United States Environmental Protection Agency

Solar Photovoltaic Screening Study of Properly Closed Municipal Solid Waste Landfills - Siting Solar Photovoltaics at the Town of Bethel Landfill

Prepared by the Environmental Protection Agency, Region 2

August 2016

Acknowledgments:

We would like to thank Daniel Sturm, Town Supervisor and Karen London, Co-chair - Bethel Green Committee for their assistance with facilitating the Town of Bethel landfill visit.

This report is to be used for screening purposes only.

Additional evaluations will need to be conducted to fully characterize the feasibility and economics of the Town of Bethel landfill for photovoltaic (PV) installation. Third party solar developers and local utility companies may have technical and financial interests in pursuing potential solar renewable energy projects and should perform additional solar assessments to determine if projects are economically viable.

While the Town of Bethel landfill has been screened for solar PV, the findings of this solar screening study should not be the sole basis for determining if a PV system at the site is viable. The results of this study are presented in an unbiased manner.

This study does not assess the environmental conditions at the site.

EPA Region 2 Solar Team members:

Fernando Rosado,
rosado.fernando@epa.gov

Vince Pitruzzello
vince.pitruzzello@gmail.com

EPA Student Interns:

Lena Suponya,
Macaulay Honor Program - Hunter College
suponya.lena@epa.gov

Leah Curry,
Columbia University
curry.leah@epa.gov

Technical Support: Department of Energy/National Renewable Energy Lab (DOE-NREL)

Table of Contents:

List of Tables:

Attachments:

I. Purpose of the Solar Screening Report

Through the U.S. EPA RE-Powering America's Land Initiative, EPA promotes the reuse of potentially contaminated properties, landfills, and mining sites for renewable energy generation. This initiative identifies the renewable energy potential of these sites and provides useful resources for communities, developers, industry, state and local governments or anyone interested in reusing these sites for renewable energy development. A list of RE-Powering America Initiative resources is provided at the end of this report (Section VIII) and can be found at http://www.epa.gov/oswercpa.

This solar screening report provides screening/preliminary information to assist the Town of Bethel officials in determining the potential for solar photovoltaic (PV) electricity generation at the Town landfill. In general, the solar PV system represented in this report is a standalone system sized on proposed available area located at the Town of Bethel landfill. It should be noted that the viability of implementing a solar PV system on a landfill is highly impacted by the available area for an array, solar resource, shading, operating status, landfill cap status, distance to transmission lines, distance to major roads, favorable economic conditions, and community support.

II. Background

The Town of Bethel landfill serviced the Town until its closure in 1999. According to the US Census as of 2010, the population of the Town of Bethel is 4,204 people. The Town of Bethel landfill is operated by Town officials. The landfill is situated approximately a quarter mile east from NYS Route 55 in Swan Lake, Sullivan County, New York. It is about three miles north of NYS Route 17B.

A geomembrane cap was used to cover the landfill in 2000, upon which some vegetation exists. The grass is mowed annually. A passive venting system exists on the site. A groundwater and leachate collection system is in place along the southeast border of the landfill. Gas monitoring occurs annually. The most recent landfill inspection was completed in September 2015 by Sterling Environmental Engineers, P.C. There are currently no concerns regarding settlement, flooding or erosion.

A checklist of additional information about the landfill provided by the Town of Bethel can be found in Attachment #1.

III. Solar PV System Overview

Major System Components - A typical PV system is made up of several key components including:

- PV modules,
- Inverters and
- Balance-of-System components (including mounting racks, hardware for the panels, and wiring for electrical connections). Electrical connections (including wiring, disconnect switches, fuses, and breakers) are required to meet electrical code (e.g., NEC Article 690) for both safety and equipment protection.

In most traditional applications, wiring from the arrays to inverters (typically positioned off the landfill cap) and inverters to point of interconnection is generally run as direct burial through trenches or above ground using water/gas proof electrical conduits. For landfills, a solar PV array is connected to a mounting system that is anchored to a uniformly loaded concrete foundation or a ballasted system (see figure 1). It is recommended that PV system vendors reflect these costs in the requests for proposals when costing out the overall system.

Additional information about solar PV systems can be reviewed in Attachment #4.

Figure 1. - Fixed Axis Solar PV Array on a ballasted concrete foundation

IV. Solar PV System Siting Consideration/Assessment

Siting Considerations

On May 3, 2016, the U.S. Environmental Protection Agency, Region 2 (EPA) team, in cooperation with Town of Bethel officials visited and screened the closed landfill and surrounding non-landfill areas for potential solar photovoltaic (PV) renewable energy generation. In general for closed landfills, a minimum of 2 usable acres is recommended to site PV systems. Usable acreage is typically characterized as "flat to gently sloping" southern exposures that are free from obstructions and get full sun for at least a 6-hour period each day.

Other considerations for siting landfills for solar PV generation include:

Siting Concerns	Looking for:
Age of the properly closed/capped landfill	Minor settlement impacts based on the type of waste and age of the landfill. Landfill cap integrity must be maintained during construction and life of the solar PV array.
Site topography	Existing flat area and surface stability for the PV Array. Avoid slope/grade landfill areas > 10 degrees. Slope instability can give way and displace panels & impact solar performance.
Surface and vegetative conditions	Well maintained vegetative cover with minimum soil erosion concerns. Need to have existing storm water controls.
Shading/physical sunlight obstructions on the landfill	Open area with minimum shading from trees and existing on-site buildings in order to maximize sunlight on each solar panel.
Available access roads and close distance to highways/developed roads	Developed roads and easy access for material shipment and to support heavy construction vehicles entering the landfill.
Distance to available electrical transmission lines	Nearby utility lines to interconnect with the proposed solar PV system. Longer distance will have cost and efficiency impacts.
Landfill Gas	Inactive or passive gas wells with proper engineering controls. Integrating solar and landfill gas systems may require the use of gas-proof electrical conduits/fittings.
Nearby natural resources	Nearby wetlands or streams/water bodies. Be aware of any potential flooding concerns and existing endangered species inhabiting the landfill.
Town restrictions	Any specific local codes requirements/restrictions and future land reuse established by the municipality.

During the landfill visit, the EPA solar team screened for available flat and open landfill area free from sunlight obstruction and suitable to support solar panels. The EPA solar team also used a Solmetric SunEye[1] solar path calculator to assess shading at particular locations by analyzing the sky view where solar panels can be potentially located. By finding the solar access, the instrument can determine if the area is appropriate for solar energy generation.

For information about the Solmetric SunEye and the SunEye annual solar access summary for the Town of Bethel landfill is available in Attachment #2

[1] More information on this tool can be found at: http://www.solmetric.com/

Usable Landfill Acreage

Figure 2 shows the terrain map for the Town of Bethel landfill. The total estimated usable area for solar PV consideration at the Town landfill is approximately **5.45 acres based on GIS and on-site assessment**. This proposed area is where the slope of the landfill is relatively flat and avoids the area where there is a steeper gradient along the eastern section. It should be noted that this map does not include all of the non-landfill areas that were also evaluated for their potential to support PV panels.

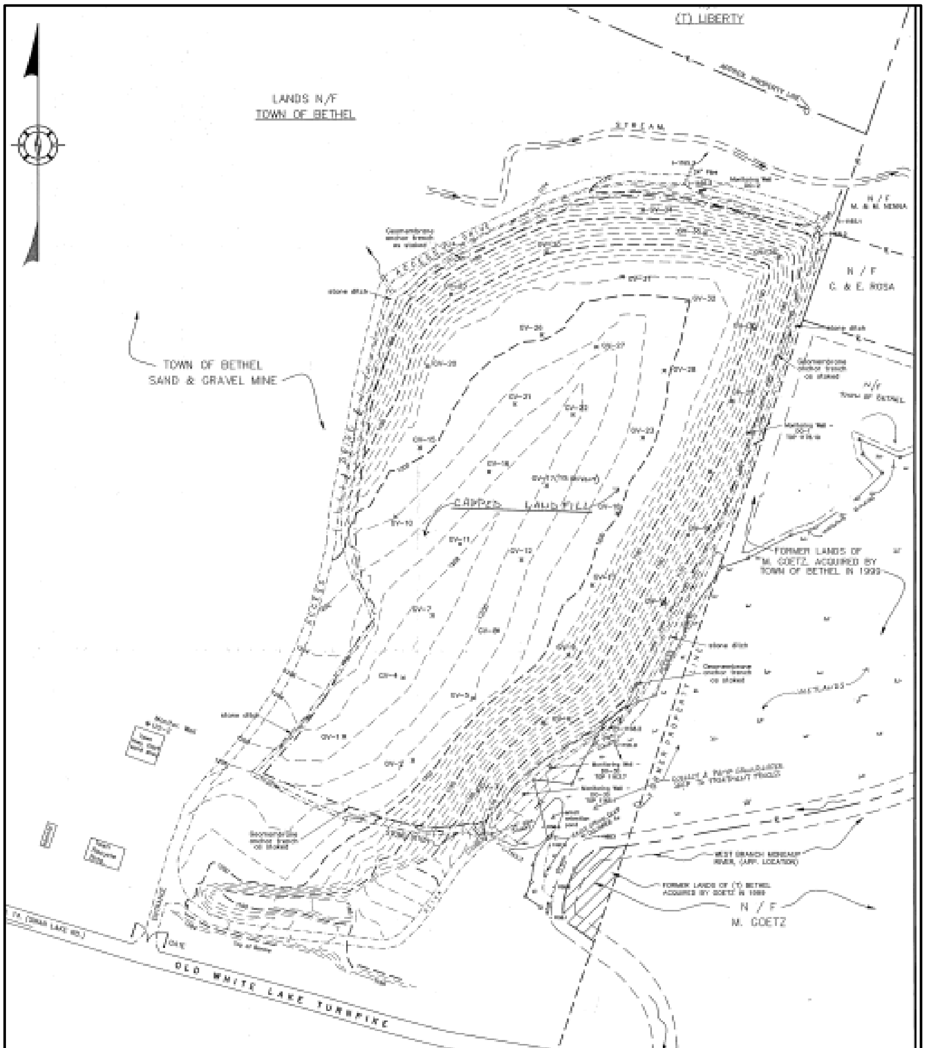


Figure 2. Topographic map of the Town of Bethel landfill

Figure 3 shows an aerial image of the proposed solar PV areas on the Town of Bethel landfill and surrounding area west of the landfill. An additional 1.55 acres was determined to be potentially viable outside of the perimeter of the landfill, bringing the total area to 7 acres. The proposed area on the landfill is shaded blue while the non-landfill areas that were considered viable for solar PV panels is shaded green. Although the EPA team recommends an estimated 7 acres for the proposed solar PV usable area, this acreage can be reassessed and adjusted by the municipality or potential third-party solar developers.

Figure 3 also includes sun icons that represent the locations where SunEye data points were taken to measure solar potential. **Overall, solar access yields averaged 99% annual solar exposure, which is within the favorable annual solar access range for PV systems.** More SunEye data can be found in Attachment #2. Areas closer to the tree line contained a higher amount of shading and obstruction, therefore these areas were not included in the 5.45 acres. The additional 1.55 acres of potential area (non-landfill areas #1 and #2) may need more preparation than the landfill area, due to additional vegetation.

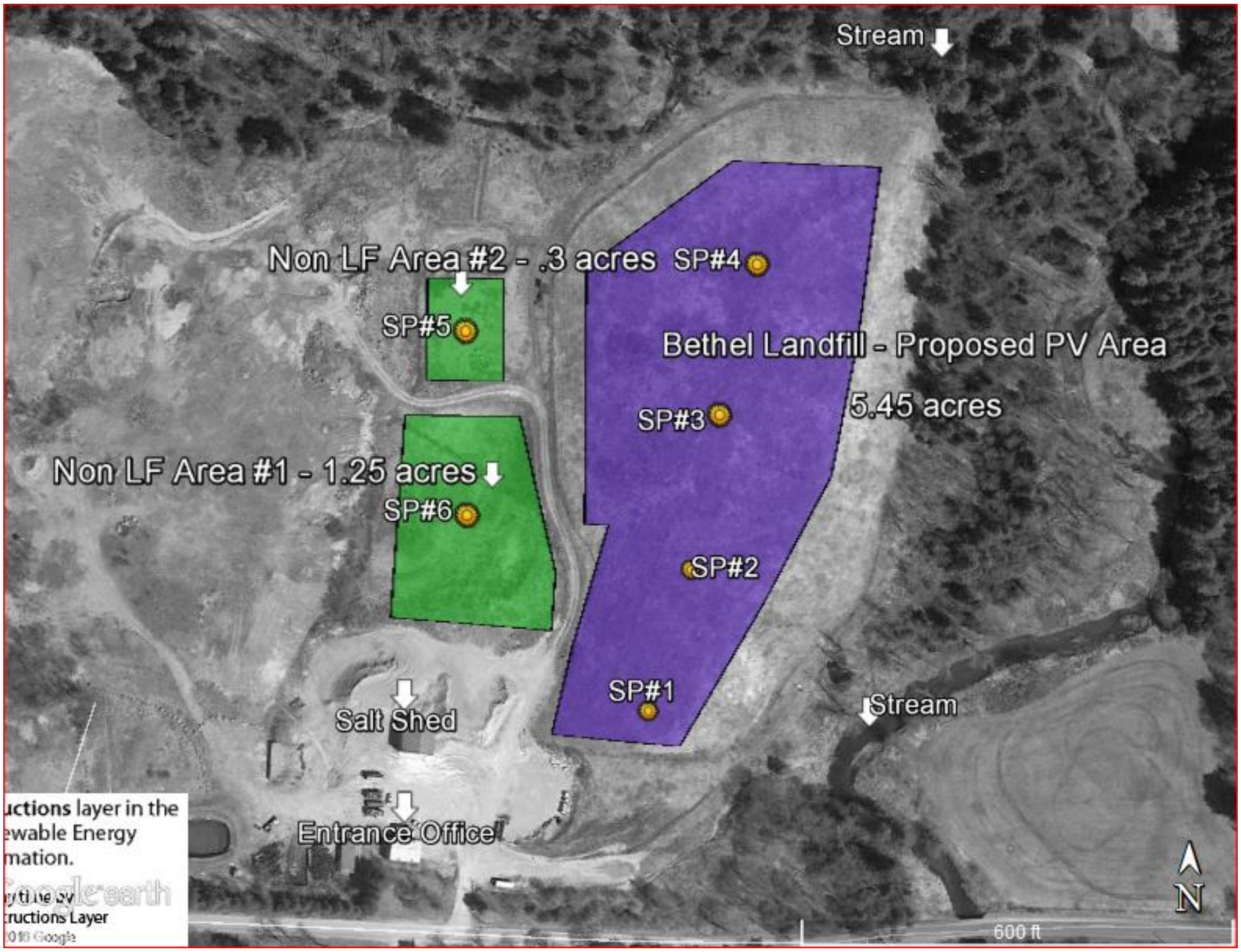


Figure 3. Aerial view of the feasible areas for PV on the Town of Bethel landfill (taken with Google Earth Pro)

The following photos of the Town of Bethel Landfill were collected during the site visit and illustrates the general potential usable PV solar areas.

Figure 4a: Looking south from northern portion of landfill

Figure 4b: Northeast view of the landfill

Figure 4c: Northern portion of landfill looking west towards non-landfill area #2

Figure 4d: Southeast view of the landfill, showing transmission lines

Figure 4e: Non-landfill #1 area southwest of landfill

Figure 4f: Looking east from center of the landfill

Figures 4A – 4F: Images of Bethel landfill (EPA Solar Team)

Transmission/Utility Resources

Electrical transmission lines run along the southeast perimeter of the landfill site as depicted in Figure 5. A utility meter is located approximately 100 feet from the proposed solar PV area. Transmission lines also run along the utility road that is just south of the entrance to the site. This distance is approximately 427 feet. In general, the distance from the proposed solar PV system to the point of interconnection with electrical transmission should be within a half mile distance in order to yield more viable economic conditions.

It is highly recommended that the Town consult with the electric distribution company (EDC) serving the area to discuss the potential for a solar project. In general, a preliminary interconnection transmission study from the local EDC is highly recommended early in the process if the Town officials decide to pursue PV solar generation on the landfill. The EDC that serves the Town of Bethel is New York State Electric and Gas[2] (NYSE&G).

Figure 5. Distance between the proposed solar PV area and transmission lines

The interconnection study will help NYSE&G to determine the feasibility of interconnecting to the electrical grid, assess if potential electrical upgrades are needed, and estimate the interconnection costs.

---

[2] https://www.nyseg.com/

All technical pertinent information about the proposed solar PV system should be provided to NYSE&G in accordance with the application requirements. While the interconnection of the landfill to the local transmission lines seems favorable, the transmission line available capacity to accommodate the solar power generated from the landfill will need to be assessed by NYSE&G. Coordination with NYSE&G is required to ensure that installations of distributed generation systems are properly designed to safely operate in parallel to the utility system, and to provide for net metering if applicable. In New York State, net metering is allowed for non-residential solar PV generation systems less than 2 MWs in size. For more information about NYSE&G's interconnection process and net metering, go to **http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/Shared/SuppliersPartners/PDFs%20and%20Docs/Bulletin%2086-01.pdf**.

Additional information about net metering can be found in section VII of the study.

Potential Off-Takers of the Generated Solar PV from the Town of Bethel Landfill:

As part of the PV siting consideration, potential solar PV off-takers were also identified. Directly adjacent to the landfill is the Town of Bethel Sand and Gravel Mine. The next closest buildings are the Sullivan County International Airport and the County 911 Emergency Control facility, located approximately 1 mile away. In Hamlets of White Lake and Kauneonga Lake, approximately 3 miles southwest of the landfill, there are several municipal buildings including two firehouses.

Electrical consumption among these facilities can be offset by the proposed solar power generated at this landfill. However, the actual electrical power consumption for these facilities are unknown, therefore further research would need to be done to determine if their consumption matches the power that would potentially be generated.

V. PVWatts System Sizing and Performance Results

PVWatts Analysis

PVWatts[3] calculator is an online tool developed by the Department of Energy - National Renewable Energy Laboratory (DOE-NREL) to estimate the electricity production of a grid-connected ground- or roof-mounted photovoltaic system. It requires only a few inputs including the location of the system, system size, and basic design parameters such as if it will be a fixed tilt or a single-axis tracking PV system. The design parameters have default values or users can adjust them according to their needs.

The DC system size required in PVWatts is determined with an acre-to-power conversion factor. Based on research done by NREL of ground mounted solar PV systems, a value of 5.74 acre/MW factor was used for a fixed-tilt system. For the Town of Bethel, this study recommends usable solar PV area on the landfill and non-landfill areas for a combined estimated area of 7 acres for a total system size of 1.2 MW DC.

The landfill location is used to connect to NREL's Typical Meteorological Year (TMY) data which is the closest weather data source. NREL has compiled TMY data for thousands of locations throughout the United States. This data includes the solar irradiance, which is a measurement of solar radiation on the surface of the earth and is measured by the power (Watts) per unit area (m^2), W/m^2. The solar radiation values represent 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. Solar radiation, or insolation (irradiance multiplied by time), is measured in units of Watt hours per unit area during a specific time interval. Solar radiation above 3.5 $kWh/m^2/day$, is considered favorable when considering PV siting locations.

[3] http://www.nrel.gov/rredc/pvwatts/ PVWatts®

For the Town of Bethel landfill, the TMY data is taken from Monticello, New York (1.2 miles from the landfill location) and the solar radiation level was measured at **4.07 kWh/m²/day.** The weather station identification information, PV system specifications, energy specifications, and performance results for the Town of Bethel landfill are provided in Table 1 and Table 2.

The monthly performance results for the proposed solar PV systems at the Town of Bethel Landfill as calculated by PVWatts can be found in Attachment #3.

Table 1 – PV Watts Site Identification Information for the Town of Bethel Landfill

Weather and PV System Technical Specifications	
Weather Data Source:	**Monticello, Sullivan County, New York**
State (TMY3):	**New York**
Latitude:	**41.7° N**
Longitude:	**74.8° W**
Array Type:	**Fixed-Tilt**
Solar Radiation Levels:	**4.07 kWh/m²/day**
System Losses*:	**14%**
Array Tilt:	**20°**
Array Azimuth:	**180° South**

**Systems Losses is another input parameter for the PV Watts calculator. It is also referred to as the DC to AC Derate Factor and is calculated from all of the losses that the system experiences when converting DC power to grid-ready AC power. These include accuracy for PV module nameplate DC rating, conversion efficiency of the inverter and transformer, mismatch, diodes and connections (voltage drops), DC and AC wiring (resistive losses), soiling, system availability, shading, sun-tracking and age.*

Table 2. PV System Yearly Performance Results for the Town of Bethel Landfill and surrounding area for a Fixed-Tilt System

Location	Usable PV Area	DC System Size	AC Energy Based on PVWATTS	GHG Reduction* (metric tons CO_2e)	GHG Emissions Equivalent to # of Vehicles Driven Yearly
Landfill	5.45 acres	949.5 kW DC	1,134,706 kWh/year	797 $MTCO_2$e	168 cars
Non-Landfill Area #1	1.25 acres	217.8 kW DC	260,283 kWh/year	183 $MTCO_2$e	39 cars
Non-Landfill Area #2	0.3 acres	52.3 kW DC	62,501 kWh.year	44 $MTCO_2$e	9 cars
Combined Total	**7 acres**	**1.2 MW DC**	**1.46 million kWh/year**	**1,024 $MTCO_2$e**	**217 cars**

**EPA's Greenhouse Gas (GHG) Equivalencies Calculator (http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator) was used to determine the GHG reductions based on the proposed AC energy.*

Cautions for Interpreting Results – Weather Variability

Monthly and yearly energy production is modeled using photovoltaic system selected parameters and weather data that is typical or representative of long-term averages. Because weather patterns vary from year to year, the values in Table 2 are better indicators of long-term performance than of performance for a specific month or year. Photovoltaic system performance is largely proportional to the amount of solar radiation received, which may vary from the long-term average by ±30% for monthly values and ±10% for annual values.

VI. Forecasted Economics

In general, the forecasted economics for the solar PV system will factor in the needed PV arrays/tilt and orientation and balance of system (BOS) components including the inverter and electrical supply/equipment costs, as well as installation cost. Other cost factors for a PV system will depend on the system size, geographic location, mounting structure, type of PV module, and other soft costs (permit fees, installation/interconnection labor costs, sales tax, installer/developer profit, customer acquisitions costs, and transaction costs). For more information about understanding and managing solar soft costs go to **http://energy.gov/eere/sunshot/soft-costs.**

Based on NREL's Solar PV price and cost breakdown study[4], significant cost reductions in 2015 shows the average cost for utility-scale ground-mounted systems (includes the engineering, procurement, and construction (EPC) system hardware, other EPC direct/indirect costs, and developer costs) declined from $3.76/W in the fourth quarter of 2010 to $1.77/W in the first quarter of 2015. However, this price is for systems 100 MW in size, much larger than the system that is being proposed for the Town of Bethel landfill and the surrounding areas. Therefore, a median price of $1.96/W was used for a preliminary economic analysis. This was obtained as the median between $1.77//W and $2.15/W, a typical cost for a system 0.2 MW in size. For a landfill site, it is necessary to use a ballasted system in order to ensure the integrity of the landfill cap. This can increase the cost by approximately 25%, bringing the price used in this analysis to $2.45/W. In the non-landfill areas, it is not necessary to use a ballasted system, therefore the $1.96 price was used to estimate the cost of those areas.

With an increasing demand and supply, potential cost reductions may be expected as market conditions continue to evolve. It should be emphasized that this is a very rudimentary estimation of the economics involved for this proposed area and a more detailed analysis will be necessary moving forward. The projected estimated cost only factors the estimated initial installation costs and does not reflect the true cost of the system since available NYS incentives that may lower the costs are not included and the associated soft costs to develop the solar PV can vary for this project. Additional steps may be necessary in order to install PV panels at these sites, such as site preparation and the interconnection requirements, which can drive the overall cost.

[4] http://www.nrel.gov/docs/fy15osti/64746.pdf U.S. Photovoltaic Prices and Cost Breakdowns: Q1 2015 Benchmarks for Residential, Commercial, and Utility Scale Systems

Table 3 provides the initial system costs for a fixed tilt PV system based on the above stated pricing assumptions. The project is expected to have an optimal 25 year lifespan, although the system can be reasonably expected to continue operation past this point.

Table 3. PVWatts Initial Economic Considerations

Fixed-Tilt PV System	
Initial installation system cost (ballasted)	$2.45 /Wdc
Landfill PV System Size (5.45 acres)*	949.5 kW DC
Landfill Projected Estimated Cost	$2,326,275
Initial installation system cost (non-ballasted)	$1.96 /Wdc
Non-Landfill Area #1 PV System Size (1.25 acres)	217.8 kW DC
Non-Landfill Area #1 Projected Estimated Cost	$426,888
Non-Landfill Area #2 PV System Size (0.3 acres)	57.5 kW DC
Non-Landfill Area #2 Projected Estimated Cost	$112,700
Total Proposed System Size	**1.2 MW DC**
Total Projected Estimated Cost	**$2,865,863**
Average regional cost of electricity* (combined sectors as of April 2016)	13.85 ₵/kWh

Average regional combined cost of electricity for the State of NY found through the US Energy Information Administration (USEIA) as of April 2016.* ***http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a*

VII. Benefits

In general, due to the presence of suspected or known contaminants, landfills have limited redevelopment potential and solar PV installations can be a viable reuse. Many municipal solid waste (MSW) landfills are particularly well-suited for solar development because they are often:

- Located near critical infrastructure including electric transmission lines and roads;
- Located near areas with high energy demand (e.g., large population bases);
- Constructed in areas of low grade (0-10%) needed for siting of solar PV structures;
- Offered at lower land costs when compared to open space;
- May be adequately zoned for renewable energy;
- May have environmental conditions that are not well-suited for commercial or residential redevelopment;
- Can provide job opportunities in urban and rural communities;
- Are able to accommodate net metered or utility scale projects; and
- May reduce the environmental impacts of energy systems (e.g., reduce greenhouse gas emissions).

The **New York State Energy Research and Development Authority (NYSERDA)** promotes energy efficiency and the use of renewable energy sources in New York. According to NYSERDA, solar PV generation offers the following key benefits:

- PV systems are gentle on the environment, in contrast with electricity generated by fossil fuels;
- PV-generated electricity creates no noise, air, or water pollution;
- PV systems provide long-term stabilization of electrical costs;
- When combined with a battery backup system, a PV unit can provide power when utility power is not available.

In addition, this study outlines various financial incentives (Section VI – Incentives) that could assist in financing the implementation of a solar PV system including incentives offered by NYSERDA.[5] To learn about programs and funding opportunities available through NYSERDA from the NY-Sun Initiative, contact Maureen Leddy, Associate Project Manager, NYSERDA via email at maureen.leddy@nyserda.ny.gov or go to http://www.ny-sun.ny.gov/.

Net Metering/Remote Net Metering:

In New York State, another benefit to implementing a renewable energy system is **net metering/remote net metering**. Net metering/remote net metering is allowed for non-residential solar PV generation systems less than 2 MWs in size. In a conventional net metering situation, a **customer-sited renewable energy system** is connected to the utility grid through a customer's utility meter. This is known as "behind-the-meter generation." At any given moment, if the site is using more electricity than the system is producing, all the electricity produced by the system is used on-site and the site's electricity needs are supplemented from the grid. If the site is using less electricity than the system is producing, the excess electricity is exported to the grid and the customer receives a credit. This is typically recorded as negative use and is commonly referred to as the "meter spinning backwards." At the end of the billing cycle, the grid-supplied electricity and the credits for any exported electricity are reconciled, and any surplus credits can be carried forward to the next billing cycle. The specifics of net metering are dependent on the customer's service classification. Customers who are eligible for remote net metering may apply those credits to electric bills from facilities that are not located at the same physical location as the PV system. Additional information about net/remote net metering can be found at: http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Renewables/Net-Metering-Interconnection.aspx

It should be noted that the New York State Public Service Commission (PSC) ordered (effective December 15, 2014) changes to net metering minimum caps, tariff revisions, and other related items and findings for further consideration. The PSC order can be found at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={460384B1-A9DE-4306-B3D2-6B9211FB9056}. It is highly recommended that the Town of Bethel consult with New York State Electric and Gas to discuss net metering opportunities.

Power Purchase Agreements:

A number of municipalities that own or operate landfills have expressed interest in potential revenue flow from solar PV systems. In some cases, revenue can be generated by the use of PV on a landfill site pending actual site conditions, financial incentives, economic conditions, and support from the utility companies. While the findings of this report do not recommend how a solar array at a landfill will be financed, if the municipality decides that they do not want to invest their own funds to build the solar site, they can consider entering into a Power Purchase Agreement (PPA) with a solar developer who would assume the cost of development.
To learn more about PPA structures, please go to the following PPA checklist for state and local governments link: http://www.nrel.gov/docs/fy10osti/46668.pdf or the Interstate Renewable Energy Council PPA toolkit for local governments: http://www.irecusa.org/solar-power-purchase-agreements-a-toolkit-for-local-governments/

[5] http://www.nyserda.ny.gov/

Incentives

The economics of a PV system will also depend on NYS financial incentives, available federal tax credit, the regional cost of electricity, the solar resource, solar panel tilt and orientation, site conditions, distance to the electrical interconnection, and other critical requirements highlighted in this report. Table 4 provides several possible financial incentives that can be considered by the Town of Bethel officials to assist with financing the proposed solar PV systems.

Table 4. Summary of Applicable Incentives

Federal and State Investment Tax Credit*	As of December 2015, System owners may continue to qualify up to 30% Federal Investment Tax Credit which is expected to step down to 26 percent in 2020 and 22 percent in 2021. After 2023, the residential credit will drop to zero while the commercial and utility credit will drop to a permanent 10 percent. Always consult with your qualified tax professional or accountant to determine your eligibility for tax credits.
Modified Accelerated Cost Recovery System (MACRS)	MACRS depreciation is also considered another important financial incentive. The MACRS is a method of depreciation in which a business' investments in certain tangible property are recovered, for tax purposes, over a specified time period through annual deductions. Qualifying solar energy equipment is eligible for a cost recovery period of five years. More information about MARCS is available at: http://www.seia.org/policy/finance-tax/depreciation-solar-energy-property-macrs.
NY-Sun Solar Electric Incentive Program	NYSERDA provides cash incentives for the installation by Eligible Installers/Contractors of new grid-connected Electric Photovoltaic (PV) systems that are 200 kW or less for non-residential sites. (Revised 4/2016) More information is available at: http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-2112-Solar-PV-Program-Financial-Incentives
NY-Sun Initiative for PV Systems Greater than 200 kW	Incentives for solar PV installations are available on a rolling application first-come, first-served basis for eligible projects. More information is available at: http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-3082-NY-Sun-Commercial-Industrial-Incentive-Program.
Community Solar NY Round 2	NYSERDA provides marketing materials and technical assistance as well as funding for campaign expenses for local governments, school districts, and other community partners who qualify to participate in Community Solar NY, a new effort to make solar easier and more affordable through community-driven initiatives. More information about the short term support from NYSERDA go to: http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-3011-Community-Solar-NY-Round-2
Clean Energy Financing Arrangements	The New York Green Bank invites private sector capital providers and other clean energy industry participants to propose partnership arrangements with the Green Bank that would facilitate the financing of clean energy projects (including energy generation and energy savings projects) in the State of New York. More information is available at: http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/RFP-1-Clean-Energy-Financing-Arrangements
Other Incentives	For other applicable incentives, go to the following website: http://www.dsireusa.org/incentives/index.cfm?state=NY

VIII. RE-Powering America's Land

Through the RE-Powering America's Land Initiative, the U.S. EPA promotes the reuse of potentially contaminated properties, landfills, and mining sites for renewable energy generation. This initiative identifies the renewable energy potential of these sites and provides useful resources for communities, developers, industry, state and local governments or anyone interested in reusing these sites for renewable energy development. Various RE-Powering America Initiative resources are summarized below and can be found at http://www.epa.gov/oswercpa.

- **Mapping and Screening Tools -** Under Mapping and Screening tools, EPA's RE-Powering America's Land team screened more than 80,000 potentially contaminated sites and MSW landfills covering nearly 43 million acres across the United States for suitability to site renewable energy generation facilities, including utility-scale solar. Maps depicting the locations of these EPA tracked sites and their potential for supporting renewable energy generation can be found at www.epa.gov/oswercpa/mapping_tool.htm. These maps enable users to view screening results for various renewable energy technologies at each site.

- **Technical Assistance and Support** - As part of the RE-Powering America's Land Initiative, the EPA and the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) are evaluating the feasibility of developing renewable energy production on Superfund, brownfields, and former landfills or mining sites. This project pairs EPA's expertise on contaminated sites with the renewable energy expertise of NREL. A list of feasibility studies for renewable energy production for various technologies including solar and can be found at www.epa.gov/oswercpa/rd_tech_assist.htm.

- **Redevelopment Tools and Resources –** Under Redevelopment Tools and Resources, EPA and NREL created the joint publication, "**Best Practices for Siting Solar PV on Municipal Solid Waste Landfills**" to provide assistance in addressing common technical challenges of siting PV on MSW landfills (such as impacts to landfill settlement differentials and the PV solar performance, impacts to other landfill systems, understanding landfill cap integrity/characteristics, and understanding landfill post-closure requirements for solar PV design considerations) and provide other useful information for solar developers, landfill owners, and federal, state, and local government entities. Other documents for stakeholders to consider are "**RE-Powering Finance Fact Sheet, "Handbook on Siting Renewable Energy Projects while Addressing Environmental Issues", and "Revised Bona Fide Prospective Purchaser (BFPP) Provisions Enforcement Guidance for Tenants.**"

- **Fact Sheets and Success Stories -** The RE-Powering team highlights numerous successful stories and fact sheets of renewable energy projects implemented throughout the United States. The RE-Powering America team also maintains a list of completed renewable energy installations on contaminated sites and landfills. To date, the RE-Powering Initiative has identified 179 renewable energy installations on 171 contaminated lands, landfills, and mine sites, with a cumulative installed capacity over 1124 megawatts (MW) and consistent growth in total installations since the inception of the RE-Powering Initiative.

IX. Conclusions

Overall, the Town of Bethel landfill appears to have favorable site conditions to support solar PV generation and viable reuse. Additionally there are areas nearby the landfill that also had favorable properties. The majority of the landfill was relatively flat vegetative area with high solar access, making it an ideal site to install solar panels. Shading obstructions were only apparent near the perimeter of the landfill where there is a high tree line. Transmission lines are conveniently placed near the landfill, offering potential interconnection with the local utility. In general, the proposed location appears to offer adequate usable area for the installation of solar photovoltaic panels, especially when considering both the landfill and non-landfill areas. Based on EPA's screening and assessment of the existing physical landfill conditions, EPA supports the potential of solar PV generation at the Town of Bethel landfill.

While this solar screening study provides the PV system sizes based on proposed usable areas, the Town of Bethel would need to further assess the actual system PV size, installation costs, availability of funds, and the amount of power that can be utilized and sold. As indicated earlier, a third-party developer power purchase agreement (PPA) is another feasible way for a system to be financed for these sites. In exchange for access to a site through a lease arrangement, third-party solar developers can finance, develop, own, and operate the solar projects utilizing their own expertise and sources of financing. These private enterprises are also able to take advantage of the federal tax benefits that cannot be captured by municipalities (or other entities that do not pay corporate income taxes), which should lower the total system cost. If solar PV systems were considered physically and financially viable to install at this site by a third-party solar developer, the third-party solar developer could sell the electricity to the site host (local town facilities) or local utility via a PPA at negotiated rates for a period of time typically varying from 20-25 years

Benefits from solar generation on the landfill could include competitively priced electricity from the project, revenues via land lease payments from a solar developer, potentially reduced landfill operation and maintenance responsibilities and costs, job creation and stimulation of the local economy during solar construction, and reduction in greenhouse gas emissions from current power sources. Thus, using obtainable and accessible land that is unavailable for redevelopment allows for repurpose of land that would not otherwise be productive.

X. Next Steps

Early and proper planning with other key stakeholders is critical to the success of a solar PV system. The following stakeholders should be consulted in the early stages of a solar PV project:

New York State Department of Environmental Conservation (NYSDEC):

NYSDEC

The Town of Bethel must coordinate early with the **NYSDEC.** To initiate this process, contact James Lansing, Region 3 Materials Management Engineer at (845) 256-3123 or via email at james.lansing@dec.ny.gov. NYSDEC's review and approval of the proposed solar PV work is necessary in order to ensure that the integrity and protective measures put in place for the existing landfill cap are maintained throughout the life of the project.

To that end, it will be necessary to provide all related information to NYSDEC for the proposed solar PV system including:

- Location of the landfill and the PV system size,
- Estimated usable area on the landfill for the solar PV installation,
- The mounting foundation type placed on the landfill,
- The landfill cap's ability to withstand both the construction and long-term operation loads of the PV system,
- Impacts to the landfill cap integrity,
- Proper set back from the gas vents and no impacts to the gas venting,
- Potential storm water management issues, and
- Any additional information requested by NYSDEC.

In general, NYSDEC regional representatives' names and contact information can be found at http://www.dec.ny.gov/chemical/76718.html. For general questions associated with solar development at New York landfills, contact Gus Carayiannis, Chief, Bureau of Permitting and Planning at (518) 402-8678 or via email at gus.carayiannis@dec.ny.gov.

Coordination with the Local Utility Provider:

NYSE&G

New York State Electric and Gas (NYSE&G) should be consulted early in the planning stages so that the municipality can be alerted to any potential transmission interconnection issues that might exist or equipment upgrades needed to facilitate the solar project. The Town of Bethel officials may request a transmission interconnection study from NYSE&G. As indicated earlier, all technical pertinent information about the proposed solar PV system should be provided to NYSE&G in accordance with their application requirements.

Coordination with the NYSERDA, NY SUN - PV Training Network (PVTN):

NYSERDA NY SUN - PVTN

In addition to the solar PV financial incentives from NYSERDA, the NY-Sun PV Trainer Network can offer education, training, and technical assistance for municipalities interested in identifying and developing solar electric markets while mitigating barriers. The NY-Sun PVTN can also provide help and training to municipalities with the solar procurement process, streamlining the solar permit process, and one on one technical assistance. For more information and training offered by the NY-Sun PVTN, go to https://training.ny-sun.ny.gov or contact Vicki Colello at vicki.collelo@nyserda.ny.gov or call (518) 862-1090.

NY-Sun PVTN offers additional resources at https://training.ny-sun.ny.gov/resources. Of particular interest to municipalities, is the "Solar Procurement Guidelines for Local Governments in New York State".

As a reminder, this report is to be used for screening purposes only.

Additional evaluations will need to be conducted to fully characterize the feasibility and economics of the Town of Bethel landfill for PV installation. Third party solar developers and local utility companies may have technical and financial interests in pursuing potential solar renewable energy projects and should perform additional solar assessments to determine if projects are economically viable.

This study does not assess the environmental conditions at the site.

Attachment #1 – The Town of Bethel Landfill Information:

Landfill General and Closure Information	
Landfill/site name	Town of Bethel Landfill
Landfill physical address	608 Old White Lake Turnpike, Swan Lake, NY 12783
Landfill site operator/owner	Town of Bethel
County official contact	Daniel Sturm, Town Supervisor (phone: 845-583-4350; email: bethelsupervisor@libertybiz.rr.com
Landfill closure date	1999
Annual post-closure monitoring/maintenance report	"Annual 2015 Post-Closure Monitoring Report", dated Sept. 3, 2015 by Sterling Environmental Engineers, P.C.
Final landfill closure plan	Landfill Closure As-Built Plan, dated Feb 9. 2000, available upon request
Landfill Physical Characteristics	
Landfill size	8.7 acres
Landfill cap type	Grass cover on 6" topsoil layer over 12" soil drainage layer over a 40 mm thick HDPE geomembrane. Landfill is mowed annually.
Potential usable landfill area for solar PV	Approx. 300'x800'=5.5 acres *(note this study found 7 potential usable acres)*
Landfill orientation	North to south orientation, top is generally a shallow mound, 5% slopes
Physical conditions	Vegetated, high grass-no erosion
Landfill shading concerns	Tree line at the perimeter
Landfill settlement/floodplains/wetlands concerns	None
Existing landfill treatment systems	Some groundwater/leachate collected along southeast edge of footprint, pumped 800 ft to settling/aeration basin, discharged to subsurface absorption bed. No institutional limitations, cannot disturb landfill cover
Landfill contour maps or other site maps	See attached Figure #2.
Utility Information	
Utility company serving the area	New York State Electric and Gas Corp (NYSE&G)
Nearby major highways	1500' (+/-) to NYS Rt 55, approx. 3 south to NYS Rt 17B
Distance to electrical transmission lines	NYSE&G distribution lines exist along property frontage on town road, +/- 300 ft from landfill
Location of substations	3.5 miles to Coopers Corner substation along NYS Rt 17B, east of Mongaup Valley; 4 miles to NYSEG substation on Kelly Bridge Road, just south of Ferndale-Loomis Rd.
Landfill electrical load/classification	Undetermined
Other	
Ongoing remediation at the site	Annual post closure report
Private parties associated with the landfill	No
Existing site liens/bankruptcy status	None
Previous solar or interconnection studies	No
Nearest critical infrastructure from landfill	1) Approx. 3 miles east to Sullivan County Regional Medical Center/Hospital in Harris, NY 2) Approx. 3 miles southwest to Hamlets of White Lake and Kauneonga Lake, with town gov't buildings, town firehouses, town S.T.P. 3) 1 mile south to Sullivan County International Airport & County 911 Emergency Control facility
Potential off-takers of solar power generated	Yes
Community/municipality support	TBD
Can the load bearing capacity of the landfill accommodate loading from a solar system?	TBD
Potentially responsible parties (PRPs)	No
Estimated PV solar energy generation based on potential usable landfill area	Fixed-tilt PV system – 1.2 MW (based on 5.74 acres/MW area-to-power conversion factor)

Attachment #2 – SunEye Solar Measurements

The EPA solar assessment team used a Solmetric SunEye[6] solar path calculator to assess shading at particular locations by analyzing the sky view where solar panels will be located. By finding the solar access, the instrument can determine if the area is appropriate for solar panels. PV modules are very sensitive to shading. When shaded (either partially or fully), the panel is unable to optimally collect the high-energy beam radiation from the sun. PV modules are made up of many individual cells that all produce a small amount of current and voltage. These individual cells are connected in series to produce a larger current. If an individual cell is shaded, it acts as resistance to the whole series circuit, impeding current flow and dissipating power rather than producing it. By finding the solar access, it can be determined if the area is appropriate for solar power generation.

The assessment team collected six Solmetric SunEye data points (skyline views) across the entire perimeter of the landfill in sections with adequate flat area as shown is Figure #3. Overall, solar access yields averaged **99% annual solar exposure**, which is well within the favorable annual solar access range for PV systems.

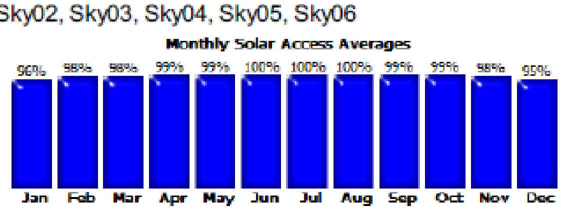
Session Properties

Name	Bethel Landfill, New York
Creation Date	6/2/2016 9:55
Note	Performed on May 3, 2016
Location	41.7°N, 74.8°W Mag Dec: 12.8°W Time Zone: GMT-05:00

Solar access averages of 6 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06

Annual	May-Oct	Nov-Apr
99%	99%	98%



TSRF averages of 6 skylines in this session: 96%

The Total Solar Resource Fraction (TSRF) is the ratio of insolation available accounting for both shading and Tilt and Orientation Factor (TOF), compared to the total insolation available at a given location at the optimum tilt and orientation and with no shading. TRSF is also expressed in percent. The TOF is the solar insolation at the actual tilt and orientation divided by the insolation at the optimum tilt and orientation, expressed in percent.

[6] More information on this tool can be found at: http://www.solmetric.com/

Attachment #3 – Monthly Performance Results for the Town of Bethel Landfill

Performance Results Fixed-Tilt PV System:		949.5 kW DC on landfill area	217.8 kw DC on non-landfill area #1	52.3 kw DC on non-landfill area #2
Month	**Solar Radiation* (kWh/m²/day)**	**AC Energy (kWh)**	**AC Energy (kWh)**	**AC Energy (kWh)**
January	2.37	60,768	13,939	3,347
February	3.34	76,646	17,581	4,222
March	4.14	104,147	23,890	5,737
April	4.09	94,644	21,710	5,213
May	4.42	104,390	23,945	5,750
June	6.21	136,049	31,207	7,494
July	6.65	147,205	33,766	8,108
August	5.25	118,206	27,115	6,511
September	4.28	94,107	21,587	5,184
October	3.71	88,293	20,253	4,863
November	2.33	55,970	12,839	3,083
December	2.10	54,282	12,451	2,990
Total	**4.07* Monthly Average**	**1,134,707** Annual**	**260,283** Annual**	**62,501** Annual**

***Solar radiation values above 3.5 kWh/m²/day are considered favorable when considering PV siting locations.**

**The solar photovoltaic performance degradation, a reduction in power generation due to long-term exposure, is under 1% per year. Silicon modules have a lifespan range of 25–30 years but can keep producing energy beyond this range. For information about, a reduction in power generation due to long-term exposure, go to http://www.nrel.gov/docs/fy12osti/51664.pdf.

Attachment #4 – PV Systems Overview

Major System Components - A typical PV system is made up of several key components including:

- PV modules,
- inverters and
- balance-of-system components (including mounting racks, hardware for the panels, and wiring for electrical connections). Electrical connections (including wiring, disconnect switches, fuses, and breakers) are required to meet electrical code (e.g., NEC Article 690) for both safety and equipment protection.

In most traditional applications, wiring from the arrays to inverters and inverters to point of interconnection is generally run as direct burial through trenches. It is recommended that PV system vendors reflect these costs in the requests for proposals when costing out the overall system.

Figure 6. Ground mounted array (source: NREL)

Solar PV cells are the electricity-generating component of a solar energy system. When sunlight (photons) strikes a PV cell, an electric current is produced by stimulating electrons (negative charges) in a layer in the cell designed to give up electrons easily. The existing electric field in the solar cell pulls these electrons to another layer. By connecting the cell to an external load, this current (movement of charges) can then be used to power the load, e.g., light bulb.

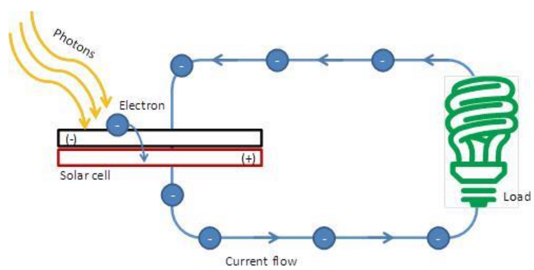


Figure 7. Generation of electricity from a PV cell (source: EPA)

PV cells are assembled into a PV panel or module. PV modules are then connected to create an array. The modules are connected in series and then in parallel as needed to reach the specific voltage and current requirements for the array. The direct current (DC) electricity generated by the array is then converted by an inverter to usable alternating current (AC) that can be consumed by adjoining buildings and facilities or exported to the electricity grid. PV system size varies from small residential (2-10 kilowatts (kW)), commercial (100-500 kW), to large utility scale (10+ megawatts (MW)). Central distribution plants are also currently being built in the 100 MW+ scale. Electricity from utility-scale systems is commonly sold back to the electricity grid.

The solar array has to be secured and oriented optimally to maximize system output. The structure holding the modules is referred to as the mounting system. The mounting systems can be ground mounted utilizing a ballast system on top of a landfill cap where there are commonly large unshaded areas. For ground mount systems, the mounting system can be either directly anchored into the ground (via driven piers or concrete footers) or ballasted on the surface without ground penetration. Mounting systems must withstand local wind loads, which range from 90–120 mph range for most areas or 130 mph or more for areas with hurricane potential. Depending on the region, snow and ice loads must also be a design consideration for the mounting system.

PV Module

Module technologies are differentiated by the type of PV material used, resulting in a range of conversion efficiencies from light energy to electrical energy. The module efficiency is a measure of the percentage of solar energy converted into electricity. Two common PV technologies that have been widely used for commercial- and utility-scale projects are crystalline silicon and thin film.

Crystalline Silicon

Traditional solar cells are made from silicon. Silicon is quite abundant and nontoxic. It builds on a strong industry on both supply (silicon industry) and product side. This technology has been demonstrated for a consistent and high efficiency over 30 years in the field. The performance degradation, a reduction in power generation due to long-term exposure, is under 1% per year. Silicon modules have a lifespan in the 25-30-year range but can keep producing energy beyond this range.

Typical overall efficiency of silicon solar panels is between 12% and 18%. However, some manufacturers of mono-crystalline panels claim an overall efficiency nearing 20%. This range of efficiencies represents significant variation among the crystalline silicon technologies available. The technology is generally divided into mono- and multi-crystalline technologies, which indicates the presence of grain-boundaries (i.e., multiple crystals) in the cell materials and is controlled by raw material selection and manufacturing technique. Crystalline silicon panels are widely used based on deployments worldwide.

Figure 10 shows two examples of crystalline solar panels: mono- and multi-silicon installed on tracking mounting systems.

Figure 8. Mono- and multi-crystalline solar panels. ***Photos by (left) SunPower Corporation, NREL 23816 and (right) SunPower, NREL 13823***

Thin Film:

Thin-film PV cells are made from amorphous silicon (a-Si) or non-silicon materials such as cadmium telluride (CdTe). Thin-film cells use layers of semiconductor materials only a few micrometers thick. Due to the unique nature of thin films, some thin-film cells are constructed into flexible modules, enabling such applications as solar energy covers for landfills such as a geomembrane system. Other thin film modules are assembled into rigid constructions that can be used in fixed tilt or, in some cases, tracking system configurations.

The efficiency of thin-film solar cells is generally lower than for crystalline cells. Current overall efficiency of a thin-film panel is between 6% and 8% for a-Si and 11-12% for CdTe. Figure 4 shows thin-film solar panels. Industry standard warranties of both crystalline and thin film PV panels typically guarantee system performance of 80% of the rated power output for 25 years. After 25 years, they will continue producing electricity at a lower performance level.

Mounting Systems:
The array has to be secured and oriented optimally to maximize system output. The structure holding the modules is referred to as the mounting system. Typical ground mounted systems can be categorized as fixed-tilt or tracking. Fixed-tilt mounting structures consist of panels installed at a set angle, typically based on site latitude and wind conditions, to increase exposure to solar radiation throughout the year. Fixed-tilt systems are used at many landfill sites. Fixed-tilt systems have lower maintenance costs but generate less energy (kWh) per unit power (kW) of capacity than tracking systems. The selection of mounting type is dependent on many factors including installation size, electricity rates, government incentives, land constraints, soil conditions, alignment and latitude requirements, and local weather.

The mounting system design will also need to meet applicable local building code requirements with respect to snow, wind, and seismic zones. Selection of mounting types should also consider frost protection needs especially in cold regions. Contaminated land applications may raise additional design considerations due to site conditions, including differential settlement. Selection of the mounting system is also heavily dependent on anchoring or foundation selection.

Inverters:
Inverters convert DC electricity from the PV array into AC electricity, which can connect seamlessly to the electricity grid. Inverter efficiencies can be as high as 98.5%. Inverters also sense the utility power frequency and synchronize the PV-produced power to that frequency. When utility power is not present, the inverter will stop producing AC power to prevent “islanding,” a condition which could be dangerous to utility workers trying to fix a de-energized distribution system. This safety feature is built into all grid-connected inverters in the market.

Electricity produced from the PV system may also be fed to a step-up transformer to increase the voltage to match the grid. There are two primary types of inverters for grid-connected systems: string and micro inverters. Each type has strengths and weakness and may be recommended for different types of installations.

Wiring for Electrical Connections:
Electrical connections, including wiring, disconnect switches, fuses, and breakers are required to meet electrical code (e.g., NEC Article 690) for both safety and equipment protection. In most traditional applications, wiring from (i) the arrays to inverters and (ii) inverters to point of interconnection is generally run as direct burial through trenches.

Attachment #5 – <u>Glossary or Definition of Terms</u>

Glossary or Definition of Terms	
PV	Photovoltaic energy
AC	Alternating current, which can be transmitted over+ power lines
DC	Direct current, which cannot be transmitted over power lines
Ballast	A footing on which a solar panel can be placed which will not penetrate the landfill cap
Inverter	A machine which takes in direct current and converts it to alternating current, which can then be transmitted to an electrical substation for transmission to a utility company
Energy Density	The amount of energy available per a given region of space (per unit volume); this is impacted by the packing factor, which is the number of solar arrays that can be placed in a specific area
kW or kWh	Kilowatt or kilowatt hours
MW or MWh	Megawatt or megawatt hours
ITC	Investment tax credits
O&M	Operations and maintenance
Payback Period	Number of years until the project is paid for
PPA	Power purchase agreement, which is a legal contract between an electricity provider and a purchaser that defines all commercial terms for the sale of electricity
Transformer	An electrical device used to increase or decrease the alternating voltage in electrical power applications. A transformer on a solar power facility is primarily used to step-up the voltage to deliver the renewable energy to the utility grid.