

# PARANS

Leading sunlight



Parans Light Guide



# PARANS LIGHT GUIDE

**THE OBJECTIVES WITH THE LIGHT GUIDE ARE TO:**

- Educate specifiers, the project team and the property owner
- Provide a better understanding of the function of daylight in buildings
- Understand the role of daylight in certification systems, urban development and legislation
- Guide specifiers, project teams and the property owners in facilitating decisions
- Show good examples of how to use the Parans system
- Educate in appropriate calculation methods

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**WELCOME!**

The purpose of this guide is to to better understand the daylight's function in buildings and its role in environmental certifications, city developments and legislation. It also serves as a help for everyone interested in installing a Parans system. It contains practical examples on fields of use and technical information about energy savings as well as calculations on daylight levels.

**THE GUIDING PROCESS**

**WHY NATURAL LIGHT?**

- General about natural light
- Measure and quantify light
- Using natural light
- Natural light and health
- Natural light and value creation
- Daylight in urbanization and densification
- Daylight in legislations

**PARANS LIGHT HOW DOES IT WORK?**

- General concept
- 1. Sun collector
- 2. Fiber optic cable
- 3. Luminaire

**WHAT ARE YOUR REQUIREMENTS?**

**WHEN TO USE PARANS?**

- Meet certification requirements
- Effective use of deep buildings
- Energy savings
- Sustainability work

**HOW TO SPECIFY?**

- Parans simplified calculation method
- Parans Daylight Autonomy Tool
- Use case
- Local weather data

**DECISION MAKING**

- Cost estimation
- Quotation

# NATURAL LIGHT

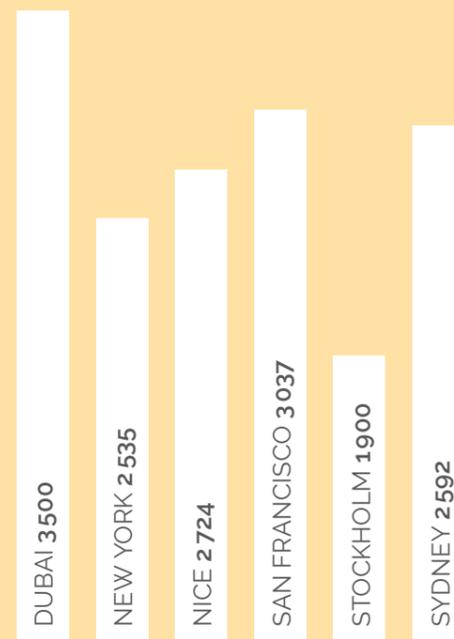
To successfully work with natural light a basic understanding of how we define and measure both direct and indirect light is required. This chapter explains the differences between daylight and sunlight as well as various ways to measure light. The chapter also examines how natural light can be used in buildings to promote health, value statements and sustainability. Furthermore, references are made in showing the positive effects on people when exposed to natural light.

## WHAT IS SUNLIGHT AND DAYLIGHT?

We often distinguish between daylight and sunlight. Daylight refers to the diffuse natural light that comes from the sky or that gets reflected off surrounding surfaces. Sunlight is the direct light from the sun and is much stronger than daylight. Sunlight is also much harder to utilize than daylight. This partly due that the sun is constantly changing position and it is also often hindered by clouds, trees or surrounding buildings. In addition, it is also way too strong. Daylight can also fluctuate during the course of the day but never so much that it results in blinding. Other advantages with direct light is that it renders exciting contrasts, clear colors, variation during the day, warmth during winter and it also gives you a sense of connection with your surroundings.



MOST OF US SPEND 90 %  
OF OUR TIME AWAKE  
INDOORS



Average hours of sunlight per year.

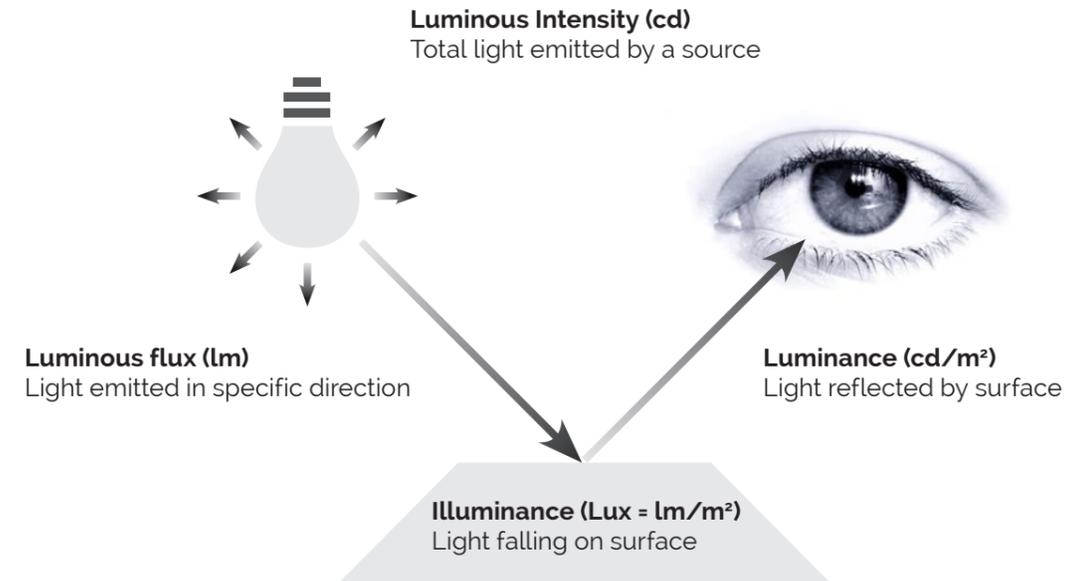
### Learn more

The earth's outer atmosphere is on average hit by 1350 W/m<sup>2</sup> solar radiation. The wavelength of this electromagnetic radiation varies a lot. It ranges from ultraviolet to infrared and the visible light in between that occupies almost 50 percent of the energy. Around 25 percent of the visible light gets absorbed or reflected in the atmosphere, which means that around 1000 W per square meter hits the earth's surface on a clear day. If there is a cloud cover, more light gets absorbed on its way through the atmosphere.

It is the light absorbance in the atmosphere combined with the fact that the light gets spread more or less diffuse that makes us see the whole sky as bright. If it hadn't been for the atmosphere the sky had been black part from the sun. The amount of sun radiation on the earth's surface varies through the year due to the earth's elliptical course and its axis. During winter when the sun is lower on the sky, the sunlight has a longer way to travel through the atmosphere, but it is also spread over a bigger area due to the earth's angle towards the sun.

## TO MEASURE AND QUANTIFY LIGHT

There are many ways to measure and quantify natural light. Some carries a larger weight than others in terms of energy matters, physical traits and the human eye.



### luminous intensity (cd)

Luminous intensity is measured in candela (cd) and is the unit of the flow of light that radiates out in space within a certain space angle, i.e. in a certain direction. A light candle with a diameter of 25 mm has a luminosity of around 1 cd.

### Luminous flux (lm)

Luminous flux is the measure of the perceived power of light. It accounts for the sensitivity of the eye by weighting the power at each wavelength with the luminosity function, which represents the eye's response to different wavelengths. The luminous flux is a weighted sum of the power at all wavelengths in the visible band. Light outside the visible band does not contribute. Luminous flux is often used as an objective measure of the useful light emitted by a light source, and is typically reported on the packaging for light bulbs. Consumers commonly compare the luminous flux of different light bulbs since it provides an estimate of the apparent amount of light the bulb will produce, and a lightbulb with a higher ratio of luminous flux to consumed power is more efficient.

### Source

40 W incandescent lamp at 230 volts  
7 W high-output white LED  
18 W fluorescent lamp  
1 cable from a Parans system

### Luminous flux (lm)

325  
450  
1250  
900 - 1300

(Values are approximate and based on solar illuminance of 100 000 Lux and dependent on the cable length.)

### Illuminance (Lux)

Illuminance indicates how much light that falls on a certain surface and is measured in lux. (or lumen per square meter). If a certain amount of light hits a surface the illuminance has a certain value and if the surface is larger but still hit by the same amount of light the illuminance decreases.

The illuminance indicates how much light hits a surface, but how light that surface is perceived by someone looking at it is also affected by how the light is reflected, i.e. how light or dark that surface is. Consequently you can not see illuminance. In spite of this, illuminance is the most commonly used concept when working with natural light and it is also the concept most used in different standards and regulations within the area.

Usually an appropriate interval for indoor lighting is set to between 300 and 2500 lux. In certain countries 500 lux is used as an appropriate lowest level. The level is usually measured between 750 to 850 mm above the floor. On bright sunny summer days the illuminance levels outside can be between 100 000 to 120 000 lux on bright horizontal surfaces, while in winter they can drop to between 4000 to 5000 lux.

A foot-candle is a non-SI unit of illuminance. One foot-candle is equal to one lumen per square foot or approximately 10.764 lux. In practical applications, as when measuring room illumination, it is very difficult to measure illuminance more accurately than ±10%, and for many purposes it is quite sufficient to think of one foot-candle as about ten lux as is typically done in the lighting industry.

### Luminance (cd/m)

Luminance describe the amount of light that passes through or gets emitted from a surface and falls again a certain space angle. This corresponds to the amount of light that the eye perceives when looking in a certain direction. I.e. how light the surfaces in your surrounding is. In this case the space angle becomes the field of vision of the pupil.

Luminance is also used to describe how much light lamps emits. When the sun is at its highest it has a luminance of about 1600 000 000 cd / m<sup>2</sup> and at the horizon 600 000 cd / m<sup>2</sup>. A clear sky have a luminance of about 8000 cd / m<sup>2</sup> and while on a cloudy day it only is around 2000 cd / m<sup>2</sup>. When working with daylight simulations you often use images that shows the amount of luminance in a field of view. How this division looks affects your visual comfort and risk of blinding. In other words it is not meaningful to use a mean value for the whole field of vision. Luminance is much harder to measure than illuminance. Usually it demands a special luminance camera or a standard camera with a luminance meter.

### Luminous efficacy [lm/W]

Luminous efficacy defines the relationship between lumen and watts for a lightsource and can be seen as the efficiency of a lightsource. The light exchange for daylight, especially for diffuse sun is better than most kinds of electric light. Normally you want an as high light exchange as possible as this will bring the electricity cost down. You also avoid an unnecessary heatspill.

Light source	Luminous efficacy [lm/W]
150 W lightbulb	16-40
Fluorescent lamp (40 W, CWX)	50-80
Natrium high pressure lamp	40-140
LED	60-100
Parans (SP4-20)	1800-2600

### Uniformity Ratio [%]

The Uniformity Ratio is defined as the ratio between the lowest and the mean illuminance level in the area to be evaluated. The result is a minimum level. A Uniformity Ratio in the range 0.3 to 0.4 is commonly recommended for side-lit rooms. Letting in large amounts of light by the facade creates, besides the risk of glare, large light differences especially in deep buildings. This means that those seated deep inside the building will experience it as dark and want to compensate that with more electric lighting. This phenomena is often overlooked when working with daylight in facades.

### Daylight autonomy [%]

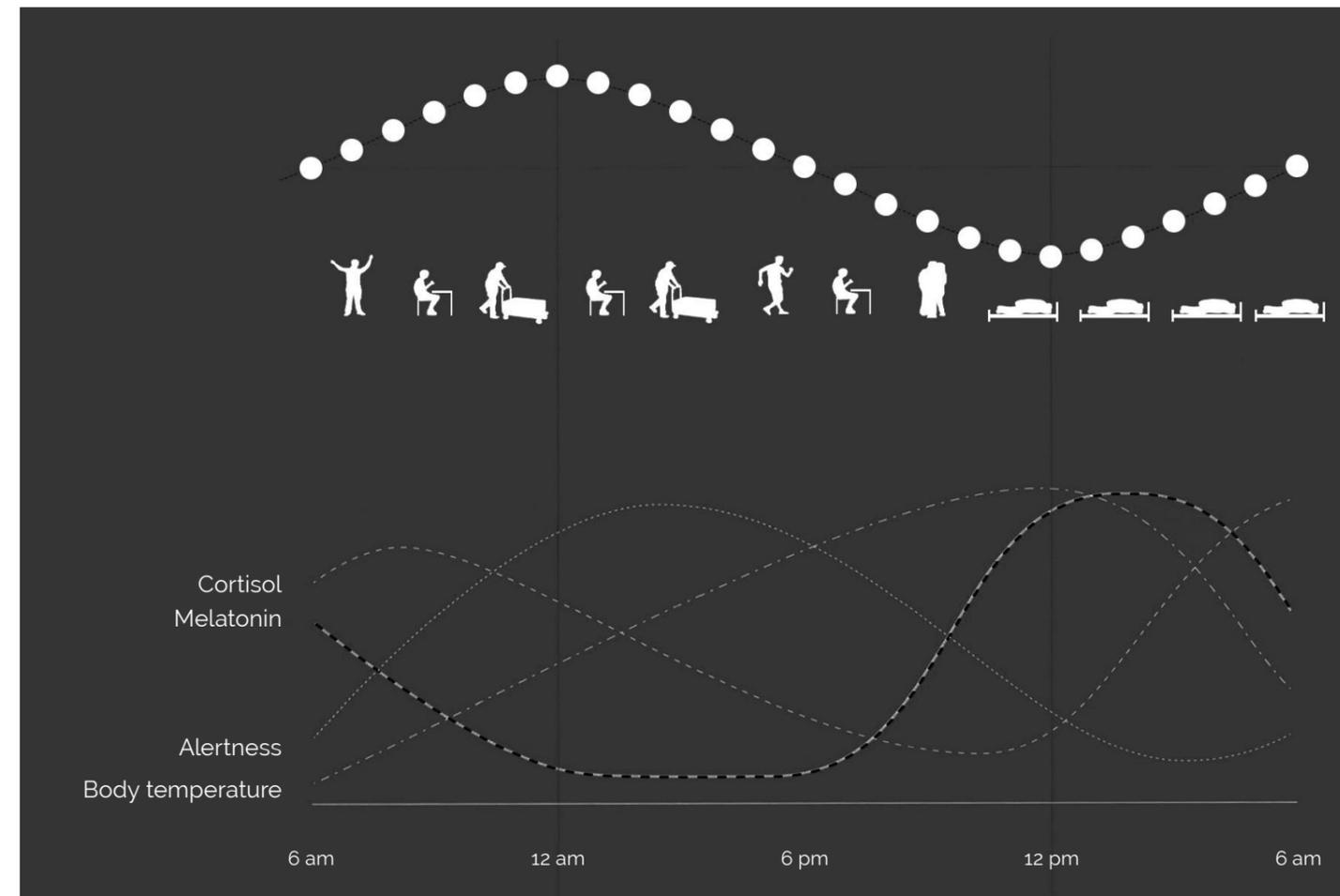
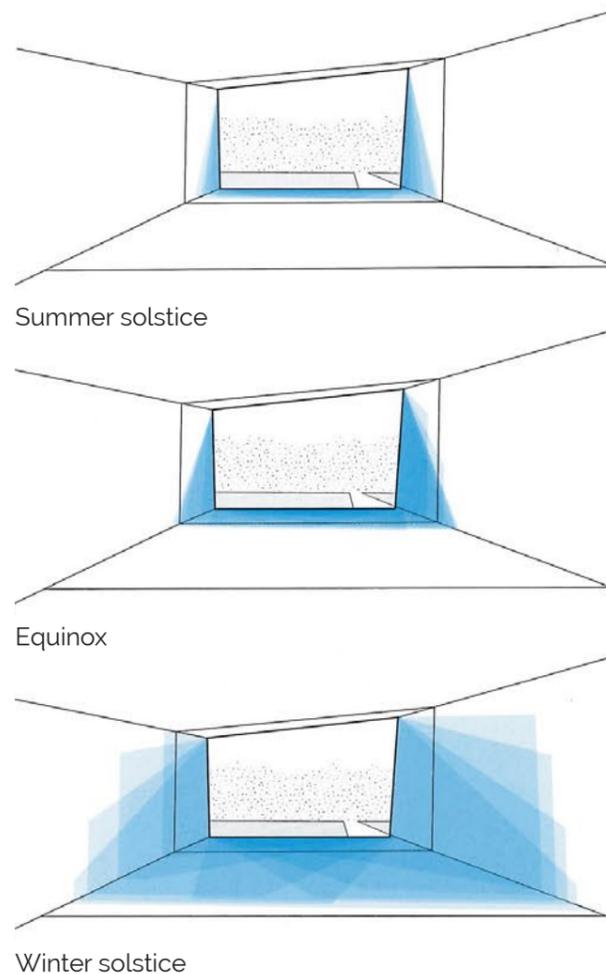
Daylight autonomy (da) was the first of a number of annual daylight metrics, now commonly referred to as climate based daylight metrics. It is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level. It is a major innovation since it considers geographic location specific weather information on an annual basis. It also has power to relate to electric lighting energy savings if the user defined threshold is set based upon electric light criteria. The user is free to set the threshold above which daylight autonomy is calculated. A daylight autonomy threshold of 300 lux (da300) is common but 200 and 500 lux is also used. Daylight autonomy can also be calculated for whole rooms and will then state how big part of the room that exceeds the given amount during a specified amount of time.

A room where part of the surface should have an illuminance higher than 300 lux during more than 50 % of the specified time is usually labeled "da 300,50". The specified time can either be static, for instance during work hours, or it can emanate from the total amount of sun hours.

Light also has other, more hard quantifiable characteristics than those mentioned. These characteristics concern for instance the relationship between direct and diffuse light and colors and variations on shadows. Furthermore our eyes have an incredible ability to adjust to different types of light which is one of the reasons that it is hard to produce pictures of how the light in a room will be perceived.

### THE IMPACT OF SOLSTICE IN THE BUILDING

#### Solar range / Inside view



### NATURAL LIGHT AND HEALTH

The circadian rhythm is fundamental to the health and well-being in the long term. Our biological clock requires exposure to darkness at night and the clear blue light during daytime<sup>1</sup>, especially in the morning<sup>2</sup>. This should be done in a rhythm of 24 hours otherwise, the clock starts to go out of tune. Disruptions in circadian rhythms leads to direct health problems in the long term<sup>3</sup> and also increased risks of accidents.

Although the visual system affects our health and well-being. High visual effort in everyday and work-related tasks require light of good quality and quantity. Suitable light provides visual comfort, while inappropriate light can cause eyestrain and cause headache, dazzle and prevent orientation.

What we see also affects job satisfaction, mood, motivation, performance and satisfaction with the office environment. It is also the link between the lack of natural light and impaired sleep and increase the risk of serious accidents.

Sleep, alertness and performance are directly linked with our 24-hour biological rhythm. Sleep, the effect and quality have all been linked with the natural light.

Insufficient sleep causes fatigue, which in turn cause accidents at home and at work. In a new scientific paper leading experts wrote that the main cause of traffic accidents that could have been avoided was not drugs or alcohol, but fatigue<sup>8</sup>.

In recent years it has been conducted a lot of research showing the physiological and psychological benefits of natural light. In an extensive literature review from 2012, "The physiological and psychological effects of windows, daylight, and view at home" the authors state that they only found positive health aspects of natural light.

Lisa Hescong, a world leading daylight researcher, describes that when she talks to people who work in day lit buildings, they report about the benefits "they consistently report how they love working there, and hope they never have to transfer elsewhere".

In the article "Daylight exposure and other predictors of Burnout Among Nurses in a University Hospital" published in Int J Nurs Stud. 2005, 141 nurses were examined and it was found that those who were exposed to daylight for at least three hours per day thrived better at work and had lower stress levels.

In the article "View through a Window May Influence Recovery from Surgery" published in Nature in 1984, Professor Roger Ulrich reported that patients in rooms with views of trees recovered 8.5% faster after surgery than patients with a view of a brick wall. They also needed smaller amount of painkillers.

### Can natural light be replaced by electric light?

In densely populated cities it can be tempting to replace natural light with electric light. However, the positive health effects we get from sunlight and natural light cannot be achieved by electric light.

The light we obtain needs to consist of a broad spectrum to make people feel good. In addition, our eyes need visible light to function. It has been proven that certain wavelengths have a particular impact on human health and well-being. To avoid health problems, our biological clock will have to be activated by plenty of blue light during the day. Limbic reactions have so far been discovered to improve human performance and productivity by using red light during daytime (9) as well as dynamic light for shift work (10). Although there is no complete picture of how different parts of the spectrum affect human health and well-being, it is clear that the spectrum needs to be significantly wider than that given by incandescent bulbs, fluorescent lamps, high pressure sodium lamps or LEDs.

Another challenge for electric light is to reflect the rhythm and shifts of natural light. Sun and daylight brings unique changes in intensity and color, from short shifts due to passing clouds, through day rhythm to seasonal variations. This gives us a connection to the outside world that electric light can not. In the case of circadian rhythm, LED light may even have a negative impact through an overexposure of blue light in the evening. Natural light is naturally changing, while electric light is controlled by man. It is difficult to create an illumination system that would be healthy for all users. There is also the risk that people will find it more difficult to accept light patterns created by man instead of the naturally varied daylight.



- (1) Figueiro (2013). 'An Overview of the Effects of Light on Human Circadian Rhythms: Implications for New Light Sources and Lighting Systems Design.' *Journal of Light & Visual Environment*, Vol. 37 (2013) No. 2 - 3.
- (2) Veitch och Galasiu. (2012). The Physiological and Psychological Effects of Windows, Daylight, and View at Home: Review and Research Agenda. NRC-IRC projekt 44-B3256 för Velux A/S.
- (3) Boyce, Hunter och Howlett (2003). The Benefits of Daylight through Windows, literature review, Capturing the Daylight Dividend Program, U.S. Department of Energy mm.
- (4) Smolders, K. (2013). Daytime light exposure - Effects and preferences, PhD dissertation TUDelft.
- (5) Strong, D. for Glass for Europe. (2012). The distinctive benefits of glazing: The social and economic contributions of glazed areas to sustainability in the built environment.
- (6) Boubekri M., Cheung I.N., Reid K.J., Wang C.H. och Zee P.C. (2014). 'Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study.' *Journal of Clinical Sleep Medicine* 2014;10(6):603-611.
- (7) Mottram, V., Middleton, B., Williams, P. och Arendt, J. (2010). 'The impact of bright artificial white and blue-enriched light on sleep and circadian phase during the polar winter'. *Journal of Sleep research*. 2011 Mar;20(1 Pt 2):154-61.
- (8) Åkerstedt T., Czeisler C., Dinges D., Horne J. (1993). 'Accidents and sleepiness: A consensus statement.' At: International Conference on Work Hours, Sleep and Accidents; Stockholm, Sweden: *J Sleep Res*. 1994;3.
- (9) Sahin och Figueiro. (2013). 'Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon.' *Elsevier, Physiology & Behavior* Volumes 116-117, 27 May 2013, sid 1-7.
- (10) Lowden A., Åkerstedt T. (2012). Ljus i kontrollrummet vid Forsmark 3 anpassat till skiftschema för optimering av synergonomi, vakenhet och återhämtning. Stockholm: Stressforskningsrapport nr 323.

### NATURAL LIGHT AND ADDED VALUE

Most people experience natural light more pleasant and stimulating than electric light. There is research showing that natural light facilitates learning and makes us more productive. Natural light also affects the production of several hormones, melatonin is the most famous. But there are other advantages as well. Below we list a few:

#### • Increased learning

Heschong Mahone Group published in 1999 "Daylighting in Schools: An Investigation Into The Relationship between Daylighting and Human Performance". A clear correlation was found between the increased use of daylight and result in studies. In a later report, "Daylighting Impacts on Human Performance in School" published in Leukos, the Journal of the Illuminating Engineering Society in 2002, the same connection was found, but could not find the cause.

In 2005 Peter Boyce published an article in Leukos, "Reflections on Relationships in Behavioral Lighting Research", where he states that "ample and pleasant view out of a window, that includes vegetation or human activity and objects in the far distance, support better outcomes of student learning."

#### • Better light quality

Natural light has perfect color rendering without the flicker, which can be valuable to provide an accurate picture of the textiles and furniture. People are also very tolerant of wide variations in natural light in compare with electric lighting. In a large survey from 2012, "Daylight Metrics, PIER Daylighting Research Program Plus" no correlation was found between glare and high levels of illuminance.

#### • Increased property value

Natural light affects the properties' value. In the report, "The Benefits of Daylight Through Windows" written by Lighting Research Center in 2003, it was concluded that the rent for commercial buildings without windows was 20% lower than in buildings with windows.

#### • Rewards in green certification systems

Most eco-labeling schemes, such as LEED, BREEAM and Green Building reward the use of natural light. In order to save energy by using natural light, electric lighting and blinds need to be controlled effectively. One of the benefits with a well-functioning light control is that it reduces the need for heating and cooling. For this to be possible, the building need to be designed for this. For additional information about how Parans can be used in the certification system, see chapter "When to use Parans?" on page 16-17.

#### • Less need for electric light

Good access for natural light means less need for electric light, which can mean energy savings.

#### • Increased sales

Two studies conducted by the Heschong Mahone Group, "Skylighting and Retail Sales: An Investigation Into The Relationship Between Daylighting and Human Performance" in 1999 and "Daylighting Impact on Retail Sales Performance" in 2002, reports in detail the relation between natural light stores and sales. It was stated that skylights had a greater impact on sales than, for example change in opening hours, customer base and renovation.

Another study, "Daylighting Enhances Sales: A Case Study" published in Environmental Building News in 1999 investigated 108 similar stores belonging to the same chain. Two thirds of these had skylights. Also in this study, it was concluded that skylights had the greatest positive impact of the examined parameters. It is worth to note that in all these studies examined the same parameters (location, opening hours, average income of the customers, when the store were renovated and skylights).

## DAYLIGHT IN URBAN AND DENSE CITIES

Today more than half of the world's population lives in cities and if the urbanization and people growth continues in the same way, it is expected that 2,5 billion more people lives in cities in year 2050. The urbanization creates today a huge interest for densify the cities and at many places in the world this means that the daylight will be a challenge. Deep buildings, dens block structure, increased demands on energy efficiency and older buildings to be adapted to new types of uses means that more and more people risk to end up in living and working environments with insufficient daylight.

Densification and urbanization also has many benefits and is often talked about as a possible solution to the challenges of our time. For example, sustainable and efficient transports are facilitated. However, one of the greatest challenges today is to ensure that urbanization is not done at the expense of human health and good living environments.

## DAYLIGHT REQUIREMENTS IN LEGISLATION

Most countries in the world and all European countries have some form of requirement of daylight in building legislation. The most common is that it requires windows / glass area per floor area, specify a minimum level of daylight and requires outlook.

It is more and more common to make demands on the amount of natural light throughout the year which also includes the use of sunlight. In 2013 Education Funding Agency published PSBP baseline designs: daylight strategy, which is a guide line for daylight in schools.

In this guide line the dynamic and some part qualitative indicators Useful Daylight index (UDI) and Daylight Autonomy (DA) are used.

The lowest level of UDI is 80% and 50% for DA, which is far from easy to achieve. Since several years back, there is also a project to develop a European standard for daylight in buildings, Daylight of buildings EN 17037, which contains the use and the need for sunlight, for example, Parans.

# PARANS LIGHT HOW IT WORKS

Sunlight is important for us humans. We feel better, learn better and faster, achieve better and become more productive – we succeed better. Many people spend an essential part of their day indoors and do not experience the sun's healthy natural light. Through innovative technology and design the Parans system follow the sun during the day just like a sunflower.

Since 2003 Parans has brought natural light to the indoor environment with the help of its green Swedish innovation – the Parans system. Fibre optic cables transport the sunlight in and through the property and spread the light in all rooms.

With the new fourth generation system the light is transported up to 100 meters. This means 30 floors down. Both the high light quality and intensity is retained all the 100 meters. This way sunlight can be experienced deep into buildings and far away from windows.

## THE PARANS SYSTEM

A Parans system consists of three parts. A collector, fiber optic cables and luminaires spreading the light indoors. One or more collectors is placed on or near the building on a place where they will have good access of direct sunlight. The collector consists of lenses mounted in aluminum profiles with a covering glass as protection. These lenses concentrates the sunlight down in the fiber optic cables. The lenses are made of plastic and cover laser especially made to resist dirt and reflection.

The collectors are modular which means they come with either 4,6,8,12 or 20 cables depending on the need. Every cable can have a individual length. This way they can meet your need for natural light in best possible way. That means you can optimize both the number of cables and their length on every installation. The fibre optic cables transport the natural light 100 meters (30 floors) in and through the property while retaining both a high lever of light quality and light intensity.

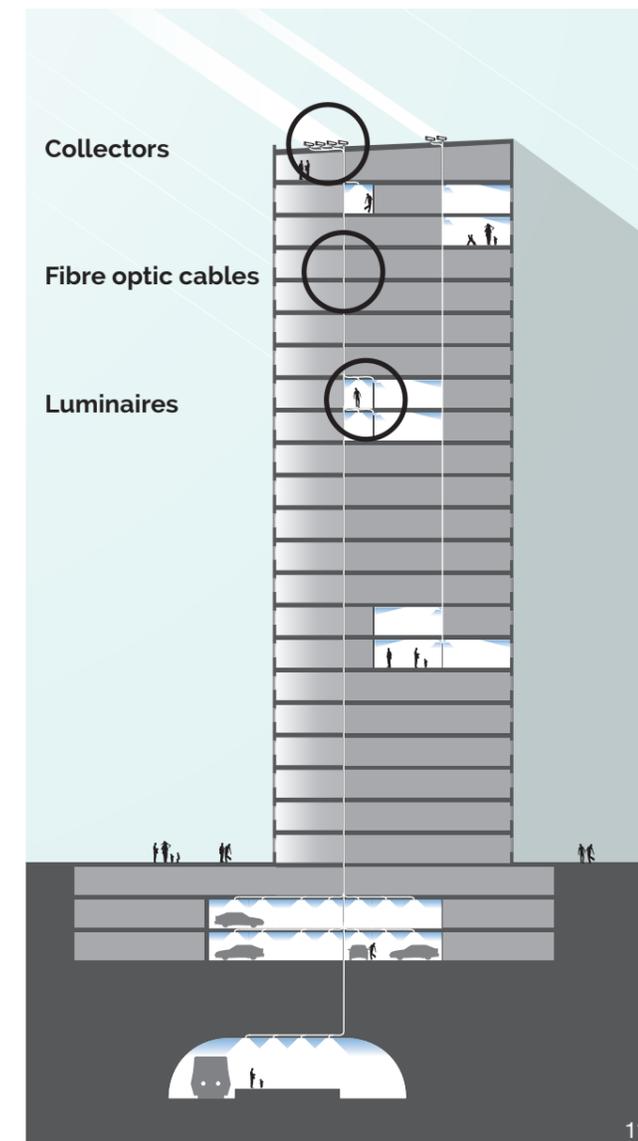
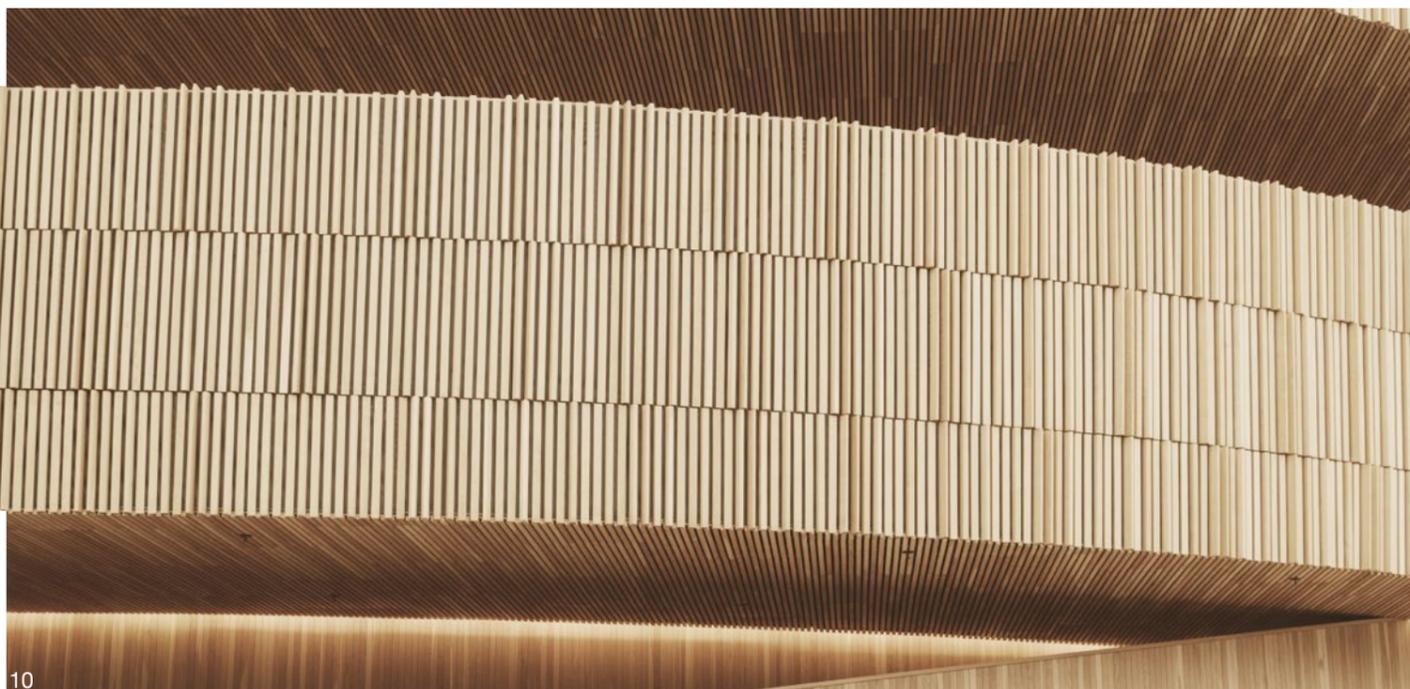
## The natural light experience you demand

All people in every room, even deep into the building, can experience healthy natural light. The light can be spread in a variety of ways, creating the experience you demand.

## Always connected to the cloud

The Parans system is constantly connected with the internet in order to provide performance data. Customers can receive information on the amount of hours of sunlight in the building and the service organisation can monitor its level to ensure maximum up-time.

A parans system is built to deliver light for tens of years, but it will need maintenance and service to function properly. Parans offers a basic guarantee that can be expanded with different kinds of service agreements. See details in our service and guarantee document.





## Leading sunlight

### SP4 PRODUCT SPECIFICATION

– FOURTH GENERATION PARANS SYSTEM

- Highest light quality available
- Customized cable length – up to 100 meters
- Modular system: 4-20 light points/collector
- No IR and UV
- Flexible and thin cables
- Connected to the cloud



Five sizes

SP4-4

SP4-6

SP4-8

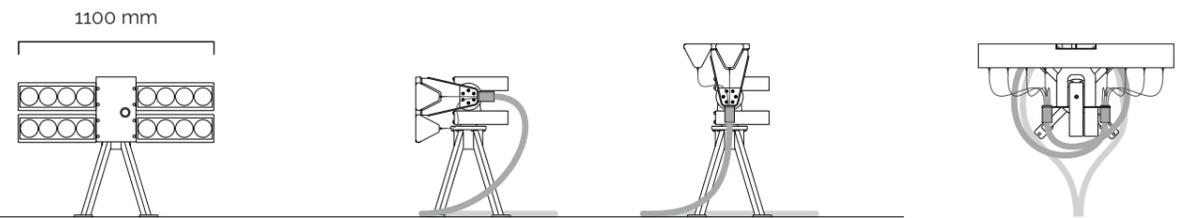
SP4-12

SP4-20

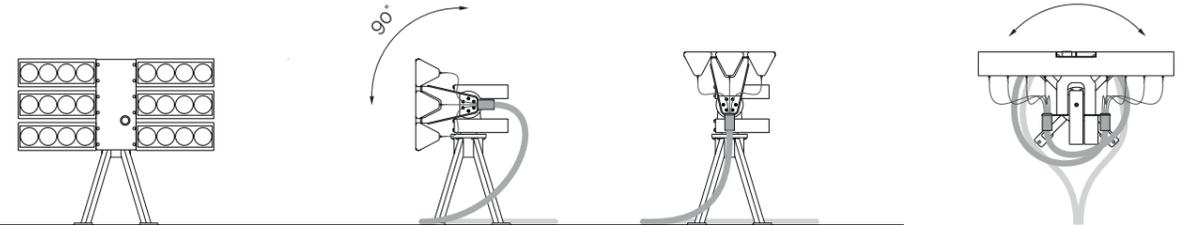
	SP4-4	SP4-6	SP4-8	SP4-12	SP4-20
Width (mm)	1100	1100	1950	1950	1950
Height (mm)	820	940	820	940	1120
Weight (kg) without cables	60	65	75	85	95
Fibre optic cables - light points	4 pcs	6 pcs	8 pcs	12 pcs	20 pcs
Light output (lm)*	3600-5200	5400-7800	7200-10400	10800-15600	18000-26000
Light output (lm) per cable*	900-1300 (depending on cable length)				
Maximum cable length	100 meters (customized for each cable)				
Fiber optic cable diameter	6 mm				
Minimum bending radius	150 mm				
Power supply	100-250 V AC, 50-60 Hz, 1 cable per system				
Power consumption	0-12 W				
Operating Temperature	-20°C - +50°C				
Materials	Aluminium, Steel, Glass, Acrylic, PE				
IP rating (electronics)	IP65				
Connection	Web Interface (GPRS/3G/4G)				

\* All values are based on solar illuminance of 100 000 Lux and dependent on the cable length.

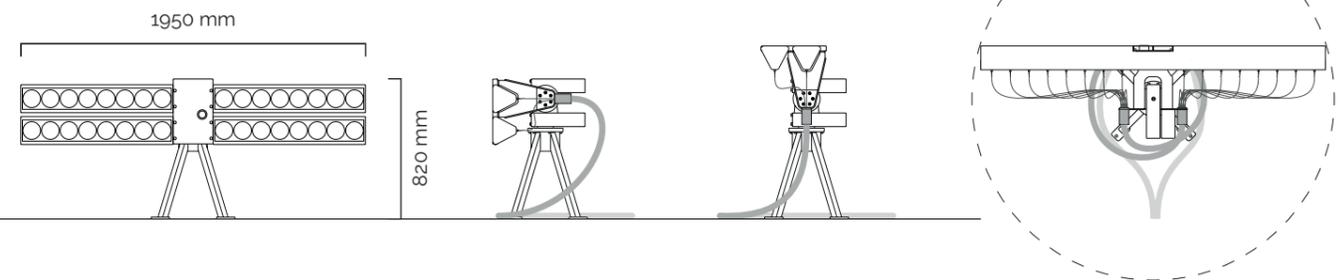
SP4-4



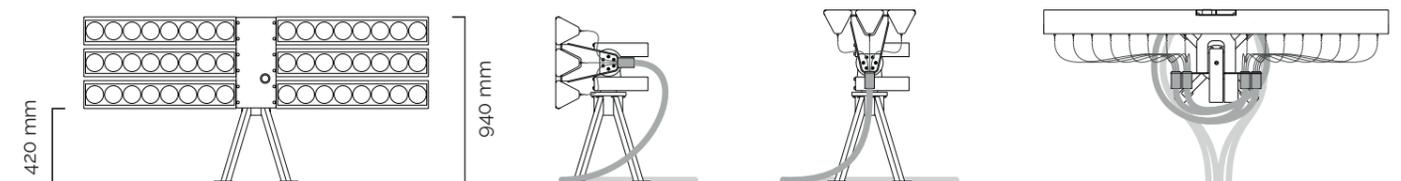
SP4-6



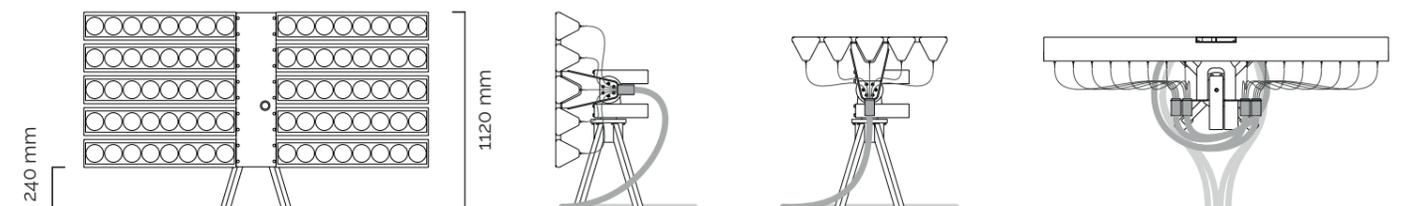
SP4-8



SP4-12



SP4-20



## Leading sunlight

### SP4 LUMINAIRES

- NATURAL LIGHT INSIDE

Spread the light in a variety of ways meeting your demands:

**POINT LIGHT** — provides light over a large area

**CEILING LIGHT** — providing light over the ceiling

**WALL LIGHT** — providing light over the wall

Which light experience do you prefer?

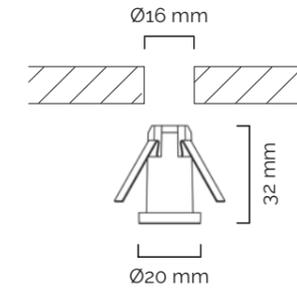


	Point Light	Point Light 2	Ceiling Light	Wall Light
Fibre optic cables - light points	1 pcs	1 pcs	1 pcs	1 pcs
Beam angle	55°	55°	55°	55°
Colour*	White/Black/Chrome	White/Black	White/Black/Chrome	White/Black/Chrome
Size (mm)	Ø20 x 32	Ø33 x 30	Ø47 x 34	Ø47 x 34
Weight (kg)	0,1	0,1	0,1	0,1
Tilt	-	20°	50°	50°
Rotate	-	360°	360°	360°
Protection rating	IP 20	IP 20	IP 20	IP 20
Built-in height (mm)	180	180	180	180
Mounting hole (mm)	Ø16	Ø29	Ø26	Ø26
Mounting	Recessed with spring	Recessed with spring	Semi-recessed with screws	Semi-recessed with screws
Material	UV-stable thermoplastics			
Light output (lm) per cable**	900-1300 (depending on cable length)			
Maximum cable length	100 meters (customized for each cable)			
Fiber optic cable diameter	6 mm			
Minimum bending radius	150 mm			

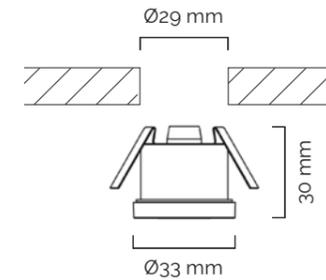
\* For other colors or special requests on luminaires, please contact your local sales agent.

\*\* All values are based on solar illuminance of 100 000 Lux and dependent on the cable length.

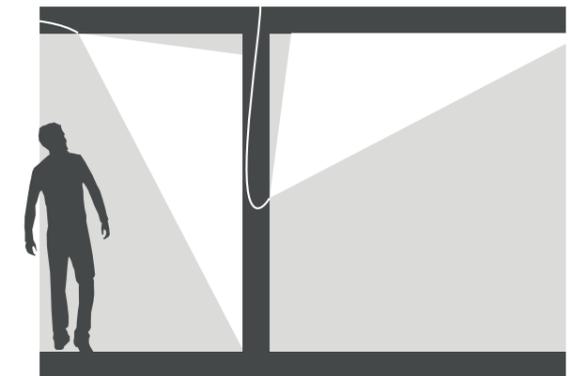
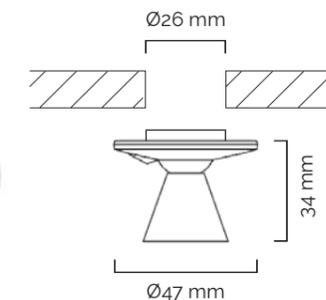
Point light



Point Light 2



Ceiling/Wall Light



# WHEN TO USE PARANS?

Parans' solutions can be used to avoid extensive refurbishment, receive valuable scores in green building certifications and save energy. These facts, combined with the favorable health aspects mentioned in previous chapters positions Parans as a core component in all sustainable construction projects. Following chapter elaborate how Parans can be a contributor in sustainability and buildings.

BREEAM®



## FULFILLING CERTIFICATION DEMANDS WITH PARANS

### BREEAM New Construction

The BREEAM indicator called "Hea 01 - Visual comfort" can give up to 6 points through the following criteria:

- Potential for disabling glare has been designed out of all relevant building areas.
- Good practice daylighting levels have been met.
- Floor space in relevant building areas has an adequate out view to reduce eye-strain and provide a link to the outside.
- Internal and external lighting systems are designed to avoid flicker and provide appropriate illuminance (lux) levels.
- Internal lighting is zoned to allow for occupant control.

Of these Parans can mainly be used to make sure that good practice daylighting levels have been met, which gives maximum 2 points. Daylighting can be established in two ways, method A and method B. Method A take into consideration the average daylight factor, while method B, the average illuminance.

As the daylight factor per definition does not contain any sunlight, Parans can not be used to improve that indicator.

The average illuminance on the other hand, will be highly improved by Parans products. Especially in rooms with darker areas. Depending on type of room, demands are put on the lowest average illuminance level. (100 - 300 lux) as well as the amount of hours every year that this level needs to be upheld. (2000 - 3150 hours).

### LEED version 4

LEED rewards buildings that connects occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space. This can give maximum 3 points. There are two methods of simulation to show that the demands for daylight is met. Method 1 and method 2. Parans can be used for both methods.

### Method 1

In a yearly computer simulation you will have to show that the spatial daylight autonomy 300/50% (sDA 300/50) is at least 55%, 75% or 90% depending on the amount of points and type of premises. We do not think that Parans should be a part of the ASE calculation (annual sunlight exposure) as the system usually is mounted on the roof and do not cause blinding. In the method the following conditions are stated.

The sDA and ASE calculation grids should be no more than 2 feet (600 millimeters) square and laid out across the regularly occupied area at a work plane height of 30 inches (760 millimeters) above finished floor (unless otherwise defined). Use an hourly time-step analysis based on typical meteorological year data, or an equivalent, for the nearest available weather station. Include any permanent interior obstructions. Movable furniture and partitions may be excluded.

### Method 2

Depending on the amount of points the illumination-levels for 75 or 90% of the room should be between 300 and 3000 lux at 9 am and 3 pm on a clear day. In the methods the following conditions are stated.

Calculate illuminance intensity for sun (direct component) and sky (diffuse component) for clear-sky conditions as follows:

- Use typical meteorological year data, or an equivalent, for the nearest available weather station.
- Select one day within 15 days of September 21 and one day within 15 days of March 21 that represent the clearest sky condition.
- Use the average of the hourly value for the two selected days.

Exclude blinds or shades from the model. Include any permanent interior obstructions. Movable furniture and partitions may be excluded.

### WELL

The WELL Building Standard is seeking to implement, validate and measure features that support and advance human health and wellness. 10% of all the indicators within Well concerns light in different forms. Parans can be used to ensure indicator 53, Visual lighting design, 54 Circadian lighting design, 58, Color quality and 62, Daylight modeling

### EFFECTIVE USE OF DEEP BUILDINGS

Parans allows the effective utilization of deep buildings and can be an easy and cost-effective alternative to major engagement in the property such as light shafts and complex retrofits. This allows buildings that are under retrofitting for new use area can to a greater extent be used as they are. In cases where an existing building is going to be converted from a business area with less persons (industry, commerce, secondary area underground, etc.), to instead, for example, offices Parans may do this in a more resource effective and sustainable way.

### ENERGY SAVINGS WITH PARANS

Parans' solutions gives a possibility to replace artificial lighting with natural sunlight when the sun is shining, even further into a building. This means energy savings, and is an effective way to use direct solar energy. In the case of an installation whereas the primary objective is to save energy it is recommended to combine it with artificial lighting and light sensors. The artificial lighting is then switched on when the sun is not available, but dims down immediately when Parans is active. Daylight Illuminated buildings can reduce energy consumption for electric lighting by 20 to 60 percent. This is reported in a variety of studies, including "Photoelectric Control: The Effectiveness of Techniques to Reduce Switching Frequency" in 2001 and "Summertime Performance of an Automated lighting and blinds Control System" from 2002.

How much savings, will depend on the location and function of the control system, the desired illuminance level and available sun on the resort. To accurately calculate the potential energy savings with a Parans installation the indicator daylight autonomy can be used. Daylight autonomy can be calculated by Parans Daylight Autonomy Tool described on page 22-23.

### Less need for cooling/lower room temperature

Natural light has very good light exchange, the relationship between light and heat or light and electric power. The light exchange varies depending on the weather but can be up to 150 lux/W. This is more than twice as effective than a standard fluorescent lamp and as good as the most efficient LEDs. This could lead to a reduced need for cooling and/or a cooler room climate in the summer. However, this requires that you limit the direct solar radiation and has a well functioning control system.

### Decreased need for power?

Sunlight is especially well suited for those commercial buildings whereas the need of light coincides with the timings of when the sun shines. Hence, when the maximum power consumption for mechanical cooling coincides at the time when the sunlight is the most accessible at the buildings' power consumption can be reduced.



# HOW TO SPECIFY?

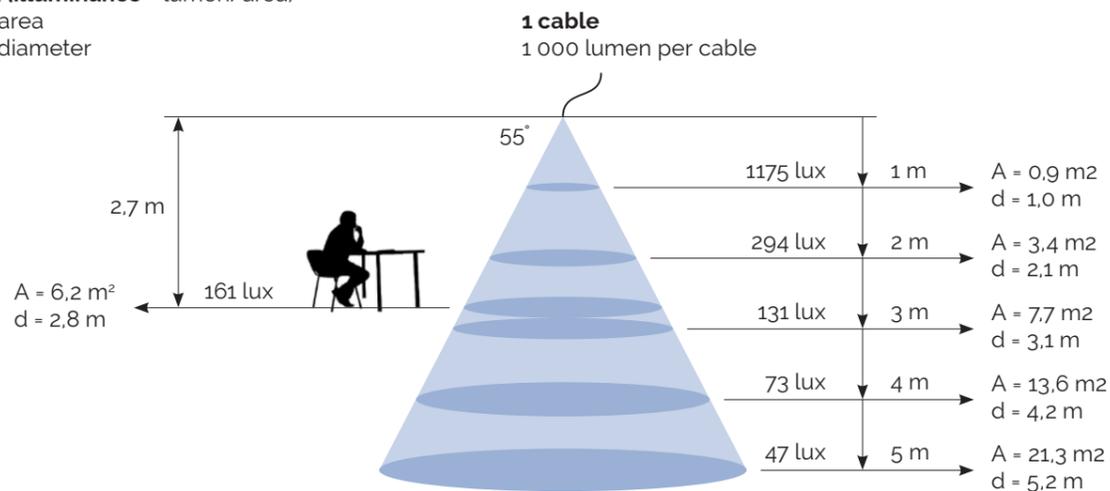
We have developed two methods, i.e. calculations methods, that supports you in scoping an installation. One simplified version however with less accuracy and a more complex one but with the advantage that it provides superior accuracy. Use the methods to for example calculate the number of luminaires that is needed in a certain project or calculate the theoretical saving of lighting energy a Parans system will give once it is installed.

## PARANS SIMPLIFIED CALCULATION TOOL

To easily estimate how much light a Parans system gives just change the parameters and see how the results change by using the excel tool. You can change lumen output, ceiling height and cable length. The different illuminance for the individual cables as well as for the total amount of cables are easily calculated.



**Lumen** (luminous flux)  
**Lux (illuminance = lumen/area)**  
**A** = area  
**d** = diameter

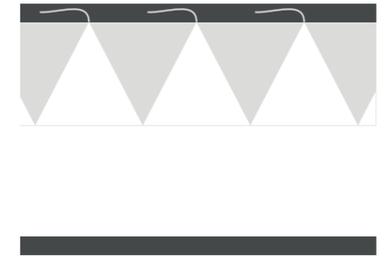
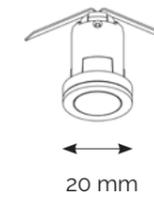


All values are approximate and based on solar illuminance of 100 000 Lux and dependent on the cable length.

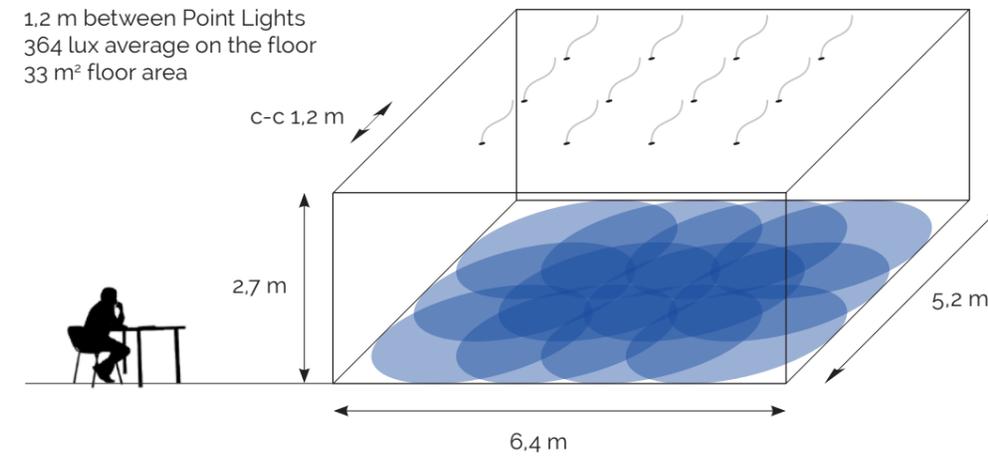
## 12 Point Lights

(aprox. 1000 lumen per cable)

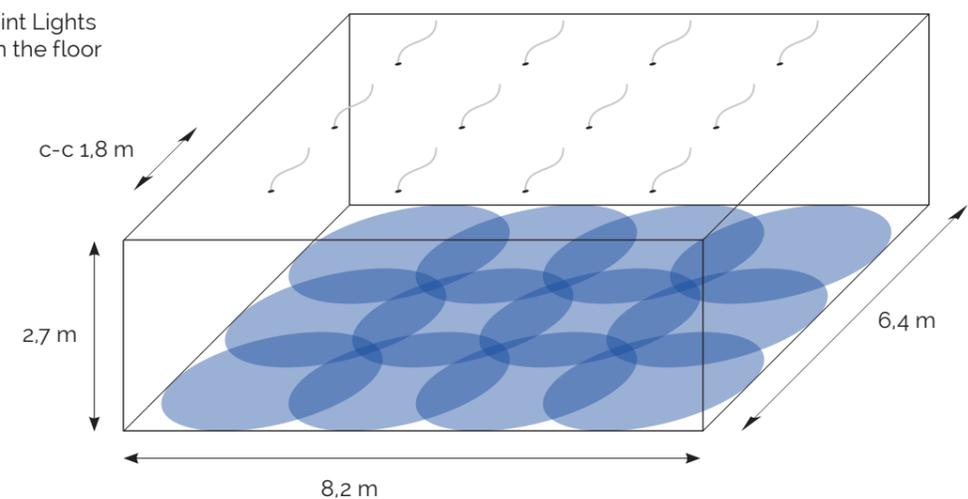
Beam angle	55°
Colour	White
Size	Ø20 x 32 mm
Built-in height	180 mm



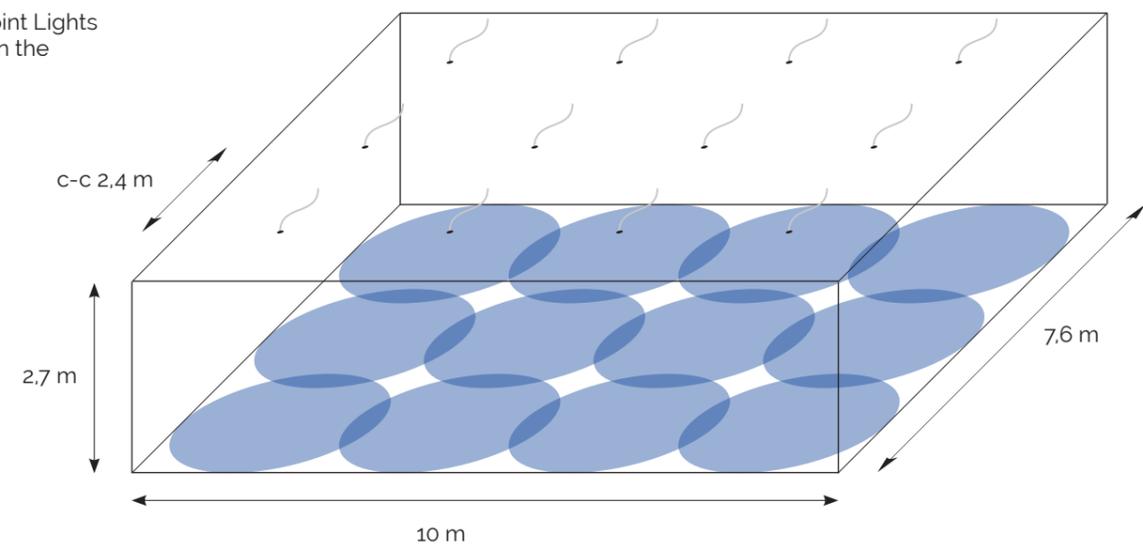
1.2 m between Point Lights  
 364 lux average on the floor  
 33 m² floor area



1.8 m between Point Lights  
 231 lux average on the floor  
 52 m² floor area



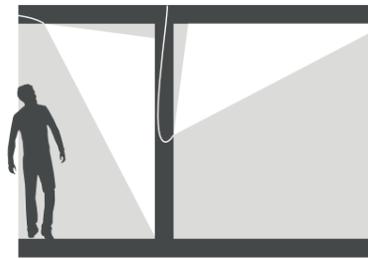
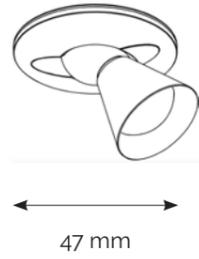
2.4 m between Point Lights  
 158 lux average on the floor  
 76 m² floor area



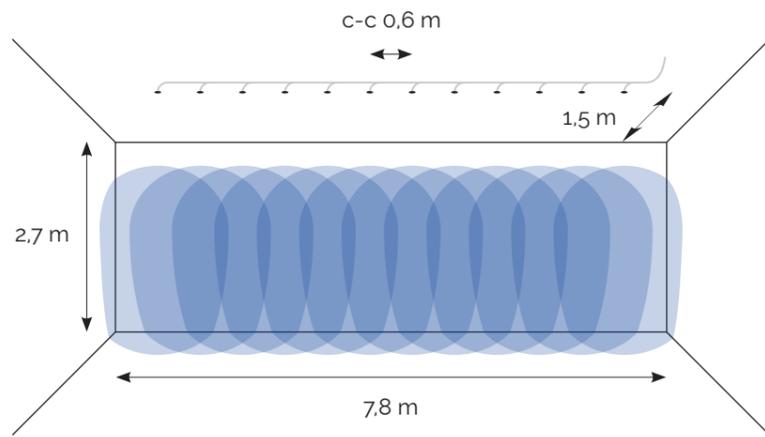
All values are approximate and based on solar illuminance of 100 000 Lux and dependent on the cable length.

**12 Wall Lights**  
(aprox. 1000 lumen per cable)

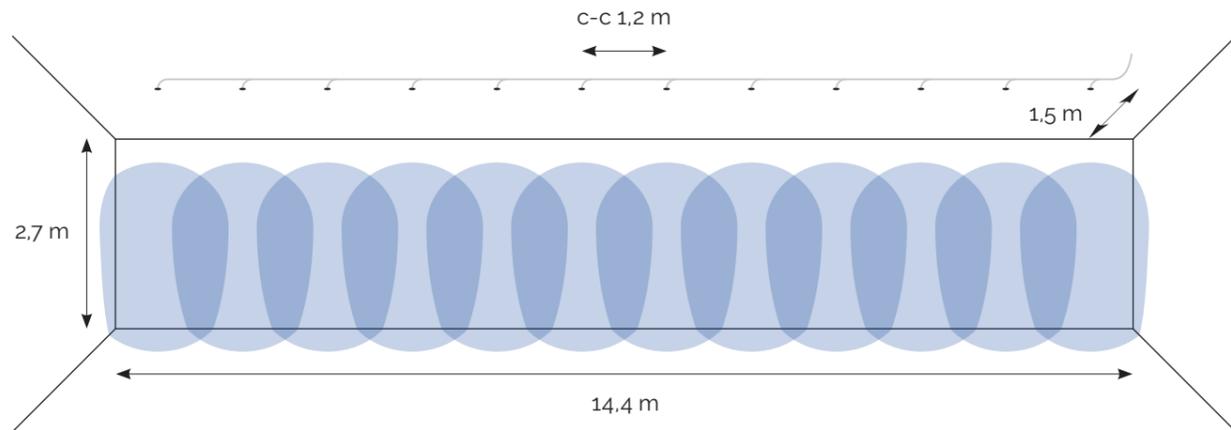
Beam angle	55°
Colour	White
Size	Ø47 x 34 mm
Tilt	50°
Rotate	360°
Built-in height (mm)	180 mm



0,6 m between Wall Lights  
571 lux average on the wall  
21 m² wall area



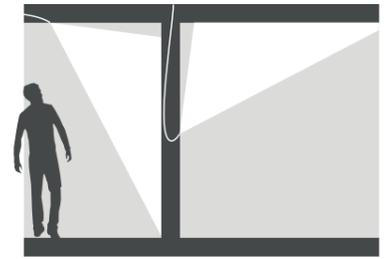
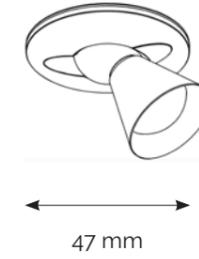
1,2 m between Wall Lights  
308 lux average on the wall  
39 m² wall area



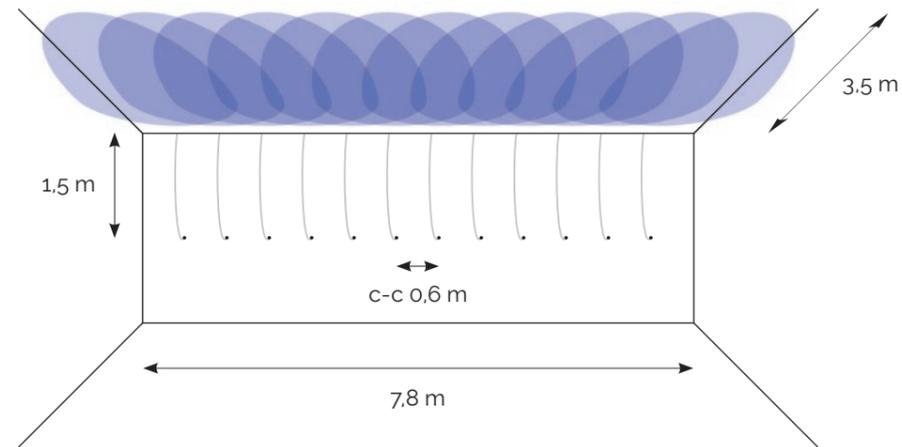
All values are approximate and based on solar illuminance of 100 000 Lux and dependent on the cable length.

**12 Ceiling Lights**  
(aprox. 1000 lumen per cable)

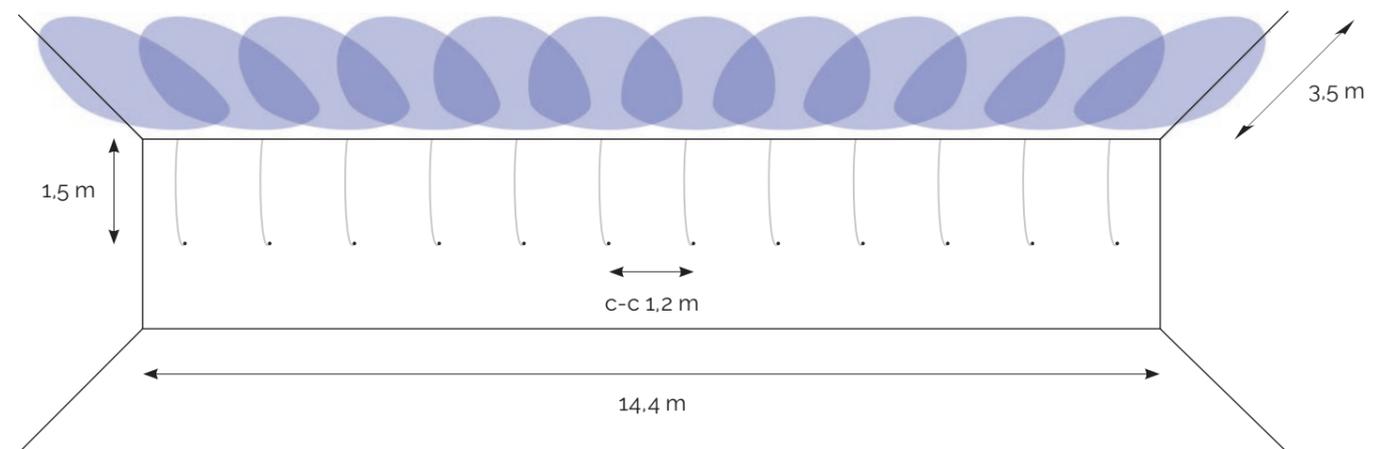
Beam angle	55°
Colour	White
Size	Ø47 x 34 mm
Tilt	50°
Rotate	360°
Built-in height (mm)	180 mm



0,6 m between Ceiling Lights  
444 lux average on the ceiling  
27 m² ceiling area



1,2 m between Wall Lights  
240 lux average on the wall  
50 m² wall area



All values are approximate and based on solar illuminance of 100 000 Lux and dependent on the cable length.

## PARANS DAYLIGHT AUTONOMY TOOL

When more complex situations are studied we recommend weather-data in combination with IES files in an simulation environment in connection with the validated calculation software Radiance and Daysim. This is valid for example when concurrence between the Parans system and the natural light from windows are to be studied. This also goes for studies of time dependant connections (for example daylight autonomy). In the simulation method described below, the simulation environment Grasshopper is used in combination with the geometry handler Rhinoceros.

### Weather data

EPW files is a standard format to describe the normal weather during a year in a certain location. The files are distributed free of charge for a large number of locations in the world. Through the VIA Energy plus weather database (<http://energyplus.net/weather>) the behaviour of the Parans system during a year can be simulated by taking the direct sun illuminance of the EPW file. This parameter is called "directNormalIlluminance".

### Methodology

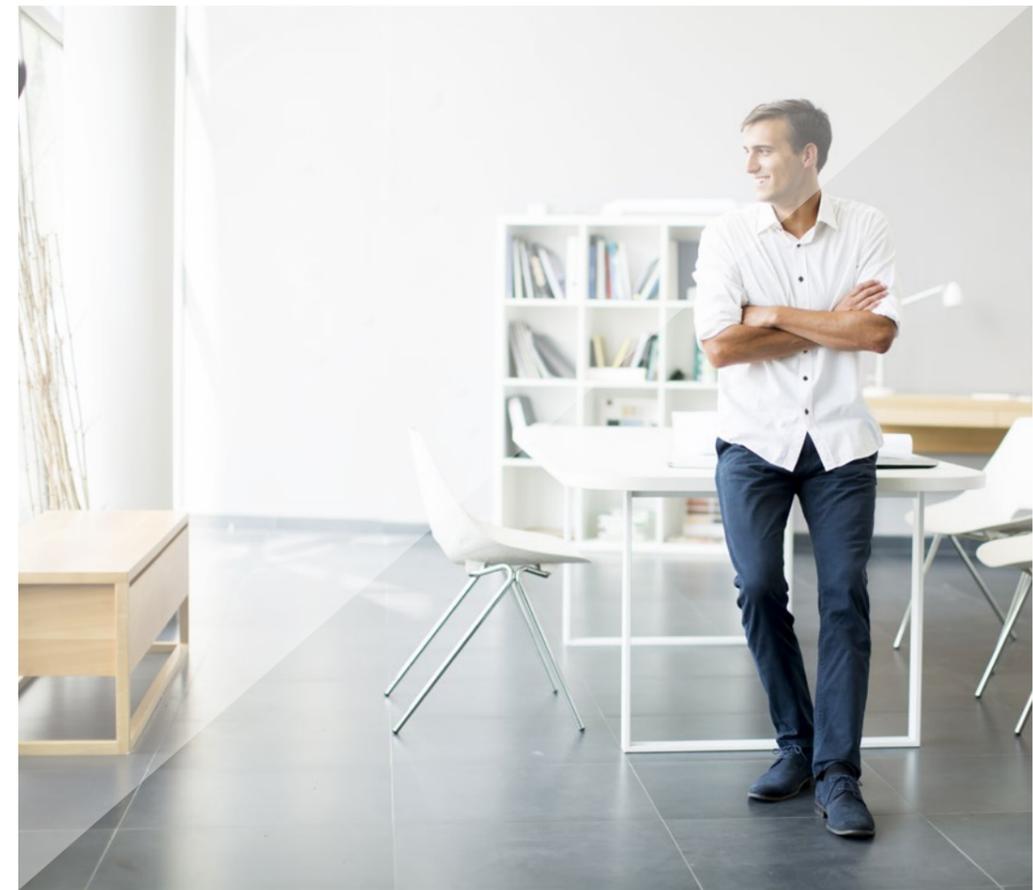
To handle Parans behaviour over the period of a year, grid based simulations works well. A clear and simple method is to make a grid based simulation with IES files and the rescale the result according to the direct connection between the direct sun illuminance outdoors and the flow from the Parans system. This will result in hourly results for each point in a studied simulationgrid, where there for each point is a resulting illuminance for one whole year.

If there are both a Parans system and windows in the studied room, the Parans illuminance can be simulated separately and the resulting illuminance levels can then be added hourly since illuminance is additive. The Parans system is simulated according to the method mentioned above with a totally black sky. The influence by daylight through windows is simulated as usual without the Parans system.

### To consider

When simulating Parans light, this is what you need to consider

- Panes, window depth and profiles has an impact on a windows ability to let light in.
- Remember to modulate the windows light-transmittance properly. Low emissive coatings and dirt is resulting in modern windows having a lower light transmittance than normal clear glass. When calculating with the BREEAM standard, the contamination of the windows will have to be considered.
- Avoid unnecessary details and simplify as much as possible. Often it can be better to modulate the room yourself than to use ready made 3D and BIM models.
- Take shadows from nearby buildings into consideration.
- Use the right size of detailed calculation grids. 3 dm in normal sized rooms is usually a good number.
- Most often you dont need to take furniture and technical installations into consideration.
- Make sure the quarters are correct if there are windows in the model.
- The analyses requires the Parans collectors to be unshadowed. If that is not the case, a shadow analysis needs to be done.



## THE PROCESS FOR PARANS DAYLIGHT AUTONOMY TOOL

### INPUT-DATA

- Geographic location of the building (city)
- Orientation (quarter)
- Overriding surroundings if there are any. For example other buildings or typography
- The analyzed rooms geometry. Either blueprints to draw the room from or a ready made 3D geometry. Most formats can be handled (for instance 3D-dwg, obj, skp, 3ds etc) Simple volume models is preferred before very complex geometry modulations.
- Precense (for daylight autonomy)
- Window characteristics (if the room has windows and their characteristics are known)
- Approximate fiber length from the roof collector to the luminaires.

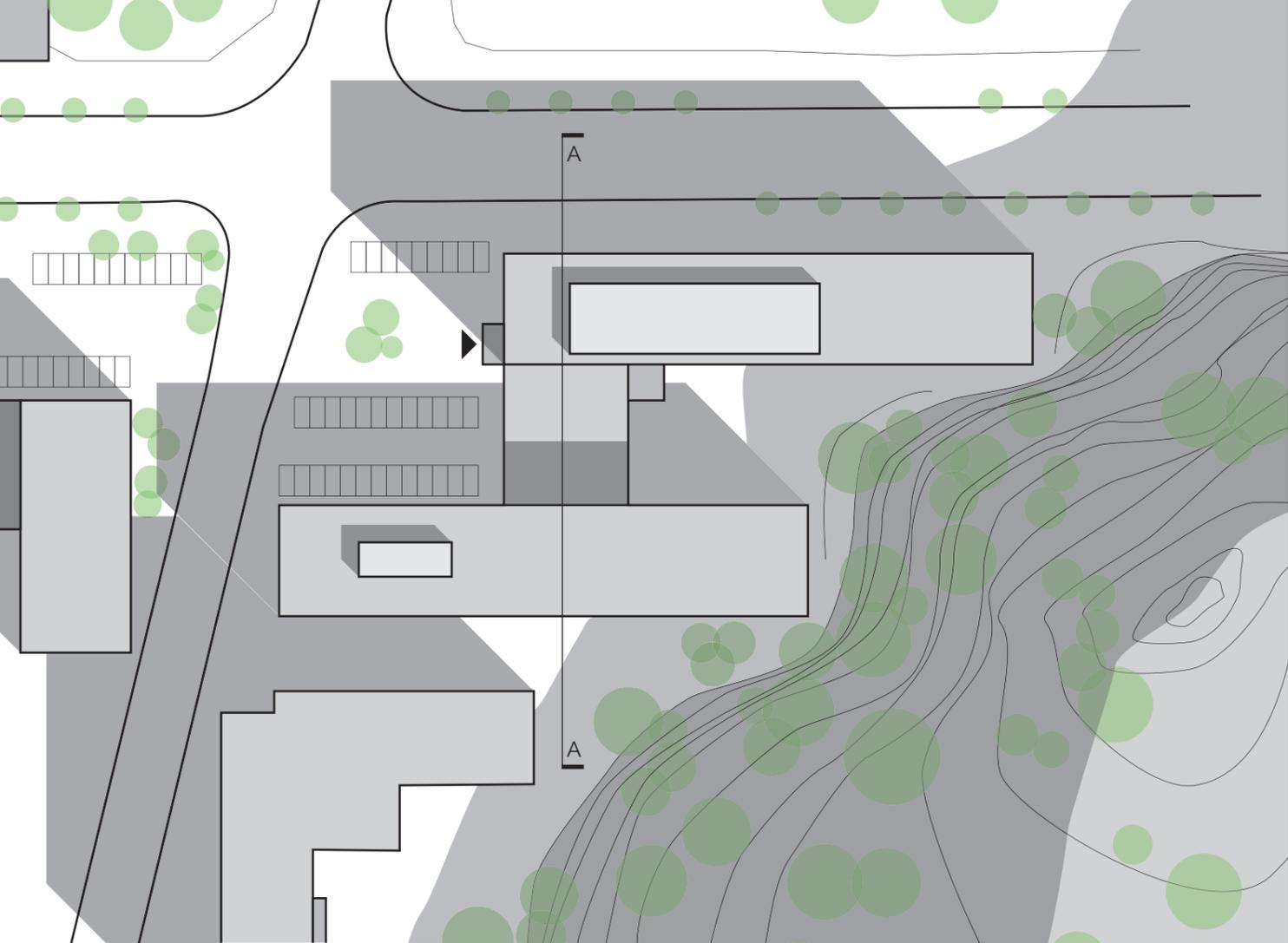
And then either a proposed placement of the Parans collectors and luminaires that you want to analyse or a requirement specification or a specific request:

### For example:

- We want a light level of 300 lux on these surfaces.
- We want this room to meet the LEED-requirements.
- We want to have the Parans light on this wall
- We want to achieve a certain daylight autonomy
- We want to...

### OUTPUT-DATA

- The out-data can be presented as diagrams or as graphs. If required, certain indicators (for example average illuminance or illuminance on a certain point) also be presented as diagrams over time.
- Number of hours with Parans light on the current location and distribution over a year and work day.
- DA (Daylight Autonomy)
- sDA (spatial Daylight Autonomy)
- UDI (Useful Daylight Illuminance), gives an indication of problems with too much sun radiation which can cause problems with windows, but not correctly installed Parans.
- Illuminance distribution in the room at any given time.
- Illuminance distribution on sunny days.
- Theoretical energy savings (with electric lights that dims down depending on the day light levels).
- An answer wether the room is expected to pass the demands in BREEAM or LEED.
- Proposed placements of the Parans collectors and luminaires



Site Plan 1:1000 

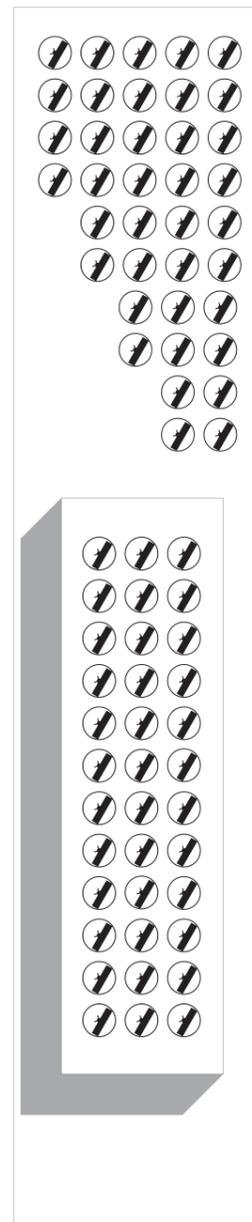
**USE CASE - OFFICE BUILDING, SAN DIEGO, USA**

This chapter will help you in your installation planning of the Parans light by guiding you through the steps and questions that you need to consider and answer regarding your specific project. To guide you in the simplest way, we will use a project showing you each step to consider.

This use case is an office building that is geographically located in San Diego and is used primarily during working hours. The main part of the day the building is shaded by surrounding mountains and buildings. The building itself is deep and therefore has many deep rooms that does not have enough access to daylight.



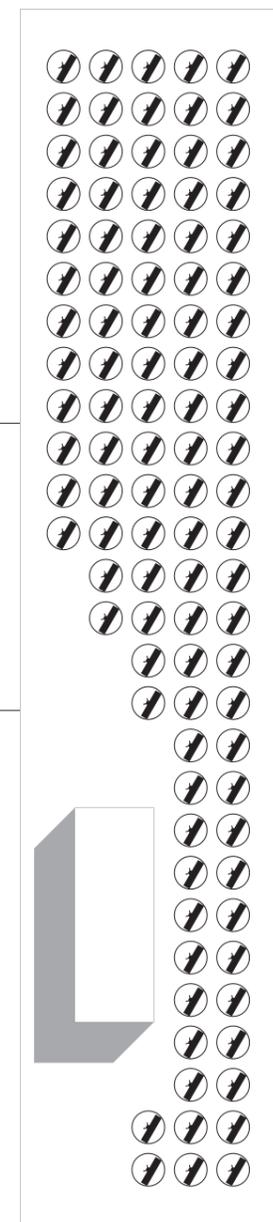
Sektion A-A 1:1000



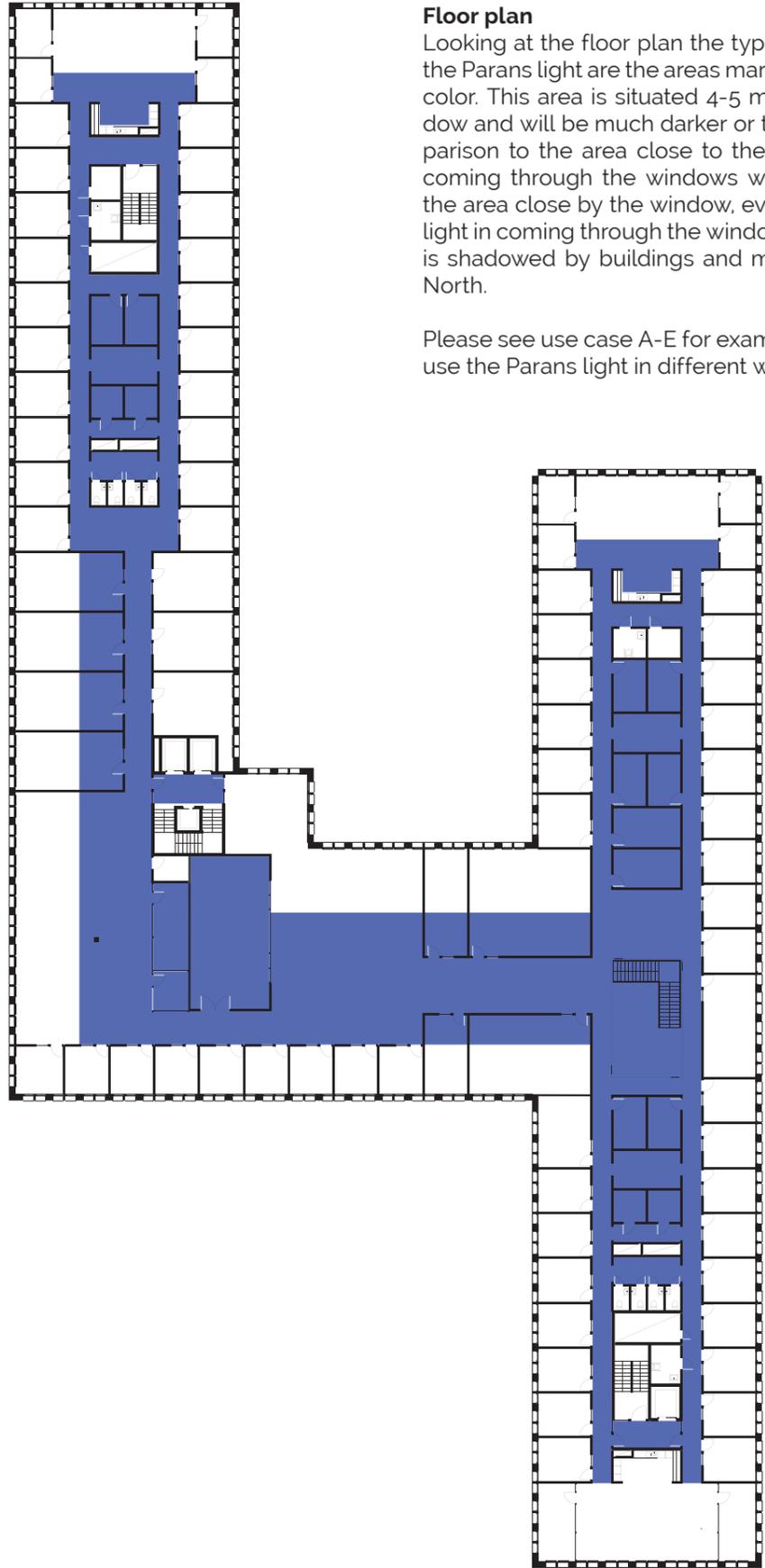
 = One SP4 Parans collector

**Roof plan**

The roof plan shows how the Parans system's collectors could be placed on the roof. The collectors need to have direct access to the sun. The collectors do not cover the whole roof due to that they would be shadowed by higher buildings or by each other. A center to center distance of 3 meter is usually enough between the collectors.



 Roof Plan 1:500



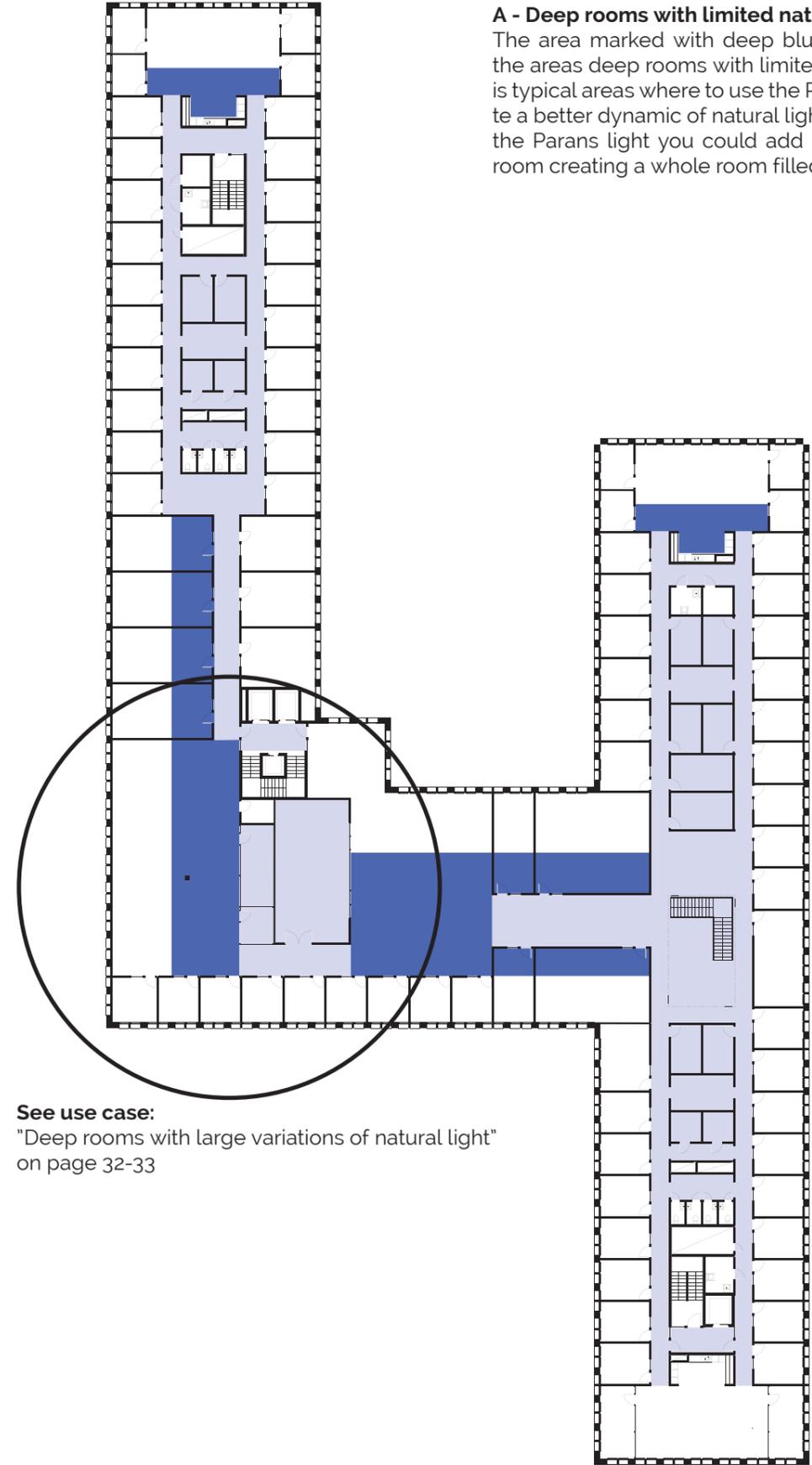
**Floor plan**

Looking at the floor plan the typical areas for using the Parans light are the areas marked with deep blue color. This area is situated 4-5 meter from the window and will be much darker or totally dark in comparison to the area close to the window. The light coming through the windows will be sufficient for the area close by the window, even if no direct sunlight is coming through the window since the façade is shadowed by buildings and mountains or facing North.

Please see use case A-E for example how you could use the Parans light in different ways.



Floor Plan 1:500



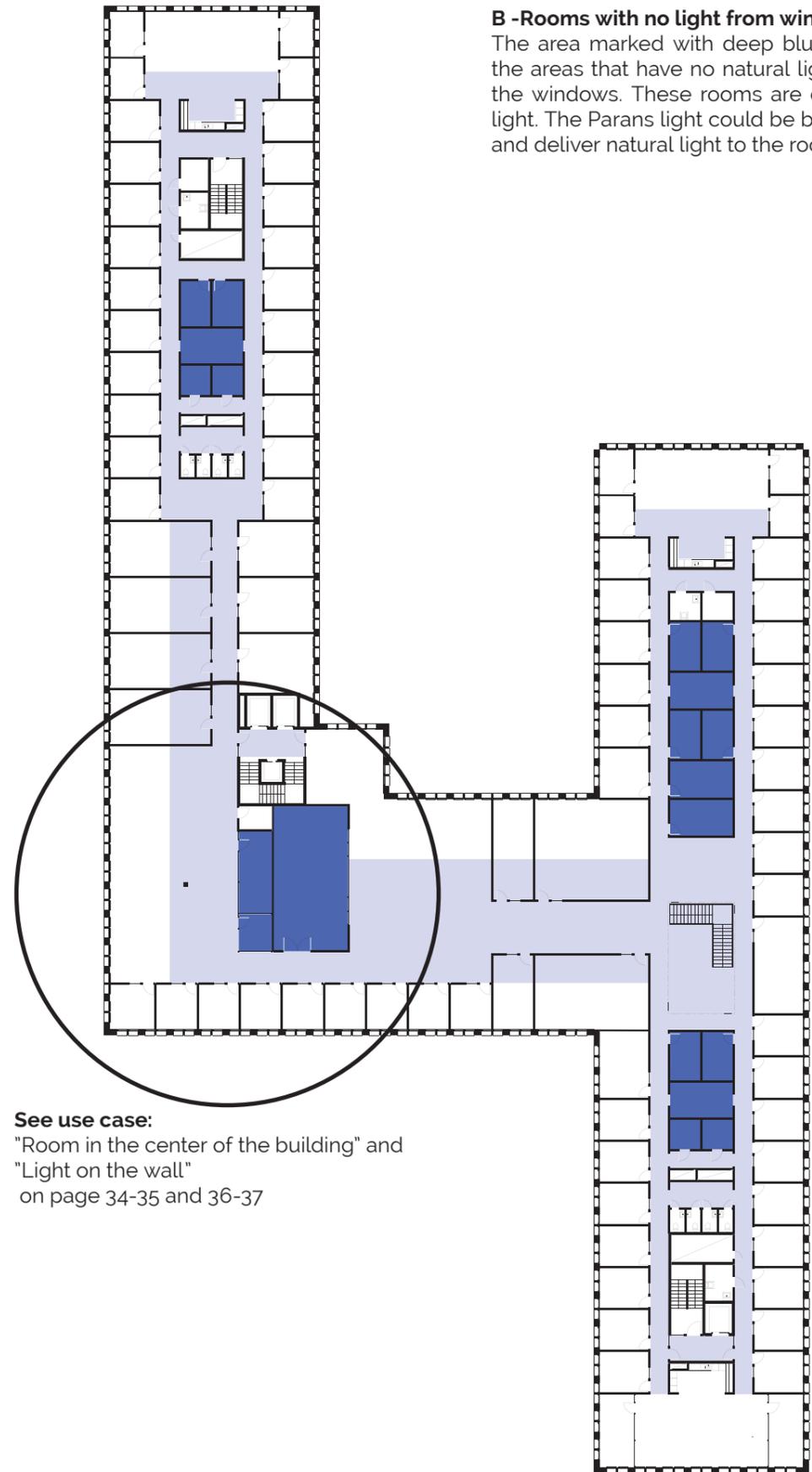
**A - Deep rooms with limited natural light**

The area marked with deep blue color is showing the areas deep rooms with limited natural light. This is typical areas where to use the Parans light to create a better dynamic of natural light in the room. With the Parans light you could add natural light to the room creating a whole room filled with light.

**See use case:**  
 "Deep rooms with large variations of natural light"  
 on page 32-33



Floor Plan 1:500



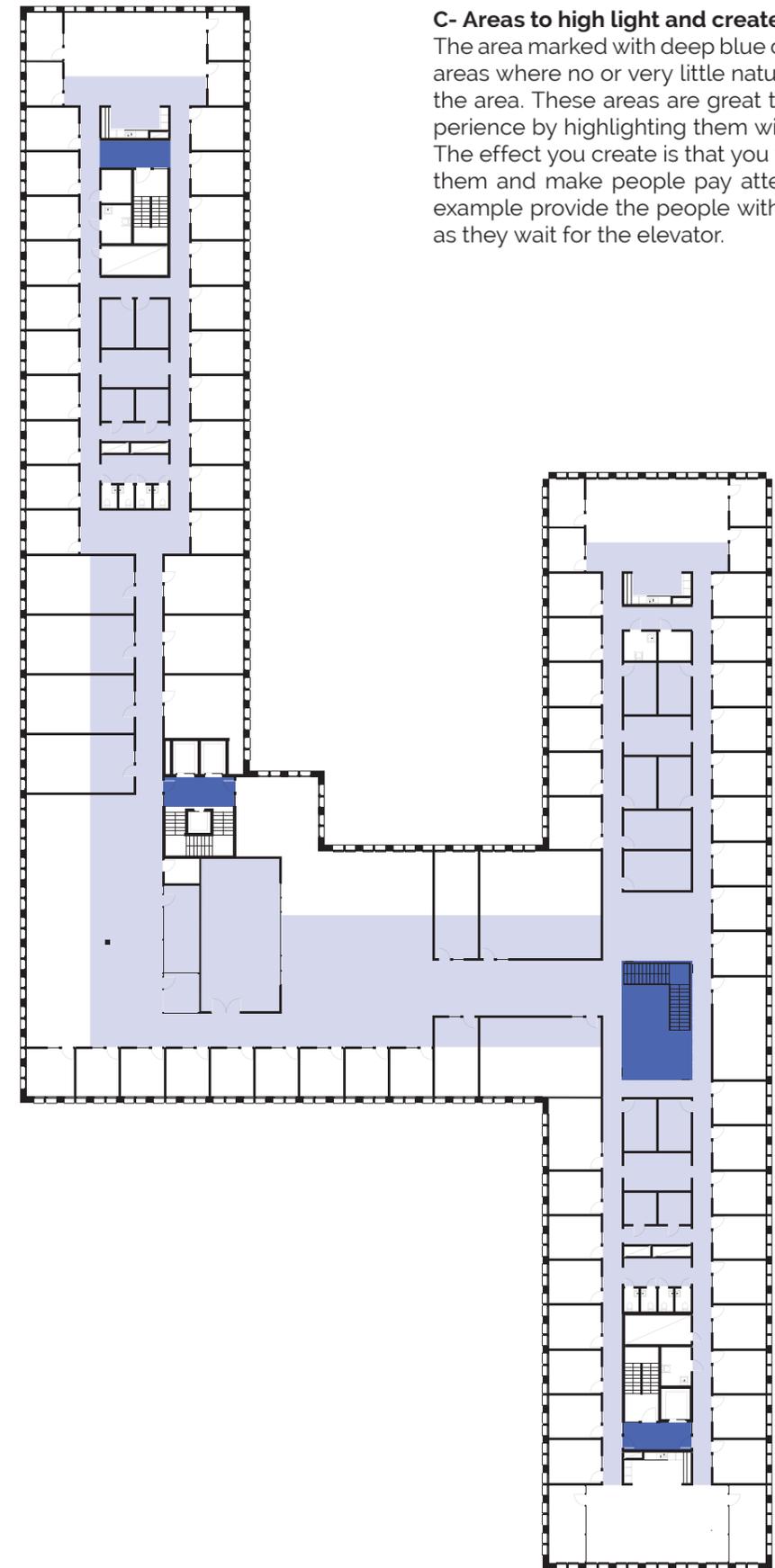
**B - Rooms with no light from window**

The area marked with deep blue color is showing the areas that have no natural light coming in from the windows. These rooms are demanding natural light. The Parans light could be brought to the room and deliver natural light to the room in full.

**See use case:**  
 "Room in the center of the building" and  
 "Light on the wall"  
 on page 34-35 and 36-37



Floor Plan 1:500

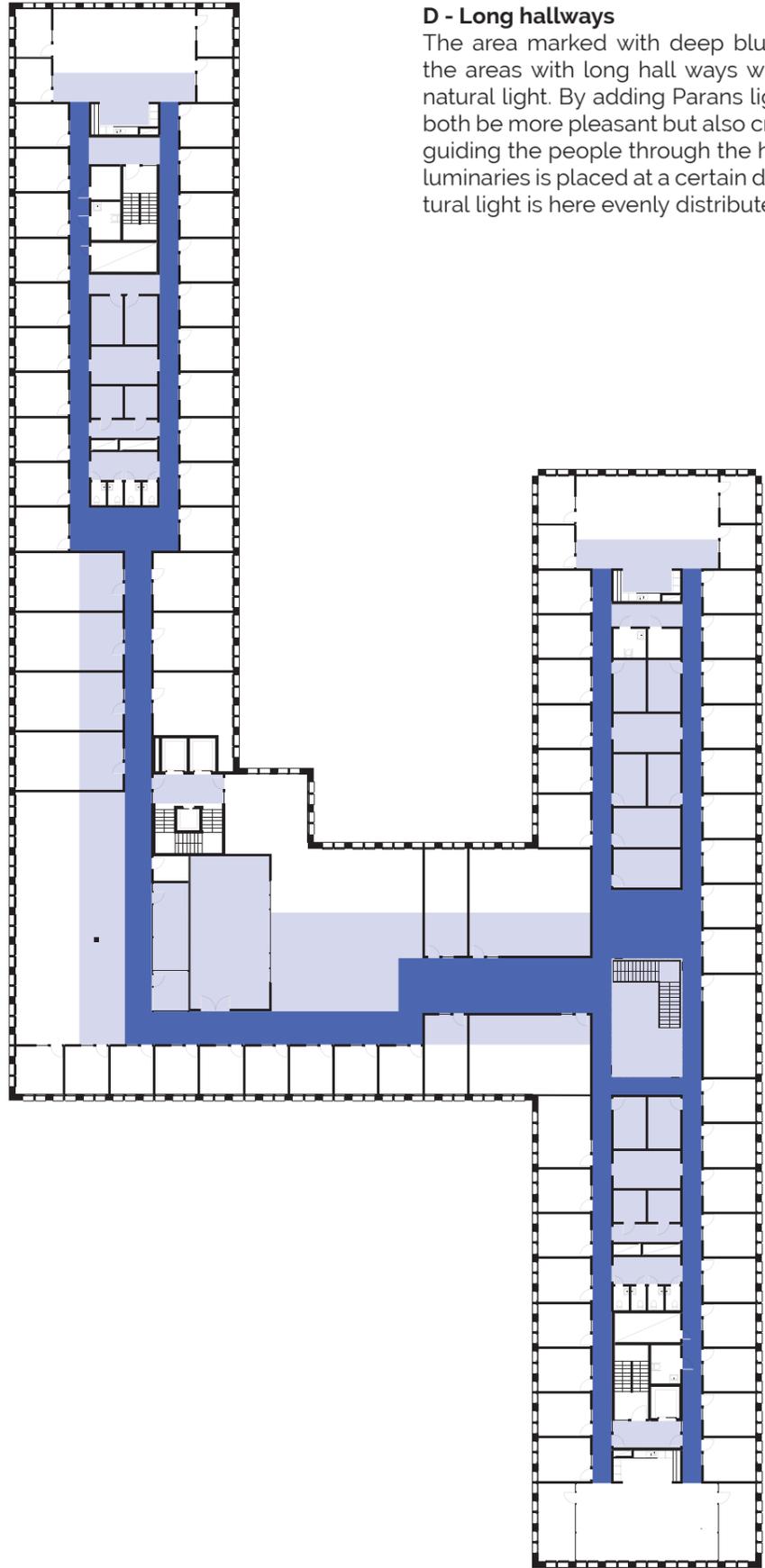


**C- Areas to high light and create a light effect**

The area marked with deep blue color is showing the areas where no or very little natural light is reaching the area. These areas are great to create a light experience by highlighting them with the natural light. The effect you create is that you will draw people to them and make people pay attention to them. For example provide the people with more natural light as they wait for the elevator.



Floor Plan 1:500

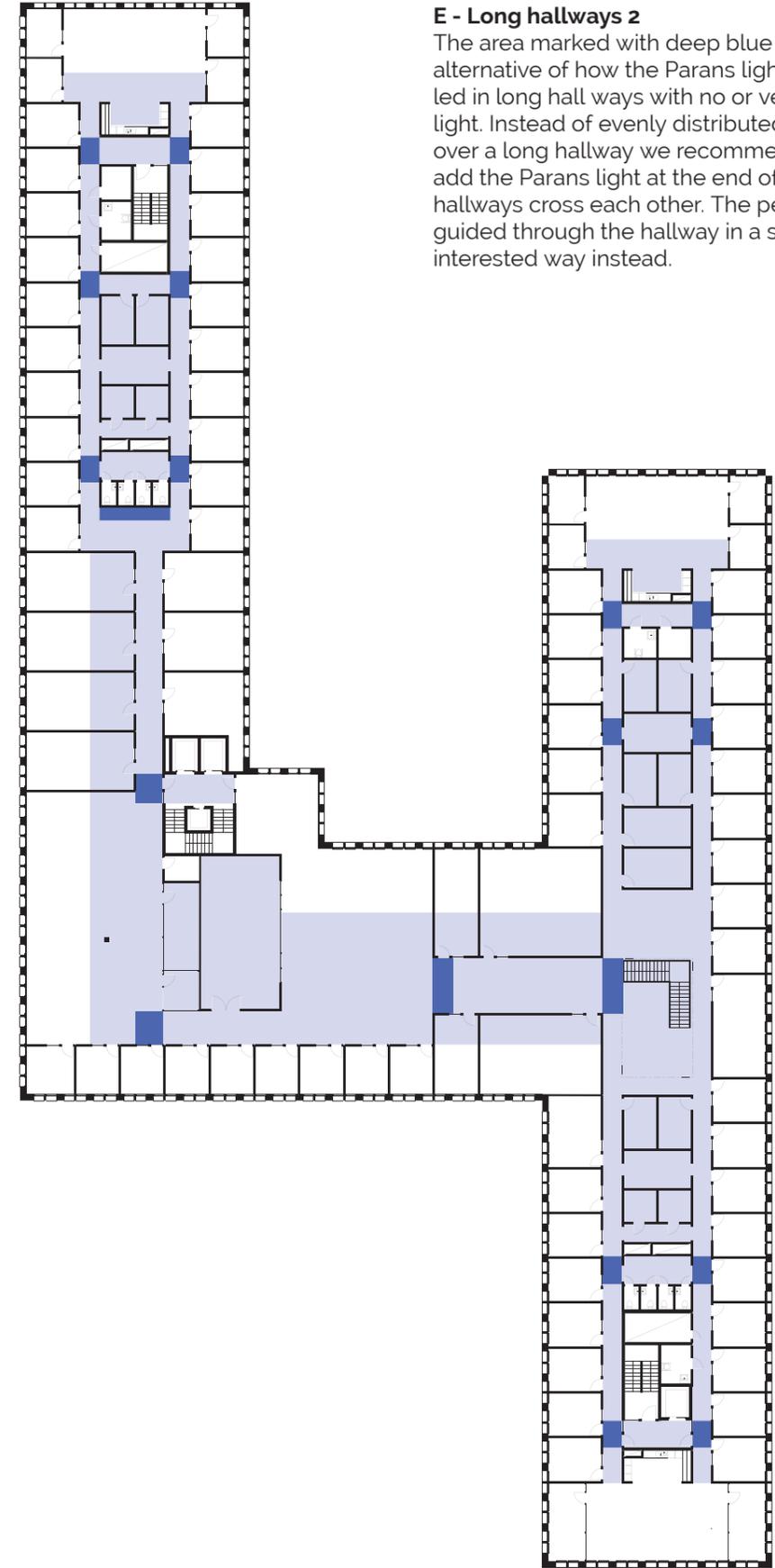


**D - Long hallways**

The area marked with deep blue color is showing the areas with long hall ways with no or very little natural light. By adding Parans light the hallway will both be more pleasant but also creating an effect by guiding the people through the hallway. The Parans luminaries is placed at a certain distance and the natural light is here evenly distributed over the area.



Floor Plan 1:500



**E - Long hallways 2**

The area marked with deep blue color is another alternative of how the Parans light could be installed in long hall ways with no or very little natural light. Instead of evenly distributed the natural light over a long hallway we recommend that instead add the Parans light at the end of it or where the hallways cross each other. The people will be guided through the hallway in a subtler and more interested way instead.



Floor Plan 1:500

**A- DEEP ROOMS WITH LARGE VARIATIONS OF NATURAL LIGHT**

Natural light from windows is a great resource but at the same time difficult to use. It quickly disappears further into the room and easily creates great contrasts and glare, especially in deep rooms. Parans work well in combination with rooms with windows. The light levels from windows and Parans often coincide both in time and intensity and with a suitable number of luminaires the light levels can be kept even. The number of luminaires can be determined

using the Parans simplified calculation method on page 18 or with the more advanced Parans daylight autonomy tool on page 18 where the windows and seasonal variations also are considered.

**Example:**

- Deep open office space
- Lecture halls
- Classrooms
- Canteens
- Reception



**PARANS DAYLIGHT AUTONOMY TOOL**

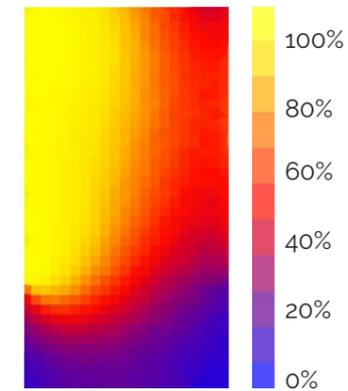
**CONDITIONS**

Usage: Office  
 Preceance: 9 am to 5 pm  
 Room depth: 11 m  
 Parans luminaires: 36 Point Light  
 Geographic location: San Diego  
 Sunhours: 3366 (direct sun >10 000 Lux)  
 Windows:: 40% lighttransmittans

**RESULTS**

	Without Parans	With Parans
Spatial daylight autonomy:	21%	40%
BREEM:	No	Yes
LEED	No	Yes

Visualization without parans

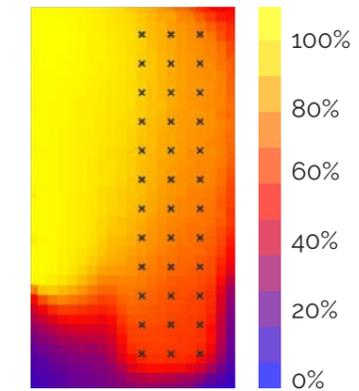


Daylight Autonomy without parans

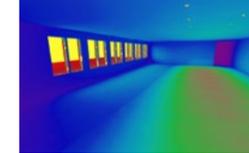


Luminance picture

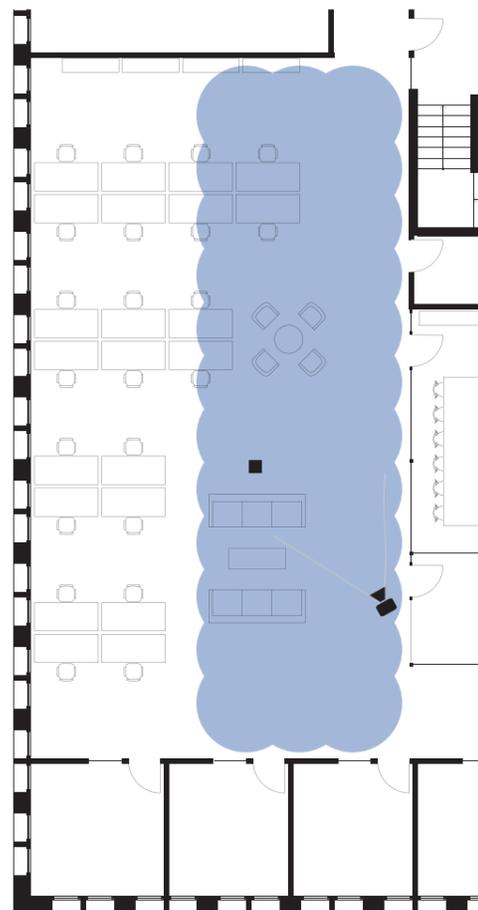
Visualization with parans



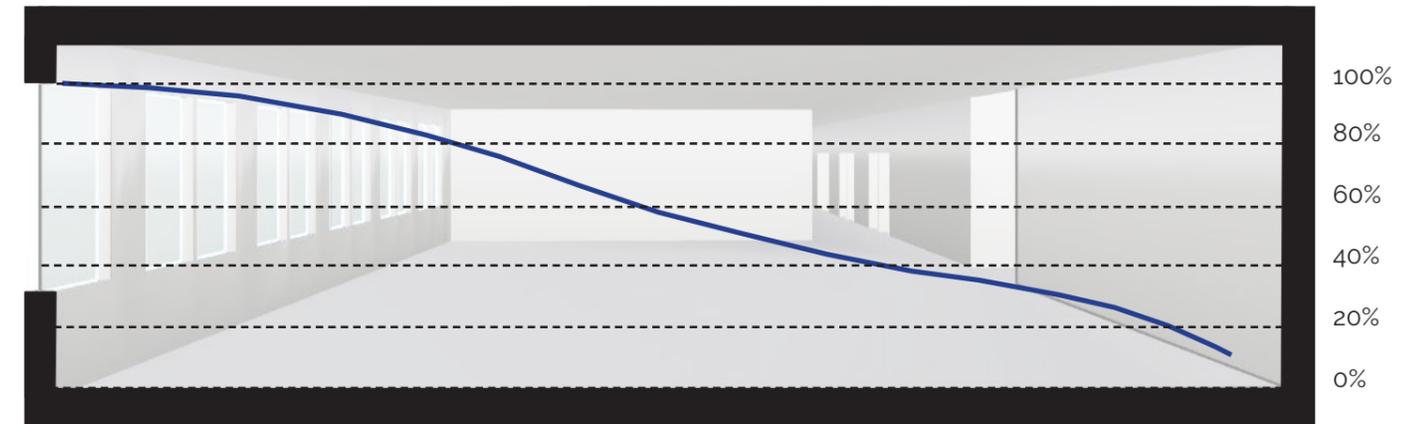
Daylight Autonomy with parans



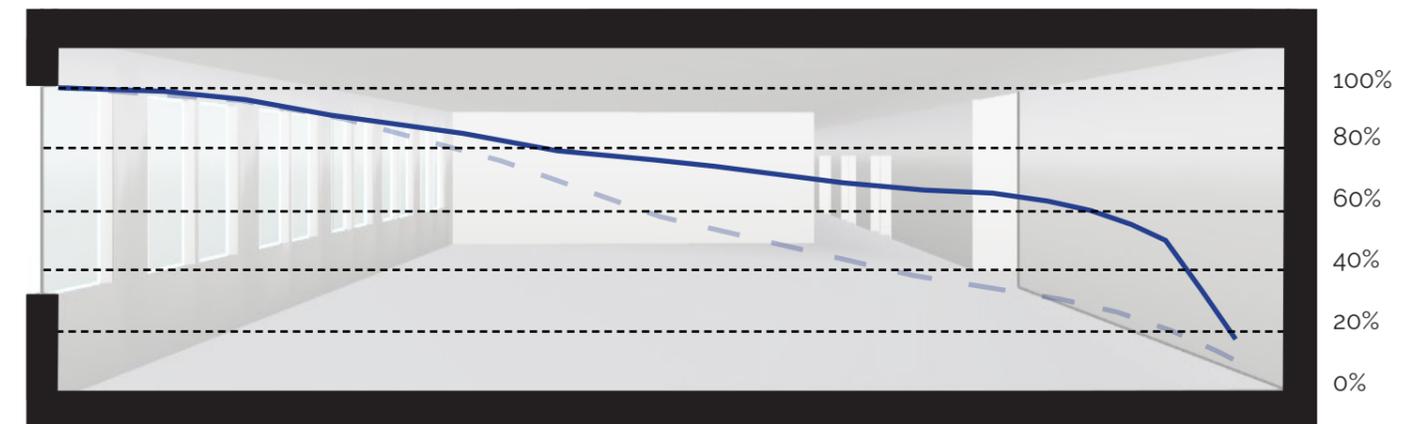
Luminance picture



Floor Plan 1:200



Daylight Autonomy without parans, sektion (%)



Daylight Autonomy with parans, sektion (%)

**B - ROOM IN THE CENTER OF THE BUILDING**

In order to utilize a building volume as well as possible, it is sometimes required that functions are placed inside the building core, alternatively below ground level. To get the natural and good effects of natural light, such as a connection to the outside and time of the day, the Parans system can be installed. In this example, daylight autonomy during working hours is 50-60% on the surfaces used for work. This

means that 50-60% of the electrical lighting in the room can be replaced with natural light from the Parans system.

**Example:**

- Conference rooms
- Staff canteens
- Breakout rooms
- Pedestrian tunnel



Visualization without parans



Visualization with parans

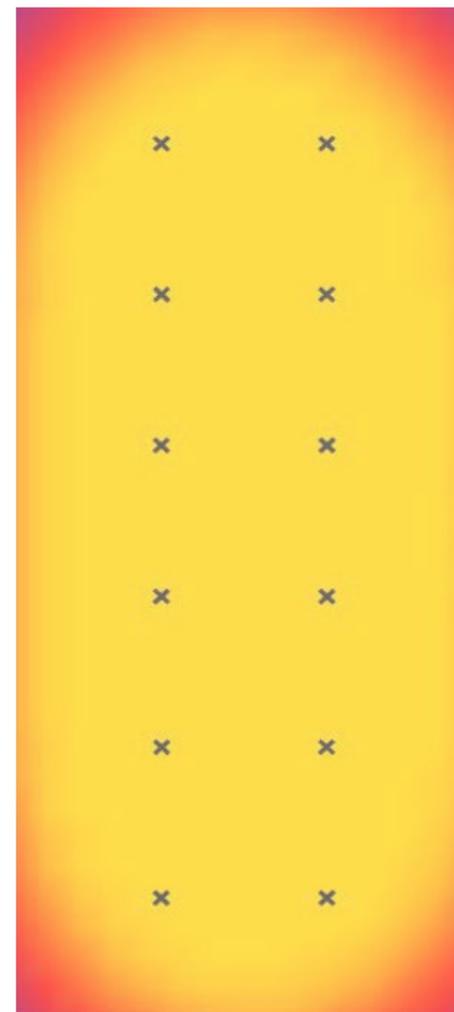
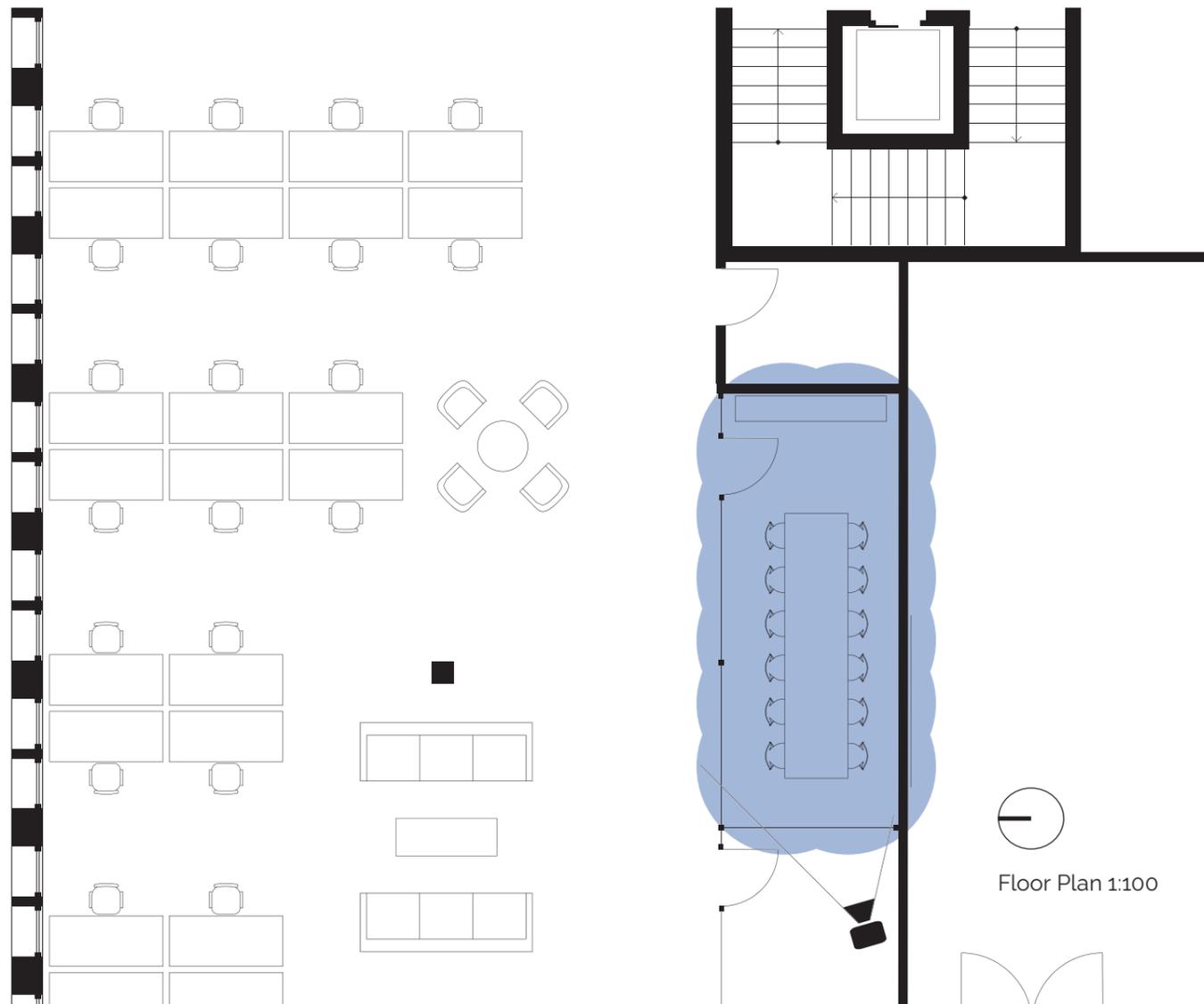
**PARANS DAYLIGHT AUTONOMY TOOL**

**CONDITIONS**

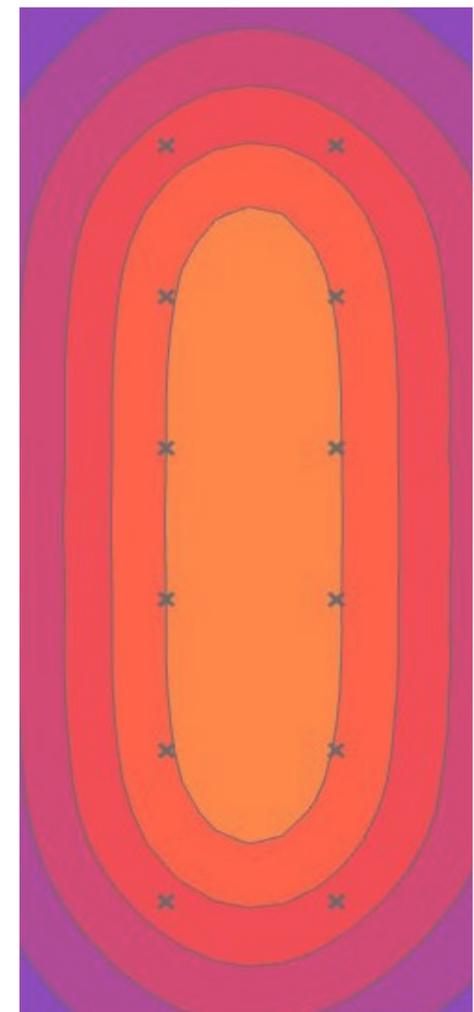
Usage: Office  
 Preceance: 9 am to 5 pm  
 Room size: 3 x 7 m  
 Parans luminaires: 12 Point Light  
 Geographic location: San Diego  
 Sunhours: 3366  
 (direct sun >10 000 Lux)

**RESULTS**

	Without Parans	With Parans
Average daylight level on sunny day:	0%	519 lux
Spatial daylight autonomy:	0%	49%



Daylight on sunny day with parans (Lux)



Daylight Autonomy with parans

## B - LIGHT ON THE WALLS

In order to both bring the natural light to the indoor environment and to perform a good visual effect some spaces are best of with spreading the light on the wall. This will high light an area in an effective way, both drawing attention to the area but also giving a pleasant stay in the area. If light onto the walls is combined with plants, this could give an extra boost to the indoor environment.



Visualization without parans



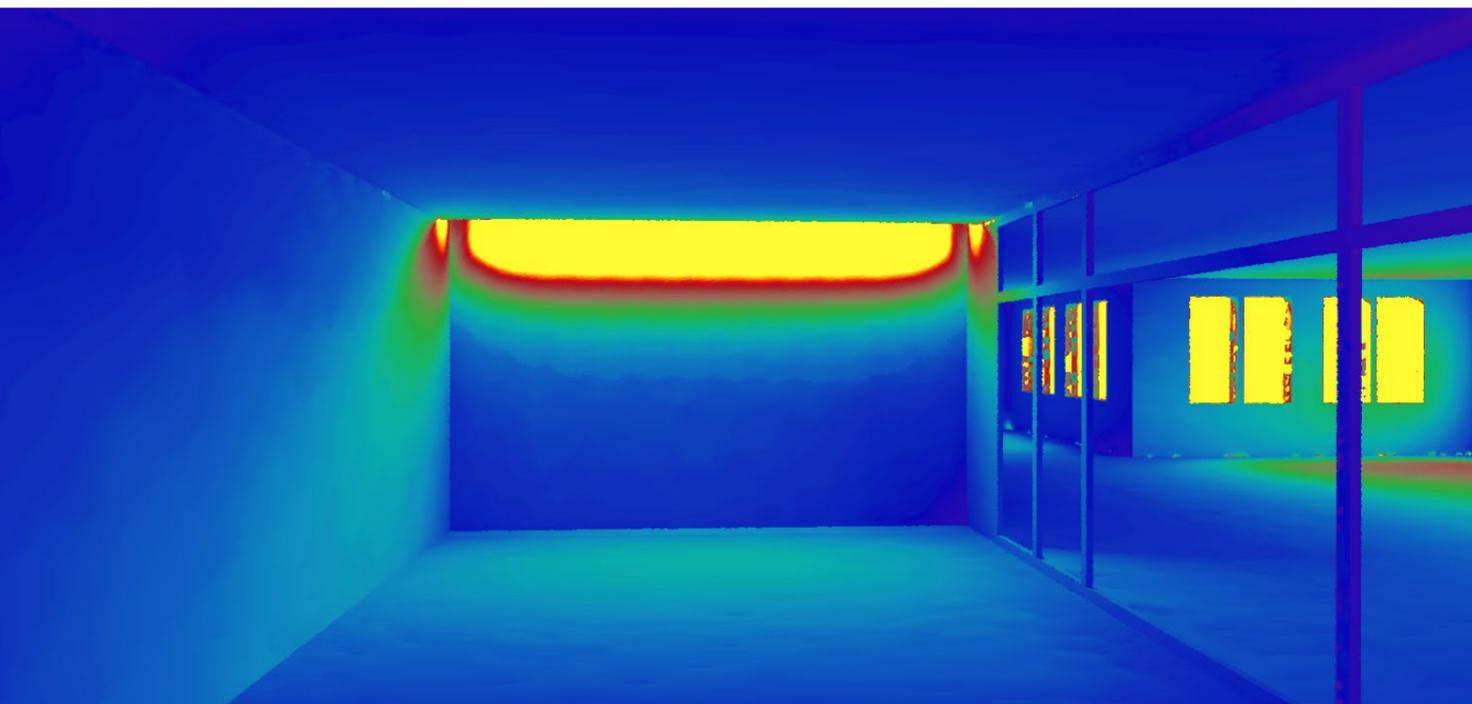
Visualization with parans

### CONDITIONS

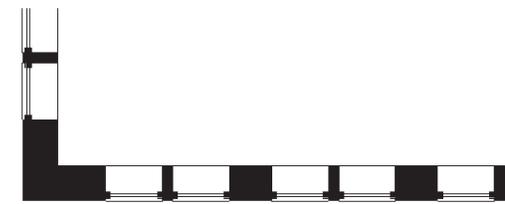
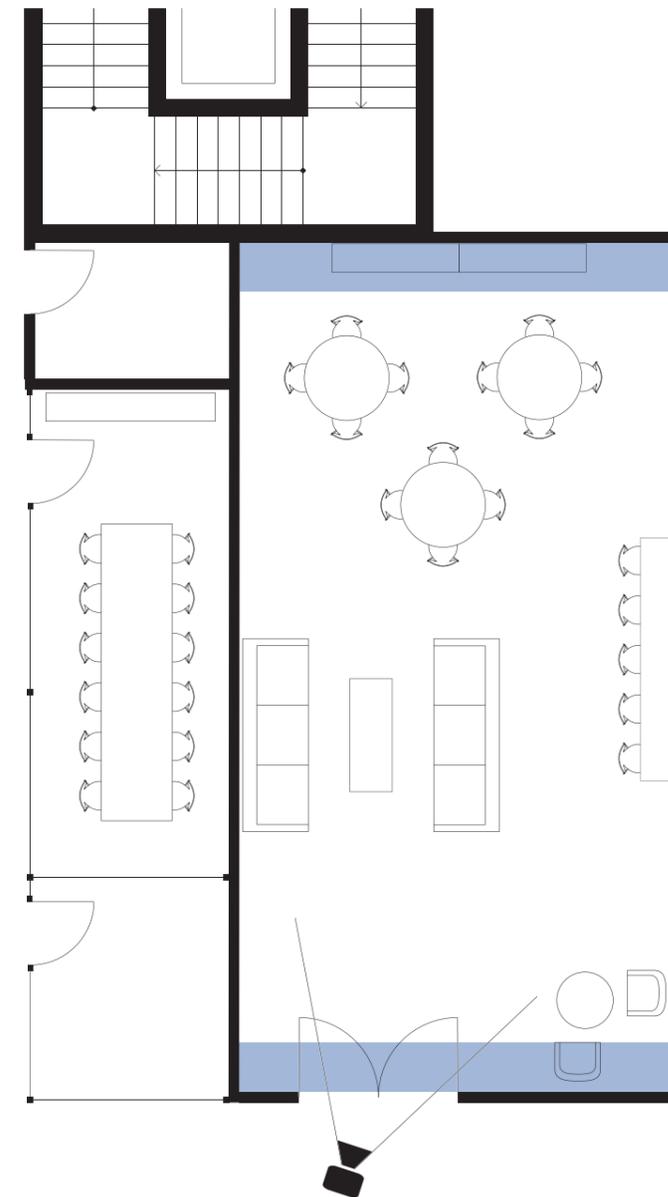
Usage: Office  
 Precence: 9 am to 5 pm  
 Room size: 6 x 12 m  
 Parans luminaires: 12 Wall Light  
 Geographic location: San Diego  
 Sunhours: 3366  
 (direct sun >10 000 Lux)

### RESULTS

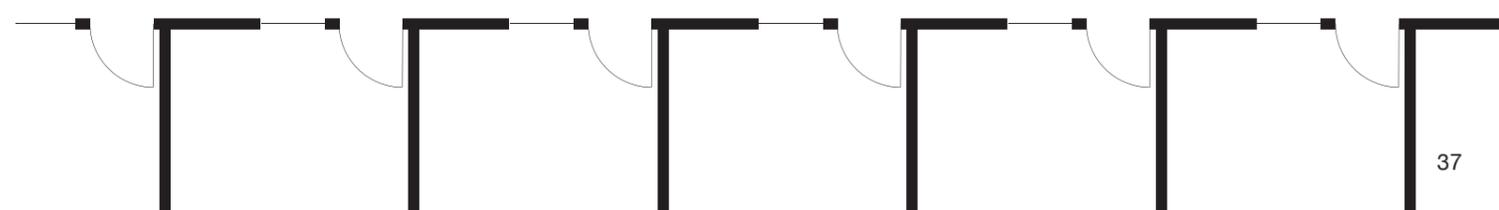
	Without Parans	With Parans
Average daylight level on sunny day:	0%	700 lux (on the wall)



Luminance picture



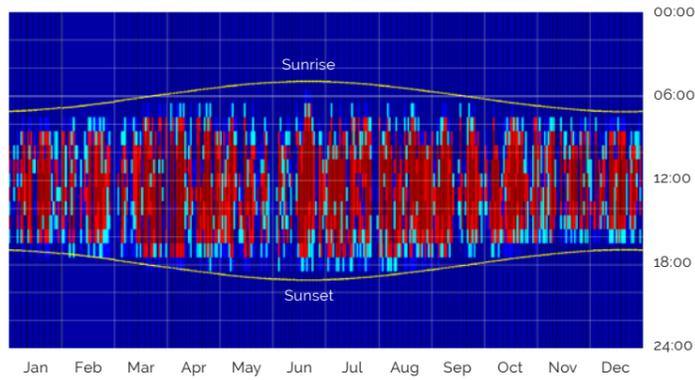
Floor Plan 1:100



### LOCAL WEATHER

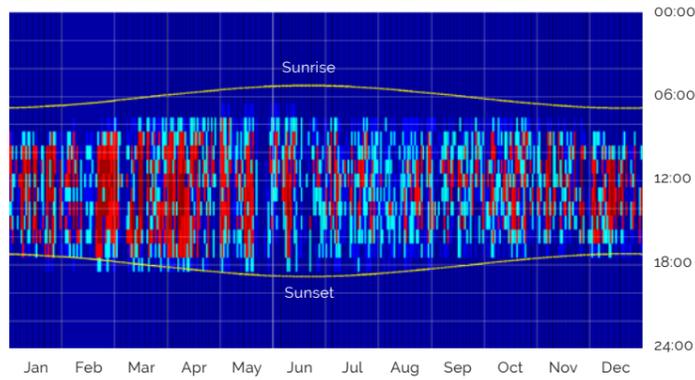
Parans require direct sunlight to work. The availability of sunlight varies from city to city and from year to year. Normal years exist for a variety of cities. These are easily reported in so-called carpet plots in which one sees the variation in direct sunlight hour by hour. Parans work best at direct normal illumination over 60 000 lux.

#### San Diego



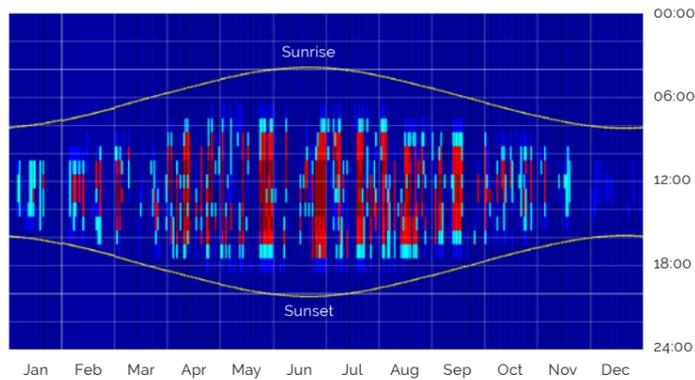
Lux	Percent	Number of sun hours
> 80 000	11%	964
60 000 - 80 000	8%	701
40 000 - 60 000	6%	526
20 000 - 40 000	5%	438
< 20 000	68%	5957

#### Miami



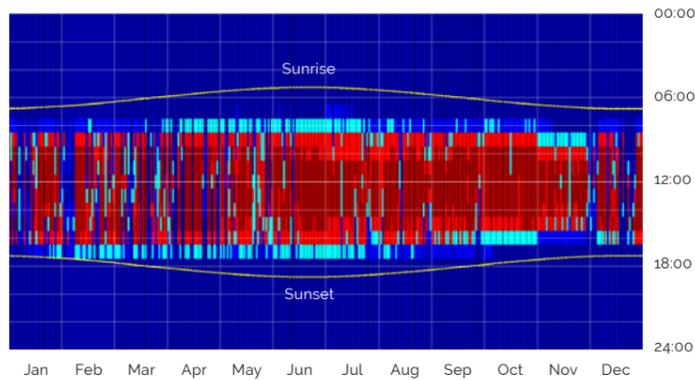
Lux	Percent	Number of sun hours
> 80 000	2%	175
60 000 - 80 000	7%	613
40 000 - 60 000	9%	788
20 000 - 40 000	9%	788
< 20 000	70%	6132

#### London



Lux	Percent	Number of sun hours
> 80 000	1%	88
60 000 - 80 000	3%	263
40 000 - 60 000	3%	263
20 000 - 40 000	4%	350
< 20 000	86%	7534

#### Riyadh



Lux	Percent	Number of sun hours
> 80 000	14%	1226
60 000 - 80 000	8%	701
40 000 - 60 000	5%	438
20 000 - 40 000	5%	438
< 20 000	64%	5606



PARANS

Leading sunlight

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