Solar Electricity for PA Homeowners

August 13, 2014

Kalmbach Memorial Park

Macungie, PA

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About…

Mid-Atlantic Renewable Energy Association
A nonprofit 501(c)3 organization, dedicated to informing and educating the public on renewable energy production, energy efficiency, and sustainable living through meetings, workshops, educational materials, and energy fairs. (www.themarea.org)

Penn State World Campus
Energy and Sustainability Policy
BA degree, Online

Tonight…

- How Solar Electric Works
- Estimating Electricity Generation from Solar
- Solar Site Requirements
- Financial Considerations
- SunnyMoney
- Environmental Impact (or lack thereof)

All on-line resources used in this presentation are listed with links, following the last slide.

Lehigh County "Sunshine" Rebates

- Residential Rebates
  - Number of Systems = 183 (9th highest)
  - Average Size = 7.4 kW
  - Total = 1,348 kW
- Commercial (Small Business) Rebates
  - Number of Systems = 19 (15th highest)
  - Average Size = 78.2 kW
  - Total = 1,486 kW
- For full report (all counties), see "PA Sunshine Counts, Our Common Solar Wealth," available from MAREA (free) at www.themarea.org

For more info and easy on-line access, see list of links at end of this presentation

The amount of the sun's energy that reaches the surface of the Earth every hour is greater than the total amount of energy that the world's human population uses in a year.

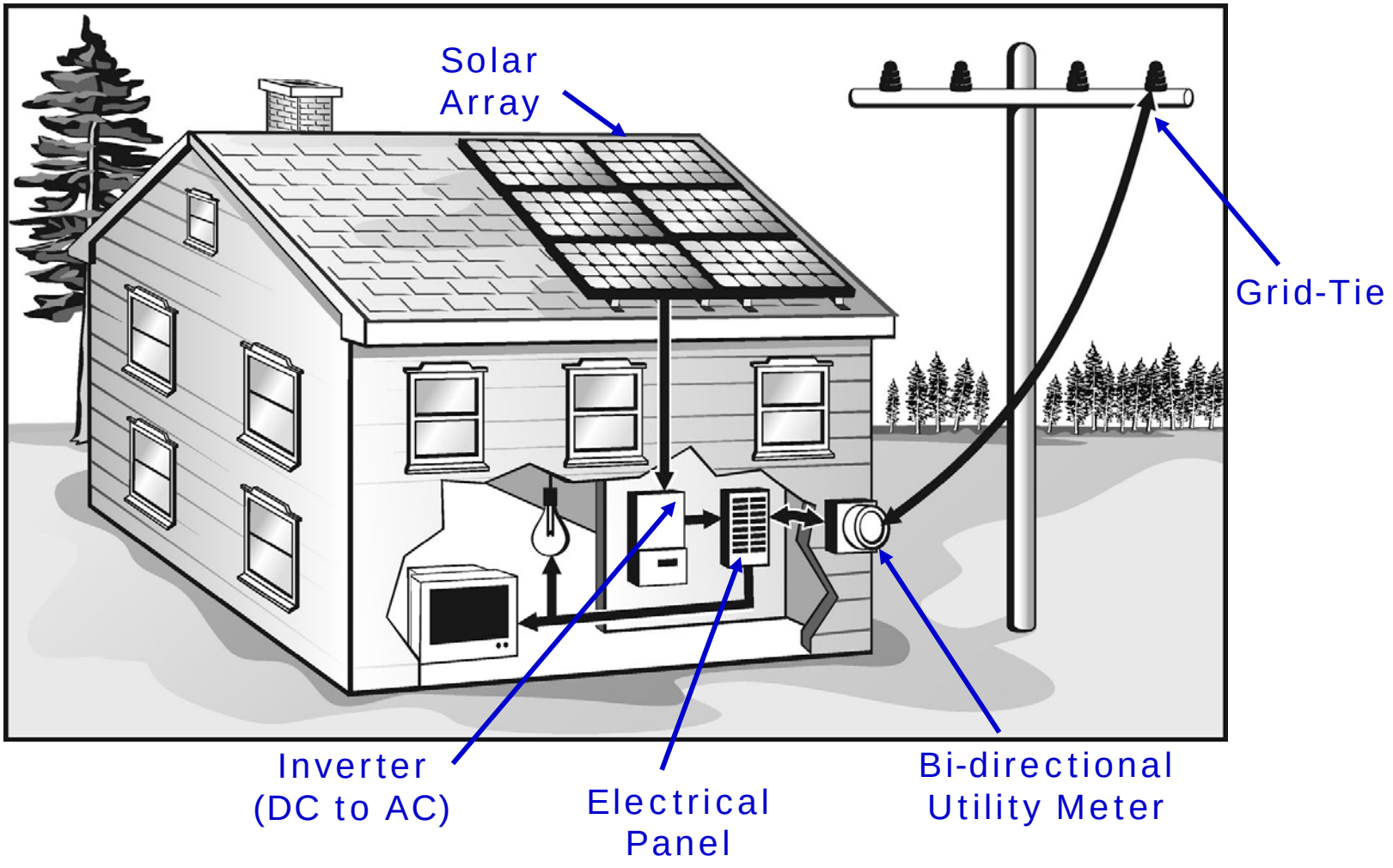
“Solar Energy”

- Passive Solar
- Solar Hot Water
- Concentrating Solar
- *Photovoltaics*

Small Scale (Residential)

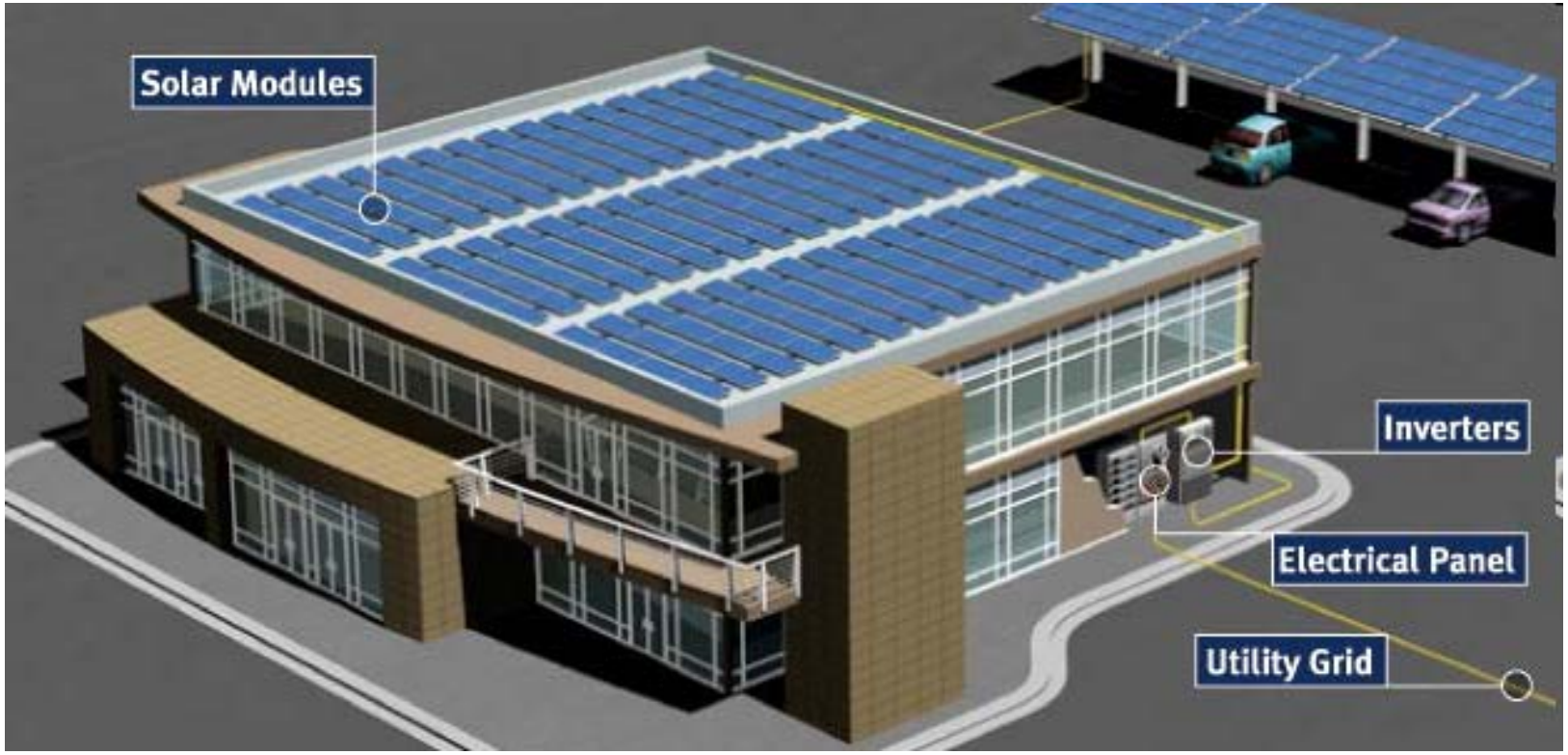
DeSoto Next Generation Solar Energy Center (25 MW)

Grid-Tied Solar Electric

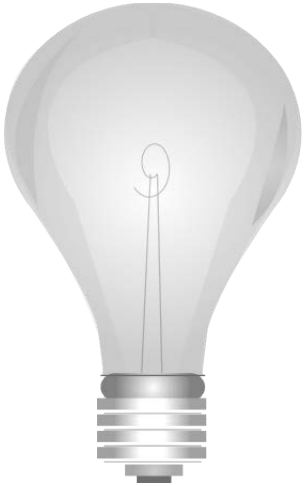


Installed Components

Small-Business Solar

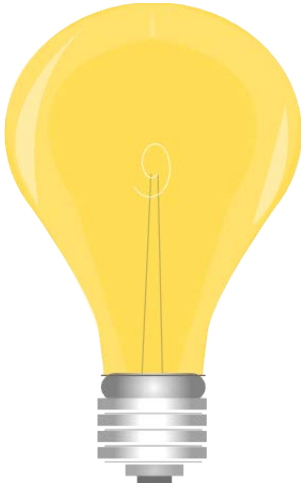


Power and Energy



POWER

Watts



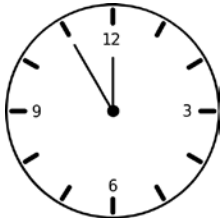
ENERGY

Watt-hours (Wh)

Installed…

25 Watt bulb

150 Watt bulb

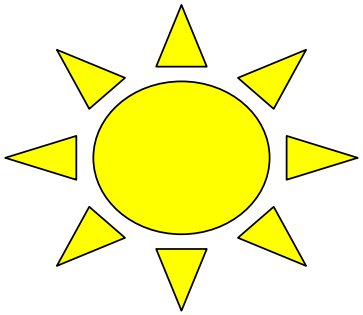


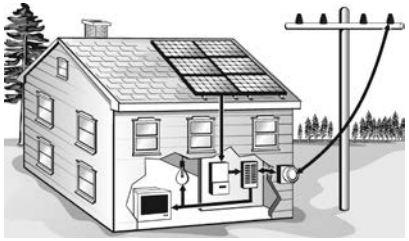
On for two hours…

50 Watt-hours

300 Watt-hours

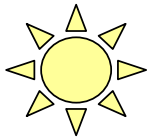
2.4 kW System, Allentown, PA

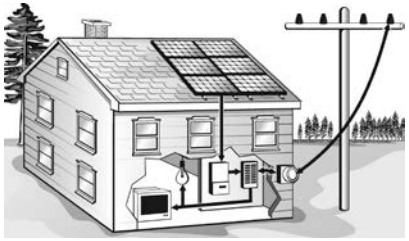




Typical July

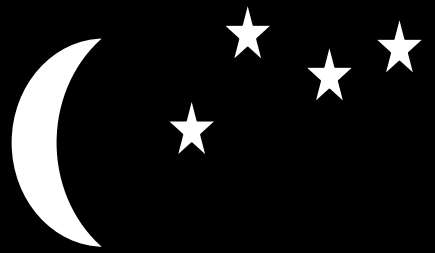
283 kWh





Typical November

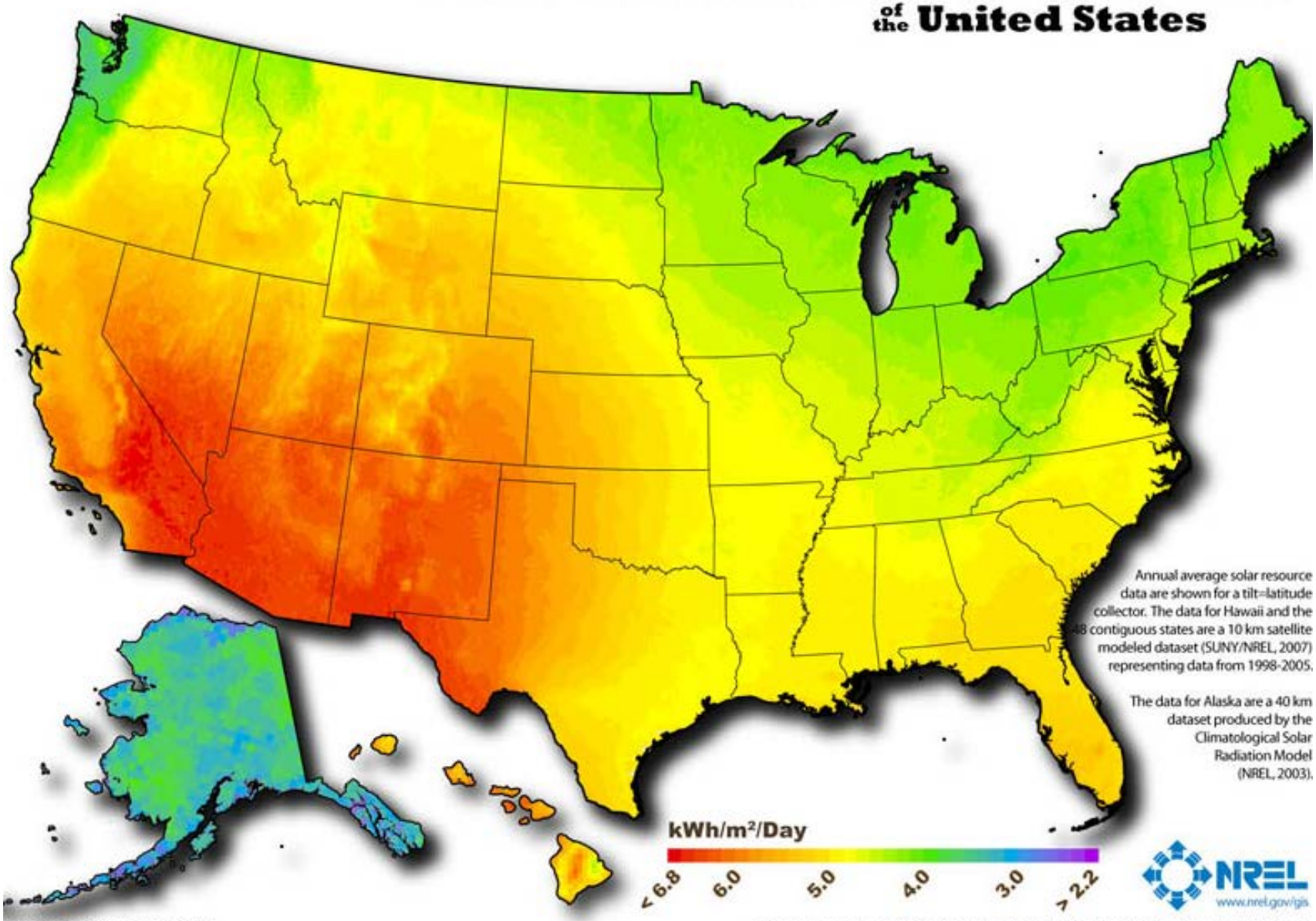
159 kWh



Night time

0 kWh

Photovoltaic Solar Resource of the United States



Annual average solar resource data are shown for a tilt=latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.

The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

NREL
www.nrel.gov/gis

Author : Billy Roberts - October 20, 2008

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Estimating Electricity Generation

- The amount of electricity generated depends on solar array's **power rating** and available **sunlight** (fuel!)
- Power rating is measured in Watts (W) or kilowatts (kW), where 1 kW = 1,000 W
- Sunlight is energy, measured in kWh/m2/day, where kWh = kilowatt-hours or 1,000 Wh.

Annual Estimated Production

Each module = 240 W_{DC}

12 modules = 2,880 W

Array power = 2.88 kW

In Allentown area, this system will generate about 2,369 kWh/yr

In Tucson, AZ, this system will generate about 4,789 kWh/yr

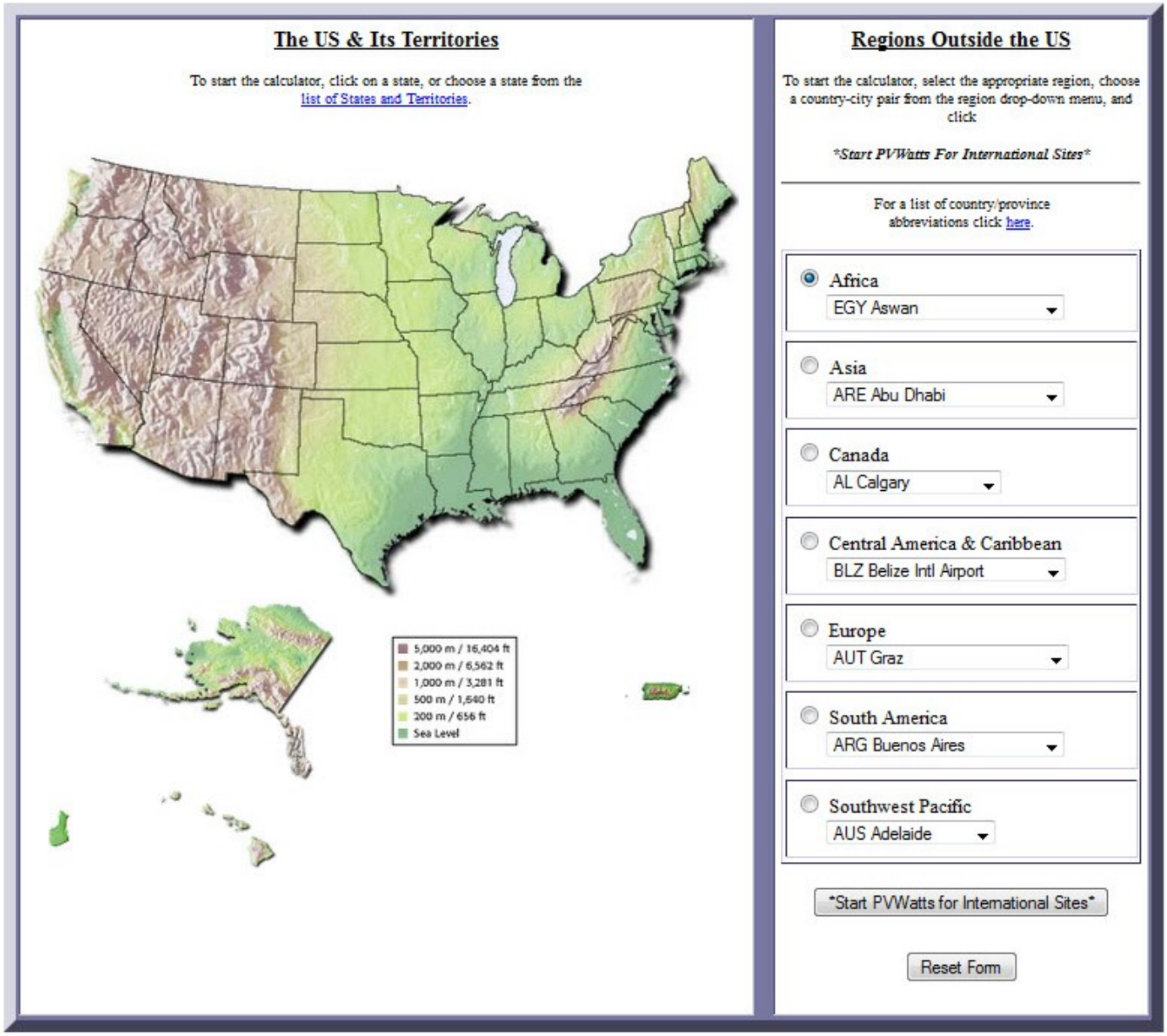
(NREL PVWatts, version1)

PVWatts® Calculator

"…a web application developed by the National Renewable Energy Laboratory (NREL) to estimate the electricity production of a grid-connected roof- or ground-mounted photovoltaic (PV) system based on a few simple inputs that allow homeowners, installers, manufacturers, and researchers to easily gauge the performance of hypothetical PV systems that use crystalline modules."

NOTE: NREL has recently posted a test ("beta") version of a newly formatted PV Watts. For now, MAREA recommends use of the established "Version 1." Screenshots & links in this presentation are for "Version 1," not beta version.

For more info and easy on-line access, see list of links at end of this presentation



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PVWatts

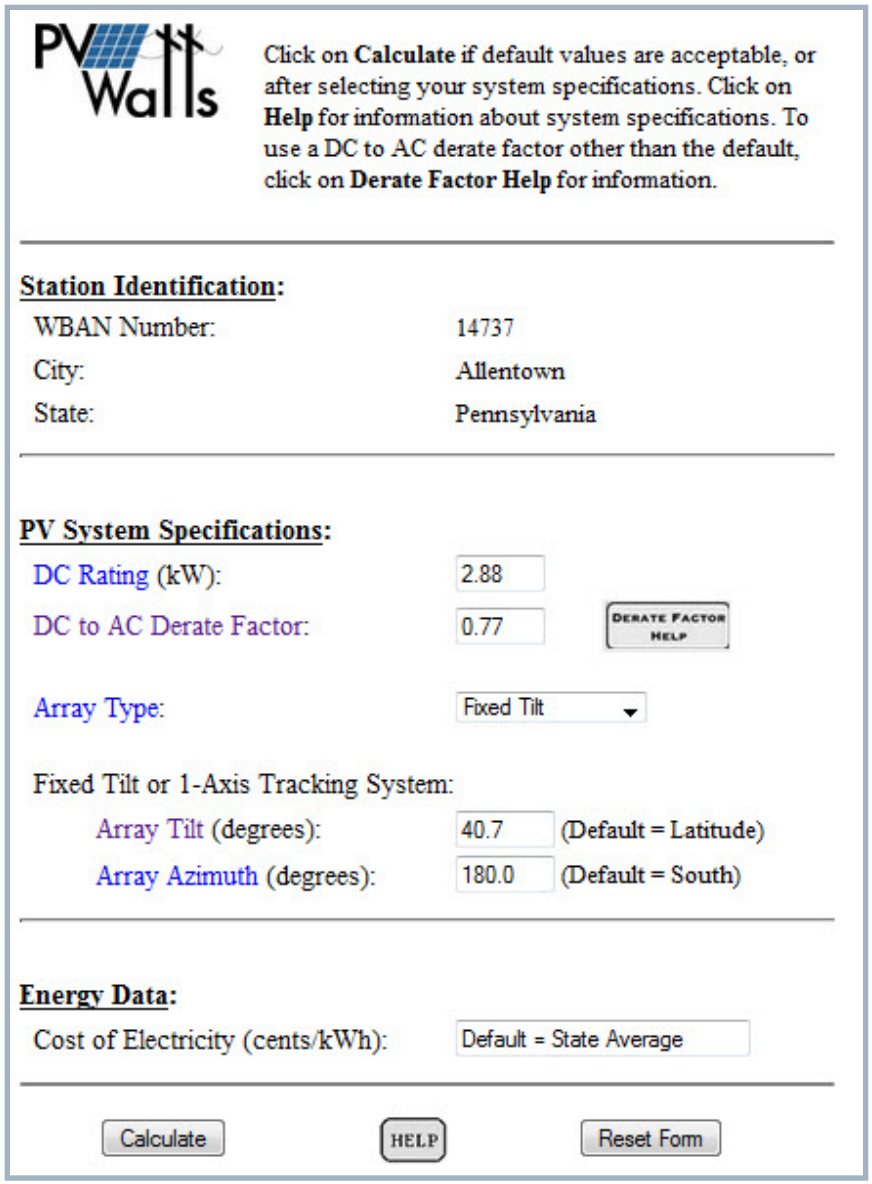
Click on the site where you want to use PVWATTS to calculate the electrical energy produced. Choose the site nearest to your location that has similar topography. If near a state border, you may wish to review site locations in the adjacent state.

Pennsylvania

Adjacent States:

Delaware Maryland New Jersey New York Ohio West Virginia

For more info and easy on-line access, see list of links at end of this presentation



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Station Identification	
City:	Allentown
State:	Pennsylvania
Latitude:	40.65° N
Longitude:	75.43° W
Elevation:	117 m
PV System Specifications	
DC Rating:	2.9 kW
DC to AC Derate Factor:	0.770
AC Rating:	2.2 kW
Array Type:	Fixed Tilt
Array Tilt:	40.7°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	9.6 ¢/kWh

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.22	231	22.18
2	3.85	247	23.71
3	4.71	325	31.20
4	5.24	337	32.35
5	5.24	329	31.58
6	5.25	314	30.14
7	5.57	339	32.54
8	5.23	319	30.62
9	4.85	296	28.42
10	4.37	286	27.46
11	2.93	191	18.34
12	2.81	196	18.82
Year	4.44	3411	327.46

For more info and easy on-line access, see list of links at end of this presentation

/

PV Watts uses a “derating factor” to make realistic estimate of output. For more info, see HELP in PV Watts or use link below.

Calculator for Overall DC to AC Derate Factor

Component Derate Factors	Component Derate Values	Range of Acceptable Values
PV module nameplate DC rating	0.95	0.80 - 1.05
Inverter and Transformer	0.92	0.88 - 0.98
Mismatch	0.98	0.97 - 0.995
Diodes and connections	0.995	0.99 - 0.997
DC wiring	0.98	0.97 - 0.99
AC wiring	0.99	0.98 - 0.993
Soiling	0.95	0.30 - 0.995
System availability	0.98	0.00 - 0.995
Shading	1.00	0.00 - 1.00
Sun-tracking	1.00	0.95 - 1.00
Age	1.00	0.70 - 1.00
Overall DC to AC derate factor	**0.77**	*(PVWATTS Default)*

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Solar Site Requirements

- 1 installed kW requires *about* 75 ft^2 of area. For example, an 8 kW array would need about 600 ft^2 of roof or yard space.
- Area needs to be
  - **unshaded** (9 am – 3 pm)
  - **south facing**
- Will need access to existing electrical service (main panel)

2.88 kW Roof Mount

Roof Mount

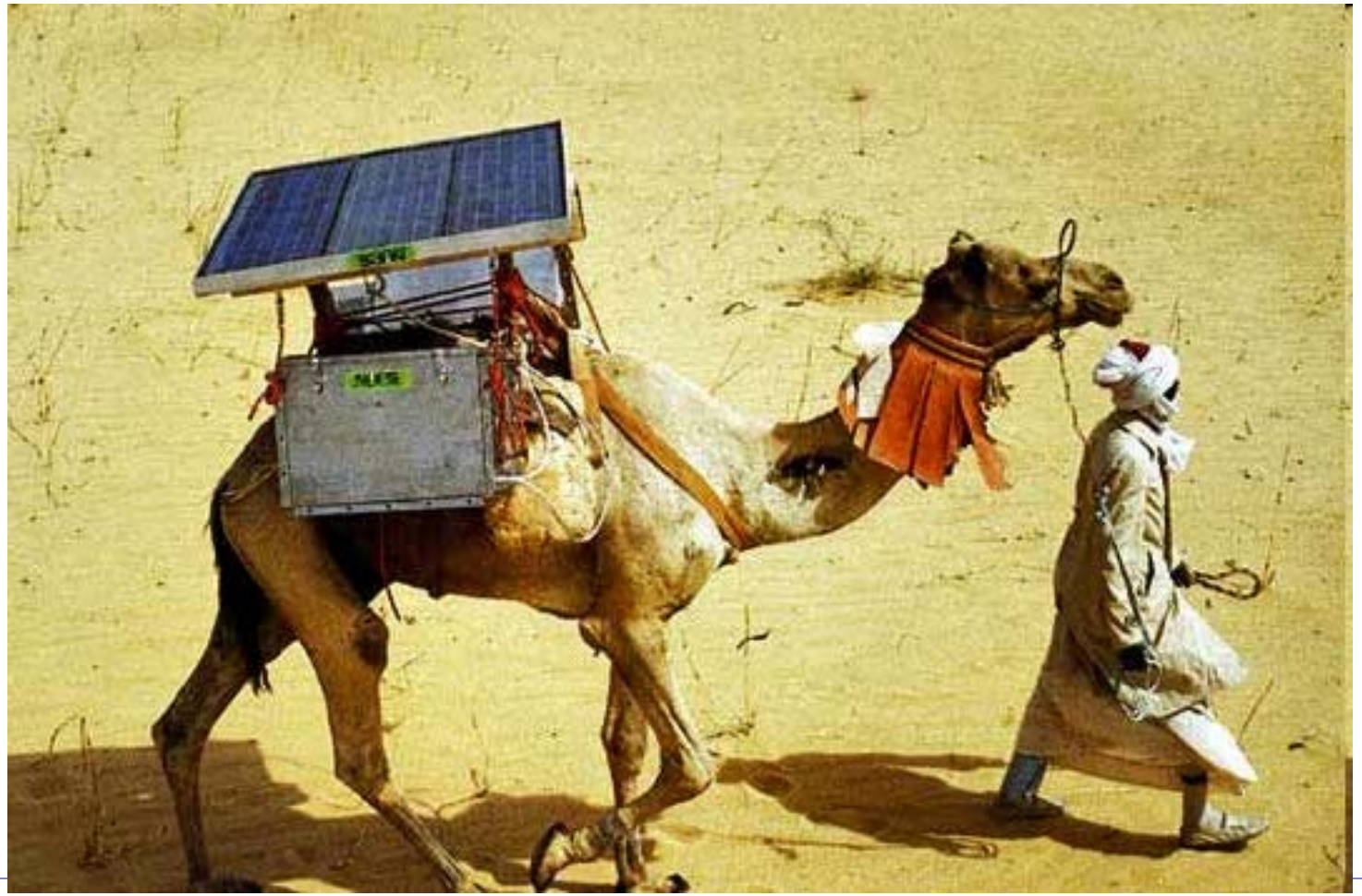
Carport & Multi-Pole

Single Pole Mount

Multiple single poles

Single-pole mounting system can give option for manual tilt adjustment (seasonal)

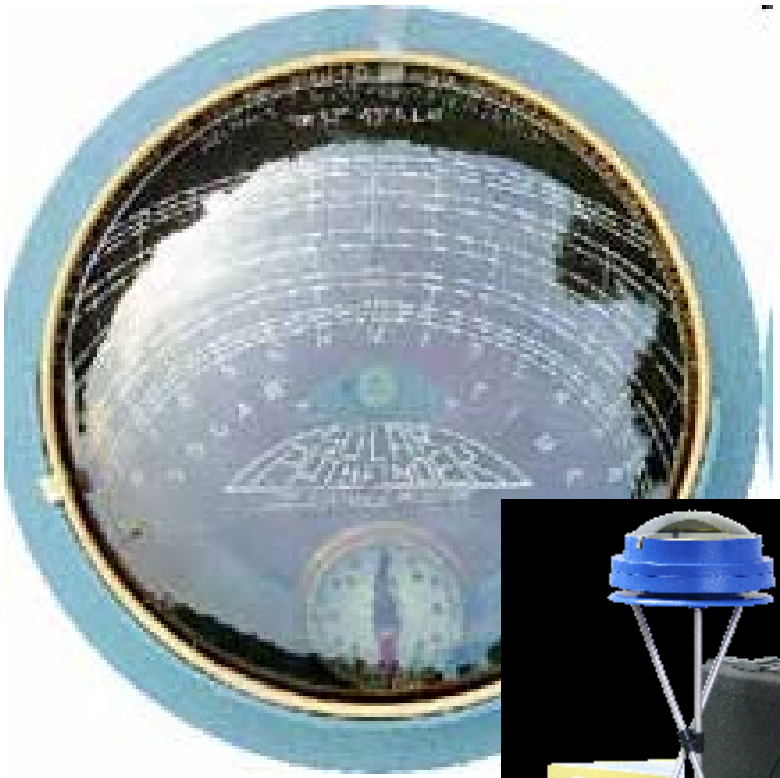
Mobile health clinics in Kenya

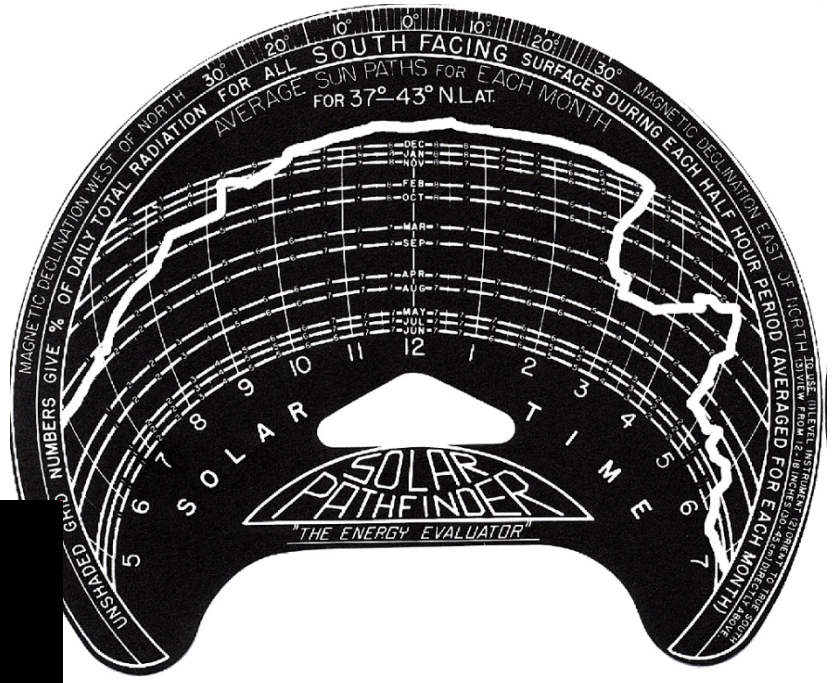


Google Maps

South

Solar Pathfinder





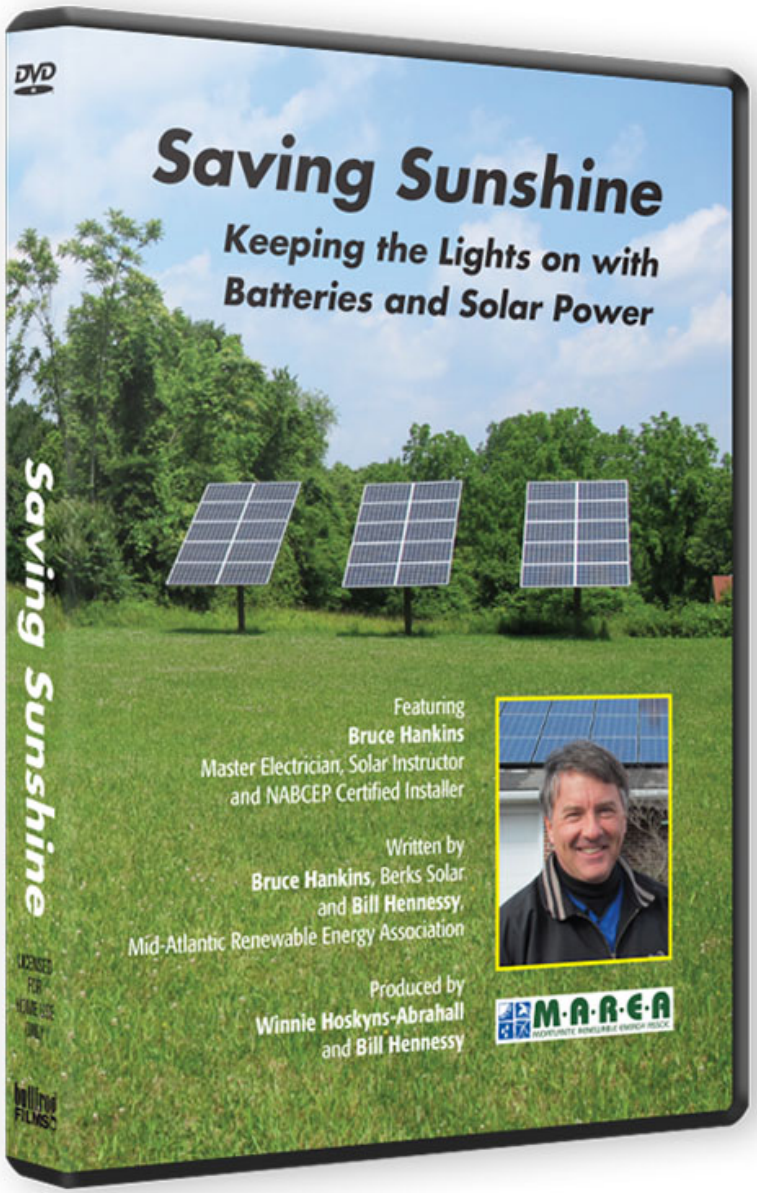
Microinverters (Enphase)

About Microinverters

- Alternative to central (“string”) inverter
- One microinverter installed on each module
- Minimize impact of shade; all modules operate independently
- Greater design flexibility—modules do not need to have same “solar experience”; can be installed at different times
- Often, higher performance (more electricity generation)
- Higher cost
- More components; in field—reliability?
- Monitoring necessary

About Battery Backup

- During electrical power outages, NO electricity from solar unless equipped with batteries.
- Battery backup may be installed at time of initial installation *or* added on to existing systems
- “Essential loads” will need to be identified. These loads will be powered during outages.
- Number of batteries (and cost of backup system) is determined by essential loads and number of outage days planned for.



30-minute DVD produced by MAREA with funding from the Berks Community Foundation and distributed by Bullfrog Films. It's terrific film, offering an interesting and easily understood explanation of the electricity grid and distribution generation, especially the role of batteries with solar.

Available at www.themarea.org

Trailer:
http://www.youtube.com/watch?v=A-i6N9oVmCQ

For more info and easy on-line access, see list of links at end of this presentation

Free & Easy List of Incentives

Easy-to-use, well organized & fully detailed list of all federal and state incentives for renewable energy & energy efficiency.

For more info and easy on-line access, see list of links at end of this presentation

Federal Renewable Energy Tax Credit

- **30% of cost of installation**
- Starting with 2009 tax year, **no limit** (formerly capped at $2,000)
- Does not have to be primary residence
- Tax credit can be carried over indefinitely
- Expires Dec 31, 2016

For more info and easy on-line access, see list of links at end of this presentation

Net Metering

- State policy that allows for the flow of electricity to and from the customer.
- Customer facility uses solar electricity *first*
  - gets more as needed from the grid
  - sends excess electricity to the grid
  - utility company keeps track of balance
- At end of year, customer gets credit for annual net excess generation at “price to compare”
- Policy applies to big utility companies, not locally-owned utilities & co-ops, CHECK FIRST

For more info and easy on-line access, see list of links at end of this presentation

Solar Renewable Energy Credits (SRECS)

- System owners earn 1 SREC for every 1,000 kWh generated
- A REC represents the generation “attributes” of the electricity (solar, clean, renewable)
- Doesn’t matter who uses electricity
- SRECs have market value determined by supply and demand
- To sell SRECs, must register facility with PA AEPS

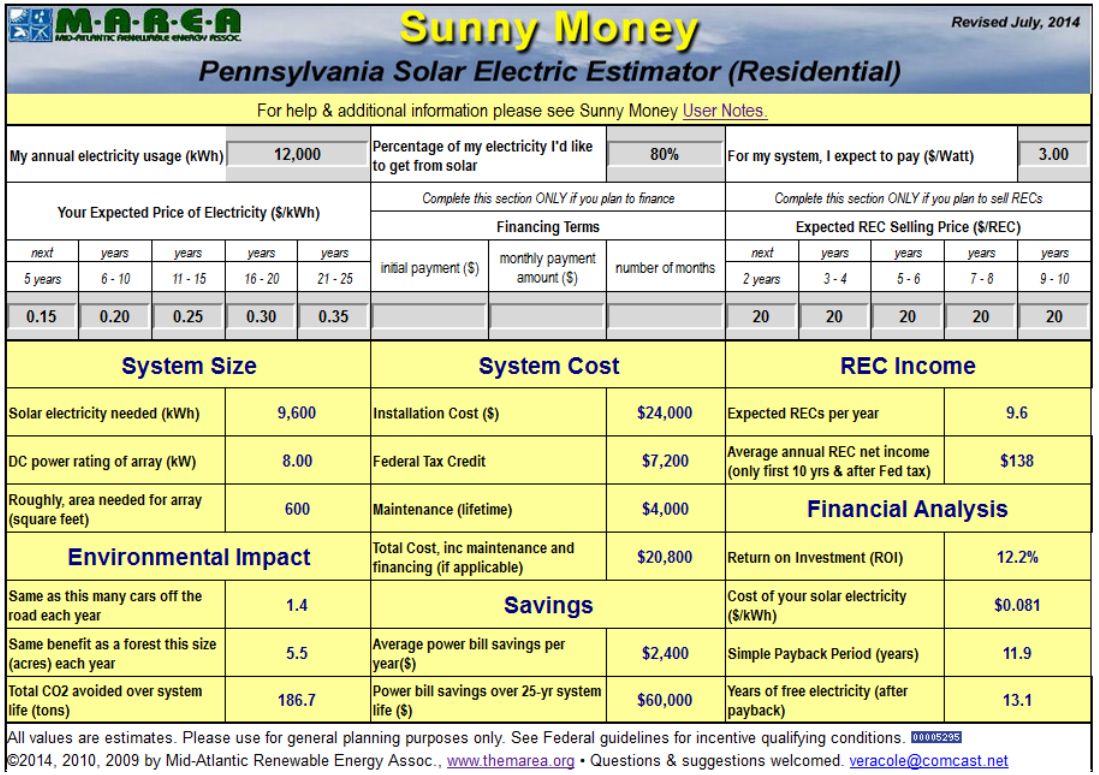
For more info and easy on-line access, see list of links at end of this presentation

Payback, hmmm

- Benefits last for a long time—”free” electricity for 25+ years!
- Depends on assumptions-
  - Future price of electricity
  - REC markets and values
  - Tax rates, time-value of money

SunnyMoney

Easy, on-line tool developed by MAREA to help Pennsylvania homeowners plan & budget for solar electric projects. Quick & accurate estimates for system size, electricity generation, savings, cost, Federal tax credit, environmental payback & more.



M-A-R-E-A Mid-Atlantic Renewable Energy Assoc.

Sunny Money — Revised July, 2014

Pennsylvania Solar Electric Estimator (Residential)

For help & additional information please see Sunny Money User Notes.

My annual electricity usage (kWh)	12,000	Percentage of my electricity I'd like to get from solar	80%	For my system, I expect to pay ($/Watt)	3.00

Your Expected Price of Electricity ($/kWh)					Complete this section ONLY if you plan to finance — Financing Terms			Complete this section ONLY if you plan to sell RECs — Expected REC Selling Price ($/REC)				
next 5 years	years 6 - 10	years 11 - 15	years 16 - 20	years 21 - 25	initial payment ($)	monthly payment amount ($)	number of months	next 2 years	years 3 - 4	years 5 - 6	years 7 - 8	years 9 - 10
0.15	0.20	0.25	0.30	0.35				20	20	20	20	20

System Size		System Cost		REC Income	
Solar electricity needed (kWh)	9,600	Installation Cost ($)	$24,000	Expected RECs per year	9.6
DC power rating of array (kW)	8.00	Federal Tax Credit	$7,200	Average annual REC net income (only first 10 yrs & after Fed tax)	$138
Roughly, area needed for array (square feet)	600	Maintenance (lifetime)	$4,000	**Financial Analysis**	
Environmental Impact		Total Cost, inc maintenance and financing (if applicable)	$20,800	Return on Investment (ROI)	12.2%
Same as this many cars off the road each year	1.4	**Savings**		Cost of your solar electricity ($/kWh)	$0.081
Same benefit as a forest this size (acres) each year	5.5	Average power bill savings per year($)	$2,400	Simple Payback Period (years)	11.9
Total CO2 avoided over system life (tons)	186.7	Power bill savings over 25-yr system life ($)	$60,000	Years of free electricity (after payback)	13.1

All values are estimates. Please use for general planning purposes only. See Federal guidelines for incentive qualifying conditions. 00005295

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For more info and easy on-line access, see list of links at end of this presentation

Avoided Emissions, *for real*

- According to PV Watts, an 8.0 kW system in Allentown will generate about 9,474 kWh per year.
- Based on electricity-generation emissions data from EPA Power Profiler, this system would avoid, over its 25 year life
  - **251 tons CO_2**
  - **525 lbs sulfur dioxide**
  - **225 lbs nitrogen oxide**

Can you imagine going out into your yard and dumping 250 tons of pollution?

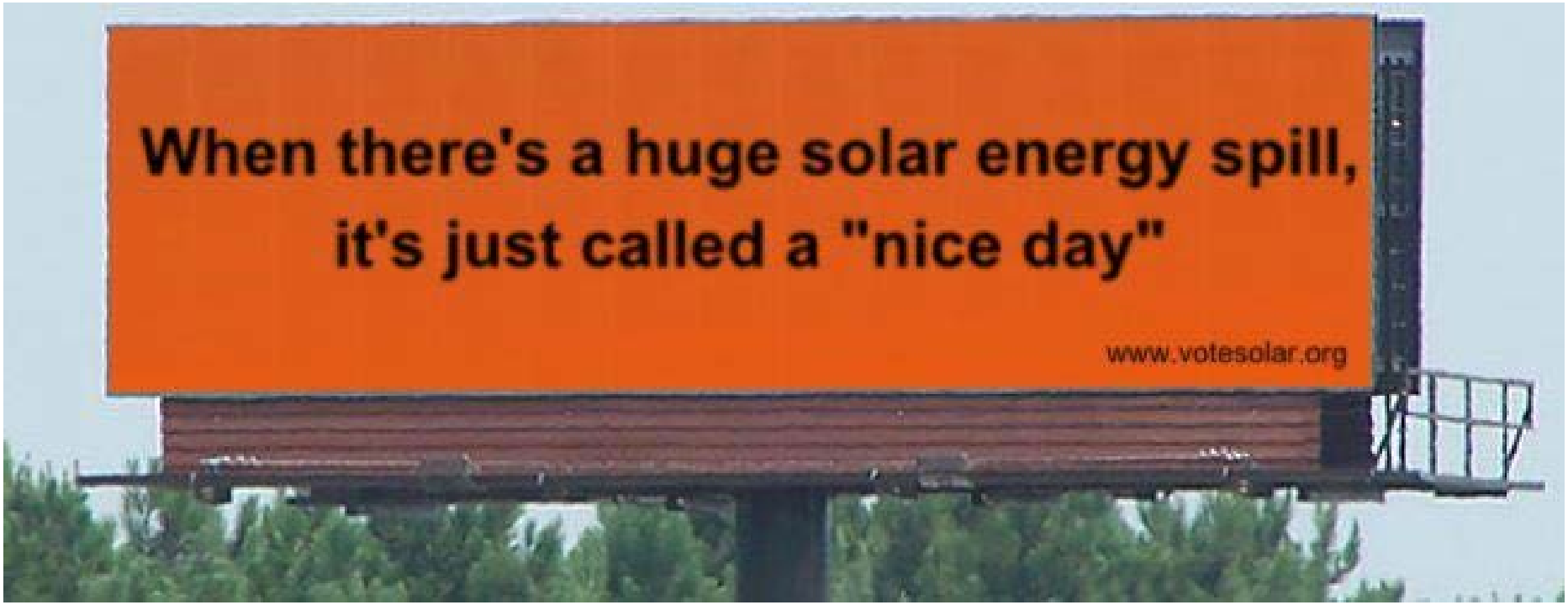
For more info and easy on-line access, see list of links at end of this presentation

Perspective...

- We are less than 5% of the world's population
- We use nearly a quarter of the world's electricity
- One quarter of the world has no electricity. More than a third of the world relies on fire to cook.
- World electricity demand is expected to grow more strongly than any other final form of energy.
- We have choices.

Solar Electricity…One Bright Idea!

- Just sits in the sun and makes electricity
- Warranted for 25 years or longer
- Free fuel, without limit
- No moving parts, no noise, no maintenance
- No emissions


When there's a huge solar energy spill,
it's just called a "nice day"
www.votesolar.org

Thank you! Questions?

Vera Cole

Mid-Atlantic Renewable Energy Association
Penn State World Campus, Energy and Sustainability Policy

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Penn State Bachelor of Arts degree in Energy and Sustainability Policy (fully online)

www.worldcampus.psu.edu/degrees-and-certificates/energy-and-sustainability-policy-bachelors/overview

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www.themarea.org

"**PA Sunshine Counts, Our Common Solar Wealth**"

an analysis of records obtained from the Pennsylvania Department of Environmental Protection for more than 7,000 solar electric systems receiving PA Sunshine Rebates, with detailed findings related to cost trends, system size, installation locations, component manufacturers, and installers.

www.themarea.org

PV Watts Version 1

use to estimate electricity generation

rredc.nrel.gov/solar/calculators/pvwatts/version1/

for details of “derating factor” used in PV Watts

rredc.nrel.gov/solar/calculators/pvwatts/version1/change.html#derate

Saving Sunshine: Keeping the Lights on with Batteries and Solar Power

30-minute DVD produced by MAREA with funding from the Berks Community Foundation and distributed by Bullfrog Films. Offers an interesting and easily understood explanation of the electricity grid and distribution generation, especially the role of batteries with solar.

Trailer

www.youtube.com/watch?v=A-i6N9oVmCQ

Available

www.themarea.org

DSIREUSA.ORG

Database of all federal and state incentives for renewable energy and energy efficiency

www.dsireusa.org

Federal Renewable Energy Tax Credit

www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F&re=1&ee=1

PA's net metering rules

www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=PA03R&re=1&ee=1

How to Find a Qualified Solar Installer

NABCEP uses training, tests and experience to certify qualified solar installers. You can find a list of NABCEP-certified installers in your area, using the link below.

http://www.nabcep.org/certified-installer-locator

Resister System to Qualify for SRECs

www.paaeps.com

How to sell SRECs

www.pjm-eis.com/getting-started/how-do-I-sell-recs.aspx

Sunny Money

Easy on-line tool to help PA homeowners plan & budget for solar electric projects

www.themarea.org

EPA Power Profiler

Gives fuel mix and air emissions rates of grid electricity generation by zip code

oaspub.epa.gov/powpro/ept_pack.charts