

BUILDING INTEGRATED PHOTOVOLTAICS

STEVE COONEN



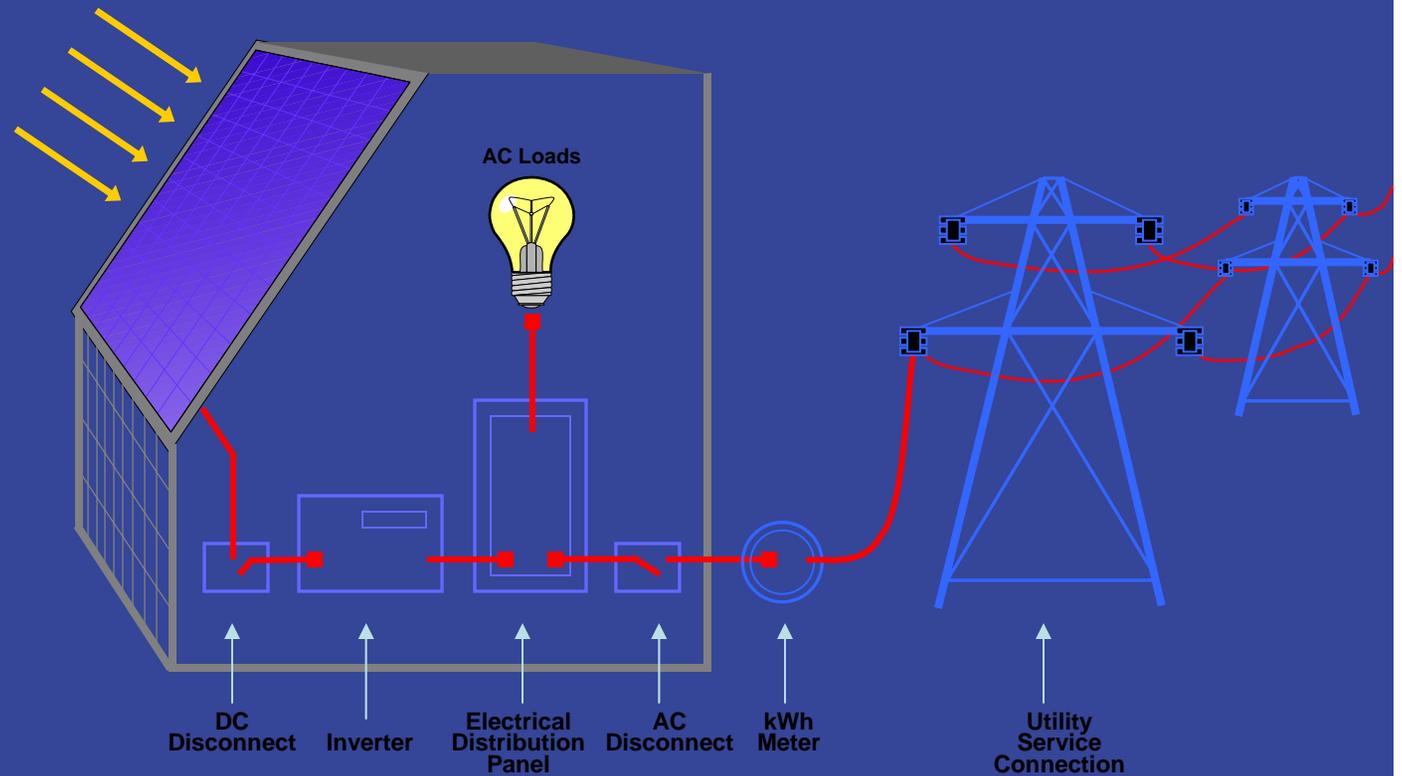
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BIPV

DEFINITION

Building Integrated Photovoltaics (BIPV)

- Grid Connected BIPV Schematic



DEFINITIONS

- Photovoltaics = Solar Electric = PVs
- BIPV = Building Integrated PV
- Solar Module = Glass Aperture
- Solar Cell = Base Unit (5 or 6 inch square)

WHY INTEGRATE PV?

- IMPROVED AESTHETICS
- LOWER COST
- WIDER DISTRIBUTION

BUILDING INTEGRATION APPLICATION TYPES

- ROOFING
- SKYLIGHTS – CANOPIES
- CURTAINWALLS – VERTICAL GLASS

Crystalline Photovoltaic Technology and Thin-Film Photovoltaic Technology



In the past, photovoltaic modules were mostly attached to racks mounted on rooftops or near-by buildings or nearby, on-grade....

A “classic” residential ground mount system



...and an occasional two-axis solar tracker... usually to the dismay of the neighbors....

..both with crystalline modules



70% of roofs in the United States are flat roofs... and this is a typical polycrystalline *rack-mounted* solar photovoltaic array mounted ON a flat roof





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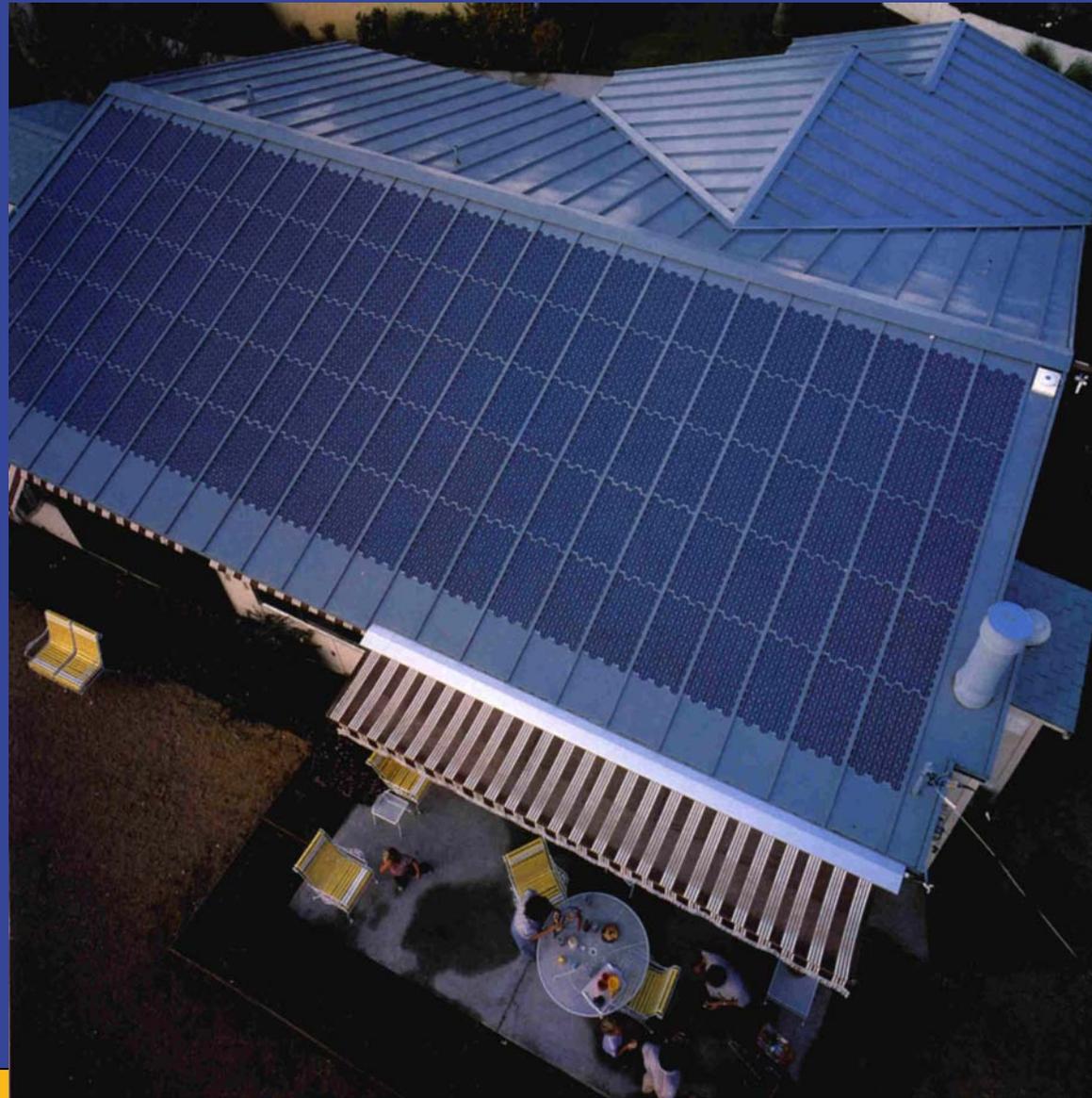
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Frameless
thin film
modules
applied to
sleepers
parallel
with roof
slope



Arial view
shows total
roof
integration
on the John
Long model
home...

--- 1978



2 KW, 400 sq. ft. thin film solar-electric system integrated into a standing seam metal roofed residence in Mendocino, California, by Steven Heckeroth



2 KW, 200 sq. ft.

crystalline solar electric
system integrated into a
concrete roof tiled
residence in Eldorado
Hills, CA



FERRY TERMINAL NYC



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SPANDREL GLASS POLYCRYSTALLINE



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ARCHITECTURAL BUILDING INTEGRATED PHOTOVOLTAICS

Solar Metal Roofs and Wall Systems

Solar Metal Roofing -

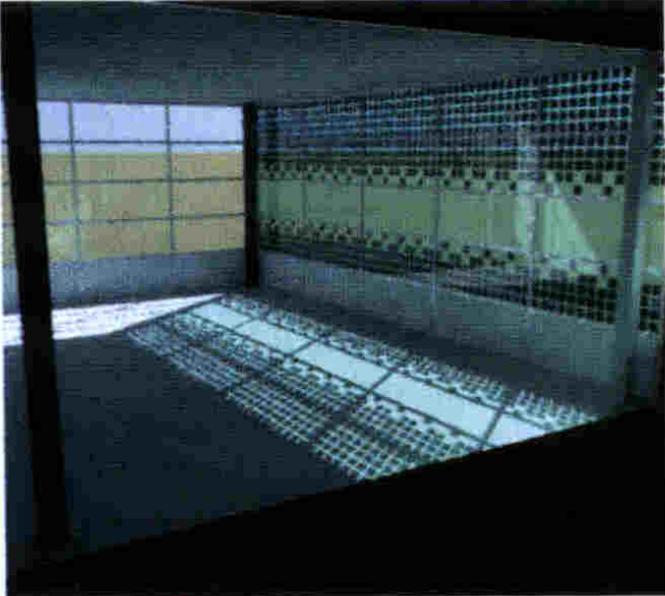
Typical specification for metal on these applications calls for factory-applied Galvalume with flourocarbon (KYNAR) finish coat over



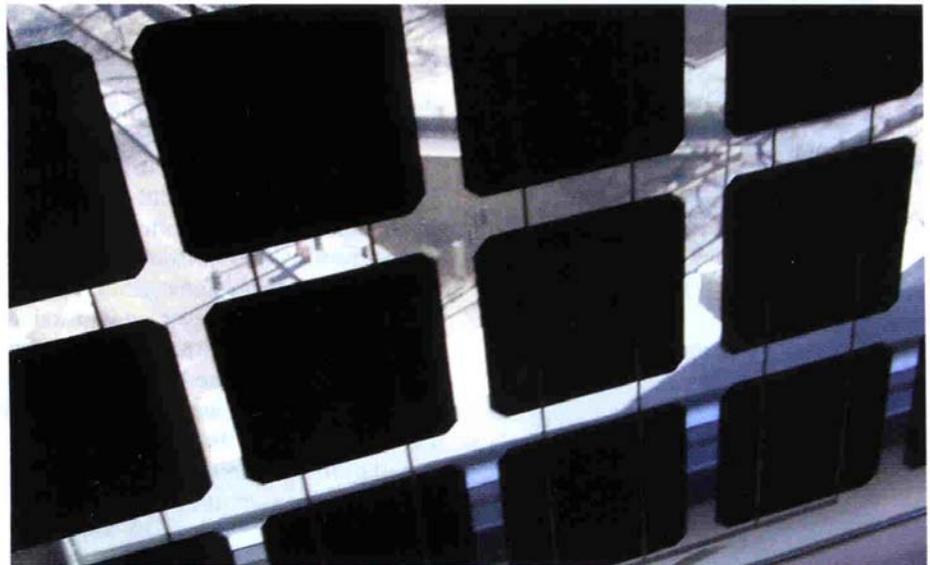
Solar Spandrel Wall Systems –



PV AND DAYLIGHTING



Desktop Radiance 3D image of a San Francisco office building incorporating PVs, courtesy of Charles Eley and Associates, San Francisco, CA. Building design by Peter Ellis, SOM Chicago.



Siemens 4 x 4-inch solar cells laminated with clear low-e. Design by Adrian Smith, SOM Chicago.

PV MARKET IN AMERICA



- Over 8 Million Sq. Ft.
- 85% Grid Connected
- 400K S.F./year BIPV
- Most growth in BIPV

BIPV Completed in America

- San Francisco, California
- 2 kw
- First BIPV for Federal Government





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PV Laminate Installation



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BIPV Completed in America



- Aspen, Colorado
- 8 kw
- Glass/Glass laminate
- City Central Park

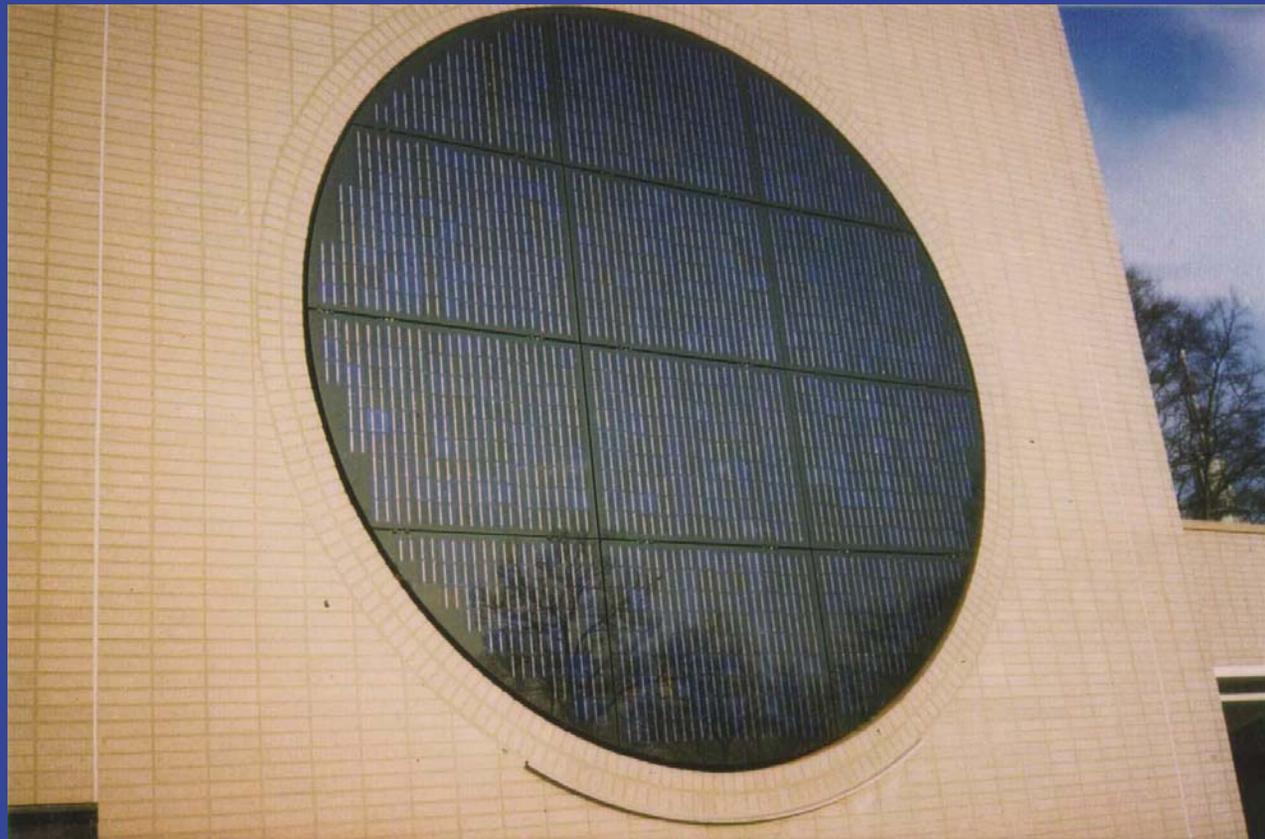
PV Installation in Europe



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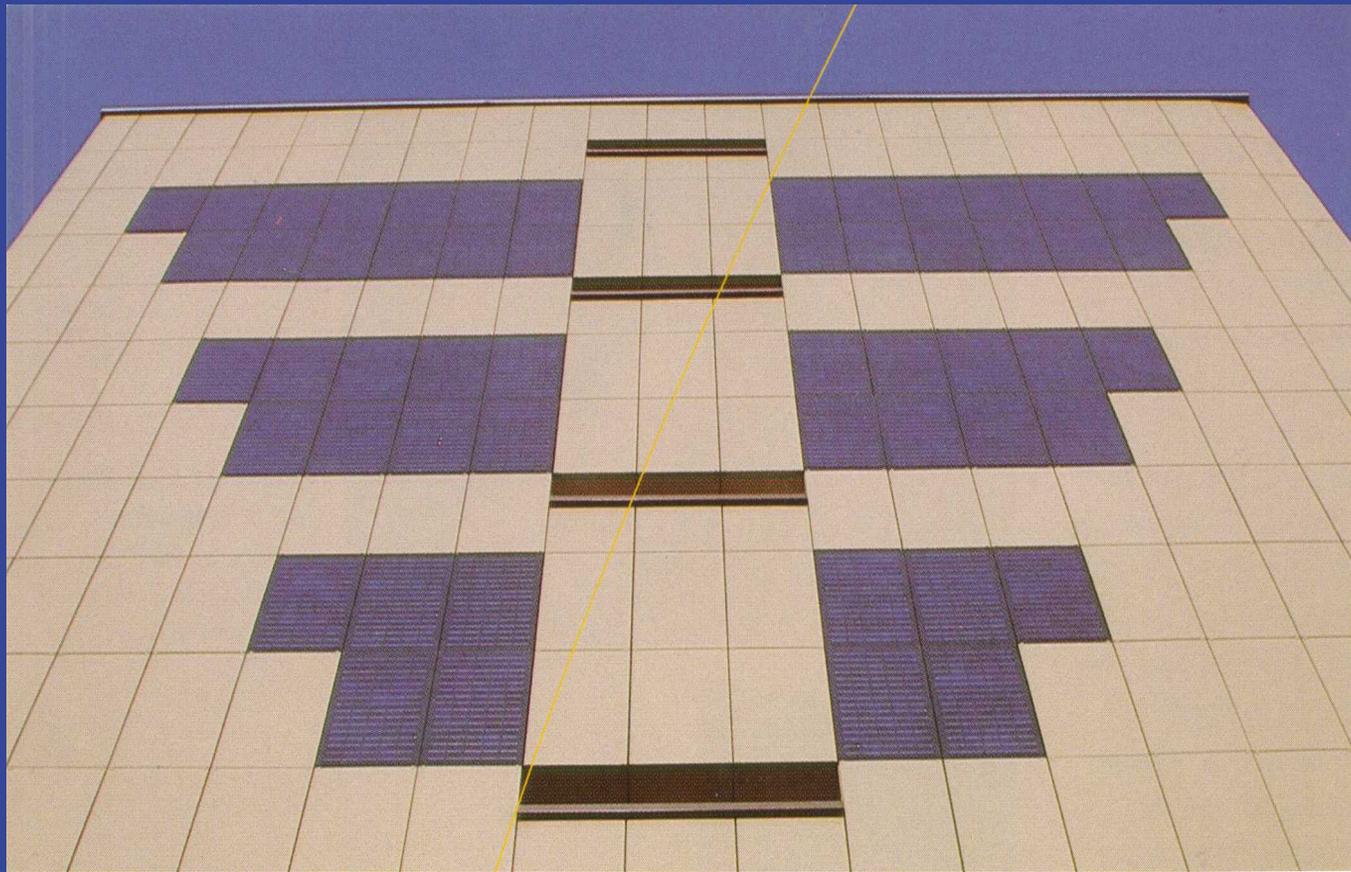
PV Installation in Europe



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PV Installation in Europe



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BIPV Completed in America



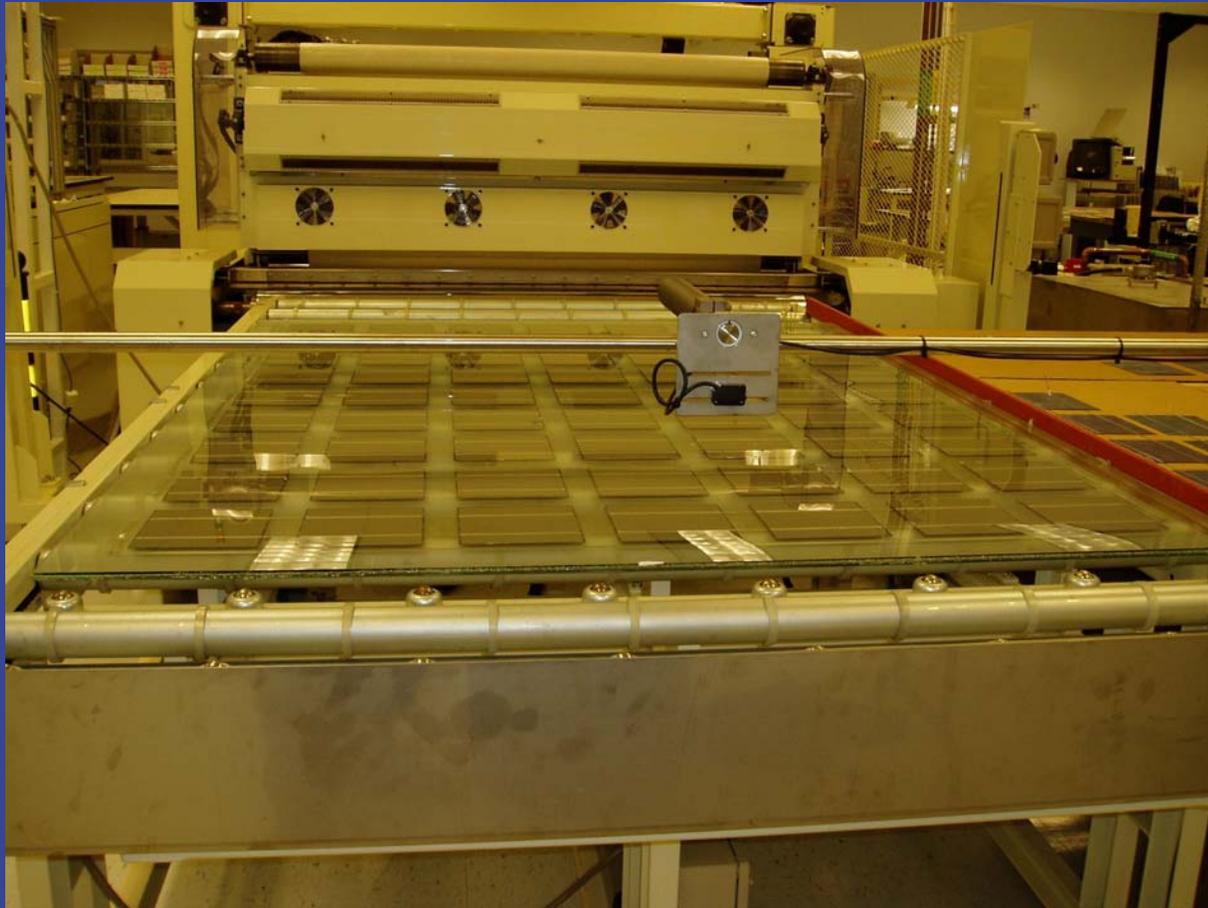
- 3 kilowatt
- Insulated Glass
- 80% shading coeff.
- Photo courtesy
Solaria Corporation

PV Laminator

Clamshell type



PV Laminator 4 Post type



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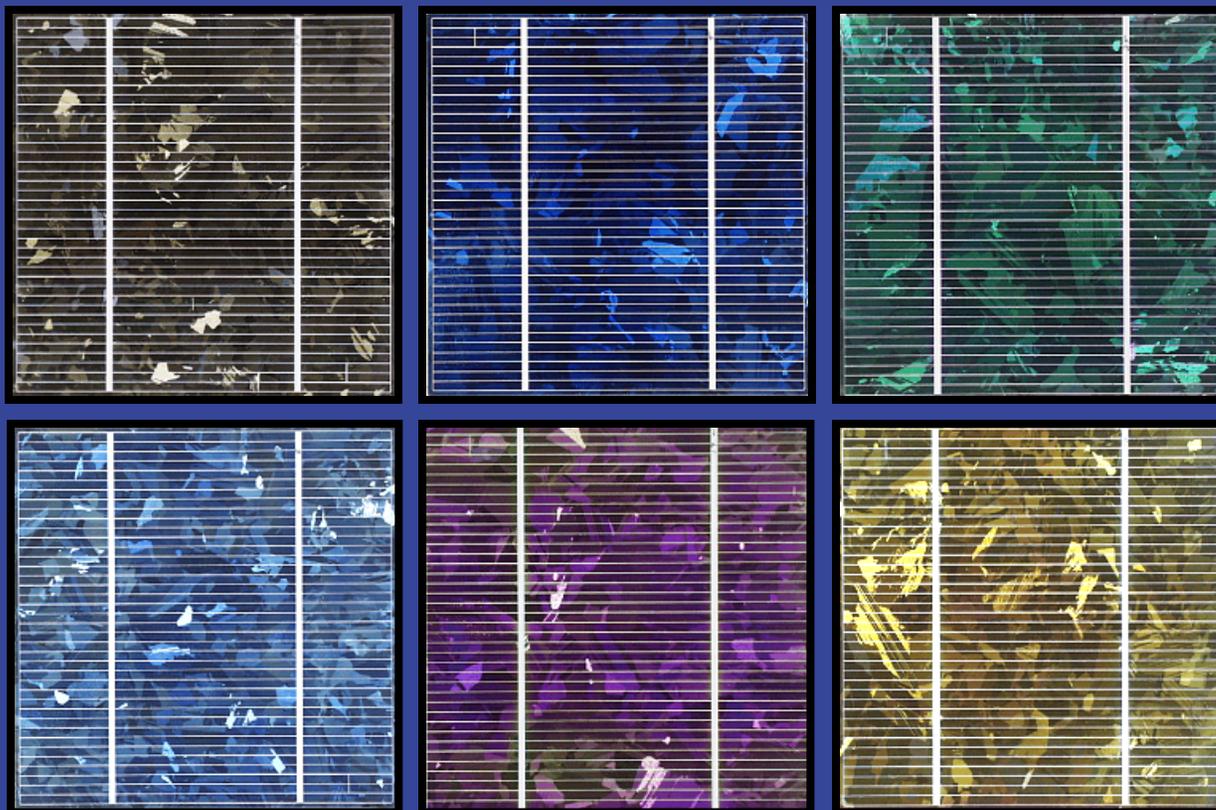
PV Laminate in Factory



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MULTICRYSTALLINE PV CELL COLORS



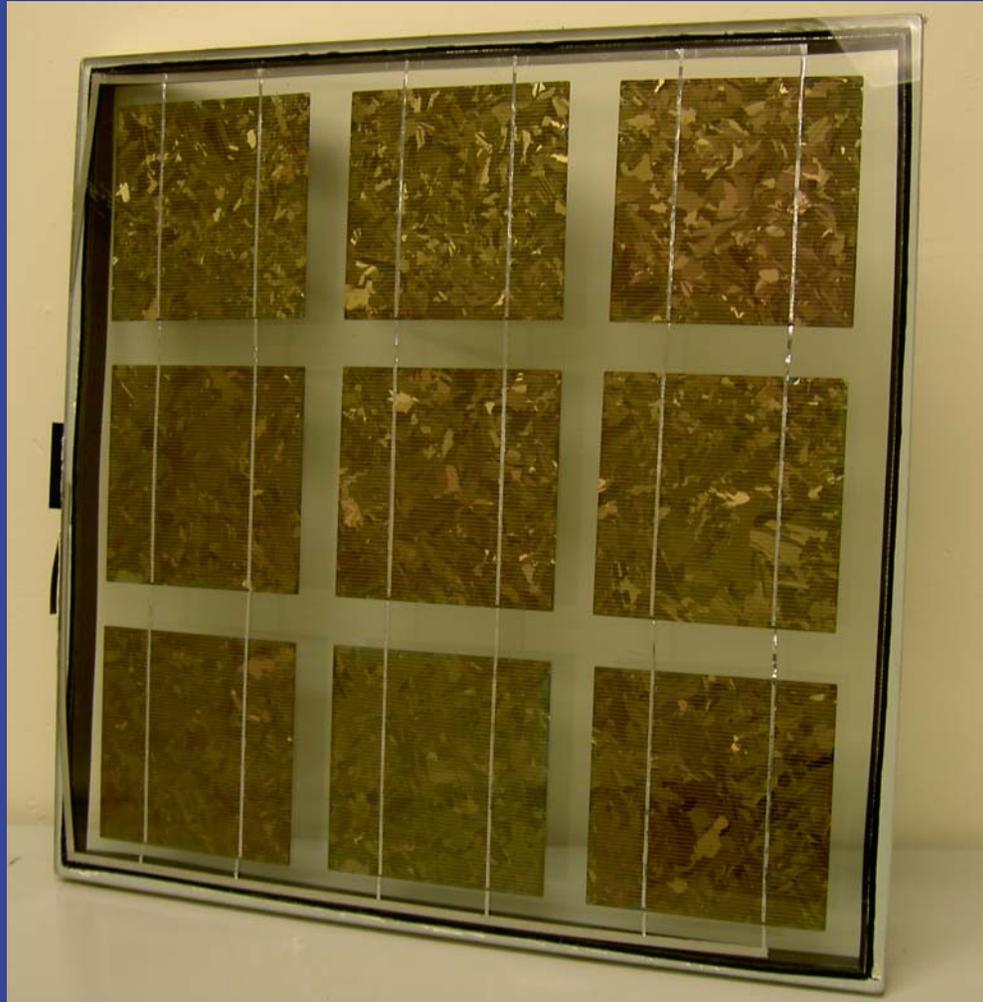
Polycrystalline Color Samples

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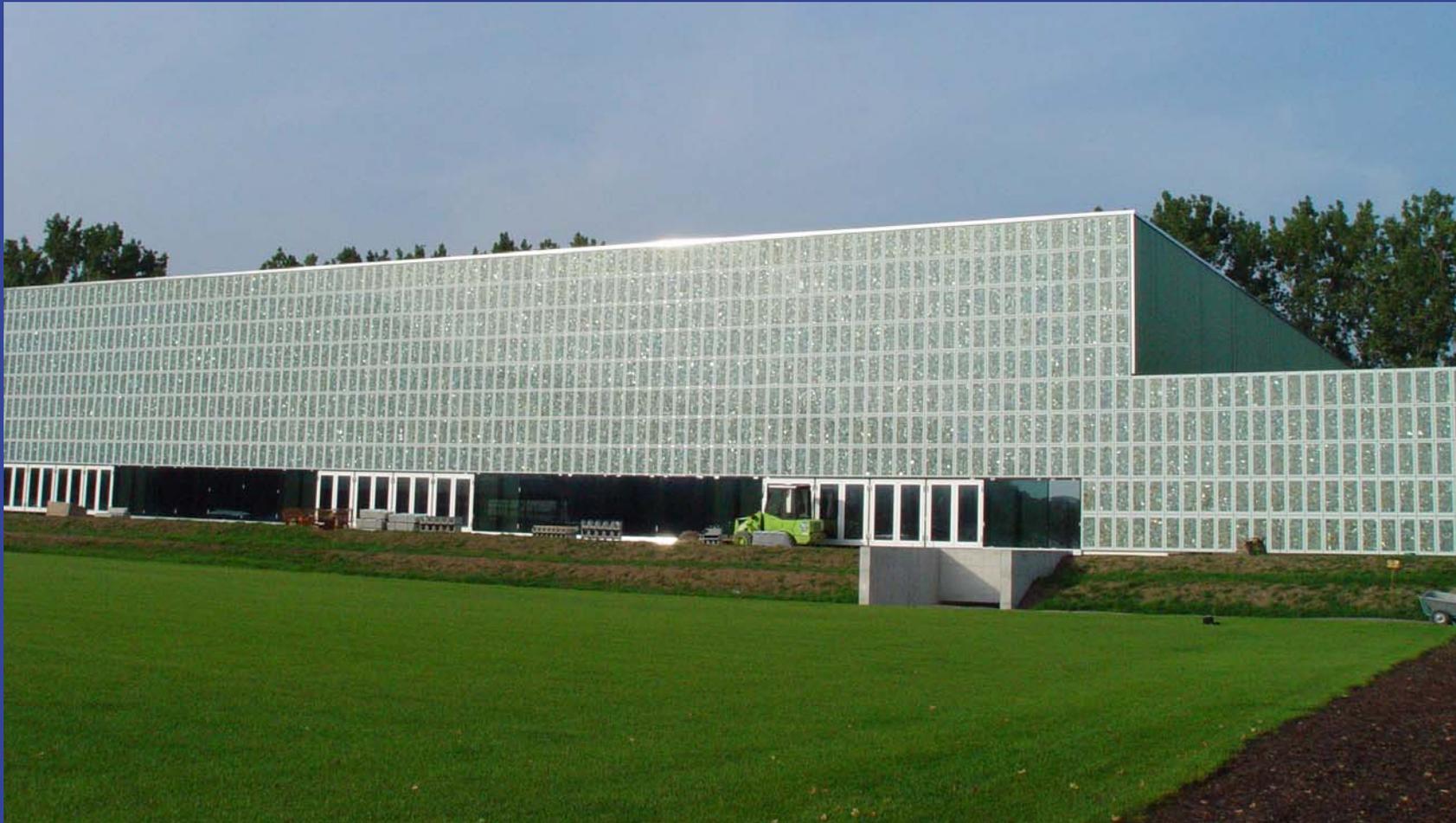
Insulated PV Glass Unit

- PV Cells on Surface #2



GREEN SOLAR CELLS IN CURTAINWALL

Photo by Sunways AG

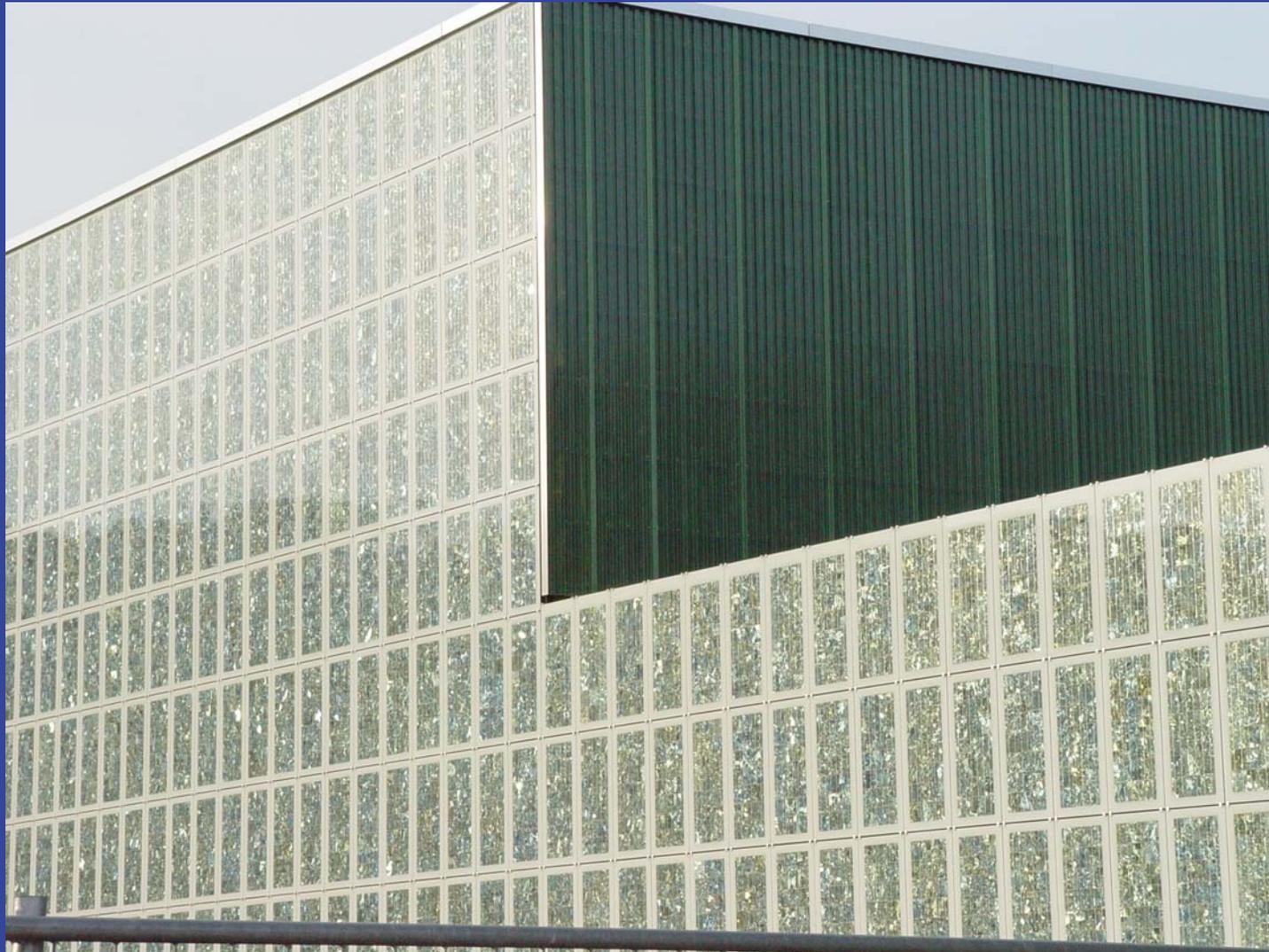


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GREEN SOLAR CELLS IN CURTAINWALL

Photo by Sunways AG



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GREEN POLYCRYSTALLINE PV CELL

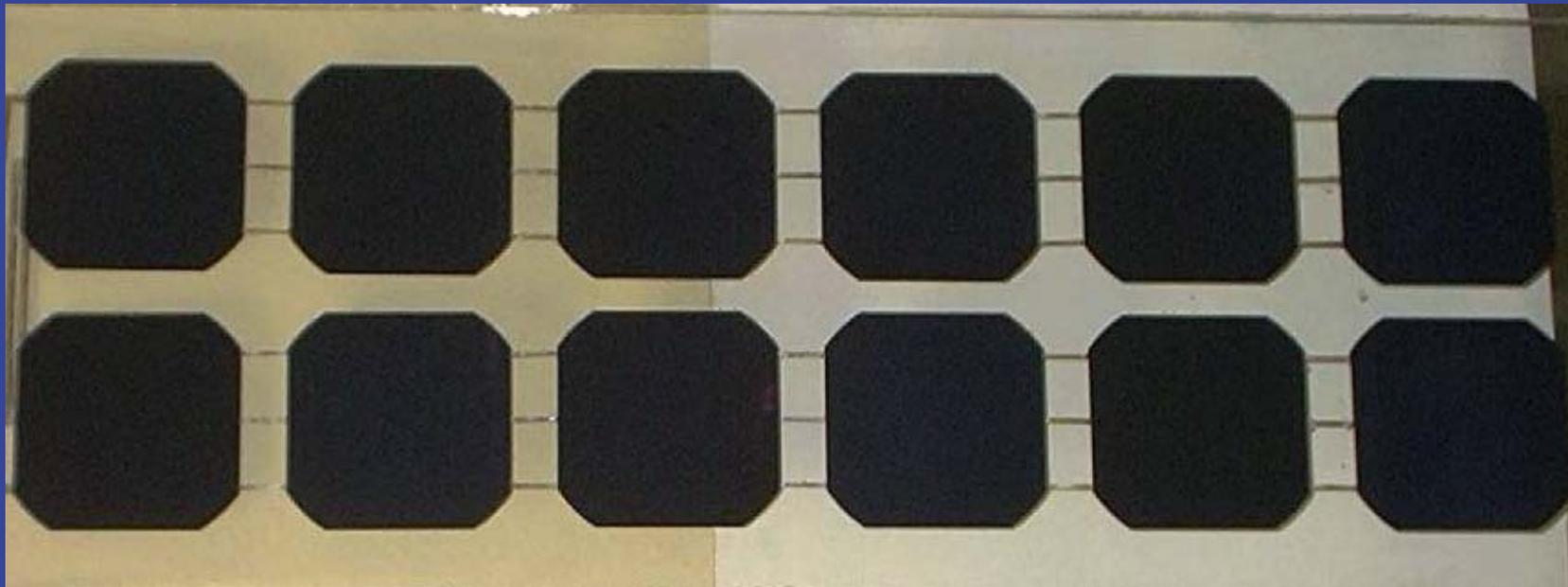


Polycrystalline Color Sample

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SINGLE CRYSTALLINE



POWER OUTPUT

- 15 WATTS DC PER SQ. FT. MAX
- 10 WATTS DC PER SQ. FT. TYPICAL
- CONVERT TO AC --- MULTIPLY BY .83

SYSTEM COST

- \$80 PER SQ. FT TYPICAL
- PRICE INFLUENCES:
 - SYSTEM SIZE
 - VARIATIONS IN GLASS SIZE
 - CELL TYPE AND SPREAD

COST JUSTIFICATIONS

- 30% TAX CREDIT ON FULL SYSTEM
- 5 YR. ACCELERATED DEPRECIATION = ~ 35%
- ELECTRICITY VALUE - TYPICAL
\$.10 PER KILOWATT HOUR (KWH)
PLUS
POLLUTION CREDITS (AKA: REC OR GREENTAGS) \$.03/KWH

\$80 PER SQ. FT. BECOMES ABOUT \$30 PER SQ FT (INCLUDES GLASS)

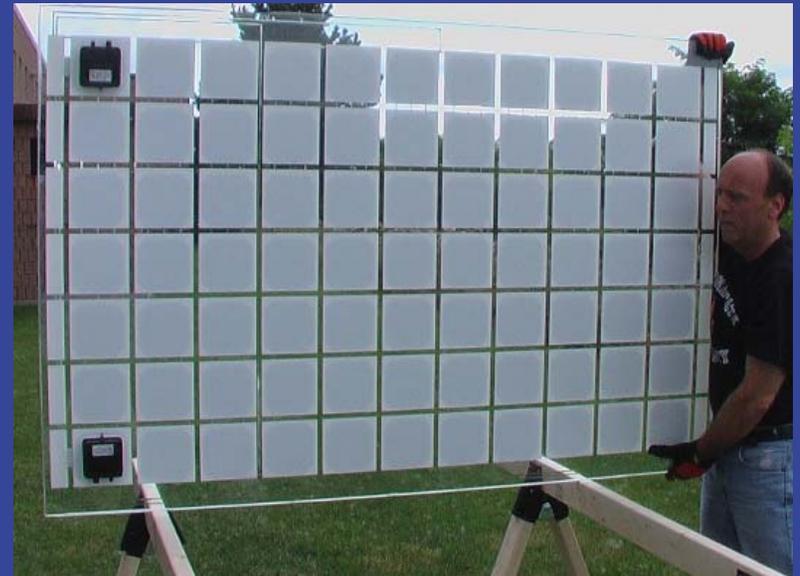
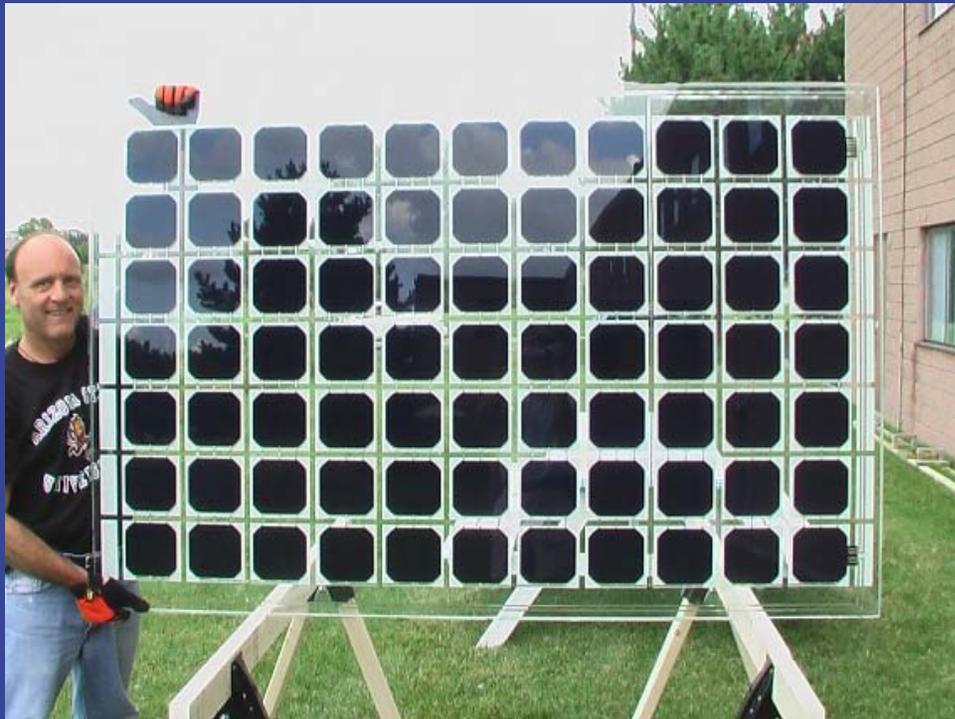
SOLAR GLASS CANOPY



- CALIFORNIA ACADEMY OF SCIENCE –MUSEUM
- GOLDEN GATE PARK S.F.
- 130 KW AC CANOPY AROUND PERIMETER
- Rendering courtesy Chong Architects, S.F.

PV Skylight Laminate

SUBMITTAL UNIT



INSTALLED PV CANOPY



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TOWER CRANE LIFTING GLASS



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SOLAR GLASS CANOPY



- INSTALLED BY GLAZER ON-SITE
- WIRING BY ELECTRICIAN ON-SITE
- CUSTOM BUILT
- Rendering courtesy Chong Architects, S.F.



Integrating PV Technology with Curtain Walls

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Assembling the “Team”

- Architect
- Electrical Engineer
- General Contractor / Glazing Contractor
- PV Supplier / Consultant
- Curtain Wall Manufacturer

Design Considerations

- Roof Areas Available Vision Glass Applications
- Spandrel Area Installation
- Wires / Connectors (Concealed or Exposed)
- Type of PV Cells (Size, Color and Spacing)
- Orientation of Elevations
- Anticipated Energy Production



PV as an Aesthetic Element

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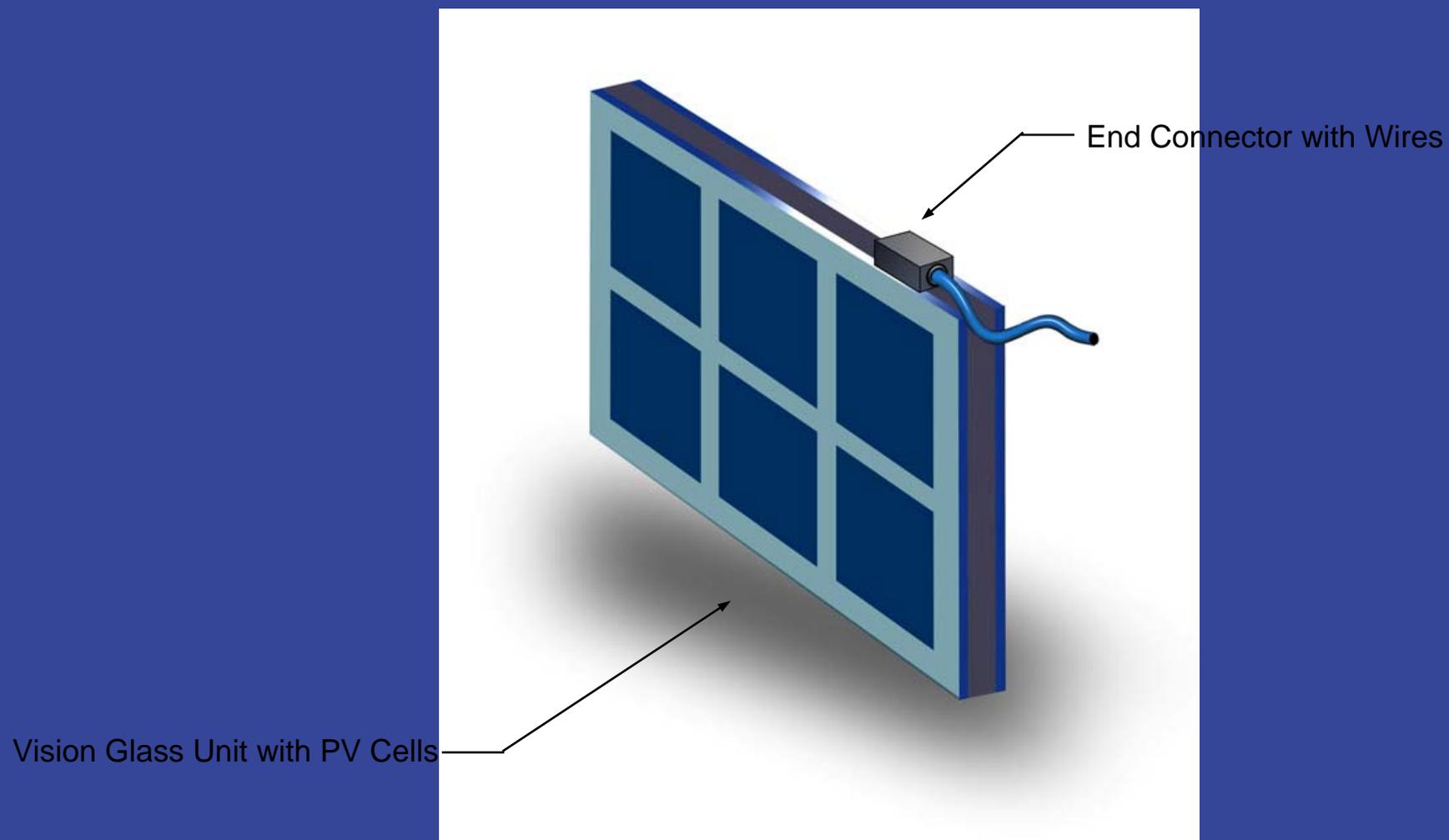
Curtain Wall Considerations

- Accommodate Glass with End Connectors
- Incorporate Wires and Junction Boxes
- Comply with Building Codes, NEC and UL
- Gasket and Sealant Compatibility
- Air, Water, and Thermal Performance
- Allow for Future Access to Wiring

Installation Considerations

- Safety
- Comply with Building Codes, NEC and UL
- System Integrity
- Proper Sequence of Events
- Coordinate Electricians and Glaziers
- Testing During Installation

Insulating Vision Glass with PV



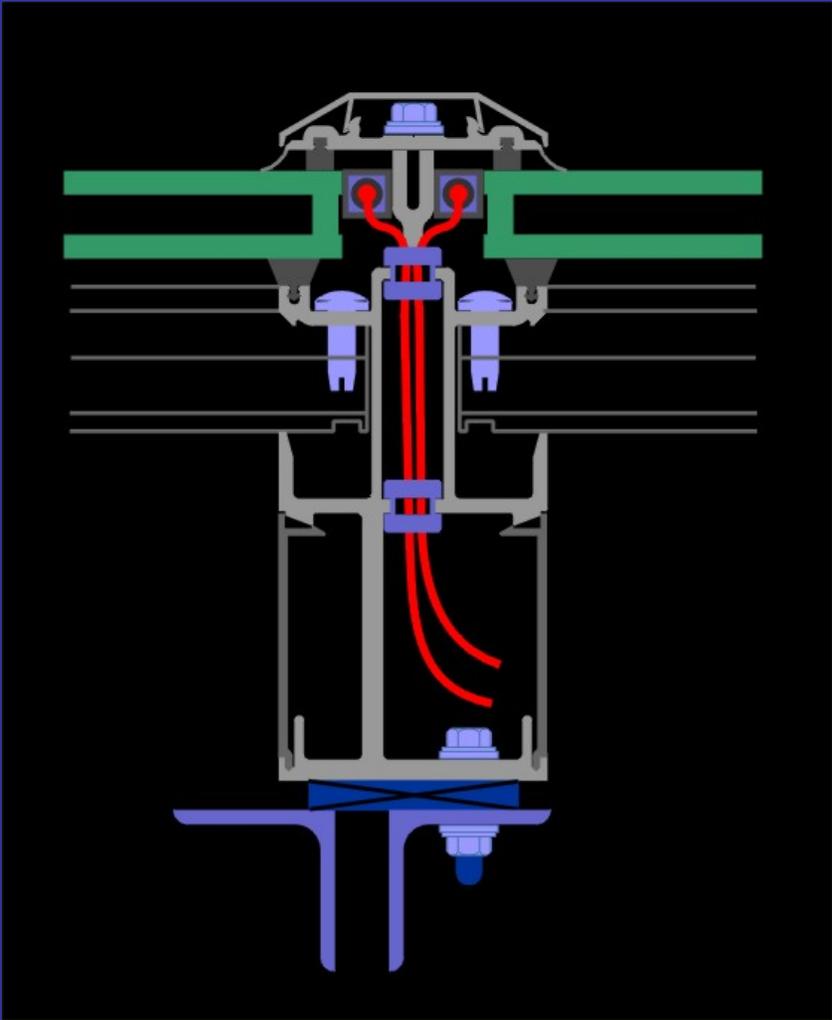
Insulated Glass with Edge Connector



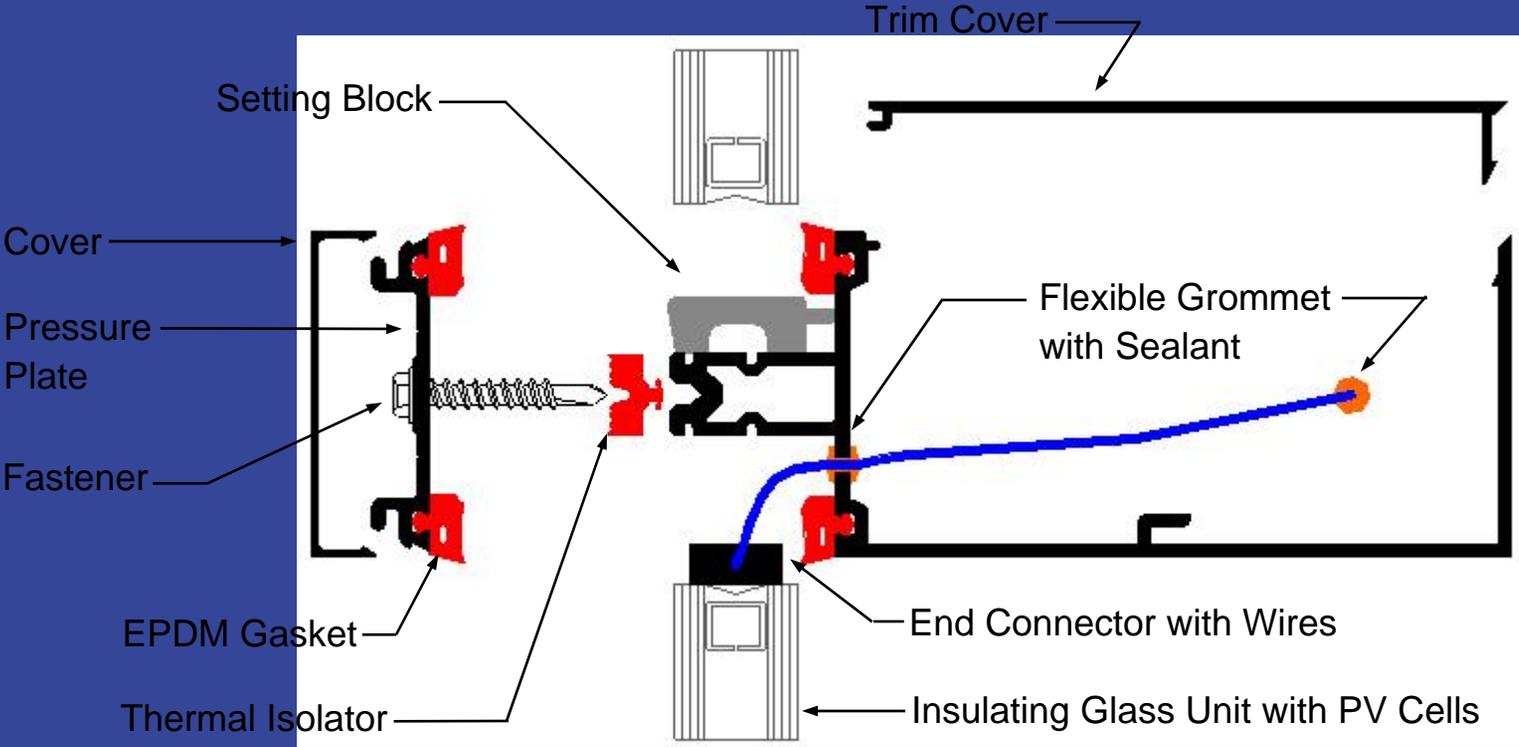
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EDGE
CONNECTION
DETAILS



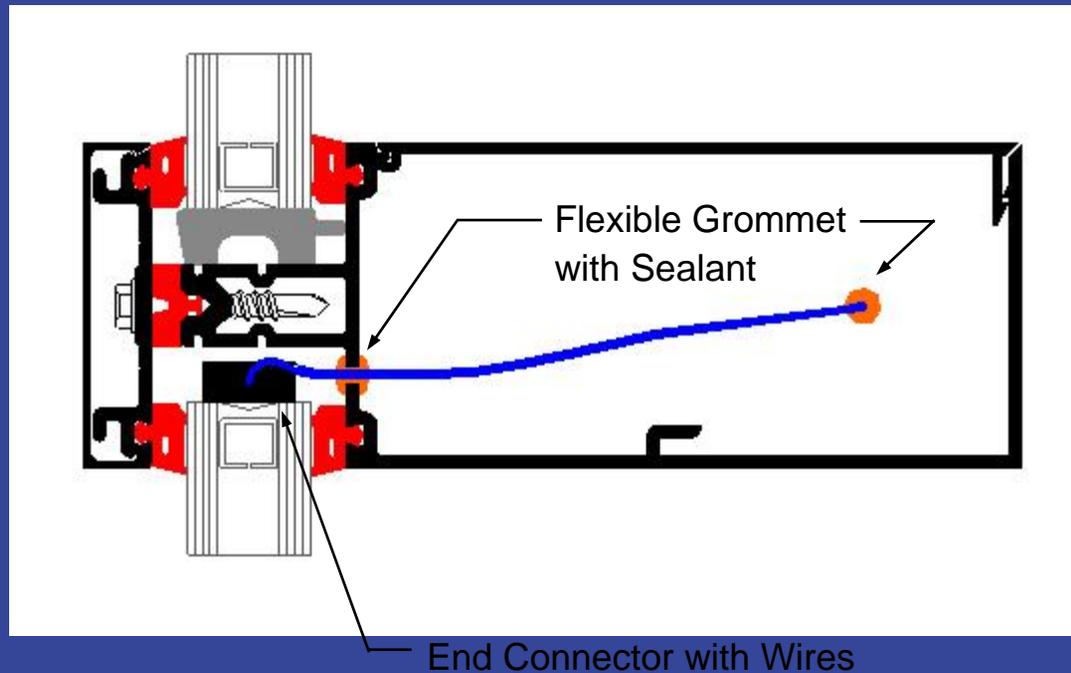
Intermediate Horizontal Member Vision Area



Intermediate Horizontal Member

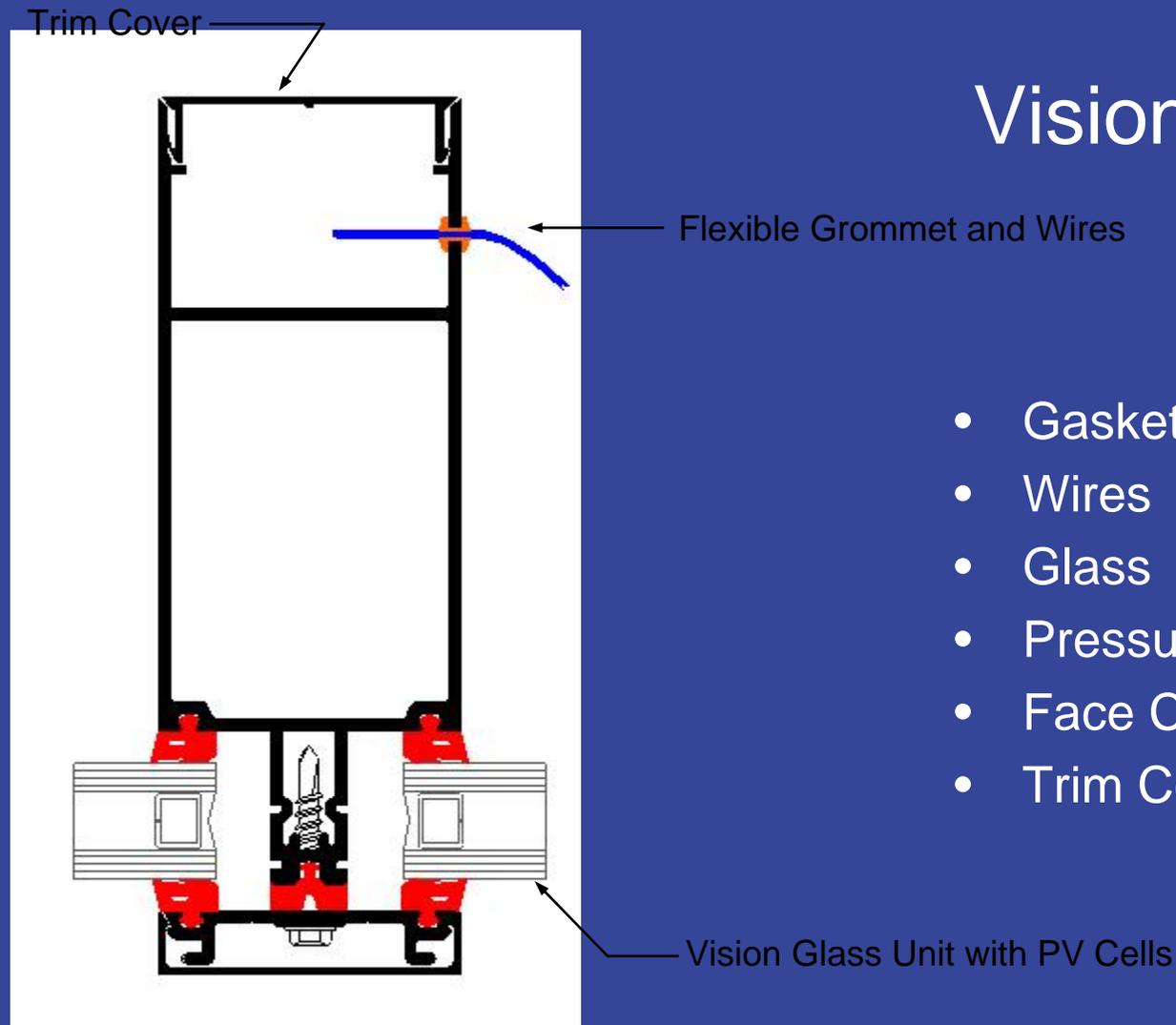
Vision Area

- Gaskets
- Wires
- Glass
- Pressure Plate
- Face Covers
- Trim Cover



Vertical Mullion

Vision Area

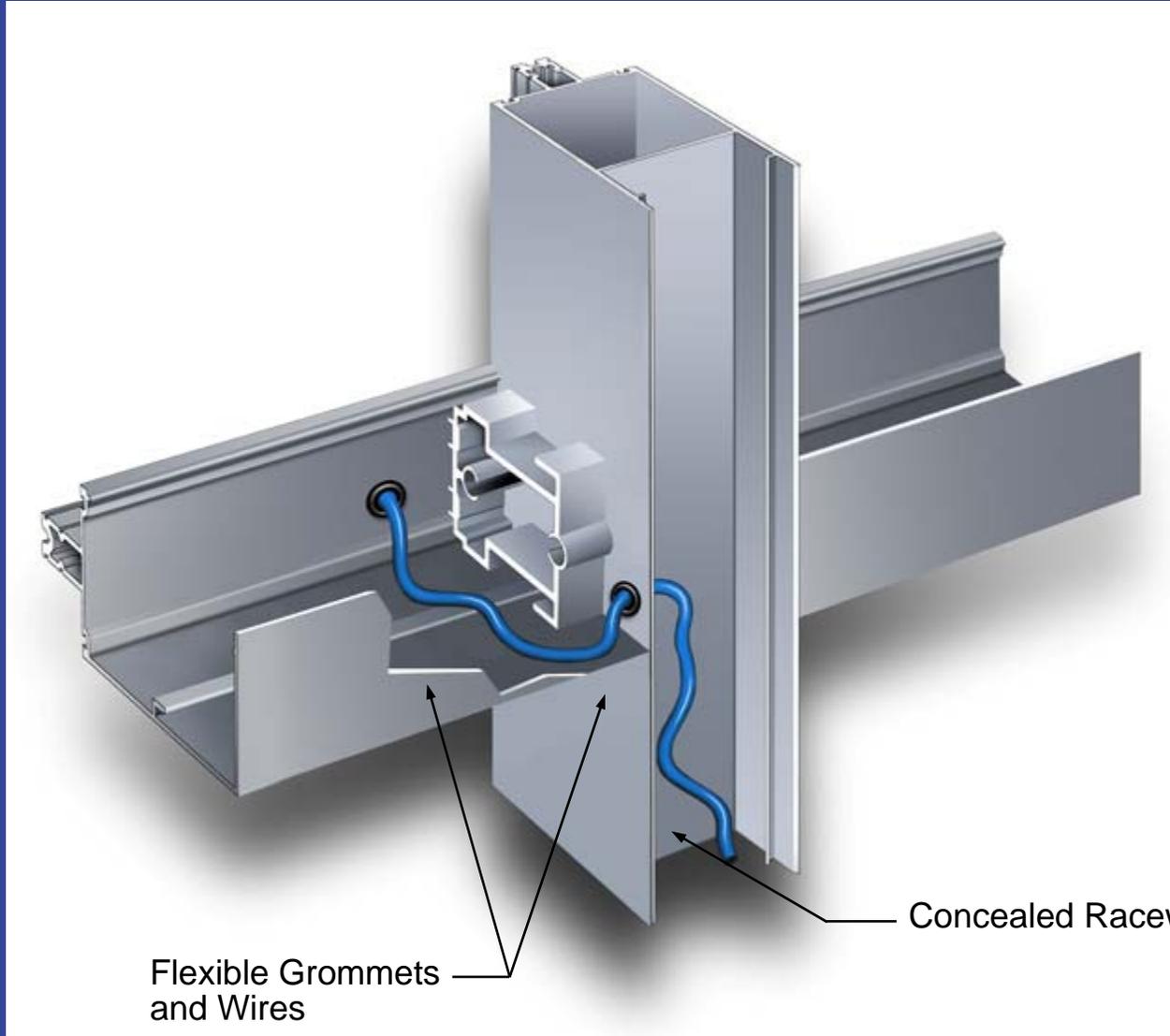


- Gaskets
- Wires
- Glass
- Pressure Plate
- Face Covers
- Trim Cover

Interior Intersection

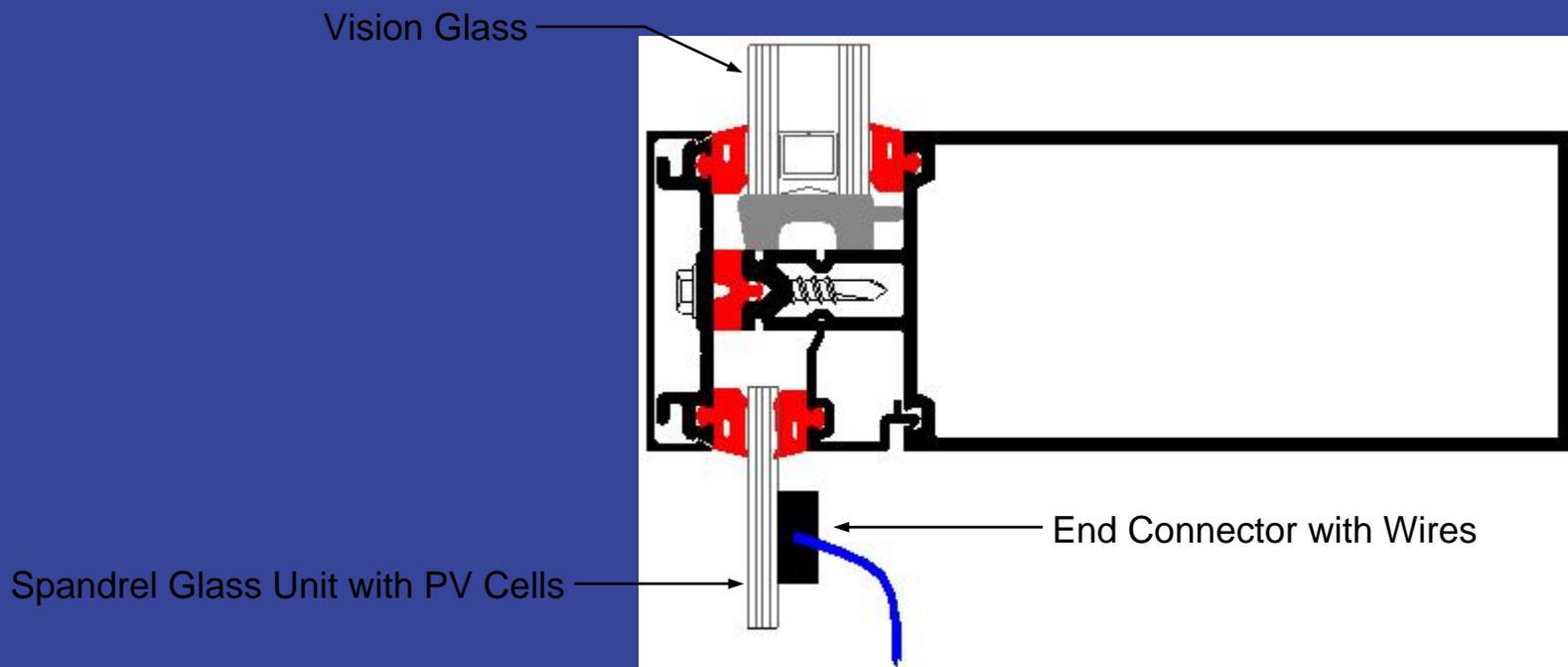
Interior Access to:

- Wires
- Connectors
- Junction Boxes



Intermediate Horizontal Member

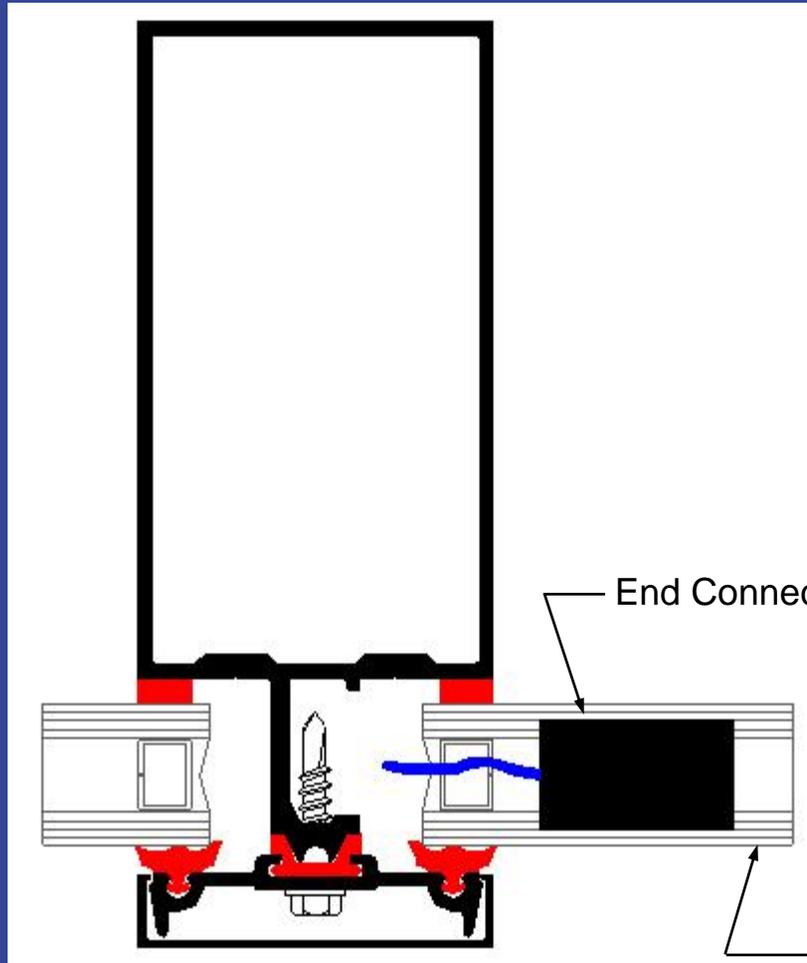
Spandrel Area



Curtain Wall Details

- Accommodate Wiring within Glazing Pockets of the Horizontal and Vertical Members
- Note: Additional Raceways or Conduit may be Required to Meet Local Building Codes

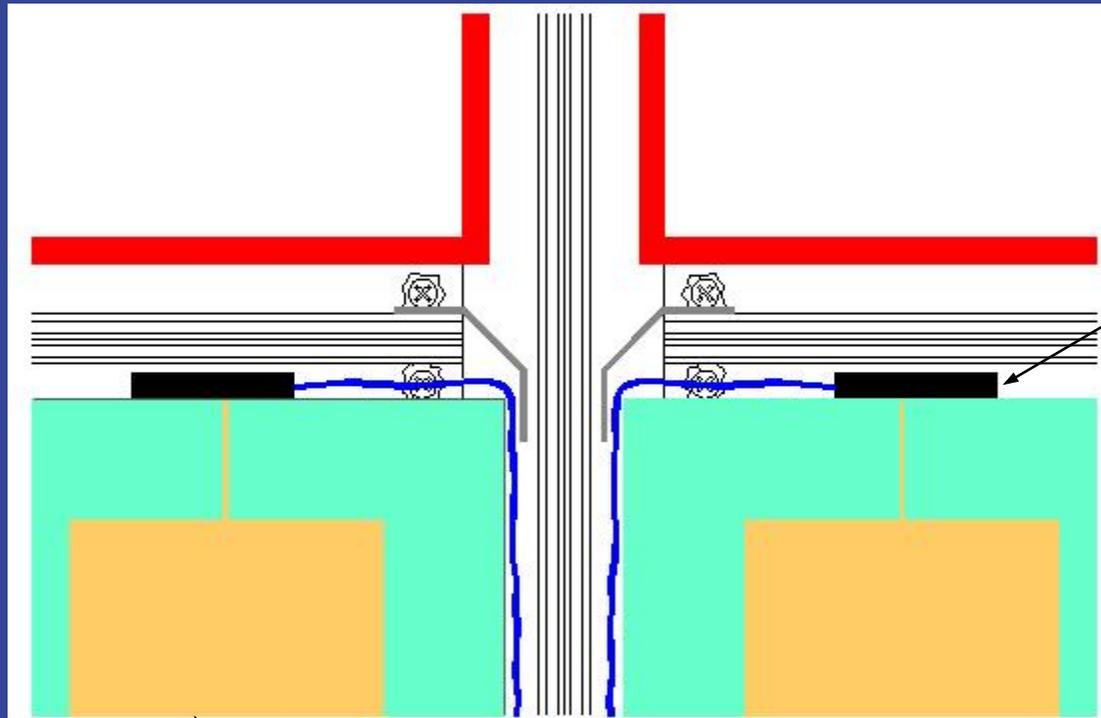
Vertical Mullion



Vision Area

- Wires
- Glass
- Pressure Plate
- Face Covers
- Gaskets

Vertical / Horizontal Intersection



Wires within
Glazing
Pockets

End Connector with Wires

Vision Glass Units with PV Cells

Integrating PV Technology with Curtain Walls

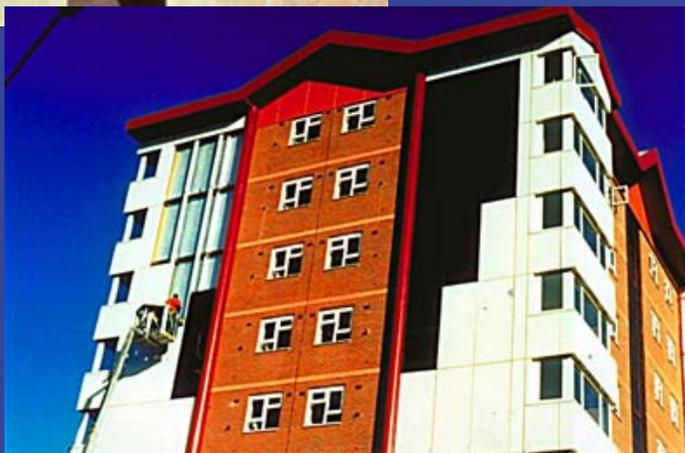


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GALLERY



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BIPV SPANDREL GLAZING IN #4 TIMES SQUARE, NYC

Flack and Kurtz,
Architects,

Kiss + Cathcart,
Architects BIPV

New York



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Translucent
BP Solar
Photovoltaic
Modules
Integrated
into a BP
Service
Station
Canopy



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BP
Translucent
Solar
Photovoltaic
Canopy at
Dusk



Looking up
through the BP
Solar Service
Station Island
Canopy





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THYSSEN
HEADQUARTERS
Germany



Amorphous Silicon Thin film flexible
modules integrated into façade design



CALTRANS Southern Headquarters Bldg., Downtown Los Angeles -Under Construction 2001

Thom Mayne, FAIA and MORPHOSIS

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Solar-Fabrik Freiburg
BIPV as part of a zero
emission solar factory
Freiburg/Breisgau,
Germany



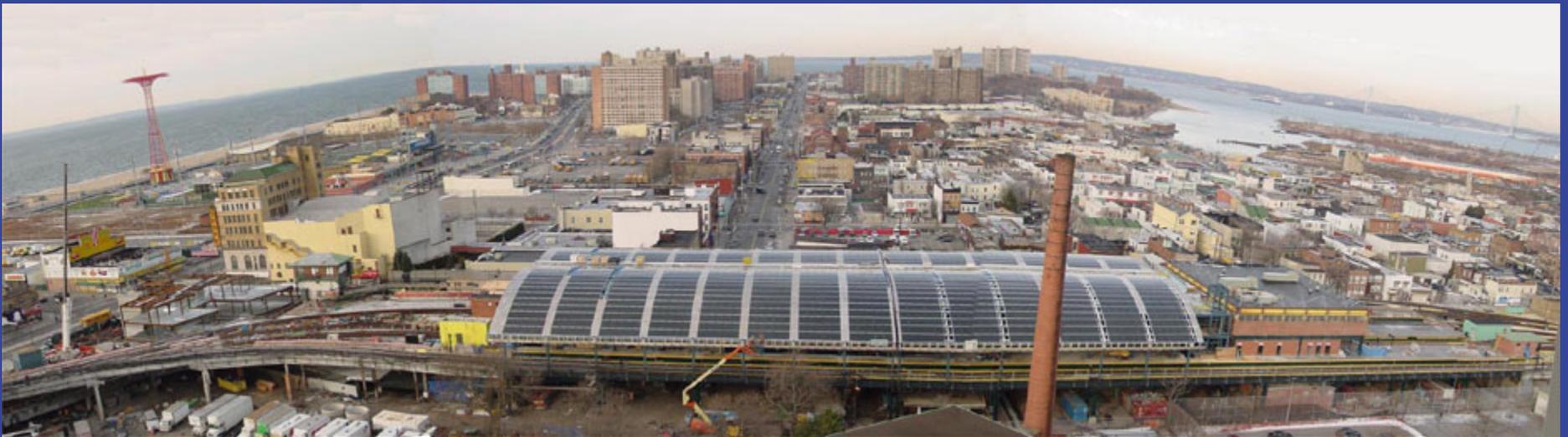
Stadtwerke Karlsruhe GmbH



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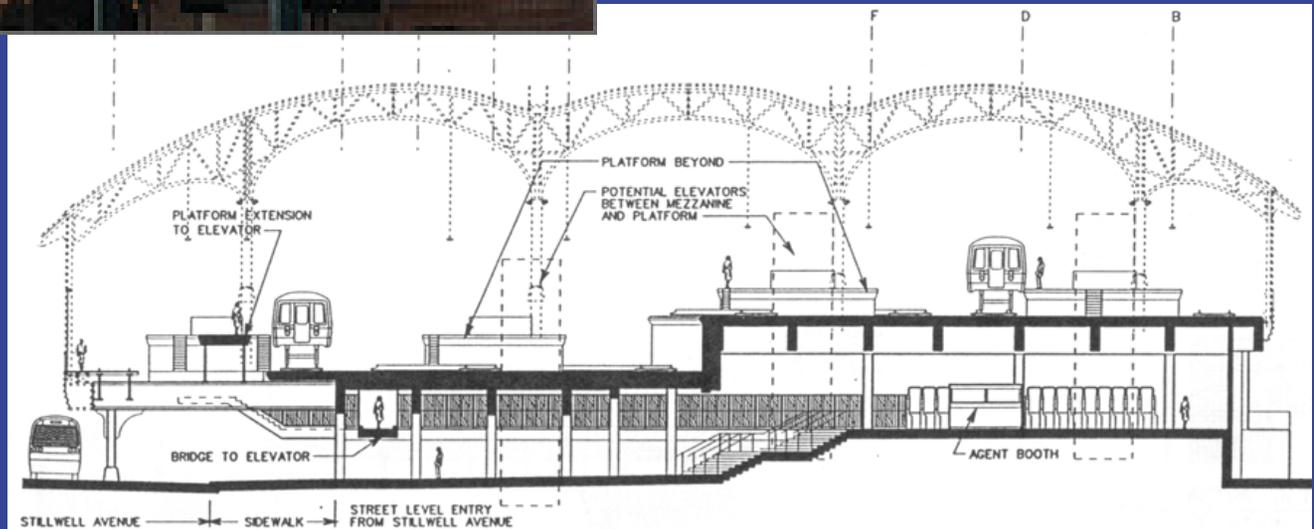
THE STILLWELL AVENUE STATION, Coney Island



Kiss + Cathcart, Architects, NYC, NY

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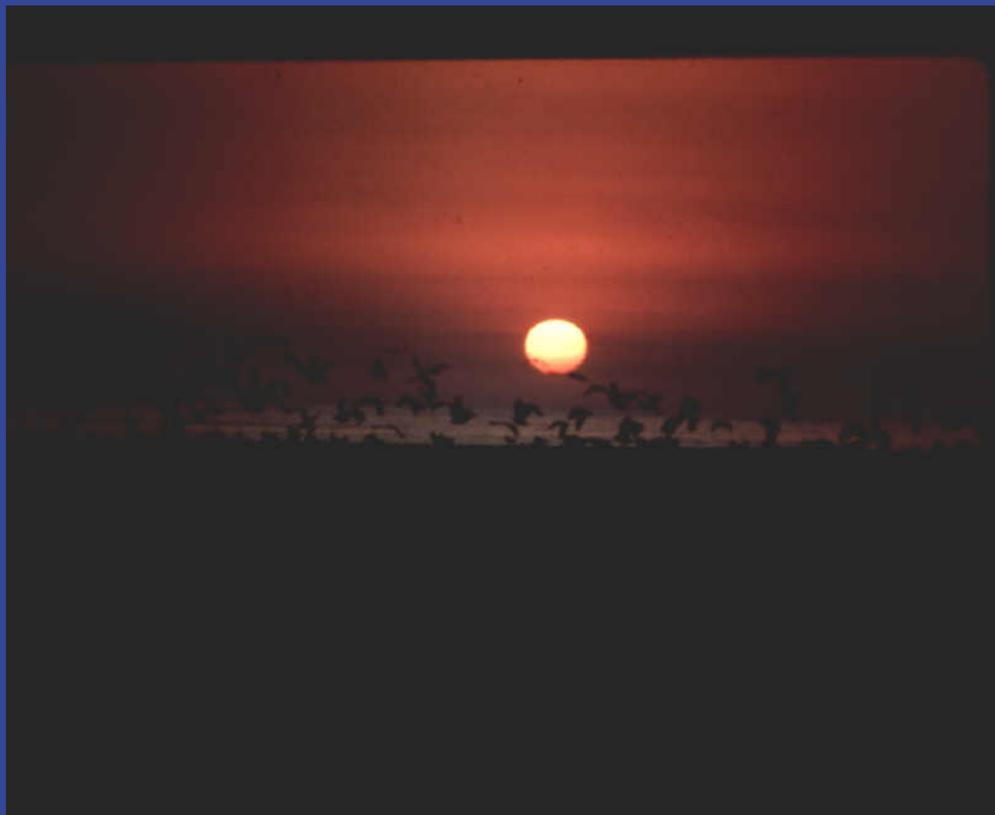
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Thank you for your interest



QUESTIONS

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