

Teadmistepõhine ehitus 2017

Päevavalgus ja insolatsioon liginullenergiamajades

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Estonian standard Daylight in dwellings and offices (EVS 894:2008+A1:2010, EVS 894:2008/A2:2015)

Daylight requirements

The minimum mean Daylight Factor required are:

- Residential - bedroom 1%
- Residential - living room 1.5%
- Residential - kitchen 2%
- Office – working area 2%
- School – classroom 2%

The minimum DF at 1m from the wall opposite the room window is 0.4%

Insolation requirements

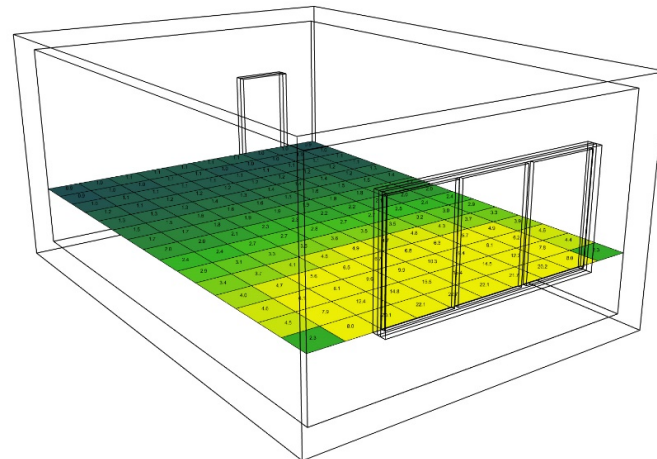
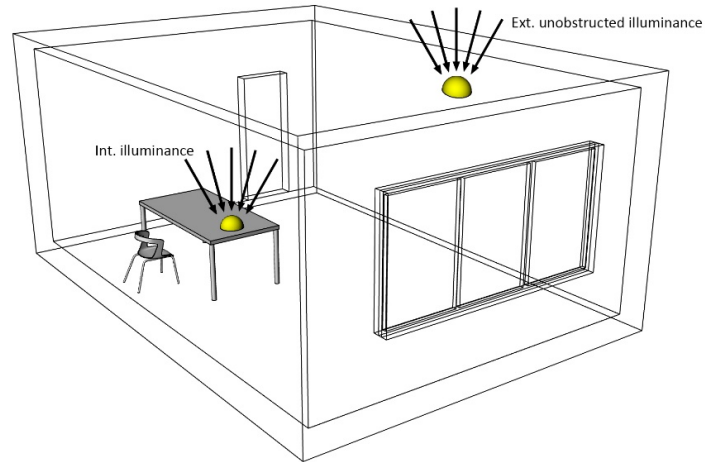
- In a new residential building at least one room of the premises, among living room and bedrooms, is required to receive at least 2.5 continuous hours of direct sun light (or 3 hours if interrupted in urban environments) for every day of the period between 22nd of April and 22nd of August
- In an urban environments a new building cannot decrease the amount of hours of direct solar access received by the surrounding buildings' premises for more than 50% for every day of the same period



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Daylight Factor

DF = (Internal Illuminance / External Unobstructed Illuminance) x 100



$$DF = \frac{T \cdot A_w \cdot \theta \cdot m}{A \cdot (1 - R^2)}$$

DF - mean Daylight Factor of the room

T - Visible Transmittance of the window glass

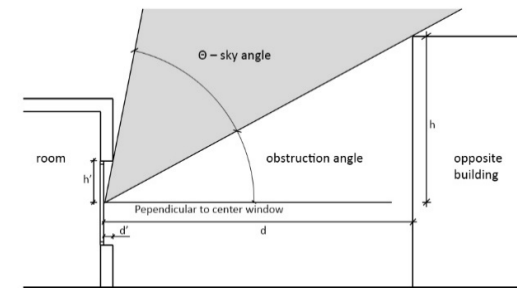
θ - sky angle (in degrees)

m - clearness of the glazing (usually 0.9)

A - total area of interior surfaces (including windows)

A_w - total glazed area of windows (excluding frames)

R - mean surface reflectance (usually 0.5)

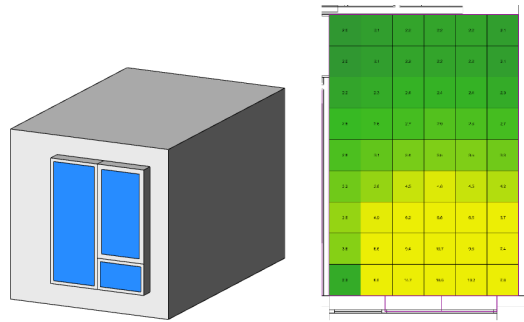


Simulations

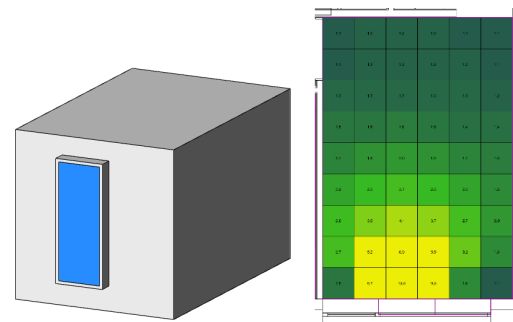


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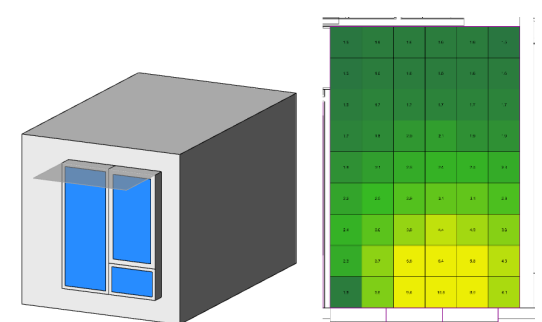
Daylight Factor - Residential project assessment



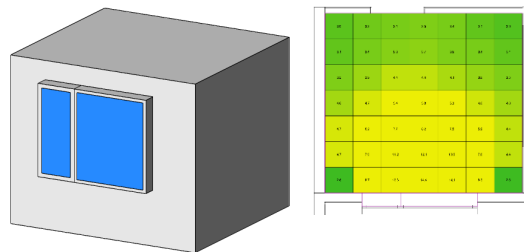
WFR=22.78 mDF=4.49%



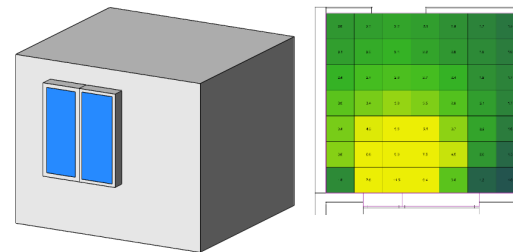
WFR=12.18 mDF=2.45%



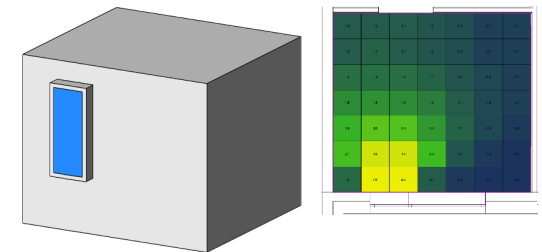
WFR=22.78 mDF=2.91%



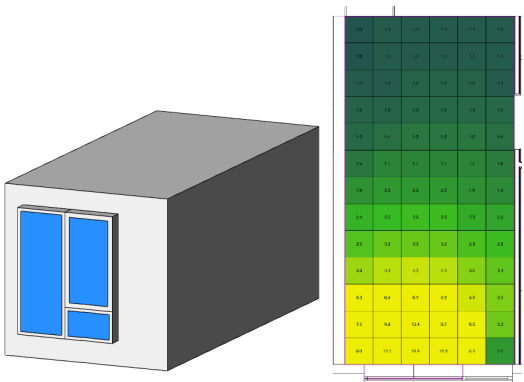
WFR=24.23 mDF=5.62



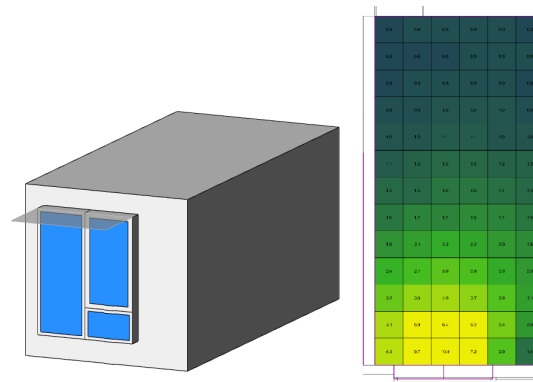
WFR=15.0 mDF=3.29



WFR=7.22 mDF=1.6%

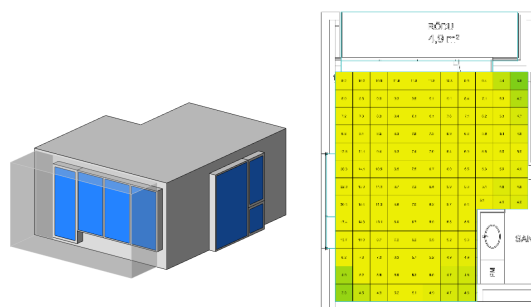


WFR=16.02 mDF=3.21%

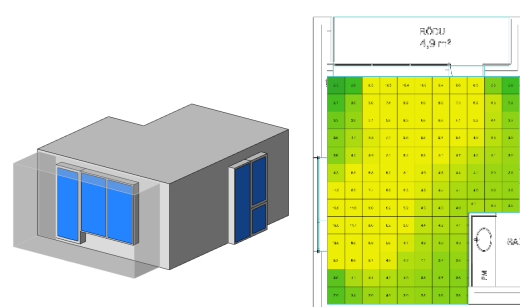


WFR=16.02 mDF=2.08%

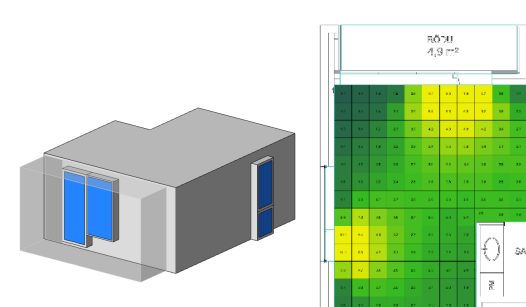
Daylight Factor - Residential project assessment



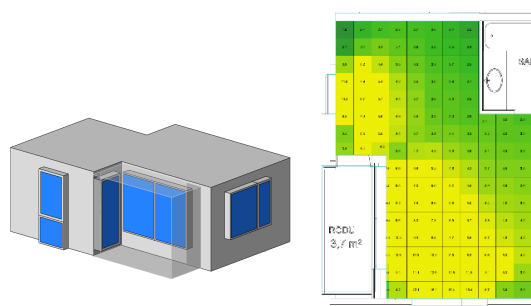
WFR=44.56 mDF=7.63%



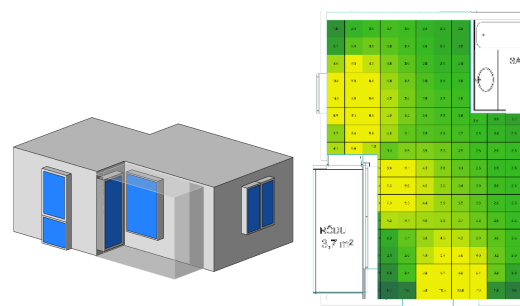
WFR=30.89 mDF=5.47%



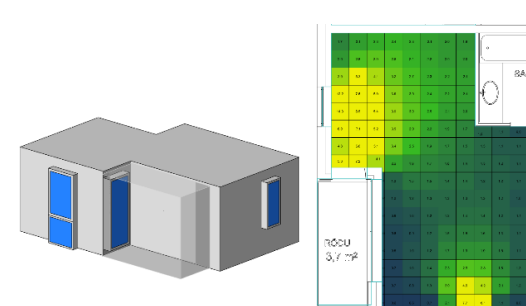
WFR=18.13 mDF=3.04%



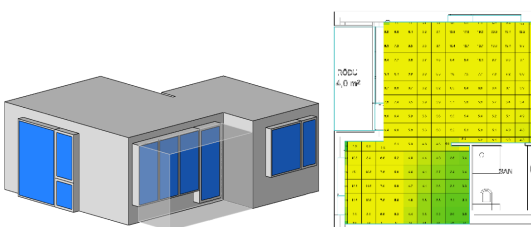
WFR=38.17 mDF=5.44%



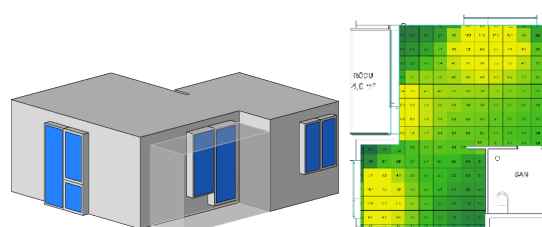
WFR=26.64 mDF=3.90%



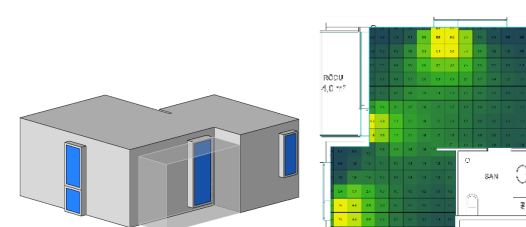
WFR=15.63 mDF=2.45%



WFR=40.12 mDF=6.79%



WFR=23.04 mDF=3.92%



WFR=11.41 mDF=1.91%

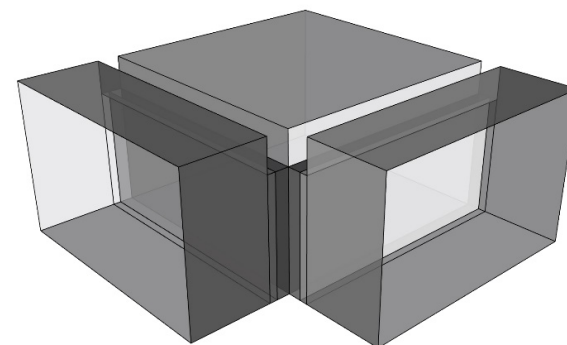
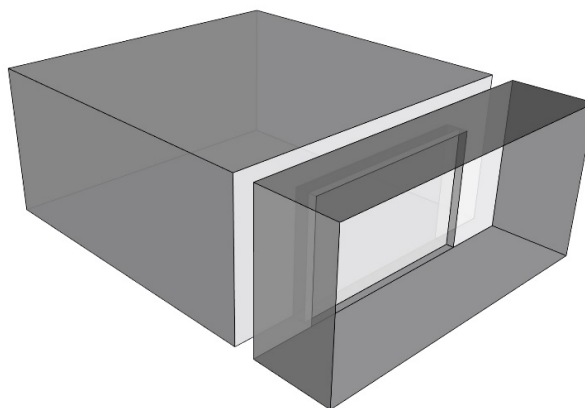
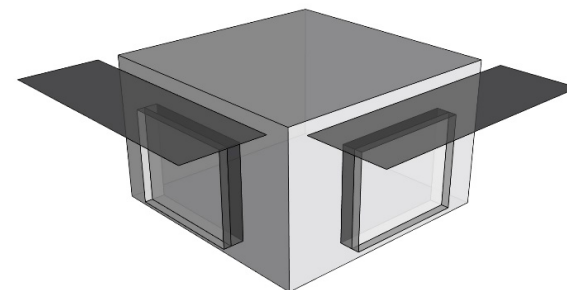
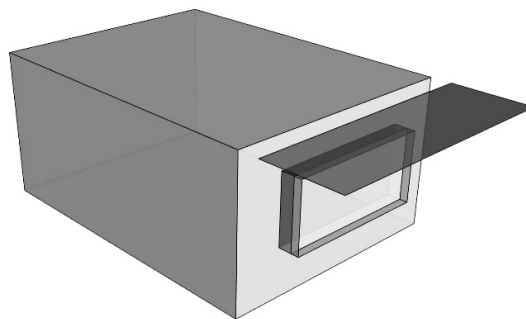
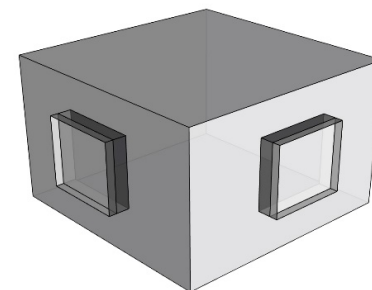
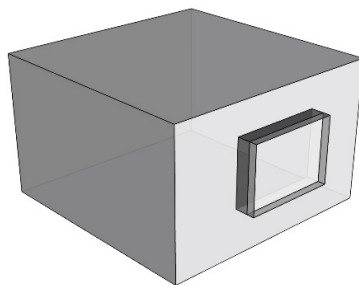


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Daylight Factor

Determination of minimum Window to Floor Ratio (and relative room ratio for single window room cases) for different room types to fulfill the Estonian daylight standard of minimum mean Daylight Factor and $DF \geq 0.4$ at 1m from the wall opposite the window.

- Single side window
- Double side window
- Without balcony
- With upper balcony
- With recessed balcony





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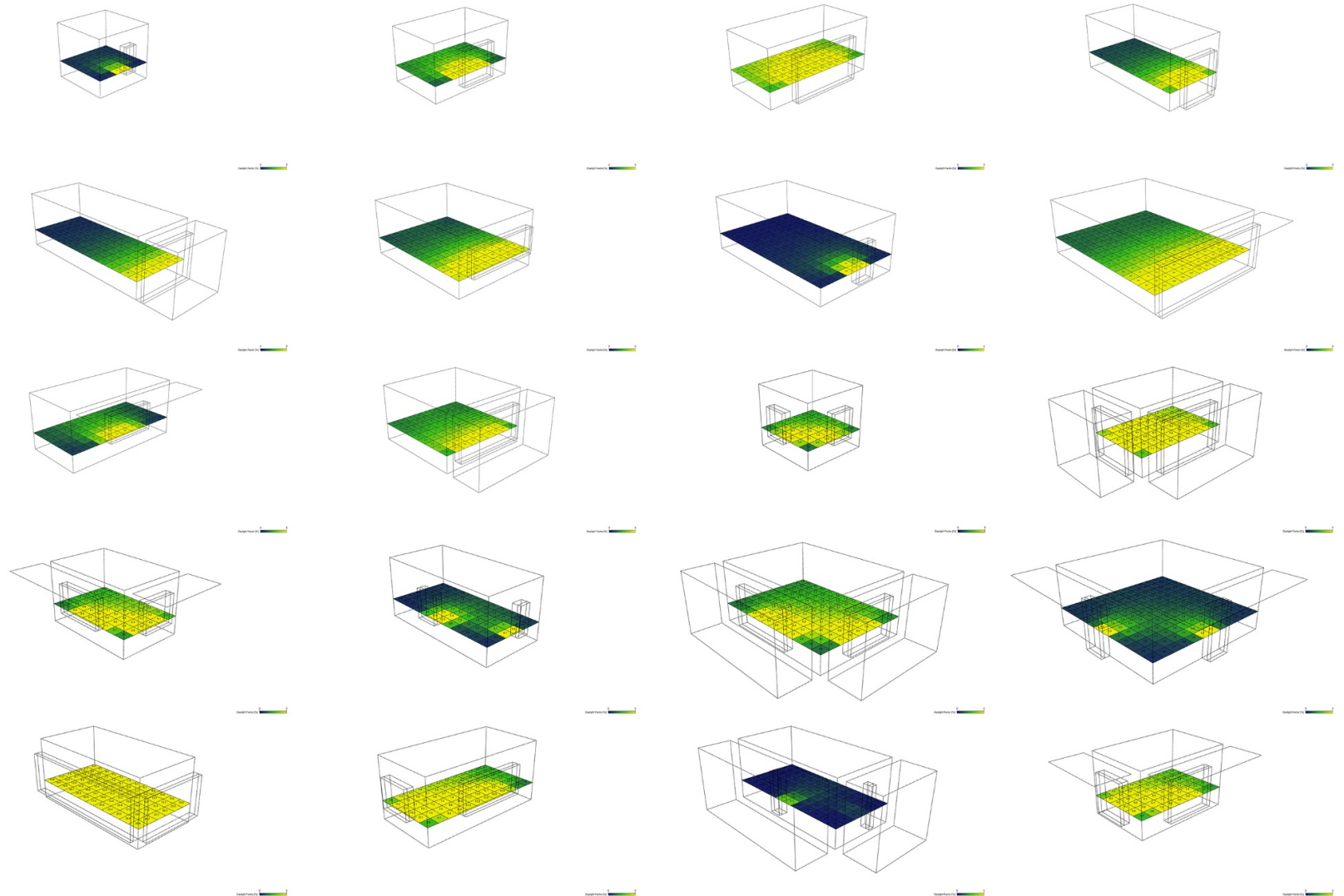
Daylight Factor

1242 cases

Characteristics of simulations

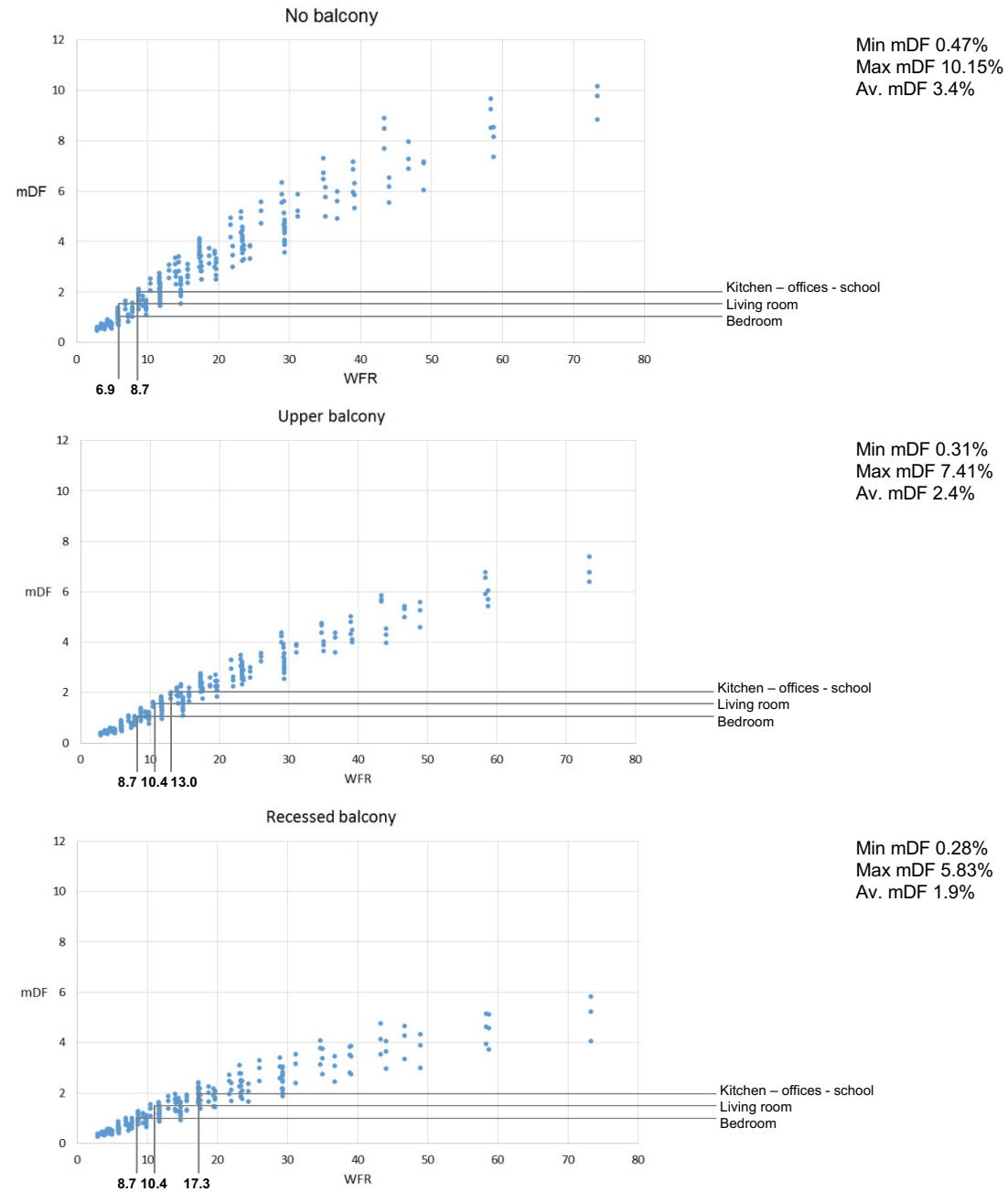
Materials: floor reflectance 40, wall reflectance 70, ceiling reflectance 80, glass VT 70, outside facade reflectance 35, ground reflectance 20.

Sky: CIE overcast



Results - Single facade window (675 cases)

Mean Daylight Factor / Window to Floor Ratio



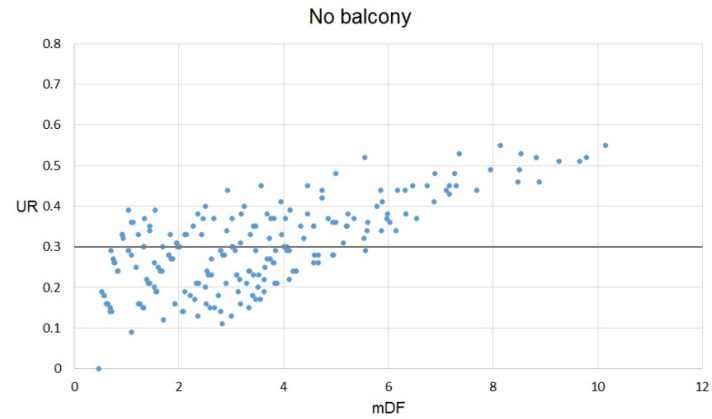


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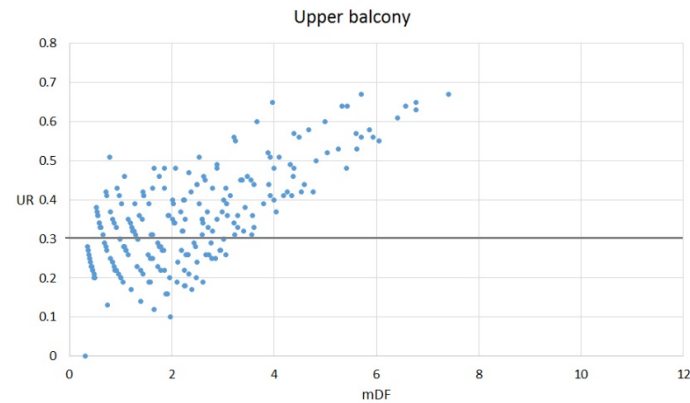
Results - Single facade window (675 cases)

Uniformity Ratio / mean Daylight Factor

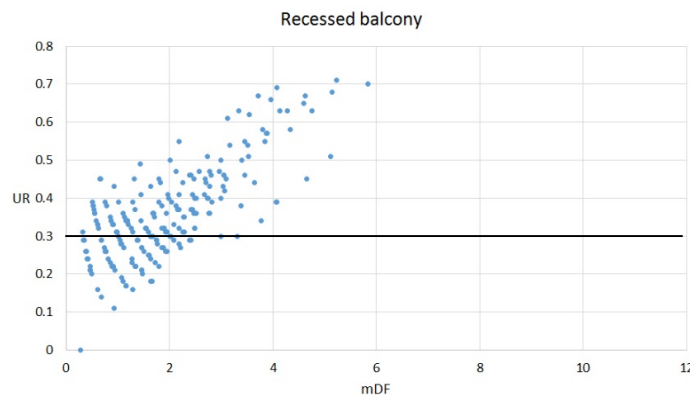
Uniformity ratio from BREEAM
requirement for daylight (Hea 02)
 $\text{min DF}/\text{mean DF} \geq 0.3$



Av. UR 0.3
47.1% ≥ 0.3



Av. UR 0.35
64.4% ≥ 0.3



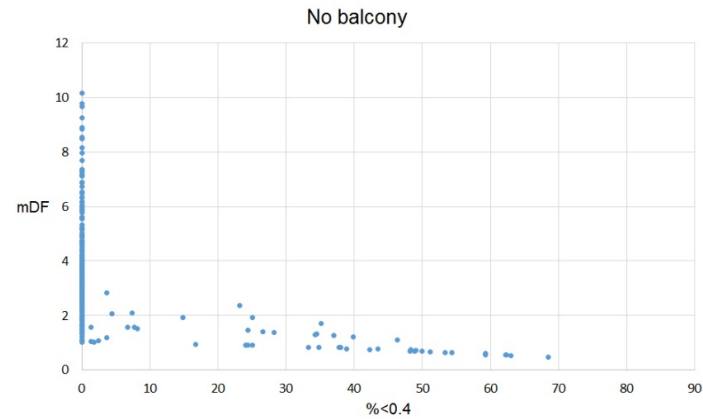
Av. UR 0.36
67.1% ≥ 0.3



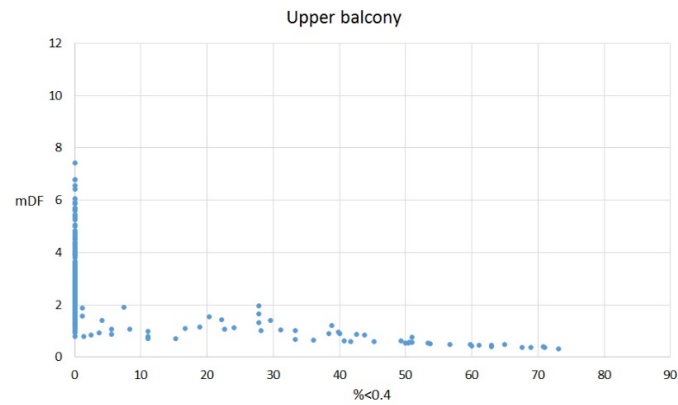
TTU

Results - Single facade window (675 cases)

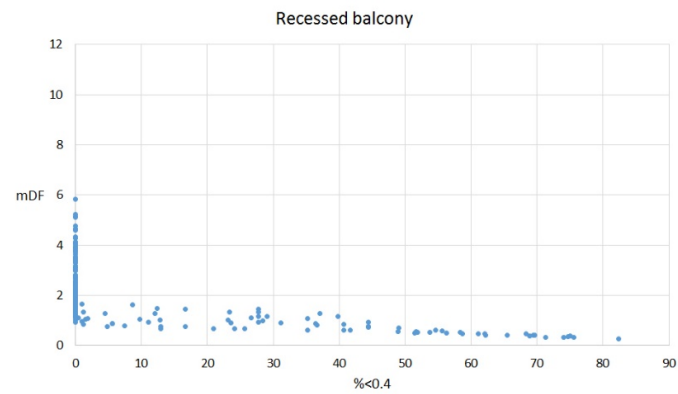
Mean Daylight Factor / % of floor area mDF < 0.4



0% of floor area ≥ 0.4
78% of the cases



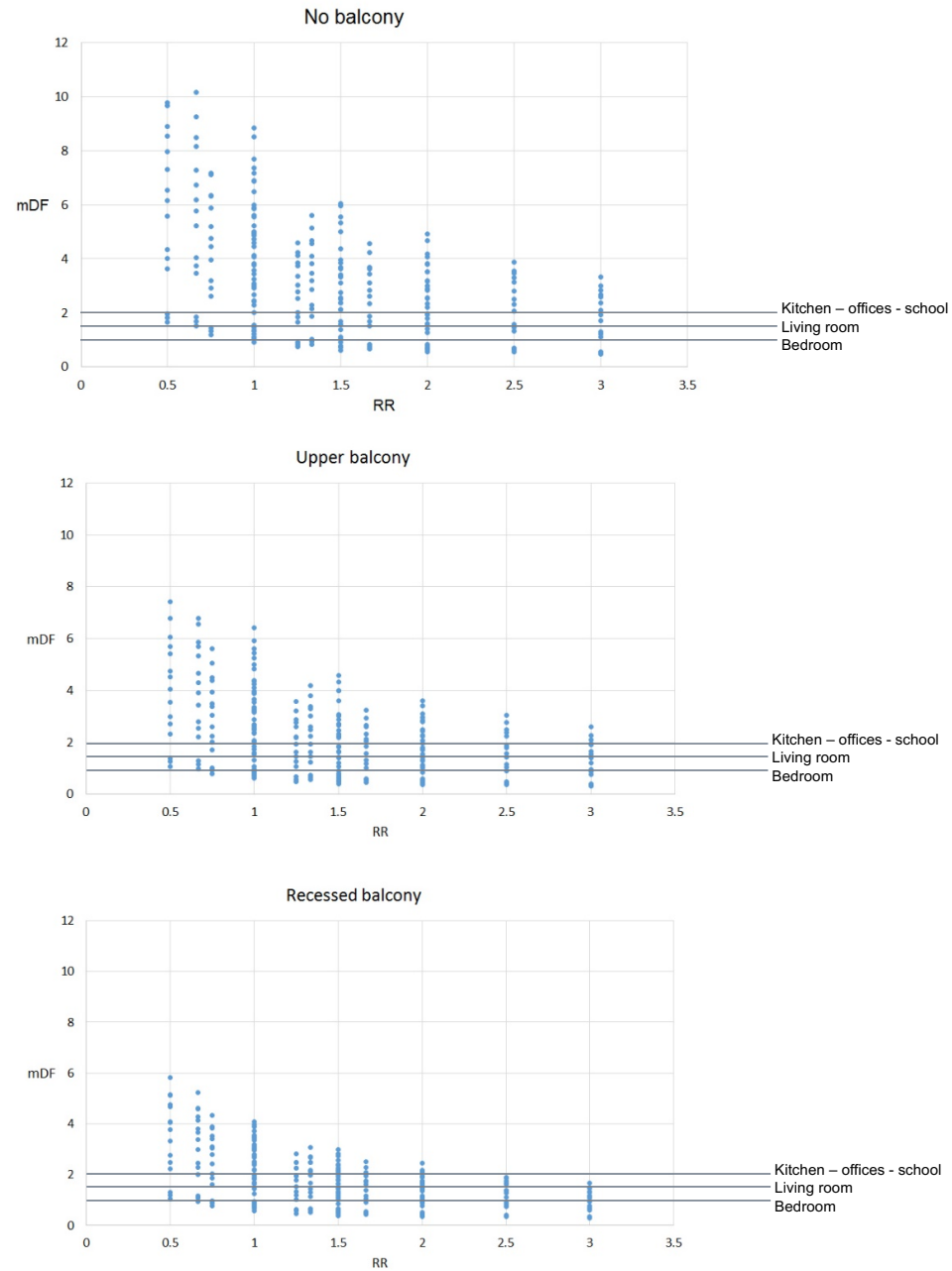
0% of floor area ≥ 0.4
72% of the cases



0% of floor area ≥ 0.4
67% of the cases

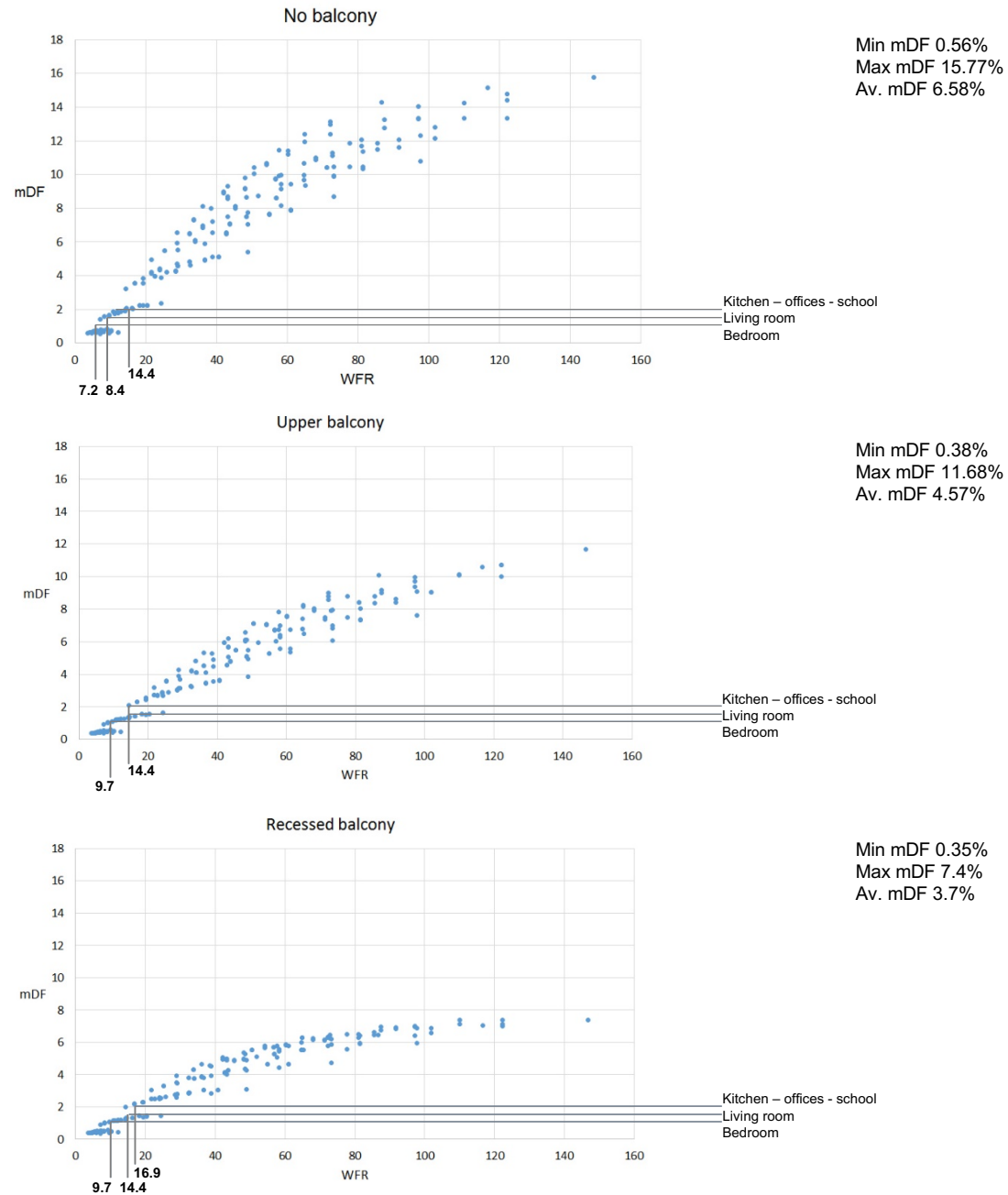
Results - Single facade window (675 cases)

Mean Daylight Factor / Room Ratio (depth/width)



Results - Double facade window (567 cases)

Mean Daylight Factor / Window to Floor Ratio



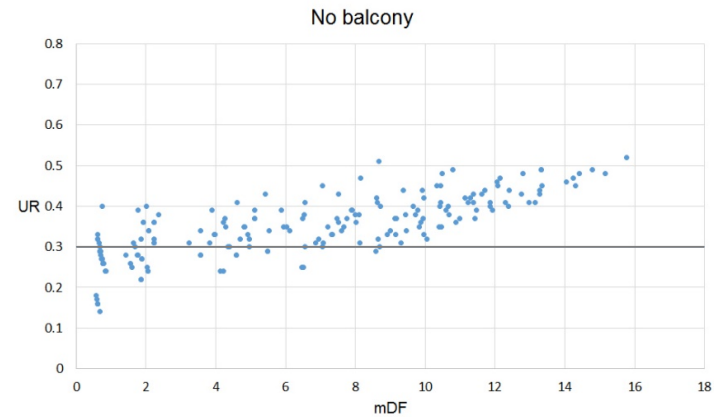


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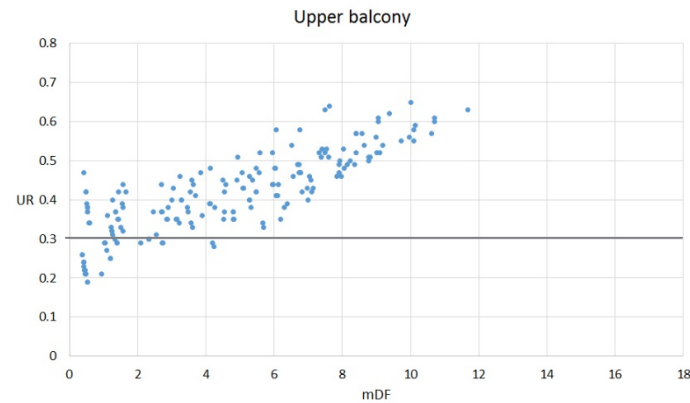
Results - Double facade window (567 cases)

Uniformity Ratio / mean Daylight Factor

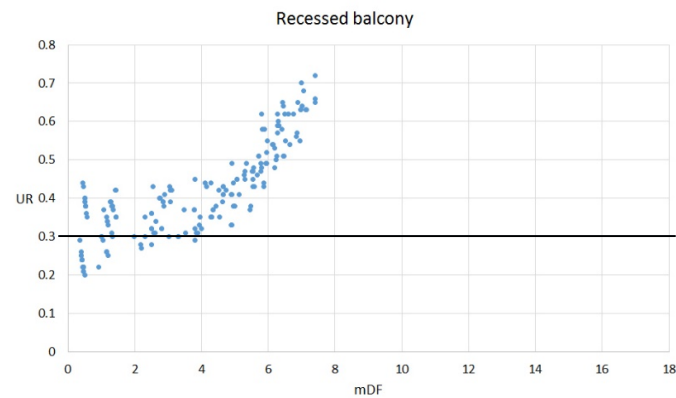
Uniformity ratio from BREEAM
requirement for daylight (Hea 02)
 $\text{min DF}/\text{mean DF} \geq 0.3$



Av. UR 0.35
76.7% ≥ 0.3



Av. UR 0.41
85.1% ≥ 0.3



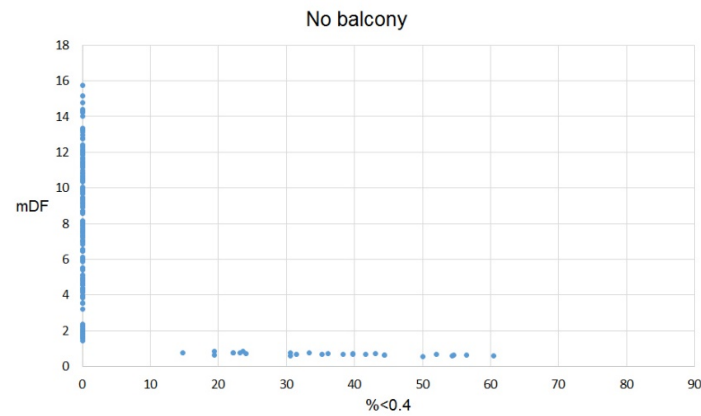
Av. UR 0.41
85.7% ≥ 0.3



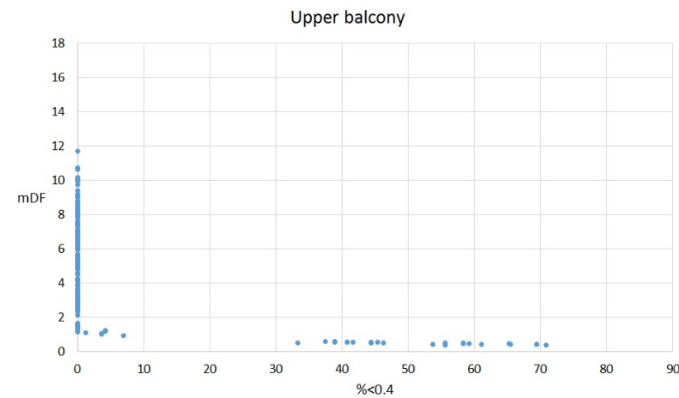
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Results – Double facade window (567 cases)

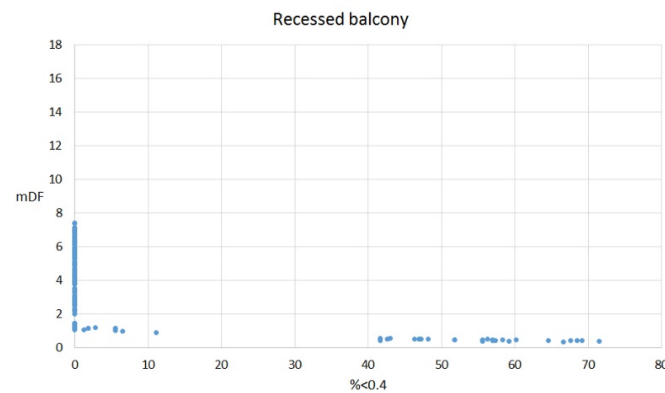
Mean Daylight Factor / % of floor area mDF < 0.4



0% of floor area ≥ 0.4
85% of the cases



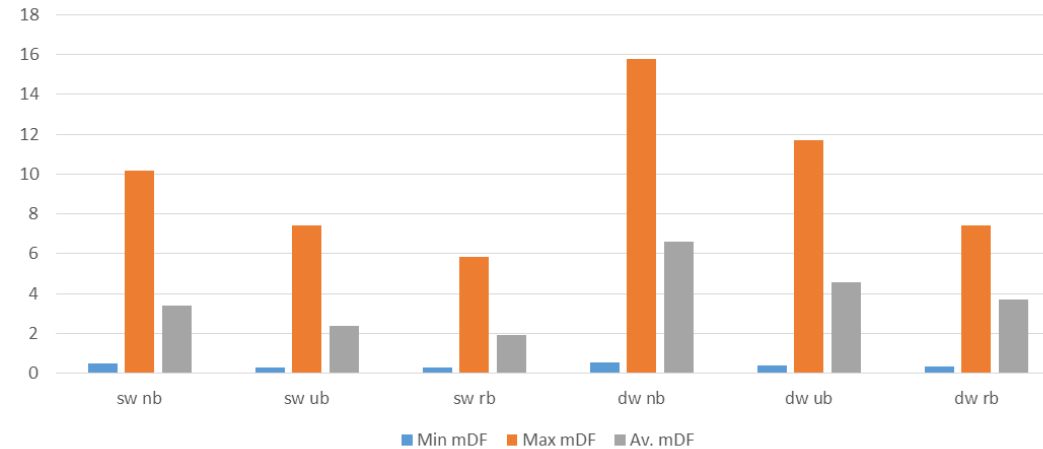
0% of floor area ≥ 0.4
82% of the cases



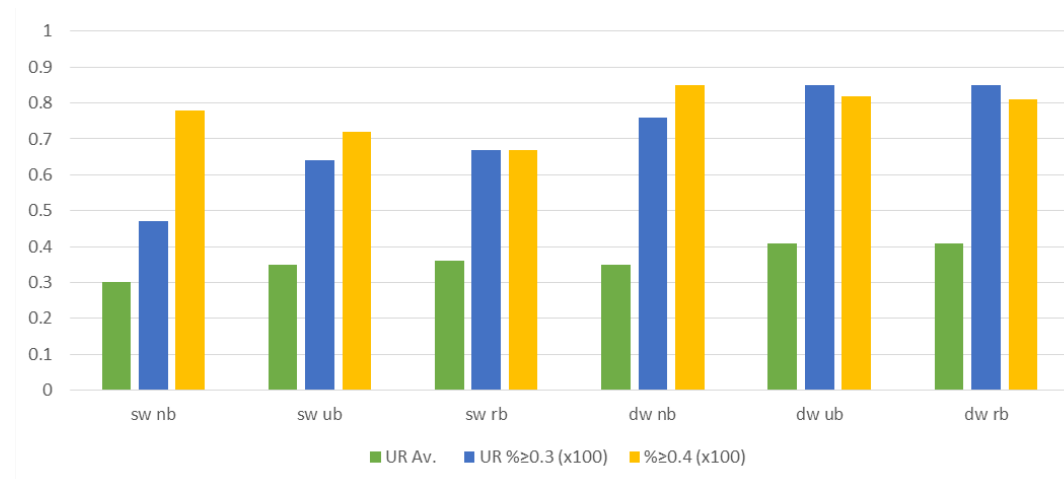
0% of floor area ≥ 0.4
81% of the cases

Results – Summary

The following chart shows how the Daylight Factor (Min, Max and Average) decreases when using balconies or shading devices for both single side window and double side window rooms.



The following chart shows how the Uniformity Ratio increases and the quantity of cases that fulfill the requirement of the $DF \geq 4$ decreases when using balconies or shading devices for both single side window and double side window rooms. This suggests to thoroughly evaluate case by case using computer simulation





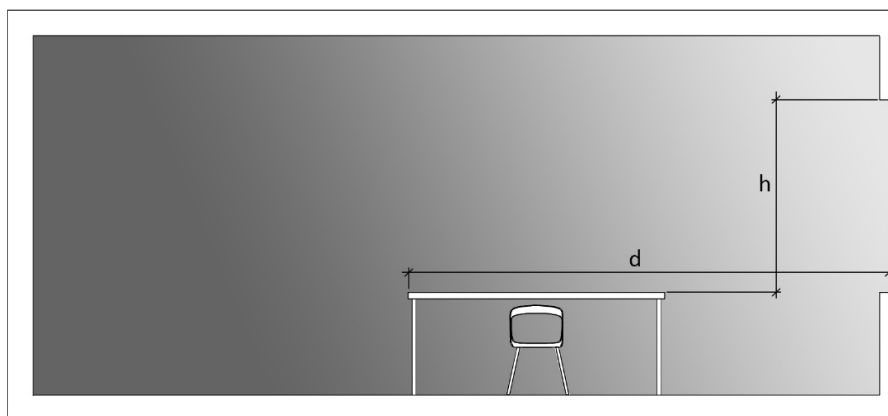
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Rules of thumb for daylighting

Indicative minimum Window to Floor Ratio, and relative Room Ratio for the cases with single window, for different room type and presence of balcony to fulfill the Daylight Factor requirements of the Estonian daylight standard.

		Single Window			Double Window		
		No Balcony	Upper Balcony/ Shading	Recessed Balcony	No Balcony	Upper Balcony/ Shading	Recessed Balcony
Bedroom	Min WFR/Room Ratio	6.9/1.25	8.7/1.33	8.7/1.33	7.2	9.7	9.7
Living room	Min WFR/Room Ratio	6.9/1.25	10.4/1.66	10.4/1.25	8.4	14.4	14.4
Kitchen	Min WFR/Room Ratio	8.7/1.5	13.0/1.0	17.3/1.33	14.4	14.4	16.9
Living room + kitchen	Min WFR/Room Ratio	8.7/1.5	11.6/2.0	13.0/1.0	10.8	14.4	14.4
Office and school	Min WFR/Room Ratio	8.7/1.5	13.0/1.0	17.3/1.33	14.4	14.4	16.9

The useful depth (d) of a room is 2.5 times the height of the window from desk height (h), and 2 times if there is a balcony or shading above the window, in the case of a single window natural light source.





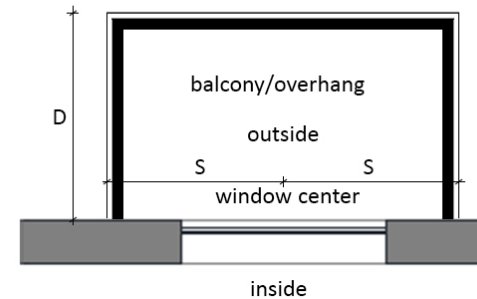
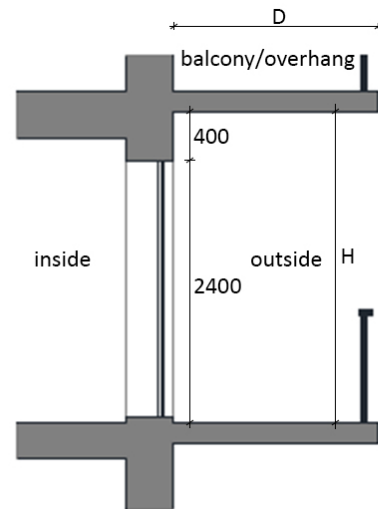
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Rules of thumb for insulation

Direct sun light is required by the Estonian daylight standard but for design purposes or for energy efficiency (to reduce the direct solar gains) can be necessary to build balconies or shadings.

The following sizes for two types of balconies allow the window below to get the minimum insolation as required by the Estonian daylight standard.

Balcony/overhang



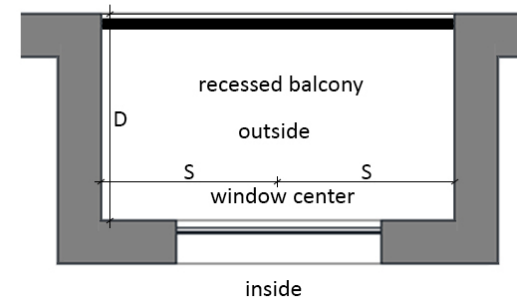
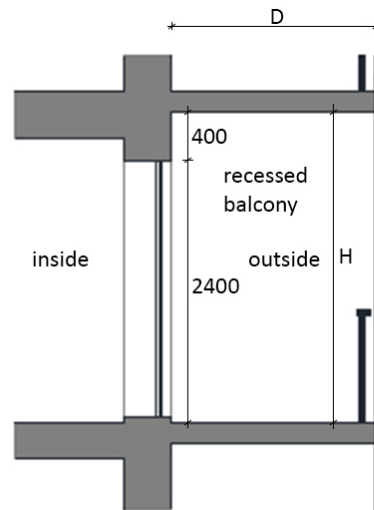
	Vertical window		Horizontal window	
	S	D	S	D
South	≤ 2	no limit	≤ 1.5	no limit
	> 2	1.1 (0.4 H)	> 1.5	0.8 (0.3 H)
East/West	≤ 1	no limit	≤ 0.5	no limit
	> 1	3 (1.07 H)	> 0.5	2 (0.7 H)



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Rules of thumb for insulation

Recessed balcony



	Vertical window		Horizontal window	
	S	D	S	D
South	all	1 (0.35 H)	all	0.8 (0.3 H)
East/West	≤ 0.5	1.2 (0.4 H)	≤ 0.5	1.2 (0.4 H)
	1	2.5 (0.9 H)	≥ 1	2.1 (0.75 H)
	≥ 1.5	3 (1.07 H)	-	-



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Key aspects

- An adequate WFR increase the energy efficiency of buildings
- Minimum WFR for single facade window rooms = 7-9 (9-17 with balconies)
- Minimum WFR for double facade window rooms = 7-14 (10-17 with balconies)
- Balconies, overhangs and recessed balconies increase the light evenly distribution
- Balconies, overhangs and recessed balconies decrease the direct solar gains
- Balconies, overhangs and recessed balconies makes more difficult to fulfill the requirement of DF 0,4 (but less than how much they decrease mDF and overheating and increase uniformity)
- Balconies, overhangs and recessed balconies allow to fulfill the insolation requirement (if properly dimensioned)



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Thank you

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