

Teadmistepõhine ehitus 2018

Tabeliväärtustest erineva valgustusvõimsuse arvutusmetoodika

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Electric Light Guidance



Estonian Building Code, Building Energy Efficiency charter

Electric lighting energy efficiency strategies

- High efficiency lamps
- Division of the space in task and surrounding area
- Occupancy sensors and controls
- Daylight dimming
- Lighting zones

Study outcome

- Methodology
- Minimum power density and annual consumptions



European Lighting Standard EN12464-1

- Office
- Commercial
- Educational

Type of building	Type of room	Maintained illuminance $\bar{E}_m$ (lx)	Uniformity U_0
Traffic zones in buildings	Circulation and corridors	100	0.4
Traffic zones in buildings	Rest rooms	100	0.4
Traffic zones in buildings	Stairs, escalators	100	0.4
General areas in buildings	Cloakrooms, toilets and bathrooms	200	0.4
General areas in buildings	Canteens, pantries	200	0.4
General areas in buildings	Stairs, escalators	100	0.4
Offices	Writing, typing, reading and data processing	500	0.6
Offices	Filing and copying	300	0.4
Offices	Technical drawing	750	0.7
Offices	Conference and meeting rooms	500	0.6
Offices	Reception desks	300	0.6
Offices	Archives	200	0.4
Educational	Classrooms	300	0.6
Educational	Lecture halls and workshop rooms	500	0.6
Educational	Sport hall	300	0.6
Educational	Technical drawing rooms	750	0.7
Educational	Computer rooms	300	0.6
Educational	Library - bookshelves	200	0.6
Educational	Library - reading areas	500	0.6
Commercial	Sales area	300	0.4
Commercial	Till areas	500	0.6

Typical use of buildings

- Residential

The building purpose use	Usage time			Uses	Lighting (a) W/m ²	Equipment W/m ²	People (b) W/m ²	People m ² /person
	Hour of the day	h/24h	d/7d					
Family house	00:00–00:00	24	7	0.6	8(c)	2.4(d)	2	42.5
Apartment building	00:00–00:00	24	7	0.6	8(c)	3(d)	3	28.3
Office building, library and science building	07:00–18:00	11	5	0.55	12	12	5	17.0
Commercial building	07:00–21:00	14	7	0.55	20	1	5	17.0
Accommodation building	00:00–00:00	24	7	0.5	8	1	4	21.3
Catering service buildings	12:00–22:00	10	7	0.4	20	4	14	6.1
Public the building	08:00–22:00	14	7	0.5	14	0	5	17.0
Educational buildings (e)	08:00–16:00	8	5	0.5(f)	15	8	14	5.4
Pre-school and children health care	07:00–19:00	12	5	0.4	15	4	20	3.8
Health care facility	00:00–00:00	24	7	0.6	9	4	8	10.6

For the calculation of the annual electric light energy consumption using the tabulated values of power density for the typical use of building the following formula is used

$$Q = kP \frac{\tau_d}{24} \frac{\tau_w}{7} \frac{8760}{1000}$$

Q = energy consumption (kWh/m²y)

K = room usage rate

P = installed power density

τ_d = number of operating hours per day (h)

τ_w = number of days of use per week (d)



Instructions for electric light simulations and calculations

Room selection

Type of building	Room type				
Residential	Kitchen	Bathroom	Utility room	Living room – reading area	Vestibule
Office	Office room	Open office	Meeting room	Corridor	Canteen
Educational	Classroom	Lecture hall	Workshop room	Sport hall	Library – reading room
Commercial	Sales area	Till areas	Wrapper tables	Circulation	Canteen

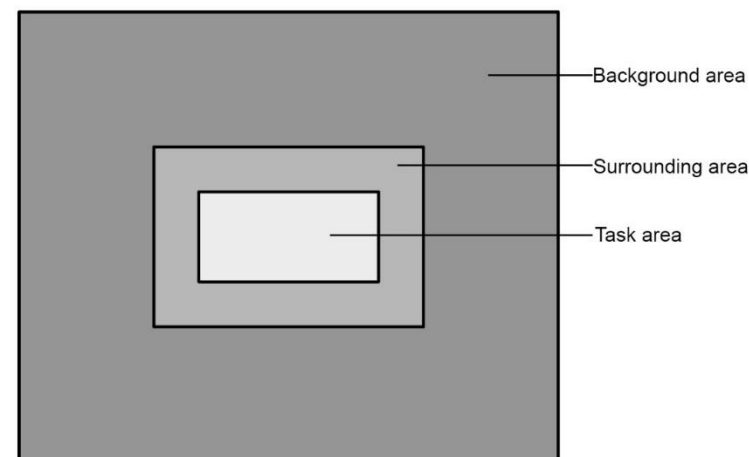
Determination of installed power

- Maintained illuminance and uniformity requirements by the European Lighting Standard EN12464-1
- Simulation software, i.e. DIALux Evo, Relux or Radiance, capable of calculating illuminance levels using luminaires data from digital and online catalogues
- Task of the lighting designer: test three different types of luminaires and choose the one that permit to the required maintained illuminance and uniformity with the smallest installed power and power density.

Calculation areas and simulation grid

Illuminance and uniformity on

- Task area
- Immediate surrounding (0.5m wide)
- Background area (3m wide or up to room walls)
- Simulation grid h 0.80m – 0.25m-0.5m



Reflectance coefficient

Interior surface	Reflectance coefficient
Walls	0.5-0.8
Floor	0.2-0.4
Ceiling	0.7-0.9

Maintenance factor

Environment	Maintenance factor
Clean environment	0.7
Mean environment	0.6
Dirty environment	0.5

LED luminaires 0.8 is recommended

$$MF = LLMF \cdot LSF \cdot LMF \cdot RMF$$

MF: Maintenance Factor LLMF: Lamp Lumen Maintenance Factor LSF: Lamp Survival Factor
LMF: Luminaire Maintenance Factor RMF: Room Maintenance Factor



Determination of annual energy consumption

Residential premises (not possible to foresee the use - design not by standards)

- Formula
- Tabulated values of the typical use of buildings and formula

Other type of buildings offices - educational – commercial (design by standards)

- Simulations
- Switch on/off occupancy controls
- Dimmable daylight controls
- Lighting zones

Annual daylight simulation software

- IDA-ICE (simplified daylight simulations)
- Radiance/Daysim (accurate ray tracing)
- Daylight Autonomy (DA)
- Continuous Daylight Autonomy (CDA)
- Statistical climate data (weather file)
- Simulation grid
- Interior finishing reflectance
- Windows properties
- Exterior objects reflectance
- Occupancy schedules
- Lamps characteristics (i.e. standby power)
- Lighting controls
- Lighting groups



Determinantion of annual energy consumption

Lighting controls

	Control	Comment	Simulation software
1	Setpoints AND Schedule	Control that uses the lighting setpoint (lx) and the occupancy schedule selected.	IDA-ICE
2	Manual On/Off Switch	Control that mimics the behavior of occupants in switching off the light when there is enough daylight illuminance on the desktop.	Radiance/Daysim
3	Switch Off with Occupancy	Control that mimics the behavior of occupants in switching off the light when there is enough daylight illuminance on the desktop and makes sure that occupants do not leave the light on at night when they are not in the room.	
4	Photosensor Controlled Dimming	Control that uses a continuous dimming sensor in relation to the available daylight.	
5	Dimming with Occupancy Off Sensor	Control that uses a continuous dimming sensor in relation to the available daylight and that makes sure that occupants do not leave the light on at night when they are not in the room.	

Settings are required for the daylight and electric light simulation:

- Sensor nodes to be located in the center of the task areas (Radiance/Daysim)
- Installed Power (W) (IDA-ICE and Radiance/Daysim)
- Lighting Setpoint / Required illuminance (lx) (IDA-ICE and Radiance/Daysim)
- Ballast Loss Factor (%) (in case of dimmable luminaires) (Radiance/Daysim)
- Standby Power (W) (in case of dimmable luminaires) (Radiance/Daysim)

Lighting groups (only Radiance/Daysim)

- Different daylight zones
- Large rooms
- Significant difference of daylight
- One sensor each group of luminaires
- Different controls

Office electric light survey

Room size 3m x 4.5m - Height 2.8m

Window size of 2m x 1.5m oriented toward south

Window to Wall Ratio is 37%

Location: Tallinn

Electric lighting plan and annual energy consumption
European Lighting Standard EN12464-1

Task area average maintained illuminance (lx) = 500

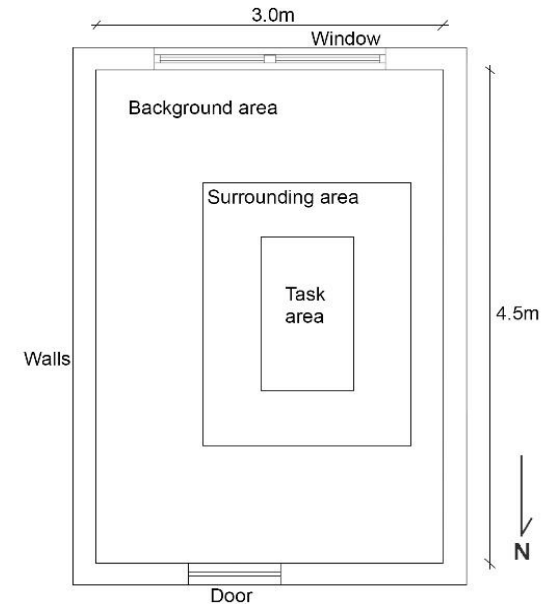
Task area uniformity = 0.6

Surrounding area average maintained illuminance (lx) = 300

Surrounding area uniformity = 0.4

Background area average maintained illuminance (lx) = 100

Background area uniformity = 0.1



Office room plan with indication of calculation areas.

- Option 1 – Suspended TL5 fluorescent lamps 38W x 4 (tot installed power 152W) without occupancy control and with daylight manual control.
- Option 2 – Ceiling recessed high efficiency LED luminaires 41W x 3 (tot installed power 123W) with occupancy control and with daylight manual control.
- Option 3 – Ceiling mounted high efficiency dimmable LED luminaires 47.5W x 2 (tot installed power 95W) with occupancy control and with daylight photosensor dimming control.

Lighting groups option - One lighting group all the room

Options	Power density (W/m ²)	Average Illuminance (lx)	Uniformity (U ₀)	Control type	Annual electric consumption (kWh/m ² y)
Tabulated value	12.0	-	-	-	18.91
1	11.2 (-6.7%)	531	0.96	Manual On/Off Switch	7.36 (-61.1%)
2	9.1 (-24.2%)	523	0.96	Switch Off with Occupancy	4.10 (-78.3%)
3	7.04 (-41.3%)	512	0.94	Dimming with Occupancy Off Sensor	2.49 (-86.8%)

Office electric light survey



ELECTRIC LIGHT CONSUMPTION SURVEY FORM					
BUILDING DATA					
Address					
Type of building	Office				
Tot. floor area					
ROOM DATA					
Room type	Single office				
Tot. floor area of the room type into the building					
Lighting description		Ceiling mounted high efficiency dimmable LED luminaire 47.5W x 2			
Total installed power (W)		95			
Luminaire used		Philips SlimBlend Rectangular SP402P LED50S/830			
Luminaire data		Lighting maintenance factor	Ballast loss factor (%)	Maximum dimming level (%)	
		0.8	0	1	
Room use		d/7d	h/24h	h	
		5	8	9-17	
Data		Floor area (m ²)	Calc. areas height (m)	Reflection coefficient surfaces (%)	
				Walls	Ceiling
Room name: Office 1		13.5	0.80	50	70
				20	
SIMULATION SOFTWARE					
Electric light plan		DIALux Evo			
Daylight simulations and electric light calculations		Radiance/Daysim			
Date		Name (operator)		Signature (operator)	
ELECTRIC LIGHT PLAN CALCULATION					
Power density (W/m ²)		7.04			
		Task area	Surrounding area	Background area	
Average Illuminance (lx)		512 (≥500)	421 (≥300)	238 (≥100)	
Uniformity (U ₀)		0.94 (≥0.6)	0.80 (≥0.4)	0.45 (≥0.1)	
GRAPHICS					
Values in lx					

DAYLIGHT AND ELECTRIC LIGHT SIMULATION SETTINGS	
Occupancy schedule	Weekdays 09-17
Control type	Dimming with Occupancy Off Sensor
Window glass Visible Transmittance (%)	70
Grid size (m)	0.25
DAYLIGHT PARAMETER AND SIMULATION RESULTS (for Radiance/Daysim only)	
Radiance Ambient Bounces parameter (-ab)	4
Mean Daylight Autonomy (%)	57
Mean Continuous Daylight Autonomy (%)	73
GRAPHICS	
Continuous Daylight Autonomy (500 lx) Mean Continuous Daylight Autonomy = 73% of occupied time	
ELECTRIC LIGHT CONSUMPTION RESULTS	
Annual electric consumption (kWh/m ² ·y)	2.49
Date	Name
	Signature

Open office electric light survey

Room size 12m x 6m - Height 2.8m

Windows size of 2m x 1.35m oriented toward south

Window to Wall Ratio is 32%

Location: Tallinn

Electric lighting plan and annual energy consumption

European Lighting Standard EN12464-1

Task area average maintained illuminance (lx) = 500

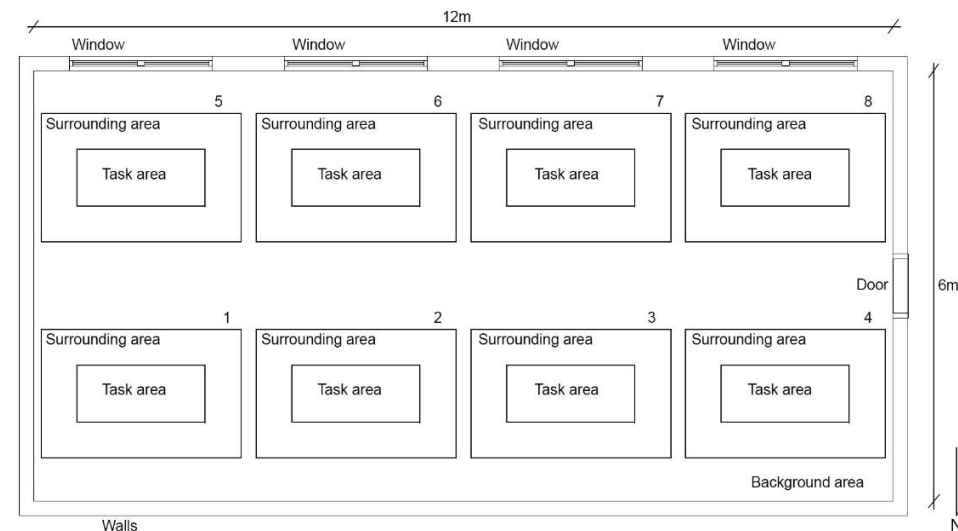
Task area uniformity = 0.6

Surrounding area average maintained illuminance (lx) = 300

Surrounding area uniformity = 0.4

Background area average maintained illuminance (lx) = 100

Background area uniformity = 0.1



Open office room plan with indication of calculation areas.

- Option 1 – Ceiling mounted TL5 fluorescent lamps 100W x 8 (tot installed power 800W) without occupancy control and with daylight manual control.
- Option 2 – Ceiling recessed high efficiency LED luminaires 41W x 16 (tot installed power 656W) with occupancy control and with daylight manual control.
- Option 3 – Ceiling mounted high efficiency dimmable LED luminaires 24.5W x 16 (tot installed power 392W) with occupancy control and with daylight photosensor dimming control.

Lighting groups option 1 - One lighting group all the room

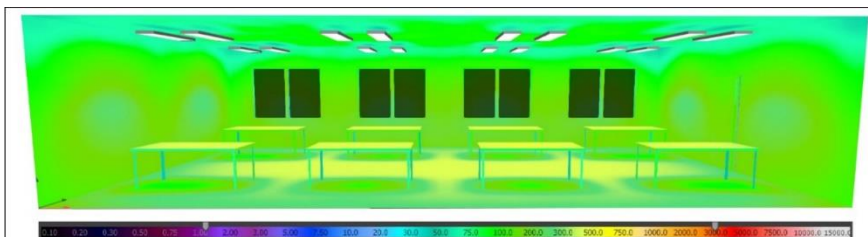
Lighting groups option 2 - Two lighting groups for the two rows of desks

Options	Power density (W/m ²)	Average (Min) Illuminance (lx)	Uniformity (U ₀)	Control type	Lighting groups	Annual electric consumption (kWh/m ² y)
Tab. value	12.0	-	-	-	-	18.91
1	11.1 (-7.5%)	509	0.83	Manual On/Off Switch	1-2	10.25/8.23 (-45.8%/-56.5%)
2	9.11 (-24.1%)	519	0.86	Switch Off with Occupancy	1-2	6.26/5.04 (-66.9%/-73.3%)
3	5.44 (-54.7%)	505	0.86	Dimming with Occupancy Off Sensor	1-2	3.06/2.37 (-83.8%/-87.5%)

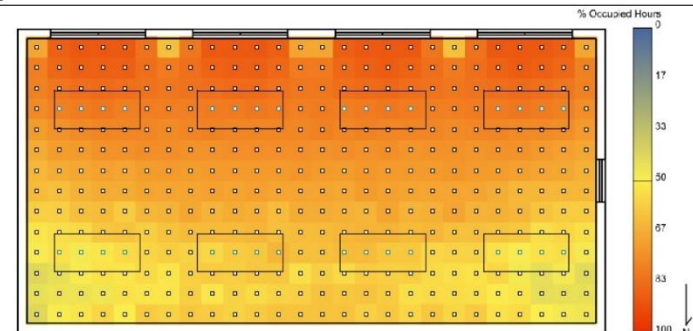
Open office electric light survey



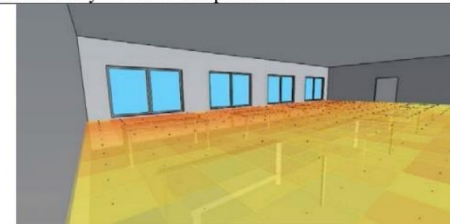
ELECTRIC LIGHT CONSUMPTION SURVEY FORM					
BUILDING DATA					
Address					
Type of building Office					
Tot. floor area					
ROOM DATA					
Room type Open office					
Tot. floor area of the room type into the building					
Lighting description Ceiling mounted high efficiency dimmable LED luminaires 24.5W x 16					
Total installed power (W) 392					
Luminaire used Philips SlimBlend Rectangular SP400P LED50S/830					
Luminaire data					
Lighting maintenance factor		Ballast loss factor (%)		Maximum dimming level (%)	
0.8		0		1	
Room use					
d/7d		h/24h		h	
5		8		9-17	
Data					
Floor area (m ²)		Calc. areas height (m)		Reflection coefficient surfaces (%)	
72		0.80		Walls Ceiling Floor	
Room name: Office 1		72		0.80 50 70 20	
SIMULATION SOFTWARE					
Electric light plan DIALux Evo					
Daylight simulations and electric light calculations Radiance/Daysim					
Date					
Name (operator)				Signature (operator)	
ELECTRIC LIGHT PLAN CALCULATION					
Power density (W/m ²) 5.44					
Area					
Task area		Surrounding area		Background area	
≥500/≥0.6		≥300/≥0.4		≥100/≥0.1	
1 - Average Illuminance (lx) / Uniformity (U ₀) 505/0.86 382/0.66 231/0.51					
2 - Average Illuminance (lx) / Uniformity (U ₀) 533/0.93 477/0.80 448/0.52					
3 - Average Illuminance (lx) / Uniformity (U ₀) 594/0.92 514/0.79 445/0.52					
4 - Average Illuminance (lx) / Uniformity (U ₀) 507/0.84 434/0.63 452/0.51					
5 - Average Illuminance (lx) / Uniformity (U ₀) 559/0.86 474/0.65 449/0.51					
6 - Average Illuminance (lx) / Uniformity (U ₀) 584/0.94 515/0.81 445/0.52					
7 - Average Illuminance (lx) / Uniformity (U ₀) 587/0.93 517/0.80 445/0.52					
8 - Average Illuminance (lx) / Uniformity (U ₀) 553/0.84 467/0.62 449/0.51					
GRAPHICS					
Values in lx					



Values in lx	
DAYLIGHT AND ELECTRIC LIGHT SIMULATION SETTINGS	
Occupancy schedule	Weekdays 09-17
Control type	Dimming with Occupancy Off Sensor
Window glass Visible Transmittance (%)	70
Grid size (m)	0.5
DAYLIGHT PARAMETER AND SIMULATION RESULTS (for Radiance/Daysim only)	
Lighting zones	2
Radiance Ambient Bounces parameter (-ab)	4
Mean Daylight Autonomy (%)	50
Mean Continuous Daylight Autonomy (%)	68
GRAPHICS	



Continuous Daylight Autonomy (500 lx)
Mean Continuous Daylight Autonomy = 68% of occupied time



ELECTRIC LIGHT CONSUMPTION RESULTS		
Annual electric consumption (kWh/m ² y)	2.37	
Date	Name	Signature

Class room electric light survey

Room size 9m x 8m - Height 2.8m

Windows size of 2.4m x 1m oriented toward south

Window to Wall Ratio is 38%

Location: Tallinn

Electric lighting plan and annual energy consumption
European Lighting Standard EN12464-1

Task area average maintained illuminance (lx) = 300

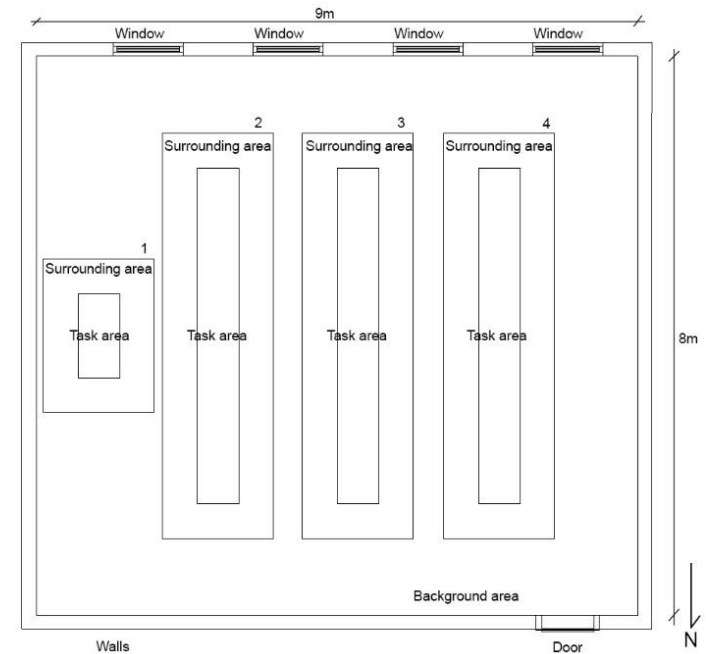
Task area uniformity = 0.6

Surrounding area average maintained illuminance (lx) = 200

Surrounding area uniformity = 0.4

Background area average maintained illuminance (lx) = 66.7

Background area uniformity = 0.1



Class room plan with indication of calculation areas.

- Option 1 – Ceiling mounted TL5 fluorescent lamps 29W x 10 (tot installed power 290W) without occupancy control and with daylight manual control.
- Option 2 – Ceiling mounted high efficiency LED lamps 24.5W x 7 (tot installed power 171.5W) with occupancy control and with daylight manual control.
- Option 3 – Suspended high efficiency dimmable LED lamps 21.5W x 7 (tot installed power 150.5W) with occupancy control and with daylight photosensor dimming control.

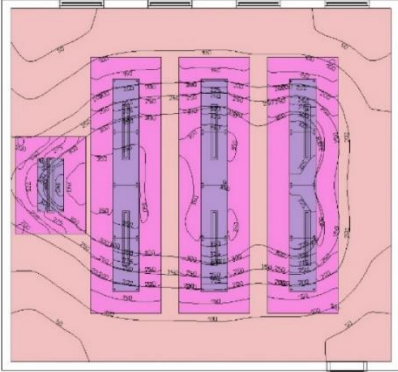
Lighting groups option 1 - One lighting group all the room

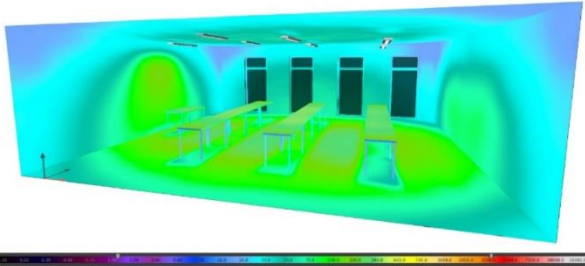
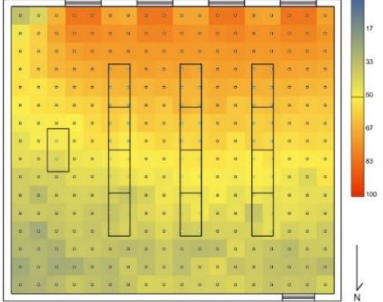
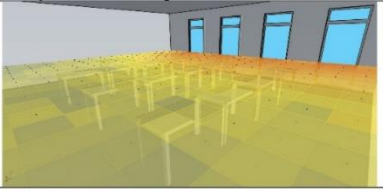
Lighting groups option 2 - Three lighting groups (desks close the windows, teacher desk, desks far from the windows)

Options	Power density (W/m ²)	Average (Min) Illuminance (lx)	Uniformity (U ₀)	Control type	Lighting groups	Annual electric consumption (kWh/m ² y)
Tab. value	15	-	-	-	-	15.64
1	4.03 (-73.1%)	318	0.85	Manual On/Off Switch	1	6.17 (-60.5%)
2	2.38 (-84.1%)	319	0.66	Switch Off with Occupancy	1	3.71 (-76.3%)
3	2.09 (-86.1%)	300	0.62	Dimming with Occupancy Off Sensor	1/3	2.22/1.99 (-85.8%/-87.3%)

Class room electric light survey



ELECTRIC LIGHT CONSUMPTION SURVEY FORM					
BUILDING DATA					
Address					
Type of building					
Tot. floor area					
ROOM DATA					
Room type					
Tot. floor area of the room					
type into the building					
Lighting description					
Total installed power (W)					
Luminaire used					
Luminaire data					
Lighting maintenance factor		Ballast loss factor (%)		Maximum dimming level (%)	
0.8		0		1	
Room use		d/7d		h/24h	
5		8		8-16	
Data					
Floor area (m ²)		Calc. areas height (m)		Reflection coefficient surfaces (%)	
Room name: Office 1		72		0.80	
		50		70	
				20	
SIMULATION SOFTWARE					
Electric light plan					
Daylight simulations and electric light calculations					
Date					
Name (operator)					
Signature (operator)					
ELECTRIC LIGHT PLAN CALCULATION					
Power density (W/m ²)					
Area					
Task area		Surrounding area		Background area	
≥300/≥0.6		≥200/≥0.4		≥66.7/≥0.1	
1 - Average Illuminance (lx) / Uniformity (U ₀)		321/0.90		286/0.68	
2 - Average Illuminance (lx) / Uniformity (U ₀)		308/0.60		263/0.40	
3 - Average Illuminance (lx) / Uniformity (U ₀)		326/0.64		276/0.46	
4 - Average Illuminance (lx) / Uniformity (U ₀)		300/0.62		245/0.40	
180/0.17					
173/0.17					
170/0.18					
178/0.17					
GRAPHICS					
					
Values in lx					

	
Values in lx	
DAYLIGHT AND ELECTRIC LIGHT SIMULATION SETTINGS	
Occupancy schedule	Weekdays 08-16
Control type	Dimming with Occupancy Off Sensor
Window glass Visible Transmittance (%)	70
Grid size (m)	0.5
DAYLIGHT PARAMETER AND SIMULATION RESULTS (for Radiance/Daysim only)	
Lighting zones	3
Radiance Ambient Bounces parameter (-ab)	4
Mean Daylight Autonomy (%)	34
Mean Continuous Daylight Autonomy (%)	52
GRAPHICS	
	
Continuous Daylight Autonomy (500 lx)	
Mean Continuous Daylight Autonomy = 52% of occupied time	
	
ELECTRIC LIGHT CONSUMPTION RESULTS	
Annual electric consumption (kWh/m ² y)	1.99
Date	Name
Signature	



Commercial room electric light survey

Room size 30m x 15m and 15m x 5m - Height of 4m

Window size of 15m x 2.5m oriented toward south

Window to Wall Ratio is 38%

Location: Tallinn

Electric lighting plan and annual energy consumption

European Lighting Standard EN12464-1

Task area average maintained illuminance (lx) = 500 (area 1) 300 (area 2)

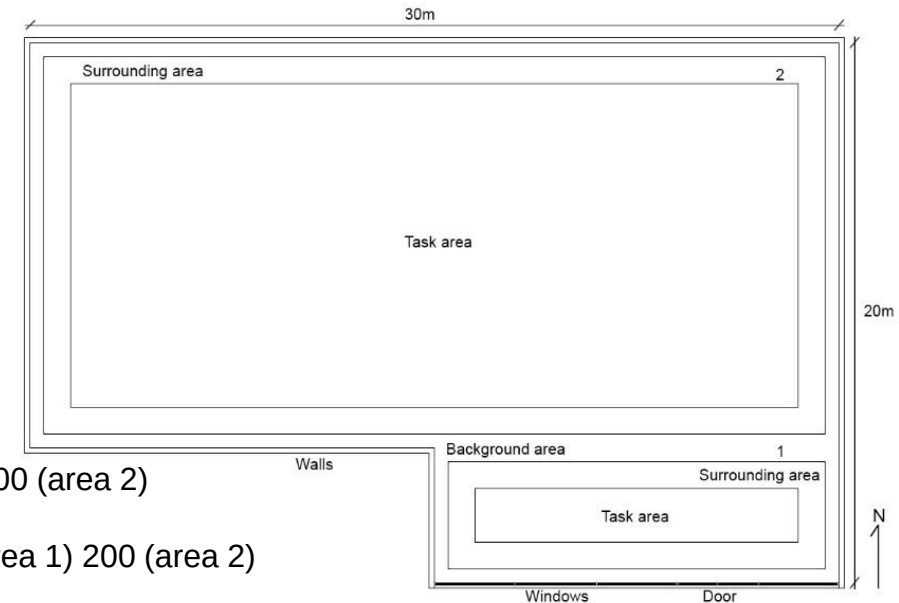
Task area uniformity = 0.6

Surrounding area average maintained illuminance (lx) = 300 (area 1) 200 (area 2)

Surrounding area uniformity = 0.4

Background area average maintained illuminance (lx) = 100 (area 1) 66.7 (area2)

Background area uniformity = 0.1



Commercial room plan with indication of calculation areas.

- Option 1 – Ceiling mounted TL5 fluorescent lamps 110W x 32 (tot installed power 3520W) without occupancy control and with daylight manual control.
- Option 2 – Ceiling recessed high efficiency LED lamps 41W x 68 (tot installed power 2788W) without occupancy control and with daylight manual control.
- Option 3 – Suspended high efficiency dimmable LED lamps 24.5W x 69 (tot installed power 1690.5W) without occupancy control and with daylight photosensor dimming control.

Lighting groups option – Two lighting groups one for the till area and one for the sales area (two different illuminance levels)

Options	Power density (W/m ²)	Average Illuminance (lx)	Uniformity (U ₀)	Control type	Lighting groups	Annual electric consumption (kWh/m ² y)
Tab. value	20	-	-	-	-	56.18
1	6.70 (-66.5%)	569-334	0.73-0.66	Manual On/Off Switch	2	31.7 (-43.6%)
2	5.31 (-73.45%)	543-349	0.73-0.52	Manual On/Off Switch	2	25.6 (-54.4%)
3	3.22 (-83.9%)	501-330	0.71-0.66	Photosensor Controlled Dimming	2	15.62 (-72.2%)

Commercial room electric light survey



ELECTRIC LIGHT CONSUMPTION SURVEY FORM					
BUILDING DATA					
Address					
Type of building					
Tot. floor area					
ROOM DATA					
Room type					
Tot. floor area of the room type into the building					
Lighting description					
Total installed power (W)					
Luminaire used					
Luminaire data					
Lighting maintenance factor		Ballast loss factor (%)		Maximum dimming level (%)	
0.8		0		1	
Room use		h/24h		h	
7		14		9-23	
Data					
Floor area (m ²)		Calc. areas height (m)		Reflection coefficient surfaces (%)	
Room name: Office 1		525		0.80	
		Walls		Ceiling	
		50		70	
				20	
SIMULATION SOFTWARE					
Electric light plan					
Daylight simulations and electric light calculations					
Date		Name (operator)		Signature (operator)	
ELECTRIC LIGHT PLAN CALCULATION					
Power density (W/m ²)		3.22			
Area 1 (till and wrapper tables)		Task area		Surrounding area	
		≥500/≥0.6		≥300/≥0.4	
1 - Average Illuminance (lx) / Uniformity (U ₀)		501/0.71		341/0.44	
Area 2 (sales)		Task area		Background area	
		≥300/≥0.6		≥200/≥0.4	
2 - Average Illuminance (lx) / Uniformity (U ₀)		330/0.66		202/0.55	
				389/0.57	
GRAPHICS					
Values in lx					

Values in lx	
DAYLIGHT AND ELECTRIC LIGHT SIMULATION SETTINGS	
Occupancy schedule	Whole week 09-23
Control type	Photosensor Controlled Dimming
Window glass Visible Transmittance (%)	70
Grid size (m)	1
DAYLIGHT PARAMETER AND SIMULATION RESULTS (for Radiance/Daysim only)	
Lighting zones	2
Radiance Ambient Bounces parameter (-ab)	4
Mean Daylight Autonomy (%)	6
Mean Continuous Daylight Autonomy (%)	13
GRAPHICS	
Continuous Daylight Autonomy (300/500 lx)	
Mean Continuous Daylight Autonomy = 13% of occupied time	
ELECTRIC LIGHT CONSUMPTION RESULTS	
Annual electric consumption (kWh/m ² y)	15.62
Date	Name
Signature	



Thank you.

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