



# EXPLORING DAYLIGHTING

AN INTRODUCTORY PERSPECTIVE  
ON ROOFLIGHTS

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## 1. INTRODUCTION

Daylight is a free and invaluable natural resource for human beings.

The positive impact of daylight on our circadian rhythms has only been thoroughly studied in recent decades. However, with Europeans spending about 90% of their time indoors, the significance of daylight in shaping the built environment cannot be overstated.

The benefits of integrating daylight into building design extend beyond health and well-being, offering improvements in comfort, energy efficiency, and overall quality of life.

Daylighting reduces reliance on electric lighting, contributing to lower energy bills and a reduced environmental footprint. Furthermore, natural light enhances architectural aesthetics, creating spaces that are both beautiful and functional.

In this paper, we explore the potential of integrating natural lighting via rooflights in buildings, highlighting how it enhances occupants' quality of life, creates beautiful and comfortable spaces, and supports energy-efficient practices.

## 2. HARNESSING THE POWER OF DAYLIGHT FOR BETTER LIFE QUALITY

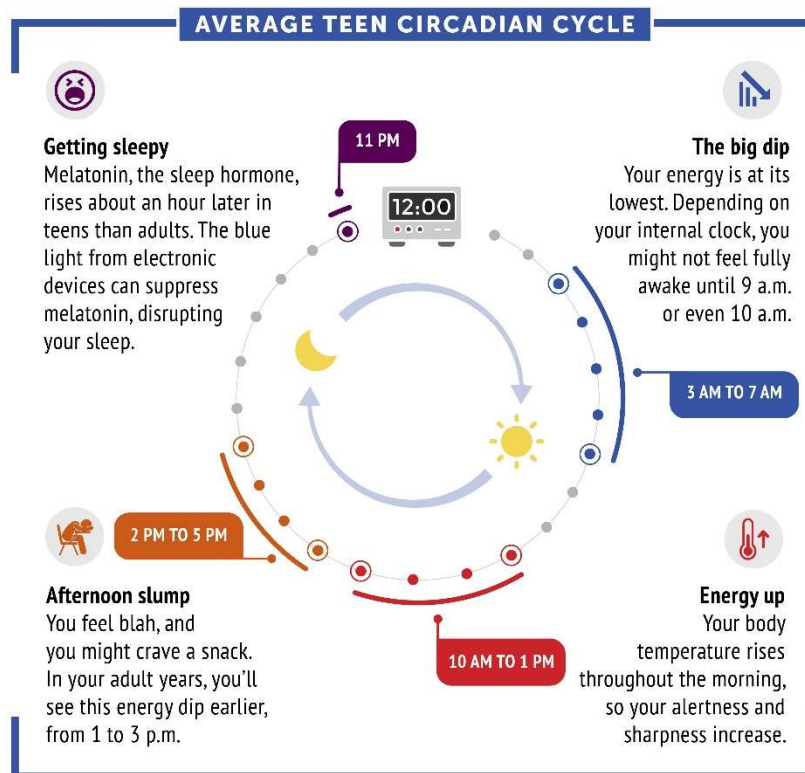
The importance of daily exposure to daylight has been increasingly emphasised in the past decade. Natural light encompasses a rich spectrum of colours that significantly impact our non-visual systems and circadian rhythm.

However, in modern societies, individuals spend about 90% of their time indoors and often fail to receive sufficient daily light exposure.

**Rooflights** channel daylight into buildings, fostering a connection to the outdoors and creating an indoor environment that promotes well-being and comfort.

### 2.1. HEALTH & WELL-BEING

Daylight acts as the primary regulator of our circadian rhythms, synchronising our internal clock with the natural day-night cycle. It influences the production of hormones such as melatonin and cortisol, which are crucial for concentration, learning, creativity, mood, and maintaining healthy sleep-wake patterns.



Circadian rhythm cycle of a typical teenager

Credit: [National Institute of General Medical Sciences](#)

## PSYCHOLOGICAL BENEFITS



Credit: [iStock](#)

Scientific evidence<sup>1</sup> indicates that inadequate light exposure is linked to diminished well-being and health, leading to compromised sleep quality, lowered mood, decreased energy levels, and impaired social interactions.

Exposure to natural light during the day helps synchronise our internal body clocks, enhancing alertness, improving mood, and optimising cognitive performance.

Morning light, in particular, serves as the most crucial signal for aligning our 24-hour circadian rhythms. Conversely, reduced light exposure in the evening aids in promoting restful sleep during the night.

Studies<sup>2 3</sup> highlight the connection between ample daylight exposure and increased productivity, creativity, and overall satisfaction in various environments, from workplaces to educational settings.

**Elevated mood:** Daylight exposure stimulates the release of serotonin, a neurotransmitter associated with feelings of happiness and well-being. As a result, incorporating natural lighting into architectural designs can foster a positive mental

<sup>1</sup> [Time spent in outdoor light is associated with mood, sleep, and circadian rhythm-related outcomes: A cross-sectional and longitudinal study in over 400,000 UK Biobank participants - ScienceDirect](#)

<sup>2</sup> [Daylight and School Performance in European Schoolchildren - PMC \(nih.gov\)](#)

<sup>3</sup> [Daylight and Productivity - A Field Study \(researchgate.net\)](#)

state, alleviating conditions such as Seasonal Affective Disorder (SAD), depression, sleep disturbances, and irritability. People in naturally lit environments often report higher levels of contentment and a more positive outlook on life.

**Increased efficiency:** Research shows that natural lighting can boost productivity and cognitive function. Employees in well-lit environments exhibit higher levels of focus, improved decision-making skills, and less fatigue. Enhanced visibility and reduced eye strain contribute to better work performance and fewer errors.

**Reduced stress:** Numerous studies<sup>4</sup> indicate that natural light can mitigate stress and anxiety. Individuals who spend time in naturally lit spaces tend to report lower stress levels and increased feelings of relaxation throughout the day. Natural light can reduce the body's production of stress hormones, leading to a calmer and more balanced state of mind.

**Enhanced Sleep Quality:** Exposure to natural light during the day helps regulate circadian rhythms, resulting in better sleep quality at night. Morning light exposure, in particular, helps set the body's internal clock, making it easier to fall asleep at night and wake up refreshed. Improved sleep quality is closely linked to better overall health and well-being.

**Increased Energy Levels:** Natural light exposure helps combat fatigue and boosts energy levels throughout the day. The invigorating effect of daylight keeps the body alert and energised, reducing the likelihood of midday slumps or feelings of lethargy.

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<sup>4</sup> [The impact of daytime light exposures on sleep and mood in office workers \(researchgate.net\)](https://www.researchgate.net/publication/321111111)

## PHYSIOLOGICAL BENEFITS



Credit: [iStock](#)

Among the various health advantages of natural light, the most well-known is its role in initiating the production of vitamin D within the body.

When UVB rays penetrate the human skin, they interact with proteins, leading to the synthesis of vitamin D<sub>3</sub>. While individuals can obtain vitamin D through their diet and supplements, daylight serves as a crucial source of this essential nutrient.

Vitamin D plays a pivotal role in numerous biological processes within the body, including the maintenance of healthy bones, regulation of calcium levels, reduction of inflammation, and support of the immune system and glucose metabolism.

Researchers<sup>5</sup> have observed a correlation between sun exposure and lower blood pressure levels, resulting in decreased mortality rates from cardiovascular conditions. They propose that exposure to daylight prompts the skin to release nitrogen oxides, which induce the dilation of arteries, thereby lowering blood pressure and potentially mitigating the effects of metabolic syndrome. Additionally, according to other studies<sup>6</sup>, increased sun exposure may offer protection against various diseases such as type 1

<sup>5</sup> [Sunlight exposure and cardiovascular risk factors in the REGARDS study: a cross-sectional split-sample analysis - PMC \(nih.gov\)](#)

<sup>6</sup> [Sunlight and mortality from breast, ovarian, colon, prostate, and non-melanoma skin cancer: a composite death certificate based case-control study - PMC \(nih.gov\)](#)



diabetes, multiple sclerosis (MS), and several types of cancer, including colon, breast, and prostate cancer.

### IMPACTS OF DAYLIGHT ON PATIENT AVERAGE LENGTH OF STAY (ALOS)



Credit: [iStock](#)

Integrating daylight in the design process of healthcare facilities, both hospitals and healthcare centres, remains a key tool, not only to reduce their energy bills and enhance their indoor environment, but also to maximise physiological advantages for patients and residents.

With a focus on delivering optimal healthcare experiences for patients, hospitals are increasingly acknowledging the influence of the physical environment on patient well-being.

A significant consideration in this regard is the inclusion of natural light, which has been noted to offer a multitude of advantages for patients.

Researches<sup>7</sup> demonstrated that patients with beds next to the window, exposed to daylight had shorter length of stay than did those next to the door. Being exposed to light had a faster effect than did taking antidepressants. It was reported that it took at least 4-6 weeks for an antidepressant to show its effect in seasonal depressive disorders (SAD), whereas light could decrease depressive symptoms within 2 weeks.

<sup>7</sup> [Impacts of indoor daylight environments on patient average length of stay \(ALOS\) in a healthcare facility - ScienceDirect](#)



## PERFORMANCE AND PRODUCTIVITY IN WORKPLACES AND EDUCATIONAL FACILITIES



Credit: [iStock](#)

In professional settings, such as workplaces and educational facilities, the benefits of incorporating natural light extend beyond health considerations.

The presence of ample daylight has been linked to increased productivity and better performance among employees and students alike.

Research has shown that individuals working or studying in well-lit environments tend to be more focused, motivated, and alert. They exhibit improved cognitive function, enhanced creativity, and reduced absenteeism<sup>8</sup>.

In workplace environments, employees often report higher job satisfaction and increased job performance, resulting in enhanced overall productivity.

Moreover, in educational institutions<sup>9</sup>, students exposed to natural light tend to perform better academically, with higher test scores and greater engagement in the learning process.

<sup>8</sup> [Daylight and Absenteeism - Evidence from Norway | PDF](#)

<sup>9</sup> [Daylighting in Schools An Investigation into the Relationship Between Daylighting and Human Performance](#)

## SAFETY IN A WORKPLACE



Credit: [iStock](#)

Depending on the task and use, complex demands are placed on the design of effective lighting of a workplace.

Lighting design shall therefore be done in a way that the requirements of people in terms of vision, wellbeing and non-visual effects are met as comprehensively as possible. This applies in particular to **health and safety in the workplace**.

Adequate daylighting reduces the likelihood of accidents by providing better visibility, enabling employees to navigate their surroundings with greater ease and awareness.

Enhanced visibility decreases the risk of slips, trips, and falls, which are among the most common workplace accidents. Moreover, exposure to natural light has been shown to regulate circadian rhythms, promoting alertness and reducing the occurrence of fatigue-related incidents.

## DAYLIGHT AND RETAIL SALES



Retailers have recognised the strategic value of natural light in shopping centres to enhance the overall shopping experience, captivate customers, and encourage them to explore products with greater interest.

A well-designed interior that incorporates natural daylight increases customer satisfaction and can potentially boost sales.

While daylight is not the sole consideration when designing a shopping centre, the correlation between natural daylight and retail profits is significant. It allows retailers to maximise the psychological and physiological benefits of natural light on consumers while optimising energy bills.

Effective daylighting design creates a welcoming and inviting atmosphere, attracting foot traffic, encouraging prolonged stays, and fostering customer engagement, ultimately leading to more opportunities for sales conversions.

A study conducted in 1999<sup>10</sup> <sup>11</sup> found that retail spaces lit with daylight experienced a sales increase of over 40% compared to similar spaces selling comparable products without natural light.

Daylight elevates the mood and provides a sense of well-being among shoppers, potentially influencing their purchasing decisions positively.

<sup>10</sup> [Skylights and Retail Sales PG&E 1999 \(researchgate.net\)](https://www.researchgate.net/publication/312511111)

<sup>11</sup> [Daylighting and Productivity in the Retail Sector \(aceee.org\)](https://www.aceee.org/publications/daylighting-and-productivity-in-the-retail-sector)

## 2.2. ARCHITECTURAL AESTHETICS

The use of natural light is one of the most critical aspects of architecture in non-residential buildings. Designers introduce daylight into their building designs to enhance the visual appeal of large spaces.

Strategically optimising the dispersion of natural light throughout a building, using rooflights and other transparent elements, maximises daylight penetration and distribution.

This modern approach not only provides effective illumination for large indoor spaces but also allows designers to seamlessly integrate the outdoors with the interior. The interplay of light and shadow adds depth and texture, enriching the visual experience of the space.



Credit: [Shutterstock](#)

Daylight is not only a free and sustainable resource but is also rich in vibrancy and colour. Its dynamic qualities and aesthetic benefits make it a favourite among designers.

Well-daylit non-residential buildings bring feelings of spaciousness and connection to the natural world. These qualities, often associated with high design standards, foster an uplifting mood that enhances both physical and mental well-being.

## 2.3. ENERGY EFFICIENCY

Rooflights are not only a source of natural lighting but also significantly enhance a building's energy efficiency.

By harnessing daylight, they reduce reliance on electric lighting during the day, cutting lighting energy consumption. Additionally, rooflights contribute to passive solar heating in winter while mitigating overheating in summer.

This dual role in reducing lighting, heating, and cooling demands makes rooflights a cost-effective solution for designing sustainable and energy-efficient non-residential buildings.

As energy prices rise and regulations become increasingly stringent, optimising natural light is essential for reducing energy consumption and minimising a building's environmental impact.

### CASE STUDY: INDUSTRIAL BUILDING

A study<sup>12</sup> on energy consumption and overheating in an industrial building in the UK estimated that covering 12% of the roof area with rooflights could reduce electricity usage by up to 70%.

The combination of ridge ventilation and lighting controls significantly decreased overheating hours by dissipating internal heat through ridge openings and minimising lighting-related heat gains.

Furthermore, applying both lighting controls and ridge ventilation resulted in an overall CO<sub>2</sub> reduction of approximately 45%, accounting for energy savings in both electricity and heating.

The implementation of opening rooflights for building ventilation is a significant step toward energy savings, combating climate change, and addressing overheating.

Natural ventilation through roof openings improves indoor air quality while significantly reducing reliance on energy-intensive Heating, Ventilation, and Air Conditioning (HVAC)

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<sup>12</sup> [A case study on energy consumption and overheating for a UK industrial building with rooflights - ScienceDirect](#)



systems. This approach cuts electricity consumption and lowers greenhouse gas emissions.

With growing concerns about environmental sustainability and the urgent need to reduce carbon footprints, innovative solutions like opening rooflights with automatic controls offer a cost-effective strategy for creating energy-efficient, environmentally conscious, and socially responsible non-residential buildings.

## 2.4. VISUAL COMFORT

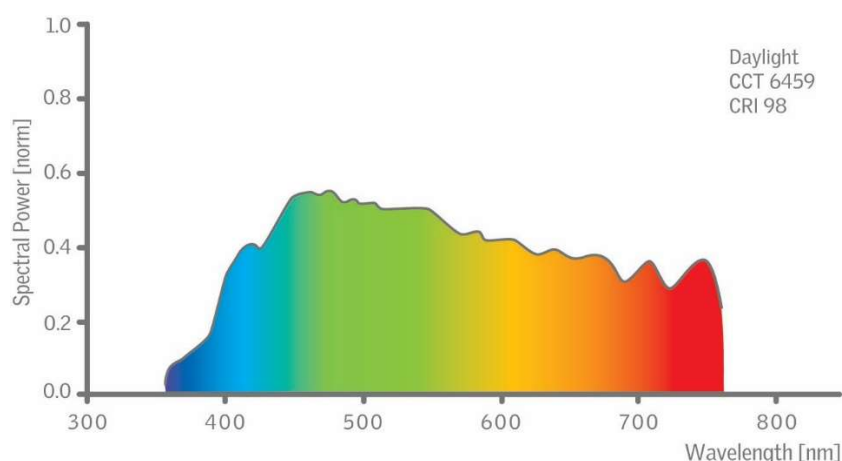
### ADVANTAGE OF DAYLIGHT PROPERTIES

The sun generates outdoor illuminance levels ranging from approximately 3,000 lx on cloudy winter days to 100,000 lx on sunny summer days.

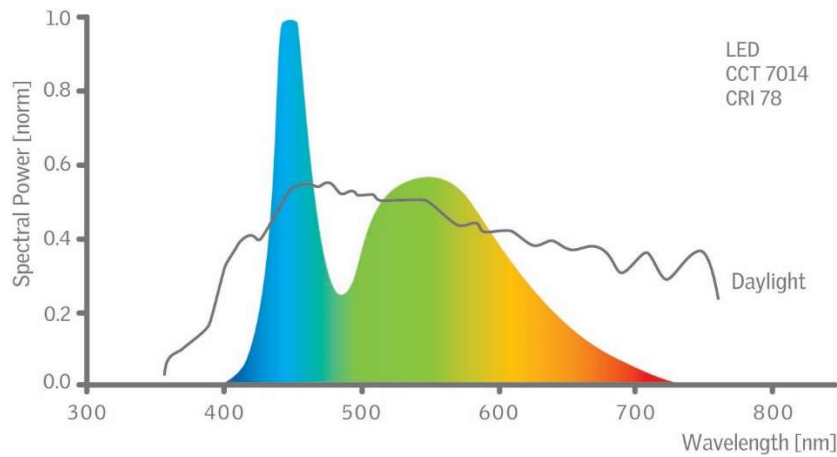
Daylight undergoes changes throughout the day and is influenced by cloud cover.

In contrast, electric light remains constant throughout the day and night, and typically provides indoor illuminance levels between 100 and 1,000 lx.

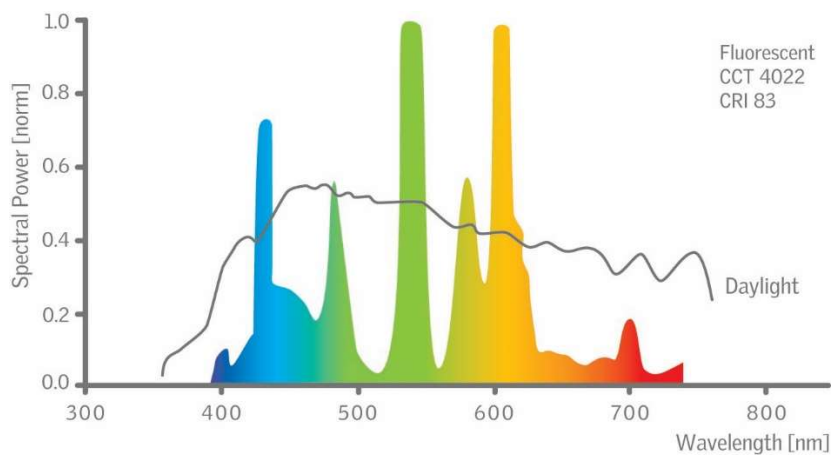
The human eye is adapted to the comprehensive spectrum of visible solar radiation. Due to its composition and dynamics, daylight provides the levels of light necessary for biological functions when compared to typical electric light sources.



*Spectral composition of daylight*



*Spectral composition of LED light source*



*Spectral composition of fluorescent light source*

Source: [Daylight and energy efficient design | Velux](#)

Although some electric light sources (like halogen, fluorescent, and LED) are being engineered to approximate daylight spectra, none replicate the variances in the light spectrum observed with daylight across different times, seasons, and weather conditions.

## COLOUR RENDERING

Colour rendering is the ability of a light source to accurately reproduce the colours of objects within a space, influencing how we perceive our surroundings and the objects within them.

Daylight provides excellent colour rendering, meaning it accurately represents the colours of objects.



The spectrum of natural light encompasses a wide range of colours, and the changes in colour temperature from sunrise to sunset contribute to the diverse visual experiences. While electric light works to mimic the colour of daylight, achieving the same level of colour rendering remains a challenge.

Generally, the human eye is more adaptable to luminance variations in spaces lit by daylight compared to electric lighting, emphasising the importance of a well-designed daylighting system for optimal visual comfort within buildings.

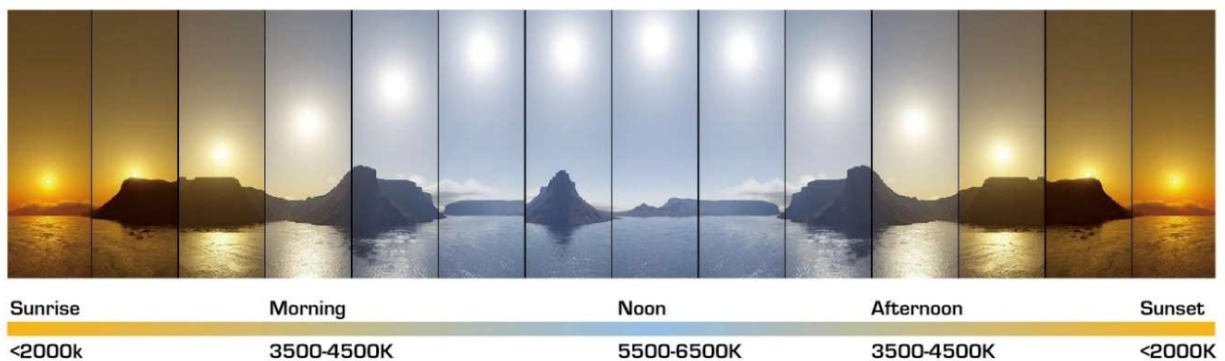
Achieving a balance in daylighting that considers both physical (like luminance) and non-physical parameters (such as user perception) is essential for efficient daylighting and visual comfort.

### COLOUR TEMPERATURE OF LIGHT

Colour temperature characterises the tone of visible light by comparing it to the light emitted by a theoretical opaque, non-reflective object.

The temperature of this theoretical emitter that closely matches the observed colour defines the colour temperature of the light source. Typically measured in kelvins (K), a unit for absolute temperature, colour temperature indicates the warmth or coolness of light.

Light sources with colour temperatures exceeding 5000 K are referred to as "cool colours," exhibiting bluish tones, while those with lower temperatures, typically between 2700–3000 K, are termed "warm colours," displaying yellowish hues.



Source: [Lumistrips](#)

*Colour temperature scale of daylight*

Cool lighting, typically falling within the range of 4000K-6500K, enhances alertness and wakefulness, making it ideal for daytime activities or in environments requiring focus, such as offices and classrooms. Exposure to blue light in the morning can aid in resetting the body's circadian rhythm.

Warm lighting, typically ranging from 2700K-3000K, fosters a cosy and tranquil atmosphere, making it suitable for nighttime use or in areas where relaxation is desired, such as bedrooms or living rooms. Exposure to warm lighting in the evening can promote better sleep and facilitate winding down after a hectic day.

## GLARE

Daylight will always be the most comfortable for human beings since it is the source of illumination to which our eyes adapt naturally. However, both too little and too much light can cause visual discomfort.

Significant changes in light levels or sharp contrast (which is perceived as glare) can cause stress and fatigue as the human eye is permanently adapting. Adequate lighting increases visual performance but also adapts better to our circadian and perceptual systems, minimising eye strain, eye irritation, and headaches.

The designer's objective remains to integrate daylight and electric light to ensure sufficient and uniform illuminance in all interior areas that are in constant use.

Glare can be prevented by careful design and use of more diffusing materials. Maintaining an ideal brightness level, ensuring glare-free perspectives, and uniform indoor illuminance significantly impact occupants' visual satisfaction.

### 3. SMART LIGHTING – MAXIMISATION OF DAYLIGHT

Opening rooflights have become popular in modern building design, as they allow for the adaptation of lighting levels based on daylight availability, as well as the automatic control of daily ventilation.

The integration of opening rooflights equipped with sensors enables occupants to benefit from the optimisation of energy consumption by illuminating spaces with electric lighting only when and where required.

Smart lighting leads to substantial cost savings for businesses by minimising energy consumption, concurrently lowering electricity bills.

The constant evolution of technology and its integration into building design is revolutionising the market, while paving the way for the creation of beautiful, energy-efficient spaces and reduced operational costs.

## 4. SUMMARY

The integration of daylight into building design offers numerous benefits, including health improvements, energy savings, and enhanced aesthetics.

Rooflights, as key sources of natural light, are crucial in creating spaces that support well-being and sustainability.

Automation ensures that electric lighting is only activated when needed, working in harmony with the varying levels of daylight throughout the day.

In an era where functionality and energy efficiency are paramount, rooflights serve as cost-effective elements, fostering a harmonious balance between architectural integrity and environmental responsibility.



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