



NatureConnect and Daylight

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Context

NatureConnect by Signify is a lighting product proposition of Signify which brings the benefits of **daylight indoors**, like improving productivity and alertness, reducing stress and contributing to better sleep. This whitepaper provides an overview of relevant Daylight definitions, standards and regulations, since Daylight is a natural reference for NatureConnect by Signify. It also contains a Frequently Asked Question (FAQ) list which addresses most common questions raised by installers, specifiers and end-users:

- What are the CIE, IES or other formal definitions of Daylight?
- Why is Daylight important?
- How is Daylight specified in Lighting regulations and standards?
- Daylight in buildings
- NatureConnect by Signify and Daylight standards
- How does NatureConnect by Signify perform compared to other HCL solutions?
- NatureConnect by Signify and the WELL building standard



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What is the CIE definition of Daylight?

Daylight is the part of global **solar radiation** capable of causing a visual sensation¹.

What is the IES definition of Daylight?

Daylight is direct and/or diffuse light from the **sun**².

What are other formal definitions of Daylight?

Daylight is the combination of all direct and indirect **sunlight** during the daytime hours from sunrise to sunset³. It consists of direct sunlight, diffuse sky radiation, and sunlight reflected from the ground and terrestrial objects. Daylight undergoes **dynamic** changes in irradiance and spectral power composition due to latitude, time of day, time of year and the nature of the physical environment (reflections, buildings and vegetation)⁴.

The intensity of daylight can vary from more than 100.000 lux for a sunny bright day to 1000 – 2000 lux for a typical overcast day and lower than 1000 lux during sunrise or sunset.

Daylight is our most important source of lighting. Many lighting specifications of artificial lighting like Correlated Color Temperature (CCT) or Color Rendering Index (CRI) use daylight as benchmark.

Why is Daylight important?

Daylight is important because it helps to regulate our **biological clock**, also known as the circadian rhythm. Exposure to natural daylight during the day helps to entrain our human bodies to the natural light-dark cycles, which in turn improves our overall health and well-being⁵. Additionally, daylight provides us with **vitamin D**, which is important for bone health and immune system function. It can also improve our mood and productivity and help us feel more **connected to the natural world**.

What about Daylight Regulations?

There are very few daylight requirements or recommendations in existing building or workplace regulations which are mandatory and can be enforced. The European Commission Workplace **Directive** (89/654/EEC)⁶ requires that workplaces must receive as much daylight as possible and be equipped with artificial lighting that is appropriate for the safety and health protection of employees. This EU directive provides requirements for national laws like e.g. the German Workplace Ordinance⁷, the Dutch Occupational health and safety law⁸ or the Danish executive order on building regulations⁹.

National building regulations typically specify a minimum window or glazing area in relation to the room area¹⁰ to ensure a minimum amount of daylight. Besides, building regulations give guidance on how to measure the amount of daylight. The so-called daylight factor is calculated as the ratio of the illuminance at a point on a given horizontal plane indoor to the illuminance on a horizontal plane outdoor under overcast sky conditions.

However, many spaces are exempted from these daylight requirements because they cannot comply due to their application field or intrinsic location in the building¹¹. Typical exemptions for daylight regulations are applications like industry, laboratories, retail, theaters, hospitality, office meeting rooms, certain healthcare, or sport/fitness facilities¹². Other exemptions are spaces without direct natural access to daylight, like basements or inner rooms positioned in the central part of buildings.¹³ Finally, monumental buildings or buildings constructed before a defined date (e.g. in Germany this is December 2016) are exempted from this daylight regulation (reference ASR A3.4).

Likewise, labor laws do not prohibit workplaces from having windowless environments, but employers should consider implementing strategies to compensate for the lack of natural light. For example, for workplaces without daylight, in Germany Workplace Ordinance ASR A3.4 recommends providing break rooms with sufficient daylight⁷. Similar, Article 6.3 “Daylight and artificial light” of the Dutch working conditions Act does not include mandatory lighting requirements for the workplace. It does provide a general framework to encourage optimization of lighting in order to ensure the lighting conditions do not increase the risk for or impact the health of workers¹⁴. In other words, the employer must ensure 'as far as reasonably possible' that good light conditions of the workplace are guaranteed.

How is Daylight specified in Lighting Standards?

Several international standards include daylight requirements and relevant daylight metrics for both existing, to be renovated or new buildings.

The standard EN 17037 “Daylight in buildings”¹⁵ defines how to use daylighting within buildings and how to limit glare. Besides, it includes recommendations and criteria for view-out and advises on the minimum exposure to sunlight. For example, EN 17037 defines a target horizontal illuminance of 750 lux as the highest recommendation of daylight provision by daylight openings.

Complementary, the standard EN 12464-1 “Indoor workplaces”¹⁶ specifies the minimum horizontal illuminance levels for a wide range of applications. The illumination can be provided by either daylight, artificial lighting or a combination of both. The required illuminance levels increase with 50% when one or two of following conditions apply (aka context modifiers):

- Reduced visual capacity of the worker (e.g. relevant for aging workforces)
- Low daylight conditions
- Unusual long duration of the task
- Other conditions are: costly errors, low contrast task details.

In case more than two of these conditions apply, the recommended illuminance levels even increase with 100%. For example, an elderly person doing critical visual work in a room with (almost) no daylight access will require a minimum horizontal illuminance level of 1000 lux to perform the task adequately.

Finally, the ISO/CIE standard 8995-1 describes the generic benefits of daylight, like high level of color rendering, promotion of circadian regulation, positive impact on mood and satisfaction and productivity¹⁷. Furthermore, this ISO 8995-1 standard defines the task lighting requirements but also the required room brightness levels for a wide range of different tasks and activity areas. The values mentioned need to be achieved with electric lighting only (not assuming any daylight contribution).

Daylight in Buildings

Daylight should be a significant source of illumination for all spaces with daylight opening(s). Daylight is strongly favored by building occupants to adequately illuminate the indoor surfaces with high color rendering and variability in illuminance, direction and spectral composition throughout the day and seasons¹⁸.

In interiors with side windows, however, the available daylight decreases rapidly with the distance from the window. Besides, direct sunlight can be a major source of discomfort glare and can cause overheating of the space. Weather conditions may also influence the daylight intensity and distribution which may impact the indoor illuminance uniformity level. Exposure to sunlight and the effective hours of sunlight exposure in an indoor space depend, obviously on the outside weather conditions, but also on the orientation of the building façade¹⁹.



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For any space with daylight openings, it is recommended to use shading devices to reduce risk of glare and direct view to the sun or a reflection of it should be avoided. Personal lighting control can include daylight control using shading systems.

Buildings typically have multiple rooms which have no natural direct access to daylight either because they have no outside walls or they are positioned in the inside of the building far away from windows connected to the outside. Also, in case of renovations, it is not always economically possible or even not allowed to create openings in the facades of a building because of existing architectural heritage legislation.

NatureConnect by Signify and Daylight Standards

Lighting of indoor workplace standards, like EN12464-1 “Indoor Workplaces” and the EN17037 “Daylight in buildings” standard, typically define minimum **horizontal illuminance levels** for a wide range of activity areas. NatureConnect by Signify not only meets the maintained illuminance requirements for indoor workplaces but also the highest recommendation levels for daylight provision as required in EN17037. Moreover, also the recommended increased illuminance levels for the aging workforce and spaces with no- or low daylight conditions can be achieved by NatureConnect.

View to the outside and exposure to sunlight are two other daylight quality criteria defined in EN17037. NatureConnect mimics the view to the sky and provides a “sunlike” experience, independent of the outdoor weather conditions, giving a productivity boost to the people in the (meeting) room. People feel more alert and activated, especially in the afternoon. Next to that, people above the age of 41 feel more vital under NatureConnect²⁰.

“Conventional” sunlight exposure is intrinsically dynamic and highly depending on the time of the day and time of the year but also on the building orientation and the relative window position. For example, a window in the north façade of a building will not receive any direct sunlight during the winter months. A similar window at the south façade of a building will get optimum solar radiation in the winter but during the summer the angle of solar incidence is too high resulting in less effective sunlight exposure in the summer compared to the spring and autumn seasons²¹.

Direct sunlight exposure can also reduce the indoor comfort level due to resulting **discomfort glare** and possible overheating of the indoor space^{22,23,24}. Sun protection using e.g. venetian blinds or curtains will reduce the (thermal) discomfort impact but will at the same time reduce the view-out and significantly reduce the number of hours of sunlight exposure²⁵.

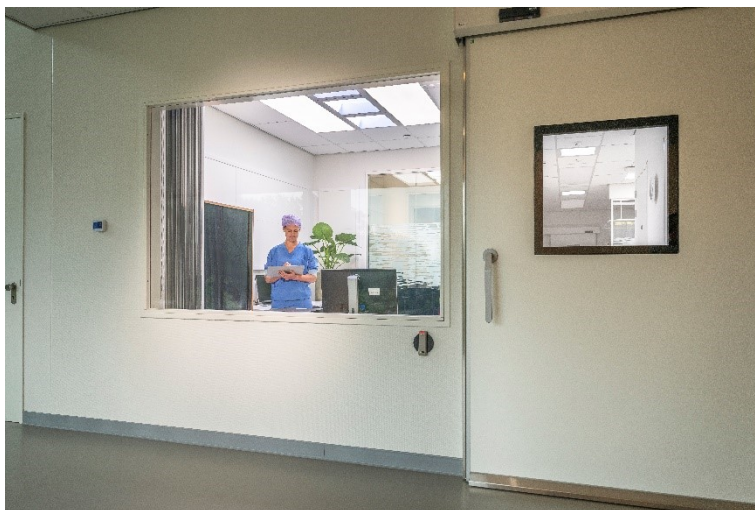
In summary, NatureConnect by Signify cannot be formally defined as Daylight according to above-mentioned daylight standards. Instead, NatureConnect can provide the right light at the right moment, it mimics the view to the sky, it has circadian impact and provides a “sunlike” experience.

NatureConnect by Signify and the WELL building standard

WELL²⁶ is a Building certification program focused on **the human health and well-being** of people in buildings. The WELL Light concept aims to provide a lighting environment that reduces circadian phase disruption, improves sleep quality and positively impacts mood and productivity. To support the human body circadian rhythm, sufficient light should enter on the vertical plane at eye level (i.e. > 250 melanopic EDI for at least four hours, beginning by noon at the latest).

NatureConnect delivers horizontal and vertical light levels which are more than adequate compared to the WELL requirements as defined in WELL section L03 Circadian Lighting Design. Other WELL sections where NatureConnect²⁷ can contribute to:



















- L01 Provide Indoor Light; provide appropriate light exposure in indoor environments through lighting strategies.
- L02 Visual Lighting Design; provide appropriate illuminances on work planes for regular users of all age groups.
- L04 Electric Light Glare Control.
- L07 Visual Balance; develop and implement strategies to create a visually comfortable lighting environment.
- L08 Electric Light Quality; includes color rendering quality and flicker.
- L09 Occupant Lighting control; enhance occupant controllability and provide supplemental lighting.



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How does NatureConnect by Signify perform compared to other HCL solutions?

A comparison of NatureConnect by Signify with alternative solutions like Human Centric Lighting troffers or HCL retrofit kits is shown in the Table below. It also shows the performance of NatureConnect by Signify compared to a conventional skylight providing daylight.

| | Target Horizontal illuminance | Target Vertical illuminance | View Out | Sunlight | Glare & heat comfort | Ease of retrofit |
|---|--|--|--|--|---|--|
| Conventional Skylight |  1) |  1) |  1) |  1) |  |  |
| NatureConnect |  |  |  2) |  3) |  |  |
| Human Centric Lighting Troffer / Retrofit kit |  |  |  |  |  4) |  |

- 1) Highly variable, depending on external conditions
- 2) Mimics view to the sky
- 3) Provides a “sunlike” experience
- 4) Depending on the luminaire UGR

Summary

Daylight is the most natural light source we have on earth. Daylight is favored by building occupants because it supports a healthy circadian rhythm and therefore improves our overall health and well-being. Daylight is however not always (easily) accessible in many parts of a building. Daylight regulations, standards and building certification include therefore many exemptions to allow spaces in buildings where people spend long hours indoors, while having no access to daylight.

NatureConnect by Signify brings the benefits of natural light indoors for comfortable, engaging and attractive environments. Although it cannot be formally positioned as Daylight, it is the best alternative bringing a sunlike human centric light experience which positively impacts sleep quality, entrains the human circadian system and positively impacts mood and productivity. It is indistinguishable from a real window, giving a daylight effect, a view to the sky and increases the feeling of spaciousness. NatureConnect by Signify applies light recipes with high melanopic values to boost energy of people, while at the same time offer comfortable functional lighting.

To learn more, please visit

www.signify.com/NatureConnect

Frequently Asked Questions (FAQ)

Does NatureConnect comply to Daylight provision requirements as defined in Building decrees?

No, the area covered by the NatureConnect luminaire cannot be counted as equivalent Daylight surface area. However, NatureConnect does comply to the highest illumination recommendation level (i.e. 750 lux) as required for daylight provision in the standard EN17037 “Daylight in Buildings”.

Could NatureConnect score us additional WELL points in internal offices?

To attain the highest level of achievement in e.g. the WELL building standard, NatureConnect provides many opportunities to contribute. For example, the NatureConnect WELL application guide²⁸ provides an overview of WELL features where NatureConnect can contribute by providing the right design strategies required to earn up to 14 points spread over different features and concepts.

What are the Human Centric Lighting metrics MDER and MEDI?

The melanopic daylight efficacy ratio (MDER) is a dimensionless, relative quantity that describes the melanopic effectiveness of the spectrum of a light source. It expresses the melanopic activation of a (test) light source as compared to a reference light source that emits a daylight spectrum (D65) and produces the same photopic illuminance as the test light. For instance, a test light source with a melanopic-DER of 0.70 has a melanopic activation per lumen that is 30% less than daylight.

The melanopic equivalent daylight illuminance (MEDI) is a measure for the amount of melanopic light received by a surface area. It is, like regular (photopic) illuminance, expressed in lux, but is ‘melanopic-weighted’ using the following formula:

$$\text{MEDI [lx]} = E_v [\text{lx}] \cdot \text{MDER}$$

As melanopic activation goes via the eye, the melanopic-EDI as well as the photopic illuminance E_v is the amount of light falling on the eye: vertical illuminance, as opposed to the horizontal illuminance regularly reported when the focus is on visual tasks. See for more information the paper of Rene Wegh and Mart Peeters²⁹.

What is the difference between regulations, standards and building certifications like WELL?

A **Directive** is a legislative act that sets out a goal that all (27) EU Member States must achieve. It is up to the individual Members to decide how. Timing of transposition is laid down in the directive. Examples are:

- Waste Electrical and Electronic Equipment (WEEE) Directive
- Low Voltage Directive
- Energy Performance of Buildings Directive (EPBD)

A **Regulation** is a binding legislative act which must be applied in its entirety across the EU. Examples include:

- Ecodesign Regulations (product-specific, EC 2019/2020)
- Energy Efficiency Labeling Regulations (EC 2019/2015, Delegated Act)
- REACH (Registration, Evaluation and Authorization of CHEmicals)

A **Standard** is a document approved by a recognized body that provides a set of agreed-upon rules, guidelines or characteristics for activities or their results. Standards are not enforceable by law; a standard has to be incorporated by reference in an Act or delegated legislation in order to be mandatory.

Building certifications like WELL and LEED are certification programs that assess the sustainability and environmental impact of buildings. Some certification programs, like the WELL Building Standard, are focused on enhancing human health and well-being in the built environment.

WELL is a certification program that focuses on the health and wellness of people in buildings. It evaluates factors such as air quality, water quality, lighting, and acoustics.

LEED (Leadership in Energy and Environmental Design) is a certification program that evaluates the sustainability of a building's design, construction, and operation. It considers factors such as energy efficiency, water conservation, and materials selection.

Each certification program has its own set of criteria and levels of achievement, but all aim to promote sustainable and healthy building practices.

Glossary

| | |
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| Technischen Regeln für Arbeitsstätten (German Workplace Ordinance) | ASR |
| Correlated Color Temperature | CCT |
| Commission Internationale de l'Éclairage | CIE |
| Color Rendering Index ¹ | CRI |
| Standardized daylight spectrum | D65 |
| Energy Performance of Buildings Directive | EPBD |
| European Union | EU |
| Human Centric Lighting ² | HCL |
| Health and Wellbeing category (BREEAM) | HEA |
| International Organization for Standardization | ISO |
| Leadership in Energy and Environmental Design | LEED |
| Melanopic Daylight Efficacy Ratio | MDER |
| Melanopic Equivalent Daylight Illuminance | MEDI |
| Registration, Evaluation and Authorization of Chemicals | REACH |
| Waste Electrical and Electronic Equipment | WEEE |
| WELL Building Standard | WELL |

¹ CRI is often referred to as Ra

² Human Centric Lighting is also called Integrative lighting. CIE definition 17-29-028 for integrative lighting: "Lighting integrating both visual and non-visual effects, and producing physiological and/or psychological benefits upon humans"

References

- ¹ CIE S 017/E:2020, International Lighting Vocabulary, 2nd edition.
- ² ANSI/IES RP-16-10 “Nomenclature and Definitions for Illuminating Engineering” (2010)
- ³ Cambridge Dictionary
- ⁴ M.Muench et.al (2020), “The Role of Daylight for Humans: Gaps in Current Knowledge”, *Clocks Sleep*, 2020 Mar; 2(1):61-85
- ⁵ Duffy, J (2005), “Entrainment of the human circadian system by light”, *Journal Biol Rhythms* 20(4): 326-338
- ⁶ EU COUNCIL DIRECTIVE of 30 November 1989 (89/654/EEC) concerning the minimum safety and health requirements for the workplace (first individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC).
- ⁷ ASR A3.4 “Beleuchtung und Sichtverbindung”, Lighting and line of sight, technical rule for workplaces, May 2023.
- ⁸ <https://www.arboportaal.nl/onderwerpen/arbowedgeving>
- ⁹ <https://at.dk/en/regulations/executive-orders/building-construction-2107/>
- ¹⁰ Bouwbesluit 2012, Dutch Building Decree (2012)
- ¹¹ Boubekri, M (2004), “A Overview of The Current State of Daylight Legislation”, *Journal of the Human-Environmental System* Vol. 7; No. 2: 57–63, 2004
- ¹² Berghuis, M (2021) “Praktijkboek Besluit bouwwerken leefomgeving (Bbl)” ISBN 978-94 93196 68 1
- ¹³ NEN-EN17037 Daglichttoetreding: regels bij nieuwbouw
- ¹⁴ https://wetten.overheid.nl/BWBR0008498/2024-01-01#Hoofdstuk6_Afdeling2_Artikel6.3
- ¹⁵ EN17037 (2018) “Daylight in buildings”
- ¹⁶ EN12464-1 (2021), “Light and lighting – Lighting of work places – Part 1: Indoor work places”
- ¹⁷ CIE 158:2004/2009, ISO/CIE DTR 21783.2, ISO/DTR 9241-610.2
- ¹⁸ EN17037 (2018) “Daylight in buildings”
- ¹⁹ Nederlandse Praktijkrichtlijn NPR 4057 “Daylight in buildings – Guidance for NEN-EN 17037, May 2022
- ²⁰ Peeters, S (2023), “NatureConnect – The positive impact of NatureConnect in meeting rooms with no natural daylight”
- ²¹ NPR 4057 (2022), Nederlandse praktijkrichtlijn, “Daylight in buildings – Guidance for NEN-EN 17037”
- ²² Aries, M (2010), “Windows, view, and office characteristics predict physical and psychological discomfort”, *Journal of Environmental Psychology* 30 (2010) 533–541
- ²³ Knoop, M (2019), “Daylight: What makes the difference?”, *Lighting Res. Technol.* 2020; 52: 423–442
- ²⁴ Veitch, J (2005), “Satisfaction with lighting in open-plan offices: COPE field findings”, *Proceedings of Lux Europa*, 10th European Lighting Conference, Berlin, Germany, Sept. 19-21, 2005, pp. 414-417
- ²⁵ Roche, L (2000), “Occupant reactions to daylight in offices”, *Lighting Res. Technol.* 32(3) 119-126
- ²⁶ <https://v2.wellcertified.com/en>
- ²⁷ Signify (2023), “NatureConnect – User experience guide for office lighting experience”
- ²⁸ Signify (2023), “NatureConnect – WELL application guide”, May 2023
- ²⁹ Wegh, R (2023) LED Professional Issue 96 (Mar/Apr 2023) “Healthy Daytime indoor Lighting – How to design the optimum Melanopic Light Source”