BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Solar Master Plan

Made possible by a U.S. Department of Energy *Solar America Showcase* Award to the Sequoia Foundation and KyotoUSA/HELiOS (2009)

November 2011

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Berkeley Unified School District (BUSD)

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Acknowledgments

Transforming a successful local solar project into something that has statewide application and benefits can be challenging. In the years ahead, we hope the effort by the contributors to this Solar Master Plan (SMP) helps make renewable energy generation a possibility for schools throughout the state. One thing is certain – everyone who participated in the SMP project genuinely believes that our schools will become important local sources of clean energy. We hope that this document will help to spread their enthusiasm for local electricity generation far and wide.

This project was made possible by a Solar America Showcase technical assistance grant from the U.S. Department of Energy. Alicen Kandt from the National Renewable Energy Lab in Golden, Colorado was the Project Manager. Alicen did a remarkable job of bringing in experts in all aspects of solar energy generation who drafted many of this document's chapters.

Staff from all three school districts who completed SMPs as part of this project actively participated in the development of the plans. In addition, many experts gave freely of their time to help us understand the complexities of the purchase of a large-scale solar installation. We are especially grateful to SunPower Corporation for their contribution to the development of the Aerial Assessments chapter. We wish to thank Clyde Murley and Steve Nielsen for their willingness to educate us about the procurement process and the complex world of financing. In addition, we would like to acknowledge all the professional and personal support provided by MIG, Inc. throughout the two-year period during which the SMPs were developed.

Finally, our thanks to our supporters and the many volunteers who provided countless hours of their time and who were always willing to do anything we asked of them. Without their support, this project would not have gone beyond the "good idea" stage.

— Tom Kelly

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An example of a complete Solar Master Plan is available to download at: www.heliosproject.org

Executive Summary

In June 2006, KyotoUSA and Berkeley Unified School District (BUSD) management met to discuss the possibility of installing renewable energy systems on BUSD schools. That meeting – and those that followed – traversed a path similar to the one other school districts in the state have followed or are likely to follow when asked to consider generating electricity from school rooftops and parking lots. BUSD's attitude toward installing renewable energy systems went from skepticism and doubt in 2006 to an openness that enabled the District to add $7 million dollars for solar projects to a general obligation bond request in 2010, which passed with the overwhelming support of Berkeley voters.

The path to energy conservation, energy reduction, and energy generation is a difficult one for most school districts – fraught with concerns about diminishing operating budgets, up-front costs of new equipment, the time and effort busy district staff must expend to oversee a project, as well as doubts about whether a solar project will "pencil out." However, many school districts are recognizing that energy savings and electricity generation can result in significant benefits to a district's financial health.

In working on our first successful solar project with BUSD (Washington Elementary 2006 –2008), we learned a number of important lessons. The most important lesson was that trying to get solar installed on a single school is going to be challenging. We often meet students or parents who are helping a school to "go green" and would like to see renewable energy be part of that plan. They demonstrate a high level of enthusiasm, organization, and energy – characteristics that are remarkably valuable to the education of our children, the health of their schools, and the future of our society. However, school districts generally develop Facilities Master Plans (FMPs) that describe the construction that will take place in the district over a 5- to 10-year period and therefore are not well equipped to respond positively to a community's request for a major construction project like solar at an individual school. The funding for projects described in a FMP is likely to have been approved by local voters in the form of a General Obligation bond that is limited to the projects described in the FMP. The commitments made in the FMP may not provide enough flexibility to take on a newly introduced idea like a large solar array that benefits a single school. We realized we had to find a way to integrate solar projects into a district's overall long-term construction plans if we were going to see solar installed on schools throughout a district.

KyotoUSA and our fiscal sponsor, the Sequoia Foundation, approached the U.S. Department of Energy (DOE) in early 2009 to find out if we could qualify for a technical assistance grant through DOE's Solar America Showcase program. We wanted to develop a Solar Master Plan (SMP) that could be integrated into any school district's Facilities Master Plan. DOE encouraged us to apply, and in April 2009, we learned that our application had been successful. We immediately began work with the National Renewable Energy Laboratory (NREL) in Golden CO. During the next two years, NREL, KyotoUSA, and our school district partners (Berkeley, Oakland, and West Contra Costa Unified School Districts) worked together to develop a Solar Master Plan for each of the districts.

A requirement of the Solar America Showcase award was that the grantee had to commit to installing at least 250 kilowatts (kW) within the districts. We made a "good faith" commitment to do so. **As of November 2011, more than 400 kW has already been installed; BUSD has local bonds for PV that could result in the installation of an additional 800 kW in the next few years; WCCUSD will install another 350 kW in 2012; and OUSD will install a PV system at its Downtown Education Complex in 2012. OUSD also has enough federal bond authorization to install PV systems at another 17 of its schools.**

Our school district partners – all facilities directors and staff – provided us with important guidance on the information we would need to integrate plans for photovoltaic (PV) systems into an FMP. We received an incredible amount of donated technical assistance and support in the development of the SMPs from organizations, companies, and individuals listed in the Acknowledgments section. As a result, we have assembled a document that covers every aspect of what a district should consider as it begins to move away from relying on increasingly expensive utility-provided electricity toward its own self-generated, clean, renewable solar energy.

The first eight chapters of this Solar Master Plan address a range of topics that a district must consider in planning for solar energy. Chapter Nine is a Case Study on a student-initiated project installed at San Ramon Valley Unified School District in October 2011.

Any California public school district can use this SMP as a template. It can also provide helpful guidance to districts in other parts of the country. Data and studies specific to the individual district are covered in Chapters One, Three, and Four. The remaining chapters are applicable to all districts. Therefore, the SMPs for the three districts that participated in this DOE project are identical except for the site-specific information in those three chapters.

Chapter One discusses "benchmarking" of the district's energy use through the U.S. Environmental Protection Agency's ENERGY STAR Portfolio Manager software tool. Every district – regardless of its current or future plans for renewable energy – should be aware of its energy consumption and energy costs so that it can make energy-efficiency improvements and encourage better conservation behavior at its schools. The energy data is also essential to making Chapter Four a more robust report.

Chapter Two discusses what makes a school building a good candidate for PV installation and offers information on tools that can help in evaluating a building's potential for hosting a solar array.

Chapter Three presents a structural analysis of the roofs of several schools in the district. To prepare this analysis, NREL hired a local structural engineer to determine whether, based on the architectural drawings, the buildings could handle the added loads of a PV system. California public schools have very strict building codes, administered by the Division of the State Architect (DSA), which can make any construction project a challenge. The reports in this chapter provide an overview of issues that DSA will consider when looking at plans for roof-mounted PV systems.

Chapter Four provides detailed information on the district's electricity consumption and energy costs, the total amount of PV that each district facility is capable of hosting, and the amount of PV that each facility needs to reduce its electricity costs to the minimum charge. Also included are the estimated costs, savings, and electricity generation of each PV system, as well as the greenhouse gas (GHG) emissions avoided and renewable energy credits (RECs) earned. All of these criteria are calculated for the district as a whole and for each facility individually. Aerial imagery identifies the buildings and parking areas appropriate for PV installation and is the basis for estimating the amount of space available for the renewable energy systems.

Chapter Five provides an overview of today's solar technology, how it works, net metering rules, monitoring systems, and ways to ensure that a PV system provides maximum efficiency and output throughout the 20 to 40 years during which the system can be expected to generate electricity.

Chapter Six provides a thorough, well-researched Design-Build contract template that covers all aspects of procuring a commercial-scale PV system. This chapter explains that school districts will achieve the best pricing and best overall value when using a well-constructed Request for Proposals and seeking public bids rather than sole-sourcing a PV project.

Chapter Seven discusses financing options for acquiring PV systems. Financing can be the single biggest challenge in acquiring PV; however, costs – for PV systems and for financing – continue to come down and are increasingly within reach for school districts. The chapter describes in detail the two primary methods of acquiring PV systems – district ownership and third-party ownership (Power Purchase Agreement).

Chapter Eight covers rate/tariff structures that are associated with the delivery of electricity from the utility to each school. Understanding how tariffs work and how they are applied will assist a district in determining which tariffs are most favorable for a specific school even if a PV system is not yet contemplated.

Chapter Nine describes how a Monte Vista High School junior, Julia Mason, inspired San Ramon Valley Unified School District to install 3.3 megawatts of PV throughout the district. Julia began her advocacy effort with an attempt to get district officials to install solar at her high school. Demonstrating commitment, patience, and a lot of heart, Julia and her classmates were able to overcome the district's initial hesitance and eventually persuaded the school board to move forward. The board's journey took them from concerns about whether the district could "afford to install solar" to the point where all board members eventually agreed that the district could "not afford to not install solar."

Chapter Nine does not provide a step-by-step formula for achieving success in a district, but it demonstrates the types of concerns that arise and how they were overcome. It is our hope that Julia's story will inspire school districts to start on a path toward reducing their energy consumption and producing all the electricity needed to operate their schools.

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 1

Benchmarking with ENERGY STAR's Portfolio Manager

Benchmarking with ENERGY STAR's Portfolio Manager

Every school district should know how much energy it is consuming and what its associated costs are. Energy benchmarking is especially important if a district is interested in becoming more energy efficient and should be standard policy for all school districts regardless of whether PV systems are currently contemplated. Knowing where the district is consuming energy and how much this energy costs are the first steps in improving energy efficiency and encouraging energy-conserving behaviors.

Fortunately, the U.S. Environmental Protection Agency and the U.S. Department of Energy offer a free, easy-to-use program from ENERGY STAR called Portfolio Manager.

Portfolio Manager allows a district to track its energy consumption and costs and provides a variety of reports that will help the district to measure the results of its efforts to reduce energy consumption. Getting started with Portfolio Manager is easy enough that an environmental class at a district high school could do it as a project. The major California utilities also offer trainings on Portfolio Manager. To get started, see, www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

California's major energy utilities provide monthly automated data to Portfolio Manager subscribers, so a participating district will always have up to date information on its energy use. Portfolio Manager can also track water consumption. Although few water utilities currently have the ability to report water data automatically, efforts are underway to encourage them to offer this service in the future.

This chapter shows a Portfolio Manager screen-shot of all district facilities that have been benchmarked. The ENERGY STAR rating accurately reflects the status of K-12 facilities only. Non K-12 facilities, e.g. adult schools, administrative offices, are included in this report so the district has a comprehensive assessment of energy consumption and costs for all its buildings.

Also included in this chapter are the data required to enroll K-12 schools and other building types, and Portfolio Manager's Quick Reference Guide.

PORTFOLIO MANAGER

ACCOUNT INFORMATION | CONTACTS | FREQUENTLY ASKED QUESTIONS | CONTACT US | HELP | LOGOUT

Home > **My Portfolio**

Portfolio Averages	
Baseline Rating: 82 Facilities Included: 24	**Current Rating: 88** Facilities Included: 24
Change from Baseline: Portfolio Adjusted Percent Energy Use (%): -0.1% Facilities Included: 25	
Averages are weighted by Total Floor Space. More about Baselines More about Change from Baseline: Adjusted Energy Use	

Add a Property
Import Facility Data Using Templates

Work with Facilities
Update Multiple Meters
Share Facilities

Reporting and Analysis
New! Generate Reports and Graphs
Request Energy Performance Report

Apply for Recognition
Apply for the ENERGY STAR
ENERGY STAR Leaders

Automated Benchmarking
Automated Benchmarking Services Console

GROUP: All Facilities — Create Group | View All   VIEW: Summary: Facilities — Create View | Edit View | View All

Download in Excel

Search Facility Name: [Search]

Results **1 - 25** of 25

All # A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Facility Name	Current Rating (1-100)	Change from Baseline: Adjusted Energy Use (%)	Total Floor Space (Sq. Ft.)	Energy Use Alerts	Current Energy Period Ending Date	Eligibility for the ENERGY STAR	Last Modified
B- Tech Academy	93	-10.4	20,000		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Berkeley Adult School	96	-1.8	82,717		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Berkeley HS	95	13.7	550,000		07/31/2011	Apply for the ENERGY STAR	10/20/2011
Bus Depot	N/A	8.8	13,800		08/31/2011	N/A	10/13/2011
BUSD Admin Offices	32	14.4	33,500		07/31/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
Cragmont	95	-19.8	50,000		09/30/2011	Apply for the ENERGY STAR	10/13/2011
Emerson	96	-3.7	32,000		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Franklin PreSchool	97	-9.2	9,800		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Hillside	100	-67.3	41,000		07/31/2011	Apply for the ENERGY STAR	10/13/2011
Hopkins Childcare	79	-12.1	9,200		08/31/2011	Apply for the ENERGY STAR	10/13/2011

Jefferson	100	-32.2	51,800		07/31/2011	Apply for the ENERGY STAR	10/13/2011
John Muir	69	-4.3	36,800		08/31/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
King Child Dev Ctr	97	4.7	9,800		09/30/2011	Apply for the ENERGY STAR	10/13/2011
KING JR HIGH	77	-8.1	144,000		07/31/2011	Apply for the ENERGY STAR	10/13/2011
LeConte	73	29.6	50,152		08/31/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
Longfellow	74	6.1	68,000		07/31/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
Maint Yard	52	-0.6	44,100		07/31/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
Malcolm X	84	-13.5	70,900		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Old Adult School	100	-73.7	121,000	Data > 120 days old	05/31/2011	Not Eligible: Current period ending over 120 days (ENERGY STAR Eligibility Rules)	10/13/2011
Oxford	94	27.6	32,000		07/31/2011	Apply for the ENERGY STAR	10/13/2011
Rosa Parks Elementary	93	-8.5	51,000		08/31/2011	Apply for the ENERGY STAR	10/13/2011
Thousand Oaks	68	30.1	50,000		09/30/2011	Not Eligible: Rating must be 75 or above (ENERGY STAR Eligibility Rules)	10/13/2011
Washington Elementary	100	-49.7	45,000		07/31/2011	Continue applying for the ENERGY STAR	10/13/2011
Whittier / Arts Magnet	97	99.6	48,600		07/31/2011	Not Eligible: Eligible again starting with a period ending date of 08/31/2011. (ENERGY STAR Eligibility Rules)	10/13/2011
Willard	77	23.3	107,000		07/31/2011	Apply for the ENERGY STAR	10/13/2011

Download in Excel

Search Facility Name: Search

Results **1 - 25** of 25

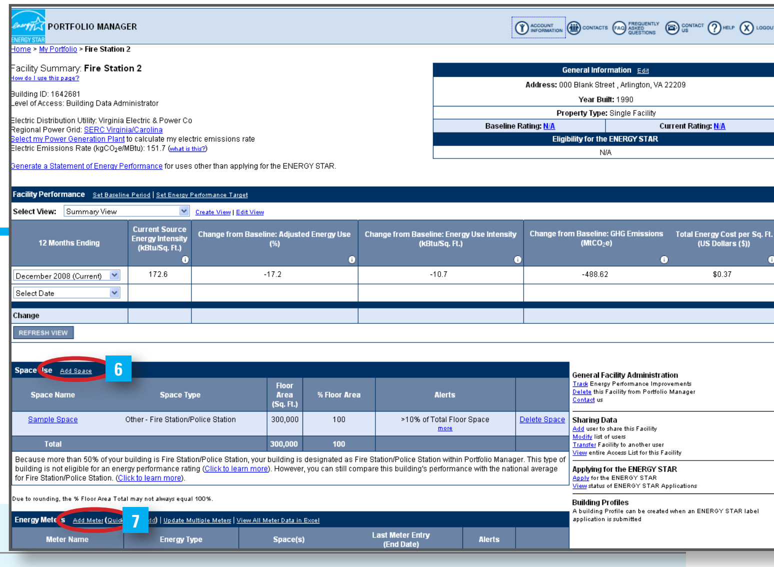
All # A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

The rating is calculated by using the last day of the latest full calendar month where all meters in the facility have meter entries; the Period Ending date reflects that particular date.

PORTFOLIO MANAGER QUICK REFERENCE GUIDE

ENERGY STAR

Portfolio Manager is an interactive energy management tool that allows you to track and assess energy and water consumption across your entire portfolio of buildings in a secure online environment. Use this Quick Reference Guide to identify opportunities for energy efficiency improvements, track your progress over time, and verify results.

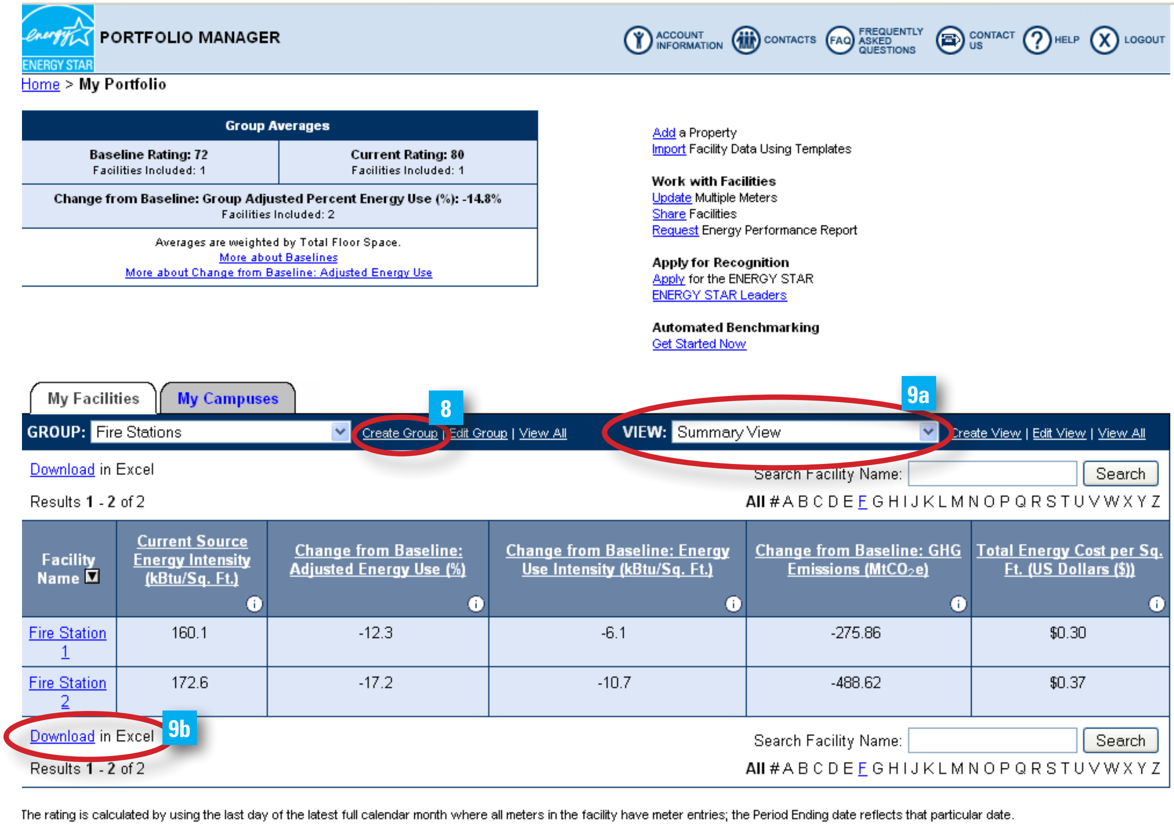


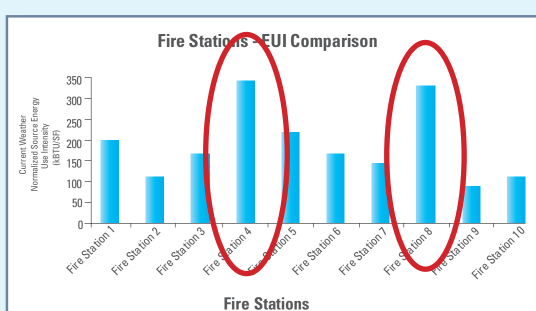
IDENTIFY ENERGY EFFICIENCY PROJECTS

Use Portfolio Manager to identify under-performing buildings to target for energy efficiency improvements and establish baselines for setting and measuring progress for energy efficiency improvement projects over time.

STEP	ACTIVITY	ACTION
1	Access Portfolio Manager. (step not shown)	Visit **www.energystar.gov/benchmark**. Scroll down to the **Login** section on the right-hand side in the middle of the page.
2	Access your account: (step not shown) • Create a new account. • Login to an existing account.	• Click **REGISTER,** and follow instructions. • Enter user name and password, and click **LOGIN**.
3	Review system updates and enter account. (step not shown)	Click **ACCESS MY PORTFOLIO**, located below **Welcome to Portfolio Manager**.
4	Add a new facility. (step not shown)	Click **ADD** a Property, located in the upper right portion of the screen.
5	Select property type and enter general facility information. (step not shown)	Select the option that most closely resembles your facility and click **CONTINUE**. Enter general data and click **SAVE**. For more information on facility space types, see: www.energystar.gov/index.cfm?c=eligibility.bus_portfoliomanager_space_types.
6	Enter space use data.	From the **Facility Summary** page, shown above, go to the **Space Use** section, located half way down the page, and click **ADD SPACE**. • Enter a facility name. In the **Select a Space Type** menu, select the appropriate space type(s) for your building. If your space is not listed, select **Other**. Click **CONTINUE**. • Enter building characteristics. Click **SAVE**. Information required for each space type is listed here: www.energystar.gov/index.cfm?c=eligibility.bus_portfoliomanager_space_types. • Repeat steps above to add all major spaces in your facility. Use bulk import service to minimize manual data entry of large sets of facility data (10 or more facilities or campuses are required). • Go back to **My Portfolio** by clicking on the link in the upper left portion of the page. • Click **IMPORT** Facility Data Using Templates, located below **Add a Property**.
7	Enter energy use data.	From the **Facility Summary** page, go to the **Energy Meters** section, located below the **Space Use** section, and click **ADD METER**. • Enter meter name, type, and units. Click **SAVE**. • Enter number of months and start date. Click **CONTINUE**. • Enter energy use and cost for each month. Click **SAVE**. • Repeat for all energy meters and fuel types.

www.energystar.gov/benchmark



STEP	ACTIVITY	ACTION
8	Create custom groups.	Organize facilities into groups (e.g., Fire Stations, Northwest Region). Groups are completely customizable, and each facility may belong to multiple groups. • From the **My Portfolio** page, click **CREATE GROUP**, located directly to the right of the **Group** drop-down menu. • Follow instructions to select buildings and name your group. • Once they have been saved, custom groups will be available in the **Group** drop-down menu.
9	View and interpret results.	Option 1: Go to **My Portfolio** and view all buildings to compare performance metrics. Option 2: Export data to Microsoft® Excel. • On the **My Portfolio** page, select the view, from the **View** drop-down menu that will display the data you wish to export. The **My Portfolio** page will update to display the selected view. (9a) • Select the **DOWNLOAD IN EXCEL** link. A File Download dialog window will open. Follow the steps provided by Excel. (9b) • Use Excel functionality to view building energy performance graphically . The example below shows a comparison of Energy Use Intensity for a portfolio of fire stations, identifying under-performing buildings to target for energy eficiency improvements. 

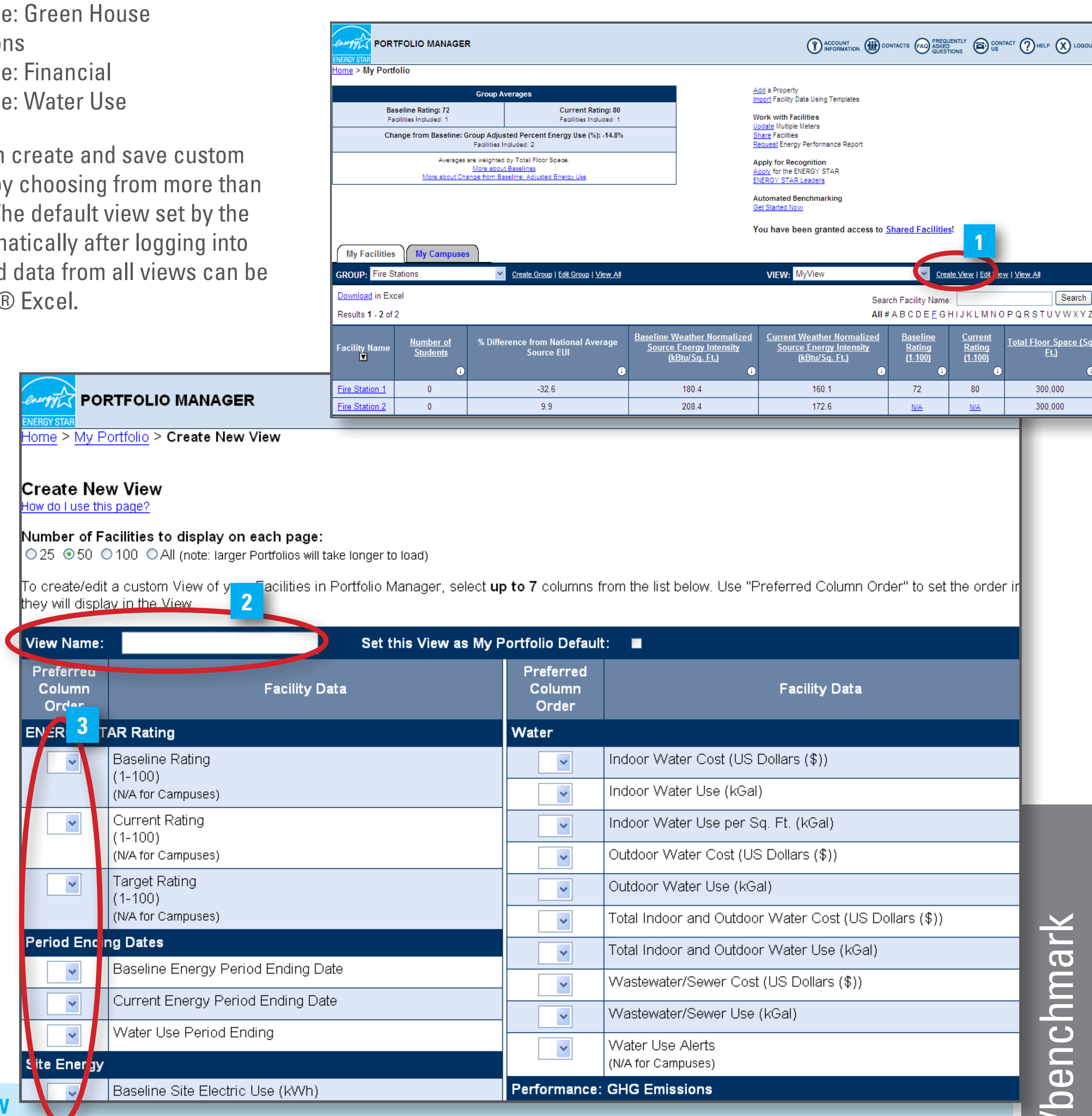
www.energystar.gov/benchmark

TRACK PROGRESS OVER TIME

Portfolio Manager comes pre-populated with nine standard summary views of facility data, which are displayed on the My Portfolio summary page. These standard views include:

- Summary: Energy Use
- Performance: Green House Gas Emissions
- Performance: Financial
- Performance: Water Use

Additionally, users can create and save custom downloadable views by choosing from more than 70 different metrics. The default view set by the user will display automatically after logging into Portfolio Manager, and data from all views can be exported to Microsoft® Excel.



CREATE A CUSTOM VIEW

STEP	ACTION
1	From the **My Portfolio** page or the **Facility Summary** page, select the **Create View** link, located directly to the right of the **View** drop-down menu.
2	Enter a name for the view. To set as the default view, select the box labeled **Set this View as My Portfolio Default**, located directly to the right of **View Name**. You may include up to 7 (seven) columns in each view.
3	Choose each metric to be included in the view by selecting an order number from the **Preferred Column Order** drop-down menu to the left of the **Facility Data** column.
4	Click **SAVE** at the bottom of the page. You will be returned to the **My Portfolio** page, and your custom view will be available in the **View** drop-down menu. (step not shown)

www.energystar.gov/benchmark

VERIFY AND DOCUMENT RESULTS

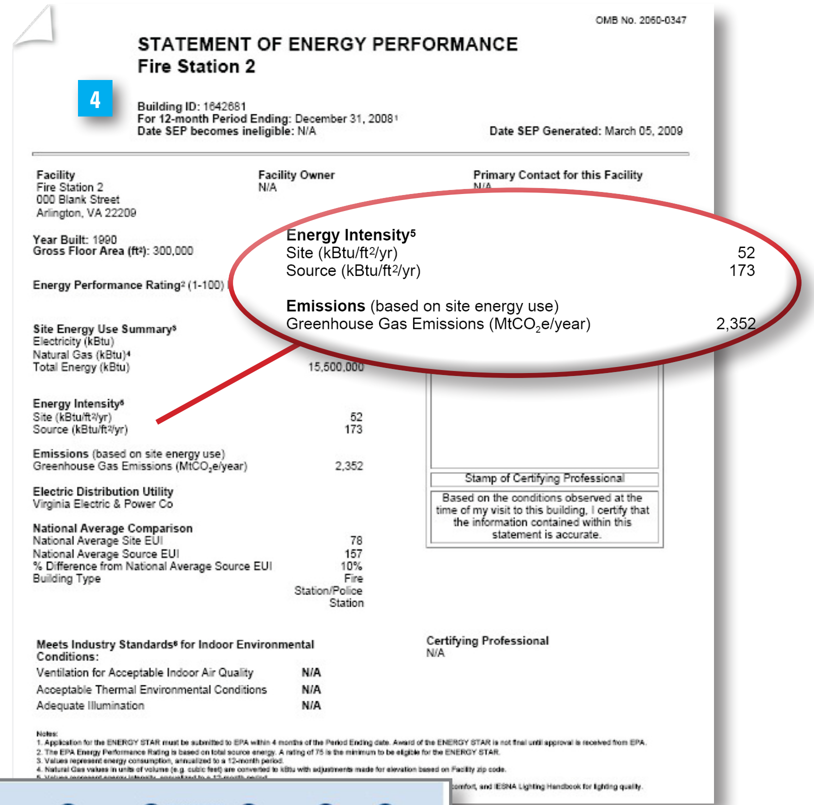
Use Portfolio Manager to quickly and accurately document reductions in energy use, greenhouse gas emissions, water use, and energy costs for an individual building or an entire portfolio. This valuable information can be used to provide a level of transparency and accountability to help demonstrate strategic use of funding.

Generate a Statement of Energy Performance that includes valuable information about your building's performance, including:

- Normalized energy use intensity
- National average comparisons
- Greenhouse gas emissions
- Energy performance rating (if available)

In addition, you can also request an Energy Performance Report to see the change in performance over time for selected buildings or an entire portfolio. Available comparative metrics in this report include:

- Normalized energy use intensity
- Total electric use
- Total natural gas use
- Energy performance rating (if available)



OMB No. 2060-0347

STATEMENT OF ENERGY PERFORMANCE
Fire Station 2

4

Building ID: 1642681
For 12-month Period Ending: December 31, 2008[1]
Date SEP becomes ineligible: N/A
Date SEP Generated: March 05, 2009

Facility: Fire Station 2, 000 Blank Street, Arlington, VA 22209
Facility Owner: N/A
Primary Contact for this Facility: N/A

Year Built: 1990
Gross Floor Area (ft^2): 300,000

Energy Performance Rating[2] (1-100)

Site Energy Use Summary[3]
Electricity (kBtu)
Natural Gas (kBtu)[4]
Total Energy (kBtu) 15,500,000

Energy Intensity[5]
Site (kBtu/ft²/yr) 52
Source (kBtu/ft²/yr) 173

Emissions (based on site energy use)
Greenhouse Gas Emissions ($MtCO_2e$/year) 2,352

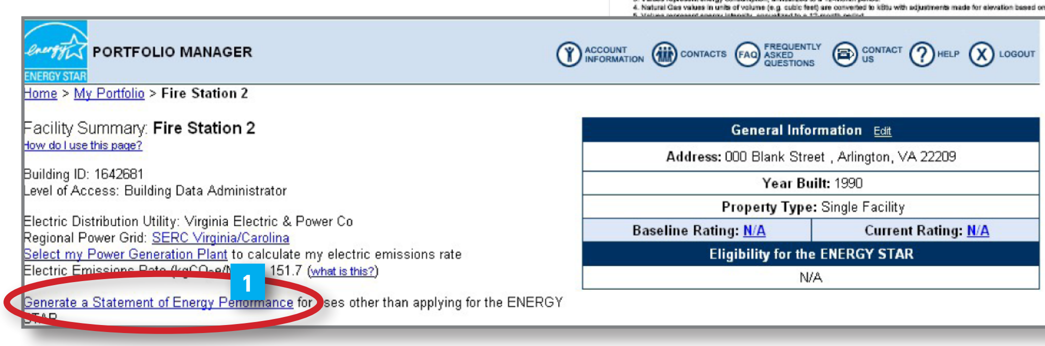
Electric Distribution Utility
Virginia Electric & Power Co

National Average Comparison
National Average Site EUI 78
National Average Source EUI 157
% Difference from National Average Source EUI 10%
Building Type: Fire Station/Police Station

Stamp of Certifying Professional
Based on the conditions observed at the time of my visit to this building, I certify that the information contained within this statement is accurate.

Meets Industry Standards[6] for Indoor Environmental Conditions:
Ventilation for Acceptable Indoor Air Quality N/A
Acceptable Thermal Environmental Conditions N/A
Adequate Illumination N/A

Certifying Professional
N/A



GENERATE A STATEMENT OF ENERGY PERFORMANCE AND AN ENERGY PERFORMANCE REPORT

STEP	ACTION
1	From your selected building's **Facility Summary** page, click **GENERATE A STATEMENT OF ENERGY PERFORMANCE**.
2	On the next page, select a period ending date. (step not shown)
3	Click **GENERATE REPORT,** located in the bottom right corner of the screen. (step not shown)
4	Save the Statement of Energy Performance, accompanying Data Checklist, and Facility Summary that include information on energy use intensity and greenhouse gas emissions.
5	From the **My Portfolio** page, click **REQUEST ENERGY PERFORMANCE REPORT**, located under **Work with Facilities**, which shows reductions in key performance indicators over a user-specified time period. Specify the type of report, the facilities to be included, and the requested report columns. The report will be e-mailed to a user-specified address within one business day. (step not shown)

www.energystar.gov/benchmark

ENERGY STAR® Portfolio Manager Data Collection Worksheet

This worksheet was designed to help building owners and managers collect data to benchmark buildings using EPA's ENERGY STAR Portfolio Manager. The information in this worksheet will be used to establish your building's profile in Portfolio Manager, which is critical to calculate benchmarks of key metrics such as energy intensity and costs, water use, and carbon emissions. **All building types can be entered into Portfolio Manager and receive energy and water benchmarks, as well as a comparison of performance against a national average for buildings of a similar type.**

Some buildings will also receive an ENERGY STAR score. The ENERGY STAR score is a benchmark that indicates how efficiently buildings use energy on a 1-100 scale. A score of 50 indicates that energy performance is average compared to similar buildings, while a score of 75 or better indicates top performance, and means your building may be eligible to earn the ENERGY STAR label. To receive an ENERGY STAR score, the gross floor area of the building must be comprised of more than 50% of one of the following space types: bank/financial institution, courthouse, data center, hospital (acute care and children's), hotel, house of worship, K-12 school, medical office, office, residence hall/dormitory, retail store, senior care facility, supermarket/grocery store, warehouse (refrigerated and unrefrigerated), and wastewater treatment plant.

Use this worksheet to collect the data for all space types applicable to your facility.

Required Data for ENERGY STAR Benchmarking

- Portfolio Manager username and password.
- The building street address, year built, and contact information.
- The building gross floor area and key operating characteristics for each major space type. Use this worksheet to collect this information before logging in to Portfolio Manager.
- 12 consecutive months of utility bills for all fuel types used in the building. If you don't have this information readily available, contact your utility provider(s) as most will be able to easily supply this historical information.

General Building Information

Facility name ____ Year built______________

Building address ____

City ____ State ____________ZIP ____________________

Space Use Attributes

Before compiling the information noted in the boxes below, review the following important information:

- Specific definitions and instructions for each of the data fields listed in the boxes below can be viewed by navigating to Portfolio Manager Help, selecting "Space Type Definitions," choosing the appropriate building type, and selecting "Space Use Information."
- Some buildings may contain multiple space types within a single building (e.g. office, data center, and parking OR K-12 school and swimming pool). Complete the fields below for each applicable major space types within the building.
- For buildings with multiple tenants with the same space type, these spaces should be entered separately only when the number of weekly operating hours among tenants differs by more than 10 hours. For example, in a 100,000 square foot (SF) office building where 75,000 SF operates 60 hours a week and 25,000 SF operates 80 hours a week, please list as two separate spaces – one 75,000 SF space and one 25,000 SF space. As this is most common in office buildings, multiple office space fields are provided below to capture data for multiple tenants if necessary.
- Default values supplied by Portfolio Manager can be used for all space use characteristics with the exception of gross floor area. Using default values will result in an approximate energy performance score which can be a beneficial metric for estimating energy performance. If defaults are used for an initial score, it is recommended that actual data be added later to more accurately measure a facility's energy performance. Facilities using default values are not eligible to apply for the ENERGY STAR label. Leave any of the requested information below blank (except gross floor area) to use a default value for the field.

Bank/Financial Institution:

Required:

_______ **Gross floor area (SF)**

_______ Weekly operating hours

_______ # of workers on main shift

_______ # of personal computers

_______ Percent of floor area that is air conditioned (>=50%, <50%, or none)

_______ Percent of floor area that is heated (>=50%, <50%, or none)

Courthouse:

Required:

_______ **Gross floor area (SF)**

_______ Weekly operating hours

_______ # of workers on main shift

_______ # of personal computers

_______ Percent of floor area that is air conditioned (>=50%, <50%, or none)

_______ Percent of floor area that is heated (>=50%, <50%, or none)

Data Center:

Required:

_______ **Gross floor area (SF)**

_______ IT Energy Configuration – Select one from:

1. Uninterruptible Power Supply (UPS) Meter supports only IT Equipment. ***(Preferred)***
2. UPS Meter includes non-IT load of 10% or less.
3. UPS Meter includes non-IT load greater than 10%. Non-IT load is sub-metered.
4. UPS Meter includes non-IT load greater than 10%. Non-IT load is **not** sub-metered.
5. Facility has no UPS Meter.
6. IT Energy is not current metered at this facility – Apply Estimates.

_______ IT Energy Data – 12 months of measured energy consumption data is required from either the UPS or PDU Meter, depending on IT Energy Configuration

Meter Type (select 1): UPS Output or PDU Input			
Month	Start Date	End Date	Energy Consumption (kWh)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Optional:

_______ UPS System Redundancy (N, N+1, N+2, 2N, greater than 2N, none of the above)

_______ Cooling System Redundancy (N, N+1, N+2, 2N, greater than 2N, none of the above)

Hospital (acute care and children's): ***Required:*** _______ **Gross floor area** (>20,000 SF) _______ # of licensed beds _______ Maximum # of floors _______ Tertiary care facility – yes or no ***Optional:*** _______ Laboratory on-site – yes or no _______ Laundry facilities on site – yes or no _______ Number of Buildings _______ Ownership Status (drop down of options)	**House of Worship:** **Required:** _______ **Gross floor area (SF)** _______ Maximum seating capacity _______ Weekdays of operation _______ Hours of operation per week _______ # of personal computers _______ Presence of cooking facilities - yes or no _______ # of commercial refrigeration/freezer units
Hotel: ***Required:*** _______ **Gross floor area (SF)** _______ # of rooms _______ # of workers on main shift _______ # of commercial refrigeration/freezer units _______ On-site cooking – yes or no _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ***Optional:*** _______ Hours per day the guests are on-site _______ Number of guest meals served _______ Square footage of full-service spas _______ Square footage of gym/fitness center _______ Laundry processed at site (drop down of options) _______ Annual quantity of laundry processed on-site _______ Average Occupancy (%)	**K-12 School**: ***Required:*** _______ **Gross floor area (SF)** _______ # of personal computers _______ # of walk-in refrigeration/freezer units _______ High school - yes or no _______ Open weekends – yes or no _______ On-site cooking – yes or no _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ***Optional:*** _______ Months of use _______ School District

Medical Office: ***Required:*** ________ **Gross floor area (SF)** ________ # of workers on main shift ________ Weekly operating hours ________ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) ________ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.)	**General Office 1:** ***Required:*** ________ **Gross floor area (SF)** ________ Weekly operating hours ________ # of workers on main shift ________ # of personal computers ________ Percent of floor area that is air conditioned (>=50%, <50%, or none) ________ Percent of floor area that is heated (>=50%, <50%, or none)
Multifamily Housing: ***Required:*** ________ **Gross floor area (SF)** ***Optional:*** ________ Number of units ________ Number of bedrooms ________ Number of floors ________ Percent of square footage devoted to individual units ________ Number of laundry hookups in each unit ________ Number of laundry hookups in common area ________ Number of dishwashers in each unit ________ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) ________ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ________ Affordable or market rate	**General Office 2:** ***Required:*** ________ **Gross floor area (SF)** ________ Weekly operating hours ________ # of workers on main shift ________ # of personal computers ________ Percent of floor area that is air conditioned (>=50%, <50%, or none) ________ Percent of floor area that is heated (>=50%, <50%, or none)
Other: ***Required:*** ________ **Gross floor area (SF)** (must be less than 10% of gross building floor area in order for the building to be eligible for a rating) ***Optional:*** ________ # of personal computers ________ Weekly operating hours ________ # workers on main shift	**General Office 3:** ***Required:*** ________ **Gross floor area (SF)** ________ Weekly operating hours ________ # of workers on main shift ________ # of personal computers ________ Percent of floor area that is air conditioned (>=50%, <50%, or none) ________ Percent of floor area that is heated (>=50%, <50%, or none)

Parking: ***Required:*** _______ Gross floor area that is enclosed (SF) _______ Gross floor area that is not enclosed with a roof (SF) _______ Gross floor area that is open (SF) _______ Weekly hours of access	**Retail Store:** ***Required:*** _______ **Gross floor area (SF)** _______ Weekly operating hours _______ # of workers on main shift _______ # of personal computers _______ # of cash registers _______ # of walk-in refrigeration/freezer units _______ # of open & closed refrigeration/freezer cases _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) _______ Exterior entrance to the public – yes or no
Residence Hall/Dormitory: ***Required:*** _______ Gross floor area (SF) _______ # of rooms _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ***Optional:*** _______ Computer lab on-site – yes or no _______ Dining Hall on-site– yes or no	**Senior Care Facility:** ***Required:*** _______ Gross floor area (SF) _______ # of units _______ Average Number of Residents _______ Total Resident Capacity _______ # of workers on the main shift _______ # of PCs owned by the community (does not include PCs owned by residents) _______ # of commercial refrigeration/freezer units _______ # of commercial washing machines _______ # of residential washing machines _______ # of residential electronic lift systems _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.)

Supermarket/Grocery Stores: ***Required:*** _______ **Gross floor area (SF)** _______ Weekly operating hours _______ Workers on main shift _______ On-site cooking – yes or no _______ # of walk-in refrigeration/freezer units _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ***Optional:*** _______ # of open or closed refrigeration/freezer cases _______ # of registers and/or personal computers	**Swimming Pool:** ***Required:*** __________ Swimming pool size, choose from: Olympic (50 meters x 25 meters) Recreational (20 yards x 15 yards) Short Course (25 yards x 20 yards) __________ Indoor or outdoor ***Optional:*** _______ Months of use
Warehouse (refrigerated and unrefrigerated): **Warehouse (Unrefrigerated):** ***Required:*** _______ **Gross floor area (SF)** _______ Weekly operating hours _______ # of workers on main shift _______ # of walk-in refrigerators/freezer units _______ Percent of floor area that is cooled in 10% increments (10%, 20%, 30%, etc.) _______ Percent of floor area that is heated in 10% increments (10%, 20%, 30%, etc.) ***Optional:*** _______ Distribution Center – yes or no **Warehouse (Refrigerated):** _______ **Gross floor area (SF)** _______ Weekly operating hours _______ # of workers on main shift	**Wastewater Treatment Plant**: ***Required:*** _______ Average influent flow (mgd) _______ Average influent biological oxygen demand (BOD_5) _______ Average effluent biological oxygen demand (BOD_5) _______ Plant design flow rate (mgd) _______ Presence of fixed film trickle filtration process – yes or no _______ Presence of nutrient removal process – yes or no
	Water Treatment and Distribution Utility: **Required:** _______ Average flow (mgd)

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 2

Selecting and Prioritizing Renewable Energy Sites: Introduction to Solar PV and Solar Mapping Tools

Selecting and Prioritizing Renewable Energy Sites: Introduction to Solar PV and Solar Mapping Tools

A district must review a number of important considerations when determining where to install renewable energy systems.

PV systems can be installed on rooftops or parking lots, as shade structures, or in other open spaces on district property. Districts are likely to consider the following criteria:

- Location – does the site receive enough exposure to the sun throughout the year to allow for year-round electricity production?
- System size – is the proposed PV system large enough to benefit from "economies of scale". Will the PV system produce enough electricity to make the project financially viable?
- What is the condition of the proposed site? Do roofs need to be replaced or resurfaced? Will a building support the additional weight of a PV system?
- Does the district have any plans to modernize or replace the structure?
- How high is the building? Is it easily accessible to trespassers?
- Will the community accept highly visible PV structures?
- Are the buildings already highly efficient, or should the project include energy-efficiency improvements?

Answering these questions will help districts to determine where PV installations are best sited.

The National Renewable Energy Lab conducted a webinar in November 2010 for the school districts participating in the development of Solar Master Plans. The information in the following PowerPoint presentation will provide additional guidance on selecting appropriate sites for PV installations.

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

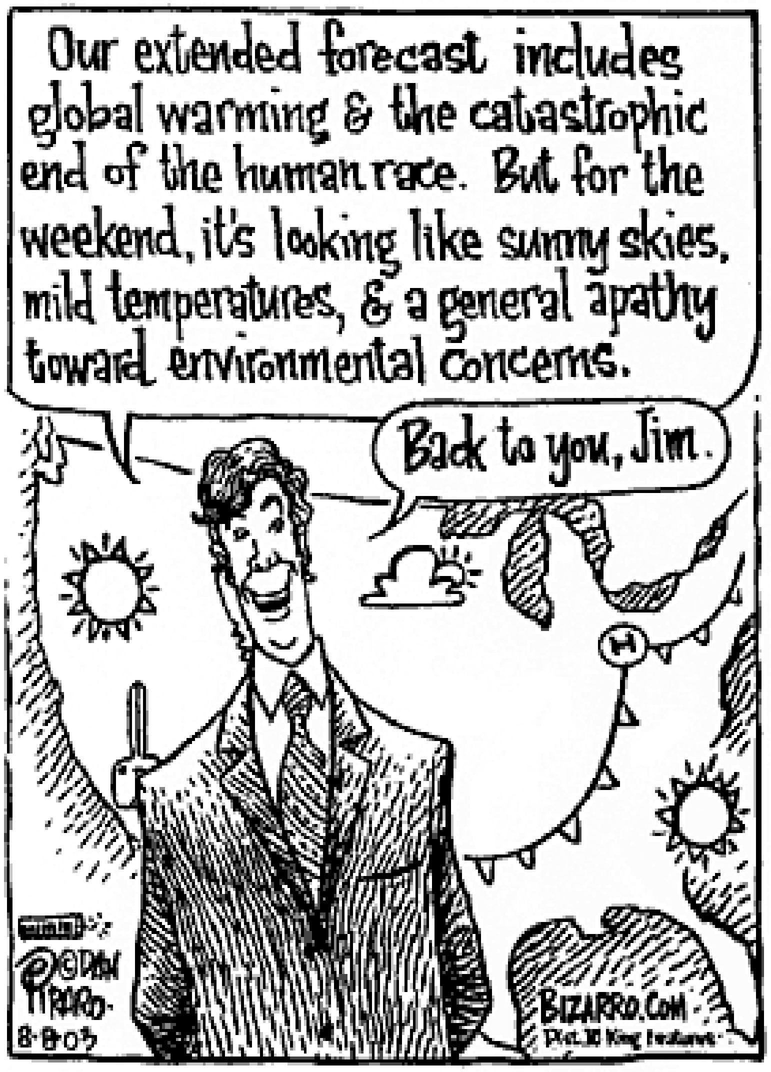
Introduction to Solar PV and Solar Mapping tools

Andy Walker
Principal Engineer
Integrated Applications Office
National Renewable Energy Laboratory

November 12, 2010
Presentation for: SSAIP Showcase

Presentation Overview

- Energy efficiency overview
- Motivations for RE technologies
- PV overview
  - How it works
  - Applications
  - Costs
  - Efficiency
  - Applicability to schools and siting
- Mapping tools
  - IMBY
  - San Francisco map
  - Berkeley map
- Resources



Energy Efficiency First

- Every $1 spent on efficiency saves at least as much as $2 spent on renewable technologies

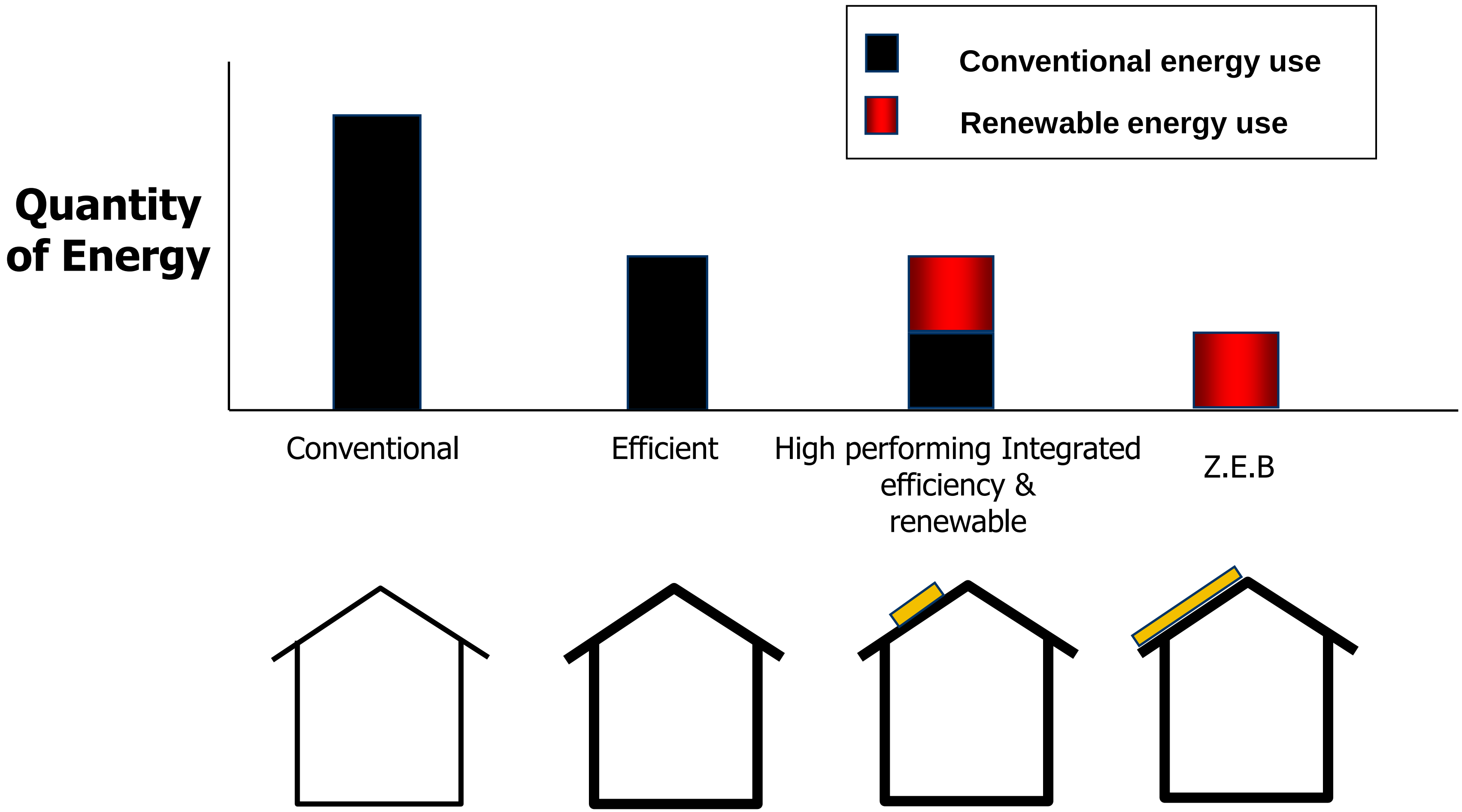
Reduce energy loads through:

- Efficient building envelope
- Building orientation
- Renewable energy (architectural):
  - Daylighting
  - Passive solar heating
  - Cooling load avoidance

Meet remaining loads with:

- Efficient HVAC & lighting equipment
- Renewable energy (building equipment):
  - Solar thermal: water heating, transpired collectors
  - Solar electric: photovoltaics, wind
  - Geothermal heat pumps

Integrated Solutions: Renewables Go Hand-in-Hand with Energy Efficiency



Prior to considering renewable technologies

- Consider performing audits or having audits completed on all facilities prior to installation of renewable energy technologies

Drivers for using RE technologies

- Reduce energy and water use
- Achieve greater energy price stability
- Minimize peak demand
- Decrease O&M costs
- Lower risk of fuel spills in environmentally sensitive, remote locations
- Reduce need for imported fuels
- Take advantage of potentially lower utility bills or new income streams
- Conserve natural resources and reduce emissions
- Meet state and agency goals
- Enhance energy security with reliable, distributed power supplies and fuel diversification

Solar Photovoltaics (PV)

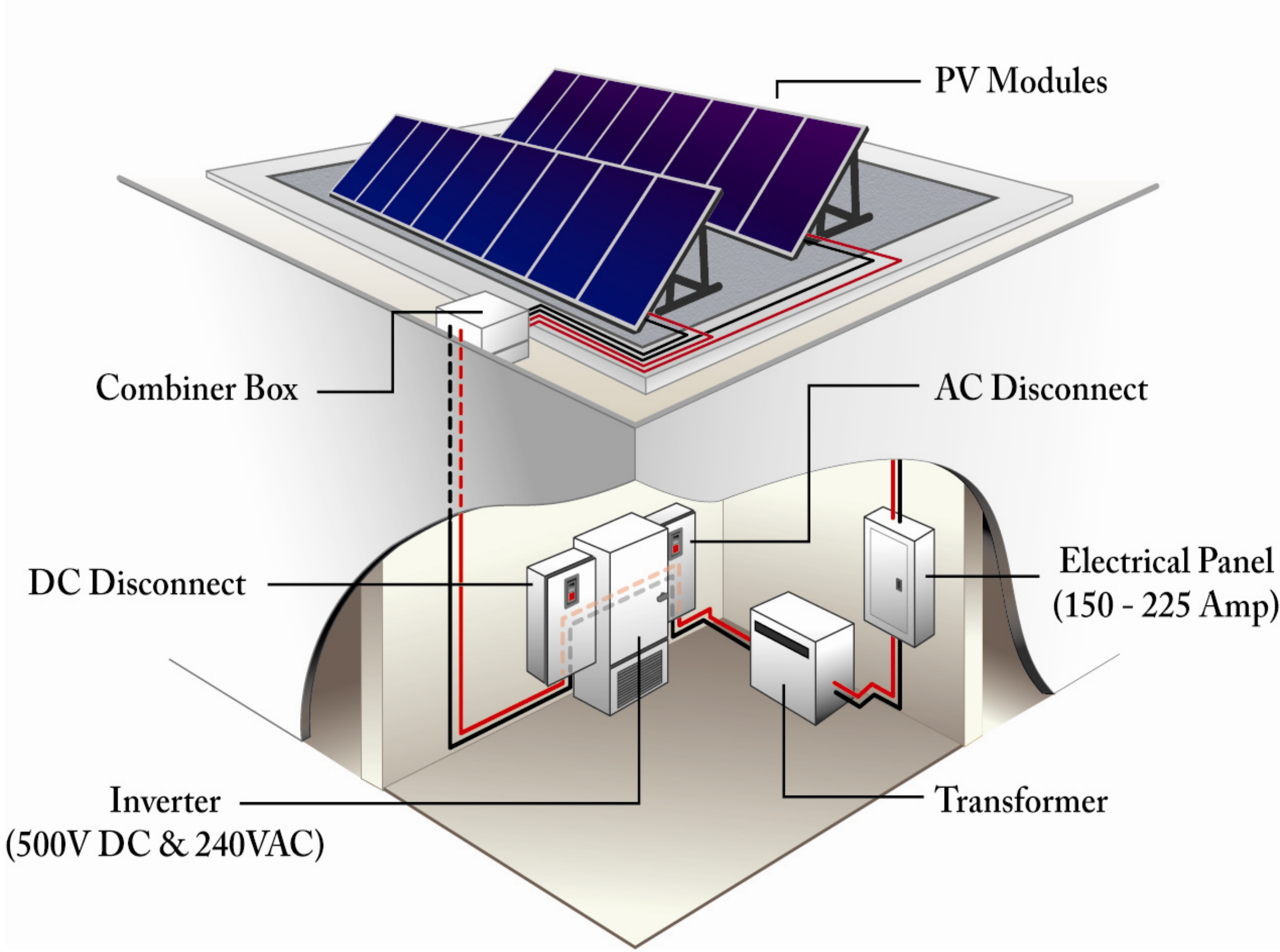
Grant Elementary School in Redding, CA

PV Installation Considerations

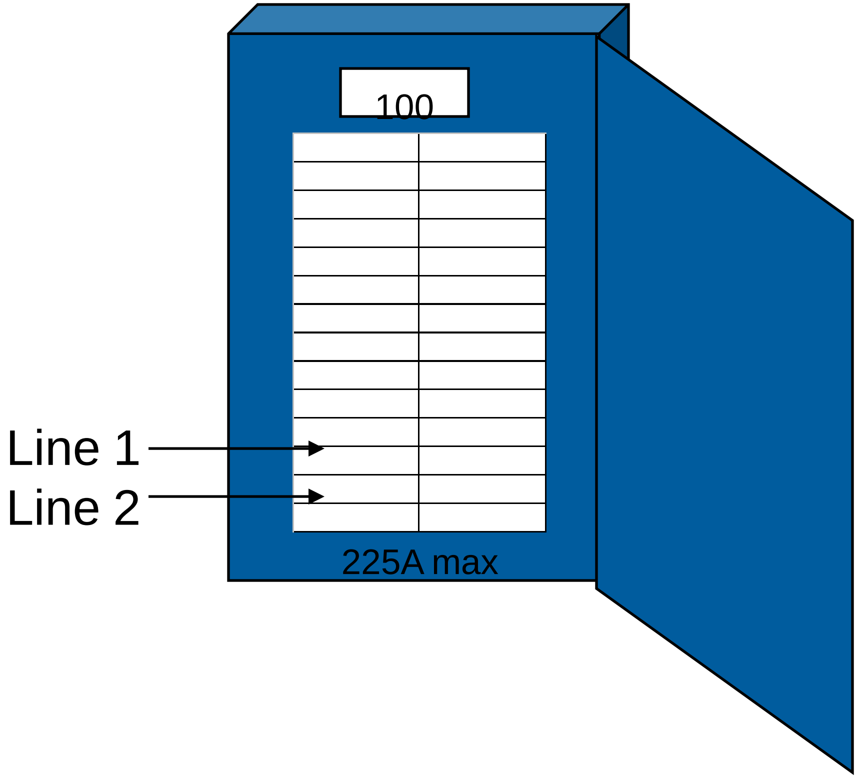
- Panel installation on south-facing, un-shaded area
- Install on ground, roof, or carport
- Panel tilt
- Tracking vs. Fixed
- Utility grid connection or stand-alone ('off the grid')
- Battery storage needed for off-grid operation

Photovoltaics System Components (grid connected)

- Solid-state electronics, no-moving parts
- High reliability, warranties of 20 years or more
- PV modules are wired in series and parallel to meet voltage and current requirements
- Direct conversion of sunlight into DC electricity
- DC converted to AC by inverter

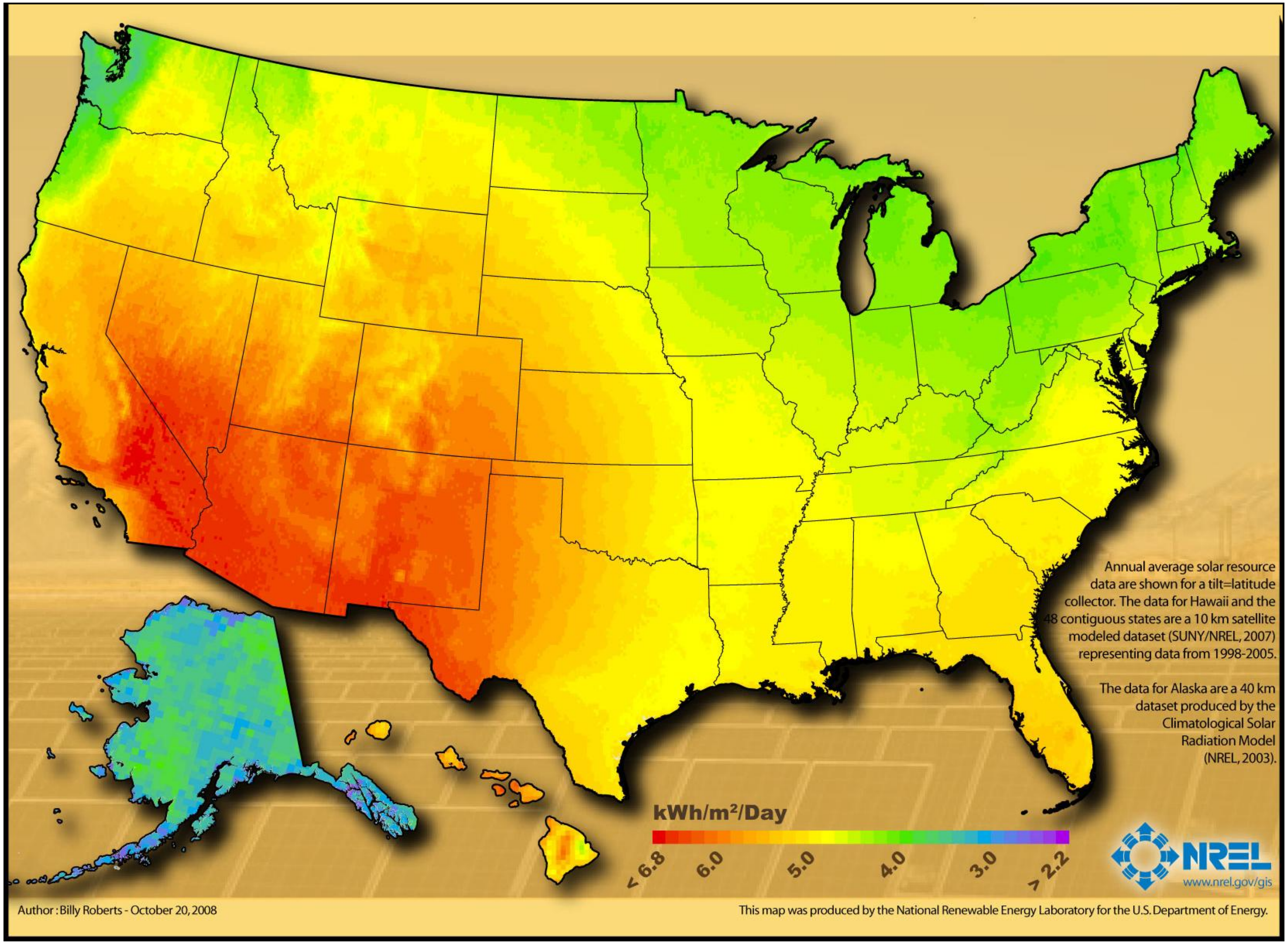


Utility Interconnection – Where to land the power?



- Backfeed Breaker in Building Panel (Sum of Main Breaker and PV breaker not to exceed 120% of panel rating for commercial and residential buildings)
- Too big?- Survey Loads and reduce main breaker rating
- Too big?- Upgrade Panel
- Too big?- Line-side-tap
- Too big?- Upgrade Electrical Service

U.S. Solar Resource Map



PV Cost and O&M

Average installed costs declined from $10.80 per watt (W) in 1998 to $7.50/W in 2008

Size matters—small residential PV systems completed in 2008 that were less than 2 kilowatts (kW) in size averaged $9.20/W, while large commercial systems in the range of 500 to 750 kW averaged $6.50/W.

Location: Systems completed in 2008 and less than 10 kW in size, range from a low of $7.30/W in Arizona, followed by California, which had average installed costs of $8.20/W, to a high of $9.90/W in Pennsylvania and Ohio.

New construction: among small residential PV systems in California completed in 2008, those systems installed in residential new construction cost $0.80/W less than comparably-sized systems installed in rooftop retrofit applications.

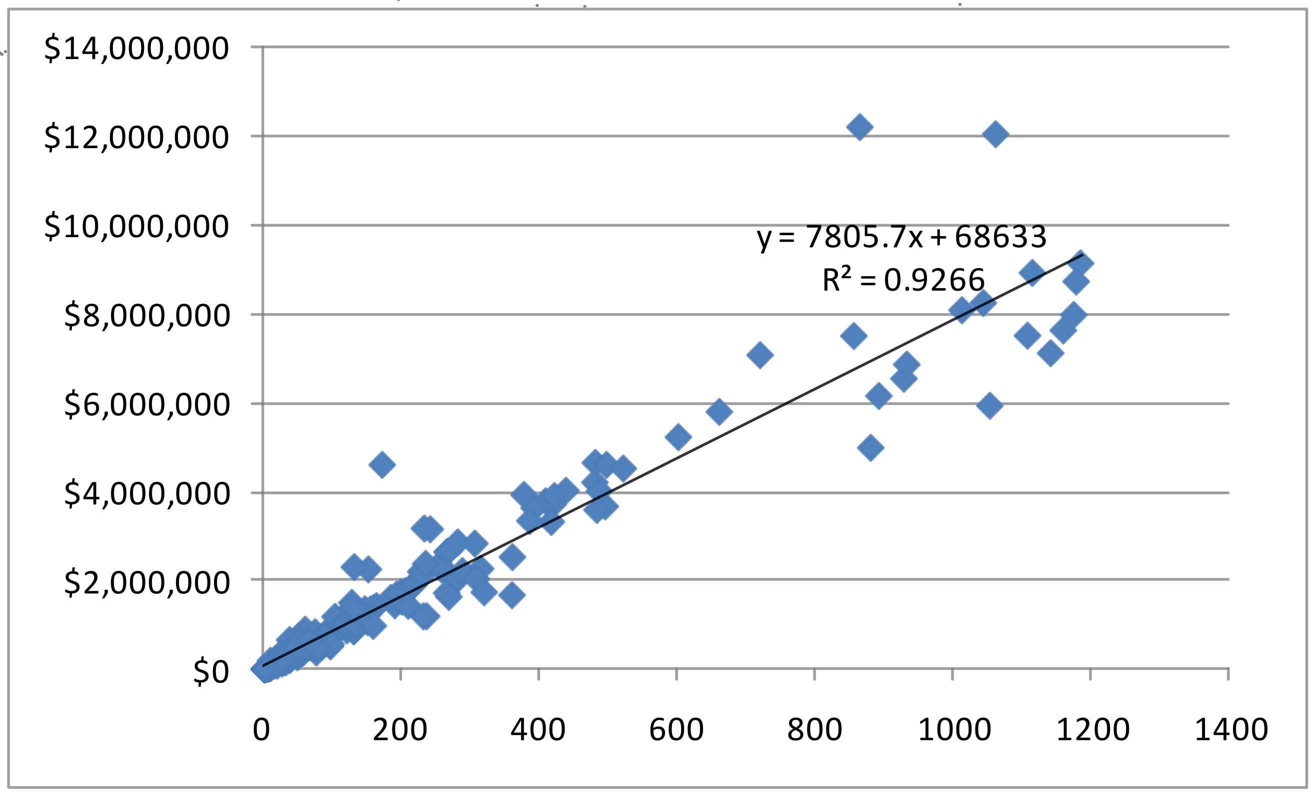
"Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998–2008," by Ryan Wiser, Galen Barbose, Carla Peterman, and Naim Darghouth may be downloaded from http://eetd.lbl.gov/ea/emp/re-pubs.html.

Operations and Maintenance

- Includes visual inspection, maintenance of PV area, conductor tightening, trip resets, etc.
- Inverter replacement after 10 -15yrs

Annual O&M Cost
$12.50/kW-DC + amortized 1 time replacement of inverter = $37.50/kW-DC per year

California Solar Initiative, Government



$7,805/kW

Recent School PV Projects in California

- Baldwin Park USD
  - $15 MM at 2.24MW - $6.70/w
- Butte College
  - $17 MM at 2.7MW - $6.30/w
- San Ramon VUSD
  - $23.3 MM at 3.357 MW - $6.93/w
- Peralta Community College District
  - $8.1M at 1.2MW - $6.75/w

PV Efficiency

Efficiency= power out/power in

Module Efficiencies	Single Crystal	14-19%
	Multi Crystal	13-17%
	Thin Film	6-11%
Balance of System Efficiency		77%

Efficiency versus Size

- 1 kW of 15% eff. crystalline 71ft^2
- 1 kW of 9.5 % eff. amorphous 99ft^2
- 1 kW of 19.3% eff. hybrid 55ft^2

PV viability depends on:

- Site cost of electricity
- Site solar energy resource
- Technology characteristics
  - Cost ($/kW installed, O&M Cost)
  - Performance (efficiency)
- State, utility policies (interconnection, net metering charge structure)
- State, utility and Federal Incentives
- Economic parameters (discount rate, escalation rates)
- Site and/or school district’s policies and mandates

PV Installation Considerations

Orientation / Tilt Angle

- –PV panels should be mounted facing due south
- –tilt angle = latitude is ideal for annual output

•Mounting Techniques

- –Roof mounting:
  - •Flat roof mount: tilt angle between 2°and 20°, max output in summer
  - •Flush roof mount: tilt angle = roof tilt
  - •Ballasted roof mount – no roof penetrations,
- –Ground mount: usually fixed at latitude or single axis tracking
- –Pole mount: usually fixed at latitude or single axis tracking

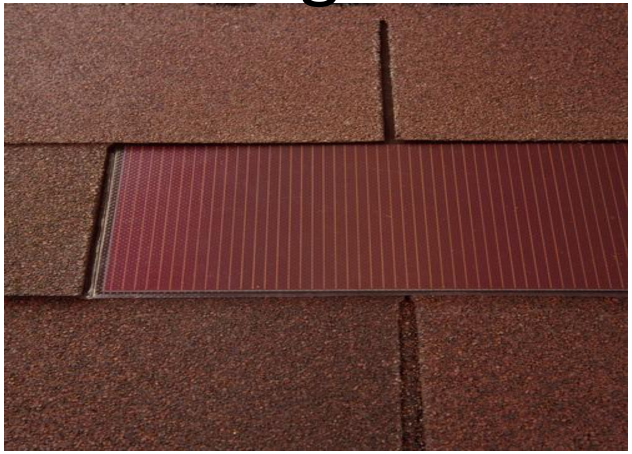
•Other Considerations

- –Roof age – PV systems should only be installed on new or refurbished roofs
- –Shading – sites with shading obstructions should be eliminated from analysis
- –Roof structural analysis – roof must be able to support weight load and wind load
- –Electrical system interconnection – can be load site or utility side interconnection

Building-Integrated Photovoltaics

Glazing

Shingles



Standing Seam

Single-Ply

Site Assessment Guidance

- **Step 1:**
  - Research resources and incentives
    - DSIRE: Database of State Incentives for Renewables and Efficiency (http://www.dsireusa.org/)
- **Step 2:**
  - Preview site
  - Assemble utility bills and other information
  - Understand types and magnitude of loads
- **Step 3:**
  - Evaluate possible land/roof areas for PV installation, measure, and take pictures
  - Roof: size, shading, slope, age of roof, orientation;
  - Land areas: shading, slope, soil conditions.
- **Step 4:**
  - Identify connections to existing systems and location and limits of utility connection
- **Step 5:**
  - Calculate economics

Let's discuss how to perform the steps in red

Process for Identifying Opportunities for PV

- Identify potential location and quantify potential area and system size
  - South-facing
  - Unshaded
  - Minimal existing roof penetrations
  - New or good quality roof

- Use mapping software for remote assessment
  - IMBY
  - GoogleEarth and PVWatts

Study by SunPower Corp.

School	Address	Location	Sq Ft total	Sq Ft avail	PV Capacity (kWp)	PV Output (kWh/year)	Cost ($)
Hercules Middle/High	1900 Refugio Valley Rd., Hercules CA 94547	Parking Lot A	12,600	12,600			
		Parking Lot B	18,450	18,450			
		Parking Lot C	7,380	7,380			
		Parking Lot D	7,056	7,056			
		Parking Lot E	3,924	3,924			
		Parking Lot F	3,780	3,780			
		Building A	5,200	3,276			
		Building B	9,660	7,245			
		Building C	5,200	3,276			
		Building D	7,470	5,603			
TOTALS				**72,590**	**672**	**907,730**	**$3,866,255**
Lavonya DeJean Middle	3400 MacDonald Ave., Richmond, CA 94805	Building A	5,400	3,402			
		Building B	5,400	3,402			
		Building C	5,400	3,402			
		Building D	8,960	5,645			
		Parking Lot 1	5,270	5,270			
		Parking Lot 2	5,270	5,270			
TOTALS				**26,391**	**460**	**621,000**	**$2,645,000**

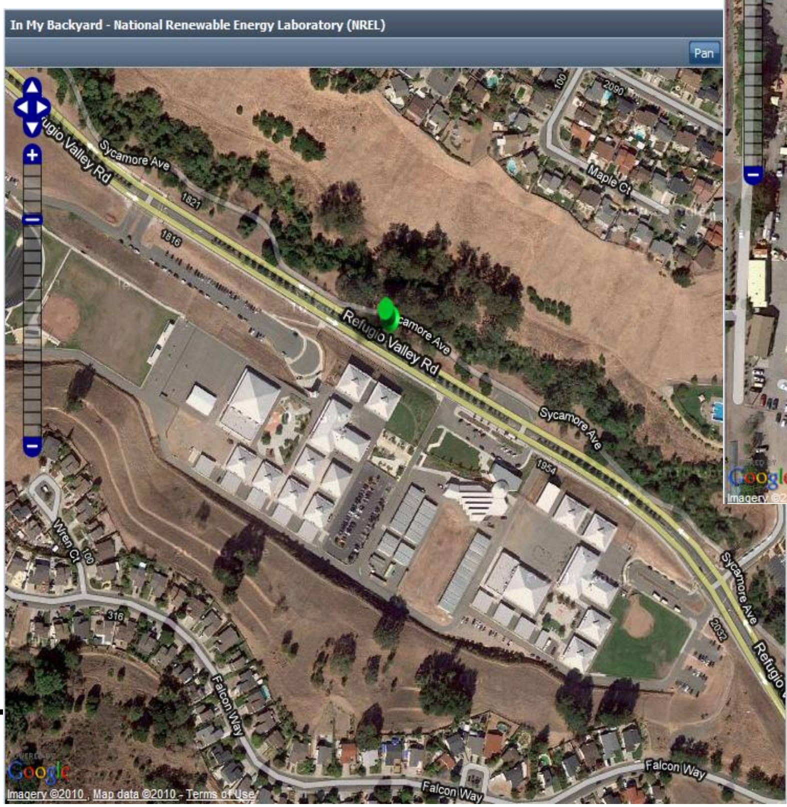
IMBY

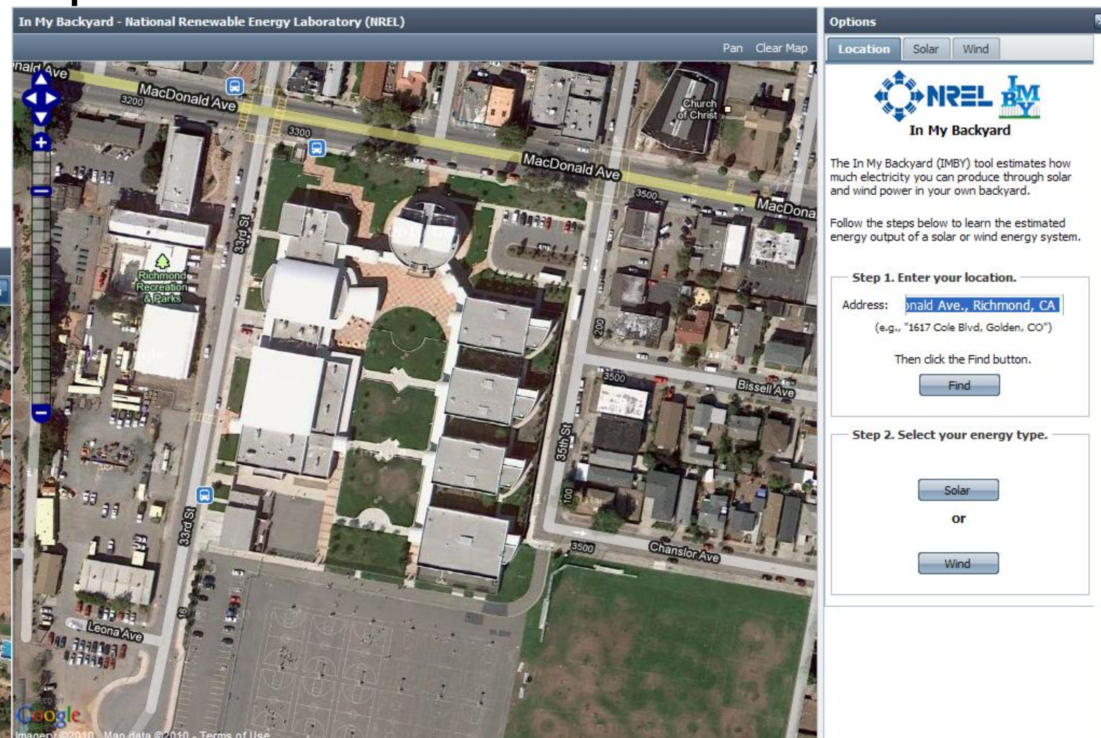
- In My Backyard (IMBY) - aerial photo view
  http://www.nrel.gov/eis/imby/

- Estimates the electricity you can produce with a solar photovoltaic (PV) array or wind turbine at your home or business.
- Uses a map-based interface to allow you to choose the exact location of your PV array or wind turbine.
- IMBY estimates the electricity production you can expect from your system.

Examples: WCCUSD

Hercules Middle/High –
1900 Refugio Valley Road
Hercules, CA 94547

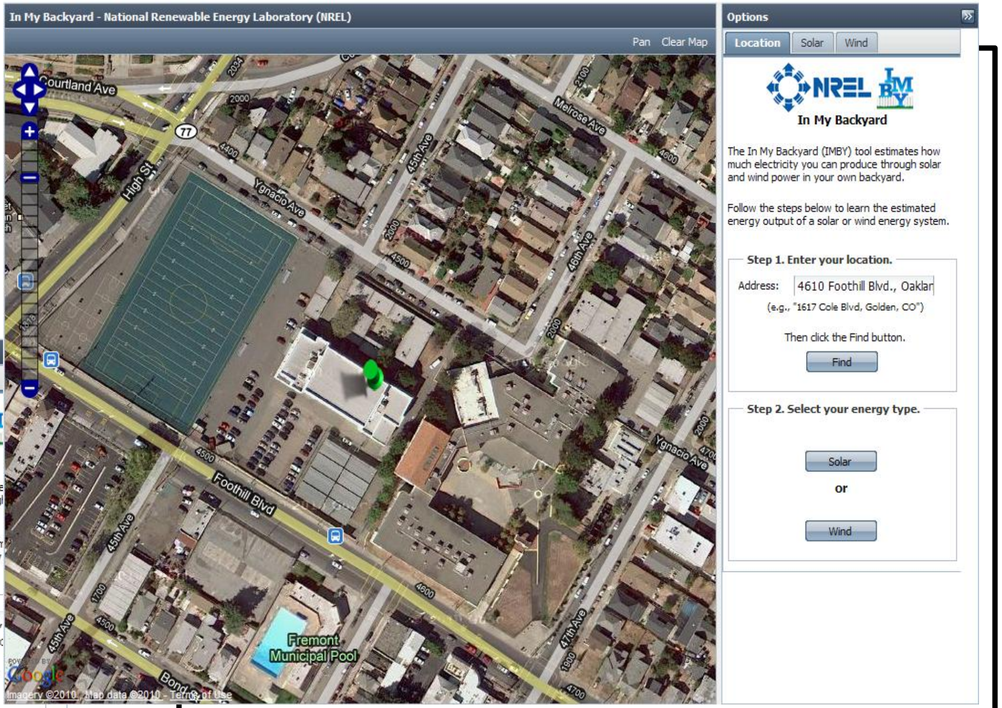


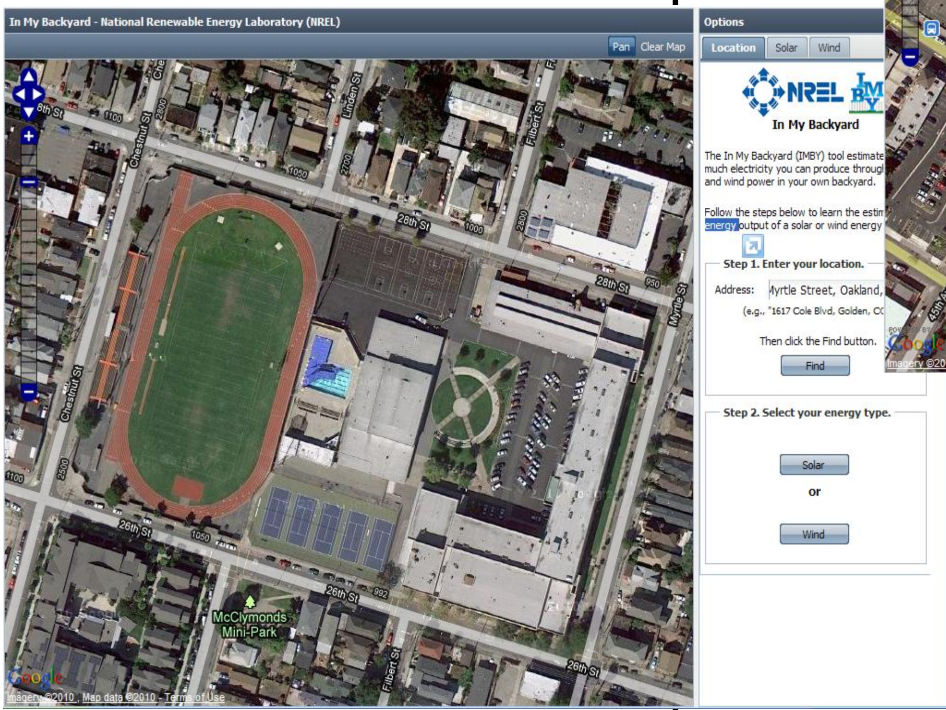


Lavonya DeJean Middle –
3400 MacDonald Ave.
Richmond, CA 94805

Examples: OUSD

McClymonds High School
2607 Myrtle Street
Oakland, CA 94607





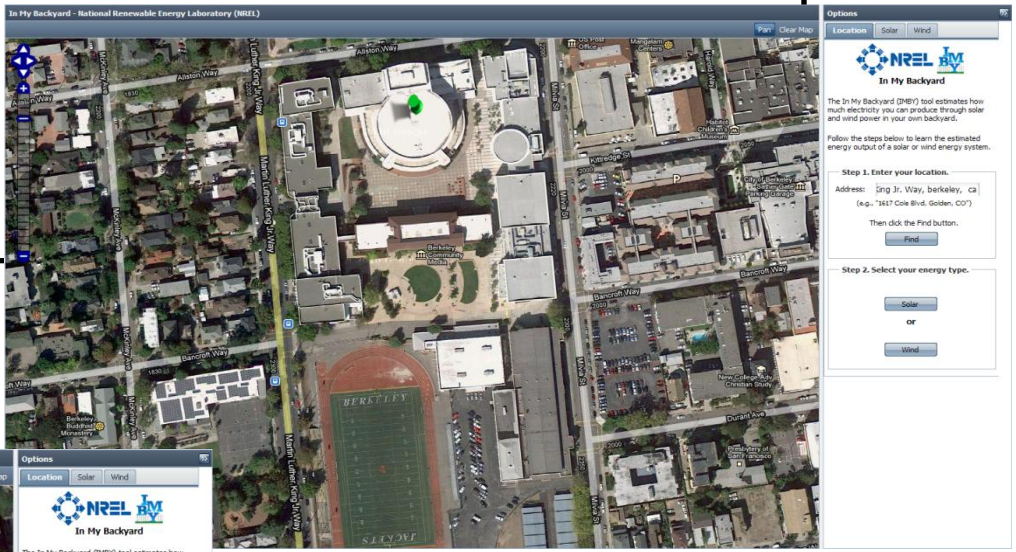
Fremont High School
4610 Foothill Blvd.
Oakland, CA 94601

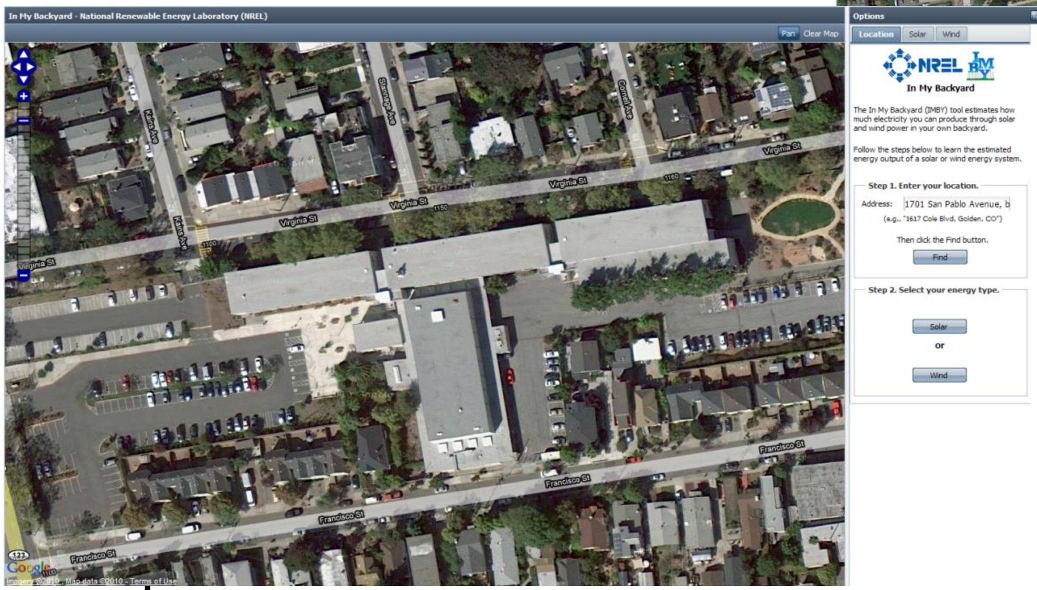
Examples: BUSD

Berkeley High School

2223 Martin Luther King Jr. Way

Berkeley, CA 94704





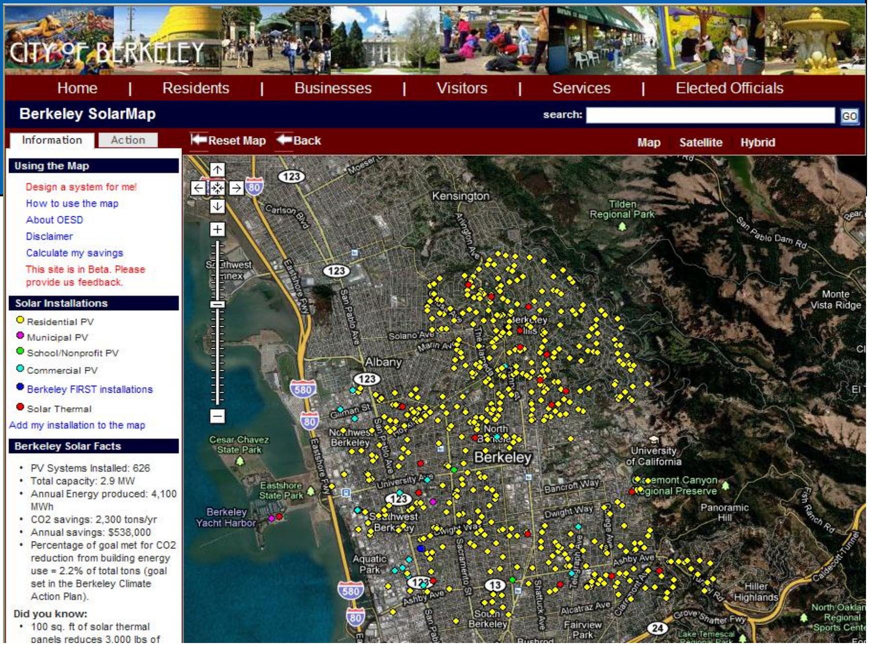
Franklin Adult School

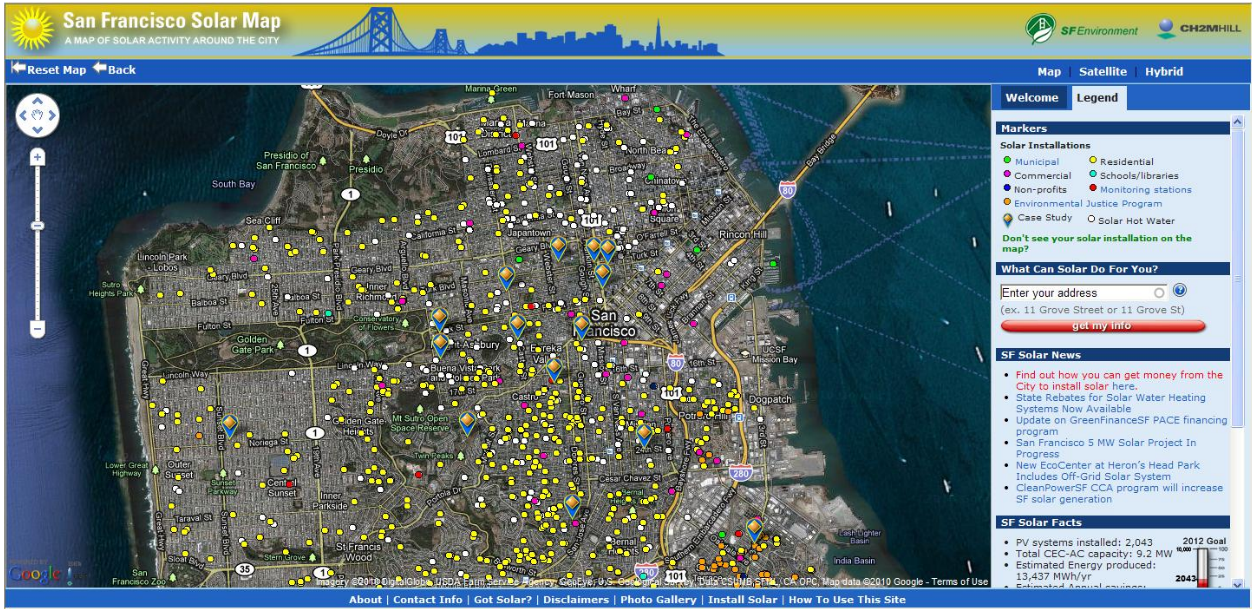
1701 San Pablo Avenue

Berkeley, CA 94702

Other Online Solar Maps

- City of Berkeley
  - http://berkeley.solarmap.org/solarmap_v4.html
- City of San Francisco
  - http://sf.solarmap.org/





Information Resources

- Tester, et al., *Sustainable Energy: Choosing Among Options*
- PV: http://www1.eere.energy.gov/solar/photovoltaics.html
- Solar Heating: http://www1.eere.energy.gov/solar/solar_heating.html
- Solar Ventilation Preheat: http://www1.eere.energy.gov/femp/technologies/renewable_svp.html
- Concentrated Solar: http://www1.eere.energy.gov/solar/csp.html
- Wind Power: http://www1.eere.energy.gov/windandhydro/wind_technologies.html
- Biomass: http://www1.eere.energy.gov/biomass/

Resources (cont.)

- DOE Energy Efficiency and Renewable Energy Solar Energy Technologies Program

  http://www1.eere.energy.gov/solar/solar_heating.html
- FEMP Federal Technology Alerts

  www.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf

  www.eere.energy.gov/femp/pdfs/FTA_para_trough.pdf
- FEMP Case Studies

  www.eere.energy.gov/femp/technologies/renewable_casestudies.html
- Resource maps

  http://www.nrel.gov/gis/solar.html
- Solar Radiation Data Manual

  http://rredc.nrel.gov/solar/pubs/redbook

Design Tools

- RETScreen - Solar Hot Water, PV, Solar Vent Preheat
  http://www.retscreen.net
- PVWatts- PV hourly simulation
  http://www.pvwatts.org/
- IMBY- aerial photo view
  http://www.nrel.gov/eis/imby/
- SAM - PV, Solar Water Heating, Concentrating Solar Power
  https://www.nrel.gov/analysis/sam/
- Fchart – Active and Passive Systems Analysis (PV and Solar Thermal)
  http://www.fchart.com/fchart/fchart.shtml

Thank you!

- Contact Information:

  - Andy Walker
  - andy.walker@nrel.gov
  - (303) 384-7531

  - Alicen Kandt
  - alicen.kandt@nrel.gov
  - (303) 384-7518

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Chapter 3

Structural Evaluations

Structural Evaluations

Once a school district has identified the buildings that it believes are the best candidates for a PV system, the district will want to consider whether the roofs can support the gravitational, wind and seismic loads of a PV system. In other words, can the PV system meet the strict building code requirements that apply to California's public schools?

The U.S. Department of Energy contracted with Interactive Resources in Richmond, CA to review the "as-built" drawings for a selection of schools identified as good candidates for PV systems. The purpose of the review was to identify any structural conditions that might indicate that the roof of a target building would not meet the building code requirements. The buildings were not physically inspected during this review; the assessment was based on a review of the drawings only.

The reports that follow describe in detail what Interactive Resources considered in its evaluation of several school roofs located in this district. While it is not necessary to conduct this type of evaluation prior to seeking bids on a PV project – a review and inspection can be done at a later point in the process – the district can save itself and interested vendors time and money by doing a preliminary assessment prior to seeking bids.

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October 8, 2010

Mr. Dan Olis
National Renewable Energy Laboratories
1617 Cole Blvd.
Golden, CO 80401

Subject: **NREL: Structural Evaluations** **2010-004.01**
BUSD - Berkeley Arts Magnet
Evaluation of Existing Framing

Dear Mr. Olis:

In accordance with the provisions of our agreement, we have completed our preliminary structural investigation of the existing roof framing for the Berkeley Arts Magnet School located in Berkeley, CA. The purpose of the evaluation is to rapidly assess if the existing framing can support a solar array and determine if there are potential structural deficiencies that may preclude the addition of a solar array.

The evaluation is based on an in-house review of the available "as-built" drawings furnished by the Berkeley Unified School District. No site visit has been performed as part of this phase of the work; however, should the project move forward, a site visit during a subsequent phase is planned to confirm that the structure, in general, conforms to the "as-built" drawings. At that time the results presented in this rapid evaluation should be reviewed and any refinement prepared as necessary.

This letter summarizes the results of our preliminary evaluation.

Existing Conditions

The existing structure is located at 2015 Virginia St in Berkeley, California. It is a 1 and 2 story U-shaped structure measuring approximately 27,500 sqft. The original year of construction was around 1940 with an upgrade designed around 1993/1994.

The roof of the existing structure is a membrane roof over a panelized plywood deck supported by timber trusses spaced at 24" on center. The trusses are supported by wood purlins and steel joists. The roof framing is supported by interior and perimeter concrete bearing walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal plywood diaphragm and the vertical concrete shear walls.

Preliminary Structural Evaluation

The evaluation involves investigating two distinct aspects of the framing. First, can the framing support the added gravity loads to be imposed by the proposed solar array and second, can the existing lateral force resisting system support the added wind and/or seismic horizontal forces without triggering a code required upgrade of the structure? The latter is limited to a maximum of 10% of the existing tributary structural dead load as permitted by ASCE 7-05 Section 11B.3 and the California Building Code (CBC) Section

3403.2.3.1, Exception 2. The analysis assumes that there is only one roof membrane present and that should a re-roof be performed either prior to installation of the solar array or during the life of the array that the existing will be removed and not roofed over. For the purposes of this analysis, a second roof membrane over the existing has been excluded to maximize the potential size of the solar array.

Where the racking system keeps the array close to the roof, wind loads generally do not represent a significant increase in forces to the existing main lateral force resisting elements. The proposed array used in the analysis is planned to be positively anchored to the structure without the use of any ballast. The design wind speed for this site is 85 MPH (3-second gust), Exposure C. A Suntech STP 260 solar module has been selected for use in the framing evaluations. To support the modules and provide a 20° tilt to the array, a SunLink racking system has been used. The anticipated weight of the array (module + racking system) use in the analysis is estimated to be 80.5# per module. A breakdown of the design loads used in the evaluation of the existing framing is shown in the Table at the end of this report.

1) Evaluation of Gravity Loads:

The existing roof deck is shown as ½” plywood over 2x trusses spaced at 24 inches on center. At this time the array layout has not been determined. In order to perform an evaluation of the gravity loads on the existing framing, we used a 4x1 panel arrangement as manufactured by SunLink. Our evaluation shows that the existing plywood deck and supporting framing are adequate to support the anticipated gravity loads and that, therefore, the existing framing is acceptable for any orientation or distribution of modules in the array(s). Attached for your reference are our preliminary calculations.

2) Evaluation of Lateral Loads:

The total existing roof area is approximately 27,488 sq. ft. with an estimated dead load of 15 psf. The minimum area of exterior walls that is tributary to the roof in either the north–south or east–west direction, is 4,329 sq ft. with an estimated dead load of 137.5 psf. Combined together the total effective existing roof dead load is = 1,007,558 lbs.

In order to avoid triggering a code required upgrade, the weight of any added solar array should not exceed 10% (Total Dead Load) or 100,756#. Dividing this weight by the combined weight per module of the proposed array (59.5+21) the maximum number of permissible modules for the array can be determined as 1,255. However, checking the available roof area against the plan area of each module, the actual number of modules that can be used is significantly less than that based on 10% of the existing mass. This module count is 884. Please note this module quantity does not account for any setbacks that may be required or aisle ways, shading restrictions or any other roof obstructions that may affect the final array layout.

Conclusions

In conclusion, we believe that positively anchored solar (PV) arrays can be supported on the existing structures. They should not exceed either the Maximum Array Weight or the

Maximum Number of Modules shown below. Either the SunLink 4x1 or 3x1 panel system is acceptable for this project.

Design Parameters	
Existing roof dead load	15 psf
Basic Wind Speed (3-second gust)	85 MPH (Exposure C)
Seismic force (Allowable Stress Design)	0.441 $W_p \simeq$ 35# per module
Module	Suntech STP 260
Module weight	Approximately 59.5# each
Module Area	20.9 square feet
Module Mounting System	By SunLink Corporation
System weight	Approximately 21# per module
System tilt angle	20º
Maximum PV Array	
Maximum Array Weight (10% Total Est. Roof DL) (with or w/o ballast)	100,756#
Maximum Number of Modules	884

If you have any questions regarding this letter, please call me at (209) 736-2079.

Sincerely,
Interactive Resources

Paul M. Westermann, P.E., S.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
PAUL M. WESTERMANN
NO. S 003097
REN. 9-30-11
STRUCTURAL
STATE OF CALIFORNIA

Enclosure

Design Criteria

Roof Framing

Roof Live Load	20 psf	Slope 1/4:12 Reducible
Live Load at Solar Modules	10	(Special roof load, greenhouse)

Roof Dead Load

Built-up Roof	4.0 psf	
1/2" Plywood	1.5	
Insulation	1.5	
2x roof framing (trusses)	1.1	
Steel Beams	1.2	
Ceiling Framing (trusses)	1.5	
Acoustical Tile Ceiling	1.5	
Mech/Elec/Misc	2.0	
	14.3 psf	USE 15 psf

Existing Exterior Walls DL

11" Concrete 137.5 psf

Parapet Height ~ 3.0 ft

Determine Allowable Solar Array Size

Determine allowable loads as a percent of the exisitng tributary DL so as not to trigger a Code reqired Seismic Upgrade

Per ASCE 7-05, Section11B.3 - a seismic upgrade is not required if the addition does not increase the seismic forces by 10%

(E) Building Dimensions

B = 235.00' D = 234.00'

Existing Roof Area - 27,488 sf (per original construction documents)

(E) DL = 1,007,558 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)

Trib Wall DL = 137.5 psf*min(235, 234')*2*(12.5/2+3' Parapet)

10% DL = 100756

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Prposed Solar Array

Module - Suntech STP260 Titl-angle - 20°
Module Area - 20.9 sf Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 # Frmg per Module - 20.8

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 1255 \text{ modules}$$

Array Wt = 80.3 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 884 \text{ modules}$$

Check (E) Framing

(E) D+L = 1007558+27488*20 psf = 1,557,318
(E) D+L+ array = 1007558+27488*10 psf +884*1254.7 = 1,353,423

$$\Delta = \frac{1,353,423}{1,557,318} - 1 = -0.131 \quad \underline{\text{Ok}}$$

Change in load on deck

(E) D+L = 35 psf
(E) D+L+ array = 27.6 psf

$$\Delta = \frac{27.6}{35} - 1 = -0.21 \quad \underline{\text{Ok}}$$

Racking Point Loads

for SunLink System

No. Modules per Support ~ 2

P = 2 * (59.5+20.8) = 161

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NREL Structural Evaluation
BUSD - Berkeley Arts Magnet

rev.	description	date	by	drawn PMW
				scale
				date 10/8/10

job 2010-004.01

SUNTECH

Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

270 Watt

POLY-CRYSTALLINE SOLAR PANEL

Features

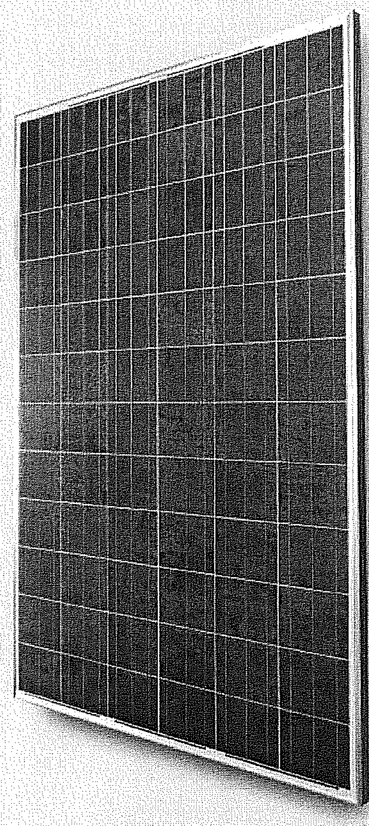
- High conversion eff ciency based on innovative photovoltaic technologies
- High reliability with guaranteed +/-3% power output tolerance
- Withstands high wind-pressure and snow load, and extreme temperature variations

Quality and Safety

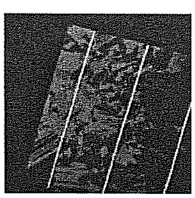
- Industry-leading, transferable 25-year power output warranty
- Rigorous quality control meeting the highest international standards
- ISO 9001:2000 (Quality Management System) and ISO 14001:2004 (Environmental Management System) certified factories deliver world class products
- UL listing:UL1703, CULus, Class C fire rating, conformity to CE

Recommended Applications

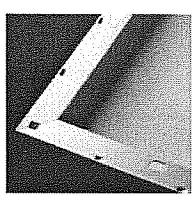
- On-grid utility systems
- On-grid commercial systems
- Off-grid ground mounted systems



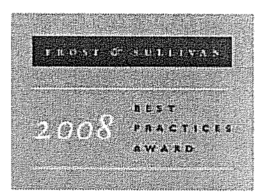
c UL us CE



Suntech's technology yields improvements to BSF structure and anti-reflective coating to increase conversion efficiency



Unique design on drainage holes and rigid construction prevents frame from deforming or breaking due to freezing weather and other forces



Suntech was named Frost and Sullivan's 2008 Solar Energy Development Company of the Year

The panel provides more field power output through an advanced cell texturing and isolation process, which improves low irradiance performance

BUSD- ARTS MAGNET   2010-004.01   3 of A

SUNTECH

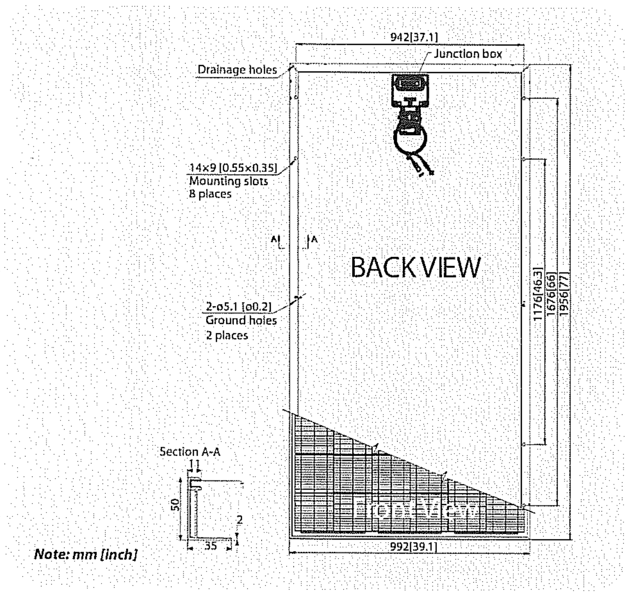
Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

Electrical Characteristics

Characteristics	STP280-24/Vb-1	STP270-24/Vb-1	STP260-24/Vb-1
Open - Circuit Voltage (Voc)	44.8V	44.5V	44V
Optimum Operating Voltage (Vmp)	35.2V	35V	34.8V
Short - Circuit Current (Isc)	8.33A	8.2A	8.09A
Optimum Operating Current (Imp)	7.95A	7.71A	7.47A
Maximum Power at STC (Pmax)	280Wp	270Wp	260Wp
Operating Temperature	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Maximum System Voltage	600V DC	600V DC	600V DC
Maximum Series Fuse Rating	20A	20A	20A
Power Tolerance	±3 %	±3 %	±3 %

STC: Irradiance 1000W/m², Module temperature 25°C, AM=1.5



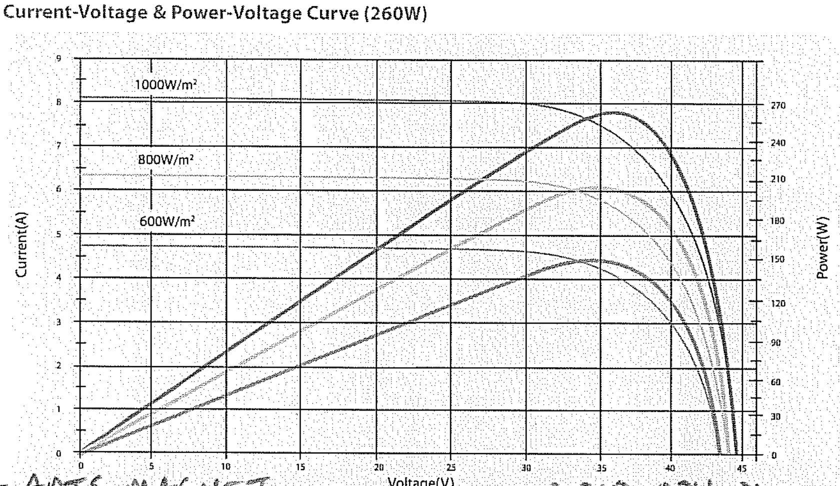
Mechanical Characteristics

Solar Cell	Poly-crystalline 156×156mm (6 inch)
No. of Cells	72 (6×12)
Dimensions	1956×992×50mm (77.0×39.1×2.0 inch)
Weight	27 kg (59.5 lbs.)
Front Glass	4mm(0.16 inch) tempered glass
Frame	Anodized aluminium alloy
Junction Box	IP65 rated
Output Cables	AIW(12AWG), asymmetrical lengths (-) 1200mm (47.2 inch) and (+) 800mm (31.5 inch), MC Plug Type IV connectors

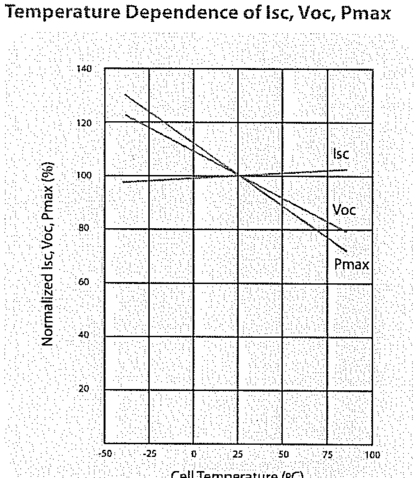
Temperature Coefficients

Nominal Operating Cell Temperature **(NOCT)**	45±2°C
Temperature Coefficient of Pmax	-(0.47 ± 0.05) %/°C
Temperature Coefficient of Voc	-(0.34 ± 0.01) %/°C
Temperature Coefficient of Isc	(0.055 ± 0.01) %/°C

Current-Voltage & Power-Voltage Curve (260W)



Temperature Dependence of Isc, Voc, Pmax



BUSD - ARTS MAGNET 2010-004.01 4 OF A

Seismic (IBC / ASCE 7)

Seismic Design Category - D (CBC 1613.5.6 & ASCE 7-05, Sect. 11.6)

Building Category - II (ASCE 7-05 Table 1-1)
Seismic Importance Factor, I - 1.00 (ASCE 7-05 Table 11.5-1)
Soil Site Class - D (ASCE 7-05 Chapter 20)

Site Location		
Latitude	37.887°	N
Longitude	122.270°	W

S_s = 1.970
S_1 = 0.764 } See next Page

$S_{MS} = F_a S_s =$ 1.97 $F_a = 1$
$S_{M1} = F_v S_1 =$ 1.146 $F_v = 1.5$

$S_{DS} = 2/3\ S_{MS} =$ 1.313 $T_0 = 0.2\ S_{D1}/S_{DS} =$ 0.116
$S_{D1} = 2/3\ S_{M1} =$ 0.764 $T_s = S_{D1}/S_{DS} =$ 0.582

for $T < T_0$, $S_a = S_{DS}\,(0.4 + 0.6\ T/T_0)$

for $T_0 < T < T_s$, $S_a = S_{DS}$

for $T_s < T$, $S_a = S_{D1}/T$

$T = C_t\, h_n^{x} =$ 0.22 (ASCE Eq. 12.8-7)
C_t = 0.020 (ASCE Table 12.8-2)
h_n = 25.00
x = 0.75 (ASCE Table 12.8-2)

Component Force (ASCE Section 13.3.1)

ASCE Eq. 13.3-1

$$F_p = \frac{0.4\, a_p\, S_{DS}\, W_p}{R_p / I_p}\left(1 + 2\,\frac{z}{h}\right) = 0.630\ Wp$$ ***Controls*** z = h h = roof elev.

ASCE Eq. 13.3-2

$F_p\ max = 1.6\ S_{DS}\, I_p\, W_p =$ 2.101 Wp

ASCE Eq. 13.3-3

$F_p\ min = 0.3\ S_{DS}\, I_p\, W_p =$ 0.394 Wp

I_p = 1.0 a_p = 1.0 R_p = 2.5

W_p = 80 # $\therefore F_p$ = 51 # for ASD, USE 0.7 * F_p = 35 #

2010-004-01 10 Solar Design.xls, ASCE Seis

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NREL Structural Evaluation
BUSD – Berkeley Arts Magnet

rev.	description	date	by	drawn	job
				PMW	2010-004.01
				scale	
				date 10/8/10	

Berkeley Unified School District
Berkeley Arts Magnet

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.009999999776482582 deg grid spacing

Period (sec)	Sa (g)
0.2	1.970 (Ss, Site Class B)
1.0	0.764 (S1, Site Class B)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.970 (SMs, Site Class D)
1.0	1.147 (SM1, Site Class D)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.313 (SDs, Site Class D)
1.0	0.764 (SD1, Site Class D)

Reference: "USGS Seismic Hazard Curves and Uniform Hazard Response Spectra", **NSHMP_HazardApp.jar** application

Berkeley Arts Magnet at Whittier

Location		Gross Available Area (ft^2)	Estimated PV Capacity		
			Rooftop (kWp)	Parking (kWp)	Total (kWp)
Berkeley Arts Magnet at Whittier					
2	Roofs (total)	22,000	140	0	140
	Building A	22,000			
Totals		**22,000**	**140**	**0**	**140**

Questions/Comments for District

1. Need PG&E billing information
2. What is age & condition of roofs?
3. Are there roof structural concerns?
4. Roof obstructions: ***significant***

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October 8, 2010

Mr. Dan Olis
National Renewable Energy Laboratories
1617 Cole Blvd.
Golden, CO 80401

Subject: **NREL Structural Evaluation** **2010-004.01**
BUSD – Jefferson Elementary
Evaluation of Existing Framing

Dear Mr. Olis:

In accordance with the provisions of our agreement, we have completed our preliminary structural investigation of the existing roof framing for the Jefferson Elementary School Facility located in Berkeley, CA. The purpose of the evaluation is to rapidly assess if the existing framing can support a solar array and determine if there are potential structural deficiencies that may preclude the addition of a solar array.

The evaluation is based on an in-house review of the available "as-built" drawings furnished by the Berkeley Unified School District. No site visit has been performed as part of this phase of the work; however, should the project move forward, a site visit during a subsequent phase is planned to confirm that the structure, in general, conforms to the "as-built" drawings. At that time the results presented in this rapid evaluation should be reviewed and any refinement prepared as necessary.

This letter summarizes the results of our preliminary evaluation.

Existing Conditions

The existing structure is located at 1400 Ada Street in Berkeley, California. It is comprised of 3 "Wings"; two 2-story Wings with classrooms and a final single story Wing with the Multi-Use and Kitchen facilities. Solar has been identified for potential installation on each of the "Wings". The year of construction is 1950.

The roof of the existing structure is a specified as a composition roof over concrete joist construction on Wings 1 and 2 and a composition roof over metal deck and steel framing at the Multi-Use at Wing 3. The roof framing at the Classroom wings is supported by concrete columns and concrete shear walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal concrete diaphragm and the vertical concrete shear walls.

The roof framing over the Multi-Use building is supported by steel columns and perimeter concrete shear walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal metal deck diaphragm and the vertical concrete shear walls.

Preliminary Structural Evaluation

The evaluation involves investigating two distinct aspects of the framing. First, can the framing support the added gravity loads to be imposed by the proposed solar array and second, can the existing lateral force resisting system support the added wind and/or seismic horizontal forces without triggering a code required upgrade of the structure? The latter is limited to a maximum of 10% of the existing tributary structural dead load as permitted by ASCE 7-05 Section 11B.3 and the California Building Code (CBC) Section 3403A.2.3.1, Exception 2. The analysis assumes that there is only one roof membrane present and that should a re-roof be performed either prior to installation of the solar array or during the life of the array that the existing will be removed and not roofed over. For the purposes of this analysis, a second roof membrane over the existing has been excluded to maximize the potential size of the solar array.

Where the racking system keeps the array close to the roof, wind loads generally do not represent a significant increase in forces to the existing main lateral force resisting elements. There are no parapets to prevent the array from sliding off of the roof, therefore, the proposed array used in the analysis is planned to be positively anchored to the structure without the use of any ballast. The design wind speed for this site is 85 MPH (3-second gust), Exposure C. A Suntech STP 260 solar module has been selected for use in the framing evaluations. To support the modules and provide a 20° tilt to the array, a SunLink racking system has been used. The anticipated weight of the array (module + racking system) use in the analysis is estimated to be 80.5# per module. A breakdown of the design loads used in the evaluation of the existing framing is shown in the Table at the end of this report.

1) Evaluation of Gravity Loads:

The existing roof deck at the classrooms is shown as 2 ½" concrete slab over 4x14 concrete joists spaced at 24 inches on center. At this time an array layout has not been determined. In order to perform an evaluation of the gravity loads on the existing framing, we used a 4x1 panel arrangement as manufactured by SunLink with the north-south axis parallel to existing concrete joists. This orientation results in the maximum concentration of loads to the least number of concrete joists. Our evaluation shows that the existing framing is adequate to support the anticipated loads and that, therefore, the existing framing is acceptable for any orientation or distribution of modules in the array(s). Attached for your reference are our preliminary calculations.

At the Multi-Use, the existing deck is not readily identified on the available "as-built" drawings. However, the proposed array has a dead load based on its plan area of approximately 3 psf. Per DSA IR 16-8, the design roof live load based on the array racking system selected may be taken as zero (racking system is low to the roof preventing storage beneath it). The existing deck (and supporting framing) can, therefore, be seen as adequate to support the proposed array.

2) Evaluation of Lateral Loads:

The total existing roof area where placement of arrays has been proposed is approximately 21,340 sq. ft. At the two story classroom wings, the roof area is 7,969 sq. ft. and 7,227 sq. ft. respectively with an estimated dead load of 72 psf. The exterior walls are 8" concrete with an estimated dead load of 100 psf. Combined together the total effective existing roof dead load at the @ Wing 1 is 697,007 lbs. and 639,873 lbs. @ Wing 2. At the Multi-Use, Wing 3, the roof area is 6,144 sq. ft. with an estimated dead load, including the exterior concrete walls, of 299,520 lbs.

In order to avoid triggering a code required upgrade, the weight of any added solar array should not exceed 10% (Total Dead Load) or 69,701# (Wing 1), 63,987# (Wing 2) and 29,952# (Wing 3). Dividing these weights by the combined weight per module of the proposed array (59.5+21) the maximum number of permissible modules for the array can be determined as 866+795+372 respectively. However, checking the available roof area against the plan area of each module, the actual number of modules that can be used is significantly less than that based on 10% of the existing mass. These module counts are 256+232+198 respectively. Please note these module quantities do not account for any setbacks that may be required or aisle ways, shading restrictions or any other roof obstructions that may affect the final array layout.

Conclusions

In conclusion, we believe that positively anchored solar (PV) arrays can be supported on the existing structures. They should not exceed either the Maximum Array Weight or the Maximum Number of Modules shown below. Either the SunLink 4x1 or 3x1 panel system is acceptable for this project.

Design Parameters	
Existing roof dead load	72 psf (Wings 1 & 2) 30 psf (Wing 3, Multi-Use)
Basic Wind Speed (3-second gust)	85 MPH (Exposure C)
Seismic force (Allowable Stress Design)	0.425 $W_p \simeq$ 34# per module
Module	Suntech STP 260
Module weight	Approximately 59.5# each
Module Area	20.9 square feet
Module Mounting System	By SunLink Corporation
System weight	Approximately 21# per module
System tilt angle	20º
Maximum PV Array	
Maximum Array Weight (10% Total Est. Roof DL)	69,701# (Wing 1) 63,987# (Wing 2) 29,952# (Wing 3)
Maximum Number of Modules (Limited by the available roof area)	256 (Wing 1) 232 (Wing 2) 198 (Wing 3)

If you have any questions regarding this letter, please call me at (209) 736-2079.

Sincerely,
Interactive Resources

Paul M. Westermann, P.E., S.E.
Principal

Enclosure

Design Criteria

Roof Framing

Roof Live Load	20 psf	Slope 1/4:12 Reducible
Live Load at Solar Modules	10	(Special roof load, greenhouse)

Classrooms (Wings 1 & 2)

Roof Dead Load		
Built-up Roof	6.0 psf	
4x14 Concrete Joists @ 24" o.c.	62.5	
w/ 2 1/2" concrete slab	0.0	
Acoustical Tile Ceiling	1.5	
Mech/Elec/Misc	2.0	
	72.0 psf	USE 72 psf

Multi-Use (Wing 3)

Roof Dead Load		
Built-up Roof	6.0 psf	
Metal Deck	2.1	
Steel Framing	6.7	
Plaster Ceiling	10.0	
Mech/Elec/Misc	5.2	
	30 psf	USE 30 psf

Existing Exterior Walls DL

8" CMU Solid Grouted 100 psf

Parapet Height ~ 0.0 ft

Trib Ht. at Classrooms - 9.0' @ Multi-Use - 9.0'

Interior Partitions

USE 5.0 psf for seismic loads at roof at Classrooms only

Determine Allowable Solar Array Size

Determine allowable loads as a percent of the exisitng tributary DL so as not to trigger a Code reqired Seismic Upgrade

Per ASCE 7-05, Section11B.3 & CBC 3403A.2.3 - a seismic upgrade is not required if the addition does not increase the seismic forces by 10%

2010-004-01 Jefferson Solar Design xls, (E) Frmg Eval

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Structural Engineers
117 Park Place
Point Richmond, CA 94801
510.236.7435
510.232.5325 (FAX)

NREL Structural Evaluation
BUSD – Jefferson Elementary

rev.	description	date	by	drawn PMW	job 2010-004.01
				scale	page
				date 10/8/10	1 of 2

(E) Building Dimensions - Classroom Wing 1

B = 172.00' D = 46.33'

Existing Roof Area - 7,969 sf (per original construction documents)

(E) DL = 697,007 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(172, 46.33')*2*(9+0' Parapet)

10% DL = 69701

Prposed Solar Array

Module - Suntech STP260 Titl-angle - 20°
Module Area - 20.9 sf Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 # Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 866 \text{ modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 256 \text{ modules}$$

Check (E) Framing

(E) D+L = 697007+7969*20 psf = 856,387
(E) D+L+ array = 697007+7969*10 psf +256*80.5 = 797,305

$$\Delta = \frac{797,305}{856,387} - 1 = -0.069 \quad \text{Ok}$$

Change in load on deck

(E) D+L = 92 psf
(E) D+L+ array = 84.6 psf

$$\Delta = \frac{84.6}{92} - 1 = -0.08 \quad \text{Ok}$$

Racking Point Loads

for SunlLink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

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				date 10/8/10

job 2010-004.01

SUNTECH

Solar powering a green future℠

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

270 Watt

POLY-CRYSTALLINE SOLAR PANEL

Features

- High conversion eff ciency based on innovative photovoltaic technologies
- High reliability with guaranteed +/-3% power output tolerance
- Withstands high wind-pressure and snow load, and extreme temperature variations

Quality and Safety

- Industry-leading, transferable 25-year power output warranty
- Rigorous quality control meeting the highest international standards
- ISO 9001:2000 (Quality Management System) and ISO 14001:2004 (Environmental Management System) certified factories deliver world class products
- UL listing:UL1703, CULus, Class C fire rating, conformity to CE

Recommended Applications

- On-grid utility systems
- On-grid commercial systems
- Off-grid ground mounted systems

Suntech's technology yields improvements to BSF structure and anti-reflective coating to increase conversion efficiency

Unique design on drainage holes and rigid construction prevents frame from deforming or breaking due to freezing weather and other forces

Suntech was named Frost and Sullivan's 2008 Solar Energy Development Company of the Year

The panel provides more field power output through an advanced cell texturing and isolation process, which improves low irradiance performance

SUNTECH

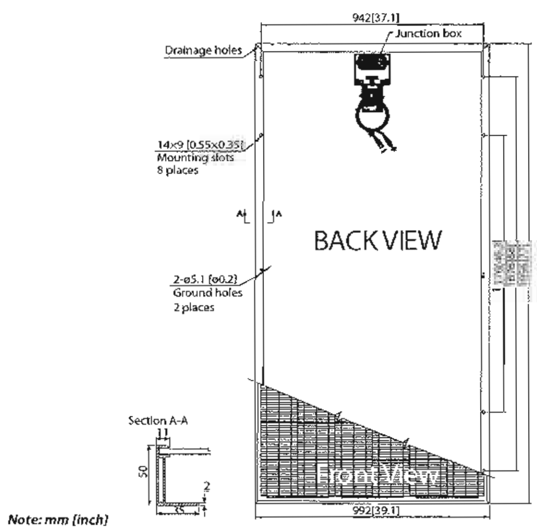
Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

Electrical Characteristics

Characteristics	STP280-24/Vb-1	STP270-24/Vb-1	STP260-24/Vb-1
Open - Circuit Voltage (Voc)	44.8V	44.5V	44V
Optimum Operating Voltage (Vmp)	35.2V	35V	34.8V
Short - Circuit Current (Isc)	8.33A	8.2A	8.09A
Optimum Operating Current (Imp)	7.95A	7.71A	7.47A
Maximum Power at STC (Pmax)	280Wp	270Wp	260Wp
Operating Temperature	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Maximum System Voltage	600V DC	600V DC	600V DC
Maximum Series Fuse Rating	20A	20A	20A
Power Tolerance	±3 %	±3 %	±3 %

STC: Irradiance 1000W/m², Module temperature 25°C, AM=1.5



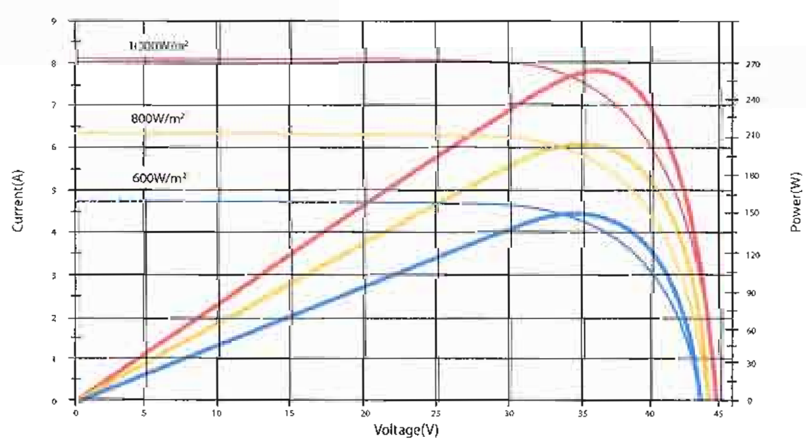
Mechanical Characteristics

Solar Cell	Poly-crystalline 156×156mm (6 inch)
No. of Cells	72 (6×12)
Dimensions	1956×992×50mm (77.0×39.1×2.0 inch)
Weight	27 kg (59.5 lbs.)
Front Glass	4mm(0.16 inch) tempered glass
Frame	Anodized aluminium alloy
Junction Box	IP65 rated
Output Cables	AIW(12AWG), asymmetrical lengths (-) 1200mm (47.2 inch) and (+) 800mm (31.5 inch), MC Plug Type IV connectors

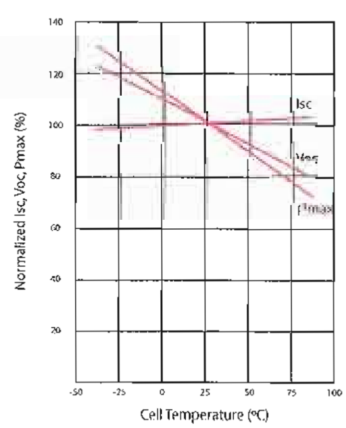
Temperature Coefficients

Nominal Operating Cell Temperature (NOCT)	45±2°C
Temperature Coefficient of Pmax	-(0.47 ± 0.05) %/°C
Temperature Coefficient of Voc	-(0.34 ± 0.01) %/°C
Temperature Coefficient of Isc	(0.055 ± 0.01) %/°C

Current-Voltage & Power-Voltage Curve (260W)



Temperature Dependence of Isc, Voc, Pmax



(E) Building Dimensions - Classroom Wing 2

B = 156.00' D = 46.33'

Existing Roof Area - 7,227 sf (per original construction documents)

(E) DL = 639,873 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(156, 46.33')*2*(9+0' Parapet)

10% DL = 63987

Prposed Solar Array

Module - Suntech STP260
Titl-angle - 20°
Module Area - 20.9 sf
Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 #
Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 795 \text{ modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 232 \text{ modules}$$

Check (E) Framing

(E) D+L = 639873+7227*20 psf = 784,413
(E) D+L+ array = 639873+7227*10 psf +232*80.5 = 730,819

$$\Delta = \frac{730{,}819}{784{,}413} - 1 = -0.068 \quad \underline{\text{Ok}}$$

Change in load on deck

(E) D+L = 92 psf
(E) D+L+ array = 84.6 psf

$$\Delta = \frac{84.6}{92} - 1 = -0.08 \quad \underline{\text{Ok}}$$

Racking Point Loads

for SunILink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

2010-004-01 Jefferson Solar Design.xls, (E) Frmg Eval

(E) Building Dimensions - Multi-Use Wing 3

B = 96.00' D = 64.00'

Existing Roof Area - 6,144 sf (per original construction documents)

(E) DL = 299,520 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(96, 64')*2*(9+0' Parapet)

10% DL = 29952

Prposed Solar Array

Module - Suntech STP260
Module Area - 20.9 sf
Module Wt. - 59.5 #

Titl-angle - 20°
Plan Area ~ 1.49 * Module Area = 31.1 sf
Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{\text{10\% (E) DL}}{\text{Array Wt}} = \text{372 modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = \text{198 modules}$$

Check (E) Framing

(E) D+L = 299520+6144*20 psf = 422,400
(E) D+L+ array = 299520+6144*10 psf +198*80.5 = 376,899

$$\Delta = \frac{376{,}899}{422{,}400} - 1 = -0.108 \quad \text{Ok}$$

Change in load on deck

(E) D+L = 50 psf
(E) D+L+ array = 42.6 psf

$$\Delta = \frac{42.6}{50} - 1 = -0.15 \quad \text{Ok}$$

Racking Point Loads

for SunlLink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

2010-004-01 Jefferson Solar Design xls, (E) Frmg Eval

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NREL Structural Evaluation
BUSD – Jefferson Elementary

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rev.	description	date	by	drawn PMW
				scale
				date 10/8/10

Seismic (IBC / ASCE 7)

Seismic Design Category - D (CBC 1613.5.6 & ASCE 7-05, Sect. 11.6)

Building Category - II (ASCE 7-05 Table 1-1)
Seismic Importance Factor, I - 1.00 (ASCE 7-05 Table 11.5-1)
Soil Site Class - D (ASCE 7-05 Chapter 20)

Site Location				
Latitude	37°	52'	43.54"	N
Longitude	122°	17'	4.07"	W

S_s = 1.879
S_1 = 0.714
} See next Page

$S_{MS} = F_a S_s =$ 1.879 F_a = 1
$S_{M1} = F_v S_1 =$ 1.071 F_v = 1.5

$S_{DS} = 2/3\ S_{MS} =$ 1.253 $T_0 = 0.2\ S_{D1}/S_{DS} =$ 0.114
$S_{D1} = 2/3\ S_{M1} =$ 0.714 $T_s = S_{D1}/S_{DS} =$ 0.57

for $T < T_0$, $S_a = S_{DS}(0.4 + 0.6\ T/T_0)$

for $T_0 < T < T_s$, $S_a = S_{DS}$

for $T_s < T$, $S_a = S_{D1}/T$

$T = C_t h_n^x =$ 0.29 (ASCE Eq. 12.8-7)

C_t = 0.020 (ASCE Table 12.8-2)
h_n = 36.00
x = 0.75 (ASCE Table 12.8-2)

Component Force (ASCE Section 13.3.1)

ASCE Eq. 13.3-1

$$F_p = \frac{0.4\ a_p S_{DS} W_p}{R_p / I_p}\left(1 + 2\frac{z}{h}\right) = 0.601\ Wp$$

Controls z = h h = roof elev.

ASCE Eq. 13.3-2

$F_p\ max = 1.6\ S_{DS} I_p W_p =$ 2.005 Wp

ASCE Eq. 13.3-3

$F_p\ min = 0.3\ S_{DS} I_p W_p =$ 0.376 Wp

I_p = 1 a_p = 1 R_p = 2.5

W_p = 81 # ∴ F_p = 48 # for ASD, USE 0.7 * F_p = 34 #

2010-004-01 Jefferson Solar Design xls, ASCE Seis

Berkeley Unified School District
Jefferson Elementary

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.009999999776482582 deg grid spacing

Period (sec)	Sa (g)
0.2	1.879 (Ss, Site Class B)
1.0	0.714 (S1, Site Class B)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.879 (SMs, Site Class D)
1.0	1.071 (SM1, Site Class D)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.252 (SDs, Site Class D)
1.0	0.714 (SD1, Site Class D)

Reference: "USGS Seismic Hazard Curves and Uniform Hazard Response Spectra", **NSHMP_HazardApp.jar** application

Jefferson Elementary

Location		Gross Available Area (ft^2)	Estimated PV Capacity		
			Rooftop (kWp)	Parking (kWp)	Total (kWp)
2	Roofs	19,800	210	0	210
	Building A	7,650			
	Building B	6,750			
	Building C	5,400			
Totals		**19,800**	**210**	**0**	**210**

Questions/Comments for District

1. Need PG&E billing information
2. What is age & condition of roofs?
3. Are there roof structural concerns?
4. Roof obstructions: ***minimal***

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 4

Aerial Assessments of Selected Sites

Aerial Assessments of Selected Sites

Aerial Assessments were prepared for each individual district to allow each to integrate renewable energy systems into its Facilities Master Plan. The aerial assessments provide:

- an inventory of solar appropriate schools and facilities
- total annual electricity consumption and cost for the district
- each individual school's electricity annual consumption and cost
- gross and net space available for PV systems
- the maximum PV capacity for each school and the size of the PV systems that will meet 75% of a school's annual electricity consumption (reducing the school's electricity bill to the minimum)
- PV system cost estimates
- estimated rebates and savings from avoided electricity costs
- greenhouse gas emissions avoided and Renewable Energy Credits (RECs) earned

The above assessments will prepare school districts to seek local General Obligation bonds from their constituencies for financing the installation of renewable energy systems in conjunction with other school construction or modernization work.

In addition, when a district identifies the best locations for solar installations and their energy characteristics, it is prepared to take advantage of funding opportunities that may arise, such as low-interest federal bonds, low-interest state loans, or grants from regional agencies to reduce energy consumption and/or greenhouse gas emissions. As the need for renewable energy increases, other opportunities are sure to emerge. Districts that plan and assess their schools and facilities for renewable energy will be in a good position to take advantage of future funding opportunities.

SunPower Corporation, Richmond CA prepared the aerial assessments in consultation with the individual school districts. KyotoUSA volunteers assembled the electricity consumption and cost information from data provided by PG&E via Energy Star's Portfolio Manager.

The aerial assessment information in this chapter is specific to the school district for which this individual Solar Master Plan was prepared.

Berkeley Unified School District Solar Site Assessments

October 2011

Washington Elementary

BUSD's first solar school!

1. 103 kWp system installed by Eshone Electric in Summer 2008. It is still the largest single PV system in the City of Berkeley.
2. System offsets the cost of the building's electric load which was historically about $25K per year.
3. System avoids approximately 31 tons of CO2 and other toxic air pollutants each year.
4. School has a second meter tied to portable classrooms across the street. In the future, the value of electricity produced that exceeds the value of the electricity consumed, could be applied to the 2nd meter.
5. Panels should be cleaned at least twice a year and inspected annually to maintain maximum production.
6. System production is monitored by Fat Spaniel at http://view2.fatspaniel.net/PV2Web/merge?&view=PV/standard/Simple&eid=146113

SECTION ONE

- Assumptions and Benefits
- Roof Utilization Factors
- System Cost
- Scenario 1: Installing Maximum Capacity
- Scenario 2: Offsetting Electricity Costs Only

Assumptions and Benefits

Assumptions

All information is preliminary and intended to provide BUSD with estimates of PV system sizes, siting possibilities, production values, incentives, avoided electricity costs, and installation costs.

1. Annual electricity consumption and cost were provided by PG&E via Portfolio Manager. Twelve month periods vary slightly – ending in either April or May 2011.
2. Assumed PG&E Electric Rate A6 yielding year 1 solar savings = $0.223.
3. CSI incentive assumed: Tier 8 at $0.15/kWh (Emerson & Rosa Parks); Tier 9 at $0.12/kWh for all others. CSI rebates from PG&E are likely to be exhausted in late 2011/early 2012.
4. **Scenario 1** "Installing Maximum Capacity" Based on aerial assessments done by SunPower Corporation which shows how much solar each site is capable of hosting. Assumes a total cost per Wp = $6.20 for all schools except Berkeley High and Franklin Adult which are estimated at $5.77 per Wp. Pricing is based on using SunPower's 230 high efficiency solar panels and estimated based on industry pricing in February 2011.

   Scenario 2 "Offsets Electricity Costs Only" Based on estimated PV system size that would eliminate electricity bill. (PV systems are typically designed to produce 75% of consumption, thus "zeroing out" a building's electricity expense.) Assumes a total cost per Wp = $6.20 for all schools except Berkeley High which is estimated at $5.77 per Wp. Pricing is based on using SunPower's 230 high efficiency solar panels and estimated based on industry pricing in February 2011.
5. Year one electric yield = 1,350 kWh per kWp. (This is a conservative estimate. Newer panels may provide a higher yield, making it possible to increase production values.)
6. Size and location of PV systems may vary significantly after design completion.
7. Although BUSD has locations that would be appropriate for shade/carport structures, BUSD is reluctant to consider these types of systems based on concerns about vandalism and/or theft potential.
8. Electricity costs and consumption are combined for all electric meters at each site and shown as a single total value. Further analysis is needed to evaluate impact of PV system on electric meter(s) where PV system will be connected.

Benefits

If the District installs PV systems as described in Scenario 2 (Offset Only), the following estimated benefits will accrue:

- Annual savings: $408,000
- Annual electricity production: 1,800,000 kWh
- Annual greenhouse gases avoided: 465 metric tons*
- Annual Renewable Energy Credits (RECs) earned: 1,830

*Avoided greenhouse gases were calculated by multiplying the number of kWh produced by the PV system by PG&E's estimated emissions factor for electricity for 2010–2011.

kWh x 0.000254

Roof Utilization Factors

Methodology

To determine how much electricity can be generated from a school rooftop or from a structure in a parking lot, it is necessary to determine how much usable space is available. Solar panel efficiency is affected by shadows cast by surrounding hills, buildings, trees, flagpoles, other obstructions, as well as equipment, conduit, walls, or structures placed on a roof. When a solar project is contemplated, it is important to determine if the roof or parking lot is free of shadow casting obstructions, making it possible to install a renewable energy system that will produce enough electricity to make the project viable. A school district does not have to make this determination on its own. A district can hire its own consultant to evaluate roof and parking lot conditions before soliciting bids for a renewable energy project or it can simply leave that determination to the Design-Build Request for Proposal process described elsewhere in this document.

For our aerial assessments shown here, SunPower Corporation used Google Map images of all district schools and facilities. District officials then reviewed the aerial photos with SunPower staff to determine which schools should be assessed. In some cases, schools were slated for closure, in other cases the schools were being razed and a new facility was planned, and in several cases, the orientation of the roof, its height, or the amount of equipment on it, made it an unlikely candidate for the installation of solar panels.

Once the appropriate schools and facilities were identified, SunPower Corporation used a web tool to outline the most appropriate sites. This tool is able to estimate the amount of square feet available (gross) on a roof or parking lot. Then technicians applied the “roof utilization factors” in the chart at right to estimate how much of the total space could be used (net) for solar panel arrays. Once this calculation was made, it was possible to determine how many panels could be installed and what their estimated output would be.

SunPower Corporation used conservative estimates for the “roof utilization factors” which means that it may be possible to install more PV than is described here. It is also the case that once a physical inspection of a roof or parking area is made, the district may find that there is less space for a PV installation. It is important to keep in mind that these calculations presented here are estimates based on an assessment of aerial imagery. The information included here is intended to be a guide for the district and should be relied on in that context only.

ROOF UTILIZATION FACTORS	
Clear	75%
Minimal	63%
Moderate	50%
Significant	38%

System Cost

The turn-key cost of a PV system is frequently described as the cost per Watt peak or "$/Wp." The primary factors that make up that cost are: equipment, design, permitting, installation, labor costs, commissioning, warranties, guarantees, and maintenance services. Other products may be included in the $/Wp, e.g. educational component, or provided as a separate cost.

Roof mounted systems are generally less expensive than carport or shade structures. The size of the PV project is also a factor in its cost. Generally, the larger the PV system, the lower the $/watt cost. This means that a district should benefit by aggregating its PV projects rather than doing them invididually.

See the chapter on the "Design-Build Contract for Photovoltaic Systems Installation" for a fuller description of the elements that make up the turn-key cost of a PV system.

Note: BUSD has installed a 103 kW PV system at Washington Elementary (2008) and an 83 kW PV system at Emerson Elementary (2011). The installed $/watt was $8.49 and $9.03 respectively.

SYSTEM SIZE	FEBRUARY 2011 COST ($/Wp)
Roof (100-250 kWp)	$6.20
Roof (250-500 kWp)	$5.77
Roof (500-750 kWp)	$5.52
Roof (750-1000 kWp)	$5.22
Carport (100-250 kWp)	$7.78
Carport (250-500 kWp)	$7.08

Please see Appendix D for updated pricing information (October 2011).

Scenarios

These tables summarize the data described in the individual school and facility assessments that follow. Scenario 1 demonstrates the total estimated potential PV capacity for the district. Scenario 2 demonstrates the estimated PV capacity when the PV system is sized to produce 75% of the school's consumption — an amount that brings the school's electricity cost close to $0.

SCENARIO 1 INSTALLING MAXIMUM CAPACITY*	
Estimated Gross Available Area (ft^2)	210,355
Net Available Area (ft^2)	109,268
Potential PV Capacity (kWp)	1,886
Estimated PV Production (Annual kWh)	2,530,650
Estimated Year 1 Savings	$564,335
Estimated Cost	$10,202,500
Estimated CSI Rebate	$1,373,323

**Based on aerial assessments done by SunPower Corporation, which show how much solar each site is capable of hosting.*

SCENARIO 2 OFFSETS ELECTRICITY COSTS ONLY	
Estimated Gross Available Area (ft^2)	210,355
Net Available Area (ft^2)	109,268
Potential PV Capacity (kWp)	1,367
Estimated PV Production (Annual kWh)	1,830,296
Estimated Year 1 Savings	$408,156
Estimated Cost	$7,195,502
Estimated CSI Rebate	$964,010

Scenario 1:
Installing Maximum Capacity

SCHOOL	ESTIMATED PV CAPACITY (FULL SCALE) (kWp)	ESTIMATED PV PRODUCTION (kWh)	ANNUAL USAGE OFFSET BY SOLAR	ESTIMATED COST OF FULL SCALE PV SYSTEM	ESTIMATED CSI REBATE (JUNE 2011)	NET COST
Berkeley Arts Magnet at Whittier	140	189,000	125%	$868,000	$112,272	$755,728
Cragmont	90	121,500	69%	$558,000	$72,175	$485,825
Emerson Elementary	83	112,050	83%	N/A	N/A	N/A
Jefferson Elementary	210	283,500	197%	$1,302,000	$168,408	$1,133,592
Leconte Elementary	210	283,500	158%	$1,302,000	$168,408	$1,133,592
Malcolm X Elementary	100	135,000	58%	$620,000	$80,194	$539,806
Oxford Elementary	100	135,000	101%	$620,000	$80,194	$539,806
Rosa Parks	50	67,500	33%	$310,000	$50,121	$259,879
Washington Elementary	103 kW installed	123,600	~100%	N/A	N/A	N/A
Martin Luther King Middle	50	67,500	8%	$310,000	$40,097	$269,903
Berkeley High	400	540,000	17%	$2,300,000	$320,776	$1,979,224
Franklin Adult School	350	472,500	162%	$2,012,500	$280,679	$1,731,821
Total	**1,886**	**2,530,650**	**36% of load**	**$10,202,500**	**$1,373,323**	**$8,829,177**

Installing Maximum Capacity = estimated PV capacity at each school based on available roof space. Does not include an estimate for potential carport or shade structures.

- *Emerson* system installed in September 2011; *Rosa Parks* is scheduled for early 2012.
- *John Muir, Thousand Oaks, Longfellow, Willard,* and *Berkeley Tech* are not considered to be good candidates for PV at this time due to roof types and/or ease of access. Aerial views of these sites are included in Appendix A.
- Pre-school sites and other district properties were not assessed, however, their energy use has been benchmarked using Portfolio Manager. See Appendix B for listing.

Scenario 2: Offsetting Electricity Costs Only

SCHOOL	ESTIMATED PV CAPACITY (OFFSET ONLY) (kWp)	ESTIMATED PV PRODUCTION TO MATCH ANNUAL COST (kWh)	ANNUAL USAGE OFFSET BY SOLAR	ESTIMATED COST OF "OFFSET ONLY" PV SYSTEM	ESTIMATED CSI REBATE (JUNE 2011)	NET COST
Berkeley Arts Magnet at Whittier	84	113,418	75%	$520,883	$67,374	$453,509
* Cragmont Elementary	90	121,500	69%	$558,000	$72,175	$485,825
Emerson Elementary	75	100,740	75%	N/A	N/A	N/A
Jefferson Elementary	80	107,828	75%	$495,210	$64,053	$431,157
Leconte Elementary	99	134,220	75%	$616,418	$79,731	$536,687
* Malcolm X Elementary	100	135,000	58%	$620,000	$80,194	$539,806
Oxford Elementary	74	99,840	75%	$458,524	$59,308	$399,216
* Rosa Parks	50	67,500	33%	$310,000	$50,121	$259,879
Washington Elementary	103 kW installed	123,600	100%	N/A	N/A	N/A
* Martin Luther King Middle	50	67,500	8%	$310,000	$40,097	$269,903
* Berkeley High	400	540,000	17%	$2,300,000	$320,776	$1,979,224
Franklin Adult School	162	219,150	75%	$1,006,467	$130,182	$876,285
Total	**1,367**	**1,830,296**	**26% of load**	**$7,195,502**	**$964,010**	**$6,231,491**

Offsetting Electricity Costs Only = estimated PV capacity at each school based on current energy consumption.

* These schools may not have the physical capacity to site a PV system of the size needed to offset the cost of the school's consumption. The chart reflects the PV system sizes for these schools that are consistent with the available space. See "Contextual Data" in the sidebars for the PV system size that would offset the school's current electricity consumption.

• *John Muir, Thousand Oaks, Longfellow, Willard,* and *Berkeley Tech* are not considered to be good candidates for PV at this time due to roof types and/or ease of access. Aerial views of these sites are included in Appendix A.

• Pre-school sites and other district properties were not assessed, however, their energy use has been benchmarked using Portfolio Manager. See Appendix B for listing.

SECTION TWO

- PV Capacity and Cost Breakdown by Individual School

Key to Presentation of Data

SOLAR AMERICA SHOWCASE REPORT
Berkeley Unified School District

Berkeley Arts Magnet at Whittier
2015 Virginia Street

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	22,000	140	0	140				
Totals	22,000	140	0	140	$868,000	$112,272	189,000	125%
System size and pricing to meet current electricity demand				84	$520,883	$67,374	113,418	75%

Annual Electricity Cost and Consumption
Cost: $26,445
Consumption: 151,224 kWh

Contextual Data
- Roof scheduled for replacement in 2012.
- PV scheduled to be installed in 2012.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding that "positively anchored solar (PV) ar[...] can be supported on the [...] Full re[...] Maste[...]
- Roo[...] signif[...]

Greenho[...] Avoi[...] tons
Renewable Energy Credits Generated Annually: 113

Berkeley Arts Magnet at Whittier

2015 Virginia Street

Annual Electricity Cost and Consumption
Cost: $26,445
Consumption: 151,224 kWh

Contextual Data

- Roof scheduled for replacement in 2012.
- PV scheduled to be installed in 2012.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding that "positively anchored solar (PV) arrays can be supported on the existing structures." Full report included in Solar Master Plan.
- Roof obstructions: **significant**

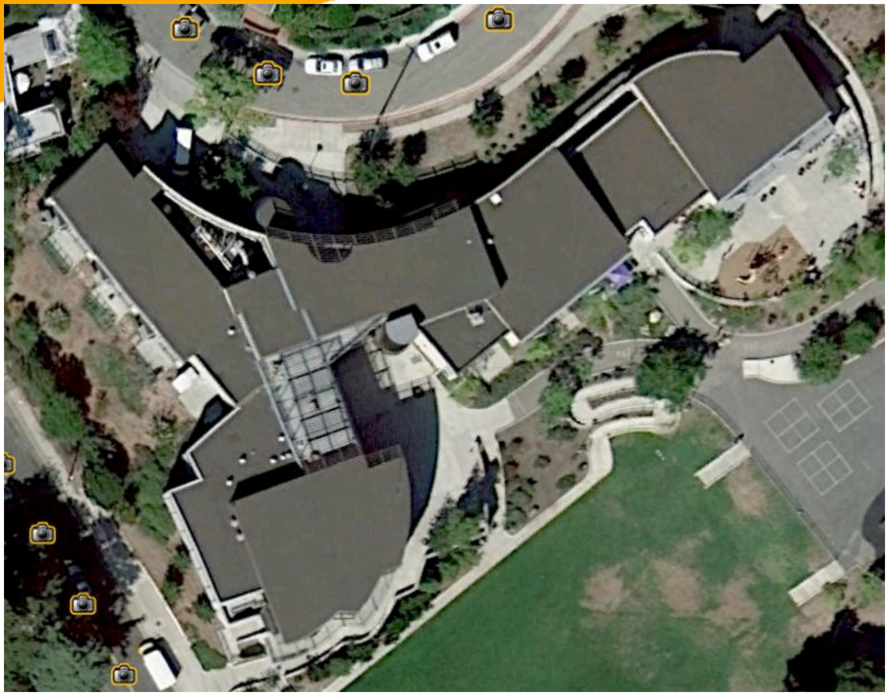
LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	22,000	140	0	140				
Totals	**22,000**	**140**	**0**	**140**	**$868,000**	**$112,272**	**189,000**	**125%**
System size and pricing to meet current electricity demand				**84**	**$520,883**	**$67,374**	**113,418**	**75%**

Greenhouse Gases Avoided Annually: 29 metric tons

Renewable Energy Credits Generated Annually: 113

Cragmont Elementary

830 Regal Road



LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roofs	8,000	90	0	90				
Totals	**8,000**	**90**	**0**	**90**	**$558,000**	**$72,175**	**121,500**	**69%**
System size and pricing to meet current electricity demand				*	*	*	*	*

*Cragmont may not have sufficient roof space for a PV system that will meet current electricity demand.

Annual Electricity Cost and Consumption
Cost: $31,224
Consumption: 176,640 kWh

Contextual Data

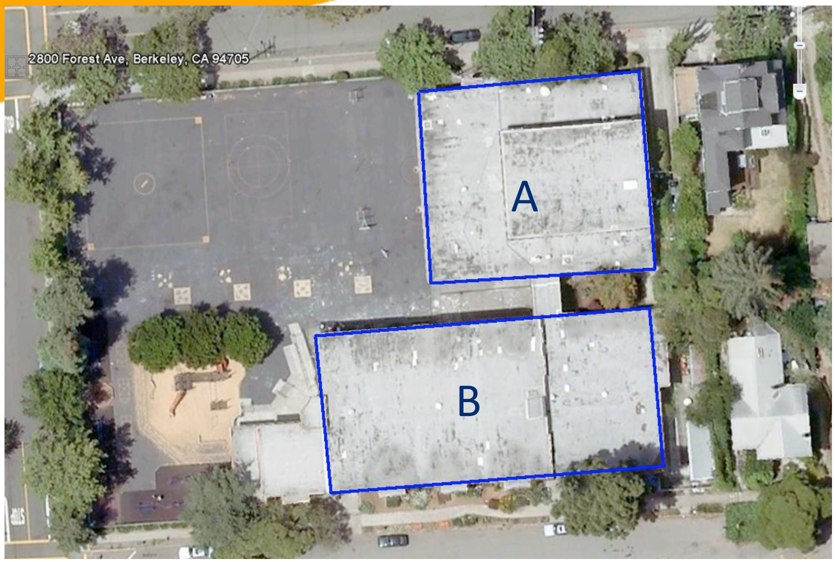
- A system size of ~98 kWp would produce 75% of the school's load.
- Appropriate roofs not identified in this assessment. More than two roofs may be available to meet load.
- Roof scheduled for replacement in 2015.
- PV scheduled to be installed in 2015.
- The roof structure has not been analyzed as of the date of this report.
- Roof obstructions: ***minimal***

Greenhouse Gases Avoided Annually: 31 metric tons

Renewable Energy Credits Generated Annually: 122

Emerson Elementary

2800 Forest Avenue



LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	8,500	*	0	*				
Roof B	10,500	83	0	*				
Totals	**19,000**	**83**	**0**	**83**	*	*	**112,050**	**83%**
System size and pricing to meet current electricity demand				*	*	*	*	*

*83 kWp PV system installed on Roofs A and B in September 2011.

Annual Electricity Cost and Consumption
Cost: $23,694
Consumption: 134,320 kWh

Contextual Data

- ~83 kWp PV system will be installed on Roofs A and B in Summer 2011 that will provide 83% of consumption. System production should offset all electricity costs at the school.
- Roofs were replaced in 2010.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding that "positively anchored solar (PV) arrays can be supported on the existing structures". Full report included in Solar Master Plan.
- Roof obstructions: ***moderate***

Greenhouse Gases Avoided Annually:
26 metric tons

Renewable Energy Credits Generated Annually:
101

Jefferson Elementary

1400 Ada Street

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	7,650	80	0	80				
Roof B	6,750	70	0	70				
Roof C	5,400	60	0	60				
Totals	**19,800**	**210**	**0**	**210**	**$1,302,000**	**$168,408**	**283,500**	**197%**
System size and pricing to meet current electricity demand				**80**	**$495,210**	**$64,053**	**107,828**	**75%**

Annual Electricity Cost and Consumption
Cost: $27,560
Consumption: 143,771 kWh

Contextual Data

- Roof scheduled for replacement after 2021.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding that "positively anchored solar (PV) arrays can be supported on the existing structures." Full report included in Solar Master Plan.
- Roof obstructions: ***minimal***

Greenhouse Gases Avoided Annually:
27 metric tons

Renewable Energy Credits Generated Annually:
108

LeConte Elementary

2241 Russell Street

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	11,760	100	0	100				
Roof B	2,700	20	0	20				
Roof C	10,274	90	0	90				
Totals	**24,734**	**210**	**0**	**210**	**$1,302,000**	**$168,408**	**283,500**	**158%**
System size and pricing to meet current electricity demand				**99**	**$616,418**	**$79,731**	**134,220**	**75%**

Annual Electricity Cost and Consumption
Cost: $32,088
Consumption: 178,960 kWh

Contextual Data

- Roof scheduled for replacement in 2020.
- No current plans to install PV.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding that "positively anchored solar (PV) arrays can be supported on the existing structures". Full report included in Solar Master Plan.
- Roof obstructions: ***moderate***
- Condition of trees south of building A & C?

Greenhouse Gases Avoided Annually: 34 metric tons

Renewable Energy Credits Generated Annually: 134

Malcolm X Elementary

1731 Prince Street

Annual Electricity Cost and Consumption
Cost: $37,270
Consumption: 234,080 kWh

Contextual Data

- A system size of ~130 kWp would produce 75% of the school's load.
- Roof A scheduled for replacement in 2012.
- PV scheduled to be installed in 2012.
- Are there roof structural concerns?
- Roof obstructions: ***moderate***

Greenhouse Gases Avoided Annually:
34 metric tons

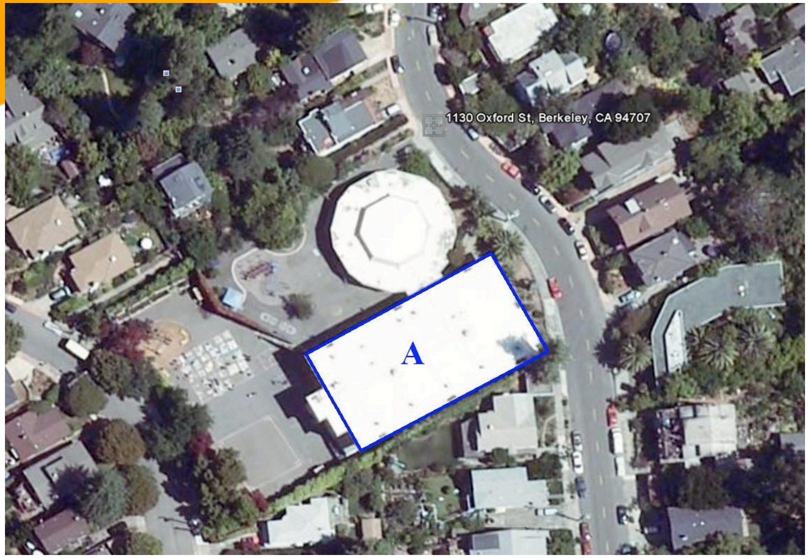
Renewable Energy Credits Generated Annually:
135

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	11,840	100	0	100				
Totals	**11,840**	**100**	**0**	**100**	**$620,000**	**$80,194**	**135,000**	**58%**
System size and pricing to meet current electricity demand				*	*	*	*	*

*Estimated PV capacity is not enough to offset current electricity consumption

Oxford Elementary

1130 Oxford Street



LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	12,000	100	0	100				
Totals	**12,000**	**100**	**0**	**100**	**$620,000**	**$80,194**	**135,000**	**101%**
System size and pricing to meet current electricity demand				**74**	**$458,524**	**$59,308**	**99,840**	**75%**

Annual Electricity Cost and Consumption
Cost: $24,104
Consumption: 133,120 kWh

Contextual Data

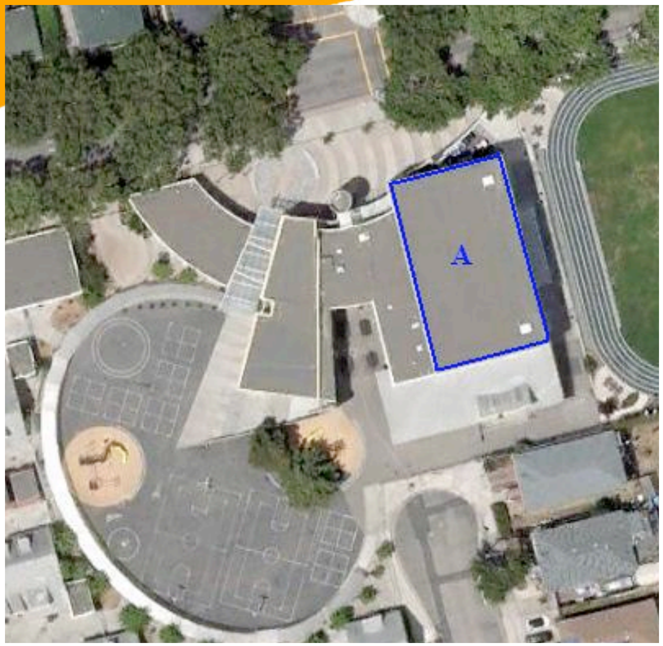
- Roof A scheduled for replacement in 2019.
- PV scheduled to be installed in 2019.
- Preliminary roof structural assessment conducted by Interactive Resources (Oct. 2010) concluding: "positively anchored solar (PV) arrays can be supported on the existing structures." Full report included in Solar Master Plan.
- Roof obstructions: ***moderate***
- It would be beneficial to consider modifying tree (remove and/or trim) to southeast of building

Greenhouse Gases Avoided Annually:
25 metric tons

Renewable Energy Credits Generated Annually:
100

Rosa Parks Environmental Science Magnet

920 Allston Way



LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	5,400	50	0	50				
Totals	**5,400**	**50**	**0**	**50**	**$310,000**	**$50,121**	**67,500**	**33%**
System size and pricing to meet current electricity demand				*	*	*	*	*

*Estimated PV capacity is not enough to offset current electricity consumption

Annual Electricity Cost and Consumption
Cost: $31,808
Consumption: 203,040 kWh

Contextual Data

- A system size of ~113 kWp would produce 75% of the school's load.
- 50 kWp system slated to be installed on Roof A in Fall 2011/Winter 2012.
- District has applied for CSI rebate at Step 8 ($0.15 per kWh). CSI application is currently on waiting list pending approval of SB 585 (Kehoe).
- Roof obstructions: ***moderate***

Greenhouse Gases Avoided Annually:
17 metric tons

Renewable Energy Credits Generated Annually:
68

Martin Luther King, Jr. Middle School

1781 Rose Street

Annual Electricity Cost and Consumption
Cost: $133,066
Consumption: 852,278 kWh

Contextual Data
- A system size of ~473 kWp would produce 75% of the school's load.
- Roofs (Media and Gym) scheduled to be replaced in 2011.
- No current plans to install PV.
- Are there roof structural concerns?
- Are any areas appropriate for ground mounted PV shade structures?
- Roof obstructions: ***significant***

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	7,500	50	0	50				
Totals	**7,500**	**50**	**0**	**50**	**$310,000**	**40,097**	**67,500**	**8%**
System size and pricing to meet current electricity demand				*	*	*	*	*

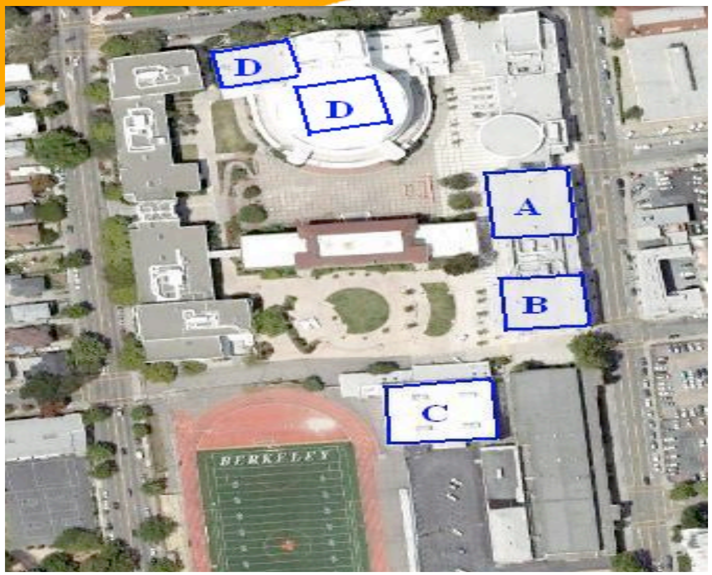
*Estimated PV capacity is not enough to offset current electricity consumption

Greenhouse Gases Avoided Annually:
17 metric tons

Renewable Energy Credits Generated Annually:
68

Berkeley High School

1980 Allston Way



LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	10,800	90	0	90				
Roof B	8,100	70	0	70				
Roof C	13,200	110	0	110				
Roof D	15,185	130	0	130				
Totals	**47,285**	**400**	**0**	**400**	**$2,300,000**	**$320,776**	**540,000**	**17%**
System size and pricing to meet current electricity demand				*	*	*	*	*

*Estimated PV capacity is not enough to offset current electricity consumption.

Annual Electricity Cost and Consumption
Cost: $452,132
Consumption: 3,102,728 kWh

Contextual Data

- A system size of ~1,724 kWp would produce 75% of the school's load.
- What is age & condition of roofs?
- Roofs will be replaced in stages starting in 2011.
- PV for Roof C (Donahue): 2015
- PV for Roof D (Community Theatre): 2019
- Roof obstructions: ***moderate***
- Could PV be installed on any of the rooftops on the buildings on the west side of the campus?
- Is there a parking area or other open space that could support a ground mounted PV system?

Greenhouse Gases Avoided Annually:
137 metric tons

Renewable Energy Credits Generated Annually:
540

Franklin Adult School

1701 San Pablo Avenue

LOCATION	GROSS AVAILABLE AREA (FT^2)	ESTIMATED PV CAPACITY (kWp)			ESTIMATED SYSTEM COST	CSI REBATE (STEP 9)	ESTIMATED OUTPUT OF PV SYSTEM (kWh)	% USAGE OFFSET BY PV
		ROOFTOP	PARKING	=TOTAL				
Roof A	6,688	70	0	70				
Roof B	7,260	80	0	80				
Roof C	8,672	90	0	90				
Roof D	10,176	110	0	110				
Totals	**32,796**	**350**	**0**	**350**	**$2,012,500**	**$280,679**	**472,500**	**162%**
System size and pricing to meet current electricity demand				**162**	**$1,006,467**	**$130,182**	**219,150**	**75%**

Annual Electricity Cost and Consumption
Cost: $46,029
Consumption: 292,200 kWh

Contextual Data

- Roof scheduled for replacement in 2020-21
- PV scheduled to be installed in 2020-21
- Parking lots offer significant opportunity for ground mounted PV structures.
- Roof obstructions: **minimal**

Greenhouse Gases Avoided Annually:
56 metric tons

Renewable Energy Credits Generated Annually:
219

APPENDICES

- Appendix A—Schools Not Assessed
- Appendix B—Other Facilities Not Assessed
- Appendix C—Annual Cost and Consumption
- Appendix D—System Cost, October 2011

APPENDIX A

Schools Not Assessed

These schools were not assessed for one or more of the following reasons: roof orientation, ease of access, roof type, presence of obstructions and shading.

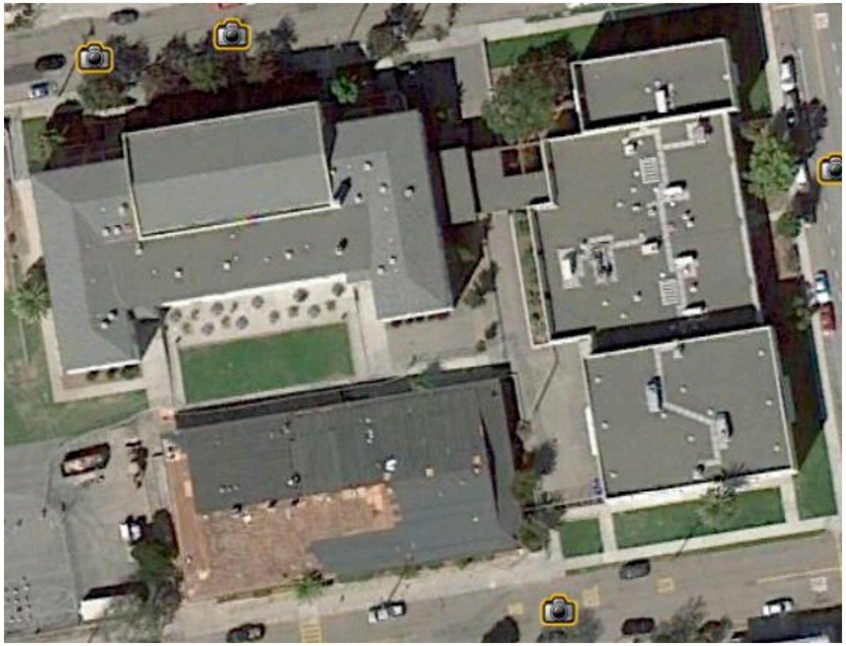
John Muir Elementary

Thousand Oaks Elementary

APPENDIX A *continued*

Schools Not Assessed

These schools were not assessed for one or more of the following reasons: roof orientation, ease of access, roof type, presence of obstructions and shading.



Longfellow Elementary

Willard Middle School

APPENDIX A *continued*

Schools Not Assessed

This school was not assessed for one or more of the following reasons: roof orientation, ease of access, roof type, presence of obstructions and shading.

Berkeley Tech Academy

APPENDIX B

Other Facilities Not Assessed

The following other BUSD facilities were not assessed for PV:

1. BUSD Administrative Office – 2134 Martin Luther King, Jr. Way
2. Old Adult School – 1222 University Avenue
3. Maintenance Building – 1707 Russell Street
4. Bus Depot – 1325 Sixth Street
5. Franklin Preschool – 1460 Eighth Street
6. Hopkins Early Childhood – 1810 Hopkins Street
7. King Child Development Center – 1939 Ward Street
8. Hillside School – 1581 Leroy Avenue

The energy consumption and cost for these facilities have been benchmarked using Energy Star's Portfolio Manager.

APPENDIX C

Annual Cost and Consumption: Electricity

BUSD FACILITY	ANNUAL kWh	ANNUAL COST	% OF TOTAL kWh	% OF TOTAL $
B- Tech Academy	150,240	$25,332	1.9%	2.0%
Berkeley Adult School	292,200	$46,029	3.7%	3.7%
Berkeley HS	3,102,728	$452,132	39.2%	36.2%
BUSD Admin Offices	216,562	$36,479	2.7%	2.9%
Cragmont	176,640	$31,224	2.2%	2.5%
Emerson	134,320	$23,694	1.7%	1.9%
Franklin PreSchool	78,080	$15,675	1.0%	1.3%
Hillside	24,720	$4,994	0.3%	0.4%
Hopkins Childcare	52,520	$9,792	0.7%	0.8%
Jefferson	143,771	$27,560	1.8%	2.2%
John Muir	163,760	$28,085	2.1%	2.2%
King Child Dev Ctr	69,760	$11,806	0.9%	0.9%
King Jr High	852,278	$133,066	10.8%	10.7%
LeConte	178,960	$32,088	2.3%	2.6%
Longfellow	308,387	$51,981	3.9%	4.2%
Maint Yard	206,240	$33,364	2.6%	2.7%
Malcolm X	234,080	$37,270	3.0%	3.0%
Old Adult School	195,787	$34,044	2.5%	2.7%
Oxford	133,120	$24,104	1.7%	1.9%
Rosa Parks Elementary	203,040	$31,808	2.6%	2.5%
Thousand Oaks	230,560	$35,471	2.9%	2.8%
Transportation Facility	95,040	$16,295	1.2%	1.3%
Washington Elementary	68,160	$7,406	0.9%	0.6%
Whittier / Arts Magnet	151,224	$26,445	1.9%	2.1%
Willard	450,920	$73,023	5.7%	5.8%
Total all BUSD facilities	**7,913,097**	**$1,249,166**	**100%**	**100%**

APPENDIX D

System Cost, October 2011

SunPower Corporation provided updated pricing information just before publication of this document. The last column in the table reflects a 3% to 5% decrease in the pricing since February 2011. This decrease is not reflected in the estimated pricing shown in other sections of this document. All estimated costs are based on February 2011 pricing.

SunPower Corporation's pricing is fairly conservative and reflects the higher end of current industry costs. The cost of the systems are driven by a variety of factors including mounting type, system size, location of the tie-in respect to the array, number of arrays, etc. In the case of urban school districts, it may be the case that a relatively small PV system is spread across a number of roofs and/or parking lots, which might require several points of interconnection or long DC/AC trenching that can elevate the cost.

These prices are meant to provide the district with an indication of what a quality PV system will cost. Actual pricing could be higher or lower depending on the complexity of the installation and the equipment used. Best pricing and best system value will be achieved by using a publicly bid design-build process.

SYSTEM SIZE	PREVIOUS COST ($/Wp)	FEBRUARY 2011 COST ($/Wp)	OCTOBER 2011 COST ($/Wp)
Roof (100-250 kWp)	$6.75	$6.20	$6.00
Roof (250-500 kWp)	$6.42	$5.77	$5.60
Roof (500-750 kWp)	$6.08	$5.52	$5.35
Roof (750-1000 kWp)	$5.75	$5.22	$5.00
Carport (100-250 kWp)	N/A	$7.78	$7.45
Carport (250-500 kWp)	N/A	$7.08	$6.75

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 5

Solar Photovoltaic Technology Overview

Solar Photovoltaic Technology Overview

This chapter provides a basic overview of how a solar photovoltaic (PV) system works, as well as providing information on net metering rules, monitoring systems, incentives, and security equipment. The chapter also includes links to valuable resources that can provide quick estimates of how much electricity a PV system can produce and how much money can be saved by avoiding the purchase of electricity from the local utility.

The process of converting the energy in light to electricity has not changed much since Charles Fritts built the first conversion device in 1883. The first commercial solar cells were produced in 1956 at a cost of about $300/watt. Today's solar panels sell for less than $3/watt with production costs of about $1 per watt. So, although there have been many improvements in solar energy technologies over time (e.g., more efficient panels and inverters, better mounting systems, fewer wires, better and faster monitoring, security improvements, longer lasting components), the biggest change has been in the cost of PV. Delaying the purchase of PV in the hope that a newer, more efficient solar panel will come along will only delay the savings and benefits that could be accruing now.

See SolarBuzz for more on current pricing:
www.solarbuzz.com/facts-and-figures/retail-price-environment/module-prices

SEQUOIA FOUNDATION - SOLAR SCHOOLS ASSESSMENT AND IMPLEMENTATION PROJECT (SSAIP)

Solar Photovoltaic Technology Overview
August 25, 2011

Solar PV Technology Overview

Photovoltaic (PV) arrays convert sunlight to electricity without moving parts and without producing fuel waste, air pollution, or greenhouse gases (GHG). They require very little maintenance and make no noise. Arrays can be mounted on all types of buildings and structures. PV direct current (dc) output can be conditioned into grid-quality alternating current (ac) electricity or used to charge batteries.

Traditional "single crystal" solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. "Multi-crystal" are a similar technology but slightly less efficient. A third type of cells is called "thin-film" solar cells because they are made from amorphous silicon or nonsilicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Table 1 presents typical module efficiencies for each type of module.

Table 1. Typical Efficiency of Different Types of PV Modules

Single Crystal	14–19%
Multi-crystal	13–17%
Thin Film	6–11%

Building-integrated PV (BIPV) products can double as rooftop shingles and tiles, building facades, or the glazing for skylights.[1] They can be particularly well-suited for applications on historic buildings or where the PV panel needs to architecturally blend in with a building. Figure 1 shows an example of this technology integrated into shingles. Other examples of building-integrated PV (BIPV) include singly-ply membrane, standing seam metal roofs, among others. In some cases BIPV can add cost and complexity to a project and may not be universally available, but may help enhance acceptance of a project on a visible surface.

Figure 1. Thin film solar PV shingles (Credit: United Solar Ovonic/PIX 13572)

Most systems installed today are in flat-plate configurations which are typically made from solar cells combined into modules that hold about 40 cells. A typical home will use about 10 to 20 solar panels to power the home. Many solar panels combined together to create one system is called a solar array. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.[2] These systems are generally fixed in a single position, but can be mounted

[1] http://www.nrel.gov/learning/re_photovoltaics.html
[2] http://www.nrel.gov/learning/re_photovoltaics.html

on structures that tilt toward the sun on a seasonal basis or on structures that roll east to west over the course of a day.[3] The figure below shows the components of a typical PV system.

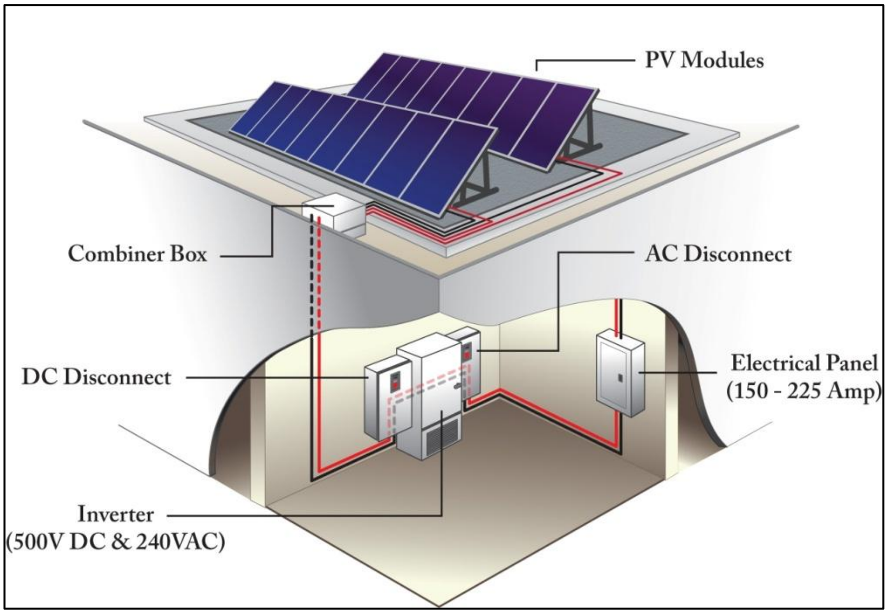


Figure 2: PV system schematic (Credit: Jim Leyshon, NREL)

The cost of PV-generated electricity has dropped 15- to 20-fold in the last 40 years; grid-connected PV systems sell for about \$5/Wp to \$8/Wp (20¢/kWh to 32¢/kWh) in 2011, including support structures and power conditioning equipment. Here "Wp" stands for "watt peak," which is the power rating that a PV system measures under standard test conditions, and under which a panel could be expected to deliver its peak output. A National Renewable Energy Laboratory (NREL) study of 7,074 PV systems installed in 2007 reported a range of total capital cost averaging \$8.32/Wp for small systems less than 10 kW and \$6.87/Wp for large systems greater than 100 kW. Costs reported for PV projects are falling rapidly so a local solar installer may be your best source of cost information. Operation and maintenance costs are reported at \$0.008/kWh produced, or at 0.17% of capital cost without tracking and 0.35% with tracking.[4] Solar panels are very reliable and last 20 years or longer.

The amount of electricity that a system produces depends on the system type, orientation, and the available solar resource. The solar resource is the amount of the sun's energy reaching the earth's surface, which varies across the United States. A higher solar resource means that more of the sun's energy is reaching the surface, which is optimal for PV system performance. The solar resource map in Figure 3 details the available solar resource throughout the country in kWh/m^2/day. Resources are highest in the Southwest, and fairly high throughout the western states, Texas, and Florida.

[3] DOD RE Replication Pilot ESPC
[4] Mortensen, J. *Factors Associated with Photovoltaic System Costs*. NREL/TP 620.29649. June 2001; p. 3.

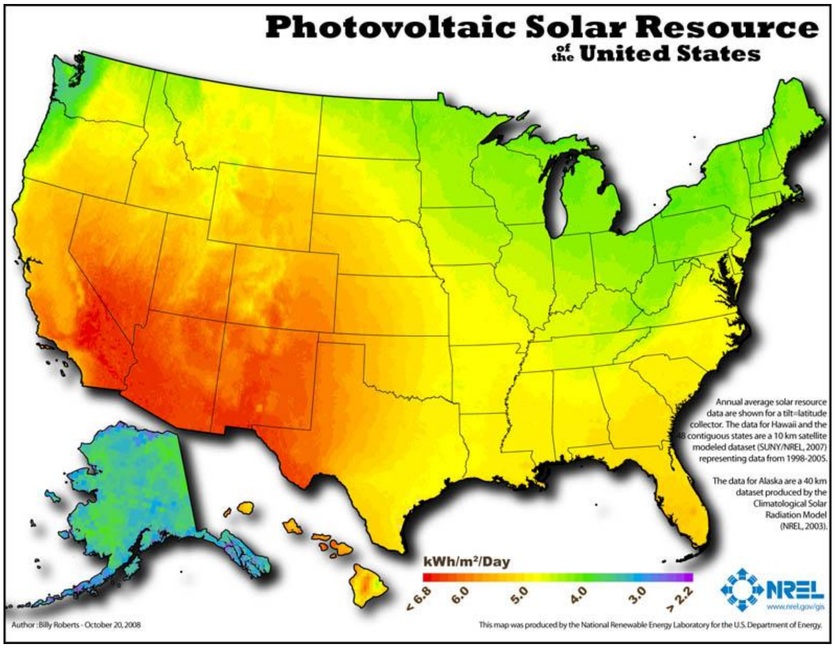


Figure 3. GIS map of U.S. solar resources[5]

Referring to Figure 3, a properly oriented and unshaded PV panel in Washington state, west of the Cascade mountains, may be expected to deliver its rated capacity for about 3.4 hours per day, while one in the desert in Daggett, CA may deliver its capacity for 6.6 hours per day. A typical house uses about 25 kWh/day. Considering losses in the PV system, this could be supplied by a system of about 6.5 kW which would occupy about 500 sf of roof area.

<u>Siting of Solar PV</u>

There are typically three size-based categories of solar installations: utility-scale, commercial, and residential. Note that while there are no industry-standard definitions, these general distinctions are useful to understand.

- Utility-scale installations are very large arrays located on open lands, providing power for hundreds or even thousands of homes and businesses.
- Commercial systems are smaller and may provide power for multiple or single commercial or municipal buildings on campuses, in complexes, in neighborhoods, or in other special districts.
    - Commercial-scale systems offer potential advantages for locating solar PV in historic districts and campuses. Rather than attempting to find appropriate locations for solar panels on individual historic structures, a commercial-scale system might be located in a less visible or impactful location, such as above a parking structure or on an open lot. Power can be lost in transmission from these arrays to the end use location, however, so distances need to be minimized.
- Residential-scale photovoltaic systems produce power for use on a single property.

[5] http://www.nrel.gov/gis/images/map_pv_national_lo-res.jpg

This publication focuses on commercial-scale solar installations.

The major challenge for siting solar PV technologies is identifying an appropriate location for maximum electricity production. An ideal solar installation would be situated in an unshaded, south-facing location with an optimum tilt angle, and would supply electricity to a site where there is a demand for the electricity being produced. Not all sites are suitable for solar technologies. There are a few general rules that may be helpful in siting a solar PV system.

- It is important to identify an unshaded area for solar PV installation, particularly between the peak hours of 9 a.m.–3 p.m. Shade will reduce the output of a solar panel. Shade can be caused by trees, nearby buildings, roof equipment such as HVAC systems and vents, or structural features such as chimneys.
- It is best to orient fixed-mount panels due south in the northern hemisphere. Siting panels so that they face east or west of due south will decrease efficiency. However, that effect varies by location and could be minimal.

  In the area of San Francisco, California, for example, the losses due to orientation are about 10% for a panel facing 45 degrees east of south and about 4% for one facing 45 degrees west of south. A key assumption is that there is no loss of efficiency for a system facing due south.[6] While an orientation east or west of south is not ideal because of the resulting reduction in efficiency, it may be necessary due to the roof or building configuration.

- In the United States, the optimal tilt angle for achieving the highest performance from a fixed-mount PV panel is a tilt angle equal to the latitude of a location, for locations in latitudes less than 20 degrees north. At higher latitudes, the correlation is not valid. Christensen and Barker (2001) analyzed the annual solar resource data for different latitudes.[7] At a location of 40° north latitude, an optimal tilt varies from 30° to 35° to maximize the annual energy production.

  Fixed-mount solar panels can be flush- or tilt-mounted on roofs, pole-mounted on the ground, or can be integrated into building materials, such as into roofs, windows, and awnings. However, a tilt angle equal to latitude is not always feasible because of factors such as roof pitch, wind, or snow loading considerations. It is possible to install panels at a different angle. The impact of a non-ideal tilt angle varies by location, and could be minimal.

  In San Francisco, for example, the losses due to tilting a panel 10 degrees greater than latitude are 3%, but there are no losses due to tilting 10 degrees less than latitude. It is assumed that there is no loss of efficiency for a system oriented at latitude.[8]

- The size and nature of an electric load must be well understood to properly select and size a PV system. PV systems can be designed to provide power simultaneously with the utility (grid-connected); independent of the utility (stand-alone, with batteries); or to do either

[6] Analysis in PVWATTS. Assuming: location = San Francisco, CA; tilt=latitude (37.6 deg); DC to AC derate factor =0.77.
[7] Christensen, C.; Barker, G. (2001). "Effects of Tilt and Azimuth on Annual Incident Solar Radiation for United States Locations." Presented at 2001 Solar Energy Forum, Washington, D.C.
[8] Analysis in PVWATTS. Assuming: location = San Francisco, CA; orientation = 180 deg (south); DC to AC derate factor =0.77.

(dual mode). The systems can be designed to power any percent of an electric load, from a very small percentage to over 100% of the load, depending on available area for the panels, availability of the sun, and depending on what is allowed by the interconnecting utility. When considering a system that will be tied to the utility grid, or grid-connected, it is essential to understand the applicable net metering rules and interconnection standards for the serving electric utility company.

For electric customers who generate their own electricity, net metering allows for the flow of electricity both to and from the customer typically through a single, bi-directional meter. When a customer's generation exceeds the customer's usage, electricity flows back onto the grid. This effectively offsets electricity consumed by the customer at a different time during the same billing cycle or is carried over as a credit on future billing cycles. Many state rules allow a credit to be carried for 12 months, with a resulting electricity credit resulting in either a check to the customer or a forfeiture of the value of the excess electricity produced at the end of the 12 month period. Net metering is required by law in most U.S. states, but these policies vary widely.[9] Some net metering programs reimburse customers for excess generation at the wholesale rate, while others reimburse at the retail value. Some policies specify a limit on the capacity of PV systems that can participate in the net metering program.

Interconnection standards specify the technical and procedural process by which a customer connects a PV system to the grid. Such standards include the technical and contractual arrangements by which system owners and utilities must abide. State public utilities commissions typically establish standards for interconnection to the distribution grid, however, Federal Energy Regulatory Commission (FERC) has adopted interconnection standards for small generators interconnected to the distribution system that sell power in the wholesale market. Additionally, FERC has adopted standards for interconnection to the transmission system. Many states have adopted interconnection standards, but some states' standards apply only to investor-owned utilities—not to municipal utilities or electric cooperatives. Several states have adopted interconnection guidelines, which are weaker than standards and generally only apply to net-metered systems.[10]

- Since PV modules have different efficiencies, it is important to consider the efficiency versus the available or required area of the PV system. Fewer modules made of a higher efficiency cell (such as single crystalline) would be needed for approximately the same power output as more modules made of a lower efficiency cell (such as thin film). Therefore, if a project location is space-constrained, a higher efficiency, and potentially higher cost, module may make the most sense. However, if a project has an abundance of space, a lower efficiency, less costly module may be most practical.

Table 1: Area and Efficiencies Associated with 1 kW of PV of Various PV Module Types

Module Type	Module Efficiency	System Area (ft^2)
Single Crystal	19.3%	55 ft^2
Multi-Crystalline	15%	71 ft^2
Thin Film	9.5%	99 ft^2

[9] http://www.dsireusa.org/glossary/
[10] http://www.dsireusa.org/glossary/

Module efficiency in Table 2 is defined as the fraction of incident solar radiation converted to electricity. These values are established by testing under the standard rating conditions of 1000W/m^2 sun, 25°C temperature, and 1 m/s wind speed.

Incentives for Solar PV

Financial incentives offered by federal and state governments, local utilities and municipalities, and private organizations have a great effect on renewable energy project economics, including solar PV, and should be taken into account at all of the planning and feasibility stages. Potential incentives could include rebates, loans, tax incentives, grants, industry recruitment/support, bond programs, green building incentives, leasing/lease purchase programs and performance-based incentives. The Database of State Incentives for Renewables and Efficiency (DSIRE) website provides a listing of all applicable incentives for each potential project location.

Resources for Assessing Solar PV Potential

Many tools exist to help assess the technical and economic potential for solar PV at a specific location. These free tools can be used as a preliminary estimate of project potential by a property owner or project developer. However, a detailed feasibility study should be performed prior to making a decision.

- DSIRE: www.dsireusa.org

  The Database of State Incentives for Renewables and Efficiency (DSIRE) is a comprehensive database of federal, state, local, and utility incentives and policies relating to energy efficiency and renewable energy. DSIRE is funded by the U.S. Department of Energy and is updated by the North Carolina Solar Center and the Interstate Renewable Energy Council on a quarterly basis. Solar project planners should refer to DSIRE to determine ways in which to improve the value proposition of the project.

- IMBY: http://www.nrel.gov/eis/imby/

  The In My Backyard (IMBY) tool estimates the amount of electricity that can be produced with a solar PV array or wind turbine at a home or business. Homeowners, businesses, and researchers use IMBY to develop quick estimates of renewable energy production at locations throughout the continental United States, Hawaii, and northern Mexico.

  IMBY uses a map-based interface to allow users to choose the exact location of a PV array or wind turbine. Based on the location, system size, and other variables, IMBY estimates the expected electricity production for a system.[11]

- PVWATTS: http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/

  The PVWatts™ calculator determines the energy production and cost savings of grid-connected PV energy systems throughout the world. It allows homeowners, installers, manufacturers, and researchers to easily develop estimates of the performance of hypothetical PV installations.

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[11] http://www.nrel.gov/eis/imby/

The PVWatts calculator works by creating hour-by-hour performance simulations that provide estimated monthly and annual electricity production in kilowatts and energy value. The tool is user-friendly, robust, and reasonably accurate – and is widely used and referenced by most utilities. Users can select a site nearest to their location that has similar topography and choose to use default values or their own system parameters for size, electric cost, array type, tilt angle, and azimuth angle. In addition, the PVWatts calculator can provide hourly performance data for the selected location.[12]

- SAM: https://www.nrel.gov/analysis/sam/

  The System Advisor Model (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, small wind, and geothermal power systems and economic estimates for distributed energy and central generation 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. SAM also calculates the value of saved energy from a domestic solar water heating system.[13]

Monitoring of Photovoltaic Systems

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 kWh, and cumulative kWh locally on a LCD display on the inverter. For 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: Ethernet, internet, dial-up access, and via cellular data networks. Systems can send alerts and status messages to the control center or user via SMS (text message) service, cellular data networks, or fax. Data can also be stored in the inverter's memory or in external data loggers for further system analysis.

Monitoring system data can facilitate outreach and education through publicly-available online displays, wall-mounted systems, or smart phone applications. Figure 4 illustrates a Web-based PV tracking system.

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[12] http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/
[13] https://www.nrel.gov/analysis/sam/

Figure 4: Web-based PV Performance Display[14]

Tying PV Systems into the Curriculum

Implementing solar PV technologies on schools has a variety of benefits. These include the on-site production of sustainable, renewable electricity, a reduction in a school's greenhouse gas emissions and other toxic air contaminants, and a reduction in utility-purchased grid energy. An additional benefit is the educational opportunities associated with having a PV system installed on school grounds.

Renewable energy technologies can be incorporated into the curriculum from elementary through high school. The National Renewable Energy Laboratory (NREL) has developed a variety of educational resources, which are available at http://www.nrel.gov/education/educational_resources.html.

In Northern and Central California, Pacific Gas and Electric (PG&E) offers a Solar Schools programs, which aims to teach the value of renewable energy and energy efficiency to K-12 public schools. The program turns school buildings into engaging, "hands-on" science experiments, teaching students how their everyday energy choices can reduce their environmental impact.[15]

The PG&E Solar Schools Program includes a solar-curriculum training package and workshops for teachers and Bright Ideas grants. Since its inception in 2004, PG&E shareholders have contributed more than $9 million to the PG&E Solar Schools program. With over 125 schools participating throughout PG&E's service area, the program has trained more than 3,000 teachers, benefiting nearly 200,000 students.[16]

Barriers and Potential Solutions for School PV Installations

Solar PV systems comprise expensive components such as PV modules and inverters. They are frequently located in a highly visible location to ensure unimpeded solar access and to facilitate the education and outreach efforts associated with the PV system. Because of their exposed placement, PV systems on schools are particularly prone to vandalism and theft. Most vandalism acts are random and

[14] http://www.luciddesigngroup.com/kiosk/features.php
[15] http://www.pge.com/about/environment/pge/solarschools/
[16] http://www.pge.com/about/environment/pge/solarschools/

tend to occur in the evenings and on weekends. They also occur during the summer months when school is on break, the weather is warmer, and the days are longer.

Common anti-vandalism and -theft strategies include:

- **Install keyed fasteners at intermodule and end clamps.** These fasteners use a unique pattern, which are incompatible with standard wrenches and screwdrivers. The installer or owner keeps the key needed to unfasten the hardware. Although fasteners cost approximately $2-5 each, they are inexpensive relative to the cost of the modules.

Figure 7: Solar panel locks[17]

- **Install PV-specific alarm systems**, which tie into all PV modules, detect when a module is being disconnected, and send an alert to on-call staff or security.
- **Lock all panels together with heavy gauge, nylon coated wire** or other similarly designed systems. These essentially tie all panels together so that removal of individual panels is extremely difficult.
- **Check fences and gates for damage.** Make repairs as needed and keep gates locked.
- **Cut back weeds and other vegetation** around the campus to reduce fire risk and hiding places.
- **Keep surrounded areas clean.** Loose rocks that can be used by vandals should be removed.
- **Check all lighting on campus.** Replace all burned out bulbs. Install lighting in currently dark areas. Consider installing motion sensor lights.
- **Add or increase nightly patrols of campus**, especially during the summer months.
- **Install a reliable security camera system.** Post signage around the perimeter of the system alerting of the security systems in place.
- **Encourage neighbors to be concerned and watch for vandalism and theft.**
- **Engrave each system component** with the school name to deter reselling of stolen equipment.
- **Post warnings about potential hazards** and electric shocks from the system.

[17] http://www.solarpanelcleaningsystems.com

- **Educate the staff and students on the consequences of theft and vandalism** and create a sense of ownership of the PV system.

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 6

Design-Build Contract for Photovoltaic System Installation

Design-Build Contract for Photovoltaic System Installation

INTRODUCTION TO RFP TEMPLATE

Procuring a commercial-scale solar photovoltaic ("PV") system for a school district can and should be a solid investment for the district. PV systems should reduce utility costs for several decades and protect the district against rising electricity costs. Nevertheless, the landscape of solar PV procurement is dotted with projects in which the cost-saving potential of solar PV was not fully realized. Some school districts have ended up signing sole-source contracts with a solar vendor but without qualified assistance in crafting the contract terms or negotiating the pricing. In many cases, the results have been PV installations that are more expensive than they need to be; not as well designed, constructed, and maintained as they ought to be; and contracts that do not obligate the vendor to do proper operations and maintenance (O&M) and performance monitoring. Conducting a competitive procurement for design-build solar PV systems – if the procurement process is done rigorously and with the assistance of experienced, knowledge-based advisors or consultants – helps ensure competitive pricing, contractual protection, and successful system performance.

While districts that have relatively large installations planned (i.e., ~1 MW or larger) are likely to benefit from professional assistance in developing an RFP and evaluating proposals, districts that are considering smaller installations may find it more difficult to justify the cost of professional assistance and decide to carry out the RFP process on their own. The Request for Proposals (RFP) template that follows will help a district that opts to procure a PV system without the help of a consultant in avoiding some of the pitfalls experienced by other school districts. In addition, some districts have created internal solar committees composed of interested and informed community stakeholders to review smaller projects. KyotoUSA is also available to provide suggestions and recommendations to any interested school district regarding where to get help.

The template integrates features from RFPs for several successful school district solar PV procurements in California. No single RFP will work best for all districts. Each district and its advisors from whom this template was assembled included or excluded certain components from the RFP to achieve that district's particular goals. The number, size, and types of PV systems that the district seeks will influence the RFP content. So too will the market conditions, the local utility's rate structures (including whether there is a "solar friendly" rate structure), whether or not the district has or expects to secure solar incentives, specific external regulatory and legal requirements, and the district's own legal and procurement requirements and particular procurement strategy. For all these reasons, this RFP template should simply be a starting point for your district's specific PV project.

The Case for Using a Competitive Process

It is generally advantageous to use an RFP process to acquire a PV system. The justification is to achieve the best possible pricing and system quality. Rarely will a solar vendor shave its profit margin without being forced to do so by a strong competitor. A vendor may agree to reduce its price in negotiations, but, unless there is a competing proposal, a district generally will not know how much further the price could be lowered. In recent years, PV module prices have dropped dramatically, making it difficult to know whether competitive pricing from just several months ago is still the best pricing possible. Using an RFP process will also make it more likely that quality as well as price considerations will be emphasized. The best solar PV offer is rarely the lowest-price offer; rather, it is the offer with the best combination of price, output, quality components, performance assurances, and construction management expertise. A district will have difficulty evaluating the overall worthiness of a sole-source proposal if there are no competing proposals to which it can be compared.

The Importance of Having Qualified Assistance

Taking this RFP template from its current form to one ready for issuance by an individual district to solar PV vendors may require assistance from one or more experts knowledgeable about PV procurement and contracting as well as rate and economic analysis. Important judgments will need to be made both in crafting the RFP and in evaluating the resulting proposals. Analysis and evaluation should also be done pre-RFP (i.e., regarding the district's current and projected electricity usage patterns, the potential for switching to alternate electric rate structures, the potential to feed solar electricity into the utility grid and any associated limitations, and estimates of optimally sized solar PV systems), and post-RFP (i.e., evaluating on a comparable basis the various proposals in terms of each firm's strength, experience, proposed system designs, O&M agreements, and performance guarantees). A good consultant and a good attorney, each with the requisite experience, knowledge, and skills, generally pay for themselves on projects as large as 1,000 kW (1 MW) or more.

The consultant will provide significant value by: (a) writing an RFP that fits the needs, circumstances, and goals of the district; (b) providing an integrated analysis of system sizes and outputs, rates, and expected solar PV savings in order to solicit the systems that offer the best cost-savings potential; (c) designing strong long-term performance guarantees; (d) designing the RFP and reviewing the proposals in such a way that a clear "apples-to-apples" comparison can be made, which will facilitate the selection of the truly superior vendor/proposal/system; (e) conducting scenario analyses of different PV systems under different utility rate forecasts; (f) discovering pertinent information about the competing vendors through the RFP, interviews, reference checks, and the consultant's prior knowledge and experience; and (g) bringing all this analysis to bear in contract negotiations.

The attorney will provide value by ensuring that the commitments made in the proposal are carried into the contract; that the contract complies with public contract codes and all other applicable regulations, laws, and standards; and that the resolution of negotiable and open-ended issues reflect an overall fair balancing of issues from the district's perspective. Although it is somewhat risky to generalize about costs, it is not unusual for qualified consultant services to cost 1 to 2% of the overall contract cost. Attorney services may be more expensive per hour, but attorneys typically are needed for much less time than the consultant because an attorney's involvement is primarily or even solely during contract negotiations. Attorneys' fees can thus be expected to be less than consulting fees.

Setting the RFP "Bar"

Preparing a responsive solar PV proposal can be a large undertaking for potential respondents to the RFP. An RFP must strike a balance between:

1. setting the bar high enough in terms of the amount and quality of information required so that the resulting proposals provide the district with enough specificity about what is being proposed and enough information about the vendor, and

2. not setting the bar so high that vendors are dissuaded from putting in the effort to develop a responsive proposal.

Setting the bar at the right level requires thoughtfulness throughout the drafting of the RFP. For example, generally, the more lucrative the business opportunity – i.e., the larger and pricier the system being procured – the more a district can require of RFP respondents without dissuading them from preparing proposals. Similarly, an RFP seeking proposals for many different school sites generally imposes greater demands on the respondents, so, all other factors being equal, it might be prudent in such cases to require less technical specificity in proposals. A district might be interested in receiving alternate proposals for a given site; the district should consider whether the extra work required of the responding vendors to prepare alternate proposals appears justified by the relative attractiveness (i.e., the profit potential) of the business opportunity.

How Many Responses Does the District Need?

A key purpose of an RFP is to attract a sufficient number of qualified solar vendors. A "sufficient" number is generally at least three, but two may be sufficient if the two vendors offer comparable system scope and if each is cost competitive with the other.

District Owned or Power Purchase Agreement?

The RFP template is written for a district that intends to pay for the PV system up front, with its own capital or financing it has secured or a combination of the two. Districts interested in considering a power purchase agreement (PPA), in which the district does not own the PV system but merely "hosts" the system and purchases the electricity output from the system's owner, would need to supplement this RFP template with additional language specifying the PPA arrangements the district may be seeking.

The RFP template is written to suit a variety of circumstances that an individual district might encounter. When using the template, the district should make the language quite specific so that it is easier for the responding vendors to know what the district is and is not interested in considering. Preparing complete, responsive proposals is a lot of work; the last thing an RFP should be is so vaguely written that it scares off reputable, high-quality, competitive vendors or results in proposals that fail to meet the district's needs. In the latter case, a district may have to reissue a rewritten, better-scoped RFP, which is time consuming and can impose significant extra costs.

Performance Guarantee

Having a performance guarantee as part of a district's contract with the winning solar vendor can provide a strong measure of long-term performance assurance and thus instill confidence in the district's decision makers that the winning vendor's electricity production claims will be achieved. A strong performance guarantee provides an incentive to the solar vendor to keep the PV system in good repair, minimize the system's down time, and keep the PV modules clean.

The RFP template invites respondents to propose contractual language for a performance guarantee but does not specify performance guarantee language. Ostensibly, there is an incentive for competing vendors to submit strong performance guarantee language because this language will make a proposal more attractive. Unfortunately, at least at this point in the development of the commercial solar PV industry, many vendors' proposed guarantees are likely to be relatively weak, i.e., they may provide quite limited long-term performance assurance. Often, the guarantees are little more than what are provided by the manufacturer warranties included in the solar PV contract.

It goes beyond the scope of this discussion to address details of a strong performance guarantee. The important point to remember is that a performance guarantee should obligate the solar vendor to compensate the district monetarily whenever the value of the PV system's actual production is less than an agreed-upon minimum value, such as the 95% level specified in this RFP template. A contract may also be negotiated that contains an even higher minimum value, or, perhaps, a lower one. The "value" of the solar PV system is primarily based on the electricity bill reduction that results from the PV system's actual electricity production. If a district has secured a performance-based incentive, the value of the PV system would also include the monetary value of the incentive. If a district has the ability and inclination to sell Renewable Energy Credits (RECs) produced by its PV system, a performance guarantee could also include RECs as one of the value components.

Key issues to address in crafting a performance guarantee, and a brief example of how these issues may be addressed, include the following:

- weather variations as they affect electricity output (a reasonable approach is to "correct" the PV system output for weather that deviates from typical conditions, which is fairly straightforward using nearby weather station data)
- the likelihood that electricity rates will rise significantly over the long term (it is typical to include a set utility rate "escalator" in which the starting utility rate increases by a specified percentage each year – say, 3-4% per year, based on historical records – of the guarantee period, thereby increasing the value of the solar output in later years)
- the fact that electricity is generally valued on a time-of-use basis, making some periods of solar production more valuable than other periods (a reasonable approach is to use the expected hourly production profile of the solar PV system to calculate the annual weighted average time-of-use "avoidance" rate)
- both planned and unplanned system outages (it is reasonable to hold the vendor harmless for "acts of god" and "acts of utility" while making the vendor responsible for outages related to its own maintenance activities and to equipment failures)
- generally expected degradation in the PV cells over time (it is typical to build in 0.5% output degradation per year of PV system operation).

Pulling the Elements Together

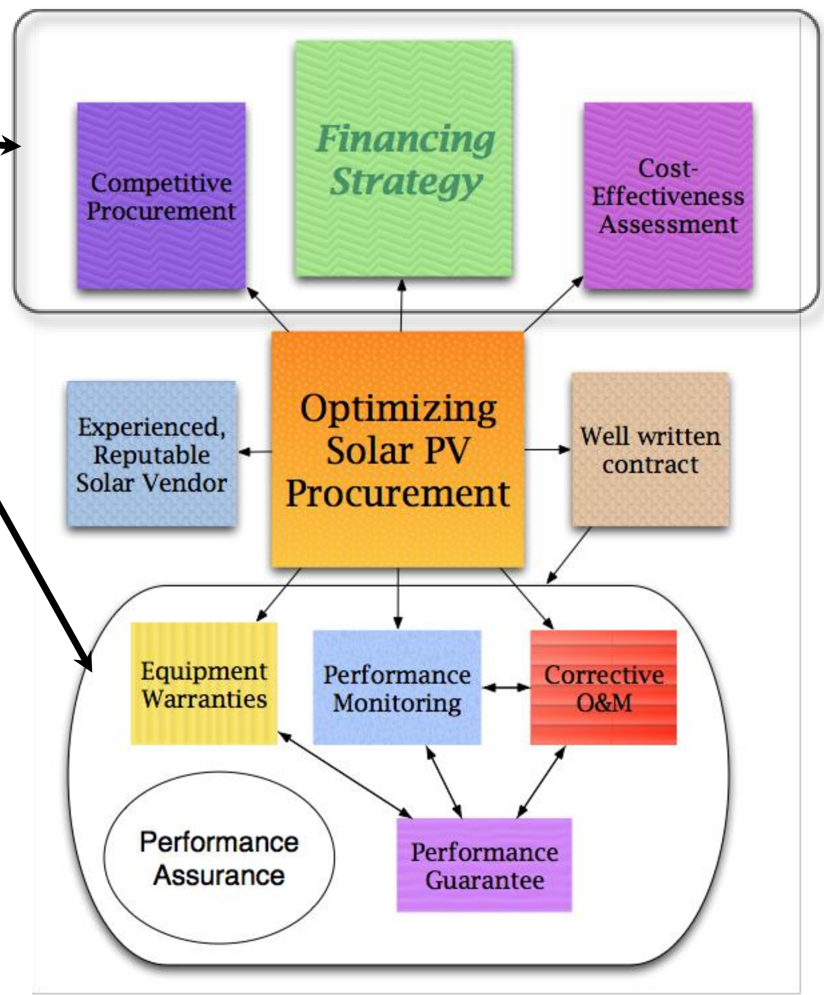
Figure 1 depicts key elements of a successful solar PV RFP process. Paying careful attention to each element will go a long way toward achieving a successful outcome. It is equally important to address each piece in view of and in coordination with all other related pieces. Finally, it is vitally important to have someone in charge of and driving each of the RFP process components, as well as an overall project manager keeping the total RFP process in view and championing its successful outcome with an eye toward procuring the best value PV system possible. Good luck!

Figure 1.

A School District's Ultimate Objective When Procuring a Solar PV System: Creating the *Highest Value* Solar System

Use a rigorous, tightly integrated competitive procurement and evaluation process.

- The key **monetary** considerations are shown on the top.
- The key **performance assurance** considerations are shown on the bottom. Warranties alone are not sufficient to protect your investment.
- Both sets of considerations--***monetary*** and ***performance assurance***--are essential to maximizing the value of your solar system.
- A strong ***competitive procurement process*** not only delivers good pricing and terms but also enables you to select a well qualified solar vendor.
- All these elements need to be tightly integrated, both in your overall **procurement process** and in the **crafting and negotiation of your contract**.



Prepared by Clyde Murley (clyde.murley@comcast.net)

Sequoia Foundation - Solar Schools Assessment and Implementation Project (SSAIP)

Request for Proposals
(RFP) No.

Design-Build Contract for

Photovoltaic System Installation

(Insert Location)

Vendor's Conference & Site Walk-through: **Date (time)**

Proposals due by: **Date (time)**

Acknowledgements

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For more information related to Solar America Showcase, please visit:
http://www.solar.energy.gov/solar_america_showcases.

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INTRODUCTION

A Request for Proposal (RFP) process requires development of a package with essential information, well defined objectives, and evaluation criteria that will enable potential vendors to provide high quality/high value proposals at competitive pricing. The RFP can be targeted to local businesses or cast wider to state or national vendors. When the focus of the RFP is performance, then the criteria slanted toward "best value" will be more effective than "lowest price." [1]

A performance-based design-build RFP will describe specific "end-state" and performance objectives. The following are a few key objectives of a Design-Build RFP:

1. Find a high quality vendor-partner for design and construction
2. Ensure an open and competitive process
3. Develop concrete, measurable project requirements
4. Receive innovative technical solutions with competitive pricing

The use of an experienced renewable energy projects consultant familiar with California schools is recommended and may be instrumental in ensuring incentive requirements are met and impact to schools is minimized. Schools may also benefit from keeping the following elements under consideration throughout the RFP process:

1. Benchmark the district energy use
2. Site conditions for potential PV locations (including roof condition)
3. Minimize the impact to schools, e.g., school closings during project installation
4. Integrate PV awareness and education into the school and classroom

[1] Clyde Murley; Solar Program Manager, Community College League of California; Spring 2011 ACBO Conference; May 16, 2011

SECTION 1: OVERVIEW, OBJECTIVE AND SITE INFORMATION

OBJECTIVE

The objective of this document is to develop a Request for Proposal (RFP) that can provide a model to identify and select the most qualified and cost-competitive design-build contractor (Contractor) for the survey, design, Division of State Architect approval, installation, commissioning, and service of a "grid-connected" photovoltaic (PV) system (Project) of future solar projects in the three school districts within the Bay Area or in other public school districts in the State of California. This document is intended to provide guidance to school districts on the PV procurement process. It is strongly recommended that school districts obtain the guidance of local experts who keep up with the ever changing field of renewable energy and the best practices of financing, construction, and procurement and, focus on renewable energy for schools.[2]

SITE INFORMATION

For the sake of the RFP the term "District" will be used to mean the implementing school district. The District is looking for the best combination of price including cost per unit output; technology; post-construction services, experience and proven performance; qualifications; optional items such as educational opportunities and customer kiosk; and overall thoroughness of proposal and responsiveness to the RFP. In making its solar PV vendor selection, the District reserves the right to take these factors into account as it sees fit.

The District's award of contracts, if at all, will be made in accordance with applicable statutory requirements and will be based on the Contractor's skill, experience, qualifications, proven performance, cost, value, operations and maintenance support, guarantee of stated kWh performance of the PV system, overall thoroughness of proposal and responsiveness to this RFP.

The District will acquire the Project from the Contractor pursuant to a Design-Build Contract (DBC) entered into with the Contractor selected through this RFP process. The DBC will be on a District provided form.

The District will own the Project and intends to finance the direct purchase through the use of District Funding, General Obligation Bonds, Federal Bonds, or Tax Exempt Leasing as they may be available. Responses to this RFP that offer a Power Purchase Agreement (PPA) or other ownership model will be considered non-responsive and will not be reviewed. Additionally, the District intends to secure incentives through Pacific Gas and Electric (PG&E) or other electricity utility under the California Solar Initiative (CSI). RFP respondents are responsible for ensuring that any proposed system is in compliance with the requirements of the CSI program (see California Solar Initiative Program Handbook, published by the California Public Utilities Commission (CPUC), for further details on the CSI).

When a low interest federal bond is being used, e.g. Qualified School Construction Bonds (QSCB) and/or Clean Renewable Energy Bonds (CREB), an objective of the District is that the electric savings combined with any incentives cover re-payment of the (bond type) within the bond repayment period.

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[2] Clyde Murley

The District is considering one solar installation with the location currently undetermined to be selected based on the most cost effective investment in solar including annual electric bill reduction, space, technology, and solar incentives including CSI opportunities.

For purposes of the RFP, the District has identified areas on school roofs and/or parking lots that are available for PV installations. Respondents should confine their proposals to the use of these areas. [See appendix A]

The following school sites are being considered for the project:

	1	2	3
School Name			
Street Address			
City			
Annual Electricity Usage (kWh)			
Annual Cost			
Rate (PG&E Electric Rate)			

The District generally expects the selected location and system size to be optimized based on the available space, incentives, solar resource, and project economics with consideration given to long-term system operations and maintenance, performance, and impact to roofs and infrastructure.

[Insert statement about easement or other agreement for system access for future O&M if included]

[Insert interconnect agreement information]

SECTION 2: SOLICITATION PROCESS

Responses to this RFP must be submitted in writing and signed by an authorized officer of the respondent. Each respondent must provide sufficient information to enable the District to understand the overall proposal, the materials and services to be provided. The District reserves the right to deem any proposal as non-responsive and to give it no further consideration. The District also reserves the right to request clarification and/or additional information from any respondent.

Responses to the RFP are due no later than [Date and Time]. Responses submitted after this date and time cannot be accepted, and responses that are incomplete or do not conform to the requirements of this RFP will not be considered.

Responses shall consist of

- One (1) signed original
- Three (3) printed copies of submittals
- Two (2) CDs, each containing
    - A PDF file of the response
    - An Excel file of the hourly kWh production estimate for each proposed site system
    - An Excel file of the calculations and analyses used to demonstrate compliance with the X-year QSCB payback requirement
- An electronic version of the entire response sent to [Contact Name at Contact Email].

Responses must be delivered to:

[District Name]
[Attn: District Contact, Office Title]
[District Mailing Address]

All questions to this RFP must be received by [Date and Time ~ 2 weeks prior to the RFP due date and directed by email to

[Contact Name]
[Office Title]
[Email address]

RFP SCHEDULE:

Milestone	Date & Time
Request for Proposal released to vendors	
Vendors' conference and site visit	
Written questions due	
Answers delivered	
Proposals due	
Interviews of short-listed respondents	
Update District "Board" and request direction to negotiate with firms in order of ranking	
Conclude contract negotiations	
Board considers / approves final solar contract	

The District reserves the right to interview any or all respondents to this RFP, or to ask for additional information or clarifications. The District reserves the right, at its sole discretion, to accept a response that does not satisfy all requirements but which, in the District's sole judgment, sufficiently demonstrates the ability to produce, deliver, design, permit and install grid-connected PV projects and to satisfy the major requirements set forth in this RFP. The District reserves the right to change the above schedule.

DISTRICT MODIFICATION TO RFP:

The District expressly reserves the right to modify any portion of this RFP prior to the latest date/time for submission of RFP responses, including without limitation, the cancellation of this RFP. Modifications, if any, made by the District to the RFP will be in writing; potential respondents who have obtained this RFP from the District prior to any such modifications will be issued modifications to the RFP by written addenda.

NO ORAL CLARIFICATIONS/MODIFICATIONS:

The District will not provide any oral clarifications or modifications to the RFP or the requirements hereof; no employee, officer, agent or representative of the District is authorized to provide oral clarifications or modifications to the RFP. No respondent shall rely on any oral clarification or modification to the RFP.

PUBLIC RECORDS:

Except for materials deemed Trade Secrets (as defined in California Civil Code §3426.1) and materials specifically marked "Confidential" or "Proprietary", all materials submitted in response to this RFP are deemed property of the District and public records upon submission to the District. The foregoing notwithstanding, the District may reject for non-responsiveness the RFP response of a respondent who indiscriminately notes that its RFP response or portions thereof are "Trade Secret", "Confidential", or "Proprietary" and exempt from disclosure as public record. The District is not liable or responsible for the disclosure of RFP responses, or portions thereof, deemed to be public records, including those exempt from disclosure if disclosure is by law, by an order of a court of competent jurisdiction, or which occurs through inadvertence, mistake or negligence on the part of the District or its agents or representatives. If the District is required to defend or otherwise respond to any action or proceeding wherein request is made for the disclosure of the contents of any portion of a RFP response deemed exempt from disclosure hereunder, by submitting a response to this RFP, each respondent agrees to defend, indemnify and hold harmless the District in any action or proceeding from and against any liability, including without limitation attorneys' fees arising there from. The party submitting materials sought by any other party shall be solely responsible for the cost and defense in any action or proceeding seeking to compel such disclosure of such materials; the District's sole involvement in any such action shall be that of a stakeholder, retaining the requested materials until otherwise ordered by a court of competent jurisdiction.

ERRORS/DISCREPANCIES/CLARIFICATIONS TO RFP:

If a respondent: (i) encounters errors or discrepancies in this RFP or portions hereof; or (ii) requires clarifications of any portion of the RFP, the respondent shall immediately notify (insert contact name, title, email address). Responses of the District to the notice of any errors or discrepancies herein, or request for clarification will be in writing; if, in the sole judgment of the District, any clarification response affects the RFP or other respondents, the District will issue the clarification response by a written addendum distributed to all potential respondents who have theretofore obtained this RFP from the District.

SECTION 3: ASSUMPTIONS AND PROJECT REQUIREMENTS

PROJECT ASSUMPTIONS

Respondents are asked to make the following general project assumptions:

- Access during [allowable working hours], with vendor responsible to meet the District safety and security requirements.
- Required completion [date].
- Assume CSI Performance Based Incentive (PBI) will be [designate incentive including cost per kWh incentive for initial five years of operation of government owned solar systems]. The District may, at its discretion, submit the CSI reservation prior to, or at the conclusion of the RFP process. The winning bidder will be responsible for the coordination of the submission and/or completion of the CSI reservation process.

  For further information on CSI program, visit:
  http://www.gosolarcalifornia.org/documents/CSI_HANDBOOK.PDF.

COMPLIANCE WITH LAWS AND DISTRICT CONSTRUCTION PROCEDURES

Contractor will be required to comply with all relevant federal, state, and local statutes, regulations, ordinances, rules, orders, and other laws in any Contract with the District including but not limited to the following as appropriate:

- Division 2, part 7, chapter 1 (commencing with section 1720) of the California Labor Code, which requires payment of prevailing wages and regulates working hours.
- Project Labor Agreement requirements of the District's Bond Construction Program.
- Sections 11135 and 12940 of the California Government Code, which prohibit employment discrimination on the basis of race, religious creed, color, national origin, ancestry, physical disability, mental disability, medical condition, marital status, or sex. Workers' safety laws, including but not limited to regulations promulgated by Cal-OSHA.

Contractor is expected to be inclusive in any proposal obtaining all necessary permits, including but not limited to permits required by the State of California; and shall pay all taxes and regulatory fees including interconnect processing cost.

CODES AND STANDARDS

All products, components, construction, and installations must comply with applicable codes, standards, and rating methodologies, including but not necessarily limited to the following:

- All equipment provided, where applicable (e.g. PV modules, inverters and meters) must meet the equipment certification and eligibility requirements of the current California Solar Initiative or its successor.
- If PV modules using hazardous materials are to be provided by the respondent, then the environmental impact of the hazardous material usage must be discussed, including any special maintenance requirements and proper disposal/recycling of the modules at the end of their useful life. Modules containing hazardous materials must comply with the EPA Landfill

Disposal Requirements. Any additional costs and/or District responsibilities related to PV modules containing hazardous materials must be clearly identified.
- UL certification
- National Electrical Code – [Most current].
- Title 24 of the California Code of Regulations.
- All outdoor enclosures should be at minimum rated NEMA 3R.
- Occupational Health and Safety Administration (OSHA) directives.
- Pacific Gas and Electric Company's applicable interconnection requirements.
- All system components and design and construction work must comply with the requirements of the Division of State Architect (DSA) and California Department of Education.

Warranty and Service Contract Requirements

- Provide a detailed 10 year operations and maintenance plan with three 5 year options.
- All respondents must offer comprehensive on-site training in PV system safety, operations and maintenance consistent with the warranty and service contract provisions.
- The respondents standard warranty coverage will be twenty (20) years for any PV panels, and ten (10) years for all inverters, or consistent with current CSI Guidelines for PV System warranty requirements, whichever is greater; and should provide daily system monitoring, annual on-site system inspection, including system testing and routine preventive maintenance, repair and/or replacement of defective parts (equipment and labor).
- Provide optional extended warranties on inverter and other key system components.
- System performance monitoring and historical data access should be provided to the District via a secure website. This service is to be provided for 5 years with four 5-year options.
- Performance monitoring data should include system energy and power production, ambient temperature, wind speed, and insolation.
- Provide an option for public access to production and consumption information.
- Work performed by the Contractor must not render void, violate, or otherwise jeopardize any preexisting District facility or building warranties.

SECTION 4: SUBMITTAL REQUIREMENTS

TRANSMITTAL LETTER

Each response should include a transmittal letter signed by a party authorized to sign binding agreements for the project described by this RFP. The letter shall clearly indicate that the respondent has carefully read all the provisions in the RFP.

QUALIFICATIONS

COMPANY INFORMATION

Company Profile

- Year founded
- Status (private or publicly held)
- Number of employees (full-time, excluding contractors)
- Number of employees in California (full-time, excluding contractors)
- Total revenue and Megawatt Peak (MWp) installed for the past three (3) years.
- Local office location.

Construction and Professional Engineering Licenses held by Company or full-time employees:

Provide information confirming a contractor's license in active and good standing with the Contractors State License Board. Have all necessary licenses (architectural and engineering) to design the project.

- Provide a list of all California State Contracting Licenses, including classification and number
- As applicable, list the name and license number of at least one full-time employee that is a professional engineer in each of these disciplines:
  - Electrical
  - Structural
  - Mechanical

Financial Performance

- If public, provide a website link to your audited annual investment reports. If private, the short listed companies will be asked to provide audited financial statements for the past two (2) years. The statements will be audited with the firm present and the firm will be allowed to take statements after the review.

Legal

- If applicable, provide a summary of the issues and the status of any lawsuit your firm or any executive officers of your firm have been a party to involving the performance of any equipment it has installed.

Project Team

- Identify and provide full contact information for the Proposal Team leader.
- Identify each business entity, person or firm involved in the proposal and their role (e.g. design, installation, permitting, equipment supply by component, operations and maintenance)

- Provide resumes of personnel directly involved with the development of the proposed systems

Insurance & Bonding

Provide the following information on your firm:

- Commercial General Liability Limits (per occurrence and aggregate)
- Commercial Automobile Liability Limits (per occurrence and aggregate)
- Professional Liability Limits (per occurrence and aggregate)
- Employer's Liability Limits (per occurrence and aggregate)
- Employment Practices Liability Limits (per occurrence and aggregate)
- Product insured for damage during installation / Builders' Risk Limits
- Number or Percentage of employees covered by Workers' Compensation Insurance
- List your firm's Experience Modification Rate (EMR) (California workers' compensation insurance) for each of the past three premium years
- Financially viable insurance (rating)
- What is your company's bonding capacity?

Solar Project Experience

- Describe all the currently operating, non-residential, grid-connected PV systems similar in size to the scope of this RFP [kW (ac)] that your company installed in California within the past three (3) years (not in development). For each, provide the following information:
    - Total kilowatt peak (kWp) installed/ system size (kWp rating)
    - Customer/owner name with contact person's name, email, address, phone number, and system location
    - Installation date and on-line date
    - Current operating status
    - Precise role(s) your company performed for the project (e.g. material supplier, lead contractor, electrical subcontractor, design, consulting, etc.)
    - Indicate the type of system:
        - Rooftop
        - Ground-based
            - Fixed
            - Tracking
        - Carport
            - Fixed
            - Tracking
    - Indicate if the customer/owner was a California public school or community college. If so, describe your experience with the Division of State Architect (DSA) in gaining the necessary DSA approvals.
    - Indicate if the installation was for multiple sites
- Describe any additional elements of your experience or offered services that you believe the District should take into account when evaluating your proposal.

PROPOSED SOLAR PV SYSTEMS

The proposal for each school should be developed by focusing on the most cost-effective way to produce solar PV at that site. For each of the schools identified in this RFP (See Section 1) provide the following information. Additional information on each of these sites is contained in *Appendix A, B, and C*

TECHNOLOGY OVERVIEW

- Provide a detailed description of the complete system proposed for each of the schools identified in this RFP.
- Indicate the specific location, dimensions, and "footprint" of each proposed system.
- Indicate system size in both kWp (dc) and kW (ac) terms, based on applicable California Energy Commission conventions.
- Describe the key design and construction features of the systems that serve to optimize performance and aesthetics on each site.
- Provide details of mounting system. Identify any products or mounting strategies unique or proprietary to the respondent.
- When roof mounted, consider technologies that minimize or eliminate roof penetrations; include a warranty letter demonstrating an established working relationship with the roofing manufacturer or installer to provide integrated consultation to maintain roof integrity.
- Describe any identified issues or challenges and provide detailed strategies for resolution.
- Provide anti-theft/anti-vandalism measures as a separate line item for each site considered.

SYSTEM COMPONENTS

PV Modules

- Number of PV modules for each proposed school.
- PV module description and brand and model number.
- PV module efficiency %; PV cell efficiency
- Provide manufacturing data sheets for the proposed PV modules
- Indicate the PTC ratings for the proposed PV modules.
- Provide an explanation for your choice of PV module.

Inverters

- Number and size for each proposed system.
- Inverter brand(s), model(s), and efficiency (%).
- Provide manufacturing data sheets for the proposed inverters.
- Provide an explanation for your choice of inverter.

Roof Mounting Systems

- Describe each type of mounting system proposed, and its features to optimize performance and to enhance aesthetics at each school site.
- Describe system capability to minimize or eliminate roof penetrations.
- Describe specific activities to maintain roof integrity.
- Do you manufacture your own mounting system?

Project Implementation Schedule

- Submit a detailed implementation schedule for all of the proposed PV systems indicating the expected milestones and timing.

System Performance Monitoring, Warranty and Service Contract

Performance Estimation

- How many of your employees are dedicated to PV system performance estimation, and what is their FTE equivalent?
- Provide resumes of your employees engaged in system monitoring.
- Do you own, maintain, and update your own estimation tool? If so, provide a detailed description of the tool and the associated performance estimation methodology, including but not limited to weather assumptions. If not, identify and provide a detailed description of the modeling tool your company uses to estimate PV system performance, and its associated performance estimation methodology, including but not limited to weather assumptions.
- Provide a detailed description of the methodology and procedures used, and research conducted to ensure accuracy and calibration of performance modeling.

Performance Verification & Monitoring

Performance verification and monitoring must meet the eligibility requirements of the California Solar Initiative which include performance monitoring requirements.

- Provide a detailed plan for performance verification and monitoring including methodology, end-user interface, low performance alerts.
- At a minimum, provide web-based performance verification and monitoring service for 5 years with four 5 year options.
- Describe proposed system performance monitoring and customer access of historical data via secure website.
- Provide as a line item option, a customer kiosk; demonstrate strategy for educational opportunity and show production and consumption information.
- Provide the number of employees employed by your firm in charge of system monitoring and their associated FTE equivalent.
- Provide resumes of individuals in system monitoring.
- Provide the number of operational systems under management.

System Maintenance and Support

The District intends the Contractor to provide for comprehensive operations and maintenance of the PV system(s). The operations and maintenance should be presented as a term of ten years with three 5 year options.

- Provide a complete description of the scope and price of the proposed maintenance of the Project,
- Provide a detailed description of Contractor’s relevant prior experience performing system maintenance. Highlight distinguishing elements of the services to be provided that will benefit the District and optimize system performance.

- State the location of the nearest service office.
- If maintenance is to be sub-contracted, identify the subcontractor and provide a detailed description of their relevant experience and qualifications.
- Response Rates impact rebate and electricity savings benefits.
    - Include service office address and phone number
    - Telephone response time, not to exceed 2 hours from alert to confirmation of alert
    - System outage response time, not to exceed 24 hours from alert to repair team on-site
    - System outage response time from notification to maintenance and repair.

Performance History

- For the systems maintained by the proposed maintenance firm, what is the average system availability?
- Provide at least three years of actual system energy production data that demonstrates system performance and availability, and indicates the degree of accuracy of predicted performance, for at least five existing grid-connected PV projects similar to the proposed project.

Warranties and Service Information

- Provide a PV module warranty that meets the requirements of CSI and as a minimum a period of 20 years.
- Provide an inverter warranty that meets the requirements of CSI and as a minimum a period of 10 years.
- For roof mounted systems, provide a roof guarantee to maintain the integrity of the roofing system at the PV system penetration points for the remaining life of the roof at installation.
- Include a copy of the PV module warranty.
- Include a copy of the inverter warranty.
- Provide your standard system warranty and service contract provisions.
- Confirm whether your company finds the warranty requirements acceptable.

Performance Guarantees

Provide detailed descriptions and price impact for solar PV output performance guarantees. Submit actual contract language to be used for a performance guarantee including your standard terms for such guarantees. Performance guarantee should target 95% annual estimated output for ten years with three 5 year options.

Contract

The District will provide a Design-Build Contract form to a short-listed group of firms or to the top-ranked firm(s) during the District's evaluation process.

Pricing and Performance Information

For each school identified in this RFP, describe the PV system you propose to design and build, providing the following information.

The applicable measure of cost effectiveness is the expected 25-year electric bill savings compared to the non-solar option. Consider:

1) Applicable utility tariff(s);

2) Provide results of calculations for both a utility rate escalator of 4.5% per year and 3% per year.
3) CSI and other available incentives; and associated participation deadlines;
4) Pre-solar electric bill; and the avoided electricity costs including savings from consumption ($/kWh) and where applicable savings from demand charges ($/kW);
5) Specify all other assumptions including any assumed tariff switch following the installation of the PV system and provide information supporting permissibility of the switch.

The proposed price for each school should reflect any and all cost savings, incentives, and price discounts. All pricing elements should be well described with assumptions and calculations included.

1) System size (kWp)
2) Total gross, all-inclusive system price (design, permitting, installation, commissioning, warranties, guarantees, and maintenance service). Cost and services shall include, but not necessarily be limited to:
    - All electrical switch gear preparation to accept solar system
    - All electrical connectors, cabling and components necessary for a complete solar system
    - Complete electrical engineering services including diagrams
    - Complete structural engineering services including diagrams
    - Planning and design review services
    - Utility interconnection agreement processing costs
    - Rebate application processing and coordination
    - Incentive program inspections coordination
    - Local building and electrical inspection coordination
    - Secure storage facility at job site for all PV system equipment and supplies
    - Lavatory facility at job site
    - System operation and safety manuals and customer training
    - Final PV system "as-built" schematics
    - Final clean-up to "broom clean" conditions
    - Post-construction services
        - Operations and maintenance (10 years with three 5 year options)
        - Performance monitoring (5 years with four 5 year options)
        - Performance guarantee (95% for 10 years with three 5 year options)
3) System Performance
    - One complete year of hourly kWh production estimates with date and time stamp for each hour (excel format)
    - Expected total cumulative kWh output over 25 years
    - Expected annual performance degradation over 25 years (expressed as % degradation per year)
    - Identify the model(s) used to derive the kWh production estimates and describe and discuss all associated modeling assumptions.
4) Provide the cost per unit of expected output ($/kWh) as well as all underlying assumptions:
    - Over 15 years; and
    - Over 25 years.
5) Calculate estimated incentives including the PG&E or other utility incentive (i.e., California Solar Initiative Incentive)

6) State any additional assumptions made in the course of developing responses to 1) through 5)

Provide recommendation for the school and system(s) that achieve the best overall economics and provide supporting discussion and analysis. Provide calculations and analyses in working, formula-based Excel spreadsheets.

Provide recommendations for added-value line items the District may consider including

1. Provide optional detailed Educational Opportunities Plan including a Customer Kiosk, student access to web-based monitoring results, teacher training and curriculum.

Appendix A: Site Solar Assessment with Site Aerial Views

For each school to be considered in the District, the RFP should provide:

- School Name,
- Location, and
- Estimated Gross Available Area (square feet)
- Picture with available area highlighted
- Site Solar Assessment
    - Site specific notes related to the potential project
    - Identify potential obstructions e.g., trees, other buildings

Appendix B: Electrical Diagrams and Site Plans

Provide diagrams and site plans

Or provide a website where potential contractors can download the information

- Include site specific notes related to the potential project
    - Roof system age, type
    - Structural integrity for mounting the system
    - Area for inverters, etc
    - Available conduit

Appendix C: Historical Electricity Usage Data

Provide data for schools within the District to be considered or provide a website where data can be downloaded.

APPENDIX D: RFP PROCESS, LESSONS LEARNED, AND CHECK LIST

THE RFP PROCESS[3]

1. Scope the Project – for community support and the best quality proposals, provide an avenue for stakeholder input and develop a well-defined project scope;
2. Identify Project Constraints – budget, deadlines, technical requirements;
3. Write the RFP – to ensure high quality technical solutions and competitive pricing, enlist experience, hire a seasoned advisor and engage stakeholders;
4. Identify information that vendors must include - determine the information needed to make the best fit selection for the school district and the project.
    a. Describe in detail the firm's proposal to address the requirements outlined in this RFP, including details such as technologies to be used.
    b. Provide a timeline for the completion of this proposal; if the project involves a multi-phase approach please provide approximate timeframes.
    c. Describe the fee structure and how the organization will be charged. The costs involved may be categorized separately as design, construction, maintenance, and other post construction.
    d. Provide a brief history and profile of the firm and its experience providing services for organizations similar to ours. Provide a list of the firm's clients comparable to our organization; include contact name, telephone number, website location, services provided and length of service.
    e. Describe the project process and methodology including sample deliverables from past projects of similar size and scope. Document examples of the firm's experience in designing/developing each of the project requirements.
    f. List the project team and short biographies of each team member.
    g. Provide an unsigned copy of your standard service contract for our review and any additional stipulations of which we should be aware.
5. Develop scoring criteria weighted to reflect project priorities
    a. Effective project solution that meets project constraints and objectives;
    b. Clear description of deliverables;
    c. Monitoring plan;
    d. Maintenance plan;
    e. Performance guarantee, what does it include and how much extra does it cost;
    f. Reasonable timeline;
    g. Detailed and reasonable pricing, utility rate, $/kwh from pv system, impact of changing utility rate;
    h. Strong project team;
    i. Corporate longevity;
    j. Performance track record;
    k. Customer satisfaction;
6. Distribute the RFP considering preferences such as local companies, companies with experience working with schools - RFPs are often placed electronically with project

[3] Clyde Murley

documents available for download; save potential bidders time and resources if only accepting local vendors;
7. Describe the RFP timeline – include dates for RFP release, submitting RFP questions, question responses published, proposal submission, notification of finalists, finalist interviews, selection, contract signed;
8. Review proposal responses starting with an initial read-through with attention to their proposed solution;
9. Narrow the field based on key criteria such as vendor experience and track records; discussions with contact references; and appraisal of sample work;
10. Invite the short list to present their solution to your evaluation team;
11. Score the responses and make a selection;
12. The proposal is a starting point, use as-is or refine the details, finalize deliverables and schedules, and include them in the contract as an addendum;
13. Negotiate and sign the contract.

LESSONS LEARNED [4]

Lesson 1: Craft RFP and organize responses to facilitate an "apples-to-apples" comparison.

Lesson 2: Require a proper analysis of electrical rates; compare actual utility rate schedules with expected/derived hourly solar production; research solar-favorable tariffs.

Lesson 3: Determine cost effectiveness; most solar PV will pay off during the operating lifetime of the solar system. Don't rely on solar vendors' analyses alone; get a year's worth of hourly solar production estimates from your vendors; obtain informed estimates of future electricity costs, surcharges, and Renewable Energy Credit values. Incorporate long-term maintenance and equipment replacement costs.

Lesson 4: Require strong performance monitoring; evaluate vendors' monitoring capabilities and track records; visit the facilities of finalist vendors to observe their monitoring system for existing customers; request performance data from past customers; and tie monitoring to corrective response in your contract.

LESSON 5: Evaluate performance guarantee options; determine the value of the guarantee as written and how much it cost; tie guarantees to both lost utility bill savings and lost solar incentive savings.

LESSSON 6: Educate along the way; support your implementation team and decision makers with knowledge and examples; and clarify the benefit/cost/risk of solar against the *status quo, e.g.* continuing to get all your electricity from the utility.

LESSON 7: Engage an Expert; partner with an experienced consultant to write your RFP; assist with proposal evaluations, meeting with utilities, understanding tariffs, rates, and incentives; and to support all of the phases of the project through construction and performance testing.

LESSON 8: Require system commissioning

[4] Clyde Murley

LESSON 9: Include performance based operations and maintenance and review system performance

LESSON 10: Engage the roofing manufacturer to ensure roof systems are not compromised.

RFP CHECKLIST

- Cover Letter
- Signature Page
- Title Page
- Table of Contents
- Schedule of Events
- Standard Terms and Conditions
- Special Terms and Conditions
- General Information
    - Definitions
    - Purpose or Intent
    - Background
    - Method of Payment
    - Contract Term
    - Presentations or Demonstrations
    - Pre-Proposal Conference
- Technical Specifications
    - Specifications (Goods)
    - Scope of Work (Services)
    - Scope of Activity
    - Project Management
    - Deliverables/Measurable Standards Schedule
    - Support
    - Training
    - Maintenance
- Vendor Requirements
    - Mandatory Requirements
    - Vendor Organization
    - Vendor Qualifications & Experience
    - References
    - Financials
    - Resumes
- Proposal Response Format
- Cost Proposal
- Method of Evaluation & Award
    - Evaluation Criteria
    - Discussions, Best & Final Offer
    - Negotiations

Attachments

APPENDIX E: DEFINITIONS

Definitions[5]

Expected Performance Based Buydown (EPBB): The EPBB incentive methodology pays an up-front incentive to participants installing systems less than 30 kW in size that is based on a system's expected future performance. EPBB incentives combine the performance benefits of PBI with the administrative simplicity of a onetime incentive paid at the time of project installation. The EPBB Incentive will be calculated by multiplying the incentive rate by the system rating by the Design Factor.

Host Customer: An individual or entity that meets all of the following criteria: 1) has legal rights to occupy the Site, 2) receives retail level electric service from PG&E, SCE, or SDG&E, 3) is the utility customer of record at the Site (GM CSI only) or owns the site, 4) property owner or persons/entity responsible for the building at the location where the generating equipment will be located (MASH only), 5) is connected to the electric grid, and 6) is the recipient of the net electricity generated from the solar equipment (GM CSI only).

Insolation: A measure of solar radiation energy received on a given surface area in a given time. It is commonly expressed as average irradiance in watts per square meter (W/m^2) or kilowatt-hours per square meter per day ($kWh/(m^2 \cdot day)$) (or hours/day).

Interconnection: The equipment and procedures necessary to connect an inverter or power generator to the utility grid; IEEE Std. 100-1996 – *The physical plant and equipment required to facilitate transfer of electric energy between two or more entities. It can consist of a substation and an associated transmission line and communications facilities or only a simple electric power feeder.*

Interconnection Agreement: An interconnection agreement is a legal document authorizing the flow of electricity between the facilities of two electric systems. Under the CSI Program, eligible renewable energy systems must be permanently interconnected and operating in parallel to the electrical distribution grid of the utility serving the customer's electrical load. Portable systems are not eligible. Proof of interconnection and parallel operation is required prior to receiving an incentive payment.

Kilowatt (kW): KW is a unit of electrical power equal to 1,000 watts, which constitutes the basic unit of electrical demand. The watt is a metric measurement of power (not energy) and is the rate (not the duration over which) electricity is used. 1,000 kW is equal to 1 megawatt (MW). Throughout this Program Handbook, the use of kW refers to the CEC-AC wattage ratings of kW alternating current inverter output.

Kilowatt Hour (kWh): A kWh is the use of 1,000 watts of electricity for one full hour. Unlike kW, kWh is a measure of energy, not power, and is the unit on which the price of electrical energy is based. Electricity rates are most commonly expressed in cents per kilowatt hour.

Measurement and Verification (M&V): A process or protocol to confirm the actual energy savings realized from a project once the project is implemented and operating.

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[5] California Public Utilities Commission, California Solar Initiative Program Handbook, June 2010.

Megawatt (MW): Unit of electrical power equal to one million watts; also equals 1,000 kW.

Meter: A device used to measure and record the amount of electricity used or generated by a consumer. The CSI Program requires accurate solar production meters for all solar projects that receive incentives. Systems receiving an EPBB incentive require a meter accurate to within ± 5%, while systems receiving PBI payments require a more precise meter accurate to within ± 2%.

Metering System: A metering system should include all distinct components necessary to measure the energy produced by a solar generating system. This must include equipment that allows the system to monitor and record 15-minute interval data either internally or externally through additional equipment such as a data logger. The system must include a 2% accurate meter either socket based or panel style allowing for a visual or remote display.

Net Energy Metering (NEM) Agreement: An agreement with the local utility which allows customers to reduce their electric bill by exchanging surplus electricity generated by certain renewable energy systems such as the PV systems the CSI subsidizes. Under net metering, the electric meter runs backwards as the customer-generator feeds extra electricity back to the utility. The CSI Program permits net energy metering agreements.

Photovoltaic (PV): PV is a technology that uses a semiconductor to convert light directly into electricity.

Power Purchase Agreements (PPA): specific to a PPA for purchase of on-site solar electricity; a PPA is an agreement for the purchase of the solar electricity generated and consumed on the Host Customer Site.

Performance Based Incentives (PBI): The CSI Program will pay PBI in monthly payments based on recorded kWh of solar power produced over a five-year period. Solar projects receiving PBI incentives will be paid a flat per kWh payment monthly for PV system output that is serving on Site load. The monthly PBI incentive payment is calculated by multiplying the incentive rate by the measure kWh output.

Performance Data Provider (PDP): A PDP service provider monitors and reports the energy production data from the solar energy system to the Program Administrator to serve as the basis for PBI payments.

Site: The Site is the Host Customer's premises, consisting of all the real property. Each individual Site must be able to substantiate sufficient electrical load to support the proposed system size.

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 7

Financing Options for Solar Installations on K-12 Schools

Financing Options for Solar Installations on K-12 Schools

Financing is the key to making a PV project a reality in any school district. Securing financing so that no new pressure is placed on a district's General Fund overcomes what is typically a major impediment to PV projects. If the financing creates a new revenue stream for the district, i.e., the combined value of the avoided electricity costs and any incentives is greater than the cost of the financing, then the district will have more money in its General Fund for teachers and programs.

This chapter provides an overview of the two primary models for procuring PV projects in public schools: ownership by the district and ownership by a third party (through a power purchase agreement or energy savings performance contract, for example). The overall benefits of district ownership are significant, especially over the lifetime of the PV system. Nevertheless, some districts do not have access to low-cost financing or voter-supported bonds that would make district ownership possible. In these cases, a district may find that a well-crafted power purchase agreement or other third party arrangement is the more effective option.

Financing options for school district PV projects are always changing. This chapter gives an overview of financing in late 2011, but options will likely have changed by the time a district begins to seriously consider its financing options. Districts looking at ways to finance their PV projects should find current, reliable, and unbiased sources to help guide them through this very important and evolving element in a renewable energy system transaction.

Note:
NREL provided the appendices to this chapter to each district on a CD. Some of those materials (PPA and Lease templates) were purchased from SolarTech for use exclusively by the districts. For information on the templates and their cost, see **http://www.solartech.org/publication**






Solar Schools Assessment and Implementation Project: Financing Options for Solar Installations on K–12 Schools

J. Coughlin and A. Kandt
National Renewable Energy Laboratory

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
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September 2011

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www.solar.energy.gov/solar_america_showcases.html

List of Acronyms and Abbreviations

AC	alternating current
ARRA	American Recovery and Reinvestment Act
BAB	Build America Bond
CA-CHPS	California Collaborative for High Performance Schools
CDE	community development entity
CDoE	California Department of Education
CDLAC	California Debt Limit Allocation Committee
CEC	California Energy Commission
CHPS	Collaborative for High Performance Schools
CREB	Clean Renewable Energy Bond
CSI	California Solar Initiative
DC	direct current
DOE	U.S. Department of Energy
DSA	Division of the State Architect
DSIRE	Database of State Incentives for Renewables and Efficiency
ECM	energy conservation measure
EE	energy efficiency
EERE	energy efficiency and renewable energy
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act
ESCO	energy service company
ESPC	energy services performance contract
FEMP	Federal Energy Management Program
FERC	Federal Energy Regulatory Commission
FMV	fair market value
FY	fiscal year
GHG	greenhouse gas
HIRE Act	Hiring Incentives to Restore Employment Act of 2010
HPI	High Performance Incentive
HPS	High Performance Section
HVAC	heating, ventilating, and air-conditioning
IOU	investor-owned utility
IRS	U.S. Internal Revenue Service
ITC	Investment Tax Credit
kW	kilowatt
kWh	kilowatt-hours
MACRS	modified accelerated cost recovery system
MUSD	Milpitas Unified School District
NAESCO	National Association of Energy Service Companies
NMTC	New Market Tax Credit
NREL	National Renewable Energy Laboratory

O&M	operations and maintenance
OPSC	Office of Public School Construction
PG&E	Pacific Gas and Electric Company
POU	publicly owned utility
PPA	power purchase agreement
PV	photovoltaic
QECB	Qualified Energy Conservation Bond
QSCB	Qualified School Construction Bond
QTCB	Qualified Tax Credit Bond
QZAB	Qualified Zone Academy Bond
REC	Renewable Energy Certificate
SAB	State Allocation Board
SDG&E	San Diego Gas and Electric
SFP	school facility program
SJUSD	San José Unified School District
SMP	Solar Master Plan
TREC	Tradable Renewable Energy Credit
W	watt
Wp	watt-peak

Executive Summary

The Sequoia Foundation is supporting three California public school districts—Oakland, Berkeley, and West Contra Costa Unified School Districts—in the development of Solar Master Plans (SMPs), documents that are intended to be incorporated into the districts' facilities' master plans. The National Renewable Energy Laboratory (NREL) is providing technical assistance to these school districts and the Sequoia Foundation as part of the U.S. Department of Energy (DOE) Solar America Showcase program (see http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=165). One element of this assistance is the development of a resource guide for financing the installation of photovoltaic (PV) systems on California's public schools. This guide contains an overview of financial options. A variety of templates, signed project documents, and other reference materials that school districts can review as they pursue their solar electricity generation projects were provided in a separate appendices document for the three school districts. Some of the documents are publicly available online, and where this is the case, links to the websites are provided.

This document focuses on financial options developed specifically for renewable energy and energy efficiency projects, including the traditional methods of financing capital investments at schools. Section 1 provides an introduction to financing PV on schools, including consideration of energy efficiency, roof viability, and classroom impact. Section 2 discusses the direct-ownership option. After selecting a solar developer through a request for proposal (RFP) process, the school district finances the project's purchase price with 100% debt financing, which could include traditional tax-exempt municipal bonds, leasing, or taxable bonds that provide a form of federal subsidy. Section 3 focuses on the third-party finance model, including power purchase agreements and energy services performance contracts, with a brief description of New Markets Tax Credits. Examples and case studies are incorporated when relevant and available. The separate appendices to this report include a number of pertinent documents related to financing solar installations on public schools and other public facilities.

It is important to remember that all aspects of financing renewable energy systems—regardless of whether they are in school districts or in other settings—are very fluid and dynamic. Laws are changing, incentives are being offered or exhausted, federally subsidized bonds come and go, and interest rates rise and fall. Establishing the cost of projects—whether owned by a district or by an investor—also changes based on local economic conditions, tax law, installation costs, utility tariffs, and how much profit an investor must make to participate in a third-party installation. This document is intended to provide an overview of the basics of PV projects and PV financing. Once you have a good understanding of your options, you are encouraged to seek additional help from trustworthy colleagues in the industry.

Note that newly elected State Superintendent of Schools Tom Torlakson has created a "Schools of the Future Initiative," which recommends changes in policy, laws, and regulations to help fast-track improved energy efficiencies and renewable energy systems for California's public schools. This effort could result in additional opportunities for school districts beyond what is described here. Updated information and resources are available on the HELiOS Project website at www.heliosproject.org (accessed June 8, 2011).

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1 Introduction to Financing Solar Installations on K–12 Public Schools

Solar energy systems installed on public schools have a number of benefits that include utility bill savings, reductions in greenhouse gas emissions (GHGs) and other toxic air contaminants, job creation, demonstrating environmental leadership, and creating learning opportunities for students. In the 2011 economic environment, the ability to generate general-fund savings as a result of reducing utility bills has become a primary motivator for school districts trying to cut costs. To achieve meaningful savings, the size of the photovoltaic (PV) systems installed (both individually on any one school and collectively across a district) becomes much more important; larger systems are required to have a material impact on savings. Larger PV systems require a significant financial commitment, and financing therefore becomes a critical element in the transaction.

In simple terms, school districts can use two primary types of ownership models to obtain solar installations and cost savings across a school district. The PV installations can be financed and owned directly by the districts themselves. Alternatively, there are financing structures whereby another entity, such as a solar developer or its investors, actually own and operate the PV systems on behalf of the school district. This is commonly referred to as the "third-party ownership model." Both methods have advantages and disadvantages that should be weighed carefully.

1.1 Direct Ownership

If a district owns its PV systems, then it receives all of the electricity savings and any available rebates, and retains the associated renewable energy certificates (RECs) that allow a district to make environmental claims about its PV systems. Thus, savings to the general fund that result from reduced or eliminated utility bills can be used to repay the loan or bond that was used to purchase a PV system. The district also can publicly claim to be reducing its GHG and toxic air contaminant emissions.

When a school district uses voter-approved general obligation bonds for the purchase of a PV system, or when the cost of repaying the debt incurred in purchasing the PV system is less than the utility savings, these excess funds can be used for other needed school services. Also, to compensate for the inability to directly benefit from federal tax incentives, the California Solar Initiative (CSI) incentives are greater for governmental and nonprofit organizations than for commercial entities. [1] The CSI incentives, when available, provide another revenue stream for a school district. Finally, given the productive life of a PV system (25–40 years), it is likely that any debt incurred to finance the PV will be paid off well before the end of the useful life of the system.

A primary disadvantage of direct ownership is the capital commitment involved. School districts rarely have cash reserves and might not have voter-approved bonding authority or access to the financial mechanisms needed to purchase PV systems. The district also simply might be unwilling to incur any new debt. Additionally, with a direct purchase, the school district is responsible for operations and maintenance (O&M) for the systems, unless it signs a long-term maintenance agreement with the solar developer—an option that is becoming increasingly common. Lastly, the federal tax credits available to tax-paying entities are not available for public entities directly purchasing a PV system.

1.2 Third-Party Ownership

The advantages of third-party financed PV installations for school districts include: little to no capital investment is required on the part of the school district; districts are not responsible for O&M; private-sector tax incentives can be incorporated into the transaction, which should result in reduced cost of the electricity sold to the district; and the districts can purchase the system for "fair market value" (FMV) during or at the end of the contracted term.

The disadvantages of the various third-party finance models, and of the third-party power purchase agreement (PPA) model in particular, include the following:

- A PPA is a complicated transaction that requires the school district to invest time and money in assuring that it negotiates a fair and equitable contract. Utility bill savings will be less than if the districts directly owned the system, because 100% of the solar electricity generated by the PV system must be purchased by the schools from the third-party investor.
- A PPA generally allocates the RECs to the investor, in which case the district is not entitled to claim the environmental benefits associated with clean electricity production.
- If, in the future, the district decides to purchase the PV system from the investor, there is no way to determine the purchase price in advance because the system must be sold for its fair market value at the time of sale.
- Unless the district exercises its buyout option to purchase the system at the end of the PPA term, the school will not own the PV system. In such cases, the PPA should include a provision for the removal of the system at the investor's expense.

Regardless of how a school district decides to finance or acquire PV installations on its buildings, several key issues should be highlighted, including benchmarking of district energy use, energy efficiency, PV siting considerations (including roof condition), the potential for school closings during project installation, and the integration of the PV system into the classroom environment.

1.3 Energy Efficiency and Benchmarking

Energy efficiency improvements if not already undertaken should be incorporated in the planning stages prior to installing a PV system. Energy conservation measures (ECMs) are the most cost-effective way to save energy and realize utility-bill savings. The return on investment in PV can be enhanced when the building hosting the system is already energy efficient. Furthermore, to qualify for rebates under the California Solar Initiative, an energy audit of existing buildings is required. For new schools, the project is required to meet either of the following two tiers of energy efficiency.

- Tier I—15% reduction in the commercial building's combined space heating, space cooling, lighting, and water-heating energy compared to the 2008 Title 24 Standards.

- Tier II—30% reduction in the commercial building's combined space heating, space cooling, lighting, and water-heating energy compared to the 2008 Title 24 Standards.

Achieving the Tier I level is the minimum condition required to qualify for the rebate. Tier II is the preferred level that builders are encouraged to meet. For either Tier I or II, any equipment or appliance provided by the builder must be ENERGY STAR-labeled if this designation is applicable. [2] Schools can implement energy efficiency measures either prior to the PV installations or in combination with them. An energy savings performance contract (ESPC) is a mechanism to finance the energy efficiency upgrades and possibly the PV installations as well. These contracts are discussed elsewhere in this document.

To identify schools that are most in need of energy efficiency upgrades, the schools' energy use should be benchmarked. A simple way to do this is to compare the energy intensity—the energy use per square foot, determined by dividing total annual energy use by total facility square footage—for all schools. Those with the greatest energy intensity should be a priority for energy audits and ECM identification. The U.S. Environmental Protection Agency (EPA) offers a free benchmarking tool called Portfolio Manager, which can help identify the energy performance of a district's schools. High-performing schools are eligible for an ENERGY STAR certification.[1] In some cases, the local utility can assist with energy audits and might provide rebates for many of the audit's recommended upgrades.

1.4 Solar Photovoltaics

Photovoltaic arrays convert sunlight to electricity without moving parts and without producing fuel wastes, air pollution, or GHGs. They require very little maintenance and make no noise. Arrays can be mounted on all types of buildings and structures, as well as in parking lots or other open spaces. A PV system's direct current (DC) output can be conditioned into grid-quality alternating current (AC) electricity, or DC can be used to charge storage batteries. Most systems installed on schools do not generally have batteries because they are cost-prohibitive. More information on PV systems, siting PV, and overcoming the barriers of theft and vandalism is found in the document entitled "PV Technology Overview."

1.4.1 Roof Condition

Photovoltaic systems should only be installed on roofs that are in good shape and can reasonably be expected to remain in good condition for the entire expected lifetime of the PV system (at least 25 years). Roofs should therefore be relatively new or be upgraded prior to the PV installation. It generally is not cost effective to remove a previously installed PV system to replace or upgrade a roof, although certain rooftop-PV mounting systems now make it possible to upgrade a roof without removing the PV structure. Ideally, roofs that need repair or are slated for a replacement can be improved or replaced in conjunction with the installation of the PV system. Structural assessments might also be required to confirm that the roof can support the additional weight and wind loading. If the best sites for solar are those that need new or improved roofs, then this near-term capital expense must be budgeted for accordingly. Building-integrated PV systems that combine the roofing material with the PV installation (thin-film applications) could also be an option.

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[1] Portfolio Manager is available at http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager. Accessed June 8, 2011.

1.4.2 School Closings

With an expected life of 25 years or more, once installed, a PV system will generate electricity to offset the building's load for a long time. To the degree possible, it is best to identify sites that are expected to remain in service for the foreseeable future. Given the current economic climate and the stress on school budgets, school closings are unavoidable. Although a PV system can be removed from a roof and reinstalled elsewhere in the district, this can be a costly process that also results in lost electricity production during system downtime. State regulations are evolving on the issue of whether the electricity generated by a PV system has to be consumed on site. It might be possible in the future to continue generating electricity from a school that has been closed and to apply the value of the generated electricity to another electricity account in the district.

1.4.3 Classroom Impact

Utility-bill savings are becoming the primary motivation for school districts to install PV systems. The impact of an on-site solar installation, however, goes beyond the value of the electricity produced and the greenhouse gases avoided. Photovoltaic installations sited throughout a school district create an excellent platform to introduce energy issues to students, teachers, and the school community, and provide hands-on experience for an issue that is traditionally given little attention in standard K–12 curriculums. Therefore, incorporating the PV systems into all school curricula should be a key element in any district-wide solar program. To maximize the classroom impact, the following are key activities.

- Curriculum development
- Data acquisition/monitoring system with Web access
- Training for facility staff
- Training for teachers
- Kiosks or other appropriate signage.

On large system purchases, some of these activities could be provided by the PV provider as part of the negotiated contract. With these general concepts in mind, the remainder of this introductory report focuses on the financial alternatives available to school districts as they implement their Solar Master Plans.

2 Direct Ownership of Photovoltaic Systems

In fiscal year (FY) 2009–2010, local governments and school districts were often the beneficiaries of low-interest or 0% interest bonds backed by the federal government. In some cases the bonds have been used to purchase PV systems. Prior to 2009, school districts had to think creatively if they wanted their schools to become energy generators. Some California school districts chose to enter into power purchase agreements. Other districts used voter-approved bonds, school modernization grants from the state, and up-front rebate payouts to help underwrite the cost of their PV systems.

It doesn't seem likely that the federal government will reauthorize the bond programs that helped to build so many solar projects. Additionally, rebates in California are evaporating and might not be replenished. On the plus side, solar-panel costs have been dropping, their efficiency levels have been increasing, and the slowed economy has made the cost for construction projects much more competitive and favorable for solar projects. An emerging market for a Tradable Renewable Energy Credit (TREC) in California could provide some additional financial incentives lost when the CSI rebates end. The California Energy Commission (CEC) has the authority to allow school districts to participate in the TREC market but, as of May 2011, the question of whether the CEC will use this authority remains unanswered.

One way to avoid the "boom-and-bust" cycle associated with PV financing for school districts is to incorporate the cost of solar installations into the next request that a district makes to its residents for general obligation bonds that support school construction projects. General obligation, tax-exempt, municipal bonds are common financing tools for schools. Photovoltaic projects can be bundled with other investments into a much larger bond transaction. The bond cycle is relatively infrequent for school districts (every 5 to 10 years), so planning is critical if these bonds are going to be used for PV installations. [7] The pursuit of Solar Master Plans is a key element in this planning process. Specific sites can be identified, their solar resources can be characterized, and an estimate of costs can be determined to create a priority list of installations. By creating this list of qualified projects a district will be ready to include them in the next funding cycle, instead of inserting vague language stating that some of the proceeds will be used for renewable energy projects and taking the risk of losing them to other investment priorities.

A school district can directly purchase, own, and operate PV systems using a variety of financing mechanisms. These include using existing reserves available from the General Fund, traditional tax-exempt bond financing, proceeds from state transfers of funds (e.g., state school construction and modernization funds) and other forms of grants (e.g., from foundations and private businesses), and a variety of tax credit bonds. With the exception of tax credit bonds, the other mechanisms are relatively common ways that school districts traditionally finance their capital investments and are not discussed in detail. Utility rebates, if available, also can be used to supplement the financing of the PV system.

As noted, CSI incentives are greater for school districts under the direct-ownership scenario. Check the CSI Statewide Trigger Point Tracker regularly for the status of rebates from California's major investor-owned utilities. [1] As of May 4th, 2011, CSI incentives were suspended in Pacific Gas and Electric Company (PG&E) and San Diego Gas and Electric (SDG&E) territory for all sectors except residential installations. [1] Legislation (S.B. 585 Kehoe) is attempting to replenish the CSI so that it can fulfill its original legislative mandate. Check the Database of State Incentives for Renewables and Efficiency (DSIRE) for all state and federal incentives, including rebates from publicly owned utilities.[2] Municipal utilities or public-owned utilities (POUs) also offer solar rebates; however, the cost of the electricity delivered by a municipal utility is sometimes too low to make districts served by POUs attractive candidates for PPAs. If a school district decides to finance and own a solar energy system, it can certainly finance it with voter-approved general obligation bond proceeds and other forms of traditional tax-exempt financing, or it could possibly use cash on hand if available.

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[2] *See* http://www.dsireusa.org/. Accessed June 8, 2011.

2.1 Using Cash on Hand

Although it is unlikely in the current economic environment that a school district has available general-fund resources on hand to directly purchase a PV system without financing, it is not out of the question. A district could be the recipient of grant funding or, as a result of a sale of unused property, could have the resources to purchase and install a PV system. If this is the case, then the school district would install the system and immediately begin accruing utility bill savings. The CSI production incentives, if available when the project is initiated, would enhance this positive cash flow in the first 5 years. Simple calculators can be developed to illustrate these savings to a school district.

2.2 California Energy Commission Loans for Energy Efficiency and Renewable Energy

Using funds from a variety of sources including federal stimulus dollars, the CEC has a low-interest loan program available for public entities, including schools. [8] The list of eligible projects includes renewable energy in addition to a host of energy efficiency measures. The interest rate of the loans is 3% per annum, and the maximum term cannot exceed 15 years or the expected life of the equipment (whichever is less). For PV systems, 15 years is less than the expected system life, thus 15 years would be the maximum term. The loan is repaid using the energy savings. Loans are given on a first-come, first-served basis and are based on available funding. For more information, consult the CEC website at http://www.energy.ca.gov/efficiency/financing/index.html.

2.3 Other Tax-Exempt Financing

2.3.1 Tax-Exempt Municipal Leasing

Leasing equipment instead of purchasing it is a common way for schools to finance certain hard assets (e.g., vehicles, software, computers, office equipment). Leasing is used much less frequently, however, for solar installations. This is a function of the inability of the owner of the PV system (the "lessor") to receive the federal tax incentives, given that the school, as the user of the equipment (the "lessee"), is not subject to U.S. income taxes. Investment tax credits are so valuable that alternatives to a tax-exempt lease often are more attractive. For some school districts, however, the low cost and familiarity of a tax-exempt lease combined with greater incentives of the state rebate program and the ability to execute a lease without voter approval could outweigh the loss of the tax credits in the transaction. Information on Yolo County, California, which used a tax-exempt lease as part of the capital structure to finance 1 MW of PV energy, can be found at http://www.nrel.gov/docs/fy11osti/49450.pdf and also in the electronic appendices of this report.

In early 2010, another option for leasing was created under the U.S. Treasury's 30% Cash Grant in Lieu of the Investment Tax Credit program (the "1603 Program"). [9] A third party who elects to receive the cash grant to finance a PV system instead of taking the 30% Investment Tax Credit (ITC) can lease this system to a school despite its tax-exempt status. [10] Although certain caveats are associated with this structure—such as the inability to benefit from accelerated depreciation—it does create an additional option for schools to consider. [10] The U.S. Treasury cash grant program was set to expire at the end of 2010 but has been extended by one year. Although the authors are unaware of any use of this mechanism to lease PV systems to schools, it does remain an alternative for school districts to consider through the end of 2011.

2.3.2 Office of Public School Construction Funds

A potential source of funds for solar projects could be the State of California's Office of Public School Construction (OPSC) and the High Performance Incentive (HPI) Program. The OPSC implements and administers the School Facility Program (SFP), which includes the New Construction Grants and Modernization Grants as well as other programs of the State Allocation Board (SAB). The HPI Program was established to distribute funds set aside for high energy performing schools to promote the use of high-performance attributes in new construction and modernization projects for K–12 schools. The HPI awards credits through a scorecard tied to the 2006 Collaborative for High Performance Schools (CHPS) guidelines, which determine the HPI points and the HPI amount that the school can receive.

2.3.2.1 New Construction Grant

The New Construction Grant offered by OPSC provides state funds on a 50/50 state-local sharing basis for public schools' capital facility projects in accordance with the statute. Eligibility for state funding is based on a district's need to house pupils and is determined by criteria set in law. This new construction grant amount is intended to provide the state's share for all necessary project costs except those for site acquisition, utilities, and off-site, service-site, and general-site development that might qualify for additional project funding. The necessary project costs include, but are not limited to, funding for design and the construction of the building, educational technology, tests, inspections, and furniture/equipment.

2.3.2.2 Modernization Grant

The modernization grant made by OPSC provides state funds on a 60/40 basis for improvements to educationally enhance school facilities. Projects eligible under this program include upgrades to air conditioning systems, plumbing, lighting, roof replacement, PV systems, and electrical systems. Site acquisition cannot be included in modernization applications. The modernization grant amount is intended to provide the state's share for all necessary project costs. The necessary project costs include, but are not limited to, funding for design and the modernization of the building, educational technology, tests, inspections, and furniture/equipment. School districts typically use local bond financing or secure alternative funding to meet the 50% funding requirement for new construction projects or the 40% funding requirement for modernization projects. The application filing timelines are presented in Table 1.

Table 1. Application Filing Timelines

Program[a] / Type of Application	Application Acceptance Date	Application Due Date
New Construction		
Design [b]	Ongoing	Prior to occupancy of any of the classrooms
Separate Site [a,c]	Ongoing	Prior to occupancy of any of the classrooms
Construction (Full Adjusted Grant)	Ongoing	Prior to occupancy of any of the classrooms
Modernization		
Design [a,c]	Ongoing	None[c]
Construction (Full Adjusted Grant)	Ongoing	None[a,c]

a. For application submission requirements, see the OPSC website, http://www.dgs.ca.gov/Default.aspx?alias=www.dgs.ca.gov/opsc, and the SFP Regulations, http://www.bondaccountability.opsc.dgs.ca.gov/bondac/oversight_K12.asp.

b. Application only can be submitted if the district qualifies for financial hardship assistance.

c. Applications accepted for reimbursement for any contracts signed after August 27, 1998.

Table 2 presents the status of the funds. Proposition 1D, Proposition 47, and Proposition 55 have an available combined balance for new construction and modernization of $3 billion as of May 25, 2011. Most of this amount, however, appears dedicated to activities other than energy investments. The School Facility Program requirements for the New Construction Grant and Modernization Grant can be found here at www.documents.dgs.ca.gov/opsc/Resources/SFP_NC_Rqmnts.pdf and www.documents.dgs.ca.gov/opsc/Resources/SFP_Mod_Rqmnts.pdf as well as in the electronic appendices of this report.

Table 2. Status of Funds

STATUS OF FUNDS Per June 22, 2011 State Allocation Board Meeting (Amounts In Millions of Dollars)				
Program	Remaining Bond Authority As of May 25, 2011	Apportionments - June 22, 2011	Adjustments After Board - June 22, 2011	Remaining Bond Authority As of June 22, 2011
Proposition 1D				
New Construction	$32.5			$32.5
Seismic Repair	194.8			194.8
Modernization	1,350.5			1,350.5
Career Technical Education	120.1	3.4		123.5
High Performance Schools	79.0			79.0
Overcrowding Relief	509.2	4.8		514.0
Charter School	409.3			409.3
Joint Use	0.6			0.6
Sub-total	**$2,696.0**	**$8.2**	**$0.0**	**$2,704.2**
Proposition 55				
New Construction	$721.5			$721.5
Modernization	5.8			5.8
Critically Overcrowded Schools				
Reserve	286.7			286.7
Charter School	132.2			132.2
Relocation/Dtsc Fees	13.1			13.1
Hazardous Material/Waste Removal	2.6			2.6
Conversion Increase Fund	23.3			23.3
Joint Use				
Sub-total	**$1,185.2**	**$0.0**	**$0.0**	**$1,185.2**
Proposition 47				
New Construction	$109.9			$109.9
Energy	0.1			0.1
Modernization	4.3	0.2		4.5
Critically Overcrowded Schools				
Reserve				
Charter School	45.9			45.9
Conversion Increase Fund	15.6			15.6
Joint Use				
Sub-total	**$175.8**	**$0.2**	**$0.0**	**$176.0**
Sub-total	**$4,057.0**	**$8.4**	**$0.0**	**$4,065.4**
Proposition 1A				
New Construction	$0.9			$0.9
Modernization	0.6			0.6
Hardship	6.2	0.3		6.5
Class Size Reduction				
Sub-total	**$7.7**	**$0.3**	**$0.0**	**$8.0**
SFP Total	**$4,064.7**	**$8.7**	**$0.0**	**$4,073.4**
Williams Lawsuit				
Needs Assessment Program				
Emergency Repair Program	$457.1 [A]			457.1
Sub-total	**$457.1**	**$0.0**	**$0.0**	**$457.1**
GRAND TOTAL	**$4,521.8**	**$8.7**	**$0.0**	**$4,530.5**

Note:
A. Funds are not available at this time.

Source: http://www.documents.dgs.ca.gov/opsc/Resources/Funds_Status.pdf

2.3.2.3 High Performance Incentive Program

In 2006, the HPI program was established to distribute the $100 million set aside for high-performance schools from Proposition 1D to promote the use of high-performance attributes in new construction and modernization projects for K–12 schools. On the Status of Funds (dated January 26, 2011), the High Performance Schools Program had an available balance of $80.5 million. [11] The School Facility Program regulations were based on 2006 California Collaborative for High Performance Schools (CA-CHPS) and referenced the 2005 Title 24 standards. According to the Division of the State Architect (DSA) website, the 2009 CA-CHPS Criteria now are accepted for the DSA/HPI grant review.[3] The HPI points are calculated from a project scorecard. The HPI project scorecard was based on the 2006 CHPS guidelines, which remain unchanged. The HPI amount is based on the points attained by the district within the following five categories: Site, Water, Energy, Materials, and Indoor Environmental Quality. The DSA's High Performance Section (HPS) verifies the HPI rating criteria to determine the number of points the project receives. A checklist for HPI projects and the DSA/HPI scorecards/guidelines can be found on these websites, respectively: www.documents.dgs.ca.gov/dsa/other/HPI_Checklist_rev02-07-10.pdf and www.dgs.ca.gov/dgs/tabid/1378/Default.aspx#t4, as well as in the electronic appendices of this report.

Table 3. High Performance Incentive Points Summary [12]

Modernizations and Additions	
Minimum to Qualify	20
Maximum	77
New Construction (New Campus Only)	
Minimum to Qualify	27
Maximum	75

2.4 Qualified Tax Credit Bonds

A number of qualified tax credit bonds (QTCB) have proven to be suitable vehicles for financing solar installations on schools, including Clean Renewable Energy Bonds (CREB), Qualified Energy Conservation Bonds (QECB), Qualified School Construction Bonds (QSCB), and Qualified Zone Academy Bonds (QZABs). Unfortunately, QTCBs are no longer available but are included here for informational purposes. Some school districts may still have access to prior

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[3] *See* www.dsa.dgs.ca.gov (accessed June 9, 2011).

years' allocations, and it is possible that some form of QTCB could be made available in the future.

By providing allocations of federal tax credits for certain categories of projects, the cost of capital is reduced and, ideally, more of these projects are built. The CREBs and QECBs are tax credit bonds aimed at renewable energy and energy efficiency investments. The QSCBs and QZABs are directed at schools and are defined broadly enough to also include renewable energy and energy efficiency.

2.4.1 Build America Bonds

Although not technically a QTCB, Build America Bonds (BABs) have a tax credit feature similar to that of the QTCBs. Their success, however, has been a result of what is known as the "direct payment" option. Instead of BAB buyers receiving federal tax credits in lieu of interest payments, the issuer can elect to receive a subsidy from the U.S. Treasury. This subsidy is equivalent to 35% of the bond's interest rate. Therefore, it is possible for state and local governments, including school districts, to issue taxable bonds that actually are cheaper than tax-exempt bonds once the subsidy is included. As a result, BABs have been very successful since the program's creation in 2009. To date, more than $120 billion in BABs have been issued. [13]

According to the *Bond Buyer*, although initial BAB transactions were large (for example, the first was a $250-million bond issued by the University of Virginia), the average size of a BAB issuance is decreasing; bonds in the $1-million to $5-million range now are more common. A bond of this amount could be issued as a dedicated solar bond for an individual school district. Note that, as of March 2011, there was no reauthorization of funding for BABs. Funding could possibly occur in late 2011.

2.4.2 Hiring Incentives to Restore Employment Act of 2010 and the Impacts on Qualified Tax Credit Bonds

The Hiring Incentives to Restore Employment (HIRE) Act of March 2010 made a very significant modification to the CREB, QECB, QSCB, and QZAB tax credit bond programs, creating a direct-pay subsidy mechanism similar to the BAB program (but much more generous). Under the new HIRE Act provisions, the subsidy that the issuer of a direct-pay bond receives is the lesser of either the actual interest rate of the bond or the reference credit rate found on the Treasury Direct website.[4] As an example, on December 14th, 2010, the reference credit rate on the Treasury Direct website was 5.63% (annual rate) for a qualified tax credit bond with a maximum maturity of 18 years. The QSCB and QZAB issuers get a direct-pay subsidy equal to 100% of the applicable tax credit rate of 5.63%. The CREBs and QECBs receive 70% of the applicable rate, which is 3.94%. Therefore:

- If a QSCB or QZAB was issued on December 14th, 2010, then the interest rate subsidy the issuer receives is the lesser of the actual interest rate of the bond or 5.63%. In other words, any bond with an interest rate of 5.63% or less is, in effect, an interest-free bond because the government subsidy offsets the entire interest payment.

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[4] *See* "Qualified Tax Credit Bond Rates." *TreasuryDirect.* https://www.treasurydirect.gov/GA-SL/SLGS/selectQTCDate.htm. Accessed June 9, 2011.

If the interest rate is more than 5.63%, then the net interest cost to the issuer is the difference between the actual rate and 5.63%.

- If a CREB or QECB was issued on December 14th, 2010, then the interest rate subsidy the issuer receives is the lesser of the actual interest rate of the bond or 3.94%. In other words, any bond with an interest rate of 3.94% or less is, in effect, an interest-free bond because the government subsidy offsets the entire interest payment. If the interest rate is more than 3.94%, then the net interest cost to the issuer is the difference between the actual rate and 3.94%.

For school districts with access to allocations of different types of tax credit bonds, issuing QSCBs or QZABs is more likely to result in interest-free financing, given the greater subsidy available for these bonds versus CREBs and QECBs.

2.4.3 Clean Renewable Energy Bonds

Initially authorized under the Energy Policy Act (EPAct) of 2005, Clean Renewable Energy Bonds (CREBs) [14] are an attempt to level the playing field for public entities unable to benefit from the tax incentives available to private entities. These bonds must be used for qualified renewable energy projects, which include PV. In 2009, the State of California received $640 million—80% of the total amount allocated for local governments in the United States. Most of the California allocations are for solar projects. Many California school districts received CREB allocations, including the Oakland Unified School District, which received 17 separate allocations for a total of $39 million. Berkeley and West Contra Costa school districts do not appear on the IRS list as having received any CREB allocations.

Clean Renewable Energy Bonds also can also be combined with other tax credit bonds or with more traditional tax-exempt financing. In early 2010, for example, Yolo County, California, combined CREBs, QECBs, a California Energy Commission Loan, and a tax-exempt municipal lease to finance a 1-MW solar installation on the Yolo County Justice Center. [15] Additionally, the project is receiving a CSI incentive of $0.24/kWh for 5 years. Bank of America Corporation structured this transaction. This project is noteworthy in that it is one of the first QECB issuances in the country and was the first to combine QECBs with CREBs. [15] A total of $7.265 million was raised across the four financial products. This transaction was completed prior to the HIRE Act coming into effect; therefore, the CREBs and QECBs are using the tax credit feature in which the buyer receives a federal tax credit in addition to a 3.90% supplemental interest payment from Yolo County. More information on this transaction can be found at http://www.nrel.gov/docs/fy11osti/49450.pdf and also in the electronic appendices of this report. Note that, as of March 2011, there was no reauthorization of funding for CREBs.

2.4.4 Qualified Energy Conservation Bonds

A Qualified Energy Conservation Bond (QECB) is very similar to a CREB. Unlike CREBs, however, up to 30% of QECBs can be used to finance private-sector activity. Also, there are numerous additional renewable energy and energy conservation projects that can be financed with QECBs, one of which is capital expenditures for reducing energy consumption in publicly owned buildings by at least 20%. [16] This is relevant for those cases in which a school district plans to finance energy efficiency upgrades in addition to installing PV systems.

Unlike CREBs, which required submitting an application to the IRS to solicit a tax credit allocation, the QECB tax credits were allocated to states based on population. This state-by-state allocation occurred in 2009. California received an allocation of approximately $381 million. [16] Cities and counties in California that have populations greater than 100,000 automatically received sub-allocations of this amount, with $170 million going to cities, $198 million to counties, and the remaining $13 million to state and tribal governments. [17] According to the California Debt Limit Allocation Committee (CDLAC), the cities of Oakland, Berkeley, and Richmond received QECB allocations of approximately $4 million, $1 million, and $1 million, respectively. [18] Note that, as of March 2011, there was no reauthorization of funding for QECBs.

2.4.5 Qualified School Construction Bonds

Qualified School Construction Bonds (QSCBs) were created in 2009 under the American Recovery and Reinvestment Act (ARRA). [19] As is the case for the other bonds discussed in this section, QSCBs originally were designed as tax credit bonds. The proceeds from a QSCB can be used for school construction, rehabilitation, and repair, as well as land acquisition to site a school. Energy efficiency and renewable energy projects are permissible uses of bond proceeds under this definition. The first QSCB issued in the United States was from the San Diego Unified School District in 2009 (for $39 million) in combination with Capital Appreciation Bonds.[5] Since then, a number of California school districts have issued QSCBs, including West Contra Costa County Unified School District, which issued a $25-million bond on June 10, 2010. [20]

As noted, with the passage of the 2010 HIRE Act, QSCBs can now be issued as taxable bonds with the issuer receiving a subsidy from the U.S. Treasury. As a result of this change, QSCB issuances have increased tremendously. In the first half of 2010, 167 QSCBs were issued for more than $2.5 billion. [21] This compares to three bonds for a total of $106 million in the first half of 2009 and a total of $2.8 billion for 2009.

In 2010, California received a QSCB allocation of $720 million, and Oakland Unified School District received its own allocation of $24 million. [22] The application for local school districts to tap into this 2010 QSCB allocation was posted on the California Department of Education (CDoE) on October 1, 2010. The CDoE has reported that the program is oversubscribed; it now prioritizes the awards based on criteria established in the enabling legislation. Existing voter-approved bond authority is required to be eligible. Additionally, large school districts—such as Oakland Unified, which received a direct allocation from the IRS—are not eligible to apply. For more information, consult the California Department of Education website at http://www.cde.ca.gov/ls/fa/qs/2010qscboverview.asp.

In July 2010, a $12-million, 10-year QSCB bond with an interest rate of approximately 5% was issued by the California School Finance Authority on behalf of a San Diego, California, charter school, High Tech High. [23] The direct-pay federal subsidy is greater than 5%; therefore, the entire interest rate is offset, thus creating a true interest-free bond for the school. Note that, as of March 2011, there was no reauthorization of funding for QSCBs.

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[5] Goldman Sachs, "Overview of Tax Credit Bonds" (May 2009). http://www.nast.net/2009TreasuryMgmt/Files/WED%20MarvinMarkus.pdf. Accessed January 15, 2011.

2.4.6 Qualified Zone Academy Bonds

Although similar to QSCBs in structure, Qualified Zone Academy Bonds (QZABs) predate the other tax credit bond programs and were created in 1997.[6] The QZABs are directed at schools serving significant numbers of low-income families. Qualified Zone Academy Bonds provide a source of funding that can be used for renovating school buildings, purchasing equipment, developing curricula, and training school personnel, but not for new construction.[7] There is an additional requirement of partnering with the private sector, which includes financial contributions. It is conceivable that QZABs could be used much like QSCBs to finance energy efficiency and solar projects. The additional requirements for QZABs, however, could make them a less flexible instrument than a QSCB.

In 2010, the California allocation of QZABs was $163 million. [24] Individual school districts can apply to the state for an allocation, or districts can jointly apply. [25] Note that, as of March 2011, there was no reauthorization of funding for QZABs. For more information, see the California Department of Education website at http://www.cde.ca.gov/ls/fa/qz/introd.asp.

3 Third-Party Financing

The use of third-party financing to install large PV systems is common in California, including in K–12 public school districts. For example, in August 2010, the San Diego Unified School District board approved the use of third-party financing to install 5.2 MW of solar on more than 80 school district rooftops. [26] This adds to the 4 MW of PV that the district has already installed. [26] Third-party financing is particularly useful in helping non-tax-paying entities, such as school districts, implement solar projects that cannot otherwise benefit from federal incentives. Using solar power purchase agreements (PPAs) and, possibly, energy savings performance contracting, districts can host on-site PV systems without any up-front capital investment.

3.1 Power Purchase Agreement

Under the terms of a solar PPA, the solar developer/investor owns, operates, and maintains the PV system and sells 100% of the solar electricity produced to the host (school district) at a fixed price for a negotiated term of up to 20 years. The federal tax incentives available to businesses—the business energy investment tax credit (ITC) and accelerated depreciation—can offset 50% or more of the installed cost of a PV system. [27] The PPA provider can then pass a portion of the savings on to the school in the form of a lower PPA cost of electricity. As a result, the third-party ownership model can be a cost-effective arrangement for many public entities that are interested in pursuing solar but lack access to the necessary funding or prefer to forego ownership for other reasons. Additionally, buyout options can be negotiated into the contract for the host to purchase the system sometime after 6 years and up through the end of the PPA term at the PV system's fair market value.

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[6] Taxpayer Relief Act of 1997, section 226(a). Available at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=105_cong_public_laws&docid=f:publ34.105. Accessed June 9, 2010.
[7] U.S. Department of Education. Qualified Zone Academy Bond. http://www2.ed.gov/programs/qualifiedzone/index.html.

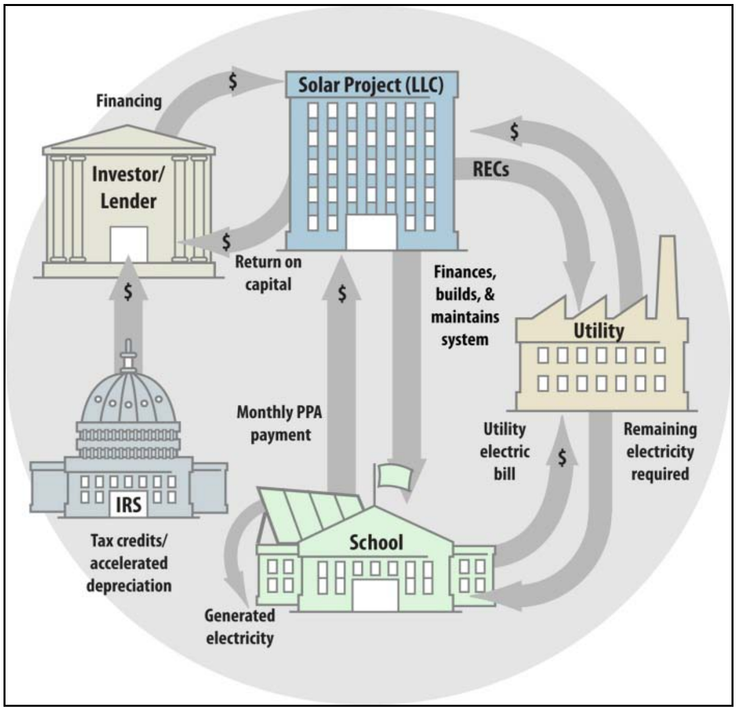

Figure 1. PPA flowchart (NREL 2010)

3.1.1 Advantages of the Third-Party Power Purchase Agreement Model for Solar

There are both advantages and disadvantages associated with third-party ownership models and solar PPAs. [28] Some of the commonly recognized benefits include the following:

- **Ability to benefit from the federal Business Investment Tax Credit.** As noted, commercial entities can benefit from the 30% ITC. By lowering the cost of the project to the solar developer and its investors, a lower PPA price can be offered to the public-sector host of the PV system.
- **Ability to benefit from modified accelerated cost recovery system (MACRS).** Photovoltaic installations can be depreciated over a 5-year period rather than over the expected useful life, which is much longer. Depreciation is treated as an expense for accounting purposes and reduces the income that is subject to taxes. As it relates to PV projects, the impact of depreciation usually is greater losses for the investors, which then are used to offset other taxable gains. Like the ITC, the host benefits from accelerated depreciation in that it could allow for a lower price per kilowatt-hour of electricity in the PPA.
- **No up-front capital investments.** Although installed costs are declining, the required initial investment to install a PV system is still significant, even after rebates. The cost of a 100-kW PV system on a middle school, for example, can exceed $500,000. Using the third-party PPA model, it is the solar developer and investors that finance and own the system, thus eliminating the need for the host to invest its own capital into the project.
- **Stable and predictable electricity prices for 20 years.** Power purchase agreements are commonly structured with an initial price per kilowatt-hour of electricity in the first year, combined with an annual rate of escalation in the range of 2% to 5%.

Alternatively, the price per kilowatt-hour can be fixed for the entire term of the PPA. Regardless, the host locks in the cost per kilowatt-hour of solar-generated electricity for the length of the contract. In today's economic environment, the initial PPA price must likely be competitive with the utility rates that a school is currently paying.

- **Operation and maintenance responsibility is handled by the system owner.** The system owner operates and maintains the PV system, removing this burden from the host. This includes replacing the system's inverters should they fail after the standard 10-year warranty but prior to the end of the PPA term.
- **Buyout option provides ownership potential.** Often PPAs can be structured so that the host has the option to buy the system from the developer at various points during the life of the PPA. The first option to buy the system takes place sometime after year 6, because ownership of the PV system cannot change before then without significant tax penalties. After that, the options could be every year, every 5 years, or whatever period is negotiated by the parties. If the buyout option is exercised, then the price should be discounted to reflect the tax benefits that the developer has received during the first 5 years. It is common in a PPA to calculate the buyout price as the greater of either a predetermined termination value or the system's fair market value.
- **Risk avoidance.** The risk of electricity production is borne by the PPA provider. The host only is obligated to purchase what the system produces. Additionally, the PPA provider commonly guarantees a certain level of minimum production of electricity, compensating the host for any shortfall. This is especially important if retail electricity rates are greater than the PPA rates, as the host would have to purchase more expensive power from the utility to make up the shortfall of the PV system.

3.1.2 Disadvantages of Third-Party Ownership

- **No free electricity.** Although the PPA price will ideally be less than retail utility prices, the host does not own the PV system; therefore, it will continue to pay for all of the electricity consumed at the facility.[8] This stands in stark contrast to owning a PV system, which generates "free electricity" (finance costs notwithstanding). In the case of a school district, which has access to funds that it doesn't have to repay directly (e.g., taxpayer-financed bonds, transfers from the state), owning a PV system reduces utility bills and frees up cash in the general fund to be used for other purposes.
- **No ownership of the "clean" energy attributes produced by a PV system.** Whoever owns the system claims its environmental benefits, unless those benefits have been sold to another party, such as the utility. If a school district has signed a PPA, it cannot make explicit environmental claims such as being "solar-powered" unless the PPA allows the district to retain the renewable energy certificates. Allowing the district to retain the RECs, however, often can make a transaction unattractive for the solar developer. Therefore, electricity-only PPAs are most common. If the solar RECs have not been bundled with the electricity, public claims

[8] A district is obligated to purchase all the electricity produced by the PV system it hosts. If additional electricity is required, then it must be purchased from the local utility at the utility's standard rates.

of being solar-powered must be tempered, given that only the owners of the RECs can make such a claim. One solution is to purchase "replacement RECs"—usually cheaper wind or biomass RECs—to "green up" the project.

- **Transaction costs are high.** Negotiating a PPA is very labor intensive. An RFP is developed and issued to select a solar developer. The PPA and the lease agreement must then be negotiated with the winning bidder. This negotiation process can easily take 6 months or more. To recoup some of these transaction costs, some PPAs include a requirement that the solar developer must reimburse the host for expenses incurred. These costs, of course, are in turn recouped by the developer in the form of an increased PPA price. However, this could be a way to develop internal support for a transaction.
- **Project will likely need a large, anchor PV system.** The PPA providers will seek the opportunity to install one or more large PV systems in a school district for the transaction to benefit from economies of scale. Placing numerous small PV systems on many school buildings is unlikely to be cost effective. Ideally, for example, a high school or maintenance facility that can host a system as large as 1 MW to anchor a system-wide PPA project could be required. In the absence of a large installation, costs will increase. Projects that rely on a number of small systems also risk falling apart should the "anchor" drop out.
- **Facility access by third parties is necessary.** The developer and its subcontractors need access to the site to install the PV system and then to maintain it over time. For school districts this often must be coordinated so that students and faculty are not disrupted during the installation process. For certain facilities, this might be a concern; for others, such as a bus maintenance facility, it could be less so.

In cases where a public entity has signed a PPA, it is because the advantages outweigh the disadvantages. Alternatively, the lack of funding makes a third-party financed transaction the only realistic solution. If funding is obtained in the future, then ownership can be acquired by exercising the buyout option.

3.1.3 California Case Studies of Third-Party Financing Solar on K-Through-12 School Districts

In addition to the information contained in the following case studies, this document contains copies of the signed PPAs: https://www.musd.org/cms/page_view?d=x&piid=&vpid=1217983977356. This and other PPAs are available in the electronic appendices of this report.

3.1.3.1 San José Unified School District, San José, California[9]

In 2007, Chevron Energy Solutions entered into a partnership with the San José Unified School District (SJUSD) to install solar panels on school buildings. The genesis of the project was the

[9] Information for this section was obtained from the Chevron Energy Solutions website, http://www.chevronenergy.com/case_studies/sjusd.asp; a SJUSD press release, http://www.naesco.org/resources/casestudies/documents/SJUSD-Solar-Press%20Release-final.pdf; and an interview with a representative of the school district (January 1, 2010) (on file with author).

initiative of a local high school in the district that was interested in installing PV. It then became a district-wide effort. The SJUSD had the following goals for the project:

- Deliver general fund savings
- Create education opportunities
- Demonstrate environmental stewardship and leadership.

In partnership with BankAmerica, the institution that financed and owns the PV installations, Chevron is installing a total of 5.5 MW of solar at 14 different sites across the district in three phases. Four high schools will host a total of 2 MW, and the remaining 10 sites will host 3.5 MW. Many of the sites are shade structures on parking lots, and the others are rooftop installations. BankAmerica is capturing the tax benefits as well as $11 million in incentives from the CSI Program. Chevron Energy Solutions is under contract to operate, monitor, and maintain the installations during the life of the PPA.

Solar energy is being incorporated into the district's science curriculum, and each of the 14 sites will have an educational display that includes system monitoring and real-time production information. The district expects to reduce energy costs by 30% during the life of the transaction (25 years) and save $25 million. Additionally, 100,000 metric tons of carbon dioxide will be avoided. Key design elements of the program are listed below:

- The district signed the PPA with the solar developer and is the party responsible for purchasing the solar electricity.
- The district negotiated an easement at each of the schools stipulating the conditions for third-party access and operation.
- From initial discussions to the first installation, the process took 18 months.
- Significant coordination was necessary with the selected schools during the pre-construction and construction phases because the installations took place during the school year.
- Several neighbors near one of the schools expressed concerns about the aesthetics of the solar installations. After viewing a computer-generated rendition, however, the neighbors ultimately supported the project.
- Some schools wanted to host PV systems but could not participate because they could site only small systems and not the large-scale capacity required for economies of scale to make the project "pencil out" for the investor.
- Initially, there was a great deal of skepticism on the part of the onsite building maintenance staff that had to be overcome. Installed systems have been relatively hassle free, however, so the project is currently meeting expectations.
- The maximum amount each system generates as a percentage of the building's electricity load is roughly 30% to 40%. The district has a net-metering agreement with the local utility.

- The district might be interested in buying the systems outright before the end of the contract, possibly using bond financing.
- The school district contracted with a third party to conduct independent inspections of the systems after they were installed.

3.1.3.2 Milpitas Unified School District, Milpitas, California[10]

In 2007, Milpitas Unified School District (MUSD) began discussions with Chevron Energy Solutions to carry out energy efficiency investments and install PV systems on school buildings. The district had the following four key objectives:

- Demonstrate economic leadership (general fund savings)
- Demonstrate environmental stewardship
- Create educational opportunities
- Receive positive public recognition and perform community outreach.

Figure 2. Solar PV array hosted by Milpitas Unified School District.S *Photo by John Cimino*

The project consists of 3.4 MW of PV installations at 14 of the district's sites. These systems will meet 75% of the school district's annual electricity needs and 100% of its peak electricity needs during the summer. The installations are designed as both shade and carport parking structures. As with San José Unified, each site has an educational display showing system performance. Additionally, solar energy is integrated into the fifth-grade and sixth-grade curriculum. [29] BankAmerica financed and owns the PV installations and receives the tax benefits. The bank also received $4.2 million in CSI incentives.

[10] Information for this section was obtained from the Chevron Energy Solutions website, http://www.chevronenergy.com/case_studies/musd.asp.

The MUSD estimates that the system will save the district $12 million over the life of the project by reducing annual energy costs by 22%. The project will also reduce carbon dioxide emissions by 23,600 metric tons. The PV systems are assisting the school district in meeting California's Grid Neutral Initiative. [30] A phone interview was conducted with Director of Maintenance Operations and Transportation for MUSD, John Cimino, as part of a similar solar for schools report and revealed that the PV systems are producing more energy than guaranteed in the contract, resulting in additional savings to the district. According to Mr. Cimino, the project has been a win-win for all parties involved, and was a fiscally responsible venture for the district as well as an environmental-stewardship measure.

3.1.4 Third-Party Power Purchase Agreements and New Market Tax Credits

The New Market Tax Credit (NMTC) is a mechanism by which private capital is channeled into low-income neighborhoods with the express intent of promoting economic development and jobs. [31] An investor in a community development entity (CDE) will benefit from a 39% federal tax credit over 7 years, in addition to the actual returns on the investment itself. The CDE, in turn, uses this investment to make either equity investments or loans to qualified projects within qualified neighborhoods. Although not a traditional source of capital for solar projects, certain public-sector projects are partnering with CDEs to finance PV installations, including the City of Denver, [32] Denver Public Schools, and Salt Lake County, Utah.

In the Denver case, a solar developer was able to obtain low-cost loans from a local CDE to finance a portion of what will be 3.9 MW of solar installations on city buildings and schools. The low-interest loans from the CDE reduced the cost of electricity in the power purchase agreement by 5% to 15%, depending on the project. More information on the City of Denver's NMTC project can be found at http://www.nrel.gov/docs/fy10osti/49056.pdf.

3.2 Energy Savings Performance Contracting

In 2008, $2.8 billion, or 69% of the total revenue for the energy savings performance contract industry, was generated by projects with municipal and state governments, universities and colleges, K–12 schools, and hospitals. [33] This illustrates that ESPCs are a viable mechanism to fund energy efficiency investments for public entities. The more difficult question is their applicability to solar energy projects.

An ESPC is a contract between a building owner (e.g., a school district) and an energy service company (ESCO) to carry out energy efficiency (including renewable energy) investments. The ESCO conducts a comprehensive energy audit for buildings throughout the district and identifies improvements to save energy. [34] In consultation with the schools, the ESCO designs and constructs projects that meet the district's needs. The ESCO guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. [34] After the contract ends, all additional cost savings accrue to the district. [34] The energy service company can either finance the project or partner with a third party to finance it. Alternatively, the school district itself can finance the project and repay the debt with the guaranteed savings from the performance contract.

According to the National Association of Energy Service Companies (NAESCO), energy service companies handle the following tasks.

- Develop, design, and arrange financing for energy efficiency projects
- Install and maintain the energy efficient equipment involved
- Measure, monitor, and verify the project's energy savings
- Assume the risk that the project will save the amount of energy guaranteed.

These services are bundled into the project's cost and are repaid through the dollar savings generated. [35]

3.2.1 Incorporating Photovoltaics into an Energy Services Performance Contract

There are various approaches to including photovoltaics in ESPCs. Solar projects are usually only feasible within an ESPC with the help of incentives, rebates, or other forms of capital that can contribute to reducing the amount of financing required for the project. The ESCO can be a valuable resource to identify these grants, rebates, and incentives. One benefit of the ESPC model is the ability to bundle many energy efficiency measures from several buildings across a school district into one large performance contract. This method can leverage savings to reduce the payback period of a solar system that if implemented as a stand-alone project would not be feasible. This is possible because ESPCs use an average of the payback of all conservation measures included to determine the contract term. This is the most common method to implement small-scale solar projects in ESPCs.

3.2.2 Including Photovoltaics in an Energy Services Performance Contract

The Roslyn School District in New York has partnered with an ESCO in a performance contract that will save $230,000 annually over 15 years and capture $130,000 in solar and lighting state rebates. [36] Improvements to the schools across the district include building envelope and insulation improvements, lighting upgrades, boiler and heating system upgrades, and two 11-kW PV systems. [36, 37]

Although this anecdotal example illustrates that PV installations have been installed as part of an ESPC, in general it has proven to be difficult, especially for larger installations. One issue is that the return on investment for projects that include a PV system bundled with energy efficiency investments such as lighting; heating, ventilating, and air-conditioning (HVAC) controls; and chiller upgrades could still exceed the requirements of the project sponsors. A second issue is that title of the equipment installed under an ESPC normally transfers automatically to the public agency upon the completion of the work. This impacts the ESCO's ability to benefit from the federal tax credits because the intended owner of these assets is a tax-exempt, public entity. To work around this issue, an ESPC could be structured whereby the ESCO immediately transfers title to all of the energy efficiency equipment, but retains ownership of the PV system for at least 6 years to allow for the tax benefits to vest. After the 6-year term, the ESCO could sell the PV system to the school district at fair market value. Anything less than FMV could trigger the recapturing of tax benefits earned by the ESCO. Finally, although an ESCO might have expertise with a wide range of energy efficiency investments, it might be less familiar with solar projects, thus adding complexity to the transaction.

A possible alternative to the ESCO retaining title to the PV system for at least 6 years is to bundle the physical installations of both the PV systems and the energy efficiency projects, but separate the financing mechanisms into a performance contract and a PPA. The guaranteed savings under the ESPC would pay for the energy efficiency investments. In parallel, the building owner would purchase the electricity generated by the PV system under a PPA rather than buying the system outright. This preserves the shorter return-on-investment timeline for the energy efficiency improvements, avoids the need to purchase the system at fair market value at the time, and also allows the federal tax credits to be monetized through the PPA.

Despite these complexities, ESCOs have been expanding the types of technologies included in ESPCs. In 2006, 10% of the ESCO industry revenue came from onsite renewable energy projects. [33] By 2008, this had increased modestly to 14% of total revenues. [33] The individual renewable energy technologies themselves were not broken out in this particular study, but it does appear that the ESPC industry is increasing its expertise in this area.

3.3 Resources

The best resource for additional information on ESPCs is the Energy Services Coalition. [38] Its website provides a variety of ESCO template documents and is available at http://www.energyservicescoalition.org/resources/model/index.html. For additional information, please consult the National Association of Energy Service Companies (http://www.naesco.org/), the State Energy or Commercialization Office, and the Status of ESPC Enabling Legislation in the United States (http://www.ornl.gov/info/esco/legislation/newesco.shtml).

Assistance from a national laboratory also can be accessed through the DOE Technical Assistance Program (http://www1.eere.energy.gov/wip/assistance.html). Federal ESPC best practices and guidance documents are valuable resources that often can be modified for local government initiatives and can be found on the DOE Office of Energy Efficiency and Renewable Energy (EERE) Federal Energy Management Program (FEMP) Resources website at http://www1.eere.energy.gov/femp/financing/espcs_resources.html.

4 Summary

This report presents a number of energy efficiency and renewable energy options that are available to school districts as they implement their Solar Master Plans. Both direct-purchase and third-party finance alternatives are feasible, depending on the particular circumstances of each district. In certain cases the use of the various tax credit bonds will be limited to those districts with allocations in hand. Given its various allocations, Oakland Unified, for example, is well positioned to compare a variety of tax-credit bond options. Depending on available funding, third-party finance options could also be a course of action to pursue, even if eventual ownership in the medium term of the PV systems is the desired outcome.

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Appendices

Appendices for this report are contained on an accompanying CD. These references include a number of pertinent documents related to financing solar installations on schools and other public facilities. A list of these documents follows.

Request for Proposal for Procurement of Photovoltaics on Public Schools

- San Ramon Valley Unified School District: http://www.srvusd.net/solar
- Mount Diablo Unified School District

ESPC Documents

- RFP Template for ESPC: http://www.energyservicescoalition.org/resources/model/index.html
- Energy Performance Contract Template: http://www.energyservicescoalition.org/resources/model/index.html
- Financing Solicitation Template: http://www.energyservicescoalition.org/resources/model/index.html

Third-Party PPA Documents

- NREL Checklist: http://www.nrel.gov/docs/fy10osti/46668.pdf
- SolarTech PPA Template
- SolarTech Lease Template
- Milpitas Unified School District PPA with BankAmerica: https://www.musd.org/cms/page_view?d=x&piid=&vpid=1217983977356

New Markets Tax Credit

- NREL Fact Sheet on the City of Denver: http://www.nrel.gov/docs/fy10osti/49056.pdf
- NREL Fact Sheet on Yolo County: http://www.nrel.gov/docs/fy11osti/49450.pdf

Office of Public School Construction Funds

- School Facility Program requirements for the New Construction Grant: www.documents.dgs.ca.gov/opsc/Resources/SFP_NC_Rqmnts.pdf
- School Facility Program requirements for the Modernization Grant: www.documents.dgs.ca.gov/opsc/Resources/SFP_Mod_Rqmnts.pdf
- Checklist for High Performance Incentive (HPI) Projects: www.documents.dgs.ca.gov/dsa/other/HPI_Checklist_rev02-07-10.pdf
- DSA High Performance Incentive (HPI) Scorecard and Guidelines: http://www.documents.dgs.ca.gov/dsa/other/GL-5_HPI.pdf

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 8

Maximizing the Value of Photovoltaic Installations on California Schools: Choosing the Best Electricity Rates

Maximizing the Value of Photovoltaic Installations on California Schools: Choosing the Best Electricity Rates

Utility rates or tariffs are among the least understood and most complicated elements of a renewable energy system transaction. Not considering applicable and available utility rates, or making a mistake in choosing rates, when installing a PV system could diminish the benefits the school district receives from the PV system.

Every utility has a variety of tariffs for different types of customers, e.g. residential, commercial, agricultural, and industrial. Each customer within these categories also pays different tariffs based on the amount of electricity consumed and the time of day when it is consumed.

Tariffs within a school district vary; for example, different rates might apply to metered sports field lights, gymnasiums, and buildings housing classrooms. When a district sites a PV project, it is generally true that the PV should be tied into the meter that is recording the greatest electricity consumption because doing so will maximize the district's energy cost reduction.

It is important to analyze the district's historical electricity consumption and cost against the projected electricity production promised by the PV vendor. This analysis will help to ensure that the district selects the best utility tariff and that the projected savings from the PV project will be realized.

One way to achieve electricity bill savings even when PV is not contemplated is to ask your utility to analyze the district's schools electricity consumption against all relevant tariffs. It is not unusual that the tariff originally selected for the school is no longer the best tariff available. This occurs when the school is being operated in a different manner than when the tariff was set. Most utilities will run this analysis annually for a district at no cost. The utility may also provide tools that allow the district to run a "what-if" analysis. For example, see PG&E's "what if" analysis tool here: **http://www.pge.com/mybusiness/myaccount/rates/tools/**.

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Maximizing the Value of Photovoltaic Installations on Schools in California: Choosing the Best Electricity Rates

Sean Ong and Paul Denholm

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Sean Ong and Paul Denholm

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Executive Summary

Schools in California often have a choice between multiple electricity rate options. For schools with photovoltaic (PV) installations, choosing the right rate is essential to maximize the value of PV generation. The rate option that minimizes a school's electricity expenses often does not remain the most economical choice after the school installs a PV system. The complex interaction between PV generation, building load, and rate structure makes determining the best rate a challenging task. Twenty-two rate structures across three of California's largest electric utilities—Pacific Gas and Electric Co. (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E)—were evaluated in order to identify common rate structure attributes that are favorable to PV installations. Key findings include:

- **The best electricity rate for a school depends on the amount of PV capacity installed.** The rate structure that minimizes the school's electricity expenses prior to a PV installation still remains the best rate after a PV system is installed, as long as the system is small compared to the school's electric load. Other rates become more economical than the initial rate for larger PV system sizes (see Figure ES-1).
- **When a school's PV installation is large, rates with high daytime prices are favorable.** The best rates for schools with relatively large PV systems, or high penetrations, are those with very high afternoon energy prices and little or no demand charges. However, when the PV installation is small, these expensive rates increase the school's annual electricity expenses, even with the PV system helping to offset costs.
- **The best size for a school's PV system depends on the available rate options.** When evaluating the economics of a PV system, bigger is not always better. In San Diego, the best PV system is one that is sized to meet about 10% of a school's annual electric load. For PG&E customers, maximizing the size[1] of the PV installation is best.
- **With the best rates considered, power purchase agreements (PPAs) may be a better option for schools than cash purchases.** A school purchasing a PV system up front will break even[2] at a PV cost of about \$3–\$5/W. This is below the average installed cost of \$6/W,[3] as determined at the time of this report. Because public schools cannot take advantage of tax incentives, purchasing the system up front may not be in the school's best economic interest. The break-even PPA prices, however, are in the range of \$0.16–\$0.22/kWh, making the PPA option economically attractive.

[1] It is important, however, to stay within the net-metering limits. Exported PV that is not compensated at retail rates will cause the value to decrease sharply. The limit at the time of this report is 100% of net annual consumption.
[2] See Section 2.4 on the definition for break-even and how it is calculated.
[3] See Section 2.4.

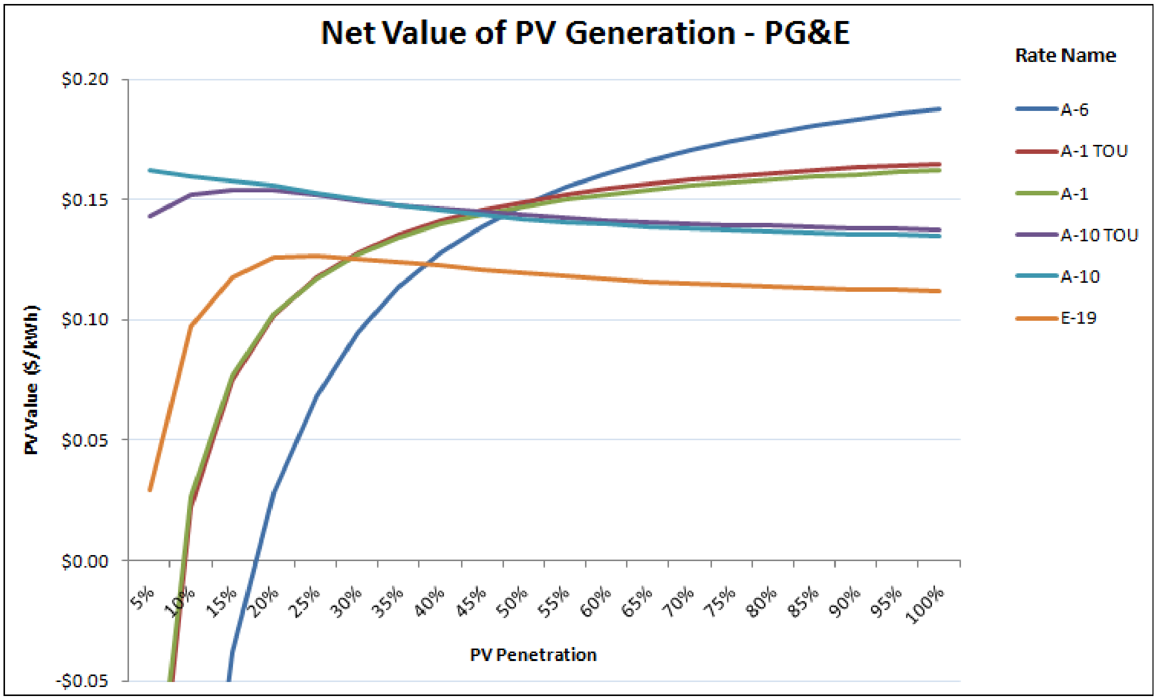

Figure ES-1. Value of PV generation under various rate structures and penetration levels for schools in the PG&E service territory

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1 Introduction

In California, schools are increasingly considering solar technologies as a way to help offset a portion of their annual energy expenditures. School buildings in the state typically have relatively large roofs that could allow for solar photovoltaic (PV) systems capable of generating a significant portion of their annual electricity needs. However, the value of this generation is highly dependent on the school's electricity rate. Schools often have a choice between multiple rate options. Understanding what rate structure optimizes savings requires an analysis of the interaction between the building load, PV generation, and rate structure. High resolution data (hourly or sub-hourly resolution) is essential when determining the impacts of time-of-use (TOU) charges and demand charges. The cost of the PV installation must also be factored into the analysis in order to determine the net effect on the school's annual expenses. These considerations may present a challenging task for schools that are trying to determine whether or not solar makes economic sense for their campus or for schools deciding whether or not to switch rates in order to maximize existing PV system value. This report identifies the rate structure elements that are beneficial to schools and the conditions under which various rate structures should be considered.

In this study, 22 rate structures from the top three electric utilities in California were evaluated. These utilities are Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E). These rate structures were used to assess PV value and annual savings for schools in each of the three utility service territories. Two case studies were also conducted for actual schools in Berkeley (Berkeley High School) and San Diego (Lewis Middle School). These case studies can be found in Appendix A and Appendix B. Rate impacts are dependent on individual school load profiles, which vary from one school to another. These results are not intended to represent all schools in California. Schools considering a solar installation should evaluate their facility's unique load profile and use this report as a guide to analyze the potential impacts of a PV system. The report results are intended to explore rate structure elements that are typically beneficial for PV installations and to help identify general trends for the impacts of rate structures on schools with solar systems.

2 Data and Methodology

2.1 Load Data

Building load data are an important component in any rate structure analysis that includes demand charges and tiered rates. Demand charges are usually based on the peak monthly power demand of a building; consequently, quantifying the demand reduction value of a PV system requires a load profile. Load profiles are also required when evaluating tiered rates, where rates vary depending on monthly energy usage. This analysis uses load profile data created in part for the U.S. Department of Energy (DOE) commercial building benchmark models (Torcellini et al. 2008), which were simulated using the EnergyPlus simulation software.[4] All loads and buildings for the benchmark models were simulated under typical meteorological year 2 (TMY2) conditions. TMY2 is a dataset of the National Solar Radiation Database (Marion and Urban 1995; Wilcox 2007). For consistency, TMY2 conditions were used when simulating PV performance. Although the benchmark models consist of a variety of different commercial building types across 16 climate zones, the data used for this analysis consist of only simulated high school buildings across two climate zones.[5] Figure 1 shows the locations of each climate zone in the United States. Table 1 summarizes the climate zones associated with each utility service territory covered in this analysis along with the schools' annual electricity usage patterns.

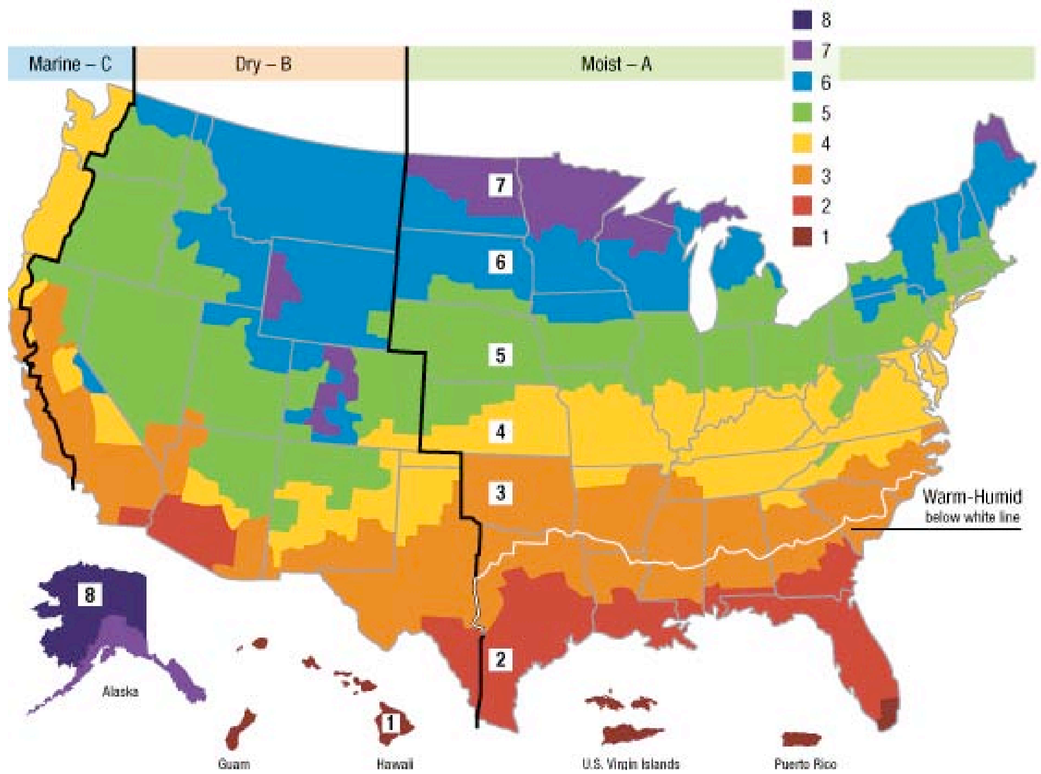

Figure 1. Climate zone map of the United States

Source: DOE 2011

[4] For more information on the EnergyPlus model, see http://apps1.eere.energy.gov/buildings/energyplus/.

[5] The climate zones used in Figure 1 are 3B-Coast and 3C. These zones are a subset of the climate zones officially recognized by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

Table 1. Climate Zone and Building Characteristics Associated with Each Utility Service Territory

Utility Service Territory	ASHRAE Climate Zone	Annual Building Load (MWh)	Peak Annual Load (kW)
Pacific Gas and Electric	3C	2,682	1,150
Southern California Edison	3B-Coast	2,632	941
San Diego Gas and Electric	3B-Coast	2,632	941

The high school buildings are modeled to have three floors with a total floor area of 210,890 ft². The building simulation data includes aggregated hourly load profiles for all electrical loads associated with each school building and includes smaller loads such as plug loads. EnergyPlus simulated this data using the 2003 Commercial Building Energy Consumption Survey[6] (CBECS) results as guidance on the various load types within each facility. The total hourly electrical load of each building was entered into the System Advisor Model (SAM).[7] See Section 2.4 for SAM details. Figures 2 and 3 show the hourly load profile for each of the three simulated school buildings.

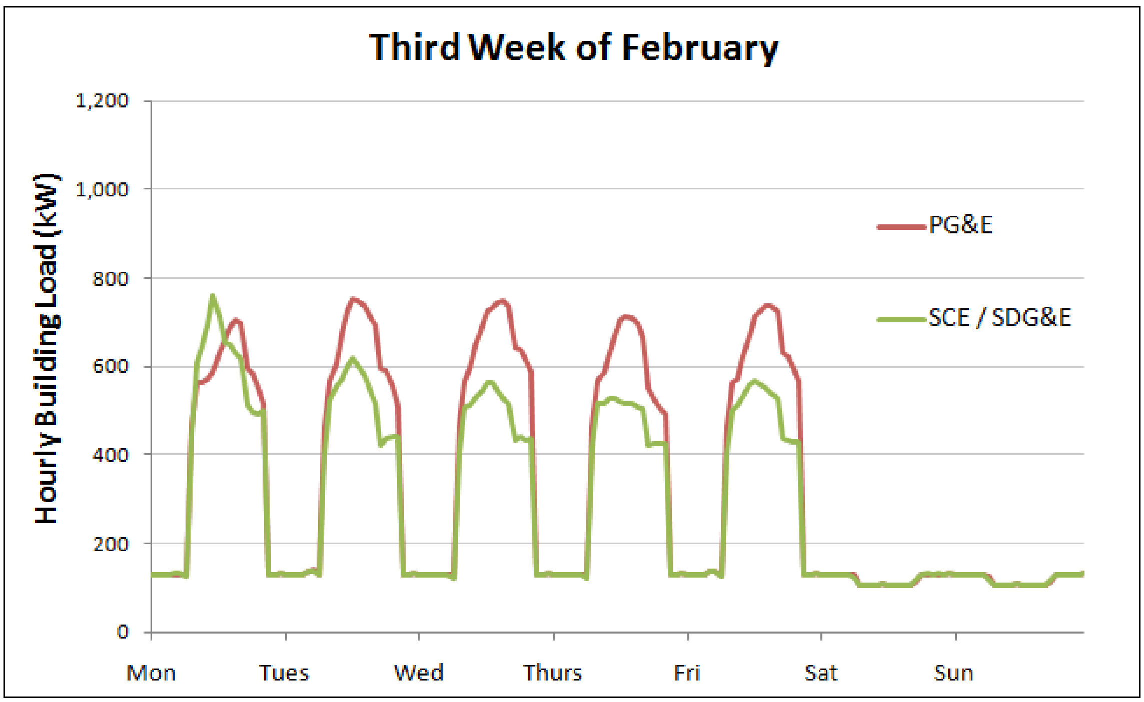

Figure 2. Hourly school load profiles during the third week of February

[6] For more information on CBECS, visit http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html.

[7] Demand charges are usually measured and billed according to 15-minute time increments. The lack of 15-minute data resolution for this analysis may present an overestimation of a PV system's ability to offset demand charges. This could occur if the hourly data masks or smoothes sub-hourly spikes and dips in demand and production. Despite a potential for overestimation, previous studies still show that rates with demand charges are poorly suited for PV systems (Ong et al. 2010).

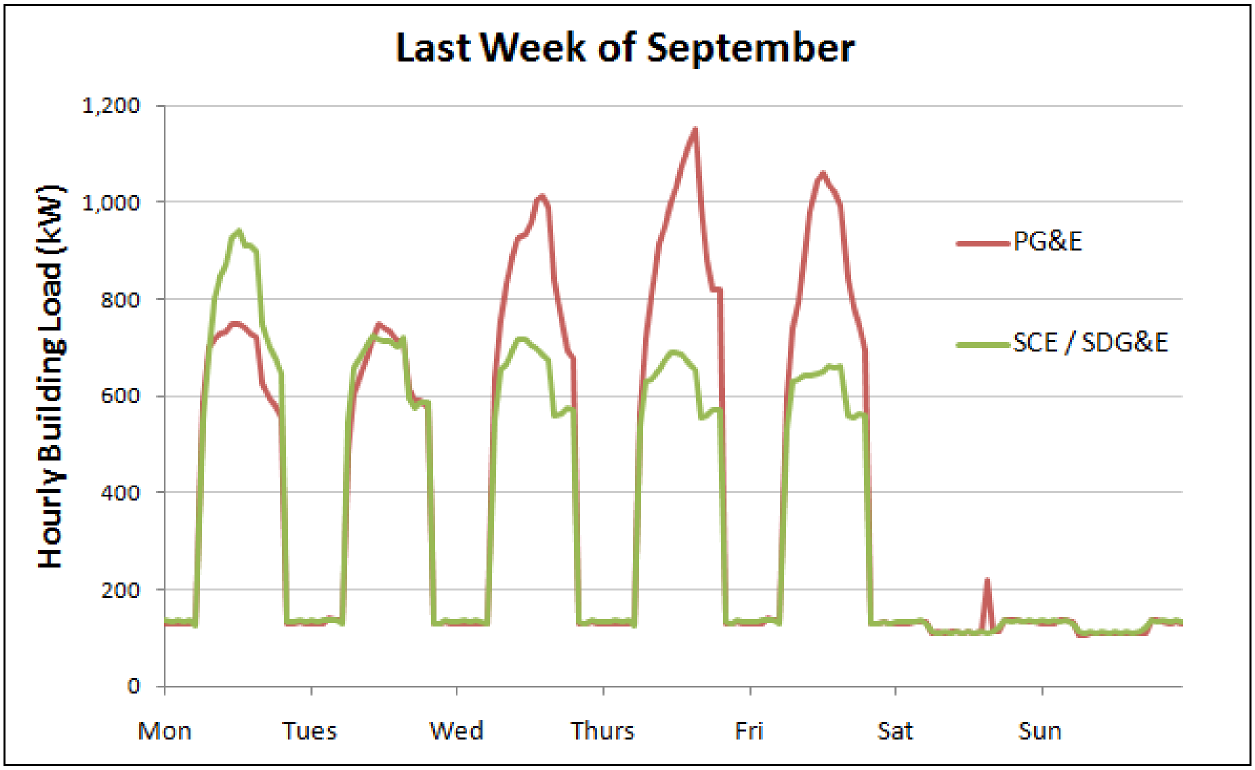

Figure 3. Hourly school load profiles for the last week of September

2.2 Rate Data

A total of 22 utility rates in the three utility service territories were evaluated. These rates were obtained from the online Utility Rate Database (URDB) on the OpenEI platform[8] and verified with the official utility tariff sheets to ensure accuracy. The utilities offer various commercial rate structures for different load sizes and types. Smaller loads typically have more rate choices than larger loads since smaller users may sometimes choose to be on rates designed and made mandatory for larger loads. In some cases, larger facilities with solar installations have the option to use rates designed for smaller facilities. In some cases, large schools may divide electricity consumption across multiple meters. Each meter is treated independently and measures only a portion of the campus's total load, thereby allowing for greater flexibility in rate choice. Figure 4 illustrates the eligibility range for each of the 22 utility rates. Note that rates A in SDG&E and rates GS-1 and GS-1-TOU in SCE are only available to customers with a maximum demand of 20 kW or less. Because this limit is very low compared to typical school campus loads (even with split meters), they were not considered in the rate and cost impact calculations, though they were still analyzed for reference purposes.

[8] Open Energy Information (OpenEI) is a knowledge-sharing online community dedicated to connecting people with the latest information and data on energy resources from around the world (http://www.OpenEI.org). OpenEI was created in partnership with the DOE and federal laboratories across the nation. OpenEI's URDB (http://en.openei.org/wiki/Gateway:Utilities) contains downloadable rate structure information from hundreds of electric utilities around the United States.

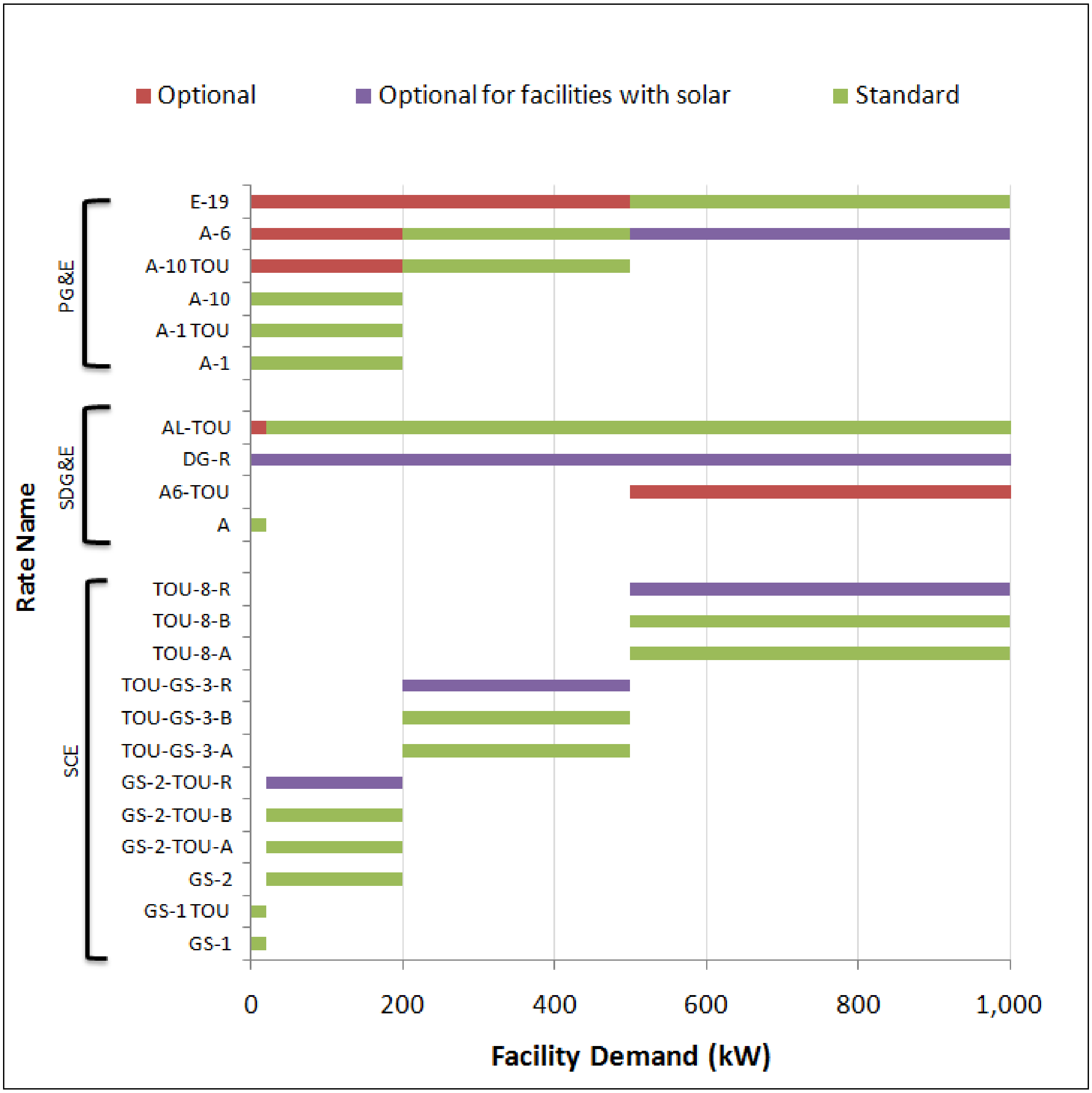

Figure 4. Applicability of electricity rates for commercial facilities in each of the three utility service territories studied

Various types of utility rates are used throughout the United States. The most common rate types (Ong et al. 2010) include the following:

- **Flat rates**. Fixed cost of energy that does not vary except for fuel cost adjustments and other fees.
- **Seasonal rates**. Rates that vary by season. A typical seasonal rate structure has a lower rate for winter months and a higher rate for summer months.

- **Time-of-use rates**. Time-of-use (TOU) or time-of-day rate structures usually vary 2–4 times a day. A typical TOU rate has a lower cost at night, a higher cost during the late afternoon, and an intermediate cost during the mornings and evenings. The term “on-peak” or “peak” is generally used to describe hours with higher prices while “off-peak” is used to describe hours with lower prices.
- **Demand charges**. Normally included with energy charges in applicable rate structures, demand charges charge customers for their peak power (kilowatts) usage. Demand charges can also be fixed or vary by season or hour.
- **Tiered or block rates**. Tiered rates typically refer to rates that increase with increasing electricity usage while block rates typically refer to rates that decrease with increasing electricity usage. These rates are most common in the form of energy charges; however, tiered demand charges are also used.

Table 2 summarizes the various categories represented by the 22 rates used for this analysis. Tiered or flat rates were not evaluated. There was a good representation of seasonal rates, TOU rates, and demand charges; 13 of the 22 rates combined all three of those categories.

Table 2. Summary of Applicable Categories and Price Levels for the Rates Evaluated

Utility	Rate Name	Flat	Seasonal	TOU	Demand	Tiered	Relative Price Level
SCE	GS-1		✓				Moderate-to-high energy prices
	GS-1 TOU		✓	✓			Very high energy prices during summer afternoons
	GS-2		✓		✓		Moderate energy prices; high summer demand charges.
	GS-2-TOU-A		✓	✓	✓		High energy prices; moderate demand charges
	GS-2-TOU-B		✓	✓	✓		Moderate energy prices; high demand charges.
	GS-2-TOU-R		✓	✓	✓		Very high energy prices; low demand charges
	TOU-GS-3-A		✓	✓	✓		Moderate-to-high energy prices; moderate demand charges
	TOU-GS-3-B		✓	✓	✓		Low energy prices; moderate-to-high demand charges.
	TOU-GS-3-R		✓	✓	✓		High energy prices; low demand charges
	TOU-8-A		✓	✓	✓		High summer afternoon energy charges
	TOU-8-B		✓	✓	✓		Low energy prices; high summer afternoon demand charges
	TOU-8-R		✓	✓	✓		High energy prices; low demand charges
SDG&E	A		✓				Very high energy prices
	A6-TOU		✓	✓	✓		Low energy prices; high demand charges
	DG-R		✓	✓	✓		High energy prices; low demand

Utility	Rate Name	Flat	Seasonal	TOU	Demand	Tiered	Relative Price Level
							charges
	AL-TOU		✓	✓	✓		Intermediate energy prices; high demand charges
PG&E	A-1		✓				Moderate-to-high energy prices
PG&E	A-1 TOU			✓			High energy prices during summer afternoons; moderate prices otherwise
PG&E	A-10		✓		✓		Moderate energy prices; high demand charges
PG&E	A-10 TOU		✓	✓	✓		Low off-peak energy prices; moderate peak energy prices; high demand charges
PG&E	A-6			✓			Very high energy prices during summer afternoons; low-to-moderate prices otherwise
PG&E	E-19			✓	✓		Moderate energy prices during summer afternoons; lower energy prices otherwise; very high demand charges during summer afternoons; moderate demand charges otherwise

2.3 Solar Data

The PV production data used in this analysis were simulated using the TMY2[9] dataset of the National Solar Radiation Database (Marion and Urban 1995; Wilcox 2007). The TMY2 dataset is intended to represent a typical year's weather and solar resource patterns, though the dataset does not consist of an actual representative year. Rather, TMY2 was created by combining data from multiple years.[10] The meteorological dataset was used as an input for the SAM, which simulated hourly PV production for use in the financial calculations.

2.4 System Advisor Model and Calculations

Developed by the National Renewable Energy Laboratory (NREL) in collaboration with Sandia National Laboratories and DOE, SAM is a performance and economic model designed to facilitate decision making and analysis for renewable energy projects (NREL 2011). The TMY2 meteorological data was provided as an input for SAM, which uses a performance model and user-defined assumptions to simulate hourly PV generation data. The following assumptions were used when generating the PV performance data:

- 15-degree tilt

[9] Although TMY3 data was available at the time of this analysis, the TMY2 data was used because the DOE benchmark buildings simulation data was also simulated using the TMY2 data. This allows for a more consistent treatment of building demand reduction and demand charge benefits.

[10] For example, the month of January may be from one year (e.g., 1989) while February may be from another year (e.g., 1994). Each TMY2 file may contain data from up to 12 different years. Data was intentionally selected to be representative of typical meteorological conditions.

- South facing (180-degree azimuth)
- A de-rate factor of 85%
- Annual degradation of 0.5%.

In addition to the meteorological data, hourly building load data and utility rate data[11] were given as inputs for SAM. A rooftop PV system was simulated for various penetration levels ranging from 0% (no PV system) to 100% (PV system generates the same amount of energy as each school's annual electrical energy consumption[12]) in increments of 5%. PV penetration is defined as the percentage of a facility's annual electrical energy consumption that is met by a PV system. The value of the PV system's generation under various penetration levels and rate structures was evaluated by comparing the schools' annual electricity costs both with and without the PV system in each scenario. Any resulting difference from the comparison was attributed to the PV system. The combination of scenarios requires hundreds of unique simulations, from which the model can determine the PV penetration and rate structures that are likely optimal.

The impacts of system costs were also considered in the analysis. Schools may choose various ways to finance a rooftop solar installation. For schools in California, typical choices include:

- **Third-party ownership/power purchase agreements**. This arrangement consists of a third party owning and maintaining the PV system installed on campus. The third party charges the school for the energy generated by the PV system, usually based on a pre-negotiated price (in cents per kilowatt-hour). The school, in turn, will realize savings from a reduced electricity bill because of the energy offset by the PV production. Since schools are non-profit entities, they cannot take advantage of tax incentives such as the 30% federal investment tax credit. However, the system owner can take advantage of the tax incentives, which may result in the solar system being economically beneficial to both the third party and the school.[13] Third-party ownership may also be in the form of a lease agreement, where the school pays a fixed monthly lease payment for the solar equipment instead of a price per generated kilowatt-hour.
- **Cash purchase**. The school district directly pays for the PV system with general funds. Schools may be less attracted to this option for large installations due to high upfront costs and ineligibility for tax incentives.
- **Publically funded/general obligation bond**. Schools paying for solar systems under a general obligation (GO) bond will have little or no upfront costs. This option is favorable to schools because they can realize the benefits of a reduced electricity bill while having little or no costs associated with the system. Public financing arrangements are not always available to schools and must first be approved by local governments or voters.

[11] SAM communicates directly with OpenEI's online URDB to obtain the latest rate information available on OpenEI. For more information about the rate data and the online rate database, see Section 2.2 and http://apps1.eere.energy.gov/buildings/energyplus/.

[12] Although the PV system generates the equivalent of 100% of the school's annual electricity consumption, there will be times that the PV system exports energy to the grid (afternoons) and times that the school imports energy (nights). Existing net-metering policies allow excess generation to be credited toward the following month's bill, effectively allowing the generation to be compensated, up to 100% of annual consumption, at retail rates.

[13] Being able to take advantage of the 30% investment tax credit allows the system owner to pass their savings on to the school (in the form of a lower PPA rate) while still making a reasonable return on their investment.

Four metrics are used to evaluate PV system economics under the three ownership models described above. For power purchase agreements (PPA) and GO bonds, the bill impacts metric is used, which quantifies the percentage increase or decrease in the schools' annual electricity expenses. The bill impact metric is calculated as follows:

$$Annual\ bill\ savings\ (\%)\ = \frac{Lowest\ cost\ bill\ without\ PV - Lowest\ cost\ bill\ with\ PV - PPA\ payments}{Lowest\ cost\ bill\ without\ PV}$$

For GO bonds, the equation above still applies but without a PPA payment cost. It is important to note that many PPA prices include an annual escalation factor (including inflation). In this analysis, it is assumed that annual electricity escalation (including inflation) is equivalent to the PPA price escalation. This simplifying assumption allows any annual escalation factors to be cancelled out of the bill impacts equation.

In the analysis, PPA prices were also evaluated on a break-even basis. The break-even PPA price is the PPA price at which the schools' annual electricity expenses neither increase nor decrease. Essentially, the break-even PPA price is the point at which the PPA price equals the net PV value. The break-even PPA prices help to determine if the schools will be saving or losing money annually. If the PPA price is above break-even, then the school will be losing money (annual expenses are increased). However, if the PPA price is below break-even, then the school will be saving money (annual expenses are decreased).

The third metric considered is the break-even PV cost, which is the point at which the lifetime costs associated with a PV system are equivalent to the lifetime benefits (Denholm et al. 2009). The break-even cost was calculated by varying the installed PV cost until the net present cost equaled the net present benefits. The following assumptions were used in the break-even cost calculations:

- Upfront cash payment
- 30-year system lifetime, 30-year analysis period
- Real discount rate of 5%
- No federal, state, or local incentives
- Annual PV degradation of 0.5%
- Inverter replacements at year 10 and year 20 ($500/kW each time).

When evaluating a cash purchase scenario, the simple payback metric is used, which roughly quantifies the number of years required to "pay back" the upfront investment using the savings from a PV system. Simple payback is calculated as follows:

$$Simple\ payback\ (years) = \frac{Initial\ upfront\ cost}{Annual\ benefit\ from\ PV\ system\ under\ best\ rate}$$

According to the California Solar Initiative database (CSI 2011), government and non-profit solar installation costs in California range from less than $3/W to well over $10/W. The weighted average cost for government/non-profit solar installations is \$6/W.[14] In this analysis, upfront purchases were evaluated using \$3/W, \$4/W, \$5/W, and \$6/W.

[14] Evaluated for systems with nameplate capacities ranging from 20 kW to 800 kW.

3 Results

3.1 Net Value of Photovoltaic Generation

In order to compare the PV value across various penetration levels, it is important to focus more on value per unit of energy than absolute PV value—in this case, dollars per kilowatt-hour. Figure 5 illustrates the value of a rooftop PV system on a school building using PG&E rates under different penetration levels. PV value under rates A-6, A-1, and A-1 TOU do not vary with penetration level, while the remaining rates decrease with increasing penetration. This is because the first three rates in question do not have any demand charge components, but the latter rates do (see Table 2 in Section 2.2). Studies have shown that PV value under rates with demand charge components tend to lose value with increasing PV penetration (Wiser et al. 2007).[15] Rate A-6 yields the greatest PV value at $0.23/kWh, far above the other rate structures. Rate A-6 is a very expensive rate, with summer afternoon rates approaching $0.45/kWh. Although this gives high value to a PV system, results show that a school switching to this rate from a less expensive rate experiences an increase in total electricity cost, rendering any PV savings useless. Evaluating a rate structure in isolation without considering net bill impacts or other rate structure options is insufficient when conducting a rate analysis.

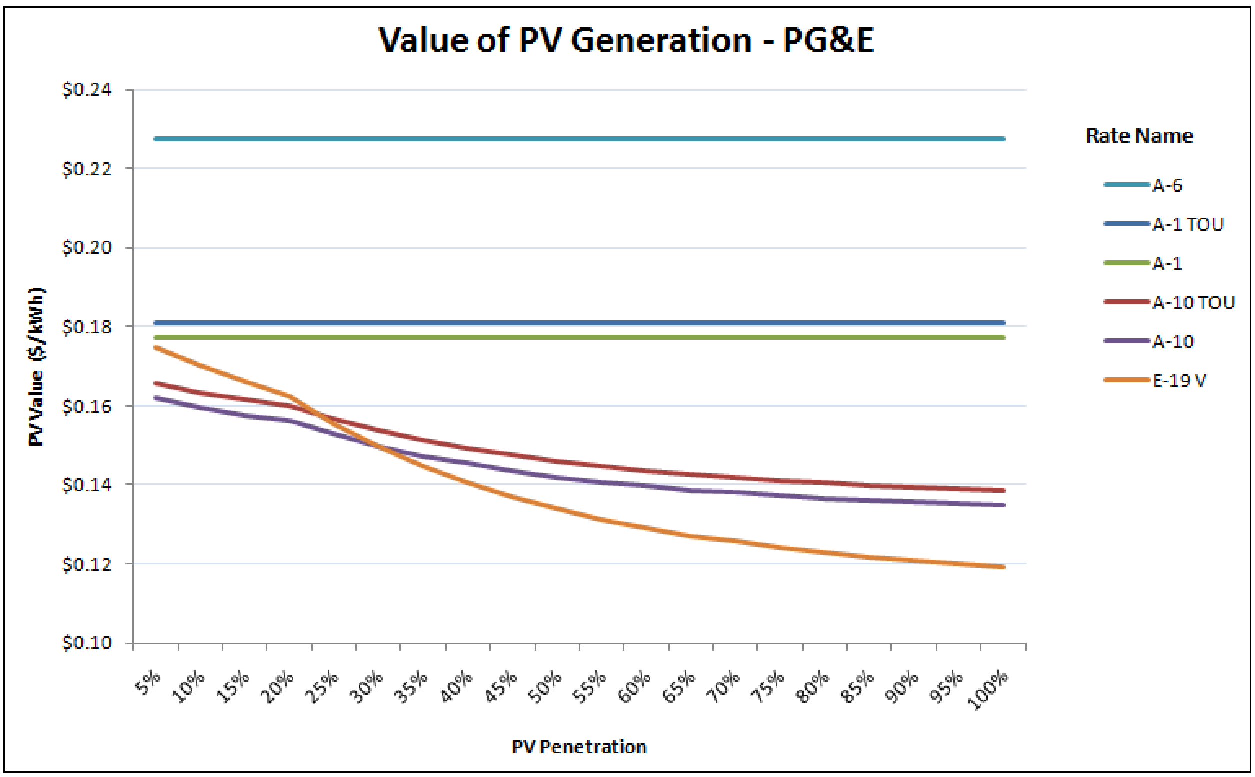

Figure 5. Value of PV generation under various rate structures and penetration levels for schools in the PG&E service territory

In order to accurately assess the value of PV under each rate structure, it is necessary to compare the schools' annual electricity costs without PV using the least cost rate. The least cost rate is the

[15] This is because PV generation is limited to the afternoon hours, and increasing PV production simply shifts the facility's peak demand to hours when the sun is not shining.

rate that minimizes annual electricity expense. This allows for the proper assessment of PV value in relation to the schools' lowest cost option prior to the PV installation. This calculation can be expressed as the following equation:

Net PV value = Energy cost with PV under rate in question – Energy cost without PV under least expensive rate

Rate A-10 turns out to be the least cost rate for the school load profile used in PG&E before installing PV. Figure 6 shows how the PV value changes once A-10 is set as the rate against which all other rates are compared. This is a significant change from the previous chart, showing that rate A-6 is no longer the most attractive rate at all penetration levels. Many rates yield a negative value when PV penetration is small. This is because switching to these rates from rate A-10 increases the school's annual energy cost, despite having a small rooftop PV system.[16] At higher solar penetrations, the increase in PV value (under rates with high energy charges and high daytime rates) is enough to offset the cost increases from switching rates, yielding a net savings. For PG&E, rate A-10 is the most economical rate until a 45% PV penetration, at which time rate A-1-TOU briefly becomes the best rate. After a 50% penetration, rate A-6 becomes and remains the most economical rate. The net PV value under various penetrations is also shown for schools in SCE and SDG&E (see Figures 7 and 8). The dotted lines denote rates that were only eligible for loads with peak demands of 20 kW or less. These rates were included in Figures 7 and 8 for comparison. Since typical school loads are much larger, these rates were not used in the bill savings and payback calculations in Section 3.2. See Section 2.2 for details on the applicable load levels for each rate.

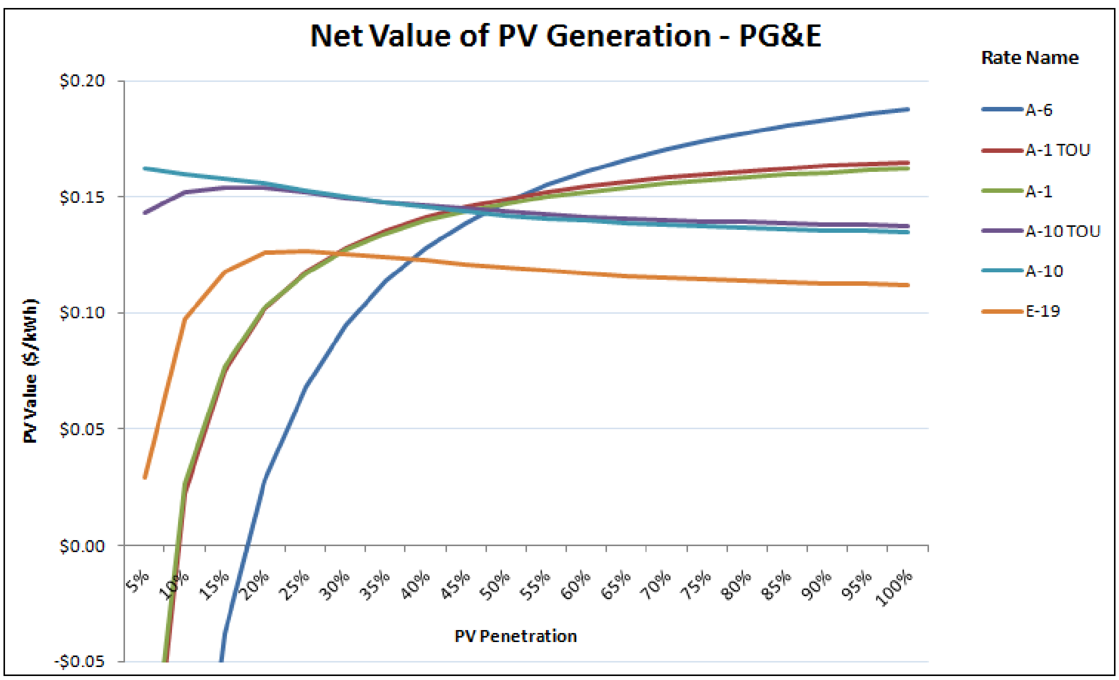

Figure 6. Net value of PV generation under various rate structures and penetration levels for schools in the PG&E service territory

[16] Though the PV system is still providing value to the school, it is not enough to overcome the increase in cost associated with switching to a more expensive rate. The result is a net annual loss to the school.

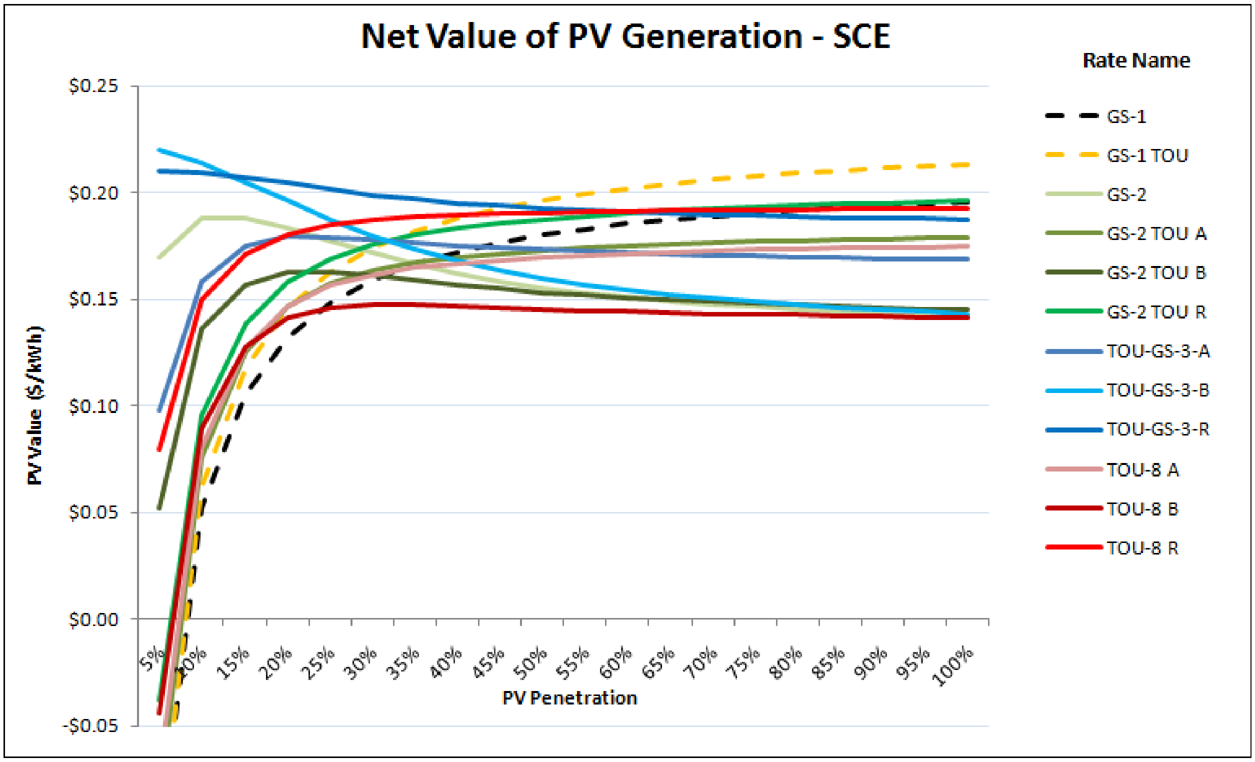

Figure 7. Net value of PV generation under various rate structures and penetration levels for schools in the SCE service territory

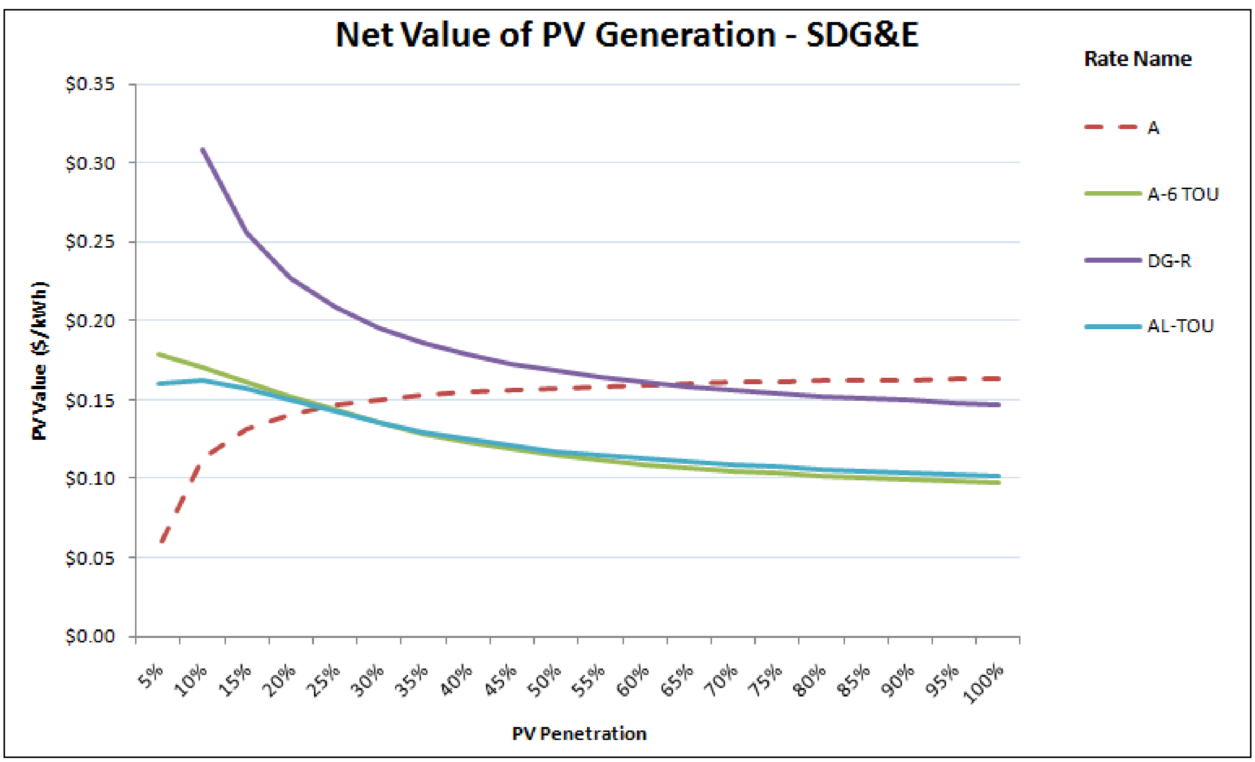

Figure 8. Net value of PV generation under various rate structures and penetration levels for schools in the SDG&E service territory

3.2 Impacts of Cost

Identifying the best rates under various PV penetration levels is important; however, in order to make a decision about installing a PV system, costs have to be factored into the analysis. Four metrics were used to evaluate PV system economics under the three ownership models described in Section 2.4:

- Simple payback
- Break-even PV cost
- Break-even PPA price
- Annual bill savings.

The simple payback period was calculated under the best rate option for each cost and PV penetration scenario. Payback periods for PG&E, SCE, and SDG&E are shown in Figures 9, 10, and 11, respectively. Payback periods at PG&E peak at a 45% PV penetration (13–27 years) and are shortest when approaching 100% penetration (10–21 years). Payback periods at SCE are shortest when PV penetration is under 30% and longest with 60% penetration. PV installations at SDG&E have a unique payback period curve due to the DG-R rate being applicable only with a 10% or greater PV penetration.[17] This causes abrupt minimum payback periods at a 10% penetration. At $6/W, the payback period for a PV system with a 5% penetration level is 21 years and quickly drops to 12 years with a 10% penetration. Payback periods continue to increase as penetration increases, with the longest periods occurring at 100% penetration.

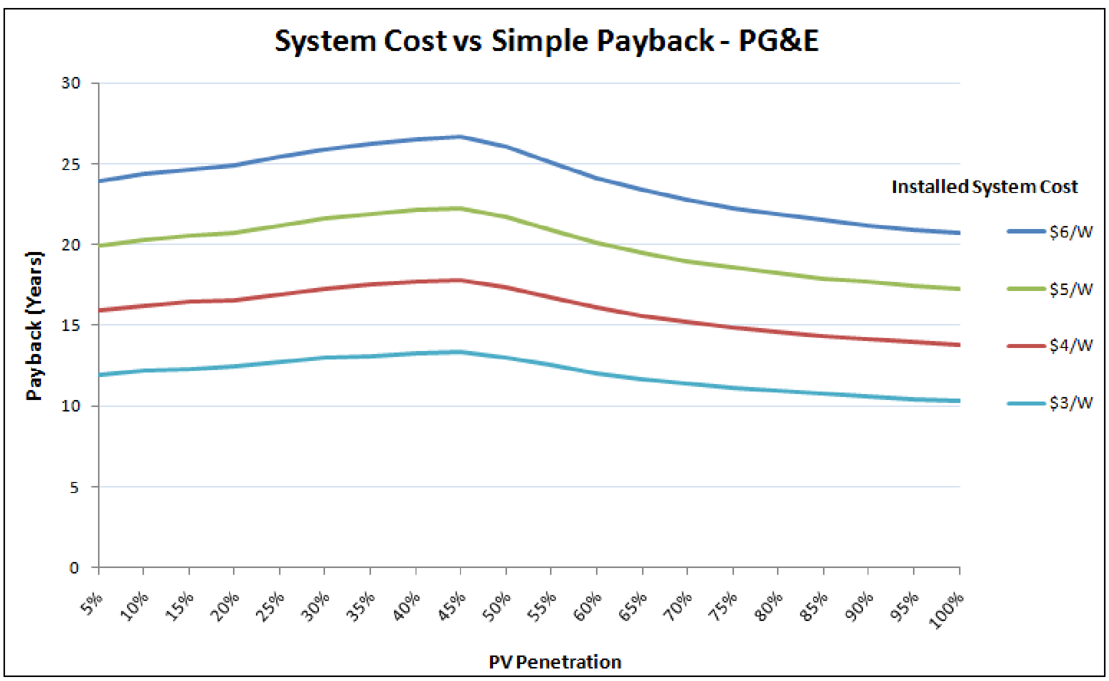

Figure 9. Simple payback for school PV system in PG&E service territory

[17] DG-R requires at least a 10% capacity penetration rather than a 10% energy penetration. It was discovered that a 7.5% energy penetration is sufficient to provide 10% of peak annual load. Because the PV penetration resolution is limited to 5% increments, DG-R was chosen to become effective at a 10% energy penetration.

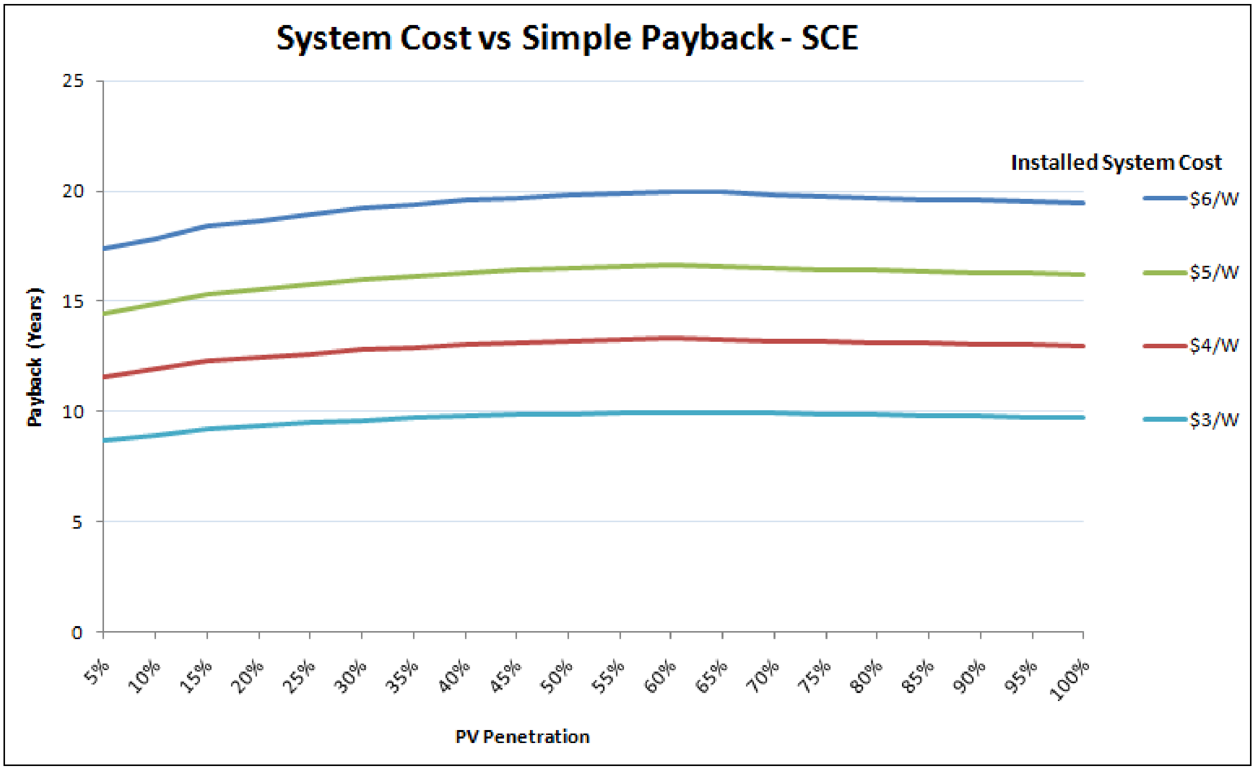

Figure 10. Simple payback for school PV system in SCE service territory

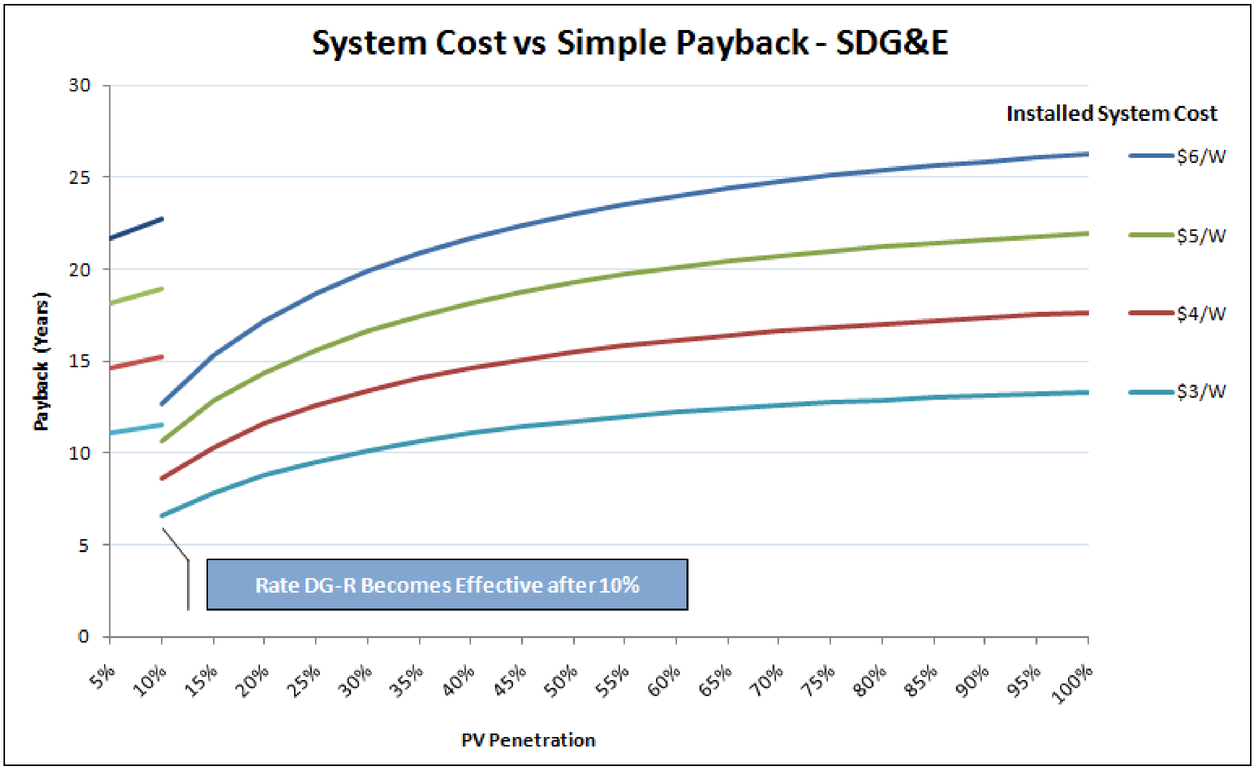

Figure 11. Simple payback for school PV system in SDG&E service territory

The simple payback metric is useful when trying to roughly determine if an investment is reasonable, but the break-even cost metric provides a more thorough economic analysis. Figure 12 shows the break-even PV costs for the three utility service territories. Break-even PV cost in PG&E ranged from $2.86/W to $3.78/W. These prices are well below the $6/W average installed cost determined at the time of this report (see Section 2.4). Break-even PV costs will be lower for schools compared to other commercial buildings in California, partly because public schools are ineligible to take advantage of the 30% federal tax credit. Break-even costs for SCE are slightly higher, ranging from $4.05/W to $4.58/W, while SDG&E has the highest break-even cost of $6.58/W at a 10% penetration.

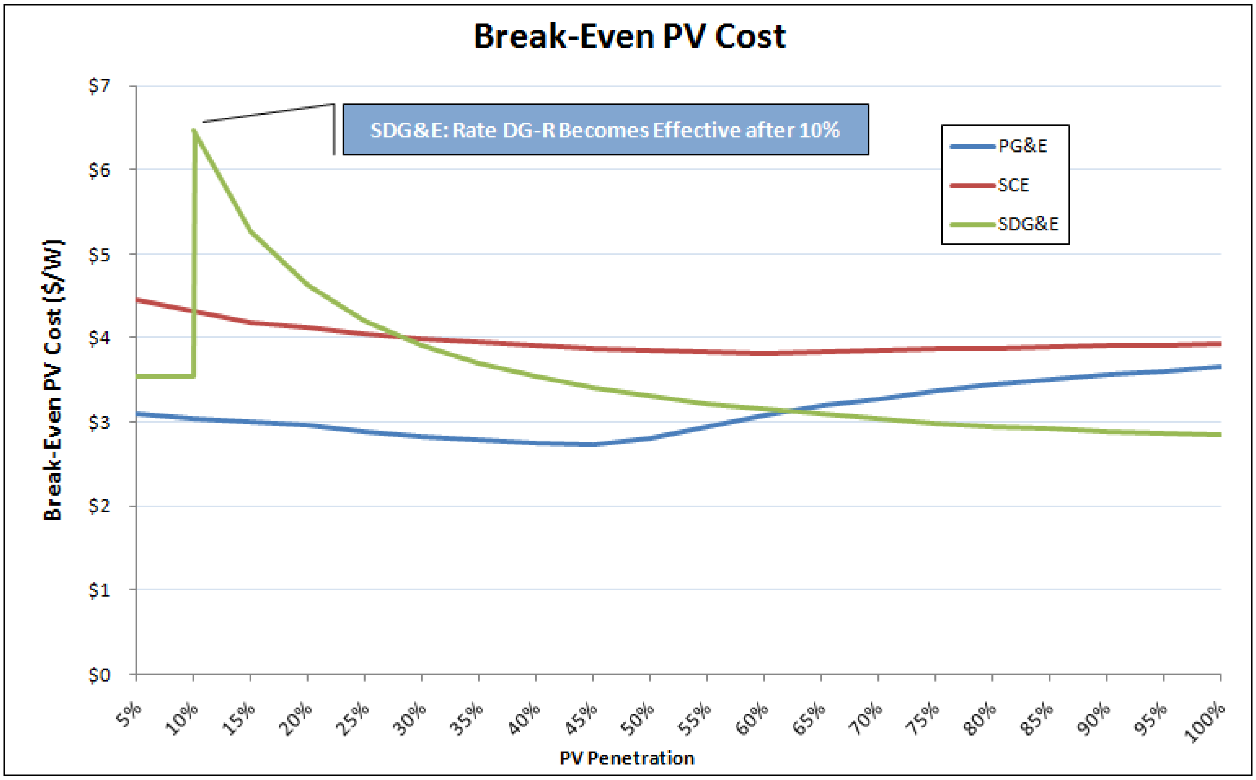

Figure 12. Break-even PV cost for each utility

When evaluating PV systems under a PPA, it is important to look at the net effect on the school's annual electricity expense. If the PV value is greater than the PPA price, then the school will realize a net savings on annual energy expenses. If the PV value is less than the PPA price, then the school will realize a net loss. The break-even PPA price (PPA price at which the school neither saves nor loses money) is shown in Figure 13. The highest break-even PPA price is seen at SDG&E, where prices exceed $0.20/kWh for PV penetrations of 10%–30%, with a peak above $0.30 at a 10% penetration. Break-even price is also above $0.20/kWh at SCE until a 30% penetration, after which prices level between $0.19 and $0.20. PG&E's minimum break-even PPA price occurs at a 45% penetration with $0.146/kWh, after increasing to nearly $0.19/kWh when approaching a 100% penetration.

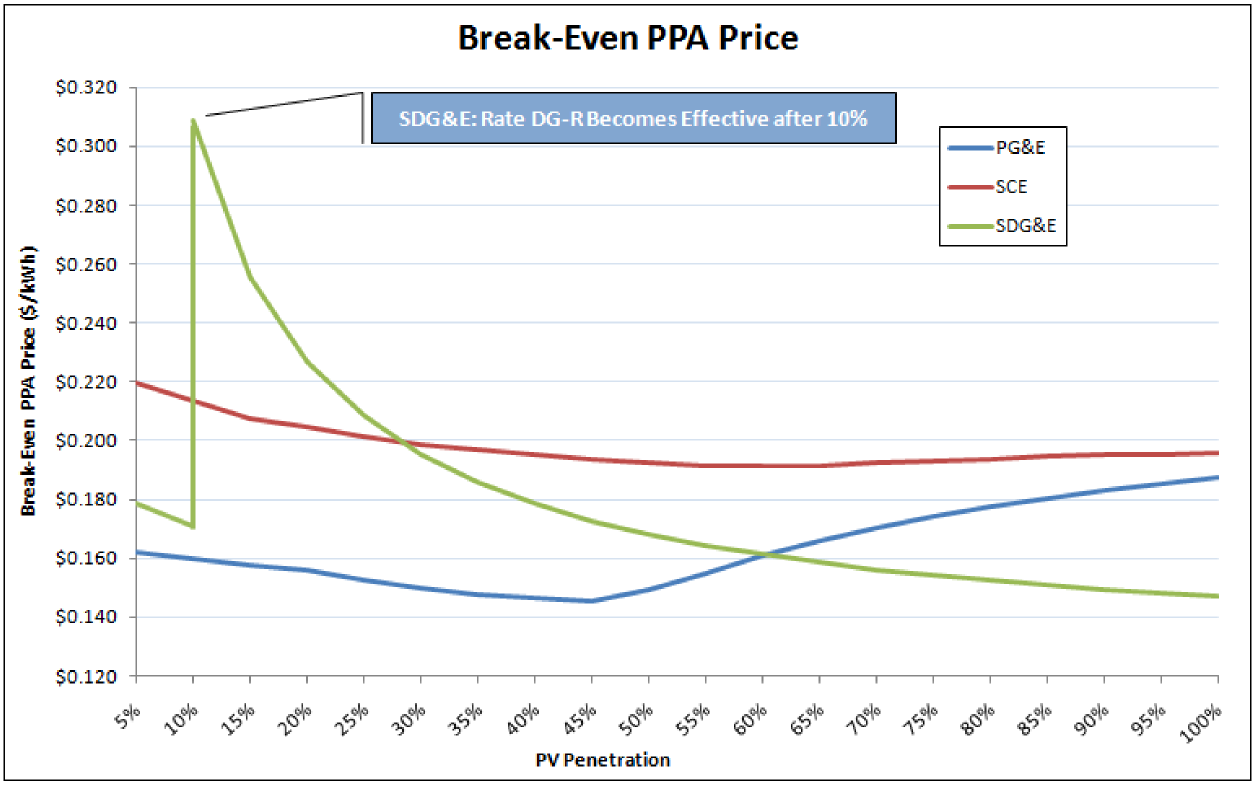

Figure 13. Break-even PPA price for each utility

In addition to the break-even PPA price, it is also useful to understand how annual electricity expenses will be impacted at various PPA price levels. Figures 14, 15, and 16 show the annual bill savings (as a percentage) under various PPA prices and penetration levels for schools in each of the three utility service territories. A change in PG&E's most economical rate, from A-10 to A-6, causes the elbow seen at the 45%–50% penetration level (see Figure 9). This chart shows that PPA prices of $0.15/kWh and below will result in a net savings to the school's annual electricity bill under most penetration levels. PPA prices of $0.20/kWh and above will always result in a net increase in the school's expenditures.

Schools in the SCE service area will always realize a net savings with PPA prices of $0.15/kWh and below. Very little change in annual electricity expenses will result under a PPA price of $0.20. Above that price, schools in the SCE service area will likely see an increase in annual electricity expenses.

Schools in the SDG&E service area can realize an annual savings under any of the evaluated PPA prices with a 10% PV penetration. This is because of the DG-R rate. Switching to this rate results in notable savings even when a PV system is not installed. However, SDG&E offers the DG-R rate only to buildings with at least 10% capacity penetration[18] from an eligible distributed generation installation. When PV penetration is small (10%), and even when the PPA price is high, switching to the DG-R rate may cover the PPA price and yield enough savings.

[18] The DG-R rate requires at least a 10% capacity penetration rather than a 10% energy penetration. This analysis found that a 7.5% energy penetration is sufficient to provide 10% of peak annual load. Because the PV penetration resolution is limited to 5% increments, DG-R was chosen to become effective at a 10% energy penetration.

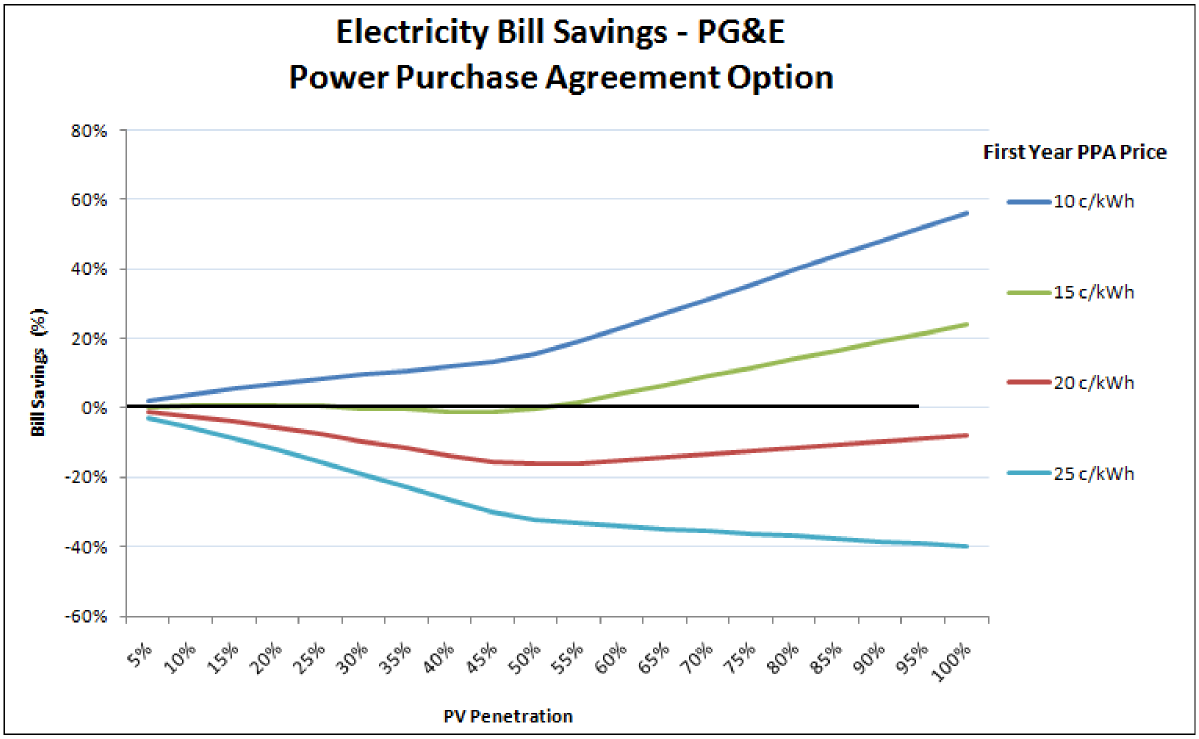

Figure 14. Annual electricity bill savings under various PPA prices and penetration levels for school in the PG&E service territory

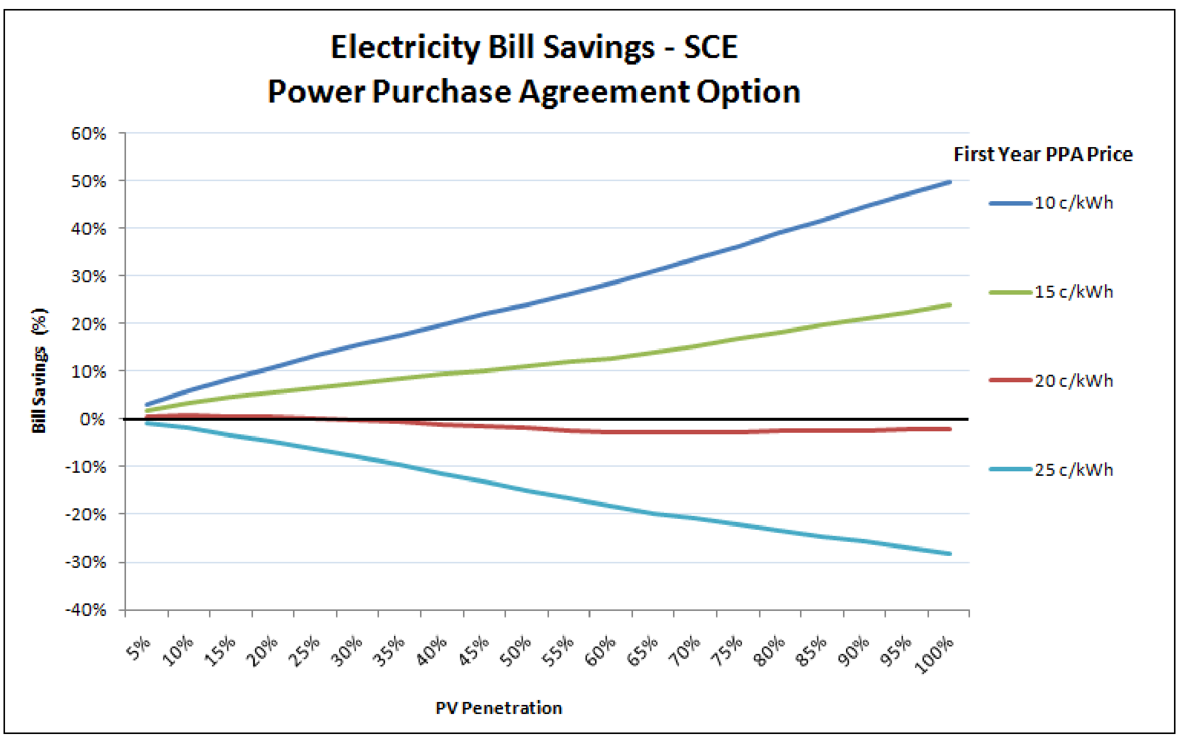

Figure 15. Annual electricity bill savings under various PPA prices and penetration levels for school in the SCE service territory

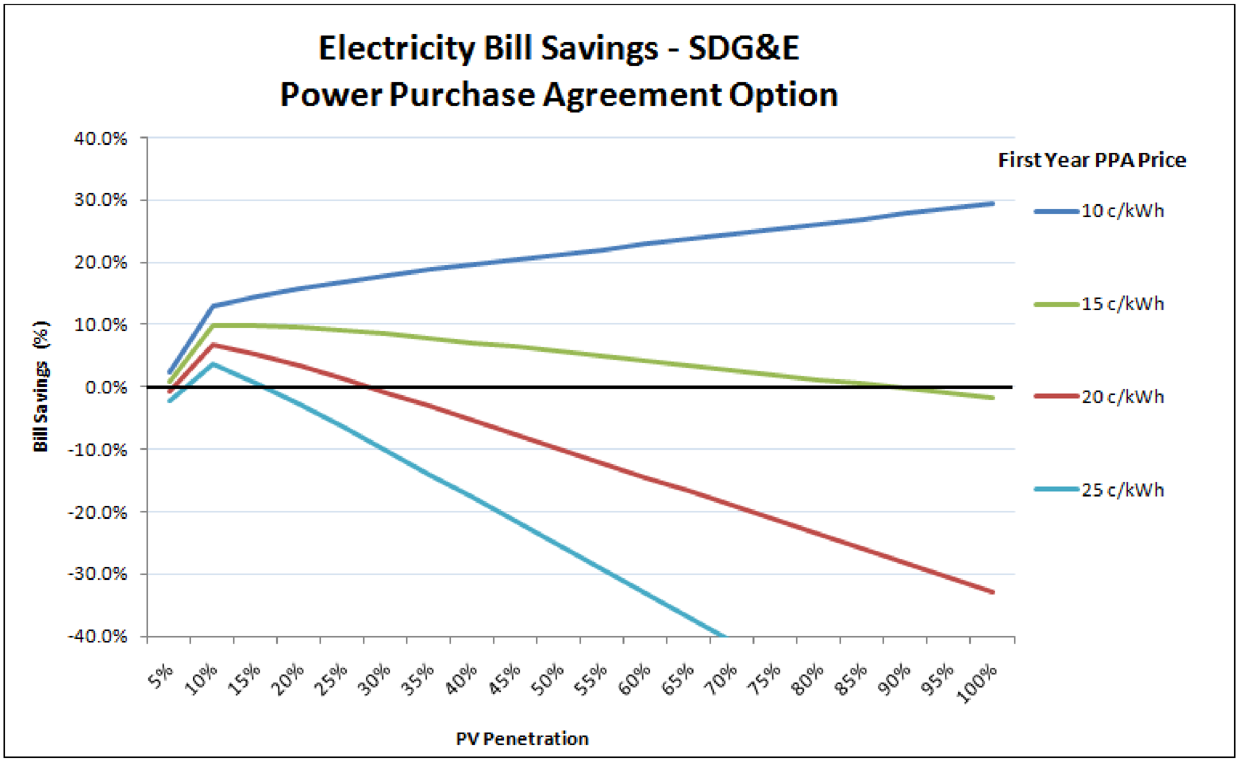

Figure 16. Annual electricity bill savings under various PPA prices and penetration levels for school in the SDG&E service territory

PV systems purchased under a GO bond require little or no upfront or recurring costs for the school. Figure 17 shows the potential annual savings that can be realized by the schools in each of the three utility service territories. Note that schools in the PG&E service area may actually realize a net revenue (even though the penetration is limited to 100%) by taking advantage of California's net-metering rules.[19]

[19] This is because the net-metering rules allow on-peak generation to be compensated at retail electricity prices even if electricity is exported during the on-peak hours as long as there are no net exports (all hours considered) at the end of each year (CPUC 2010). PG&E's A-6 rate has very high on-peak energy charges while having low-to-moderate prices during other hours, allowing for the PV system to benefit from this net-metering rule.

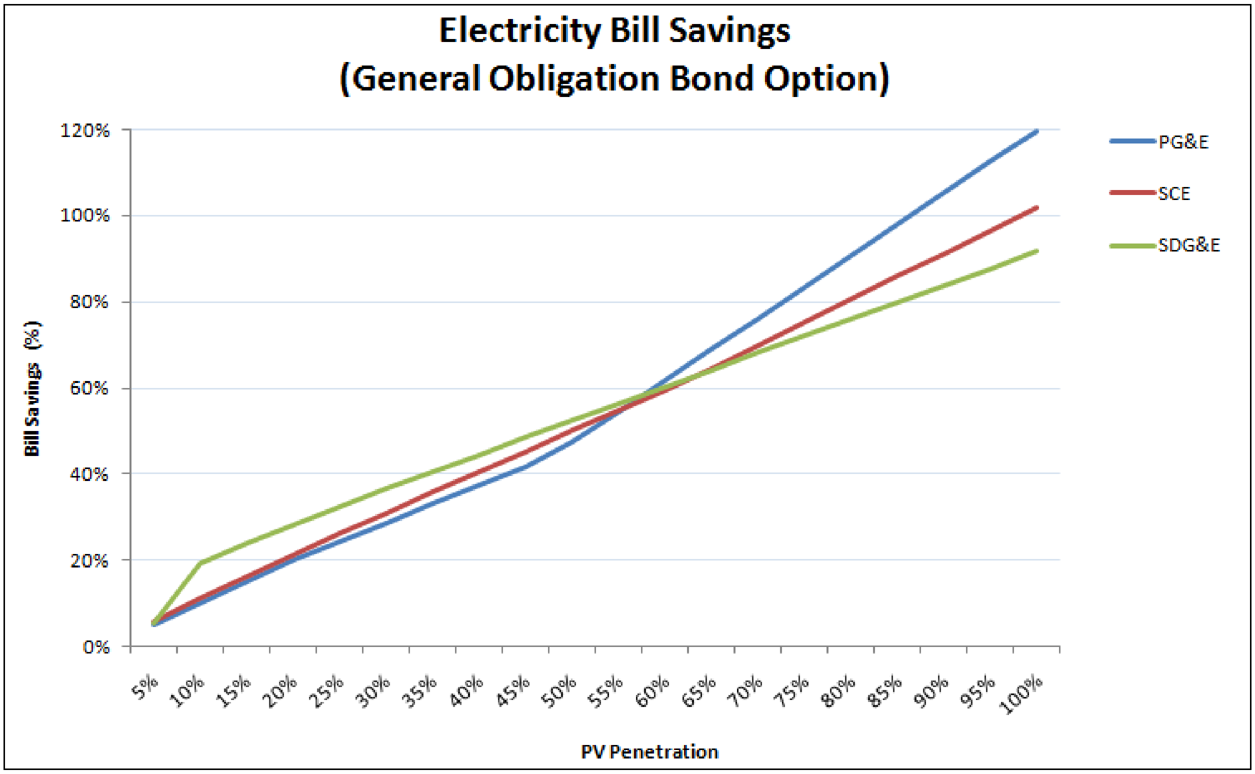

Figure 17. Annual electricity bill savings under the GO bond scenario

4 Conclusion

PV system economics are highly dependent on the host building's rate structure. System economics—under current net-metering rules—favor rates with high on-peak energy prices and low-to-moderate prices at other times. Rates with little or no demand charges are also favorable. This analysis found that there was no single best rate in any of the three utility service territories evaluated. Rather, the most economical rate depended on PV penetration. The rate that minimizes electricity expenses without PV was found to remain the rate of choice for low PV penetrations. For high PV penetration, rates with low demand charges and high on-peak energy prices became the most cost-effective option.

These results identify general relationships between rate structures and PV installations on schools. It is important to reiterate that the rate analysis applies to specific school load profiles (see Section 2.1) and is not intended to represent all schools in California. Results in case studies conducted for PG&E and SDG&E (see Appendix A and Appendix B) using actual school load profiles differ from those reached when using the simulated load profiles, showing that the results are sensitive to individual school load profiles. Recommendations for future studies include identifying the impacts of various school load variations, such as schools with summer or evening classes; assessing the impacts of critical-peak pricing; and evaluating the impacts of potential changes in net-metering rules.

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Appendix A. Case Study: Berkeley High School

Introduction and Summary of Findings

Berkeley High School (BHS) in Berkeley, California, serves approximately 3,000 students and has a large campus that consists of several buildings, some of which have been identified as favorable for rooftop PV placement (denoted as A through D in Figure A-1). These areas total approximately 47,000 ft^2—or enough to support 400 kW of PV capacity. The remaining roof space may support additional PV capacity.

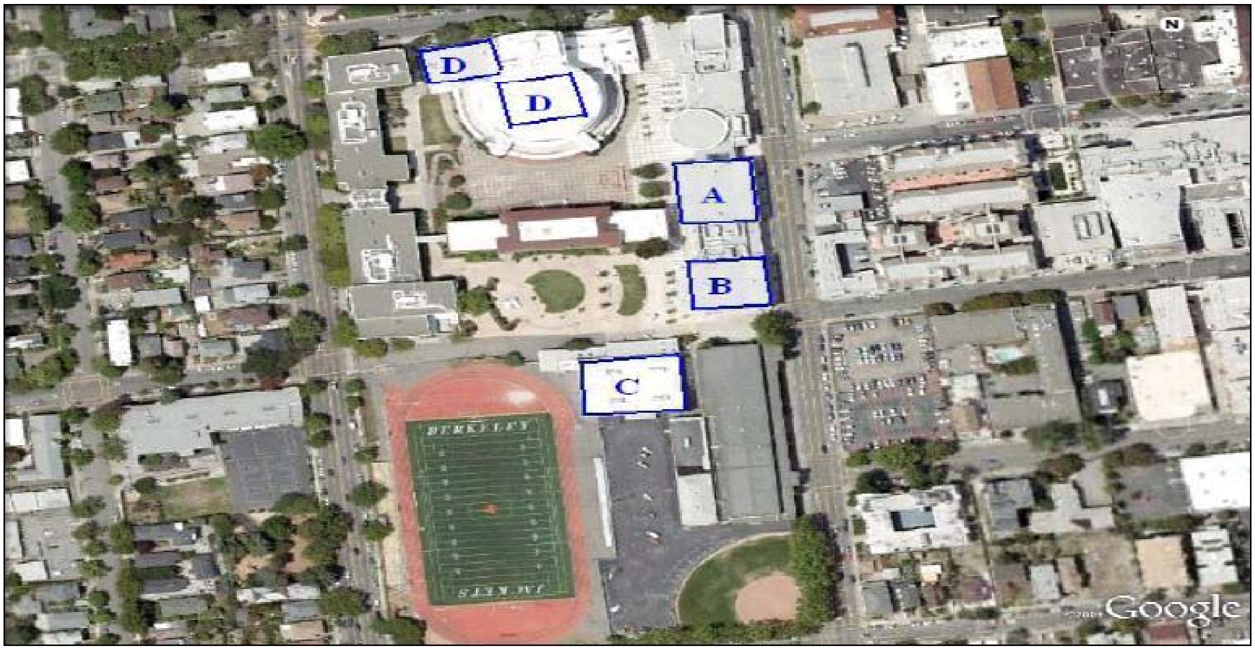

Figure A-1. Berkeley High School campus with locations favorable for rooftop PV identified (A–D)

Source: SunPower 2009

The aggregated annual electricity consumption for all BHS facilities exceeds 3 million kWh. The school qualifies for a total of six PG&E rates on the four meters that measure the school's load. These rates were evaluated to determine likely conditions for maximizing value and savings in annual energy expenses. Figure A-2 illustrates the PV value under different penetration levels and rate structures. The evaluation found that rate E-19 is the optimal option for PV penetrations up to 35%. At higher penetrations, rate A-6 becomes and remains the most economical rate option. This is because rate A-6 consists of very high daytime energy rates, which makes it too expensive under lower PV penetrations but more attractive with higher PV penetrations (see Section 3.1). Figure A-3 shows how system costs impact simple payback under optimal utility rates. Payback periods are longest at a 35% PV penetration and shortest when penetration levels approach 100%. Figure A-4 shows the impacts of various PPA prices on annual electricity expenses. System costs below $0.20/kWh are necessary in order to realize a positive impact on the school's annual energy costs. Figure A-5 shows the annual electricity bill savings under a general obligation bond scenario. Since little or no upfront or recurring costs are required of the school and annual savings are very high and exceed 100% for penetrations above 80%. This is possible under net-metering rules that are applicable at the time of this report (see Section 3.2).

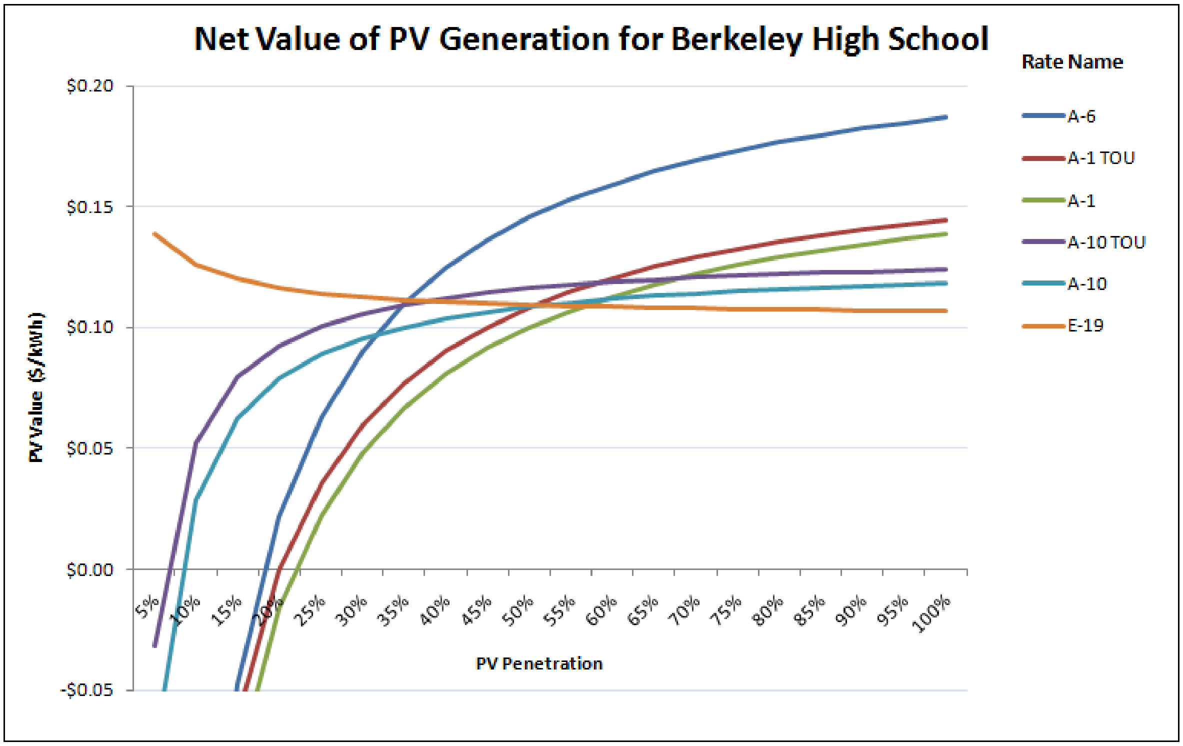

Figure A-2. Net value of PV generation under various rate structures and penetration levels

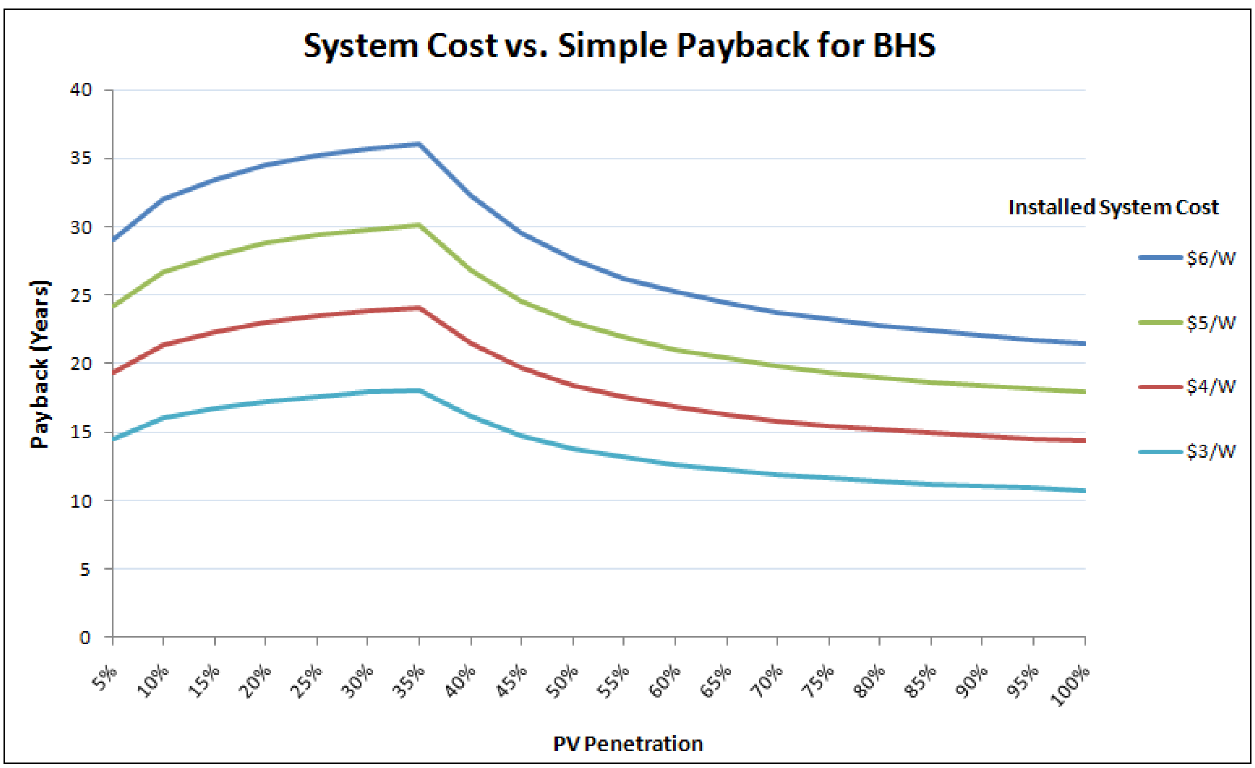

Figure A-3. Payback period for Berkeley High School under various PV system costs and penetration levels

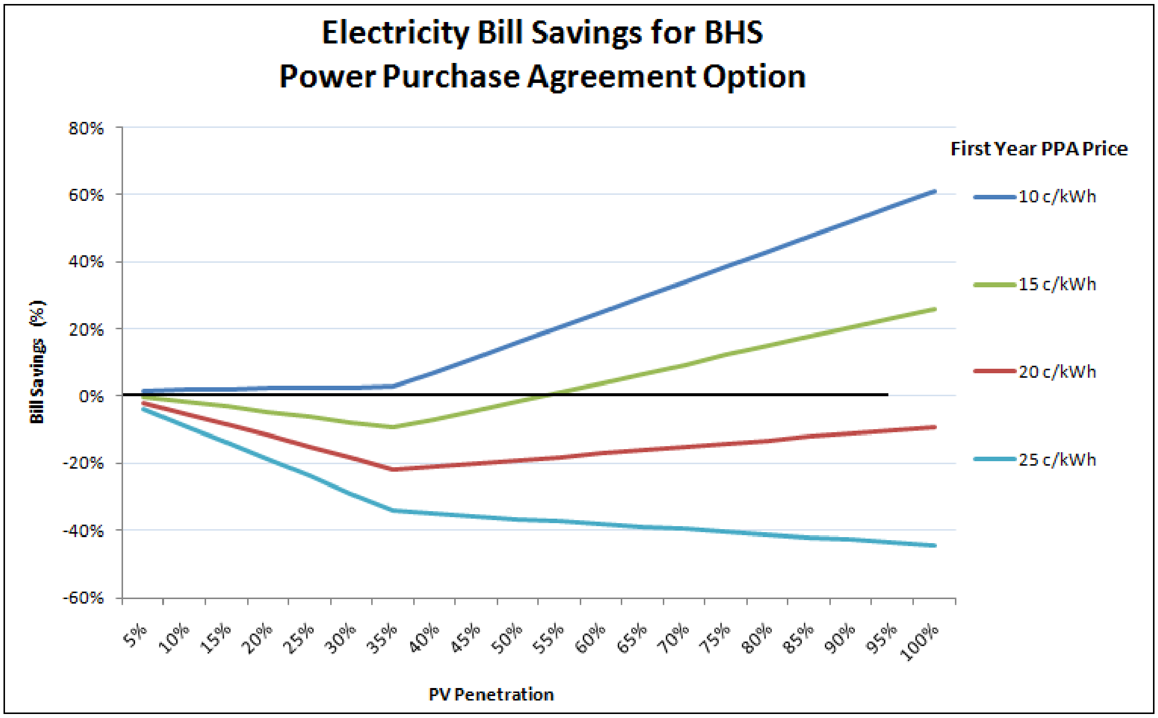

Figure A-4. Annual electricity bill savings for Berkeley High School under various PPA prices and penetration levels

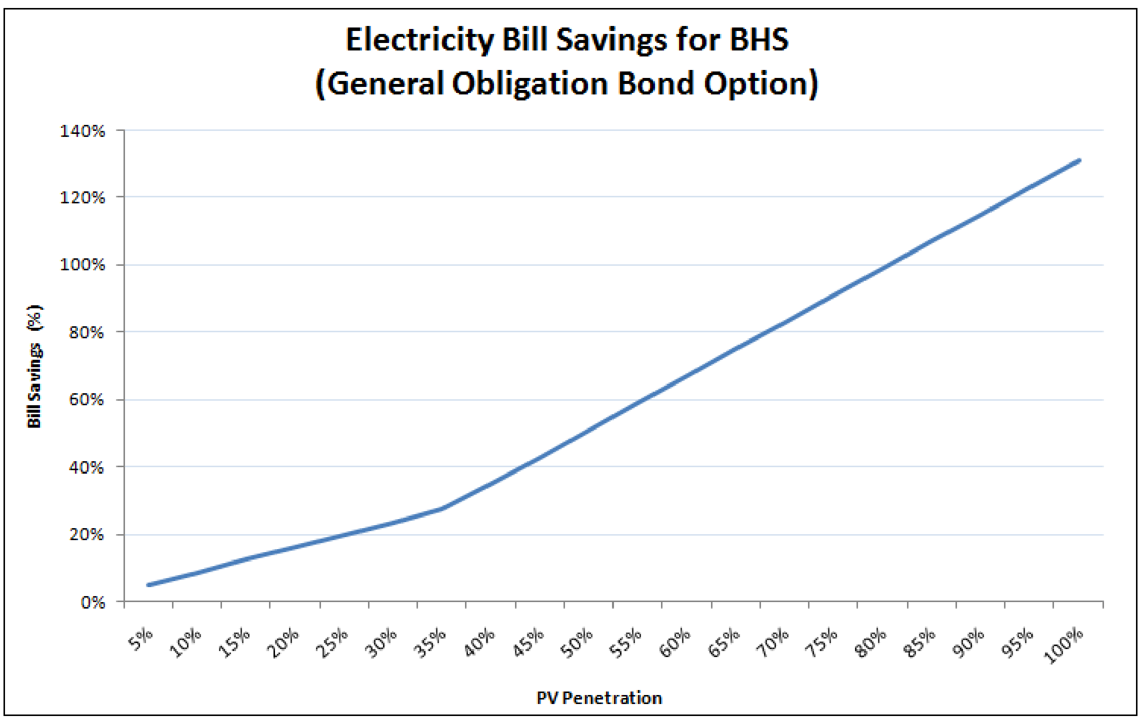

Figure A-5. Annual electricity bill savings for Berkeley High School under the GO bond option

Data and Methodology

Load Data

Due to the size of BHS and its energy use, PG&E has four separate meters that measure electricity usage from the school's various buildings and sections. Table A-1 shows the annual energy consumption of BHS during 2010, grouped by each of the four PG&E meters.

Table A-1. 2010 Energy Consumption of Berkeley High School

	2010 Energy Use (kWh)
Meter 1	788,915
Meter 2	2,074,653
Meter 3	315,200
Meter 4	44,160
Total	**3,222,928**

Monthly billing and energy data were available for each of the four meters. For detailed analyses, however, hourly or sub-hourly data are preferred.[20] Of the four meters, only meter #2 met the threshold for PG&E to make sub-hourly measurements. In order to conduct analyses, it was assumed that the sub-hourly measurements for meter #2, recorded in 30-minute intervals, reflect the hourly pattern for the entire campus. The data from meter #2 was scaled to match the annual load from all four BHS meters. Figure A-6 illustrates that, on a monthly basis, meter #2 represents the total BHS campus consumption pattern adequately. The scaled sub-hourly data (light blue) has a seasonal variation similar to that of the actual monthly measured energy data for the entire campus (dark blue).

[20] By using hourly or sub-hourly data, the impacts of TOU rates and demand charges on PV system economics can be determined. High resolution data also helps identify hours that the PV system is exporting energy to the grid, which may significantly impact system economics depending on the net-metering policy in place.

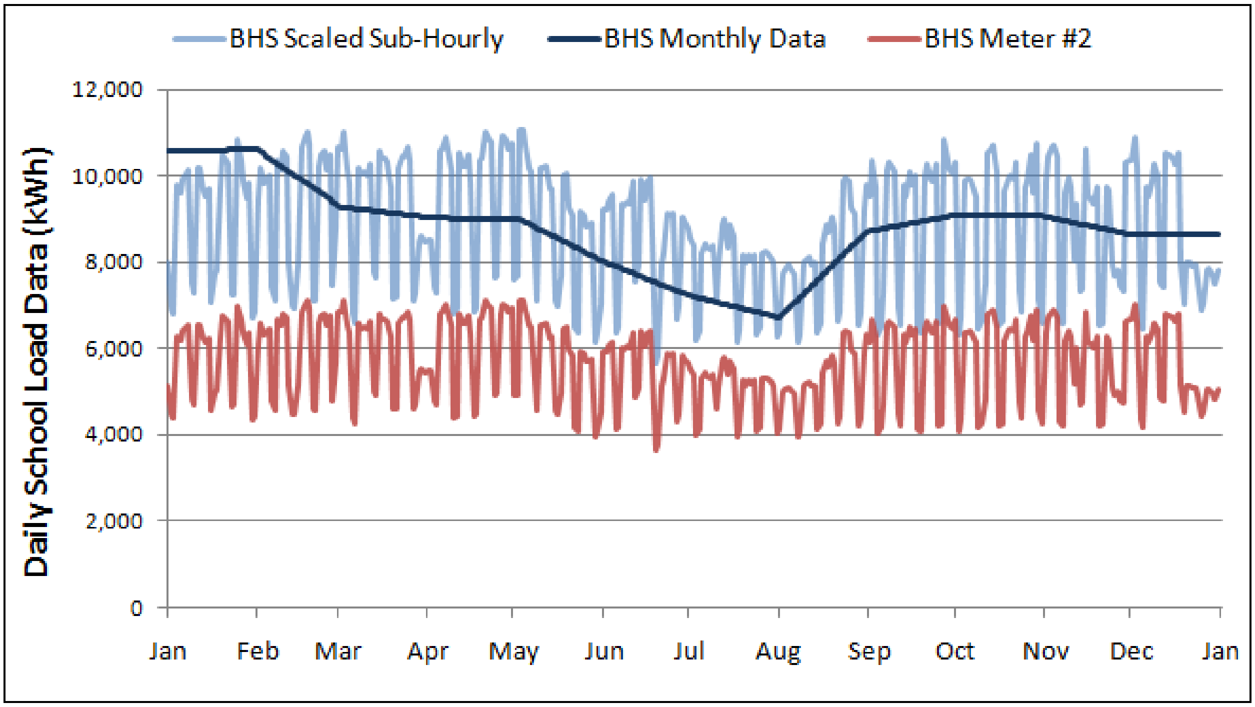

Figure A-6. Berkeley High School electricity load data during 2010—measured monthly energy data is compared with measured sub-hourly data and scaled sub-hourly data

Rate Data

BHS qualifies for a total of six PG&E utility rates. These rates were obtained from the online URDB on the OpenEI platform and verified them with the PG&E tariff sheets to ensure accuracy. PG&E offers various commercial rate structures for different load sizes and types. Smaller loads have more rate choices than larger loads since smaller users may optionally be on rates designed and made mandatory for larger loads. Larger facilities with solar installations may also be on rates designed for smaller facilities. At BHS, each of the four separate meters is treated independently and can utilize any of the eligible rate structures. Figure A-7 illustrates the eligible facility demand range for each of the six utility rates. Except for meter #2, all meters qualified for all six rates. Due to its monthly peak demand of approximately 400 kW, meter #2 qualified only for rates E-19, A-6, and A-10 TOU.

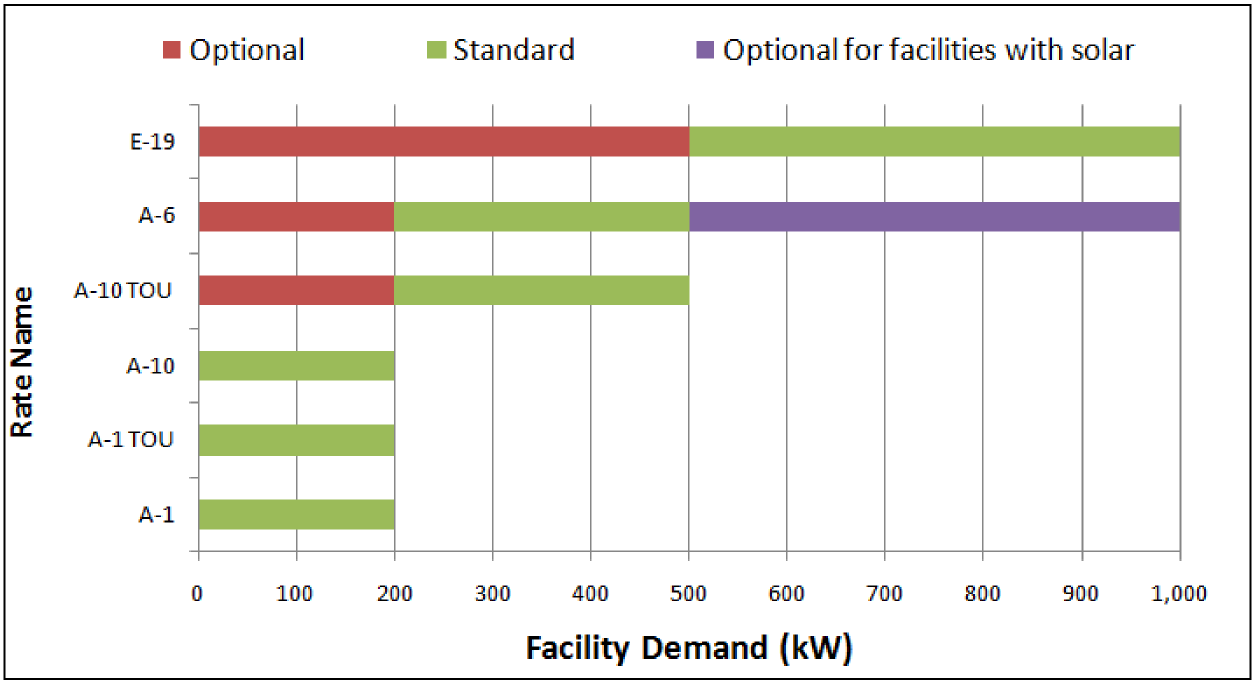

Figure A-7. Applicability of PG&E rates for commercial facilities up to 1,000 kW

Table A-2 categorizes the six PG&E rates used for this analysis. BHS did not qualify for any tiered or flat rates but did qualify for a good representation of seasonal rates, TOU rates, and demand charges. Three of the six rates fell into two or more categories.

Table A-2. Summary of Applicable Categories and Price Levels for the Rates Evaluated

Rate Name	Flat	Seasonal Flat	TOU	Demand	Tiered	Relative Price Level
A-1		✓				Moderate-to-high energy prices
A-1 TOU			✓			High energy prices during summer afternoons; moderate prices otherwise
A-10		✓		✓		Moderate energy prices; high demand charges
A-10 TOU		✓	✓	✓		Low off-peak energy prices; moderate peak energy prices; high demand charges
A-6			✓			Very high energy prices during summer afternoons; low-to-moderate prices otherwise
E-19			✓	✓		Moderate energy prices during summer afternoons; lower energy prices otherwise; very high demand charges during summer afternoons; moderate demand charges otherwise

Solar Data

The PV production data used for BHS was simulated using hourly meteorological data from the SolarAnywhere® database (Clean Power Research 2011). The SolarAnywhere dataset is similar to the National Solar Radiation Database (Wilcox 2007); however, it contains more recent data.[21] Hourly meteorological data was obtained for the year 2010 from a 10 km-by-10 km grid cell that contained the BHS campus. The meteorological dataset was used as an input for SAM, which simulated hourly PV production for use in the financial calculations.

System Advisor Model and Calculations

Using SAM, PV performance data was generated using the meteorological data obtained from SolarAnywhere and the following assumptions:

- 15-degree tilt
- South facing (180-degree azimuth)
- A de-rate factor of 85%
- An annual degradation of 0.5%.

In addition to the meteorological data, hourly building load data[22] and utility rate data were given as inputs for SAM. A rooftop PV system was simulated for BHS for various penetration levels ranging from 0% (no PV system) to 100% (PV system produces 100% of the school's annual electrical energy needs) in increments of 5%. The value of the PV system's generation under various penetration levels and rate structures was evaluated by comparing the school's annual electricity costs both with and without the PV system. Any resulting difference was attributed to the PV system. The combination of scenarios required 240 unique simulations, from which the model determined the economically optimal PV penetration and rate structure.

Conclusion for Berkeley High School Case Study

Under the conditions of this analysis, two rates maximize PV value at BHS. Rate E-19 maximizes savings for lower PV penetrations (35% and under), and rate A-6 maximizes savings for penetrations above 35%. This assessment assumes that there are no significant changes in the school's load profile. Changes in the size or shape of the school's electricity usage pattern will likely impact the results.

[21] The most recent National Solar Radiation Database update contains data through 2005. The SolarAnywhere dataset is continuously updated and contains data through the present time. Since the BHS load data is from 2010, it is important to use solar and meteorological data from the same time period to accurately capture TOU and demand charge impacts.

[22] Although sub-hourly (30-minute) resolution load data were obtained from PG&E, this data was converted to hourly resolution because SAM is currently an hourly performance model. The meteorological data obtained was also limited to hourly resolution.

Appendix B. Case Study: Lewis Middle School

Introduction and Summary of Findings

Lewis Middle School (LMS), located in San Diego, California, is a moderately sized school with an existing 200 kW PV installation. The installation provided approximately 98% of the school's electricity consumption in 2010 (98% penetration). Figure B-1 shows the LMS campus with the PV installation (dark rectangles) covering a significant portion of the available rooftop area. After obtaining detailed, 15-minute resolution data for the campus electricity consumption and PV generation, the data was scaled to evaluate a range of PV penetration scenarios. The results from this case study are intended to inform other similar schools that are exploring their options for solar generation. Since the LMS PV installation and financing is already complete, the options and recommendations given are for reference only.

LMS installed the rooftop PV system as part of a re-roofing effort, hence the high utilization of available rooftop area. The added value of combining the re-roofing and PV installation was not taken into consideration in this analysis and may significantly increase the overall economics for the school.[23]

Figure B-1. Lewis Middle School with existing rooftop PV installation

Source: Google Maps, 2011

With an aggregated annual electricity consumption exceeding 300,000 kWh, LMS qualifies for two SDG&E rates. These rates were evaluated to determine optimal conditions for maximizing

[23] LMS re-roofed its buildings using new roofing material with flexible solar panels bonded to it. The school was guaranteed maintenance-free roofs for 20 years.

value and savings in annual electricity expenses. Figure B-2 illustrates the PV value under different penetration levels and rate structures. The evaluation found that rate AL-TOU is the optimal option for PV penetrations up to 10%. At higher penetrations, rate DG-R becomes and remains the most economical rate option. Rates A and A-6 TOU, denoted by the dotted lines, are not applicable to be used at LMS and were included in the chart for comparison only. Rate DG-R is available only to buildings that have an eligible distributed generation technology with a capacity that is 10% or more of their peak annual load.[24]

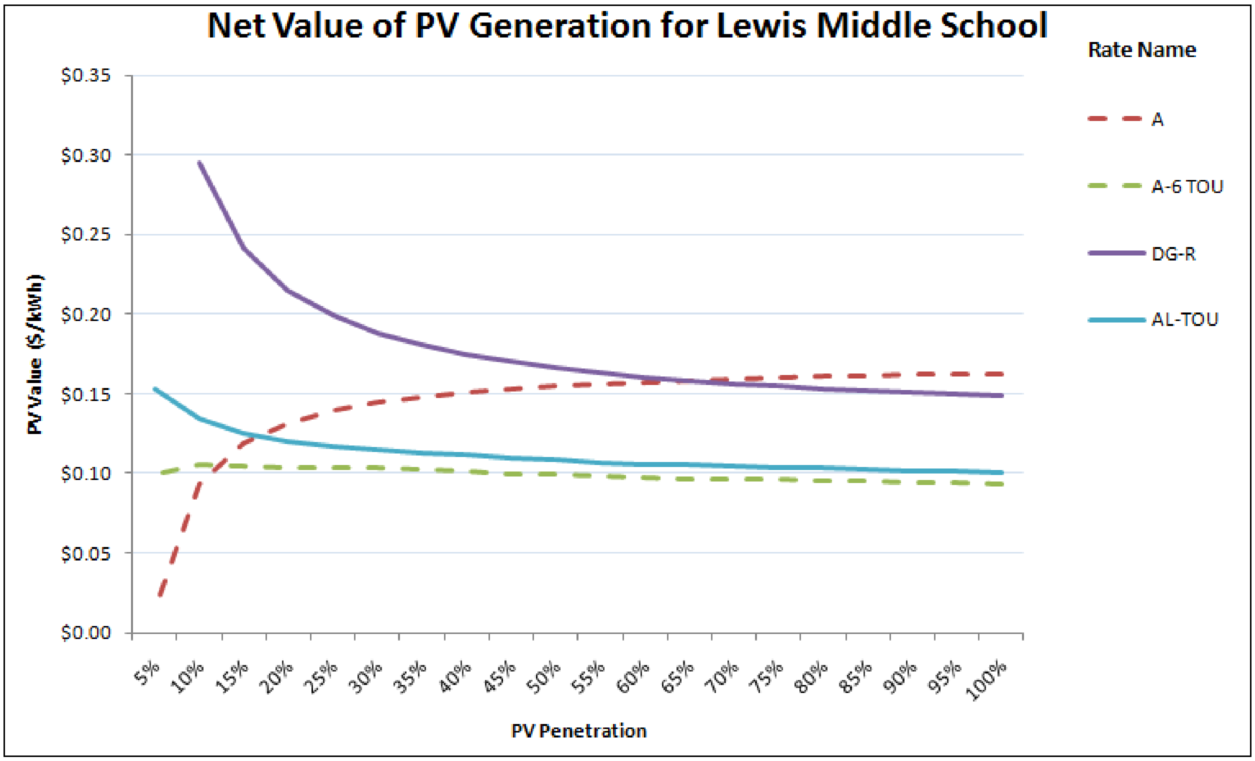

Figure B-2. Net value of PV generation under various rate structures and penetration levels

Figure B-3 shows how system costs impact simple payback under optimal utility rates. Payback periods are longest when approaching 100% PV penetration and shortest when penetration is at 10%. The abrupt dip in payback period at the 10% mark is due to the effect of rate DG-R becoming available for use after a 10% penetration.[25] Figure B-4 shows the impacts of various PPA prices on annual electricity expenses. With all PPA prices evaluated, LMS will always realize a net savings on annual electricity expenses when PV penetration is at 10% due to the DG-R rate. Below a PPA price of $0.15/kWh, LMS will always realize a net savings on annual electricity expenses, regardless of penetration level. Figure B-5 shows the annual electricity bill savings under a GO bond scenario. Since little or no upfront or recurring costs are required of the school, annual savings are very high and exceed 90% for penetrations approaching 100%.

[24] A 7.5% PV penetration is sufficient to provide 10% of the LMS peak annual load. Because the PV penetration resolution is limited to 5% increments, the DG-R rate was chosen to become effective at a 10% PV penetration.
[25] Ibid.

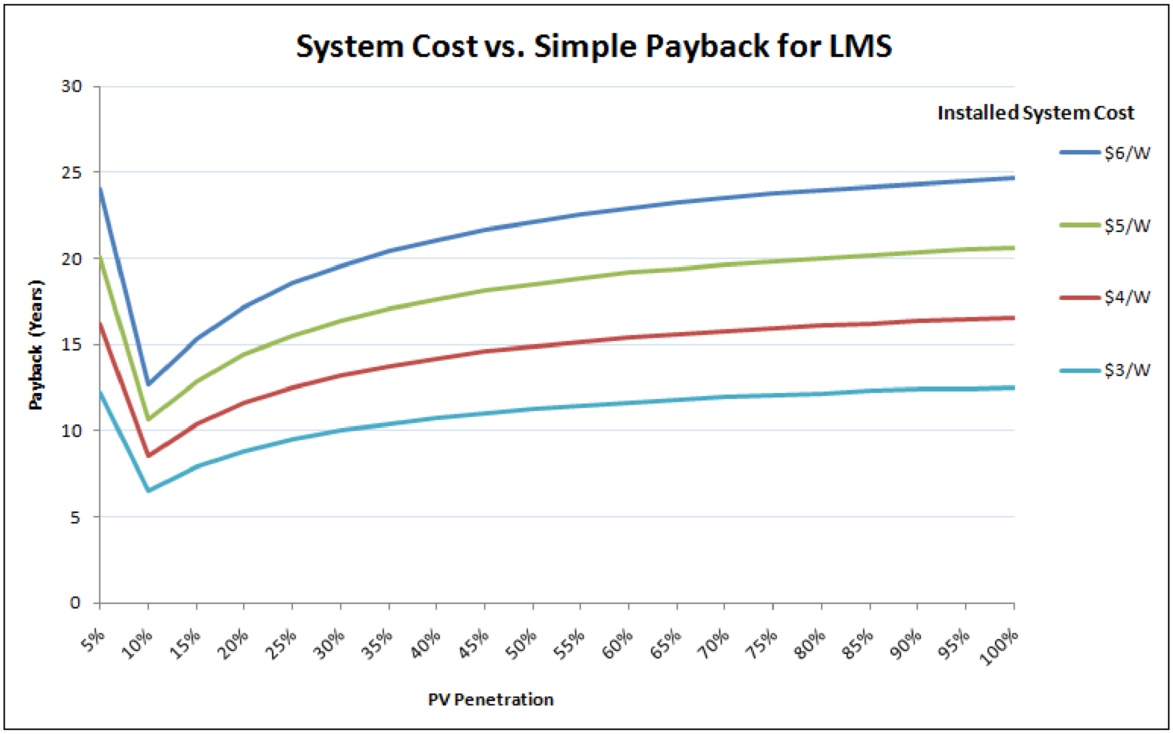

Figure B-3. Payback period for LMS under various PV system costs and penetration levels

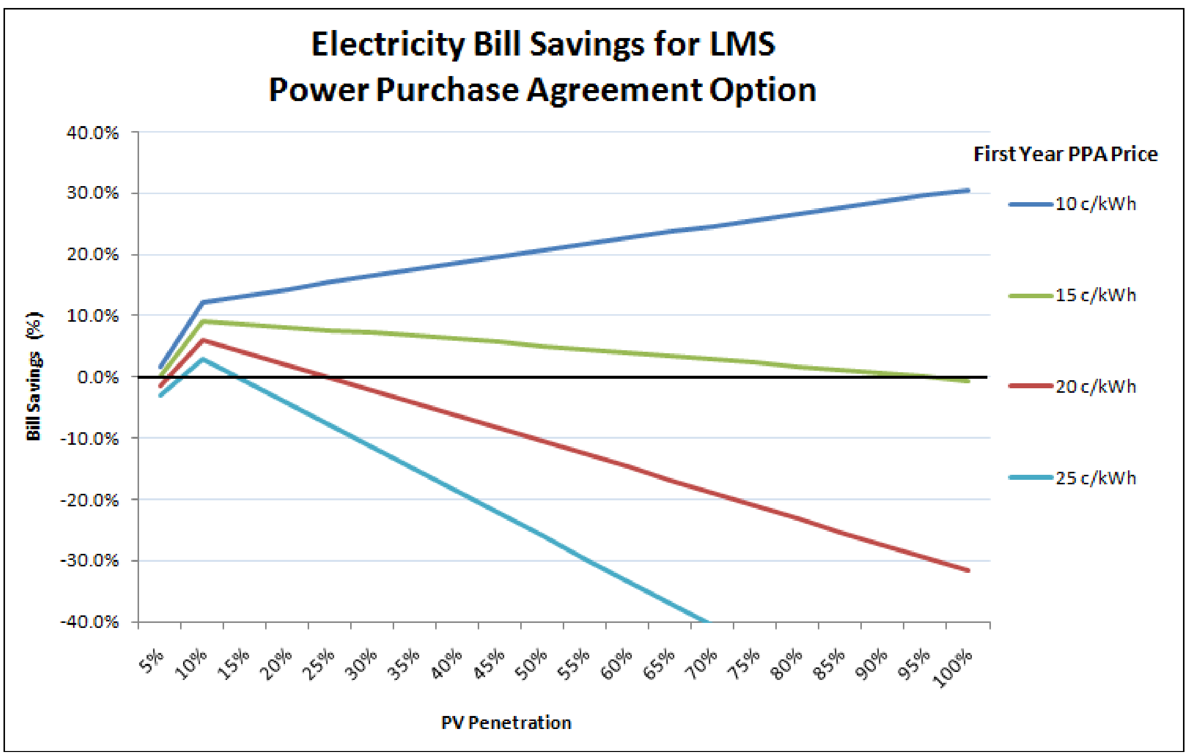

Figure B-4. Annual electricity bill savings for LMS under various PPA prices and penetration levels

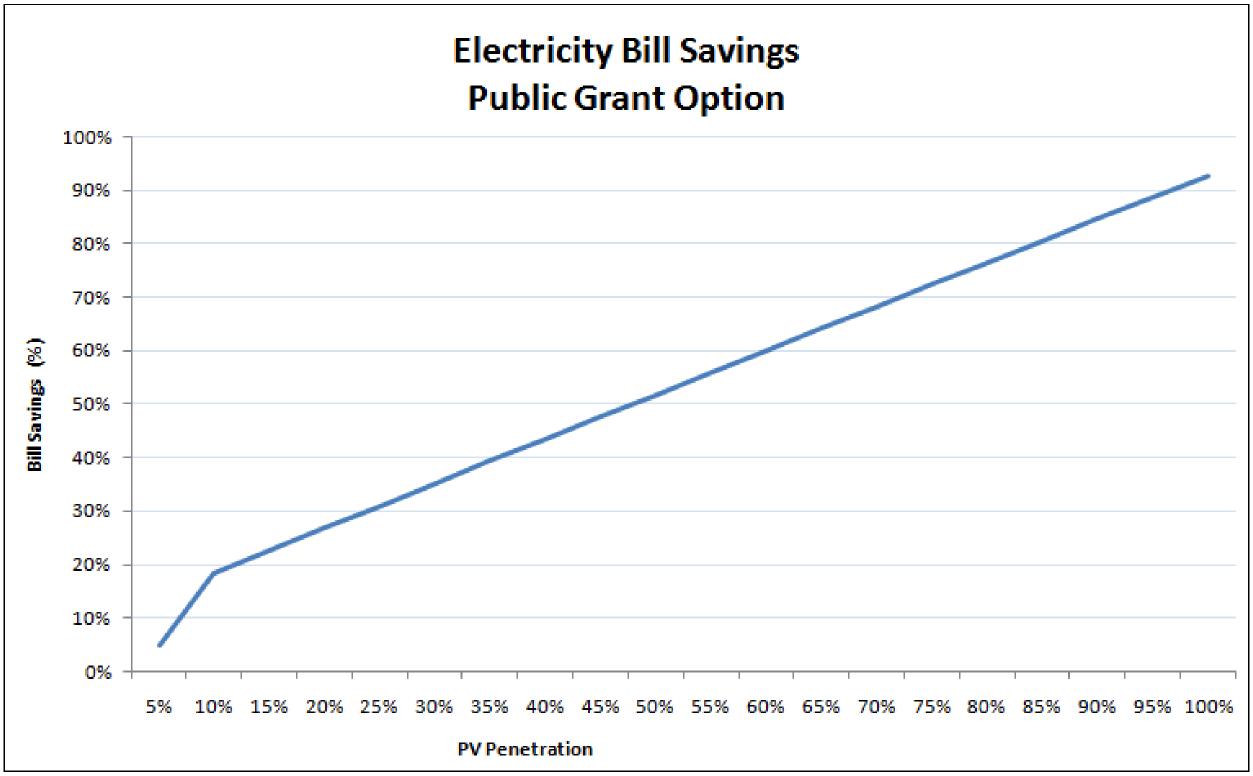

Figure B-5. Annual electricity bill savings for LMS under the GO bond option

Data and Methodology

Load and Solar Data

SDG&E measures and records LMS's energy data, including actual building energy use and PV production, in 15-minute increments. The detailed records eliminated the need to simulate data for this case study. Figure B-6 illustrates the daily school energy consumption and PV generation data for the year 2010. The PV system met approximately 98% of the LMS load in 2010. The data were entered into SAM in order to determine the impact of available rate structures on the economics of the PV system.

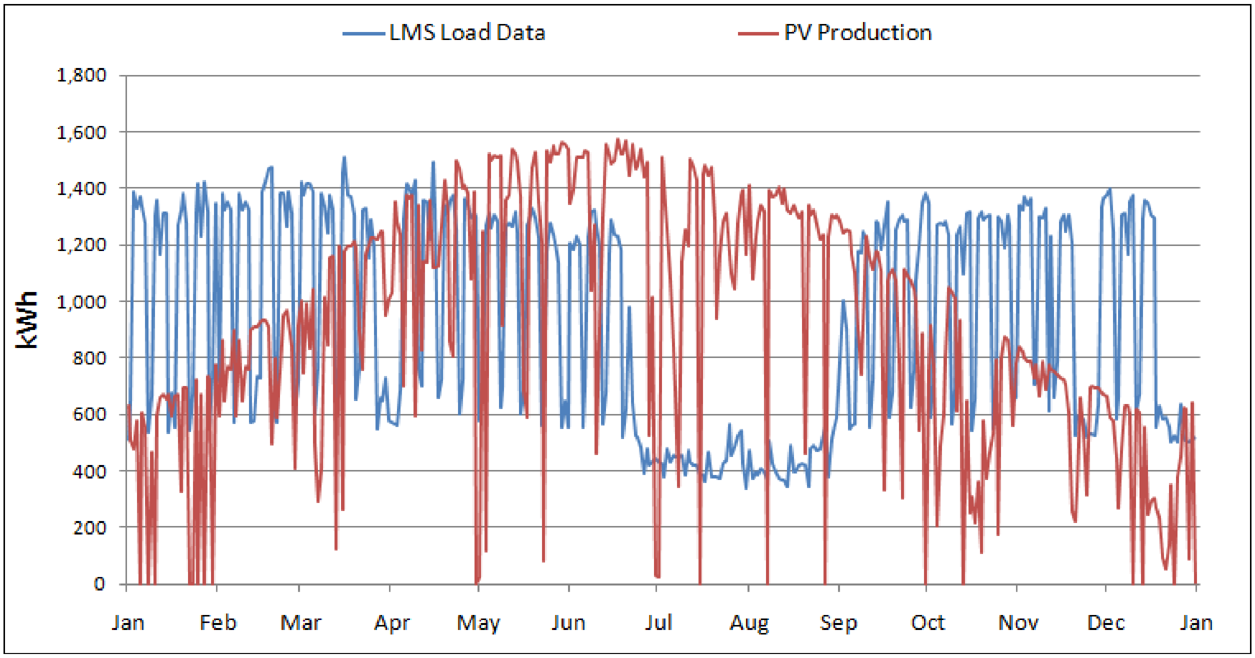

Figure B-6. 2010 daily load profile and PV generation for Lewis Middle School

Rate Data

LMS qualifies for two SDG&E utility rates. A total of four rates were evaluated for comparison, but used only the LMS-eligible rates to calculate bill savings and payback periods. All rates were obtained from the online URDB and verified with the SDG&E tariff sheets to ensure accuracy. Figure B-7 illustrates the eligibility range for each of the four utility rates. Since LMS had a peak annual load of 130 kW, the only rates applicable are AL-TOU and DG-R.

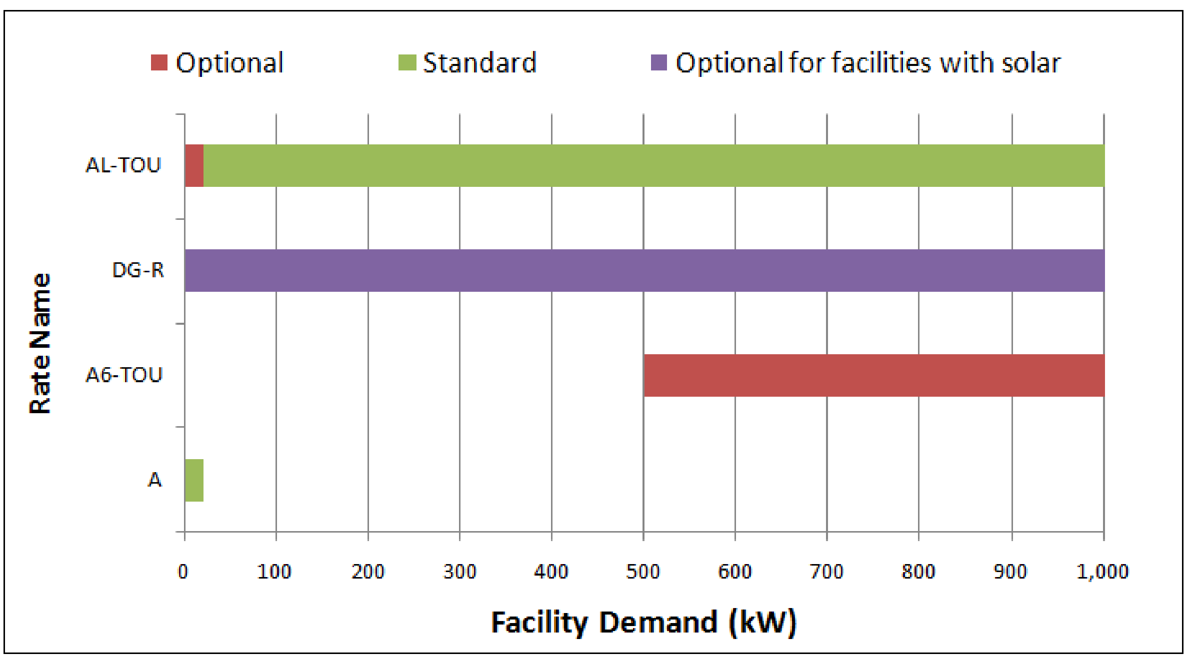

Figure B-7. Applicability of SDG&E rates for commercial facilities up to 1,000 kW

Table B-2 summarizes the various categories and features of the four SDG&E rates used for this analysis. There were no tiered or flat rates in the four SDG&E rates evaluated.

Table B-2. Summary of Applicable Categories and Price Levels for the Rates Evaluated

Rate Name	Flat	Seasonal Flat	TOU	Demand	Tiered	Relative Price Level
A		✓				Very high energy prices
A6-TOU		✓	✓	✓		Low energy prices; high demand charges
DG-R		✓	✓	✓		High energy prices; low demand charges
AL-TOU		✓	✓	✓		Intermediate energy prices; high demand charges

System Advisor Model and Calculations

Hourly PV generation data, hourly building load data,[26] and utility rate data[27] were entered into SAM. The PV generation data were analyzed for various penetration levels ranging from 0% (no PV system) to 100% (PV system produces 100% of school's annual electrical energy consumption) in increments of 5%. The value of the PV system's generation was evaluated under various penetration levels and rate structures by comparing the school's annual electricity costs both with and without the PV system. Any resulting difference was attributed to the PV system.

Conclusion for Lewis Middle School Case Study

LMS boasts a PV system that meets nearly 100% of the school's annual electricity consumption. Under a PPA, results show that large PV penetrations are ideal for PPA prices at or below $0.10/kWh, where increasing PV penetrations yield increased bill savings. For PPA prices $0.15/kWh and above, the optimal penetration level is 10%, or the lowest penetration level for rate DG-R to be used. A 10% penetration is also the point that minimizes the payback period for systems purchased up front. This case study did not look at the California Solar Initiative incentives, which were not available at the time of this report but may have been available when the PV system was installed at LMS. Including the incentives will alter these results and increase PV value. The LMS PV system was also installed as part of a re-roofing effort, which may also increase the overall economics for the school.

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[26] Although sub-hourly (15-minute) resolution load data were obtained from SDG&E, the data were converted to hourly resolution because SAM is currently an hourly performance model.
[27] SAM communicates directly with OpenEI's online URDB to obtain the latest rate information available on OpenEI.

Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 9

Going Solar at San Ramon Valley Unified School District: How a Small Idea Energized an Entire School Community (Case Study)

Going Solar at San Ramon Valley Unified School District: How a Small Idea Energized an Entire School Community (Case Study)

The preceding chapters in this Solar Master Plan describe many of the technical and financial issues a district must consider when exploring the possibility of purchasing and installing renewable energy systems. This chapter is dedicated to all the students and their communities who are encouraging their school districts to make the shift to renewable energy.

Julia Mason, a former student at Monte Vista High School, Danville CA, drafted this "case study" in 2010. Her intent was to memorialize her community's efforts to encourage the San Ramon Valley USD school board to purchase renewable energy systems for its schools. She hoped that the case study would show students and community members around the state that it is possible for a school community to play a positive role in helping their districts "go solar."

The case study also includes a Frequently Asked Questions (FAQ) document that Julia, her family, and KyotoUSA prepared in 2009 when the district was beginning to consider seriously purchasing a solar system. The FAQ was distributed at community gatherings and school board meetings to address questions that were frequently raised about the transition to renewable energy. The FAQ document was helpful in informing the community about the benefits of solar and dispelled many misunderstandings about the project.

San Ramon Valley Unified School District installed 3.3 MW of solar panels at five sites (four high schools and a middle school) in the summer of 2011. The PV systems are expected to provide a new revenue stream for the District's General Fund.

Going Solar at San Ramon Valley Unified School District:
How a Small Idea Energized an Entire School Community

In spring 2008, a student at Monte Vista High School in the San Ramon Valley Unified School District (SRVUSD) approached KyotoUSA (an all volunteer organization) with the hope of installing solar panels on her high school. Two years later, in May 2010, the SRVUSD school board unanimously approved an even more encompassing plan: a 3.3 Megawatt (MW), $23 million project to install solar on six campuses in the District. The project is financed with U.S. government-backed, low-interest Qualified School Construction Bonds (QSCBs) and will be repaid from the District's energy savings. Ground-breaking will take place in spring 2011.

The Idea Begins

In early 2008, Monte Vista High School (MVHS) junior Julia Mason and her family began thinking about initiating a project to install solar panels at MVHS , inspired by their concerns about global warming, increasing gas prices, huge profits reported by multi-national energy companies, and school budget cuts. They researched several other California school districts, including San Jose and San Diego Unified School Districts, that had gone solar using a form of financing called a Power Purchase Agreement (PPA). Their initial plan was to seek grant support for the high school project from Chevron Energy Solutions, whose parent company, Chevron, is headquartered within the school District. This idea was eventually abandoned in favor of proposing a larger scale project using low-interest bond financing that would allow the District to own the photovoltaic (PV) systems and accrue all the economic, educational, and environmental benefits generated by the PV systems.

Julia formed a student group and researched and contacted organizations dedicated to helping school districts install solar. Tom Kelly from Berkeley's KyotoUSA immediately responded with enthusiasm and encouragement, offering to help find financing sources and vendors. KyotoUSA had just concluded a successful pilot project for a 100 kilowatt (kW) photovoltaic system (PV) at Washington Elementary in the Berkeley Unified School District. Tom was happy to help share what they had learned in that effort, called the HELiOS Project (**H**elios **E**nergy **Li**ghts **O**ur **S**chools). KyotoUSA's quick and enthusiastic response gave the students a sense that their idea was indeed worthwhile and inspired greater energy: the project now seemed possible.

MVHS teachers and her school's administration responded positively to Julia's request for their support and input, and were encouraging from the outset. Nevertheless, they had little influence with District administrators because construction and facilities projects are handled at the district level. Other stakeholders in the District had to be identified and presented with the concept. Julia and her team got to work.

Persuading the District

In Julia and Tom's first communications and meetings with District officials in April and May 2008, the District staff listened but were reluctant to move forward, especially with a project that appeared to have such high upfront costs during a period of economic uncertainty. The District was also wary because it was aware that some public school solar projects that used private financing (PPAs) had not always lived up to their promise. The District emphasized that, at a minimum, it had to be certain that the project would break even financially (energy savings = repayment costs) before considering undertaking such a major project.

Through the summer and fall of 2008 and the spring of 2009, Tom and Julia met with District facilities staff, who thought the solar project was a good idea and, in fact, had unsuccessfully advocated for solar in the past. Solar vendor Eshone Energy came to inspect the MVHS roofs and generated a proposal for a 1MW system that would cost $7 million ($5 million after the California Solar Initiative rebates). Although the proposal was estimated to pay for itself after 14 years and generate $14.5 million in savings over a 25-year period, the District found the upfront costs too high, especially in the face of the economic downturn. Nevertheless, Tom continued to correspond with District staff throughout the spring of 2009, fine-tuning the project, suggesting that the District use available modernization funds from the Office of Public School Construction to help underwrite the cost of the project. Although his estimates showed positive cash-balances, the District's continued response was that it was not pursuing any new projects. At times, it was difficult to maintain the attention of the District, especially in the summer of 2008 when the District was hiring a new superintendent and dealing with pressing District concerns that always occur at the start of a new school year.

In July 2009, Tom approached District officials with information about Qualified School Construction Bonds (QSCBs) - low interest bonds issued as part of the American Reconstruction and Recovery Act intended to make low cost financing available for public school construction projects. While the District earlier had expressed interest in the Clean Renewable Energy Bonds (CREBs), it was unable to make the deadline for requesting a CREBs allocation. In hopes of making the later QSCB deadline, Tom communicated with the District about the possibility of using QSCBs for solar, and assisted the District in getting help in completing an application.

The District was one of a handful of school districts that received an allocation of $25 million in QSCBs. QSCBs represent a powerful solution for solar for schools because unlike other construction projects, solar panels actually help to pay for themselves: the savings from electricity costs and rebates would be used to pay back the bonds. Not only would the District benefit from low interest rates and rebates, but each year the money from energy savings could be put aside and invested, thus gaining interest and allowing the District to actually pay back less than it borrowed.

The Board Acts Cautiously

In early October 2009, the school board discussed the possibility of using its $25 million allocation of QSCB bonds for solar. In the days prior to the meeting, Julia e-mailed the board members and Superintendent, explaining the benefits of solar and its importance to the student body. The board was open to the idea of solar but wanted more certainty and more information. One problem that arose was that although the bonds were intended to be interest-free (the federal government paid the interest to the investor), there was only one company willing to buy the bonds, and this company wanted a 0.75-1% premium over and above the interest the government was prepared to pay. Although this was still “cheap money,” the board was hesitant to consider anything that would put the District into greater deficit. Also, there were proposals from the community for other types of construction projects including new bleachers and a new swimming pool, expansion of the District bandwidth, and other facilities improvements. The board eventually ruled out these types of projects because none of them would generate the revenue necessary to pay off the bonds. Furthermore, the board needed to use the bonds for “shovel-ready” projects because 10% of the funding would have to be spent within the first six months. Concerns were raised about how the community would react to the aesthetics of the solar panels; the board members agreed that they needed more input from the community, more time, and more certainty that the financing would “pencil out.”

At the October school board meeting, board members again expressed concerns about the financial risks and community reaction. Proposals were made for community outreach efforts, including putting information on the District website and sending a mailer to all residents living within 300 feet of the schools. Staff issued a Request for Proposals (RFP) for the solar project, as vendor bids and renderings of the project at the eight campuses under consideration for solar would provide a more detailed picture of the costs and appearance of the panels. The Board formed a Solar Advisory Committee and allocated $30,000 to undertake a detailed financial analysis of the project to determine if it was financially viable and to provide a definite answer to concerns and uncertainties about risks, potential utility rebate reductions, and the District's ability to repay the bonds within 15 years.

Through November 2009, the board continued to narrow down vendors who had responded to the RFP. Financial consultants addressed the board, explaining that solar generated electricity would be cheaper over a 25-35 year period than continuing to purchase energy from PG&E, and that acting sooner rather than later would be optimal for taking advantage of PG&E rebates, which were quickly falling. Furthermore, going solar would help the District comply with any future state mandates to reduce greenhouse gas emissions. The board remained skeptical of the project and wanted more certainty of the costs, but board members agreed to form a Joint Exercise of Powers Agreement (JPA), in which the District would deposit and invest funds annually, so they would accrue interest to help repay the bonds.

Another special board meeting was held in November to keep the board on track to meet the state mandated December deadline to formalize the acceptance of the QSCB allocation. Community members addressed the board, citing other districts that had gone solar and pointing out that students, teachers, and the community were enthusiastic about the project. Board members remained anxious about the risks and were feeling rushed about the deadline; it seemed possible that they would defer their decision to go forward letting the 2009 QSCB allocation lapse, and wait for the 2010 allocation[1].

A Reprieve

In December, the California Department of Education extended the deadline on the acceptance of QSCBs due to complications with the manner in which the bonds were allocated. District staff organized mailings and e-mails to the community, and local press published several articles about the project. At the December board meeting, community members addressed the board, expressing concerns about the appearance, maintenance, and safety of solar panels. The board was relieved to have the extension, feeling that the previous deadline was "unmanageable," and expressed its desire for public approval of the proposed project. Further concerns abounded about uncertain future PG&E rate increases and the District's exposure if the awarded solar firm went out of business after the panels were installed.

In March 2010, SunPower Corp. emerged as the preferred vendor. The Solar Advisory Committee visited the firm and reported that they felt confident that the District had made the right choice. The board was convinced that the project would pencil out within 16 years, and be cost-neutral or generate savings for the District, even if PG&E rates remained constant over the payback period. This affirmation marked a turning point for many members of the board, who began to see the solar project as a superior alternative to purchasing electricity from PG&E, and that the risks of *not* doing the project far outweighed those of doing it.

[1] The enabling legislation for the 2010 QSCB allocation (AB2560) requires that a school district have voter approved bonds to qualify for an allocation. SRVUSD would not have been eligible for a 2010 allocation under this criterion.

The Plan is Approved

On May 25, 2010, the board unanimously voted to approve the solar project. They were presented with the contract with SunPower Corp. to install solar panels on the parking lots of six campuses: California High School, Dougherty Valley High School, Monte Vista High School, San Ramon Valley High School, Diablo Vista Middle School, and Gale Ranch Middle School. The project would cost $23 million and generate $31 million in energy savings over a 16-year period, almost $5 million of which would benefit the general fund over that period (with a total of $22 million benefiting the general fund over the 25 year life expectancy of the PV systems).

The 3.3 MW PV system would generate 6.2 million kWh per year, about 66% of the electricity needed to run the schools[2]. SunPower Corp. will provide operations and maintenance (O&M) and performance guarantees for 16 years. The PV will reduce the District's carbon footprint by 1,400 metric tons of CO_2 annually. The installation of the panels will generate the equivalent of 60 jobs in construction and design, injecting $4 million in wages into the local economy. Construction will begin in the summer of 2011.

Epilogue

The SRVUSD Superintendent is very proud of the solar project and the work that the school community did to help the District reach a good result. Because SRVUSD is a California Distinguished School District, the Superintendent believes that it should model good stewardship—since the District is so visible, it should be working to reduce its carbon footprint and practice sustainable energy use. Moreover, he believes that the District's consideration of solar was a model of good decision making in the public sector, and is proud to be using the money wisely, in a way that will generate savings, stimulate the economy, and benefit the children of the school District. Initially, he thought that solar was the right thing to do, but he wanted to be sure that the project would make financial sense before recommending that it be approved. He recalls that the Solar Advisory Committee, formed of a cross-section of experts and citizens (both believers and skeptics), lent validity to the project, and their positive report about SunPower Corp.'s proposal gave him the confidence to move forward. When the bonds were sold at a rate that met the most optimistic models, the Superintendent became even more enthusiastic about the project. He is pleased with the District's communication with the public, and felt that concerns expressed by the community and local newspapers enabled the District to address and clarify questions about the project. He is proud to be using this money in a way that benefits the District's students, promotes sustainable practices, and reflects well on the District.

Board members expressed concerns about the financing of the project, the uncertainty of future PG&E rate increases, and the possibility that solar technology would become cheaper or obsolete in the future. They also felt extremely rushed with the initial timeline associated with putting QSCBs on the market, not feeling confident that they had all the necessary information, and time to do their due diligence. The Solar Advisory Committee report that the project would pencil out even with the most conservative models was a turning point for many of the board members: it was now clear that the project made financial sense. One board member suggested that forming the committee and consulting experts sooner would have made for a smoother, swifter negotiation process, and may have allowed the District to take advantage of higher PG&E rebates.

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[2] School PV systems are often sized to produce between 70-80% of needed electricity because the *value* of that amount of PV generated electricity will often be enough cover a school's electricity bill. Energy efficiency improvements and better conservation behaviors should be a continuous goal of the District's school community since districts will now receive a credit from PG&E for the value of any electricity that exceeds the value of the consumed electricity (AB2466).

Appendices

Appendix 1: District website and “Solar Scenarios”

- District Website Solar Information: http://www.srvusd.k12.ca.us/solar
  Includes photographs of the projected solar installations and notices sent out to the community.
- Financial modeling with conservative to optimistic PG&E rate increases: Solar Scenarios

Appendix 2: Mason/KyotoUSA FAQ

These questions are based on concerns we heard expressed by the community in board meetings, local newspapers, and online comments on news articles and blogs about the project.

Solar FAQ

Q: Why doesn’t the District use the $25 million on projects that the schools really need, like improving facilities, or hiring more teachers?

A: The $25 million in Qualified School Construction Bonds (QSCBs) cannot be used to hire teachers or expand programs; they are intended to help districts pay for construction projects only. QSCBs are different from the General Obligation (GO) bonds that the District normally uses for construction projects. First, the GO bonds are approved by the District’s voters and are secured by the value of the assessed property in the District. In effect, local property owners pay off the bonds. The QSCBs are different. The tax payers are not directly paying off the bonds; rather, the District is using the savings on the avoided electricity costs, utility incentives, and accrued interest to pay off the QSCBs. For that reason, it is essential that the District invest the money in projects that will be either revenue neutral (no pressure on the General Fund) or, better yet, revenue positive – putting more money into the General Fund than what is needed to pay off the bonds. We believe that an investment in the solar project will always be revenue neutral and likely generate revenue for the District.

Q: Solar is a notoriously inefficient energy source. Solar is not pollution free: it takes toxic chemicals to produce the cells. The amount of pollution generated per kilowatt hour is relatively large with solar. Why don't we wait until something better comes along?

A: Solar panels and the inverters that convert the Direct Current (DC) produced by the panels to Alternating Current (AC) that is exported to the grid are improving all the time. In our Request for Proposals we are looking at a number of factors, including the number of kilowatt hours that the offered panels produce.

The production of solar panels, like the production of all electronic equipment e.g. computers, monitors and cell phones, produces toxic by-products. Organizations like the Silicon Valley Toxics Coalition are pressuring manufacturers to clean up the production process and agree to recycle the solar panels when their useful life is over. Some US manufacturers have already agreed to recycle the panels.

The technology associated with solar panels has changed little over the past 50 years. Panel and inverter efficiency is improving marginally. New types of materials are being used, but in general, the crystalline panels we are considering are, in effect, state of the art. They are also reliable, long-lived, and produce more electricity per square foot than other technologies, like thin-film solar.

Q: Can we wait a few years to see if solar gets less expensive and/or more efficient?

A: This bond is only available for a limited time, and we don't know if similar bonds or stimulus money will be available in the future. Also, right now the PG&E rebates for solar energy are generous and the price of solar panels is relatively low because of the recession. Installation costs have also been falling due to the economic downturn. There's no guarantee that this favorable combination will last; this is an excellent opportunity.

Q: Why aren't other school districts going solar?

A: Actually, many districts in California are turning to solar energy, including Milpitas, San Jose, San Mateo, San Diego, Los Angeles, Oxnard, Mt. Diablo Unified School Districts to name just a few.

Q: How can the District even consider incurring so much debt with the budget problems we are facing?

A: Financial consultants have analyzed the solar project and determined that it will provide cost savings and actually generate income for the school District. The District will be paying the solar panels with savings on electricity (which gets more expensive every year!), rebates, and accrued interest.

Q: Why can't we put the solar panels on the roofs of the schools? Solar panels in the parking lots will be ugly.

A: A number of the schools' roofs are not oriented well for solar panels. There are also issues about the ages of the roofs and concerns about penetrating the roofs to anchor the solar panels. Panels in the parking lots will provide shaded parking and better lighting at night.

Q: Has anyone considered that the panels may be vandalized, or that kids will crash into the solar supports? Are the solar panels going to be dangerous? What if kids climb on them or get shocked? There is a lot of theft of solar panels going on. How will we prevent that? Will we be insured?

A: All of these issues have been considered. Insurance and security costs are included in the projected cost of the project.

Q: Will there be batteries on the school sites used for energy storage?

A: No.

Q: I've heard that there are problems with firefighters putting out fires if solar panels are present.

A: This has been considered and discussed with the fire department. Fire lanes and fire access roads will not be affected.

Q: How will the District handle maintenance and repair of the system? Solar needs washing and weatherproofing: systems are costly to maintain and repair. That could be a huge expense down the road. How will we find the money to pay for this out of our general fund?

A: Maintenance costs are included in the projected cost of the project for the first 16 years.

Q: What if the panels don't generate as much energy as is claimed? Are there performance guarantees or warranties?

A: The company that is awarded the contract will guarantee the output of the panels. If the production of electricity falls below the guarantee, the company will compensate the District accordingly.

Q: What if the company that guaranteed performance and maintenance goes out of business?

A: The major elements of a solar installation are the panels and the inverters. These components are warranted by the manufacturers, not the installer.

Q: I don't believe global warming is a problem. Why are we considering this project?

A: Regardless of your views on climate change, solar panels are a good choice for the District for economic reasons. The District is facing a budget crisis, and solar panels will provide fixed energy costs for years to come and will generate income for the District.

Q: Why are we wasting all of this money on a "feel good" project when the District faces real financial problems?

A: This is more than a "feel-good" project: solar panels will provide much-needed income and cost savings for the District. The panels also provide important environmental benefits, i.e. reduction in CO_2, SO_2 and NOx from fossil fuel combustion, and economic benefits by creating jobs that benefit California as well as the local economy.

Q: Does someone on the Board or at the District have a relative in the solar business or anything to gain financially from this project?

A: No.

Q: How are the solar vendors being selected?

A: A Request for Proposals (RFP) was issued by the District. The Board is reviewing the proposals now and will select the vendor that best meets the criteria set out in the RFP.

Q: Why aren't we looking into reducing energy use at the schools? I have seen doors open with the A/C blasting in hot weather, lights left on all night, etc. Why aren't we addressing conservation before spending so much money on generating solar?

A: Conservation is a key element in reducing energy costs, and it is important that it be addressed. Conservation together with solar will provide even greater savings.

Q: How will we meet the state mandate (AB32) to reduce CO2 emissions if we do not do this project? What will happen if PG&E rates go up more than 3.2% a year and we don't do the solar project? Where will the money come from to pay those energy costs? What if cap and trade passes and energy costs go way up? How will the District deal with those increased expenses if we don't do solar now?

A: It is unlikely that the District would be able to deal with these energy costs and mandates without further strain on the general fund. These are all reasons why going solar now is a good idea for the District.

Q: How likely is it that the school District will lose money on this project? What is the worst case scenario and what is the best case scenario?

A: The District has asked its consultants to provide the most conservative estimate of the cost and benefits. Under this scenario, the District will see no pressure put on its General Fund. Should the PV system ultimately perform above the production guarantee provided by the vendor and PG&E prices increase above the modest estimates, the District will realize even greater benefits than have been described.

Appendix 3: Sustainable Contra Costa Nomination

The Mason family and KyotoUSA nominated the SRVUSD Superintendent and Board of Education for the 2010 Sustainable Contra Costa Award. The nomination letter can be found here.