Solar energy economics in Pennsylvania

A Webinar provided by the
Pennsylvania Housing Research Center

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Topics

Also see the PHRC webinars on Intro to Residential Solar Technologies: Resources and Solutions from 1/13/09, and Zero Energy Houses in PA - A technical review from 4/13/10

- Important principles
  - Economics
  - Solar
- Proven systems
- Recent developments
  - Drainback SWH
  - Changing economic incentives

David & Virginia Jackson passive solar house in Carlisle

So … is solar economical in PA?

It depends …

1. Cost of conventional energy
2. Cost of solar features
3. Government incentives
4. Cost of money
5. Resale value
6. System lifetime
7. Intangibles

7. Intangibles

84,000,000,000,000 cu.ft.

U.S. use (2009):
24,000,000,000,000 cu.ft.
Would last 3.5 years

U.S. residential use (2009):
4,900,000,000,000 cu.ft.
Would last 21 years

Economics comes from Greek *Oikonomia*, "management of the household so as to increase its value to all members of the household over time."

What if we would build and retrofit all houses to use ½ as much energy via efficiency, passive solar and solar water heating?

Would save equivalent of 20,000,000,000 cu.ft. EACH YEAR.

Would equal Marcellus in just over 4 YEARS.

In 50 years, equals 12X Marcellus.

Four Important Solar Principles

1. Solar is ***abundant***, in one minute what hits the Earth equals all of our energy use in a year,

BUT,

2. it is ***diffuse***, spread out, and
3. it is ***intermittent***, not always available when we need it

PLUS

4. we can't capture all of it so there is always an ***efficiency***, where

   Efficiency = Useful Energy / Solar Energy

Important principles applied …

- ***Diffuse***: the more energy needed, the bigger amount of ***area*** is needed
- ***Intermittent***: solar energy is ***stored*** for use when the sun isn't shining
  - Masonry for space heat
  - Water tank for domestic hot water
  - Grid for solar electricity (and/or batteries)

Passive solar uses concrete slab floor to store heat gain from windows

David & Virginia Jackson passive solar house in Carlisle

Efficiency applied to windows …

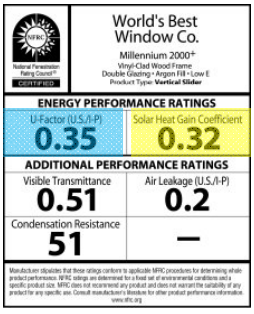
2 important characteristics:

1. U-factor: indicates heat loss so want a *low value*.
2. SHGC: solar heat gain coefficient – indicates solar gain so want a *high value*

Look for:

U = 0.25-0.30

SHGC = 0.40-0.60



NFRC Label

There are 3 proven solar technologies (in order from most cost-effective)

Passive solar / Low energy housing

Solar Domestic Hot Water (SDHW)

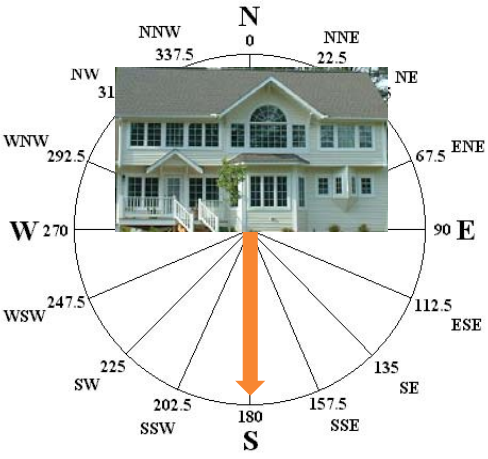
Photovoltaic (PV)

Questions

Passive solar heating

1. All homes get some heat from the sun!
2. Sun Tempered
   - House has a long wall facing ± 30° of true S
   - Windows moved from W, E and N sides to up to 7% FA on S side
   - Provides up to 30% of heat needs
3. Passive Solar
   - 7-15%+ FA on S side
   - Added mass in floor and walls
   - Up to 50% of heat needs

Passive Solar windows work best within 30° of south



Direction	%Winter	%Summer
South	0	0
± 30°	- 5	+ 14
± 60°	- 20	+ 32
± 90°	- 43	+ 29

Passive Solar Economics

- Moving windows to south side and orienting house to south may add NO cost.
- Adding more windows and slab floor may add very little due to less basement (lose some SF)
- Savings of 30-50% of heating cost.
- Translates to $300 - $1,000+ annual savings.

Solar Domestic Hot Water (SDHW)

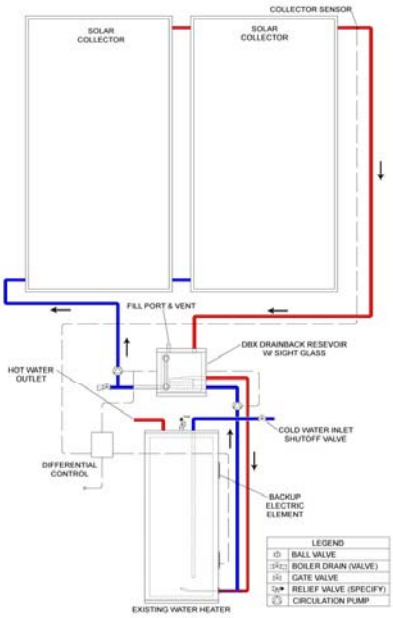
- Hot water heating is second only to space heating in energy use
- Hot water needed year round; uses more abundant summer sun
- Efficient (75% reduction in water heating cost)
- Proven
- Positive cash flow with long term financing
- Tax credits available

5.5 kw PV system and solar water heater by Envinity in State College

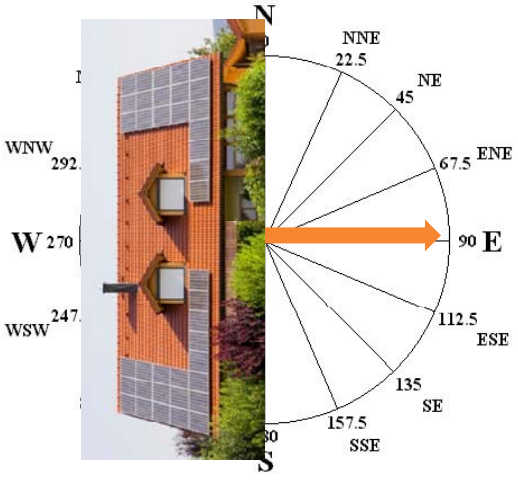
Emerging SDHW system in freezing climates

Drain-back

- Water in collector loop only when pump runs (no freezing or overheating)
- Uses a small drainback tank with heat exchanger
- Low maintenance
- Storage tank can be ordinary electric water heater.



Solar water heaters and solar electric panels do **not** have to face south



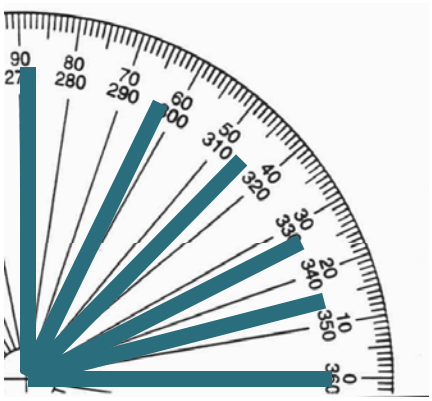
For a tilt of 30º (7/12)

Direction	%Less
East	18
Southeast	6
South	0
Southwest	5
West	17

Solar water heaters and solar electric can be flush or aligned with roof

For south-facing

Roof Pitch	%Less
Flat (0º)	12
3/12 (14º)	4
6/12 (27º)	0
12/12 (45º)	1
24/12 (63º)	9
Vertical (90º)	33



Solar water heaters save money instantly

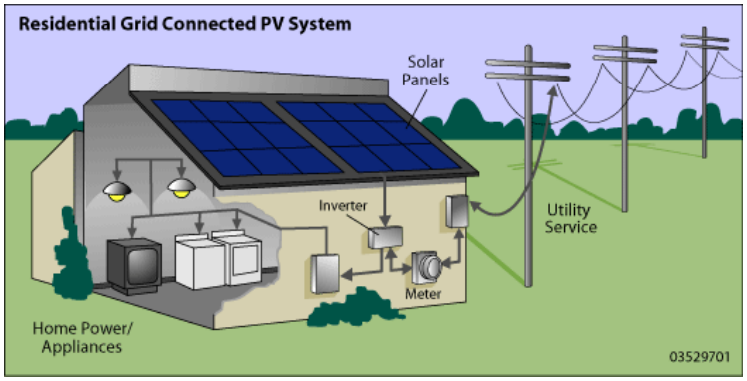
- Installed cost is ~$6,000
- Mortgage: 10% down, 30 year, 6% mortgage
- 80 gal/day of hot water is 5,600 kwh a year (with 20% losses). At $0.10 / kwh that costs $560 a year.
- SDHW can save 75% of that, or $420 a year.

So at end of first year:

Down payment (10%)	$ (600)
Tax credit	$1,800
Mortgage payment	$ (390)
Electricity savings	$ 420
NET	**$1,230**

Plus each year after that $30+ is saved.

Solar electricity has two main components



1. Solar electricity panels (photovoltaic or PV)
2. Inverter

PV Economics

- Home value increases $20 for every $1 reduction in annual utility bills (true for SDHW systems too)
- Solar electricity systems ***now*** cost about $6 per installed Watt of capacity; a 4,000 W system would cost about $24,000.
- Annual savings in PA is 1.3 kwh per installed watt; a 4,000 Watt system would save 5,200 kwh; at an electricity cost of $0.10 / kwh that's $520 per year.
- Home value would increase by $10,500.
- Federal tax credit of 30% reduces system cost by $7,200.
- Renewable Energy Credit is ~$0.10/kwh, or $520/yr

PV Economics – cash flow

So at end of first year:

Down payment (10%)	$(2,400)	
Tax credit	$ 7,200	
Mortgage payment (5%)	$(1,391)	$(1,391)
Electricity savings	$ 520	
RECS	$ 520	$ 1,040
NET	**$ 4,449**	

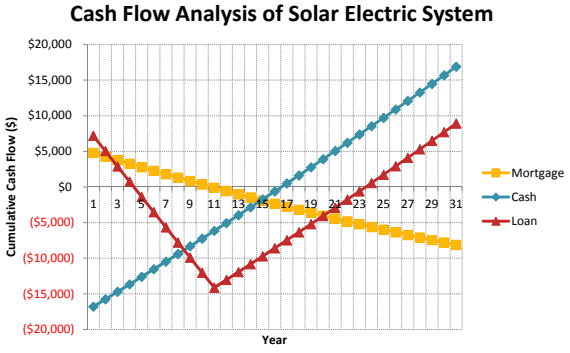
But the following year mortgage exceeds utility savings by $ (341)

Other considerations:

- Future cost of electricity
- Environmental benefits
- Resale value

The economics of solar depends on how it is paid for: cash, loan, or mortgage

INPUTS		
PV Size	4000	Watts
Installed Cost	6.00	$/Watt
Electricity Rate	0.100	$/kwh
Cost	$24,000	
Electricity Production	5200	kwh/yr
Utility Savings	$520	per year
RECS	$0.100	$/kwh
Tax Credit	30%	
Utility Inflation Rate	1%	
Mortgage interest	6%	
Loan interest	6%	



What makes sense for builders to do?

First reduce energy use by

1) increasing insulation and sealing cracks, and
2) installing energy efficient appliances and fixtures.

Then capture solar heat by

1) orienting house to within 30^{o} of true south,
2) moving windows from W, N and E to S (sun-tempered),
3) and possibly adding even more S windows and mass (passive solar),
4) using a Solar Water Heater (30% tax credit)

You can reduce the utility costs by 1/2. Then PV can be added to further cut utility costs.

Resources, p.1

Pennsylvania Solar Manual:

Send email to andylau@psu.edu (solar overview plus lots of PA examples of projects)

Solar Economics:

Send email to andylau@psu.edu (for spreadsheet that looks at cash flow for different economic assumptions and financing options)

Solar Resource

http://www.ngdc.noaa.gov/geomagmodels/struts/calcDeclination (magnetic declination calculator)

Passive Solar

http://www.energysavers.gov/your_home/designing_remodeling/index.cfm/mytopic=10250 (general)

http://www.efficientwindows.org/index.cfm (windows)

Resources, p.2

Solar Water Heating

http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12850 (general)

http://www.ecs-solar.com/publications.html (Book on lessons learned and practical knowledge)

Solar Electricity / PV

http://www1.eere.energy.gov/solar/pdfs/planning_for_pv.pdf (general)

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/41085.pdf (overview with economics)

Tax Credits

http://www.energytaxincentives.org (Federal incentives)

http://www.dsireusa.org/ (state incentives)