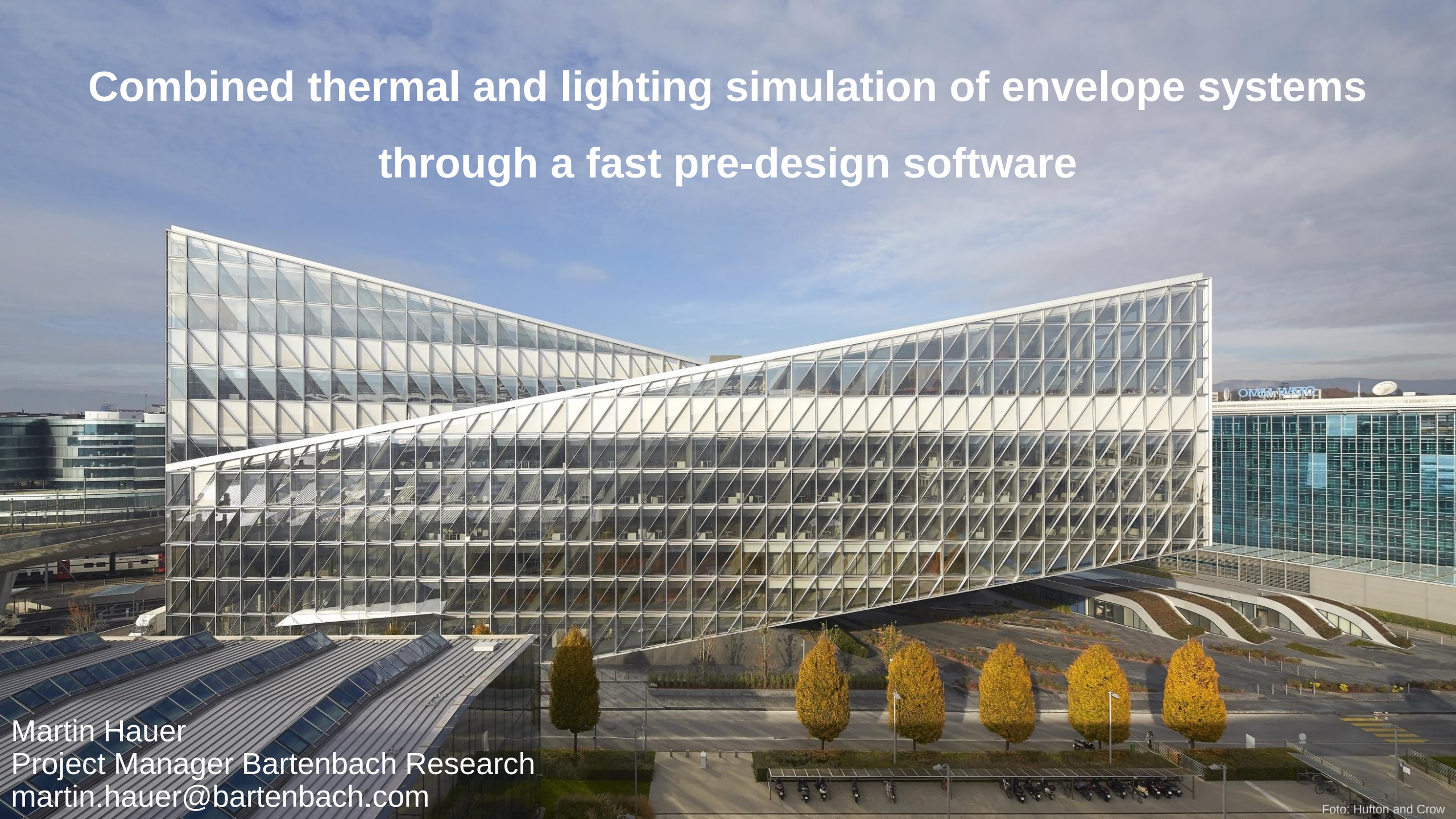
Combined thermal and lighting simulation of envelope systems through a fast pre-design software



Martin Hauer
Project Manager Bartenbach Research
martin.hauer@bartenbach.com

Foto: Hufton and Crow

Bartenbach

founded 1976 (Prof. Dr. h.c. Ing. Christian Bartenbach) Independent from manufacturers

90 employees, ca. 40 in lighting design

Location: Aldrans, Austria

More than 10.000 projects worldwide

DIVISIONS

Flexible planning and consulting teams for best solutions.

LIGHTING DESIGN

- Day & artificial lighting design
- Competition support
- Model construction & simulation
- Material- and colour consultation

LIGHTING SOLUTIONS

- Secured solution quality
- From the concept to the realisation
- Special and complex lighting applications Neutral and independent from the industry
- Latest state of research
- One point of contact
- Lighting control and Service

RESEARCH & DEVELOPMENT

- Light impact research on beings
- Product development for daylight & artificial light
- Energy performance analysis
- Optical design
- Photometry

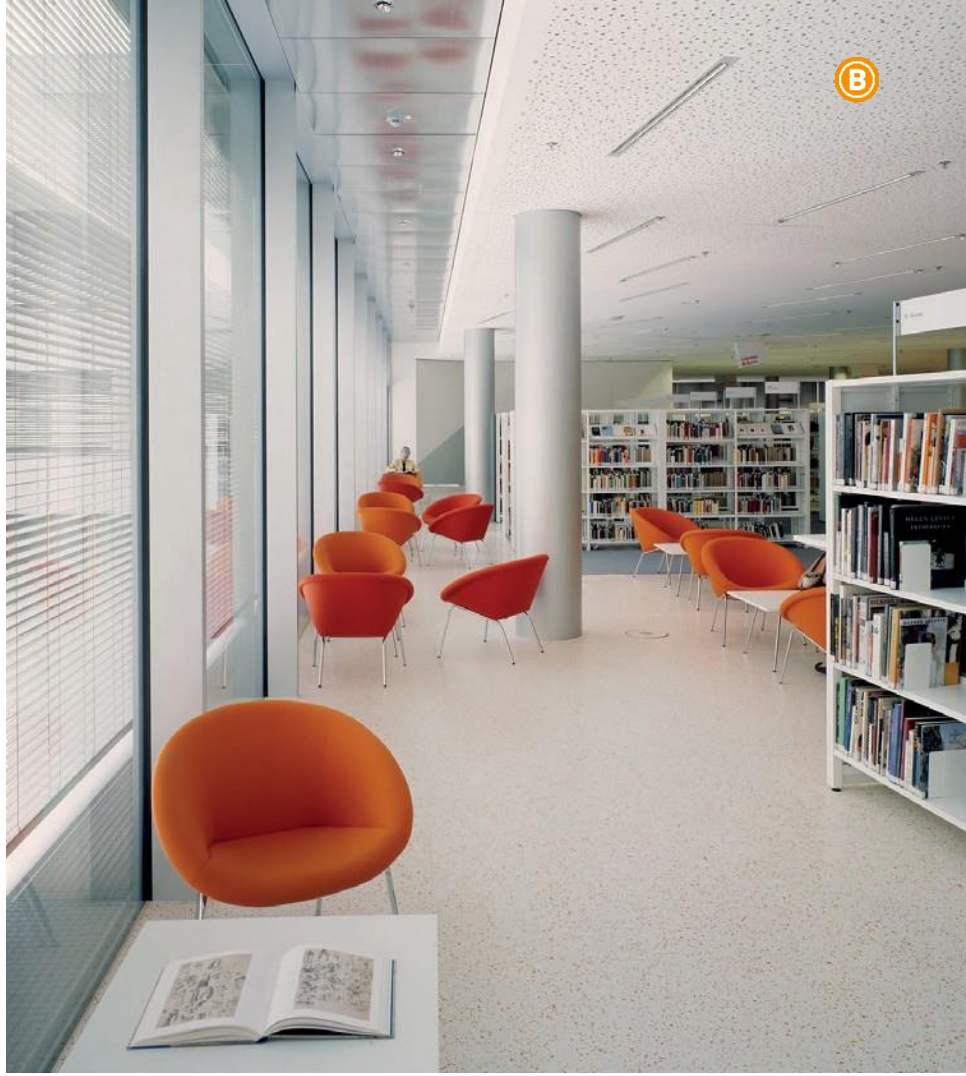
ACADE MY

- Academic symposia
- Seminare und Workshops
- Light experience worls

Human beings are creatures of light. Light shapes our daily rhythm, it influences our moods
and our ability to perform. The effect light has on people is one
of the core issues at Bartenbach.

Daylight requirements

relevant – and concurring – criteria



Visual

- **Daylight - Level:** guiding daylight into buildings
- **Daylight - Distribution:** homogeneous room distribution
- **Glare protection:** ensure visual comfort
- **View to outside:** relation towards outside

Energy

- **Overheating** avoid during cooling periods in summer
- **Solar gains** use to reduce heating loads in winter

Non-visual

- **Perception and Mood:** attention, concentration, memory
- **Circadian Rhythm:** hormone, heart rate, body temperature

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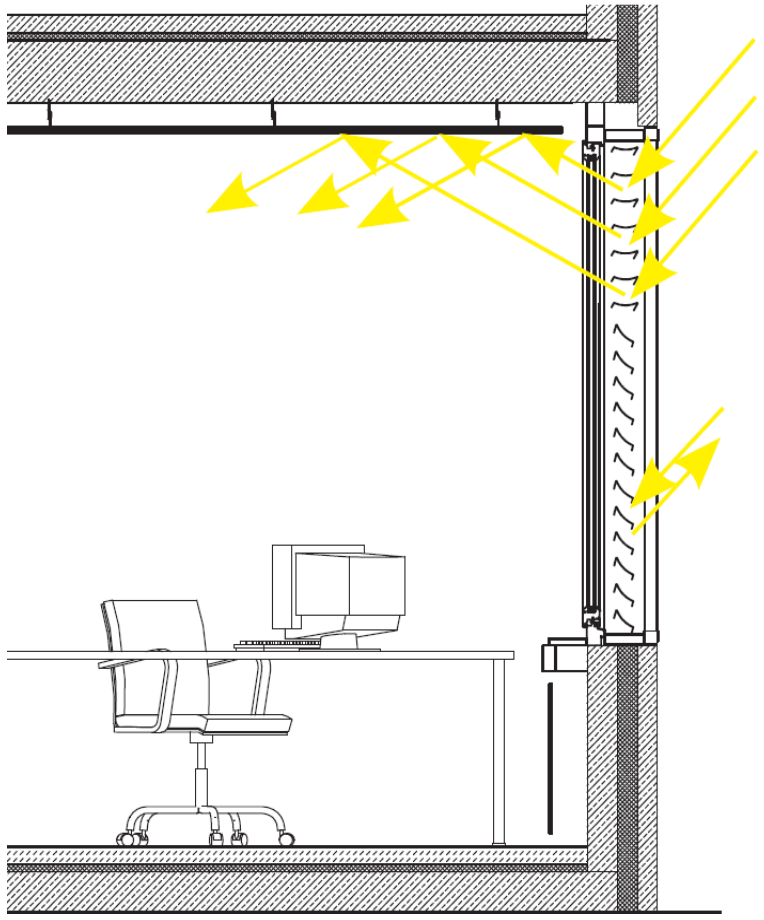
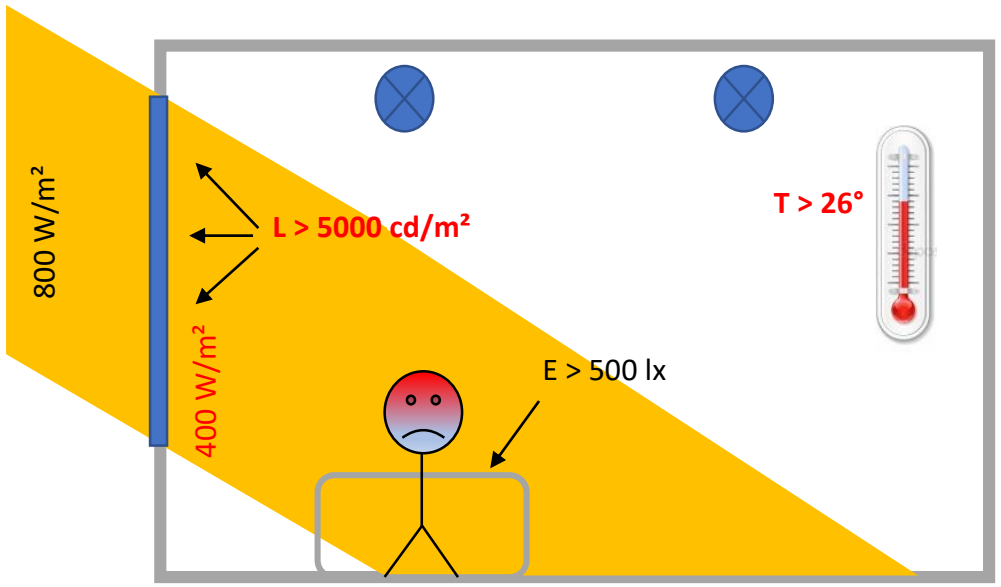


Integral Façade control

Solar control vs. Daylight utilization

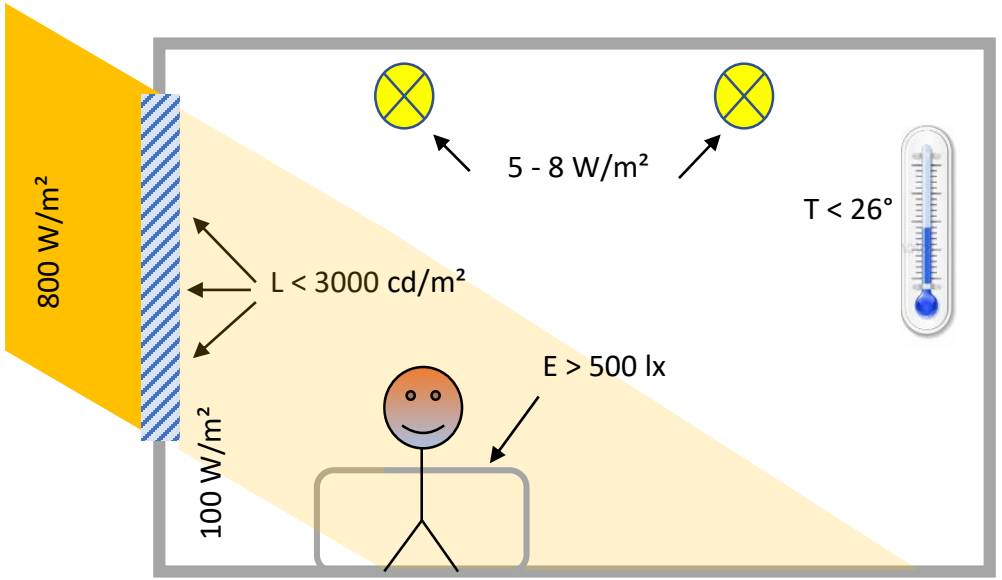
Without solar control:

- Visual discomfort
- Thermal stress
- High cooling loads

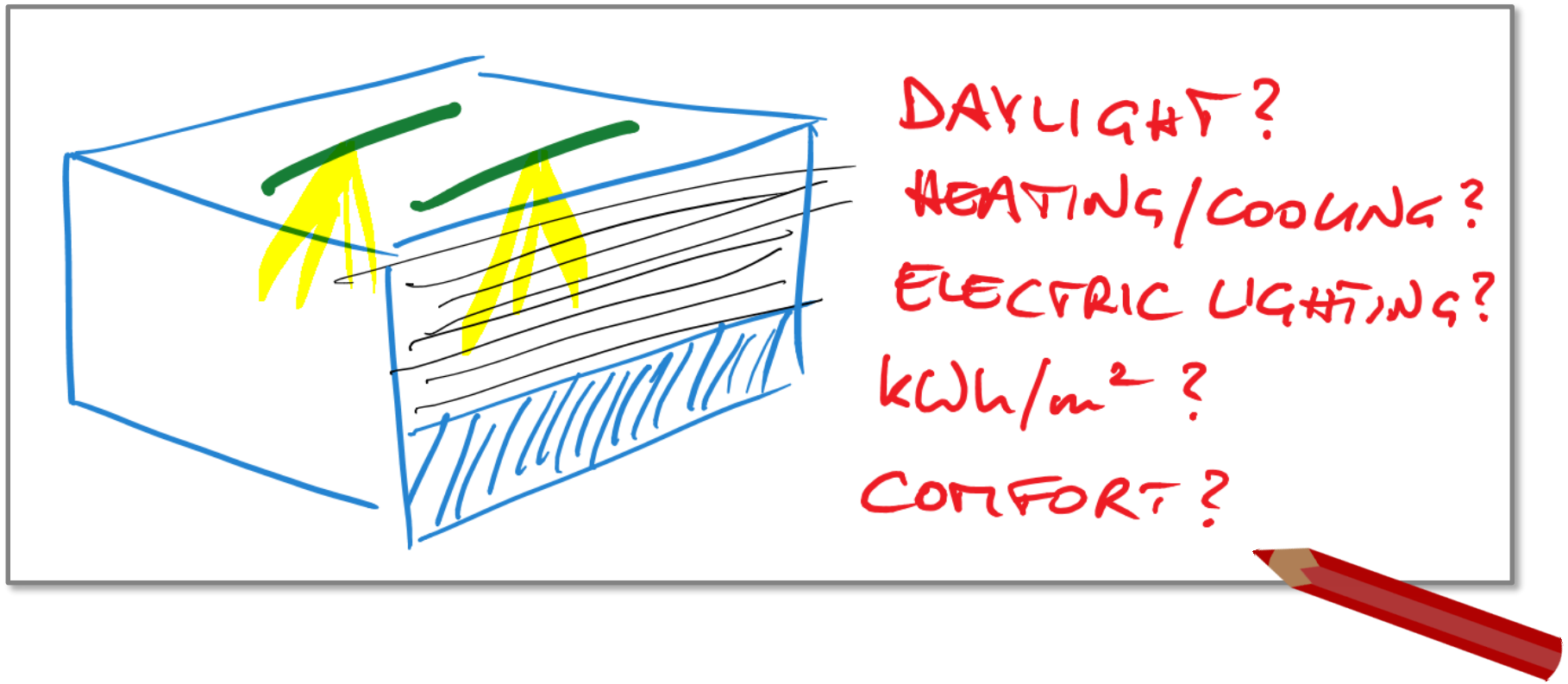


Using shading systems:

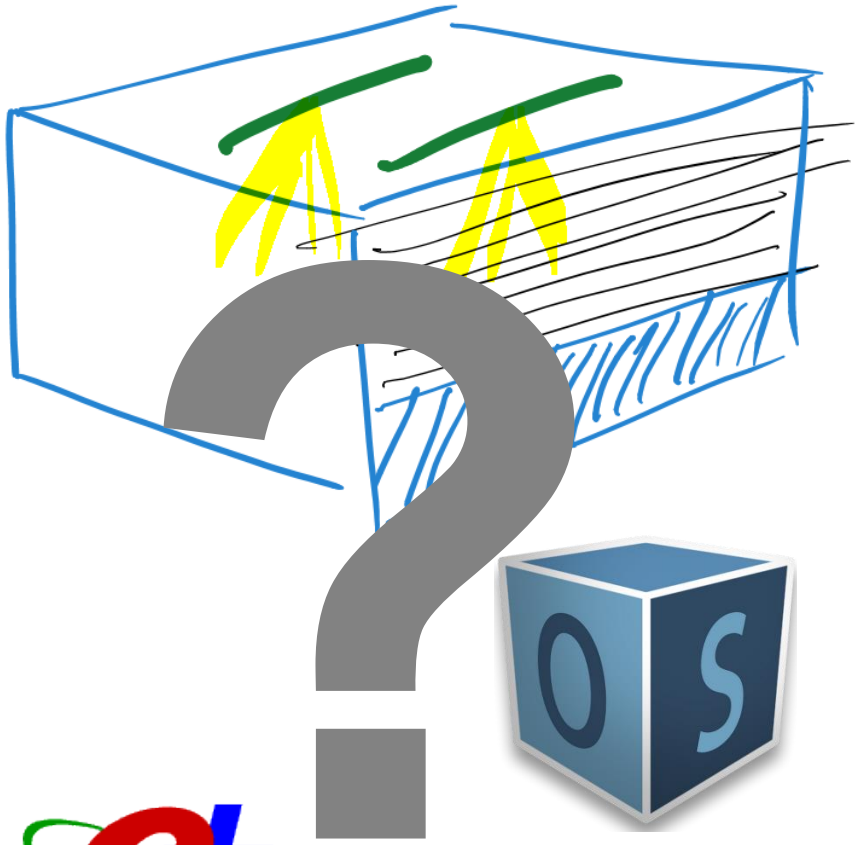
- Glare protection
- Reducing solar gains
- High artificial light loads



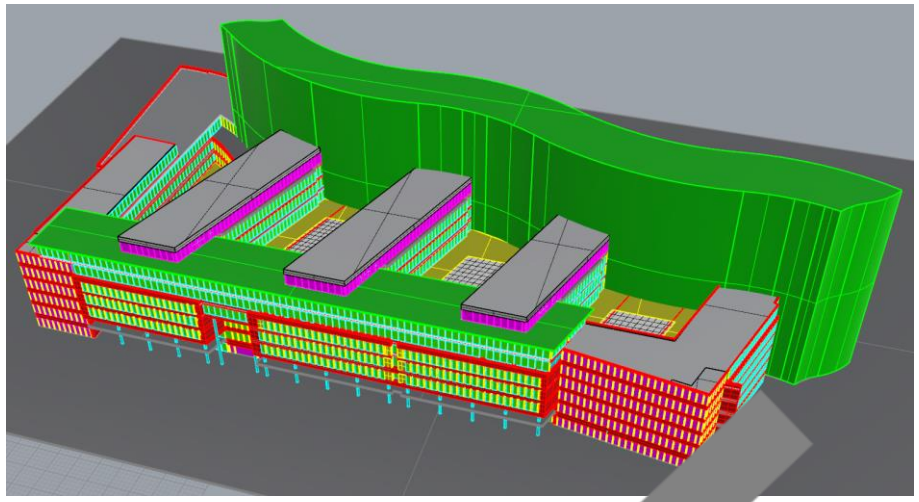
Motivation


DAYLIGHT?
HEATING/COOLING?
ELECTRIC LIGHTING?
kWh/m²?
COMFORT?

Motivation



DIALux
made by DIAL.



RADSITE | radiance-online.org

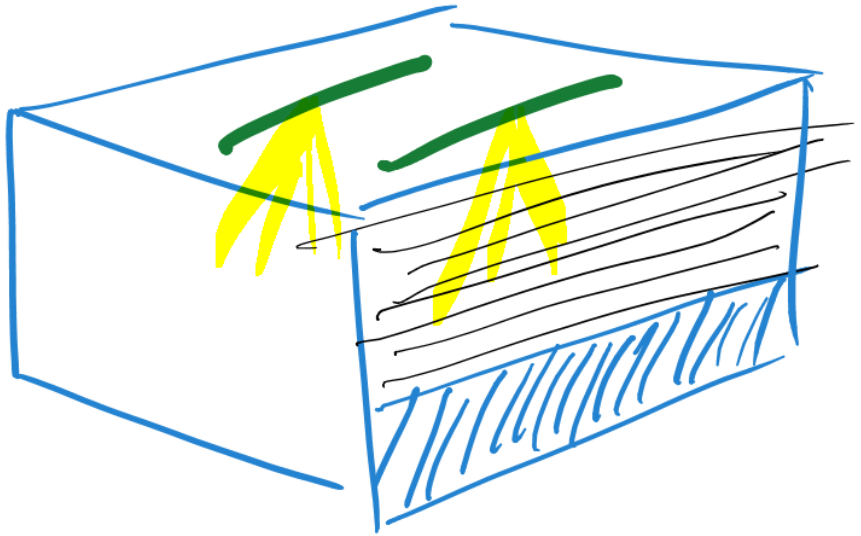
EnergyPlus

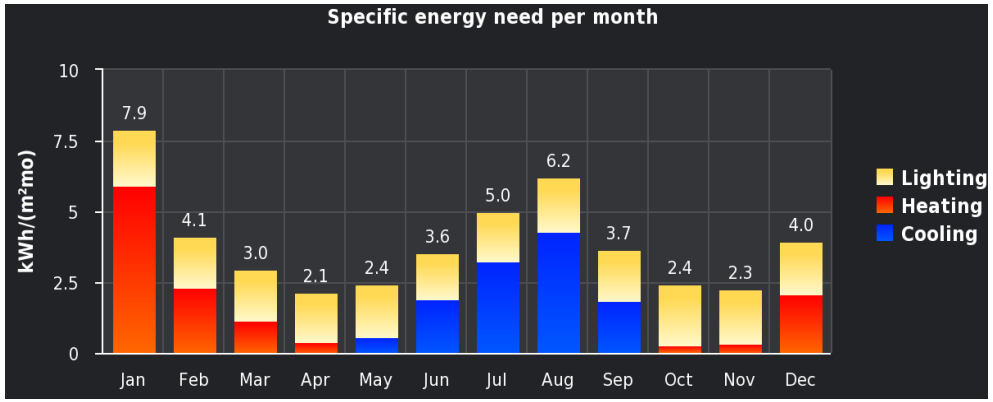
RELUX®
light simulation tools

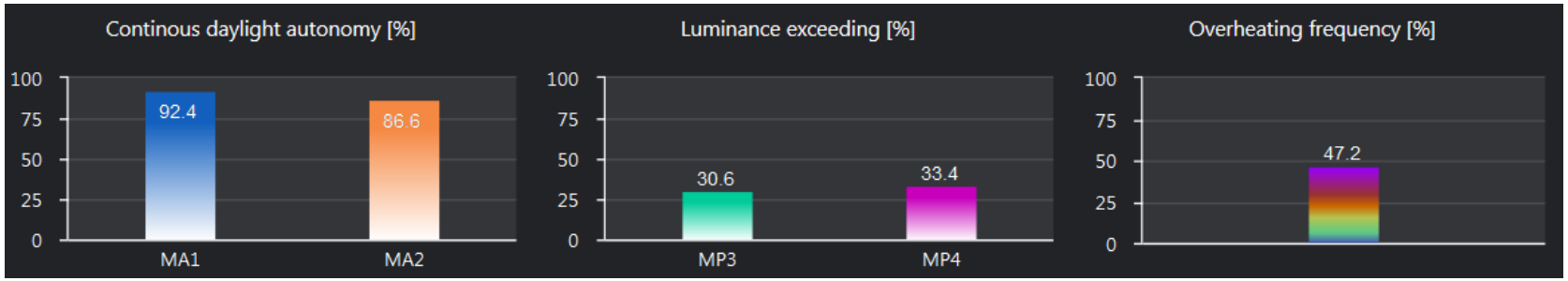
TRNSYS 17

AGi32
lighting software
by Lighting Analysts

Vision




Specific energy need per month
kWh/(m²mo)
10
7.5
5
2.5
0
7.9
4.1
3.0
2.1
2.4
3.6
5.0
6.2
3.7
2.4
2.3
4.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Lighting
Heating
Cooling


Continous daylight autonomy [%]
100
75
50
25
0
92.4
86.6
MA1
MA2
Luminance exceeding [%]
100
75
50
25
0
30.6
33.4
MP3
MP4
Overheating frequency [%]
100
75
50
25
0
47.2

DALEC Online Tool

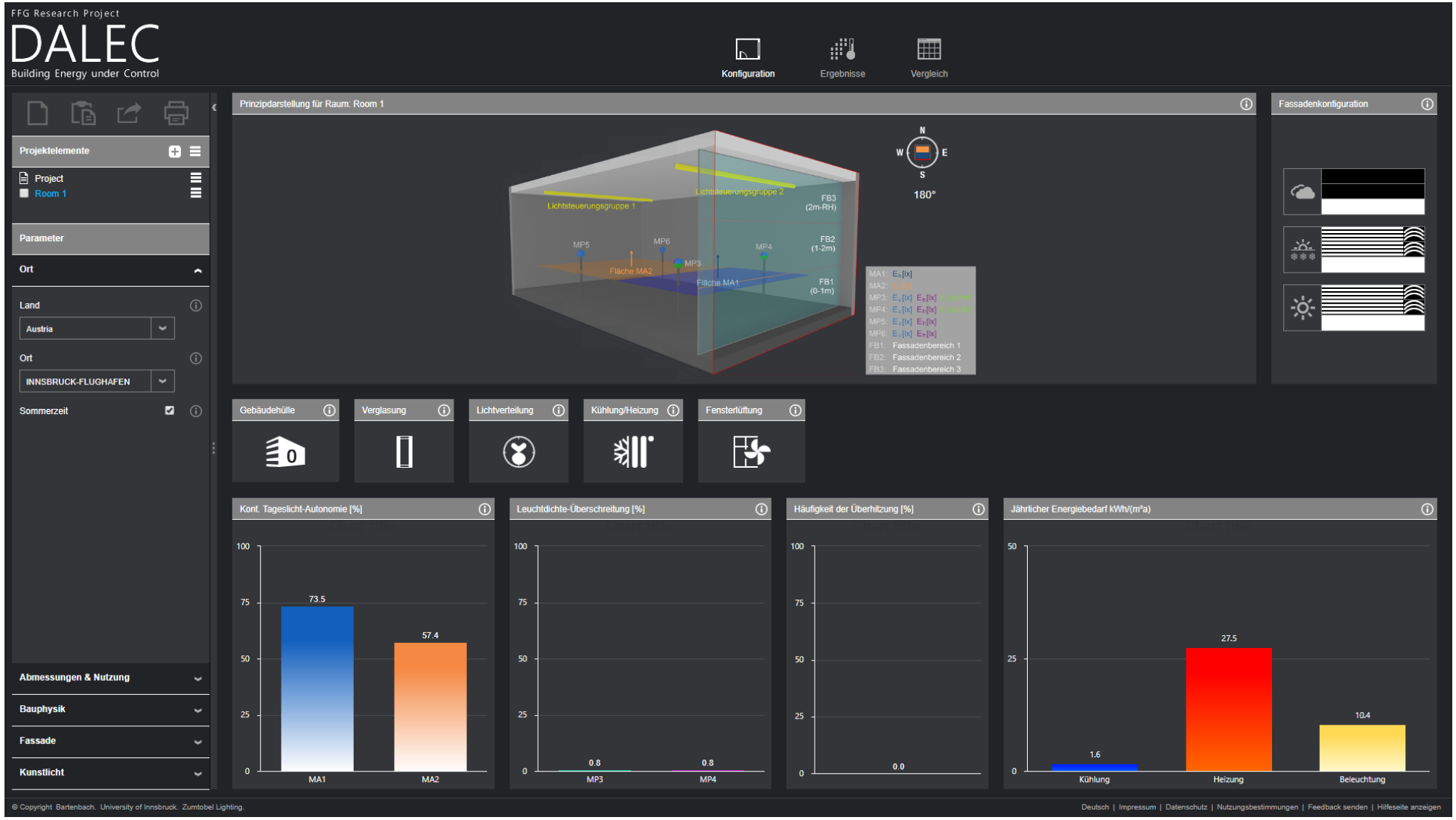
Day- and Artificial Light with Energy Calculation

www.dalec.net

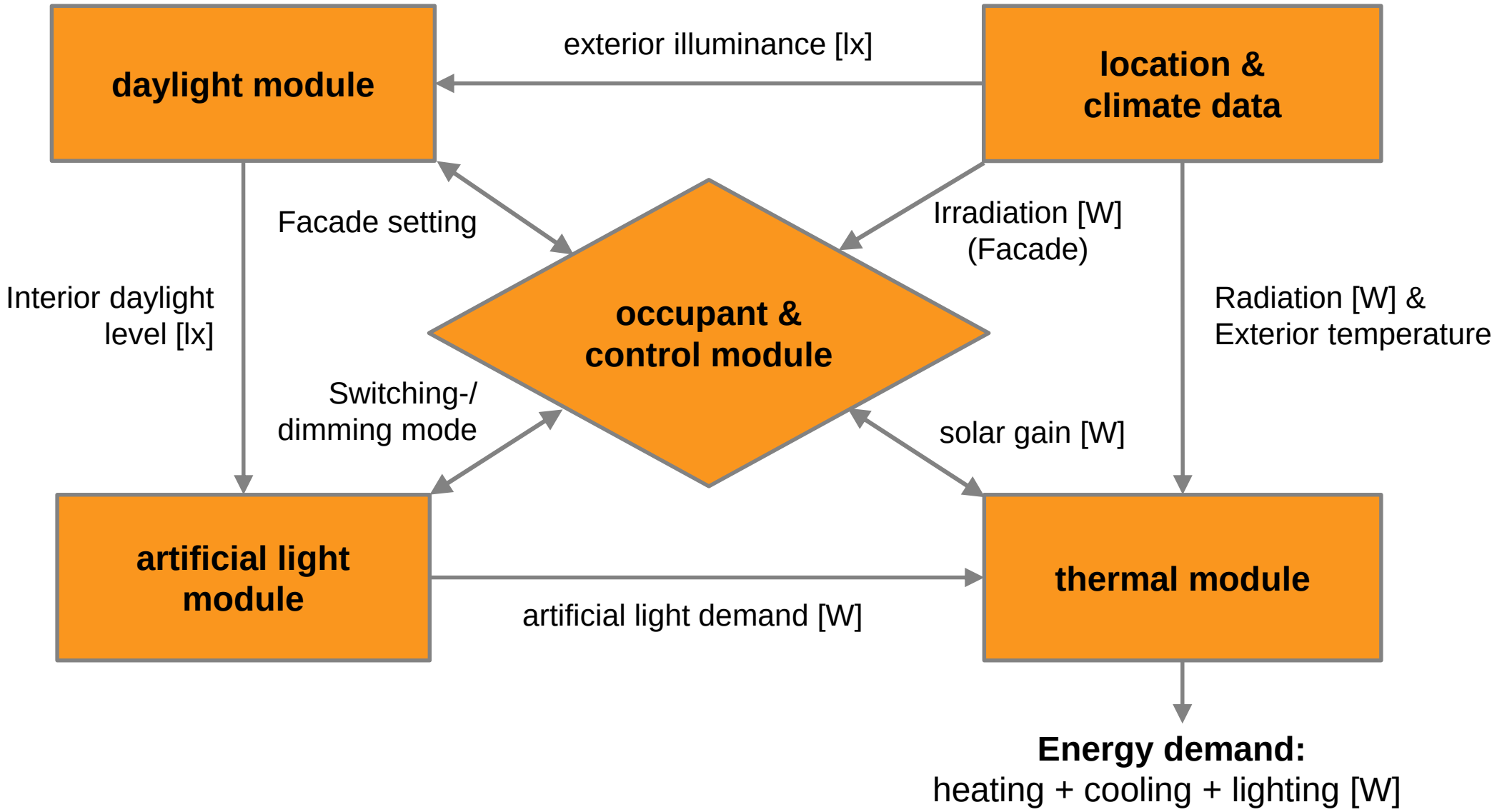
Bartenbach

universität innsbruck

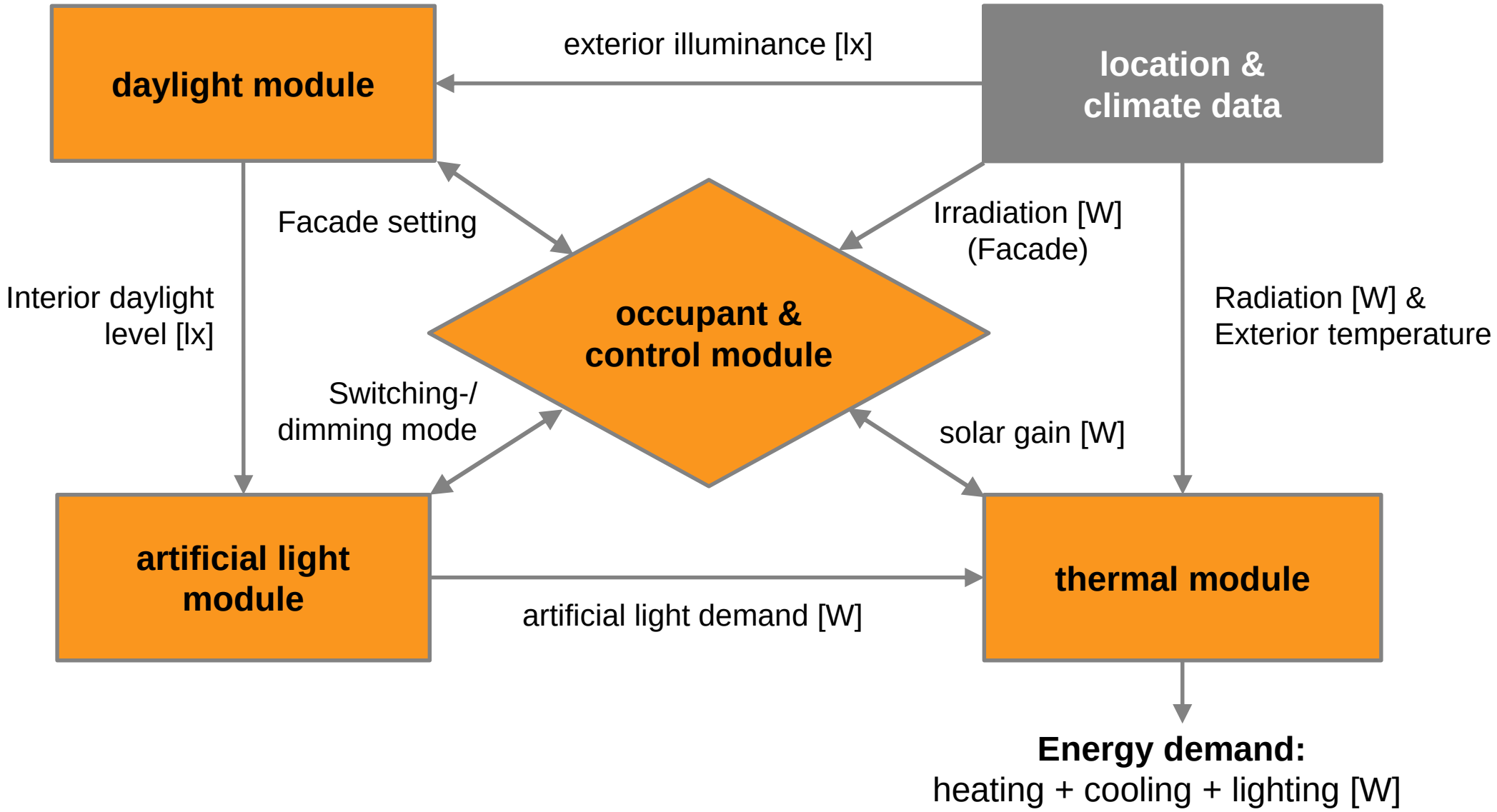
ZUMTOBEL



Concept


daylight module
exterior illuminance [lx]
location & climate data
Facade setting
Irradiation [W] (Facade)
Interior daylight level [lx]
occupant & control module
Radiation [W] & Exterior temperature
Switching-/ dimming mode
solar gain [W]
artificial light module
artificial light demand [W]
thermal module
Energy demand:
heating + cooling + lighting [W]

Concept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solar gain [W]
artificial light
module
thermal module
artificial light demand [W]
Energy demand:
heating + cooling + lighting [W]

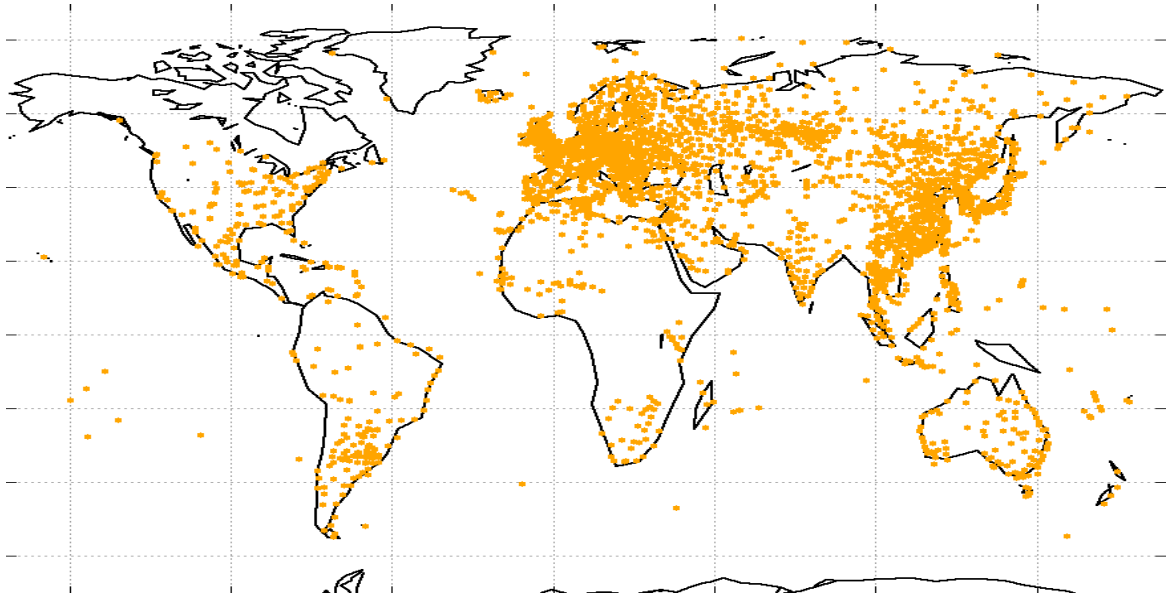
Location & Climate data

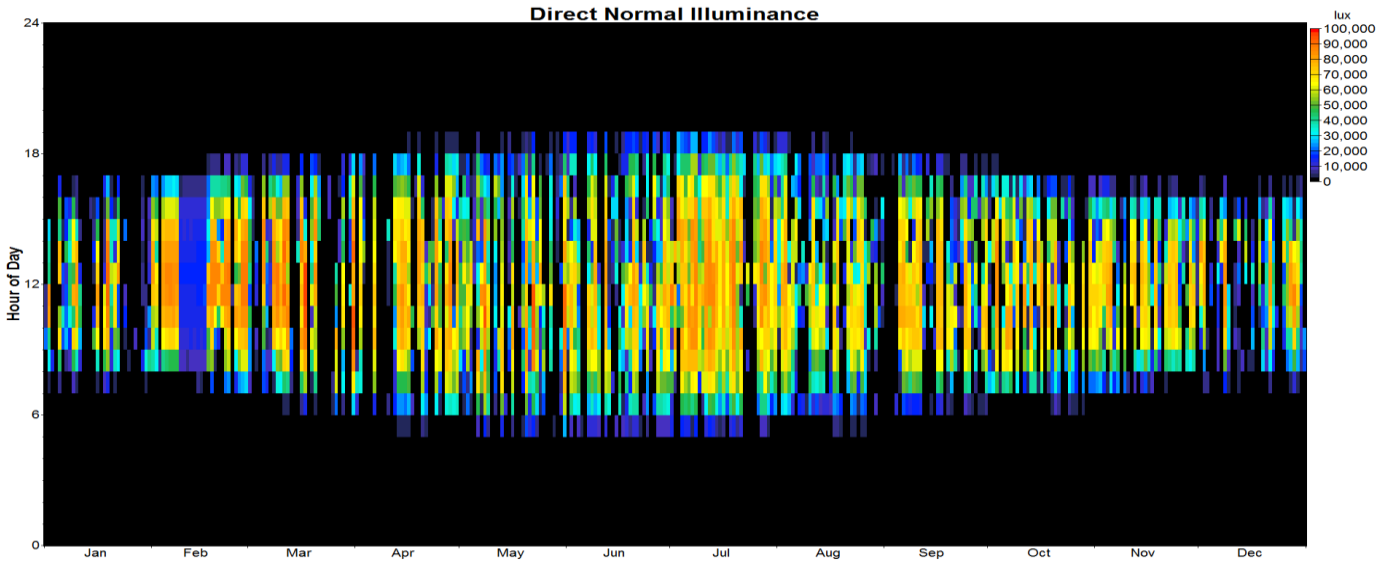
DALEC Calculations based on:

- **IWEC2**
- **TMY3** and
- **CWEC**

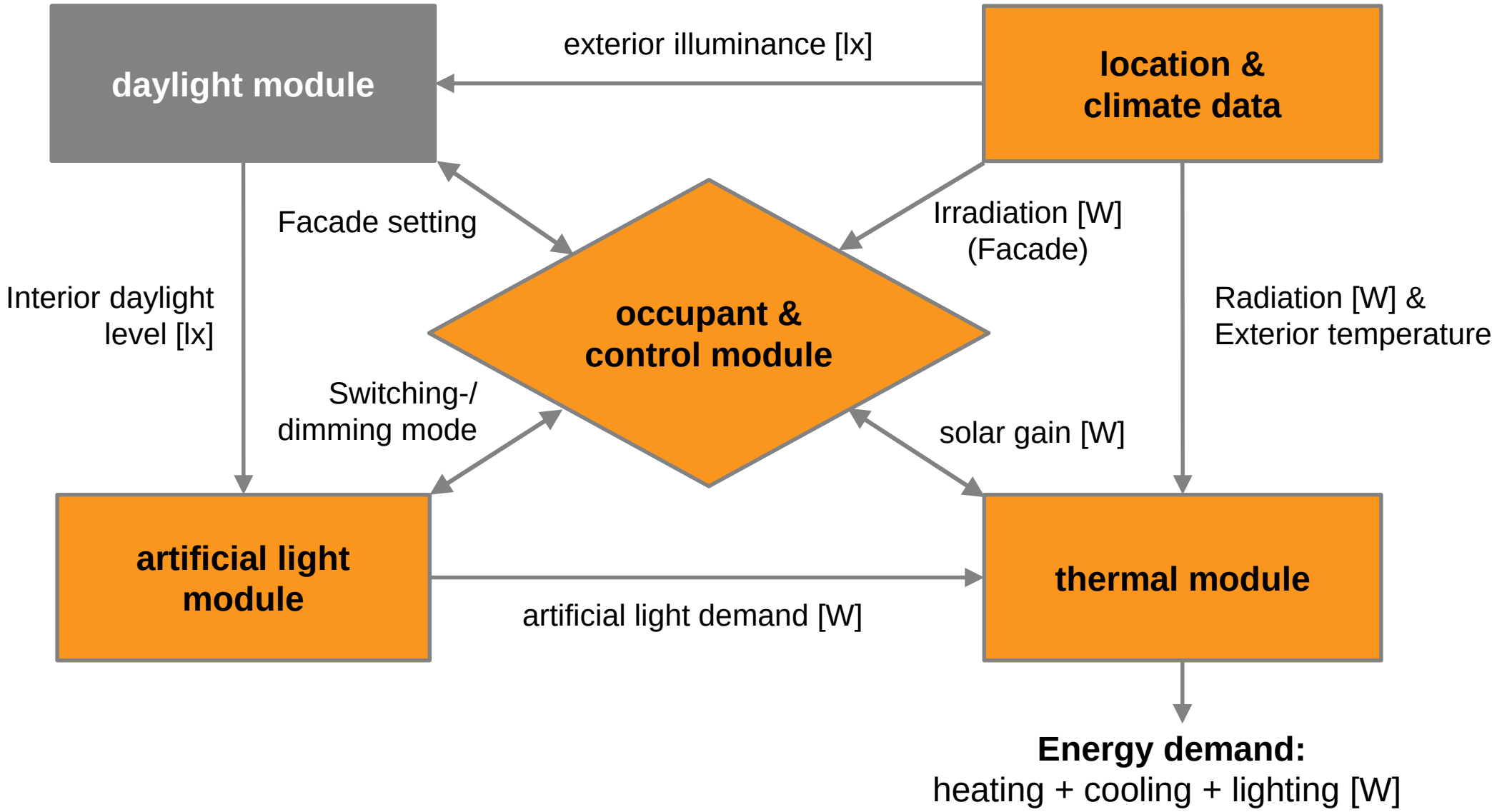
weather data for

- **> 3100 Locations** worldwide





Concept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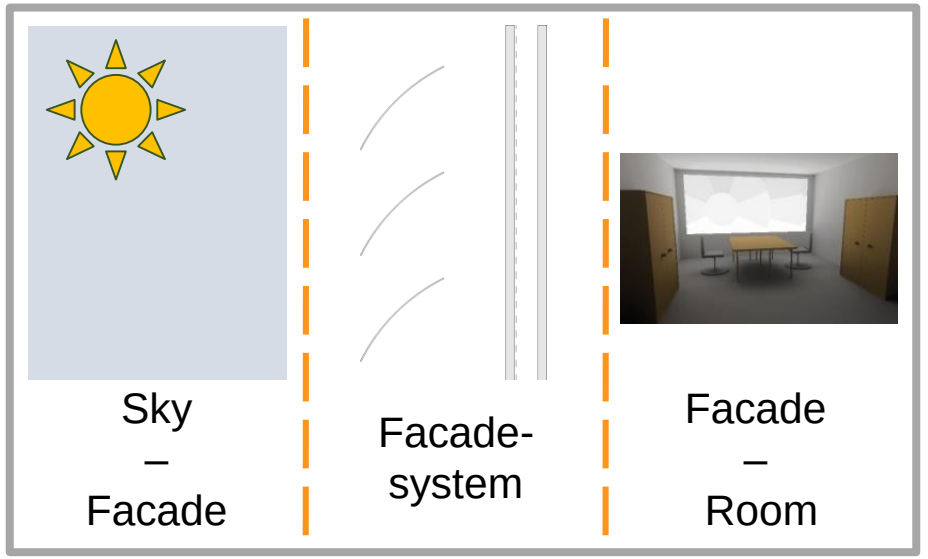
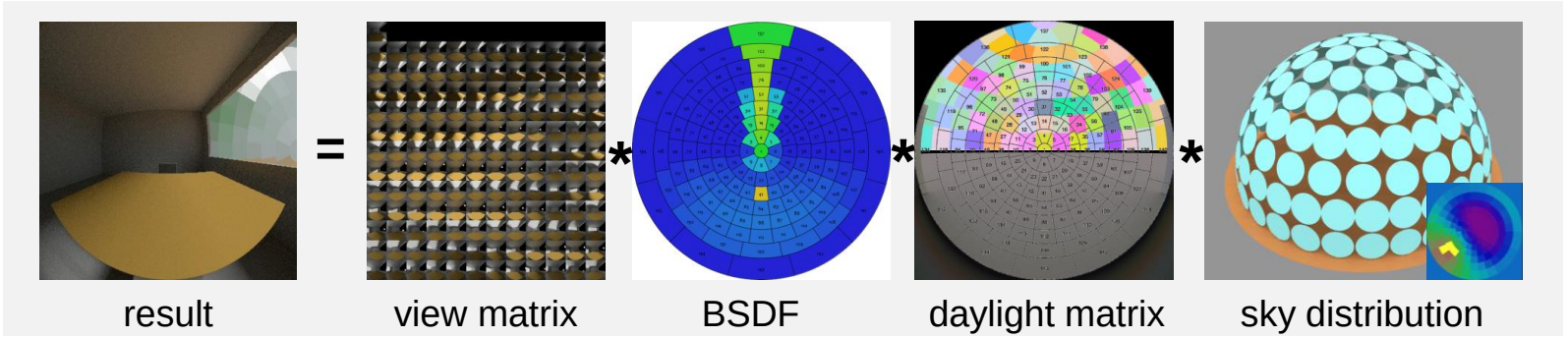
Switching-/ dimming mode
solar gain [W]
artificial light module
artificial light demand [W]
thermal module
Energy demand:
heating + cooling + lighting [W]

Daylight module

Daylight calulation: based on 3-phase method

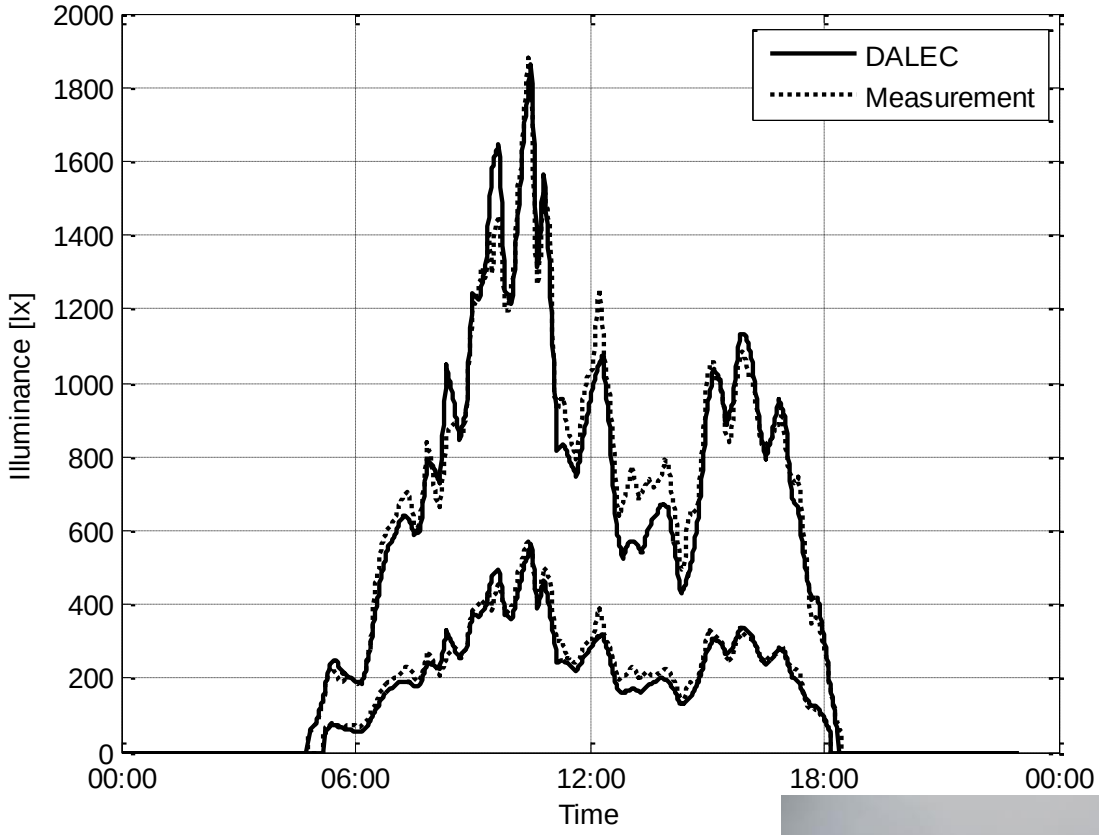
- division of flux transfer into 3 stages
- time consuming simulations during pre-calculation
- fast calculation for single sky distributions
- factors stored in database





Daylight module

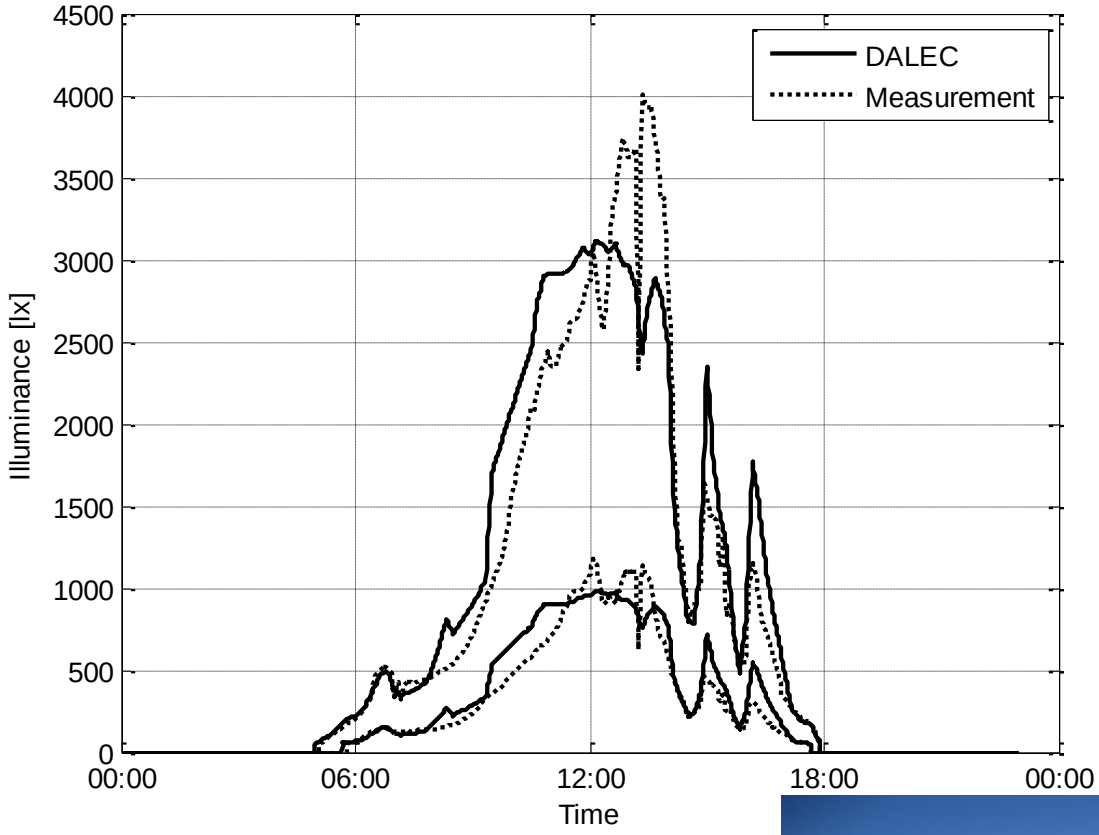
Validation



Overcast sky

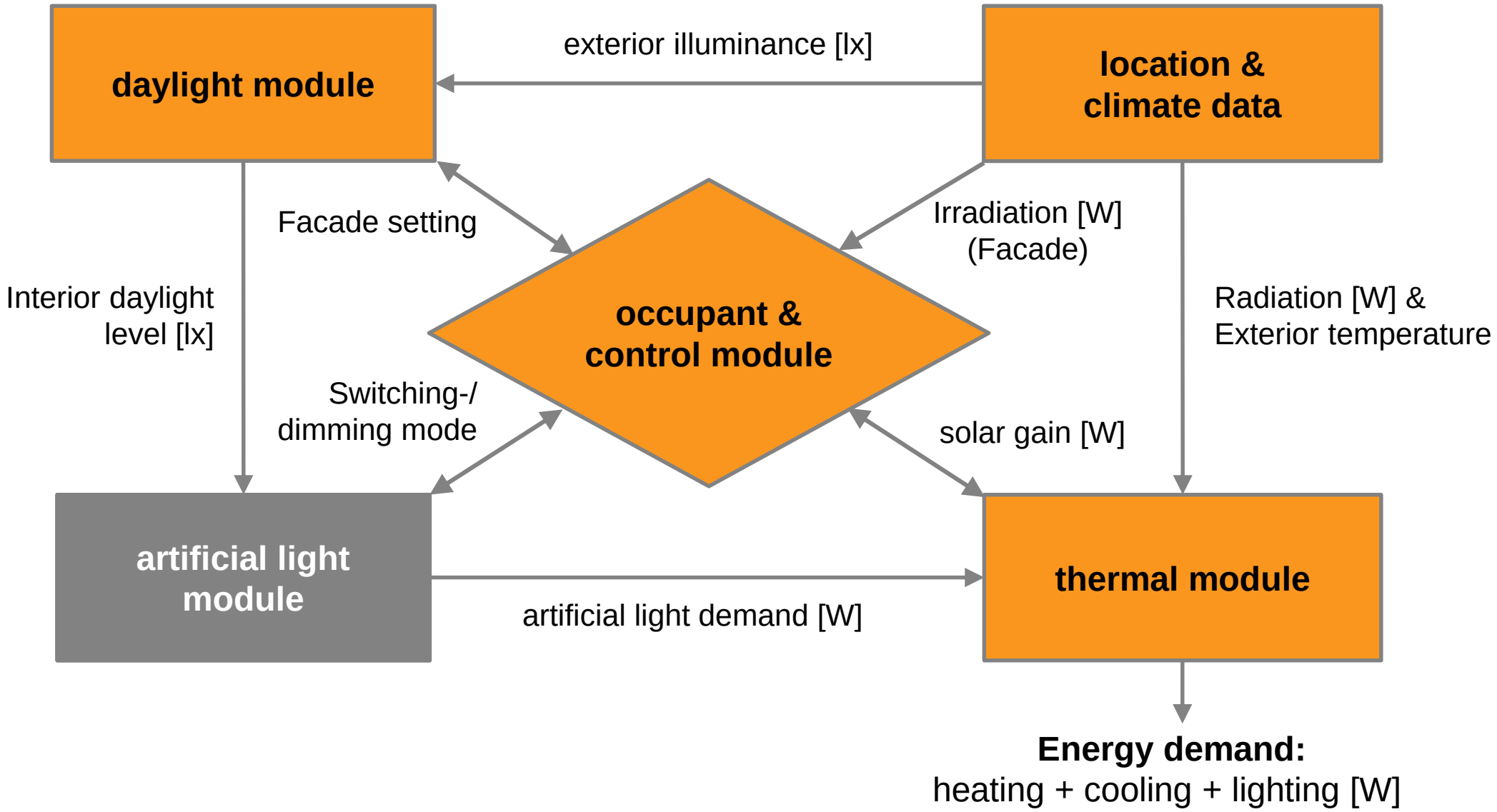
Daylight module

Validation



Clear sky

Concept


daylight module
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artificial light
module
thermal module
artificial light demand [W]
Energy demand:
heating + cooling + lighting [W]

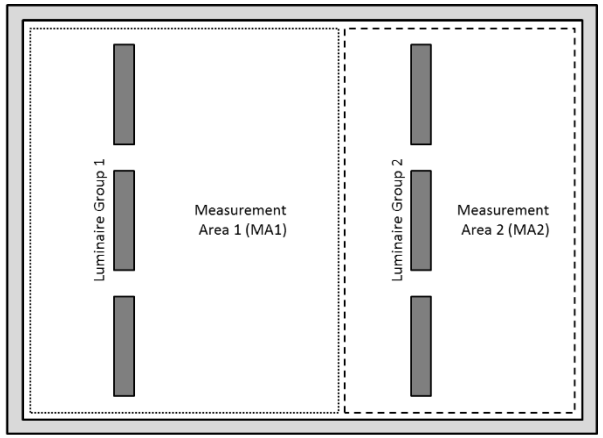
Artificial light module

Lumen efficiency method for

- number of luminaires
- resulting average illuminance

Database with precalculated factors for normalized lumen output

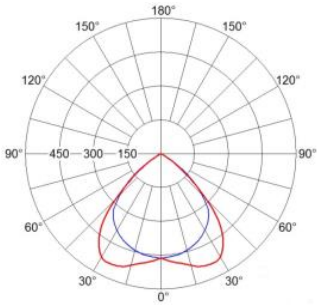

Bild: Zumtobel



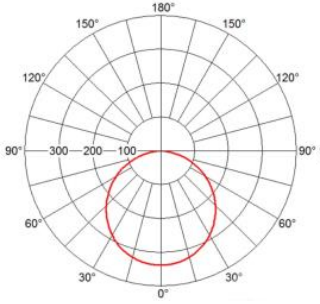
Available light intensity distributions

Direct

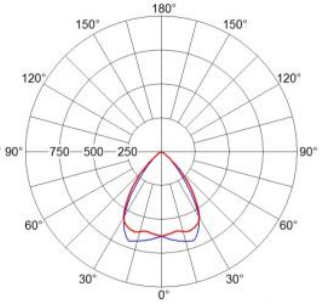
wide beam



diffuse

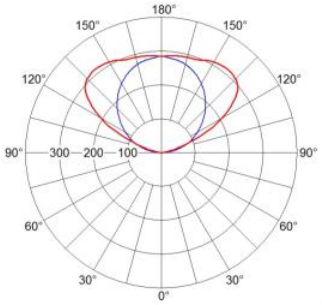


narrow beam

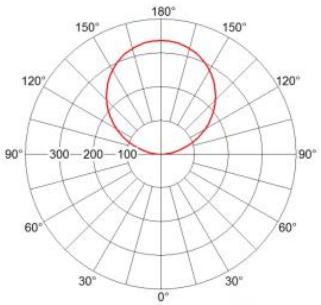


Indirect

wide beam



diffuse



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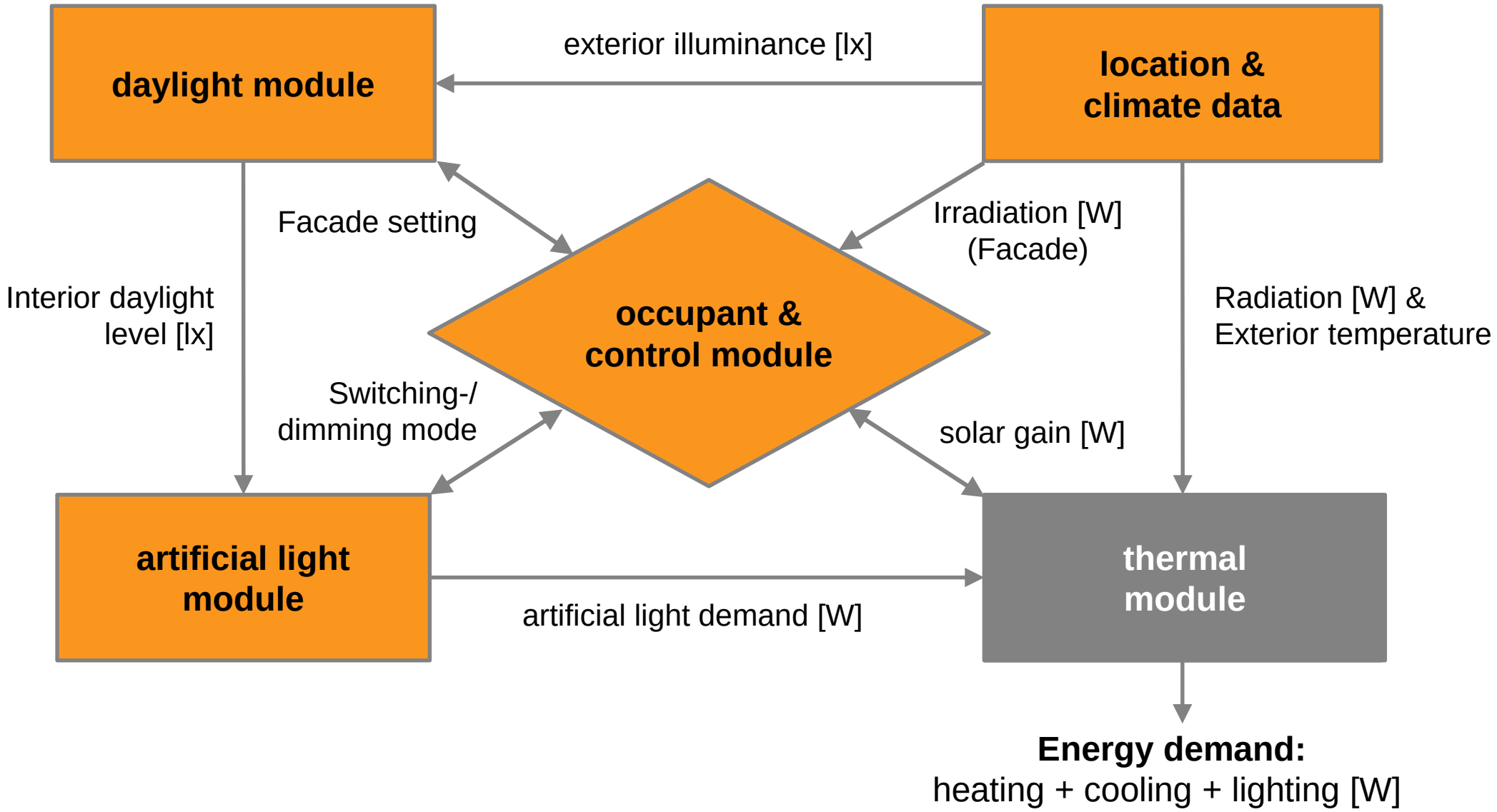
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(Facade)
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Radiation [W] &
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Switching-/
dimming mode
solar gain [W]
artificial light
module
thermal
module
artificial light demand [W]
Energy demand:
heating + cooling + lighting [W]

Thermal module

Energy balance

Dynamic thermal model

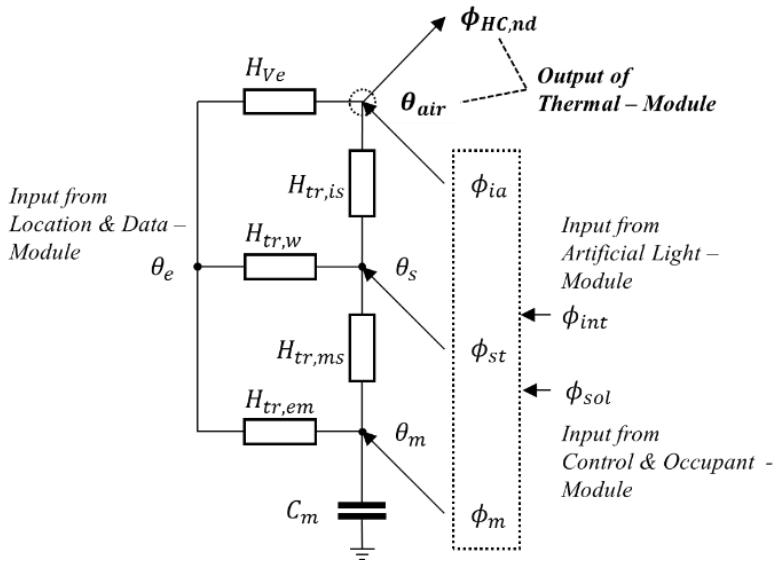
- **EN ISO 13790**
- default values

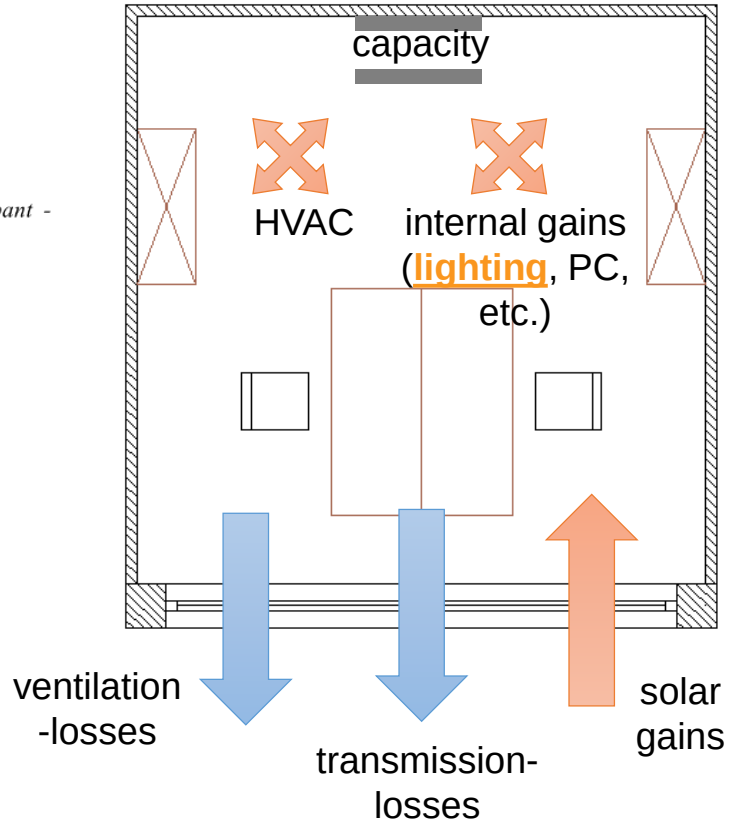
Input

- weather data
- **artificial light** (internal gains)
- **solar heat gain** (through facade)

Output

- energy demand for **heating** and **cooling**
- interior temperatures, overheating frequency



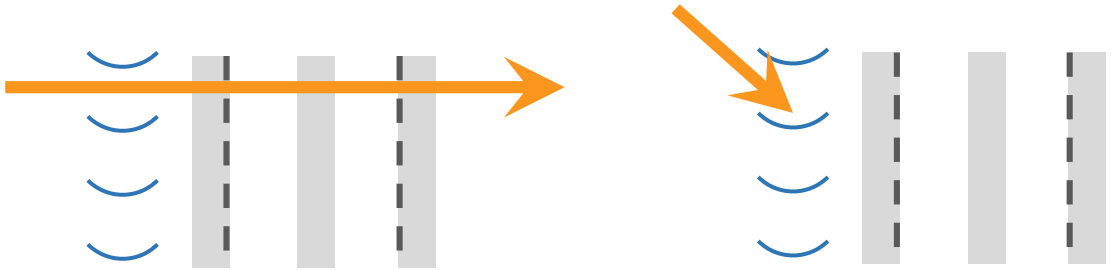


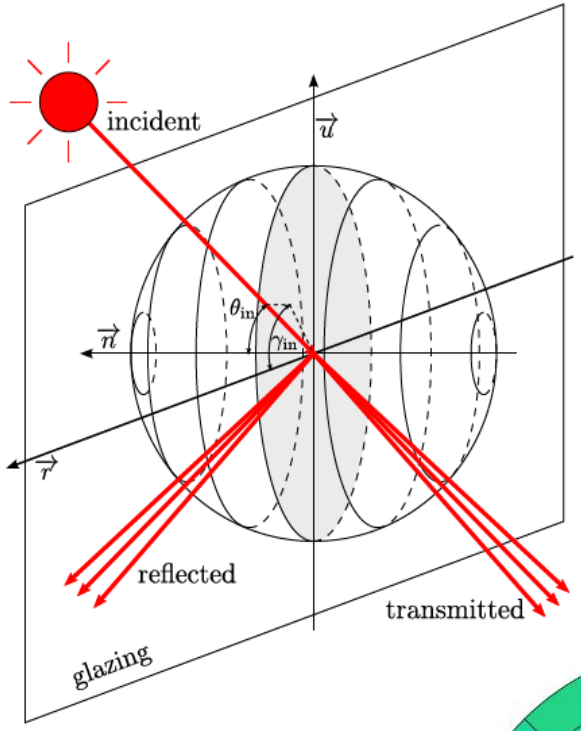
Thermal module

Facade calculation

Thermal characterisation of the facade system

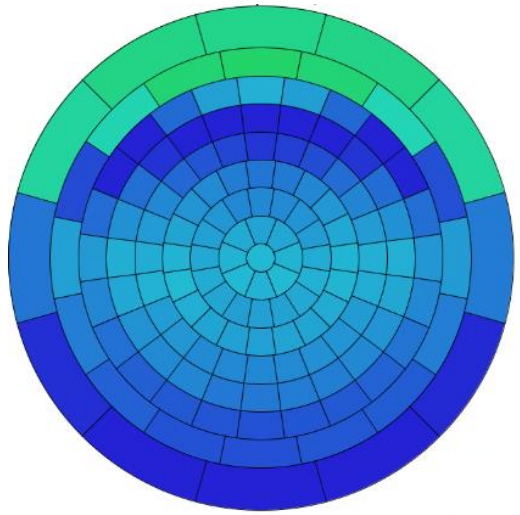
- **angular dependency** known for glazings
- unkown for daylight systems → cannot be neglected





Database:

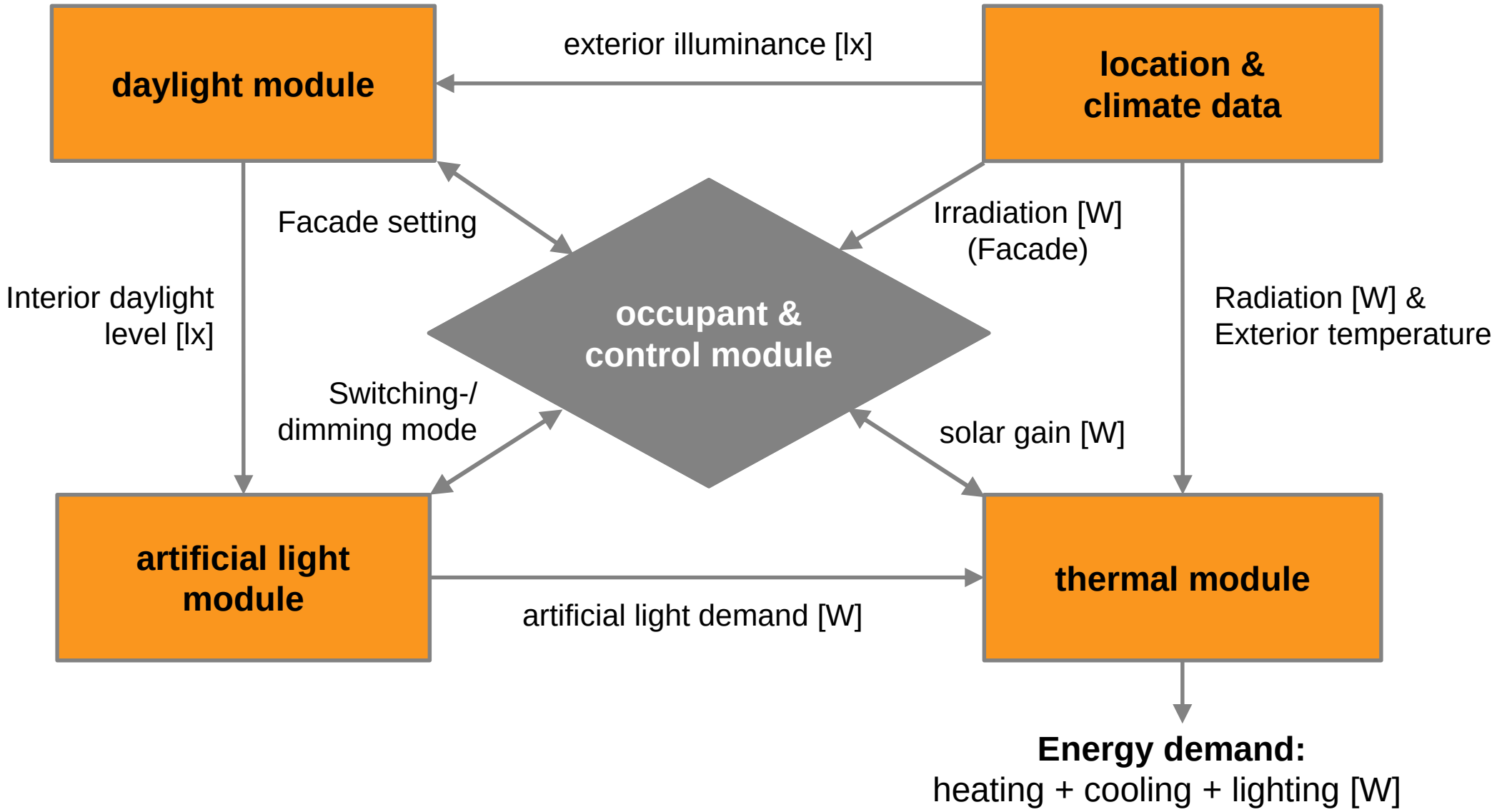
- angular dependent SHGC (145 Klems directions)



Input:

- SHGC of glazing at normal incidence

Concept


daylight module
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Interior daylight
level [lx]
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Radiation [W] &
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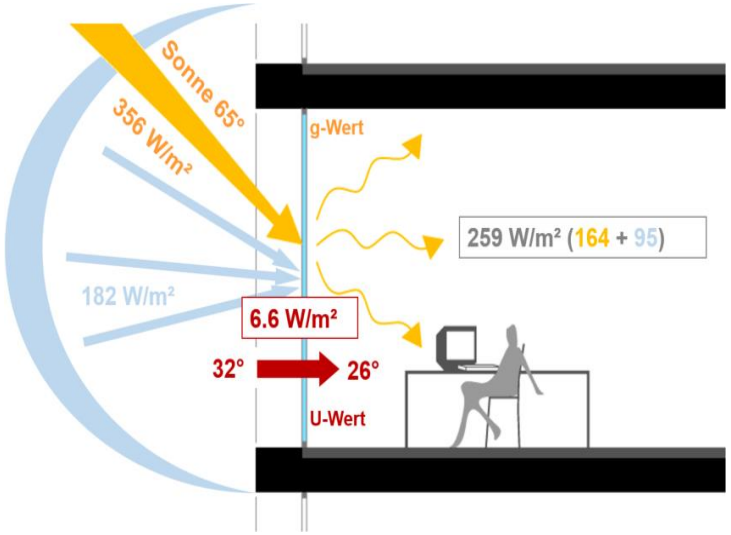
Switching-/
dimming mode
solar gain [W]
artificial light
module
thermal module
artificial light demand [W]
Energy demand:
heating + cooling + lighting [W]

Occupant & Control Module

Thermal control:

- **radiation limit at façade (outside)** → façade setting
- **interior temperature** → heating / cooling / night ventilation



DALEC controls mimicking occupants:

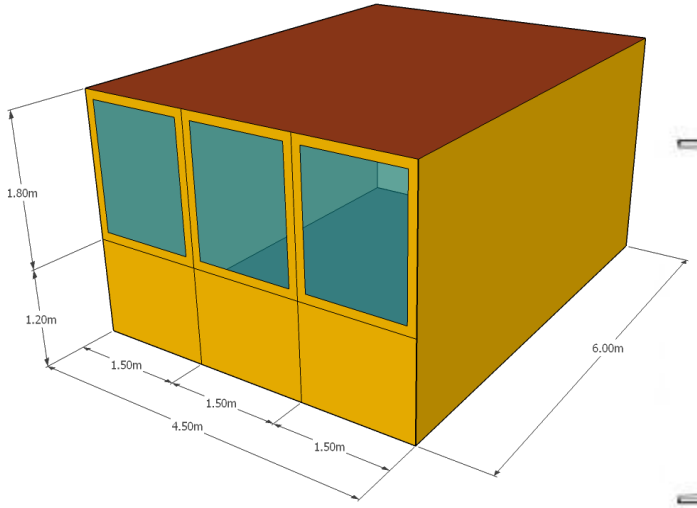
- **luminance threshold at façade (inside)** → façade setting
- **interior temperature** → window ventilation

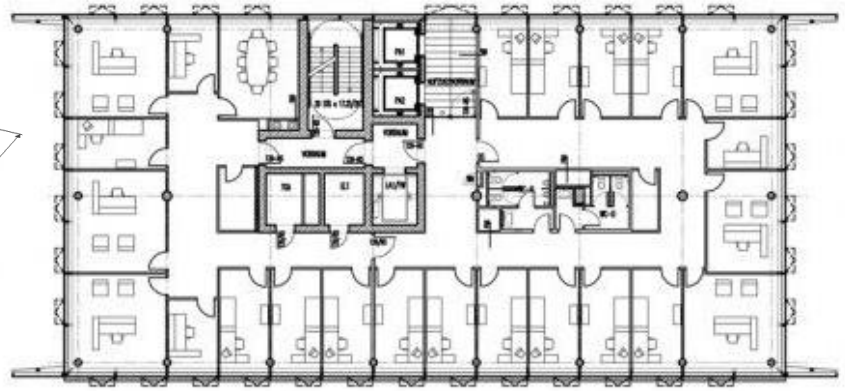
Comparative simulation study

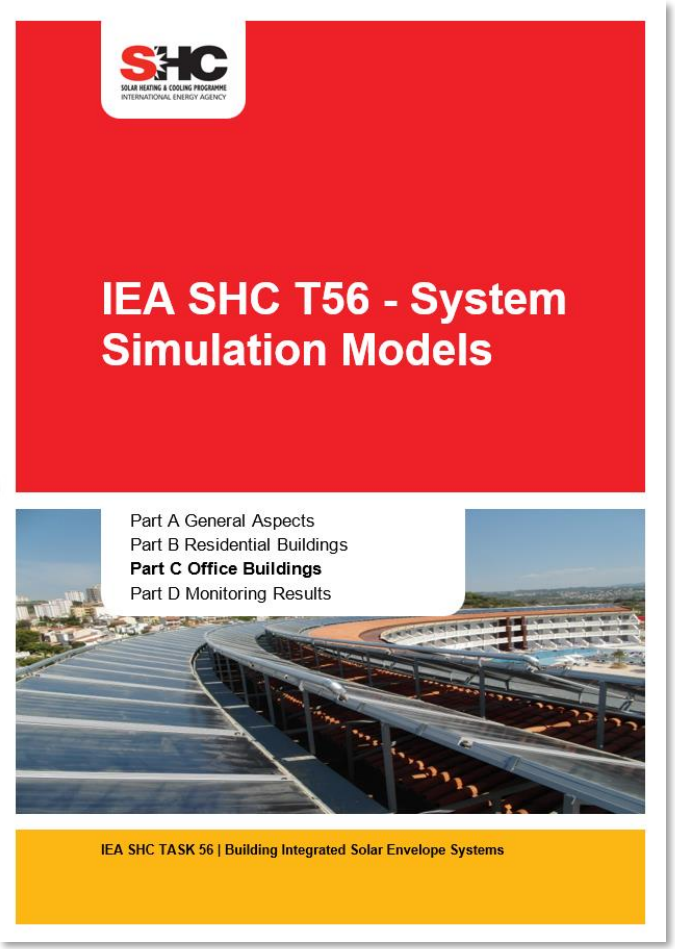
Reference office

IEA SHC Task 56
Building Integrated Solar Envelope Systems for HVAC and Lighting

- Definition of reference office building
- Comparison of different building simulation tools

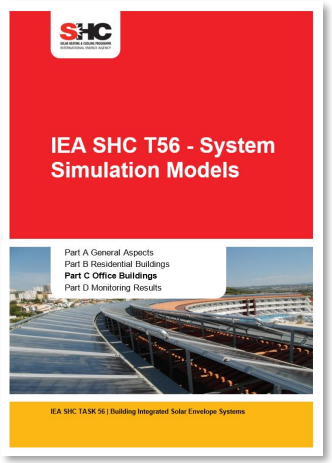






DALEC vs. TRNSYS

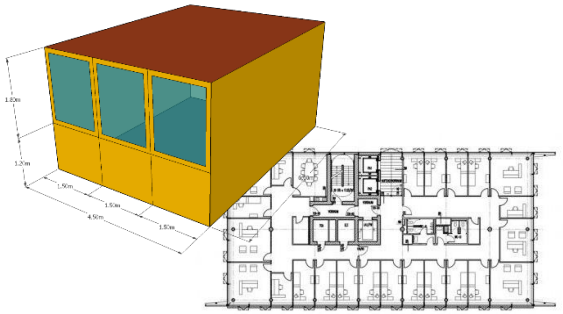
TASK 56



FFG Research Project
DALEC
Building Energy under Control

David Geisler-Moroder

Bartenbach
research & development



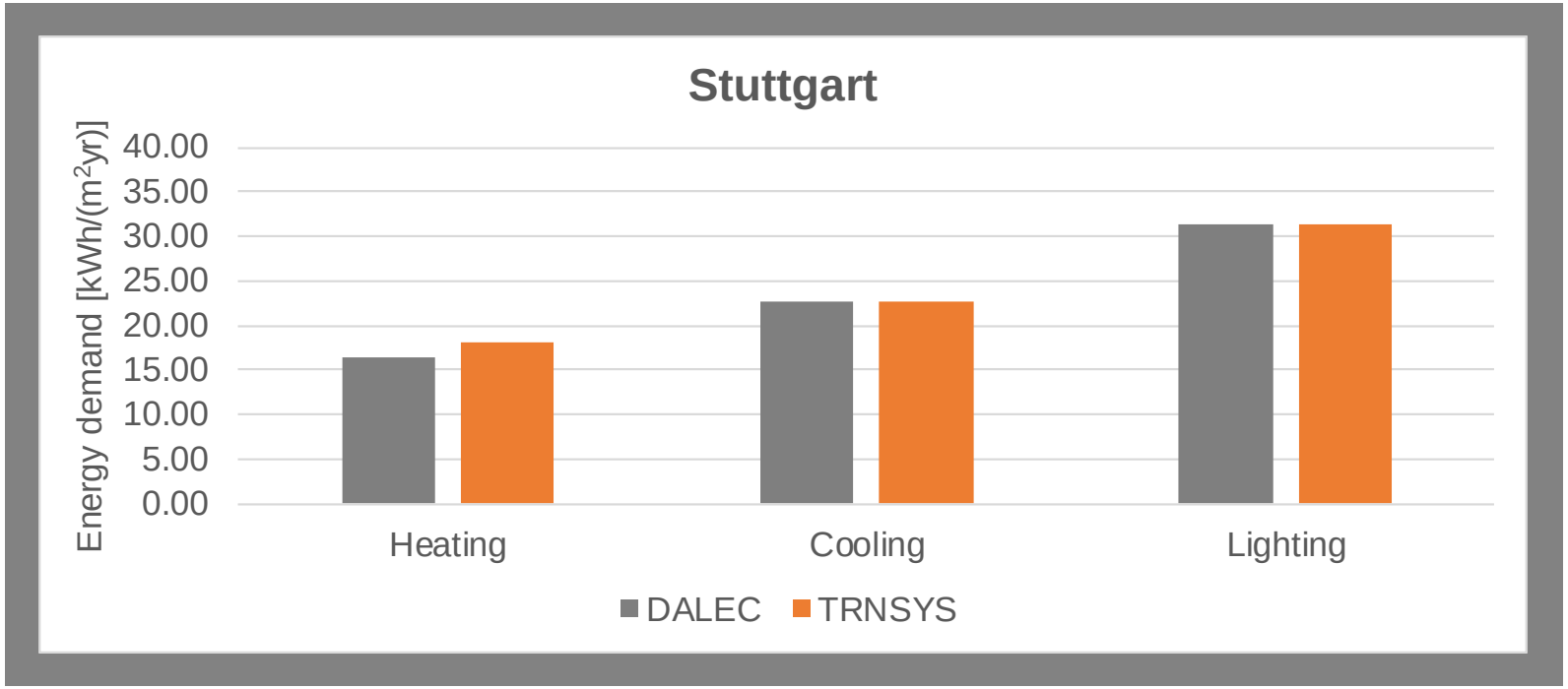
TRNSYS 17

Matteo D'Antoni

eurac research

DALEC vs. TRNSYS

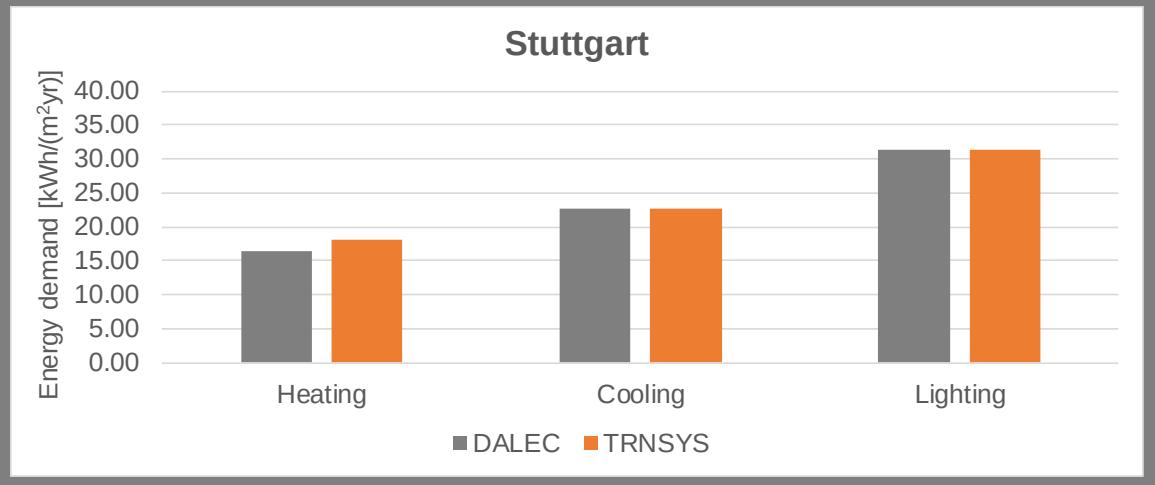
Annual energy balance

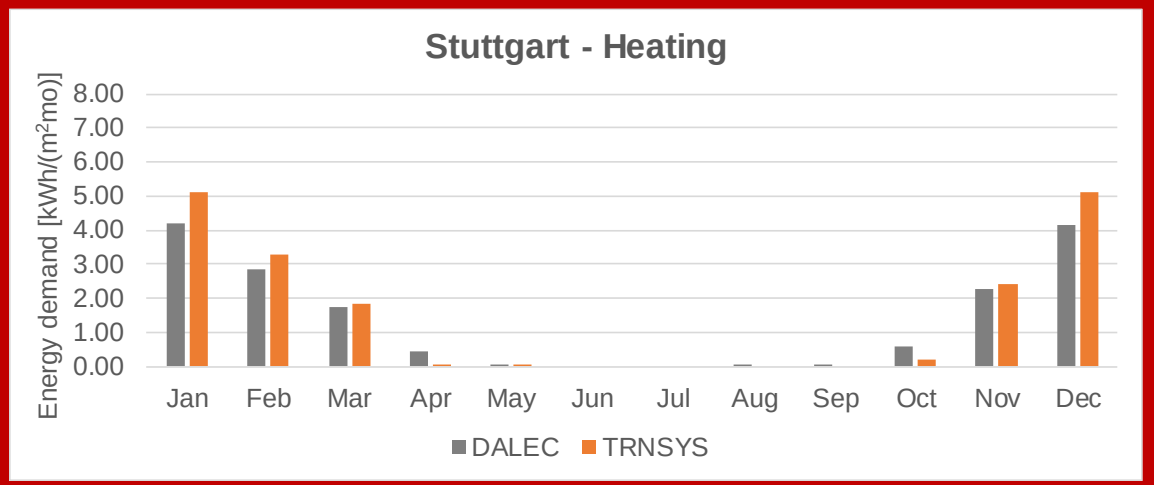


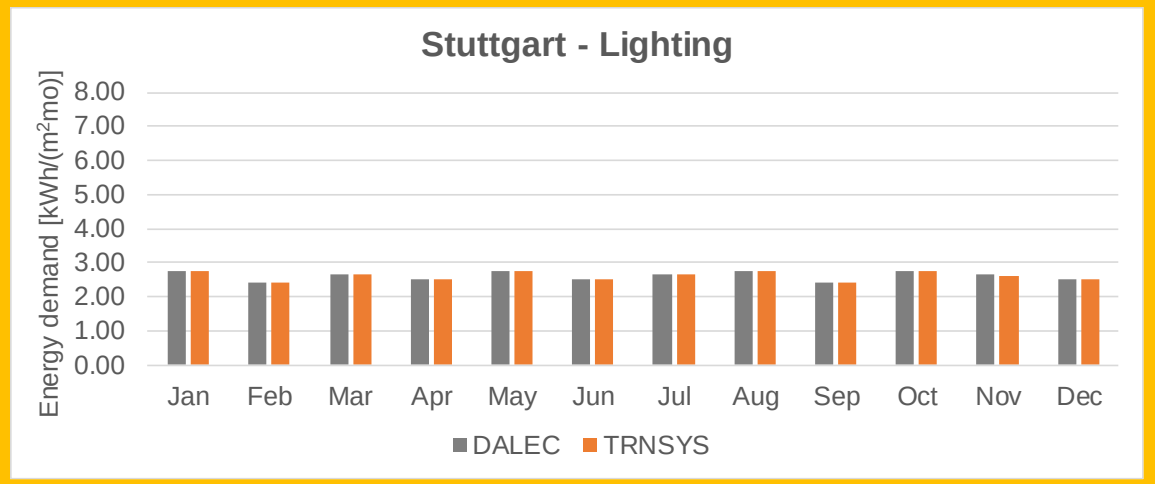
David Geisler-Moroder
@ Bartenbach

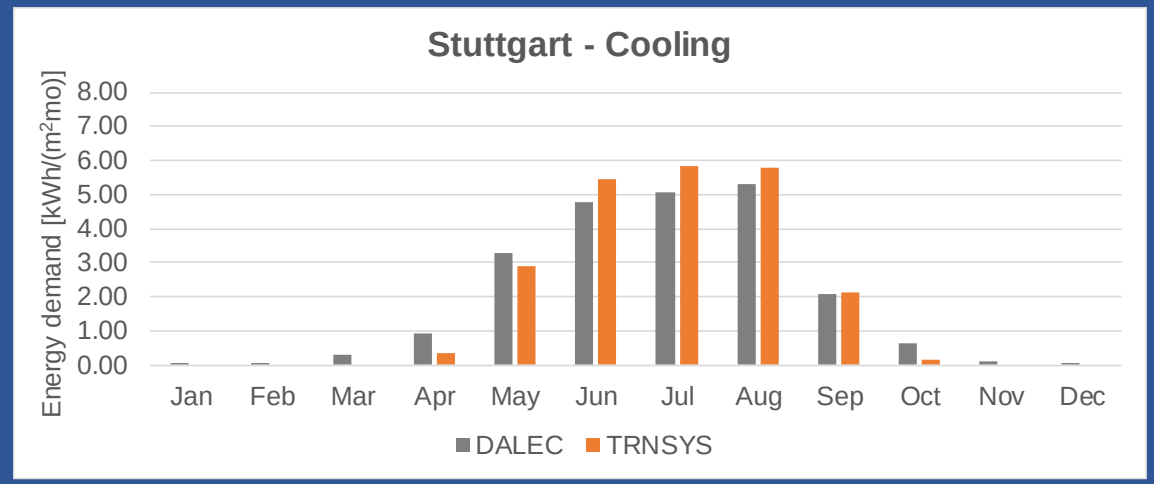
Matteo d'Antoni
@ EURAC

DALEC vs. TRNSYS









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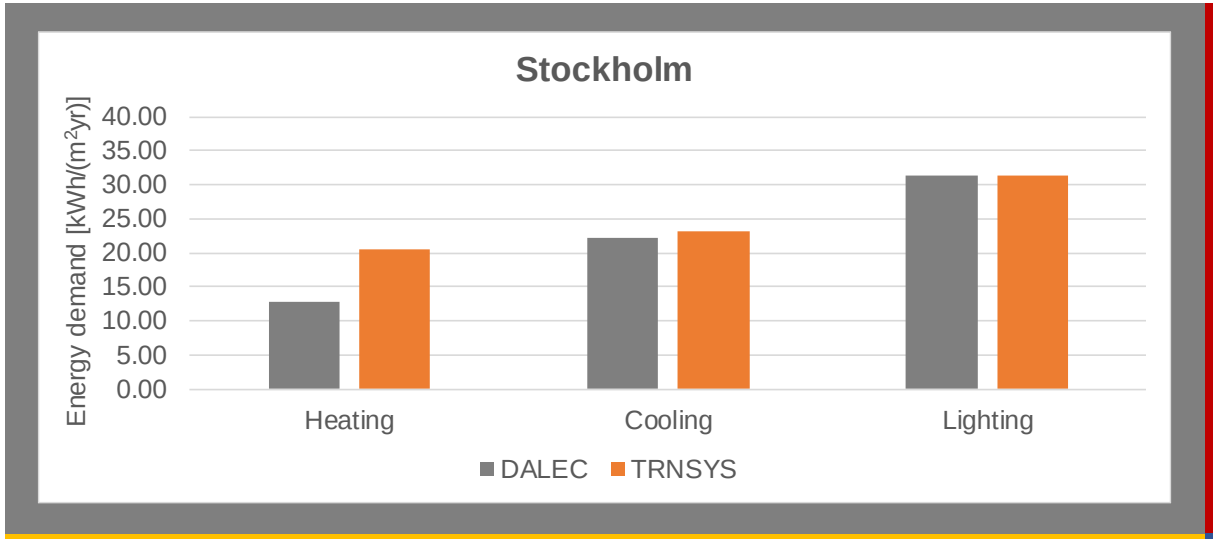
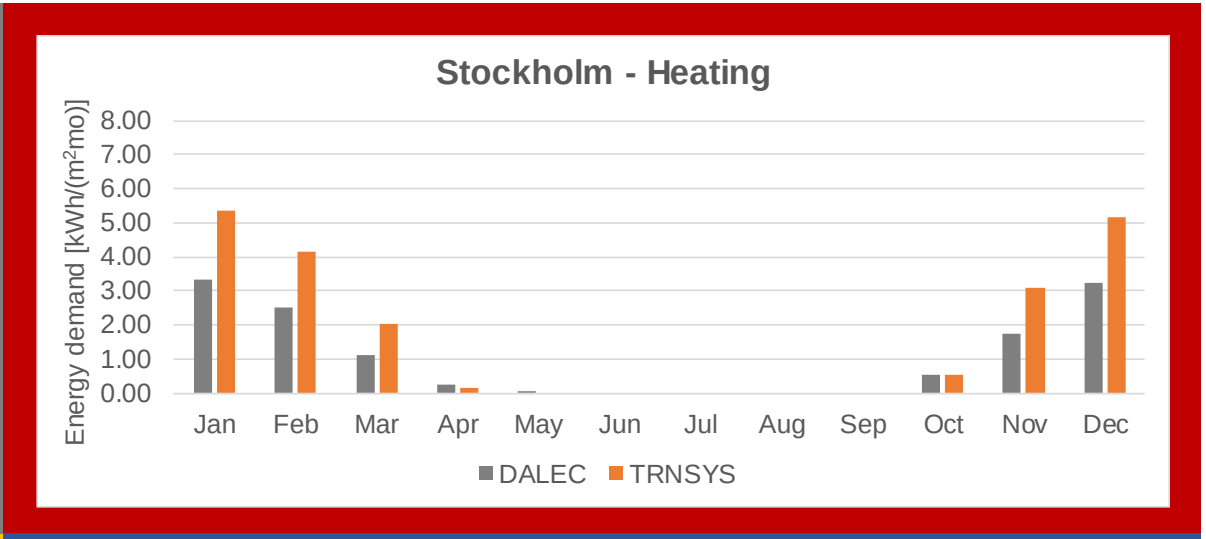
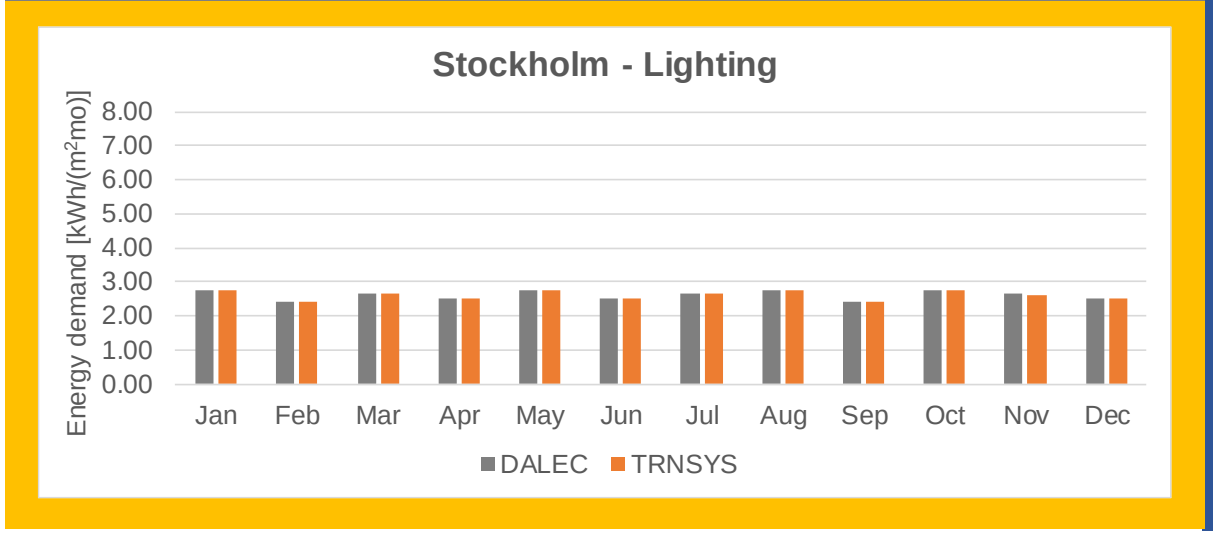
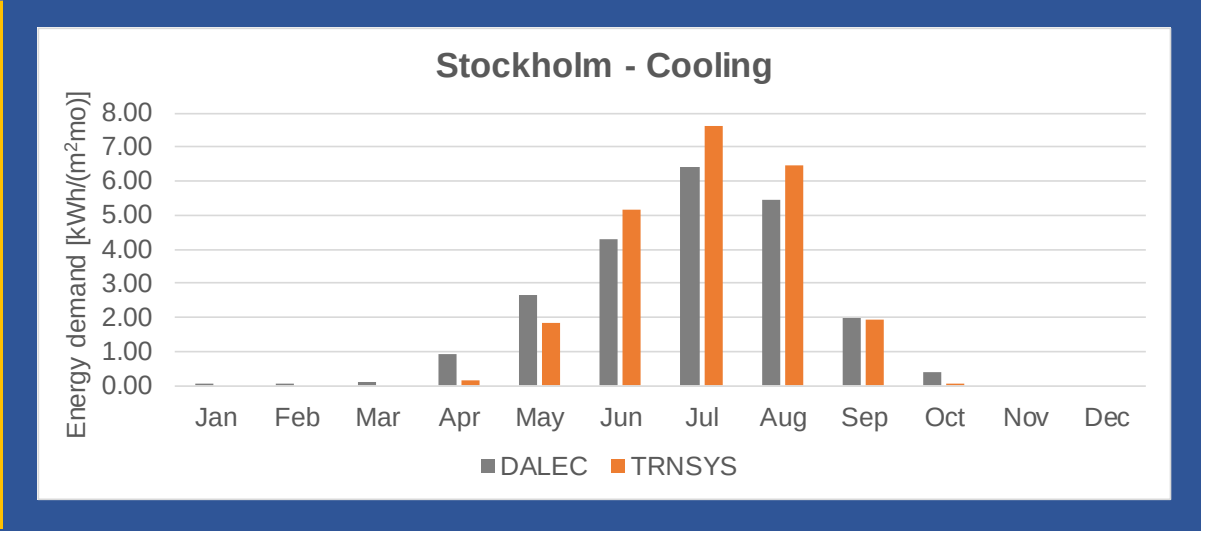
DALEC vs. TRNSYS









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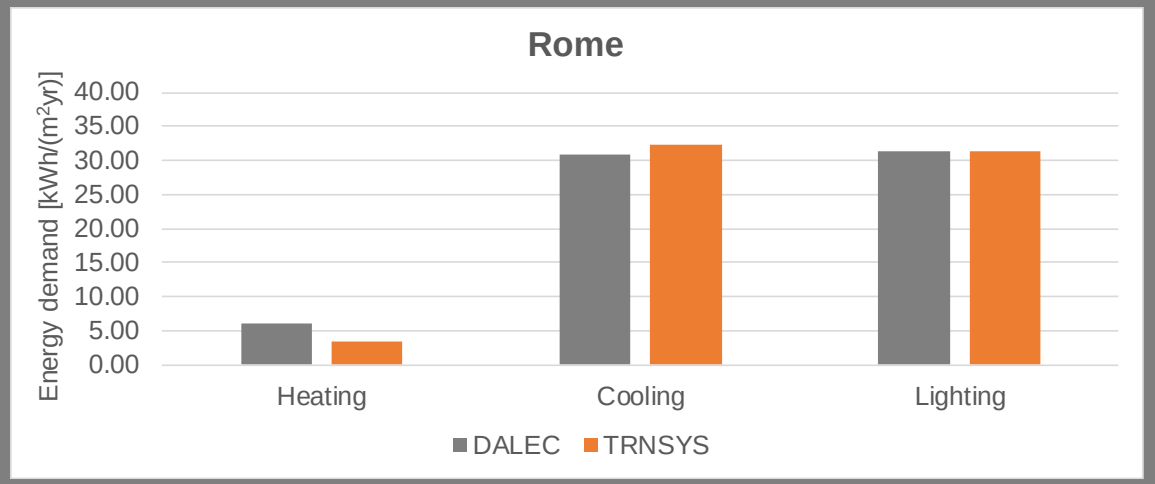

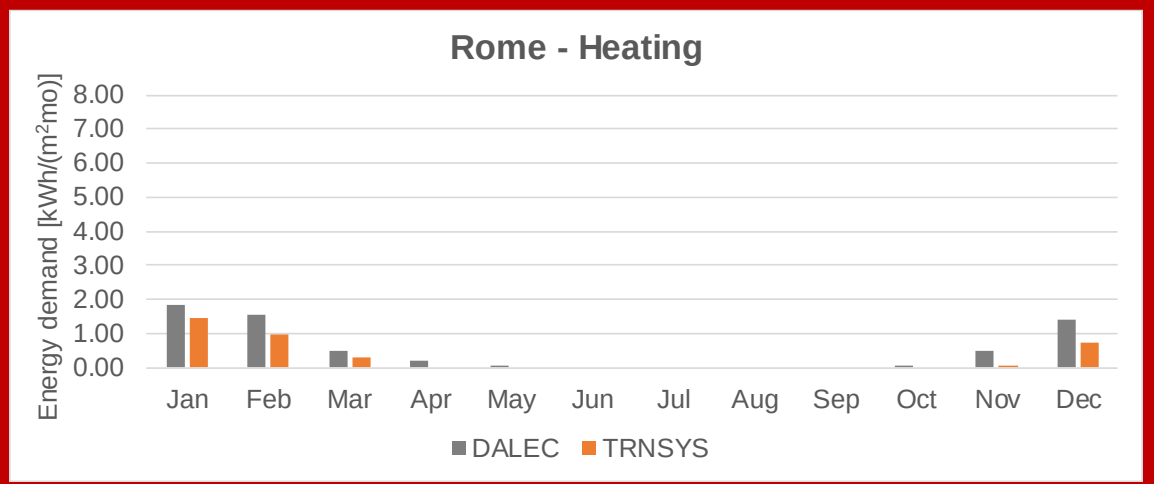

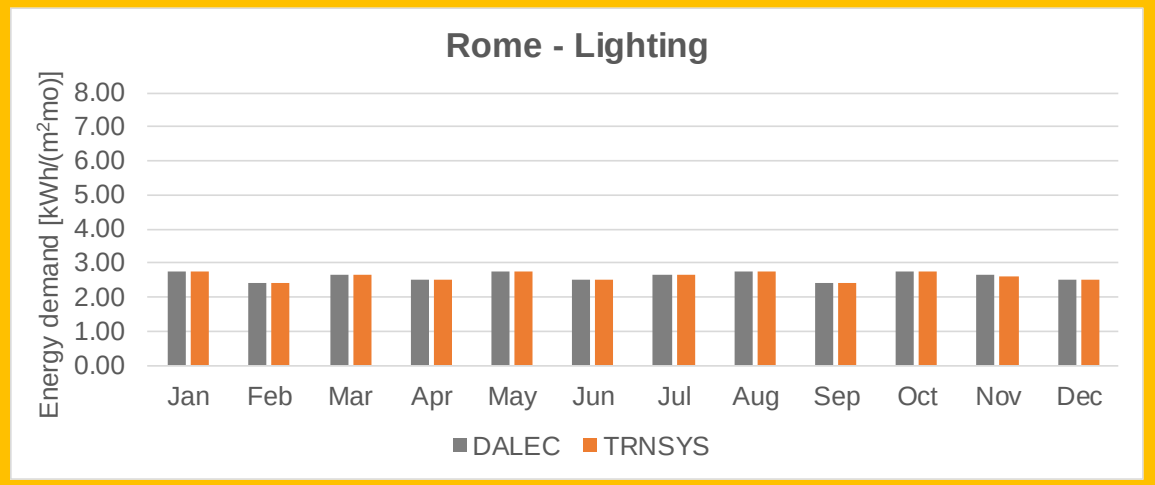

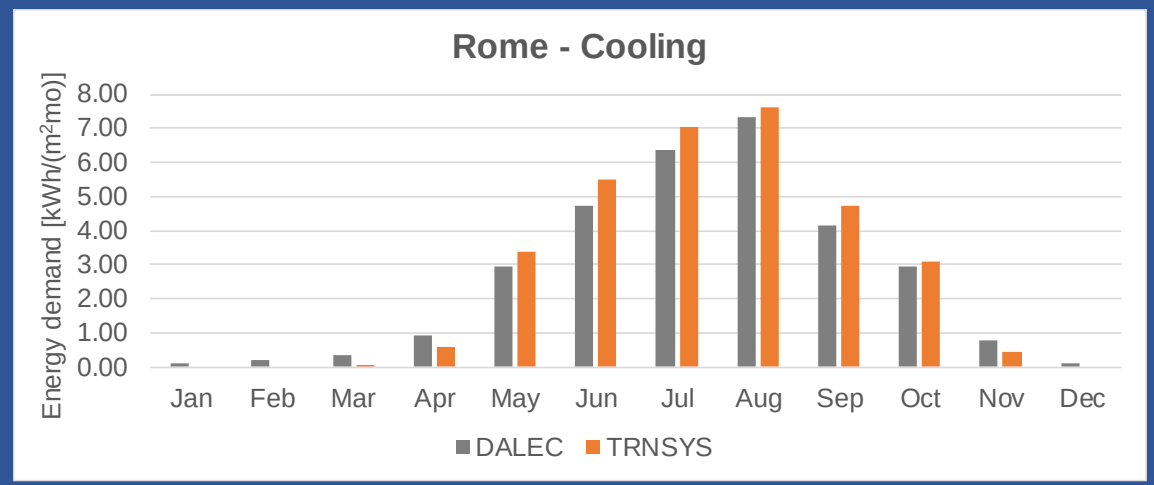

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IEA SHC Task 56

Building Integrated Solar Envelope Systems for HVAC and Lighting

TASK 56

- Comparison with other simulation tools ongoing
- Application for comparisons of the solutions for envelope-integrated, solar facade

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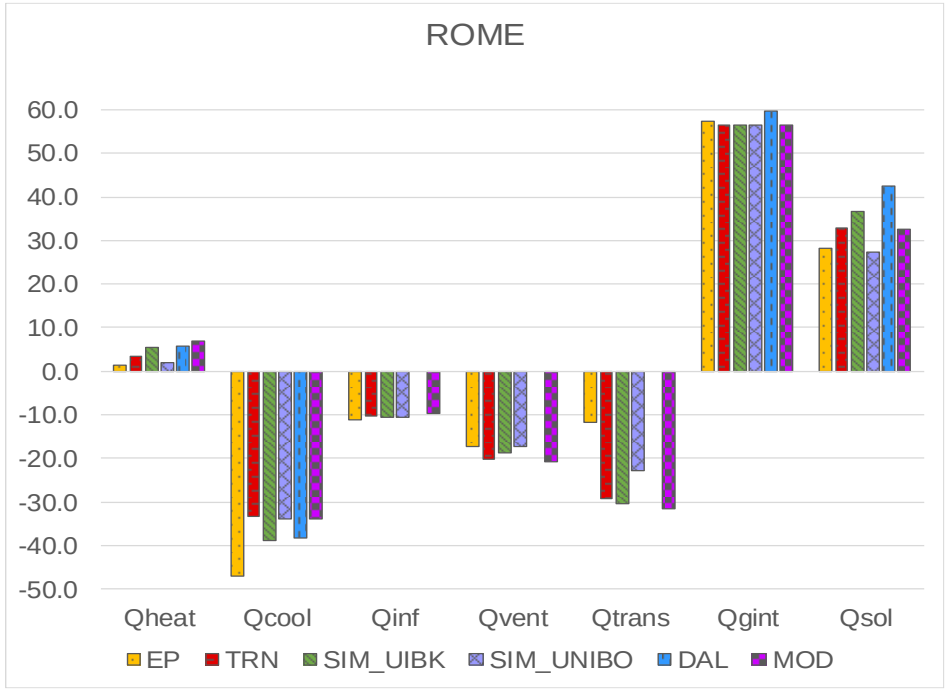

Comparison of Simulation Results for an Office Building Between Different BES Tools – The Challenge of Getting Rid of Modeller Influence and Identifying Reasons for Deviations

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Thank you!

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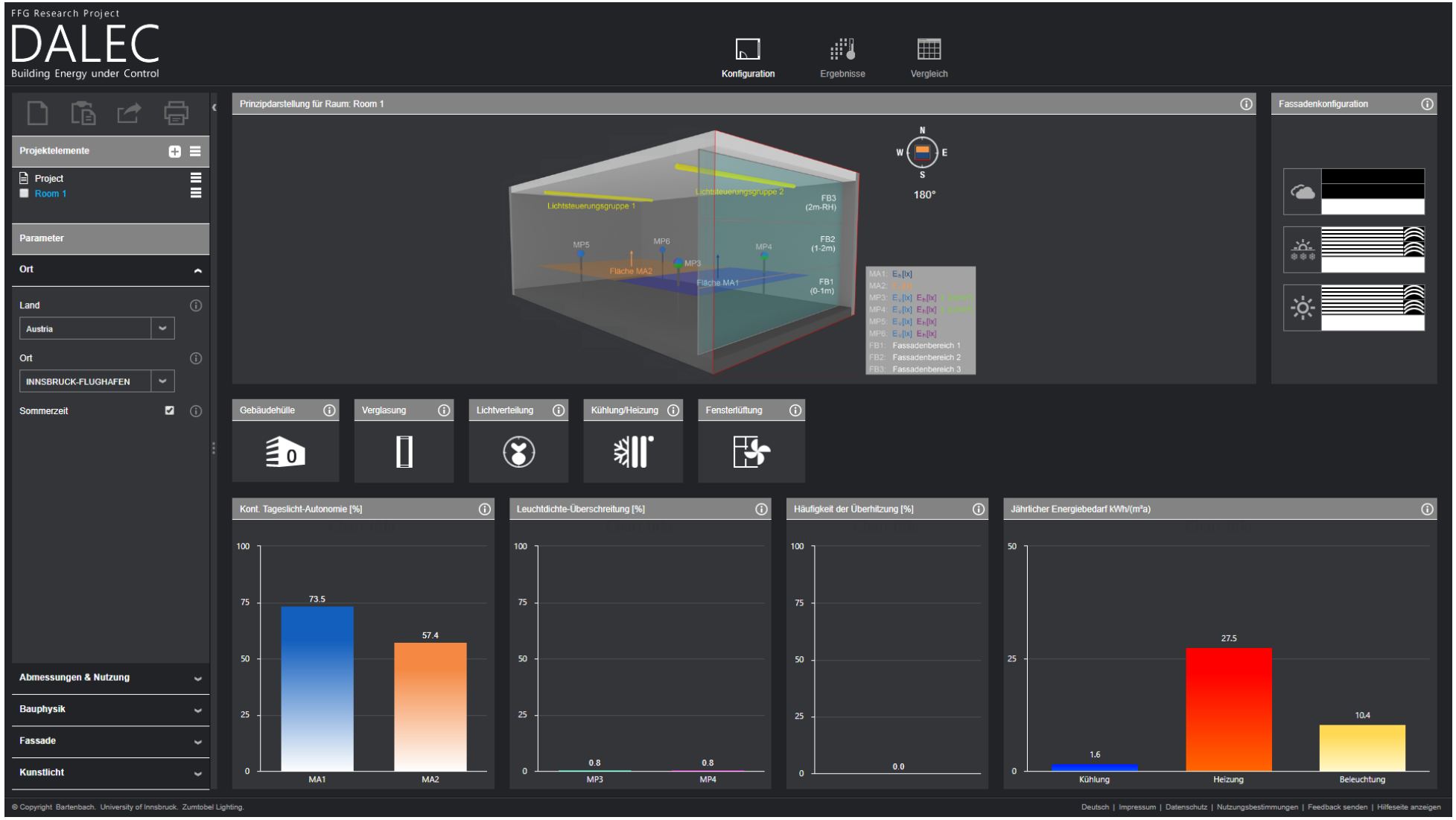

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