NECA 2009 Convention & Trade Show
Seattle, Washington

ELECTRI International Emerging PV Market Guide

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The University of Kansas
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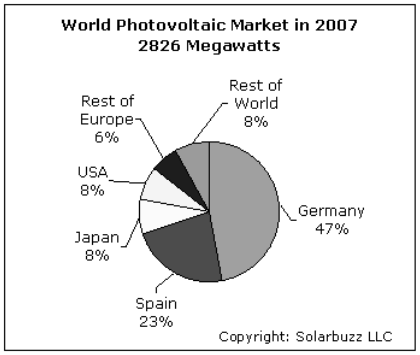
Green Building Defined

A building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional, and global ecosystems both during and after its construction and specified service life.

ASTM International, *Standard Terminology for Sustainability Relative to the Performance of Buildings,* ASTM Standard E 2114 – 06a, 2006.

Worldwide PV Installations



Every hour the sun provides the earth with as much energy as needed by the earth's population for an entire year.

Chart From: *www.solarbuzz.com/Marketbuzz2008-intro.htm*

Converting just 10% of incident solar energy into electric power on a piece of land 100 miles by 100 miles would produce enough power for the entire United States. (Earth: The Sequel, 2008)

Carbon-Neutral Buildings & Zero Energy Buildings (ZEBs)

- AIA "2030 Challenge" sets the goal for carbon-neutral buildings by 2020.
- ASHRAE plans to create a "Net Zero" guide for building design and construction by 2020.
- U.S. Department of Energy's (DOE) Building Technologies Program has set a goal of "zero-energy buildings" by 2025.

PV Drivers

- Advances In PV Technology
- Decreasing PV Production Costs
- Increasing Energy Costs
- Need For Energy Security
- Greater Environmental Awareness
- Government & Utility Incentives

1 kWh PV Offsets 1.15 - 2 Pounds CO_2 Emissions From Fossil Fuels

Solarbuzz Solar Module Retail Price Index

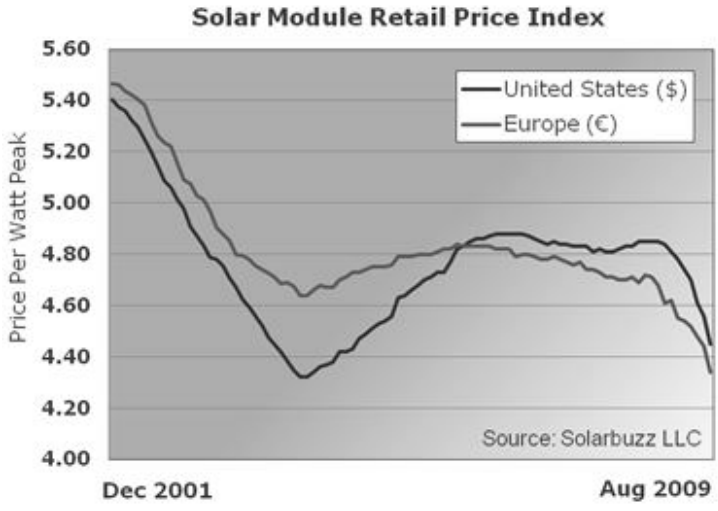


Chart Source: *www.solarbuzz.com/Moduleprices.htm*

U.S. Green Building Council
Leadership In Energy & Environmental Design (LEED™)
LEED 2009 for New Construction & Major Renovations

LEED 2009 for New Construction and Major Renovations

For Public Use and Display
USGBC Member Approved November 2008

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation In Design
- Regional Priority

USGBC 2009 LEED-NC
Energy & Atmosphere (EA) Category

EA	P1	Fundamental Commissioning Of Bldg & Energy Systems	Requ
EA	P2	Minimum Energy Performance	Requ
EA	P3	Fundamental Refrigerant Management	Requ
EA	C1	Optimize Energy Performance	1-19
EA	C2	On-Site Renewable Energy	1-7
EA	C3	Enhanced Commissioning	2
EA	C4	Enhanced Refrigerant Management	2
EA	C5	Measurement & Verification	3
EA	C6	Green Power	2
Total Energy & Atmosphere Category Points Possible			**35**

USGBC 2009 LEED-NC
EA C2: On-Site Renewable Energy

- Intent is to *encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use*.
- Points awarded based on energy produced by renewable systems as a percentage of the building annual energy cost.
- Building annual energy cost is determined by:
  - EA Credit 1/Optimize Energy Performance using Energy Cost Budget Method specified in Section 11 of ASHRAE/IESNA 90.1-2007.
  - Use of U.E. Department of Energy's Commercial Buildings Energy Consumption Survey database.

USGBD 2009 LEED-NC
EA C2: On-Site Renewable Energy
Points Toward LEED Certification

PERCENTAGE RENEWABLE ENERGY	POSSIBLE POINTS
1	1
3	2
5	3
7	4
9	5
11	6
13	7

Percentage Renewable Energy Is Based On The Percentage Of The Building's Annual Energy Cost Calculated Per EA Credit 1

USGBC 2009 LEED-NC PV Contribution To Building Certification Requirements

Certification Level	Points Required	Max PV Pts Possible As Pct Minimum Pts For Level
Certified	40 – 49	17.5%
Silver	50 – 59	14.0%
Gold	60 – 70	11.7%
Platinum	80 – 110	8.8%

Percent Based On Maximum 7 Points For 13 Percent Of EA CR 3 Energy Cost Offset By On-Site Renewables

PV Conversion Efficiency

- Conversion efficiency measures how effectively a PV device converts sunlight into electricity.
- Conversion efficiency is calculated as the ratio of the peak power produced by the PV device in watts (W_p) to the power of the sunlight incident on that device in watts.
- Standard test conditions (STC) are used to measure PV conversion efficiency:
  - Device temperature of 25°C (77°F).
  - Light source intensity of 1,000 watts/square meter.
  - Spectral distribution that corresponds to air mass (AM) 1.5 global standard.

PV Technologies

- Crystalline (90% Market)
  - Monocrystalline
  - Polycrystalline
- Thin Film (10% Market)
  - Amorphous Silicon
  - Other Compounds

Crystalline PV

- Currently 90% PV market.
- Conversion efficiency 10% to 13%.
- Panels are generally opaque and have either a dark blue or black antireflective coating.
- Can get other custom colors but blue and black are most efficient.
- Typically manufactured and installed as a unit that requires separate structural support.
- Can also be integrated into glass skylights and facades by spacing cells to allow light in and create an architectural feature.

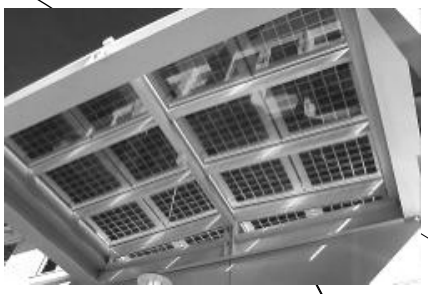
Flat Roof Installation

Los Angeles Electrical JATC

Integrating PV Into Parking Lot

Shell Solar installation at California State University Northridge (*www.shellus.com*)

Photovoltaic Glazing



PV Atrium, Golden Gate National Sea Shore, California

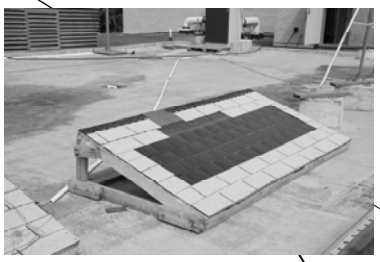
Photos from Energy Center of Wisconsin website *www.ecw.org*

Thin Film PV

- Currently 10% PV market.
- Amorphous silicon is the most common material used although more exotic non-silicon materials are in development.
- Conversion efficiency 5% to 8%.
- Thin film PV conversion efficiency better than crystalline PV in low or diffuse light making it more efficient on cloudy days.
- Can be made an integral part of many building materials that make up the exterior of the building.
- Manufacture of thin film PV much more efficient than crystalline PV using 1% to 5% of materials and lower cost per square foot.

Thin Film PV Technology

Colorado Home With PV Roof
Photo by NREL (*www.wisconsun.org*)

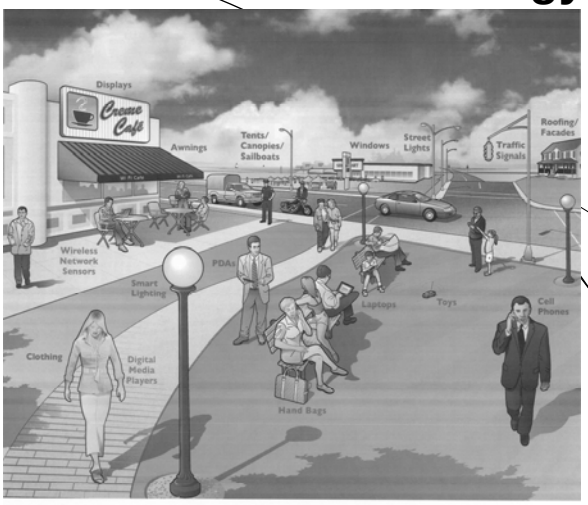


KU Solar Lab - PV Shingles

Thin Film PV Technology

Photo from *Metal Building Developer* http://metalbuildingdeveloper.com/

Thin Film PV Technology



Rendering from Konarka *www.konarka.com*

Bldg Integrated PV

- Building integrated photovoltaics (BIPV) incorporate PV into exterior building elements.
- Building skin generates electricity for some or all of building loads.
- PV is part of building architecture and does not detract from building appearance.
- Reduces material & construction costs because building material and PV are manufactured and installed as one.
- Available PV surface area is typically increased with BIPV increasing amount of energy that can be produced.
- PV decreases building cooling load by converting solar energy into electricity instead of heat.

University of Wisconsin - Green Bay

Mary Ann Cofrin Hall

- 120,000 Square Foot Classroom Building
- 4,300 Square Feet Of PV Installed That Produce About 25,500 kWh Annually
- PV Integrated Into:
  - Roofing System
  - Glass Curtain Wall

Photo by HOK (*www.hoksustainabledesign.com*)

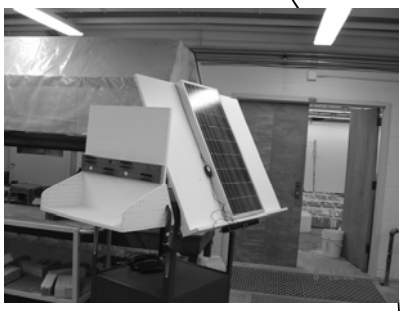
2008 NEC Article 690
PV System Installation Requirements

PART	TITLE
I	General
II	Circuit Requirements
III	Disconnection Means
IV	Wiring Methods
V	Grounding
VI	Marking
VII	Connection To Other Sources
VIII	Storage Batteries
IX	Systems Over 600 volts

"PV Panel" Defined

NEC Section 690.2

A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.



AP-160 PV Panel Nameplate

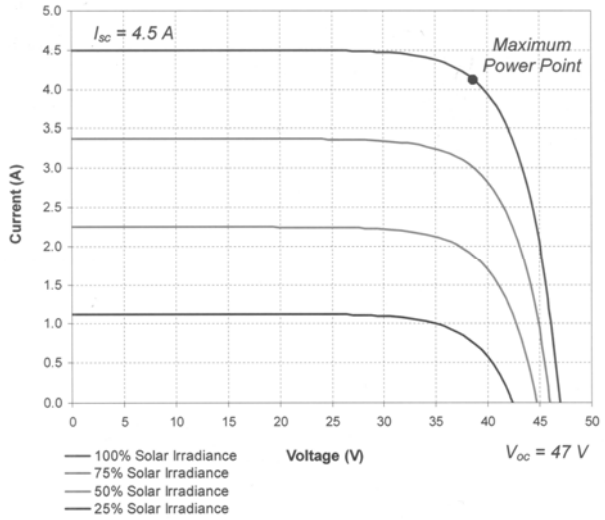
Model	AP-160	**Serial Number**	AP-160-4864-876237
Manufacturer	ACME Photovoltaics, Inc.		

Performance at STC: 1000 W/m^2, spectrum AM 1.5, and 25°C cell temperature.

Rated Power	Short Circuit Current	Operating Current
160 W	4.5 A	4.1 A
Max. System Voltage	**Open Circuit Voltage**	**Operating Voltage**
600 V	47.0 V	38.9 V
Fire Rating	**Series Fuse**	**Field Wiring**
Class C	15 A	14 AWG 75°C CU min.

NEC Section 690.51 Requirements

AP-160 PV Panel I-V Curve



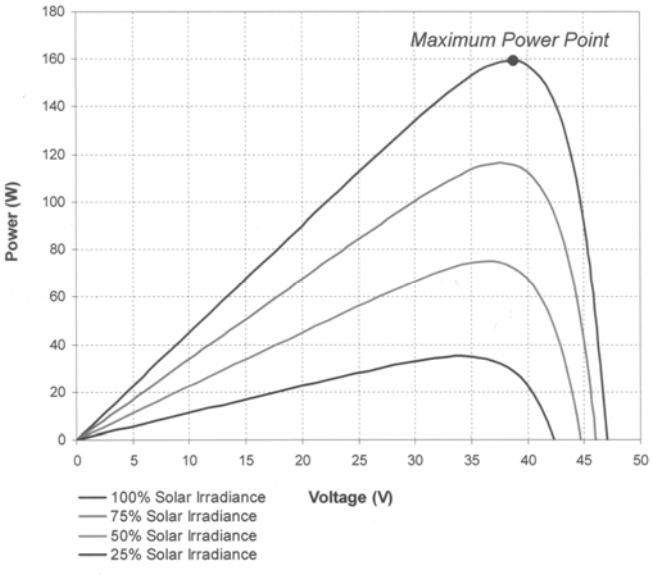
Interactive PV System NEC Section 690.2

A solar photovoltaic system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a solar photovoltaic system, such as a battery, is not another electrical production source.

PV Inverter Characteristics

- DC Input:
  - Maximum Input Voltage (Number Panels In Series)
  - Maximum Input Current (Number Panels In Parallel)
- DC Ground Fault Protection (GFP) [NEC 690.5]
- Integral PV System Disconnect [NEC 690.17]
- Maximum Power Point Tracking (MPPT)
- AC Output:
  - Voltage
  - Frequency
  - Number Of Phases
  - Apparent Power
- Anti-Islanding [NEC 690.61]

AP-160 PV Panel Power Curve



PV Balance Of System

- PV panels and inverter only represent a portion of the total PV system installed cost for a commercial or residential building.
- Balance Of System (BOS) is all other materials and equipment required to make the PV system work.
- BOS includes:
  - Combiner Boxes & Disconnects
  - Transient Surge Suppressors
  - PV Panel Support System
  - Raceway & Conductors
  - Other Required Materials & Equipment

PV Installation Case Study

Lemberg Electric Company, Inc.
GE Research Park - Milwaukee, Wisconsin

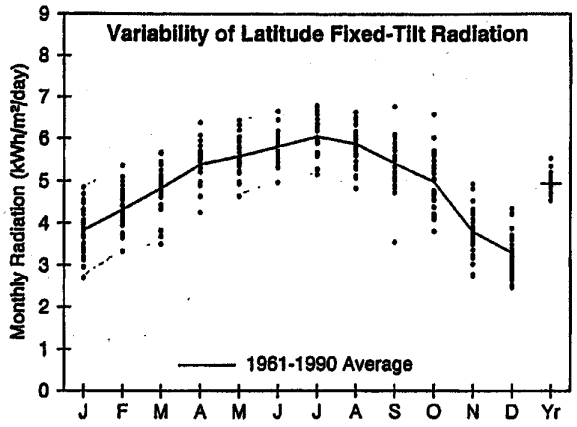
PV Installation Case Study

Lemberg Electric Company, Inc.
GE Research Park - Milwaukee, Wisconsin

PV Sys Performance Factors

- Location Sun Hours
- Module Compass Orientation
- Module Tilt Angle
- Module Temperature
- Particulate Build Up
- Interconnection Losses
- Conversion Losses
- Others

Solar Radiation Flat Plate Collector
South Facing – Fixed Tilt (kWh/m^2/day)
Monthly Variation In Radiation – KCMO Latitude = 39.30^{o}N



Solar Radiation Data Manual for Flat Plate and Concentrating Collectors
National Renewable Energy Laboratory

Solar Radiation Flat Plate Collector
South Facing – Fixed Tilt (kWh/m^2/day)
Monthly Variation In Radiation – KCMO Latitude = 39.30^{o}N

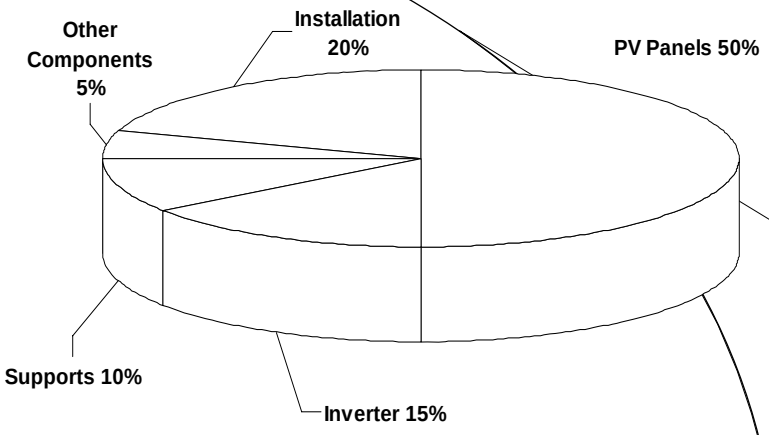
Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.2	3.0	3.9	5.1	5.9	6.5	6.6	5.8	4.6	3.6	2.3	1.9	4.3
	Min/Max	1.8/2.6	2.5/3.5	3.1/4.5	4.2/5.9	4.9/6.8	5.5/7.4	5.7/7.4	4.9/6.4	3.3/5.6	2.9/4.4	1.9/2.8	1.6/2.2	4.1/4.7
Latitude -15	Average	3.4	4.0	4.7	5.5	5.9	6.3	6.5	6.1	5.3	4.6	3.4	2.9	4.9
	Min/Max	2.4/4.2	3.1/4.9	3.5/5.4	4.4/6.5	4.9/6.8	5.4/7.3	5.6/7.4	5.1/6.9	3.6/6.6	3.6/6.0	2.5/4.3	2.2/3.7	4.6/5.4
Latitude	Average	3.8	4.3	4.8	5.4	5.6	5.8	6.0	5.9	5.4	5.0	3.8	3.3	4.9
	Min/Max	2.7/4.8	3.3/5.4	3.5/5.7	4.2/6.4	4.6/6.4	4.9/6.6	5.2/6.8	4.8/6.6	3.5/6.8	3.8/6.6	2.7/4.9	2.5/4.3	4.5/5.5
Latitude +15	Average	4.1	4.4	4.7	5.0	4.9	5.0	5.3	5.3	5.2	5.0	4.0	3.5	4.7
	Min/Max	2.8/5.2	3.3/5.6	3.3/5.6	3.9/5.9	4.1/5.7	4.3/5.7	4.5/5.9	4.4/6.0	3.3/6.5	3.8/6.7	2.8/5.3	2.6/4.7	4.3/5.3
90	Average	3.8	3.8	3.5	3.1	2.7	2.5	2.7	3.1	3.6	4.0	3.5	3.3	3.3
	Min/Max	2.5/4.9	2.7/4.8	2.4/4.2	2.5/3.6	2.3/2.9	2.3/2.7	2.4/2.9	2.6/3.5	2.3/4.5	3.0/5.5	2.4/4.8	2.3/4.5	2.9/3.7

KCMO Avg Solar Radiation = 4.9 kWh/m^2/day
STC Irradiation = 1 kW/m^2
Peak Sun Hours = 4.9 hours/day

Solar Radiation Data Manual for Flat Plate and Concentrating Collectors
National Renewable Energy Laboratory

PV System Cost Breakdown



Breakdown Can Vary Greatly By Installation

PV Economic Incentives

- Net Metering
- Feed-In Tariffs
- Time Of Day (TOD) Differential
- Utility & State Solar Rebate Programs
- Federal & State Tax Credits
- Accelerated Depreciation For Businesses
- Others

See Database of State Incentives for Renewables & Efficiency (DSIRE) maintained by the Solar Center at North Carolina State University at www.dsireusa.org.

Emergency Economic Stabilization Act of 2008
Fed Solar Investment Tax Credit

- Extend 8 years until 2016
- 30% Investment Tax Credit
- No Cap On Residential & Offsets AMT
- "Public-Utility Exemption" Removed
- ITC In Addition To Other Incentives & Accelerated Depreciation

Tax Recovery Act 1986
Modified Accelerated Cost Recovery System
MACRS Accelerated Depreciation
PV Installation – 5-Year Class Life

YEAR	RECOVERY RATE
1	0.2000
2	0.3200
3	0.1920
4	0.1152
5	0.1152
6	0.0576

PV Work Challenges

- Procurement Of PV Modules:
  - Competitive Price Per Watt
  - Reliable Supply
  - Quality Product
  - Reasonable Lead Time
- Customers Want Financing:
  - No up Front Capital Investment
  - No Debt
  - Off Balance Sheet
  - Guaranteed Energy Price Through PPA
- Water Penetration & Mold Risk
- Certification Requirements

ELECTRI International PV Market Guide

- *PV Market Guide* goal is to assist EC firm getting into the PV market:
  - Management
  - Estimators
  - Project Managers
  - Others
- Emphasis is on system concepts and economic feasibility.
- *PV Market Guide* is not intended to be:
  - PV design guide.
  - PV installation guide.

PV Market Guide - Contents

Questions?