Home Scale Solar Power

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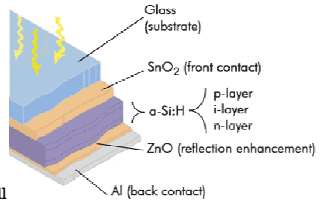
Abstract

Our goal in researching this topic was to create a guide to cost-effective solar power solutions for anyone interested in applying solar power to their home, regardless of their budget. We analyzed the feasibility of implementing solar panels in residential applications. The solar technology market can seem daunting to the average consumer. This was rectified by compiling information into a table and comparing the cost of several different types of systems with the efficiency and the estimated payback period of each system. We looked at solar manufacturing company websites to find estimates on photovoltaic and thermal water heating systems. The payback period was estimated by subtracting the amount of money saved on the average consumer's utility bill, factoring in federal and state incentives, and calculating the amount needed to pay off the adjusted cost of the system.

Background

Photovoltaic Cells –

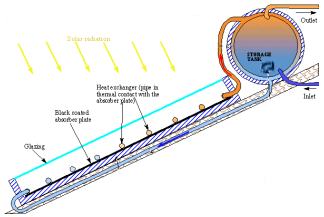
- Convert sunlight directly into electricity
- Made of special materials, such as silicon, called semiconductors
- Light strikes the silicon, knocking electrons loose and allowing them to move freely
- Free electrons are directed in a path by electric fields and generate a current which is directed out of the cell by metal contacts



Yvon, Horiba. "Characterization of Photovoltaic Devices". <http://www.azom.com/Details.asp?ArticleID=3744>.

Solar Water Heaters –

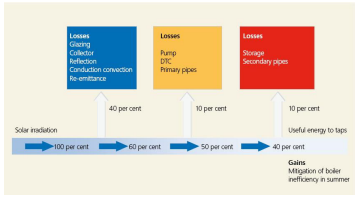
- Liquid is pumped through the solar panel where it is heated by sunlight
- It is then pumped through a water tank to pre-heat the water
- The water is pumped into a regular water heater where it is heated to the desired temperature



GreenNav, "Understanding Solar Panels". <http://greennav.wordpress.com/2008/03/21/understanding-solar-panels-1-solar-thermal/>.

Efficiency –

- Of the amount of sunlight that strikes the panels, only 20% is converted
- Energy is lost by light being reflected and in the process of conversion
- As the panels get hotter through out the day, they loose efficiency
- solar thermal water heating system generally have an efficiency of 40%



Energy Savings Trust, "Solar Water Heating, 19". <http://www.greenspec.co.uk/documents/energy/EST-solarWaterHeating.pdf>.

Results

System Type	Estimate Total Cost ($)	Total Incentives	Amount Subtracted From Energy Bill	Estimate Out of Pocket Expense	Estimated Payback Period (Years)	Special Notes
PV-System (Off Grid)[1]	$28,000	$13,900	$600	$14,100	20.0	
PV-System (Grid Inter-tied)[1]	$18,000	$10,900	$600	$7,100	8.3	
Water Heating [2] [4] (Glycol)	$4,600	$2,070	$1,000	$2,530	2.6	$25 annual maintenance cost of glycol
Water Heating [3] [4] (Drainback)	$5,000	$2,250	$1,000	$2,750	2.8	

Generally, photovoltaic systems were more expensive as well as less cost-effective. Government incentives, however, favor photovoltaic systems. An off-grid photovoltaic system has a payback period of about 20 years, whereas a grid inter-tied photovoltaic system has a payback period of around 8 years. This difference is due mainly to cost, as off-grid systems tend to cost more than grid inter-tied systems.

Thermal water heaters have generally much smaller payback periods, more on the order of 2-3 years. The drainback system has a slightly larger payback period, despite the annual cost of glycol replacement.

Conclusion

The most cost-effective system was the glycol water heater, with a payback period of about 2.6 years. The second more cost-effective was the drainback water heater at around 2.8 years. The grid inter-tied photovoltaic system (probably the most common) has a payback period of about 8 years. The least cost effective system, the off-grid photovoltaic, had a payback period of around 20 years.

For a consumer unit of moderate income, a glycol thermal water heater seems to be the best choice regarding solar power technology. Federal incentives are becoming more progressive towards photovoltaic systems, however, but water heaters remain the more cost-effective choice for a residential environment. New legislation and incentives may change the cost of various technologies in the future, and thus also the cost-effectiveness, as technology inevitably also becomes cheaper and more efficient.

Methodology

The cost of each system was obtained by either a listed price under a manufacturer's website or multiplying the cost per Watt by the size of the system (in Watts).

The incentives used were a combination of federal and state credits. The main federal program used was the Residential Renewable Energy Tax Credit, which provides a tax credit of up to 30% of the cost of the system with a maximum amount of $2000 for hot water heaters. Beginning in 2009, the $2000 limit will be lifted for photovoltaic systems, which is why no cap was factored into the PV credits. The programs provided by the Commonwealth of Massachusetts were :

1 - Residential Renewable Energy Income Tax Credit:
- Provides a tax credit of $1000 towards a taxpayer's income equal to 15% of the cost of the system

2 - Renewable Energy Certificate Program:
- Energy Consumers Alliance of New England buys Renewable Energy Credits from the owner at $0.03 per kW-h which the system generates for three years.
- At the end of the three year contract, the homeowner may renew the contract or donate the credits toward the development of the renewable energy market.
- This program only applies to photovoltaics.

3 – Massachusetts Technology Collaborative – Commonwealth Solar Rebates:
- Pay the owner $2.00 toward the cost of the system for each Watt that the system is rated
- $0.25 per watt is added if the components come from a Massachusetts based company

We subtracted government tax credits and other one-time incentives from the total cost of each system to get an adjusted cost for each. Monthly payments (such as maintenance) and gains (such as selling the solar energy back to the grid) were tallied up to a year's total net value. An assumed price of 16.6 cents/kWh and 5 hours of sunlight were used in calculations. This net value was then added to the cost of the energy saved by switching to solar power, which gave us an amount of money that could be used to calculate the payback period of each system. To calculate the payback period, we took the adjusted cost of the system and divided it by the amount of money gained through incentives and savings.

$$\text{Payback Period} = \frac{\text{Cost} - \text{Incentives} - \text{Credits}}{\text{Net Value} + \text{Savings}}$$

Sources

[1] K-12 Energy Education Program, "On_Off_Grid". <http://www.uwsp.edu/cnr/wcee/keep/NR735/Unit_1/On_Off_Grid.htm>.

[2] The Solar Guide, "Solar Thermal". <http://www.thesolarguide.com/solar-thermal>.

[3] SunMaxx Solar, "Solar Hot Water Heating Products". <http://solarhotwater.siliconsolar.com/solarhotwaterpricing.php>.

[4] ECS Solar Energy Systems, Inc, "Chapter 2". <http://www.ecs-solar.com/Solar_Articles/Chapter2.pdf>.