Applying the New European Daylight Standard to Enhance Daylight Quality in Dense Urban Environments

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The new European Standard EN17037

Daylight

Daylight factor on reference plane

Reference plane 0.85 m above floor

Overcast sky

Method: Method 1 - D_{TM} for 95% and D_T for 50% of working area

View Out

Visual connection with the surrounding

Reference plane 1.2 m above floor (sitting height)

Method: 3 step criteria verification

- Total horizontal sight angle
- Distance of outside view
- Number of layers seen

Exposure to sunlight

Direct sunlight

Reference date: 21 March

Clear sky

Method: Simulation for sunlight duration

Glare

Protection from glare

Method: Daylight Glare Probability (DGP)

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Reference office

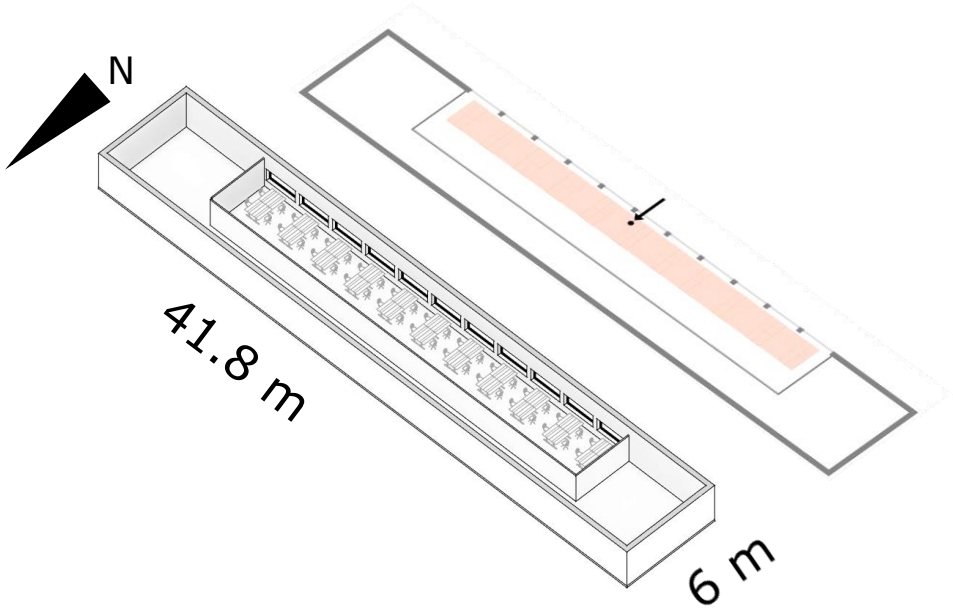
44 office work places in 2 rows parallel to window

Net area: 250 m^2

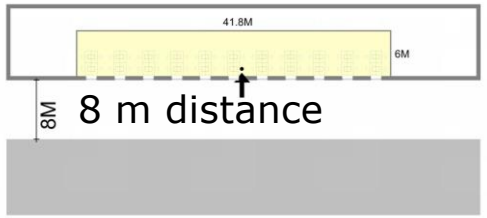
2.8 m ceiling height

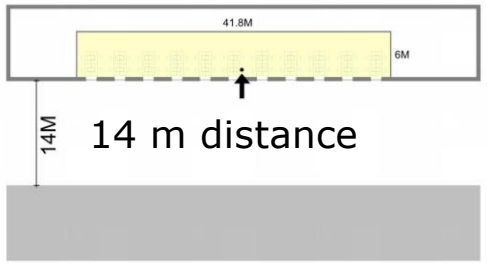
0.84 m window sill height

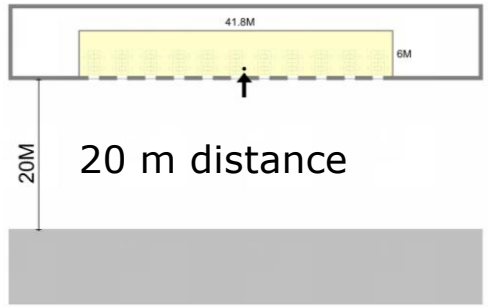
11 windows of 4.74 m^2 each (25% glazing-to-floor-area ratio), visible transmittance: 0.73



3 distance parameters

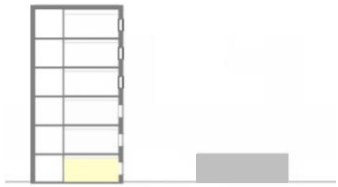




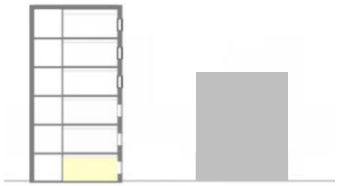


6 height parameters

1 storey

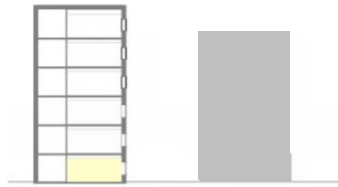


4 storeys

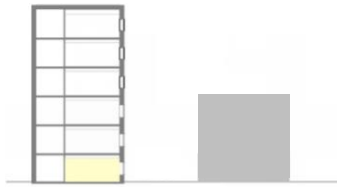


2 storeys

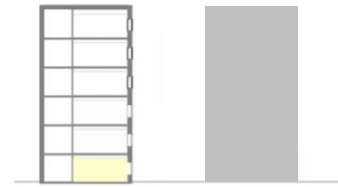
5 storeys



3 storeys



6 storeys



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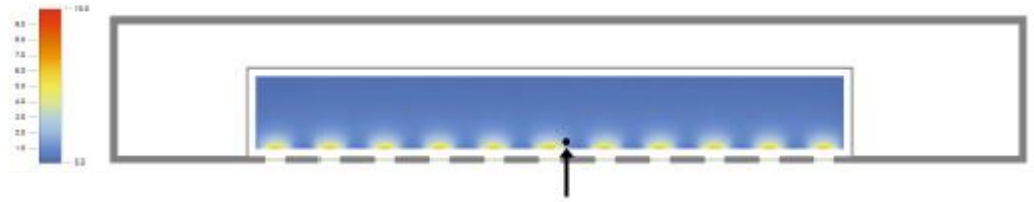
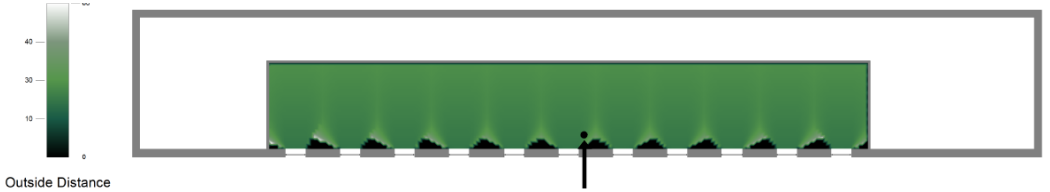
Simulation tool – Aftab Rad

- Daylight Study using Aftab Rad, a newly developed add-in for Autodesk Revit (Aftab means ”Sun” in Farsi/Persian)
- Uses Radiance and Daysim as the main daylighting simulation engine
- It can calculate: Illuminance, Luminance, Daylight Factor, Radiance or Luminance based Cumulative Sky, Sunlight Hours, Shadow Range, Exposure to Sunlight (based on EN-17037), Annual Sunlight Exposure, Dynamic Metrics such as Daylight Autonomy, Useful Daylight Illuminance, etc., by exporting a 3D model and other needed data to Daysim 3.0, View Out (based on EN-17037), Visibility Analysis, as well as Dynamo nodes for calculating all above metrics except the ones based on Daysim.

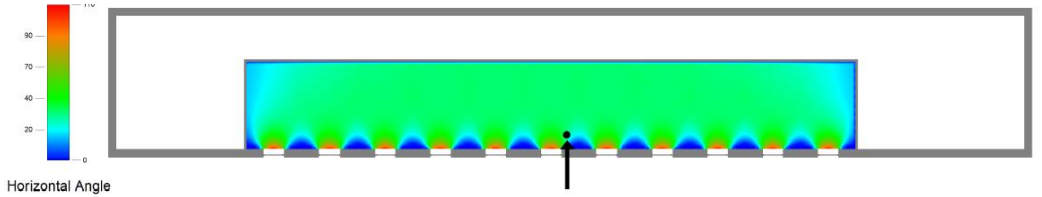
DF



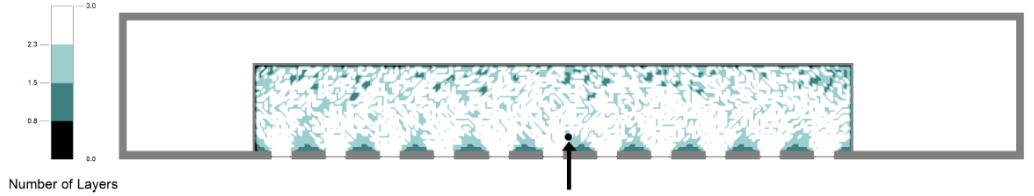
Distance of outside view



Horizontal view angle



Number of layers



Miri, M. and Ashtari, E. (2019). The Applicability of a Newly Developed Revit Add-in for Architects and Urban Designers When Doing Daylight Study from Early Stages to the End of Architectural/Urban Design. In Proceedings of Building Simulation 2019, Rome, 02-04 September 2019.

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Simulation parameters

- Location: Hamburg, Germany
- Simulation grid dimension: 0.2 m x 0.2 m
- Working plane height: 0.85 m
- Eye height for the view analysis for a seated person: 1.2 m

Surface	Light reflectance / transmittance
Ceiling	0.70
Indoor wall surfaces	0.50
Floor surfaces	0.20
Glass surfaces	0.15 / 0.73
Window sash/frame	0.70
Outdoor surroundings, trees, terrain, etc.	0.10
Surrounding buildings	0.20

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Daylight factor

		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3

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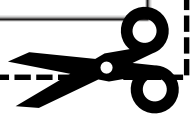
Daylight factor

		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)	≥			
View out	≥			
Horizontal Sight Angle (°)	≥			
Distance to outside (m)	L			
Number of layers				
Discomfort glare	<			
DGP_e				

Table A.1 — Recommendations of daylight provision by daylight openings in vertical and inclined surface

Level of recommendation for vertical and inclined daylight opening	Target illuminance E_T lx	Fraction of space for target level $F_{plane,\%}$	Minimum target illuminance E_{TM} lx	Fraction of space for minimum target level $F_{plane,\%}$	Fraction of daylight hours $F_{time,\%}$
Minimum	300	50 %	100	95 %	50 %
Medium	500	50 %	300	95 %	50 %
High	750	50 %	500	95 %	50 %

NOTE — Table A.3 gives target daylight factor (D_T) and minimum target daylight factor (D_{TM}) corresponding to target illuminance level and minimum target illuminance, respectively, for the CEN capital cities.



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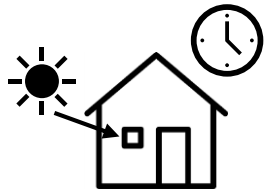
Exposure to sunlight



		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out				
	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare				
	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3

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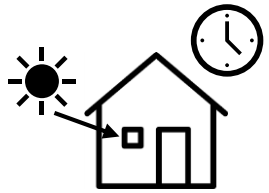
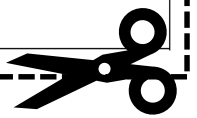
Exposure to sunlight



	MINIMUM	MEDIUM	HIGH
Daylight factor target	(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
	100% 65.9%	46%	30.7%
Exposure to sunlight (h)	≥1.5 h	≥3 h	≥4 h
	9.66	9.66	9.66
View out			
Horizontal Sight Angle (°)			
Distance to outside (m)			
Number of layers			
Discomfort glare			
DGP_e			

Table A.6 — Recommendation for daily sunlight exposure

Level of recommendation for exposure to sunlight	Sunlight exposure
Minimum	1,5 h
Medium	3,0 h
High	4,0 h



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View out

		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out				
	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare				
	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3

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View out

Table A.5 — Assessment of the view outwards from a given position

Level of recommendation for view out	Parameter [a] Horizontal sight angle	Outside distance of the view	Number of layers to be seen from at least 75 % of utilized area: - sky - landscape (urban and/or nature) - ground
Minimum	≥ 14°	≥ 6,0 m	At least landscape layer is included
Medium	≥ 28°	≥ 20,0 m	Landscape layer and one additional layer is included in the same view opening
High	≥ 54°	≥ 50,0 m	all layers are included in the same view opening

[a] For a space with room depth more than 4 m, it is recommended that the respective sum of the view opening(s) dimensions is at least 1,0 m × 1,25 m (width × height).

				GH
Daylight factor target	(D_{TM} ≥0.7) 95%			& (D_T ≥5.4) 50%
	100%			0.7%
Exposure to sunlight (h)		9.66	9.66	9.66
View out				
		≥14°	≥28°	≥54°
	Horizontal Sight Angle (°)	35.8	35.8	35.8
		≥6.0 m	≥20.0 m	≥50.0 m
	Distance to outside (m)	9.89	9.89	9.89
		Landscape layer	Landscape layer and one additional layer	All layers
	Number of layers	3	3	3
Discomfort glare				
	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3

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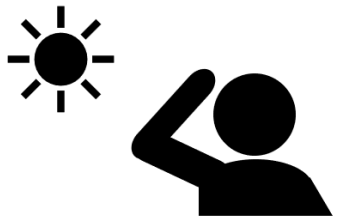

Glare

		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out				
	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare				
	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3

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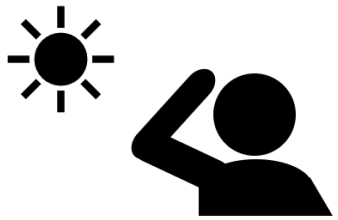
Glare



	MINIMUM	MEDIUM	HIGH
Daylight factor target	(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
	100% 65.9%	46%	30.7%
Exposure to sunlight (h)			
View out			
Horizontal Sight Angle (°)			
Distance to outside (m)			
Number of layers	3	3	3
Discomfort glare			
DGP_e	<0.45	<0.40	<0.35
	0.3	0.3	0.3

Table A.7 — Proposed different levels of threshold $DGP_e < 5\ \%$ for glare protection

Level of recommendation for glare protection	$DGP_e < 5\ \%$
Minimum	0,45
Medium	0,40
High	0,35

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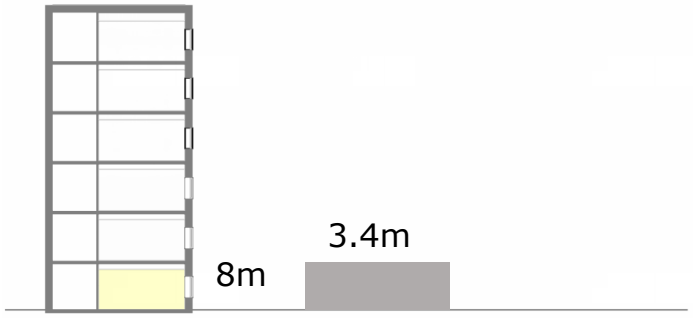
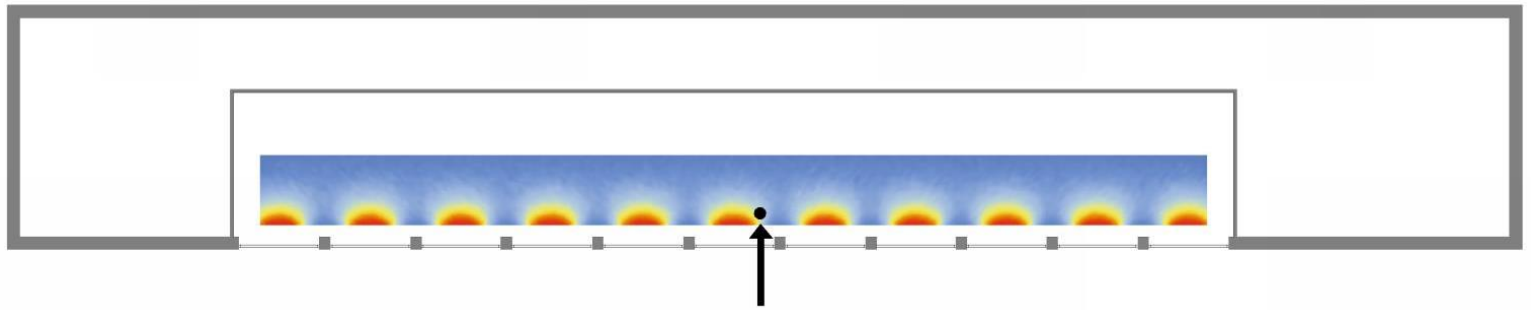
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 65.9%	46%	30.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3





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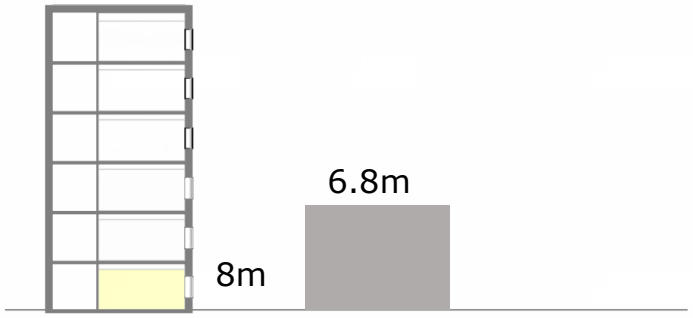
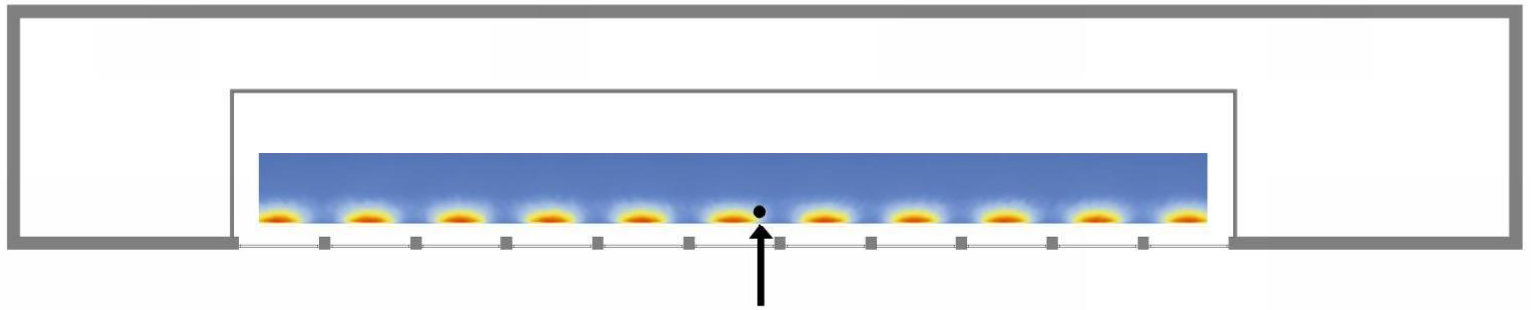
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		64.9% 37.7%	27.5%	18.7%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		0.51	0.51	0.51
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.29	0.29	0.29





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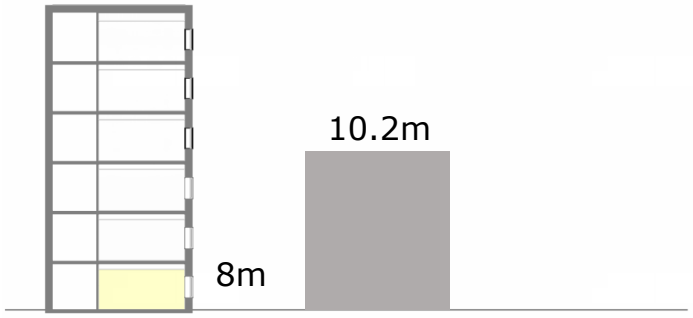
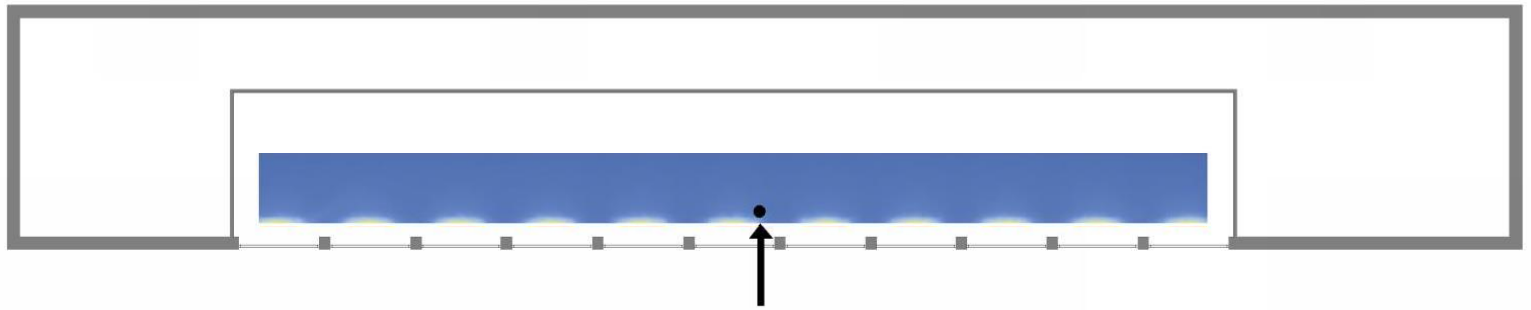
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		41.2% / 21%	14.3%	9%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		0.51	0.51	0.51
View out		≥14°	≥28°	≥54°
	Horizontal Sight Angle (°)	35.8	35.8	35.8
		≥6.0 m	≥20.0 m	≥50.0 m
	Distance to outside (m)	9.89	9.89	9.89
		Landscape layer	Landscape layer and one additional layer	All layers
	Number of layers	2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.13	0.13	0.13





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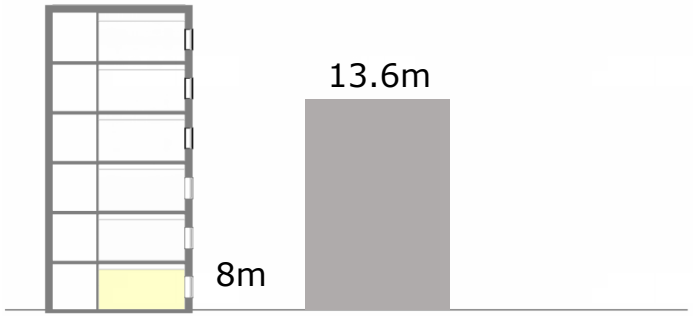
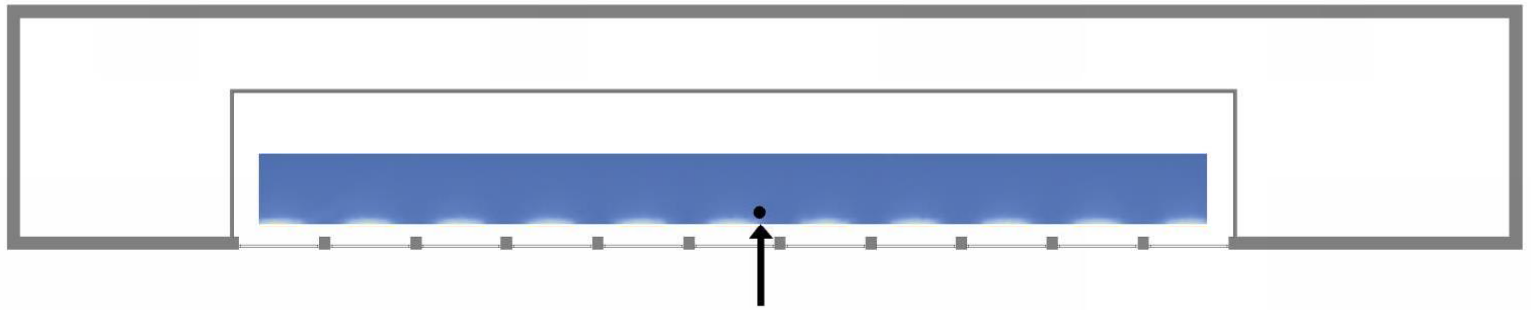
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		28.2% 10.2%	8.4%	3.9%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		0.51	0.51	0.51
View out				
	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.07	0.07	0.07





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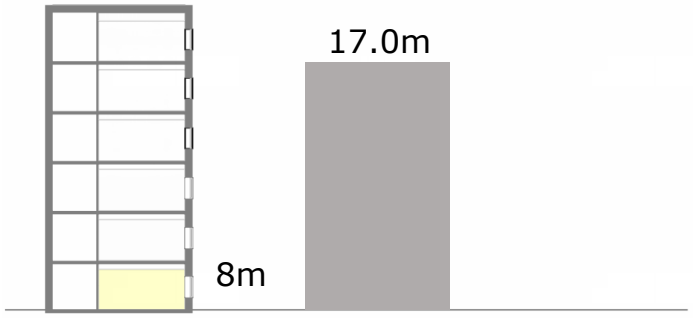
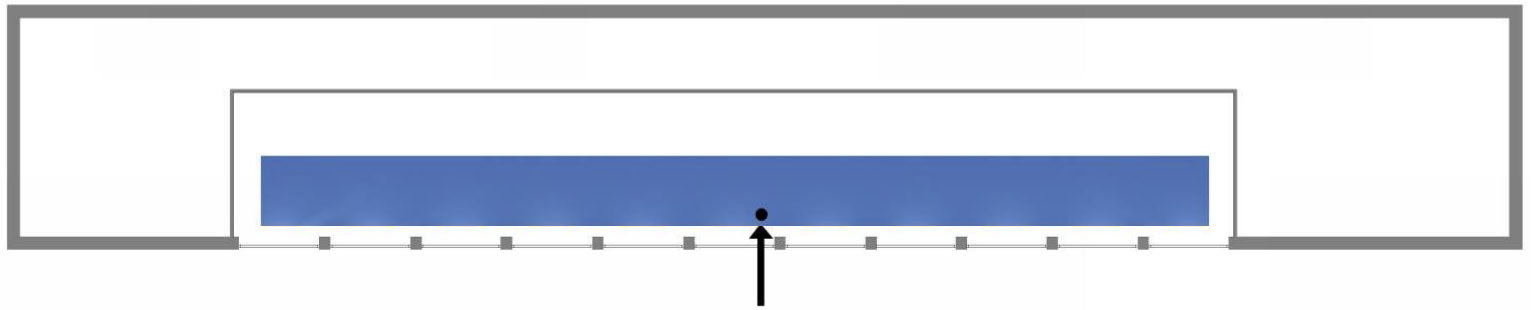
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		21.9% 5.5%	3.9%	0.1%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		0.51	0.51	0.51
View out				
	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.05	0.05	0.05





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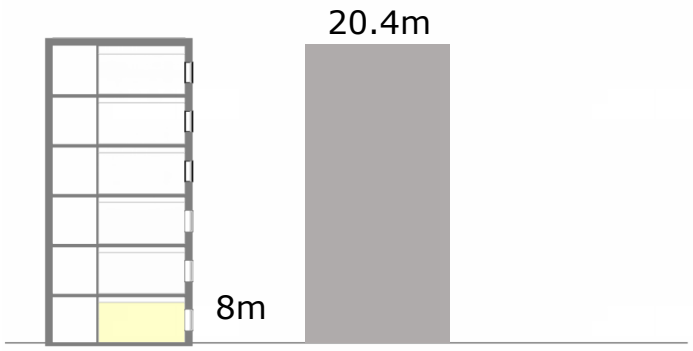
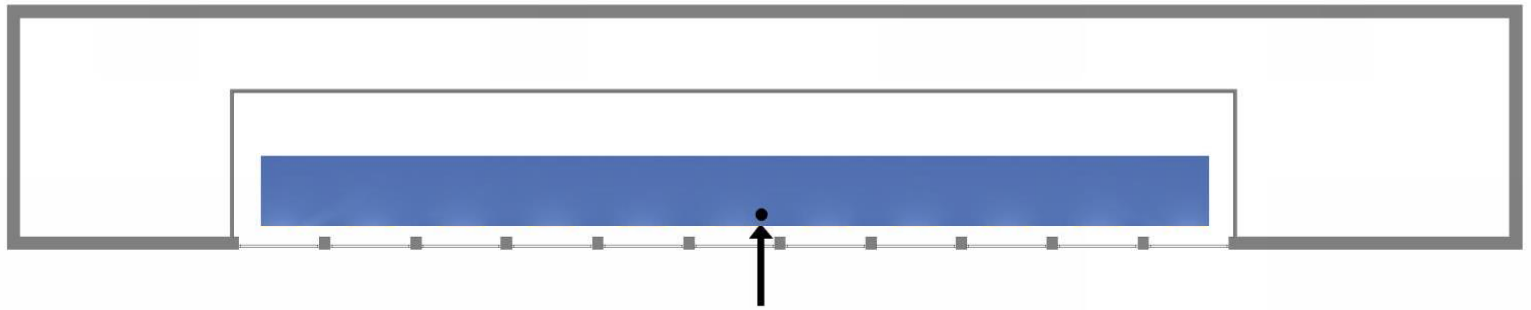
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		17.6% 3.7%	0.1%	0.1%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		0.51	0.51	0.51
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		35.8	35.8	35.8
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		9.89	9.89	9.89
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.03	0.03	0.03





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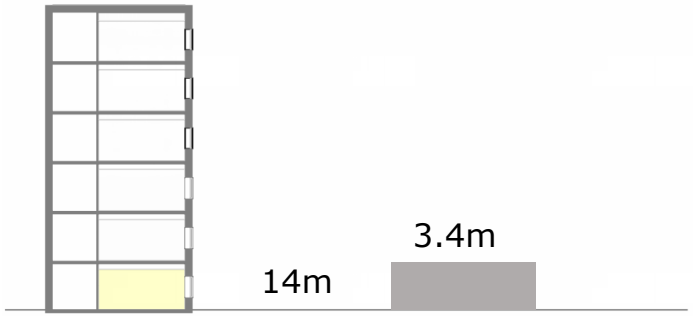
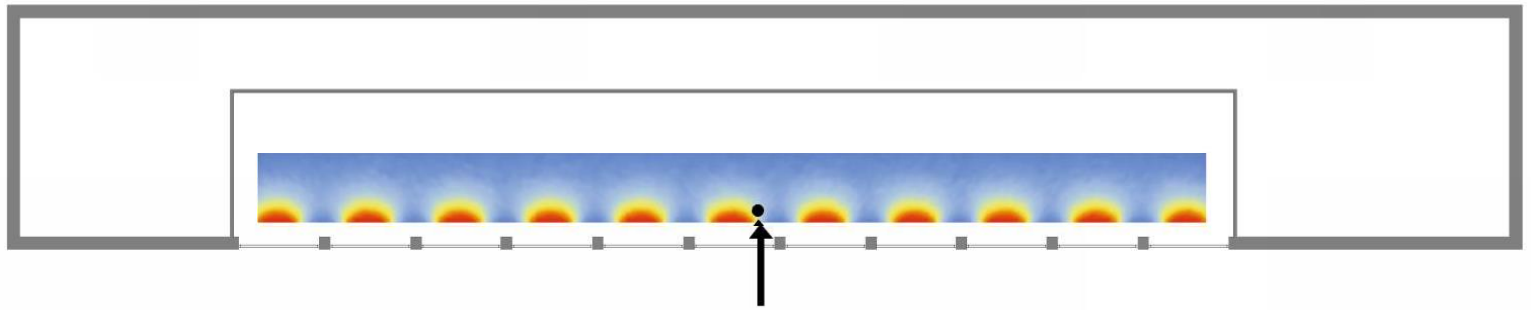
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 74.1%	50.2%	34.3%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.3	0.3	0.3





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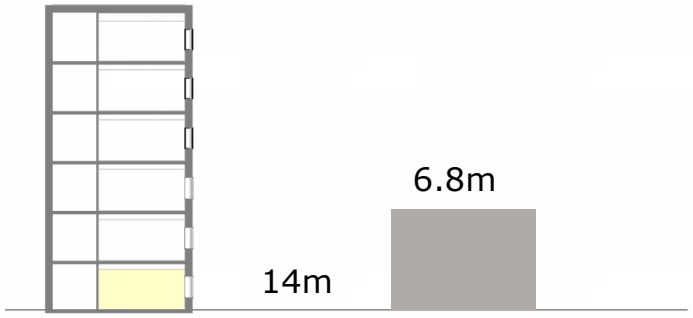
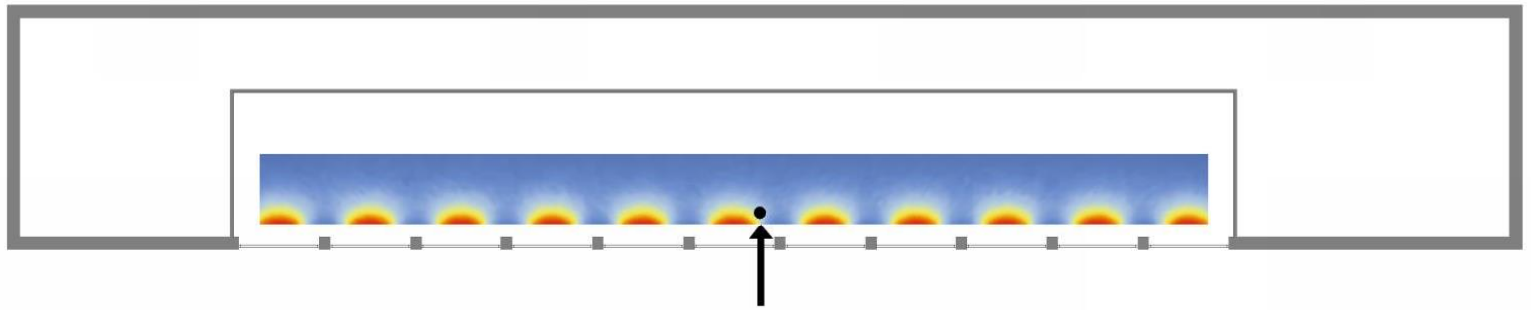
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		96.8% 56.4%	40.9%	28.6%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.29	0.29	0.29





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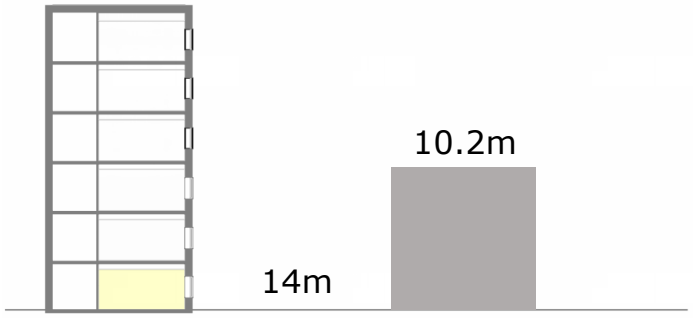
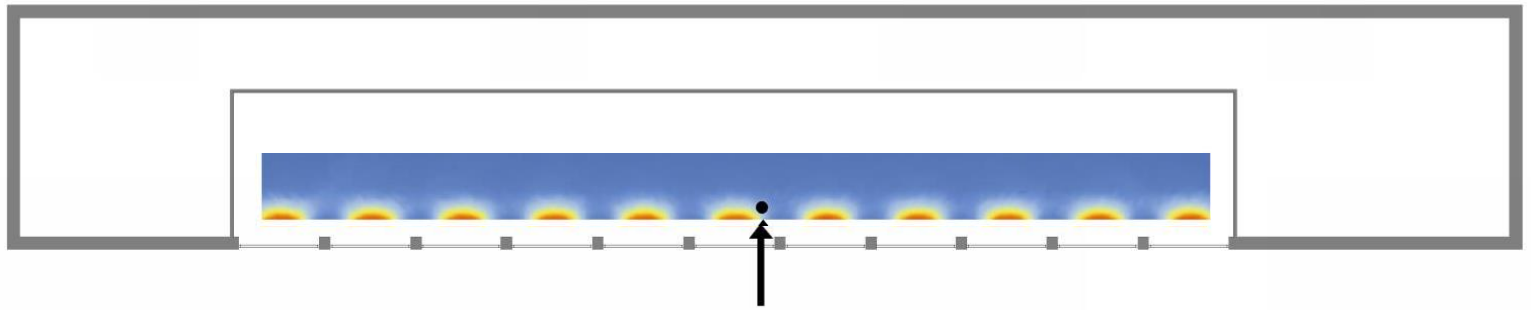
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		77.9% 38.7%	30.5%	20%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.29	0.29	0.29





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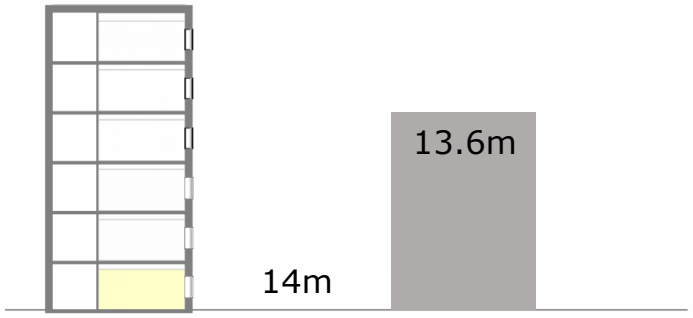
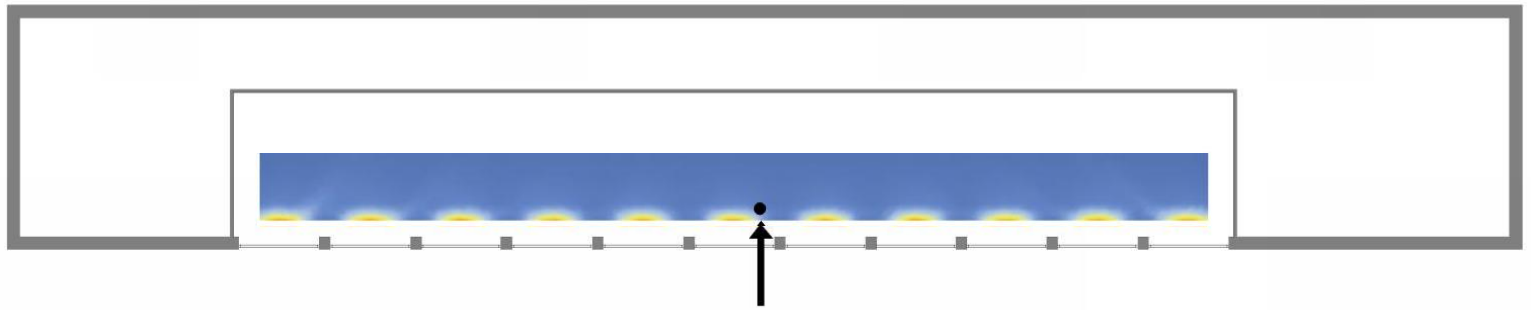
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		66.7% 27.4%	21.5%	14%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		2.01	2.01	2.01
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.18	0.18	0.18





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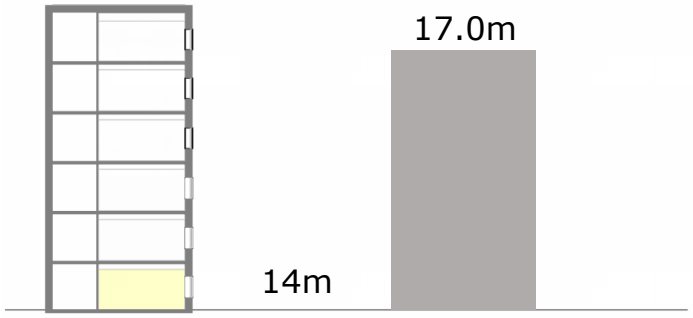
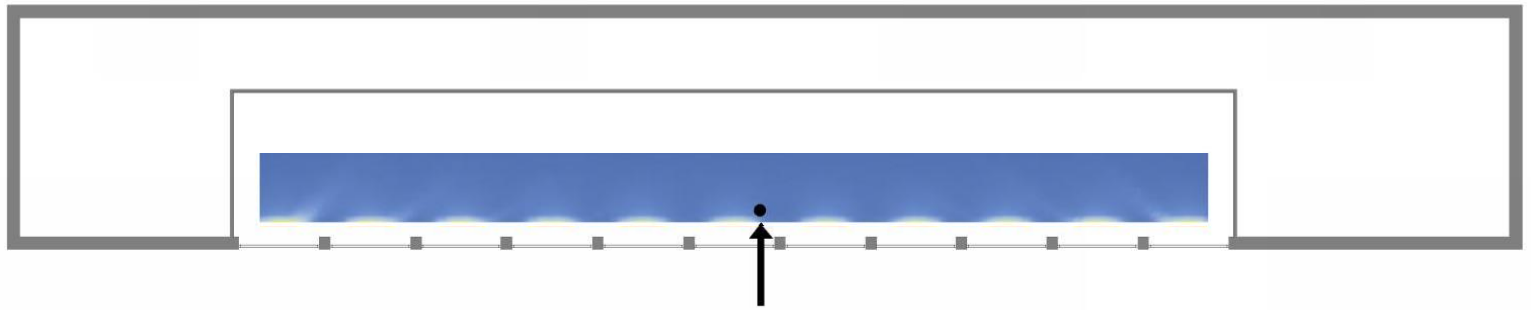
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		58.3% 2.1%	3.5%	5.3%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		2.01	2.01	2.01
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.16	0.16	0.16





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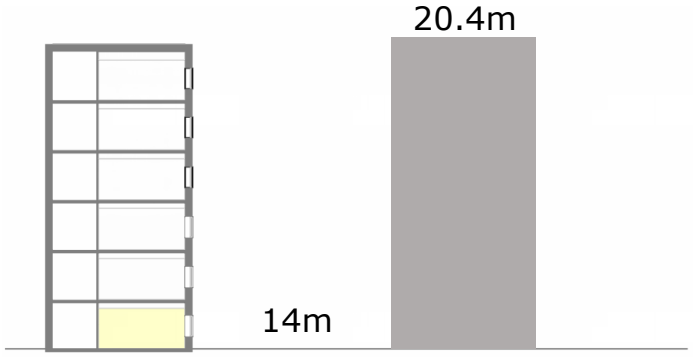
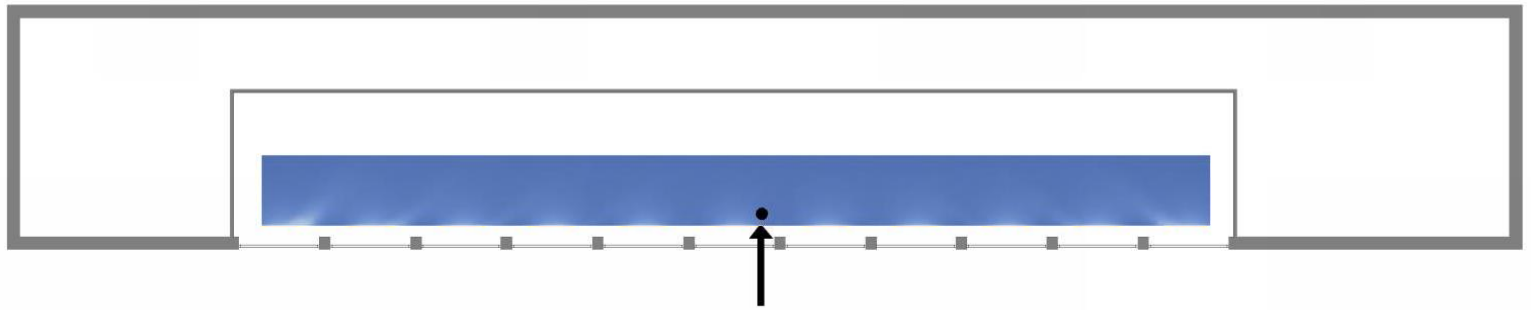
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		51.8% 16.1%	10.1%	6.9%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		2.01	2.01	2.01
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		16.64	16.64	16.64
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.13	0.13	0.13





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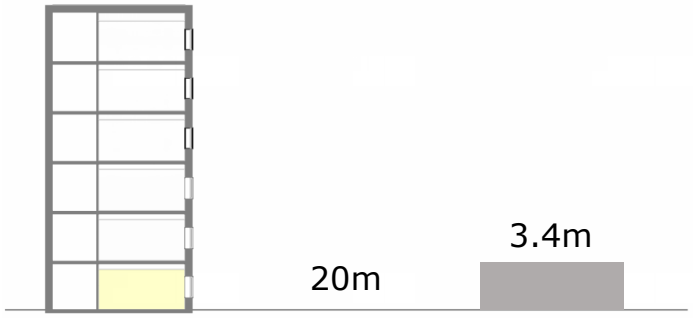
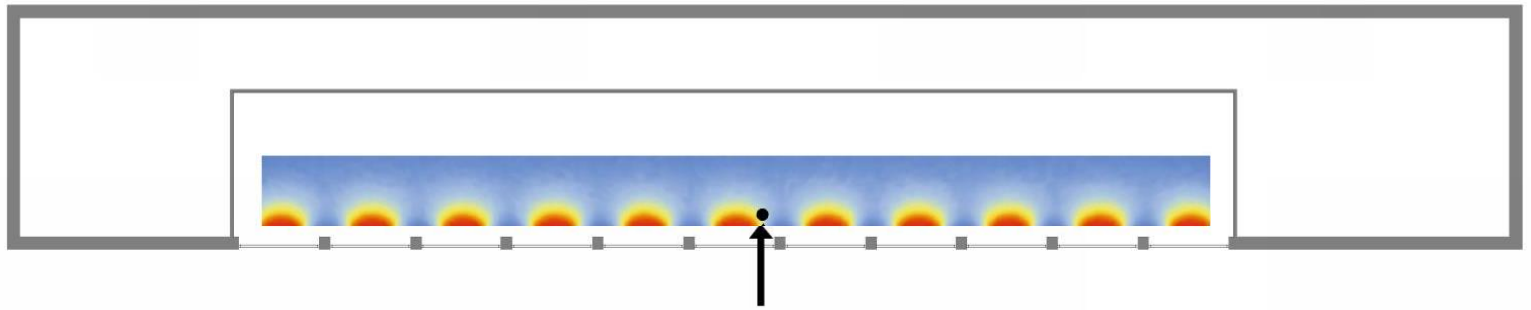
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 77.3%	52.2%	35%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.32	0.32	0.32





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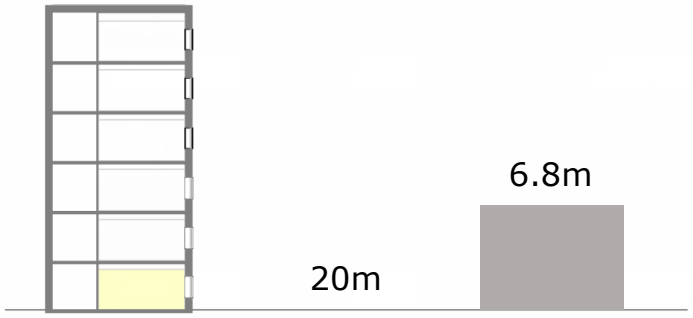
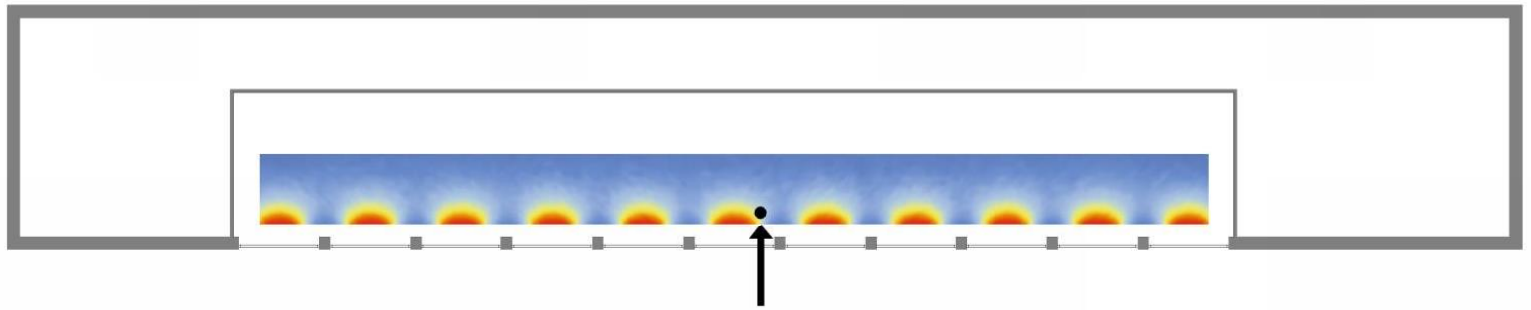
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		100% 66.6%	46.9%	31.2%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.30	0.30	0.30





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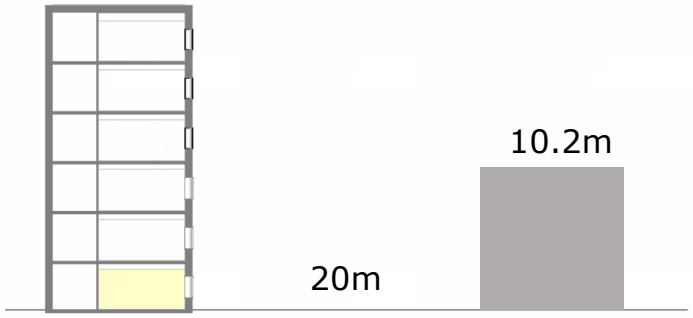
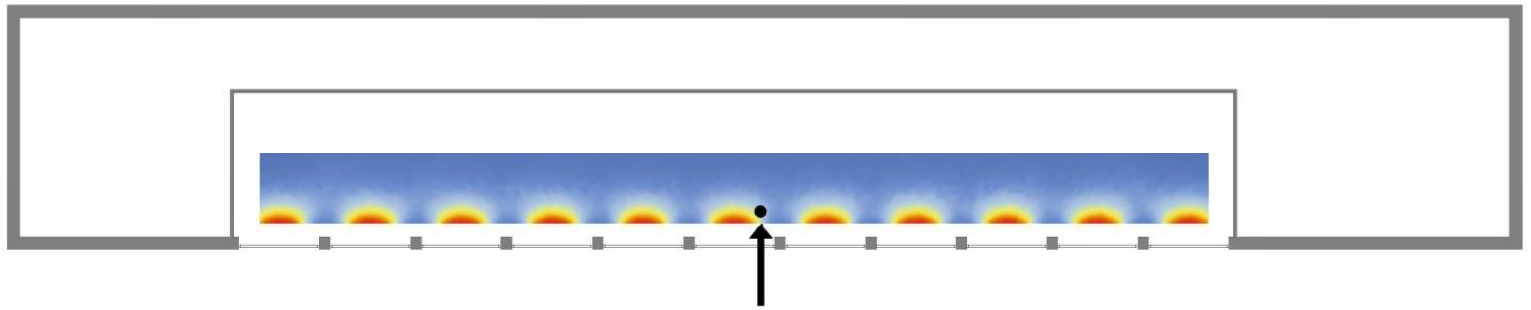
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		97.9% 53.5%	38.7%	26.5%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.29	0.29	0.29





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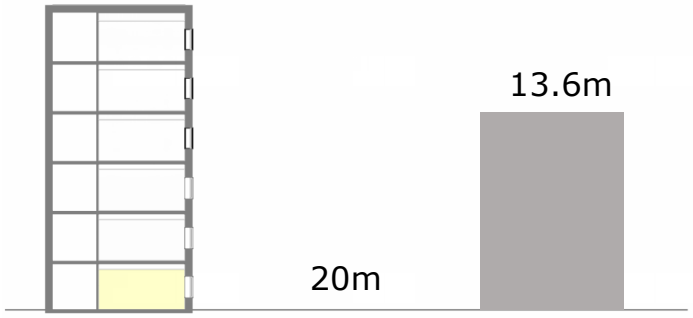
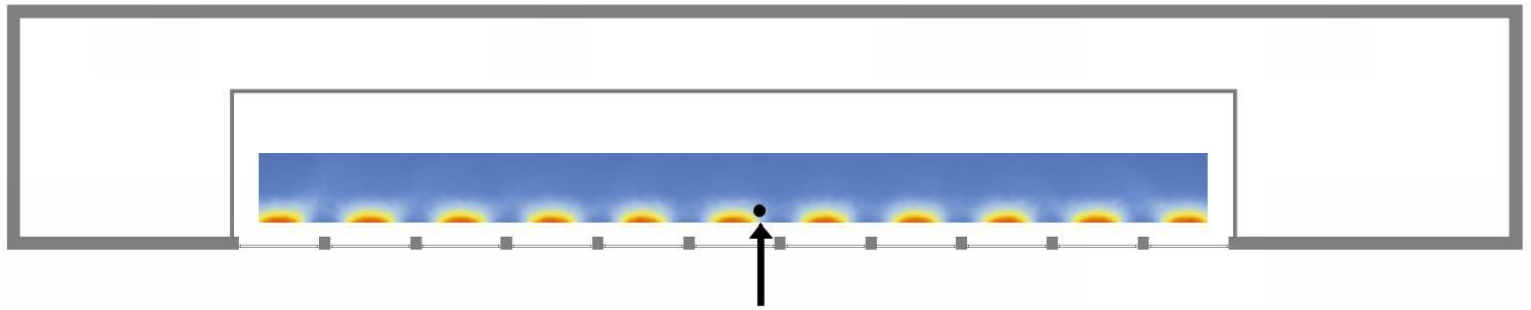
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		89.9% 42.2%	32.4%	22.3%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		9.66	9.66	9.66
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.29	0.29	0.29





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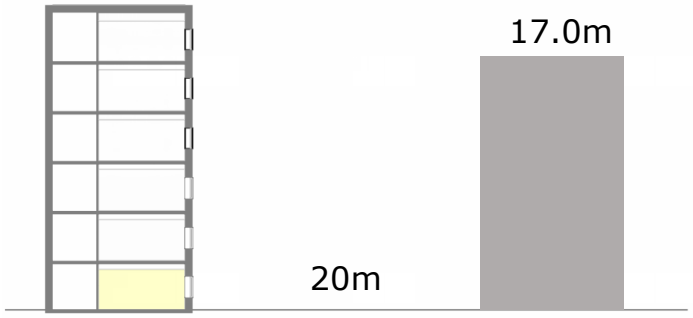
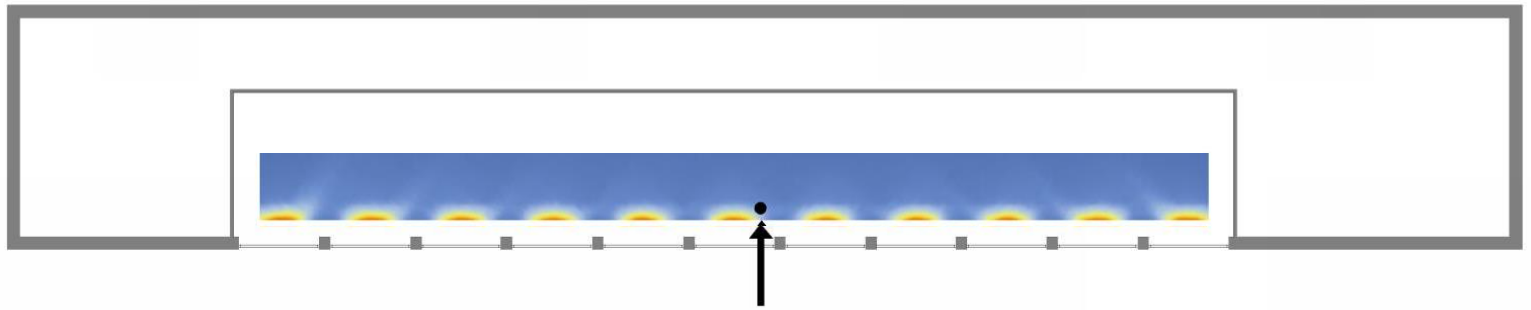
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		81.8% 32.9%	26.5%	17.9%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		3.24	3.24	3.24
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		3	3	3
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.20	0.20	0.20





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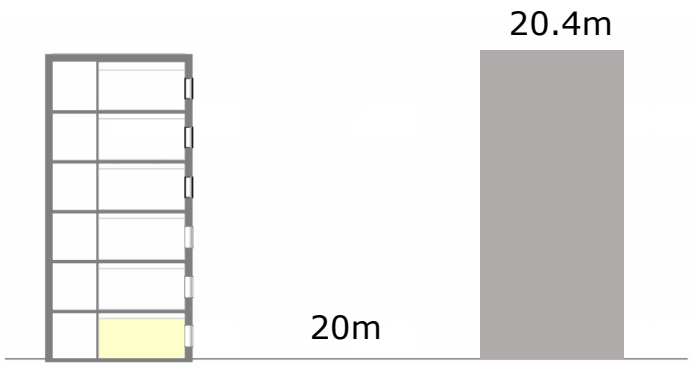
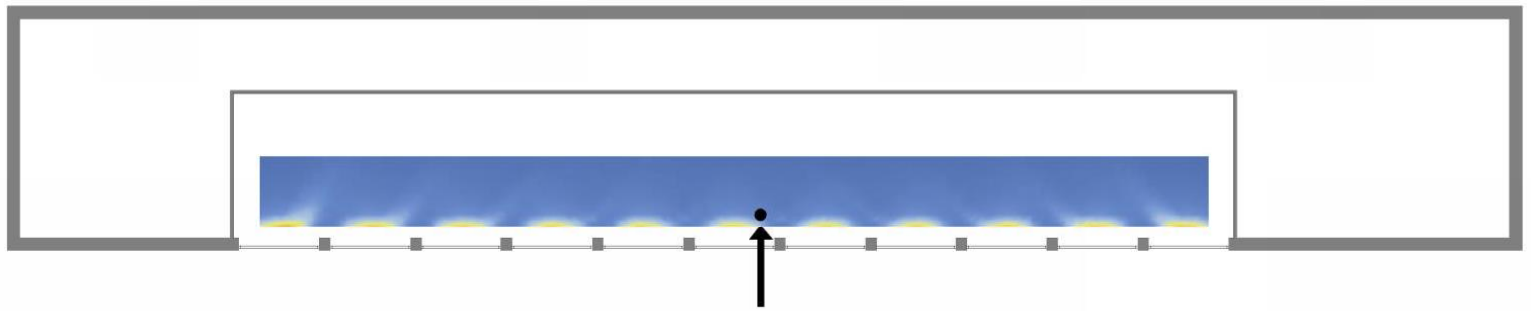
		MINIMUM	MEDIUM	HIGH
Daylight factor target		(D_{TM} ≥0.7) 95% → & (D_T ≥2.2) 50%	(D_{TM} ≥2.2) 95% & (D_T ≥3.6) 50%	(D_{TM} ≥3.6) 95% & (D_T ≥5.4) 50%
		75.9% 27.5%	20.6%	13.3%
Exposure to sunlight (h)		≥1.5 h	≥3 h	≥4 h
		3.24	3.24	3.24
View out	Horizontal Sight Angle (°)	≥14°	≥28°	≥54°
		33.0	33.0	33.0
	Distance to outside (m)	≥6.0 m	≥20.0 m	≥50.0 m
		23.09	23.09	23.09
	Number of layers	Landscape layer	Landscape layer and one additional layer	All layers
		2	2	2
Discomfort glare	DGP_e	<0.45	<0.40	<0.35
		0.20	0.20	0.20





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Conclusions

- In densely built-up areas (obstruction angle ≥ ca. 10°), it is impossible to reach daylight factor targets for the medium and high performance levels (despite 25% glazing-to-floor-area ratio)
- View of the sky from different positions in the room is limited → low circadian stimulus, potentially resulting in poorer health of occupants
- Achieving minimum daylight factor targets for 95% of the room is nearly impossible with windows in one façade only → we therefore used a defined work area instead of using the whole floor area of the room (as is commonly done in Danish design practice)
- View connections to the outside and sunlight exposure are also severely restricted
- But discomfort glare due to daylight is mitigated by higher buildings

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Recommendations

- Adjust window size according to placement height in façade → larger windows on lower floors and smaller windows on higher floors (also addresses thermal loads)

Image Source: Werner Osterhaus

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- Design rooms to have daylight openings in more than one exterior surface whenever possible

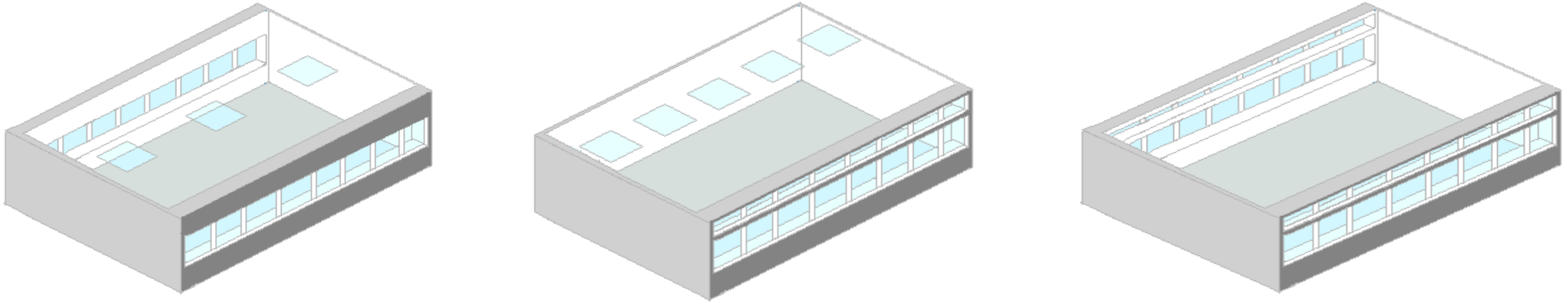
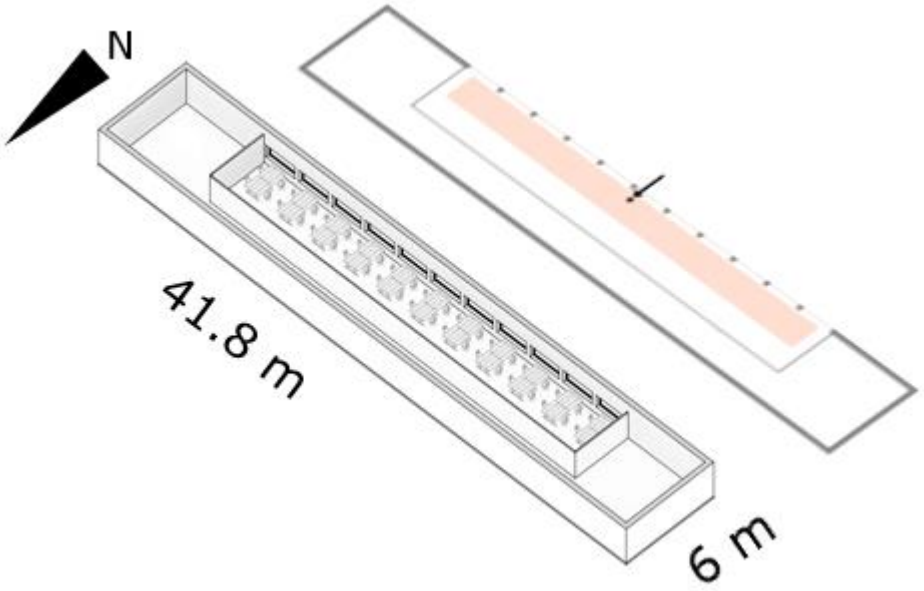


Image Source: Sophie Stoffer and Pil Kirstin Brix Lauridsen

Recommendations

- Adjust window size according to placement height in façade → larger windows on lower floors and smaller windows on higher floors (also addresses thermal loads)
- Design rooms to have daylight openings in more than one exterior surface whenever possible
- Clearly define/indicate occupied areas for working or living in each space on plan drawings



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- Seriously consider where windows are placed to allow for best possible view connections and sunlight exposure - placement of windows for view/sunlight and for daylight provision might be different

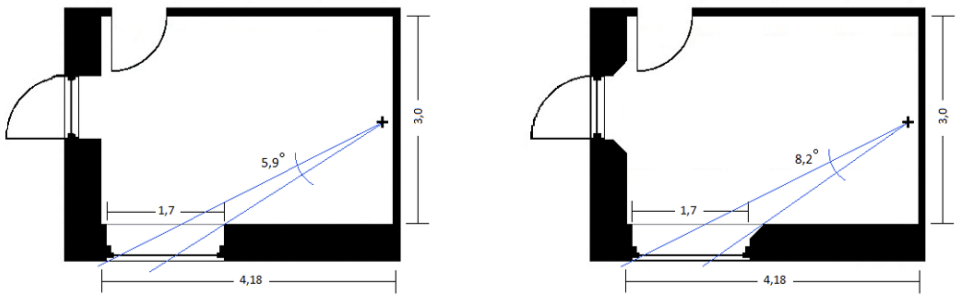

Image Source: Maria Garcia Alvarez

Image Source: Werner Osterhaus

Recommendations

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- Seriously consider where windows are placed to allow for best possible view connections and sunlight exposure (placement of windows for view/sunlight and for daylighting might be different)
- Daylight standard is good means to ensure that quality of daylight in existing buildings will not be diminished during urban densification processes → potentially add requirement that new construction documentation must include assessment of impact on existing buildings

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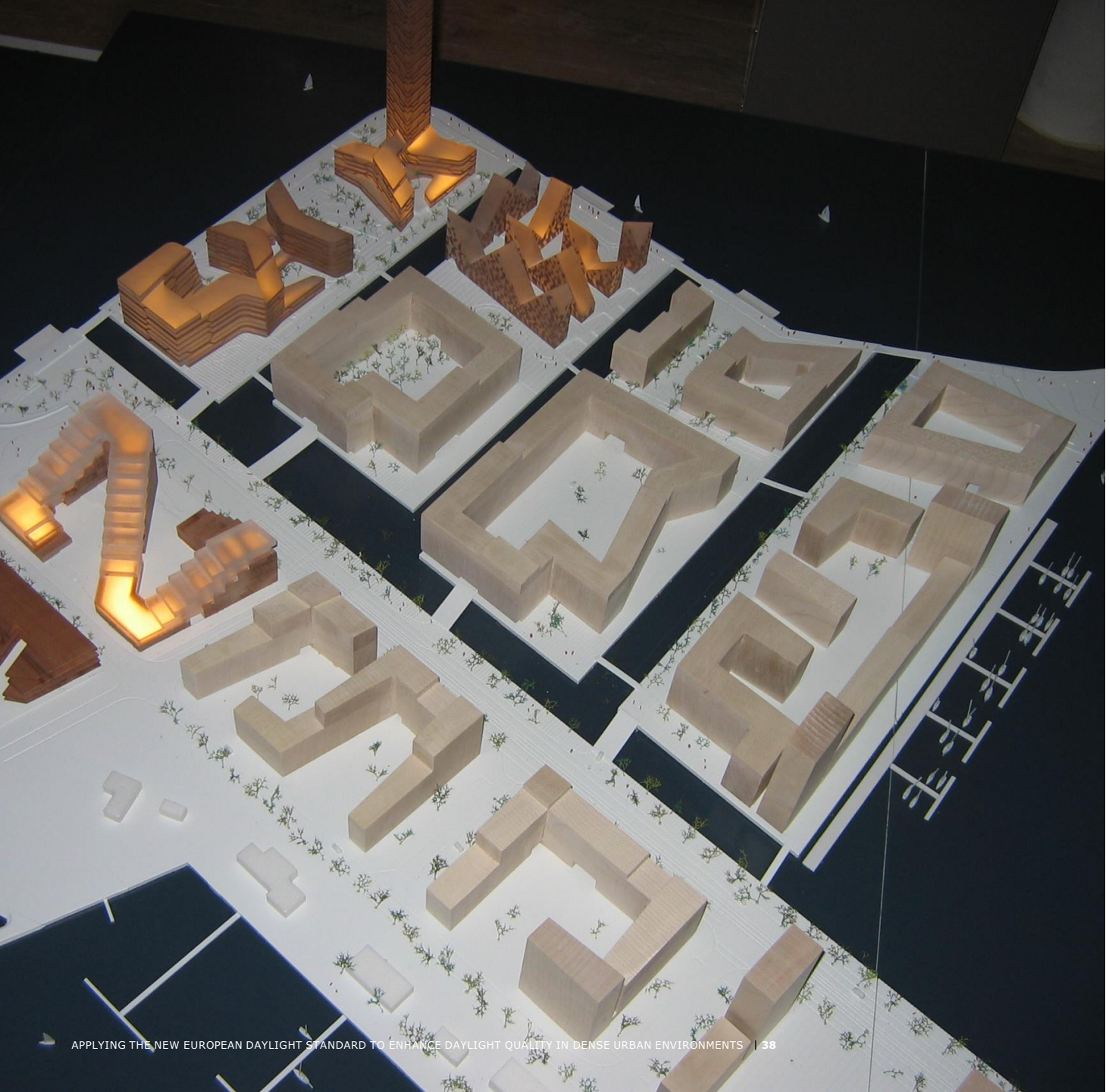

Acknowledgements

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For more information, please see http://aftabsoft.net/aftab-rad.php

We wish to thank Kinga Erika Fodor for completing the parametric simulations using Aftab Rad

Image Source: Werner Osterhaus

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Thank you for your attention and the opportunity to present

Questions or comments ???