Payback and other Financial Tests for Solar Electric Systems

By Andy Black

How to calculate the return on your solar electric system investment before you buy.

For years, questions about returns on the expensive investment in a solar electric system were dismissed with the analogy, "What's the payback on your swimming pool?" That sentiment might speak to the converted, but for most people considering a solar energy system, the financial case is a major deciding factor.

Fortunately, photovoltaic (PV) technology has matured such that the payback question can now be given a serious answer, backed by solid math and accounting. The answers vary significantly by local climate, utility rates and incentives. In the best cases in California, the compound annual rate of return is well over 10 percent, the cash flow is positive, and the increase in property resale value more than covers the cost of the PV system. In other parts of the country where electric rates are low and incentives may be less, a grid-tied system may barely cover its maintenance costs.

This article focuses on residential analyses for homes in Northern California's PG&E utility territory. Similar calculations can be done for commercial situations, but significant differences in the tax and accounting rules exist. See the resources mentioned at the end of this article to learn more about commercial analyses.

What Factors Improve Payback?

The most important factors for making solar an attractive investment include high electric rates, financial incentives, net-metering policies and good sunlight (available in almost all of the continental United States).

High electric rates can come in various ways. California has a tiered pricing system penalizing large residential users with prices as high as $0.36 per kilowatt-hour (see Fig. 1).

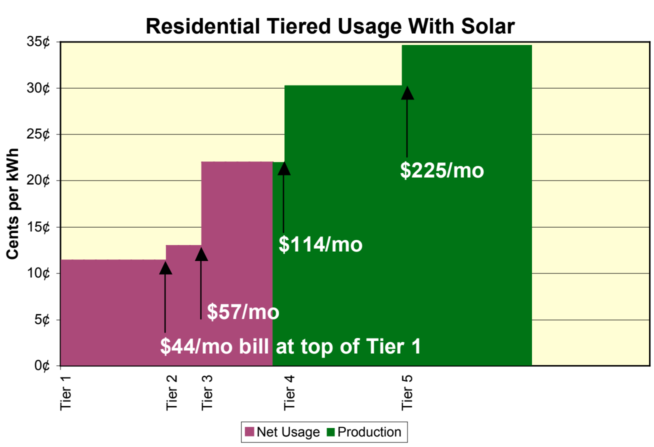

Fig. 1. Tiered rate pricing penalizes large users most with a marginal electricity cost up to 36¢/kWh. The combined green & red areas show the customer's total usage (equal to his usage before solar), and the relative value in each tier. Solar energy offsets highest tier usage first, making the solar customer look like a small user, with a lower marginal cost.

Under net-metering laws, solar energy offsets the retail cost of the electricity generated. Even better, in California, solar systems are allowed to operate on a time-of-use rate schedule, which enables users to sell back electricity to the utility at peak rates, which can be even more valuable. Time-of-use rates vary electricity price by time of day, with the higher rates occurring during times of shortage, when the utility must pay more to purchase electricity from generators. Solar tends to produce its electricity during these higher rate periods. These high rates are the most important factor in improving the payback.

Direct incentives can include tax benefits such as credits or depreciation. The most celebrated recent incentive is the federal tax credit for solar systems that went into effect Jan. 1, 2006. The credit is for 30 percent of the system cost up to $2,000 for residential systems (no cap on commercial credits). For PV systems, that typically means a $2,000 credit on the purchaser's tax return for the year the system was installed. This credit can be coupled with state, local, & utility incentives. One such popular incentive is the California Solar Initiative (CSI) rebate, which can discount up to an additional 30-40 percent of the system's cost. Consult a certified tax advisor to check the applicability of such incentives to your situation.

A big factor in the economics is inflation in electric rates *(see Fig. 2).* Solar is an inflation-protected investment, because it offsets electricity costs at the current prevailing retail rate. As rates rise, the owner saves even more.

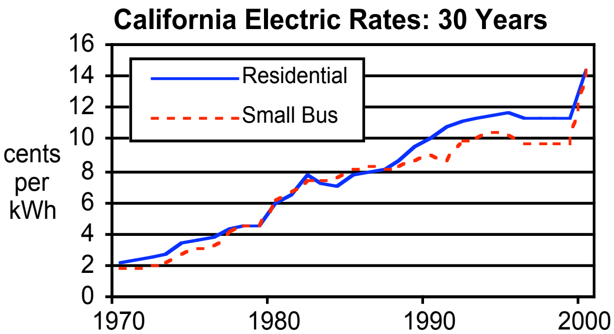

Fig. 2. Rates have gone up an average of 6.7% per year for 30 years. Source: CPUC "Electric Rate Compendium" Nov. 2001. This article assumes inflation will be 5% going forward.

Newer forms of direct incentives are PBIs (performance-based incentives) and RECs (renewable energy credits, or "green tags"). Both incentives are paid on a per-kilowatt-hour basis. Unlike rebates, they don't help reduce the up-front cost, but they do increase the cash payments received after commissioning the system. Payments can be as much as $0.39 per kilowatt-hour for five years for the PBI, and between $.01 than $0.05 per kilowatt-hour for a 5-plus-year contract on RECs if the system size is large enough (usually at least 10kW). Because these payments often can be combined with net-metering value, the PV system is capable of garnering substantial revenue per kilowatt-hour generated.

Determining the Payback

Several useful ways to measure the economic value of a solar system are: *compound annual rate of return, cash flow* and *increase in property resale value.* In strong economic cases, the annual returns will be over 10 percent, the cash flow positive and the increase in resale value greater than system cost. These are common returns in PG&E territory.

Compound annual rate of return, or CARR, on an investment is another term for interest-rate yield, which is a way of comparing one investment to another. For example, a savings account might pay 1 percent interest and the long-term stock market has paid about 10.5 percent. Solar systems in California can often see a pre-tax CARR of 10 percent or more.

Several examples are shown in Table 1. For more detailed information on these and the subsequent calculations, see the articles at www.ongrid.net/papers

The cash flow will be positive, either immediately or within the first few years, for many homeowners who finance their solar systems using home equity loans.

Before Solar		Solar System Size & Cost				Results, Savings, & Benefits					
Electric Bill	kWh Usage per Month	PV System Size (CEC Rating)	Gross Cost	PG&E Rebate @ $2.43/W	Final Net Cost w/ $2K Fed Tax Credit	Pre-Tax Compound Annual Rate of Return	Appraisal Equity / Resale Increase in First Year	New Electric Bill With Solar	Net Monthly Cash Flow Compared to 7.5% 30-yr Loan in First Year	Net Monthly Cash Flow Compared to 7.5% 30-yr Loan in Fifth Year	Total Savings Over 25 Years
$ 100	675	3.0 kW	$28K	$7K	$20K	11.3%	$20K	$11/mo	$-13/mo	$0/mo	$43K
$ 200	1010	5.0 kW	$46K	$12K	$33K	14.5%	$44K	$6/mo	$26/mo	$62/mo	$96K
$ 374	1500	8.0 kW	$72K	$19K	$51K	17.1%	$84K	$7/mo	$106/mo	$181/mo	$183K
$ 374	1500	5.0 kW	$46K	$12K	$33K	19.9%	$63K	$102/mo	$104/mo	$160/mo	$137K

Table 1. Example residential systems and their financial costs and benefits

The cash-flow calculation compares the estimated savings on the electric bill to the cost of the loan. Monthly loan cost is the principal plus interest payment required to pay off the loan, less any tax savings. In the case of "deductible" loans, such as home equity-based loans, the interest is usually tax-deductible and thus the loan effectively costs less. Home equity loans are also excellent sources of funds because interest rates on real estate-secured loans are relatively low and payment terms can be long.

Inflation plays an important part. Inflation affects electric rates and thus effectively increases the savings from a solar system over time. Inflation doesn't affect loan rates, particularly with fixed-rate loans. Hence, as electric rates rise, the savings grows, but the cost of the loan stays relatively constant (it rises a little over time as the interest portion of the payment declines and the tax deductibility declines). See Fig. 3 for an example.

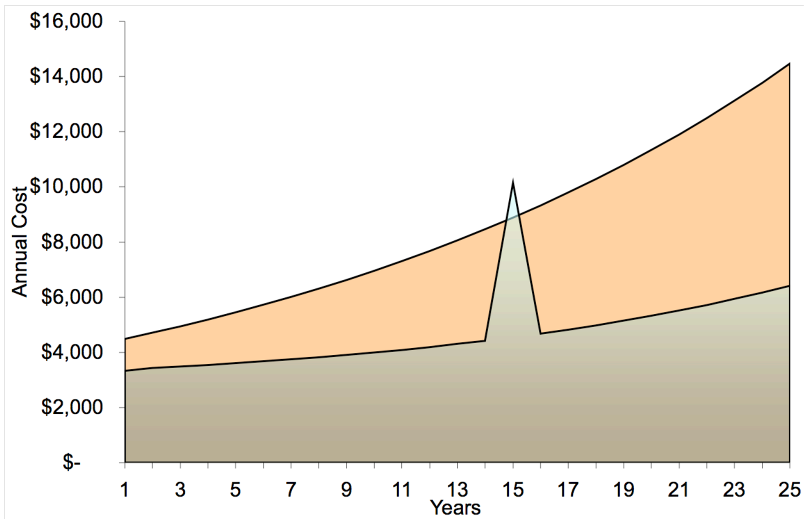

Fig. 3. Inflation's Effect on Loan Costs Versus Electric Costs Without Solar

Fig. 4 highlights the difference in the curves in Fig. 3. This figure shows the net annual savings — old bill minus new bill, loan, maintenance and inverter-replacement costs — and shows the effects of inflation over time.

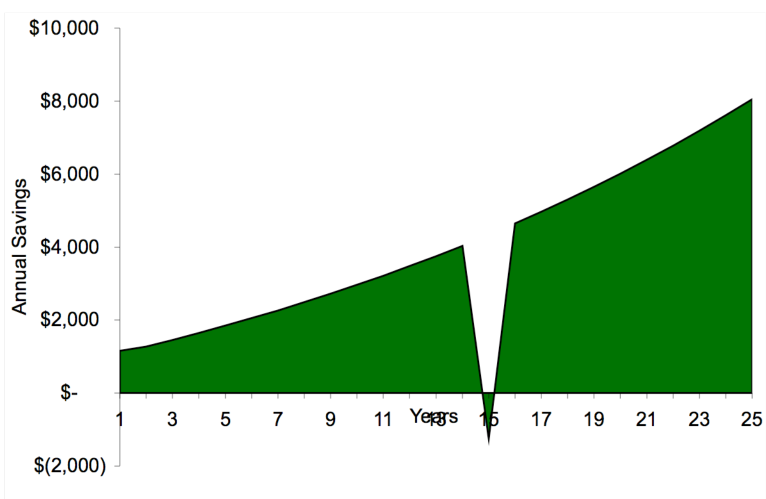

Fig. 4. Net Annual Savings With a Photovoltaic System
Net annual savings consists of the old electric bill minus the new bill, loan principal payments, loan net interest (after taxes), maintenance and inverter-replacement costs. This example system is cash-positive from the first day at no "out of pocket" costs to the purchaser.

Fig. 5 shows the accumulation of net annual savings. This accumulation is free and clear with no initial outlay of cash, because that was covered by the loan. In the example in Fig. 5, the system will save the owner about $90,000 over 25 years, with no up-front cost. The savings are small though significant in the first years, but increase over time due to inflation. Of course, the purchaser can select any loan term that suits his needs.

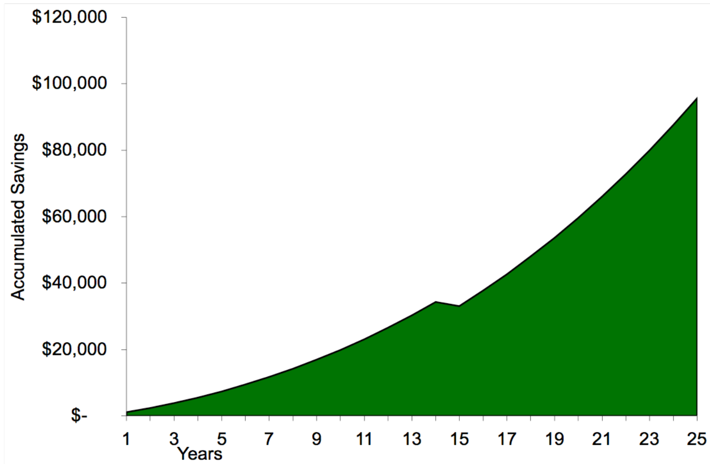

Fig. 5. Accumulated Savings With a Photovoltaic System
Accumulated Savings over 25 years with no "out of pocket" costs to the purchaser.

Table 1 includes several examples showing the initial monthly cash flow, assuming 100 percent financing of a solar system's final net cost.

An Increase In Property Resale Value occurs in homes with solar electric systems because these systems decrease utility operating costs. According to a 1998 *Appraisal Journal* article by Rick Nevin and Gregory Watson, a home's value increases $20,000 for every $1,000 reduction in annual operating costs from energy efficiency. *(See www.icfconsulting.com/Markets/Community_Development/doc_files/apj1098.pdf.)*

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. Nevin and Watson state that historic mortgage costs have an after-tax effective interest rate of about 5 percent. If $1,000 of reduced operating costs is put toward debt service at 5 percent, it can support an additional $20,000 of debt. To the borrower, total monthly cost of home ownership is identical. Instead of paying the utility, the homeowner pays the bank, but the total cost is unchanged.

See the column labeled "Appraisal Equity Increase" in the table for examples of the increase in home value. This increase can effectively reduce the payback period to zero years if the owner chose to sell the property immediately, and it removes the purchase risk. It could even lead to a profit on resale in some cases.

This increase in property value to date is currently theoretical. A high fraction of the grid-tied solar electric systems have been installed since 2001. Most of these homes have not been sold, so there are no broad studies of comparable resale values available. However, emerging evidence suggests that some solar-home sellers are realizing significant jumps in resale value.

A 2004 National Renewable Energy Laboratory (NREL) study demonstrated that San Diego zero-energy homes with solar features increased in value faster than comparable conventional homes in a nearby community. *(Access the report at www.nrel.gov/docs/fy04osti/35912.pdf.)* On average, the homes increased in value $40,000 more than the conventional homes, at a higher rate of appreciation and with a shorter length of ownership. This boost in resale value outstrips the estimates shown in Table 2.

PV systems will appreciate over time, rather than depreciate as they age. The appreciation comes from the increasing annual savings the system will yield as electric rates and bill savings rise. All the calculations in this article assume annual electric rate inflation will be 5 percent. If so, the PV system will save 5 percent more value each successive year, and thus gain from the 20:1 multiplier effect. The property resale value will then increase 5 percent per year compounded.

This appreciation cannot continue forever, as the increase in resale value runs into the second limit, which relates to the system's remaining life. For these analyses, the system is assumed to be worthless at the end of 25 years. This estimate is conservative, since the panels are warranted at 25 years to work at 80 percent of their new capability. If the system is worthless at the end of 25 years, the only value the system has as it nears that time are the savings it can generate before the end of the 25th year. Fig. 6 shows both the increasing property resale value due to increasing annual savings and the remaining-value limitation that takes over at approximately year 11. As the NREL resale study suggests, however, actual resale could be much higher depending on the market mood for solar.

Creating Markets That Reward Investment

For more information on calculating photovoltaic system economic analyses and to see the analyses in this

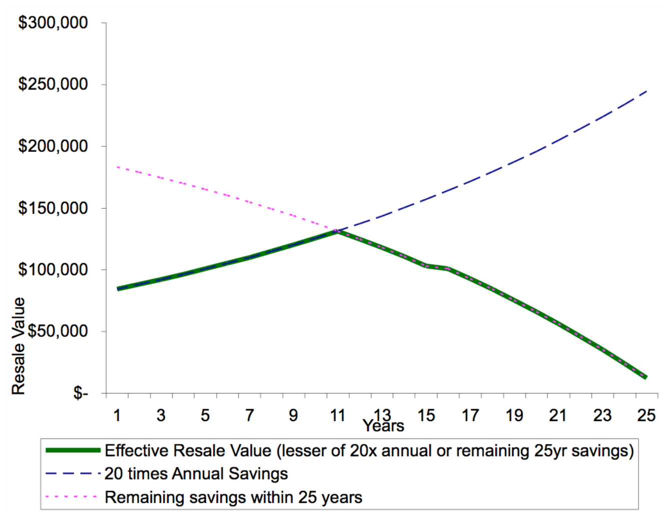

Fig. 6. Resale Value
Increases over time due to solar until limited by remaining system lifetime savings.

article explained in more depth, access www.ongrid.net/papers. Additional resources are listed in the sidebar, "Payback Calculators and Resources." Be aware that some tools don't account for tiered or time-of-use electric rates in interaction with PV production, and as such, their results may over- or underestimate the value of a PV system in a particular situation.

Solar has finally come into its own in certain markets. These markets are exploding because individuals are discovering the financial benefits of owning PV systems in those regions. In order to encourage widespread adoption of solar energy, we need to empower everyone with this knowledge and expand the components that make it possible — tiered rates, time-of-use net metering, RPSs with solar requirements and RECs. Market forces will take it from there.

 Andy Black is CEO of OnGrid Solar, providing solar financial analysis tools and consultation. He serves as a board member of the American Solar Energy Society and the Advisory Board of NorCal Solar. Contact him at 408.428.0808 or www.ongrid.net. Black regularly teaches and consults on "Payback on Solar Electricity" for many audiences.