FINANCIAL PAYBACK ON CALIFORNIA RESIDENTIAL SOLAR ELECTRIC SYSTEMS

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ABSTRACT

Cost effectiveness for consumers of solar electric systems has been achieved in the California residential market due to Time-of-Use Net Metering, a tiered electric rate structure with high rates, and subsidies by the state government.

Three different approaches test and validate this hypothesis for a large fraction of consumers. Solar electricity can generate rates of return of 11% to 21% exceeding most other common investments, can increase property value by more than the cost to install the system, and generate a positive cash flow if financed.

This paper suggests further study in the commercial sector and a survey to document evidence of increased home resale value.

1. INTRODUCTION

Achieving cost effectiveness for solar energy has long been the Holy Grail. A combination of factors has conspired to achieve this for certain California energy consumers.

Three different tests of financial feasibility show that solar electricity can be a good investment on financial terms alone. These tests include:

- Rate of Return greater than 11% per annum
- Increase in property value with respect to system cost
- Savings on utility costs versus system financing costs

2. BACKGROUND

The contributing factors to this financial feasibility are:

1. Government Incentives
2. Net Metering on an annual basis
3. Time of Use Billing
4. High Electric Rates
5. Declining System Costs
6. High Tax Brackets

2.1 Government Incentives

The two most important state government incentives include the $4.00/Watt rebate based on the AC output wattage as rated by the California Energy Commission and the 15% California state income tax credit based on the net after rebate cost of the system. For home businesses, there are a 10% fed tax credit and 5-year MACRS depreciation applicable to the proportion of the system allocated to the business use of the home.

It should be noted that there is a federal income tax consequence to receiving a state income tax credit. If federal taxes are itemized, then the state income tax deduction is reduced. The result is increased federally taxable income.

These factors reduce the up-front costs and can reduce tax burdens, reducing the required capital to purchase a system.

2.2 Net Metering on an Annual Basis

Net Metering on an annual basis provides for the exchange of energy at full retail value. This allows the system owner to produce energy when convenient, effectively store it in the utility grid (like a 100% efficient battery), and consume energy when needed. Net Metering in California is done on an annual basis; so summer excess production can be stored for winter, when production is often lower.

2.3 Time Of Use Billing

Time of Use Billing for electricity costs values electricity differently at different times of the day. Pacific Gas & Electric (PG&E) residential customers can select a Time of Use billing plan that has an on-peak period from Noon to 6 PM during the week-days of the “summer” months (May 1 to October 31). There is a winter on-peak period, and summer and winter off-peak periods. Each has its own value associated per kWh.

TABLE 1: TIME OF USE METERING CHARGES IN PG&E TERRITORY FOR E-7 RATES

Rate level	Rate	Period
Summer peak	$.31	Noon-6pm Mon-Fri Summer
Summer off-peak	$.09	all other times
Winter peak	$.12	Noon-6pm Mon-Fri Winter*
Winter off-peak	$.09	all other times

*Winter is November 1 to April 30

2.3.1 Combining Net Metering and Time of Use Billing

Combining Net Metering and Time of Use Billing has great advantage with a solar electric system under certain common conditions. Full retail value is given depending on time of day. Solar electricity generated in excess of on-site demand can be sold for $.31/kWh during the summer peak hours. During off-peak periods (i.e. at night), energy can be repurchased at about $.09/kWh.

The juggling of purchases and sales of energy can occur on an annual basis as well. So high value summer credit can be accumulated, and used to offset lower cost winter usage.

2.3.2 The Logic of Time-Of-Use Net Metering

If sized right, and facing ample southwest sunlight, in order to offset nighttime usage, a system must produce surplus energy when sun shines which is during the peak period.

The system must be selling during afternoon on peak, and the bulk of its net buying must be off peak

2.3.3 Value Of Time of Use Net Metering

Sales during summer peak occur at $.31/kWh. Purchases during off-peak occur at $.09. The ratio is about 3.5 to 1 in customer favor. That is, the utility is storing power for the customer like a battery at 350% efficiency.

This can allow for a substantial reduction in system size. The reduction depends on percentage of energy used on peak and by season. It also depends on solar array orientation with respect to southwest, and shading that may occur during the peak period, especially in the summer.

It should be noted that the solar electricity system supplies less total kWh than is consumed by loads in the home. This allows a designer to target maximum financial benefit, rather than complete energy usage offset.

2.4 High Electric Rates

In June 2001 in response to the California Power Crisis, the state adopted a 5-tiered rate structure. For residential PG&E customers on any electric schedule, customers are assessed energy surcharges that increase with higher monthly usage totals. Surcharges begin at $.05/kWh for each kWh over the average usage of all customers in their regional area. Customers using roughly 2.5 times the average are surcharged $.11/kWh for incremental usage above that level. For many customers this results in an average per kWh charge that is 2-4 times most other parts of the US.

2.4.1 California Rate History

According to the California Public Utilities Commission[1], California electric rates have increased 6.7% per year on average from 1970 to 1995 (See Fig. 1). In 1996 deregulation began and rates temporarily froze. The 2001 adjustment realigned average rates with the historical 6.7% rate increase curve.

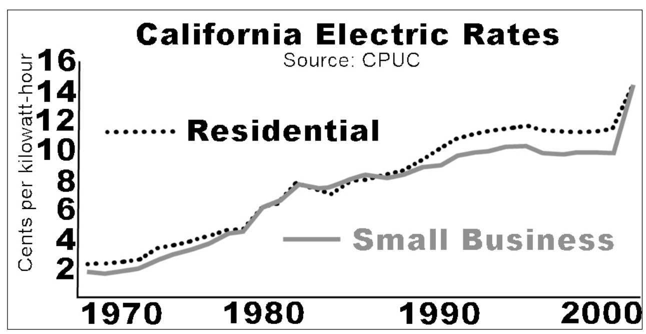

Fig. 1: California electric rate history.

2.5 Declining System Costs

Solar electric system costs have generally declined each year as a result of lower parts costs and simpler systems thanks to grid-tied inverters. Labor costs have declined due to improved mounting and wiring options.

2.6 High Income Tax Brackets

Residential electricity expenses are paid with after tax dollars – they aren’t tax deductible. Higher customer income tax brackets make after-tax costs more expensive with respect to income. That is, as tax rates goes up, the customer needs to earn more money to have same amount left to pay the electric bill after taxes are applied.

2.6.1 Comparable To Other Investments
In order to compare solar to other investments, all should be on the same side of the tax equation. Since most investments are taxable (i.e. stocks, savings interest, etc.), it is advantageous to covert solar savings to pre-tax value so all investments are measured on an even playing field. This demonstrates the increased value of a dollar saved with solar.

3. RATE OF RETURN CALCULATION

There are several methods to calculate the return on an investment. Two of the more common are Simple Payback and Rate of Return.

3.1 Simple Payback Is Inappropriate For Residential Solar

The Simple Payback method compares the total cost versus the annual savings. There are numerous flaws with using simple payback for a residential long-term investment. It may not properly include the tax savings and consequences. It does not account for inflation in electric prices, which at 6.7% per year will cause electric rates to double every 11 years. It does not account for maintenance or inverter replacement expenses. It makes it difficult to compare to other investments such as stocks, savings, etc.

Simple payback analysis on an after-tax basis does not reflect the true value of the saved utility expense, because after tax savings are worth much more on a pre-tax basis. However, trying to do a simple payback case using the pre-tax value of the savings, gives an unrealistically optimistic view of when "payback" has occurred.

Simple payback is appropriate for commercial analysis, but does not measure true value in residential cases.

3.2 Rate Of Return

Using a 25-year timeline (the warranted life of most modules) to represent cash flows for each year in the analysis allows the accurate inclusion of all relevant cost and benefits components. Tax savings and consequences, inverter replacement, cleaning & maintenance, and other significant financial events can be included at their appropriate places on the timeline. Then total cash flow for each year in the analysis can be summed. Using the internal rate of return (IRR) tool in a spreadsheet, one can find the effective interest rate of return for the investment.

It is then easy to incorporate inflation in the electricity savings, as well as maintenance costs. It is also possible to include effects from solar module degradation and the resultant reduction in production over time.

3.3 Pre-Tax Annual Rate of Return

To make the analysis most meaningful and comparable, it is necessary to convert the entire analysis to the pre-tax values for all amounts. This can be accomplished by adjusting the after tax amount using the following equation, where *TaxRate* is the net total effective income tax rate and *PreTax* is the resultant pretax amount.

$$PreTax = \frac{AfterTax}{(1 - TaxRate)}$$

All amounts in the analysis (including tax credit, tax expense, maintenance, inverter replacement and utility bill savings) need to be adjusted to the pre-tax amount except the initial capital cost. That amount is the net system up front cost (total out of pocket), and is unaffected by the taxation or lack thereof of future savings in the utility bill. Consider it the same as principal that is invested anywhere. The principal is never taxed upon its departure or return.

3.4 Example Pre-Tax Annual Rates of Return

To illustrate the tremendous opportunity represented by this form of analysis, Table 2 details several example cases showing returns from 11% to 21%. These cases are for custom full service residential system installations in Santa Clara County, California using prevailing rates for installed system costs. The Santa Clara area (Silicon Valley) is a higher cost area, so the system costs tend to be higher, implying that returns will be even higher for lower cost systems elsewhere.

TABLE 2: EXAMPLE PRE-TAX RATES OF RETURN

Pre-Solar Bill	kWh per Month	System AC Size	Final Net Cost
$75	570	2.0 kW	$14K
$100	710	2.8 kW	$17K
$150	930	2.8 kW	$17K
$250	1340	2.8 kW	$17K

Assumptions and explanations:

- Pre-Solar Bill refers to the electric bill before solar using the typical PG&E E-1 flat rate residential tariff. The analysis assumes the customer will switch to Time-of-Use E-7 billing to take maximum advantage of the savings.
- System AC Size refers to the California Energy Commission rating of the AC power production capability of the system. It includes some loss factors, but not others. Those other loss factors have been included to bring the estimated system productivity to the conservative side of realistic for the region.

- Final Net Cost refers to the total net cash out of pocket including total of installed system costs, permitting, PG&E fees, state tax credit savings, and federal costs on the state tax credit.
- Assumes the customer is in the 31% federal and 9.3% state tax bracket. Electric rate inflation is 6%. Module degradation is 0.5% per year. System maintenance cost is 0.25% of gross system cost per year, adjusted for inflation. Inverter replacement costing $2,700 occurs in year 20.

The 2.8kW AC system is used for the final 3 cases. It will not completely offset the total energy cost, so the new electric bill will not drop all they way to $0. However, the rate of return in based on the billed cost savings that the system will provide. It is designed to illustrate the increase in returns for customers with larger electric bills.

4. INCREASE IN PROPERTY VALUE

Solar electric systems decrease a site's utility operating costs, and therefore should increase property resale value. According to articles in the Appraisal Journal, a home's value is increased by $20 for every $1 reduction in annual operating costs from energy efficiency.

The authors of the Appraisal Journal[2,3] articles state that historic mortgage costs have an after tax effective interest rate of about 5%. If a dollar of reduced operating costs is put towards debt service, at 5% it can support an additional $20 worth of debt. Then to the borrower, total monthly cost of ownership is identical.

4.1 Example Increases in Home Value

In many cases the increase in property value is larger than the final net system cost, effectively reducing the payback period to 0 years if the owner chose or needed to sell the property immediately.

TABLE 3: EXAMPLE INCREASES IN HOME VALUE

Pre-Solar Bill	kWh per Month	System AC Size	Final Net Cost	
$75	570	2.0 kW	$14K	
$100	710	2.8 kW	$17K	
$150	930	2.8 kW	$17K	
$250	1340	2.8 kW	$17K	

For the highest use customer in Table 3, the savings enjoyed will be $1,590 per year. The home's value will increase by $31,800, but the buyer only paid a net $17,100 for the system, putting the owner $14,700 in the black.

Solar with the tiered nature of California electric rates shaves off the highest cost energy first. High users will see substantially larger annual savings and therefore larger increases in their home equity. In the extreme case, the increase in equity is nearly twice what the system cost.

While it is reassuring to claim such increase in property value, because few grid-tied solar homes have been sold in the real estate market, there is as yet little evidence to validate these claims.

5. CASH FLOW USING FINANCING

Financing makes the large capital outlay for a solar system achievable to more consumers. Weighing the savings in utility costs versus the cost of borrowing includes several factors.

- The cost of money, which is a function of the prevailing interest rate, loan term, and credit risk.
- Inflation risk. If utility rate inflation is expecting to continue at 6.7%, the amount saved will grow, but the loan costs will remain tied to interest rates.
- Income tax bracket. If the interest on the borrowed money is deductible, the higher the tax bracket, the smaller the initial loan costs.
- Interest rate risk. At the time of writing, the Prime Rate is at 4.25% and 30-year fix rate loans are commonly available at about 6% or less. If the interest rate on the loan rises, the loan cost will increase.

5.1 Example Cash Flows with Financing

In many cases the initial after-tax loan costs are less than the savings on the utility bill, creating a positive cash flow position from day one. With a fixed interest rate loan, as electric rates rise, the proposition gets more cash positive over time, even as the interest rate deduction decreases.

TABLE 4: EXAMPLE CASH FLOWS WITH FINANCING

Pre-Solar Bill	kWh per Month	System AC Size	Final Net Cost	N(
$75	570	2.0 kW	$14K	
$100	710	2.8 kW	$17K	-
$150	930	2.8 kW	$17K	-
$250	1340	2.8 kW	$17K	-

Assumptions:

- 30-year fixed loan at 6% interest. Borrower is in combined 40% tax bracket. Interest is deductible.
- Borrowed amount is equal to the final net cost.

The smallest usage customer in Table 4 will see a $6 per month increase in their initial cash flow. That amount will grow as the $75 electric bill is affecting by inflation. Larger electricity consumers see significantly larger improvements in cash flow because of the tiered rate structure.

6. CONCLUSION

To many, the bottom line question is about the bottom line - “Does solar electric make financial sense?” In many residential cases in California, it has been demonstrated by 3 independent tests that the answer is yes if there is:

- Good exposure to afternoon sun.
- Electric usage over $75/month
- Location in California’s PG&E territory
- Compared on equal footing using a 25-year analysis

7. RECOMMENDATIONS

7.1 Future Areas of Study

While it is reassuring to claim an increase in property value due to the savings on electric bills, because few grid-tied solar homes have been sold in the real estate bid market, there is as yet little evidence to validate these claims. A survey of solar home sales prices and comparison to comparable homes would validate this claim.

The commercial sector was ignored in this report. A similar analysis taking into account the 10% Federal Income Tax Credit and 5 Year MACRS depreciation and any additional commercial benefits may prove valuable. An important consideration would include factoring in the loss of tax deductible energy costs. Commercial analyses are done on an after tax basis, lending the perception of lower returns.

Quantifying the value of the hedge against future price spikes like those that occurred in June 2001 would help establish a market value to this benefit. This is often stated anecdotally as a reason to purchase a solar energy system.

Quantifying the value of the hedge against future inflation that is greater than the 6% estimate included in this study may expose additional value added.

A study on which of the 6 factors that contribute to this desirable situation for California solar electric consumers are the most valuable, and an sensitivity analysis of those factors.

7.2 Suggestions for Implementation in Other States

In the author’s opinion the most important factors that could lead to solar financial viability in other states are:

- Application of Time-of-Use Net Metering
- Establishing a tiered rate structure penalizing large users
- Small and declining subsidies.

A smaller direct subsidy could be tolerated. For example, a reduction of the CEC rebate program by 50% (to $2.00/watt) would adjust the $150/month customer’s results from 17.4% to 13.7%, increase system cost to $22K, and reduce positive cash flow from $45/month to $27/month. In the author’s opinion, this is still an attractive proposition, though it would reduce the attraction at lower usage levels.

8. REFERENCES

(1) CPUC Energy Division, PowerPoint Slide: California Electric Rates Residential, Small Business and Large Business Sectors 1970 to 2001, California Public Utilities Commission, November 2001

(2) Nevin, Rick et al, Evidence of Rational Market Valuations for Home Energy Efficiency, The Appraisal Journal, The Appraisal Institute, October 1998

(3) Nevin, Rick et al, More Evidence of Rational Market Values for Home Energy Efficiency, The Appraisal Journal, The Appraisal Institute, October 1999

9. APPENDIX A: Financial Detail of the Examples.

See Table 5 for additional financial detail of the examples. See Figure 2 & 3 for details on the 25-year financial analysis modeling.

TABLE 5: ADDITIONAL FINANCIAL DETAIL OF THE EXAMPLES

Pre-Solar Bill	kWh per Month	System AC Size	System Gross Cost	Final Net Cost	Pre-Tax Annual Return	Appraisal Equity Increase	Monthly Bill Savings	Annual After-Tax Savings	Loan (befo deduc
$75	570	2.0 kW	$23K	$14K	12.1%	$13.5K	$56	$672	$8
$100	710	2.8 kW	$30K	$17K	13.8%	$20K	$83	$996	$10
$150	930	2.8 kW	$30K	$17K	17.4%	$25K	$106	$1269	$10
$250	1340	2.8 kW	$30K	$17K	21.3%	$32K	$132	$1590	$10

Solar Electric System Analysis for:

Happy Customer
123 Solar Street
Sunnyvale, CA
1-800-SUN-PHONE
1-800-SUN-FAX
savings@sun.com

Project Location:
123 Solar Street
Sunnyvale, CA

March 17, 2003
v2.11

2.8 kW AC Solar System
20 Photowatt PW 1650 Photovoltaic Modules
1 SMA America SWR2500/D Inverter

Andy Black
M.S. Electrical Engineering
Solar Electric Specialist
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ELECTRICAL ENERGY USAGE, BILLING & TAX INPUTS

1,340	kWh Summer average monthly consumption
1,340	kWh Winter average monthly consumption
	Residential Rates
E1	Current Rate Schedule
E7	New Rate Schedule (E7=Time of Use)
X	Baseline Territory
B	Basic Quantities
	Avg Monthly Summer Baseline: 371.1
	Avg Monthly Winter Baseline: 349.8
2.0%	Utility Tax Rate
31%	Federal Income Tax Rate
9.3%	State Income Tax Rate
40.3%	Combined Fed & State Income Tax Rate
4.5%	Inflation
1.5%	Real Annual Increase in Electricity Price
6.0%	Total Electricity Price Inflation
	The CPI has increased 5.1% annually since 1970
	PG&E Electric Rates have increased 6.7% annually (including inflation) since 1970

ENERGY COSTS

CURRENT ENERGY COSTS WITHOUT SOLAR:

$	3,006.15	Annual Charges without Solar
$	**250.51**	**Average Monthly Charges without Solar**
$	0.19	Average per kWh energy charge

FUTURE ENERGY COSTS WITH SOLAR:

$	1,415.82	Annual Charges with Solar
$	117.99	Average Monthly Charges with Solar
$	0.29	per kWh Solar Production Value (Savings/Production)

SAVINGS USING SOLAR:

$	1,590.33	Annual (after tax) Savings with Solar
		$ 2,664 pre-tax value of energy savings
$	**132.53**	**AVERAGE MONTHLY SAVINGS WITH SOLAR**

This information is provided as an illustration of potential financial benefits stemming from ownership of a renewable energy power system. This is not a production guarantee. These estimates should be confirmed by a professional accountant or tax advisor. EcoEnergies does not warrant the applicability of these estimates for particular business cases

SOLAR ELECTRIC SYSTEM

20	Slope of Array (degrees up from horizontal)		
5.4	Equivalent Peak Sun Hours for this site (full sun is 5.4 +/- 9% for Sunnyvale Area)		
4.6	Effective peak sun hours. The lower effective sun level is used because of misc. losses		
0.5%	Annual Module Degradation Rate (normally 0% to 1%)		
2.801	**kW = PV system size selected (Feb2002 CEC AC kW)**		
-		4,679	kWh/year estimated production
1	SMA America SWR2500/D Inverter	310	square feet (approximate) roof area required
20	Photowatt PW 1650 Photovoltaic Modules	43x49	module dimensions (inches)

RETURN ON INVESTMENT

21.3% Effective Pre-Tax Rate of Return
For comparison with other investments
Additional value is the hedge against future electric rate increases

HOME EQUITY:
$ 31,807 Increase in Property Value at 5% loan cost
Home equity increases $20 for every $1 saved in annual utility expenses
ref: The Appraisal Journal, Oct 98

LOANS: Valley Financial, Terry Phenicie, (800) 216-0086

	6.00%	Rate
	30	Year Term
$	17,100	Borrowed Amount (System cost minus tax credits = $0 out of pocket)
$	(102.53)	Loan Cost per month before tax deduction of interest
$	(61.21)	Initial after tax loan cost (when interest portion is dominant)
$	132.53	Avg Monthly Energy Bill Savings
$	**71.32**	**INITIAL NET MONTHLY SAVINGS**

Net monthly savings will increase due to electricity inflation, but decrease due to reduced interest (tax deduction) portion of loan repayment. Savings get larger, because inflation works faster than reduction in interest.

SYSTEM PRICING

$	29,502	System Base Price
$	-	Mounting costs for Composition Shingle Roof
$	-	Additional Costs
$	29,502	Total System Price (includes full service, parts, delivery, sales tax, installation, 5 year warranty)
$	(11,205)	CEC Rebate at: $ 4.00 per Watt (Rebate guaranteed to be $4.00/Watt until further notice)
$	18,298	After Rebate Price (Contract Price)
$	(2,861)	15% State Tax Credit
$	**15,436**	**System Cost including Rebate, Tax Credit, Parts, Installation, Sales Tax, Delivery**

Additional Costs of Ownership (included in the financial analysis)

$	277	PG&E One-Time Fee for Time-of-Use metering
$	500	Permit Fee (estimate, this varies by jurisdiction, and will be billed as we are)
$	887	Effective Federal Tax on State Tax Credit
$	17,100	

Fig. 2: Input to the 25-year financial analysis tool and system description.

PreTax values: all values are adjusted to pre-tax equivalents

Year:	0	1	2	6	7	8	9	10	12	15	20	25
Operating Savings:												
Avoided electricity Purchases	-	2,664	2,810	3,482	3,673	3,875	4,088	4,313	4,801	5,637	7,367	9,629
Operating Expenses:												
System Maintenance (about .25%/yr)	-	(133)	(139)	(165)	(173)	(181)	(189)	(197)	(215)	(246)	(306)	(382)
Capital Cost - Initial System	(19,075)											
Capital Cost - Inverter Replacement	-	-	-	-	-	-	-	-	-	-	(2,680)	-
Operating profit (loss):	(19,075)	2,531	2,672	3,316	3,500	3,695	3,900	4,116	4,585	5,391	4,381	9,247
Federal & State Tax benefits												
	-											
15% State Tax Credit (Pre-Tax Value)	4,793											
		-										
		-	-	-								
Taxable Income (loss) = Operating profit+depr		2,531	2,672	3,316	3,500	3,695	3,900	4,116	4,585	5,391	4,381	9,247
		-	-	-	-	-	-	-	-	-	-	-
Fed income tax on state tax credit		(1,486)										
		-	-	-								
Net Income after taxes	(14,282)	1,045	2,672	3,316	3,500	3,695	3,900	4,116	4,585	5,391	4,381	9,247
		-	-	-								
Pre-Tax Cash Flow, Net	**(14,282)**	**1,045**	**2,672**	**3,316**	**3,500**	**3,695**	**3,900**	**4,116**	**4,585**	**5,391**	**4,381**	**9,247**
Pre-Tax Cash Flow, Cumulative	(14,282)	(13,237)	(10,565)	1,690	5,190	8,885	12,784	16,900	25,830	41,169	70,275	111,904

21.3% IRR (Pre-Tax Rate of Return)

Fig. 3: Timelines for 25-year analysis of cash flows.