



—— The Power of ——
**DAYLIGHTING
SYSTEMS**

in Building Design



CIRALIGHT

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Introduction

Before the advent of electricity, the sun was our primary source of light, and out of necessity, buildings were designed with this in mind. Structures were oriented in relation to the sun's position in the sky, and windows and doors were positioned to allow the maximum amount of light to enter. While these strategies are still in play with present-day architectural design, electrical lighting has made daylighting less of a priority.

However, a combination of financial, cultural, and environmental factors are now bringing the pendulum back in the direction of daylighting in order to reduce our dependence on fossil fuels. In addition to the traditional methods of harnessing daylight, new technologies can be utilized to maximize natural light and minimize the use of electricity.

For architects, lighting strategies are just one of many components that go into building design, and it is too often an after-thought that is contracted out to a lighting designer who has to work within existing plans. By taking a more holistic approach that includes developing a daylighting strategy early in the design process, both architects and their clients can benefit from more sustainable structures, less expensive lighting, and a better occupant experience.

This eBook outlines **what** daylighting is, **why** architects should embrace it, and **how** to select the right daylighting systems for specific projects. After reading this eBook you should be armed with the necessary information to convince reluctant clients that investing in daylighting systems will benefit them in multiple ways throughout the lifetime of the building.

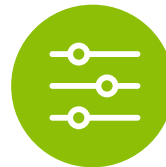
The Importance of Daylighting in Architectural Design

The definition of daylighting is the controlled admission of natural light into a building to reduce electric lighting and conserve energy. However, daylighting is not as simple as putting in a few skylights and assuming that the building occupants will have as much natural light as they want or need.

Daylighting requires a more comprehensive strategy that encompasses several methods of lighting, including:



Building orientation and siting



Daylight-responsive lighting control systems



Apertures such as windows, doors, and skylights



Energy-efficient lighting fixtures and bulbs



Glazing or shading on apertures to diffuse direct sunlight



Interior design that optimizes daylighting

The potential adverse effects of allowing natural light into a building must also be considered. For example, if measures are not taken to prevent it, solar heat gain from direct sunlight can increase the temperature inside the building and impact thermal comfort. Similarly, apertures that allow heat to escape in winter can increase heating costs during the cooler months. Direct sunlight can also cause undesirable glare for building occupants at certain times during the day.

Architects and building owners are inclined to adopt a good daylighting strategy for a number of reasons such as reducing energy use to save money, minimizing their carbon footprint, improving the experience for building occupants, and receiving a favorable return on investment. Fortunately, data supports all of these objectives.



Energy savings

According to the U.S. Energy Information Administration (EIA), in 2014, about 262 billion kWh were used for lighting in the commercial sector. This represents about 19% of the commercial sector's electricity consumption and is the largest percentage of energy use in commercial buildings, closely followed by heating and cooling. Taking measures to reduce the energy consumed by lighting has the potential to make a significant impact on the overall energy consumption of commercial buildings.

A good lighting strategy can help reduce the amount of energy used, without sacrificing comfort or functionality.

For example, the U.S. Department of Energy designed their Thermal Test Facility in Golden, Colorado to maximize daylighting. It is estimated that the building uses 75% less energy for lighting and an additional 10 - 20% less energy for cooling. If all buildings were designed in this way, the energy profile of the commercial sector would change dramatically. Of course, individual results vary based on the building's design, location, and how it is used, but it is clear that significant energy savings can be generated with daylighting.

From an operational perspective, any reduction in electricity consumption translates to financial savings, a benefit that every client will appreciate.

“Lighting in the commercial sector was responsible for over 150 million tons of CO2 emissions in 2013.”



Carbon footprint reduction

A reduction in energy consumption goes hand-in-hand with a decrease in carbon emissions. According to the EIA's Annual Energy Outlook 2015, lighting in the commercial sector was responsible for over 150 million tons of CO2 emissions in 2013 – this is projected to decline, but at a very slow pace if current building practices continue.

Additional information from the 2011 Buildings Energy Data Book shows that in 2010, total greenhouse gas emissions from residential and commercial buildings in the United States accounted for about 40% of total U.S. carbon dioxide (CO2) emissions and 7% of global CO2 emissions. This is more than the CO2 emissions for both industry and transportation. Fortunately, it is also an area where architects can make a difference with smart lighting design.

Incorporating daylighting strategies is one way to make a meaningful impact on carbon emissions created by electricity production.

Occupant satisfaction

In addition to delivering energy savings and lower carbon dioxide emissions, daylighting has also been shown to provide a better occupant experience, which often translates to measurable financial benefits for building owners.

The data that supports daylighting as a strong contributor to occupant satisfaction ranges across multiple sectors:

Retail

The California Energy Commission (CEC) published a report indicating that more hours of daylight in a retail store are strongly associated with increased sales, ranging from 6 - 40%. Employees also reported higher satisfaction with lighting quality conditions in the stores that used daylighting. In another study performed by Pacific Gas and Electric, one retail chain experienced 40% higher sales in stores with skylights.



Education

Daylighting in Schools, a report prepared for Pacific Gas and Electric, stated that students in classrooms with the most daylighting were found to have 7 - 18% higher test scores than those in classrooms where less natural light was available. A follow-up study for the CEC, Daylighting in Schools: Reanalysis Report, supported these findings identifying a 21% improvement in student learning rates in daylit classrooms.

Corporate

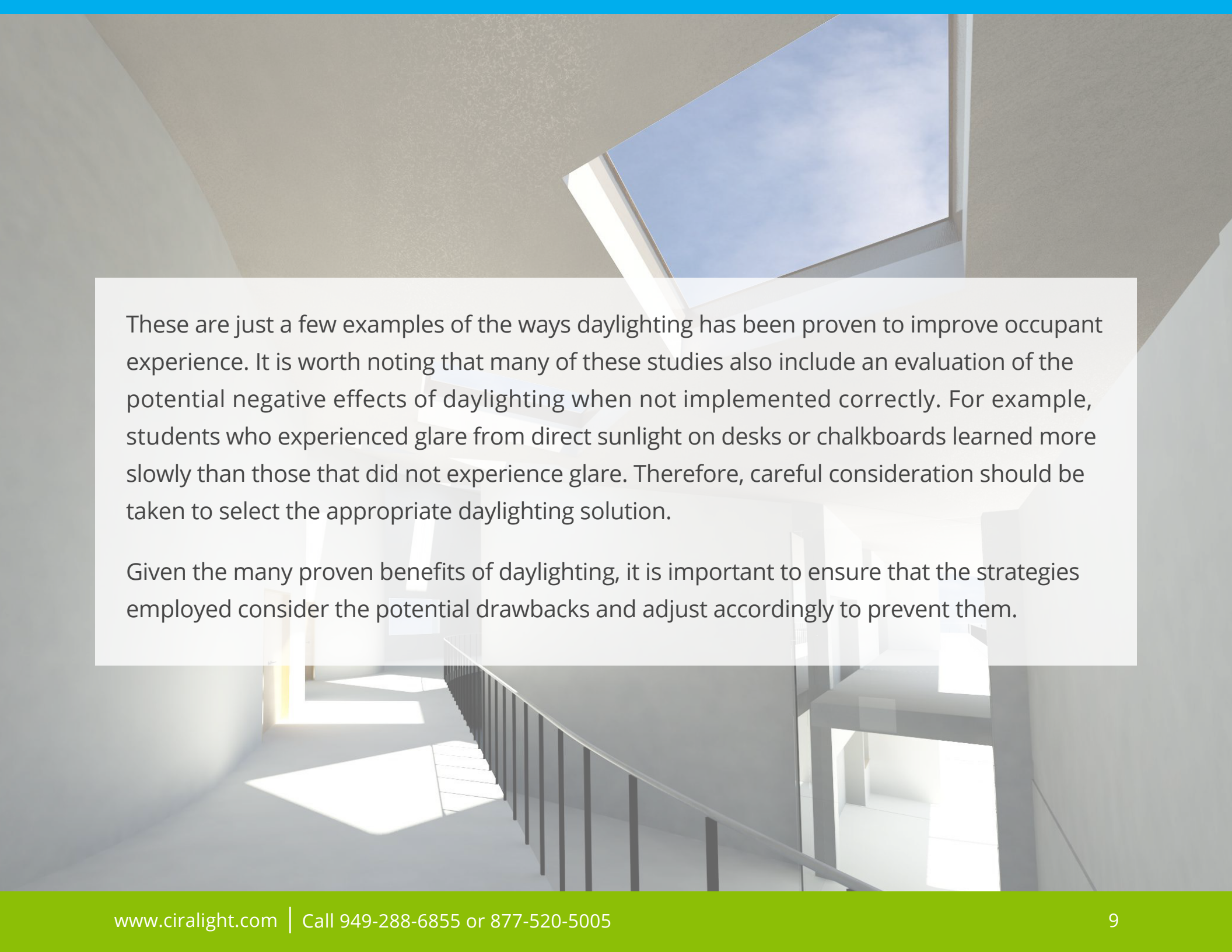
A Carnegie Mellon University report that compiled data from multiple case studies showed that daylighting can increase worker productivity by an average of 5.5% and with a potential improvement of up to 40%. The report also stated that daylighting can provide annual productivity gains equal to \$2,475 per employee.

Additionally, The Verifone Company has reported a drop in worker absenteeism of 40 - 45% after implementing a daylighting strategy as part of its Costa Mesa Experiment.

Healthcare

Researchers at Texas A&M University published a study that evaluated the relationship between daylighting and patient recovery in hospitals. The study concluded that patients in rooms with more daylight had shorter hospital stays than those in rooms with less daylight.





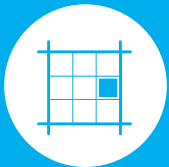
These are just a few examples of the ways daylighting has been proven to improve occupant experience. It is worth noting that many of these studies also include an evaluation of the potential negative effects of daylighting when not implemented correctly. For example, students who experienced glare from direct sunlight on desks or chalkboards learned more slowly than those that did not experience glare. Therefore, careful consideration should be taken to select the appropriate daylighting solution.

Given the many proven benefits of daylighting, it is important to ensure that the strategies employed consider the potential drawbacks and adjust accordingly to prevent them.

Return on investment

One common thread in all of the above sections – energy savings, carbon footprint reduction, and occupant satisfaction – is financial savings. However, the initial cost of implementing daylighting must be considered when evaluating the return on investment.

The payback period for a daylighting strategy varies on a case-by-case basis, but the calculation can be performed for any project. Determining the ROI for daylighting requires evaluating factors such as:



Total square footage
of the building



Hours of operation



Hours and level of
daylight provided



The type of fixtures
and bulbs used



Energy costs associated
with lighting

With all the right information in hand these numbers are not difficult to estimate, so architects can provide realistic numbers to clients for easy decision-making. It is important to remember that the payback period is even faster when the calculation includes intangible benefits such as increased productivity, higher sales, and other positive impacts associated with daylighting.

Benefits of Daylighting for Architects

All of the data outlined above shows clear benefits for building owners and occupants. However, architects and engineers can also take advantage of the many merits of daylighting.

Return on Investment

All architects struggle with finding the balance between project goals, budgets, and design aesthetics. Many clients are focused on reducing construction costs and trimming expenses whenever possible, particularly in the commercial sector where both budgets and timelines are clearly defined and enforced. Although implementing a daylighting strategy might cost more upfront, architects have the power to show building owners that using the right combination of smart design, high-performance

windows, skylights, and responsive lighting controls can actually save money in the long run and reduce operating expenses over the life of the building.

The latest technology in daylighting systems also allows shorter payback periods, and when combined with other technology like solar panels, daylighting contributes to net-zero energy consumption, which allows clients to virtually eliminate energy costs. Having the ability to demonstrate a clear, predictable payback period for building owners allows architects to leverage new technologies to deliver the best possible results.

Sustainable design

With buildings (both commercial and residential) responsible for 40% of the total carbon dioxide emissions in the U.S., architects have the power to make a meaningful impact by committing to design strategies which reduce energy use. The architecture industry has responded to this reality with initiatives like Architecture 2030, a program designed to help architects meet energy and emission reduction targets and achieve carbon neutrality in the building sector by 2030.

Employing strategies which maximize natural light and using the most advanced technology in daylighting systems shows an architect's commitment to preserving the planet, and positions them as a leader in the world of sustainable design.

“Daylighting is a significant component of any sustainable building certification, so it is important for architects to be aware of not just the design tactics that increase natural light, but also the products that can help harness it.”

Certifications and benchmarks

The ability to design structures that are eligible for energy efficiency certifications such as LEED and Passive House gives architects an edge over the competition. More and more, individuals and companies are interested in net-zero buildings that produce as much energy as they consume. Sustainable design is becoming not just desirable but necessary as building owners have higher expectations for performance.

Retailers gain consumer loyalty by investing in sustainable initiatives; schools that meet Passive House standards demonstrate the importance of sustainability for the next generation; and companies show their commitment to employees by creating healthy building workspaces that consider their comfort and workplace environment. These are just a few examples of why people are increasingly turning to architects for sustainable design that meets measurable standards. If you are not prepared to meet that demand, potential clients will continue searching until they find an architect who is.

Daylighting is a significant component of any sustainable building certification, so it is important for architects to be aware of not just the design tactics that increase natural light, but also the products that can help harness it. High-performance windows, active skylights, and responsive lighting controls are just a few examples of the new technologies that can play a role in reducing artificial lighting and optimizing natural light.



Satisfied clients

Everybody knows that the best form of marketing is word-of-mouth referrals.

When people talk to their friends, families, and colleagues about their experiences with a product or service provider, the information resonates far more than an advertisement. When architects design buildings that help owners save money, reduce their environmental impact, and optimize the occupant experience, those clients are more likely to recommend their services.

Case studies are another powerful method of demonstrating client satisfaction. For new constructions, images of bright, airy spaces along with client testimonials about low energy bills can draw the attention of new customers in the same sectors. Showing before-and-after pictures of a commercial renovation in combination with an analysis

of the money saved by implementing day-lighting will attract new clients who want to achieve the same results.

All architects know that their interactions with the client during the design process are just as important as the final building results. By working together closely to create a day-lighting strategy that meets their functional needs while also reducing energy costs, you can create a lasting relationship that will pay dividends for years to come.



How to Choose The Best Daylighting Option

Incorporating effective daylighting in a building requires a comprehensive design strategy that must be identified early in the process. Architects and engineers must remember several general considerations to achieve daylighting objectives in any project. They should also consider some specific strategies that are applicable to either new construction or retrofits.

General considerations

Building science has come a long way in the past several decades. Incorporating a few key points into a building's design will ensure that occupants have the opportunity to maximize daylighting for the life of the building. Some of the factors to consider include:



Building orientation

A foundation that optimizes exposure to the North and South (with the largest façade facing South) and minimizes exposure to the East and West will provide the best position for daylighting.



Floor depth

Limiting floor depth to 60 feet or less from North to South will provide the optimal interior size.



Window-to-wall ratio

Balancing the number of openings relative to wall area is critical for maintaining thermal performance. The specific ratio will depend on the local climate and the performance of the glazing system, which is measured by its R-value.



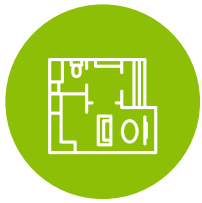
Toplighting

Skylights allow light to enter the building from above, either actively or passively. Much like windows, design considerations include thermal protection, glazing, size, and position.



Balancing heat gain and loss

Because admitting sunlight directly into a building also has the potential to allow heat to enter, and apertures might allow heat to escape, measures must be taken to prevent too much heat gain or loss. Overhangs for shading, diffuser lenses for skylights, and window shades are all possible methods that can be employed. The National Fenestration Rating Council sets standards to measure and compare the thermal performance of windows, doors and skylights. Consumers should request to see the thermal ratings of such items when considering the different options.



Interior layout

The location of interior walls, height of partitions, and placement of large furniture can impact how natural light enters a room. The interior layout of your building could cause some areas to be shaded. Some buildings may even require supplemental artificial light.



Room surfaces

The color and surface type of walls and other large objects in a room can have an impact on the overall daylighting strategy. For example, light-colored and reflective surfaces can be leveraged or avoided to deliver a balanced light level in the space.



Privacy and security

Windows and doors that allow light into buildings also present potential security risks, and depending on their location, can create privacy issues. Using certain types of glazing and shades can help mitigate these risks, but often require aesthetic sacrifices or limit the amount of light that can enter the space. Incorporating skylights introduces fewer security and privacy risks while allowing light to penetrate more areas of the building.

Bearing all of these considerations in mind throughout the design process will help ensure an intelligent daylighting strategy that optimizes natural light without sacrificing thermal comfort.

New design

New construction projects have the benefit of starting with a blank slate. Of course, each site presents its own challenges and limitations, but unlike a retrofit, the architect will have some control over building orientation to maximize Southern and Northern exposures. The designer also has the power to decide where to place the various elements on a roof to optimize placement of skylights, how deep to make the floors, and all of the other factors that go into a good daylighting strategy.

When designing a new building, it is important to use an integrated approach to ensure all parties are on the same page about the daylighting strategy. Engaging engineers and other consultants early in the design process will ensure that they understand the project goals and can adjust their

calculations accordingly. For example, if a professional who is determining the cooling load of a building knows the intent behind design decisions, considers that the building occupants will not be turning on electric lights for the majority of the day, and has the Solar Heat Gain Coefficient and U-value for all windows and skylights, they can make a more accurate determination that will likely produce a smaller cooling load.

As with any other component of the project, it is important to include specific daylighting technologies in the project specifications along with manufacturer recommendations and detailed installation instructions.



Retrofits

Retrofitting an existing structure always comes with challenges, especially if the objective is to make an older structure more energy efficient. Some of the limitations that might arise when creating a daylighting strategy include the pitch of the existing roof, placement of mechanical systems, existing floor depth, and structural elements that influence interior layout.

Code challenges can also play a role in how the daylighting strategy is developed. For example, the fire code might require an entire wall to have no windows or other openings. If that wall happens to be oriented to the South, utilizing other natural light sources, such as skylights, will be the only viable option for maximizing daylight.

Because there are so many potential design challenges with a building retrofit, the

specifications of a system are even more important. In the above example, skylight selection is critical if the goal is to harness as much natural light as possible. Using active skylights that are designed to track the sun as it moves through the sky will dramatically increase the number of hours that artificial lighting can be avoided for any type of project.

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Conclusion

By using smart daylighting strategies that leverage modern technology, architects have the potential to make a meaningful difference in multiple ways. Daylighting reduces energy consumption, minimizes the carbon footprint of a building, and perhaps most importantly for clients, can produce a measurably fast return on investment.

One of the most effective ways to reduce the use of electrical lighting is with solar tracking skylights that employ a sophisticated solar-tracking GPS system to position mirrors that track and direct natural light down through diffuser lenses into a building. Depending on the building location and other factors, active skylights can deliver ten or more hours of abundant off-the-grid natural lighting anywhere in the world.

By reducing or eliminating the need for electrical lighting throughout the day, the return on investment for solar tracking skylights can be achieved in just two to four years, which is just a fraction of the payback period for skylights on the market.

If you are currently working on projects that would benefit from daylighting with active skylights, use the [Ciralight ROI Calculator](#) to estimate how long it will take your clients to see a return on their investments.



With Ciralight SunTrackers, your clients get superior lighting, the benefits of lower energy consumption with up to 80% cost savings, and a better occupant experience. As an architect or engineer, you get the benefits of clearly demonstrating a commitment to sustainability, increasing your ability to achieve important certifications, and generating more work through satisfied clients.

To learn more about Ciralight and our award-winning SunTrackers, [visit our website](#) or [contact us](#) today to speak with a product specialist.



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