



HUMAN-CENTRIC LIGHTING: HOW THE DESIGN OF THE BUILDING ENVELOPE CAN BRING LIGHT TO LIFE

VELUX®

Commercial

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INTRODUCTION

It's easy to think of light as being required only for vision. After all, light levels are typically specified in terms of the level of illumination needed at a surface to allow people to work safely. Instinctively, we know that daylight spaces are more pleasant to live and work in, but many of us are frequently forced to rely on artificial lighting for illumination.

In recent years, the phrase 'human-centric lighting' has become prevalent. Starting as a synonym for 'lighting quality', it soon replaced that term outright. Now, it is not uncommon for lighting design services or artificial lighting products to be offered as 'human-centric'.

'Human-centric lighting' carries an element of meaning to do with health and wellbeing, in a way that 'lighting quality' doesn't convey. By describing something as 'human-centric' it's possible to market it in a different way, tapping into the zeitgeist of being more people-focused and achieving healthier outcomes.

As good as some artificial lighting is, however, no electric

light source has yet been created that can match the quality of natural light or mimic the variation in its spectrum throughout the course of a day, a season, or a year. All of which puts a focus on 'daylighting', or the controlled use of natural light in and around buildings.

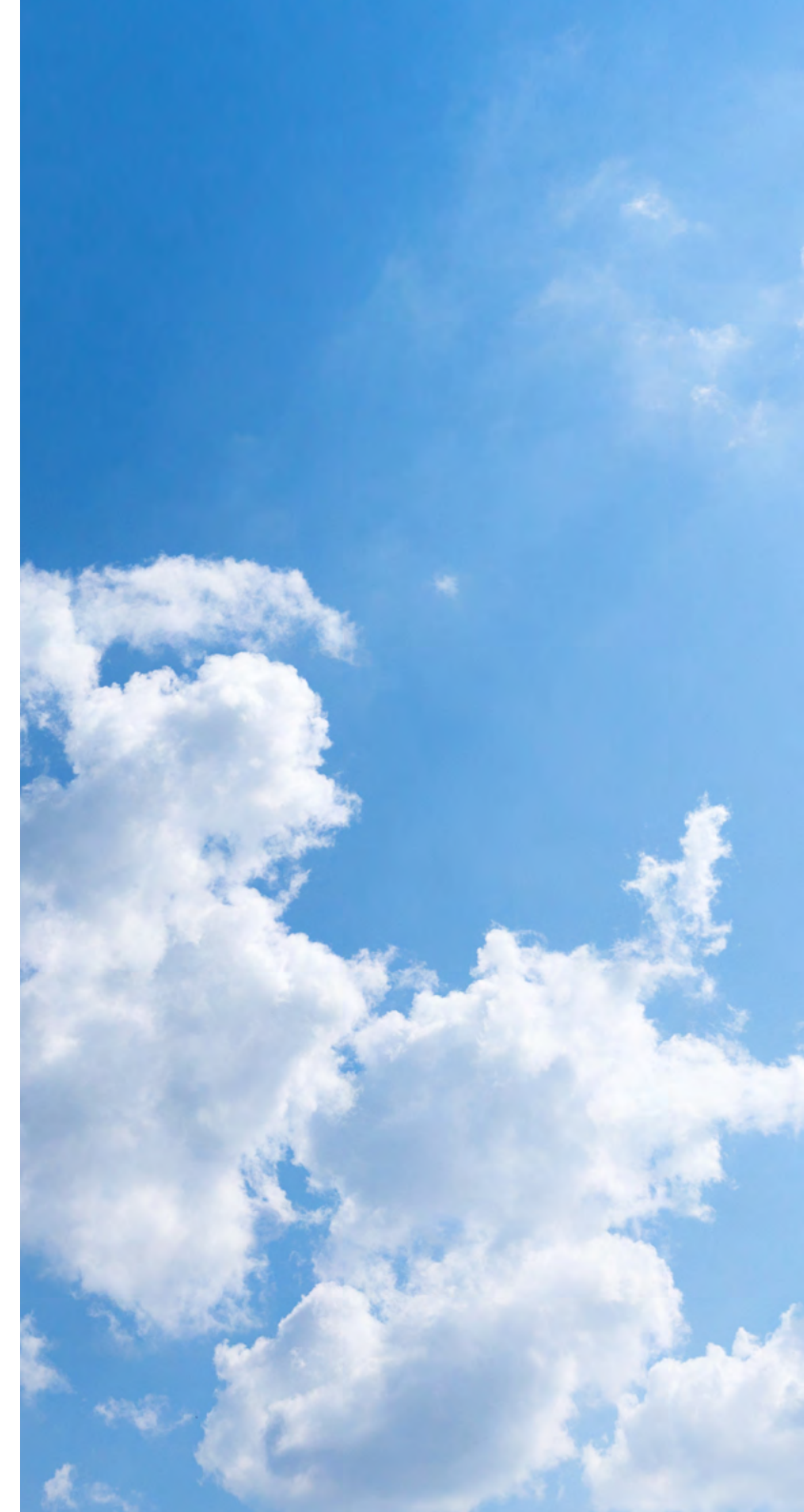
As part of human chronobiology we have evolved circadian rhythms and our building designs should reflect the importance of those rhythms. Our bodies are naturally in tune with the changing quality of natural light during the day, followed by the darkness of night time, to ensure we are alert and productive when we need to be, and able to sleep and recover when we need to.

The [VELUX Daylight Symposium](#) is a biennial conference for researchers, architects and others with a professional interest in using daylight to create a healthy and resilient built environment. At the 2019 event, Kevin Houser, professor at Oregon State University, gave a presentation about human-centric lighting and the way the human body responds to daylight. To use his words: "Daylight is already human-centric".

Anything else is a compromise. While it may not be possible or desirable to design out artificial light from our buildings all together, we can be more aware of the benefits of maximising daylight. That way we create something that is truly 'human-centric' rather than something that sounds good for marketing purposes but doesn't necessarily deliver in reality.



We can create indoor environments that not only provide a good visual experience and high levels of visual comfort but which are also in tune with the physiology of our circadian rhythms. This document looks at the role of natural light in human health and how commercial buildings can be designed to achieve genuine human-centric daylighting throughout the building fabric.



DAYLIGHT AND EVERYDAY LIFE

When we think of light in terms of being only for vision, we are thinking about the 'image forming pathways' - the image processing in the eyes and the brain that creates what we see. The non-visual aspect of light, or the non-image forming pathway, however, is every bit as critical to how the body functions during the day.



CIRCADIAN RHYTHMS

This is where our circadian rhythms enter the equation, the human body's natural response to changing light levels including the production of different hormones at different times. The hormone melatonin governs our pattern of wakefulness and sleep and the type of light to which we expose ourselves plays a role in managing the cycle.

Exposure to 'cooler' more distributed blue-rich light during the day suppresses the production of melatonin and maintains alertness by effectively encouraging the production of serotonin, dopamine and cortisol. Following this with 'warmer' and more focused light during the evening stimulates the release of melatonin and helps us to feel sleepy. This is our circadian rhythm.

Good lighting and true 'human-centric' lighting combines both visual and non-visual aspects to stimulate the correct physiological responses and promote good health. We need daily daylight exposure because daylight is rich in the spectrum to which the non-visual system is most sensitive.

The greater the contrast between daytime and night-time light exposure, the greater the production of melatonin. More melatonin means more sleep signals for the body. At this point we need darkness. An absence of light at night is every bit as important to good daylighting as the correct light levels during the day.

DAYLIGHT FOR HEALTH

Society is often failing us because we usually do not receive enough daylight on a daily basis, and often the 24 hour nature of society then exposes us to too much light during the hours of darkness. The Las Vegas Strip for example is reported to be the brightest place on Earth at night - and that brightness is essentially 'flipping nature on its head'² for the people who are there.

In his talk at the 2019 Daylight Symposium, Kevin Houser identified the temporal pattern of light, the timing of our exposure to it during the day, as the number one influence on health. The quantity of light followed by the spectrum of light, to which we are exposed, were second and third respectively.

During the day, we need light that is high in 'melanopic content'³ followed by light that is low in melanopic content during the evening (and then darkness). This is human-centric, but artificial lighting that is sufficiently high in melanopic content is rare. This is why exposure to natural light is so important when thinking about building design.

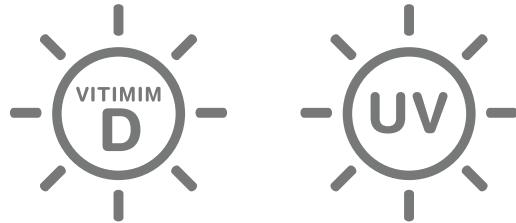
When it comes to quantity, indoor light is typically a whole order of magnitude lower than outdoor light. A sunny summer's day can provide an illuminance of up to 100,000 lux. Even on a grey and cloudy day 5000 lux of illuminance is possible. By contrast, indoor lighting might be designed to offer just 200 or 300 lux.



BEYOND CIRCADIAN RHYTHMS

Although a detailed exploration is beyond the scope of this document it is worth acknowledging the role of exposure to sunlight, specifically ultraviolet (UV) light with the wavelength known as UVB, in helping to maintain levels of vitamin D in the body.

Vitamin D boosts the immune system and helps to fight cancer. Getting enough of it through food alone is difficult so some sunlight exposure is necessary. Getting the right level of exposure is also difficult, however, and over-exposure can cause sunburn and skin cancer.



THE IMPACT OF BEING INDOORS

It is popularly held that we spend around 90% of all our time indoors. Around 200 years ago, people would have spent most of their waking hours outdoors⁴. The light we are usually exposed to indoors, as well as offering a much lower illuminance than natural light, is not dynamic. It has a constant colour temperature and our bodies do not respond to it in the same way.

People with a 'typical' 9 to 5 office job can easily spend their day in a poorly lit interior, then when they get home any positive effect from ideal indoor evening light conditions may well be diminished by the light emitted by a television, computer, smartphone and/or tablet screens.

In this situation the circadian rhythm is still evident, but its peaks and troughs are not as pronounced. Feelings of sluggishness are likely as well as making it harder to get to sleep.

By contrast seeing daylight early in the day appears to start the process of getting the body ready for sleep later that night, and can even mitigate exposure to bright light later in the day. In one study exposure to bright light between 8am and midday halved the amount of time it took participants to get to sleep, compared to those who did not get the same 'dose'.



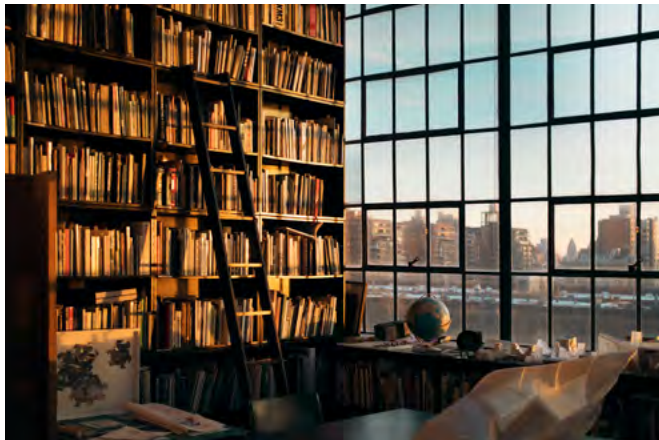
'SOCIAL JET LAG'

Exposure to light later in the day has the effect of shifting a person's circadian rhythm. This is not a problem in itself and simply means that feelings of sleepiness will be shifted to a later time. But if it's necessary to get up early the next morning, then the rhythm gets disrupted again.

The effect of this can be the equivalent of changing time zones. Till Roenneberg, a professor of chronobiology who also spoke at the VELUX Daylight Symposium, describes this as 'social jet lag'.

Society is set up for people who consider themselves to be 'larks' rather than 'night owls'. Schools and workplaces start early in the day, but people persist in allowing their circadian rhythm to be pushed later into the evening. Then at the weekend they try to sleep in and exacerbate the feeling of 'jet lag'.

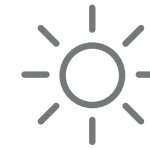
'Morning people' appear to be less prone to depression or mental ill health, so there are some considerable potential benefits to be had from shifting circadian rhythms earlier through better exposure to light during the day.



EN 17037 DAYLIGHT IN BUILDINGS

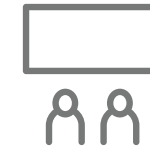
To help improve the provision of daylight in all building types - including our homes and workplaces - and the ways in which that provision is measured, 2018 saw the publication of a new European standard for daylighting.

More information about EN 17037 is available in a separate [VELUX Commercial whitepaper](#). For the purposes of this document, however, it is helpful to understand the four different areas of daylighting covered by the standard. Before its publication designers may have been familiar with designing to provide daylight, however, the other three aspects have extended the scope of the standard.



DAYLIGHT PROVISION

Daylight provision or illuminance levels allow users to carry out tasks and play a part in determining the likelihood of artificial lighting being switched on.



ASSESSMENT OF THE VIEW OUT OF WINDOWS

Building users should have a large and clear view of the outside. EN 17037 considers the width and outside distance of the view as well as landscape 'layers' (sky landscape and ground). The view should be perceived to be clear, undistorted and neutrally coloured.



ACCESS TO SUNLIGHT

Calculating access, or exposure, to sunlight is a comfort and health factor for users of dwellings, nurseries and hospital wards.



PREVENTION OF GLARE

As its name suggests, prevention of glare is concerned with removing the probability of glare for building users, especially those who do not choose where they sit.

EN 17037 recommends a minimum level of performance for each area. On top of that, there are two further performance levels: medium and high. To provide flexibility users of the standard are free to select the performance level that best relates to the building design and proposed building use.

CONNECTION WITH THE OUTSIDE

The development of EN 17037 has helped to highlight the importance of access to a view as part of good daylighting.

Another speaker at the VELUX Daylight Symposium was Lisa Heschong, Fellow of the Illuminating Engineering Society of North America. She talked about studies into daylight and productivity and how the availability of a view tends to have a more consistent effect on results than illumination. In a call centre, a view resulted in better worker speed; in schools it resulted in better test scores.

Analysis of people's behaviour shows that we want to look out of windows. 'Mind wandering' or daydreaming is central to our personal 'insight' for giving us a larger working memory, more capacity to plan, and better creative problem solving.

Not only that but ganglion cells in the back of our eyes are calibrated to the 480nm wavelength of natural light. This is critical for the circadian stimulus we have so far discussed at length. With that in mind we can move on to look at different elements of building fabric and how they can contribute to a human-centric daylighting approach.



HUMAN-CENTRIC LIGHTING AND BUILDING DESIGN

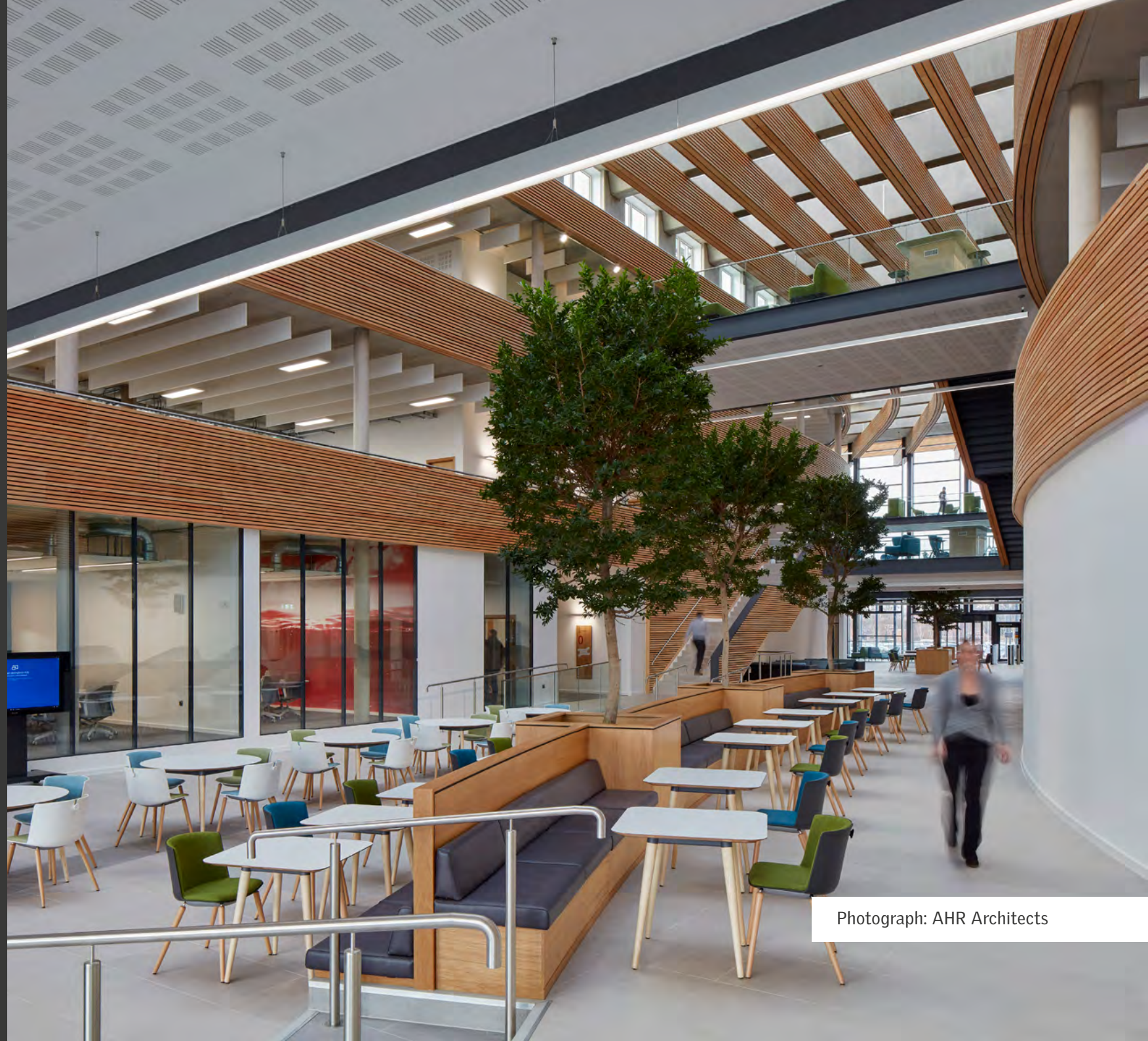
We concluded 'daylight and everyday life' by discussing the provision of a connection with the outside for building occupants. As part of Lisa Heschong's presentation, she talked about technology companies replacing real views with simulated outdoor views. Her message, however, was clear: providing daylight is the key to creating healthy buildings, not simulating what we think a healthy building is.

Commercial pressures on building design, especially in North America, commonly result in office buildings where around a third of employees have no access to daylight. European building standards have helped to avoid a similar crisis in occupant comfort and the publication of EN 17037 should ensure that daylighting only improves in buildings throughout Europe.

Even so, there is always more that can be done. At the 2019 VELUX Healthy Buildings Day, Joseph Allen from the Harvard School of Public Health, pointed out that regulators and legislators rarely put in place the same protections for our indoor climates that they do for our external environments.

"The people who design and manage our buildings are more important than our doctors," was his stark message.

There is little doubt that daylight should be a significant component of a building design that claims to embrace human-centric lighting. This section looks at how different parts of a building may be designed to properly account for daylight and to provide naturally well-lit spaces.



Photograph: AHR Architects

WALLS

Tall buildings with fully-glazed facades will always possess a 'wow' factor. External aesthetics still tend to dominate popular thinking but the real thing to say 'wow' about is a building that isn't just attractive from the outside, but which also provides a comfortable internal environment.

All too often fully-glazed buildings are designed to extract maximum commercial potential, with no consideration for the heating and cooling loads, and energy demand that such a design imposes. Occupants will have a good view to the outside, but at what cost in terms of over-exposure to daylight and glare, and reliance on mechanical systems for internal temperatures and ventilation?

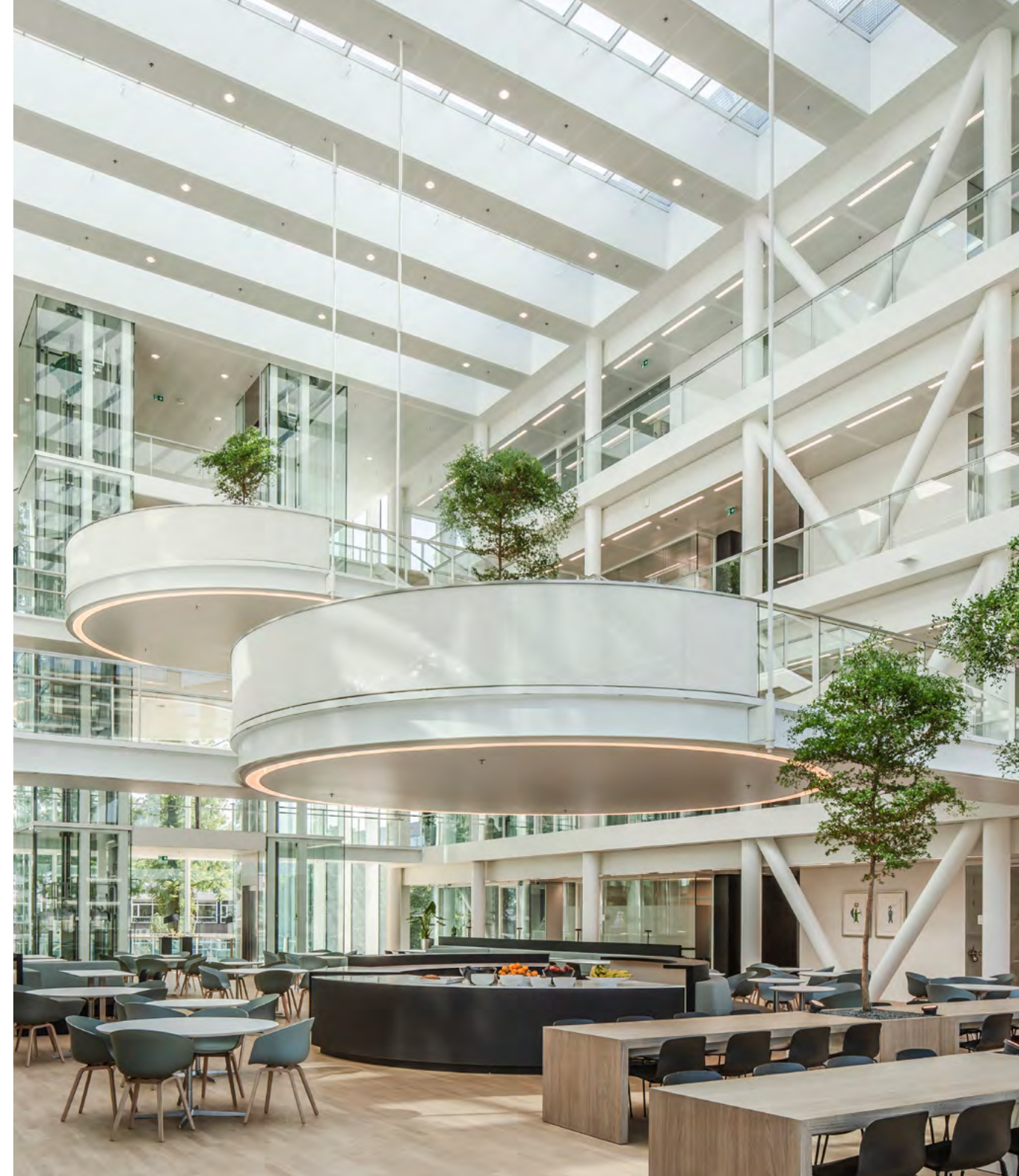
A glazed facade might look like a clever or intricate design, but it is even more intelligent to realise a building which simply works, delivering a healthy interior without consuming more resources than it needs to. That means selecting the appropriate size and location of window openings to maximise daylight while minimising heat losses.

There is also the impact of certification schemes such as BREEAM, WELL or LEED to consider too.

At the opposite end of the spectrum is avoiding spaces that have too little glazing, or are entirely windowless. At the VELUX Daylight Symposium, Kevin Houser stressed that design and construction has a massive impact on quality of life, explaining that too long in a windowless room reduces vitality.

Where the walls of a building are concerned it is not just the placement of windows within them. It is the site planning, and the orientation of the external walls⁵ to make best use of the site location and the movement of the sun across the day.

Vertical facade windows can give a better view, especially in terms of the ground plane, but they can also cause glare, so getting the right balance is essential. Features such as shading elements and light shelves can all be part of the design of an external wall to help manage daylight distribution, reduce glare, and control solar gains as part of thermal comfort.



ROOFS

Where floor areas are too large or deep, or where site constraints or external obstructions restrict access to daylight, facade glazing alone is unlikely to meet the daylighting requirements of a building. This is where roof glazing solutions come in.

Good use of unobstructed roof glazing can help to achieve better illumination and balance glare from facade glazing. Like the walls of a building, orientation influences the availability and quality of daylight in the interior.

In the northern hemisphere light coming from the north is mainly composed of diffuse skylight and provides the interior with a functional and comfortable light that is stable throughout the day. In many cases light from the south, east and west provides the interior with direct sunlight and light levels that vary significantly throughout the day.

It's therefore necessary to think about whether one large opening will serve a space⁷ or whether multiple smaller openings with different orientations will maximise daylight during the day. Roof glazing installed in low-pitched roofs and flat roofs, meanwhile, is also likely to deliver direct sunlight.

It is also worth considering that roof areas may offer glazing options where there is a restriction on what can be done with the walls. While it's tempting to think that new-build projects tend to offer unrestricted possibilities there are often constraints, and the constraints on a refurbishment project can be even more onerous. While the quality of a view through roof glazing may not be as varied as can be achieved with facade glazing, it is better placed to offer an unrestricted view of the sky and help further a sense of connection with the outdoors.

ATRIA

Historically, an atrium was the centrepiece of a building design. Modern atria designs and solutions continue that tradition, and at the same time support meeting the demands of modern building performance.

What makes an atrium an atrium is not always clear, as different definitions exist. The function of a space classed as an atrium can vary depending on whether it is defined from an architectural and space planning point of view, or a more technical and regulatory point of view.

Generally speaking an atrium is a way of bringing the outside in - a space that is sheltered from the elements whilst giving building users a connection to the external environment.

The glazing to an atrium therefore falls under different criteria to the roof glazing described above. Where 'standard' roof glazing is primarily intended to light an individual space, an atrium can also offer the potential to 'harvest' daylight⁸. It brings natural light into a large central space, from where other parts of the building can then benefit without needing direct access to facade glazing.



TERRACES AND OUTDOOR SPACES

However well designed a building is, when it comes to access to daylight there is no substitute for actually being outside. Ensuring the availability of high quality outdoor amenity space can help encourage people to leave a building and enjoy various benefits, including access to daylight.

Depending on location and site constraints, such space might be part of the site planning at ground level, or in the form of rooftop terraces and gardens.

A roof terrace has the potential advantage of offering unobstructed access to daylight at any time of day (subject to the position and height of any surrounding buildings). There is arguably greater scope for the design of outdoor spaces at ground level, providing not only daylight but also contact with nature that may have its own mental health benefits.

For example rather than the path between an office building and its car park being across a featureless expanse

of grey roads and pavements, could it be a short wooded walk instead, putting people in close proximity to trees and greenery?

One point of discussion at the VELUX Daylight Symposium was the concept of 'daylight showers' and their effectiveness. Where we are tied to living and working indoors for much of the day, can short bursts of daylight exposure confer the same benefit as spending extended periods of time outside?

The consensus was that any daylight exposure is better than no daylight exposure. Taking even short opportunities to get outside during the day, especially in the morning, can help set the body up for its sleep routine that night. It increases the amplitude of the circadian rhythm, improves alertness, and promotes a little more movement - something that is generally good for wellbeing anyway.



TURNING CONCEPT INTO REALITY

VELUX Commercial wants to help designers and specifiers deliver more daylight, and therefore a more human-centric environment, in their commercial building designs. They do this by offering a range of modular skylight solutions which are designed to work as a single system, backed up by comprehensive design and technical support.



VELUX DAYLIGHT VISUALISER

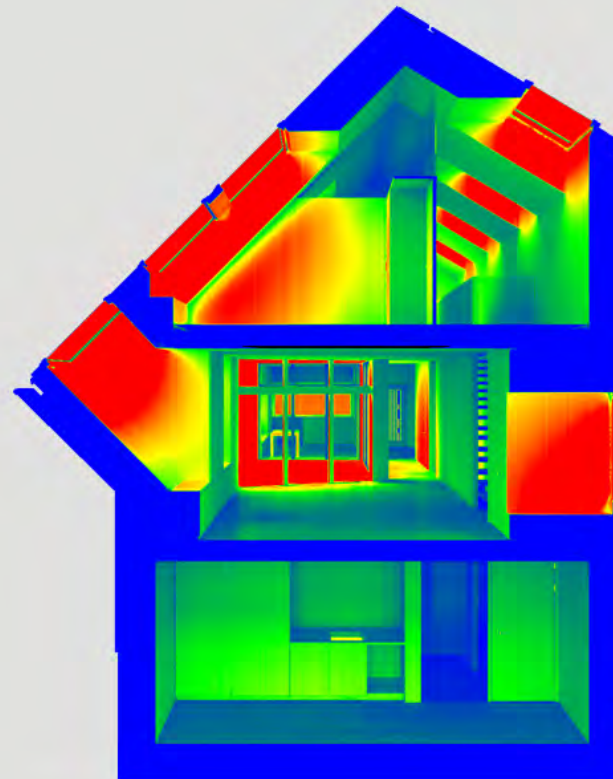
Where high levels of daylight are intended in a public, industrial or commercial building, the building design should be assessed at an early stage when it is easiest to make changes. M&E consultants do conduct such checks, but usually only at a later stage of the project.

If daylight design is undertaken from the early stages of a project, it means roof glazing products - like VELUX Modular Skylights - can be specified in the right size and quantity from the outset. The project benefits from greater certainty, and the glazing can be priced with confidence.

The [VELUX Daylight Visualiser](#) is a unique professional lighting simulation tool that VELUX Commercial is able to offer. As a free service for architects and designers it allows for the analysis of daylight conditions within buildings.

Instead of using rules of thumb or gut feeling to set out the initial number and size of skylight modules, the Daylight Visualiser helps to eliminate uncertainty. VELUX Commercial works with the building designer to assess daylight levels in the proposal at a much earlier stage, rather than them having to rely on instinct.

The size and quantity of modular skylights can be incorporated into the design from the outset. The proposal is still passed to the M&E consultant for verification but, with the bulk of the assessment already done, and with greater certainty that the proposed design is already adequate, the whole process is made much quicker - and with less risk of further design work to accommodate changes.

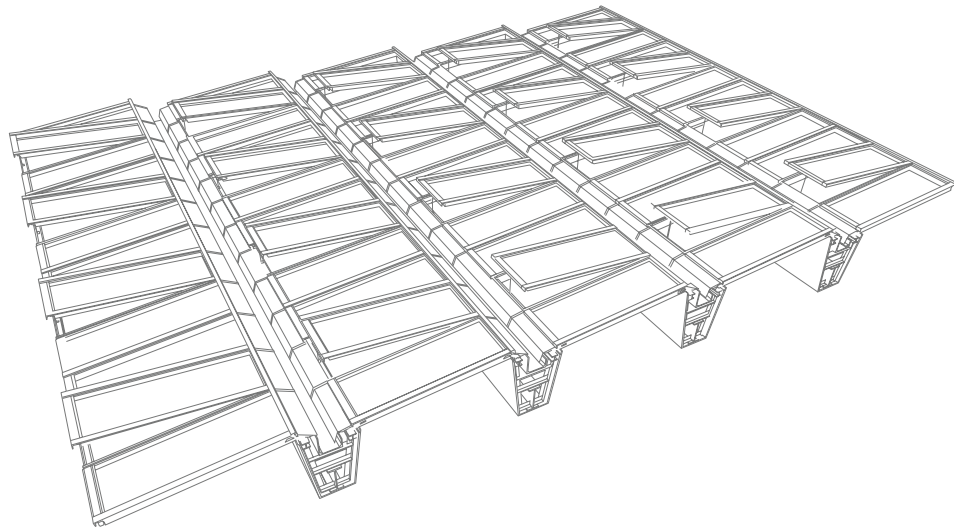


VELUX MODULAR SKYLIGHTS

The range of [VELUX Modular Skylights](#) from VELUX Commercial offers different types of modular roof glazing, which can be combined to create almost any roof design and any daylighting solution. Modular skylights come with a 10 year guarantee on all skylight modules and flashings.

The [VELUX Longlight 5-30°](#) is a mono-pitch solution ideal for providing natural light to hallways, corridors and large rooms. The Longlight solution is also available as a [Wall-mounted Longlight 5-45°](#) and a [Northlight 25-90°](#) for design flexibility.

The [Ridgelight solution](#) provides dual-pitch glazing, connecting two rows of skylights at an apex, or providing visual interest in a flat roof design.



The [VELUX Step solution](#) allows for the creation of even larger glazed roofs while minimising the joint details between rows and can be used to create striking atrium designs. Alternatively, the [VELUX Atrium Longlight/Ridgelight products](#) feature multiple rows of modules with a drainage gutter between each row.

VELUX Commercial's white paper showcasing [seven different commercial buildings](#) illustrates how VELUX Modular Skylights provide complete flexibility for buildings of all shapes, sizes and occupancies, and contribute to certification schemes that demonstrate a commitment to sustainability.



MODULAR SKYLIGHT ACCESSORIES

One key advantage of the VELUX Modular Skylight system is the option for daylight, glare and heat control.

External shading is the most efficient means to prevent direct solar radiation into the building and a VELUX Commercial roller blind can be specified as a factory-fitted accessory to skylight modules or Renson awnings can also be specified. Alternatively, a sun protection coating can be applied to the glazing.

Another key advantage is the availability of [smoke ventilation](#) as well as comfort ventilation.

[Comfort ventilation](#) is essential for occupant wellbeing, helping to ensure a consistent supply of fresh air to the interior of a building and emphasising a connection with the outside. Smoke ventilation is an important part of fire safety measures in large buildings, and should be specified to comply with national building codes and regulations.



SPECIFICATION SUPPORT

The prefabricated nature of VELUX Modular Skylights provides reliable and consistent performance. Module sizes can be selected to suit the roof type and building shape, with the repeatability of the modular system keeping complexity out of the design.

Using the [CAD and BIM object downloads](#) available from VELUX Commercial, designers can place modular skylights in their drawings with complete confidence that what is shown on the drawing is what will be delivered to, and constructed, on site.



CONCLUSION

For any building's lighting strategy to be considered truly human-centric, it should incorporate daylight as much as possible to provide well-lit, dynamic, and comfortable internal spaces. Not only does daylight provide a higher level of illumination, it also helps maintain the circadian rhythms of the building's occupants.

Speaking at the 2019 VELUX Daylight Symposium, Vivian Loftness, of Carnegie Mellon University, presented on the concept of 'environmental surfing'. She bemoaned the current poor state of commercial buildings and their lack of environmental resilience in the face of an uncertain future.

Vivian emphasised the need to make use of natural lighting, in order to rely less on artificial lighting and save money while reducing energy demand. She also presented case studies demonstrating how it's possible to quantify design features like good daylighting, factoring in their positive economic impact in terms of improved health, comfort and productivity.

A human-centric daylighting approach not only improves the quality of spaces in buildings, it can also help reduce the payback of such design features from nearly a decade to just one year.

Building fabric should therefore be designed to make the best possible use of daylight. That includes walls and floors, and outdoor spaces. It particularly includes roofs, with a well-planned use of unobstructed roof glazing bringing daylight deeper into the building and achieving better illumination.

VELUX Commercial are on hand to help achieve that best possible use of daylight. Using a tool like the [Daylight Visualiser](#) helps to refine designs, making sure they deliver what the designer wants and ensuring that projects can be priced accurately, without unnecessary revisions to the design and specification late in the day.

For designers, the [VELUX Commercial blog](#) contains a wealth of additional information to help illustrate the benefits of daylight and inform daylighting strategies. In addition to CAD and BIM object downloads, [project support, price estimates and technical advice](#) are all available via the VELUX Commercial website.

Thanks to VELUX Commercial's passion for daylight and its benefits, any roof glazing design can be made a reality using the VELUX Commercial range. This document also references a range of equally passionate speakers from the 2019 VELUX Daylight Symposium and VELUX Healthy Buildings Day. Every presentation has been made available to view, and the full benefit of their insight is available [here](#).

REFERENCES

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