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Money from the Sun

An Investor's Guide to Solar-Electric Profits

Paul Symanski

It happened quietly. On an ordinary day, a few years after the end of the last century, solar-electric energy became cheaper than fossil fuel energy. There were no great celebrations, no dancing in the streets, no discussion or mention in the news. The fossil fuel age has begun its decline, and the too-long-delayed renewable energy age is ready to supplant it.

Of course, photovoltaic (PV) energy has been economical for many years and in many situations—in remote areas where fossil fuels are not readily available, where the fossil energy utility grid does not reach, or in nations that do not control adequate supplies of fossil fuels. What happened recently is different, and has much more far-reaching consequences. It is becoming less expensive for us in the Sunbelt of the southwestern United States to power our homes and businesses with energy that is generated on-site by a solar-electric system than it is to purchase fossil fuel energy from the utility.

This is not to say that everyone can generate all of their electricity and do it economically. But, if your system is sized and sited properly, you are working within a comprehensive energy management plan, and if a number of other factors converge, then a small investment in supplemental solar-electric energy generation for your home or enterprise can exceed the average, long-term real return of the stock market.

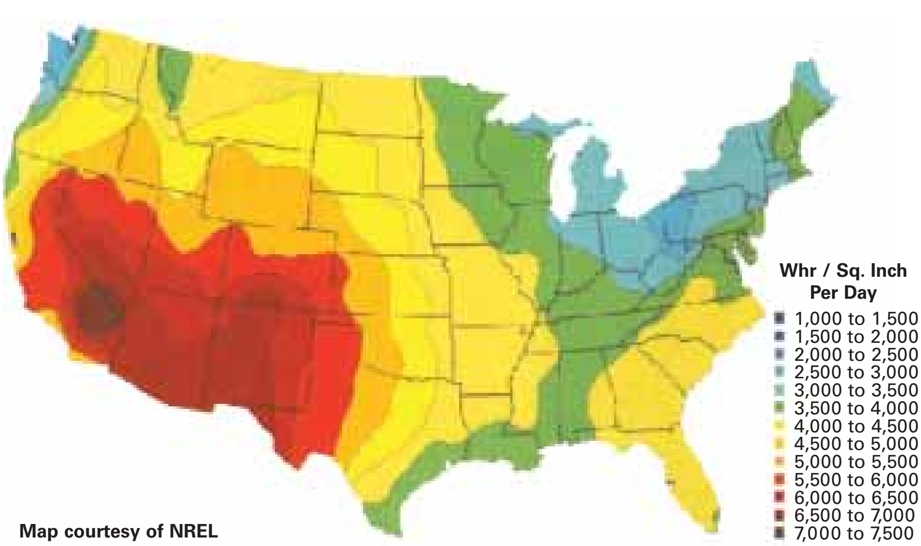
In more than fifteen years as a software engineer, I performed a multitude of roles, including designer, developer, system and information architect, systems analyst, network engineer, project and program manager, human factors specialist, author, and publisher. Several years ago, becoming disillusioned with the extravagances of the software industry, I returned to my roots as an electrical engineer and began to explore the fascinating world of renewable energy and sustainable living. To convince myself that pursuing a career in renewable energy would not just benefit society but would also support my family, I began to examine the economics of solar energy. I had to prove to myself that renewable energy would pay.

Fundamentals

To understand how to profit from solar-electric energy generation, you can perform a competitive investment analysis (CIA) between traditional investments, say, in the stock market or in treasury bills, and an investment in a solar-electric system. The fundamental question of this analysis is, "If I have a sum of money to invest today, can I expect a higher return with traditional investments or with an investment in a supplemental solar-electric energy system?"

The analysis shows that generating your own solar-electric energy is often the better investment. The factors

Solar insolation map of the continental United States.



Map courtesy of NREL

of this analysis come from five areas—natural resource assessment, technology, energy consumption, economics, and policy.

Natural Resource Assessment

The first factor to consider is the energy that the sun provides us. The insolation map shows the amount of solar radiation that is received throughout the United States.

Obviously, the Southwest has a great natural resource in the sun. To perform an accurate analysis, we need solar radiation data for each month throughout the year. The National Solar Radiation Database (NSRDB) can be found at the Renewable Resource Data Center (RReDC). For this analysis, the data is found in *The Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors.* (See Access.)

From this data, we can determine how much energy an unshaded array of solar-electric modules will receive in a specific location. We can then calculate how much energy the array will produce throughout the year. For example, see the table on page 89. It shows the average daily equivalent peak sun hours and production for an array of modules in Phoenix, Arizona.

Technology

Solar-electric energy systems consist of two basic types—those connected to the utility and those that operate independently of the utility. These are referred to as "grid-tied" (or "utility-tied") and "off-grid" systems, respectively. Some grid-tied systems include energy storage for when the utility is down. Others operate only when the utility is operating.

For my analysis, I focused on systems that are connected to the grid and have no storage component. If you are fortunate to be in a region where true net metering (i.e. your electric meter spins in both directions) is provided, you already have the perfect storage if backup is not needed. An investment in a solar-electric energy system of any size can then earn a maximum return, up to the amount of energy that is consumed.

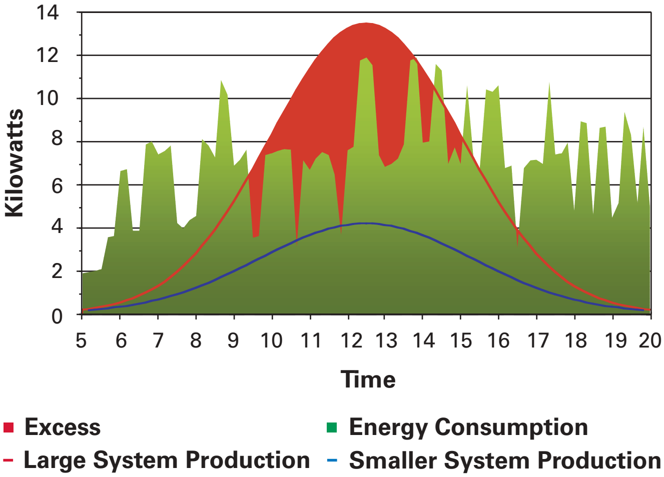
Today, most solar-electric modules are warranted for 25 years. Many first generation modules are still generating significant output after 35 years. For this analysis, a 20-year period is considered. In a batteryless grid-tied system, the one component that is subject to failure is the inverter. Repair costs for inverters are incorporated into the analysis, as are additional insurance costs for the entire system. The good news is that inverters of the latest generation may be far more durable and reliable than those of the previous generation.

The final element of solar technology to consider is module degradation. This competitive investment analysis uses an annual degradation rate of 0.7 percent based on an NREL white paper. (See Access.)

Energy Consumption

The first aspect to consider when specifying a solar-electric energy solution is the energy consumption. An electric load analysis must be performed, and energy consumption patterns must be considered.

Energy Production & Consumption for Phoenix



This analysis contains one critical assumption. Either you have true net metering that is zeroed annually, or in the absence of this optimal energy storage, all the energy produced by the PV system is consumed. In other words, unless you can sell the solar energy you generate at the same price that you pay for utility energy, don't make it!

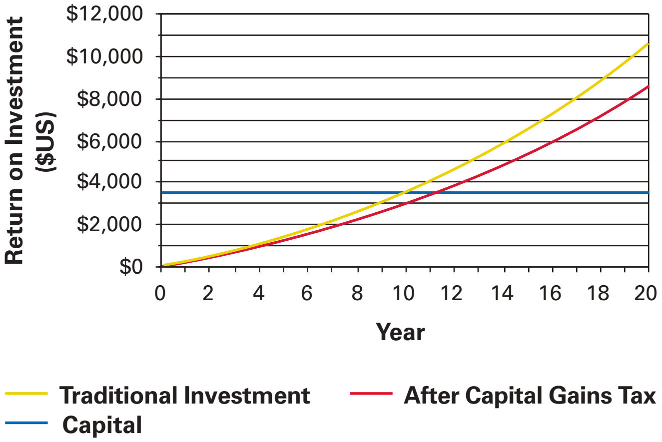
Without net metering, to maximize your profit while also maximizing your energy generation, you must implement energy management techniques. It is not only how much energy you use, but how and when you use it. A solar-electric system generates energy throughout a consistently sunny day in a smooth fashion. The red and blue lines in the Energy Production & Consumption for Phoenix graph (above) are clear-day energy production profiles of two different sized solar-electric systems.

The irregular, green area shows the daily consumption profile for a typical, 3,000 square foot (280 m^2) home in Phoenix, Arizona. The red area under the taller production profile represents the excess energy that will be returned to the public energy grid.

Without true net metering, to accomplish the largest annual return with the smallest possible system, the production and consumption curves must match for every day of the year. The energy consumption curve must be made smoother. In Arizona, cooling typically demands the greatest energy, just as it does during the longer summer days in more northern latitudes. The availability of solar energy matches this demand. With very little adjustment to lifestyle, an energy consumer can take a few simple measures to control how energy is used.

The degree to which the energy generation curve matches the consumption curve is called a load-matching factor. A factor of 1.0 indicates that solar-electric generation meets all energy demand and no energy is returned to the grid. In lieu of implementing energy management techniques, the PV system can be sized to fit the daily energy consumption profile. This smaller system generates the shorter energy production profile in the graph.

Traditional Investment Growth at 7.15%



Economics

The time value of money is critical to our analysis. Whether my utility bill is paid monthly or annually is just as important as how often my interest is compounded. All the rates in the analysis are effective rates adjusted for relevant periods and based on nominal annual percentage rates.

Traditional Investments

Since 1926, the average, long-term annual rate of return on large company stocks has been 10.2 percent. However, over this same period, the rate of inflation has been 3.05 percent. Therefore, the real rate of return on large company stocks has been 7.15 percent. The Traditional Investment Growth graph shows the growth of an investment at 7.15 percent over twenty years with interest payments being reinvested. An initial capital investment of US$3,250 earns US$10,500 in accumulated interest in twenty years. Not bad! Unfortunately, something is missing.

Taxes

Savings on utility bills are like post-tax income. This is a critical point for this analysis: you pay taxes on interest income; you don't pay taxes on money you save.

Currently, the capital gains tax rate stands at 15 percent, lowered from its previous rate of 20 percent on May 28, 2003. I used the current rate in my analysis. I ignored eligibility, brackets, effective dates, sunset provisions, and other capital gains tax complexities. The long-term annual return on large company stocks thus becomes 5.65 percent. The lower curve in Traditional Investment Growth represents the return on investment after capital gains taxes are subtracted.

An important aspect of the analysis is the point at which interest earnings match the original investment. This is when your earnings have doubled. For capital expenditures, this is known as "simple payback." Before taxes, at 7.15 percent, this occurs at month 110 (9 years, 2 months). After taxes, this occurs at month 130 (10 years, 10 months)!

Solar Investment

Question: If you were to take the savings realized from the lower energy bills resulting from the on-site generation of solar-electric energy, invest those savings at the same rate as the traditional investment, and reinvest any interest earned just as we do for traditional investments, how would the two alternative investments compare?

In this analysis, the interest earnings on the reinvested savings realized from on-site solar-electric generation are taxed at the capital gains rate, just as are the earnings on the traditional investment. The practical issues of brokerage fees are not considered as part of this analysis.

Before the returns can be compared, another key factor must be understood—utility rate schedules. By understanding rate schedules, you can calculate your avoided costs. The utility energy that you avoid consuming by replacing it with solar-electric energy is typically the most expensive energy that you purchase from the utility. The Monthly Production and Consumption table is an example of monthly consumption for a residence in Phoenix, Arizona.

The savings realized from on-site solar-electric generation can be calculated with knowledge of the monthly energy consumption, the avoided costs (including sales taxes, regulatory fees, etc.), and the amount of energy provided by the PV system. For example, the system illustrated in the table offsets 22.5 percent of the peak usage during the month of May. Since peak usage is charged at a higher rate than off peak, the savings are significant.

Efficiencies

For a 1 kilowatt array, you might expect that if 4.4 sun hours per day were available in January, you would achieve 4.4 kilowatt-hours per day from the system. However, no solar-electric system is 100 percent efficient. For example, high module temperatures will diminish an array's performance. Also, modules do not usually produce the output that the manufacturers imply by their ratings.

Other factors contribute to the total AC output of the inverter being lower than the total solar-electric array output rating. For the calculations in the Monthly Production and Consumption table, we use monthly overall efficiencies that give an annual average efficiency of 71 percent. In January (with a monthly efficiency of 75 percent) the actual daily kilowatt-hours available from the solar energy system will be 3.3 KWH per m^2 rather than the ideal 4.4 KWH per m^2.

Without true net metering, if you want to maximize the return on your investment, you must size the system to minimize the amount of excess energy produced. The calculations for our sample home with a solar-electric system size of 1,000 watts show that we are generating on average about 20 percent of the monthly on-peak energy needs. Is it reasonable to assume that this home will consume all the solar-electric energy it is generating? No, not necessarily.

This Phoenix, Arizona, home has two independent, split HVAC systems with heat pumps. If these two systems operate concurrently, the energy demand during that period will be higher than can be met by the PV system. Conversely, if neither is running after they have together

Monthly Production & Consumption for Phoenix, Arizona Residence

Consumption	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
	Billing Period (Data in KWH unless Otherwise Noted)												
Total used	2,923	2,528	1,731	1,618	1,908	2,604	2,434	2,556	2,312	1,396	1,797	3,116	26,923
On-peak	781	600	470	474	793	963	984	1,116	973	473	587	932	9,146
Off-peak	2,142	1,929	1,261	1,144	1,116	1,641	1,450	1,441	1,339	923	1,210	2,184	17,780
Days in billing period	29	34	28	29	32	30	29	31	28	31	33	32	366
Average daily	100.8	74.4	61.8	55.8	59.6	86.8	83.9	82.5	82.6	45.0	54.5	97.4	73.6
Average daily on-peak	26.9	17.6	16.8	16.3	24.8	32.1	33.9	36.0	34.8	15.3	17.8	29.1	25.0
Average daily off-peak	73.9	56.7	45.0	39.4	34.9	54.7	50.0	46.5	47.8	29.8	36.7	68.3	48.6
% On-peak	26.7%	23.7%	27.2%	29.3%	41.6%	37.0%	40.4%	43.7%	42.1%	33.9%	32.7%	29.9%	34.0%

Production*

Production*	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average daily sun hours	4.4	5.4	6.4	7.5	8.0	8.1	7.5	7.3	6.8	6.0	4.9	4.2	6.4
% Seasonal system efficiency	75.2%	74.3%	73.3%	71.6%	69.6%	67.5%	66.3%	66.8%	68.1%	70.6%	73.4%	75.1%	71.0%
Adjusted sun hours available	3.3	4.0	4.7	5.4	5.6	5.5	5.0	4.9	4.6	4.2	3.6	3.2	4.5
Avg. daily on-peak use	26.9	17.6	16.8	16.3	24.8	32.1	33.9	36.0	34.8	15.3	17.8	29.1	25.0
Remainder on-peak use	23.6	13.6	12.1	11.0	19.2	26.6	29.0	31.1	30.1	11.0	14.2	26.0	20.5
% Solar on-peak	12.3%	22.7%	27.9%	32.8%	22.5%	17.0%	14.7%	13.5%	13.3%	27.7%	20.2%	10.8%	18.1%

*1 KW PV system in Phoenix, AZ with a fixed mount facing south at a 20 degree tilt.

sufficiently chilled the house, the energy from the PV system may be wasted (returned to the grid for less than its full value), if true net metering is not in force. The technique of load balancing multiple air conditioning systems is perhaps the best example of the importance of effective energy management for maximizing the return on an investment in solar-electric energy generation. Of course, there are many other energy management techniques, and the effectiveness of any technique depends on the region and other interdependent factors.

Policy

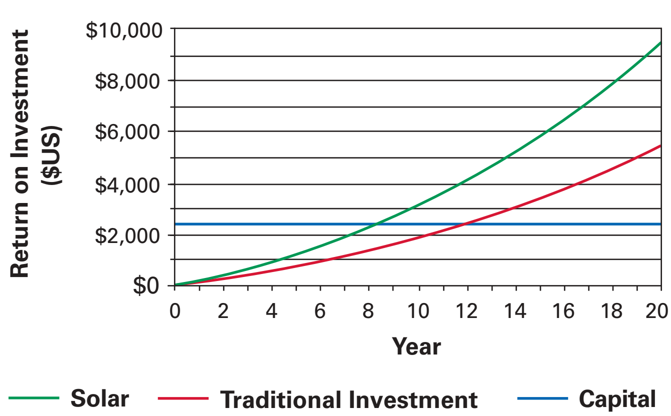
Policy dramatically affects the return on investment in solar-electric energy. Existing policies provide some important incentives for solar-electric and other forms of renewable energy. An excellent resource that lists renewable energy incentives is the Database of State Incentives for Renewable Energy (DSIRE).

The state of Arizona provides several incentives to homeowners for solar-electric systems. There is a one-time tax credit for 25 percent of the cost of a qualifying system up to a maximum of US$1,000. In addition, PV systems are exempt from sales taxes in Arizona. Arizona has also implemented an environmental portfolio standard (EPS), which includes Arizona Public Service (APS) providing a rebate of US$4 per DC watt, up to 50 percent of the installed cost of the system, for small (less than 5 KW), grid-tied, solar-electric energy systems.

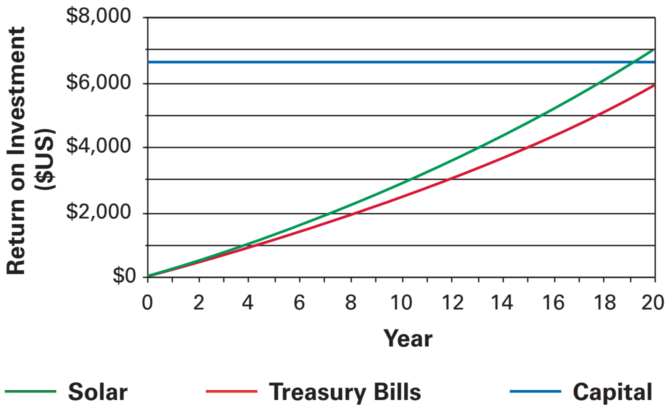
Results

The PV vs. Traditional Investments graph (below) shows the results of the comparative analysis of on-site solar-electric generation versus a traditional investment with a 7.15 percent annual return. The installed cost of this system

PV vs. Traditional Investment at 7.15%



PV, No Incentives vs. Treasury Bills



is US$6,500 (1,000 watts at US$6.50 per watt). After incentives, the effective cost is US$2,250.

Utility rates are rising. The Arizona Corporation Commission (ACC) recently approved a request by APS to increase rates by 9.8 percent. The price of natural gas, the fossil fuel that powers the newest generating plants, is increasing. The ACC also recently approved a so-called "power supply adjuster" that allows APS to pass on to consumers the cost of electricity purchased on the open market. My analysis includes the 9.8 percent rate increase and a conservative 2 percent increase in each following year.

More complex factors can be introduced into the analysis, such as the value of the equipment over time, or a comparison that includes the value of the original capital. Inflation has a near equivalent effect on both sides of the comparison, so it does not need to be considered in calculations for projected earnings.

Another question often raised regarding on-site solar-electric energy generation comes from the fact that we live in a mobile society. What happens to my investment when I move to a new home in five or ten years? As on-site solar-electric generation becomes more prevalent, the value of these systems is becoming better understood and accorded value just as is a pool, a kitchen upgrade, or other home improvement. According to the National Association of the Remodeling Industry and Wells Fargo Bank, "The [increase in home] appreciation ranges from 20 times your expected annual savings to the full cost of the solar system."

Risks

The return on your investment in home solar-electric energy generation compares favorably with the average, long-term return on stock market investments. But what are the comparative risks? Solar electricity can be considered a low-risk investment because its return is relatively predictable.

The PV, No Incentives vs. Treasury Bills graph (above) shows the results of the comparative analysis of on-site solar-electric generation *without* incentives versus treasury bills as a low-risk investment. The average, long-term return (before inflation) of treasury bills is 3.79 percent. Remember, inflation was 3.05 percent over the same period, so the real rate of return on treasury bills was actually 0.74 percent! Even without incentives, on-site solar-electric generation is an extraordinary investment today. Consider your portfolio diversification strategy—what better low-risk investment than solar energy?

Many Happy Returns

We have shown that in Arizona and with incentives, the return on investment in home solar-electric generation is comparable to the average, long-term return on investment in the stock market. However, the return for PV generation is predictable. Therefore, an investment in PV generation may be considered a low-risk investment. Even when incentives are excluded, an investment in home solar-electric generation is comparable to a traditional low-risk investment.

The same analysis can be performed for systems on commercial or industrial buildings. Even though different incentives apply, the results are as good or better than for residential systems, especially when utility energy rates rise. Rates for commercial and industrial utility customers are usually higher than for residential customers.

In regions outside the Sunbelt, incentives can result in comparable returns. An excellent example is New Jersey where, despite a relatively low natural resource, the combination of high energy costs and extraordinary incentives combine to deliver a high return on investment in on-site solar-electric energy generation. Finally, when benefits, such as improving the environment, natural resource conservation, and job creation, are considered as part of the investment analysis, the return for an investment in solar-electric generation is immeasurably better!

As exciting as the return on investment for on-site PV generation is, the returns for energy management measures such as efficient lighting, solar domestic hot water, solar pool heating, etc., can be even greater. When implemented as a complement to PV generation, these measures increase the amount of energy that can be profitably generated, thereby maximizing the initial capital investment and subsequent returns.

Consequences

The immediate personal reward is that there is money to be made with on-site solar-electric generation. The scale of the investment correlates with your energy needs and is a relatively small investment of capital whether you are a homeowner, a business owner, or a large institution. Because of its low-risk nature, on-site solar-electric energy generation makes an excellent addition to your portfolio and complements an investment diversification strategy.

With today's low financing rates, now is a good time to fund capital projects. You can finance a system at a portion of the expected rate of return for a relatively short initial period before realizing the full return during the remaining decades of the system's life.

On-site solar-electric energy generation can also be an effective risk management tool, since our aging, fragile, vulnerable electricity grid is susceptible to disruptions. A solar-electric energy system can be designed to meet your energy surety needs. Risk prevention may balance the greater costs of such a system. In any event, investing today in a small, supplemental solar-electric system can provide valuable experience with on-site energy generation and prepare you for the future.

Finally, within the warranty period of the system, you will have accumulated as much or more savings with a solar-electric energy system than you would have with a traditional investment. It will be enough savings to expand or upgrade your existing system, or to purchase an entirely new, next-generation system. To wait is to waste.

Access

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Renewable Resource Data Center (RReDC), National Renewable Energy Laboratory, 1617 Cole Blvd. MS/1612, Golden, CO 80401 • mary_anderberg@nrel.gov • http://rredc.nrel.gov

The Database of State Incentives for Renewable Energy (DSIRE), NC Solar Center, NC State University, Campus Box 7902, Raleigh, NC 27695 • susan_gouchoe@ncsu.edu • www.dsireusa.org

Arizona Public Service, PO Box 53999, Phoenix, AZ 85072 • 602-250-1000 • www.aps.com

National Association of the Remodeling Industry (formerly The National Remodelers' Association), 780 Lee St. Suite 200, Des Plaines, IL 60016 • 800-611-6274 or 847-298-9200 • Fax: 877-685-NARI • info@nari.org • www.nari.org

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