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.

National Renewable Energy Laboratory
Innovation for Our Energy Future

Introduction to Solar PV and Solar Mapping tools

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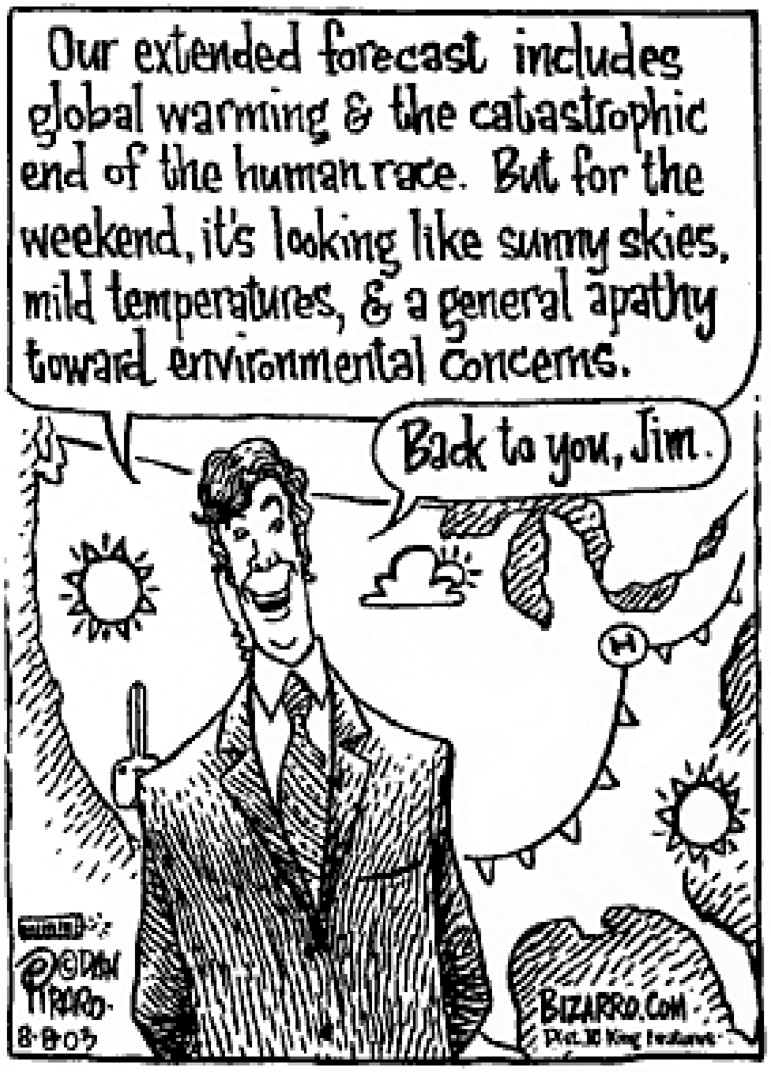
November 12, 2010
Presentation for: SSAIP Showcase

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

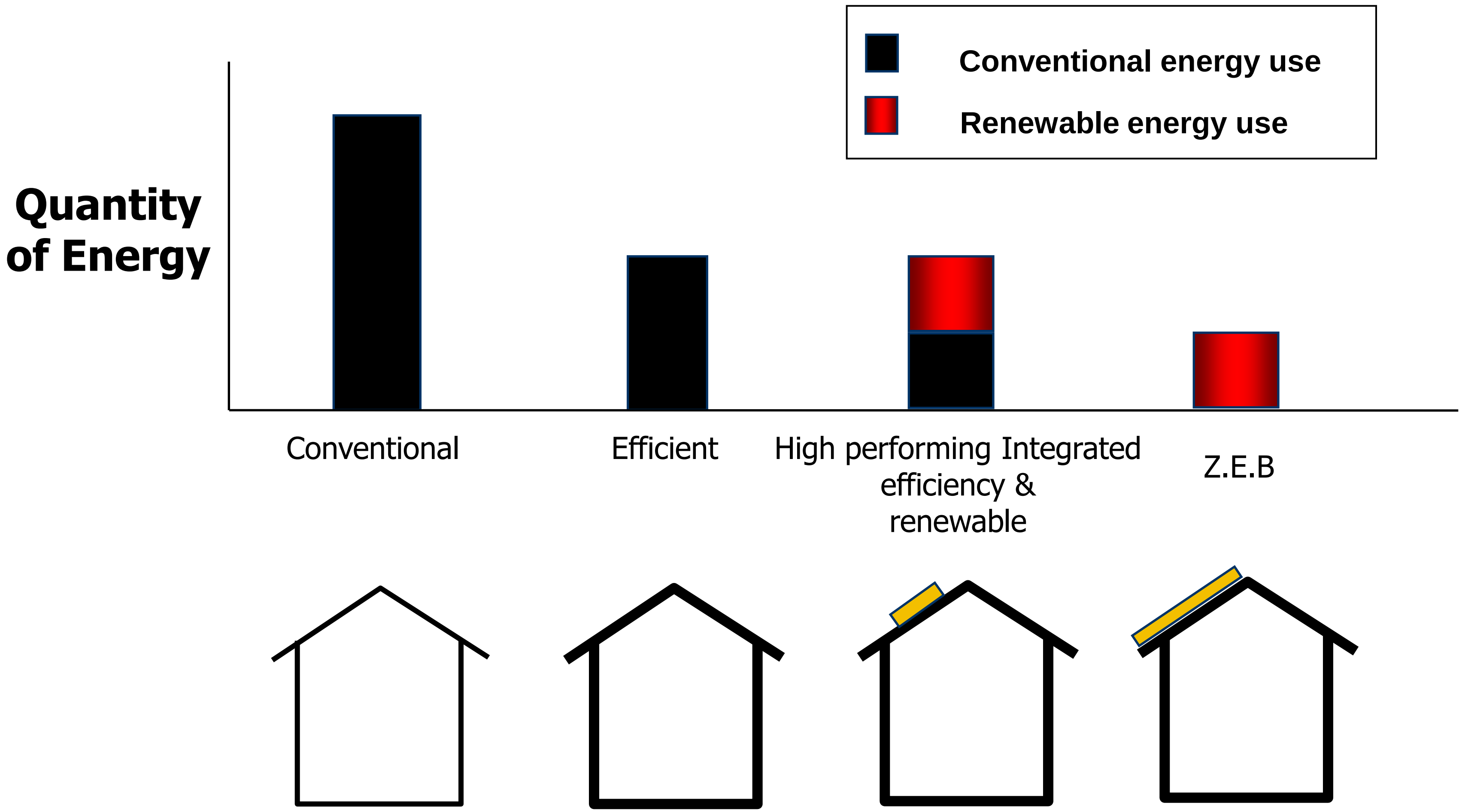
Reduce energy loads through:

- 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)

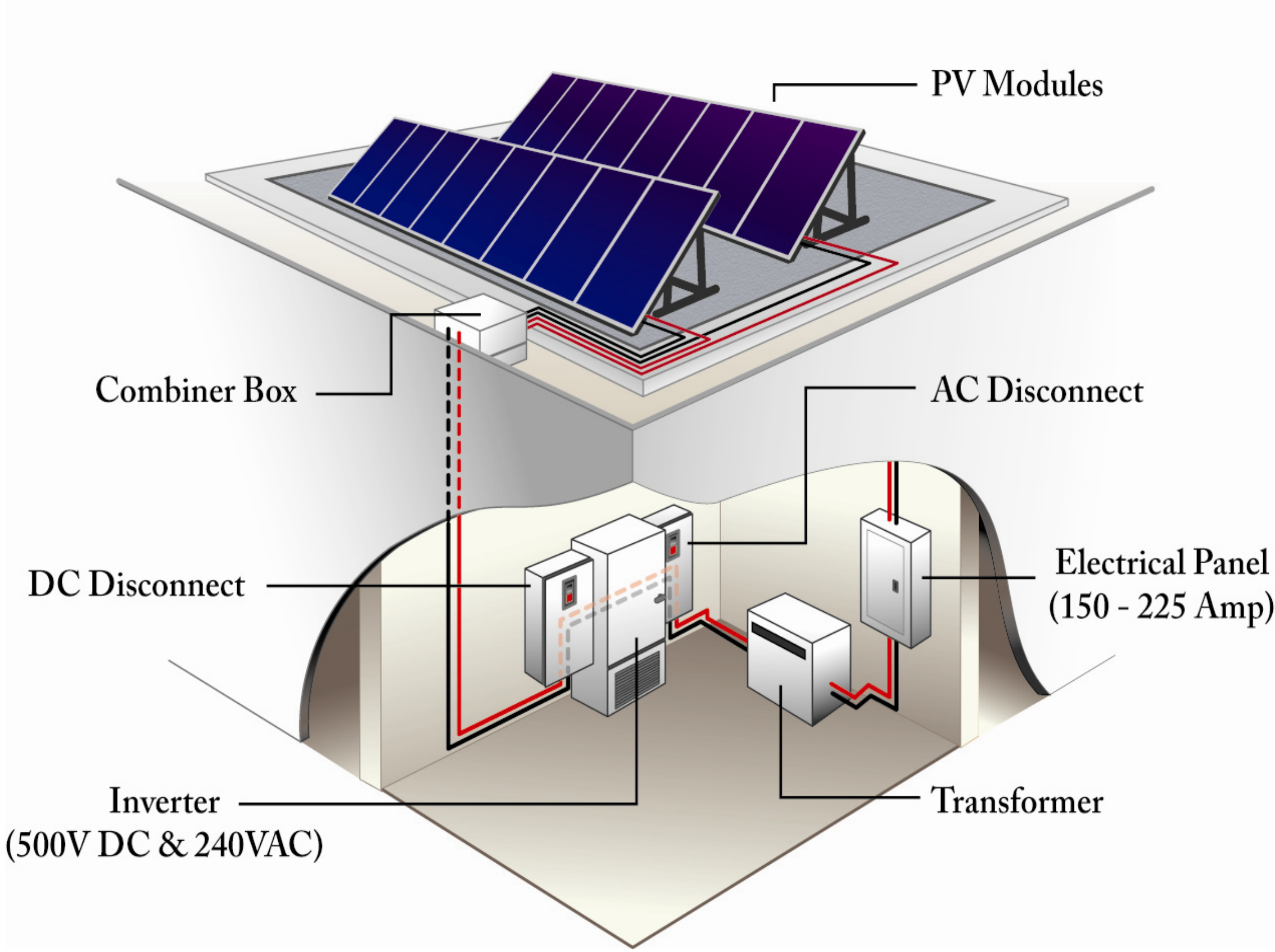
Grant Elementary School in Redding, CA

PV Installation Considerations

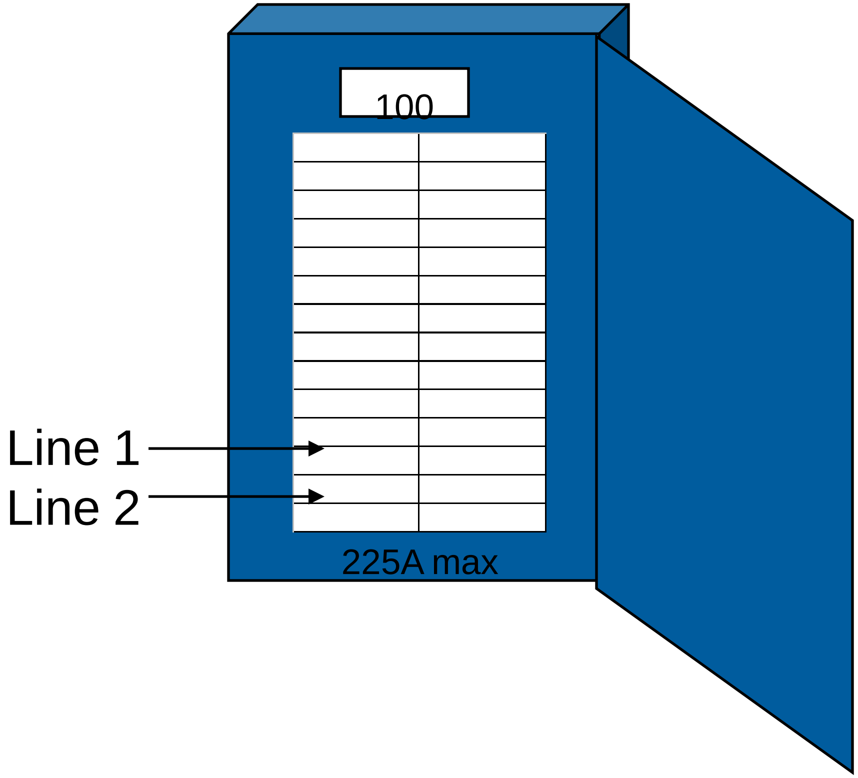
- Panel installation on south-facing, un-shaded area
- Install on ground, roof, or carport
- Panel tilt
- Tracking vs. Fixed
- Utility grid connection or stand-alone ('off the grid')
- Battery storage needed for off-grid operation

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

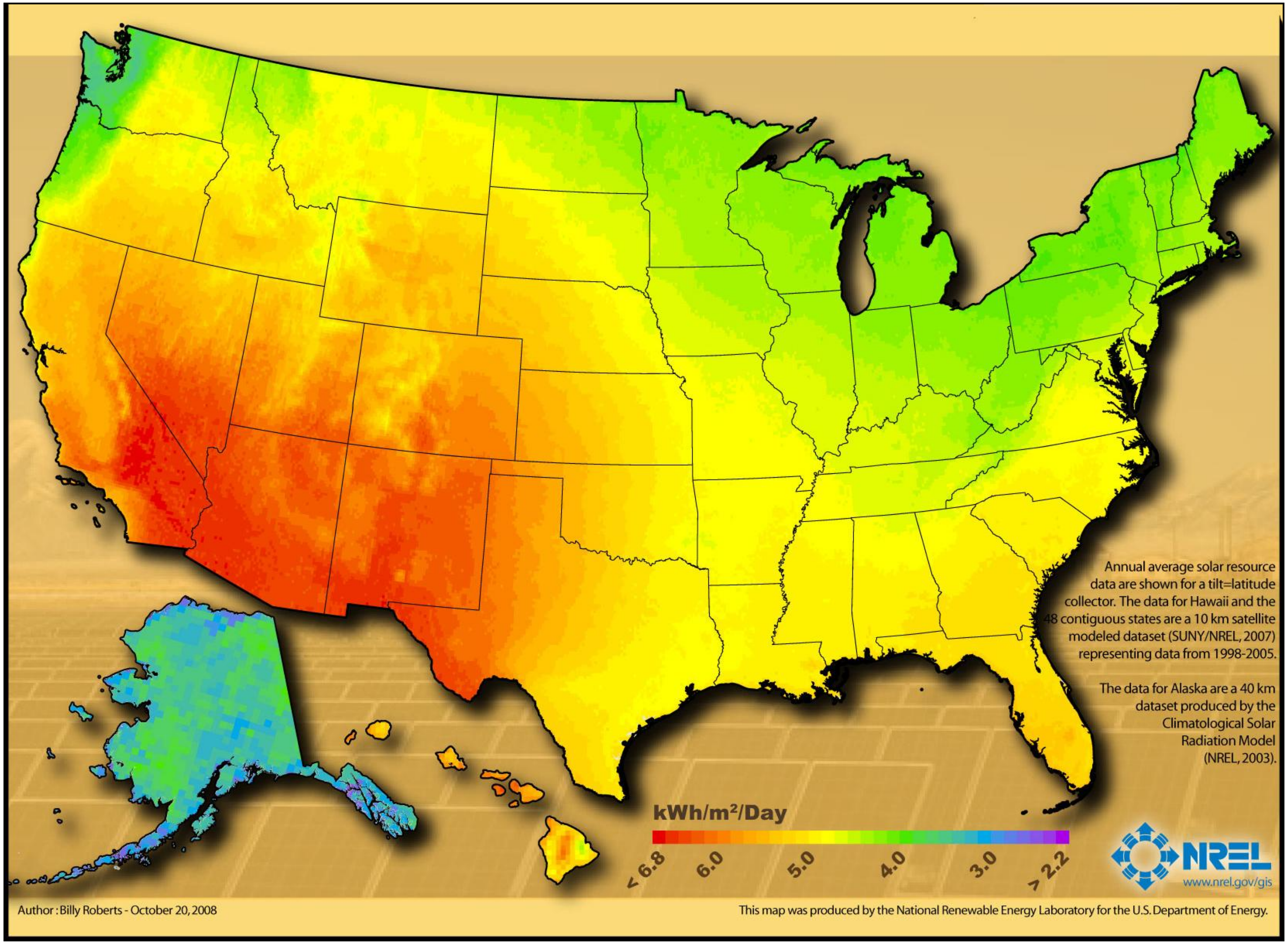


Utility Interconnection – Where to land the power?



- 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.

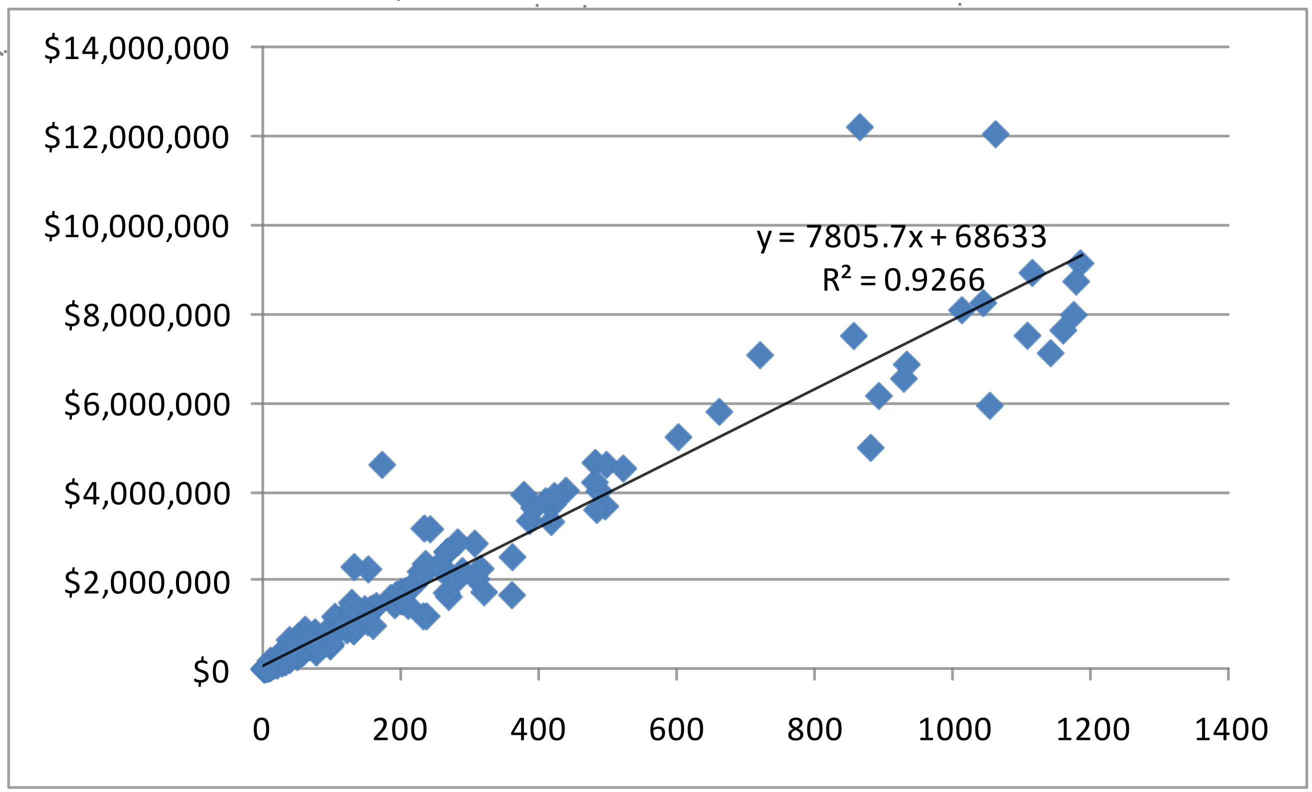
"Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998–2008," by Ryan Wiser, Galen Barbose, Carla Peterman, and Naim Darghouth may be downloaded from http://eetd.lbl.gov/ea/emp/re-pubs.html.

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

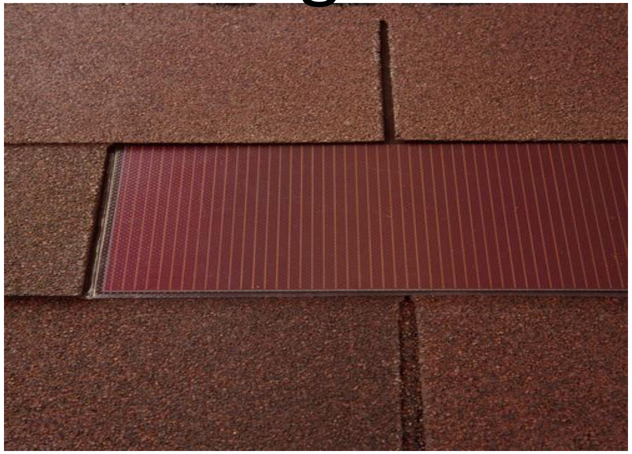
•Other Considerations

- –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**

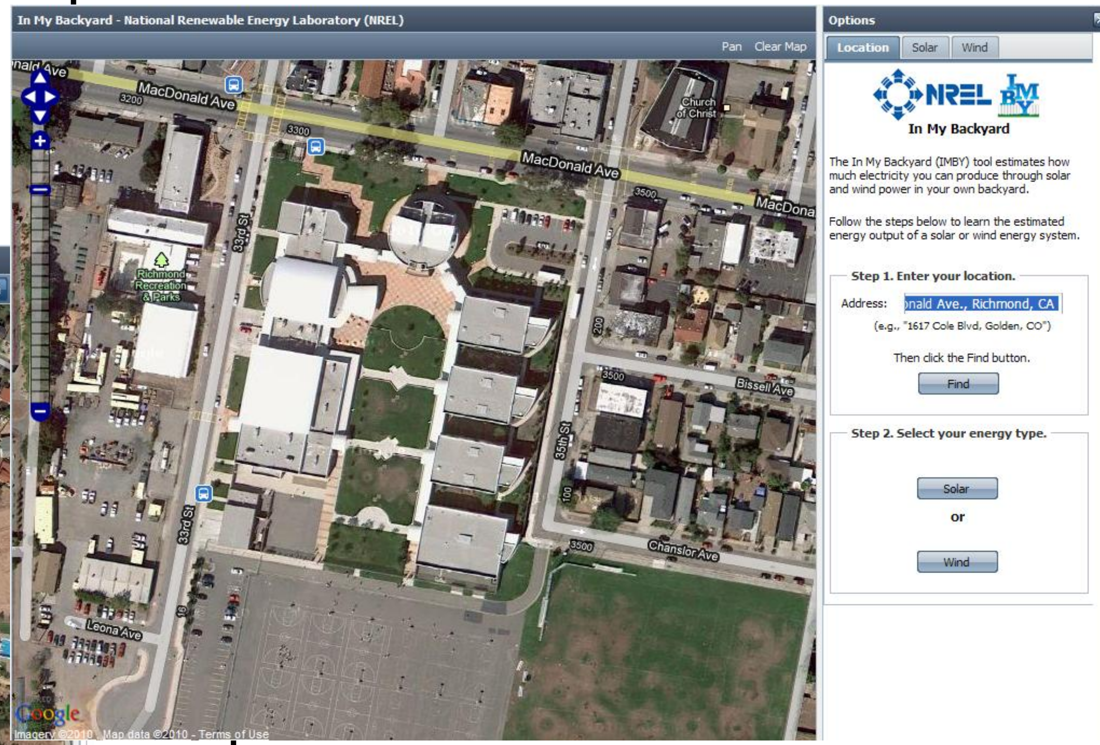
IMBY

- 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

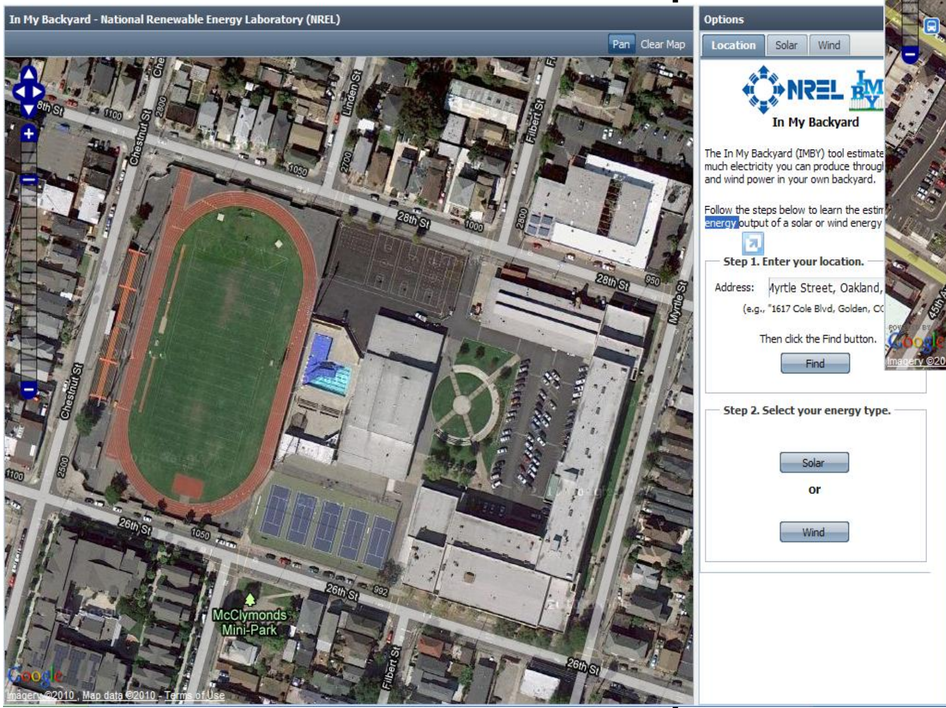
Hercules Middle/High –
1900 Refugio Valley Road
Hercules, CA 94547

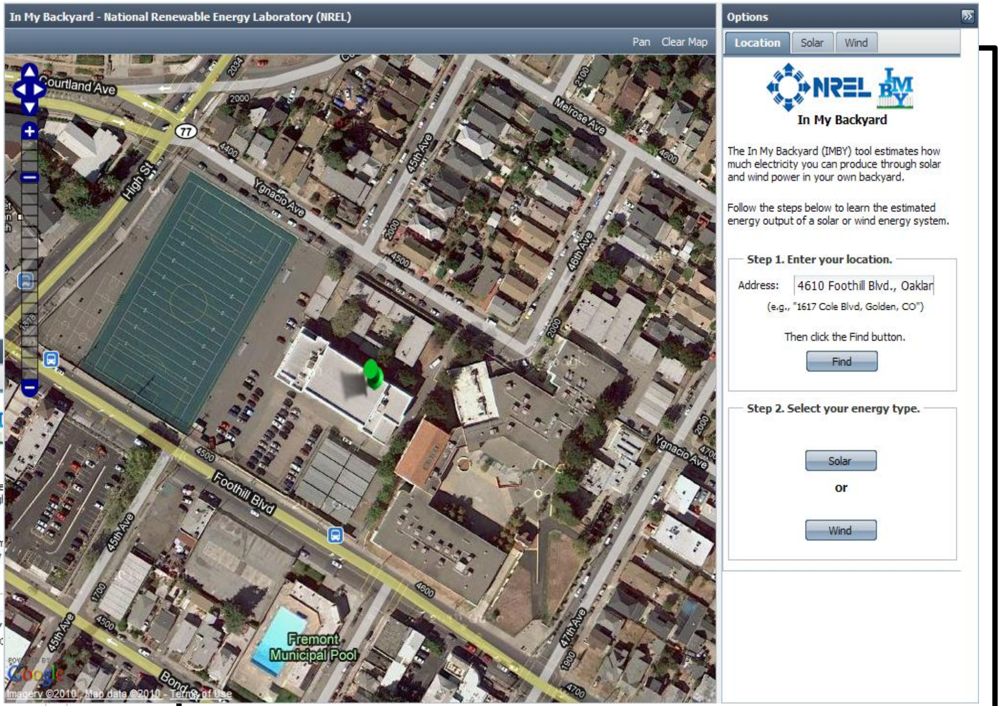


Lavonya DeJean Middle –
3400 MacDonald Ave.
Richmond, CA 94805

Examples: OUSD

McClymonds High School
2607 Myrtle Street
Oakland, CA 94607





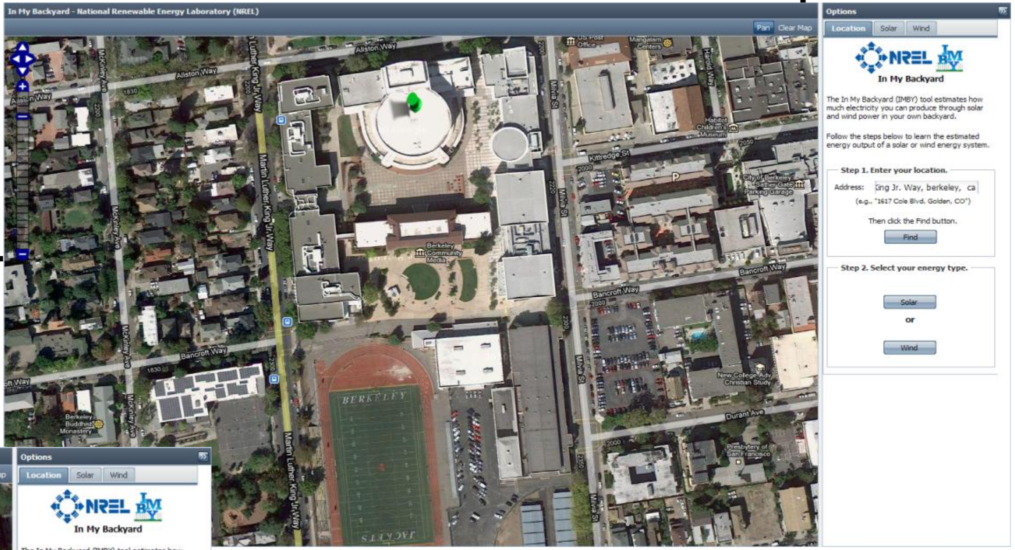
Fremont High School
4610 Foothill Blvd.
Oakland, CA 94601

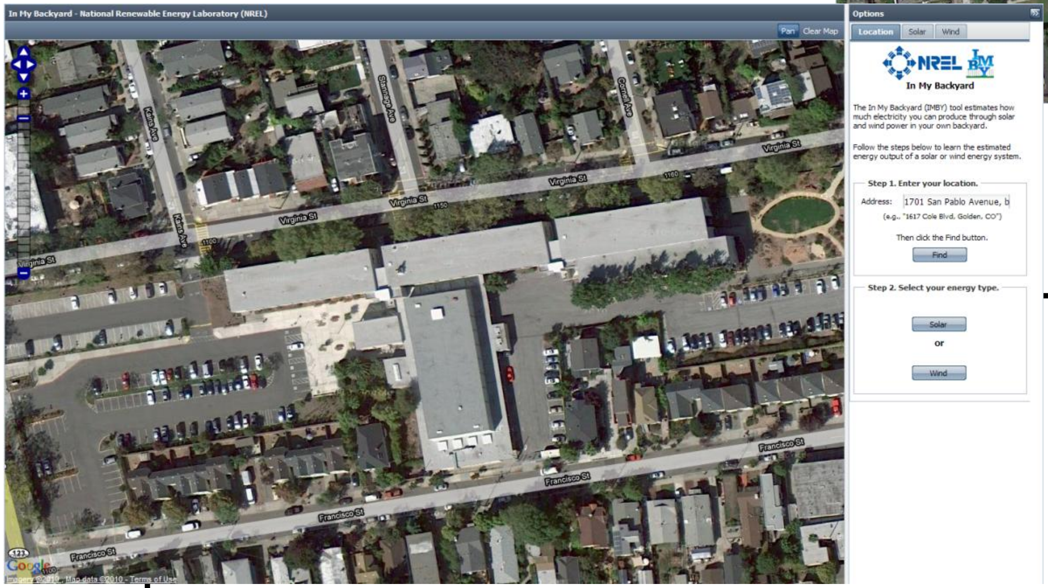
Examples: BUSD

Berkeley High School

2223 Martin Luther King Jr. Way

Berkeley, CA 94704





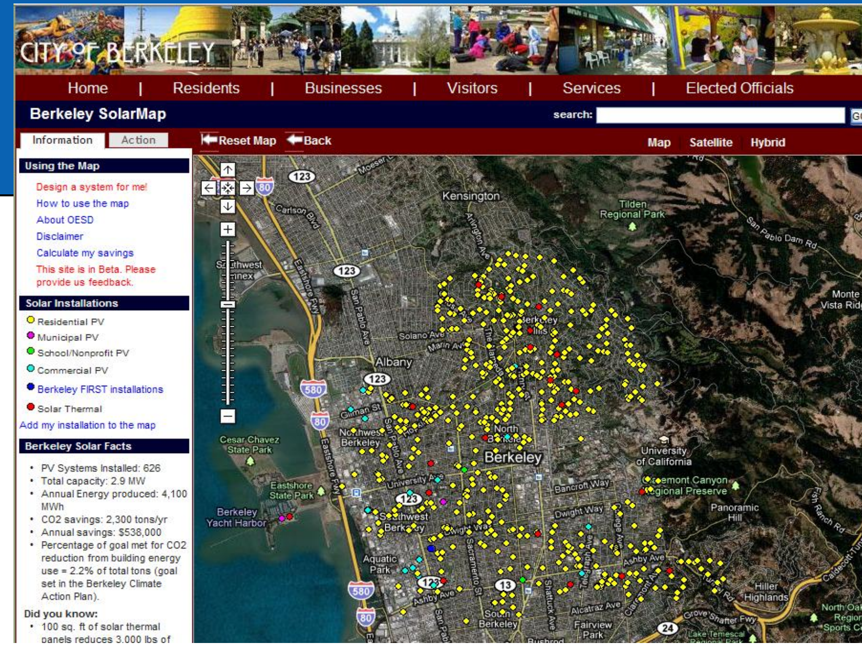
Franklin Adult School

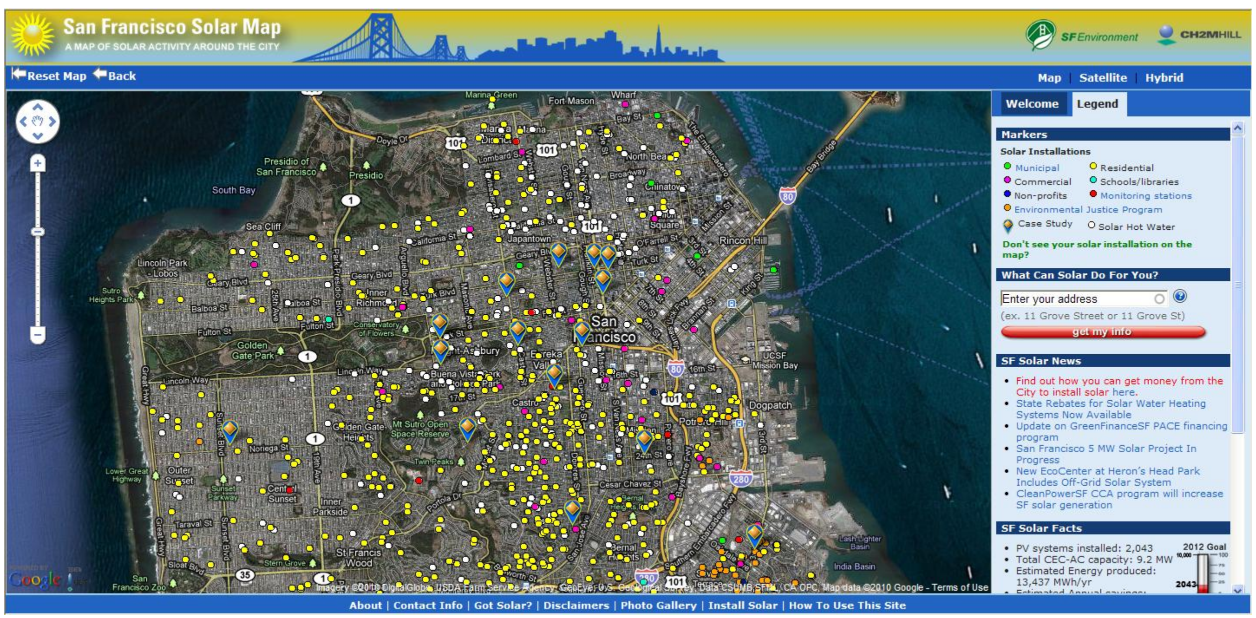
1701 San Pablo Avenue

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!

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Innovation for Our Energy Future

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