Elevating & Evaluating Southwestern Pennsylvania's Grid Scale Solar Future

Version 3.0

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Southwestern Pennsylvania's Grid-Scale Solar Future

BY: Natasha Gonzalez, Atsumi Kainosho, Krista Mobley, & Clarissa Paz

FACULTY ADVISOR: Anna Siefken

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DISCLAIMER

This report has been prepared as part of a student project and is not meant to be quote referenced or cited as it has not been subject to critical review. The report has been prepared to highlight the benefits and opportunities available in Southwestern Pennsylvania for grid-scale solar development, as a capstone project within Carnegie Mellon University's Heinz College of Information Systems and Public Policy.

[1] Version 3.0 of this report was updated by co-author Clarissa Paz to incorporate further siting analysis completed from January 2019 to May 2019. Updated sections will be denoted by a footnote.

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EXECUTIVE SUMMARY

The Pennsylvania Department of Environmental Protection (DEP) has developed a plan with an inspirational goal for increasing solar electricity generation across the state to support 10% of in state retail electricity use by 2030 in *Finding Pennsylvania's Solar Future*. The creation of this goal involved the collaboration of many stakeholders, from solar developers, to policymakers, and Pennsylvania (PA) residents. This collaboration led to the conclusion that grid-scale solar installations will be integral to meeting the 10% by 2030 goal.

This whitepaper explores the feasibility of deploying grid-scale solar throughout a nine-county region in Southwestern Pennsylvania (SW PA). The nine counties evaluated in this study include: Allegheny, Beaver, Butler, Cambria, Fayette, Greene, Lawrence, Washington, and Westmoreland. To assess the opportunity for deploying solar installations in these counties, this study employed the following types of analysis.

- **Policy:** Analyzed the current policies that promote PA's solar development at the federal, state, and local levels. This study also explored the solar policies and programs of other states to assess the gaps in PA's policy landscape
- **Environmental:** Examined the potential greenhouse gas (GHG) emissions that can be avoided with solar development, and the benefits grid-scale solar could have on PA's environment
- **Financial:** Assessed the financial feasibility of grid-scale solar development by creating a model that factored in a list of assumptions and expected costs to determine the net-present value and internal rate of return for grid-scale solar installations under today's pricing structure and market conditions
- **Geospatial:** Utilized geospatial analysis to determine which land parcels may be feasible sites for grid-scale solar installations. Feasible sites were determined as parcels with the following siting criteria:
    - Greater than or equal to 100 acres
    - An annual chance of flood hazard of 0.2% or less
    - Outside of priority resilient and connected landscapes
    - Distance of 5 miles or less from transmission lines
    - Cleared land
    - Flat (a slope of 10% or less)

Based on these analyses, this study reached the following conclusions:[2]

- SW PA is indeed feasible for the development of grid-scale solar

[2] **This section of the report was updated to reflect the new findings from further siting analysis.**

- As of December 2018, this study identified 3,771 potential sites for grid-scale solar deployment
- Of these potential sites, we analyzed all of 243 sites that were 250 acres and larger and found that 29 of these sites were the most financially feasible
    - By deploying grid-scale solar at these sites, 2.25 million tons of greenhouse gas emissions could be avoided
    - These sites were deemed financially feasible by yielding an average Internal Rate of Return (IRR) of approximately 9%
- As of May 2019, this study identified 675 feasible sites that were 100 acres and larger
    - By deploying grid-scale solar at all of these sites, there is the potential to generate approximately 11 GW in solar capacity
- If grid-scale solar was deployed at all 675 sites, Southwestern Pennsylvania would have the capacity to reach the 10% state goal
- Neighboring states, such as Massachusetts, New Jersey, and New York, have existing policies that promote the development of solar. If Pennsylvania created similar policies, deployment of grid-scale solar could be more attractive

To increase in-state solar generation to 10% by 2030, the state will have to employ a strategic plan to increase the demand for grid-scale solar. Based on this study's findings, this report provides the following policy recommendations to increase solar development in PA to meet the 10% by 2030 goal. A more in-depth explanation of these recommendations can be found in the policy analysis section and in the recommendation section:

- **Provide support to PA municipalities** for updating and including clear and broad positions on active and passive solar systems, and developing solar-friendly provisions
- **Increase and stabilize the PA Solar Renewable Energy Credits (SREC) market** by:
    - **Creating a higher Alternative Energy Portfolio Standard (AEPS)** to better reflect the DEP's 2030 energy goals
    - **Creating more state and local incentives** for solar development
- **Introduce these incentives with a statewide program** to make solar development a feasible option and support the reclamation of brownfields to be pad ready
- **Create more private-public partnerships** to build and expand the state's offering of solar incentives
- **Consider more partnerships with SW PA's utility companies**, particularly for the remediation of brownfields and/or support of additional regional incentive programs
- **Create incentives to promote long-term Solar Power Purchase Agreements** to improve the financial feasibility of solar

Through stakeholder inquiry post the midpoint presentation of our project the following recommendations were also compiled as additional opportunities to increase the deployment of grid-scale solar.

- **Carbon pricing**
- **Create a renewable action team** at the state level to streamline and ease permitting for solar projects. Any streamlining initiative should focus on obtaining quantifiable results without sacrificing the conservation and protection goals of the permitting program.
- **Compile solar energy educational information** into one online, easy to use, central location. This could be a valuable asset for educational purposes that may allow for more solar development across the state
- **Stimulate long-term solar energy contracting** by increasing the amount of electricity that utilities are required by state law to get from solar.

INTRODUCTION

The Pennsylvania Department of Environmental Protection (DEP) worked collaboratively with numerous stakeholders to create *Finding Pennsylvania's Solar Future*. In that document, the DEP established a goal for PA to consume 10% of its electricity from solar power generation by 2030.[3] This aspiration goal is higher than the state's Alternative Energy Portfolio Standard (AEPS), which requires PA to reach 0.5% electricity sales from in-state solar generation by 2030.[4]

Currently, PA's electricity usage consists of less than 0.25% of solar power.[5] To reach the DEP's goal, the state will be required to develop approximately 11 gigawatts (GW) of solar generation. This will require a 97% increase in Pennsylvania's solar generation capacity. In order to meet the scale of that requirement, Pennsylvania must advance its in-state solar generation by deploying grid-scale solar statewide.

According to *Finding Pennsylvania's Solar Future*, grid-scale solar installations are generally identified as projects with a generation capacity of 3 megawatts (MW) of energy or greater. Each MW produced requires a total of 8 acres of land for the solar installation.[6] In order to reach 11 GW of generation, 40,000 to 50,000 acres of land will be required to deploy ground mounted grid-scale solar.[7]

The goal of this report is to analyze the feasibility of deploying grid-scale solar installations throughout a nine-county region in Southwestern PA (SW PA). The nine counties include: Allegheny, Beaver, Butler, Cambria, Fayette, Greene, Lawrence, Washington, and Westmoreland. In terms of land area, the state of Pennsylvania is 29.475 million acres. The nine-county region analyzed in this study makes up approximately 4.01 million acres or 13.7% of Pennsylvania's total land area. Subsequently, this study analyzed the region's potential for contributing 13% of solar generation to the 10% goal.

First, this report will outline the benefits of solar generation, before providing an analysis of the policy landscape that has the potential to promote PA's solar development. The report will then shift its focus to understanding the environmental impact of deploying grid-scale solar and evaluating the financial feasibility of this transition. The geospatial analysis then provides insight on the siting criteria and breakdown of feasible sites. In closing, there will be a series of recommendations for enhancing PA's opportunity for solar development to meet the DEP's 2030 goal.

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[3] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx

[4] Diskin, Paul, and Patrick McDonnell. "2017 Annual Report: Alternative Energy Portfolio Standards Act of 2004." http://www.puc.pa.gov/Electric/pdf/AEPS/AEPS_Ann_Rpt_2017.pdf.

[5] US Energy Information Administration. "Electric Power Monthly with Data for September 2018." November 2018. https://www.eia.gov/electricity/monthly/current_month/epm.pdf.

[6] Ong, Sean, Clinton Campbell, Paul Denholm, Robert Margolis, and Garvin Heath. "Land-Use Requirements for Solar Power Plants in the United States." June 2013. https://www.nrel.gov/docs/fy13osti/56290.pdf.

[7] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx

THE BENEFITS OF SOLAR

Grid-scale solar will have a tremendous bearing on the environment, economy, and quality of life in SW PA. The benefits of in-state solar generation will affect the following:

Public Health

Deploying grid-scale solar could mitigate the threat of pollution caused by the fossil fuel industry. This pollution serves as a driver for several human health problems, such as respiratory problems, including increases in asthma rates, neurological damage, heart attacks, cancer, and premature death. According to the EPA, greenhouse gas (GHG) emissions exacerbate ground-level ozone pollution, which results in respiratory problems ranging from decreased lung function and aggravated asthma.[8] Southwestern PA has been in recent times at the heart of the Marcellus Shale boom which has caused a rapid increase in methane emissions, a GHG 80 times more potent than carbon dioxide. Deploying grid-scale solar, by offsetting high amounts of fossil fuel generation would reduce these public health risks to PA residents.

Economic Growth

In recent years, costs for the implementation and use of renewables have largely decreased. Solar energy can provide affordable electricity and be economically profitable, even with the cost of installation.

According to the International Renewable Energy Agency, the benefits derived from energy transformation, significantly outweigh the costs.[9] The cost savings resulting from improved human health, lower rates of air pollution, and avoided environmental damage by 2050 is expected to equal five times the additional investment needed to make the transition.[10]

The economic prosperity that renewable energy provides is prevalent in the states with a Renewable Portfolio Standard (RPS) of 50% by 2030. These states include New York, Hawaii, California, New Jersey, and Vermont. Each state with the 50% target has generated growth in their annual GDP that is significantly higher than the US average. These states also boast some of America's largest clean energy job workforces per capita.[11]

Job Opportunities

According to the Solar Jobs Census, job creation in the solar industry has continued to show significant growth since the first census was released in 2010.[12] The solar workforce increased by 168% in the past

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[8] United States Environmental Protection Agency. "EPA's Endangerment Finding." January 2010. https://www.epa.gov/sites/production/files/2016-08/documents/endangermentfinding_health.pdf
[9] International Renewable Energy Agency. "Renewables are the key to a climate-safe world." November 2018. https://www.irena.org/newsroom/articles/2018/Nov/Renewables-are-the-key-to-a-climate-safe-world
[10] Ibid.
[11] Mike O'Boyle and Barbara Blumenthal. "New Jersey Is Now The United States' Hottest Clean Energy Economy." June 2018. https://www.forbes.com/sites/energyinnovation/2018/06/18/new-jersey-is-now-the-united-states-hottest-clean-energy-economy/#4f97a2e5334f
[12] The Solar Foundation. "National Solar Jobs Census 2017." March 2018. https://www.thesolarfoundation.org/national/

seven years, from about 93,000 jobs in 2010 to over 250,000 jobs in 2017. In PA, there were a total of 3,848 solar jobs in 2017.[13]

The top three jobs in PA's solar industry focus on the installation, manufacturing, and distribution of solar panels. These jobs account for 42.0%, 35.5%, and 9.6% of the total jobs, respectively.[14] Expanding solar development in SW PA will lead to the creation of additional jobs and a stronger economy overall.

Cleaner Air

Electricity generation accounts for 29% of U.S. GHG emissions, and PA is the nation's third highest producer of these emissions. Solar electricity generation emits no GHG. Developing grid-scale solar plants will contribute to less pollutants being emitted into the atmosphere and will ensure that PA residents are breathing cleaner air.

Why Solar in Southwestern Pennsylvania?

In addition to the benefits discussed above, PA has clear potential for deploying grid-scale solar successfully.

Solar Resource Potential

Solar resource potential is the amount of energy that can be generated from available solar exposure. Many individuals believe that PA does not receive enough sun exposure to deploy grid-scale solar. However, according to the Commonwealth's Energy Assessment Report, PA has the potential to increase grid-scale solar by 3,687% and distributed generation solar by 225% from 2015 to 2050.[15]

Additionally, the states that neighbor PA, such as New York and New Jersey, have very similar solar resource potential. These neighbors have capitalized on their potential with a variety of financial incentives and wide-scale investment in solar. PA has an opportunity to do the same to meet or exceed the 10% by 2030 goal.

Abundant land

PA's land is reasonably priced compared to other states, which provides financial feasibility for solar developers.

Within the state there is a vast number of brownfields, or former industrial sites. These brownfields have the potential to serve as sites for grid-scale solar. According to the Environmental Protection Agency

[13] The Solar Foundation. "Solar Jobs Census 2017, Pennsylvania." March 2018. https://www.solarstates.org/#state/pennsylvania/counties/solar-jobs/2017
[14] Ibid.
[15] Department of Environmental Protection. "Energy Assessment Report for the Commonwealth of Pennsylvania". April 2018. http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Advisory%20Committees/CCAC/2018/4-24-18/DRAFT%20PA%20Energy%20Assessment%20Report.pdf

(EPA), brownfields are served by existing infrastructure, such as transmission lines, substations, roads, water, and railways.[16] These contaminated lands can often be acquired or leased at a lower cost than comparable undeveloped sites, which results in improving the viability of the developing grid-scale solar up front.[17]

Abandoned mines are an example of brownfields. These mines can be found in nearly every county because of PA's history with coal mining. Coal mining in PA prior to 1965 left 200,000 acres of subsidence-prone land.[18] Since developers must consider the large costs required to remediate these abandoned mines, the Abandoned Mine Drainage Set-Aside Grant Program offered by PA can incentivize their remediation by providing developers with subsidies.[19]

The next portion of this report will evaluate policies that promote solar development in PA. It will also provide insight on how these policies can be improved to better capitalize on PA's opportunity to deploy grid-scale solar effectively.

[16] EPA. "RE-Powering America's Land Potential Advantages of Reusing Potentially Contaminated Land for Renewable Energy." April 2015. https://www.epa.gov/sites/production/files/2015-04/documents/contaminated_land_resuse_factsheet.pdf
[17] Ibid.
[18] U.S. Environmental Protection Agency. "Mine Site Cleanup for Brownfields Redevelopment: A Three-Part Primer." November 2005. https://brownfieldstsc.org/pdfs/mining.pdf
[19] Department of Community & Economic Development, PA. "Abandoned Mine Drainage Abatement and Treatment Program (AMDATP)." https://dced.pa.gov/programs/abandoned-mine-drainage-abatement-treatment-program-amdatp/

FINANCIAL ANALYSIS

Determining the feasibility of the 10% goal by 2030 required a thorough financial analysis. For the purpose of this study, a series of assumptions was created to guide the analysis, estimated costs were outlined, and financial incentives for solar were factored into the financial model to assess whether deployment of grid-scale solar is financially feasible.

General Assumptions

To begin conducting the financial analysis of grid-scale solar in SW PA, this study created a list of assumptions. These assumptions include the following. Given the solar potential of SW PA and the technology currently available, *Finding Pennsylvania's Solar Future* provided this study with its first general assumption: 8 acres of land is equivalent to 1 MW of capacity. [20]

From there, this study assumed that the forecast for every site is 25 years. This analysis also assumes that in the first year there is no income, just investment. In this study, as it is considered in several case studies published by the Environmental Protection Agency (EPA), the average energy conversion rate from direct current (DC) to alternating current (AC) is equal to 83%. [21] This study assumes a discount rate of 10%, as it is for many infrastructure projects.

It is important to note that the financial analysis conducted in this study did not include long-term power purchase agreements (PPA). A PPA is an agreement between an energy generation facility and large offtaker to purchase an agreed amount of power. An offtaker can be a commercial or industrial entity, institution, municipality or formalized collective group, such as used in community solar. One project may have multiple PPAs, which would increase the likelihood of smaller-medium sized users bringing a grid-scale solar project to fruition. By having a PPA, the return on investment would increase because the price at which electricity is sold to the market would be higher. Subsequently, our financial analysis provides a conservative estimate on the financial feasibility of potential sites; including PPAs will only increase the financial feasibility.

Costs of Installation

In order to create the most realistic simulation of grid-scale solar's financial feasibility, this study used the System Advisor Model (SAM) from the National Renewable Energy Laboratory (NREL) to estimate the costs of installation, operation, and maintenance. Installation costs are featured in Table 1.

[20] Campbell, Kerry, and Allen Landis "Pennsylvania's Solar Future Plan" Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx.
[21] Salasovich, James and Mosey Gail, Feasibility Study of Economics and Performance of Solar Photovoltaics at Johnson County Landfill, January 2015. https://www.nrel.gov/docs/fy12osti/53186.pdf

According to the National Council of Electricity Policy, the cost of the distance from the transmission line for a 138 kilovolt (KV) single circuit is equal to $390,000 per mile.[22]

Table 1: Installation Costs

Concept	$/Wdc*
PV Modules Supply	$0.64
Inverter	$0.10
Other System Equipment	$0.20
Labor (installation)	$0.15
Overhead	$0.08
Permitting & Environmental Studies	$0.05
Developer and Engineering Overhead	$0.09
Grid Interconnection	$0.03
Land Preparation	$0.08
Taxes	$0.06
Total	**$1.48**

Fixed costs

The fixed costs in this model are for maintenance and operation. According to SAM, both maintenance and operation costs are equivalent to $0.02 per KWh, and the labor costs are equal to $0.03 per KWh.

This model assumes that the solar developers are going to lease the land where they deploy solar. Each of the nine counties has different land prices obtained from the United States Department of Agriculture. On average the cost per acre per month is equal to $47.06.[23]

Income

From NREL's PVWatts calculator, this model assumes the average electricity rate is equivalent to $0.034 per KWh.[24] As in the SAM, this study considers the federal tax rate to be equivalent to 21% and the state income tax equivalent to 7%.

[22] American Transmission Company, 10-year transmission Assessment, Sep 2003 https://www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/primer.pdf

[23] National Agricultural Statistics Service, Quick Stats, https://quickstats.nass.usda.gov/

[24] National Renewable Energy Laboratory, PVWatts calculator, https://pvwatts.nrel.gov/

Financial Incentives

Similar to the SAM, this study included the ITC incentive for the first year of operation. Per recommendation of industry experts, the model created for this study considered a 22% rate for this financial instrument. This model did not consider SRECs, because it is assumed that those are could drive fluctuation in the electricity rates.

Forecast

This study performed a 25-year forecast. The costs, such as maintenance and labor, are expected to increase by the average U.S. inflation rate of 2.1%, which was published by the Bureau of Labor Statistics from the Department of Labor.[25]

Regarding the electricity rates, this model considered the average annual growth rate of the market prices from 2007 to 2017 from the U.S. Energy Information Administration (EIA) and used the rate to forecast future electricity prices.[26] The model did not consider the impact that the closing of two central generation plants will have on electricity prices.

Greene County Example

To demonstrate the analysis employed, this study will provide an example of one site in Greene County. Greene County was selected because the average cost of land is among the lowest and the electricity rate is one of the highest.

The selected site has an area of 500 acres, it is 3 miles from the transmission line. The KWh expected to be generated is equal to 232, 697,500 per year. Table 2 demonstrates the expected internal rate of return (IRR), net present value (NPV), and break-even based on the model's assumptions and the characteristics of the site. Since IRR and NPV are positive, it can be concluded that the solar development of this site would be financially feasible.

Table 2: Financial Metrics

IRR	9.3%
NPV	**8 million dollars**
Break-even point	**10 years**

[25] United States Department of Labor, Bureau of Labor Statistics, https://data.bls.gov/timeseries/CUUR0000SA0L1E?output_view=pct_12mths
[26] U.S. Energy Information Administration, Electricity Power, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

Siting Criteria

Prior to performing the financial and geospatial analyses, it was necessary to determine the characteristics of the ideal site for solar developers to install grid-scale solar. After discussions with various stakeholders in the solar industry, it was determined that the ideal site for grid-scale solar must have the characteristics listed in Table 3:

Table 3: Siting Criteria for Grid-Scale Solar

Criteria	Benchmark
Minimum Size	**100 Acres**
Flood Risk	**0.2% Annual Chance of Flood Hazard**
Ecological	**OUTSIDE OF PRIORITY RESILIENT AND CONNECTED LANDSCAPES**
Distance to Transmission Line	**Less than 5 miles**
Land Cover	**cleared land**
topography	**Less than 10% slope**

Minimum Size[27]

While solar technologies/facilities have varying rates of efficiency, *Finding Pennsylvania’s Solar Future* estimates that 8 acres of land are needed to produce 1 MW of electricity. The document also defined grid-scale as having a minimum of 3 MW of generating capacity, or a minimum of 24 acres large. Industry experts defined grid-scale solar as a minimum of 20 MW, which amounts to 160 acres. For the purposes of our geospatial analysis, we set a minimum of 100 acres, which amounts to 12.5 MW in generating capacity. The rationale behind setting the minimum size of sites to 100 acres is that technological advancements in solar will require less acreage to produce the same amount of capacity. Subsequently, we decided to compromise between the minimum acreage outlined in the *Finding Pennsylvania’s Solar Future* and the minimum acreage outlined by solar industry standards.

[27] Campbell, Kerry, and Allen Landis. "Pennsylvania’s Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx

Flood Risk[28]

Considering the significant amount of rainfall experienced in SW PA (between 36 - 50 inches annually), and the fact that over-exposure to water could destroy an electrical power generating facility, flood risk zones are an important consideration for finding potential sites. FEMA has 16 different area designations for severity of flood risk, with Zone C and X being the 2 zones least likely to be affected by flooding. FEMA's specific coding doesn't have any Zone C areas in SW PA.

Land Cover[29]

The term "greenfield" is generally defined as an area of agricultural or forest land, or some other undeveloped site earmarked for commercial development or industrial projects. Commercial developers have little to no incentive to develop grid-scale sites on forested land in PA for three primary reasons:

- Clearing forested land could create challenges for permitting (e.g. erosion and sedimentary runoff, impacts to federally or state-listed species)
- Clearing forested land creates an additional construction, development, and permitting costs, as well as can impact a project schedule
- Clearing out forest land acts against the environmental concerns solar energy attempts to address

A standard preference is to develop grid-scale solar projects on previously disturbed land such as pasture, farmland, brownfield, or commercial sites.

Distance to Transmission Lines

New grid-scale solar sites would have to be connected to the transmission infrastructure in order to deliver its electricity to the grid. To facilitate this, site establishment would have to include some creation of additional power line infrastructure to connect the solar site to existing transmission lines.

Research indicates that this was one of the most expensive variable costs to establishing new sites. Many commercial developers would not consider sites if they were too far away from existing transmission infrastructure. This distance consideration could be extended if the site would produce a large amount of electricity. Based on interviews with industry experts, this study created 2 limits for the distance a site could be from existing infrastructure.

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[28] "National Flood Hazard Layer (NFHL)." Emergency Support Function Annexes | FEMA.gov. https://www.fema.gov/national-flood-hazard-layer-nfhl.

[29] "Resilient and Connected Landscapes." Tnc.maps.arcgis.com. https://tnc.maps.arcgis.com/apps/MapSeries/index.html?appid=73c99463525a4d74957463cbe110f09c.

- The site had to be adjacent to existing transmission lines, if energy production would be close to 3 MW

- The site had to be located 5 Miles or less from existing transmission lines, if energy production would be more than 100 MW

Topography

Low-slope angles are necessary for grid-scale projects. Placing solar panels on a heightened slope causes each solar panel to create more shade for the other solar panels located in rows behind the initial panel, thus decreasing the solar resource provided to the system. After consulting with industry experts local to SW PA regarding the magnitude of the slope, this study established a 10% maximum. Despite being able to identify slope as a siting criterion, we were unable to locate slope data for all counties analyzed. Since creating the slope data was beyond the scope of our project, we decided not to incorporate slope into our geospatial analysis.

GEOSPATIAL METHODOLOGY[30]

To find potential sites to deploy grid-scale solar, this study used the defined criteria outlined in Table 4 as benchmarks. After applying each of the criteria requirements, the necessary datasets for each of the established benchmarks were determined, except for slope.

Table 4: Defined Criteria and Benchmarks

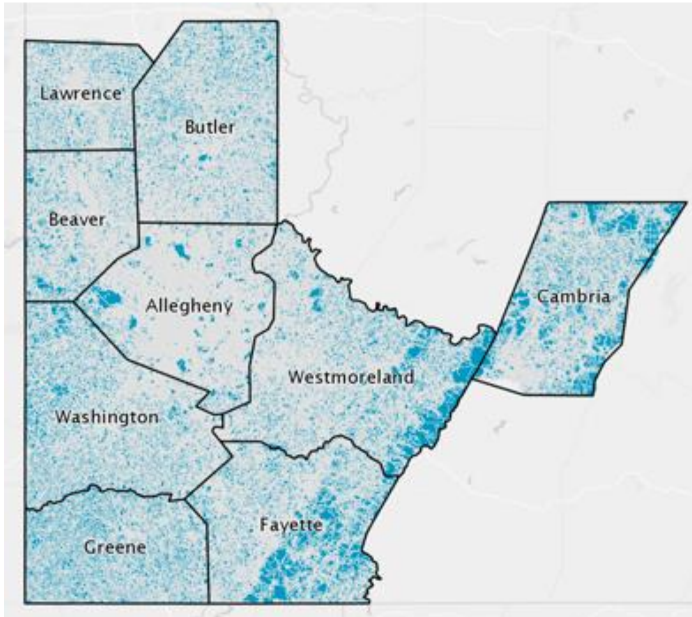
CRITERIA	BENCHMARK
MINIMUM SIZE	100 ACRES
FLOOD RISK	0.2% ANNUAL CHANCE OF FLOOD HAZARD
ECOLOGICAL	OUTSIDE OF PRIORITY RESILIENT AND CONNECTED LANDSCAPES
DISTANCE TO TRANSMISSION LINE	LESS THAN 5 MILES
LAND COVER	CLEARED LAND
TOPOGRAPHY	LESS THAN 10% SLOPE

The first dataset collected was parcel data. With parcel data, this study was able ascertain the geographical parcel boundaries, the acreage of each parcel, the owners of the parcel, and land use. Collecting parcel data for all of the counties in SW PA provided a large hurdle for this study's completion. The only county that had its parcel data on an open source data site was Allegheny County. The rest of the counties required a fee to purchase its parcel data.

After reaching out to each county's respective Geographic Information Systems (GIS) departments, the parcel data from Cambria, Fayette, and Lawrence were obtained. These 3 counties were willing to waive their fees due to this study's academic nature. The rest of the parcel data had to be purchased from ReportAll. Due to budget constraints, the study was only able to retrieve the following 5 county's parcel data: Beaver, Butler, Greene, Washington, and Westmoreland.[31] Thus, this study analyzes the feasibility for 9 of the 12 counties in SW PA, outlined in Figure 1.

[30] **This section of the report was updated to reflect the new findings from further siting analysis.**
[31] "The Smart Choice for Property Parcel Data." Shapefiles, Parcel Data, Boundaries & Property Lines Online. https://reportallusa.com/.

Figure 1: Southwestern Pennsylvania Counties Analyzed



This section will include a case study of Greene County. The purpose of the case study is to showcase each step used in this study's geospatial analysis methodology.

The original report that showcased the findings from this project was created in December 2018. From January 2019 to May 2019, further geospatial analysis was conducted in an effort to find more feasible sites for grid-scale solar. Version 3.0 of this report is meant to incorporate the findings from the continued geospatial analyses. To reflect the updated results, an addendum section is included at the end of each aspect of geospatial methodology. All new results used the same siting criteria with a slight modification to the land cover criteria. Results not included in the addendum section reflects the outputs from the original analyses. The results from the original analyses was kept in the report to contrast the new findings.

Minimum Size

From the parcel data collected, this study analyzed the distribution of the parcel acreage size for each county. Table 5 outlines general summary statistics on the acreage of each parcel in each county. From these statistics, one can see that counties with a higher number of parcels tend to have a smaller average acreage size. In order to factor out infeasible sites for grid-scale solar, this study initially eliminated parcels that were smaller than 24 acres, since the study defined grid-scale solar as having the capacity of 3 MW. For each MW of capacity, 8 acres is needed, hence the 24-acre minimum.

However, further research indicated that the industry standard for grid-scale solar is a minimum capacity of 20 MW. Taking this into account, the study increased the minimum acreage criteria to 100 acres. For the purpose of the geospatial analysis, the parcels between 24 acres to 100 acres were still included. This range of parcels was included to see if smaller feasible sites that are adjacent to one another could total a larger site.

Table 5: Summary Statistics of Parcels

County Name	Number of Parcels	Number of potential Parcels	Percentage of Potential Parcel
Allegheny	580,784	477	0.08%
Beaver	89,445	266	0.30%
Butler	93,370	357	0.38%
Cambria	84,400	399	0.47%
Fayette	77,550	596	0.77%
Greene	29,180	589	2.02%
Lawrence	61,049	112	0.18%
Washington	121,889	640	0.53%
Westmoreland	121,889	335	0.27%
Total	**1,259,556**	**3,771**	**0.56%**

When analyzing the acreage distribution for each county, this study created 6 ranges. Table 6 outlines the parcel acreage breakdown for Greene County. Just by applying the minimum acreage criteria of 100 acres, the analysis identified a total of 933 potential sites and eliminated 28,247 infeasible sites within Greene County. Figure 2 showcases a map of these potential sites, identified just by applying the acreage criteria.

Figure 2: Acreage Distribution of Greene County

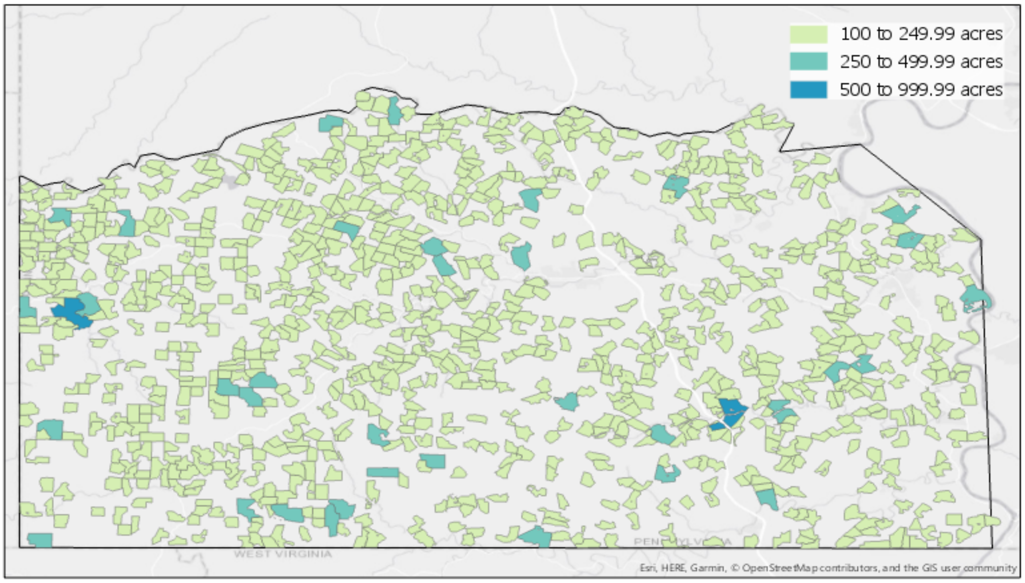


Table 6: Acreage Distribution of Greene County

Number of Potential Parcels in Greene County After Applying the Following Criteria	
Size Class (Acres)	**Y = a**
100-250	896
250-500	35
500-1,000	2
Over 1,000	0
Total	**933**

Where Y = Total Number of Potential Parcels, a = Acreage

Addendum

As previously stated, the industry standard for grid-scale solar is a site having the capacity to generate 20 MW. To reflect this, the new round of geospatial analysis kept the minimum size of sites to 100 acres. However, sites below 100 acres were not included in the analyses. To indicate which sites met the minimum size criteria, a dummy variable was created. A value of 1 of the dummy variable indicates it does meet the criteria, whereas a value of 0 indicates it does not meet the criteria. The purpose of creating a dummy variable was to keep the integrity of the original dataset by not deleting parcels that did not meet this criterion. It also helped to ensure that no duplicate records were being created. The number of potential parcels after applying this criterion is the same as illustrated in Table 6.

Flood Risk[32]

The potential for flooding was identified as a risk that concerns developers. Subsequently, this study collected flood zone data from the National Flood Hazard Layer (NFHL) from the Federal Emergency Management Agency (FEMA). As defined by FEMA, flood zones X and C are areas of minimal flood hazard with a 0.2% annual chance of flood.

In order to identify sites that share this flood zone distinction, this study used the *Spatial Join* tool. This tool allowed for the identification of sites that already fulfilled the acreage criterion and satisfied the flood risk criterion. Since the geographical boundaries of FEMA flood zones are not identical to the geographical boundaries of the parcel data, *Spatial Join* duplicates were created for parcels that contained multiple flood zones. To ensure that no duplicate sites were accounted for, this study used the *Delete Identical* tool. Figure 3 shows the location of all the parcels that fulfill the acreage and flood zone criteria. Table 7 showcases the number of potential parcels that fulfilled both the acreage and flood risk criteria.

[32] "National Flood Hazard Layer (NFHL)." Emergency Support Function Annexes | FEMA.gov. https://www.fema.gov/national-flood-hazard-layer-nfhl.

Figure 3: Potential Parcels after Applying Minimum Size Criteria

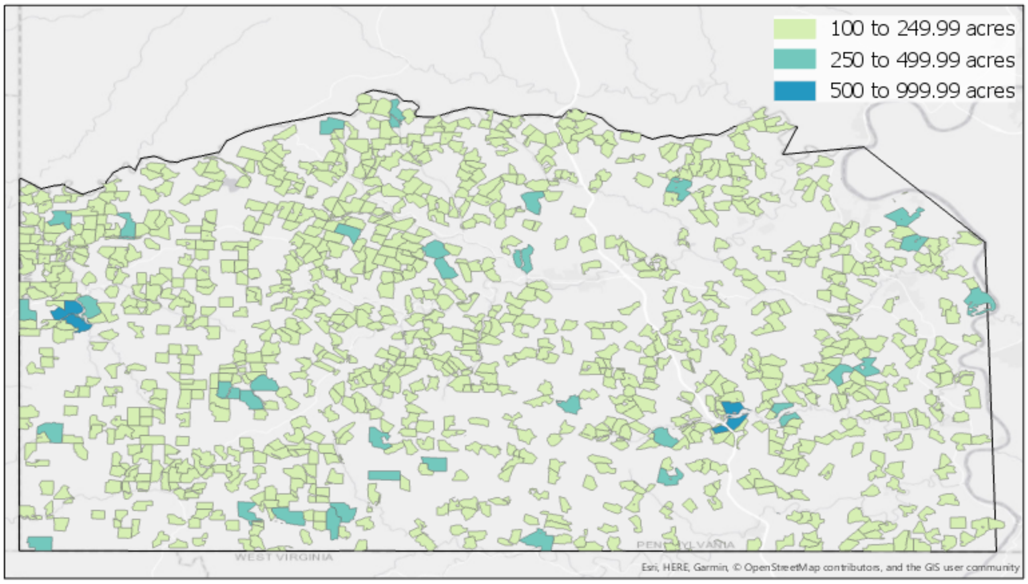


Table 7: Acreage Breakdown of Potential Parcels

Number of Potential Parcels in Greene County After Applying the Following Criteria		
Size Class (Acres)	**Y = a**	**Y = a + b**
100-250	896	895
250-500	35	35
500-1,000	2	2
Total	**933**	**932**

Where Y = Total Number of Potential Parcels, a = Acreage, b = Flood Risk

Addendum

The criteria for parcels to have a FEMA flood zone of X or C was also incorporated in the second round of analyses. The *Spatial Join* tool was used to identify which parcels were completely within the desired flood zones. Instead of deleting parcels that did not meet this criterion, a dummy variable was created to indicate which parcels met and failed to meet this criterion. The value of 1 indicated the parcel did meet the criterion and a value of 0 indicated the parcel did not meet this criterion. Upon further analysis, Butler, Cambria, and Lawrence county were the only three counties that had flood risks zones other than X or C. The rest of the six counties only contained flood risk zone X. It is for this reason that the *Spatial Join* tool was only performed on three counties. Subsequently the number of potential parcels did not change after applying the flood risk criteria to Greene County.

Ecological[33]

When deciding which factors to include in the siting criteria, this study incorporated an environmental criterion. Specifically, it was crucial to ensure that any potential sites did not infringe upon priority conservation lands that provide important habitats and movement corridors for a diversity of species. The dataset used to filter out these lands is the *Priority Resilient and Connected Landscapes* identified by The Nature Conservancy (TNC). These priority landscapes combine TNC's resiliency analysis and regional connectivity modeling and are the focus of TNC's protection and restoration work.

In order to remove parcels within Priority Resilient and Connected Landscapes, a one to many join was created with the *Spatial Join* tool. Once the join was complete, any parcels that contained a join count of one were removed. A join count of one identified parcels that contained the *Priority Landscapes*. In other words, any parcel that contained even a tiny sliver of the *Priority Landscape* was removed as a potential site for grid-scale solar. Subsequently, this study ran a definition query that only kept parcels that had a join count of zero; parcels that contained none of the *Priority Landscape*. Table 8 identifies the number of potential parcels that were identified after applying this filter to the previous two analyses of acreage and flood.

[33] "Resilient Land Mapping Tool." Migrations in Motion - The Nature Conservancy. http://maps.tnc.org/resilientland/.

Figure 4: Priority Resilient and Connected Landscapes

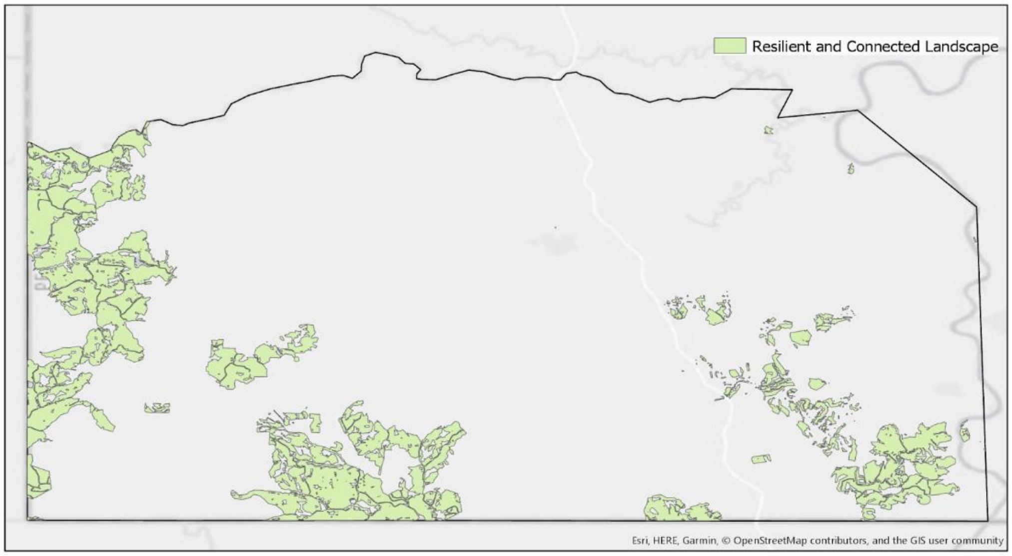


Figure 5: Potential Parcels after Applying Ecological Criteria

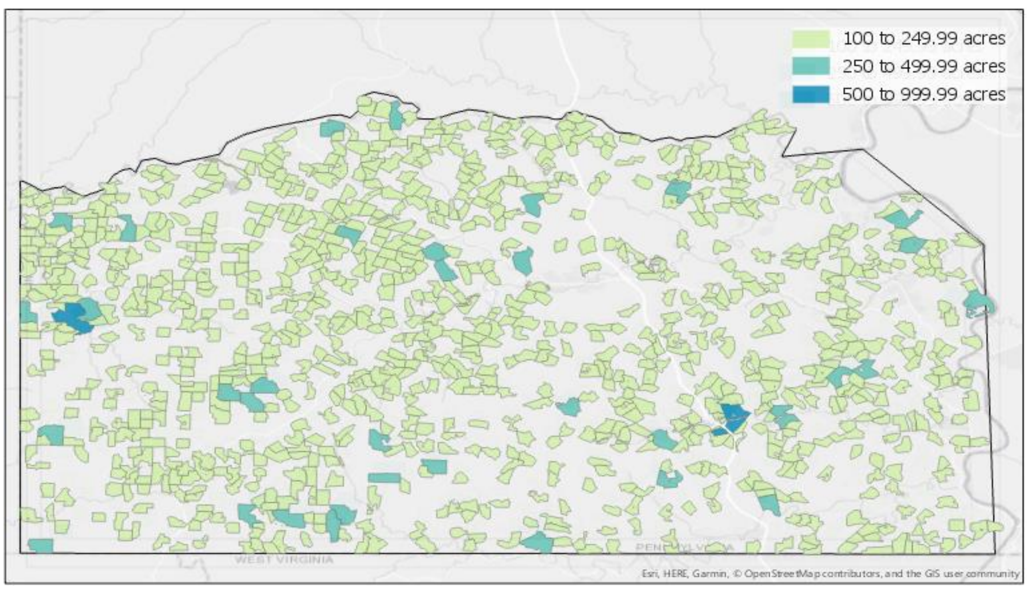


Table 8: Acreage Breakdown of Potential Parcels

Number of Potential Parcels in Greene County After Applying the Following Criteria			
Size Class (Acres)	**Y = a**	**Y = a + b**	**Y = a + b + c**
100-250	896	895	795
250-500	35	35	25
500-1,000	2	2	1
Total	**933**	**932**	**821**

Where Y = Total Number of Potential Parcels, a = Acreage, b = Flood Risk, c= Environmental

Addendum

The importance of finding feasible sites that did not infringe upon priority conservation lands that provide important habitats and movement corridors for a diversity of species was included in the second round of analyses. The only modification of applying this criterion was the created of the dummy variable. The dummy variable was created to ensure the integrity of the original dataset. In this case, the value of 1 of this variable indicates that the parcel did not contain any part of The Nature Conservancy's *Priority Resilient and Connected Landscapes* and therefore met this criterion. The resulting potential parcels from applying this criteria remained the same as outlined in Table 8.

Distance to Transmission Line

Collecting a dataset that contained the location of existing transmission lines proved to be difficult due to national security issues. However, we were eventually able to locate a dataset from the Homeland Infrastructure Foundation-Level Data website.[34]

Further research indicated that sites with a distance of more than 5 miles from transmission lines are generally infeasible. The research indicated that sites less than 3 miles away are the most feasible. This study used both the 3-mile and 5-mile benchmarks to see how many infeasible sites would be

[34] "Homeland Infrastructure Foundation Level Data." Hifld-geoplatform.opendata.arcgis.com. https://hifld-geoplatform.opendata.arcgis.com/.

eliminated. The 3-mile and 5-mile buffer from the transmission lines was created with the *Buffer* tool. Once the buffers were created, the *Intersect* tool was used to identify parcels that fell within the boundaries of each buffer. This means that any parcels that had a distance greater than 5 miles from the transmission lines were excluded as potential sites. Table 10 highlights the number of potential parcels that fulfill all our acreage, flood risk, environmental, and transmission line criteria.

Figure 7: 5-Mile Buffer from Transmission Lines

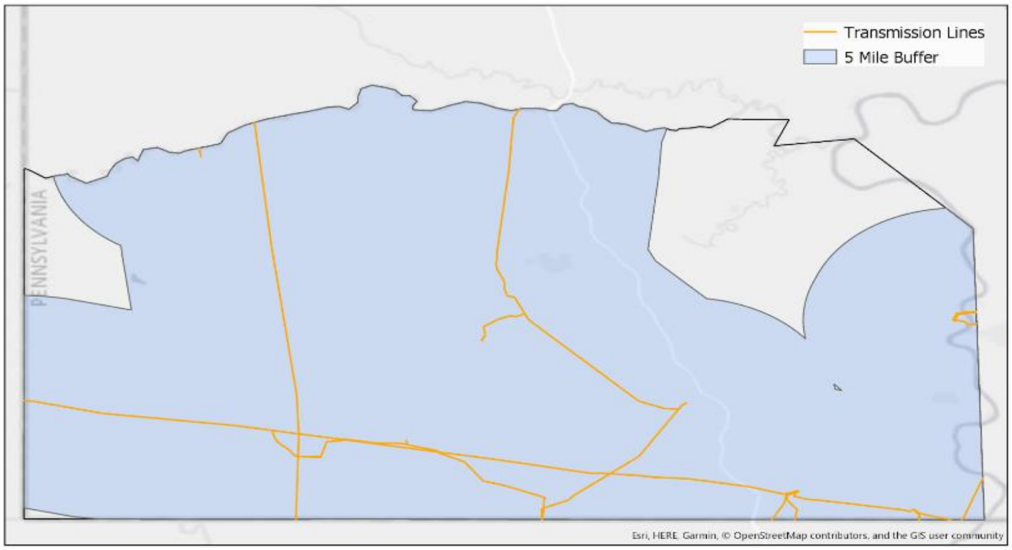


Figure 8: Potential Parcels within 5-Mile Buffer

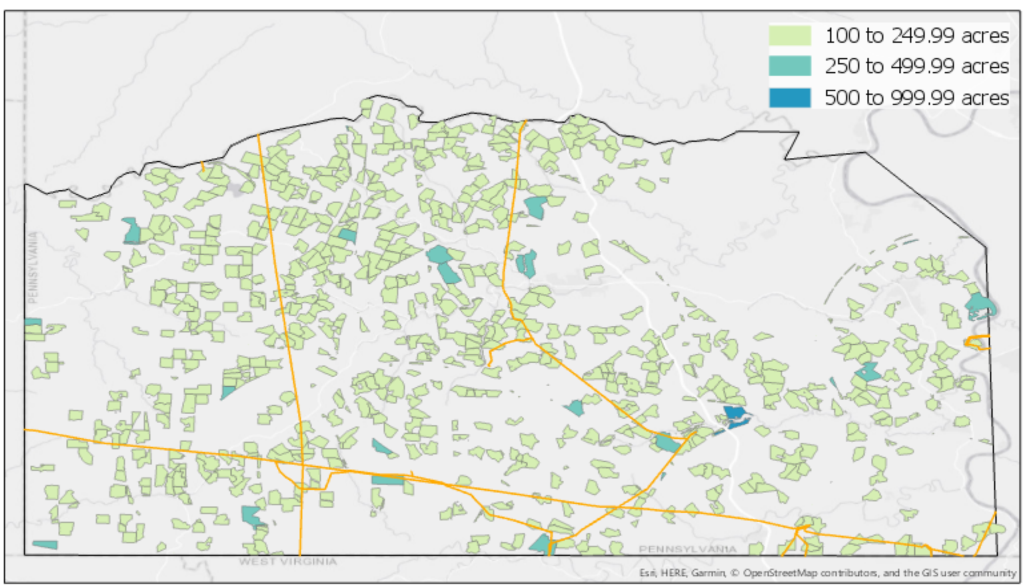


Figure 9: 3-Mile Buffer from Transmission Lines

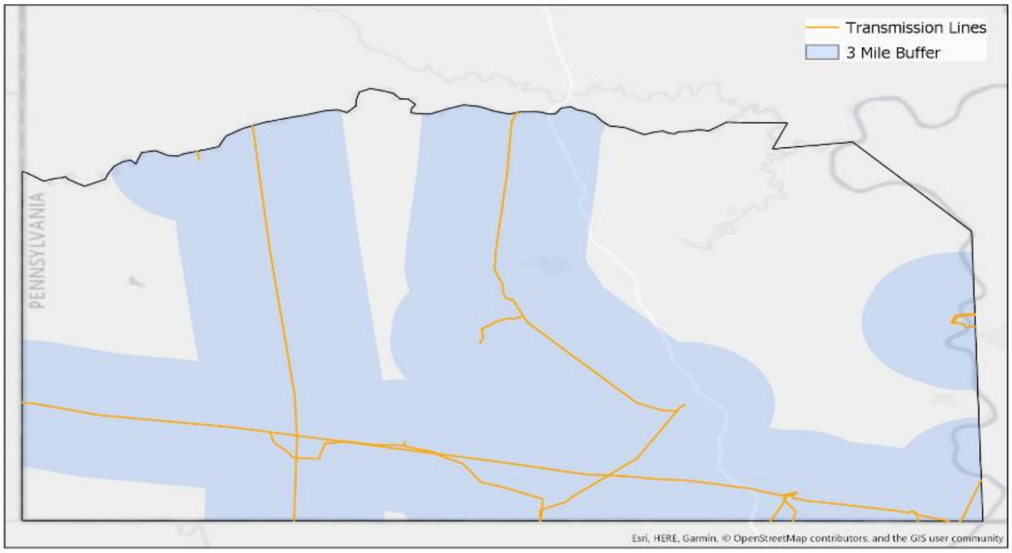


Figure 10: Potential Parcels within 3-Mile Buffer

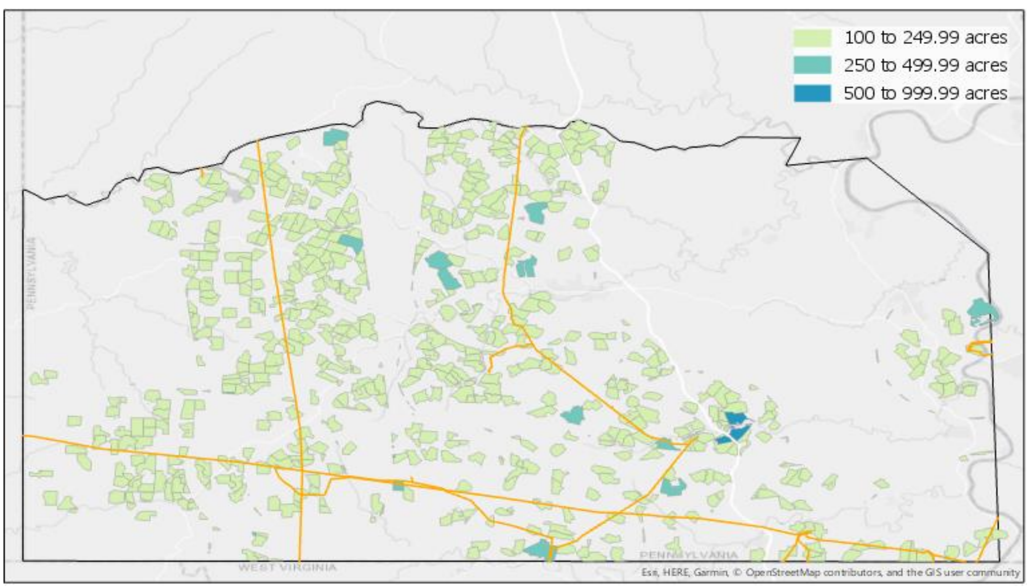


Table 9: Potential Parcels

Number of Potential Parcels in Greene County After Applying the Following Criteria					
Size Class (Acres)	**Y = a**	**Y = a + b**	**Y = a + b + c**	**Y = a + b + c + d_5**	**Y = a + b + c + d_3**
100-250	896	895	795	723	572
250-500	35	35	25	23	16
500-1,000	2	2	1	1	1
Total	**933**	**932**	**821**	**747**	**589**

Where Y = Total Number of Potential Parcels, a = Acreage, b = Flood Risk, c= Environmental, d_5 = 5 Miles to Transmission, d_3 = 3 Miles to Transmission

Addendum

The 5-mile and 3-mile cutoffs were also incorporated into the new analyses. The *Spatial Join* tool was used to identify which parcels fell within the 5-mile and 3-mile buffers that were created. Based off the outputs of the *Spatial Join* tool, a dummy variable was created to reflect which parcels met this criterion. In an effort to increase the financial feasibility of the potential sites, only parcels within the 3-mile buffer were identified as the most feasible sites. The breakdown of potential parcels remained the same as outline in Table 9.

Land Cover

The last criteria applied to identify potential sites for grid-scale solar was land cover. The purpose of incorporating this into the GIS analysis was to filter out land cover classes that were unsuitable for solar development. The dataset used to accomplish this was from the *2011 National Land Cover Database* (NLCD).[35] The NLCD included various land cover classes that were unsuitable for grid-scale solar development. Subsequently, the legend included in Figure 13 denotes the land cover classes that were generally cleared open land that would be feasible for solar deployment.

[35] Data Summary. (n.d.). Retrieved from http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=3141

In order to target the land use codes in Figure 13, this study used the *Spatial Join* tool. We specifically joined the land cover layer to a layer that identified potential parcels after applying the previous siting criterions; the output parcels in Figure 10. Upon joining these two layers, multiple records were created for each parcel since one parcel could have multiple land cover classes. As long as a parcel had at least one of the desired land cover classes and none of the unsuitable land cover classes, we identified it as a potential parcel for solar development. However, in order to get an accurate count just how many parcels fulfilled this requirement, we used the *Delete Identical* tool to remove duplicate records for each record. Table 10 outlines the number of parcels that fulfilled of the criteria discussed so far.

Figure 11: Land Cover

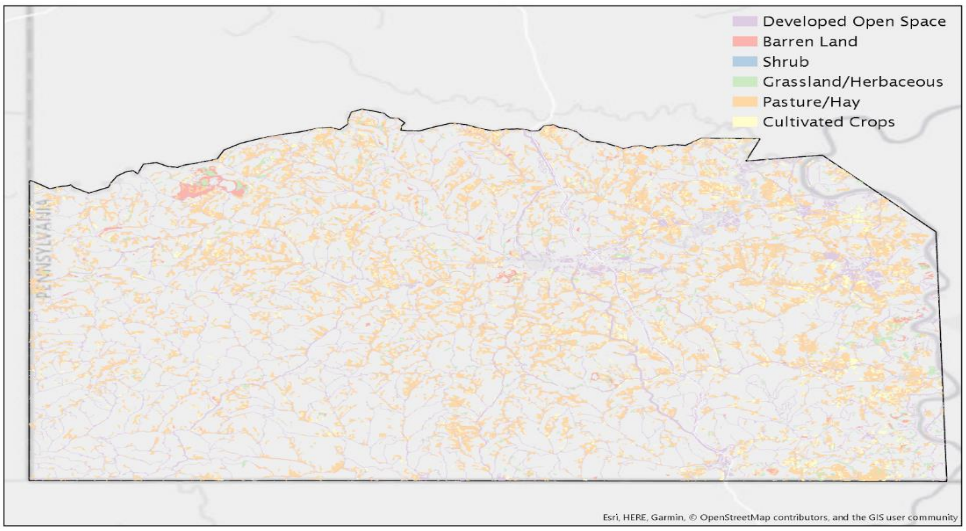


Figure 12: Potential Parcels

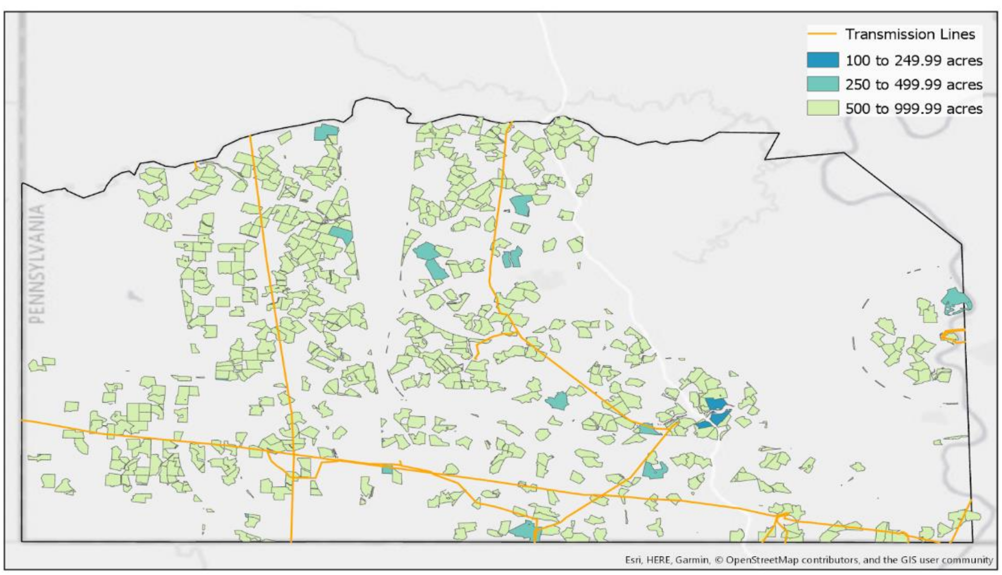


Table 10: Potential Parcels

Number of Potential Parcels in Greene County After Applying the Following Criteria						
Size Class (Acres)	**Y = a**	**Y = a + b**	**Y = a + b + c**	**Y = a + b + c + d5**	**Y = a + b + c + d3**	**Y = a + b + c + d3 + e**
100-250	896	895	795	723	572	572
250-500	35	35	25	23	16	16
500-1,000	2	2	1	1	1	1
Total	**933**	**932**	**821**	**747**	**589**	**589**

Where Y = Total Number of Potential Parcels, a = Acreage, b = Flood Risk, c = Environmental, d_5 = 5 Miles to Transmission, d_3 = 3 Miles to Transmission, and e = Land Cover

Addendum

Land cover was also incorporated into the second round of geospatial analyses however the land cover codes that were included differs. The legend in Figure 13 outlines which land cover codes were targeted as land cover codes of feasible sites for grid-scale solar. The purpose of incorporating these new land cover codes was to prevent the identification of green-fields as feasible sites. After the first round of analyses, the identified sites were verified by inputting the coordinates of said sites into Google Earth. The purpose of using Google Earth was to ensure the sites were not in forested areas. Unfortunately, several of the feasible sites identified in the first round of geospatial analyses were in forested areas, golf courses, gamelands, etc. The decision to include these new land cover codes was in an effort to prevent identifying sites in uncleared land such as those aforementioned. The *Spatial Join* tool was used to identify parcels that had land cover codes deemed feasible. As with the previous criteria, a dummy variable was created to identify which sites meet the land cover requirement. Figure 14 illustrates which parcels meet all of the siting criterion and Table 11 outlines the acreage breakdown of all feasible sites within Greene County. The color of the map in Figure 14 differs from the map outputs of the original analyses, this was done purposefully to easily distinguish between maps from the original analyses versus the new analyses.

Figure 13: Land Cover Codes Used

Figure 14: Potential Parcels after Applying the Land Cover Criteria

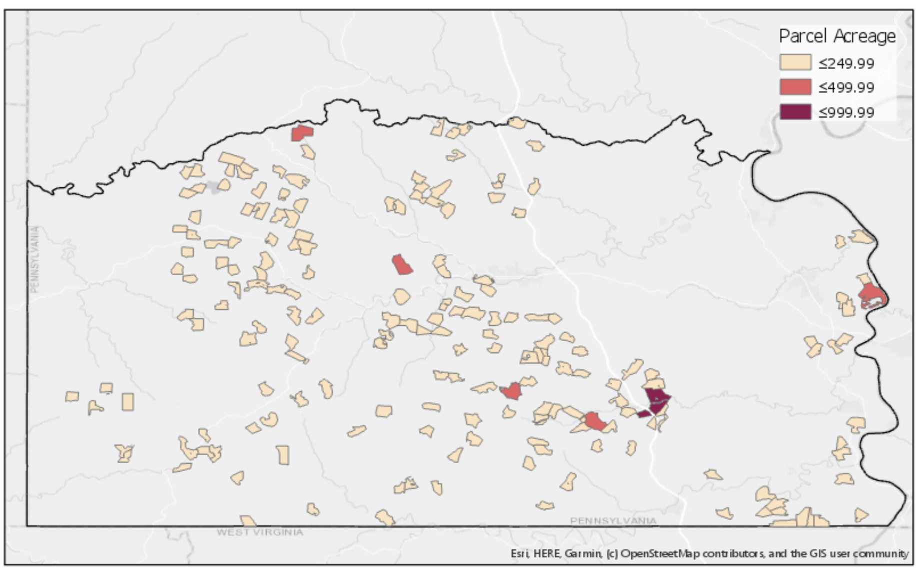


Table 11: Acreage Distribution of Greene County

Number of Potential Parcels in Greene County After Applying the Following Criteria						
Size Class (Acres)	**Y = a**	**Y = a + b**	**Y = a + b + c**	**Y = a + b + c + d5**	**Y = a + b + c + d3**	**Y = a + b + c + d3 + e**
100-250	896	895	795	723	572	179
250-500	35	35	25	23	16	52
500-1,000	2	2	1	1	1	1
Total	**933**	**932**	**821**	**747**	**589**	**232**

Where Y = Total Number of Potential Parcels, a = Acreage, b = Flood Risk, c = Environmental, d_5 = 5 Miles to Transmission, d_3 = 3 Miles to Transmission, and e = Land Cover

Feasible Sites In Southwestern Pennsylvania[36]

By applying all of the geospatial criteria to the 9 counties analyzed, this study identified 3,771 potential sites for grid-scale solar in Southwestern Pennsylvania. The acreage breakdown of 3,771 potential sites can be found in Table 12.

Table 12: Number of Potential Sites per Acreage Breakdown

Size Class (Acres)	Feasible Parcels
100-250	**3,528**
250-500	**182**
500-1,000	**38**
Over 1,000	**23**
Total	**3,771**

After filtering out the infeasible sites, this study further analyzed the 243 potential parcels that were 250 acres and larger by inputting them into the financial model to see if the sites were financially feasible. Once sites were deemed financially feasible, a visual assessment in Google Earth was used to confirm that these parcels were not located in unsuitable areas (e.g. mines, greenfields). After applying these steps, 29 feasible sites were identified within SW PA. The following list includes key findings derived from the study's analysis:

- Out of the 243 sites analyzed, only 11.9% of them were deemed feasible
- The majority of the sites deemed infeasible was a result of their location on state game lands, golf courses, country clubs, cemeteries, and forested areas
- Of the 243 sites analyzed, this study was unable to locate any feasible sites within Beaver county

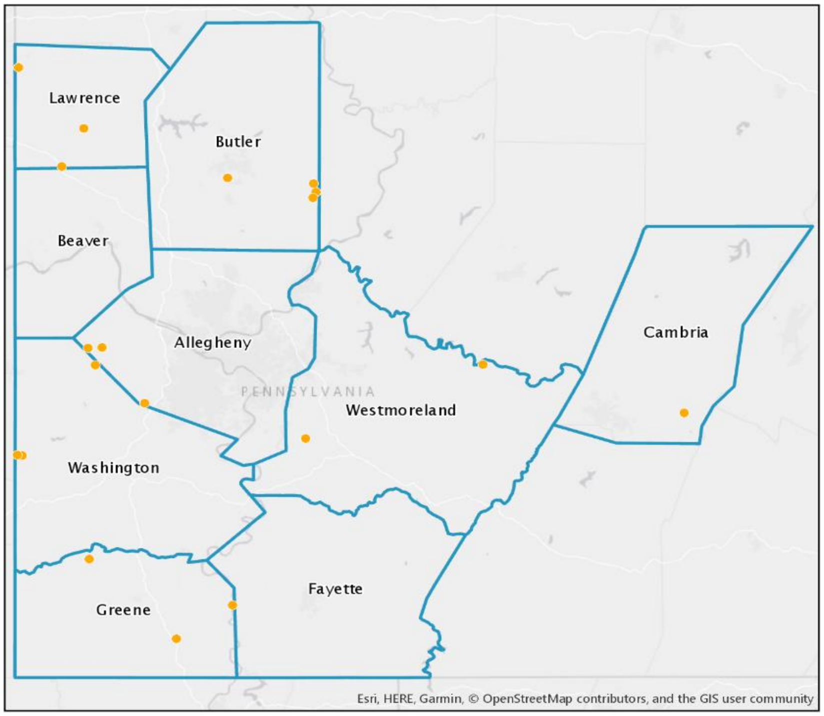
The 29 sites identified as feasible for grid-scale solar can be found in Table 13. This table showcases the sites broken down by county, as well as the total capacity, avoided GHG emissions, and average IRR of the sites. Figure 15, showcases the locations of these sites with a map of the 9 counties.

[36] **This section of the report was updated to reflect the new findings from further siting analysis**

Table 13: Feasible Sites

Concept	Number of Sites	Total Acres	Total Capacity (MW)	Avoided GHG Emissions (Tons)	Average IRR (%)
Allegheny	4	1,249	156.1	0.26	9.30%
Butler	4	3,629	453.6	0.76	9.00%
Cambria	3	1,292	161.51	0.25	9.47%
Fayette	6	2,461	307.5	0.52	9.20%
Greene	3	1,175	146.9	0.25	9.10%
Lawrence	4	1,037	117.1	0.2	8.85%
Washington	3	774	113.7	0.19	9.00%
Westmoreland	2	421	52.6	0.09	9.31%
Total	**29**	**12,038**	**1,509.07**	**2.51**	

Figure 15: Map of Feasible Sites



Addendum

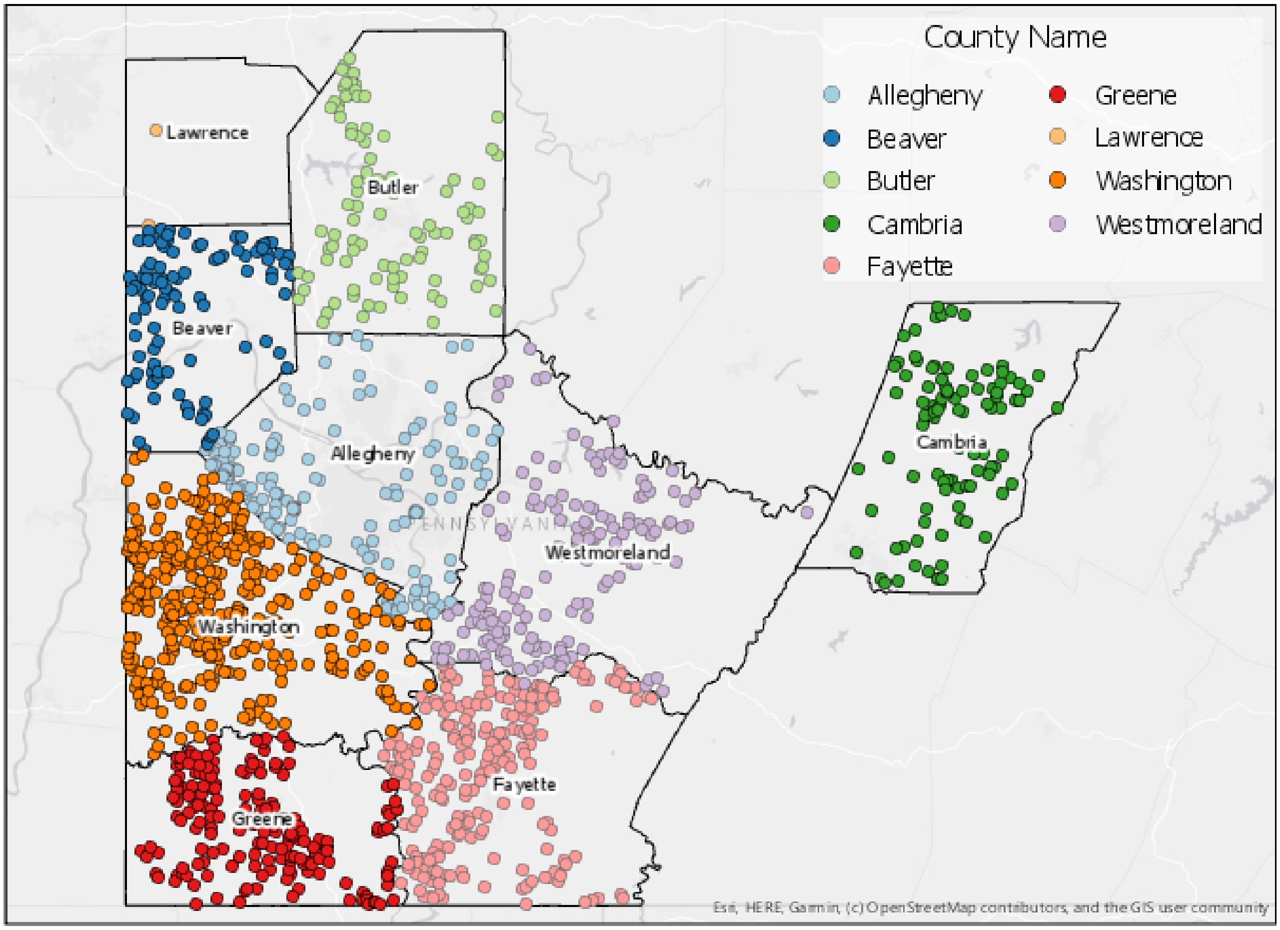
After applying all of the siting criteria to the second round of geospatial analyses, a total of 1,545 sites were identified as potentially feasible for grid-scale solar. The reason behind the approximate 2,000 difference between the initial round and second round of analyses is the modification to the land cover codes that were used. To ensure that these 1,545 identified sites were in fact not clear unforested land, each sites was verified using Google Earth. After using Google Earth a total of 675 sites were identified as feasible for grid-scale solar. Table 14 outlines the breakdown of feasible sites by each of the 9 counties. Figure 16 illustrates the location of all 675 sites in Southwestern Pennsylvania. The following list includes key findings derived from the second round of geospatial analysis:

- Out of the 1,545 sites analyzed, 43.69% of them were deemed feasible
- Of the 675 feasible sites, only one of them were located in Lawrence county
- If all 675 sites deployed grid-scale solar, there is the potential to generate approximately 11 MW in capacity

Table 14: Feasible Sites

County	Number of Sites	Total Acreage	Average Site Acreage	Median Site Acreage	Minimum Site Acreage	Maximum Site Acreage	Total Capacity (MW)
Allegheny	42	6,413.0	152.7	133.2	100.9	457.1	801.6
Beaver	57	7,855.3	137.8	122.3	100.1	287.9	981.9
Butler	63	8,165.6	129.6	123.2	100.8	222.8	1,020.7
Cambria	69	9,096.8	131.8	121.5	100.1	345.2	1,137.1
Fayette	130	18,820.9	144.8	124.2	100.0	609.7	2,352.6
Greene	62	9,138.1	147.4	136.5	100.2	294.1	1,142.3
Lawrence	1	128.2	-	-	-	-	16.0
Washington	164	23,045.4	140.5	129.7	100.0	340.4	2,880.7
Westmoreland	87	11,243.3	129.2	119.5	100.0	233.6	1,405.4
Total	**675**	**93,906.7**	**-**	**-**	**-**	**-**	**11,738.3**

Figure 15: Map of Feasible Sites



Summary of Findings[37]

In conclusion, grid-scale solar development is feasible in Southwestern Pennsylvania.

From a policy perspective, Pennsylvania's laws are more challenging towards solar development than its neighboring states, such as New York and New Jersey. Pennsylvania could use new regulation and policy incentives that make grid-scale solar development more financially feasible.

According to this study's research into the environmental landscape, the development of grid-scale solar would have a significant impact on the environment of SW PA. If grid-scale solar were deployed per the specifications of *Finding Pennsylvania's Solar Future*, greenhouse gas emissions would be reduced by 6.27 billion kg CO2e over the next decade.

This study's financial analysis concluded that grid-scale solar sites are financially feasible. This includes a positive net present value and a market-competitive internal rate of return. This financial analysis did not account for the financial incentives guaranteed through policy. Those incentives would make grid-scale solar installations more attractive financially.

Based on the geospatial analysis, this study found that Southwest Pennsylvania contains 3,771 parcels that are potentially feasible for grid-scale solar.

Table 15: Potential Sites Per County

County	Total Number of Parcels	Number of Potential Parcels	Percentage of Potential Parcels
Allegheny	580,784	477	0.08%
Beaver	89,445	266	0.30%
Butler	93,370	357	0.38%
Cambria	84,400	399	0.47%
Fayette	77,550	596	0.77%
Greene	29,180	589	2.02%
Lawrence	61,049	112	0.18%
Washington	121,889	640	0.53%
Westmoreland	121,889	335	0.27%
Total	**1,259,556**	**3,771**	**0.56%**

[37] **This section of the report was updated to reflect the new findings from further siting analysis**

This study identified 29 feasible sites that are financially feasible and not located on greenfields within Southwestern Pennsylvania. The total capacity of these sites meets Southwestern Pennsylvania's contribution to the Department of Environmental Protection's 2030 goal.

Addendum

Through the second round of geospatial analyses, 675 sites were identified as feasible for grid-scale solar. If grid-scale solar was deployed at all 675 sites, Southwestern Pennsylvania would have the capacity to reach the 10% state goal by 2030. The greenhouse gas emissions avoided by these 675 sites were not calculated. The financial feasibility of these sites have yet to be assessed.

POLICY LANDSCAPE

Policy is tremendously impactful in the growth of solar development. Exploration of the federal, state, and local policies that provide financial incentives for the development of grid-scale solar is critical for understanding true feasibility. Additionally, it is vital to analyze the policies of other states that have implemented solar rapidly and on a large scale. The exploration of other states' programs will allow for the assessment of gaps in SW PA. After providing an overview of these policies, this report will provide conclusions about how implementation of policy will further utility-scale solar in SW PA and throughout the rest of the state.

Federal Incentives for Utility-Scale Solar

There are three federal policies likely to play crucial roles in the development of grid-scale solar in SW PA. Each could incentivize some aspect of utility-scale solar in the region. These policies include the following:

- **Modified Accelerated Cost-Recovery System (MACRS):** MACRS accelerates the rate of depreciation for which an investment in solar energy technology can be recovered after 5 years of installation/use instead of its useful life.[38] In 2017, Congress extended bonus depreciation. Solar energy facilities that are placed in service after 2017 and before 2023 are generally eligible for 100% bonus depreciation. Between 2023 and 2026, the bonus depreciation rate ramps down 20% each year, such that by 2027 there is no longer bonus depreciation under current law.[39]

- **Business Energy Investment Tax Credit (ITC):** This is a 30% federal tax credit for all solar projects on residential and commercial properties. An organization that owns the project when it is placed in service is eligible for the ITC. The ITC is gradually reduced to 10% under the following schedule:

Table 14: ITC Percentage Breakdown

Start of Construction:	Placed in Service Data:	ITC Perentage
During 2017	Before 1/1/2022	30%
During 2018	Before 1/1/2023	30%
During 2019	Before 1/1/2024	30%

[38] Solar Energy Industry Associates. "Depreciation of Solar Energy Property in MACRS." https://www.seia.org/initiatives/depreciation-solar-energy-property-macrs
[39] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx

During 2020	Before 1/1/2024	26%
During 2021	Before 1/1/2024	22%
After 2021 OR	After 2023	10%

This ITC reduction could limit some developers' willingness to invest in solar. There should be consideration given to extending the ITC on a state level.[40]

- **Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Guaranteed (REAP):** This program gives both loans, grants, or a combination of the two to small businesses in rural areas with at least 50% of their income coming from agricultural practices.

  REAP is intended to support these businesses in their installation of renewable energy systems or support improvements to their energy consumption. The loan amount disbursed to any business cannot exceed $25 million. The grants are divided into two separate types: renewable and efficiency. Grants that support the implementation of renewable energy will fall between $2,500-500,000. Grants to improve energy efficiency will fall between $1,500-250,000.[41]

  REAP Grants and Loans are critical when analyzing the feasibility of grid-scale solar in SW PA because of the region's agricultural sector.

State Incentives for Utility-Scale Solar

The following portion of this study includes two incentives that support grid-scale solar at the state-level.

- **Solar Renewable Energy Credits (SREC):** SRECs incentivize distributed and commercial solar at the state-level. Each credit represents 1 MWh of electricity generated from solar, and these credits earn an amount of money depending on a state's bid prices. When the SREC bid prices are high, they promise a greater return on an investment in solar, no matter the scale. Without stable and sufficient SREC prices, solar development becomes a less attractive option for developers and landowners.

  Under AEPS, PA once allowed systems outside the state to register and participate in its SREC market. This flooded the PA market and depressed the state's SREC prices. In response to this problem, Act 40 was passed in October of 2017 to close PA's borders and allow only solar systems located within the state to participate in its SREC market. The bid price of PA's SRECs

[40] Ibid.
[41] DSIRE. "USDA- Rural Energy for America (REAP) Grants." http://programs.dsireusa.org/system/program/detail/917

has increased by an average of one dollar per credit since Act 40 was enacted, and as time goes on, it will likely continue to increase and stabilize, making deployment of grid-scale solar a more attractive option.[42]

- **Act 129 Energy Efficiency:** This policy mandates that the PUC establish cost-effective targets to improve energy efficiency and reduce peak demand for qualifying utilities.[43] The qualifying utilities provide plans for meeting these targets to the PUC. Solar programs could be included in the utility companies' plans but are not required. This policy could have an indirect impact on in-state solar generation.[44]

Even though the state government does not offer them, there are additional incentives, which can accelerate the introduction of grid-scale solar in SW PA.

- **The Reinvestment Fund:** This fund brings together individual investors, banks, government officials, private foundations and faith-based and community organizations to invest in projects that transform communities including clean energy.

- **Sustainable Energy Fund:** This fund provides grants, loans, and equity investments to promote:

    - The development and use of renewable energy and clean energy technologies

    - Energy conservation and efficiency, sustainable energy businesses, projects that improve the environment in the companies' service territories

Municipal Zoning Codes for Utility-Scale Solar

This project's nine-county region hosts numerous municipalities that may pose many challenges for permitting and supporting grid-scale solar development. There are over hundreds of municipalities throughout these counties with their land use policies. Fortunately, most of the local policies can be boiled down to three main types.

These types include municipal zoning ordinances, subdivision and land development ordinances (SALDO or SLDO), and multi-municipal comprehensive plans. This study employed the Pennsylvania eLibrary to explore various municipal land documents and synthesize key details about the support or limitations they may provide for grid-scale solar development.

- **Municipal Zoning Code:** Zoning dictates how land can be used within a municipality. Municipal zoning policies establish control over the use and development of critical features in a community,

[42] SREC Trade. "Pennsylvania." https://www.srectrade.com/srec_markets/pennsylvania
[43] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx
[44] Ibid.

including farmland or fragile environmental areas.[45] County zoning is not common in SW PA, and the municipalities have the power override county zoning with its own policies according to the PA Municipalities Planning Code.[46] Zoning is critical for land use planning, and the exploration and potential alteration of PA's municipal zoning codes will be necessary to reach the DEP's 2030 goal.

- **Subdivision and Land Development Ordinances (SLDO):** SLDO is the mechanism employed most frequently for development control in PA. Under SLDO, municipalities have the power to review and approve proposals for land development and property improvement.[47] Local governments must be able to effectively plan and allocate the use of its land resources.[48] These ordinances are created to coordinate land use, provide acceptable design and planning standards, and align public need with private development interests.[49]

- **Municipal Comprehensive Plan:** These plans serve as a "vision" for how the land use regulation within a municipality should be carried out. The plan serves to implement the municipalities' zoning policies and SLDO. When focusing on land use policies in PA's municipalities, it is critical to ensure that any changes made to a municipality's zoning or SLDO are updated in the comprehensive plan, so that the community's plans and desired directions are put into action.[50]

All three of these policies may vary widely depending a municipality's population and land. However, there are certain features that can be adjusted in local land use policy to ease these challenges. This project explored Massachusetts' Model Zoning and the National Renewable Energy Laboratory's Best Practices in Zoning to highlight some changes that can be integrated into PA's municipal policies to support grid-scale solar more effectively. These include:

- **Definition:** Many municipalities do not explicitly regulate the installation of solar systems in their local land use policies. Without these specific solar policies and/or plans, municipalities provide a significant barrier for solar development.[51]

  It is necessary for PA's municipalities to define their position on solar energy systems. Each municipality should enact policy to outline its position on solar and provide an inclusive definition of the solar systems it allows to avoid the policies becoming too narrow or outdated with the development of new technology.[52]

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[45] The Penn State Cooperative Extension. "Land Use Planning in Pennsylvania." 2001. http://planningpa.org/wp-content/uploads/5-Zoning.pdf
[46] Ibid.
[47] Governor's Center for Local Government Services. "Subdivision and Land Development in Pennsylvania." June 2003. http://boroughs.org/ckfinder/userfiles/files/08%20Subdivision%20and%20Land%20Dev.pdf
[48] Ibid.
[49] Ibid.
[50] The Penn State Cooperative Extension. "Land Use Planning in Pennsylvania." http://planningpa.org/wp-content/uploads/5-Zoning.pdf
[51] NREL. "Best Practices in Zoning for Solar." April 21, 2017. https://www.nrel.gov/state-local-tribal/blog/posts/best-practices-in-zoning-for-solar.html
[52] Ibid.

- **Solar-Friendly Provisions:** PA municipalities should consider offering more incentives for solar, such as waiving permitting fees.[53] These incentives will help to boost the local economy and attract more solar development.

- **Impacts:** It is ideal for municipalities to define and regulate solar systems based on their impact and the area they require instead of the amount of power than the capacity they can generate.[54]

- **Overlay Zoning:** This policy creates special zoning districts over base zoning districts. These overlay districts may have special provisions that enable solar system developments. These provisions could enable solar systems to be approved without a formal site plan review in communities where the review is determined to be unnecessary.[55]

- **Agricultural Exemption:** This would exempt PA's agricultural lands from being regulated by local land use policies. This agricultural exemption would improve opportunity for solar development on farmland if the solar system is integral for the farm's production.[56]

Other States' Incentives for Utility-Scale Solar

PA trails many states in solar energy generation. Numerous states along the East coast of the US have deployed solar at a much faster rate and larger scale than PA despite their climate and solar resource. This section of the study will examine the policies implemented in New Jersey, New York, Massachusetts, and North Carolina. All four have effectively incentivized and developed solar energy and are revered as some of the top states for solar energy generation.

New Jersey

The growth of NJ's solar generation was initially spurred by its RPS of reaching 22.5% in-state renewable energy generation by 2021. The state's Clean Energy Program was created to support its RPS goal. The program once provided a rebate of up to $1.75 per watt for residential solar and a $1.00 rebate for businesses whose usage was greater than or equal to 50,000 watts.[57]

NJ has moved away from this rebate program in recent years. However, their SREC prices serve as an attractive option for those considering solar development. SREC bid prices in the NJ market as of December 2018 are $218.00 per credit.

[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Ibid.
[57] Solar New Jersey. "Why has New Jersey become a leader in solar in the US?" August 15, 2012. http://www.solar-new-jersey.org/2012/08/15/why-has-new-jersey-become-a-leader-in-solar-in-the-us/

The Public Service Enterprise Group's (PSE&G), a NJ utility company, has developed its Solar 4 All program to support the deployment of solar. This program has supported the wide-scale transition of NJ's brownfields and landfills to solar arrays. Solar 4 All's goal is to generate 158 MW from their solar installations to power over 25,000 homes across the state.[58] PSE&G unveiled its Clean Energy Future proposal in September of 2018. The plan involves a $4 billion investment in smart meters, energy storage, and, most notably, energy-efficient technology to improve affordability of energy for NJ residents.[59]

One of the most recent developments in NJ's pursuit of solar generation are their recent bills, A3723 and S2314. The companion bills were passed in the NJ Assembly and Senate in spring of 2018 to stabilize the state's solar industry.[60] This stabilization of NJ's solar industry is intended to follow the state's increased RPS goal to 50%.[61] This legislation will also support the development of community solar, and it will also close down the state's SREC market by June of 2021.

NJ has also implemented state incentive programs that offer tax exemptions for solar equipment and property tax exemptions for solar energy facilities. The Solar Energy Sales Tax Exemption is offered through the NJ Division of Taxation, which authorizes all solar equipment to be 100% exempt from state sales tax.[62] The Solar Energy Property Tax Exemption is offered through the NJ Department of the Treasury and grants property tax exemptions for 100% of the value added to a property by a renewable system.[63]

New York

The New York State Energy Research and Development Authority's (NYSERDA) NY-Sun is a public-private partnership that strives to make solar development and technology more affordable with the expansion of new and existing programs.[64] NY-Sun supported a near 800% growth of in-state solar development from December 2011 to December 2016 within NY.[65]

NY-Sun developed a $1 billion Megawatt Block Program that incentivizes solar development, particularly large-scale systems on brownfields and landfills. As of June 2018, this program supported 652 MW of completed solar installations, and there are over 950 MW being developed currently.[66] NY-Sun provides a clear incentive structure for solar development at all levels. These incentives include

[58] PSE&G. "Solar 4 All Program." https://corporate.pseg.com/aboutpseg/ourvision7values/solar4all
[59] Walton, Robert. "Advocates warn New Jersey solar market could collapse again." October 22, 2018. https://www.utilitydive.com/news/advocates-warn-new-jersey-solar-market-could-collapse-again/540214/
[60] Misbrener, Kelsey. "Solar advocates celebrate New Jersey solar policy success." April 6, 2018. https://www.solarpowerworldonline.com/2018/04/solar-advocates-celebrate-new-jersey-policy-success/
[61] Ibid.
[62] New Jersey. Retrieved from https://www.nrel.gov/solar/rps/nj.html
[63] Ibid.
[64] New York State, "NY-Sun: Making solar affordable for all New Yorkers." https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun
[65] Frangoul, Anmar. "New York sees almost 800 percent growth in solar power over five years." February 22, 2017. https://www.cnbc.com/2017/02/22/new-york-sees-almost-800-percent-growth-in-solar-power-over-five-years.html
[66] Misbrener, Kelsey. "NYSERDA expands solar incentives to brownfields and affordable housing." June 18, 2018. https://www.solarpowerworldonline.com/2018/06/nyserda-expands-solar-incentives-brownfields-affordable-housing/

state tax credits, a variety of financing options, and resources for local governments to mitigate barriers for solar development.[67]

One resources NYSERDA has developed for local governments includes the Municipal Solar Procurement Toolkit. This toolkit was created in 2018 to support governments, as well as communities and individuals, with the resources and tools required for solar development on landfills and brownfields. The toolkit includes a step-by-step process for municipal procurement, permitting, and even templates for land-use agreements.[68] This resource and NYSERDA's NY-Sun incentives are all building blocks for NY to reach its 50% renewable energy goal by 2030.

The New State Department of Taxation and Finance has also implemented a property tax exemption program for residential and non-residential solar systems. The program allows commercial, industrial, residential, schools, and institutional sectors to obtain property tax abatement for solar system expenditures at a reduced rate.[69] The program specifically exempts 5% of the solar system's expenditures per year for four years.[70]

MASSACHUSETTS

Massachusetts Clean Energy Center (MASSCEC) is responsible for supporting renewable energy development within the state. MASSCEC has facilitated a number of initiatives to expand in-state solar generation, including Solarize MA. Solarize is a group-buying program that enables MA residents to save money and deploy small-scale solar installations together. This program has led a number of groups and businesses to sign contracts to deploy installations that generate 22.3 MW of solar capacity.[71]

MASSCEC also provides low-interest loans and solar advisors to residents and businesses respectively.[72] In addition, the agency invests in innovation for renewable energy. MASSCEC provides a variety of grants for the incubation, acceleration, and full development of entrepreneurial endeavors that further innovation within the renewable energy sector.

SREC bid prices in the MA market as of December 2018 are over $300.00 per credit. These high prices provide a very strong incentive for developers to gain a return on their investment in solar energy. MA has also been highlighted by the National Renewable Energy Laboratory (NREL) for its zoning regulation that supports a less cumbersome process for deployment of solar.

MA's success with solar is also be a product of its zoning regulations that support a less cumbersome process for deployment of solar. MA's Model Zoning document was a resource created in 2014 by the

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[67] New York State, "NY-Sun: Making solar affordable for all New Yorkers." https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun
[68] Hogdon Russ LLP. "NYSERDA's Municipal Solar Pocurement Toolkit promotes the development of solar projects on brownfields and landfills." November 28, 2018. https://www.jdsupra.com/legalnews/nyserda-s-municipal-solar-procurement-76026/
[69] New York. Retrieved from https://www.nrel.gov/solar/rps/ny.html
[70] Ibid.
[71] Massachusetts Clean Energy Center. "Solar."https://www.masscec.com/business/solar-0
[72] Massachusetts Clean Energy Center. "Solar." https://www.masscec.com/get-clean-energy/residential/solar

state's Department of Energy Resources to assist the state's local governments in establishing smarter regulation and policy that supports the development of solar systems throughout MA.[73]

NORTH CAROLINA

North Carolina has become a leader in solar development as a result of its policy incentives driving development and even corporate sponsorships.[74] The state of NC provides a wealth of opportunities from rebates to tax credits that have increased the demand and development for in-state solar generation. These incentives have allowed the state to reach nearly 5,000 MW of in-state solar generation in the second quarter of 2018.[75] The state is expected to add another 4,400 MW of in-state solar generation in the next year.[76]

NC's RPS of 12.5 % by 2021 helped fuel the growth of the state's solar development.[77] NC also provided a 35% investment tax credit on renewable energy projects until December 2015. Combining this tax credit with the ITC made the development of solar installations more financially feasible.

A study done by Duke University and RTI International found that for every dollar the state provided for its tax credit, there was $1.93 returned to state and local governments.[78] RTI also reported that from 2007 to 2014, NC attracted $3.5 billion in solar investment.

In 2017, the state passed House Bill 589, which authorized solar leasing in NC. Duke Energy, an NC utility company, plans on offering leases that range up to twenty years for the state's residents. Lessees would be able to use all of a system's energy generation and receive the benefits of net metering and rebates provided by the utility.[79] The solar leasing program will allow NC residents to have access to renewable energy without the upfront investment.[80]

Another outcome of this bill includes Duke Energy beginning a rebate program. The program offered a rebate of 50, 60, and 75 cents per kilowatt for commercial, residential, and nonprofit customers' solar installations respectively.[81] Additional rebate programs have been created at the county level to make

[73] Department of Energy Resources, Massachusetts Executive Office of Energy and Environmental Affairs. "Model Zoning for the Regulation of Solar Energy Systems." December 2014. https://www.mass.gov/files/documents/2017/10/16/model-solar-zoning.pdf
[74] Clean Energy Authority. "North Carolina solar rebates and incentives." https://www.cleanenergyauthority.com/solar-rebates-and-incentives/north-carolina
[75] Solar Energy Industries Association. "North Carolina Solar." https://www.seia.org/state-solar-policy/north-carolina-solar
[76] Davis, Dillon. "Renewable energy: North Carolina again ranks second to California in solar power." March 20, 2018. https://www.citizen-times.com/story/news/local/2018/03/20/renewable-energy-north-carolina-again-ranks-second-california-solar-power/438840002/
[77] Smith, Owen. "5 Reasons for North Carolina's rapid emergence as a solar energy leader." April 29, 2015. https://cleantechnica.com/2015/04/29/5-reasons-for-north-carolinas-rapid-emergence-as-a-solar-energy-leader/
[78] Ibid.
[79] Walton, Robert. "Duke Energy plans to offer nonresidential solar leases in North Carolina." October 30, 2018. https://www.utilitydive.com/news/duke-energy-plans-to-offer-nonresidential-solar-leases-in-north-carolina/540896
[80] Ibid.
[81] Solarize North Carolina. "Pricing, Tax, and Financing Information." http://solarize-nc.org/taxes/

solar more attractive. Duke Energy's rebates are expected to triple the size of the state's private solar market in the next five years.[82]

Assessing the Needs for Additional Policy in PA

The development of policy that will support large-scale investment in solar development throughout PA is vital. Successful implementation of new policy and programs similar to those highlighted in other states will ensure that the DEP's 2030 goal is reached.

Moving forward, PA could consider doing all or a combination of the following to improve opportunity for deployment of grid-scale solar.

- **Provide support to PA municipalities** for updating and including clear and broad positions on active and passive solar systems, and developing the following:
  - **Solar-Friendly Provisions:** PA municipalities could consider offering more incentives for solar, such as waiving permitting fees.[83]
  - **Impacts:** Municipalities can define and regulate solar systems based on their impact and the area they require instead of the amount of power than the capacity they can generate.[84]
  - **Overlay Zoning:** Local governments could enable special zoning provisions in certain districts for solar systems to be approved without a formal site plan review.[85]
  - **Agricultural Exemption**: This could exempt PA's agricultural lands from being regulated by local land use policies, if the solar system would become integral for farms' production.[86]
- **Increase and stabilize the PA SREC market** by:
  - Creating a higher Alternative Energy Portfolio Standard to better reflect the DEP's 2030 energy goals
  - Creating more state and local incentives for solar development
- **Introduce these incentives with a statewide program** to make solar development a feasible option and support the reclamation of brownfields to be pad ready
- **Creating more private-public partnerships** to build and expand the state's offering of solar incentives
  - Consider more partnerships with SW PA's utility companies, particularly for the remediation of brownfields and/or support of additional regional incentive programs

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[82] Henderson, Bruce. "NC regulators just made it cheaper to install solar panels on your roof. Here's how." April 16, 2018. https://www.charlotteobserver.com/news/local/article208992734.html
[83] NREL. "Best Practices in Zoning for Solar." April 21, 2017. https://www.nrel.gov/state-local-tribal/blog/posts/best-practices-in-zoning-for-solar.html
[84] Ibid.
[85] Ibid.
[86] Ibid.

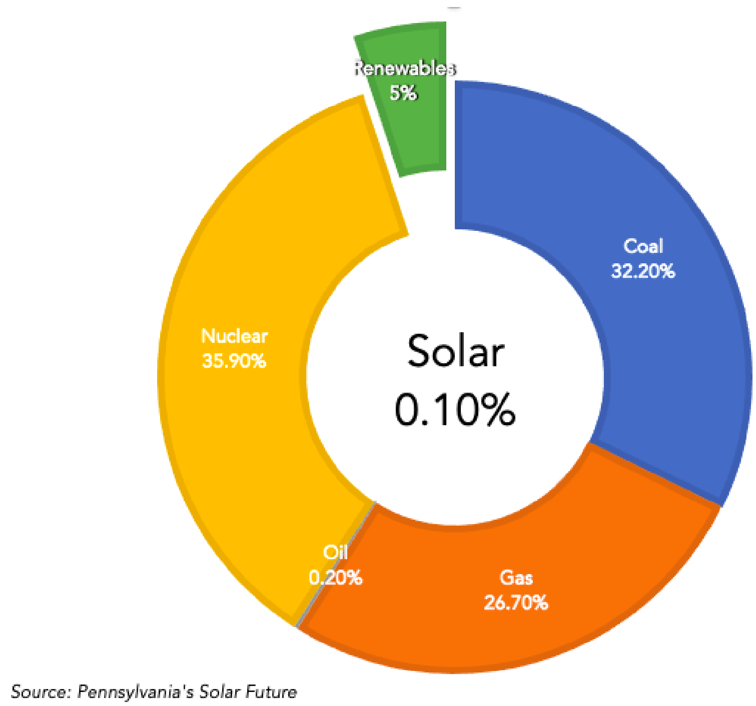
ENVIRONMENTAL LANDSCAPE

This study considered some aspects of environmental impacts and conditions relevant to the expanded development of solar in Pennsylvania (PA).

Calculation of Avoided GHG Emissions

One of the benefits of implementing solar is the amount of GHG emissions that can be avoided. As part of our analysis we wanted to include an estimate of just how much GHG emissions could be avoided. In order to assess this, we first calculated an emission coefficient for PA's current energy portfolio. Figure 31 showcases the breakdown of PA's current energy portfolio.[87]

Figure 13: Pennsylvania's Current Energy Portfolio



The calculations of the emission coefficients for each energy source in PA's current energy portfolio was based on calculations by the National Energy Technology Laboratory.[88] Table 15 denotes the National Energy Technology Laboratory breakdown of the emission coefficients based on energy source.

[87] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx
[88] National Energy Technology Laboratory. "NETL Upstream Dashboard Tool Documentation." January 2015.

Table 15: Emission Coefficients by Energy Resources

Category (Units)	Material or Energy Flow	Current							
		Fleet Coal	Fleet Natural Gas	Existing Nuclear	Existing Hydro	Petroleum	Onshore Wind	Geothermal	Solar Thermal
GHG (kg/MWh)	CO_2	1.06E+03	4.67E+02	3.23E+01	1.82E+01	1.12E+03	1.79E+01	2.31E+02	3.31E+01
	N_2O	1.95E-02	1.52E-03	7.43E-04	7.15E-07	1.53E-02	8.49E-04	4.03E-05	6.55E-03
	CH_4	1.60E+00	1.81E+00	1.03E-01	2.51E-01	1.33E+00	4.23E-02	4.29E-01	9.40E-02
	SF_6	1.45E-04	1.44E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04
	CO_2e (IPCC 2007 100-yr GWP)	1.11E+03	5.16E+02	3.83E+01	2.77E+01	1.17E+03	2.25E+01	2.45E+02	4.07E+01

This study considered carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and sulfur hexafluoride (SF6) to be the most critical GHG to assess and determine the environmental impact of grid-scale solar development. This report employed the weighting factors for global warming potential from the International Panel on Climate Change (IPCC) to convert all GHG emissions to carbon-dioxide equivalents (CO2e).

Currently, for 1 MWh of electricity generation, 0.4126 tons CO2e of GHG are emitted. However, for 1 MWh of solar, 0.04 tons CO2e of GHG is emitted. If the electricity from today's energy systems were substituted with electricity generated from solar, for every 1 MWh of solar, 0.3726 tons CO2e of GHG would be avoided.

According to the *Finding Pennsylvania's Solar Future*, total retail electric sales are estimated to be 150.4 TWh by 2030. In order to reach the 10% by 2030, PA will need to generate 15 TWh from solar.[89] As a result, 5,589,000 tons CO2e of GHG is expected to be avoided. This equals the amount of GHG emitted by 1,194,509 vehicles driven over the course of one year.[90]

Brownfields

When analyzing the environmental benefits of solar development, exploring the remediation and reuse of brownfields for renewable energy is critical. Research indicates that unreclaimed brownfields are less attractive for developers because of the costs involved in remediating the land.

When developing a solar project on a brownfield, the project requires complex analysis, including the review and modification of current closure plans and permits to ensure no conflicts, evaluation of soil erosion, storm water flows, and any impacts on the landfill cap.[91] Additionally, the reclamation costs are

[89] Campbell, Kerry, and Allen Landis. "Pennsylvania's Solar Future Plan." Compiled by David Althoff and Robert Altenburg. Finding Pennsylvania's Solar Future, November 2018. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Pennsylvania's-Solar-Future-Plan.aspx
[90] United States Environmental Protection Agency. Accessed to December 2018. "Greenhouse Gas Equivalencies Calculator." https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[91] New Jersey Institute of Technology. "Brownfield Site Contamination Investigation." https://www.njit.edu/tab/managing/pre-development/contamination-investigation.php

high, averaging $602,000, according to Northeast Midwest Institute.[92] In an effort to minimize the reclamation costs, the EPA provides cleanup grants up to $500,000.[93]

Below is a case study that explores the reclamation of a brownfield in New Jersey. This case highlights some key details including the capacity of the solar installation and the amount of carbon it offsets.

Case: South Brunswick Landfill, New Jersey

The South Brunswick landfill is a superfund site, where municipal reuse and chemical waste was collected from 1959-79.[94] The remediation of this site was completed in 1985 following a consent order.[95]

Capacity: 13 MW (providing enough energy to power 1,360 homes)

[92] Evans Paull, Northeast-Midwest Institute. "The environmental and economic impacts of brownfields redevelopment." July 2008. http://www.nemw.org/wp-content/uploads/2015/06/2008-Environ-Econ-Impacts-Brownfield-Redev.pdf

[93] United States Environmental Protection Agency. "Multipurpose, Assessment, RLF, and Cleanup (MARC) Grant Application Resources." Accessed December 2018. https://www.epa.gov/brownfields/multipurpose-assessment-rlf-and-cleanup-marc-grant-application-resources

[94] Jennifer Amato. "Landfill converted to 13-megawatt solar energy farm in South Brunswick." July 2018. https://cms.centraljersey.com/2018/07/24/landfill-converted-to-13-megawatt-solar-energy-farm-in-south-brunswick/

[95] ibid

Area: 68 acres

Construction duration: 5 years

Developer: NJR Clean Energy Ventures (CEV)

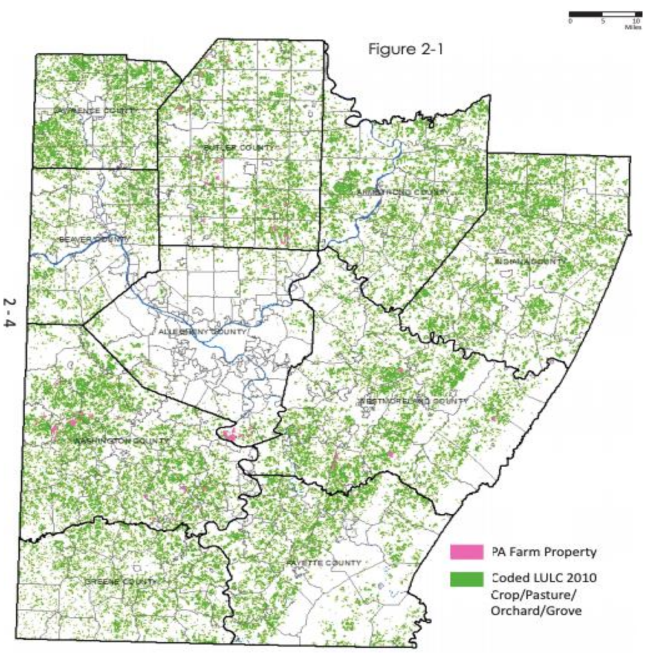
CO2 Offset: 14,000 tons (equivalent of the pulling 2,700 cars off the road)

Jobs: 200 union jobs used in the construction

Farmland

In contrast to developing brownfields, deploying grid-scale solar on farmland can be far less costly. As Figure 14 showcases, there is an abundance of farmland in Southwest Pennsylvania (SW PA).[96] Throughout history, farming and agriculture have been mainstays in SW PA's economy.[97] Farmland tend to be flat and open, since it is used for cultivating crops. Thus, farmlands are ideal for the deployment of grid-scale solar. Since farmland does not require remediation, it is much more financially feasible for solar.

Figure 14: Farmlands in Southwestern Pennsylvania



[96] Southwestern Pennsylvania Commission. "Food Production in Southwestern Pennsylvania." https://www.spcregion.org/pdf/food/Chapter%202.pdf
[97] Pennsylvania Historical & Museum Commission. "Southwestern Pennsylvania Diversified Agriculture and Sheep Raising, c. 1840-1960." http://www.phmc.state.pa.us/portal/communities/agriculture/files/context/southwestern_pennsylvania.pdf

In analyzing how the 10% goal can be reached by 2030, it is important to consider how the installation of solar on farmlands can be made attractive to the landowners. One solution is to encourage farmers to lease their land for grid-scale solar installations. Farmers tend to be reluctant to relinquish ownership of their lands in the hopes to retain it for future generations.[98] Leasing allows farmers to retain ownership of their land and collect rent as a stream of revenue. Leasing also gives farmers the option to return the land to agricultural production, if they so desire.

Deploying solar on farmlands have also brought up concerns from agriculturalists. The main concern being the impact that solar development on farmlands could have on our food production.[99] To remedy this there is research currently underway looking into what livestock could live alongside solar farms and what crops could be grown under the solar panels.[100] After conferring with stakeholders, we were able to identify the following benefits of deploying solar on farmlands:

- Solar offers a less permanent and less intrusive alternative to more intensive residential or commercial development
- After decommissioning, property is generally restored to the previous or better condition, and agricultural activities may resume
- By supplementing farmers' income, solar promotes the long-term preservation of intergenerational farms
- Project benefits could include pollinators, compatible use with grazing sheep, ongoing use by native birds, wildlife and plant species
- Significant reduction in soil erosion and nitrogen loadings to local waterways typically associated with agricultural practices
- Standard maintenance and monitoring programs can control weeds and invasive species during solar operations

[98] Andrea Stone. "American Farmers Are Growing Old, With Spiraling Costs Keeping Out Young." https://news.nationalgeographic.com/news/2014/09/140919-aging-american-farmers-agriculture-photos-ngfood/
[99] Ibid.
[100] American Farmland Trust. "Smart Solar Sitting." Accessed December 2018. https://www.farmland.org/initiatives/solar

RECOMMENDATIONS

The development of policy that will support large-scale investment in solar development throughout PA is vital. Successful implementation of new policy and programs similar to those highlighted in other states will ensure that the 10% goal is reached by 2030.

Moving forward, PA should consider doing all or a combination of the following to improve opportunity for deployment of grid-scale solar.

- **Increase and stabilize the PA SREC market** by:
  - **Creating a higher Alternative Energy Portfolio Standard** to better reflect the 10% 2030 renewable energy goals by increasing the in-state solar carve out requirement
  - **Creating more state and local incentives** for solar development
- **Introduce these incentives with a statewide program** to make solar development a feasible option and support the reclamation of brownfields to be pad ready
- **Create more private-public partnerships** to build and expand the state's offering of solar incentives
  - **Consider more partnerships with SW PA's utility companies**, particularly for the remediation of brownfields and/or support of additional regional incentive programs
- **Create incentives to promote long-term Solar Power Purchase Agreements** to improve the financial feasibility of solar
- **Provide support to PA municipalities** by updating and including clear and broad positions on active and passive solar systems, providing access to educational information and opportunities related to solar and developing the following:
  - **Solar-Friendly Provisions:** PA municipalities could offer more incentives for solar development, such as tax abatements. They could also allow solar projects to be permitted by right or by a zoning waiver, waiving permitting fees, streamline and/or expediting permitting
  - **Impacts:** Municipalities could define and regulate solar projects based on long0term vision and plans for their community
  - **Overlay Zoning:** Local governments could enable special zoning provisions in certain districts for solar facilities to be approved without zoning variance or modification or a length formal site plan review
  - **Agricultural Exemption**: This policy could exempt PA's agricultural lands from being regulated by local land use policies
- **Create a centralized and free-to-use database** with all the necessary GIS and other data needed to forecast solar projects

Through stakeholder inquiry post the midpoint presentation of our project the following recommendations were also compiled as additional opportunities to increase the deployment of grid-scale solar.

- **Carbon pricing**
  - PA's participation in the Regional Greenhouse Gas Initiative (RGGI) or other similar structures could have a large impact on the market. In August 2017 RGGI announced a further C)2 reduction to 55.7 million tons by 2030; a 65$ drop from regional CO2 levels in 2009. Subsidizing coal generation sources could directly impede the achievement of RGGI states' emissions reduction goals.
- **Create a renewable action team** at the state level to streamline and ease permitting for solar projects. Any streamlining initiative should focus on obtaining quantifiable results without sacrificing the conservation and protection goals of the permitting program.
- **Compile solar energy educational information** into one online, easy to use, central location. This could be a valuable asset for educational purposes that may allow for more solar development across the state
- **Stimulate long-term solar energy contracting** by increasing the amount of electricity that utilities are required by state law to get from solar.

PHASE II: FUTURE RESEARCH

Public Benefit Funds (PBF): PBFs are state-level programs that support research and use of more cost-effective or efficient renewable energy systems. They commonly collect funds through either a small charge on customer utility bills or directly from utilities as a percentage of a utility's revenue. PBFs are an effective way to ensure that renewable energy systems are made feasible on a state level.

Job Training and Re-Training: Since Pennsylvania is a state heavily invested in coal and natural gas, the expansion of in-state solar generation poses a threat to the jobs of many PA residents working in the non-renewable energy sector. Exploring the development of a program that reskills existing energy workers to work in the solar industry could alleviate this threat.

Assess Economic Impact: Solar power has the potential to bring more jobs to PA and serve as a revenue source and economic catalyst. These would include use of local resources, such as consultants, engineering firms, land agents to manufacturing plants, construction staff, use of local restaurants and hotels. It would be useful to measure and forecast, measure, and track the potential economic benefits grid-scale solar could have on a regional and local level.

Analyze Impacts to Agriculture: Flat farmland is some of the most attractive land for grid-scale solar development in PA, but this development likely would remove the land's agricultural production for 25+ years. Determine if the conversion of farmland to solar arrays would damage either the short term or long-term regional food supply. Exploring incentives to promote solar on less productive agricultural land: researching crops that may be able to successfully grow under solar arrays, use of sheep or pollinators, as ways to minimize potential impacts to food production.

Determine Drivers that Affect Electricity Rates: Electricity rates can be influenced by a variety of factors. Understanding these factors is particularly important to solar, since solar installations generate income by selling their excess energy back to the grid.

Research Municipal Zoning Regulations: SW PA has hundreds of municipalities each having with their own local land use ordinances and zoning laws. Exploring the opportunity to create uniform solar-friendly policy across these municipalities would increase the feasibility of deploying solar in Pennsylvania.

Obtain Geospatial Data on Game Lands, Cemeteries, Golf Courses, Country Clubs, Greenfields: Collecting these datasets could further eliminate infeasible sites without having to use Google Earth to confirm how the land is currently being used.

Conduct Further Geospatial Analysis on Smaller Adjacent Parcels: In this study we analyzed parcels that had a minimum acreage of 100 acres. A deeper dive into smaller parcels that are adjacent to each other could result in more potential sites for solar development.