Daylight driven and user centered lighting and energy management

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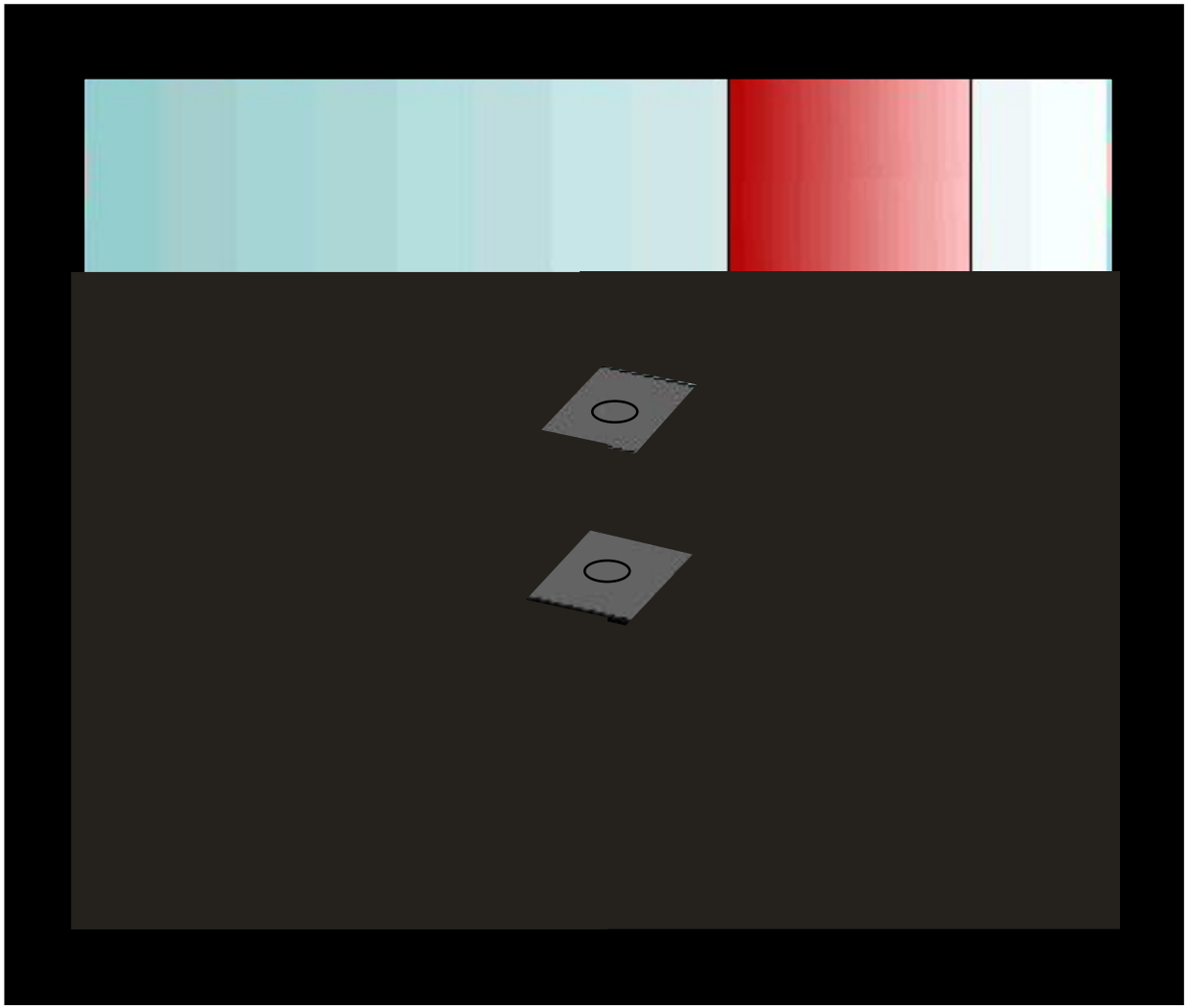
ADVANCED
BUILDING SKINS

- **iNSPiRe**
  Refurbishment of residential and tertiary buildings

- **IEA SHC Task 56**
  Building Integrated Solar Envelope Systems for HVAC and lighting

Light and information

Seeing is a mental process



Physics

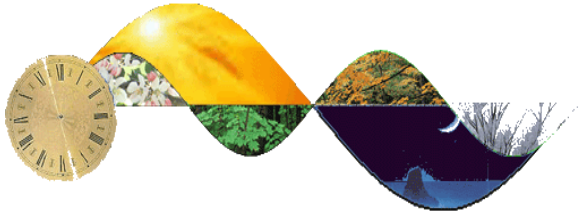
Psychology

Impact of light on humans

visual response

non-visual response

- visual conditions to ‚see‘
- mood/emotions
- mental performances
- physical processes
- well-being, health



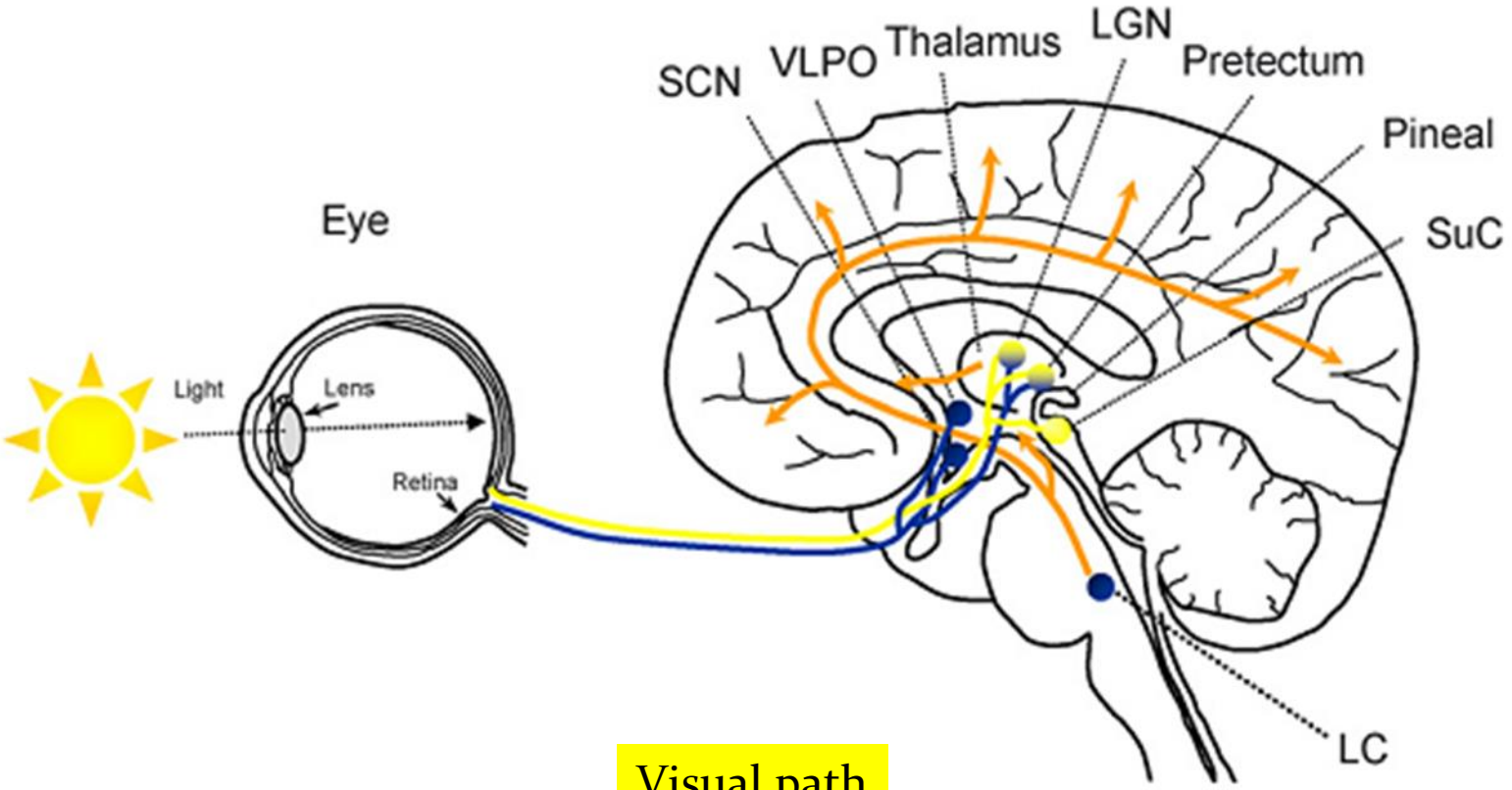
LIGHT is the most important timer!

You need light to ……..

- See (visual perception)…..
- feel good (emotion, well-being)…..
- create special atmospheres, appearances, (emotion)…..
- enjoy the beauty (emotion)…..
- trigger your circadian rhythm (health)…..
- create preventive and therapeutic effects (long term health effects))…..
- relax and to activate (short term health effects)…..
- optimize working conditions (>performance)
- Etc.

Most effects of light are unconscious and not perceivable !

Neurophysiological background



Identified non-visual light effects

Modification of

- **Circadian (physiological) parameters** (melatonin, cortisol, core body temperature, heart rate)
- **Feeling of Sleepiness / Alertness**
- **Cognition** (attention, memory, problem solving)
- **Mood**

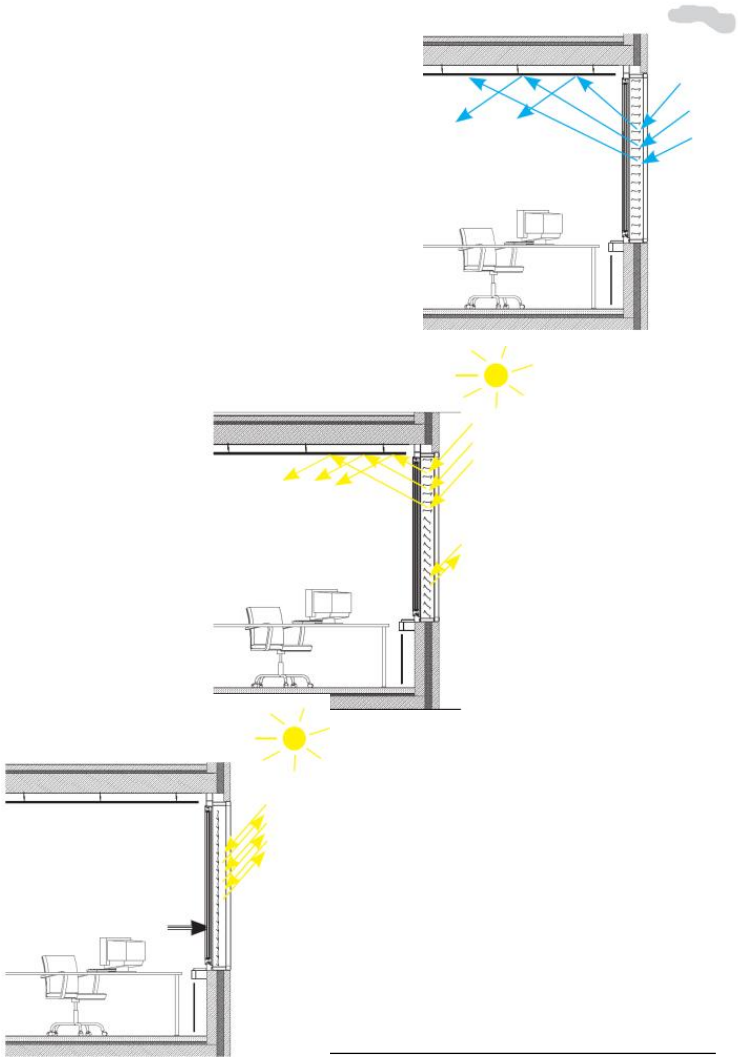
daylighting requirements

visual

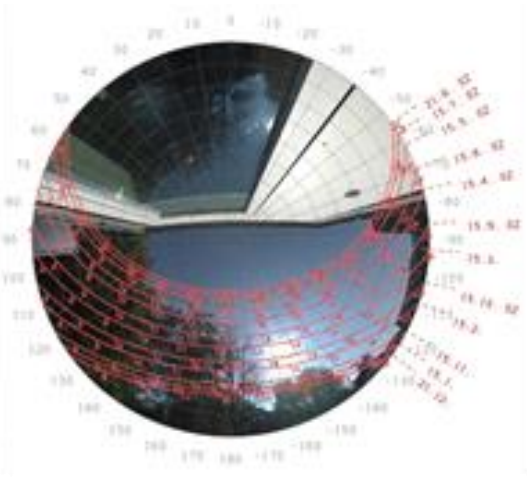
- **amount of daylight/daylight distribution:**
  guide daylight into the depth of the building
- **glare protection:**
  provide visual comfort
- **view to the outside:**
  allow a good contact to the outside
- **Non-visual effects:**
  Sleepiness / Alertness (circadian)
  Cognition
  Mood

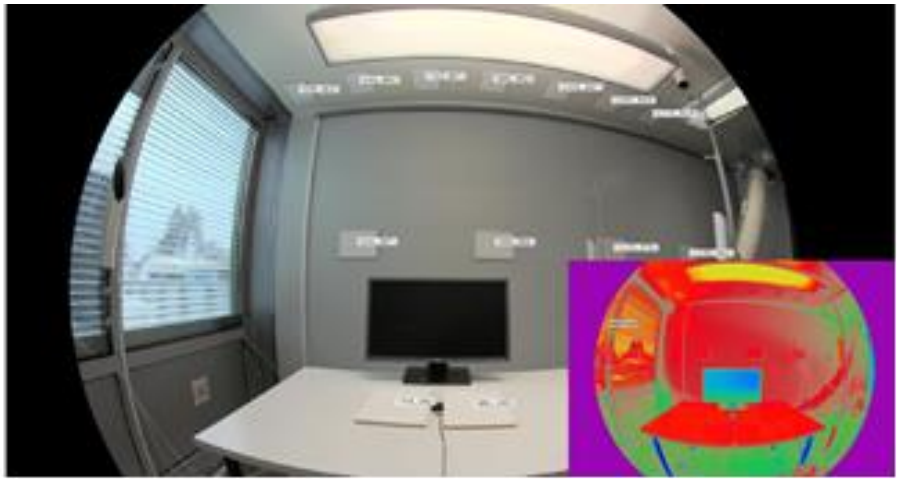
energetic

- **shade the solar heat in summer**
- **provide solar gains in winter**



Integrated lighting control scheme





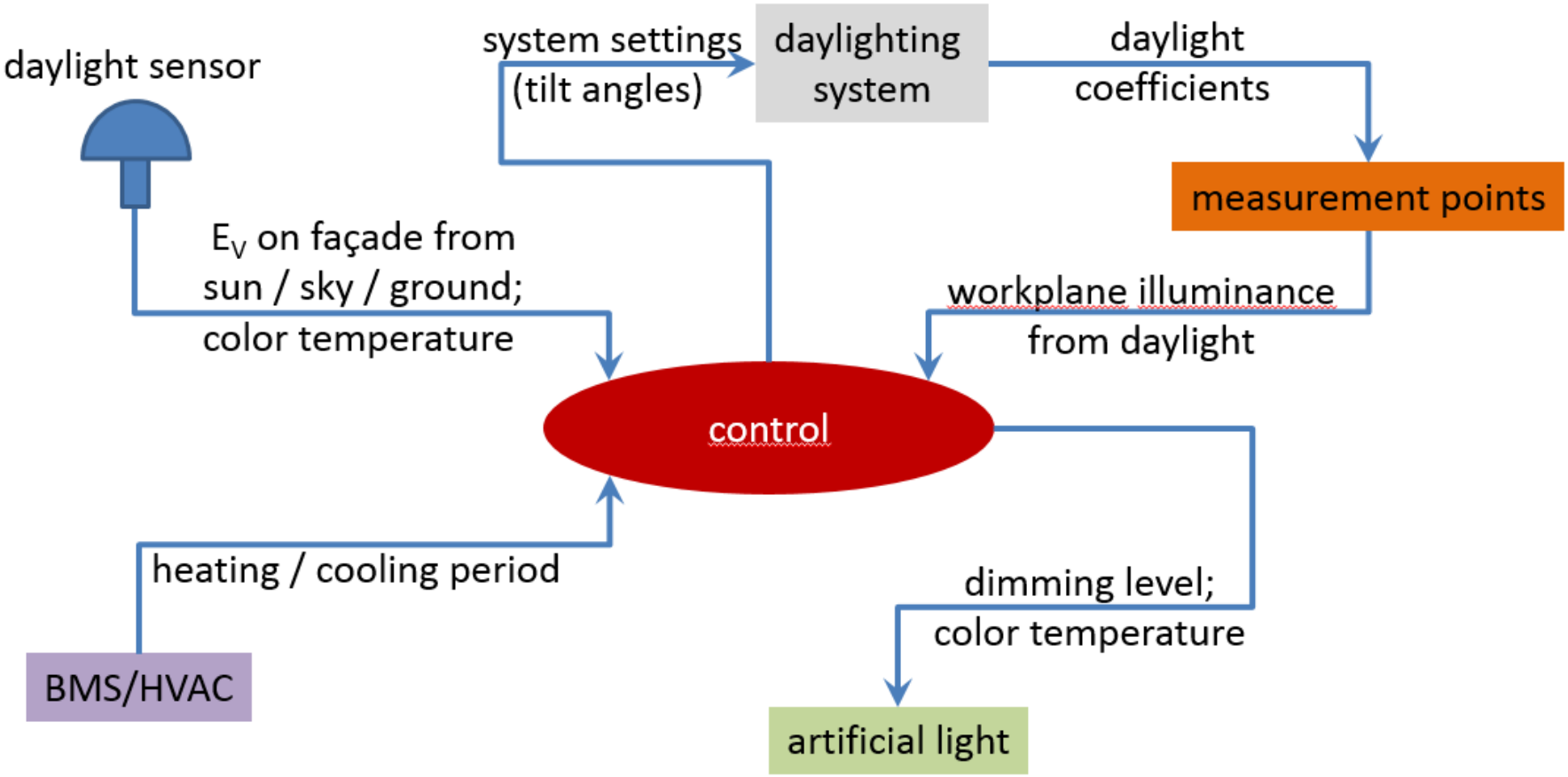
Need for an integral control for day- and artificial light

Consideration of

- Visual and melanopic needs
- Intelligent sensor technology
- Interface human – machine

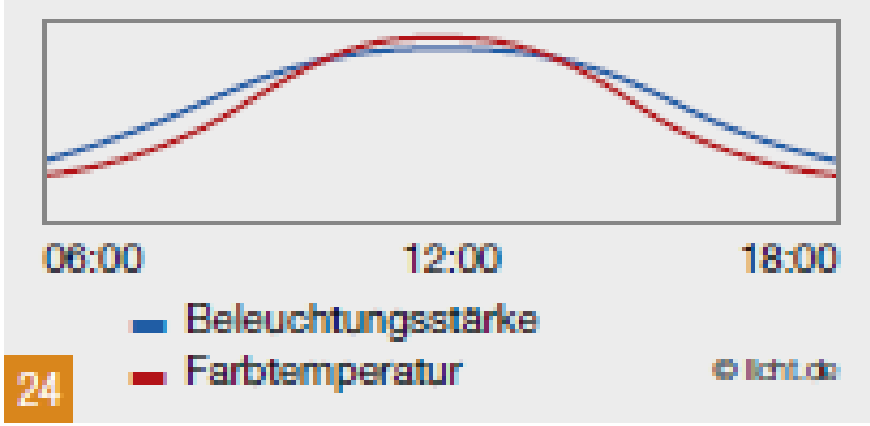
- Energy demands

Integrated lighting control scheme

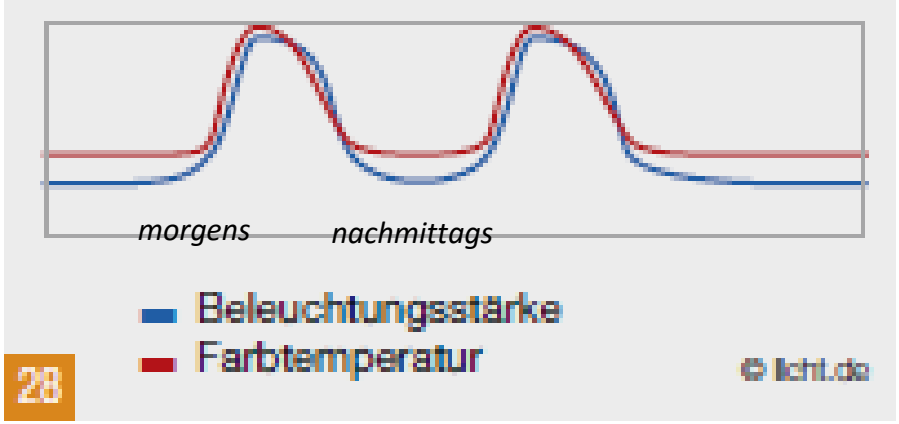


Circadian light: colour temperature variation

Daylight oriented



Intervention oriented
(activation)



Control specifications

Visual Criteria:

- mean window luminance ≤ 1000 cd/m²
- maximal window luminance ≤ 3000 cd/m²
- Illuminance at eye ≤ 1000 lux

Control specifications

Emotional criteria:

Evaluation of look through

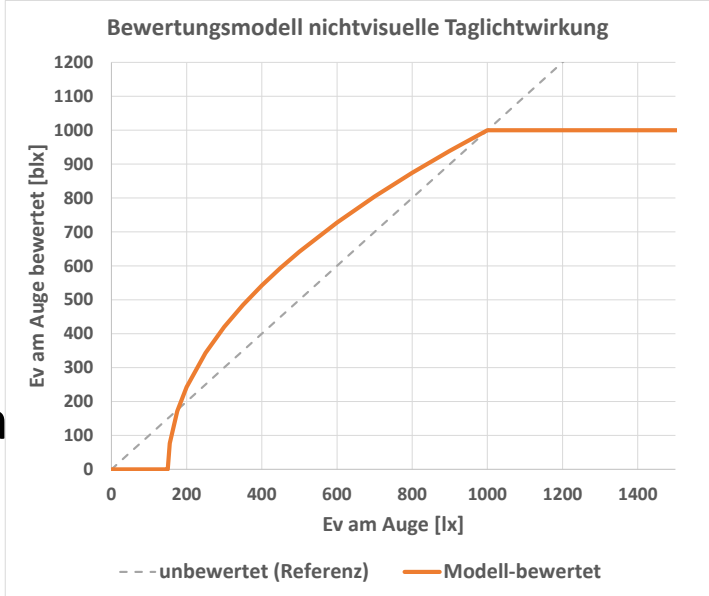
(e.g. acc. DIN 14501 oder Konstantzos et al., 2015)

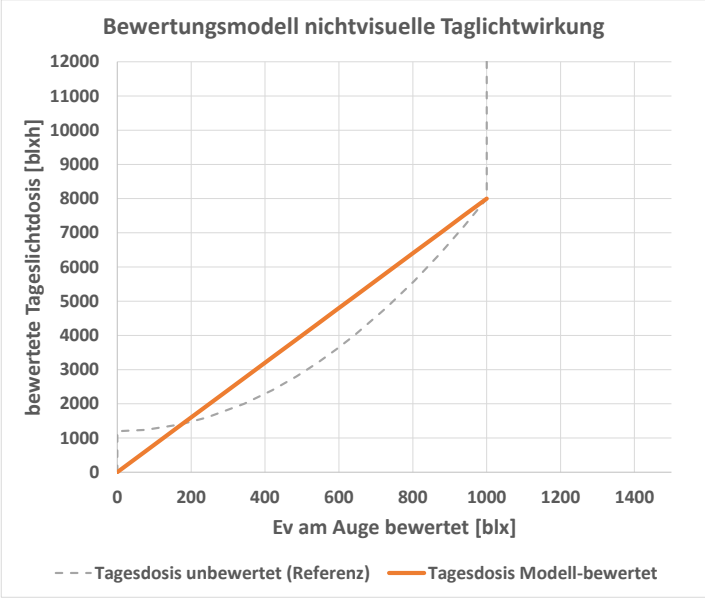
Control specifications

Non-visual criteria:

- Vertikal illuminance at eye evaluated with model

- Weighted light dose:
  aim: D ≥ 5000wlxh
  (weighted lux * hours)





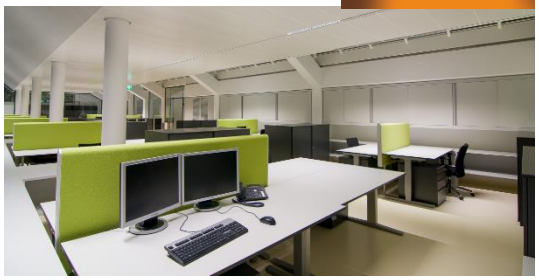
Bartenbach R&D Office, Aldrans, AT

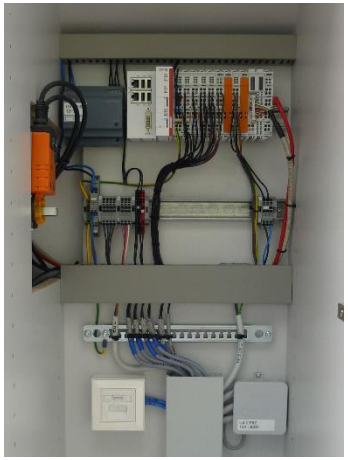
Comprehensive retrofit of office: daylight solution, artificial lighting solution, control, interior redesign

Bartenbach R&D Office, Aldrans, AT

Daylight solution: exterior louvers with varying distance between slats optimized for location, additional screen for luminance control

Artificial lighting solution: architecture integrated, max. 1250lx, 14W/m^2 installed, @ 500lx < 6W/m^2 , CCT 2200K – 5000K



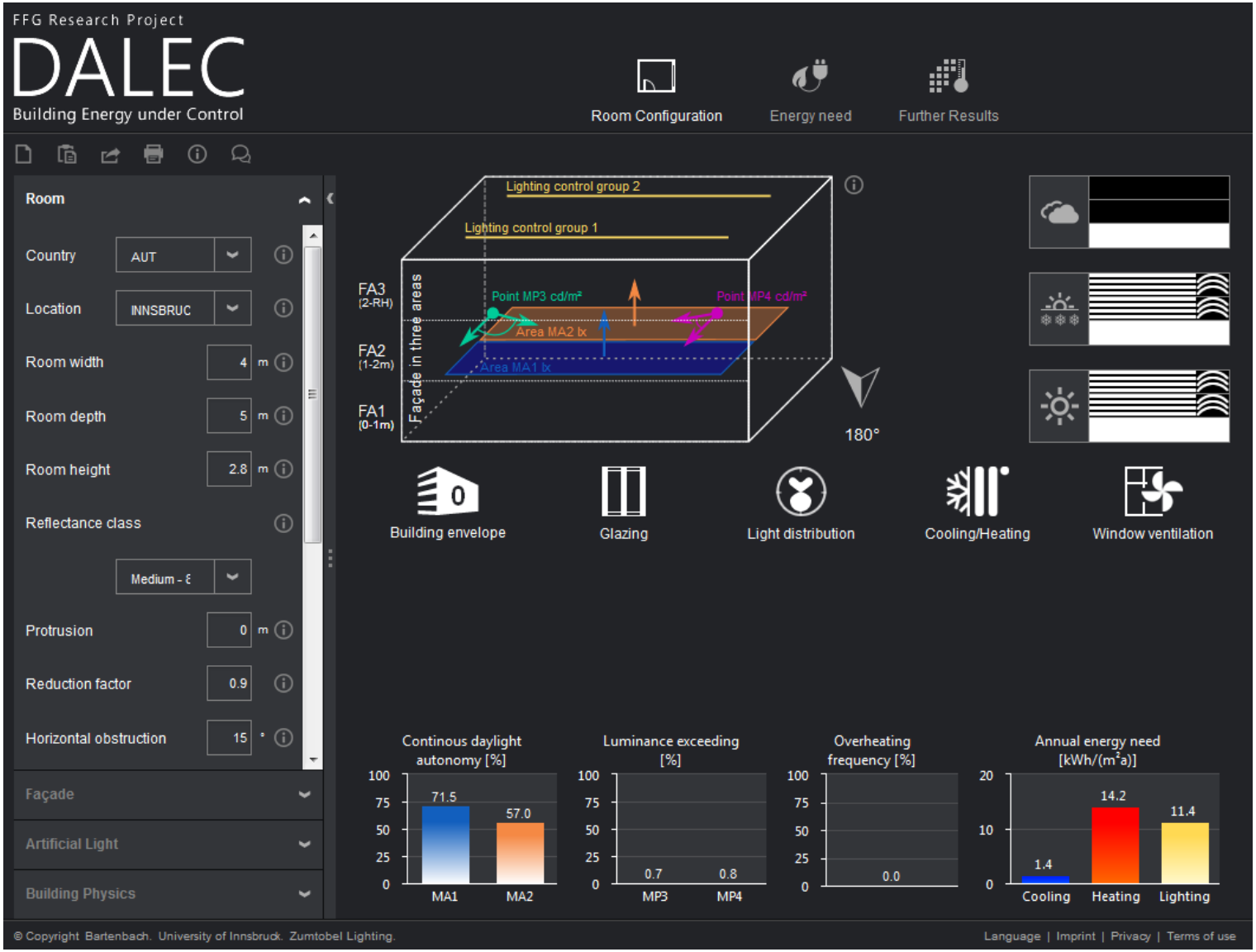


Control: sensors for occupancy, workplane and exterior illuminance, wind speed, temperature

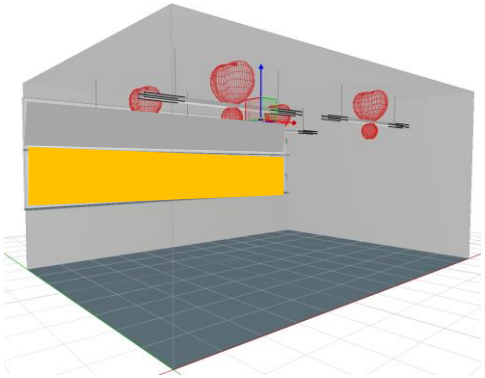
Interior design: redesign of interior surfaces, acoustical ceiling, acoustical panels

DALEC Online Tool

www.dalec.net



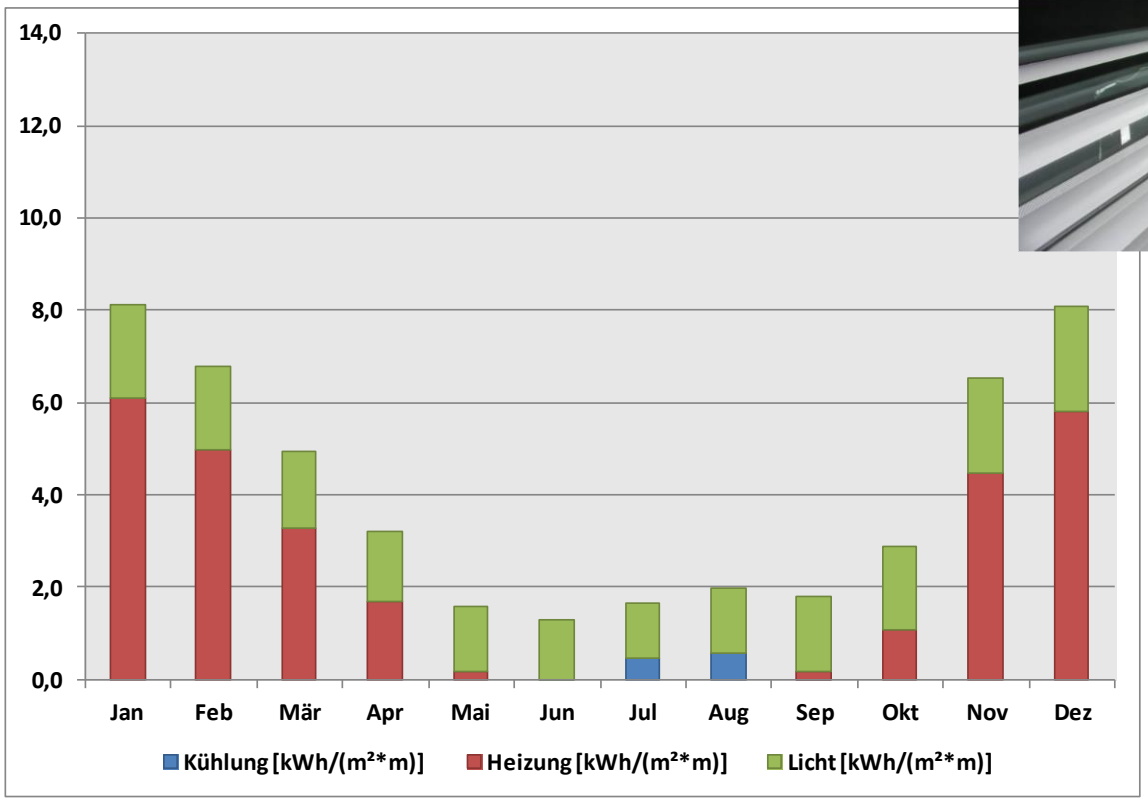
Daylight and Energy



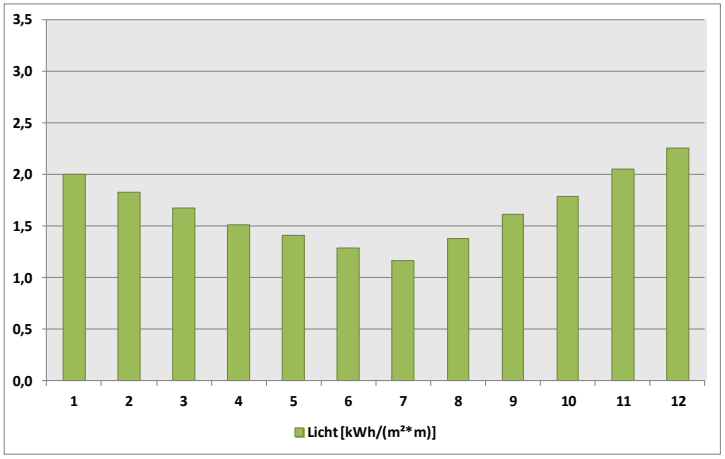
Außenraffstore (45°)
im Sichtbereich

g-Wert$^{\perp}$: 22%

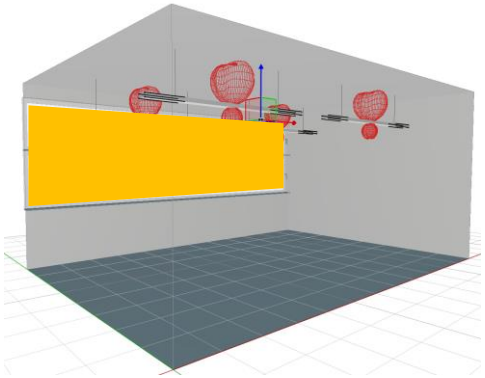
$\tau_{vis}{}^{\perp}$: 12%



	cooling	heating	light
kWh/[m²a]	1,2	27,8	20,0



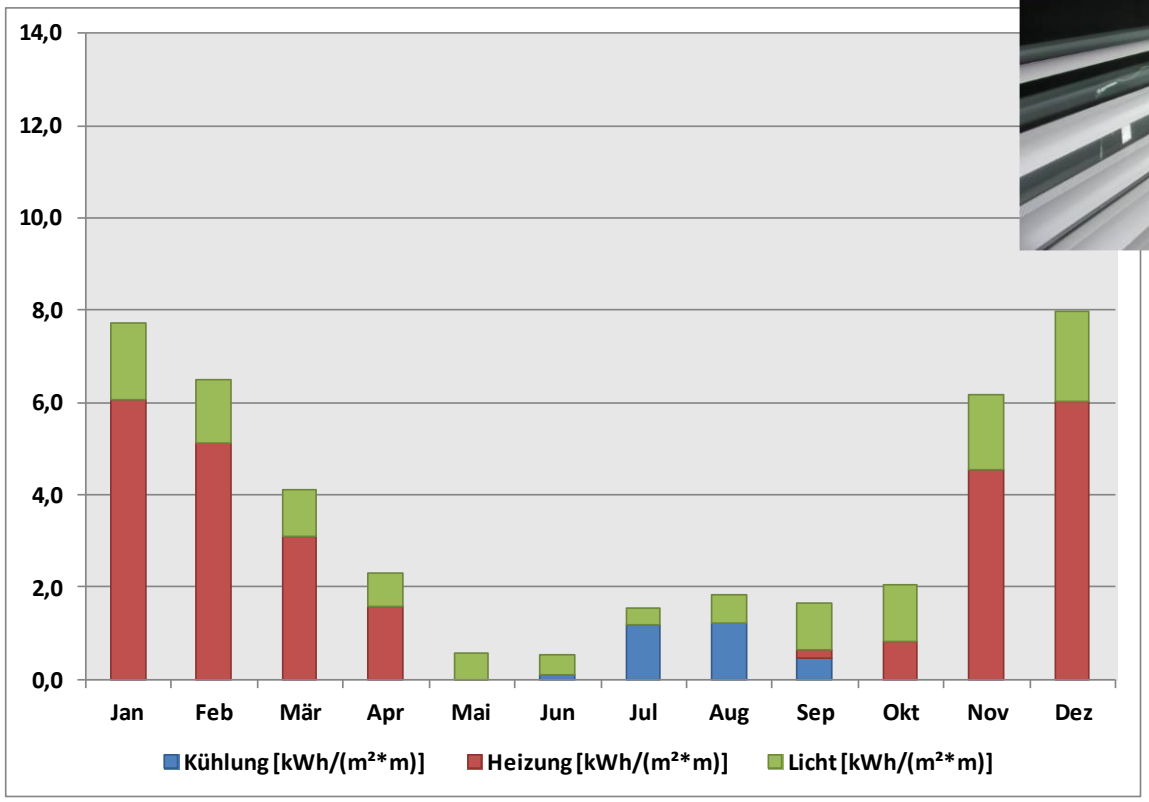
Daylight and Energy

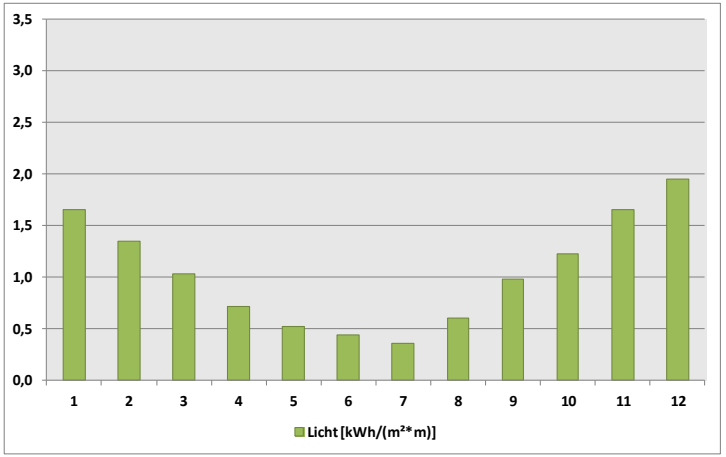


Außenraffstore (45°) oben & unten

g-Wert$^{\perp}$: 22%

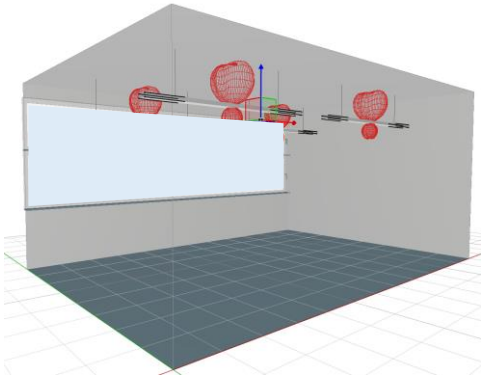
$\tau_{vis}{}^{\perp}$: 12%





	cooling	heating	light
kWh/[m²a]	3,1	27,6	12,5

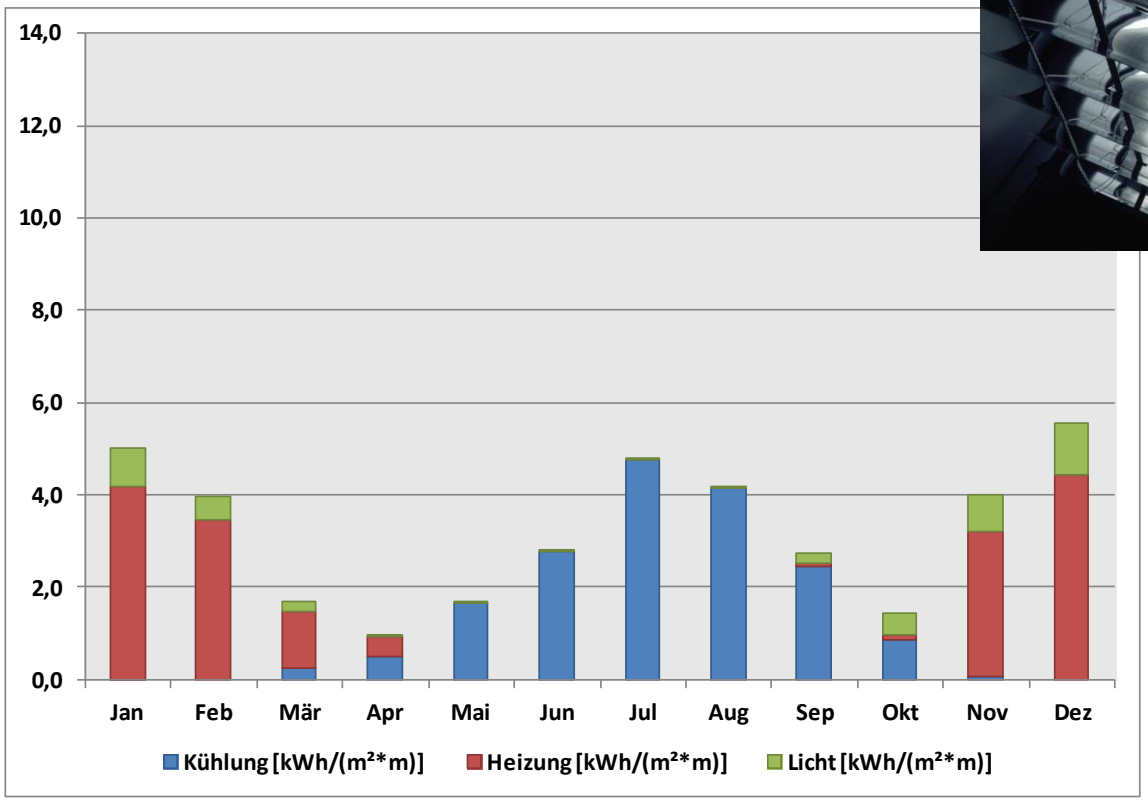
Daylight and Energy



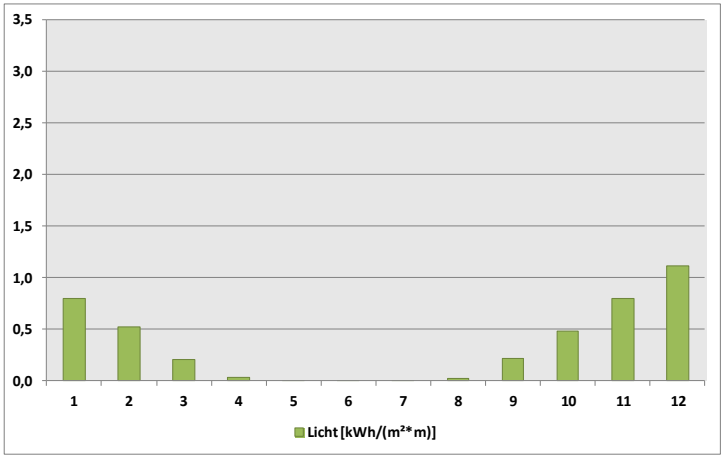
Innenliegende Umlenklamelle (0°)

g-Wert$^{\perp}$: 44%

$\tau_{vis}{}^{\perp}$: 57%



	cooling	heating	light
kWh/[m²a]	17,7	17,0	4,2



Conclusions

Chances

- **Integrated design and control** of daylight systems
  - Integration in BMS
  - Integration with artificial light

- increase building **energy efficiency** by
  - good daylighting (replace artificial light)
  - efficient sun shading (minimize cooling loads), e.g. block the heat while utilizing the light
  - solar gains when needed (use for heating)

Conclusions

Chances

- increase **visual and thermal comfort** by intelligent systems
    - avoiding glare and redirecting light into the room depth
    - blocking the heat and avoiding high indoor surface temperatures

- increase **health (non-visual) effects** by exploiting daylight
    - Optimizing circadian effects (light dosage)

Conclusions

CURRENT LIMITATIONS:

- **complex system architecture** which require a high background knowledge
- existence of **equivocal lighting control schemes** for lighting designers, and electrical engineers
- **restricted interoperability** of mostly proprietary lighting control hard- and software
- high investment and installation **costs**
- **confusing user interfaces** and troublesome user-lighting interactions
- sophisticated **maintenance** and high service costs

Conclusions

Risks:

- Open buildings create severe thermal and visual **comfort problems**
  - glare
  - high indoor surface system temperatures
  - overheating

- **Higher energy consumption** by
  - high solar gains (cooling loads)
  - bad shading practice and daylighting > need for artificial lighting and additional cooling

Future

- **scientific evidence** for non-visual light effects is quite weak at the moment
- more **resilient scientific basis** on non-visual light effects is needed
- By documenting the added value of biodynamic lighting, we will change the value of light from a cheap and thus unimportant issue to a **valuable part of our environment, life quality and life style**