A NEW SOLAR FINANCIAL ANALYSIS CALCULATOR

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ABSTRACT

The *OnGrid PV Sizer and Solar Financial Analysis Calculator* is presented and intended to be a consistent, conservative, and comprehensive tool to aid in the evaluation and presentation of the economic case for PV systems, and to simplify and ease the sales process.

The Calculator is a PV system design tool, predicting system performance, including shading analysis from the Solar Pathfinder. It is a pricing and quoting tool, estimating the system costs and calculating incentives and net customer costs. It calculates electric bill savings. It is a financial analysis tool. With savings, cost and maintenance factors, it calculates IRR, CARR, Cash Flow, Resale Value Increase, and Total Lifecycle Payback of the PV system, and presents the results in graphical form.

It is applicable throughout the United States, with particular focus on California, New Jersey, Colorado and Hawaii, and to residential, commercial, industrial, municipal, non-profit, agricultural, and affordable housing scenarios.

1. INTRODUCTION

Attractive financial payback has been a major driver to increasing sales of PV systems in California, New Jersey, Japan, and Germany in recent years. Effectively demonstrating the payback has fallen largely on company proprietary analysis tools for internal use by their sales people. It is believed, that at this time in the U.S., the only other commercially available financial analysis and quote presentation tool is QuickQuotes from Clean Power Research[1].

After five years of use and development as a proprietary tool used in making numerous sales, conference papers,[2,3,4,5] and public presentations[6], the author is making the *OnGrid PV Sizer and Solar Financial Analysis Calculator* (the Calculator) available for public use.

This paper will discuss the major and unique features of the Calculator, as well as its applicability to various cases. It will refrain from discussing specific benefits in order to avoid making a sales pitch of this paper

2. MAJOR FUNCTIONS OF THE CALCULATOR

The Calculator:

- Predicts system performance and required size
- Calculates system price and incentives
- Performs several financial analyses
- Produces quoting and proposal documents
- Produces sales and contracting documents

2.1 System Predicted Performance and Required Sizing

The Calculator estimates system performance, including factors for array tilt (altitude) and orientation (azimuth), all the typical system loss factors (module temperature, inverter efficiency, dust and dirt, module mismatch, manufacturer production tolerance, wiring, and module degradation), and insolation from the NREL "Redbook"[7] for select locations. All variables are under user control, including fine-tuning the insolation for micro-climatic conditions.

The performance estimates from the Calculator are in good agreement with the results from the PV Watts Performance Calculator[8].

The Calculator also has an input for shading as measured by the Solar Pathfinder[9]. The user enters the data from the display of the Solar Pathfinder. The matrix of this data is multiplied by the tilt and orientation biased matrix of expected performance to produce a half-hourly estimated performance matrix for every day of the year (grouped by month, as the Solar Pathfinder does).

The half-hourly matrix of predicted performance including shading can be subtracted from estimated or known customer usage patterns. This net usage matrix can then be cross-referenced with time-of-use rate schedules to determine the net new bill under a net-metered time-of-use billing system.

The size of the PV system can be adjusted to bring this new net bill down to the desired level. Hence, the Calculator assists in the sizing of systems, based on desired net financial results. At this time, this is an iterative process, which has not yet been automated.

2.2 Estimates System Price

The Calculator will assist in pricing a system based on size (including fixed and variable cost components relating to size), plus the addition of "adders" to the basic cost of a system. Adders cover the additional cost components of parts and labor for sites and installations that are more expensive than the typical base case. Common adders include costs of steep roofs, connecting multiple sub arrays, difficult roofing materials such as tile, ground mounting, trenching, long wire runs, etc.

2.3 Calculates Incentives and Final Net Cost

Based on system size or performance and customer tax brackets, the tool will calculate applicable rebates, tax incentives such as credits and depreciation, and performance-related incentives such as Performance Based Incentives (PBIs) and Renewable Energy Certificates (RECs or Green Tags).

The final net cost of the system to an owner is then easily calculated. Some incentives are paid over time such as depreciation, RECs and PBIs, therefore the final net cost may not be the true cost, or accurately reflect the cost of the system to the owner. In these cases, it is often more transparent to include these time-affected payments on a long-term financial timeline. This financial timeline is also useful in performing some of the financial analyses. This will be discussed below in the financial analysis section.

2.4 Produces Quoting, Proposal, Sales, and Contracting Documents

The Calculator provides quotes detailing system top line and net costs, incentive payments and expected performance. This is used in producing several quoting and proposal options varying from 1 to 16 pages in length. Depending on the desired level of detail, some or all of the assumptions and results can be displayed to help the customer make an educated decision. The tool also displays the 25-year timeline for inclusion in proposals, to allow the customer to reproduce the results, or have them confirmed by an independent advisor.

The Calculator also produces some of the sales and contracting documents necessary to complete a sale. Since all the customer and installer data is already entered for quoting purposes, the tool produces incentive application forms, Third Party Authorization forms and net-metering agreement and application forms pre-filled out. All that's required in most cases is customer and installer signatures and date.

3. FINANCIAL ANALYSIS CALCULATIONS

The Calculator performs several financial analyses:

- Total Lifecycle Payback
- Simple Payback (commercial only)
- Internal Rate of Return (IRR) / Compound Annual Rate of Return (CARR)
- Resale Value Increase
- Cash Flow

To perform these analyses correctly, the Calculator must take proper account of:

- Net Metering (assumes Annual Cycle)
- Time of Use Billing
- Electric Rates with Tiers and Electric Rate Inflation
- System Production Over Time
- System Costs
- Incentives
- Tax Brackets
- State and Federal Tax Credits for Solar
- State and Federal Depreciation
- System Maintenance
- Inverter Replacement Cost

If production, usage, billing, and maintenance are properly accounted for, monthly and annual savings due to rate schedule switching and the addition of a solar system can be determined.

This monthly or annual savings can then be included into a long-term timeline (in this case, a 25-year timeline) to properly account for savings in the future, maintenance costs, inverter replacement costs, tax benefits and costs. Note that savings will increase over time due to electric rate inflation. This inflation effect will be somewhat diminished due to long-term system performance degradation. These and all other factors mentioned in this paper are under the user's control.

3.1 Total Lifecycle Payback

The Calculator determines this rather crude, but visually interesting analysis to illustrate to the customer the increased savings over time due to inflation, and how the savings in the years after "payback" has occurred are usually significantly greater than savings beforehand. This can be a useful analysis to a customer who complains about a 12-year payback. Figure 1 shows an example of the Calculator's output for Total Lifecycle Payback.

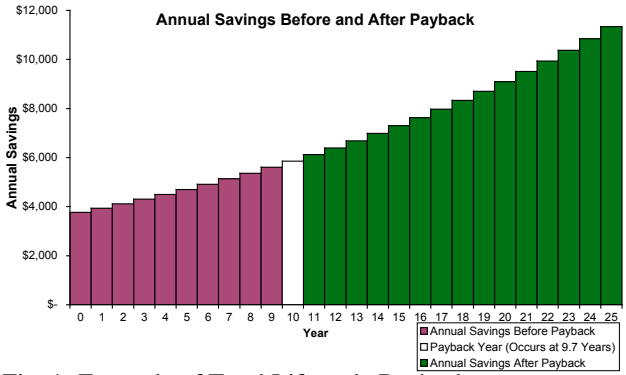

Fig. 1: Example of Total Lifecycle Payback.

The Calculator performs a Simple Payback calculation in commercial and non-taxable applications only, since all calculations in those instances are done on an after-tax basis. The Calculator provides a simple numerical figure.

In residential applications, because of the more complicated pre-tax nature of the analysis, Simple Payback does not lead to meaningful results,[2] so is not calculated directly or provided as a numerical figure. It is included by default in the Total Lifecycle Payback analysis.

3.2 Internal Rate of Return or Compound Annual Rate of Return

The Internal Rate of Return (IRR) or Compound Annual Rate of Return (CARR) reveal the effective interest rate yield an investment in a solar system will pay over time on a compound annual basis. This result is drawn from the series of 25 annual bottom line numbers plus the initial outlay, as seen in the 25-year timeline. IRR analysis is performed on this series of numbers to determine the CARR. Details of this calculation are available in *Financial Payback on California Solar Electric Systems*.[2] An example of this 25-year timeline is visible in Fig. 4 in Appendix A.

3.3 Resale Value Increase

Solar systems significantly increase the value of the property they are associated with due to reduction in operating costs.[3,5,10,11]

Resale value increases over time due to increased annual savings, until it reaches the limit imposed by remaining savings expected before the end of 25 years. Figure 2 shows an example of the Calculator's output demonstrating increased resale value.

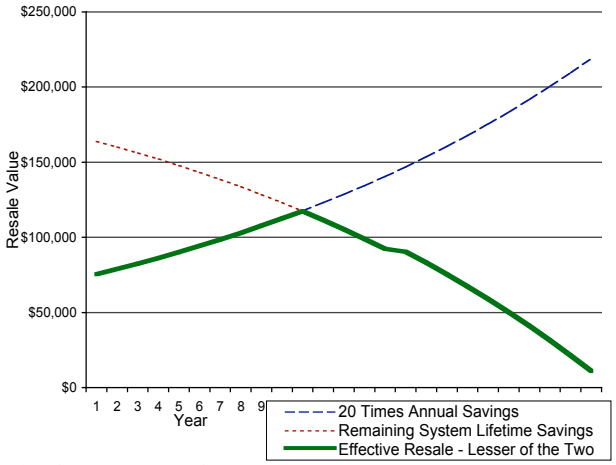

Fig. 2: Example of Resale Value over Time. The heavy green line represents the justifiable limit to appreciation.

3.4 Cash Flow

If the purchaser finances the solar system, they avoid the up-front, out-of-pocket costs, but incur increased expenses paying for the loan principal and interest. The interest cost is often deductible, however, this benefit declines over time as the interest portion of the loan payment diminishes over time. On the positive, the effect of inflation usually more than offsets this loss, so cash flow increases over time. Please see references [3], [4], and [5] for more details on cash flow analysis.

The Calculator produces graphical output illustrating the relative cash flows over time with and without solar. It also shows the net annual savings or expense, and the accumulated net savings over the 25-year analysis. Figure 3 shows an example of these graphical results.

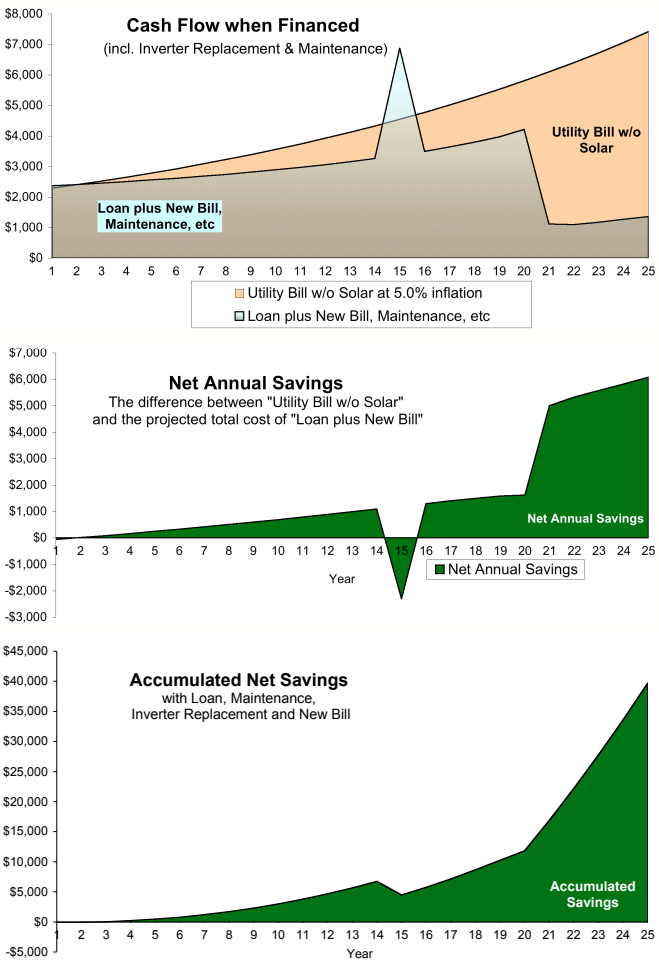

Fig. 3: Examples of Cash Flow Analysis over time.

4. APPLICATIONS FOR THE CALCULATOR

The Calculator is designed to provide rigorous financial analysis of residential, commercial, industrial, municipal, non-profit, agricultural, and affordable housing projects. These various categories differ by tax treatment, typical energy usage patterns, electric rate applicability, and incentive type and quantity. The user can override any of the defaults, and set the Calculator up any way they wish.

Geographically, the Calculator will work anywhere, since the user has control over all inputs and variables. It is preprogrammed with electric rate schedules and insolation data in the most popular areas for solar, such as much of California, New Jersey, Colorado, and Hawaii. However, there is a "User Defined Rate Schedule" input in which the user can specify the rates for other locations. Similarly, there is a "User Defined Redbook Location" input in which the user can specify other insolation characteristics.

5. UNIQUE FEATURES OF THE CALCULATOR

The Calculator provides unique control over:

- All variables
- Shading input using Solar Pathfinder
- Selection of electric rate schedule
- Inverter replacement cost
- Incorporation of energy efficiency into the analysis
- Scenario simulation with various incentives

5.1 User Control over All Variables

The Calculator provides tremendous flexibility to fine tune an analysis to the customer's specific situation. It also provides a lot of rope to hang oneself, so caution needs to be exercised.

It has many automatic default calculations to simplify use, however, compared to other tools, there are more inputs and controls, so it is somewhat more complex to use. It does free users from being forced into certain scenarios. For example, the ZIP codes for Redding, California are geographically closer to Arcata, but the climate is more similar to Sacramento. The Calculator allows the user to choose the correct climate model, rather than being forced to the closest, but incorrect one by the "convenience" of automated ZIP code proximity.

5.2 Shading Input using the Solar Pathfinder

The user enters data directly from the display on the Solar Pathfinder, which most accurately represents the actual shading. This is different than an azimuth and elevation obstruction model, which can do a rough calculation for most situations, but cannot accurately include shade from an overhanging tree branch or other irregular shaped shade objects.

5.3 Selection of Electric Rate Schedule

The user has complete control over which "new" electric rate schedule they'd like to test, and ultimately recommend to the customer. Certain rate schedules may be advantageous depending on many variables. The Calculator shows the financial results depending on those variables and choice of rate schedule.

5.4 Inverter Replacement Cost

The user can specify the cost and time of an anticipated inverter replacement, since it is unlikely that the inverter will last the full 25-year module warranty lifetime. The default is $700 per kilowatt of inverter capacity at year 15.

5.5 Inclusion of Energy Efficiency Measures

The Calculator allows the user to specify estimated savings, costs, rebate, and tax benefits from the incorporation of energy efficiency measures simultaneous with the PV system. Often, energy efficiency is even more economically attractive. This allows the user to present a combined package of PV and energy efficiency measures, which has both improved financial results and greater environmental benefit than just the PV system alone.

5.6 Scenario Simulation with Various Incentives

A user can try various scenarios in "What if…?" queries, incorporating any desired combination of incentives at any user defined level. I.e., the user can specify a PBI of a certain rate and term, combined with an estimated REC contract of a certain rate and term, followed by a different anticipated REC value for the remainder of the systems life, combined with user defined state and federal tax incentives for users with various tax brackets, combined with user defined tiered and time-of-use rate schedules. This may be particularly useful for incentive and rate planning by utility and government officials in evaluating what level of stimulus might be needed under various scenarios.

6. FUTURE ENHANCEMENTS

It is planned to include other technologies such as Solar Domestic Hot Water (SDHW) systems into the analysis portion of the tool. In these cases, it is thought that the expert user would define the system cost, expected annual savings, maintenance costs, and major equipment replacement costs and interval. From this, the financial analysis can be conducted. This could then be easily extended to additional technologies.

The author is always open to, and requests, suggestions and constructive criticisms of the tool, for the purposes of improving tool quality and raising the standards within the solar industry. To that end, many other enhancements have and will be suggested by users, and will be implemented. It is very much a work in progress and a living tool.

7. CONCLUSION

The *OnGrid PV Sizer and Solar Financial Analysis Calculator* is intended to be a consistent, conservative, and comprehensive tool to aid in the evaluation and presentation of the economic case for PV systems. This paper has discussed the major and unique features of the Calculator, as well as its applicability to various cases. It has attempted to refrain from discussing specific benefits, in order to avoid making a sales pitch. For more information on the Calculator, the reader is invited to visit www.ongrid.net/payback.

8. ACKNOWLEDGMENTS

The author wishes to thank the many audience members and customers for questions that have inspired new insights.

9. REFERENCES

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APPENDIX A: 25-year Financial Analysis Timeline
Example.

NJ SREC & Rebate

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Residential Pre-Tax Analysis: After-Tax amounts are adjusted to pre-tax equivalents. Pre-Tax amounts are not adjusted

Year:	0	1	2	3	4	5	6	7	8	9	10	11	12
Operating Savings:													
Avoided electricity Purchases		2,207	2,306	2,410	2,518	2,631	2,750	2,874	3,003	3,138	3,279	3,427	3,581
REC (Green Tag) Income. Assumed Taxable		1,937	1,928	1,918	1,908	1,899	1,889	1,880	1,870	1,861	1,852	1,084	1,078
No Performance Based Incentive Included													
Operating Expenses:													
System Maintenance at 0.25% of gross system cost pe		(291)	(301)	(312)	(323)	(334)	(346)	(358)	(370)	(383)	(397)	(411)	(425)
System Capital Cost after Rebates & Fees	(26,413)												
Inverter Replacement at $700 per kW in Year 15													
Energy Efficiency Net Expense													
Operating profit (loss):	**(26,413)**	**3,853**	**3,932**	**4,016**	**4,104**	**4,196**	**4,294**	**4,396**	**4,503**	**4,616**	**4,735**	**4,100**	**4,235**
Federal & State Tax benefits													
Fed Tax Creditable Basis:	26,413												
30% Federal Tax Credit up to $2,000, Infl to Pre-Tax	3,173												
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Pre-Tax Net Annual Profit/Loss for IRR	(23,240)	3,853	3,932	4,016	4,104	4,196	4,294	4,396	4,503	4,616	4,735	4,100	4,235
Pre-Tax Cash Flow, Cumulative	(23,240)	(19,387)	(15,455)	(11,439)	(7,335)	(3,138)	1,155	5,551	10,054	14,670	19,405	23,505	27,740

<----- <----- <----- next 13 years follow below <----- <----- <----- <----- <----- <----- <-----
v

Year:	13	14	15	16	17	18	19	20	21	22	23	24	25
Operating Savings:													
Avoided electricity Purchases	3,742	3,911	4,087	4,271	4,463	4,664	4,873	5,093	5,322	5,561	5,812	6,073	6,346
REC (Green Tag) Income. Assumed Taxable	1,073	1,068	1,062	1,057	1,052	1,046	1,041	1,036	1,031	1,026	1,021	1,015	1,010
No Performance Based Incentive Included													
Operating Expenses:													
System Maintenance at 0.25% of gross system cost pe	(440)	(455)	(471)	(488)	(505)	(522)	(541)	(560)	(579)	(599)	(620)	(642)	(665)
System Capital Cost after Rebates & Fees													
Inverter Replacement at $700 per kW in Year 15			(5,870)										
Operating profit (loss):	4,376	4,523	(1,192)	4,840	5,010	5,188	5,374	5,569	5,774	5,988	6,212	6,447	6,692
.													
Pre-Tax Net Annual Profit/Loss for IRR	**4,376**	**4,523**	**(1,192)**	**4,840**	**5,010**	**5,188**	**5,374**	**5,569**	**5,774**	**5,988**	**6,212**	**6,447**	**6,692**
Pre-Tax Cash Flow, Cumulative	**32,115**	**36,638**	**35,446**	**40,286**	**45,296**	**50,484**	**55,858**	**61,427**	**67,200**	**73,188**	**79,400**	**85,846**	**92,539**

ANNUAL RATE OF RETURN

Pre-Tax Annual Rate of Return

17.6% IRR (Pre-Tax Rate of Return)

For comparison with other investments
Additional value as a hedge against future electric rate increases

SFA-B4EI1ZMZL3SM9HVAIOM4

Fig. 4: Timeline for 25-year analysis for calculating IRR and CARR.