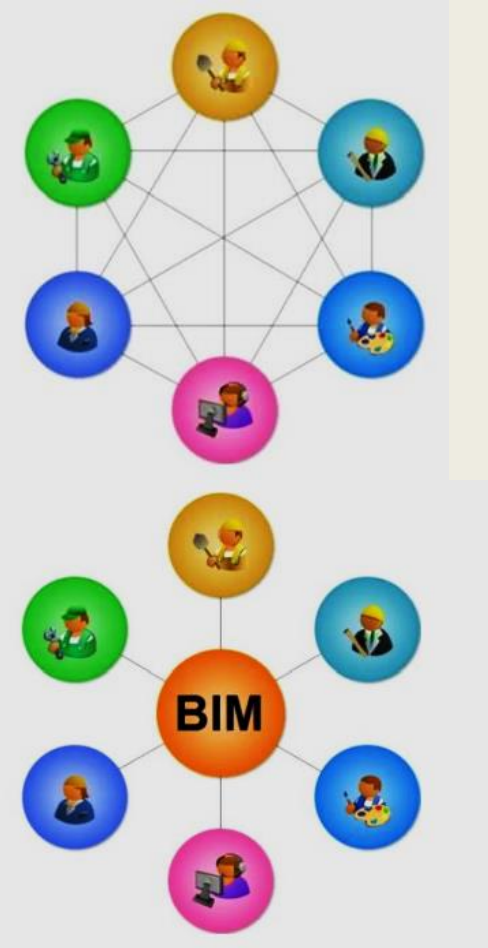
BIM pristup građevinskoj fizici uz primjer LEED/nZEB zgrade Seven Gardens

Vanja Keindl, Paula Topić,
Antonio Jambrač, Martina Radevska

Vanja Keindl, dipl.ing.građ., KEINDL BAU j.d.o.o. Zagreb
Paula Topić, mag.ing.aedif., KEINDL BAU j.d.o.o. Zagreb
Antonio Jambrač, mag.ing.aedif., KEINDL BAU j.d.o.o. Zagreb
Martina Radevska, mag.ing.aedif., KEINDL BAU j.d.o.o. Zagreb

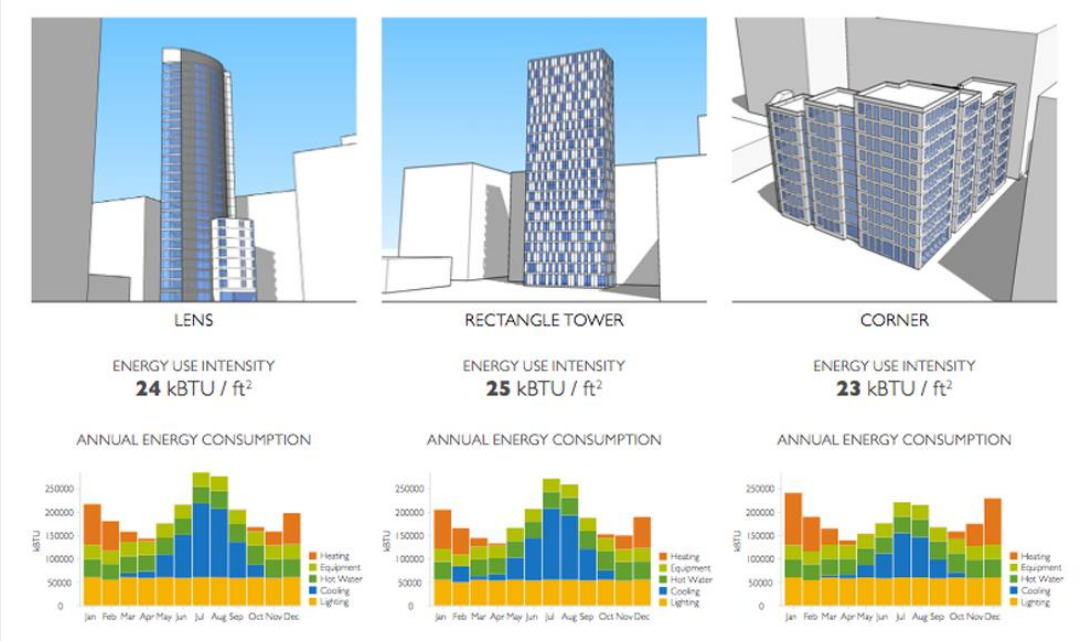
BIM (eng. Building Information Model/Modeling/Management)



- jednostavniji i precizniji pregled geometrije objekta (neusporedivo brže, točnije i ažurnije od klasičnog 2D crtanja)
- veći obim dostupnih informacija (debljina, gustoća, fizikalne karakteristike, pozicija itd.)
- odmah vidljive promjene (smanjenje pogrešaka zbog nedovoljne ili nejasne komunikacije)
- maksimalna vrijednost iz vremena koje investiramo u modeliranje
- bolja i veća suradnja svih sudionika u procesu građenja (projektanti, investitori, upravitelji, izvođači, proizvođači materijala itd)

Energetske simulacije

- vizualizacija trošenja energije, na temelju kojih se mogu identificirati područja koja imaju najveći potencijal uštede energije,
- komparativna analiza između predloženog dizajna i izmijenjenog dizajna,
- identifikacija najisplativijeg dizajna koji zadovoljava zadane ciljeve,
- utvrđivanje operativne uštede tijekom životnog ciklusa zgrade,
- Ispravan dizajn izbjegava skupe nadogradnje ili rekonstrukcije u budućnosti



HRVATSKA NORMA

HRN EN 15251

ICS: 91.140.01

Prvo izdanje,
kolovoz 2008.

Ulazni mikroklimatski parametri za projektiranje i ocjenjivanje energijskih značajka zgrada koji se odnose na kvalitetu zraka, toplinsku lagodnost, osvjetljenje i akustiku (EN 15251:2007)

Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (EN 15251:2007)

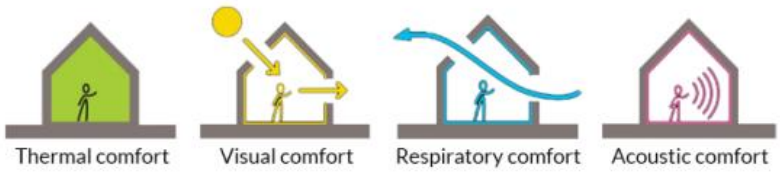
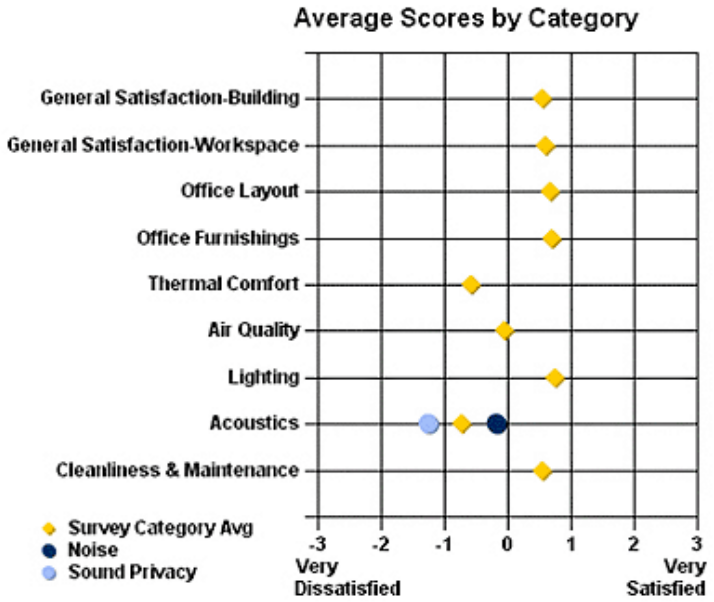


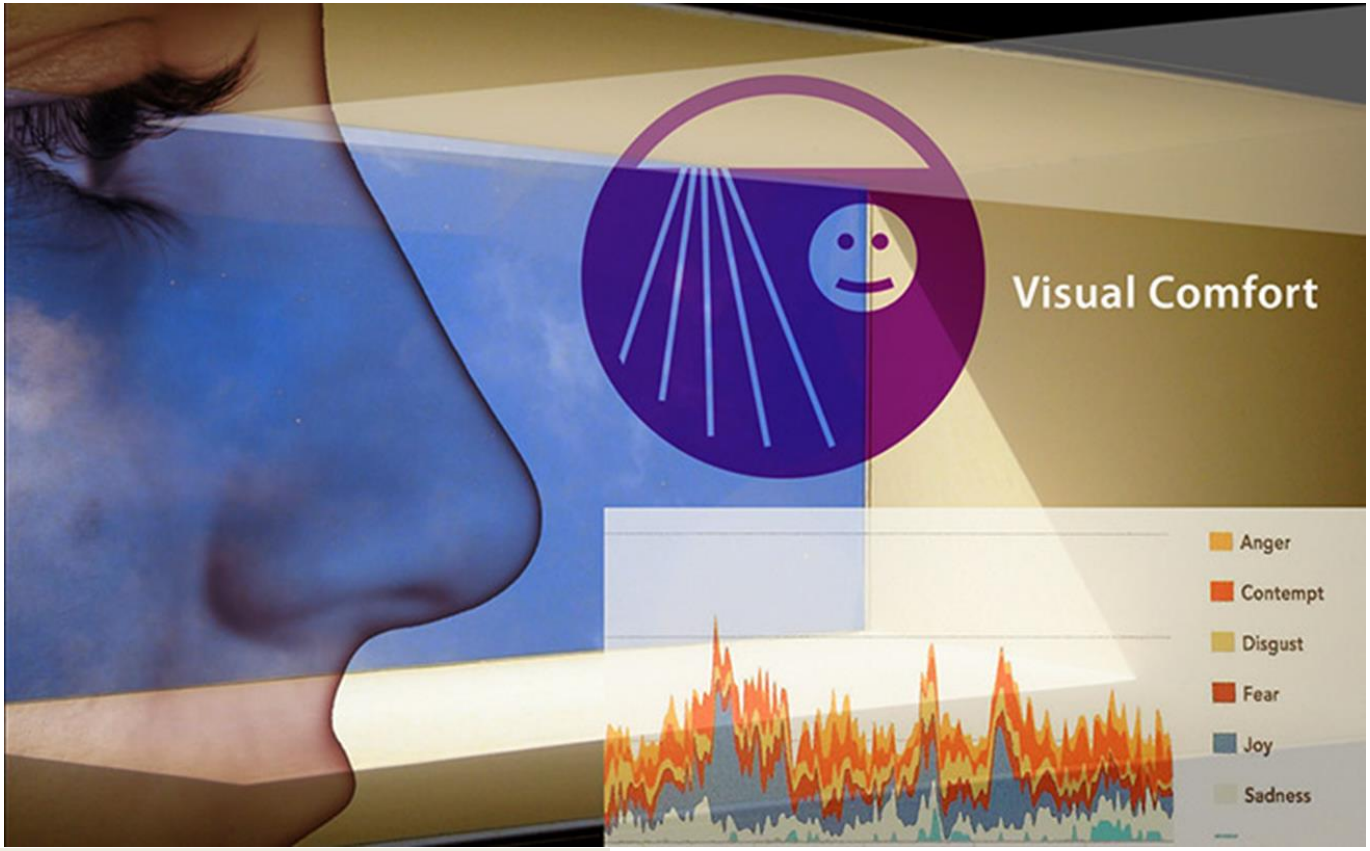
Figure 1: The four dimensions of comfort



Acoustical Analysis in Office Environments Using POE Surveys
Credit: The Center for the Built Environment (CBE) at U.C., Berkeley

Vanja Keindl
Paula Topić
Antonio Jambrač
Martina Radevska

Vizualna udobnost je subjektivna percepcija prikladnosti rasvjete uzimajući u obzir njenu ujednačenost, razinu, odsjaj, kontrast, boje i odsutnost stroboskopskog efekta



Vanja Keindl
Paula Topić
Antonio Jambrač
Martina Radevska

Akustička udobnost je osjećaj psihofizičkog zadovoljstva koje osoba doživljava tijekom obavljanja određene aktivnosti unutar zvučnog polja

Vanja Keindl
Paula Topić
Antonio Jambrač
Martina Radevska

Toplinska udobnost je stanje svijesti koje izražava zadovoljstvo toplinskim stanjem okoliša

HRVATSKA NORMA

HRN EN ISO 7730

ICS: 13.180

Drugo izdanje,
lipanj 2008.

Zamjenjuje HRN EN ISO 7730:2003

Ergonomija toplinskog okoliša – Analitičko utvrđivanje i tumačenje toplinske udobnosti uporabom izračuna PMV i PPD indeksa i lokalnih toplinskih kriterija udobnosti (ISO 7730:2005; EN ISO 7730:2005)

Ergonomics of the thermal enviroment – Analitycal determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (ISO 7730:2005; EN ISO 7730:2005)

Vrednovanje toplinske ugodnosti

Toplinska ugodnost se prema normi EN ISO 7730 vrednuje pomoću dva indeksa:

PMV (engl. Predicted Mean Vote) i

PPD (engl. Predicted Percentage of Dissatisfied)

PMV vrednuje razinu ugode, a PPD predviđa postotak nezadovoljnih osoba.

Skala PMV indeksa prema normi HRN EN ISO 7730

Toplinska ravnoteža tijela postignuta je kada je proizvedena toplina tijela jednaka onoj izmijenjenoj s okolišem.

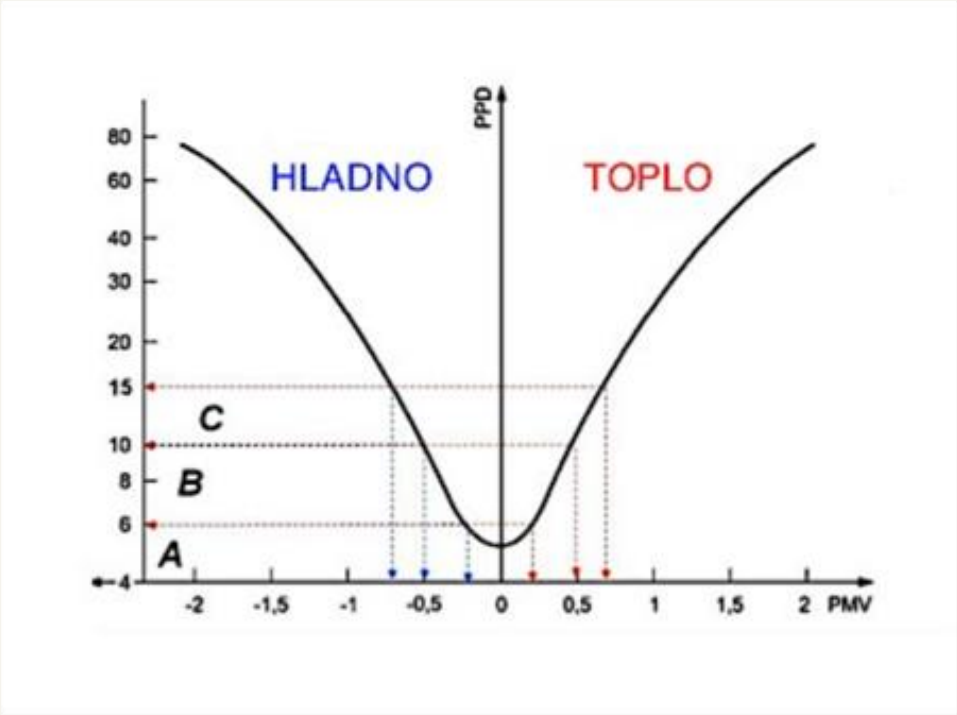
+3	Vruće
+2	Toplo
+1	Blago toplo
0	Neutralno
-1	Prohladno
-2	Hladno
-3	Ledeno

PPD predstavlja postotak nezadovoljnih osoba

...odnosno onih koji bi glasali da im je toplo, vruće, hladno ili ledeno (+3, +2, -2, -3)

U normi je dana jednadžba za izračun PPD.

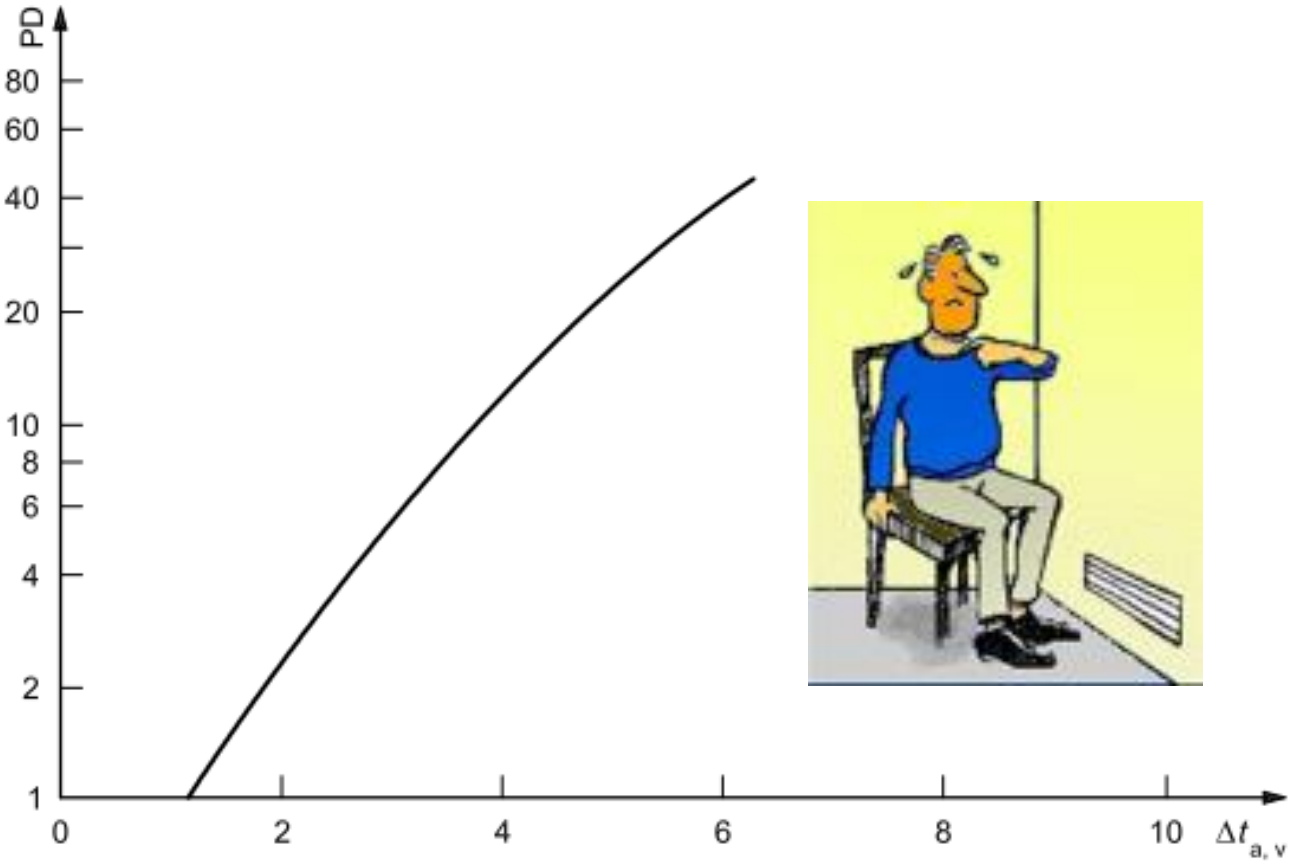
PPD kao funkcija od PMV



Toplinska ugodnost u različitim prostorijama podijeljena je u 3 kategorije: A, B i C.

Kategorije toplinskog okoliša i utjecaj lokalne neugode prema EN ISO 7730

Kategorija	Toplinsko stanje cijelog tijela		Lokalna neugoda			
	PPD (%)	PMV	DR (%)	PD (%)		
				Razlika temp. po visini	Topli ili hladni podovi	Razlika temp. ploha
A	<6	-0,2 < PMV < +0,2	<10	<3	<10	<5
B	<10	-0,5 < PMV < +0,5	<20	<5	<10	<5
C	<15	-0,7 < PMV < +0,7	<30	<10	<15	<10

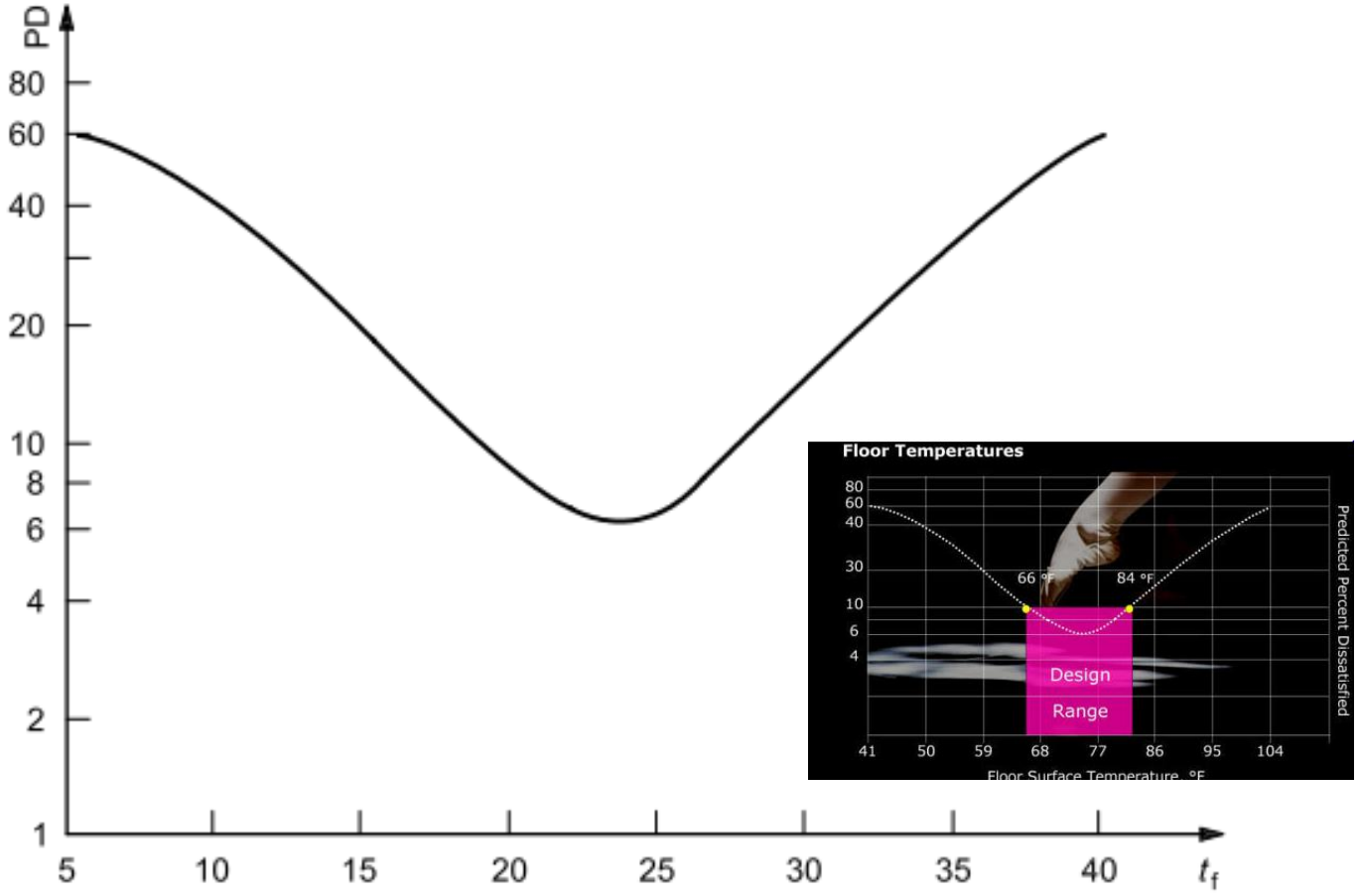


Key

PD percentage dissatisfied, %

$\Delta t_{a,v}$ vertical air temperature difference between head and feet, °C

Figure 2 — Local discomfort caused by vertical air temperature difference

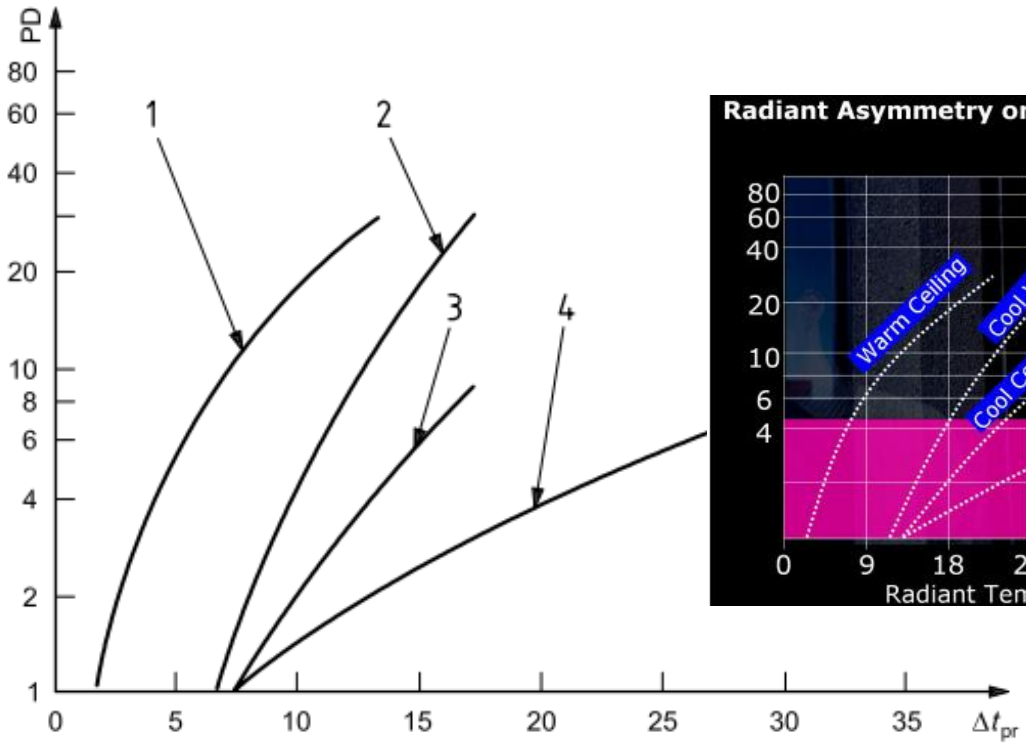


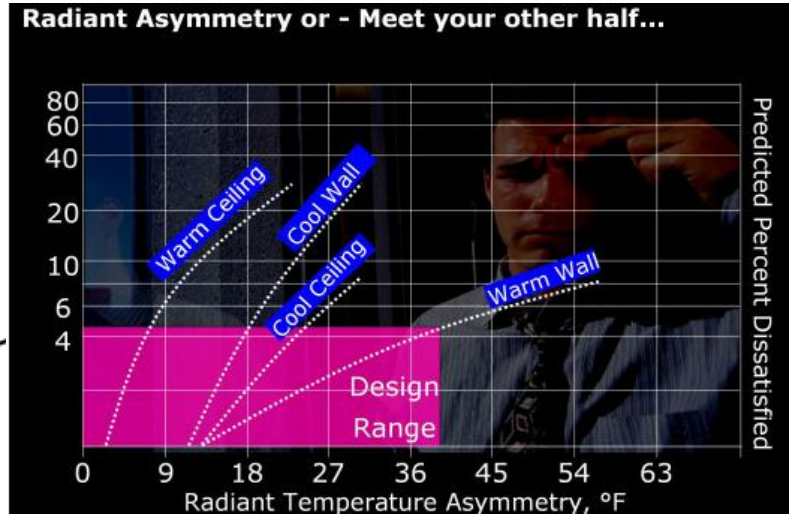
Key

PD percentage dissatisfied, %

t_f floor temperature, °C

Figure 3 — Local thermal discomfort caused by warm or cold floors





Key

PD	percentage dissatisfied, %
Δt_{pr}	radiant temperature asymmetry, °C
1	Warm ceiling.
2	Cool wall.
3	Cool ceiling.
4	Warm wall.

Figure 4 — Local thermal discomfort caused by radiant temperature asymmetry

Radna temperatura (engl. Operative temperature)

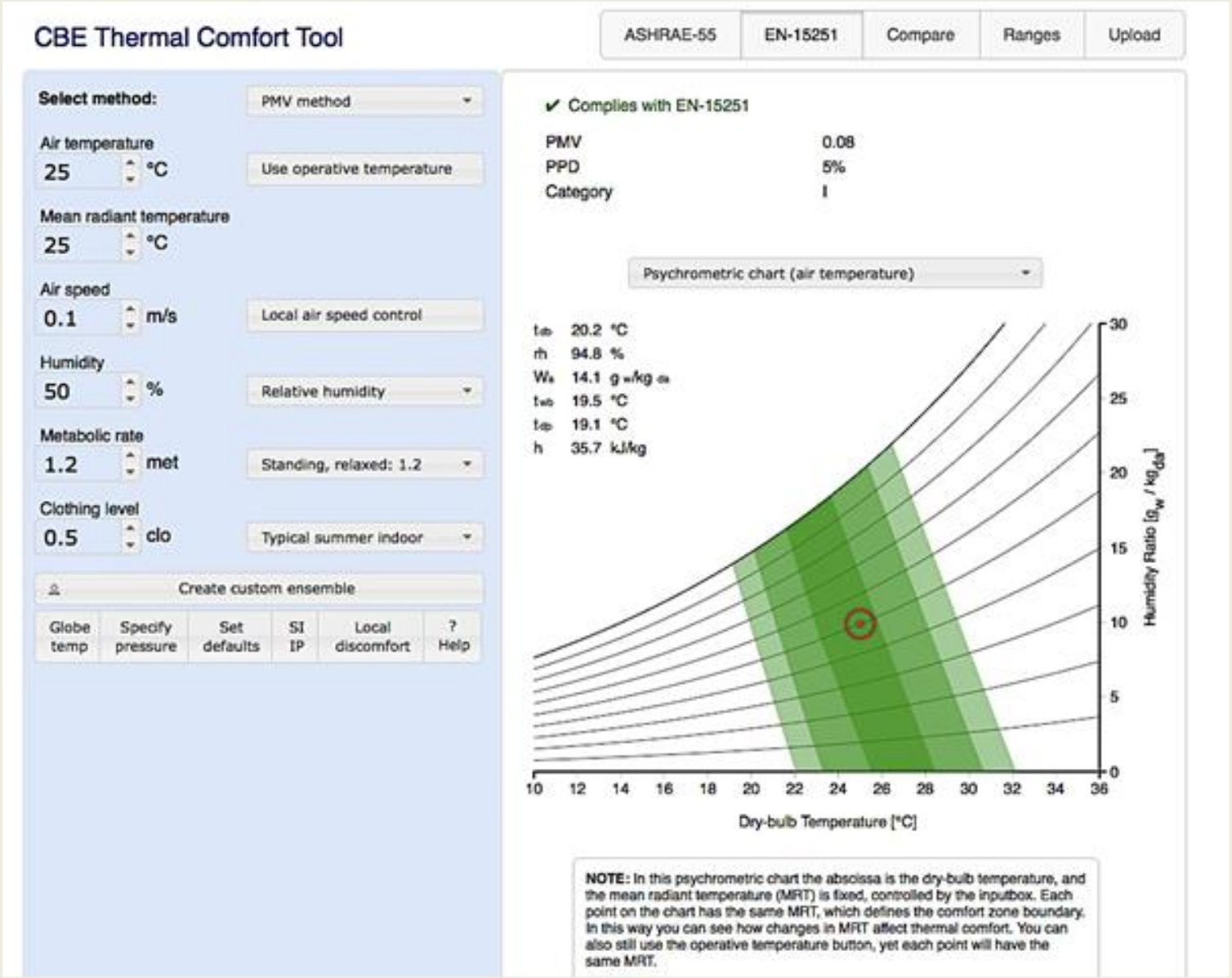
jednolika temperatura zamišljenog zatvorenog crnog prostora u kojem bi subjekt mogao razmijeniti jednaku količinu topline zračenjem i prijenosom kao i u stvarnoj nejednolikoj okolini

Tip prostorije/zgrade	Kategorija	Operativna temperatura (°C)	
		Zima (sezona grijanja) Razina odjevenosti ≈ 1,0 clo	Ljeto (sezona hlađenja) Razina odjevenosti ≈ 0,5
Kućanstva (dnevni boravak, spavaonica, kuhinja i sl.) Razina aktivnosti (sjedenje)≈ 1,2 met	I	21	25,5
	II	20	26
	III	18	27
Kućanstva (ostave, hodnici i sl.) Razina aktivnosti (hodanje, stajanje) ≈ 1,6 met	I	18	/
	II	16	/
	III	14	/
Uredi Razina aktivnosti (sjedenje)≈ 1,2 met	I	21	25,5
	II	20	26
	III	19	27
Auditorij Razina aktivnosti (sjedenje)≈ 1,2 met	I	21	25,5
	II	20	26
	III	19	27
Restoran Razina aktivnosti (sjedenje)≈ 1,2 met	I	21	25
	II	20	26
	III	19	27
Učionica Razina aktivnosti (sjedenje)≈ 1,2 met	I	21	25
	II	20	26
	III	19	27
Dječji vrtić Razina aktivnosti (stajanje, hodanje) ≈ 1,4 met	I	19	24,5
	II	17,5	25,5
	III	16,5	26
Trgovački centar Razina aktivnosti (stajanje, hodanje) ≈ 1,6 met	I	17,5	24
	II	16	25
	III	15	26

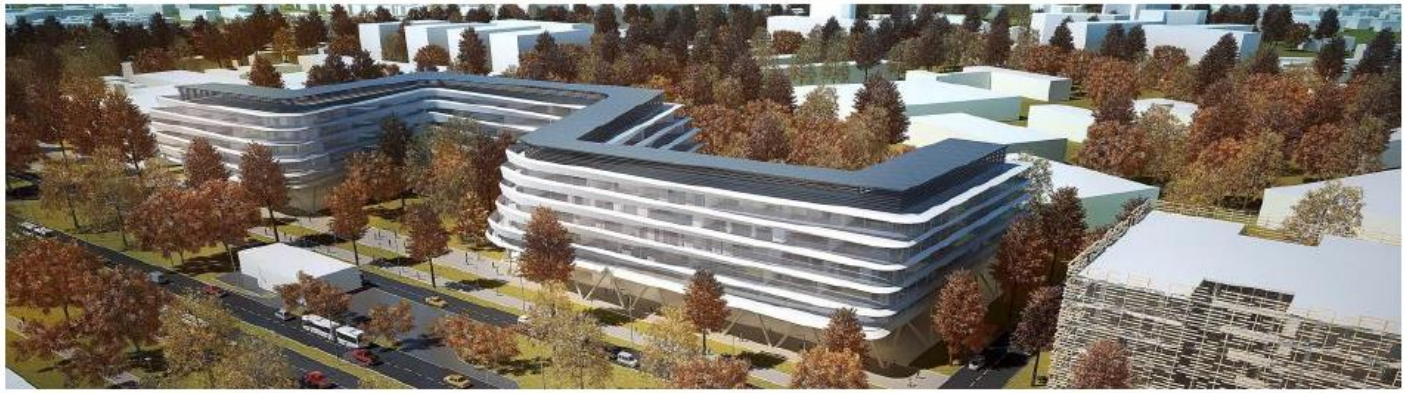
Preporučene vrijednosti operativne temperature prema HRN EN 15251: 2008

Optimalna operativna temperatura je idealna temperatura koja bi odgovarala za PMV=0 odnosno da su svi ljudi u prostoriji zadovoljni.

Kategorije I, II i III odgovaraju kategorijama A, B i C.

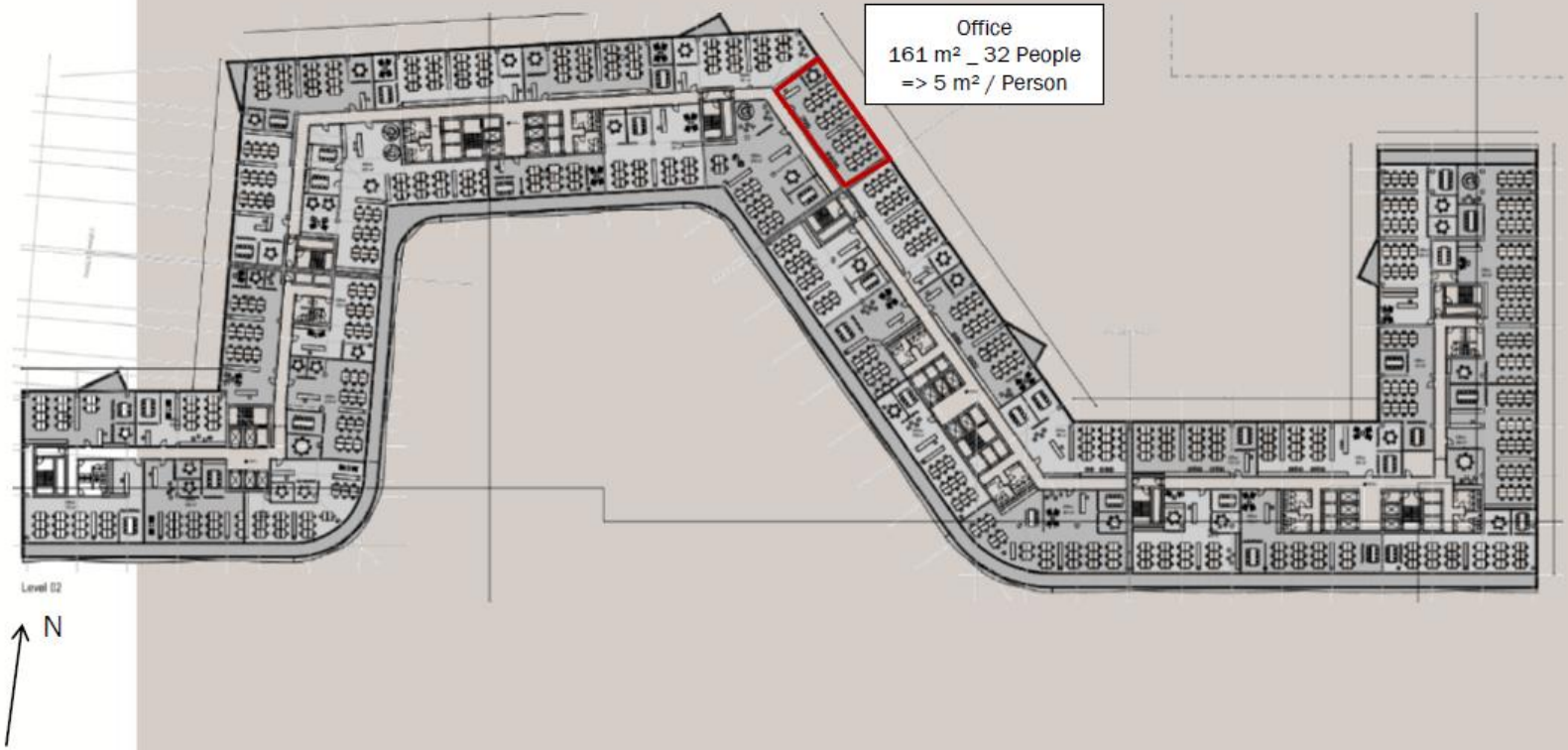

CBE Thermal Comfort Tool
ASHRAE-55
EN-15251
Compare
Ranges
Upload
Select method:
PMV method
Air temperature
25 °C
Use operative temperature
Mean radiant temperature
25 °C
Air speed
0.1 m/s
Local air speed control
Humidity
50 %
Relative humidity
Metabolic rate
1.2 met
Standing, relaxed: 1.2
Clothing level
0.5 clo
Typical summer indoor
Create custom ensemble
Globe temp
Specify pressure
Set defaults
SI IP
Local discomfort
? Help
✔ Complies with EN-15251
PMV 0.08
PPD 5%
Category I
Psychrometric chart (air temperature)
20.2 °C
94.8 %
14.1 g/kg
19.5 °C
19.1 °C
35.7 kJ/kg
Humidity Ratio
Dry-bulb Temperature [°C]
NOTE: In this psychrometric chart the abscissa is the dry-bulb temperature, and the mean radiant temperature (MRT) is fixed, controlled by the inputbox. Each point on the chart has the same MRT, which defines the comfort zone boundary. In this way you can see how changes in MRT affect thermal comfort. You can also still use the operative temperature button, yet each point will have the same MRT.

SEVEN GARDENS



Thermal Comfort

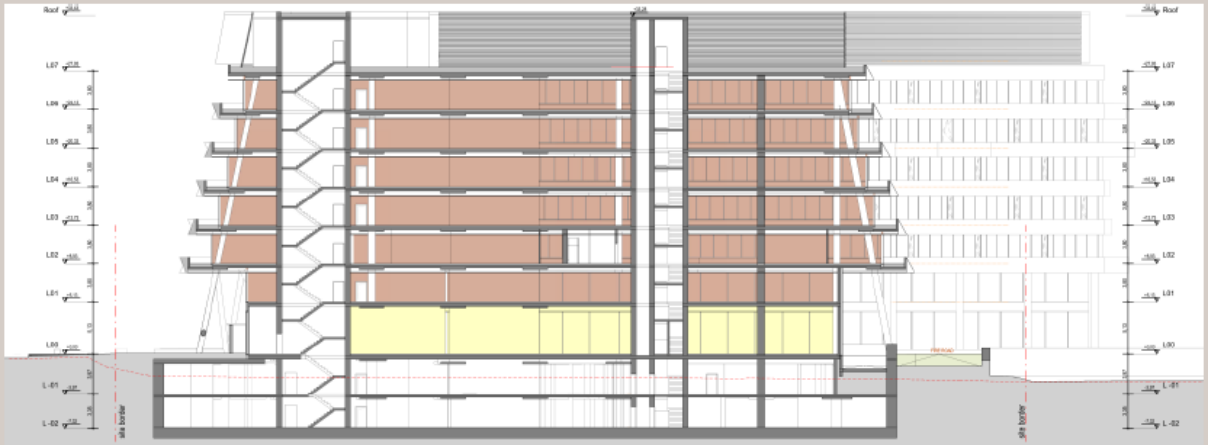
STANDARD
OPEN OFFICE

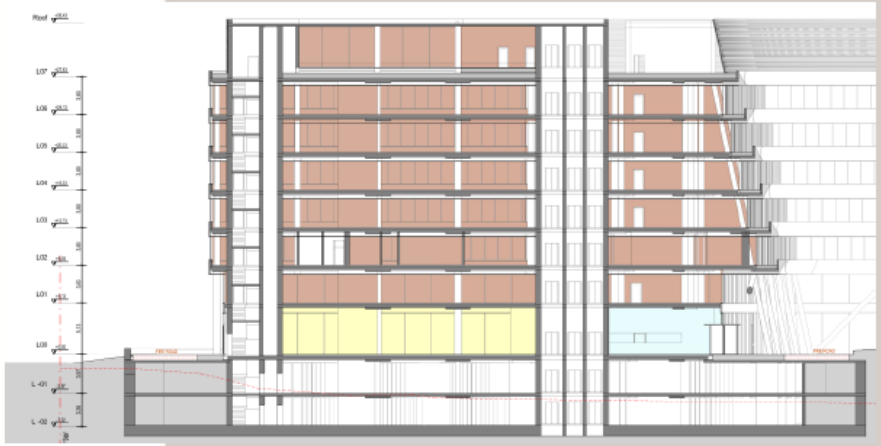


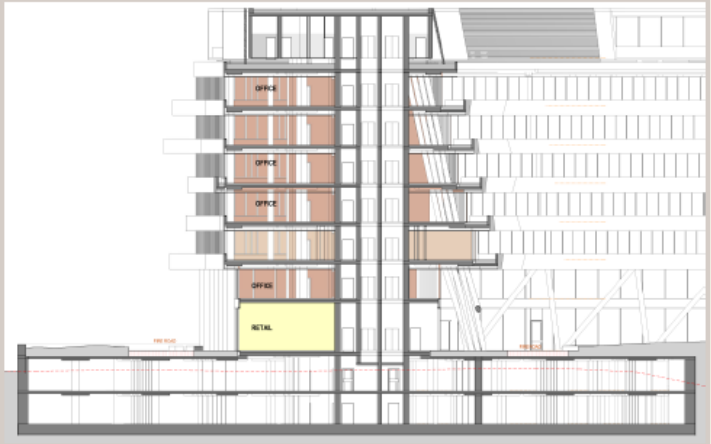
Building Physics

688 _ SEVEN GARDENS | 10000 ZAGREB | THERMAL COMFORT | DYNAMIC SIMULATION

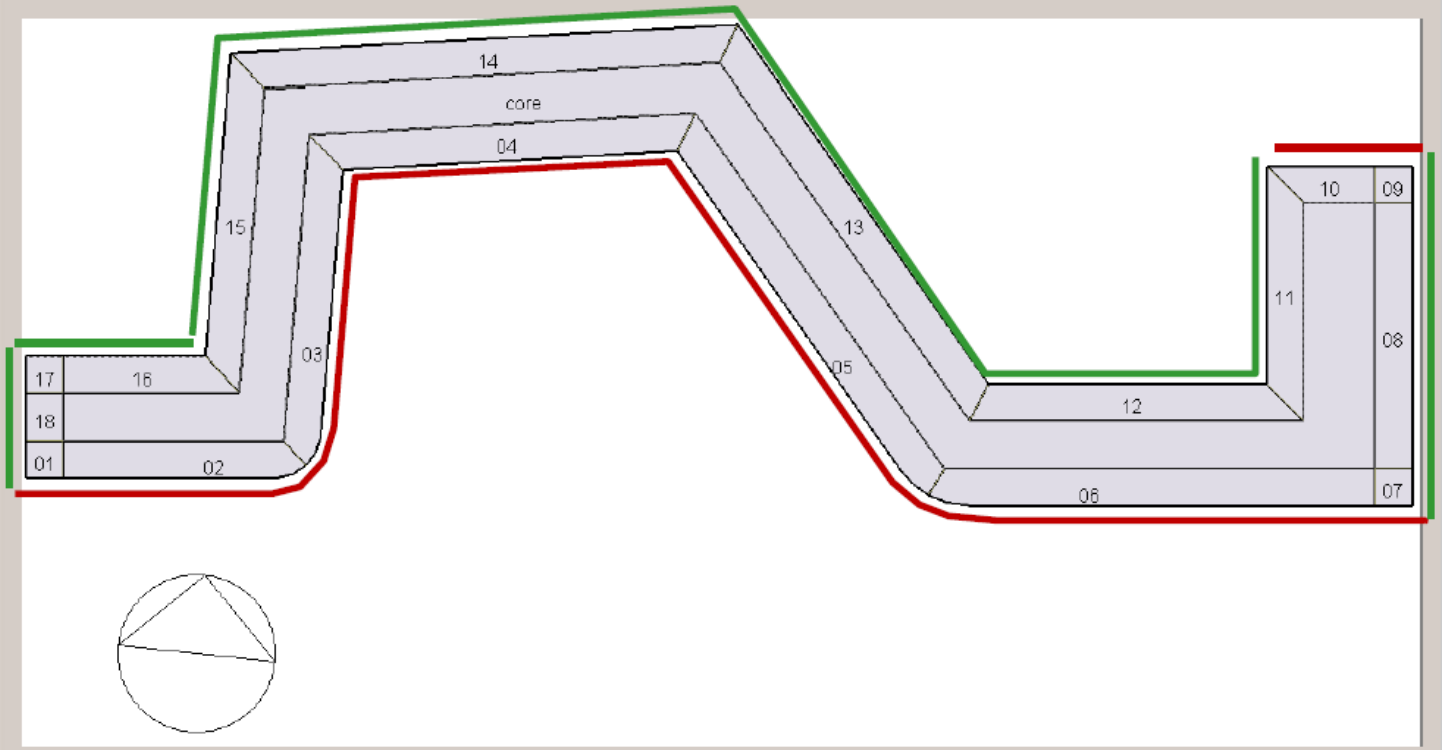
SECTION PLANS



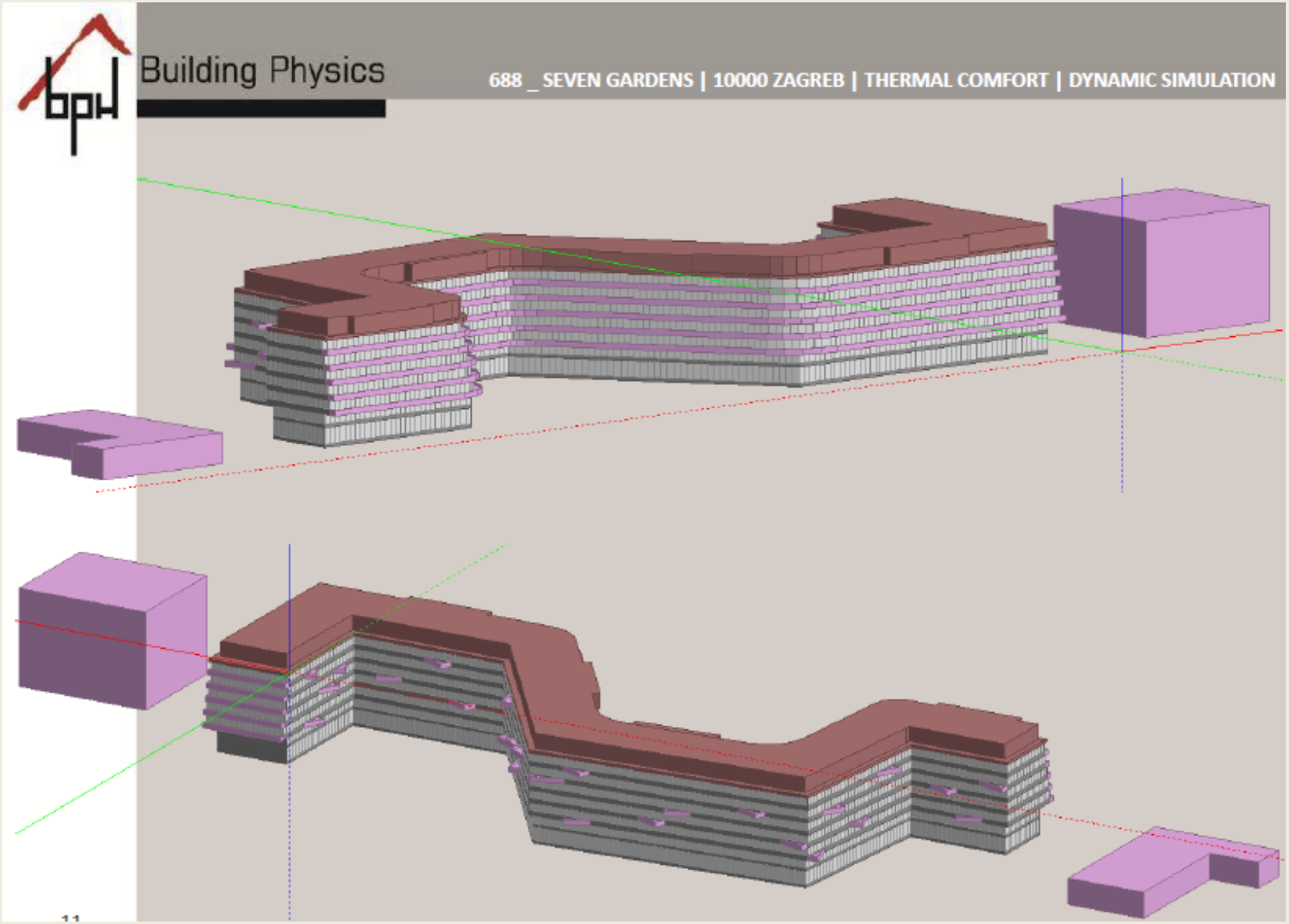




6th FLOOR PLAN _ THERMAL ZONES
SIMULATED MODEL



Façade with overhang construction (Glazing height 2,9 m)
Façade with balustrade _ height 60 cm (Glazing height 2,3 m)

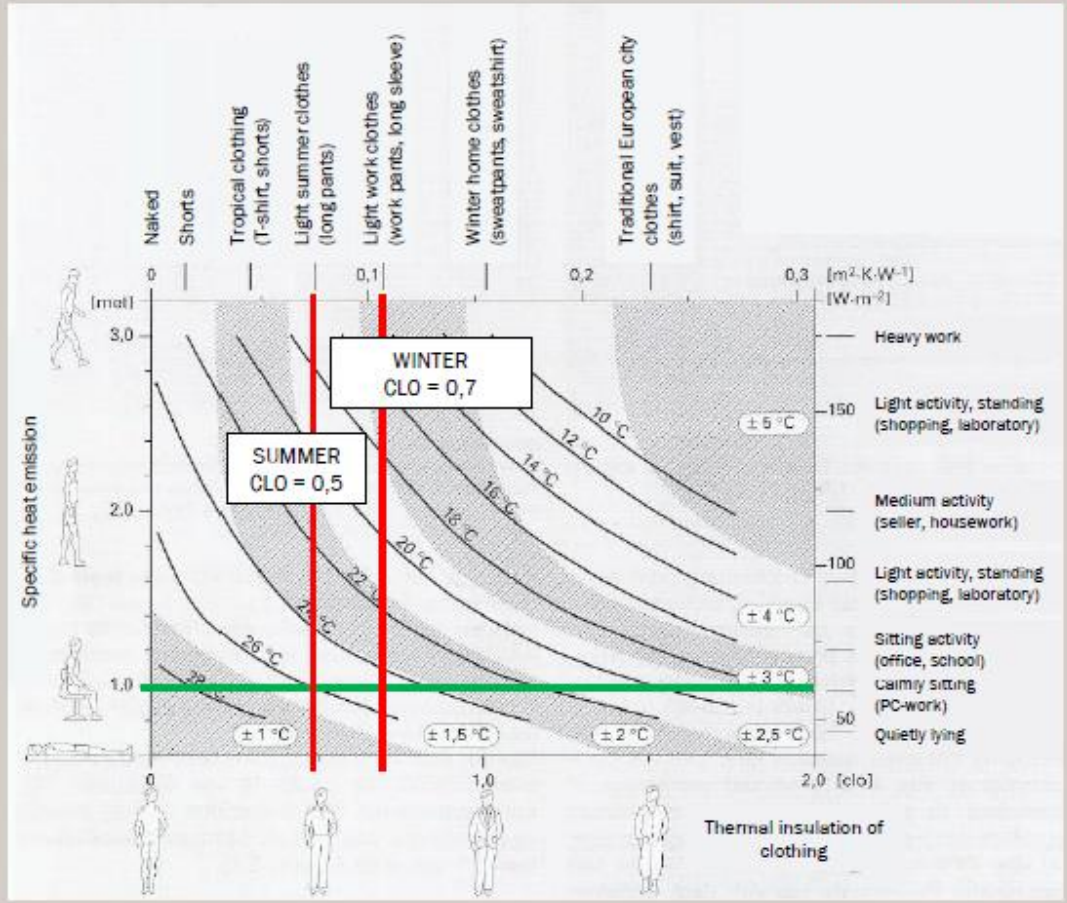

Building Physics
688 _ SEVEN GARDENS | 10000 ZAGREB | THERMAL COMFORT | DYNAMIC SIMULATION

EVALUATION OF THERMAL COMFORT
REQUIREMENT CLASSES _ CONFORMITY CRITERIA _ EN ISO 7730

Category	Rating of thermal sensibility with respect to the whole body		Specific discomfort expressed in PPD, on the basis of:			
	Predicted percentage of dissatisfied [PPD]	Predicted mean vote [PMV]	Draft	Vertical stratification of room air temperature	Too warm or too cold floor	Asymmetric heat radiation of the surfaces
A	< 6 %	−0,2 < PMV < +0,2	< 15 %	< 3 %	< 10 %	< 5 %
B	< 10 %	−0,5 < PMV < +0,5	< 20 %	< 5 %	< 10 %	< 5 %
C	< 15 %	−0,7 < PMV < +0,7	< 25 %	< 10 %	< 15 %	< 10 %

Remarks: PPD _ PREDICTED PERCENTAGE OF DISSATISFIED (%);
PMV _ PREDICTED MEAN VOTE;

BOUNDARY CONDITIONS
THERMAL INSULATION OF CLOTHING



OFFICE
MET 1,0

BOUNDARY CONDITIONS

ZAGREB _ OUTDOOR CLIMATE _ TEMPERATURE / DIRECT / DIFFUSE SOLAR RADIATION

BOUNDARY CONDITIONS
FAÇADE PROPERTIES

Wärmedämmglas

Produktbezeichnung	Aufbau außen/ SZR/ (Mitte/ SZR/) innen	U_g-Norawert EN 673	Lichttechnische und strahlungsphysikalische Nennwerte EN 410: g-Wert	Lichtdurchlässigkeit	dfg Farbwiedergabe-Index in Durchsicht	Lichtreflexionsgrad nach außen	Energieabsorption außen	Energieabsorption Mitte	Energieabsorption innen	Shading Coefficient (g-Wert EN 410:0.87)	Selektivitätskennwert	Dicke	Gewicht
	mm	W/(m²K)	%	%		%	%	%	%	%		mm	kg/m²
iplus top 1.1 on Clearlite	4/16/4	1,1	64	82	98	12	7	–	7	74	1,28	24	20
iplus top 1.1 on Clearlite	6/16/6	1,1	63	80	98	12	10	–	8	72	1,27	28	30
iplus top 1.1 on Clearlite	4/12/4	1,3	64	82	98	12	7	–	7	74	1,28	20	20
iplus top 1.1 on Clearlite	6/12/6	1,3	63	80	98	12	10	–	8	72	1,27	24	30
iplus advanced 1.0 on Clearlite	4/16/4	1,0	57	77	98	15	8	–	8	66	1,35	24	20
iplus advanced 1.0 on Clearlite	4/12/4	1,2	56	77	98	15	8	–	8	64	1,35	20	20
iplus top 1.1 T on Clearlite	4/16/4	1,1	66	82	98	12	7	–	6	76	1,24	24	20
iplus top 1.1 T on Clearlite	6/16/6	1,1	64	81	98	12	10	–	8	74	1,27	28	30
iplus top 1.1 T on Clearlite	4/12/4	1,3	66	82	98	12	7	–	6	76	1,24	20	20
iplus top 1.1 T on Clearlite	6/12/6	1,3	64	81	98	12	10	–	8	74	1,27	24	30
iplus advanced 1.0 T on Clearlite	4/16/4	1,0	62	81	98	13	7	–	6	71	1,31	24	20
iplus advanced 1.0 T on Clearlite	6/16/6	1,0	60	80	97	13	10	–	7	69	1,33	28	30
iplus advanced 1.0 T on Clearlite	4/12/4	1,2	62	81	98	13	7	–	6	71	1,31	20	20
iplus advanced 1.0 T on Clearlite	6/12/6	1,2	60	80	97	13	10	–	7	69	1,33	24	30
iplus top 3	4:/16/4/16/:4	0,6	53	74	97	16	13	4	5	61	1,40	44	30
iplus top 3	4:/12/4/12/:4	0,7	53	74	97	16	13	4	5	61	1,40	36	30
iplus top 3C	4:/12/4/12/:4	0,5	53	74	97	16	13	4	5	61	1,40	36	30
iplus top 3C	4:/10/4/10/:4	0,6	53	74	97	16	13	4	5	61	1,40	32	30
iplus 3LS	4/16/:4/16/:4	0,7	62	74	99	17	7	9	5	71	1,19	44	30
iplus 3LS	4/12/:4/12/:4	0,8	62	74	99	17	7	9	5	71	1,19	36	30
iplus 3CLS	4/12/:4/12/:4	0,6	62	74	99	17	7	9	5	71	1,19	36	30
iplus 3CLS	4/10/:4/10/:4	0,7	62	74	99	17	7	9	5	71	1,19	32	30
iplus Energy N on Clearlite	4:/16/4	1,0	41	73	97	12	22	–	1	47	1,78	24	20
iplus Energy N on Clearlite	6:/16/4	1,0	41	73	96	12	26	–	1	47	1,78	26	25
iplus Energy NT on Clearlite	4:/16/4	1,0	42	74	99	12	20	–	1	48	1,76	24	20
iplus Energy NT on Clearlite	6:/16/4	1,0	42	73	99	12	23	–	1	48	1,74	26	25
iplus AF & iplus top 1.1 on Clearlite	:4/16/:4	1,1	61	76	99	16	13	–	6	70	1,25	24	20
iplus AF top on Clearlite	:4:/16/4	1,1	58	76	99	16	17	–	2	67	1,31	24	20
iplus AF Energy N	:4:/16/4	1,0	39	69	98	16	27	–	1	45	1,77	24	20
iplus AF Energy N	:4:/12/4/12/:4	0,7	36	62	97	18	27	1	2	41	1,75	36	30
iplus AF top 3	:4:/12/4/12/:4	0,7	50	69	98	19	18	4	4	57	1,38	36	30
iplus AF 3LS	:4/12/:4/12/:4	0,8	59	69	99	20	12	8	5	68	1,17	36	30

: kennzeichnet die Lage der Schichten; mittlere Scheibe bei Dreifachverglasungen aus Clearlite.

Remarks: Exemplary glazing type for double (triple) insulation glazing used in dynamic building simulations (Source: Interpane)
Frame to glazing ratio _ frame _ 10 % -> glazing _ 90 %;
Double insulation glazing _ Ug = 1,0 W/(m²*K) _ g = 0,62 _ TL = 81 %
Triple insulation glazing _ Ug = 0,6 W/(m²*K) _ g = 0,53 _ TL = 74 %

BOUNDARY CONDITIONS
SHADING DEVICES _ INTERNAL _ PRODUCT EXAMPLE
TEXTILE SCREEN _ e.g. SOLTIS SCREEN

Ref.	TS	RS	AS	TV n-h	TV n-n	g_{tot}*	g_{tot}'	NCS-Farbsystem
92-2012	7	30	63	6	5	0.08	0.46	S 4010 Y 30 R
92-2013	18	57	25	16	4	0.14	0.38	S 0540 Y 10 R
92-2039	3	8	89	3	3	0.07	0.53	S 8010 B 90 G
92-2043	2	12	86	2	3	0.06	0.52	-
92-2044	20	70	10	19	5	0.14	0.34	S 0500 N
92-2045	3	35	62	3	3	0.05	0.45	-

TS: Strahlungstransmission in %
RS: Strahlungsreflexion in %
AS: Strahlungsabsorption in %
TS + RS + AS = 100 % der einfallenden Energie

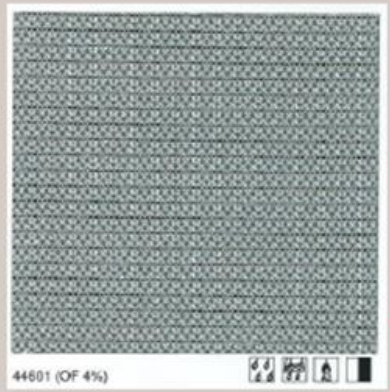
g_{tot}*: Sonnenschutzfaktor außen
g_{tot}': Sonnenschutzfaktor innen
Verglasung Typ «C»: doppelte Isolierverglasung, schwach wärmeleitend auf der Isolierinnenseite der zum Raum gewandten Glasscheibe (4 + 16 + 4; Argon-Füllung).

TVn-h: Transmission von sichtbarem Licht normal-hemisphärisch in %
TVn-n: Transmission von sichtbarem Licht normal-normal in %

A : Die der Sonne zugewandte Aluminiumseite
B : Die der Sonne zugewandte farbige Seite

Remarks: SHADING DEVICES _ INTERNAL _ SET POINT q,sol = 200 W/m²
Shading devices are activated, when the direct + diffuse solar radiation incident on the window exceeds the 200 W/m²

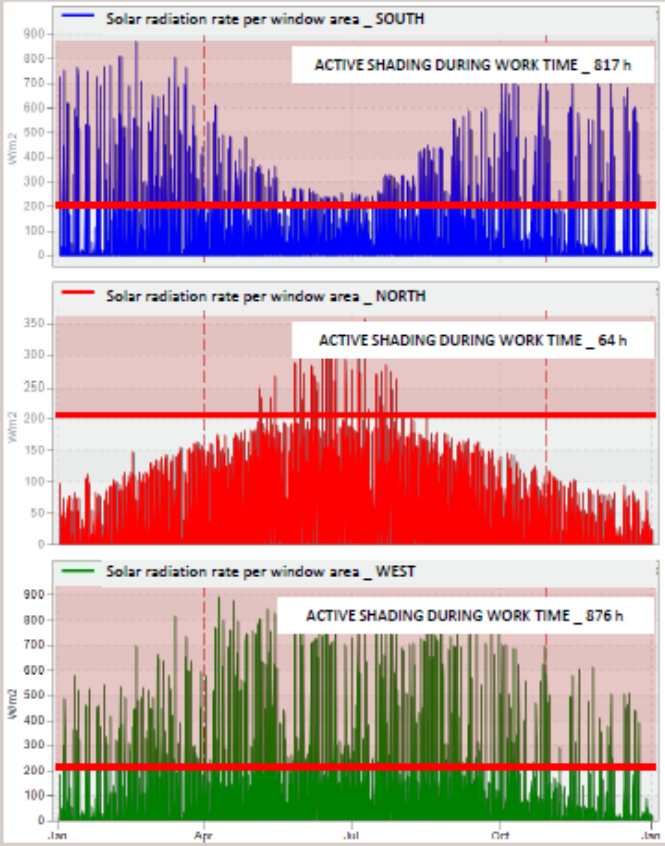
BOUNDARY CONDITIONS
SHADING DEVICES _ EXTERNAL _ PRODUCT EXAMPLE
WAREMA SecuTex _ 44601 _ SILBER

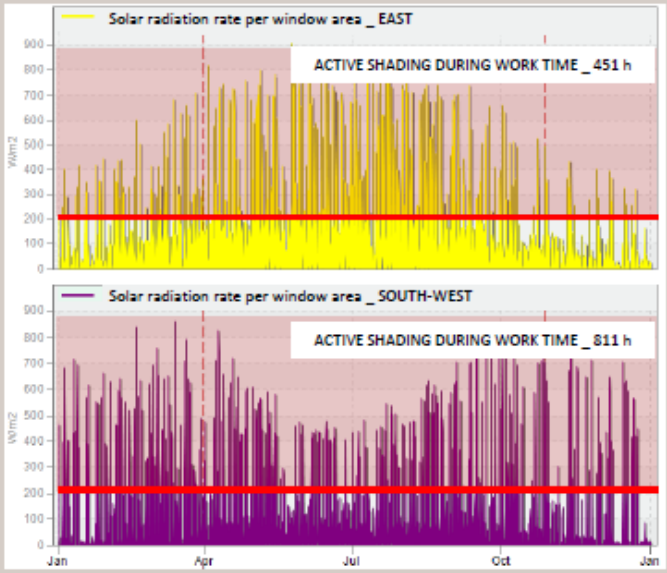


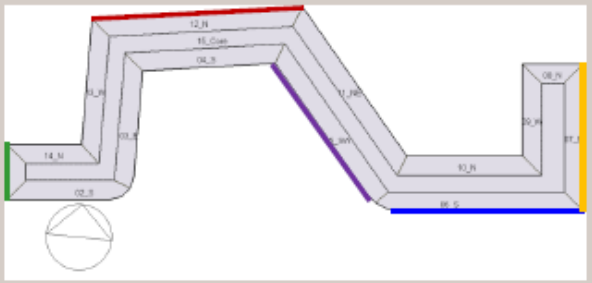
Dessin	Außenliegende Farbe (bei mehrfarbigen Dessins)	Öffnungsfaktor in %	Lichtreflexionsgrad in %	Lichttransmissionsgrad in %	Lichtabsorptionsgrad in %	Strahlungsgesamtreflexionsgrad in %	Strahlungstransmissionsgrad in %	Strahlungsabsorptionsgrad in %	Farbwiedergabeindex R_a	Pflegeanleitung
44500	weiß	1	57	9	34	55	8	37	98	
	silber	1	53	9	38	54	8	38	98	
44501	silber	1	51	4	45	52	4	44	98	
44502	grau	1	20	3	77	24	4	72	99	
	silber	1	50	3	47	52	4	44	99	
44600	weiß	4	48	15	37	46	14	40	99	
	silber	4	43	15	42	44	14	42	99	
44601	silber	4	47	7	46	48	7	45	98	
44602	grau	4	18	5	77	21	6	73	99	
	silber	4	41	5	54	43	6	51	99	

Remarks: SHADING DEVICES _ EXTERNAL _ SET POINT q,sol = 200 W/m²
Shading devices are activated, when the direct + diffuse solar radiation incident on the window exceeds the 200 W/m²

BOUNDARY CONDITIONS
FAÇADE ORIENTATIONS _ SHADING DEVICES _ SET POINT 200 W/m²

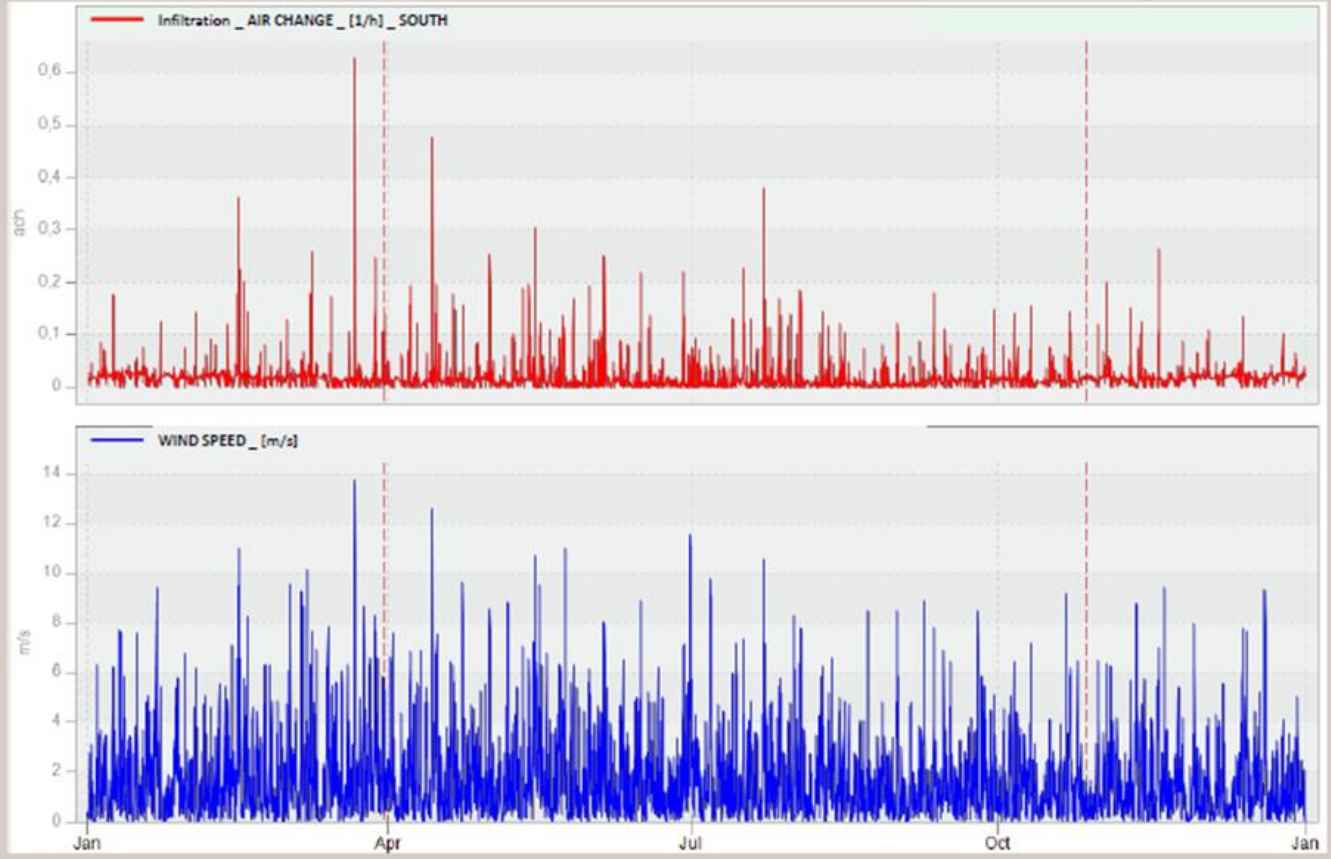






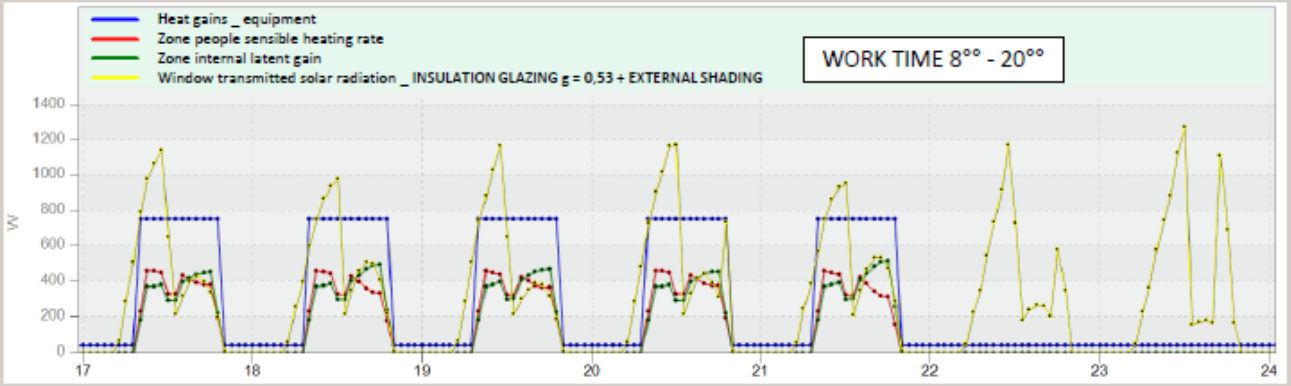
Remarks: Set point of external/internal shading devices _ 200 W/m²;
Work time total 2.871 h (8°° - 20°° _ Monday – Friday = 2.871 h)

BOUNDARY CONDITIONS
AIRTIGHTNESS OF BUILDING ENVELOPE _ INFILTRATION



Remark: Infiltration rate depending on wind speed (part of ventilation losses)

BOUNDARY CONDITIONS
INTERNAL HEAT GAINS _ OFFICE _ WEST
TYPICAL SUMMER WORK WEEK _ WORK TIME 8°° - 20°°



OCCUPANCY

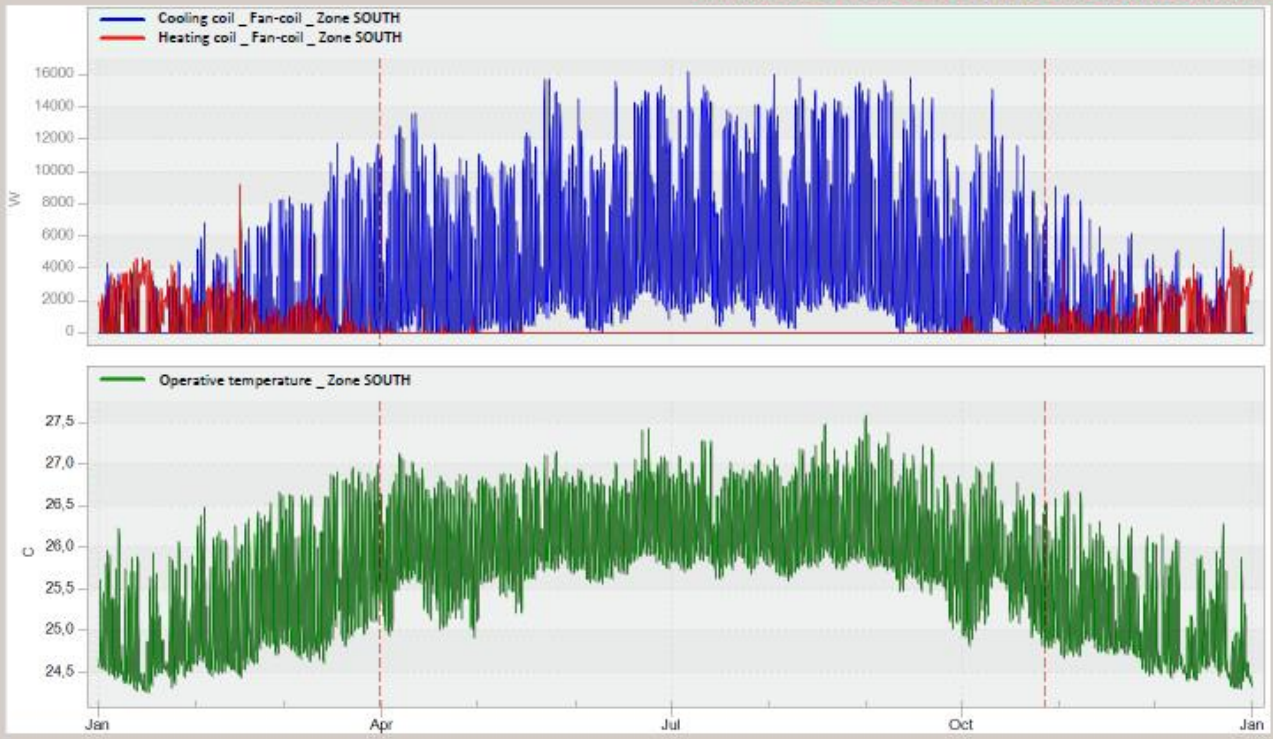
Office_OpenOff_Occ,
Fraction,
Through: 31 Dec,
For: Weekdays SummerDesignDay,
Until: 08:00, 0,
Until: 09:00, 0.5,
Until: 12:00, 1,
Until: 14:00, 0.75,
Until: 19:00, 1,
Until: 20:00, 0.5,
Until: 24:00, 0,
For: Weekends,
Until: 24:00, 0,
For: Holidays,
Until: 24:00, 0,
For: WinterDesignDay AllOtherDays,
Until: 24:00, 0;

EQUIPMENT

Office_OpenOff_Equip,
Fraction,
Through: 31 Dec,
For: Weekdays SummerDesignDay,
Until: 08:00, 0.05394,
Until: 20:00, 1,
Until: 24:00, 0.05394,
For: Weekends,
Until: 24:00, 0.05394,
For: Holidays,
Until: 24:00, 0.05394,
For: WinterDesignDay AllOtherDays,
Until: 24:00, 0;

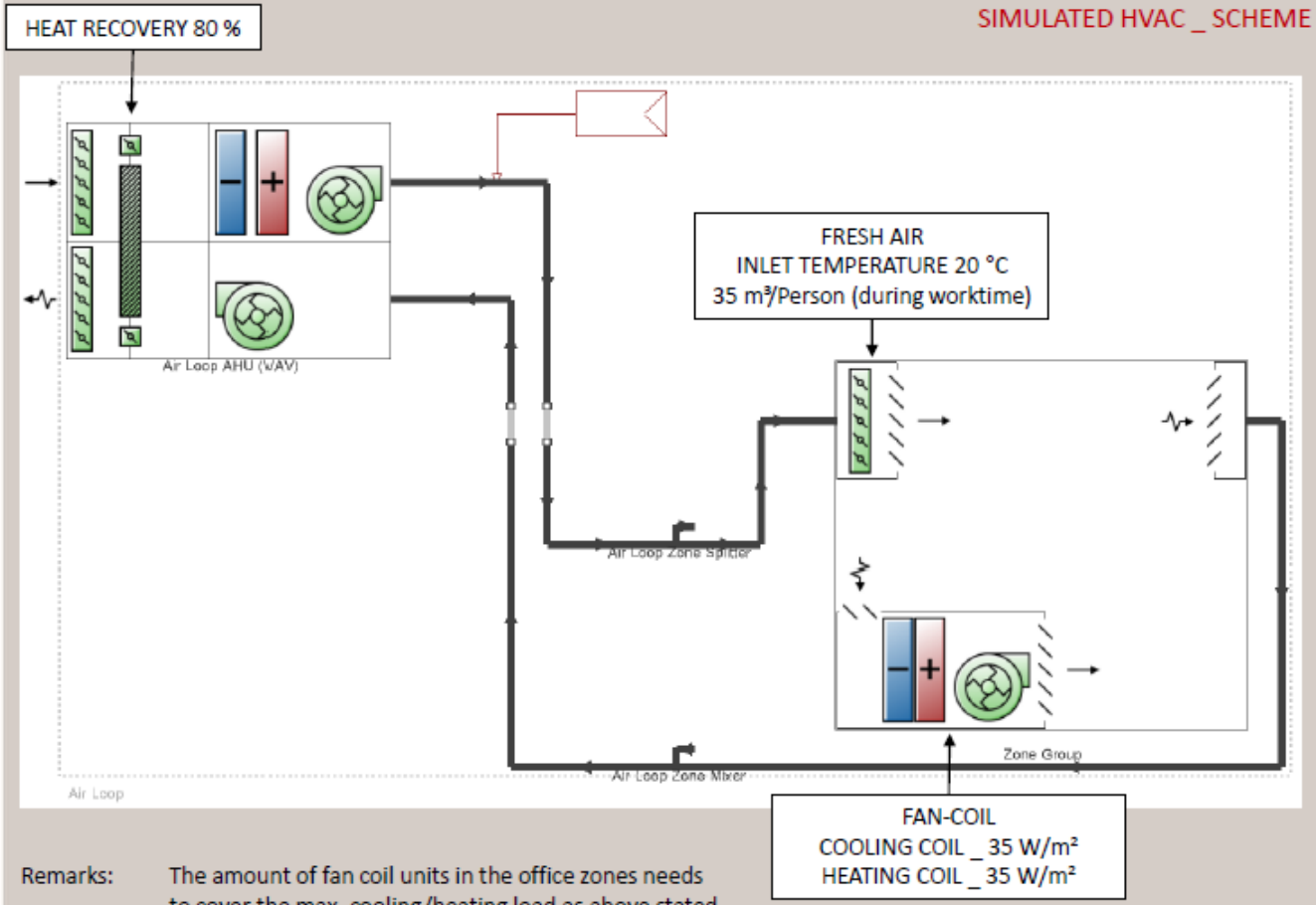
Remarks: Office equipment _ 100 W per workplace (energy efficient laptops and LED lights);
People (light office work) 123 W/Person (latent + sensible heat gains)

BOUNDARY CONDITIONS
FAN COIL _ COOLING / HEATING
EXAMPLE _ OFFICE _ SOUTH _ EXTERNAL SHADING



Remark:
_ Heating coil _ critical rooms _ max. 20 W/m²
_ Cooling coil _ critical rooms _ max. 20 W/m²
_ Cooling load in different zones caused also during winter on critical days (clear sky, low sun, room high glazing of facade), additional venting with outside air to prevent overheating resp. 4-pipe cooling/heating system

BOUNDARY CONDITIONS
SIMULATED HVAC _ SCHEME



Remarks: The amount of fan coil units in the office zones needs to cover the max. cooling/heating load as above stated in W per m² of gross office floor area.

VARIANTS

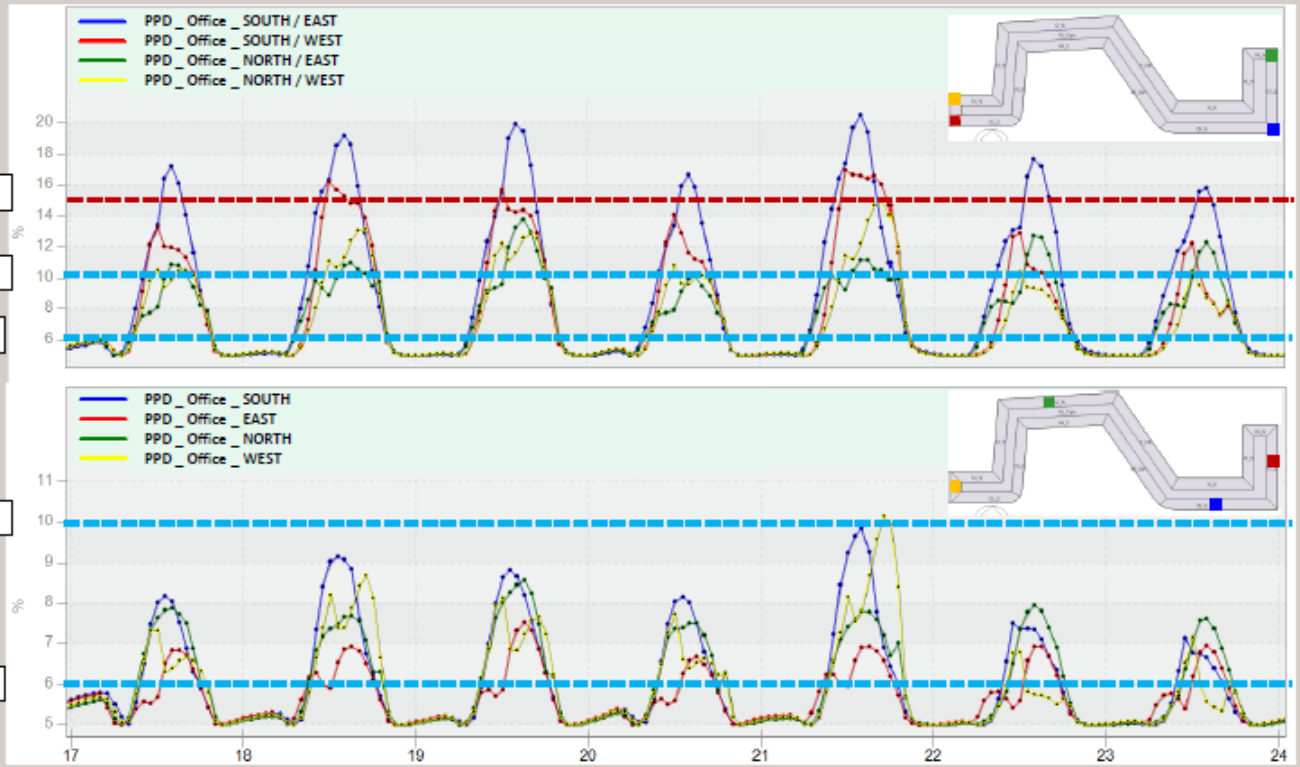
V1 _ EXTERNAL SHADING SCREENS + TRIPLE INSULATION GLAZING _ Ug = 0,6 W/(m²*K) _ g = 0,53 _ TL = 74 %

V2 _ EXTERNAL SHADING SCREENS + DOUBLE INSULATION GLAZING _ Ug = 1,0 W/(m²*K) _ g = 0,62 _ TL = 81 %

V3 _ INTERNAL SHADING SCREENS + DOUBLE INSULATION GLAZING _ Ug = 1,0 W/(m²*K) _ g = 0,62 _ TL = 81 %

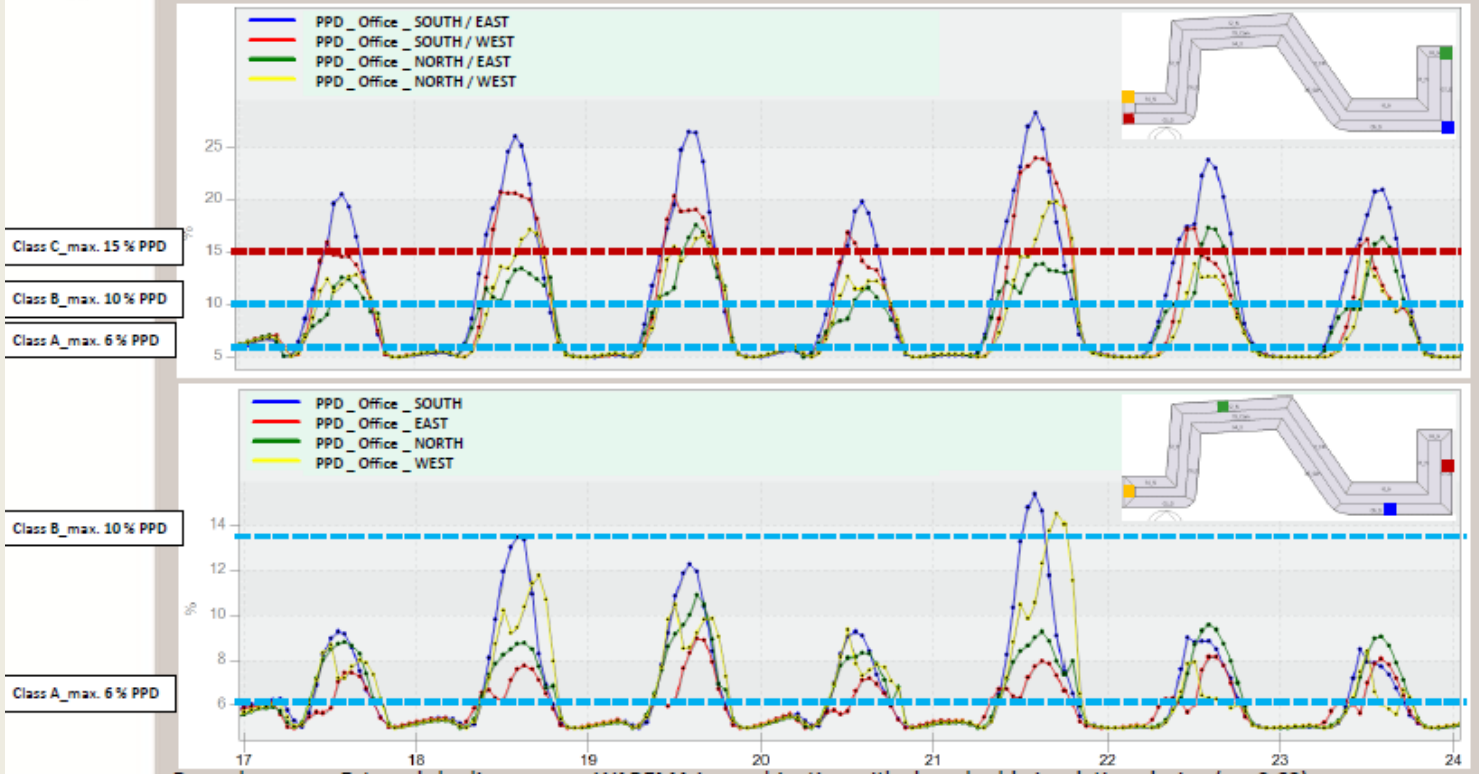
DYNAMIC ENERGY SIMULATIONS _ THERMAL COMFORT
"PPD" _ PREDICTED PERCENTAGE OF DISSATISFIED (%)
RESULTS

V1 _ EXTERNAL SHADING SCREENS + TRIPLE INSULATION GLAZING _ g = 0,53
THERMAL COMFORT "PPD" _ CRITICAL SUMMER WEEK



Remark:
_ External shading screens WAREMA in combination with clear triple insulation glazing (g = 0,53)
_ Significant reduction of solar (diffuse + direct) gains results in significant reduction of overheating risk
_ In combination with cooling coil 35 W/m² _ thermal comfort "PPD" Class C except critical corner offices
_ CFD simulation of local thermal comfort for typical offices with planned fan-coils units necessary

V2 _ EXTERNAL SHADING SCREENS + DOUBLE INSULATION GLAZING _ g = 0,62
THERMAL COMFORT "PPD" _ CRITICAL SUMMER WEEK

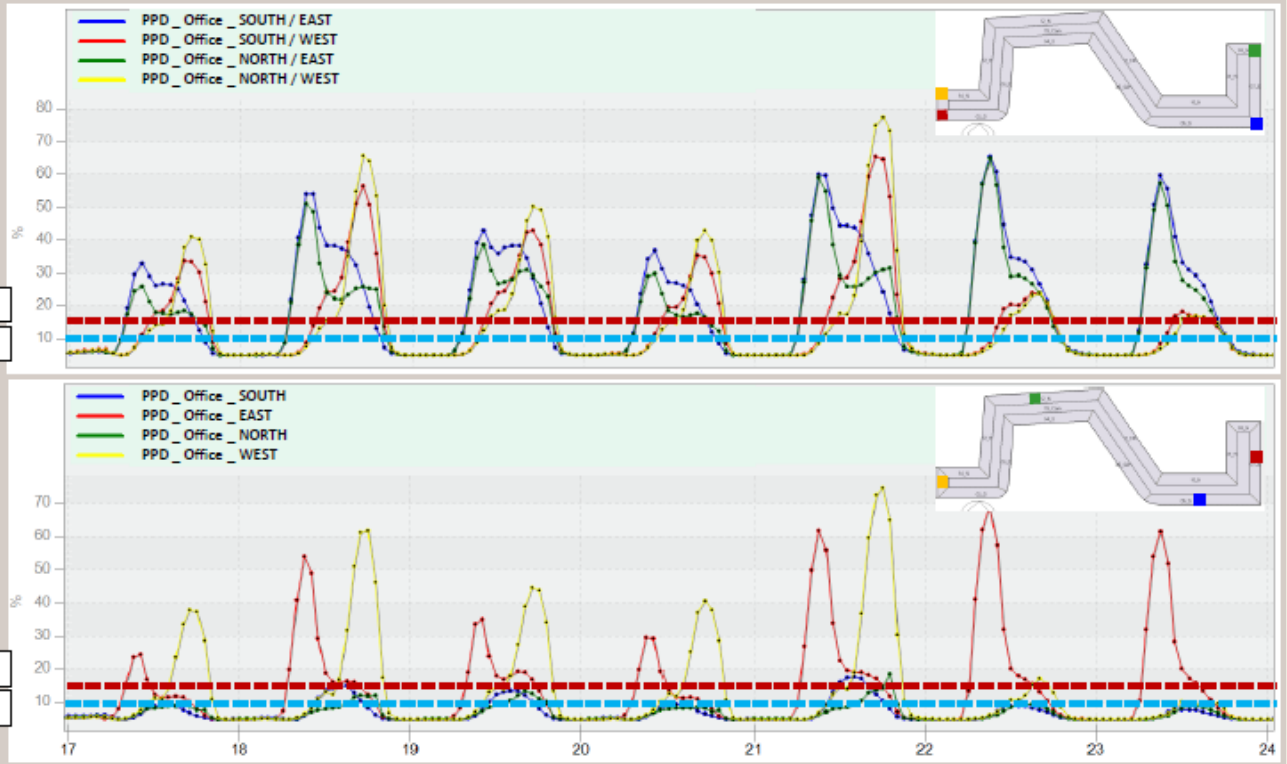


Remark:
- _ External shading screens WAREMA in combination with clear double insulation glazing (g = 0,62)
- _ Significant reduction of solar (diffuse + direct) gains results in significant reduction of overheating risk
- _ In combination with cooling coil 35 W/m² _ some hours above thermal comfort "PPD" Class C
- _ Higher cooling coil necessary (e.g. 40 W/m²)
- _ CFD simulation of local thermal comfort for typical offices with planned fan-coils units necessary

Building Physics

688 _ SEVEN GARDENS | 10000 ZAGREB | THERMAL COMFORT | DYNAMIC SIMULATION

V3 _ INTERNAL SHADING SCREENS + DOUBLE INSULATION GLAZING _ g = 0,62
THERMAL COMFORT "PPD" _ CRITICAL SUMMER WEEK

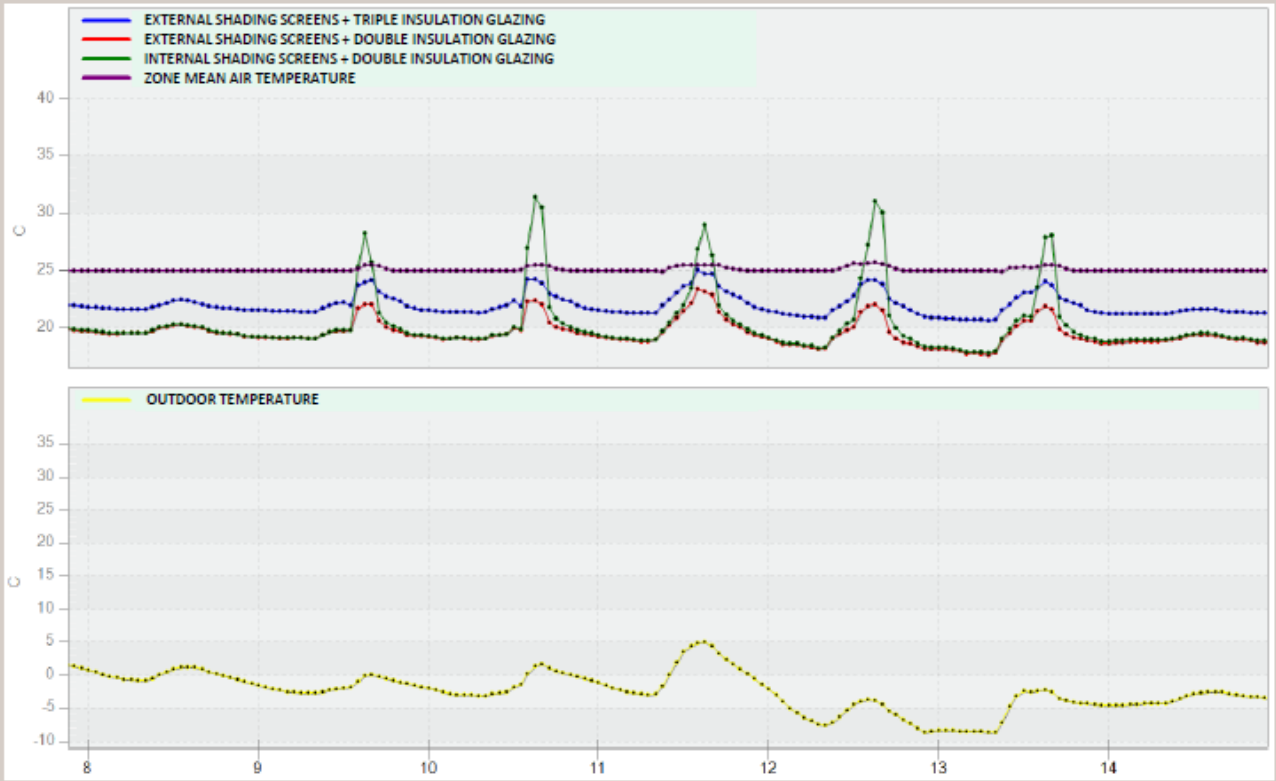


Remark:

_ Internal shading screen SOLTIS in combination with clear double insulation glazing (g = 0,62);
_ Low effectivity of internal shading, causes high thermal discomfort in interior;
_ Very warm internal screen during hours with direct solar impact causes high levels of PPD especially for the work places nearest to the glazing and internal shading device (local thermal discomfort)

DYNAMIC ENERGY SIMULATIONS
INTERIOR SURFACE TEMPERATURES _ GLAZING
RESULTS

INTERIOR SURFACE TEMPERATURES _ GLAZING
CRITICAL WINTER WEEK



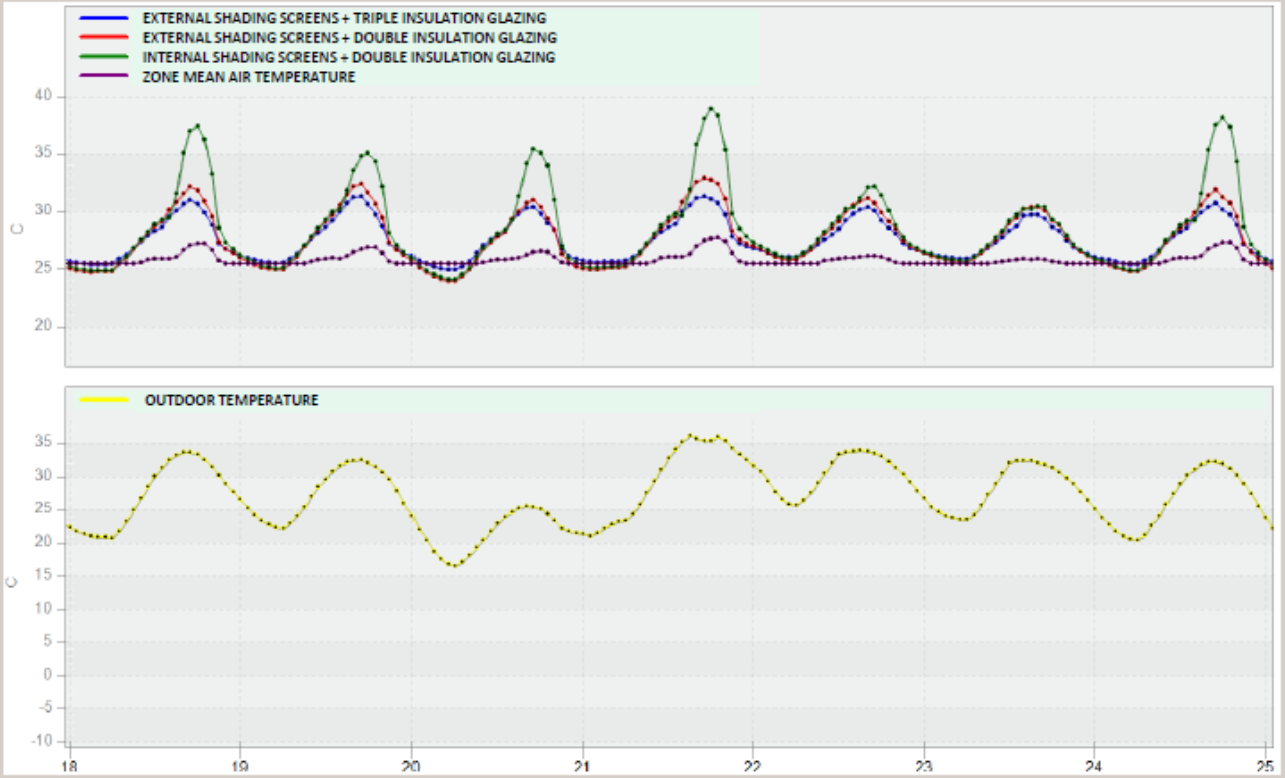
Remark:

_ During winter days without direct solar radiation on façade _ difference between triple / double glazing ca. 2 – 3 K

_ During winter days with direct solar radiation on façade _ difference between internal / external shading ca. 5 – 10 K

_ Due to low surface temperatures on double glazing during winter _ triple insulation glazing recommended

INTERIOR SURFACE TEMPERATURES _ GLAZING
CRITICAL SUMMER WEEK



Remark:

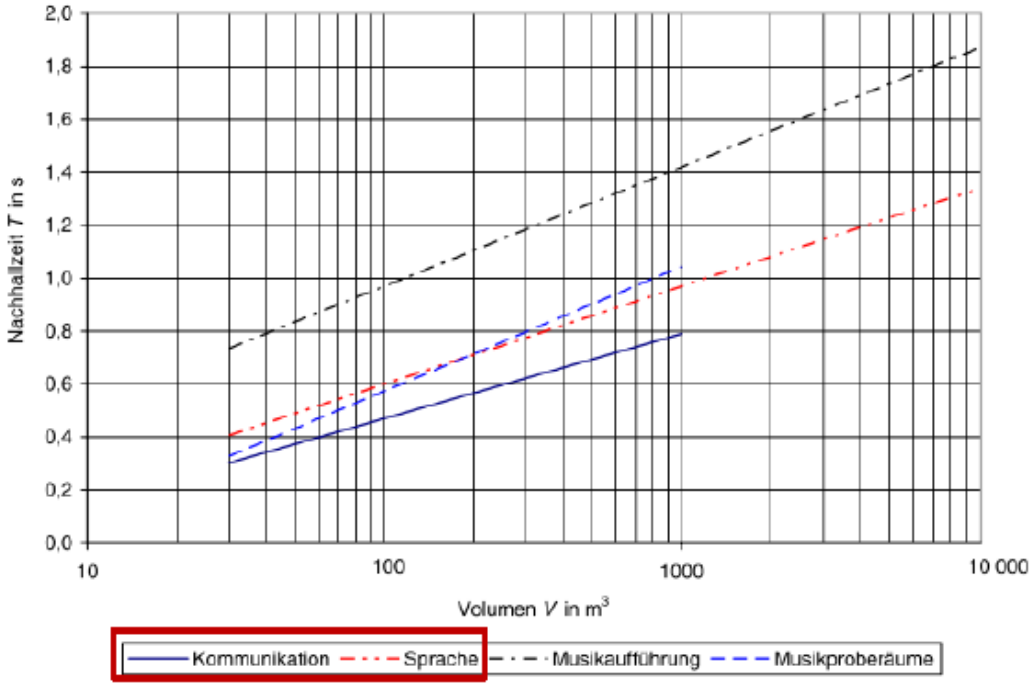
_ During summer days with direct solar radiation on façade _ difference between internal / external shading ca. 5 – 7 K

_ Due to high surface temperatures on internal shading during summer _ external shading recommended

Acoustical Comfort

AUSTRIAN STANDARD _ ÖNORM B 8115-3
REVERBERATION TIME _ REQUIREMENTS

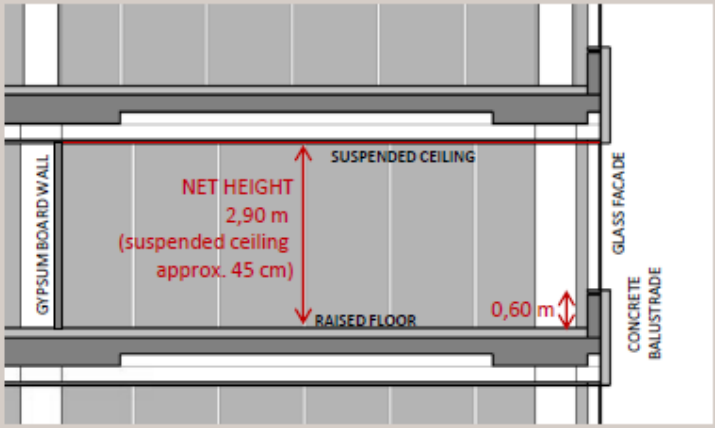
Die Berechnung der Nachhallzeit *T* bei der Planung erfolgt nach ÖNORM EN 12354-6 (diese enthält auch Angaben für die Schallabsorptionsgrade der üblichen Baustoffe und die Berechnung der Schallabsorption der Einrichtungen, wie Möbel, Maschinen uÄ).



Remarks: Speech [red dash dotted line] _ relevant for multipurpose rooms (conference rooms, presentation rooms etc.)
Communication [blue solid line] _ relevant for all remaining room types


Acoustical Comfort
building physics
688 _ SEVEN GARDENS | 10000 ZAGREB | CROATIA | ROOM ACOUSTICS
STANDARD OPEN OFFICE
Level 02
N
OPEN OFFICE _ V1

OPEN OFFICE_V1 _ 352 m²
SOUND ABSORPTION COEFFICIENTS



MATERIAL	SOUND ABSORPTION COEFFICIENTS _ α					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
DOUBLE FLOOR _ SOUND REFLECTING	0,08	0,07	0,06	0,07	0,08	0,08
DOUBLE FLOOR _ SOUND ABSORBING _ D	0,67	0,65	0,37	0,37	0,54	0,67
SUSPEND. CEILING _ STANDARD	0,25	0,15	0,10	0,05	0,05	0,05
SUSPEND. CEILING _ SOUND ABSORBING _ D	0,40	0,45	0,45	0,45	0,45	0,50
CONCRETE WALL / BALUSTRADE	0,02	0,02	0,03	0,04	0,05	0,05
GYPSUM BOARD WALL	0,08	0,11	0,05	0,03	0,02	0,03
GLASS FACADE	0,20	0,15	0,10	0,05	0,03	0,02
FACADE TRANSOM MULLION PROFILES	0,02	0,02	0,02	0,02	0,02	0,02

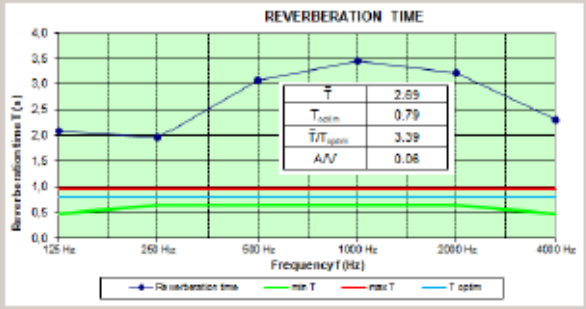
Floor area: 352 m²
Volume: 1.021 m³
No persons in calculation
No furniture in calculation

Remarks: Design plans from _ 14.11.2018 _7G_AR_CD_AP_5600 - Standard Open Office.pdf
_ 7G_AR_CD_AP_3000 – Sections.pdf

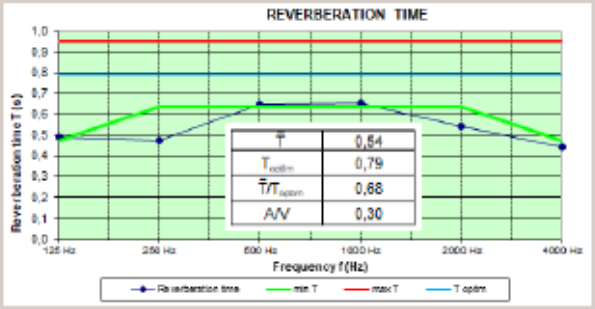
14

OPEN OFFICE_V1 _ 352 m²
REVERBERATION TIME

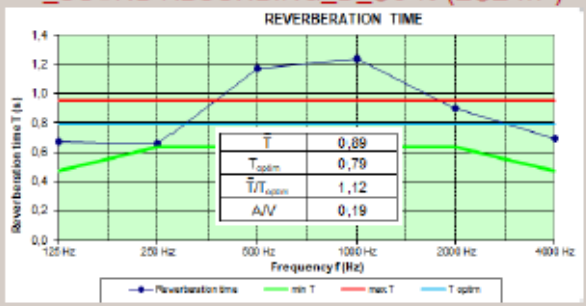
V0_WITHOUT SOUND ABSORBING MEASURES



V2_+ CEILING _SOUND ABSORBING_D_80 % (282 m²)

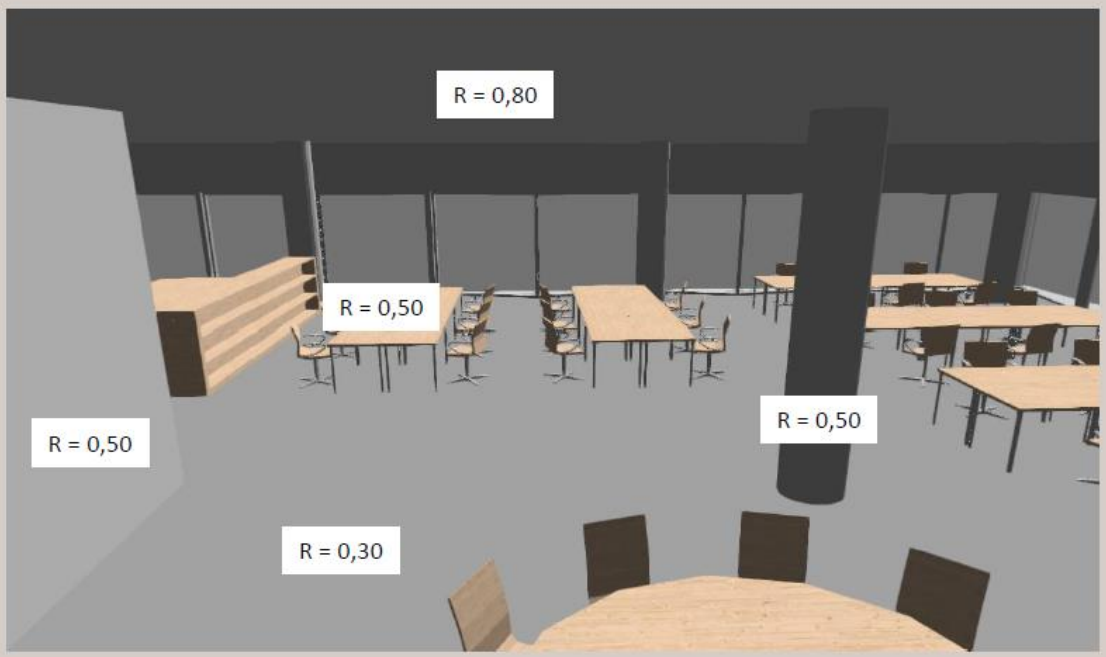


V1_RAISED FLOOR _SOUND ABSORBING_D_80 % (282 m²)



Visual Comfort

SEVEN GARDENS
SURFACE REFLECTANCE _ OFFICE



Surface reflectances

_ Ceiling:	R = 0,80	(Recommended values from EN 12464-1:2011, 4.2 are 0,7 - 0,9)
_ Walls:	R = 0,50	(Recommended values from EN 12464-1:2011, 4.2 are 0,5 - 0,8)
_ Floor:	R = 0,30	(Recommended values from EN 12464-1:2011, 4.2 are 0,2 - 0,4)
_ Work desks:	R = 0,50	

BOUNDARY CONDITIONS
FAÇADE PROPERTIES

Wärmedämmglas

Produktbezeichnung	Aufbau außen/ SZR/ (Mitte/ SZR/) innen	U_g-Nennwert EN 673	lichttechnische und strahlungsphysikalische Nennwerte EN 410											
			g-Wert	Lichtdurchlässigkeit	allg. Farbwiedergabe-Index in Durchsicht	Lichtreflexionsgrad nach außen	Energieabsorption außen	Energieabsorption Mitte	Energieabsorption innen	Shading Coefficient (g-Wert EN 410/0,87)	Selektivitätskennzahl	Dicke	Gewicht
	mm	W/(m²K)	%	%		%	%	%	%	%		mm	kg/m²
iplus top 1.1 on Clearlite	4/16/:4	1,1	64	82	98	12	7	–	7	74	1,28	24	20
iplus top 1.1 on Clearlite	6/16/:6	1,1	63	80	98	12	10	–	8	72	1,27	28	30
iplus top 1.1 on Clearlite	4/12/:4	1,3	64	82	98	12	7	–	7	74	1,28	20	20
iplus top 1.1 on Clearlite	6/12/:6	1,3	63	80	98	12	10	–	8	72	1,27	24	30
iplus advanced 1.0 on Clearlite	4/16/:4	1,0	57	77	98	15	8	–	8	66	1,35	24	20
iplus advanced 1.0 on Clearlite	4/12/:4	1,2	56	77	98	15	8	–	8	64	1,35	20	20
iplus top 1.1 T on Clearlite	4/16/:4	1,1	66	82	98	12	7	–	6	76	1,24	24	20
iplus top 1.1 T on Clearlite	6/16/:6	1,1	64	81	98	12	10	–	8	74	1,27	28	30
iplus top 1.1 T on Clearlite	4/12/:4	1,3	66	82	98	12	7	–	6	76	1,24	20	20
iplus top 1.1 T on Clearlite	6/12/:6	1,3	64	81	98	12	10	–	8	74	1,27	24	30
iplus advanced 1.0 T on Clearlite	4/16/:4	1,0	62	81	98	13	7	–	6	71	1,31	24	20
iplus advanced 1.0 T on Clearlite	6/16/:6	1,0	60	80	97	13	10	–	7	69	1,33	28	30

Sonnenschutzglas - Magnetron-Beschichtungen (Softcoatings)

Produktbezeichnung	Aufbau außen/ SZR/ (Mitte/ SZR/) innen	U_g-Nennwert EN 673	lichttechnische und strahlungsphysikalische Nennwerte EN 410												
			g-Wert	Lichtdurchlässigkeit	allg. Farbwiedergabe-Index in Durchsicht	Lichtreflexionsgrad nach außen	Energieabsorption außen	Energieabsorption Mitte	Energieabsorption innen	Shading Coefficient (g-Wert EN 410/0,87)	Selektivitätskennzahl	Dicke der Isoliergaseinheit	Gewicht	vorspannbar / biegbar	Festmaßbeschichtung
Zweifach-Verglasungen															
	mm	W/(m²K)	%	%		%	%	%	%	%		mm	kg/m²		
ipasol neutral 70/27	6/16/4	1,0	37	70	96	12	28	–	1	42	1,89	26	25	–	•
ipasol Ultraselect 62/29	6/16/4	1,0	29	62	93	10	32	–	1	33	2,14	26	25	–	•
ipasol light grey 60/33	6/16/4	1,0	33	60	93	10	34	–	1	38	1,82	26	25	–	•
ipasol neutral 50/27	6/16/4	1,1	27	50	94	9	48	–	1	31	1,85	26	25	–	•
ipasol platin 47/29	6/16/4	1,0	29	47	95	40	29	–	1	33	1,62	26	25	–	•
ipasol shine 40/22	6/16/4	1,1	22	40	91	16	53	–	1	25	1,82	26	25	–	•
ipasol sky 30/17 [1]	6/16/4	1,1	17	30	86	18	63	–	0	20	1,76	26	25	–	•
ipasol platin 25/17	6/16/4	1,0	17	25	97	64	19	–	1	20	1,47	26	25	–	•
ipasol bright neutral	6/16/:4	1,1	47	58	99	35	17	–	5	54	1,23	26	25	•	•
ipasol bright white	6/16/:4	1,1	51	59	98	36	4	–	6	59	1,16	26	25	•	•

DAYLIGHT FACTOR
ÖGNI / DGNB _ EVALUATION POINTS

$$TQ = \frac{\text{Horizontal illuminance in room}}{\text{Horizontal illuminance in exterior}} \times 100 \text{ in } \%$$

Target values:

	50 % of net area has a daylight factor Dm:	Evaluation:	Points:
1	2 %	Very good	16
2	1,5 %	Average	12
3	1 %	Low	8
4	< 1%	None	0

Remarks: TQ = Dm _ Average daylight factor on evaluation area (work desk height _ 0,85 m)

LIGHTING OF WORK PLACES
ÖNORM EN 12464-1

Table 5.26 — Offices

Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	UGR_L –	U_o –	R_a –	Specific requirements
5.26.1	Filing, copying, etc.	300	19	0,40	80	
5.26.2	Writing, typing, reading, data processing	500	19	0,60	80	DSE-work, see 4.9.
5.26.3	Technical drawing	750	16	0,70	80	
5.26.4	CAD work stations	500	19	0,60	80	DSE-work, see 4.9.
5.26.5	Conference and meeting rooms	500	19	0,60	80	Lighting should be controllable.
5.26.6	Reception desk	300	22	0,60	80	
5.26.7	Archives	200	25	0,40	80	

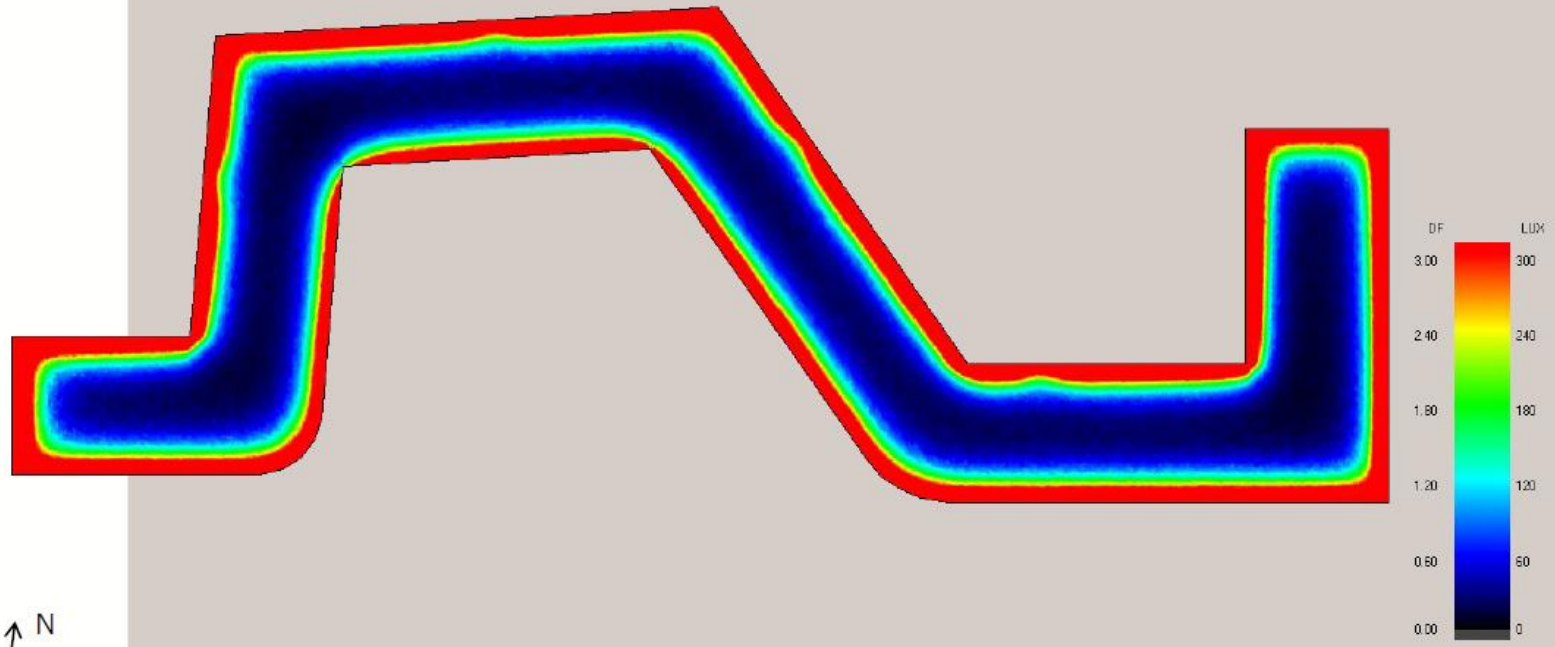
Table 5.27 — Retail premises

Ref. no.	Type of area, task or activity	$\bar{E}_m$ lx	UGR_L –	U_o –	R_a –	Specific requirements
5.27.1	Sales area	300	22	0,40	80	
5.27.2	Till area	500	19	0,60	80	
5.27.3	Wrapper table	500	19	0,60	80	

Building Physics

688 _ SEVEN GARDENS | 10000 ZAGREB | SLAVONSKA AVENIJA | CROATIA | VISUAL COMFORT

V1C _ DOUBLE INSULATION GLAZING _ TL = 81 %
2nd FLOOR
DAYLIGHT _ CIE OVERCAST SKY _ 10.000 lux



Remark:
_ Dm = 2,31 %
_ Em > 300 lx → 22 % of floor area can be without active artificial lights during overcast sky (red colour)
_ In critical areas during overcast sky _ artificial lights necessary
_ Ca. 2,5 - 4 m near the facade during overcast sky Em > 300 lux satisfied without active artificial lights

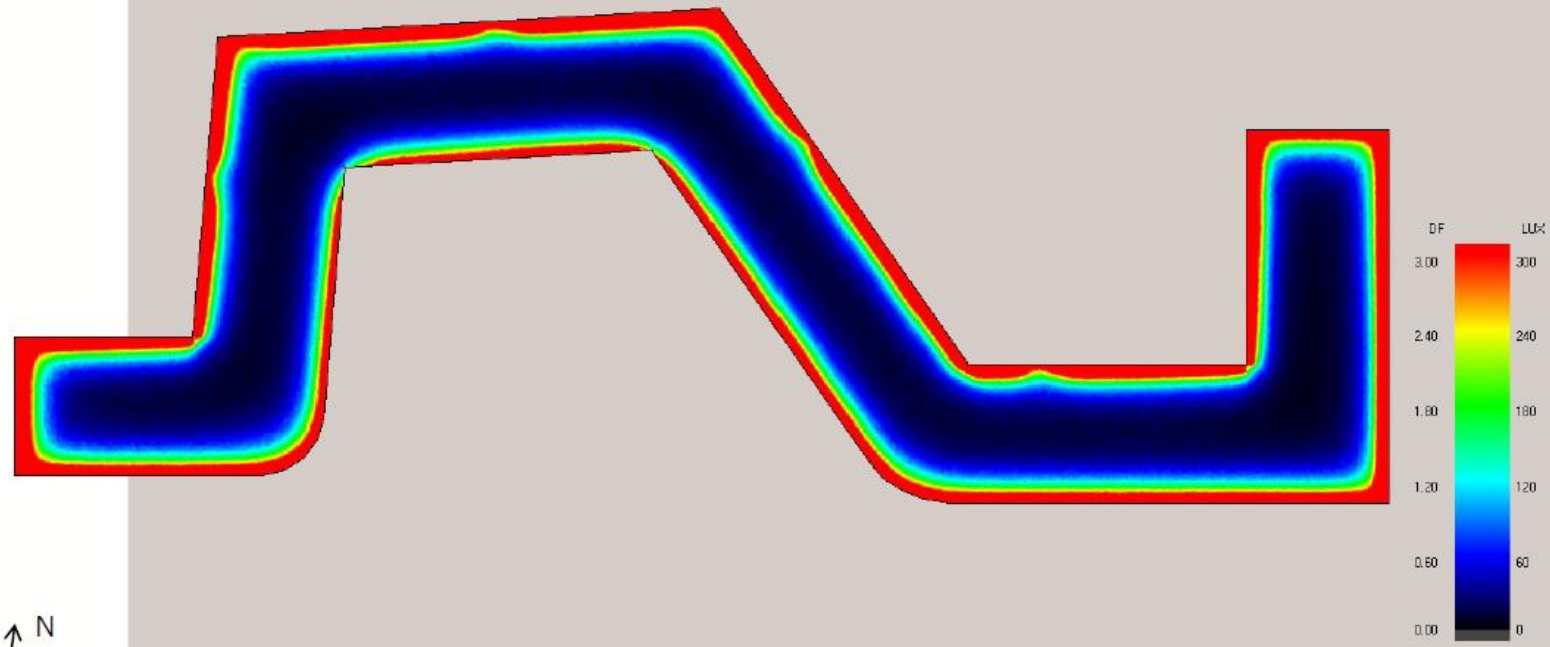
Building Physics

688 _ SEVEN GARDENS | 10000 ZAGREB | SLAVONSKA AVENIJA | CROATIA | VISUAL COMFORT

V2C _ DOUBLE INSULATION GLAZING _ TL = 62 %

2nd FLOOR

DAYLIGHT _ CIE OVERCAST SKY _ 10.000 lux



Remark:

_ Dm = 1,48 %

_ Em > 300 lx → 15 % of floor area can be without active artificial lights during overcast sky (red colour)

_ In critical areas during overcast sky _ artificial lights necessary

_ Ca. 1,5 - 3 m near the facade during overcast sky Em > 300 lux satisfied without active artificial lights

Co-funded by the Erasmus+ Programme of the European Union

BIMZeED

Education for zero energy buildings using Building Information Modelling

Vanja Keindl
Paula Topić
Antonio Jambrač
Martina Radevska

BIMzeED

Co-funded by the Erasmus+ Programme of the European Union

- trogodišnji projekt kojeg financira Europska unija, kroz program Erasmus+.

Budžet: 955.633,00 €

Početak projekta: studeni 2018.

Završetak projekta: listopad 2021.

Poziv: EAC/A05/2017

Erasmus+, Cooperation and Innovation for Good Practices (KA2) Knowledge Alliances for higher education

Koordinator projekta

Co-funded by the Erasmus+ Programme of the European Union

LIT LIMERICK INSTITUTE OF TECHNOLOGY

Limerick Institute of Technology (LIT)
Development Unit, Nenagh Road, Thurles
Tipperary, Ireland E41 PC92

Kontakt koordinatora projekta BIMzeED:

+354 50 42 80 40

elisabeth.obrien@lit.ie

Partneri

Co-funded by the Erasmus+ Programme of the European Union

Tipperary Energy Agency

University of Zagreb, Faculty of Civil Engineering

North West Croatia Regional Energy Agency

Non-Profit Limited Liability Company for Quality Control and Innovation in Building

Óbuda University

The Catalonia Institute of Construction Technology

Universitat Politècnica de Catalunya - technological center - CIM UPC foundation

Architects' Council of Europe

Izazov projekta BIMzeED

Co-funded by the Erasmus+ Programme of the European Union

Prevladavanje neusklađenosti vještina i poboljšanje zapošljivosti (u području NZEB-a i BIM-a) na sadašnjem europskom građevinskom tržištu.

- KAKO?
  - **poboljšanjem i proširenjem postojećih vještina trenera**, malih i srednjih poduzeća, voditelja gradilišta, obrtnika i drugih iskusnih djelatnika.

Projekt BIMzeED namjerava:

Co-funded by the Erasmus+ Programme of the European Union

1. **Utvrditi nedostatak znanja i vještina u digitalizaciji (BIM) i nZEB-u**
   - unutar visoko obrazovnih institucija i građevinskog sektora za svaku državu partnera (Irska, Španjolska, Mađarska i Hrvatska).
2. **Unaprijediti ljudski potencijal u građevinskom sektoru**
   - djelujući na visoko obrazovne institucije i sustave strukovnog obrazovanja i osposobljavanja u Europi.
3. **Poduprijeti građevinski sektor kroz edukaciju i unaprjeđivanje vještina** za rad s tehničkim inovacijama i digitalizacijom.
4. **Prenijeti znanje o BIM-u i nZEB-u** na i iz drugih zemalja.

Projekt BIMzeED namjerava:

Co-funded by the Erasmus+ Programme of the European Union

5. **Uspostaviti i razviti 12-16 nastavnih jedinica**
   - u cilju povećanja razumijevanja BIM alata i nZEB-a unutar postojećih kurikuluma u građevinskom sektoru.
6. **Trenirati i osposobiti 120 trenera na europskim visokim učilištima i strukovnim školama**
   - kroz niz edukacija korištenjem inovativnih i novih obrazovnih materijala koji će biti javno dostupni i prijenosni na portalu za e-učenje.



Projekt BIMzeED namjerava:

Co-funded by the Erasmus+ Programme of the European Union

7. **Educirati 400-500 studenata, voditelja gradilišta, obrtnika i drugih sudionika u građevinskom projektu**
   - u cilju poboljšanja mogućnosti njihovog zaposlenja.
8. **Poboljšati veze između učitelja, industrije te malih i srednjih poduzeća pomoću inovativnih tehnologija**
   - stvarajući tako povezane zajednice (učenje kroz primjere dobre prakse, obilasci gradilišta, demonstracije u industriji).
9. **Povećati mogućnost zaposlenja u nastavi te malim i srednjim poduzećima**
   - poznatije kao suradnja na razvoju poslovanja.



Literatura

(1) Mueller, Roland, DI, Dr.techn.: DINAMIC ENERGY SIMULATION - THERMAL COMFORT – PPD, Preliminary Analisys / Estimation, Stand 28.9.2018.

(2) Mueller, Roland, DI, Dr.techn.: VISUAL COMFORT Preliminary Analisys / Estimation, Stand 6.11.2018.

(3) Mueller, Roland, DI, Dr.techn.: ROOM ACOUSTICS AND MINIMAL SOUND ABSORPTION MEASURES Preliminary Analisys / Estimation, Stand 05.12.2018.

(4) Milovanović, Bojan, dr.sc.: BIM zeED, Education for zero energy buildings using Building Information Modelling, prezentacija, Prvi sastanak NSG Hrvatska, 15. 04.2019., Sveučilište u Zagrebu, Građevinski fakultet

Hvala na pažnji