and which requires a very significant investment of time and resources to catalogue (Lee et al., 2026). This data set was also manually generated from publicly available laws and ordinances, which may not capture the true extent of restrictive county-level policies nationwide (Lopez et al., 2022). As dates were not included for the majority of ordinances, they often had to be inferred from publicly available legal documents, which frequently only list one date associated with LSS ordinances even when those ordinances were revised over time. To better capture minor increases in restrictiveness, higher granularity date information would be needed.

Across all specifications, R-squared values are modest, ranging from 0.06 in the First-Differences and Panel Fixed Effects specifications to 0.13 in the Cross-Sectional and Lagged Cross-Sectional specifications. While not out of line for local-level policy analysis, these values suggest the presence of other, unobserved institutional factors that may bear further investigation. As documented in the literature, attitudes regarding LSS development are varied and complex, and there are likely additional relevant explanatory factors beyond those considered here.

### 7.3 Future Direction

Future research could further investigate other county-level characteristics that may be related to county-level restrictiveness outcomes, seeking to understand what other factors could predict restrictive ordinances. Investigating these relationships at the sub-county level, as well as taking into account state-level zoning policies to determine where "silent" ordinances are actually restrictive, could contribute greatly to the depth and usefulness of these findings. Engaging with LSS development professionals to identify other anecdotal factors could better inform future research direction, and help tailor the scope to be more directly relevant to practitioners. In particular, the economic structure of counties, which was captured by several highly correlated variables, Median Home Value, Median Income, and % Bachelor's, merits further study.

Recently, a 2025 vintage of LSS ordinances has become available from the authors of the data set used in this paper, which includes sub-county ordinances and an expanded set of ordinance types (Castelão et al., 2025). This data provides an excellent starting point for future research, in addition to emerging catalogues maintained by other authors (Eisenson et al., 2025; Lee et al., 2026). As data for county characteristics was not yet available, the full analysis conducted in this paper could not be applied to this updated data set. However, a preliminary investigation of 2025 outcomes suggests that identified relationships held beyond the 2010-2022 time period, further supporting the robustness of the core results. Details regarding the Forward-Looking Adoption specification are available in Appendix D.

## 8. Conclusion

As LSS development accelerates, county-level opposition will continue to be a critical determinant in its success as well as that of the overall energy transition. Where previous scholarship has focused on individual-level attitudes towards LSS development, their predictors, and the outcomes of restrictive ordinances, this paper expands on the literature by establishing relationships between county-level "attitudes," as captured by certain key characteristics, and restriction outcomes. Further, this paper takes initial steps towards categorizing the strength of these relationships, both cross-sectionally and over time, providing direction for future research and empirical backing for the anecdotal findings of LSS developers.

Specifically, this paper finds that counties with higher installed and pending LSS capacity, as well as median property values, were more likely to have adopted severe restrictions on LSS development, while those with higher population densities were less likely to have done so. Additionally, counties that experienced increases in population density, installed LSS capacity, and neighboring counties with restrictions over time were more likely to have also experienced increases in their own restrictiveness during that time. Meanwhile, counties that experienced increases in property values over time were less likely to have experienced increases in restriction severity. Relationships between a county's restrictions and that of its neighbors over time were especially pronounced, supporting the idea of restrictive ordinance diffusion across county borders, on which private sector companies are placing greater weight in their own models of LSS opposition.

These results were not only robust to controls for demographic characteristics, "silent" ordinances, and changes in variable construction, but also showed partial robustness to analogous out-of-sample restriction scores calculated for 2025, indicating the persistence of relationships across time and specifications. Overall, these findings support the idea of significant, quantifiable relationships between county characteristics and their likelihood of adopting more severe LSS ordinances, which could prove valuable for developers and other stakeholders looking to support the development of renewable energy. Future research should build on these results by incorporating the bevy of ordinances passed since 2022, examining a wider set of explanatory variables including but not limited to economic structure, and employing more granular restriction data to better capture county behavior. Local opposition will be a defining feature of LSS development in the years to come, and an accurate understanding of these dynamics is critical if the energy transition is to continue at pace.

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# Appendix

## Appendix A. Further Background Information

*Table 13: Documented Concerns About and Reasons for Opposition to LSS Development*

| Concern or reason for opposition | Related variable(s) |
|---|---|
| Decrease in surrounding property values | Median Home Value |
| Misuse of agricultural land or other land use change | Agricultural Employment Level |
| Large size of facilities and potential for expansion | Operational LSS Capacity, LSS in Interconnection Queue |
| LSS relies on government assistance | Republican Vote Share |
| Electricity generated will be exported | Share IOU |
| Insufficient economic benefits to local community | Median Income, Median Rent, % Unemployment |
| Developers are not receptive to community concerns | Voter Turnout |
| Change in character and values of the community | Population Density, Total Population, Median Age |
| Impact on local electricity rates | Residential Electricity Price |
| Negative aesthetic impact | |
| Contamination of groundwater and soil | |
| Impacts to human health and safety | |
| LSS is still an inefficient, emerging, or technology | |
| Failure to plan for project end-of-life | |
| Lack of developer accountability | |
| Use of imported materials | |
| Noise during construction | |
| Disruption to wildlife | |
| Residents are unaware of LSS development | |
| Influx of ex-local workers during construction | |
| Benefits accrue to external parties | |
| Impact on tourism and related industries | |

Concerns and reasons for opposition are compiled and synthesized from prior research, language condensed and modified for clarity and consistency (Benetti et al., 2026; Bessette et al., 2024; Crawford et al., 2022; Uebelhor et al., 2021)

## Appendix B. Robustness Checks

For "Score Parameters" robustness checks, nine combinations of λ and α were created, with values of 0.5, 0.6, and 0.7 evaluated for λ and values of 0.3, 0.4, and 0.5 evaluated for α. The baseline specification uses 0.6 for λ and 0.4 for α. Each of the four core specifications were run with all nine combinations of Scaled Combined Score generated using these parameters, and the maximum and minimum coefficient across these combinations was reported for each.

*Table 14: Robustness Checks for Cross-Sectional Model Coefficients*

| **Variable** | **Baseline** | **Demographics** | **Silent Ordinances** | **Score Parameters (Min)** | **Score Parameters (Max)** |
|---|---|---|---|---|---|
| Neighbor Restrictions | 0.059 | 0.050 | 0.060 | 0.049 | 0.070 |
| Log Population Density | -0.006** | -0.009** | -0.007** | -0.007** | -0.006** |
| Log Operational LSS Capacity | 0.007** | 0.007** | 0.007** | 0.007** | 0.008** |
| Log LSS in Interconnection Queue | 0.005*** | 0.004*** | 0.005*** | 0.004*** | 0.005*** |
| Voter Turnout | 0.011 | 0.029 | 0.011 | 0.008 | 0.008 |
| Log Median Home Value | 0.030*** | 0.043*** | 0.030*** | 0.026*** | 0.034*** |
| Log Agricultural Employment Level | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| Residential Electricity Price | 0.136 | 0.140 | 0.136 | 0.117 | 0.154 |
| Share IOU | -0.004 | -0.006 | -0.004 | -0.005 | -0.004 |
| Median Age‡ | | -0.001 | | | |
| % Hispanic‡ | | -0.043 | | | |
| % White‡ | | -0.025 | | | |
| % Female‡ | | 0.155 | | | |
| % Bachelor's‡ | | -0.070* | | | |
| % Republican‡ | | -0.011 | | | |
| **Model Statistics** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Observations | 2,973 | | | | |
| R-squared | 0.139 | 0.142 | 0.139 | 0.132 | 0.145 |
| State Fixed Effects | Yes | | | | |
| Year Fixed Effects | No | | | | |
| Clustered Standard Errors | State | | | | |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01, ‡ denotes demographic controls.

*Table 15: Robustness Checks for Lagged Cross-Sectional Model Coefficients*

| **Variable** | **Baseline** | **Demographics** | **Silent Ordinances** | **Score Parameters (Min)** | **Score Parameters (Max)** |
|---|---|---|---|---|---|
| Neighbor Restrictions | 0.324 | 0.300 | 0.324 | 0.273 | 0.376 |
| Log Population Density | -0.003 | -0.005 | -0.003 | -0.003 | -0.003 |
| Log Operational LSS Capacity | -0.130 | -0.014 | -0.013 | -0.015 | -0.012 |
| Log LSS in Interconnection Queue | 0.009** | 0.008* | 0.009** | 0.008** | 0.010** |
| Voter Turnout | 0.022 | 0.062 | 0.024 | 0.017 | 0.028 |
| Log Median Home Value | 0.017* | 0.041*** | 0.017* | 0.015* | 0.019* |
| Log Agricultural Employment Level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Residential Electricity Price | -0.012 | -0.027 | -0.009 | -0.021 | -0.004 |
| Share IOU | -0.001 | -0.004 | -0.002 | -0.002 | -0.001 |
| Median Age‡ | | -0.001 | | | |
| % Hispanic‡ | | -0.051 | | | |
| % White‡ | | 0.242*** | | | |
| % Female‡ | | -0.063* | | | |
| % Bachelor's‡ | | -0.142** | | | |
| Republican Vote Share‡ | | 0.022 | | | |

| Model Statistics | | | | | |
|---|---|---|---|---|---|
| Observations | 2,926 | | | | |
| R-squared | 0.128 | 0.136 | 0.127 | 0.122 | 0.133 |
| State Fixed Effects | Yes | | | | |
| Year Fixed Effects | No | | | | |
| Clustered Standard Errors | State | | | | |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01, ‡ denotes demographic controls.

*Table 16: Robustness Checks for First-Differences Specification Coefficients*

| **Variable** | **Baseline** | **Demographics** | **Silent Ordinances** | **Score Parameters (Min)** | **Score Parameters (Max)** |
|---|---|---|---|---|---|
| Neighbor Restrictions | 0.304*** | 0.286*** | 0.303*** | 0.261*** | 0.351*** |
| Log Population Density | 0.051*** | 0.061*** | 0.051*** | 0.047*** | 0.056*** |
| Log Operational LSS Capacity | 0.007** | 0.007** | 0.007** | 0.006** | 0.008** |
| Log LSS in Interconnection Queue | 0.003* | 0.003* | 0.003* | 0.003* | 0.004* |
| Voter Turnout | 0.091* | 0.086* | 0.086* | 0.082* | 0.102* |
| Log Median Home Value | -0.038* | -0.050** | -0.050** | -0.043 | -0.033 |
| Log Agricultural Employment Level | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| Residential Electricity Price | 0.003 | 0.005 | 0.000 | 0.000 | 0.006 |
| Share IOU | -0.025 | -0.029 | -0.026 | -0.029 | -0.022 |
| Median Age‡ | | -0.002** | | | |
| % Hispanic‡ | | 0.118 | | | |
| % White‡ | | 0.298** | | | |
| % Female‡ | | -0.184* | | | |
| % Bachelor's‡ | | 0.265*** | | | |

| | | | | | |
|---|---|---|---|---|---|
| Republican Vote Share‡ | | -0.000 | | | |
| **Model Statistics** | | | | | |
| Observations | 2,926 | | | | |
| R-squared | 0.066 | 0.076 | 0.066 | 0.062 | 0.069 |
| State Fixed Effects | No | | | | |
| Year Fixed Effects | No | | | | |
| Clustered Standard Errors | State | | | | |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01, ‡ denotes demographic controls.

*Table 17: Robustness Checks for Panel Fixed Effects Model Coefficients*

| **Variable** | **Baseline** | **Demographics** | **Silent Ordinances** | **Score Parameters (Min)** | **Score Parameters (Max)** |
|---|---|---|---|---|---|
| Neighbor Restrictions | 0.213*** | 0.209*** | 0.213*** | 0.183*** | 0.247*** |
| Log Population Density | 0.044** | 0.049*** | 0.044*** | 0.040*** | 0.049*** |
| Log Operational LSS Capacity | 0.006** | 0.006*** | 0.006*** | 0.005*** | 0.007*** |
| Log LSS in Interconnection Queue | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Voter Turnout | 0.039 | 0.036 | 0.039 | 0.035 | 0.044 |
| Log Median Home Value | -0.021* | -0.025** | -0.021* | -0.024* | -0.018* |
| Log Agricultural Employment Level | -0.000 | -0.000 | -0.000 | -0.001 | -0.000 |
| Residential Electricity Price | 0.033 | 0.034 | 0.033 | 0.032 | 0.036 |
| Share IOU | -0.018 | -0.019 | -0.018 | -0.021 | -0.016 |
| Median Age‡ | | -0.000 | | | |
| % Hispanic‡ | | 0.100 | | | |
| % White‡ | | 0.188** | | | |
| % Female‡ | | -0.089** | | | |

| | | | | | |
|---|---|---|---|---|---|
| % Bachelor's‡ | | 0.010** | | | |
| Republican Vote Share‡ | | -0.008 | | | |
| **Model Statistics** | | | | | |
| Observations | 39,050 | | | | |
| Groups (counties) | 3,066 | | | | |
| R-squared (within) | 0.067 | 0.069 | 0.067 | 0.064 | 0.068 |
| County Fixed Effects | Yes | | | | |
| Year Fixed Effects | Yes | | | | |
| Clustered Standard Errors | State | | | | |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$, ‡ denotes demographic controls.

## Appendix C. Forward-Looking Adoption

Published in 2025, the Open Energy Data Initiative's updated LSS restriction data set uses large language models to identify a more granular set of state and local ordinances, including restrictions at the township level and an expanded range of ordinance types. These ordinance types, documented below, are not an exact match for those in the 2022 dataset, and as such, a directly comparable restrictiveness score cannot be constructed. However, an analogous score variable was created using the same methods, focused only on the categories of restrictions observed in the core specification.

*Table 18: 2025 Restrictive Ordinance Categories and Weightings*

| Type | Description | Units | Category | Weighting |
|---|---|---|---|---|
| Ban | Prohibition on LSS development | N/A | N/A | N/A |
| Coverage* (Coverage) | Maximum percent of lot covered | Percent | Site-based | 0.05 |
| Maximum Height* (Maximum Height) | Maximum array height | Meters | Height | 0.2 |
| Maximum Lot Size* | Maximum lot size | Acres | Site-based | 0.05 |

| | | | | |
|---|---|---|---|---|
| (Maximum Size) | | | | |
| Minimum Lot Size**<br>(Minimum Size) | Minimum installation size | Acres | Site-based | 0.05 |
| Noise*<br>(Noise) | Maximum allowed decibel level | dBA | Site-based | 0.05 |
| Property Line**<br>(Setback – Property) | Distance from property lines | Meters | Site-based | 0.05 |
| Roads**<br>(Setback – Road) | Distance from roads | Meters | Landscape | 0.15 |
| Water**<br>(Setback – Waters) | Distance from waters and wetlands | Meters | Landscape | 0.15 |
| Structures**<br>(Setback – Structures) | Distance from structures | Meters | Landscape | 0.05 |
| Transmission | Distance from overhead transmission lines | | | |
| Railroads | Distance from railroads | | | |
| Other SECs | Distance from other Solar Energy Conversion systems | | | |
| Public Conservation Lands | Distance from public conservation lands and preservation areas | | | |
| Maximum Project Size | Maximum project size | | | |
| Panel Spacing | Minimum required spacing between individual solar panels or arrays | | | |
| Glare | Glare restrictions | | | |
| Screening | Screening requirements | | | |
| Fencing | Fencing requirements | | | |
| Decommissioning | Decommissioning requirements | | | |
| Visual Impact | Visual impact assessment requirements | | | |
| Repowering | Repowering requirements | | | |
| Signage | Signage requirements | | | |
| Soil | Soil erosion plan requirements | | | |
| Primary Use Districts | Districts where Solar Energy Conversion Systems are permitted as a primary use | | | |
| Special Use Districts | Districts where Solar Energy Conversion Systems are permitted as a special/conditional use | | | |
| Accessory Use Districts | Districts where Solar Energy Conversion Systems are permitted as an accessory use | | | |

| | |
|---|---|
| Prohibited Use Districts | Districts where Solar Energy Conversion Systems are prohibited |

* denotes ordinances for which lower values are more restrictive (inverse normalization is used), ** denotes ordinances for which higher values are more restrictive, variable names in parentheses are the equivalents from the core specification, there is no direct analogue for the Density or Setback – Highway categories.

Based on this new score measure, the following variables were created to identify counties that had no recorded ordinances in 2022 but had adopted at least one by 2025. The goal of this specification is to examine whether the relationships between county characteristics and restriction outcomes during the 2010-2022 sample period hold true into 2025, during which time installed LSS capacity and restrictions increased dramatically (Eisenson et al., 2025).

*Table 19: Descriptions of 2025 Variables*

| **Variable** | **Description** | **Cat.** | **Source** |
|---|---|---|---|
| 2025 Score | Scaled Combined Score constructed using 2025 data | RO | NLR OEDI |
| 2025 Gained Restriction | Binary indicating counties that had a Scaled Combined Score of 0 in 2022, and a non-zero 2025 Score | RO | Calculation |
| 2025 Amount Gained | Difference between 2025 Score and Scaled Combined Score in 2022, for counties that had a Scaled Combined Score of 0 in 2022 | RO | Calculation |

Categories are Restrictive Ordinances (RO), Socio-Demographics (SD), Solar Development Pressure (SDP), Political Environment (PE), Economic Structure (ES), and Utility Structure (US).

*Table 20: Summary Statistics for 2025 Variables*

| **Variable** | **Obs.** | **Mean** | **Std. dev.** | **Min** | **Max** |
|---|---|---|---|---|---|
| 2025 Score | 2,973 | 0.0780 | 0.1995 | 0.0000 | 1.0000 |
| 2025 Gained Restriction | 2,973 | 0.1150 | 0.3191 | 0.0000 | 1.0000 |
| 2025 Amount Gained | 2,973 | 0.0545 | 0.1728 | 0.0000 | 1.0000 |

A linear probability model is then employed to investigate the relationship between first-time ordinance adoption within counties by 2025, as characterized by 2025 Gained Restriction, and county characteristics in 2022. This specification is intentionally more narrow than core specifications, including only counties with no LSS restrictions in 2022, and measuring binary changes in restrictions, as 2025 scores are not directly comparable with the core data set.

$$
\begin{aligned}
2025\ Gained\ Restriction_{i,2025} = {} & \beta_1 NeighborRestrictions_{i,2022} \\
& + \beta_2 log(PopulationDensity_{i,2022}) \\
& + \beta_3 log(OperationalLSSCapacity_{i,2022}) \\
& + \beta_4 log(LSSinInterconnectionQueue_{i,2022}) \\
& + \beta_5 Turnout_{i,2022} \\
& + \beta_6 log(MedianHomeValue_{i,2022}) \\
& + \beta_7 log(AgriculturalEmploymentLevel_{i,2022}) \\
& + \beta_8 ResidentialElectricityPrice_{i,2022} \\
& + \beta_9 ShareIOU_{i,2022} \\
& + \gamma_s + \varepsilon_i
\end{aligned}
$$

Counties are represented by $i$, states are represented by $s$, state fixed effects are represented by $\gamma_s$, and the error term is $\varepsilon_i$. State fixed effects are included to control for unobserved differences between states, including policy choices regarding renewable energy, and decisions on siting and zoning authority. Standard errors are clustered by state to account for correlated shocks across counties within states.

*Table 21: Regression Results from Linear Probability Model*

| **Variable** | **Coefficient** | **Standard Error** | **t-Statistic** |
|---|---|---|---|
| Neighbor Restrictions | 0.288 | 0.181 | 1.59 |
| Log Population Density | -0.024** | 9.010 | -2.36 |

| | | | |
|---|---|---|---|
| Log Operational LSS Capacity | 0.010* | 0.005 | 1.98 |
| Log LSS in Interconnection Queue | 0.007** | 0.003 | 2.08 |
| Voter Turnout | -0.159* | 0.081 | -1.96 |
| Log Median Home Value | 0.107*** | 0.030 | 3.52 |
| Log Agricultural Employment Level | 0.004 | 0.003 | 1.18 |
| Residential Electricity Price | -0.130 | 0.276 | -0.47 |
| Share IOU | 0.029 | 0.031 | 0.93 |
| **Model Statistics** | | | |
| Observations | 2,674 | | |
| R-squared | 0.173 | | |
| State Fixed Effects | Yes | | |
| Year Fixed Effects | No | | |
| Clustered Standard Errors | State | | |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01.

Population Density has a significant, negative effect at the five percent significance level, indicating that counties with higher population densities in 2022 were less likely to have adopted restrictions for the first time by 2025. This is consistent with the Cross-Sectional model, in which Population Density similarly had a negative effect at the same significance level. Both Operational LSS Capacity and LSS in Interconnection Queue have significant, positive effects on 2025 restrictiveness, at the ten percent and five percent significance levels, respectively. Voter Turnout has a negative effect, significant at the ten percent significance level, a relationship that was not observed in core specifications. Median Home Value has a positive effect at the one percent significance level, suggesting that counties with higher property values in 2022 were more likely to have adopted restrictions by 2025, consistent with findings in the Cross-Sectional and Lagged Cross-Sectional Models. Finally, Neighbor Restrictions has a positive effect, but has only borderline statistical significance at the ten percent significance level.

*Table 22: Comparison of Regression Coefficients Across Model Specifications, Including 2025*

| Variable | Cross-Sectional | Lagged Cross-Sectional | First-Differences | Panel Fixed Effects | Linear Probability Model |
|---|---|---|---|---|---|
| Neighbor Restrictions | 0.059 | 0.324 | 0.304*** | 0.213*** | 0.288 |
| Log Population Density | -0.006** | -0.003 | 0.051*** | 0.044** | -0.024** |
| Log Operational LSS Capacity | 0.007** | -0.13 | 0.007** | 0.006** | 0.010* |
| Log LSS in Interconnection Queue | 0.005*** | 0.009** | 0.003* | 0.001 | 0.007** |
| Voter Turnout | 0.011 | 0.022 | 0.091* | 0.039 | -0.159* |
| Log Median Home Value | 0.030*** | 0.017* | -0.038* | -0.021* | 0.107*** |
| Log Agricultural Employment Level | -0.001 | 0.000 | -0.001 | -0.000 | 0.004 |
| Residential Electricity Price | 0.136 | -0.012 | 0.003 | 0.033 | -0.130 |
| Share IOU | -0.004 | -0.001 | -0.025 | -0.018 | 0.029 |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01.

These results are limited by 2025 data quality and structural differences, as well as the lack of covariate data from 2025 and major changes in the LSS development landscape during that time period. However, similarity in sign, magnitude, and significance across Operational LSS Capacity, LSS in Interconnection Queue, Median Home Value, Population Density, and Neighbor Restrictions indicate some degree of robustness beyond the core sample period, which is promising for future research.

## Appendix D. Effect Sizes

To allow for comparison across models, effect sizes are reported across all four core specifications. For each predictor, effect size is calculated as the product of that predictor's coefficient and its standard deviation, which should be interpreted as the change in Scaled Combined Score associated with a one standard deviation change in the predictor. For interpretability, effect size is also reported as a percent of the standard deviation of Scaled Combined Score. In Cross-Sectional and Lagged Cross-Sectional models, standard deviations are calculated from the estimation sample. In the First-Differences specification, standard deviations are calculated from changes between 2010 and 2022. Finally, for the Panel Fixed Effects model, standard deviations are calculated within-county, over time, consistent with the rest of the specification.

*Table 23: Effect Sizes for Cross-Sectional Model*

| Variable | Coefficient | Std. Dev. | Effect of 1 SD Increase in X | Effect (% of SD of Y) |
|---|---|---|---|---|
| Neighbor Restrictions | 0.059 | 0.073 | 0.004 | 3.6 |
| Log Population Density | -0.006** | 1.695 | -0.011 | -9.0 |
| Log Operational LSS Capacity | 0.007** | 1.635 | 0.012 | 9.9 |
| Log LSS in Interconnection Queue | 0.005*** | 2.493 | 0.012 | 9.6 |
| Voter Turnout | 0.011 | 0.094 | 0.001 | 0.8 |
| Log Median Home Value | 0.030*** | 0.478 | 0.014 | 11.9 |
| Log Agricultural Employment Level | -0.001 | 2.561 | -0.002 | -1.9 |
| Residential Electricity Price | 0.136 | 0.034 | 0.005 | 3.8 |
| Share IOU | -0.004 | 0.363 | -0.002 | -1.3 |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

*Table 24: Effect Sizes for Lagged Cross-Sectional Model, 2022 Scores and 2010 Variables*

| **Variable** | **Coefficient** | **Std. Dev.** | **Effect of 1 SD Increase in X** | **Effect (% of SD of Y)** |
|---|---|---|---|---|
| Neighbor Restrictions | 0.324 | 0.016 | 0.005 | 4.3 |
| Log Population Density | -0.003 | 1.629 | -0.005 | -4.0 |
| Log Operational LSS Capacity | -0.013 | 0.265 | -0.003 | -2.9 |
| Log LSS in Interconnection Queue | 0.009** | 0.796 | 0.007 | 5.8 |
| Voter Turnout | 0.022 | 0.091 | 0.002 | 1.6 |
| Log Median Home Value | 0.017* | 0.490 | 0.009 | 6.9 |
| Log Agricultural Employment Level | 0.000 | 2.543 | 0.001 | 0.8 |
| Residential Electricity Price | -0.012 | 0.022 | -0.000 | -0.2 |
| Share IOU | -0.001 | 0.357 | -0.001 | -0.4 |

* denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$

*Table 25: Effect Sizes for First-Differences Specification, Change from 2010 to 2022 Scores and Variables*

| **Variable** | **Coefficient** | **Std. Dev.** | **Effect of 1 SD Increase in X** | **Effect (% of SD of Y)** |
|---|---|---|---|---|
| Δ Neighbor Restrictions | 0.304*** | 0.069 | 0.021 | 17.6 |
| Δ Log Population Density | 0.051*** | 0.106 | 0.005 | 4.6 |
| Δ Log Operational LSS Capacity | 0.007** | 1.589 | 0.011 | 9.5 |
| Δ Log LSS in Interconnection Queue | 0.003* | 2.559 | 0.008 | 6.8 |
| Δ Voter Turnout | 0.091* | 0.046 | 0.004 | 3.5 |
| Δ Log Median Home Value | -0.038* | 0.167 | -0.006 | -5.3 |

| | | | | |
|---|---|---|---|---|
| Δ Log Agricultural Employment Level | -0.001 | 2.539 | -0.002 | -2.0 |
| Δ Residential Electricity Price | 0.003 | 0.023 | 0.000 | 0.1 |
| Δ Share IOU | -0.025 | 0.108 | -0.003 | -2.3 |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01

*Table 26: Effect Sizes for Panel Fixed Effects Model, Annual from 2010 to 2022*

| **Variable** | **Coefficient** | **Std. Dev.** | **Effect of 1 SD Increase in X** | **Effect (% of SD of Y)** |
|---|---|---|---|---|
| Neighbor Restrictions | 0.213*** | 0.029 | 0.006 | 12.6 |
| Log Population Density | 0.044** | 0.036 | 0.002 | 3.2 |
| Log Operational LSS Capacity | 0.006** | 0.715 | 0.004 | 8.4 |
| Log LSS in Interconnection Queue | 0.001 | 1.498 | 0.001 | 2.1 |
| Voter Turnout | 0.039 | 0.036 | 0.001 | 2.8 |
| Log Median Home Value | -0.021* | 0.088 | -0.002 | -3.7 |
| Log Agricultural Employment Level | -0.000 | 1.346 | -0.001 | -1.3 |
| Residential Electricity Price | 0.033 | 0.013 | 0.000 | 0.8 |
| Share IOU | -0.018 | 0.048 | -0.001 | -1.7 |

* denotes p < 0.10, ** denotes p < 0.05, *** denotes p < 0.01