PV Value™

User Manual v. 1.0

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Executive Summary

This user manual describes the methods used to develop a model for appraising the value of a photovoltaic (PV) system installed on residential and commercial properties. This model follows the Income Capitalization Approach used by appraisers to determine the value of a PV system as a function of the potential energy produced over the system's lifetime. Instructions on how to properly input values into the spreadsheet tool are presented along with a detailed description of each parameter. PV Value™ is intended for use by real estate appraisers, mortgage underwriters, credit analysts, real property assessors, insurance claims adjusters, and PV industry sales staff. This user manual references version 1.0 of the "Photovoltaic Energy Valuation Model," (PV Value™) with a copyright date of December 29, 2011. Please check back to http://pv.sandia.gov/pvvalue for newer versions of the spreadsheet tool. A new release is anticipated on or before September 1, 2012. Any questions or comments can be directed to Geoff Klise: gklise@sandia.gov and Jamie Johnson: jjohnson@spefl.com

This project represents the results of a collaborative effort between Solar Power Electric™ and Sandia National Laboratories that was made possible through funding provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. This valuation tool will reduce non balance-of-system (BOS) market barriers to PV by reducing uncertainty about the value of a PV system. Acceptance and use of this tool by the real estate industry will contribute to the overall penetration of PV systems across the U.S.

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1. ABBREVIATIONS & DEFINITIONS

Solar Nomenclature

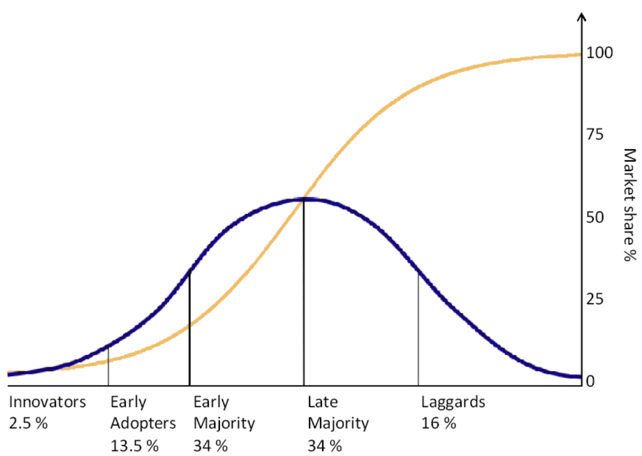
Watt	A unit of power defined as (voltage x current)	
kW	Kilowatt	1000 watts
kWh	Kilowatt hour	1000 watts for an hour
PV	Photovoltaic	
AC	Alternating Current	
DC	Direct Current	
TOF	Tilt and Orientation Factor	
STC	Standard Test Condition	

Financial Nomenclature

CAGR	Compound annual growth rate
DR	Discount rate
IRR	Internal rate of return
MIRR	Modified internal rate of return
MPB	Modified payback
NPV	Net present value
SPB	Simple payback
WACC	Weighted average cost of capital

2. VALUATION ISSUES FACING DISTRIBUTED PV

Assigning a reasonable valuation for an existing installed Solar Electric / Photovoltaic (PV) System is important for the distributed PV industry as it continues its transition from the innovation stage through early adoption and eventually to mainstream use.



Rogers bell curve showing the adoption rate for technological innovations. Distributed PV in the US is currently believed to be in the Innovators stage. (Image Credit – Wikipedia.org/diffusion of innovations)

With the consequences of the recent over valuation issue in the real estate market still making headlines, mortgage lenders and appraisers have begun to question the valuation of PV systems and the potential value of the annual energy that can be generated. There are also concerns that if separate financing is obtained by the home or commercial building owner to pay for a PV installation, the monthly loan payment may exceed the monthly energy savings, thereby creating a potential negative effect on the value of a residential or commercial building that the system is installed upon.

Often relying on the system owner's estimate of annual energy savings is difficult at best for various reasons. The system owner's expectations of annual energy production can be higher than the actual energy production measured at the point of use. This can be due to improper installation techniques or poor equipment selection by the installing contractor, sub-optimal location, current and future shading, over-estimating potential kWh production by the PV salesperson, and not the least of which can be due to overall system reliability.

2.1 APPRAISAL VALUATION METHODS

Typical metrics used for an appraisal valuation are usually based on either the sales comparison (comparable), cost or income capitalization approaches.

2.2 SALES COMPARISON APPROACH

As a general rule, a purchaser of residential or commercial property will not pay more for a given property than what a similar property can be purchased for. There is often a lack of comparable sales data on existing residential and commercial buildings with installed PV systems in the various regional multiple listing service (MLS) databases, and in some cases there may not even be a search option for renewable energy technology. It can be difficult for an appraiser to determine a value for a PV system using the principle of substitution with the sales comparison approach.

This should improve once the various MLS database providers add search options for renewable technologies such as PV, and more residential and commercial buildings with PV systems are put on the market and close escrow. Some examples of solar features added to MLS data entry fields can be found at the Green MLS Tool Kit. http://greenthemls.org/index.cfm

2.3 COST APPROACH

It is also often difficult when using the cost approach to calculate the replacement cost of the PV system due to the following reasons: the installed cost quoted by competing solar companies can vary by 20 – 30% or more, the incentives that are used to bring down the installed net cost may also vary from time to time although generally they have been declining, and the beneficial effect of tax credits (and accelerated/bonus depreciation for commercial systems) can vary from one system owner to another due to differing effective federal tax rates.

The replacement cost is often relied on by insurance companies in order to determine a replacement value. If the PV installation is recent, then the replacement cost can sometimes be higher than the original PV installation net cost, which could be due to the ending of a PV rebate program, a decline in the rebate amount, or the PV system owner qualifying for a rebate on the original PV system (due to incentive program rules, they may not be able to qualify for a second rebate on a replacement PV system).

It is also important to note that in many cases PV installations are done before the end of the year in order for the prospective PV system owner to lighten their tax burden through the use of the 30% federal tax credit, state tax credits (and accelerated/bonus depreciation for commercial systems). If a replacement PV system is needed, the PV system owner may no longer be in the same tax situation and may not be able to utilize the tax write off.

2.4 INCOME CAPITALIZATION APPROACH

The income approach is based on the idea that the value of a property is equal to the capitalized value of the net income stream generated by that property. Applying this approach to PV looks at what one may be willing to pay today for the opportunity to receive future cash flows using a discounted cash flow model. This model needs to adequately consider the present value of projected future energy production along with estimated operation and maintenance costs that are anticipated to occur during the solar module power production warranty timeframe.

The residential or commercial building owner or purchaser's weighted average cost of capital (WACC) is used along with a risk premium spread to determine a discount rate for the present value calculation. The purchaser's WACC is then calculated based off of a readably available benchmark interest rate such as the Fannie Mae or Freddie Mac 30-year fixed rate 60-day commitment (if the purchaser is using a 30-year fixed rate purchase mortgage). Regardless of the benchmark chosen, for the purpose of this model it should closely mirror the cost of borrowing for the purchaser of the income stream.

Note: Although some states have eliminated real property taxes on renewable energy systems, as accurate valuations become necessary for PV systems due to lending requirements, it might be easier to assign a value to the PV system if the Standard Test Condition (STC) kW size, along with the month and year of the installation is listed on the respective real property assessors website, just like other pertinent data which may be useful for appraisal purposes.

Using the income approach, a reasonable valuation can be arrived at through the observation of visible installed components and a review of the latest system performance test and installation documentation, including a digital shading analysis. This information should have been provided by the installing contractor to the original system owner after the system was successfully commissioned.

If a system performance test has not been performed within the past 12 months, and/or a digital shading analysis is not available, and the value of the system is critical, both should be performed by a trained and certified solar PV installer who works for a properly licensed contractor.

Currently there are two organizations that certify installers: The North American Board of Certified Energy Practitioners (NABCEP) has over 1600 certified solar PV installers nationwide. NOTE: NABCEP currently has 2 different certifications for the PV industry, Solar PV Installer™ and PV Technical Sales Professional™. www.nabcep.org

Underwriters Laboratory (UL), which certifies electricians through their UL University personal certification program. www.uluniversity.us

3. CALCULATING THE FUTURE ENERGY PRODUCTION

3.1 GRID-TIED SOLAR ELECTRIC (PV) SYSTEM BASICS

First a word of caution – PV Systems can operate at lethal voltages approaching 600 volts or more and should only be accessed by qualified personnel such as a trained and certified solar PV installer who works for a properly licensed contractor.

A grid-tied PV system (without battery backup) usually consists of one or more modules which may be wired together in series or parallel to form an array which is then connected to an inverter. The modules convert sunlight energy into DC voltage, which must then be converted by a power conditioning unit (inverter) to the same AC voltage that is required at the point of use.

Solar PV systems are most often found mounted on a rooftop and may also occasionally be mounted on a ground rack or solar canopy. They are installed so that ideally the modules are tilted near the local latitude and if in the northern hemisphere oriented towards true south. To achieve the maximum potential annual energy production the modules also need to have unshaded access to the sun during the peak solar insolation (or peak sun hours) time of 9am to 3pm solar time.

It is important to note that two otherwise similar solar PV systems of equal size and cost that are installed at a different tilt and orientation from each other and which also have different amounts of shading, will not necessarily produce equal amounts of energy, and in some cases may have dramatically different annual energy production figures.

3.2 DIFFERENT TYPES OF SOLAR

The two photographs shown here outline some of the differences between solar PV and solar thermal. Typically a home will have either one or the other, though sometimes both solar PV and solar thermal will be present.

The example shown in the above photo is of a grid-tied solar electric (PV) system. PV module sizes vary and it is difficult to estimate the total system size in watts just by casual observation. This PV array consists of 11 PV modules rated at 230 watts STC each. (Photo Credit – Solar Power Electric™)

This photo shows two other non-PV solar collector types, a solar pool heater in the bottom left and a solar domestic hot water heater in the upper right. Although the solar water heater in the upper right may look similar to the PV modules in the grid tied example, the copper tubing extending off the upper right and bottom left of the collector indicates that these are hot water collectors. (Photo Credit – The Leveredge)

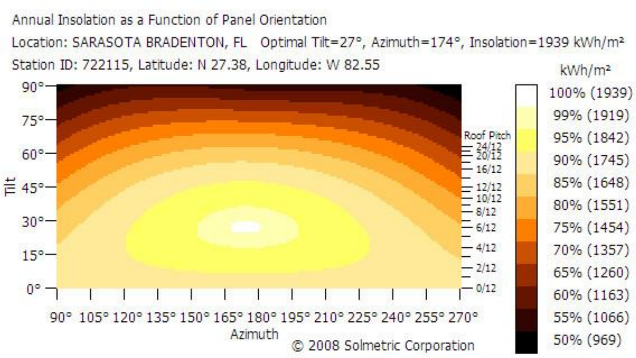
3.3 TILT & ORIENTATION FACTOR

The tilt angle of the modules with respect to the horizontal plane, along with the direction the array faces with respect to south (the orientation or azimuth) will also have an impact on the potential solar insolation available and is expressed as a tilt and orientation factor or TOF.

Tilt and orientation are expressed in degrees. For example if the PV modules are within the same plane as the roof surface and you have a roof pitch of 6/12 the tilt angle would be expressed as a slope of 26.6°. The rooftop may or may not be facing true south. If the system is facing true south and you are in the northern hemisphere, true south would be expressed as an azimuth of 180°.

Roof Pitch	Tilt Angle (°)
1/12	4.8
2/12	9.5
3/12	14.0
4/12	18.4
5/12	22.6
6/12	26.6
7/12	30.3
8/12	33.7
9/12	36.9
10/12	39.8
11/12	42.5

In the following example for Sarasota FL, in order to receive 100% of the available solar insolation the optimal tilt angle is 27° and for the azimuth it is 174°.



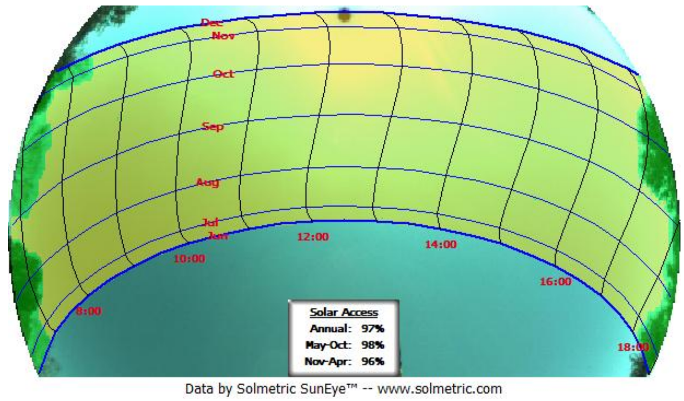
Using the above graph of annual insolation for Sarasota FL, an array installed with a tilt angle of 22.6° (5/12 pitch) and an azimuth of 90° (east facing) would experience a loss of nearly 11% of the available solar insolation resulting in a TOF of 89%.

3.4 SHADING

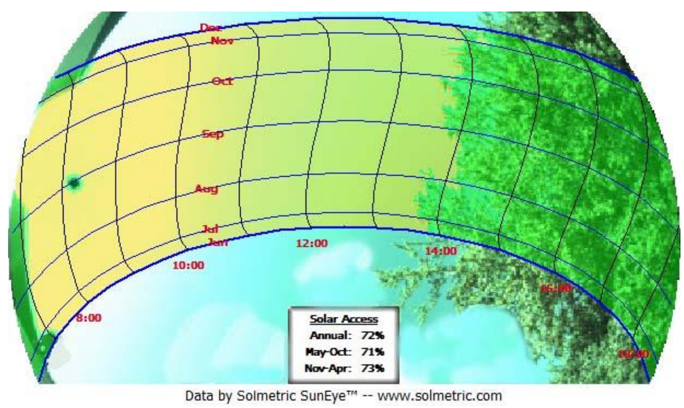
Shading can be a critical factor in determining the potential energy output and may greatly affect the amount of solar insolation that the system receives. A proper digital shading analysis, including a sun graph showing any shading obstructions, should have been performed by the installing contractor before beginning the design and installation process, and should have been provided to the original system purchaser.

In the following examples using the Solmetric Suneye™ 210 digital shade analysis model, the TOF was set to 100% in order to determine the total effect of any shade obstructions.

Shading is referenced as a percent of total solar insolation available, so if 5% shading is observed then the percent of the total solar insolation available would be 95%.



Solar Access Graph with minimal visible shading (3%) right at sunrise and sunset. Most of the shading in this photo is due to mature trees which were not on the surveyed property. The graphs are relatively easy to read with only half the months shown due to the overlapping nature of the spring and fall equinox. This photo was taken in December just after 12pm solar time. (Photo Credit – Solar Power Electric™)



Solar Access Graph with shade starting at 1:30pm in the summer and 2pm in the winter and continuing through the rest of the day. The potential solar insolation in this example is reduced by nearly 30%. This will have a major impact on the potential energy production and must be accounted for in the valuation model. This photo was taken in March just after 8:00am solar time. (Photo Credit – Solar Power Electric™)

Solar Access Graph with minor shade in the winter months until 8:30am and again in the early afternoon between 3:30 and 4:00pm solar time. This is a panoramic shade graph taken with the Wiley Asset Shade Tool. (Photo Credit – Solar Power Electric™)

3.5 DESIGN, PERMITTING & INSTALLATION

The proper design, legal permitting, code compliant installation, and commissioning of a PV system by a properly trained, licensed and certified contractor and a final inspection by a local electrical inspector all play a key role in the long term success of the PV system and can have an impact on the future energy production.

Designing and installing a PV system can involve varying degrees of complexity depending on the size, local site limitations or other factors. However, determining if the PV system is designed or installed correctly is beyond the intent of this article.

A study commissioned by NYSERDA (McRae et al., 2008) found that, "The initial program PV installations of NABCEP-certified installers had fewer problems than those of non-certified installers."

Legal permitting and the inspection of PV systems is usually required and performed by the local municipality or Authority Having Jurisdiction (AHJ). It is important to verify that a permit has been issued and also that a final inspection has been passed before attempting to assign a value to an existing PV installation.

If a completed PV system is encountered that has not been properly permitted (if required by the AHJ) or was permitted but the final inspection has not been passed, the value may be suspect and/or difficult to determine - similar to any other unpermitted or unfinished major construction improvement project.

3.6 CALCULATING FUTURE ENERGY PRODUCTION

Although there are many reasons that one may choose for installing PV, the primary reason that most PV systems are installed is for the current value of the future solar energy kWh production.

That production can be accurately estimated using an equation that takes into account:

1) The average hourly solar radiation received at a specific location which is based on up to 30 years of measured data.
2) The hourly measured temperature for the same location.
3) The tilt and orientation factor (TOF) with respect to optimal.
4) Shading factor expressed as a fraction of total solar resource, ie. 95% would be shown as 0.95.
5) And normal losses experienced in the conversion of DC to AC which are expressed as a derate factor.

There is a web based program called PVWatts™ that can estimate the future solar energy production using a similar analysis model. The algorithm was initially developed by Sandia National Laboratories as PVFORM (Menicucci, 1985) and is now maintained by the National Renewable Energy Laboratory (NREL) and available online in two different versions:

Version 1 provides data from major cities throughout the U.S. to calculate the estimated energy production.[1] Simply select the closest city to the location of the solar PV system. For example, In Punta Gorda, FL the closest city available would be Tampa.

Version 2 flex viewer uses satellite radiation data, and provides solar radiation estimates down to individual 40 by 40 kilometer cells.[2] Simply enter the zip code that the solar electric system is located in and click "go," then click on "Send to PVWatts™" and it will pass the solar radiation data into the PVWatts™ calculator for determining the first year energy production. This version improves accuracy compared to Version 1 due to its ability to provide data which is measured closer to location of the array.

A third version of PVWatts™ is available within NREL's System Advisor Model (SAM) and is used in the valuation model spreadsheet. The main difference in this version is the use of the Perez et al. (2002) 10 kilometer satellite data, which can be accessed from NREL's Solar Power Prospector.[3] In order to call PVWatts™ within a spreadsheet, NREL's Developer Network web service is used to pass input values from the spreadsheet and return outputs such as first year energy production and electricity rates. Currently, the web service

[1] http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/
[2] http://www.nrel.gov/rredc/pvwatts/version2.html
[3] http://maps.nrel.gov/node/10/

provided by NREL only uses PVWatts™ with the 10 kilometer satellite data.

The results from PVWatts™ are considered for the purposes of this valuation tool a fairly accurate estimate for crystalline silicon modules, which currently make up the majority of installed residential and commercial solar electric systems. For systems using thin film modules, which have a different temperature coefficient factor, a calculation would need to be made to account for the difference between the standard temperature coefficient used in PVWATTS™ of -0.05%/C° and the lower temperature coefficient of the specific thin film module. If the thin film modules are flush mounted, then a separate calculation for increased module temperatures would also need to be made. Currently, there is no standard way to do this with PVWatts™.

Net metering is worth mentioning though it is not included in the valuation tool. If the utility offers net metering and the customer has a signed net metering agreement in place, then any excess energy which is produced but not used at the time can be distributed to the utility for later use. When production is lower than the customer's usage or non-existent, such as at night, the excess energy previously distributed to the utility is used first and credit is given on a kWh per kWh basis

3.7 MODULE DEGRADATION

It is well known within the solar industry that modules degrade with age starting from the first day of production. Although improvements have been made in the manufacturing process over the years, recent research by NREL (Jordan and Kurtz, 2011; Osterwald et al., 2006) demonstrate that the energy output of higher quality crystalline silicon modules degrade at rates of 0.1% to 0.9% per year, and currently for some thin film modules the rate of yearly degradation can be 1% or more.

Although this may not have a large effect on the first year of energy production, when calculated over the module warranty timeframe the cumulative effect of module degradation on lifetime energy production will be significant and needs to be factored into the valuation model.

Until more research data is available which justifies a lower annual degradation rate, a conservative valuation may factor in an annual degradation rate of 0.5% (Osterwald et al., 2006) for crystalline silicon and 1% for thin film modules. The calculation is cumulative so that for a crystalline silicon module during year 10, the module could be expected to produce at 95% of its rated capacity. This is one area that a certified PV installer can assist the appraiser through a review of the system's condition at the time of appraisal compared with data provided from the original commissioning report.

3.8 UTILITY RATE ESCALATION PERCENT

In most areas of the country the retail rate charged by the local utility has been increasing steadily over much of the past decade. The rate of escalation in any location in the U.S. can be determined by obtaining at least the 20 year history from the Energy Information Agency's (EIA) "Average Price by State Provider, 1990-2010" and "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State – Table 5.6.B."[4] The history file lists the yearly residential, commercial and Industrial rates for each state in nominal terms.

YEAR	Residential	Commercial
1990	7.77	6.66
1991	7.91	6.77
1992	7.75	6.58
1993	7.99	6.69
1994	7.78	6.35
1995	7.82	6.39
1996	7.99	6.63
1997	8.08	6.62
1998	7.89	6.38
1999	7.73	6.22
2000	7.77	6.25
2001	8.59	7.08
2002	8.16	6.64
2003	8.55	7.13
2004	8.99	7.61
2005	9.62	8.16
2006	11.33	9.91
2007	11.22	9.75
2008	11.65	10.14
2009	12.30	10.86
2010	11.52	9.80

[4] http://www.eia.doe.gov/cneaf/electricity/epa/average_price_state.xls
http://www.eia.gov/electricity/monthly/excel/epmxlfile5_6_b.xls

Average retail rates of electricity for FL from the EIA website shown in ¢/kWh. Rates shown are through 2010.

Timeframe	Residential	Commercial
20 YR CAGR	1.99%	1.95%
10 YR CAGR	4.01%	4.60%
5 YR CAGR	3.67%	3.73%

20, 10 & 5 year compound annual growth rate (CAGR) or escalation rate of retail rates in FL, calculated from the EIA website data.

As shown in the previous table, electric utility rates for this location in Florida have risen more over the past 5 to 10 years, and knowing that the percent of rate escalation will have a measurable impact on the present value of the future energy production (since we are performing a valuation based on 25 or 30 years of future energy production) it is generally not an acceptable practice to take the shorter term averages and extrapolate out for the long term.

A more conservative approach is to take at least the 20 year growth rate and apply it to the kWh production estimate each year for years 1 through 25 or 30.

In the valuation tool, the 1990 state average electricity rate and the most recent electricity rate as reported by the EIA are used in determining the Compound Annual Growth Rate (CAGR). For example, the escalation rate for a valuation performed now would use the time period of 1990 to 2011 (21 years) along with the CAGR equation as shown below.

$$CAGR = \frac{(starting\ electricity\ rate)^{\left(\frac{1}{\#\ of\ years}\right)}}{(ending\ electricity\ rate)} - 1$$

3.9 DISCOUNT RATE

The discount rate chosen will have an impact on the present value calculation and is based on the PV system purchasers WACC. The WACC can be calculated by using the Fannie Mae or Freddie Mac 15 or 30 year fixed rate 60 day commitment and the purchaser's basic investment rate of return during the estimated life of the project. This is to compensate for risk associated with owning the PV system, and is expressed as a basis point spread which is added to the debt interest rate. A custom discount rate can be entered for systems that are not tied to the Fannie Mae or Freddie Mac rates.

An important note about other instruments: Treasury yields are currently AAA rated by some rating agencies and assume no risk other than a rare catastrophic event. They are not used in this example to calculate a discount rate assumption on PV projects as they do not accurately reflect an available borrowing rate which is accessible to the PV system purchaser.

Risk spreads should be utilized in a way that accurately takes into account an acceptable investment rate of return along with adequate compensation for unforeseen risks associated with an investment in a PV system. Unforeseen risks can include accidental module breakage, windstorm damage, corrosion of or damage to electrical components requiring replacement, roof replacement requiring the PV system owner pay for removal and reinstallation of a roof mounted PV system. A range of 50 to 200 basis points is the default setting for this valuation tool to compensate for risk, with the average being 125 basis points. Once more data becomes available a detailed analysis will be performed to improve on this range.

3.10 OPERATION & MAINTENANCE EXPENSES

PV systems require periodic maintenance that ranges from washing the dirt off of the modules during periods of minimal rain, to replacing the inverter if it fails after the warranty has expired. Although modern crystalline silicon modules have a standard 25 or 30 year power warranties and sufficient data exists indicating continued performance over that timeframe, grid-tied inverters usually only have a 10 or 15 year warranty and the potential for replacing the inverter after the warranty term has ended must be accounted for. Although the inverter rarely fails the day after the warranty expires, and some inverter models based on existing designs have data showing they can last up to 20+ years if installed and maintained properly, using a 15 year replacement cycle for the inverter and including labor charges in the cost can also be used to conservatively estimate the operation and maintenance expenses for residential and small commercial systems.

Note: some inverters with promising new designs have been introduced in recent years with warranty terms of 20 or even 25 years. It is currently unknown due to lack of manufacturer and inverter operating history if the inverter will last for the longer warranty period or if the manufacturers will still be in *business to cover the longer warranty in the event of a failure during the warranty timeframe. Until more data becomes available a conservative approach entails taking the existing data with a 15 year timeframes for the replacement cycle on these newer inverters with a 20 or 25 year warranty.*

O&M expenses are usually figured on a cost per watt basis, with small PV systems (under 5kW) and PV systems with micro-inverters or DC optimizers having a higher O&M cost per watt than a medium sized residential or commercial PV system. Commercial PV systems larger than 100kW that utilize central inverters can have an even lower replacement cost per watt.

System Size In kW	15 year O&M cost per watt
< 5kW and Microinverter	75¢+
5 kW to 25 kW	55¢
25 kW to 100kW	50¢
>100 kW	35¢

Estimated O&M expenses for small to medium size systems based on current 2011 inverter and labor cost data from solar electric projects in FL.

O&M expenses are figured using a present value calculation on a 15 year replacement cycle in year 16, so that the O&M expense in year 16 on a 10kW system would be $5,500.00 for the replacement cycle, before the present value calculation is performed. Since the cost is incurred later and will be paid for with inflated dollars, the future O&M expenses may be discounted using the chosen discount rate.

The model is built to use the range of O&M costs expressed in cents per watt in the above table. If the user has other information on these costs, there is an option to override the default values.

Note: Current estimates for O&M expenses are expected to drop in the next few years as the Department of Energy's SunShot goals are met, with a goal of reducing the installed cost of solar energy systems by about 75%.

3.11 SALVAGE VALUE

The value of the components at the end of 25 or 30 years (the standard module warranty period) is similar to other rapidly advancing technologies which have reached the end of their warranty period, and although the PV system may continue to produce energy at a reduced rate for 40+ years (a bonus for the system owner at that time), electrical codes, efficiencies and manufacturing practices will have changed over the years. These factors combined with an expired warranty could render the technology obsolete. Currently there is no existing, reliable secondary market in place that can assign a value to mass produced 25+ year old modules and inverters. In its absence, a scrap value of the components (metals) could be used. Since a present value calculation over 25 or 30 years must also be used against the scrap value, the end result adds very little to the valuation and therefore is not included in the model.

3.12 VALUATION MODEL FOR THE INCOME APPROACH

(© 2010 Solar Power Electric™)

The method of valuation for the income approach uses the present value of the future energy production from PVWatts™. This is accomplished using the following formula for each year over the remaining life of the project:

$$\left((E_{kWh} * Deg_{rate} * U_{rate} * UEsc_{rate} * Disc_{rate}) - O\&Myr16 * Discrate\right.$$

E_{kWh} – Annual Energy Output (kWh)
Deg_{rate} – Module Degradation rate (%)
U_{rate} – Current Utility Rate (¢/kWh)
$UEsc_{rate}$ – Utility Escalation Rate (%)
$Disc_{rate}$ – Discount Rate (%)
$O\&M_{yr16}$ – O&M Expenses for year 16 (¢)

The degradation rate is calculated starting in the first year, the utility rate escalation % and the discount rate are calculated starting in the first month of year 2, and the O&M expenses are calculated for year 16 only. If the appraisal is made in year 15 and beyond, an option comes up asking the user whether the inverter has been replaced. If it has been replaced before the 15-year warranty period, the appraisal range of value estimate will be higher. If it has not been replaced within the 15-year warranty period, the O&M amount will then be discounted for the remaining warranty lifetime of the panels, which will result in a lower appraisal range of value estimate.

For example, if the solar electric system is 3 years old and the module warranty is for 25 years, the present value of the future energy production would be calculated for years 4 through year 25 to determine the total remaining value of future energy production, remembering to account for the first 3 years of module degradation in the calculation. If a recent custom derate factor is available which accounts for actual module degradation up to the current time frame, then in this example the first 3 years of module degradation would not need to be factored in.

4. EXCEL® SPREADSHEET INSTRUCTIONS

PV Value™ – Photovoltaic Energy Valuation Tool v. 1.0

An Excel® spreadsheet has been created to perform the calculations used in the valuation model. The spreadsheet has been tested in Excel® 2007 and 2010. No other spreadsheet programs or earlier versions of excel have been tested and therefore may not allow the spreadsheet to open or work property. A link for downloading the spreadsheet is provided in the resources section.

Note: due to the rounding of values in the spreadsheet, if you are checking the end result with a financial calculator you may experience a difference of a few cents per year.

You must have macros enabled and internet access in order for the spreadsheet to function properly. User input cells are yellow, calculated value cells are green and user defined cells used to override calculated data are orange.

4.1 ANALYSIS TAB

Starting out with the solar resource calculation, you will see seven user input cells that will need to be defined in order to calculate the number of kWh's produced per year. The inputs are as follows:

<u>Zip code</u> – Where the PV system is located.

<u>System size in watts</u> – This is calculated at STC. A 5.06kW array would be input as 5060 watts.

<u>Derate Factor</u> – The model defaults to 0.77, which is the same as the PVWatts™ standard derate. However if direct shading is observed or if the value is critical, then it is recommended that a custom derate factor with a digital shading analysis be performed by a certified PV installer who is properly licensed. There is a space in the spreadsheet that allows entry of a Commissioning Report number, which will change the derate factor to a user input override cell. Entering this number into the spreadsheet verifies that a certified PV installer inspected the system to provide a custom derate factor.

<u>Module degradation rate</u> – This is defaulted to 0.5 and reflects a 0.5% annual degradation rate more common for crystalline systems. For thin-film PV, see the above section on appropriate degradation rates.

<u>Array type</u> – The choices are: fixed, 1-axis or 2-axis. Most PV installations are fixed and will not track the sun. If a tracker is encountered then the number of axis will need to be selected. 1-axis is typically east to west with the tilt angle fixed. 2-axis tracks east to west and also changes the tilt angle to where the direct component of the solar irradiance is perpendicular to the array at all times.

<u>Array tilt</u> – if left unchecked this will be calculated as the local latitude. The user must check the box and input the actual module tilt to get an accurate calculation if the module tilt is known. If the module is mounted flat with no tilt, check the box and make sure the array tilt is set to 0.0.

<u>Array azimuth</u> – this is defaulted to 180° or true south. Input the azimuth angle that the array faces. In some cases, the module will be a few degrees off of south so knowing the azimuth angle is important.

Click outside of the yellow cells and then click on "Calculate PV Production." This will call PVWatts™ using the Perez (2002) model through the SAM interface. You should now see kWh Produced/Year for the PV system.

<u>Discount rate</u> – The discount rate calculation defaults to the current 30 year fixed rate 60 day commitment from Fannie Mae as the WACC along with a basis point calculation that accounts for an investment rate of return for the risk that is assumed through purchasing the income stream. An option to use a 15 year fixed rate or a custom rate is available. If the magenta cell states "rate is out of date" click on "update FNM rate" and the discount rate will be automatically updated.

<u>Utility rates</u> – Under remaining inputs, the electricity rate data needs to be accounted for. This is done automatically by

selecting either the residential or commercial averages as reported within PVWatts™ and clicking on the "Current Utility Reported Electricity Rate." The current utility rate in ¢/kWh for the state the PV system is located in will be updated. The residential and commercial utility escalation rates can also be selected, and are calculated using a CAGR equation for the years between 1990 and the current year. As there are over 330 electric utilities nationwide and rates vary within each state, there is a user defined inputs option for ¢/kWh and utility escalation rates that will override the PVWatts™ and EIA specific data if the rate is not current. If a user defined utility escalation rate is used, it is important to make that calculation as a CAGR before using as input to the model and not as an average annual growth rate.

O&M expenses – The O&M expenses are automatically calculated based on the PV system size in watts using inverter & labor pricing data. If a different value is anticipated, then a user defined input is available. Select the checkbox and input the new value in ¢/W and this will override the automatic calculation.
Most module warranty terms will be for 25 years. However there are some manufacturers that offer a 30 year term. Select the term of the module warranty from the drop down box and input the PV system age in years.

If the age of the system is 15 years or greater, there is an option to select if the inverter has been replaced. If it has not been replaced then the eventual inverter replacement expense must be accounted for in the calculation.

Lease to purchase – There is an option to look at a Lease to Purchase, where the value can be calculated for the remaining energy in years after the lease is bought out, based on the module warranty period. This option does not currently account for the purchase price of the PV system. It is anticipated that a future version will have a more robust calculation for this scenario.

After all of the user defined data cells have been input correctly the present value of the expected lifetime energy production will be calculated as the "Appraisal Range of Value Estimate."

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APPENDIX

OTHER FINANCIAL ANALYSIS METHODS USED FOR SOLAR PV

NET PRESENT VALUE

The net present value is the sum of all positive and negative cash flows which are discounted to the present value.

The Present Value discussed earlier is what is used for the NPV calculation. For the netting effect the negative initial cash flow is based on the prospective PV system purchaser's true cost once all tax credits, treasury grant, rebates, depreciation, bonus depreciation, taxes on rebate and loss of utility energy bill tax deductions (for commercial businesses) are factored in.

In order to calculate the initial cost, a basic understanding of Internal Revenue Code sections 25D, 48, and other sections that directly relate is necessary. Excerpts from the Internal Revenue Code as related to solar are presented in the next section of the appendix.

INTERNAL RATE OF RETURN

An internal rate of return (IRR) calculation is related to the NPV calculation where the NPV equals zero and the discount rate at that point becomes the IRR. In general it is assumed that when comparing projects of equal duration and risk the project with the highest IRR should be chosen.

Caution should be used with comparing a PV project to other investment opportunities based solely on the IRR as a project with a large initial negative cash flow in the first year may produce a lower IRR compared to a project with a small initial negative cash flow. However, the project with the large initial negative cash flow may have a higher NPV upon reaching the end of its life cycle, and therefore a higher return in the number of dollars on capital invested.

There are issues associated with using IRR with a PV project. IRR assumes that the positive cash flow will be reinvested immediately at the IRR. This is often not the case since there is rarely another project with a comparable IRR waiting to be started on a monthly or annual basis.

Another issue is that with multiple negative cash flows during a project life such as with an inverter replacement cost during year 16, the IRR may return multiple values based on the negative and positive cash flows.

Due to this a modified internal rate of return might be a better approach for PV projects.

If a high IRR is the sole reason for choosing to invest in a PV project compared to investment vehicles with a low rate of return such as a certificate of deposit, then another look at the other financial analysis methods mentioned here may be warranted.

MODIFIED INTERNAL RATE OF RETURN

The modified internal rate of return (MIRR) is just that, a modified version of the IRR which resolves two of the issues mentioned previously regarding the IRR as it relates to PV projects. The first assumption is the potential for multiple rates of return due to multiple positive and negative cash flows, and second is the assumption that all positive cash flows will be reinvested at the stated IRR.

For example, in the case of a business that has a PV system installed with net metering, the positive cash flows may be in the form of a lowered utility bill which frees up cash flow to invest within the business. Rarely is the cash flow reinvested at the same rate of return as the IRR and in some cases the cash flow may simply be paid out to the business owner as a return of capital and reinvested in low risk, low rate of return investments.

In the modified version it is assumed that positive cash flows will be reinvested at a chosen fixed rate of return which is less than the MIRR, and negative cash flows are discounted to present value using the WACC, thereby producing a single rate of return which may more closely resemble purchaser's financial situation.

SIMPLE PAYBACK

The simple payback (SPB) is often used within the PV sales industry to calculate the time it takes for the purchaser of a PV system to recoup their original investment. This method of analysis has limitations that must be understood before being relied upon.

Simple payback is just that, it does not include a discounted cash flow model, nor does not take into account risk, lost opportunity costs, O&M expenses, or module degradation. The assumed electricity cost per kWh is fixed during the payback period.

It is simply the initial upfront non-discounted net cost of the PV project divided by the annual fixed non-discounted cash flow (annual kWh times the fixed utility rate). The end result is displayed in years or fractional years.

Caution is warranted when using only a simple payback analysis on a PV project as the PV system owners actual payback in years will often take longer once all of the other financial considerations are taken into account.

MODIFIED PAYBACK

A case can be made for a modified payback analysis which would allow a prospective PV system purchaser to determine when they would recoup their original investment.

This modified payback or MPB would take into account many of the financial considerations that are excluded from the SPB model.

The MPB is fairly easy to calculate from the present value and NPV analysis results, it is the time in years it takes for the negative cash flow (as determined in the NPV and PV calculations) to be equaled by the present value of the positive cash flow.

This may produce multiple payback timeframes, since the initial investment may be recouped before the inverter is scheduled to be replaced. If this is the case, once the inverter is replaced a new investment cycle is started with a new payback timeframe determined. If the initial investment is not recouped before the inverter is replaced, then a single payback timeframe would be produced.

The MPB timeframe will often be considerably longer than the SPB timeframe. However, it should be a more accurate presentation of the prospective PV system purchaser's recoupment of their actual investment.

Prospective PV system purchasers may find that the cost to replace an old technology inverter near the end of the PV systems life cycle in a small number of cases may not make sense, and in fact it may make more sense financially to upgrade the entire PV system at that time using current technology as it is likely that efficiencies will have improved, costs will have come down and life cycle timeframes will most likely have been extended.

RETURN ON INVESTMENT

Return on investment or ROI is a return calculated in percentage terms on the total investment. It can be calculated over a single annual period or annualized over multiple years.

Sometimes it is also used in a more unconventional sense to show the total return over an investment timeframe. This unconventional use can be somewhat meaningless to an investor. For example if the total ROI is 50% that may sound like a great investment. However, if that total return is over a 30 year timeframe and has not been annualized, then that may not be considered by some as a great ROI.

ROI calculations are difficult to perform accurately when multiple positive or negative cash flows are involved during an annual time period. In the scenario where multiple positive or negative cash flows are involved then the MIRR may be more appropriate.

FINANCIAL MODEL SUMMARY

Some things simply can't be quantified into a financial model, such as when a business owner chooses to install a PV system so they can advertise that they are a green business and most or all of their electricity needs are met with PV, or when a homeowner installs a PV system in order to be the first home on their street to generate electricity from the sun.

There are other considerations such as what happens if the utility rates go up faster than the long term growth rates. If this happens then several of the financial models presented may underestimate the value or financial return to the PV system owner.

No financial model is perfect, and each model presented here does contain flaws. However when presented together, a more accurate picture will emerge and allow a prospective PV system purchaser to make better informed decisions.

INTERNAL REVENUE CODE SECTIONS RELATING TO SOLAR

Brief excerpts of the IRS notice(s) or IRC sections are shown, although readers are encouraged to visit the IRS website and read each section thoroughly in order to determine how each section applies to their individual situation.

"The following is not to be construed as tax advice, readers are advised to consult with their own legal and tax professionals"

NOTE: As of January 2012, the IRS has not issued official guidance for several of the IRC sections mentioned below.

RESIDENTIAL SECTIONS

Section 25D (from IRS Notice 2009-41)

Section 25D provides a tax credit to individuals for residential energy efficient property. The amount of a taxpayer's section 25D credit for a taxable year beginning after December 31, 2008, is equal to 30 percent of the qualified solar electric property expenditures made by the taxpayer during the taxable year.

Qualified solar electric property expenditures are further defined as expenditures for property which uses solar energy to generate electricity for use in a qualifying dwelling unit.
A qualifying dwelling unit is defined as a dwelling unit that is located in the United States and is used as a residence by the taxpayer.

The notice further states that a taxpayer claiming a credit with respect to an expenditure, is responsible for determining whether the expenditure appropriately relates to a qualifying dwelling unit and cannot rely on a manufacturer's certification for that purpose.

Section 136 Energy Conservation Subsidies Provided by a Public Utility

Gross income shall not include the value of any subsidy provided (directly or indirectly) by a public utility to a customer for the purchase or installation of any energy conservation measure.

Notwithstanding any other provision of this subtitle, no deduction or credit shall be allowed for, or by reason of, any expenditure to the extent of the amount excluded under subsection (a) for any subsidy which was provided with respect to such expenditure. The adjusted basis of any property shall be reduced by the amount excluded under subsection (a) which was provided with respect to such property.

Energy conservation measure - In general for purposes of this section, the term "energy conservation measure" means any installation or modification primarily designed to reduce consumption of electricity or natural gas or to improve the management of energy demand with respect to a dwelling unit.

The term "dwelling unit" has the meaning given such term by section 280A(f)(1).

The term "public utility" means a person engaged in the sale of electricity or natural gas to residential, commercial, or industrial customers for use by such customers. For purposes of the preceding sentence, the term "person" includes the Federal Government, a State or local government or any political subdivision thereof, or any instrumentality of any of the foregoing.

Exception: This section shall not apply to any payment to or from a qualified cogeneration facility or qualifying small power production facility pursuant to section 210 of the Public Utility Regulatory Policy Act of 1978.

See IRS PLR2010350003 for more clarity. Note: Private letter rulings only apply to the taxpayer that requested the ruling and are not to be applied to or relied on by other taxpayers.

Section 280A(d)(1) Use as residence defined

In general for purposes of this section, a taxpayer uses a dwelling unit during the taxable year as a residence if he uses such unit (or portion thereof) for personal purposes for a number of days which exceeds the greater of 14 days, or 10 percent of the number of days during such year for which such unit is rented at a fair rental. A unit shall not be treated as rented at a fair rental for any day for which it is used for personal purposes.

Section 280A(d)(2) Personal use defined
For purposes of this section, the taxpayer shall be deemed to have used a dwelling unit for personal purposes for a day if, for any part of such day, the unit is used—
For personal purposes by the taxpayer or any other person who has an interest in such unit, or by any member of the family (as defined in section 267(c)(4)) of the taxpayer or such other person;

By any individual who uses the unit under an arrangement which enables the taxpayer to use some other dwelling unit (whether or not a rental is charged for the use of such other unit); or
By any individual (other than an employee with respect to whose use section 119 applies), unless for such day the dwelling unit is rented for a rental which, under the facts and circumstances, is fair rental.

Section 280A(f)(1) Dwelling unit defined
For purposes of this section, In general the term "dwelling unit" includes a house, apartment, condominium, mobile home, boat, or similar property, and all structures or other property appurtenant to such dwelling unit.
Exception the term "dwelling unit" does not include that portion of a unit which is used exclusively as a hotel, motel, inn, or similar establishment.

COMMERCIAL SECTIONS

Section 48(a) Business Investment Tax Credit (Energy Credit)
The energy credit for any taxable year is the energy percentage of the basis of each energy property placed in service during such taxable year. The energy percentage is 30 percent in the case of energy property but only with respect to periods ending before January 1, 2017.

The term "energy property" means any property which is equipment which uses solar energy to generate electricity. The construction, reconstruction, or erection of which is completed by the taxpayer, or which is acquired by the taxpayer if the original use of such property commences with the taxpayer, with respect to which depreciation (or amortization in lieu of depreciation) is allowable.

In the case of any property with respect to which the Secretary makes a grant under section 1603 of the American Recovery and Reinvestment Tax Act of 2009. No credit shall be determined under section 45 with respect to such property for the taxable year in which such grant is made or any subsequent taxable year.

Any such grant shall not be includible in the gross income of the taxpayer, but shall be taken into account in determining the basis of the property to which such grant relates, except that the basis of such property shall be reduced under section 50 (c) in the same manner as a credit allowed under subsection (a).

Section 50(c)(1) and (3)(a) Reduction in basis for credits and grants.
If a credit is determined under this subpart with respect to any property, the basis of such property shall be reduced by the amount of the credit so determined. Special rule - In the case of any energy credit—only 50 percent of such credit shall be taken into account.

Section 168 Accelerated Cost Recovery System (5 Year Accelerated Depreciation)(100% and 50% Bonus Depreciation)

Section 162(a) Trade or business expenses
In general there shall be allowed as a deduction all the ordinary and necessary expenses paid or incurred during the taxable year in carrying on any trade or business.