



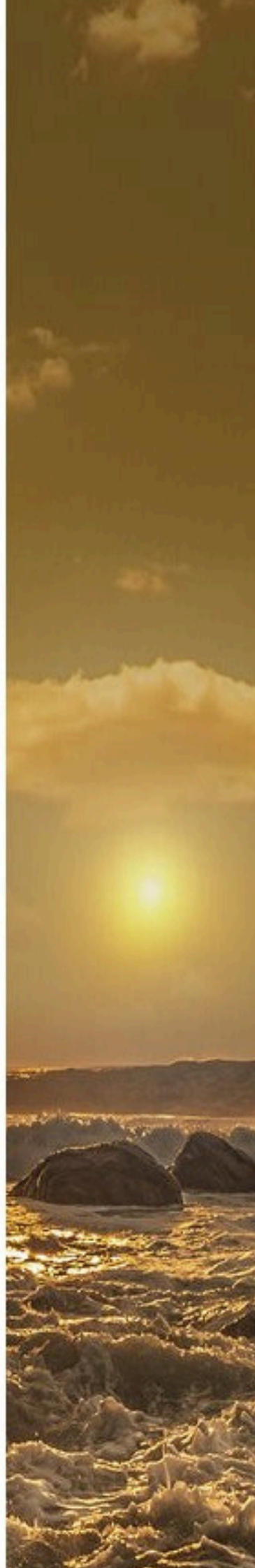
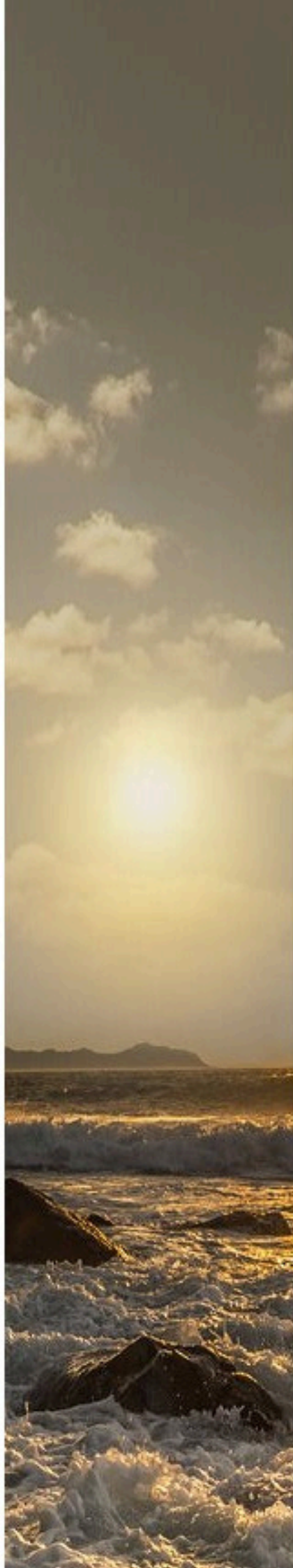
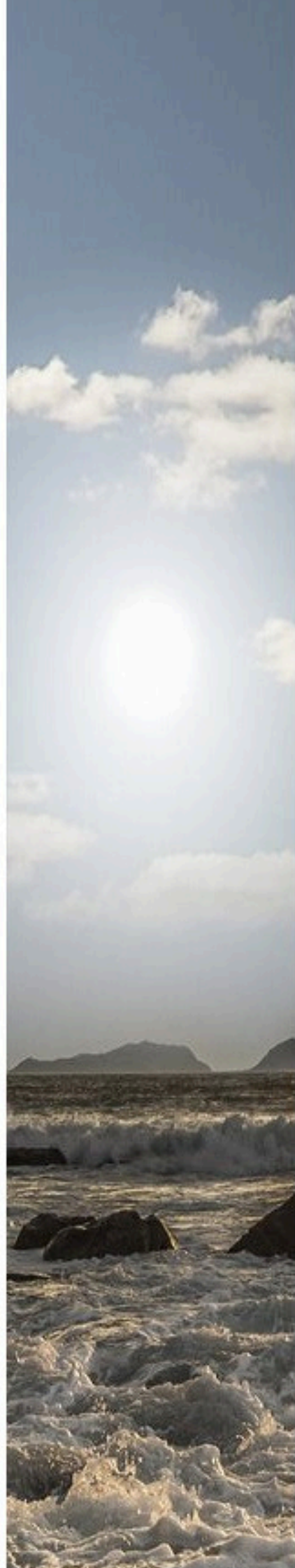
EN



HUMAN CENTRIC LIGHTING

onework GmbH
2026

Human Centric Lighting
in Schools & Educational Institutions



Human Centric Lighting

Human Centric Lighting (HCL) is an innovative lighting concept that specifically takes into account the biological, emotional, and cognitive needs of learners and teachers.

In a school context, this means that lighting is dynamically adapted to the daily routine and specific teaching activities. The scientific basis for this concept is the discovery of intrinsically photosensitive retinal ganglion cells (ipRGCs), which are particularly sensitive to short-wave blue light due to their melanopsin pigment.

The problem in a school context is considerable: many students spend around 70% of their school time in classrooms, often under suboptimal lighting conditions, which leads to attention deficits, fatigue, and reduced learning success. This is particularly problematic for young people, as their circadian rhythm is already biologically delayed and early school start times pose an additional challenge.





Key benefits for students

Significantly improved reading skills and academic performance	Page 06 - 07
Dramatically improved concentration and attention	Page 08 - 09
Reduction of ADHD symptoms and hyperactivity	Page 10 - 11
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Reduction of depression and seasonal affective disorder (SAD)	Page 14 - 15
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Significantly improved reading skills and academic performance

This is one of the best-documented effects of HCL in a school context. Heschong Mahone Group – flagship study (1999):



- Capistrano Unified School District (California): Students with the most daylight in their classrooms showed
 - 20% faster progress on math tests
 - 26% faster progress on reading tests
 - Compared to students with the least daylight (99% statistical significance)
- Window effect: Students in classrooms with the largest window areas made
 - 15% faster progress in mathematics
 - 23% faster progress in reading
 - Compared to students with the smallest windows
- Skylight effect: Students in classrooms with well-designed skylights improved
 - 19-20% faster than students without skylights.
- Ventilated windows: Even seemingly minor factors had an effect:
 - Students with access to windows that could be opened made 7-8% faster progress.
 - This was true regardless of whether air conditioning was available.
- Seattle and Fort Collins: Final test results confirmed the findings:
 - Students with the most daylight: 7-18% higher test scores than those with the least

Philips SchoolVision studies (dynamic classroom lighting):

Several schools with dynamic lighting systems (four settings: Normal, Focus, Energy, Calm) showed:

- Epsom and Ewell High School (UK): Concentration tests (D2 tests) using SchoolVision:
 - Year 7 Group 1: +17 points average percentile improvement
 - Year 7 Group 2: +40 points average percentile improvement
 - Control group: no improvement
- Hamburg Primary School (Germany, 1-year study):
 - 35% increase in reading speed
 - 45% reduction in error rate
 - 75% reduction in restlessness
- Amsterdam (Netherlands):
 - 18% higher concentration test scores
 - Increased motivation and better assessment of the learning environment

Dramatically improved concentration and attention

Van der Zande et al. - Dynamic lighting meta-analysis:

A systematic analysis of quasi-experimental field studies and randomized laboratory experiments showed:

- Focus setting (1000 lux, 6500K): Positive effects on concentration in elementary school students.
- Error rates decreased measurably under this lighting.
- These effects were consistent across different seasons (winter/spring).

Hamburg study (Schulle-Markwort et al., 2010):

With dynamic lighting systems in German schools:

- Increased alertness and concentration, especially in the early morning hours.
- Students were able to work with concentration for longer periods of time.

Mechanism - Blue-enriched light stimulates ipRGC cells and leads to:

- Reduced melatonin release (reduces fatigue)
- Increased cortisol and serotonin production (promotes alertness)
- Improved executive function in the prefrontal cortex

Study results (University of Mississippi, 2014):

Students in stimulating light (focus setting) performed better on cognitively demanding tasks (attention tests), while text comprehension and motivation were less affected.



Reduction of ADHD symptoms and hyperactivity

Seasonal ADHD variation (Hospital Sant Joan de Déu, Barcelona, 2024):
A groundbreaking study showed that ambient light directly influences ADHD symptoms:

- Summer months (intense light exposure, longer days): Children with ADHD show
 - significantly fewer attention deficit symptoms ($p < 0.05$)
 - This is the season with the highest light intensity and longest daylight hours during the year.
- Winter months: Significant worsening of ADHD symptoms in the same children
 - Correlated with shorter days and reduced light intensity

Interpretation: The study proves that ambient light is a significant modulator of ADHD symptoms – regardless of medication.

Practical implication:

HCL systems with increased light intensities and blue light components in the morning can contribute to symptom reduction as a non-pharmacological intervention.

Hamburg study (Schulle-Markwort & Barkmann, 2010):

With dynamic lighting in schools:

- 75% reduction in restlessness
- Improved behavior control
- This indicates a direct reduction in hyperactivity symptoms.



Improved sleep quality and sleep rhythm

The problem with adolescent sleep patterns:

Adolescents have a biologically delayed melatonin release rhythm, which leads to them falling asleep later. Early school start times (before 8:30 a.m.) cause sleep deprivation, which affects health.

HCL solution – classroom lighting in the morning:

Blue light in the morning during school hours can advance the circadian phase:

- Reduces melatonin in the morning (promotes alertness)
- Strengthens the circadian rhythm
- Enables better sleep at night

Melatonin study (Eckerberg et al., 2012):

A randomized, double-blind, placebo-controlled study involving 21 adolescents (aged 14–19) with difficulty falling asleep:

- Afternoon melatonin (1 mg, 4:30–6:00 p.m.) for 6 days per week over 5 weeks
- Sleep onset: 68 minutes earlier after melatonin weeks vs. placebo weeks ($p < 0.005$)
- Sleep duration: 62 minutes longer with melatonin ($p < 0.05$)
- Daytime sleepiness: Significantly reduced during melatonin weeks ($p < 0.05$)
- These results demonstrate the powerful effect of rhythm optimization.

Blue light and sleep quality (Choi & Suk, 2019):

A study compared morning exposure to 3500K (warm) vs. 6500K (blue-enriched):

- Melatonin decline: Significantly greater under blue light ($p < 0.05$)
- Subjective alertness: Significantly improved under blue light ($p < 0.05$)
- This morning exposure leads to better nighttime melatonin production.





Reduction of depression and seasonal affective disorder (SAD)

Light and serotonin:

Natural and blue light stimulate the production of serotonin, the “happiness hormone.” Lack of light exposure during the winter months reduces serotonin while melatonin increases, leading to depression.

Light therapy for SAD symptoms (Magnusson et al., 1998):

Although this study showed only mild effects on school attendance, light therapy improved concentration and morning alertness in some students:

- Students with SAD symptoms showed improvements in concentration ability.
- Improvements in waking up in the morning (albeit mild).

Sunlight exposure and mental health (Wang et al., 2023):

A systematic analysis of studies on sunlight exposure showed:

- People with longer exposure to sunlight report fewer depressive symptoms.
- People in areas with longer daylight hours have lower rates of depression and suicidal thoughts.
- The mechanism: increased vitamin D production and serotonin regulation

Practical application in schools:

Schools with predominantly artificial lighting or in northern regions with winter darkness can reduce SAD symptoms in students in the morning by using HCL systems with increased blue light.



Improved well-being and mood

Choi & Suk (2019) - Subjective mood parameters:

Below 6500K (blue-enriched) vs. 3500K (warm) light:

- Mood: Significantly improved under blue light ($p < 0.05$)
- Visual comfort: Increased compared to warm light

Gender-specific effects:

A study (Mott et al., 2012) showed that mood and performance react differently depending on gender:

- Women: Better mood under warm light (3000K)
- Men: Better cognitive performance under cool light (5500K)

This suggests that optimal HCL systems should allow for flexible, situation-specific adjustments.

Emotional well-being (University of Hamburg, 2010):

With dynamic lighting systems in classrooms:

- Students report feeling better and more comfortable
- Mental stress reduced
- Emotional stability improved



Improved social behavior and reduced aggression

Hamburg Study (Schulle-Markwort & Wessolowski, 2010):

With dynamic lighting systems in classrooms:

- 75% reduction in restlessness (already mentioned, but also behavioral effect)
- During “calm” setting (warm, dimmed light for group work):
 - Children were 20% faster at solving joint tasks
 - Children spoke 95% more in the relaxed lighting setting than in standard lighting

Interpretation:

Warm, diffused light promotes collaboration, while intense blue light improves concentration-both are valuable for different stages of learning.

Behavioral rules:

Several schools reported:

- Reduced disciplinary problems
- Fewer aggressive conflicts between students
- Improved social interactions

These effects are partly attributed to better sleep quality and stabilized hormone rhythms.

Increased attention and reduced distractibility

Blue light and cognitive function (Alkozei et al., 2016):

A neurobiological study with students:

- 30 minutes of blue light in the morning led to:
 - Faster reaction times in cognitive working memory tests ($p < 0.05$)
 - Increased functional brain activity in the prefrontal cortex
 - These effects persisted throughout the subsequent test phase
- This is the first study to show that a single brief exposure to blue light causes measurable, lasting changes in brain activation





Less absenteeism and better school attendance

Daylighting in Green Schools (Arastirmax, 2018):

A systematic review of schools with optimized daylighting showed:

- Students in schools with abundant daylight: Significantly higher attendance rates
- Comparison with standard schools: Significantly lower absenteeism

Full-Spectrum Lighting Study (Canada, 2-year study):

Children in elementary schools with full-spectrum lighting vs. conventional lighting:

- Fewer days of absence per year ($p < 0.05$)
- Improved student health

Interpretation:

Better lighting conditions lead to greater well-being and thus to reduced absenteeism.





Improved reading skills and language development

Mündliche Leseflüssigkeit (ORF) – Mott et al. (2012):

A study using dynamic classroom lighting (focus setting at 6000K, 100 foot candles) on third graders:

- Experimental group (with focus lighting): Baseline ORF started lower (M=94) than the control group (M=103)
- However, mid-semester showed stronger growth: experimental group +34 points on average vs. control group +18 points
- At the end of the semester, the experimental group was superior ($p < 0.001$)
- **ORF measures reading fluency and is a key factor in reading comprehension

English study (500 lux + increased indirect light):

With 500 lux workplace lighting and an increase in indirect light from 100 to 300 lux:

- Learning outcomes improved in:
 - Mathematics
 - Reading
 - Writing
- In the morning: Students were more attentive and active (especially in winter).





Key benefits for teachers

Improved work performance and cognitive abilities

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Improved health and reduced burnout symptoms

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Better adaptation to early school start times

Page 32 - 33

Improved mood and emotional well-being

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Improved work performance and cognitive abilities

Activating light and teacher focus:

Similar to students, teachers benefit from:

- Morning blue light: Increased alertness and attention during lesson planning and teaching
- Better concentration on administrative tasks
- Reduced error rates when assessing student work





Improved health and reduced burnout symptoms

Teacher well-being and light:

Although there is little specific literature on HCL and teachers, studies on general teacher stress show that:

- 76% of teachers report sleep problems and physical exhaustion.
- 62% report psychological stress and anxiety disorders.
- 68% report impairments to their social well-being.

Role of the working environment:

A systematic review of teacher health showed that the physical working environment is a significant factor in well-being. A positive school climate reduces stress and the risk of burnout.

HCL effect:

Optimal lighting supports:

- Better sleep-wake rhythms despite early school start times
- Improved mood and emotional stability
- Less susceptibility to stress



Better adaptation to early school start times

School start times and adolescent sleep deprivation:

A Rochester study (2022) showed:

- ~90% of high school students do not get enough sleep (less than the recommended 8-10 hours)
- Early school start times (before 8:30 a.m.) lead to mental health problems:
 - Increased depression and anxiety disorders
 - Early school starts result in 1 hour of additional sleep loss (due to circadian delay), not just the nominal time difference

HCL as a solution:

Schools with HCL systems can:

- Create strong blue light conditions in the morning (at least 250-500 lux with a high blue component)
- This helps students wake up despite biological delay
- Teachers also benefit from the same stimulating lighting

Improved mood and emotional well-being

Warm white, dimmed lighting during school breaks and quiet activities leads to:

- More relaxed teachers
- Better teacher-student relationships
- Fewer conflicts in the classroom









Additional benefits: Special student populations

Students with special needs

Students with ADHD:

The Barcelona Study (2024) showed that increased light intensity directly reduces ADHD symptoms. HCL systems could be a non-pharmacological support measure.

Autism and sensory sensitivity:

Although there are no specific HCL studies available, many students with autism benefit from:

- Consistent, predictable lighting conditions
- Reduced sensory overload through dynamic adjustments
- Better structure through clear light-associated activity phases



Additional benefits

Costs and energy efficiency

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Implementation standards and best practices

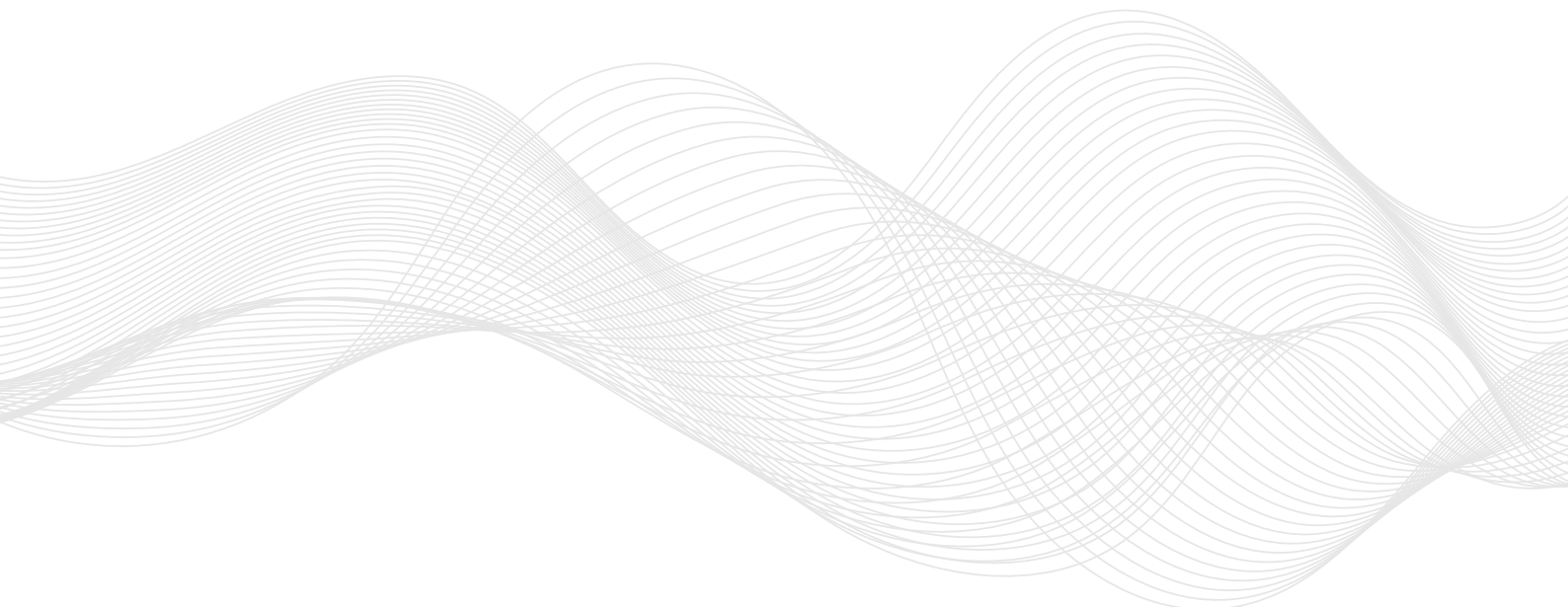
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Summary

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Final recommendation

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Costs and energy efficiency

Financial benefits

LED lighting with light management:

- Energy savings: Up to 85-88% with LED + smart control
- Sample calculation for a school:
 - Old installation: 1,598 kWh per year; \$489 in costs
 - New LED + LM: 188 kWh per year; \$57 in costs
 - Annual savings: 1,410 kWh; €432
 - CO2 reduction: 0.85 tons per year
- Payback period: 1-3 years for medium-sized school buildings
- Additional savings: Reduced maintenance costs due to long LED service life (15+ years)
- BAFA and BEG subsidy programs often reduce the payback period by a further 1–2 years

Indirect financial benefits through improved performance:

- Improved grades → higher school graduation rates
- Reduction in funding requirements
- Fewer disciplinary measures





Implementation standards and best practices

DIN SPEC 67600 and CIE S 026 guidelines

During the day (morning/mid-morning):

- Vertical illuminance at the eye: At least 250-500 lux
- Light color: At least 5,000-6,500 Kelvin (cool, blue-enriched light)
- Melanopic EDI: At least 250-500 (better standard than CCT alone)

Mid-morning (around noon):

- Optimal learning phase: 500-1000 lux at 6000-6500K
- Focus setting for exams/concentrated work

Afternoon:

- Gradual reduction: 300-500 lux, 4000-5000K
- Energy setting to overcome afternoon fatigue (often after lunch)

For group work and creative activities:

- Warm, dimmed light: 300 lux, 3000-3500K
- Calm setting to support collaboration

Summary

benefit	effect size
Reading performance (ORF)	+20-35% improvement
Progress in mathematics	+15-20% faster
concentration	+17-40% percentile improvement
ADHD symptoms	Seasonally significant
sleep quality	+62-68 minutes of sleep
Attention (in the morning)	+8-35% improvement
error rates	-45% reduction
Restlessness/hyperactivity	-75% reduction
school attendance	Significantly increased
energy efficiency	-85-88% energy costs





Final recommendations

HCL in schools and educational institutions should:

Be prioritized in critical learning spaces:

- Classrooms (especially mathematics and language teaching)
- Examination rooms
- Classrooms with low daylight incidence

Be implemented flexibly:

- Different lighting settings for different activities (concentration, group work, creativity)
- Be adapted to school hours (stimulating in the morning, supportive in the afternoon)

Be combined with teacher training:

- Understanding of optimal lighting settings for different teaching scenarios
- Sensory and automatic control reduces manual effort

Be particularly valuable for schools in northern latitudes:

- Winter lighting conditions can be compensated for by HCL
- SAD symptoms in students and teachers can be reduced

Can be planned with moderate investment costs and rapid amortization:

- LED + light management amortizes in 1-3 years
- Significant long-term cost savings through energy efficiency

To be evaluated regularly:

- Measurement of student performance before and after HCL installation
- Feedback from students and teachers on subjective improvement
- Adjustment of lighting conditions based on results

Successful projects
start with the
right decision





We stand for educational buildings that go beyond pure functionality. Our aim is to create learning environments in which technology is seamlessly integrated: efficiently controlled in the background, effectively experienced in everyday life. We achieve this through intelligent building automation, resource-saving system solutions, and room concepts that consistently focus on the health, comfort, and performance of students.



Solutions for your project



onework CORE

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onework LUX

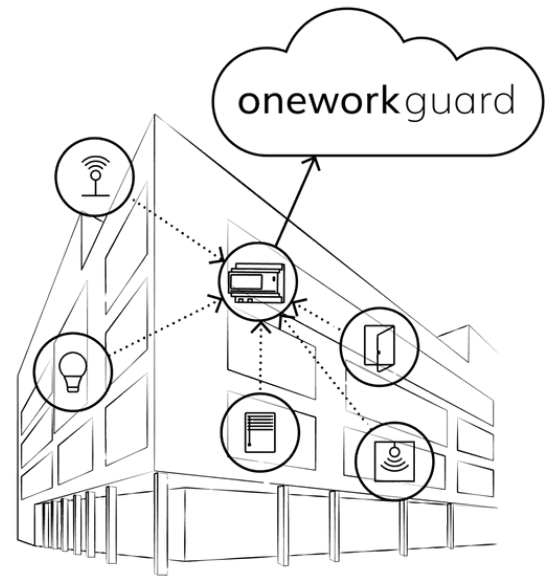
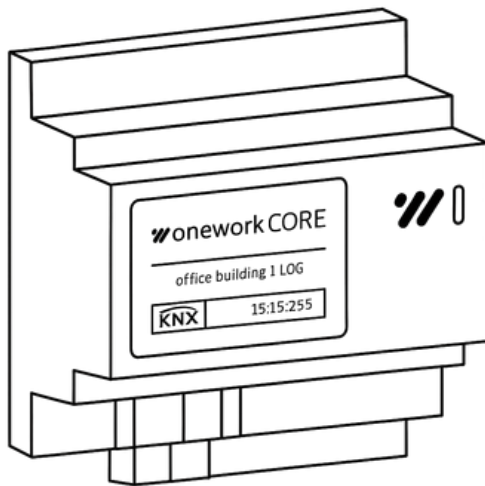
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onework TOUCH

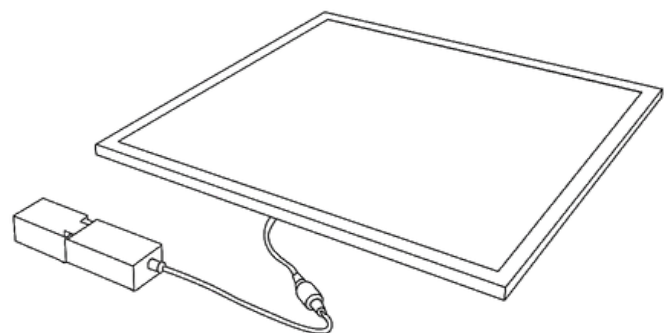
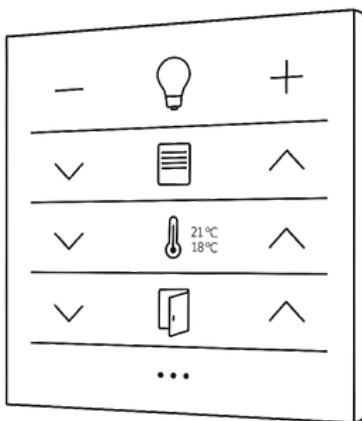
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onework GUARD

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Our
products
are your
foundation



onework CORE

The onework CORE automates lighting, climate control, air quality, and glare protection - for efficiency, comfort, and a healthy indoor climate.



With its cross-functional room automation, onework CORE improves the quality of stay and energy efficiency of commercial real estate. onework CORE is a certified KNX device. It integrates all devices and components available in the room into the automation of lighting, temperature, air quality, and glare protection. Communication with peripheral devices takes place exclusively via the KNX bus. Overriding the room automation systems, e.g., using our onework TOUCH, is possible at any time.

Maximum control, minimum effort

We believe in spaces that are more than just functional - that inspire, motivate, and invite people to linger. Our vision is to create places where technology works in the background but is noticeable in everyday life: through intelligent control, sustainable systems, and an atmosphere that focuses on people's well-being.

Certified KNX device. It integrates all devices and components available in the room into the automation systems for lighting, temperature, air quality, and glare protection.

Control of up to 30 rooms



Light

Intelligent lighting control that automatically adjusts brightness and color temperature to daylight, presence, and usage.

- Human Centric Lighting (HCL) for more productive working environments
- Tunable White for dynamic adjustment from cool to warm white
- Scene control for meetings, presentations, and workspaces



Temperature

Automatically optimizes heating and cooling systems. Saves energy through smart use of solar heat and occupancy data.

- Energy harvesting: Use of solar energy for passive heating
- Automatic adjustment to room occupancy and outside temperature
- Integration of blinds for effective summer heat protection



Air quality

Monitors CO₂, VOC, and humidity in real time. Automatically optimizes air quality—for better health and productivity.

- CO₂ & VOC monitoring for a healthy indoor climate
- Automatic window control for optimized fresh air supply
- Ventilation recommendations for manual air quality optimization



Glare protection

Automatically controls blinds and shutters based on sun position, weather, and room usage. Reduces glare and saves energy.

- Calculation of dynamic limit values based on theoretical brightness
- Stable positioning with fewer unnecessary movements
- Consideration of shading, reflections, and dynamic light behavior

onework LUX

With human-centric lighting, precise optics, and state-of-the-art LED technology, onework LUX creates light quality of the highest standard.

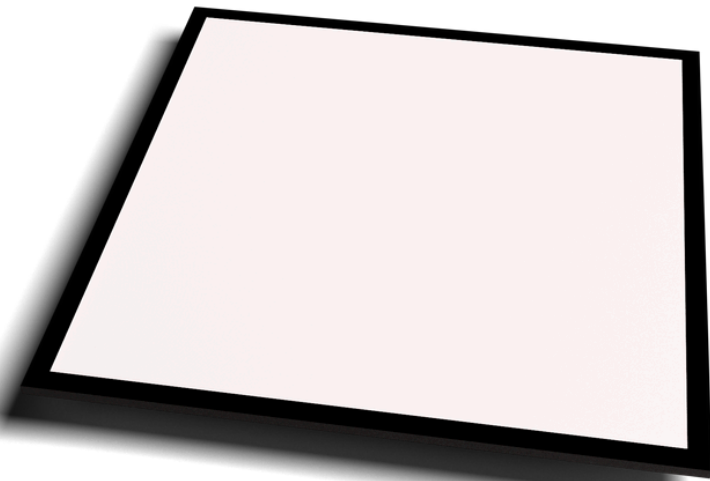


Stands for innovative lighting solutions that showcase both people and spaces. With state-of-the-art LED technology, clear design language, and maximum efficiency, our luminaires offer the highest level of lighting quality. Thanks to glare-free light distribution and precise optics, Onework LUX luminaires create uniform, pleasant illumination - perfectly tailored to the requirements of modern working and living environments.



Human Centric Lighting

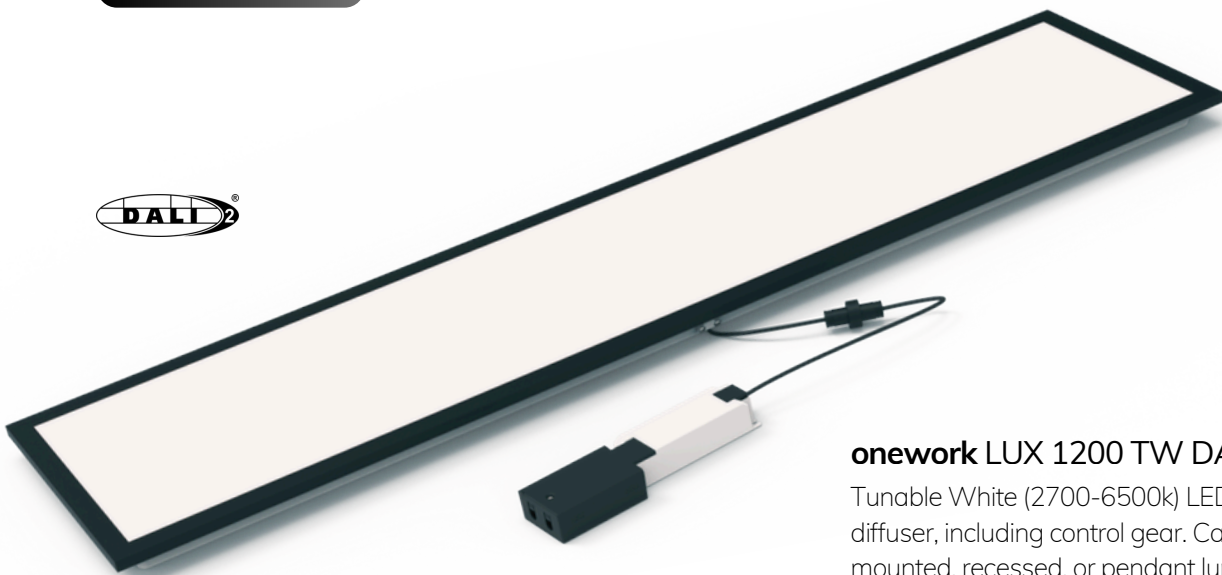
Light that can do more



onework LUX 600/625 TW DALI

Tunable White (2700-6500k) LED panel with prismatic diffuser, including control gear. Can be used as a surface-mounted, recessed, or pendant luminaire for system dimensions of 600mm x 600mm or 625mm x 625mm.

Available in
black and white



onework LUX 1200 TW DALI

Tunable White (2700-6500k) LED panel with prismatic diffuser, including control gear. Can be used as a surface-mounted, recessed, or pendant luminaire for the system dimensions 1200mm x 300mm.

Available in
black and white

DALI - dimmable

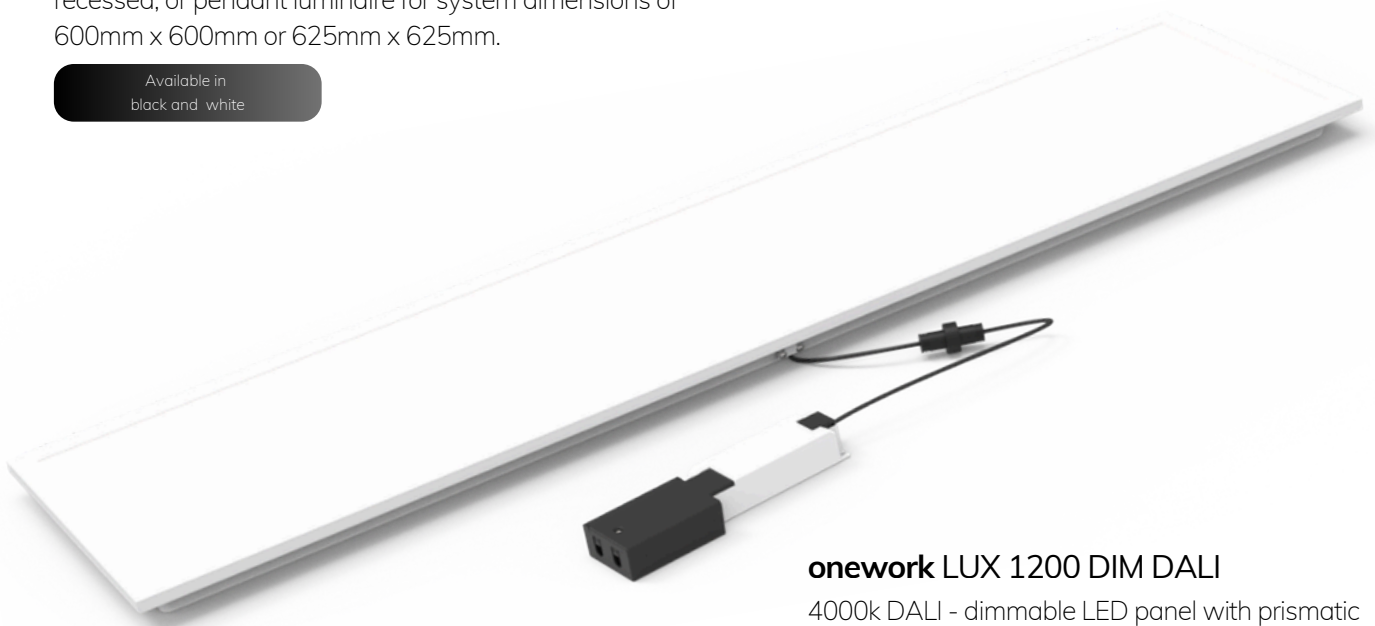
More control, more comfort



onework LUX 600/625 DIM DALI

4000k DALI - dimmable LED panel with prismatic diffuser, including control gear. Can be used as a surface-mounted, recessed, or pendant luminaire for system dimensions of 600mm x 600mm or 625mm x 625mm.

Available in
black and white



onework LUX 1200 DIM DALI

4000k DALI - dimmable LED panel with prismatic diffuser, including control gear. Can be used as a surface-mounted, recessed, or pendant luminaire for the system dimensions 1200mm x 300mm.

Available in
black and white



onework LUX TL TW DALI

Tunable White (2700-6500k) LED spotlight, incl. control gear. Can be used in track lighting systems.
Beam angle: 15°, 24°, 60°

Available in
black and white



Tunable White Tracklights

Dynamic lighting, precision on the track



onework LUX TL P TW DALI

Tunable White (2700-6500k) LED projection spotlight, incl. control gear. Can be used in track lighting systems. Beam angle: 45°

Available in
black and white





Linear light Clarity that makes an impact



onework LUX LL 1200 TW DALI

Tunable White (2700-6500k) pendant light, incl. control gear. For optimal lighting conditions, system dimensions: 1200mm x 70mm x 70mm.

Available in
black and white

Downlights

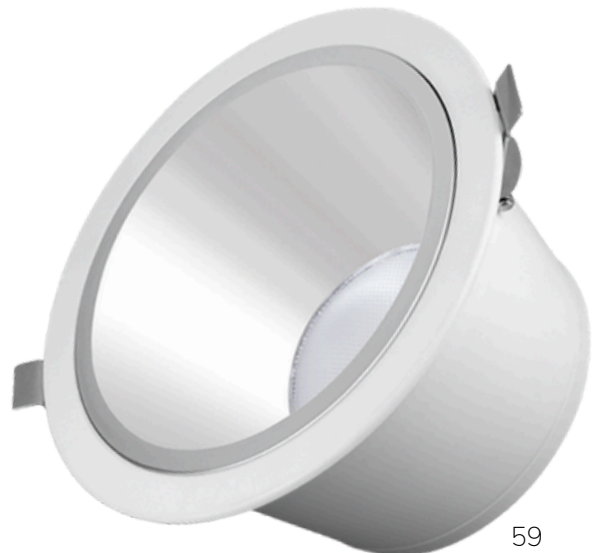
Discreetly powerful, visibly effective



onework LUX DL 180 TW DALI

Tunable White (2700-6500k) downlight with prismatic diffuser, including control gear. Can be used as a recessed luminaire for the system dimensions 180mm x 92mm.

Available in
black and white



onework TOUCH

The intuitive 4-inch onework TOUCH control panel combines lighting, climate, shading, and scene control in one elegant interface.



The onework TOUCH is a 4-inch touch display for intuitive and efficient building control. Developed for seamless integration into KNX systems, it combines modern design with the familiar operation of a classic push button. Thanks to its customizable user interface, the onework TOUCH enables precise control of lighting, shading, climate, and scenes - all with a single touch.

Everything under control With just one touch

onework TOUCH

onework TOUCH is a modern touch control panel that brings together all room control functions on a single, intuitive user interface. Whether lighting, temperature, air quality, shading, or individual scenes - all relevant functions can be intelligently controlled with just a few touches.



Full KNX compatibility

Manufacturer-independent and flexible for use in any KNX environment.



Intuitive operation

Button-based interface for maximum user-friendliness - no adjustment necessary.



Versatile control

Lighting, blinds/shutters, windows, temperature, and scenes with just one tap.



Advanced features

Automatic/manual detection, window instructions, and intelligent automation with onework CORE.

onework GUARD

The cloud-based fault reporting management system onework GUARD detects errors in real time, analyzes causes, and provides proactive recommendations for action.



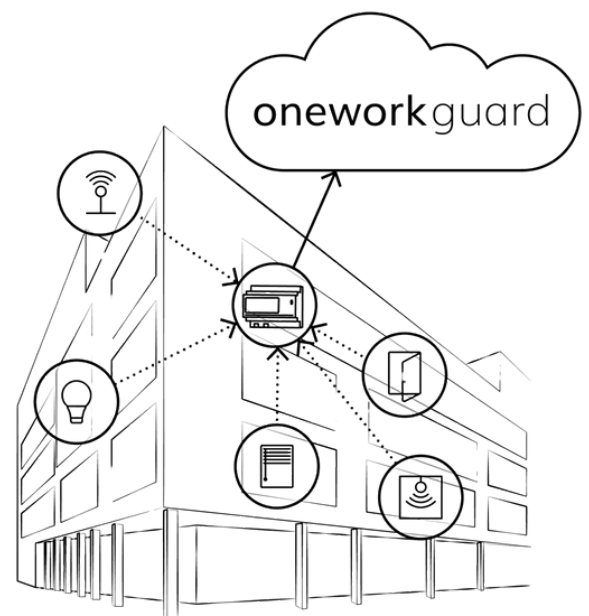
The development of onework GUARD is funded as an innovation project called guard building management system (guard BMS) as part of the Schleswig-Holstein state program Economy 2021–2027 (LPW 2021) and proportionally by the European Regional Development Fund (ERDF). The aim of the project is to create a cloud-based, manufacturer-independent building management system for KNX-based commercial properties that uses a digital twin and AI-supported algorithms to detect errors in real time, analyze causes, and provide proactive instructions for rectification. The system is complemented by the ETS app “Project Health Check,” which automatically avoids configuration errors in KNX projects. This innovation reduces operating costs, increases energy efficiency, and improves the quality of stay - a future-proof milestone for modern buildings.

Fully protected, monitored at all times, always one step ahead

onework GUARD

onework GUARD, the digital twin of the building infrastructure, is a cloud-based fault reporting management system for KNX bus systems. It enables demand-oriented monitoring of devices and data points. Alarm rules can be predefined and individually configured. Alarms and their effects are clearly displayed and system statuses are vividly visualized.

SaaS



Visualize system states



Define custom alarm rules



Aggregation of sensor data



Processing of alarm and status messages



Monitor devices and data points



Analyze malfunctions and make recommendations



Automatic error analysis

building better workplaces -





together



Standards and literature

DIN EN 12464-1 Light and lighting -

Lighting of workplaces, Part 1: Indoor workplaces

The following standards are relevant to the workplace:

DIN EN 12464-2 Light and lighting -

Lighting of workplaces, Part 2: Outdoor workplaces

DIN 5035-7 Lighting with artificial light - Part 7:

Lighting of rooms with computer workstations

DIN EN 12665 Light and lighting -

Basic terms and criteria for defining lighting requirements

DIN V 18599 Energy assessment of

buildings - calculation of useful, final, and primary energy demand for heating, cooling, ventilation, domestic hot water, and lighting

DIN 5035-7 Lighting with artificial light - Part 7:

Lighting of rooms with computer workstations

DIN SPEC 5031-100 Radiation physics in the optical range and lighting technology - Part 100: Non-visual effects of light on humans mediated by the eye – Quantities, symbols, and effective spectra

DIN SPEC 67600 Biologically effective lighting -

planning recommendations. This document provides planning recommendations for living spaces that may be workplaces or non-workplaces. It also includes areas where uses may overlap or mix..

ASR A3.4 Technical rules for workplace lighting

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Studies on 405 nm environmental disinfection (violet-blue light/HINS light) with staphylococcus reduction and SSI reduction

DIN SPEC 67600 (2013) - Biologically effective lighting... DIN German Institute for Standardization



onework GmbH
Koboldstraße 4
24117 Kiel

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