Confidential!
Pre-Press Release

THE VALUE OF BUILDING INTEGRATED PHOTOVOLTAICS

Joseph McCabe, P.E.
Energy Ideas
217 Creekside Way
Winters, CA 95694 USA
http://www.energyi.mccabe.net
e-mail: energyi@mccabe.net

Christy Herig
National Renewable Energy Laboratory
National Center for Photovoltaics
1617 Cole Boulevard, Golden, CO 80401, USA
e-mail: christy_herig@nrel.gov

ABSTRACT

This paper explores the values attributable to photovoltaics (PV) as a distributed energy resource (DER) specifically when applied as building integrated photovoltaics (BIPV). Value is dependent upon the stakeholder's perspective, which could be consumer, commercial business, utility or government agency. For these stakeholders value has different components. However, the greatest value occurs when multiple stakeholder perspectives are combined and result in financial benefits to the BIPV system owner. Building integrated photovoltaics is particularly suited in maximize the building owner value through net metering, building efficiency and building material displacement.

Multiple values can be obtained from integrating photovoltaics into building facades. Installations that reduce "whole building energy consumption" include rooftop arrays, roof-integrated insulation, shading devices, sloped glazing, spandrel glass and curtain wall systems. These BIPV systems supply electricity to the building and possibly the utility grid, displace conventional building materials, and increase a building's thermal efficiency. Additionally, BIPV systems do not need expensive balance of systems equipment required by field-mounted arrays.

Reduced building energy requirements, electricity value, tax credits, accelerated depreciation, state, local and federal financial incentives and space easily marketed for occupancy due to green image, all combines to add value in favor of BIPV for the building owner. This paper will examine the building owner value as well as other stakeholder perspective values that may be passed on to the building owner.

1. FIELDS OF PV VERSUS BIPV

The early focus for power production facilities using photovoltaics was to compete in the utility central generation market which meant ground mounted fields of solar arrays (see Photo 1). These installations maximized the cost of the system, mainly due to land and mounting structure costs. To erect such a system, the land needed to be purchased, permits needed to be pulled, the land needed clearing, holes needed to be dug, concrete needed to be poured, mounting structures needed to be erected, electrical lines needed to be strung in conduit, wires needed to connect to the existing utility along with transformers and switching gear, and a fence needed to be erected around the system for safety. Notice the photovoltaics aren't even mentioned yet! These systems only provide the wholesale value of the electricity produced.

Photo 1. Fields of PV (Photo Courtesy of NREL).

Photo 2. Which building has PV? (Photo Courtesy of Jane Willeboordse).

Compare that to a building with BIPV (see Photo 2); the land comes with the building, the permits come with the building (if not a retrofit), the structure to hold the photovoltaics is the building, an existing electrical distribution system comes with the building, a fence isn't needed to secure the grounds. The PV becomes the finished weather skin of the building, giving a credit for the displace materials you would have used, such as glass, marble or granite. Most important, the retail value of the energy produced can be realized, since it occurs at the distribution level of the utility grid, rather than the central generator level. Line losses, operation and maintenance costs, and capital investment of the transmission and distribution system are not incurred.[1]

2. TYPES OF BIPV

Building integrated PV either shade the building, provide exterior area shade, insulate a building or directly displace the exterior façade of the building. The added value[1] of these BIPV systems are as follows:

- Building shade PV systems such as awnings (see Photo 3) can decrease both the thermal load or HVAC requirements, maximize day-lighting design and provide opportunities for independent exterior lighting systems.
- Exterior shade PV systems such as porticos (see Photo 4) or covered parking provide added comfort to the resident or business customer, with an upscale image and resulting property or business value.
- Building insulating systems such as the PowerLight[2] product (see Photo 5) , will also reduce the building's HVAC requirements as well as extend the life of the existing roof.
- Building façade integrated with PV add the value of the displaced building material. This may be extremely high, as in the case of curtain walls displacing granite or marble or in the case of displacing glazing or spandrel glass. PV integrated roofing slates represent a midrange value. And standing seam (see Photo 6) or shingle roofing products are the low material displacement value products.

As the BIPV market grows, creative new products are emerging with additional values.

PV technology is versatile in both function and appearance. Functionally, PV is the uniquely most modular DER. At the “watts” level, PV will provide reliable grid-independent or grid back-up energy for building control or security systems. At a larger system level, PV reduces both demand and energy costs [2]. Aesthetically, PV can reflect many colors and provide varying transparency. The energy generating efficiency is less than optimal as the reflected color is changed, but as the BIPV market emerges, the aesthetic value may prove greater than the loss of energy value to the architect and/or the building owner.

Photo 3. Architectural PV Awning, PV Below Sign (Photo Courtesy of NREL).

Photo 4. AC PV Modules (Photo Courtesy of NREL).

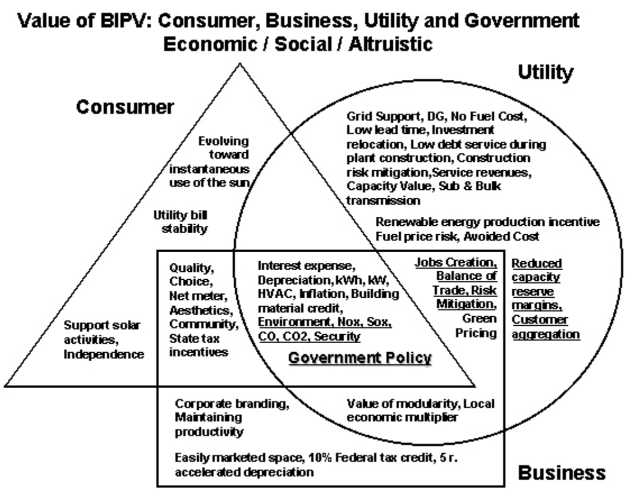
The energy produced by BIPV systems can be used to power critical loads[3], isolated or independent loads, or tied to the building energy system. In the current market, determining the highest BIPV value is dependent on whether the system is integrated during initial building design or as a retrofit to the building.

[1] In addition to energy and demand savings on the electric bill.

[2] The PowerLight product is PV mounted on an insulating, interlocking roof tile.

[3] This requires energy storage with batteries.

Photo 5. PowerLight Roof Installation (Photo Courtesy of PowerLight).



Graphic 1. PV Values for Various Entities

3. ECONOMIC PERSPECTIVE

The full value for BIPV systems is realized when multiple economic perspectives are combined. Many value streams have been analyzed by stakeholder or ownership scenario. The following discussion identifies value streams by stakeholder and the potential for accruing multiple value perspectives to a single ownership scenario. Graphic 1 illustrates this concept, with underlined government interests. Residential consumers, commercial businesses, utilities, and governments all have both tangible and intangible values. Energy and building integration values are realized by all stakeholder groups when the BIPV system is installed on their own facilities. However, to simplify the discussion, the ownership focus will be on consumers and businesses.

3.1 Residential Consumer

Tangible values for consumers include incentives, interest expense (for those with a tax liability) state tax incentives[4] and energy, both electrical generation and building efficiency value of systems. Net metering brings retail energy rates to the PV generated electricity. Other values to consumers, many tangible but not yet quantified, include electricity price risk mitigation, supporting solar activities, independence, quality, choice, security, aesthetics, community, and environmental stewardship. For this paper, we will call these social values. Analysis has shown the PV system installed cost at which a consumer breaks even ranges $1/W to over $10/W, with most heavily populated states well above $5/W [3]. This analysis did not include the building material value. Though low for residential applications at $0.10/W to replace asphalt shingles, to $1/W for roof slates, it often also adds to the intangible aesthetic value of the residence as shown in Photo 5.

Photo 5. Proud Berkley Homeowner with PV (Photo Courtesy of Homestead Enterprises).

3.2 Commercial Business

In addition to the consumer values, commercial businesses typically have monthly demand charges, which can be reduced by BIPV systems and can take advantage of the federal 10% tax credit and 5 year accelerated depreciation[5]. Net metering still applies where available, but typically a BIPV system output is fully used by the commercial building deferring the retail rate even without net metering. Commercial businesses may also have high values associated with critical loads, interfacing PV with the building's load management system [4], public relations associated with environmental stewardship and the building materials displaced are often glass and marble.[5] Additional intangible business values also include local economic multiplier, corporate branding, space easily

[4] See DESIRE http://www.dsireusa.org/
[5] see http://californiasolarcenter.org/incentives.html

marketed and maintaining productivity. Analysis has shown these values to range to over $5,000 for a large part of the country. [5] [6]

3.3 Utility

The highest value for PV occurs when sited at the distribution voltage level, as a DER, regardless of ownership.

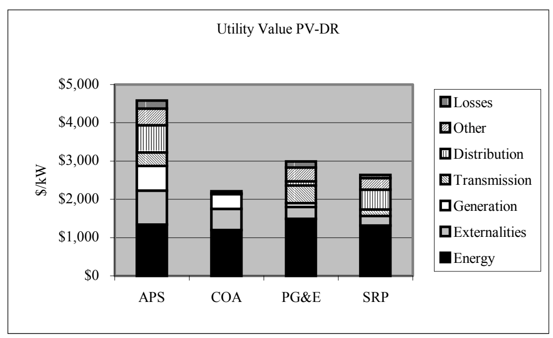
The modular aspect of PV provides the versatility for both size and siting making it the ultimate DER technology. The two highest value applications for utilities are either: 1) Low density rural distribution areas where the investment in distribution infrastructure is expensive due to the length of the lines and is not recovered by revenues due to the low population density, or; 2) High density, urban areas where construction costs are extremely high due to the built-out nature of the urban area. In addition to modularity, PV's electronic interconnection and generating profile result in minimum impact to utility operations[7].

Utility DER benefits have been analyzed for investor owner utilities, municipal utilities, and rural electric cooperatives. Graphic 2 shows that the range in utility value is between $2,200 and $4,500 per kilowatts (kW) capacity of PV. For the grid areas chosen for each analysis, this value represents the amount, without loss or gain that the utility could spend on PV, rather than capital expenditures on the grid. Energy is the largest portion of the stack of values, even though the calculation uses avoided cost at typically one fifth the retail value of the energy. The deferred capacity value, together with line losses, also forms a large portion of the value, and would delineate excessive T&D values. In specific geographic areas, where the T&D values exceed the grid system average used to determine customer rates, there is an opportunity for the utility to create new business relations with customers by sharing the savings to the utility grid of the PV investment. In addition to some of the consumer and business values for DER BIPV, Utility values include grid support, no fuel costs, low lead time, investment relocation, low debt service during plant construction, construction risk mitigation, service revenues, capacity value, subtransmission, bulk transmission, renewable energy production incentive, fuel price risk, and avoided cost.

Energy, capacity, line losses, and system average T&D expenditures are all included in retail rates for commercial and residential customers and accounted for in electricity bill savings. When separated in the analysis these values range from $1000-$1,500/kW from the utility perspective. [8] However, excessive T&D, peak electricity price deferral, risk mitigation, economic development and business opportunities are all additional values the utility could share with the customer. In addition to excessive T&D costs, new development that incorporates PV, solar hot water and energy efficiency will decrease the distribution system infrastructure requirements well below the system standard. To date, the only examples of passing these values on to the customers are:

- Orange and Rockland, a utility in the northeast with geographically specific T&D rates for DER installations [9] making the connection
- Real-time pricing experiments such as Puget Sound. [10]
- Tiered rate structures which increase the kWh charge in tiered blocks resulting in higher use customers paying a premium for energy as exemplified by the recently implemented California rate structures.[11]

None of these examples incorporate the full range of extended values and the detailed utility stacked benefit analysis, which was completed prior to deregulation and the market and fuel price volatility experienced in recent years. A conservative value is used by taking the differential between utility system values and extended values for these detailed analyses, which ranges from $600 - $2,500/kW. The average value is $1,100/kW and this also corresponds to the present value worth of the tiered block rate difference to the customer[6].



Graphic 2. Utility DER-PV Value [8].

3.4 Government

Federal, state and local governments also benefit from extended value streams for BIPV installations on government facilities, as well as value streams from market development through constituency technology deployment. The focus here will be the government values from market development translating to policy incentives for consumers

[6] Assumes 1800 kWh per year at a 6% discount rate, and a tiered rate differential of $0.14 to $0.18/kWh over the 30-year life of the system.

and businesses. The broad equation for government policy is for market development benefits to be greater than or equal to the government tax revenue impacts.

To date federal policy has been targeted at commercial businesses with a 10% investment tax credit and a 5-year accelerated depreciation allowance. Several federal legislative bills have been introduced for both personal income tax credits, amounting to approximately 15% of the installed BIPV systems cost and interconnection rules applying to BIPV systems. The Federal Energy Regulatory Commission (FERC) has also attempted to address interconnection rules[7]. The federal value stream consists of economic development, emissions mitigation, and energy independence or national security. PV will produce more jobs than importing foreign fuel thereby increasing federal tax revenues. U.S. energy independence, is often interpreted as a national security value. The cost to defending the Persian Gulf has been estimated at $33 billion and the cost to maintain the strategic petroleum reserve is $5.4 billion[12]. Though the PV industry is small, it is growing fast, and represents reduced dependence on foreign fuel imports. Additionally, BIPV represents energy infrastructure decentralization with resulting security benefits. Finally, the solar resource driving the PV generating profile is often the cause of the grid peak.[2]. Even though PV is an intermittent generator, BIPV deployment may result in reduced requirements for capacity reserve margins.

State governments have created innovative market development policies in conjunction with utility restructuring. Due to the price of PV, it is typically viewed as a stranded system benefit. Policies adding to the value of BIPV include:

- Renewable portfolio standards, with solar set-asides.
- Systems benefits charge allocated to grants, buy-downs and government purchase programs.
- Tax incentives (refunds, credits, and sales and property tax exemptions)
- Financing/loan programs
- Manufacturing production incentives
- Net metering
- Interconnection rules
- Disclosure and certification
- Green pricing mandates

The value stream justifying these policies are similar to those discussed under federal policy. However, the western energy crisis and parallel natural gas price volatility emphasizes the value of fuel diversity on a healthy state economy.

Local governments have a more direct relationship with their constituency and can implement policy directly reflecting social preferences. Maintaining a minimum level of energy service to include reliability and environmental preferences, not only attracts new, but also retains the existing commerce base and associated revenues. Local and regional governments can integrate the DER attributes of BIPV with land-use and development infrastructure to manage electric demand growth and reliability. Though the Sacramento Municipal Utility District as a municipal utility proves an example, the recent revenue bond passed in San Francisco shows a municipal utility structure is not necessary. Another potential value stream is the potential to manipulate the load profile with PV-DER to use as a negotiating tool for customer aggregation rates and services.

4. EXAMPLE VALUE ANALYSIS

Many of the value discussions here are difficult to quantify. We propose an exercise to have each entity quantify and evaluate the accumulative values from their perspective. Using the above discussion, we'd like to propose an example 20 year value analysis for a consumer, assuming 1 kW system costs $9,000, produces 1,800 kWh / year at the lowest tiered rates for California PGE of $0.12 / kWh[8] (1,800 kWh * $0.12 / kWh = $216 year / kW). Include an incentive justified by utility and government discussion at $4,500 per kW (California Public Utility Commission and Energy Commission). Assume the sum of consumers' HVAC efficiency, building material credit, and social value discussed above is $250 per year (maintenance, potential new inverter costs are include in this as negative $50). The straight-line economic evaluation becomes:

Value = 20 years * ($216 + $250) + $4,500 - $9,000 = $4,820

An additional 15% or $675 can be obtained by residents of California from a state income tax credit.[9]

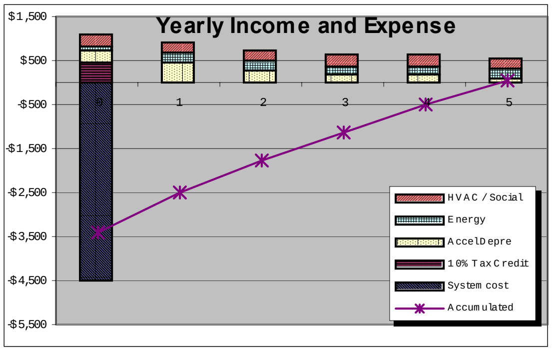
A profitable business, in a 33% tax bracket would also benefit from the 10% tax credit and five-year accelerated

[7] Though interconnection costs are not included here this has proven to be an extreme barrier to PV installations.[12]

[8] Compare utility expenditures carefully, include all taxes and fees that would be associated with energy.

[9] http://www.ftb.ca.gov/forms/01_forms/01_3508.pdf

depreciation[10]. The annual income / expense graph would be represented by Graphic 3. At the end of year 5, the system provides energy and social values for the expected life of the system. A financed system could have a more attractive cash flow in the beginning years, but this decreases over time.



Graphic 3. 5 year Business Values

5. CONCLUSIONS - REALIZING THE VALUE

If a properly design BIPV system shades building components, especially glazing, and is net metered to reduce high utility tariffs, it can have high values for socially conscience consumers. Similar systems can provide attractive corporate branding, cash flow, present value and return on investments for businesses. If strategically located, these systems can provide utility distributed generation value, risk reduction, and increased energy diversity. Local, state and federal governments obtain environmental, jobs creation, energy security and social values from BIPV.

6. ACKNOWLEDGEMENTS

We would like to thank all those who helped in the preparation of this paper, including, but not limited to the Department of Energy, the National Renewable Energy Laboratory and the California Energy Commission's Public Interest Energy Research office.

7. REFERENCES

(1)Steven Strong, Solar 98: Renewable Energy for the Americas, Albuquerque, NM, June 17, 1998

(2)Perez R., Wenger H., Herig C., (1998): Geographical Distribution of the Value of Demand-Side Commercial PV Systems in the United States. Plenary article, 2nd World PV Conference, Vienna Austria.

(3) Herig, C., Thomas, H., Perez, R., M. and H. Wenger, (1999): Residential Customer Sited Photovoltaics Niche Markets 1999, Proc. ASES Annual Meeting, Portland ME.

(4) Perez, R., J. Schlemmer, B. Bailey and K. Elsholtz, (2000): The Solar Load Controller -- End-use maximization of PV's peak shaving capability. ASES-2000 Conference, Madison, WI

(5) Mapping the Value of Commercial PV Applications in the US Accounting for Externalities. Proc. ASES Annual Meeting, Portland ME.

(6) Herig, C. R. Perez, H. Wenger (1998): Commercial Buildings and PV, a Natural Match. NREL Brochure DOE/GO-1998 NREL, Golden, CO
http://www.nrel.gov/ncpv/pdfs/pv_com_bldgs.pdf

(7) Herig, C., The Role and Value of Utilities in promoting PV, Invited Paper, Proceedings 12th International Photovoltaic Science and Engineering Conference, Cheju Island, Korea
June 11-13, 2001.

(8) Wenger, H., QuickScreen software at www.pacificenergy.com

(9) Alderfer, B., Eldridge, M., and Starrs, T., Making Connections, National Renewable Energy Laboratory, NREL/SR-200-28053, May 2000.

(10) Personal conversations with Mike Sheehan, Pudget Sound Energy.

(11) Hoff, T., California's Energy Crisis:
Causes and Recommended Solutions, Dec. 2000, www.clean-power.com

(12) Koplov, D., and Martin, A., Fueling Global Warming: Federal Subsidies to Oil in the United States, A report produced for Greenpeace, Jan. 2002.

(13) Starrs,T., Wenger, H., Brooks, B., Herig, C., "Barriers and Solutions for Connecting PV to the Grid", Proc. ASES Solar '98 Conference, Albuquerque, NM, June 1998

---

[10] Mid year convention for taxes and energy, 95% basis for accelerated depreciation.