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You Can Make a Positive Return by Investing in Residential Solar Systems: An Arizona Case Study

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Introduction

The Emergency Economic Stabilization Act of 2008 (Public Law 110-343, section 103) was essentially designed to remedy the financial crisis, yet the bill included an extension of the individual tax credit for installing residential solar systems. This extension reopened the opportunity for Arizonans to reap the financial benefits of installing green power. Following the 2005 Energy Bill (Public Law 109-58) Smith and Tallman wrote, "Arizonans are poised to reap the benefits of new technology in the production of electricity. This production will occur at the household level harvesting one of the state's vast resources: solar energy. Changes in the federal energy policy and the state's Environmental Portfolio Standard are likely to result in a rapid growth in the use of solar panels within the state (Smith and Tallman, 2005, page 1)." APS recognized the expected increase in demand: "Due to the large number of requests this year APS has re-allocated the available funds to increase the total 2008 budget for Non-Residential Up Front Incentives to $3,150,000."[1] Whereas the 2005 Energy Bill had a sunset clause beginning on January 1, 2008, the new legislation is in effect through 2017. Moreover, the 2008 legislation removed the federal caps on the amount of the tax credit.

The earlier article by Smith and Tallman included the financial calculations based on a hypothetical system. Following the 2005 legislation one of the authors (Smith) installed a residential system that became operational in August 2007 on which the current article is based. Using actual costs and production data combined with current (2009) policy, this paper shows the economic decision process for an individual household's evaluation of an investment in a solar photovoltaic (PV) system. For exemplar purposes a simple PV system for a grid-connected (connected to a commercial electricity supply system) house will be used. The various assumptions and decision processes are then developed.

Policy Benefits

Residential homeowners in Arizona are able to avail themselves of several policies and programs that will substantially reduce the cost of installing a solar PV system. For the exemplar, a 2.912 kilowatt panel was installed on a home in the Flagstaff area. The actual cost of this system was $22,393.[2] Based on this actual system, our discussion will now focus on the current (2009) policy. In this scenario, the homeowner will pay the installation costs and be reimbursed as discussed below. Three distinct policies and programs influence the decision to invest in a solar system.

1) The State of Arizona has a tax credit on the purchase of such a system. This allows for a tax credit of 25% of the installation price to a maximum of a $1,000 credit. Given the $22,393 price, the homeowner will receive the full $1,000 tax credit to be applied during the tax year when the system goes into service. If the total tax due for the year is less than the credit, the balance may be carried forward to the next year.

2) The State of Arizona has an ongoing Environmental Portfolio Standard (EPS), which requires the electricity providers, APS in the scenario, to have a certain percentage of the electricity sold produced by renewable energy means. At this writing the EPS has a 2.0% requirement for 2009 and it will increase to 15% in 2025. In an effort to meet the EPS, APS offers an EPS Credit Purchase Program.

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[1] "Solar Partners Incentive Program 2008 Funds," http://www.aps.com/my_community/Solar/Solar_80_archive.html, March 1, 2008, accessed March 2, 2009.

[2] The W. A. Franke College of Business, Sustainable Energy Solutions Center for Excellence and Northern Arizona University do not warrant or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, or process disclosed in this paper. The financial data presented in this plan are based on general assumptions and the accuracy of said assumptions is in no way promised or guaranteed. It is recommended that professional guidance be sought prior to installing a solar system.

Under this program APS will reimburse the homeowner $3 a watt up to a maximum of 50% of the installed costs if the house is grid-connected. In the exemplar, the homeowner received a $8,736 payment from APS. Under the agreement APS is "purchasing" the right to claim the electricity produced by the panel as an addition to the amount of renewable energy produced to meet the EPS requirement. As is explained below, the homeowner owns the electricity. APS is simply purchasing the ability to "count" it; whereas, the homeowner still owns the panel itself.

3) The new federal legislation also includes an important component for the current discussion. Beginning in 2009, residential solar systems are eligible for a 30% tax credit. Unlike the 2005 Energy Bill, there is no maximum credit. The eligible cost for the federal tax credit is net of the $1000 Arizona tax credit, so the basis is $21,393

Table 1: Net cost of a 2.912kW system

Retail Cost	APS $3 (x) DC watts	Az Tax Credit	Federal Tax Credit 30%	Out of Pocket Expense
22,393	- 8,736	- 1,000	-6,418	6,239

Producing, Using and Selling Electricity

The system under study went into operation in August 2007. Through September 2008 (14 months) the system produced 6,100 kilowatt hours of electricity. This was an average of 436 kilowatt hours per month. The monthly variation in production is substantial depending on weather and season of the year. Since the winter of 2007-8 had substantial snowfall in Flagstaff, there were numerous days when the system was covered in snow and therefore did not produce any electricity. The system in question is placed on a western facing roof.[3] As such, the exemplar system produces toward the lower end of the production outcomes for houses in Arizona. The Department of Energy (2000) estimates roughly 10% higher production in Phoenix and Tucson over Flagstaff.

The process with APS may be deemed *pure* net metering. At times when the residence is consuming more electricity than is being produced, the meter runs "forward." When the PV system is producing more electricity than is being consumed, the excess is fed back into the APS grid system and the meter runs "backward." The residential user then pays the net difference between what is being purchased from APS and what is being "sold" to APS. The digital meter, which was installed at the time the system became operational, keeps track of both the amount purchased from and the amount sold to APS.

During months when the amount of electricity produced by the PV system exceeds the amount purchased from APS, the residential homeowner accrues a balance of electricity which is then carried forward to future months. On January 1, the account is set to zero and the new year starts afresh. More will be said about the APS procedures below in the Discussions section.

An APS monthly bill can be rather confusing since there are up to 18 itemized charges on said bill. Some of these vary depending on electricity use and others are constant. Those that are constant can then vary with the number of days within the specific billing period. For the author's home, the monthly bill varies between $7.84 and $8.94 per month depending on the number of days between meter readings. Based on the October 2008 bill of another one of the authors (Allen) the variable cost of electricity was 11.269 cents per kilowatt hour. Thus, the first method of evaluating the financial investment in a solar

[3] This is not ideal since a southern facing roof both reduces the installation costs and increases production. However, by an oddity of the universe the Director of the SES Business Program owns the only house in the neighborhood without a south facing rooftop! As such, the panels required a fixed support structure to aim south and the morning sun has to clear the roof's pinnacle to reach the panels.

system is an average monthly saving of $49.13 or an annual production value of $590.[4] The simple payback calculation indicates that the out-of-pockets expense will be paid off in 10.6 years and thereafter the system provides "free" electricity.

A more sophisticated method for evaluation of investments is the net present value method. It calculates the present value of the future savings promised by the investment so that this value can then be compared to the cost today of the investment. The net present value of this annual savings over the expected lifetime of the system of 25 years was calculated using an interest rate of 5.7%.[5] The net present value (NPV) is estimated at $1,625. This number implies that the out-of-pocket expense of $6,239 results in a net return of $1,625 over the next 25 years through the monthly (on average) reduction of $49.13 on the residential electricity bill. As such, the investment is viable since the net present value is positive.

Another method of evaluating the investment is the Internal Rate of Return (IRR). The IRR provides a percentage value that is the return on the investment which can then be compared to returns on other investments of similar risk. In this case the IRR based on 25 years is 8.26%. In other words, if the owner invests $6,239 in the solar panel system, he/she will receive a 8.26% return on the investment.[6] Recalling that the extension of the federal tax credits was passed during the financial meltdown of 2008, this return shows a valuable asset!

The homeowner may be concerned not only with the purely financial aspects of the solar system, but also the environmental implications of the decision to go solar.

Environmental Implications[7]

Although estimates vary, electricity generation in the U.S. released roughly 5.8 million tons of sulfur dioxide (SO_2) and 6 million tons of nitrogen oxide (NO_x)into the atmosphere in 1998.[8] Many additional effluent compounds are known or suspected carcinogens and neurotoxins that can cause acute respiratory problems, and aggravate asthma and emphysema.[9] . In particular, coal-burning electric power plants account for roughly 57 percent of the total industrial air pollution in the U.S.[10] About two-thirds of SO_2, one-third of carbon dioxide (CO_2) emissions and one-quarter of the NO_x emissions in the U.S. are produced by coal burning.[11] Furthermore, burning coal also results in the emission of fine particulate matter into the atmosphere. These fine particulates become lodged in lung tissue raising lung cancer rates and, when combined with SO_2, are linked to at least 64,000 premature deaths annually.[12] NO_x and fine airborne particles exacerbate asthma, reduce lung function and cause respiratory diseases and premature death for many thousands of Americans. In 2002 there were 4,565 deaths and 465,000 hospitalizations due to asthma.[13]

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[4] Some minor rounding errors will be present throughout the calculations herein.

[5] Based on a 30 year fixed mortgage as estimated on January 25, 2009 by MarketWatch, http://www.marketwatch.com/tools/pftools/.

[6] The Rebuild America program in the Department of Energy has a simple calculator for determining the IRR of a project. http://www.rebuild.org/lawson/irrex.asp, accessed September 23, 2005.

[7] See Ratliff, N. and Smith, D., "Renewable Energy Electricity Generation In Arizona: What, Why and Maybe How," December 2002, Northern Arizona College of Business Administration Working Paper Series, 02-35, for further details on the pollution discussion. See Ratliff, N. and Smith, D., "Renewable Energy Electricity State Level Policies in the WRAP Region: What, Why and Maybe How," *Energy Sources*, V. 27 #5, pages 431-444, 2005, for a further discussion on policy issues regarding air pollution.

[8] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Purchasing Renewable Energy: A Guidebook for Federal Agencies, FEDERAL ENERGY MANAGEMENT PROGRAM, September 2000.

[9] Sierra Club, Dirty Coal Power, http://www.sierraclub.org/cleanair/factsheets/power.asp, accessed October 26, 2005.

[10] Mayer, Rudd; Blank, Eric; Udall, Randy; Nielsen, John, Promoting Renewable Energy in a Market Environment: A Community-Based Approach for Aggregating Green Demand, Land and Water Fund of the Rockies/U.S. Department of Energy Report Boulder, Colorado, May 1997.

[11] Reese, April, Bad Air Days, E Magazine: The Environmental Magazine, Nov/Dec99, Vol. 10 Issue 6, p28, 7p.

[12] Reese, April, Bad Air Days, E Magazine: The Environmental Magazine, Nov/Dec99, Vol. 10 Issue 6, p28, 7p.

[13] CDC National Center for Health Statistics, Asthma Prevalence, Health Care Use and Mortality, 2000-2001.

Smog formed by NO_x and reactive organic gases cause crop, forest and property damage. NO_x is also the primary cause of ozone smog. Each summer, smog provokes 6 million asthma attacks, and results in 160,000 emergency room visits, and 53,000 hospital admissions, in addition to causing visibility issues across the country.[14] SO_2 and NO_x combine with water in the atmosphere to create acid rain. Acid rain acidifies the soils and water supplies killing off flora and fauna that depend on pure water. Furthermore, global warming is mainly caused by CO_2 emissions released when fossil fuels like coal are burned. In America in 1999, coal-fired power plants alone released 490.5 million metric tons of CO_2 into the atmosphere (32 percent of the total CO_2 emissions for 1999).[15] In addition, coal contains trace amounts of mercury. When thousands of pounds of coal are burned in power plants every hour, mercury becomes a considerable problem. Mercury in freshwater fish has led 40 states to issue warnings about eating contaminated fish.[16] Mercury can cause neurological problems and developmental delays in children. The EPA estimates that at least six million women of childbearing age have levels of mercury in their bodies that exceed what the EPA considers acceptable and that 375,000 babies born each year are at risk of neurological problems due to exposure to mercury in the womb.[17]

Coal mining causes severe erosion, resulting in the leaching of toxic chemicals into nearby streams and aquifers, which pollutes drinking water and destroys habitats. Thomas Casten, author of *Turning Off the Heat*, writes, "In short, the excessively rapid consumption of fossil fuel in old power plants with out-of-date pollution control is causing local and global environmental problems."[18]

The energy created using the nonpolluting solar system described in this paper would reduce dependence on energy derived from a nonrenewable source. A 2.9kW system similar to the one described avoids creating up to 135 metric tons of CO_2 over the 25 year useful life of the system.

Table 2: Pollution abatement over the life of the system measured in lbs.[19]

	NOx	SO_2	Particulate	CO_2
15 years	691	708	397	162,454
20 years	921	944	529	216,605
25 years	1151	1180	662	270,756

Sensitivity Analysis

The analysis in this paper depends on key assumptions dealing with electricity costs and interest rates. The following analysis explores the sensitivity of the conclusions change to changing assumptions.

It appears likely at this time that energy costs are rising. The variable costs per kilowatt hour have been increasing over the last few years. In an earlier version of this paper in 2002, the average variable costs were 8.2 cents versus the current 11.3 cents. How the net present values will change if electricity costs increase is presented in Table 3 below. The benefits of the investment increase as the cost of electricity increases because the PV system continues to produce the same volume of electricity as the cost of the purchased electricity it displaces increases. An investment in a PV system will be a good hedge against

[14] Pianin, Eric, Study Ties Pollution, Risk of Lung Cancer Effects Similar to Secondhand Smoke, Washington Post, March 6, 2002.

[15] Sierra Club, Dirty Coal Power, http://www.sierraclub.org/cleanair/factsheets/power.asp, April 2001

[16] Meek, Jim, The Control of Nonpoint Sources of Water Pollution, Nonpoint Source, October 2000, #62.

[17] Sierra Club, Dirty Coal Power, http://www.sierraclub.org/cleanair/factsheets/power.asp, accessed October 26, 2005.

[18] Casten, Thomas R., Turning Off the Heat, Prometheus Books, 1998, p.77.

[19] The estimates in Table 6 are based on estimates from BP Solar's calculator. The estimates are then transformed for the estimated production of the exemplar system. BP Solar does not identify the assumed substitution fuel, but it can be presumed to be coal.

higher rates. This will be even more so when carbon taxes are placed on electricity production. Increasing the per unit cost of electricity to 15 cents per kilowatt hour increases the NPV to $4,079.

Table 3: Net Present Values for Varying Electricity Rates

Varying Electricity Rates						
NPV of						
Projected Savings minus Investment	0.10/kwh	.11/kwh	.12/kwh	.13/kwh	0.14/kwh	.15/kwh
25 years	$640	$1,327	$2,015	$2,703	$3,391	$4,079

The homeowner may also be concerned with the interest rate assumption of 5.7% used in the analysis. One interest rate that is easily observable is the current 30 year Treasury note rate. Treasury notes are virtually free of risk and as such are a good base rate to start from in exploring the sensitivity of the analysis to different interest rate assumptions. On January 25, 2009 this rate was 3.32%. The sensitivity analysis therefore uses a variety of interest rates, specifically 3.3, 5.7, 6.5, 7.5 and 8.2%.

Table 4: Interest Rate Sensitivity

NPV of Projected Savings minus Investment	3.32%	5.7%	6.5%	7.5%	8.2%
25 years	$3,810	$1,625	$1,053	$423	$32

Notice that as the interest rate goes up, the NPV of the investment obviously goes down, but for the range of interest rates used the investment more than pays for itself. As shown earlier, the IRR is 8.26%, so at rates above that the investment has a negative return.

The price of electricity where the system breaks even is 9 cents/kWh.[20] Since the current variable price from APS is in excess of 11 cents, this system proves to have a positive return on investment.

Discussion

The current Arizona state tax credit is capped at a maximum of $1000 or 25% of the cost of the system. The system in question far exceeded this maximum value. Indeed the author's system was installed when the federal cap was only $2000 so the financial benefits obtained from the actual system proved to be less from a financial situation. Given the current financial crisis in Arizona it is highly unlikely that this cap will be removed in the foreseeable future. Using linear conversions on the 2912 watt system, the IRR increases for *smaller* systems since the state tax credit is a larger proportion of the investment. For a 1 kilowatt system the IRR is 14.3% for the base assumptions. This is relevant since the sample system is actually too large for the home in question. A coincidental investment that can be made by the homeowner is in energy efficiency, Figure 1 below shows the entire history of the Smith electricity bills since the house was built. The obvious seasonality between winter (high) and summer (low) is clearly seen. Beginning in 1998 an effort was made toward improving the energy efficiency of the home. This process was essentially completed by 2002. The installation and operation of the solar system is also clearly seen in 2007. The minor peak in the early months of 2008 indicates the winter months following the beginning of a new calendar year.

Recall that APS zeros out the accrued electricity credit in January. Since this coincides with the months of lowest production and highest consumption, the bills for January and February 2008 were an "exorbitant" $26.53 and $18.91 respectively! Since the system had only operated during the last five

[20] This is the price where the NPV switches from a positive return to a negative return.

months of the year, and December 2007 was snowy and cloudy, a credit of 39 kilowatt hours was lost due to the APS policy. Beginning in March 2008 and throughout the rest of the year, the monthly bill was the minimum possible. The minimum monthly bill is for the following: basic service charge, metering, meter reading and billing. The resulting charge is roughly 27 cents per day for electricity to operate the entire Smith household!

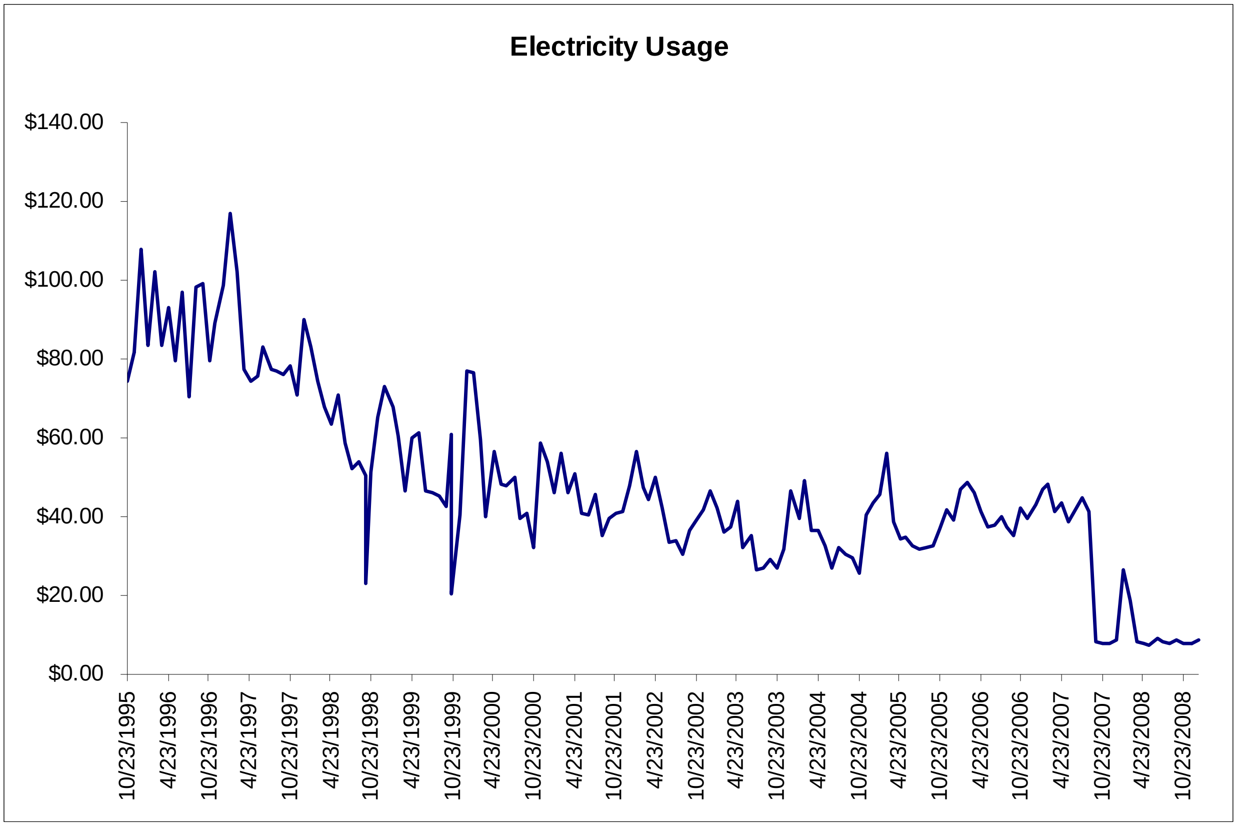

Figure 1: Smith household electricity bills 1995-2008

As mentioned, the system in question is actually too large for the existing electricity use at the Smith home. Figure 2 shows a breakdown of the average monthly bill for four time periods. Between moving into the home in 1995 and the end of 1998, the home was simply operated according to 20th Century habits and the average monthly bill was $78.10. Beginning in 1999 efforts were made to reduce the use of electricity. The average monthly bill was reduced by over one third to $48.88. This was followed in 2002 by a more concerted effort to minimize electricity consumption and yielded a further average savings of $20 for an overall saving of 50% from the baseline monthly bill. These changes included new investments in compact florescent light bulbs, new Energy Star appliances and a variety of other energy efficiency practices.

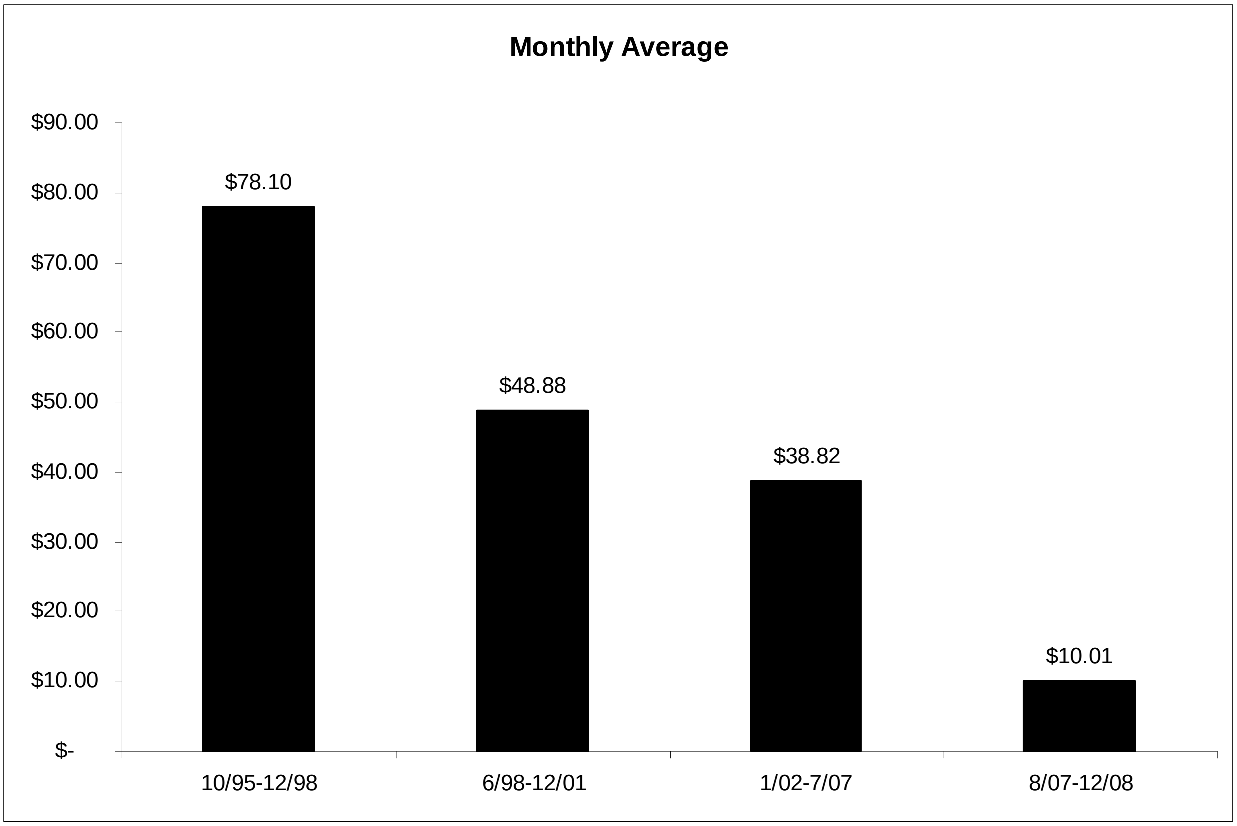

Figure 2: Average Smith household electricity bills 1995-2008 .

It should be pointed out that the time span 1995-2007 included a period of increasing per unit electricity rates.[21] Thus a household energy efficiency program, based on 21st Century electricity habits, can drastically reduce household bills. A wide variety of rebate and tax credit programs are available.[22]

The energy efficiency practices in the Smith household resulted in an electricity profile that is well below the expected production of a 2912 watt system as installed in August 2007.[23] As such, the overall actual savings has been less than that estimated for a home using in excess of the average monthly production of 436 kilowatt hours. However, this situation was fully understood prior to the investment. In 2009 the system "lost" 726 kilowatt hours for 2008 when the credit account was zeroed out. In other words, the system produced roughly 14% more electricity than was consumed by the Smith home.

This "extra" electricity offset roughly 1500 pounds of carbon dioxide or roughly the equivalent of 75 gallons of gasoline or roughly 3750 miles of driving, which is roughly 1/3 of the driving done by Professor Smith in 2008. But that is another story.

[21] The authors were unable to retrieve from APS the actual electricity consumption history of the Smith household. As such, the monthly bill amount must serve as a proxy. Any APS residential user can retrieve their billing history from the APS website.

[22] Visit the Database for State Incentives for Renewable Energy website for full details for your state.

[23] In 2007 two additional measures were taken to reduce energy consumption both of which have an impact on electricity consumption: a new efficient furnace and energy efficient windows. The main energy impact of these systems is on natural gas consumption, but the furnace does use electricity.

Final Notes

The new federal tax credit on a solar panel system makes an investment financially worthwhile. In this paper it is assumed that the homeowner has directly applied the tax credits from the state and federal governments against the purchase price of the system. There may also be some additional accrued interest between the time of installation and the tax credits are received in the form of lower taxes owed. Depending on the amount of time between these events, the amount will be minimal. The payment from APS faces the same issues.

The homeowner needs to shop around to find a good system and compare the various warranties and maintenance schedules. The Arizona Solar Center is a nonprofit organization promoting the utilization of solar energy in Arizona. Their website has links to several companies that sell solar systems such as the one discussed here. (http://www.azsolarcenter.com/index.html, accessed September 23, 2005) The seller should be able to provide the specific details of the tax credits. (If the seller cannot do this, then that is surely a negative sign.)

Once a contract has been negotiated with a company for the purchase of a system, the homeowner *must* contact APS to "reserve" an EPS agreement. The number of EPS credits available to homeowners is limited. The website for the program is a useful starting place. The homeowner needs to make sure the system qualifies for the agreement before signing a contract with the seller! (http://www.aps.com/my_community/Solar/solar_35.html, accessed September 23, 2005)

References

Casten, Thomas R., Turning Off the Heat, Prometheus Books, 1998

CDC National Center for Health Statistics, Asthma Prevalence, Health Care Use and Mortality, 2000-2001.

Database for State Incentives for Renewable Energy, "Residential Solar and Fuel Cell Tax Credit," Database for State Incentives for Renewable Energy, http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US37F&State=Federal&currentpageid=1, accessed September 30, 2005.

Energy Information Administration, Annual Electric Utility Report: Average Monthly Bill by Sector, Census Division and State, 2000 Residential, Form EIA-861, 1999.

Mayer, Rudd; Blank, Eric; Udall, Randy; Nielsen, John, Promoting Renewable Energy in a Market Environment: A Community-Based Approach for Aggregating Green Demand, Land and Water Fund of the Rockies/U.S. Department of Energy Report Boulder, Colorado, May 1997.

Meek, Jim, The Control of Nonpoint Sources of Water Pollution, Nonpoint Source, October 2000, #62.

National Renewable Energy Laboratory, Arizona Consumer's Guide to Buying a Solar Electric System, http://www.azsolarcenter.com/design/azguide.pdf , September 2000.

Pianin, Eric, Study Ties Pollution, Risk of Lung Cancer Effects Similar to Secondhand Smoke, Washington Post, March 6, 2002.

Ratliff, N. and Smith, D., "Renewable Energy Electricity Generation In Arizona: What, Why and Maybe How," December 2002, Northern Arizona College of Business Administration Working Paper Series, 02-35.

Ratliff, N. and Smith, D., "Renewable Energy Electricity State Level Policies in the WRAP Region: What, Why and Maybe How," *Energy Sources*, V. 27 #5, pages 431-444, 2005,

Reese, April, Bad Air Days, E Magazine: The Environmental Magazine, Nov/Dec99, Vol. 10 Issue 6, p28,

Sierra Club, Dirty Coal Power, http://www.sierraclub.org/cleanair/factsheets/power.asp, accessed October 26, 2005.

Smith, D. H. & Tallman, G. (2005). Investing In Your Future: With Current Arizona Policy A Solar Panel Is A Good Investment. *CBA Working Papers* 05-16, October 2005, .

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Purchasing Renewable Energy: A Guidebook for Federal Agencies, FEDERAL ENERGY MANAGEMENT PROGRAM, September 2000.

U.S Department of Energy Arizona Consumer's Guide to Buying a Solar Electric System, September 2000. http://www.azsolarcenter.com/design/azguide.pdf, accessed January 25, 2009.