Basics of Photovoltaic (PV) Systems for Grid-Tied Applications

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Courtesy of DOE/NREL

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Pacific Gas and Electric Company

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PG&E Solar Information

www.pge.com/solar

Pacific Energy Center (San Francisco)

www.pge.com/pec

Energy Training Center (Stockton)

http://www.pge.com/myhome/edusafety/workshopstraining/stockton

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Agenda

1. Big picture: Team California
2. Electricity Fundamentals
3. PV Technology
4. Feasibility
5. Finances
6. Sales & Installation Process
7. Jobs Overview and Future Trends

One Minute Summary

Rent a portion of utility grid output

Buy your own power plant

CURRENT

Courtesy of DOE/NREL

Same electricity

Source: Pete Shoemaker

POSSIBLE

Your home needs electricity

The basic economics are just like the "rent vs. buy" of purchasing a home.

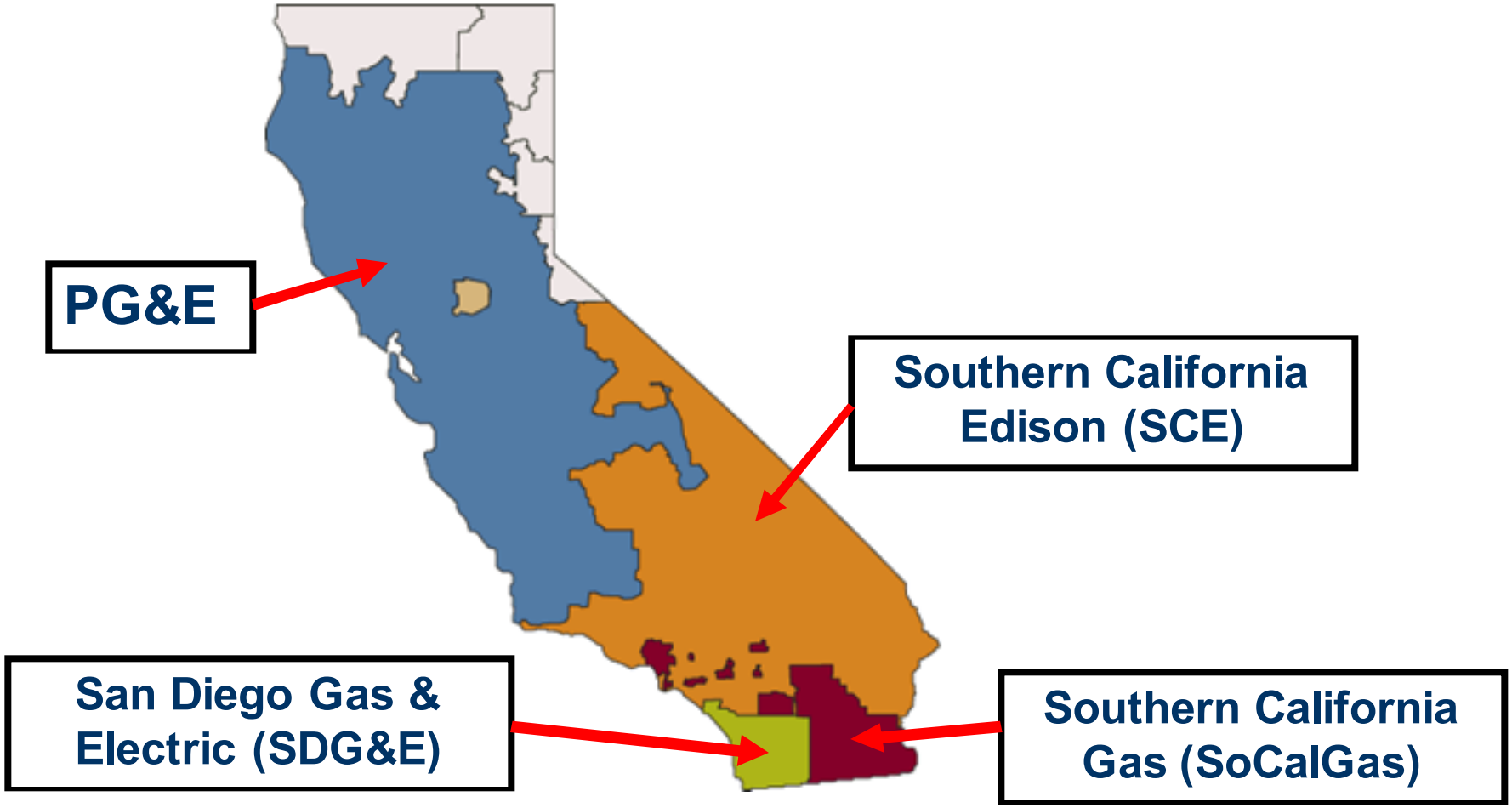
The Big Picture:
Team California

The California Regulated Utility Financial Structure

How the utilities make money,

and why they can support energy efficiency and conservation.

California's regulated utilities cover most of the state.



They are essentially monopolies in their respective territories, and so need to be regulated.

CPUC

PG&E

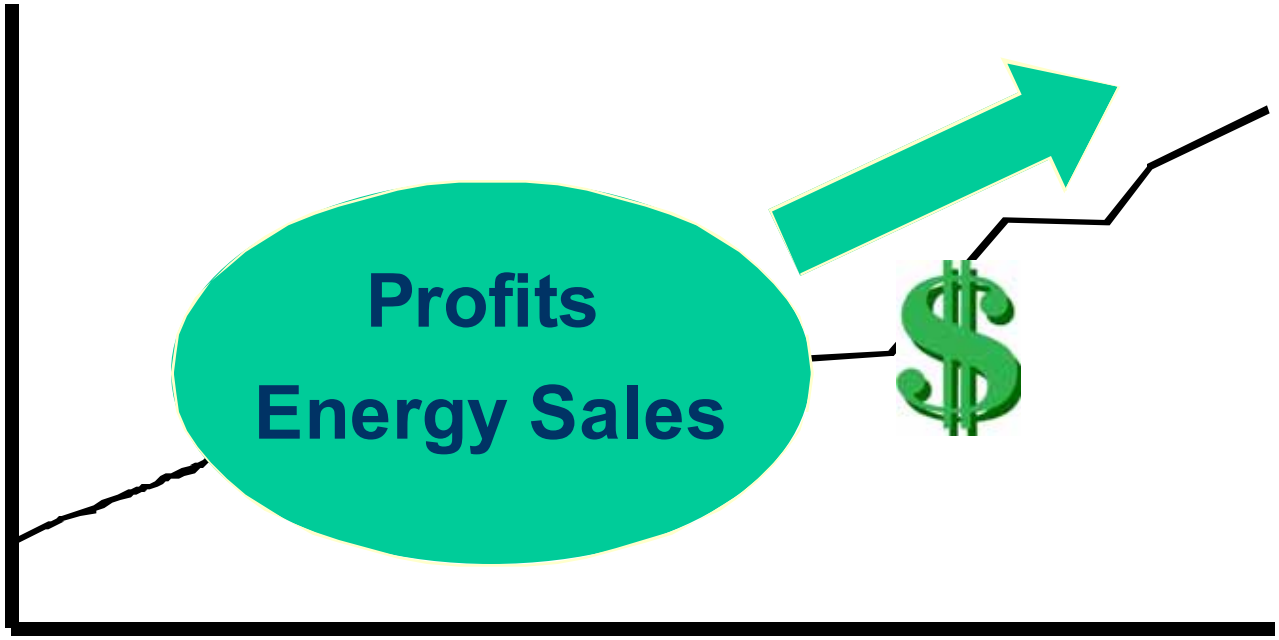
SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

SDGE

Southern California Gas Company

The California Public Utilities Commission is the regulatory body.

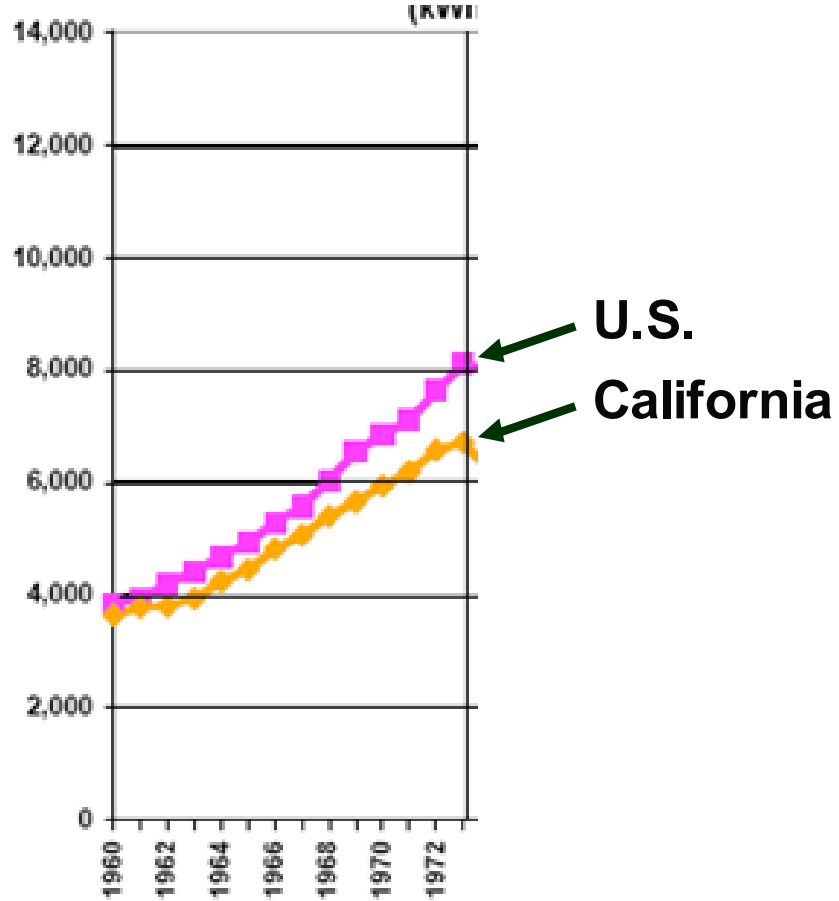
30 years ago, the utilities made money like most businesses: on profits from sales.



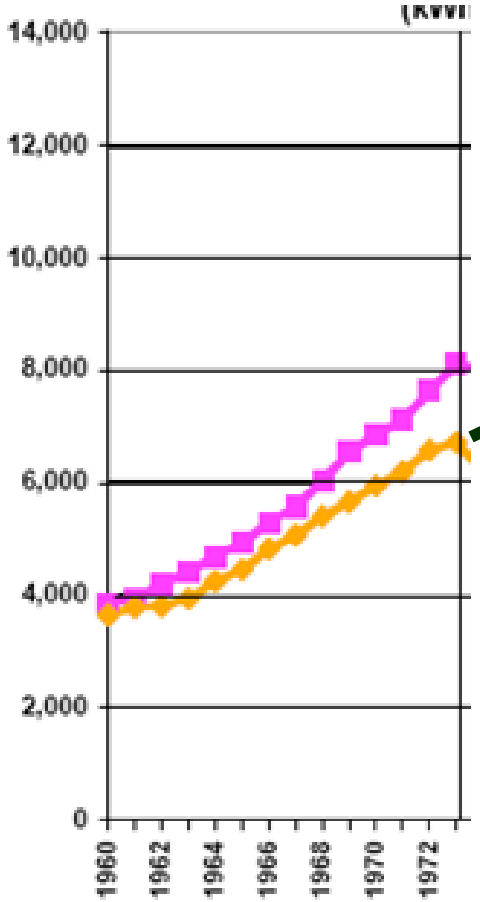
The more energy they sold, the more profit they made.

Also 30 years ago, California's power consumption was rising rapidly, along with the rest of the country.

Per-capita power consumption.



Projecting this into the future made people realize that it was not sustainable, and that something needed to be done.



Very high utility bills

Many more new power plants

Serious environmental consequences

We needed to lower people's energy usage, but how?

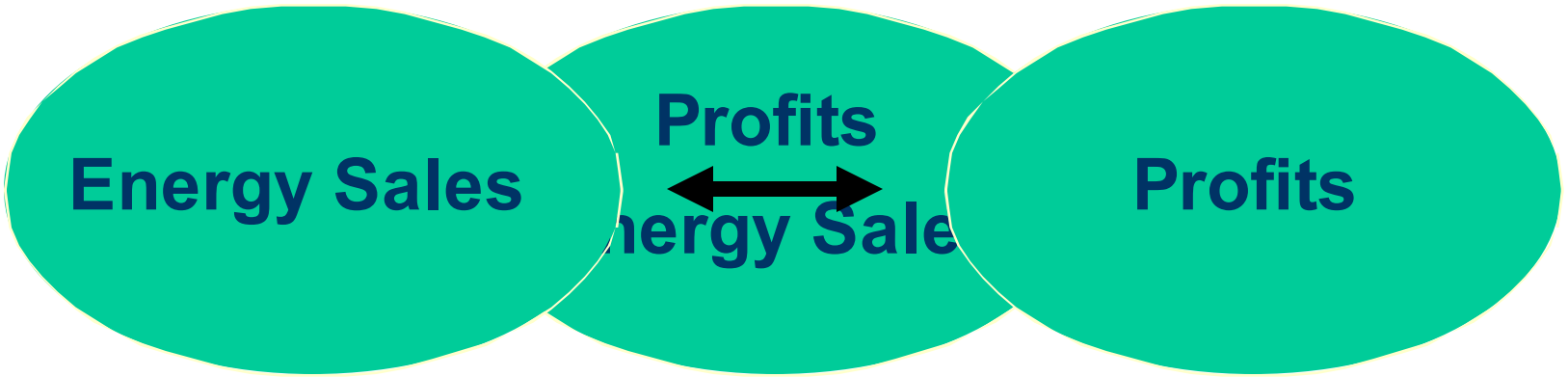
The utility companies had to be involved, but how could you require them to encourage less energy usage, since their profits and business model depended on more sales?

<u>Conclusion:</u>

The utility financial structure must change.

DECOUPLING

Separating profits from sales.



Since 1978 (gas) and 1982 (electricity) California's regulated utilities have made profits on INVESTMENTS, not SALES.

These investments are directed by the CPUC and include energy efficiency and conservation.

Example of EE investment and target:

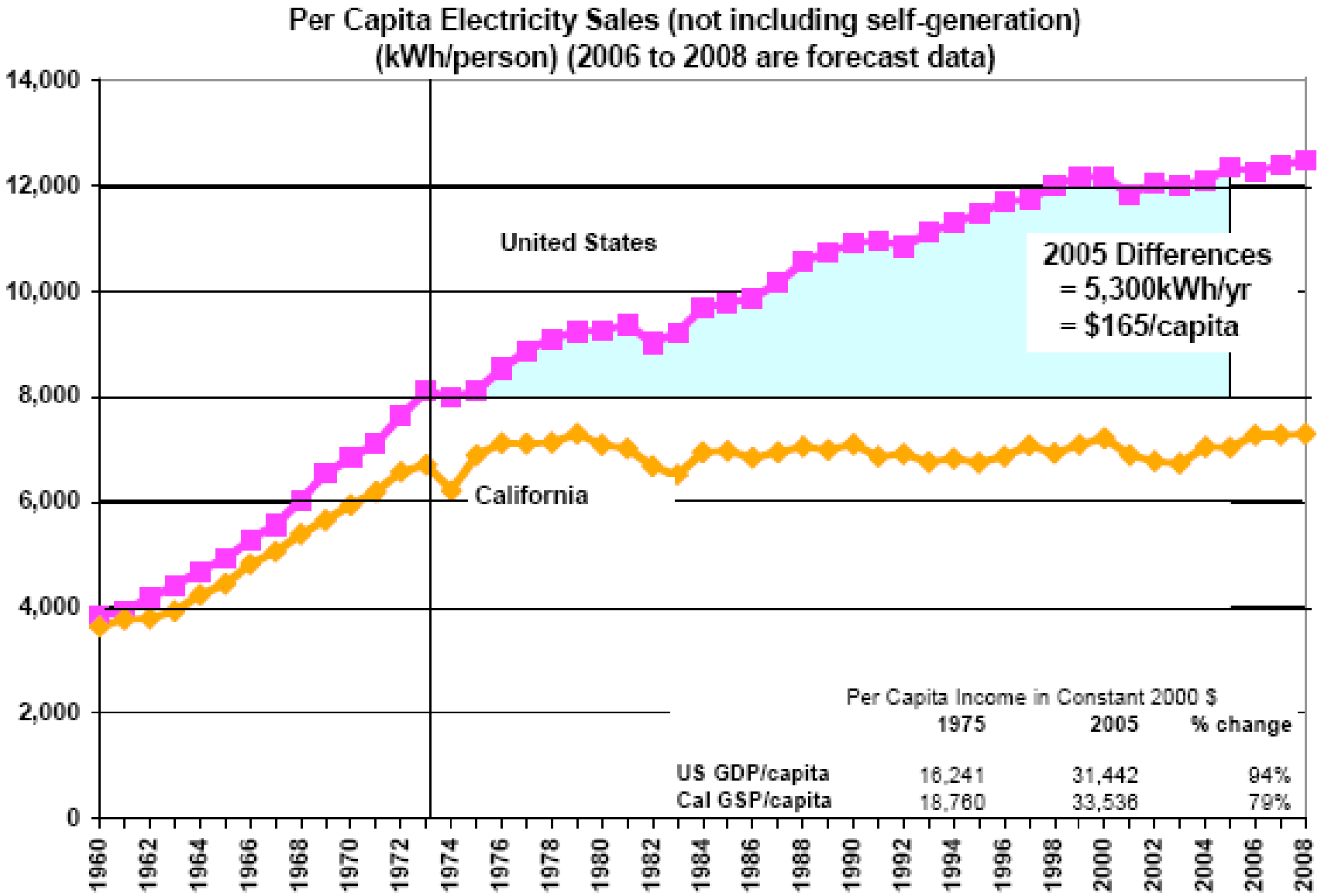
1. The CPUC authorizes PG&E to spend the money to give away 1,000,000 CFLs.
2. The target over 3 years is to reduce electric consumption [xx] mWh.
3. If PG&E makes the target they can set rates so that they earn [x]% for their shareholders.
4. If they exceed the target they can earn more, if they miss the target they earn less or even get penalized.

California utilities have NO incentive to increase energy usage.

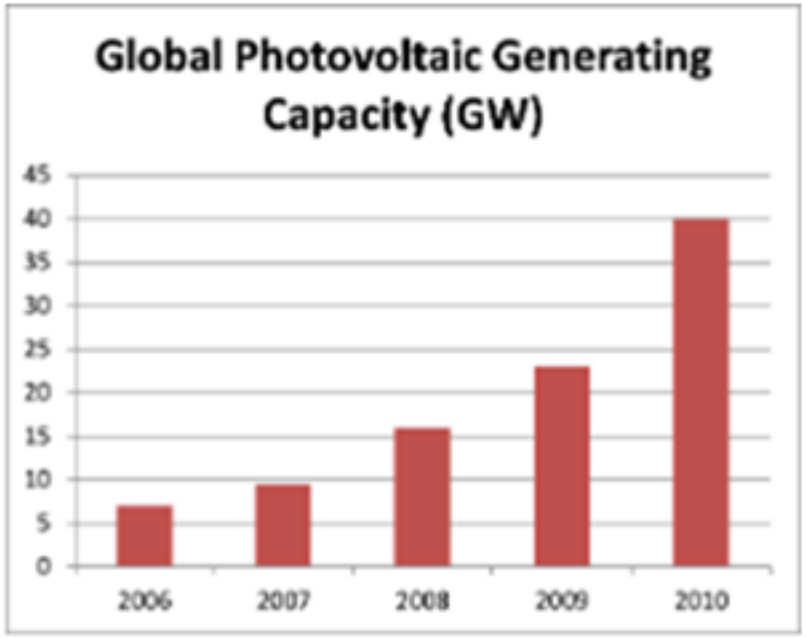
They DO have mandates and incentives for energy efficiency, conservation, and renewables.

The result?

California, and PG&E, is the leader in energy efficiency and renewable generation.


Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
United States
California
2005 Differences
= 5,300kWh/yr
= $165/capita
Per Capita Income in Constant 2000 $
1975
2005
% change
US GDP/capita 16,241 31,442 94%
Cal GSP/capita 18,760 33,536 79%
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

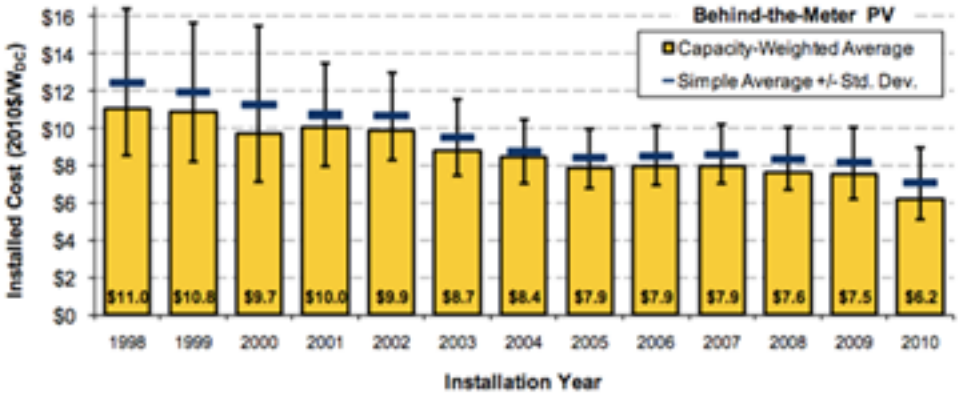
Solar Electric Trends



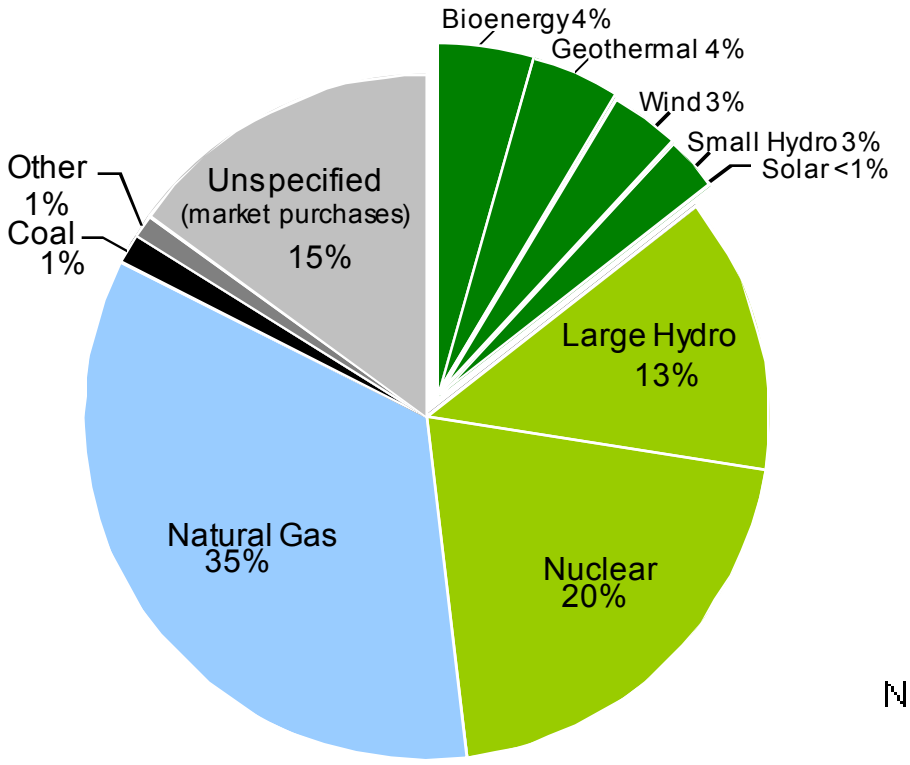
Installation

"One of the fastest growing industries in the U.S."

Price

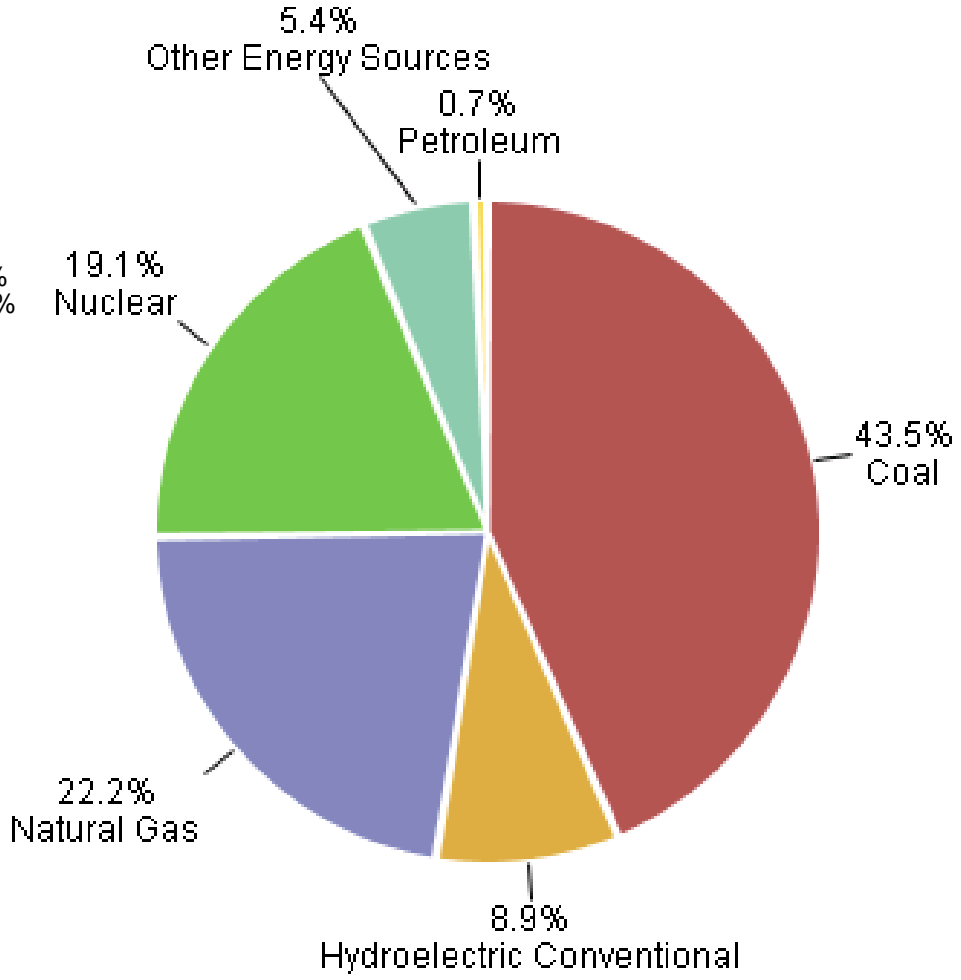


PG&E Electrical Power Mix 2009



Source: PG&E

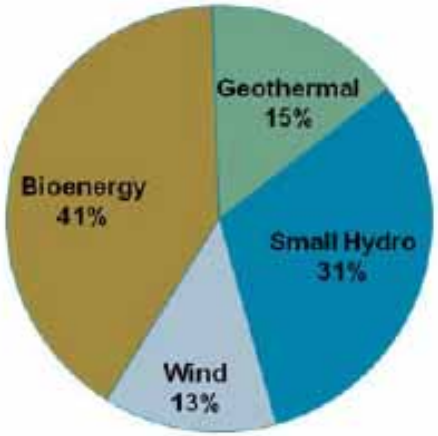
U.S. Electrical Power Mix June 2011



Source: U.S. Energy Information Administration, *Electric Power Monthly*

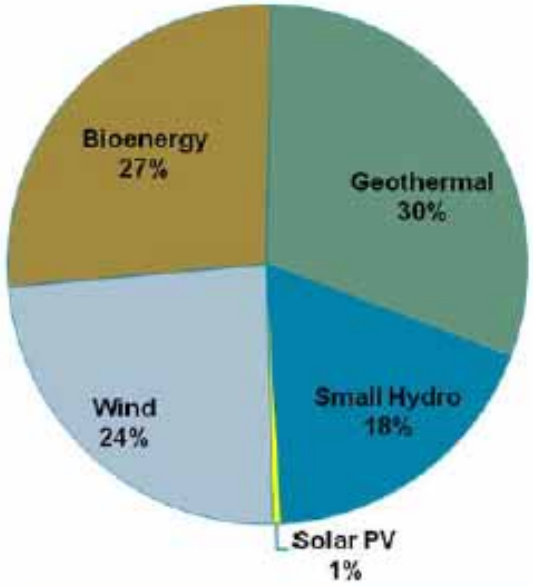
Portfolio: Past, Present, and Future

2002 Actual
10.6% of total bundled retail sales



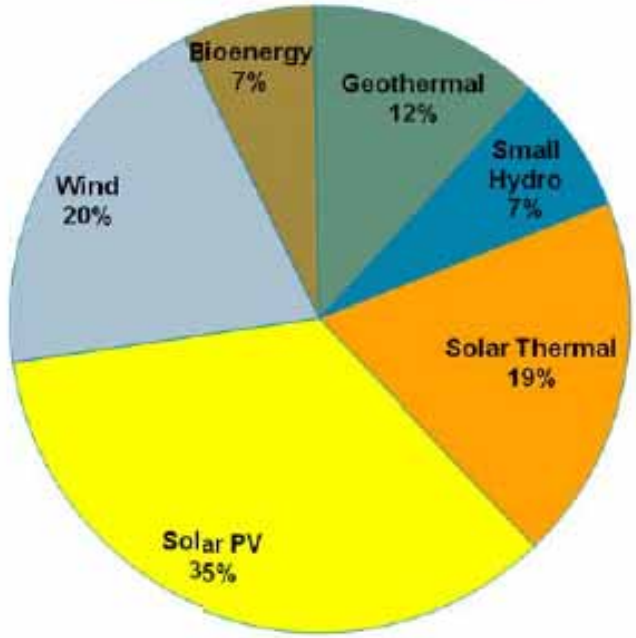
Total RPS-Eligible Procurement
7,504 GWh

2010 Actual
16% of total bundled retail sales



Total RPS-Eligible Procurement
12,340 GWh

2020 Projected
33% of total bundled retail sales



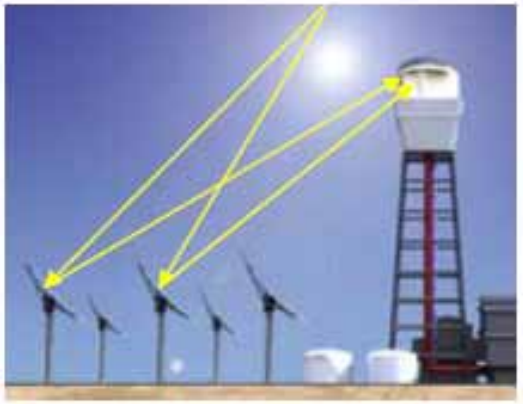
Projected RPS-Eligible Procurement
~27,000 GWh

Source: PG&E's 2002 Corporate Environmental Report and PG&E's August 2011 RPS Compliance Report.
Note: 2020 deliveries are based on current and projected future contractual commitments.

Solar Thermal Technologies
Under Contract

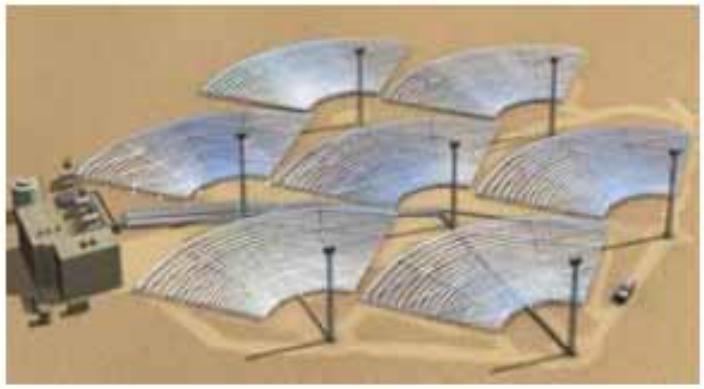
Parabolic Trough

Compact Linear Fresnel Reflector

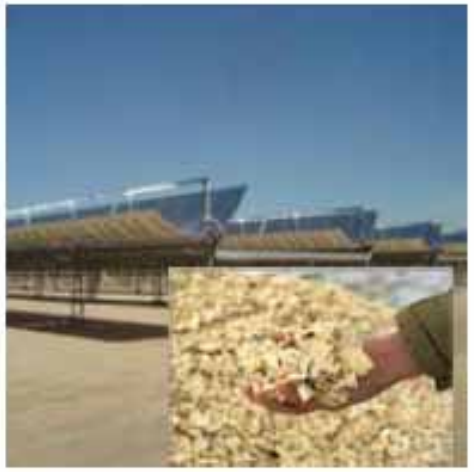


Power Tower

Dish Engine (SCE/SDG&E)



Power Tower (SCE)



Trough/Biomass Hybrid

Courtesy PG&E

Solar PV Technologies
Under Contract

Fixed Thin Film (a-Si)

Tracking Crystalline Silicon

Fixed Thin Film (Cd Tel) (SCE)

Unspecified CPV (illustrative)

Concentrating PV

Courtesy PG&E

Other Renewable Technologies
Under Contract

Biomass Energy

Wind Energy

Geothermal Energy

Small Hydropower (<30MW)

BioGas

Ocean Power

Courtesy PG&E

The Big Picture

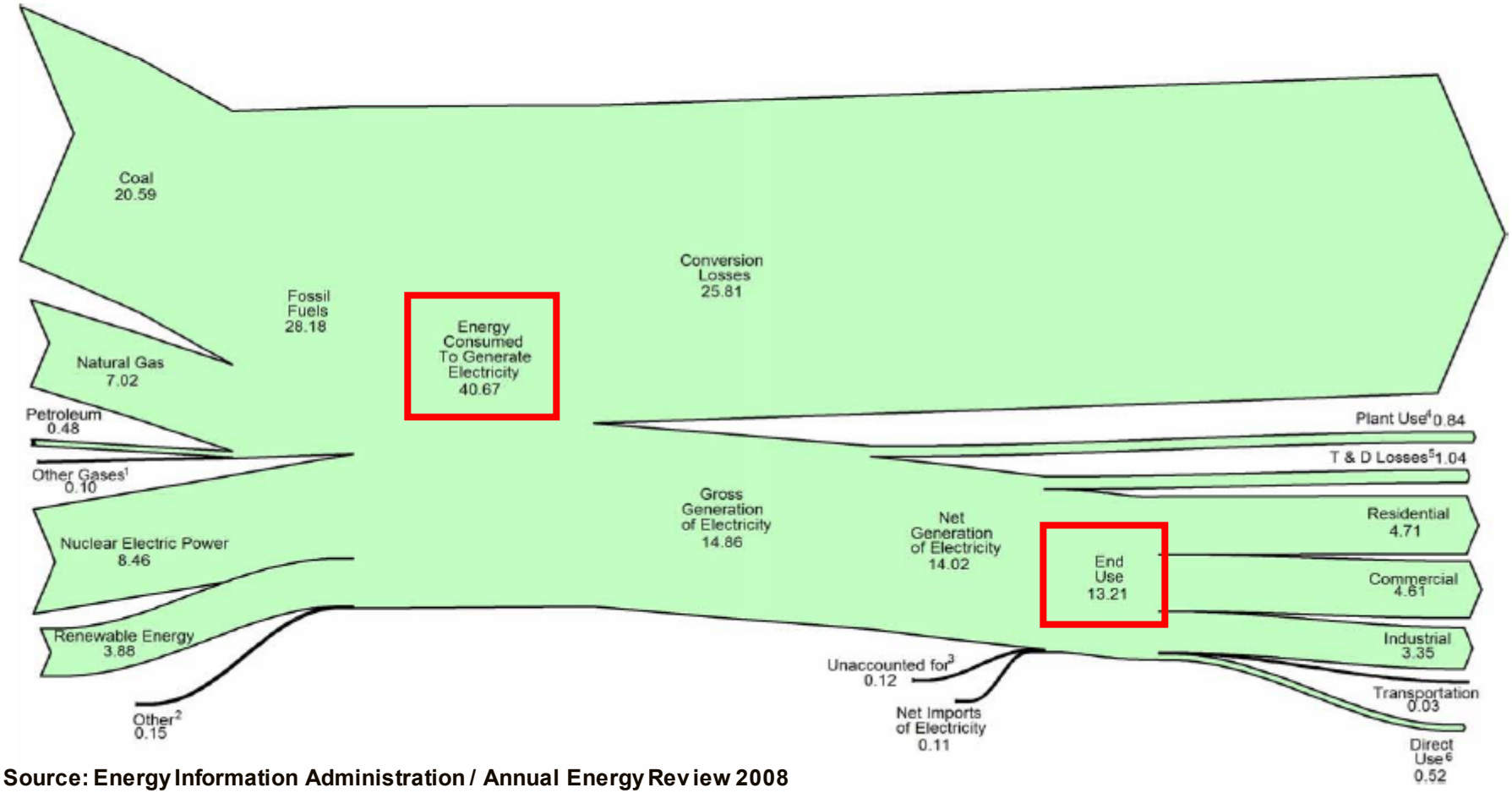
California Public Utilities Commission (CPUC) "Loading Order"

How we fill in new supply in California

1. **Energy Efficiency/Demand response**
2. **Renewables**
3. **Distributed Generation (such as CHP)**
4. **Conventional efficient fossil generation**

U.S. Electricity Generation 2008

Figure 8.0 Electricity Flow, 2008
(Quadrillion Btu)

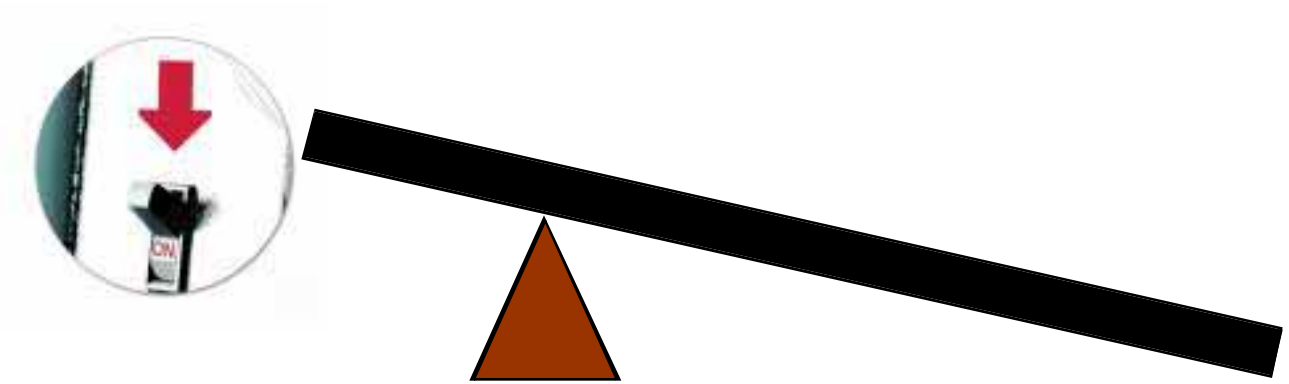


Source: Energy Information Administration / Annual Energy Review 2008

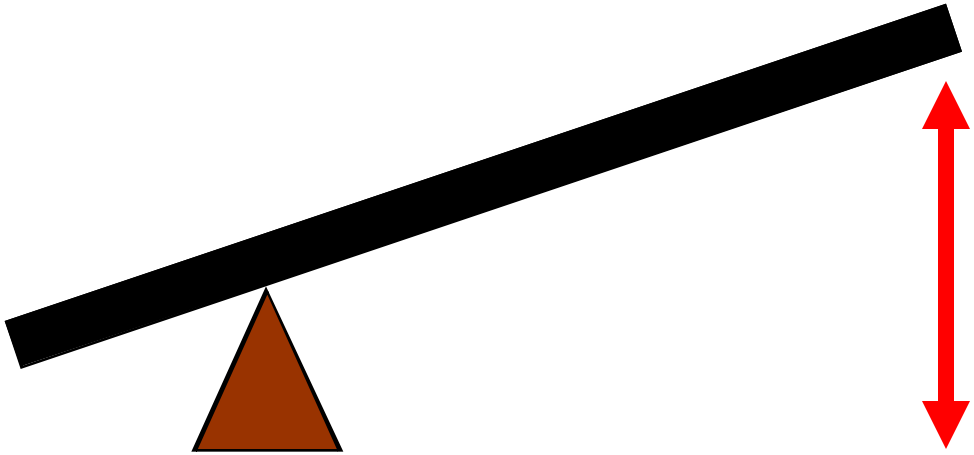
Total energy consumed = 40.67 **Delivered for end use = 13.21 (32%)**

Over 2/3 of the energy is wasted.

Energy Conservation



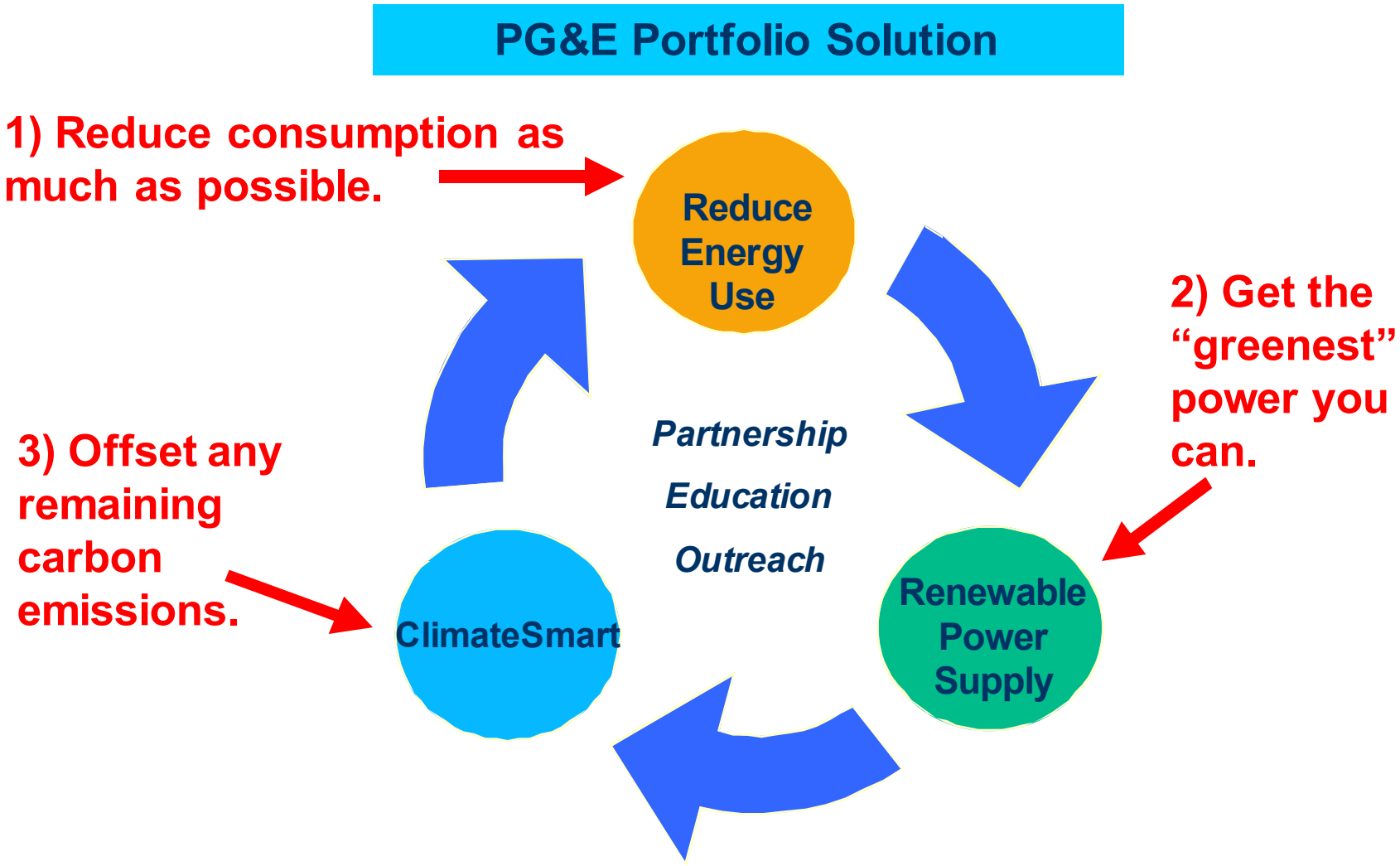
Energy Conservation



3 times the value!

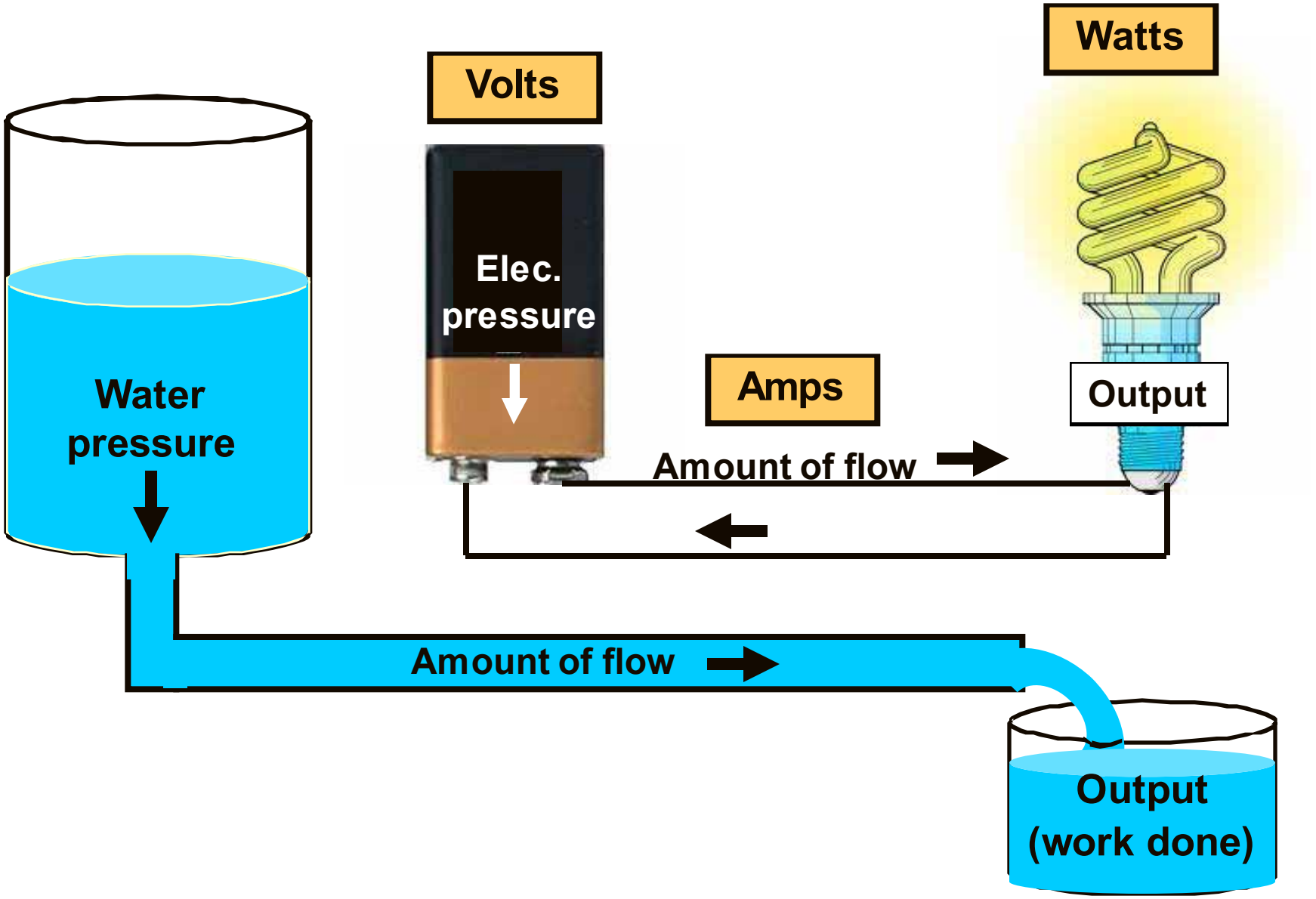
That's leverage!

PG&E as a Partner and Solutions Provider



Electricity Fundamentals

Electricity Fundamentals



Electricity Fundamentals

Watt (W) = Basic unit of Power

In generator: Capacity to do work
In appliance (load): Requirement for work to be done

Electrical terms:

- Amps x Volts = Watts
  - 5A x 12V = 60 W
  - 0.5A x 120V = 60 W

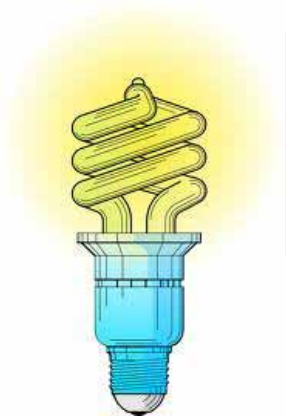
Kilowatt (kW), Megawatt (MW)

- 1 kW = 1,000 Watts
- 2.5 kW = 2,500 Watts
- 1 MW = 1,000,000 Watts
- 500 MW = 500,000,000 Watts

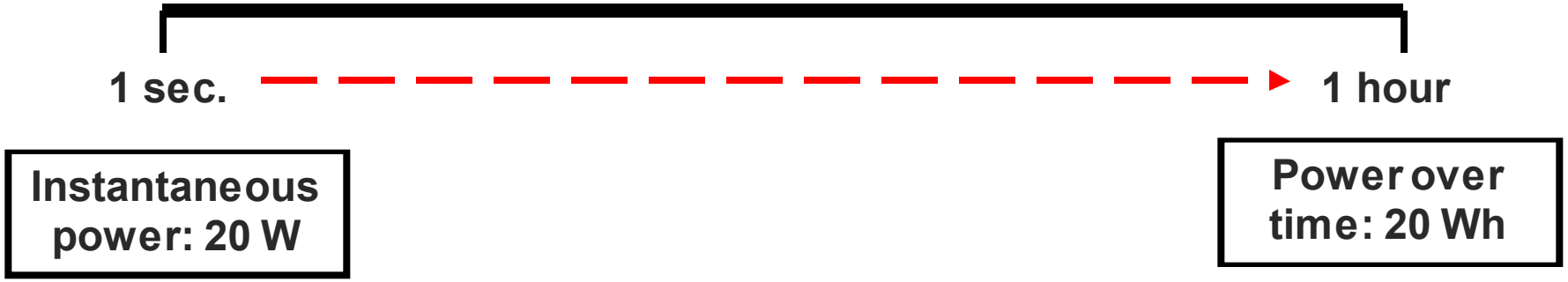
Electricity Fundamentals

Power over time = Work

Watts over time = Watt-hours (Wh)



Power x Time



Electricity Fundamentals

Watt-hour (Wh) x 1000 = Kilowatt-hour (kWh)

In a generator:

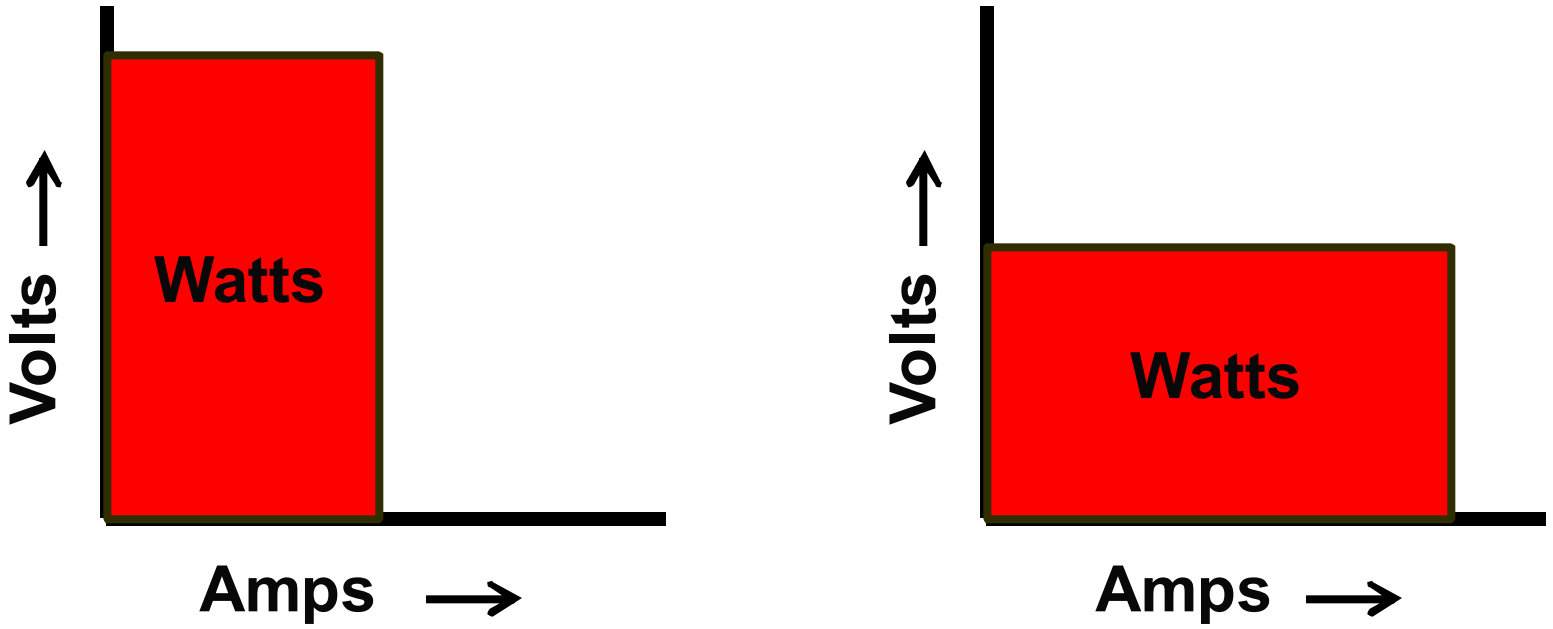
How many kWh are produced when a 5 kW PV system operates at full power for 6 hours? **30 kWh**

In a load:

How many kWh are used when a 200 W bulb shines for 10 hours? **2000 Wh or 2 kWh**

Voltage and Current

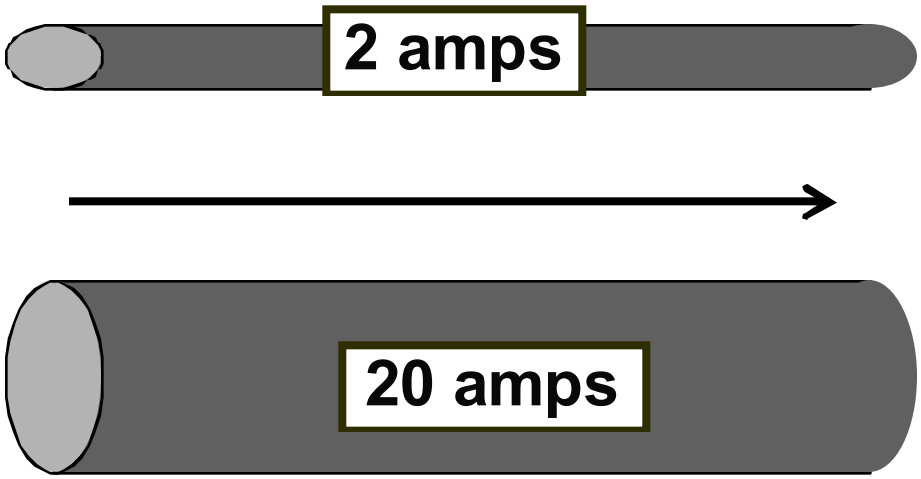
Volts x Amps = Watts



Area of rectangle = total power (watts)

Same area = same power, just in different form.

Voltage and Current

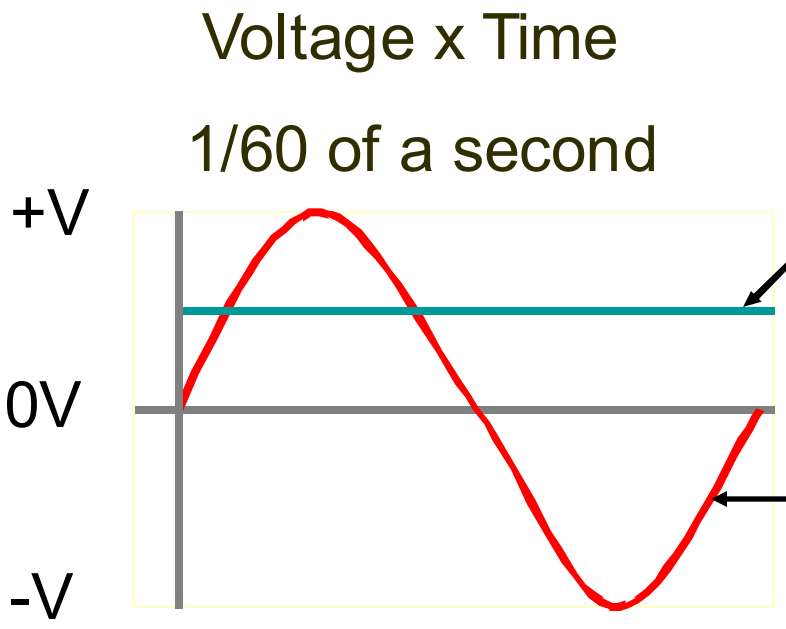


The larger the current, the larger the wire needed to make it flow efficiently (more “pipe”).

Copper wire is expensive.

Using higher voltage allows the same amount of power to be transmitted with lower current, saving money.

Types of Electrical Current



DC = Direct current

*PV panels produce DC

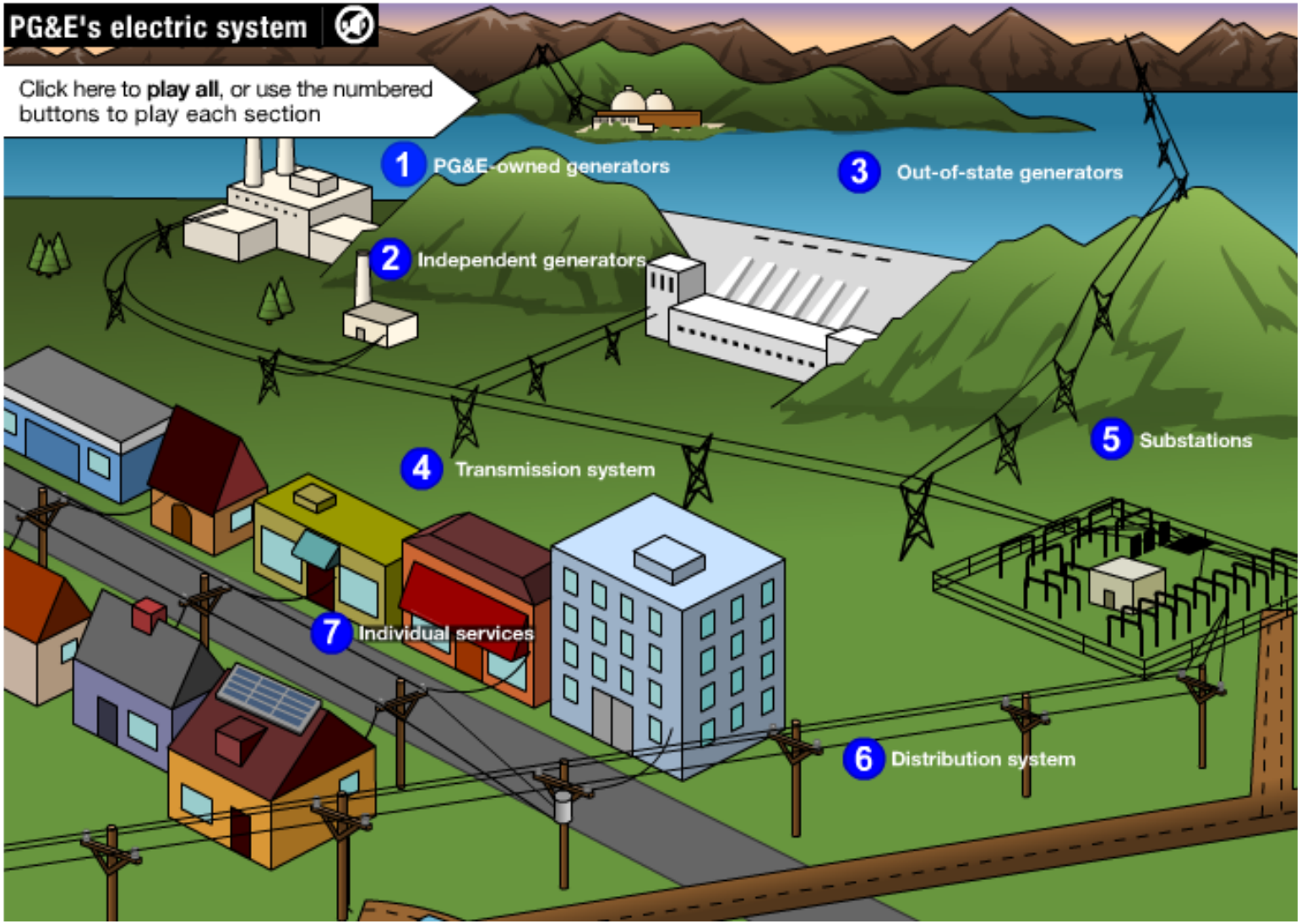
*Batteries only store DC

AC = Alternating current

*Utility Power

AC power can be stepped up and down in voltage much easier than DC power, therefore most power is AC.

The Electric Grid



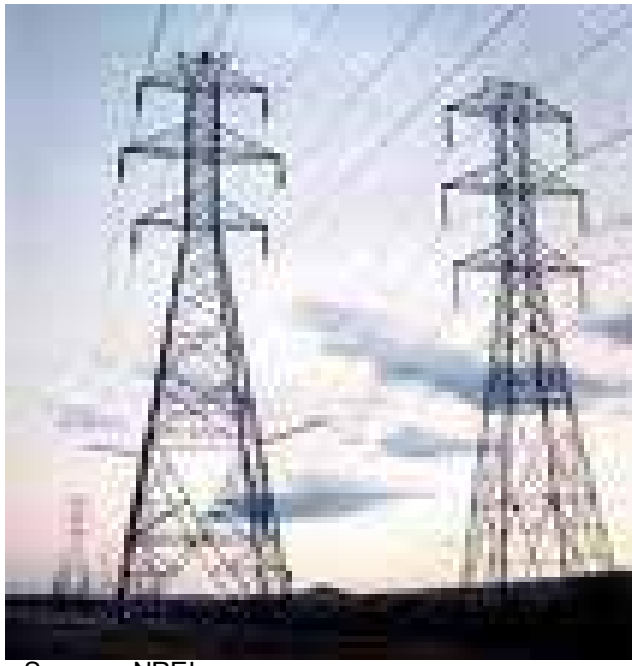
Source: PG&E

The Electric Grid

Electricity can be transported at the speed of light, therefore any point can be said to be connected to all others.

This network is called the GRID and is nation-wide.

Source: NPR
http://www.npr.org/templates/story/story.php?storyId=110997398



Source: NREL

The Electric Grid

There are three main components of the grid:

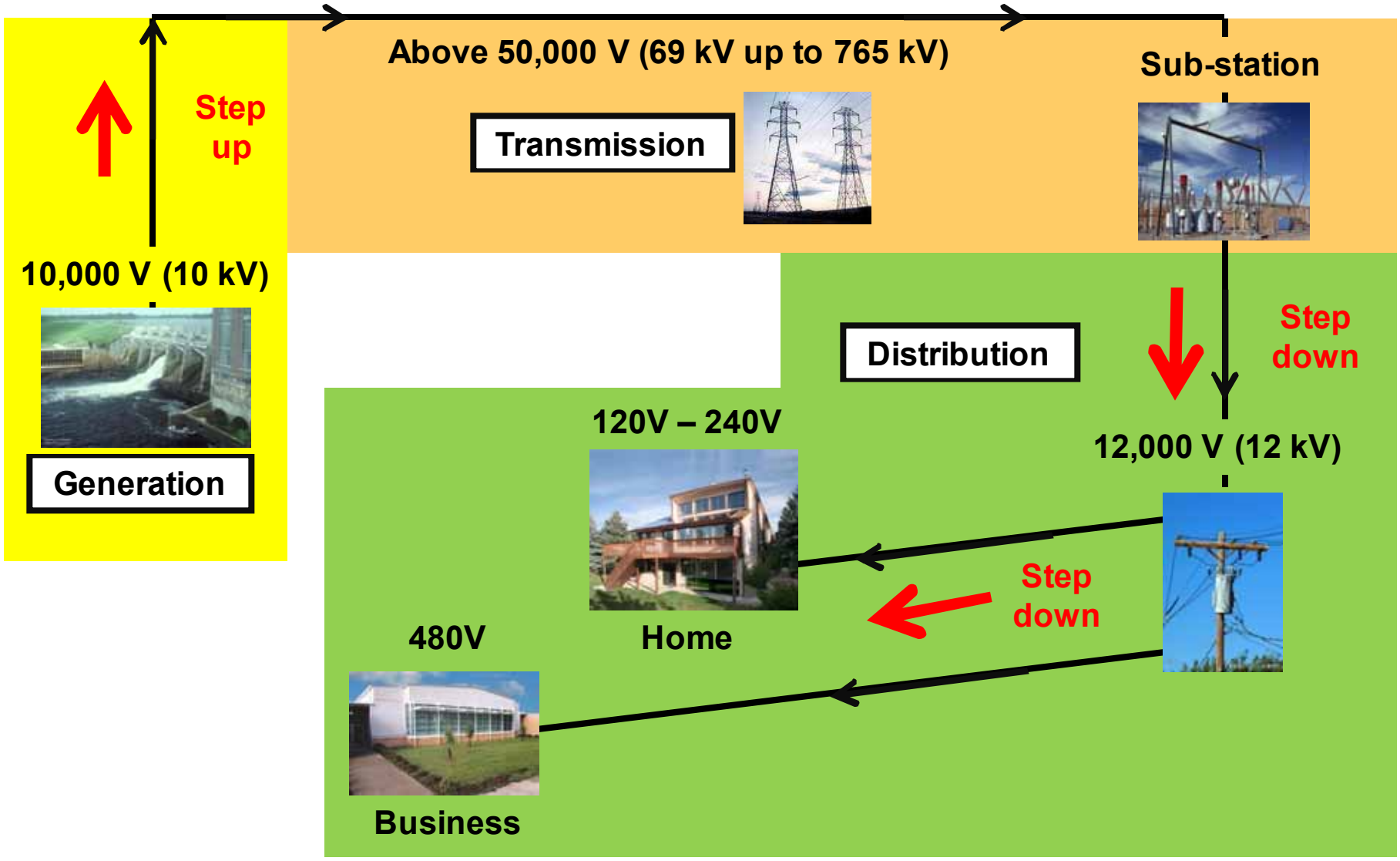
Generation: Creating electricity.

Transmission: Moving it in bulk from generators to distribution centers.

Distribution: Bringing it from centers (sub-stations) to individual homes and businesses.

Source: NREL

The Electric Grid

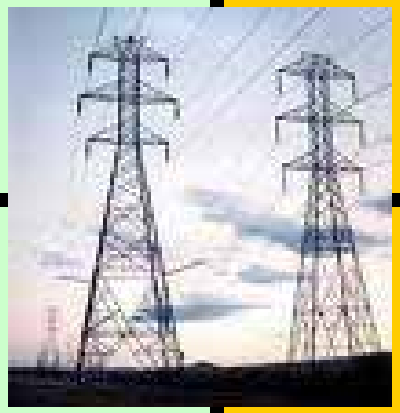


Source: NREL

Grid Terms

Supply side

Generation



Demand side

Usage (load)

Source: NREL

Grid Terms

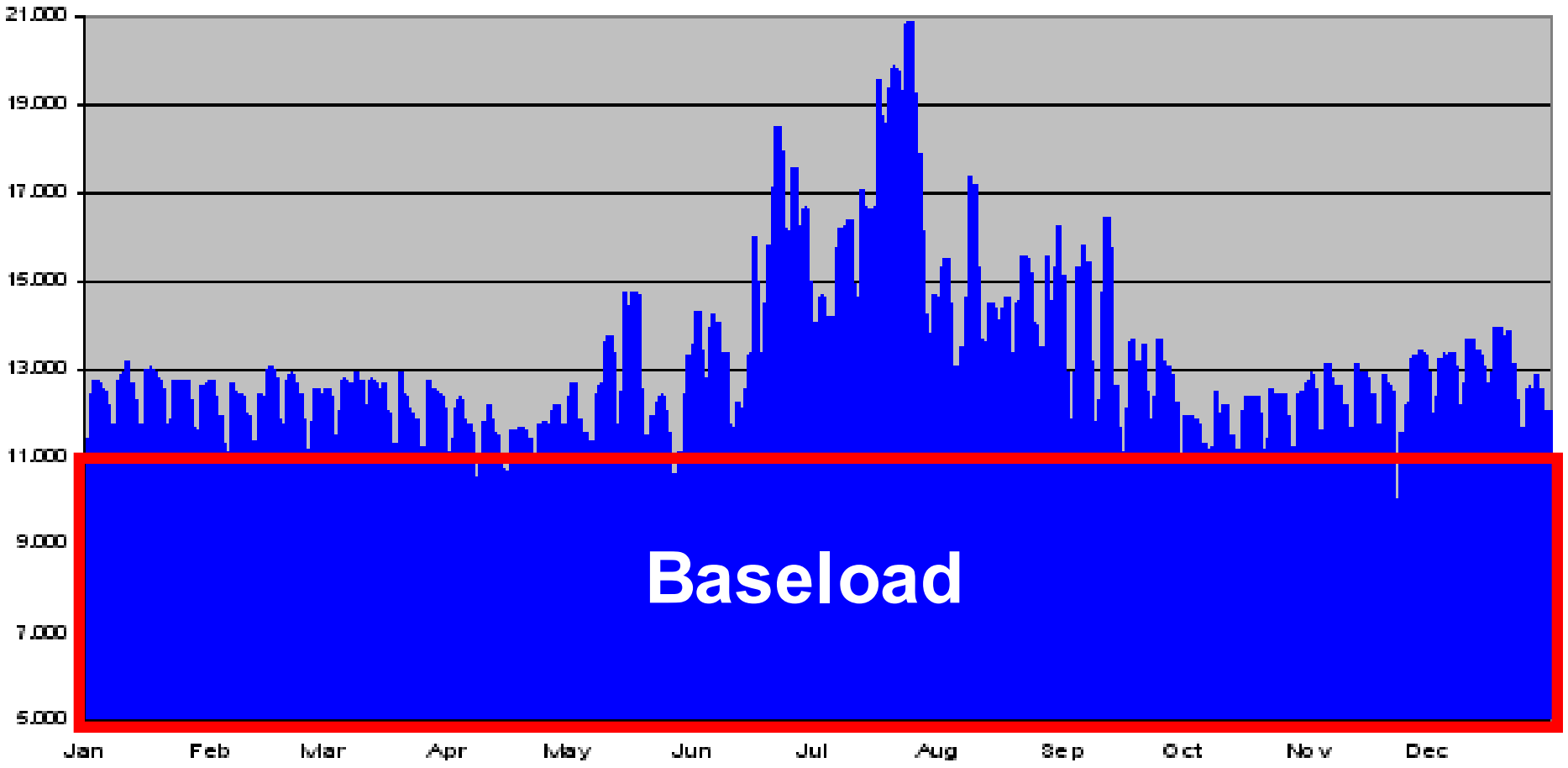
Baseload: Minimum amount of power that is always needed

Seasonal load: Increase in demand in specific times of the year.

Peak load: Maximum amount needed.

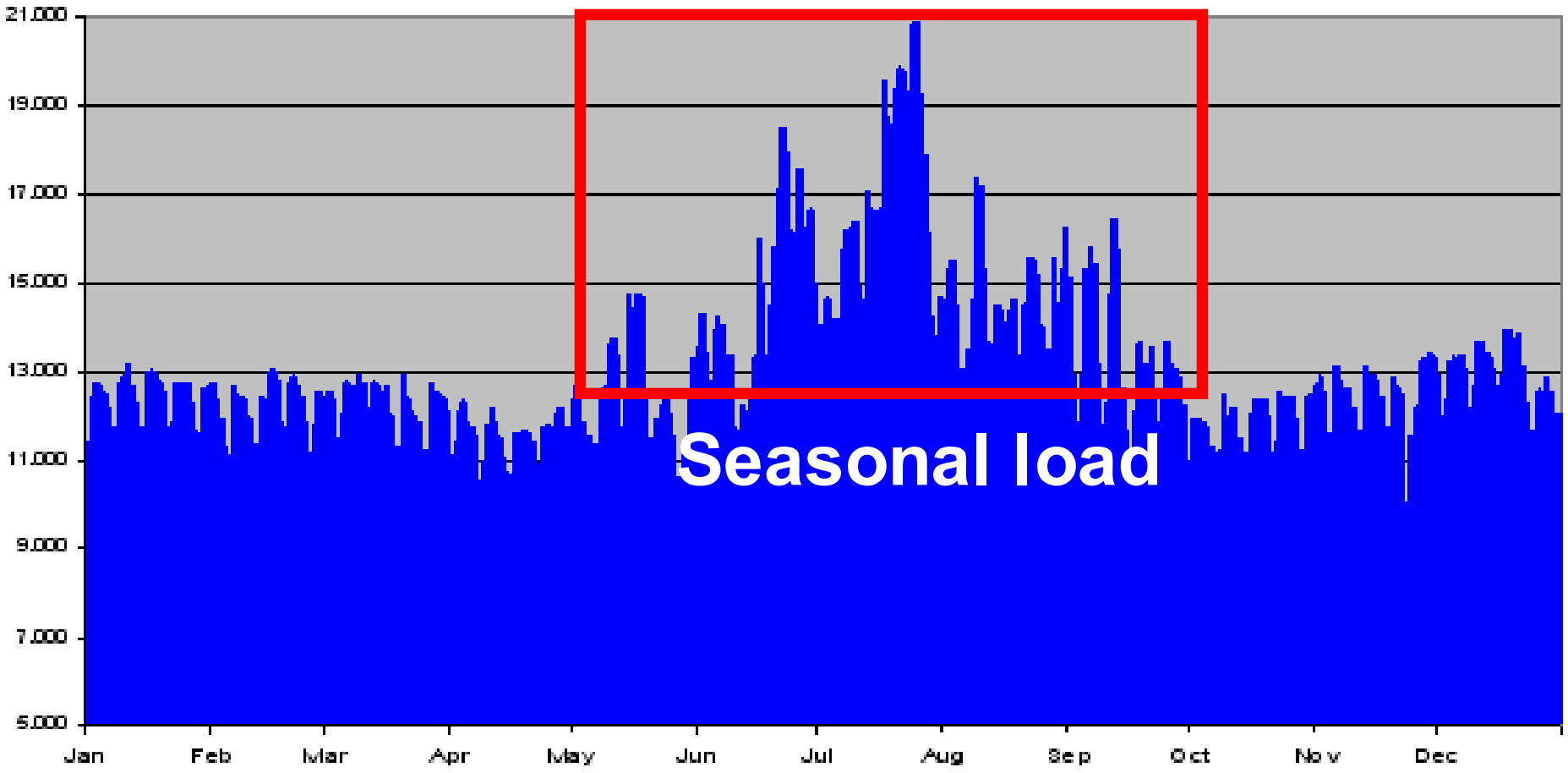
Capacity: Total power that the system can provide.

Grid Terms



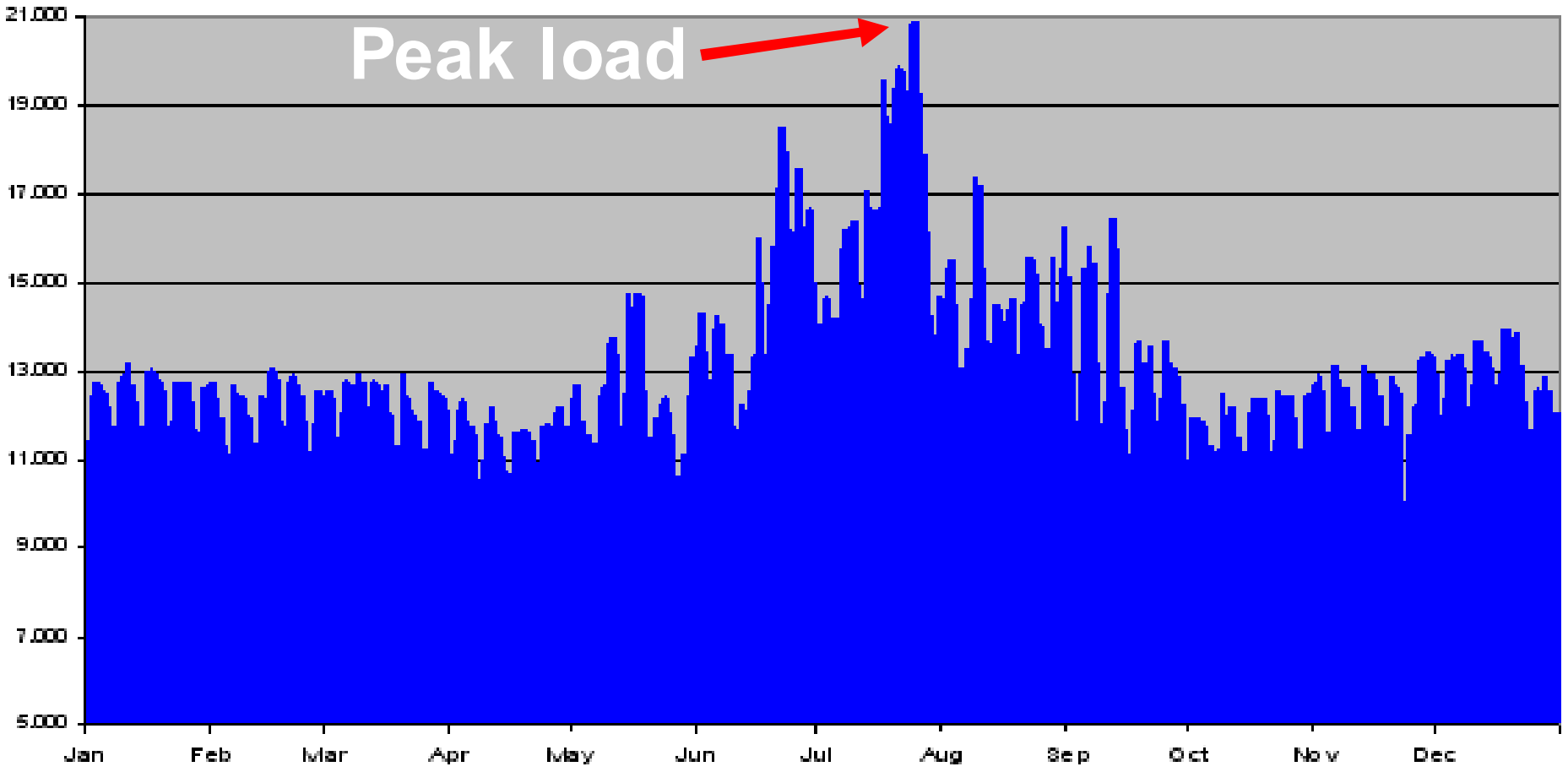
PG&E 2006 Annual Usage

Grid Terms



PG&E 2006 Annual Usage

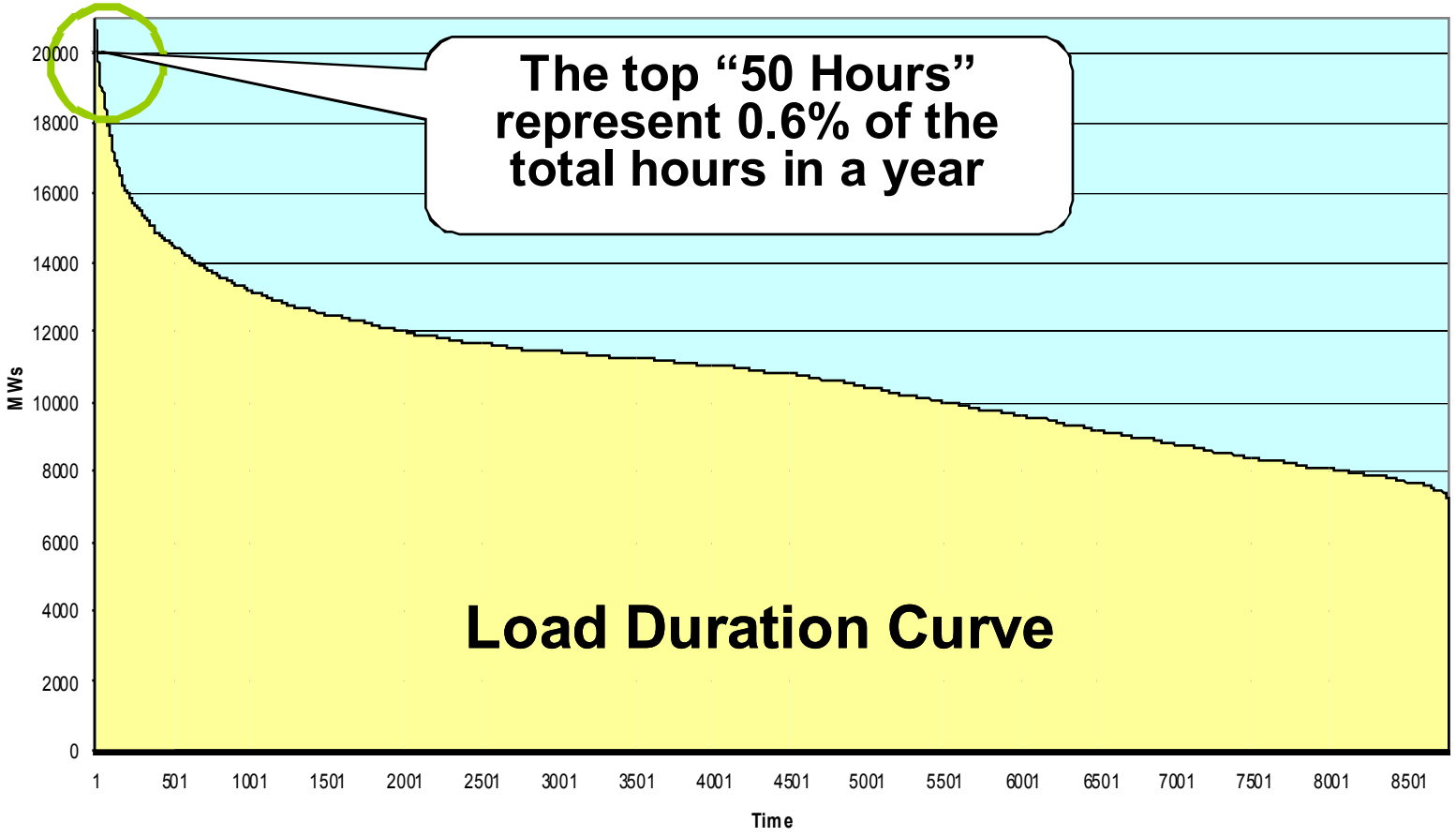
Grid Terms



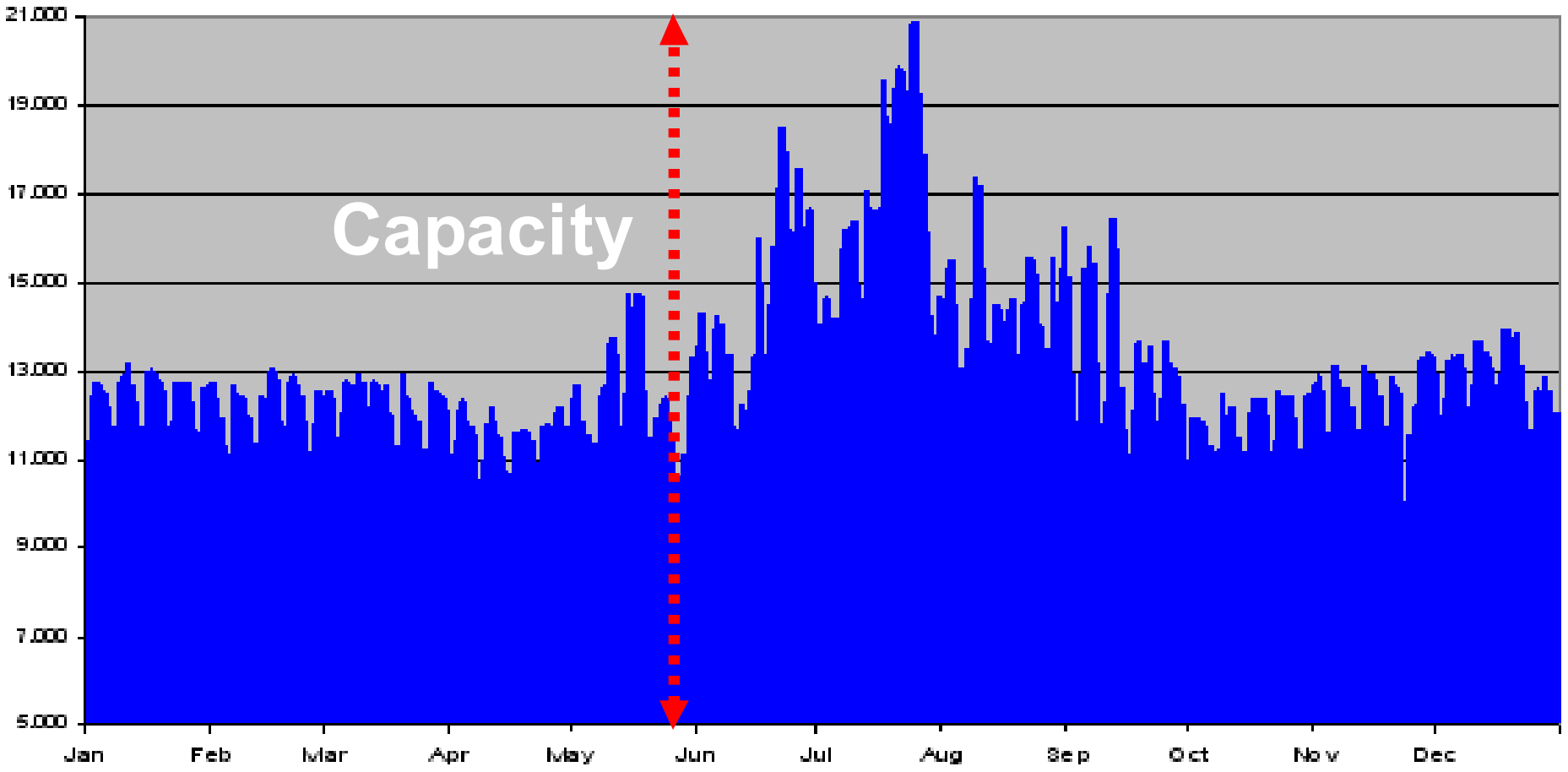
PG&E 2006 Annual Usage

Grid Terms

Highest demand occurs on only a few hours in the year

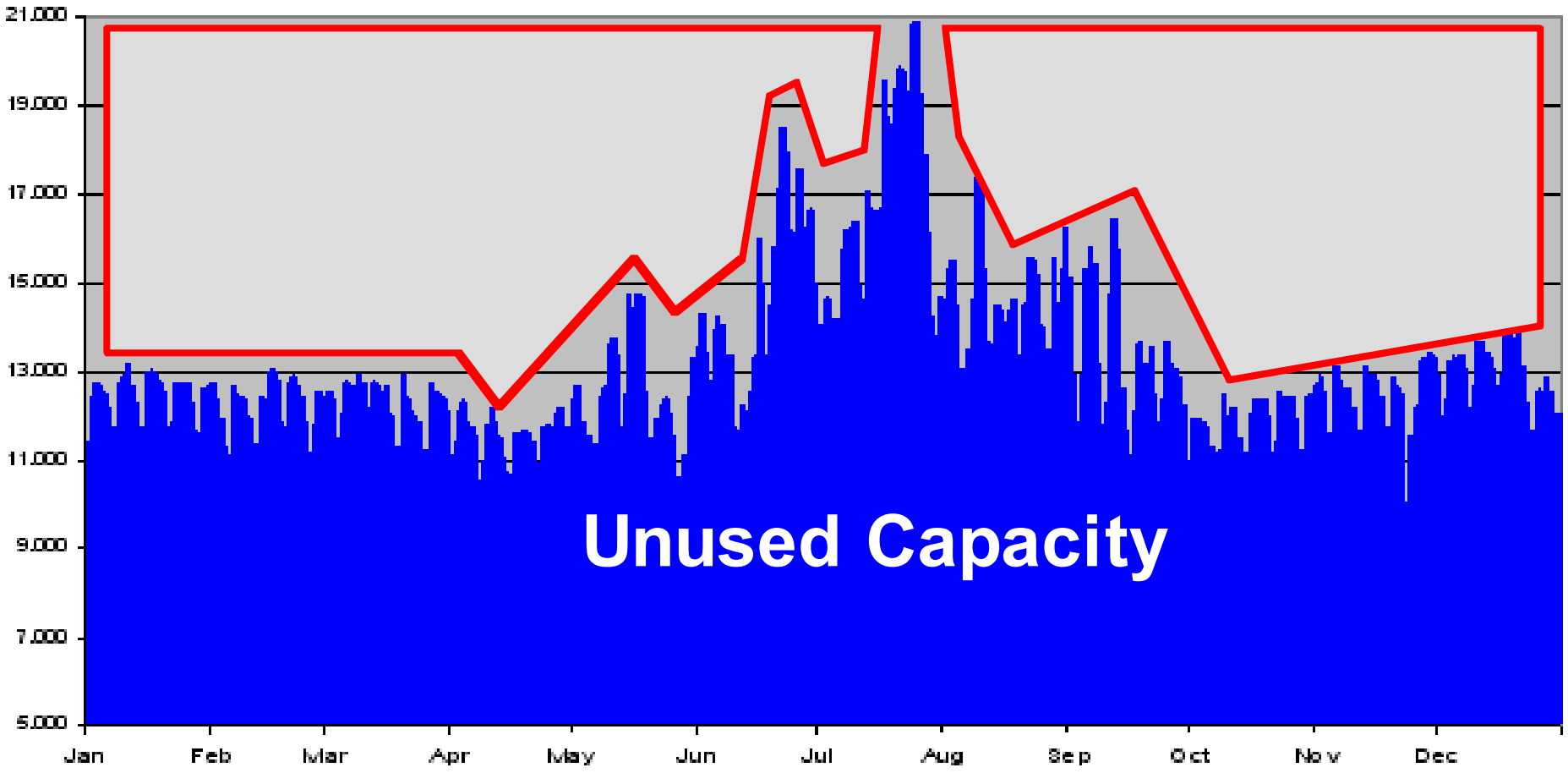


Grid Terms



PG&E 2006 Annual Usage

Grid Terms



PG&E 2006 Annual Usage

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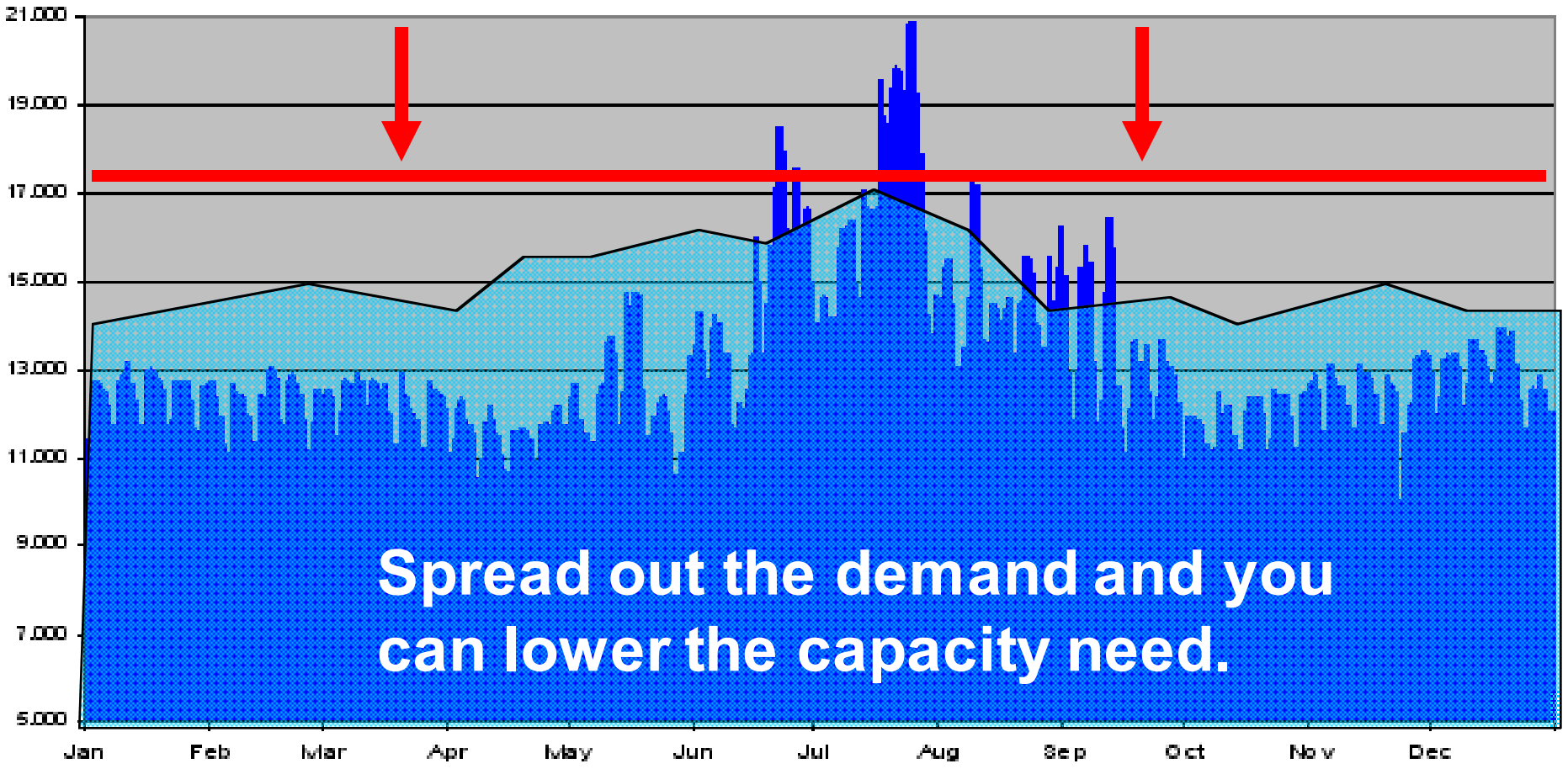


PG&E 2006 Annual Usage

Grid Terms

Demand Management or

Demand-side Management

Load-shifting

“How do you get people to use less power during peak times and more during off-peak?”

Demand Management Strategies

1. **Reduce overall load.**
   — Energy efficiency, conservation
2. **Inform people so they can cooperate voluntarily.**
   — Publicity, "Flex Your Power" alerts
3. **Create the ability to remotely turn off certain appliances.**
   — Smart AC, smart meters, etc.
4. **Charge more for peak usage.**
   — Time-of-Use rates, Peak-Time pricing

… and others.

PV Technology

Different types of “Solar”

Light energy

Photovoltaic (PV)

Electricity produced directly from light

Heat energy

Concentrated Solar Power (CSP)

Electricity produced by steam

Water Heating

Solar Pool Heating

Hot water for pools

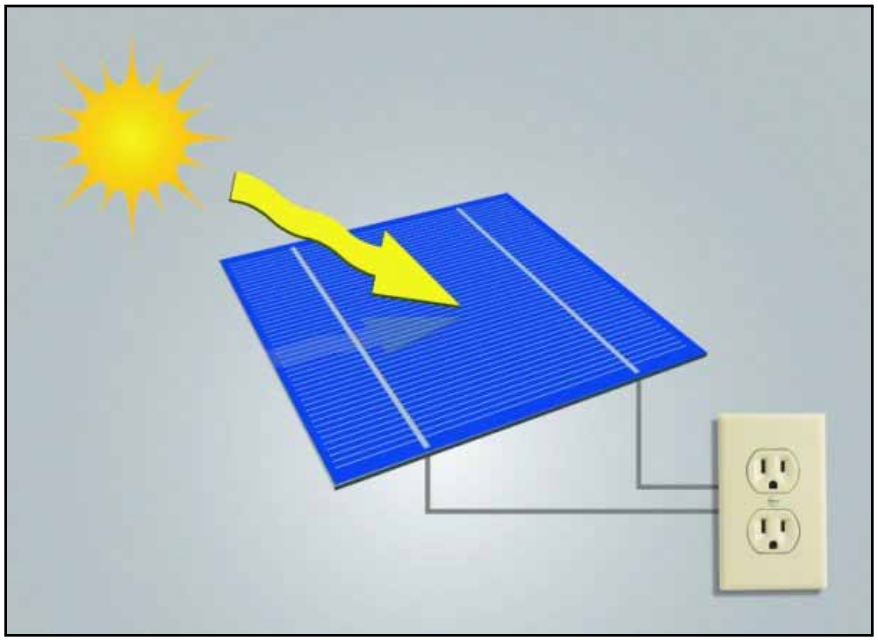
Solar Water Heating (SWH or Solar Thermal)

Hot water for domestic use (DHW)

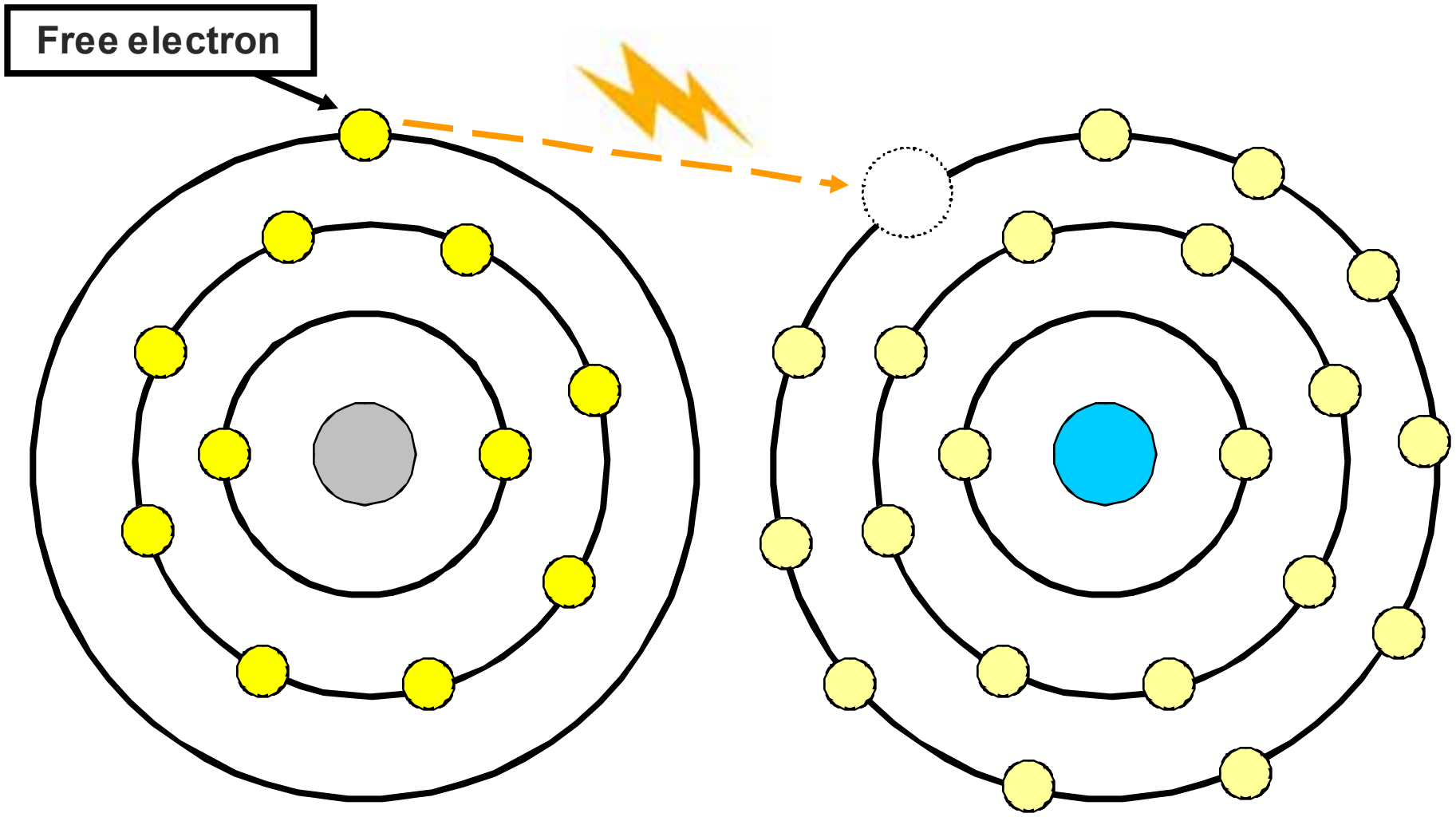
All courtesy of DOE/NREL

Solar Electricity

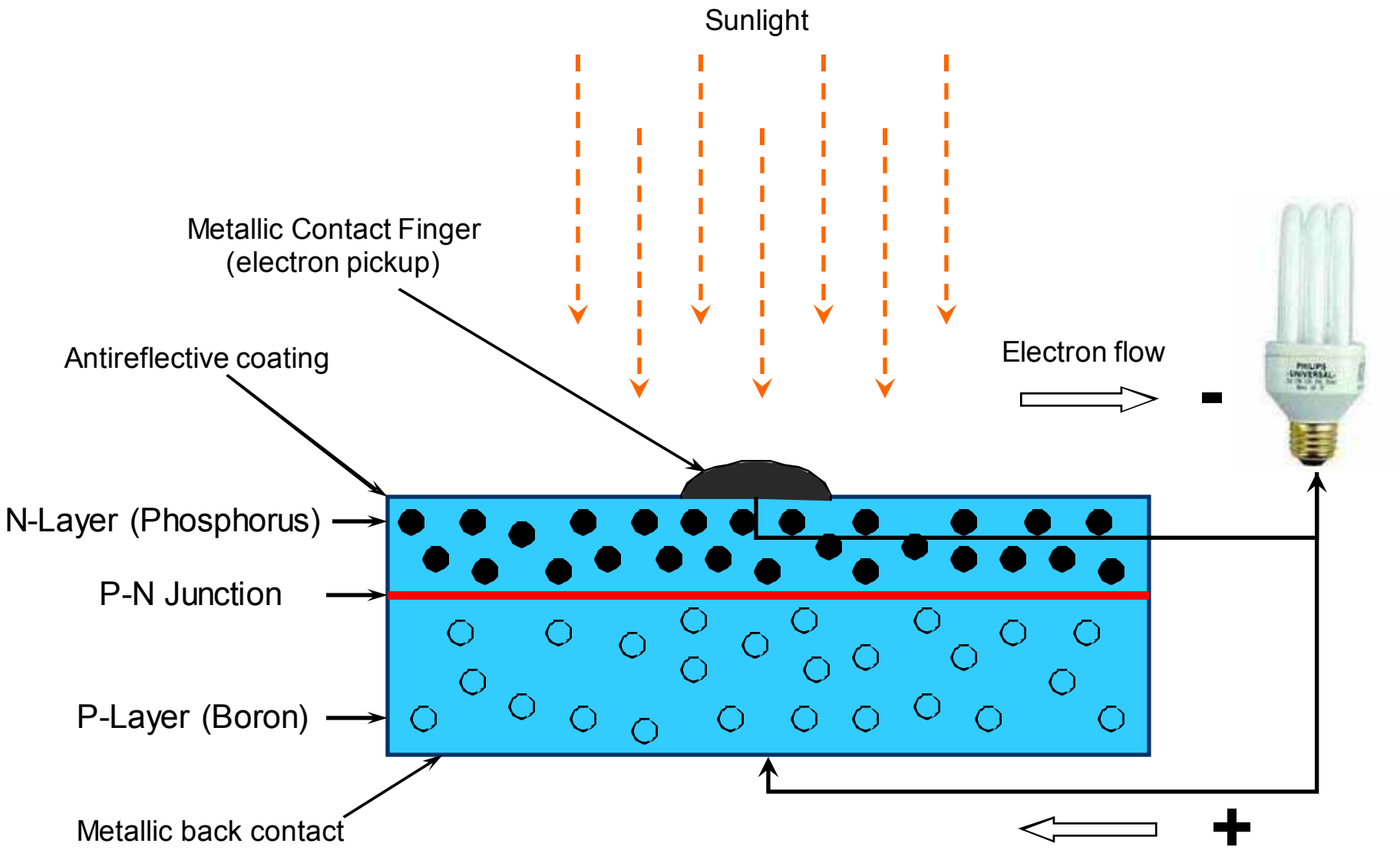
- **Photovoltaic Effect**
  - photo = light; voltaic = produces voltage
  - Photovoltaic (PV) systems convert light directly into electricity (using semiconductors)



Electron Orbits



How a PV Cell Works



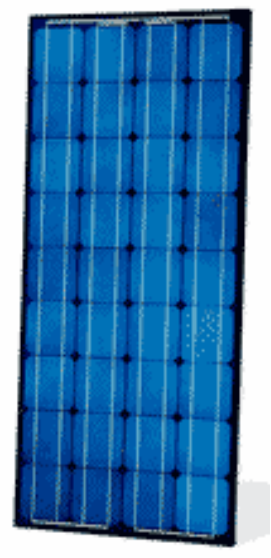
Solar Cells & the PV Effect

- Usually produced with semiconductor grade silicon
- Dopants create positive and negative regions
- P/N junction results in .5 volts per cell
- Sunlight knocks available electrons loose for potential electrical current
- Wire grid provides path for current

PV Terminology

Cell

Module



Array

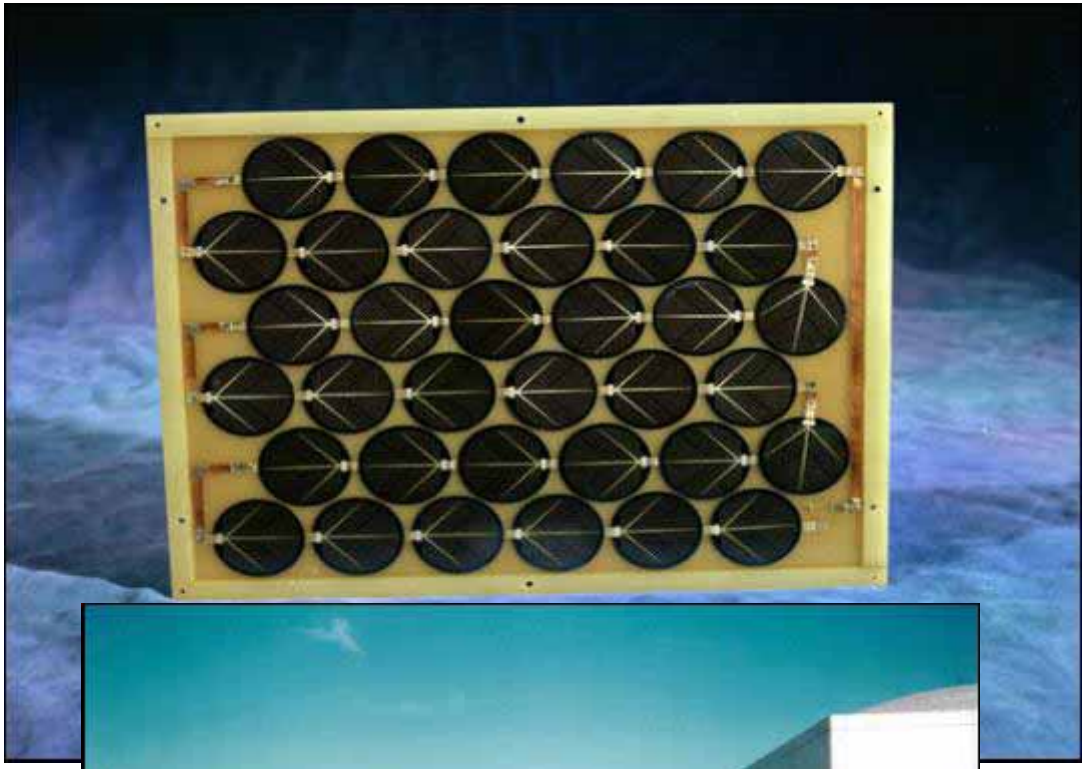
Courtesy of DOE/NREL

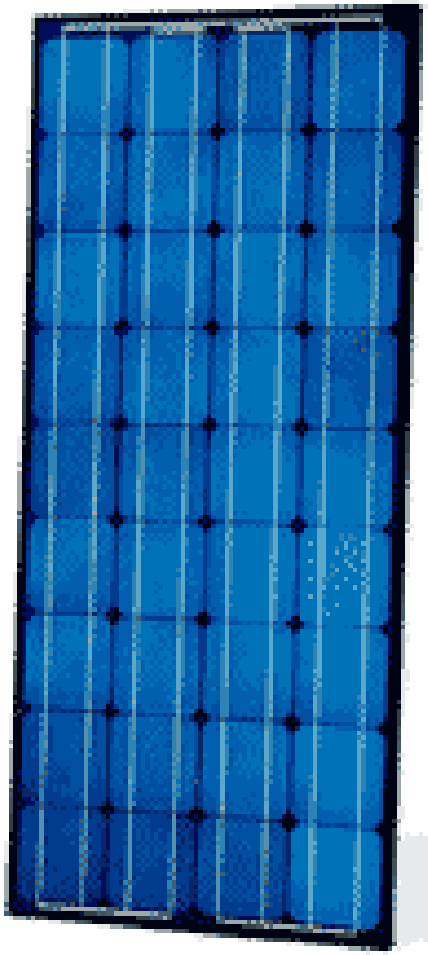
PV System Sizing

200 HP engine: means that 200 horsepower is the MAXIMUM it will produce.

4 kW PV system: means that 4,000 watts (4 kW) is the MAXIMUM it will produce in full sunlight.

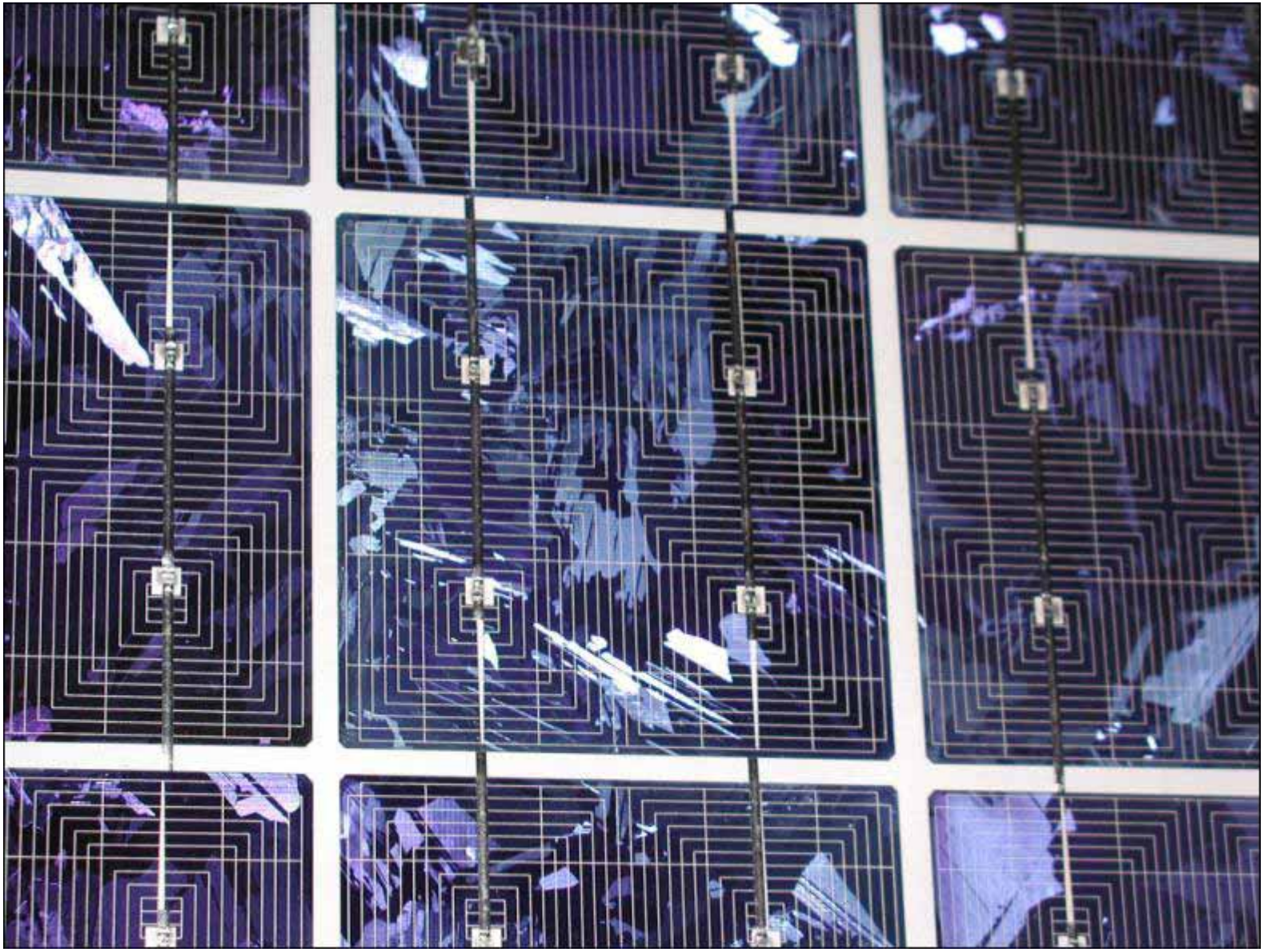
Crystalline Silicon (Mono)





Source: DOE National Renewable Energy Laboratory

Crystalline Silicon (Poly)



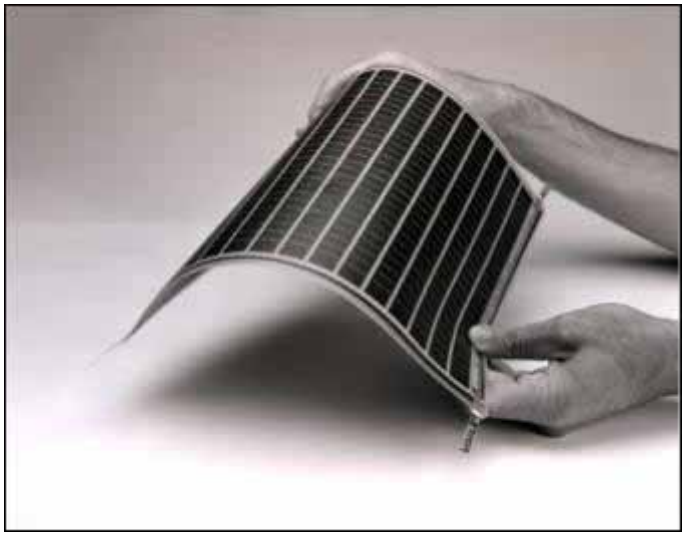
Source: Darren Bouton

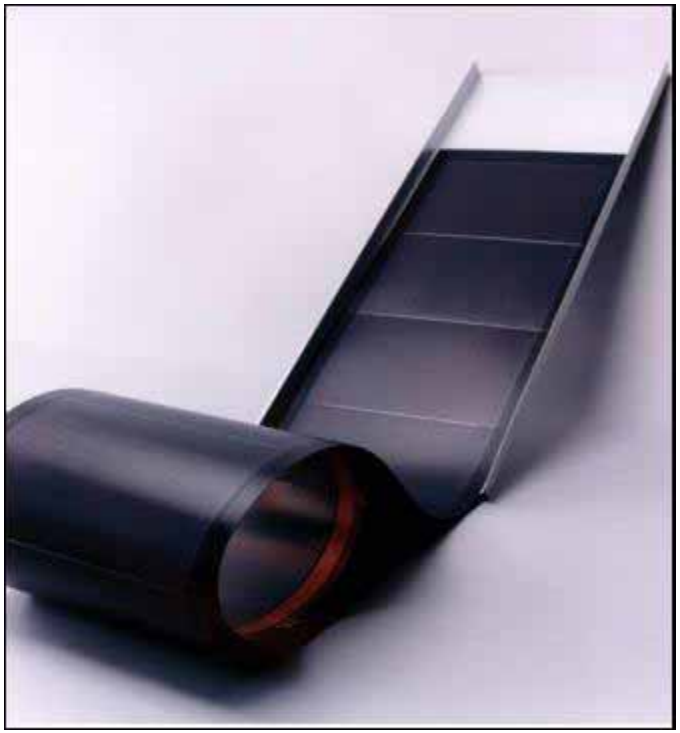
Crystalline Silicon PV Products

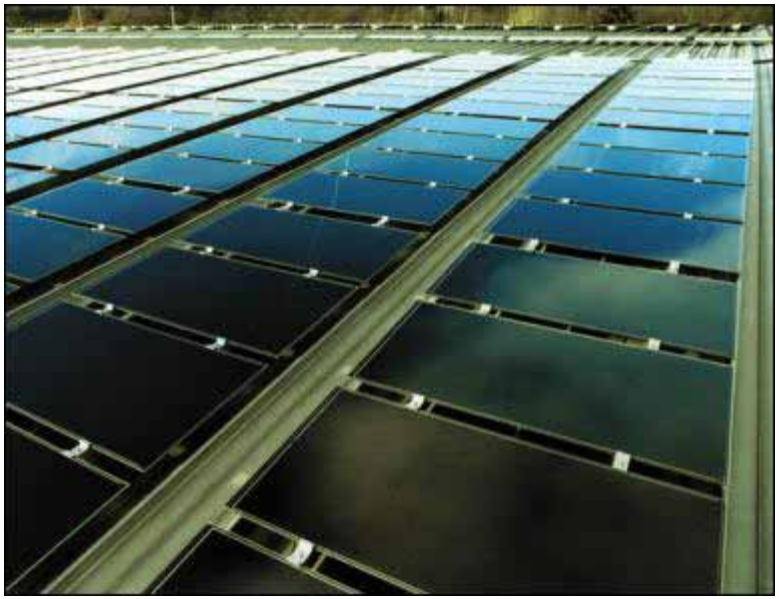
- Firm, like crystals
- Longest track record, over 50 years
- Most common, over 85% of the market
- Highest efficiencies: avg. 15%, up to 22%
- Requires about 100 sf. per kilowatt

Source: DOE National Renewable Energy Laboratory

Thin-Film PV Products



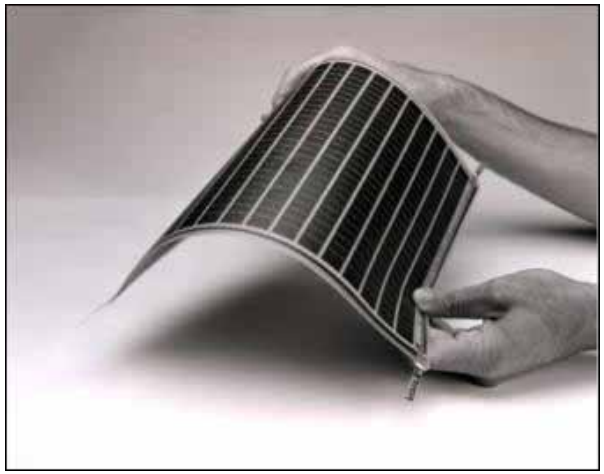


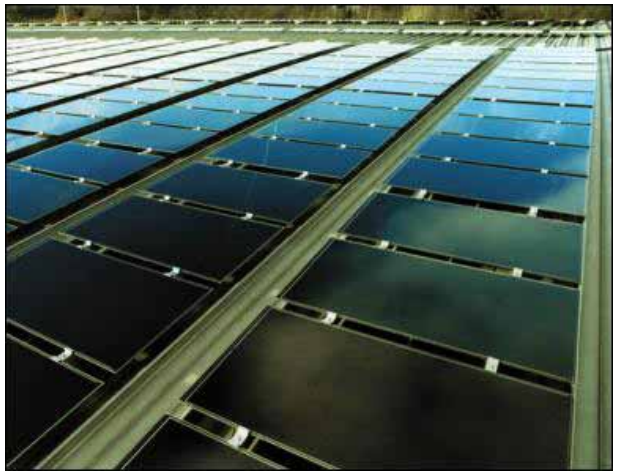


Source: DOE National Renewable Energy Laboratory

Thin-Film PV Products

Source: DOE National Renewable Energy Laboratory





- Can be applied on many different materials
- Longevity still to be proven
- Production growing at high rate
- Lower efficiencies: avg. 7%, up to 15%
- Has potential for big cost reduction
- Requires about 200 sf. per kilowatt

PV "General Rules"

- **Crystalline PV Products**
  - **Efficiencies (rated) range from 12-22%**
  - **Space required: 90-150 s.f. per kW**

- **Thin-Film PV Products**
  - **Efficiencies (rated) range from 5-10%**
  - **Space required: 170-300 s.f. per kW**

Crystalline vs. Thin-Film

1.2 kW
Crystalline Silicon

Thin-film needs about twice as much space for the same-size system, but the total cost is about the same.

1.2 kW
Thin-Film

Source: DOE National Renewable Energy Laboratory

Efficiency vs. Capacity

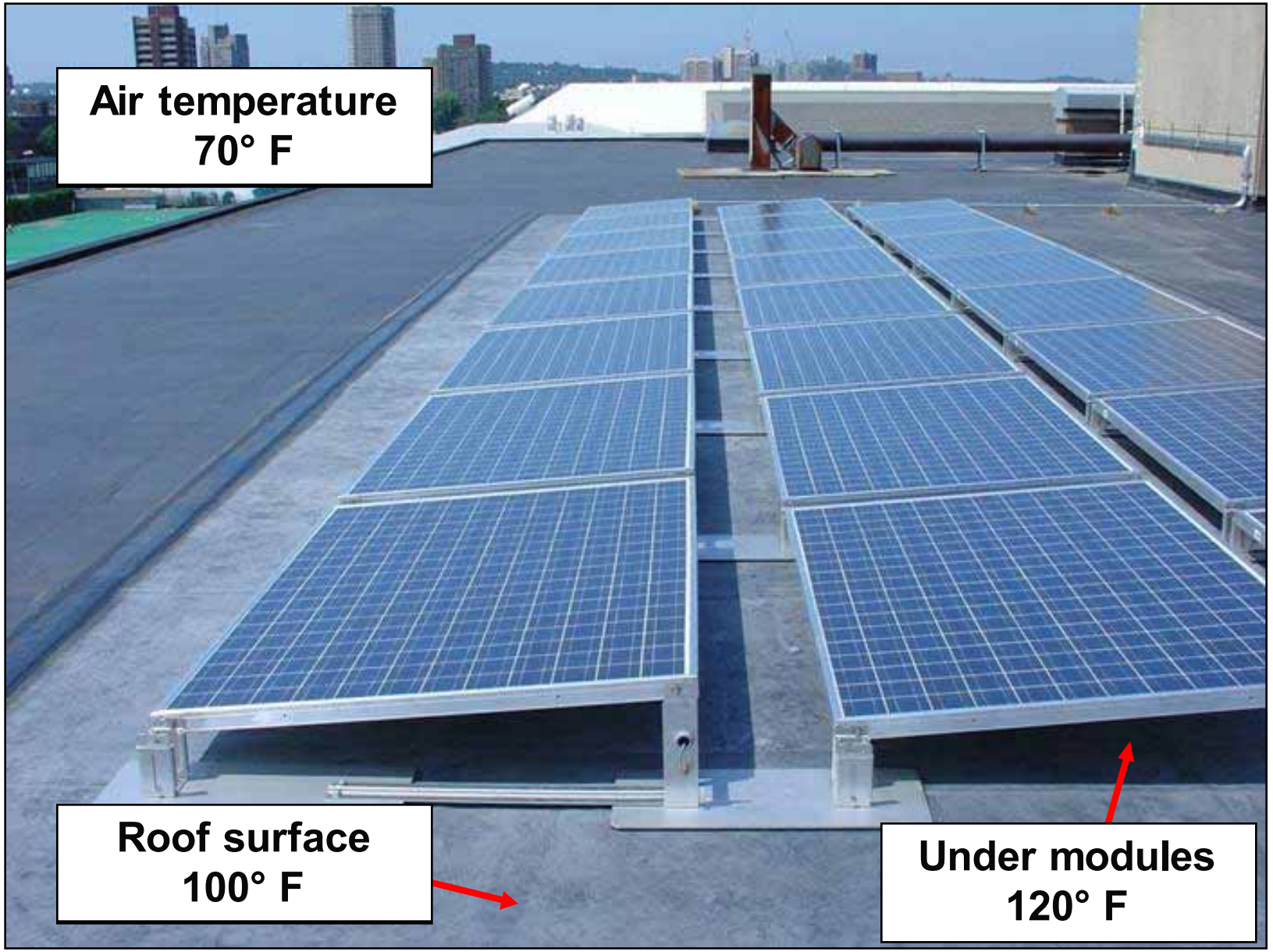
1.2 kW (1,200w)
75 square feet
16w per sq.ft.

Capacity = total power
Efficiency = power per sq.ft.

1.2 kW (1,200w)
150 square feet
8w per sq.ft.

Courtesy of DOE/NREL

Heat effect



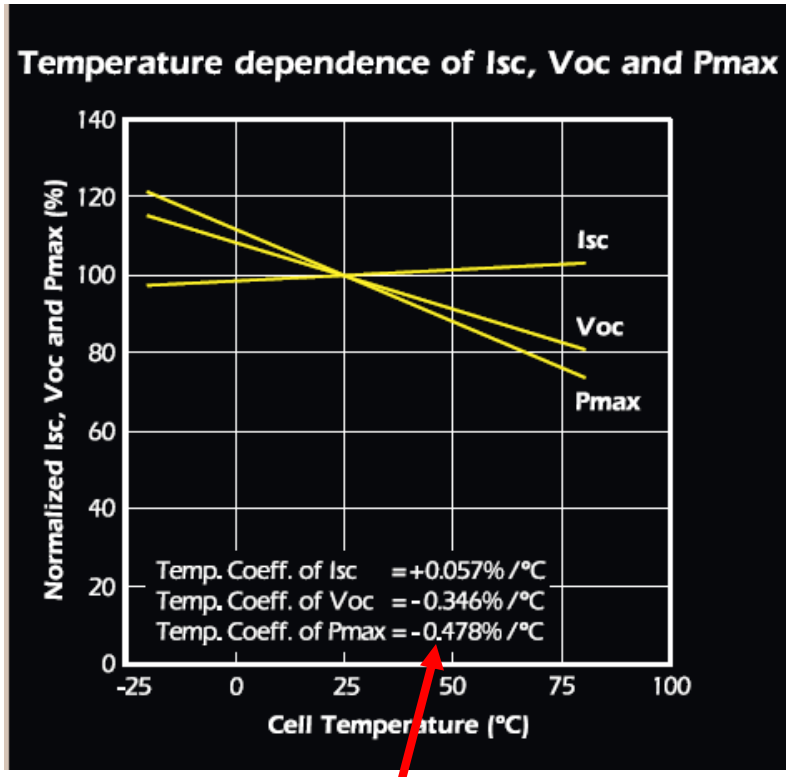
Courtesy: Schott Solar

Crystalline vs. Thin-Film: Heat response

- Heat increases electrical resistance, which lowers power output.
- Output begins dropping at 20°C (68°F).
- Percentage of drop is called Temperature Coefficient of Power.
- It is measured in % per degree Centigrade, i.e. -0.35%/°C
- Thin film degrades less than crystalline.

Crystalline vs. Thin-Film: Heat response

Sample data from spec sheets



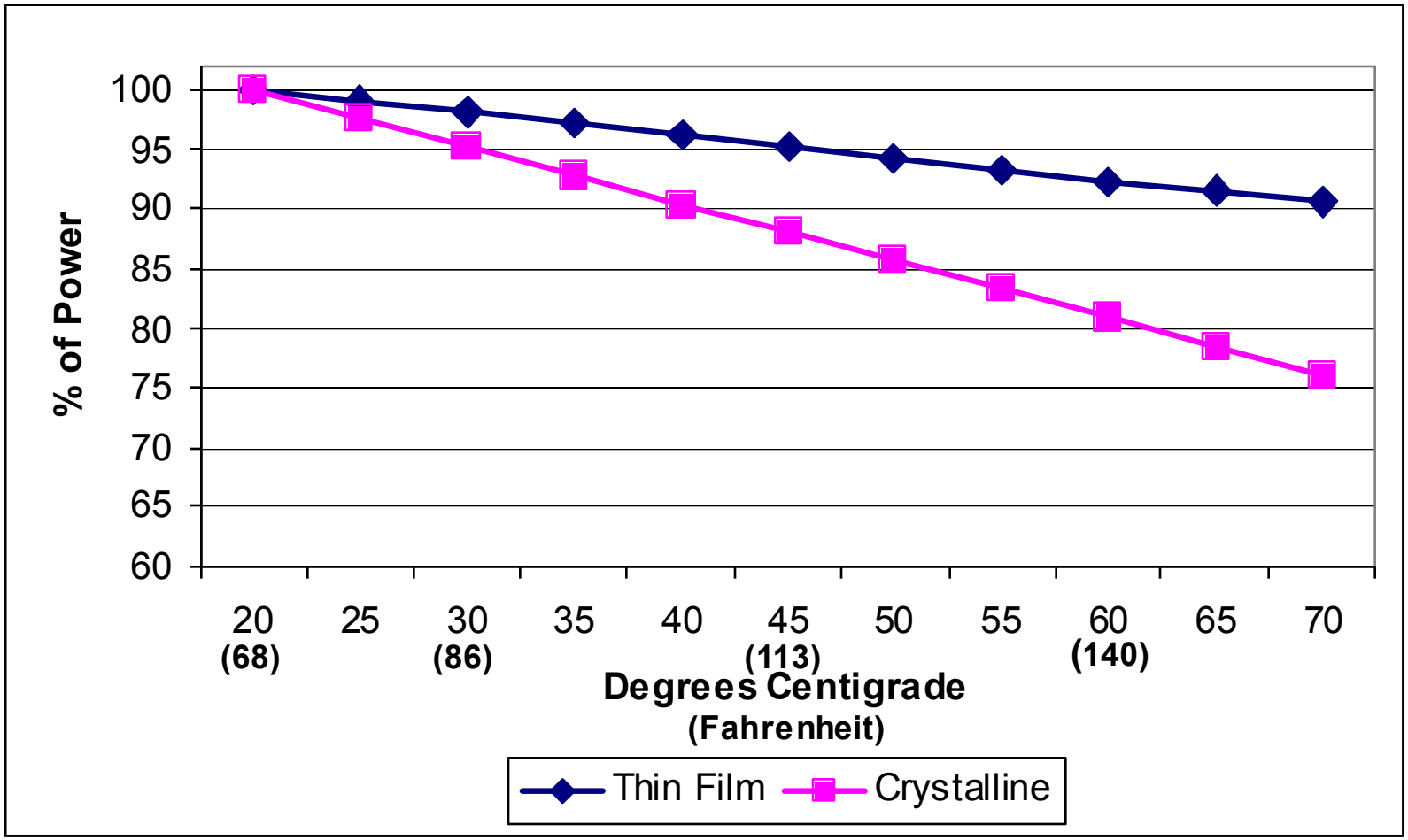
Model: CGS-40H/G1245*635
Substrate material:Deposit A-Si on float glass
The kind of solar cell: Double junctions A-Si solar cell
Categories: Opaque A-Si PV module

Rating power: 40w
Optimal operating voltage (V):44.9v
Open circuit voltage(v): 61V
Optimal operating current (A): 0.94A
Short circuit voltage(A):1.16A
Power error rate:±3%
Temperature coefficient of Im: +0.09%/°C
Temperature coefficient of Vm:- 0.28%/°C
Temperature coefficient of power: -0.19%/°C
Length (mm): 1245
Width(mm): 635
Thickness(mm):7
Weight(kg):13.2
Operating temperature: -40'C~+85°C
System maximum open circuit voltage:≤600VDC

Crystalline -0.478%

Thin film -0.19%

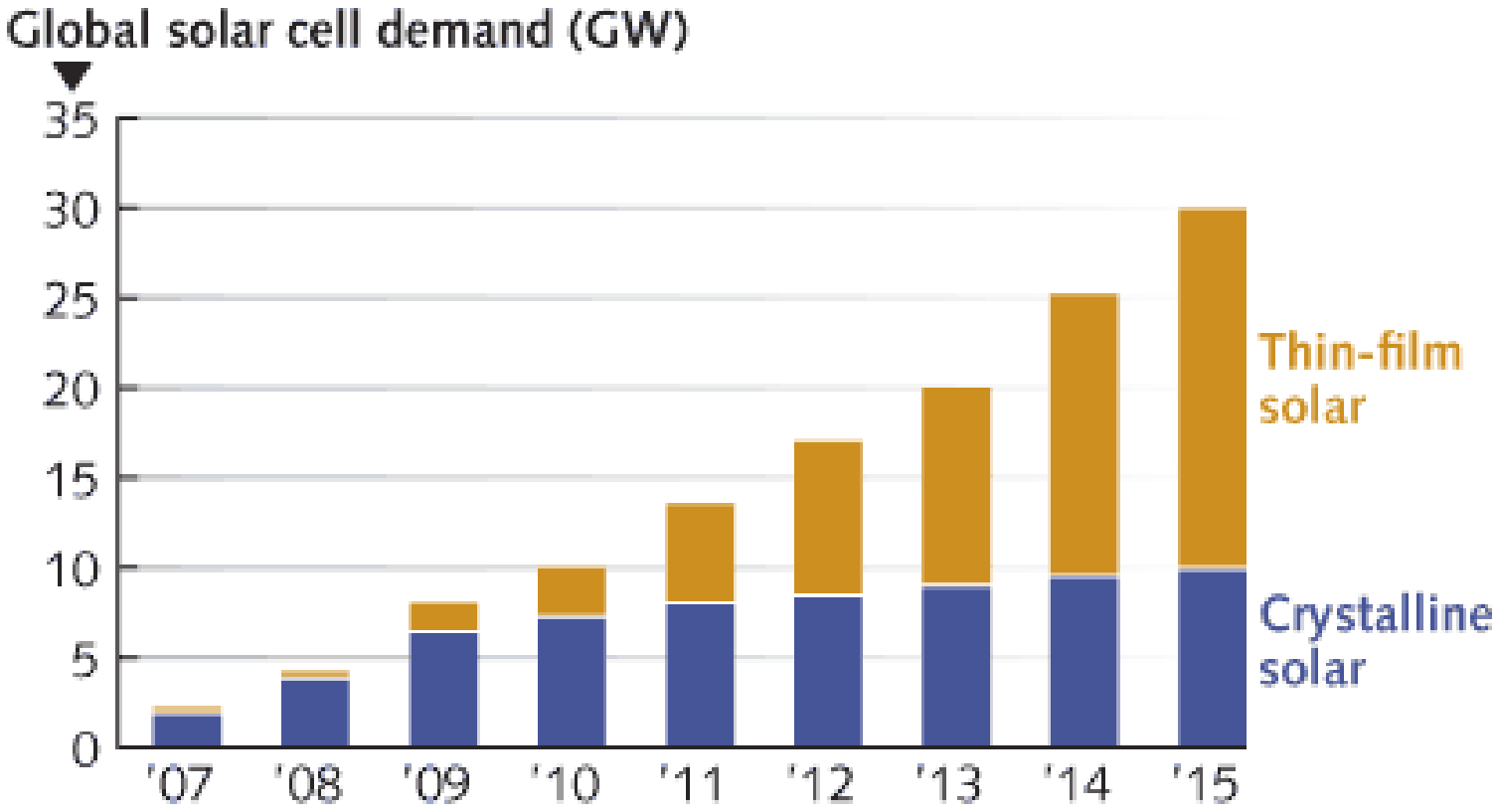
Crystalline vs. Thin-Film: Heat response



PV Panel Technology Summary

Technology	Description	Module Efficiency (Commercial)	Cell Efficiency (Laboratory)	Sample Companies Employing Technologies
Crystalline Silicon	The orignal approach; grow silicon crystal structures in a variety of ways. Represents almost 90% of total market. Appearance dark blue to black but other colors possible with changes to anti-reflective coatings.			
Single Crystal	Grown in Cylinders and wire- or laser-sliced into circular wafers as thin as 200 microns. Cells are circular and modules are inherently flat black or charcoal.	14 - 15%	25%	BP Solar GE/AstroPower Sanyo Sharp SunWorld
Multi-Crystalline	Cast in blocks or drawn through a die to create a "ribbon" and wire-sliced or cut into rectangular wafers. Cells are typically vibrant blue.	12 - 14%	19%	BP Solar Evergreen Solar Kyocera Solar Schott Solar Sharp SunWorld
Thin-Film Materials	Near single-atom vapor or electro-deposition on low-cost materials (glass, stainless steel, or plastic). Modules can be flexible. Appearance dark charcoal to near black; can also be semi-transparent.			
Amorphous Silicon (a-Si)	Cell and module production part of same process. Widely used in consumer products and on flexible substrates.	5 - 7%	13%	BP Solar Kaneka Solar TerraSolar United Solar Ovonic
Copper Indium Diselenide (CIS)	Alternative semiconductor material under commercialization.	8 - 10%	19%	Global Solar Shell Solar
Cadmium Telluride (CdTe)	Alternative semiconductor material under commercialization.	7 - 9%	17%	BP Solar First Solar

Growth Forecast?



Source: Renewable Energy World.com

Inverters

Changes Direct Current (DC) to Alternating Current (AC)

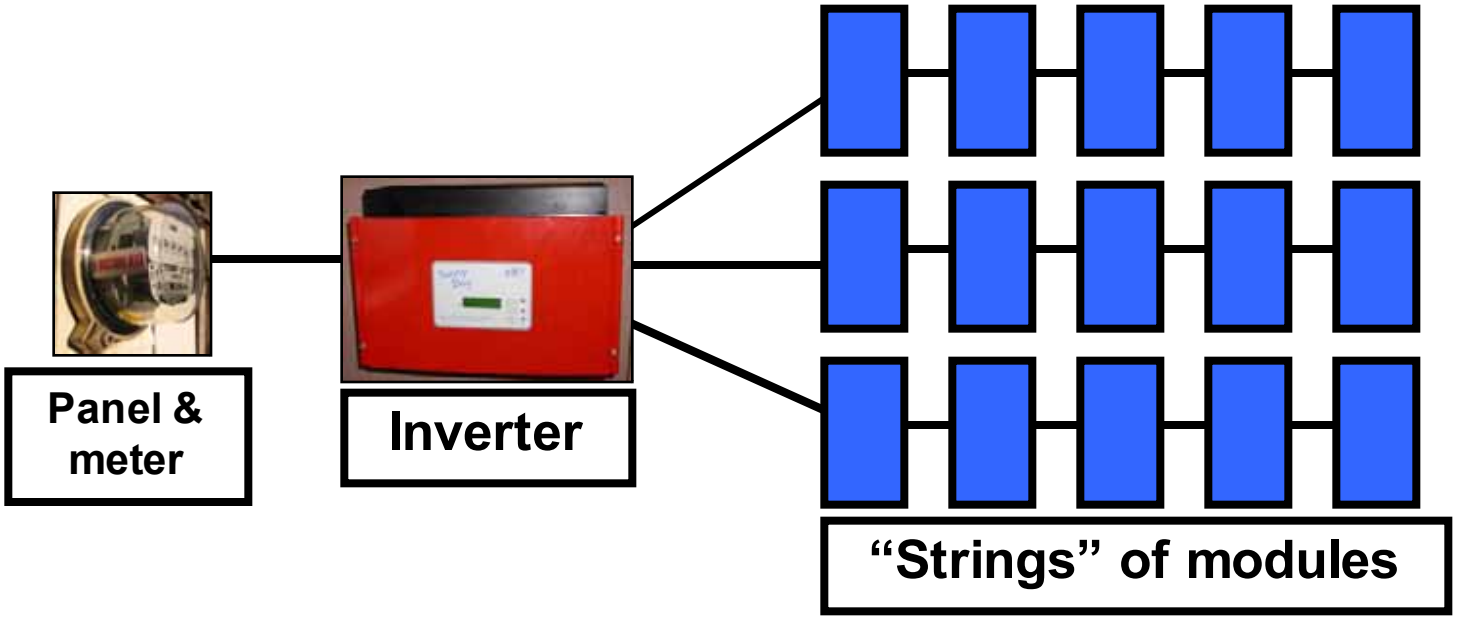
Inverters

- Range in size from 1 Kw to 500+ Kw
- Can easily be connected together, even different models
- Best to locate in cooler area

Source: Darren Bouton

Inverters

Typical system layout

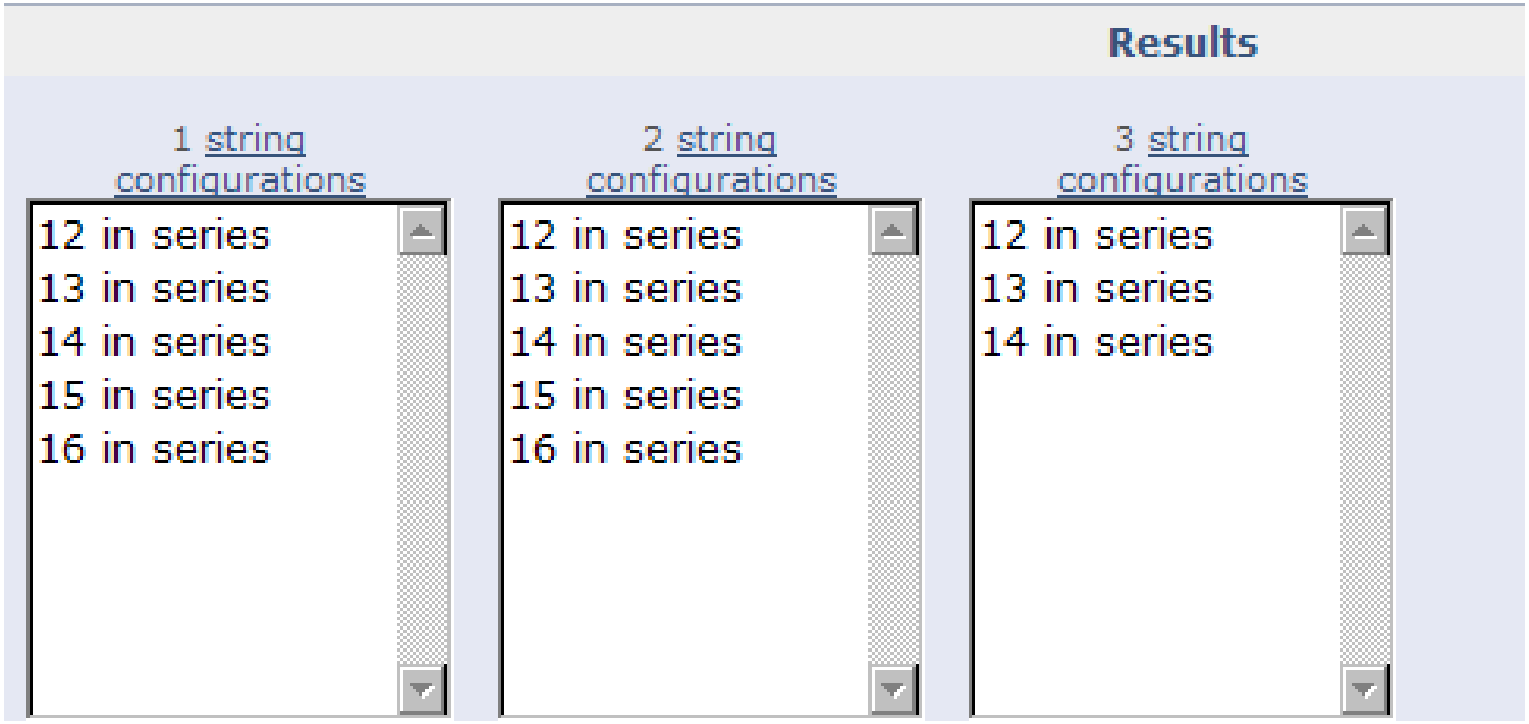


Strings must be of specific length and number, of equal size, and on the same plane.

Power production is very sensitive to shading.

System Inverters: Online string sizing tool

Limited configurations, cannot deviate.

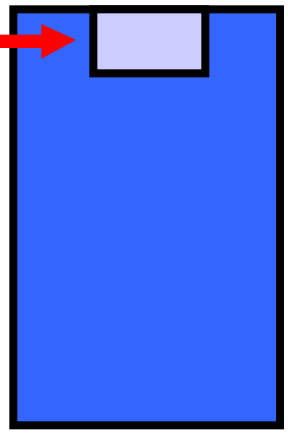


Inverters

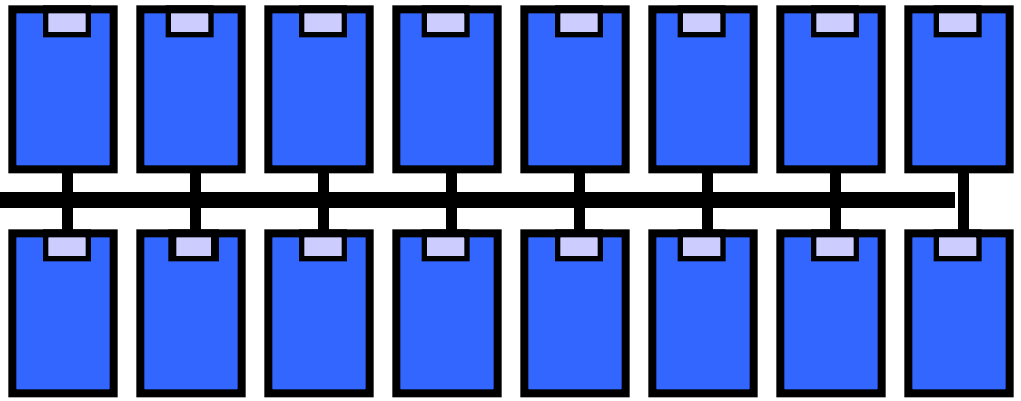
Micro-inverter

One per module

Inverts DC to AC right there



System layout



Panel & meter

Combiner box & communicator

Reliability

Source: NASA

Reliability

- Mature technology—over 50 years old
- Essential to the space program
- Millions in use
- Products tested and approved by CEC
- Long warranties backed by large, stable companies
  - — 20 to 25 years on panels
  - — 10 to 25 years on inverters
  - — 10 year labor warranty

It works during the day, but what about at night?

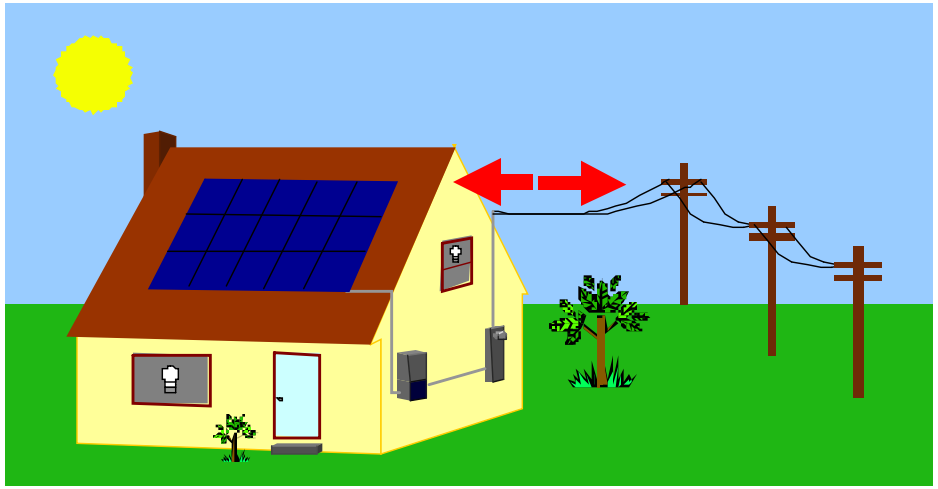
Courtesy of DOE/NREL

Previously, there was only one solution:

Store the excess in batteries during the day, then draw off the batteries at night, or when it's cloudy.

But now?

Net Metering



Source: Andy Black

The utility grid is a two-way street!

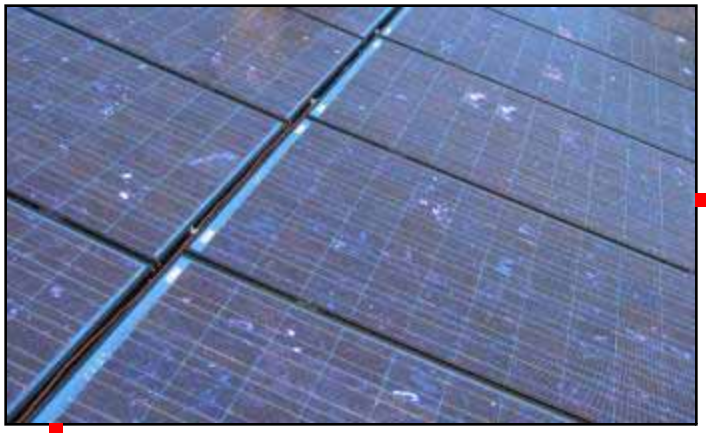
Electricity can be "sent back" to the grid by the customer.

Source: DOE NREL

- **Eliminates the need for batteries.**
- **Reduces cost and maintenance.**
- **Ensures a constant supply of electricity.**

Typical System Components

Array



Inverter

Meter

Panel

Balance of System (BOS)

Loads

Source: Darren Bouton

Typical System Components

Source: PG&E

1. Solar array
2. Inverter
3. House electrical panel

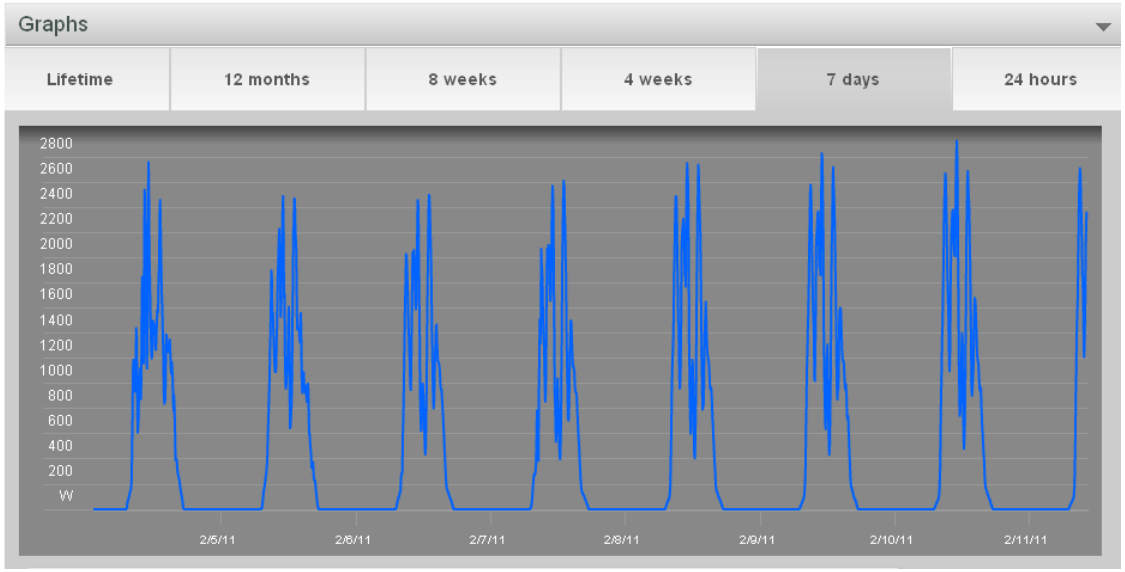
Monitoring

- Extra hardware sends inverter data to internet
- Inverter company or 3rd party hosts website
- Customer can view system from home or remotely
- Current and historical data can be displayed

Can cost extra but some companies are offering it as standard package.

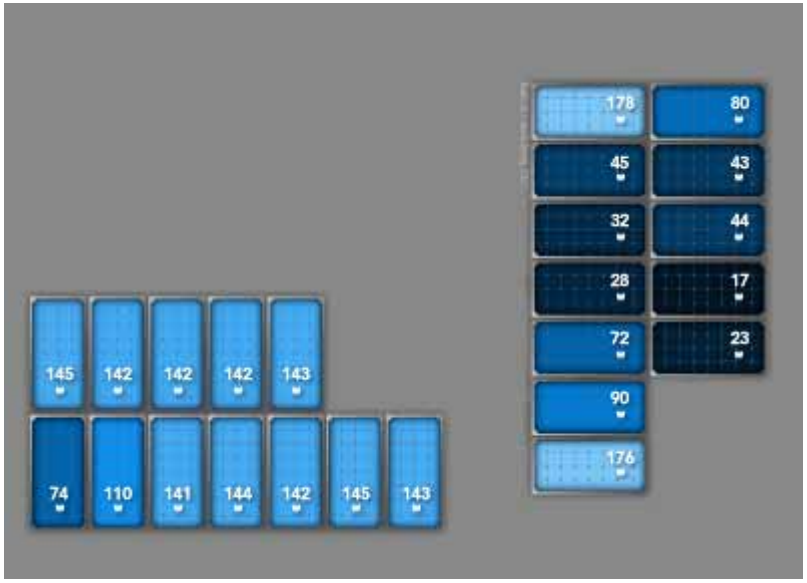
Courtesy SMA http://www.sma.de/en/products/monitoring-systems/sunny-beam-with-bluetoothr.html

Monitoring



Total system history.

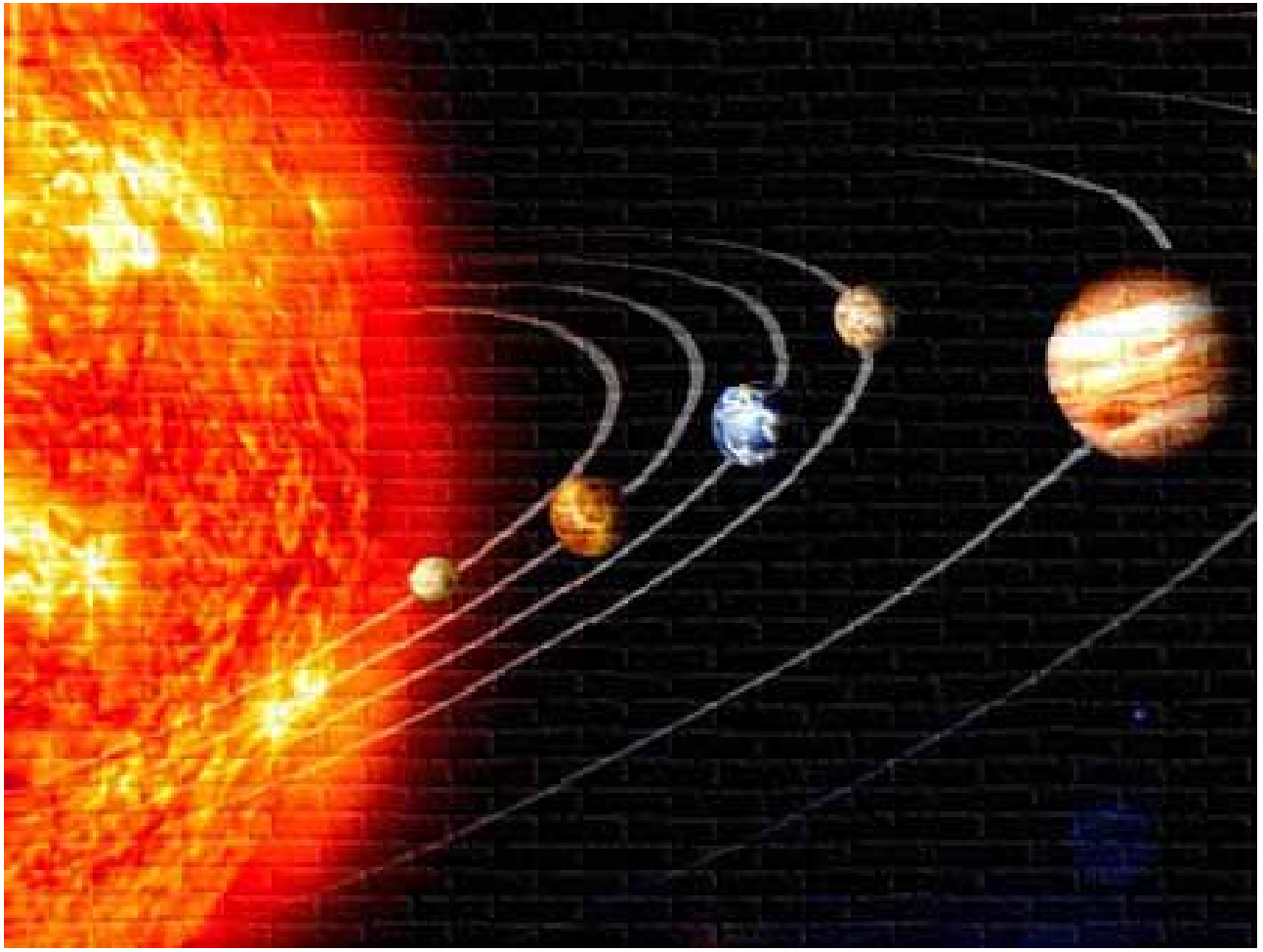
Real-time, per panel.



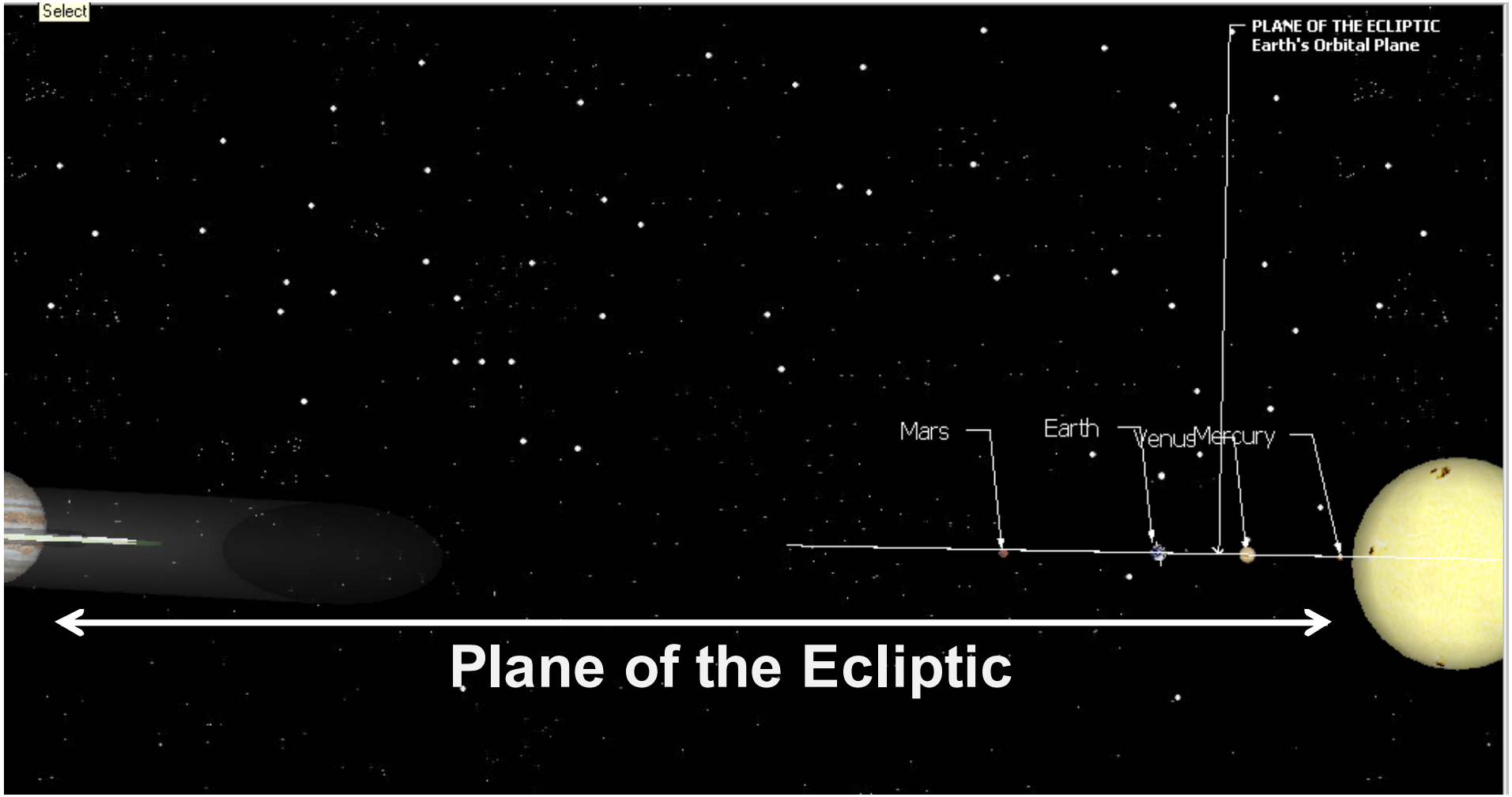
Courtesy Enphase http://enlighten.enphaseenergy.com/public/systems/LWtm4844

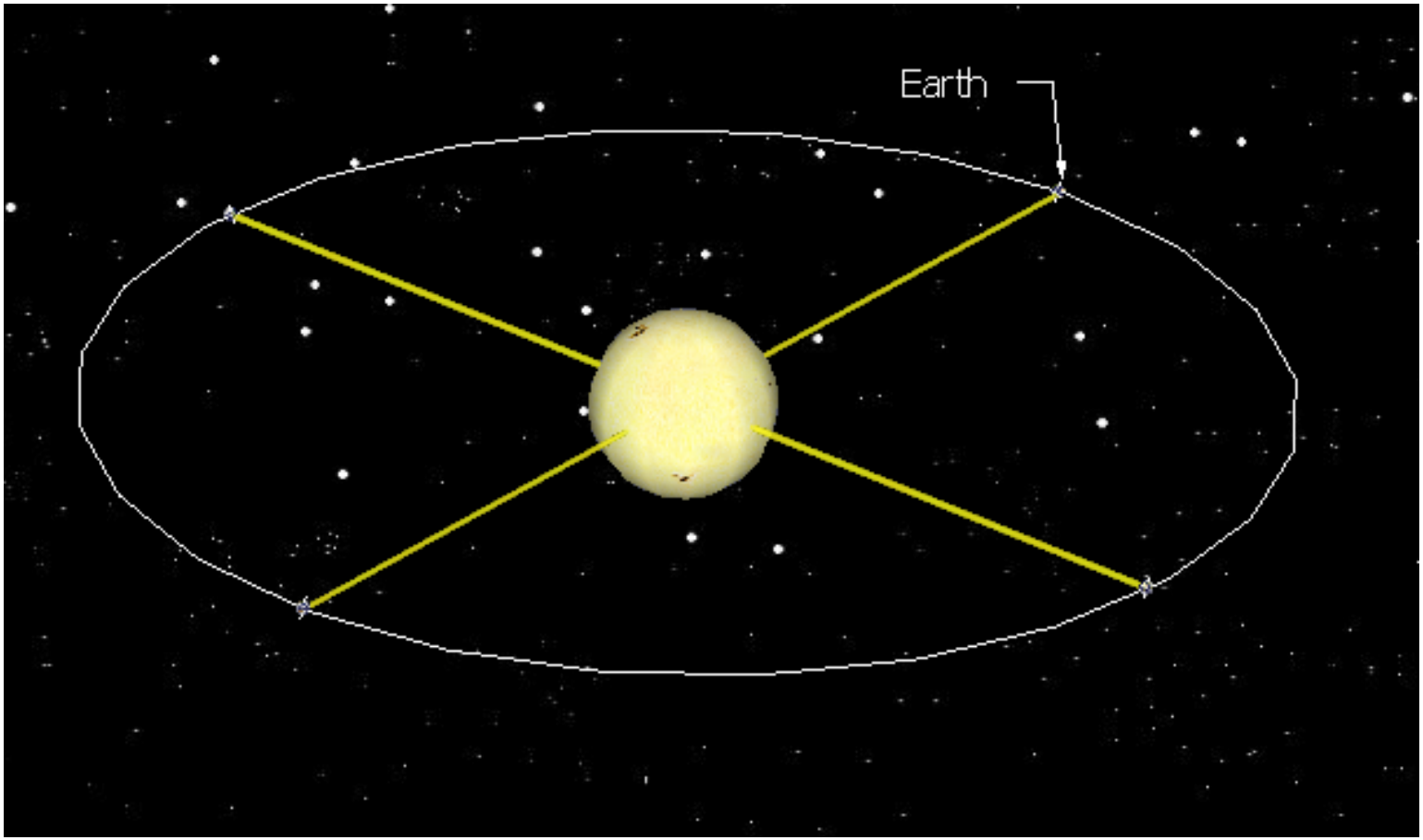
Feasibility

Solar Geometry

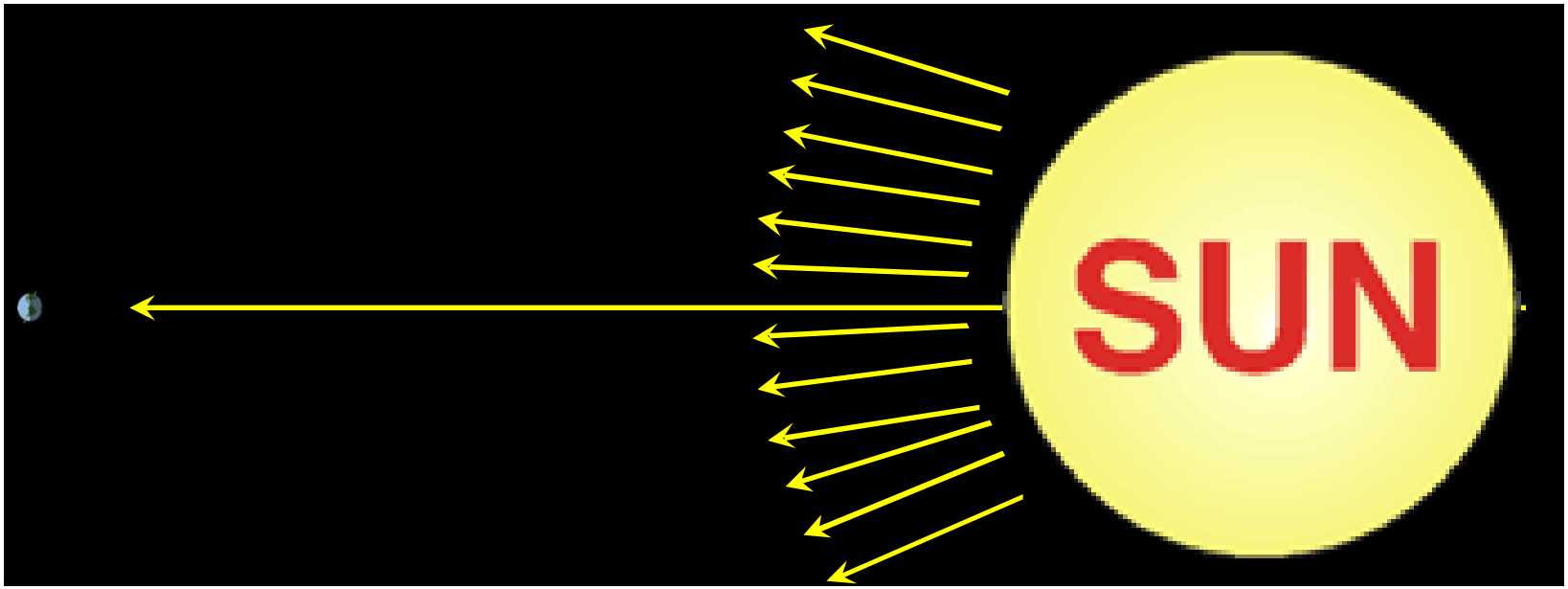


Solar Geometry



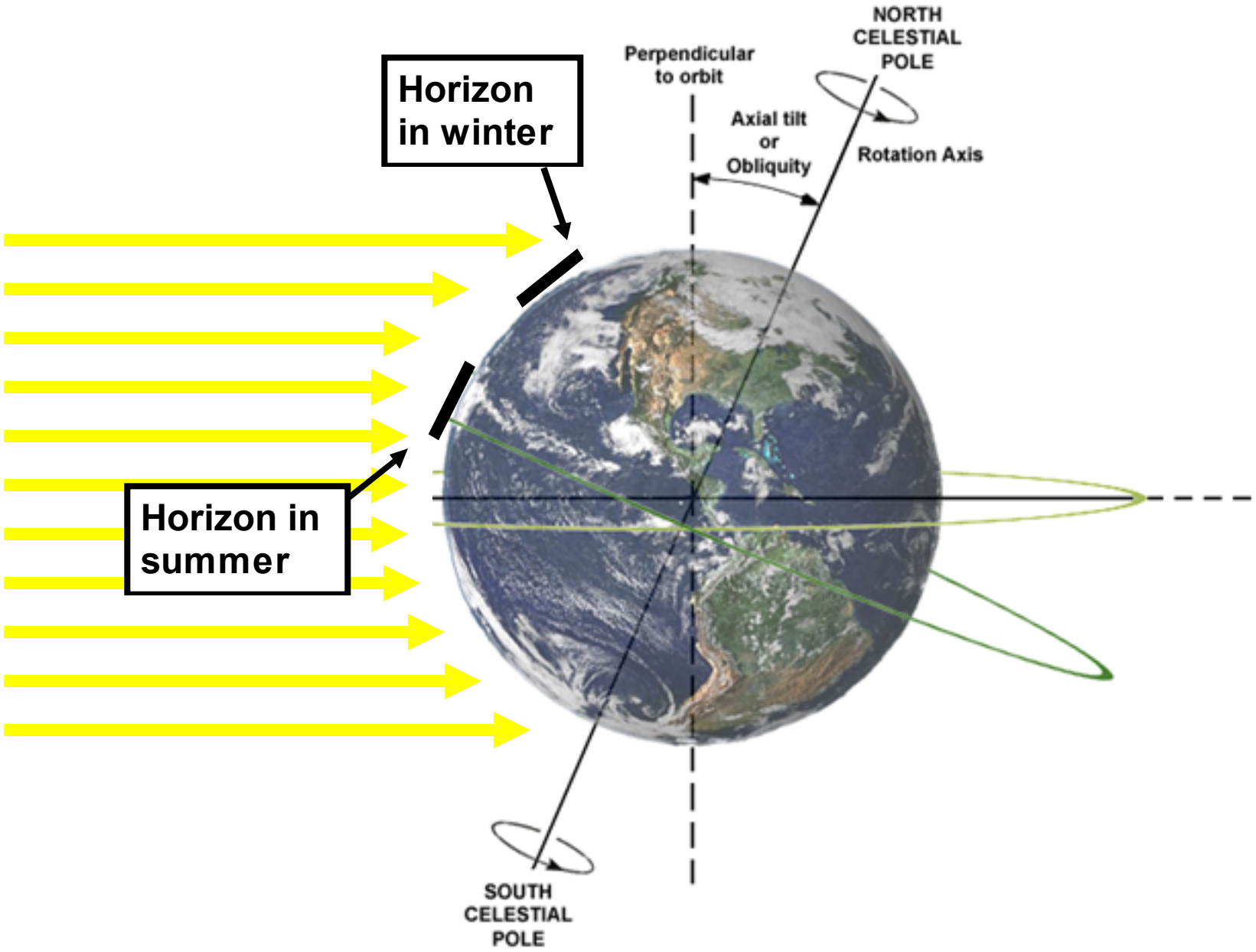

Earth

Solar Geometry



ACTUAL:
The sun radiates in all directions.

EXPERIENTIAL:
On Earth all radiation from the sun is parallel to one another.



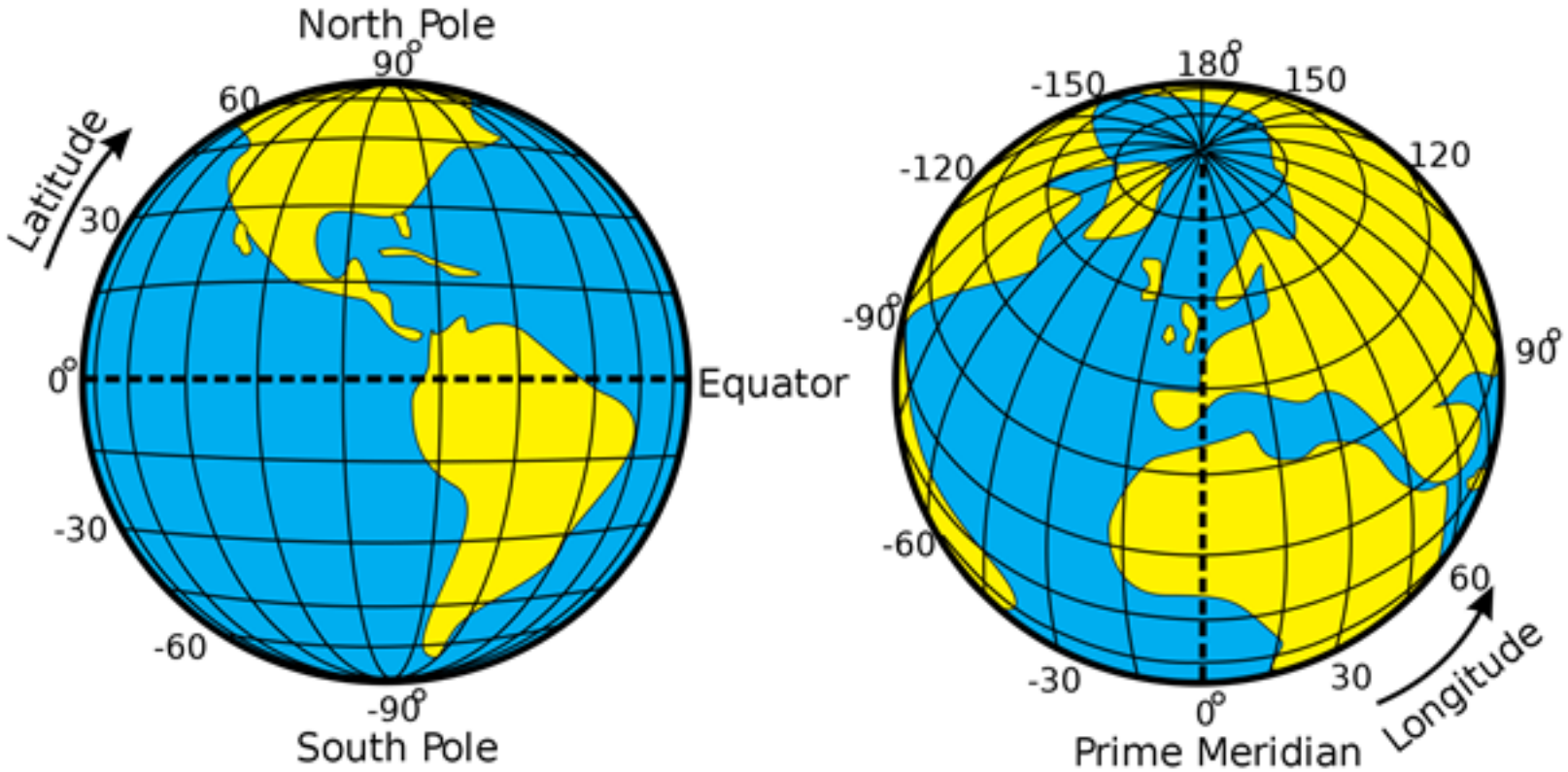
Source: Wikipedia

This ray strikes parallel to the surface.

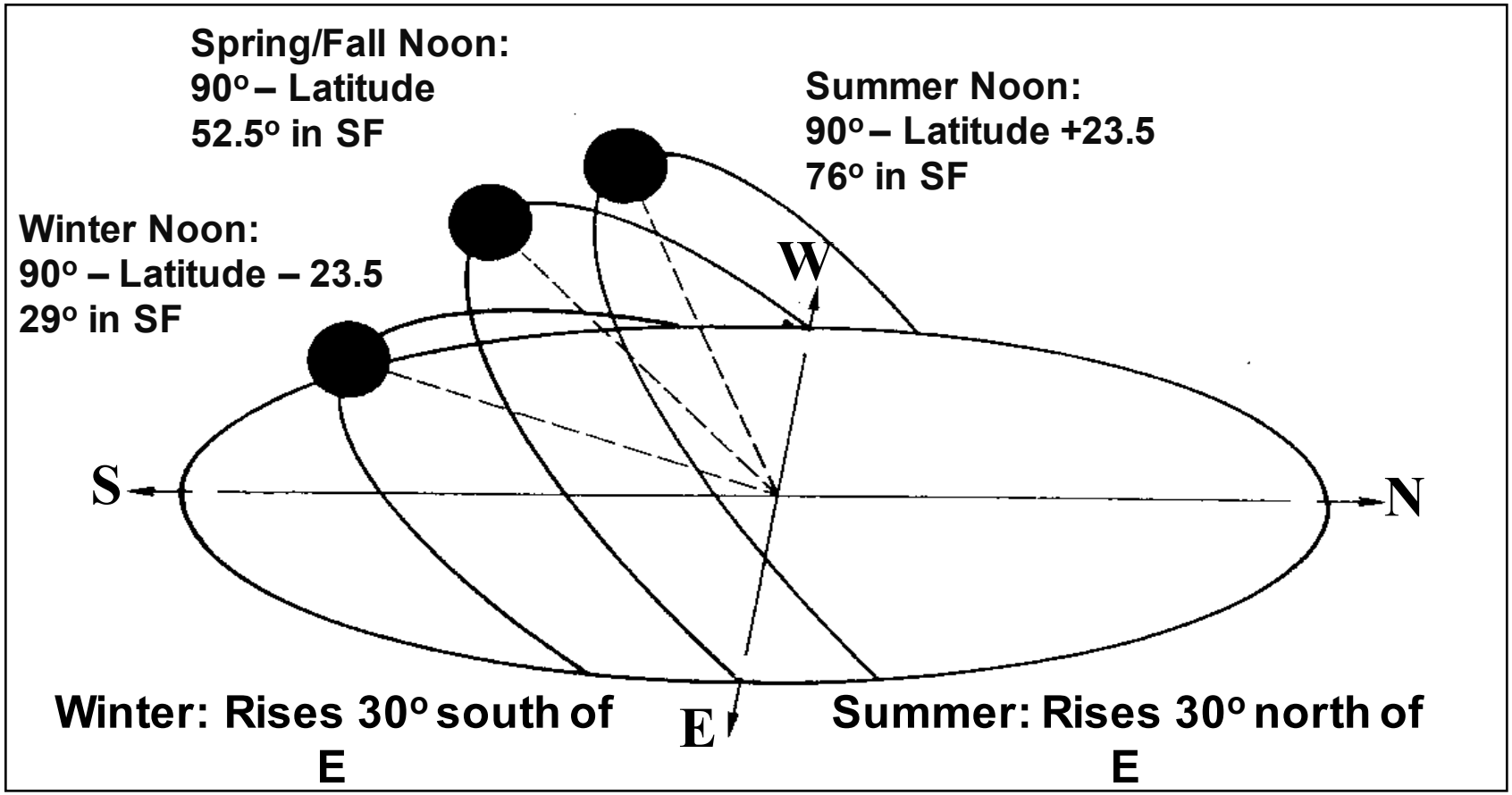
This ray strikes ±45 degree angle to the surface.

This ray strikes perpendicular to the surface.

Latitude and Longitude

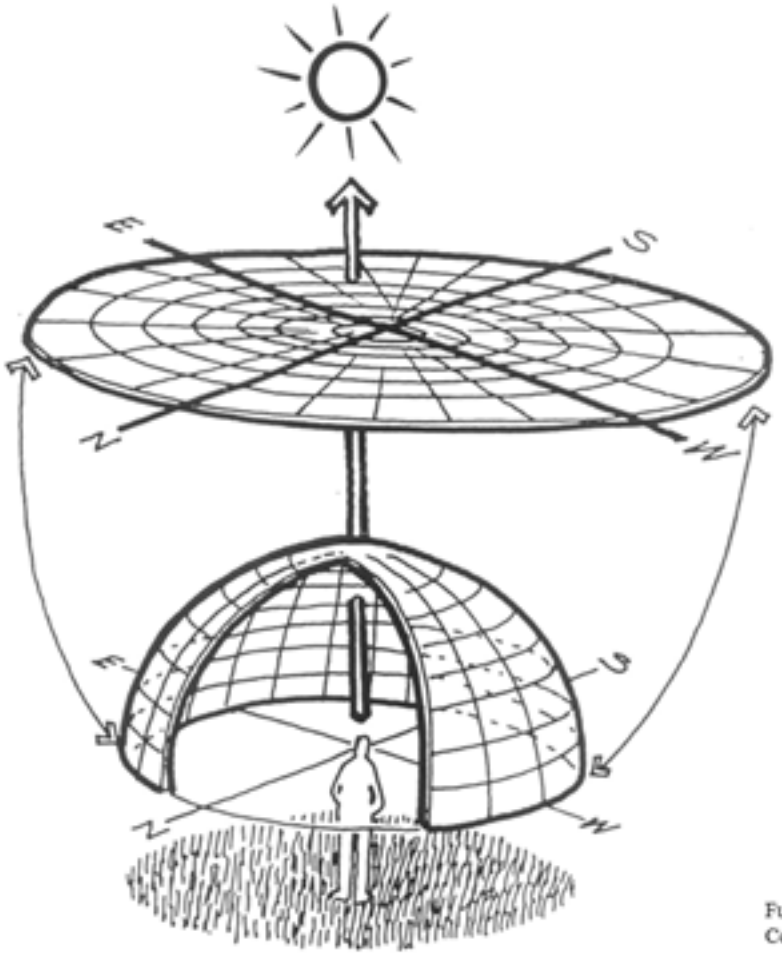


Sun Path



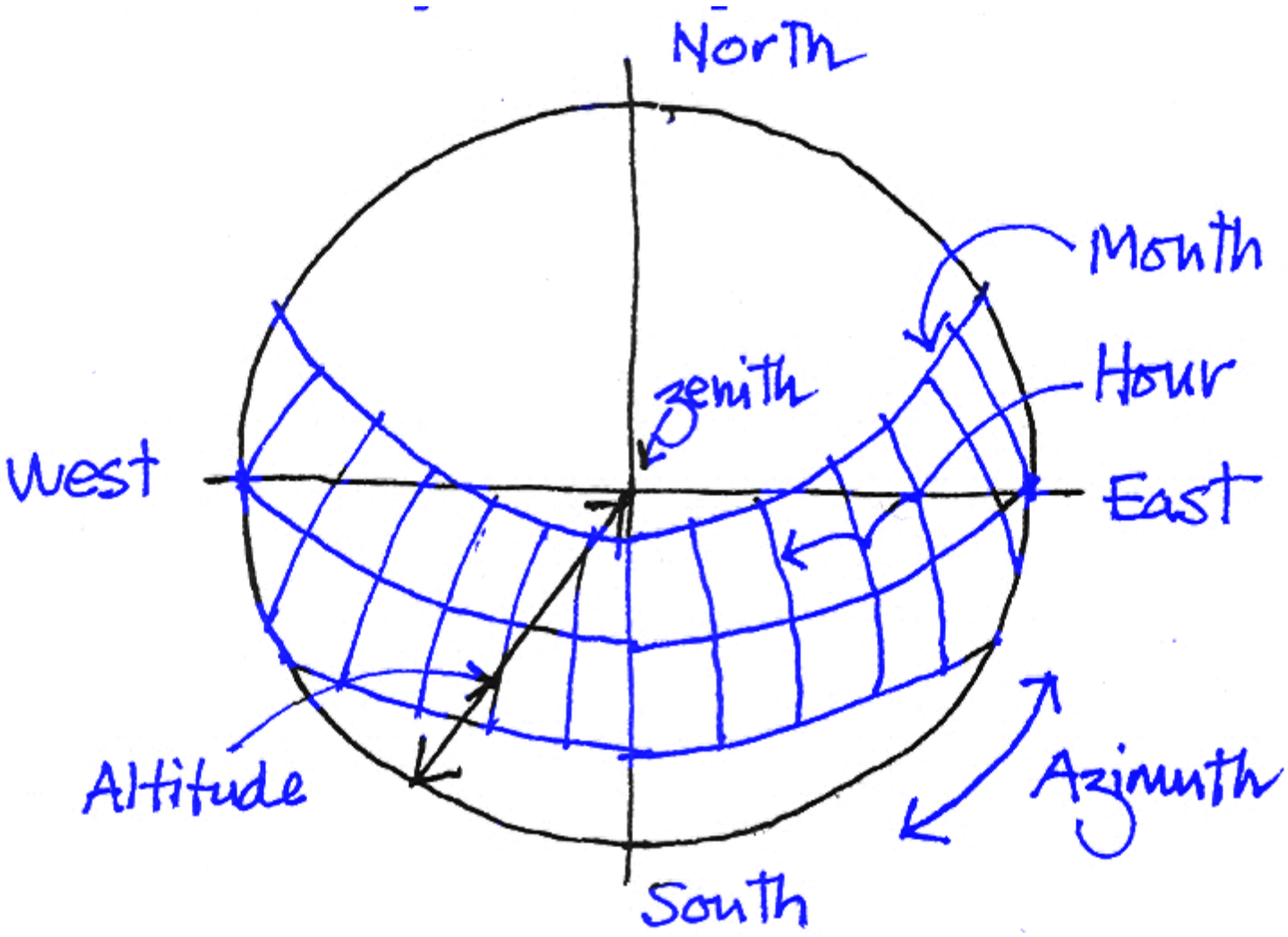
Source: PG&E

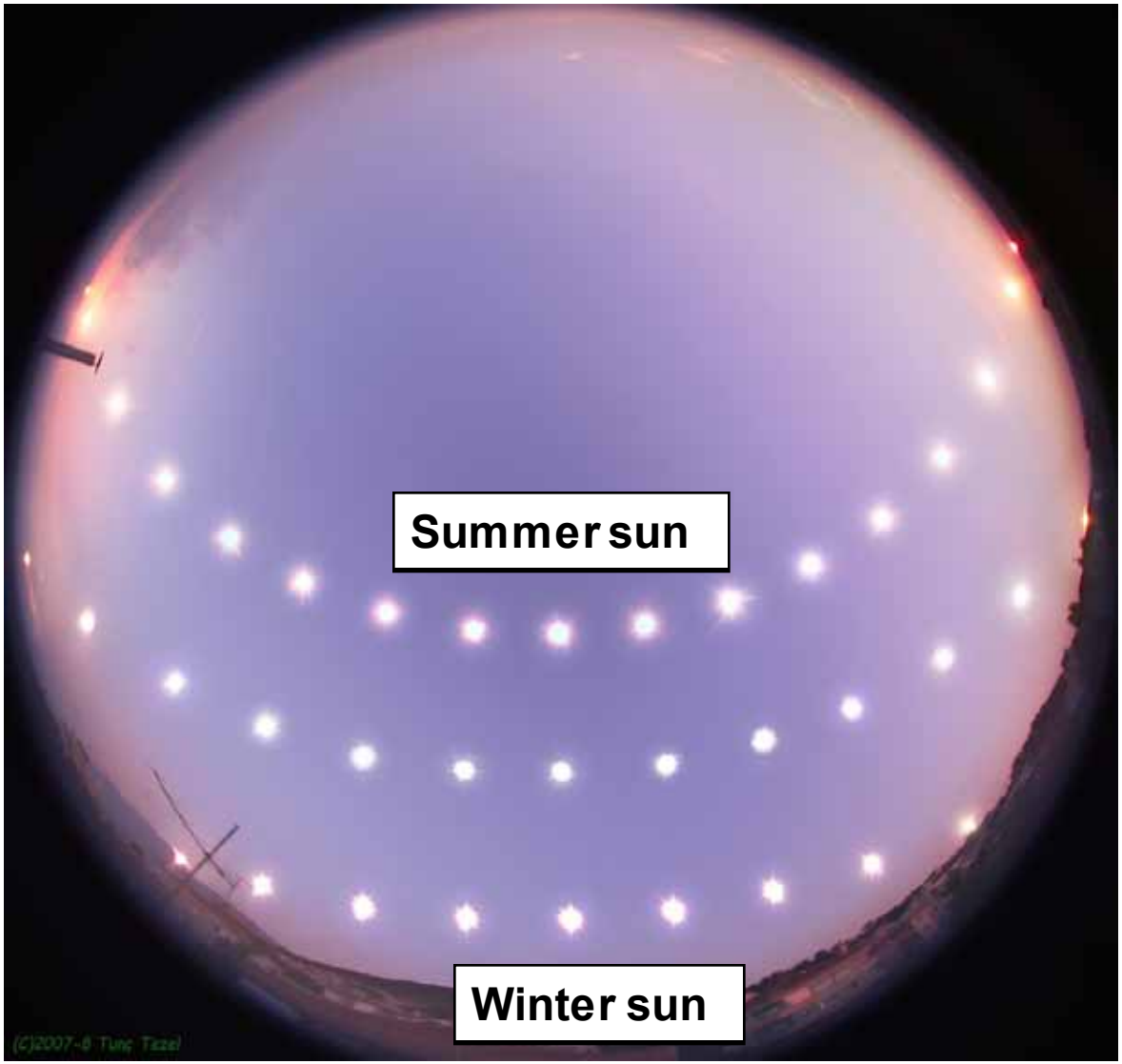
Sun Path Overhead Projection



Fuller Moore. Environmental Control Systems: Heating Cooling Lighting. McGraw Hill 1993,

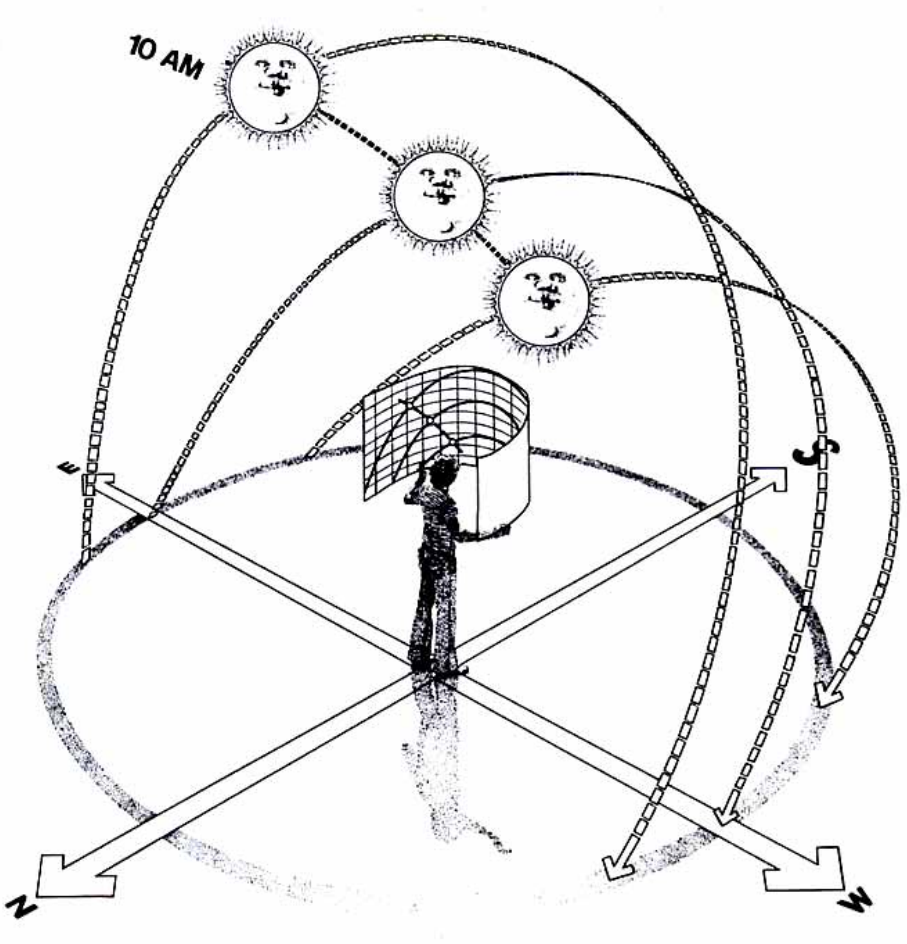
Sun Path Overhead Projection

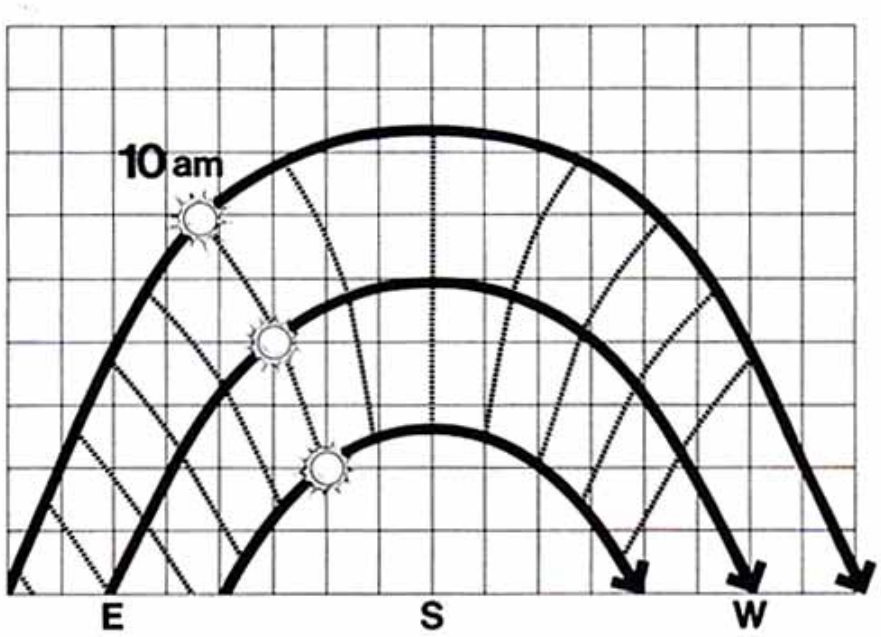




Source: NASA

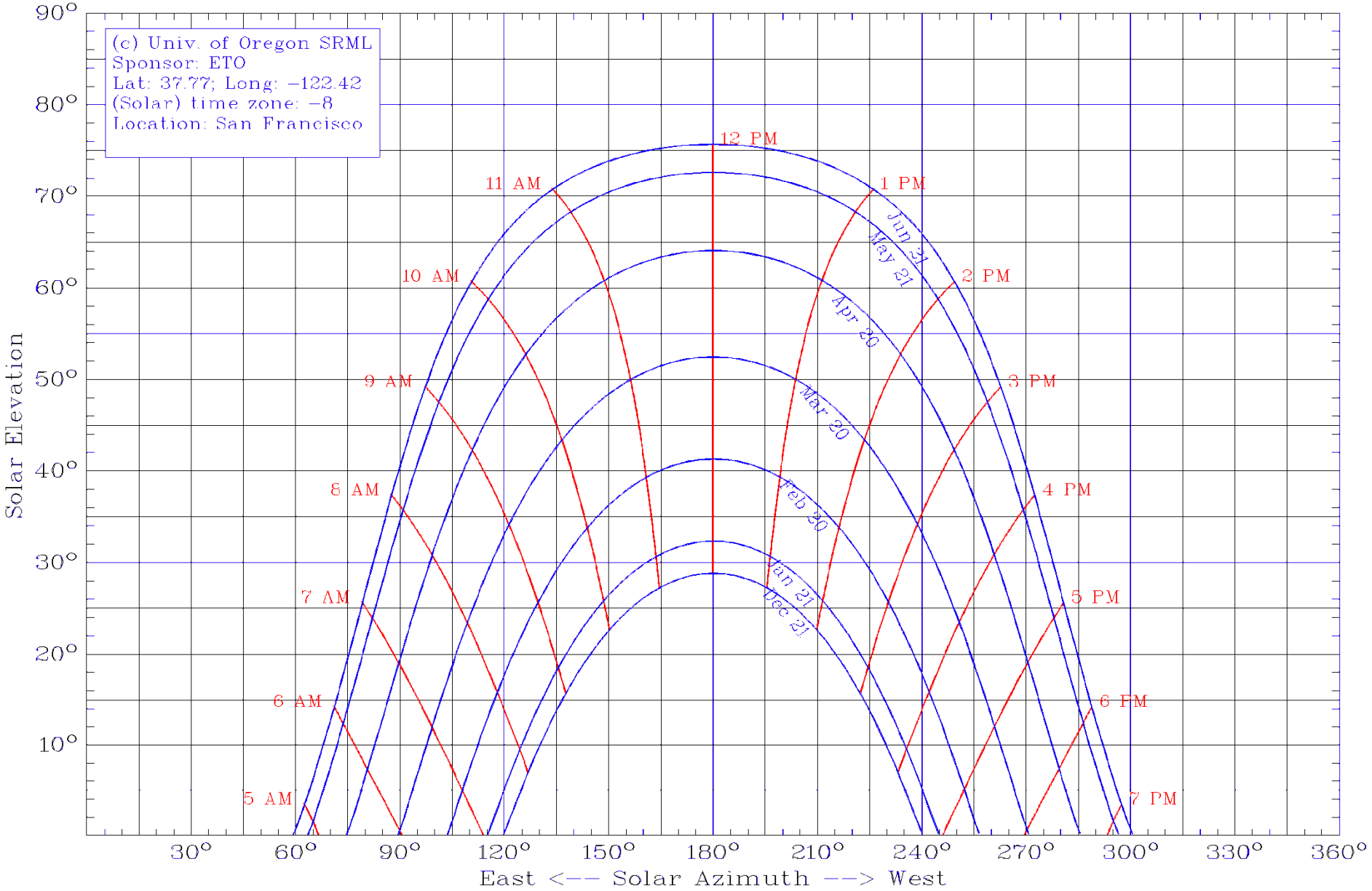
Sun Path Horizon Projection





Edward Mazria. Passive Solar Energy Book, Expanded Professional Edition
Rodale Press, 1979, Pg. 311

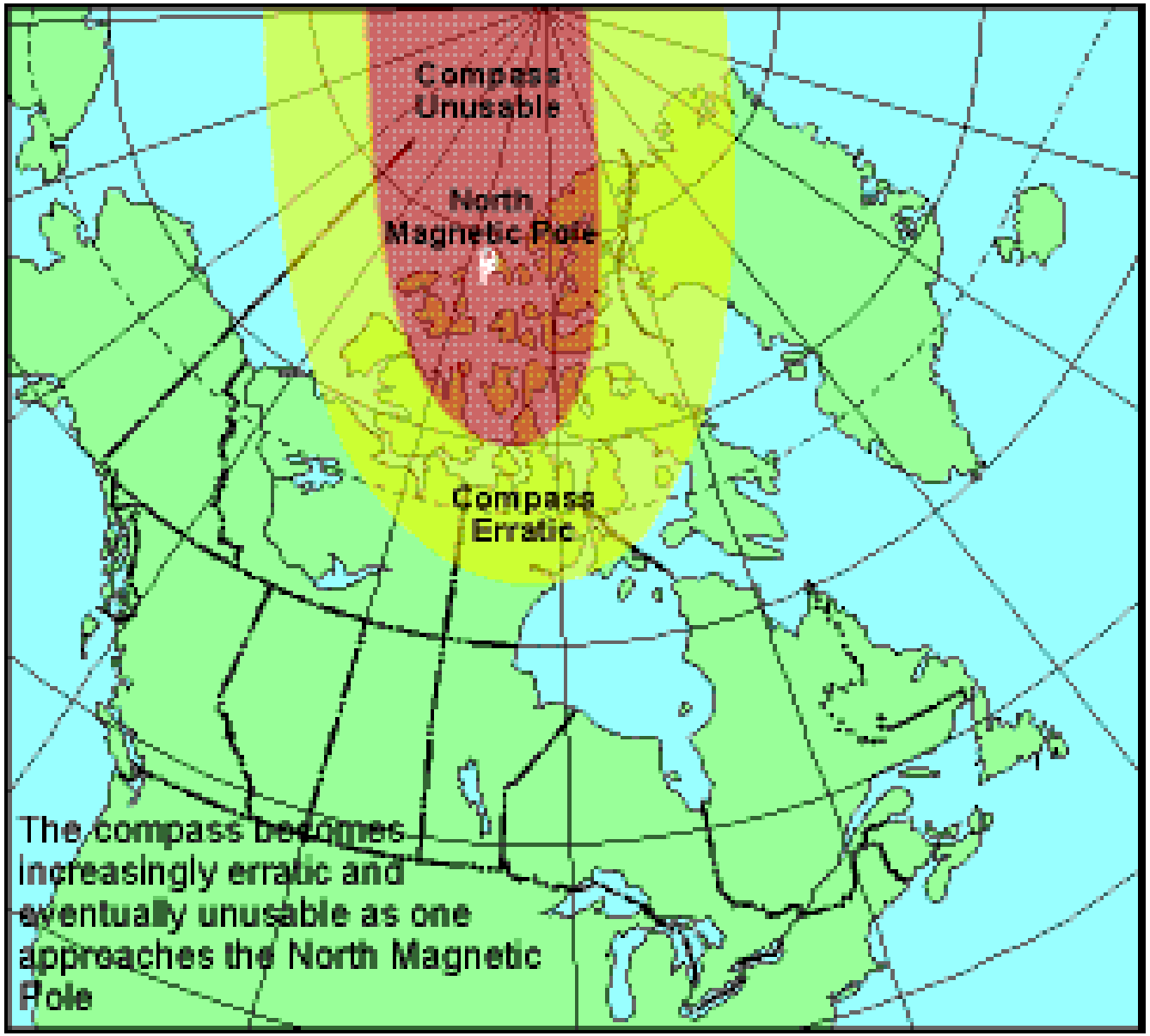
Sun Chart: San Francisco

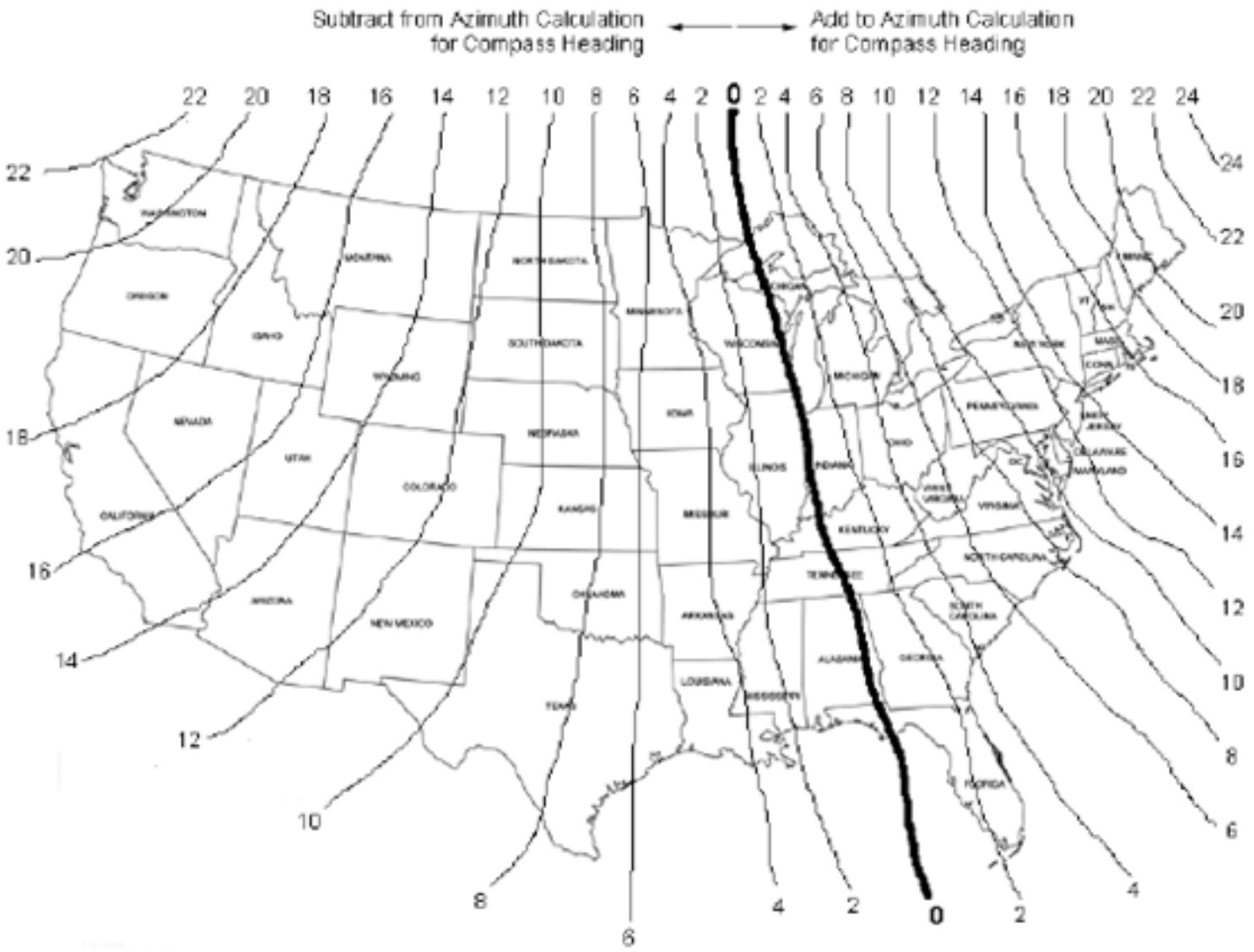


Source: University of Oregon, Solar Radiation Monitoring Laboratory
http://solardat.uoregon.edu/SunChartProgram.html

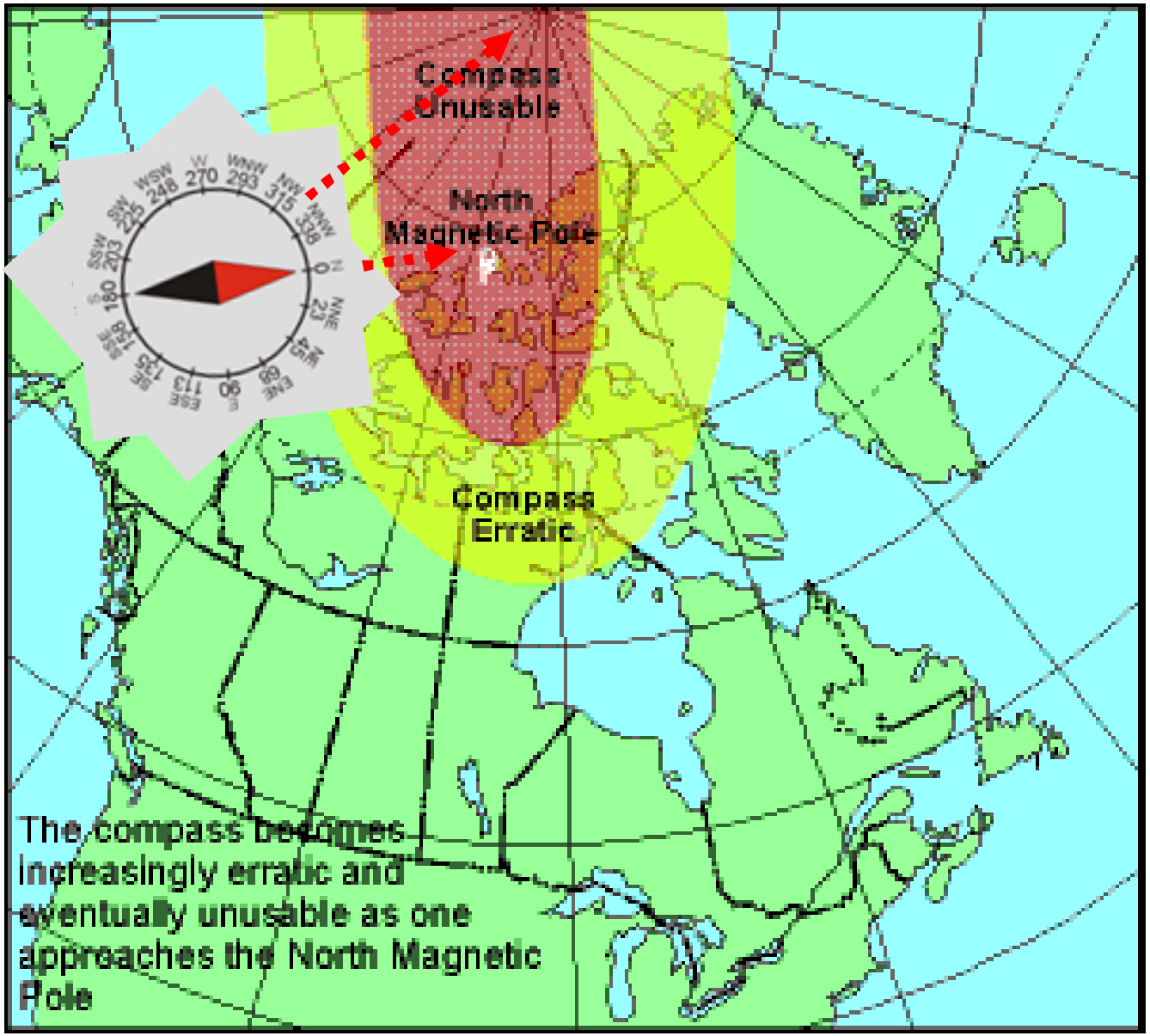
Does the site have an appropriate southern exposure?

Use a compass to identify north (and thus south), a first step in assessing solar access at a site.


Compass Unusable
North Magnetic Pole
Compass Erratic
The compass becomes increasingly erratic and eventually unusable as one approaches the North Magnetic Pole



U.S. Map Showing Magnetic Declination for Azimuth Compass Indications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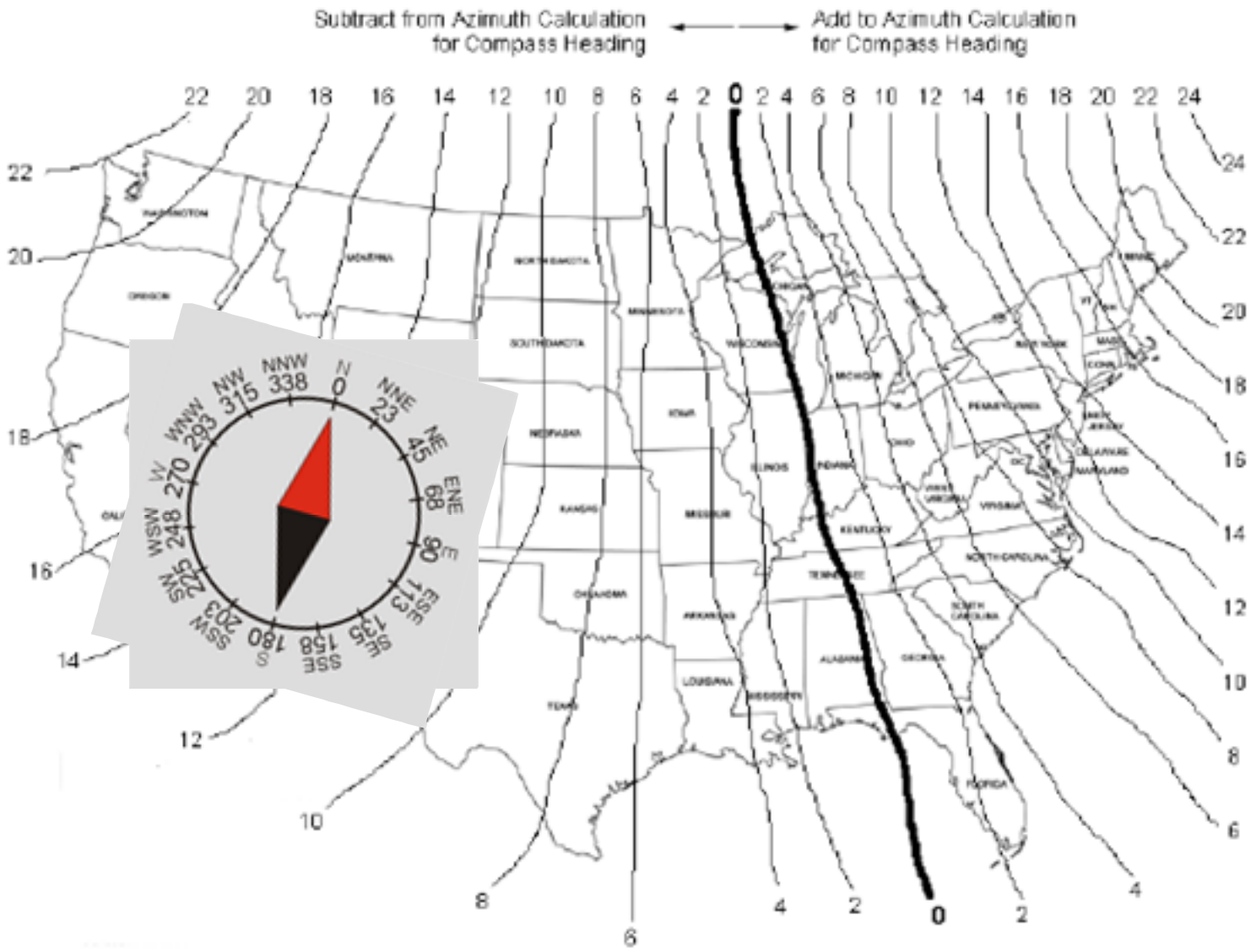
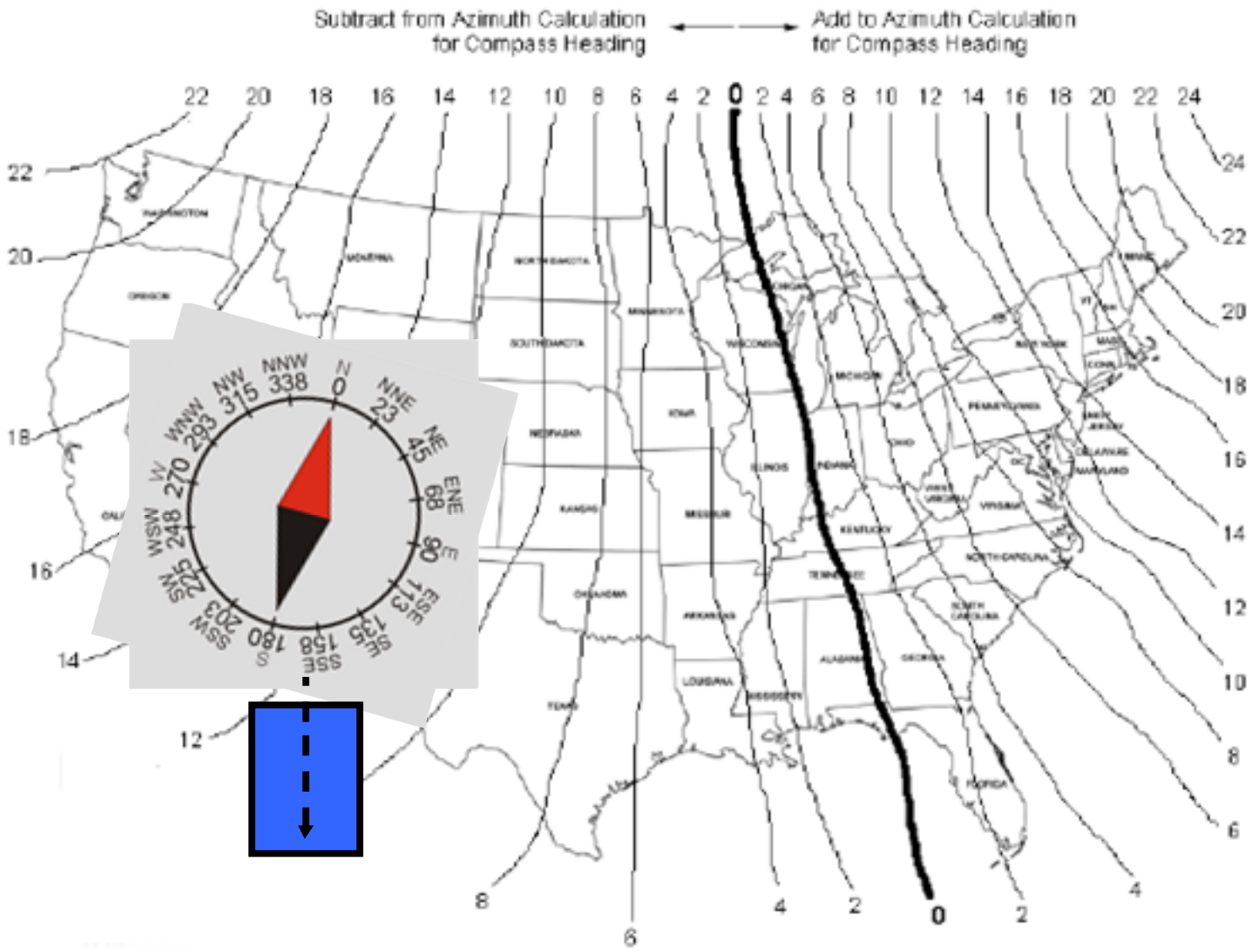
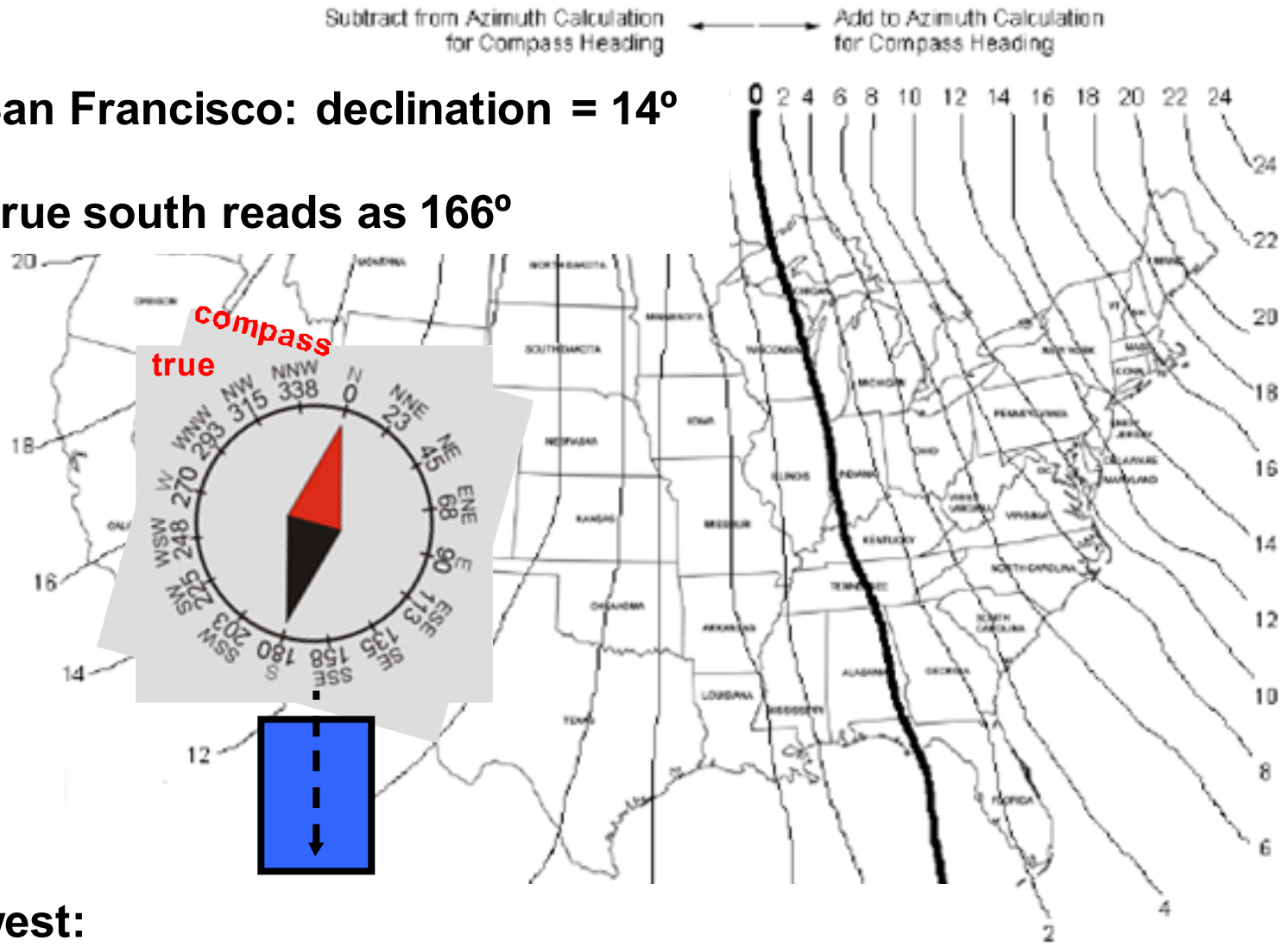


U.S. Map Showing Magnetic Declination for Azimuth Compass Indications



U.S. Map Showing Magnetic Declination for Azimuth Compass Indications

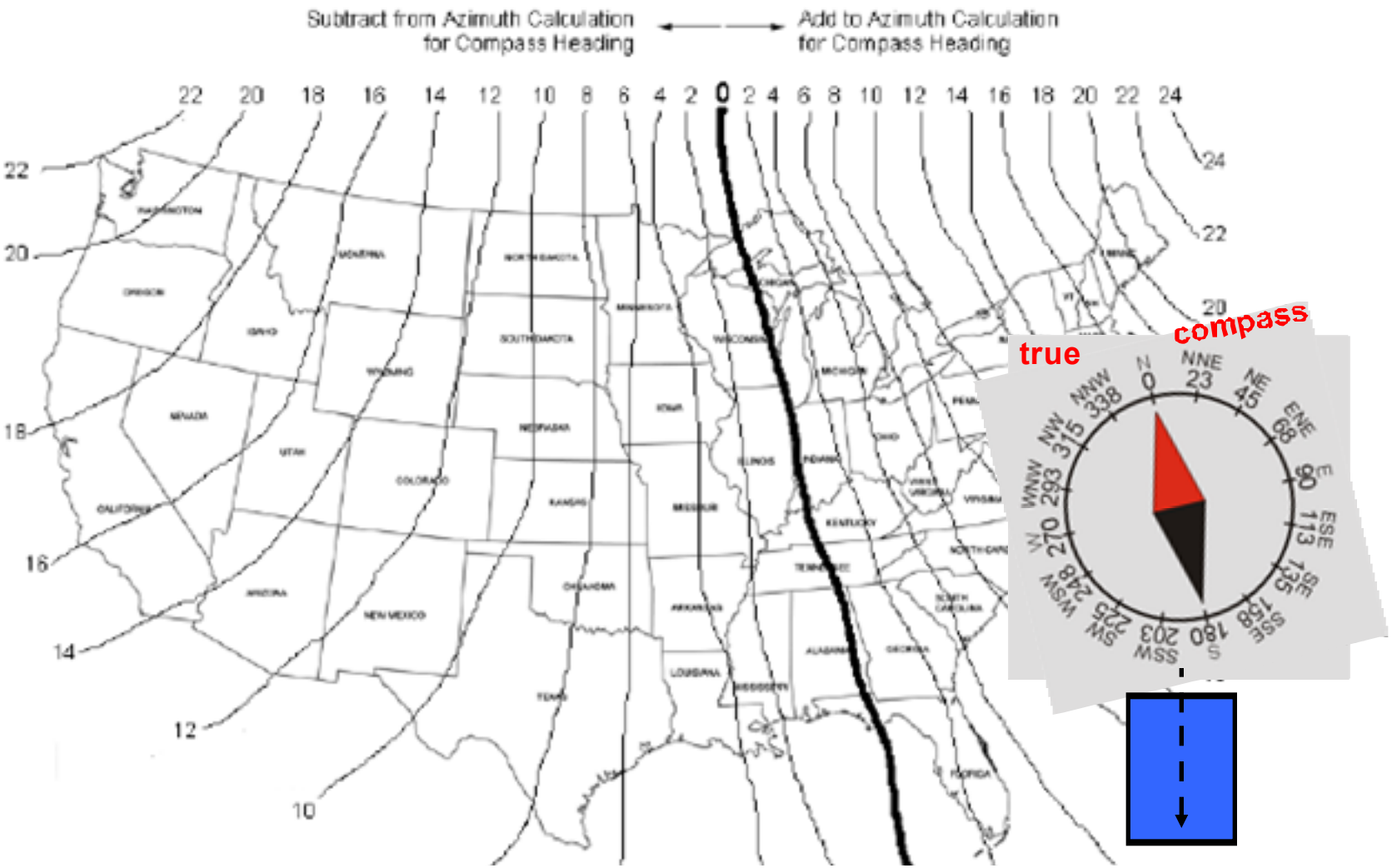


San Francisco: declination = 14º

True south reads as 166º

In west:

True azimuth = Compass azimuth + Declination



In east:

True azimuth = Compass azimuth - Declination

Magnetic South vs. True South

Magnetic South = Compass South

- **A compass aligns with the earth's magnetic field, which is not exactly aligned with the earth's rotational axis.**
- ***Magnetic Declination* = the number of degrees that true south is east or west from magnetic south.**
- **True south ~ 15° east of magnetic south (SF, SJ, Stockton)**

True South = Solar South

NOTE: go to National Geophysical Data Center (NGDC) at

http://www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp

to determine your site's magnetic declination

Describing Location of the Sun

First understand where it is!

- ***Azimuth*** - horizontal angle of sun east or west of due south
- ***Altitude*** - angle of sun above the horizon
- ***Azimuth*** and ***altitude*** describe the location of the sun in the sky at a given time.

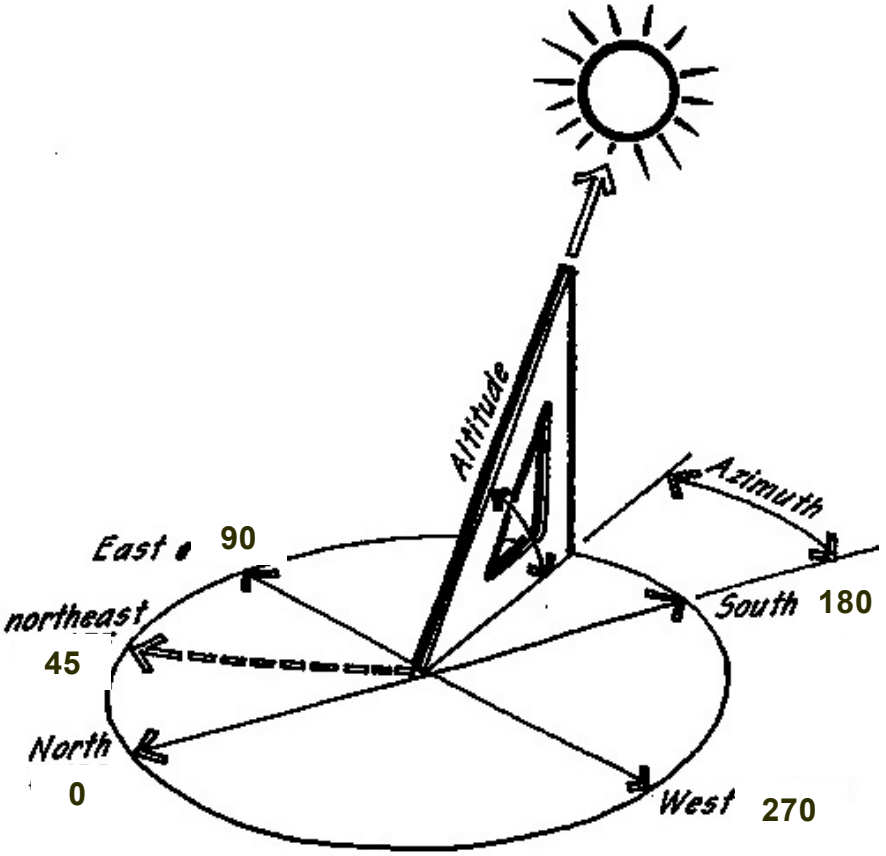
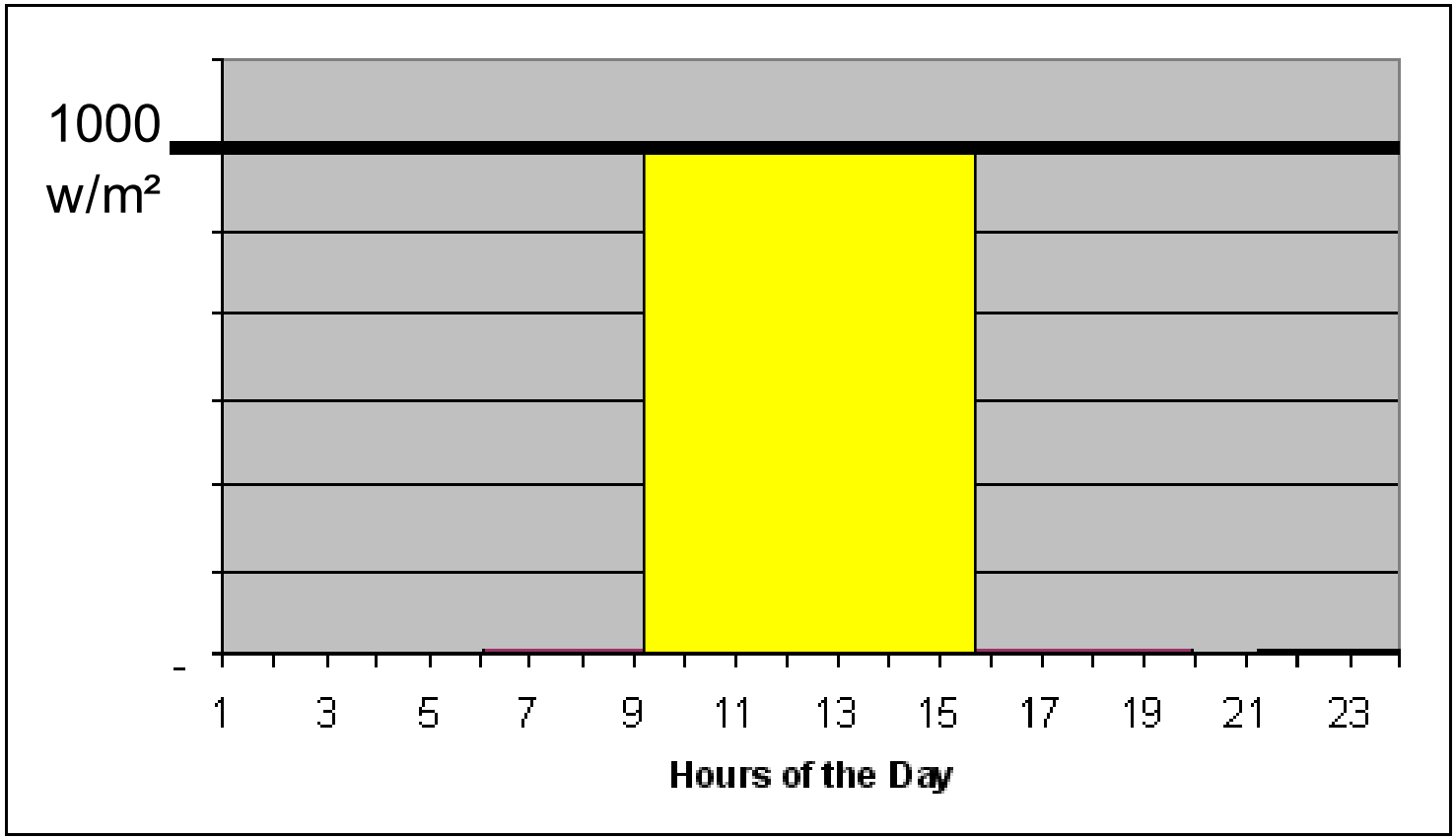


Illustration from *Environmental Control Systems* by Fuller Moore, McGraw-Hill, Inc., 1993, p. 76.

PV Siting Issues to Consider

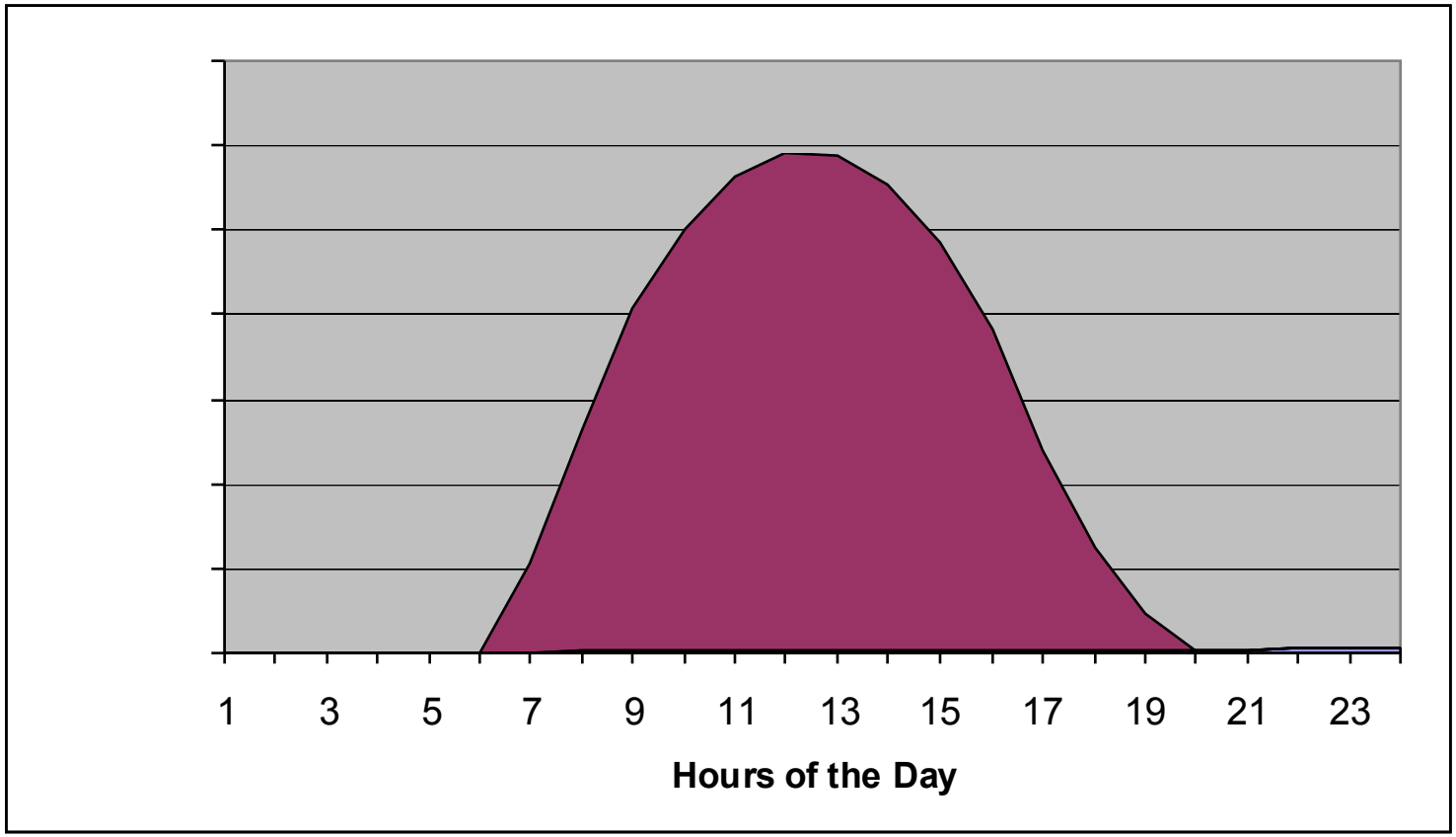
1. Sun energy potential (insolation)
2. Space
3. Shading
4. Orientation (N – S)
5. Tilt angle
6. Aesthetics

Peak Sun Hours Equivalent



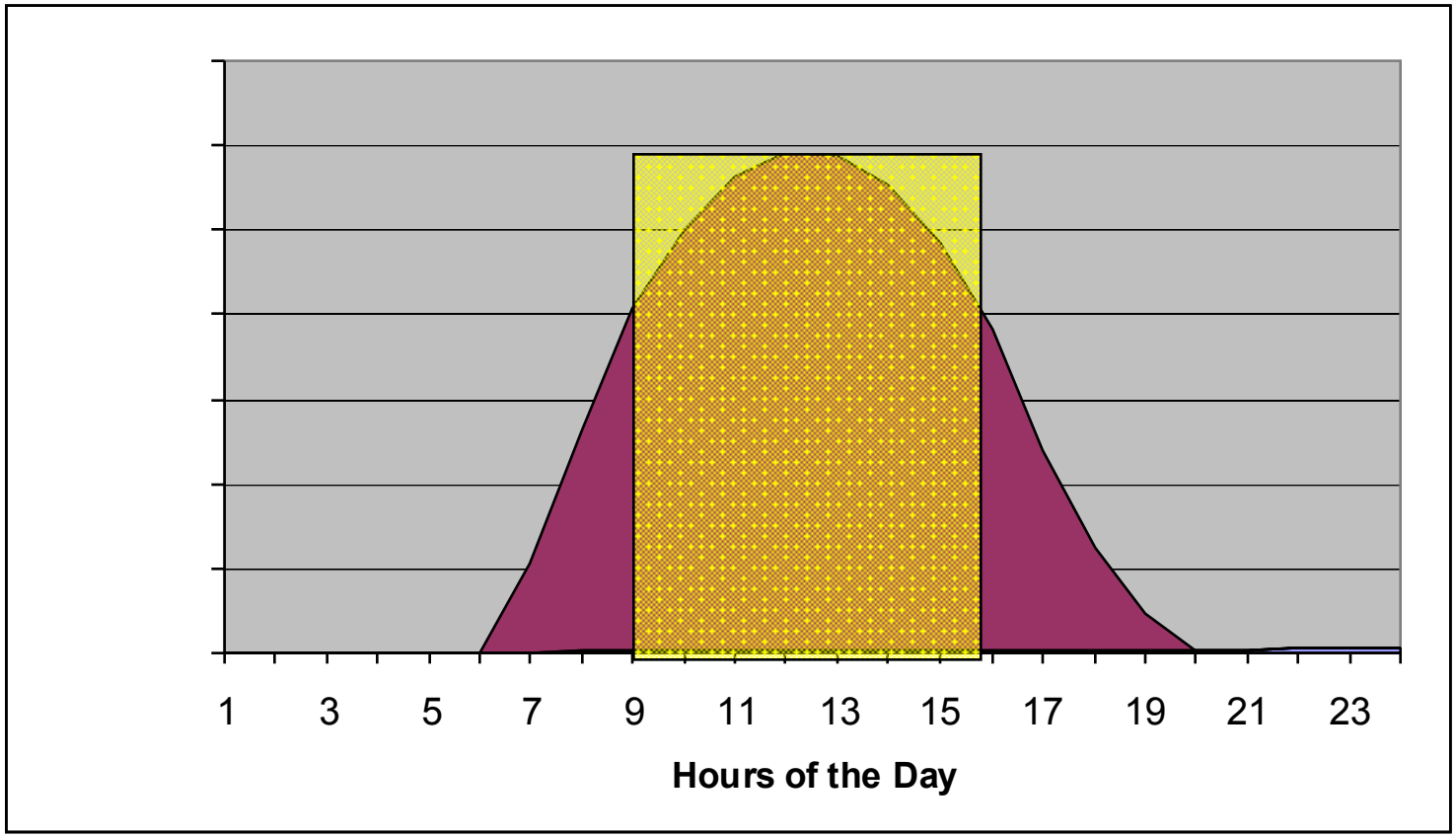
“Digital” sunlight

Peak Sun Hours Equivalent



Typical daily pattern

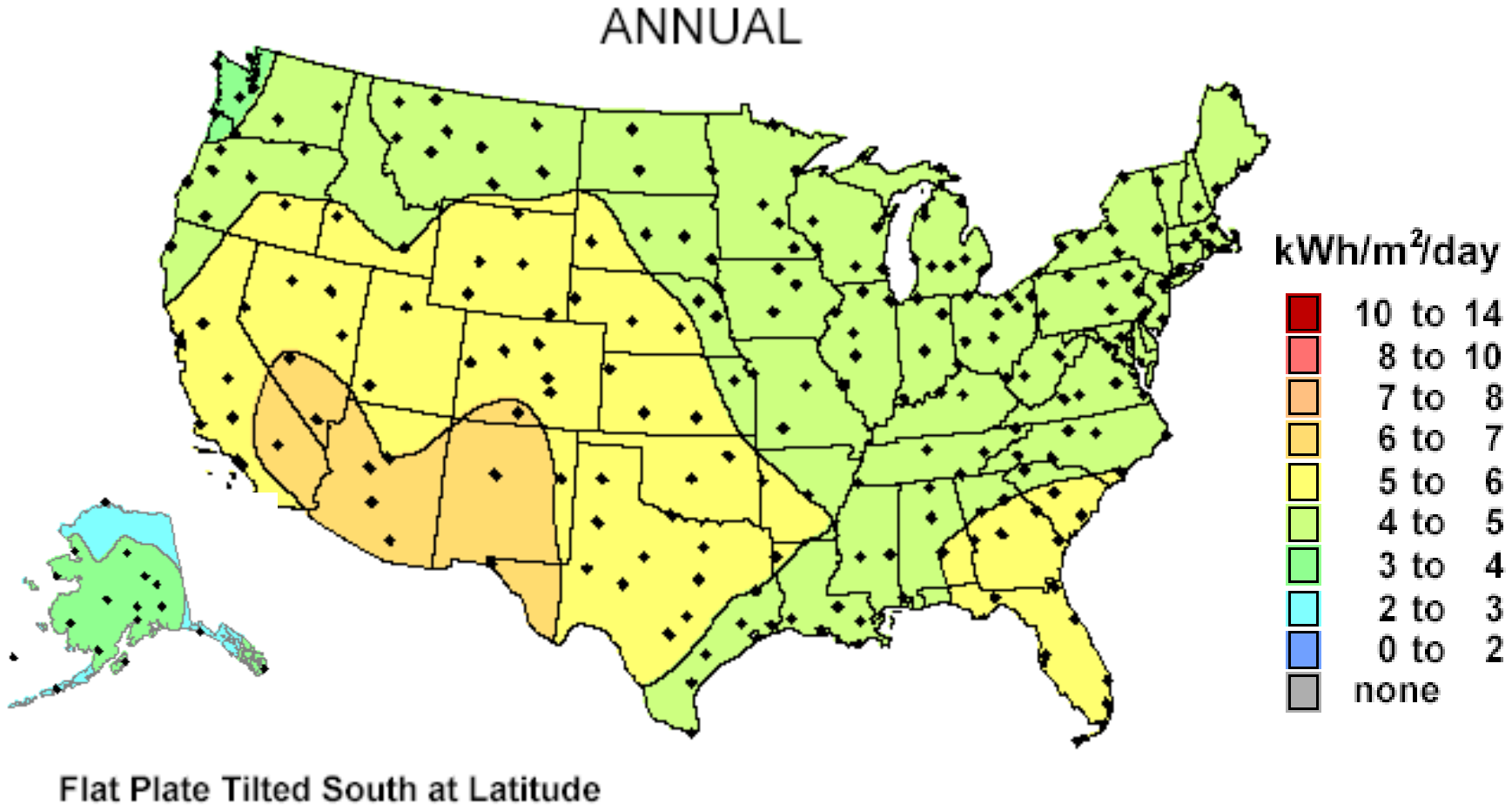
Peak Sun Hours Equivalent



Equal areas

What is the solar resource potential?

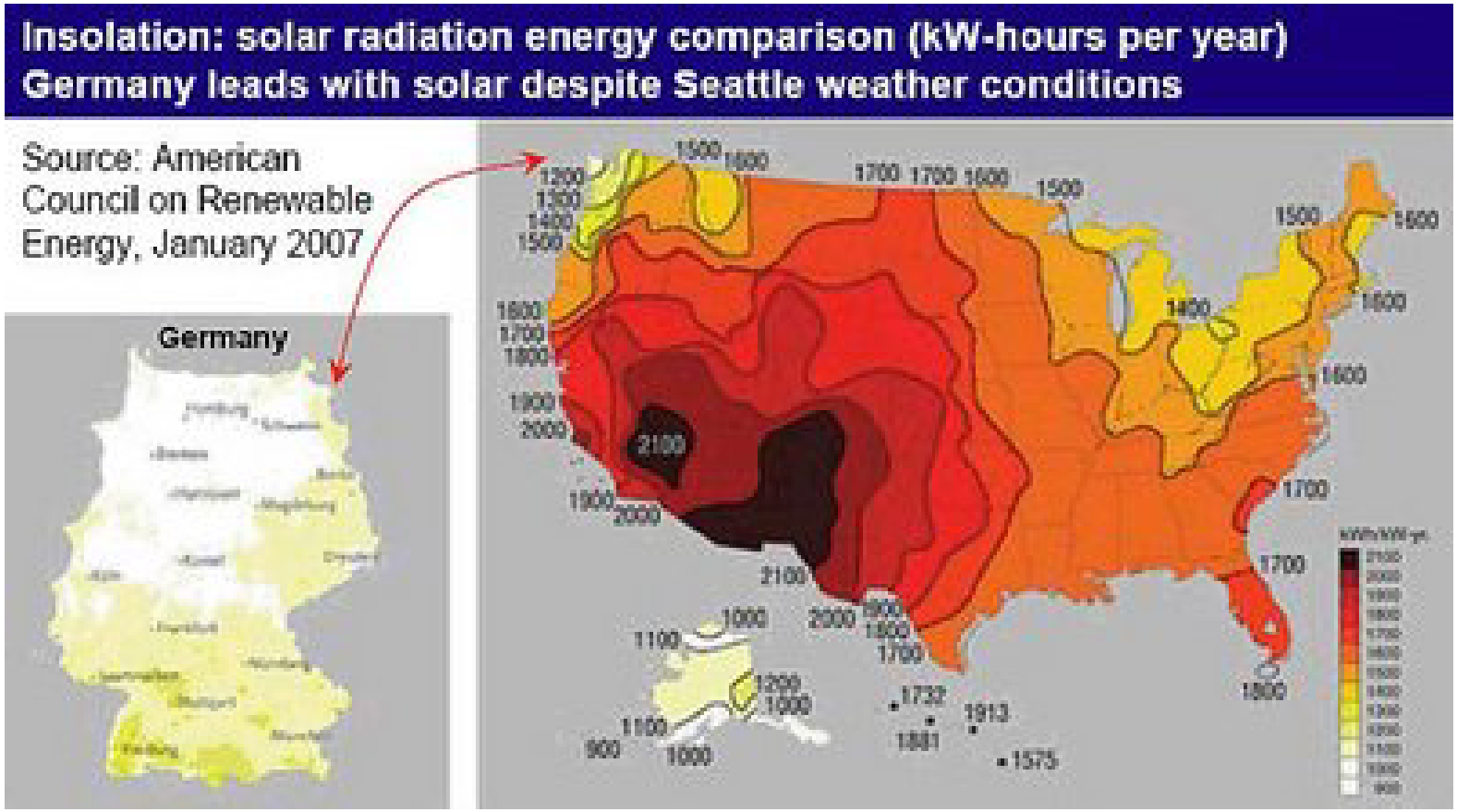
Peak Sun-hours Measured in kWh/m^2/day



Source: DOE National Renewable Energy Laboratory (NREL) Resource Assessment Program
http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/atlas/serve.cgi

What is the solar resource potential?

Peak Sun-hours Measured in kWh/m^2/day



Monthly Percentages

Source: morehead.unc.edu

Percentage of yearly insolation per month

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Francisco	4.0%	5.7%	7.5%	10.1%	11.6%	12.6%	12.9%	11.1%	9.8%	6.7%	4.5%	3.5%
Los Angeles	4.8%	6.6%	7.9%	10.2%	11.3%	11.8%	11.5%	10.4%	9.4%	6.8%	5.3%	4.2%
Portland	3.0%	5.1%	7.6%	10.0%	11.9%	13.3%	14.5%	12.6%	10.5%	6.1%	3.1%	2.4%

Ratio of sunniest six months to least sunny ("summer to winter")

City	Sunniest	Least sunny	Ratio
San Francisco	68.1%	31.9%	2.14 to 1
Los Angeles	64.5%	35.5%	1.82 to 1
Portland	72.7%	27.3%	2.67 to 1

Weather/Sun Potential Summary

- California climate ideal for solar
- Panels produce in all light
- Fog has cooling effect, which raises efficiency
- Microclimates likely less than 15% loss from normal

Space Requirements

Roof / Ground Area:

- **Crystalline Silicon**

  90-150 square feet per kW

- **Thin-Film**

  170-250 square feet per kW

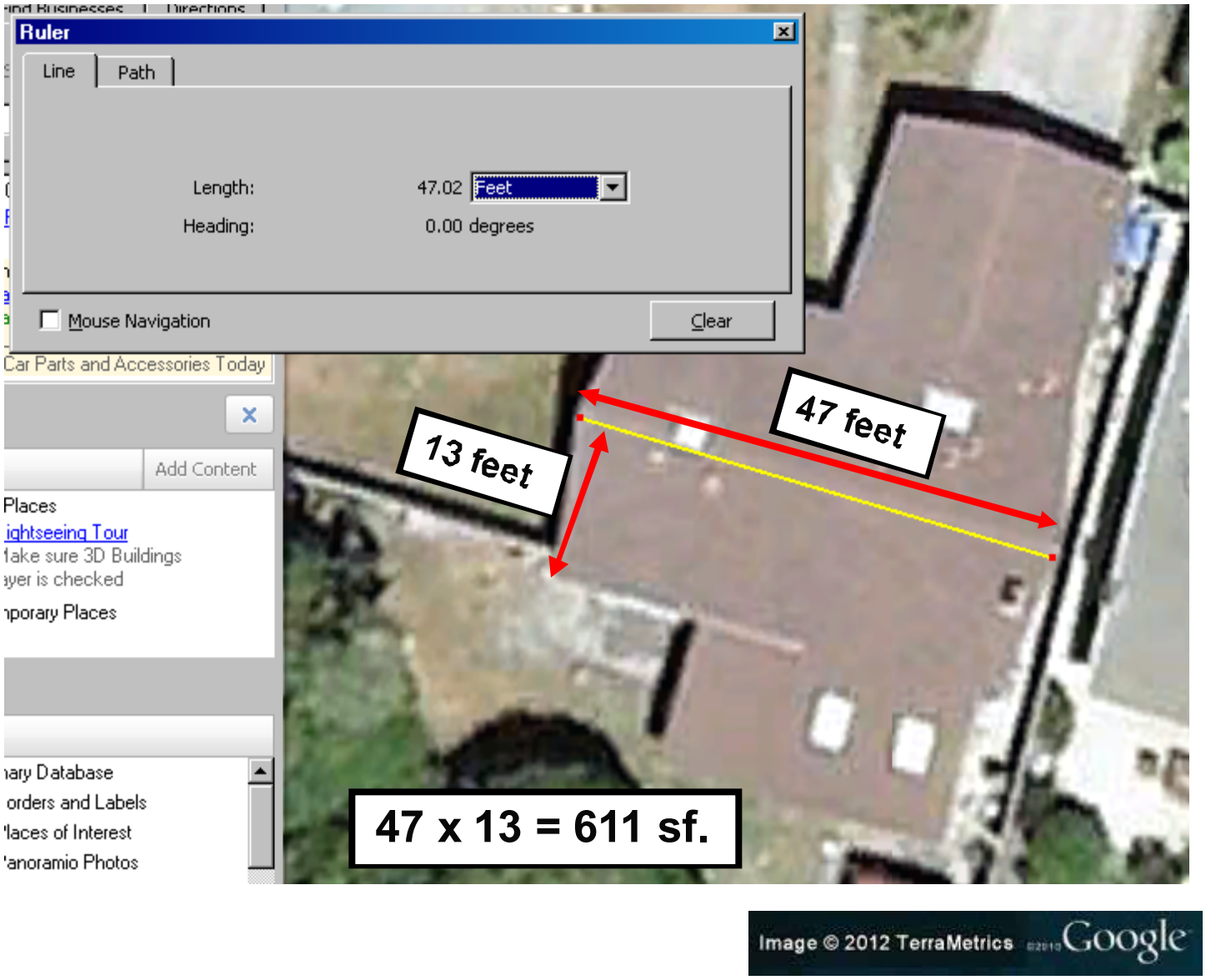
For a 4 kW residential system:

Crystalline: 360 to 600 sf.

Thin film: 650 to 1000 sf.

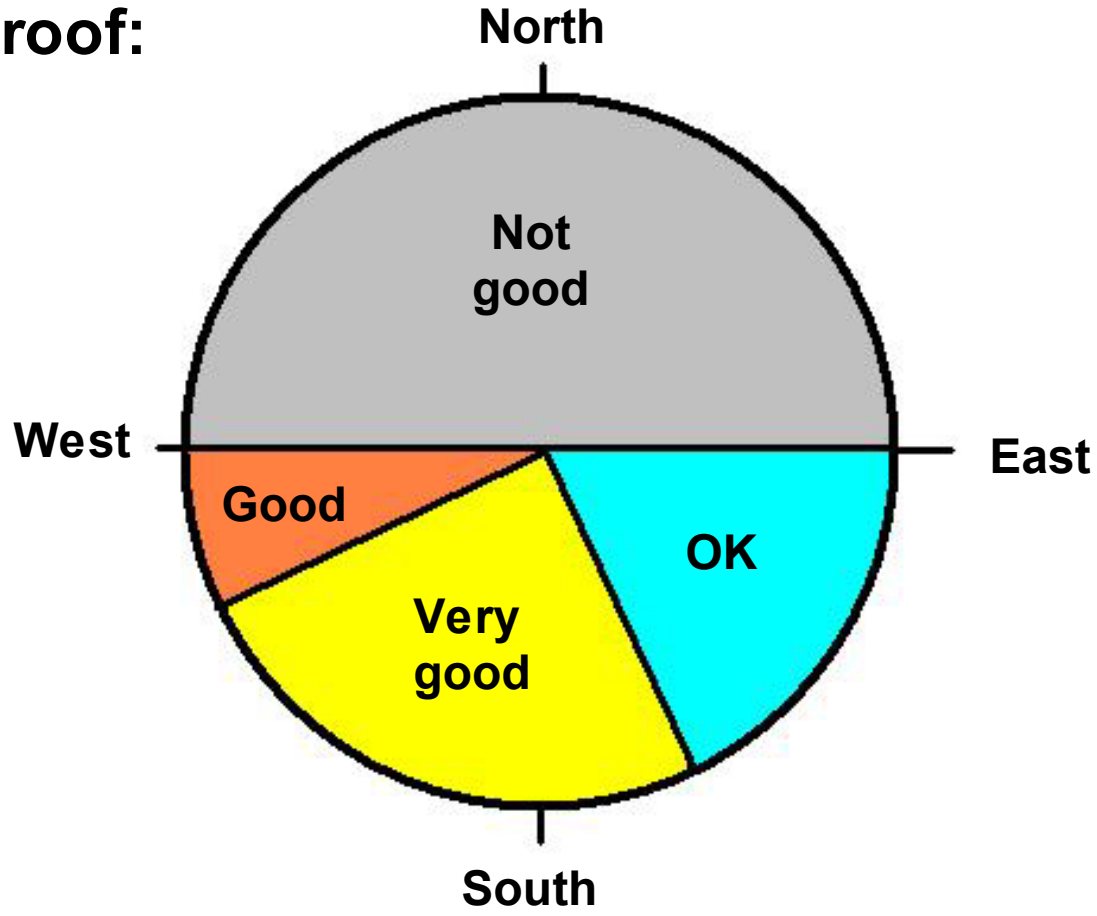
Note: Consideration should also be given for access to the system (can add up to 20% of needed area)

Space Requirements: Overhead Photos

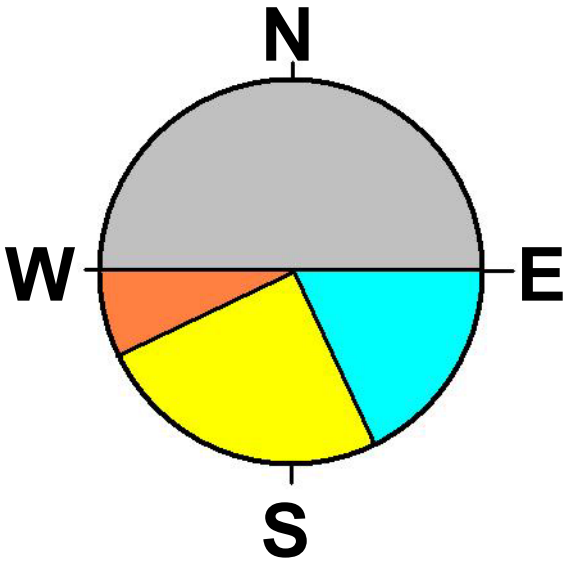


PV Orientation

For tilted roof:



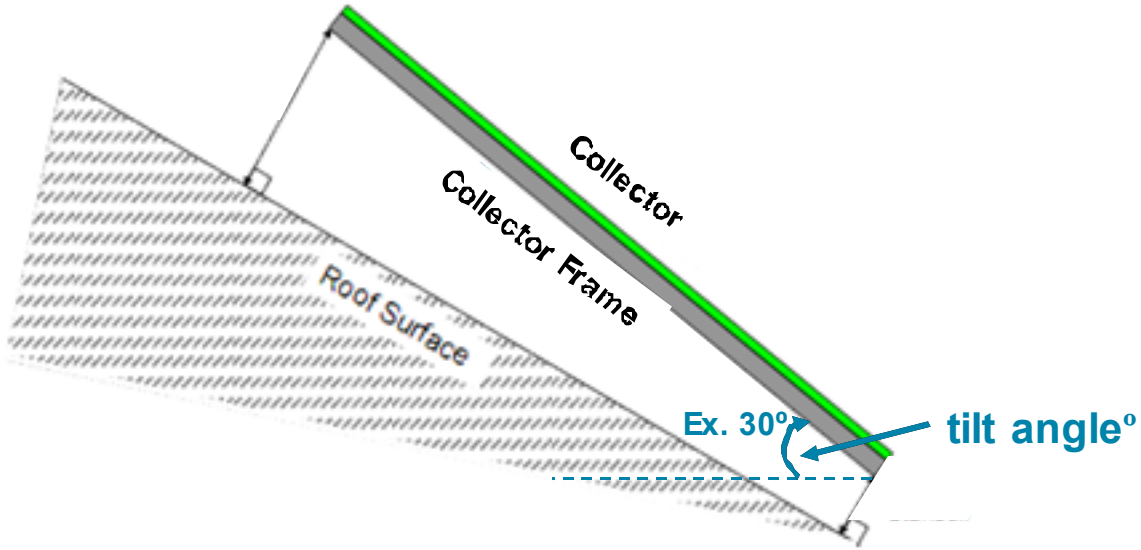
PV Orientation



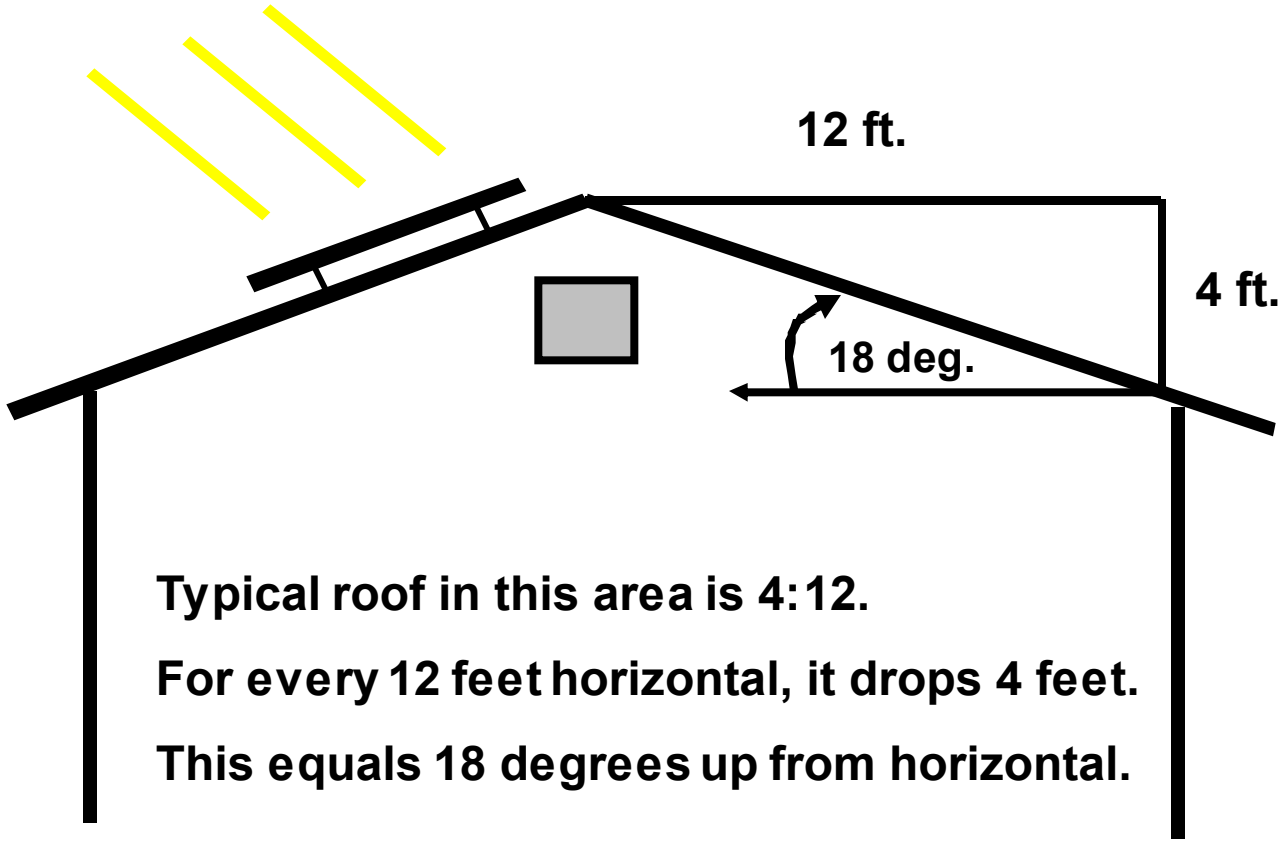
Overhead maps: true N-S

Tilt

Tilt = Angle at which the collectors are mounted relative to 0° (flat horizontal surface)



Tilt



Normal roof pitch is a very good mounting angle.

Tilt Angle vs. Building Orientation

Orientation / Degrees from South

	0° Flat	18° 4:12	30° 7:12	45° 12:12	60° 21:12	90° Vertical
0° (South)	0.89	0.97	**1.00**	0.97	0.89	0.58
23° (SSE, SSW)	0.89	0.97	0.99	0.96	0.88	0.59
45° (SE, SW)	0.89	0.95	0.96	0.93	0.85	0.60
68° (ESE, WSW)	0.89	0.92	0.91	0.87	0.79	0.57
90° (E, W)	0.89	0.88	0.84	0.78	0.70	0.52

Source: "A Guide to Photovoltaic (PV) System Design and Installation" -- *CEC, June 2001*

Bottom line: Tilt is a factor, but not a major one.

Tracking

Courtesy of DOE/NREL

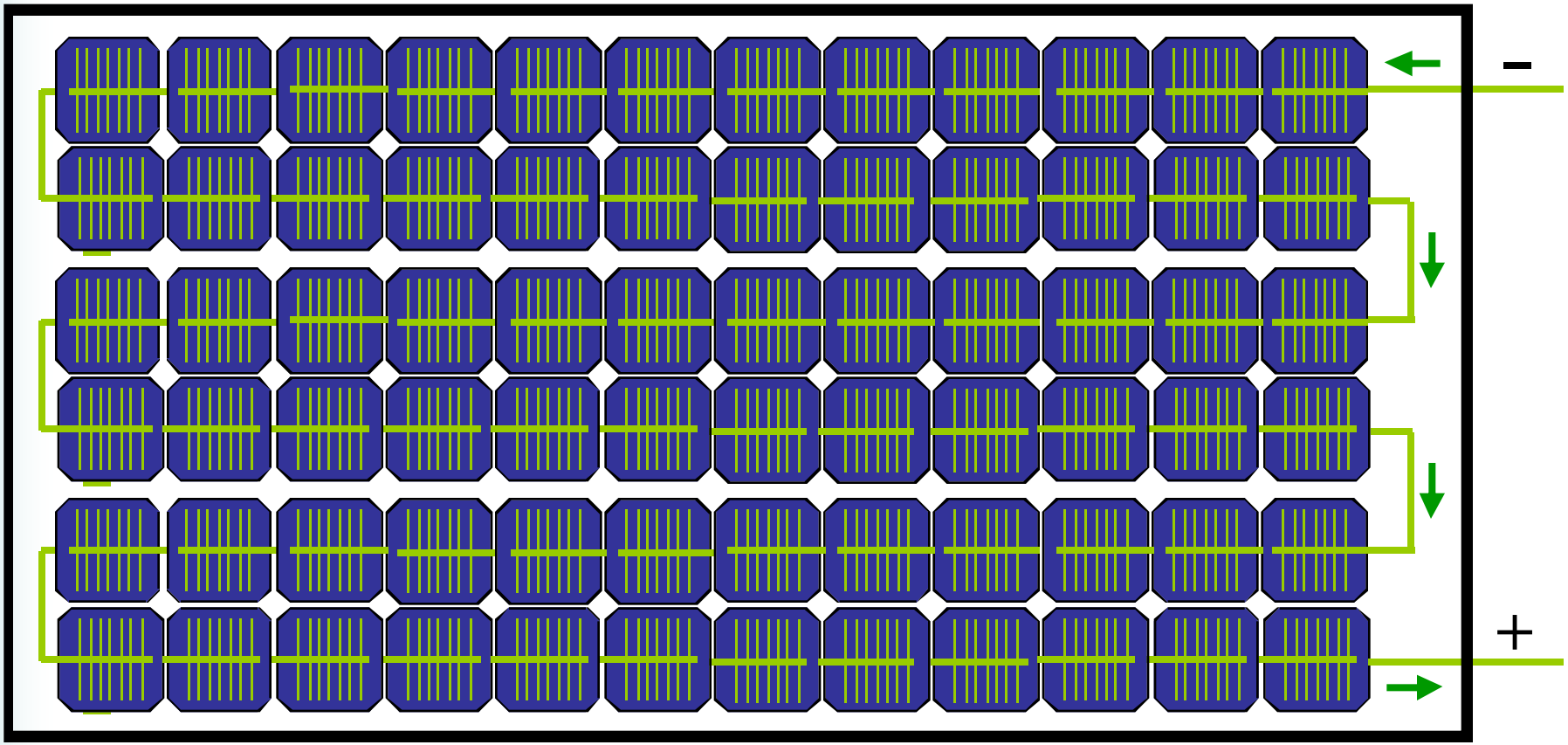
For most home systems, the extra expense and maintenance of tracking motors is not worth the efficiency gain. Better to buy a few extra panels.

For large commercial systems it may be worth it.

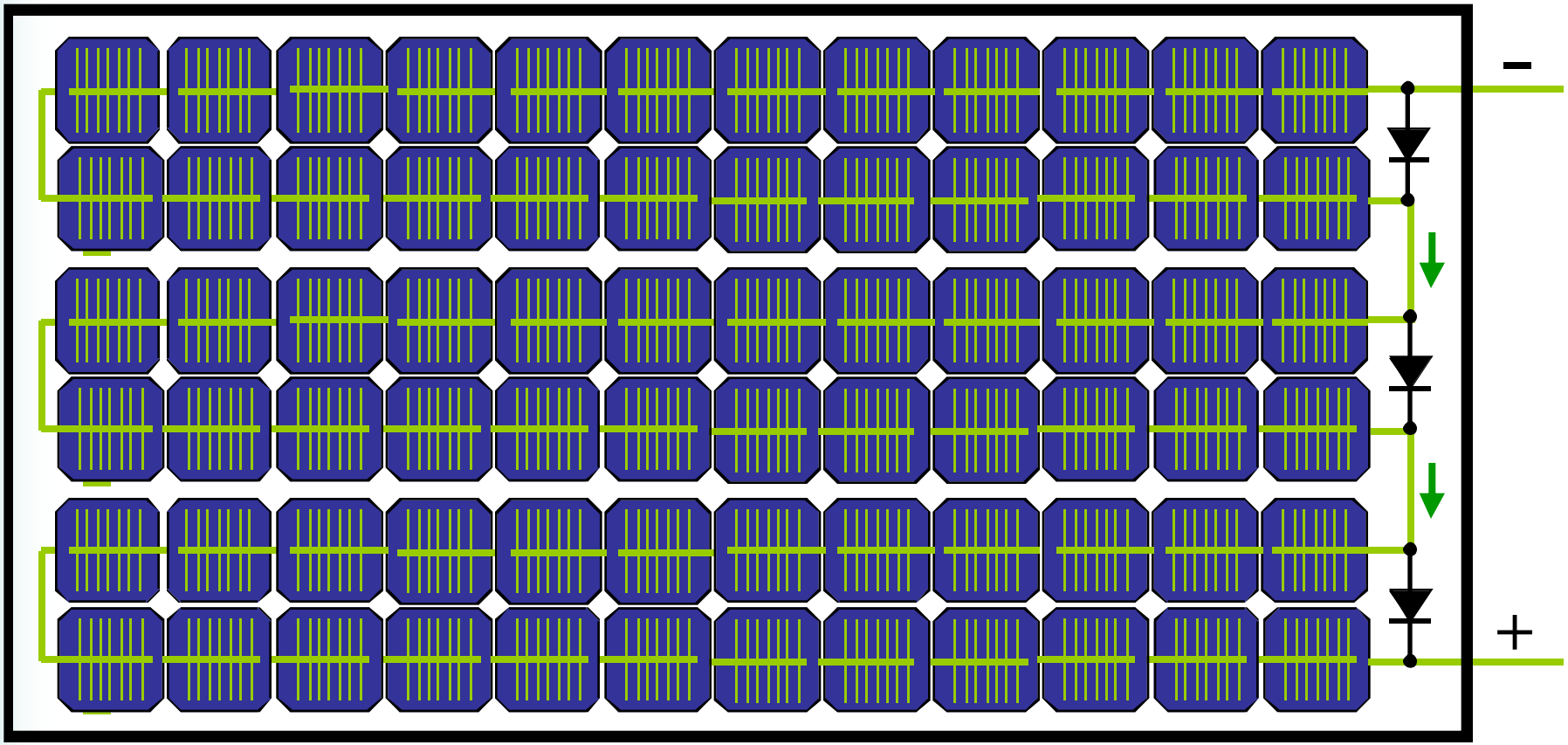
Will the PV system be free from shade?

Source: DOE National Renewable Energy Laboratory

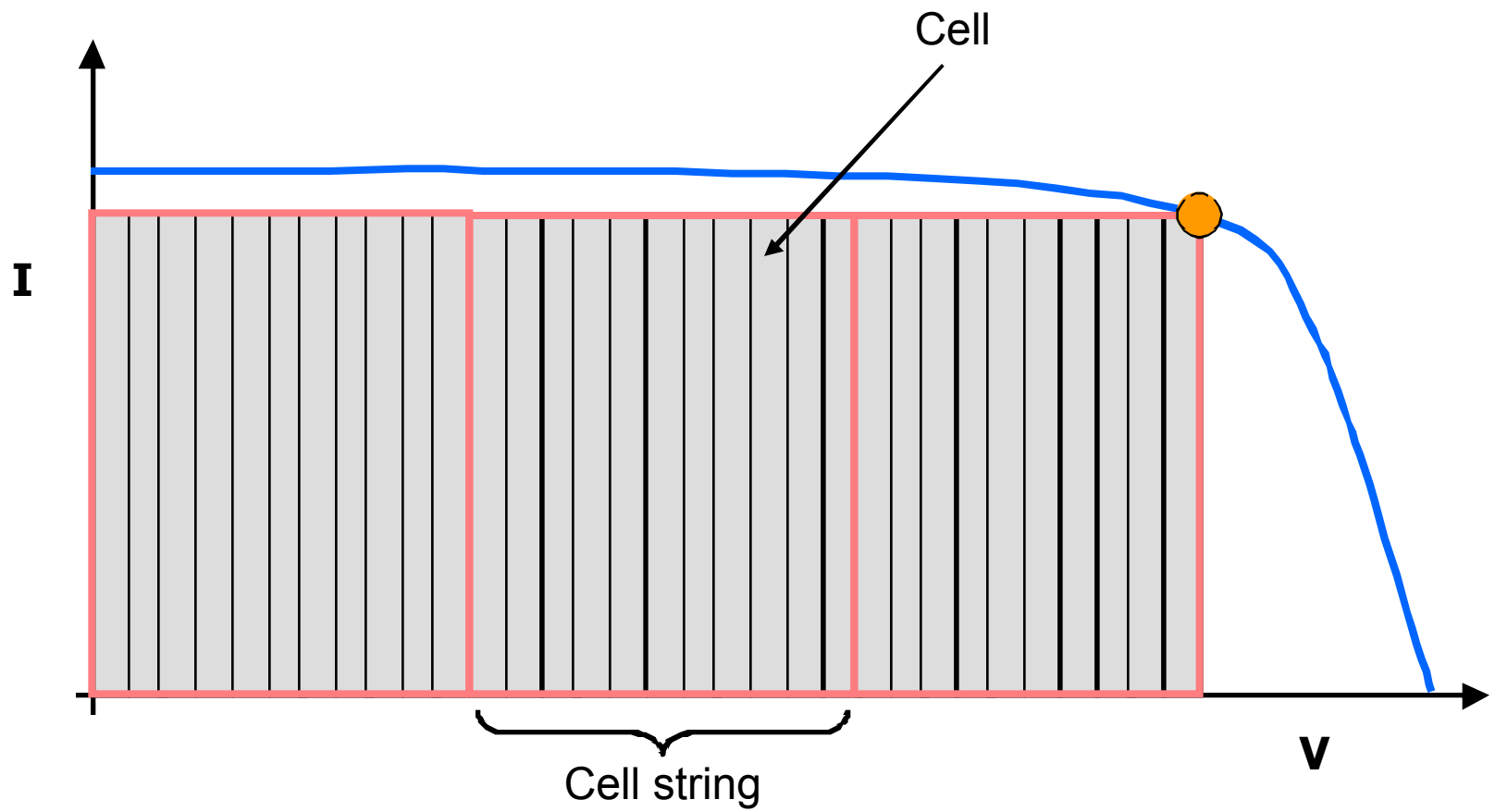
72-cell PV module



72-cell PV module with bypass diodes

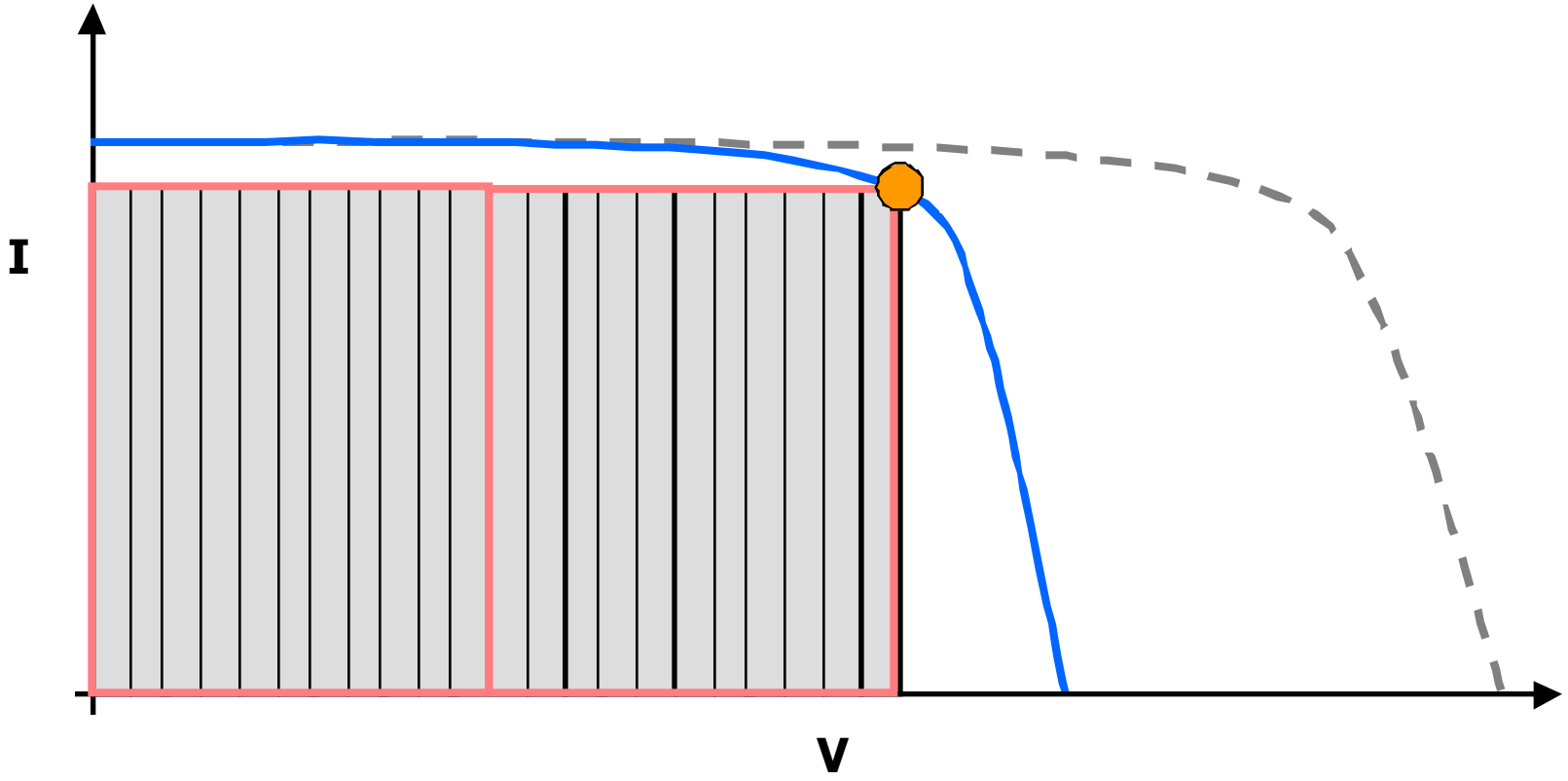


Module I-V curve with shaded cell strings



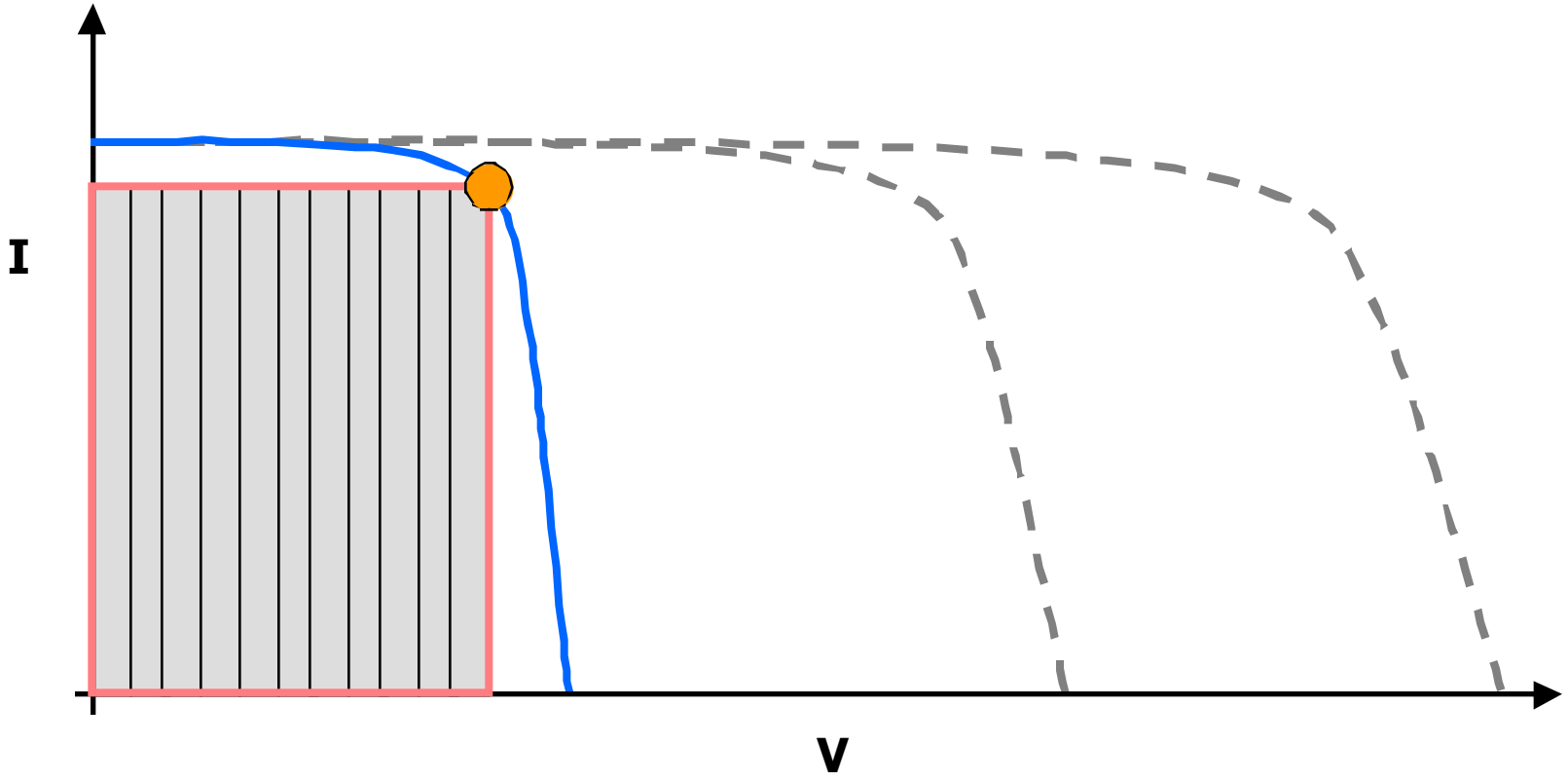
Shade one cell of one cell string

One bypass diode turns on

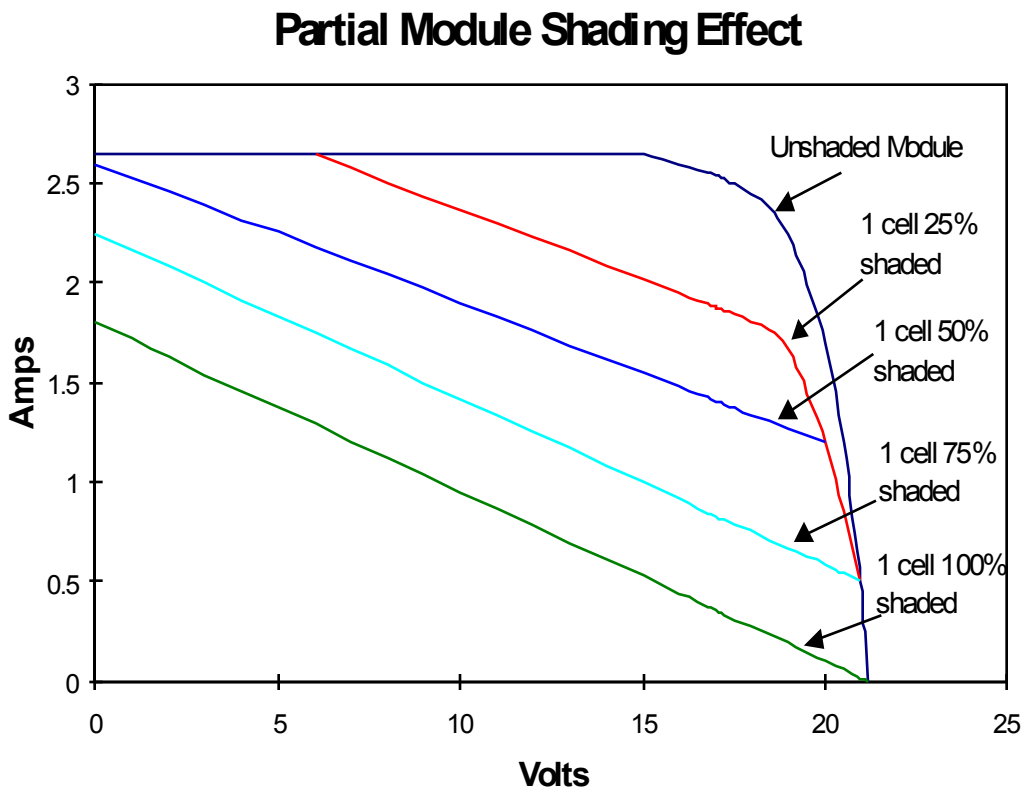


Shade one cell in each of two cell strings

Two bypass diodes turn on



Monocrystalline Shading Effect



The Extreme Effects of Shading	
% of One Cell Shaded	% Loss of Module Power
0 %	0%
25 %	25 %
50 %	50 %
75 %	66 %
l00 %	75 %
with 3 cells shaded	93 %

Courtesy: Solar Energy International

Per-Module Devices

Solar Magic
National Semiconductor

Module Maximizer
Tigo Energy

PV AC Module
EXELTECH

PowerBox
Solar Edge

Enphase Microinverter
Enphase Energy

Direct Grid Microinverter
Direct Grid Technologies

SunMizer
Xandex

Parallux vBoost
eIQ Energy

Per-Module Devices: Two Basic Types

Enphase Microinverter
Enphase Energy

Microinverter

Changes DC to AC

Needs no other inverter

Module Maximizer
Tigo Energy

Maximizer

Adjusts DC voltage: DC to DC

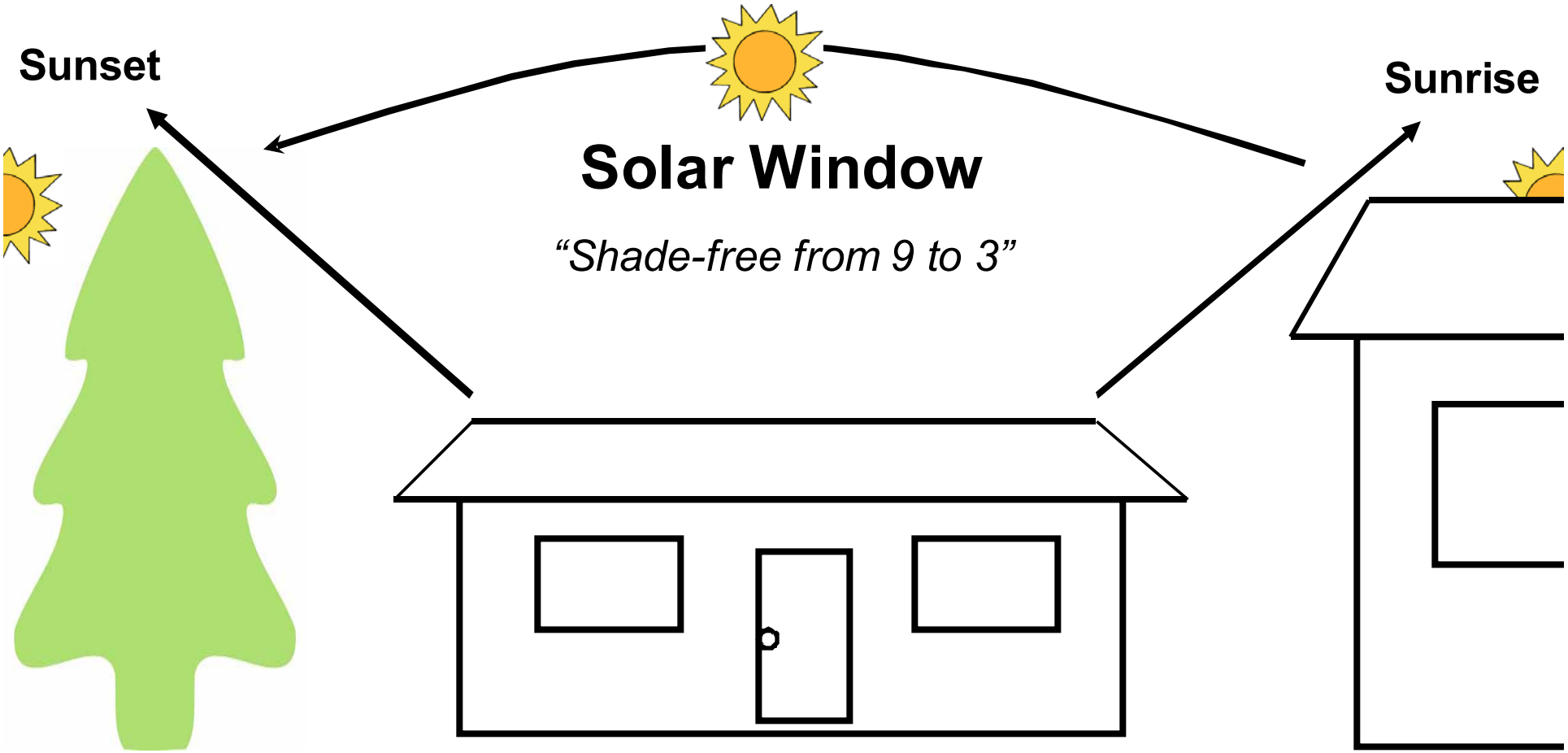
Needs system inverter

Solar Access

PV Requirements

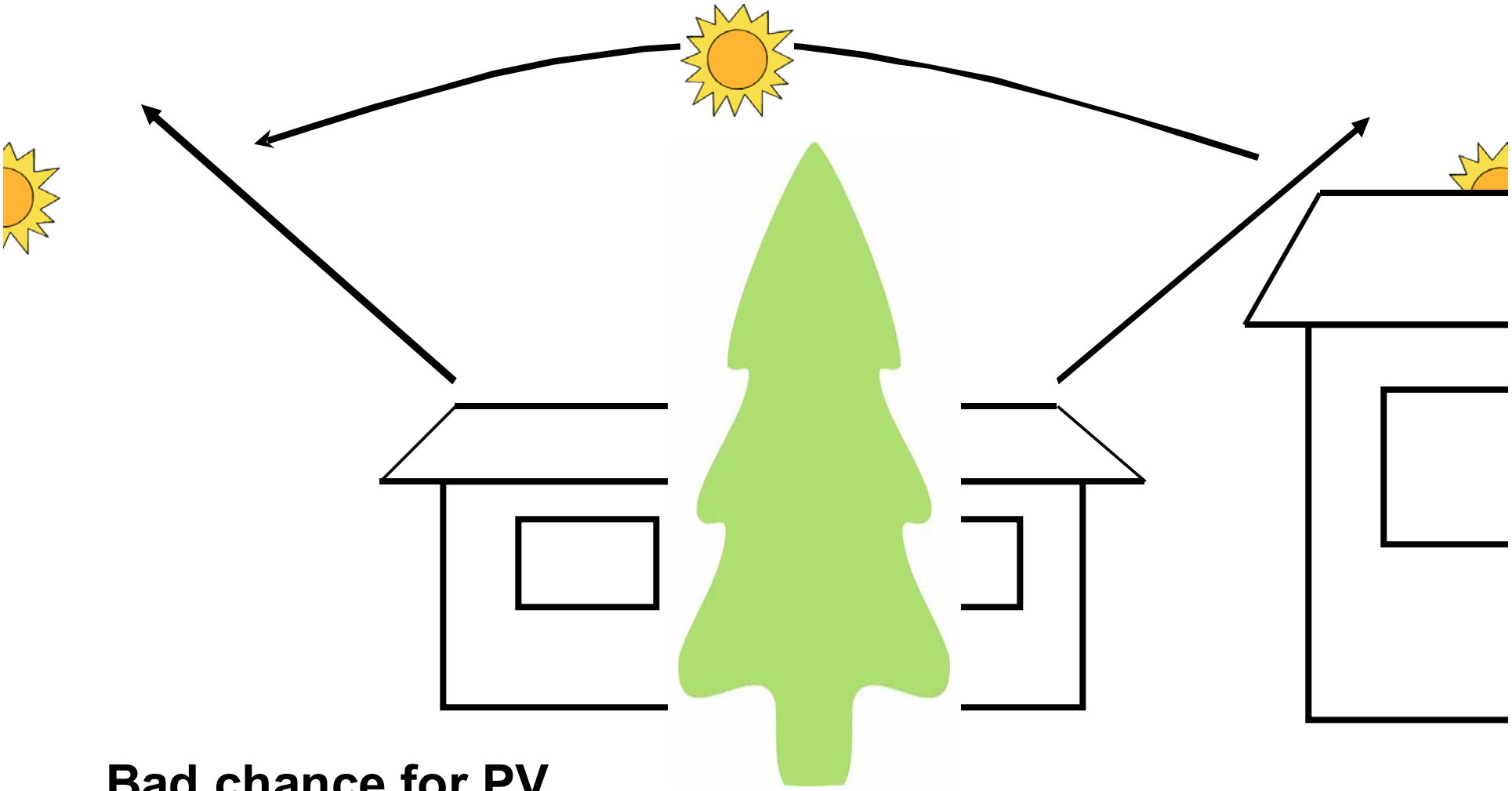
- **Solar Window = 9 am - 3 pm (ideal)**
  8 am - 4 pm (possible)
- **Need minimum of 4 hours during solar window with no shade (prefer 5 hours)**
- **Summer more important than winter**

Shading



Good chance for PV

Shading

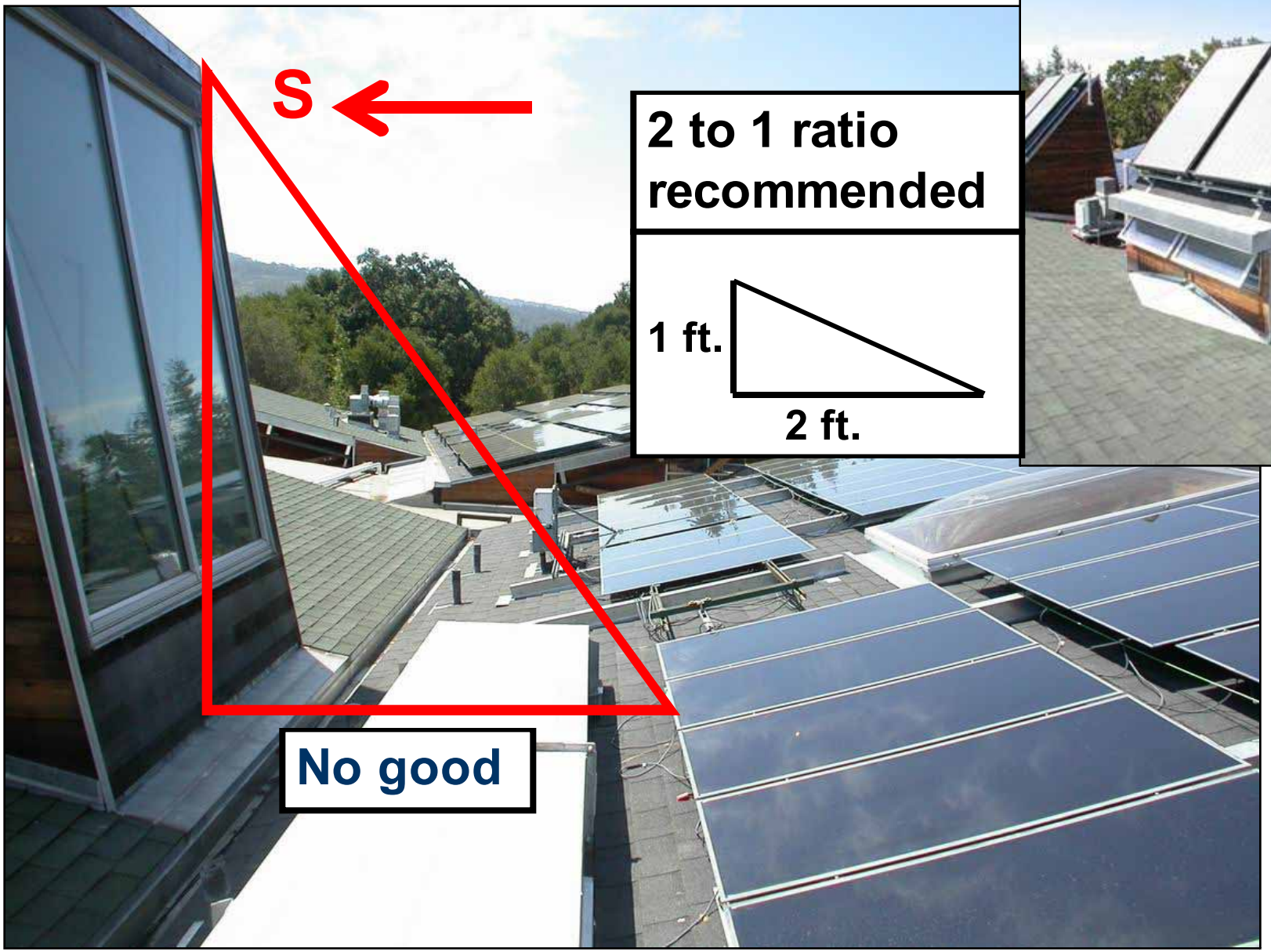


Bad chance for PV

Planning for Shade

Source: PEC Staff

Planning for Shade



Source: PEC Staff

Solar Pathfinder

Used to gain a quick and approximate understanding of solar access and objects on the horizon that shade a given location.

- **Latitude specific sun path diagram is placed in the pathfinder.**
- **The transparent, convex plastic dome reflects objects on the horizon, enabling the user to see the relationship between these objects and the path of the sun.**
- **Obstructions can be traced onto sunpath diagram.**

Courtesy of Andy Black

Solmetric SunEye™

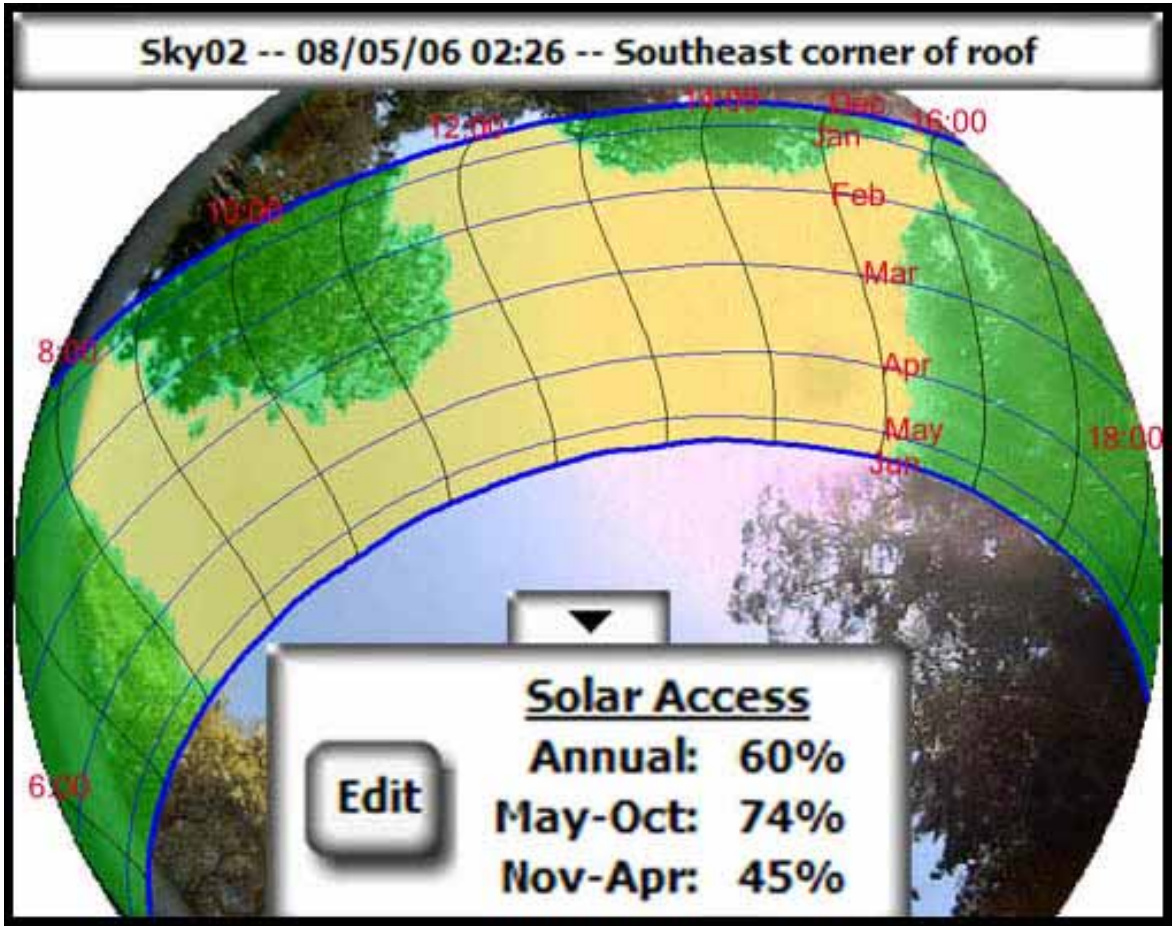
110

210

Courtesy: Solmetric, Corp.

Sunpath View

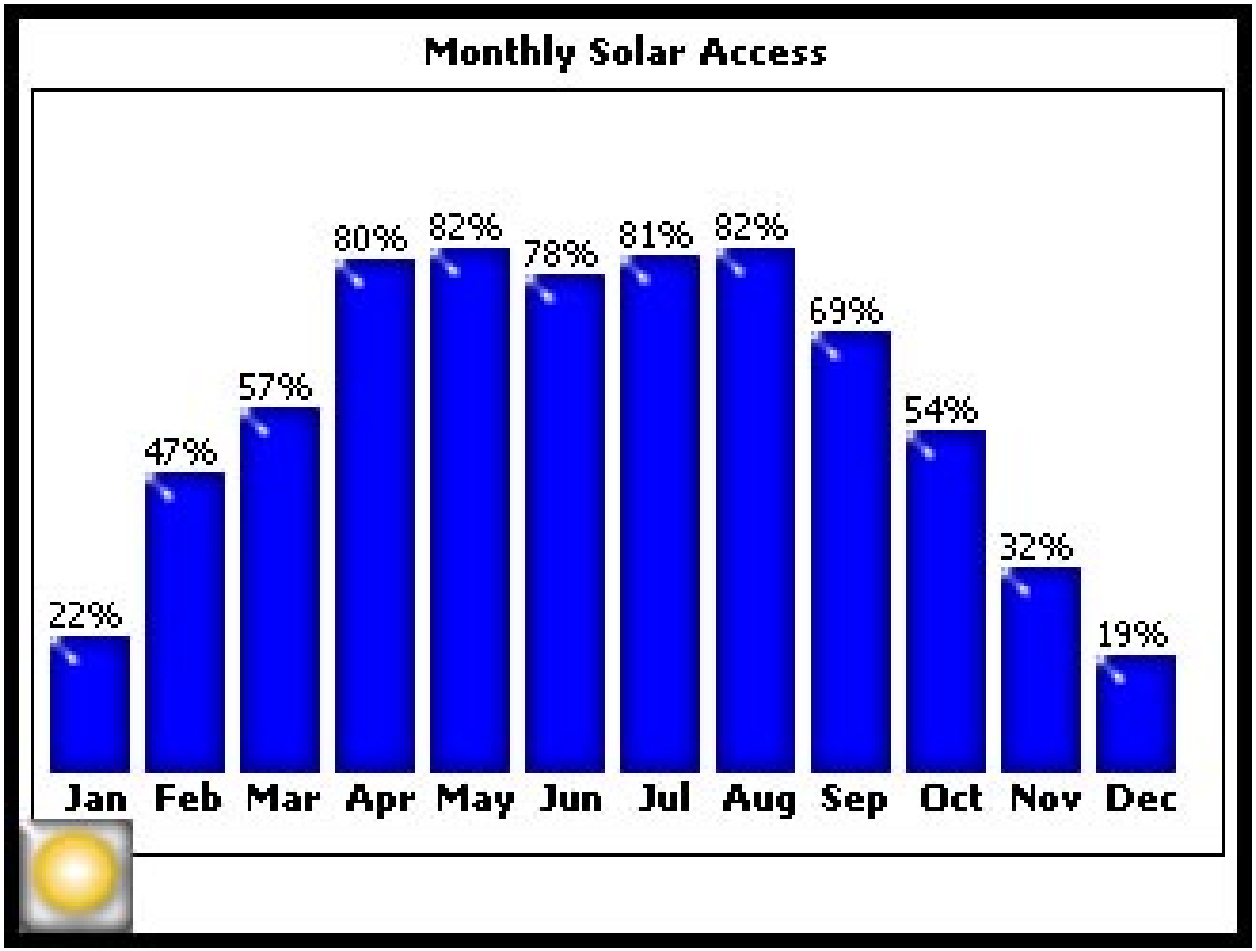
- Visually demonstrates seasonal sun path and shading effects of obstructions
- Summary tabular data



Courtesy: Solmetric, Corp.

Detailed View

- Chart shows proportion of total solar energy available at this site each month



Courtesy: Solmetric, Corp.

Where to Go for Tools

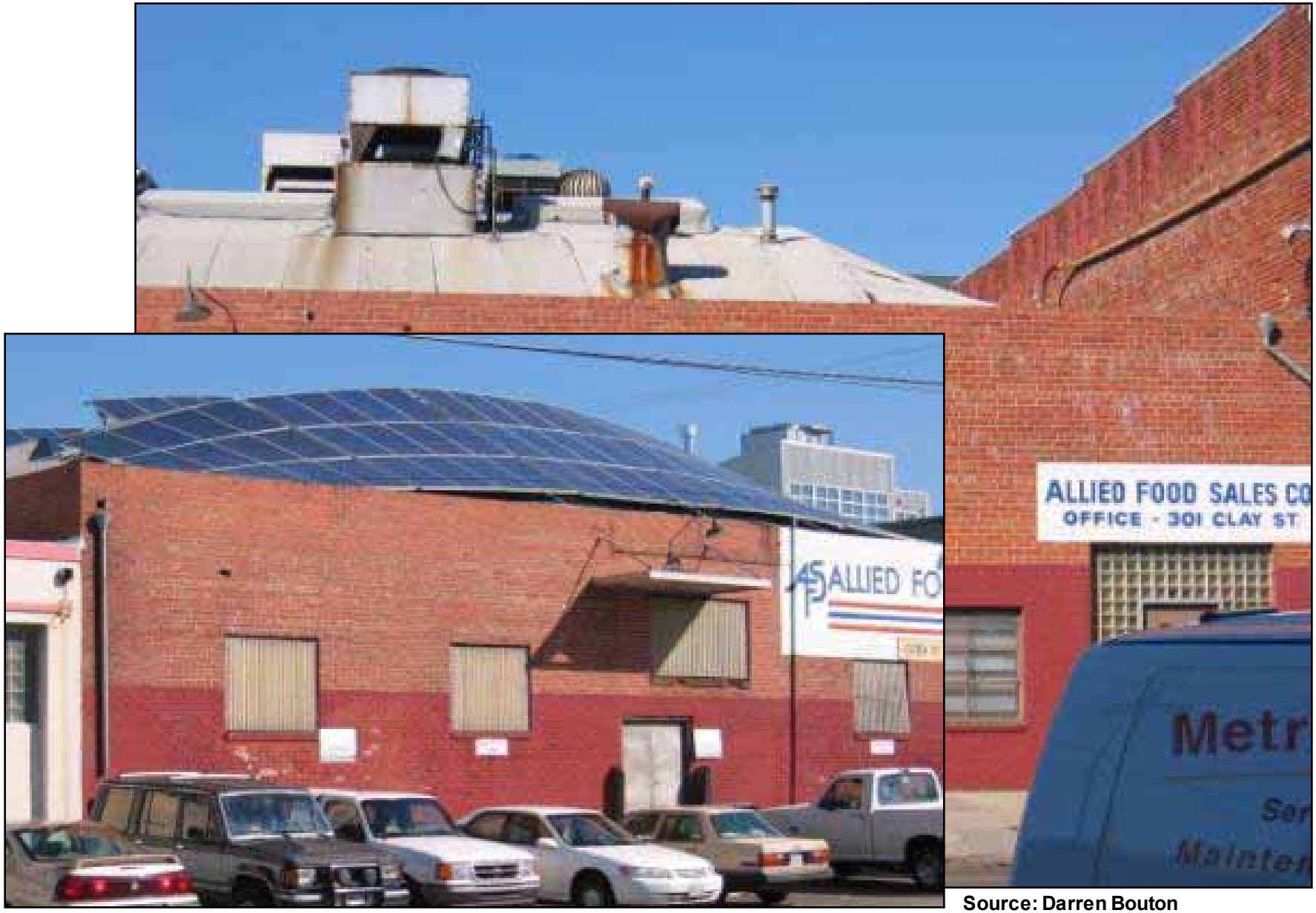
- **Pacific Energy Center: Tool Lending Library**
  Phone: 415-973-9945
  Email: pectools@pge.com

- **Pacific Energy Center Web Site:**
  www.pge.com/pec/tll

How will PV affect site aesthetics?

Source: Darren Bouton

How will PV affect site aesthetics?



Source: Darren Bouton

Roof Issues

Don't put a new PV system on an old roof!

- **Minimum roof life should be 5 – 7 years.**
- **Good idea to do PV and roof at same time**
- **Estimate for panel removal/replacement is $1,000 per Kw of system size.**

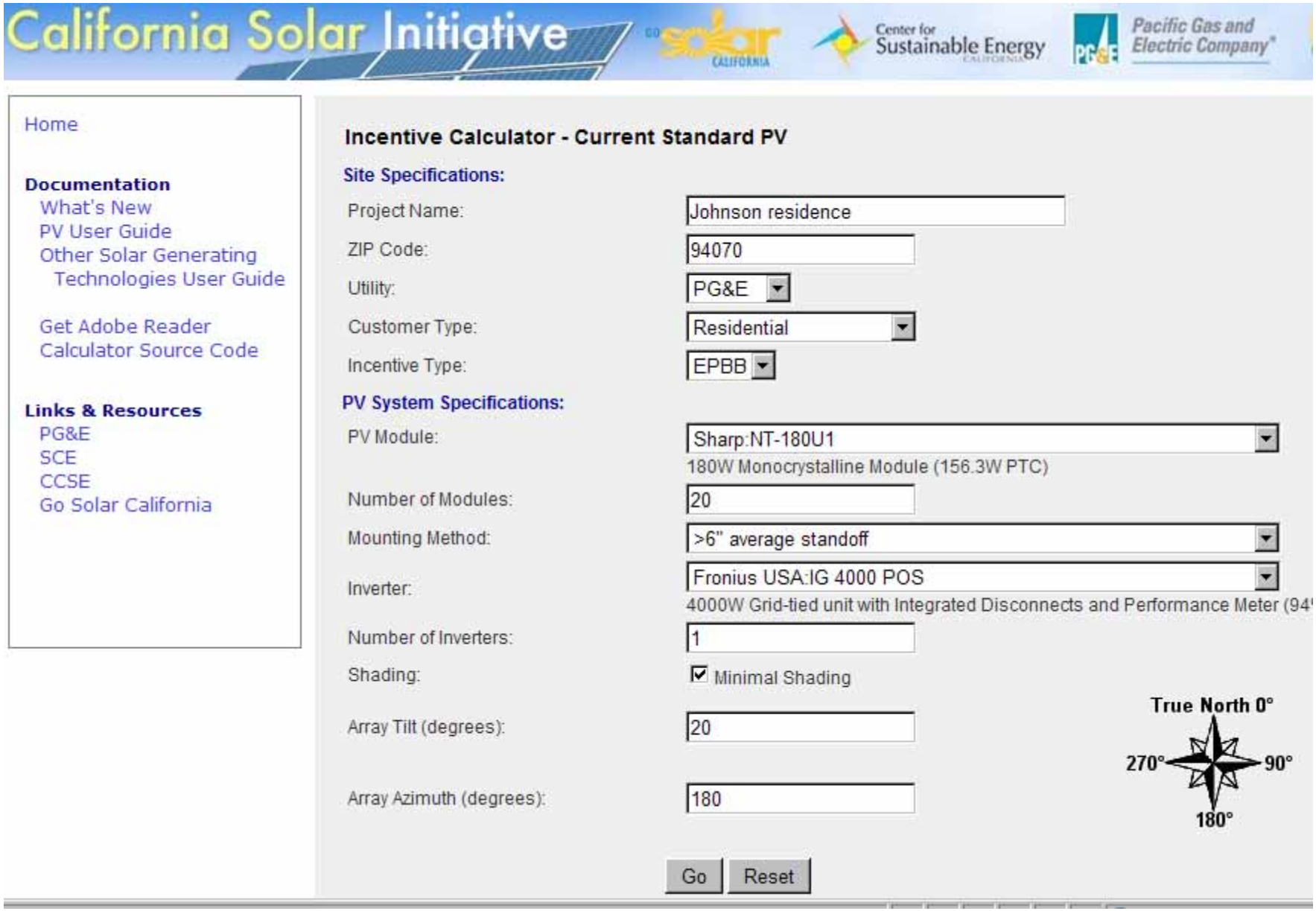
Courtesy London Flat Roofing, Ltd http://www.londonflatroofing.co.uk/flat-roof-repairs/asphalt-flat-roofs/

Online Production Calculator

www.csi-epbb.com

- **Official program for CSI rebate, everyone must use.**
- **Buyers don't have to "trust the salesperson".**
- **Takes all relevant factors as input and gives estimated annual production and rebate amount.**

Online Production Calculator



Online Production Calculator

Incentive Calculator - Current Standard PV

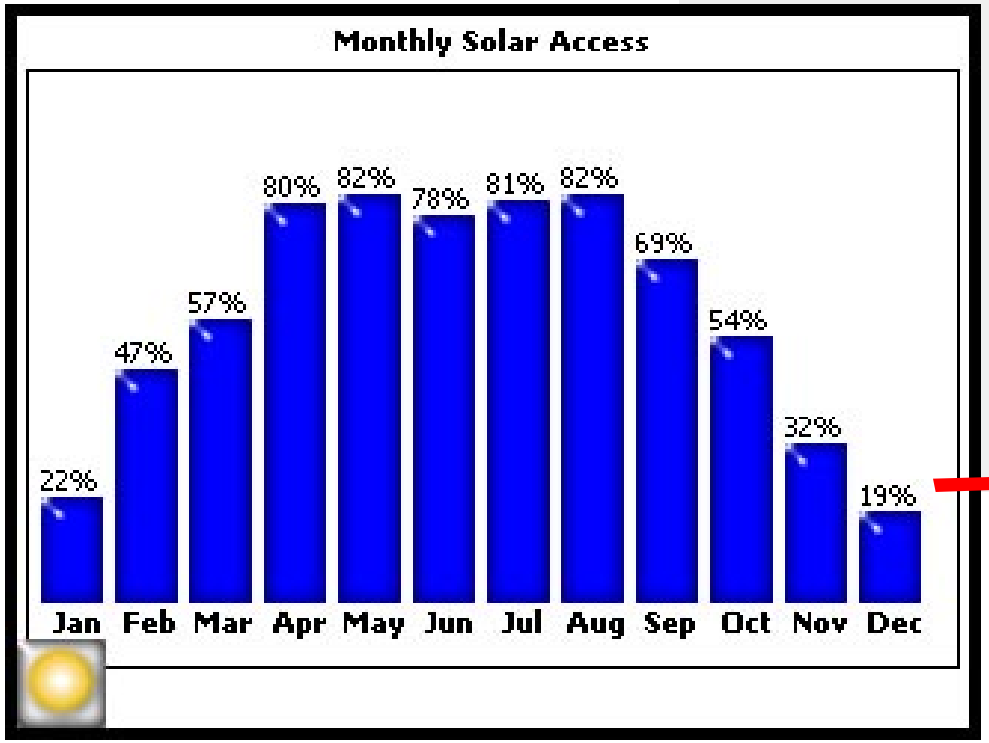
Save as a PDF

	Proposed	Reference
Site Specifications:		
Project Name	Johnson residence	
ZIP Code	94070	92867
City	San Carlos	Orange
Utility	PG&E	
Customer Type	Residential	
Incentive Type	EPBB	
PV System Specifications:		
PV Module	Sharp:NT-180U1 180.0W STC, 156.3W PTC, 158.9W PTC_{adj}[1]	
Number of Modules	20	
Mounting Method	>6" average standoff	
DC Rating (kW STC)	3.6000	
DC Rating (kW PTC)	3.1260	
Inverter	Fronius USA:IG 4000 POS	
Number of Inverters	1	
Inverter Efficiency (%)	94.00 %	
Shading	Minimal Shading	Minimal Shading
Array Tilt (degrees)	20	
Array Azimuth (degrees)	180 **True North 0°**	

Online Production Calculator

Array Azimuth (degrees)	180 True North 0° 	
Optimal Tilt (proposed azimuth)	21	
Optimal Tilt (facing South)	21	17
Results		
Annual kWh	5,160 (a)	
at optimal tilt	5,179 (b)	
facing south at optimal tilt	5,179 (c)	5,289 (d)
Summer Months	May-October	May-October
Summer kWh	3,145 (e)	
at optimal tilt	3,146 (f)	
facing south at optimal tilt	3,146 (g)	3,056 (h)
CEC-AC Rating	**2.938 kW**	
Design Correction[2]	99.968%	
Geographic Correction[3]	97.920%	
Installation Correction[4]	100.000%	
Design Factor[5]	**97.889%**	
CSI Rating[6]	**2.876 kW**	
Incentive Rate	**$0.65/Watt**	
Incentive[7]	**$1,869**	
Report Generated on	7/28/2010 3:08:24 PM	

Online Production Calculator: Shading



Number of Inverters: 1

Shading: ☐ Minimal Shading

	Shading Derate Factors (%)
January	100
February	100
March	100
April	100
May	100
June	100
July	100
August	100
September	100
October	100
November	100
December	100

Online Production Calculator: Shading

Array Azimuth (degrees)	180 True North 0°
Optimal Tilt (proposed azimuth)	21
Optimal Tilt (facing South)	21
Results	
Annual kWh	5,160 (a)
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Summer Months	May-October
Summer kWh	3,145 (e)
at optimal tilt	3,146 (f)
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CEC-AC Rating	**2.938 kW**
Design Correction[2]	99.968%
Geographic Correction[3]	97.920%
Installation Correction[4]	100.000%
Design Factor[5]	**97.889%**
CSI Rating[6]	**2.876 kW**
Incentive Rate	**$0.65/Watt**
Incentive[7]	**$1,869**
Report Generated on	7/28/2010 3:08:24 PM

No shade

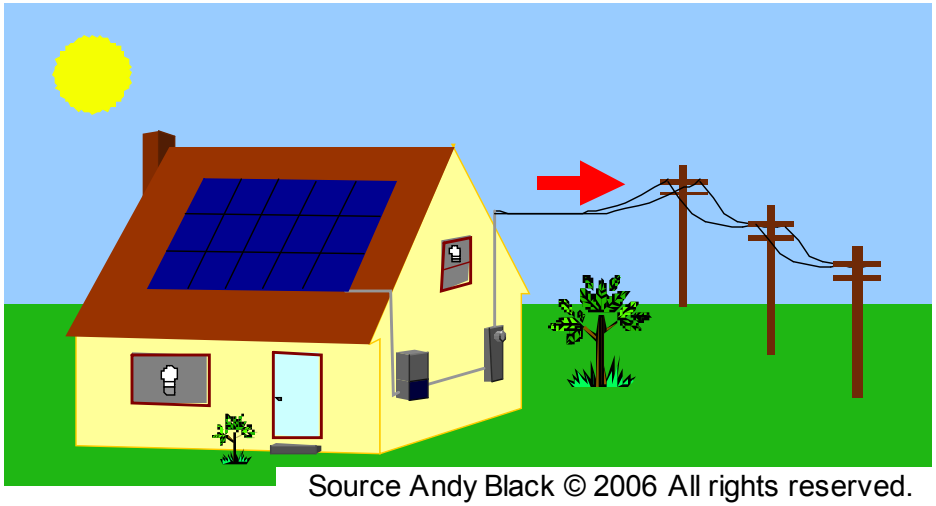
Results	
Annual kWh	3,345 (a)
at optimal tilt	5,179 (b)
facing south at optimal tilt	5,179 (c)
Summer Months	May-October
Summer kWh	2,375 (e)
at optimal tilt	3,146 (f)
facing south at optimal tilt	3,146 (g)
CEC-AC Rating	**2.938 kW**
Design Correction[2]	75.493%
Geographic Correction[3]	97.920%
Installation Correction[4]	100.000%
Design Factor[5]	**73.923%**
CSI Rating[6]	**2.172 kW**
Incentive Rate	**$0.65/Watt**
Incentive[7]	**$1,412**
Report Generated on	7/28/2010 3:17:23 PM

With shade

Finances

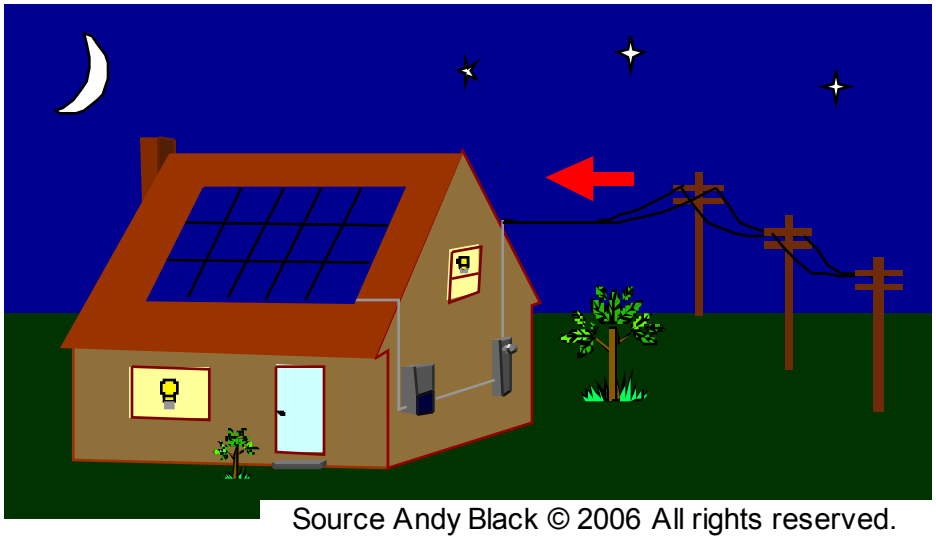
Net Metering

Sell Power to the Utility by Day



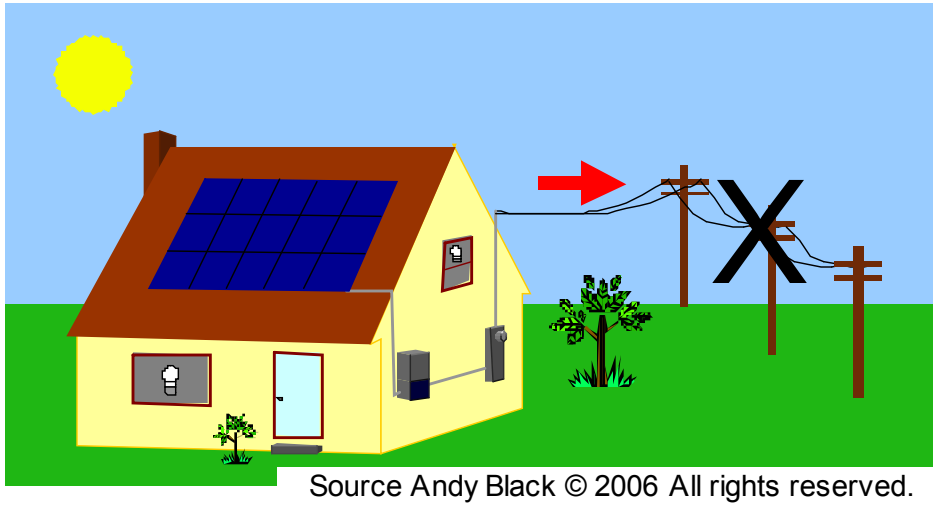
Buy Power at Night and Winter

- Exchange at Retail
- Annual Cycle

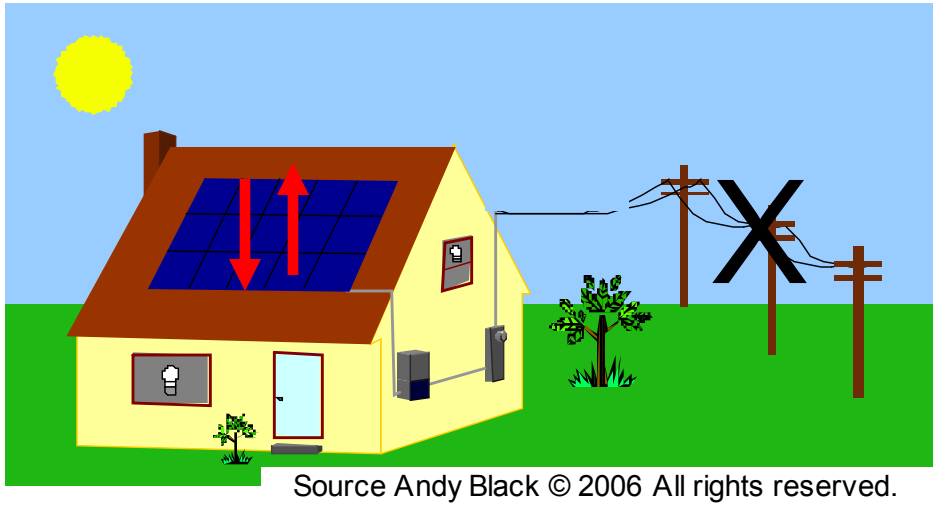


Net Metering – No Blackout Protection

Unsafe to send live power into grid while workers repairing downed lines



No "voltage reservoir" means house current could fluctuate and damage appliances



Reduce Your Energy Bills!

Source: Darren Bouton

Spin Your Meter Slower

- Use the electricity you generate first to reduce electricity you would normally buy from the utility or electric service provider

Spin Your Meter Backwards

- Excess electricity generated goes through your meter and into the grid
- Spins your meter backwards!
- Get credit for “stored” electricity on the grid

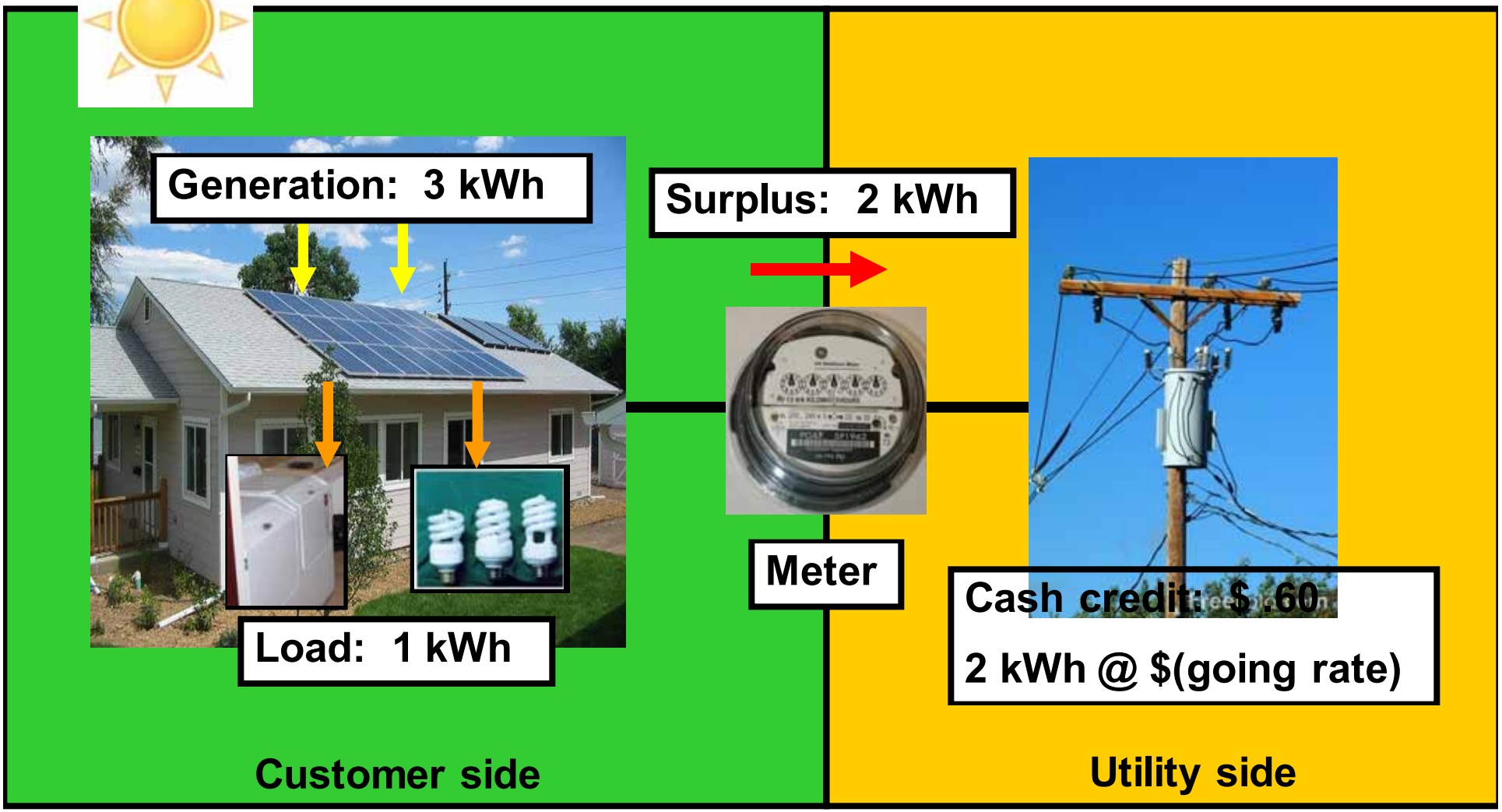
Net Metering

Meter

Customer side

Utility side

Net Metering



Net Metering

Surplus: 0 kWh

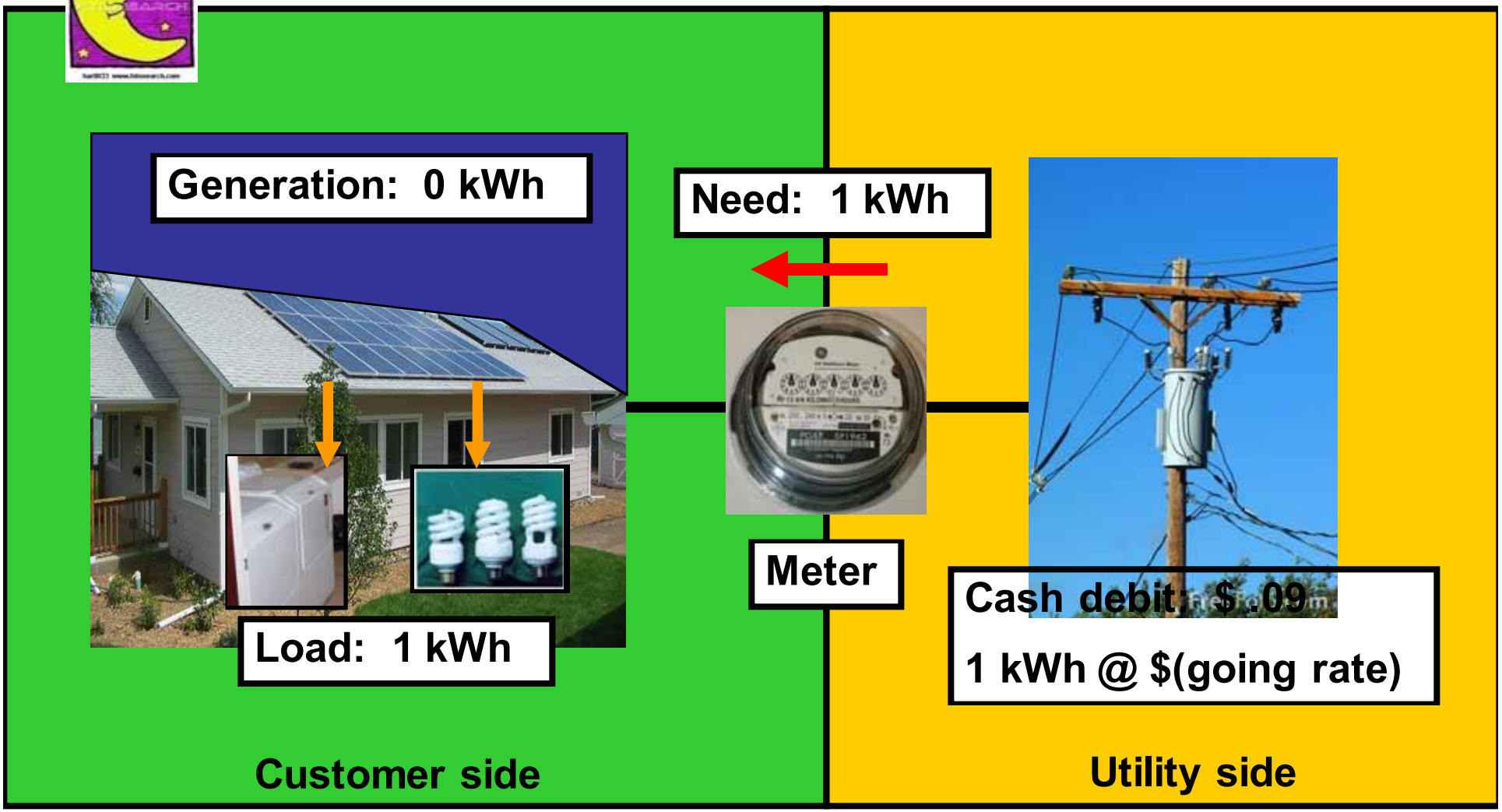
Meter

Cash credit: $ .00

Customer side

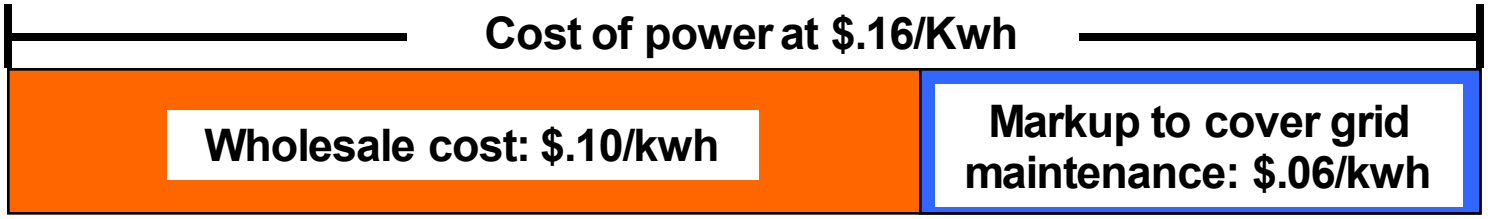
Utility side

Net Metering



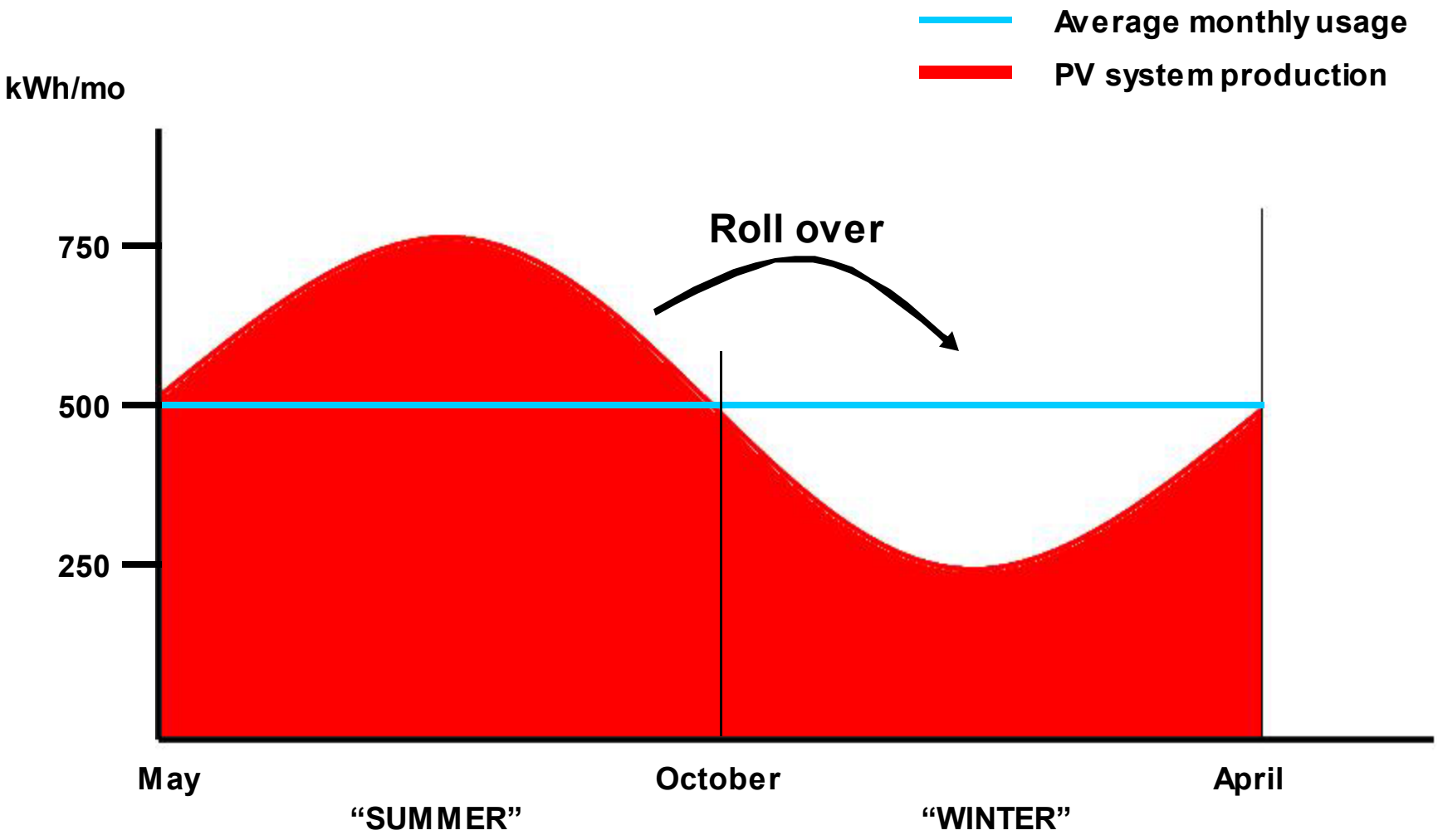
Net Metering

What do you get paid if your system over-produces?

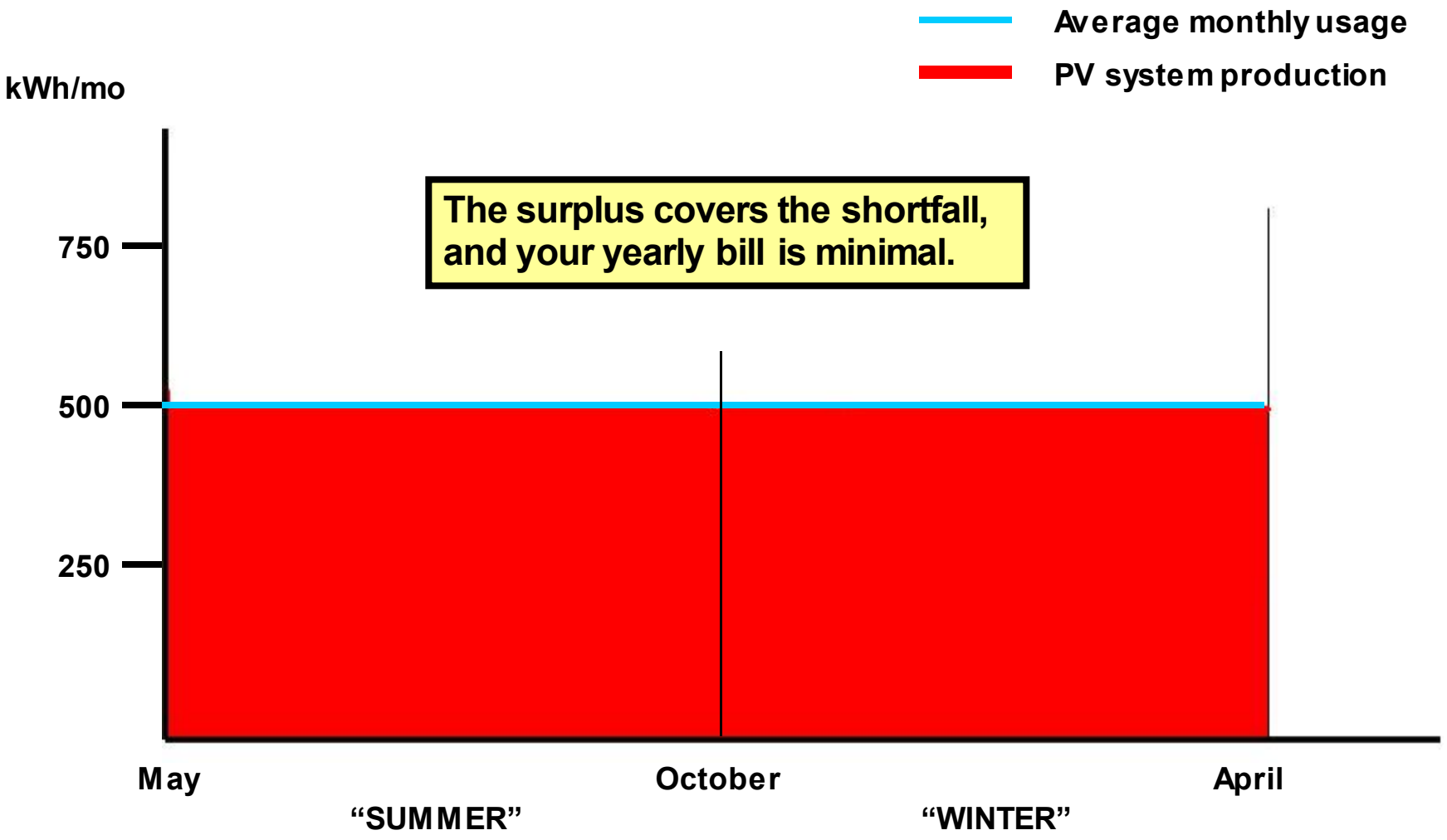


- CPUC rule—PG&E must comply
- The "full retail" rate that PV owners get paid for their power includes a subsidy (markup) that comes from all rate payers.
- The CPUC determined that this full subsidy would only be allowed to cover your usage, not for you to go into the power-generation business.
- For over-production, compensation will be at a lower rate, to be determined.

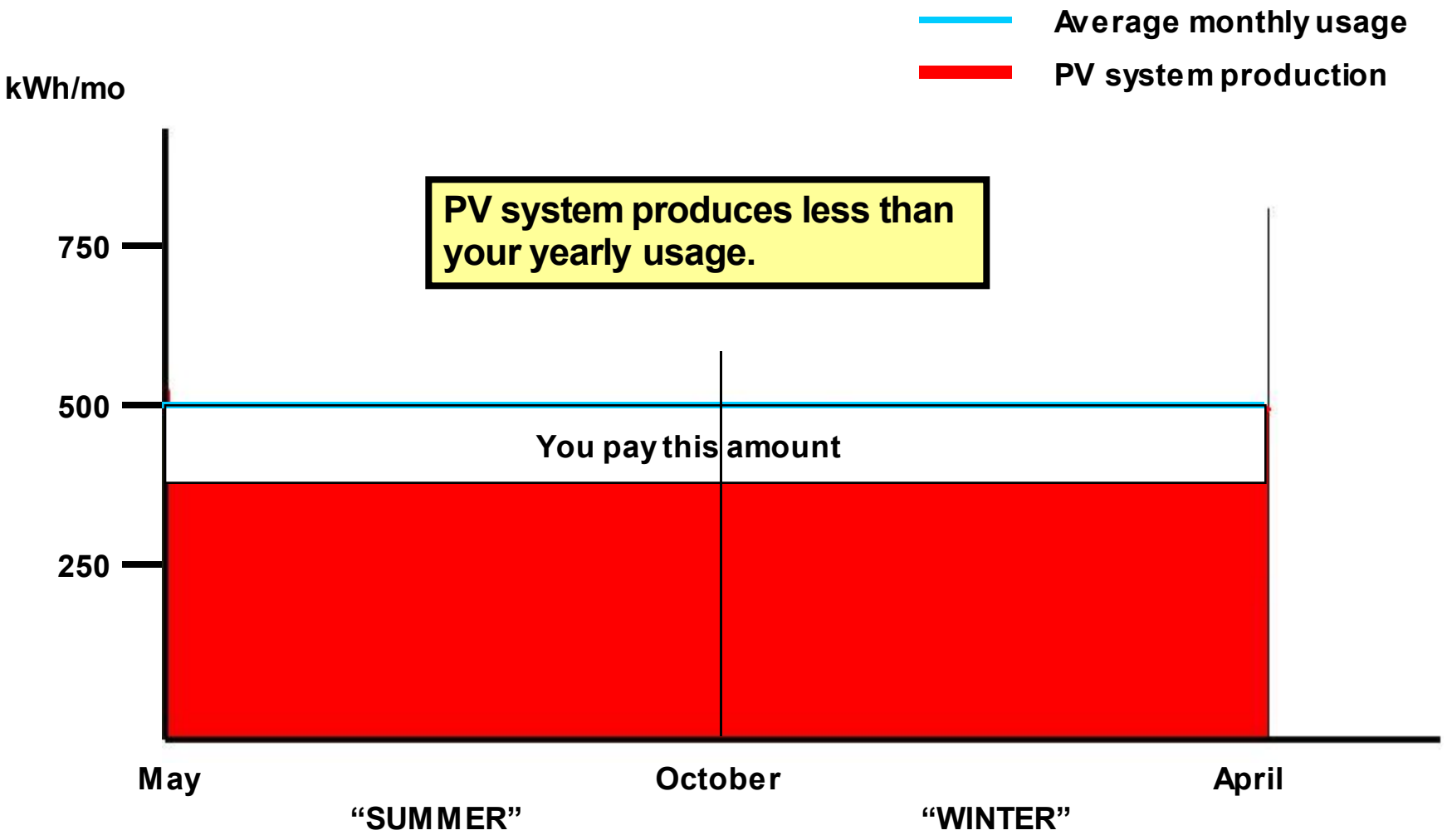
Net Metering



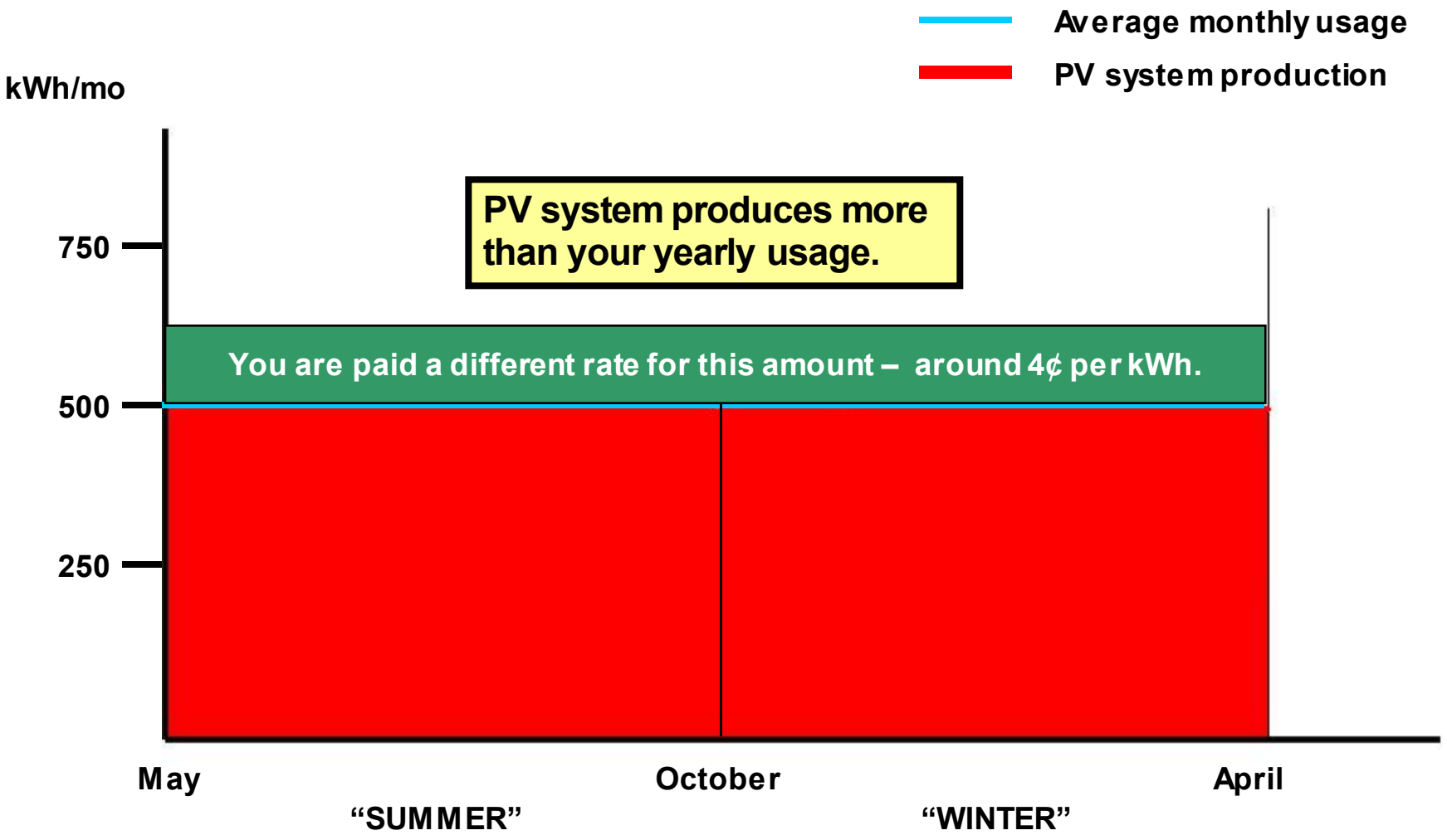
Net Metering



Net Metering



Net Metering



Methods of Payment

Two fundamentally different concepts:

Net Metering

Serves the onsite load FIRST, then interacts with the utility grid.

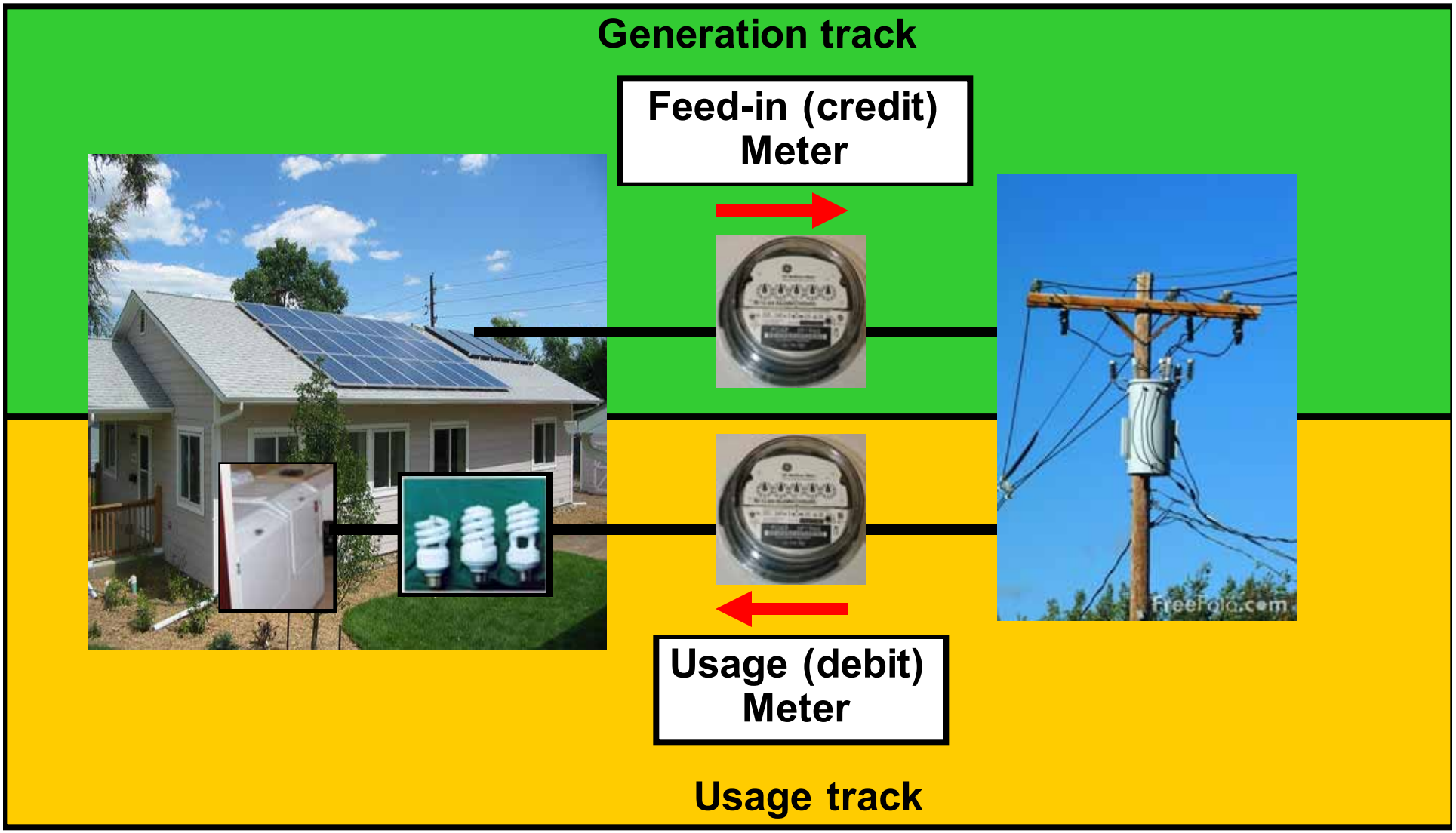
One meter

Feed-in Tariff

Does not serve the onsite load and ONLY interacts with the utility grid.

Two meters

Feed-in Tariff



Net Metering vs. Feed-in Tariff

Net Metering:

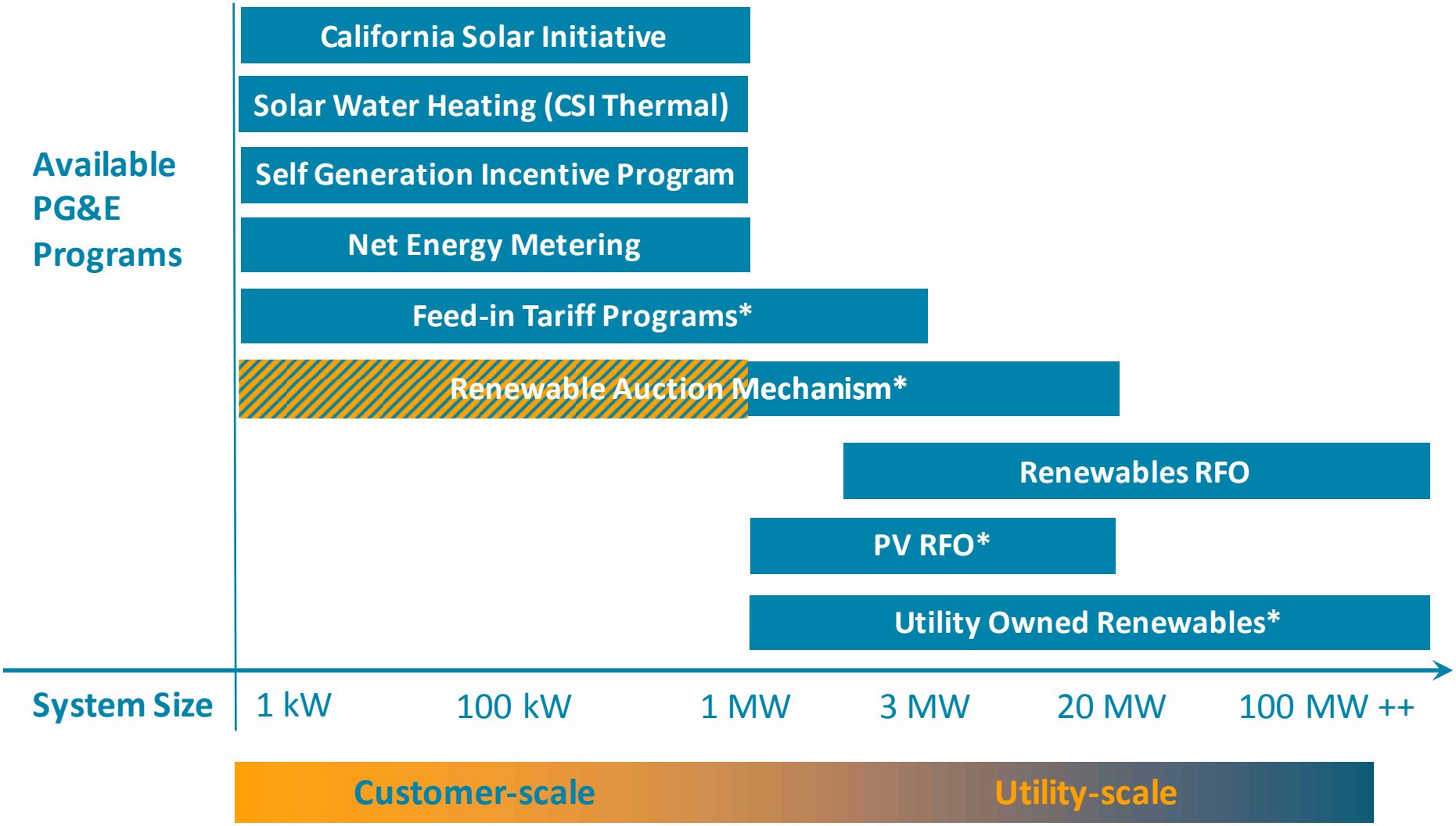
For PV systems from 1 kW to 1 mW

Feed-in Tariff:

For PV systems from 1 mW to 20 mW.

See www.pge.com/feedintariffs

PG&E Renewable Energy Programs



* New or revised program

Rate Schedules (Tariffs)

Two main types of residential rates:

TIERED (E-1)

The more you use, the more you pay.

Baseline amounts plus tier charges based on percentage of baseline.

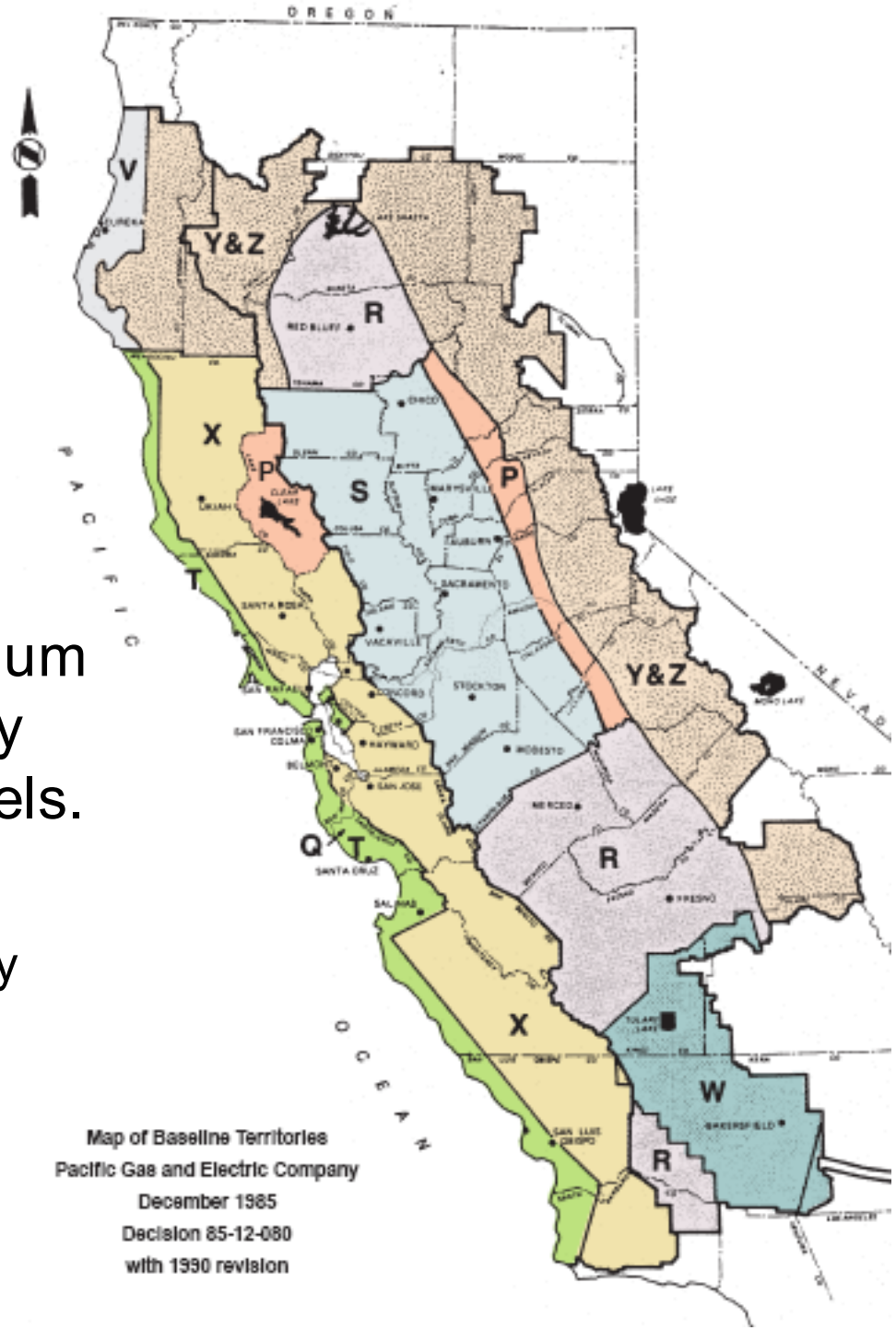
Time-of-Use (TOU)

Additional factor depending on when you use the power.

PG&E Baseline Territory Map

Baseline=guaranteed minimum amount of low cost electricity for everyone--all income levels.

Baseline allocation determined by geographic territory averages.



PG&E Baseline Territory Allocations

Effective June 20, 2011 - Present

Winter

(Effective November 1, 2011)

TERRITORY	INDIVIDUALLY METERED (E-1,E-6,E-7,E-9,EL-1,EL-6, EL-7,ES,ESL,ESR,ESRL,ET,ETL)		MASTER METERED (EM,EM-TOU,EML,EML-TOU)
ALL-ELEC. (Code H)	Daily[1/]		Daily[1/]
P	33.9*		18.0*
Q	19.3*		15.1*
R	30.2*		16.4*
S	28.6*		16.4*
T	16.8*		10.9*
V	33.4**		18.9**
W	22.8*		14.3*
X	19.3*		15.1*
Y	30.7*		20.9**
Z	22.5*		15.2*
BASIC ELEC. (Code B)			
P	12.7*		6.1*
Q	11.7*		6.7*
R	11.7*		5.8*
S	12.0*		5.6*
T	9.1*		5.2*
V	13.6*		6.5*
W	10.9*		6.1*
X	11.7*		6.7*
Y	13.2*		8.6**
Z	10.6*		6.9*

Summer

(Effective June 20, 2011)

TERRITORY	INDIVIDUALLY METERED (E-1,E-6,E-7,E-9,EL-1,EL-6, EL-7,ES,ESL,ESR,ESRL,ET,ETL)		MASTER METERED (EM,EM-TOU,EML,EML-TOU)
ALL-ELEC. (Code H)	Daily[1/]		Daily[1/]
P	18.0*		10.2*
Q	9.1*		5.8*
R	20.9*		10.3*
S	18.0*		10.2*
T	9.1*		5.8*
V	19.4**		11.5**
W	23.5*		11.4*
X	10.3*		8.1*
Y	14.1*		8.7*
Z	11.2*		6.9*
BASIC ELEC. (Code B)			
P	15.3*		6.6*
Q	7.5*		4.2*
R	17.1*		7.4*
S	15.3*		6.6*
T	7.5*		4.2*
V	12.0**		5.4*
W	18.5*		8.1*
X	11.0*		5.9*
Y	11.7*		8.6**
Z	7.9*		5.8**

Tiered Rate (E-1)

PG&E monthly electric bill for a large home user:

ELECTRIC ACCOUNT DETAIL

Service ID #: 460818 ...
Rate Schedule: E1 TB Residential Service
Billing Days: 33 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
J	50	790E07	28,052	29,030	978	1	978 Kwh

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	33	978	29.6
Last Year	31	900	29.0

Tiered Rate (E-1)

PG&E monthly electric bill for a large home user:

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	33	978	29.6
Last Year	31	900	29.0

Charges

11/04/2010 - 12/06/2010

Baseline = 9.8 x 33 = 323.4 kWh

Electric Charges				
Baseline Quantity	323.40000 Kwh			**5 rate tiers**
Baseline Usage	323.40000 Kwh @	$0.11877	= $ 38.41	1
101-130% of Baseline	97.02000 Kwh @	$0.13502	= $ 13.10	2
131-200% of Baseline	226.38000 Kwh @	$0.29062	= $ 65.79	3
201-300% of Baseline	323.40000 Kwh @	$0.40029	= $ 129.46	4
Over 300% of Baseline	7.80000 Kwh @	$0.40029	= $ 3.12	5
	978.00		**$ 249.88**	

Used 978 Kwh costing $ 249.88

Tiered Rate (E-1)

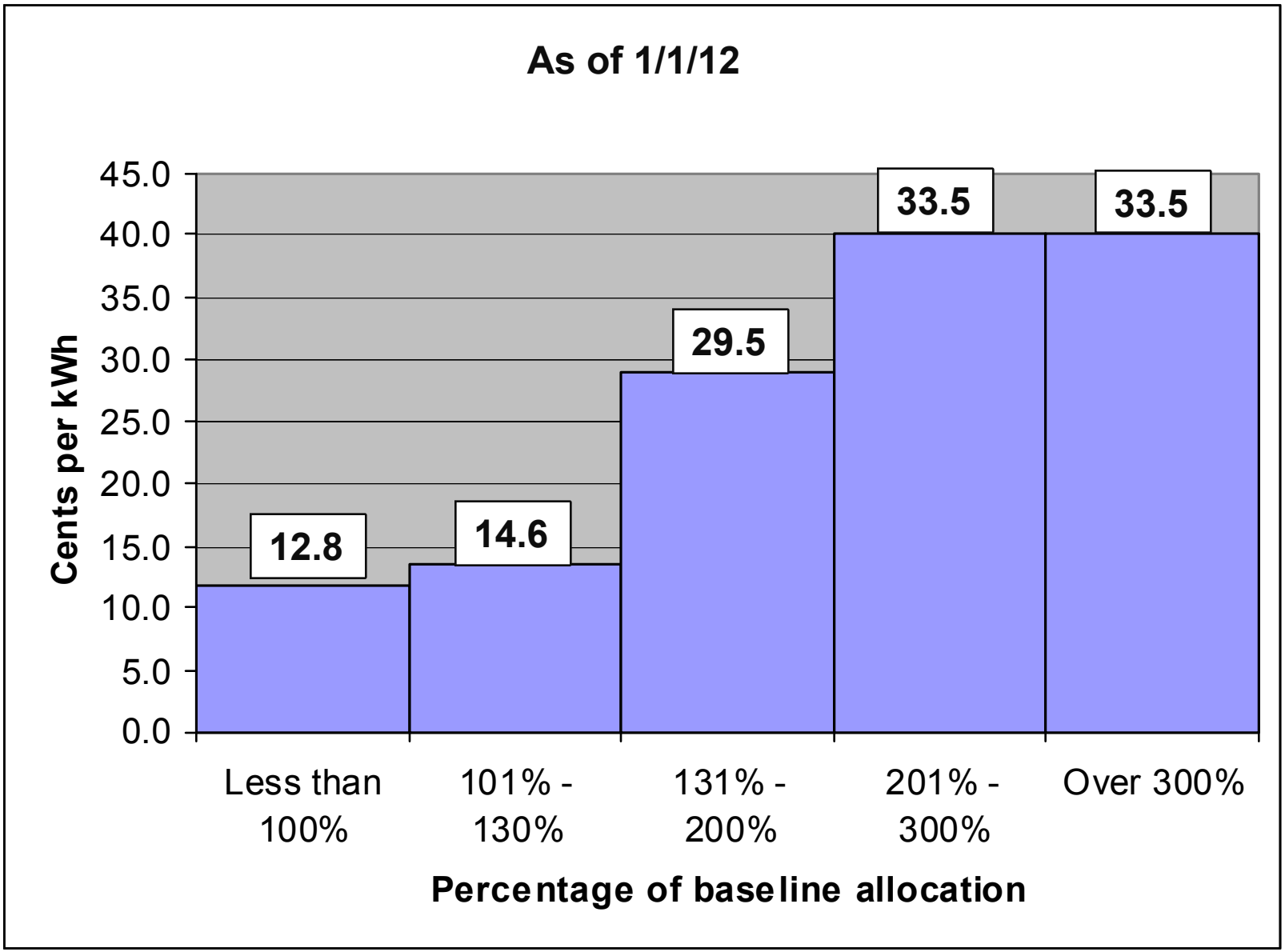
Breakdown of charges:

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$119.27
Transmission	10.62
Distribution	95.07
Public Purpose Programs	11.97
Nuclear Decommissioning	0.28
DWR Bond Charge	5.04
Ongoing CTC	5.42
Energy Cost Recovery Amount	2.21

Taxes and Other	
Energy Commission Tax	$0.22
TOTAL CHARGES	**$250.10**

E-1 / PG&E Standard Rate Schedule (Residential)



Rate Tiers

The less you use, the more you eliminate the expensive upper tiers:

Charges

11/04/2010 - 12/06/2010

Electric Charges

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Charges

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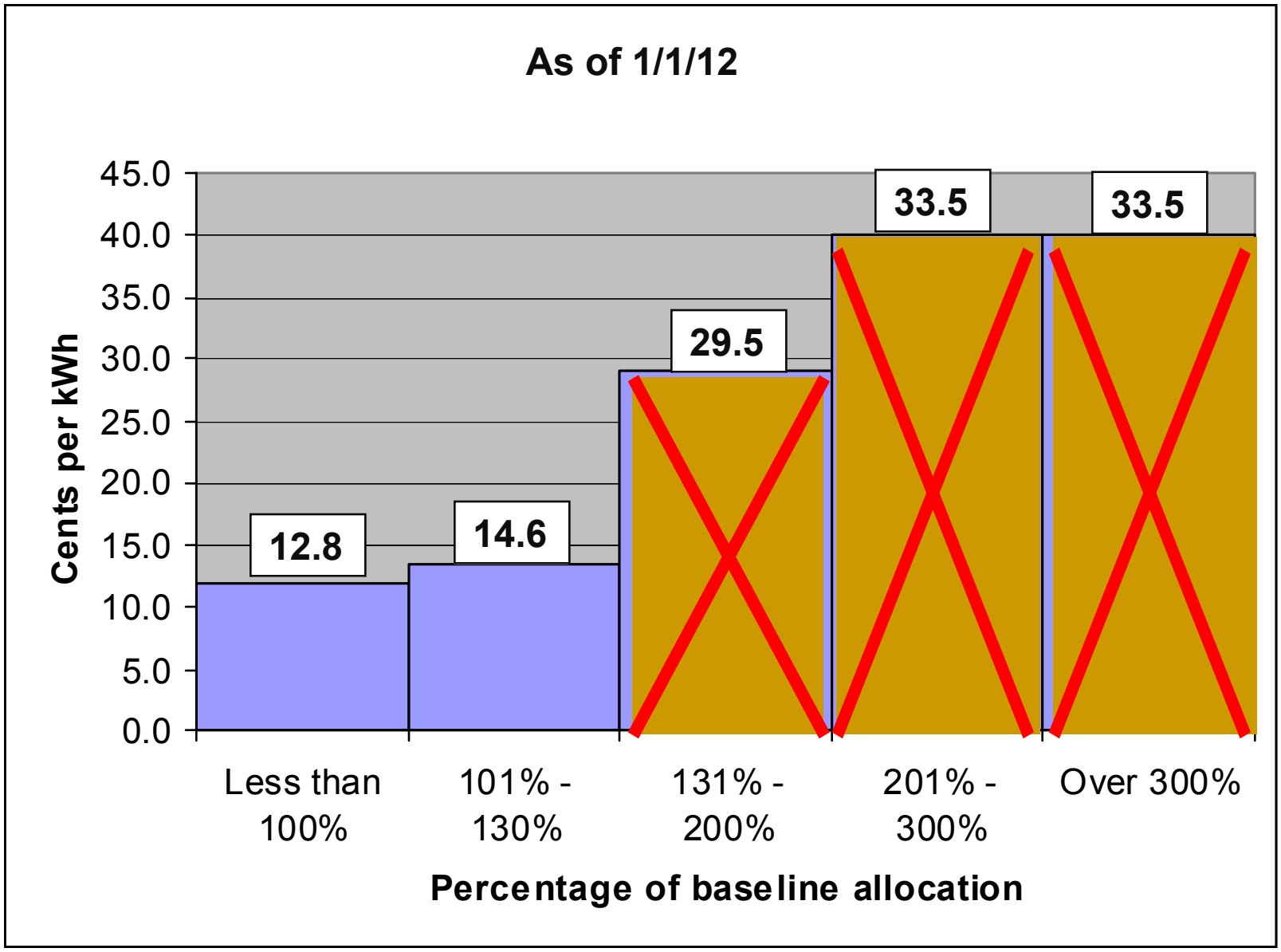
101-130% of Baseline	97.02000 Kwh @	$0.13502	= $ 13.10	2
131-200% of Baseline				3
201-300% of Baseline				4
Over 300% of Baseline				5
	421.42		**$ 51.52**	

Used 421 kWh costing $ 51.52

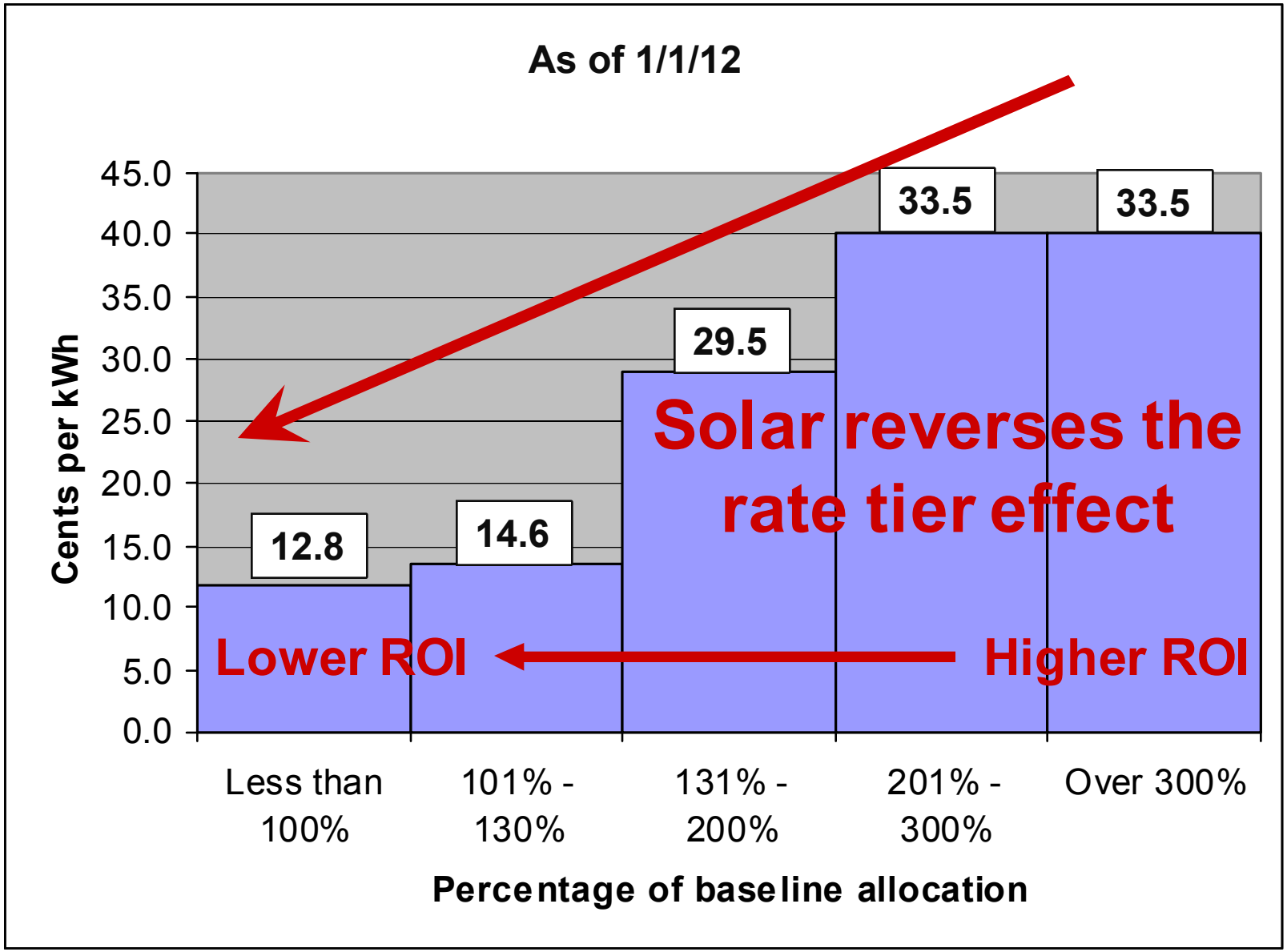
From 978 Kwh to 421 Kwh -- from $250 to $50.

Lowering the usage 57% lowers the bill 80%.

E-1 / PG&E Standard Rate Schedule (Residential)



E-1 / PG&E Standard Rate Schedule (Residential)



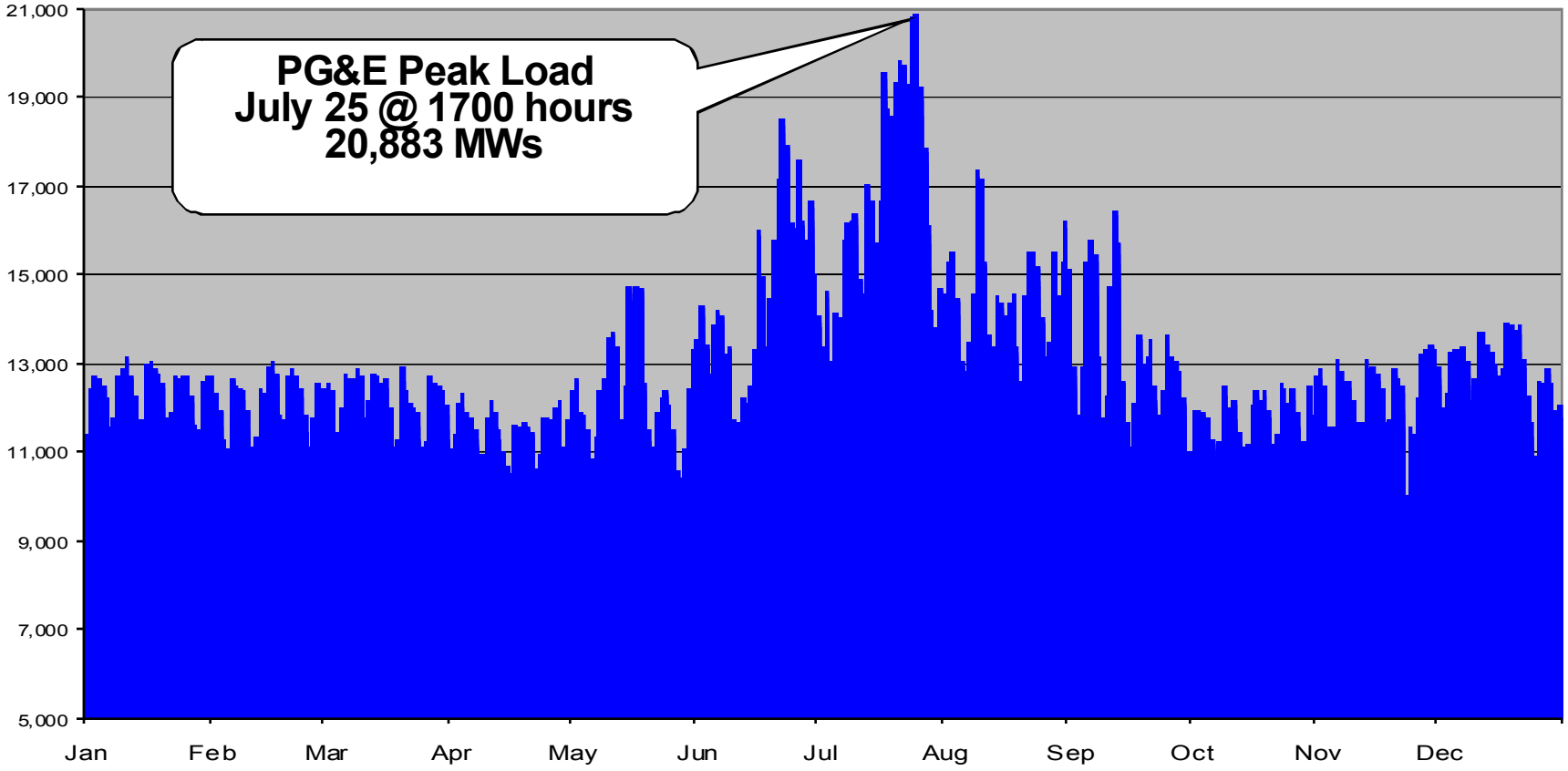
Demand Management Strategies

1. **Reduce overall load.**
   — Energy efficiency, conservation
2. **Inform people so they can cooperate voluntarily.**
   — Publicity, "Flex Your Power" alerts
3. **Create the ability to remotely turn off certain appliances.**
   — Smart AC, smart meters, etc.
4. **Charge more for peak usage.**
   — Time-of-Use rates, Peak-Time pricing

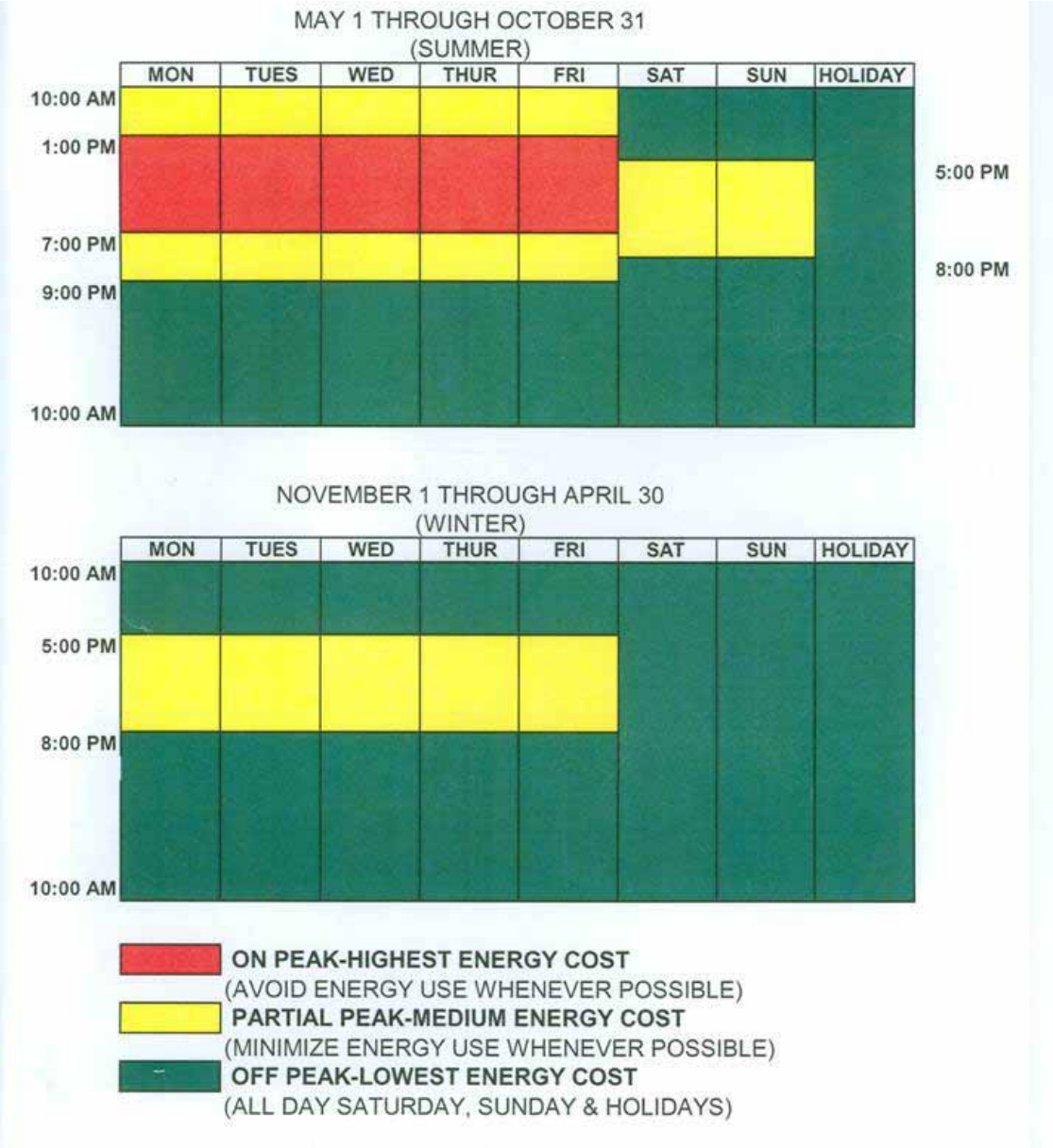
… and others.

Time of Use Rates

PG&E 2006 Annual Usage



Time of Use Rates



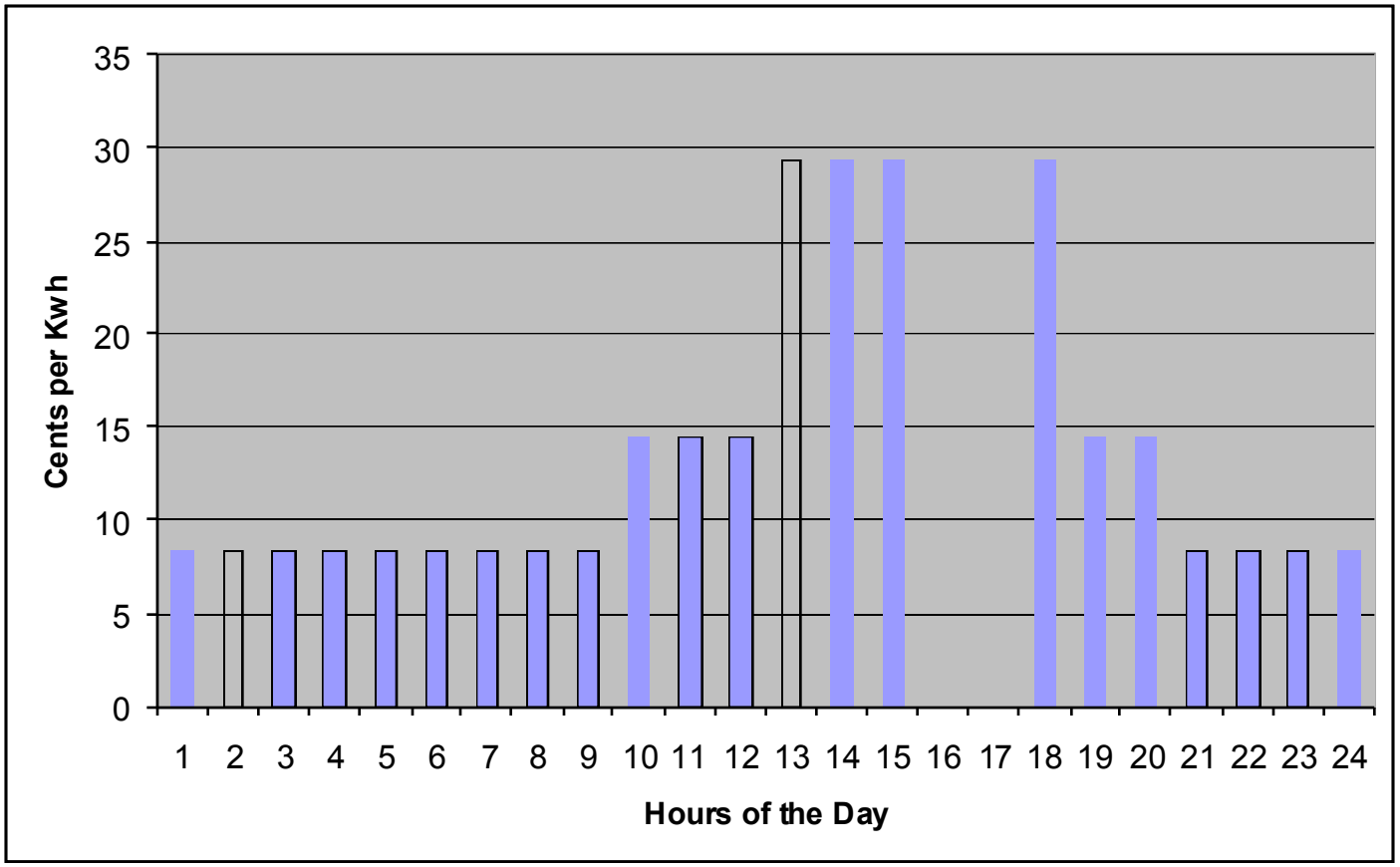
Time of Use Rates

Residential "E6" Time-of-Use Pricing Periods

	Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	Saturday
Midnight - 6am	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak
6am - 10am	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak
10am - 1pm	Off-Peak	Part-Peak	Part-Peak	Part-Peak	Part-Peak	Part-Peak	Off-Peak
1pm - 7pm	Off-Peak	**Peak**	**Peak**	**Peak**	**Peak**	**Peak**	Off-Peak
7pm - 9pm	Part-Peak	Part-Peak	Part-Peak	Part-Peak	Part-Peak	Part-Peak	Part-Peak
9pm - Midnight	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak	Off-Peak

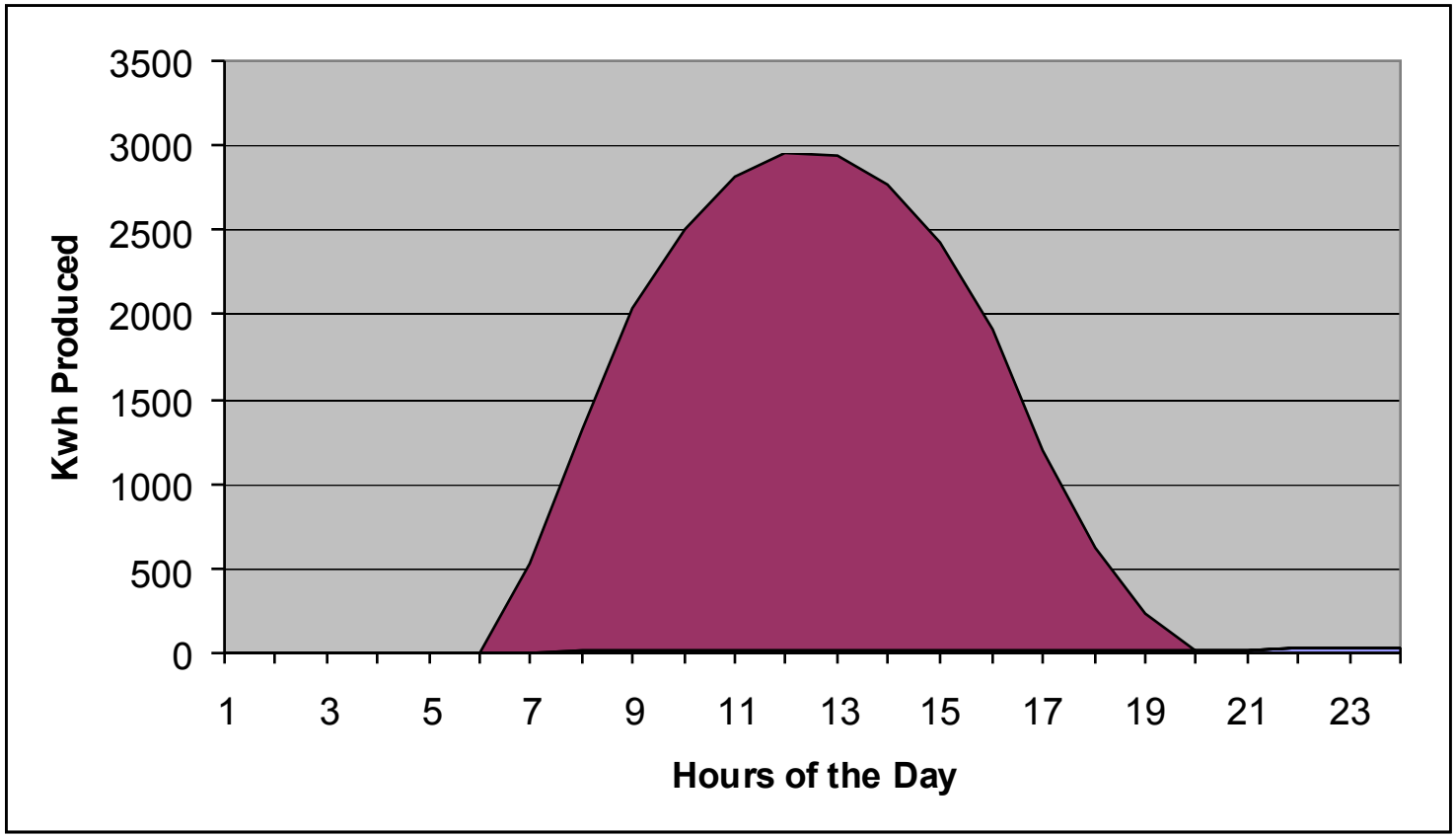
- Peak rates in Summer Afternoons 29¢/kWh + tier surcharges
- Part-Peak rates: 14¢/kWh + tiers
- Off-Peak rates (Nights & Weekends) 8.5-10¢/kWh + tiers

Time of Use Rates



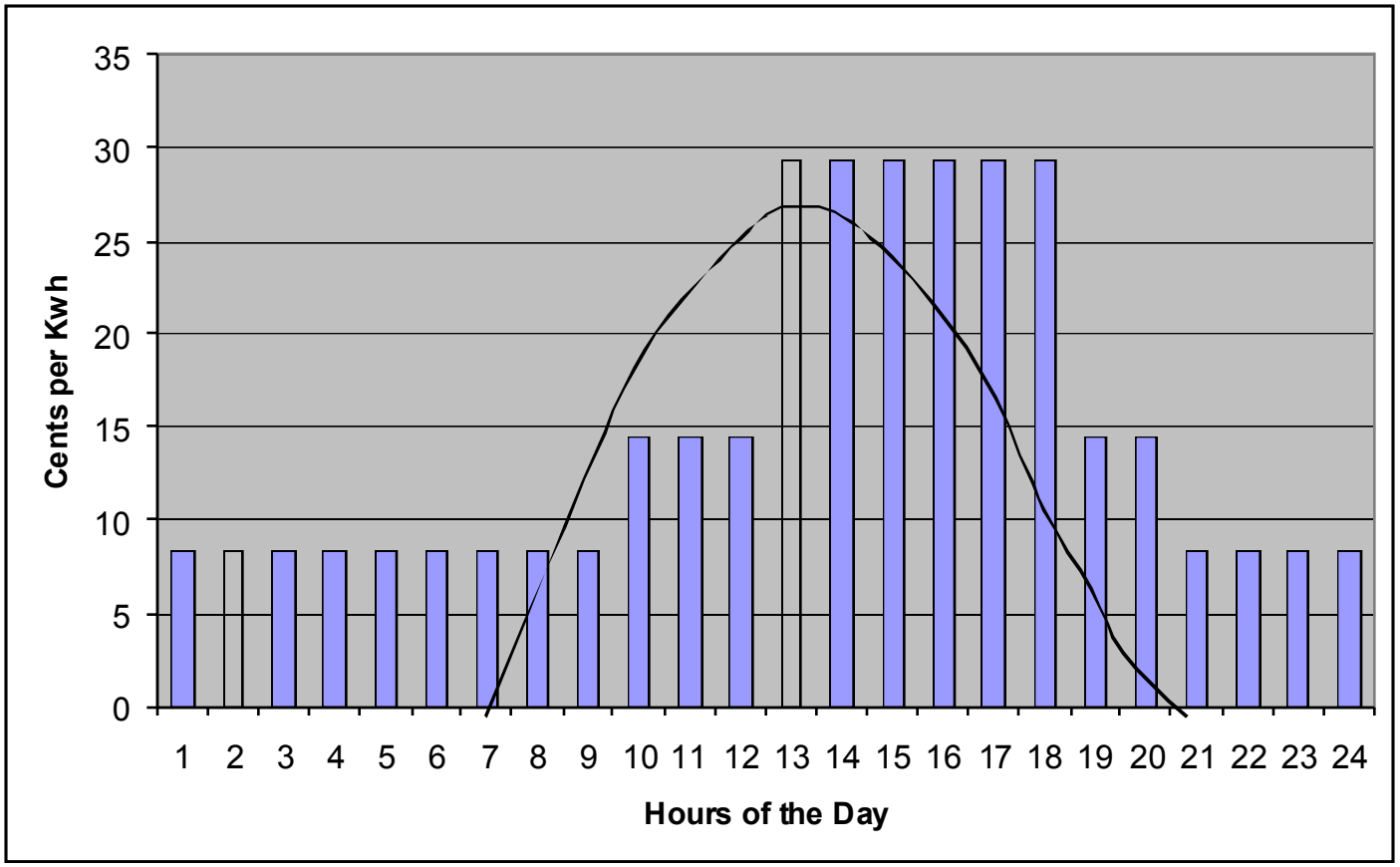
E-6 summer rates (May – October)

Time of Use Rates



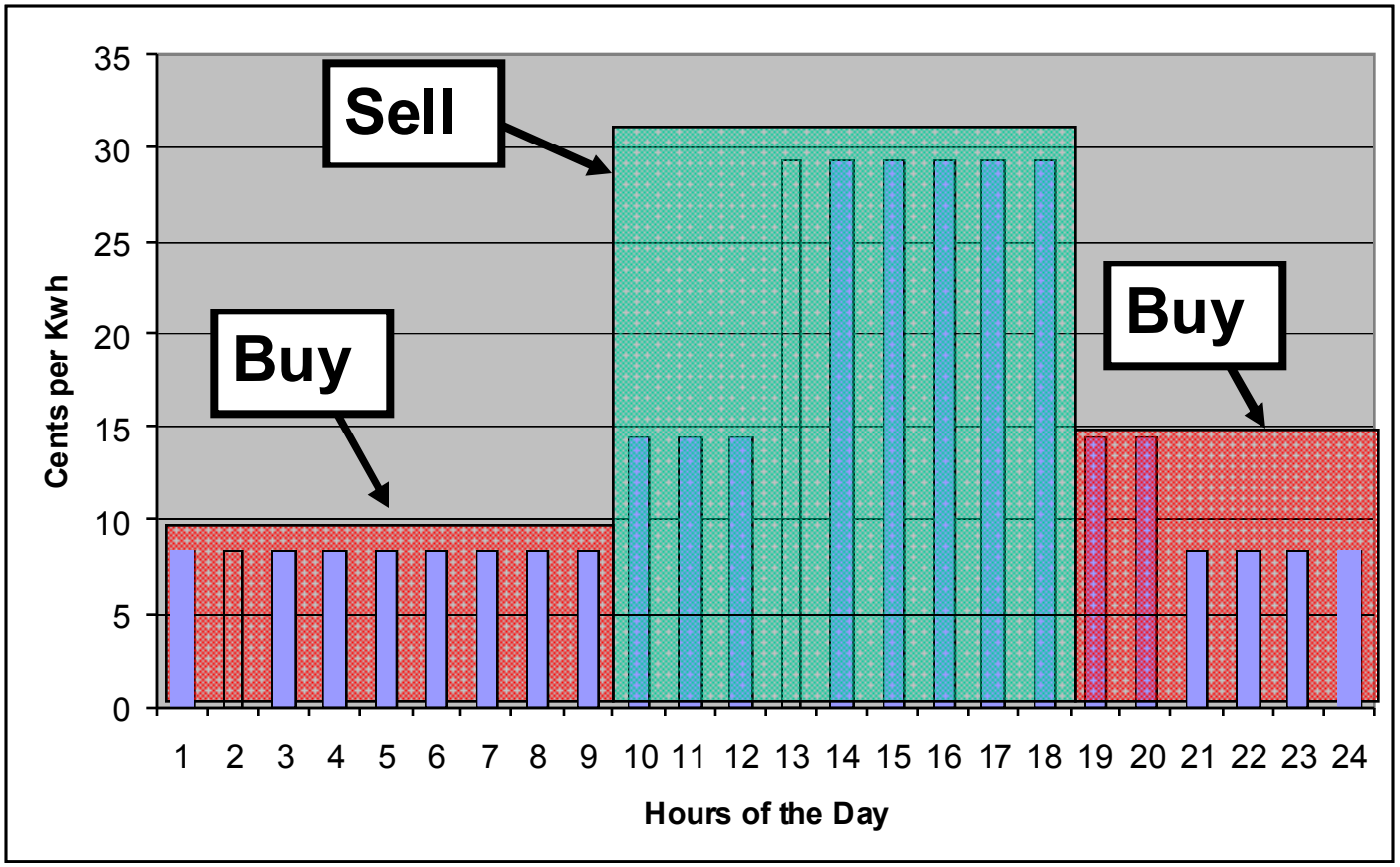
Typical summer production

Time of Use Rates



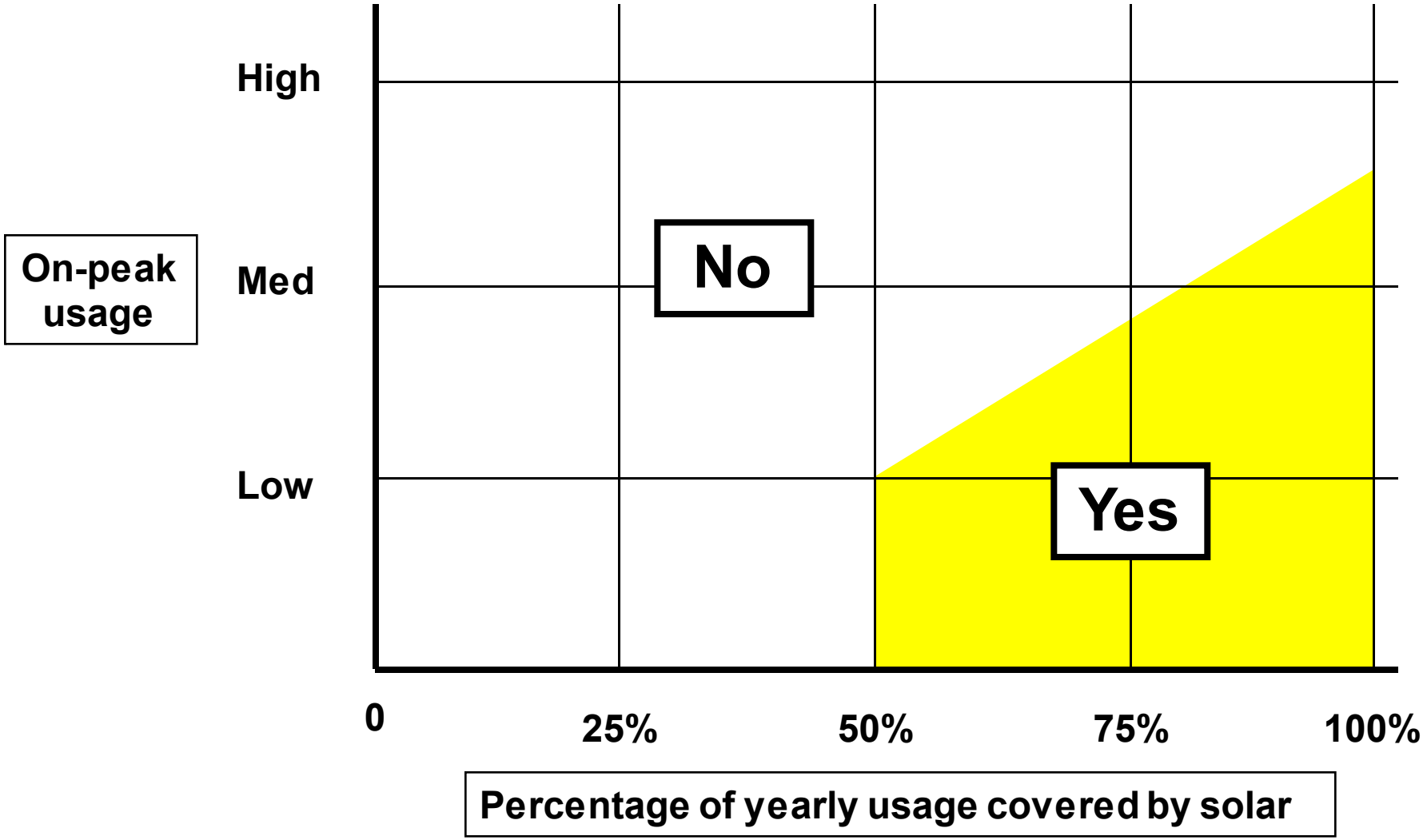
Summer pattern (May – October)

Time of Use Rates



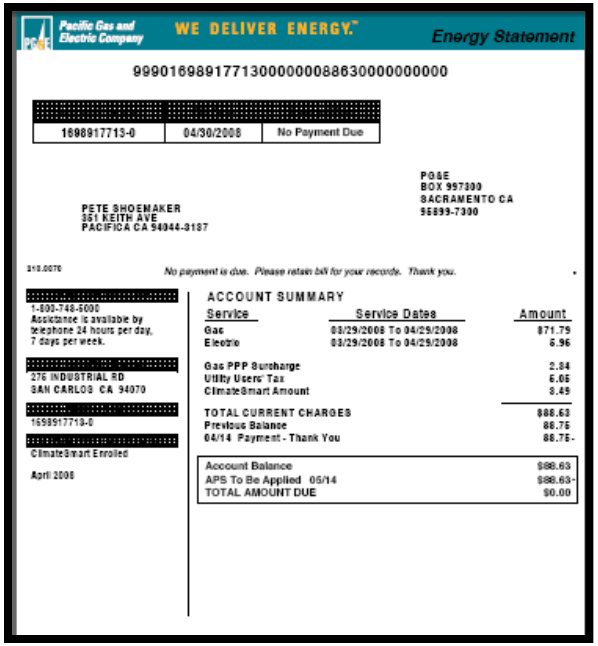
Buying low and selling high adds value.

Should I go on a TOU rate with my PV system?



With PV: Change in Utility Billing

- Two bills, gas & electric
- Yearly billing cycle for electricity
- Fixed minimum electric charge reflected on gas (blue) bill



Pacific Gas and Electric Company WE DELIVER ENERGY. Energy Statement

9990169891771300000008863000000000

1698917713-0	04/30/2008	No Payment Due

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

PETE SHOEMAKER
351 KEITH AVE
PACIFICA CA 94044-3187

No payment is due. Please retain bill for your records. Thank you.

1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

276 INDUSTRIAL RD
SAN CARLOS CA 94070

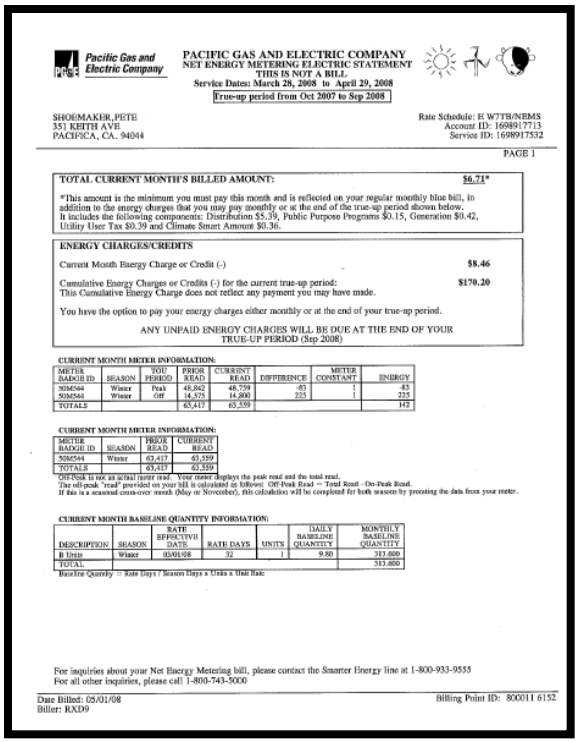
1698917713-0

ClimateSmart Enrolled

April 2008

ACCOUNT SUMMARY

Service	Service Dates	Amount
Gas	03/29/2008 To 04/29/2008	$71.79
Electric	03/29/2008 To 04/29/2008	6.96
Gas PPP Surcharge		2.84
Utility Users' Tax		6.05
ClimateSmart Amount		3.45
TOTAL CURRENT CHARGES		$88.63
Previous Balance		88.75
04/14 Payment - Thank You		88.75-
Account Balance		$88.63
APS To Be Applied 05/14		$88.63-
TOTAL AMOUNT DUE		$0.00



Pacific Gas and Electric Company

PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT
THIS IS NOT A BILL.
Service Dates: March 29, 2008 to April 29, 2008
True-up period from Oct 2007 to Sep 2008

SHOEMAKER, PETE
351 KEITH AVE
PACIFICA, CA. 94044

Rate Schedule: E W7TR/NEMS
Account ID: 1698917713
Service ID: 1698917532

PAGE 1

TOTAL CURRENT MONTH'S BILLED AMOUNT: $6.71*

*This amount is the minimum you must pay this month and is reflected on your regular monthly blue bill, in addition to the energy charges that you may pay monthly or at the end of the true-up period shown below. It includes the following components: Distribution $5.39, Public Purpose Programs $0.15, Generation $0.42, Utility User Tax $0.39 and Climate Smart Amount $0.36.

ENERGY CHARGES/CREDITS

Current Month Energy Charge or Credit (-) $8.46

Cumulative Energy Charges or Credits (-) for the current true-up period: $170.20
This Cumulative Energy Charge does not reflect any payment you may have made.

You have the option to pay your energy charges either monthly or at the end of your true-up period.

ANY UNPAID ENERGY CHARGES WILL BE DUE AT THE END OF YOUR TRUE-UP PERIOD (Sep 2008)

CURRENT MONTH METER INFORMATION:

METER BADGE ID	SEASON	TOU PERIOD	PRIOR READ	CURRENT READ	DIFFERENCE	METER CONSTANT	ENERGY
30M544	Winter	Peak	48,842	48,759	-83	1	-83
30M544	Winter	Off	14,575	14,800	225	1	225
TOTALS			63,417	63,559			142

CURRENT MONTH METER INFORMATION:

METER BADGE ID	SEASON	PRIOR READ	CURRENT READ
30M544	Winter	63,417	63,559
TOTALS		63,417	63,559

Off-Peak is not an actual meter read. Your meter displays the peak read and the total read.
The off-peak "read" provided on your bill is calculated as follows: Off-Peak Read = Total Read - On-Peak Read.
If this is a seasonal cross-over month (May or November), this calculation will be completed for both seasons by prorating the data from your meter.

CURRENT MONTH BASELINE QUANTITY INFORMATION:

DESCRIPTION	SEASON	RATE EFFECTIVE DATE	RATE DAYS	UNITS	DAILY BASELINE QUANTITY	MONTHLY BASELINE QUANTITY
B Units	Winter	03/01/08	32	1	9.80	313.600
TOTAL						313.600

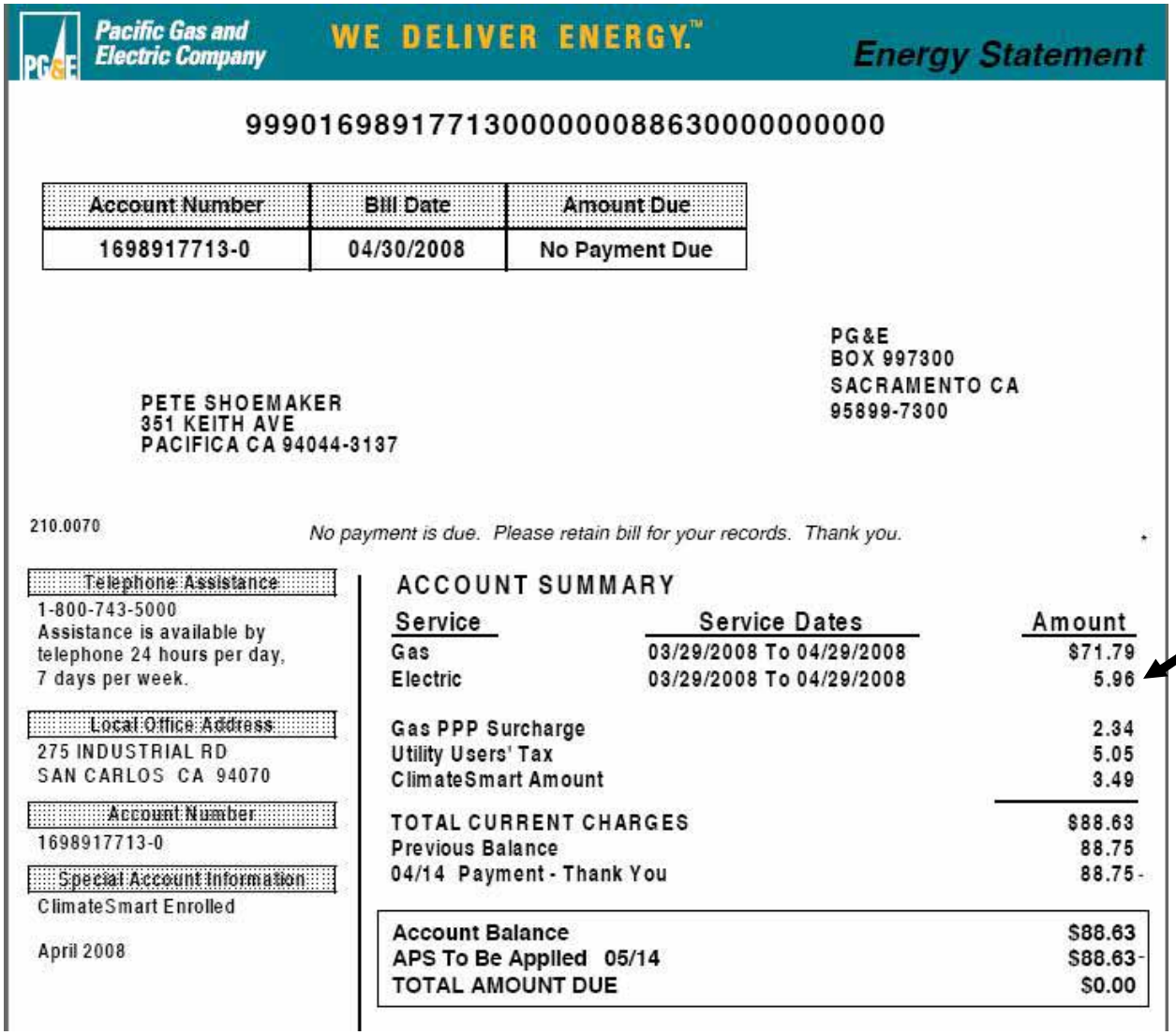
Baseline Quantity = Rate Days * Season Days x Units x Unit Basic

For inquiries about your Net Energy Metering bill, please contact the Smarter Energy line at 1-800-933-9555
For all other inquiries, please call 1-800-743-5000

Date Billed: 05/01/08
Biller: RXD9

Billing Point ID: 800011 6152

Change in Utility Billing



Pacific Gas and Electric Company WE DELIVER ENERGY.™ Energy Statement

99901698917713000000088630000000000

Account Number	Bill Date	Amount Due
1698917713-0	04/30/2008	No Payment Due

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

PETE SHOEMAKER
351 KEITH AVE
PACIFICA CA 94044-3137

210.0070

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1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address
275 INDUSTRIAL RD
SAN CARLOS CA 94070

Account Number
1698917713-0

Special Account Information
ClimateSmart Enrolled

April 2008

ACCOUNT SUMMARY

Service	Service Dates	Amount
Gas	03/29/2008 To 04/29/2008	$71.79
Electric	03/29/2008 To 04/29/2008	5.96
Gas PPP Surcharge		2.34
Utility Users' Tax		5.05
ClimateSmart Amount		3.49
TOTAL CURRENT CHARGES		$88.63
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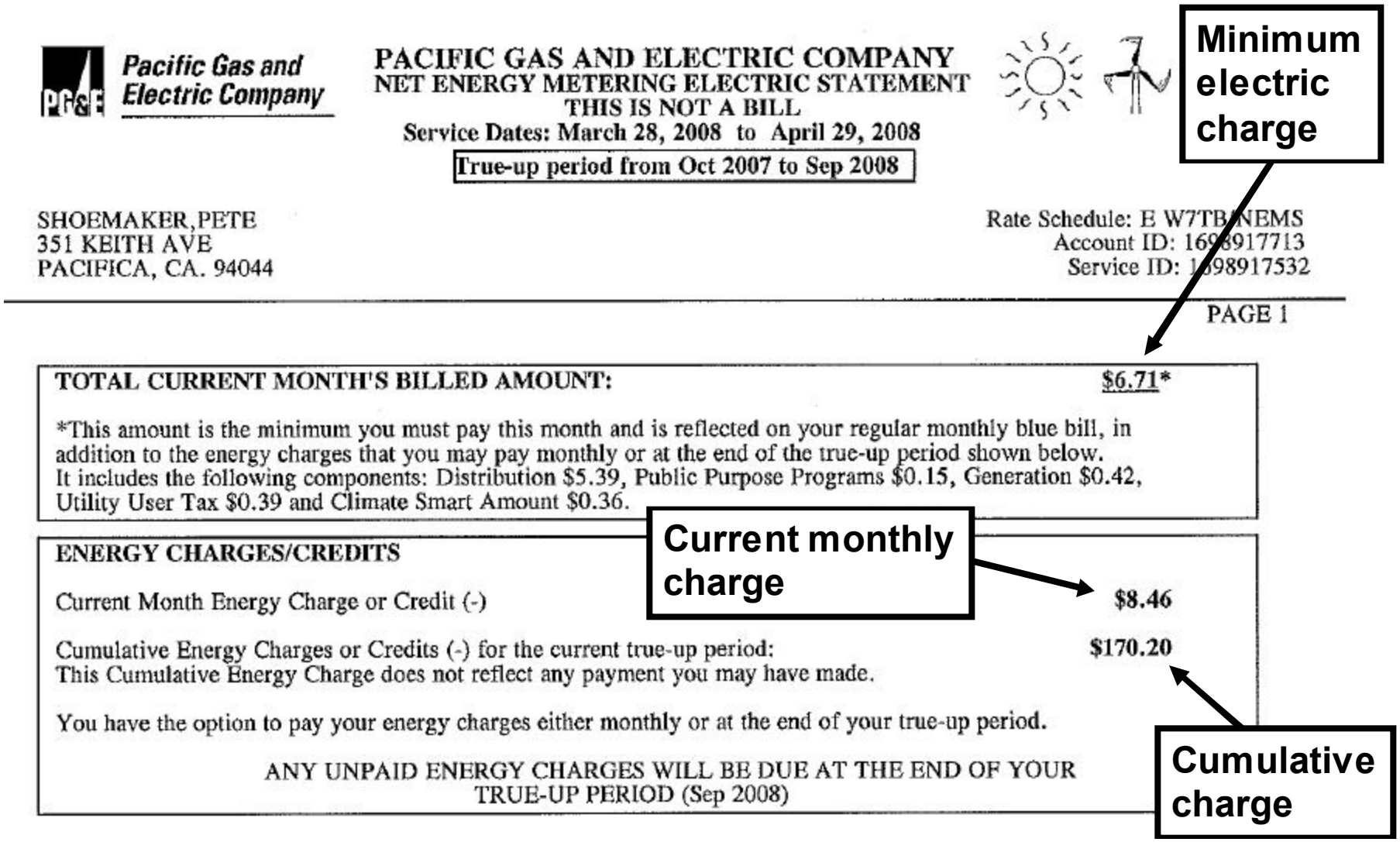
Account Balance		$88.63
APS To Be Applied 05/14		$88.63-
TOTAL AMOUNT DUE		$0.00

Minimum electric hookup charge

Change in Utility Billing



Pacific Gas and Electric Company

PACIFIC GAS AND ELECTRIC COMPANY
NET ENERGY METERING ELECTRIC STATEMENT
THIS IS NOT A BILL
Service Dates: March 28, 2008 to April 29, 2008
True-up period from Oct 2007 to Sep 2008

SHOEMAKER,PETE
351 KEITH AVE
PACIFICA, CA. 94044

Rate Schedule: E W7TB NEMS
Account ID: 1698917713
Service ID: 1698917532

PAGE 1

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Current Month Energy Charge or Credit (-) $8.46

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ANY UNPAID ENERGY CHARGES WILL BE DUE AT THE END OF YOUR TRUE-UP PERIOD (Sep 2008)

Change in Utility Billing

PV electric bill: meter readings

CURRENT MONTH METER INFORMATION:

METER BADGE ID	SEASON	TOU PERIOD	PRIOR READ	CURRENT READ	DIFFERENCE	METER CONSTANT	ENERGY
50M544	Winter	Peak	48,842	48,759	-83	1	-83
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If this is a seasonal cross-over month (May or November), this calculation will be completed for both seasons by prorating the data from your meter.

CURRENT MONTH BASELINE QUANTITY INFORMATION:

DESCRIPTION	SEASON	RATE EFFECTIVE DATE	RATE DAYS	UNITS	DAILY BASELINE QUANTITY	MONTHLY BASELINE QUANTITY
B Units	Winter	03/01/08	32	1	9.80	313.600
TOTAL						313.600

Baseline Quantity = Rate Days / Season Days x Units x Unit Rate

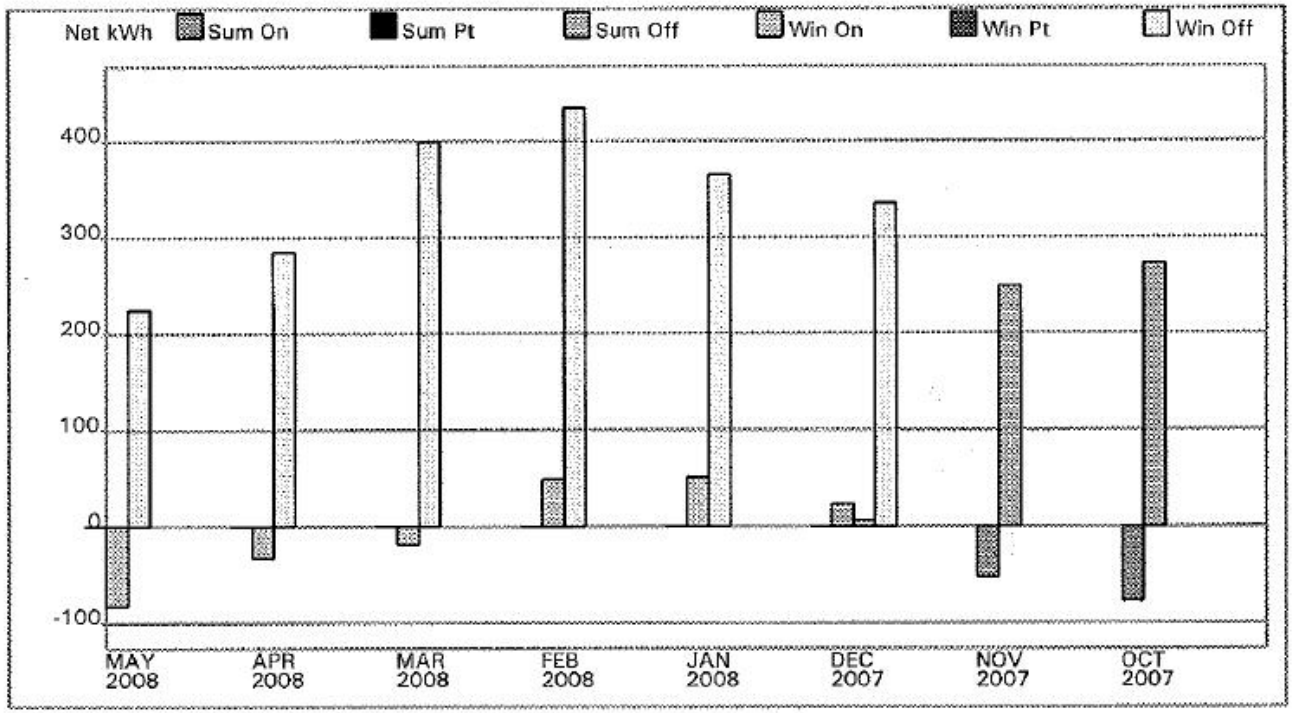
Change in Utility Billing

PV electric bill: usage history

ENERGY TRUE-UP HISTORY:

BILLING MONTH	BILL TO DATE	SUMMER ON	SUMMER OFF	WINTER ON	WINTER OFF	TOTAL ENERGY	ENERGY CHARGES /CREDITS
MAY 2008	04/29/08			-83	225	142	$8.46
APR 2008	03/28/08			-33	285	252	$17.93
MAR 2008	02/28/08			-19	399	380	$29.24
FEB 2008	01/29/08			49	434	483	$50.79
JAN 2008	12/31/07			51	365	416	$34.58
DEC 2007	11/29/07	0	23	6	335	364	$28.27
NOV 2007	10/29/07	-53	249			196	$2.98
OCT 2007	10/01/07	-77	272			195	$-2.05
TOTALS			*			2,428	$170.20

**Energy Charges/Credits (-) include all energy related amounts and taxes.



Change in Utility Billing

Yearly “trueup” example

- Yearly usage total $170.20
- Already paid the fixed amount of $6.71 per month for 12 months, total of $80.52
- Amount owed is 170.20 – 80.52 = $89.68

Relatively Low Maintenance

Source: DOE National Renewable Energy Laboratory

Soiling Factors

- Three basic categories for rainy / dry season areas
  - **Washed as often as necessary ~ 1.0**
  - **Washed once in July ~ 0.96**
  - **Never washed ~ 0.93**

- Factors affecting number
  - Rainy / dry seasons
  - Dirt roads
  - Near agricultural activity
  - Close to road surface of busy street
  - In airport flight path

Cleaning Costs

Residential systems

- Around $5 per panel
- High because of fixed costs (travel, insurance, etc.)

Commercial systems

- In PPA, contracted out to separate company
- Cleaning and inspections typically done together
- Frequency usually twice per year
- Full service cost about 2¢/watt per year
- One time cleaning-only cost around 1/2¢/watt or $1/panel
- Must be careful with power washers, psi not too high

500 kW system = 2,500 panels:
Yearly cleaning & maintenance = $10,000.

Environmental "Footprint"

- Best overall estimates from 1 to 2.5 years
- Depends on site and power production--in California is about 1.1 years.
- Shrinking as costs drop and production gets "greener"
- Pays back 10 to 30 times or more its environmental cost

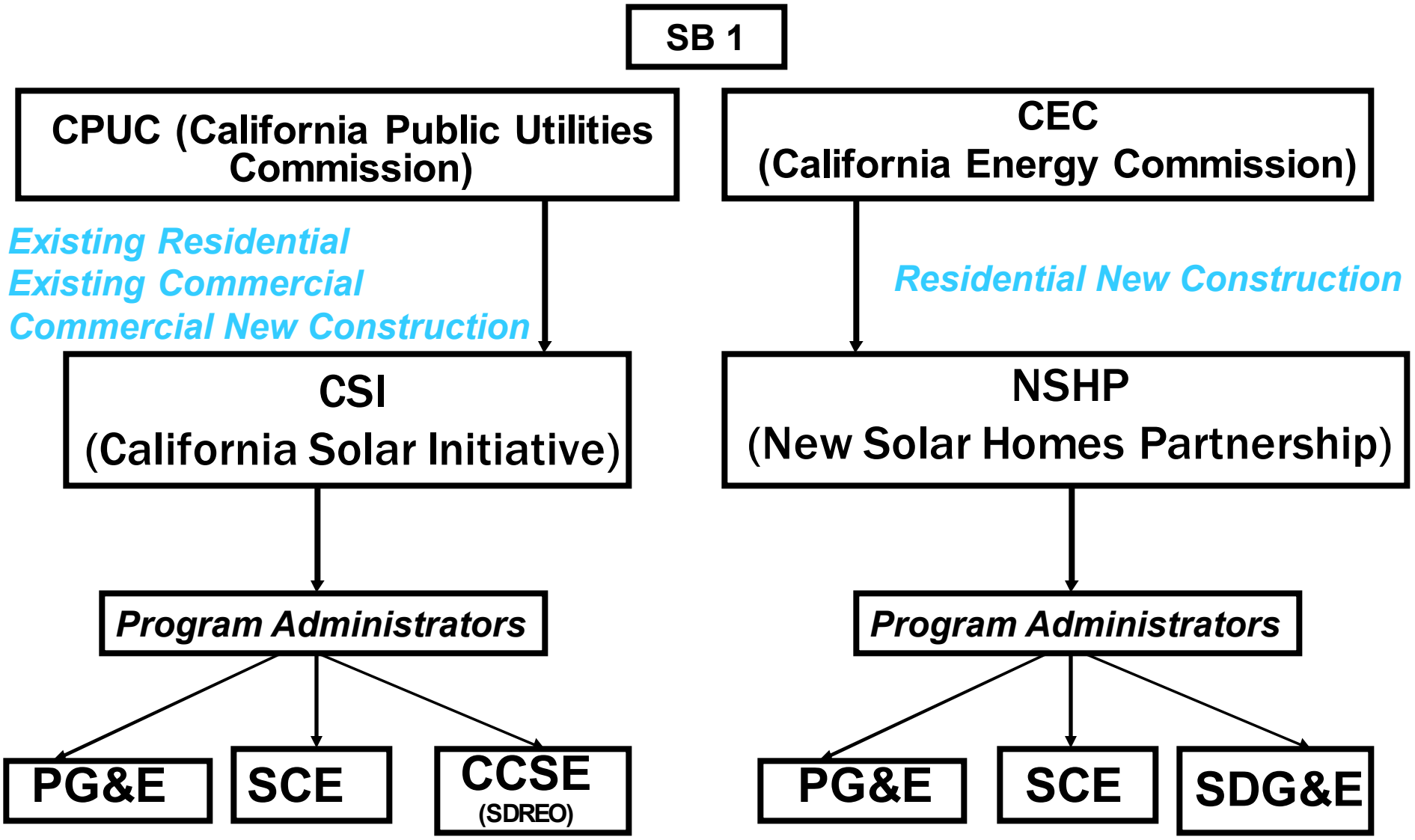
Most PV manufacturing plants will have their own PV system on the roof.

Courtesy of DOE/NREL

Source: January *2008 Environmental Science & Technology*

http://sustenergy.blogactiv.eu/2008/05/29/emissions-from-photovoltaic-manufacturing/

California Solar Initiative (CSI)



The CSI makes PV …

- **Economical:**
  Gives financial incentives to lower the cost
- **Secure**
  Screens and tests equipment
  Requires long warranties
  Helps screen and check installers
  Standardizes production estimates
- **Easy**
  Helps installers handle everything

CSI Financial Incentives—two types

EPBB (Expected Performance-Based Buydown)

- *One-time, up-front payment (rebate)*
- *Based on expected production*
- *Only for smaller systems (< 50 kW)*

PBI (Performance-based Incentive)

- *Ongoing monthly payment for 5 years*
- *Based on actual production*
- *Possible for all systems, but required for large ones (> 50 kW)*

CSI Financial Incentives—numbers

		EPBB			PBI		
		EPBB Payments (per Watt)			PBI Payments (per kWh)		
Step	Statewide MW in Step	Residential	Commercial	Government/ Non-Profit	Residential	Commercial	Government/ Non-Profit
1	50	n/a	n/a	n/a	n/a	n/a	n/a
2	70	$2.50	$2.50	$3.25	$0.39	$0.39	$0.50
3	100	$2.20	$2.20	$2.95	$0.34	$0.34	$0.46
4	130	$1.90	$1.90	$2.65	$0.26	$0.26	$0.37
5	160	$1.55	$1.55	$2.30	$0.22	$0.22	$0.32
6	190	$1.10	$1.10	$1.85	$0.15	$0.15	$0.26
7	215	$0.65	$0.65	$1.40	$0.09	$0.09	$0.19
8	250	$0.35	$0.35	$1.10	$0.05	$0.05	$0.15
9	285	$0.25	$0.25	$0.90	$0.03	$0.03	$0.12
10	350	$0.20	$0.20	$0.70	$0.03	$0.03	$0.10

Overall outline:

Incentives step down according to amount of PV installed (MW)

CSI Financial Incentives—numbers

Data as of 2/7/12

Administrator	Customer Class *	Current Step	Initial MW in Step	Unused MW from Previous Steps	Revised Total MW in Step	Issued Conditional Reservation Letters (MW)	MW Remaining	MW Under Review
PGE	Residential	9	41.10	1.07	42.17	15.70	26.48	1.08
	Non-Residential	9	83.40	5.24	88.64	17.19	**71.46**	**90.68**[1]
SCE	Residential	7	32.60	1.15	33.75	23.90	9.85	0.70
	Non-Residential	8	77.10	32.54	109.64	54.99	54.65	2.99
CCSE	Residential	9	9.70	0.77	10.47	6.32	4.15	0.66
	Non-Residential	8	17.30	6.95	24.25	9.03	15.21	4.84

MW remaining – MW under review = best estimate of how much left.
For PG&E residential: 26.48 – 1.08 = 25.4 MW.

Trigger Tracker. Helps determine when incentives drop.

http://www.csi-trigger.com/

CSI Rebate Adjustments

Base system size in AC kilowatts (CEC) may be adjusted downwards depending on design and geography.

Determined by EPBB calculator: www.csi-epbb.com

according to the following inputs:

1. **Zip code**
2. **Orientation (azimuth)**
3. **Tilt (from horizontal)**
4. **Shading (detailed shading table)**

- **Design rewards summer energy, not annual**
- **No design penalty for any orientation from South to West**
- **Geography factor capped at 1.0 relative to Orange, CA**

Sample Current Situation

Case study

Electric bill: $100/month = $1200/year

After 10 years you will have paid $12,000

… if rates do not rise.

Is this a reasonable assumption?

Sample Current Situation

Case study

Electric bill: $100/month = $1200/year

***With inflation,* after 10 years you likely will have paid $14,000 to $17,000 …**

With nothing to show for it except higher electric bills ($150+/mo).

- **No equity**
- **Nothing "paid off"**

So the real question is

Can solar be less expensive than this?

PV Statistics & Performance for the "Average" Family of Four

(monthly electrical bill $100-$200)

4.0 Kw_{AC} System

COST (*before rebate = $6,500 / kW*)	$26,000
REBATE *(est. $230 / kW)*	$920
TAX CREDIT	$7524
NET COST	$17,556
Maintenance (25 – 40 yrs.)	$5,000
Total lifecycle cost	

kWh Production	~ 6,500 kWh / year
Space requirements	~ 350 - 500 s.f.

Avg. cost of power now ($150/mo)	$.18/Kwh
25-yr. cost of power (est.)	$.14/Kwh
40-yr. cost of power (est.)	$.09/Kwh

$22,556

Three Ways to Buy

1. Full purchase (cash or borrowing)

You

Owner of system

Borrow money or pay cash

Full payment up front

Maintain and monitor system

Economics:

Cash / total savings

Loan pmt. / monthly savings

$$$

PV Vendor

Design and install

Sell

Honor warranties (equipment & labor)

Three Ways to Buy

2. Solar Lease

You

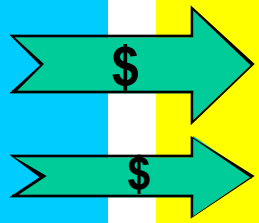
Low or no money down

Fixed lease payment

Possible buyout in the future

Economics:

Lease pmt. / monthly savings



PV Vendor

Owner of system

Design and install

Lease

Maintain and monitor system

Honor warranties (equipment & labor)

Remove system at end if needed

Three Ways to Buy

3. Power Purchase Agreement (PPA)

You

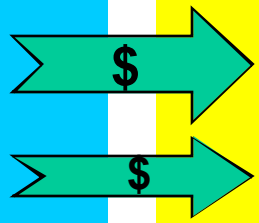
Low or no money down

Monthly power payment

Possible buyout in the future

Economics:

Monthly pmt. / monthly savings



PV Vendor

Owner of system

Design and install

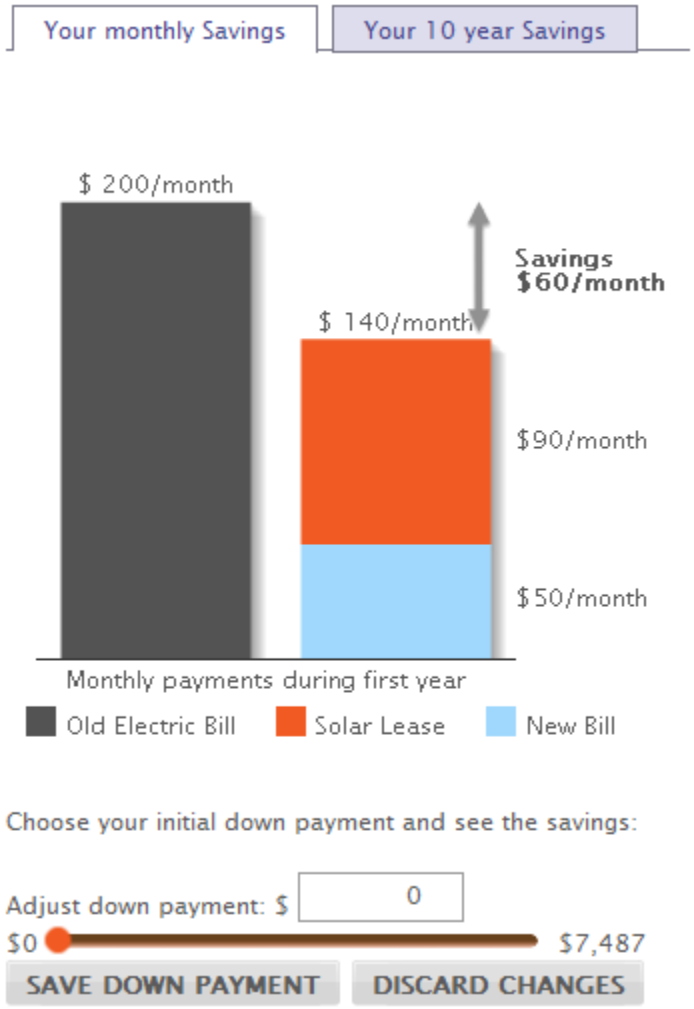
Sell power

Maintain and monitor system

Honor warranties (equipment & labor)

Remove system at end if needed

Solar lease



Choose your initial down payment and see the savings:

Adjust down payment: $ 0

$0 $7,487

SAVE DOWN PAYMENT DISCARD CHANGES

$0 up front

How it works:

	Utility	Lease	Total
Old Bill	$200	-	$200
New Bill	$50	$90	$140
Monthly savings (yr.1)			$60

- Pay monthly, just like you pay your utility today...
- ...but your electricity spend will be $60/month less...
- ...this generates $12,834 savings over the life of the lease!
- Easy

Get the details on this lease

APPLY FOR LEASE

Solar lease

Why Purchase?

You want to own your solar home system

You want the maximum tax break associated with solar power

You view a solar home system as a worthy investment that adds to the value of your home

Total System Cost:	$22,435
State Rebate:	$3,726
Out of Pocket Cost:	$20,484
Federal Tax Credit:	$6,970
Net Cost:	$13,514

A VALUABLE INVESTMENT

Why lease?

You want to save money without the out of pocket expense of purchasing a solar system

You want the assurance of ! extended Performance Guarantee

You don't want to worry about routine maintenance and monitoring of your system

$0 DOWN

$90 MONTHLY PAYMENT

SAVE MONEY FROM DAY ONE

PV System Costs by Component

- **Retail costs of system under 30 kW**
  - PV Panels ~ $2 per Watt
  - Inverter ~ $.50 per Watt
  - Balance of System ~ $1 per Watt
  - Installation / Labor ~ $3 per Watt

Total cost ~ $6.50 per watt installed

THE BIG QUESTION:

What's the payback?

Return on Investment

Different ways to measure

"Payback": Time period when savings = investment cost

IRR (internal rate of return): Percentage of annual return which looks at full life cycle

NPV (net present value): Cash flow projection which takes in financing costs

Monthly Cash Flow: Change in your monthly payment

Return on Investment

Monthly Cash Flow:

- **Financed by a home-secured loan**
- **Loan interest is tax-deductible**
- **Assuming historical rate escalation continues**

Monthly cash flow can be immediately *positive* for many people with higher electric bills.

They can start making money from day one and continue for over 30 years!

Lower bill amounts will typically start out slightly negative and improve over time.

Grid Parity

When the price per kWh of electricity from a renewable source is equal to the current average grid price.

PV example:

System net cost: $20,000, lifetime maintenance $4,000.

Expected to generate average of 5,000 kWh per year for 30 years, total of 150,000 kWh.

$24,000 / 150,000 = $ .16 per kWh

Current utility average price = $ .16 per kWh

= Grid Parity

Increase in Home Value

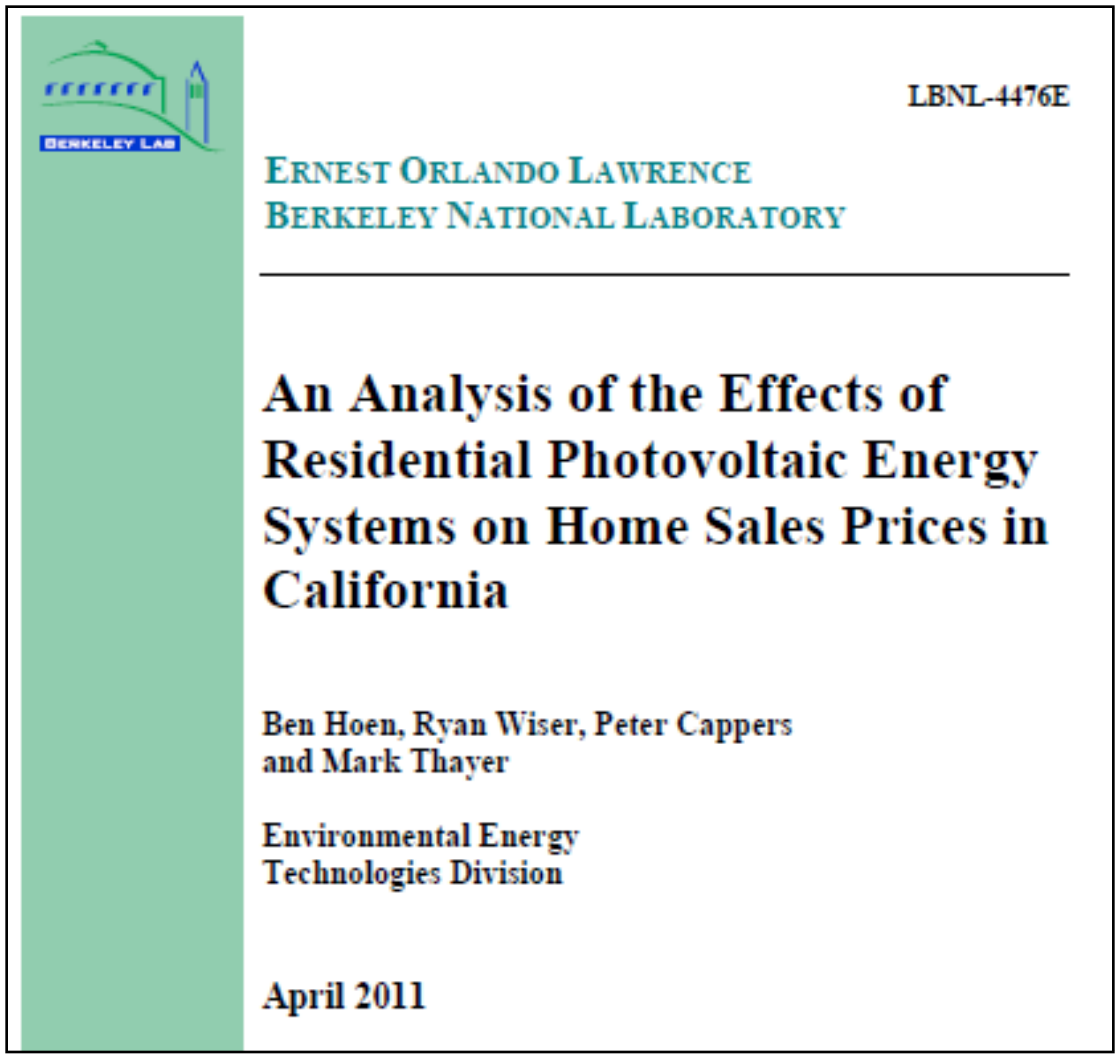
Appraisal Value

- Will likely go up
- Less utility cost means more money available for mortgage payment
- Data so far is supportive, new report just released
- Much more to come as solar houses turn over

Solar Rights Act

- California law that supports solar
- Keeps HOAs and other CC&Rs from prohibiting solar systems
- Forbids increased property taxes on owner's system
- Restriction ends when home is sold, and assessment can go up to reflect system

“We find compelling evidence that solar PV systems in California have boosted home sales prices.”



LBNL-4476E

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California

Ben Hoen, Ryan Wiser, Peter Cappers
and Mark Thayer

Environmental Energy
Technologies Division

April 2011

http://eetd.lbl.gov/ea/emp/reports/lbnl-4476e.pdf

Renewable Energy Credits

- Called RECs or “green tags”
- The “green attribute” of the power
- Connected to carbon offset accounting

Central feature of a system to move money from polluters to non-polluters.

Bad guys

Renewable Energy Certificates

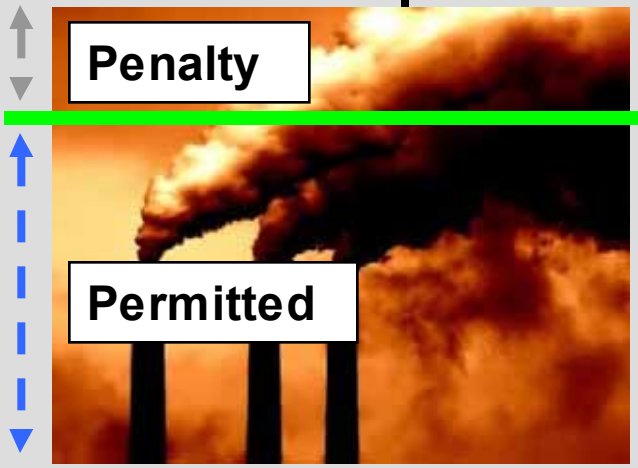
Good guys

Cap and Trade

Trade

Polluters must buy RECs according to penalty.

Pollution preventers



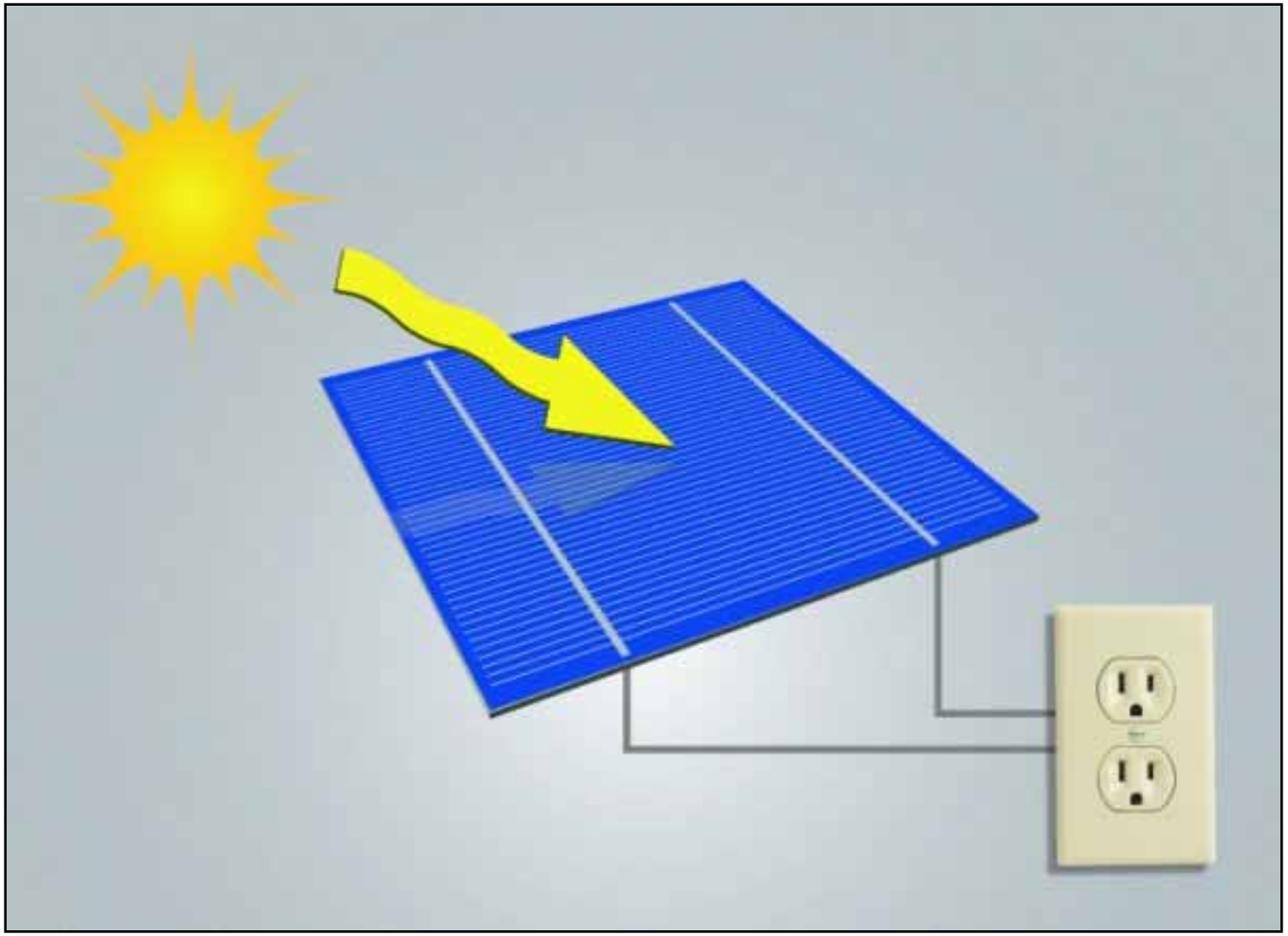
Polluters

Pollution removers

Source: Wikipedia free license

Carbon Offsets

- Making activity “carbon neutral”
- Funding projects that remove as much carbon as you generate
- Additional social & business image value



Strategies for Cost Reduction

Strategies for Cost Reduction

- Installation efficiencies/roofing
- Multiple benefits from one strategy
- Design integration
- Package with energy efficiency
- The PV Bulk-Buy?

Installation Efficiencies

PV Roof Tiles

BIPV Building Integrated Photovoltaics

Installation Efficiencies

Tiles interlock quickly with NO roof penetrations

Source: DOE National Renewable Energy Laboratory

Installation Efficiencies

PV Integrated Roofing Membrane

Courtesy: Solar Integrated

Installation Efficiencies

PV Skylights

Source: DOE National Renewable Energy Laboratory

Multiple Benefits

- Mitigate unwanted solar heat gain
- Control glare
- Displace existing materials cost
- Produce electricity

Source: Darren Bouton

Package with Energy Efficiency

- Conservation gives best payback
- Many EE rebates available
- Will be required for rebate
- Can handle entire package for client

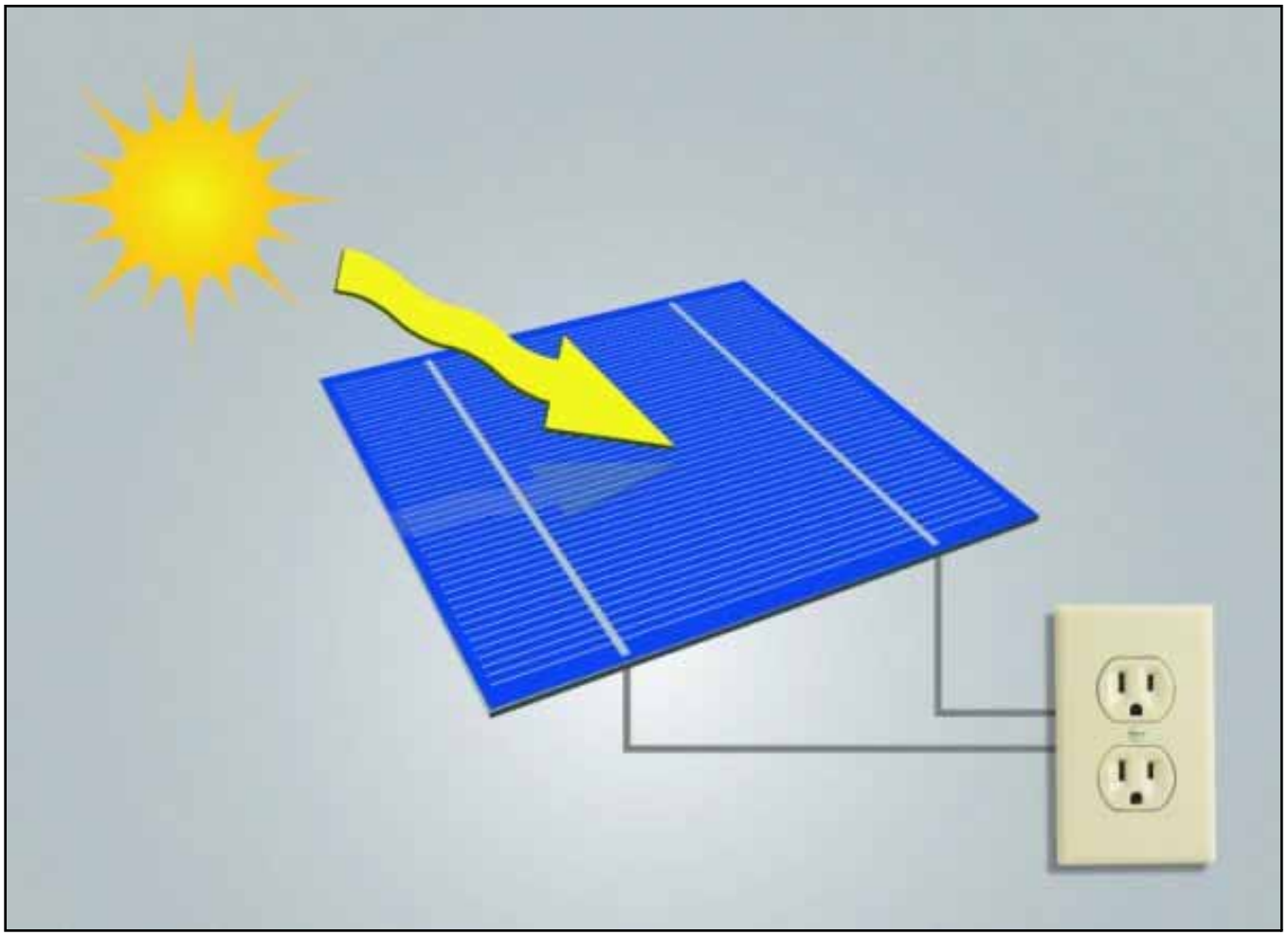
Source: DOE National Renewable Energy Laboratory

PV Bulk Buy

- Community targets for total Kw
- Can lead to 10% or more discounts
- Many companies offering it

Source: Pete Shoemaker

Sales and Installation Process



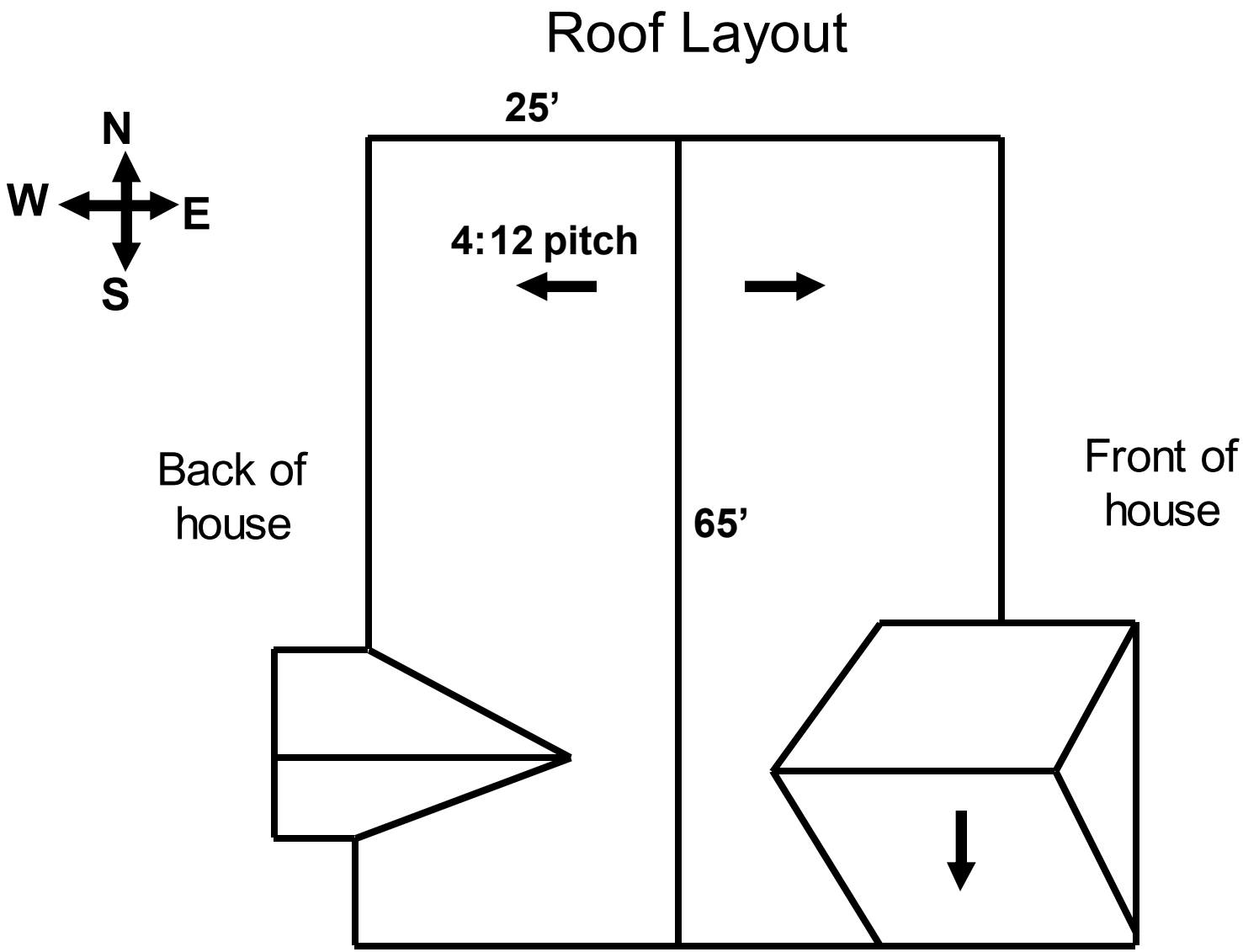
Case Studies

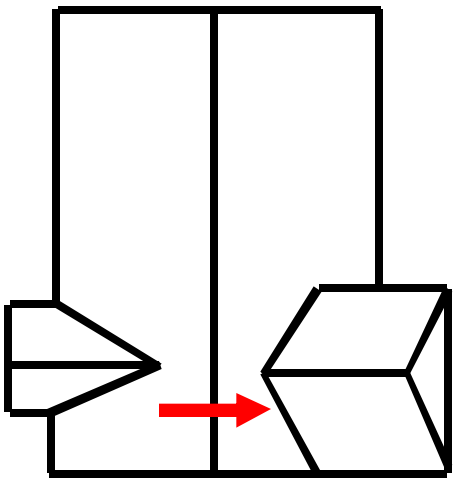
Residential Case Study

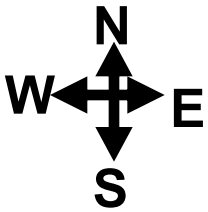
Phone screening information:

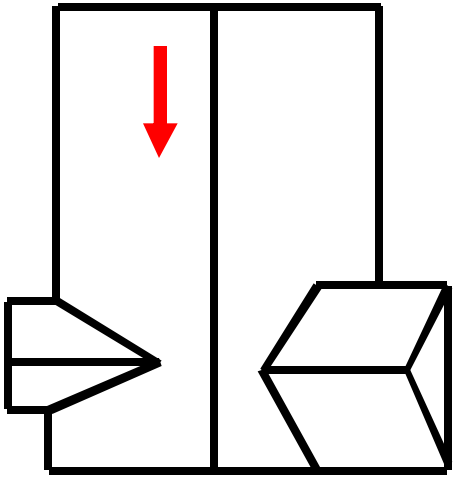
- **“John Doe” in Gilroy, CA**
- **$200/month PG&E electric bill**
- **Usage projected to stay the same**
- **Composition shingle roof**
- **Thinks there are no shade issues**
- **Overhead photos not clear**

Site Visit Data:









Source: Pete Shoemaker

Site Visit First Pass

- No shading issues
- Roof in good shape
- About 200 sf. south-facing
- Lots of room west-facing
- Good site for inverter(s)
- Electrical service and panel OK
- Substantial electric bill

What Size System?

Usage History	
Jul-06	946
Aug-06	1127
Sep-06	1349
Oct-06	970
Nov-06	1093
Dec-06	1077
Jan-07	1349
Feb-07	867
Mar-07	886
Apr-07	768
May-07	815
Jun-07	836
Total	12083
Avg.	1007

- Usage pattern normal
- Monthly average is good starting point
- Propose maximum size system and then work to customer's budget
- Check for competitive bids, ask to see them

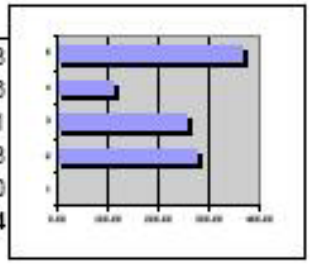
5. PG&E Bill Analysis

System Size: 4.56 Kw DC 3.81 Kw AC

Before solar:

Avg. baseline allowance per day:	12.2	
Avg. billing days for month:	30	
Avg. baseline per month:	366.00	Kwh
Avg. usage per month:	1007	Kwh

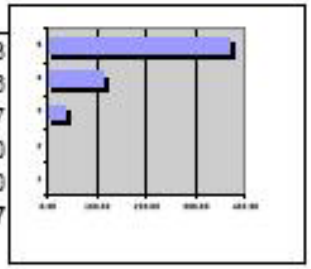
Rate Tiers	Tier Usage (Kwh)	Charge/Kwh	Amount
0 to 100% of Baseline	366.00	$0.11430	$41.83
101 to 130% of Baseline	109.80	$0.12989	$14.26
131 to 200% of Baseline	256.20	$0.22722	$58.21
201 to 300% of Baseline	275.00	$0.31719	$87.23
Over 300% of Baseline	0.00	$0.36434	$0.00
Total	**1007**		**$201.54**



After solar:

Solar produces on avg.:	497	Kwh
Net usage with solar:	510	Kwh

Rate Tiers	Tier Usage (Kwh)	Charge/Kwh	Amount
0 to 100% of Baseline	366.00	$0.11430	$41.83
101 to 130% of Baseline	109.80	$0.12989	$14.26
131 to 200% of Baseline	34.20	$0.22722	$7.77
201 to 300% of Baseline	0.00	$0.31719	$0.00
Over 300% of Baseline	0.00	$0.36434	$0.00
Total	**510**		**$63.87**



Estimated increase in value with Time-of-Use rate (E7): 8%

Est. bill with E7 rate: $52.85

Acme Solar final bid

3. Financial Summary

John Doe—4.56 DC system

Gilroy, CA 95020

System size: 3.81 KwAC (CEC)

24 190-watt modules

Two 2000-watt inverters

Your system is expected to produce an average of 5967 Kilowatt hours per year. It is expected to save you $1784 the first year, with this amount increasing steadily for the next 30 years or more.

Pricing:	
Full system price	$34,900
Includes everything except permit fees	
CSI rebate	($7,992)
Out of Pocket cost	$26,907
Federal tax credit	($2,000)
Net system cost	$24,907
Price per AC watt (CEC)	$9.16

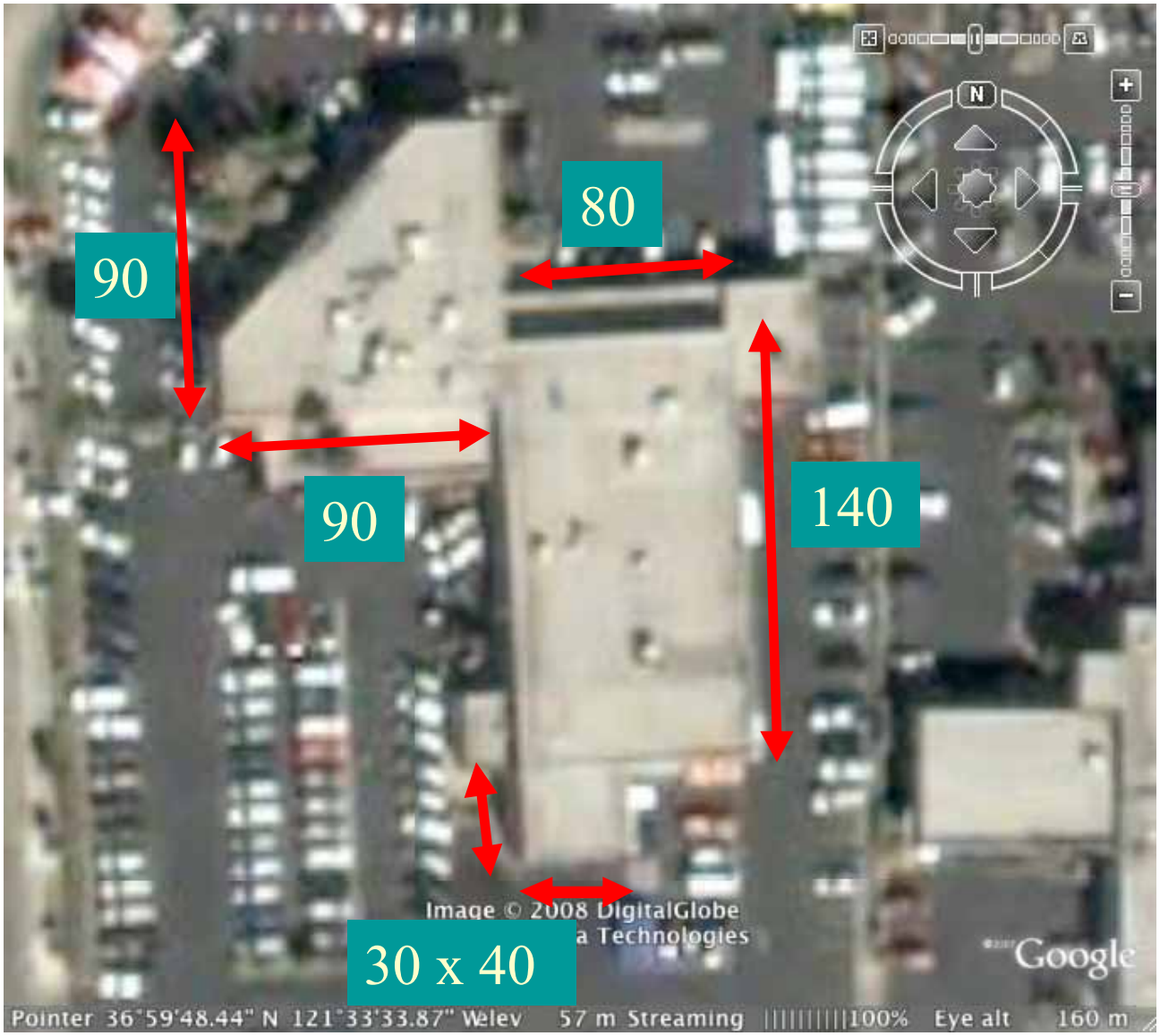
Savings:	
Old monthly electric bill	$202
Estimated new bill with solar	$53
Percentage of bill to offset	74%
Savings in first month	$149
Savings in first year	$1,784
Net savings over 30 years	$89,561
Assuming an annual utility rate increase of 6%.	

Commercial Case Study

Car dealership in Gilroy

Commercial Case Study

- Check usable space
- Estimate maximum size of system
- Determine average usage from bill
- Give ballpark financial numbers


90
80
90
140
30 x 40
Image © 2008 DigitalGlobe
a Technologies
Google
Pointer 36°59'48.44" N 121°33'33.87" Welev 57 m Streaming 100% Eye alt 160 m

Total space is about 16,000 square feet, but how much is usable? Need site visit to determine.

Visual estimate about 60+% usable space.

about 10,000 sf. total =

100 KW system maximum.

Electric bill yearly average: 31,000 Kwh/month

Rate Schedule	Season	Total Energy Charge[1/] (per kWh)		"Average" Total Rate[2/] (per kWh)
A-1 Basic general service rate. Generally optimal rate for customers with low electric use and low load factors, with most usage during PG&E's peak and partial peak TOU periods.	**Summer**	$0.18264		$0.16594
	Winter	$0.12941		

Average blended rate per Kwh = $ .16594

Average monthly bill = 31,000 x $ .16594 = $5,144

or about $5,000 per month.

From website: www.csi-epbb.com

California Solar Initiative
Incentive Calculator - BIPV Compatible

	Proposed
Site Specifications:	
ZIP Code	95020
City	Gilroy
Utility	PG&E
Customer Type	Commercial
Incentive Type	PBI
PV System Specifications:	
PV Module	Sharp Corporation:ND-200U1F 200.0W STC, 176.0W PTC
Number of Modules	600
Mounting Method	>3" to 6" average standoff
DC Rating (kW STC)	120.0000
DC Rating (kW PTC)	105.6000
Inverter	SatCon Power Systems Canada Ltd.:AE-135-60-PV-A
Number of Inverters	1
Inverter Efficiency (%)	95.50 %
Shading	Minimal Shading
Array Tilt (degrees)	10
Array Azimuth (degrees)	180

True North 0°

Results

Annual kWh	163,010
Summer Months	May-October
Summer kWh	98,673
CEC-AC Rating	**100.848 kW**
Capacity Factor[1]	18.452%
Prevailing Capacity Factor[2]	20.000%
Design Factor[3]	**92.260%**
Incentive Rate	**$0.22/kWh**
Incentive[4]	**$179,311**
Report Generated on	5/1/2008 3:43:23 PM

The CSI-EPBB calculator is a tool available to the public and participants of the CSI program, whose sole purpose is to determine the EPBB Design Factor and calculate an appropriate incentive level based on a reasonable expectation of performance for an individual system. The results of the calculator should not be interpreted as a guarantee of system performance. Actual performance of an installed PV system is based on numerous factors, and may differ with the results summarized in the CSI-EPBB calculator. For this reason, contractors, participating customers, and other interested parties should only utilize the calculator to determine an appropriate incentive when applying to the CSI incentive program. Additional uses for the calculator other than its intended purpose as stated above are not endorsed or encouraged.

Notes:

1. **Capacity Factor**: This is the estimated annual output of the proposed system divided by 8760 times the CEC-AC rating.
2. **Prevailing Capacity Factor**: This is 18% during incentive steps 2 and 3 and 20% during incentive steps 4 through 10.
3. **Design Factor**: This is the ratio of the Capacity Factor and the Prevailing Capacity Factor.
4. **Incentive**: This is the estimated total incentive for the proposed system, and is calculated as the estimated annual output times the incentive rate times 5 years. The incentive paid will be based on the actual production of the installed system.
5. As of 8/10/07, the CSI-EPBB calculator performs rounding as follows:
   - Estimated kWh production is rounded to the kWh
   - CEC-AC rating is rounded to the watt
   - Capacity factor is rounded to 5 significant digits
   - Design factor is rounded to 5 significant digits

Name: Car Dealership	**Date:** 5/8/2008	
System Size: 100 Kw AC (CEC)		
FULL SYSTEM PRICE (out-of-pocket cost)	$825,000	
FEDERAL TAX CREDIT (30%)	($247,500)	
Note: This could revert to 10% after 1/1/2009 if current law is not extended		% of full cost
NET COST AFTER TAX CREDIT	$577,500	70%
TOTAL FED. TAX DEPRECIATION (over 5 years at 30% tax bracket)	($210,375)	
TOTAL STATE TAX DEPRECIATION (over 5 years at 7% tax bracket)	($49,088)	
NET COST AFTER DEPRECIATION	$318,038	39%
CSI PBI PAYMENTS (estimated total over 5 years @ $.22/Kwh)	($179,311)	
Note: These payments are taxable		
CSI PBI PAYMENTS (tax adjusted)	($112,966)	
NET COST AFTER 5 YEARS (all financial incentives deducted)	$205,072	25%
AVERAGE YEARLY PRODUCTION (Kwh)	163,000	
AVERAGE UTILITY COST PER Kwh	$0.165	
YEARLY SAVINGS, FIRST YEAR	$26,895	
YEARLY SAVINGS (tax adjusted)	$16,944	
YEARS TO PAYBACK, NO RATE INCREASES	12.1	
YEARS TO PAYBACK, 6% ANNUAL RATE INCREASES	9.5	

PV Sales-Installation Process

- **STEP 1: Complete an Energy Survey**
- **STEP 2: Contact and Choose an Installer**

INSTALLER HANDLES THE REST

- **STEP 3: Complete and Submit Applications for CSI**
- **STEP 4: Obtain Building Permits**
- **STEP 5: Install System**
- **STEP 6: Schedule Final Building Inspection**
- **STEP 7: Schedule Final Utility Inspection**
- **STEP 8: Claim Incentives**

Find Installers

- **Personal references**
- **CSI website**

  http://gosolarcalifornia.org
- **CalSEIA Members**

  http://calseia.org/, “Find an Expert” link
- **Internet**
- **Advertising**
- **Better Business Bureau**
- **Diamond Certified**

Comparing Bids: DC vs. AC watts

- DC watts are “name only”
- DC rating is determined under Standard Test Conditions (STC), not real-world
- DC must be changed to AC before use

DC system size: 20 Sharp 200-watt modules

= 20 x 200 = 4000 watts = 4.0 kW DC

Comparing Bids: DC vs. AC watts

Lookup CEC ratings for panels.

Manufacturer Name	Module Model Number	Description	CEC PTC* Rating	BIPV (Y/N)	Crystalline Module (Y/N)	Notes
Sharp Corporation	ND-187U1F	187W Multisilicon Module	164.8	N	Y	NA
Sharp Corporation	ND-187U2	187W Multisilicon Module	164.8	N	Y	NA
Sharp Corporation	ND-200U1	200W Multi-crystalline Silicon Module	176	N	Y	NA
Sharp Corporation	ND-200U1F	200W Multisilicon Module	176	N	Y	NA
Sharp Corporation	ND-200U2	200W Multisilicon Module	176.1	N	Y	NA
Sharp Corporation	ND-205U1	205W Multi-crystalline Silicon Module	180.6	N	Y	Added 4/22/2005.
Sharp Corporation	ND-208U1	208W Multisilicon Module	183.3	N	Y	NA

http://www.gosolarcalifornia.org/equipment/

Comparing Bids: DC vs. AC watts

Lookup CEC ratings for inverters.

Manufacturer Name	Inverter Model number	Description	Power Rating (Watts)	Weighted Efficiency	Approved Built-in Meter	Notes
SMA America	SB3800U (240V)	3.8kW, 240Vac Sunny Boy Utility Interactive Inverter with display	3800	94.5	Yes	Added 7/13/2005
SMA America	SB4000US (208V)	4kW, 208Vac Sunny Boy Utility Interactive Inverter with display	4000	95.5	Yes	None
SMA America	SB4000US (240V)	4kW, 240Vac Sunny Boy Utility Interactive Inverter with display	4000	96	Yes	None
SMA America	SB5000US (208V)	5kW, 208Vac Sunny Boy Utility Interactive Inverter with display	5000	95.5	Yes	None
SMA America	SB5000US (240V)	5kW, 240Vac Sunny Boy Utility Interactive Inverter with display	5000	95.5	Yes	None

http://www.gosolarcalifornia.org/equipment/

Comparing Bids: DC vs. AC watts

- AC watts are “real power”
- AC rating is determined under Practical Test Conditions (PTC), real-world
- AC takes efficiency losses into account

AC system size: 20 Sharp 200-watt modules

PTC rating 176 watts, inverter efficiency 96%

= 20 x 176 = 3520 watts x .96 = 3379 watts

= 3.38 kW AC

Comparing Bids: DC vs. AC watts

System size: 20 Sharp 200-watt modules
1 SMA SB 4000US inverter

4.0 kW DC **3.38 kW AC** (CEC rating)

DC is about 18% more, but misleading.
AC is the important number, and if installer only gives DC numbers ask for CEC AC size.

Comparing Bids: Per-watt price

1. **Full price**, ***before*** **incentives. This includes all "adders" (such as extra roof charges), and extras (such as monitoring), an estimate for permit fees (around $300), and taxes.**
2. **The system size in similar units: CEC AC watts is the preferred measurement.**
3. **The per-watt price. This is determined by dividing the full price by the system size. This is the "unit price" that allows you to compare "apples to apples". It will typically be around $6.50/watt.**

Comparing Bids: Per-watt price

Base price:	$20,000
Roof adder:	$2,000
Permit fee:	$500
Total:	$22,500

System Size:
4.0 Kw DC
3.38 Kw AC (CEC)
(3,380 watts)

Per-watt price:

$22,500 / 3,380 = $6.65/watt

Comparing Bids: Group discount

Three options:

1. **20 Sharp 185 panels, 3.19 Kw AC, $6.05/watt**
2. **20 Evergreen 180 panels, 3.12 Kw AC, $6.45/watt**
3. **20 Kyocera 190 panels, 3.28 Kw AC, $6.90/watt**

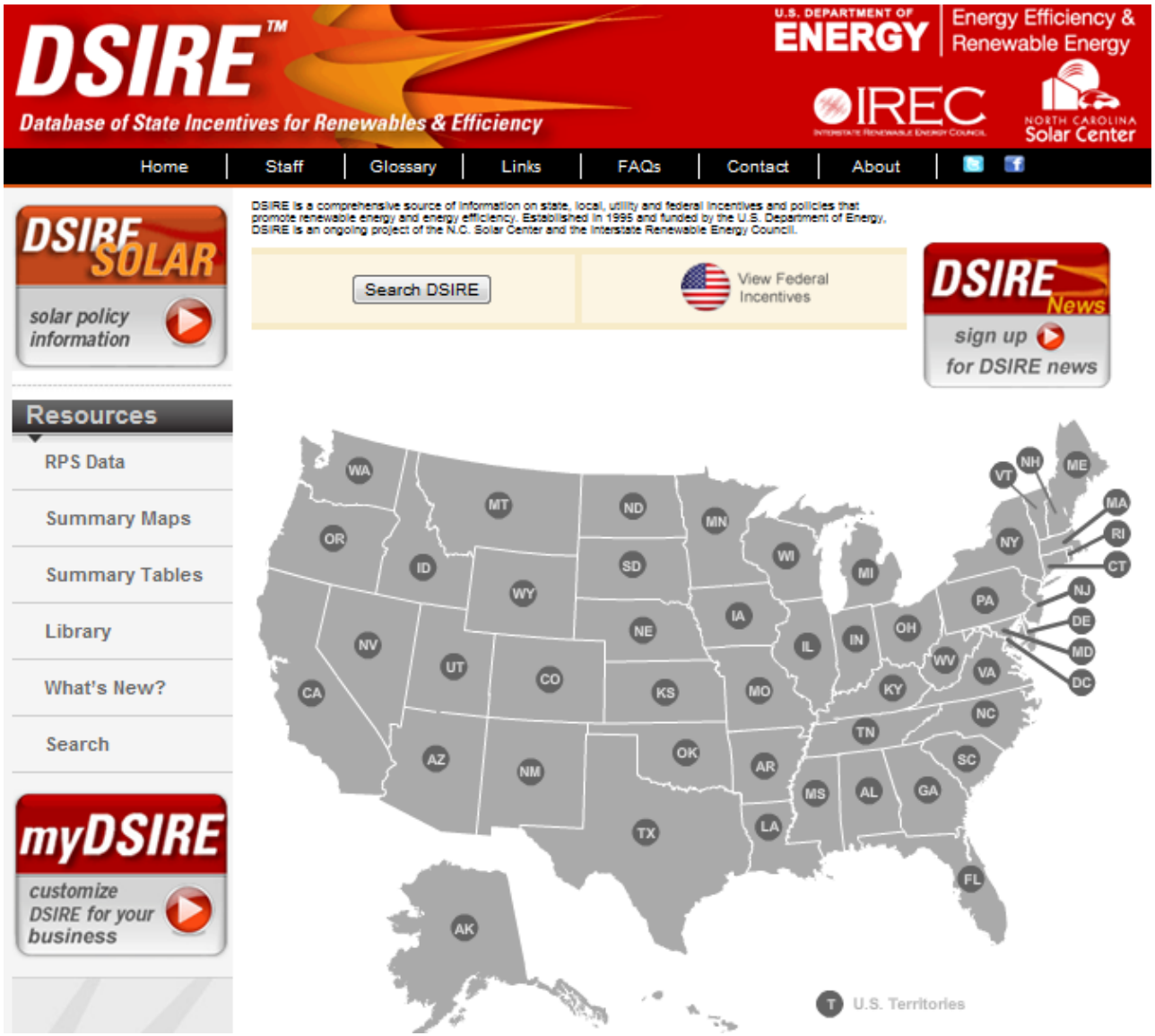
If group target of 100 kW is met, price will drop to $6.00/watt

Review of Learning Objectives

Class Quiz

Jobs Overview
and
Future Trends

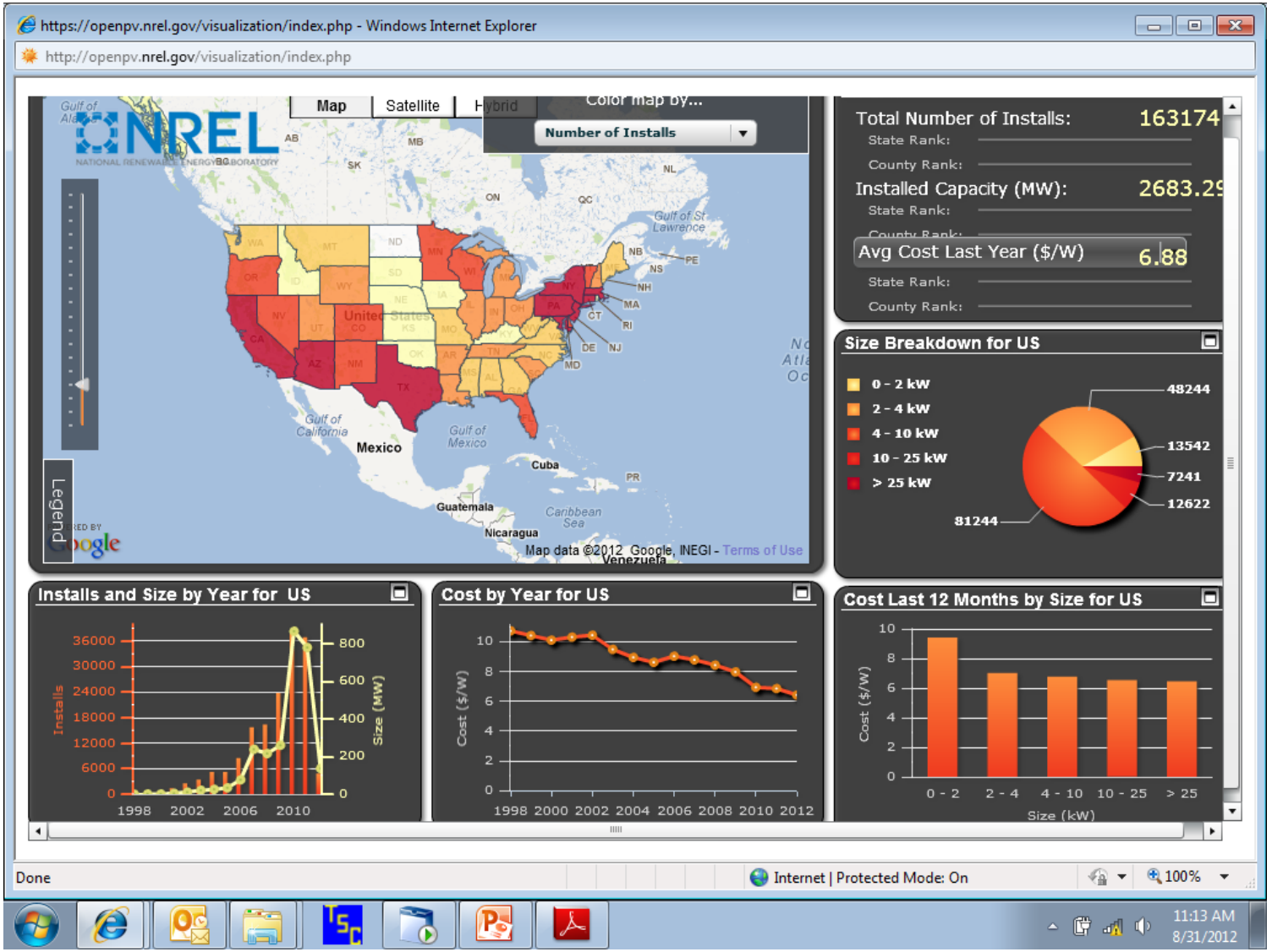
Solar Incentive Data: National and State



http://www.dsireusa.org/

Courtesy DOE

Solar Installation Data: National and State



http://openpv.nrel.gov/visualization/index.php

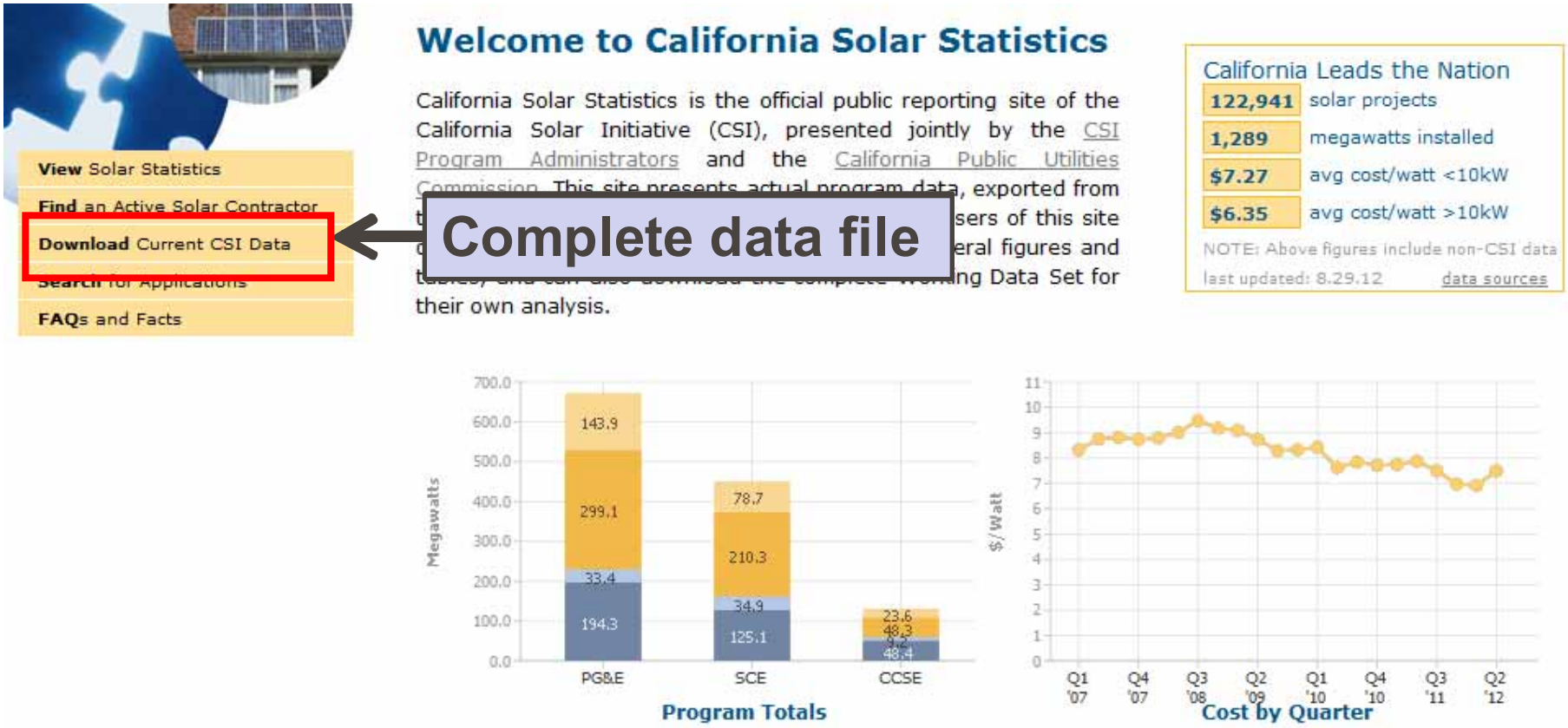
Courtesy NREL

Solar Installation Data: State

http://www.gosolarcalifornia.org/

Courtesy CSI

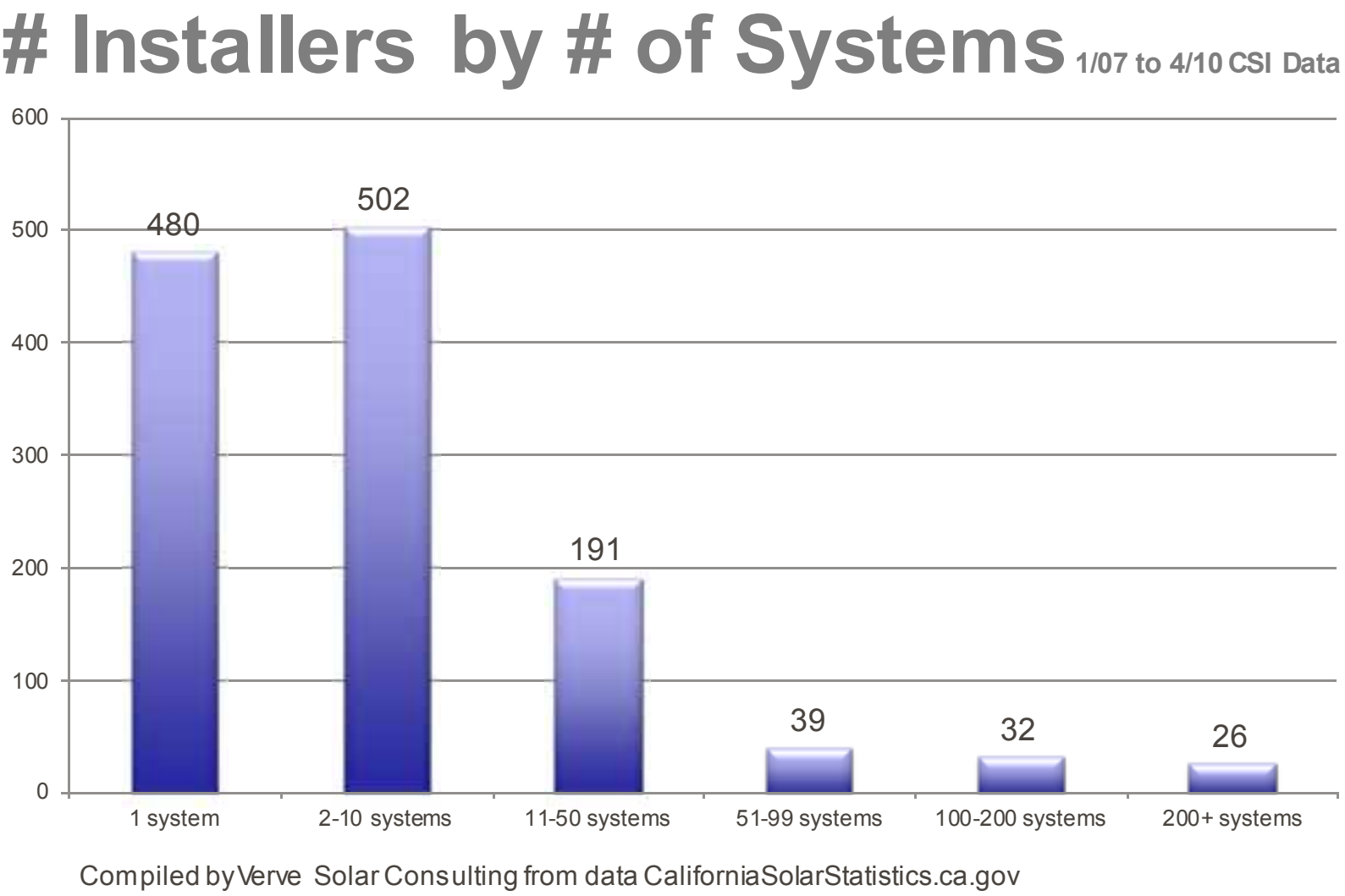
Solar Installation Data: State



Courtesy CSI

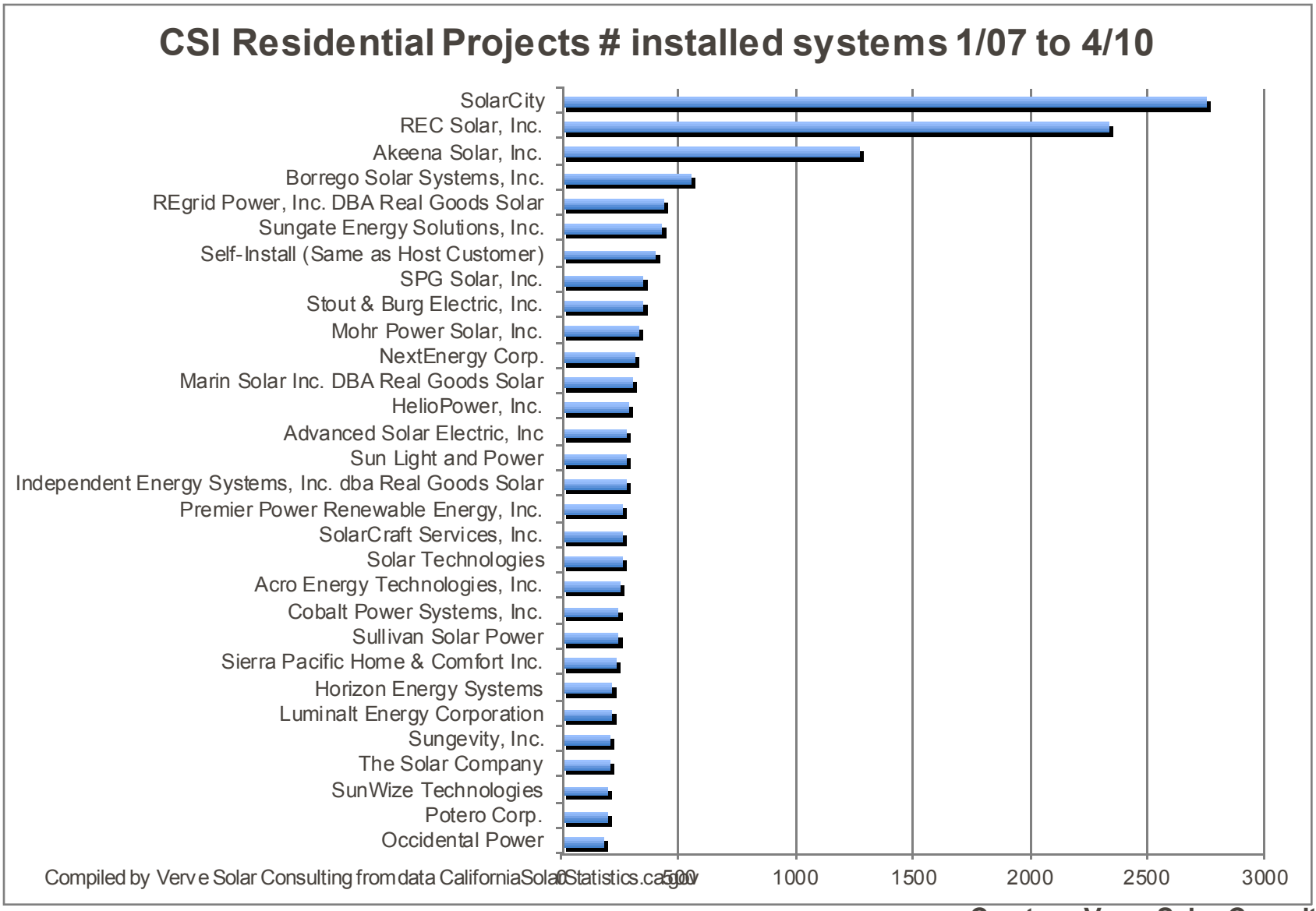
http://www.gosolarcalifornia.org/

Information Available from Analysis of Full Data File



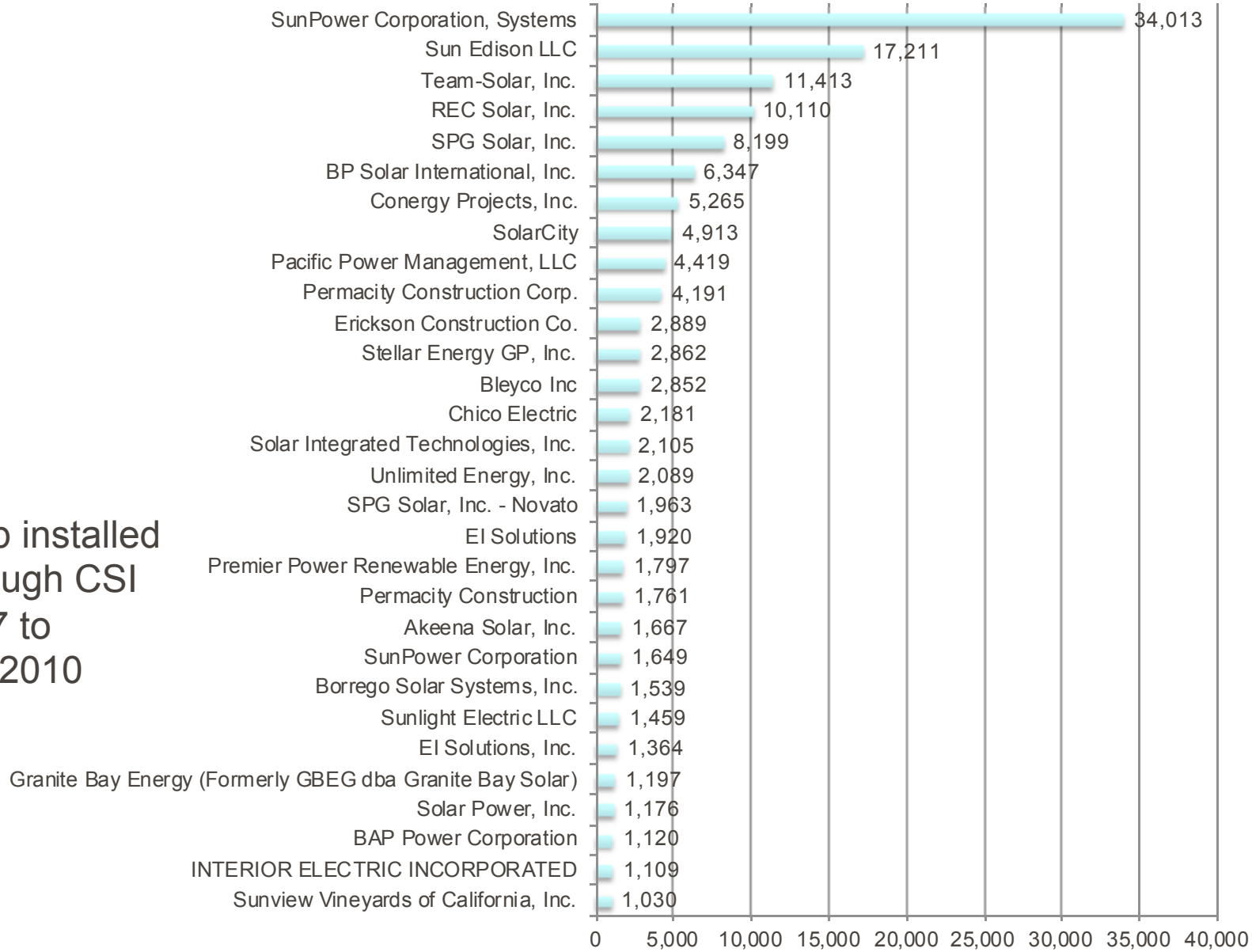
Courtesy Verve Solar Consulting

Top 30 Residential Installers by total # installs



Courtesy Verve Solar Consulting

Top 30 Lg Commercial CSI Installers



kWp installed through CSI 1/07 to 4/7/2010

Compiled by Verve Solar Consulting from data CaliforniaSolarStatistics.ca.gov

Courtesy Verve Solar Consulting

Solar job trends

Courtesy Verve Solar Consulting

SWIC Employer Surveys
2011 Summary Report
Workforce and Hiring Trends with a California focus

SAN JOSÉ STATE
UNIVERSITY

SolarTech
An initiative of Silicon Valley Leadership Group

http://library.constantcontact.com/download/get/file/1105585926298-73/SWIC_EmployerSurvey_SummaryReport_1.23.2011.pdf

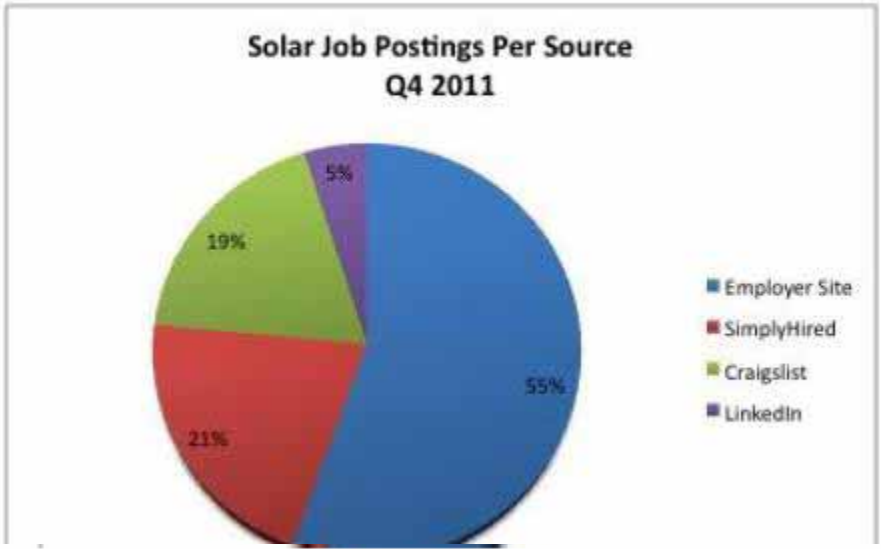
SWIC Weekly Jobs Report Summary
Q4 2011

Solar – Total Unique Q4 2011 Postings: 590
Sources of Data: Employer Websites, Craigslist, SimplyHired, LinkedIn
Regional Scope: San Francisco Bay Area (includes North Bay, East Bay, San Francisco, Peninsula, and South Bay)

The total number of job postings in Q4 2011 was 2,116. However, after the list was deduplicated, the total number of unique job postings was 590.

Solar Postings Per Source

- Employer sites: 328
- SimplyHired: 124
- Craigslist: 109
- LinkedIn: 29

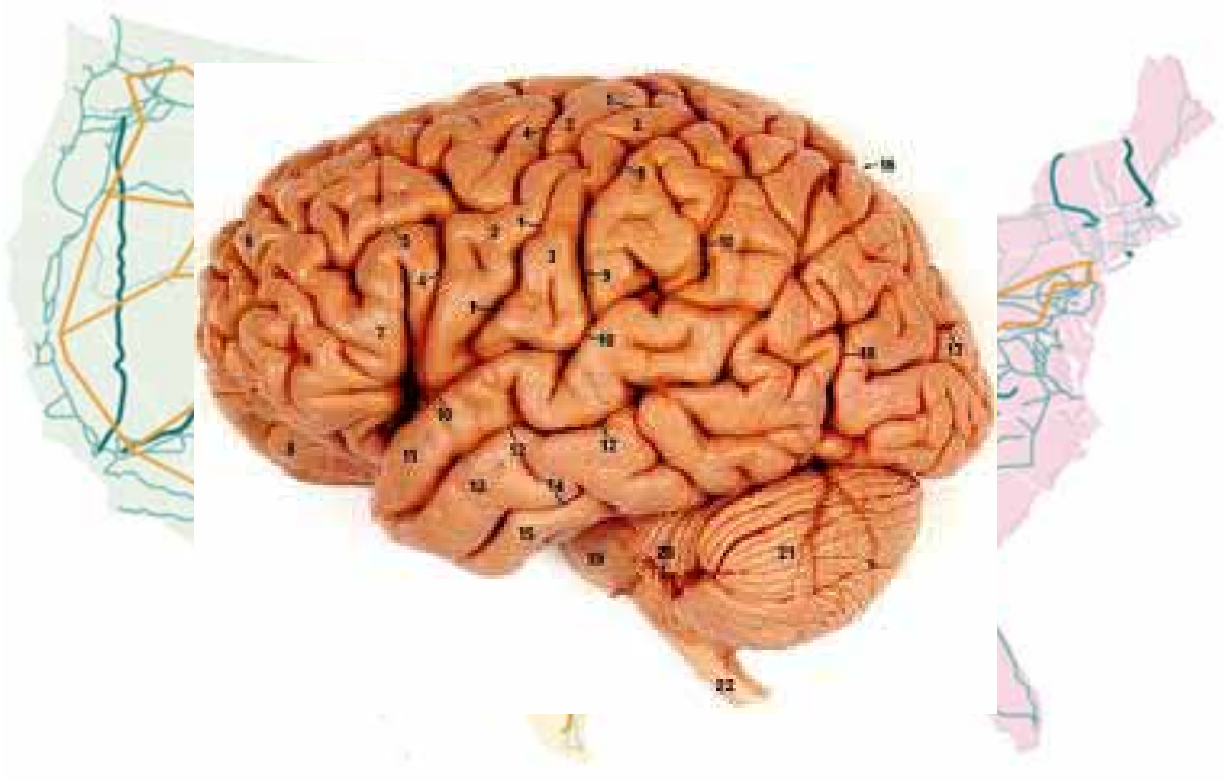


http://library.constantcontact.com/download/get/file/1105585926298-74/2011Q4_SWIC_JobsReport_Summary_1+23+2012.pdf

PV Job Categories

- Lead Generator (canvasser, outside sales)
- Sales 1 (inside sales, lead qualifier)
- Sales 2 (field rep, closer)
- Project Developer (creating and selling large, longer-term projects)
- Designer 1 (pre-sale, estimation)
- Designer 2 (typical designer category, creates plans and drawings)
- Designer 3 (large-scale, commercial)
- Project Manager (post-sale, operations)
- Application Processor (paperwork, rebates, etc.)
- Permit Processor (w/ building officials, inspections)
- PV Installer 1 (laborer, apprentice, entry level)
- PV Installer 2 (typical crew member)
- Installer Crew Lead
- Monitoring / Maintenance
- Technician / Troubleshooter
- Safety Manager
- Financial Operations (work with banks, etc.)
- HR / Hiring
- Marketing

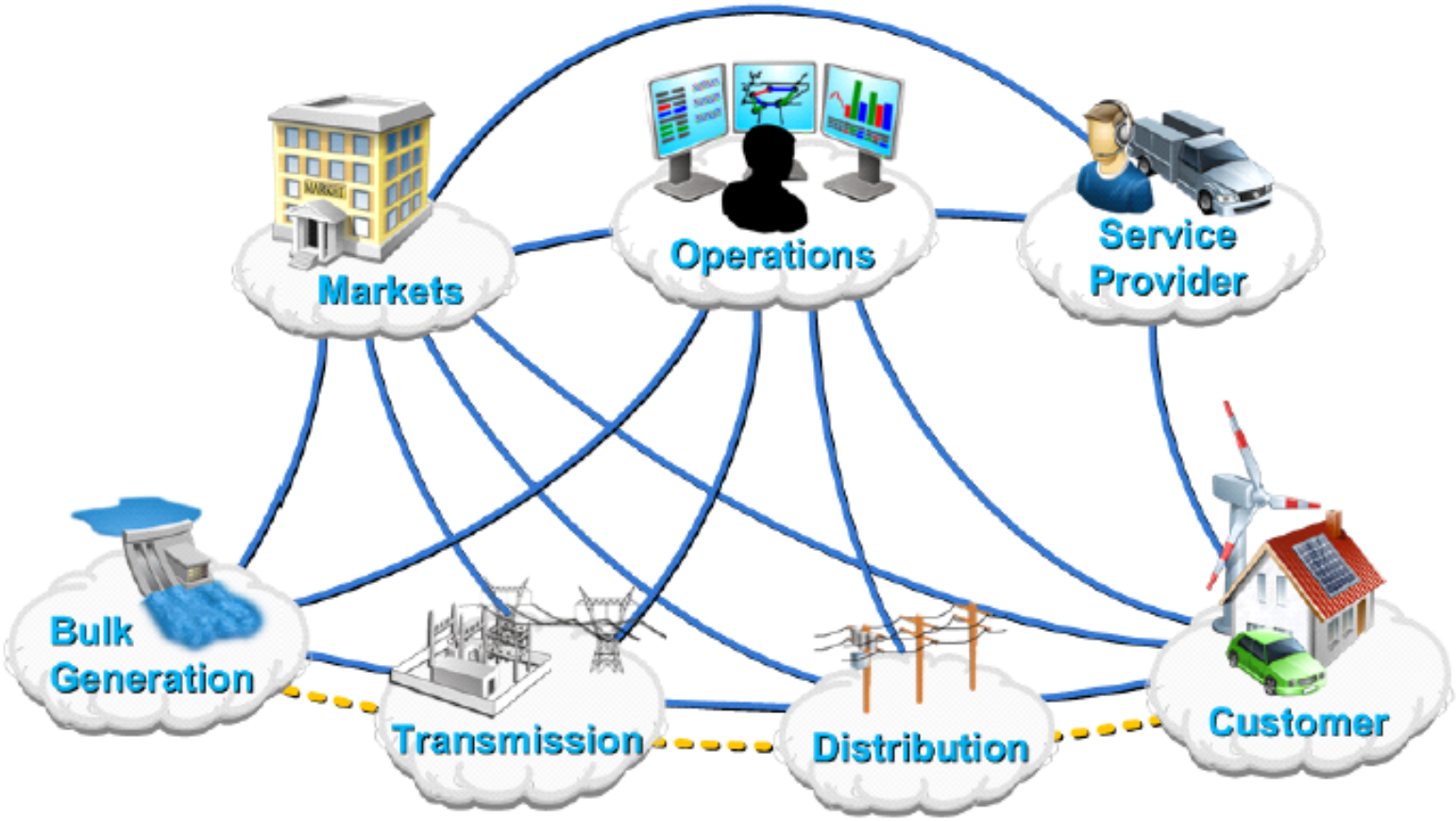
Smart Grid



Adding information technology to the electric grid infrastructure

http://www.smartgridnews.com/artman/publish/Technologies_Communications_Resources/CSR-2009-Environment-The-Smart-Grid-Vision-1563.html

Smart Grid



Source: NIST

Adding information technology to the electric grid infrastructure

A Smart Grid

Overlay with intelligence and automation

Sense

Communicate

Compute

Control

Power Plants

Transmission Networks

Substations

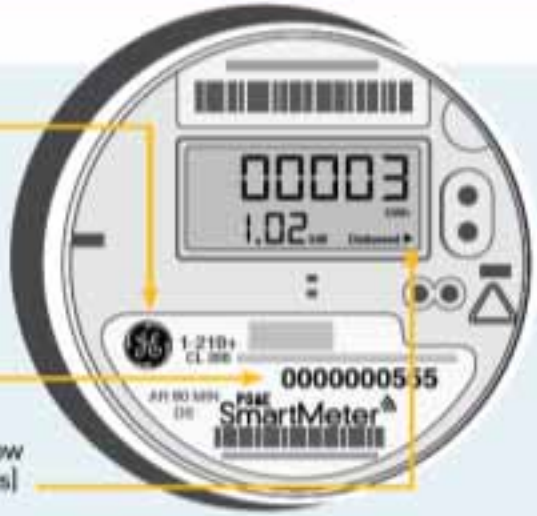
Distribution Networks

Consumers

Courtesy PG&E

Smart Meter

How to read your GE-brand electric meter.



1. **GE Logo:** Confirm you have a GE-brand meter
2. **Meter Number:** This is the number shown in the Electric Account Detail of your energy statement under the heading Meter #
3. **Digital Display Window:** Check your energy use (see below and right for display descriptions)

Your GE SmartMeter™ electric meter automatically cycles through four displays.

A

The **five-digit number at the top** is the amount in kilowatt hours (kWh) of energy you have used to date since the installation of the meter. For reference, if you leave a 100-watt light bulb on in your home for one hour per day for 30 days, the energy used is 100 watts × 30 hours = 3,000 watt hours, or 3 kWh. The **three-digit number at the bottom** is the actual amount of energy you're using right now. For instance, 1.02 means you're using 1.02 kilowatts—or 1,020 watts.

B

The **number 88888** with all the elements lit verifies that the display is working properly. The **three-digit number at the bottom** is the actual voltage (or electrical potential) right now.

C

On indicates the switch is closed, and power is being delivered. **Off** indicates the switch is open, and power is not being delivered.

D

Adl (for Advanced Distribution Infrastructure) displays when the meter is communicating with the on-board SmartMeter™ module. **Delivered,** at the bottom right of the displays, indicates use. If there is no power being used, it doesn't display.

Gas Meter with SmartMeter™ Module

Gas Meter Module

- Attaches to existing gas meters
- Measures 5.5 x 6.5 inches
- Transmits wireless signals to the Data Collector Unit
- 20 year life span
- A.k.a. Meter Transmission Unit (MTU)

Electric Network Components

Meters | Relays | Access Points | 3G Cellular Network | Head End

Utility IQ

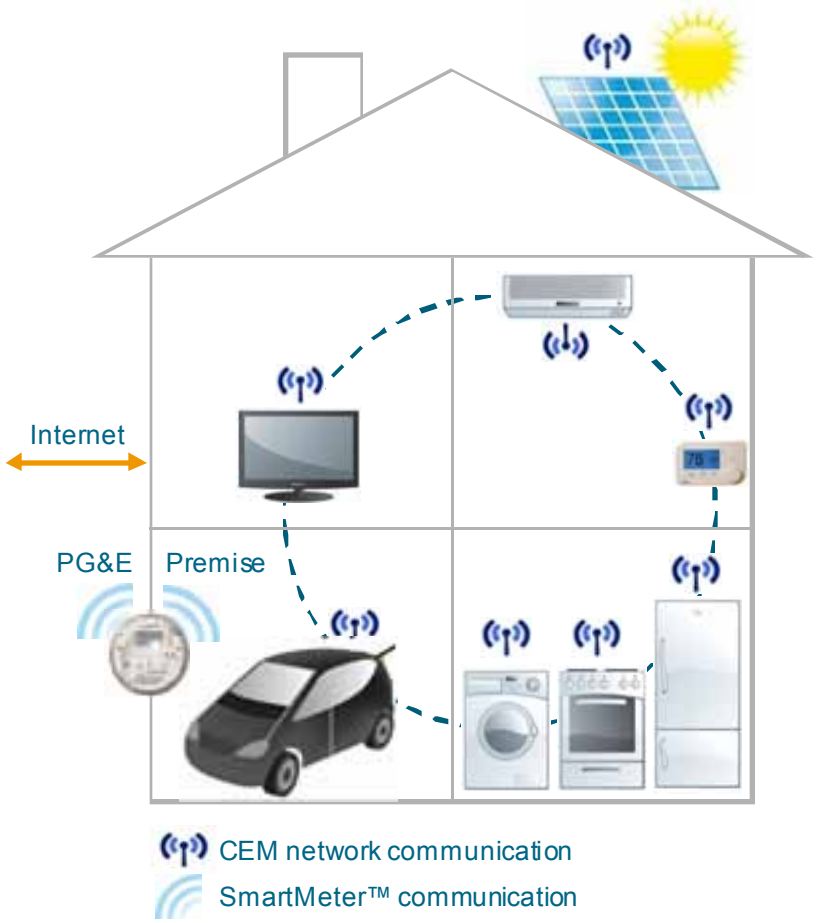
A Platform for Innovation
Customer Energy Management

From meter to the home

- Near-time electric usage information
- Timely price signals
- Appliance / energy management control signals

From meter to utility

- Customer electric use
- Customer energy generation (e.g. solar)
- Appliance response to energy management control signals



Don’t forget the bottom line

Paper

Wealth

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Pacific Gas and Electric Company
Pacific Energy Center