# ONYX SOLAR - SKYCO


## PHOTOVOLTAIC (PV) GLASS
40107985


## PHOTOVOLTAIC (PV) GLASS
PVGLAZING 101


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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# What is BIPV?

## Building Integrated Photovoltaics

## versus

# BAPV

## Building Applied Photovoltaics

# WHAT IS A PHOTOVOLTAIC GLASS?

Photovoltaic(PV) glass is an architectural glass which besides providing the building with the same properties as a conventional glazing, it also generates free electricity from the sun. It is therefore, the only building material available in the market that provides your building a return on the investment.

# Designs Features

- PV Glass substitutes conventional glass within the building envelope.
- PV Glass offers the same mechanical behavior as a conventional glass that has the same build-up.
- PV Glass is always a laminated glass product.
- PV Glass generates free electricity from the Sun.
- Basic idea: think of PV Glass as a traditional, architectonic glazing, which also provides you free electricity from the Sun.

## BIPV System Components

- Glass lites – coatings, patterns, etc.
- Solar cells – most commonly utilized solar cells
- Interlayers – laminated glass options
- Junction box - locations
- Optional configuration elements

# Glass lites

There are no special requirements for the glass lites that compose a photovoltaic glass unit.

**COMMON HEAT TREATMENTS:** **Heat Strengthened Glass**: two times stronger than annealed glass of the same thickness and size. If broken, this type of glass reduces the chance of vacating the opening since it breaks in large shards similar to annealed glass.

- **Fully Tempered Glass**: two times stronger than Heat Strengthened Glass of the same thickness and size. If broken, it will shatter into fine pieces, reducing the chances of injury. It will likely vacate the opening.

**Heat Soaking Glass**: due to nickel sulfide inclusions, the glass material can be fragile when there is a sudden change in the temperature. The heat-soak process is carried out to help rigidify the glass in such scenario, which also makes it stronger than the tempered glass. –

***Low-emissivity coatings**: low-e coatings can be applied on the glass for a greater thermal performance whenever required. Pyrolytic/hard coatings are usually applied. *

***Reflective coatings**: these may be applied to the photovoltaic glass whenever required, note the coating must be placed always in a surface behind the solar cells, to not hinder the efficiency of the photovoltaic glass.

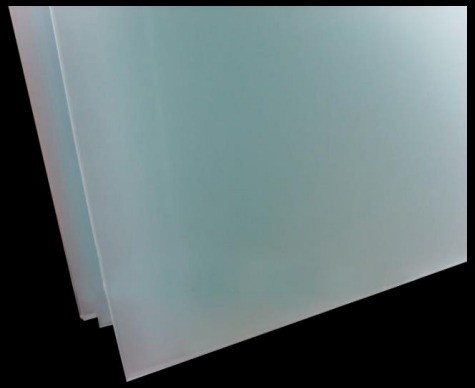
***Hydrophobic coatings**: can also be applied on to the glass, but will drastically lower the power output since they reduce the amount of sunlight reaching the photovoltaic cells.

# Glass lites

## FRITS, SILKSCREENING:

-Frit patterns, silkscreen designs are also available and compatible with the glass used for PV Glazing applications. The only rule is to place it behind the solar cells to not obstruct the sunlight for the photovoltaic cells.

## ACID ETCHING:



Photovolatic glass can incorporate acid etch treatments too; if required on the outer surface of the photovoltaic glass, it is important to select a good treatment to keep the performance of the photovoltaic glass as unaffected as possible. Acid etching over the solar cells could decrease the efficiency of the system by only 2% if they are well selected and counting on the amorphous Silicon technology. If the acid etch treatment goes on any surface # that is behind the solar cell, there will not be any decrease in the power output of the system.

# Solar cells

Solar technology keeps evolving everyday, aiming to improve efficiencies, lifespan, and even the aesthetics of the technology. The following table shows several of the major solar technologies available in the market, however this course will focus on the most robust ones for photovoltaic glass applications: amorphous silicon and crystalline silicon solar cells. This course will be reviewing both technologies deeper.

| TYPE OF PV SOLAR CELL | | PRIMARY MATERIALS | EFICIENCY (%) |
|---|---|---|---|
| Thin Film | CIGS | Compound of Copper Indium Gallium Selenium | 7% - 12% |
| | CdTe | Compound of Cadmium and Telluride | 8% - 11% |
| | A-Si | Silicon | 6% - 10% |
| Crystalline Silicon | Monocrystalline | | 16% - 20% |
| | Polycrystalline | | 13% - 16% |
| III-V multijunction PV | Tandem Cells | Indium Gallium Phosphide Indium Gallium Arsenide | 27% - 30% |
| Excitonics and quantum-structured photovoltaics | OPV | Polymer | 3% |
| | DSSC | Titanium Dioxide | 6% - 8% |

# Solar cells

**EFFICIENCY:**

Related to the amount of energy from the 1000 W/m² under STC the monocrystalline cells are the most efficient, followed by polycrystalline. The best monocrystalline panels measure slightly over 20% efficiency, most of the panels in production today measure about 15% efficiency of the available light energy.
Summary: Monocrystalline cells can transform slightly over 200 W/h (under the STC of 1000 W/m²).

•**NOMINAL PEAK POWER (kWp) VS. GENERATED POWER (kWh/year)**:

Installed PV glass brings its own nominal peak power that is also referred to as installed power. It is fundamental to distinguish between the two concepts that are often confused: installed power (kWp) and energy generated (kWh).
The **kWp** relates to the integration surface, the applied technology, transparency degree, etc. The generated energy, expressed as **kWh/year**, on the other hand, will depend on the local radiation conditions that affect the building and the tilt and orientation of the photovoltaic glass. The performance of the PV glass decreases as the transparency increases due to the amount of collection capabilities.

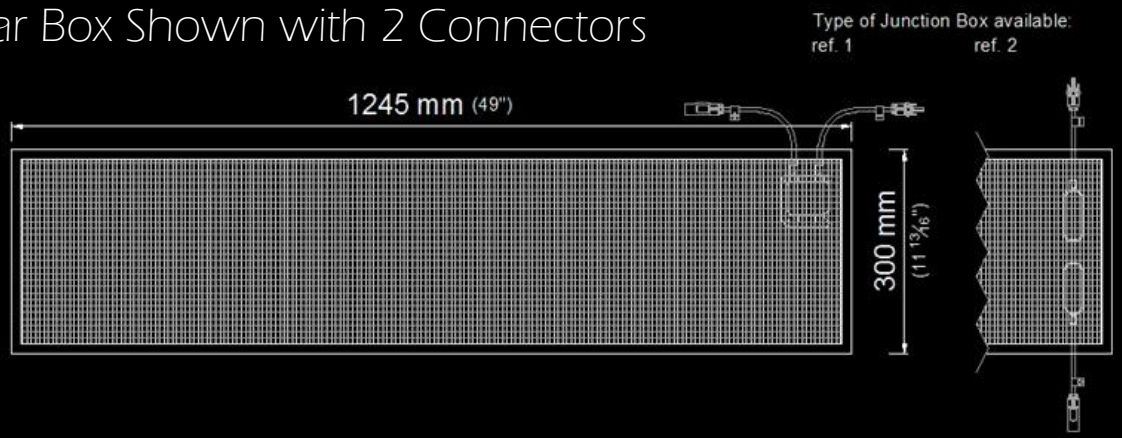
# Junction Box

The Junction Box is the component of the photovoltaic module necessary for its electrical connection.

Electrical junction boxes are attached to the PV glass unit, either at the edge of the laminated glass, or in the rear lite of the composition. Within these two possible options, there is certain flexibility to place it in the most suitable location within the rear glass or within the edge.

Each module is supplied with its own junction box. The junction box can be bipolar or monopolar. The bipolar model has positive and negative polarities and is the most commonly used for modules. The monopolar junction box, on the other hand, only has a single active pole (positive or negative), and two units per module must therefore be placed.

Monopolar Box Shown with 2 Connectors



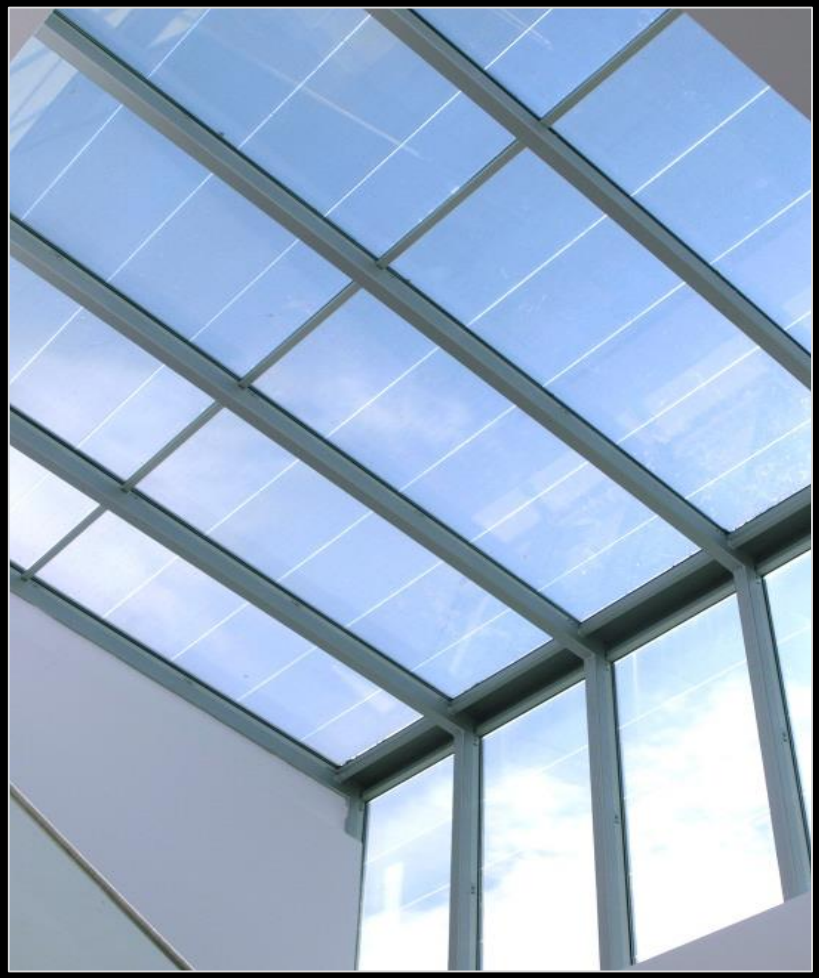

Bi Polar Box

# AMORPHOUS SILICON

Amorphous silicon technologies (a-Si) are formed by depositing various types of treated silicon onto the surface layer of the glass, followed by laser etching to establish the edges of the cells and to create transparency when necessary. The efficiency of this photovoltaic glass ranges between 6% and 10%.

Within constructive solutions on curtain walls and skylights, where transparency and asthetics (if desired by client) take precedence, then amorphous silicon technology is commonly chosen.

# AMORPHOUS SILICON



**Advantages of the amorphous silicon technology**:

- Low temperature coefficient. The yield of amorphous silicon photovoltaic glass under high temperature conditions is better than in crystalline modules.

- Greater capability of producing more energy under indirect/ diffused sunlight & overcast climate(e.g. indirect sun irradiation, overcast climate, early morning and late at night, less favorable orientation, etc.).

- Better behavior in the presence of shadows.

- Less reliant on the angular positioning of the installed glass.

- Enables a more aesthetic integration to the architecture of the building.

- Sunscreen effect and daylight facilitator, better transparency.

# Physical characteristics

The appearance of the amorphous silicon glass is different from the exterior and the interior side of the PV glass. Viewed from a distance the exterior side is similar to the tinted glass, whereas from the interior, the views outside are clear and unobstructed.

Let's take an office building with an amorphous silicon curtain wall for example: you will have a clearer view of the outside from the office during the daytime, whereas during the night time, the opposite is true when the office spaces are illuminated with the lighting.

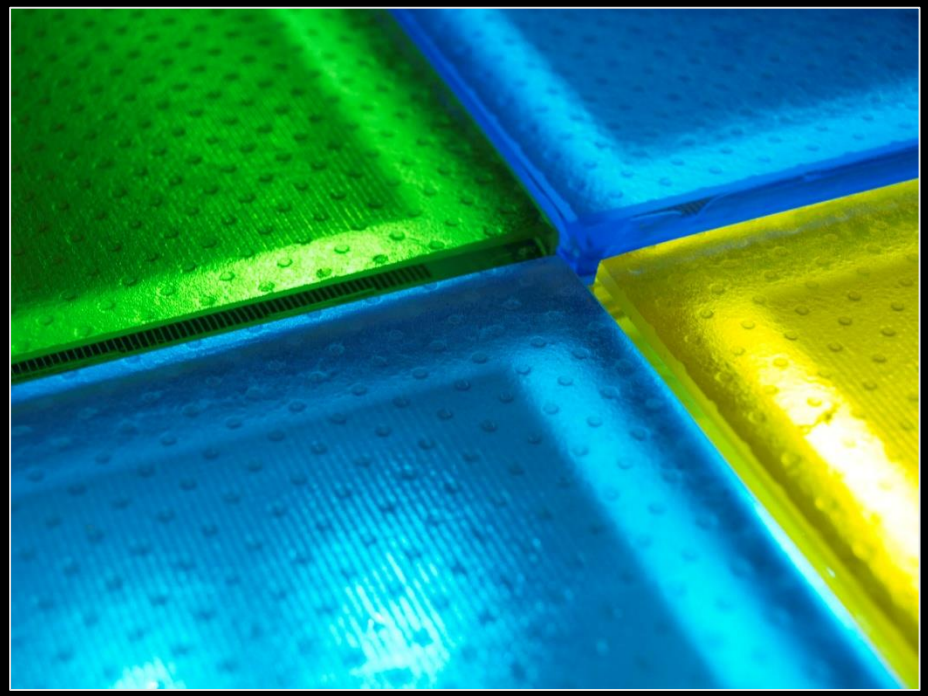
**PV Skylight. 20% Semitransparent. View from the exterior.**

**PV Skylight. 20% Semitransparent. View from the interior.**

# Shape & Colors

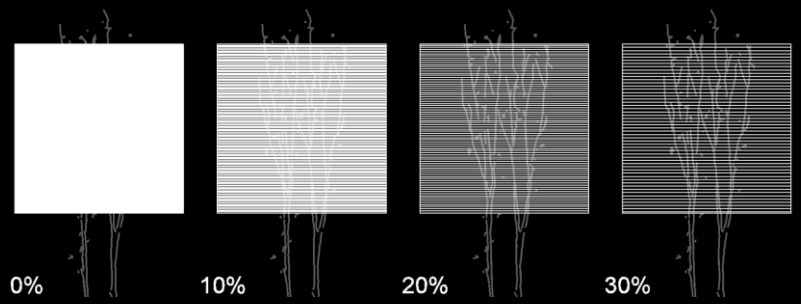
Although the amorphous silicon PV Glass normally comes in rectangular shapes, irregular shapes such as trapezoid could also be manufactured. The irregular shapes are not recommended for the monocrystaline Silicon.

A wide range of colors –up to 1,500- is available on the market for a-Si photovoltaic glass. The colored PVB interlayer is incorporated during the lamination process.



# Transparency

During the manufacturing process, transparency is achieved by removing some portion of the amorphous silicon layers via the  laser etching.
Since the etching removes the photovoltaic material, the output power of the glass is inversely proportional to the transparency degree. The higher the transparency degree, the lower the output power with more transmitted daylight.  Normally 10 and 20% semi-transparency degrees offer a perfect balance between light transmission and energy yield.



# Applications – Amorphous Silicon

Due to its semi-transparency property, the Amorphous Silicon is often used where the transparency takes precedence and/or the integration takes place where there is a limited direct sunlight irradiation.

Moreover, the tinted glass appearance of the PV glass allows an easier architectural integration with the design of the building than it is with the crystalline silicon (explained on the following pages).

Its application includes any form of façade system (ventilated, curtain wall, cladding, etc.), as well as skylights, canopies, glass railing, flooring, parking lot canopy structures, electric car generating stations, roof decks exposed to direct sun and patio floors.

# AMORPHOUS SILICON PV SKYLIGHT AND CURTAIN WALL

An example of PV Curtain Wall and PV Skylight from a project in Spain. Both of the components feature 20% transparency degree PV glass with the combination of non-PV Glass, providing more homogeneous appearance.

# AMORPHOUS SILICON PV SKYLIGHT

Retrofit of an historic market in Madrid, Spain. The a-Si photovoltaic Skylight with 20% transparency provides the market underneath with natural illumination as well as to filter most of the UV and IR radiations, while simultaneously generating electricity from the Sun.

# AMORPHOUS SILICON PV SKYLIGHT

Photovoltaic Skylight Retrofit in Spain. Three different levels of transparency (10%, 20% and 30%) combined with different colors

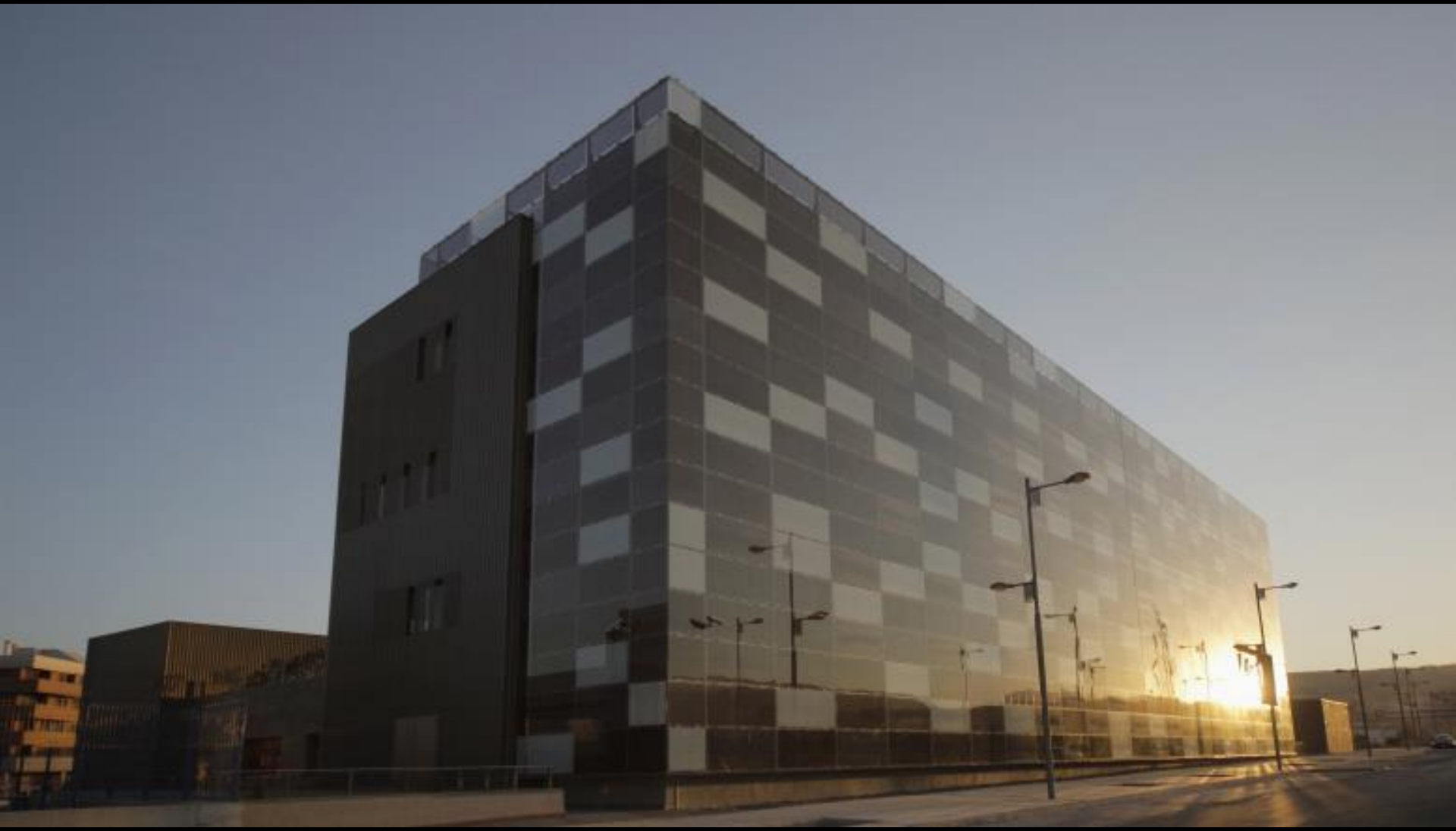
# AMORPHOUS SILICON PV SKYLIGHT AND CURTAIN WALL

Photovoltaic Skylight and Curtain Wall. University Building in Spain. 20% transparency IGU was chosen for both systems to assure natural sunlight illumination for the interior space, as well as the thermal and acoustic insulation.

# AMORPHOUS SILICON PV PARKING LOT

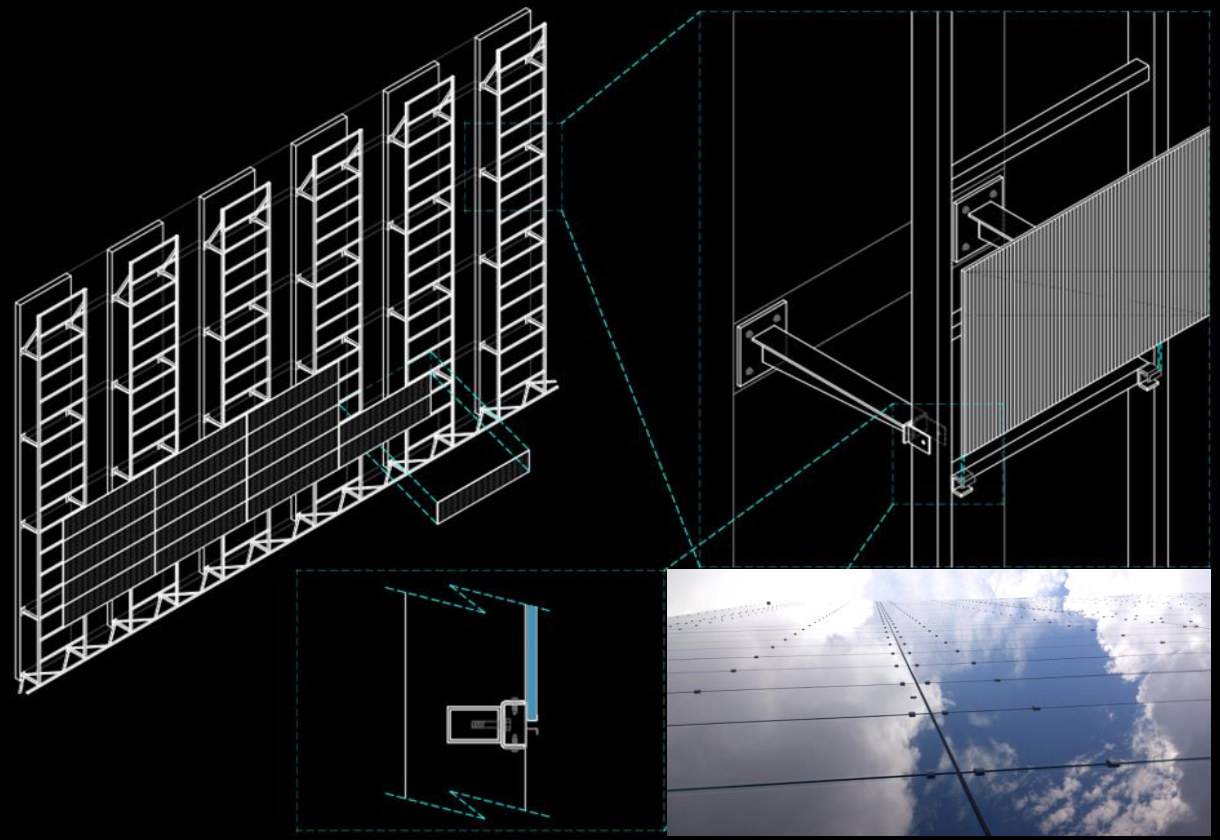
PV Parking Lot, Italy. Dark a-Si modules selected for the solution with a high level efficiency.

# AMORPHOUS SILICON PV VENTILATED FAÇADE



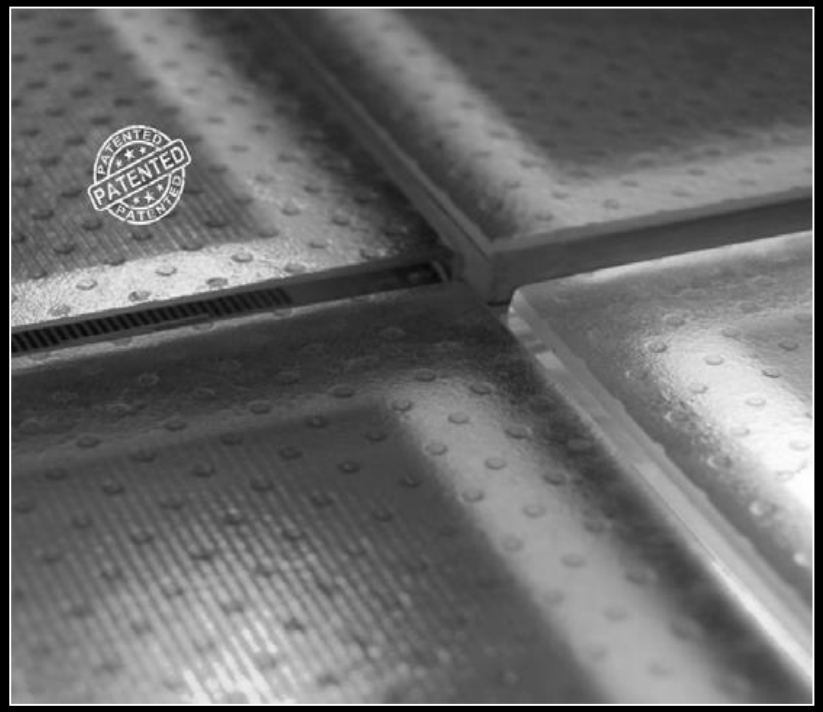
Photovoltaic Ventilated Façade for Pzifer Building in Spain. Combination of different degrees of semitransparency together with white glass.

# STRUCTURAL/FRAMING SYSTEMS



PV Ventilated Facade's structural detail. Primary and mounting structures. Ventilated facade structures usually receive  and withstand the photovoltaic glass incorporating a clip/clamp system as shown in the figure above.

# Special Application: Amorphous Silicon PV Floor Pavers



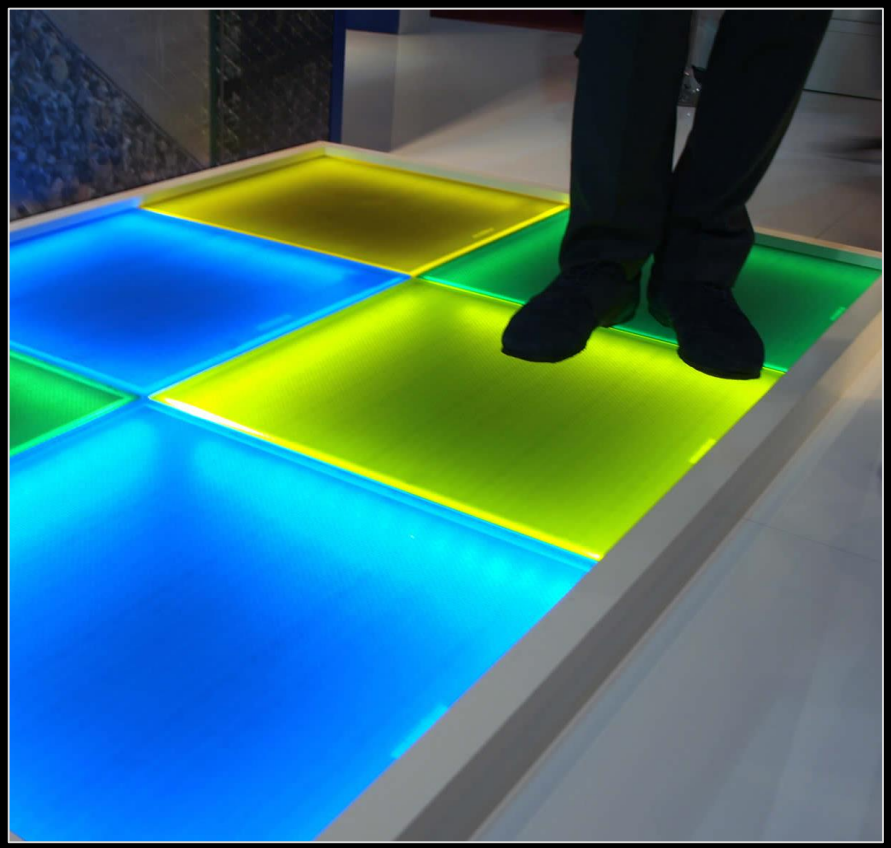

Counting on standard sizes, any deck flooring, terrace and sidewalk can easily incorporate the PV tile.

This type of integration has been developed as a raised flooring system. In this sense, like the rest of photovoltaic solutions we have seen so far, these pavers have been developed to be installed just as any other exterior technical floor.

The photovoltaic paver consists of triple pane, laminated glass. The outer layer features an acid etching treatment to give it a slip-resistant finish.

PV Pavers comes in several sizes; a common size is 600 mm x 600 mm (24" x 24") since it is a standard size for the conventional raised flooring systems such as ceramic or stone pavers.

# Special Application: Amorphous Silicon PV Floor Pavers



The PV flooring system can be designed such that it works as a beacon element or outdoor lighting, operating autonomously with self sustaining LED system.

The system consists of a number of semitransparent photovoltaic tiles units that are retro-lighted from the pit by a LEDs system.
A battery (connected to the PV source) is incorporated to the system to feed the LEDs according to the needs of the facility.

Other electrical device manages the energy produced by the photovoltaic tiles feeding the battery during the day and giving energy to the LEDs (from the battery) in low light level periods.

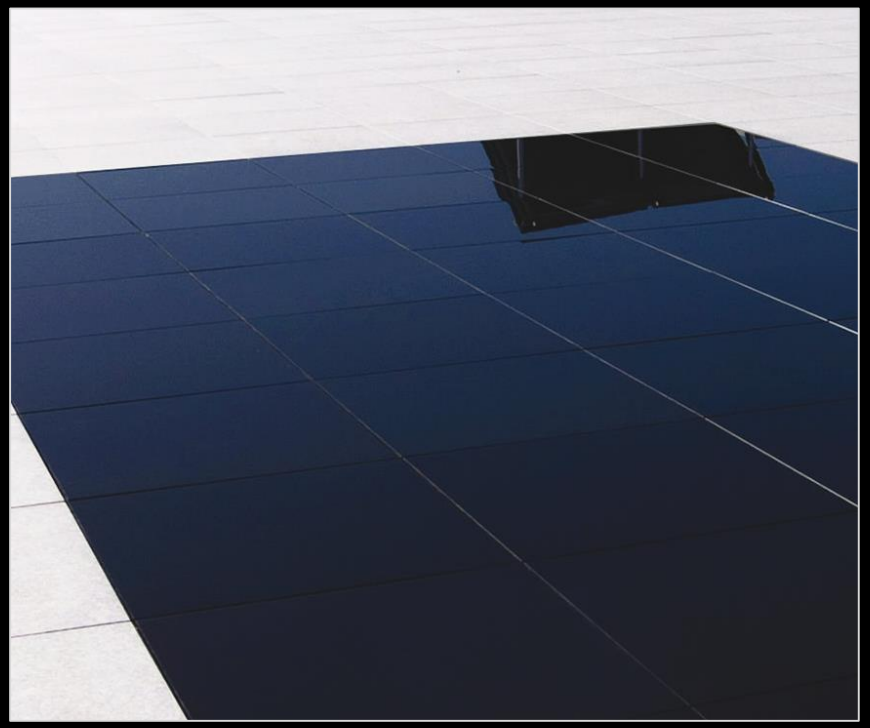
# Special Application:
# Amorphous Silicon PV Floor Pavers

**PV Floor is also available in customized sizes, up to 10' x 5'.**
**Colors are also an option whenever a fancy finish might be of interest.**

1.- PV floor pavers do not take up any extra space on the rooftop, deck, or any other given area. They can be walked on and can withstand the weight of the people standing on them.

2.- PV floor pavers generate electricity from the diffused sunlight; they can still generate electricity when the tiles are under shades.

3.- Great P.R. benefits; PV floor tiles are one of the most innovative ways to incorporate technology. They have been patented by the PV Glass manufacturer Onyx Solar, and they offer the users the possibility to walk on the sunshine.



# CRYSTALLINE SILICON PHOTOVOLTAIC GLASS

Crystalline Silicon (c-Si) is probably the most renown solar technology because it is normally used to manufacture traditional PV panels for roof-mounted applications and solar farms. However, it is also a very useful technology for building integrated photovoltaic applications.

Within crystalline technology, there are monocrystalline silicon cells (formed from a single silicon crystal) and polycrystalline cells (formed by different macrocrystals that are formed from different crystalline seeds in vertical growth ovens). These cells can, in turn, be of different sizes: 5'' or 6'', typically.

Crystalline glass usually has power values of around 100 – 180 Wp per square meter, depending on the technology, the separation between cells and the efficiency of the cells.

In constructive solutions where electricity generation takes precedence over transparency, such as pergolas, brise soleils or canopies, it is common to choose crystalline silicon technology.

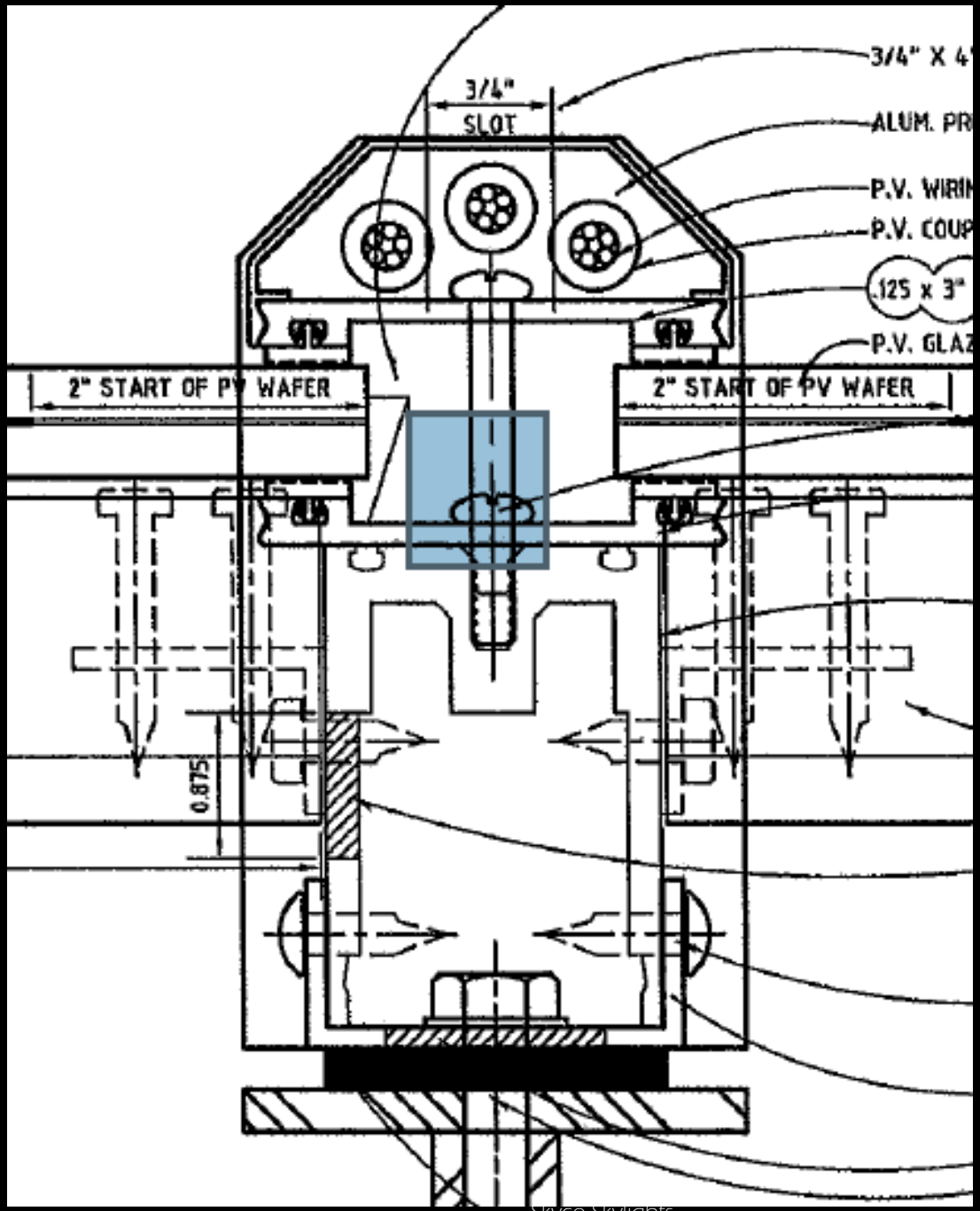
# CRYSTALLINE SILICON PHOTOVOLTAIC GLASS

**The advantages of crystalline silicon technology over amorphous:**

- Greater nominal power per square meter ($Wp/m^2$).
- Less installation surface area to equal power.
- Greater efficiency (between 15% – 18%). Photovoltaic efficiency is defined as the percentage of power converted into electricity from the total sunlight absorbed by a module.
- Produces greater power under direct sunlight.
- Better transparency

# CRYSTALLINE SILICON PHOTOVOLTAIC GLASS

To generate maximum power output under the direct sunlight while providing shade, the crystalline silicon is often utilized. Though its applicability is not limited, the crystalline is more often manifested in canopies, skylights, parking lots, and spandrel glass. The picture below illustrates its use as a canopy system at the Bay Area Rapid Transit Station in Union City, CA, where the transparency is not need but still benefits from the natural sunlight that is filtered through

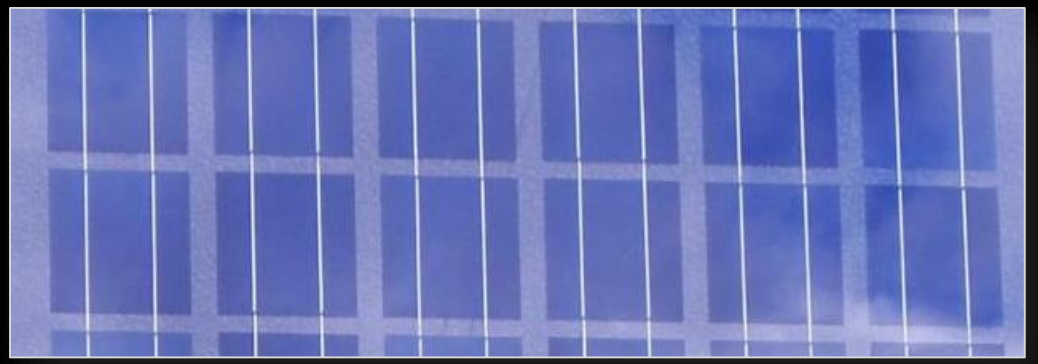



Skyco Skylights Customized elevated Snap-cap to Facilitate Simply access to the wiring

# 4.1.- Physical characteristics

The crystalline silicon technology includes two subcategories; Mono and Poly crystalline. Mono-crystalline is slightly more efficient than poly-crystalline (the internal structure is composed by aligned crystals). The Poly-crystalline technology is based on the same technology but in its internal structure the crystals are misaligned, this means less efficiency, and its appearance consists of varying shades of blue.

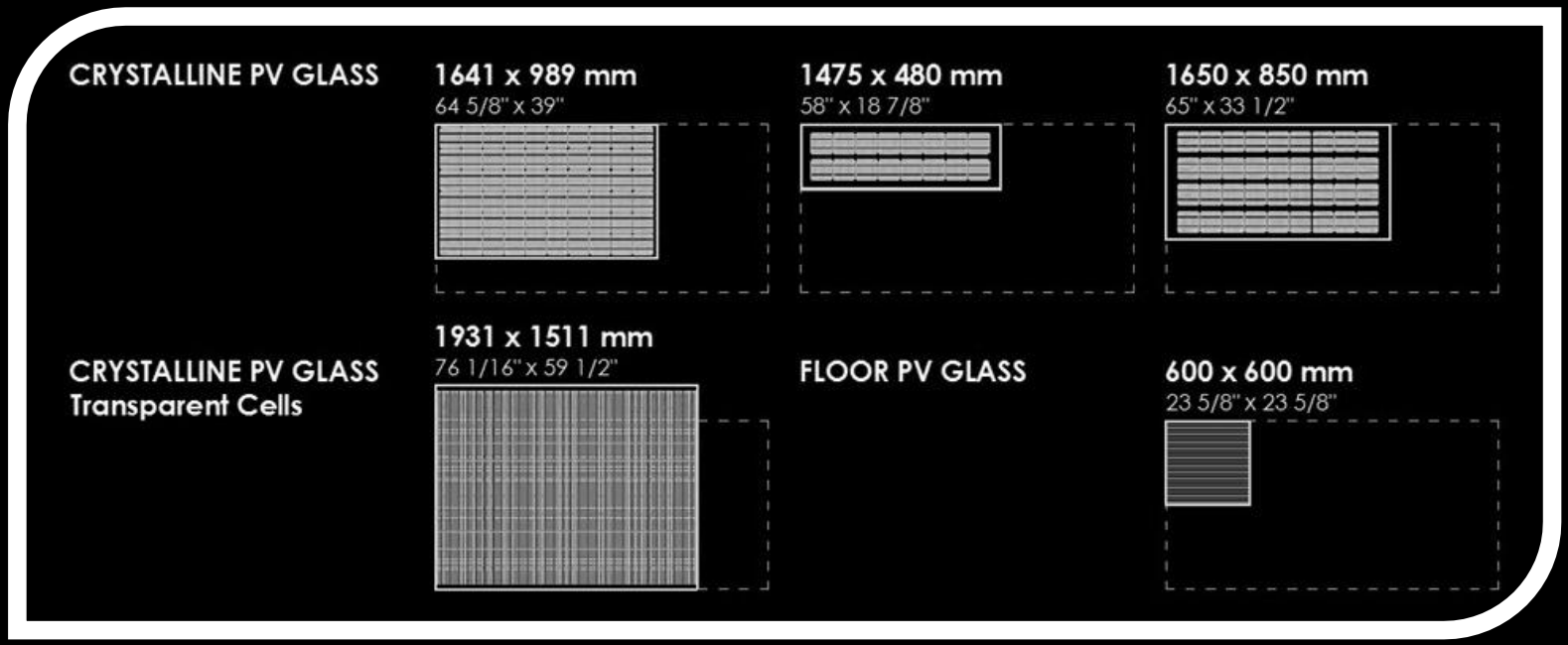
**Mono-crystalline Silicon, glass on glass**



**Poly-crystalline Silicon, glass on glass**

# GLASS SIZES

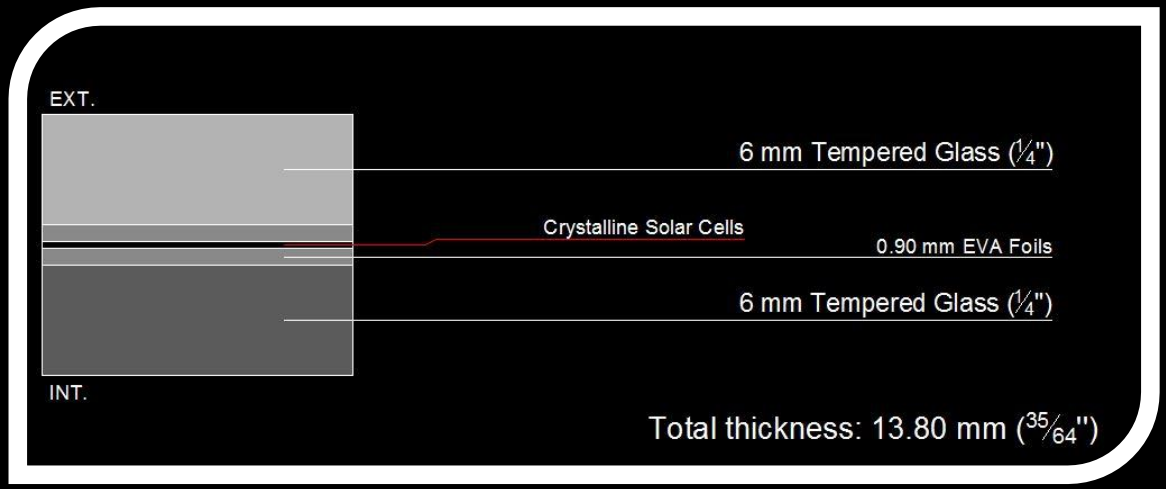
A glass on glass crystalline silicon unit can be manufactured in variety of sizes, thicknesses and shapes. Its typical maximum size is of approximately 2100 mm x 2100 mm (83" x 122"). Both the typical industrial standard sizes (shown below) and the customized sizes are available to suit each project's needs. For sizes larger than 2100 mm x 2100 mm, please consult with a PV Glass manufacturer.



# Thickness Options

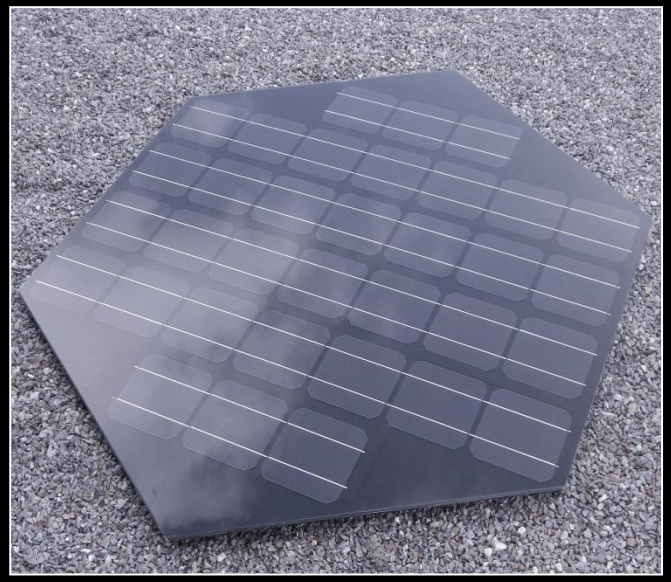
Regarding to thicknesses, glass on glass crystalline units consist of the solar cells embedded in between two layers of glass, which is laminated with different interlayers as required. The typical individual glass pane thicknesses are 4, 5, 6, 8 and 10 mm each. (5/32", 3/16", ¼" and 5/16"). Besides these, there is another option available for applications which may require very light weight PV modules; it consists of a 4 mm front glass + 1 mm tedlar (Polyvinyl Fluoride), resulting in a very light weight option that can be integrated for a component such as brise soleils.

While almost all glass on glass units are frameless for an aesthetic integration within any structural system, the glass/tedlar composition requires framing at the perimeter with an aluminum channel to provide it more rigidness.



# Shapes

Crystalline silicon glass-on-glass units can also provide interesting design options through different shapes. While the rectangular is the most frequent, trapezoids and non-regular shapes are also available.  As an example, see the picture below showing a hexagonal, crystalline silicon glass-on-glass unit, installed at the Denver Botanic Gardens, Colorado, USA. The rear glass contains a black colored frit pattern for enhanced aesthetics.



**Hexagonal PV glass on glass unit to clad the pyramidal building on the right. Design by Onyx Solar.**

**Pyramidal design at Denver Botanic Gardens. Design and renderings by Burkett Design/Studio NYL.**

# Transparency

In contrast to the amorphous, the crystalline silicon is composed of solid opaque photovoltaic cells that are not customizable (the cell have standard sizes of 5" and 6").

The spacing of the cells, however, is customizable, which is how the transparency is accomplished with the crystalline units. Similar to the amorphous, the higher the transparency required the less power output installed due to the less number of cells per unit. The pictures on the right are examples of how these two technologies can be used. The top right picture is from a canopy project in PA with the Mono-crystalline. It consists of larger spacing between the PV cells to allow more natural light to be transmitted through. In comparison, the picture on the bottom right shows a canopy project in Morocco where the smaller gaps between the PV cells provide the shading while still allowing a substantial amount of the natural light to filter through to radiate the space underneath.

**Larger spacing of solar cells, more day lighting, lower efficiency per SqFt.**

**Smaller spacing of solar cells, less day lighting, more sun control, higher efficiency per SqFt.**

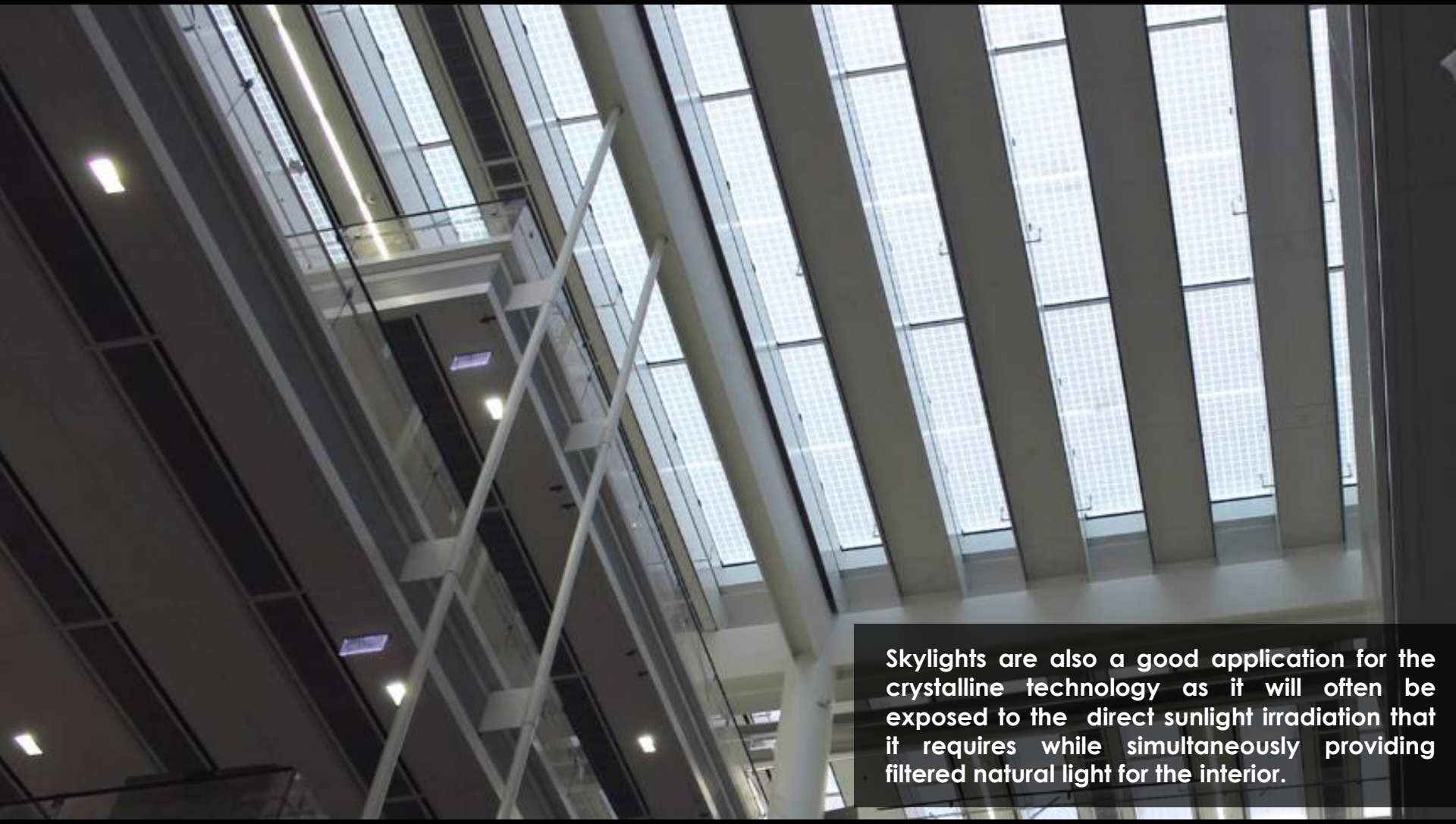
# Performance

Crystalline Silicon technology performs the best under the direct sunlight and is one of the most efficienct solar technologies. Therefore, its performance significantly decreases when installed under shadows or overcast weather. So it is very important to configure the most suitable angular positioning and orientation of the unit, as well as the geographic location of the project in order to ensure the best performance.

# Applications

One of the most effective ways that the crystalline technology can be utilized is when it is integrated onto a large surface area which does not require much transparency. Since it performs better when exposed to the direct sunlight, canopies, skylights, parking lots and other roof applications are ideal integration options; notwithstanding, vertical applications such as ventilated façades or spandrel glass for curtain walls are also interesting options. Let's see some examples.

# CRYSTALLINE SILICON GLASS ON GLASS SKYLIGHTS



**Skylights are also a good application for the crystalline technology as it will often be exposed to the direct sunlight irradiation that it requires while simultaneously providing filtered natural light for the interior.**

Crystalline Silicon Skylight system installed in New Jersey for a large Pharmaceutical Corporation. PV Glass shows a 30% light transmission, providing diffuse, natural illumination inside the office building.

# CRYSTALLINE SILICON GLASS ON GLASS SKYLIGHTS

Crystalline Silicon Skylight system installed in New Jersey. Open-able system counting on perforated solar cells.

# Novartis Hinged PV
# Custom Designed By Skyco

**Hinged support structure provided to facilitate cleaning of skylights**

# CRYSTALLINE SILICON GLASS ON GLASS CANOPIES

**Canopies are also a good applications as it often requires shades and the protection from the weather elements more than transparency. Transit stations, such as shown here at BART's Union City Station are great for this application.**

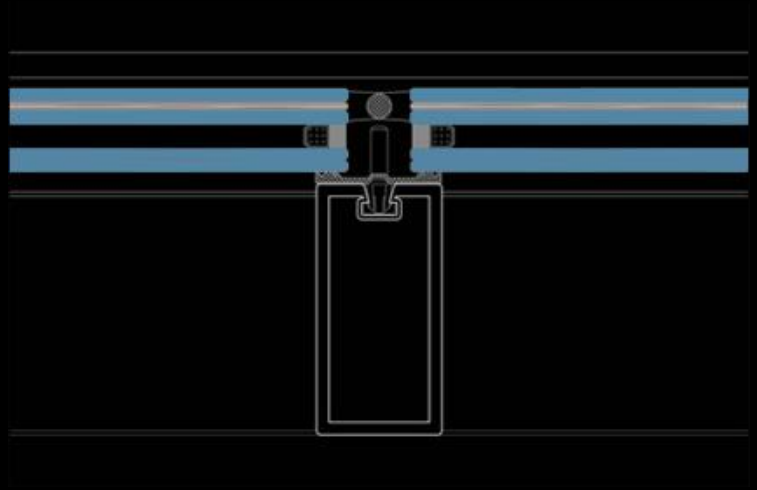
This PV Canopy is made of mono-crystalline Silicon solar cells embedded into two layers of fully tempered, laminated glass. The rear glass incorporates a white color ceramic frit pattern which covers the shape of the solar cells.

# CRYSTALLINE SILICON GLASS ON GLASS CANOPIES

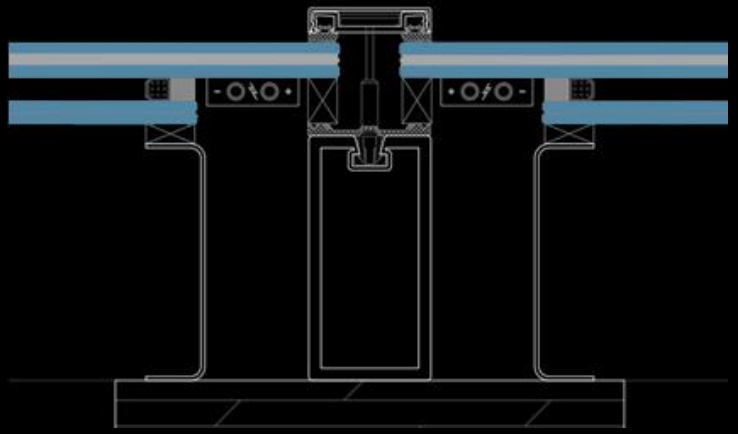
Record: each module of this PV Canopy in Morocco has the capacity to produce a peak power of 626Wp; equivalent to 160 Wp/sqm, which means 16% of efficiency.

# STRUCTURAL/FRAMING SYSTEMS

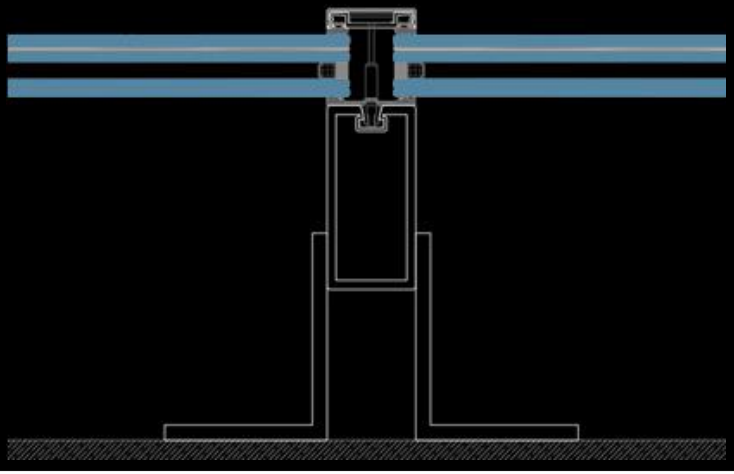
**But how does the junction box work with the insulating glass unit spacer?**

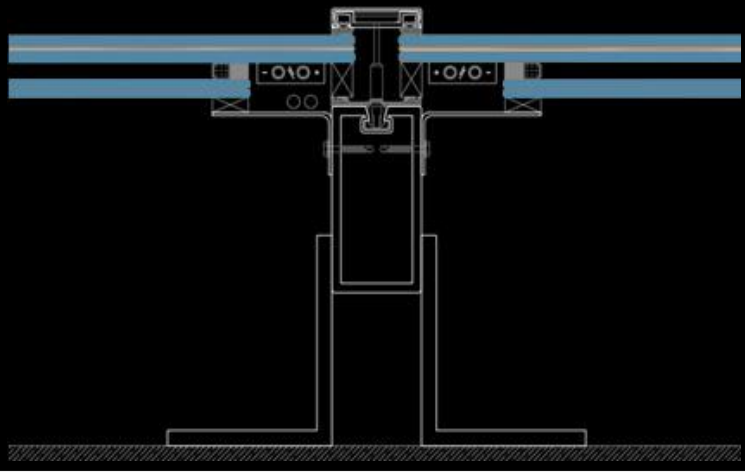


Typical curtain wall detail, normal glass.



Typical curtain wall detail, photovoltaic glass.

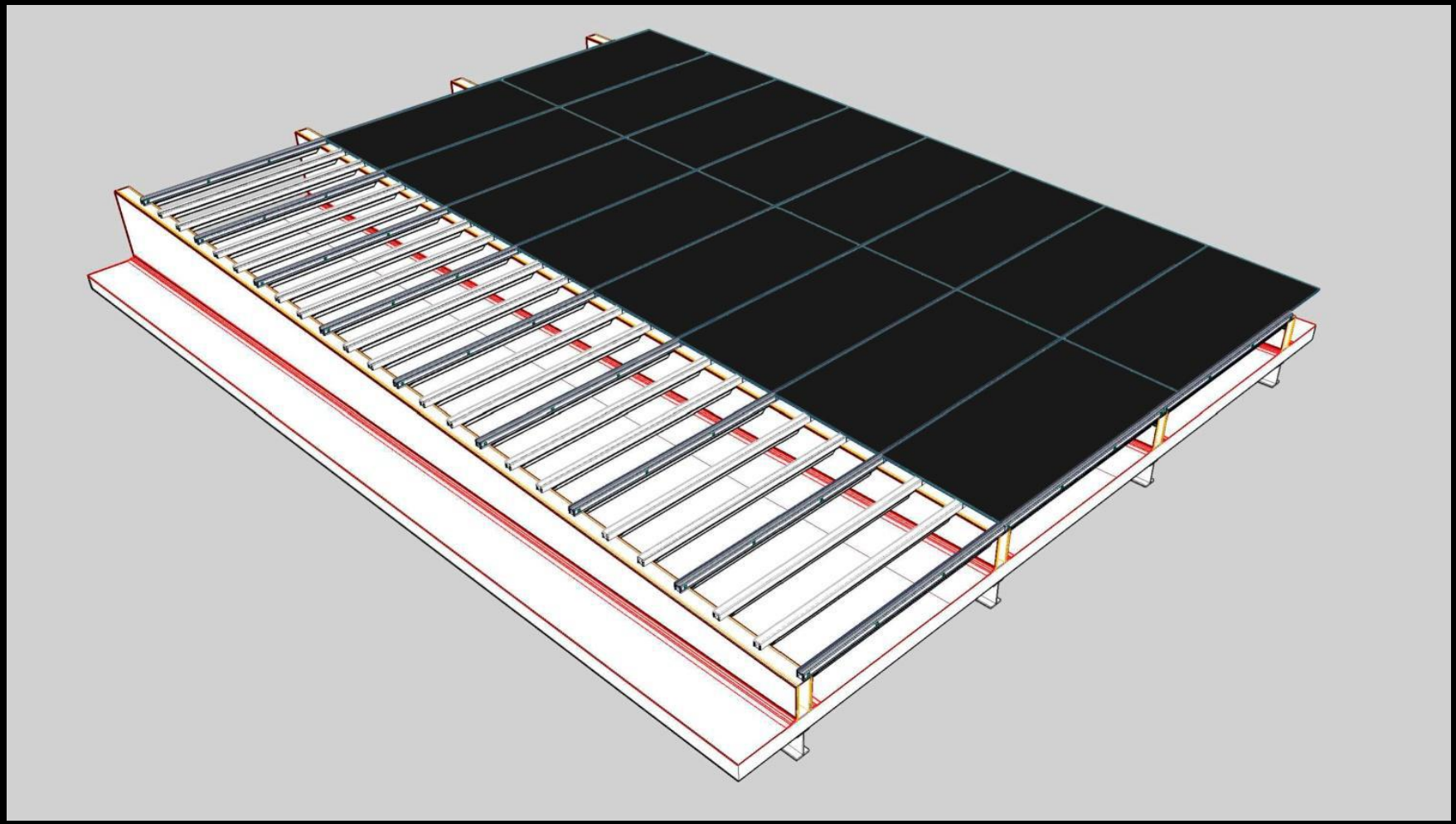




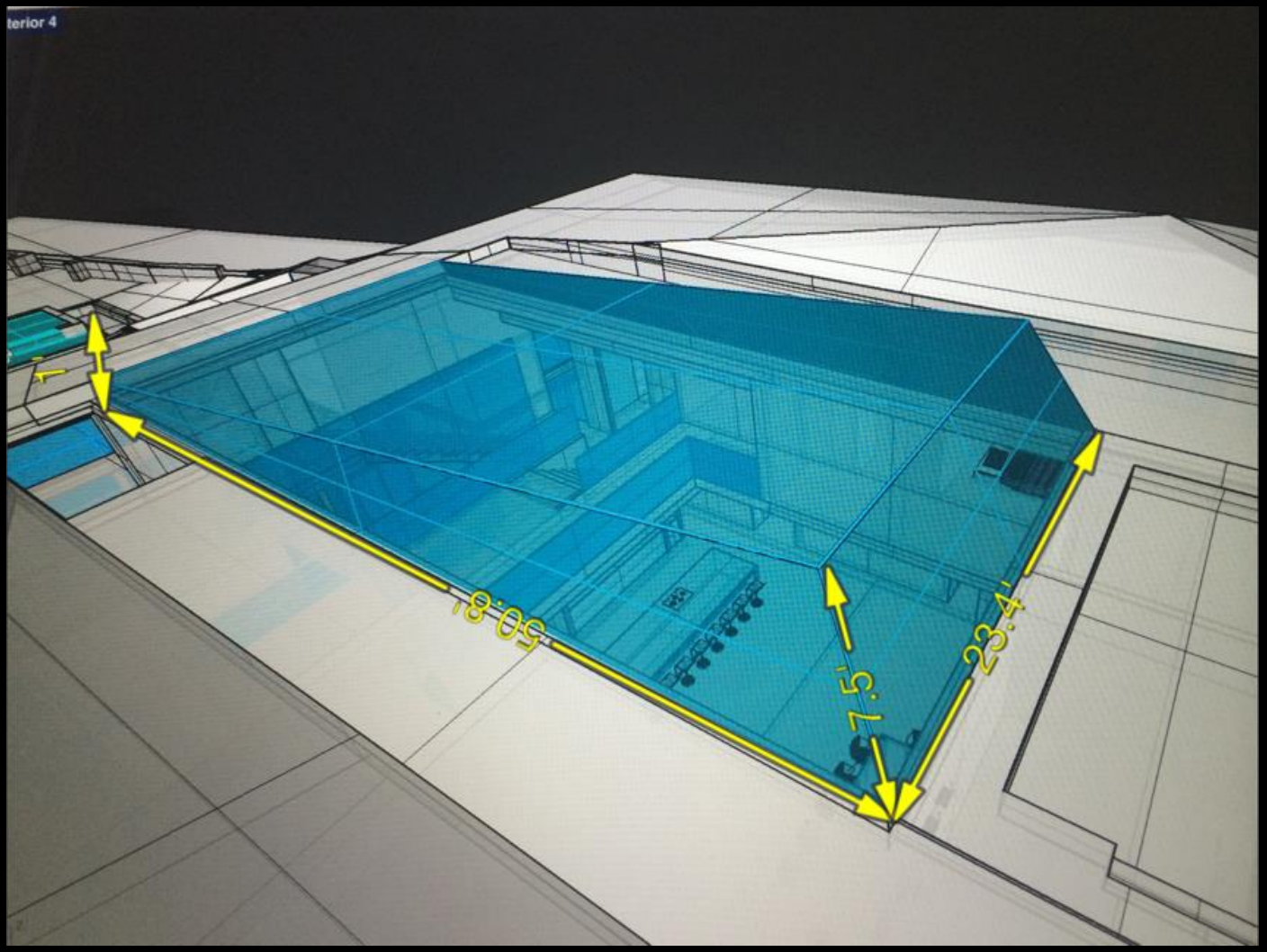
# Apple Store, Union Square San Francisco
# 6500 sq/ft PV Glass Roof Area


GRAND
HYATT

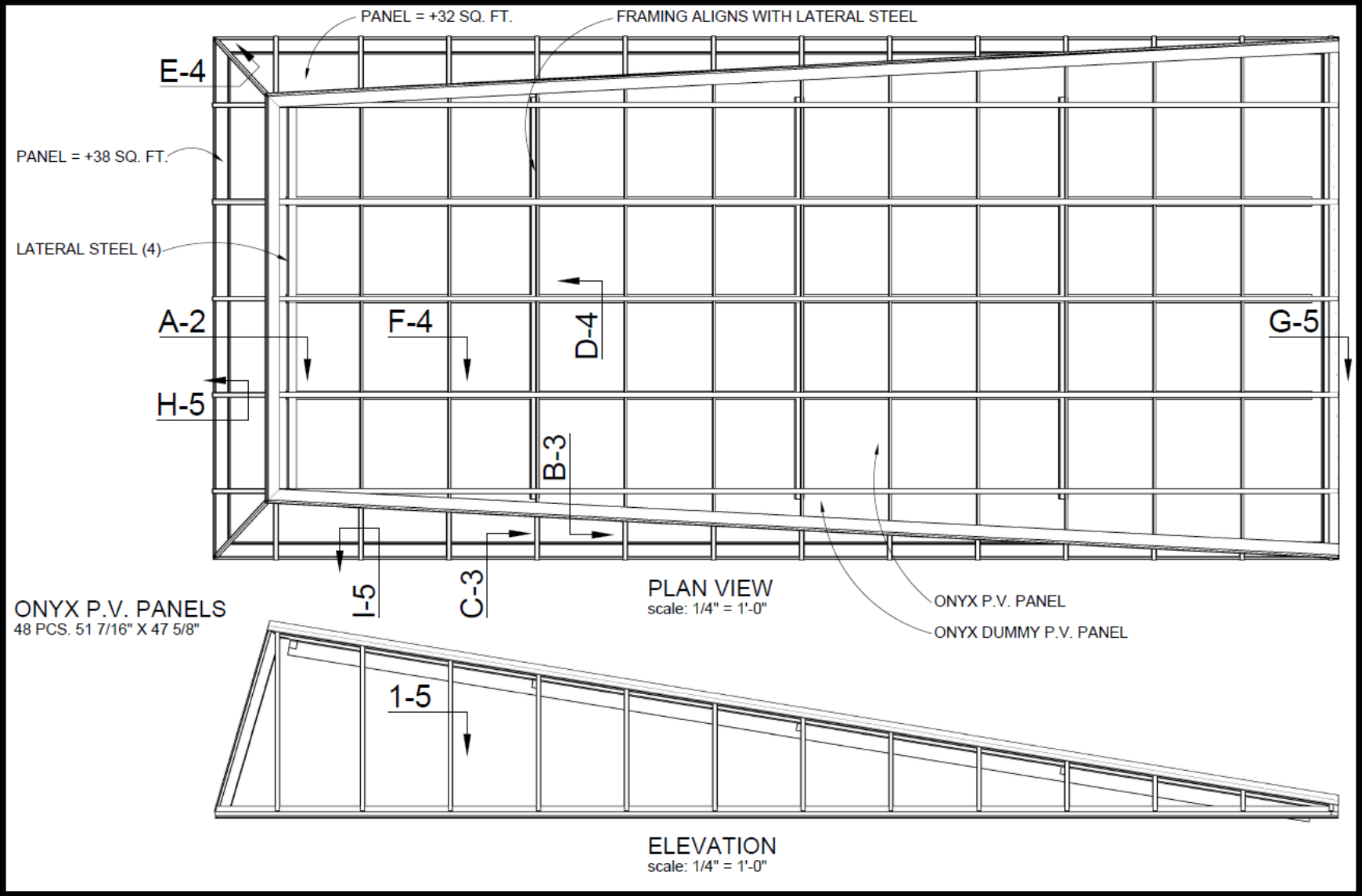
# Apple Store PV Glass Layout and Support Structure



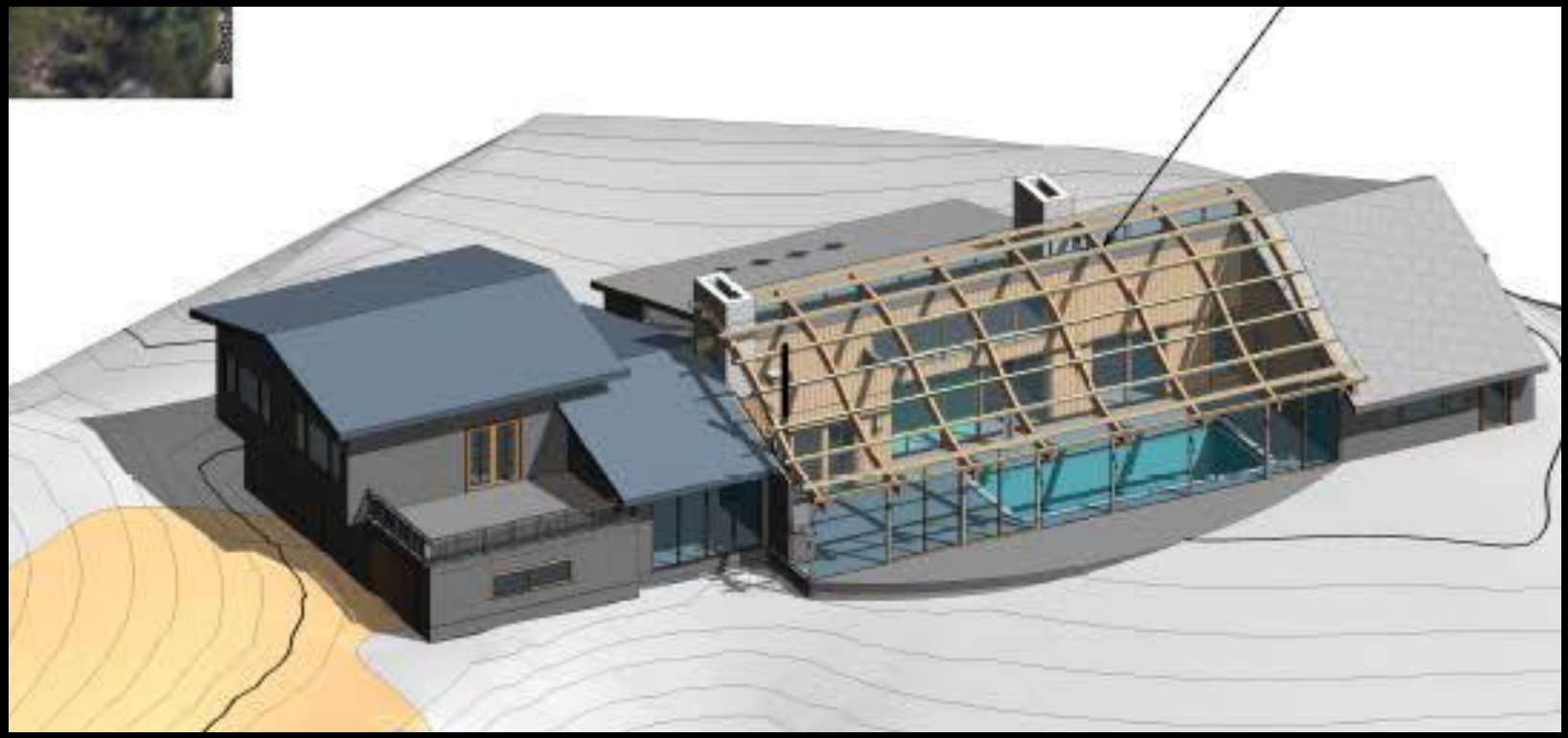
# PHOTOVOLTAIC ATRIUM SKYLIGHT – COSTA RICA
## Vertical and Sloped Onyx Solar PV Glass



# Skylight framing system designed by Skyco Skylights



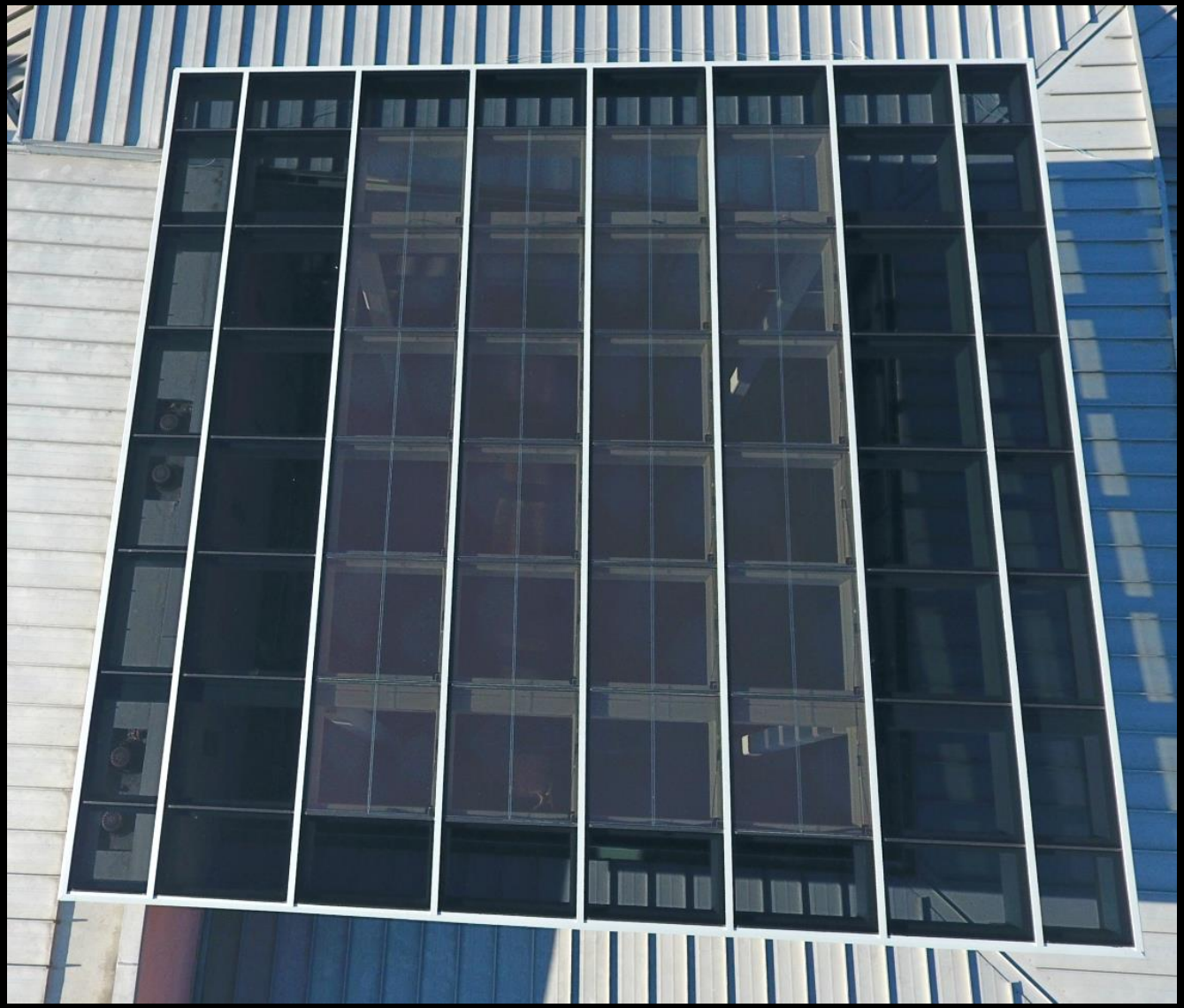
# Tiburon, CA, PV Glass Sloped Skylight Structure



# Tiburon Installation in process

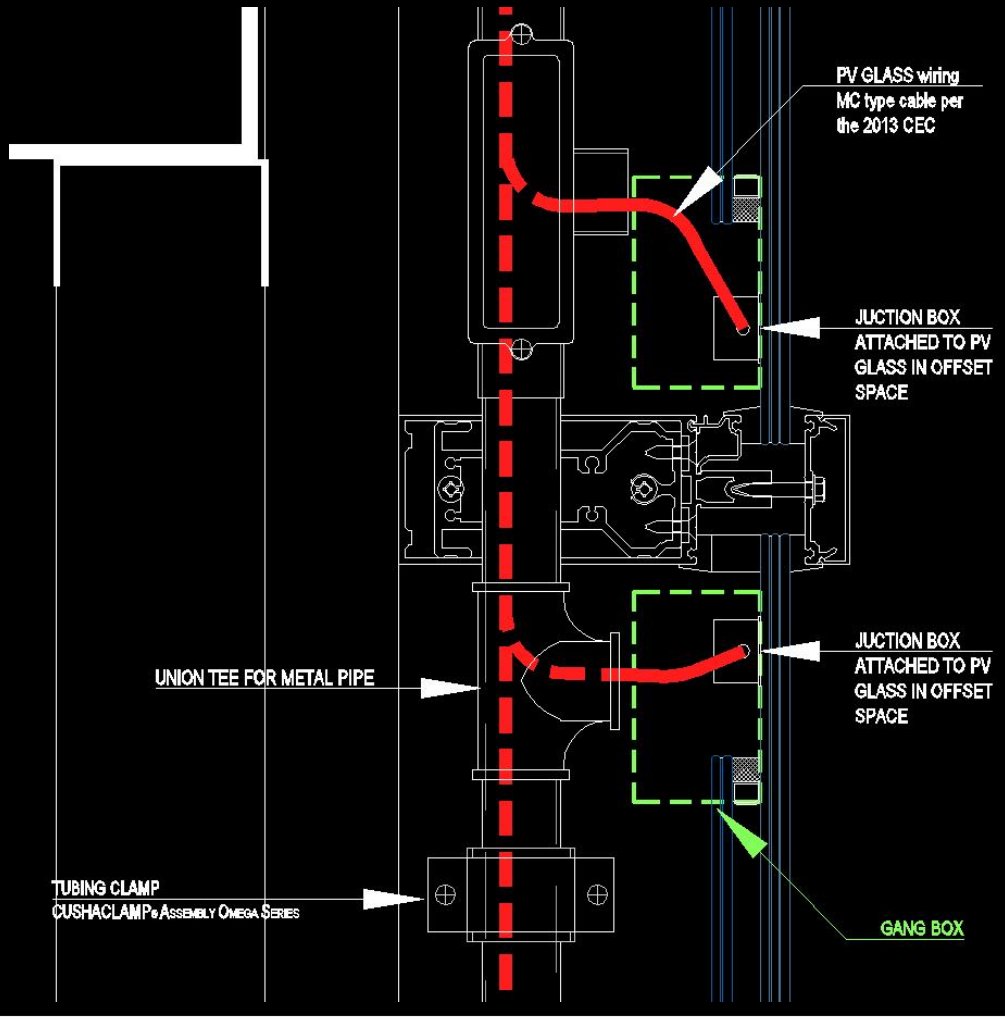

WANE

# Madrona Marsh Nature Center – Torrance, CA

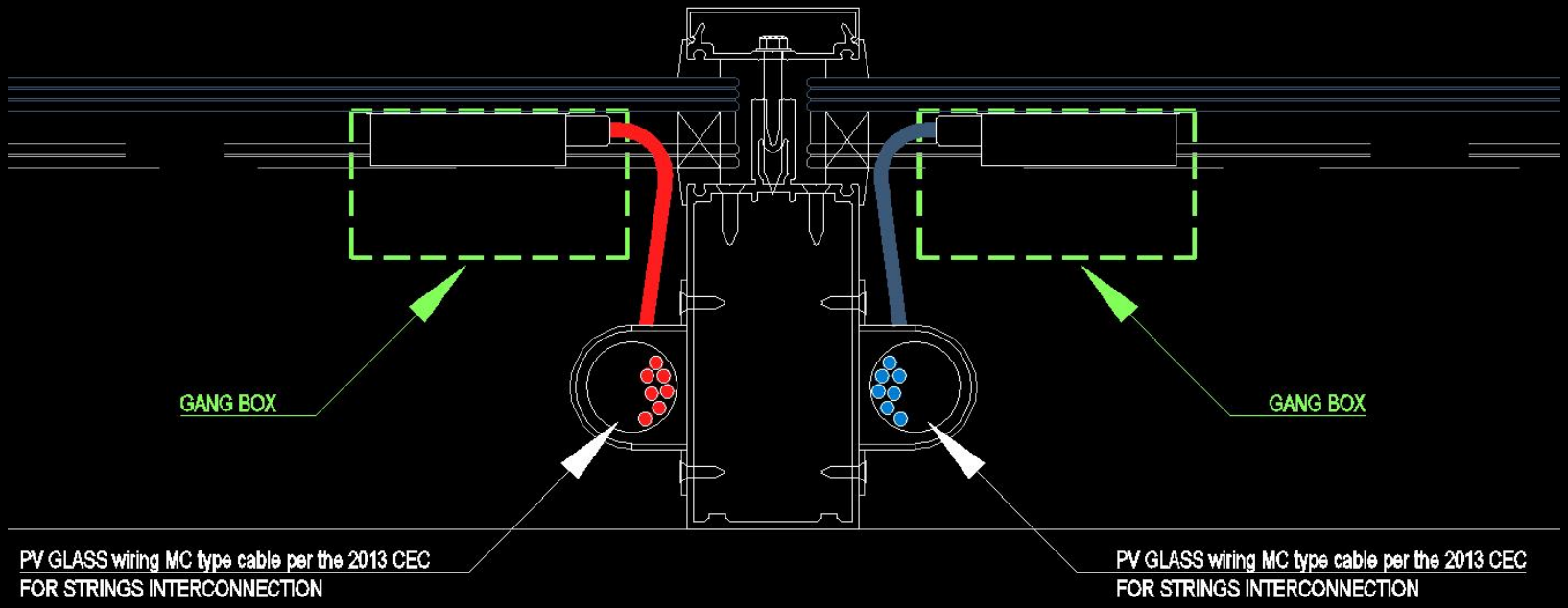


# STRUCTURAL/FRAMING SYSTEMS

Crystalline Silicon glass units are available for PV parking lots. Considering electrical vehicles are becoming more and more popular each day, a PV parking lot can be aesthetically pleasant and feed the electric vehicle charging station whenever required.



# STRUCTURAL/FRAMING SYSTEMS




An alternative design for photovoltaic curtain wall. The figure above illustrates a PV curtain wall which incorporates a wire conduit anchored to the mullion system to run all wiring up to the combiner boxes.

# ELECTRICAL BALANCE OF SYSTEM: BOS MAIN COMPONENTS

(BOS) refers to the components and equipment that move DC energy produced by the solar panels through the conversion system which, in turn, produces AC electricity.

- Inverters
- Cables and Wires
- Switches
- Enclosures for PV wiring
- Fuses and circuit breakers
- Ground Fault Detectors
- Battery Back-up system (If required)
- Monitoring equipment for reverse metering

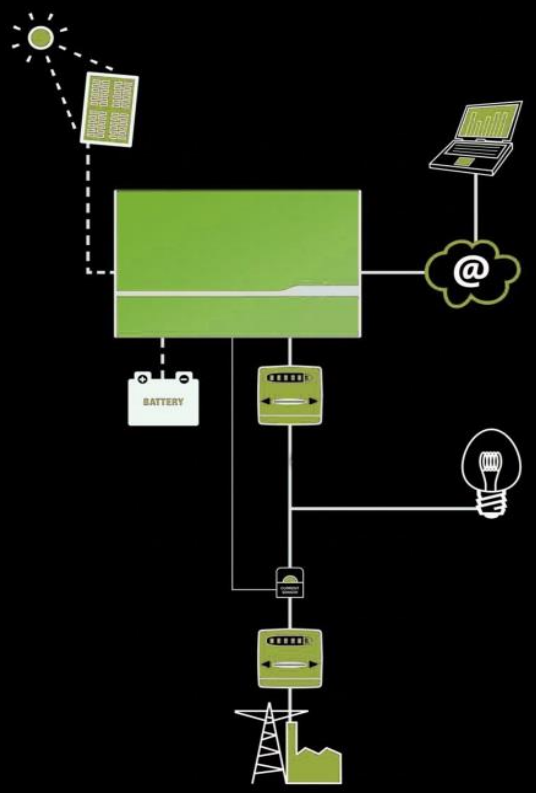
# Energy Management alternatives

Collecting solar properties and generating electricity with the PV glass integration provides the following three options to manage the design:

A. Direct consumption with battery: This is a useful option where the PV integration will generate more power than what is consumed.

B. Direct consumption: When power output from the PV glass integration is less than the consumption. At a hospital building, for instance, where the energy consumption is high, it is better to simultaneously feed the power source in real time.

C. Connecting to the grid system: This option may apply for a large scale community development, where the larger entity could produce a great amount of energy collectively. The grid system would also allow for one individual to sell the harvested energy to others who are connected to the system.



# LEED CERTIFICATION and GREEN BUILDING ELEMENTS

The PV glass integration solution provides numerous effective ways in which LEED certification can be attainable including some of the following areas.

**INDOOR EVIRONMENTAL QUALITY (EQ):**
- EQ CREDIT: THERMAL CONFORT
- EQ CREDIT: DAYLIGHT
- EQ CREDIT: QUALITY VIEWS
- EQ CREDIT: ACCOUSTIC PERFORMANCE

**LOCATION AND TRASNPORTATION (LT):**
- LT CREDIT: BICYCLE FACILITIES
- LT CREDIT: GREEN VEHICLES

**ENERGY & ATMOSPHERE (EA):**
- EA CREDIT: RENEWABLE ENERGY PRODUCTION

**SUSTAINABLE SITES (SS):**
- SS CREDIT: HEAT ISLAND REDUCTION

**INNOVATION (IN):**
- IN CREDIT: INNOVATION

# Cost information

Photovoltaic glass is not merely a construction material but also a great source of green building design that brings a very interesting investment. The elements below show the main cost streams to consider when designing a building integrated photovoltaic.

**COST OF THE PV GLASS:** the cost of photovoltaic glass varies depending on:

1.- Total PV Glass SqFt. $22/sq.ft (Amorphous) to $30/Sq.ft. (Crystalline) for single laminate. Price will be more based on Insulated glass, frit patterns, Low E Coatings, etc. Keep in mind that PV Glass production is more economical in larger quantities. The saving can be up to 70% compared to small PV glass orders. Therefore, commercial projects are normally more interesting for photovoltaic glass.

2.- PV Glass dimensions. Whenever you can stick to a standard size, cost will be 8 – 16% cheaper than a customized size. Consider this fact early in the design phase!

3) Electrical Components. $10 - $20/sq.ft range (Inverters, combiner boxes, junction boxes, disconnects, fuses, over-current protection, wiring, and conduit)
Electrical Labor typically calculated on the level of complexity and if Union or Non-Union

4) Structural Framing Systems: Varies depending on project design requirements and support system requirements. Previous systems have ranged from $15 to $40/sq.ft depending on complexity

# Return on the investment

**What is the return on the investment for a traditional glazing?** The answer is none. A building enclosure can be designed specifying an energy efficient glass with sun control coatings. It would possibly provide savings in HVAC systems, but not a return on the investment.

Photovoltaic glass allows for the decrease on the operation and management costs associated with HVAC systems since it is an energy efficient glazing and it generates electricity from the sun. The generated solar electricity will prove its value on the electricity bill of the building which makes it a multifunctional glazing for any construction project.

In order to calculate the return on the investment for a photovoltaic glazing, the following premises have to be taken into consideration:
+ Cost of PV glass installation – Cost of traditional glass installation = Net Investment
Then the following items need to be factored into the ROI as well.

Electricity Production over the lifespan of the installation (25 to 30+ years)
*Cost of electricity and projected cost increases over 25 to 30+ years)
*Expenses in HVAC systems vs. savings due to the energy efficient PV Glass installation
*Operation and Management costs for the PV Glass system
*Tax incentives and rebates (30% Federal Tax Credit of the total cost of all components of the photovoltaic system + State & Local incentives via rebates or performance-based).

# Cost Summary Example: Project: Ontario Mills Mall 3 Gable Ridge Skylights – 18’ wide x 76’ long, 4/12

**Total of 4333 Square feet of surface area**

**Skylight cost with 1” Insulated Glass = $80/sq.ft x 4333 = $344,640 Furnished & Installed**

**Skylight Cost with 1” PV Glass = $463,631 Furnished & Installed**

**30% Federal Tax Rebate = $139,089.60**

**Actual Cost for PV Skylights = $324,542 Furnished & Installed**

**Difference in cost = $20,098.00 Less for PV Glass Skylights**

# Cost Summary example continued

**Estimated Electrical Costs at $20/sq.ft = $86,660.00**

**Less 30% Tax rebate of $25,998 = $60,662**

**Less reduced actual cost for PV with Rebate $20,098**

**Actual Associated electrical Costs = $40,564**

**Average output = 4 watts/hr/sq.ft x 4333 = 17,332 wph = 17.332 KW**
**17.332 KW at $.20/kw electric cost = $3.46**

**$3.46 x 4.5 hours efficiency = $15.57 per day savings**

**$15.57 x 365 days = $5,683 savings per year**

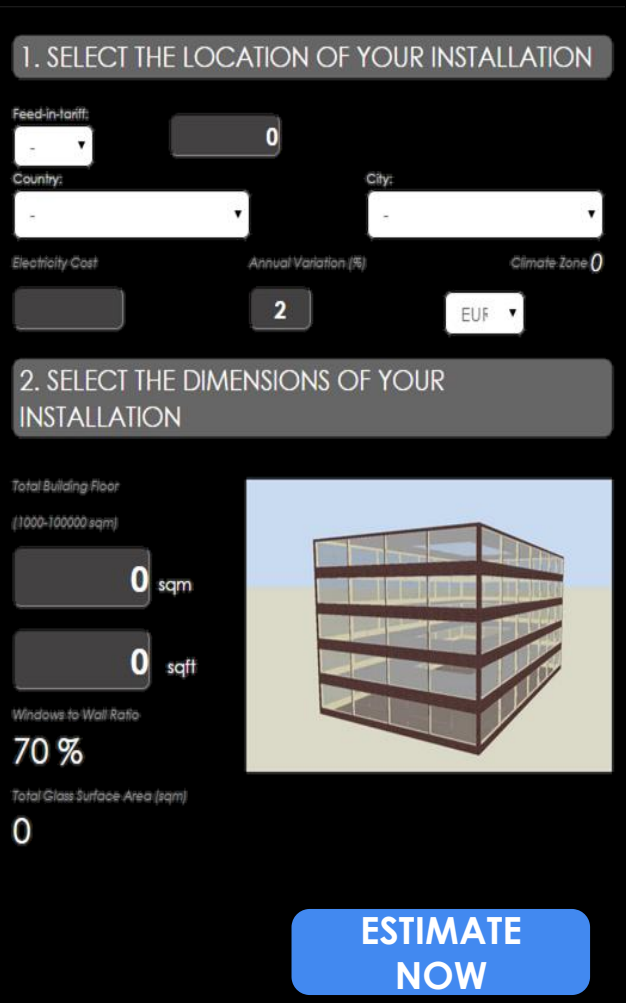
**25 years x $5,683 $142,075 (less $40,564 electric cost) = a savings of $101,511.00 based on current energy costs (which we all know will increase, thus raising the long-term savings)**

# Energy Modeling Tool

## How it works

This tool allows you to calculate the energy and cost savings in a building by using PV glass, thereby allowing you to see the reduction of energy demand. Two simple steps, selecting the location and dimension of the building, will help you to know in a few seconds the amount of energy saved in a building thanks to the passive properties of the glass and the amount of energy produced by its active properties.

The PV glass is the only building material that provides return on the investment by generating clean electricity throughout the year. This is made possible by the multi-functionality of the PV glass: in addition to the on-site solar electricity generation, it allows for the entry of natural light into the building, reducing the need for artificial lighting; it filters the harmful ultraviolet and infrared radiation, which also preserves the interior of the building; it provides thermal/acoustical insulation to minimize the solar factor/SHGC, making the PV glass the best choice for accomplishing the HAVC energy saving by optimizing the indoor temperature.



# Photovoltaic Estimation Tool

**How it works**

Enter the value for the photovoltaic installation area you have in mind, then select the type of the photovoltaic technology. The result will display the energy that would be generated and its equivalences in avoided CO2 emissions, hours of light and electric car mileage.

Use the screen of your smartphone or computer to simulate the active surface of the photovoltaic glass, and just place it in the same position that your installation would be. The results will vary according to the angular positioning and the orientation of the device. Try it out and compare the results for different design purposes.

*This concludes The American Institute of Architects Continuing Education Systems Course*

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www.onyxsolar.com

# Skyco Skylights Products and Services

# SKYCO SKYLIGHT PRODUCTS

- Commercial/Industrial Unit Skylights
- Vortex – Louvered Skylights and Smoke Vents
- UL Listed Smoke Vents
- Standard Commercial/Residential Unit Skylights
- Fall-protection/Security Bars
- Custom Skylights and Canopies
- Skyglaze Translucent Glazing System
- Polycarbonate Systems
- BIPV- Building Integrated Photovoltaics

# Skypro Illuminator™ Skylights

- High-impact Skypro polycarbonate domes
- Unique Skywave™ Arc design – 30% more light-collecting surface area and added strength
- Glazing Meets UL 972 Impact Resistance Standard
- Certified to meet an 800 lb Impact Load (OSHA and CalOSHA)
- Curb mounted or Self-flashing units (Height as required)

# Oakmont DC – Livermore, CA

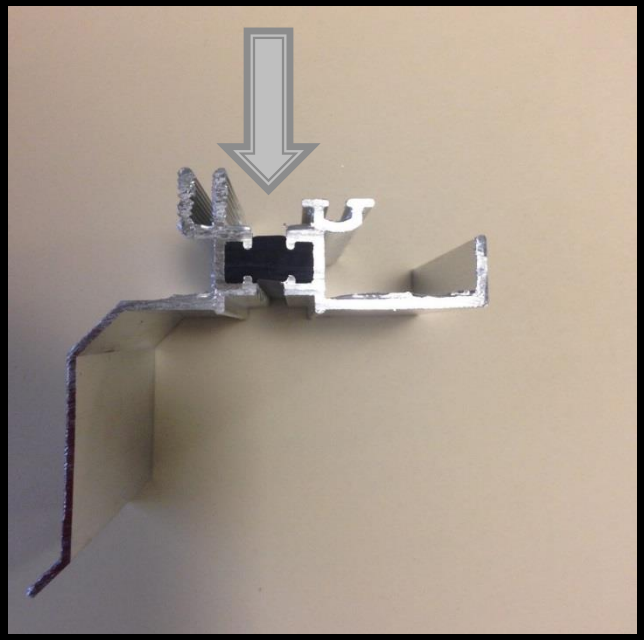
# Skyco Skylights Illuminator Interior Photo (With No Lights)

# FM Listed Unit Skylights

- Tested to FM 4431 Standard
- Flame Spread, Ice Ball Test, Impact and Wind Uplift Tested
- Wind Uplift/Load – 195 MPH Unit (Highest in the market)
- Class IV Hail Resistance Rating (2" diameter)
- Polycarbonate Domes
- 10 Year Warranty against yellowing and breakage

# Thermally-Broken Frame Option for Unit Skylights

Eliminates the thermal transfer of varying temperatures from the exterior to the interior to reduce potential condensation



AAMA Compliant Poured and De-bridged Thermal Break

Increases the energy efficiency and performance

# UL Listed Smoke Vents

- Tested and Certified to UL 973 Standard for Smoke Vents
- Skypro High-impact polycarbonate domes
- Tested to an 800 lb Impact Load (UL requires 400 lbs)
- Skywave™ arc domes for increased light distribution
- Galvanized steel or aluminum frames

# Smoke Vent to automatically remove heat, smoke, and hot gases

# Trojan Battery – Santa Fe Springs, CA

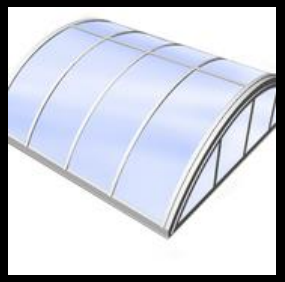
# Roof Access Hatches & Accessories

**Roof Hatch with Railing Shown**

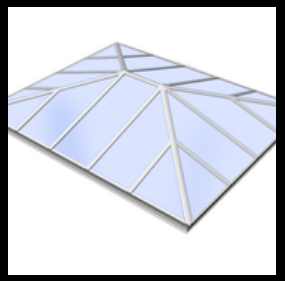
**Roof Hatch with Ladder Assist**

# SKYCO Custom Structural Skylights

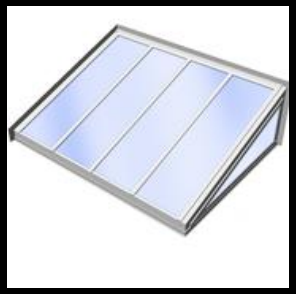
# Standard Custom Configurations



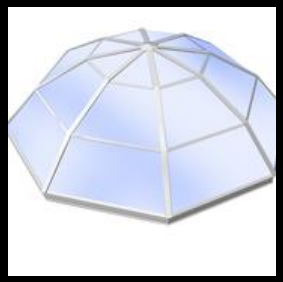
Barrel Vault



Hip Ridge

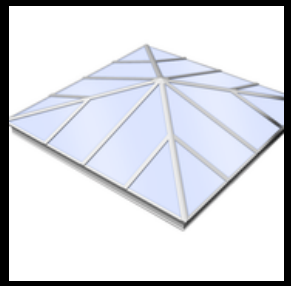


Lean-to

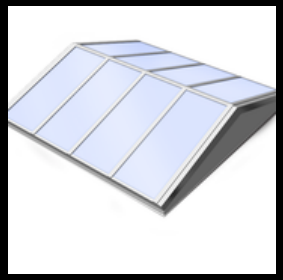


Segmented Dome

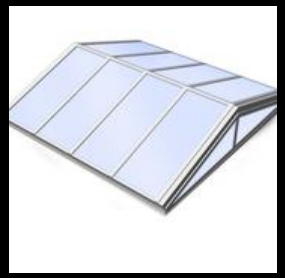
Polygon



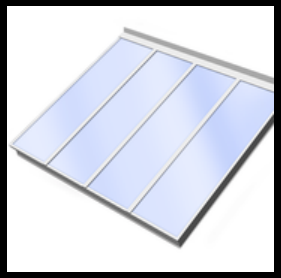
Pyramid



Ridge



Ridgelite



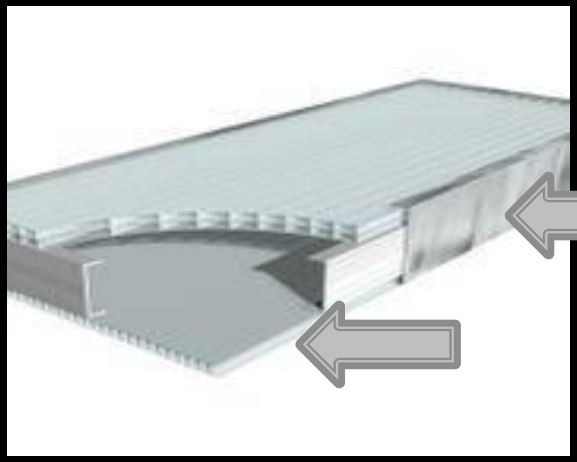
Single Slope

# Glazing Options for Custom Skyco Skylights

- Full Range of Insulated Glass and tints
- High-performance Low E Coated Glass
- Multi-wall polycarbonate panels
- Dynamic Glass – electronically tintable
- Photovoltaic Glass – generates electricity
- Polycarbonate sheet for curved barrel vaults
- Acrylic sheet for curved barrel vaults
- Standing seam polycarbonate systems for canopy structures

# SKYGLAZE™ Translucent Panels

Standard Panel is 2 ¾" Thick




- Cost-effective alternative to FRP -Fiberglass Reinforced Polyester
- Flexible system performance values to meet project requirements
- Panels will not crack, turn yellow or fiberbloom
- Does not require a periodically applied protective coating
- Systems may vary in thickness from 1 ½" to 4" thick
- Light transmittance and SHGC to meet the Energy Codes
- Impact strength 200 times that of glass

# Skyglaze Translucent Panels

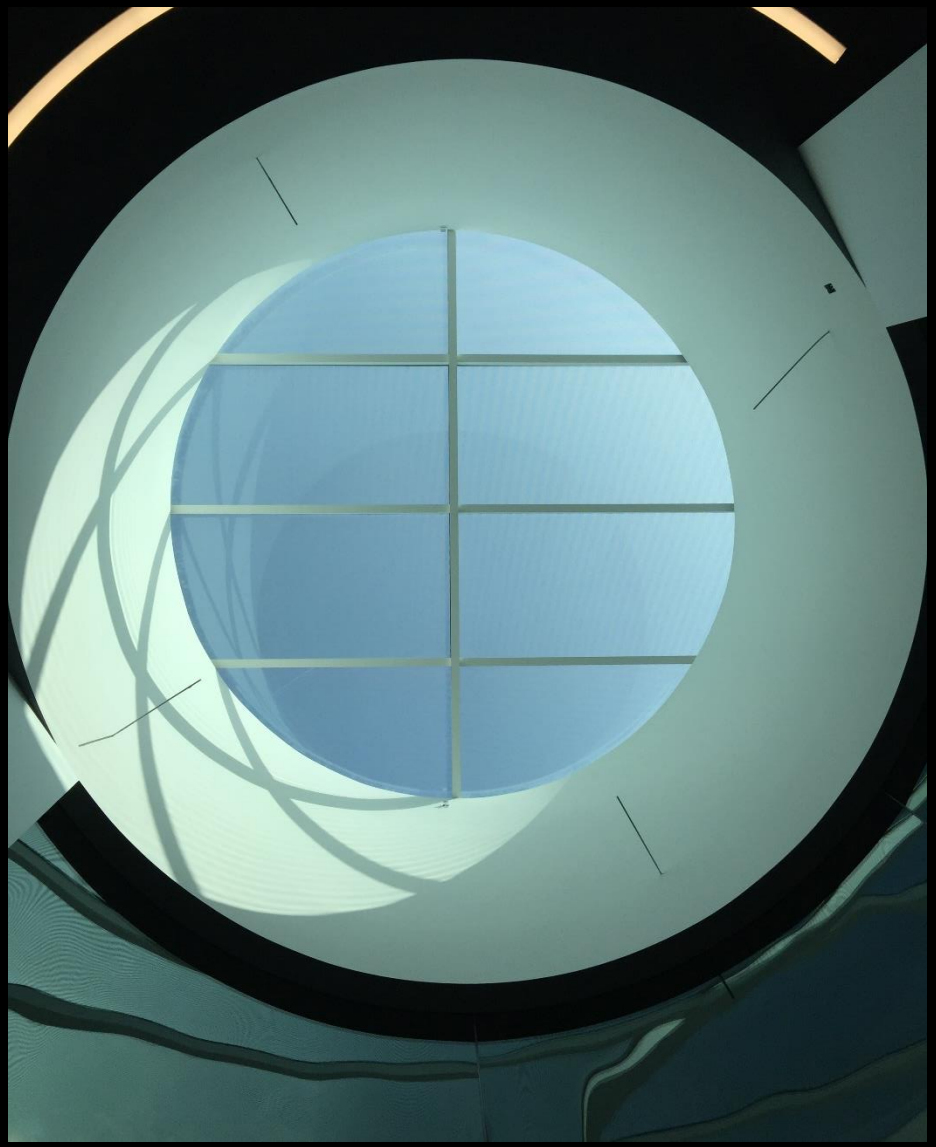
**FRP Panels**

- Polycarbonate
- Economical
- Long Lasting
- Class A Fire Rating
- 10 Year warranty
- No Coating Needed
- Maintenance Free
- Higher VLT
- Adjustable SHGC
- Light weight Panels

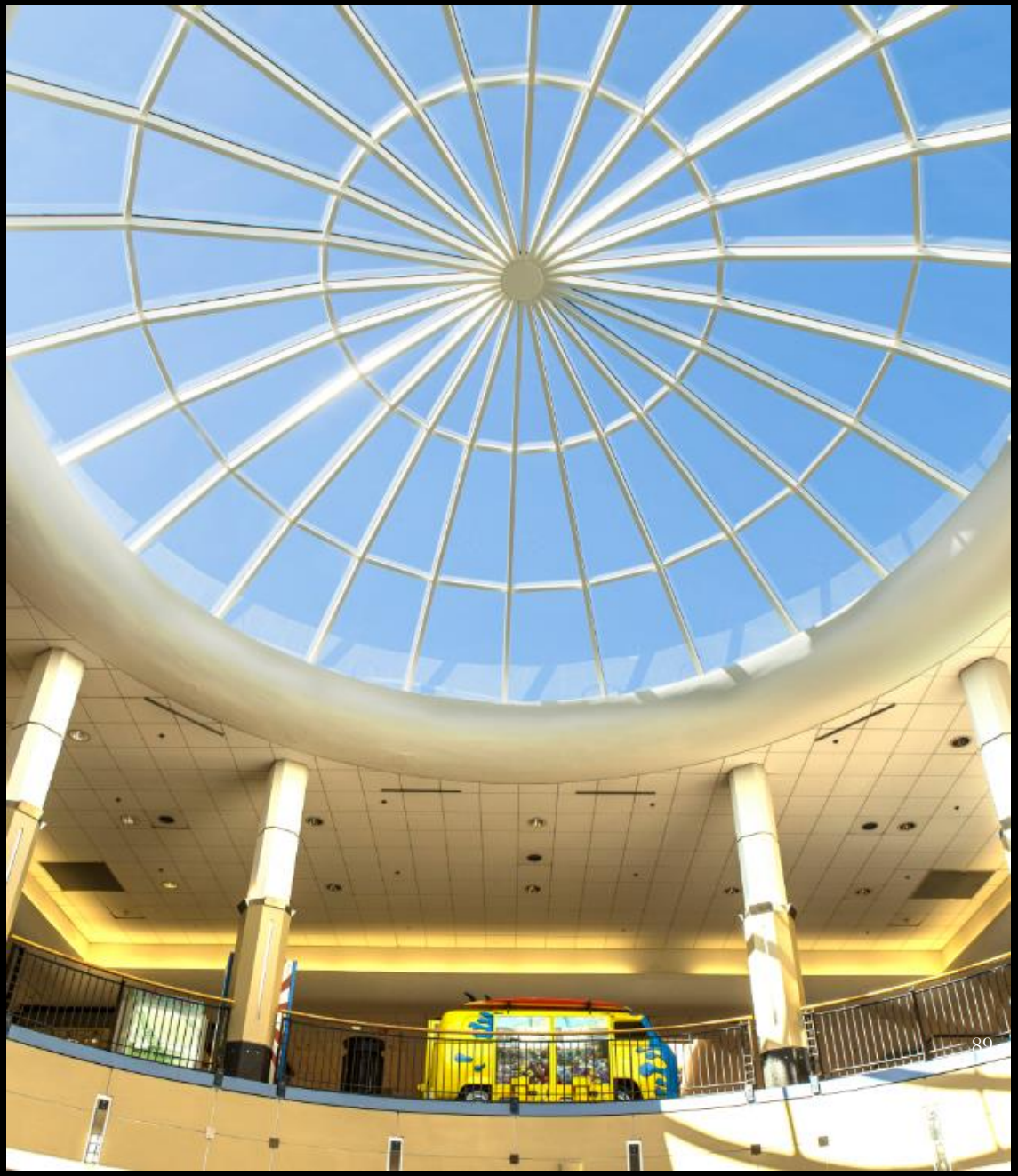
**SkyGlaze Panels**

# Google Project – Santa Monica

# Google Project



# Carlsbad Mall – Carlsbad, CA



# Shalhevet High School - LA

# Exterior Canopy Structure

# Canopy Structures

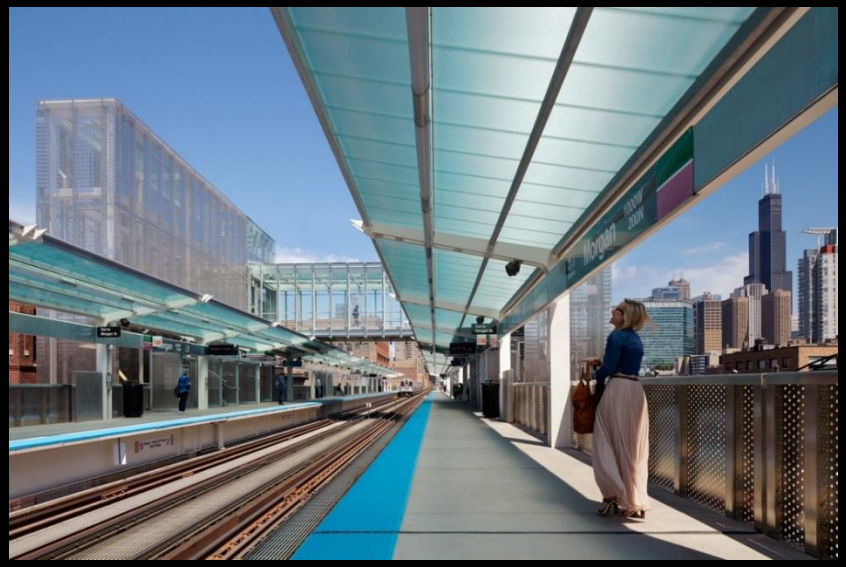
Multi-wall Polycarbonate

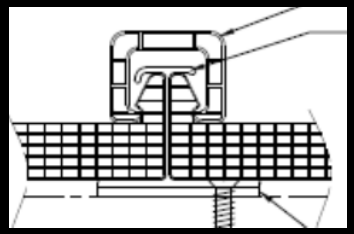
Laminated Tinted Glass

# Canopy Structures – Custom Designs

# Polycarbonate Canopy Systems

- Mullion-less canopy systems; 12-20mm standing seam polycarbonate panels

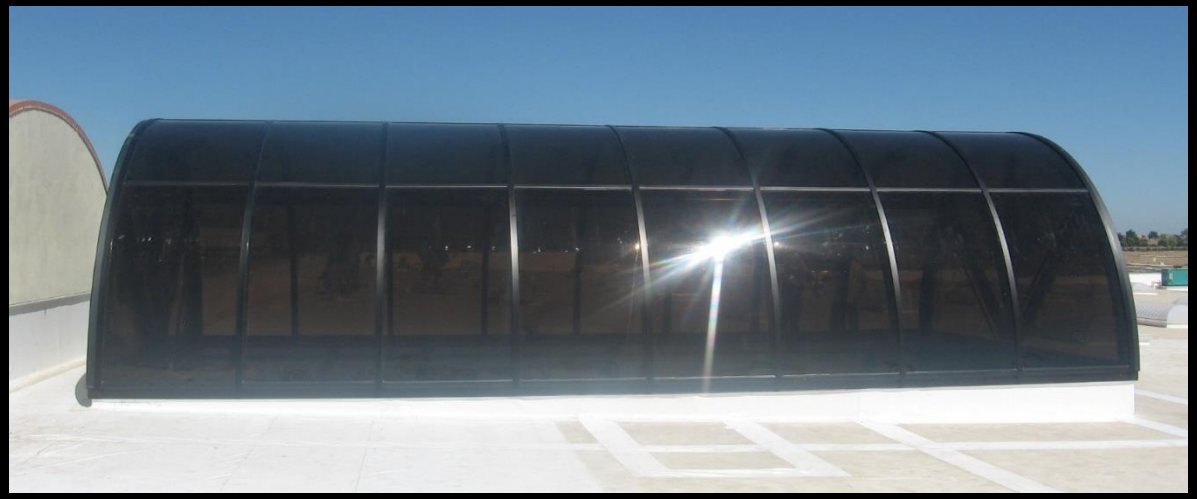




# Segmented Custom Canopy Structure

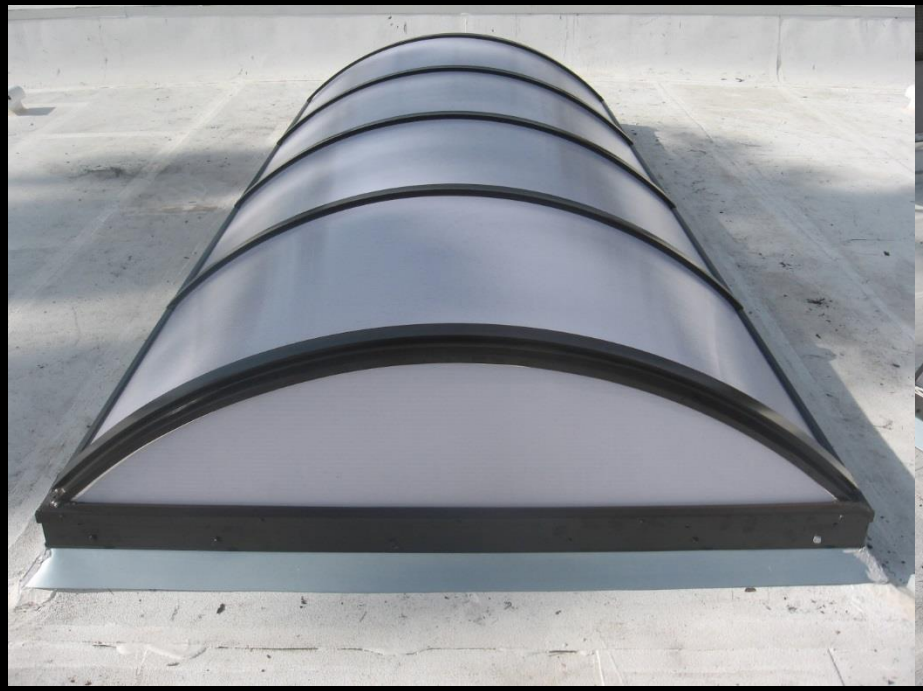
# Segmented Custom Canopy Structure

# Custom Acrylic Barrel Vault Skylights



# Segmented Glass Vault

# Acrylic Curved Barrel Vaults



# Retractable Custom Skylight

# Custom Ridges with Multi-Wall Polycarbonate

# Residential Glass Ridge Skylight

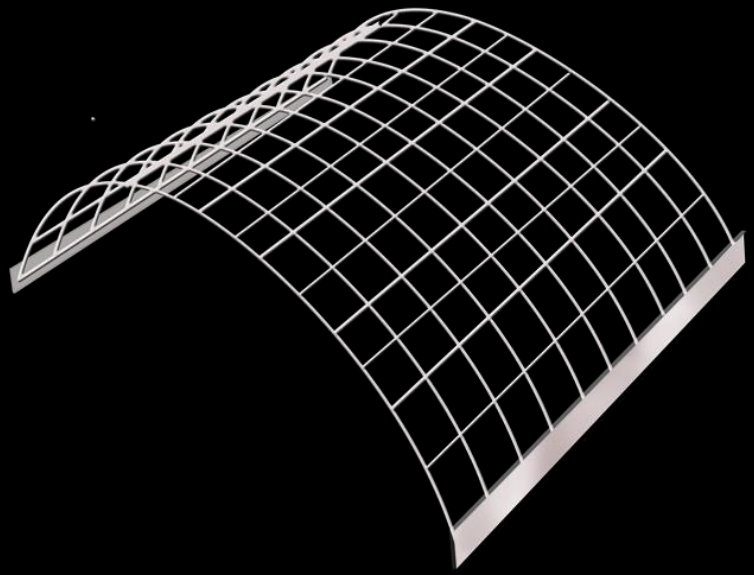
# Lean-to Skylight

# Ridgelite Shipping Assembled Reduces Field Labor to Install

# Hip Ridges with white multi-wall polycarbonate glazing

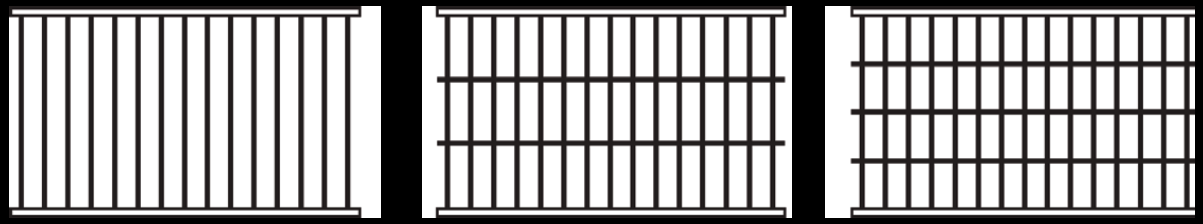
# Continuous Barrel Vault

# Fall-Protection Screens – Standard/Custom



- Standard and Custom Sizes
- For mounting on Skyco Units
- Retro-fit on competitor skylights
- Secure Fastening System
- Meets OSHA 200 Lb Impact
- Meets CalOSHA 400 lb Impact

# Security/Safety Bars



SB-1 SB-2 SB-3

Features a standard white powder coat finish
Standard and custom sizes available
Custom bar spacing available
Meets CalOSHA Title 8 Fall-protection Standard
For curb mount or self-flashing applications

# Thank You
# QUESTIONS???

**Contact information**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*This concludes The American Institute of Architects Continuing Education Systems Course*

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