Farm Energy IQ

Farms Today Securing Our Energy Future

Solar Energy on Farms

Ed Johnstonbaugh, Penn State Extension

NORTHEAST SARE Sustainable Agriculture Research & Education

Farm Energy IQ

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Presents:

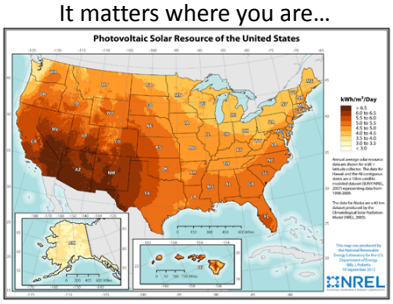
Solar Energy on Farms:
Photovoltaic (PV) Electric and Thermal

What You Will Learn

- How sunlight is converted to electric (PV) and thermal energy
- How to harness useful electricity from PV systems
- How to estimate system performance
- How solar energy systems can benefit your operation

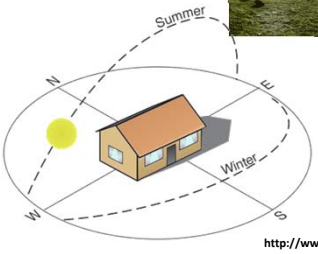
Fundamentals of Renewable Energy

It matters where you are…



Sun's Daily Path through the Sky

Northern hemisphere



http://www.ecowho.com

Solar Equipment Siting

- Important considerations when considering solar PV or thermal energy systems:
  - Panels should not be shaded at any time during the year
  - Site must accommodate reasonable orientation of the collector panels
  - Site must be accessible for inspection and cleaning
  - Site system close to point of use

Solar PV modules

- A solar PV module is an electrical device which contains a string of PV cells that produce, under full direct sunlight, a specific voltage and current flow. This voltage and current is called the capacity.
- PV modules produces direct current (DC) electricity. In most cases, DC electricity is converted to more widely used alternating current (AC) electricity
- Modules have no moving parts and are typically warranted for 25 yr
- Over 10 years, single module capacity increased from < 200 watts to 230–300 watts

Solar PV system integration

- **Solar Modules** are strung together to form arrays. Arrays feed Direct Current (DC) to inverters that convert DC to Alternating Current (AC).
- **Inverters** act as safety equipment during outages and interrupt the solar array's ability to produce electricity and send it to the building or grid
- **Meters** measure the electricity produced so that Renewable Energy Credits (RECS) can be applied
- **With net-metering, meters** measure electricity purchased from the grid and electricity sent back to the grid.
- **Virtual metering** is a net metering system in which surplus energy is applied to another account.

Net Metering
Page I

- **Net metering** rules vary by state. In general, net metering permits a PV system owner to:
  - **Purchase** energy from the grid at the standard tariffed rate
  - **Use** solar-produced electricity to offset grid-purchased electricity (deduct one kWh purchased from the grid for each kWh supplied to the grid)
  - **Carry** excess generation forward to succeeding months to apply against purchases from the grid
  - **Cash** out any outstanding balance at the end of the 12-month period

Net Metering
Page II

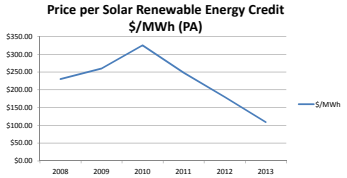
- Notice the "01" channel number which indicates the **net** amount of electricity that has been purchased from the grid
- The "04" channel number in the upper right indicates the electricity that has been purchased **from** the grid
- At bottom, the "40" channel number indicates the total amount of electricity that has been sold **to** the grid
- Do the math to see if it adds up

Fundamentals of Renewable Energy

- National Renewable Energy Laboratory (NREL) data shows that the solar resource for Greensburg, PA is 4.35 kWh/m^2/day or 0.404 kWh/ft^2/day.
- This equals approximately 147.5 kWh/ft^2/yr
- At a conversion efficiency of 16%, a PV system in Greensburg, PA would produce about 24 kWh/ft^2/yr

Fundamentals of Renewable Energy

The value of Alternative Energy Credits (a.k.a. Renewable Energy Credits or certificates) vary by year and location:



Source: http://www.puc.pa.gov/consumer_info/electricity/alternative_energy.aspx

Cash Value of Sunlight

1 ft^2 of panel area ≈ 24 $kWh_{electric}$/yr

24 kWh x (10¢ per kWh + 11¢ per AEC/kWh) =
$5.04 per ft^2 of panel area per yr

Corn @ 150 bushel/acre and $7.50/bushel =
$0.03/$ft^2$ of growing area

PVWatts Calculator*

Station Identification	
City:	Pittsburgh
State:	Pennsylvania
Latitude:	40.50° N
Longitude:	80.22° W
Elevation:	373 m
PV System Specifications	
DC Rating:	4.0 kW
DC to AC Derate Factor:	0.770
AC Rating:	3.1 kW
Array Type:	Fixed Tilt
Array Tilt:	30.0°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	9.6 ¢/kWh

Results			
Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
1	2.49	244	23.42
2	3.36	298	28.61
3	4.20	391	37.54
4	5.04	452	43.39
5	5.45	481	46.18
6	5.76	476	45.70
7	5.58	475	45.60
8	5.58	478	45.89
9	4.65	394	37.82
10	4.00	364	34.94
11	2.52	226	21.70
12	1.80	163	15.65
Year	4.21	4442	426.43

* PVWatts can be accessed at http://pvwatts.nrel.gov/pvwatts.php

Roof Mounted Solar PV

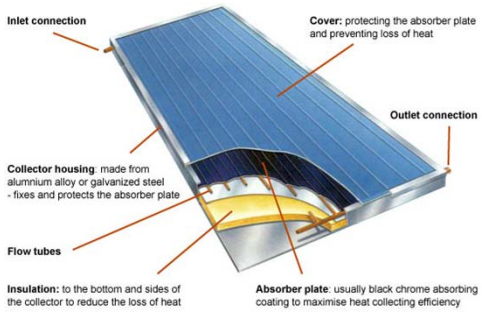
Ground Mounted Solar PV

Safety Issues

An outdoor, visible disconnect is required for solar PV systems

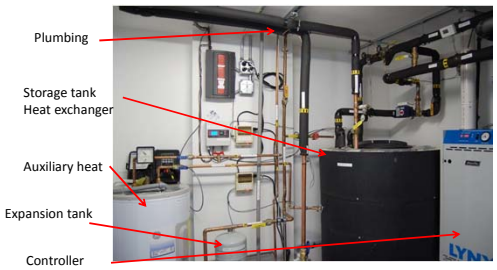
Mounting Thermal Collectors

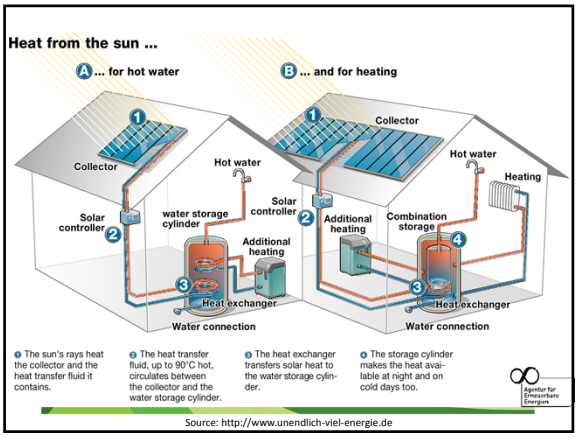
Solar Hot Water Collector



Source: http://www.greenspec.co.uk

Additional Equipment - Thermal





Source: http://www.unendlich-viel-energie.de

Solar Thermal System Types

- Since our region is frosty at times, systems must be freeze resistant. Two options are:
  - Drain back system – all fluid is drained from the collector when it's cold
  - Antifreeze system – antifreeze is used in the collector loop to prevent freezing

Solar Thermal System Issues

- Typical installations cost between $6,000 and $10,000 (professionally installed)
- A typically-sized system produces about half the typical household's hot water needs in the Northeast
- Solar thermal was the more attractive option years ago before PV equipment dropped in price and reliable, high-efficiency heat pump water heaters became available

The Case for Solar

- Transitioning from fossil based energy to renewables calls for a financial analysis
- Analysis must consider all benefits and expenses to produce a realistic financial scenario
- Payback period expectations should be realistic
- Market stability creates a stable playing field
- Other considerations are non-economic (i.e., doing the right thing)

The Economic Case

- Total system costs, permits, insurance, overall efficiency, expected system life, maintenance, etc.
- Value of incentives such as grants, tax credits, rebates, avoided future costs, Renewable Energy Credits, etc.
- Opportunities to participate in hourly pricing, demand response, or other innovative energy programs (PV only)
- Innovative financing opportunities

Making the Economic Case - PV

A typical 5,000 watt solar system produces about 6,000 kWh annually in the Northeast

System cost @ $4.00/watt……$20,000

Estimated annual return on investment

Avoided kWh cost/yr @ $0.10/kWh……$600

Federal tax credit @ 30% = $20,000 x 30% ……$6,000

Renewable Energy Credits @ $110/1000 kWh……$660

Making the Economic Case - PV

Sum of installation costs……$20,000

Less tax credit……$6,000

Total……$14,000

Calculated simple payback

$$\$14{,}000 \div (\$600 + \$660) = 11 \text{ yr}$$

Payback period will improve as energy costs rise

The Economic Case – Thermal

- Typical solar thermal system: with two, 4' x 8' collectors, producing 40 to 60% of hot water needs annually depending on climate
- Assume: 44 gal/day family hot water use (16,000 gal/yr); 60% produced by solar thermal is ≈ 9,600 gal; Water heated from 50° to 120°F. (To heat 1 gal water by 70 °F requires approximately 0.17 kWh)

9,600 gal/yr x 0.17 kWh/gal = 1,642 kWh/yr

1,642 kWh/yr x $0.10 per kWh = $164/yr avoided electricity costs

The Economic Case – Thermal

Investment in solar thermal system……$10,000

Estimated annual return on investment:

Federal tax credit @ 30% = $10,000 x 30%……$3,000

Net cost……$7,000

Avoided kWh cost/yr @ $0.10 /kWh……$164

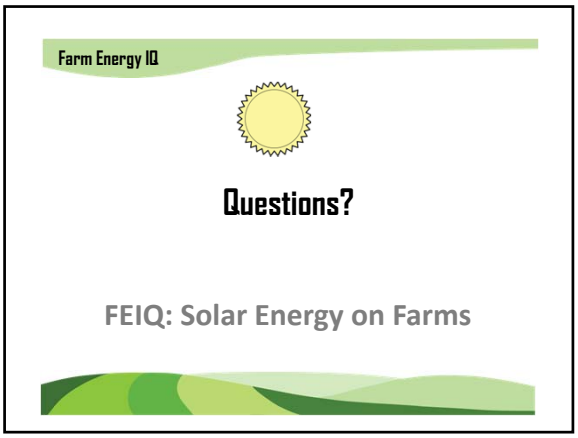
Renewable Energy Credits @ $110/1000 kWh……$180

$7,000/($164 + $180) = 20 yr simple payback

Solar PV pays back much more quickly!

Summary

- You now have a basic understanding of the equipment needed and the workings of a solar PV system
- You now have a basic understanding of a solar thermal system
- You have an idea of the costs and benefits related to these systems including tax credits and Renewable Energy Credits
- You also have an appreciation of the environmental benefits each such system provides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Questions?
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