



**Task 47 Workshop:  
Solar Renovation of Non-Residential Buildings  
Frankfurt 03.04.14**

**How to achieve high daylighting  
quality in retrofitted non-residential  
buildings? Cross-comparison of  
retrofitted European buildings and  
recommendations**

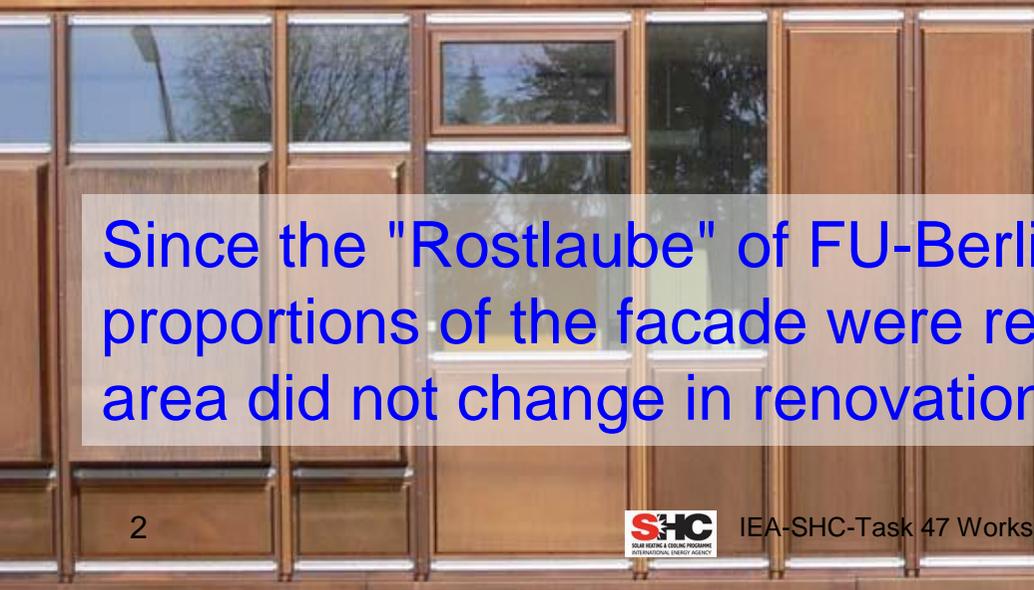
**Roman Alexander Jakobiak  
jakobiak@daylighting.de**



“Rostlaube” (rusty shed) after renovation.



"Rostlaube" (rusty shed); 1967 -1973 by Georges Candilis, Alexis Josic and Shadrach Woods.

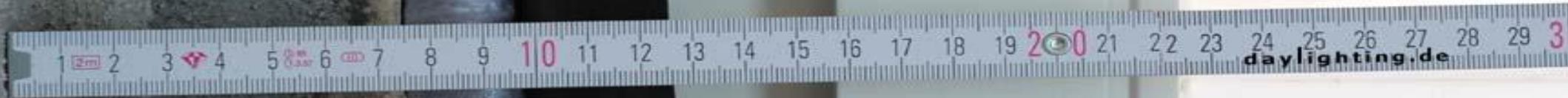


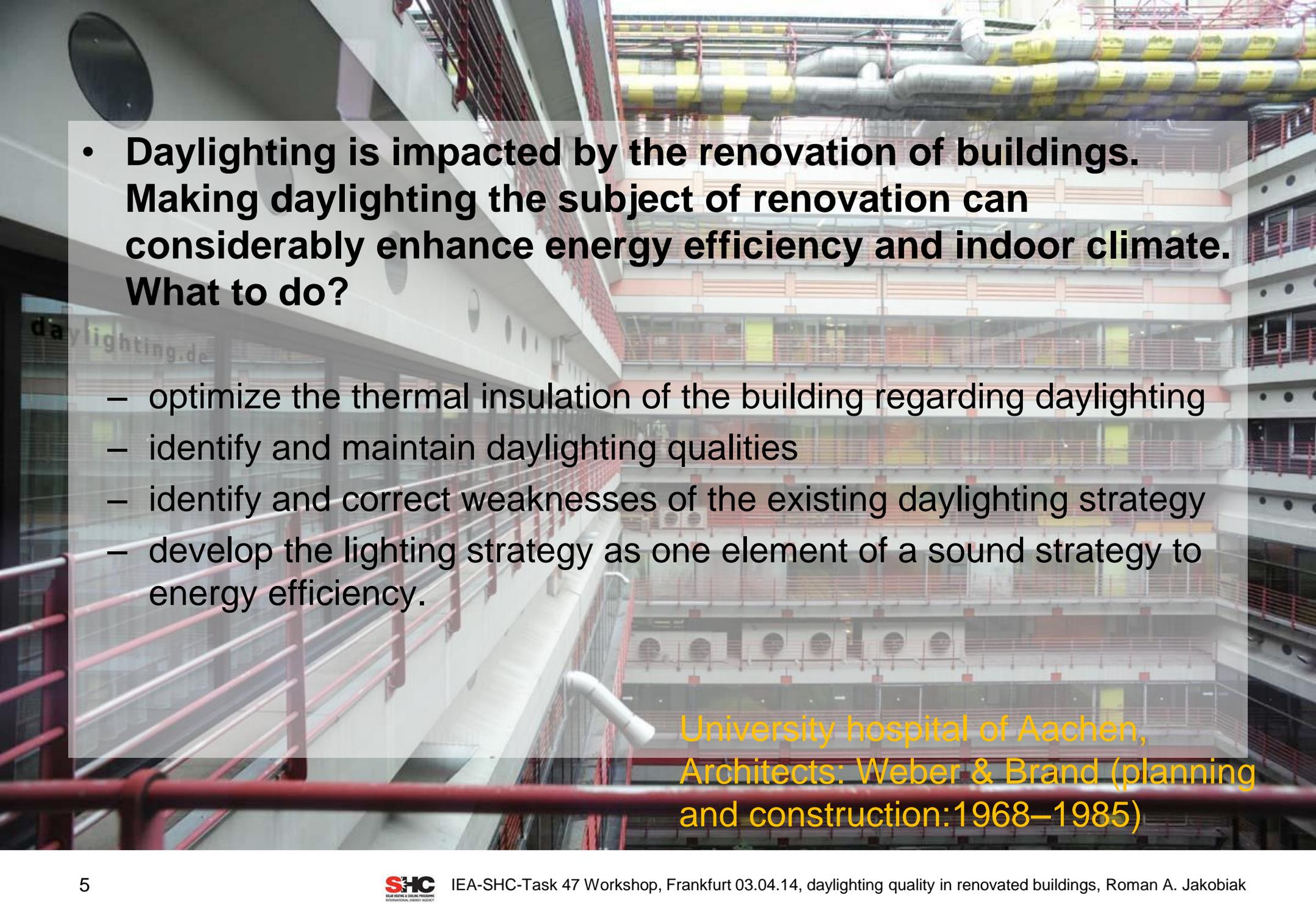
Since the "Rostlaube" of FU-Berlin is a listed monument, the proportions of the facade were retained unchanged. The glazing area did not change in renovation.



When exchanging windows, typically the focus is on improving the heat insulating capacities of the facade. The daylight performance of the building often is not considered adequately.

While the old window frame was fixed at the rabbet, the new frame is mounted between the embrasure and hence considerably reduces the glazing area.





- **Daylighting is impacted by the renovation of buildings. Making daylighting the subject of renovation can considerably enhance energy efficiency and indoor climate. What to do?**

- optimize the thermal insulation of the building regarding daylighting
- identify and maintain daylighting qualities
- identify and correct weaknesses of the existing daylighting strategy
- develop the lighting strategy as one element of a sound strategy to energy efficiency.

University hospital of Aachen,  
Architects: Weber & Brand (planning  
and construction: 1968–1985)



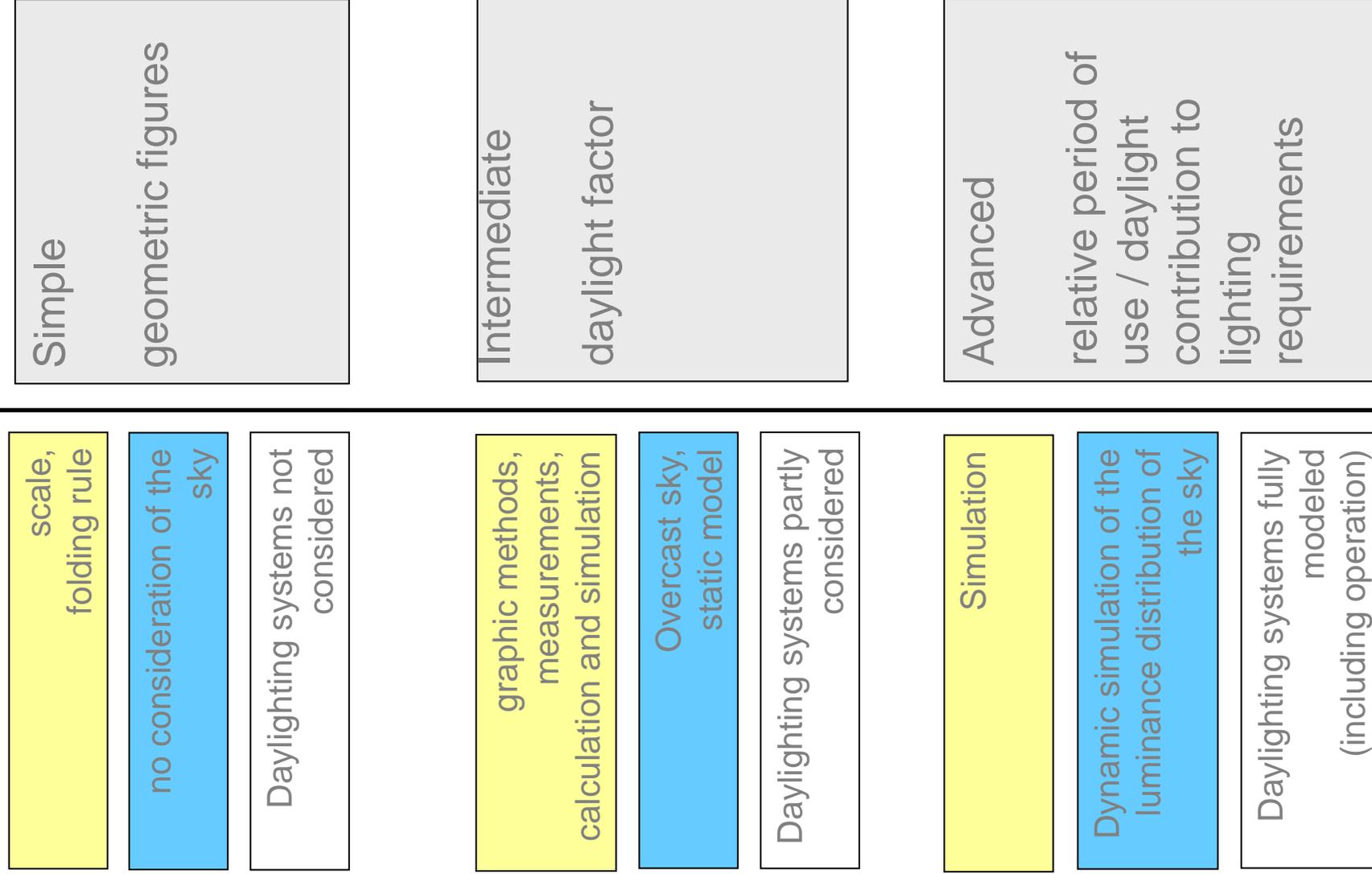
# Overview Buildings and renovation strategies

Building	new Facade	retrofitting all facade components	retrofitting of singular facade components	new electric lighting system	electric lighting system was already renovated	upgrading components of the electric lighting system	new controls (daylight / occupancy responsive)
AT_Bruck_Admin-building							
<a href="#">AT_Graz_Franziskanerkloster</a>							
AT_Schwanenstadt_School							
AT_Vienna_Plus-energy-Univ							
<a href="#">BE_Brussels_Forest_OCMW</a>							
BE_Brussels_Riva-Bella-School							
DE_Berlin_Königin Luise School							
DE_Cottbus_3l-school							
DE_Freiburg_office-workshop							
DE_Freiburg_printing_office							
<a href="#">DE_Olbersdorf_School</a>							
<a href="#">DE_Ulm_Kindergarten</a>							
DK_Copenhagen_Kindergarten							
<a href="#">DK_Copenhagen_Osram</a>							
IT_Cesena_School							
IT_Padova_Schueco-HQ							
<a href="#">NO_Oslo_Kampen-skole</a>							
<a href="#">NO_Oslo_NVE building</a>							
NO_Oslo_Powerhouse							
NO_Oslo_Tax_Authority							

Listed buildings (blue)

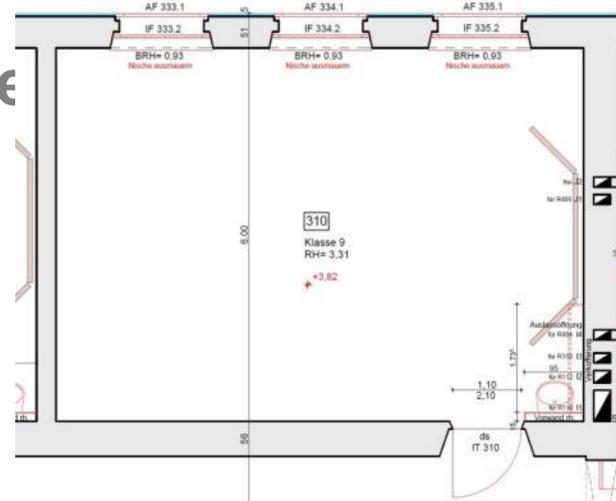


# Categories of metrics regarding daylighting



# eff. Window area to floor area ratio

The **eff. Window area to floor area ratio** allows to evaluate the impact of the renovation on the transparency of the window system.

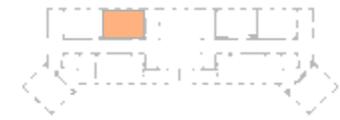
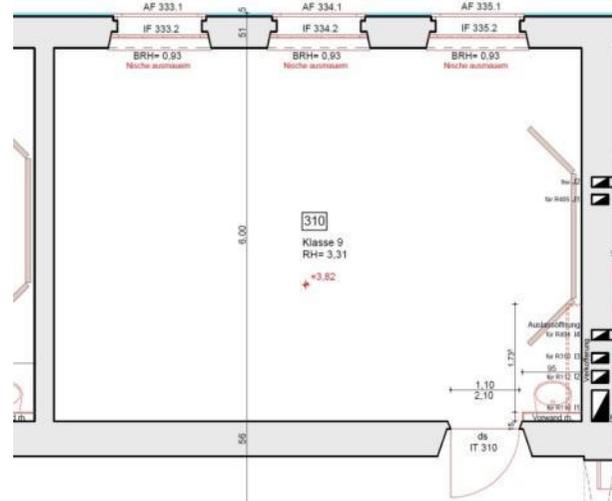


Southeast orientation,  
glazing:  
interior: double low-E ,  
exterior: single white  
shading: blinds in double-  
window

		before renovation	after renovation
area of classroom	$A_{NGF}$	50,76 m <sup>2</sup>	50,76 m <sup>2</sup>
opening area (gross)	$A_F$	8,70 m <sup>2</sup>	8,70 m <sup>2</sup>
opening to floor area ratio	$A_F / A_{NGF}$	17%	17%
reduction factor of frame	$k_1$	0,60	0,55
glazing area	$A_G$	5,24 m <sup>2</sup>	4,79 m <sup>2</sup>
glazed to floor area ratio	$A_G / A_{NGF}$	10%	9%
visible transmission of glazing	$\tau_{D65}$	0,84	0,76
reduction factor for dirt	$k_2$	0,9	0,9
reduction factor for light incidence	$k_2$	0,85	0,85
reduction factor for thickness of wall	$k_e$	0,84	0,83
effective window area	$A_{eff}$	2,84 m <sup>2</sup>	2,33 m <sup>2</sup>
<b>eff. Window area to floor area ratio</b>	<b><math>A_{eff} / A_{NGF}</math></b>	<b>5,6%</b>	<b>4,5%</b>

# daylight factor

The **daylight factor** allows an estimation of the daylighting level on an absolute scale, hence allowing to compare the daylight level in different buildings.



Southeast orientation,  
glazing:  
interior: double low-E ,  
exterior: single white  
shading: blinds in double-  
window

	before renovation	after renovation
Daylight Factor in Center of room	1,3%	1,4%

Measured data if available,  
otherwise the daylight factor is  
calculated.

# Kindergarten (Gruppenraum)

Example with relatively large window area

	before renovation	after renovation
eff. Window area to floor area ratio	0,24	0,2
daylight factor in center of space	1,7 %	1,4%

first results – data not consolidated yet

# Monastery

## Example with relatively small window area

	before renovation	after renovation
eff. Window area to floor area ratio	0,03	0,02
daylight factor in center of space	0,3%	0,2%

first results – data not consolidated yet

## eff. Window area to floor area ratio

	before	after	
office-building	0,12	0,06	50%
monastery	0,03	0,02	83%
office-building	0,17	0,13	76%
school	0,07	0,07	100%
school	0,06	0,05	82%
Kindergarten	0,24	0,20	84%
Kindergarten	0,10	0,08	81%

first results – data not consolidated yet

# Daylight factor

	before	after
office-building	2,0%	0,8%
monastery	0,3%	0,2%
office-building	2,1%	1,4%
school	0,6%	0,6%
school	0,9%	0,7%
Kindergarten	1,7%	1,4%
Kindergarten	1,1%	0,7%

first results – data not consolidated yet

## installed power density

	before	after
office-building	28,0 W/m <sup>2</sup>	24,6 W/m <sup>2</sup>
monastery	5,7 W/m <sup>2</sup>	5,7 W/m <sup>2</sup>
office-building	12,6 W/m <sup>2</sup>	7,0 W/m <sup>2</sup>
school	9,4 W/m <sup>2</sup>	23,5 W/m <sup>2</sup>
school	17,0 W/m <sup>2</sup>	8,2 W/m <sup>2</sup>
Kindergarten	-	8,7 W/m <sup>2</sup>
Kindergarten	8,2 W/m <sup>2</sup>	8,2 W/m <sup>2</sup>

first results – data not consolidated yet

Listed buildings (blue)



# Lighting retrofit in selected classrooms of Königin-Luise-Schule, Berlin

This lighting renovation was part of a research project of TU-Berlin, IBUS and Charité with Trilux.



- **Energy efficient lighting**

- Energy efficient fixtures, additional blackboard lighting



ambient lighting  
4 x Trilux 5041 (RPX-L/35/49/80 EDD),  
equipped with: 1 x 35 W T16  
and dimmable electronic ballast.



blackboard lighting  
2 x Trilux 5041 (RAV-L/35/49/80 E)  
equipped with: 1 x 80 W T16  
and electronic ballast.

- **Light for better learning**

- Possibility to shift color temperature to bluish and to increase lighting level beyond standard requirements, additional blackboard lighting



4 x Trilux Valuco active,  
equipped with: 1 x 35 W T16 for ambient  
lighting and 2 x 49 W T16 for activating  
light, dimmable electronic ballast.



blackboard lighting  
2 x Trilux 5041 (RAV-L/35/49/80 E)  
equipped with: 1 x 80 W T16  
and electronic ballast.

» daylight responsive controls and occupancy sensors for ambient lighting.

Pictures of luminaires: Trilux ([www.trilux.com](http://www.trilux.com))

# Classroom 120: Energy efficient lighting



Classroom 120 before renovation



Classroom 120 after renovation

The calculation according to DIN V 18599-4 :2011-12 includes no method for lighting on a vertical plane.

# Classroom 120: Energy efficient lighting

profile of usage: classroom (schools)

		after renovation			before	Reference
		total	blackboard	working plane	working plane	EnEV 2009
<b>installed power density</b>	$p_j$	<b>9,9 W/m<sup>2</sup></b>	<b>5,3 W/m<sup>2</sup></b>	<b>4,7 W/m<sup>2</sup></b>	<b>13,8 W/m<sup>2</sup></b>	<b>9,2 W/m<sup>2</sup></b>
expenditure figure for electric lighting system	$e_{l,K}$	-	-	1,53	4,53	3,15
gross window area	$A_{RB}$	6,23 m <sup>2</sup>	6,23 m <sup>2</sup>	6,23 m <sup>2</sup>	6,23 m <sup>2</sup>	6,23 m <sup>2</sup>
area of daylighting zone	$A_{TL}$	29,87 m <sup>2</sup>	29,87 m <sup>2</sup>	29,87 m <sup>2</sup>	29,87 m <sup>2</sup>	29,87 m <sup>2</sup>
area of electric lighting zone	$A_{KTL}$	2,51 m <sup>2</sup>	2,51 m <sup>2</sup>	2,51 m <sup>2</sup>	2,51 m <sup>2</sup>	2,51 m <sup>2</sup>
<b>daylight factor for structure</b>	$D_{Rb}$	<b>3,4%</b>	<b>3,4%</b>	<b>3,4%</b>	<b>3,4%</b>	<b>3,4%</b>
<b>classification of daylight level</b>	-	<b>poor</b>	<b>poor</b>	<b>poor</b>	<b>poor</b>	<b>poor</b>
factor daylight contribution (without shading)	$C_{TL,Vers,SNA}$	0,70	0,70	0,70	0,70	0,67
factor daylight contribution (with shading)	$C_{TL,Vers,SA}$	0,15	0,15	0,15	0,15	0,15
<b>factor daylight contribution over all</b>	$C_{TL,Vers}$	<b>0,59</b>	<b>0,59</b>	<b>0,59</b>	<b>0,59</b>	<b>0,56</b>
<b>factor of daylight responsive controls</b>	$C_{TL,Kon}$	<b>0,63</b>	<b>0,5</b>	<b>0,781</b>	<b>0,5</b>	<b>0,5</b>
reduction factor for daylighting	$F_{TL}$	0,63	0,71	0,54	0,71	0,72
expenditure figure daylight	$e_{l,TL,Kon}$	-	-	1,26	1,59	1,54
<b>factor of occupancy responsive controls</b>	$C_{prä,Kon}$	<b>0,71</b>	<b>0,50</b>	<b>0,95</b>	<b>0,50</b>	<b>0,50</b>
reduction factor for occupancy	$F_{Prä}$	0,82	0,88	0,76	0,88	0,88
expenditure figure - occupancy	$e_{l,Präs,Kon}$	1,10	1,17	1,02	1,17	1,17
<b>reduction factor for maintenance</b>	$F_{KL}$	<b>0,95</b>	<b>1,00</b>	<b>0,90</b>	<b>1,00</b>	<b>0,90</b>
expenditure figure - maintenance	$e_{l,Präs,Kon}$	1,06	1,11	1,00	1,11	1,00
eff. operation time in daylighting zone (day)	$t_{eff,Tag,TL}$	701 h	863 h	518 h	863 h	790 h
eff. operation time (night)	$t_{eff,Nacht}$	2 h	2 h	1 h	2 h	2 h
eff. operation time in el. lighting zone (day)	$t_{eff,KTL}$	1099 h	1223 h	959 h	1223 h	1101 h
final energy use of building zone	$Q_{l,b,j}$	235 kWh/a	152 kWh/a	84 kWh/a	400 kWh/a	243 kWh/a
<b>specific final energy use per squaremeter</b>	$Q_{l,b,n}$	<b>6,5 kWh/m<sup>2</sup>a</b>	<b>4,2 kWh/m<sup>2</sup>a</b>	<b>2,3 kWh/m<sup>2</sup>a</b>	<b>11,1 kWh/m<sup>2</sup>a</b>	<b>6,8 kWh/m<sup>2</sup>a</b>
expenditure figure for lighting	$e_l$	-	-	1,96	9,34	5,66

# Classroom 14: Light for better learning



Classroom 14 before renovation



Classroom 14 after renovation

# Classroom 14: Light for better learning

profile of usage: classroom (schools)

		after renovation			before	Reference
		total	blackboard	working plane	working plane	EnEV 2009
<b>installed power density</b>	$p_j$	<b>23,2 W/m<sup>2</sup></b>	<b>5,3 W/m<sup>2</sup></b>	<b>18,0 W/m<sup>2</sup></b>	<b>8,7 W/m<sup>2</sup></b>	<b>9,2 W/m<sup>2</sup></b>
expenditure figure for electric lighting system	$e_{l,K}$	-	-	5,54	2,68	3,15
gross window area	$A_{RB}$	5,95 m <sup>2</sup>	5,95 m <sup>2</sup>	5,95 m <sup>2</sup>	5,95 m <sup>2</sup>	5,95 m <sup>2</sup>
area of daylighting zone	$A_{TL}$	30,44 m <sup>2</sup>	30,44 m <sup>2</sup>	30,44 m <sup>2</sup>	30,44 m <sup>2</sup>	30,44 m <sup>2</sup>
area of electric lighting zone	$A_{KTL}$	1,77 m <sup>2</sup>	1,77 m <sup>2</sup>	1,77 m <sup>2</sup>	1,77 m <sup>2</sup>	1,77 m <sup>2</sup>
<b>daylight factor for structure</b>	$D_{Rb}$	<b>2,4%</b>	<b>2,4%</b>	<b>2,4%</b>	<b>2,4%</b>	<b>2,4%</b>
<b>classification of daylight level</b>	-	<b>poor</b>	<b>poor</b>	<b>poor</b>	<b>poor</b>	<b>poor</b>
factor daylight contribution (without shading)	$C_{TL,Vers,SNA}$	0,55	0,55	0,55	0,55	0,52
factor daylight contribution (with shading)	$C_{TL,Vers,SA}$	0,15	0,15	0,15	0,15	0,15
<b>factor daylight contribution over all</b>	$C_{TL,Vers}$	<b>0,47</b>	<b>0,47</b>	<b>0,47</b>	<b>0,47</b>	<b>0,44</b>
<b>factor of daylight responsive controls</b>	$C_{TL,Kon}$	<b>0,72</b>	<b>0,5</b>	<b>0,78</b>	<b>0,5</b>	<b>0,5</b>
reduction factor for daylighting	$F_{TL}$	0,66	0,77	0,63	0,77	0,78
expenditure figure daylight	$e_{l,TL,Kon}$	-	-	1,17	1,40	1,36
<b>factor of occupancy responsive controls</b>	$C_{prä,Kon}$	<b>0,85</b>	<b>0,50</b>	<b>0,95</b>	<b>0,50</b>	<b>0,50</b>
reduction factor for occupancy	$F_{Prä}$	0,79	0,88	0,76	0,88	0,88
expenditure figure - occupancy	$e_{l,Präs,Kon}$	1,05	1,17	1,02	1,17	1,17
<b>reduction factor for maintenance</b>	$F_{KL}$	<b>0,92</b>	<b>1,00</b>	<b>0,90</b>	<b>1,00</b>	<b>0,90</b>
expenditure figure - maintenance	$e_{l,Präs,Kon}$	1,03	1,11	1,00	1,11	1,00
eff. operation time in daylighting zone (day)	$t_{eff,Tag,TL}$	683 h	937 h	608 h	937 h	856 h
eff. operation time (night)	$t_{eff,Nacht}$	1 h	2 h	1 h	2 h	2 h
eff. operation time in el. lighting zone (day)	$t_{eff,KTL}$	1019 h	1223 h	959 h	1223 h	1101 h
final energy use of building zone	$Q_{l,b,j}$	526 kWh/a	162 kWh/a	364 kWh/a	267 kWh/a	258 kWh/a
<b>specific final energy use per squaremeter</b>	$Q_{l,b,n}$	<b>14,7 kWh/m<sup>2</sup>a</b>	<b>4,5 kWh/m<sup>2</sup>a</b>	<b>10,2 kWh/m<sup>2</sup>a</b>	<b>7,5 kWh/m<sup>2</sup>a</b>	<b>7,2 kWh/m<sup>2</sup>a</b>
expenditure figure for lighting	$e_l$	-	-	6,61	4,86	5,00

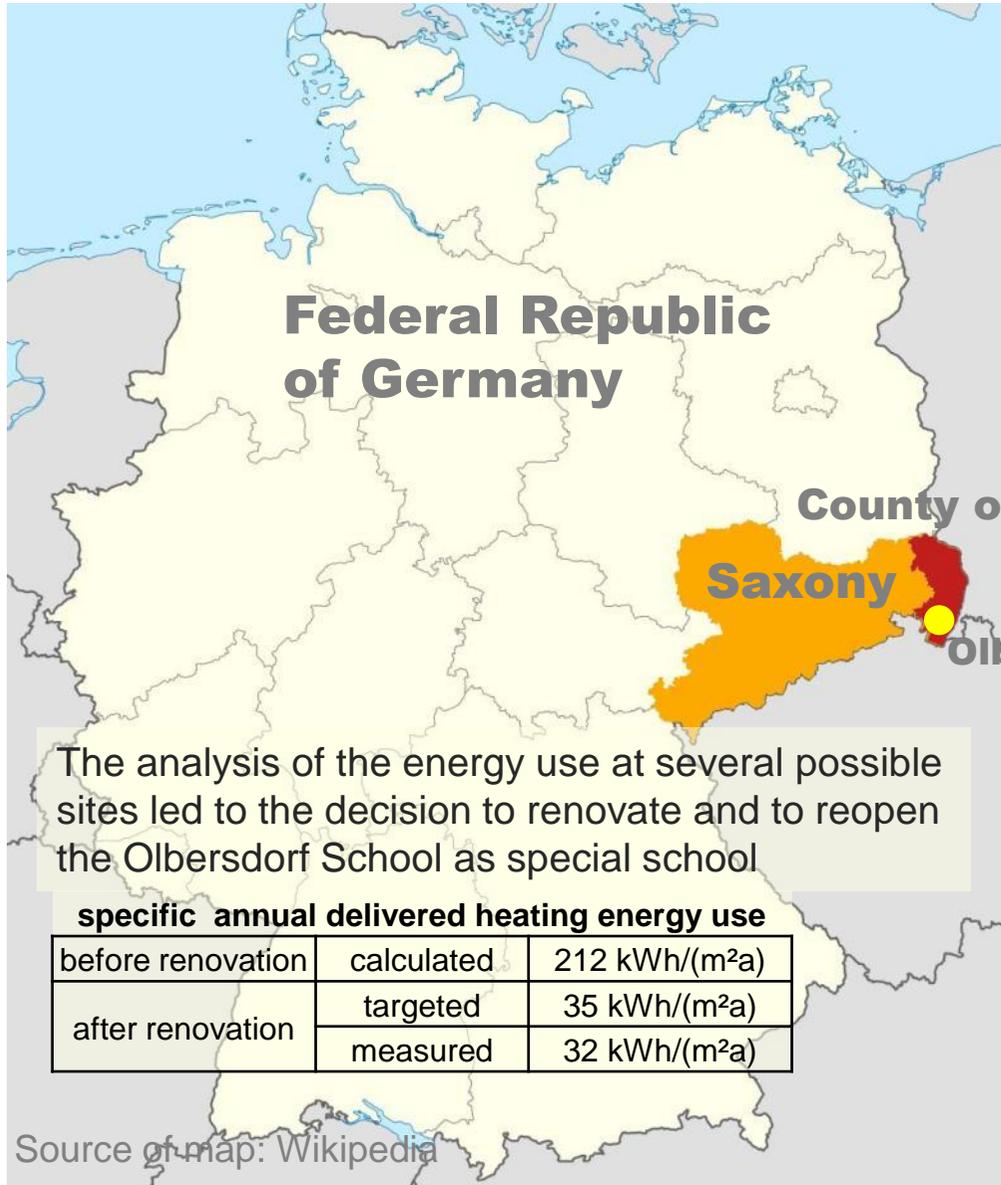
IEA-Task 47 Workshop, Frankfurt, Germany

# **R e n o v a t i o n   o f   t h e F r i e d r i c h - F r ö b e l - S c h o o l i n   O l b e r s d o r f**

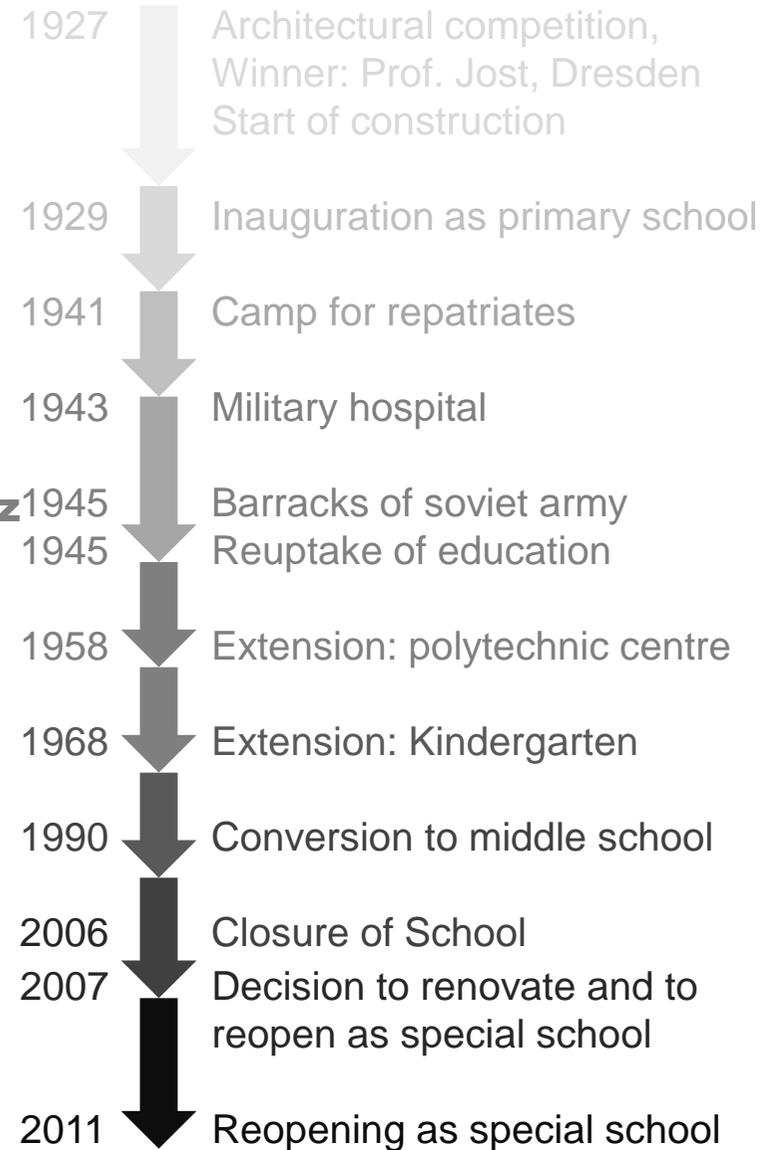


Involved Institutions	
Client	Landkreis Görlitz
Leader of Research Project	HS Zittau/Görlitz, Fakultät Bauwesen, Lehrgebiet Bauklimatik, Prof. Dr. Bolsius
Subcontractor for Lighting	TU-Dresden, Fakultät Architektur, Institut für Bauklimatik
Subcontractor of Subcontractor for Lighting	Roman Jakobiak (Werkvertrag)
Projektbegleitung	Projektträger Jülich
Architect	AIZ - Architektur- und Ingenieurbüro für Hoch- und Tiefbau Zittau GmbH
Electrical engineering	ILM - Ickrath Land Messner, Ingenieurbüro für Elektroenergieanlagen

# Location of Olbersdorf



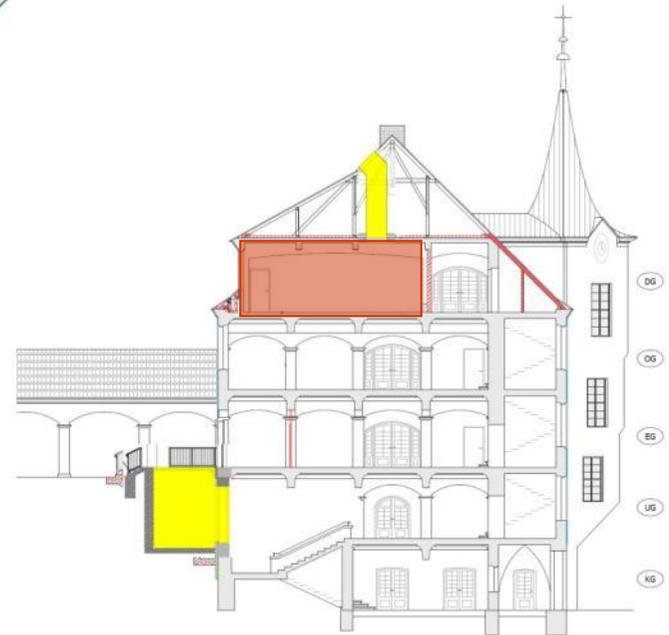
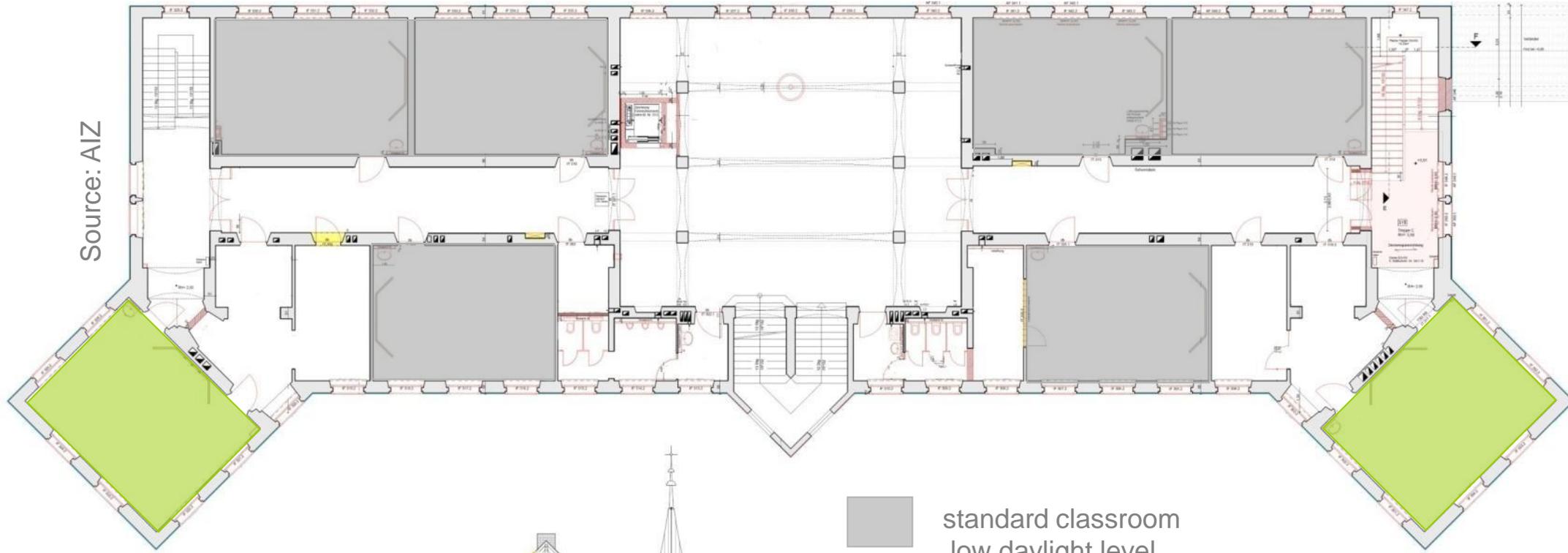
# Timeline of school



# 2<sup>nd</sup> floor plan and cross section, daylight level before renovation

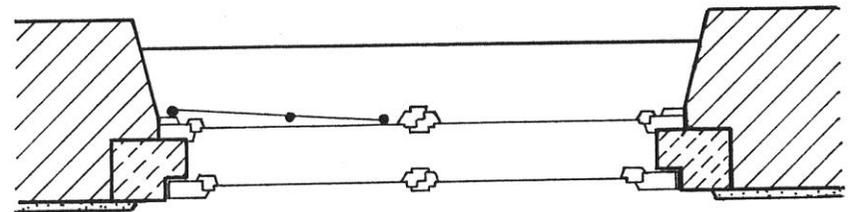
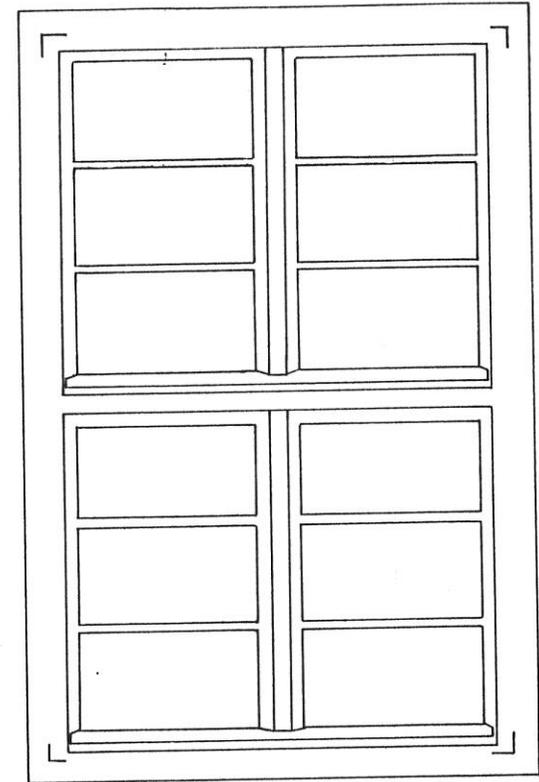
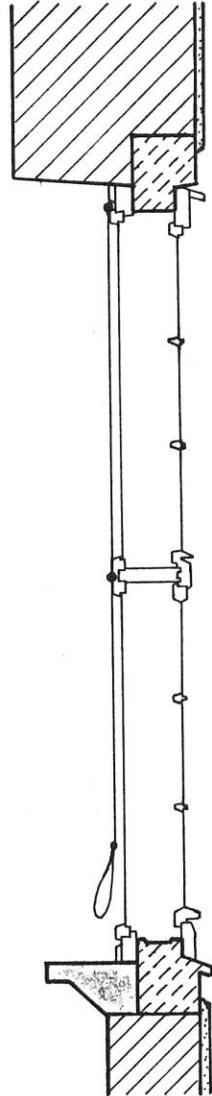
North

Source: AIZ



- standard classroom  
 low daylight level  
 window to floor area ratio = 17%, DF 1,3%
- Classroom with three facades  
 adequate daylight level  
 window to floor area ratio = 32 %, DF 2,4%
- Classroom in the attic  
 unacceptable daylight level  
 window to floor area ratio = 11 %, DF 0,6%

# Box-type-window, old, i



# mock up with different glazing and daylighting systems



exterior upper window: daylight  
redirecting glass "Okasolar W";  
exterior lower window: electrochromic  
glazing; interior window: double low-E

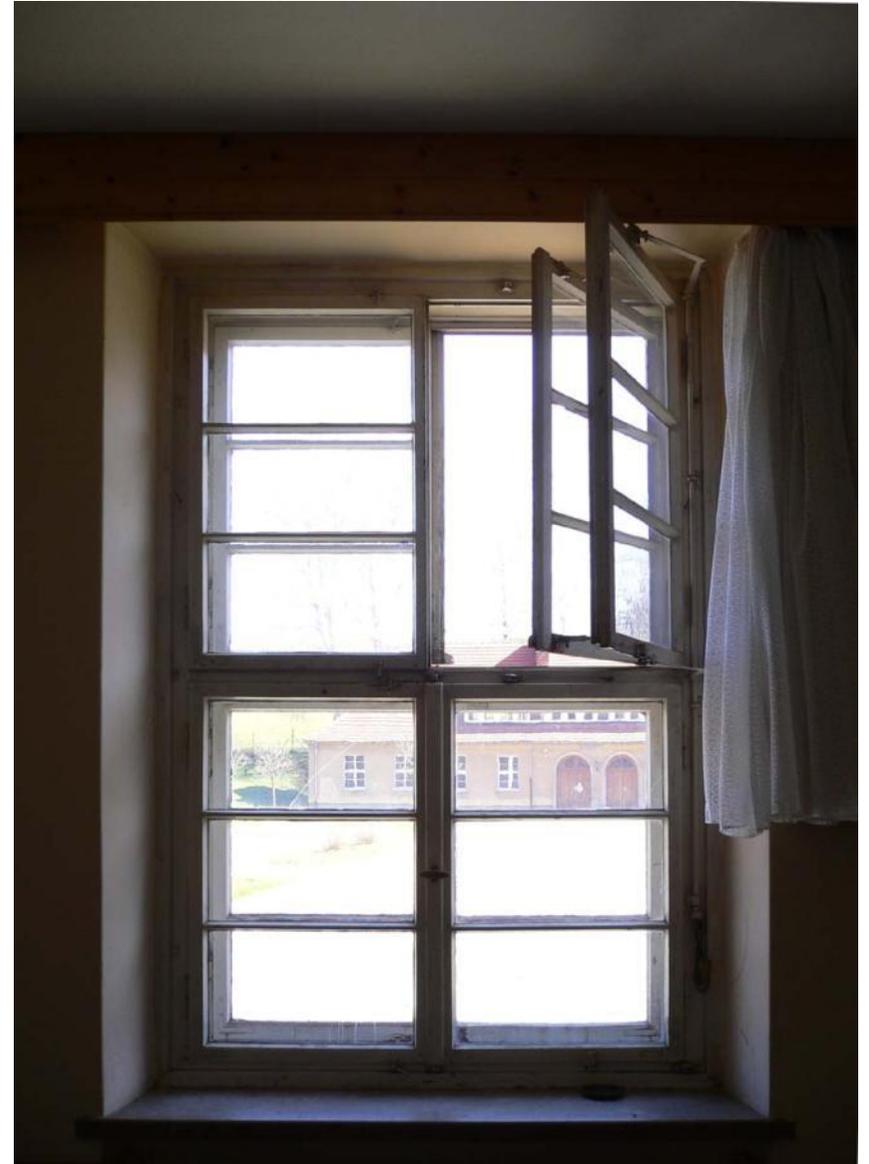


exterior and interior glazing:  
double low-E;  
shading system: Blinds: Warema  
Genius E 50 (white)

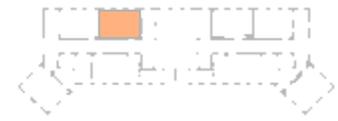
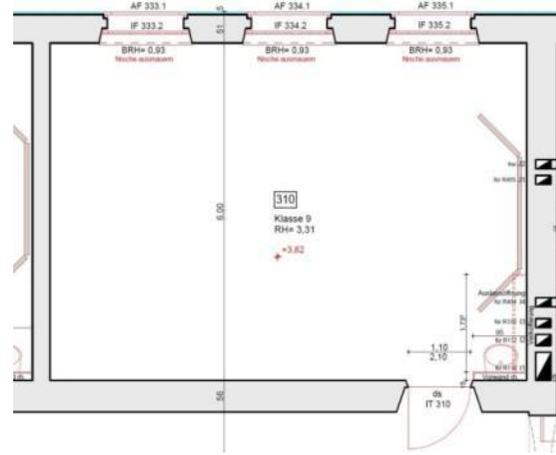


exterior and interior glazing:  
double low-E;  
shading system: Blinds: Warema  
Genius C/E 50 (mirrored aluminum)

# Window, old and new



# standard classroom – metrics on window system



Southeast orientation,  
glazing:  
interior: double low-E ,  
exterior: single white  
shading: blinds in double-  
window

	before renovation	after renovation
area of classroom	50,76 m <sup>2</sup>	50,76 m <sup>2</sup>
opening area (gross)	8,70 m <sup>2</sup>	8,70 m <sup>2</sup>
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reduction factor of frame	0,60	0,55
glazing area	5,24 m <sup>2</sup>	4,79 m <sup>2</sup>
glazed to floor area ratio	10%	9%
visible transmission of glazing	0,84	0,76
<b>eff. Window to floor area ratio</b>	<b>5,6%</b>	<b>4,6%</b>

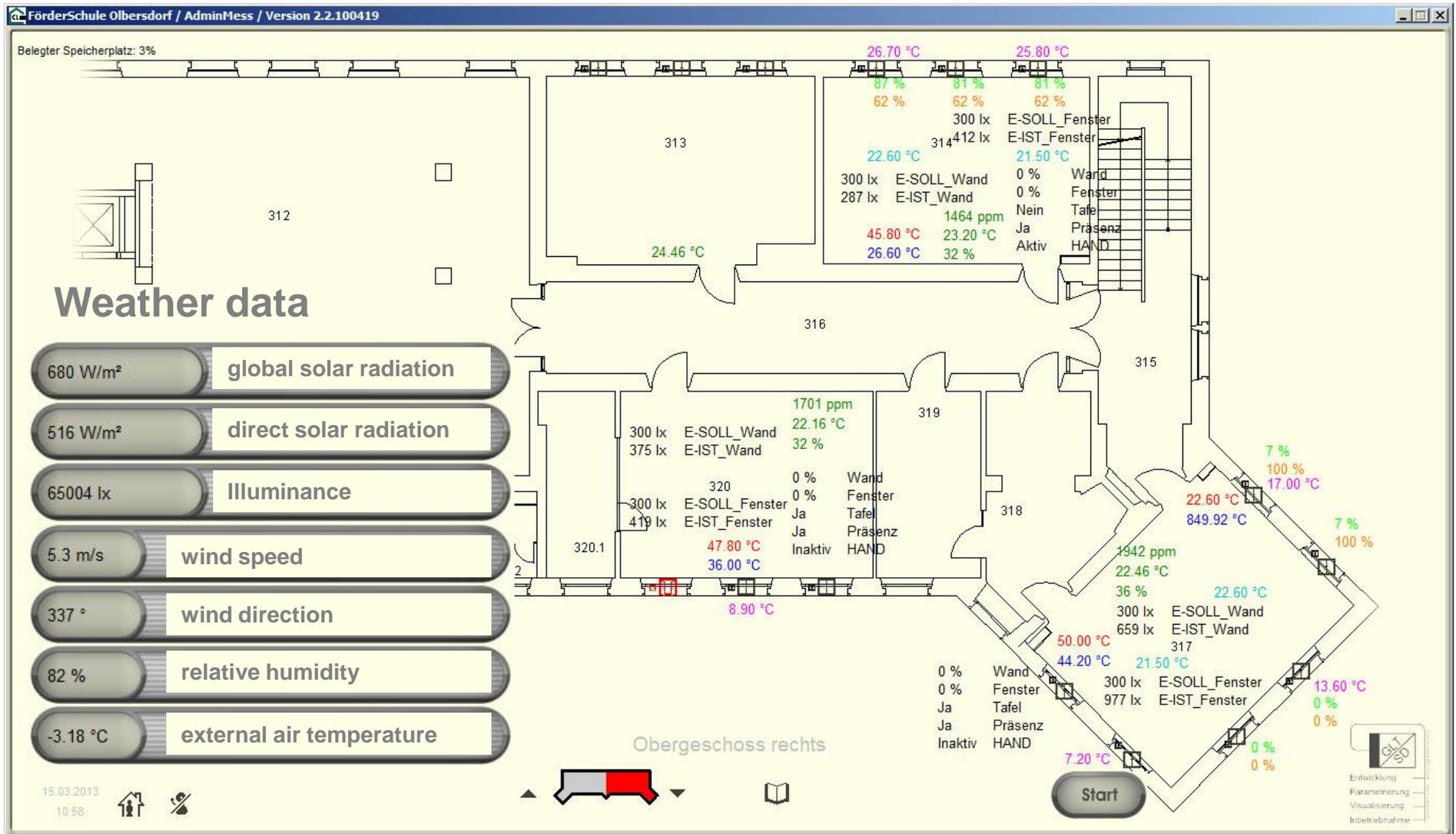
-9%

-10%

Metrics on Window-System before and after renovation

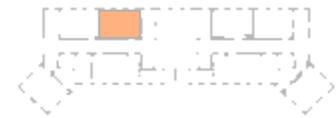
	before renovation	after renovation
<b>Center</b>	<b>1,3%</b>	<b>1,4%</b>
Reference point left side (half depth, 1 m from left sidewall)	1,1%	0,9%
Reference point right side (half depth, 1 m from right sidewall)	0,9%	0,8%

# Screen dump of monitoring system on 15<sup>th</sup> of March, 10:58



monitoring of 549 data points in the lighting scan

# standard classroom – interior view



	window (point 2)	middle (point 3)	corridor (point 4)
relative usable lighting contribution (spring / fall*, 9. am – 2 pm, base: 300 lx)	99,5%	92,4%	85,2%
relative period of use (spring / fall*, 9. am – 2 pm, base: 300 lx)	96,4%	71,7%	62,7%
cylindric / horizontal illuminance	66,2%	87,5%	100,9%

\*) monitoring was performed from 20.10.2011 until 25.10.2011 and from 11.02.2012 until 16.02.2012.

# standard classroom – control system

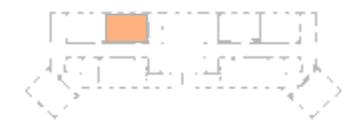
light switch;  
location: next to entrance.



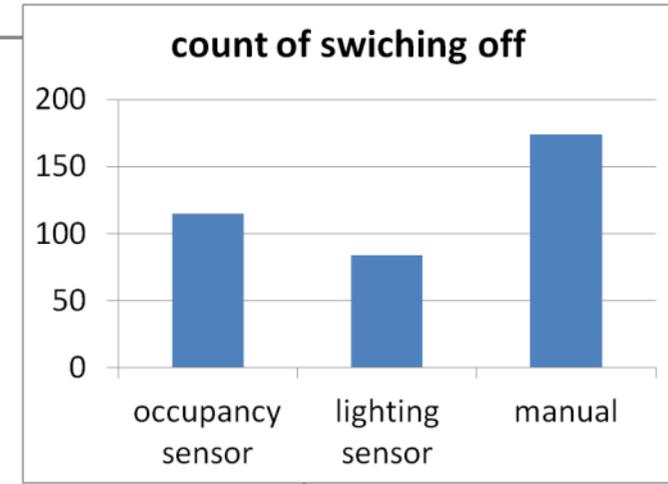
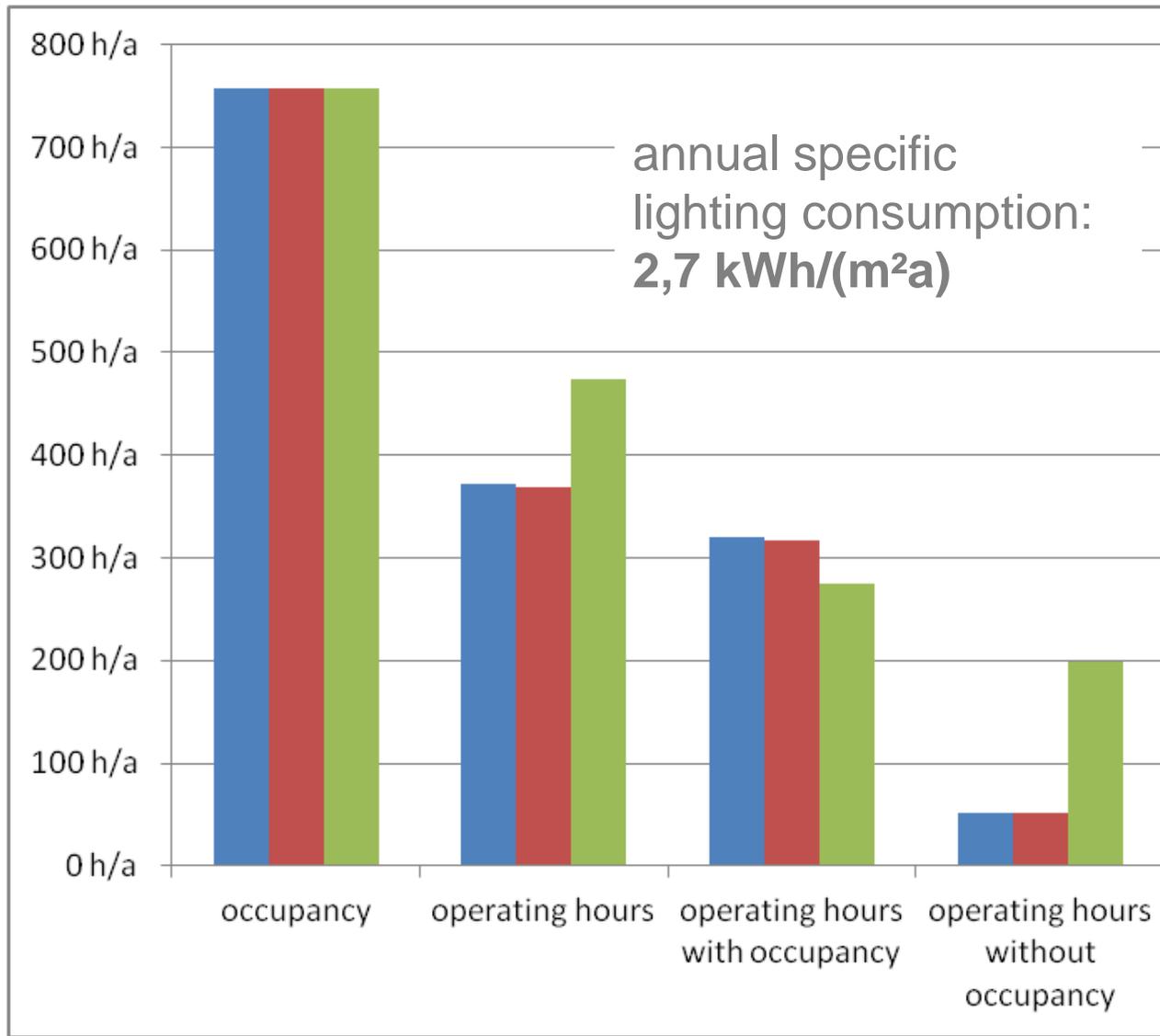
Activation of room-lighting:  
daylighting systems and electric lighting systems are adjusted in order to safeguard the set-point-illuminance.  
In case of direct sunlight automated louver-blinds prevent from glare.

Control panel for teacher;  
location: next to blackboard  
secured by keyswitch.





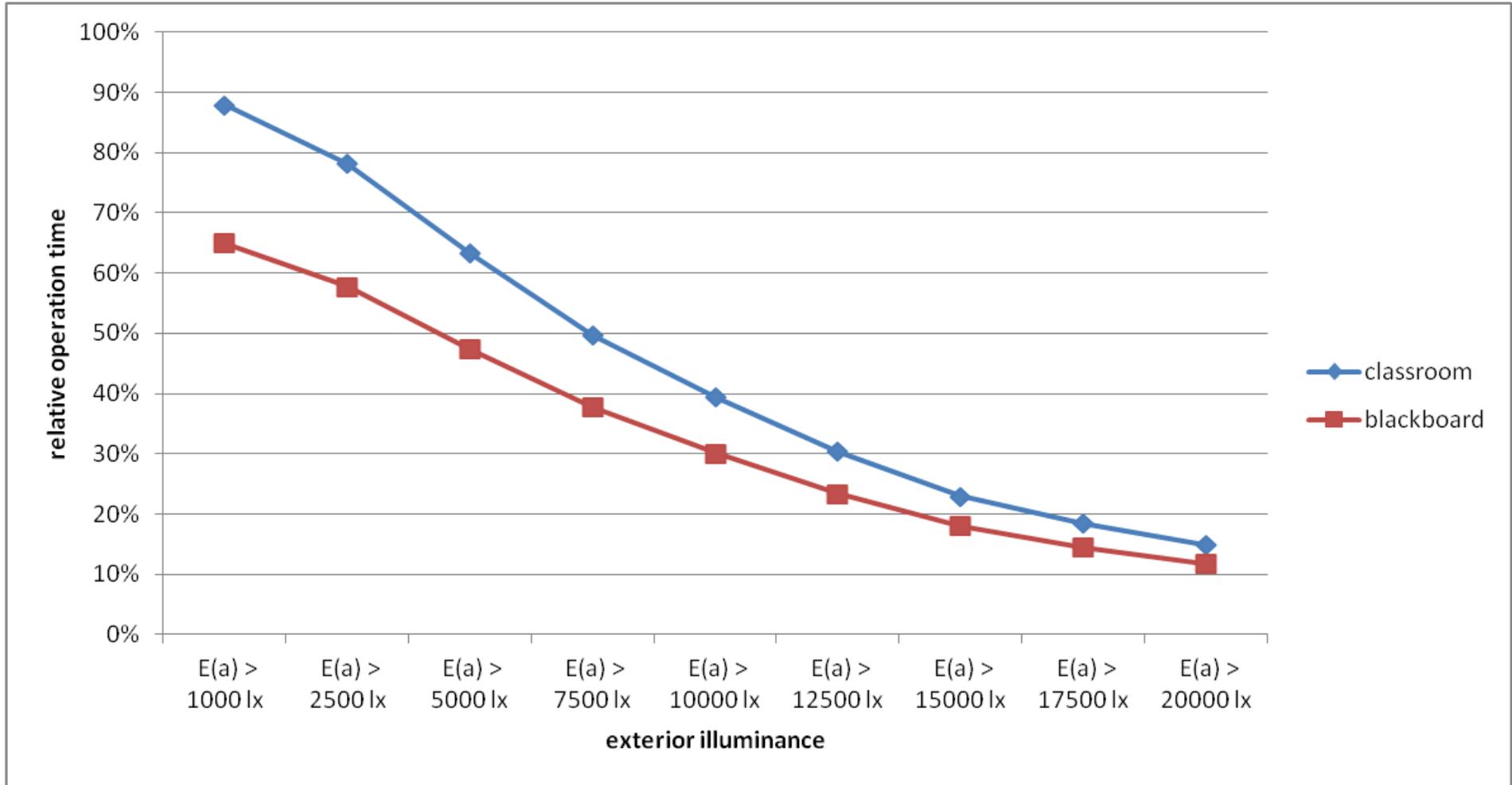
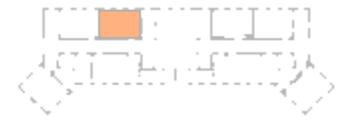
# occupancy & operating hours of electric lighting



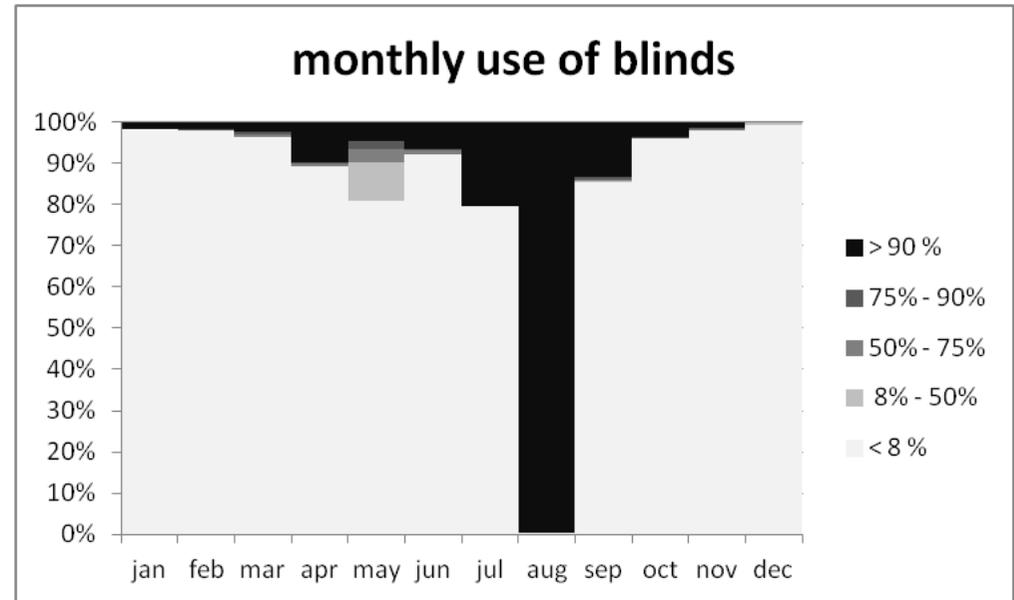
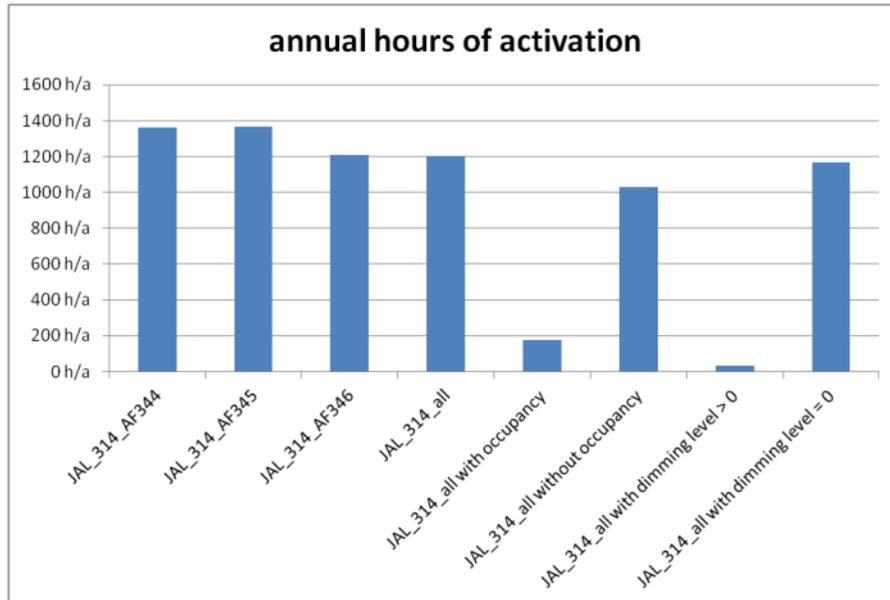
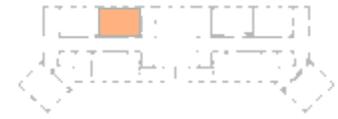
- 314\_wall
- 314\_window
- 314\_blackboard

specific final annual energy lighting energy use calculated with adjusted profile of usage according to DIN V 18599-4:  
 after renovation: **2,73 kWh/(m²a)**  
 before renovation: **10,95 kWh/(m²a)**

# daylight & operating hours of electric lighting



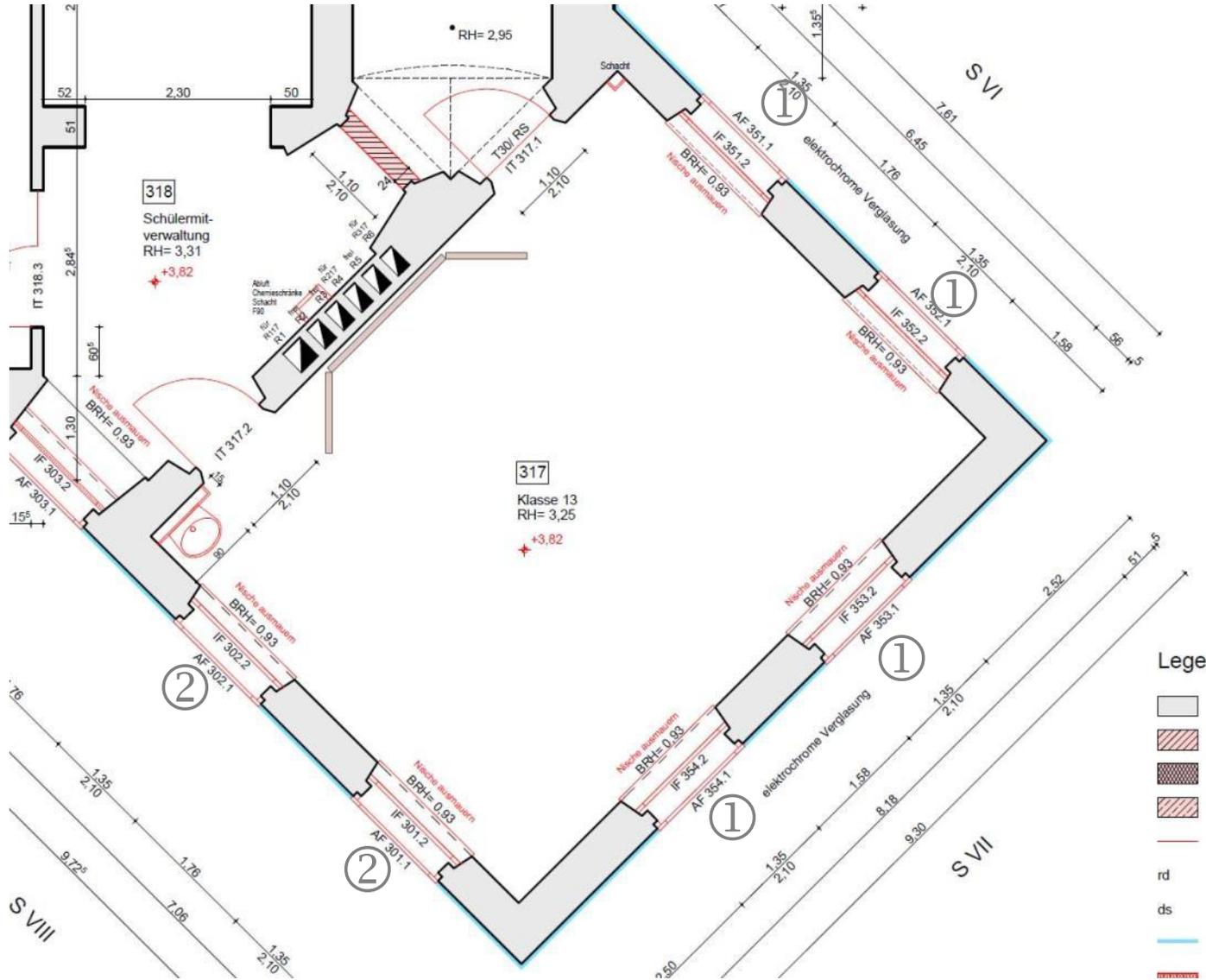
# Shading systems – Blinds (Southeast-facing)



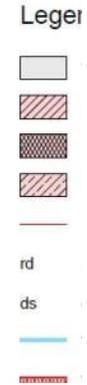
monthly relative period of relative extension of blinds  
 (<8%: recessed; >90 blinds completely cover the window)

# floor plan of classroom with three facades

Source: AIZ



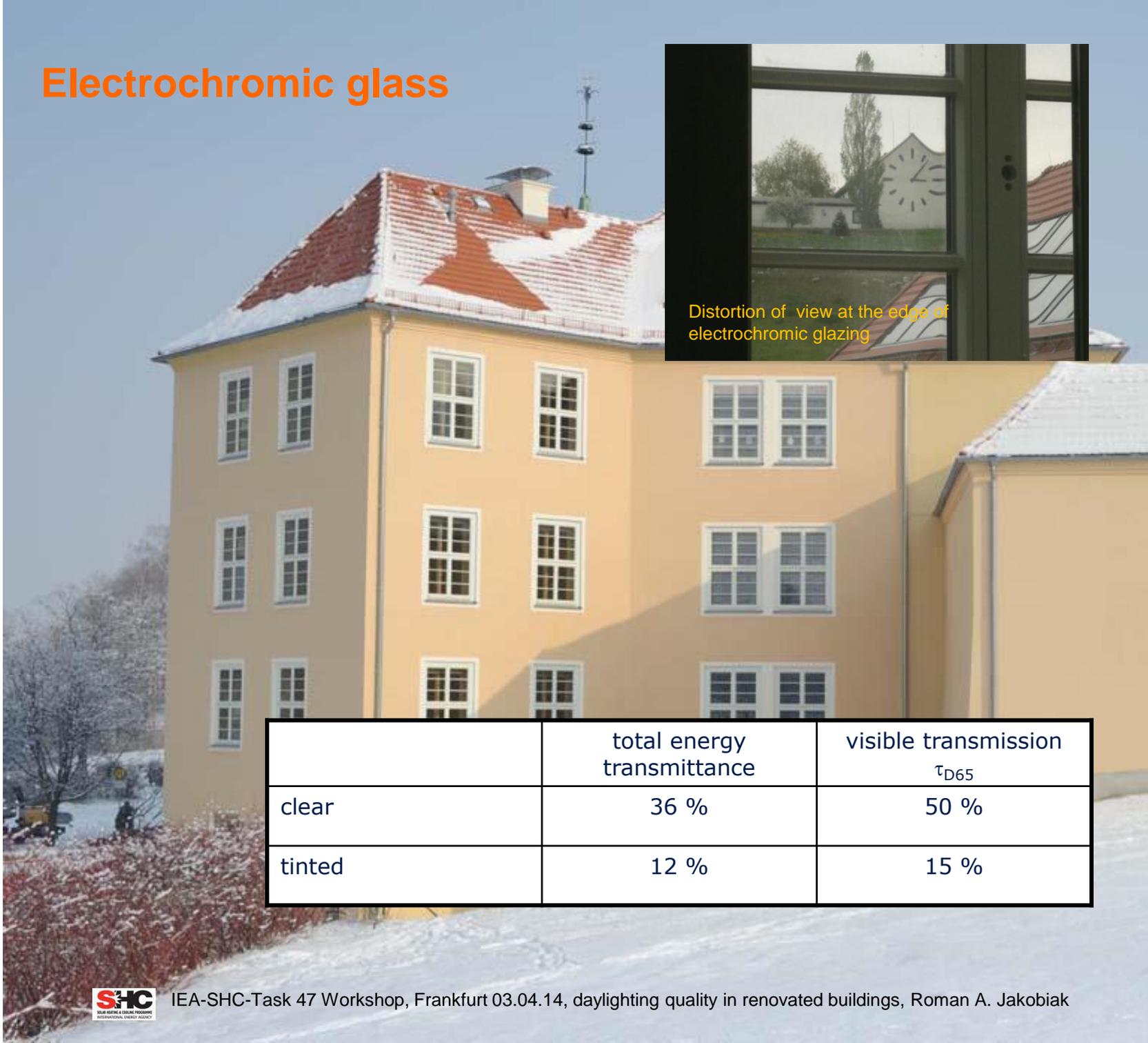
- ① South and West:  
glazing:  
interior: double low-E ,  
exterior: electrochromic  
  
shading: blinds in double-  
window
- ② North:  
glazing:  
interior: double low-E ,  
exterior: single white  
  
shading: none



# Electrochromic glass

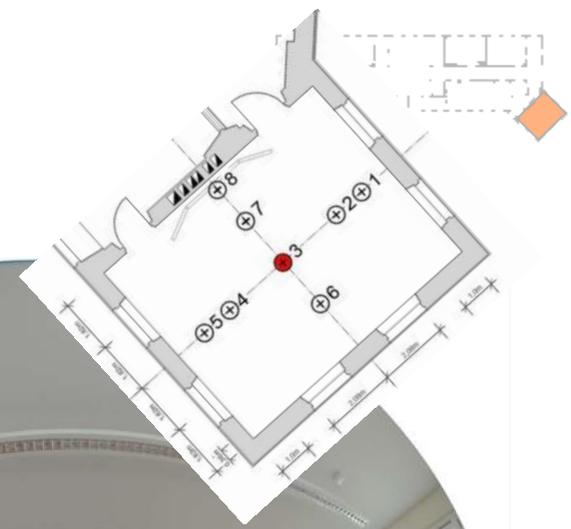


Distortion of view at the edge of electrochromic glazing



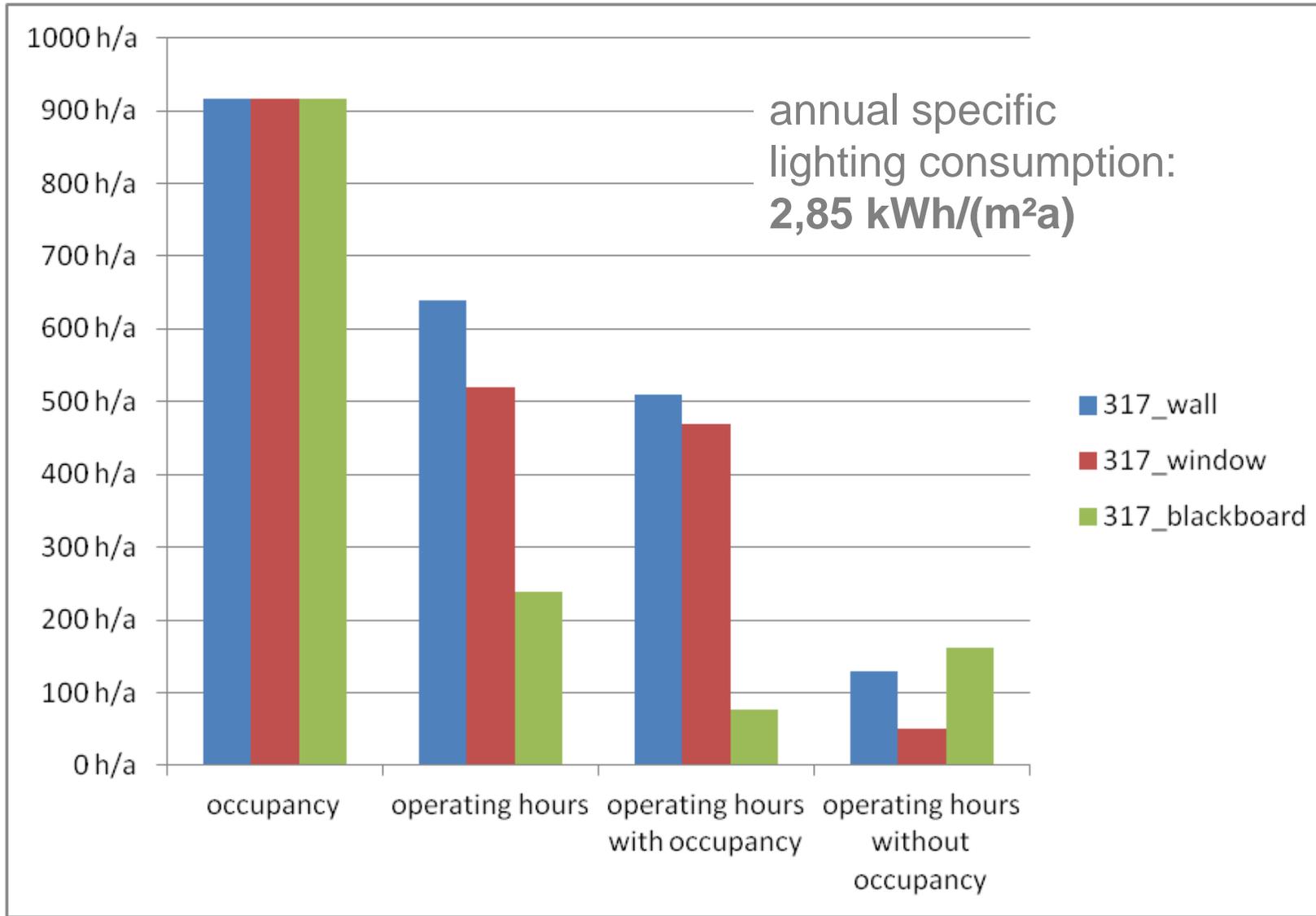
	total energy transmittance	visible transmission $\tau_{D65}$
clear	36 %	50 %
tinted	12 %	15 %

# Classroom with three facades

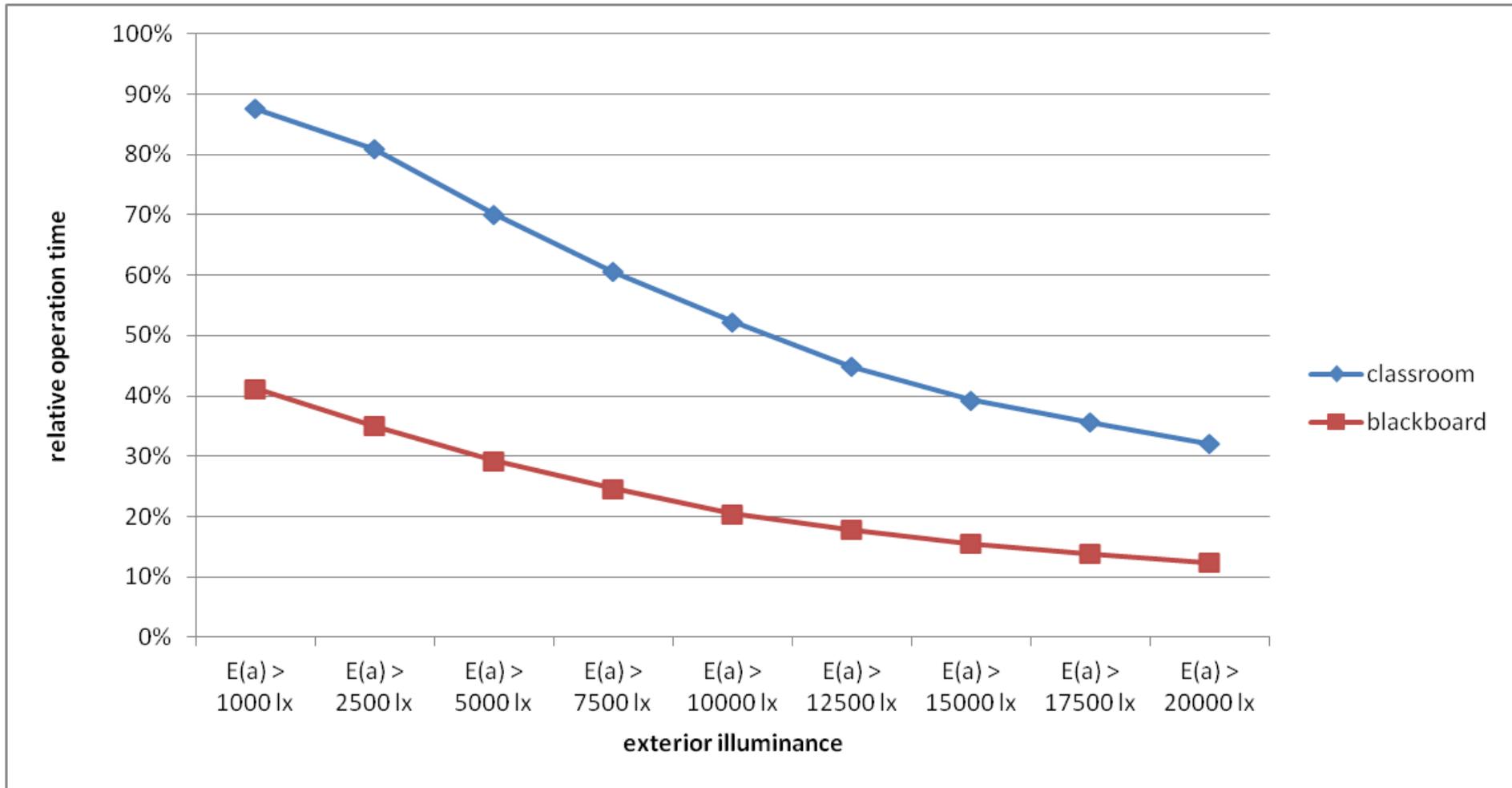


	summer	spring / fall	winter
relative usable lighting contribution (9. am – 2 pm, base: 300 lx)	99%	93%	82%
relative period of use (9. am – 2 pm, base: 300 lx)	93%	74%	61%
cylindric / horizontal illuminance	100%	98%	106%

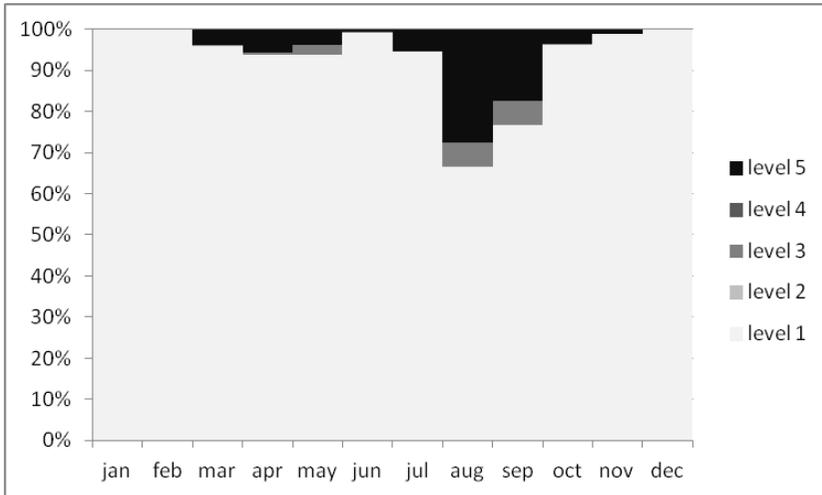
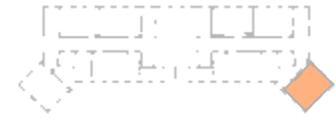
# occupancy & operating hours of electric lighting



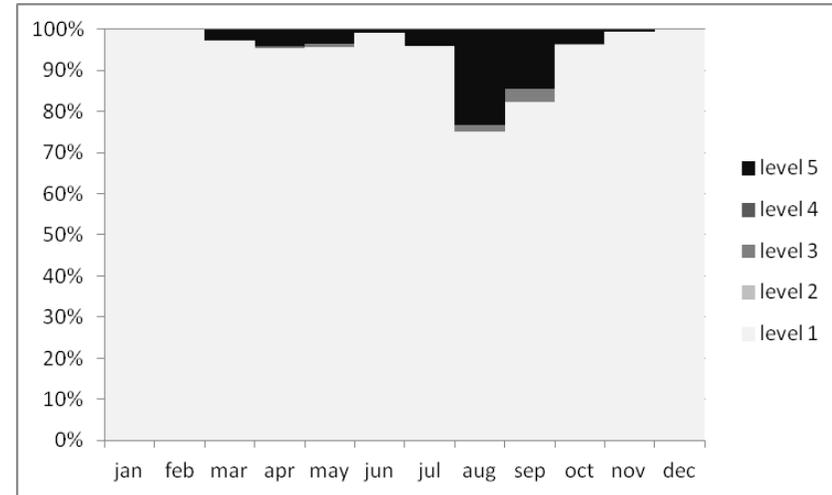
# daylight & operating hours of electric lighting



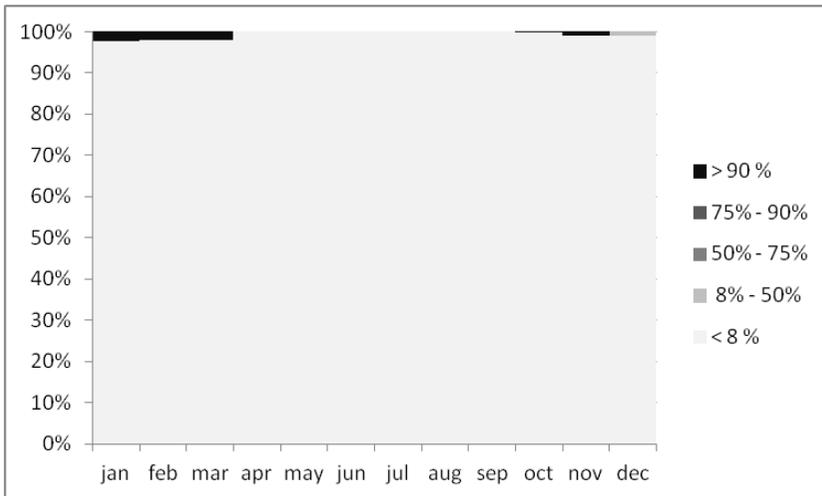
# Shading systems



EC-Glass – South facing  
(automated + manual override)



EC-Glass – West facing  
(automated + manual override)



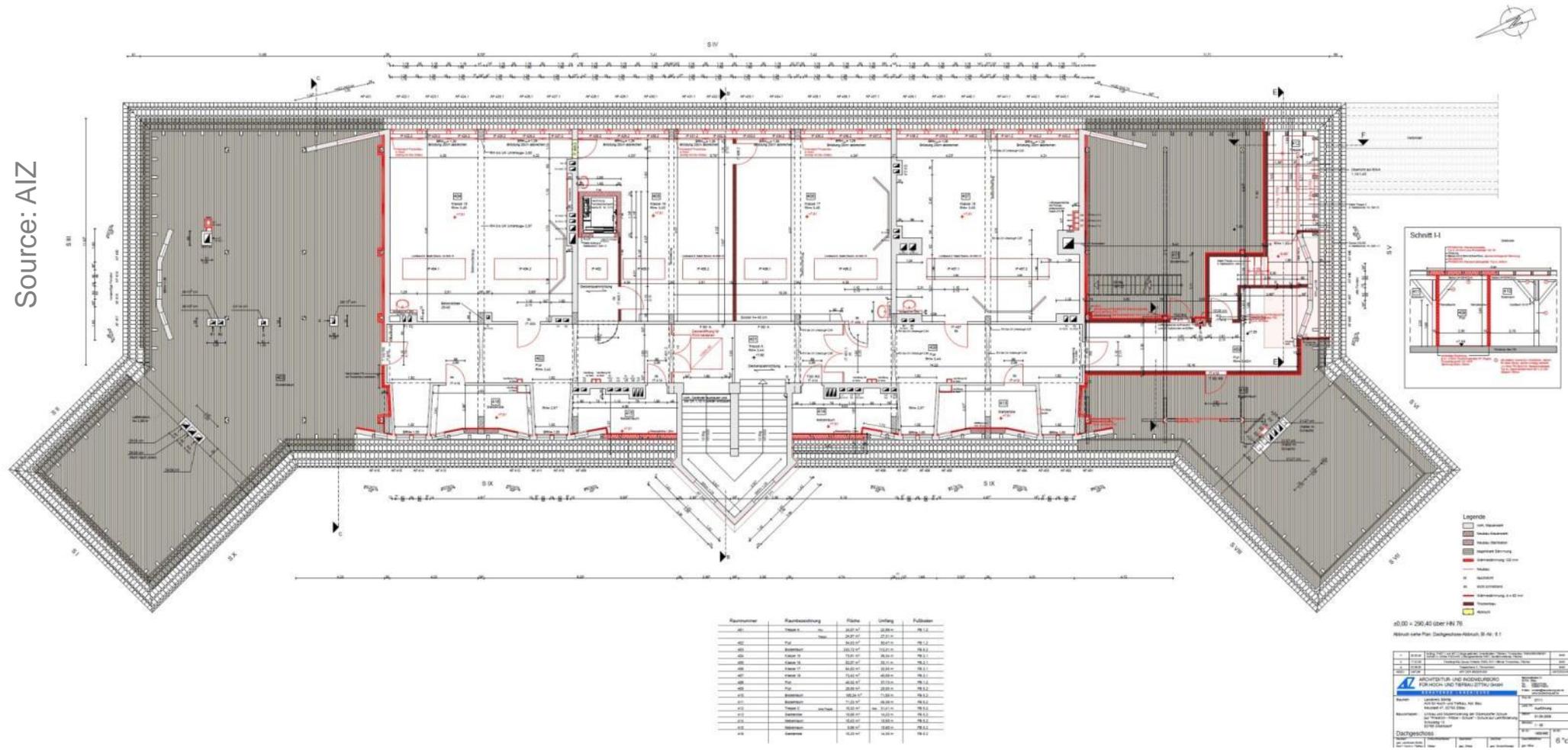
Blinds – South facing  
(operated manually)



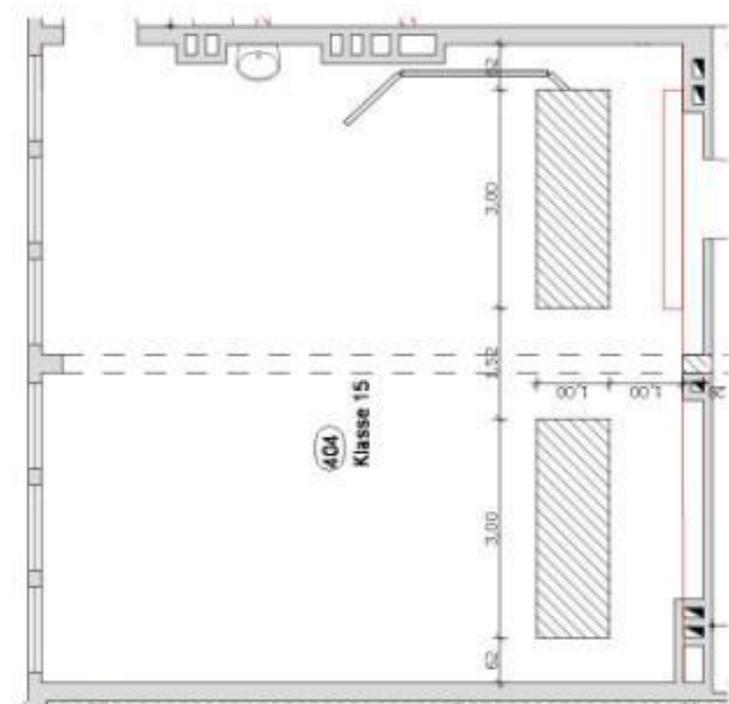
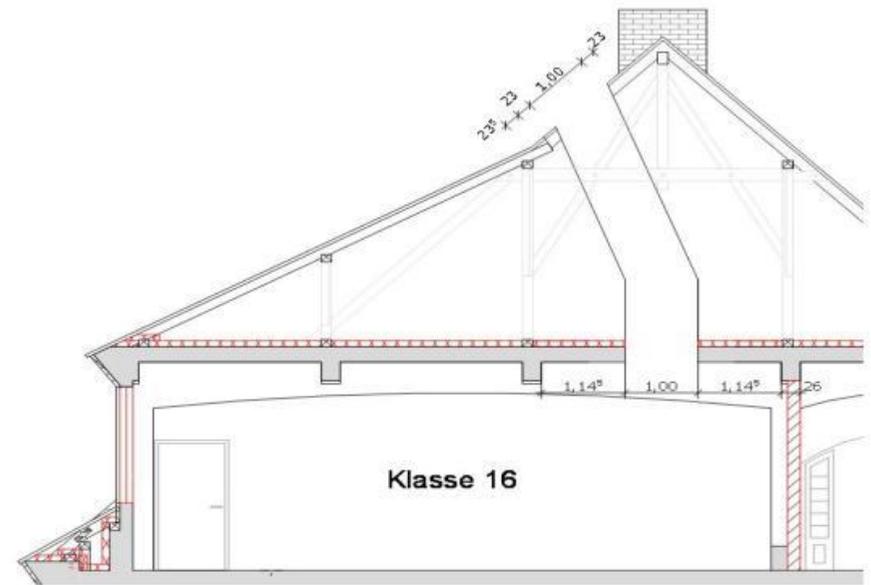
Blinds – West facing  
(operated manually)

# Floor plan of the attic

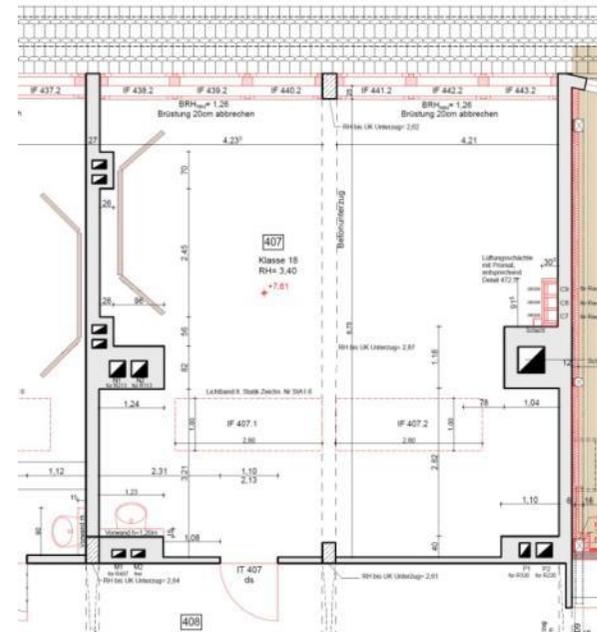
Source: AIZ



# new rooflight



# Classroom in the attic

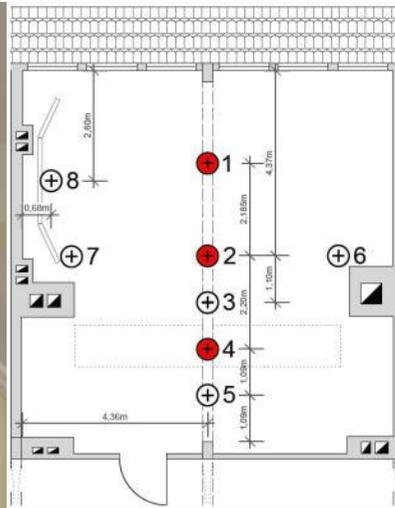
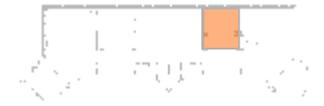


	before renovation	after renovation
area of classroom	75 m <sup>2</sup>	75 m <sup>2</sup>
opening area (gross)	8,03 m <sup>2</sup>	17,32 m <sup>2</sup>
opening to floor area ratio	11%	23%
glazing area	5,08 m <sup>2</sup>	11,09 m <sup>2</sup>
glazed to floor area ratio	7%	15%

Metrics on Window-System before and after renovation

	before renovation	after renovation
middle axis, distance from window: 2,26 m	2,5%	1,2%
center of room	1,3%	1,1%
middle axis, distance from window: 6,77 m	0,6%	1,7%

# Classroom in upper storey

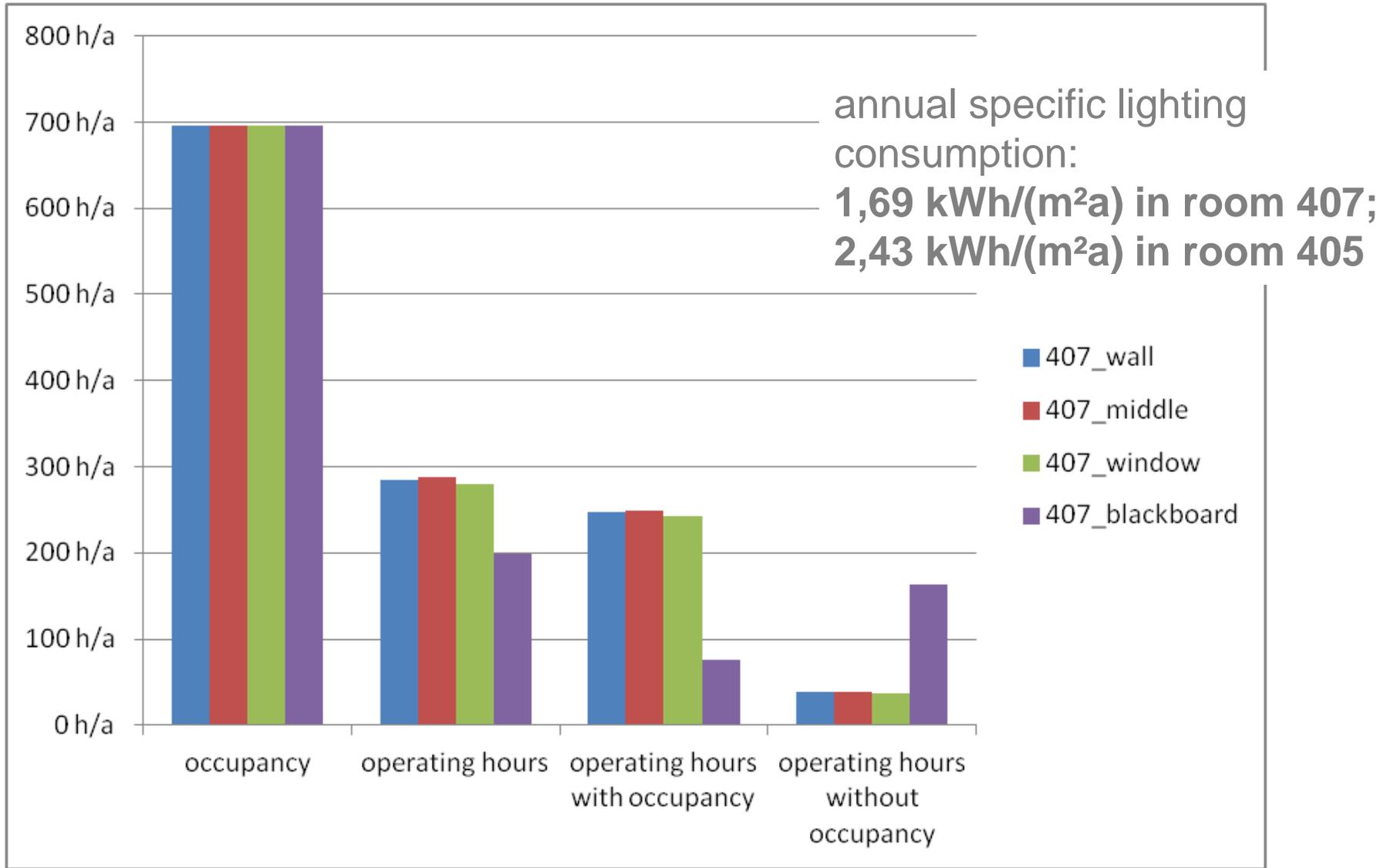
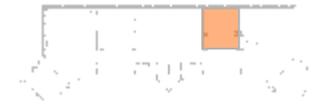


Snow on rooflights

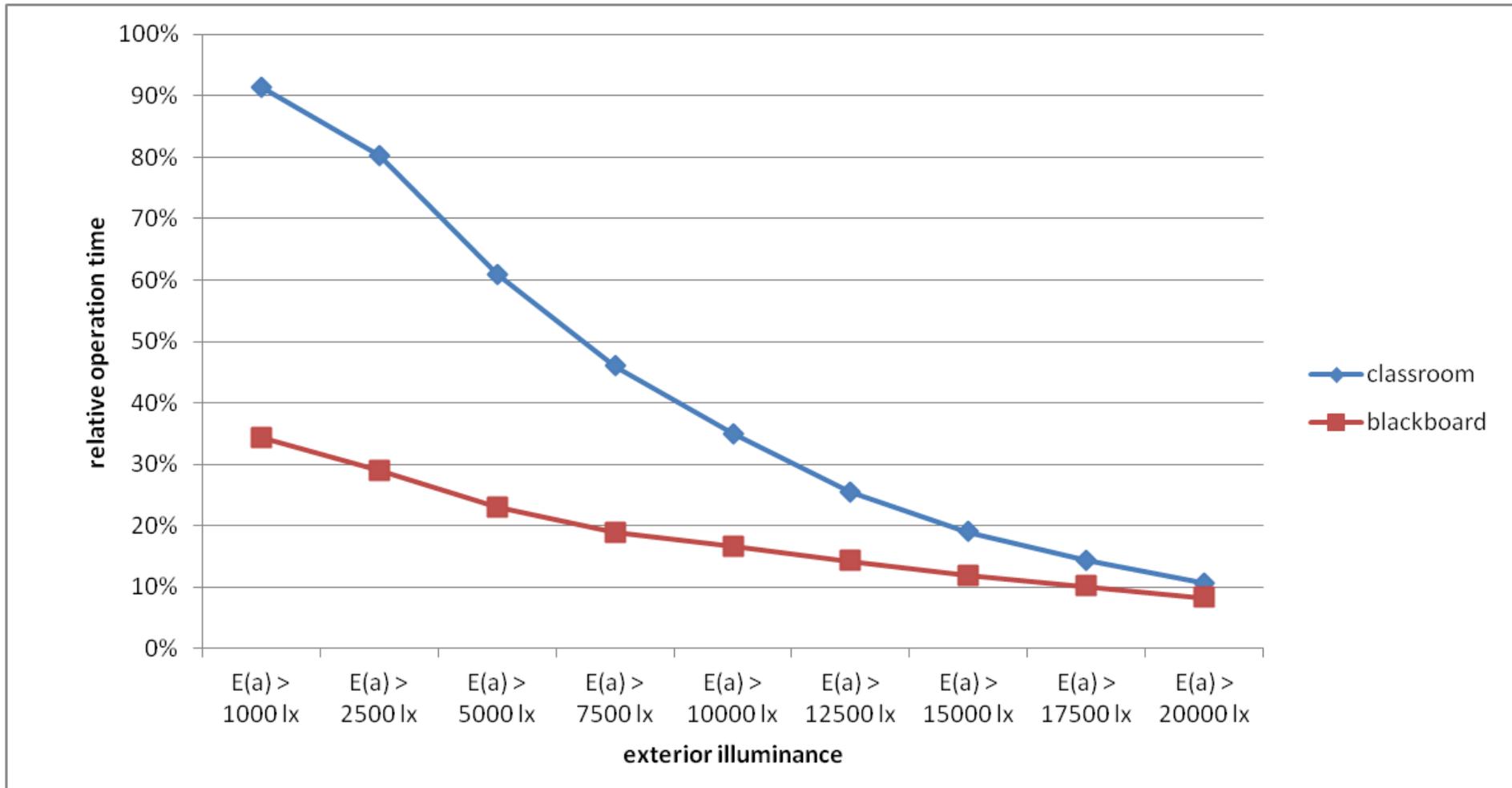
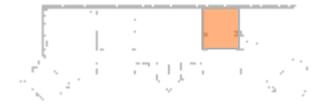
EC-Glass temporarily tinted

		corridor (point 4)	middle (point 2)	window (point 1)
relative usable lighting contribution (9. am – 2 pm, base: 300 lx)	summer	92%	80%	79%
	spring	94%	91%	88%
	winter	40%	33%	37%
relative period of use (9. am – 2 pm, base: 300 lx)	summer	74%	53%	50%
	spring	86%	78%	73%
	winter	8%	8%	10%
cylindric / horizontal illuminance	summer	34%	66%	65%
	spring	39%	59%	78%
	winter	48%	75%	75%

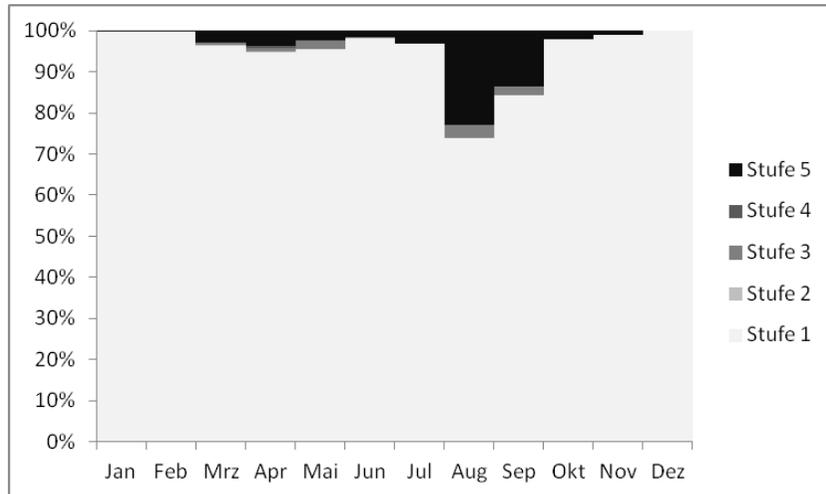
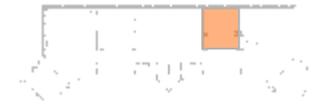
# occupancy & operating hours of electric lighting



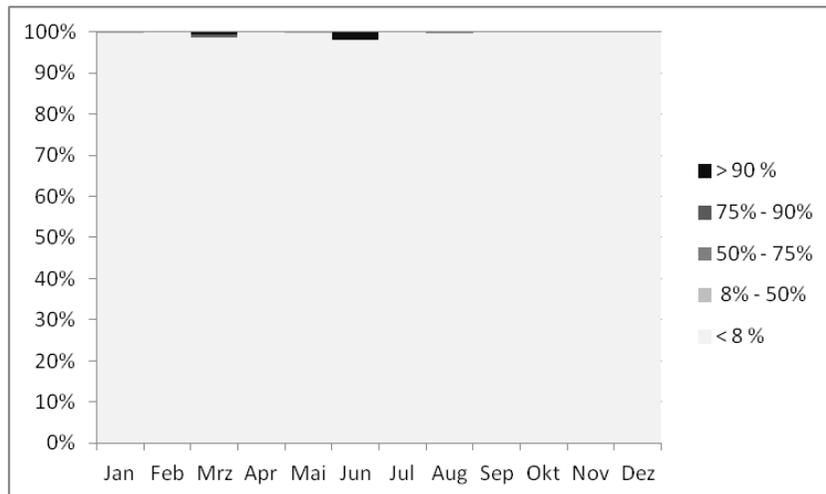
# daylight & operating hours of electric lighting



# Shading systems

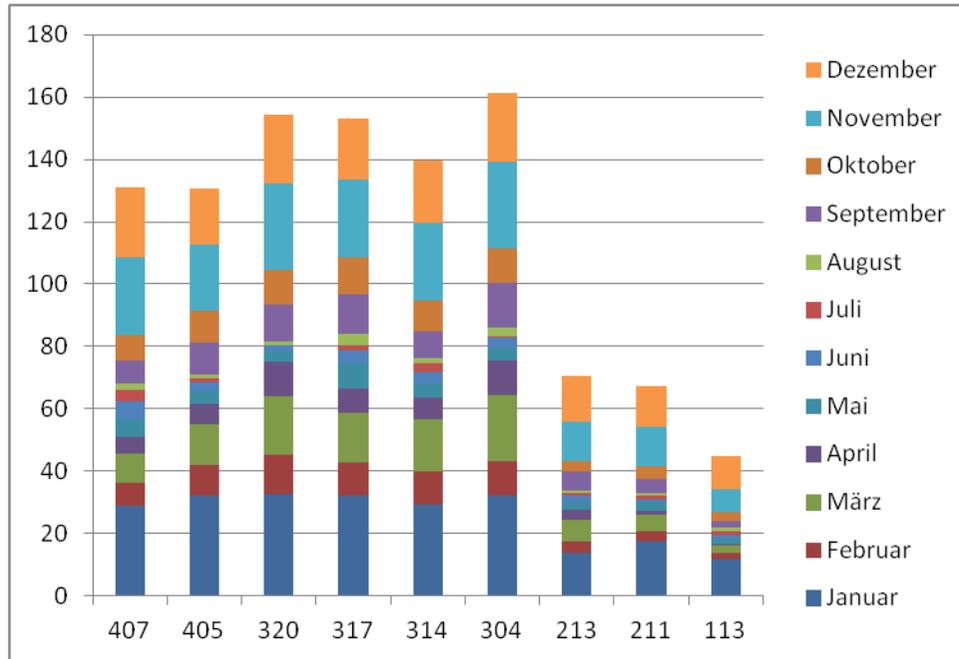


EC-Glass – Southeast facing  
(automated + manual override)

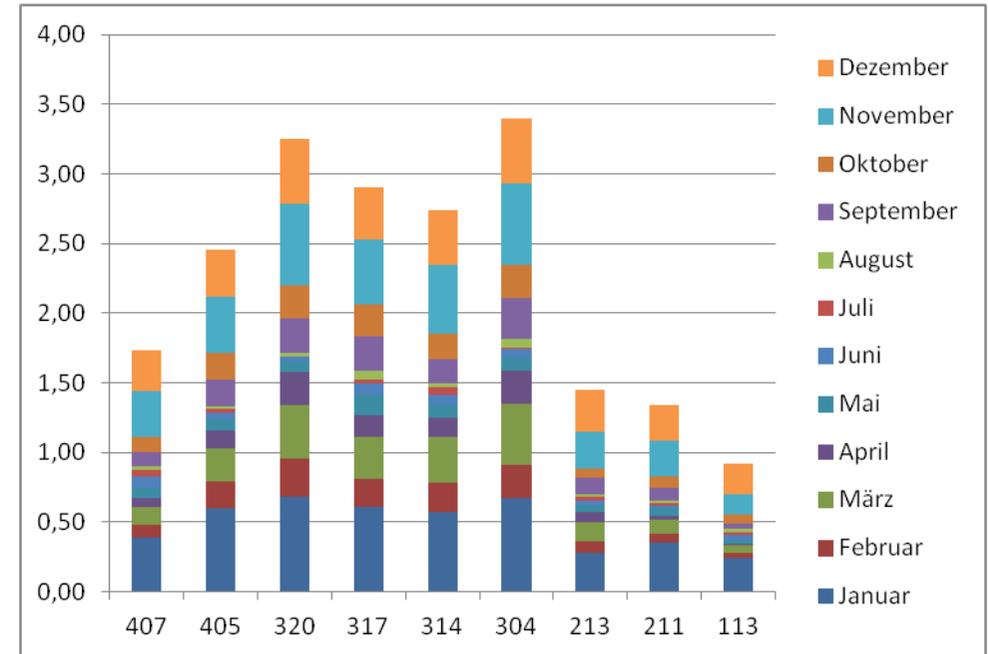


Blinds – Southeast facing  
(operated manually)

# classrooms, lighting energy consumption



lighting energy consumption in classrooms in the first year of operation [kWh]



Specific lighting energy consumption in classrooms in the first year of operation [kWh/m²]

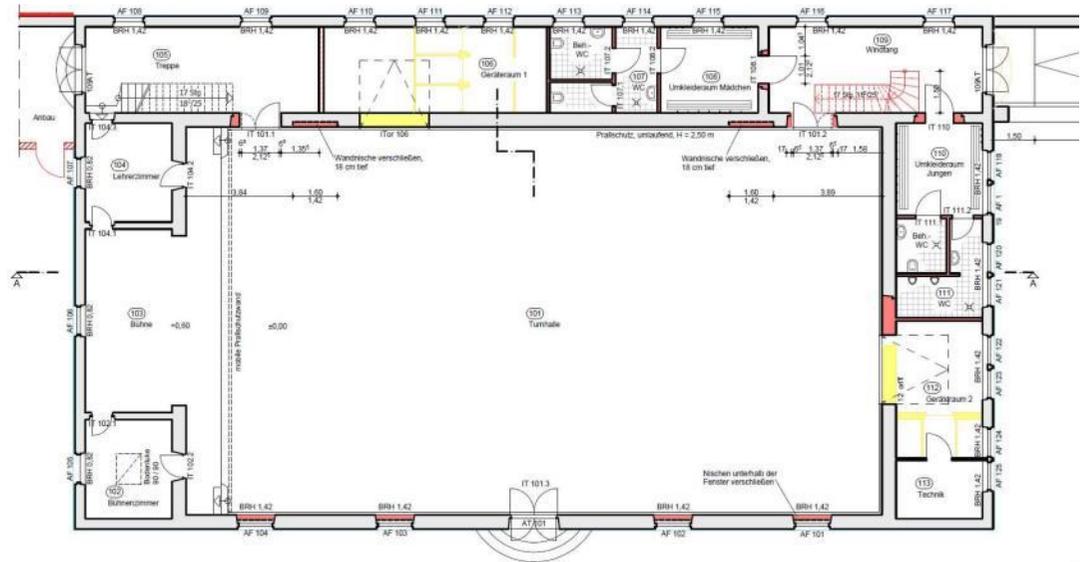
# Olbersdorf special school, sports hall before refurbishment



# Sports hall – construction of new rooflight



# Sports hall

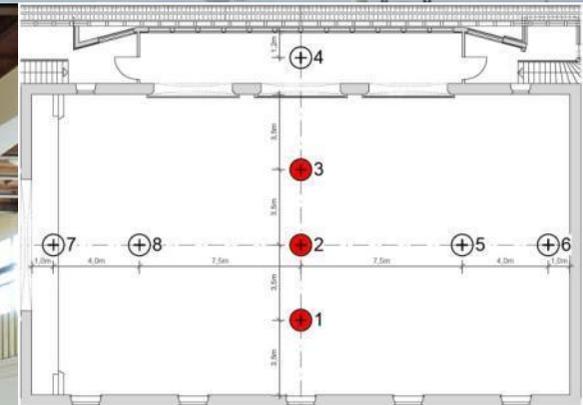


	before renovation	after renovation
floor area	350 m <sup>2</sup>	350 m <sup>2</sup>
opening area (gross)	39,3 m <sup>3</sup>	80,2 m <sup>2</sup>
opening to floor area ratio	11%	23%
glazing area	21,17 m <sup>2</sup>	58,02 m <sup>2</sup>
glazed to floor area ratio	6%	17%

Metrics on Window-System before and after renovation

	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%

# Sports hall with new rooflight



		window (point 1)	middle (point 2)	next to gallery (point 3)
relative usable lighting contribution (9. am – 2 pm, base: 300 lx)	summer	100%	100%	99%
	spring	96%	97%	91%
	winter	55%	60%	42%
relative period of use (9. am – 2 pm, base: 300 lx)	summer	98%	98%	97%
	spring	79%	85%	68%
	winter	12%	18%	3%
cylindric / horizontal illuminance	summer	42%	42%	49%
	spring	48%	47%	51%
	winter	40%	40%	46%

## Lessons learnt from the Friedrich Froebel School

- **Although carefully planned, the light transmission of existing windows was reduced by the renovation.**
- **New rooflights and windows could significantly improve the quality of interior spaces.**
- **Due to optimized controls and an efficient electric lighting system , the electric consumption in standard classrooms was below 3 kWh/m<sup>2</sup>a even with fair daylight levels.**
- **Glare from daylight does counteract energy efficient electric lighting.**

Outlook: More research on lighting renovation in buildings ...

## ***IEA SHC Task 50***

# **Advanced lighting solutions for retrofitting buildings**

*Operating Agent: J. de Boer, DE*

### **Subtask A**

*M. Fontoynt, DK*

**Market  
and  
Policies**

### **Subtask B**

*M. Knoop, DE*

**Daylighting  
and Electric  
Lighting  
Solutions**

### **Subtask C**

*J. Kaempf &  
B. Paule, CH*

**Methods  
and  
Tools**

### **Subtask D**

*M.-C. Dubois, SE*

**Case  
Studies**

**Joint Working Group: "Lighting Retrofit Adviser"**

daylighting.de

**T h a n k   Y o u   !**



**Task 47 Workshop:  
Solar Renovation of Non-Residential Buildings  
Frankfurt 03.04.2014**

**How to achieve high daylighting  
quality in retrofitted non-residential  
buildings? Cross-comparison of  
retrofitted European buildings and  
recommendations**

**Roman Alexander Jakobiak  
office@daylighting.de**