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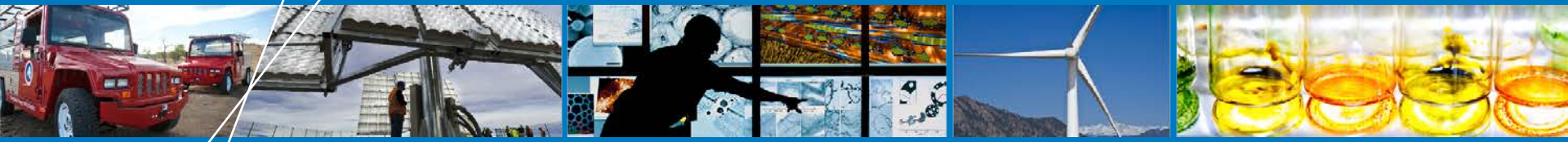
Building-Integrated Photovoltaics (BIPV) in the Residential Section: An Analysis of Installed Rooftop Prices



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Residential PV: a continuum of integration with building materials and designs

Least integrated

"Open rack-mounted systems"

"Rack-mounted PV" or "PV"

More integrated

"Close roof rack-mounted systems"

"Low profile systems"

"Building-applied PV" or "BAPV"

Fully integrated

"Direct-mounted systems"

"Building-integrated PV" or "BIPV"

- Both using racking hardware
- Neither replacing building materials

- No racking hardware
- Replaces building materials
- Install methods are similar to those of traditional materials

Sources: www.eeremultimedia.energy.gov ; www.buildingenergyvt.com

James, T. et al. "Building-Integrated Photovoltaics (BIPV) in the Residential Sector: An Analysis of Installed Rooftop System Prices." NREL Technical Report. NREL/TP-6A20-53103. November 2011.

BIPV – no consensus definition

In their descriptions of BIPV, some market reports and incentive programs include PV systems that are partially integrated with building materials or architectural designs. These systems often represent a combination of independent products.

Definitions we use for cost modeling:

Building-Integrated Photovoltaics (BIPV)

- A multifunctional product that generates electricity and replaces traditional building materials by serving as a significant weather barrier on building surfaces. Installation methods are similar to those of traditional building materials.

Rack-mounted Photovoltaics (PV)

- Traditional PV systems that are designed to generate electricity only, are mounted on racks, and do not replace the function of building materials.

All costs in this presentation are in 2010 U.S. dollars and in terms of U.S. dollars per peak watt of DC PV capacity ($/W or $/Wp DC)

Potential opportunities for BIPV market growth

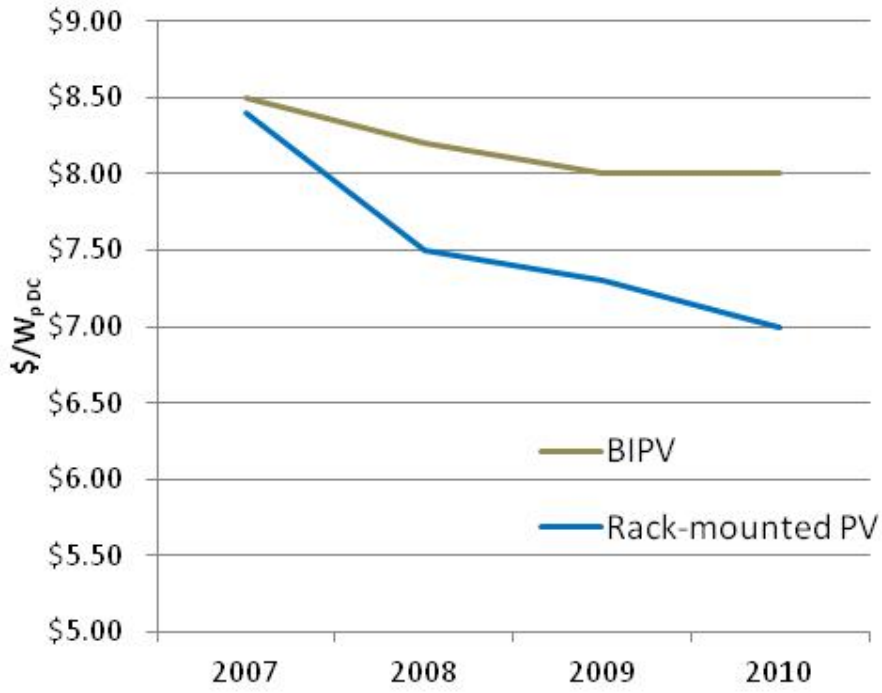
Installation cost reductions	Lower non-module costs -- elimination of racking hardware, greater use of traditional roofing labor and installation methods
	Cost offsets for displaced traditional building materials
	Lower supply chain costs -- utilizing established channels to market
Improved aesthetics	Consumer willingness to pay premiums in some markets
	Broader appeal for residential solar product designs
Higher technical potential	Increased PV-suitable space on buildings
Solar industry interest	Showcase applications
	High growth potential
	Help PV suppliers distinguish themselves
	Leverage more established channels to market
Government support	Maintain historic/cultural building designs
	BIPV-specific incentives in select international markets

…many opportunities but limited deployment: the cumulative installed capacity of BIPV (and related semi-integrated PV products) worldwide was about 250–300 MW by the end of 2009 – about 1% of the cumulative installed capacity of distributed PV systems at that time.

Sources: EuPD Research 2009, Pike Research 2010, Mints and Donnelly 2011.
James, T. et al. (2011) "Building-Integrated Photovoltaics (BIPV) in the Residential Sector: An Analysis of Installed Rooftop System Prices." NREL Technical Report. NREL/TP-6A20-53103.

Market prices are higher for BIPV than for rack-mounted PV

Average market prices for rooftop BIPV and PV systems (2- to 3-kW) on newly constructed homes in California



- Illustrated prices are from an analysis of about 3,000 systems
- BIPV prices do not include cost offsets for traditional roofing materials
- In Europe, increasing price convergence in some markets

***Market prices* are not necessarily representative of downward trends in system costs.**

These prices are influenced by several factors, including:

- Consumers' willingness to pay premiums for the aesthetic values of BIPV
- Supply chain considerations (supply and demand)
- Incentives

Source: Barbose, G. et al. (2011). Tracking the Sun IV: An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2010. Berkeley, CA: Lawrence Berkeley National Laboratory.

Module and system considerations for cost modeling

Modules: additional materials required for BIPV modules

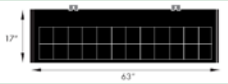
- Framing, flashing, adhesives, etc.
- We added a flat 10% cost premium to commercially-available PV modules

Module dimensions and system geometry

- Smaller modules may increase total labor costs (time to install) but may enable installation methods that are similar to those of traditional roofing products – single contractor, nails and hammers
- BIPV modules may have greater "dead space" (reducing efficiencies) as a result of extra framing, flashing, or other materials
- Some system geometries can reduce total system efficiencies

Examples of commercial modules

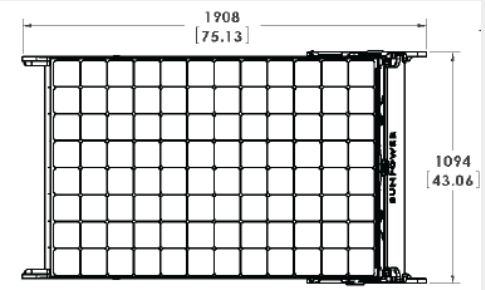
Building-applied PV / Building-integrated PV



SunPower SunTile (0.69 m^2)

Luma Solar Shingle (0.55 m^2)

Rack-mounted PV



SunPower T5 (2.09 m^2)

Suntech 190S – 24/Ad+ (1.20 m^2)

Cost analysis of a hypothetical BIPV rooftop case

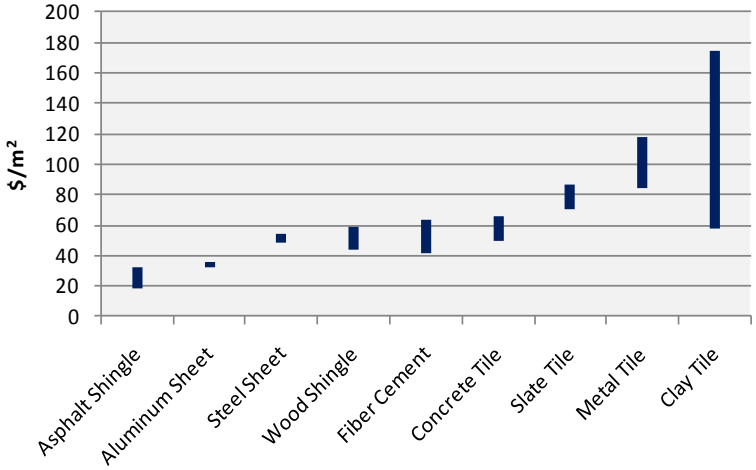
Comparative crystalline silicon (c-Si) cases – PV and BIPV

Scenario	Technology	Form	Efficiency	Module Area (m^2)
PV Reference Case	c-Si	Rigid	14.8%	1.28
BIPV Derivative Case	c-Si	Rigid	14.1%	0.58

Our analysis approximates the cash purchase prices (overnight capital costs) for a hypothetical BIPV system and a typical rack-mounted PV system installed on residential rooftops in the United States. This bottom-up method of estimating BIPV system prices disregards the pricing parameters determined by markets, focusing instead on objective inputs as a means to assess cost-reduction opportunities and challenges.

BIPV – Potential off-sets for traditional materials

Installed prices of residential roofing products (2008–2009)



Source: RSMeans 2010. Image from LUMA Resources, LLC. 2012.

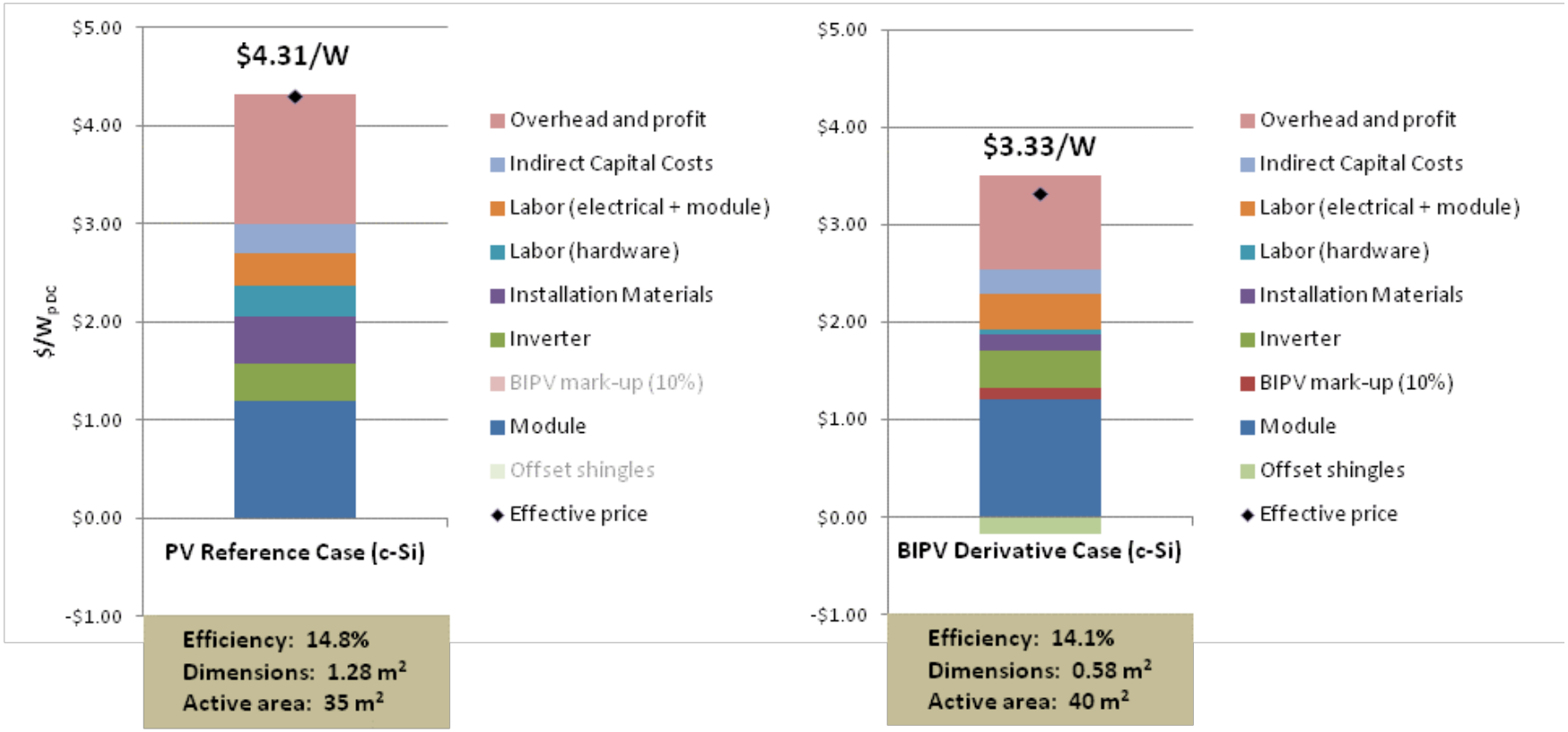
Estimated Offset Values for the Residential BIPV Case

Technology	PV metrics		Residential Material Offsets ($/W)	
	Efficiency	W_p/m^2	Asphalt Shingle	Clay Tile
c-Si	14.1%	141	$0.18	$0.83

Offsets are inversely related to PV efficiencies

BIPV has the potential to achieve lower installed prices than rack-mounted PV

Comparison of installed residential rooftop prices for the PV Reference Case and the BIPV Derivative Case – Q4 2011 estimate



"Effective price" values include shingle cost offsets, shown as a negative bar, in the BIPV case (right)

- Cost reductions of the simulated BIPV case are mostly from the elimination of hardware racking and associated labor costs (and resulting channel cost reductions)
- BIPV may experience reduced performance compared to rack-mounted PV, impacting levelized costs of energy

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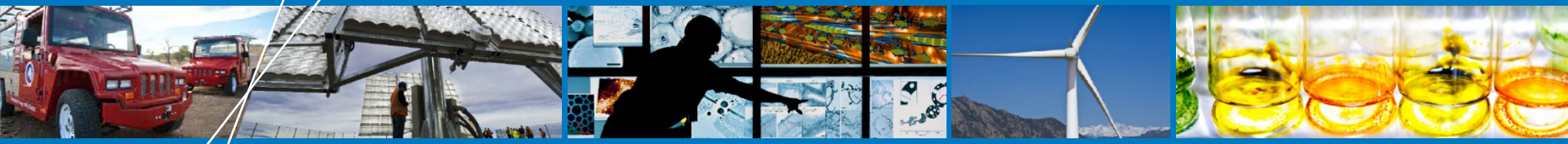

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