Feasibility Study of Economics and Performance of Solar Photovoltaics at the Price Landfill Site in Pleasantville, New Jersey

A Study Prepared in Partnership with the Environmental Protection Agency for the RE-Powering America's Land Initiative: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites

James Salasovich, Jesse Geiger, Gail Mosey, and Victoria Healey

Produced under direction of the U.S. Environmental Protection Agency (EPA) by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-09-1751 and Task No. WFD4.1001.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-7A40-58480
May 2013

Contract No. DE-AC36-08GO28308

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Executive Summary

The U.S. Environmental Protection Agency (EPA), in accordance with the RE-Powering America's Land initiative, selected the Price Landfill site in Pleasantville, New Jersey, for a feasibility study of renewable energy production. The National Renewable Energy Laboratory (NREL) provided technical assistance for this project. The purpose of this report is to assess the site for a possible photovoltaic (PV) system installation and estimate the cost, performance, and site impacts of different PV options. In addition, the report recommends financing options that could assist in the implementation of a PV system at the site. This study did not assess environmental conditions at the site.

The Price Landfill is a privately owned Superfund site that is approximately 26.4 acres and is currently inactive. The Price Landfill was in operation from 1969–1976. The main contaminants at the site are heavy metals and volatile organic compounds (VOC), which resulted from dumping industrial chemicals, sewage, greases, and oils into the landfill. It is estimated that over 9 million gallons of chemical waste was disposed of at the landfill. The site recently received $16.3 million in American Reinvestment and Recovery Act (ARRA) funds for the construction and operation of a groundwater extraction and treatment system.[1] The City of Pleasantville is interested in using the currently underutilized site for solar PV in order to minimize its impact on the environment.

The feasibility of a PV system installed is highly impacted by the available area for an array, solar resource, available incentives and renewable energy certificates (RECs), distance to transmission lines, and distance to major roads. In addition, the operating status, ground conditions, and restrictions associated with redevelopment of the landfill site impact the feasibility of a PV system. Based on an assessment of these factors, the Price Landfill is suitable for deployment of a large-scale PV system.

Of the total acreage at the Price Landfill site, approximately 8.2 acres is currently appropriate for installation of a PV system. While this entire area does not need to be developed at one time due to the feasibility of staging installation as land or funding becomes available, calculations for this analysis reflect the solar potential if the total feasible area is used. The 8.2 acres on the north side of the site is currently the most suitable location for a large-scale PV system. This area is flat but still has trees and other shading obstructions, which would need to be cleared before the installation of a PV system.

The economic feasibility of a potential PV system on Price Landfill depends greatly on the purchase price of the RECs gained. The economics of the potential system were analyzed using the current average REC purchase price of $0.225/kWh and an expected electricity generated purchase rate from Atlantic City Electricity at $0.04594/kWh. Many incentives have expired in New Jersey this past year, and while they are expected to be extended, they were not included in the analysis. The incentives considered include: the federal 30% of installed cost tax credit, New Jersey property tax exemption of 100% of the increased value attributed to a solar system, the New Jersey solar energy sales tax exemption of 100% of sales tax for all related solar equipment, and bonus depreciation

[1] "Superfund Program Implements the Recovery Act." U.S. Environmental Protection Agency, 2011. Accessed August, 2012: http://www.epa.gov/superfund/eparecovery/price_landfill.html.

modified accelerated cost recovery system schedule. Table ES-1 summarizes the system performance and economics of a potential system that would use all available areas that were surveyed at Price Landfill. The table shows the annual energy output from the system, along with the number of average American households that could be powered off of such a system and estimated job creation.

As indicated in Table ES-1, the investor-owned system is expected to have a payback of 7 years and an annual energy revenue of $95,000 for a 1,182-kW PV system producing approximately 1,901,489 kWh estimated annual energy generation. This includes the current cost of energy, expected installation cost, site solar resource, and existing incentives for the proposed PV system.

Table ES-1. Price Landfill PV System Summary

System Type	PV System Size[a] (kW)	Array Tilt (deg)	Annual Output (kWh/year)	Number of Houses Powered[b]	Jobs Created[c] (job-year)	Jobs Sustained[d] (job-year)
Crystalline Silicon (Fixed Tilt)	1,434	20	1,822,307	165	45.2	0.5
Crystalline Silicon (1-Axis)	1,182	20	1,901,489	172	48.1	0.4

System Type	System Cost	Initial Base Incentives	Annual Revenue ($/year)	Annual O&M ($/year)	Payback Period with Incentives (years)
Crystalline Silicon (Fixed Tilt)	$ 5,736,000	$ 1,720,800	$ 92,020	$ 71,700	7.5
Crystalline Silicon (1-Axis)	$ 5,484,480	$ 1,645,344	$ 95,074	$ 62,882	7

a Data assume a maximum usable area of 8 acres

b Number of average American households that could hypothetically be powered by the PV system assuming 11,040 kWh/year/household.

c Job-years created as a result of project capital investment including direct, indirect, and induced jobs.

d Jobs (direct, indirect, and induced) sustained as a result of operations and maintenance (O&M) of the system.

Table of Contents

List of Figures

List of Tables

1 Study and Site Background

The U.S. Environmental Protection Agency (EPA), in accordance with the RE-Powering America's Land initiative, selected the Price Landfill site in Pleasantville, New Jersey, for a feasibility study of renewable energy production. The National Renewable Energy Laboratory (NREL) provided technical assistance for this project. The purpose of this report is to assess the site for a possible photovoltaic (PV) system installation and estimate the cost, performance, and site impacts of different PV options. In addition, the report recommends financing options that could assist in the implementation of a PV system at the site. This study did not assess environmental conditions at the site.

The Price Landfill is located in Pleasantville, New Jersey. Pleasantville is approximately 6 miles northwest of Atlantic City and has a population of 20,249 as of the 2010 census. On average, Pleasantville has approximately 205 sunny days per year, and the climate is hot and humid in the summer and moderately cold in the winter. Atlantic City Electric, a regulated utility, is the energy-holding company that provides electricity to Pleasantville.

The Price Landfill is a privately owned Superfund site that is approximately 26.4 acres and is currently inactive. The Price Landfill was in operation from 1969–1976. The City of Pleasantville is interested in using the currently underutilized site for solar PV in order to minimize its impact on the environment.

The remediation of the Price Landfill is being addressed through federal and state actions. The main contaminants at the site are heavy metals and volatile organic compounds (VOC), which resulted from dumping industrial chemicals, sewage, greases, and oils into the landfill. It is estimated that over 9 million gallons of chemical waste was disposed of at the landfill. The site recently received $16.3 million in American Reinvestment and Recovery Act (ARRA) funds for the construction and operation of a groundwater extraction and treatment system.[2] It is estimated that the pump and treat system has a 1-MW load. The site is scheduled to be capped starting in 2013. There are concerns with trenching and disturbing the soil at the site due to the contaminants present and the future installation of a landfill cap.

Atlantic City Electric owns the transmission lines that run through the site. The Wisteria Street Substation is located less than 0.1 mile to the west of the Price Landfill. Interconnection is governed by Atlantic City Electric. Performing an interconnection study is a relatively slow process that would have to be performed through Atlantic City Electric and would involve considerable cost. There is currently approximately 1 MW of electrical load at the site associated with the pump and treat system. There are also surrounding buildings that could be potential off-takers of electricity produced by a utility-scale PV system.

To gather information integral to this feasibility study, feasibility assessment team members from NREL and EPA conducted a site visit on February 8, 2012. The team considered information such as solar resource, transmission availability, community acceptance, and ground conditions.

[2] "Superfund Program Implements the Recovery Act." U.S. Environmental Protection Agency, 2011. Accessed August, 2012: http://www.epa.gov/superfund/eparecovery/price_landfill.html.

2 Development of a PV System on Superfund Sites

Through the RE-Powering America's Lands initiative, EPA has identified several benefits for siting solar PV facilities on Superfund sites, noting that they:

- Can be developed in place of limited greenfields, preserving the land carbon sink
- Could have environmental conditions that are not well-suited for commercial or residential redevelopment and might be adequately zoned for renewable energy
- Generally are located near existing roads and energy transmission or distribution infrastructure
- Might provide an economically viable reuse for sites that may have significant cleanup costs or low real estate development demand
- Can provide job opportunities in urban and rural communities
- Can advance cleaner and more cost-effective energy technologies and reduce the environmental impacts of energy systems (e.g., reduce greenhouse gas emissions).

By taking advantage of these potential benefits, PV can provide a viable, beneficial reuse, and, in many cases, generate significant revenue on a site that would otherwise go unused.

The Price Landfill is owned by Rutala Associates, LLC, which is interested in potential revenue flows on the site. For many Superfund sites, the local community has significant interest in the redevelopment of the site, and community engagement is critical to match future reuse options to the community's vision for the site.

Understanding opportunities studied and realized by other similar sites demonstrates the potential for PV system development. For example, the Aerojet solar project near Rancho Cordova, California, is a 6-MW PV system built on a Superfund site. The Aerojet Superfund site is a manufacturing site for liquid and solid propellant rocket engines that is currently in operation. The site is 5,900 acres and owned by Aerojet General Corporation, who teamed up with Solar Power to implement the PV system. The Aerojet solar project was built in two phases; the final phase was completed in 2010 and is a 6-MW single-axis tracking system.[3]

The subject site has potential to be used for other functions beyond the solar PV systems proposed in this report. Any potential use should align with the community vision for the site and should work to enhance the overall utility of the property. Installing large-scale wind turbines at the site could be another possible use of the site but would require a detailed wind feasibility study.

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[3] "Celebrating Success: Aerojet General Corporation Site Rancho Cordova, California." U.S. Environmental Protection Agency, 2010. Accessed August, 2012: http://epa.gov/superfund/programs/recycle/pdf/aerojet-success.pdf.

There are many compelling reasons to consider moving toward renewable energy sources for power generation instead of fossil fuels, including:

- Renewable energy sources offer a sustainable energy option in the broader energy portfolio
- Renewable energy can have a net positive effect on human health and the environment
- Deployment of renewable energy bolsters national energy independence and increases domestic energy security
- Fluctuating electric costs can be mitigated by locking in electricity rates through long-term power purchase agreements (PPAs) linked to renewable energy systems
- Generating energy without harmful emissions or waste products can be accomplished through renewable energy sources.

3 PV Systems

3.1 PV Overview

Solar PV technology converts energy from solar radiation directly into electricity. 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., a light bulb).

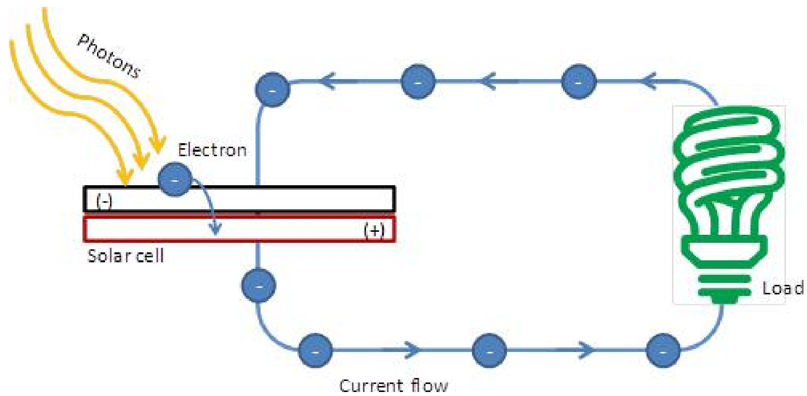

Figure 1. Generation of electricity from a PV cell

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 useable 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 kW), to commercial (100–500 kW), to large utility scale (10+ 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.

3.2 Major System Components

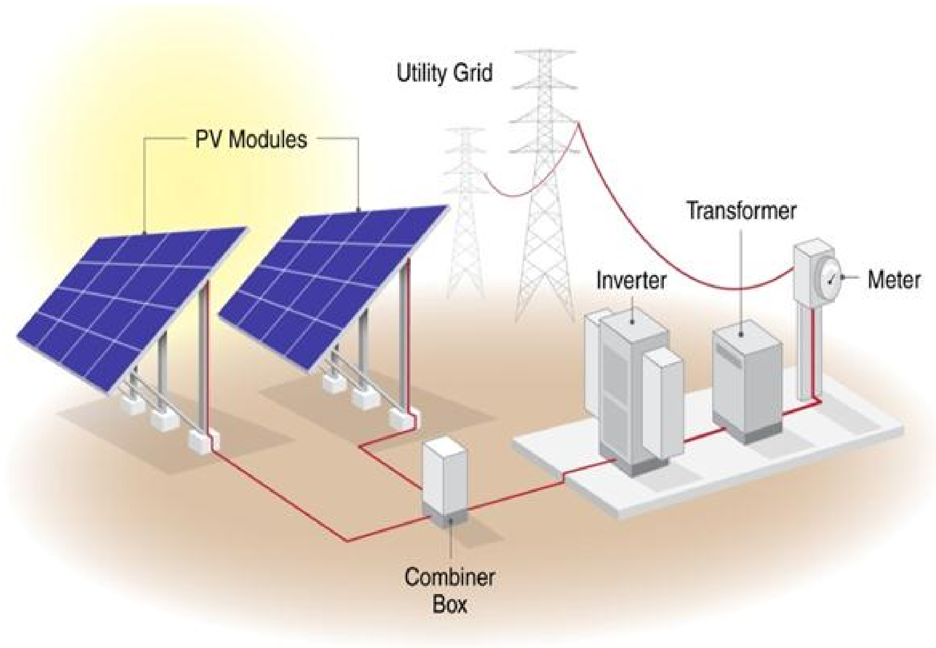

Figure 2. Ground-mounted array diagram

Source: NREL

A typical PV system is made up of several key components, including:

- PV modules
- Inverter
- Balance-of-system (BOS) components.

These, along with other PV system components, are discussed in turn below.

3.2.1 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.

3.2.1.1 Crystalline Silicon

Traditional solar cells are made from silicon. Silicon is quite abundant and nontoxic. It builds on a strong industry on both the supply (silicon industry) and product side. This technology has been demonstrated to be consistent and highly efficient for 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 range of 25-30 years 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 3 shows two examples of crystalline solar panels: mono- and multi-silicon installed on tracking mounting systems.

Figure 3. Mono- and multi-crystalline solar panels. ***Photos by (left) SunPower Corporation, NREL 23816 and (right) SunPower, NREL 13823***

3.2.1.2 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% and 12% for CdTe. Figure 4 shows thin-film solar panels.

Figure 4. Thin-film solar panels installed on (left) solar energy cover and (middle/right) fixed-tilt mounting system. ***Photos by (left) Republic Services, Inc., 23817; (middle) Beck Energy, NREL 14726; and (right) U.S. Coast Guard Petaluma site, NREL 17395***

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.

3.2.2 Inverter

Inverters convert DC electricity from the PV array into AC and 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," or putting power into the grid while utility workers are trying to fix what they assume is a de-energized distribution system. This safety feature is built into all grid-connected inverters in the market. Electricity produced from the system could 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 weaknesses and might be recommended for different types of installations.

String inverters are most common and typically range in size from 1.5 kW to 1,000 kW. These inverters tend to be cheaper on a capacity basis, be highly efficient, and have lower operation and maintenance (O&M) costs. String inverters offer various sizes and capacities to handle a large range of voltage output. For larger systems, string inverters are combined in parallel to produce a single point of interconnection with the grid. Warranties typically run between 5 and 10 years, with 10 years being the current industry standard. On larger units, extended warranties up to 20 years are possible. Given that the expected life of PV panels is 25–30 years, an operator can expect to replace a string inverter at least one time during the life of the PV system.

Micro-inverters are dedicated to the conversion of a single PV module's power output. The AC output from each module is connected in parallel to create the array. This technology is relatively new to the market and in limited use in larger systems due to potential increase in O&M associated with significantly increasing the number of inverters in a given array. Current micro-inverters range in size between 175 W and 380 W. These inverters can be the most expensive option per watt of capacity. Warranties range from 10–20 years. Small projects with irregular modules and shading issues typically benefit from micro-inverters.

With string inverters, small amounts of shading on a solar panel will significantly affect the entire array production. Instead, it impacts only that shaded panel if micro-inverters are used. Figure 5 shows a string inverter.

Figure 5. String inverter. ***Photo by Warren Gretz, NREL 07985***

3.2.3 *Balance-of-System Components*

In addition to the solar modules and inverter, a solar PV system consists of other parts called BOS components, which include:

- Mounting racks and hardware for the panels
- Wiring for electrical connections.

3.2.3.1 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.

3.2.3.1.1 Ground-Mounted Systems

For ground-mounted 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 for most areas to 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. For Superfund site applications, mounting system designs will be primarily driven by these considerations coupled with settlement concerns.

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 Superfund sites. Fixed-tilt systems have lower maintenance costs but generate less energy (kWh) per unit power (kW) of capacity than tracking systems.

Tracking systems rotate the PV modules so they are following the sun as it moves across the sky. This increases energy output but also increases maintenance and equipment costs slightly. Single-axis tracking, in which PV is rotated on a single axis, can increase energy output up to 25% or more. With dual-axis tracking, PV is able to directly face the sun all day, potentially increasing output up to 35% or more. Depending on underlying soiling conditions, single- and dual-axis trackers might not be suitable due to potential settlement effects, which can interfere with the alignment requirements of such systems.

Table 1. Energy Density by Panel and System

System Type	Fixed-Tilt Energy Density (DC-Watts/ft^2)	Single-Axis Tracking Energy Density (DC-Watts/ft^2)
Crystalline Silicon	4.0	3.3
Thin Film	3.3	2.7
Hybrid High Efficiency	4.8	3.9

The selection of mounting type is dependent on many factors, including installation size, electricity rates, government incentives, land constraints, latitude, and local weather. Contaminated land applications could 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. 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 such as New England.

3.2.3.2 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 (1) the arrays to inverters and (2) inverters to point of interconnection is generally run as direct burial through trenches. In Superfund site applications, this wiring might be required to run through above-ground conduit due to restrictions with cap penetration or other concerns. Therefore, developers should consider noting any such restrictions, if applicable, in requests for proposals in order to improve overall bid accuracy. Similarly, it is recommended that PV system vendors reflect these costs in the quote when costing out the overall system.

3.2.3.3 PV System Monitoring

Monitoring PV systems can be essential for reliable functioning and maximum yield of a system. It can be as simple as reading values, such as produced AC power, daily kilowatt-hours, and cumulative kilowatt-hours, locally on an LCD display on the inverter. For more sophisticated monitoring and control purposes, environmental data, such as module temperature, ambient temperature, solar radiation, and wind speed, can be collected. Remote control and monitoring can be performed by various remote connections. Systems can send alerts and status messages to the control center or user. Data can be stored in the inverter's memory or in external data loggers for further system analysis.

Collection of this basic information is standard for solar systems and not unique to landfill applications.

Weather stations are typically installed in large-scale systems. Weather data, such as solar radiation and temperature, can be used to predict energy production, enabling comparison of the target and actual system output and performance and identification of under-performing arrays. Operators can also use this data to identify required maintenance, shade on panels, and accumulating dirt on panels, for example. Monitoring system data can also be used for outreach and education. This can be achieved with publicly available, online displays, wall-mounted systems, or even smartphone applications.

3.2.4 Operation and Maintenance

PV panels typically have a 25-year performance warranty. Inverters, which come standard with a 5-year or 10-year warranty (extended warranties available), would be expected to last 10–15 years. System performance should be verified on a vendor-provided website. Wire and rack connections should be checked annually. This economic analysis uses an annual O&M cost computed as $20/kW/yr, which is based on the historical O&M costs of installed fixed-axis grid-tied PV systems. In addition, the system should expect a replacement of system inverters in year 15 at a cost of $0.25/W.

3.3 Siting Considerations

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. As explained above, 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.

The NREL solar assessment team uses a Solmetric SunEye 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 NREL team can determine if the area is appropriate for solar panels.

Following the successful collection of solar resource data using the Solmetric SunEye tool and determination that the site is adequate for a solar installation, an analysis to determine the ideal system size must be conducted. System size depends highly on the average energy use of the facilities on the site, PPAs, incentives available, and utility policy.

4 Proposed Installation Location Information

This section summarizes the findings of the NREL solar assessment site visit on February 8, 2012.

4.1 Price Landfill Site PV System

As discussed in Section 1, the Price Landfill site is owned by Rutala Associates LLC, and the remediation of the site is being addressed by federal and state actions.

The 8.2 acres on the north side of the landfill will be flat and cleared of trees and other shading obstructions after the landfill cap is constructed, currently making this area the most suitable location for a large-scale PV system. There is no major infrastructure on the 8.2-acre site that would have to be removed. There are Atlantic City Electric transmission lines that run through the 8.2-acre site, but the shading from the lines is minimal. The remaining 18.2 acres to the south is planned for other uses by the owner. The 8.2-acre site is close to existing roads, and transmission lines run through the site. An interconnection study would have to be performed to determine if a large-scale PV system could tie into these lines without major upgrades.

In order to get the most out of the ground area available, it is important to consider whether the site layout can be improved to better incorporate a solar system. If there are unused structures, fences, or electrical poles that can be removed, the unshaded area can be increased to incorporate more PV panels.

Figure 6 shows an aerial view of the Price Landfill site taken from Google Earth; the current feasible area for PV is shaded in yellow, and the landfill is shaded in black. Currently, the area shaded in yellow has vegetation and needs to be leveled. After the landfill cap has been installed, there will be large expanses of relatively flat, unshaded land, which makes it a suitable candidate for a PV system. The area of the site that currently appears feasible (yellow) for PV has an area of 8.2 acres.

Figure 6. Aerial view of the current feasible area (yellow) for PV at the Price Landfill site

Image generated in Google Earth

PV systems are relatively well-suited to the Pleasantville, New Jersey, area, where the average global horizontal annual solar resource—the total solar radiation for a given location, including direct, diffuse, and ground-reflected radiation—is 4.59 kWh/m^2/day.

Figure 7 shows various views of the Price Landfill site. As shown, the site will have to be leveled and cleared of tall vegetation and trees before the installation of a PV system.

Figure 7. Views of the feasible area for PV at the Price Landfill. ***Photos by James Salasovich, NREL***

4.2 Utility-Resource Considerations

The expected electrical tie-in point for the PV system at the Price Landfill site is located less than 0.1 mile to the west of the site at the Wisteria Street Substation. Atlantic City Electric owns the transmission lines that run through the site. The location of the Wisteria Street Substation relative to the Price Landfill and the transmission lines that run through the site are shown in Figure 8. Photos of the Wisteria Street Substation and the transmission lines are given in Figure 9. Interconnection is governed by Atlantic City Electric. A detailed interconnection study would have to be performed in order to determine if this would be a suitable location for interconnection. Performing an interconnection study is a relatively slow process that would have to be performed through Atlantic City Electric and would involve considerable cost. The tie-in location is limited by the available capacity at the substation. When considering a ground-mounted system, an electrical tie-in location should be identified to determine how the energy would be fed back into the grid.

Figure 8. Price Landfill, transmission lines, and the Wisteria Street Substation

Image generated in Google Earth

Figure 9. Wisteria Street Substation and electrical transmission lines at the Price Landfill. ***Photos by James Salasovich, NREL***

4.3 Useable Acreage for PV System Installation

Typically, a minimum of 2 useable acres is recommended to site PV systems. Useable 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. For example, eligible space for PV includes underutilized or unoccupied land, vacant lots, and/or unused paved area (e.g., a parking lot or industrial site space, as well as existing building rooftops). After the landfill cap is installed, the 8.2-acre site is flat and free of all major shading obstructions.

4.4 PV Site Solar Resource

The Price Landfill site has been evaluated to determine the adequacy of the solar resource available using both on-site data and industry tools.

The assessment team for this feasibility study collected multiple Solmetric SunEye data points and found a solar access of 90% and above on the 8.2-acre area.

The predicted array performance was found using PVWatts Version 2[4] for the city closest to Pleasantville, New Jersey. Table 2 shows the station identification information, PV system specifications, and energy specifications for the site. For this summary, array performance information and a hypothetical system size of 1 kW was used to show the estimated production for each kW so that additional analysis can be performed using the data indicated below. It is scaled linearly to match the proposed system size.

Table 2. Site Identification Information and Specifications

Station Identification	
Cell ID	93730
City	Atlantic City
State	New Jersey
Latitude	39.37° N
Longitude	74.41° W
PV System Specifications	
DC Rating	1.00 kW
DC to AC Derate Factor	0.8
AC Rating	0.8 kW
Array Type	Fixed Tilt
Array Tilt	20°
Array Azimuth	180°
Energy Specifications	
Cost of Electricity	$0.0459/kWh

[4] For more information on NREL's PVWatts Version 2, see http://www.nrel.gov/rredc/pvwatts/.

Table 3 shows the performance results for a 20-degree fixed-tilt PV system in Pleasantville, as calculated by PVWatts.

Table 3. Performance Results for 20-Degree Fixed-Tilt PV

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.00	76	3.49
2	3.71	85	3.90
3	4.57	112	5.15
4	5.33	123	5.65
5	5.84	137	6.29
6	6.04	132	6.06
7	6.01	134	6.16
8	5.62	126	5.79
9	5.10	112	5.15
10	4.15	97	4.46
11	3.05	72	3.31
12	2.62	65	2.99
Year	4.59	1,271	58.39

Table 4 shows the performance results for a zero-tilt single-axis tracking PV system in Pleasantville, as calculated by PVWatts.

Table 4. Performance Results for Zero-Degree Single-Axis PV

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	2.95	76	3.49
2	3.87	91	4.18
3	5.17	130	5.97
4	6.39	150	6.89
5	7.22	172	7.90
6	7.60	168	7.72
7	7.49	170	7.81
8	6.66	152	6.98
9	5.91	134	6.16
10	4.45	106	4.87
11	3.04	73	3.35
12	2.54	63	2.89
Year	5.28	1,485	68.22

4.5 Price Landfill Energy Usage

The Price Landfill currently has approximately 1 MW of electrical load at the site associated with the pump and treat system. Monthly electric bills showing the usage and cost were not available. There are also surrounding buildings that could be potential off-takers of electricity produced by a utility-scale PV system.

It is important to understand the energy use of the site to allow for a full analysis of whether or not energy produced would need to be sold or if it could offset on-site energy use.

4.5.1 Net Metering

Net metering is an electricity policy for consumers who own renewable energy facilities. In this context, "net" is used to mean "what remains after deductions"—in this case, the deduction of any energy outflows from metered energy inflows. Under net metering, a system owner receives retail credit for at least a portion of the electricity it generates. As part of the Energy Policy Act of 2005, under Sec. 1251, all public electric utilities are required upon request to make net metering available to their customers:

> (11) NET METERING.—Each electric utility shall make available upon request net metering service to any electric consumer that the electric utility serves. For purposes of this paragraph, the term 'net metering service' means service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period.[5]

New Jersey's net-metering law, which took effect in 1999 and was significantly expanded in 2004, requires utilities to offer net metering to all customers with PV, solar thermal electric, wind, geothermal electric, wave, tidal, biomass, landfill gas, anaerobic digestion, and fuel cells. There is no system capacity limit in New Jersey, but the system size cannot exceed the customer's annual onsite energy use. In July of 2012, New Jersey started to develop rulemaking to allow public entities to engage in "net metering aggregation" of solar systems.

> In July 2012, New Jersey enacted legislation (S.B. 1925) requiring the Board of Public Utilities to develop rules within 270 days to require electric utilities to allow public entities, such as state and local governments, local agencies, and school districts, to engage in "net metering aggregation" of solar facilities. In order to qualify for net metering aggregation, the solar facility must be on property owned by the customer, be owned by the single customer, and with the exception of state entities, be located within the customer's territorial jurisdiction. For state entity projects, all facilities must be located within 5 miles of one another. In addition, for all customers, all facilities must be located within

[5] http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf.

> the territory of the same electric utility, be served by the same basic generation service provider or electric power supplier, and all facilities must be within the same customer class of the applicable electric utility tariff. The law also outlines certain other requirements and procedures for net metering aggregation. A rulemaking will be necessary to implement the new provisions of the law.[6]

RECs,[7] also known as green certificates, green tags, or tradable renewable certificates, are tradable commodities in the United States that represent proof of electric energy generation from eligible renewable energy resources (renewable electricity). The RECs that are associated with the electricity produced and are used on site remain with the customer-generator. If, however, the customer chooses to receive financial compensation for the net energy gain remaining after a 12-month period, the utility will be granted the RECs associated with only that surplus they purchase.

Currently, New Jersey has one of the most aggressive renewable portfolio standards (RPS) in the United States, and therefore has a very good REC market. The Database of State Incentives for Renewable Energy (DSIRE)[8] website provides a good summary of the RPS in New Jersey:

> New Jersey's renewable portfolio standard (RPS)—one of the most aggressive in the United States—requires each supplier/provider serving retail customers in the state to procure 22.5% of the electricity it sells in New Jersey from qualifying renewables by 2021 ("energy year" 2021 runs from June 2020-May 2021). In addition, the standard also contains a separate solar specific provision, which requires suppliers and providers to procure at least 4.1% of sales from qualifying solar electric generation facilities by energy year 2028.

4.5.2 Virtual Net Metering

Some states and utilities allow for virtual net metering (VNM). This arrangement can allow certain entities, such as a local government, to install renewable generation of up to 1 MW at one location within its geographic boundary and to generate credits that can be used to offset charges at one or more other locations within the same geographic boundary. California, Colorado, Connecticut, Massachusetts, and Pennsylvania currently allow VNM.

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[6] http://www.dsireusa.org/

[7] For a description of RECs, see http://apps3.eere.energy.gov/greenpower/markets/certificates.

[8] For a full description of the renewable portfolio standard in New Jersey, see http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NJ05R&re=0&ee=0.

5 Economics and Performance

The economic performance of a PV system installed on the site is evaluated using a combination of the assumptions and background information discussed previously, as well as a number of industry-specific inputs determined by other studies. In particular, this study uses NREL's System Advisor Model (SAM).[9]

SAM is a performance and economic model designed to facilitate decision making for people involved in the renewable energy industry, ranging from project managers and engineers to incentive program designers, technology developers, and researchers.

SAM makes performance predictions for grid-connected solar, solar water heating, wind, and geothermal power systems and makes economic calculations for both projects that buy and sell power at retail rates and power projects that sell power through a PPA.

SAM consists of a performance model and financial model. The performance model calculates a system's energy output on an hourly basis (sub-hourly simulations are available for some technologies). The financial model calculates annual project cash flows over a period of years for a range of financing structures for residential, commercial, and utility projects.

The model calculates the cost of generating electricity based on information provided about a project's location, installation and operating costs, type of financing, applicable tax credits and incentives, and system specifications.

5.1 Assumptions and Input Data for Analysis

The cost of a PV system depends on the system size and other factors, such as geographic location, mounting structure, and type of PV module. Based on significant cost reductions seen in 2011, the average cost for utility-scale ground-mounted systems have declined from $4.80/W in the first quarter of 2010 to $2.79/W in the first quarter of 2012. With an increasing demand and supply, potential of further cost reduction is expected as market conditions evolve. For this analysis, the following input data were used. The installed cost of fixed-tilt ground-mounted systems was assumed to be $3.20/W, and the installed cost of single-axis tracking was assumed to be $3.84/W. These costs represent plausible scenarios for purchase price on EPA landfills. The estimated increase in cost from this baseline for a ballasted system is 25%. This increased cost is due to limitations placed on design and construction methods due to the ground conditions at the site. Such limitations include restrictions on stormwater runoff, weight loading of construction equipment, inability to trench for utility lines, additional engineering costs, permitting issues, and nonstandard ballasted racking systems. The installed system cost assumptions are summarized in Table 5.

[9] For additional information on the NREL System Advisor Model, see https://sam.nrel.gov/cost.

Table 5. Installed System Cost Assumptions

System Type	Fixed-Tilt ($/Wp)	Single-Axis Tracking ($/Wp)
Baseline system	3.20	3.84
With ballast (+25%)	0.80	0.96
Total installed cost	4.00	4.64

These prices include the PV array and the BOS components for each system, including the inverter and electrical equipment, as well as the installation cost. This includes estimated taxes and a national average labor rate but does not include land cost. The economics of grid-tied PV depend on incentives, the cost of electricity, the solar resource, and panel tilt and orientation.

It was assumed for this analysis that relevant federal incentives are received for taxable entities. It is important to consider all applicable incentives or grants to make PV as cost-effective as possible. If the PV system is owned by a private tax-paying entity, this entity could qualify for federal tax credits and accelerated depreciation on the PV system, which can be worth about 56% of the initial capital investment. The total potential tax benefits to the tax-paying entity can be as high as 60% of the initial system cost. Because state and federal governments do not pay taxes, private ownership of the PV system would be required to capture tax incentives.

For the purposes of this analysis, the project is expected to have a 25-year life, although the systems can be reasonably expected to continue operation past this point. Inflation is assumed to be 2.5%, 5.85% discount rate for private investors, financing secured via a 15-year loan at a 6% interest rate and 55% debt fraction. The panels are assumed to have a 0.5% per year degradation in performance. The O&M expenses are estimated to be $30/kW/yr for the first 15 years to replace the inverter and $20/kW/yr for the remaining 10 years of the study. A system DC-to-AC conversion of 80% was assumed. This includes losses in the inverter, wire losses, PV module losses, and losses due to temperature effects. PVWatts Version 2 was used to calculate expected energy performance for the system.

5.2 SAM-Forecasted Economic Performance

Using varied inputs and the assumptions summarized in Section 5.1 of this report, the SAM tool predicts net present value (NPV) and after-tax internal rate of return (IRR). When considering only the two main solar options and no other clean energy opportunities, all solar scenarios were economically feasible. The economics for this site are determined by the assumed solar REC market price of $0.225/kWh for the solar energy produced, while it is estimated that produced electricity will sell for $0.04594/kWh. Because it is assumed that a solar investor will be undertaking this project, the economic simulations centered on fixed or single-axis tracking systems. As seen in Table 6, single-axis tracking gives the higher NPV and IRR at the expected PPA price and is recommended by the feasibility team. An IRR of 15% is considered acceptable for a solar investor to invest in a project, so both options are highly favorable.

Table 6. Summary of Model Results

Economics Cases	IRR (%)	NPV ($)	PPA ($/kWh)
Crystalline Silicon (Fixed Tilt)	25.02	471,732	0.04594
Crystalline Silicon (Single Axis)	29.13	705,119	0.04594

5.2.1 Fixed Tilt vs. Single-Axis Tracking

According to the simulations, single-axis tracking for the ground-mounted system will provide the best payback for a slightly lower levelized cost of energy (LCOE). While this might seem like an obvious choice, single-axis systems could be considered a higher-risk option. Installation costs might be higher than modeled due to availability of installers and equipment. Despite having similar O&M costs to fixed-axis systems, more moving parts generally lead to higher malfunctions. While these higher-risk considerations are important for evaluation, it is the recommendation of the feasibility study to pursue single-axis tracking systems for Price Landfill. If the installation cost for a single-axis tracking system were to increase above the fixed-tilt system by more the $1.25, the fixed-tilt system would become the more economically beneficial option.

5.2.2 Renewable Energy Certificate Market Fluctuations

The REC market price of $0.225/kWh is the average price suggested on the DSIRE website and is not a guaranteed price. Sensitivity studies were performed around the REC price in both the fixed-tilt and single-axis cases. The full table can be found in Appendix A. An approximately $0.06/kWh decrease would increase the PPA price to nearly the current utility purchase price. This would still be a favorable project to a developer and purchaser. While the solar renewable energy certificate (SREC) price is expected to lower and fluctuate, this site is still recommended for further investigation for PV development.

A summary of the results of the economic analysis and the system considered is available in Table 7. The entire results and summary of inputs to the SAM is available in Appendix B.

Table 7. PV System Summary

System Type	PV System Size[a] (kW)	Array Tilt (deg)	Annual Output (kWh/year)	Number of Houses Powered[b]	Jobs Created[c] (job-year)	Jobs Sustained[d] (job-year)
Crystalline Silicon (Fixed Tilt)	1,434	20	1,822,307	165	45.2	0.5
Crystalline Silicon (1-Axis)	1,182	20	1,901,489	172	48.1	0.4

System Type	System Cost	Initial Base Incentives	Annual Revenue ($/year)	Annual O&M ($/year)	Payback Period with Incentives (years)
Crystalline Silicon (Fixed Tilt)	$ 5,736,000	$ 1,720,800	$ 92,020	$ 71,700	7.5
Crystalline Silicon (1-Axis)	$ 5,484,480	$ 1,645,344	$ 95,074	$ 62,882	7

a Data assume a maximum usable area of 8 acres

b Number of average American households that could hypothetically be powered by the PV system assuming 11,040 kWh/year/household.

c Job-years created as a result of project capital investment including direct, indirect, and induced jobs.

d Jobs (direct, indirect, and induced) sustained as a result of operations and maintenance (O&M) of the system.

5.3 Job Analysis and Impact

To evaluate the employment and economic impacts of the PV project associated with this analysis, NREL's Jobs and Economic Development Impact (JEDI) models are used.[10] JEDI estimates the economic impacts associated with the construction and operation of distributed-generation power plants. It is a flexible input-output tool that estimates, but does not precisely predict, the number of jobs and economic impacts that can be reasonably supported by the proposed facility.

JEDI represents the entire economy, including cross-industry or cross-company impacts. For example, JEDI estimates the impact the installation of a distributed-generation facility would have on not only the manufacturers of PV modules and inverters but also the associated construction materials, metal fabrication industry, project management support, transportation, and other industries that are required to enable the procurement and installation of the complete system.

For this analysis, inputs, such as the estimated installed project cost ($/kW), targeted year of construction, system capacity (kW), O&M costs ($/kW), and location, were entered into the model to predict the jobs and economic impact. It is important to note that the JEDI model does not predict or incorporate any displacement of related economic activity or alternative jobs due to the implementation of the proposed project. As such, the JEDI results are considered gross estimates as opposed to net estimates.

For the Price Landfill site, the values in Table 8 were assumed.

[10] The JEDI models have been used by the U.S. Department of Energy, the U.S. Department of Agriculture, NREL, and the Lawrence Berkeley National Laboratory, as well as a number of universities. For information on the NREL Jobs and Economic Development Impact tool, see http://www.nrel.gov/analysis/jedi/about_jedi.html.

Table 8. JEDI Analysis Assumptions

Input	Assumed Value
Capacity	1,182 kW
Placed In Service Year	2013
Installed System Cost	$5,484,480
Location	Pleasantville, New Jersey

Using these inputs, JEDI estimates the gross direct and indirect jobs, associated earnings, and total economic impact supported by the construction and continued operation of the proposed PV system.

The estimates of jobs associated with this project are presented as either construction-period jobs or sustained-operations jobs. Each job is expressed as a whole, or fraction, full-time equivalent (FTE) position. An FTE is defined as 40 hours per week for one person for the duration of a year. Construction-period jobs are considered short-term positions that exist only during the procurement and construction periods.

As indicated in the results of the JEDI analysis provided in Appendix C, the total proposed system is estimated to support 37.9 direct and indirect jobs per year for the duration of the procurement and construction period. Total wages paid to workers during the construction period are estimated to be $2,157,700, and total economic output is estimated to be $5,525,300. The annual O&M of the new PV system is estimated to support 0.3 FTEs per year for the life of the system. The jobs and associated spending are projected to account for approximately $20,000 in earnings and $34,700 in economic activity each year for the next 25 years.

5.4 Financing Opportunities

The procurement, development, construction, and management of a successful utility-scale distributed-generation facility can be owned and financed a number of different ways. The most common ownership and financing structures are described below.

5.4.1 Owner and Operator Financing

The owner/operator financing structure is characterized by a single entity with the financial strength to fund all of the solar project costs and, if a private entity, sufficient tax appetite to utilize all of the project's tax benefits. Private owners/operators typically establish a special purpose entity (SPE) that solely owns the assets of the project. An initial equity investment into the SPE is funded by the private entity using existing funds, and all of the project's cash flows and tax benefits are utilized by the entity. This equity investment is typically matched with debt financing for the majority of the project costs. Project debt is typically issued as a loan based on each owner's/operator's assets and equity in the project. In addition, private entities can utilize any of federal tax credits offered.

For public entities that choose to finance, own, and operate a solar project, funding can be raised as part of a larger, general obligation bond, as a standalone tax credit bond, through a tax-exempt lease structure, bank financing, grant and incentive programs, internal cash, or some combination of the above. Certain structures are more common than others and grant programs for solar programs are on the decline. Regardless, as tax-exempt entities, public entities are unable to benefit directly from the various tax-credit-based incentives available to private companies. This has given way to the now common use of third-party financing structures, such as the PPA.

5.4.2 Third-Party Developers with Power Purchase Agreements

Because many project site hosts do not have the financial or technical capabilities to develop a capital intensive project, many times they turn to third-party developers (and/or their investors). In exchange for access to a site through a lease or easement arrangement, third-party developers will finance, develop, own, and operate solar projects utilizing their own expertise and sources of tax equity financing and debt capital. Once the system is installed, the third-party developer will sell the electricity to the site host or local utility via a PPA—a contract to sell electricity at a negotiated rate over a fixed period of time. The PPA typically will be between the third-party developer and the site host if it is a retail "behind-the-meter" transaction or directly with an electric utility if it is a wholesale transaction.

Site hosts benefit by either receiving competitively priced electricity from the project via the PPA or land lease revenues via a lease payment for making the site available to the solar developer. This lease payment can take on the form of either a revenue-sharing agreement or an annual lease payment. In addition, third-party developers are able to utilize federal tax credits. For public entities, this arrangement allows them to utilize the benefits of the tax credits (low PPA price, higher lease payment) while not directly receiving them. The term of a PPA typically varies from 20–25 years.

5.4.3 Third-Party "Flip" Agreements

The most common use of this model is a site host working with a third-party developer who then partners with a tax-motivated investor in a SPE that would own and operate the project. Initially, most of the equity provided to the SPE would come from the tax investor, and most of the benefit would flow to the tax investor (as much as 99%). When the tax investor has fully monetized the tax benefits and achieved an agreed-upon rate of return, the allocation of benefits and majority ownership (95%) would "flip" to the site host (but not within the first 5 years). After the flip, the site host would have the option to buy out all or most of the tax investor's interest in the project at the fair market value of the tax investor's remaining interest.

A "flip" agreement can also be signed between a developer and investors within an SPE, where the investor would begin with the majority ownership. Eventually, the ownership would flip to the developer once investors' returns are met.

5.4.4 Hybrid Financial Structures

As the solar market evolves, hybrid financial solutions have been developed in certain instances to finance solar projects. A particular structure, nicknamed "The Morris Model" after Morris County, New Jersey, combines highly rated public debt, a capital lease, and a PPA. Low-interest public debt replaces more costly financing available to the solar developer and contributes to a very attractive PPA price for the site hosts. New markets tax credits have been combined with PPAs and public debt in other locations, such as Denver and Salt Lake City.

5.4.5 Solar Services Agreement and Operating Lease

The solar services agreement (SSA) and operating lease business models have been predominately used in the municipal and cooperative utility markets due its treatment of tax benefits and the rules limiting federal tax benefit transfers from nonprofit to for-profit companies. Under IRS guidelines, municipalities cannot enter capital leases with for-profit entities when the for-profit entities capture tax incentives. As a result, a number of business models have emerged as a workaround to this issue. One model is the SSA, wherein a private party sells "solar services" (i.e., energy and RECs) to a municipality over a specified contract period (typically long enough for the private party to accrue the tax credits). The nonprofit utility typically purchases the solar services with either a one-time up-front payment equal to the turn-key system cost minus the 30% federal tax credit or may purchase the services in annual installments. The municipality might buy out the system once the third party has accrued the tax credits, but due to IRS regulations, the buyout of the plant cannot be included as part of the SSA (i.e., the SSA cannot be used as a vehicle for a sale and must be a separate transaction).

Similar to the SSA, there are a variety of lease options that are available to municipalities that allow the capture of tax benefits by third-party owners, which result in a lower cost to the municipality. These include an operating lease for solar services (as opposed to an equipment capital lease) and a complex business model called a sales/leaseback.

5.4.6 Sales/Leaseback

In the widely accepted sales/leaseback model, the public or private entity would install the PV system, sell it to a tax investor, and then lease it back. As the lessee, they would be responsible for operating and maintaining the solar system, as well as have the right to sell or use the power. In exchange for use of the solar system, the public or private entity would make lease payments to the tax investor (the lessor). The tax investor would have rights to federal tax benefits generated by the project and the lease payments. Sometimes, the entity is allowed to buy back the project at 100% fair market value after the tax benefits are exhausted.

5.4.7 Community Solar/Solar Gardens

The concept of "community solar" is one in which the costs and benefits of one large solar project are shared by a number of participants. A site owner might be able to make the land available for a large solar project that can be the basis for a community solar project. Ownership structures for these projects vary, but the large projects are typically owned or sponsored by a local utility. Community solar gardens are distributed solar projects wherein utility customers have a stake via a prorated share of the project's energy output. This business model is targeted to meet demand for solar projects by customers who rent/lease their homes or businesses, do not have good solar access at their site, or do not want to install solar system on their facilities. Customer prorated shares of solar projects are acquired through a long-term transferrable lease of one or more panels, or they subscribe to a share of the project in terms of a specific level of energy output or the energy output of a set amount of capacity. Under the customer lease option, the customer receives a billing credit for the number of kilowatt-hours their prorated share of the solar project produces each month; this is also known as VNM. Under the customer subscription option, the customers typically pay a set price for a block of solar energy (i.e., 100 kWh per-month blocks) from the community solar project. Other models include monthly energy outputs from a specific investment dollar amount or a specific number of panels.

Community solar garden and customer subscription-based projects can be solely owned by the utility, solely owned by third-party developers with facilitation of billing provided by the utility, or be a joint venture between the utility and a third-party developer leading to eventual ownership by the utility after the tax benefits have been absorbed by the third-party developer.

There are some states that offer solar incentives for community solar projects, including Washington State (production incentive) and Utah (state income tax credit). Community solar is also known as solar gardens depending on the location (e.g., Colorado).

6 Conclusions and Recommendations

The feasibility study team recommends Price Landfill as a solar PV development site that could potentially generate 1,901 MWh annually using a single-axis tracking system. The site should be an attractive option for investors under the current REC market conditions. As summarized in Section 5, the SAM economic analysis predicts a significant NPV for an expected PPA price of nearly $0.05/kWh for both the fixed-axis and single-axis tracking systems. Securing REC prices similar to the DSIRE average will be important for the feasibility of this site, but the price is flexible to a 36% decrease in REC prices.

Appendix A. Assessment and Calculations Assumptions

Table A-1. Cost, System, and Other Assessment Assumptions

Cost Assumptions			
Variable	**Quantity of Variable**	**Unit of Variable**	
Cost of Site Electricity	0.0459	$/kWh	
Annual O&M (fixed)	25	$/kW/year	
System Assumptions			
System Type	**Annual energy kWh/kW**	**Installed Cost ($/W)**	**Energy Density (W/ft^2)**
Ground Fixed	1,271	$3.00	4.0
Ground Single Axis	1,485	$3.84	3.3
Other Assumptions			
	Ground utilization	90% of available area	

Appendix B. Results from the System Advisor Model

Figures B-1 to B-10 show the graphs from the SAM models.

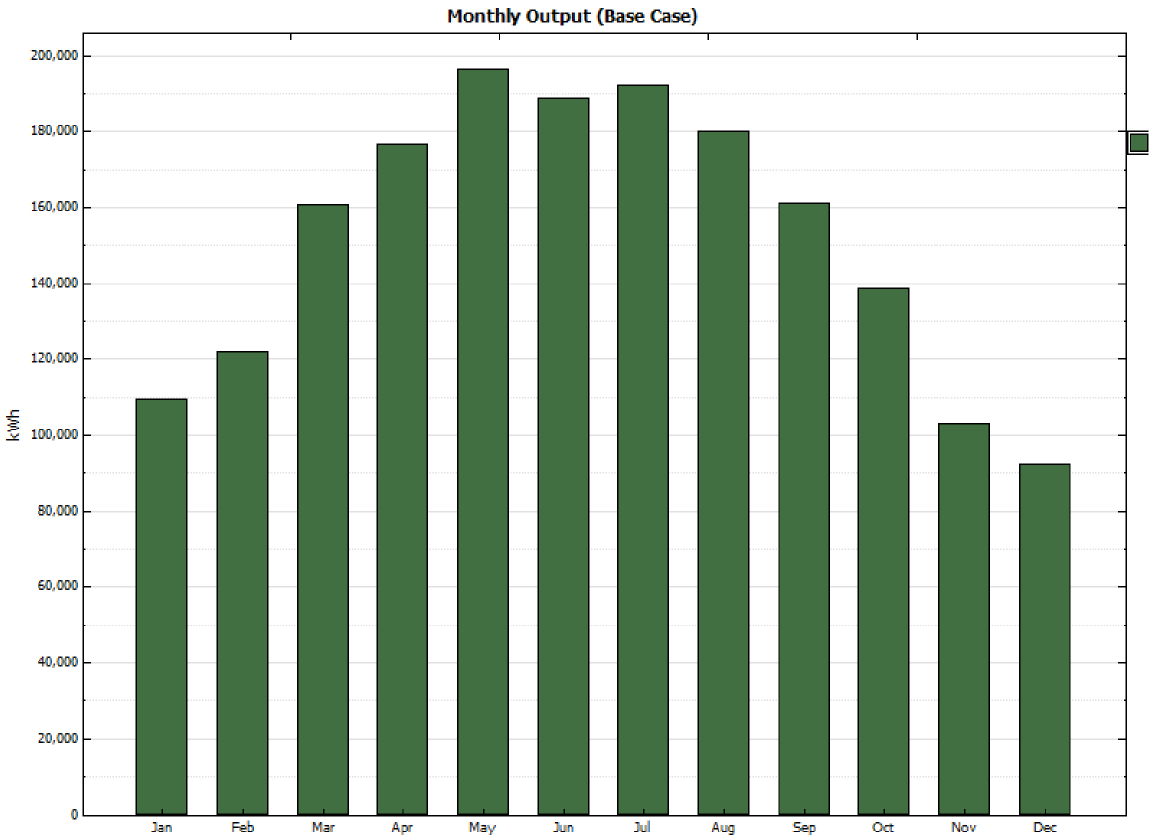

Figure B-1. Modeled output for a fixed-axis ground system

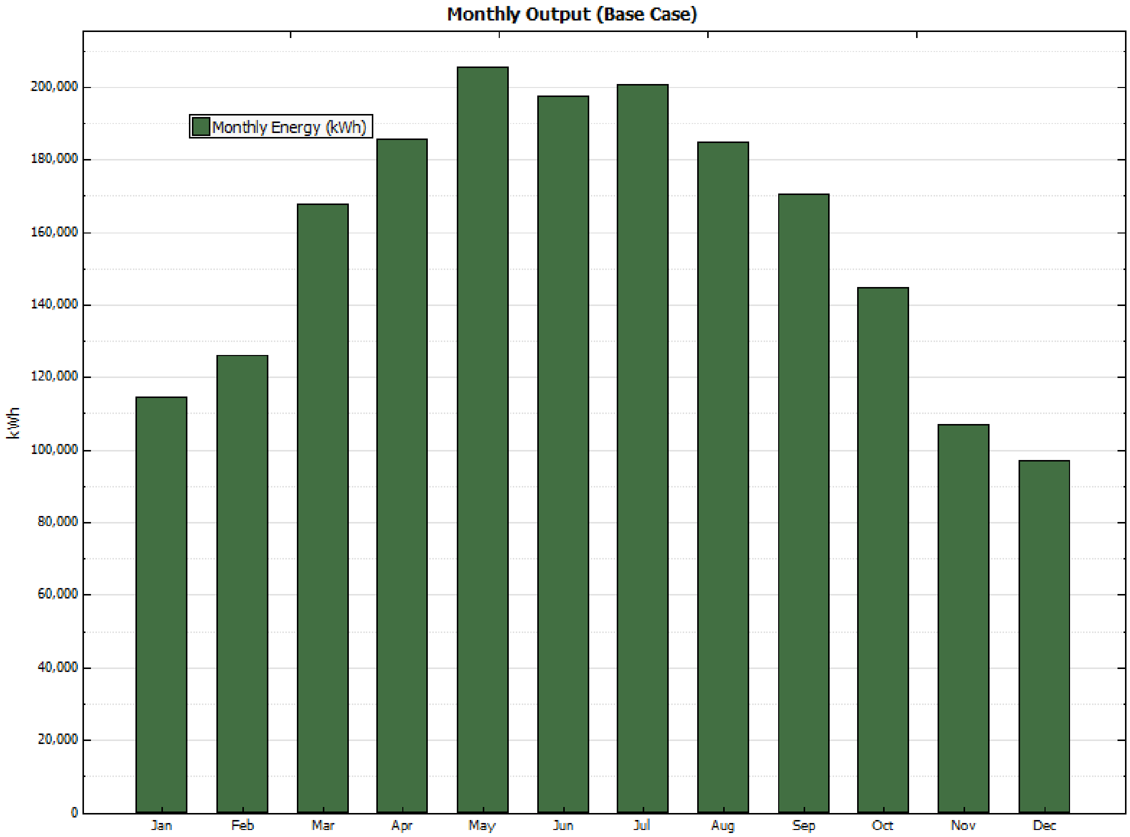

Figure B-2. Modeled output for a single-axis tracking PV system

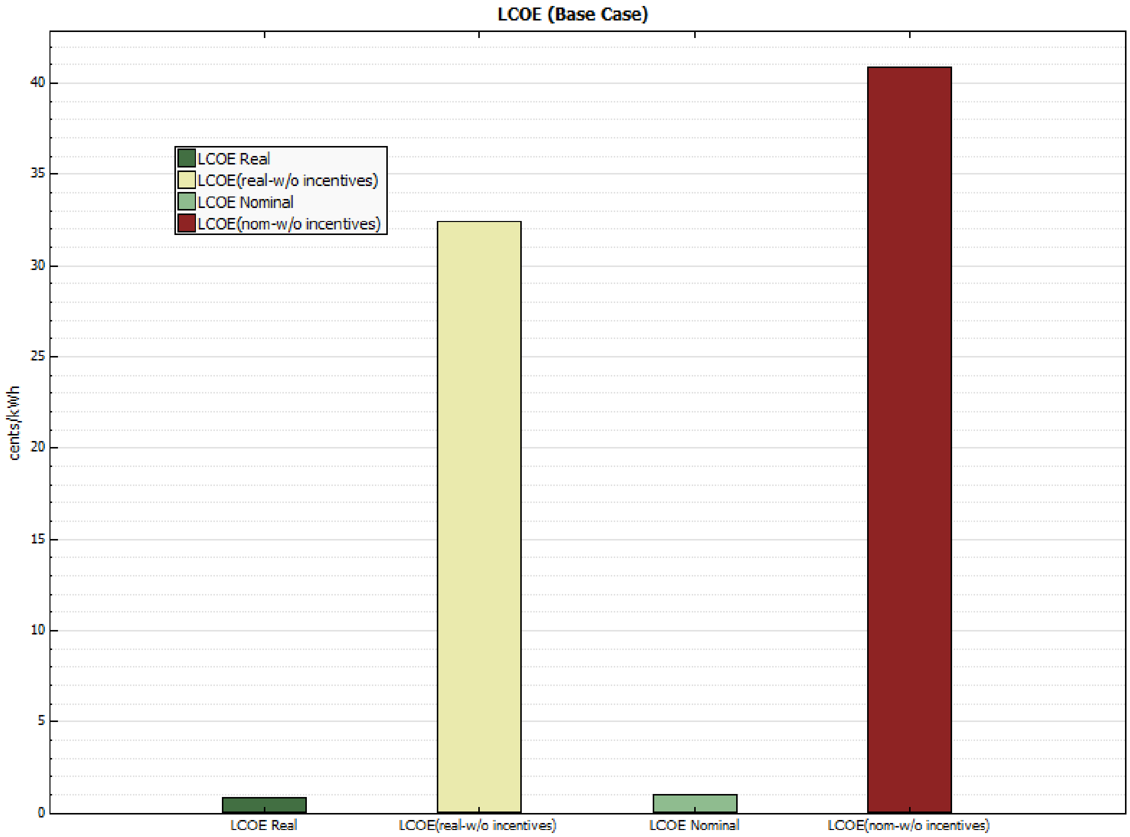

Figure B-3. LCOE for owner purchase of a fixed-axis system

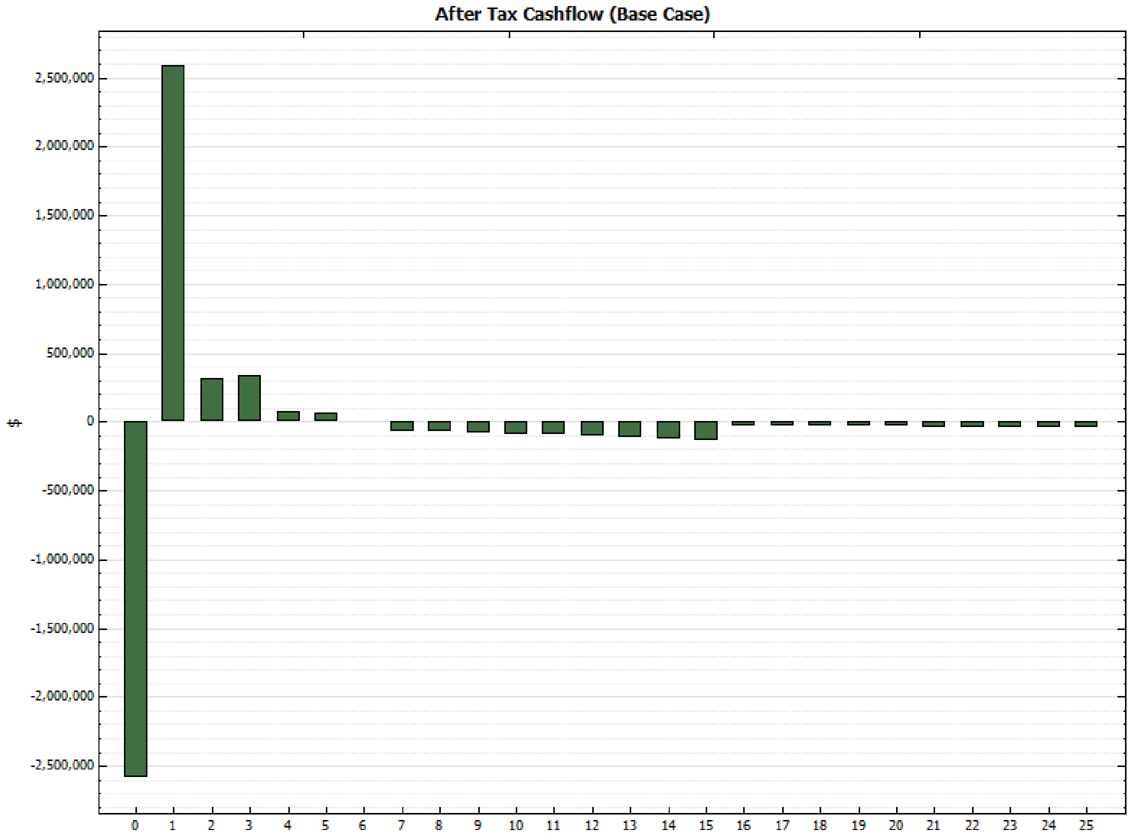

Figure B-4. After-tax cash flow for owner purchase of a fixed-axis system

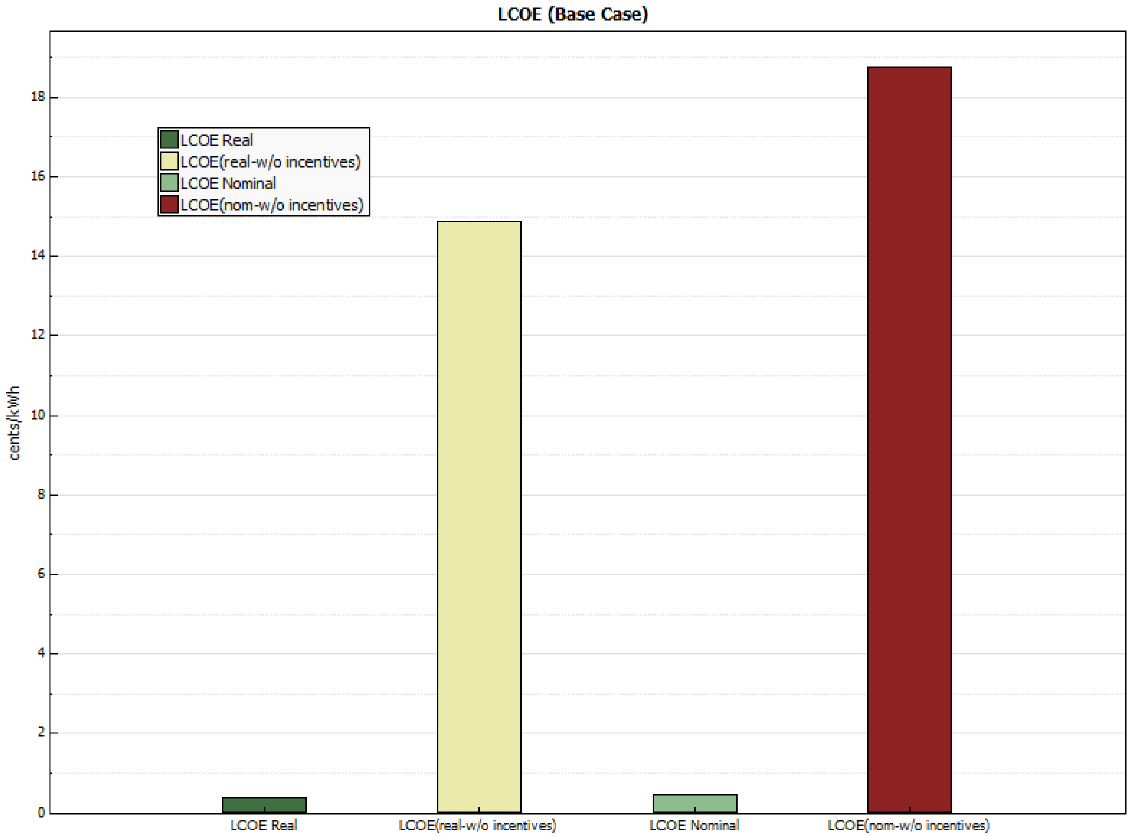

Figure B-5. LCOE for a developer-purchased fixed-axis system

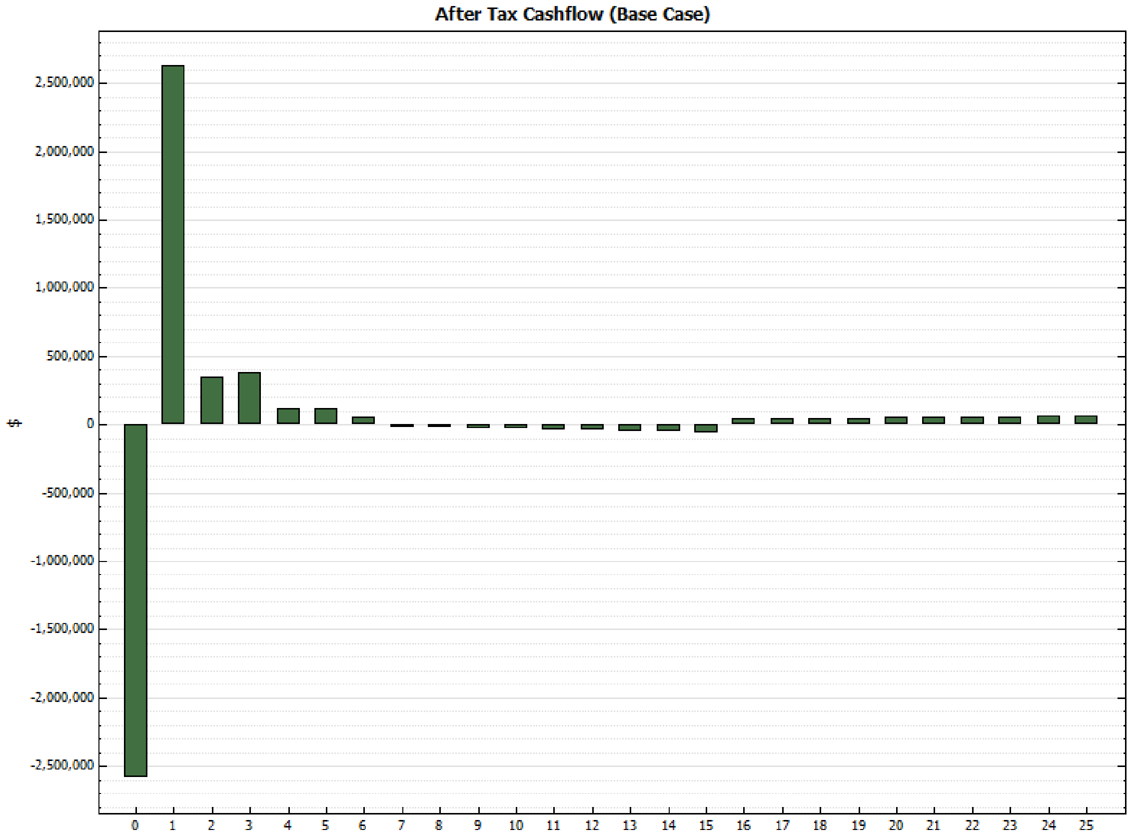

Figure B-6. After-tax cash flow for a developer-purchased fixed-axis system

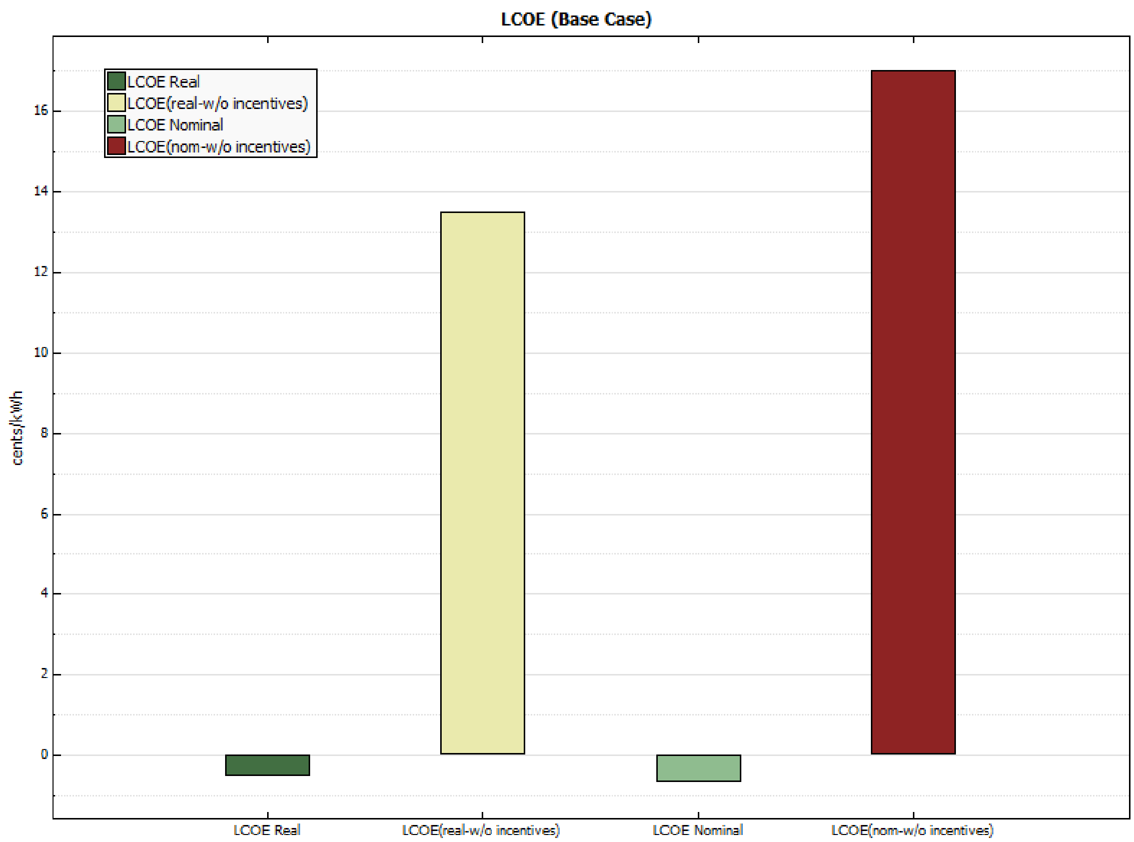

Figure B-7. LCOE for owner-purchased single-axis tracking PV system

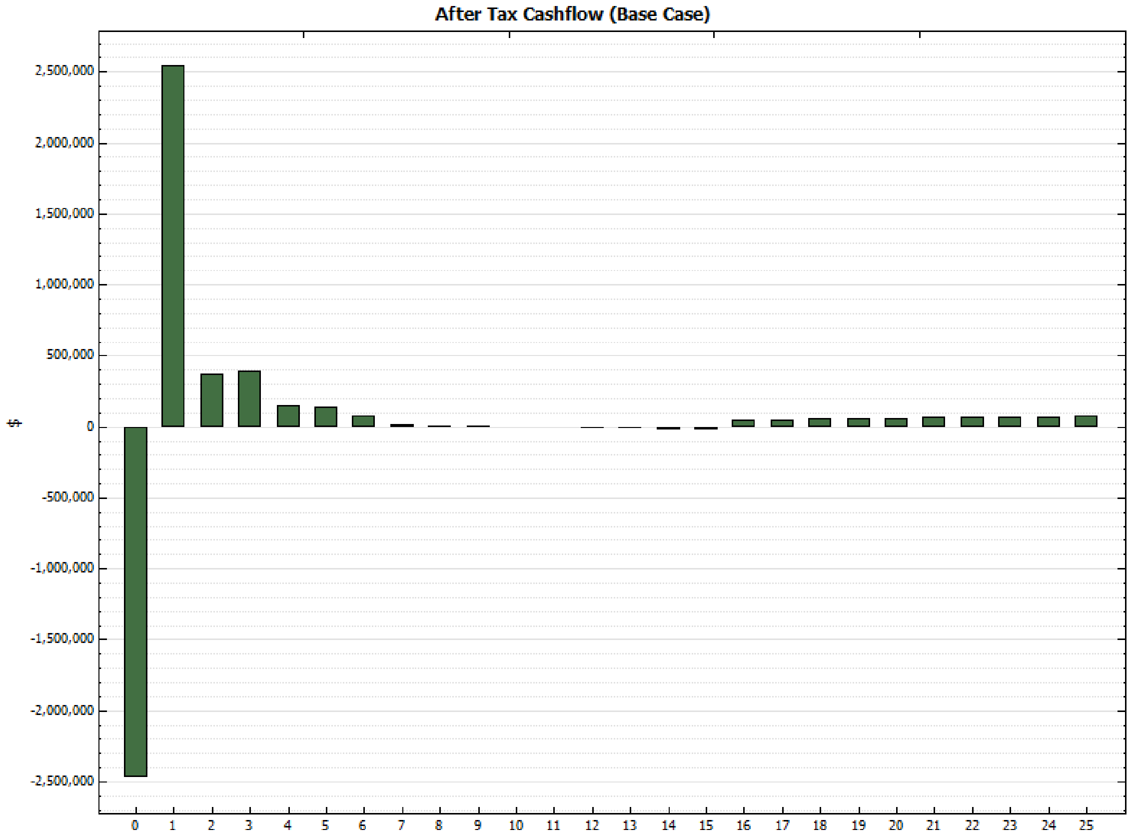

Figure B-8. After-tax cash flow for owner-purchased single-axis tracking PV system

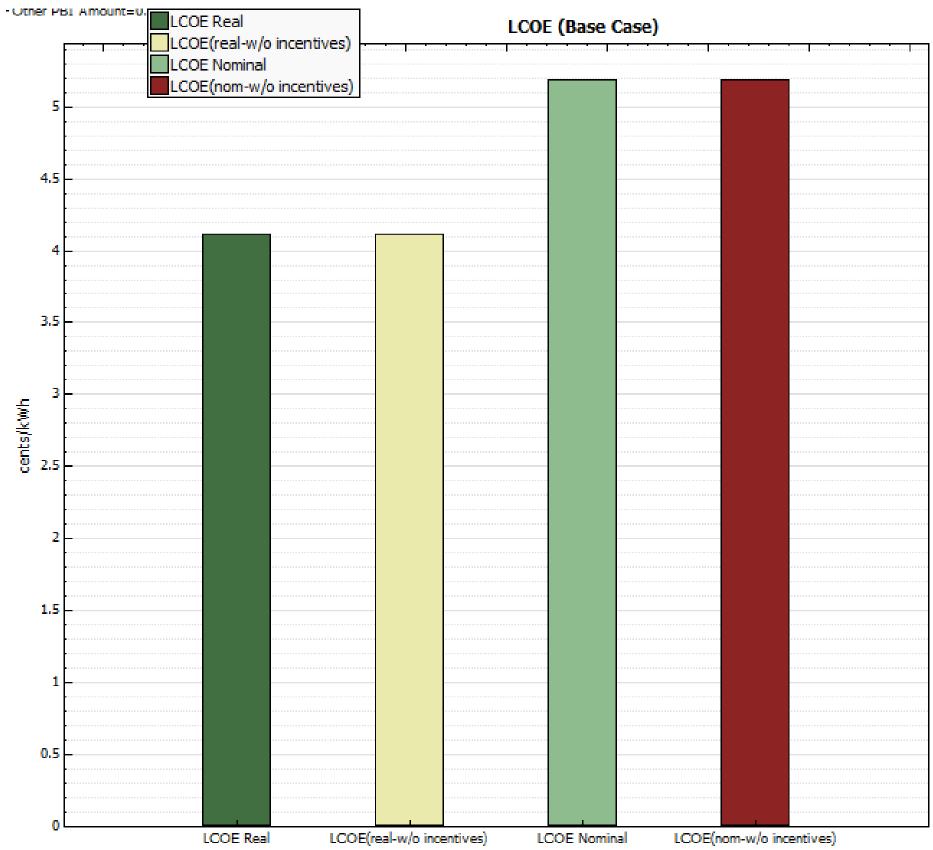

Figure B-9. LCOE for a developer-purchased single-axis tracking PV system

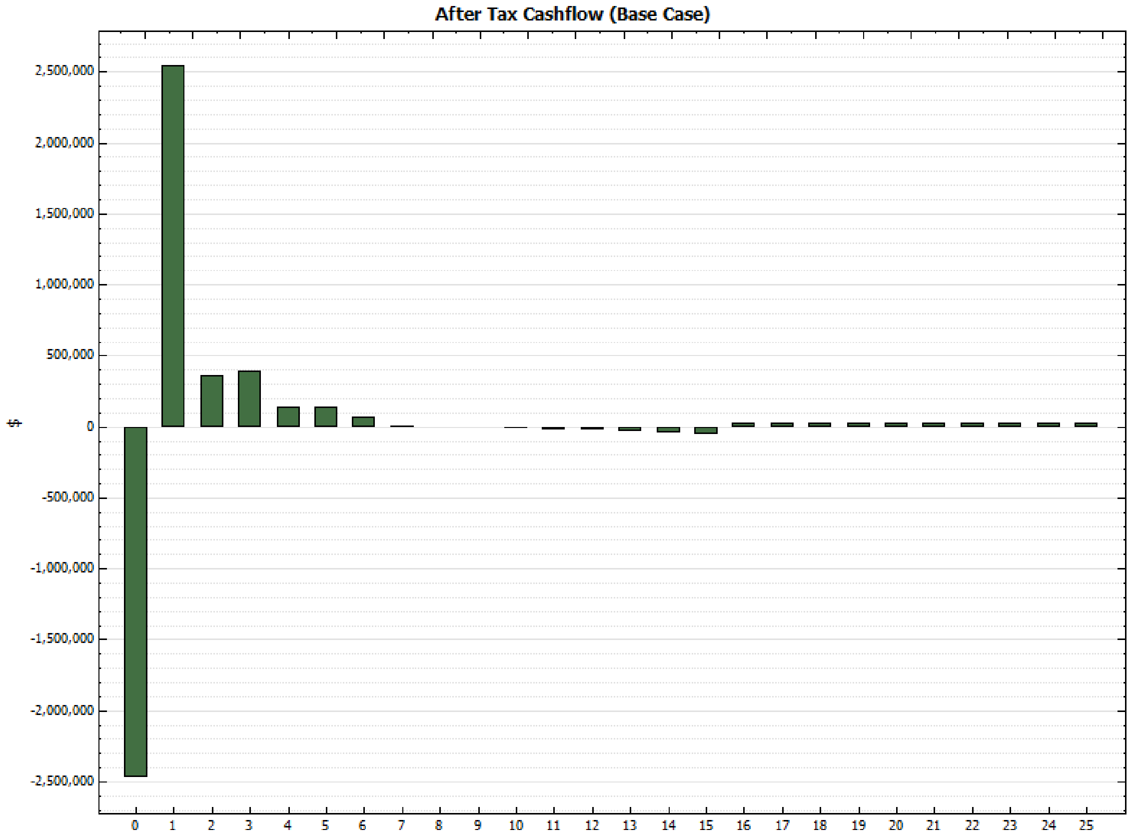

Figure B-10. After-tax cash flow for a developer-purchased single-axis tracking PV system

Table B-1. PPA Price Variation Based on SREC Price Variation

Fixed-Tilt PV Panel			Single-Axis PV Panel		
Installed Cost	SREC Price $/kWh	PPA $/kWh	Installed Cost	SREC Price $/kWh	PPA $/kWh
$ 4.00	0	0.19642	$ 4.64	0	0.177262
	0.01	0.188089		0.01	0.168931
	0.02	0.179758		0.02	0.1606
	0.03	0.171427		0.03	0.152269
	0.04	0.163096		0.04	0.143938
	0.05	0.154766		0.05	0.135607
	0.06	0.146435		0.06	0.127277
	0.07	0.138104		0.07	0.118946
	0.08	0.129773		0.08	0.110615
	0.09	0.121442		0.09	0.102284
	0.1	0.113111		0.1	0.093953
	0.11	0.10478		0.11	0.085622
	0.12	0.09645		0.12	0.077291
	0.13	0.088119		0.13	0.06896
	0.14	0.079788		0.14	0.06063
	0.15	0.071457		0.15	0.052299
	0.16	0.063126		0.16	0.043968
	0.17	0.054795		0.17	0.035637
	0.18	0.046464		0.18	0.027306
	0.19	0.038133		0.19	0.018975
	0.2	0.029802		0.2	0.010644
	0.21	0.021472		0.21	0.002313
	0.22	0.013141		0.22	7.45E-10
	0.225	0.008975		0.225	7.45E-10

Appendix C. Results from the Jobs and Economic Development Impact Model

Tables C-1 to C-8 provide results from the JEDI model.

Table C-1. Data Summary for JEDI Model Analysis of Fixed-Tilt PV System

Project Location	NEW JERSEY
Year of Construction or Installation	2013
Average System Size - DC Nameplate Capacity (KW)	1,434.0
Number of Systems Installed	1
Project Size - DC Nameplate Capacity (KW)	1,434.0
System Application	Utility
Solar Cell/Module Material	Crystalline Silicon
System Tracking	Fixed Mount
Total System Base Cost ($/KW$_{DC}$)	$4,151
Annual Direct Operations and Maintenance Cost ($/kW	$20.00
Money Value - Current or Constant (Dollar Year)	2012
Project Construction or Installation Cost	$5,952,064
Local Spending	$2,865,435
Total Annual Operational Expenses	$694,859
Direct Operating and Maintenance Costs	$28,680
Local Spending	$26,386
Other Annual Costs	$666,179
Local Spending	$803
Debt Payments	$0
Property Taxes	$0

Table C-2. Summary of Local Economic Impacts for JEDI Model Analysis of Fixed-Tilt PV System

	Jobs	Earnings	Output
During construction and installation period		**$000 (2012)**	**$000 (2012)**
Project Development and Onsite Labor Impacts			
Construction and Installation Labor	8.1	$522.7	
Construction and Installation Related Services	7.4	$469.4	
Subtotal	15.4	$992.1	$1,593.3
Module and Supply Chain Impacts			
Manufacturing Impacts	0.0	$0.0	$0.0
Trade (Wholesale and Retail)	1.7	$115.1	$331.9
Finance, Insurance and Real Estate	0.0	$0.0	$0.0
Professional Services	2.2	$129.7	$402.0
Other Services	3.6	$329.6	$1,112.0
Other Sectors	6.7	$233.0	$417.9
Subtotal	14.2	$807.4	$2,263.9
Induced Impacts	8.8	$437.4	$1,460.8
Total Impacts	**38.5**	**$2,236.9**	**$5,318.0**
		Annual	**Annual**
	Annual	**Earnings**	**Output**
During operating years	**Jobs**	**$000 (2012)**	**$000 (2012)**
Onsite Labor Impacts			
PV Project Labor Only	0.3	$16.0	$16.0
Local Revenue and Supply Chain Impacts	0.1	$5.3	$16.3
Induced Impacts	0.1	$2.9	$9.8
Total Impacts	**0.4**	**$24.2**	**$42.1**

Notes: Earnings and Output values are thousands of dollars in year 2012 dollars. Construction and operating period jobs are full-time equivalent for one year (1 FTE = 2,080 hours). Economic impacts "During operating years" represent impacts that occur from system/plant operations/expenditures. Totals may not add up due to independent rounding.

Table C-3. Detailed Summary of Costs for JEDI Model Analysis of Fixed-Tilt PV System

	NEW JERSEY	**Purchased**	**Manufactured**
Installation Costs	**Cost**	**Locally (%)**	**Locally (Y or N)**
Materials & Equipment			
Mounting (rails, clamps, fittings, etc.)	$209,179	100%	N
Modules	$2,297,301	100%	N
Electrical (wire, connectors, breakers, etc.)	$238,500	100%	N
Inverter	$341,650	100%	N
Subtotal	$3,086,630		
Labor			
Installation	$522,654	100%	
Subtotal	$522,654		
Subtotal	$3,609,283		
Other Costs			
Permitting	$24,151	100%	
Other Costs	$533,740	100%	
Business Overhead	$1,568,825	100%	
Subtotal	$2,126,717		
Subtotal	$5,736,000		
Sales Tax (Materials & Equipment Purchases)	$216,064	100%	
Total	$5,952,064		

Table C-4. Annual O&M Costs for JEDI Model Analysis of Fixed-Tilt PV System

	Cost	Local Share	Manufactured Locally (Y or N)
Labor			
Technicians	$17,208	100%	
Subtotal	$17,208		
Materials and Services			
Materials & Equipment	$11,472	100%	N
Services	$0	100%	
Subtotal	$11,472		
Sales Tax (Materials & Equipment Purchases)	$803	100%	
Average Annual Payment (Interest and Principal)	$665,376	0%	
Property Taxes	$0	100%	
Total	$694,859		
Other Parameters			
Financial Parameters			
Debt Financing			
Percentage financed	80%	0%	
Years financed (term)	10		
Interest rate	10%		
Tax Parameters			
Local Property Tax (percent of taxable value)	0%		
Assessed Value (percent of construction cost)	0%		
Taxable Value (percent of assessed value)	0%		
Taxable Value	$0		
Property Tax Exemption (percent of local taxes)	100%		
Local Property Taxes	$0	100%	
Local Sales Tax Rate	7.00%	100%	
Sales Tax Exemption (percent of local taxes)	0%		
Payroll Parameters	**Wage per hour**	**Employer Payroll Overhead**	
Construction and Installation Labor			
Construction Workers / Installers	$21.39	45.6%	
O&M Labor			
Technicians	$21.39	45.6%	

Table C-5. Data Summary for JEDI Model Analysis of Single-Axis Tracking PV System

Project Location	NEW JERSEY
Year of Construction or Installation	2013
Average System Size - DC Nameplate Capacity (KW)	1,182.0
Number of Systems Installed	1
Project Size - DC Nameplate Capacity (KW)	1,182.0
System Application	Utility
Solar Cell/Module Material	Crystalline Silicon
System Tracking	Single Axis
Total System Base Cost ($/KW$_{DC}$)	$4,640
Annual Direct Operations and Maintenance Cost ($/kW	$20.00
Money Value - Current or Constant (Dollar Year)	2012
Project Construction or Installation Cost	$5,484,480
Local Spending	$2,963,253
Total Annual Operational Expenses	$660,502
Direct Operating and Maintenance Costs	$23,640
Local Spending	$21,749
Other Annual Costs	$636,862
Local Spending	$662
Debt Payments	$0
Property Taxes	$0

Table C-6. Summary of Local Economic Impacts for JEDI Model Analysis of Single-Axis Tracking PV System

	Jobs	Earnings	Output
During construction and installation period		**$000 (2012)**	**$000 (2012)**
Project Development and Onsite Labor Impacts			
Construction and Installation Labor	6.6	$425.3	
Construction and Installation Related Services	8.8	$560.3	
Subtotal	15.4	$985.7	$1,703.3
Module and Supply Chain Impacts			
Manufacturing Impacts	0.0	$0.0	$0.0
Trade (Wholesale and Retail)	1.8	$130.6	$376.6
Finance, Insurance and Real Estate	0.0	$0.0	$0.0
Professional Services	2.7	$154.8	$479.9
Other Services	4.3	$393.2	$1,326.4
Other Sectors	4.9	$55.3	$175.8
Subtotal	13.6	$733.9	$2,358.9
Induced Impacts	8.9	$438.1	$1,463.2
Total Impacts	**37.9**	**$2,157.7**	**$5,525.3**
		Annual	**Annual**
	Annual	**Earnings**	**Output**
During operating years	**Jobs**	**$000 (2012)**	**$000 (2012)**
Onsite Labor Impacts			
PV Project Labor Only	0.2	$13.2	$13.2
Local Revenue and Supply Chain Impacts	0.1	$4.4	$13.4
Induced Impacts	0.0	$2.4	$8.1
Total Impacts	**0.3**	**$20.0**	**$34.7**

Notes: Earnings and Output values are thousands of dollars in year 2012 dollars. Construction and operating period jobs are full-time equivalent for one year (1 FTE = 2,080 hours). Economic impacts "During operating years" represent impacts that occur from system/plant operations/expenditures. Totals may not add up due to independent rounding.

Table C-7. Detailed Summary of Costs for JEDI Model Analysis of Single-Axis Tracking PV System

	NEW JERSEY	**Purchased**	**Manufactured**
Installation Costs	**Cost**	**Locally (%)**	**Locally (Y or N)**
Materials & Equipment			
Mounting (rails, clamps, fittings, etc.)	$293,785	100%	N
Modules	$1,876,486	100%	N
Electrical (wire, connectors, breakers, etc.)	$71,889	100%	N
Inverter	$279,067	100%	N
Subtotal	$2,521,227		
Labor			
Installation	$425,350	100%	
Subtotal	$425,350		
Subtotal	$2,946,577		
Other Costs			
Permitting	$29,921	100%	
Other Costs	$661,243	100%	
Business Overhead	$1,846,739	100%	
Subtotal	$2,537,903		
Subtotal	$5,484,480		
Sales Tax (Materials & Equipment Purchases)	$0	100%	
Total	$5,484,480		

Table C-8. Annual O&M Costs for JEDI Model Analysis of Single-Axis Tracking PV System

	Cost	Local Share	Manufactured Locally (Y or N)
Labor			
Technicians	$14,184	100%	
Subtotal	$14,184		
Materials and Services			
Materials & Equipment	$9,456	100%	N
Services	$0	100%	
Subtotal	$9,456		
Sales Tax (Materials & Equipment Purchases)	$662	100%	
Average Annual Payment (Interest and Principal)	$636,200	0%	
Property Taxes	$0	100%	
Total	$660,502		
Other Parameters			
Financial Parameters			
Debt Financing			
Percentage financed	80%	0%	
Years financed (term)	10		
Interest rate	10%		
Tax Parameters			
Local Property Tax (percent of taxable value)	0%		
Assessed Value (percent of construction cost)	0%		
Taxable Value (percent of assessed value)	0%		
Taxable Value	$0		
Property Tax Exemption (percent of local taxes)	100%		
Local Property Taxes	$0	100%	
Local Sales Tax Rate	7.00%	100%	
Sales Tax Exemption (percent of local taxes)	0%		
Payroll Parameters	**Wage per hour**	**Employer Payroll Overhead**	
Construction and Installation Labor			
Construction Workers / Installers	$21.39	45.6%	
O&M Labor			
Technicians	$21.39	45.6%	