Final Report

U.S. Department of Energy
2007 Solar America Showcase
City of San Jose, California
Environmental Innovation Center
Solar Site Evaluation

San Jose, California

Prepared for

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Acronyms and Abbreviations

$/kWh	dollars per kilowatt-hour
BIPV	building integrated photovoltaic
BOS	balance of system
City	City of San Jose, California
DC	direct current
DC_{STC}	direct current - standard test conditions
DOE	United States Department of Energy
EIC	San Jose Environmental Innovation Center
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
PG&E	Pacific Gas and Electric Company
PPA	power purchase agreement
PV	photovoltaic
SAM	Solar Advisor Model

1.0 Introduction

This report describes the findings of a solar photovoltaic (PV) site evaluation conducted at the San Jose Environmental Innovation Center (EIC) in the City of San Jose, California (City). This evaluation was conducted as part of a larger study to assess solar potential at multiple public facilities within the City. The DOE Tiger Team, including staff from CH2M Hill, Sandia National Labs, and New Mexico State University, conducted the evaluations in partnership with, and on behalf of, the U.S. Department of Energy (DOE) as part of the Solar America Initiative, a multi-year program aimed at accelerating demand and development of solar technologies among key end-use market sectors. Through the Solar America Showcase, DOE provides technical assistance to large-scale (in excess of 100 kilowatt [kW]), high-visibility solar installation projects that have the ability to impact the market for solar technologies through large project size, use of a novel solar technology, and/or use of a novel application for a solar technology. The City of San Jose was one of three locations awarded a Solar America Showcase award in May 2007.

1.1 Sites

Based on a list provided by the City of San Jose and documented in the Technical Assistance Statement of Work, the following sites were evaluated as part of this study:

- City of San Jose 4th Street Parking Garage
- Children's Discovery Museum
- HP Pavilion at San Jose
- San Jose Convention Center
- Story Road Landfill
- San Jose Environmental Innovation Center
- Central Service Yard
- San Jose/Santa Clara Water Pollution Control Plant

The DOE Tiger Team conducted the site evaluations on April 1-3, 2008.

1.2 Purpose and Scope

The purpose of the study was to evaluate the potential and cost-benefits for placing solar technologies on multiple public facilities within the City. The scope of the study was to provide the City with the following:

1) Determination of appropriate solar technology and size at each facility
2) Conceptual layout of a solar system for each facility

3) Estimated system cost
4) Electricity production potential and annual energy savings estimate for each facility
5) A simplified financial analysis for the highest-priority facilities.

As part of the study, the San Jose Showcase Tiger Team reviewed available data for each facility including current electrical usage, utility rate structure, site operations, and site drawings. During the site evaluations, the Tiger Team conducted an assessment of site conditions and collected relevant site data including facility orientation, roof type, potential shading, and location/availability of potential electrical interconnections.

For this analysis, the Tiger Team used publicly-available solar resource data, solar screening tools, and vendor-supplied information to assess the potential for installing a PV and/or a concentrating solar thermal electric system at the site. The solar resource data were downloaded from the National Renewable Energy Laboratory (NREL) website (www.nrel.gov) and are based on actual solar measurements and modeled values incorporating cloud cover data and satellite imagery. The Tiger Team used the PVWATTs and/or the Solar Advisor Model (SAM) screening tools (also available from the NREL website) to estimate annual energy production from the solar electric system. It is important to note that PVWatts and SAM are first-order screening tools that provide estimates of the potential peak output and energy production from a solar electric system at a particular location. The model uses the generalized capacity of the solar electric system and does not take into account design considerations such as the layout of series and parallel array strings. Further refinement of the proposed solar electric system would involve engineering design to size wiring and fuses, and determine the actual strings of modules required to create the proper input voltages and currents to the inverter. The detailed design would take into account local, state, and federal building and electric codes and would ensure that proper safety protocols are followed for interconnecting with the electric utility grid. Detailed design is beyond the scope of the current assessment.

The following sections present the findings of this study for the EIC. Section 2 presents a brief analysis of the key data for the site along with a conceptual layout, size, and specification for a potential solar system at the site. Section 3 presents the conclusions and findings from this study. Section 4 presents the references used during this study.

2.0 Solar Site Evaluation

This section presents the key information used to develop the solar evaluation for the EIC. The following data is presented:

- Site description and operations
- Current electrical usage and utility rate structure
- Site orientation and shading analysis
- Appropriate solar technology
- Conceptual solar system layout
- Potential electrical interconnection points
- Estimated cost
- Estimated electrical production and annual energy cost savings

Where appropriate, additional site-specific information collected during the site visit is also presented below.

2.1 Site Description and Operations

The EIC is located at 1608 Las Plumas Avenue, approximately three miles north of downtown San Jose (Figure 1). The Site was previously used as a plastic bag manufacturing facility. The City plans to redevelop the Site for use as a community recycling center. The City would also like to use the property as a demonstration site for solar technologies.

Figure 1 - Aerial Photograph of the San Jose Environmental Innovation Center

2.2 Current Electrical Usage

The EIC has one electrical meter. The following usage data was recorded at the meter between March 2007 and February 2008. The Site is not currently occupied and electricity consumption is minimal.

Table 1 – Monthly Electricity Data at the San Jose Environmental Innovation Center

Read Date	kW	kWh	Total Electricity Cost ($)	Unit Cost ($/kWh)
Oct-08	12	118	$239	$2.02
Sep-08	12	122	$247	$2.02
Aug-08	15	156	$269	$1.73
Jul-08	15	157	$269	$1.72
Jun-08	15	167	$287	$1.72
May-08	17	40	$202	$5.04
Apr-08	17	38	$195	$5.13
Mar-08	17	42	$215	$5.12
Feb-08	17	38	$195	$5.13
Jan-08	17	40	$202	$5.04
Sum		918	2,321	
Max	17			
Avg				$2.528

Notes:
kW = kilowatt; kWh = kilowatt-hour

The monthly electricity profile for this meter is shown graphically on Figure 2.

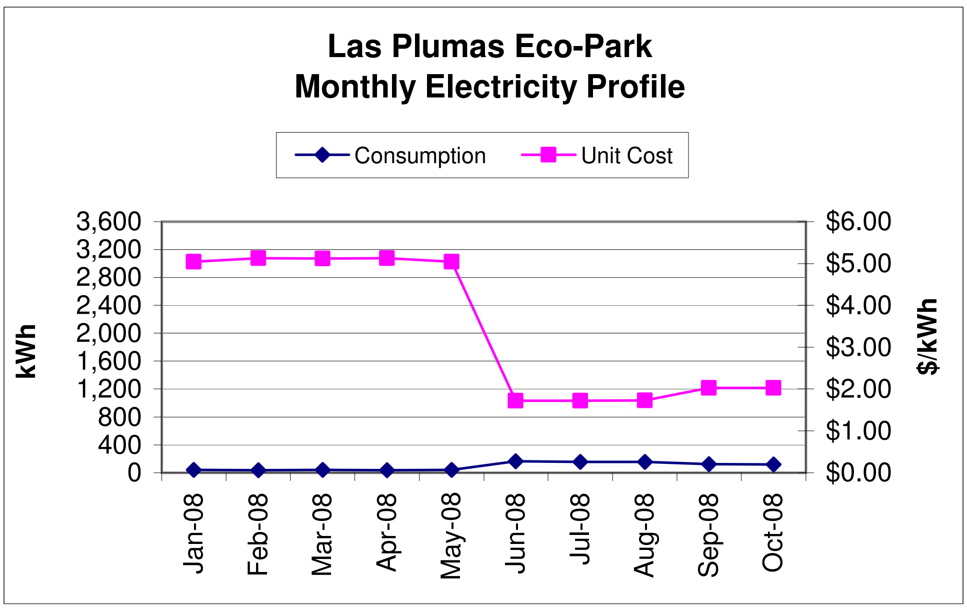

Figure 2 – Monthly Electricity Profile at the San Jose Environmental Innovation Center

Electricity service at the Site is provided by the Pacific Gas and Electric Company (PG&E) under rate schedule A-10S (Medium General Demand-Metered Service). Based on the available data, electricity consumption (in kilowatt-hours [kWh]) and power demand (in kW) through the main meter are charged at fixed rates which vary by season (winter or summer). The summer (May 1 through October 31) electricity rate is currently approximately $0.12 per kWh ($0.12/kWh). The winter (November 1 through April 30) electricity rate is currently approximately $0.09/kWh. Demand charges are applied at a fixed rate per kW of $8.86/kW during the summer months and $5.00/kW during the winter months. Currently, the blended average electricity price is abnormally high ($2.52/kWh), reflecting the fixed monthly meter charge and/or other fees which constitute a relatively large percentage of the overall electrical cost. A future solar PV system installed at the Site would benefit the City in two ways: by reducing monthly kWh consumption, particularly during the summer months when electricity is more expensive, and by reducing the overall demand charge, especially during the summer months. Note that a future solar PV system would not offset the fixed monthly meter charge or other monthly fees.

2.3 Site Orientation and Shading Analysis

The Site is located at 37° 21′ 38.08″ North latitude and 121° 52′ 04.05″ West longitude. The long axis of the building is oriented in a northwest-to-southeast direction, at an azimuth of approximately 140°. Consistent with the building orientation, solar energy systems should be installed at an azimuth of 140° or 230°. Based on modeling conducted with PVWatts, the difference in output between systems oriented at these azimuths is less than 1%. However, an orientation of 230° will produce more solar energy late in the afternoon when air conditioning loads are typically the highest. Thus, an azimuth of 230° is recommended for future PV systems installed on the existing building.

The facility is two stories tall and is currently surrounded by low-rise buildings. Shadows from adjacent buildings do not impact the Site. An old cooling tower is present at the Site and partially shades the building during part of the day, but the tower will likely be removed when the site is redeveloped. The shading analysis report for the Site is presented as Appendix A (views Sky20 through Sky22).

2.4 Appropriate PV Technology

Based on information provided by the City, there are no practical weight or mounting constraints associated with the Site's roof, and there are no adverse environmental conditions (e.g., heavy dust, heavy fog, or corrosive gases) that might impact PV module output or integrity. The significant constraint at the facility is roof space. If the City's objective is to maximize electrical production for the available roof space, mid-efficiency or high-efficiency PV modules should be utilized. Consistent with the City's objective of providing a platform for technology demonstration, however, it may also be acceptable to install less efficient PV modules at the Site.

Monocrystalline silicon PV modules generally offer higher efficiency than multicrystalline silicon and thin-film PV modules, but are typically more expensive on a cost per watt basis. The highest efficiency monocrystalline modules available today operate with an efficiency of approximately 18%. Mid-efficiency crystalline modules (both monocrystalline and multicrystalline) range from 7%-14% efficiency. The lower efficiency of these modules relative to high-efficiency monocrystalline modules is typically offset by a lower cost per installed watt. Thin-film modules have the lowest efficiency, ranging from 4%-10%, and are typically sold at a lower price than monocrystalline and multicrystalline modules. However, the cost of installing thin-film modules often brings the installed cost of thin-film within the range of crystalline modules.

Several companies are developing new thin-film PV products in an effort to improve module efficiency and/or reduce cost. These companies include Applied Materials, First Solar, HelioVolt, Nanosolar, Sharp, and SunPower. Nanosolar is a local company pursuing a novel strategy based on a nanoparticle solar "ink" that is deposited onto a metal film via a "printing" technology. Nanosolar claims to have developed a 14% efficient cell using this manufacturing method. As the efficiency of thin-film modules improves and/or the cost decreases, thin-film PV may become an attractive option for new solar projects.

Building-integrated photovoltaic (BIPV) modules could also be used at the Site. BIPV systems incorporate the solar module into the building structure. One type of BIPV product, known as a bifacial PV panel, has the ability to collect solar energy from both the front and back of the panel. The panel has transparent glass on both sides, and allows sunlight to partially pass through the structure in the spaces between solar cells, as shown in Figure 3. Bifacial modules are used as architectural features to produce energy while still allowing for natural lighting.

Figure 3 - A bifacial solar installation (Source: Sanyo)

The choice of PV technology for the Site depends on the City's objectives. Mid-efficiency crystalline PV modules would be less expensive per watt, but higher-efficiency crystalline modules would increase electrical production by as much as 50%. Bifacial solar panels could create a "high-tech" look and showcase PV technology if integrated into the proposed canopy. Costs for various technologies are explored in greater detail in Section 2.7.

Given the space constraints at the EIC, and the City's stated objective to maximize electricity production, mid-efficiency or high-efficiency monocrystalline PV modules are recommended for the roof. Bifacial modules would be a suitable technology for the proposed canopy or parking structure. Emerging PV technologies could also be installed on the proposed canopy as part of a technology demonstration effort.

2.5 Conceptual PV System Layout

Solar PV arrays could potentially be installed on the existing roof, the proposed canopy structure, and a proposed overhead parking structure. Area-specific layouts and estimated system output based on different module technologies are presented in the sections below. Roofing orientation, shading concerns, electrical connections, mounting systems, and other factors were taken into consideration in the development of the conceptual system layouts in each area.

2.5.1 Existing Roof

Figure 4 presents a conceptual PV system layout for the existing building at the EIC. The existing roof is approximately 320 feet long by 120 feet wide. There are several existing rooftop features including vents, air conditioning units, a cooling tower, and a small parapet. A PV system installed on the existing roof would need to be broken into multiple sub-arrays to avoid shading from these roof features, although it is possible that some of these features could be removed in the future depending on Site redevelopment plans. It is likely that the existing roof of the building would need to be replaced as part of site redevelopment, prior to installation of solar modules at the site.

Figure 4 – Conceptual PV system at the San Jose Environmental Innovation Center

Table 2 presents the estimated available roof area, number of modules, and approximate system capacity for each conceptual PV subarray on the existing roof. Appendix B presents the methodology and calculations used to derive the values presented in Table 2.

Table 2 – Estimated Number of Modules and Approximate PV System Capacity, Existing Roof

Roof Area #	Available Roof Area (ft^2)	Number of Modules	System Capacity Based on Different Types of PV Modules (kW DC_{STC})		
			75W Thin Film (low efficiency)	200W mono- or multicrystalline (mid efficiency)	300W Monocrystalline (high efficiency)
1	2,244	76	5.7	15.2	22.8
2	5,848	209	15.7	41.8	62.7
3	2,068	70	5.3	14.0	21.0
4	5,852	209	15.7	41.8	62.7
5	3,410	115	8.6	23.0	34.5
Total	19,422	679	50.9	135.8	203.7

Notes:
DC = direct current
ft2 = square feet
kW = kilowatts
STC = standard test conditions
W = watts

Figure 5 shows a possible ballasted, low angle (10°) mounting structure for the PV modules. Several manufacturers offer this type of mounting structure. The advantage of a ballasted mounting system is that it does not require roof penetrations, will withstand 80 to 100 mile per hour winds, and is designed to meet seismic requirements for construction.

Figure 5 – Possible ballasted mounting system. (Source: UniRac, Inc.)

2.5.2 Proposed Canopy

The City of San Jose has proposed constructing a canopy on the west side of the existing building to cover drop-off area for the recycling center. The canopy roof could potentially be used as a testing and demonstration site for new PV technologies. Two possible designs for this structure include:

- Option 1: Metal roof canopy
- Option 2: BIPV canopy

2.5.2.1 Option 1: Metal Roof Canopy

The canopy could be fitted with a traditional standing-seam metal roof. Figure 6 presents a conceptual layout for four experimental PV arrays that could be mounted on the canopy. Each array in Figure 6 is approximately 1,600 square feet in size, and a 10-foot-wide lane has been provided between each array to improve safety and access for technicians and emergency personnel who may need to work on the roof.

Figure 6 – Conceptual Layout of Proposed Metal Canopy and Early Stage PV Arrays

The PV systems could be attached directly to the standing-seam metal roof, as shown in Figure 7.

Figure 7 – PV modules installed on standing-seam metal roof (Source: Design-Build Network)

Several manufacturers offer “c” clamps for attaching PV modules or mounting racks to standing metal roof seams (Figure 8). This type of mounting system avoids the need to drill holes in the metal roof membrane. These mounting systems are capable of withstanding high winds and are designed to satisfy seismic requirements. Further engineering analysis would be required to ensure that the roof surfaces would be suitable to support the PV modules, and to determine what type of mounting “c” clamps and racking equipment would be most appropriate.

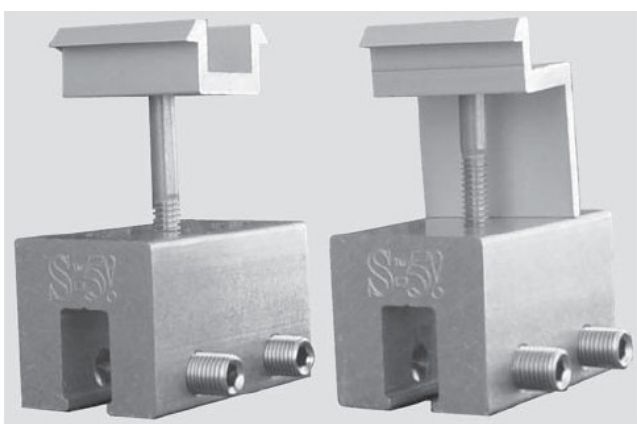

Figure 8 – Possible rack-mounting equipment for PV modules on standing-seam metal roofs. (Source: UniRac®)

Structural design considerations for this type of canopy would include static and dynamic loading as well as operations and maintenance access for PV modules. The typical dead load for PV systems with the proposed racking system is approximately 5 to 8 pounds per square foot. Dynamic loads could include wind loads, snow loads, and seismic requirements. It should be noted that a solar system attached to a standing-seam metal roof with a "c" clamp will attach only to the standing seam metal roof, and not the actual structure of the canopy. The roof should therefore be designed and constructed with adequate fasteners to tie the roof into the underlying support structure to accommodate the appropriate static and dynamic loads for the San Jose area.

To improve solar electricity generation, the canopy should be designed with a 5° to 15° tilt with the downward slope facing southwest. A roof tilt of 5° is the minimum recommended slope for a solar system, and a slope of 10° to 15° would be preferred to optimize annual energy production from the PV. The slope also ensures that rain will reduce dust accumulation on the solar modules.

2.5.2.2 BIPV Canopy

Another potential concept for the canopy is to employ a BIPV "solarscape" using custom racking with bifacial solar panels as shown in Figure 9. A bifacial solar system uses solar cells encased in glass on both sides. Bifacial solar systems collect sunlight from the front and back, so the panels collect about 130% of the energy of other panels depending on the albedo and reflectivity of the surfaces below (Sanyo, 2008). Another potential advantage of a solarscape is that it would allow site visitors to see that the facility is powered by solar energy. Traditional PV panels placed over a metal roof would not likely be seen by the community.

Figure 9 – Conceptual layout of proposed canopy with BIPV modules

The main drawbacks to a custom solarscape are the higher price for bifacial modules and the requirement for a specialized mounting structure. Several companies sell pre-fabricated structural kits designed specifically to accommodate bifacial solar panels, as shown in Figure 10.

Figure 10 – Racking system designed for BIPV bifacial solar modules (Lumos, 2008)

Another BIPV option for the proposed canopy would be to use traditional PV modules with an integrated structure, such as in the shade canopy shown in Figure 11. This canopy uses solar panels as the roofing material, saving the cost of adding a metal roof. This is similar to a solarscape using bifacial modules, but does not allow light through the canopy.

Figure 11 – Shade structure in California (Source: M Bar C Construction)

As described previously for the metal roof canopy, a BIPV canopy should be designed, if possible, with a south or southwest orientation, and with a slight tilt to reduce dust accumulation. These design features would maximize energy production from the canopy. Table 3 presents the estimated available roof area, number of modules, and approximate system capacity for the BIPV canopy options.

Table 3 – Estimated Number of Modules and Approximate PV System Capacity, Proposed Canopy

Area #	Available Roof Area (ft²)	Number of Modules	System Capacity Based on Different Types of PV Modules (kW DC_{STC})		
			75W Thin Film (low efficiency)	200W mono- or multicrystalline (mid efficiency)	300W Monocrystalline (high efficiency)
Canopy Option 1: Metal Canopy with Experimental Areas 1-4	6,400	216	16.4	43.2	64.8
Canopy Option #2: BIPV Canopy	10,000	727	-	145.4	-

Notes:
DC = direct current
ft2 = square feet
STC = standard test conditions
W = watts

2.5.3 New Parking Structure

A new covered parking structure has also been proposed for the site. The parking structure could consist of PV modules mounted on a steel carport structure, extending parallel to Las Plumas Avenue. The mounting structure would provide shade to cars parked underneath. The PV system could incorporate either a fixed-mounting structure or a single-axis tracking system, although a fixed-mount system would be expected to provide more electrical output for this application. It is possible that the PV parking structure system proposed for the 4th Street City Parking Garage could be relocated to this facility when planned high-rise buildings are constructed near that site. Figure 12 presents a conceptual layout for the proposed parking structure.

Figure 12 – Conceptual layout of proposed parking structure

Table 4 presents the estimated available area, number of modules, and approximate system capacity for a fixed-mount covered parking structure suitable for the Site.

Table 4 – Estimated Number of Modules and Approximate PV System Capacity, New Parking Structure

Area #	Available Roof Area (ft^2)	Number of Modules	System Capacity Based on Different Types of PV Modules (kW DC_{STC})		
			75W Thin Film (low efficiency)	200W mono- or multicrystalline (mid efficiency)	300W Monocrystalline (high efficiency)
New Parking Structure	18,025	716	53.7	143.2	214.8

Notes:
DC = direct current
ft2 = square feet
STC = standard test conditions
W = watts

As shown in Table 2, the estimated maximum system capacity that could be installed on existing roof areas is 203.7 kW using high-efficiency PV modules. Approximately 135.8 kW would be possible using mid-efficiency PV modules on existing roof areas.

As shown in Tables 3 and 4, an estimated 145.4 kW of capacity could be installed on the proposed canopy using mid-efficiency BIPV modules, and an estimated 214.8 kW could be installed on the proposed parking structure using high-efficiency monocrystalline PV modules. Taken together, the total estimated capacity that could be installed at the site on the existing roof area and the proposed new structures is 563.9 kW.

2.6 Electrical Interconnection

Multiple inverters would likely be required to provide operational flexibility for the multiple PV arrays that could be installed at the Site. Inverters for the PV systems could probably be installed inside the building, which would improve inverter efficiency and electrical output. A secure, fenced enclosure with bollards could be constructed to protect the inverters.

The existing electrical infrastructure at the facility is old and in need of upgrading as part of site redevelopment. Figure 13 shows the existing 3-phase, 480 volt service panel located in the main part of the building.

Figure 13 – Existing electrical panel and interconnection point

During site redevelopment, the electric service should be upgraded to accommodate the largest potential PV system. A new subpanel could be installed that has sufficient space to accommodate multiple PV arrays installed across the existing roof area, the proposed canopy, and the proposed parking structure. The new subpanel could then feed into the upgraded main service panel.

2.7 Estimated Capital Cost

Based on a large number of PV projects installed in California, staff at the National Renewable Energy Laboratory (NREL) have estimated installation, operation and maintenance (O&M), and balance of system (BOS) costs for PV projects (NREL, 2008). The data suggest an average installed cost of approximately $6.87/watt for PV systems greater than 100 kW in size. However, the actual installed cost would probably be somewhat higher at the EIC due to the difficulty of installing PV in multiple arrays using multiple mounting techniques. Furthermore, the cited cost does not include materials and construction of the parking structure or the canopy structure. Market data also suggests that high-efficiency PV modules typically carry a cost premium of approximately $0.50 to $1.00 per watt over mid-efficiency PV modules.

2.7.1 Existing Roof

Assuming an overall installed cost of $7.00/watt for mid-efficiency PV modules, the total estimated gross installed cost of the 135.8 kW DC_{STC} conceptual system on the existing roof area would be approximately $950,000. Assuming an overall installed cost of $7.50/watt for high-efficiency PV modules, the total estimated gross installed cost of the 203.7 kW DC_{STC} conceptual system would be approximately $1.53 million.

2.7.2 Proposed Canopy

Bifacial solar modules typically carry a cost premium of $0.50 to $1.00 per watt over typical mid-efficiency crystalline PV modules. One vendor estimated a total cost of $10.00 to $11.00 per watt for a simple carport solarscape installation, including the racking structure, bifacial modules, inverters, balance of system, and installation. The costs for a larger canopy such as the one envisioned for the EIC would likely be higher. Assuming a range of $12.00 to $15.00 per watt, and an estimated system size of 145.4 kW, the total estimated cost of the proposed bifacial module canopy would be approximately $1.75 million to $2.2 million.

A canopy utilizing a traditional standing-seam metal roof would probably cost significantly less, but the estimated electrical output would also be lower due to the lower system capacity assumed for experimental technologies. While the technology vendors might provide the PV modules at no cost to the City, the demonstration areas would need the electrical infrastructure (or balance of system, BOS): circuit breakers, inverters, disconnects, junction boxes, electrical service panels, wiring, roof-top racking systems, and data monitoring systems. Based on the average total installed price of $6.87/watt, and assuming a module price of approximately $3.40/watt, the installation and remaining balance of system components would likely cost at least $3.47/watt. Assuming a BOS cost of $3.50/watt, the cost to accommodate four, 16.2 kW systems on the proposed canopy is estimated to be approximately $225,000. This cost is exclusive of the cost to design and build the canopy support structure.

2.7.3 New Parking Structure

A rough estimate of parking structure costs can be made by extrapolating from structural costs of similar systems built recently in California. A PV parking structure was constructed at Fresno State University in November 2007 by Chevron Energy Solutions Company. For this system, the University spent $3.3 million for structures to hold 3,936 panels comprising a 1.1 megawatt (MW) PV system (CSU Fresno, 2007). Based on the conceptual PV system of 214.8 kW presented for the parking structure at the EIC, and assuming some price inflation in the cost of materials and labor, the structural cost for the EIC parking structure might be on the order of $600,000 to $800,000, or approximately $2.80/watt-DC to $3.70/watt-DC.

Based on these estimates, the total estimated gross installed capital cost of the 214.8 kW DC_{STC} fixed-tilt conceptual system described above would be expected to be between $9.65/watt-DC and $10.60/watt-DC, or approximately $2.07 million to $2.28 million.

All costs presented above are estimates based on current market prices and previous system installation data, and may not be representative of the actual costs that would be offered to the City during a formal procurement effort.

2.8 Estimated Electrical Production and Energy Cost Savings

Table 5 presents a summary of the PVWatts models for the conceptual PV systems based on a fixed-mount system tilted at 10°. The model was based on solar radiation data for San Francisco, California (San Francisco was used in the model instead of San Jose because it is the closest city available in the PVWatts Version 1 model). The difference between solar irradiance in San Francisco and San Jose is less than 1%.

Table 5: Estimated Annual Energy Production for Conceptual PV Systems at the San Jose Environmental Innovation Center

Area #	Roof Area (ft^2)	Number of Modules	Estimated Annual Production for Different System Types (PVWatts) (kWh/year)		
			75W Thin Film (low efficiency)	200W mono- or multicrystalline (mid efficiency)	300W Monocrystalline (high efficiency)
1	2,244	76	7,601	20,270	30,405
2	5,848	209	20,904	55,743	83,614
3	2,068	70	7,001	18,670	28,005
4	5,852	209	20,904	55,743	83,614
5	3,410	115	11,502	30,672	46,008
Existing Building	19,422	679	67,912	181,098	271,647
Future Structures					
Canopy Option 1	65.6	216	21,604	57,608	86,416
Canopy Option 2	10,000	727	-	222,985 [1]	-
New Parking Structure	18,025	716	71,612	190,966	286,450

Notes:
[1] Assumes that bifacial modules produce 115% of output calculated from PVWatts (Donahue,, 2008)

Based on the PVWatts data shown in Table 5, the conceptual PV system installed on the existing roof would be expected to produce between 181,098 kWh and 271,647 kWh in the first year of operation, depending on the type of crystalline module utilized. PV systems installed on the proposed canopy would be expected to generate between 57,608 kWh/year and 222,985 kWh/year, depending on the type of module used and the type of canopy constructed. A fixed-tilt system installed on a proposed parking structure would be expected to generate up to 286,450 kWh/year.

The current electrical load at the site is minimal, and the future electrical demand is unknown, so it is not possible to determine the percentage electrical offset that this level of production would represent. However, assuming a future average electricity price of $0.14/kWh, the conceptual PV systems described above would, in aggregate, reduce electricity charges by approximately $73,000 to $109,000 in the first year.

2.9 Financing Options

There are several different structures available to finance public sector PV projects. Unfortunately, as a non-taxpaying entity, the City is at a disadvantage vis-à-vis corporate entities in terms of its ability to take advantage of state and federal tax incentives. This is significant since tax incentives are a key factor in making the economic case for solar. San Jose can purchase a PV system outright using the proceeds from tax-exempt municipal bond issuances similar to how it may finance other capital improvements. The City can also enter into a tax-exempt municipal lease to acquire the system, financing it over the term of the lease. However, since ownership and use of the system traditionally reside with the City in both the bond-financed and lease options, neither of these structures can take full advantage of the available tax incentives for solar. Both options also impose operations and maintenance responsibilities on the City. Alternatively, San Jose can finance PV projects through a third party using a Power Purchase Agreement (PPA) model which does incorporate the tax benefits to the benefit of the City. Similar to the lease option, no up-front capital is required on the part of the City, which makes this model more attractive for municipal entities.

Under the third-party PPA model, a solar developer finances, installs, owns, and maintains the PV system on the customer's roof. The customer (i.e., the City) would sign a long term contract (the PPA) and agree to purchase 100% of the electricity produced by the PV system. The initial cost of electricity in a PPA is typically competitive with current utility electricity rates and will typically escalate over the life of the contract at a fixed annual percentage (e.g., 2-3% per year). The solar developer and its financial backers can take full advantage of the Federal investment tax credit, accelerated depreciation, and any available state incentives. Third party maintenance is another attractive feature of the PPA model.

However, there are caveats to the third party PPA model. As the City is not the owner of the system, it cannot claim ownership of the environmental attributes of the system. This means that the City can not claim to be "solar powered" since a separate entity owns the rights to claim the solar attributes of the system. Instead, the correct terminology is that the building is "hosting" solar panels. However, the City could bolster its sustainable credentials by purchasing renewable energy credits in the amount equal to the production of the PV system. A second caveat is that the City must agree to third-party access to the PV system located on a city rooftop or on city land. Third, transaction costs are high given the number of parties and contracts involved. Finally, there may be contractual barriers within the City's charter or within the local regulatory environment that might limit the ability to enter into long-term, third-party contracts for electricity.

The third party PPA option can be structured so that the City can purchase the system prior to the end of the contract. At the end of the PPA, there will likely be three options available to the City. There will be the option for the City to purchase the system, to renew the PPA, or request that the system be removed.

In accordance with the City of San Jose's recently-adopted technology demonstration partnership policy, San Jose can also negotiate a variety of financial terms and conditions with solar companies that would like the City to host the demonstration of their newly-introduced technologies. These financial options could range from the provision of rent-free land with a PPA in exchange for free or wholesale electricity, to market-rate rent and provision of electricity at a market rate. If City policy permits, an equity stake in the prospective solar company could also be part of the terms and conditions of the arrangement.

3.0 Findings

The roof of the existing building at the EIC currently offers a good location for the installation of solar PV modules. The conceptual PV systems described in this report could be used to offset future site loads once the property is redeveloped into a household waste recycling center. PV modules could be installed in a number of sub-arrays using a ballasted mounting system on the flat roof of the facility. PV modules could also potentially be installed on a proposed canopy and a proposed covered parking structure. The canopy could be designed to provide an excellent test facility for the demonstration of emerging solar technologies developed by local companies.

The solar energy generation capacity at the Site will depend on the nature of site redevelopment and the future construction of the outdoor canopy structure and/or the covered parking structure. Assuming the use of mid-efficiency PV modules on the existing roof, bifacial modules on the proposed canopy, and high-efficiency modules on the proposed parking structure, multiple arrays with an aggregated capacity of 496 kW_{DC} STC could be installed at the site. This system would produce an estimated 690,000 kWh/year, and would likely reduce future site electricity demand by a significant percentage.

4.0 References

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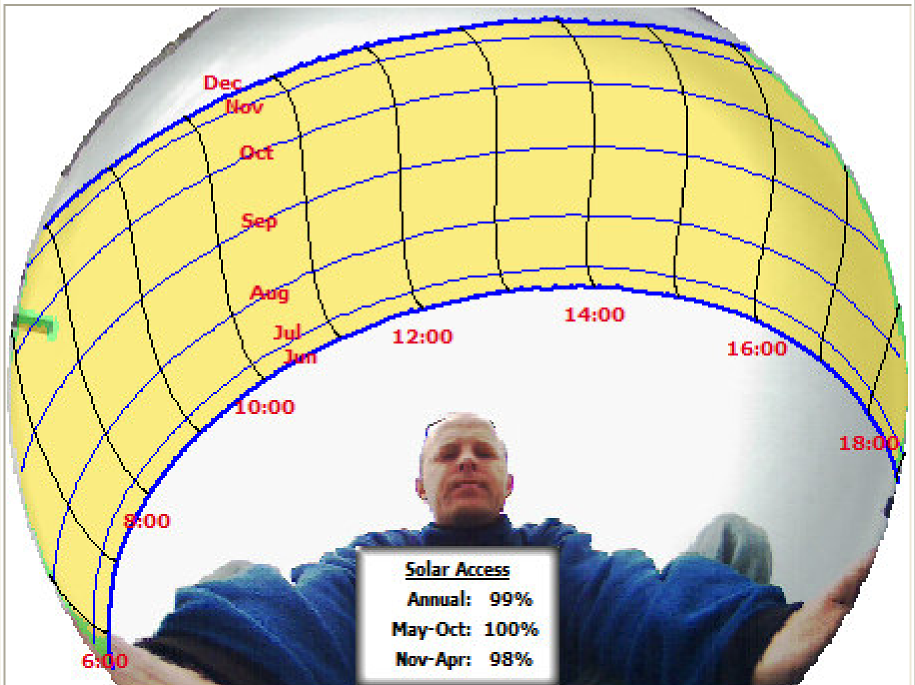
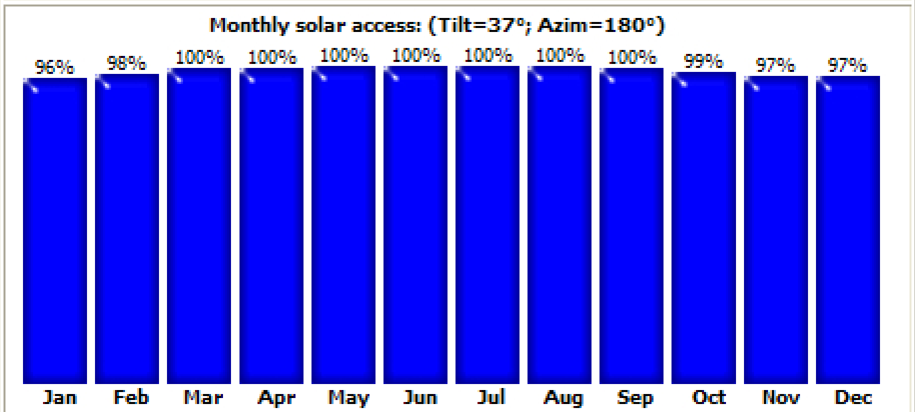
Appendix A
Shading Analysis – the San Jose Environmental Innovation Center

During the site visit, the Tiger Team used the Solmetric SunEye™ to determine potential shading at different locations on the roof. The results are presented below (Sky20 through Sky22).

<u>Sky20 -- 04/02/2008 11:14 -- lp roof center n37.21.592 w121.52.078</u>
Panel Orientation: Tilt=37° -- Azimuth=180°
Solar Access: Annual: 99% -- Summer (May-Oct): 100% -- Winter (Nov-Apr): 98%



Data by Solmetric SunEye™ -- www.solmetric.com

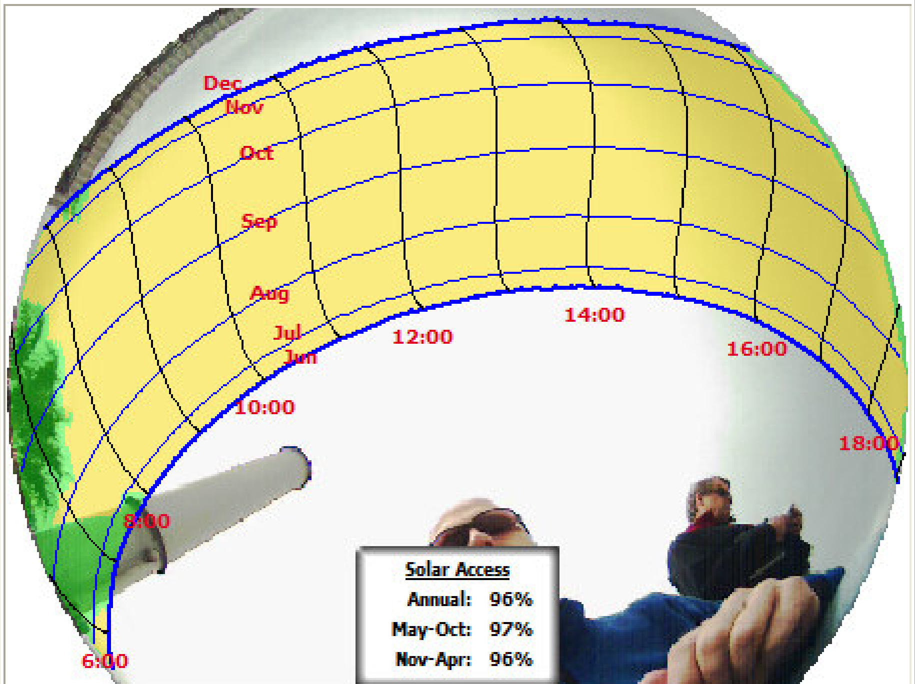


Data by Solmetric SunEye™ -- www.solmetric.com

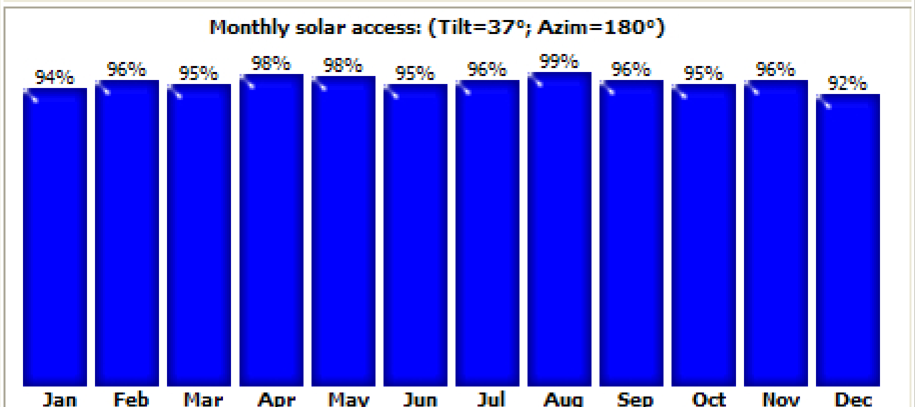
Sky21 -- 04/02/2008 11:19 -- lp roof center n37.21.596 w121.52.065

Panel Orientation: Tilt=37° -- Azimuth=180°

Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 96%



Data by Solmetric SunEye™ -- www.solmetric.com

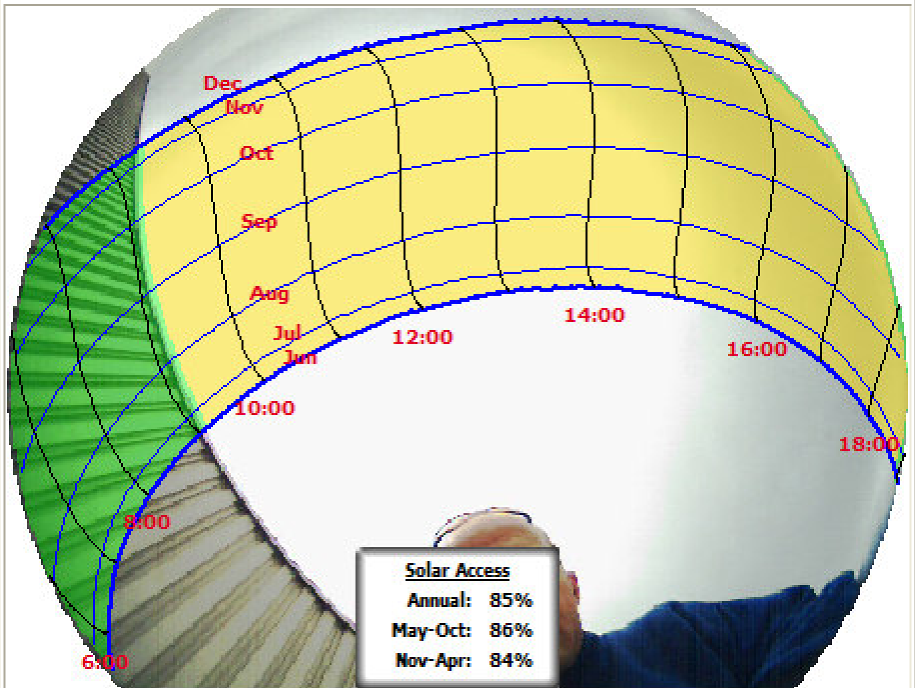


Data by Solmetric SunEye™ -- www.solmetric.com

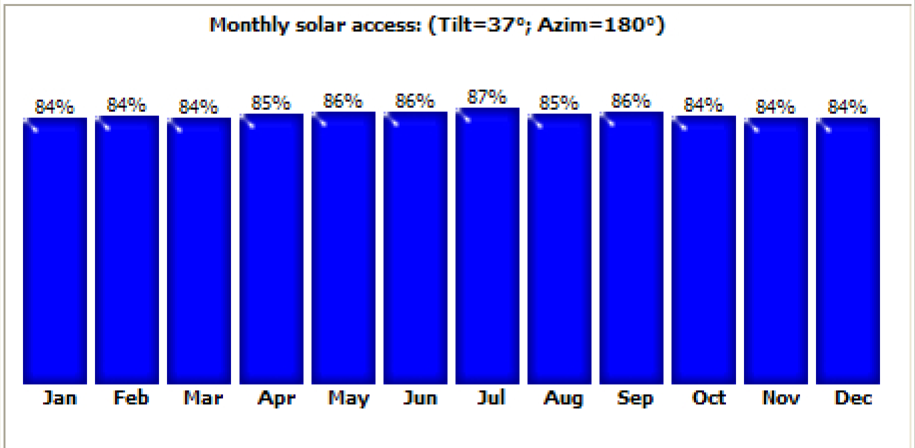
<u>Sky22 -- 04/02/2008 11:25 -- lp roof near elevated ceiling n37.21.585 w121.52.060</u>

Panel Orientation: Tilt=37° -- Azimuth=180°

Solar Access: Annual: 85% -- Summer (May-Oct): 86% -- Winter (Nov-Apr): 84%



Data by Solmetric SunEye™ -- www.solmetric.com



Data by Solmetric SunEye™ -- www.solmetric.com

Appendix B
Solar Area and System Size Calculation

The calculation for the approximate number of modules and the expected DC_{STC} output is found using the following methodology:

1) Calculate the available roof area via physical measurements and/or an estimate using satellite imagery.

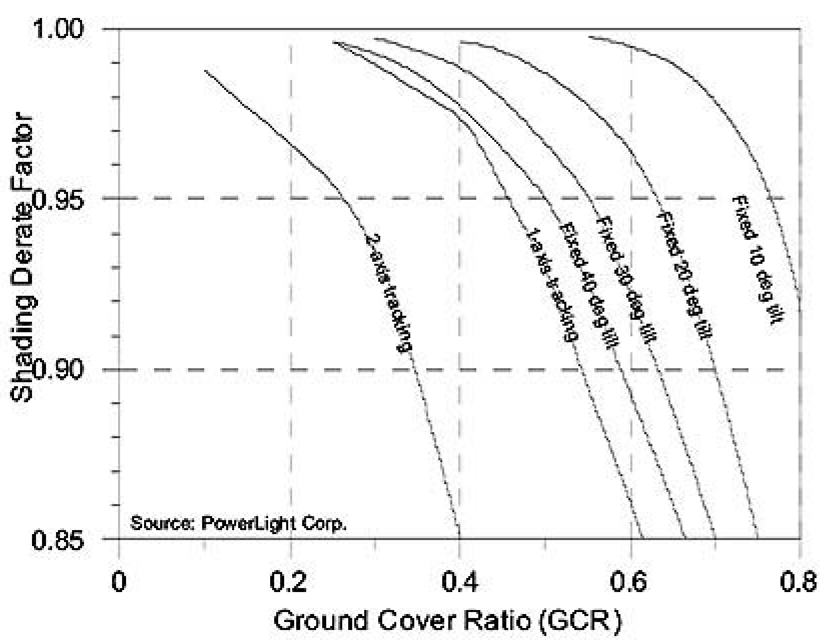
Exp 1 = 40′ X 40′ = 1,600 ft² available roof area

2) Area Shape Factor for imperfect areas, odd angles, and incomplete rows.

The Exp 1 area will have a factor of 0.85 (likely to have incomplete rows, or imperfectly fitting rows of modules)

3) Use the Ground Cover Ratio (GCR) chart from PVWatts to calculate the GCR factor to allow proper spacing between modules based on tilt, shading, and spacing between modules.

For a fixed 10° tilt at the EIC: Assume 2.5% shading. The GCR is estimated at 0.7, based on the corresponding curves in the chart below. Of the 1,600 ft² of area, only 70% will be solar panels from an overhead, or satellite view.



Source : PVWatts

4) Find the solar panel area by multiplying the available roof area by the GCR factor and the Area Shape Factor.

Fixed-tilt (10°) Exp 1 area: 1,600 ft² * 0.70 * 0.85 = 952 ft² solar panel area

5) Use a commonly available module size of 65″ x 39″ to estimate the number of modules available for this installation.

Ex: One module = 5.42′ X 3.25′ = 17.615 ft^2

Fixed-tilt (10°) area: Solar module area total / solar area per module = 1,600 ft2 / 17.615 ft2 = 54 modules

6) Calculate the potential system size in kW-DC_{STC}. Multiply the number of modules by the module capacity using three different technology types to estimate peak DC system size based on available technologies.

For a fixed-tilt (10°) system:

75W thin-film module (5-6% efficient): 54 modules x 75W/module = 4050 W = 4.050 kW

200W multicrystalline module (13% efficient): 54 modules x 200W/module = 10,800 W = 10.8 kW

300W monocystalline module (18% efficient): 54 modules x 300W/module = 16,200W = 16.2 kW

Area #	Available roof area (ft^2)	Shape Factor	Tilt	GCR factor	Available solar panel area	# Modules
1	2,244	.85	10°	0.7	1,335	76
2	5,848	.9	10°	0.7	3,684	209
3	2,068	.85	10°	0.7	1,230	70
4	5,852	.9	10°	0.7	3,687	209
5	3,410	.85	10°	0.7	2,029	115
Exp 1	1,600	.85	10°	0.7	952	54
Exp 2	1,600	.85	10°	0.7	952	54
Exp 3	1,600	.85	10°	0.7	952	54
Exp 4	1,600	.85	10°	0.7	952	54
BIPV Solarscape	10,000	.95	Even with roofline	1.0	9,500	727 [1]
Parking	18,025	1	10°	0.7	12,617	716
Total	43,847				28,390	1,562

<u>Notes:</u>

1. Analysis assumes a BIPV solarscape using bifacial modules with an area of 13.056 ft^2.