QUANTIFYING RESIDENTIAL PV ECONOMICS IN THE US

PAYBACK vs. CASH FLOW
DETERMINATION OF FAIR ENERGY VALUE

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ABSTRACT

Payback is often used as a measure of profitability by prospective PV owners. Contrasting this measure with another financial gauge -- life-cycle cash flow -- the paper discusses why payback may not be the most appropriate measure for residential PV applications and why it may hide sound financial opportunities for those deciding to invest in a PV system.

In parallel, the paper addresses another aspect of economic feasibility: the value of energy produced. For residential applications, this value is currently set at residential net-metered retail rates. We present preliminary evidence that a higher value, reflective of the local effective capacity of PV ought to be claimed for residential PV applications.

1. INTRODUCTION

One of the most important questions faced by PV system marketers and outreach spokespersons when approaching prospective customers is that of economic feasibility.

In this paper we address two issues at the heart of economic feasibility. One is an issue of perception: the metrics used to quantify feasibility have a profound impact on the perception of economic feasibility, as will be shown through a pertinent example. The second issue is an issue of fair value: PV systems derive their value from the sale -- or the displacement -- of electrical energy. We make the case that current non-time-of-day net-metered residential rates do not reflect the peak-shaving value dispersed PV may bring to local power grids.

2. QUANTIFYING ECONOMIC FEASIBILITY FOR RESIDENTIAL APPLICATIONS

2.1 Payback

Simple payback is a measure of economic feasibility that is interpreted to be the number of years an investment takes to pay for itself. It is typically defined as the net cost divided by the first year savings. That is, the simple payback equals the net cost to the user after all incentives (e.g., tax credit, buy-downs, etc.), divided by the first year savings (chiefly reduced electric bills minus expenses).

$$\text{Simple Payback} = \text{Net Cost}/\text{First Year Savings}$$

2.2 Cash-Flow

However straightforward and compelling it may be, the simple payback measure may not capture all financial benefits available to prospective buyers. These benefits include:

- The possibility of borrowing to pay for the system through a loan (e.g., home equity loan or a mortgage)
- The fact that loan interests may be tax-deductible
- The existence of loan interest buy-down incentives available in some states [e.g., see NYSERDA, 2003]
- Cash flows that vary substantially from year to year

A pragmatic way to account for all these factors is to look at a system's cash flow over its lifetime. Cash flow represents the periodic income, or out-of-pocket expense, associated with ownership of the system. For any particular year, it may be expressed as

Cash Flow = Energy Value – O&M Cost – Loan Payment + Tax Savings (from interest payment or depreciation)

The two measures of economic feasibility are contrasted in the following example case study. Please note that this is a best case scenario.

2.3 Case Study: A Residence in White Plains, NY

Using the Clean Power Estimator (Hoff, 1999) as an investigative tool, we consider a 2 kW-dc PV array to be deployed on the unobstructed roof of an Energy-Star house located in White Plains, NY, in the greater New York City metro area.

Without any incentives such a system should cost no more than $16,000 (at $8/dc-Watt). After incentives, including a $4.50/dc-Watt buy-down from the State Energy Authority - NYSERDA (2003), an after-incentive State tax credit of $1750 [and a resulting federal tax penalty of $480], the net user cost for the system is $5,730.

This system produces 2430 kWh per year worth ~ 15 cents per kWh in the considered utility service territory (Consolidated Edison, 2003). We assume that energy costs will escalate at 1.5% per year over the system's life (30 year). O&M expenses are assumed to be $50/yr.

With first-year savings totaling $315, the simple payback period for this case study amounts to 18 years. This may be too long a period for all but the most dedicated solar enthusiasts. Although payback is often uppermost in the mind of the potential PV customer, there is a much more to-the-point economic measure that can help overcome this apparent hurdle.

Consider now that the system may be entirely financed through a 30-yr home equity loan or a mortgage – note that the 30-yr period is commensurate with warranties available from the PV industry. Let's further assume that the loan interest rate is a conservative 6.5%. NYSERDA provides a 4.5% interest buy-down for the first five years, amounting to an initial loan interest of 2%. The interests paid on the loan are 100% deductible (State and Federal). The after-tax cash flow over the system's life is shown in fig. 1.

With no money down, the PV system provides a positive cash flow to its owner every single year, with savings exceeding expense by more than $175/yr during the first five years, and averaging $75/yr over the extent of the loan. This financial picture should be appealing to a much larger number of potential buyers, especially if one notes that other benefits such as enhanced energy security, insurance against possible drastic energy cost increase, and the priceless feeling of "doing the right thing" are not taken into account.

As a counterpoint, one may argue that borrowing has a price in and of itself, because it may limit the user's freedom to borrow for other things – *note that this may be a place where institutional incentives could step in with little institutional risk.* However, the biggest drawback of the simple payback metric is that it does not reflect all incentives and financial parameters taken as a given in many other domestic and business instances.

3. DEMAND SIDE VALUE

In the above example the retail price paid for PV generated electricity with net metering is 15 cents. This study shows that the benefits of providing this electricity, especially in capacity constrained areas like the New York Metropolitan Area, may more than offset this price payment.

The 15 cent/kWh retail rate results from the bundling of several components including primary energy generation, transmission, distribution, maintenance and utility operation expenses. Some of these costs are fixed in time (e.g., metering, billing, many distribution capacity costs), but large components – in particular, energy, generation capacity, and transmission capacity vary in relation to the time of use and to the location of the user. During peak load periods, the costs to produce and deliver electricity are highest, exceeding the average cost of service by wide margins. In areas where the capacity of transmission links to the region's supply grid can not meet peak demand, the price of electricity during peak periods can exceed the system average, sometimes by wide margins.

It is now well accepted that a dispersed PV resource has a high effective capacity in many utility service territories, because it is reliably available at high demand time, during the peak periods of daily demand and especially during the summer when daily peaks reach yearly highs (i.e., in New York: noon to 6 PM during June, July and August). However, because most residential PV owners receive a constant price per kWh in the net metered rate, the compensation they receive for their PV generated electricity may be less than the value it delivers to the electric system.

To address this issue quantitatively, we looked at the component costs, first the cost of energy and second the value of the avoided capacity, both adjusted for transmission and distribution line losses involved in moving electricity from power generators to residential consumers. We examine these costs for two regions of New York where transmission capacity falls short of demand during peak load periods, the New York City Metro Area and Long Island.

The cost of energy is available from power exchange archives for day ahead and spot price. Cost variations are reflective of supply and demand in a given region, hence are directly related to capacity constraints in that region.

Fig. 2 compares the average NYISO (2003) day-ahead hourly price of energy in the NYC-metro and Long Island regions during 2002, to the same price, but weighted as a function of PV output.[1] This figure strongly suggests that load and PV are well correlated, with the value of PV-weighted energy exceeding average cost by up to 60% in summer.

We then considered how avoided generation and transmission costs affect the balance between the price solar systems are paid for their output, and the capacity and energy costs they avoid. In the New York Metro Area and Long Island capacity constraints are reflected in part in the wholesale prices paid for electricity, summarized in Fig. 2.[2]

In the New York City area, including the White Plains location used in the example above, the avoided generation capacity adds 9.1cents/kWh to the value of the PV output.[3] Adding this to the value of the variable costs cited above and then adjusting this for line losses of 10%[4], yields system cost savings of 16.6 cents/kWh, 11 percent more than the 15 cents/kWh retail price paid for this PV output. On Long Island the 16.2 cents/kWh savings are 35 percent above the 12 cents/kWh retail price paid for this PV generated electricity. If with the addition of load management measures PV could claim closer to 100% of the potential capacity value, the full avoided cost value of PV output in New York City would approach 21.3 cents/kWh and 20.3 cents/kWh on Long Island.[5]

Over the 30 year life of a system the net present value of these energy premiums would be equivalent to PV system cost reductions in the range of $350 - $1,400/kW for the White Plains/New York Metro Area, and $900 - $1,800/kW for Long Island.

4. CONCLUSIONS

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[1] *The monthly PV weighted price is the product of PV output (kWhs) and price/kWh for each hour divided by total PV kWh output during the month. The system average price is the sum of the hourly price ($/kWh) for all hours in a month divided by the number of hours in that month.*

[2] *In New York the use of location based wholesale prices accounts for variations in transmission constraints. The NY ISO estimates the value of generating capacity at $159/kW-year in the New York City area and $139/kW-year on Long Island (information from at a 2/11/2003 meeting of the Business Issues Committee of the New York Independent System Operator - ISO). We adjust this for the avoided reserve margin requirement, an additional 18 percent.*

[3] *The avoided capacity cost depends on how much of the load during summer peak hours PV effectively serves. PV systems may be expected to deliver about 68 percent of their capacity rating during summer peak hours – noon to 6 PM daily during June, July and August. The capacity value, then, is calculated: $159/kW-year value of peak capacity divided by annual PV output, then adding 18% for reserve requirements. This result is reduced to the share of served peak hours PV serves, 68 percent.*

[4] *Line loss estimates may vary between 7 and 15 percent. Higher values are associated with higher temperatures and loads approaching system capacity limits. For the purposes of this study we use 10 percent.*

[5] *Because PV system output is closely aligned with actual peak demands, and because the effective contribution of PV may be extended beyond 68 percent with low cost load management measures to bridge periods when PV is not operating, PV capacity may increase its fair share from 68% to a value much closer to these 100% maximum values (e.g., see Perez et al., 2002)*

We have shown that the choice of metrics has a profound effect on the perceived economic viability of a residential PV application. On one hand, simple payback offers an unattractive picture because most people are turned off by pay-backs beyond 15 years – even in Westchester, NY, one of the best places to deploy PV in the country (Herig et al., 2002). On the other hand, life-cycle cash flow shows that with no money down, the same system produces positive income to its owner every single year of its life – definitely a deal-making argument.

We have also shown that current retail costs do not reflect the capacity value of dispersed residential PV installations. Based on a preliminary analysis of eight months of real time energy trading costs in southern New York, PV owner could make the case that their system ought to receive 1.6 to 6 more cents per kWh equivalent to a $350 to $1,400 system cost reduction.

5. ACKNOWLEDGEMENTS

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LIST OF FIGURES

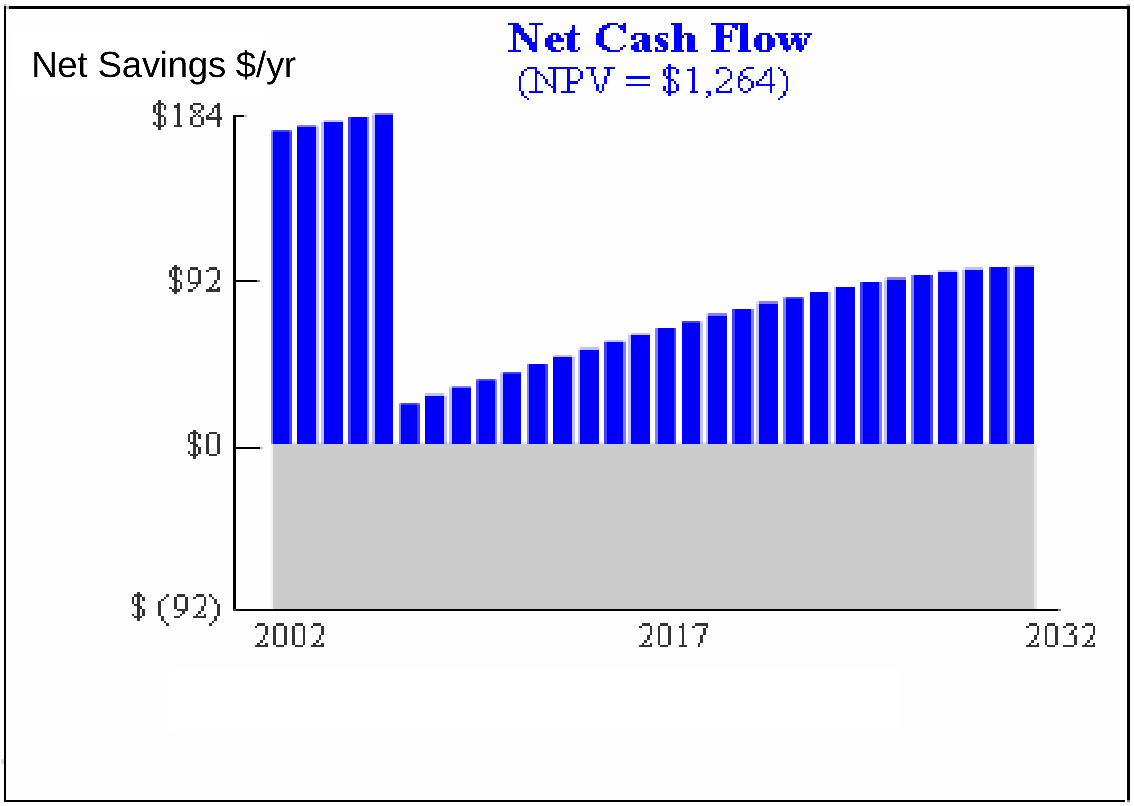

Fig. 1: After tax cash flow for the selected PV array

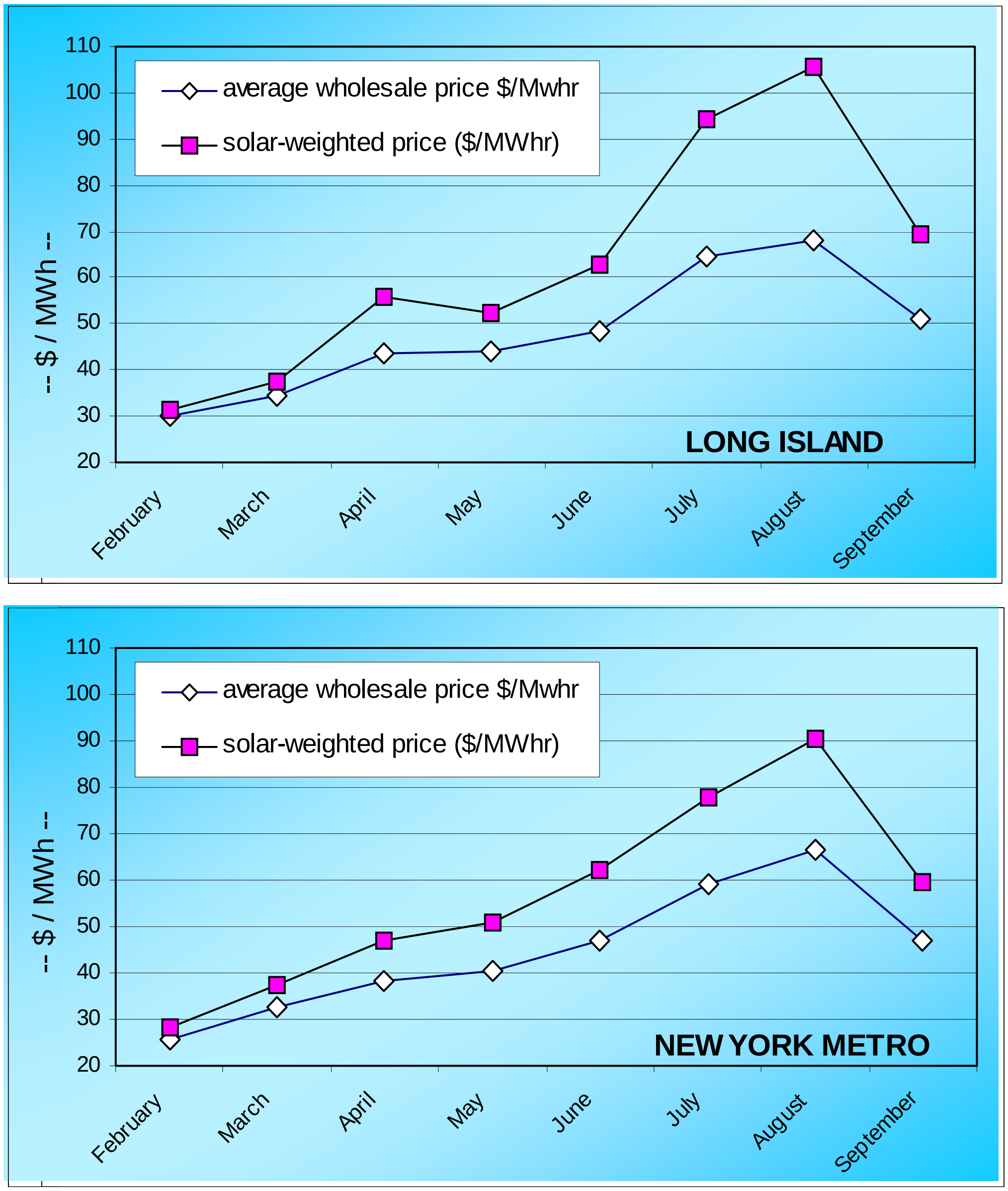

Fig.2: Comparing average wholesale energy price and solar-weighted wholesale price in New York City metro and Long Island