Subtask D: Case Studies Highlights and results

Participants in Subtask D: Marie-Claude Dubois (lead), Niko Gentile, Werner Osterhaus, Sophie Stoffer, Cláudia Naves David Amorim, Kjeld Johnsen, David Geisler-Moroder, Anna Hoier, Yasuko Koga, Roman Jakobiak, Barbara Matusiak, Fredrik Martens

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

6th Industry Workshop of IEA SHC Task 50:
Advanced Lighting Solutions for Retrofitting Buildings

IEA SHC Task 50

Advanced Lighting Solutions for Retrofitting Buildings

Operating Agent: J. de Boer, DE

Subtask A

M. Fontoynont, DK

Market and Policies

Subtask B

M. Knoop, DE

Daylighting and Electric Ligthing Solutions

Subtask C

J. Kaempf; B. Paule, CH

Methods and Tools

Subtask D

M-C Dubois, SE

Case Studies

Main aim:
demonstrate sound lighting retrofit solutions

Joint Working Group: "Lighting Retrofit Adviser"
dissemination of results

22 ongoing Case Studies call for common monitoring procedures

Sports hall in a school

before renovation

after renovation

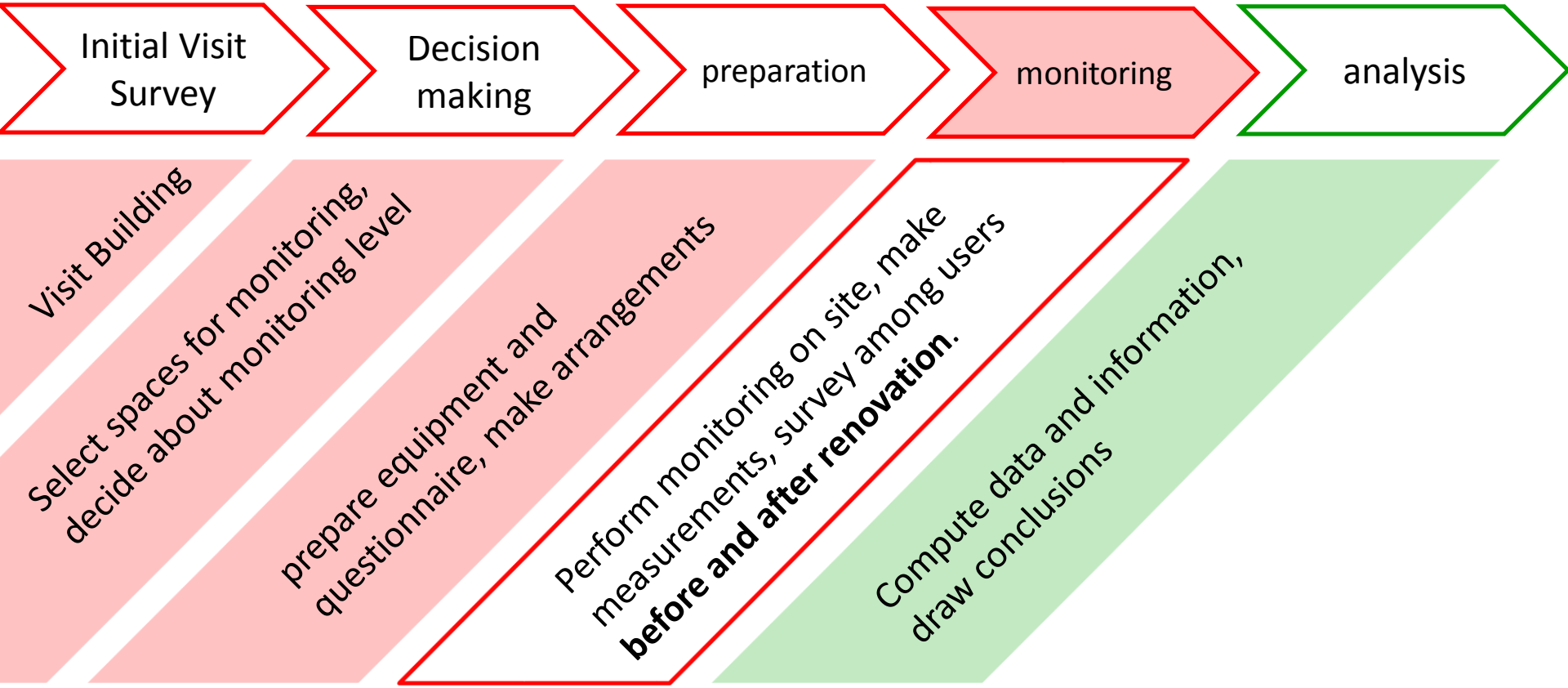
Exhibition space in a museum

after renovation

before renovation

THE PROTOCOL STRUCTURE

5-steps procedure



THE PROTOCOL STRUCTURE

two monitoring levels

basic

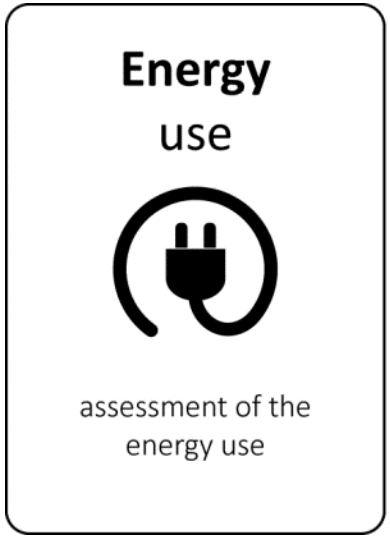
- limited instrumentation
- includes predicted performance metrics
- 2 days/year
- 1 year time frame

comprehensive

- advanced instrumentation
- based on measured performance metrics
- 4 days/year
- 3 years time frame

THE PROTOCOL STRUCTURE

four items



SUMMARY Monitoring Protocol

- The monitoring protocol offers an integral procedure to monitor lighting in buildings.
- The monitoring protocol broadly covers lighting related aspects of building performance. The main focus is on the light environment.
- The full implementation of the monitoring protocol is quite time consuming and exhaustive. It is possible to select parts of the protocol for implementation.
- The monitoring protocol so far includes no rating methodology. The evaluation of results is done individually.

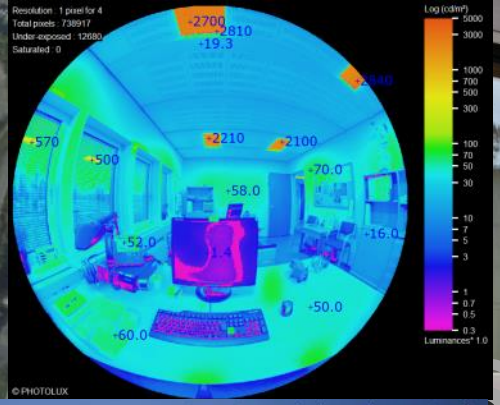





Image Source: badeanstaltenspanien.dk










WSP Headquarter, Stockholm, SE

Evaluation of daylighting and electric lighting renovation for a landscape office

WSP Headquarter, Stockholm, SE

Less “obstacles”, more daylight

Different workplaces arrangement and cellular meeting rooms removed

Improved surfaces reflectance

Back wall from dark red to white improved daylighting

Better T5 fluorescent optics

Better light distribution over the work place

…but bad designed occupancy responsive control

Automatic on-off setting for personal lighting and field of view too wide

High school, Helsingborg, SE

100% indirect
LED (4000 K)

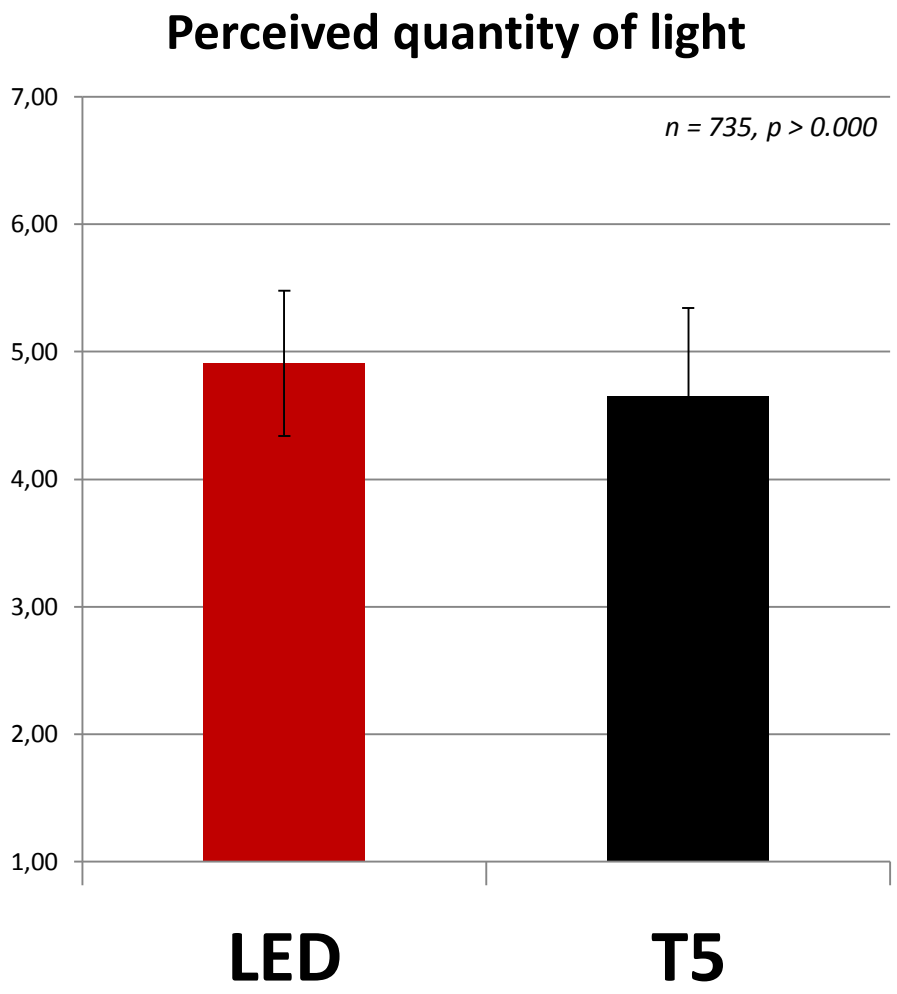
50/50% direct/indirect
FLUORESCENT T5 (4000 K)

Evaluation of students appreciation and energy saving of direct T5 Vs indirect LED lighting

High school, Helsingborg, SE

Very little saving (about 1%), BUT...
the space is perceived brighter despite the same horizontal illuminance

We might dim a bit and save more energy!



City Hall, Horsens, DK


Image Source: Werner Osterhaus

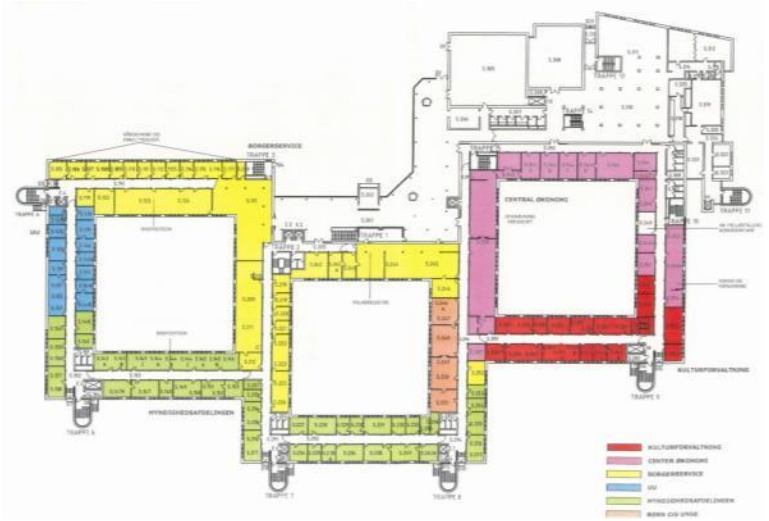



Image Source: Werner Osterhaus

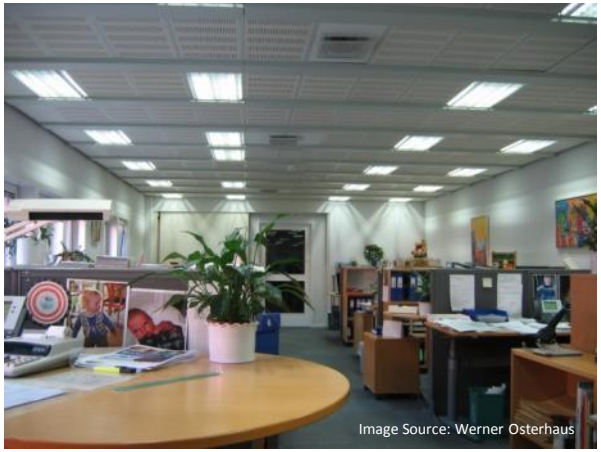
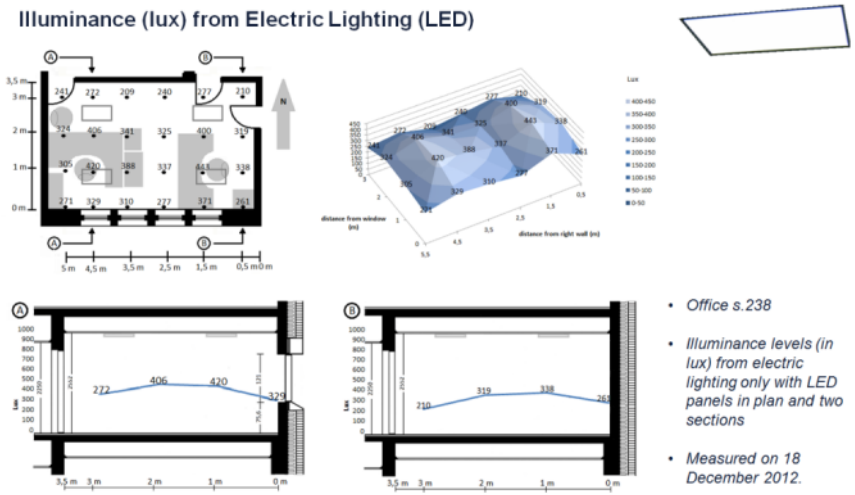


Image Source: Werner Osterhaus

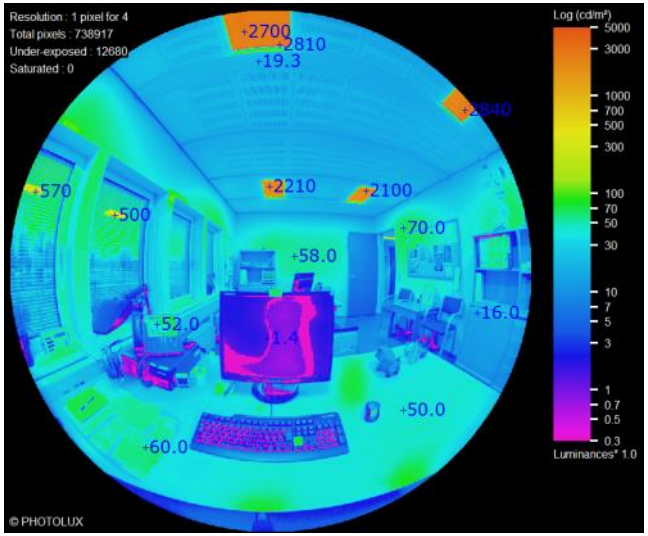

Image Source: Werner Osterhaus

Evaluation of electric lighting retrofit from T8 fluorescent tubes to LED tubes and then LED panels

City Hall, Horsens, DK



- *Office s.238*
- *Illuminance levels (in lux) from electric lighting only with LED panels in plan and two sections*
- *Measured on 18 December 2012.*



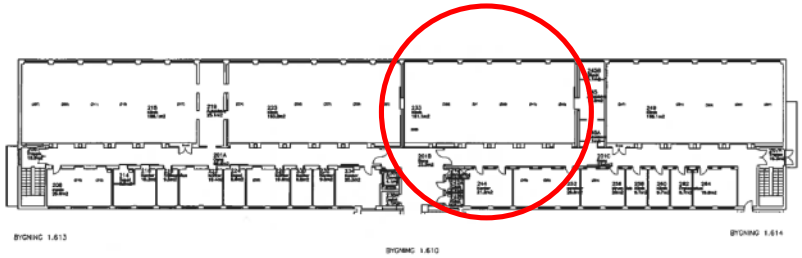
Key Observations

- Windows struggle with providing sufficient daylight
- In winter half of year, electric lighting is required at all times for most spaces
- Electric lighting is on during majority of summer day working hours as well
- Integrated venetian blinds seem to have remained in the same position throughout the year
- LED tubes performed extremely poorly for both illumination levels (just 50% of original) and comfort
- LED panels perform much better on both counts
- Several LED panels are in full view of occupants and can become a source of discomfort or disbility glare
- Some individual employees work almost exclusively under compact flourescent task lighting and daylight → CCT of LED panels perceived as too high

Measurement Dates

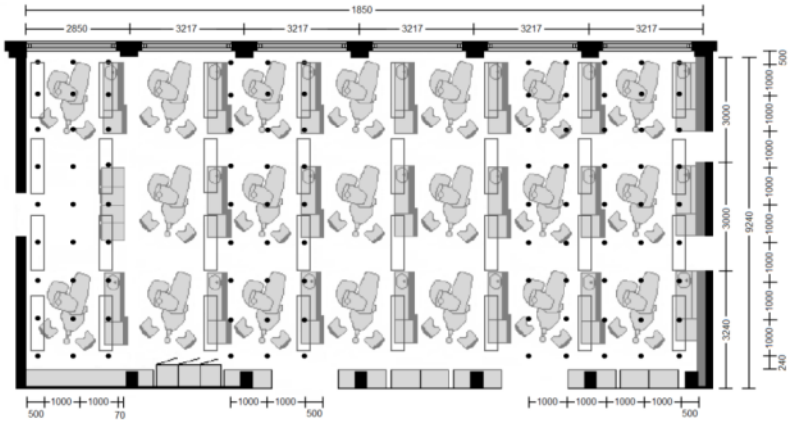
- Nov 2012 (old fluorescent T8 tubes at 2700K)
- Dec 2012 (new LED tubes at 5500K – 6000K)
- Mar 2013 (new LED panels at 5500K – 6000K)
- Jun 2013 (new LED panels at 5500K – 6000K)
- Sep 2013 (new LED panels at 5500K – 6000K)
- Dec 2013 (new LED panels at 5500K – 6000K)
- Dec 2014 (new LED panels at 5500K – 6000K)

Dental School, Aarhus University, DK



Evaluation of electric lighting and daylight-linked lighting control retrofit

Dental School, Aarhus University, DK



Measurement points in East-facing clinic space

Key Observations

- In general, low daylight factor despite large windows due to high trees in front of many windows
- Shift in correlated color temperature from 3000K to 4000K and color rendering index from 80+ to 90+ seen as appropriate
- High illuminance from electric lighting: above the 1000 lux suggested in Danish Standard → nevertheless comfortable, essentially glare-free electric lighting
- Problems with daylight-linked sensors: too sensitive → electric light levels adjusted far too frequently
- Sensors at the moment essentially disabled due to annoyance→ no daylight-linked dimming → electric lights always fully lit → energy-savings not realised

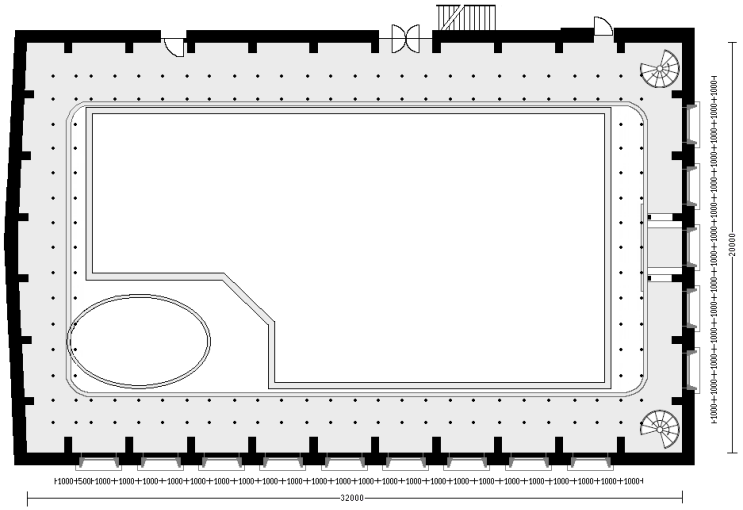
Measurement Dates

- Jul 2014
- Nov 2014
- Dec 2014 – Jan 2015
- Apr 2015
- Jun – Sep 2015 → no measurements due to façade renovation (windows covered)
- one more measurement period planned in Oct 2015

Public Indoor Pool “Spanien”, Aarhus, DK

Evaluation of electric lighting retrofit from T8 fluorescent tubes to LED tubes in swimming pool area and new fluorescent lamps in other areas

Public Indoor Pool “Spanien”, Aarhus,DK



Measurement points around swimming pool

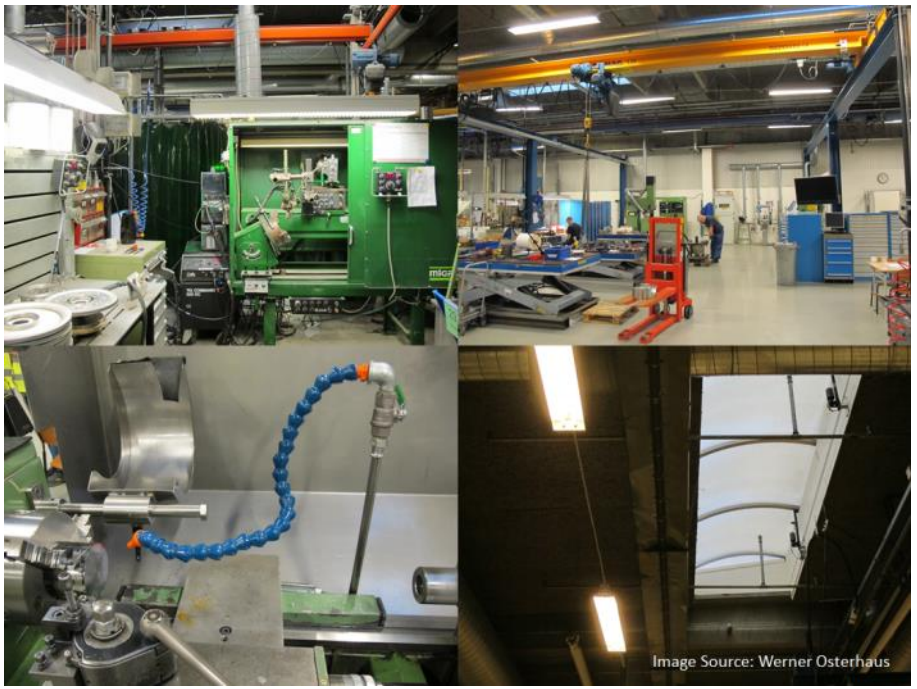
Key Observations in Main Swimming Pool Hall

- When electric lights are at full power, reflections are seen on water surface →staff have difficulities to see bottom of basin (both for fluorescent and LED)
- Due to reflections in water surface and resulting discomfort, staff are in main swimming hall normally only for a short time
- Most staff are complaining about the reflections in the water
- After LED retrofit, staff have to shield their eyes when looking across the pool horizontally when lights are at full power → lights mostly dimmed to lower setting determined by staff individually via control panel
- LED lighting can also be color-adjusted via control panel
- Some areas of swimming hall (especially under balconies) are almost only lit by electric light

Measurement Dates

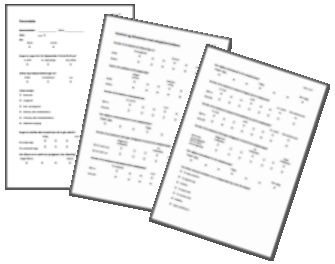
- Jun 2014 (old fluorescent tubes)
- Sep 2014 (old fluorescent tubes)
- Jan 2015 (new LED tubes)
- Apr 2015 (new LED tubes)
- Jun 2015 (new LED tubes)
- Sep 2015 (new LED tubes)

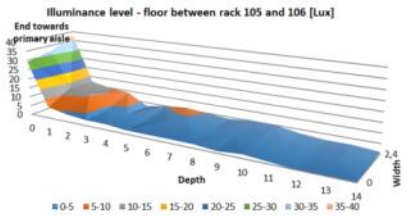
Factory Building, Kolding, DK



Evaluation of existing electric lighting and a partial retrofit in some critical manufacturing areas

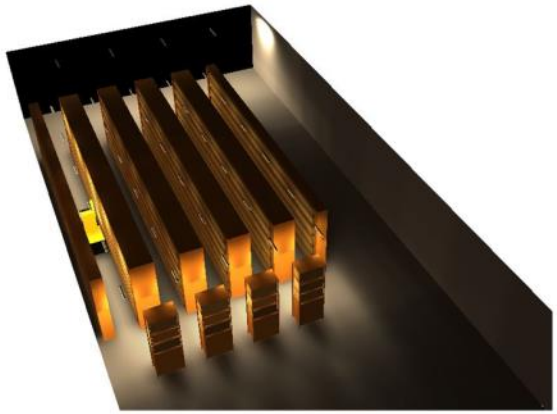
Factory Building, Kolding, DK





Key Observations

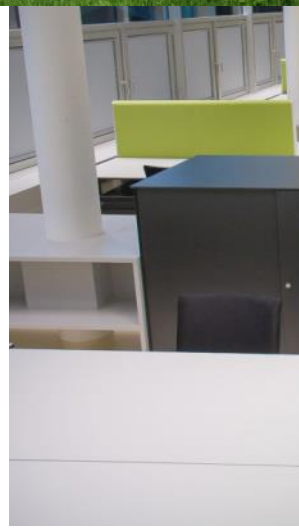
- In general, very low daylight levels due to significant obstruction of skylights through ventilation ducts, cable trays and/or storage shelves
- Electric lighting already upgraded at key factory workstations
- Disability and discomfort glare experienced at some workstations
- Electric lighting levels in aisles between storage shelves far too low
- Luminaire mounting position and/or direction not changed when shelving units were re-configured
- Proposals developed to improve lighting and thus safety in storage aisles and other critical areas



Measurement Dates

- Oct 2013
- Nov 2013

Bartenbach R&D Office, Aldrans, AT

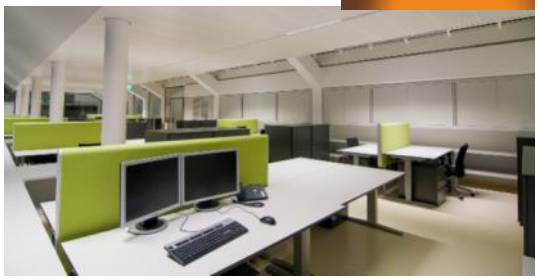


Comprehensive retrofit of office: daylight solution, artificial lighting solution, control, interior redesign

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, workplan and exterior illuminance, wind speed, temperature

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

DIY-Market, Coburg, DE

Evaluation of lighting retrofit in DIY-Market

DIY-Market, Coburg, DE

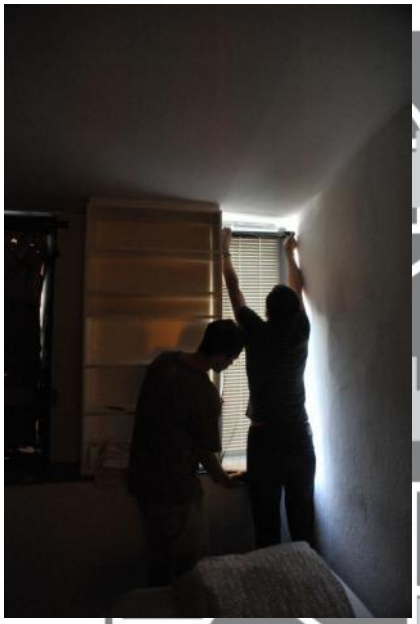
Key Observations

- Although installed, daylight responsive controls are not active, because they were considered unsuitable for selling purposes in a DIY-Market.
- The building is rented, measures on the building skin have not been considered.

Measurement Dates

- Mar 2014 before renovation
  Initial Visit Survey
- Oct 2014 after renovation
  measurements, questionnaire
- Jan 2015 additional measurements
- Apr 2015 additional measurements

Student-Village-Schlachtensee, Berlin, DE



Evaluation of student-room in listed monument before and after the renovation

Student-Village-Schlachtensee, Berlin, DE

Key Observations

- Although exterior walls were insulated and triple glazing was installed, the character of facades and interiors was maintained within renovation.
- Electric lighting only poorly illuminates the space. The old lighting system is considered part of the historical monument.

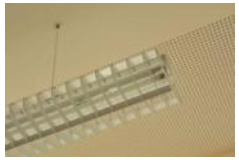
Measurement Dates

- Mar 2014 Initial Visit Survey
- July 2014, before renovation, measurements, questionnaire (Haus 6)
- Septeber 2014 after renovation, measurements, questionnaire (Haus 1)
- Measurements of an alternative renovation szenario are planned (construction work not finished yet)

Uhlandschool, Stuttgart, DE

Evaluation of four electric lighting and lighting control strategies in different classrooms

Uhlandschool, Stuttgart, DE



Classroom 008: **T8 fluorescent**, manual on/off (two control zones), blackboard manual on/off

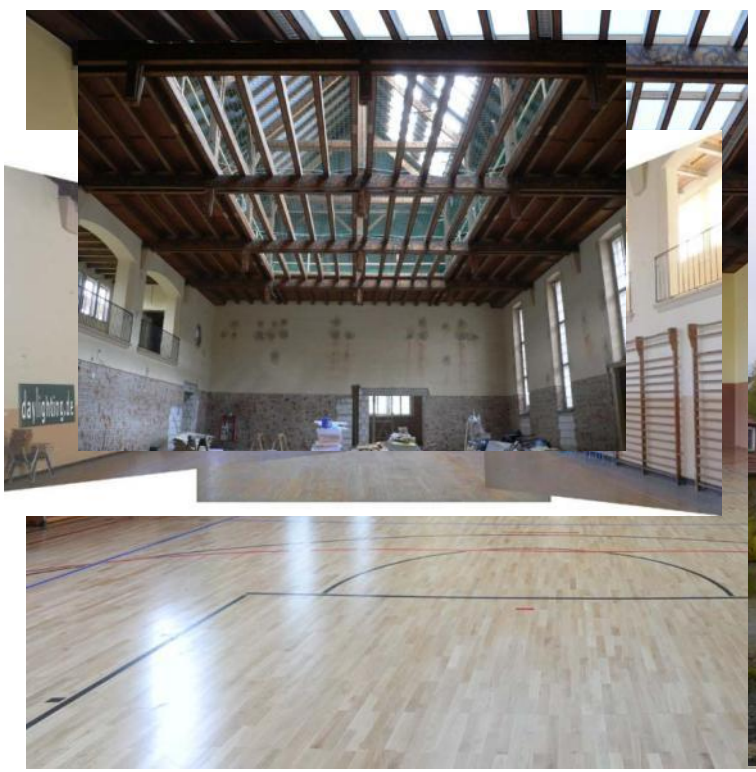
Classroom 009: **T5 fluorescent**, daylight- and occupancy responsive off, blackboard manual on/off

Classroom 108: **LED**, daylight- and occupancy responsive (two control zones), blackboard manual on/off

Classroom 109: **LED**, daylight- and occupancy responsive (three control zones), blackboard manual on/off

classroom	-	008	009	108	109
average daily activity of electric lighting system	[h]	3,78	3,29	5,38	4,81
average electric consumption per week	[kWh]	7,28	4,13	9,00	2,33
average electric consumption per hour of activity	[kWh]	0,39	0,25	0,33	0,10

Fröbelschool, Olbersdorf, DE

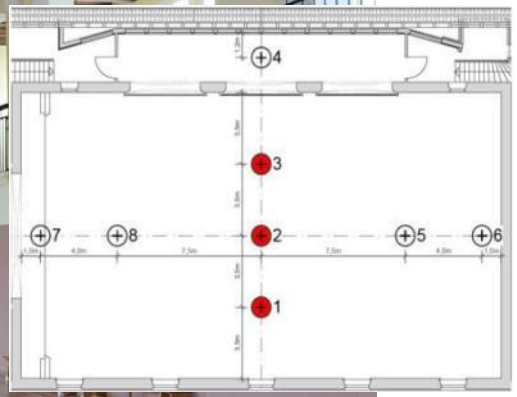


Renovation of Façade and new rooflight to increase daylight level in sports-hall

Fröbelschool, Olbersdorf, DE

	before renovation	after renovation
middle axis, window area	1,0%	2,7%
center of room	0,7%	3,1%
middle axis, rear side	0,3%	2,0%

Daylight factor before and after renovation

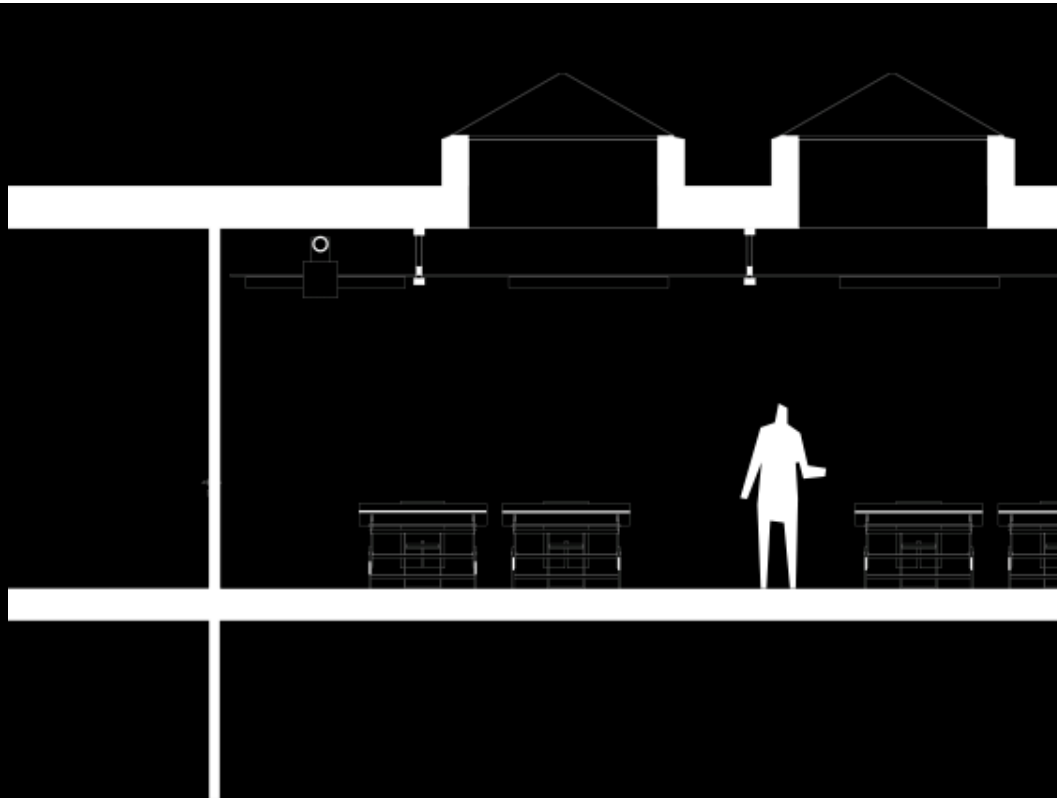


		window (point 1)	middle (point 2)	next to gallery (point 3)
relative usable lighting contribution after renovation (9. am – 2 pm, base: 300 lx)	summer	100%	100%	99%
	spring	96%	97%	91%
	winter	55%	60%	42%

Powerhouse Kjørbo, Oslo, Norway

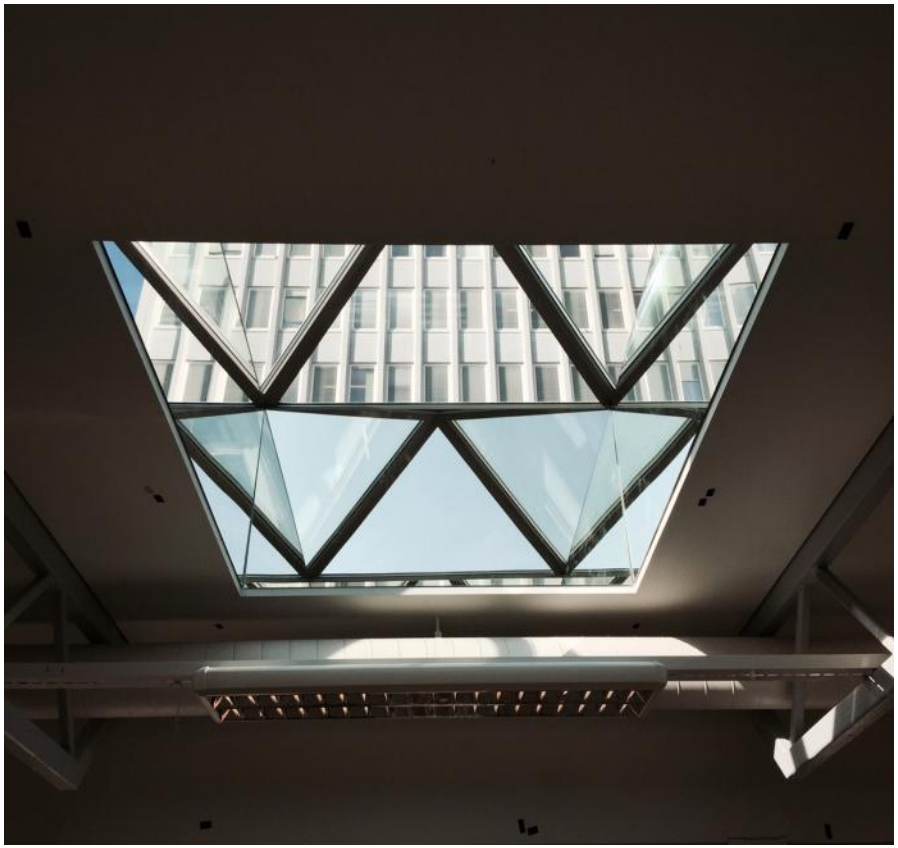
Complete renovation to achieve ZEB

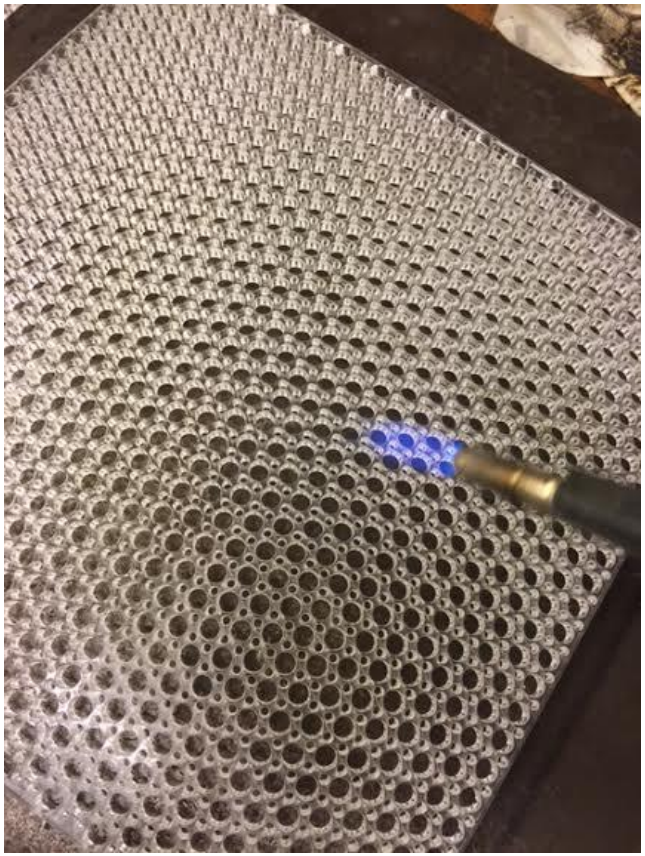
Campus studio, NTNU, Trondheim, NO



Retrofit of skylights+sunlight diffuser

Campus studio, NTNU, Trondheim, NO





Retrofit of skylights+sunlight diffuser

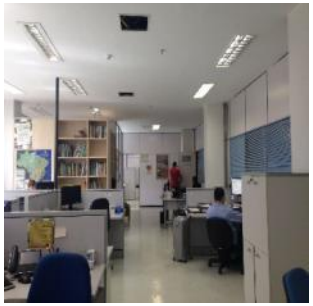
Ministries of Environment (MMA) and Energy (MME) Brasília, BR

MMA

MME

Pre

Pos



Evaluation of two different electric lighting and lighting control strategies in two buildings with the same architecture (1960)

Ministries of Environment (MMA) and Energy (MME), Brasília, BR

MMA

Pre retrofit

Fluorescent lamp, 40 W, manual on/off, electronic ballasts

Pos retrofit

T8 fluorescent lamps (4 x 16), manual on/off, electronic ballasts

MME

Pos retrofit

T5 fluorescent lamps (2 x 28) , electronic ballasts, daylighting and occupancy responsive sensors in rooms and corridors

Forum of Environment and Public FinanceTJDF-T, Brasília, BR

Evaluation of daylighting solutions and electric lighting and lighting control strategies in a new office public building

Environmental Forum TJDF-T, Brasília, BR

T5 fluorescent lamps (3 x 14 W), manual on/off, electronic ballast

Compact fluorescent lamp (1 x 18 W), manual on/off, electronic ballast

Solar protection on windows

SUMMARY Case Studies

- The work is still ongoing , many results e.g. statements about costs and energy savings have not been fixed yet, a consistent presentation of all case studies is about to being produced.
- The monitoring campaign is used as optimization loop for the monitoring protocols.
- Many renovations showed weaknesses in commissioning and operation. In many cases controls did not operate as intended in the design phase.
- Discussions with users and staff give insights in the building operation.

Thank you for your attention!