***Rural Policy: The Research Bulletin of the Center for Rural Pennsylvania*, Fall 2024, Volume 3, Issue 1**

Baseline Assessment, Development Process, and Regulatory Context of Solar Power in Rural Pennsylvania

By: Russell C. Hedberg II, Ph.D.; Kyle Myers; Alfonso Yanez Morillo; Shippensburg University of Pennsylvania, Center for Land Use and Sustainability.

Citation: Hedberg, R. et al. (2024). Baseline Assessment, Development Process, and Regulatory Context of Solar Power in Rural Pennsylvania. *Rural Policy: The Research Bulletin of the Center for Rural Pennsylvania, Volume 3* (*Issue 1*). Retrieved from https://doi.org/10.262209/rpvol3iss1pp98.

Abstract: Solar energy development in the United States has increased by 30,000% since 2001 and is likely to continue this dramatic expansion in the coming years, with much of the development pressure tracking to rural places. Despite ample solar resources and rural territory, solar development in Pennsylvania lags far behind many states in the Eastern U.S. To better understand this discrepancy and better support solar policy in the Commonwealth, we conducted a three-part analysis of solar development in Pennsylvania. First, we conducted a geographic assessment of existing and proposed solar development to date to determine the factors that contribute to the current distribution of solar development and which regions are most likely to see development in the future. We also conducted a comparative solar policy audit for Pennsylvania with New York and North Carolina, two states with significantly higher rates of solar development, and key stakeholder interviews to better understand the current solar development process in the Commonwealth. Our analysis found that much of rural Pennsylvania is suitable for utility-scale solar development, with numerous areas across the state likely to see acute development pressure in the coming years. Our policy analysis found that Pennsylvania has almost no solar energy policy, which differs quite significantly from other states. Not only does this lack of policy seem to explain the slow growth of solar in the Commonwealth, but it also significantly impacts many rural stakeholders currently involved in the development process.

Keywords: Utility-Scale Solar, Comparative Policy Analysis, GIS Modeling, Qualitative Analysis

Executive Summary

Solar energy generation has expanded dramatically in the U.S.—roughly 30,000% since 2001, based on megawatt-hours generated. Many states in the Mid-Atlantic region have seen significant development of utility-scale solar energy capacity (defined here as a solar generating facility with at least 1MW of generating capacity). Pennsylvania lags far behind its neighbors in solar development, despite having comparable solar energy potential. To better understand this discrepancy and support solar policy development in the Commonwealth, we conducted a three-pronged analysis of solar energy development in Pennsylvania.

First, we conducted a geographic analysis of existing and proposed solar development to date to determine the factors that contribute to the current distribution of solar development and which regions are most likely to see development in the future. To carry out this analysis, we compiled a database of environmental and socio-economic factors found to be important to the siting of utility-scale solar energy by government agencies, research scientists, and the solar industry. We utilized geographic information systems (GIS) to identify factors favored by solar development in Pennsylvania and develop a weighted model that identifies regions most likely to see solar development pressure in the coming years. This analysis found that, to date, utility-scale solar favors agricultural land that is near population centers and transmission infrastructure, with relatively lower property values compared to neighboring parcels.

Second, we conducted a comparative solar policy audit for Pennsylvania with New York and North Carolina, two similar states with significantly higher rates of solar development. This process involved cataloging and reviewing all state-level policies relating to solar energy in each state, as well as state offices and agencies specifically tasked with managing solar energy development. Our analysis found that these three states have a gradient of state-level solar policy, with New York having the most initiatives and Pennsylvania having almost none. While New York has far more policy and state offices addressing solar energy than North Carolina, we found that both states have robust renewable energy portfolio standards and policies that streamline the interconnection process and ensure buyers for new solar energy projects.

Lastly, we conducted semi-structured interviews with key stakeholders across Pennsylvania, including state, county, and local officials, solar developers, rural landowners, and academic experts with significant experience working with Pennsylvania landowners on solar energy development. This qualitative analysis was conducted to provide a better understanding of how the current process of utility-scale solar development is experienced by rural residents in the Commonwealth. Interview analysis indicated that there is great uncertainty surrounding the solar development process across all stakeholder groups. Participants expressed a strong desire for state-level guidance and support to help rural municipalities and communities better manage the solar development process. Interviews also indicated that there is significant rural support for solar energy development if guidelines are developed to ensure that rural interests are protected in the process.

Key takeaways from our study:

- Much of the territory of Pennsylvania is suitable for solar development, with numerous regions of the state likely to see concentrated development pressure in the coming years. Most operational utility-scale solar facilities in Pennsylvania are in the populous Southeastern region, and this trend is likely to continue, with spillover into adjacent rural counties.
- The tendency for utility-scale solar to favor land in closer proximity to population centers and infrastructure suggests that solar development will become one of numerous competing drivers of land use change, which could drive up the costs of development and ultimately make solar energy more expensive in Pennsylvania.
- Given that much of Pennsylvania is likely attractive to utility-scale solar development, it seems likely that state policy, or rather a lack thereof, helps explain the stark differences in development between the Commonwealth and the two other states included in our comparative policy analysis.
- The significant lag in the grid interconnection process is likely a significant factor in the low rate of solar buildout in Pennsylvania.

Policy recommendations resulting from this study:

- Update the Alternative Energy Portfolio Standards Act.
- Develop a policy to streamline the interconnection process and ensure power purchasing from new utility-scale solar energy facilities.
- Enact a policy enabling community solar.
- Develop state-level guidance on solar siting and leasing to better support rural counties and municipalities.

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Introduction

Pennsylvania is currently a major energy supplier, producing more electricity than nearly all other states in the US—only Wyoming and Texas export more total energy resources outside of their borders (EIA, 2021a). Despite Pennsylvania's large role in electricity and energy production, only 4% of the Commonwealth's electricity in 2020 was generated by renewable sources (EIA, 2021a). Of this 4%, solar energy accounted for only 8% of total renewable energy production (EIA, 2021a). The Commonwealth lags behind nearly every other state in the Eastern U.S. in solar development, with only 37 established utility-scale solar facilities (defined here as facilities producing at least 1 megawatt (MW) of electricity).[1] In fact, among all states on the Eastern Seaboard, only Maine and Delaware have fewer utility-scale solar facilities than Pennsylvania (Fujita et al., 2023). The bordering states of New Jersey (255 facilities), New York (243 facilities), and Maryland (99 facilities) significantly outpace Pennsylvania in utility-scale solar energy production. Yet the potential for solar energy production in Pennsylvania is "no different" than it is in leading solar states like New York and New Jersey (PA DEP, 2018). Additionally, Pennsylvania has significant transmission infrastructure due to its role in exporting electricity to neighboring states and large quantities of rural and agricultural land—both of which are attractive to utility-scale solar energy development (Evans et al., 2023; Hernandez et al., 2015). This confluence of factors that would otherwise attract solar development suggests that other factors, including public policy, may be limiting solar development in the Commonwealth.

The U.S. solar industry has grown by 30,208% since 2001 based on megawatt-hours of generated electricity (EIA, 2024). The strong market for solar, plummeting costs of solar panels, and recent federal legislation that will result in billions of dollars of investment in clean electricity (Paris et al., 2022) indicate that the transition to renewables is well underway. While Pennsylvania lags far behind neighboring states in existing solar infrastructure, the Commonwealth is a site of significant interest to solar energy developers, with hundreds of proposed utility-scale facilities currently seeking approval for interconnection and many more are likely to emerge in the coming years (PJM, n.d.). State legislative action may be warranted to ensure that future solar energy development in Pennsylvania benefits rural communities, maintains the beauty and environmental integrity of our landscapes, and strengthens the energy economy in the Commonwealth.

If managed properly, solar development also provides a unique opportunity to Pennsylvania farmers and rural communities by augmenting their income via land leases to solar developers, especially if leases are structured to allow for continued use of the land for agricultural production (so-called agrivoltaics) (ASGA 2019). However, in the current environment, where utility-scale solar is rapidly expanding, leasing terms and per-acre earnings are uncertain and vary widely by geography, project, and company (SEIA, 2016; Brocket and Ciolkosz, 2019; Kiessling, 2020); solar lease rates can vary from

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[1] Our study follows the U.S. Energy Information Administration definition of utility-scale solar as a solar site with at least 1 MW of generation capacity (EIA, n.d.). This definition suits our study by allowing the inclusion of more facilities in the data set. Other studies may use different definitions for inclusion, which may result in differences in the number of reported solar sites in Pennsylvania (or elsewhere).

$250 to $2,000 per acre (SolarLandLease, 2022). Further, the current lack of policy and guidance means that property owners bear the burden of negotiating favorable lease terms (DEP, 2022a).

Currently, Pennsylvania has no state-level laws or regulations regarding siting for utility-scale solar facilities. Solar development projects are thus subject to the decisions and zoning laws of local or municipal governments (McDevitt, 2020; DEP, 2022b). However, a recent study found that of the over 2,500 local zoning ordinances, plus local zoning ordinances in Pennsylvania, only 5% have guidance towards utility-scale solar (Badissy, 2021). Due to the increasing number of solar projects across the Commonwealth, support for developing zoning for utility-scale solar projects is of the utmost importance.

Another significant challenge is the backlog of future projects in the PJM Interconnection Queue (PJM), which coordinates the movement of wholesale electricity across 13 states in the Eastern U.S., including all of Pennsylvania (PJM 2022a). At the time the data were compiled for this report, PJM had 437 solar projects waiting in the queue for Pennsylvania alone (PJM, n.d.).[2] This backlog led PJM to suggest placing a two-year moratorium on new applications in order to streamline its processes and prioritize existing projects (Sylvia, 2022).

In order to successfully protect rural land and communities, remain competitive in the regional energy sector, and ensure climate resilience, it is essential for policymakers to fully understand this diverse set of issues. To better support state policy, we conducted a three-part analysis of solar development in Pennsylvania. First, we conducted a baseline assessment of current solar development to identify commonalities among existing and planned utility-scale solar sites in the Commonwealth and map the regions of Pennsylvania most likely to see solar development pressure in the coming years. Secondly, we conducted a comparative policy analysis of state-level solar regulation among Pennsylvania, New York, and North Carolina—two states in the Mid-Atlantic with much higher rates of solar development. Lastly, we conducted qualitative interviews with key stakeholders to better understand the process of solar development as it is experienced by public officials, solar developers, and landowners in rural Pennsylvania.

Below, we briefly review relevant research on solar development and state our specific research objectives. We then present our findings for each aspect of our three-part analysis, followed by a discussion synthesizing these findings and policy recommendations to best guide solar development in Pennsylvania.

What We Know About Solar Development in the U.S.

The rapid increase in solar energy development has resulted in a concomitant rise in research examining solar across the natural and social sciences. This research is diverse, and here we briefly review three subfields of recent scholarship on solar energy development in the U.S. that establish the broader context for our study. Below, we review recent studies on: 1) the current and future geographic distributions of solar utility-scale solar energy; 2) the relationship between public policy and solar

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[2] The total number of proposed utility-scale solar projects in the PJM queue will vary based on the date the number was compiled. The data for this report was compiled in the spring of 2023.

development; and 3) the experiences and perspectives of rural residents and landowners on solar development.

Current and Future Geography of Solar Energy

Numerous studies have used geographic information systems (GIS) and statistical models to develop a data-driven understanding of the common characteristics found at existing solar sites, both in the U.S. and elsewhere, and then use these factors to model the region's most likely to see utility-scale solar development in the future. Evans et al. (2023), for instance, used a combination of satellite imagery and predictive statistical models to assess recent and potential utility-scale solar buildout in the six states of the Chesapeake Watershed (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia). These researchers found that solar development in this region is predominantly located on agricultural land and that this trend will likely continue, with prime agricultural land (farmland with Class 1 or 2 soils) less likely to be developed. Other studies suggest that there may be regional differences in land-use preferences. Hernandez et al. (2015) found that agricultural land is a common site for utility-scale solar development in California, but nearly 48% of utility-scale solar buildout in the state occurs in shrubland and scrubland land cover types. This study also found that solar development in California had significant potential to harm protected areas and regional conservation efforts, but here, too, there seem to be significant regional differences. Dunnett et al. (2022) found that solar development is unlikely to significantly conflict with protected area conservation in the U.S., and Evans et al. (2023) found that natural habitat and conservation areas in the Chesapeake Watershed were largely undisturbed by solar buildout.

Regardless of land use and land cover types favored for solar development, numerous studies have found that utility-scale solar development favors rural regions of the U.S. that have sufficient solar resources (i.e., sunshine) and reasonable proximity to transmission infrastructure (Evans et al., 2023; Hernandez et al., 2015; O'Shaughnessy et al., 2023). O'Shaughnessy et al. (2023) also found that solar development in the U.S. is nearly twice as likely to occur in communities with lower-than-average incomes, though the researchers are careful to note that renewable energy development does not necessarily produce the same types of environmental justice concerns as fossil fuel production. To that end, Waechter et al. (2024) found that in the context of community solar development (larger solar facilities that provide energy directly to the local community rather than wholesale electricity for the entire grid service region), proximity to solar facilities can provide significant benefits to disadvantaged communities, potentially counteracting environmental justice concerns.

The Role of Public Policy in Solar Development

While the role of public policy in solar development is complex given the differences between various federal, state, and local regulations, research has identified numerous policy areas that are particularly impactful on the trajectory of solar energy in the U.S. At the state level, for instance, researchers have found that laws establishing Renewable Portfolio Standards have a strong positive effect on solar development (Barbose, 2021;

Evans et al., 2023). These statutes, which require utility providers to supply specified percentages of their energy production from renewable sources, have driven nearly half of all solar development in the U.S. since 2000. Additionally, Waechter et al. (2024) found that state policies that allow community solar development can greatly expand solar development by supporting the construction of smaller sites that are adequate for supplying local communities but too small to profitably provide wholesale electricity to the grid.

Much of the research on solar policy focuses on zoning ordinances, and here the findings are nuanced, with researchers finding that the best outcomes are found in a balance between permissive and strict zoning approaches. Interestingly, multiple studies found that one of the biggest barriers to solar development at the local level is silence on the issue of solar (Guarino & Swanson, 2022; Owusu-Obeng et al., 2024). In these cases, the lack of a specific zoning policy for solar means that utility-scale facilities can only be sited with special permitting, introducing increased costs, time delays, and uncertainty into the development process. Likewise, Owusu-Obeng et al. (2024) found that highly restrictive zoning tends to drive solar development elsewhere, often to neighboring states, and multiple studies found that strict zoning can reduce available land for solar development by as much as 38% (Lopez et al., 2023; Waechter et al., 2024).

Other research suggests that careful policy can effectively promote solar development while also protecting environmental resources and local community interests. Moore et al. (2022), for instance, found that county and local ordinances can ensure that significant tax revenue and job creation from utility-scale solar benefit local communities. Similarly, Goldberg (2023) finds that intentional policy making at the local and state level, ranging from zoning ordinances to tax incentives, can increase the practice of agrivoltaics (the co-locating of agricultural production and solar energy generation at the same site)—a practice that research suggests is highly desirable in many agricultural communities (Buckley Biggs et al., 2022; Moore et al., 2022).

Rural Perspectives on Solar Development

Given the tendency for utility-scale solar to develop in rural regions, a significant and growing body of research on solar energy has focused on the perspectives and experiences of rural residents with this development trend. The public narrative in this regard often presents rural resistance to utility-scale solar as the dominant perspective, and particularly a phenomenon known as NIMBYism ('not in my backyard'). Research on rural perspectives presents a more complex picture.

Nilson and Stedman (2023), for example, conducted a survey in rural New York State and found that while 42% of respondents opposed utility-scale solar near their communities, 44% supported these developments, and 14% did not feel strongly either way. This finding indicates that rural resistance is common, but clearly not a majority opinion. These scholars found that much of the rural resistance in their study was not typical NIMBYism, in which individuals or communities favor utility scale solar in a theory but oppose developments that are in close proximity to their homes. Nilson and Stedman found that much rural resistance in New York State seems to be connected to what they call perceived rural burden—the sentiment that rural places are forced to bear the burden of hosting utility-scale solar while the benefits flow elsewhere, particularly to urban centers.

Other studies have found that rural resistance is much more common among residents (including many more recent transplants) that are not agricultural land owners (Moore et al., 2021, 2022; Spangler et al., 2024). In many cases, researchers have found that landowning farmers consider utility-scale solar development to be a question of private property rights (Moore et al., 2022; Spangler et al., 2024) and that the economic stability offered by leasing land for utility-scale solar is a significant benefit to U.S. farmers (Buckley Biggs et al., 2022; Moore et al., 2022; Spangler et al., 2024; Stid et al., 2023). Additionally, Spangler et al. (2024) found that landowning farmers often view utility-scale solar leasing as a means of preserving farmland for future generations, which suggests that attachment to the land and a farming identity may be a significant non-financial driver of rural support for utility-scale solar.

Where rural resistance does exist, research indicates that it is broadly linked to connections to place (Buckley Biggs et al., 2022; Moore et al., 2022; Nilson & Stedman, 2023; Spangler et al., 2024). Much of this attachment to place is linked to ideals of rural landscapes that include scenic beauty and agrarian land uses (Buckley Biggs et al., 2022; Moore et al., 2022; Nilson & Stedman, 2023; Spangler et al., 2024)—what are often referred to as cultural ecosystem services (Bieling & Plieninger, 2013). Moore et al. (2022) observe that rural residents that take this view on solar development typically believe that rural landscapes are a public good, and thus decisions to site utility-scale solar should be made at the community level, which conflicts with the private property rights position taken by many farmland owners (Moore et al., 2022; Spangler et al., 2024). Spangler et al. (2024) found that these conflicting viewpoints have created tension among neighbors in some rural communities in Pennsylvania. These contrasting rural perspectives suggest that elected officials should engage the broader community in the process of developing utility-scale zoning policies in order to find a compromise that best serves their residents.

Research Objectives

As noted above, this research project had three main objectives, each drawing on methodologies that are tailored to the specific aims of the research. The methods for each of these objectives are presented in more detail in the next section.

- Objective 1: Develop a baseline assessment of the current solar development landscape in Pennsylvania and identify the regions with the greatest future development potential. This objective was assessed primarily using GIS analysis, supported by additional statistical modeling.
- Objective 2: Compare the solar regulatory context in Pennsylvania with that in New York and North Carolina. This objective was assessed through a desktop review of state-level policies regarding solar energy development across these three states.
- Objective 3: Develop a grounded understanding of how the process of utility-scale solar development currently takes place in rural Pennsylvania. This

objective was met using semi-structured interviews with public officials at the state, county, and local levels of government, solar developers working in the Commonwealth, and expert interviews to capture a broad understanding of the experience of landowners.

Methods

Geographic Analysis of Current and Future Solar Development

Addressing this research objective involved a three-part methodology. All the analysis for this objective was completed using ArcGIS Pro and the R statistical package.

In the first phase, an extensive GIS database of environmental and socio-economic factors was compiled for Pennsylvania based on factors identified by industry practices, government agencies, and past research as important for the siting of utility-scale solar energy development. These include environmental factors such as average solar radiation, topography (slope and aspect), soil resources, and climate factors such as average temperature and wind speeds; infrastructure variables like the location of power relay stations and transmission lines; and socio-economic factors such as property values and relative population density. A full list of factors and sources for the data is found in Appendix 1 at the end of this report.

After compiling this database, we first created a series of masks in ArcGIS to remove areas from the map of Pennsylvania where utility-scale solar is not possible, such as urban areas, protected areas, water bodies, and areas with very steep terrain, and identified the areas that fall within the acceptable range of values for each variable in our database. The result of this work produced a map of the geographic distribution of land in Pennsylvania that is considered suitable for utility-scale solar development by accepted U.S. standards.

In the final phase, we created a dataset that mapped the locations of all current and proposed utility-scale solar facilities in Pennsylvania for which we could verify the precise location, yielding 183 unique utility-scale solar facilities. This dataset was compiled by validating each record in the PJM interconnection queue for a utility-scale solar facility in Pennsylvania. Records were excluded from our final data set if they did not include a precise address or geographic coordinates for the solar facility. Some additional records were excluded if the provided location was a region where utility-scale solar development was not possible, such as a protected natural area, urban center, or body of water. This culling was necessary to ensure that the site data used for our model represented conditions at actual solar facilities in the Commonwealth.

Our final dataset of solar facilities was then used to compile specific values for each variable in our database to determine geographic trends in solar development that are specific to the Commonwealth. These results were then analyzed and weighted based on their relative importance. Finally, this weighted data was used to develop a Pennsylvania-specific model that can identify the regions that are most likely to see significant solar development pressure in the coming years. The details of our final model are included in Appendix 1.

Comparative Policy Analysis

To assess the extent to which the solar regulatory context in Pennsylvania affects solar development, we conducted a desktop policy audit comparing Pennsylvania to North Carolina and New York—two Eastern states with significantly higher rates of utility-scale solar development. These two states were selected for comparison here for several reasons. First, both New York and North Carolina have very high rates of utility-scale solar development (both are among the top five for all states) (Fujita et al., 2023). This significant difference in solar development compared to Pennsylvania provides clear signals for differential policy impacts. In other words, if policy differences are meaningful for solar development, these states will provide clear evidence. Second, New York and North Carolina are similar to Pennsylvania in a number of ways that allow for meaningful comparison. All three states are of a similar geographic size with comparable populations (especially when the population of New York City is discounted), and all three states are significantly rural, with similar territory in agriculture and at least some territory in the Appalachian Mountains. Finally, both New York and North Carolina are either completely (New York) or mostly (North Carolina) outside the PJM grid management region. Given that it is possible that the grid interconnection backlog mentioned above is a barrier to development, comparing Pennsylvania with these two states will better allow the assessment of policy effects in and of themselves. Other PJM states, such as Maryland and New Jersey, have much higher levels of solar development than Pennsylvania, but unfortunately, this makes for poor comparisons due to significant geographic and demographic differences.

The policy audit reviewed differences and similarities in Renewable Portfolio Standards, as well as any current state level recommendations towards land leasing and zoning laws for each state. In addition, the desktop policy audit also examined the following:

- Renewable energy certificates and solar renewable energy credits.
- State-level guidance for local decision makers and landowners (i.e., toolkits, model ordinances, etc.).
- Primary state departments or offices that are engaged with solar energy development.

The primary work of the policy audit involved reviewing state-level policies to determine the presence or absence of each program or practice. In addition, this process created an outline of which policies have or have not been adopted by each state, as well as any pending legislation relating to solar energy.[3]

[3] This policy analysis did not assess tax policy related to solar energy development for two primary reasons. First, the most significant tax incentives available to utility-scale solar development are at the federal level and thus available in all three states. Secondly, and perhaps more importantly, tax policy analysis requires a particular type of policy expertise that was not represented on our research team. Therefore, while tax policy analysis for solar development may be useful research, it is not included in this report.

Current Process of Utility-Scale Solar Development in Pennsylvania

In order to best assess the current process of solar development in Pennsylvania, we sought an in-depth understanding of the grounded experiences of the diverse stakeholders affected by utility-scale solar development in the rural regions of the Commonwealth. For the purposes of this study, solar stakeholders included local and county-level government officials, state agency officials, municipal solicitors, solar developers, landowners, and academic experts working within the field of solar energy. We conducted 27 in-depth, semi-structured interviews representing 29 solar stakeholders in Pennsylvania to serve as the primary data source for this analysis. We also conducted additional state-level interviews in New York and North Carolina (two interviews each) to better understand the impact of state-level policy implementation. A breakdown of interviews is found in Table 1, with Figure 1 presenting the geographic distribution of our interview participants in Pennsylvania.

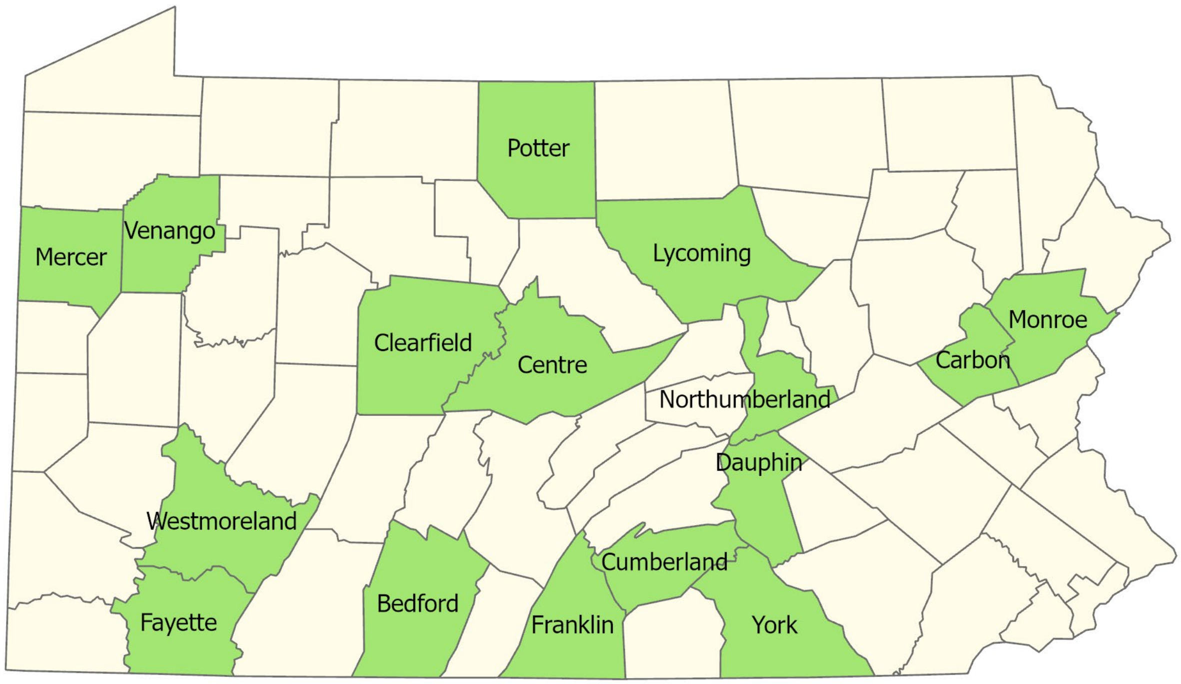
Table 1: Interview Participant Details

Category	N
County Planners	13
Township/Municipal Planners & Solicitors	3
Utility-Scale Solar Developers	5
Individual Landowners/Scholars with Landowner Expertise in PA	4
State-Level Officials in PA	4
State-Level Officials in NY & NC	4

Note: We have generalized certain details to protect the anonymity of interview participants.

Interview participants were identified and recruited using a purposive stakeholder sampling methodology (Palys, 2008). In this sampling approach, participants are strategically selected based on their connection to the phenomenon being studied—utility-scale solar development in rural Pennsylvania. Initial interview participants were recruited from stakeholders with a preexisting relationship to the Center for Land Use and Sustainability, with additional participants recruited based on recommendations from interview participants using a snowball sampling methodology that is common in institutional and policy studies (Creswell, 2006). In addition to purposive snowball sampling, this study also used criterion sampling to identify potential participants. Under criterion sampling, study participants are recruited based on a set of criteria deemed important to the research objectives (Palys, 2008). In this case, our criteria for identifying potential participants were based on the roles of individuals within a government office or organization (e.g. planners, township supervisors).

Figure 1: Geographic Distribution of Interview Participants in PA



Source: U.S. Census Bureau.

While we were able to interview one landowner for this study, additional landowner participants proved particularly difficult to recruit within the scope of our project timeline. This was a recognized challenge in our approach given that rural residents are typically reticent to work with researchers without prior relationships or significant investments in time. Additionally, the fact that there are relatively few utility-scale solar facilities in Pennsylvania made the pool of potential participants quite small. After several months of effort, we elected to capture landowner perspectives through a common research methodology known as expert interviewing (Bogner et al., 2009). To that end, we conducted three in-depth interviews with academic experts with significant experience working with rural landowners in Pennsylvania on the issues of utility-scale solar development and solar land leasing. Expert interviews can introduce bias in qualitative research if care is not taken to separate the expert's interpretation from their reporting. To that end, we took care in interviews to encourage subject experts to provide more detail and asked clarifying questions to better identify the positions and subjectivities of the experts. We also triangulated these findings with what we learned from county and local officials, who also interact directly with landowners. Together, these interviews provided a wealth of information on the diverse perspectives of landowners across the Commonwealth.

Prior to the completion of interviews, a series of interview guides were developed for each unique solar shareholder group. During interviews, each participant was asked a series of 10 to 15 questions based on the stakeholder group to which they belong and any experiences they may or may not have had with solar energy development at the time of interviewing. It is important to note that interview guides are used in qualitative research to provide baseline consistency across interviews, but they are not an oral survey. All interviews are open-ended conversations, and no two interviews are exactly alike. This allows for novel and even surprising things to be learned from each interview, but it also means that our results cannot be quantified like survey data—even for our scripted questions. Complete interview guides are included in Appendix 2.

Participant interviews were primarily completed via Microsoft Teams or Zoom, with a small number of interviews being completed in-person. Interviews lasted between 30 and 45 minutes with variance in length stemming from the key stakeholder group and the participant's willingness to converse. Questions asked during interviews also contained variance based on the key stakeholder group. Each of the key stakeholder groups was asked similar questions on topics such as, but not limited to, the impact of state-level policies, the role of local zoning and ordinances, community responses or attitudes, and the landowner leasing process. How these questions were phrased and answered varied by the key stakeholder group. In cases where participants belonged to one or more key stakeholder groups, a blended version of these questions was discussed.

The goal of this semi-structured interview process was to unveil "on the ground" conditions of solar energy development through the lens of each key stakeholder group, with questions focused on the experience of each specific stakeholder group rather than generalized "catch-all" questions. As a participant's experience with solar energy development is dependent on their role as a stakeholder, questions tailored to the participant's stakeholder group were crucial in allowing for the emergence of differences and similarities in experiences across and between key stakeholder groups. Thus, the style of questions asked in this study can be analyzed both within and outside of key stakeholder groups, allowing the data to reveal themes or patterns at different scopes and scales.

In all cases, interviews were recorded and transcribed prior to analysis. To ensure consistency, one researcher completed and transcribed all interviews in this study. Following transcription, interviews were then analyzed utilizing NVivo 14 qualitative data analysis software. The analysis of key stakeholder interviews was completed using the principles of grounded theory methodology, which seeks to develop a general theory from the experiences of study participants (Creswell, 2006). The goal of grounded theory methodology is to develop a theory that explains a process or phenomenon rooted in the "on the ground" personal accounts of those who have experienced it (Creswell, 2006). This process of data analysis entails multiple rounds of analysis with interview data, with successive rounds progressing toward generalizable themes that form the basis for a grounded understanding of the current utility-scale solar development process in Pennsylvania.

Results

Geographic Analysis of Current and Future Solar Development

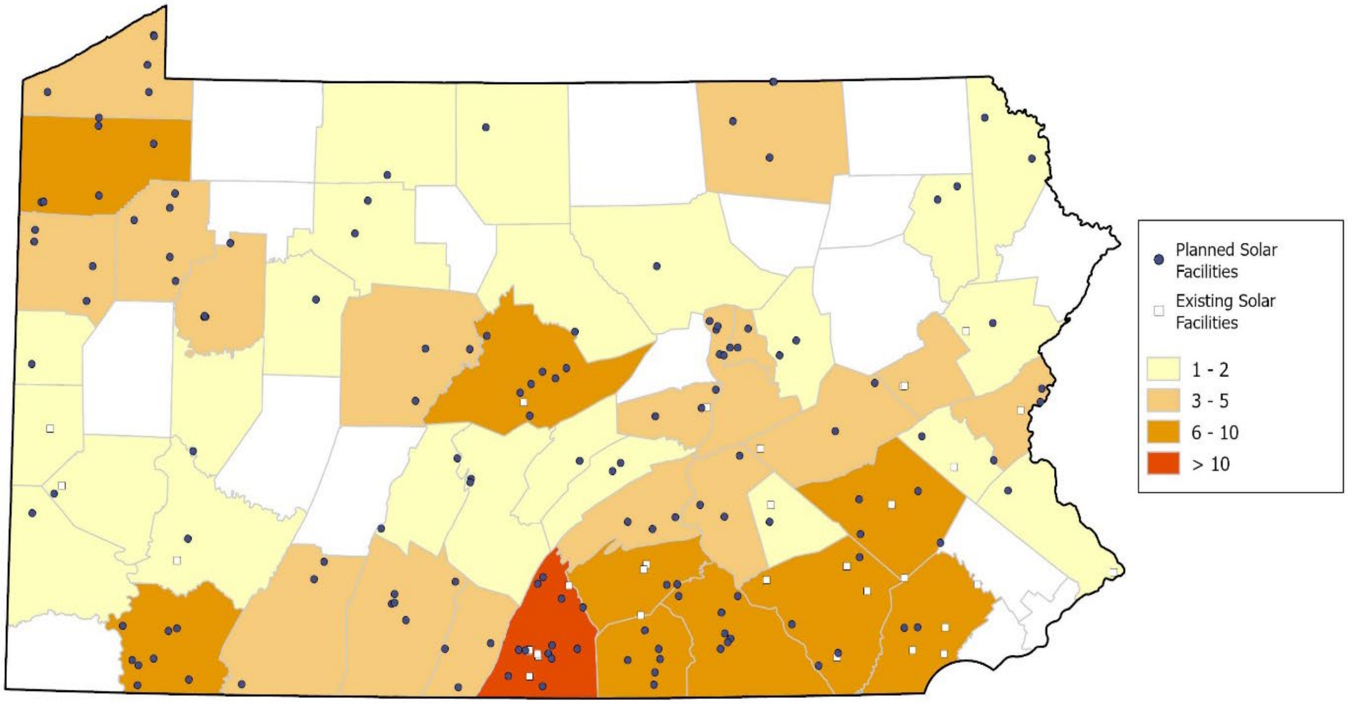
As we noted in the introduction to this report, ample solar resources, well-developed transmission infrastructure, and a significant rural and agricultural land base are attractive to utility-scale solar development. Within this general suitability, the goal of our geographic analysis is to determine the specific site characteristics associated with current utility-scale solar development in Pennsylvania to better identify regions of the Commonwealth that are more likely to see solar development in the coming years.

Our analysis indicates that of the 67 counties in Pennsylvania, 50 currently have at least one utility-scale solar project either proposed or currently in operation (see Figure 2). This is striking, especially considering that our dataset only includes geographically verifiable projects. The 183 verifiable projects in our dataset only represent approximately 42% of all PA-based utility-scale solar projects currently in the approval queue maintained by PJM Interconnection, the grid servicing company that manages the electrical grid in Pennsylvania. It is possible, then, that many counties in the Commonwealth are experiencing higher levels of solar development than what is captured by our analysis. We focus on geographically verifiable projects for this study so that we can accurately assess the site characteristics currently favored for utility-scale solar development in Pennsylvania. It is entirely possible, however, that other development activity is occurring that has not yet (and may never) been registered in the PJM interconnection queue. This first observation provides strong validation that Pennsylvania is broadly attractive to utility-scale solar development.

Social and Economic Factors

While much of Pennsylvania is experiencing some solar development pressure, there is a clear geographic concentration of utility-scale development in the Southeastern portion of the state (see Figure 2). There is a logic to this trend, as this is the most densely settled region of the state, with a concomitant density of transmission infrastructure and electricity demand. However, most of these counties are not considered rural, as defined by the Center for Rural Pennsylvania. In order to provide a more nuanced analysis, we augmented the county classification definition used by the Center for Rural Pennsylvania. The Center for Rural Pennsylvania defines urban counties as those with a population density greater than the state average of 291 people per square mile, and rural counties as those that fall below the average. We then divided each of these two categories into three subgroups based on the dominant land uses found in each county based on the U.S. Geological Survey National Land Cover Database (Dewitz & USGS, 2021). Table 2 below presents the definitions used for this classification. This new classification allowed us to determine if utility-scale solar development shows a preference for different land uses in rural vs. urban counties, or if there are broad trends across the Commonwealth.

Figure 2: Distribution of Solar Projects by County



Source: U.S. Census Bureau, PJM Interconnection.

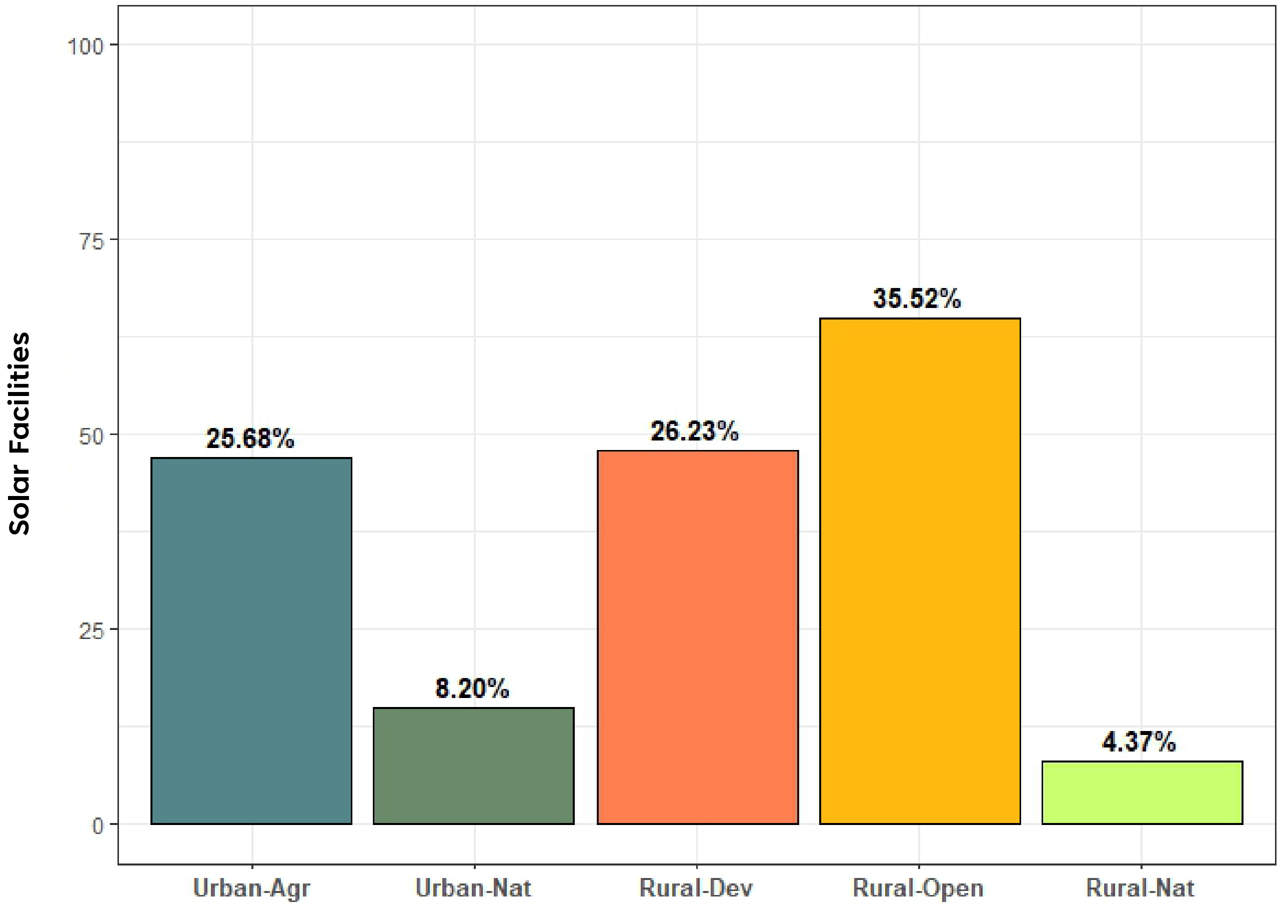
Table 2: County Classification Based on Population and Land Use

Category	Definition
Urban|Dev	Highly populated and significantly urban counties. Developed in more than 70% of the county's surface. **Typical case: Chester**
Urban|Agr	Former agricultural counties that have experienced significant growth and development. Agriculture remains a significant land use despite high population density. **Typical case: Lancaster**
Urban|Nat	Counties with significant natural land cover also contain a significant population center that increases population density at the county level. Development is in many cases constrained by topography, with urban areas occupying valleys and former agricultural land. **Typical case: Lackawanna**
Rural|Open	Rural counties with lower population density and relatively low percentages of developed land. Usually are in zones with more mountainous topography than Rural|Dev, with a balance between forest and agricultural land. **Typical case: Bedford**
Rural|Dev	Rural counties where agricultural land is dominant, yet population growth has resulted in a higher proportion of developed land use. While rural, these counties tend to have relatively higher population density within the rural category. **Typical case: Franklin**
Rural|Nat	Rural counties that are predominantly forested. Sparse population clustered in very small population centers. Generally mountainous, with complex relief and narrow valleys. Agricultural land is scarce. **Typical case: Potter**

Note: All counties with a Rural designation have population density below the Pennsylvania average, and counties with an Urban designation fall above that line. Source: (Dewitz & USGS, 2021).

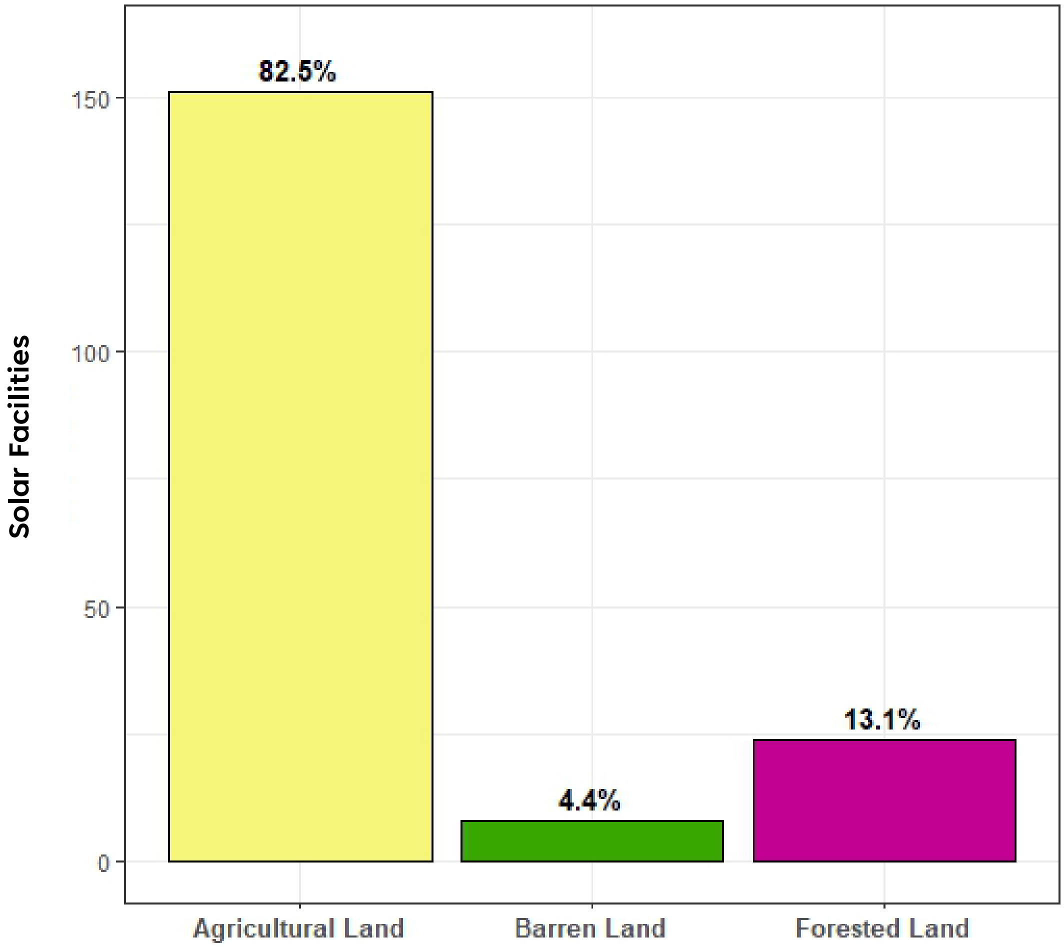
Despite the concentration of utility-scale solar development in the urban southeastern counties, our analysis indicates that the majority (66.12%, the sum of all rural subgroups) of utility-scale solar projects in our dataset are located in the primarily rural counties of Pennsylvania (Figure 3), which is in keeping with previous research on solar development in the Commonwealth (Evans et al., 2023).

Figure 3: Distribution of Utility-Scale Solar Development by County Classification



Across all counties, rural and urban, we found that the vast majority of utility-scale solar facilities are sited on agricultural land as defined by the National Land Cover Database (Dewitz & USGS, 2021) (Figure 4). Unlike other studies (e.g., Evans et al., 2023), we found no preference for lower-quality soil among current and proposed solar sites as defined by the Pennsylvania Department of Agriculture's Clean & Green program (PDA, 2023), especially in urban counties. This preference for rural and agricultural land is in keeping with trends identified in other parts of the U.S. (Evans et al., 2023; Hernandez et al., 2015; O'Shaughnessy et al., 2023). With 48 of Pennsylvania's 67 counties classified as rural and roughly 25% of its land base identified as agriculture in the most recent U.S. Census of Agriculture (USDA, n.d.), a significant portion of the Commonwealth has at least some characteristics currently favored by utility-scale development in Pennsylvania. In particular, the preference for agricultural land across rural and urban counties suggests that policy action intended to support and regulate solar development in rural Pennsylvania may also have a broader impact across the state.

Figure 4: Distribution of Utility-Scale Solar by Land Use



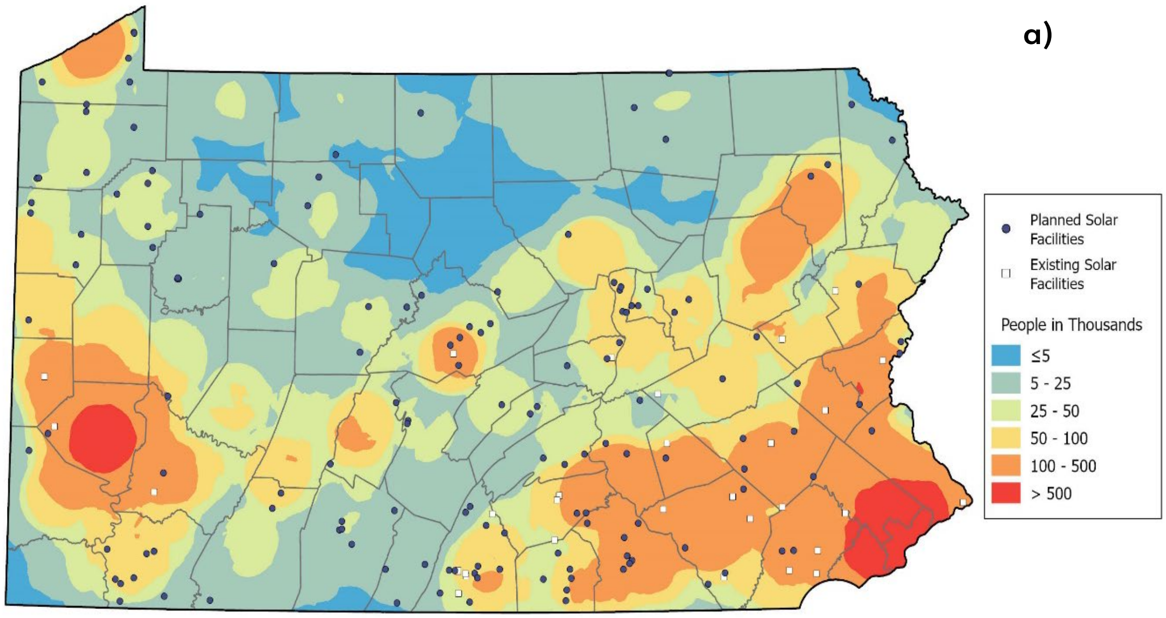
Another commonality across all counties is the tendency for utility-scale solar to site in relative proximity to population density (calculated using the Census block data from the U.S. Census). In urban counties, there is sufficient population density that the geographic attraction for siting is muted, but in rural counties, the difference is quite clear (see Figure 5). This finding is in keeping with other research on solar development in the U.S. (Evans et al., 2023; Waechter et al., 2024). Various radial distances for measuring population in the vicinity of solar facilities were tested for the model. If the radius is too short, for instance, a location that is five miles from a residential population center can incorrectly appear no different than a site that is 30 miles away. Likewise, if the radius is too long, differences between sites are difficult to detect as proximate populations become similar. Our analysis found that for Pennsylvania, the population found within a 10-mile radius was the optimal distance for assessment and inclusion in our final model.

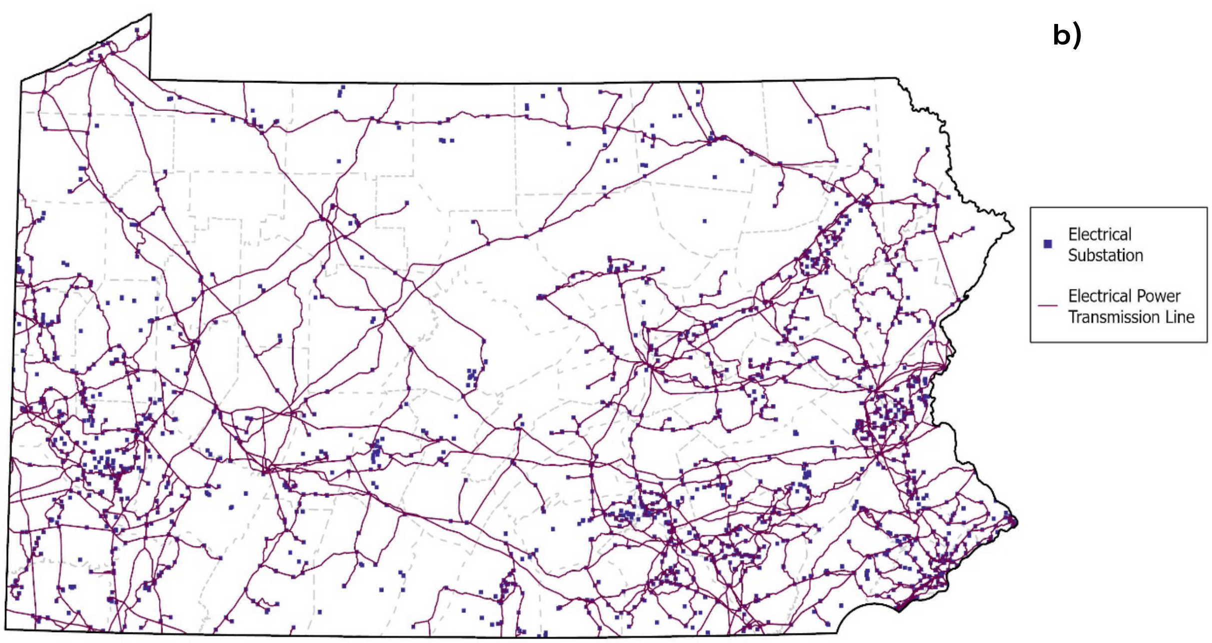
Our analysis also found a strong preference across all counties for close proximity to electricity transmission infrastructure, with approximately 82% of all sites in our dataset located within two miles of either a relay station or high-capacity transmission lines (see Figure 5). It should be noted, though, that electricity transmission infrastructure and relative population density spatially correlate, and more detailed statistical analysis is needed to determine the nature of this covariance. Our analysis suggests that these two factors act independently and are not a source of error in the model. First, the distances over which the effects are observed are quite different, with transmission infrastructure showing a preference at less than two miles, whereas a 10-mile radius is needed to assess relative population density. Furthermore, the variation in these two factors is not identical. In other words, a site that is close to infrastructure does not necessarily show the same trend in its relative population density. If anything, our analysis suggests that these factors might interact (i.e., proximity to both has a greater effect than simply adding their individual effects together), but fully parsing these questions requires predictive modeling that is beyond the scope of this study.

Finally, our analysis found a tendency for utility-scale solar to locate on land that is relatively less expensive than other properties found within a three-mile radius. As with relative population density, a three-mile radius was selected based on the scale over which property values vary. Numerous radial distances were assessed, and three miles was determined to be the optimal distance for our analysis—both eliminating statistical noise and remaining sensitive enough to detect any preference based on property values. We calculated property values using a combination of two datasets: agricultural land values as determined by the Pennsylvania Department of Agriculture and a database of fair market values for private property in the U.S. compiled by Dr. Christopher Nolte of Boston University (Nolte, 2020; PDA, 2023). It is important to note, however, that this property value preference is relative, and our analysis does not show that solar tends to locate in regions with the lowest absolute cost of land acquisition (Figure 6).

In total, our analysis finds that utility-scale solar tends to favor cost reduction relative to other nearby locations (a graphic detailing these relationships is found in Appendix 3). This conclusion is rather intuitive for property values; in addition, greater proximity to infrastructure and population centers also significantly reduces the cost of construction for utility-scale solar (MISO Energy, 2023). These findings are similar to other research referenced in this report (e.g., Evans et al., 2023; Hernandez et al., 2015), though it is also possible that the strong preferences found in our analysis are due to an abundance of high-value sites resulting from the low levels of extant solar development in Pennsylvania. As demonstrated below, there are significant regions of highly attractive land for solar development in Pennsylvania, but under very high levels of solar buildout, it is possible that the strength of these observed preferences will deteriorate as high-value sites become scarce. Interestingly, there are some significant outliers among the subset of operational solar facilities in terms of property values. In these cases, solar facilities are sited on land that is significantly more expensive than surrounding properties. This suggests that there may be other non-economic factors at play in solar siting, an observation corroborated by the fact that the value of agricultural land does not seem to influence solar siting. We discuss these discontinuities below, but further research is needed to better understand these phenomena.

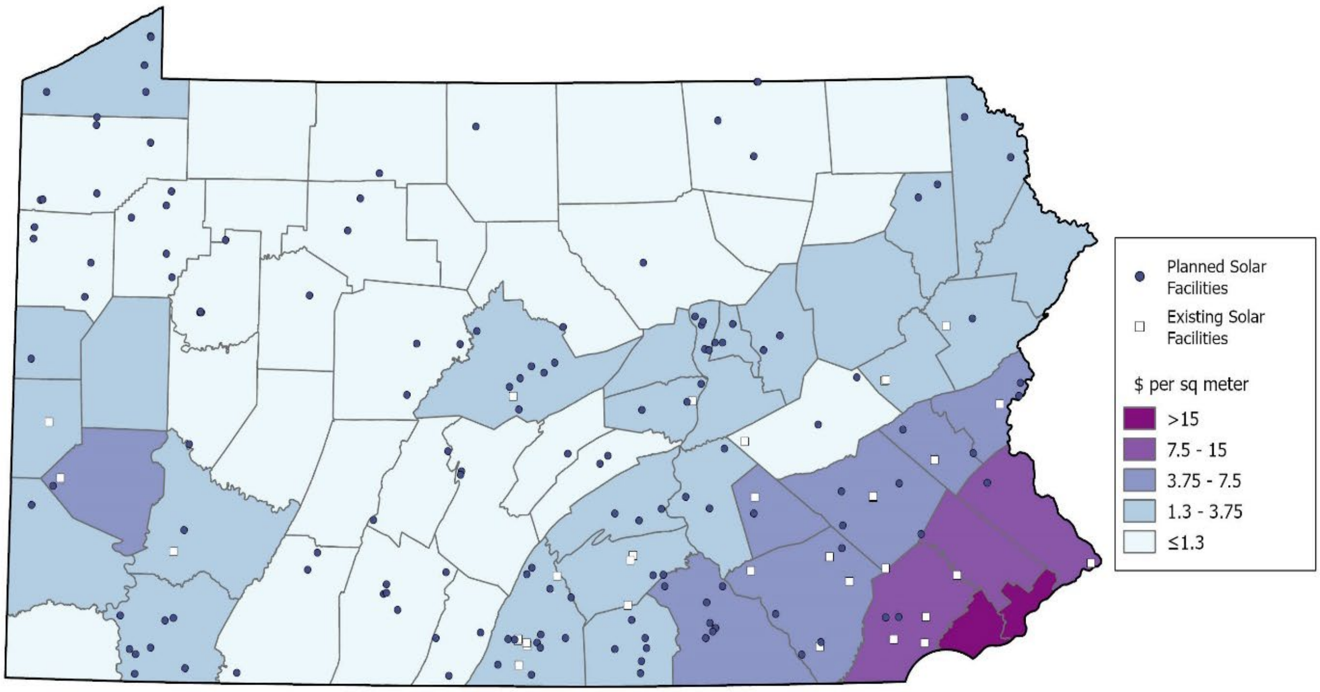
Figure 5: Utility-Scale Solar by Population Density and Transmission Infrastructure





Note: Map a) depicts the population in thousands found within a 10-mile radius, and b) the electrical transmission infrastructure. These factors show strong spatial correlation, and our analysis found proximity to both to be influential in siting. Data source: U.S. Census Bureau, U.S. Dept. of Homeland Security.

Figure 6: Cost of Land Acquisition by County



Note: Cost represents the average cost per square meter at the county level. These values translate to per-acre costs ranging from less than $5k/acre in the lowest class to more than $60k/acre in the most expensive counties. Data source: PA Dept. of Agriculture, Nolte, 2020.

Environmental Factors

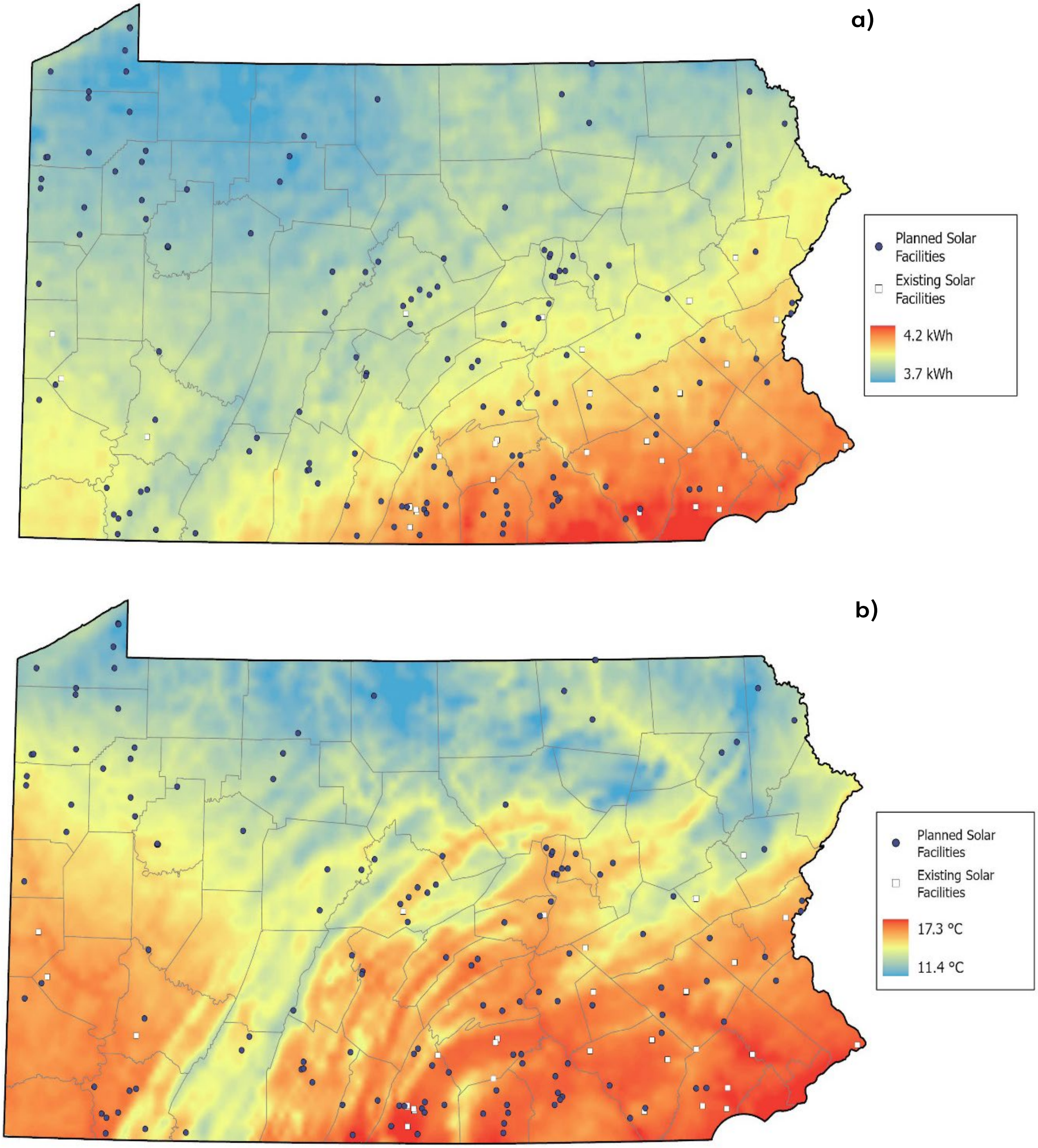
The primary environmental factor considered in solar siting is average solar irradiance, or the amount of solar energy an area typically receives, measured in kilowatt hours per square meter per day (kWh/m^2/day). Other environmental factors, such as slope and aspect, are also considered because they have the potential to limit average solar irradiance. To be economically viable in the current energy market, utility-scale solar sites require a minimum annual average irradiance of 3.5 kWh/m^2/day and a minimum of six hours of sunlight on the shortest days of the year (EPA, 2015). Studies have also shown that the energy output and efficiency of solar panels are also affected by climate conditions, where performance decreases as temperature increases, and higher wind speeds can reduce these negative interactions (Amelia et al., 2016; Gökmen et al., 2016). In general, solar panel performance begins to decrease as ambient temperatures rise above approximately 25˚C (77˚F), and significantly decline at temperatures in excess of 30˚C (86˚F), with higher wind speeds producing a cooling effect that moderates temperature effects.

Baseline analysis finds that all of Pennsylvania receives average solar irradiance above the minimum benchmark and has average annual temperatures well below the problematic range (Figure 7). Existing and planned utility-scale solar facilities show a slight preference for sites with higher solar irradiance and higher average temperatures. These factors are covariates, however, so in our final model, we chose to only give significant weight to average irradiance so as not to skew results. Our model is driven by data observations, yet it is possible that the available data is biased toward higher irradiance sites because the region of Pennsylvania with the highest average irradiance values spatially coincides with high population density and easy proximity to critical infrastructure. Further research will be needed to elucidate these findings.

While initial environmental analysis presents nearly all of Pennsylvania as well-suited for utility-scale solar development, topographic variation due to the presence of the Appalachian Mountains can have a significant local impact on suitability. This occurs either from shading introduced by steep slopes or reductions in hours of sunlight when slopes angle away from south-facing by more than 20-30° (a factor known as *slope aspect*). Sites with slopes greater than 10% also incur higher construction costs due to the need for increased grading and site preparation and more detailed and costly stormwater management plans, though the Pennsylvania Department of Environmental Protection will permit solar development on slopes in excess of 15% in some cases (DEP, 2021). Approximately 50% of Pennsylvania has a slope of less than 10%.

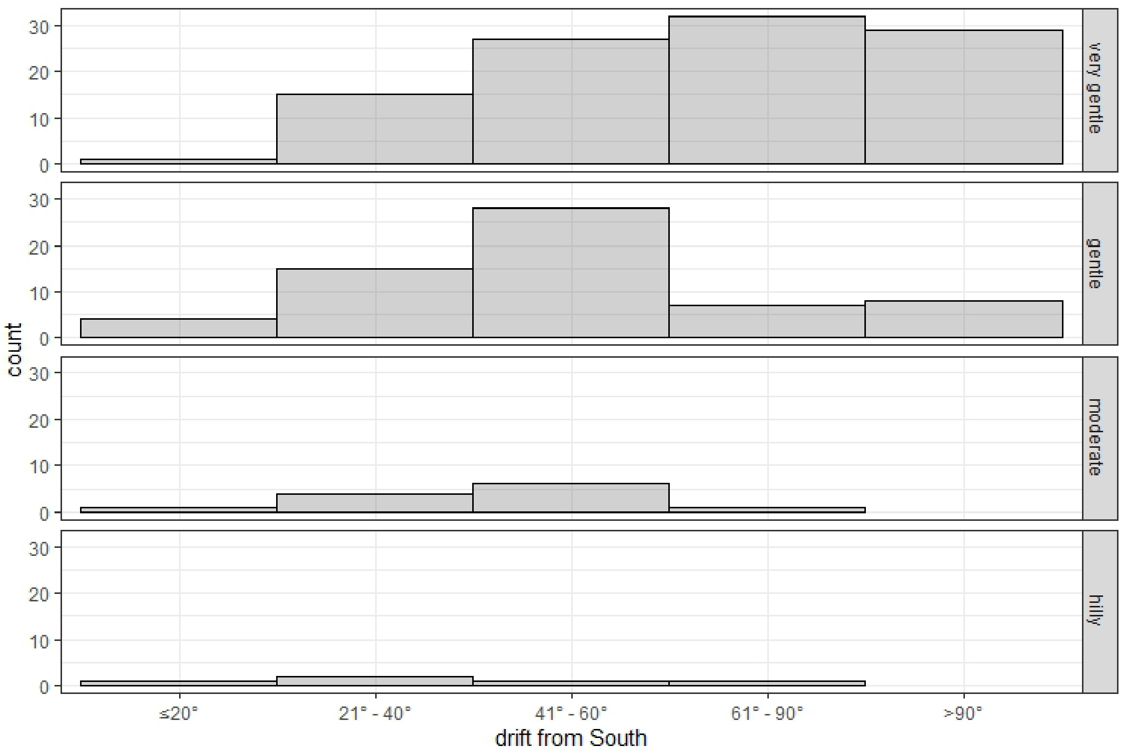
Our analysis found that 80% of utility-scale solar facilities are sited on terrain with slopes less than 8%, with 60% falling below a 5% gradient (Figure 8). This is perhaps not surprising given that flat land reduces construction costs, yet it is higher than would otherwise be expected in a state with a median slope of 10.29%. Since the impact of slope aspect on solar energy production is greatly reduced in gentle terrain, the significant preference for flat or gentle topography in Pennsylvania essentially eliminates aspect as a factor in solar siting, and it is thus not included in our final model.

Figure 7: Average Solar Irradiance and Temperature



Note: Map a) average annual solar irradiance; map b) average annual temperature.
Data source: National Renewable Energy Laboratory.

Figure 8: Distribution of Utility-Scale Solar by Slope and Aspect



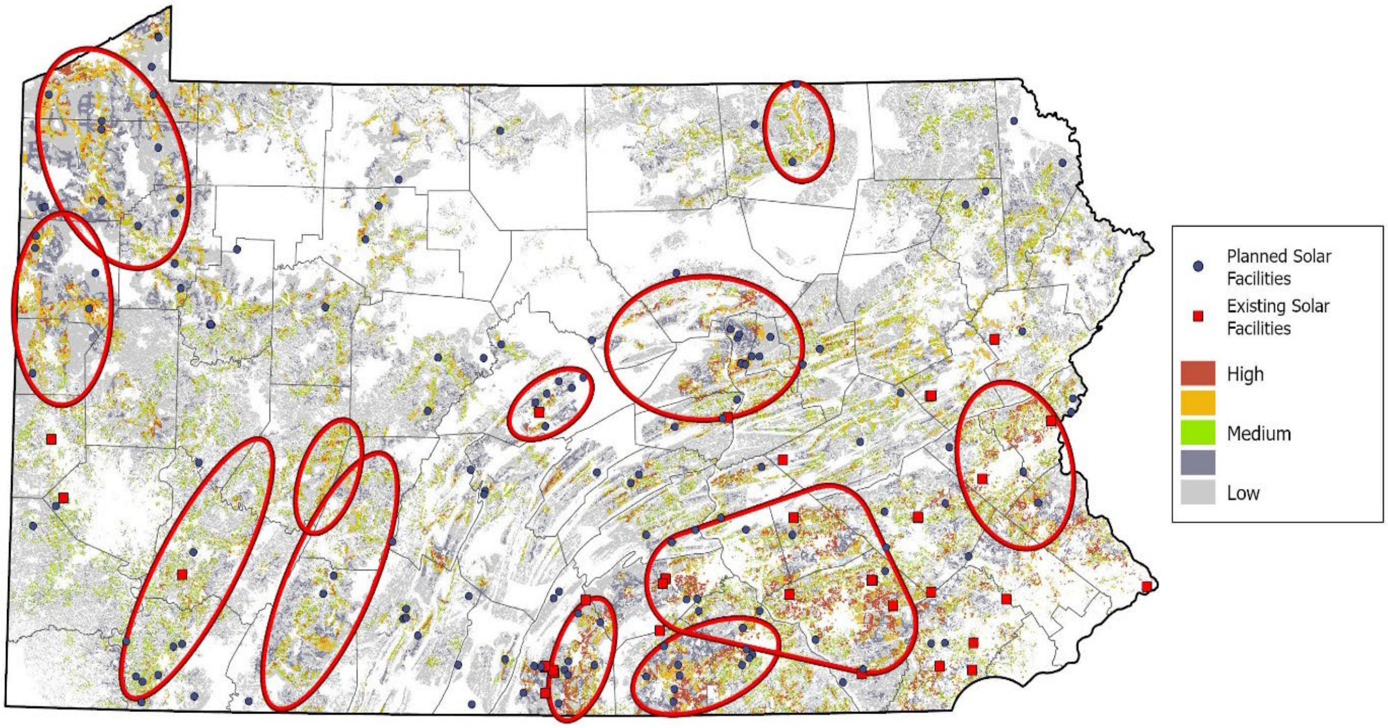
Note: Slope categories: Very Gentle: < 5%; Gentle: 5-10%; Moderate: 10-15%; Hilly: > 15%. Data: U.S. Geological Survey.

Most Desirable Regions for Utility-Scale Solar Development

Following our initial analysis, each factor found to be significant in the siting of utility-scale solar in Pennsylvania was classified into weighted categories based on demonstrated preference. Value ranges found to be most desirable were assigned a value of 1, with subsequent classes given a proportional weight between 0 and 1, depending on the rates of development found in our dataset. These weighted classes were then used to build a suitability model to determine the likelihood of utility-scale solar development across the state. The full details of these weights and the final model are included in Appendix 1.

Figure 9 depicts the results of our final model, which includes the factors outlined in this section, from temperature and radiation to land use and distance from the grid. The model assigns suitability scores; the higher the suitability score, the more attractive the location is likely to be for utility-scale solar development in the future. The regions outlined in red are those with the highest concentrations of highly suitable land.

Figure 9: Regions Most Likely to Experience Utility-Scale Solar Development Pressure



Note: Regions appearing in white are excluded due to topography, incompatible land use/land cover, or protected status. Data: Analysis based on full data set. See Appendix 1.

Model results indicate that under current conditions, the most significant clusters of highly desirable land are found in the Northwestern and Southeastern regions of Pennsylvania, significant portions of which are not considered rural. If development accelerates in these urban and suburban regions, however, it is reasonable to assume that utility-scale development will spill into adjacent rural counties with some suitable land—especially if transmission infrastructure expands. Franklin and Adams counties stand out in our analysis as rural areas of particular interest for solar development, and it is no coincidence that these counties currently have among the highest number of utility-scale solar facilities in our dataset. Franklin and Adams counties, as well as the counties in proximity to Pittsburgh, are particularly well positioned to service areas of high electricity demand without significant transmission infrastructure upgrades. Lastly, the region of high suitability in Bradford County could see additional development pressure due to its proximity to New York State, which has ambitious renewable energy goals encoded in state law.

Comparative Policy Analysis

The results of the desktop policy audit and comparative analysis indicate stark differences between state-level solar policy and regulation in Pennsylvania compared to both New York and North Carolina. As Table 3 indicates, of all the state-level solar policies, offices, and other organizations found across these three states, Pennsylvania has only one in common with New York and North Carolina and none that is unique to the Commonwealth.

Table 3: State-Level Solar Policies in PA, NY, and NC

Policy Type	Pennsylvania	New York	North Carolina
Renewable Portfolio Standard	Yes*	Yes	Yes
State-Level Decommissioning	No	No	Yes
Community Solar	No	Yes	Yes
Prime Farmland Protection	No	Yes	No
State Siting Board	No	Yes	No
Clean Energy or Decarbonizing Standard	No	Yes	Yes

*Note: *Pennsylvania's Alternative Energy Portfolio Standard expired in 2021 and has not been updated. The standards required by the previous measure prevent regression, but there is currently no new standard to advance renewable energy in PA.*

In this section of the report, we take each state in turn, offering a brief discussion of the policy approach in each state, as well as a summary of policies identified in our audit. To be clear, our audit focuses on state-level policy addressing utility-scale solar. This means that we do not consider policies (or parts of policies) that focus on what is generally referred to as 'behind-the-meter' solar generation. Behind-the-meter solar refers to small-scale solar generation adopted by individual consumers and businesses for the purpose of on-site electricity consumption. We conclude with a broader discussion that considers similarities and differences between Pennsylvania, New York, and North Carolina and the role that policy may play in differences in utility-scale solar development across these three states.

Pennsylvania Solar Policy

Our policy audit found only one piece of state-level legislation addressing solar energy—the Alternative Energy Portfolio Standards Act of 2004 (AEPS)—which expired in 2021. The standards established in the 2004 Act remain in effect, requiring, among other things, that 18% of retail electricity sales come from renewable sources, with 0.5% from solar. The remaining policy items identified by our audit are proposed bills in one or both houses of the state legislature.[4] These proposed bills address a number of issues

[4] We use specific bill numbers here to refer to proposed legislation for ease of discussion, but it should be noted that these designations are specific to the 2023-24 legislative session and would not carry over to future sessions.

pertaining to utility-scale solar, including an update and revision of AEPS, bills authorizing community solar in Pennsylvania, a bill creating tax incentives and land use requirements to govern the siting of utility-scale solar, and bills mandating end-of-life decommissioning and site remediation for utility-scale solar facilities. In some cases, as with community solar, similar bills have been introduced with action in previous legislative sessions. At the time of writing, there are no scheduled votes for any of these bills.

Among the proposed bills considered here, passage bills updating the AEPS (SB 230/HB 1467) and those authorizing community solar development (SB 550/HB 330) would likely have the largest impact on future solar development in the Commonwealth. To be clear, we are not advocating for the passage of bills. Past research and our interview findings (discussed later in the report) indicate that these or similar policies would expand solar development. An updated AEPS with expanded solar minimums would require that utilities operating in Pennsylvania continue to invest in new utility-scale solar and ensure a more predictable market of power purchasers for developer-led initiatives. One developer we interviewed went so far as to say that policies like AEPS that guarantee markets for renewable energy are among the most significant considerations for the siting of new solar facilities. Likewise, community solar legislation tends to expand development because these facilities tend to be smaller and easier to site than grid-serving solar, and they tend to expand access and reduce energy costs more than wholesale models of development (Waechter et al., 2024). Currently, Pennsylvania law requires individual power purchasers (either residential or commercial) to either invest in their own solar array or purchase solar energy directly from a utility. Community solar legislation empowers groups of consumers (e.g., a neighborhood, township, business district, etc.) to develop and subscribe to their own solar facility, thereby controlling their own energy supply and benefiting directly from a solar facility sited in their community. As with AEPS, interview participants indicated that community solar is appealing to many rural residents of Pennsylvania.

This does not mean that there is no state-level action related to utility-scale solar in Pennsylvania, but rather that there has been very little regulatory activity. For instance, the Pennsylvania Climate Change Act of 2008 requires the Department of Environmental Protection (DEP) to issue and update a state Climate Action Plan every three years, and the most recent update includes recommendations for solar energy development (DEP, 2019). The DEP also produced a more focused report—*Pennsylvania's Solar Future Plan*—in 2018 that offers more detailed policy recommendations for utility-scale solar, including proposing a goal of 10% electricity generation from in-state solar by 2030 (DEP, 2018). Other state agencies, such as the Department of Conservation and Natural Resources and a working group of several state agencies, have issued pamphlets in recent years that offer broad guidance for the siting of utility-scale solar. These resources are all publicly available, but they have not resulted in enacted policies or enforceable regulations.

Alternative Energy Portfolio Standards Act of 2004

In 2004, Pennsylvania adopted the Alternative Energy Portfolio Standards (AEPS) Act. The AEPS set a schedule across 15 years that aimed to increase the use of renewable energy across the Commonwealth (Pennsylvania Public Utility Commission [PUC], 2022). The end goal of the AEPS was for 18% of Pennsylvania's retail electricity sales to come from renewable energy, with 0.5% of retail sales coming from solar energy sources by 2021 (PUC, 2022). Under the AEPS, alternative energy sources are broken down into two tiers: Tier I and Tier II. Tier I sources include solar, wind, and hydroelectric, while Tier II includes waste coal and coal bed methane (Pennsylvania Department of Environmental Protection [DEP], 2018). A further breakdown of renewable energy tiers via Pennsylvania's AEPS is shown in Table 1. In the AEPS requirements for 2021, Tier I accounted for 8% of retail electricity sales, while Tier II accounted for 10% of retail electricity sales to meet the overall goal of 18% of retail sales from renewable or alternative energy sources (DEP, 2018). Under the Tier I requirements, a specific solar energy carve out of 0.5% is included (DEP, 2018).

In 2021, the AEPS for Pennsylvania reached the end of its 15-year period. Despite the expiration of the AEPS, no further RPS or clean energy standards have been adopted by the Commonwealth. While proposed updates to the AEPS have been recommended, the bills have not yet made it out of committees in Pennsylvania's Senate or House of Representatives (Glabicki, 2022). Until the AEPS is updated or replaced, the requirements for retail electricity sales from alternative sources in Pennsylvania will remain at the 2021 standards of 18% from Tier I and Tier II, with a solar carve out of 0.5% (DEP, 2018).

SB 230/HB 1467

Since the expiration of the Alternative Energy Portfolio Standards Act in 2021, the legislature has yet to update its renewable portfolio standards. Currently, House Bill 1467 in the General Assembly of Pennsylvania is under consideration by the Committee on Environmental Resources and Energy. HB 1467 seeks to amend and update Pennsylvania's AEPS to include provisions for community solar installations and to expand the current electricity sales from renewable resources required by electric distribution companies. HB 1467 would update the AEPS to require greater percentages of electricity sales by electric distribution companies from Tier 1 alternative energy sources, culminating in 30% by 2030. HB 1467 stipulates that at least 4% of solar energy sales be produced by customer-generator-owned solar installations (e.g., rooftop solar) by 2030 and includes the requirement that a minimum of 2% of electricity sales come from community solar by 2030.

If implemented, HB 1467 would provide for a substantial update to Pennsylvania's Alternative Energy Portfolio Standards Act of 2004, placing the Commonwealth in a stronger position to transition into a renewable energy future. By comparison, New York's Clean Energy Standard currently calls for 70% of the state's energy to be renewably sourced by 2030, and North Carolina's House Bill 951 calls for a 70% reduction in 2005's carbon emission levels by 2030.

SB 550

Introduced in April of 2023, Senate Bill 550 of the Pennsylvania General Assembly intends to provide enabling legislation for community solar facilities across the Commonwealth. Under SB 550, community solar facilities would be permitted up to 5 MW in capacity rating or up to 20 MW of capacity if sited on a rooftop or a brownfield. Members of the community would then be able to subscribe to a portion of the solar facility's production with guaranteed savings versus a traditional electric bill.

HB 330

Similar to SB 550, House Bill 330 seeks to enable the creation of "Local Solar Programs" by an electrical distribution company. Under HB 330, customers of the distribution company would have the option to subscribe to a local solar program, which would offset their traditional energy usage. Local solar facilities would be allowed up to 30 MW in nameplate capacity. A Request for Proposals process would be used to competitively contract local solar facilities to reduce costs. In addition, HB 330 would require long-term power purchase agreements lasting 15 to 25 years to be agreed upon by an electrical distribution company and a developer for all power produced by the facility.

SB 798

Senate Bill 798, or the "Solar Energy Facility Location Act," contains a two-pronged approach to state-level management of solar energy siting. First, SB 798 prevents the siting of a solar energy facility on agricultural lands with Class 1 or Class 2 soils (i.e., prime farmland). The Department of Agriculture would be responsible for reviewing requests and ensuring that any proposed solar energy facilities are not on Class 1 or Class 2 soils.

A second approach contained within SB 789 is the creation of tax credits for solar energy facilities sited on brownfields, abandoned mines, capped landfills, warehouse rooftops, or parking lots. This tax credit is only applicable to projects greater than 2 MW in nameplate capacity that are also not defined as a customer-generator under the AEPS. Eligible solar energy facilities would receive a tax credit of 3 cents per KW, up to "30% of the project's cost of electricity generated for the first 10 years" of operation, with a cap of $5,000,000 per fiscal year.

SB 211/HB 925

Senate Bill 211 and House Bill 925 both seek to address the end-of-life and decommissioning of solar energy facilities. These pieces of proposed legislation would provide for a standardized decommissioning process across Pennsylvania. This process would entail the creation of a decommissioning plan, which includes property restoration and proof of financial assurance. The requirements detailed in SB 211 or HB 925 would not be applicable to solar energy facilities under 2 MW of nameplate capacity or customer generators. In addition, this proposed legislation would preempt any local or county ordinance, giving Pennsylvania a standardized statewide approach to decommissioning.

New York Solar Policy

Among the three states considered in our policy audit, New York has the most significant array of enacted policies relating to solar energy development, and we detail only the most significant pieces here. In addition to state policy, New York also has two state-level offices that coordinate solar energy development and streamline the siting process—the New York State Energy Research & Development Authority (NYSERDA, https://www.nyserda.ny.gov/) and the Office of Renewable Energy Siting (ORES, https://ores.ny.gov/). NYSERDA was created in 1975 with a broad mandate to promote energy efficiency in the state and plays a central role in solar energy development in New York. ORES is more recent and serves as a state-level clearinghouse for environmental assessment and permitting for large-scale renewable energy projects in the state.

Solar policy in New York State has three primary avenues of action related to utility-scale solar development. First, by continually updating their Renewable and Clean Energy standards, the state has maintained strong mandates for utility providers to invest in new renewable energy capacity. Furthermore, regularly expanding requirements for solar (often referred to as *solar carve-outs*) ensured a steady flow of mandated renewable energy investment into utility-scale solar. Secondly, NYSERDA and the Renewable Energy Standard Solicitation essentially act as second guaranteed purchaser for new utility-scale solar by contracting to buy renewable energy credits (RECs).[5] This then works in concert with New York's Renewable Energy Standards by guaranteeing purchasers for both the generated electricity and RECs, thereby increasing income potential from utility-scale solar. Finally, through the establishment of ORES and other siting policies, New York has created universal siting and permitting requirements for utility-scale solar and streamlined the siting development process.

In total, the state-level policy and regulatory approach to solar in New York has created a transparent and expanding market for utility-scale solar and likely increased the rate of development by expediting the siting and permitting processes. While our geographic and qualitative analysis did not cover New York, it seems likely that policy differences between New York and Pennsylvania explain some of the differences in levels of solar development between the states.

Climate Leadership and Community Protection Act of 2019

The Climate Leadership and Community Protection Act of 2019, or CLCPA, is a sweeping climate and environmental justice law that sets a goal of reducing New York State's carbon emissions. The CLCPA established a goal of the state's carbon emissions being 40% below 1990's level by 2030 and a further goal of reaching 85% below 1990's emissions level by 2050. Under the Climate Leadership and Community Protection Act (CLCPA), the state has set a goal of procuring 70% of its energy from renewable sources

[5] Renewable energy credits/certificates (RECs) are market instruments generated by renewable energy production. One REC is issued for each MW hour of renewable electricity that is generated and delivered to the electricity grid. RECs are held by the owner of the generating facility and are considered legal proof of generated renewable electricity, and in many contexts, can be sold and traded in the marketplace.

by 2030. To implement this ambitious goal, New York has created a number of programs and policies to promote the development of clean energy across the state.

Clean Energy Standard

As a part of the Climate Leadership and Community Protection Act of 2019, New York established new goals for its Clean Energy Standard, originally enacted in 2016, with a goal of 50% of the state's electricity coming from renewable resources by 2030. As mentioned previously, this goal was expanded to 70% renewable energy by 2030 in the CLCPA.

Currently, New York is on track to have an estimated 10 gigawatts (GW) of distributed solar and 16 GW of large-scale solar in operation by 2030 (NYSERDA, 2022). Unlike Pennsylvania, which uses a tiering system to separate different types of renewable energy to meet production goals, New York has established the Renewable Energy Standard (RES) and the Zero Emission Standard within the Clean Energy Standard (CES) (DSIRE, 2021). Within the RES, Tier I supports the growth of new renewable energy projects, while Tier II is a maintenance tier for projects that were created under the old New York Renewable Portfolio Standard (DSIRE, 2021). The Zero Emission Standard, formally Tier III under the CES, serves to support nuclear energy facilities in response to New York's greenhouse gas emission goals (DSIRE, 2021). Finally, Tier IV seeks to provide New York City with renewable energy capacity by supporting renewable energy projects that serve the city (DSIRE, 2021).

Renewable Energy Standard Solicitation

Within Tier 1, NYSEDRA is designated as the "central procurement administrator" (RFP 22). In this role, NYSERDA has the authority to enter long-term contracts to purchase renewable energy credits (RECs) from eligible renewable energy facilities (RFP 22). To accomplish this, NYSERDA releases a Renewable Energy Standard Solicitation annually (RFP 22). Once a project is completed, NYSERDA buys the RECs at a fixed rate based on the RFP. Following this purchase, NYERDA then sells the RECs to other entities to meet their renewable energy requirements as mandated in the Clean Energy Standard. In 2021, NYSERDA's Renewable Energy Standard Solicitation led to the awarding of 22 new solar projects, with an estimated 2,400 MW of capacity added once the projects are completed (RFP Factsheet 2021).

Accelerated Renewable Energy Growth and Community Benefit Act

In order to achieve the ambitious goals outlined in the CLCPA and CES, the New York State legislation enacted the Accelerated Renewable Energy Growth and Community Benefit Act in 2021. This act established a new siting process for large-scale renewable projects, a Build-Ready Program, and a Power Grid Study and Investment Program.

Under the act, the Office of Renewable Energy Siting (ORES) was created to handle the siting permit process for renewable projects greater than 25 MW. Projects between 20 and 25 MW have the option to opt-in to the ORES siting process or to be reviewed under Article 10. Within the ORES process, feedback from communities and local governments is required for any permit to be approved by ORES. In addition, the ORES permitting process requires "host community benefits" to be included by developers. For the first 10 years of a project's life, these host community benefit programs will provide residents in a community of a large-scale renewable project with credits on their utility bills. These utility bill credits are derived from a $500 or $1,000 per MW annual fee paid by developers, which is then distributed amongst the host community residents via a utility bill credit.

In addition to the creation of a new siting board and process, the Accelerated Renewable Energy Growth and Community Benefit Act establishes the "Build-Ready Program," which intends to prioritize renewable energy siting on brownfields, landfills, and other less appealing locations. Under the Build-Ready Program, NYSERDA works with landowners and local governments to prepare sites for renewable energy development prior to a competitive procurement process.

A final piece of the Accelerated Renewable Energy Growth and Community Benefit Act is the call for a State Power Grid Study and Investment Program in order to evaluate the local distribution and bulk transmission capabilities of New York's electrical grid and the improvements or upgrades needed to reach the goals of the CLCPA.

Agricultural Mitigation Payment

As part of the ORES permitting process, solar energy facilities located within State Certified Agricultural Districts are subject to a Mitigation Fund payment if a solar energy facility occupies more than 30 acres of Mineral Soil Groups 1-4. If necessary, Mitigation Fund payments are based on the Mitigation Value per Acre for each Mineral Soil Group. Mitigation Fund payments are calculated based on the amount of each Mineral Soil Group being converted to a solar energy development. The purpose of this policy is to reduce the siting of utility-scale solar on prime agricultural land.

North Carolina Solar Policy

North Carolina's renewable energy policy landscape falls between New York and Pennsylvania, yet the state has one of the highest rates of solar energy development in the U.S. Our policy audit identified two areas of policy that likely contributed to the significant rate of utility-scale solar development in the state. First, North Carolina has maintained—either through legislation or Executive Order—increasing targets for renewable energy sourcing in the state. These targets were initially established through the Renewable Energy and Energy Efficiency Portfolio Standards Act in 2007. As detailed below, the targets established in the 2007 Act were lower than those in Pennsylvania, yet when this Act sunset, Governor Roy Cooper issued Executive Order 80 in 2018, which significantly expanded clean energy goals and mandated the development of an ambitious clean energy plan for the state that was published in 2019. Building on the work of Executive Order 80, the Energy Solutions for North Carolina Act (House Bill 951) was signed into law in 2021. Among its many components, HB 951 mandates a 70% reduction in electricity sector CO_2 emissions from the 2005 level by 2030 and carbon neutrality by 2050.

Secondly, in response to federal legislation passed in 1978 (detailed below), North Carolina adopted energy regulations that required public utilities to purchase electricity generated from renewable energy facilities with up to 5 MW of capacity with 15-year fixed-rate contracts. This created a guaranteed market for utility-scale solar facilities that met these requirements and a powerful incentive for development. This law was modified in 2017 (see HB 589 below) in ways that reduced its impact. The rate of solar development in North Carolina did slow following the passage of HB 589, but it has remained stable (Fujita et al., 2023), likely in part due to the updating of clean energy targets.

Public Utility Regulatory Policies Act

One of the most impactful state-level policy initiatives in North Carolina is a direct result of the federal energy policy enacted during the fuel crisis of the 1970s. In 1978, Congress passed the Public Utility Regulatory Policies Act (PURPA) as a response to growing concerns about energy security in the United States. The goal of PURPA was to use alternative energy to expand fuel diversity in the United States while also encouraging competition in the electricity market (SEIA, 2018). PURPA designated renewable energy facilities with 80 MW or less of capacity as qualifying facilities (QFs) and mandated the creation of regulations encouraging the development of QFs in the U.S. These rules include a mandate that QFs must be interconnected to the utility-controlled grid and a mandatory purchase obligation, which requires utilities to purchase the energy produced by QFs (SEIA, 2018). Under the mandatory purchase obligation, QFs are compensated according to the utility's "avoided costs," or the cost the utility would have incurred if it chose to "generate or contract for the energy and capacity in the absence of the QF" (SEIA, 2018). While PURPA created a federal mandate for the purchasing of power from QFs by utilities, the establishment of avoided cost rates and contract terms was left up to state Public Utility Commissions (PUCs), resulting in uneven implementation of PURPA from state to state.

In North Carolina, PURPA served as a key driver in the deployment of utility-scale solar installations across the state. Under North Carolina's PURPA regulations, utilities were mandated to offer QFs of up to 5 MW in capacity fixed-rate avoided cost contracts of up to 15 years in length (EIA, 2016). These PURPA terms created a favorable atmosphere for utility-scale solar development in North Carolina. In 2015, 92% of North Carolina's utility-scale solar capacity was comprised of QFs certified under PURPA (EIA, 2016). The overwhelming percentage of PURPA QFs in North Carolina's solar capacity was the largest share across the nation for any state (EIA, 2016). During this time, North Carolina also offered a renewable energy tax credit of 35% for eligible renewable energy property construction (DSIRE, 2018).

HB 589

Following the rapid growth of utility-scale solar in North Carolina via a favorable PURPA interpretation, in 2017, North Carolina state legislation passed House Bill 589 (HB 589). HB 589 created sweeping reforms to North Carolina's PURPA regulations and the solar energy market as a whole. Among the biggest changes included in HB 589 is the establishment of the Competitive Procurement of Renewable Energy, or CPRE. The CPRE was created to replace the current PURPA regulations for any renewable energy facility over 1 MW and up to 80 MW in capacity. Rather than mandating utilities to purchase energy and capacity from large QFs, the CPRE creates a competitive proposal process with a target of 2,660 MW of solar energy to be procured by the Duke Entities through a series of requests for proposals (RFPs) within 45 months after the passage of HB 589.

HB 589 not only changed the process by which QFs are developed in North Carolina, but also created changes in contract terms. Under HB 589, renewable energy projects are procured under the CPRE, and RFPs are subject to a 20-year contract term. In addition, HB 589 also reformed the terms and procurement of QFs up to 1 MW in capacity. Under North Carolina's PURPA regulations prior to HB 589, utilities were mandated to purchase capacity and energy from QFs up to 5 MW in size with 15-year contract terms. Following HB 589, the size threshold for standard contract QFs was decreased to 1 MW, and the contract term was lowered to a 10-year contract term. Once 100 MW of capacity is procured by utilities through standard contract QFs, project eligibility drops to a size of 100 KW with a contract length of 5 years (NREL, 2019).

Renewable Energy and Energy Efficiency Portfolio Standards Act of 2007

North Carolina first established the Renewable Energy and Energy Efficiency Portfolio Standards (REPS) Act in 2007. Under the REPS, North Carolina required electric public utilities, electric membership corporations, and municipalities to provide a certain percentage of their electricity demand from renewable energy sources. Within the REPS, renewable energy sources were defined to include the following: solar, wind, biomass resources, hydropower, geothermal, and wave energy, among other sources.

For electric public utilities, the REPS created a mandate that required an increasing amount of retail electricity sales to customers to be sourced from renewable energy sources. These percentages peaked in 2018 at 10% for municipalities and membership corporations and in 2021 at 12.5% for public utilities. These requirements could be met via the generation of electricity at a new renewable facility or by reducing energy consumption via energy efficiency practices. However, a public utility could only meet 25% of the REPS requirements via energy efficiency measures from 2007 to 2021. In 2021 and beyond, the REPS allows for public utilities to meet 40% of the requirements via energy efficiency approaches. Further, the REPS allowed for public utilities to purchase RECs from outside of North Carolina's borders. RECs purchased outside of North Carolina's jurisdiction could not be used to fulfill more than 25% of the REPS requirements.

Executive Order No. 80

Following the expiration of North Carolina's REPS in 2018, Governor Roy Cooper signed Executive Order No. 80 into effect. Entitled "North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy," Executive Order No. 80 builds on the clean energy growth established by the REPS. Executive Order No. 80 establishes clear climate goals for the state of North Carolina to accomplish by 2025. Among these goals is a call to lower the state's greenhouse gas emissions to 40% below 2005's emission levels. In addition, Executive Order No. 80 also establishes targets to expand the number of zero-emission vehicles in the state to 80,000 and to lower energy consumption by at least 40% from 2002-2003 levels in state government buildings.

A further action within Executive Order No. 80 is the creation of the North Carolina Climate Change Interagency Council, which is intended to facilitate the planning, implementation, and evaluation of the state's climate change efforts. In addition, Executive Order No. 80 calls for the North Carolina Department of Environmental Quality (DEQ) to create a Clean Energy Plan for the state. The order calls for this Clean Energy Plan to address the further implementation and spread of clean energy resources across North Carolina in order to create a "modern and resilient electric grid." A further measure established within Executive Order No. 80 is the development of a clean energy and clean transportation workforce assessment and support for expanding clean energy businesses by the North Carolina Department of Commerce (DOC). In culmination, Executive Order No. 80 establishes a further push towards clean energy growth and decarbonization in North Carolina via a variety of plans and goals for the state to achieve by 2025.

Clean Energy Plan

Executive Order No. 80 contained language requiring the North Carolina Department of Environmental Quality to develop a Clean Energy Plan (CEP) for the state, which was published in October of 2019 following extensive stakeholder feedback. The CEP outlines three major goals for North Carolina's energy sector:

1. Decrease electricity sector greenhouse gas emissions to 70% below 2005 levels by 2030, and to reach carbon neutrality by 2050—a more ambitious goal than originally stated in Executive Order No. 80.
2. Ensure long-term affordability and price stability for energy across the state via modernization of regulatory and planning processes.
3. Continue the expansion of clean energy innovation and implementation to create economic growth in both rural and urban North Carolina.

The North Carolina CEP also provides specific policy recommendations to ensure that the state achieves the ambitious goals of the CEP.

1. Develop specific carbon reduction policies (e.g., retirement of coal assets) in addition to policies supporting clean energy expansion.
2. Create policies that align the incentives of energy utilities with public interest and grid needs, including multi-year rate planning, revenue decoupling and performance-based mechanisms.
3. Develop a policy for modernizing North Carolina's power grid in order to promote clean energy expansion and resilience.

For each area of policy recommendation, the CEP provides detailed policy approaches to expedite the policy process and facilitate the passage of clean energy legislation. The Clean Energy Plan sets an ambitious way for North Carolina to meet its grid modernization, decarbonization, and resilience goals. While their plan is not a binding regulation, the CEP has served as a catalyst for energy development and regulation in the state, and some CEP recommendations have been accomplished since the publication of the plan in 2019.

HB 951: Energy Solutions for North Carolina

In late 2021, House Bill 951, also known as the Energy Solutions for North Carolina Act, was signed into law. This legislation both updated and expanded upon the previous Renewable Portfolio Standard Act, setting new and more ambitious climate targets and incorporating elements of the Clean Energy Plan drafted as part of Executive Order No. 80.

This legislation requires several items that pertain specifically to utility-scale solar:

1. A reduction in CO_2 emissions from the North Carolina electricity sector by 70% from 2005 levels by 2030 and carbon neutrality by 2050.
2. The Utilities Commission to develop and implement a Carbon Plan for the goals noted above.
3. The development of rules to support the early retirement of coal-fired power plants in the state.

In late 2022, as mandated by the law, the Utilities Commission issued its carbon plan for Duke Energy, the largest utility company in the state. The plan focuses on a diverse set of low- or zero-carbon energy sources but does include several requirements that will likely spur further development of utility-scale solar in North Carolina. Among these requirements are a mandate to retire all remaining coal-fired power plants by 2035, purchase 2350 MW of new solar energy by 2028, and upgrade transmission infrastructure to accommodate new solar generation.

Comparative Policy Considerations

The policy context for solar energy development is quite different in each of these three states, and yet there are commonalities found in both New York and North Carolina that suggest that certain policy approaches are particularly impactful. The lack of policies or regulations targeting solar in Pennsylvania and its commensurately low level of solar development—especially compared to these other states—only underscores the role of policy in utility-scale solar development.

The most significant policy affecting utility-scale solar development among these three states is some form of enforceable renewable portfolio standard, particularly when paired with specific targets for expanding solar energy in the state. North Carolina has done this by regulating their public utilities with HB 951 to spur them to take action on their own, while New York has set portfolio standards and then taken direct action in the energy market through NYSERDA. Both approaches have contributed to very high levels of solar energy development.

Pennsylvania, by contrast, has not updated its AEPS, and the existing standard has very low solar carve-outs, resulting in very low levels of solar development in the state. Interestingly, North Carolina's original renewable portfolio standard was the least ambitious among these three states and included solar carve-outs similar to those in Pennsylvania. Yet during this time, North Carolina also had PURPA regulations that required utilities to enter long-term purchase agreements with certain types of utility-scale solar facilities, which made solar development so attractive to developers that it essentially overrode the low solar carve-outs. A new policy mandating power purchasing from new solar would likely have a similar effect today, when the construction of new solar facilities is at an all-time low.

We do not mean to suggest that state-level policy is the only factor that affects the rate of solar development—the results of our geographic analysis make that clear. However, this comparative policy audit shows a strong correlation with particular policy approaches and high levels of solar development, and a lack of state-level policy may have a chilling effect on solar development.

Current Process of Utility-Scale Solar Development in Pennsylvania

Our interviews spanned much of the geography of rural Pennsylvania (see Figure 1) and drew on perspectives from policymakers, public officials, landowners, and solar developers. Despite this diversity in perspectives, several clear themes emerged from our qualitative analysis that offer important insight for future solar policy in Pennsylvania.

The consistency of sentiments expressed across all interviews provided a clear understanding of how the current development process for utility-scale solar in Pennsylvania is experienced by the people affected by it. In some cases, different stakeholder groups expressed these common themes differently due to their differing positions. When this is pertinent, our presentation of findings demonstrates these differences to both show variation in our data and better support our findings. We make use of exemplary quotes to support our findings here, but these are by no means the only instances in our interview data when these themes are discussed. The quotations from interviews presented here are those that we determined to best communicate our findings to readers. Our primary findings from qualitative analysis are presented below, broken down by major theme.

Current Solar Development Process is Highly Uneven and Uncertain

Interview participants consistently noted that the lack of state-level guidance on utility-scale solar development introduced numerous avenues of uncertainty in rural Pennsylvania. To be clear, the desire among participants was not for the type of broad guidance that state agencies have provided, but rather for things like land-use regulations for utility-scale solar or a model siting ordinance that could be used by municipalities across the state. The most common sentiment among county and local officials was that they lacked the resources or capacity to develop utility-scale ordinances on their own or to efficiently handle the siting and permitting processes. In some cases, these officials were hesitant to devote limited resources to ordinance development until they were certain that solar development would come to their community, while others expressed that they felt it was the state's responsibility and would not act without guidance from Harrisburg. The following quote from a county official captures much of this sentiment:

> *"I think our local governments already feel overwhelmed. Most of our municipalities have one employee, and it's the secretary. It's three supervisors and a secretary. That secretary works, I would say, in at least half of our municipalities, five hours a week or less. Some of our*

> *municipalities have office hours as needed and that's it. We do have several municipalities that have someone staffed all of the time, that's uncommon. So, if that burden of administering a solar ordinance is on the municipalities, they will be very overwhelmed. If it's in the county, it will slow things down, but we will manage it. It would be easier with one consistent ordinance."*

Solar developers also report experiencing uncertainty from the lack of policy guidance, as well as from ambiguity in the grid interconnection process managed by PJM Interconnection. In regard to policy guidance, developers consistently noted that it introduced financial risk, especially in the early stages of project development since there was no clear understanding of whether a project would be approved, how much it would cost, or how long it would take. The grid interconnection timeline was a consistent source of frustration among developers. They noted in interviews that even with the ambiguity in siting ordinances, a new utility-scale solar project can often be completed within three years, whereas the approval to connect to the grid and begin selling power can take much longer. Consider this quote from the developer:

> *"[G]enerally speaking, what we see is one of the biggest barriers to deployment of new solar projects is not the lack of desire or the lack of development. It's the lack of utilities' ability to process the applications in a way that is streamlined and efficient. They're just simply not equipped to do it this way. They generally identify loads, and then they're like, ok, we need a power plant here, and that can be a 10 to 20-year process, and right now we can literally deploy a project in two to three years, but they're just simply not equipped to handle the volume or influx of applications in a way that is effective."*

Uncertainty for landowners largely stems from a lack of clarity on the leasing and construction processes, which has contributed to a myriad challenges. Interviews revealed that the lack of state-level guidance and regulation has contributed to a kind of land grabbing in rural Pennsylvania. In many cases, the first point of contact a landowner has with solar development is with "landmen," who contract with a landowner to lease the option to develop for solar. Our interviews indicate that it is not uncommon for these individuals to be independent middlemen that are capturing leasing options and then attempting to sell the option to a developer, which may never occur. One rural official reported that some landowners do not know that this is the case and have directed their frustration at them:

> *"[T]hat was another thing that we were getting blamed for was that 'we're not getting paid because you won't approve.' And I'm like, I can't approve something I don't have, and it sounds like what you've done is sold your rights to a middleman, and they're not able to sell it to a company, but*

> *there is nothing. I have nothing on my desk that says anything about your property."*

If and when a lease does move forward, landowners also face uncertainty with the siting process in terms of how it will impact their property, with diverse stakeholders noting that state-level guidance would alleviate this. Currently, many items must be negotiated by the landowner, including where panels will be placed, whether they will retain access to the land, if they can farm the land after construction, and how much they will be compensated. Receiving the best terms often requires landowners to retain the services of legal counsel, but this practice is relatively new, and access to lawyers with the necessary expertise is uneven.

Rural Communities Need Education and Better Support

Related to the issue of uncertainty, interviews indicate that there is a need for broader public education on solar development, and better support for communities, especially landowners, as they navigate the development process. Some respondents noted that rural communities often lack a clear understanding of what utility-scale solar is, how it will affect the landscape, and how it will affect them. Consider this quote from a state-level official reflecting on experience across the Commonwealth, which speaks again to the need for state-level policy:

> *"I think it's absolutely critical that some sort of legislation come out soon that helps build that middle path and acknowledges that there's different buckets. Because there's so many people that go out there and say solar is bad, but it's like, which solar are you talking about? Because we got net metered, you've got community solar, and you have utility scale, but it's very rare that people make the distinction. So having legislation that addresses all three of those very comprehensively and respectfully to the needs and wants of the Commonwealth would be mission number one."*

Our analysis reveals that landowners are often motivated to enter leasing agreements for utility-scale solar by economic considerations, but as noted above, the current development and leasing process does not necessarily guarantee the best outcomes for landowners. Interviews indicate, for instance, that there is a poor understanding of what leasing rates are available to landowners, either because developers are reticent to make this public or because contracts generally include non-disclosure agreements that prevent other landowners from discussing the terms of their leases. Participants report that the lease negotiation process is complex, and even if a landowner contracts with a lawyer, state-level guidance in the form of model lease agreements or siting ordinances could greatly simplify this process.

Interview responses also reveal that for many farmers, the economic incentive is not just about the money, but also the opportunity to preserve farmland and keep it in the family for future generations. This may be why our GIS analysis found some solar facilities sited on land with very high relative property values. The use of non-disclosure agreements in the leasing process occludes this information, but we suspect that some farmers may be willing to forego selling their property and accept less lucrative lease agreements because solar offers the opportunity to preserve their land. This sentiment was also shared by some local and county officials, suggesting broader community support for solar as a way of preserving rural communities. Consider the following quote:

> *"We want to try to keep our farmers, you know, farming. We just wanna keep them in business, doing whatever they can. And one of the ways that they may be able to stay in business is at least a portion of the farm going into solar energy as a revenue source for them."*

Rural Solar Development is Appealing If Done the "Smart Way"

Across stakeholders, interview analysis suggests that there is significant support for solar development in rural Pennsylvania if it can be conducted in a way that benefits the community and reduces negative impacts on environmental and scenic resources. Specific ideas mentioned include guidelines that limit siting on prime agricultural land or forested land, promoting siting on brownfields and other degraded land, and siting requirements that reduce viewshed impacts. These findings add further support to the benefits of state-level guidance.

Rural stakeholders also consistently showed a clear preference for solar over other potential land uses. Interview participants understood utility-scale solar as part of a broader trend of industrial/residential development in rural PA, and many state that solar is preferable to other industrial uses like warehousing or industrial livestock farms and less damaging or permanent than housing development. The following quote is illustrative of this sentiment:

> *"Some folks say, 'well, I'd rather see a solar panel that can be removed after its useful life and the land return to agricultural production, than a warehouse or a housing development, which forever destroys the ground,' right?"*

Some also note that solar places less strain on other services such as water, sewer, first responders, and school systems. One respondent stated plainly:

> *"It's there, it don't need nothing, I mean it ain't costing us nothing, get a few tax dollars off of it for taxes, but no traffic, after it's done, it's done."*

Our interview participants also communicated a strong preference among many stakeholders for community solar, which is currently not permitted in Pennsylvania. For reference, community solar refers to an alternative model for solar generation where solar facilities sell energy directly to subscribers (i.e., any individual or business that would otherwise purchase electricity from a utility company) rather than wholesaling to a public utility provider. This model also allows community groups—a group of neighbors, residents of a township, etc.—to develop their own solar infrastructure and to directly benefit from facilities sited in their communities. Community solar facilities are often smaller than solar facilities serving the grid, and they can be either privately or cooperatively owned (Waechter et al., 2024). Among numerous benefits, participants noted that the scale of community solar was often better suited to the Pennsylvania landscape, providing more opportunities for developers and facilities that are less obtrusive in the rural landscape. This sentiment is captured well in this statement from a county official:

> *"I feel that the state-level policies hurt solar development more than they help it. Because, again, if you are offered tools to do a job and you know there's another tool that would do what you want it to do, do what people want it to do, do it better, easier, cheaper. Again, common sense dictates that that's the first tool you grab. But community solar is not even in the box."*

Another common theme emerging from interviews is the notion that community solar can directly benefit rural residents more than utility-scale facilities supplying the grid. In particular, some participants noted that a significant part of solar resistance in rural communities seems linked to the perception that the energy produced is only for distant urban communities rather than local residents that must bear the environmental and scenic burden of siting. One county official remarked:

> *"I think that if people saw a benefit, because one of the things that you hear from, for instance, the folks in our county where the solar project is being developed. Well, the city is buying the power output from the facility in our county. And so, some of the complaints we've heard is, 'well, you know, if it benefited us, it might be okay, right? But it's all going to the city. We don't wanna bear the city's burden.' So, I think it makes community solar, makes it a bit more palatable and desirable because people can see potentially an immediate benefit to that project."*

Discussion and Conclusions

Key Takeaways

Synthesizing the findings of our three-pronged analysis offers several insights that indicate a critical need for state-level policy and guidance on solar energy development in the Commonwealth.

1. Much of the territory of Pennsylvania is suitable for solar development, with numerous regions of the state likely to see concentrated development pressure in the coming years. Most (23/37) operational utility-scale solar facilities in Pennsylvania are in the populous Southeastern region, and this trend is likely to continue. Yet if the appeal of solar energy continues, it is likely that many rural and adjacent rural counties will see significant increases in solar development. In some cases, such as Franklin and Adams, these counties have significant land areas classified as highly suitable in our model. In all cases,

however, these counties tend to have denser transmission infrastructure and higher relative population density, which our analysis found to be significant attractors. The same is likely true in the regions surrounding Erie and Pittsburgh, particularly in Crawford, Mercer, and Venango counties in the Northwest and Somerset, Cambria, Indiana, and Fayette counties in the Southwest. Franklin County, in Southcentral Pennsylvania, offers an insightful case study of this possibility.

2. The tendency for utility-scale solar to favor land in closer proximity to population centers and infrastructure suggests that solar development may become one of numerous competing drivers of land-use change, which could drive up the costs of development and ultimately make solar energy more expensive in Pennsylvania. This trend also intersects with the loss of farmland, and many agricultural landowners see utility-scale solar leasing as a means of farmland preservation compared to other forms of development.
3. Much of Pennsylvania is likely to be attractive to utility-scale developers. Therefore, it seems plausible that state-level policy, or the lack thereof, has constrained solar development in Pennsylvania. The findings from our comparative policy analysis of three states, and our qualitative analysis with stakeholders, corroborate this conclusion.
4. The significant lag in the grid interconnection process is likely a significant factor in the low rate of solar buildout in Pennsylvania. Our GIS analysis found 146 geographically verifiable utility-scale solar projects currently waiting for interconnection approval by PJM, as well as several hundred more that we could not geographically locate with confidence. Interview respondents, particularly developers, also frequently noted this as one of the most significant barriers to solar development in the Commonwealth.

Policy Recommendations

Based on the findings of our research, we offer the following recommendations to support state-level solar energy policy in Pennsylvania. Based on our research, we find that state-level policy can play a significant role in supporting sustainable solar development in Pennsylvania while also ensuring that future solar energy development can protect the needs and desires of rural residents, benefit energy consumers in the state, and maintain Pennsylvania's role as a leader in the energy economy.

Recommendation 1: Update Alternative Energy Portfolio Standards Act

This legislation played an important role in solar energy development in Pennsylvania during its lifespan, and similar policies have been instrumental in continued solar development in New York and North Carolina. Furthermore, as the corresponding policy items in these other states make clear, the Alternative Energy Portfolio Standards (AEPS) Act or similar legislation can also encode policy guidance that can protect farmland and streamline the approval process. This can either be achieved by enacting land-use requirements and centralizing permitting and siting, like in New York, or by mandating the utilities decommission fossil fuel plants and purchase new solar capacity by hard deadlines, as they have done in North Carolina.

Recommendation 2: Develop Policy to Streamline the Interconnection Process and Ensure Power Purchasing from New Utility-Scale Solar Energy Facilities

Both New York and North Carolina have clear policies that provide stakeholders a clear pathway to the grid interconnection and buyers for electricity produced at new solar facilities. This is perhaps the most significant legislative difference between Pennsylvania and the other states in our analysis, and one of the only policies that New York and North Carolina share. The success of these policies in other states suggests that it could alleviate some of the problems with the PJM approval process and reduce uncertainty in the current solar development landscape in Pennsylvania. While it is true that PJM is not the primary grid manager for New York or North Carolina, other states in the PJM management region such as Maryland and New Jersey have also achieved high levels of solar development. There is little reason to believe that at least some of the PJM backlog could be addressed with clear policy requiring an expedited interconnection process, mandated power purchasing for public utility providers, or a combination of the two.

Recommendation 3: Enact Policy Enabling Community Solar

Our stakeholder interviews show a clear desire for community solar in rural Pennsylvania, with many arguing that it would better serve many communities in the Commonwealth. Furthermore, our GIS analysis indicates that portions of rural Pennsylvania meet many of our identified suitability characteristics but are too sparsely populated and/or too distant from transmission infrastructure to be attractive to grid-serving, utility-scale solar (see Figure 9). In addition to the benefits enumerated in our report, community solar can often be developed without the need for significant grid infrastructure, greatly expanding the number of residents able to benefit from solar energy (Waechter et al., 2024). Additionally, by expanding the geographic range of viability for solar development, community solar legislation could also reduce the intensity of development in regions with large swaths of highly suitable land, such as Franklin and Adams Counties.

Recommendation 4: Develop State-Level Guidance on Solar Siting and Leasing to Better Support Rural Counties and Municipalities

This guidance can take many forms, though some of the most common are the publication of a model siting ordinance or a solar development guidebook for local municipalities. Our interview analysis shows a clear desire for this at the local level, and this would be an excellent way to support rural municipalities with the zoning approval process and rural landowners with lease negotiations without the need for top-down legislation.

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Appendix 1: GIS Data and Model Parameters

Input Data and Sources

Vector Data

Block	Layer	Source
	State	tl_2018_us_state.shp 2018 TIGER/Line Shapefiles. US. Census Bureau. https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
	Counties	tl_2018_us_county.shp 2018 TIGER/Line Shapefiles. US. Census Bureau. https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
	Census Blocks	tl_2020_42_tabblock20.shp 2020 TIGER/Line Shapefiles. US. Census Bureau. https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html
	Protected Land	PADUS3_0_Region1.gdb 2022vUSGS - Gap Analysis Project (GAP), Protected Areas Database of the United States (PAD-US) 3.0 Protected Areas Database of the United States (PAD-US) 3.0 (ver. 2.0, March 2023) - ScienceBase-Catalog
	Soil Units	gSSURGO_PA.gdb/MUPOLYGON 2019 USDA/NRCS. Gridded Soil Survey Geographic (gSSURGO)
	Electrical Substations	Homeland Infrastructure Foundation Level Database (HIFLD) https://gii.dhs.gov/HIFLD Layer obtained from AGOL
	Power Transmission Lines	Homeland Infrastructure Foundation Level Database (HIFLD) https://gii.dhs.gov/HIFLD Layer obtained from AGOL

Raster Data

Block	Layer	Source
	Elevation	USGS. 1-arc-second DEM. U.S. Geological Survey, 2019, 3D Elevation Program 0.00028-degree Resolution Digital Elevation Model (published 20200606), accessed at URL https://www.usgs.gov/the-national-map-data-delivery
	Land Use	NLCD-2019. Dewitz, J. (2021) Downloaded from: https://s3-us-west-2.amazonaws.com/mrlc/nlcd_2019_land_cover_l48_20210604.zip Land cover 2013. 1 meter resolution for Chesapeake Bay & Delaware River Watershed in Pennsylvania. Univ. Vermont

	Forest Type	This dataset was obtained from the National Forest Carbon Monitoring System (NFCMS), for the Forest Service's NE region. The dataset is based on the categories defined in Ruefenacht (2008) [Conterminous U.S. and Alaska Forest Type Mapping Using Forest Inventory and Analysis Data. Photogrammetric Engineering & Remote Sensing 74] https://daac.ornl.gov/CMS/guides/AGB_NEP_Disturbance_US_Forests.html
	Roads	tlgdb_2012_roads_conus.gdb/reg230m 2012 TIGER/Line Geodatabase. US. Census Bureau.
	Land Value	Estimated fair market value of private properties in the US. (Nolte, C. 2020) downloaded from: https://datadryad.org/stash/dataset/doi:10.5061/dryad.np5hqbzq9

Imagery Data

Block	Layer	Source
	Solar Energy Projects in PJM queue.	https://mapservices.pjm.com/renewables/ Because of the difficulties in accessing data for the location of the proposed solar projects, we created an image by merging screenshots from PJM web map. This was necessary because there is not an option to download the layer and a map with the scale to cover the entire state of Pennsylvania that does not give us a very poor resolution and no reference of the location because of the solid blue background. The layer was made with N images captured Aug 21-22, 2023.

Tabular Data

Block	Layer	Source
	Annual Solar Radiation	NSRDB: National Solar Radiation Database https://nsrdb.nrel.gov/ downloads made from: https://developer.nrel.gov/api/hsds via h5pyd package. Years 2010-2020 for 4 km resolution or 2018-2022 if 2km resolution. The data is downloaded in table format with a python script.
	CHCND Stations	Global Historical Climatology Network Diary Stations. Table to locate and identify stations for climatological variables. https://www.ncei.noaa.gov/pub/data/ghcn/daily/ghcnd-stations.txt
	Sunshine	Monthly Normals, Percentage of sunshine (PSUN) and total hours of sunshine (TSUN) https://www.ncei.noaa.gov/cdo-web/
	Clean & Green Farm and Forest Values	Preferential Tax Assessment program. Two tables downloaded in pdf format, one for farms and the other for forests. https://www.agriculture.pa.gov
	Soil Name	gSSURGO_PA.gdb/muaggatt Map unit aggregated attribute table. Feature layer will be joined with the Clean and Green tables to map costs associated with land quality.

Costs	Costs for right of way based on terrain preparation and land cost for transmission lines construction. The information was obtained from the document "Transmission Cost Estimation Guide. MTEP20". Downloaded from Midcontinent Independent System Operator (MISO) https://cdn.misoenergy.org

Derived Data

Masks Exclusions	
Land Use	Terrain already occupied by incompatible uses to FV Solar farms, and it is not possible to change the use to install a solar plant. These areas must be removed from analysis. • **Urban**. Because we are not considering installations of solar panels on buildings and other structures, and the cost of terrain makes this land unaffordable to use for FV Solar. • **Water**. Although there are devices to install PV panels on the water surfaces it isn't a common practice and probably at a higher cost. • **Roads**
Topography	Topography has an impact on the suitability to install solar panels on the ground. • **Slope**. Slope affects the cost directly to adapt to the geometry of the terrain and consider new requirements such as water runoff and erosion that in a flat area have minimal impact. Slope also has an indirect effect of rising costs because panels must be more separated from each other so for the same power it requires to purchase more land. • **Aspect**. Solar panels are usually installed on flat terrains or on slopes facing South. North slopes receive less radiation, panels can shade other panels so, plants in North slopes are less efficient and less profitable.
Solar Radiation	Direct radiation duration is a limiting factor to place a solar farm. In general, profitable lands should have a minimum of 6 hours of direct sun per day. The value of 6 hours was found in a "Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills", published by NREL and EPA in 2022. This dataset was created running the Solar Radiation tool (ArcGIS Pro) for December. The tool requires the DEM as input.
Protected Land	The protected land mask is the rasterization of the Protected Land feature dataset where protected land is excluded for solar projects.
Available Land	Combination of land use, topography, protected land, and radiation exclusions.

Other Masks

Forest Land	Classification of NLCD Forests (classes: 41, 42, 43, 90) in binary raster. Forest (1), non-Forest (0).

Raster Data

Layer	Description
Annual Solar Radiation	The solar radiation downloaded represents the radiation at specific locations summarized in a table. Each row is a location defined by longitude and latitude, and with average total annual radiation (kWh m^{-2} per year). The raster derivative of the solar radiation was made by interpolating the values of the locations. The resolution is 4 km per cell.
Terrain Classes for Transmission Lines	Raster dataset with the classes that fit the table Terrain and grading unit costs of the Transmission Guide (MISO). This dataset is made combining the slope (derivative of DEM) and land use.
Land Acquisition Cost	Land acquisition cost is the sum of the market value and the "clean and green" values. Previously to the addition the prices were converted into $\$m^{-2}$.
Land Preparation Cost	This is a raster dataset with the cost ($\$m^{-2}$) related to the clearing and grading the terrain.
Clearing Cost	This raster is related to the cost of clearing operations in forested land. ($\$m^{-2}$)
Right of Way and Land Preparation	Raster dataset with values of the cost of the corridor for a transmission line. This cost is an estimation of the sum of the **right of way** cost and the operations need for preparing the **terrain** to support the elements of the line. The units are in $\$m^{-1}$, assuming the corridor is 30 m wide (valid for a 115 kV line).
Distance to Substations	Map with the planar length of the minimum cost path from substation. Units in meters. To obtain this map an intermediate subproduct with the cost associated to the terrain to connect the cell to the closest substation is also saved (Units in $).
Distance to Power Lines	This map is the same as the distance to substations but instead of the origin is a substation the origin is a current powerline. Units in meters and $.

Weighted Model Methodology

Each variable contains a limited number of classes (2–5). The maximum weighted value is 1, assigned to the areas with optimal conditions for the factor in the region. The rest of the classes take values between 0 and 1 as a function of the degree to which the factor reduces the probability of selection.

Resource factors are those that directly affect solar energy production. The Site Group is made up of factors related to site characteristics that can influence a solar project such as, slope, aspect, etc. The Access Group is made concerned with factors concerning proximity to infrastructure. Finally, the Incentive Group includes factors related to the value of the land, including acquisition price, etc.

Variables and Weights

GROUP	Factor	Feature Class	Description
Resource	Radiation	TECH_Radiation	It represents the potential interest for better performance due to more solar resources. Two classes: I (w=1), and II (w=0.42)
Resource	Temperature	TECH_Temperature	It considers the influence of the temperature on the efficiency of the system. Two classes: Warm (w=0.99), and Cold (w=1)
Resource	Wind Speed	TECH_Wind	Wind conditions affect temperature because of their cooling effects. Three classes: Cooling (w=1.05), Neutral (w=1), Warming (w=0.95)
Resource	PV Electricity Output	TECH_PowerPotential	This parameter is related to the potential energy production, which integrates climate and topographic factors. In this case, a local approach is used. That means the measure indicates a site has more chance to be selected because it has a better potential for production with respect to nearby locations (5km). Two Classes: Above (w=1), Below (w=0.5)
Resource	Insolation	TECH_TopographySolar	Land suitability based on the angle of incidence of solar rays on the ground. Flat and very gentle slopes (<5%) and slopes facing south are optimal for catching more solar energy. Sites facing East or West receive less energy, while sites facing North are not recommended. Three Classes: Optimal (w=1), Not Optimal (w=0.5), and Not Suitable (w=0)

Site	Topography	TECH_Topography	Topography is one of the most important factors defining the model. It is related to the inherent cost and construction issues related to the slope and orientation. Five classes: Optimal (w=1), Suboptimal (w=0.5), Acceptable (w=0.25), Marginal (w=012), Unsuitable (w=0)
Site	Land Use	TECH_LandUse	The land type defined by its cover and use influences aspects like construction and the availability to be transformed into a new use. Agricultural and barren land have better chances to receive solar projects. Forest and the rest of the natural types are less prone to receive solar projects, while developed and water types are not valid for solar plants. Three classes: Optimal (w=1), Not Optimal (w=0.56), and Unsuitable (w=0).
Access	Distance to Grid	TECH_GRID	Related to the distance to connect to the grid. The further away from substations and power lines the more expensive the project will be. Three classes: Optimal (w=1), Acceptable (w=0.2), and Excluded (w=0).
Access	Distance to Transportation	TECH_Road	Physical access to the site is necessary to carry out the project. The more isolated the site is, the more probable the project would face problems reaching the site, including the need to improve existent access around the construction of new ones, which will result in an excess cost. Three classes: Optimal (w=1), Acceptable (w=0.07), and Excluded (w=0).
Access	Distance to Residential	TECH_Residential	Being near to consumers is beneficial due to the energy losses during transportation. It is also preferable to be near an urban center from the point of logistics in the construction and operational phases. Four classes: Optimal (w=1), Adequate (w=0.11), Acceptable (w=0.03), and Excluded (w=0).

Incentive	Population	ECO_Pop10mi_StateLvl	We use the population around the site as a proxy for the electricity demand. The areas more densely populated in the state are expected to attract more solar projects because of the scale of the market and because more Mega-Watts will be required to be installed to cover such demand. Two classes: Attractive (w=1), Non-Attractive (w=0).
Incentive	Population	ECO_Pop10mi_CoLvl	The demand on a closer scale is important in areas with a dispersed population and projects of small size. Two classes: Attractive (w=1), Non-Attractive (w=0).
Incentive	Cost	ECO_LandValue_StateLvl	The cost of land acquisition can be the difference between a profitable and non-profitable installation. The price of the land is one of the factors that influences the ability of a solar project to compete with other uses. Areas less expensive would be more interesting to invest in. This factor considers the general gradients across the state. Two classes: Attractive (w=1), Non-Attractive (w=0).
Incentive	Cost	ECO_LandValue_CoLvl	This factor considers the preference of locations based in differences of size at smaller scale. Two classes: Attractive (w=1), Non-Attractive (w=0).

Final Model

GROUP	Feature Class	Description
Resource	VALUE_SolarProduction	Function: 2 * (PowPot + TopoSolar) + Rad + (Temp * Wind) Then stretch from 0 to 100. Range: 0-100. A value of zero does not mean the site is not suitable or does not have sun. They simply correspond with the sites with minimum solar input in the entire region.
Site	COEFF_LandQuality	Function: Mean (Topo, LandUse) Range: 0-1
Access	COEFF_Accessibility	Function: GRID * Road * Residential Range: 0-1
Incentive	VALUE_Market	Function: Pop-State + Pop-County + LandValue-State + LandValue-County Range: 0-4

Land Suitability	VALUE_SUITABILITY	Function: VALUE_SolarProduction * COEFF_LandQuality + COEFF_Accessibility Range: 0-100

Appendix 2: Semi-Structured Interview Guides

Landowners:

1. How long did it take from start to finish for solar installation to happen on your property?
2. How did you come to the decision to allow solar energy production on your property?
3. Do you feel you had ample resources to learn and understand the land lease process?
4. What (if any) difficulties did you face during the solar development process?
5. Was there anything that made the process of solar development easier for you?
6. What was your relationship like with the developer throughout the solar energy installation process?
7. How do you think Pennsylvania could improve the solar energy development process for other landowners?

Expert Interviews:

1. In your experiences with Landowners, how long does it take from start to finish for a solar installation to be constructed on their property?
2. How do Landowners come to the decision to allow solar energy production on their property? Please give examples.
3. Do you feel that Landowners currently have ample resources available to understand and learn the land leasing process? Please give examples.
4. What (if any) difficulties do you hear from Landowners during the solar development process?
5. Is there anything that currently makes the process of solar energy development easier for Landowners? Please give examples.
6. In your experience with Landowners, what is the relationship like between a Landowner and solar developer during the solar development process? Please give examples.
7. What steps do you think Pennsylvania could take to improve the solar energy development process for Landowners?

Developers:

1. What is the biggest challenge facing solar energy development in Pennsylvania?

2. What is the biggest driver towards solar energy development in Pennsylvania?
3. How long (on average) does it take for a site to go from initial planning to energy production?
4. From your experience, do you feel that Pennsylvania is adequately prepared for a higher volume of solar energy projects?
5. How do you choose a site for solar energy installation?
6. Can you describe the process of negotiating a lease contract with landowners?
7. How important are zoning laws or ordinances in your siting process? How and why?
8. What role do state level policies or incentives play in solar energy development? How and why?
9. What sorts of community issues do you encounter as you develop a site? How do you deal with these as they arise?
10. Of these four factors, which do you feel is the most impactful or important for successful solar energy development?

Local Government Officials:

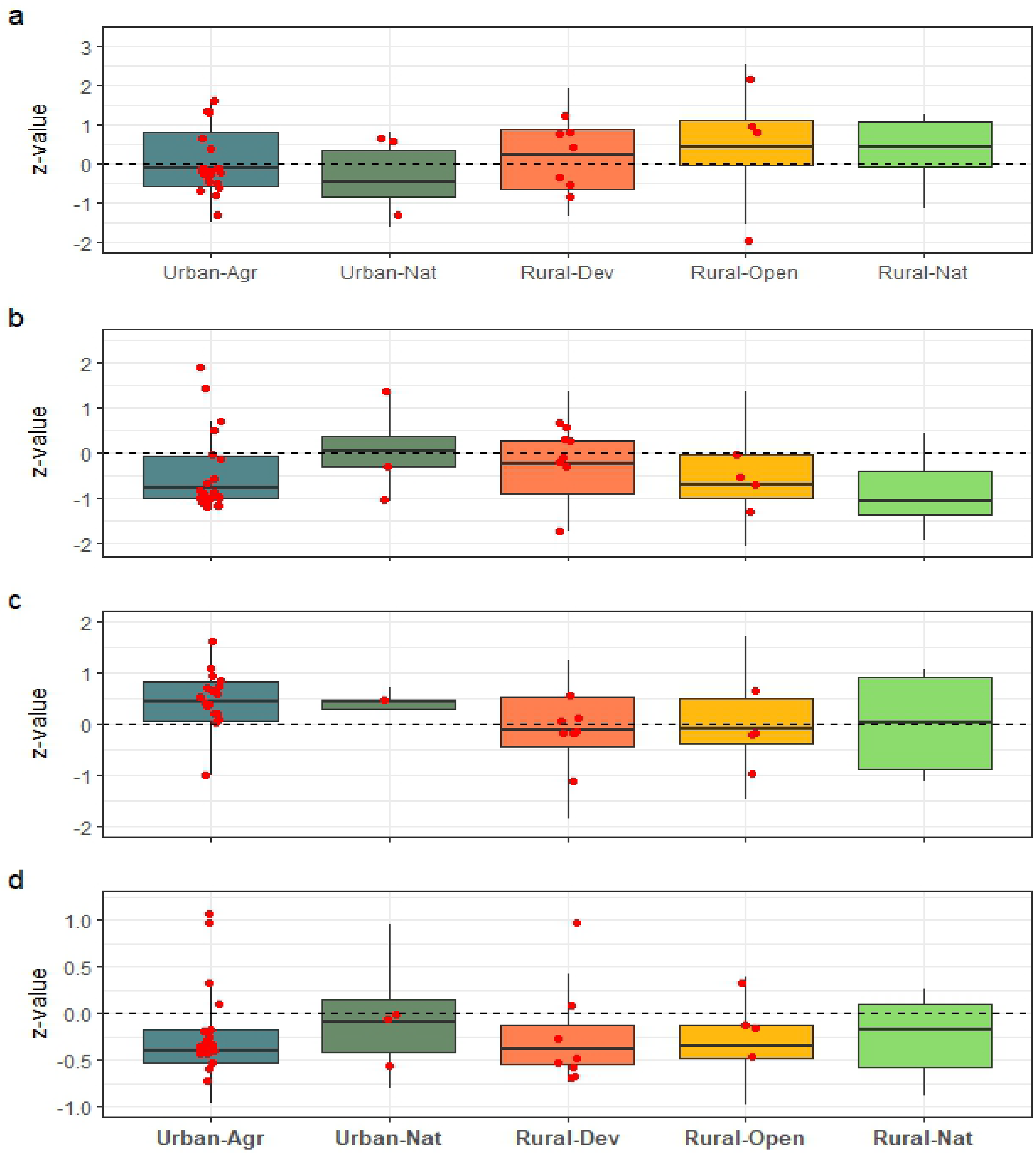
1. Are you personally in favor of, against, or neutral on solar development?
2. Do you consider solar development a priority for local (state) government?
3. How are solar energy installations addressed in your zoning ordinance, comprehensive plan, or SALDO?
4. What is currently helping or hindering your township/municipality/county's adaptation of solar friendly ordinances/plans?
5. What are your concerns regarding utility scale solar installations in your Township/Municipality/County?
6. What sorts of community issues do you encounter as you develop a site? How do you deal with these as they arise?
7. What role does state-level policy play in your township/municipality/county's view of solar energy development?
8. Do you feel that your township/municipality/county is prepared to handle a higher volume of solar energy development?
9. What resources does your township/municipality/county have access to support your regulation of solar energy development?

State Government Officials:

1. Which pieces of state level policy do you feel drive adaptation or development of solar energy systems the most?
2. How can state level recommendations or policies help local governments adopt solar friendly ordinances or plans?
3. How does the state work with solar developers?
4. What role does citizen support of clean energy sources play in further adoption of solar friendly policy?

5. How do you feel the state does in providing resources for landowners in terms of land lease contracting and other legal circumstances?
6. How important do you feel zoning ordinances are in expanding solar energy development and why?
7. How important do you feel state level policy is in expanding solar energy development and why?
8. How important do you feel community attitudes are in expanding solar energy development?
9. How important do you feel landowner contracting/leasing is in expanding solar energy development?
10. What potential concerns or issues does the state currently see with expanded utility scale solar development?

Appendix 3: Effects of Cost-Minimization on Solar Siting



Note: These boxplots depict values for utility-scale solar facilities compared to nearby locations for key socio-economic factors: (a) population in a 10-mile radius, (b) distance to residential areas, (c) agricultural land value, and (d) cost of land acquisition. Values for operational solar facilities are represented with red points. Values for solar facilities are compared with the county average for factors (a) and (b), and values within a 3-mile radius for factors (c) and (d). The zero line represents the average value in the region. For factors (a), (b), and (d), negative values indicate that solar favors below average sites, and positive values indicate above average. Agricultural land value is inversely ranked, so for factor (c), negative values indicate better than average agricultural land. Data: U.S. Census Bureau, PA Dept. of Agriculture.

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625 Forster St., Room 902, Harrisburg, PA 17120
(717) 787-9555 | www.rural.pa.gov