Bartenbach
research & development

Tageslicht im Fokus
Ergebnisse aus dem SdZ Projekt FFF-Talisys und dem IEA SHC Task 50

Christian Knoflach
David Geisler-Moroder

Bartenbach
research & development

FFF-TaliSys

Freiformflächen-Tageslichtsysteme für Fassaden und Oberlichter

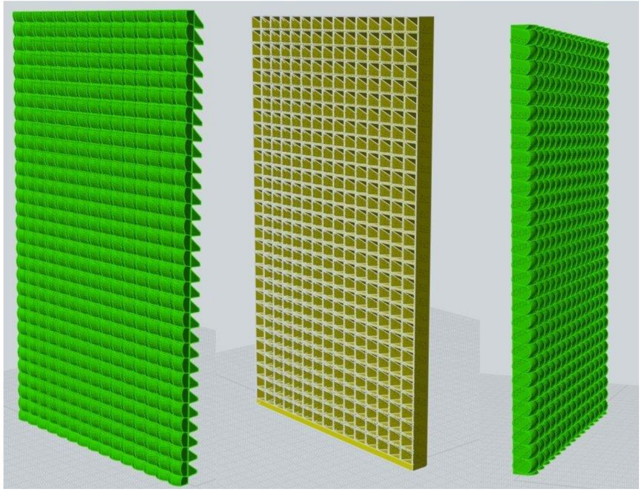
Christian Knoflach
Bartenbach GmbH

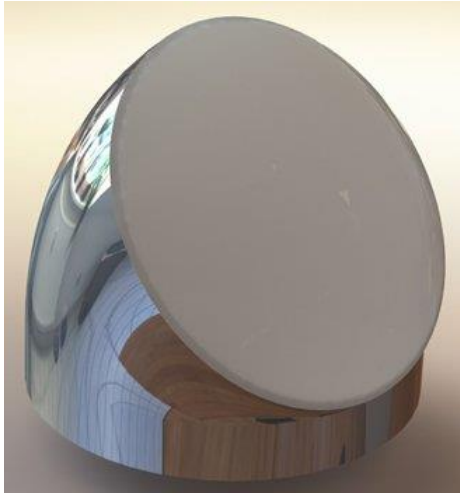
FFF-TaliSys

Freiformflächen-Tageslichtsysteme für Fassaden und Oberlichter

Projektziele:

- **neuartige Tageslichtsysteme** auf Basis der **Freiformflächentechnologie**
- Umsetzung bis zu **Funktionsmustern**
- Entwicklung von Systemen für **Fassaden** und **Oberlichter**
- möglichst **ohne bewegte Teile** und **ohne komplexe Steuerung**
- **optimale** optische und thermische **Funktionalität** (Low-Tech Systeme mit High-Tech Optiken)





FFF-TaliSys

Freiformflächen-Tageslichtsysteme für Fassaden und Oberlichter

Projektpartner:

- Bartenbach GmbH
- HELLA Sonnen- und Wetterschutztechnik GmbH
- Universität Innsbruck, Institut für Konstruktion und Materialwissenschaften, Arbeitsbereich Energieeffizientes Bauen

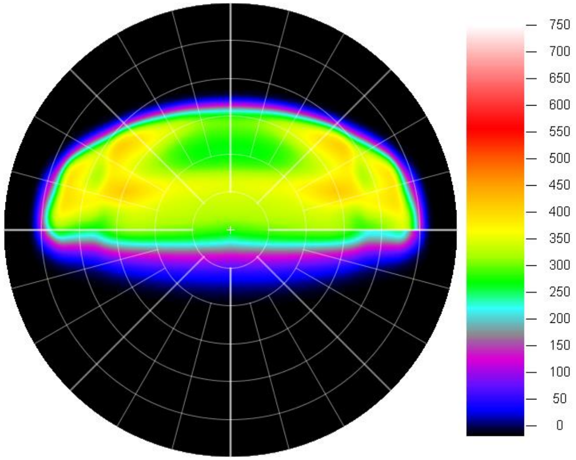
Förderung durch BMVIT / FFG im Programm „Stadt der Zukunft“

Freiformflächen

Begriffserkärung

Was sind Freiformflächen:

- **Flächen**, die **punktweise** mit numerischen Verfahren **berechnet** werden
- Berechnung nach **lichttechnischen Vorgaben** (etwa Beleuchtungsstärke-verteilung auf Nutzebene oder Lichtstärkeverteilung des Systems)
- Lösung eines Systems partieller **Differentialgleichungen**
- typischerweise keine einfache Symmetrie (etwa Rotationssymmetrie oder lineare Symmetrie), keine einfach beschreibbaren geometrischen Körper



Beispiel: Straßenleuchte mit Freiformflächen-Reflektoren (Kunstlicht)

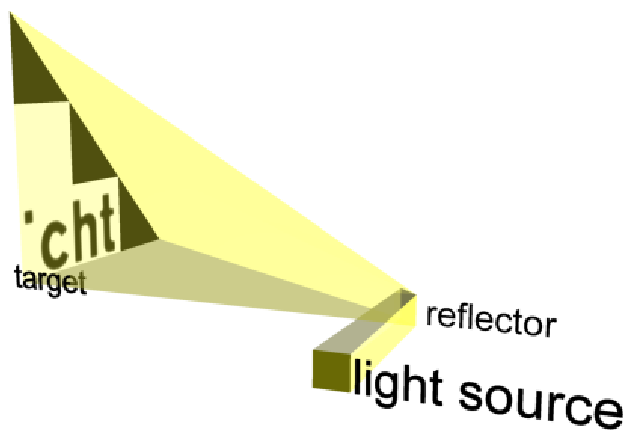
Freiformfächen

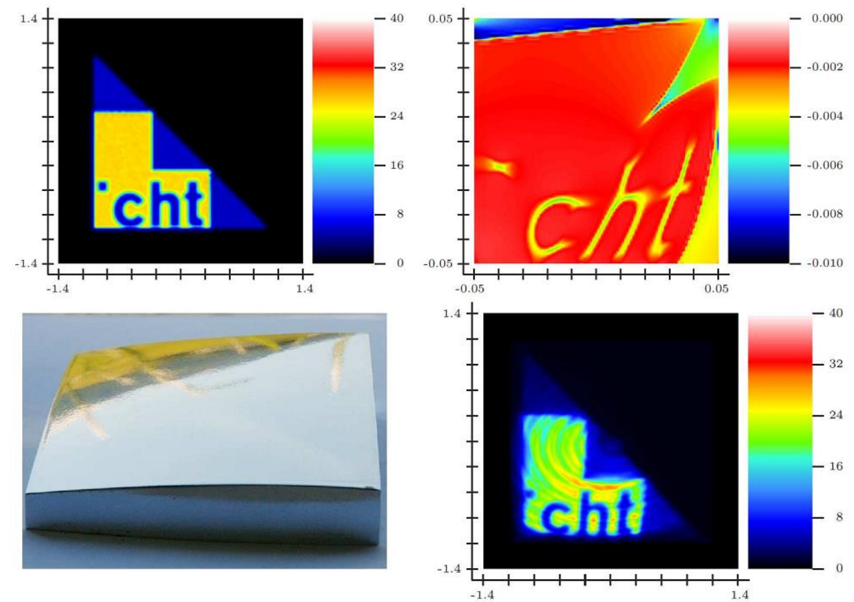
Berechnung

Berechnung für theoretische Lichtquellen

- Punktelichtquelle
- Parallelstrahl

Die Fläche wird eindeutig durch die Vorgaben bestimmt und kann mit geeigneten mathematischen Verfahren berechnet werden:





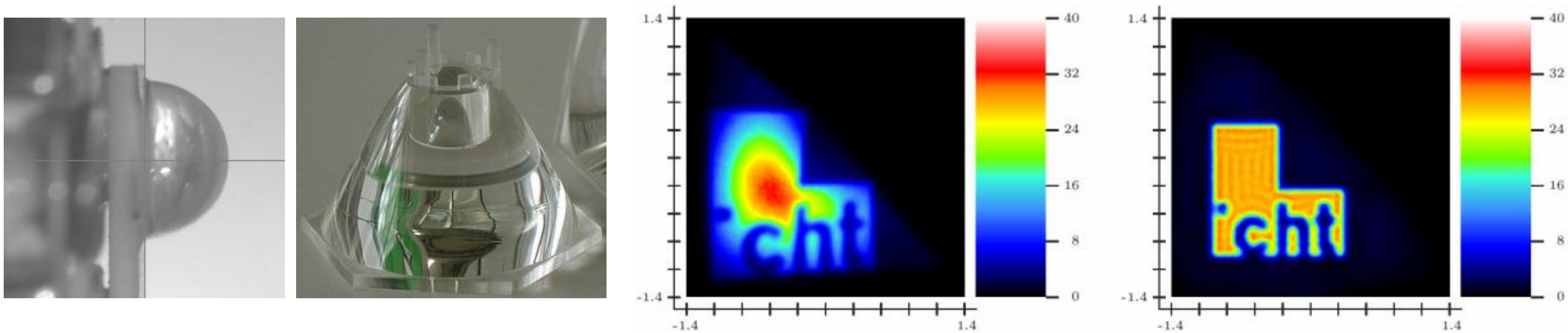
Freiformflächen

Nichtlineare Optimierung

Optimierung für reale, ausgedehnte Lichtquellen

Bei der Berechnung müssen die Ausdehnung und die Leuchtdichteverteilung der Lichtquellen berücksichtigt werden.

Etwa bei LED: Geometrisches Modell, Strahldaten oder Kombination beider Ansätze.

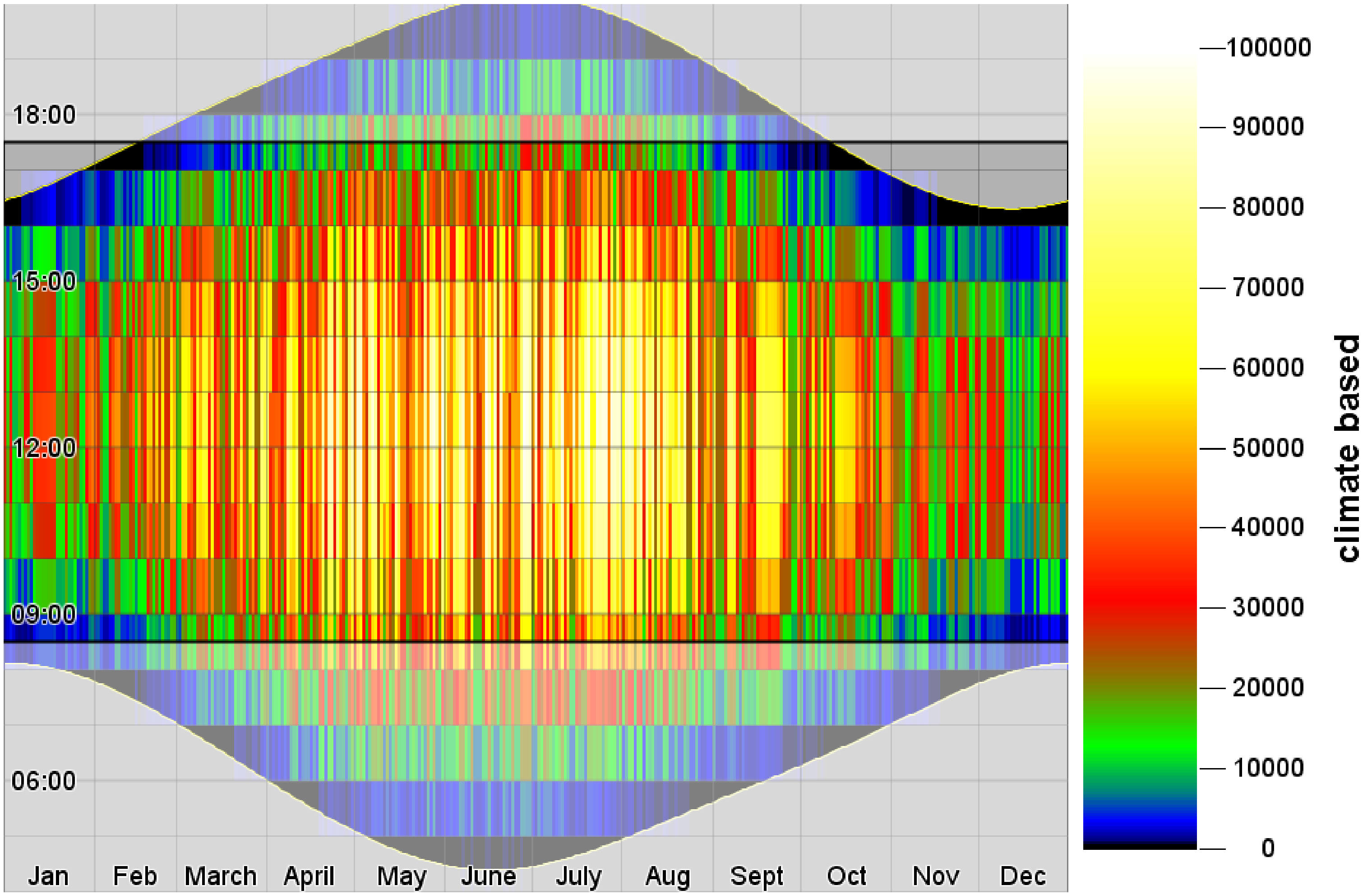


Beispiel: High Power LED + Linse als Lichtquelle. Reflektor wird nach Beleuchtungs-stärkeforderung optimiert.

Tageslicht

Zeitliche Dynamik im Jahres- und Tagesverlauf; Beispiel: Innsbruck (EnergyPlus Weather Data)

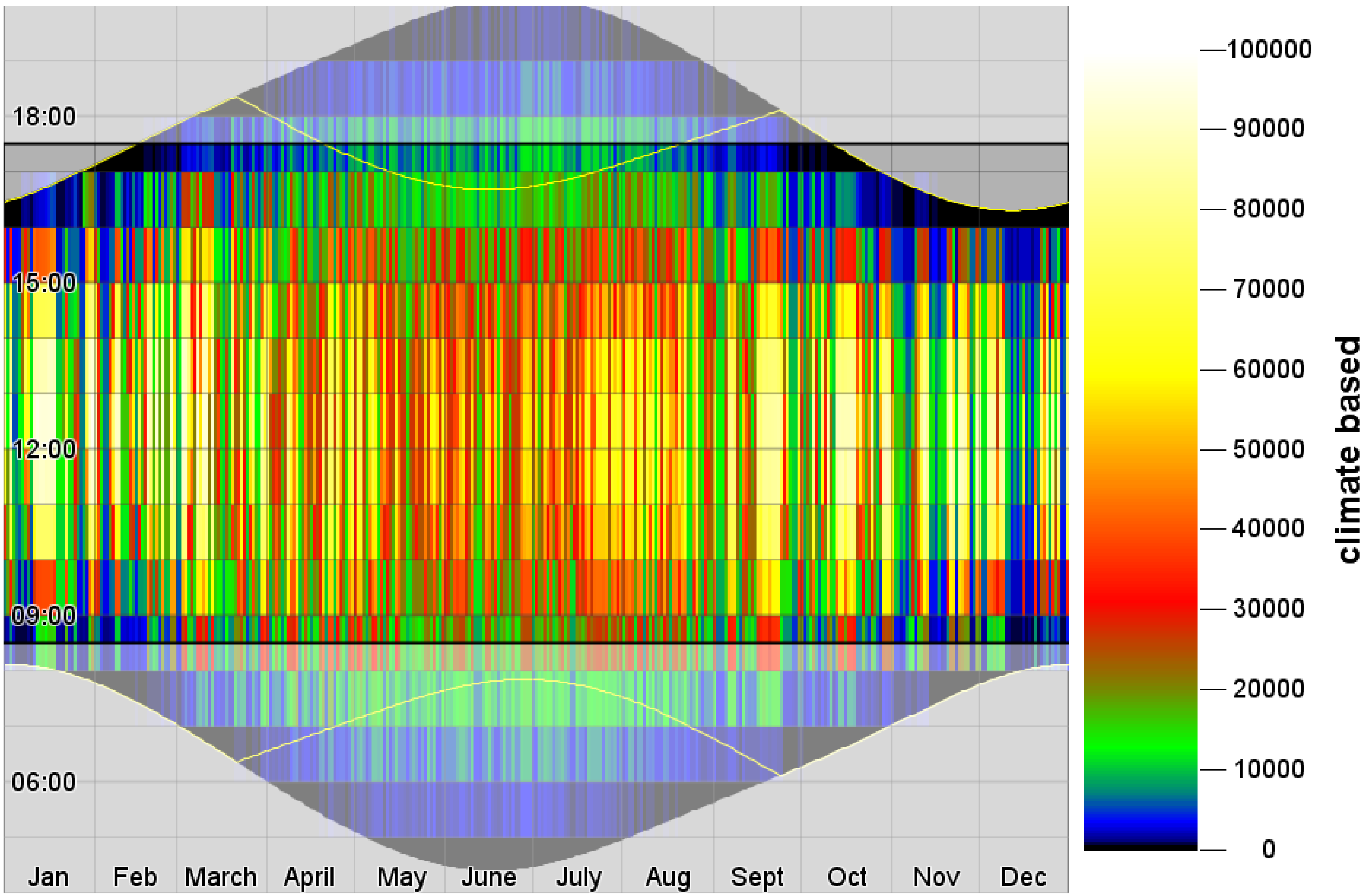
Beleuchtungsstärke auf horizontaler Ebene (Oberlicht) aus Klimadaten



Tageslicht

Zeitliche Dynamik im Jahres- und Tagesverlauf; Beispiel: Innsbruck (EnergyPlus Weather Data)

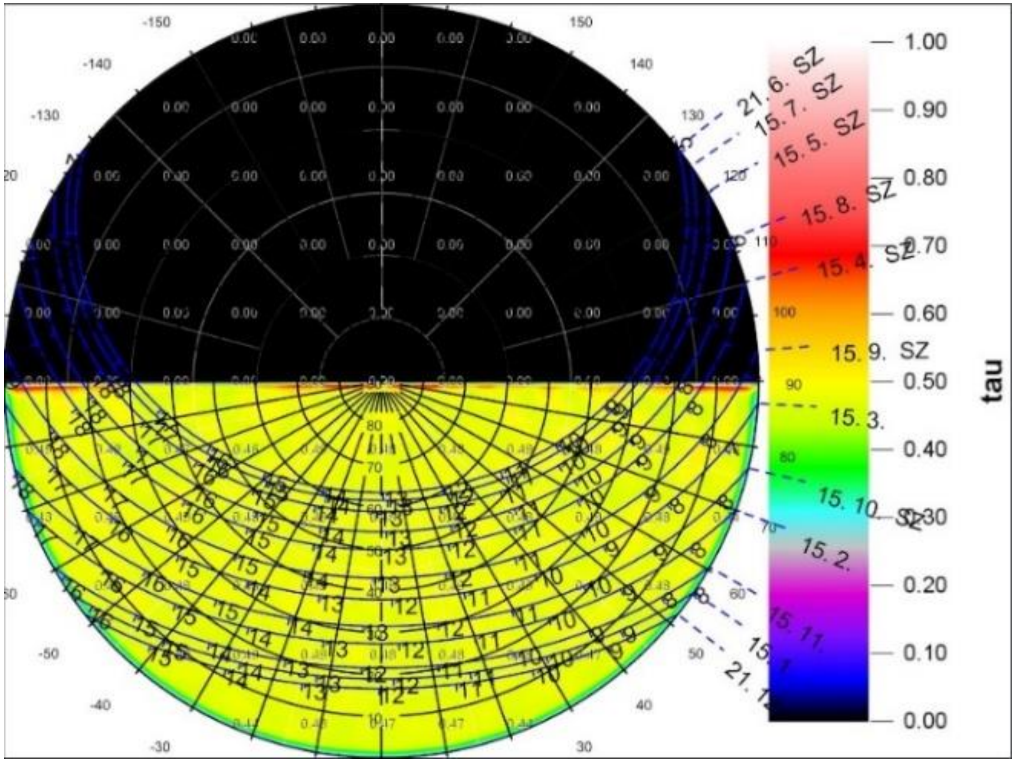
Beleuchtungsstärke auf Südfassade aus Klimadaten



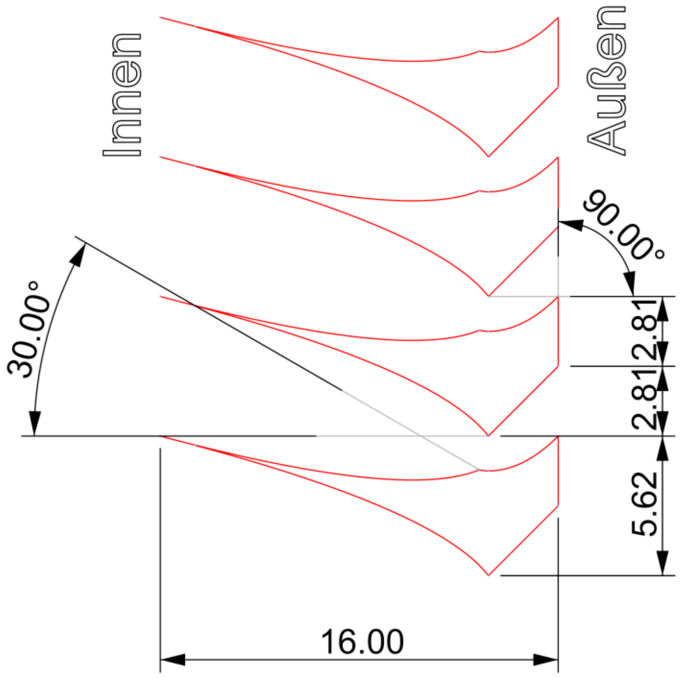
Fassadensystem: Nutzung direkte Sonnenstrahlung

Reflektorischer Hybridfisch, lineares System

Reflektorischer Hybridfisch (Viertelraum außen, 0° - 30° innen)



Gerichtete Transmission



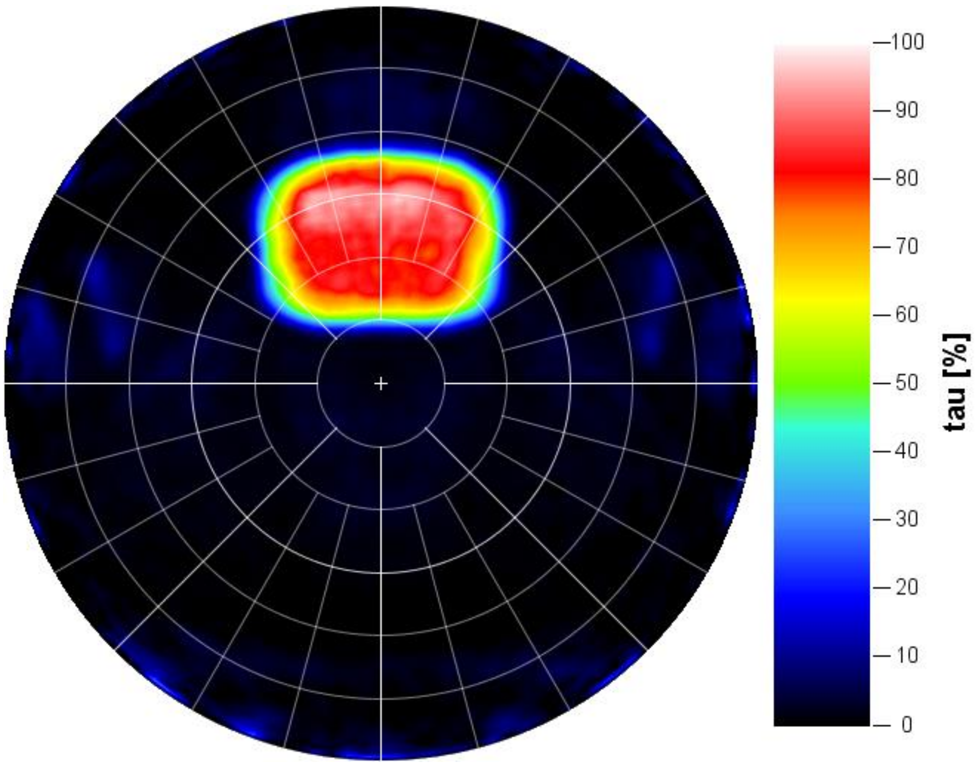
Querschnitt

Wunsch: Seitliche Ausblendung innen, kleinerer Akzeptanzbereich außen, brechend

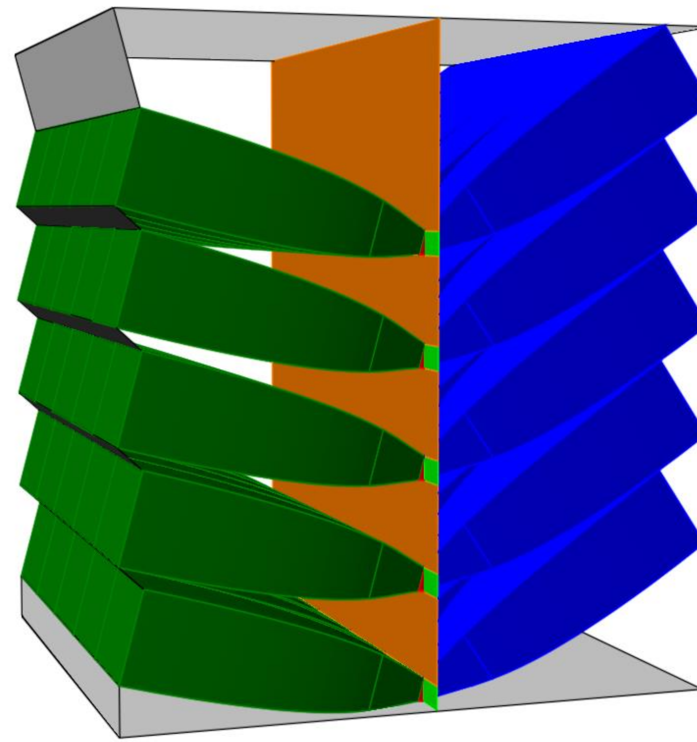
Fassadensystem: Nutzung direkte Sonnenstrahlung

Brechendes System, Einzeloptiken

Brechendes System, bedampft



Gerichtete Transmission



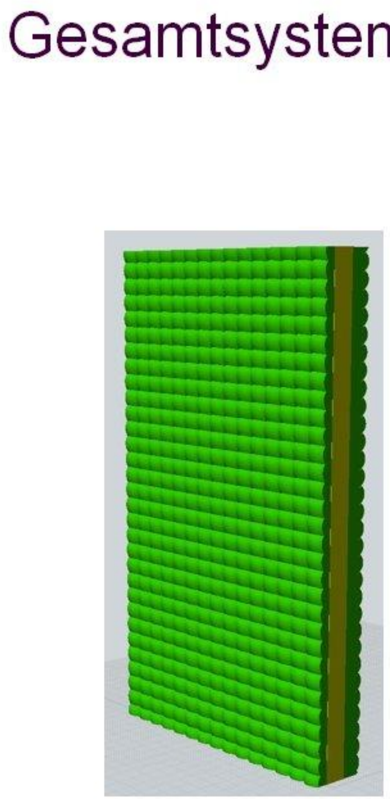
3D-Geometrie

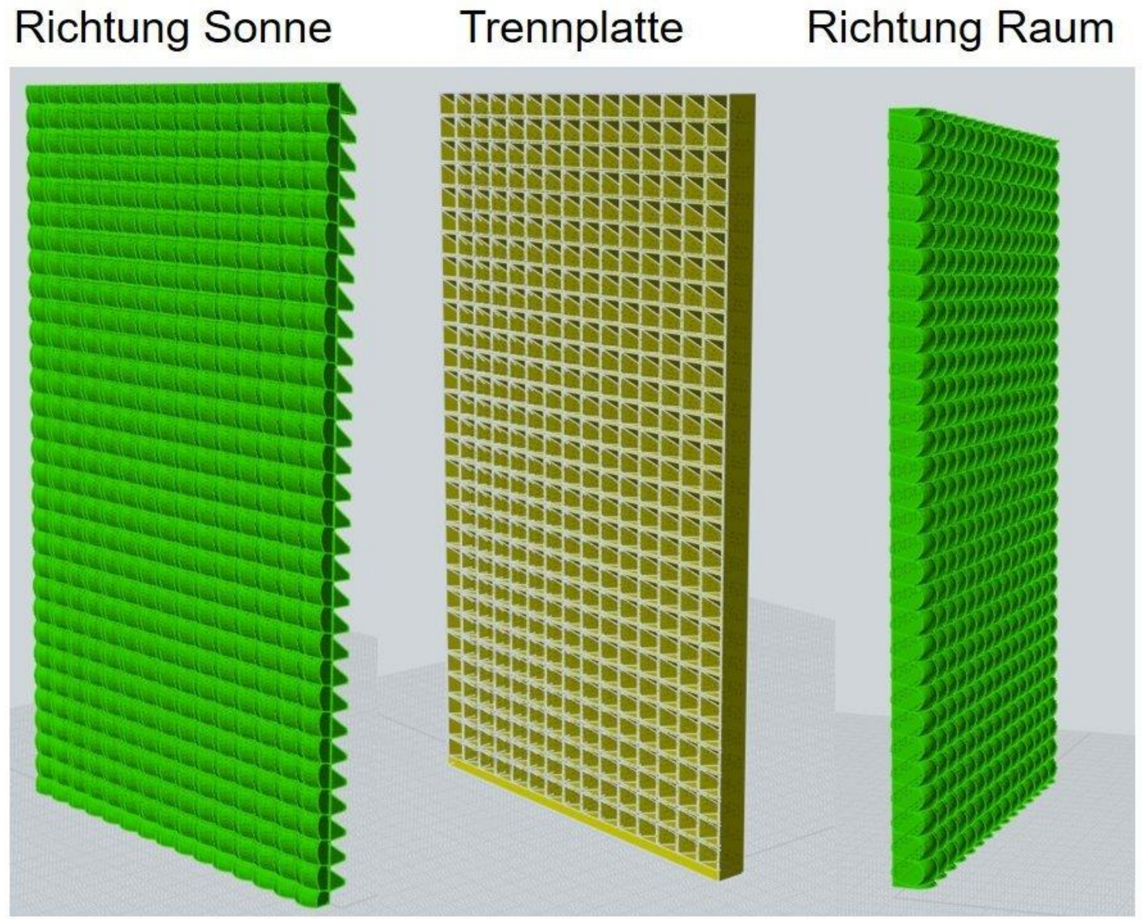
Wunsch: Gläsernes System, Linsenplatte (etwa wegfahrbahre Vertikaljalousie)

Fassadensystem: Nutzung direkte Sonnenstrahlung

Mehrteilige Freiformflächen-Linsenplatte

Freiformflächen-Linsenplatte

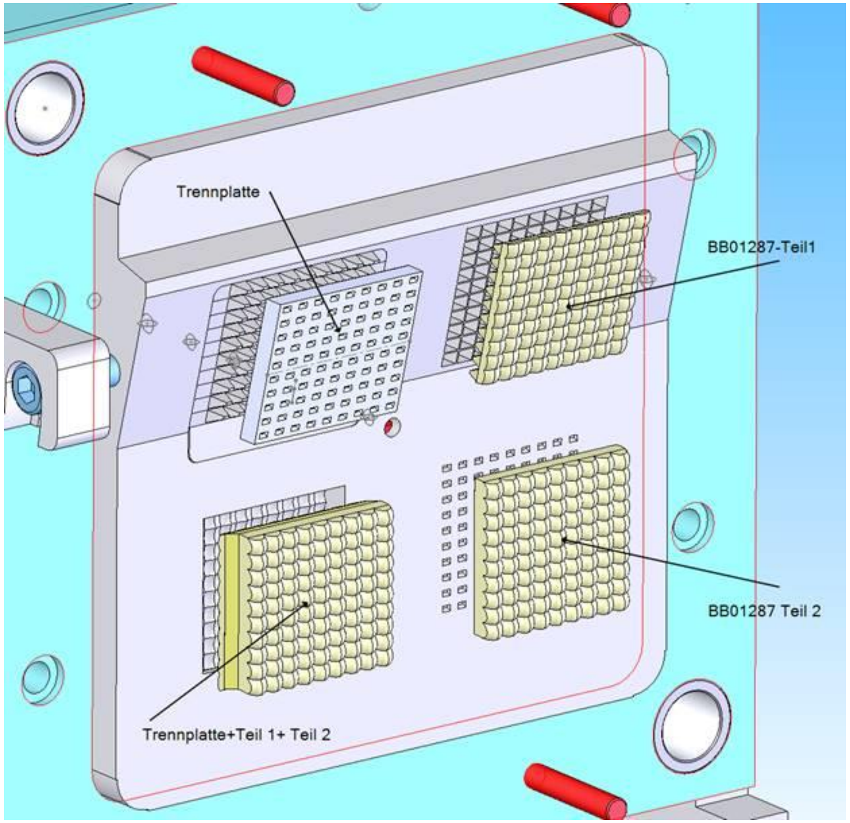




Fassadensystem: Nutzung direkte Sonnenstrahlung

Freiformflächen-Linsenplatte, Funktionsmuster

Funktionsmuster Linsenplatte (Näpfchenlinsen)



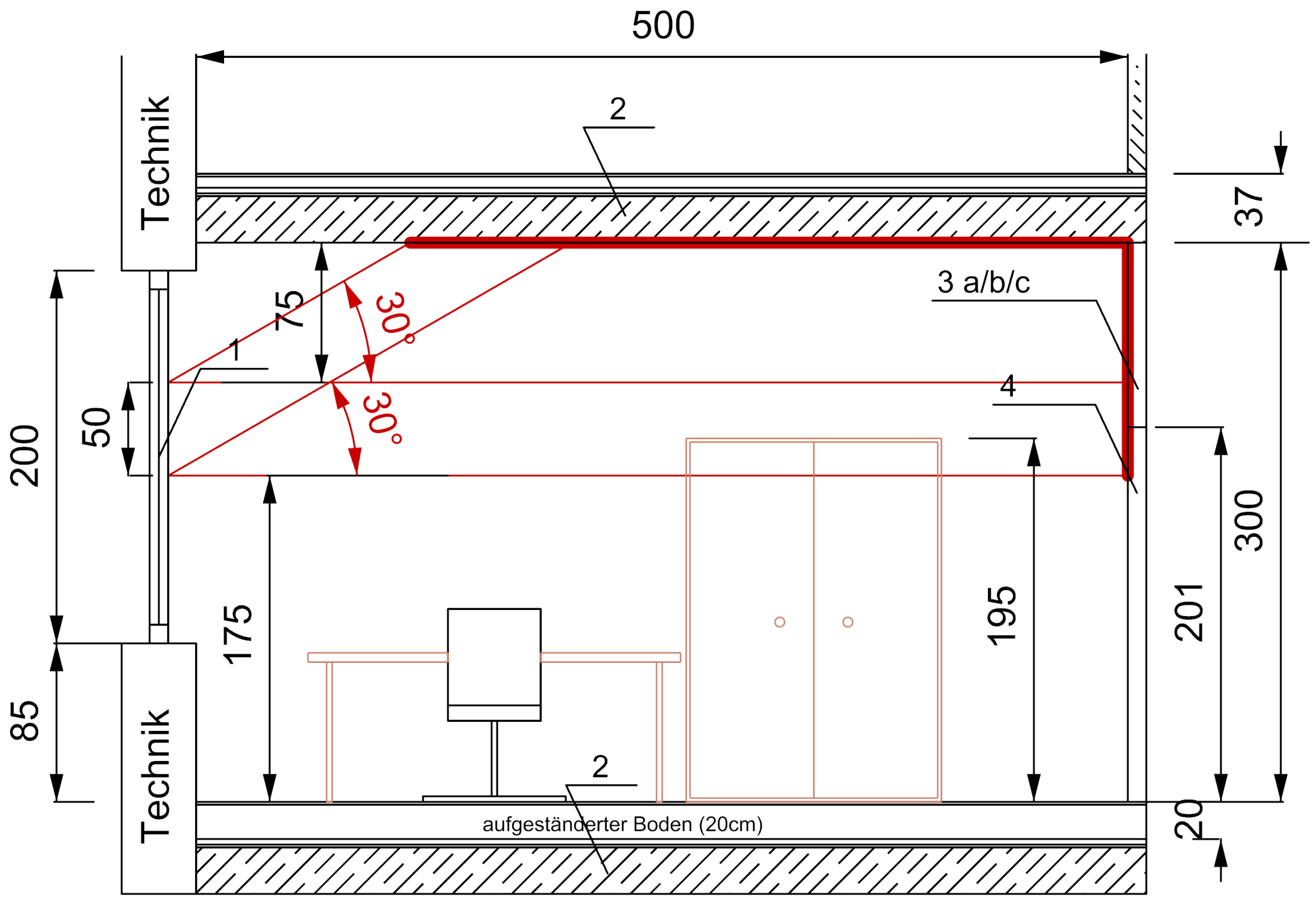
4 x 1-fach Spritzgussform (Konstruktion Beneder)

2K-Funktionsmuster

Fassadensystem: Nutzung direkte Sonnenstrahlung

Typischer Einsatz

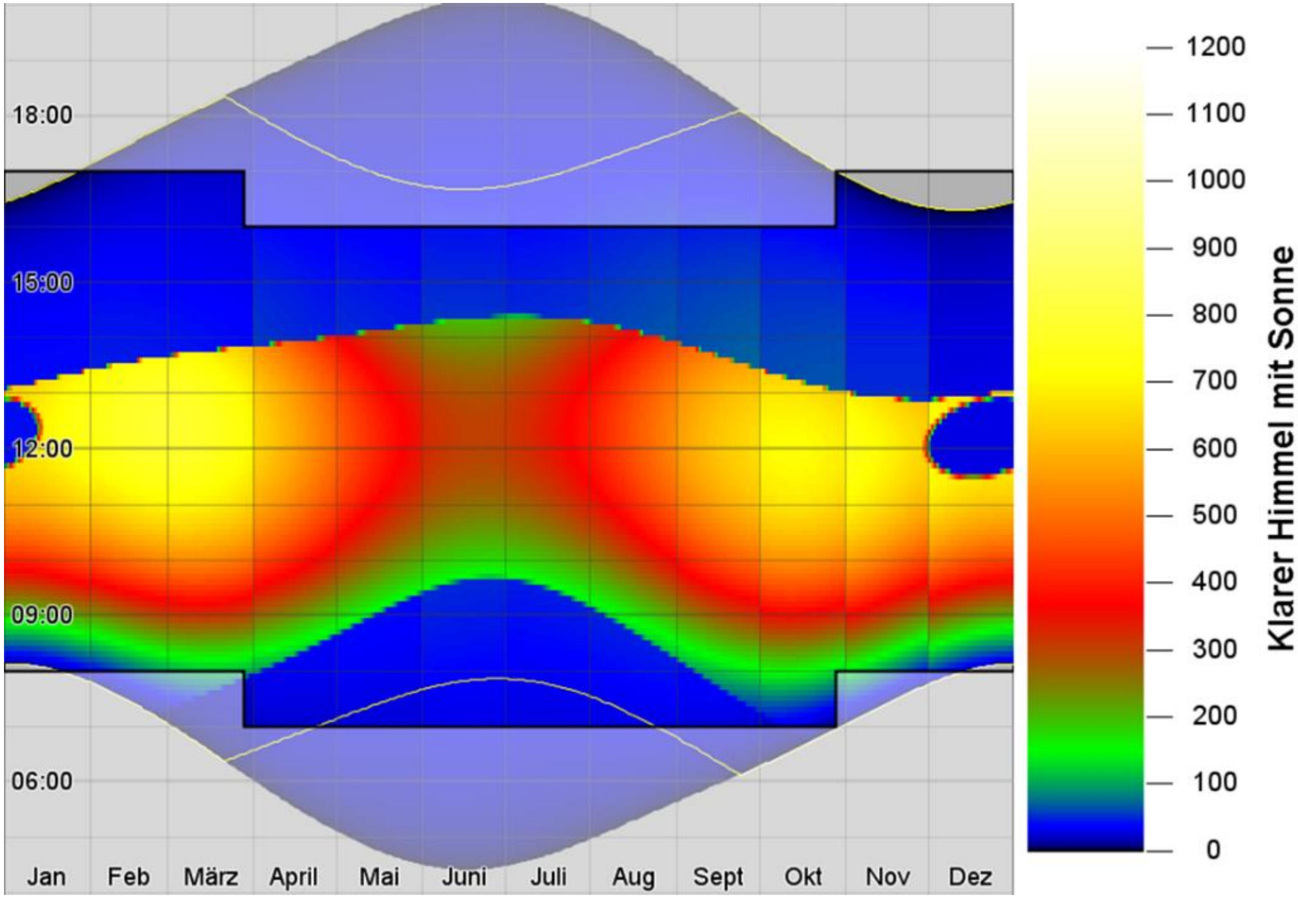
Seitenriss mit Sonnen-Nutzsystem von Höhe 1.75 m bis 2.25 m (Δ = 0.5 m)



Fassadensystem: Anwendungsmöglichkeit, Beispiel

Innsbruck Südfassade, klarer Himmel mit Sonne

Schule, Sonnen-Nutzung primär während Unterrichtszeit

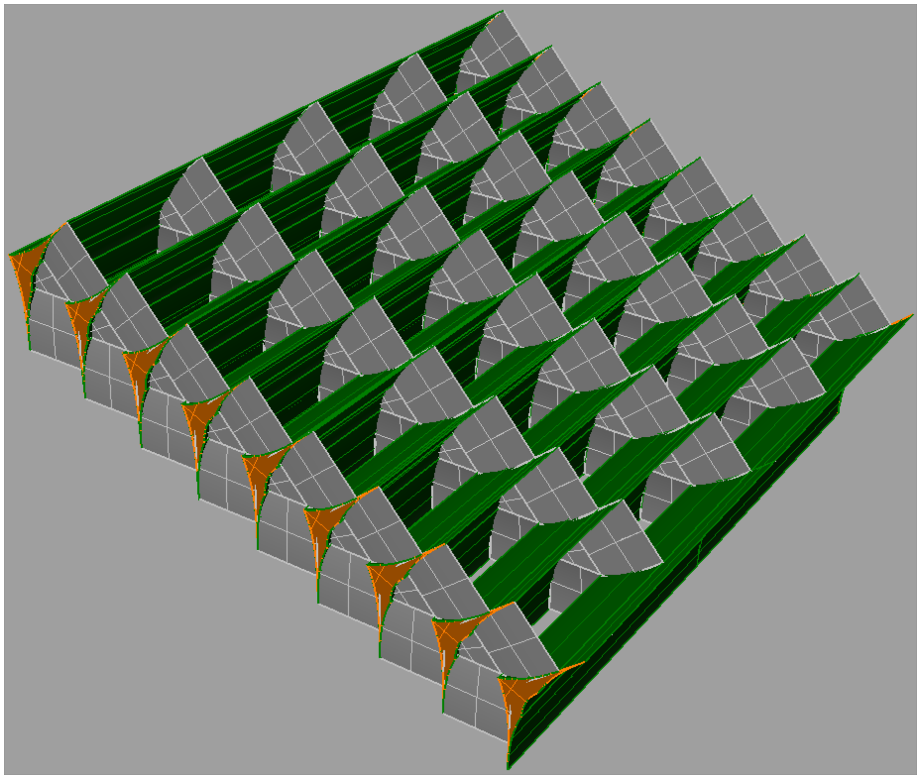


Beleuchtungsstärke in Raumtiefe 4m für geeignete Kombination von Linsenplatten

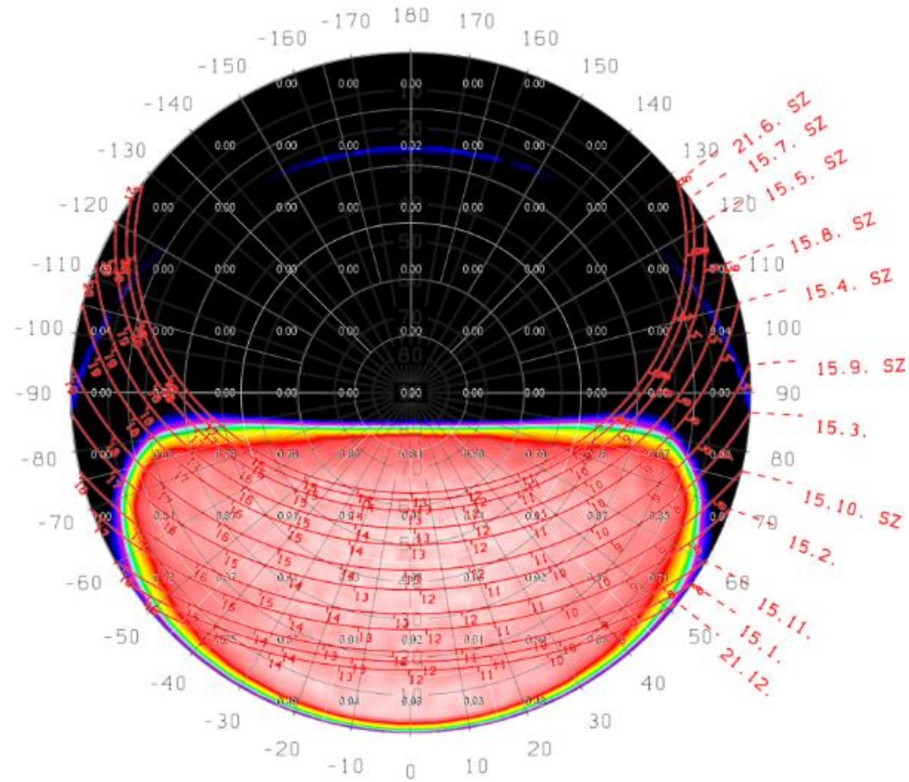
Oberlichtsystem: Nutzung direkte Sonnenstrahlung

Sonnennutzraster

Sonnennutzraster, 24.5° verkippt



Geometrie

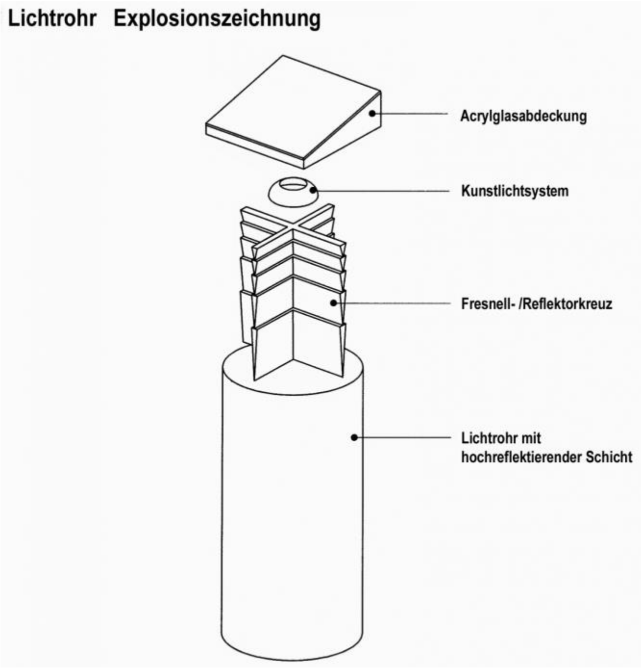


Transmission ohne Verglasung

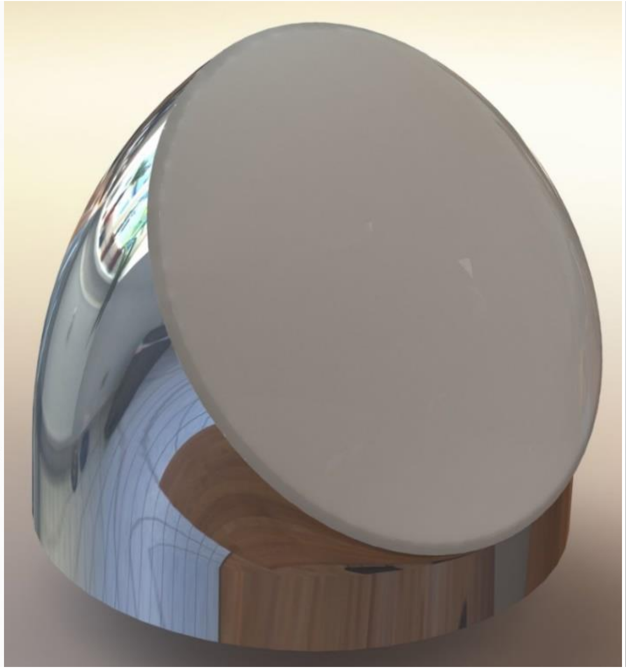
Oberlichtsystem: Nutzung direkte Sonnenstrahlung

Aufsatz für Lichtrohr

„SchlumpfHaube“ als Aufsatz für Lichtrohr



Lichtrohr



Visualisierung

Funktionsmuster

Funktion: Beeinflussung des Lichtstromeintrags durch Sonnenstrahlung.

Ergebnisse

Kooperatives F&E-Projekt (Industrielle Forschung, Experimentelle Entwicklung)

Wesentliche Ergebnisse

- neuartige **Konzepte** zur verbesserten Tageslichtnutzung mit Schwerpunkt auf die **Nutzung direkter Sonnenstrahlung** (Basis: Marktanalyse und Patentrecherche)
- **Ausarbeitung** von je einem Konzept für **Fassaden** und **Oberlichter** bis zum Funktionsmuster.
- **lichttechnische / thermische Messungen** anhand dieser Funktionsmuster

System für Seitenlicht: Linsenplatten, die das **Sonnenlicht an die Decke in der Raumtiefe** lenken. Damit wird die **natürliche Sonnenstrahlung** nicht durch Sonnen- und Blendschutzsysteme vom Raum ferngehalten, sondern **gezielt genutzt** um in **fassadenfernen Bereichen ohne** Einsatz von **Primärenergie** einen wesentlichen Beitrag zum **Human Centric Lighting** zu leisten.

Das gewählte Konzept ermöglicht eine **flexible Anpassung** an die geographische **Lage**, die **Gebäudeorientierung**, die thermischen **Gebäudeeigenschaften** und die **Raumnutzung**. Das erfolgt beim Einbau in Form einer g**eeigneten Zusammen-setzung** von **Linsenplatten-Typen** und erfordert **keine Nachführung oder** eine andere **Steuerung** der Vertikaljalousie.

IEA SHC Task 50

Beleuchtungslösungen für die Gebäudesanierung

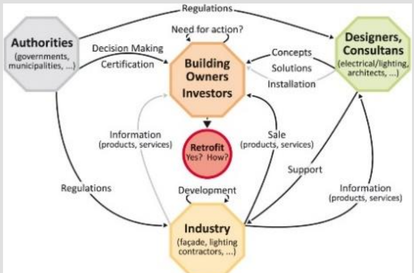
David Geisler-Moroder
Bartenbach GmbH

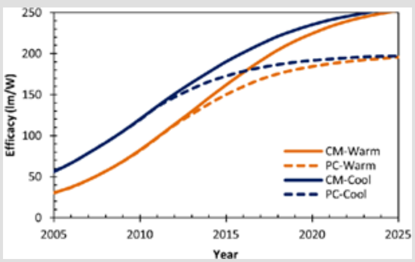
PARTICIPATING COUNTRIES: AUSTRIA · BELGIUM · BRAZIL · CHINA · DENMARK · FINLAND · GERMANY · JAPAN · NETHERLANDS · NORWAY · SLOVAKIA · SWEDEN · SWITZERLAND

IEA SHC Task 50

Beleuchtungslösungen für die Gebäudesanierung

Subtask A



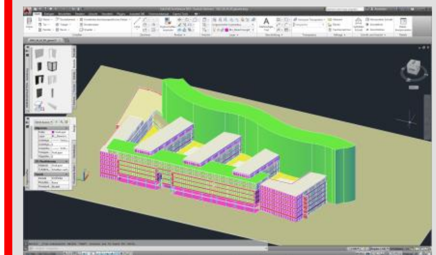


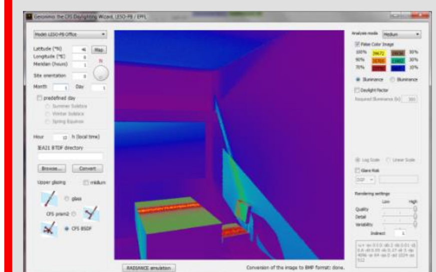
Markt und Politiken

Subtask B

Lösungen für Tageslicht und Kunstlicht

Subtask C

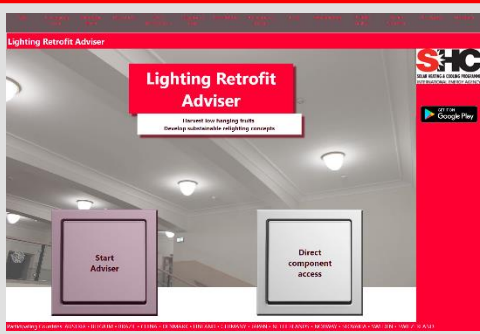




Methoden und Tools

Subtask D

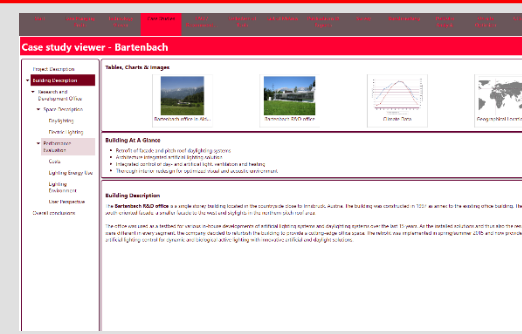
Fallbeispiele



Joint Working Group:

"Lighting Retrofit Advisor"

www.lightingretrofitadviser.com



IEA SHC Task 50

Beleuchtungslösungen für die Gebäudesanierung

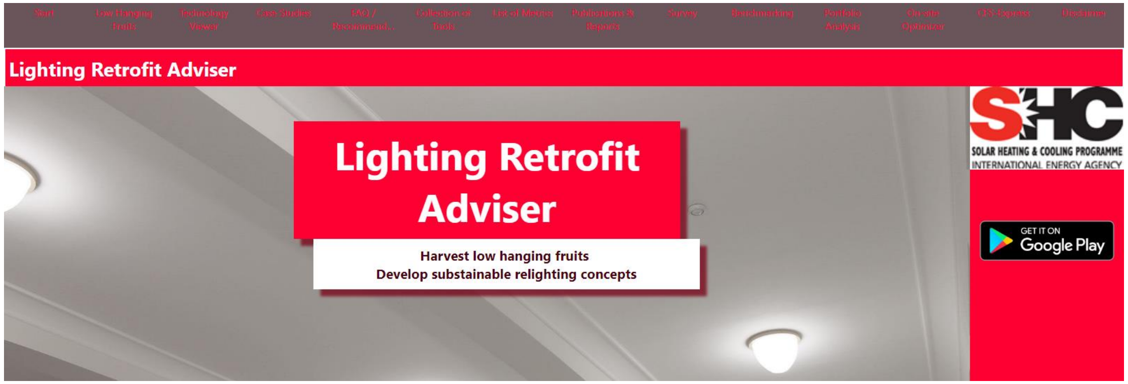
Belgien
Brasilien
China
Dänemark
Deutschland
Finnland
Italien
Japan
Niederlande
Norwegen
Österreich
Schweden
Schweiz
Slowakei

Ergebnisse

- **Dokumente** zur Information und Unterstützung bei der Sanierung von Beleuchtungsanlagen, u.a.
  - **Source Book** “Daylighting and electric lighting retrofit solutions”
  - **Kriterienkatalog** zur Bewertung von Technologien
  - **Stand der Technik** in Methoden und Tools für Beleuchtungssanierungen
  - **Monitoringprotokoll** für Beleuchtungslösungen in Gebäuden
  - **Fallstudien:** Monitoring und Dokumentation

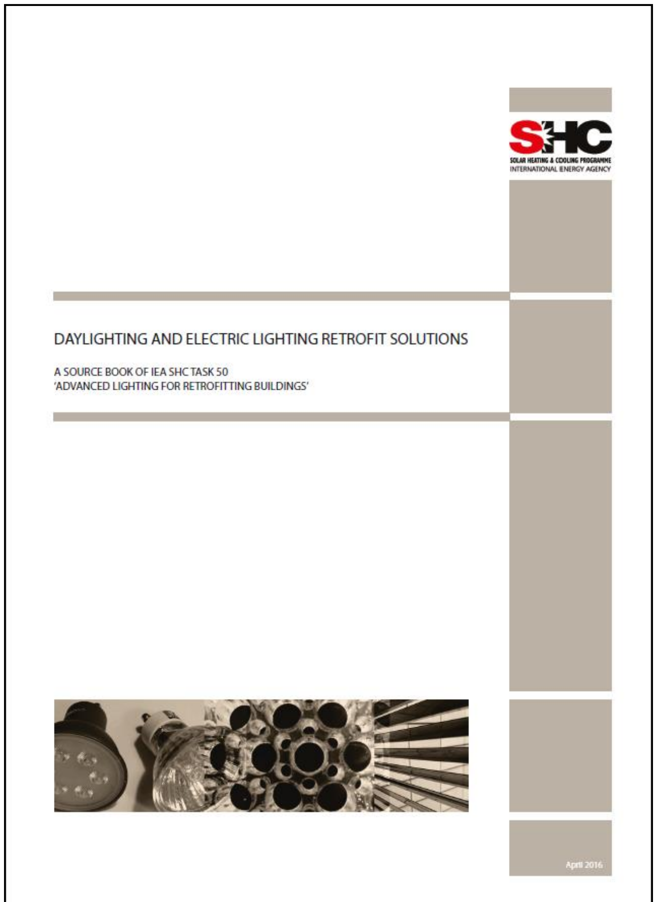
verfügbar unter task50.iea-shc.org/publications

- **Lighting Retrofit Advisor**



Source Book

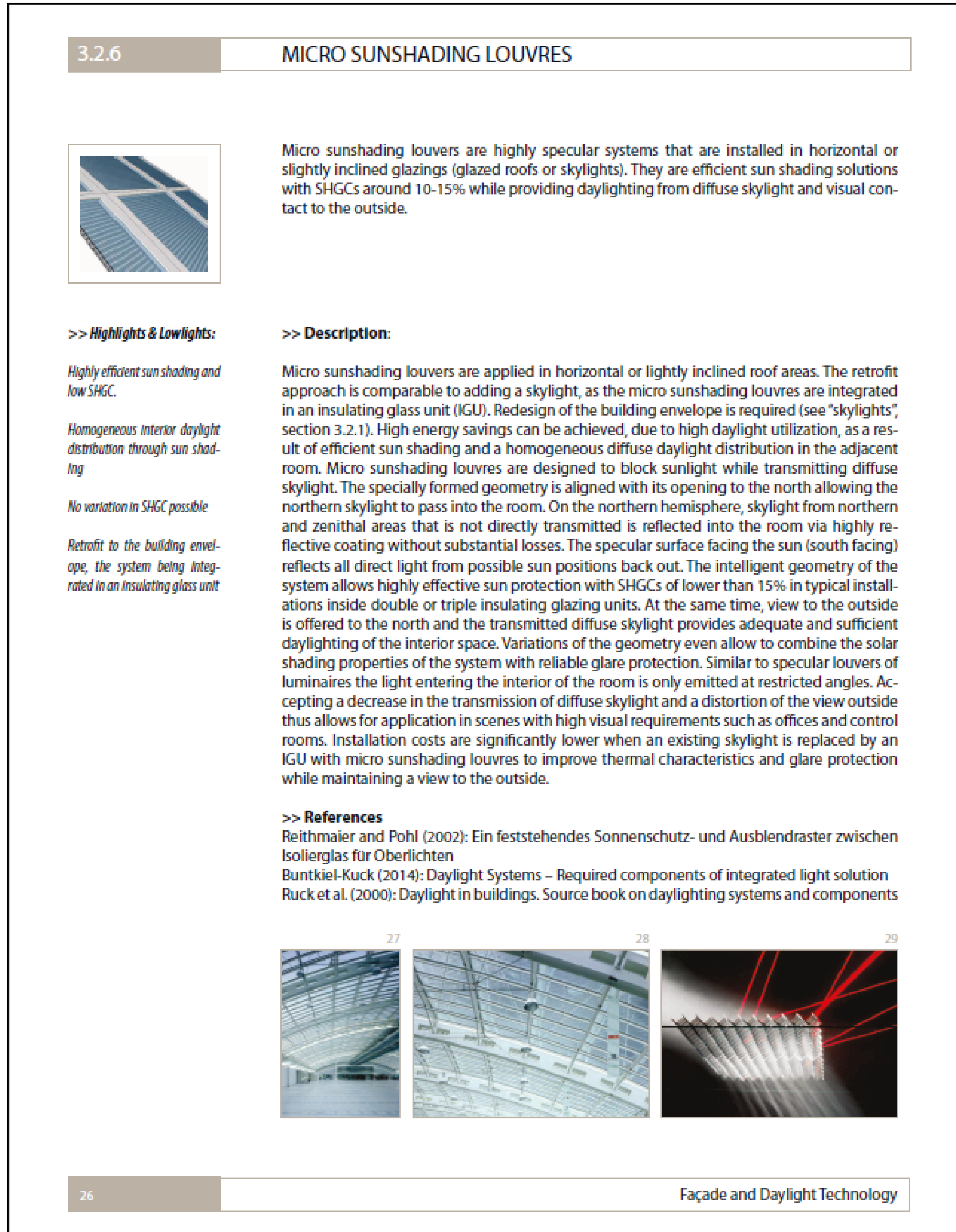
“Daylighting and electric lighting retrofit solutions”



	Upgrade of existing situation	Use new components in existing situation	Redesign
Façade & daylighting technology	'Add on' to the window plane: add simple daylighting system (e.g. light redirection blinds)	Add construction to the façade or window replacement (e.g. daylighting system fitting in existing window frame)	Redesign of façade or façade elements (e.g. increase window size, add skylight)
Blinds & shading technology	'Add on' to the window plane: add shading devices (static or dynamic)	Add construction to the façade or window replacement (e.g. electrochromic glazing, double glazing with blinds, louvres)	Redesign of façade or façade elements (e.g. add architectural shading elements, light shelves)
Electric lighting solutions	Lamp replacement: improvement in lamp or ballast technology, improvement of spectral quality of light source, increase of luminous flux, …	Luminaire replacement: improvement in luminaire technology, lamp or ballast technology that requires a new luminaire, …	Redesign of lighting installation: more efficient luminaires, use of task / ambient lighting, reduction of maintained illuminance levels, …
Electric lighting controls	Stand-alone controls: use time switch to reduce total switch-on time, use of sensors for presence detection (switching), …	Luminaire based controls: use of sensors for presence detection (dimming), daylight dimming, manual dimming, …	Install advanced lighting control system, building management system to link electric lighting to heating and cooling, networked lighting, …
Changes to the interior	e.g. increase of surface reflectance, rearrange position of work places	e.g. reduce partition height, redesign of work place position	e.g. increase ceiling height, remove walls

Source Book

"Daylighting and electric lighting retrofit solutions"



3.2.6 MICRO SUNSHADING LOUVRES

Micro sunshading louvers are highly specular systems that are installed in horizontal or slightly inclined glazings (glazed roofs or skylights). They are efficient sun shading solutions with SHGCs around 10-15% while providing daylighting from diffuse skylight and visual contact to the outside.

>> Highlights & Lowlights:

Highly efficient sun shading and low SHGC.

Homogeneous interior daylight distribution through sun shading

No variation in SHGC possible

Retrofit to the building envelope, the system being integrated in an insulating glass unit

>> Description:

Micro sunshading louvers are applied in horizontal or lightly inclined roof areas. The retrofit approach is comparable to adding a skylight, as the micro sunshading louvres are integrated in an insulating glass unit (IGU). Redesign of the building envelope is required (see "skylights", section 3.2.1). High energy savings can be achieved, due to high daylight utilization, as a result of efficient sun shading and a homogeneous diffuse daylight distribution in the adjacent room. Micro sunshading louvres are designed to block sunlight while transmitting diffuse skylight. The specially formed geometry is aligned with its opening to the north allowing the northern skylight to pass into the room. On the northern hemisphere, skylight from northern and zenithal areas that is not directly transmitted is reflected into the room via highly reflective coating without substantial losses. The specular surface facing the sun (south facing) reflects all direct light from possible sun positions back out. The intelligent geometry of the system allows highly effective sun protection with SHGCs of lower than 15% in typical installations inside double or triple insulating glazing units. At the same time, view to the outside is offered to the north and the transmitted diffuse skylight provides adequate and sufficient daylighting of the interior space. Variations of the geometry even allow to combine the solar shading properties of the system with reliable glare protection. Similar to specular louvers of luminaires the light entering the interior of the room is only emitted at restricted angles. Accepting a decrease in the transmission of diffuse skylight and a distortion of the view outside thus allows for application in scenes with high visual requirements such as offices and control rooms. Installation costs are significantly lower when an existing skylight is replaced by an IGU with micro sunshading louvres to improve thermal characteristics and glare protection while maintaining a view to the outside.

>> References

Reithmaier and Pohl (2002): Ein feststehendes Sonnenschutz- und Ausblendraster zwischen Isolierglas für Oberlichten
Buntkiel-Kuck (2014): Daylight Systems – Required components of integrated light solution
Ruck et al. (2000): Daylight in buildings. Source book on daylighting systems and components

27 28 29

26 Façade and Daylight Technology

Monitoring Protokoll

Energy use

assessment of the energy use

Retrofit **costs**

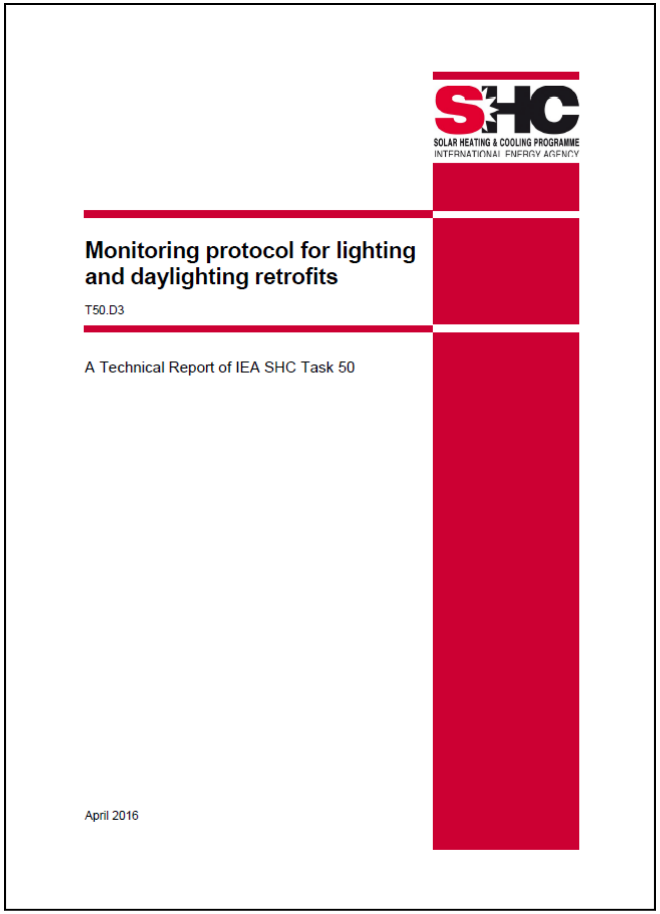
estimation of installation and running costs

Photometric assessment

objective evaluation of the luminous environment

User assessment

subjective evaluation of the luminous environment


SHC
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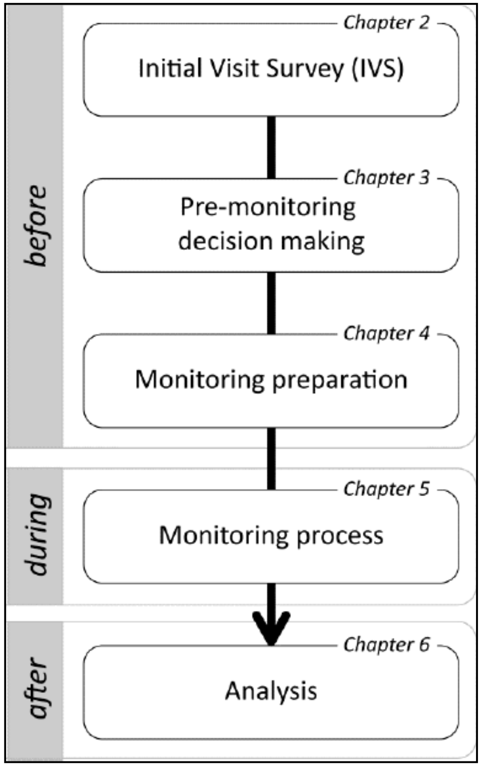
INTERNATIONAL ENERGY AGENCY

Monitoring protocol for lighting and daylighting retrofits

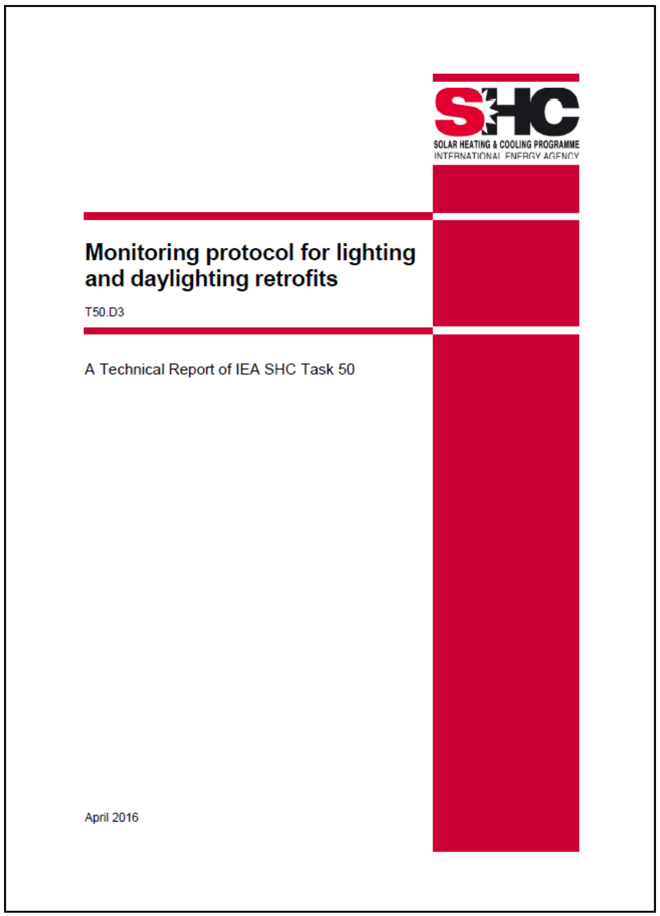
T50.D3

A Technical Report of IEA SHC Task 50

April 2016



Monitoring Protokoll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Monitoring protocol for lighting and daylighting retrofits

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April 2016

		Basic	Comprehensive
Monitoring periods			
	1 overcast day		
	1 clear day close to the equinox (±1 month)		
	1 clear day around summer solstice (±1 month)		
	1 clear day around winter solstice (±1 month)		
Time of day			
	Morning or afternoon and night		
ENERGY USE			
	Estimated use of electricity for lighting		
	Measured use of electricity for lighting		
RETROFIT COSTS			
	Total cost of ownership		
PHOTOMETRIC ASSESSMENT			
Distribution	Reflectance of room surfaces		
	Glazing transmittance		
	Task position HDR photography		
	Spot luminance measurements		
Illuminance	Exterior (global and diffuse)		
	Interior in relevant spots		
	Daylight factor		
	Grid of interior horizontal illuminances		
	Horizontal illuminance on task		
	Horizontal illuminance surrounding task		
Glare	Observations (sun patches or very bright surfaces) areas, veiling reflections, …)		
	Task position HDR analysis (UGR, DGP)		
	Vertical illuminance at the eye		
Directionality	Observations		
	Detection of shadows		
	HDR of perfectly diffuse white sphere		

Monitoring Protokoll


SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Monitoring protocol for lighting and daylighting retrofits

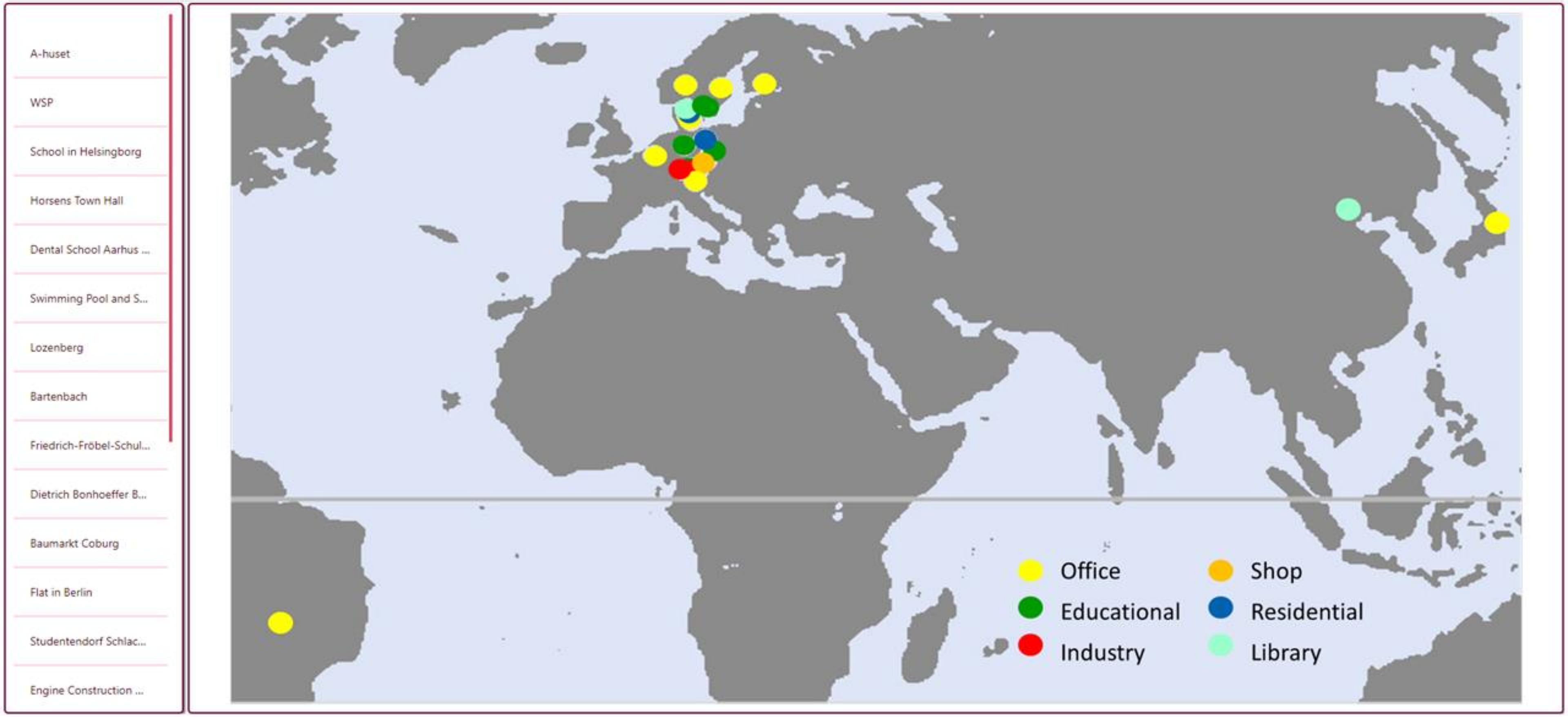
T50.D3

A Technical Report of IEA SHC Task 50

April 2016

1	**Energy use**			
	Temperature sensor for logging the operation of light sources via an on/off-temperature profile			
	Separated energy meter for electricity for lighting			
	Wattmeter with plug			
	Voltmeter			
2	**Retrofit costs**			
	Relight software			
3	**Photometric assessment**			
	1 reference reflector			
	Reference grey surface			
	1 reference colour chart			

Fallstudien

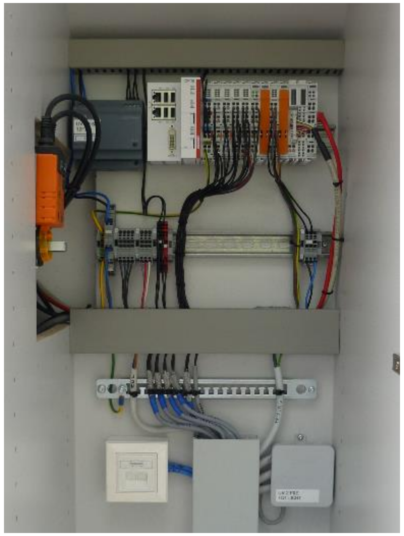


Fallstudie: Bartenbach F&E Gebäude, Aldrans

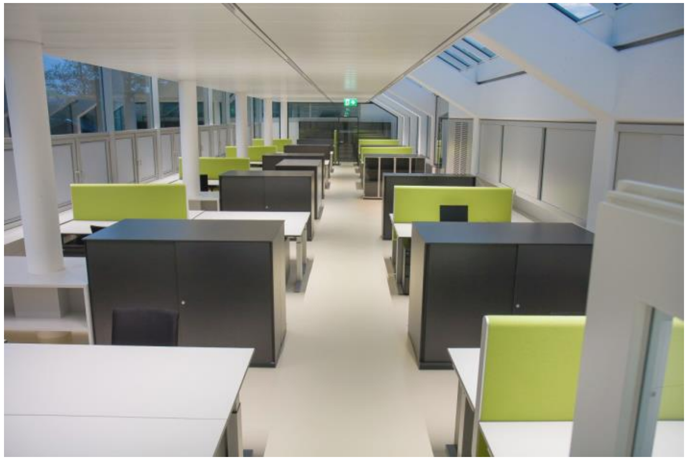
Fallstudie: Bartenbach F&E Gebäude, Aldrans

Tageslicht-System

Kunstlicht-System

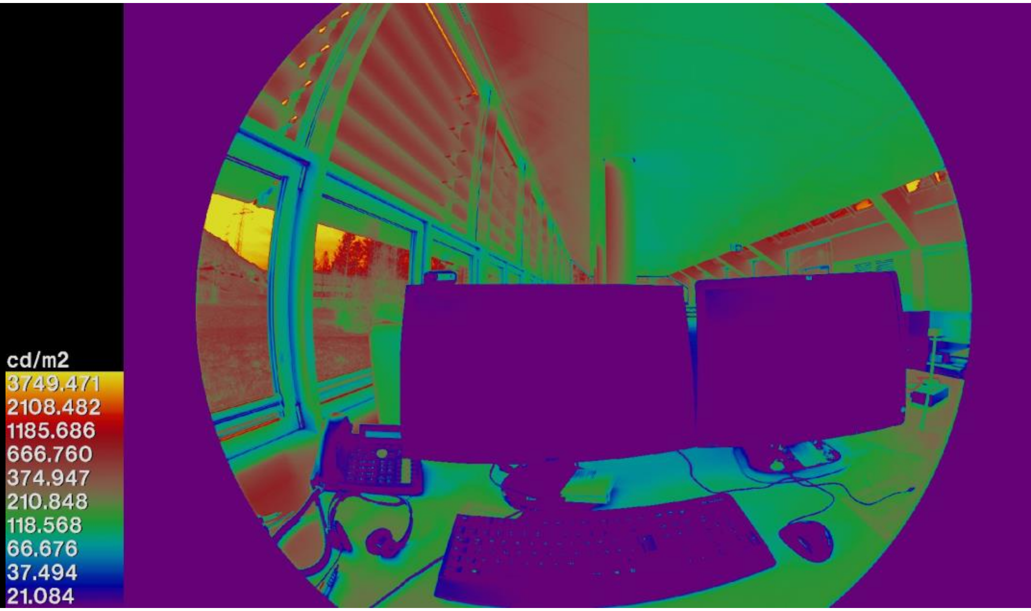


Steuerung

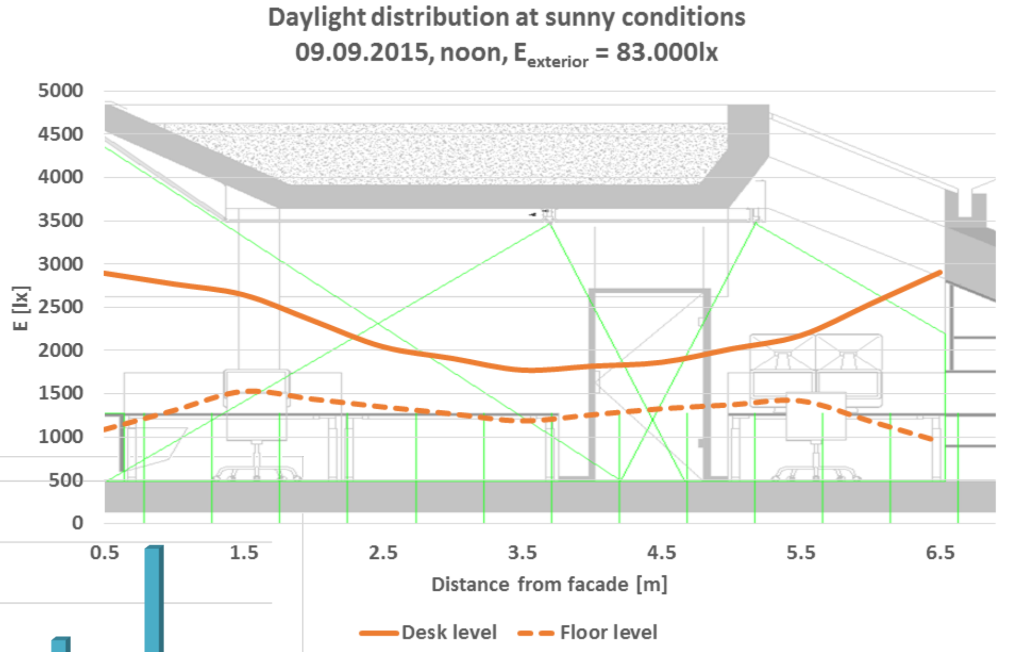


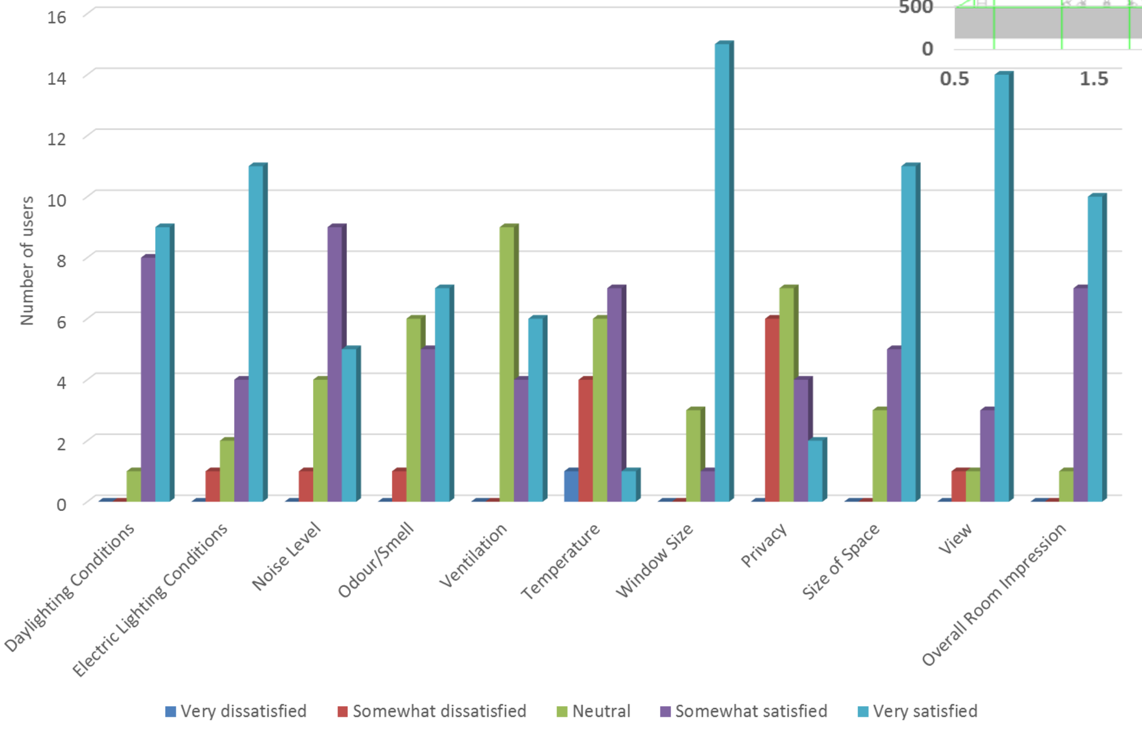
Raumgestaltung

Fallstudie: Bartenbach F&E Gebäude, Aldrans



Fallstudie: Bartenbach F&E Gebäude, Aldrans





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Light tubes

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Light tubes

Tubular daylighting systems, or light tubes, are linear devices that channel daylight into the core of a building. They consists of a linear light transport unit, a tube, with some device for collecting natural light at the outer end and a means of distribution of light within the interior at the inner end. Tubular daylighting systems are especially suitable for windowless and underground places, in which daylight contribution is desired and a view out not required.

Evaluation:

- Energy efficiency
- Lighting quality
- Thermal benefits
- Operational costs

Click on category to view detailed results

Media

light tube

light tube

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Highlights:

- Increased daylight contribution, with the subsequent benefits.
- Glare free light
- High installation costs, as a result of the redesign of the building envelope
- No view out

Performance of light tubes

Tubular daylighting systems, light pipes or light tubes have been developed to increase daylight contribution in windowless places and thus improve lighting conditions and reduce energy consumption at the same time. Light tubes are suitable for a variety of different types of buildings such as industry plants, underground car parks, supermarkets or homes and are most often used for roof applications.
A typical light transmittance of the system is 0.60-0.70 and the effective g-value is 0.20-0.35. Under overcast sky conditions the light transmittance is low due to multiple reflections. Light tubes can be applied in all climates, but might be preferred in sunny climates while giving a rather dull lighting under overcast skies. Light tubes deliver glare free light, but typically cannot adjust for the dynamic changes of exterior illuminance, resulting in light level fluctuation. The biggest flaw of the tubular daylighting system is the lack of view out. Some products offer an adaptor to adjust the daylight contribution in the room, or include LED technology to provide additional light from the same fixture when available daylight is insufficient. The installation cost for light tubes are high, as the building envelope has to be perforated. The running costs are moderate, as light tubes need cleaning from time to time. In comparison to electric lighting installations, the total cost of ownership (€/Mlm.hr, per year) for useful light on the work plane is better for light tubes and skylights then for electric lighting installations (Fontoynont 2008).

References:

Fontoynont, M. (2008) Long term assessment of costs associated with lighting and daylighting techniques. Light and Engineering 16(1):19-31.

Kim, J. T., Kim, G. (2010) Overview and new developments in optical daylighting systems for building a healthy indoor environment. Building and Environment, 45(2):256-269.

CIE (2012) CIE 173:2012 Tubular Daylight Guidance System. Vienna: Commission Internationale de l'Eclairage.

Aizenberg, J. B. (2013) Hollow light guides: 50 years of research, development, manufacture and application - A retrospective and looking to the future. Light & Engineering, 21(4):21-25.

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IEA survey on methods and tools

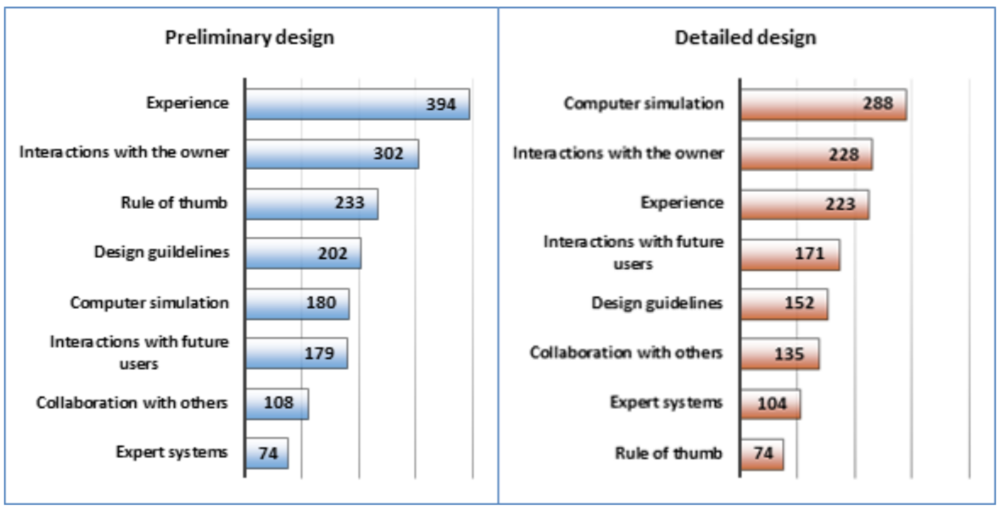
IEA survey on methods and tools

@Survey-MainDescription

- List of Questions
- Question 1
- Question 2
- Question 3
- Question 4
- Question 5
- Question 6
- Question 7
- Question 8
- Question 9
- Question 10
- Question 11
- Question 12
- Question 13a

Question 5

In the following table, please indicate for each design phase, the type of tools or methods you use for DAYLIGHTING design (multiple answers possible).



Ranking of the tools and methods used for daylighting design.

In preliminary design, the respondents mainly rely on their own experience, rules of the thumb and design guidelines. Computer simulations are less considered at this stage, but are essential at the detailed design phase. This may reflect the fact that common computer tools are too detailed and not adapted to preliminary design. Interactions with the owner remain important throughout the whole design process. Expert systems are not frequently used for the daylighting design.

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Case study viewer - Bartenbach

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- Project Description
- Building Description
  - Research and Development Office
    - Space Description
      - Daylighting
      - Electric Lighting
    - Performance Evaluation
      - Costs
      - Lighting Energy Use
      - Lighting Environment
      - User Perspective
- Overall conclusions

Main Retrofit Objectives

- Comprehensive retrofit of R&D department office
- Improvement of daylight illumination
- Dynamic and biologically active artificial lighting
- Implementation of integral control
- Interior redesign

Main Objectives For Retrofit Of Electric Lighting

- Installation of innovative, energy-efficient LED solution
- Dynamic lighting concept through high variability in illuminance levels
- Variable color temperature to account for biological effects of lighting

Main Objectives For Retrofit Of Daylighting

- Solution for optimized daylighting throughout the year
- Sun protection at south facade for reduced solar gains in summer
- Enhanced view to the outside
- Manually adjustable glare protection

Main Objectives For Retrofit Of Controls

- Maximized energy savings and user comfort
- Independent control for every work area
- Integration of daylight responsive control for electric lighting
- Integration of presence detectors

Project Description

The **Bartenbach R&D office** is a single storey building located in the countryside close to Innsbruck, Austria. The building was constructed in 1997 as annex to the existing office building. The building has a large south oriented facade, a smaller facade to the west and skylights in the northern pitch roof area.

The office was used as a testbed for various in-house developments of artificial lighting systems and daylighting systems over the last 15 years. As the installed solutions and thus also the resulting interior conditions were different in every segment, the company decided to refurbish the building to provide a cutting-edge office space. The retrofit was implemented in spring/summer 2015 and now provides an integrated day- and artificial lighting control for dynamic and biological active lighting with innovative artificial and daylight solutions.

Vielen Dank für Ihre Aufmerksamkeit!

Fragen?