ERCO

The perfect lighting for green walls

Planted walls, also called green walls, create a pleasant atmosphere and improve the indoor climate. Sufficient light indoors is crucial for healthy plants. Find out here what you should definitely pay attention to for green wall lighting design and illumination to succeed in attractively displaying so-called "living walls".

Green Walls

Contents

High-lumen output wallwashers impressively display the green wall in the foyer of the Bank of China in Sydney and ensure healthy plants.

Planted walls are also called green walls or vertical gardens. Architects and interior designers use green walls not only to promote well-being but also to improve indoor air, reduce temperature and absorb noise. This is why we increasingly find green walls in foyers, atria, offices, shops and restaurants as a component of sustainable architecture.

However, the right lighting and brightness are important for these lively installations to flourish. The lighting criteria for green walls differ from general architectural lighting, which means that the special requirements of plants have to be taken into account during lighting design – after all, only with the right light are these attractive green walls able to survive in the long run.

Would you like to know what you should consider when illuminating a green wall? We have researched the latest findings and information on the subject and respond to the most frequently asked questions. References and sources are listed at the end.

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Light spectrum

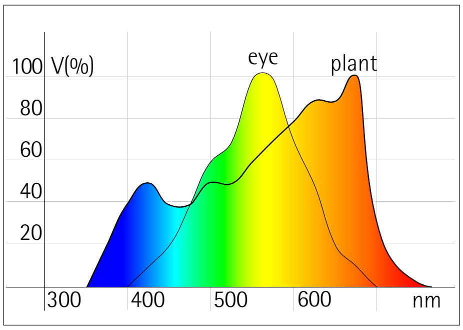
What kind of light do plants need in green walls?

Plants need light for photosynthesis. The light is absorbed by chlorophyll in the leaves and converted into chemical energy. Plants especially use the orange and red range of the spectrum as well as blue light. The green range of the light spectrum is of no importance for plant growth and is reflected – we thus see plants as being green.

As there is generally no need for good colour rendering in greenhouses there is also no need for a green spectrum. The agricultural industry therefore mainly uses lamps with red and blue spectral distribution in greenhouses. Their objective is rapid plant growth and low energy overheads. However, for a natural impression of green walls in architectural surroundings, good colour rendering with a green component in the spectrum is indispensable, even though this does not contribute to plant growth. (Egea et al. 2014; Zielinska-Dabkowska et al. 2019). For this reason, architectural luminaires are particularly suitable for illuminating green walls.

It should be noted though that the spectral sensitivity of plants differs from that of the human eye. Regarding the illumination of plants, photosynthetically active radiation (PAR) is comparable to luminous flux in lighting technology.

Light spectra are available that are equally suitable for illuminating architecture and green walls.



Spectral sensitivity of the human eye compared to that of plants in green walls.

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Illuminance and exposure

How much light do plants need?

In addition to selecting the optimal spectrum, intensity is a key difference between illuminating greenhouses and green walls. Greenhouses are intensively illuminated to achieve quick growth and rapid harvests. With green walls on the other hand, the focus is on the spatial effect and minimal maintenance effort for owners. Light in green walls should sustain the plants, but avoid excessive growth.

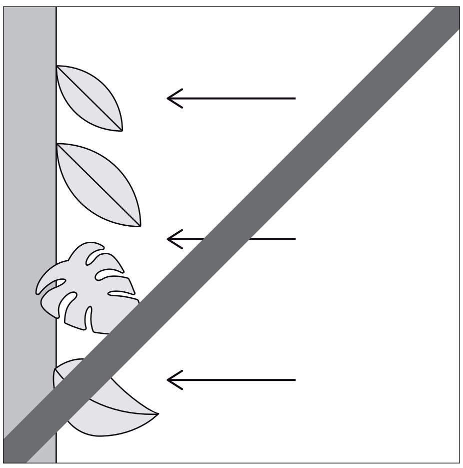
As a reference value for illuminating green walls with tropical plants, a DLI of 1.5 - 4 is recommended (Torres and Lopez 2008; Tazawa 1999). DLI stands for the "daily light integral". This unit describes the quantity of photons that a plant receives during one day. The need may be different depending on the plant. Shade plants which grow on the ground in the tropics are often used in green walls and only require a low light intensity. Sun plants, on the other hand, have a much higher requirement for light. The DLI value should not fall below 1.5 at any point on the wall. A DLI of 2 with the appropriate LEDs corresponds to an illuminance of around 2500lx over twelve hours on the leaf surface.

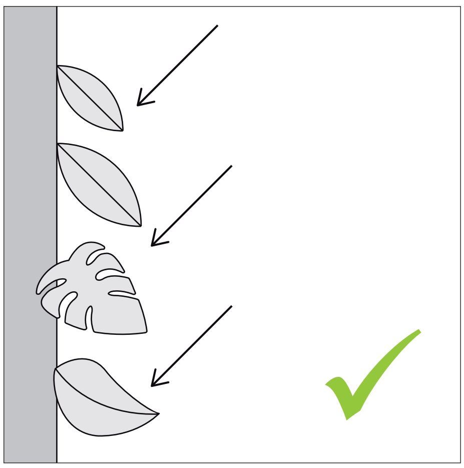
For a green wall project, and if the light spectrum is known, the daily amount of light can be calculated from the illuminance on the green wall and the duration of lighting. However, the illuminance must be converted into the "photon flux density in the photosynthetically active radiation spectrum", or PPFD (photosynthetic photon flux density), which is relevant to plants. Conversion tables from luminaire manufacturers can be used here (see page 9). These specify a PPFD value for an illuminance of 1000lx as a function of the spectrum used. ERCO LEDs with 3000K and CRI 97, for example, have a PPFD value of 16.7 for 1000lx. For an illuminance of 2500lx, the PPFD value can be converted accordingly and, multiplied by a factor of 2.5, is then 41.75.

Because green walls mainly use plants from tropical regions, an exposure time of twelve hours has proven to be useful for ensuring good growth. The time period should be without interruption to achieve a similarity with daylight. To achieve an optimal DLI value over 12 hours, the PPFD value for green walls should be above 35. This PPFD value results from the formula (1) specified on page 10 with a DLI value of 1.5 and an illumination period of 12 hours. The recommendations for illuminance are intended as guidelines and should be matched to the respective plants in the project. The time control can be automated using a light control system such as DALI or Casambi Bluetooth.

In contrast to conventional wallwashing where illuminance is calculated in relation to the vertical wall, with green walls the illuminance is determined at right angles to the leaf surface. This angle can be set for the measuring plane in light calculation programmes.

For green walls, illuminance at right angles to the leaf surface is relevant. For planning purposes, it is recommended to create a horizontal calculation line or narrow measurement area in a light simulation programme at half the height of the green wall along the entire length of the wall. Then tilt the measuring surface to take into account the alignment of the leaves. To do this, align the measuring points with the centre of the light emitting surface of the luminaire, because leaves grow towards light.





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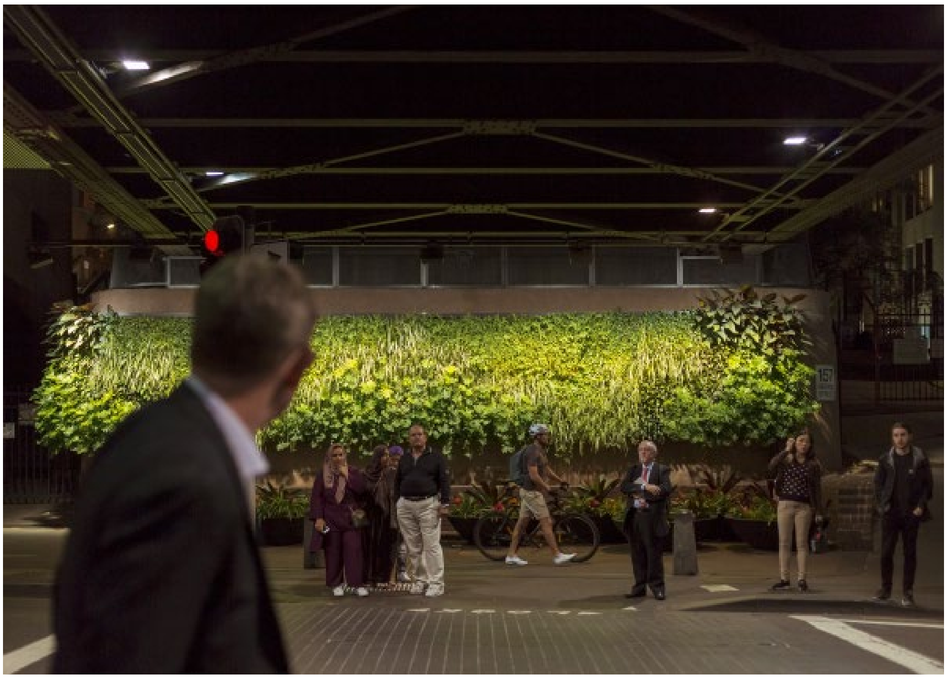
Light distribution



Adequate lighting of green walls is not only required indoors: lighting is also needed if outdoor plants are not exposed to sufficient light due to obstructions such as bridges. The green wall on George Street in Sydney is eye-catching in the area directly below the bridge. The wall is electrically illuminated as an alternative light source to daylight.

Which light distribution is optimal for vertical gardens?

Uniform brightness distribution in the vertical axis with wallwash or oval flood distribution offers the best conditions for the even, steady growth of plants in a green wall (Egea et al. 2014). Wallwash distribution achieves a very uniform horizontal and vertical brightness on the green wall. To achieve a similar effect with oval flood distribution the longitudinal axis must be aligned vertically on the green wall.

The distributions of conventional downlights are not suitable for green walls because these luminaires direct most of their light downwards to the floor. The upper wall area of vertical gardens is still supplied with sufficient light but the lower area receives too little light so that plants wither and, in worst cases, even die.

Spotlights with narrow spot distribution are also not suitable because the narrow distribution in the illuminated area results in increased plant growth. The surrounding zones also have insufficient light – plants in this area wither.

Top:
distribution with wallwash lens

Below:
distribution with oval flood lens

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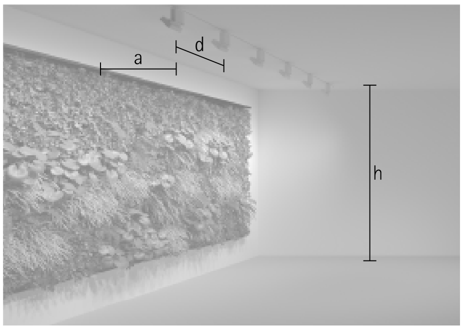
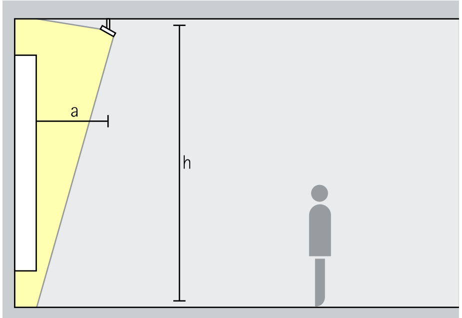
Luminaire positioning

Optimal luminaire arrangements for green walls





For many ERCO wallwashers, the ideal arrangement for positioning from the wall is one third of the room height. The luminaire spacing between two wallwashers corresponds to the distance from the wall. With a green wall of three metres in height, the distance between luminaires is therefore one metre. The wall distance of one metre is determined from the front plane of the green wall including the plants; the framing wall behind it is not used to determine the wall distance in this case.

Ideally, the lighting of the wall is based on conditions in nature: to promote natural growth in the best possible way, lighting should therefore be from above (Egea et al. 2014). Recessed or surface-mounted luminaires as well as luminaires on track are perfectly suited. Light from below, e.g. via floor recessed luminaires, should be avoided as leaves orient themselves towards light and light from below would appear unnatural.

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Luminaires

Which luminaires are suitable for green walls?

Luminaires with wallwash distribution with high lumen output and an appropriate spectrum are the optimal lighting solution for green walls. The spectrum with the highest PPFD value at ERCO is their LEDs with a 3000K light colour and CRI 97 colour rendering. With a PPFD value of 16.7 at 1000lx, this spectrum ensures optimal plant growth and is also ideal architectural lighting.

Optimal in this case means that the plant remains healthy but growth is not promoted excessively. This in turn creates a natural green wall without increased need for care.

In terms of installation, recessed downlights offer an elegant integrated solution, but wall-washers for track are an interesting alternative as they provide maximum flexibility. Track has the advantage that further luminaires can be simply added, e.g. to achieve more brightness on the green wall or to highlight other objects in the room via accent lighting. Track can be recessed, surface-mounted or suspended in the room. For outdoor spaces, projectors with wallwash distribution are suitable.

With controlled watering of the green wall and appropriate luminaire arrangement, luminaires with a particularly high protection rating (e.g. IP44 or IP54) are not required for indoor projects. If there are no other requirements for the room, IP20 is usually sufficient.

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Technical terms

Meanings of technical terms with green walls

PAR (photosynthetically active radiation)
The component of the visible spectrum important for photosynthesis in plants is called photosynthetically active radiation (PAR). The peak of spectral sensitivity of plants is in the blue and red range of the spectrum. Illumination in greenhouses is thus often a mix of blue and red LEDs, giving light a violet appearance. In order to ensure that green walls in architectural projects do not have a violet appearance but a natural green impression, a light source with a full spectrum is required, for example LEDs with 3000K and CRI 97 as used by ERCO.

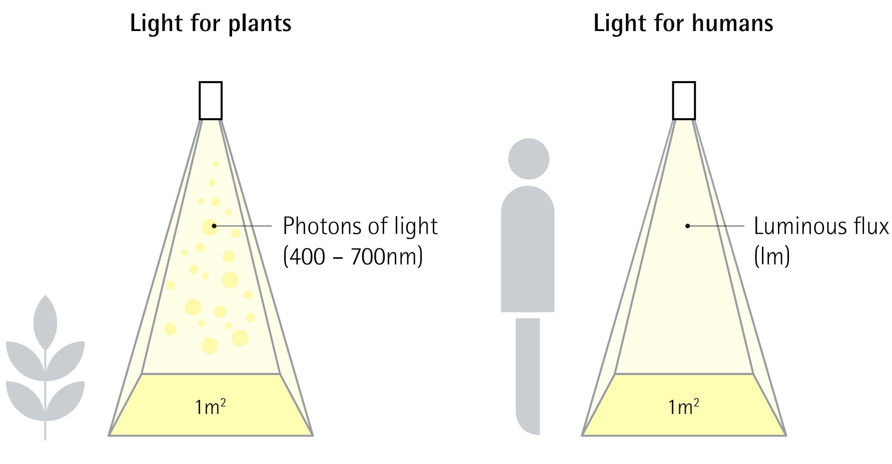
PPF and PPFD
Photosynthetic photon flux, or PPF, is the quantity of photons emitted by a light source that are relevant for photosynthesis and chlorophyll production. It is measured in µmol/s (micromoles per second) and corresponds to the photometric quantity of luminous flux in lumens (lm). The photosynthetic photon flux density, PPFD for short and measured in µmol/($m^2 \cdot s$) on the measuring plane, corresponds to the illuminance level ("E") familiar from photometry in lux (lx).

For a known spectrum of a light source, the PPFD value can be read from a table. For the high-power LEDs used by ERCO, the PPFD value with an illuminance of 1000 lux for 3000K CRI 97 is at maximum and is best for green walls. For 3000 lux, this value from the table would be multiplied by a factor of three.

Various ERCO LEDs with PPFD value at 1000lx

High-power LEDs at ERCO
(as of 2020)

Colour temperature	2700K	3000K	3000K	3500K	4000K	4000K
Colour rendering	CRI 92	CRI 92	CRI 97	CRI 92	CRI 82	CRI 92
PPFD @ 1000lux	16.0	15.6	16.7	15.4	14.0	15.2



$$PPFD = \frac{\text{Photons of light (400 – 700nm)}}{m^2 \cdot s}$$

$$PPFD = \mu mol/(m^2 \cdot s)$$

$$E = \frac{\text{Luminous flux}}{m^2}$$

$$E = lm/m^2 = lx$$

The radiation emitted by the light source is registered in plants as photosynthetically active photon flux, PPF for short, (in micromoles per second) and in photometry as luminous flux (in lumens). The PPFD value (photosynthetic photon flux density) with plant lighting corresponds to the illuminance in lux in human vision.

Figure based on Zielinska-Dablowska et al. 2019.

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Technical terms

DLI (Daily Light Integral)
The unit decisive for the health of a green wall is called the daily light integral. It describes the quantity of photons received by plants during a day.
The unit of measure is mol/(m^2 · d) (moles per square metre per day). The daily light integral can be calculated if you know the PPFD value of the lighting system being used:

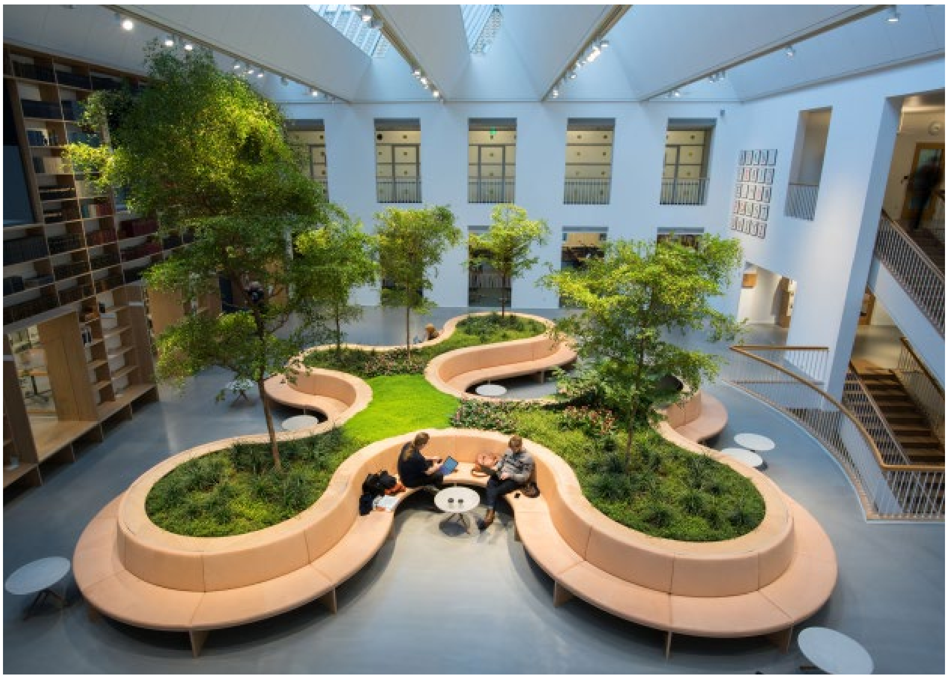
Formula 1

$$DLI = \frac{PPFD \cdot \text{daily lighting duration} \cdot 3{,}600\ s/h}{1{,}000{,}000}$$

Example:
At an illuminance of 3,000 lx with 3000K CRI 97 spectrum, you would get a PPFD of 16.7 · 3 = 50.1 (see table on page 8). The factor 3,600 s/h is used to convert seconds into hours.
The divisor is used to convert micromoles into moles. A daily illumination of twelve hours would result in a DLI value for the green wall of:

$$DLI = \frac{50.1\ \mu mol/(m^2 \cdot s) \cdot 12\ h/d \cdot 3{,}600\ s/h}{1{,}000{,}000} = 2.2\ mol/(m^2 \cdot d)$$

As a reference value for illuminating green walls with tropical plants, a DLI of 1.5 to 4 is recommended (Torres and Lopez 2008). The planned lighting is therefore within this range.



In atria, as in the Danish Royal Library in Aarhus, lighting supports the healthy growth of plants. Optec spotlights from ERCO with 3000K in this atrium generate an illuminance of 1500-2500lx.

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Checklist

Checklist for illuminating green walls with ERCO luminaires

The recommendations for illuminance are guidelines and should be matched to the respective plants in the project.

✓ **Exposure**
Rule of thumb: twelve hours daily and continuously with approx. 2500lx on the leaf surface depending on the plant species for healthy growth

✓ **Spectrum**
3000K CRI 97 for a high PPFD value

✓ **Light distribution**
Wallwash or oval flood distribution for uniform growth on the wall

✓ **Luminaire arrangement**
Rule of thumb: wall distance to the front plane of the plants consists of 1/3 of the wall height. Luminaire spacing equals wall spacing

✓ **Direction of light**
Light from above for natural leaf orientation

✓ **Light control**
Brightness interval of 12 hours per day

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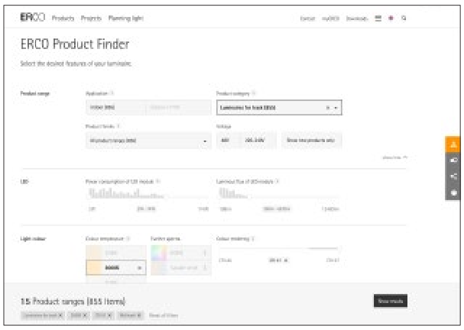
Light calculation

Calculate the lighting for a green wall in three steps

To illuminate a green wall 3m high and 5m wide in a room 4m high, wallwashers are generally recommended to be 1m from the front edge of the green wall with luminaire spacing of 1m. In this case study the vertical illuminance should be 2500lx. With ERCO, the highest PPFD values are achieved with the 3000K CRI 97 LED spectrum. The required wattage of the luminaires can be determined and their arrangement checked with use of lighting simulation programs such as Dialux, Relux, Agi32 and 3dsMax.

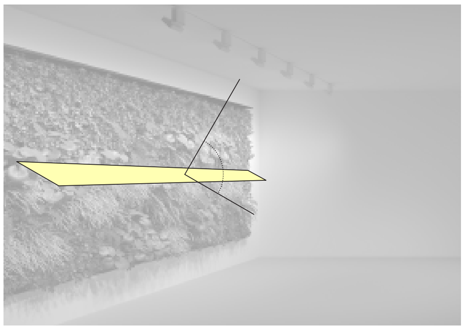
1. Determine the illuminance

- Find out the specific DLI value for the plants in your green wall.
- Determine the required illuminance using the DLI value (see page 10).
- Select luminaires with suitable light distributions and wattages, e.g. by using the Product Finder at www.erco.com.



2. Calculate the illuminance

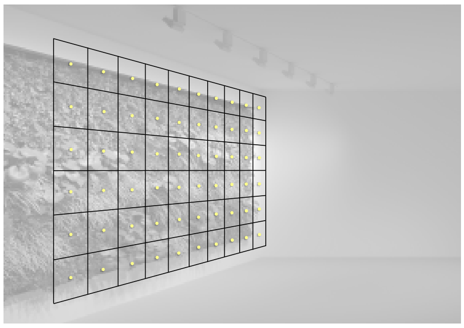
- Construct a horizontal calculation line or narrow measurement area halfway up the green wall along the entire length of the green wall.
- Tilt the measuring plane according to the orientation of the leaves. To do this, align measuring points with the centre of the luminaire's light emission surface, because leaves orient themselves towards maximum illuminance.
- To maximise the illuminance, select a higher wattage for the luminaires or reduce the luminaire spacing to obtain the target value.



Inclined measuring plane for determining the illuminance at half the height of the green wall

3. Check the uniformity

- Construct a vertical calculation surface with a periphery of 25cm in front of the front surface of the green wall.
- Determine the vertical illuminance and calculate the uniformity with minimum to mean illuminance.
- For uniform distribution of brightness, this value should be greater than or equal to 0.4.
- To optimise uniformity, check the light distribution, increase the distance between the luminaire and the green wall or reduce the luminaire spacing.



Light calculation for uniformity of the illuminance of a green wall by means of a measuring plane for vertical illuminance

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Light calculation

Illumination of a green wall with Stella wallwashers for track

Track provides a flexible infrastructure that is particularly suitable for retrofitting green walls in existing installations. In addition, other luminaires for the room such as spotlights for accent lighting can also be mounted to the track.

Luminaire	
Product range	Stella
Light distribution	wallwasher
Article no.	42676
Installed load	70W
Light spectrum	3000K
Colour rendering index	CRI 97
Luminaire luminous flux	3763lm

Lighting design	
Wall spacing	1m
Luminaire spacing	0.75m
No. of luminaires	6
Mean illuminance at mean height of the green wall (alignment of main luminaire light axis)	2816lx
Mean illuminance Ev	921lx
Minimum illuminance Ev	364lx
Maximum illuminance Ev	1708lx
Uniformity min/mean	0.4

Photosynthetic photon flux density	
PPFD @ 1000lx	16.7 µmol/($m^2 \cdot s$)
PPFD (at half height)	43.8 µmol/($m^2 \cdot s$)

Daily light integral	
Hours per day	12 h/d
DLI (at half height)	2 mol/($m^2 \cdot d$)

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Suitable luminaires

Luminaires suitable for illuminating green walls

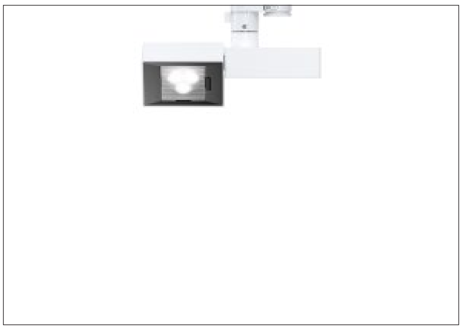
Parscan InTrack
www.erco.com/parscan-intrack

Eclipse InTrack
www.erco.com/eclipse-intrack

Stella
www.erco.com/stella

Optec
www.erco.com/optec

Light Board
www.erco.com/light-board



Opton
www.erco.com/opton

Gimbal recessed spotlight
www.erco.com/gimbal-r

Atrium double focus recessed downlight
www.erco.com/atrium-df

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References

Literature

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Torres AP, Lopez RG. 2008. Commercial Greenhouse Production: Measuring Daily Light Integral in a Greenhouse. West Lafayette.

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