

The Resale Market Value of Residential Solar Photovoltaics:
A summary of literature and insight into current value perceptions

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ABSTRACT

One of the biggest questions about buying a photovoltaic system for the home is whether the cost of the system will be recouped on home resale. The U.S. solar PV industry promotes the resale value of a PV system will be twenty times the value Year One energy savings. The purpose of this study is to describe relevant research, actual buying and selling experiences of PV homeowners, and provide insights of the PV industry using the rule in marketing its value. The paper is designed for solar salespeople, green real estate agents, and government agencies charged with supporting pro-solar policies.

The U.S. photovoltaic (PV) industry is growing quickly and residential installation of PV is becoming commonplace in some regions. As of the end of 2008 the U.S. had approximately 61,000 residential grid-tied PV systems (Sherwood, 2009). While California still represents more than 70% of the residential market, due to a 30% investment tax credit several other states will experience double-digit annual growth at least through 2016, when the tax credit is due to expire.

The financial value of installing residential PV depends primarily on the cost of electricity and the amount of sunlight available to generate power throughout the year. For a simple financial analysis a PV investment the customer would take the final, post incentive price of the PV system divided by the expected kilowatt-hour (kWh) production over 25 years and compare the cost per kWh against the expected cost per kWh from the utility.

PV Value Estimate EXAMPLE

Final Cost of 3kW PV System at \$5 per watt: \$15,000

Estimated equipment replacement and maintenance through year 25: \$5,000

Estimated 25 year production of 3kW system with 5 peak sun hours:

136,875kWh

$\$20,000/136,875 = \$.146$

In many states the current average cost of electricity from the utility is already more than \$.146 per kWh, and it is expected these prices will increase as utilities incorporate cleaner power sources into the electric grid. The PV generated electricity price is fixed because once the system is installed the fuel (sunlight) is free. So an investment in PV is at minimum a hedge against future utility price increases, and in many instances a financial investment with a double-digit annual rate of return. And, in many utility areas around the country, PV power now costs less than the utility power it offsets.

Even though the financial benefits of PV are obvious in cases where utility electricity is high, most solar installation companies claim that homeowners who install a PV system will recoup the entire cost of their initial investment when they sell their home. It is our contention that the residential PV industry would do well to downplay this claim until it is substantiated by a robust study of actual PV-home sales data. Our reasons for recommending such caution are:

- The studies on which this claim is made are not directly relevant to solar PV
- PV is still a new technology in most markets and consumers need to have a solid understanding of the equipment and electricity costs before they can place a value on PV system
- A PV appliance provides financial value, but in the current Real Estate, Appraisal, and property tax assessment industries the equipment is not treated differently than any other energy efficiency equipment. There is no systematic Real Estate industry treatment of PV that would recruit higher home prices for PV homes.

Finally, there is no reason to assume PV will be immune to standard pricing trends that rely on neighborhood features such as schools, public amenities, safety, and the health of the local economy.

We begin this analysis with a review of key studies that either generated the concept, or added to the idea that when the home is sold the PV system will be worth twenty times it's first year of a energy savings (or in the case of PV, electricity production).

Literature Review

1. Johnson, Ruth C and Kaserman, David L, *Housing Market Capitalization of Energy-Saving Durable Good Investments.* Economic Inquiry (July 1983): 374-386

Many people who sell solar PV have quoted the 20:1 rule of thumb. The Johnson/Kaserman report is the source of that original ratio. The purpose of this study was to justify investment in energy efficient appliances by demonstrating that the housing market places a value on future fuel savings through higher resale values for homes that include energy efficiency equipment. The study was conducted through the Oak Ridge National Laboratory and the University of Tennessee and sponsored by the Department of Energy. The final study sample consisted of 1,317 single family homes located in Knoxville, Tennessee in 1978, soon after the first major Middle East inspired gas crisis. The study authors had access to complete descriptive data for the homes, including utility bills provided by the utility.

If the price of a market good is related to its characteristics (e.g. Hedonic Pricing Method), then you can compare the prices of goods (e.g. houses) with and without those characteristics to assess the value of the trait in question. This study used the hedonic method to hypothesize that, all else being equal; homes with higher energy bills will sell for less than homes with lower energy bills. In other words, that the real estate market places a financial value on energy savings.

The study uses statistical analysis of actual real estate sales data to conclude: "These results provide statistical evidence that the housing market does indeed capitalize the benefits of fuel savings in the selling of the house. The estimate ... indicates that an investment in an energy-saving durable good resulting in a one-dollar reduction in the annual fuel bill of the house will *certeteris paribus* (all things being equal) increase the market value of the house by \$20.73 in 1978 dollars."

2. Nevin, Rick, Watson, Gregory, *Evidence of Rational Market Valuations for Home Energy Efficiency*, The Appraisal Journal, Oct, 1998 the Appraisal Institute, Chicago, Ill p401-409

This study was partially funded by the United States Environmental Protection Agency (EPA) and published in the *Appraisal Journal* by the Appraisal Institute in Chicago, Il. It examines two different sets of data, one from the national American Housing Survey (AHS) and one from metropolitan statistical area (MSA). The AHS data included a large sample from 1991, 1993, and 1995 and was conducted with the help of the US Census interviewers. MSA was conducted yearly, but with completely different set of subjects responding each year (1992-6).

The author's hypothesis was that in a rational real estate market homeowners would invest in energy saving equipment at a rate reflecting 4-10% of their mortgage payments, which in the 1990s results in "...an incremental home value of \$10 to around \$25 for every \$1 reduction in annual fuel bills." The study included both statistical analysis of direct sales data and a summary of seven related home value market research studies in support of their conclusions. The authors produced a statistical analysis of *homeowner reported* utility costs, not data on energy efficiency measures. The regression analysis, which shows how a dependent variable changes in relation to independent variable, used the owner's reported value of the house as the dependent variable. Neither the actual purchase price, nor the assessment for tax purposes was considered. The energy cost for the home was self-reported as the sum of expenditures for

fuel oil, gas and electricity. There was no way to break out the various utility bills, so electricity, gas, and heating oil were combined into one number.

The study demonstrated its proposed correlation between home prices and higher utility bills, i.e., operating costs, and within the predicted range. It used large randomized data samples and statistical methods to confirm that homes with a higher energy cost were sold for less than comparable homes with lower energy costs.

The study explains that money from a reduction in energy costs can be spent on a larger mortgage with no net change in the cost of owning the property. A homeowner can support an extra \$20,000 of debt if the utility bills were reduced by \$1000 a year at a 5% interest rate.

Basically the homeowner shifts their payments from the utility bill to the mortgage lender.

The article was written for the real estate appraisal industry, and concludes that energy efficient homes may be undervalued if the comparisons they used in the appraisals don't reflect the lower cost of utilities due to energy efficiency measures. The study was instrumental in confirming the statistical veracity of the premise that homebuyers place a value on energy savings, and therefore pay less for homes with larger energy bills. The study did not prove nor disprove that either specific energy efficiency measures or solar photovoltaic systems, will recoup their investment in resale value at a 20 to 1 ratio.

3. Nevin, Rick, Bender, Christopher, and Gazan, Heather, *More Evidence of Rational Market Valuations for Home Energy Efficiency*, The Appraisal Journal, Oct, 1999 the Appraisal Institute, Chicago, Ill

This second Appraisal Journal, on the value of energy efficiency investment, hypothesized that energy efficiency projects increases the resale value of homes. The study used regression analysis to compare the value of energy efficiency measures in residential real estate compared to homes without such measures.

This study was partially funded by the Department of Housing and Urban Development (HUD) and the United States Environmental Protection Agency (EPA) and was published in the *Appraisal Journal*, by the Appraisal Institute in Chicago, Ill.

The analysis was based on data from the Home Energy Rating Systems Council (HERS) and the DOE2 energy analysis program. Electric resistance, heat pump, natural gas furnace and oil furnace were the four heating systems studied, along with high efficiency windows and comparison of homes with and without air conditioning. The article describes the assumptions and data choices used by the authors to generate a "model" home and its estimated energy use.

After describing their statistical methods and confirming the outcomes reflect real-world data, the authors provide a detailed analysis of the value of replacing the windows on a home. The authors use DOE2 home energy survey data to estimate energy savings from various window replacement projects (e.g. wood frame vs. metal, single pane vs. dual pane). They then analyze what these projects would be worth in the resale of the home.

The authors compare their estimates with a specific *Remodeling Magazine* survey from 1993. In this annual "cost vs. value" study by *Remodeling Magazine*, real estate agents were asked to estimate "the amount that popular remodeling projects would add to the value of a home in their area if the home were sold within a year of project completion."

Nevin's statistical analysis of home sales found a positive correlation between higher values for homes with energy efficient windows. Analysis of a specific energy efficiency measures support the conclusion that the cost of efficiency measures (at least high efficiency windows) is recovered in home resale values." The 20:1 rule is referenced in Nevin's 1999 *Appraisal Journal* regarding window replacement costs using annual utility savings with high efficiency windows multiplied by \$20.

The study concluded that the analysis model for valuing energy-related projects is valid and compared well to the 1993 *Remodeling Magazine* survey outcomes on a window replacement

project. The study also concludes that window replacement adds resale value to a house, and this outcome can be explained by their previous paper conclusion that there is a market value to energy efficiency measures.

Similar to the 1998 study, this report suggests that appraisers who don't incorporate the utility savings from energy efficiency measures into the home valuation may be shortchanging the home sellers.

Both of the Nevin papers demonstrate standard statistical analysis of the real estate value of specific efficiency measures, like windows. These methods should be equally persuasive for solar equipment when they are applied to a large statistical study. Such a study, using actual PV home resale data, is expected from the Lawrence Berkeley Energy Laboratory in late 2010.

4. Ayton, Rupert, *Lost in Transmission: The Current Status of Loans for Solar PV Installations*, Center for the Development of Social Finance, April 2006

In this report, Ayton argues that there is a gap in understanding of the market value of solar between lending institutions, the solar PV industry and consumers. The paper was written by the Chairman and CEO of the Center for the Development of Social Finance.

The reasons for this communications gap are summarized as follows:

- There is little documentation of the financial energy savings value of solar PV installations and lack of historical proof of this value increases risk to lenders.
- Lenders who operate with a low profit margin are not willing to invest the time and money to change their evaluation process and include solar PV.
- Installers cannot guarantee the economic outcome of the PV system due to changing energy prices. The return on investment uncertainty brings a higher risk.
- The paper describes how current loan programs for energy efficiency measures are inadequate because home loan to value ratios are too strict where the home values are

capped at \$417,000 and are designed for small energy efficiency measures, not PV projects.

The appraisal issue is key when a PV homeowner wants to recapture their PV investment in the resale price of their home. The future PV produced energy value is not normally factored into the appraisal value of the home. The appraisal may include a note of the cost of the PV system, but the lack of appraisals reflecting future energy savings may discourage homeowners from investing in solar electricity.

The report refers to both of the Nevin studies (1998 and 1999) published in the *Appraisal Journal* and the *Remodeling Magazine* "2004 Cost vs. Value" Report. Ayton says that Nevin's studies are based on a "universally accepted internal return on investment as a tool for evaluating current and future cash flows. He comments that the Nevin model has not been widely applied to the PV industry. There is no specific mention of the 1:20 ratio in Ayton's report. In summary, this report describes the barriers banks face when lending funds for PV systems and then proposes strategies that would address these barriers. The author suggests the following changes that need to occur to shrink the information gap between homeowners, lenders, appraisers, and solar installers.

- Simplify the terminology used in solar PV installations with standard descriptions and output estimates so non-experts will understand.
- Teach bankers and appraisers how solar PV works and electricity is billed
- Create a method for measuring the cash flow before and after the installation of a solar PV project, and
- Adopt a property registry that will collect data on existing and new solar PV projects so that appraisers will be able to extrapolate value even without local comps.

5. Farah, Barbara C., Timothy C. Coburn. October 2006. "A New Market Paradigm for Zero-Energy Homes: The San Diego Case Study." NREL Technical Report in Two Volumes. Volume 1: NREL/TR-550-38304
6. Farah, Barbara C. "Advancing a Market for Zero-Energy Homes." 2008. Solar Today, 22:1, Jan. /Feb., pp. 24-29.

The National Renewable Energy Lab (NREL), and Institute of Behavioral Science at the University of Colorado collaborated on a multi-year comparative case study of a High Performance Home (HPH) development called the "Scripps Highland" development in San Diego. The researchers collected and analyzed data from 306 homes, from the first wave of home buyers in 2001, through the buying and selling activities of 2006. The study included the 306 homes in the HPH subdivisions, and a comparison group of 103 similar homes located in a similar subdivision that did not include the distinct HPH features.

The final technical report was published in two volumes and totaled 800 pages in length.

The homes with PV were all net metered, i.e., connected to the utility grid and provided full retail credit on their utility bills for the electricity that they their systems provided to the utility grid. The HPH homes ranged from 2,600 to 3,376 square feet in size and selling prices ranged from \$480,000 to \$840,000. The homes included high efficiency heating and cooling systems, and 293 included solar water heating while 120 included PV. The study looked closely at customer satisfaction as well as utility savings and resale value.

Study methods included data analysis of the buying and selling prices compared to the control group homes, as well as in-depth interviews, and mailed surveys. Qualitative findings included those reasons for purchase and perception of energy features. Initially, 43 respondents in 25 HPH homes were interviewed in order to form questions for a quantitative survey. The

quantitative findings were from a mailed survey in 2004, and had a 63% response rate overall. This survey examined perceptions and preferences of the new homebuyers and opinions of solar PV.

The Farhar study is summarized in a January/February 2008 article in *Solar Today* magazine called "Advancing a Market for Zero-Energy Homes."

http://www.ases.org/index.php?view=article&catid=12%3Alatest-features&id=37%3Aadvancing-a-market-for-zero-energy-homes&option=com_content&Itemid=23

The case study analysis provides a long list of insights and conclusions about the costs and benefits of energy efficiency and solar energy measures in new homes. The conclusions most relevant to the 20:1 rule under discussion here relate to the buyers and sellers decision-making factors:

- "Energy features were not an important decision making factor for most of the buyers. The data showed that energy features were far less important in the home purchase decisions than location, the safety and security of the area, the quality of the neighborhood and financial considerations."
- But, "Owners of PV homes more frequently report being satisfied with their homes than did comparison homeowners."
- Receiving feedback about PV system production was important for the PV system owners. "58 percent said they looked at their (production) display at least once a week."
- Those that monitored their use of energy were more likely to optimize energy and cost savings as a result.
- Gains in property values and length of ownership for HPHs and comparison homes showed that the mean gain per month owned was significantly higher for the HPH homes. The HPH homes increased \$14,492 per month, while the comparison homes increased \$9301 per month.

- "Aesthetics. Contrary to the conventional view that solar panel aesthetics negatively affect the resale value of HPHs, we found that solar homes had higher resale value than comparison homes. Increasing concerns about climate change may make panels a political statement in the way hybrid vehicles have been."
- "Home Purchase Decisions. It is usually thought that, other than early adopters or "environmentalists," buyers of HPHs would be motivated by economic payback for a chosen incremental financial investment. Our study found that HPH buyers may be unaware of any potential additional financial investment if the costs of energy systems are built into the homes' sales prices and mortgages. However, buyers are aware of their substantial benefits from reduced utility bills. In this paradigm, financial incentives (e.g., rebates) go to the builder, although buyers could receive income tax credits or renewable energy credits."

7.	Borenstein, Severin. (January 2008) The Market Value and Cost of Solar Photovoltaic Electricity Production. UC Berkeley: Center for the Study of Energy Markets. Retrieved from : http://www.escholarship.org/uc/ietm/3ws6r3j4
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The purpose of the Borenstein study was to analyze the social valuation of solar PV, but not the financial benefit to end-use customers. Although the paper does not address the real estate resale value of solar, analysts and critics when addressing the value of PV often cite this analysis.

The analysis describes how to value Pv's peak production capacity and the reduction of transmission costs due to on-site installation. The report describes methods to quantify each of these values and provides examples to illustrate the arguments.

The author agrees that solar PV can produce energy at times when electricity is most valuable due to high demand and increased line losses. However, this benefit only counts where solar is actually producing in peak demand events and there are supply constraints. In other words, the

author does not assign PV an additional value if it is located in an area with plenty of electricity supply during peak periods. The author argues that the peak-production and on-site values only apply in some areas, where electricity supply and peak generation are constrained.

He concludes that the favorable timing of solar PV production increases its value by 0-20%, but could have a value of 30-50% greater if the system was run with price responsive demand and peaking prices.

This study concluded that the cost of solar PV was higher than the market valuation of the power it produces. His conclusion was that solar PV did not compete on a cost basis with competitive energy sources.

8. Black, Andy Economics of Solar Electric for Consumers: Payback and other Financial Tests" July 2009 retrieved 3/5/2010
<http://www.ongrid.net/papers/PaybackOnSolarSERG.pdf>

This article is widely referenced among solar installers and salespeople and variations of the article have been published in Solar Today and through various solar industry conferences.

Black's article describes four methods for calculating the economic benefits of residential PV, including: "Rate of Return, Payback and Lifecycle Payback, Property Value Increase, and Cash Flow When Financing."

The article discussion on real estate resale value describes the findings from the Nevin paper which Black summarizes as "The rationale is that the money from the reduction in operating costs can be spent on a larger mortgage with no net change in monthly cost of ownership." The paper asserts that since the argument made in the 1998 *Appraisers Journal* study is based on mathematical principles the fact it is more than ten years old doesn't impact its accuracy.

The Black report provides example project costs and savings, including the resale value return, in order to demonstrate the financial returns from application of his assumptions and analysis methods.

Regarding resale value, the article conveys that there is emerging evidence of significant jumps in home values from some solar home sellers. Black suggests a need for a substantive study of comparable property value increases for homes with solar PV. He considers that some buyers may value solar PV, but others may not care or value it.

The article describes *Remodeling Magazine's* annual remodeler report on the resale value of various home improvements, including energy efficient windows. In the "2003 Cost versus Value Report" *Remodeling Magazine* results quoted ROI's of the 9kWh PV system (highest return 233%) and kitchen remodels (lowest return 75%). A close second to last return was the typical small home solar system, a 3kWh system (76%). This was from a "2003 Cost versus Value Report" (Alfano, 2003)¹

Table 1 summarizes each study mentioned above and how that study communicates the PV marketing message to the public.

¹ <http://www.remodeling.hw.net/windows/cost-vs-value-2003.aspx>

Table 1: Summary of Studies and How the Study Communicates the PV Marketing Message

Year	Author(s)	Study Title	Method(s) used	Conclusion/Summary
1. July 1983	Ruth Johnson, David L Kaserman	Housing Market Capitalization of Energy Saving Durable Goods Investments	Considered fixed appliances as durable investments for capitalizing future fuel savings by using utility bill comparisons, sales prices and air conditioners, for example	Investing in durable goods that decrease the utility bill should increase the value of the home in 1978 dollars of 1:\$20.73
2. October 1998	Rick Nevin, Gregory Watson	Evidence of Rational Market Valuations for Home Energy Efficiency	Regression analysis of homeowner-reported property values and utility expenditures.	Incremental home value increase of \$10-25 for every \$1 reduction in annual fuel bills
3. October 1999	Rick Nevin, Christopher Bender, Heather Gazan	More Evidence of Rational Market Valuations for Home Energy Efficiency	Regression analysis of realtors' valuations of home improvements to utility bill savings and energy efficiency	Home values increase incrementally for improvements such as low-e windows.
4. April 2006	Rupert Ayton	Lost in Transmission: The Current Status of Loans for Solar PV Installations	Analysis and explanation of various bank loan rationale and methods for financing solar photovoltaic projects.	Lenders lack the methods, data, and process for making loans for PV systems. Specific suggestions for improving the system for making bank loans are described.
5. October 2006	Barbara Farhar	A New Market Paradigm for Zero-Energy Homes: the San Diego Case Study	In depth interviews of neighborhood homeowners, mailed surveys, actual sales data, and utility expenditures were analyzed over a four year period.	Builders should offer PV as a standard feature to improve sales and satisfaction of homeowners as part of the study focused on the value of building zero energy homes, the study found that new

				home builders do recover their investment in PV because of the quicker sales and higher satisfaction by the PV home buyers as compared to non-pv home buyers
6. Jan/Feb 2008	Barbara Farhar	Advancing a Market for Zero-Energy Homes	Additional analysis of Zero Energy Homes (ZEH) and mean gains in property values, more time and perspective since study was first published.	PV homes had lower utility bills and higher resale prices than non PV homes, and were more satisfied than comparison buyers
7. January 2008	Severin Borenstein	The Market Value and Cost of Solar Photovoltaic Electricity Production. UC Berkeley: Center for the Study of Energy Markets	Analysis of the time of usage and the distribution of energy of small, i.e. 10kw PV systems compared to non-PV systems in 2000-2005.	In 2000-2005 the cost of solar PV was higher than the non-PV market wholesale cost of the power it produces, given these theoretical bases. ^{2, 3}
8. July 2009	Andy Black, P.E.	Economics of Solar Electric for Consumers: Payback and other Financial Tests	Analyzes, explains and proposes and describes several methods for defining the financial value of PV and clarifies how the 1:20 valuation should be used in the marketplace	Agrees with and promotes with conclusion from 1998 Nevin study. Uses the 1:20 valuation in describing real estate values of PV.
9. May 2010	Mary Beth McCabe and Liz Merry	The Resale Market Value of Solar Photovoltaics	Describes eight previous studies of solar valuation, presents results from a small online survey of solar home owners and buyers, and provides	Current research on the resale value of solar PV does not demonstrate there is a definite tie between installing a PV system and recouping a higher home

² <http://www.renewableenergyworld.com/rea/news/article/2008/03/estimates-guesstimates-obsolete-just-plain-wrong-severin-borensteins-pv-costs-paper-51782>

³ http://votesolar.org/linked-docs/borenstein_response.pdf

			examples of how the "20:1" theory is used in current solar marketing.	selling price. A study of actual resale data using randomized sales data is needed to clarify in which instances PV has a resale value and the size of value PV owners might expect.
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The observations below are based upon the author’s professional judgements of those studies in Table 1. Comments and our suggestions for applying these analyses are included.

Observations

1. Johnson/Kaserman report

Many people who sell solar PV have quoted the 20:1 rule of thumb, but most have not read the study from which this idea was derived. The Johnson/Kaserman report is the originator of that ratio. We observe that while the study did not address solar PV, it did apply significant statistical conclusions to demonstrate that, in a rational real estate market, and all else being equal, homes with higher energy bills will sell for less than homes with lower energy bills. So, in a "rational" real-estate market home-selling prices should reflect future energy savings.

We would like to see the same randomized statistical analysis applied to actual residential solar PV home sales.

2. Nevin 1

The article was originally written for real estate appraisers, concludes that energy efficient homes may be undervalued if the comparisons they used in the appraisals don’t reflect the lower cost of utilities due to energy efficiency measures. Now, decades later, appraisers are still not including energy costs in standard comparisons.

The study concluded that in a rational market homebuyers place a value on energy savings, and will pay less money for homes with large energy bills. But the study did not, as is often promoted, prove that either specific energy efficiency measures or solar photovoltaic systems, will recoup their investment in resale value at a 20 to 1 ratio.

The residential solar sales environment uses this study to support their 20:1 claims."⁴ However, a more accurate title for this study would be: Houses with higher energy bills are sold for less than the *equivalent* house with lower energy bills. As the study does not deal with PV, and it is not necessarily true that a PV home will draw less electricity than a non-PV home, the solar industry should not make a direct correlation between this study conclusions and the current resale values of solar PV.

3. Nevin 2

Nevin's statistical analysis of home sales found a positive correlation between higher values for homes with energy efficient windows. The distinct analysis of a specific energy efficiency measure supports the conclusion that the cost of efficiency measures (at least high efficiency windows) is recovered in home resale values.

For the renewable energy industry, we see this further indicates that appraisers need to apply the full value of PV in appraisals, including the likely reduced electricity costs.

4. Ayton article

This article did not suggest a 20:1 ratio or comparable factor to value the solar PV for residential homes or suggest that there was a ratio. The paper does provide a roadmap for the real estate

⁴ *list of websites*

<http://www.cnn.com/2008/LIVING/homestyle/03/04/solar.power/index.html>

<http://www.videojug.com/expertanswer/solar-economics-2/will-solar-panels-add-value-to-my-home>

<http://solar-plus.clickforward.com/san-diego-solar-company-solar-energy-solar-installation-solar-panels-affordable-investment-san-diego-north.php?adid-2E343B92-B097-442c-BFA5-BE371E0325A2=408643&kw-2E343B92-B097-442c-BFA5-BE371E0325A2=solar+panels+cost>

http://sullivansolarpower.com/solar_power_residential.html

<http://www.planetsolar.com/solar101.htm>

industry to accurately value PV homes and suggests accounting methods based on energy savings that would accurately value the PV system.

5, 6. Farhar studies

Homeowners who resold homes with PV during this five-year study received far more per square foot and overall much better return on their investment than the control homes. We see this as a key finding, but not a probability sample, since the sample size is small. There were only 15 HPH homes and 12 comparison homes that make up the PV cost-to-value relationship during the five year resale study.

We spoke to the former builder directly (Anfuso, 2010), who indicated that 70% of the homes sold by Shea with solar already had the PV installed upfront as standard, so buyers may have not desired solar this at the time of purchase in 2001. We also learned that the manufacturer of the panels, Astro Power, Inc. is no longer in business as a module manufacturer. The builder had a comment that in today's marketplace (2010) buyers would have to choose between PV and granite countertops or hardwood floors, and most will not choose the PV. He also said that PV is a nice ad, but part of normal direct construction costs. He sees little to no intrinsic value to the seller at this time.

We anticipate that the Farhar methodology may be utilized with these builders in the future, enabling a larger sample size and more projectable numbers. We did not find a reference to the 1:20 ratio in this study.

7. Borenstein

This study does not specifically address our paper's questions of the appraisal value of solar PV, but we thought it would be important to include the report in our study of studies because it

brings to light popular assumptions currently used when considering the purchase of solar. Those factors include the 20 year warrantee of the system and expected lifetime of 30 years. Borenstein assumes (2008) the solar PV purchase price of 2007 as \$8.00 per watt, and this has been dropping since that time.

The results assume a low increase (i.e., 1-2% annual change) in the future value of electricity. We believe, however, should energy rates increase (i.e., 5%), the findings and conclusions of his study would be remarkably different.

8. Black

Black clarifies the factors that reduce the resale value of PV, including component performance losses, soiled panels, module degradation, mismatched modules, and other technical problems. Because these factors that would reduce the resale value of PV are mentioned, the report appears more objective.

9. McCabe and Merry

This paper describes the studies on which 20:1 claim is based, documents examples of how this claim is used in marketing solar PV, and reports results from an online survey of actual PV-home buyers, sellers, and current owners.

Uses of 20:1 Real Estate Valuation

There is nearly universal acceptance of the idea that solar PV adds value to a home on resale, but as discussed, very little hard data to support the assumption. There *is* research data to show that homes with higher energy bills are sold for less than their energy efficient counterparts. And there is solid research demonstrating that new homes equipped with PV sell faster than the same homes without PV in new developments. But, the claim that a PV system that produces \$1,000 of electricity in its first year will be worth \$20,000 when the home is resold has yet to be demonstrated through solid data analysis. And claims that the PV buyer will recover *more than* the cost of the PV system when the home is sold are even less substantiated.

Specifically, the 20:1 rule is claimed by many solar installation companies, repeated in the media, and is even stated in some government agency publications. Often the marketing statement will be combined with a statement about the original source of the rule and how the rule is "cited by Wells Fargo Bank." Attributing the claim to the Real Estate Appraisal Journal and clarifying that it was cited by a well-known bank are both attempts to add credibility to the claim itself.

Examples

This is a typical solar installer example from a business in Texas. The text comes from their website FAQ section:

Q: Does installing solar increase property value?

Yes! Installing solar will increase your home's value in two ways—by reducing your annual operating costs and by increasing your home equity. According to a leading mortgage provider, saving electricity adds significant value to most homes. They point to a study showing that for every \$1,000 saved in annual energy costs, \$20,000 is added to the value of the home.

This 20 to 1 ratio was estimated by Appraisal Journal in 1998 and is cited by Wells Fargo Bank. It is justified by the fact that a homeowner with \$1,000 less annual operating costs will rationally be able to pay \$1,000 more in mortgage expense, making the home \$20,000 more affordable. Solar compares favorably to other home improvement investments, such as deck additions, kitchen and bathroom renovations, and window replacements, which typically create resale value worth about 75%-100% of the cost, according to the experts at Remodeling Online (www.remodeling.hw.net).

To illustrate, if you spent \$23,000 on a APS solar system today, a system this size might save \$1,200 in energy expenses in year one. According to the study, your solar system will immediately add over \$24,000 to the resale value of the home. That increased resale value is worth more than the cost of the solar system.

Millions of homeowners worldwide have gone solar with the knowledge that if they sell their solar home, they will cash in on the increased value of their property.⁵

And, another example from a highly popular online customer lead generation service:

With solar being a relatively new "home improvement" option has been the center of attention by real estate appraisers in recent years. In 1998 the Appraisal Journal (Cited by Wells Fargo) sited that for every \$1,000 saved in annual utility expenditures a home's value increases by \$20,000. The basic premise being that every dollar saved in utility costs is available to be spent on a higher mortgage payment without a net increase in living expenses.

For example if we take a utility bill averaging \$190 per month, over the course of a year that's \$2,280 in annual utility costs. The table below taken from an American Solar Energy Society study shows the approximate cost for a 100% energy consumption system in comparison to the increased appraisal value.

Table 2: Cost Recovery Based Upon 20:1 and system size of PV

Solar Panel System Size	Final Net Cost After 30% Solar Tax Credit *	Appraisal Equity Increase @ 20:1	% Cost Recovered
2.6 kW	\$16,380	\$17,600	107%
5.2 kW	\$32,760	\$44,200	135%
7.8 kW	\$49,140	\$72,600	147%

* Energy Rates and usage may vary, net cost calculated rate of \$9,000/kW installed from CoolerPlanet website⁶

⁵ Alternative Power Solutions (Texas) <http://www.apowersolutions.com/faq/common-questions/>

⁶ CoolerPlanet (online) <http://solar.coolerplanet.com/Articles/solar-as-a-home-improvement.aspx>

Note that in this example the claim is made explicit with a table showing examples of how the 20:1 rule would be applied. The use of "appraisal equity increase" causes the reader to believe that A) the appraisal industry uses the 20:1 rule in applying a value to the PV system - which is not the case, and B) their home would sell at or above the appraised price.

Conversations and secondhand reports from real estate agents, appraisers, and property tax assessors indicate that the value of a PV system on residential resale depends on the same factors that affect the value of a backyard pool, granite countertops, and other non-energy related amenities. The number one indicator is whether the neighborhood has already adopted solar PV. Where solar is common, it is likely to fetch a premium. Where it is rare in the neighborhood it is more likely to turn away potential buyers than attract a premium price on the property. These observations from real estate professionals with first-hand experience indicate that homebuyers do not necessarily attribute a financial value to the PV future energy savings. There are many examples of the media including the 20:1 rule as part of a story on the financial value of PV for homeowners. Our analysis is focused on the widespread use of the rule by solar PV installers, but the media promotes the rule regularly as well. Consider this example from CNNMoney.com:

Go green, a smart home improvement (October 2006)

"And solar's ability to lower energy costs also adds value. A study in Appraisal Journal found that for every utility-bill dollar saved annually because of an improvement, you gain \$10 to \$20 in property value. So if you can zero out a \$1,000 annual electric tab by installing solar, you'll get back \$10,000 to \$20,000 in home value."

http://money.cnn.com/2006/10/24/magazines/business2/newrules_gogreen.biz2/index.htm

And, the notion is not absent from real estate valuation web portals like Zillow:

ZillowBlog: How much will solar panels increase my property value? (June 22, 2009)⁷

⁷ Various posts on Zillow re: value of PV <http://www.zillow.com/advice-thread/How-much-would-solar-panels-increase-a-home%27s-property-value/244259/>

In this discussion on a blog for real estate agents there are differing opinions reflected about the idea PV will recoup its purchase price in home resale. Everything from SDhomeowner also seems to assume that the solar-energy system adds no value to the home, which is incorrect. At current pricing (in California), solar-energy systems add at least their cost to the value of the home. [from GWShaw]

Allen Deaver's Q&A on Zillow's blog for real estate agents:

<http://www.zillow.com/profile/kylebudatxhomes/Answers?p=3>

How much would solar panels increase a home's property value? That would depend if the neighbors had them. If in your particular market solar panels were something desirable.

Online Survey Analysis

The authors produced an online survey for PV homebuyers, sellers, and those who currently own PV but have not sold their home. The survey was promoted through solar industry organizations such as the American Solar Energy Society and the Interstate Renewable Energy Council, and through the authors own contacts. The purpose of the survey was to recruit subjective impressions from those who have actually invested in residential solar PV. The number of survey responses was not statistically significant but the subjective opinions provided were informative to the topic at hand. The responses stimulate our appetite for a more robust, data driven, randomized analysis of actual PV home sales data.

Our Findings as of May 8, 2010

The online survey sought to assess actual residential PV sales figures from both buyers and sellers, and to learn from those who originally purchased the PV system what they think the system will be worth when they sell their home.

<http://www.zillow.com/blog/how-much-will-solar-panels-increase-my-property-value/2009/06/22/>

<http://www.zillow.com/advice-thread/How-much-would-solar-panels-increase-a-home%27s-property-value/244259/>

Outcomes from PV Buyers and Sellers

Figure 1 summarizes the results of surveys from 7 PV home buyers, and 5 home sellers. This indicates the range in perceived value from zero to \$15,000 in selling value.

Figure 1: Perception of PV value to home sellers

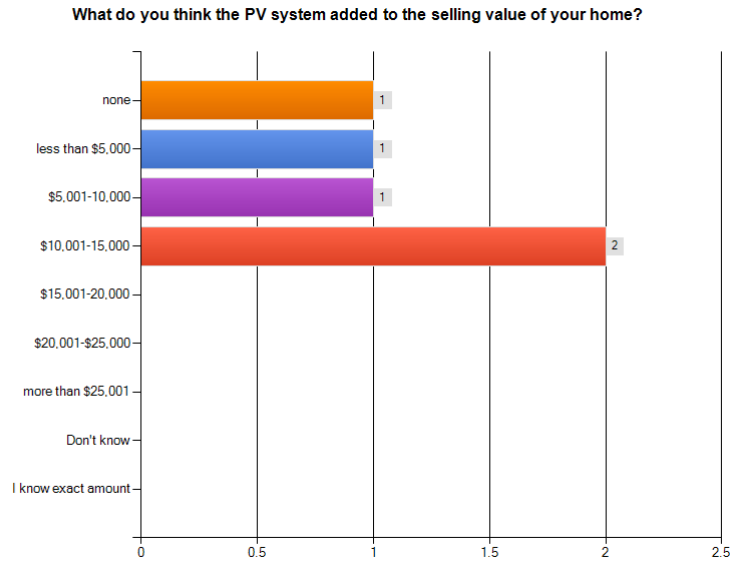
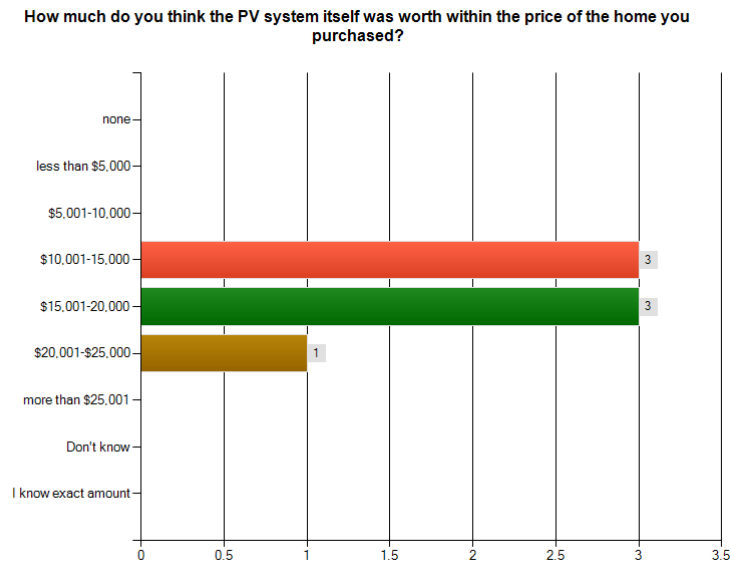


Figure 2: Perception of PV value to home buyers



Recognizing the small sample size and informal nature of the study design and promotion, it is still interesting to note the disparity in valuations between home PV home buyers and sellers. One might suppose this disparity would occur for any feature of the home as sellers naturally feel they receive a lower value and buyers always feel they are paying a premium. In that case it is interesting to note that 2 of the 5 PV home sellers felt their PV system was worth \$10,000-\$15,000 (Figure 1).

Of these two home sellers (Figure 1) who felt they received at least \$10,000 for their PV system, one (dshih714@live.com,) was located in San Diego and the home selling price was greater than \$700,000. The responder indicated they assigned the \$10-\$15k value because they “have experience with solar and know the street value.” The PV system in this instance is less than 5kW, and saved the home seller at least \$1,000 per year on electricity purchases.

The second home seller (Figure 1) (meroper@sbcglobal.net,) from Fairfield, (west of Sacramento) CA. that estimated their system garnered \$10,000 or more in the price of the home estimated that the PV system was a neutral element in their sale and the system saved less than \$1,000 on their electricity bill. This respondent selected “a bit more” to the question “How much resale value does (or did) your PV system add to your home compared to non-solar homes in your neighborhood?”

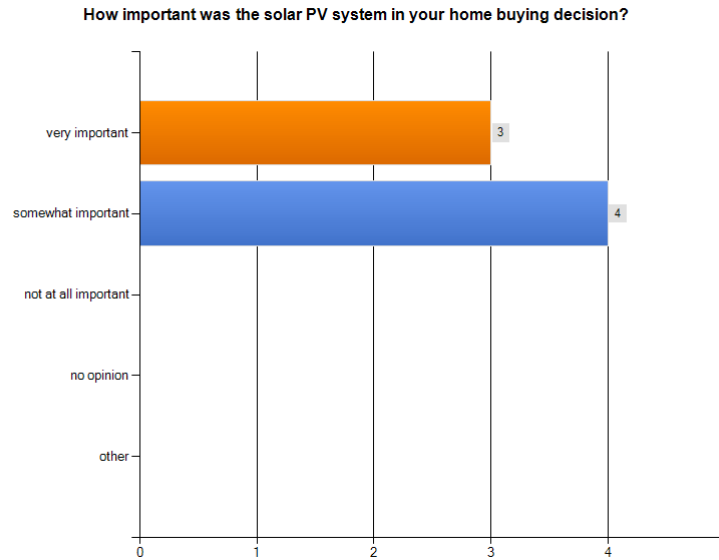
While both sellers estimated the PV system garnered more than \$10,000 (Figure 2) in their home sale, in response to the question “How important was the solar PV system in your home selling experience?” one responded “somewhat important” while the other responded “not at all important.”

Of the three remaining seller responses, one indicated the PV system added no value in the selling process and that “for many people seemed to be a negative impact.” That system is located in Los Altos, and the respondent didn’t provide an annual energy savings estimate.

Of the seven responses from PV homebuyers (Figure 2), three estimated they paid at least \$10,000 for the PV in the price of the home, and 3 indicated more than \$15,000. Not

surprisingly, these same respondents indicate the PV system (Figure 3) was at least somewhat important in their decision to buy the home.

Figure 3: Importance of PV in purchase of home

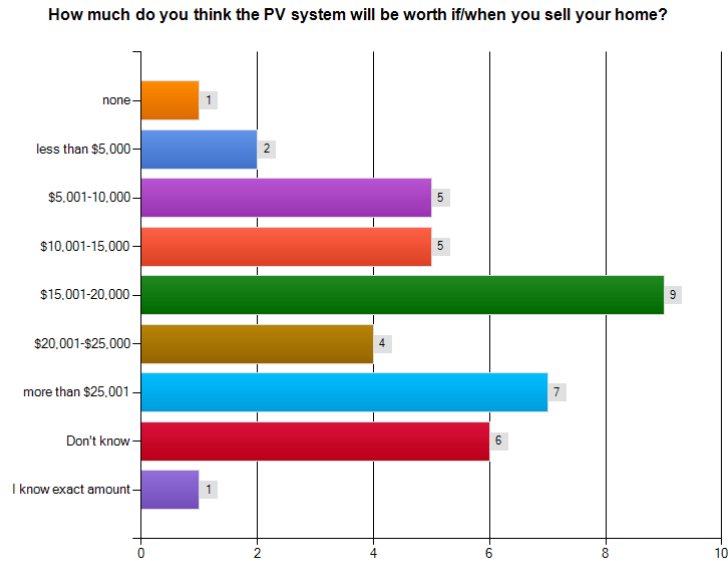


Three of the seven purchasers are saving at least \$1,000 per year from the PV system (Figure 5).

Outcomes from Current PV Owners

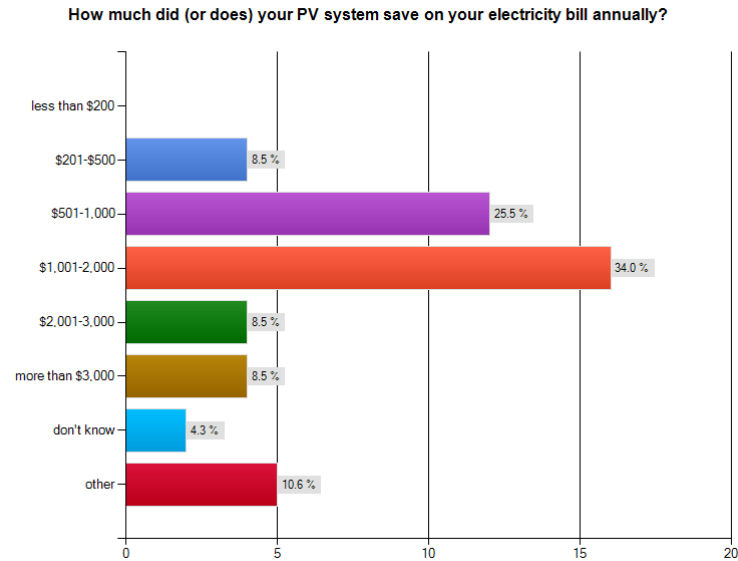
The study was also open to respondents who originally installed the PV system but have not yet sold their home. Our objective for these respondents was to capture their assumptions and projections about the value of the PV system in the home selling price.

Figure 4: Cash value of PV in sale of home



Of the responses to “How much do you think the PV system will be worth when you sell your home (Figure 4), the most popular response was \$15,000 to 20,000. System sizes vary and so does value accordingly, so this was not a surprise to the authors. Of special note is that 6 respondents do not know the value of their PV system at this time. Also, seven respondents indicated the value of greater than \$25,000.

Figure 5: Annual energy savings from PV



Online Survey Outcomes

Energy Savings:

We found that the majority of PV owners save between \$500 and \$2,000 on their electricity bill annually. One homeowner reported saving \$6000 per year. The majority saved between \$1000 and \$2000 per year (Figure 5) and these homeowners generally know they saved this much because they used actual utility bills to determine savings.

Q: "How important was the solar PV system in your home buying/selling experience?"

The 40 current PV owners' responses expect the PV system will be either somewhat (51.2%) or very important (41.5%) when they sell their home. This is supported by the 7 responses from PV home buyers, 3 of which responded the PV system was "very important," in the home buying decision, and 4 responded "somewhat important." (Figure 3)The PV home sellers experience differed slightly. Of the five seller responses 3 chose "somewhat important," 1 said "not at all important," and another commented "seemed to be a negative impact."

Q: "How much resale value does (or did) your PV system add to your home compared to non-solar homes in your neighborhood?"

Of the 47 who answered the question, 20 (42.6%) chose "a bit more" and 7 (14.9%) chose "a great deal more." This indicates that the majority of respondents assume their PV system adds value to their home.

Survey Conclusions

Those who purchased a home with PV attribute much more value to the PV system than those who sold a home with PV. Current PV owners who have yet to sell their homes expect the PV system to add significant value to their home and be at least somewhat important to the home buyer.

Summary

One of the biggest questions about buying a PV system for the home is whether and how the cost of the system will be recouped on home resale. This paper describes the studies on which 20:1 claim is based, documents examples of how this claim is used in marketing solar PV, and reports results from an online survey of actual PV-home buyers, sellers, and current owners. Subjective analysis of this information leads us to conclude that there is support for the claim that energy hog homes are less valuable than energy efficient homes. However, until there is a more comprehensive study of actual residential PV resale data the solar industry should not rely on the 20:1 rule to reflect the financial value of buying a PV system. At this time the value of PV in residential (non-new) homes is not established enough to make this universal claim.

Conclusions

The U.S. solar PV industry, media, and government agencies should downplay the claim that PV buyers will definitely recoup the cost of their initial investment in the PV system when the home is sold. The PV system may cause the home to sell faster and may recruit a premium price, but the market is highly variable. The PV system is one among many factors that determine a final selling price. Because of this high variability, and until there is a more definitive data based study of actual sales, the solar industry should focus on other financial benefits that can be more clearly substantiated.

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