New Jersey Department of Environmental Protection
Solar Siting Analysis

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New Jersey Department of Environmental Protection
Sustainability and Green Energy
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Introduction

The purpose of this analysis is to aid the Department, local communities and potential developers in planning for solar installations by distinguishing between sites where the Department encourages solar development from those where the Department discourages solar development. While green energy projects provide environmental benefits, the environmental benefit can be lost if the project is not properly sited. This analysis was performed to determine sites where solar projects are most environmentally desirable and therefore recognized by the Department as priority green energy projects. This document is intended to be used as guidance and should not be used to automatically disqualify solar installation projects prior to proper review.

A summary of each section is presented below.

Section I describes the context in which the solar siting analysis was performed.

Section II contains the results of the analysis.

Section III discusses the state of solar in New Jersey at the time of the analysis.

Section IV gives basic background information on solar technologies and highlights associated applications relevant to the siting discussion.

Section V describes common environmental impacts from different solar applications.

Section I. Context

Certain types of sites are preferred for solar development from an environmental protection standpoint. As a result of this analysis, the Department is able to distinguish between sites where solar development is preferred from those where it is not preferred. Sites where solar development is preferred by the Department are Category 1 sites. Sites where solar development is not preferred by the Department are Category 2 sites. Projects proposed on Category 1 sites are recognized by the Department as priority green energy projects**.**

It is understood that no matter what category a site falls into, all solar energy projects share the same positive environmental benefits of PV installations besides those that are specifically discussed and used to differentiate between the categories. As a result, some of the more obvious benefits shared by each solar project are not discussed (e.g., producing zero emissions while operating).

The 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 existing land use regulations and this analysis is simply meant to generally guide solar development towards projects that generate a dual benefit for the environment and the economy in New Jersey. Solar projects located in regulated areas require appropriate permitting. 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. (Note: For utility-scale applications, access to nearby transmission lines will also 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.)

In this analysis, the Department has made use of the Anderson Land Use Land Cover (LULC) classification system (with appropriate modifications) to organize its geographic information and database system. The Department's GIS is a web-based application and accessible to the public. Accordingly, the document makes reference to the Anderson system to further clarify land types and their characteristics and intended use.[1,2] Each site within a category contains a Level I classification and, where appropriate, more detailed Level II classifications or sub-categories to exclude certain lands not appropriate that would otherwise be included in Level I[3]. Appendix B of this analysis provides a comprehensive list of Anderson Land Use Codes and a corresponding designation as preferred by the Department for solar siting, not preferred by the Department for solar siting, or designated as a Gray area between preferred and not

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[1]The Anderson classification system was developed to meet the needs of Federal and State agencies for an up-to-date overview of land use and land cover throughout the country on a basis that is uniform in categorization at the more generalized first and second levels. See "**A Land Use And Land Cover Classification System For Use With Remote Sensor Data"** located at http://landcover.usgs.gov/pdf/anderson.pdf.

[2] The Anderson classification system referenced throughout this document is merely a screening tool to help locate potential sites and should not be used as a basis to justify project approval. Individual sites would still need to be evaluated.

[3] See Appendix B for a list of Anderson Land Use Land Cover Categories and their corresponding designation as Preferred (P), Not Preferred (NP) or Gray Area (G) for solar siting.

preferred. The purpose is to help guide environmentally sound location-based decisions for solar projects. As noted in Appendix B, the aforementioned designations are meant to be utilized as a tool and not meant to indicate whether a solar project proposed on such a site would be permitted or not.

Section II. Results

Category 1: Sites Preferred by the Department for Solar Development

a) Existing Impervious surface

Siting solar projects on existing impervious surfaces is desirable. Impervious surface generally exists on developed land, which is primarily an urbanized, built-up area that has basic urban infrastructure, including roads, utilities, communications, and public facilities, to sustain industrial, residential, and commercial activities. Included in this category are existing commercial or industrial roof spaces that are flat, open, and ideal for PV solar systems.

Solar siting on existing impervious surface does not introduce any additional direct land disturbance affecting existing ecosystem services. However, as discussed in the Distributed Applications portion of Section V, installations on developed areas could prompt the disturbance of adjacent land if obstructing objects (e.g. trees) prevent optimal performance of the system. Subsequently, the clearing of trees, which sequester carbon, on adjacent land to prevent shading of the solar panels may prove to negate the benefits derived from the solar installation. This results in negative environmental benefits and is not preferred. Therefore within this category, commercial or industrial roof space is advocated as most desirable.

Anderson classification: This category may include Level I Urban or Built-up Land (1000)[4] defined as being characterized by intensive land use where the landscape has been altered by human activities. Although structures are usually present, this category is not restricted to traditional urban areas. Urban or Built-up Land Level II categories include Residential (1100); Commercial and Service (1200); Industrial (1300); Transportation, Communication and Utilities (1400); Industrial and Commercial Complexes (1500); and Mixed Urban or Built-up (1600). Included with each of the above land uses are associated lands, buildings, parking lots, access roads, and other appurtenances, unless these are specifically excluded.

b) Properly capped/closed landfills and Remediated Brownfields

Generally speaking, a solar project on a properly capped/closed landfill or a remediated brownfield site is an easier undertaking because the clean-up and/or closure portion of the work has already been completed. Conversely, placing solar on an uncapped/unclosed landfill or a brownfield site still in need of remediation can be a more

[4] Numbers in parentheses refer to the Level I or Level II Anderson Classification.

complicated undertaking because proper clean-up and/or closure work must be completed prior to, or concurrently with, the solar installation.

Properly capped/closed landfills

Landfills that have completed NJDEP's Closure Requirements are the only one's considered "properly closed" and, accordingly, can proceed more easily with a solar installation. Those landfills that have gone through proper closure are generally more advantageous for solar projects than landfills that have not been closed, from purely a cost perspective.

In certain circumstances, properly closed landfills, depending on their site characteristics, might provide habitat for critical grassland species. In these cases, if loss of an ecosystem service (i.e., wildlife and/or threatened and endangered species habitat) is projected to occur at the site as a result of solar development, then the land should not be considered to be Category 1 and instead requires a site-specific assessment to determine whether it should be considered a Category 1 or Category 2 site. If the benefit of clean energy derived from the solar project would not be enough to offset the considerable negative environmental impacts and yield no or negative net environmental benefit, then the site should be re-classified as Category 2.

For more detailed and specific information regarding solar installations on closed landfills and the DEP permitting required please see "Guidance for Installation of Solar Renewable Energy Systems on Landfills in New Jersey" (Updated January 8, 2013) published by the Solid Waste Program, NJDEP.

Remediated Brownfields

A solar project on a remediated brownfield,[5] (where a No Further Action (NFA)[6] Letter or Response Action Outcome (RAO)[7] has been issued) that does not have a viable higher end use, can enable the beneficial reuse of an otherwise underutilized site. If solar can spur the redevelopment of virtually unusable remediated sites, the environmental benefits of solar would be increased beyond just the emission-free electricity. Further, there exists an environmental education component: projects can be used to educate the

[5] A brownfield site means 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 as per NJ state law N.J.S.A. 58:10B-23.d

[6] As per N.J.A.C. 7:26E-1.1. (Definitions) "No further action letter" means a written determination by the Department that, based upon an evaluation of the historical use of the site, or of an area of concern or areas of concern at that site, as applicable, and any other investigation or action the Department deems necessary, there are no contaminants present at the site, at the area of concern or areas of concern, or at any other site to which a discharge originating at the site has migrated, or that any contaminants present at the site or that have migrated from the site have been remediated in accordance with applicable remediation statutes, rules and guidance and all applicable permits and authorizations have been obtained.

[7] As per N.J.A.C. 7:26E-1.1. (Definitions) "Response action outcome" or "RAO" means a written determination by a licensed site remediation professional that the site was remediated in accordance with all applicable statutes, rules and guidance, and based upon an evaluation of the historical use of the site, or of any area of concern at that site, as applicable, and any other investigation or action the Department deems necessary, there are no contaminants present at the site, at the area of concern or areas of concern, or at any other site to which a discharge originating at the site has migrated, or that any contaminants present at the site or that have migrated from the site have been remediated in accordance with applicable remediation statutes, rules and guidance and all applicable permits and authorizations have been obtained.

public and other interested parties on the benefits of solar power, which could spur additional interest and future projects. It is assumed that compliance with all other applicable local, state and federal laws, regulations and requirements to ensure protection of human health and the environment from these sites will be achieved.

NJ defines a brownfield as 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 contamination. Given this broad definition, brownfields range from closed gas stations that litter the highways to large industrial/manufacturing facilities. 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).

Anderson classification: This category may include altered lands (7400)[8] defined as areas outside of an urban setting that have been changed due to human activities other than for mining.

c) Landfills requiring proper closure and Brownfields requiring remediation

A solar project on a landfill requiring proper closure and/or a brownfield requiring remediation can stimulate the proper cleanup of such sites by providing a source of revenue to fund the cleanup activities. If solar can spur the required clean-up of previously non-remediated sites, again the environmental benefits of solar would be increased beyond just the emission-free electricity and the redevelopment of the site. It is this category that creates the greatest environmental benefit from solar development. Further, the environmental education component described in the previous section also applies. Again it is assumed that compliance with all other applicable local, state and federal laws, regulations and requirements to ensure protection of human health and the environment from these sites will be achieved.

Some landfills that are not operating (commonly referred to as "closed landfills") have not completed the formal "Closure Requirements" pursuant to the Solid Waste Management Act, N.J.S.A. 13:1E. Landfills that have not been properly closed will have to implement all the NJDEP Closure Requirements (e.g. capping, landfill gas collection, leachate control) before, or under certain circumstances concurrent with, any solar installation.

NJDEP's Solid and Hazardous Waste Program has a searchable database (http://www.nj.gov/dep/dshw) for landfills that provides some general information that is helpful when initially evaluating the potential of a landfill for solar, such as operating status (active vs. not operating), location (block/lot) and ownership (private vs. local/county government). With nearly 850 landfills identified in New Jersey, this is a very promising area for solar projects. To support the effort of siting utility-scale solar

[8] Numbers in parenthesis indicate the Anderson code for the land-use category or sub-category being described

projects on landfills, NJDEP is currently evaluating existing information on landfills of significant size, specifically those landfills that are situated on parcels larger than 35 acres. When the information gathering is complete, NJDEP plans to identify at a minimum, ten landfills that would be suitable for this use.

To further aid in the identification of landfills suitable for solar development, NJDEP is expanding the existing GIS data layers available on its NJ GeoWeb mapping application (http://www.nj.gov/dep/gis/newmapping.htm). This information will include site specific information up-front so that a thorough evaluation can be made by a developer as to the feasibility of a solar project and minimize delays in the NJDEP permitting/approval process.

d) Barren and related lands

Barren and disturbed uplands including abandoned rock/stone quarries, sand and gravel lots or borrow pits, etc., can be desirable sites for solar under certain circumstances. The Anderson LULC classification system defines barren land (7000) as characterized by thin soil, sand or rocks and a lack of vegetative cover in a non-urban setting. Vegetation, if present, is widely spaced.

Although this category does not directly involve land clearing, potential land disturbance impacting the local ecosystem should be considered since at first blush, one might think that "barren" land implies land that is not appropriate as habitat; yet this is not necessarily the case. If loss of an ecosystem service (i.e. wildlife and/or threatened and endangered species habitat) is projected to occur at the site, then the land is not preferred and re-classified as Category 2 in this analysis. As an example, outcrops and ridgelines in Northern New Jersey may have positive environmental attributes, such as critical habitat for rattlesnakes and copperheads for denning, gestation/birthing and basking and such sites would be re-classified accordingly as Category 2 status.

Anderson classification: This category may include Level II areas classified as exposed rock (7220), quarries (7310), borrow pits (7320), severe burned upland vegetation (4500), and undifferentiated barren land (7600). The latter category encompasses cleared lands that have no apparent site preparation or any indication of past activities. Such areas vary in size and shape but generally possess little vegetation.

Category 2: Sites Not Preferred by the Department for Solar Development

a) Agriculture

The siting of solar projects on agricultural land is not preferred**,** especially when the project design exceeds the limits/thresholds (area, energy capacity, and environmental) defined in the legislation amending the Right to Farm Act (P.L. 2009, c.

213[9]). Agricultural land provides important and economically valuable ecosystem services including stormwater retention, preservation of soil and water resources, wildlife habitat, and carbon sequestration (both in the crop, grass or tree biomass and soils). These ecosystem services are critical to maintaining the productivity of agricultural land while retaining their intrinsic agricultural value. Agricultural soils are irreplaceable resources and agricultural wetlands possess significant carbon sequestration potential.

A solar project could potentially damage agricultural land, impede or reduce the productive agricultural capacity of the land for future use, and displace wildlife habitat. The benefit of clean energy derived from the solar project would not be sufficient to offset the considerable negative environmental impacts and may yield zero or negative net environmental benefit.

Anderson classification: Agricultural land includes all lands used primarily for the production of food and fiber and some of the structures associated with this production. This category at Level 1 is classified as 2000 in the Anderson LULC. It includes the following Level II sub-categories:

- Cropland and pasture land (2100) - agricultural lands managed for the production of both row and field crops and for the grazing of cattle, sheep and horses, as well as croplands left to fallow or planted with soil improvement grasses and legumes. Cropland and pastureland can easily be distinguished from other land uses with large-scale imagery. Also included in this sub-category are Agricultural Wetlands (2140) which are lands under cultivation that are modified former wetland areas, and which still exhibit evidence of soil saturation. In addition, these agricultural wetlands also exist in areas shown on soil surveys of the Natural Resources Conservation Service to have hydric soils. All cranberry farmlands have been classified under this sub-category, regardless of the presence of water. Agricultural wetlands, not under active cultivation that have become shrubby and not built-up (2150) also fall under this sub-category. These areas have not undergone any other alterations, such as filling, grading or development, and may again be returned to the 2140 category if the farmland is again placed under cultivation. Active and ongoing farming in "agricultural wetlands" is exempt from Freshwater Wetlands Protection Act. That exemption allows farmers to continue farming in fields that retain wetlands characteristics although they can be farmed. Many corn and soybean fields meet the definition of wetlands. Generally those wetland fields are only wet during the winter and early spring. Once they dry as the temperatures warm the farmers can work the fields and plant. However, constructing a solar project in a farmed wetland is not exempt and a permit would be required. In many cases the project would not meet the alternatives test for the issuance of a permit, therefore, no permit could be issued

[9] 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.

- Orchards, vineyards, nurseries, and horticultural areas (2200) - agricultural areas, which are intensively managed for production of fruits, trees, ornamental plants, and vegetable seedlings. Also included in this category are orchards, nurseries, cranberry farms and blueberry farms vineyards, and sod and seed farms. Areas delineated include actively cultivated lands as well as land associated with the operations.

b) Natural and/or Protected Lands

Solar projects on natural and/or protected lands such as forest, wetland, flood hazard areas, wildlife habitat, open space, historic lands, etc. are also not preferred. These areas include abandoned marginal farmlands that have reverted or are reverting back to forestlands or wetlands. Significant ecosystem services are associated with these areas and their ecological profiles have to be considered in proposals to locate or site solar facilities within such areas. The project developed should make every effort to minimize the project's ecological footprint and avoid/mitigate potential environmental impacts. Certain key items to evaluate are as follows:

- If forest is dominant feature or use – site biomass (for carbon storage and sequestration), productivity, and species diversity (i.e., forest ecosystem health) including identification of rare, threatened and endangered species; and
- If wetland is primary feature – assessment of proper buffers, including biological, to riparian and wetland areas.

In the event that there are solar installations on these types of sites, at the end of the project's useful life, proper decommissioning of the facility would be necessary and should include restoration of the project site to the original ecological profile to the extent possible.

Anderson classification: Examples of unobstructed/underdeveloped lands would include forestlands (4000) and wetlands (6000). The forestland Level I category contains any lands covered by woody vegetation other than wetlands. These areas are capable of producing timber and other wood products, and of supporting many kinds of outdoor recreation. Forestland is an important environmental category, because it affects air quality, water quality, wildlife habitat, climate, and many other aspects of the ecology of an area. The Level II categories under Forestland are Deciduous; Coniferous; Mixed Deciduous-Coniferous; and Brushland.

Wetlands are those areas that are inundated or saturated by surface or ground waters at a frequency and duration sufficient to support vegetation adapted for life in saturated soil conditions. Included in this category are naturally vegetated swamps, marshes, bogs and savannas which are normally associated with topographically low elevations but may be located at any elevation where water perches over an aquiclude. The wetlands of New Jersey are located around numerous interior stream systems, and along our coastal rivers and bays. New Jersey, by its numerous different physiographic regions, supports various wetland habitats dependent upon physiographic and geological variables. The Level II classification separates wetlands into two categories based on the location relative to tidal water systems: coastal wetlands (6100) and inland wetlands (6200).

Section III. Background – The State of Solar in New Jersey

Over the past few years, New Jersey has seen a large increase in solar energy projects at small residential (<10 kW), commercial (<1 MW), and utility-scale (>1 MW) levels. In 2008, 835 projects were completed representing 22.7 megawatts (MW) of added solar capacity; while in 2010, 3,139 PV projects were completed representing 132.3 MW of added capacity.[10] From 2008 to 2011, solar capacity has more than doubled each subsequent year and by October 31, 2012 total installed capacity had reached 918 MW. Figure 1 summarizes the yearly capacity added and cumulative installed capacity for the years 2001 to 2012.

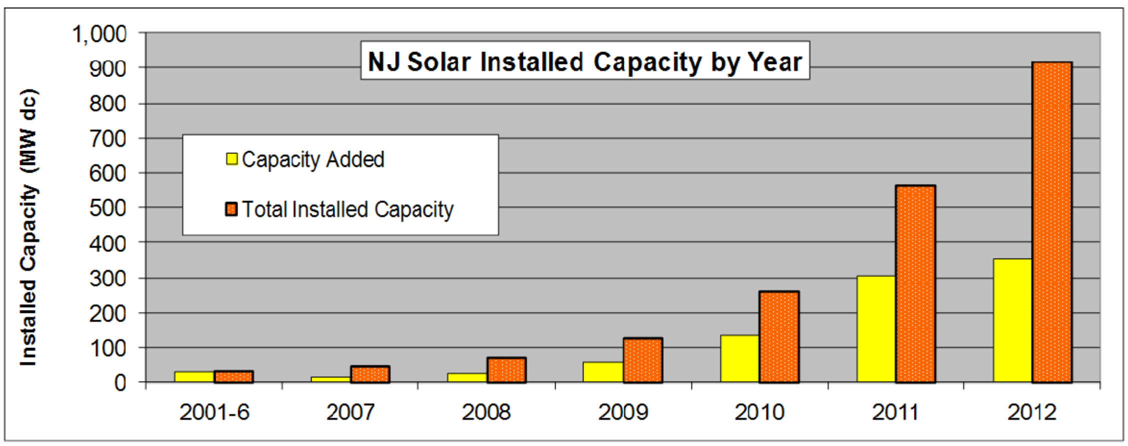

Figure 1. NJ Solar installed capacity

The recent increase of solar energy in New Jersey is driven by: a strong Renewable Portfolio Standard (RPS) with a solar electric set aside; interconnection and net metering standards set by the Board of Public Utilities that have made it easier for systems to connect to the distribution system; federal grants and tax credits; and a Solar Renewable Energy Certificate (SREC) financing model that provides energy credits[11]. New Jersey's net-metering standards specifically have helped customers maximize their renewable energy investments. Net-metering enables customers to obtain full retail credits on their utility bill for each kWh of electricity their system produces, in excess of the amount of electricity used over the course of a year.[12]

[10] New Jersey Clean Energy Program, Solar installation projects; available at http://www.njcleanenergy.com/renewable-energy/project-activity-reports/installation-summary-by-technology/solar-installation-projects

[11] New Jersey Clean Energy Program, SREC registration program; available at http://www.njcleanenergy.com/renewable-energy/programs/solar-renewable-energy-certificates-srec/new-jersey-solar-renewable-energy

[12] Net Metering and Interconnection of Class I Renewable Energy Facilities in New Jersey; available at http://www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection

A Solar Renewable Energy Certificate (SREC) represents the clean energy benefits of electricity generated from a solar electric system with one SREC issued for each 1,000 kilowatt-hour (kWh) generated. SRECs are then sold or traded, separately from the sale of power, providing solar system owners with a source of revenue to help offset the cost of installation. Electricity suppliers in New Jersey must meet solar RPS requirements through purchase of SREC's or pay a Solar Alternative Compliance Payment (SACP). By 2028, the solar RPS requires[13] suppliers/ providers serving retail customers to procure at least 4.1% of the electricity it sells from solar electric power generators in the State, which is estimated to be 4,038 gigawatt-hour (GWh) of solar power[14]. The total installed solar capacity needed to fulfill the solar RPS target would be approximately 3,423 MW.[15]

To reach this goal in 2028, New Jersey would have to install approximately 167 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 land could be covered in photovoltaic (PV) panels. To put this in perspective, to meet the RPS goal an estimated 17.6 square miles (11,264 acres) might be covered in PV panels without appropriate siting criteria.[16] If there are technological breakthroughs in materials and/or manufacturing that decrease costs, and/or Congress decreases fossil fuel subsidies[17], the land area covered by solar panels could increase from this estimate due to increased competitiveness with fossil fuels. It is prudent, therefore, to consider the potential impact on land-based resources devoted to solar energy within the state.

Section IV. Background – Solar Technology

Solar energy is a term used to describe a variety of different technologies that have the capability of converting solar radiation to useful power. These technologies are primarily grouped into two categories: solar thermal and photovoltaic.

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[13] **Revisions to the Solar Energy Advancement and Fair Competition Act** was passed by the legislature (S1925) and signed into law (P.L. 2012, c.2424) on July 23, 2012; final draft available at http://www.njleg.state.nj.us/2012/Bills/PL12/24_.PDF

[14] 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%.

[15] 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. See http://www.nrel.gov/rredc/pvwatts/version2.html for more information.

[16] 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/old_data/nsrdb/redbook/atlas/ , 14% PV module efficiency, and a DC to AC Derate factor of 0.77, see http://www.nrel.gov/rredc/pvwatts/version2.html. Combining these terms yield a PV energy density, which is defined as the annual energy produced per unit of land area, of 177.1 kWh/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 88.6 kWh/m^2.

[17] Examples of U.S. subsidies include: tax breaks such as the Foreign Tax Credit, lost government revenue through under-collection of offshore lease royalties, and direct spending in the form of expenditures on research and development. Elimination of some of these subsidies would require legislation. In addition, subsidies from other countries include price supports that artificially reduce the price of fossil fuels for end users. The International Energy Agency (IEA) reports that global fossil fuel consumption subsidies amounted to $557 billion in 2008. In June 2010, G-20 nations pledged to phase out fossil fuel subsidies. Legislation would be required to implement the U.S. commitment the G-20 agreement. There are numerous sources of information relating to fossil fuel subsidies. Here are a few http://www.bloomberg.com/news/2010-07-29/fossil-fuel-subsidies-are-12-times-support-for-renewables-study-shows.html, http://www.worldenergyoutlook.org/docs/second_joint_report.pdf, http://www.thebrokeronline.eu/en/Magazine/articles/Phase-out-fossil-fuel-subsidies, http://www.grist.org/article/2010-08-03-fossil-fuels-keep-getting-the-breaks

Solar thermal technology is comprised of three different methods to convert solar energy for use. The first method collects the energy of the sun to heat water or air for direct use in solar home 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 in order to regulate its temperature.[18] Of the available methods, only the first one impacts land use. The second method requires abundant solar resources and is limited to the southwestern United States. Therefore, for the purposes of this paper only the first method will be considered in the context of a New Jersey solar siting analysis.

Solar photovoltaic technology (PV) converts sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the 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 and solar cells were initially used to power space satellites and smaller items like calculators and watches.

Solar cells are categorized into three types of generation. The first generation involves traditional solar cells, are made from silicon, are 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 are made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies and solar dyes based on new design concepts.

Solar panels used to power homes and businesses are made from solar cells that are combined into modules. A typical 150 watt panel is about 1 square meter and has 15% conversion efficiency. The panels are mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture more sunlight. Many solar panels combined together to create one system is called a solar array. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.

The electricity generated from PV panels is in direct current (DC), while the electricity delivered to homes and appliances from the electric grid use alternating current (AC). Utility scale and net metered[19] PV systems that are typically connected to the electric grid must have their generated electricity 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 tied can be used to promote distributed electric generation.

[18] *Solar energy basics*, National Renewable Energy Laboratory (NREL). http://www.nrel.gov/learning/re_solar.html

[19] 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.

In the United States, the majority of PV panels installed are silicon-based technology (first generation) and it is expected to be the dominant technology in the coming years.[20] 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 breakthrough 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.

Section V. Environmental Impacts of Solar Siting

The applications of PV offer a spectrum of developing opportunities from individual home owners utilizing their rooftops as a supplemental source of electric generation to utility-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 Applications

In distributed generation applications relatively small solar systems are mounted on residential and commercial rooftops.[21] A typical residential system is around 5kW of panels, and produces 5,900 kWh of electrical energy per year. A typical commercial application is comprised of 25 kW of panels, and produces 29,500 kWh of electrical energy per year. As such, they generally do not directly involve any significant land disturbance besides those incurred to the existing surface or structure used to accommodate the panels. However, there is the possibility that adjacent land near the installed system could be disturbed to accommodate or maximize the energy produced by such systems. 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. The most common obstructing objects for residential roof installations are trees. Tree removal for the purposes of solar installation may result in degradation to the local ecosystem and reduce the overall net benefits achieved by the project. In addition, there may be some localized conflicts with other environmental initiatives (e.g., residential solar versus urban forestry/tree shading –already taking place in some NJ municipalities).

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[20] *2008 Solar Technologies Market Report*, US Department of Energy. http://www1.eere.energy.gov/solar/pdfs/46025.pdf

[21] This category also includes the use of Building Integrated Photovoltaics (BIPV), which integrate PV panels into buildings during design and construction. BIPV replaces traditional building materials such as roofs, window overhangs, and exterior wall facades.

Utility-Scale Applications

Utility-scale applications are typically ground-based arrays that accommodate between 10 MW and 200 MW of panels covering 33 and 660 acres respectively.[22] The main potential environmental impact[23] for utility scale applications is loss of land consumed or covered by solar arrays, panels, and support structures (e.g. inverters). Land consumed or lost to solar energy facilities may affect the local ecosystem and the benefits provided therein.

The wide range of ecosystems impacted--those relatively undisturbed (such as natural forests), landscapes with mixed patterns of human use, and 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, these 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.[24] Examples of ecosystem services impacts from solar can 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.

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[22] The acres covered are based on a performance calculation and assume 88.6 kWh/m^2 of annual PV electric production, see footnotes 2 and 3.

[23] Other potential impacts could include visual , as solar energy development projects would be highly visible in rural, natural or historic landscapes

[24] Millennium Ecosystem Assessment, Ecosystems and Human Well-Being, 2005; available at http://www.maweb.org/documents/document.356.aspx.pdf.

Appendix A – Recently Enacted New Jersey Legislation Relating to Solar Energy

- 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.
- 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.

Appendix B – Land Use Land Cover Anderson Codes (2007)

Note: The following designations of sites as P (preferred for solar), NP (not preferred for solar) and G (gray area for solar) 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.

Label07 (Duplicates removed)	P/NP/G	Anderson Classification Code
RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	P	1110
RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	P	1120
RESIDENTIAL, SINGLE UNIT, LOW DENSITY	P	1130
RESIDENTIAL, RURAL, SINGLE UNIT	P	1140
MIXED RESIDENTIAL	P	1150
COMMERCIAL/SERVICES	P	1200
MILITARY INSTALLATIONS	P	1211
NO LONGER MILITARY	P	1214
INDUSTRIAL	P	1300
TRANSPORTATION/COMMUNICATION/UTILITIES	P	1400
MAJOR ROADWAY	P	1410
MIXED TRANSPORTATION CORRIDOR OVERLAP AREA	P	1411
BRIDGE OVER WATER	P	1419
RAILROADS	P	1420
AIRPORT FACILITIES	P	1440
WETLAND RIGHTS-OF-WAY	G	1461
UPLAND RIGHTS-OF-WAY DEVELOPED	G	1462
UPLAND RIGHTS-OF-WAY UNDEVELOPED	G	1463
STORMWATER BASIN	P	1499
INDUSTRIAL AND COMMERCIAL COMPLEXES	P	1500
MIXED URBAN OR BUILT-UP LAND	P	1600
OTHER URBAN OR BUILT-UP LAND	G	1700
CEMETERY	G	1710
CEMETERY ON WETLAND	G	1711
PHRAGMITES DOMINATE URBAN AREA	G	1741
MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	G	1750
RECREATIONAL LAND	G	1800
ATHLETIC FIELDS (SCHOOLS)	G	1804
STADIUM, THEATERS, CULTURAL CENTERS AND ZOOS	G	1810
MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA	G	1850
CROPLAND AND PASTURELAND	NP	2100
AGRICULTURAL WETLANDS (MODIFIED)	NP	2140
FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)	NP	2150
ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS	NP	2200

CONFINED FEEDING OPERATIONS	G	2300
OTHER AGRICULTURE	G	2400
DECIDUOUS FOREST (10-50% CROWN CLOSURE)	NP	4110
DECIDUOUS FOREST (>50% CROWN CLOSURE)	NP	4120
CONIFEROUS FOREST (10-50% CROWN CLOSURE)	NP	4210
CONIFEROUS FOREST (>50% CROWN CLOSURE)	NP	4220
PLANTATION	NP	4230
MIXED FOREST (>50% CONIFEROUS WITH 10-50% CROWN CLOSURE)	NP	4311
MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)	NP	4312
MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)	NP	4321
MIXED FOREST (>50% DECIDUOUS WITH >50% CROWN CLOSURE)	NP	4322
OLD FIELD (< 25% BRUSH COVERED)	NP	4410
PHRAGMITES DOMINATE OLD FIELD	NP	4411
DECIDUOUS BRUSH/SHRUBLAND	NP	4420
CONIFEROUS BRUSH/SHRUBLAND	NP	4430
MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND	NP	4440
SEVERE BURNED UPLAND VEGETATION	G	4500
STREAMS AND CANALS	G	5100
EXPOSED FLATS	G	5190
NATURAL LAKES	G	5200
ARTIFICIAL LAKES	G	5300
TIDAL RIVERS, INLAND BAYS, AND OTHER TIDAL WATERS	G	5410
OPEN TIDAL BAYS	G	5411
DREDGED LAGOON	G	5420
ATLANTIC OCEAN	G	5430
SALINE MARSH (LOW MARSH)	NP	6111
SALINE MARSH (HIGH MARSH)	NP	6112
FRESHWATER TIDAL MARSHES	NP	6120
VEGETATED DUNE COMMUNITIES	NP	6130
PHRAGMITES DOMINATE COASTAL WETLANDS	NP	6141
DECIDUOUS WOODED WETLANDS	NP	6210
CONIFEROUS WOODED WETLANDS	NP	6220
ATLANTIC WHITE CEDAR WETLANDS	NP	6221
DECIDUOUS SCRUB/SHRUB WETLANDS	NP	6231
CONIFEROUS SCRUB/SHRUB WETLANDS	NP	6232
MIXED SCRUB/SHRUB WETLANDS (DECIDUOUS DOM.)	NP	6233
MIXED SCRUB/SHRUB WETLANDS (CONIFEROUS DOM.)	NP	6234
HERBACEOUS WETLANDS	NP	6240
PHRAGMITES DOMINATE INTERIOR WETLANDS	NP	6241
MIXED WOODED WETLANDS (DECIDUOUS DOM.)	NP	6251
MIXED WOODED WETLANDS (CONIFEROUS DOM.)	NP	6252
UNVEGETATED FLATS	NP	6290
SEVERE BURNED WETLAND VEGETATION	G	6500

BEACHES	NP	7100
BARE EXPOSED ROCK, ROCK SLIDES, ETC	P	7200
EXTRACTIVE MINING	P	7300
ALTERED LANDS	P	7400
DISTURBED WETLANDS (MODIFIED)	G	7430
TRANSITIONAL AREAS	G	7500
UNDIFFERENTIATED BARREN LANDS	P	7600

Key
P – DEP Category 1 (Preferred Site) for Solar
G – DEP Gray Area Site for Solar
NP – DEP Category 2 (Not Preferred) Site for Solar