FEATURES

Valuation of Solar Photovoltaic Systems Using a Discounted Cash Flow Approach

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ABSTRACT

Solar photovoltaic (PV) systems on buildings can present a valuation challenge. However, present value estimates can be easily solved with the use of the new, free PV Value tool. This Excel-based tool was developed to address the value of the electricity-generating capabilities of a PV system by using a discounted cash flow analysis. This article discusses the inputs required to use the tool to arrive at a credible opinion of value. The PV Value® tool was designed for use with the Appraisal Institute's Residential Green and Energy Efficient Addendum form, and its use is covered in the new *Residential and Commercial Valuation of Solar* class offered by the Appraisal Institute.

Solar energy systems include photovoltaic (PV) materials and devices that convert sunlight into electric energy; PV cells are commonly called solar cells.[1] The rate of PV system installations for residential and commercial markets has increased substantially over the past five years. Several reasons for the growth in PV installations include increasing energy prices, the prevalence of subsidies and tax credits, and falling costs related to PV components and installation. As properties with PV systems are bought and sold, the question arises, what is a PV system worth?

Property owners buy PV systems for lower utility bills, energy independence, and/or environmental benefits to society. According to a recent report of the Interstate Renewable Energy Council (IREC),[2] solar installations in the United States have been increasing. Distributed or dispersed electricity generation increased by 80% between 2011 and 2012 to a total of 3.3 gigawatts (GW), bringing the cumulative total of installed PV system capacity to 7.4 GW. This popularity is primarily due to the current incentives, with more installations in states where incentives are high and fewer installations in states where incentives are low or nonexistent. New third-party ownership options (i.e., leased PV systems) have also played a role in increasing the adoption of PV systems.

PV systems in the US marketplace have led to valuation challenges when sales are not available to provide paired sales. This valuation challenge is particularly acute for residential properties, where the income capitalization approach is not widely used and lender clients often expect paired sales analysis for value adjustments. The use of the cost approach in a heavily subsidized market where component and installed prices have been dropping does not usually provide the most supportable approach to value because of a lack of support for potential obsolescence. However, the cost approach does provide a test of reasonableness that should be considered.

1. Office of Energy Efficiency and Renewable Energy, "Energy Basics—Photovoltaics" (Washington, DC: US Department of Energy), http://energy.gov/energybasics/articles/photovoltaics.
2. Larry Sherwood, *US Solar Market Trends 2012* (Latham, NY: Interstate Renewable Energy Council, July 2013), available at http://www.irecusa.org/wp-content/uploads/2013/07/Solar-Report-Final-July-2013-1.pdf.

Appraisers are challenged to develop values based on buyers' and sellers' actions. The income capitalization approach most closely represents buyers' thinking when purchasing a PV system; therefore, it should not be ignored even in the residential market.

Whether the buyers are residential or commercial users, they purchase the system for its energy-generating capability and utility-cost reduction. Therefore, it is reasonable to apply the income capitalization approach to the energy produced even in the residential market. In the residential mortgage market, the income approach has its limitations, mainly because lenders and underwriters find it difficult to adjust to an approach that has been ignored in the past for other than investor-owned properties. Some of the resistance of lenders and underwriters is due to a lack of thorough documentation that would allow the client to understand the valuation methodology.

Literature Review

Some of the first articles to discuss the use of an income capitalization approach specific to PV systems were written by Webb and by Harris.[3] Their work suggested that an income approach was necessary, as not enough sales comparables were available. However, it is not clear how many appraisers adopted this approach because the market for PV systems at that time was in its infancy, and due to high costs, not many people entered the solar market during the 1980s and 1990s.

An article by Nevin and Watson,[4] often misquoted in its findings, discusses how implementing *energy efficiency* measures provides a multiplier effect where every $1.00 saved in annual energy costs is roughly equal to a $20.00 increase in value. This multiplier approach has been the basis of many subsequent reports on PV system valuation. It is worth mentioning that PV systems were never explicitly analyzed in this article by Nevin and Watson, and they provide no framework for appraisers other than concluding that the market will support paying more for energy-efficient features if the right comparables are used. This valuation concept has been described as a way to value a PV system by Black,[5] though a paper by McCabe and Merry[6] suggests analysis of actual sales data is necessary to quantify if a premium really exists.

Research conducted by Lawrence Berkeley National Laboratory[7] confirmed that in California *only*, the sale price to energy savings ratio ranged from 8:1 to 26:1. This study used a hedonic pricing model with actual sale price data over a nine-year period from 2001 through 2009. The results indicate that in the California market areas studied, homes with a PV system tend to reflect higher prices, and that the price differential tends to be higher for resales than for new homes. However, the study does not contain sufficient data to ascertain whether other factors (covariables) could be responsible for some or all of the price differential, such as other energy-efficiency improvements or a new roof installed in conjunction with the PV installation.

Appraiser Tools

As properties age and are sold, appraisers need to understand the different ownership structures and valuation considerations in the expanding market for PV systems. The Appraisal Institute has been leading efforts to educate appraisers on appropriate valuation methods with the text *An Introduction to Green Homes* and the course *Introduction to Green Buildings: Principles and Concepts*, where solar energy technologies are introduced and discussed as part of a larger green home retrofit and new construction movement.

To prepare appraisers for valuation of properties with PV systems, the Appraisal Institute developed the Residential Green and Energy Efficient Addendum (Form AI-820.04), to capture the information needed to appraise a property with a PV system.[8] The Appraisal Institute also developed a course to

3. James R. Webb, "The Influence of Solar Energy Systems on the Value of Dwellings: Theory vs. Practice," *The Real Estate Appraiser and Analyst* (January–February 1980): 4–6; Jack Harris, "The Value of Solar Energy: Chic, Patriotism and Economic Rationality," *The Real Estate Appraiser and Analyst* (Fall 1984): 5–7.
4. Rick Nevin and Gregory Watson, "Evidence of Rational Market Values for Home Energy Efficiency," *The Appraisal Journal* (October 1998): 401–409.
5. Andy Black, "Economics of Solar Electric Systems for Consumers: Payback and Other Financial Tests" (July 2009), http://www.ongrid.net/papers/PaybackOnSolarSERG.pdf.
6. Mary Beth McCabe and Liz Merry, "The Resale Market Value of Residential Solar Photovoltaics: A Summary of Literature and Insight into Current Value Perceptions" (May 2010), available at http://www.costar.com/josre/pdfs/ResaleMarketValueofResidentialSolarPVfinalfull_McCabe_5-14-10.pdf.
7. Ben Hoen, Ryan Wiser, Peter Cappers, and Mark Thayer, *An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California* (Lawrence Berkeley National Laboratory, LBNL-4476E, April 2011), available at http://emp.lbl.gov/sites/all/files/lbnl-4476e.pdf.
8. This form is available at http://www.appraisalinstitute.org/education/green_energy_addendum.aspx. For information on completing this form, see Sandra K. Adomatis, "Describing the Green House Made Easy," *The Appraisal Journal* (Winter 2012): 21–29.

help appraisers value properties with PV systems, *Residential and Commercial Valuation of Solar*.[9] This course covers the complexities of valuing solar energy collection technologies for both residential and commercial properties.

In addition, a collaborative effort between Energy Sense Finance and Sandia National Laboratories has led to a proof of concept spreadsheet that appraisers can use to value a PV system. This tool—the Photovoltaic Energy Valuation Model (PV Value®)—can be used to measure the potential market value of a PV system by using an income capitalization approach.[10] As explained later in this article, the PV Value tool is designed to help appraisers support their market value estimates of a PV system. As appraisers consider all approaches when valuing a PV system, including the cost and sales comparison approaches, this tool provides an income approach analysis that addresses the unique electricity-generating properties of a PV system. (Future versions of the tool will also help with the cost approach.)

This discounted cash flow analysis of the energy produced can assist in making adjustments in the sales comparison approach and in arriving at an opinion of the contributory value in the sales comparison approach and cost approach when market support is not present to support depreciation such as potential functional and/or external obsolescence. Residential appraisers using the Uniform Residential Appraisal Report (URAR) (Fannie Mae Form 1004/Freddie Mac Form 70) may choose to use the value estimate from the PV Value tool as the contributory value of the system and place this information under the contributory value of site improvements line in the URAR.

The discussion in this article will be as follows. First, a brief introduction to photovoltaics will be provided, then the article will discuss the challenges in valuing a PV system, and finally, the article will end with a discussion of the new PV Value tool. Many references are provided in the footnotes, which will help the reader better understand the research that supports the discussion in this article.

Photovoltaics Background and Economics

Photovoltaics have been around for over 100 years, with the first commercial version of PV cells and modules becoming available for use in the 1950s.[11] The earliest technology consisted of crystalline silicon, which is still widely used. Today, newer, thin-film technologies are also available that have advantages in terms of cost, weight, and flexibility. However, crystalline silicon continues to dominate the residential and commercial markets, while thin-film technologies are more typically seen in utility-scale applications.

Photovoltaic systems consist of multiple modules connected together and connected to either a central inverter or module-level inverter. The inverter takes direct current (DC) electricity and converts it to an alternating current (AC) at a frequency that is similar to what is delivered from a utility to grid-connected customers. The multiple modules can be mounted as an array on a rooftop (Figure 1), integrated into the rooftop, or part of a ground-mounted or canopy system. The modules both face and tilt towards the south to maximize energy production. Some arrays continually track the sun to optimize power production.[12]

Due to the size of a rooftop and orientation needed to maximize energy production, there may or may not be enough space to site the array depending on the customer's desires. PV modules are generally not very efficient, only converting 12% to 20% of sunlight into usable electricity. PV module efficiencies have been gradually increasing, however, due to the adoption of new technologies and manufacturing methods; the footprint area of a 5 kW system in the future will be much smaller than what it is today.

PV systems can be owned and operated by a utility company to provide electricity to the grid. Alternatively, a system can be operated by an

9. For a course description, see http://appraisalinstitute.org/education/course_descrb/Default.aspx?prgrm_nbr=844&key_type=C.
10. PV Value is intended to help determine the contributory value, if any, of new or existing PV systems installed on residential and commercial properties, http://pv.sandia.gov/pvvalue. More information is also forthcoming in 2014 at http://www.pvvalue.com.
11. Office of Energy Efficiency and Renewable Energy, *The History of Solar* (Washington, DC: US Department of Energy), http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf.
12. For those interested in more detail, a great online technical resource that illustrates the physics behind photovoltaics is available from PVCDROM at http://pveducation.org/pvcdrom.

Figure 1 Photo of Array on Rooftop

Watson Family Solar House, Lexington, MA, USA, http://256.com/solar/

individual or company with a distribution agreement between the utility company and the owner of the property with the PV system. Electricity generated by these decentralized sites has the ability to back feed into the larger grid. There are also many PV systems used to power off-grid applications. Energy storage—primarily from batteries—is necessary to provide continuous power as the solar resource is naturally intermittent.

The technology has changed dramatically over the past thirty years, which has resulted in greater affordability of PV systems, though the current incentives are still necessary to make the economics work in most areas of the United States. At the end of the 2013 second quarter, prices for a fully installed, residential grid-tied PV system averaged around \$4.81/watt nationally, and in the commercial sector, around \$3.71/watt. For systems greater than 100 kilowatts (kW), this price is around \$2.10/watt.[13]

What is important here is that prices for fully installed PV systems continue to decrease, as evidenced by statewide data tracked by Lawrence Berkeley National Laboratory.[14] The average residential PV system in the United Sates is around 5 kW, and with the average costs as previously stated, this is roughly \$24,000 gross cost as installed (includes materials, labor, and permitting) before incentives. Applying the 30% federal tax credit (which decreases to 10% at the beginning of 2017), the system would cost around \$16,800 net. Other incentives, such as state tax credits, utility rebates, and renewable energy credits, can bring the cost of a system down even more. The incentives available vary widely from state to state. Fortunately, the Database of State Incentives for Renewables and Efficiency (DSIRE) has compiled this state information in a way that can easily be accessed.[15]

Keep in mind that even though PV systems may have a similar price when comparing quotes from installers in different locations in the United States, to the consumer the value of the energy produced is a function of (1) the amount of energy that can be produced in kilowatt-hours (kWh), which varies geographically due to the amount of sun hours

13. All prices in this paragraph are from GTM Research and Solar Energy Industries, *US Association Solar Market Insight Report*, Q2, 2013, available at http://www.seia.org/research-resources/solar-market-insight-report-2013-q2.

14. See Galen Barbose, Naïm Darghouth, Samantha Weaver, and Ryan Wiser, *Tracking the Sun VI: A Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012* (Berkeley, CA: Lawrence Berkeley National Laboratory, July 2013), available at http://eetd.lbl.gov/sites/all/files/lbnl-6350e.pdf.

15. Database of State Incentives for Renewable Energy, “Financial Incentives” (Washington, DC: US Department of Energy, 2012–2013), http://www.dsireusa.org/incentives/index.cfm?state=us.

per year, and (2) the price of the energy offset, i.e., money not paid to the utility by the customer due to on-site electricity generation and potential payments from the utility to the customer generating solar electricity, if available.

Sample Comparison of Energy Savings Value

To better understand some factors that affect energy savings, and therefore value to the consumer, an example follows comparing identical 5 kW PV systems—one in Colorado and one in Louisiana. This example illustrates the difference in energy savings as a function of production potential, utility electricity rates, and typical electricity consumption patterns. The example uses average conditions and is only intended as an illustration, not a real-world scenario.

In Colorado, the typical household uses around 711 kWh of electricity per month, or approximately 8,532 kWh/year, according to 2011 US Energy Information Administration (EIA) data.[16] Using the typical PV system size of 5 kW, a PV system in Denver will produce approximately 7,594 kilowatt-hours (kWh) in the first year,[17] offsetting approximately 89% of the household usage. Using average electricity rates in Denver of 11.1 cents/kWh,[18] the price typically paid by the homeowner is around $947/year, and the value of electricity produced by the PV system is approximately $843 in the first year (11.1 cents/kWh × 7,594 kWh), effectively reducing the amount paid by the homeowner from $947 to $104 in the first year, an 89% reduction.

Looking at the EIA state data, Colorado is on the low end of average monthly consumption. Residential customers in southern states typically use greater amounts of electricity on average, primarily for air conditioning. Louisiana has the highest average consumption at 1,348 kWh of electricity per month, or approximately 16,176 kWh/year.[19] If a 5 kW system in New Orleans produces 6,386 kWh[20] in the first year (e.g., 1,208 kWh/year less then Denver), it would offset only 39% of household usage in New Orleans. Using an average electricity rate in New Orleans of 10.6 cents/kWh,[21] the price typically paid by the homeowner is around $1,714 in one year and the value of the electricity produced by the PV system is approximately $677 in the first year (10.6 cents/kWh × 6,386 kWh), effectively reducing the amount paid by the homeowner from $1,714 to $1,037 in the first year, a 39% reduction.

This example shows the impact that the variability in the amount of solar resource, utility prices, and electricity consumption patterns will have on the resulting value in terms of energy saved by a consumer. A 5 kW PV system in Denver will have a greater impact on first-year utility rate reduction than one in New Orleans, considering average consumption and utility rates. To offset a similar proportion of electricity use in New Orleans (compared to Denver), a larger and potentially more expensive PV system would have to be installed. However, because consumers' consumption patterns vary, someone in New Orleans could use considerably less electricity and realize greater savings from the 5 kW PV system. How the energy produced by the PV system translates to a potential market value will be explored later in this article.

Factors and Challenges that Impact Valuation

Reconciling the value from all possible valuation approaches is crucial in developing a credible opinion of value. The approach with the most direct market support should be given the most consideration. Underwriters may reject an analysis of a PV system due to lack of credible support within the appraisal report. This can be remedied by the appraiser performing a complete comparative analysis of the value of the PV system arrived at through the use of the PV Value tool, market cost indicators, paired sales data, and valuation studies on market acceptance of PV systems. However, market studies should be used a secondary method or test of reasonableness unless the study is from the local market.

16. Information from http://www.eia.gov/electricity/sales_revenue_price/xls/table5_a.xls. Only the average monthly consumption has been pulled from this data set.
17. The kWh production is calculated from http://www.nrel.gov/rredc/pvwatts/, using Denver, with no change to default parameters.
18. http://en.openei.org/wiki/Gateway:Utilities, using zip code 80239 for Denver, returning a residential average value of 11.1 c/kWh.
19. http://www.eia.gov/electricity/sales_revenue_price/xls/table5_a.xls. Only the average monthly consumption is pulled from this dataset.
20. kWh production calculated from http://www.nrel.gov/rredc/pvwatts/, using New Orleans, with no change to default parameters.
21. http://en.openei.org/wiki/Gateway:Utilities, using zip code 70115 for New Orleans, returning a residential average value of 10.6 c/kWh.

Appraiser Knowledge

As PV systems generate electricity and essentially allow the property owner to pay less for electricity (or even get paid by a utility for the electricity), there is value to the amount not paid to the utility when compared to a similar property that does not have that feature. The utility bill savings in some locations can easily be in the thousands of dollars per year. The value proposition is key to PV systems gaining market share as an alternative source of electricity generation.

The URAR used for appraisals for government-sponsored enterprises (GSEs) includes certification 11, which states, "I have knowledge and experience in appraising this type of property in this market area." GSEs do not allow a change to a URAR certification if it contradicts their policies or standard certifications.

Appraisers also must meet the competency requirements of the Uniform Standards of Professional Appraisal Practice (USPAP), as provided in USPAP's Competency Rule.[22] The Competency Rule states, "An appraiser must: (1) be competent to perform the assignment; (2) acquire the necessary competency to perform the assignment; or (3) decline or withdraw from the assignment."[23]Appraiser competency requires knowledge of the property being appraised, and this holds true for properties with PV systems. This mean the appraiser must take necessary steps and have knowledge or competency to evaluate the potential contributory value of a PV system to the property in question. In cases where appraisers have placed a value on a PV system of essentially $0, simply because there were no sales in the area that had PV systems, they may not be meeting the competency requirements of USPAP. A valuation of $0 must have as much support as a valuation of $10,000.

USPAP Statement 2, "Statement on Appraisal Standards No. 2,"[24] indicates the discounted cash flow (DCF) analysis is "an accepted analytical tool and method of valuation within the income capitalization approach to value." It further states, "DCF analysis is an additional tool available to the appraiser and is best applied in developing value opinions in the context of one or more other approaches."[25] In the case of PV systems, the income stream is not from the rent for a residential property but from the amount of electricity generated by the PV system as a function of the current electricity rate the customer pays. In the case of a commercial PV system, the rooftop lease could be treated as leased square footage and the income generated as part of the lease agreement using the income capitalization approach. Due to the many different ownership structures for both residential and commercial PV systems, and the increase in installations across the United States, educating appraisers about PV systems and providing them with valuation tools will prepare them for assignments with installed PV systems.

Some states have seen large growth and acceptance of PV systems. Other states do not have the incentive structure to overcome low electricity costs, which lowers demand for new installations as well as the supporting values for existing PV systems. More research is required using actual paired sales analysis to produce concrete evidence that the discounted cash flow approach to valuing PV systems is accurate or needs further work. Paired sales data is hard to obtain in markets where a feature is new. Where data exists to apply the cost, sales comparison, and income capitalization approaches, they should be applied and reconciled. Therefore, until PV systems are more widely available across the United States, the discounting of the future benefits of the PV system is an acceptable way to value the system.

Lender and Underwriter Decisions and PV Financing Options

Lenders are held responsible for choosing a competent appraiser; however, the next appraiser on the rotation list is not necessarily competent for the particular property type. A borrower cannot choose a particular appraiser but should be assured that a competent appraiser, having knowledge of the property type, will be chosen.

This leads into a discussion about the role of the underwriter in valuing PV systems. Although conventional mortgage product underwriters have the ability to make decisions manually on mortgage loans, many loan underwriting decisions are based on recommendations from automated

22. Appraisal Standards Board, "Competency Rule" in *Uniform Standards of Professional Appraisal Practice*, 2012–2013 ed. (Washington, DC: The Appraisal Foundation, January 2012), Lines 322–364, U-11–U-12, available at http://www.uspap.org/.
23. Ibid., Lines 323–324, U-11. The 2014–2015 edition of USPAP adds the following statement to the Competency Rule, "In all cases the appraiser must perform competently when completing the assignment."
24. Statement 2, "Statement on Appraisal Standards No. 2, in *Uniform Standards of Professional Appraisal Practice*, Lines 2617–2710, U-82–U-84.
25. Ibid., Lines 2641–2642.

underwriting programs, such as Fannie Mae's Desktop Underwriter or Freddie Mac's Loan Prospector.[26] The key to improving the acceptance rate of the income capitalization and cost approach methodologies for valuing solar improvements is giving underwriters the ability, in their respective automated underwriting programs, to verify information used by appraisers to calculate an opinion of value for PV or other high-performance improvements. This can be done by linking the respective automated underwriting programs to the PV Value web application database, and allowing certified third-party reports, along with up-to-date cost and performance data (forthcoming), to be readily accessible and more easily verified. This also allows underwriters to verify the inputs and calculations used in the PV Value program to meet USPAP requirements.

Appraisers report that underwriters often insist that they give no value to the PV system unless there is a comparable sale with a PV system. This presents a problem for the appraiser. If the PV system has value and the appraiser provides a report that says it does not, it becomes a hypothetical condition. If the appraiser makes the statement that a hypothetical condition applies, the mortgage could be rejected on the secondary mortgage market. Where paired sales data is unavailable and cost data may not be reliable, an income-based valuation method to address the contributory value of a PV system allows the appraiser to satisfy the seemingly conflicting lender-client and USPAP requirements. Using the PV Value tool, appraisers can attribute appropriate value to the PV system, and thus avoid a hypothetical condition yet satisfy lender requirements for a supportable valuation method.

The PV Value® Tool

The Photovoltaic Energy Valuation Model, or PV Value, is a valuation tool developed in response to the issues and challenges presented to valuation professionals in their appraisals of properties with photovoltaic systems. This valuation tool is in the form of an Excel spreadsheet and is a free resource for anyone to use. It was vetted by both MAI- and SRA-designated appraisers prior to its release.

The PV Value tool incorporates a discounted cash flow analysis, as a PV system is considered electricity-generating technology that saves the owner money per month or adds ongoing cash flow. As of the time of this publication, PV Value version 1.1 is available for download. It currently exists as a proof of concept, with an Excel spreadsheet that works in Excel 2007 and 2010 for Windows, and Excel 2011 for Mac. To make the tool more accessible, a web version is being developed.[27] The discussion here will cover just the inputs and assumptions that go into the tool's "Appraisal Range of Value Estimate." More detailed information is available in the user manual.[28]

Use of the Income Capitalization Approach

The PV Value tool uses the income capitalization approach in a way that considers both upward and downward impacts on value through assumptions about discount rates, utility escalation rates, and potential inverter replacement costs in the future. It calculates what is called the Appraisal Range of Value Estimate, which is the present value estimate of the future energy produced by the PV system.

The estimated value is a function of the estimated energy produced by the PV array; the discount rate (weighted average cost of capital + basis point spread); the average annual utility rate paid; the utility escalation rate; operation and maintenance expense for replacing the inverter; PV system age; and PV module warranty lifetime. Appraisers will need to review the PV Value instruction manual and understand the inputs that are used to develop the value estimate. It is especially important to understand the assumptions and justifications for each input value used in the tool. The default settings within the tool are set in a way that allows for a credible estimate of value, and certain inputs—such as the derate factor, degradation rate, and utility escalation rate—should not be changed unless additional research has been conducted and documented in a way that an underwriter or lender can understand as justifying the change. The results given by the income capitalization approach will vary based on many factors relating to the inputs, such as the available solar resource and the utility rates paid.

There is research that discusses the value of a PV system in terms of environmental benefits, avoided

26. See https://www.fanniemae.com/singlefamily/desktop-underwriter and http://www.loanprospector.com/.

27. The web version is expected to be available from Energy Sense Finance, LLC, in early 2014 at http://www.pvvalue.com.

28. Ibid. and http://pv.sandia.gov/pvvalue. The manual also provides some background that can be used in documenting the appraisal report.

costs, and rate setting for cost recovery by utility companies.[29] However, the values discussed in many of those papers do not translate directly dollar for dollar into market value in a way that is helpful to a real estate appraiser. The appraiser will use multiple appraisal techniques to identify the extent to which the market supports added value for a PV system. This is important as PV equipment prices fall, rebates decrease, or energy costs increase. For example, if it becomes relatively inexpensive to install a PV system that pays for itself in less than a year and generates five to ten times the monetary benefits compared to the gross installed cost, what would a buyer be willing to pay for the PV system? Is it the value of the energy produced, which could be much higher than a new PV system, or would buyers only pay what it would cost to install a new PV system?

What Appraisers Need to Consider

The Residential Green and Energy-Efficient Addendum[30] was released in 2011 by the Appraisal Institute. This form is designed to capture information on green features on a residential property. There is a section of the form for solar panels, and the form's inputs mirror those used in the PV Value tool. An appraiser should try to obtain as much of this information from the property owner as possible before relying on other data sources. The property owner will usually have information from when the PV system was installed. The following discussion goes through the detailed inputs, and provides an approach that appraisers can use to gather all of the information needed to make an estimate of value.

PV Value Tool Inputs

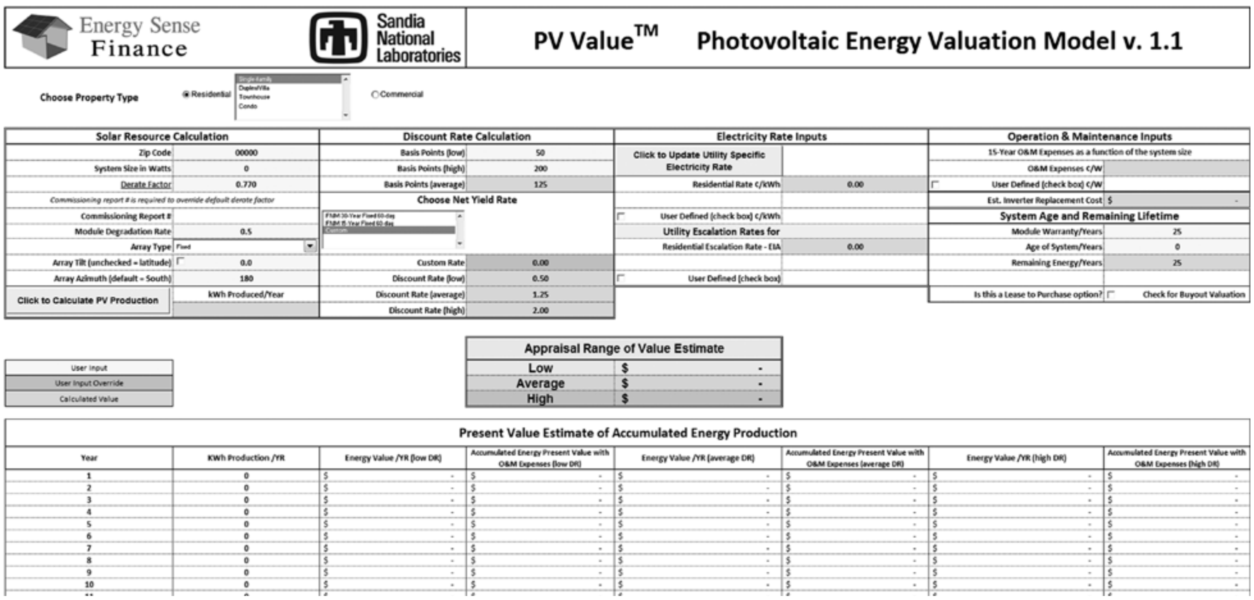
The PV Value tool's spreadsheet includes sections for inputs related to solar resource calculation, discount rate calculation, electricity rates, operation and maintenance, and system age (Figure 2).

Solar Resource Calculation

The first portion of the PV Value spreadsheet is a section titled "Solar Resource Calculation," where information is entered to calculate the energy production of the property's PV system.

To determine the energy production, the site's zip code is entered along with the PV system's size in watts (W), where 1 kW = 1000 W. Other inputs in this section include the derate factor, module degradation

Figure 2 PV Value Tool Form with Default Entries



29. For discussion see, Travis Bradford and Anne Hoskins, "Valuing Distributed Energy: Economic and Regulatory Challenges," http://travisbradford.files.wordpress.com/2012/01/de-whitepaper-final-0426.pdf.

30. Available at http://www.appraisalinstitute.org/education/green_energy_addendum.aspx.

rate, array type (fixed or tracking), the tilt, and the azimuth (orientation in degrees).

The *derate factor* is a percentage that represents the reduction that takes place when DC electricity is converted to AC electricity. The derate factor is used to simulate the real system losses that occur during the DC to AC conversion process; the PV Value tool includes a link to an online calculator. The *degradation rate* is used to simulate the annual reduction in power output that occurs due to a number of factors, such as corrosion in solder joints and silicon degradation due to UV exposure; this rate is expressed as a percentage per year.

A few notes about the parameters available for the user to modify. The default derate factor in PV Value will likely conservatively estimate the production of a newly installed PV system. In the PV Value tool, production is calculated and applied to a new array with the degradation rate also applied within the first year. If the PV system being appraised is older, the analysis starts on that year, ignoring the energy production from previous years, with the production rate going down each year as a function of the module degradation rate. The derate factor takes into consideration various components that reduce the amount of DC electricity that can be converted to AC electricity, such as electrical losses, module mismatch, soiling, and shading. This can easily be verified for a system by comparing the kWh output of one year (from monitoring software that many newer systems have) to the energy estimated within the PV Value tool by using the PVWatts performance calculator link in the spreadsheet.[31]

The derate factor value will change at different points in the system's lifetime as the module, inverter, and wiring connections age. In addition, modules degrade over time and that rate will reduce overall power production for each year of analysis. It is not advised to change the derate factor to come up with a PV production value that matches the amount that has actually been generated in the starting year of the analysis. Rather, if the property owner or appraiser wants a better estimate of the derate factor, a solar professional can be hired to make that determination, which would likely result in a more accurate value. There is a space available for a "Commissioning Report #" that captures the action of changing the derate factor. If the derate factor is changed without a report name or number that can easily explain the change in value, it may make it more difficult for the lender or underwriter to accept the valuation estimate. If a commissioning report is used, it should be attached to the spreadsheet printout.

After the input values are entered in the Solar Resource Calculation section, the user clicks on the "Calculation PV Production" button, and the first-year energy production for the starting year is calculated, with the degradation rate applied for each remaining year in the analysis.

Discount Rate Calculation

The second portion of the PV Value spreadsheet is a section titled "Discount Rate Calculation," where information on basis points, fixed rates, and discount rates are entered to calculate the average discount rate.

The discount rate for a residential borrower consists of two components: a weighted average cost of capital (WACC) and a risk premium. The GSE mortgage rate is used for developing a cost of funds, since it is typical for a conventional first mortgage that is eventually sold and securitized by Fannie Mae or Freddie Mac and is similar to the rate for most homeowners, or in this case the WACC for the borrower. The risk premium should take into account borrowers' risk and the realistic rate of return they otherwise could have made on a similar income-producing investment with minimal time or investment management required. For example, the homeowner could have invested in an investment-grade corporate bond or municipal bond with a low risk of principal loss if held to maturity. In the event a borrower's WACC is higher or lower than the stated GSE rate due to a higher-risk loan product or a lower cost of capital, the appraiser or underwriter can adjust the WACC by changing it to a custom rate and inputting the borrower's corrected WACC rate.

The residential appraiser should develop the discount rate keeping in mind both the residential borrower's WACC and a realistic comparable investment rate of return. For residential properties, the PV Value tool uses two risk-free rates tied to the Fannie Mae 15-year fixed and 30-year fixed, 60-day commitment.[32] The PV Value spreadsheet

31. http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/. A new version will be available at the end of 2013, http://pvwattsbeta.nrel.gov/.

32. https://www.fanniemae.com/content/datagrid/hist_net_yields/cur30.html and https://www.fanniemae.com/content/datagrid/hist_net_yields/cur15.html.

allows appraisers to adjust the risk premium basis point spread to what they determine is appropriate. The 50–200 basis point spread that is set as the default range is indicative of similar investment rates of return available in today's market for the residential homeowner.

For commercial properties, there is only a custom option for appraisers to enter a risk-free rate. This is important for commercial property appraisers who have access to information such as the data in the *PwC Real Estate Investor Survey*[33] or other benchmarks appropriate for the type of property being appraised.

Electricity Rate Inputs

The third portion of the PV Value spreadsheet is a section titled "Electricity Rate Inputs," where information on current electricity rates and utility escalation rates is entered.

The PV Value tool provides access to current residential and commercial utility rates through a link to the National Renewable Energy Laboratory's PVWatts calculator.[34] The rates are tied to the utility serving the zip code in question. These values may be out of date, however, and may not be as accurate as the actual rate paid by the property owner. Therefore, the PVWatts rates should be used only when more specific information cannot be gathered by the appraiser. One source of information that is more up to date is the OpenEI utility rate database,[35] which provides more specific rate schedules for the utility serving the property being appraised, as well as more up-to-date average sector rates compiled from EIA data.

Appraisers should obtain the most recent average utility rate from the past year by requesting the information from the property owner or electric utility. Often, the rate structures can be complex; if data is available as a time-of-use or tiered rate, a weighted average can be calculated to then determine the average annual amount paid in cents per kilowatt-hour.

The utility escalation rate is calculated using a compound annual growth rate equation, which is tied to the remaining warranty lifetime of the PV modules. The PV Value tool provides the default statewide escalation rate. This rate should be used unless the appraiser has utility-specific data that covers a similar time period as the remaining power producation warranty lifetime of the PV modules, and calculates the rate using a compound annual growth rate equation. The utility escalation rate will impact the appraisal range of value estimate since locations with higher escalation rates will have a greater range of value estimates. It should be noted that as the state rates are updated annually by the EIA in nominal terms, the rates will also be updated in the PV Value tool.

Operation and Maintenance and System Age Inputs

The PV Value spreadsheet sections on "Operation and Maintenance Inputs" and "System Age and Remaining Lifetime" are for information pertaining to the potential cost of maintaining equipment outside of the inverter warranty period. In the case of the PV Value tool, a 15-year operations and maintenance period is assumed; however, inverter warranty periods can range from 10 to 25 years. Many new companies with products using new technology offer longer warranties, so using 15 years as the potential replacement window may end up being a conservative estimate, but 15 years will be used until more reliable information is available from manufacturers and testing companies. The PV Value tool does allow appraisers to add a custom input for a more detailed assessment of potential inverter replacement costs if that information is available.[36]

PV Value recognizes the age of the PV system when discounting the inverter replacement costs. For example, if a new 5 kW system has a 25-year remaining warranty lifetime, a risk-free rate of 4.2, and a spread of 50 to 200 basis points, then it would have a default operation and maintenance expense of 55 cents per watt (55c/W),[37] with a total

33. http://www.pwc.com/us/en/asset-management/real-estate/publications/pwc-real-estate-investor-survey.jhtml.

34. As the NREL website explains, "The PVWatts calculator works by creating hour-by-hour performance simulations that provide estimated monthly and annual energy production in kilowatts and energy value. Users can select a location and choose to use default values or their own system parameters for size, electric cost, array type, tilt angle, and azimuth angle. In addition, the PVWatts calculator can provide hourly performance data for the selected location." See http://www.nrel.gov/rredc/pvwatts/.

35. http://en.openei.org/wiki/Gateway:Utilities.

36. Commercial properties or residential properties that have no other source of electricity (remote locations) might also consider reserves for replacement of the PV system; however, this is beyond the scope of this article.

37. The value of 55c/W is based on the author's knowledge of actual replacement costs for inverters in 2011 and is used for valuing systems 5 kW to 25 kW in size. For a more detailed explanation see the PV Value user manual, available for download at http://pv.sandia.gov/pvvalue.

estimated replacement cost of $1,241. This amount is the total replacement cost of $2,750, discounted from 15 years in the future back to the present time. If the system is 5 years old with a remaining 20-year warranty lifetime, the inverter replacement cost is $1,618, which is the total replacement cost of $2,750 discounted from 10 years back to the present time.

When the data indicates the PV system is 15 years old, the PV Value tool automatically asks the user if the inverter has been replaced. If the inverter has been replaced, then the operation and maintenance expenses are $0 for the next 15 years, as the tool assumes that the inverter was already replaced within the original warranty period and an additional replacement will not be necessary for the remaining 10 years. If the answer is no, then the entire $2,750, which is the actual cost of the inverter before discounting, is then subtracted out of the present value for the final 10 years of the system's lifetime, reducing the range of value estimate.

In PV Value version 1.1, there is a checkbox for a "lease to purchase valuation," which essentially records the fact that PV Value tool was used in developing the fair market value when a lessor has the opportunity to sell the PV system to the lessee. For this type of analysis, PV Value asks for the original lease term in whole years and then calculates the present value of the energy production for the remaining warranty lifetime of the modules.

Examples of PV Value Estimates

Case Study 1—Comparison between Locations

For Case Study 1, assume there are two similar PV systems, and the only difference between the two systems is the location. PV System 1 is in Chicago, while PV System 2 is in Tampa. The locations impact the annual PV production, as there are fewer sun hours per year in Chicago than in Tampa. The value estimate is a function of geographic setting, where the higher amount of sun hours equates to greater energy production and higher value when using an income capitalization approach. The inputs and results for PV System 1 (Chicago) are shown in Figure 3.

Table 1 shows a comparison of inputs entered to develop a value estimate of System 1 in Chicago and System 2 in Tampa. The only differences in inputs are

Figure 3 Case Study 1—PV Value Inputs Entered for PV System 1 in Chicago

Zip Code	60637	Basis Points (low)	50
System Size in Watts	5,000	Basis Points (high)	200
Derate Factor	0.770	Basis Points (average)	125
Commissioning report # is required to override default derate factor		Choose Net Yield Rate	
Commissioning Report #		FNM 30-Year Fixed 60-day FNM 15-Year Fixed 60-day Custom	
Module Degradation Rate	0.5		
Array Type	Fixed		
Array Tilt (unchecked = latitude)	0.0	Custom Rate	4.20
Array Azimuth (default = South)	180	Discount Rate (low)	4.70
Click to Calculate PV Production	kWh Produced/Year	Discount Rate (average)	5.45
	5,984	Discount Rate (high)	6.20

Click to Update Utility Specific Electricity Rate	*Commonwealth Edison Co*	15-Year O&M Expenses as a function of the system size	
		O&M Expenses ¢/W	55
Residential Rate ¢/kWh	12.62	User Defined (check box) ¢/W	
		Est. Inverter Replacement Cost	$ 1,240.61
User Defined (check box) ¢/kWh	11.00	System Age and Remaining Lifetime	
Utility Escalation Rates for	IL	Module Warranty/Years	25
Residential Escalation Rate - EIA	0.23	Age of System/Years	0
		Remaining Energy/Years	25
User Defined (check box)	1.5		

Appraisal Range of Value Estimate		
Low	$	8,297.54
Average	$	8,969.70
High	$	9,721.78

Note: Computed using PV Value version 1.1.

in zip code and array tilt (latitude). Latitude increases from Tampa to Chicago, and as a default, the Chicago system will have a steeper tilt than the Tampa system when using the default latitude tilt option.

Case Study 2—Comparison by System Age

As PV systems age, the present value of the energy production declines. Case Study 2 compares two PV systems of different ages in Tampa. Here, System 1 and System 2 have the same inputs with the excep tion of the system age and remaining years. System 1is a new system with 25 years of warranty, while System 2 has only 20 years remaining on the warranty lifetime. The PV production for System 2 has dropped from its initial 7069 kWh/year (when the system was new), to 6857 kWh/year (5 years old, beginning of year 6) due to a 0.5%/year degradation rate, which is typical with crystalline silicon modules. Table 2 shows the effect of system age on the range of value estimate.[38]

Table 1 Case Study 1—Comparison of Inputs for Systems in Different Locations

	Case Study 1	
	System 1	**System 2**
Location	Chicago, IL	Tampa, FL
Zip code	**60637**	**33605**
System size	5 kW	5 kW
Derate factor	0.77	0.77
PV production	5,984 kWh/yr	7,069 kWh/yr
Degradation rate	0.5%/yr	0.5%/yr
Array type	Fixed	Fixed
Array tilt	**Latitude**	**Latitude**
Array azimuth	180	180
Basis points (low)	50	50
Basis points (avg.)	125	125
Basis points (high)	200	200
Custom rate	4.20	4.20
Discount rate (low)	4.70	4.70
Discount rate (avg.)	5.45	5.45
Discount rate (high)	6.20	6.20
Utility rate	11 c/kWh	11 c/kWh
Utility escalation rate	1.5	1.5
O&M inputs	55 c/W	55 c/W
System age	new	new
Remaining years	25	25
Value Estimate, Low	**$8,297**	**$10,026**
Value Estimate, Avg.	**$8,969**	**$10,820**
Value Estimate, High	**$9,721**	**$11,708**

Note: Computed using PV Value version 1.1.

Table 2 Case Study 2—Comparison of Inputs for Systems of Different Ages

	Case Study 2	
	System 1	**System 2**
Location	Tampa, FL	Tampa, FL
Zip code	**33605**	**33605**
System size	**5 kW**	**5 kW**
Derate factor	0.77	0.77
PV production	7,069 kWh/yr	6,857 kWh/yr
Degradation rate	0.5%/yr	0.5%/yr
Array type	Fixed	Fixed
Array tilt	**Latitude**	**Latitude**
Array azimuth	180	180
Basis points (low)	50	50
Basis points (avg.)	125	125
Basis points (high)	200	200
Custom rate	4.20	4.20
Discount rate (low)	4.70	4.70
Discount rate (avg.)	5.45	5.45
Discount rate (high)	6.20	6.20
Utility rate	11 c/kWh	11 c/kWh
Utility escalation rate	1.5	1.5
O&M inputs	55 c/W	55 c/W
System age	new	5
Remaining years	25	20
Value Estimate, Low	**$10,026**	**$8,113**
Value Estimate, Avg.	**$10,820**	**$8,667**
Value Estimate, High	**$11,708**	**$9,297**

Note: Computed using PV Value version 1.1.

38. This example also shows that a 5-year-old, 5 kW PV system in Tampa can have a similar income value as a new, 5 kW PV system in Chicago; compare Case Study 1, System 1 in Chicago with Case Study 2, System 2 in Tampa.

Changes in other inputs would also have an impact on the resulting value estimates, though for the purposes the case studies other inputs have been held constant and at specific default values. The examples illustrate how factors can impact value when using the income capitalization approach with the PV Value tool to develop a value estimate. Therefore, as previously mentioned it is important that appraisers understand the impact of the various inputs, as described in the PV Value user manual, and become competent in the terminology.

PV Value Training and Future Efforts

The original version of PV Value (version 1.0) was released on January 30, 2012, and it had over 1,500 downloads within a nine-month period. Subsequent version 1.1 was released on September 1, 2012, and as of the time of this publication, it has been downloaded over 2000 times by appraisers, lenders, assessors, real estate agents, underwriters, government, solar sales professionals, and property owners. The tool has been used across the United States to aid in appraisals of PV systems. It is also used by solar installers to show the potential market value of the system upon installation. The PV Value tool is introduced to participants in the *Residential and Commercial Valuation of Solar* course offered by the Appraisal Institute, along with additional tools appraisers and others can use to develop the value estimate of a PV system. Two recorded webinars also are currently available on the PV Value tool.[39]

Currently, Sandia National Laboratories is working with the Appraisal Institute on continued development and refinement of the appraiser educational materials as well as collaborating with Lawrence Berkeley National Laboratory (LBNL) to expand on its report on the price impact of PV systems.[40] This work with LBNL will help in comparing the results obtained by the PV Value tool with the existing sales data on homes with PV systems. The results will shed light on the disparate methods used by appraisers in the past to value PV systems, along with a path forward to a more standardized approach that appraisers, lenders, and underwriters can rely on.

The original version of PV Value released by Solar Power Electric (now Energy Sense Finance) and Sandia National Laboratories was intended to be a proof of concept to gauge interest in the tool as well as to solicit feedback and suggestions on how to improve the tool. Based on the feedback received and overwhelmingly positive response, the PV Value tool will be moved to a web platform, enabling it to reach a larger audience. This will also allow for the addition of new features and make it easier to apply updates.

New features planned for the web application include more detailed solar resource calculations that consider different PV technologies. Additional research into different technology degradation rates will also help refine estimates of solar energy production for each year of analysis. As the web application is used, there will be an effort to document the interest rates as well as the basis point spread used by valuation professionals when determining the value of the PV system, similar to the information that PricewaterhouseCoopers provides for commercial properties on a quarterly basis. This will provide detail that will help appraisers with future assignments. Additional data also will be gathered on operations and maintenance expenses to better estimate future inverter replacement options with different technology combinations. This may allow use of different warranty periods that match specific inverter brands and models.

Finally, the inclusion of different financing options (e.g., commercial property assessed clean energy (PACE) financing) is under consideration, as well as the inclusion of other income sources such as renewable energy credits. Also under consideration is a "Green Button" feature,[41] which would provide easy access to electricity usage data; updated time-of-use rates, where applicable; and a database of certified and verifiable individual PV system information, which would make data gathering easier, improve energy value accuracy, and shorten the time spent valuing the PV system.

Conclusions

This article discusses a valuation technique for PV systems using an income-based approach and

39. One webinar was offered before the release of version 1.0 on December 7, 2011 and is available at http://energy.sandia.gov/?page_id=8047#video. The other webinar was a presentation to the Solar Instructor Training Network on April 18, 2012 at a conference hosted by the Interstate Renewable Energy Council; it is available at http://vimeo.com/40703731.
40. Hoen et al., *An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California*.
41. For additional information see http://energy.gov/articles/green-button-data-more-power-you.

discounted cash flow analysis. This approach is appropriate as solar panels generate electricity, which has value that is a function of the price of the electricity not being purchased from the utility, and in some cases, sold back to the utility to meet specific state-mandated renewable energy targets. Since there are very few comparable sales of properties with PV systems, an approach that respects the electricity-generating capacity of the solar array is warranted.

This article also has discussed the PV Value tool, which was developed to help appraisers and other valuation professionals by providing a mechanism that simplifies the process, respecting the fact that appraisers are facing tighter restrictions and lower fees due to changes recently implemented as part of the Dodd-Frank legislation.

Efforts are underway to make the PV Value tool accessible to even more users as a web application. Over time, as PV Value is utilized by the valuation industry, additional data will become available to appraisers to support valuation of properties with PV systems. Appraisers need to consider replacement cost and comparables as part of a comprehensive view of the potential market value, but at this early stage of solar adoption in the United States, use of the income capitalization approach as presented in PV Value will help appraisers make informed value estimates.

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Jamie L. Johnson is the managing member of Energy Sense Finance. He holds NABCEP certifications for PV Installation Professional and for PV Technical Sales Professional. An avid writer of financial algorithms, he has over fifteen years of experience in the financial services sector, beginning his career with the Internal Revenue Service and then spending over a decade working in the mortgage, banking, and asset management industries. Energy Sense Finance is a developer of valuation and financial solutions applicable to both mortgage lending and leasing transactions for high-performance residential and commercial buildings. PV Value is a trademarked name of Johnson and Energy Sense Finance, which is located in Punta Gorda, Florida.

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Web Connections

Internet resources suggested by the Y. T. and Louise Lee Lum Library

Appraisal Institute—Green Building Resources
http://www.appraisalinstitute.org/education/green/default.aspx

EnergyBible.com—"Calculating Payback for a Photovoltaic System"
http://www.energybible.com/solar_energy/calculating_payback.html

ICLEI-Local Governments for Sustainability USA—"Property Taxes and Solar PV Systems: Policies, Practices, and Issues"
http://www.icleiusa.org/action-center/report-property-taxes-and-solar-pv-systems-policies-practices-and-issues

National American Board of Certified Energy Practitioners (NABCEP)
http://www.nabcep.org/

Solar Energy Industries Association (SEIA)
http://www.seia.org/

Solar Pro magazine, "The Evolution of Residential Solar Leasing"
http://solarprofessional.com/article/?file=SP6_2_pg14_QA_2