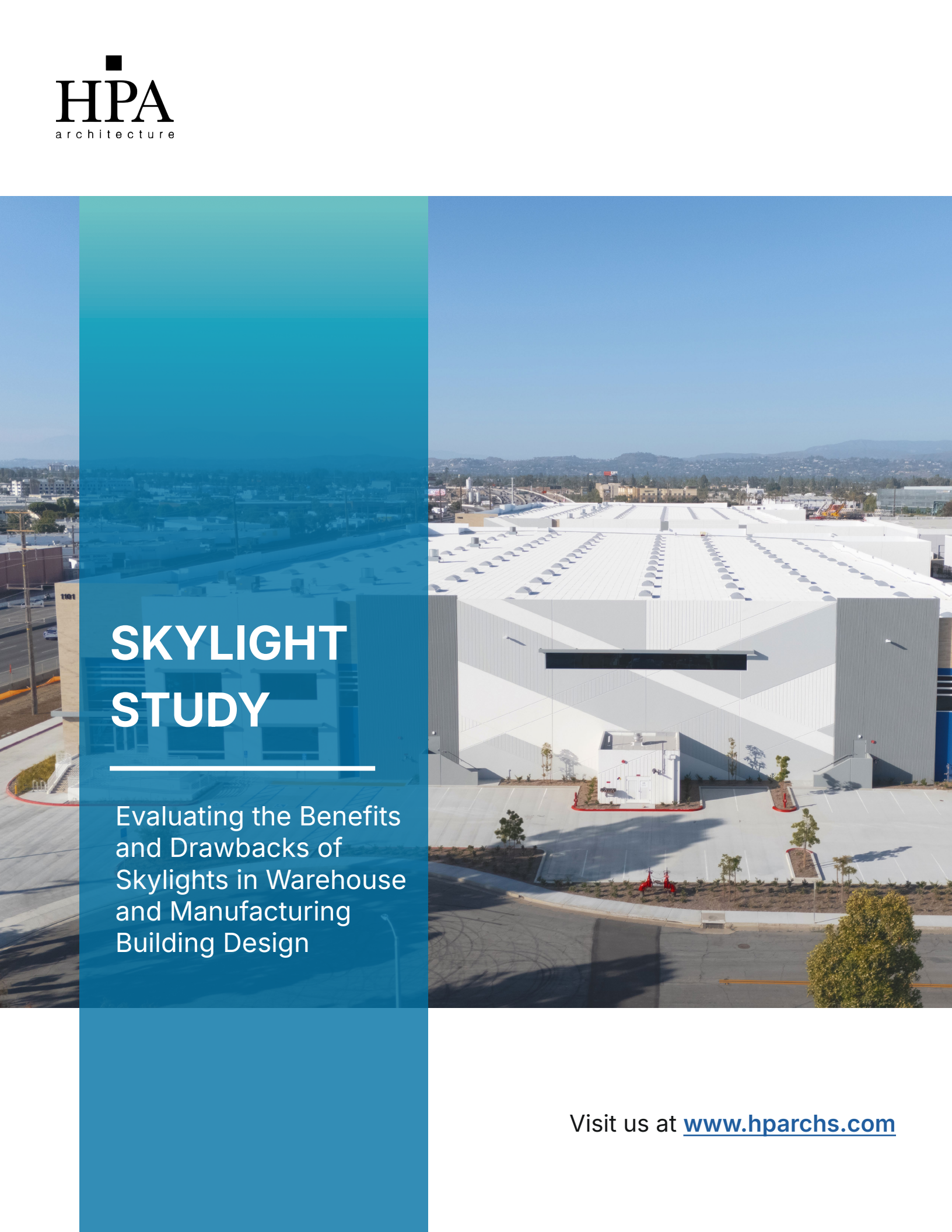




SKYLIGHT STUDY

Evaluating the Benefits
and Drawbacks of
Skylights in Warehouse
and Manufacturing
Building Design

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Introduction

Incorporating natural light into warehouse and manufacturing facilities is a common design approach. Natural light improves working environments and reduces energy consumption. The difference between a building with and without skylights is... night and day. However, their integration into building design comes with both benefits and drawbacks, which can vary significantly depending on the geographical location and climate. This white paper illuminates the key considerations for installing skylights, with a specific focus on market differences between west coast projects specifically Arizona, Washington, and California. Additionally, we examine the alternative use of clerestory windows as a viable design option.

The paper leans on [research](#) by Dolnikova, E., Katunsky, D., & Darula, S. (2020). *Assessment of overcast sky daylight conditions in the premises of engineering operations considering two types of skylights*. Building and Environment, 180, 106976.

Additionally, HPA completed daylighting analysis to compare variability in quantity of skylights and finish options to evaluate interior lighting levels.

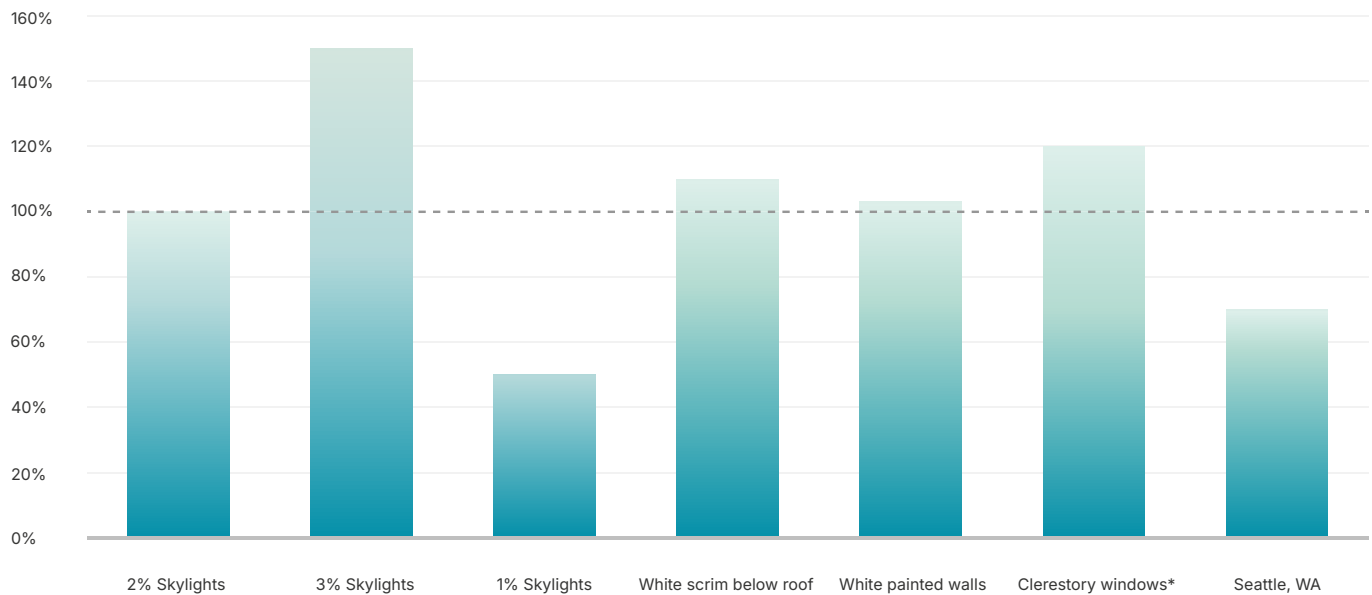
METHOD

Software:
Climate Studio + Rhinocero 3D

Baseline:

- 2% skylights
- 300,000 sqft
- Unpainted concrete walls
- Exposed wood roof
- 36' clear height
- No clerestory windows
- California
- Open shell building, no racking or equipment

Annual average: 35 footcandles



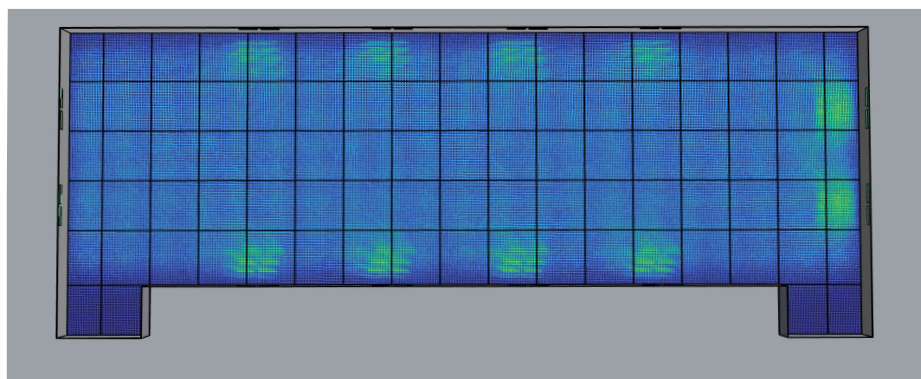
HPA Research Insights

We modeled and analyzed a 300,000 square foot, 300' deep, 36' clear building in California.

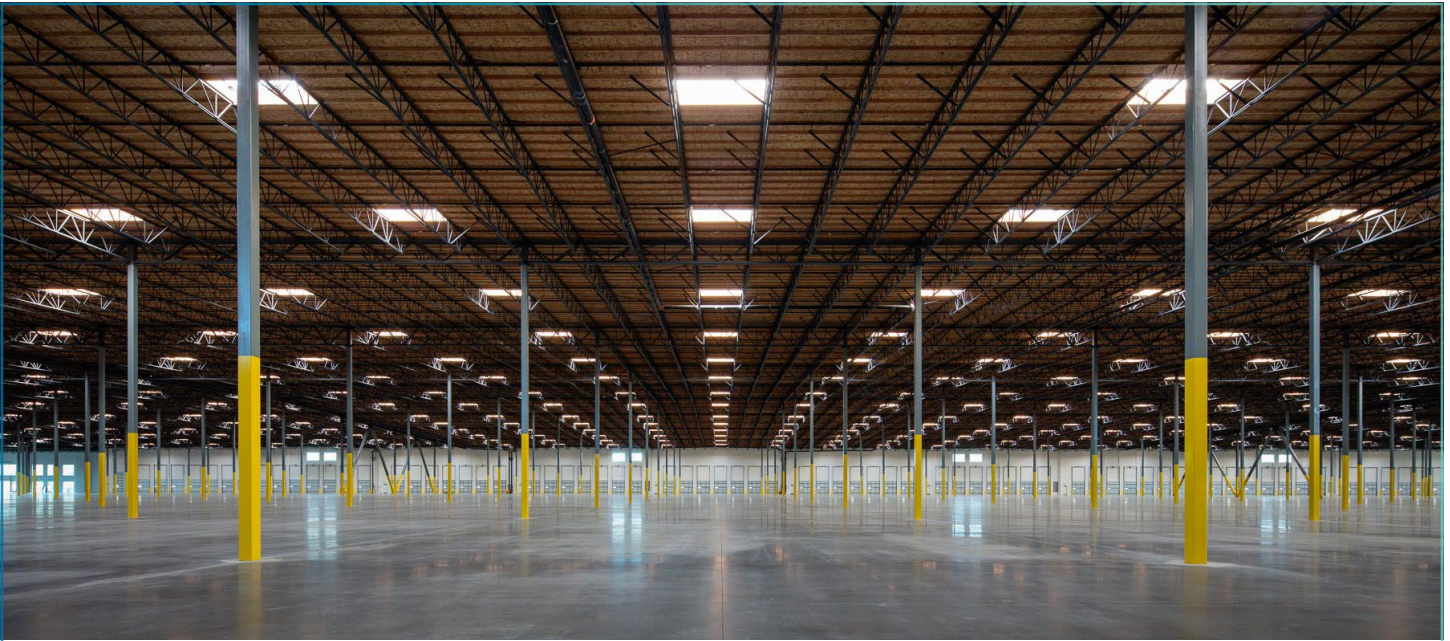
We evaluated variable skylight percentage, with and without white scrim installed below the roof, wall finish painted and unpainted concrete, and with and without clearstory windows. For skylight material we used translucent white skylights that are common in industrial buildings. We set a horizontal reference plane at 30 inches above finished floor and measured illuminance in foot candles.

Our results are included in the graph above. The baseline building included 2% skylights, no clearstory windows, unpainted concrete walls, and wood roof.

The same baseline building modeled in Seattle has an average foot candle 70% of California. While the light levels are reduced they are still adequate to reduce lighting demand.



*Clerestory windows provide increased lighting in isolated areas adjacent to window location; modeled results show 20% increase in green areas only.



800K SF cold dark shell with 2% skylights, clearstory windows, and wood deck

Key Benefits of Skylights

Access to Natural Light

The primary advantage of skylights is their ability to provide abundant natural light. Natural daylight provides the full light spectrum improving mood and making it easier to read colors and fonts. Dolnikova et al. (2020) confirmed that skylights provide superior daylighting conditions even under overcast skies, leading to improved light distribution and occupant productivity. This can enhance the working environment by reducing reliance on artificial lighting, improving worker morale, and increasing productivity. For west coast facilities, especially in regions with abundant sunlight like California, skylights can deliver consistent daylight throughout the workday.

Reduction in Lighting Demands

By utilizing natural light, skylights can significantly reduce daytime lighting demands. In a comparative study of two industrial buildings, Dolnikova et al. demonstrated that well-designed skylights achieved average daylight factors near 5%, reducing dependency on artificial lighting for up to 80% of the year. This reduction not only decreases electricity costs but also contributes to sustainability goals by lowering overall energy consumption.

Sustainability

Facilities incorporating skylights may achieve higher sustainability scores, helping them meet certifications like LEED and reducing their carbon footprint. LEED requirements for skylights are often higher than typical so often not pursued.



Solid covered smoke vent viewed from above with safety bars visible

Potential Drawbacks of Skylights

HVAC Load Implications

Skylights can impact a building's thermal performance, depending on the climate. In warmer areas like Nevada and Arizona, skylights lead to increased heat gain, driving up cooling demands. Conversely, in cooler areas skylights contribute to heat loss during colder months. Both scenarios can offset the energy savings from reduced lighting, requiring careful consideration of glazing amount and materials. Project specific analysis is required to evaluate the impacts and opportunities as the climate varies significantly from market to market.

Specifying double dome in lieu of the more common single dome skylights improve heat gain/loss optimizing performance. This comes with an increased initial cost. Double dome skylights are standard in Nevada and Arizona and should also be considered in areas where HVAC in the warehouse/factory is expected. Double dome skylights are approximately 60% more effective at reducing heat gain and cost approximately 14% more than single dome skylights. Double dome skylights are equivalent to approximately R-13 insulation. For an additional \$100 per unit skylights can be specified as thermally broken further reducing heat transfer and reducing condensation.

Increased Fall Potential Hazards

The installation of skylights introduces safety challenges. Skylights are inherently weaker points on a roof, and their presence increases the risk of falls during maintenance or inspection activities. OSHA tested safety bars are recommended to be installed in the curb to protect the opening during construction and over the life of the building.

Security

There is a concern that skylights provide an opportunity for break-ins. Security bars that also provide for fall protection are typically provided to mitigate this risk. Some skylights are tested and rated to meet UL-972 and considered to be burglar resistant. One issue is polycarbonate and other glazing materials may not maintain this rating overtime. For this reason we recommend fall protection/burglar bars be installed.



1M SF roof with smoke vents, no skylights and solar; skylights were removed to reduce heat gain

Potential Drawbacks of Skylights

Quality and Maintenance

Developers who own and operate their buildings for the long term may also have concerns with skylights because of on-going maintenance costs associated with skylight degradation of the dome material and deterioration of the frames and seals. These issues can be mitigated by specifying high quality materials, specifying frames appropriately, regular maintenance and longer warranties.

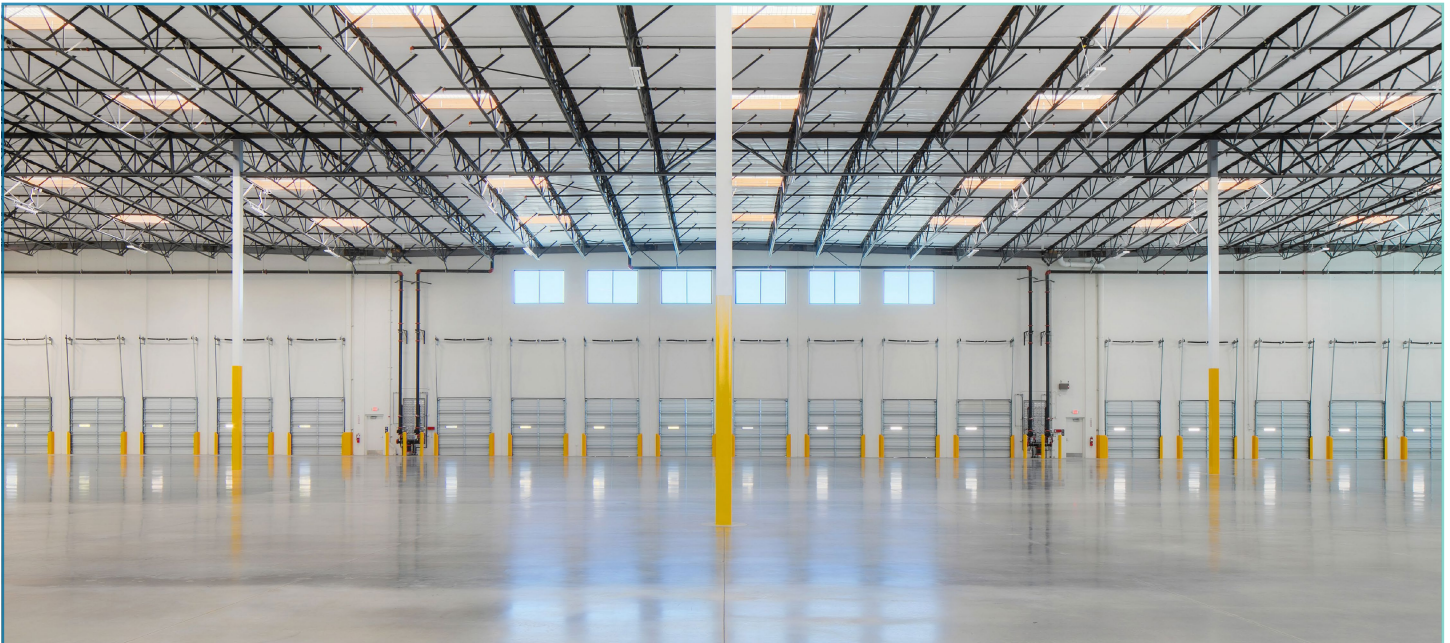
Reduced Rooftop Solar Area

With the growing adoption of rooftop solar panels, installing skylights reduces the available area for photovoltaic (PV) systems. For smaller buildings with more limited roof area the trade-off between skylights and solar panels shall be evaluated to align with energy strategies and long-term goals. In large buildings this is not a concern.

Increased Glare and Sensor Interference

Excessive natural light can introduce glare, which may interfere with the functionality of sensors and robotic systems commonly used in industrial facilities. This issue is particularly relevant for facilities with highly automated operations, where glare can disrupt productivity and require additional mitigation measures. Many tenants utilizing Automated Guided Vehicles (AGVs) have found that skylights are not an issue with operations. White glazed skylights are common in lieu of clear domes, reducing glare and providing defused lighting.

Automated facilities or areas of facilities that are not regularly occupied will not benefit from natural light so removing skylights over areas operated by robot or material handling equipment is an opportunity for value engineering. Some developers will install curbs in these areas for future use flexibility.



3% skylights, white painted walls, white scrim at roof and clerestory windows above dock doors

Building Code Requirements

We are often asked, "Aren't skylights required by Cal Green?" The answer is no, not always. There are standards in the Energy Code for minimum daylighting requirements in large enclosed spaces, see 140.3. Exception 3 typically applies to industrial buildings based on the maximum lighting power density being less than 0.5 watts per square foot. Specialized manufacturing facilities with tall clear heights may find that this exception is not possible.

The Fire Code has requirements for smoke and heat venting that vary based on the jurisdiction. In California smoke and heat vents are required for high pile storage areas where the travel distance exceeds 250' per Footnote h of the California Fire Code. The International Fire Code does not require smoke and heat vents when ESFR sprinklers are provided. When smoke vents are required the general rule is to assume 0.5% smoke and heat vents this will support average roof heights up to 45'. For taller buildings we recommend to assume 0.6% smoke vents for an average roof height up to 54' maximum.

And lastly, a few nuanced code notes for those who love the details. To improve heat gain smoke and heat vents can be provided with a solid lid. Smoke hatches and skylights have specific requirements in severe fire hazardous zones that shall be studied if applicable. California Assembly Bill, AB-98 requires skylights in at least 1 percent of the roof area, or equivalent LED efficient lighting.

No Skylights? Marketing a Dark Shell

If no skylights are provided, consider installing lighting to help market the building. One solution is to provide 20-30 foot candles in the speedbay and 1 foot candle throughout the remainder of the building. In California to achieve the 0.5 watts per square foot exception for daylighting, all of the lighting may be required to be installed.



Clerestory windows above dock doors

Clerestory Windows as Alternative

To address some of the challenges associated with skylights, clerestory windows offer an alternative. Positioned high on walls, clerestory windows allow natural light to enter while mitigating issues such as fall hazards and reduced rooftop area for solar panels. While clerestory windows can introduce natural light and enhance exterior aesthetics, their performance is often overestimated.

Our field experience has taught us that clerestory windows do not provide consistent daylighting throughout industrial spaces. Our observations are supported by our computer analysis, which found that skylights delivered more uniform and higher-quality daylight distribution compared to side illumination systems. Increased glare from clerestory windows is a concern, window coverings are a simple solution if needed to accommodate a tenants material handling systems.

In practice, clerestory windows do not offer the same lighting consistency or energy savings as skylights, particularly in large industrial buildings where ceiling height, building depth, racking, and equipment can further obstruct the reach of side lighting.

Clerestory windows do increase lighting at the perimeter, particularly in the speedbay when installed over dock doors. These areas often have concentrated occupancy. Clerestory windows in concert with skylights are a winning combination. We utilize clerestory windows in our designs to provide natural lighting, a connection to the outside and improved aesthetics with an understanding that they are not a substitute for skylights.

Conclusion

The decision to include skylights in warehouse and manufacturing building designs involves careful consideration of both benefits and drawbacks. While they provide valuable natural light and energy savings in many cases, potential issues such as increased HVAC loads, safety risks, and reduced rooftop solar capacity must be addressed. For projects on the west coast, understanding the unique climatic conditions is crucial to making informed design choices. By evaluating these options within the context of specific project requirements, architects and developers can create facilities that balance functionality, sustainability, and safety. If skylights will be utilized careful selection and design of skylights will maximized performance.

Market standards vary from no skylights, to skylights only in the speed bay, to 1% of the roof area to more than 2% of the roof area dependent on the area, building size and client.



Get in Touch

We'd love to hear from you. Whether you have questions, need support, or simply want to learn more about us, our team is here to help.

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