New Jersey Department of Environmental Protection
Solar Siting Analysis Update

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New Jersey Department of Environmental Protection
Bureau of Energy and Sustainability
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Solar Siting Analysis Update 2017

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Executive Summary

Solar photovoltaic (PV) systems are a major component in New Jersey's expanding renewable energy sector. Solar systems continue to play a key role in New Jersey meeting the Energy Master Plan (EMP) and Renewable Portfolio Standard (RPS) mandates. However, it is critical that solar projects are properly sited to protect open space, natural lands and ecosystems. The Solar Siting Analysis (2012) was developed with the purpose of providing the Department, local communities and potential solar developers with state-level guidance on siting solar PV projects using NJDEP's 2007 Land Use / Land Cover (LU/LC) data. This document is an update to that Solar Siting Analysis (2012) in that it utilizes NJDEP's 2012 LU/LC data and it identifies percentages of land placed into specific categories for siting solar PV systems. The information incorporated into this Solar Siting Analysis Update (2017) is timely as New Jersey recently surpassed a significant milestone by exceeding two gigawatts (GW) of installed solar PV energy capacity. New Jersey, despite its limited geographic footprint, is currently ranked 5th in the United States with regards to total installed solar PV capacity. On a per square mile basis, New Jersey is ranked 1st in the United States in total installed solar PV capacity.

This Solar Siting Analysis Update (2017) identifies areas in New Jersey where the Department encourages and discourages solar PV development by utilizing a Geographic Information System (GIS) mapping tool and the NJDEP's 2012 LU/LC data. Land was classified for solar PV as either "Preferred", "Not-Preferred" or "Indeterminate". Preferred lands are largely characterized as having existing impervious surfaces, typically associated with urban development, since siting solar PV at these locations would result in minimal if any additional ecosystem degradation; Not-Preferred lands were largely characterized as forests, wetlands, agricultural lands, and open space which the Department sets out to protect and preserve; and Indeterminate lands represent areas where additional information is necessary to determine whether the site is viable for siting solar PV.

The resulting GIS mapping application can be found within the Energy and Sustainability GIS Profile at http://www.nj.gov/dep/gis/geowebsplash.htm. At the state level, the analysis identified that 29% of New Jersey land is identified as Preferred for siting solar PV, dominated by existing residential and commercial areas. Furthermore, the analysis notes that 63% of New Jersey land was identified as Not-Preferred (i.e. forests, wetlands, and agriculture), while the remaining 8% of New Jersey land was identified as Indeterminate.

It is important to note that this Solar Siting Analysis Update (2017), and associated GIS mapping application, are meant to be utilized as screening tools to evaluate land for siting solar PV; they are not meant to indicate whether a proposed solar project would be allowed or not. Potential solar PV projects should be evaluated and assessed on a site by site basis. Lastly, this document will be updated periodically to account for land use changes over time as well as developments and breakthroughs in solar technology and solar markets.

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Introduction

The purpose of this analysis is to aid the New Jersey Department of Environmental Protection (NJDEP or the Department), local communities and potential solar developers in planning for solar installations by distinguishing between lands where the Department encourages solar development from those where the Department discourages solar development. While solar energy projects provide environmental benefits, environmental damage can occur if projects are not properly sited, more than negating their benefits. This analysis was performed to identify preferred development sites where solar projects are most environmentally desirable. This document is intended to be used as guidance and should not be used to automatically disqualify potential solar energy projects prior to proper review.

Section I. Context

What is Solar Power and Why Does it Matter Where it is Installed?

Solar power is obtained by capturing energy from the sun's rays using specially designed panels to convert that light into useable electricity. While solar energy is abundant, omnipresent, and "free", care must be taken to ensure that harnessing this source of power does not cause unintended consequences and ecosystem harm.

Solar installations, whether on rooftops or on the ground, and whether in urban or rural areas, must be economical. The financial firm Lazard conducted an analysis on the levelized cost of energy and found that, without accounting for the subsidies, solar energy is among the lowest cost for any power, second only to wind.[1] While the primary driver of decision-making in energy generation has been economics, other factors may also play a role. For example, forward looking states and localities are looking to improve their resilience in the face of potential natural and man-made hazards such as hurricanes and terrorist attacks by utilizing a diverse energy mix consisting of a wide variety of energy sources. Incorporating many unique sources of energy with varied strengths and weaknesses in resisting disruptions allows for a more robust energy system, and thus a more sustainable and potentially equitable economy.

From an environmental standpoint, siting energy generation facilities, whether large natural gas power plants, or smaller solar installations, can cause some environmental degradation if not planned for properly. This document provides guidance for siting decisions by classifying land use/land cover types that are either Preferred, Not-Preferred, or Indeterminate for siting solar installations based on the Department's mission and policies for protecting and preserving the environment. Full classification descriptions can be found in **Section V. Analytical Methodology**.

It is understood that no matter which category a site falls into, all solar energy projects share many of the same positive environmental benefits notwithstanding those criteria used to differentiate between installation locations. Thus, a comprehensive overview of common benefits shared by all solar projects is not included in this document (e.g., zero emission production during operation resulting in clean energy electric generation).

This analysis is general in nature and considers broad categories of potential sites for solar. It is not meant to be used as a specific determination regarding whether or not solar will be permitted on any given site. Many sites within New Jersey are constrained by physical access issues, geographic or topographic constraints, existing land use regulations and additional environmental constraints and this analysis is meant to generally guide solar development toward lands where projects would generate a dual benefit for the environment and the economy in New Jersey.[2] Solar projects located in regulated areas require appropriate permitting; however, guidance on what land characteristics are preferred for solar installations will help to identify potential solar sites that are desirable from an environmental protection perspective.

Section II. Solar Technologies

Solar energy generation can be obtained using various technologies that have the capability of converting solar radiation to useful power. These technologies are primarily grouped into two categories: solar thermal and photovoltaic.

Solar thermal technologies are comprised of three different methods for converting solar energy for use. The first method collects energy from the sun to heat water or air for direct use in solar home or hot water heating. The second method is used by large power utilities to indirectly create electricity through concentrated solar heat energy. The third method, known as passive solar, leverages energy efficiency and the design of a building to regulate the amount of solar energy it receives to regulate its temperature.[3] Of the available solar thermal technologies, the first one impacts land use more in the northeast than the others since it involves not just the design and orientation of the building but to a lesser extent, the siting of the building. The second method requires abundant solar resources and is limited to the southwestern United States and the third is generally considered to be less dependent on building site than on structure design itself.

Solar photovoltaic technology (solar PV) converts sunlight directly into electricity. Solar PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the photovoltaic effect or PV effect. The PV effect was discovered when scientists realized that silicon (an element found in sand) created an electric charge when exposed to sunlight. Solar cells were initially used to power space satellites and smaller items like calculators and watches but over time the technologies have been developed for wider usage.

The most basic building block of solar PV installation is a solar cell. Modern solar cells can be broadly categorized by generation. The first generation involves traditional solar cells, which are made from silicon, usually flat-plate, and generally are the most efficient. The second generation involves thin-film solar cells and are made from amorphous silicon or non-silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick, unlike traditional cells that are a few hundred micrometers thick. The third generation is made from a variety of new materials besides silicon, and include novel formulations including solar inks applied using conventional printing press technologies and solar dyes based on new molecular knowledge.

Solar panels used to power homes and businesses are made from solar cells that are combined into modules. A typical panel, made up of one or more modules, produces anywhere from 200W to 350W and are about 65 inches by 39 inches for residential panels and 77 inches by 39 inches for non-residential panels. Groups of panels are arranged into arrays with the energy output for any given solar array varying based on the type of panels and module system used, as well as the size, position and geographic location of the array. For example, as seen in **Figure 1: Photovoltaic Solar Resource Map of the United States**, much of California has a PV Resource Potential of >6 kWh/m^2/day whereas New Jersey's potential is around 4.5 kWh/m^2/day[4] resulting in a New Jersey system capacity factor of about 15%.[5]

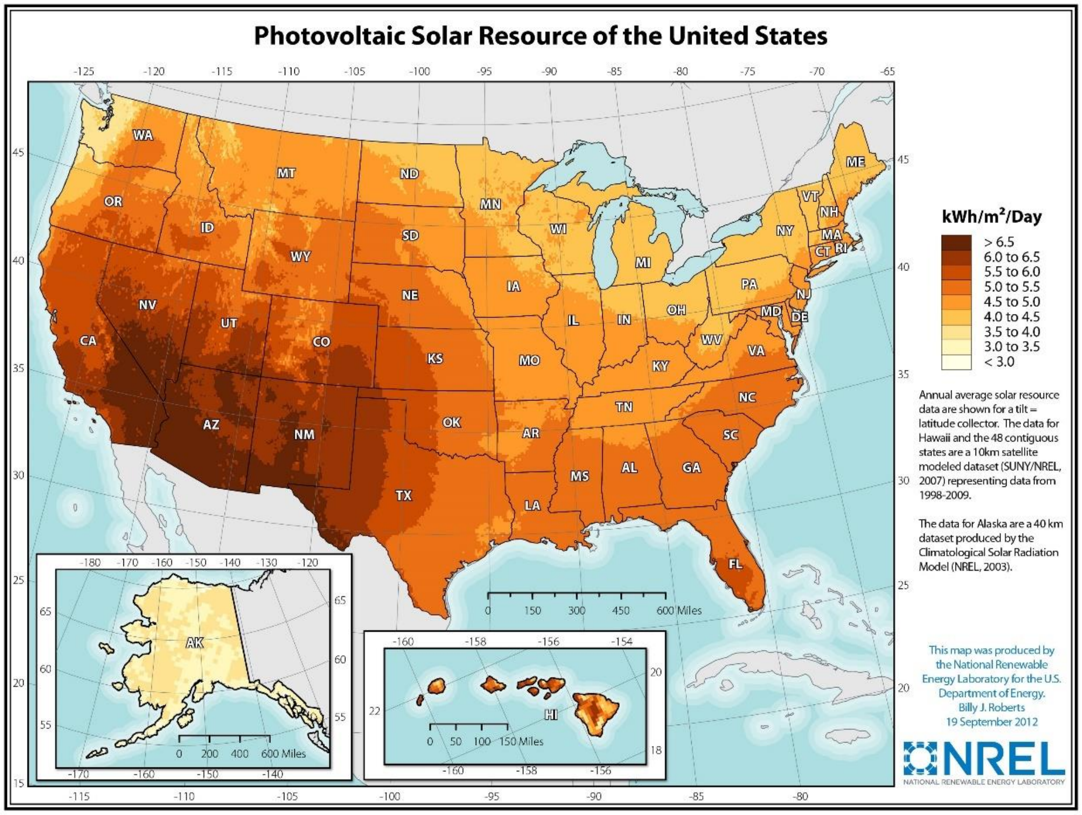


Figure 1: Photovoltaic Solar Resource of the United States[6]

The panels can either be mounted at a fixed angle facing south, or mounted on a tracking device that follows the sun, allowing them to capture more sunlight. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large-scale PV system.

The electricity generated from solar PV panels is direct current (DC), while the electricity delivered to homes and appliances from the electric grid uses alternating current (AC). Large scale and net metered[7] PV systems that are typically connected to the electric grid must have the electricity they generate converted to AC before it is delivered to the nearest AC electric interface. A DC to AC inverter is used to perform this conversion. PV systems that are grid connected can be used to promote distributed electric generation.

In the United States, most installed solar PV panels are silicon-based technology (first generation) and it is expected to be the dominant technology in the coming years.[8] Accordingly, this document assumes the typical solar panel will have the associated characteristics of silicon. The Department acknowledges that the PV market is growing and evolving rapidly with continuing technological breakthroughs in both materials and manufacturing. It is important, therefore, to continuously monitor the PV market in the context of technological changes that result in increased electricity market penetration and to make appropriate revisions to solar policy.

As the technology advances and costs continue to fall[9], solar technology will be used by more types of users in a wider range of environments. For example, floating solar arrays are now being installed around the world, including New Jersey. And while silicon-based technology is still the clear majority of solar installations, building-integrated PV such as solar roof shingles and prefabricated solar integrated building walls are approaching a price point where roof replacement or new installations with solar integrated building elements are being considered by homeowners and businesses.

Particularly in the wake of Hurricane Sandy, the state has become more active in encouraging and installing energy storage. As storage technology, such as lithium ion batteries and flow batteries become more advanced and cost effective, pairing solar PV with storage can provide backup power when the sun is not shining. Solar and storage combinations can be used to maintain power at New Jersey's critical facilities and support resiliency as well as allow additional solar capacity to be installed without the problems that result from high daytime solar power generation and low solar generation during cloudy and nighttime hours.

Section III. Environmental Impacts of Siting Solar PV Systems

The applications of solar PV offer a spectrum of developing opportunities from individual home owners utilizing their rooftops as a supplemental source of electric generation to large scale ground mounted solar arrays. This wide range of projects offers different degrees of land use environmental impacts. In this section, the common environmental impacts from the different applications are discussed. This discussion is not meant to be exhaustive but rather to identify the basis upon which the analysis has been developed.

Distributed Generation / Behind the Meter Solar PV Applications

In distributed generation applications, relatively small solar PV systems are mounted on residential and commercial rooftops.[10] A typical residential solar PV system is around 5kW, and produces 5,900 kWh of electricity per year. A typical commercial application is 25 kW and produces 29,500 kWh of electricity per year. As such, they generally do not directly involve any significant land disturbance because they are on existing impervious surfaces. There are, however, larger capacity projects installed on pervious lands which may have adverse environmental impacts.

For every location, there exists an optimized orientation in terms of array tilt and azimuth angle that maximizes a system's electrical output. Obstruction to this orientation caused by nearby buildings, trees, objects, or other structures will result in a non-optimized system. This might prompt owners or developers to remove or clear the obstruction whenever possible. The most common obstructing objects for residential roof installations are trees. Tree removal for the purposes of solar PV installation may result in degradation to the local ecosystem and reduce the overall net benefits achieved by the solar PV project; these conflicts are already being seen in some New Jersey municipalities.

Grid Supplied Solar PV Applications

Grid supplied arrays send the electricity generated directly into the grid; there is no on-site destination for the electricity. In New Jersey, grid supplied solar PV applications are typically ground-based arrays, or groups of panels greater than 1 MW. The main potential environmental impact[11] from grid supplied solar PV applications is the loss of land consumed or covered by solar PV arrays / panels and support structures (e.g. inverters). Land consumed or lost to solar PV systems may affect local ecosystems and the benefits provided therein.

Relatively undisturbed lands such as natural forests, landscapes with mixed patterns of human use, and even ecosystems intensively managed/modified by humans such as agricultural land and urban areas provide a myriad of benefits or "ecosystem services" to humans. In general, the wide range of ecosystem services can be classified into four categories: *provisioning services* such as food, water, timber, and fiber; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling.[12] Examples of potential ecosystem services impacts from solar PV systems include: reduced vegetative cover, compaction of soil, reduced infiltration, increased runoff, decreased soil activity, decreased soil organic matter, and impaired water and air quality. Minimizing the negative environmental impacts associated with ecosystem service degradation is a priority of the Department. In the context of maximizing the benefit from solar energy projects, the single most important factor in achieving this goal is simply choosing an environmentally-desirable site.

Section IV. Solar in New Jersey

Current State of Solar in New Jersey

At the end of the year in 2016, New Jersey passed a milestone by exceeding two gigawatts (GW) of installed solar energy capacity from approximately 66,000 solar projects. [13]

Table 1: Installed Solar PV Capacity[4]/Solar PV Capacity per Square Mile[14]

State	Total Installed Solar PV Capacity (MW)	Rank
CA	20,163	1
NC	3,784	2
AZ	3,335	3
NV	2,521	4
NJ	2,233	5
MA	1,898	6
TX	1,846	7
UT	1,565	8
GA	1,560	9
NY	1,175	10

State	Total Square Miles	Rank
TX	261,232	1
CA	155,779	2
AZ	113,594	3
NV	109,781	4
UT	82,170	5
GA	57,513	6
NC	48,618	7
NY	47,126	8
MA	7,800	9
NJ	7,354	10

State	Solar PV Capacity (MW) per Square Mile	Rank
NJ	0.3036	1
MA	0.2433	2
CA	0.1294	3
NC	0.0778	4
AZ	0.0294	5
GA	0.0271	6
NY	0.0249	7
NV	0.0230	8
UT	0.0190	9
TX	0.0071	10

New Jersey is presently ranked 5th in the United States, behind California, North Carolina, Arizona and Nevada for total installed solar PV capacity.[15] As seen in **Table 1: Installed Solar PV Capacity / Solar PV Capacity per Square Mile,** New Jersey is ranked 1st on a total installed solar PV capacity per square mile basis; demonstrating New Jersey's commitment to solar energy despite the state's limited geographic footprint.

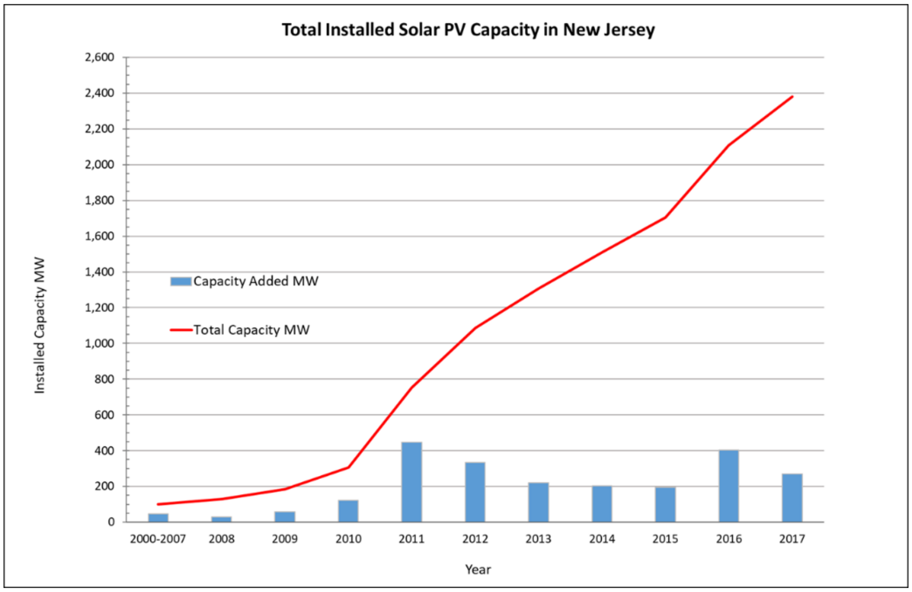


Figure 2. Total Installed Solar PV Capacity in New Jersey[16]

Figure 2. New Jersey Total Installed Solar PV Capacity summarizes the yearly capacity added and cumulative installed capacity, in megawatts (MW) for the years 2001 through most of 2017. Between 2001 and 2011 there were over 14,000 solar projects, representing about 700 MW, installed in New Jersey. In 2012 alone, over 333 MW were installed, followed by 220 MW in 2013, bringing the total installed solar PV capacity in New Jersey to over one GW. Three years later (December 2016) New Jersey reached over two GW and remains the number one state for amount of solar capacity per square mile.

Table 2. Breakdown of Total Solar Installations by Sector[17]

Behind the Meter Residential (Kw)			**Behind the Meter Non-Residential (Kw)**			**Grid Supply (Kw)**			**Total of All Projects (Kw)**	
# Projects	Capacity	% of Total Installed Capacity	# Projects	Capacity	% of Total Installed Capacity	# Projects	Capacity	% of Total Installed Capacity	**# Projects**	**Total Capacity**
79,043	648,594	27.88%	5,561	1,133,918	48.74%	160	544,162	23.39%	**84,764**	**2,326,674**

In **Table 2: Breakdown of Total Solar Installations by Sector**, one can see the distribution of projects by type and totaled in kilowatts.

To date 2,326,674 kW of solar PV capacity installed in New Jersey is made up of 84,764 individual project installations. The majority of these installations are from the residential sector, 79,043 in total, which is 27.88% (648,594kW) of the total capacity. In contrast, only 160 grid supplied project installations make up 23.39% (544,162 kW) of the total capacity. This is because the average residential rooftop installation of 0.5 MW is much smaller in capacity and size compared to a grid supplied installation. The grid supplied installations in New Jersey range from 2 MW to 20 MW and because they are larger scale and ground mounted they require significantly more land area. The remaining 48.74% (1,133,918kW) of solar PV capacity is from 5,561 non-residential installations; i.e. commercial, school, and government installations which can be either rooftop or ground mounted. These installations can vary greatly in size depending on the sites operation. For example, a firehouse would have a much smaller load and therefore install a smaller array compared to a large commercial warehouse.

Rules and Policy

New Jersey's Energy Master Plan (EMP) was released in December 2011 by the Board of Public Utilities (BPU or Board).[18] The EMP outlines the State's strategic vision for the use, management, and development of energy in New Jersey over the next decade and further serves as a guide to the present and future energy needs of the State. Specific to solar, the 2011 EMP established a goal that solar projects which offer both economic and environmental "dual benefits" should take priority and not adversely affect the preservation of open space and farmland. The 2015 EMP update, which assessed the status of goals set in the 2011 EMP, concluded that the Solar Act of 2012 supported the goal to promote certain solar projects on underutilized lands in the State.[19]

The Solar Act, signed into law by Governor Chris Christie on July 23, 2012, mandated a solar carve out in New Jersey's Renewable Portfolio Standard (RPS) that 4.1 percent of electric sales must come from solar power by 2028. Electricity suppliers in New Jersey must meet solar RPS requirements through the purchase of Solar Renewable Energy Certificates (SRECs) or they must pay a Solar Alternative Compliance Payment (SACP). A SREC represents the clean energy benefits of electricity generated from a solar electric system with, one SREC issued for each 1,000 kilowatt-hours (kWh) generated.[20] SRECs are then sold or traded, separately from the sale of power, providing solar PV system owners with another source of revenue to help offset the cost of installation.

Subsections q, r, s and t of the Solar Act directed the BPU to implement procedures to approve certain grid supplied projects eligible to receive SRECs:

> **Subsection q** projects were approved during Energy Years 2014, 2015, 2016. Applications opened at the beginning of each energy year and there was a cap of 80 MW per year. The criteria required that projects must be grid supplied, under 10 MW, and the project must commence commercial operation within two years of the date of designation set by the BPU Board.
>
> **Subsection r** is for projects following Energy Year 2016. Projects under Subsection r are eligible if they are grid supplied, not on farmland and if the Board determines that (a) the SRECs forecasted to be produced by the facility do not have a detrimental impact on the SREC market or on the appropriate development of solar power in the State; (b) the approval of the designation of the proposed facility would not significantly impact the preservation of open space in this State; (c) the impact of the designation on electric rates and economic development is beneficial; and (d) there will be no impingement on the ability of an electric public utility to maintain its property and equipment in such a condition as to enable it to provide safe, adequate, and proper service to each of its customers. Commercial operation must commence within two years of the date of designation set by the Board.
>
> **Subsection s** projects were approved by the BPU Board for grid supplied projects located on land that has been actively devoted to agricultural or horticultural use that is valued, assessed, and taxed pursuant to the Farmland Assessment Act of 1964 which the Board has approved the facility's designation pursuant to subsection q.[21]
>
> **Subsection t** is an ongoing application process where projects must be grid supplied and certified as being located on "a properly closed sanitary landfill", a "brownfield" or an area of "historic fill" as defined in the Solar Act.
>
> - "Properly closed sanitary landfill" - a sanitary landfill facility, or a portion of a sanitary landfill facility, for which performance is complete with respect to all activities associated with the design, installation, purchase, or construction of all measures, structures, or equipment required by the Department of Environmental Protection, pursuant to law, in order to prevent, minimize, or monitor pollution or health hazards resulting from a sanitary landfill facility subsequent to the termination of operations at any portion thereof, including but not necessarily

limited to, the placement of earthen or vegetative cover, and the installation of methane gas vents or monitors and leachate monitoring wells or collection systems at the site of any sanitary landfill facility.

- "Brownfield" - Any former or current commercial or industrial site that is currently vacant or underutilized and on which there has been, or there is suspected to have been, a discharge of a contaminant.

- "Historic fill" - means generally large volumes of non-indigenous material, no matter what date they were emplaced on the site, used to raise the topographic elevation of a site, which were contaminated prior to emplacement and are in no way connected with the operations at the location of emplacement and which include, but are not limited to, construction debris, dredge spoils, incinerator residue, demolition debris, fly ash, and non-hazardous solid waste. "Historic fill" shall not include any material which is substantially chromate chemical production waste or any other chemical production waste or waste from processing of metal or mineral ores, residues, slags, or tailings.

For more detailed and specific information regarding solar installations on closed landfills and the NJDEP permitting required please see the "Guidance for Installation of Solar Renewable Energy Systems on Landfills in New Jersey" manual, updated January 8, 2013 and published by the Solid Waste Program, NJDEP, found at http://www.nj.gov/dep/dshw/swp/solarguidance.pdf.

There are a number of resources to assist in locating brownfields in NJ, including the NJDEP Known Contaminated Site List (http://www.nj.gov/dep/srp/kcsnj/) and the Brownfield Development Areas program within the Office of Brownfield Reuse (http://www.nj.gov/dep/srp/brownfields/).

Before installing any solar project, NJDEP recommends scheduling a Permit Coordination Meeting with the office of Permit Coordination and Environmental Review at NJDEP to obtain any permits required for the project - http://www.nj.gov/dep/pcer/ . See **Appendix A** for additional solar related legislation

The total installed solar PV capacity needed to fulfill the solar RPS target would be approximately 3,423 MW[22] which is estimated to be 4,038 gigawatt-hours (GWh) of solar power.[23] At the end of 2016 New Jersey had installed 2,002 MW. To reach the goal of 3,423 MW by 2028, New Jersey would have to install approximately 130 MW of solar capacity each year. Assuming the current trends in solar installations persist and the solar RPS goal of 4.1% is met, a significant amount of New Jersey's land could be covered in photovoltaic (PV) panels. To put this in perspective, solar PV panel efficiencies range from 15% to 19%. With a standard 15% efficient panel to meet the RPS goal an estimated 16.4 square miles or 10,519 acres could be covered in solar PV panels without appropriate siting criteria.[24] Therefore, it is important to consider the potential impact on land-based resources devoted to solar energy within the state.

Behind the meter projects governed by New Jersey's net-metering standards have helped customers maximize their renewable energy investments. Net-metering enables customers to obtain full retail credits on their utility bill for each kilowatt-hour (kWh) of electricity their solar PV system produces over the course of a year.[25]

Federal Solar Investment Tax Credit (ITC) can be received by eligible solar projects in New Jersey and were extended at the end of 2015. The ITC is a 30% federal tax credit claimed against the tax liability of residential (Section 25D) and commercial and utility (Section 48) investors in solar energy property. The ITC remains at 30% until 2019. It then steps down to 26% in 2020 and 22% in 2021. After 2021, the residential credit will drop to zero while the commercial and utility credit will drop to a permanent 10%.[26]

Section V. Analytical Methodology

The term "land use" describes what people do with the land, while "land cover" describes what is on top of the land. While land uses include agriculture, business, housing, and recreation, land cover could include forests, crops, water, buildings and structures. Land cover alone is generally a good indicator of land use, but the use of a hybrid system accounting for both factors insures that land analyses are more robust.

This Solar Siting Analysis Update (2017) is based on the NJDEP's 2012 Land Use / Land Cover (LU/LC), released in February 2015, which utilizes Anderson Land Use Land Cover (LU/LC) classification system to organize its geographic information and database system. The LU/LC classification system allows those who study land-based phenomenon from many perspectives—geological, environmental, man-made features—to perform analyses using a common mapping language, and enables them to share and compare results with others using the same system. The Anderson LU/LC classification system was first codified in a 1976 paper by USGS scientist James R. Anderson[27] (and others) and is now widely used by organizations worldwide performing land analysis, including the NJDEP.

The foundation of the Solar Siting Analyses (2012 and 2017 Update) was developed by first categorizing each Anderson Code to indicate the Department's preference for siting solar PV on each type of land use / land cover. Anderson Codes were categorized as "Preferred", "Not-Preferred", or "Indeterminate" for siting solar PV. The complete list of Anderson Codes, as well as their categorized designations can be found in **Appendix B**. Brief descriptions of the land types associated with each designation and why they were designated the way they were can be found in the box below.

Solar Siting Category Descriptions

- **Preferred Lands**
  - Characterized by existing impervious surfaces common in urban development. These areas are most desirable for siting solar because they do not introduce any additional direct land disturbance that may affect ecosystem services.
  - *Anderson Code Classification Examples*: Residential (1100), Commercial/Services (1200), Industrial (1300), Transportation, Communication, Utilities (1400), Altered Lands—such as landfills and brownfields (7400), etc.
- **Not-Preferred Lands**
  - Characterized as natural lands that the Department sets out to protect and preserve.
  - *Anderson Code Classification Examples:* Agricultural/cropland (2100), Forests (4000), Wetlands (6000), etc.
- **Indeterminate Lands**
  - Neither Preferred or Not-Preferred; Additional information is necessary to assess the viability of siting solar in these areas
  - *Anderson Code Classification Examples:* Cemeteries (1710), Athletic Fields (1804), Stadiums, Theatres, Cultural Centers and Zoos (1810), various Rights-of-Way (1461-1463), Natural and Artificial Lakes//Reservoirs (5200, 5300), etc.

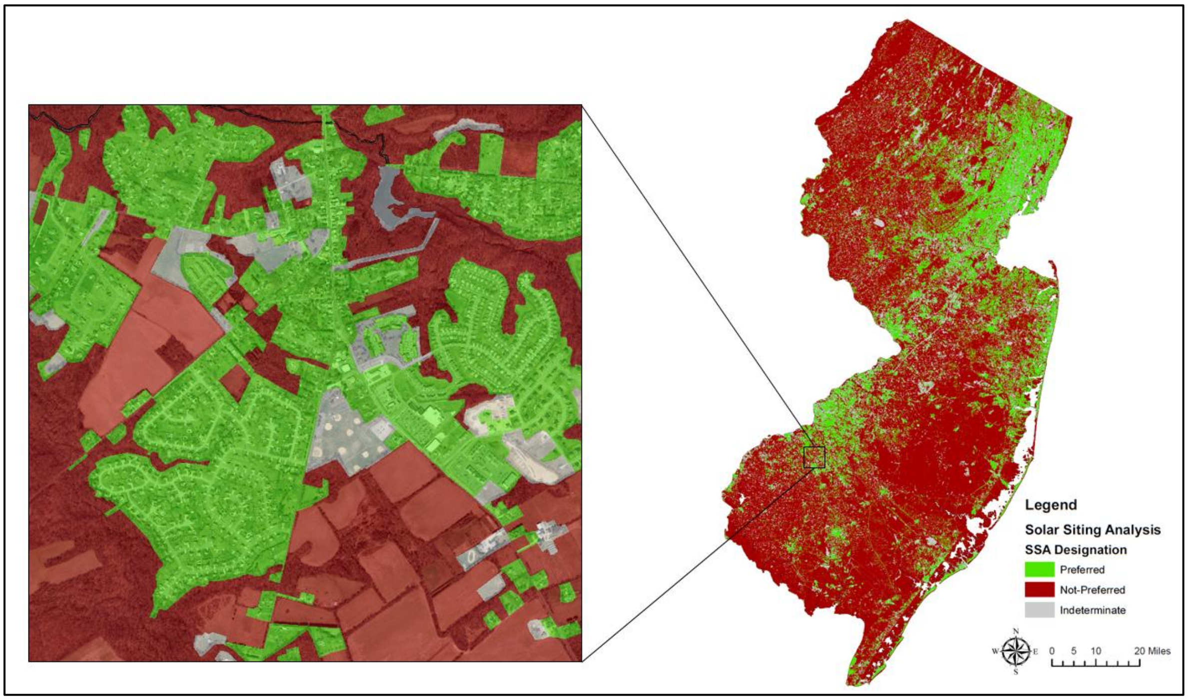
Upon assigning one of the three solar siting categories to each of the 87 Anderson Codes it became apparent that not all land use types were feasible locations for siting solar. Therefore, to improve the analysis and more accurately identify and quantify the viable lands in the state for siting solar, the Anderson Codes below (primarily associated with tidally influenced water bodies) were excluded from the analysis:

- 5100—Streams & Canals
- 5190—Exposed Flats
- 5410—Tidal Rivers, Inland Bays and Other Tidal Waters
- 5411—Open Tidal Bays
- 5412—Tidal Mud Flats
- 5420—Dredged Lagoon, Artificial
- 5430—Atlantic Ocean

It is important to note that the solar siting categories are meant to be utilized as a tool and are not meant to indicate whether a solar project proposed on a particular site would be permitted or not.

After each Anderson Code was assigned a solar siting category, the data table (CSV format) was imported into ArcMap where it was joined to the NJDEP's 2012 Land Use Land Cover data layer based on the Anderson Code attribute (LU12). For the mapping component of the analysis, symbology was assigned to differentiate between each of the categories, displaying Preferred lands as green, Not-Preferred lands as red, and Indeterminate lands as gray (see **Figure 4. Solar Siting Analysis Update (2017) Map Sample** below).

Figure 4. Solar Siting Analysis Update (2017) Map Sample



Subsequently, additional attributes were added to the table, including the Acreage and Square Mileage for each polygon, which were calculated using the "Calculate Geometry" tool in ArcMap. Using the "Summarize" tool, several new data tables were generated to calculate the total acreage/square mileage for each solar siting category, as well as a breakdown of each of the categories by land use type. These tables can be found in the **Section VI. Results & Discussion** section of the report.

Section VI. Results & Discussion

The geospatial analysis of New Jersey based on the process outlined in the **Analytical Methodology** Section identified the following:

Solar Siting Designation	Acreage	Sq. Mi	% Total
Preferred	1,355,375.11	2,117.77	29%
Not-Preferred	3,000,569.36	4,688.39	63%
Indeterminate	398,262.04	622.28	8%
TOTAL	**4,754,206.51**	**7,428.44**	**100%**

This analysis found that Preferred lands accounted for 29% of the total viable land area in the state, while Not-Preferred lands and Indeterminate lands made up the remainder of the state, at 63% and 8%, respectively.

Preferred Lands			
LU Type	**Acreage**	**Sq. Mi**	**% Preferred**
Urban	1,326,053.45	2,071.92	98%
Barren Land	28,913.48	45.18	2%
Water	426.18	0.67	0%
TOTAL	**1,355,375.11**	**2,117.77**	**100%**

When looking more closely at the Preferred lands derived from the Solar Siting Analysis Update (2017), the clear majority (98%) of the Anderson Codes were related to Urban lands. To break that out further, roughly 75% of the Preferred area was attributed to Anderson Codes related to Residential development (1110, 1120, 1130, 1140, and 1150). The next highest was Commercial/Services (1200) with 11%, followed by Industrial (1300) with 5%.

Not-Preferred Lands			
LU Type	**Acreage**	**Sq. Mi**	**% Not-Preferred**
Forest	1,526,711.14	2,385.49	51%
Wetlands	972,303.22	1,519.22	32%
Agriculture	497,670.92	777.61	17%
Barren Land	3,884.08	6.07	0%
TOTAL	**3,000,569.36**	**4,688.39**	**100%**

The Not-Preferred lands were dominated by Anderson Codes associated with Forests, at 51% of the total Not-Preferred acreage. The next highest Anderson Land Use/Land Cover Type was Wetlands at 32%, followed by Agriculture at 17%.

Indeterminate Lands			
LU Type	**Acreage**	**Sq. Mi**	**% Indeterminate**
Urban	232,230.74	362.86	58%
Water	81,623.94	127.54	20%
Agriculture	48,148.92	75.23	12%
Wetlands	20,313.58	31.74	5%
Barren Land	15,162.72	23.69	4%
Forest	782.14	1.22	0%
TOTAL	**398,262.04**	**622.28**	**100%**

The Anderson Codes and Land Use Types of the Indeterminate lands varied, but some trends emerged. More than half of these lands (58%) were attributed to urban lands, varying from rights-of-way to athletic fields and lands associated with other recreational activities. Furthermore, Natural Lakes (5200) and Artificial Lakes (5300) paired to make up 20% of the Indeterminate areas. The Anderson Codes associated with Agriculture in this category were 2300 (Confined Feeding Operations) and 2400 (Other Agriculture), totaling more than 48,000 acres. These were classified as Indeterminate due to the high variance between properties classified with these Anderson Codes, and therefore more information on a site-by-site basis would be needed to determine the true preference.

The full breakdown of acreage/square mileage for each Anderson Code can be found in **Appendix C** of this document.

The results of the Solar Siting Analysis Update (2017) concluded that, based solely on the Anderson Codes for Land Use Land Cover, 29% of the State is deemed to be Preferred lands. Furthermore, most the State (63%) is deemed Not-Preferred, while the remaining 8% is deemed Indeterminate.

The analysis also affirmed that the state has more than enough land area to fulfill its RPS obligations; on page 11 of **Section IV. Solar in New Jersey**, this report states "…to meet the RPS goal an estimated 16.4 square miles or 10,519 acres could be covered in solar PV panels....". With 4,754,206.51 acres or 7,428.44 square miles total, and 1,355,375.11 acres or 2,117.75 square miles of Preferred lands, the current RPS goal of 4.1% requires under a quarter percent of New Jersey's total land area (0.22%) and under one percent (0.77%) of New Jersey's Preferred area to fulfill that requirement.

Even a 100% solar objective for the state's electrical consumption of 74,199,076 megawatt hours[28] requires only 302 square miles or 4.1% of all New Jersey's land area or 14.3% of New Jersey's Preferred land area, well within this analyses' total Preferred area calculation of 29%.

Finally, our analysis led us to the realization that, as seen on **Table 1: Installed Solar PV Capacity / Solar PV Capacity per Square Mile** in **Section IV. Solar in New Jersey** of this report, installed solar PV capacity is 0.3036 megawatts per square mile, 25% more than the next densest state (Massachusetts) in terms of installed solar capacity.

It is important to reiterate that this analysis is meant to be used as one of many tools to consider when siting solar PV installations. It should not be used exclusively to approve or deny projects based on the historic and current land use in the proposed location.

Section VII. Potential Future Analyses

The next iteration of the LU/LC is currently projected to be completed in 2020 and released in 2022. The Bureau of Energy and Sustainability plans to complete another update to the Solar Siting Analysis at that time, which will capture land use changes between 2012 and 2020.

The analysis described in this document provides a solid foundation on which to make general site suitability determinations for solar PV installations. Future updates to this analysis should be ready to adapt to the changing viability of solar systems at particular locations based on many conditions.

For example, the Solar Siting designation for Natural Lakes (5200) and Artificial Lakes (5300) is currently Indeterminate for siting solar. However, siting solar systems in water bodies on top of floating pontoon systems is becoming more common. As this technology becomes more mature, economically feasible, and the potential environmental impacts are studied, it may be practical to change these Solar Siting designations to Preferred areas. Doing so may result in significant changes to the percentages of each solar siting category.

Future analyses might include:

- Identification of additional Preferred sites based on newly developed technologies allowing for solar to be placed on previously Not-Preferred, Indeterminate or non-viable sites such as on artificial lakes
- Additional ranking categories beyond the existing Preferred, Not-preferred and Indeterminate ones where additional site benefits or disadvantages exist e.g. identification of critical infrastructure which could benefit from the improved resilience of solar plus storage during power losses
- Improving existing data quality and analysis to more precisely identify types of sites already identified e.g. pinpointing brownfields not otherwise accounted for in the Anderson Land Use Land Cover using additional datasets
- Recognition of additional environmental restrictions e.g. adding types of sites already regulated by DEP
- Recognition of environmental changes, many stemming from sea level and climate changes and their associated hazards e.g. flood hazard areas
- Further grouping of sites by political, environmental or other subdivision (municipal, county, watershed)
- Focusing in on new potentially Preferred sites through the analysis of existing sites where solar PV has been successfully installed
- Analytical adjustments based on regulatory or policy changes
- Application of additional mapping and modeling methods to better target Preferred sites and identify site specific traits useful or detrimental to sitting solar PV e.g. shallow or steep slopes

Appendix A - Solar Related Legislation and Policy Documents

- Public Law (P.L.) 2008, chapter (c) 90 – This law exempts renewable energy systems from real property taxation.
- P.L. 2009, c. 33 – The legislation requires residential developers to install or offer to install solar on new developments.
- P.L. 2009, c. 146 (enacted 11/20/2009) – This law amends the Municipal Land Use Law, specifically by expanding the definition of Inherently Beneficial Use to include a wind, solar or photovoltaic energy facility or structure. The statute now provides, "Inherently beneficial use" means a use which is universally considered of value to the community because it fundamentally serves the public good and promotes the general welfare. Such a use includes, but is not limited to, a hospital, school, child care center, group home, or a wind, solar or photovoltaic energy facility or structure.
- P.L. 2009, c. 213 (enacted 01/16/2010) – Among other things, this law amends the Right to Farm Act to specify that energy generated from solar, wind or biomass projects is a permissible activity. This law also requires that any person who owns preserved farmland may construct, install, and operate biomass, solar, or wind energy generation facilities, structures, and equipment on the farm, … "…for the purpose of generating power or heat, and may make improvements to any agricultural, horticultural, residential, or other building or structure on the land for that purpose" will now qualify for the preferential tax treatment provided under the Farmland Assessment Act.[29]
- P.L. 2009, c. 289 (enacted 01/17/2010) – This law extends the solar Renewable Portfolio Standard (RPS) to 2026 and sets the annual requirements for solar capacity.
- P.L. 2009, c. 302 (enacted 01/17/2010) – This law establishes grants for redevelopment of brownfields for renewable energy.
- P.L. 2010, c. 4 (enacted 04/22/2010) – This law specifies that NJDEP shall not include solar panels in any calculation of impervious surfaces or impervious cover for state regulatory programs or in review of subdivisions or site plans; also limits fees for certain renewable energy installations.
- New Jersey Statutes (N.J. Stat.) § 46:3-24 *et. seq.* "Solar Easement Act" – This law provides that any easement obtained for the purpose of exposure of a solar energy device shall be created in writing and shall be subject to the same conveyance and instrument recording requirements as other easements.
- P.L.2012, c. 24 (enacted 07/23/2011) – Amends P.L.1999, c.23 to change the Solar RPS Requirements.
- Public Utilities N.J.S.A. 48:3-51 – The Solar Act amended certain aspects of the statute governing generation, interconnection, and financing of renewable energy and stabilized the solar sector to allow for continued growth.
- N.J.A.C. 14:8-7 – Rules for net metering and interconnection of Class I renewable energy facilities in New Jersey.
- New Jersey Energy Master Plan 2015 Update - The 2015 EMP update which assessed the statuses of the goals set in the 2011 EMP concluded that the Solar Act of 2012 supported the goal to promote certain solar projects on underutilized lands in the State.

Appendix B - Land Use Land Cover Anderson Codes (2012)

Anderson Code	Description	Category
1110	Residential (High Density or Multiple Dwelling)	Preferred
1120	Residential (Single Unit, Medium Density)	Preferred
1130	Residential (Single Unit, Low Density)	Preferred
1140	Residential (Rural, Single Unit)	Preferred
1150	Mixed Residential	Preferred
1200	Commercial & Services	Preferred
1211	Military Installations	Preferred
1214	Former Military; Indeterminate Use	Preferred
1300	Industrial	Preferred
1400	Transportation, Communication & Utilities	Preferred
1410	Major Roadway	Preferred
1411	Mixed Transportation Corridor Overlap Areas	Preferred
1419	Bridge Over Water	Preferred
1420	Railroad Facilities	Preferred
1440	Airport Facilities	Preferred
1461	Wetland Rights-of-Way	Indeterminate
1462	Upland Rights-of-Way, Developed	Indeterminate
1463	Upland Rights-of-Way, Undeveloped	Indeterminate
1499	Stormwater Basin	Preferred
1500	Industrial & Commercial Complexes	Preferred
1600	Mixed Urban or Built-Up	Preferred
1700	Other Urban or Built-Up	Indeterminate
1710	Cemetery	Indeterminate
1711	Cemetery on Wetland	Indeterminate
1741	Phragmites Dominate Urban Area	Indeterminate
1750	Managed Wetland in Maintained Greenspace	Indeterminate
1800	Recreational Land	Indeterminate
1804	Athletic Fields (Schools)	Indeterminate
1810	Stadium, Theatres, Cultural Centers, and Zoos	Indeterminate
1850	Managed Wetland in Built-Up Maintained Recreation Area	Indeterminate
2100	Cropland and Pastureland	Not-Preferred
2140	Agricultural Wetlands	Not-Preferred
2150	Former Agricultural Wetlands (Becoming Shrubby, not Built-Up)	Not-Preferred
2200	Orchards, Vineyards, Nurseries and Horticultural Areas	Not-Preferred
2300	Confined Feeding Operations	Indeterminate
2400	Other Agriculture	Indeterminate
4110	Deciduous Forest (10-50% Crown Closure)	Not-Preferred
4120	Deciduous Forest (>50% Crown Closure)	Not-Preferred
4210	Coniferous Forest (10-50% Crown Closure)	Not-Preferred
4220	Coniferous Forest (>50% Crown Closure)	Not-Preferred
4230	Plantation	Not-Preferred
4311	Mixed Forest (>50% Coniferous, 10-50% Crown Closure)	Not-Preferred
4312	Mixed Forest (>50% Coniferous, >50% Crown Closure)	Not-Preferred
4321	Mixed Forest (>50% Deciduous, 10-50% Crown Closure)	Not-Preferred
4322	Mixed Forest (>50% Deciduous, >50% Crown Closure)	Not-Preferred
4410	Old Field (<25% Brush Covered)	Not-Preferred
4411	Phragmites Dominate Old Field	Not-Preferred
4420	Deciduous Brush/Shrubland	Not-Preferred
4430	Coniferous Brush/Shrubland	Not-Preferred
4440	Mixed Deciduous/Coniferous Bruch/Shrubland	Not-Preferred
4500	Severe Burned Upland Vegetation	Indeterminate
5200	Natural Lakes	Indeterminate
5300	Artificial Lakes & Reservoirs	Indeterminate
6111	Saline Marshes (Low Vegetation)	Not-Preferred
6112	Saline Marshes (High Vegetation)	Not-Preferred
6120	Freshwater Tidal Marshes	Not-Preferred
6130	Vegetated Dune Communities	Not-Preferred
6141	Phragmites Dominate Coastal Wetlands	Not-Preferred
6210	Deciduous Wooded Wetlands	Not-Preferred
6220	Coniferous Wooded Wetlands	Not-Preferred
6221	Atlantic White-Cedar Wetlands	Not-Preferred
6231	Deciduous Brush and Bog Wetlands	Not-Preferred
6232	Coniferous Brush and Bog Wetlands	Not-Preferred
6233	Mixed Brush and Bog Wetlands (Deciduous Dominant)	Not-Preferred
6234	Mixed Brush and Bog Wetlands (Coniferous Dominant)	Not-Preferred
6240	Non-Tidal Marshes	Not-Preferred
6241	Phragmites Dominate Interior Wetlands	Not-Preferred
6251	Mixed Wooded Wetlands (Deciduous Dominant)	Not-Preferred
6252	Mixed Wooded Wetlands (Coniferous Dominant)	Not-Preferred
6290	Unvegetated Flats	Not-Preferred
6500	Severe Burned Wetlands	Indeterminate
7100	Beaches	Not-Preferred
7200	Bare Exposed Rock, Rock Slides, Etc.	Preferred
7300	Extractive Mining	Preferred
7400	Altered Lands	Preferred
7430	Disturbed Wetlands	Indeterminate
7440	Disturbed Tidal Wetlands	Not-Preferred
7500	Transitional Areas	Indeterminate
7600	Undifferentiated Barren Land	Preferred
8000	Managed Wetlands	Not-Preferred

Note: The following designations of lands as Preferred, Not-Preferred, or Indeterminate are meant to be utilized as a tool to generally and preliminarily assess sites for their alignment with this Solar Siting Analysis. This tool should not be used to categorically approve or deny projects. Ultimately, all solar projects will be assessed on a case by case basis based on a variety of factors.

Appendix C - Analysis Results for Each Anderson Code

LU Code	Description	LU Type	Acreage	Sq. Mi	SSA Designation
1110	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	URBAN	141,094.60	220.46	Preferred
1120	RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	URBAN	378,274.05	591.05	Preferred
1130	RESIDENTIAL, SINGLE UNIT, LOW DENSITY	URBAN	191,386.25	299.04	Preferred
1140	RESIDENTIAL, RURAL, SINGLE UNIT	URBAN	301,730.92	471.45	Preferred
1150	MIXED RESIDENTIAL	URBAN	713.07	1.11	Preferred
1200	COMMERCIAL/SERVICES	URBAN	142,741.79	223.03	Preferred
1211	MILITARY INSTALLATIONS	URBAN	8,553.17	13.36	Preferred
1214	NO LONGER MILITARY	URBAN	651.42	1.02	Preferred
1300	INDUSTRIAL	URBAN	65,842.89	102.88	Preferred
1400	TRANSPORTATION/COMMUNICATION/UTILITIES	URBAN	29,850.37	46.64	Preferred
1410	MAJOR ROADWAY	URBAN	30,855.97	48.21	Preferred
1411	MIXED TRANSPORTATION CORRIDOR OVERLAP AREA	URBAN	79.67	0.12	Preferred
1419	BRIDGE OVER WATER	WATER	426.18	0.67	Preferred
1420	RAILROADS	URBAN	10,445.69	16.32	Preferred
1440	AIRPORT FACILITIES	URBAN	4,801.08	7.50	Preferred
1461	WETLAND RIGHTS-OF-WAY	WETLANDS	6,414.28	10.02	Indeterminate
1462	UPLAND RIGHTS-OF-WAY DEVELOPED	URBAN	2,451.53	3.83	Indeterminate
1463	UPLAND RIGHTS-OF-WAY UNDEVELOPED	URBAN	16,492.72	25.77	Indeterminate
1499	STORMWATER BASIN	URBAN	15,209.20	23.76	Preferred
1500	INDUSTRIAL AND COMMERCIAL COMPLEXES	URBAN	1,086.20	1.70	Preferred
1600	MIXED URBAN OR BUILT-UP LAND	URBAN	2,719.13	4.25	Preferred
1700	OTHER URBAN OR BUILT-UP LAND	URBAN	97,811.19	152.83	Indeterminate
1710	CEMETERY	URBAN	11,148.35	17.42	Indeterminate
1711	CEMETERY ON WETLAND	WETLANDS	138.60	0.22	Indeterminate
1741	PHRAGMITES DOMINATE URBAN AREA	WETLANDS	112.69	0.18	Indeterminate
1750	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	WETLANDS	3,640.96	5.69	Indeterminate
1800	RECREATIONAL LAND	URBAN	84,942.73	132.72	Indeterminate
1804	ATHLETIC FIELDS (SCHOOLS)	URBAN	16,560.04	25.88	Indeterminate
1810	STADIUM, THEATERS, CULTURAL CENTERS AND ZOOS	URBAN	2,824.19	4.41	Indeterminate
1850	MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA	WETLANDS	4,503.27	7.04	Indeterminate
2100	CROPLAND AND PASTURELAND	AGRICULTURE	436,778.28	682.47	Not-Preferred
2140	AGRICULTURAL WETLANDS (MODIFIED)	WETLANDS	69,450.14	108.52	Not-Preferred
2150	FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	WETLANDS	2,975.70	4.65	Not-Preferred
2200	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	AGRICULTURE	60,892.64	95.14	Not-Preferred
2300	CONFINED FEEDING OPERATIONS	AGRICULTURE	824.13	1.29	Indeterminate
2400	OTHER AGRICULTURE	AGRICULTURE	47,324.78	73.94	Indeterminate
4110	DECIDUOUS FOREST (10-50% CROWN CLOSURE)	FOREST	73,504.13	114.85	Not-Preferred
4120	DECIDUOUS FOREST (>50% CROWN CLOSURE)	FOREST	694,996.67	1,085.93	Not-Preferred
4210	CONIFEROUS FOREST (10-50% CROWN CLOSURE)	FOREST	62,157.17	97.12	Not-Preferred

LU Code	Description	LU Type	Acreage	Sq. Mi	SSA Designation
4220	CONIFEROUS FOREST (>50% CROWN CLOSURE)	FOREST	225,411.52	352.21	Not-Preferred
4230	PLANTATION	FOREST	4,697.36	7.34	Not-Preferred
4311	MIXED FOREST (>50% CONIFEROUS WITH 10-50% CROWN CLOSURE)	FOREST	13,394.37	20.93	Not-Preferred
4312	MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)	FOREST	129,577.43	202.46	Not-Preferred
4321	MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)	FOREST	16,110.67	25.17	Not-Preferred
4322	MIXED FOREST (>50% DECIDUOUS WITH >50% CROWN CLOSURE)	FOREST	146,163.81	228.38	Not-Preferred
4410	OLD FIELD (< 25% BRUSH COVERED)	FOREST	41,680.30	65.13	Not-Preferred
4411	PHRAGMITES DOMINATE OLD FIELD	FOREST	2,074.15	3.24	Not-Preferred
4420	DECIDUOUS BRUSH/SHRUBLAND	FOREST	31,221.14	48.78	Not-Preferred
4430	CONIFEROUS BRUSH/SHRUBLAND	FOREST	30,809.57	48.14	Not-Preferred
4440	MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND	FOREST	54,912.85	85.80	Not-Preferred
4500	SEVERE BURNED UPLAND VEGETATION	FOREST	782.14	1.22	Indeterminate
5200	NATURAL LAKES	WATER	8,934.56	13.96	Indeterminate
5300	ARTIFICIAL LAKES	WATER	72,689.38	113.58	Indeterminate
6111	SALINE MARSH (LOW MARSH)	WETLANDS	158,360.76	247.44	Not-Preferred
6112	SALINE MARSH (HIGH MARSH)	WETLANDS	5,240.90	8.19	Not-Preferred
6120	FRESHWATER TIDAL MARSHES	WETLANDS	8,221.13	12.85	Not-Preferred
6130	VEGETATED DUNE COMMUNITIES	WETLANDS	4,290.48	6.70	Not-Preferred
6141	PHRAGMITES DOMINATE COASTAL WETLANDS	WETLANDS	23,826.11	37.23	Not-Preferred
6210	DECIDUOUS WOODED WETLANDS	WETLANDS	339,956.91	531.18	Not-Preferred
6220	CONIFEROUS WOODED WETLANDS	WETLANDS	75,113.25	117.36	Not-Preferred
6221	ATLANTIC WHITE CEDAR WETLANDS	WETLANDS	42,053.64	65.71	Not-Preferred
6231	DECIDUOUS SCRUB/SHRUB WETLANDS	WETLANDS	39,009.62	60.95	Not-Preferred
6232	CONIFEROUS SCRUB/SHRUB WETLANDS	WETLANDS	6,544.47	10.23	Not-Preferred
6233	MIXED SCRUB/SHRUB WETLANDS (DECIDUOUS DOM.)	WETLANDS	12,479.33	19.50	Not-Preferred
6234	MIXED SCRUB/SHRUB WETLANDS (CONIFEROUS DOM.)	WETLANDS	8,158.42	12.75	Not-Preferred
6240	HERBACEOUS WETLANDS	WETLANDS	30,078.88	47.00	Not-Preferred
6241	PHRAGMITES DOMINATE INTERIOR WETLANDS	WETLANDS	12,069.07	18.86	Not-Preferred
6251	MIXED WOODED WETLANDS (DECIDUOUS DOM.)	WETLANDS	59,263.94	92.60	Not-Preferred
6252	MIXED WOODED WETLANDS (CONIFEROUS DOM.)	WETLANDS	74,336.16	116.15	Not-Preferred
6290	UNVEGETATED FLATS	WETLANDS	83.70	0.13	Not-Preferred
6500	SEVERE BURNED WETLAND VEGETATION	WETLANDS	33.13	0.05	Indeterminate
7100	BEACHES	BARREN LAND	3,884.08	6.07	Not-Preferred
7200	BARE EXPOSED ROCK, ROCK SLIDES, ETC	BARREN LAND	402.41	0.63	Preferred
7300	EXTRACTIVE MINING	BARREN LAND	15,454.28	24.15	Preferred
7400	ALTERED LANDS	BARREN LAND	12,699.93	19.84	Preferred
7430	DISTURBED WETLANDS (MODIFIED)	WETLANDS	5,470.65	8.55	Indeterminate
7440	DISTURBED TIDAL WETLANDS	WETLANDS	790.61	1.24	Not-Preferred
7500	TRANSITIONAL AREAS	BARREN LAND	15,162.72	23.69	Indeterminate
7600	UNDIFFERENTIATED BARREN LANDS	BARREN LAND	356.85	0.56	Preferred

Appendix D - Solar, Utility, Land Use, and Land Cover Glossary

Alternating current is the type of electrical current distributed to residential, office and commercial buildings via street level infrastructure which powers standard wall outlets.
Array tilt means the angle at which a solar array is directed to capture the maximum amount of solar energy given the arc the sun travels across the sky at a specific location. A fixed, non-tracking solar array should tilt toward the sun's average elevation, which in New Jersey is around 20 degrees, while a tracking array can follow the sun throughout the day.
Azimuth angle is the direction from which the sun rays emanate, which for New Jersey is 180 degrees (measured from True North), and is based on latitude.
Capacity factor is the percentage of energy actually generated relative to the maximum designed potential of a system to generate power over time. For example, a 10 kW system installed in New Jersey will generate about 12,300 kWh during the year versus a 10 kW system's designed capacity of 87,600 kWh (24 hours x 365 days x 10 kW = 87,600 kWh), thus the system generates about 14% of its full designed potential and has a 14% capacity factor (12,300 kWh / 87,600 kWh = 0.14).
Capacity, see **Capacity factor**.
Direct Current is the type of electrical current created by solar photovoltaic cells; to be used in homes and businesses it generally needs to be converted to alternating current by a device called an inverter.
Distributed energy generation (DER), also known as distributed generation, on-site generation, community generation, district generation or distributed energy resources, refers to generation that is smaller scale and closer to its users and includes solar power, combined heat and power (CHP), small hydroelectric, biomass, biogas, wind power, and geothermal power and contrasts with large-scale, centralized generation transmitted over greater distances. Microgrids are modern, reimagined distributed energy resources which can disconnect from the grid and often employ multiple generation and storage technologies.
Energy grid interconnection point is the physical location at which a generator, whether a large generator or a residential solar installation, connects to the electric grid. Considerations for connection to the grid include specialized equipment for safety, measurement, and power management; a relationship and/or permission from the local electrical distribution company or grid operator depending on the magnitude of generation; payment of fees to the entity(s) managing your connection (electricity distribution company and/or grid operator) and state regulators; and potentially signing of agreements including liability insurance.
Generation, see **Capacity factor**.
Geographic Information Systems (GIS) are computer driven mapping systems designed to capture, store, organize, analyze and display spatial data.
Grid congestion, also known as power grid congestion or electric transmission congestion, occurs when the need or desire of the markets, or mandates of government policy, to transmit electricity is constrained to below demanded levels by overloaded systems, out of service lines, or transmission management failures.
Grid Supply solar generation is power generated explicitly for distribution into the electrical grid and is measured in megawatts (MW), or millions of watts, as opposed to smaller scale residential solar which is generated and measured in kilowatts (KW), or thousands of watts. Grid supply generation is often less precisely referred to as grid connected, grid tied, grid scale or utility scale. For example, many residential rooftop solar installations are "grid connected" not just for receiving power from the grid on cloudy days but for selling the excess power they generate on sunny days back into the grid but they would not be labeled as grid supply because of the small quantity of power they supply to the grid.
GW, or Gigawatt, is a unit of power equal to one billion watts. Gigawatts measured over time are expressed as gigawatt hours, abbreviated GWh.
Impervious Surface (aka impervious cover) are mostly man-made ground covers such as roads, sidewalks, parking lots, driveways, and building rooftops that are topped by impenetrable materials such as asphalt, concrete, brick, stone and a variety of roofing materials. These surfaces prevent the previously natural journey of water through pervious surfaces back into the ground, known as infiltration, to complete the water cycle. Soils compacted by intense usage are

also highly impervious.
Infiltration, see **Impervious surface**.
Insolation is solar irradiance measured over time and is also called solar irradiation, solar radiation, or solar exposure.
kW, or kilowatt, is a unit of power equal to one thousand watts. Kilowatts measured over time are expressed as kilowatt hours, abbreviated kWh.
Leachate monitoring and/or collection systems monitor and/or collect the fluids that leak out of sanitary landfills, fluids containing numerous contaminants. These systems are designed to reduce the impact of these pollutants by warning of changes in the concentrations of pollutants; reducing their quantity and concentration through collection and treatment; and constantly monitoring that conditions in the sanitary landfill have not degraded indicating failures of protective systems like weather impervious caps.
MW, or Megawatt, is a unit of power equal to one million watts. Megawatts measured over time are expressed as megawatt hours, abbreviated MWh.
Photovoltaic cell, see **Solar cell**
Photovoltaic Effect is the creation of electrical current in a material upon exposure to light or other radiant energy.
Resilience, or more concisely disaster resilience, is the ability of individuals, communities, governments, businesses and organizations to plan for, absorb, recover from, and adapt to the hazards associated with disasters, and with good planning avoid them in the future.
Rights-of-Way are the legal right to conduct an activity or place structures along a specifically mapped route through property belonging to another. Types of right-of-way legal activities can include walking, biking or boating while right-of-way legal structures can include solar arrays, roads, transmission lines or pipelines.
Sanitary landfills are garbage disposal areas run to accept waste. If well run, the waste is confined to as small and compact areas as possible, while insuring that the waste doesn't migrate through the regular overtopping of waste with spreading resistant material. When landfill sections are full, they are often closed with stabilization structures and an engineered cap, commonly made of clay.
Silicon, usually in the form of polycrystalline silicon, is used as the primary raw material for solar cells by solar photovoltaic manufacturers.
Solar array is the combination of many solar panels assembled along with the necessary additional equipment to harvest the electricity generated from the sun striking the assembled solar cells to create a single system. Sometimes referred to as Solar PV arrays.
Solar cell, also known as a photovoltaic cell, is a device designed to generate electrical by taking advantage of the photovoltaic effect, or the inherent nature of certain materials to generate energy when struck by radiant energy such as the sun's rays.
Solar panels, sometimes called solar modules, are groups of solar cells. Most solar panels are flat plate collectors, not curved or angled differently from adjacent panels.
Solar Resource Potential is the potential solar energy available for harvest at specific locations by various solar technologies, measured and calculated using inputs specific to the location of interest. Among the most important traits affecting the value of the solar resource are geographic latitude, altitude, average moisture levels, measures of cloud cover and number of foggy days. The most widely used solar resource potential data is distributed via the National Renewable Energy Laboratory of the Department of Energy via solar maps providing monthly average daily total solar resource information in grid cells with the solar exposure, or insolation, values representing "…the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location. This is typical practice for PV system installation, although other orientations are also used."[30] Solar resource is expressed in kilowatt hours per meter per day ($kWh/m^2/day$).

Appendix E - Endnotes / References

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[1] Lazard. "Lazard's Levelized Cost of Energy Analysis - Version 10.0.", Lazard.com. https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf, Table "Unsubsidized Levelized Cost of Energy Comparison" (accessed April 25, 2017)
[2] For example, in large-scale applications access to nearby transmission lines will play an important role in determining overall impacts, as the extension of interconnection lines through previously undisturbed land can create negative impacts. This factor is not taken into consideration in this document.
National Renewable Energy Laboratory (NREL). "Solar Energy Basics". nrel.gov. http://www.nrel.gov/learning/re_solar.html (accessed April 25, 2017).
[4] National Renewable Energy Laboratory (NREL). "Solar Maps". nrel.gov. http://www.nrel.gov/gis/solar.html (accessed April 25, 2017).
[5] National Renewable Energy Laboratory (NREL). "PV Watts Documentation". nrel.gov. http://pvwatts.nrel.gov/pvwatts.php (accessed April 25, 2017).
[6] National Renewable Energy Laboratory (NREL). "Solar Maps". nrel.gov. http://www.nrel.gov/gis/solar.html (accessed April 25, 2017).
[7] Net metering is an electricity policy for consumers who own their renewable energy facility, generally small, and allows the electricity meter to spin "backwards" when power generation is greater than power consumption. The meter's ability to measure both directional power flows allows consumers to take advantage of the electricity generated on site.
[8] Office of Energy Efficiency & Renewable Energy. "2008 Solar Technologies Market Report." energy.gov. https://www1.eere.energy.gov/solar/pdfs/46025.pdf (accessed April 25, 2017)
[9] Greentech Media (GTM). "Solar Costs Are Hitting Jaw-Dropping Lows in Every Region of the World". greentechmedia.com. https://www.greentechmedia.com/articles/read/solar-costs-are-hitting-jaw-dropping-lows-in-every-region-of-the-world (accessed August 1, 2017)
[10] This category also includes the use of Building Integrated Photovoltaics (BIPV), which integrate solar PV panels into buildings during design and construction. BIPV replaces traditional building materials such as roofs, window overhangs, and exterior wall facades.
[11] Other potential impacts could include visual, as solar energy development projects would be highly visible in rural, natural or historic landscapes
[12] Island Press. "Millennium Ecosystem Assessment, Ecosystems and Human Well-Being." millenniumassessment.org. http://www.millenniumassessment.org/documents/document.356.aspx.pdf (accessed April 25, 2017).
[13] New Jersey Board of Public Utilities (NJ BPU). "Christie Administration Reaches Significant Renewable Energy Milestone in 2016 - Surpasses 2 Gigawatts of Installed Solar Capacity." nj.gov/bpu. http://nj.gov/bpu/newsroom/announcements/pdf/20170118Solar.pdf (accessed April 25, 2017).
[14] Untied State Census Bureau. "State Area Measurements and Internal Point Coordinates 2010 Land Area." census.gov https://www.census.gov/geo/reference/state-area.html (accessed April 25, 2017).
[15] Solar Energy Industries Association (SEIA). "State-By-State Map | SEIA." seia.org. https://www.seia.org/states-map (accessed December 15, 2017).
[16] New Jersey Clean Energy Program. "Solar Activity Reports." njcleanenergy.com. http://www.njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports. (accessed December 15, 2017).
[17] New Jersey Clean Energy Program. "Solar Activity Reports." njcleanenergy.com. http://www.njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports. (accessed December 15, 2017).
[18] State of New Jersey. "2011 New Jersey Energy Master Plan." http://www.nj.gov/emp/. http://www.nj.gov/emp/docs/pdf/2011_Final_Energy_Master_Plan.pdf (accessed April 25, 2017).
[19] State of New Jersey. "2015 New Jersey Energy Master Plan Update." http://www.nj.gov/emp/. http://nj.gov/emp/docs/pdf/New_Jersey_Energy_Master_Plan_Update.pdf (accessed April 25, 2017).
[20] The first SREC program was implemented in 2005 by the state of New Jersey and has since expanded to several other states, including Maryland, Delaware, Ohio, Massachusetts, North Carolina and Pennsylvania. Bird, Lori; Heeter, Jenny; Kreycik, Claire (November 2011). "Solar Renewable Energy Certificate (SREC) Markets: Status and Trends" (PDF). nrel.gov National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy12osti/52868.pdf (accessed April 25, 2017)
[21] Pertaining to subsections q and s, on July 21, 2017 bill S3181 was signed by the Governor which permits solar power projects that had not commenced commercial operation within the two years of the date of designation by the Board to retain designation through May 31, 2018 as connected to distribution system.
[22] This performance calculation is made using National Renewable Energy Laboratory's (NREL) PV Watts version 2 and assumes the PV system is a fixed-tilt array type facing south located in Trenton, NJ with the default 0.77 DC to AC Derate Factor. For more information see http://pvwatts.nrel.gov/ (accessed April 25, 2017).
[23] This estimation is made using PJM's 2013 load forecast for New Jersey EDC territories for calendar year 2028, aggregating load (98,490 GWh), and applying 4.1%.

[24] This calculation assumes average solar radiation is 4.5 kWh/m^2/day for a flat plate tiled south located in New Jersey (see http://rredc.nrel.gov/solar/pubs/redbook/), 15% PV module efficiency, and a DC to AC Derate factor of 0.77 (see http://pvwatts.nrel.gov/). Combining these terms yield a PV energy density, which is defined as the annual energy produced per unit of land area, of 189.7kWh/m^2. This PV energy density value would represent the maximum yield for the stated assumptions. PV deployed on flat rooftops and ground-based PV arrays are typically tilted toward the south to maximize the amount of collected solar radiation. The larger angle tilt results in a greater array spacing to avoid self-shading. Additional spacing will reduce the energy density by as much as 60%. For this calculation, a reduction of 50% in energy density due to self-shading is assumed to yield 94.8kWh/m^2

[25] New Jersey Clean Energy Program. "Net Metering and Interconnection" njcleanenergy.com. http://www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection (accessed April 25, 2017)

[26] Solar Energy Industries Association (SEIA). "Solar Investment Tax Credit (ITC)" seia.org. http://www.seia.org/policy/finance-tax/solar-investment-tax-credit (accessed April 25, 2017)

[27] Anderson, James R., Ernest E. Hardy, John T. Roach, Richard Witmer. "A Land Use And Land Cover Classification System For Use With Remote Sensor Data." usgs.gov. https://landcover.usgs.gov/pdf/anderson.pdf (accessed April 25, 2017).

[28] State of New Jersey. "RPS Comp EY 2016 Combined Data All." njcleanenergy.com. http://www.njcleanenergy.com/files/file/Renewable_Programs/RPS/RPS%20Comp%20EY%202016%20Combined%20Data%20All.pdf (accessed August 4, 2017).

[29] For assessed farmland (i.e., lands enjoying tax benefits) the limits or thresholds are: solar projects should not exceed 10 acres, 2 megawatts, and 1:5 ratio between solar and agricultural operations. For preserved farmland, the limits are: solar project's annual generation capacity should not exceed 110% of previous year's energy demand or occupy no more than 1% of the area of the entire farm

[30] National Renewable Energy Laboratory (NREL). "Solar Maps". nrel.gov. http://www.nrel.gov/gis/solar.html (accessed April 25, 2017)