WELL STANDARD V2

CHANGES TO THE LIGHTING REQUIREMENTS

TRILUX
SIMPLIFY YOUR LIGHT.

TRILUX
SIMPLIFY YOUR LIGHT.

INTERNATIONAL
WELL
BUILDING
INSTITUTE™

Version 2

REMEMBER WHAT WELL IS ABOUT ?

Better buildings to help people thrive

REMEMBER WHAT WELL IS ABOUT ?

VOLUNTARY

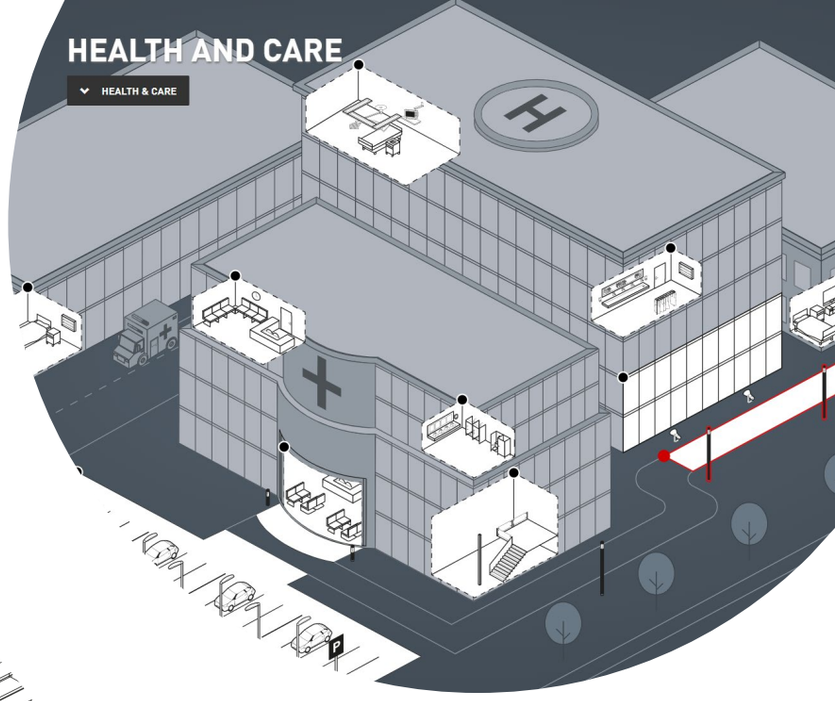
SCIENCE BASED

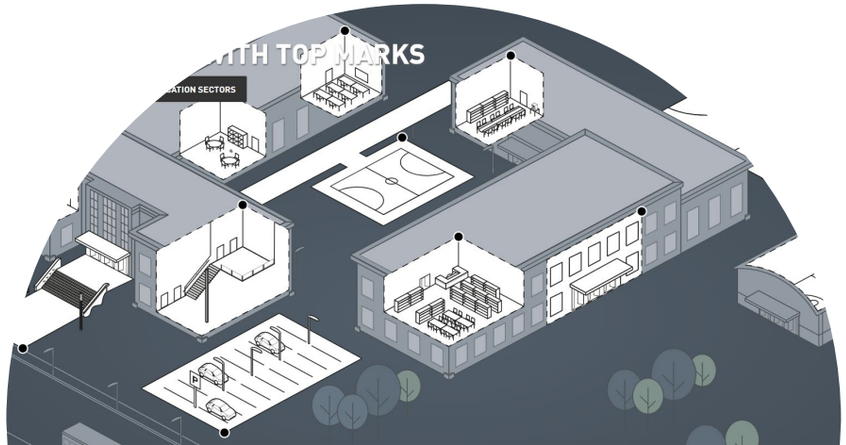
CONSTANT MONITORING

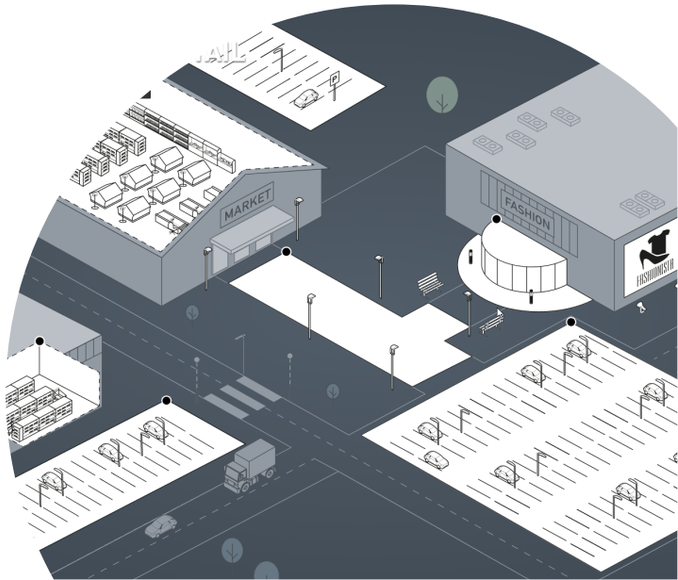
WORLDWIDE

WHO WANTS WELL ?

- Large Employers
- Large Asset owners
- Developers
- Schools
- Hospitals
- Retail
- Large Residential
- Multiplex







TRILUX
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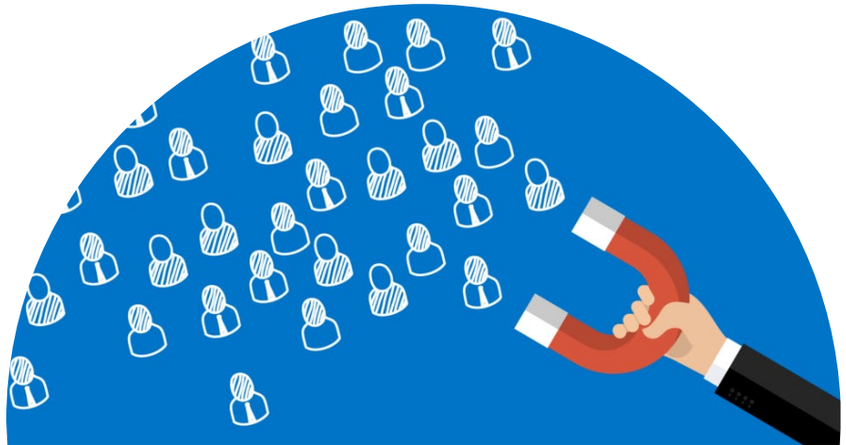
HOW WELL

Creating an environment that is…

- Sustainable
- Productive
- Satisfying to work in
- Retains existing employees
- Attracting the best new employees
- Creates a more valuable & desirable asset



HOW WELL ?

The principles

WELL v2 is founded on the following principles:

Equitable

Provides the greatest benefit to the largest number of people, inclusive of all demographic and economic groups and with special consideration to less advantaged or vulnerable populations.

Global

Proposes interventions that are feasible, achievable and relevant across many applications throughout the world.

Evidence-based

Undergirded by strong, validated research leading to conclusions that can reasonably be accepted by the scientific community.

Technically robust

Draws upon industry best practices and proven strategies, offering consistency in findings across the relevant field or discipline.

Customer focused

Defines program requirements through a dynamic development process, with multiple opportunities for stakeholder engagement, and by tapping the expertise of established leaders in science, health, business, design and operations.

Resilient

Responds to advances in scientific knowledge and technology, continuously adapting and integrating new findings in the field

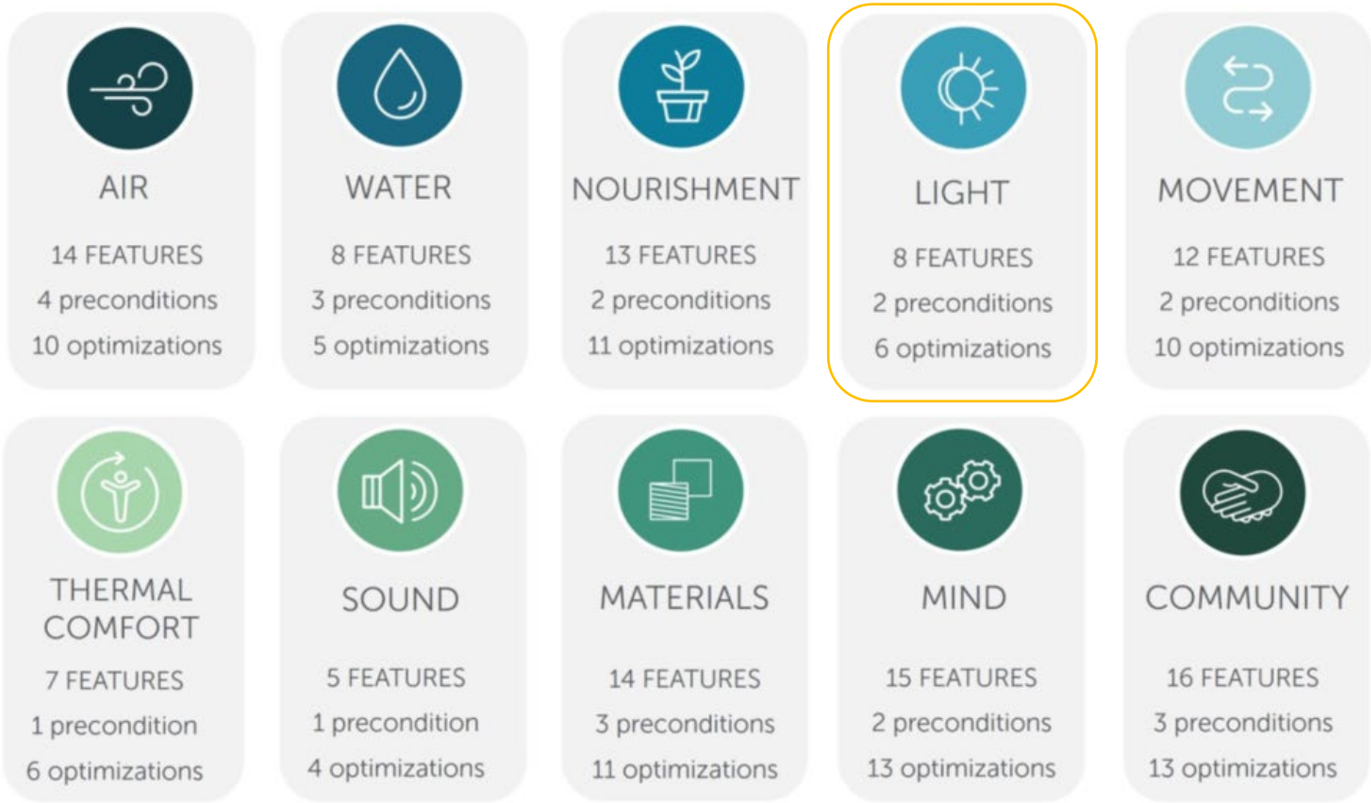
WHAT WELL ?

10 Concepts

Each with Features

Containing 97 Optimisations

Of which 23 are Mandatory



WELL POINTS

Platinum	Gold	Silver	Bronze
80 points	60 Points	50 points	40 points
All Pre conditions 80% of optimisations	All Pre conditions 40% of optimisations	All Preconditions No optimisations	Only with Shell & Core Certification

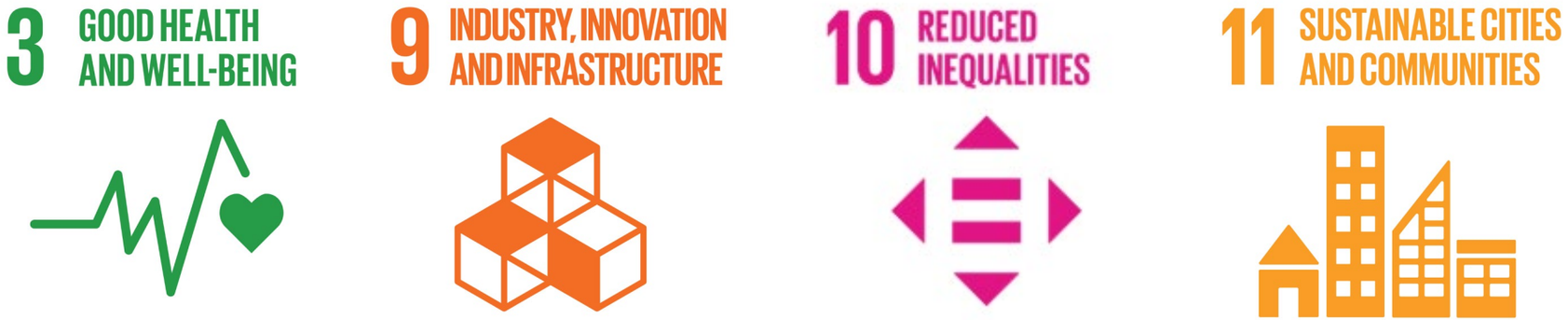
WELL BASIS


UN


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

WELL LIGHT

“The WELL Light concept promotes exposure to light and aims to create lighting environments that are optimal for visual, mental and biological health.”



WELL LIGHT

Feature No.	Feature	Points
L01	Light Exposure and Education	Pre-condition
L02	Visual Lighting Design	Pre-condition
L03	Circadian Lighting Design	3
L04	Glare Control	3
L05	Enhanced Daylight Access	3
L06	Visual Balance	1
L07	Electric Light Quality	2
L08	Occupant Control of Lighting Environments	2

WELL LIGHT

Feature No.	Feature	Points
L01	Light Exposure and Education	Pre-condition
L02	Visual Lighting Design	Pre-condition
L03	Circadian Lighting Design	3
L04	Glare Control - UGR	3
L05	Enhanced Daylight Access – Daylight Plan	3
L06	Visual Balance – Brightness comfort	1
L07	Electric Light Quality – CRI /TM30 + Flicker	2
L08	Occupant Control of Lighting Environments – Individual control	2

Generally topics of good lighting design

WELL LIGHT – FEATURE L01

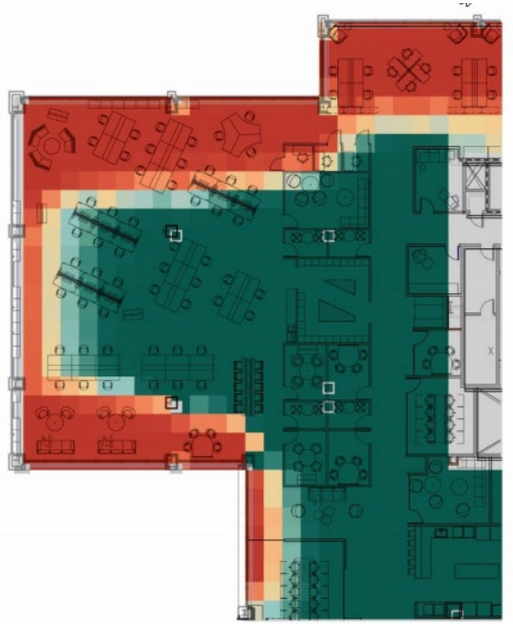
CONCEPTS / LIGHT / FEATURE L01 PRECONDITION

Light Exposure and Education

Provide access to indoor light exposure and light education.

Appropriate light exposure in indoor environments with daylighting/lighting.

Education of users about the importance of light for health & thus encourage users to seek light exposure on their own.



WELL LIGHT – FEATURE L01

Daylight in regularly occupied spaces:
Projects meet at least one of the following requirements:
1. Spatial Daylight Autonomy of $sDA_{200,40\%}$ is achieved for at least 30% of regularly occupied space.
2. 30% of all workstations are within 6 m [20 ft] of transparent envelope glazing. Visible light transmittance (VLT) of transparent glazing is greater than 40%.
3. Transparent envelope glazing area is no less than 7% of the floor area for each floor level[28]. VLT of envelope glazing is greater than 40%.

Daylight in common spaces:
Regular building occupants have unrestricted access to indoor common spaces with unassigned seating that accommodates at least 15% of regular building occupants at any given time. The spaces are located within the project boundary and each meet at least one of the following requirements:
1. Spatial Daylight Autonomy of $sDA_{300,50\%}$ is achieved for at least 70% of the space.
2. 70% of all seating in the space is within 5 m [16 ft] of transparent envelope glazing with views to the exterior. Visible light Transmittance (VLT) of envelope glazing is greater than 40%.
3. Transparent envelope glazing area is no less than 10% of gross internal floor area of the space. Visible Light Transmittance (VLT) of envelope glazing is greater than 40%.

Electric light in regularly occupied spaces:
The following requirement is met:
Achieve Feature L03: Circadian Lighting Design.

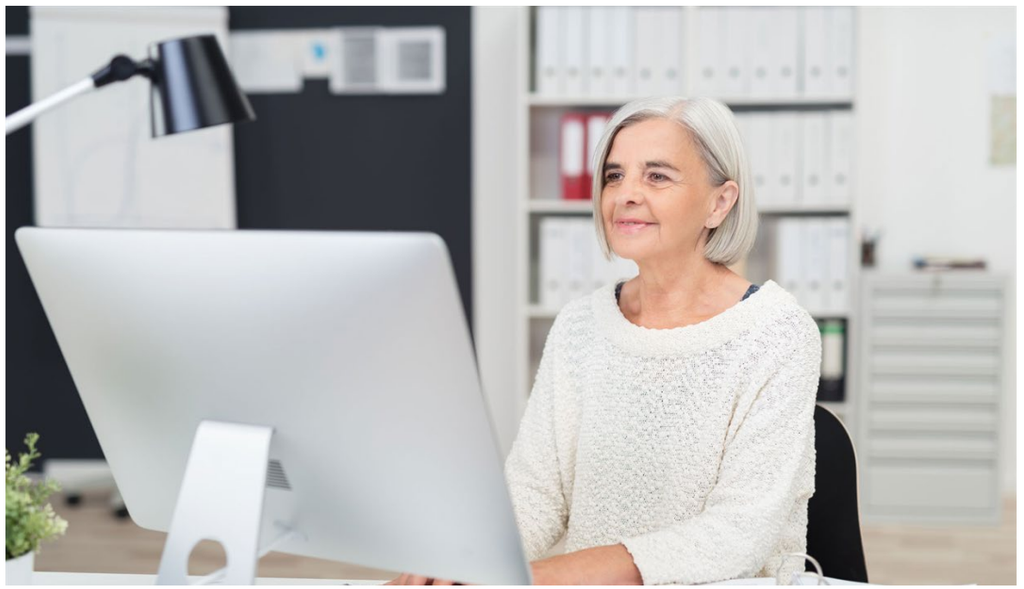
WELL LIGHT – FEATURE L02

CONCEPTS / LIGHT / FEATURE L02 PRECONDITION

Visual Lighting Design

Provide visual comfort and enhance acuity for all users through electric lighting.

Appropriate illuminances (lux) on work planes for regular users of all age groups while taking into account light levels required for the tasks performed in the space.



WELL LIGHT – FEATURE L02

For All Spaces the following requirements are met:
All indoor and outdoor spaces (including transition areas) comply with illuminance recommendations specified in one of the following lighting reference guidelines:

- IES Lighting Handbook 10th Edition.
- EN 12464-1: 2019
- ISO 8995-1:2002(E) (CIE S 008/E:2001).
- GB50034-2013.

A lighting plan details the below:

1. Tasks or activities considered for visual lighting design in the project. All tasks and activities regularly undertaken by occupants are considered.
2. Height of work plane or other target of illumination.
3. Age ranges for the majority of occupants.

Generally topics of good lighting design

WELL LIGHT – FEATURE L03

CONCEPTS / LIGHT / FEATURE L03 OPTIMIZATION

Circadian Lighting Design

Support circadian health through interventions using electric lighting.

Max
3 Pts

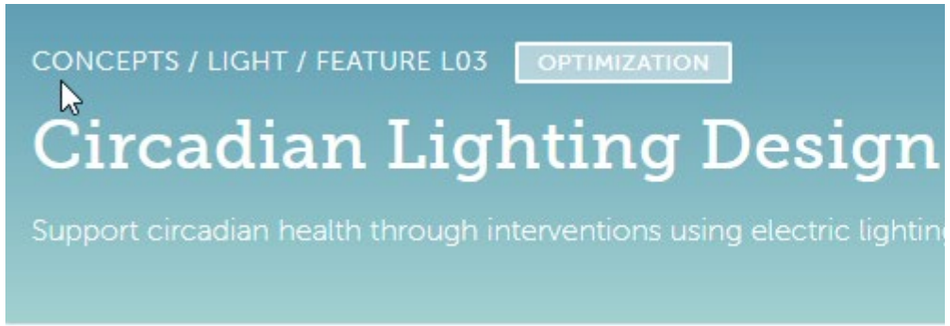
Provide users with appropriate exposure to light for maintaining circadian health and aligning the circadian rhythm with the day-night cycle.

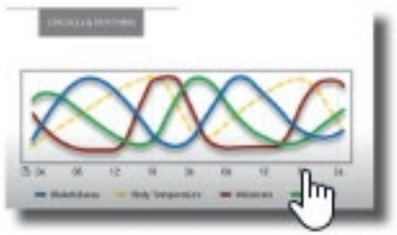
WELL LIGHT – FEATURE L03

A detailed TX Akademie Webinar is available on the full topic of Circadian lighting.

Whereby the principles of Melanopic Lux are explained.

WELL LIGHT – FEATURE





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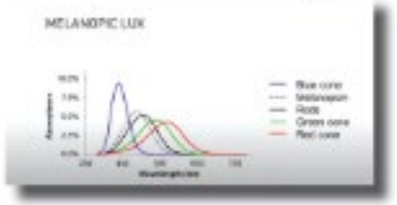
A simplified description of the Human Circadi Cycle



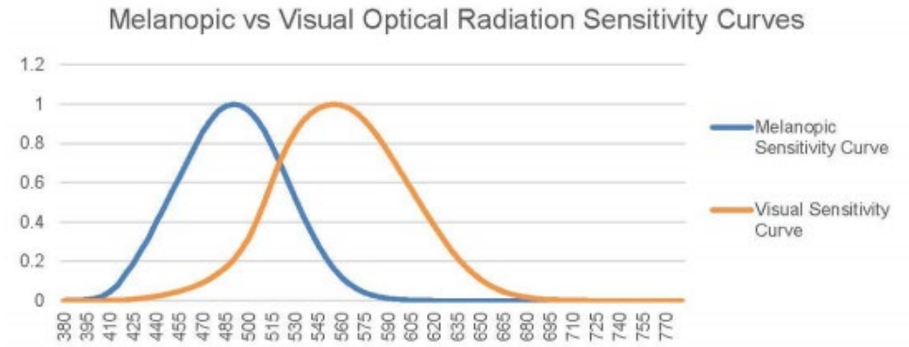
10:18

Response curves for the human eye's rods, co and ganglion receptors

13:30

How Melanopic Lux is measured / calculate

Calculating Equivalent Melanopic Lux eg. 500lux c



CCT (Kelvin)	Source	Ratio
7500	Fluorescent	1.11
6500	Daylight	1.10
6500	Fluorescent	1.02
4000	LED	0.76
4000	Fluorescent	0.58
3000	Fluorescent	0.45
2700	LED	0.45

WELL LIGHT – FEATURE L04

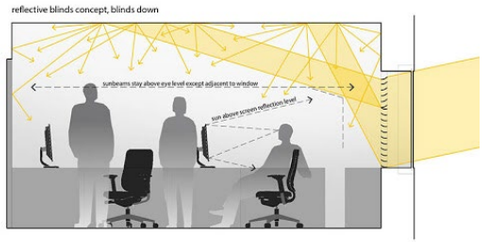
CONCEPTS / LIGHT / FEATURE L04 OPTIMIZATION

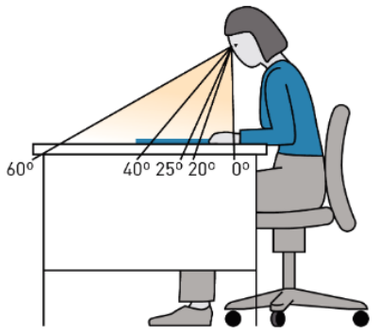
Glare Control

Minimize visual discomfort caused by glare from daylight and electric light.

Max
3 Pts

Manage natural & artificial glare by using a combination glare design calculations & appropriate luminaires for the space.





WELL LIGHT – FEATURE L04

CONCEPTS / LIGHT / FEATURE L04 OPTIMIZATION

Glare Control

Minimize visual discomfort caused by glare from daylight and electric light.

Max
3 Pts

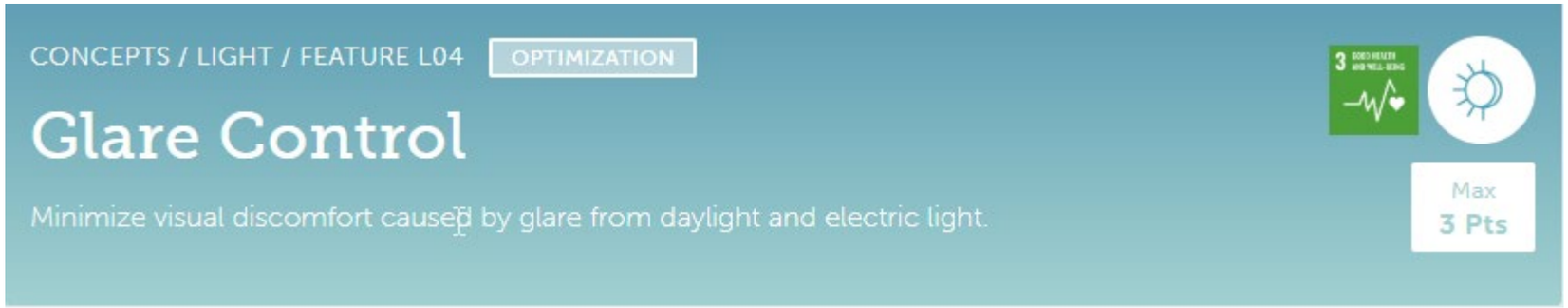
Solar Glare Control

For All Spaces Choose between the following:
Window shading - The following requirements are met:

1. All exterior envelope glazing has shading. Atria or lobbies may be excluded.
2. The shading is controllable by the occupants or set to automatically prevent glare. If shading is controlled by occupants, all shades are raised or retracted either manually or automatically at least twice per week.

Glare calculation - The following requirement is met:
Annual sunlight exposure of ASE1000,250 is achieved for no more than 10% of regularly occupied space.

WELL LIGHT – FEATURE L04

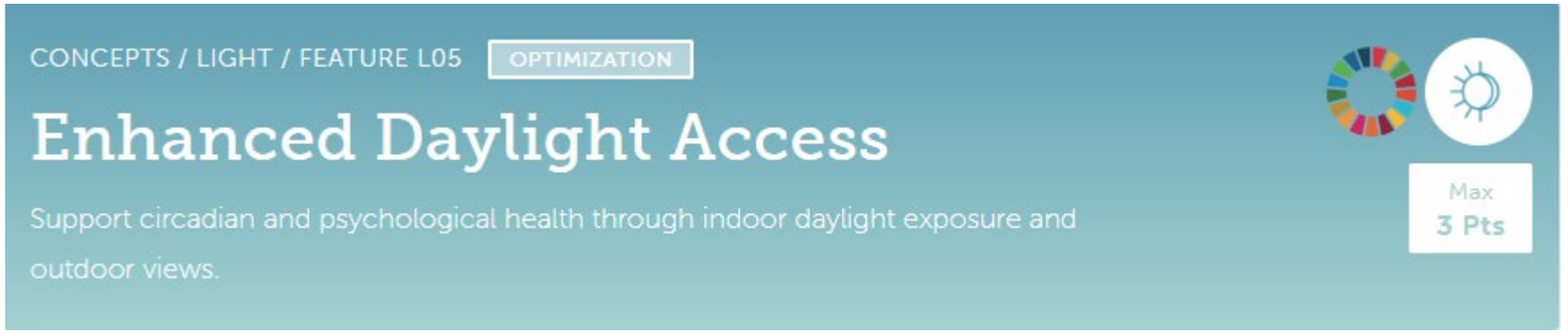


Luminaire Glare control
Each luminaire meets one of the following requirements for regularly occupied spaces. Wall wash & decorative fixtures may be excluded from meeting these requirements:

- 100% of light is emitted above the horizontal plane.
- UGR 17 below 5m / UGR 20 above 5m
- Luminance Shielding angle
  - < 20,000 cd/m² (including reflected sources) - No shielding required
  - 20,000cd/m² to 50,000 cd/m² = 15°
  - 50,000cd/m² to 500,000 cd/m² = 20°
  - > 500,000cd/m² = 30°
- Fixtures have a luminance of less than 10,000 cd/m2 between 45 and 90 degrees from nadir, and/or an intensity of less than 1,000 candela between 45 and 90 degrees from nadir.

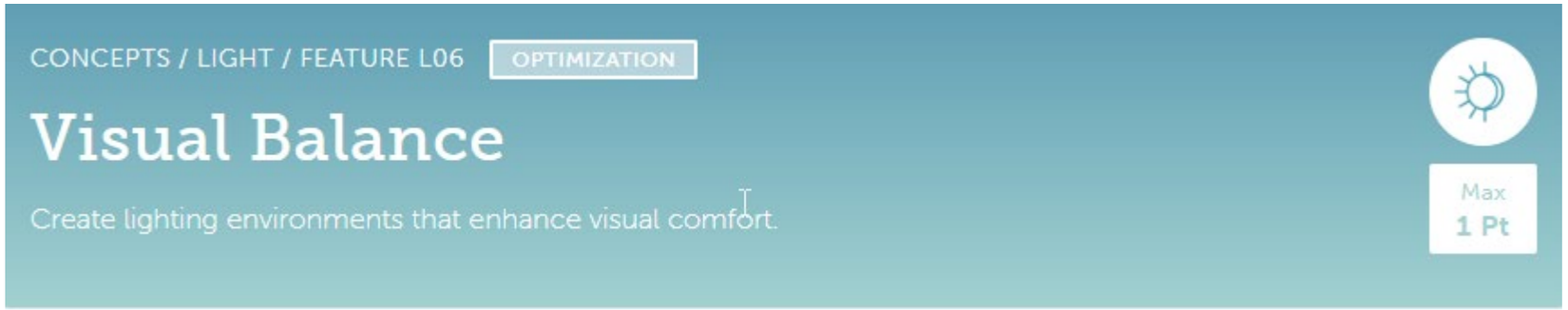
Generally topics of good lighting design

WELL LIGHT – FEATURE L05



Implement Enhanced Daylight Plan	70% workstations within 7.5 m of glazing or atria	Windows not less than 10% of regularly occupied floor area.
Implement Enhanced Daylight simulation – Spatial Daylight Autonomy	SDA 300,50% is achieved for 55% of floor	SDA 300,50% is achieved for 75% of floor
Ensure Occupant Views	Ground floor Roadway to glazing 7.5m or view factor of 3	Viewing angle to sky or ground of minimum 30degrees

WELL LIGHT – FEATURE L06



Managing Brightness – Minimum of 4

- Main rooms less than 10x brighter than ancillary space.
- Less than 3x luminance to adjacent surface.
- Less than 10x luminance to surface in the same room
- Less than 1.5x variation in light level over 30 minutes – smooth light transitions
- Uniformity of at least 0.4 is achieved on work planes.
- Ceiling hotspots – less than 10x light level variation on ceiling

Generally topics of good lighting design

WELL LIGHT – FEATURE L07

CONCEPTS / LIGHT / FEATURE L07 OPTIMIZATION

Electric Light Quality

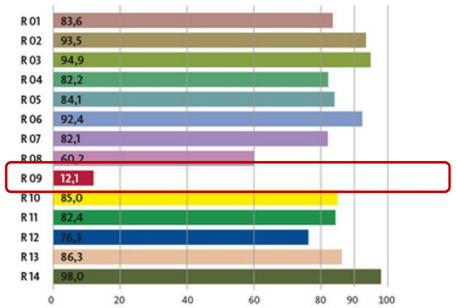
Enhance visual comfort and minimize flicker using electric lighting.

Max
2 Pts

Ensuring Colour rendering Quality – Meeting 1 of the below.

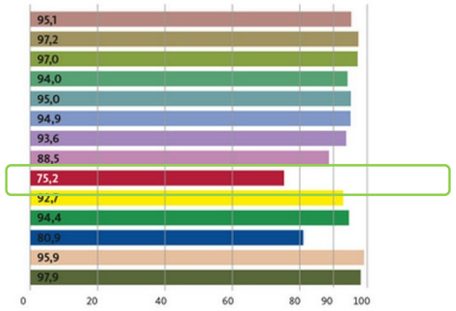
- CRI 90
- CRI 80 R9 >50
- TM30 ES Rf ≥ 78, IES Rg ≥ 100, -1% ≤ IES Rcs,h1 ≤ 15%

Oktalite Standard LED 3000 Kelvin



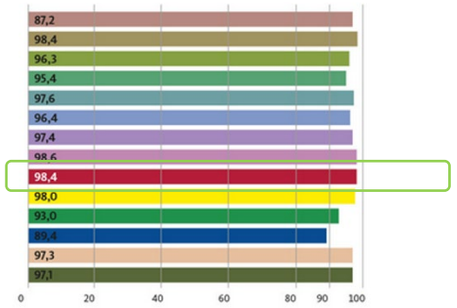
R_a 83
R_e 80

Oktalite EFFICIENT WHITE



R_a 94
R_e 92

Oktalite BRILLIANT COLOUR



R_a 96
R_e 96

WELL LIGHT – FEATURE L07

CONCEPTS / LIGHT / FEATURE L07 OPTIMIZATION

Electric Light Quality

Enhance visual comfort and minimize flicker using electric lighting.

Max
2 Pts

Ensuring Visible Flicker is controlled on Main luminaires – Meeting 1 of the below.

<90 Hz 10% Dimm to 100% (at all 10%intervals)

“Low Risk” flicker <5% when <90 Hz as per IEEEstandard 1789-2015

WELL LIGHT – FEATURE L08

Implement innovative lighting strategies that take into account personal preferences of users as well as their interaction with the physical space.

WELL LIGHT – FEATURE L08

CONCEPTS / LIGHT / FEATURE L08 OPTIMIZATION

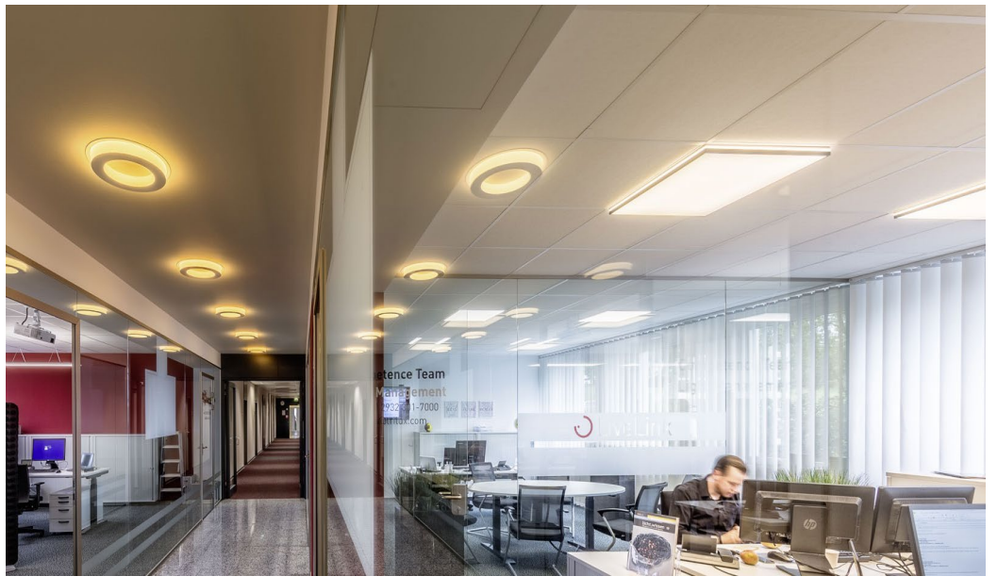
Occupant Control of Lighting Environments

Max 2 Pts

For All Spaces the ambient lighting systems in regularly occupied spaces must meet the following requirements:

Light systems are tunable and automated to meet the circadian and visual requirements of the occupants.

Occupants have control of light levels, colour temperature of artificial light in their immediate environment & can override automated settings for at least 30% of operating hours.



WELL LIGHT – FEATURE L08

CONCEPTS / LIGHT / FEATURE L08 OPTIMIZATION

Occupant Control of Lighting Environments

Max 2 Pts

Provide Supplemental lighting, meeting all the below;

Ability to increase the light level on the task surface to 2x the Lux levels in Feature L02

Increased levels provided at ‘no cost’ upon request.

Requests for supplemental light fixtures are met within 8 weeks of request.

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WELL V2 LIGHT VERIFICATION SUBMITTAL REQUIREMENTS

Concept	P/O	Feature	Part	LoA 1	LoA 2	Annotated Document 1	Annotated Document 2	Photograph	Performance Test	Notes
LIGHT	P	L01 Light Exposure and Education	1. Ensure Indoor Light Exposure			Architectural Drawing	Modeling Report			Architectural Drawing: All Spaces except Dwelling Units: Option1: b, c; Option 2: b, c Dwelling Units: b & d Modeling Report: All Spaces except Dwelling Units: Option1: a; Option 2: a Dwelling Units: a
			2. Promote Lighting Education			Educational Materials				
	P	L02 Visual Lighting Design	1. Light Levels for Visual Acuity			Design Specifications			Yes	Performance Test: 1a Design Specifications: 1b
	O	L03 Circadian Lighting Design	1. Lighting for the Circadian System						Yes	
	O	L04 Glare Control	1. Control Solar Glare			Policy Document	Modeling Report	Yes		Policy Document: Option 1: b Modeling Report: Option 2: a Photographic Verification: Option 1: a
			2. Manage Glare from Electric Lighting	Architect						
	O	L05 Enhanced Daylight Access	1. Implement Enhanced Daylight Plan			Architectural Drawing				
			2. Implement Enhanced Daylight Simulation			Modeling Report				
			3. Ensure Views			Architectural Drawing				
	O	L06 Visual Balance	1. Manage Brightness	Architect						
	O	L07 Electric Light Quality	1. Ensure Color Rendering Quality	Architect						
			2. Manage Flicker	Architect						
	O	L08 Occupant Control of Lighting Environments	1. Enhance Occupant Controllability			Professional Narrative				
			2. Provide Supplemental Lighting			Policy Document		Yes		Policy Document: b Photographic Verification: a

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TRILUX SUPPORTING YOU DOING WELL

- Good Photometric Data
- EN12464 Advice
- HCL Circadian Advice & Technology
- Good Colour Quality
- Good Luminaire Design
- Knowledge Portal

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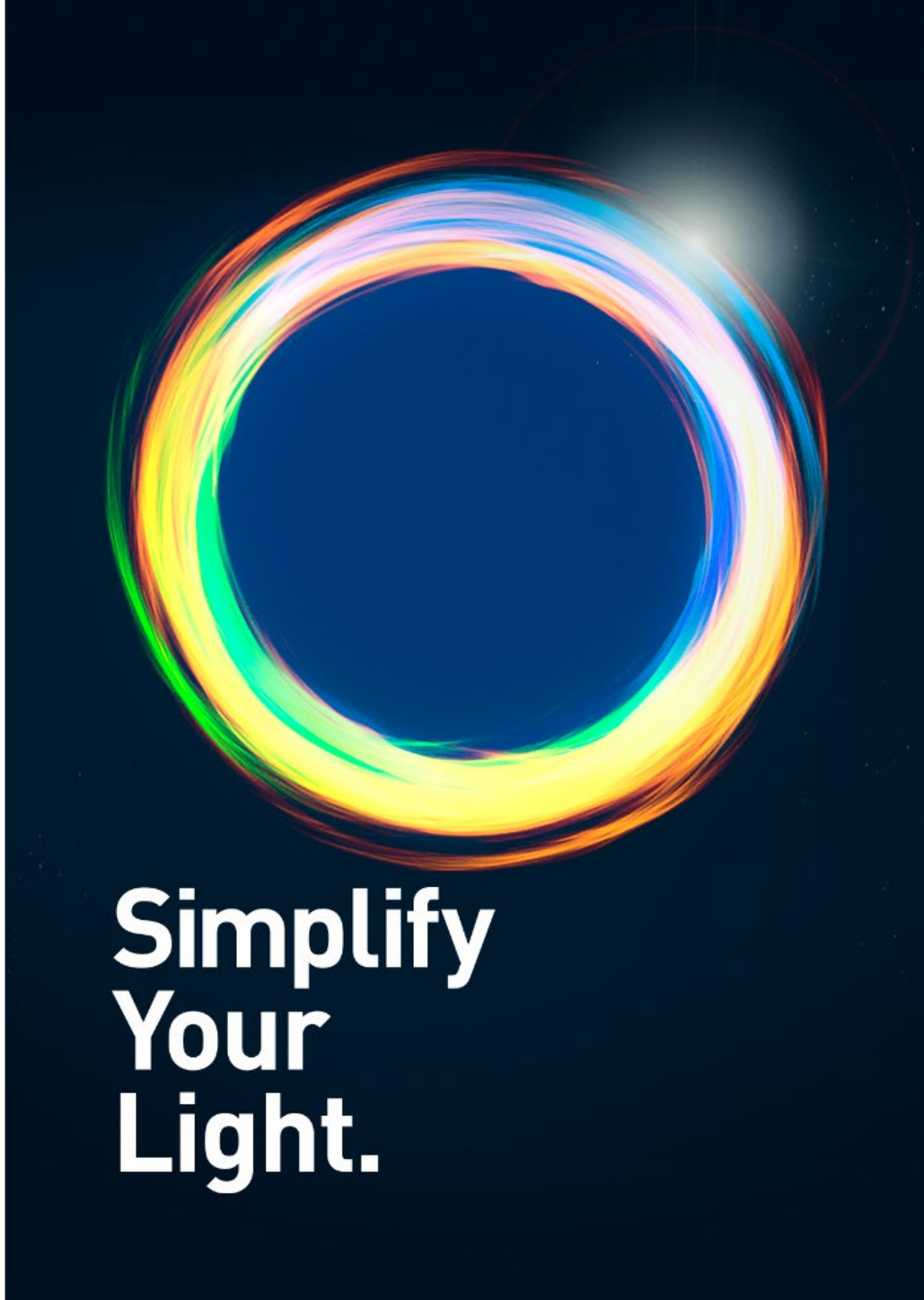
Version 2

THANK YOU FOR YOUR ATTENTION AND PARTICIPATION

JAMIE YATES MSLL

Trilux Akademie Trainer and
End User Key Accounts



LIGHT AND LIGHTING
LIGHTING OF WORKPLACES INDOORS

EN12464-1;2019

THE UPDATES…

ITS BEEN WITH US A WHILE…

2002

2011

2019

July 2019

Will supersede EN 124

English Version

Light and lighting - Lighting of work places - Part 1: Indoor work places

Lumière et éclairage - Éclairage des lieux de travail - Partie 1: Lieux de travail intérieurs

Licht und Beleuchtung - Beleuchtung von Arbeitsstätten - Teil 1: Arbeitsstätten in Innenräumen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 169.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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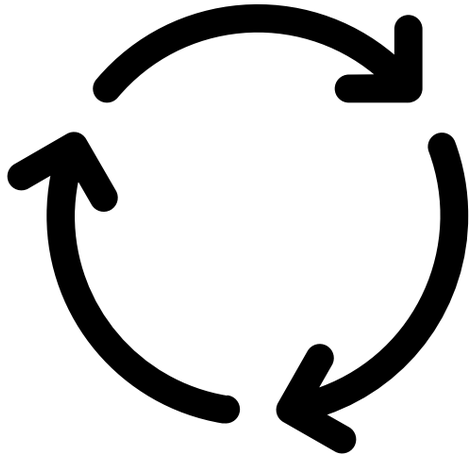
Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

REMEMBERING WHAT EN12464 IS ABOUT



DEVELOPMENT OF THE STANDARD

THE ‘TAKE HOMES’

User based focus

Improvement in **quality of light**

Info regarding the application of **non-visual light effects (HCL)**

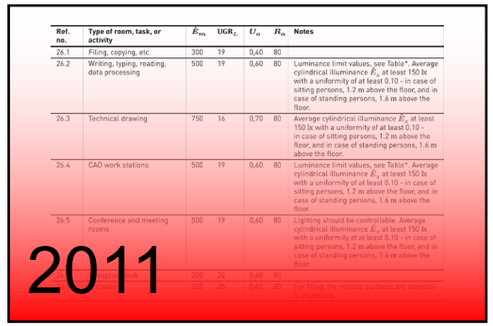
Consideration of requirements depending on **human age**

TABLE HEADERS

Expanded Headers

Introduction of a Lighting Lux “Range”

3 New Lux requirements for objects & surfaces, to improve comfort for the occupants.



Ref. no.	Type of room, task, or activity	$\bar{E}_{m,s}$	UGR_L	U_o	R_a	Notes
26.1	Filing, copying, etc.	300	19	0,40	80	
26.2	Writing, typing, reading, data processing	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.3	Technical drawing	750	16	0,70	80	Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.4	CAD work stations	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.5	Conference and meeting rooms	500	19	0,60	80	Lighting should be controllable. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
[illegible]	[illegible]	300	22	0,40	80	For filing, the vertical surfaces are essential. Illumination
[illegible]	[illegible]	200	25	0,40	80	For filing, the vertical surfaces are essential. Illumination

2011

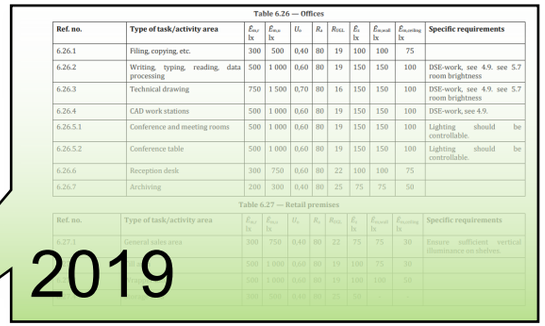


Table 6.26 — Offices

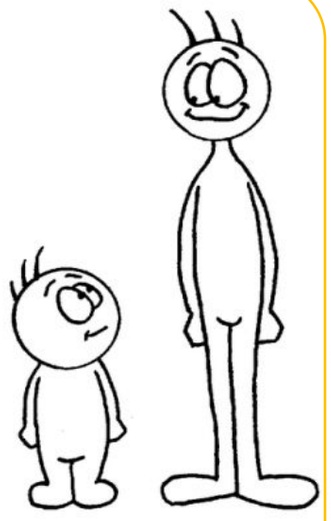
Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.26.1	Filing, copying, etc.	300	500	0,40	80	19	100	100	75	
6.26.2	Writing, typing, reading, data processing	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.3	Technical drawing	750	1 500	0,70	80	16	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.4	CAD work stations	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9.
6.26.5.1	Conference and meeting rooms	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.5.2	Conference table	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.6	Reception desk	300	750	0,60	80	22	100	100	75	
6.26.7	Archiving	200	300	0,40	80	25	75	75	50	

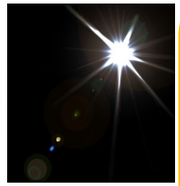
Table 6.27 — Retail premises

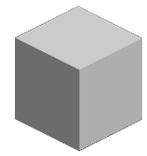
Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.27.1	General sales area	300	750	0,40	80	22	75	75	30	Ensure sufficient vertical illuminance on shelves.
[illegible]	[illegible]	500	1 000	0,60	80	19	100	75	30	
[illegible]	[illegible]	500	1 000	0,60	80	19	100	100	50	
[illegible]	[illegible]	200	300	0,40	80	22	50			

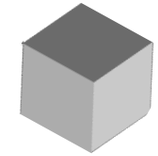
2019

Task or activity area design		Room or space design	
Task or activity related requirements		Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)



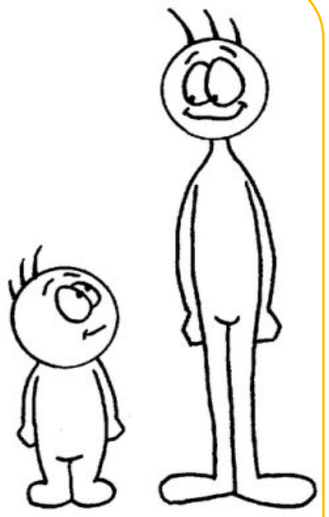
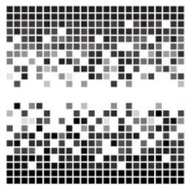
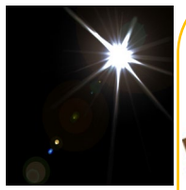
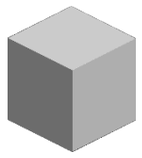
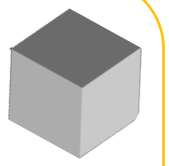






$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx

TABLE HEADERS

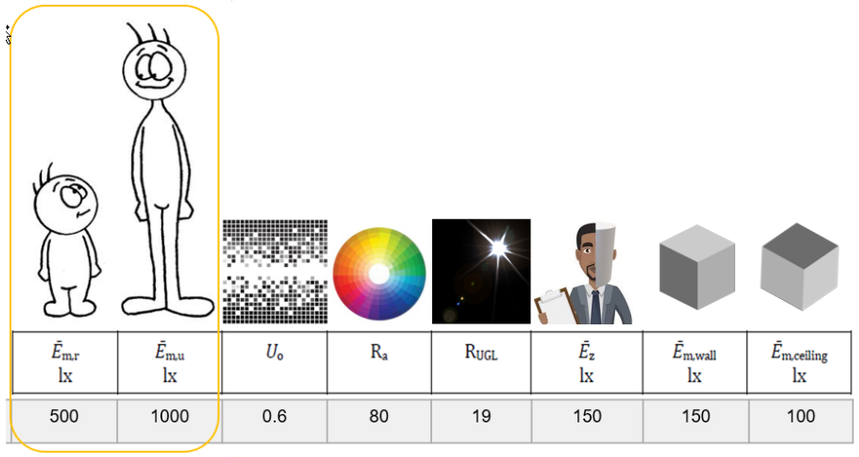
		Task or activity area design					Room or space design		
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
									
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

ILLUMINANCE SCALE ACCORDING TO EN 12665

20 – 30 – 50 – 75 – 100 – 150 – 200 – 300 – 500 – 750 – 1000 -1500 – 2000 – 3000 – 5000

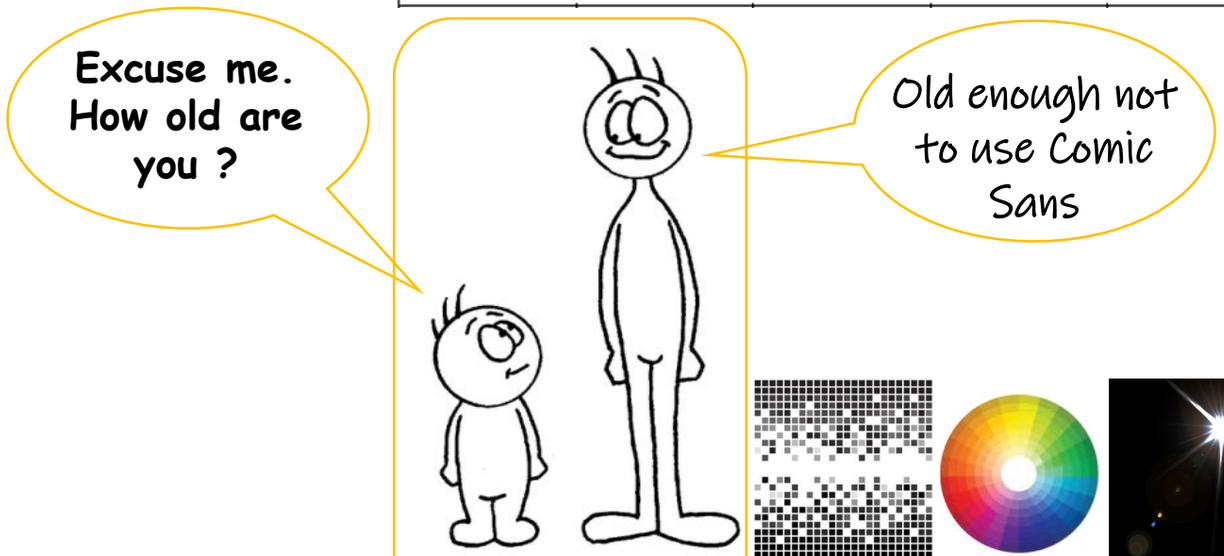
Fuel Supply Plant Machine Halls Meeting Rooms

The New Lux Levels extended over a range of levels



$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
500	1000	0.6	80	19	150	150	100

SCALE RANGE



		Task or activity area design				Room or space design			
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

DESIGNING FOR ALL

Designing high, then dimming down…..

…via Dimmable luminaires.

Allowing for Daylight changes & personnel requests for “More Light”

DELIVERING DEMAND

Is Supplementary Lighting The Answer ?

ADJUSTABLE LIGHTING = CONTROLS

Adjust to……
available daylight
occupancy
changing visual tasks
varying occupants, individual preferences or needs.

The standard recommends using the upper design value to permit the user full use of the illuminated environment. Designing a basic lighting installation which only fulfils minimum criteria constricts the benefits provided by good quality of light

NON VISUAL EFFECTS OF LIGHT = HCL

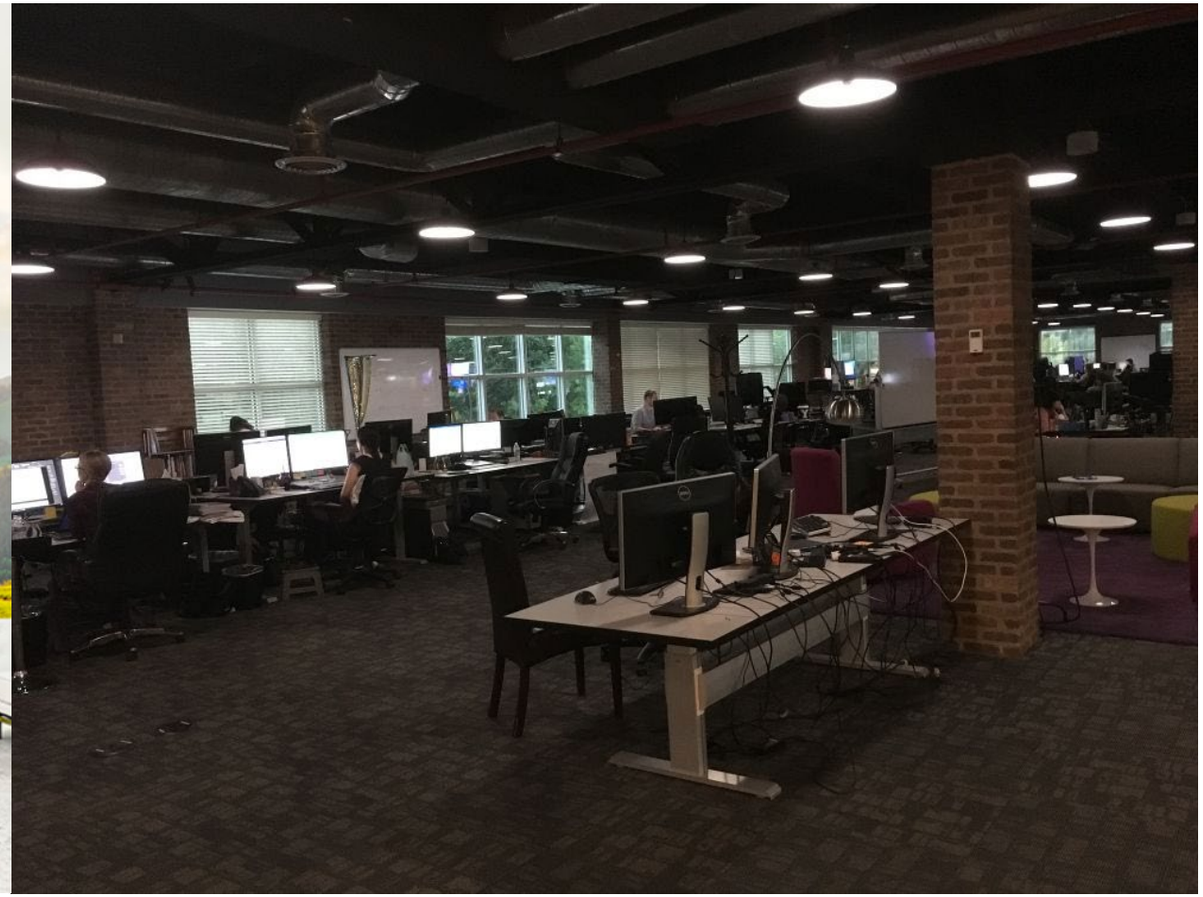
Educating designers on the advantages.
Encourage appropriate exposure to light for maintaining circadian health and aligning the circadian rhythm with the day-night cycle.
Natural or Artifical

HCL

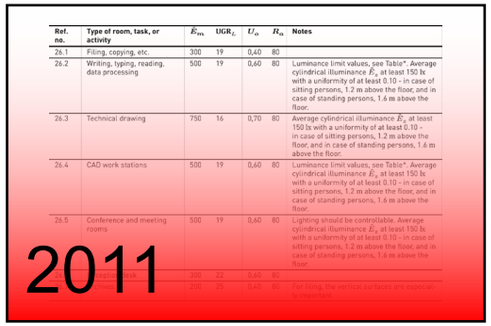
A detailed TX Akademie Webinar is available on the full topic of Circadian lighting.

TRILUX
SIMPLIFY YOUR LIGHT.

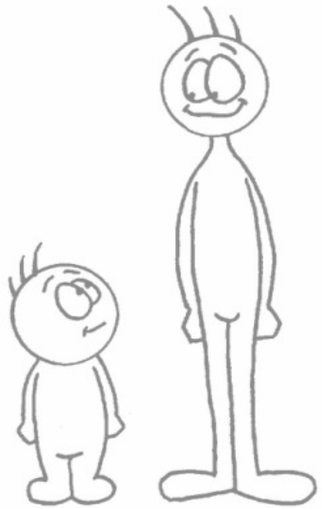
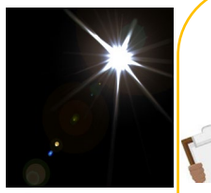
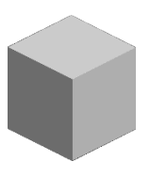
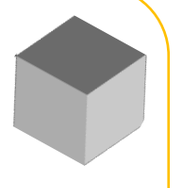
WALLS & CEILINGS



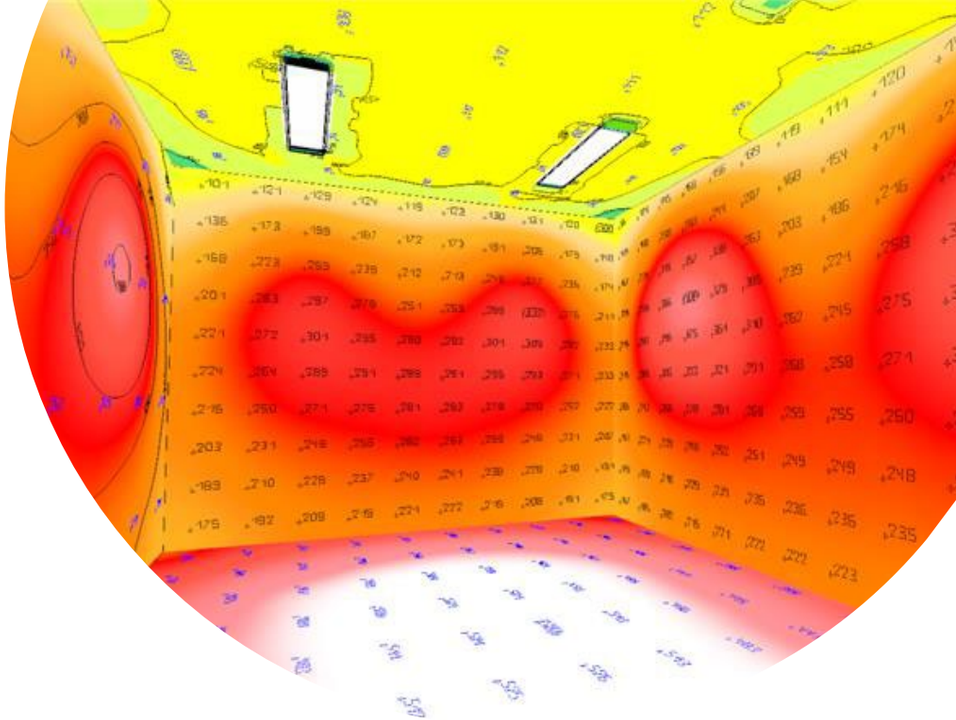
THE OBJECT & BACKGROUND BRIGHTNESS



Ref. no.	Type of room, task, or activity	$\bar{E}_m$	UGR$_L$	U_o	R_a	Notes
26.1	Filing, copying, etc.	300	19	0,40	80	
26.2	Writing, typing, reading, data processing	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.3	Technical drawing	750	16	0,70	80	Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.4	CAD work stations	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.5	Conference and meeting rooms	500	19	0,60	80	Lighting should be controllable. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.6	[illegible]	200	22	0,40	80	[illegible]
26.7	[illegible]	200	25	0,40	80	For living, the vertical surfaces are especially important.

		Task or activity area design				Room or space design		
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)
								
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

THE OBJECT
& BACKGROUND BRIGHTNESS



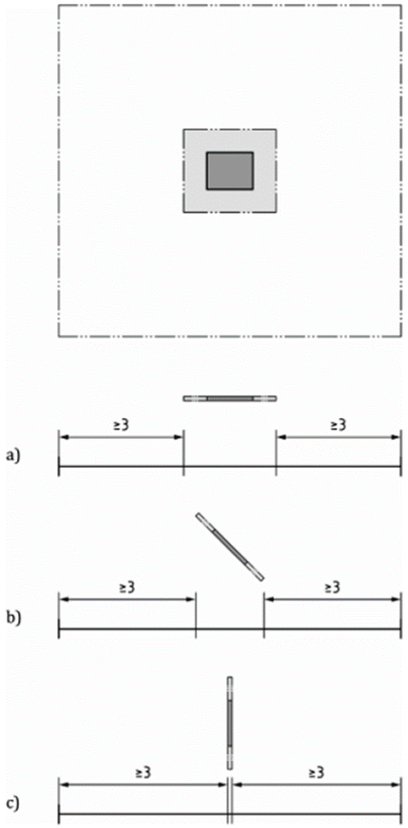
All the cylindrical / wall & ceilings illuminances are standard outputs in;

Dialux / Evo

Relux

AGI32

THE TASK VS BACKGROUND



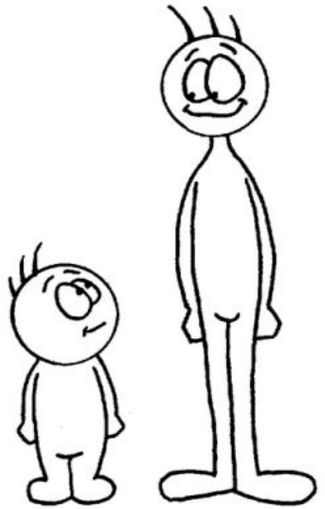
Task & background area principles remain.

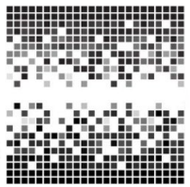
However task orientation to background has more definition & flexibility around orientation of the Task vs the background.

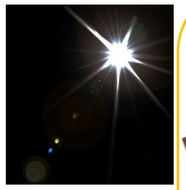
TASK, OBJECT, BACKGROUND INCREASE

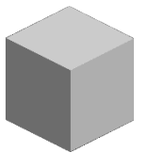
If you increase task Lux by a step, then the others must increase by a step too….

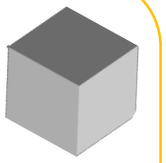
20 – 30 – 50 – 75 – 100 – 150 – 200 – 300 – 500 – 750 – 1000 -1500 – 2000 – 3000 – 5000











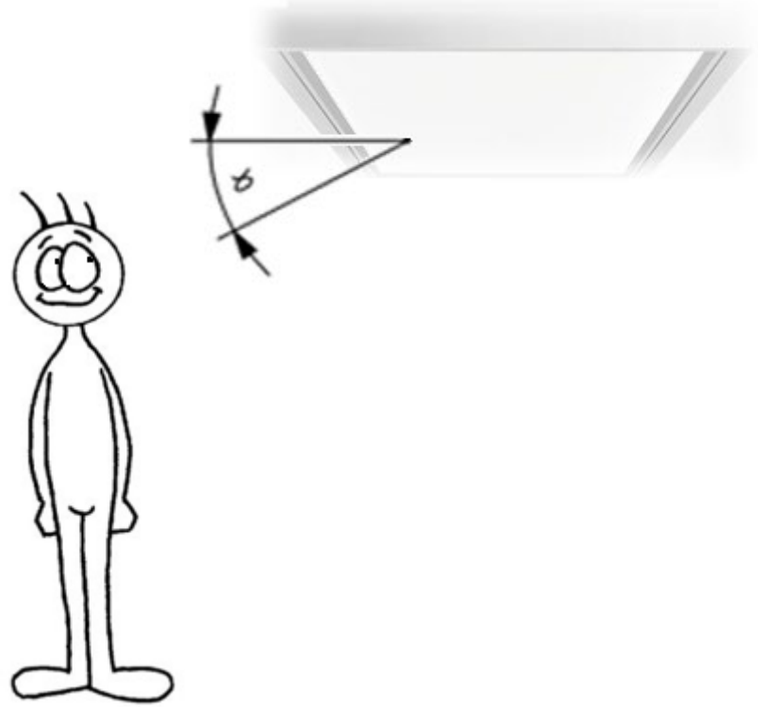
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
	Office Requirements	500	1000	0.6	80	19	150	150	100
	Office Requirements	750	1500	0.6	80	19	200	200	150

GLARE

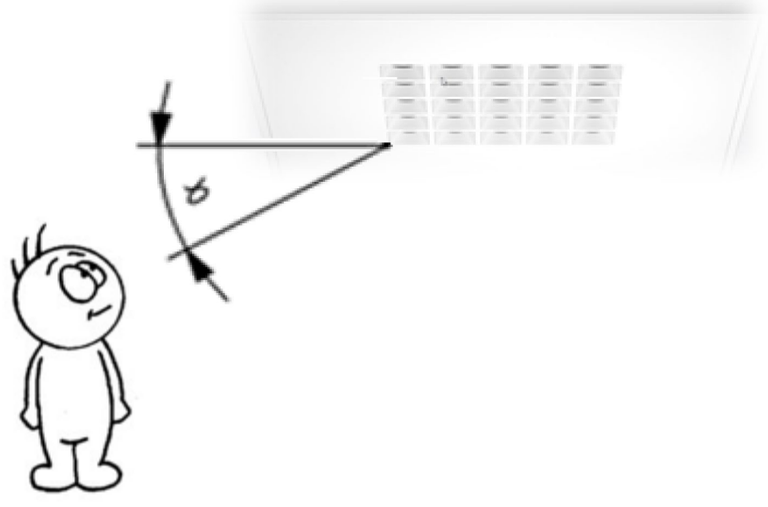
To account for LED luminaires with diffuse opal or prismatic optics or lens technology, the Luminaire must follow key maximum illuminance levels are not exceeded below certain visual angles.

Likewise un-diffused LED sources must follow the same conditions as 2011

Gamma angle γ	Maximum Average Luminaire Luminance kcd m^{-2}
$75° \le \gamma < 90°$	≤ 20
$70° \le \gamma < 75°$	≤ 50
$60° \le \gamma < 70°$	≤ 500

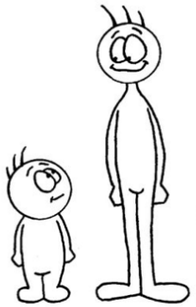


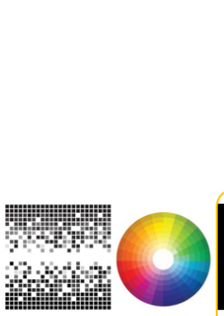
Light source luminance kcd m^{-2}	Minimum shielding angle α
20 to <50	15°
50 to < 500	20°
≥ 500	30°

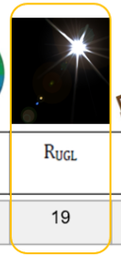


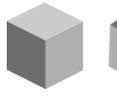
GLARE - UGR

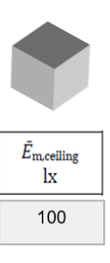
Supporting UGR Tables to be submitted,
with the defined spacing











	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
Office Requirements	500	1000	0.6	80	19	150	150	100

TRILUX Siella G6 M73 PW19 LED36-840 / Glare Data Sheet

Glare Evaluation According to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	14.4	15.5	14.7	15.7	16.0	13.7	14.9	14.0	15.1	15.3
	3H	15.6	16.6	15.9	16.9	17.1	14.9	15.9	15.2	16.2	16.4
	4H	16.2	17.2	16.6	17.5	17.7	15.4	16.4	15.7	16.7	16.9
	6H	16.9	17.7	17.2	18.0	18.3	15.8	16.7	16.2	17.0	17.3
	8H	17.2	18.0	17.5	18.3	18.6	15.9	16.8	16.3	17.1	17.4
	12H	17.5	18.3	17.8	18.6	18.9	16.0	16.8	16.4	17.1	17.5
4H	2H	14.7	15.7	15.0	15.9	16.2	14.1	15.1	14.5	15.4	15.7
	3H	16.1	17.0	16.5	17.3	17.6	15.5	16.3	15.9	16.6	17.0
	4H	16.9	17.7	17.3	18.0	18.4	16.2	17.0	16.6	17.3	17.7
	6H	17.8	18.4	18.2	18.8	19.1	16.8	17.5	17.2	17.8	18.2
	8H	18.2	18.7	18.6	19.1	19.5	17.0	17.6	17.5	18.0	18.4
	12H	18.5	19.1	19.0	19.5	19.9	17.2	17.7	17.6	18.1	18.5
8H	4H	17.2	17.8	17.6	18.2	18.6	16.6	17.2	17.0	17.5	18.0
	6H	18.2	18.6	18.6	19.0	19.5	17.4	17.9	17.8	18.3	18.7
	8H	18.6	19.1	19.1	19.5	20.0	17.7	18.1	18.2	18.6	19.1
	12H	19.1	19.5	19.6	20.0	20.5	18.0	18.3	18.5	18.8	19.3
12H	4H	17.2	17.7	17.7	18.2	18.6	16.6	17.1	17.1	17.5	18.0
	6H	18.2	18.6	18.7	19.1	19.6	17.5	17.9	18.0	18.3	18.8
	8H	18.8	19.1	19.2	19.6	20.1	17.9	18.3	18.4	18.7	19.2
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.2 / -0.4					+0.3 / -0.4				
S = 1.5H		+0.5 / -0.6					+0.6 / -0.8				
S = 2.0H		+1.1 / -1.2					+1.2 / -1.3				
Standard table		BK05					BK04				
Correction Summand		-2.8					-4.2				
Corrected Glare Indices referring to 3600lm Total Luminous Flux											

The UGR values have been calculated according to CIE Publ. 117 Spacing-to-Height-Ratio = 1.00.

THE ‘TAKE HOMES’

User based focus

Improvement in **quality of light**

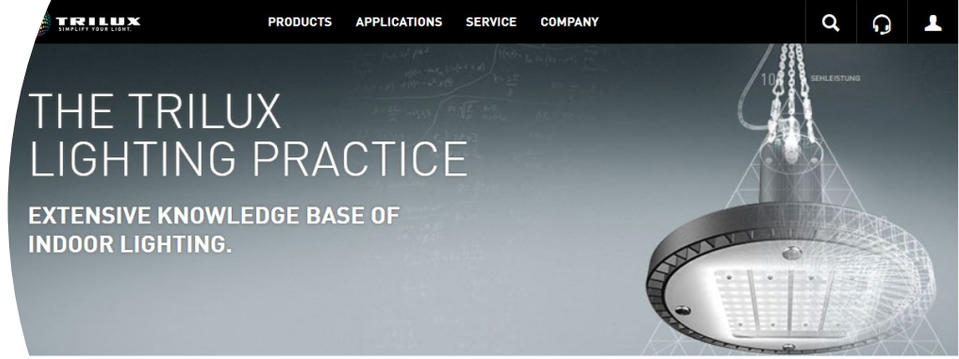
Info regarding the application of **non-visual light effects (HCL)**

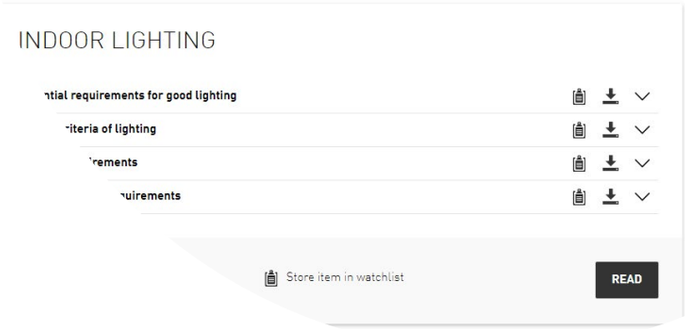
Consideration of requirements depending on **human age**

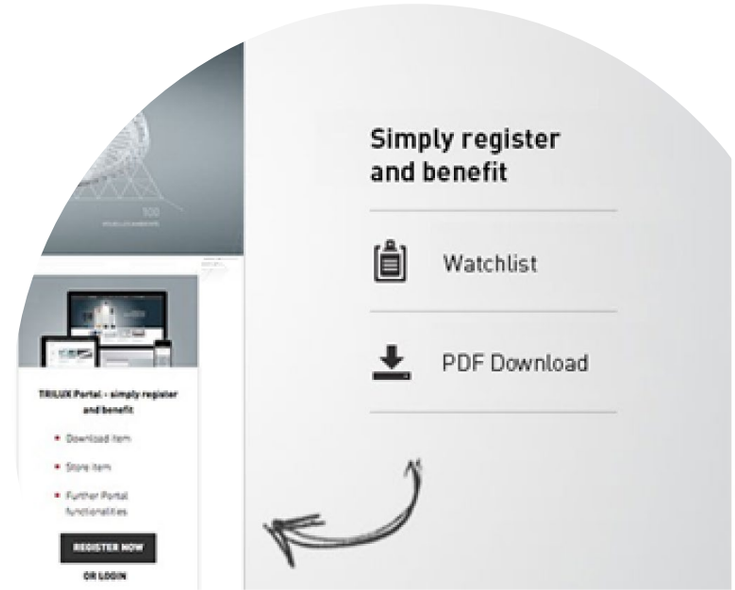
KNOWLEDGE

Expand your knowledge through the ‘Trilux Lighting Practise’

- UGR Table Application
- Glare
- Cylindrical Illuminance
- Luminaire Luminance
- etc







TRILUX
SIMPLIFY YOUR LIGHT.

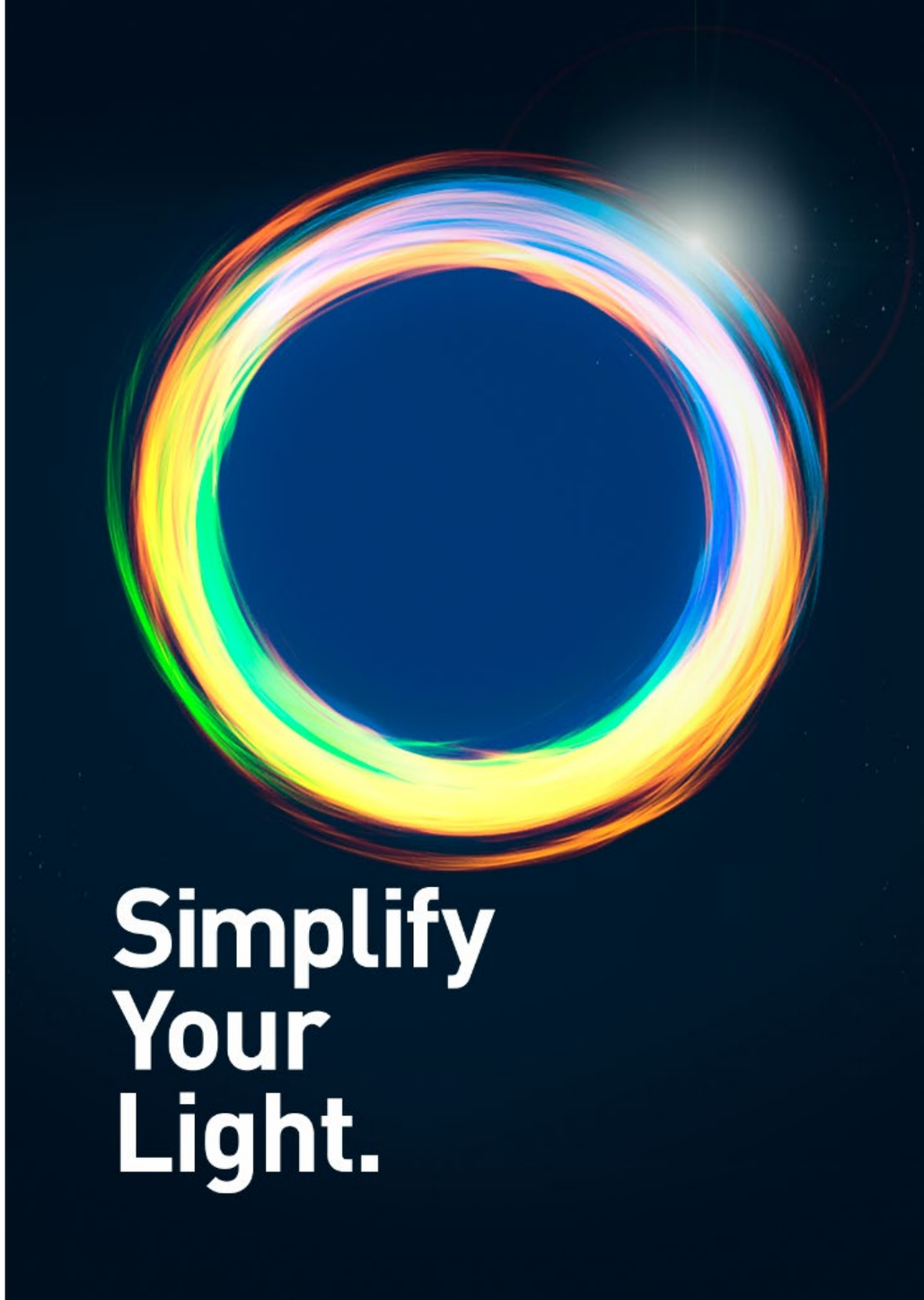
TRILUX SUPPORTING YOU EN12464-1;2019

- Good Photometric Data
- Advice
- HCL Circadian Advice & Technology
- Good Colour Quality
- Good Luminaire Design
- Knowledge Portal

THANKYOU FOR YOUR ATTENTION AND PARTICIPATION

JAMIE YATES MSLL

Trilux Akademie Trainer and
End User Key Accounts



LIGHT AND LIGHTING
LIGHTING OF WORKPLACES INDOORS

EN12464-1;2019

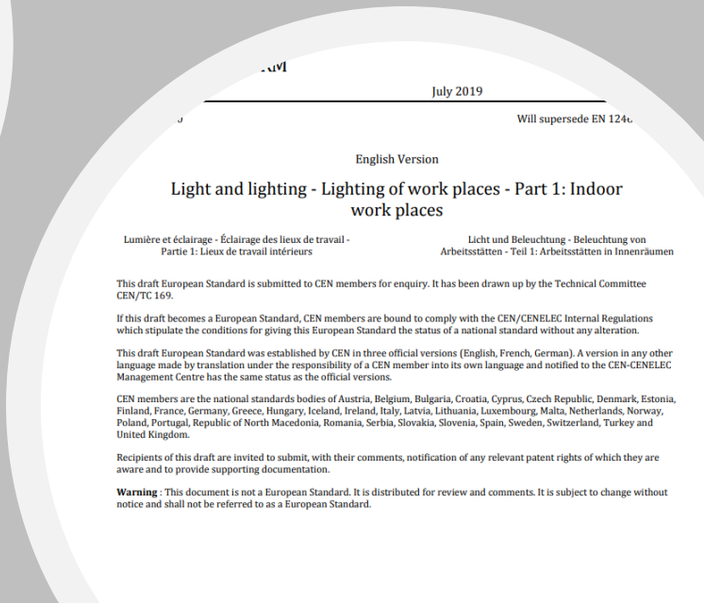
THE UPDATES…

ITS BEEN WITH US A WHILE…

2002

2011

2019



July 2019

Will supersede EN 124

English Version

Light and lighting - Lighting of work places - Part 1: Indoor work places

Lumière et éclairage - Éclairage des lieux de travail - Partie 1: Lieux de travail intérieurs

Licht und Beleuchtung - Beleuchtung von Arbeitsstätten - Teil 1: Arbeitsstätten in Innenräumen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 169.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

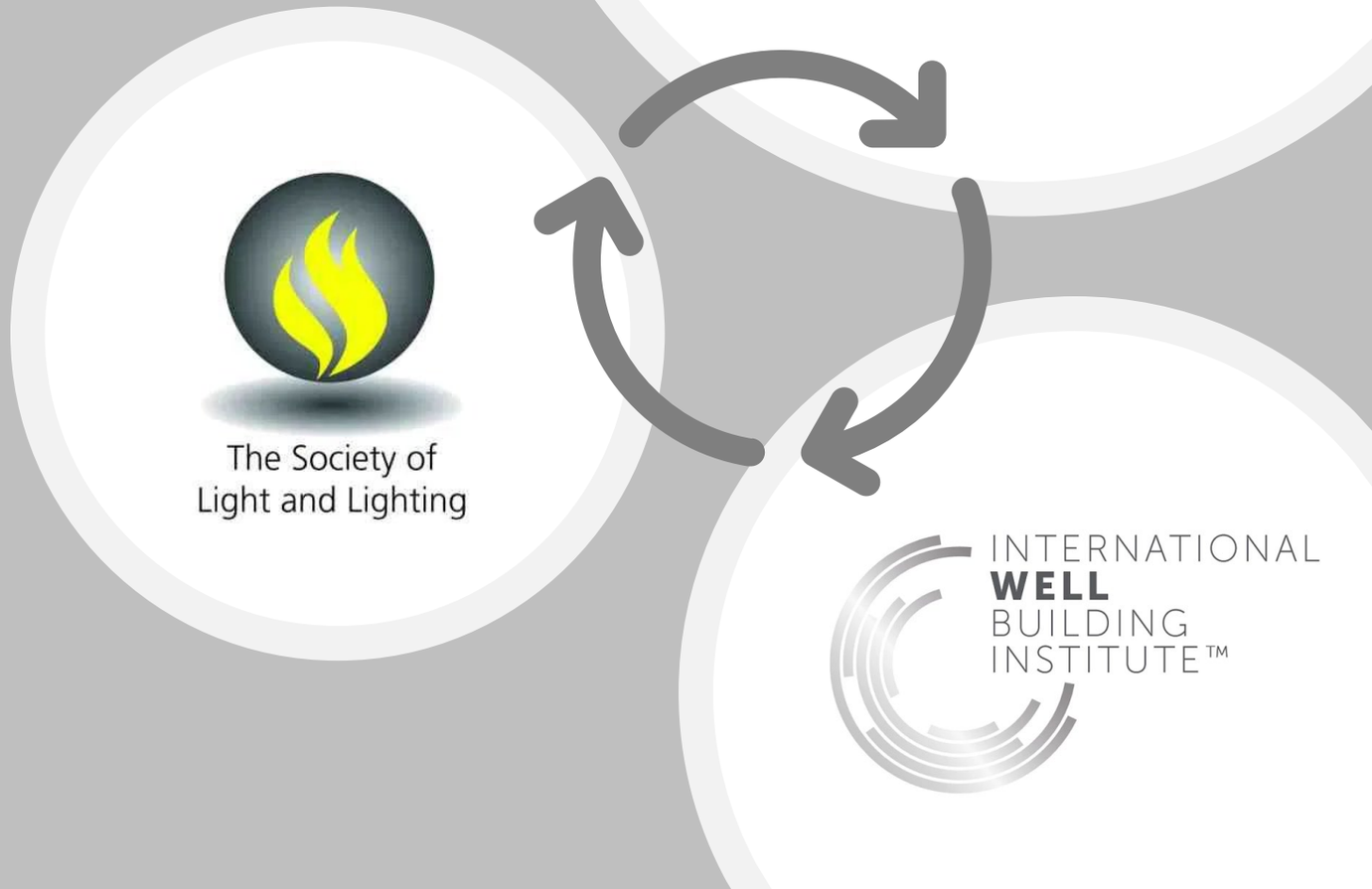
REMEMBERING WHAT EN12464 IS ABOUT

Workplace indoor lighting

European & British Standard

It’s a Recommendation not Law

It represents Good Lighting practice



DEVELOPMENT OF THE STANDARD

THE ‘TAKE HOMES’

User based focus

Improvement in **quality of light**

Info regarding the application of **non-visual light effects (HCL)**

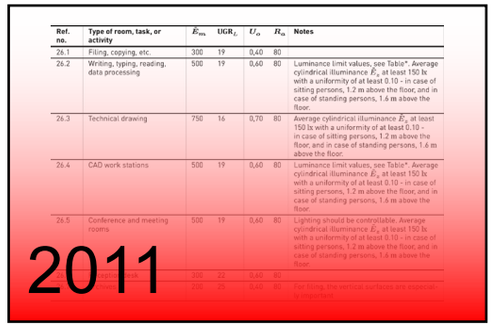
Consideration of requirements depending on **human age**

TABLE HEADERS

Expanded Headers

Introduction of a Lighting Lux “Range”

3 New Lux requirements for objects & surfaces, to improve comfort for the occupants.



Ref. no.	Type of room, task, or activity	$\bar{E}_{m,s}$	UGR_L	U_o	R_a	Notes
26.1	Filing, copying, etc.	300	19	0,40	80	
26.2	Writing, typing, reading, data processing	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.3	Technical drawing	750	16	0,70	80	Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.4	CAD work stations	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
26.5	Conference and meeting rooms	500	19	0,60	80	Lighting should be controllable. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0.10 - in case of sitting persons, 1.2 m above the floor, and in case of standing persons, 1.6 m above the floor.
[illegible]	[illegible]	300	22	0,40	80	For filing, the vertical surfaces are essential. Illumination
[illegible]	[illegible]	200	25	0,40	80	For filing, the vertical surfaces are essential. Illumination

2011

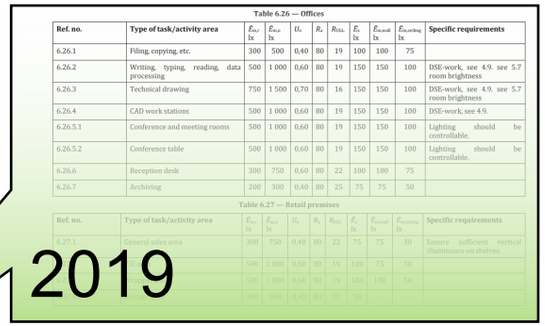


Table 6.26 — Offices

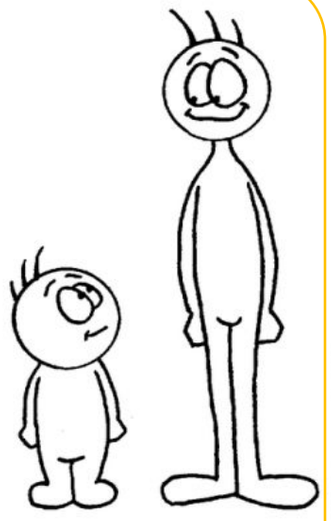
Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.26.1	Filing, copying, etc.	300	500	0,40	80	19	100	100	75	
6.26.2	Writing, typing, reading, data processing	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.3	Technical drawing	750	1 500	0,70	80	16	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.4	CAD work stations	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9.
6.26.5.1	Conference and meeting rooms	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.5.2	Conference table	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.6	Reception desk	300	750	0,60	80	22	100	100	75	
6.26.7	Archiving	200	300	0,40	80	25	75	75	50	

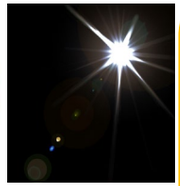
Table 6.27 — Retail premises

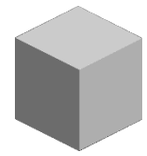
Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.27.1	General sales area	300	750	0,40	80	22	75	75	30	Ensure sufficient vertical illuminance on shelves.
[illegible]	[illegible]	500	1 000	0,60	80	19	100	75	30	
[illegible]	[illegible]	500	1 000	0,60	80	19	100	100	50	
[illegible]	[illegible]	200	300	0,40	80	22	50			

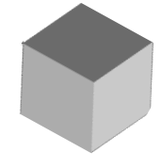
2019

Task or activity area design		Room or space design	
Task or activity related requirements		Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)



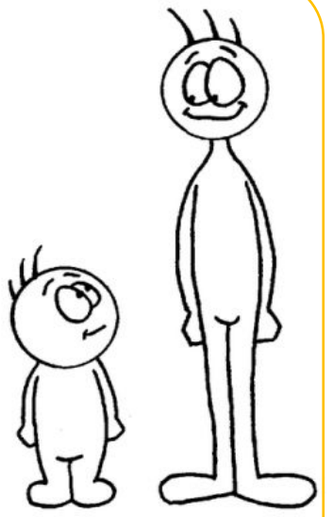
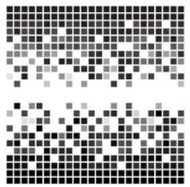
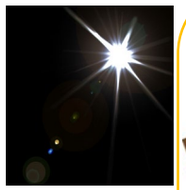
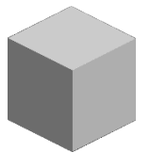
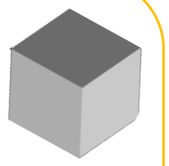






$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx

TABLE HEADERS

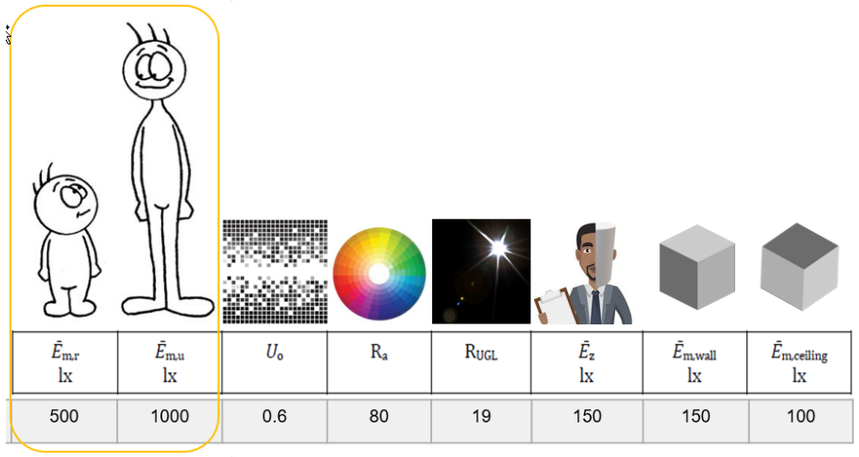
		Task or activity area design					Room or space design		
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
									
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

ILLUMINANCE SCALE ACCORDING TO EN 12665

20 – 30 – 50 – 75 – 100 – 150 – 200 – 300 – 500 – 750 – 1000 -1500 – 2000 – 3000 – 5000

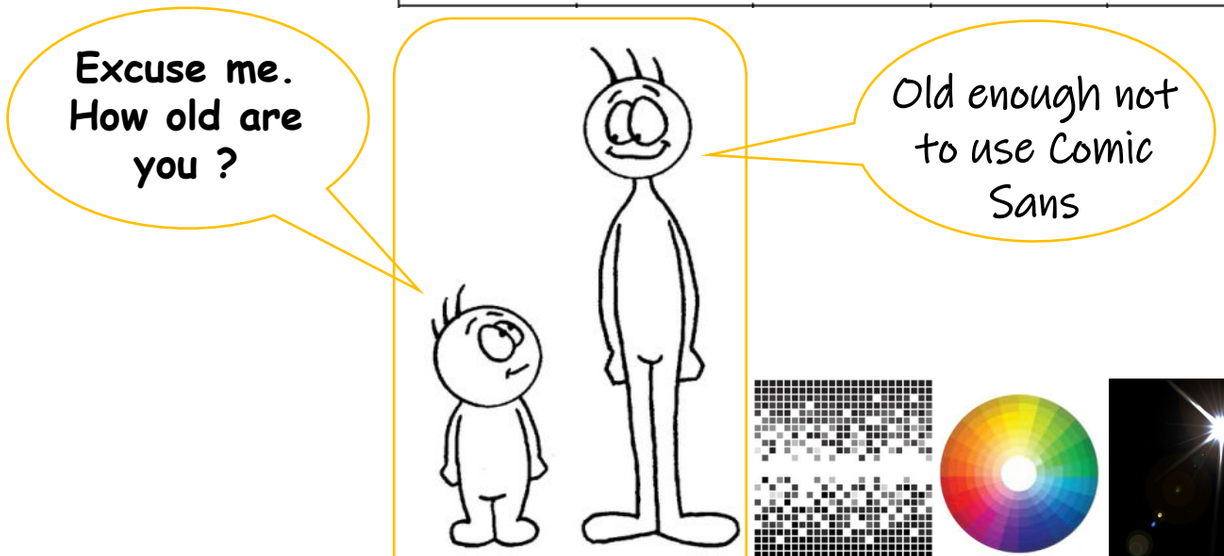
Fuel Supply Plant Machine Halls Meeting Rooms

The New Lux Levels extended over a range of levels



$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
500	1000	0.6	80	19	150	150	100

SCALE RANGE



		Task or activity area design				Room or space design			
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

DESIGNING FOR ALL

Designing high, then dimming down…..

…via Dimmable luminaires.

Allowing for Daylight changes & personnel requests for “More Light”

DELIVERING DEMAND

Is Supplementary Lighting The Answer ?

TRILUX
SIMPLIFY YOUR LIGHT.

ADJUSTABLE LIGHTING = CONTROLS

Adjust to……
available daylight
occupancy
changing visual tasks
varying occupants, individual preferences or needs.

The standard recommends using the upper design value to permit the user full use of the illuminated environment. Designing a basic lighting installation which only fulfils minimum criteria constricts the benefits provided by good quality of light

NON VISUAL EFFECTS OF LIGHT = HCL

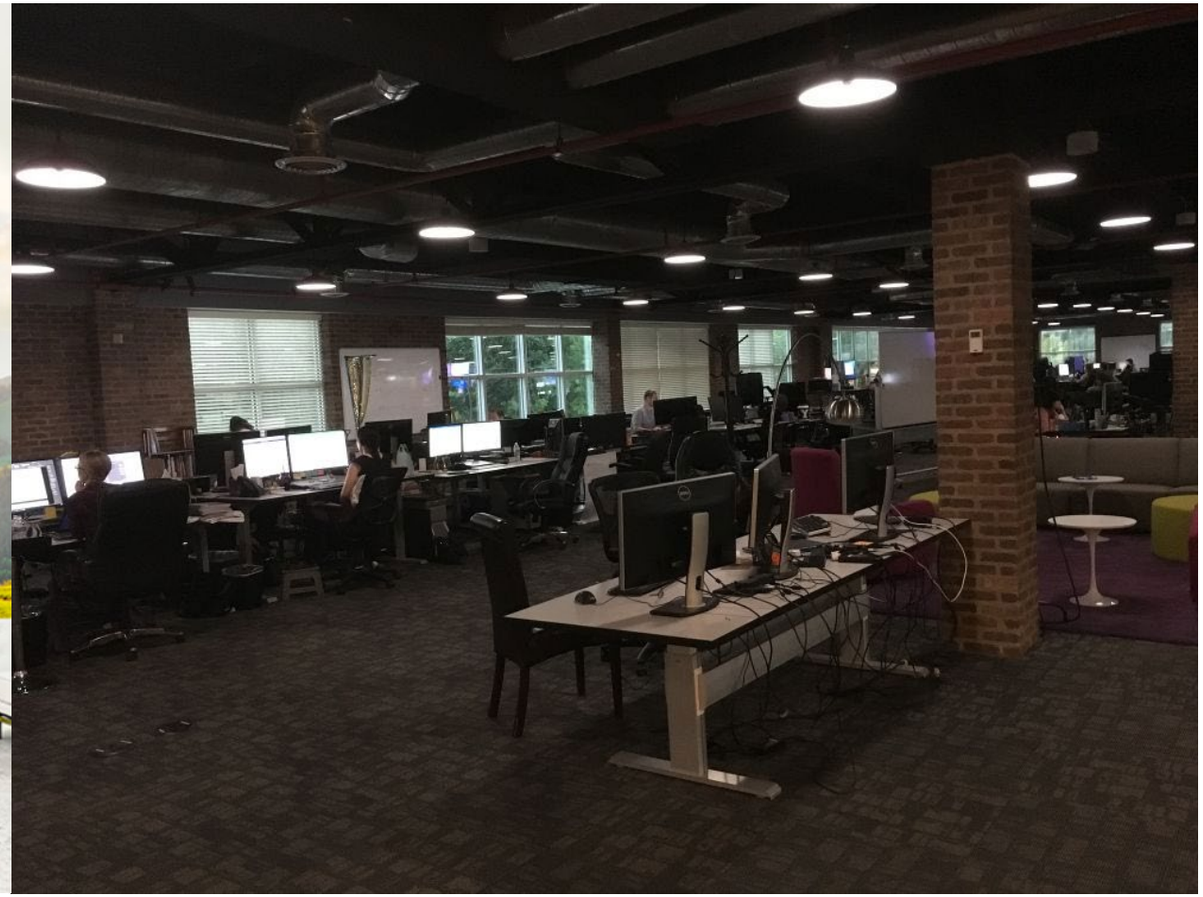
Educating designers on the advantages.
Encourage appropriate exposure to light for maintaining circadian health and aligning the circadian rhythm with the day-night cycle.
Natural or Artifical

HCL

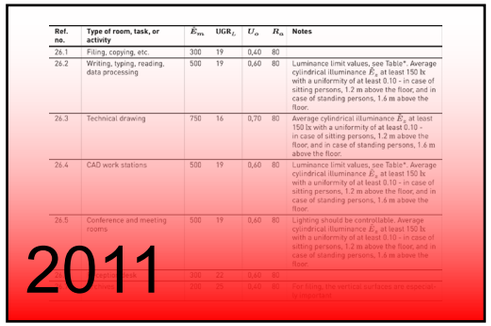
A detailed TX Akademie Webinar is available on the full topic of Circadian lighting.

TRILUX
SIMPLIFY YOUR LIGHT.

WALLS & CEILINGS



THE OBJECT & BACKGROUND BRIGHTNESS



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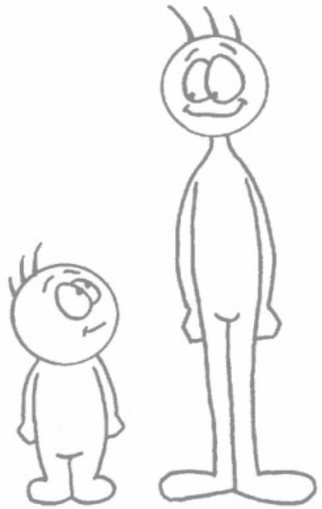
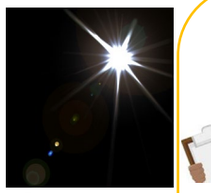
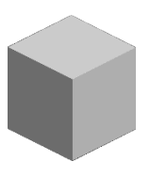
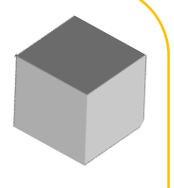
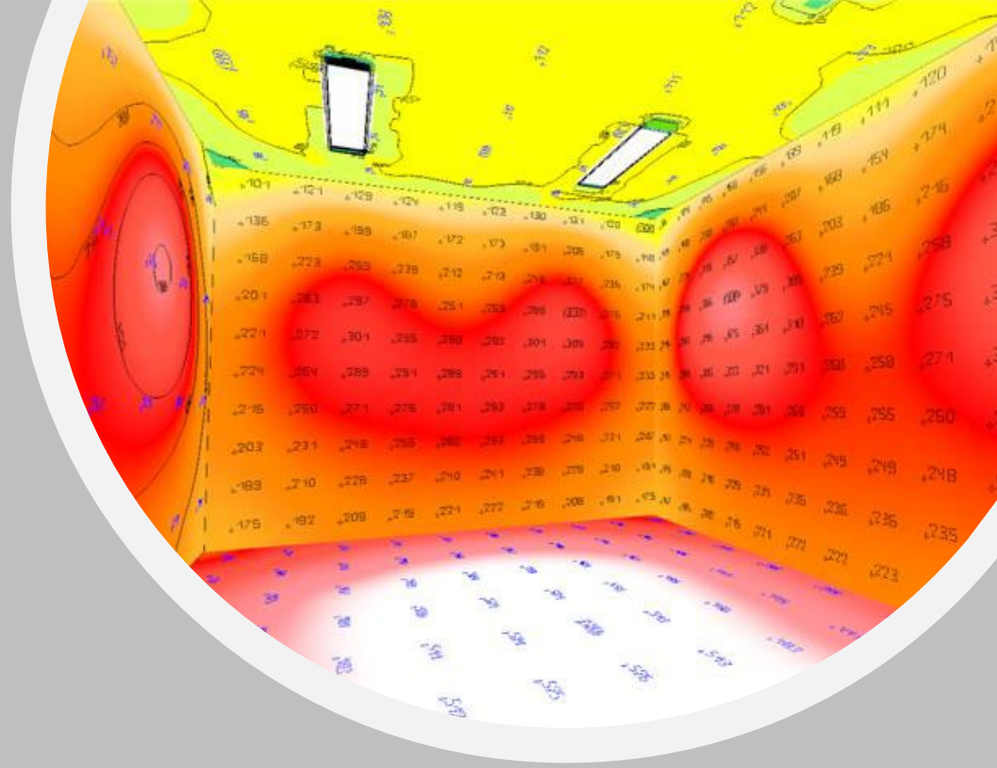
26.3	Technical drawing	750	16	0,70	80	Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.4	CAD work stations	500	19	0,60	80	Luminance limit values, see Table*. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.5	Conference and meeting rooms	500	19	0,60	80	Lighting should be controllable. Average cylindrical illuminance $\bar{E}_z$ at least 150 lx with a uniformity of at least 0,10 – in case of sitting persons, 1,2 m above the floor, and in case of standing persons, 1,6 m above the floor.
26.6	[illegible]	200	22	0,40	80	[illegible]
26.7	[illegible]	200	25	0,40	80	For living, the vertical surfaces are especially important.

		Task or activity area design				Room or space design		
		Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)
								
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
6.26.5.1	Conference & Meeting Rooms	500	1000	0.6	80	19	150	150	100

THE OBJECT
& BACKGROUND BRIGHTNESS



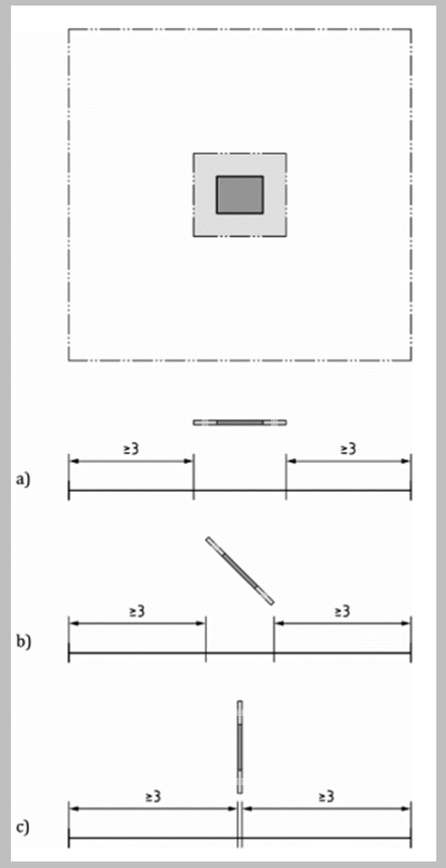
All the cylindrical / wall & ceilings illuminances are standard outputs in;

Dialux / Evo

Relux

AGI32

THE TASK VS BACKGROUND



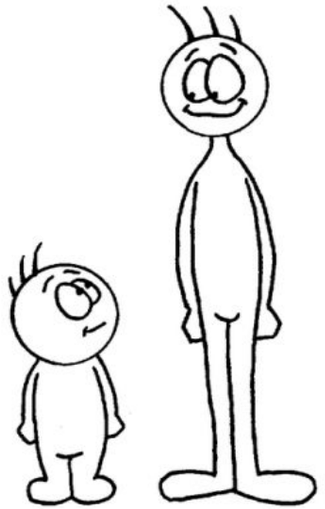
Task & background area principles remain.

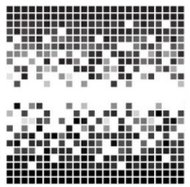
However task orientation to background has more definition & flexibility around orientation of the Task vs the background.

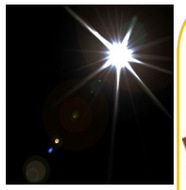
TASK, OBJECT, BACKGROUND INCREASE

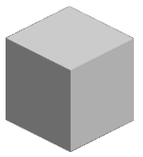
If you increase task Lux by a step, then the others must increase by a step too….

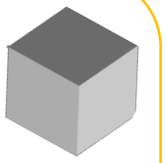
20 – 30 – 50 – 75 – 100 – 150 – 200 – 300 – 500 – 750 – 1000 -1500 – 2000 – 3000 – 5000











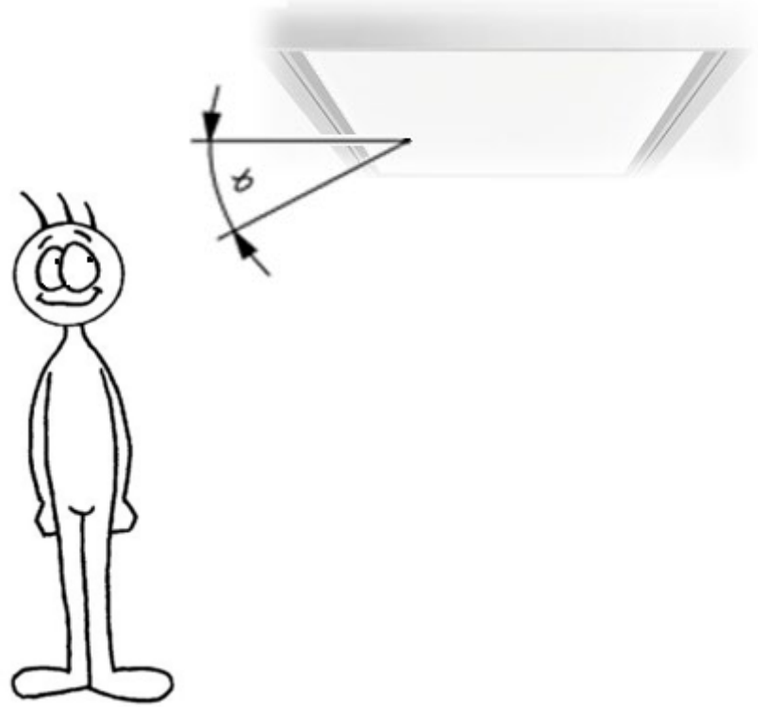
		$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
	Office Requirements	500	1000	0.6	80	19	150	150	100
	Office Requirements	750	1500	0.6	80	19	200	200	150

GLARE

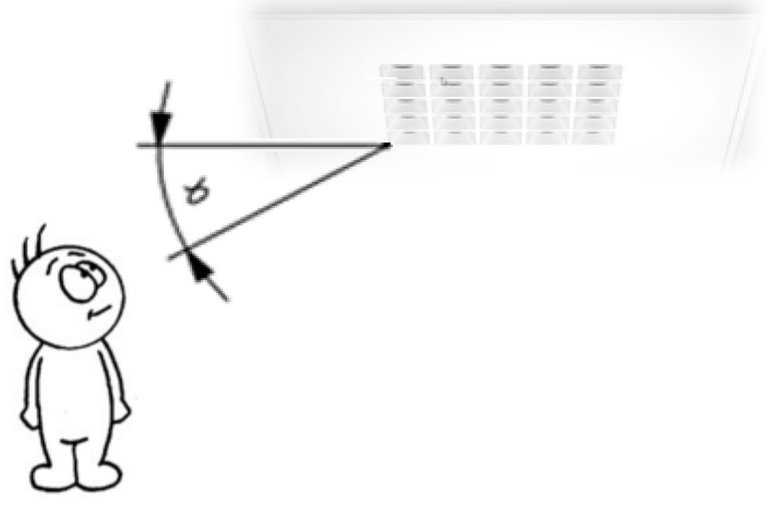
To account for LED luminaires with diffuse opal or prismatic optics or lens technology, the Luminaire must follow key maximum illuminance levels are not exceeded below certain visual angles.

Likewise un-diffused LED sources must follow the same conditions as 2011

Gamma angle γ	Maximum Average Luminaire Luminance kcd m^{-2}
$75° \le \gamma < 90°$	≤ 20
$70° \le \gamma < 75°$	≤ 50
$60° \le \gamma < 70°$	≤ 500

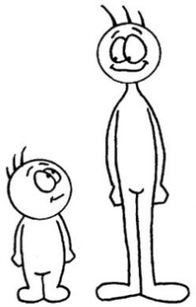


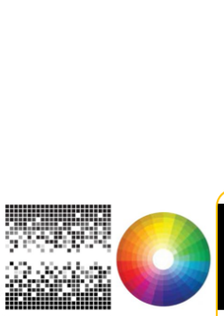
Light source luminance kcd m^{-2}	Minimum shielding angle α
20 to <50	15°
50 to < 500	20°
≥ 500	30°

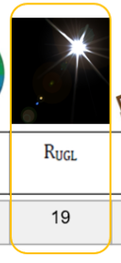


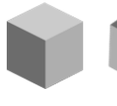
GLARE - UGR

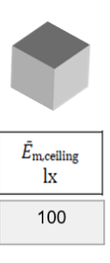
Supporting UGR Tables to be submitted,
with the defined spacing











	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx
Office Requirements	500	1000	0.6	80	19	150	150	100

TRILUX Siella G6 M73 PW19 LED36-840 / Glare Data Sheet

Glare Evaluation According to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	14.4	15.5	14.7	15.7	16.0	13.7	14.9	14.0	15.1	15.3
	3H	15.6	16.6	15.9	16.9	17.1	14.9	15.9	15.2	16.2	16.4
	4H	16.2	17.2	16.6	17.5	17.7	15.4	16.4	15.7	16.7	16.9
	6H	16.9	17.7	17.2	18.0	18.3	15.8	16.7	16.2	17.0	17.3
	8H	17.2	18.0	17.5	18.3	18.6	15.9	16.8	16.3	17.1	17.4
	12H	17.5	18.3	17.8	18.6	18.9	16.0	16.8	16.4	17.1	17.5
4H	2H	14.7	15.7	15.0	15.9	16.2	14.1	15.1	14.5	15.4	15.7
	3H	16.1	17.0	16.5	17.3	17.6	15.5	16.3	15.9	16.6	17.0
	4H	16.9	17.7	17.3	18.0	18.4	16.2	17.0	16.6	17.3	17.7
	6H	17.8	18.4	18.2	18.8	19.1	16.8	17.5	17.2	17.8	18.2
	8H	18.2	18.7	18.6	19.1	19.5	17.0	17.6	17.5	18.0	18.4
	12H	18.5	19.1	19.0	19.5	19.9	17.2	17.7	17.6	18.1	18.5
8H	4H	17.2	17.8	17.6	18.2	18.6	16.6	17.2	17.0	17.5	18.0
	6H	18.2	18.6	18.6	19.0	19.5	17.4	17.9	17.8	18.3	18.7
	8H	18.6	19.1	19.1	19.5	20.0	17.7	18.1	18.2	18.6	19.1
	12H	19.1	19.5	19.6	20.0	20.5	18.0	18.3	18.5	18.8	19.3
12H	4H	17.2	17.7	17.7	18.2	18.6	16.6	17.1	17.1	17.5	18.0
	6H	18.2	18.6	18.7	19.1	19.6	17.5	17.9	18.0	18.3	18.8
	8H	18.8	19.1	19.2	19.6	20.1	17.9	18.3	18.4	18.7	19.2
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.2 / -0.4					+0.3 / -0.4				
S = 1.5H		+0.5 / -0.6					+0.6 / -0.8				
S = 2.0H		+1.1 / -1.2					+1.2 / -1.3				
Standard table		BK05					BK04				
Correction Summand		-2.8					-4.2				
Corrected Glare Indices referring to 3600lm Total Luminous Flux											

The UGR values have been calculated according to CIE Publ. 117 Spacing-to-Height-Ratio = 1.00.

THE ‘TAKE HOMES’

User based focus

Improvement in **quality of light**

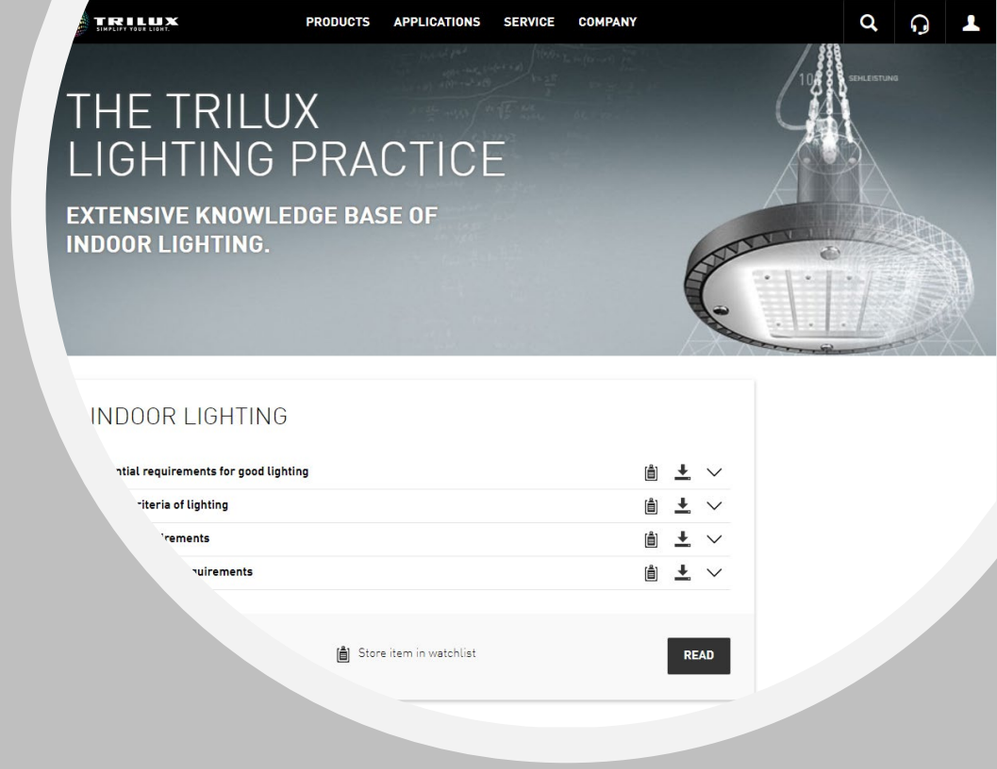
Info regarding the application of **non-visual light effects (HCL)**

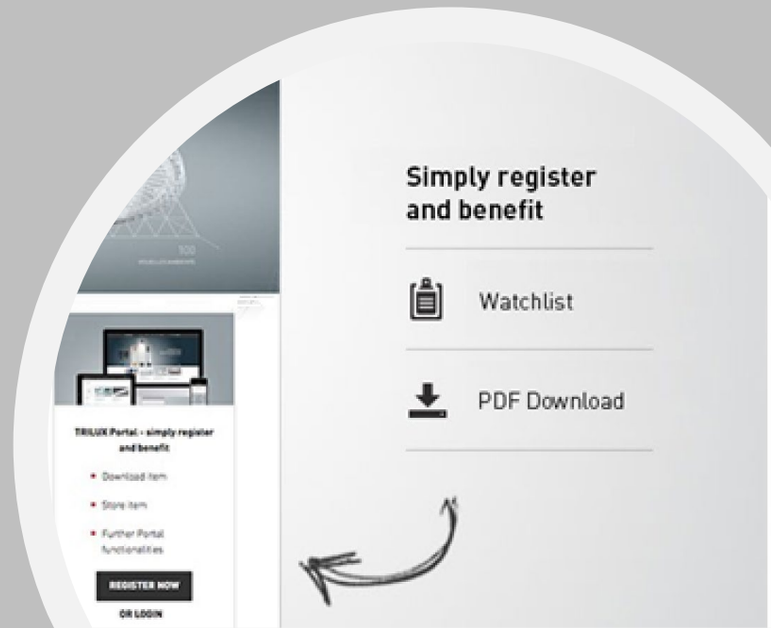
Consideration of requirements depending on **human age**

KNOWLEDGE

Expand your knowledge through the ‘Trilux Lighting Practise’

- UGR Table Application
- Glare
- Cylindrical Illuminance
- Luminaire Luminance
- etc

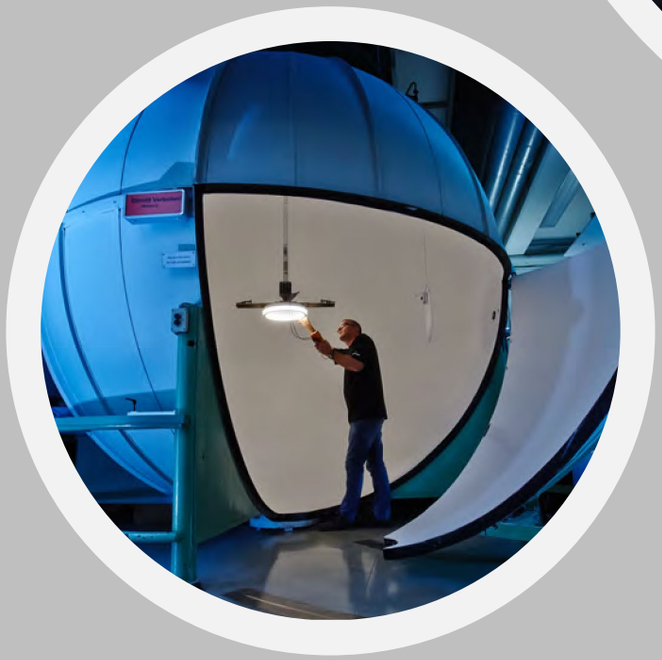




TRILUX
SIMPLIFY YOUR LIGHT.

TRILUX SUPPORTING YOU EN12464-1;2019

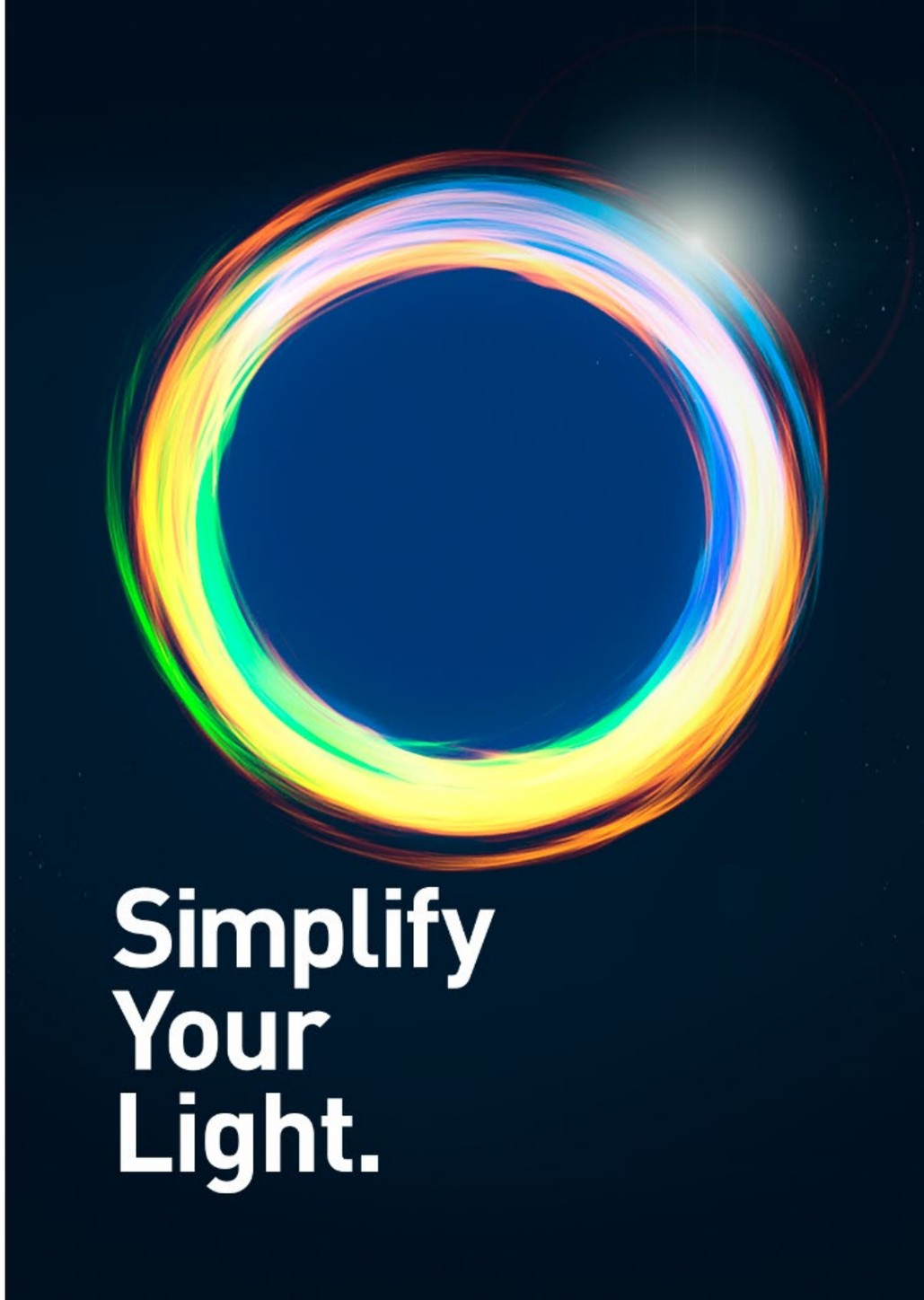
- Good Photometric Data
- Advice
- HCL Circadian Advice & Technology
- Good Colour Quality
- Good Luminaire Design
- Knowledge Portal



THANKYOU FOR YOUR ATTENTION AND PARTICIPATION

JAMIE YATES MSLL

Trilux Akademie Trainer and
End User Key Accounts



THE FUTURE OF LUMINAIRE DESIGN

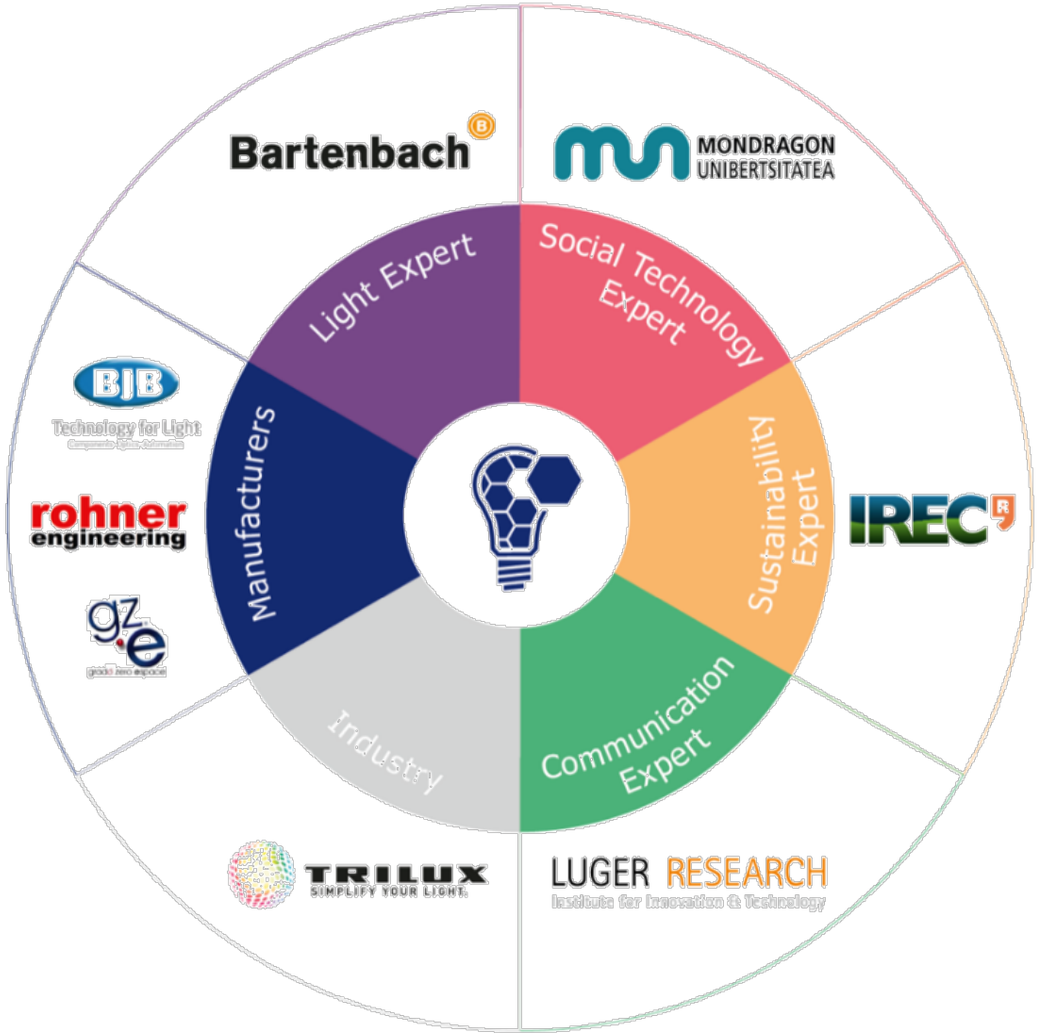
CONCLUSIONS FROM THE REPRO-LIGHT RESEARCH PROJECT

The Repro-light project and consortium

European research project that aims to support the European lighting industry in moving towards a more sustainable future

Key R&D activities:

- Sustainability and Circular Economy
- Modularisation of luminaires
- Smart production scheme

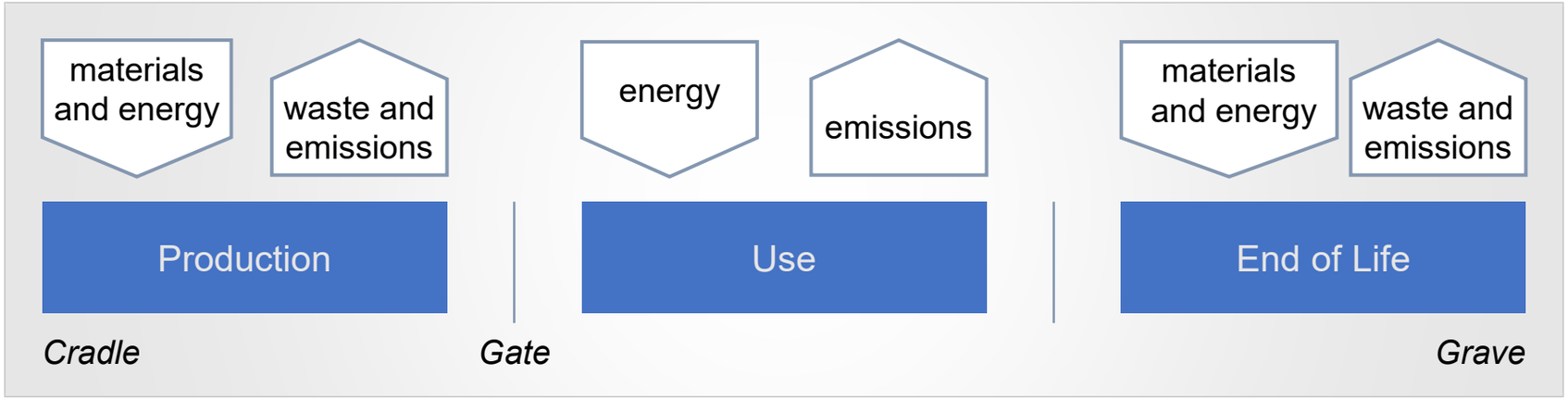


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768780.

Introduction to environmental life cycle assessment

Environmental Life Cycle Assessment

Life Cycle Assessment quantifies the **environmental impact** of a product over its entire life cycle.



The impact is quantified in different metrics, here we focus on the mid-point markers

Characterisation Factor	Unit	Environmental Relevance
PED Primary Energy Demand	Megajoule	Increased energy consumption from renewable and non-renewable energy sources
ADP elements Abiotic Depletion Potential, Elements	kg Sb-equivalent	Increased extraction of resources leading to depletion of mineral reserves

The luminaire

We considered a **continuous line luminaires** that is commonly used in industry, shop/retail, office and education.

- Modular system, many variants possible
- Top running variant considered here: see specs on the right

The results of the Life Cycle Analysis for one luminaire operated for 70.000 hours (service life L_{80}).

- Corresponds to 14 – 35 years, depending on the application:

Application	annual operation	years to 70.000 h	refurbishment cycle
Office	2500 h	28,0 years	20 years
Education	2000 h	35,0 years	25 years
Retail	5000 h	14,0 years	10 years
Manufacturing	4000 h	17,5 years	25 years

Source: Lighting Europe 2018 - Evaluating performance of LED based luminaires

Benchmark Luminaire	
connected load	53 W
luminous flux	8.300 lm
luminous efficacy	157 lm/W
service life L_{80}	70.000 h

Source: TRILUX

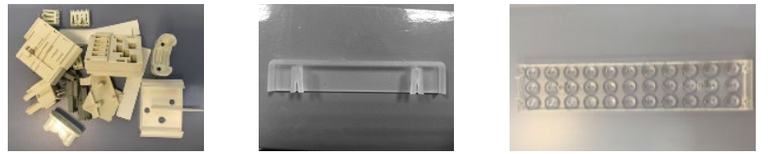
Life Cycle Assessment of a luminaire

The luminaire is decomposed and analysed in detail, using databases (GaBi professional) to quantify the contribution of each material.

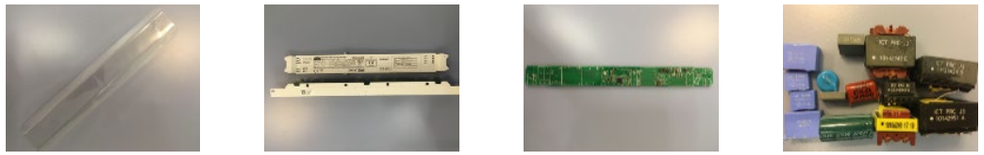
Benchmark Luminaire	
connected load	53 W
luminous flux	8.300 lm
luminous efficacy	157 lm/W
service life L_{80}	70.000 h

metal

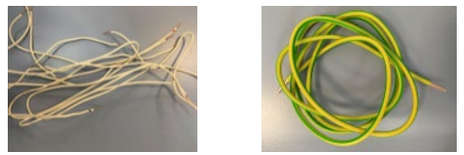
plastics



electronic control gear



wires



LEDM

The life cycle of a luminaire and its environmental impact

① Production

The first stage in the luminaire life is the production. We accounted for the ressources used during

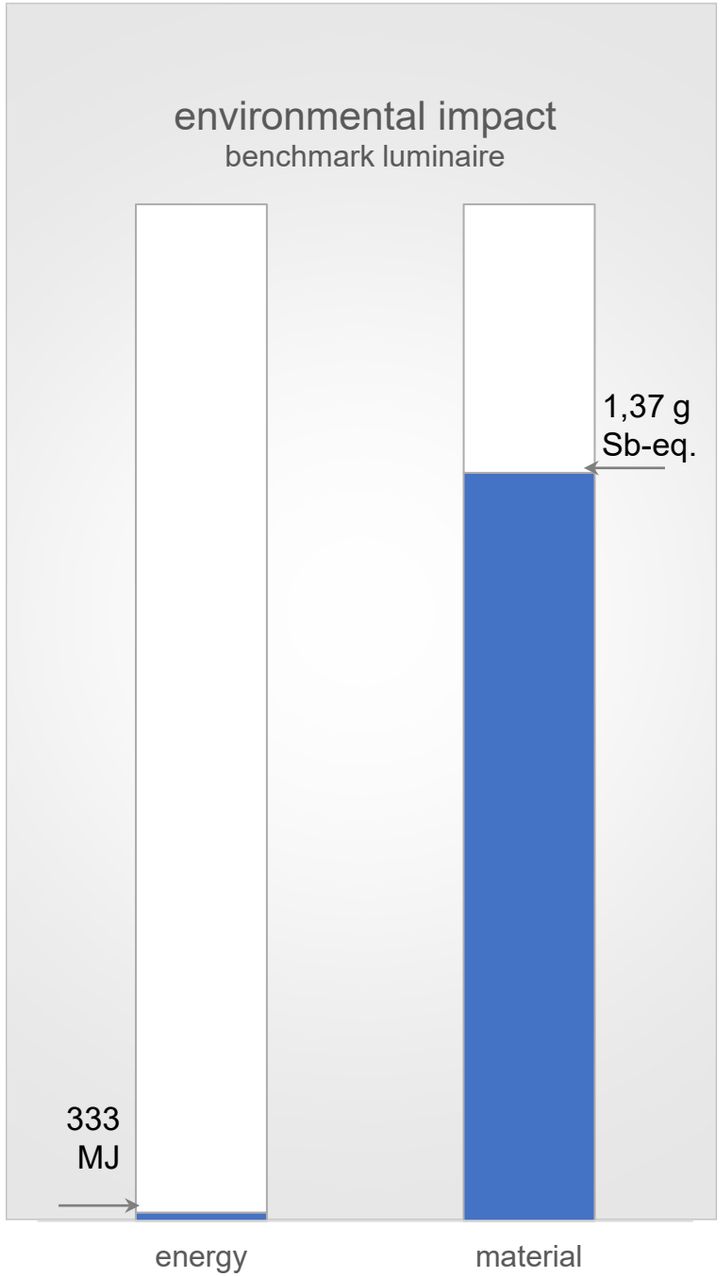
material mining

transport

manufacturing

Obvious opportunities to improve:

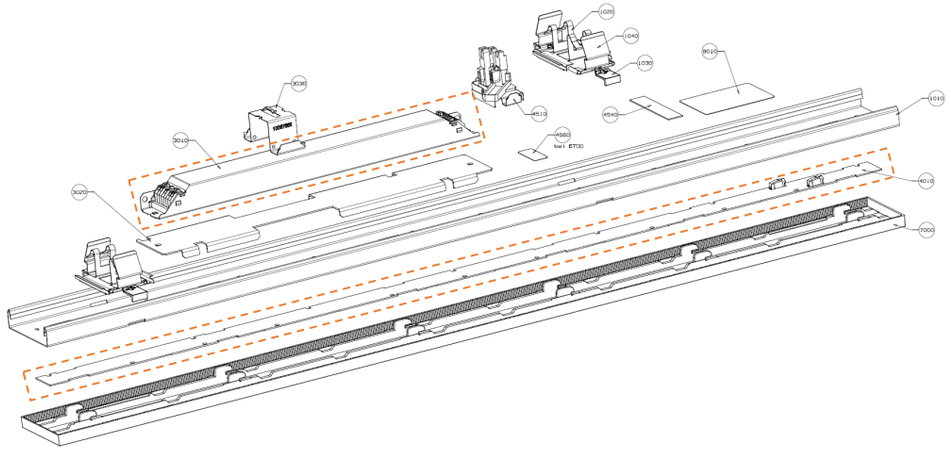
- use as little material as possible; only as much as necessary to provide the required function
- use recycled instead of virgin materials
  - steel & copper already contain recycled fractions
- design long-living systems



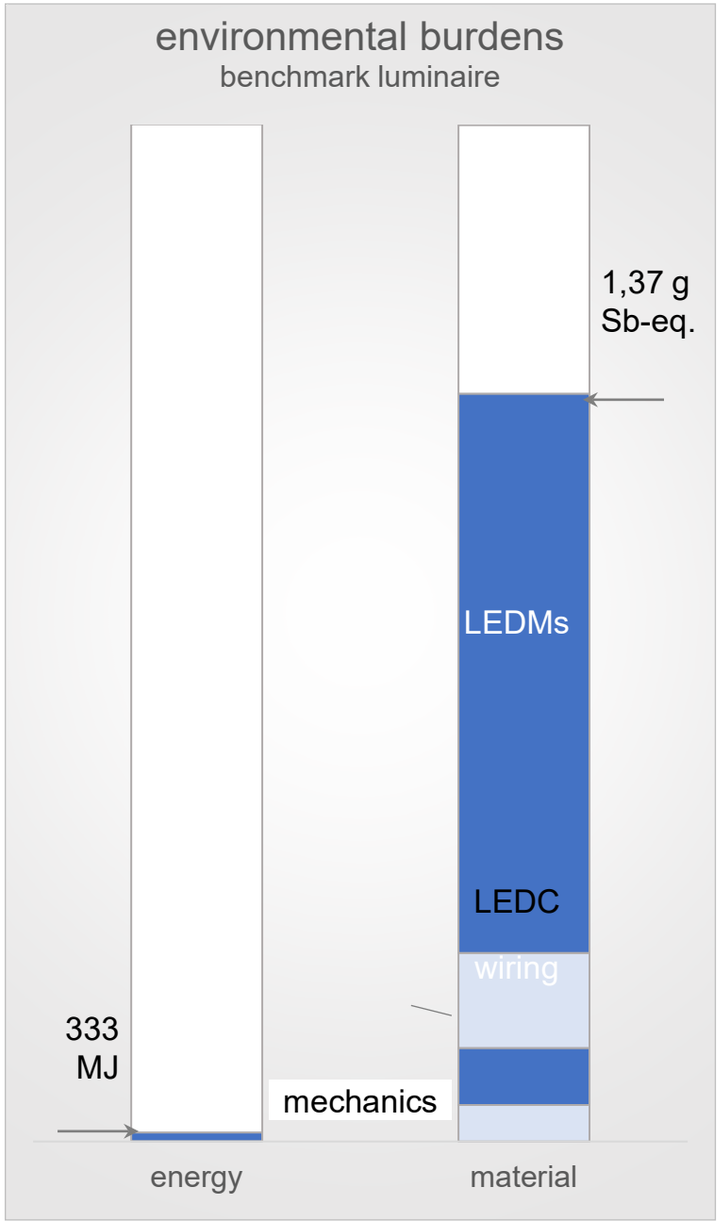
① Production

In reducing materials, we should **focus on the most precious ones** (that are limited on earth) – not just weight or volume!

- Electronics components contain major contribution
- Followed by housing and wiring
- Optics (plastics) are negligible in this respect



Component	ADPe
LED modules	75 %
LED control gear	13 %
wiring	8 %
mechanics	5 %
optics	< 0,1 %



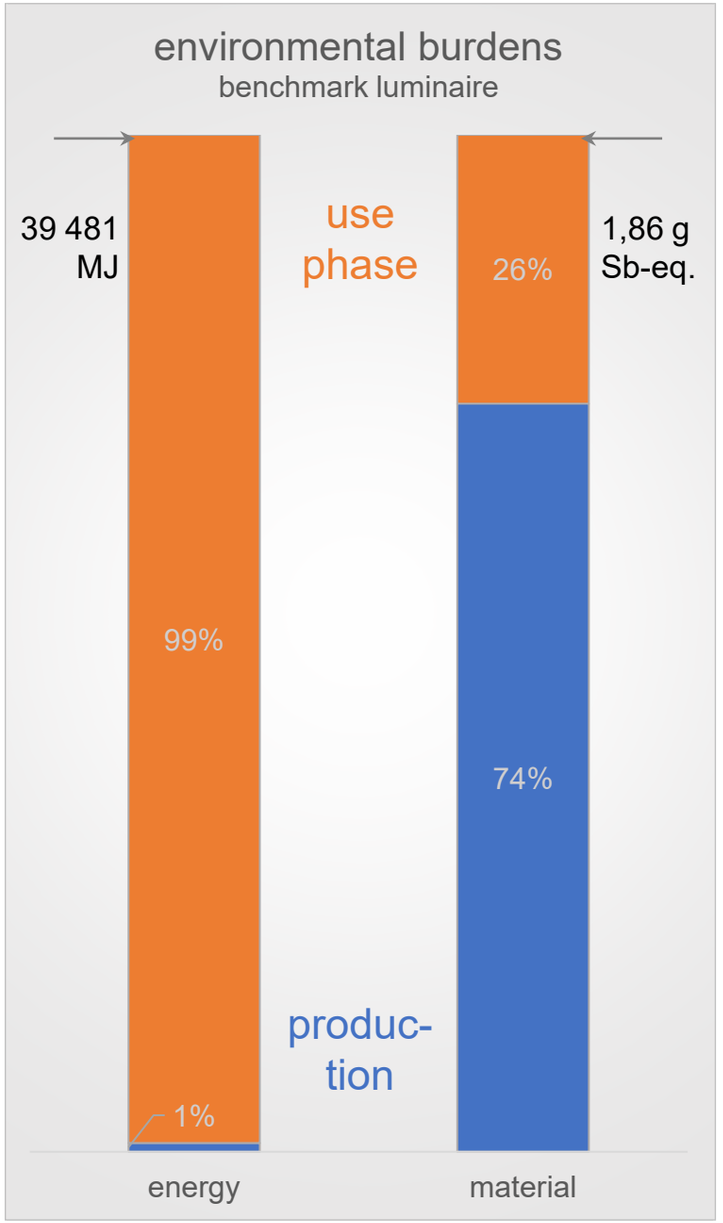
② Installation and Use

In the use phase, the luminaire consumes **energy** – much more than was used during the production.

The **material consumption** to generate the used electricity (building power plants, infrastructure, etc.) is also added to the environemental burdens.

Issues to take into account:

- increase energy efficiency by all means. e.g. by light management
- repairability in case of failure vs. exchange of complete luminaire
- maintenance: yes or no? Unlike earlier times, a maintenance-free luminaire is possible

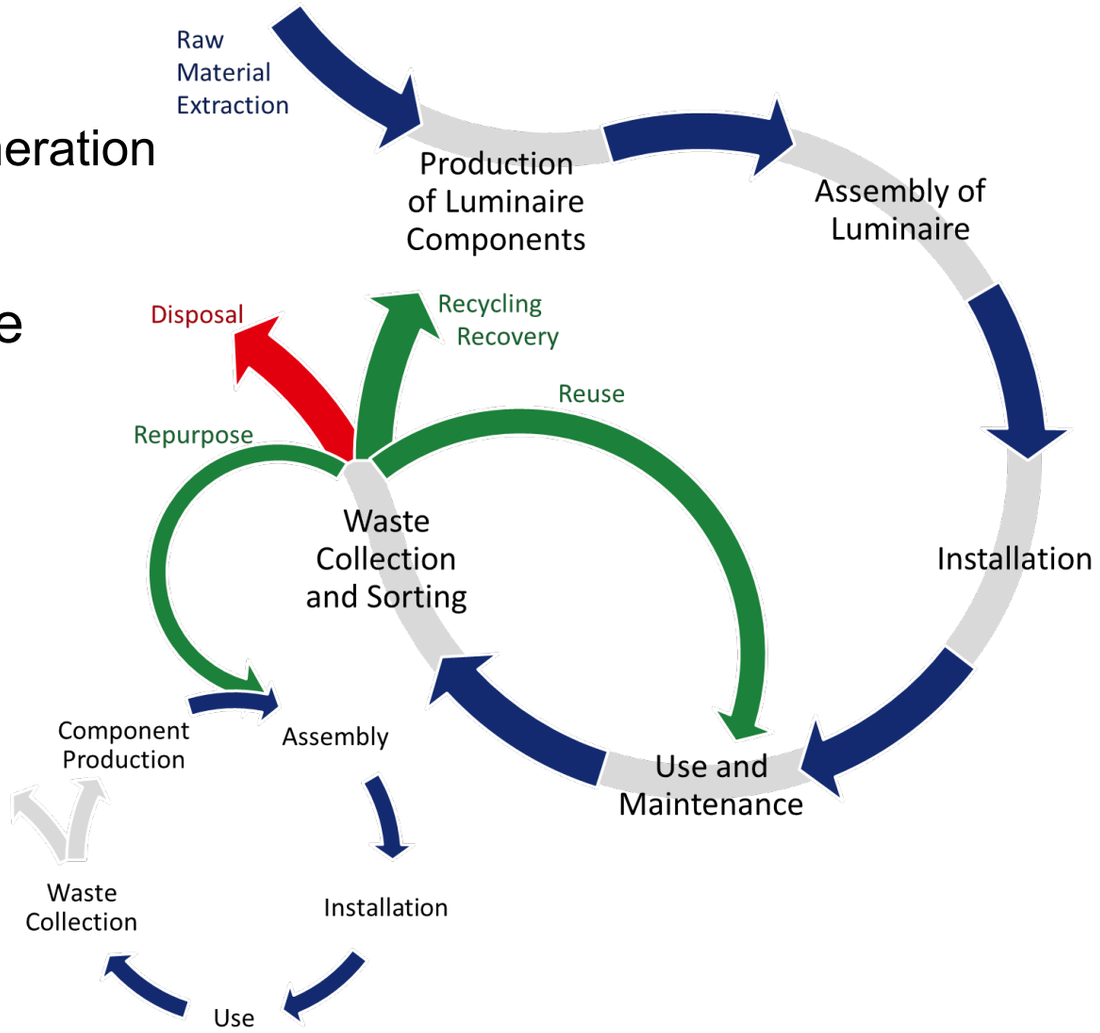


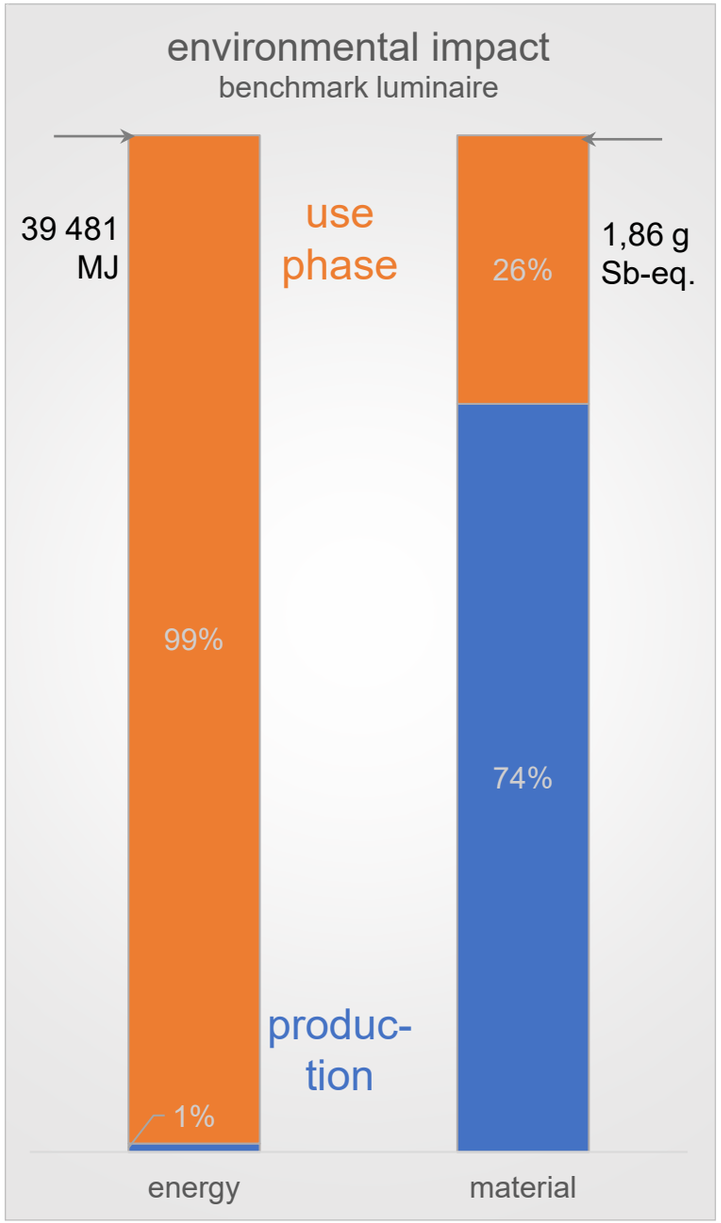
The extra burdens for disposal are too small to be shown in the diagram

- transport energy
- emissions for incineration

Opportunities to be discussed:
How to avoid the dead ends

- landfill
- incineration



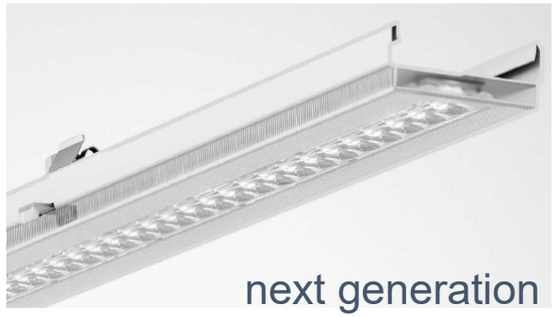


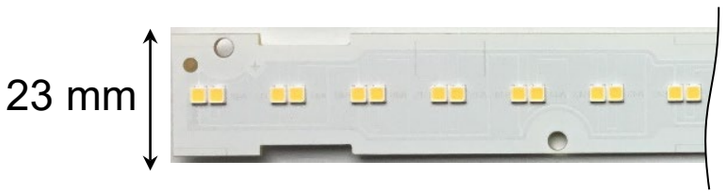
Improvements

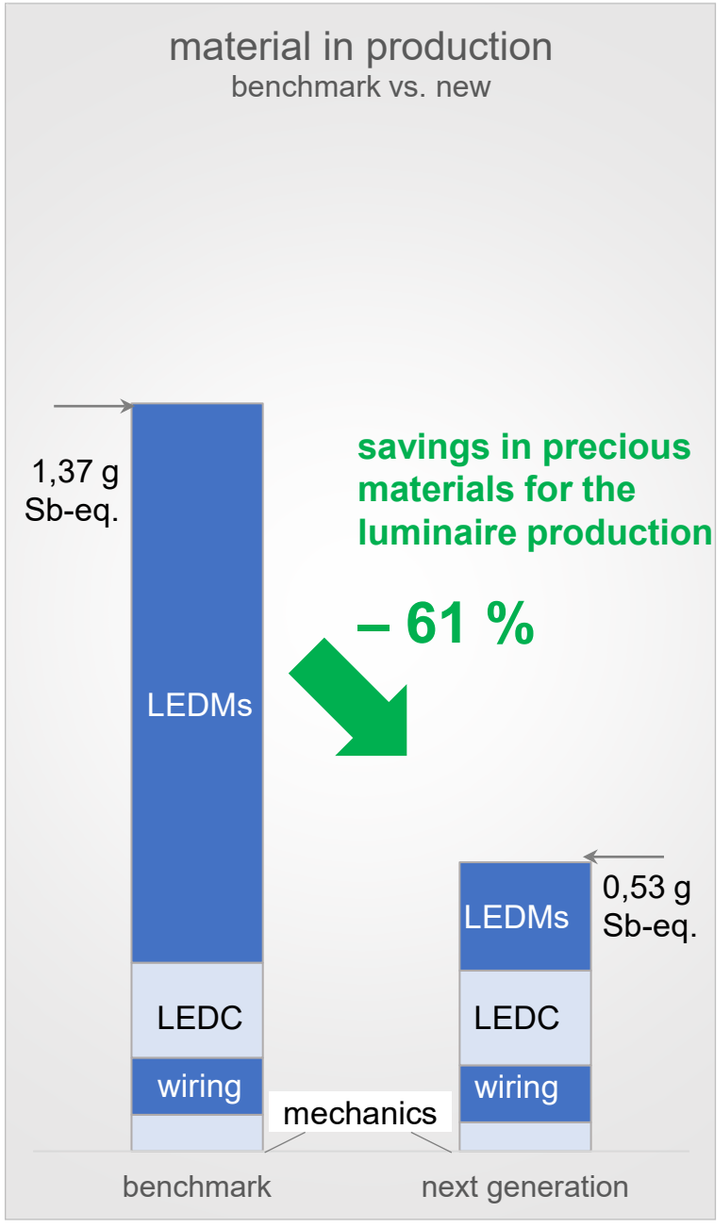
① Production

An improved product design saves material, while keeping the performance high.

- Repro-light achieved **61% reduction of ADPe burdens**
- Main contributions: reduction of LED module width & use of flip-chip LEDs without gold bond wire







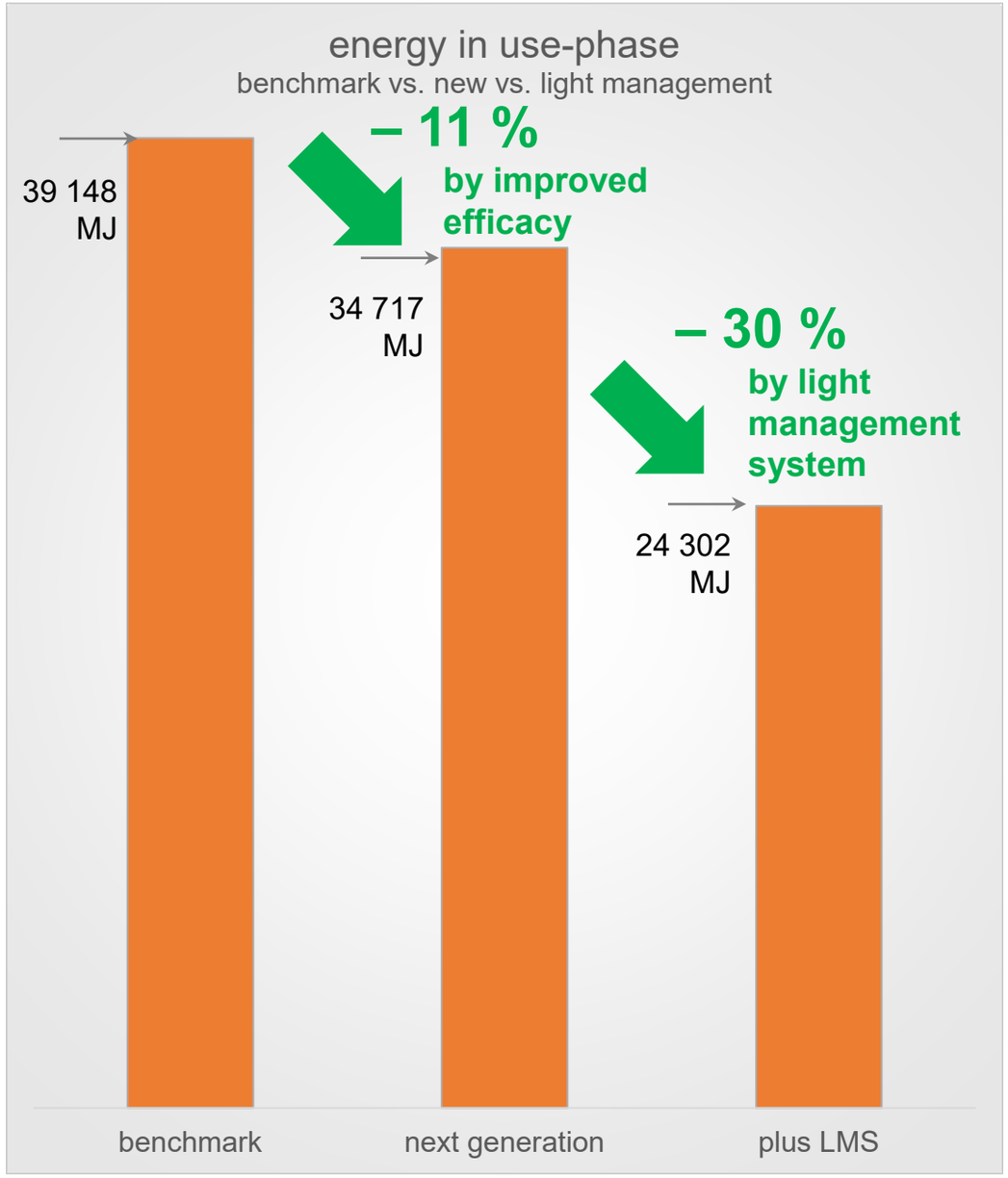
② Installation and Use

We enable considerable energy savings compared to the benchmark LED luminaire

- improved efficacy from 157 lm/W to **179 lm/W**
- light management (daylight & presence control): approx. **30% savings**, with negligible extra materials

Optimal usage time of LEDs (theoretical model)

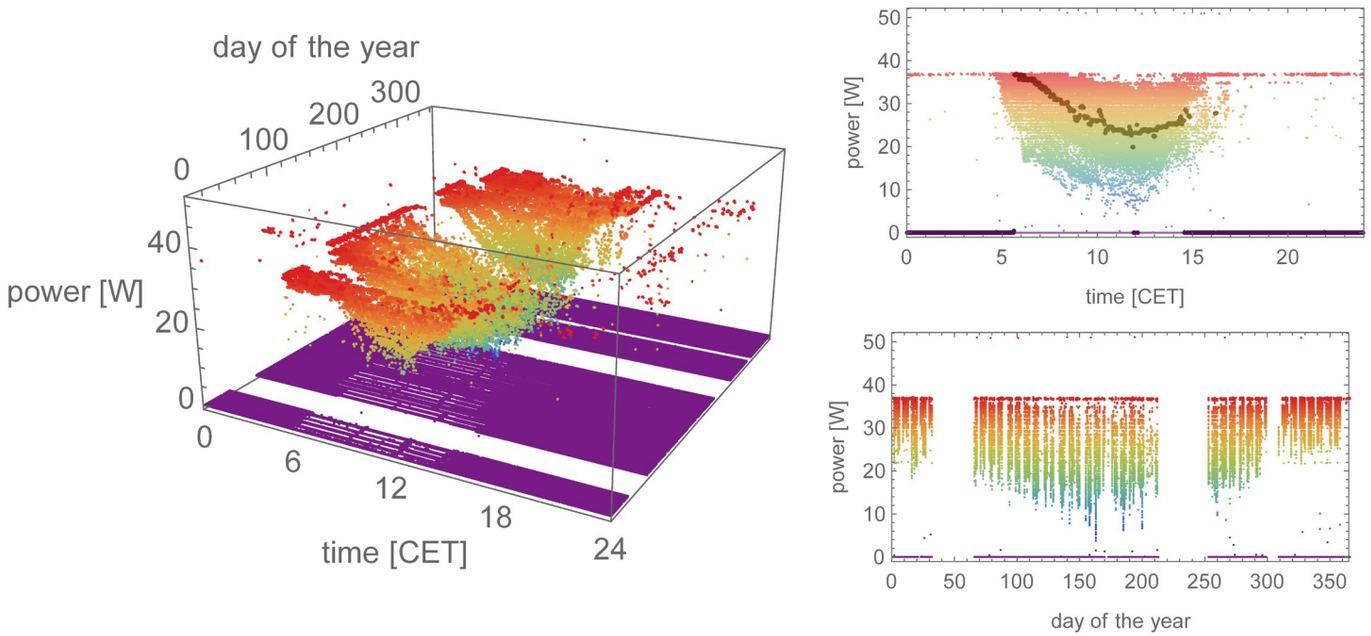
Discussion of exchangeable LEDMs



➲ Detail: Energy savings by light management – case study

We looked at cloud data generated by a **LiveLink** light management system

- installed at the TRILUX apprenticeship workshop
- presence and daylight control
- data: time series of power consumption over 1 year



Source: TRILUX, Sebastian Knoche – Data Analytics in connected lighting systems (LpS Bregenz 2019)

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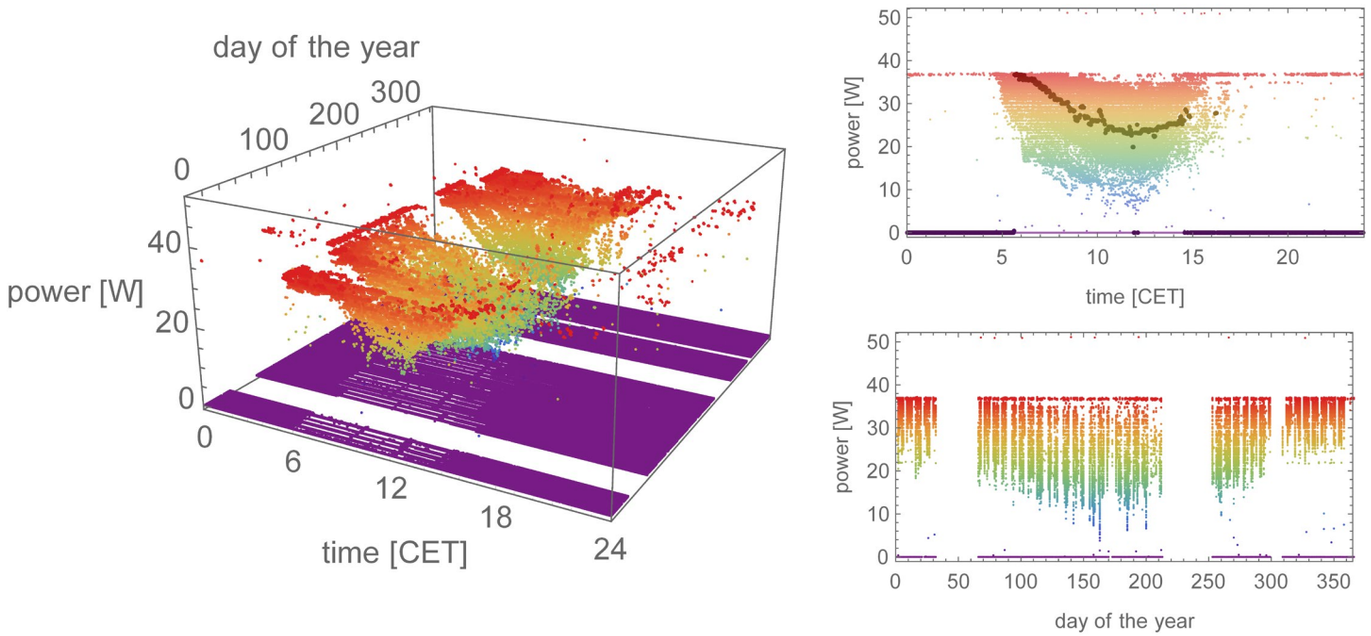

Energy savings made visible:

- **25%** by to daylight control
- **5%** by presence control (higher potential in other applications)

Lifetime elongation:

- model results: **50.000 h ⇒ 87.000 h**
- dimming ⇒ reduced temperature ⇒ reduced LED degradation rate

Source: TRILUX, Sebastian Knoche – Data Analytics in connected lighting systems (LpS Bregenz 2019)

➲ Detail: Theoretical model for optimal LED usage times

Efficiency equals **useful output** divided by **input**

- useful output is the produced luminous energy $Q(t)$ (LED degradation is taken into account)
- inputs are energy and material, both for production (ADP_0, PED_0) and over the usage time t

energy efficiency

$$\eta_{PED}(t) = \frac{Q_\infty \cdot [1 - \exp(-\alpha\, t)]}{PED_0 + m_{PED} \cdot P_{el} \cdot t}$$

material efficiency

$$\eta_{ADP}(t) = \frac{Q_\infty \cdot [1 - \exp(-\alpha\, t)]}{ADP_0 + m_{ADP} \cdot P_{el} \cdot t}$$

production

electric energy

ADPe needed to produce 1 J electricity

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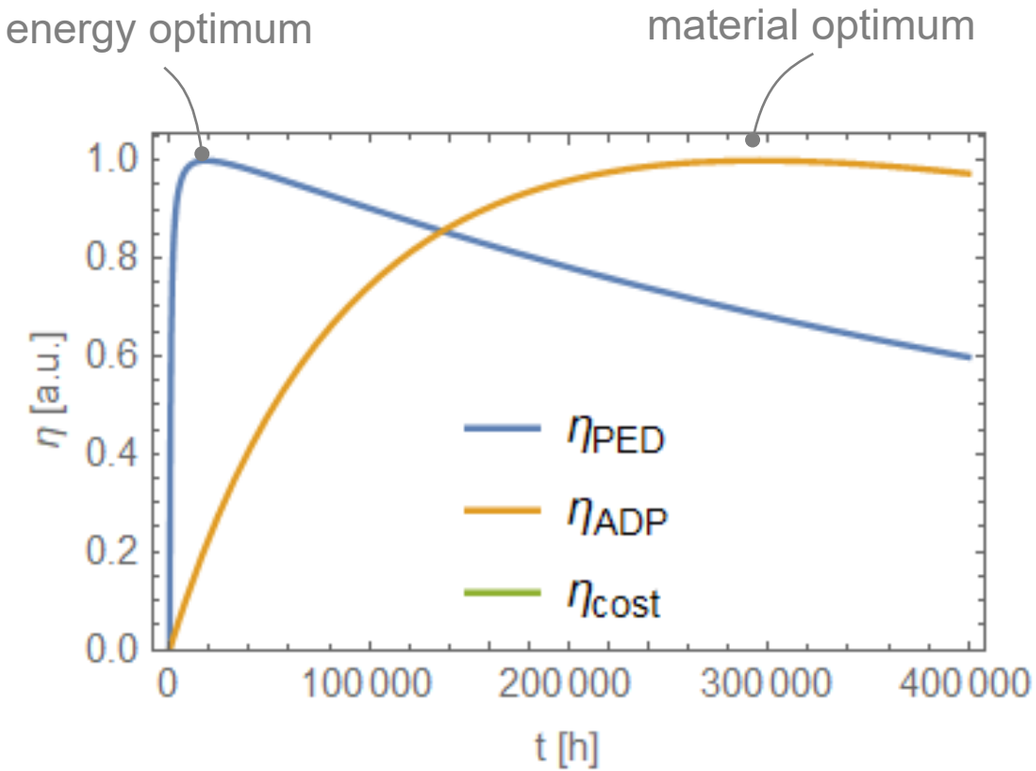
production

electric energy

ADPe needed to produce 1 J electricity

How long should we use a luminaire before replacing it to obtain maximum efficiency?

- for energy: quite short!
- for material: very long! (much longer than L_{80})



➲ Detail: **Exchangeable LED modules for repair**

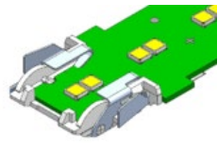
Expected failures before lifetime end:

- 1% of the luminaires (Analysis of after sales data)
- ¾ due to LEDC, less than ¼ due to LEDs

Application scenario

- Industry hall with 369 luminaire ⇒ 4 assumed to fail

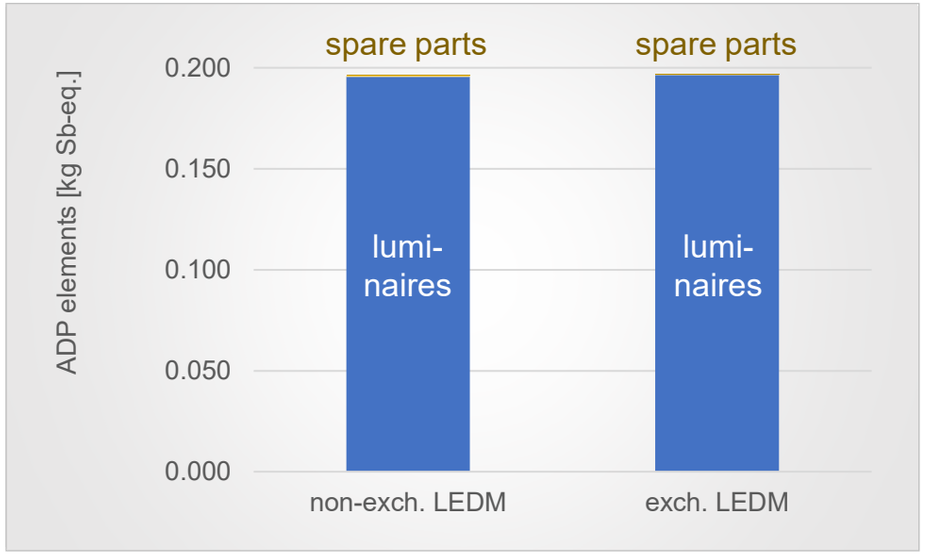
non-exchangeable LEDM	exchangeable LEDM
3 LEDC replacements	3 LEDC replacements
1 luminaire replacement	1 LEDM replacement
	additional connectors

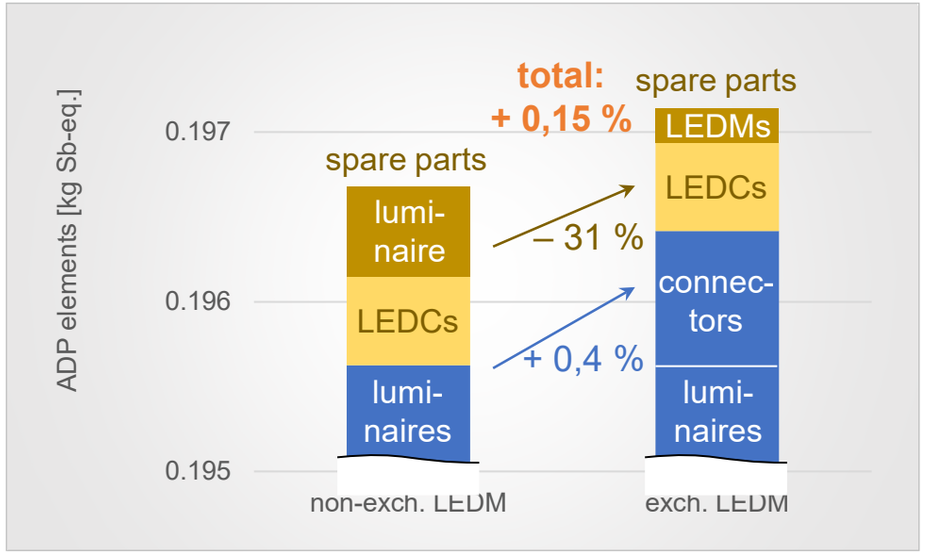


Result:

- This is a discussion of very tiny contributions!
  In this scenario, we even get a **negative** effect!

*Source: Davis et al 2017 – System Reliability Model for SSL Luminaires





➲ Detail: **Exchangeable LED modules for maintenance**

Maintenance:
Scheduled replacement of degraded LEDMs to restore the luminaire's energy efficiency.

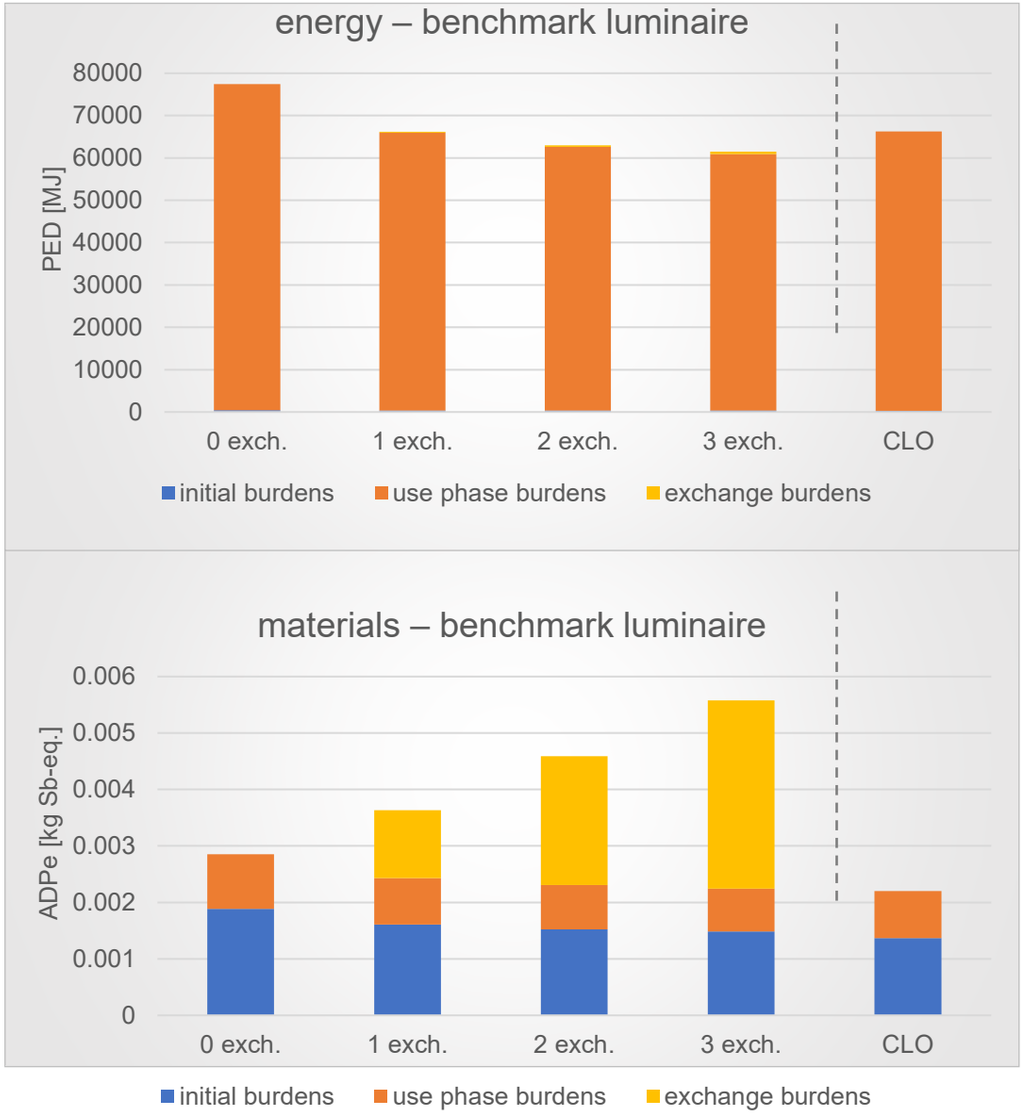
- LEDs degrade over time: Their flux & efficiency decrease
- A maintenance factor is included in light planning, ensuring sufficient illuminance at the end of lifetime

Apparent solution to both points:
Regular replacement of LEDMs

- **Drawback:** generates more LEDM-waste than necessary
- Scenario calculation over 100.000 h (LED lifetime L_{70})
- *could* become a valid case when LEDMs need less ADPe

Alternative approach:
Constant light output (CLO)

- No additional material for LEDM replacements
- Avoids maintenance factor and over-illumination



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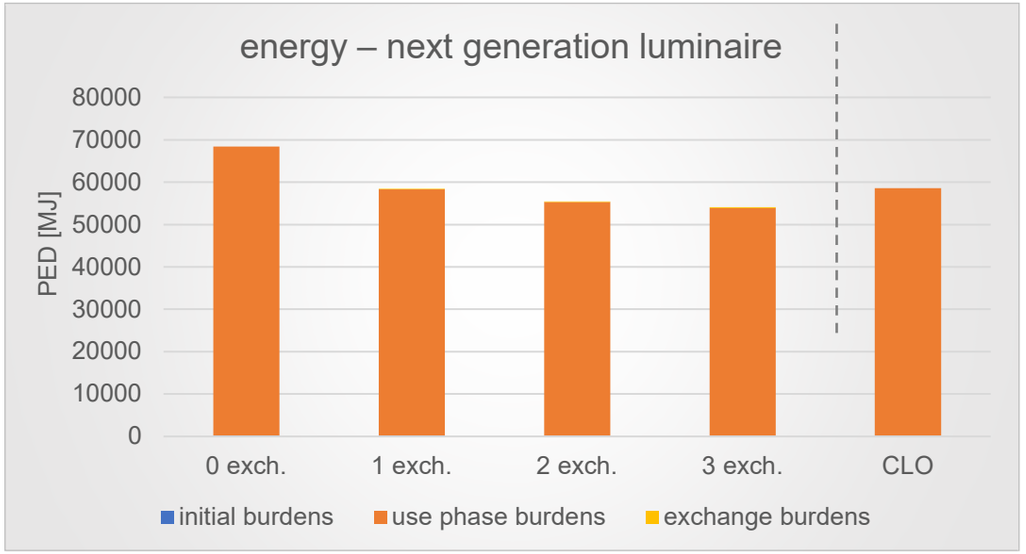
- A maintenance factor is included in light planning, ensuring sufficient illuminance at the end of lifetime

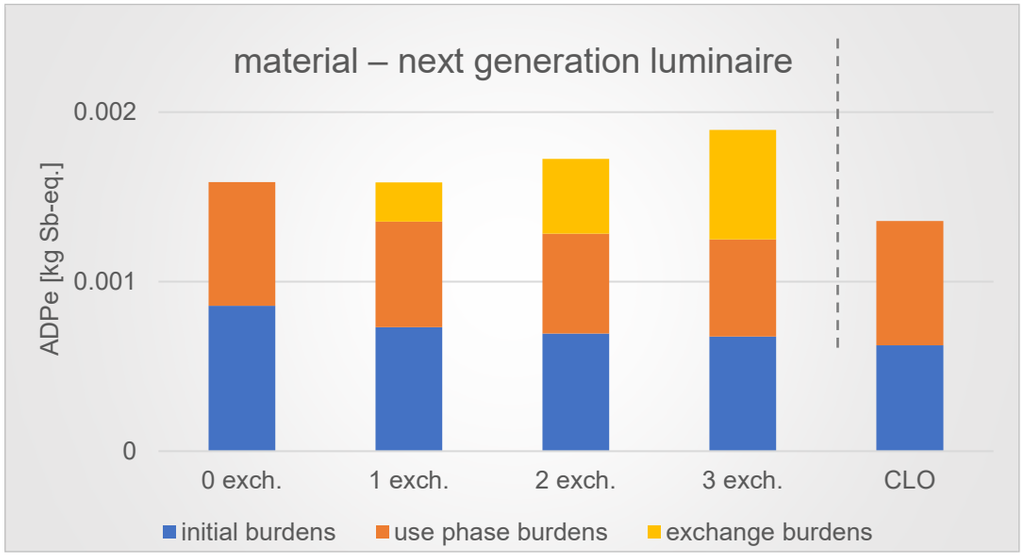
Apparent solution to both points:
Regular replacement of LEDMs

- **Drawback:** generates more LEDM-waste than necessary
- Scenario calculation over 100.000 h (LED lifetime L_{70})
- *could* become a valid case when LEDMs need less ADPe

Alternative approach:
Constant light output (CLO)

- No additional material for LEDM replacements
- Avoids maintenance factor and over-illumination

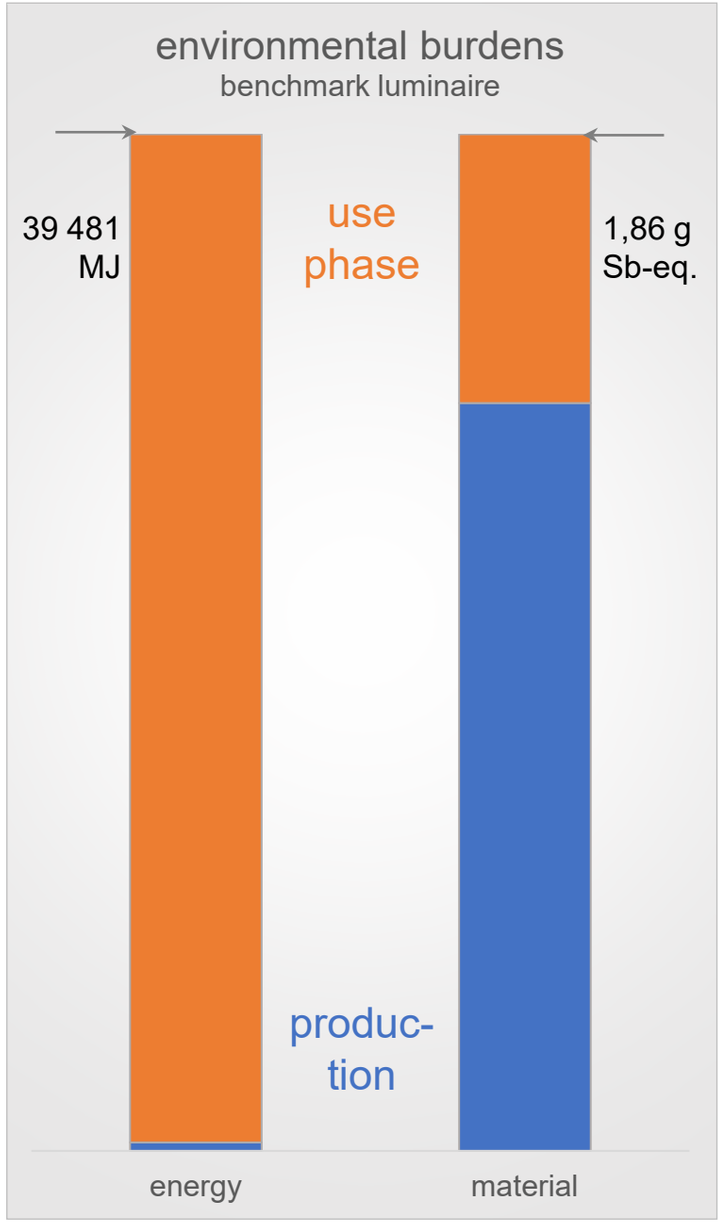


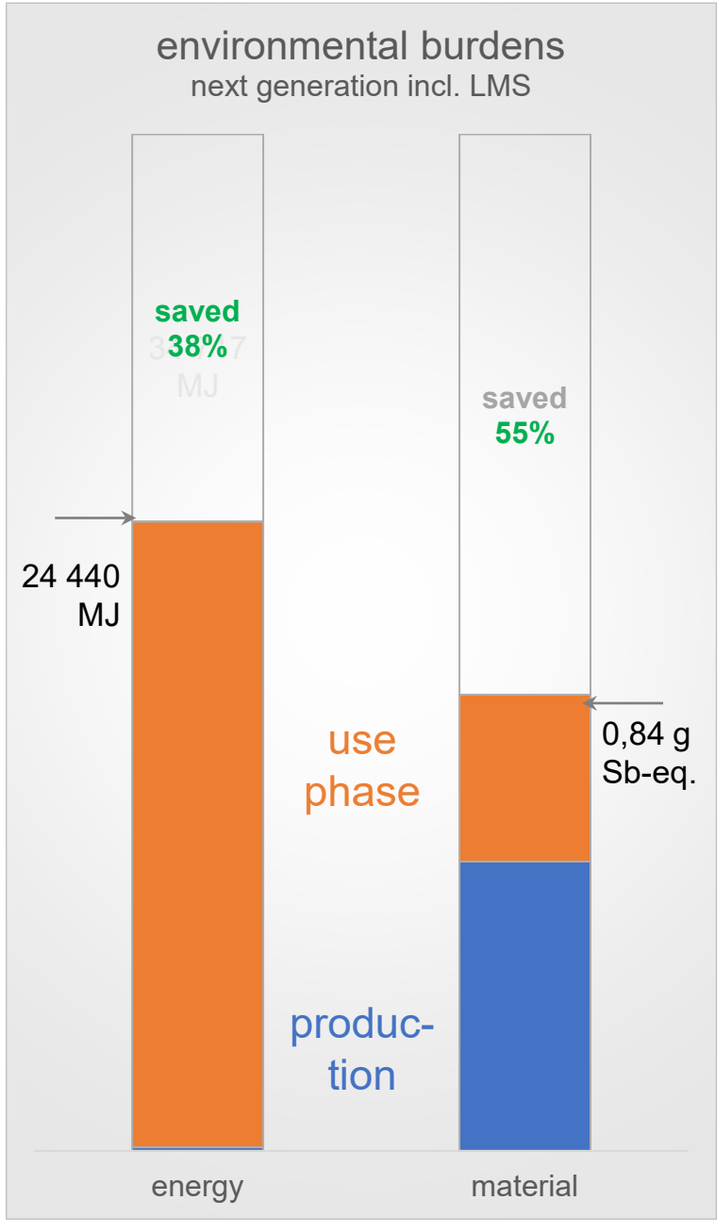


Total Savings

Successful steps towards sustainability:

- improved product design: reduce (precious) materials, use LEDs without gold
- efficiency upgrade
- light management system for additional energy savings
- alternatively: constant light output technology (CLO)
- We tried other steps, but they were not proven successful in this case.



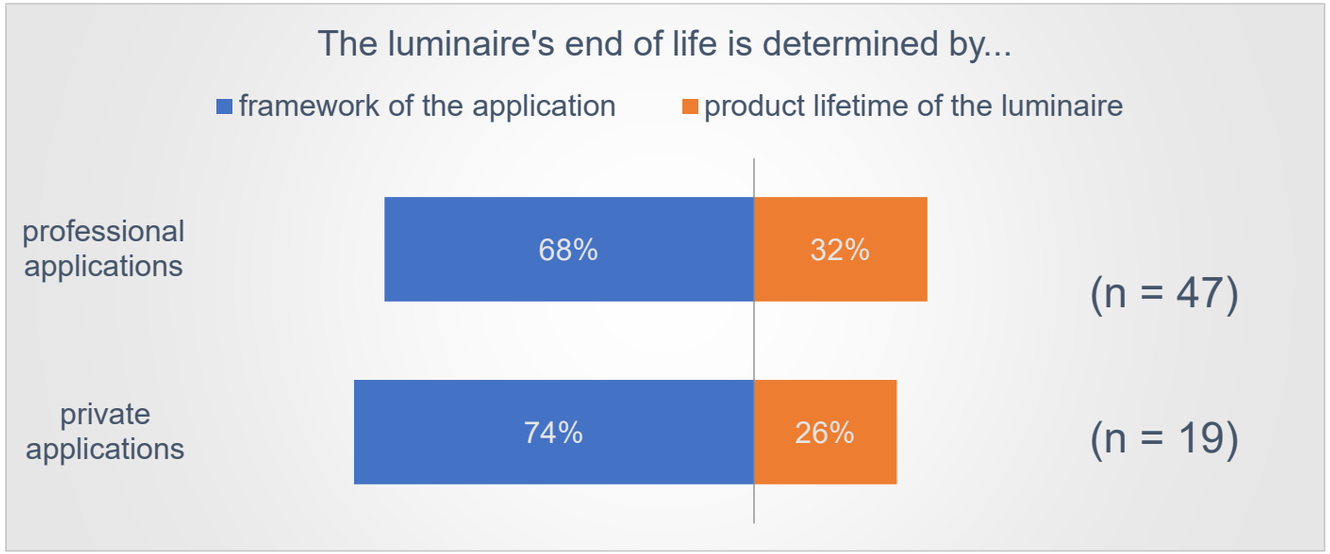


③ End of Life and Disposal

Essential question that is answered too fast in too many cases:

Why are luminaires disposed?

- Lighting Europe's list of annual operating hours and refurbishment cycles indicate:
  Lifetime is not always a problem
- Repro-light survey among lighting professionals confirms this

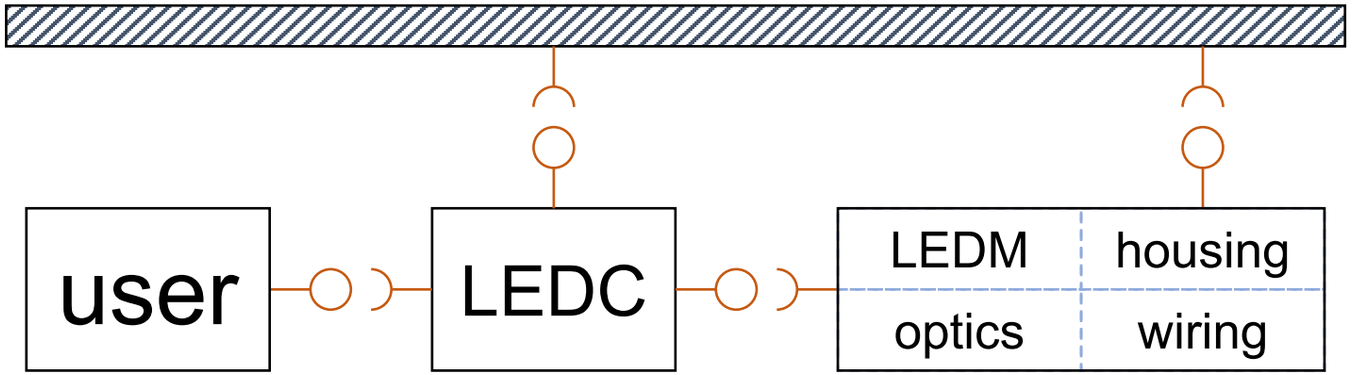


When the technical lifetime is not the critical point, we have to ask:

How can we make our customers want to use our products (or parts of them) longer than they do today?

Future luminaire design proposal

Future Luminaire Design – Proposal

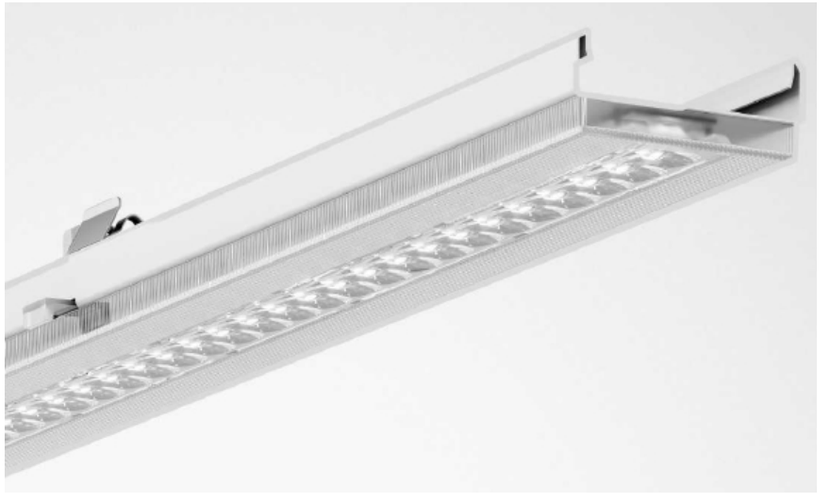


Leads to **commodity products**

- Standard design (face of the luminaire) to ensure long availability of matching products
- Long-term-availability, built in a modular fashion

internal modularity; keeping external compatibility; interface design

The downlight: **The** continuous line: **The** panel luminaire.



Electromechanical compatibility, but „face of the luminaire“ different

Lessons learnt

Detailed Life Cycle Analysis

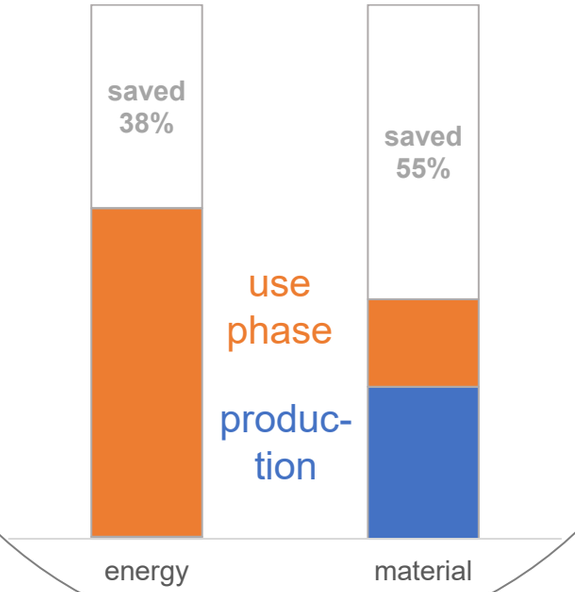
of a continuous line luminaire

Questions to think about

What is the real reason luminaires are disposed?

Will all this lead to commodity products?

Realised improvements



Exchangeable LED modules

for repair: no proven benefit

for maintenance: energy savings do no justify the waste generation

Saving energy

by software

Constant Light Output (CLO)

Light Management (daylight and presence control)

THANK YOU FOR YOUR ATTENTION

HELEN LOOMES

BUSINESS DEVELOPMENT DIRECTOR
h.loomes@trilux.co.uk