Measuring Daylight: the New European Standard and other Green Building Certificates

A study about the effect of EN-17037 on green certificates

Tim Schouws 5244153

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Building regulations: Daylight


Nederlandse norm

NEN 2057
(nl)

Daglichtopeningen van gebouwen - Bepaling van de equivalente daglichtoppervlakte van een ruimte

Daylight openings of buildings - Determination method of the equivalent daylight of a space

Vervangt NEN 2057:2001;
NEN 2057:2001/C1:2003;
NEN 2057:2011 Ontw.

ICS 91.020; 91.040.30; 91.040.99
juni 2011

2011

EN 17037

Bouwbesluit

Building regulations: Daylight

Nederlandse norm

NEN 2057

(nl)

Daglichtopeni... ...n gebo... – Bepaling van de equiv... ...cht... van een

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juni 2011

2011

Nederlandse norm

NEN-EN 17037

(en)

Daglicht in gebouwen

Daylight in buildings

2018

Background

- Minimum daylight surface in m² VS determined with daylight factors and illuminance
- Daylight provision and energy consumption

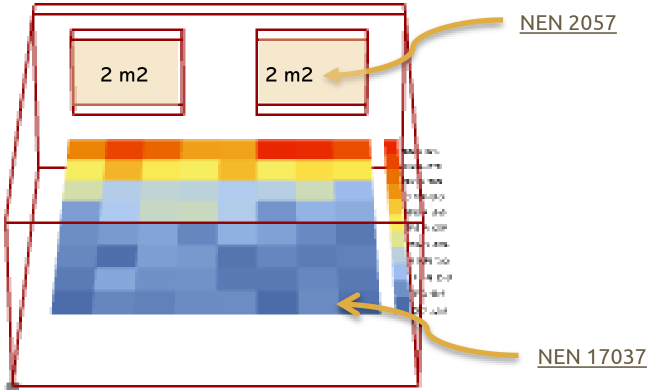


Figure 1, Difference between NEN 17037 and NEN 2057

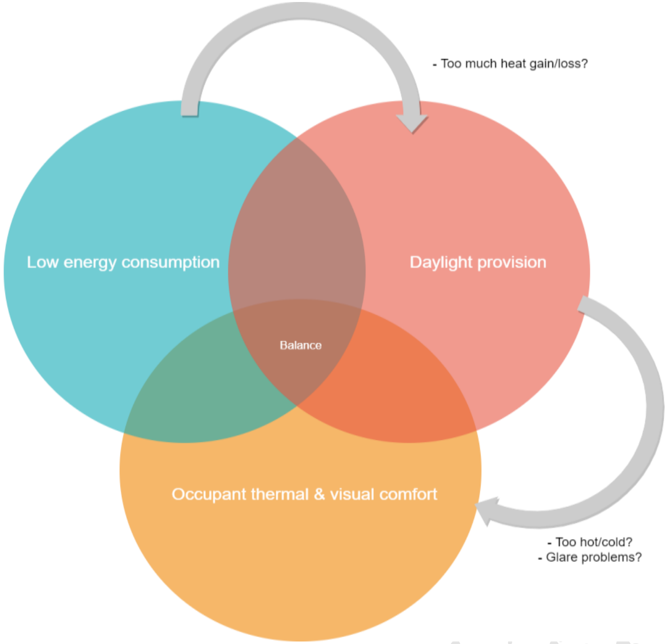


Figure 2, Balance between daylight and energy consumption

EN 17037

Assessment Method 2

Illuminance per hour for a typical year

Recommendation vertical daylight openings	Target illuminance E_t lx	Part of room for target level $F_{plane,\%}$	Minimum ambient illumination strength E_{TM}, lx	Part of space for minimum target level$F_{plane,\%}$	Part of daylight hours $F_{time,\%}$
Minimum	300	50%	100	95%	50%
Medium	500	50%	300	95%	50%
High	750	50%	500	95%	50%

Table 1, Recommendation vertical daylight openings (NEN 17037, 2018)

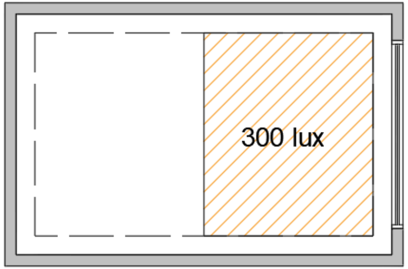


Figure 3, 300 lux for 50% of the reference plane

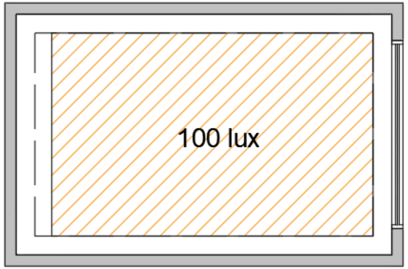


Figure 4, 100 lux for 95% of the reference plane

EN 17037

Assessment Method 2

Illuminance per hour for a typical year

Recommendation vertical daylight openings	Target illuminance E_t lx	Part of room for target level $F_{plane,\%}$	Minimum ambient illumination strength E_{TM}, lx	Part of space for minimum target level $F_{plane,\%}$	Part of daylight hours $F_{time,\%}$
Minimum	300	50%	100	95%	50%
Medium	500	50%	300	95%	50%
High	750	50%	500	95%	50%

Table 2, Recommendation vertical daylight openings (NEN 17037, 2018)

Assessment Method 1

Daylightfactor

Nation	Capital	Geographical latitude ϕ [°]	Median External Diffuse Illuminance Ev,d,med	D to exceed 100 lx	D to exceed 300 lx	D to exceed 500 lx	D to exceed 750 lx
The Netherlands	Amsterdam	52.3	14400	0.70%	2.10%	3.50%	5.20%

Table 3, Recommendation vertical daylight openings (NEN 17037, 2018)

$$D_t = \frac{\text{Illuminance Level}}{Ev,d,med} = \frac{300\ \text{lux}}{14400} \times 100\% = 2{,}1\ \%$$

$$D_{tm} = \frac{\text{Illuminance Level}}{Ev,d,med} = \frac{100\ \text{lux}}{14400} \times 100\% = 0{,}7\ \%$$

Problem statement

- Medium and high performance level, increase in window to wall ratio
- Comply with green building certificates
- Balancing between performance and energy consumption

Research questions

1. What requirements does the new European standard set for daylighting in buildings?

European Norm

Research done on the topic

2. What is the difference between the requirements of the European standard for daylight in buildings and the BREEAM and LEED requirements for daylight in buildings?

Simulation assumptions

3. How does the European standard for daylight in buildings influence the energy performance in buildings and what influence does this have on the BREEAM and LEED certificates?

Explore diff performance outcome of different variations

4. What requirements can be proposed in order to still be able to comply with the green certificates, but also to guarantee sufficient daylight in buildings?

Comparing the results

Recommendations

Methodology

Step 1: Analyze the European norm

Step 2: Analyze BREEAM & LEED

Step 3: Creating a parametric model for a small office

Step 4: Energy and daylight simulations

Step 5: Quantitative data was analyzed with the help of descriptive statistics

Step 6: Reflection, conclusion and advice

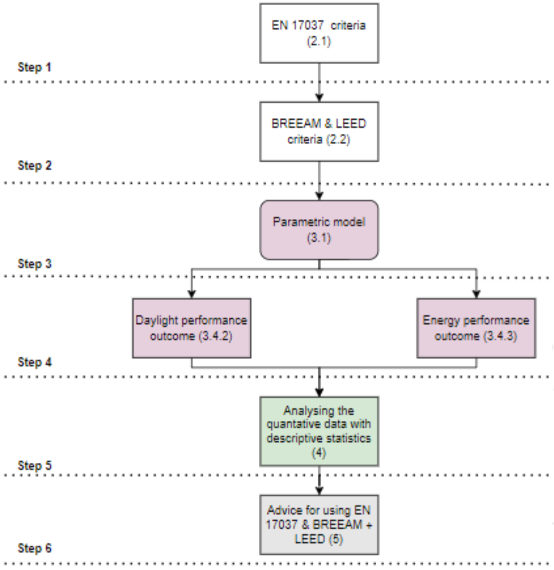


Figure 5, Research methodology

Constraint

- Standard office in the netherlands
- BREEAM NL
- Design recommendation regarding daylight provision

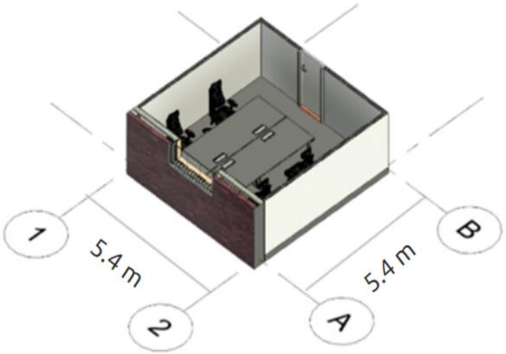


Figure 6, Reference office

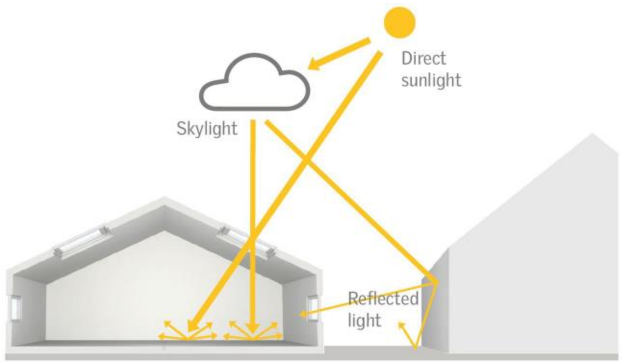


Figure 7, Daylight provision

Relevance of research

- Complements the previous conducted research, not many studies about the EN 17037
- How much influence European standard has on green certificates with respect to energy consumption and the difference between the performance measurement for daylight
- Advice for using one of the certificates or European norm for architect and building engineers
- Inverse relationship between lighting and energy consumption of heating and cooling

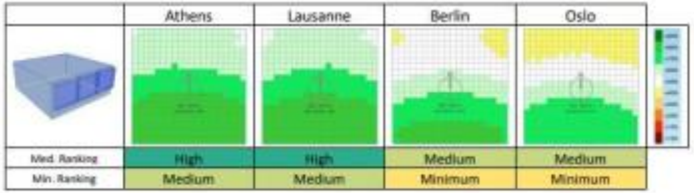


Figure 8, Daylight provision for a south oriented room (WFR = 24%) (Bernard & Flourentzos, 2019)

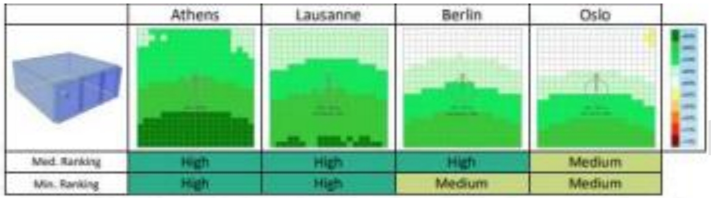
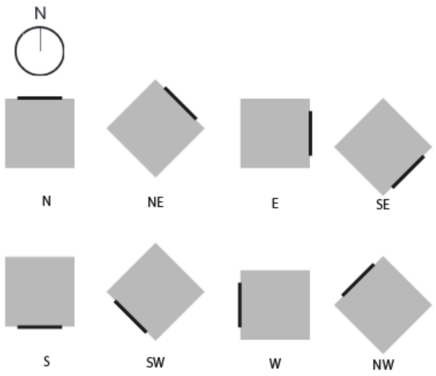


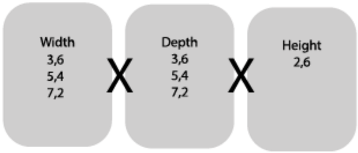
Figure 9, Daylight provision for a fully glazed south oriented room (WFR = 34%) (Bernard & Flourentzos, 2019)

Parameters

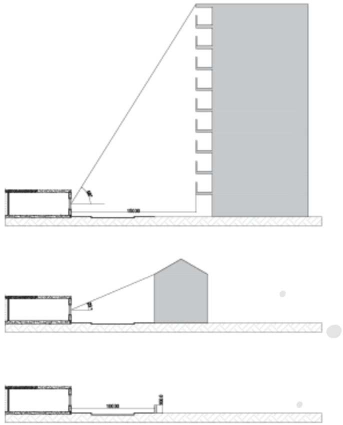


1. Rotation

Only for Annual calculation

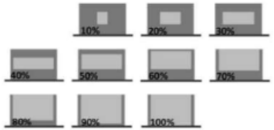


2. Size

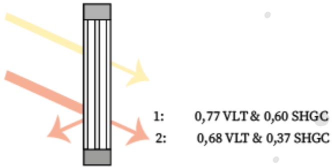


3. Context

4. Facade element



5. WWR



6. Glass characteristics

Scenarios

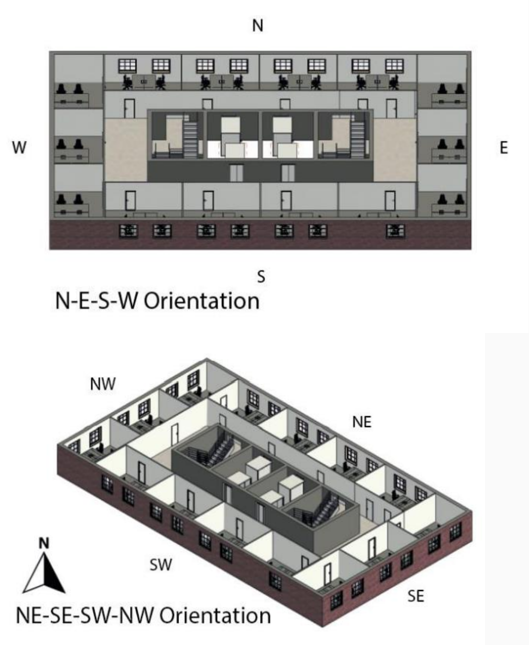


Figure 10, Scenario 1 and 2

Figure 11, Scenario 3 and 4

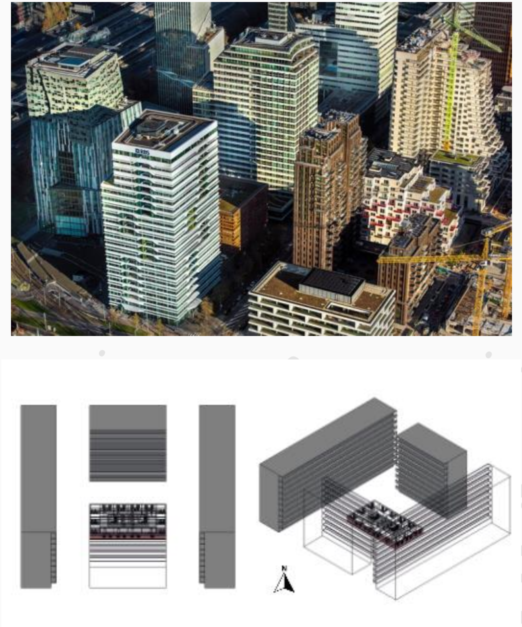


Figure 12, Scenario 5 and 6

Simulation assumptions

ATES

COP cooling: 3,02
COP Heating: 3,02
Min. heating setpoint: 20
Max. cooling setpoint: 26
Thermal comfort: -0,5 < pmv < +0,5

Ventilation

Ventilation capacity: 0,7 dm3/s per m2
Air velocity: 0,2 m/s

Insulation

Floor: 8 m2K/W
Facade: 8 m2K/W
Roof: 8 m2K/W

LED-light

lux < 300: turn on
Density: 10,1 W/m2

Blinds

> 1000 lux of direct sunlight

PV-panel

20 kWh/m2

Operating schedule

Function: Office
Time usage: 8 AM - 6 PM
ASHRAE 90.1-2016 Small office schedule

BREEAM & LEED

BREEAM

- 9 environmental categories
- Health & energy
- 39% of the total score

Pass	≥ 30%
Good	≥ 45%
Very Good	≥ 55%
Excellent	≥ 70%
Outstanding	≥ 85%

Land Use and Ecology	8%
Water	7%
Energy	20%
Materials	13%
Health and Wellbeing	19%
Transport	6%
Waste	6%
Pollution	10%
Managment	11%
Innovation	10%

Table 4, BREEAM Categories

LEED

- 7 environmental categories
- Energy & indoor environmental Quality
- 47% of the total score

Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80+

Sustainable sites	22%
Water efficiency	10%
Energy & Atmosphere	30%
Materials & Resources	12%
Indoor Environmental Quality	17%
Innovation and Design	5%
Regional Priority	4%

Table 5, LEED categories

Daylight provision

BREEAM (1 points)

- Different functions
- 80% of the space
- Uniformity ratio of at least 0,3

Daylight entry		
Function	Average daylightfactor/ function	minimum usable surface (m2) per occupied space
Office spaces	2,00%	80%
Teaching spaces	5,00%	80%
Living space	2,00%	80%

Table 6, Daylight provision BREEAM

LEED (3 points)

- Spatial daylight autonomy ($sDA_{300/50\%}$)
- Annual sunlight exposure ($ASE_{1000/250}$)
- Blinds operate hourly, close when 2% receive more than 1000 lux of direct sunlight
- Blinds are not deployed for ASE analysis

Percent of area meeting sDA requirement	Points available
The average sDA300/50% value for the regularly occupied floor area is at least **40%**	1 point
The average sDA300/50% value for the regularly occupied floor area is at least **55%**	2 points
The average sDA300/50% value for the regularly occupied floor area is at least **75%**	3 points

Table 7, Daylight provision LEED

Energy

BREEAM (15 points)

- Reference value (Office) : 40 kWh/m^2* jr

Points	Reduction of primary fossil energy consumption (BENG 2) compared to reference value
1	10%
2	20%
3	30% (required for Very Good)
4	40%
5	50%
6	60% (required for Excellent)
7	70%
8	80%
9	90%
10	100% (required for Outstanding)

Table 8 , Reduction of primary fossil energy consumption (percentage)

Points	Reduction of primary fossil energy consumption (BENG 2) compared to reference value
1	-10 kWh/m2.jr
2	-20 kWh/m2.jr
3	-30 kWh/m2.jr
4	-40 kWh/m2.jr
5	-50 kWh/m2.jr

Table 9, Reduction of primary fossil energy consumption (fixed number)

LEED (18 points)

- Baseline model VS proposed Design
- Building dimensions are identical to the proposed design
- Schedules are the same

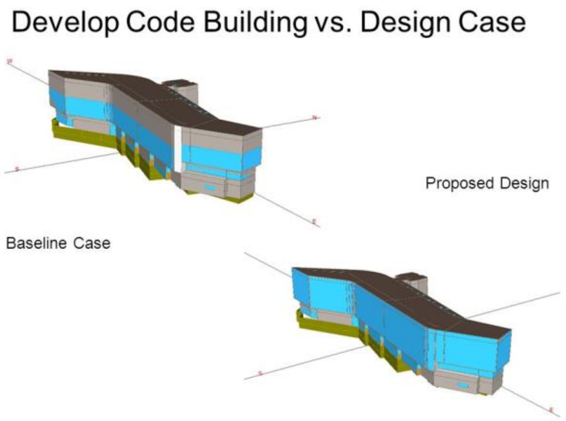


Figure 13, Example of baseline case and proposed design (CTTC, 2014)

Average energy consumption

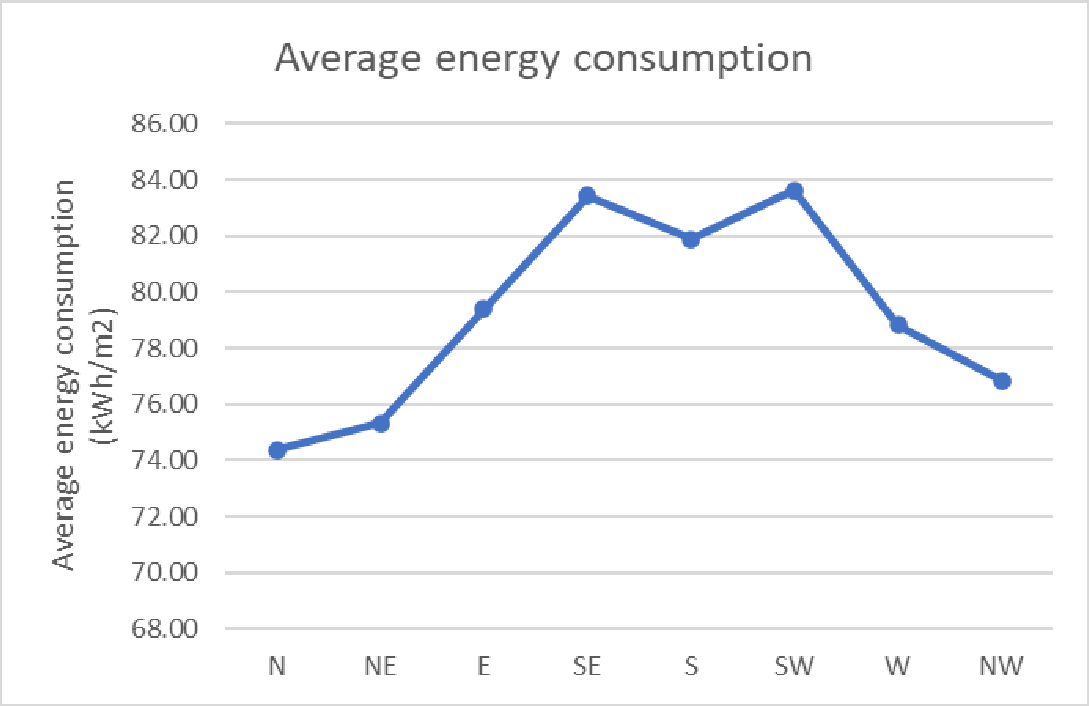


Figure 22, Energy consumption based on orientation

Window-to-wall ratio

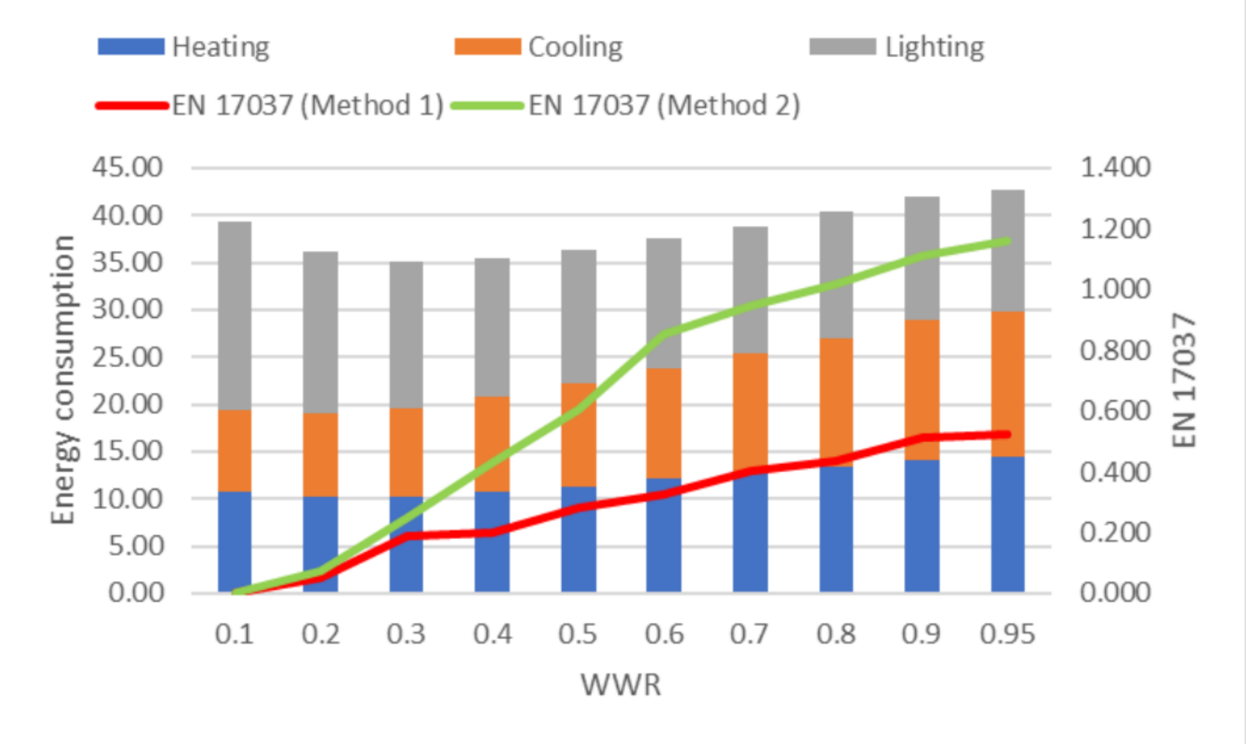


Figure 23, EN 17037 performance and energy consumption compared to the WWR

Effect on BREEAM and LEED

Daylight

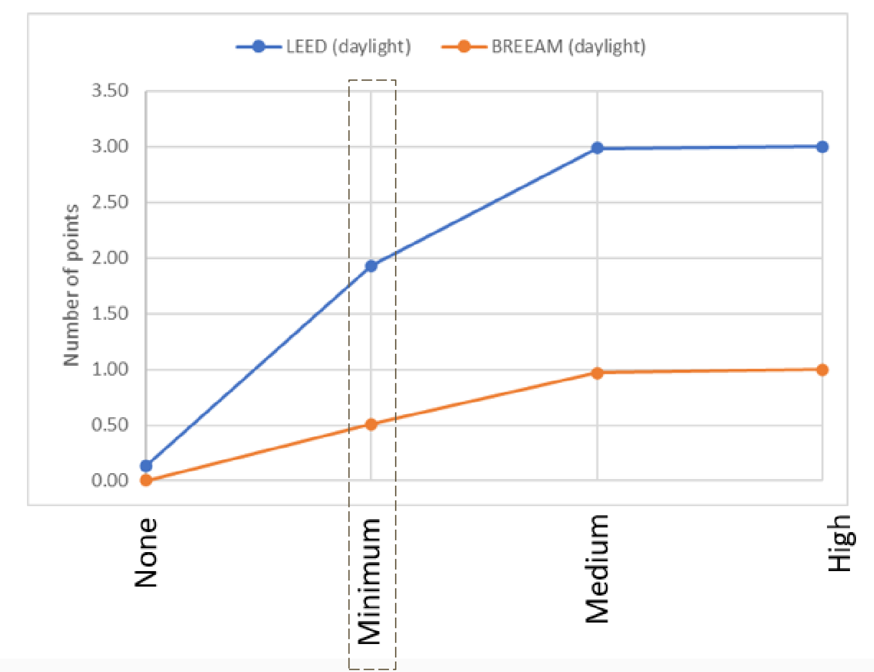
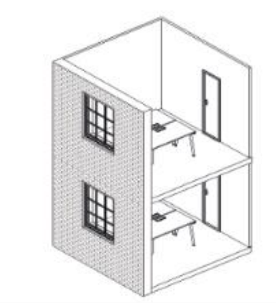


Figure 24, Effect on daylight points (Minimum)



Minimum

Effect on BREEAM and LEED

Daylight

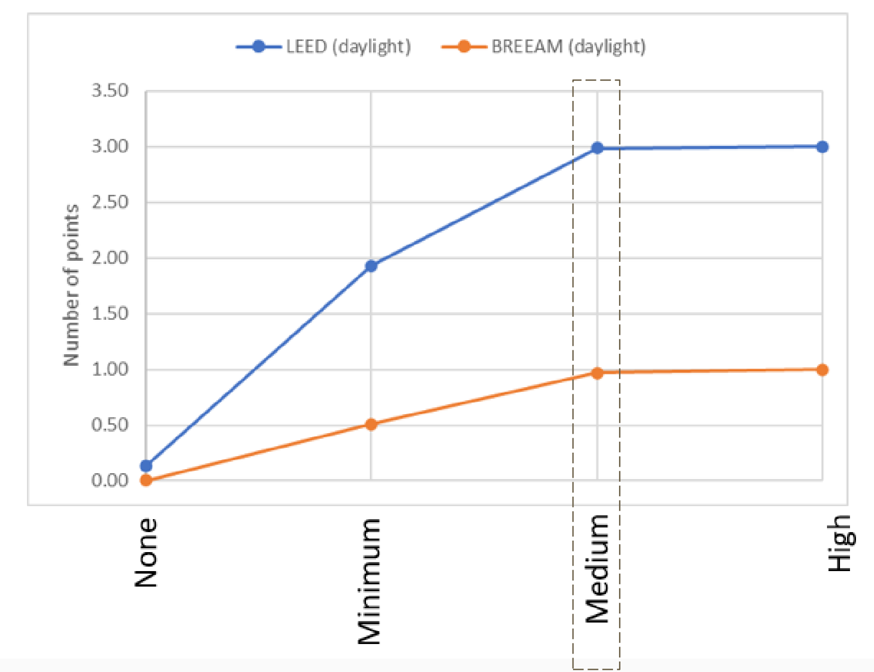
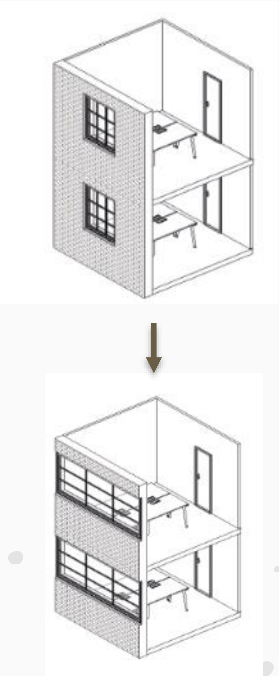


Figure 25, Effect on daylight points (Medium)



Effect on BREEAM and LEED

Daylight

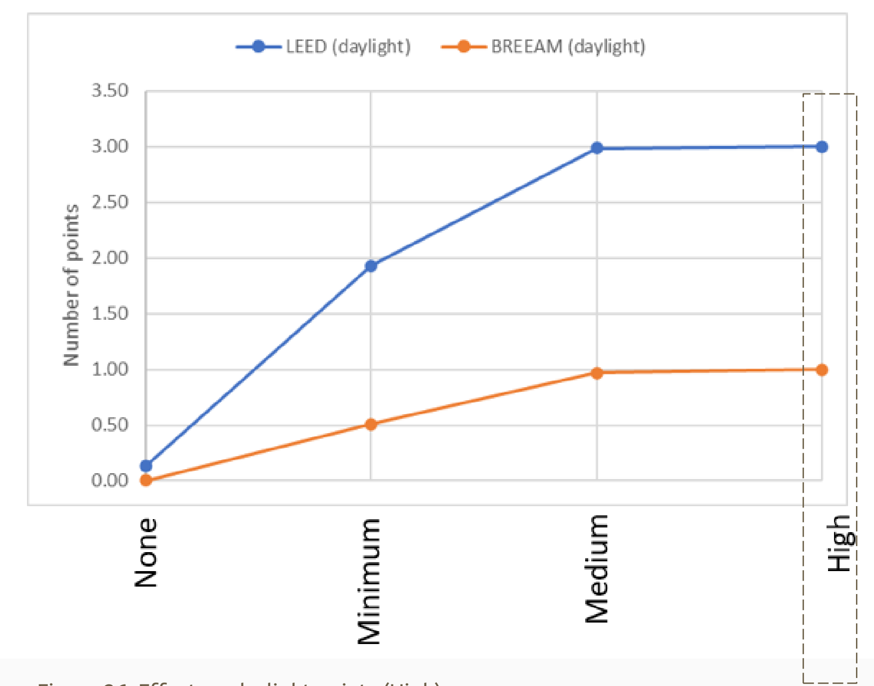
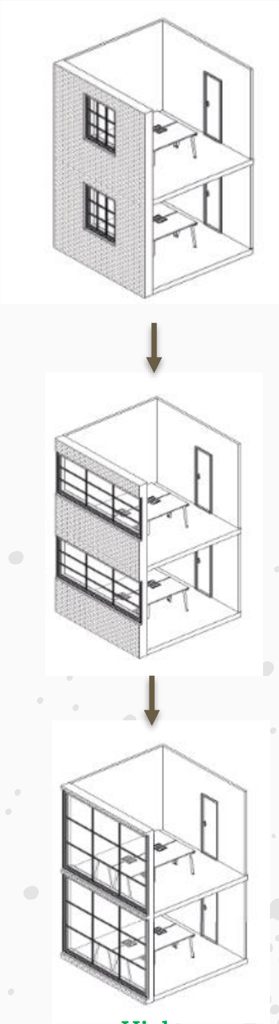


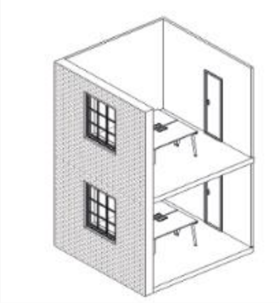
Figure 26, Effect on daylight points (High)



High

Effect on BREEAM and LEED

Energy



Minimum

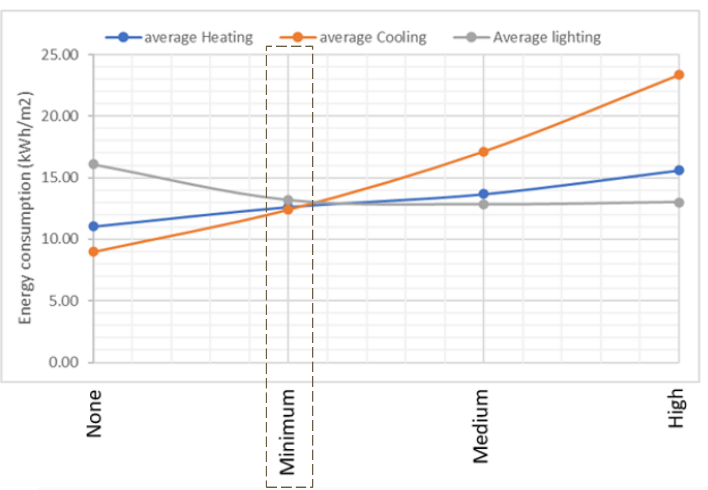


Figure 27, Effect on HVAC energy consumption (Minimum)

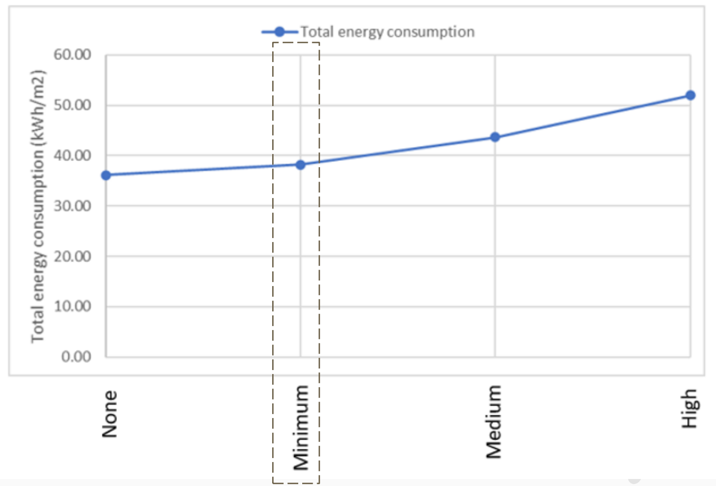


Figure 28, Effect on total energy consumption (Minimum)

Effect on BREEAM and LEED

Energy

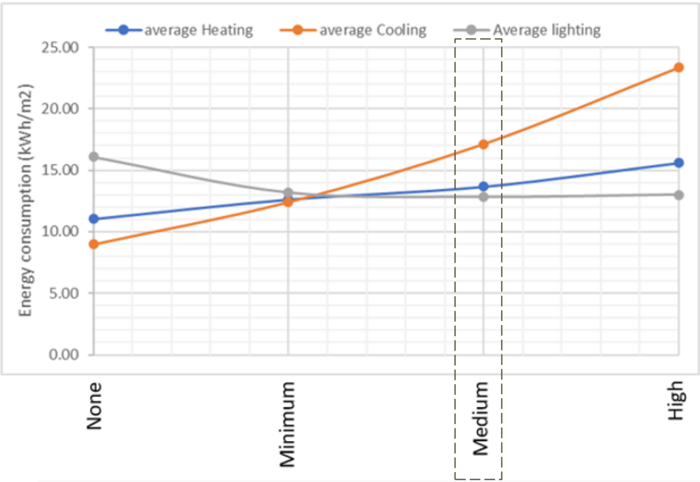


Figure 29, Effect on HVAC energy consumption (Medium)

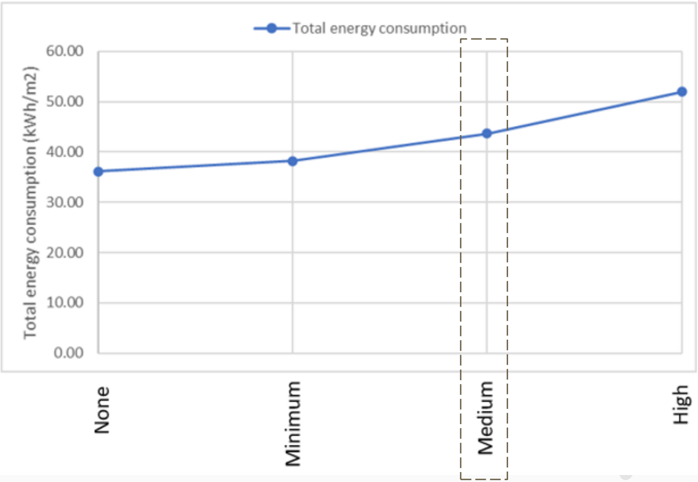
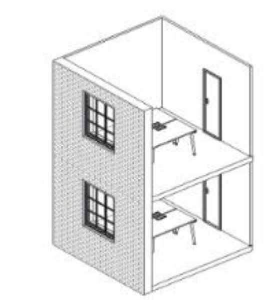
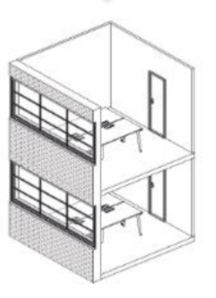


Figure 30, Effect on total energy consumption (Medium)





Medium

Effect on BREEAM and LEED

Energy

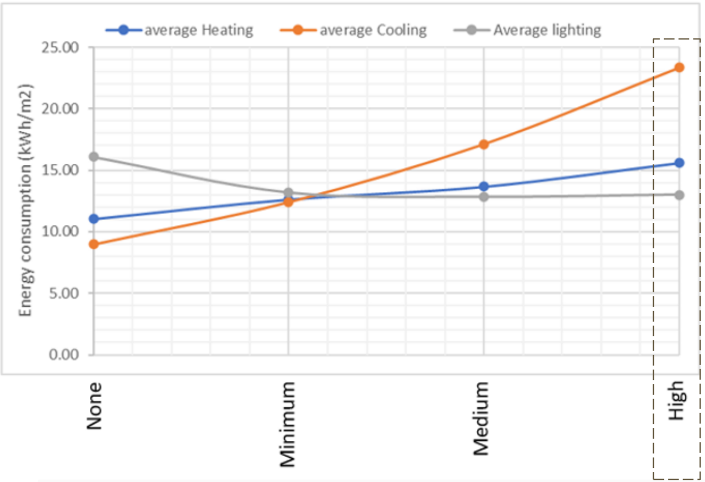


Figure 31, Effect on HVAC energy consumption (High)

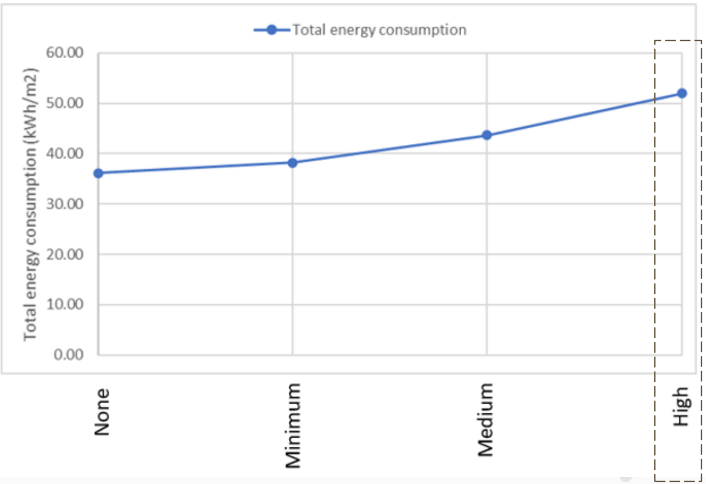
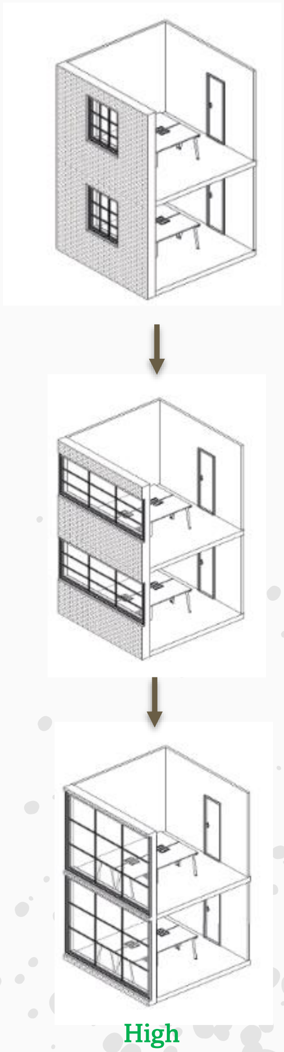
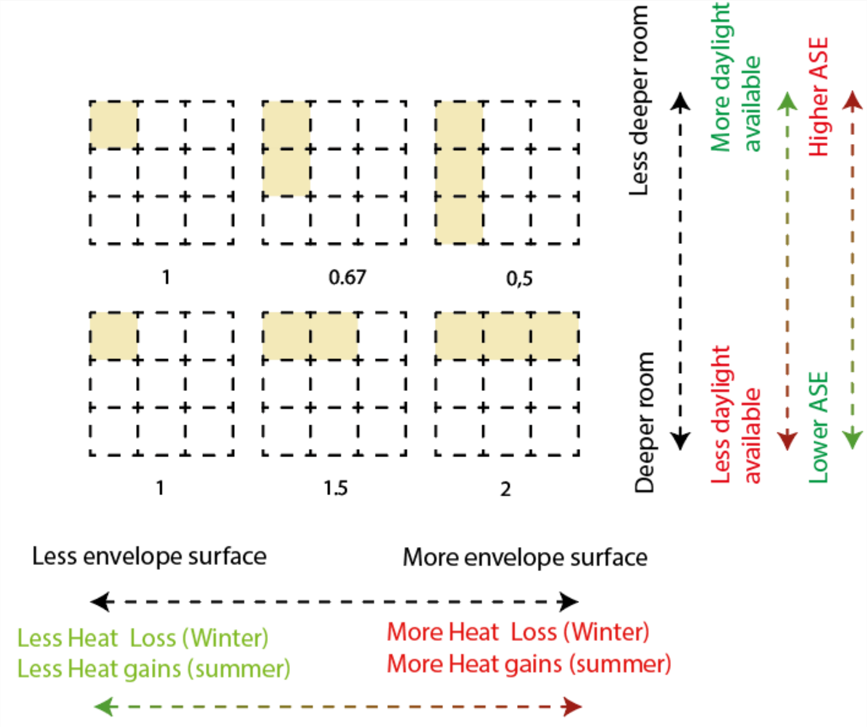


Figure 32, Effect on total energy consumption (High)

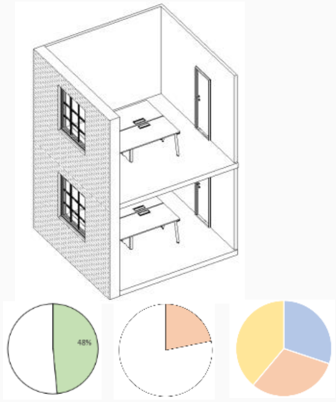


Influential parameters

Width/depth ratio

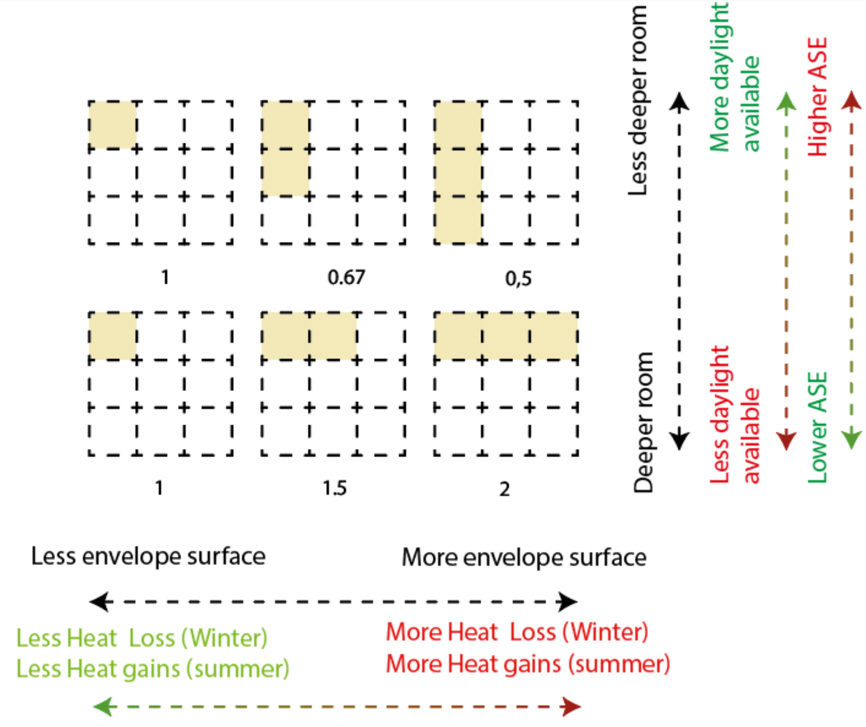


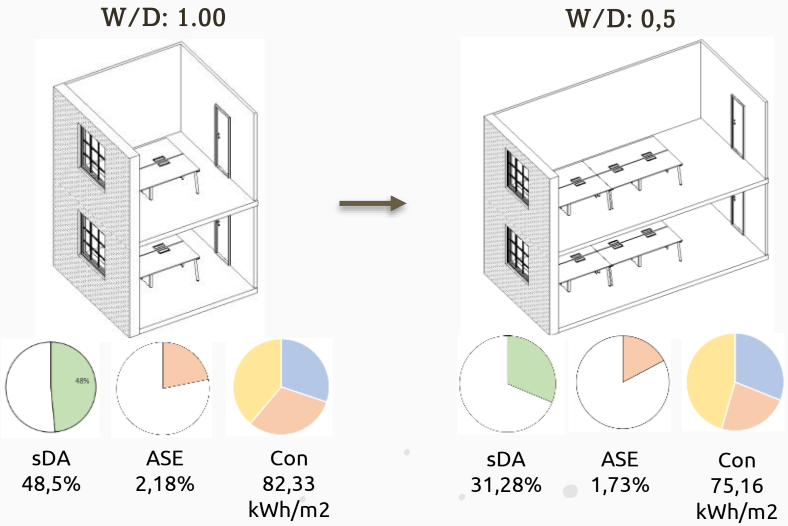
W/D: 1.00



Influential parameters

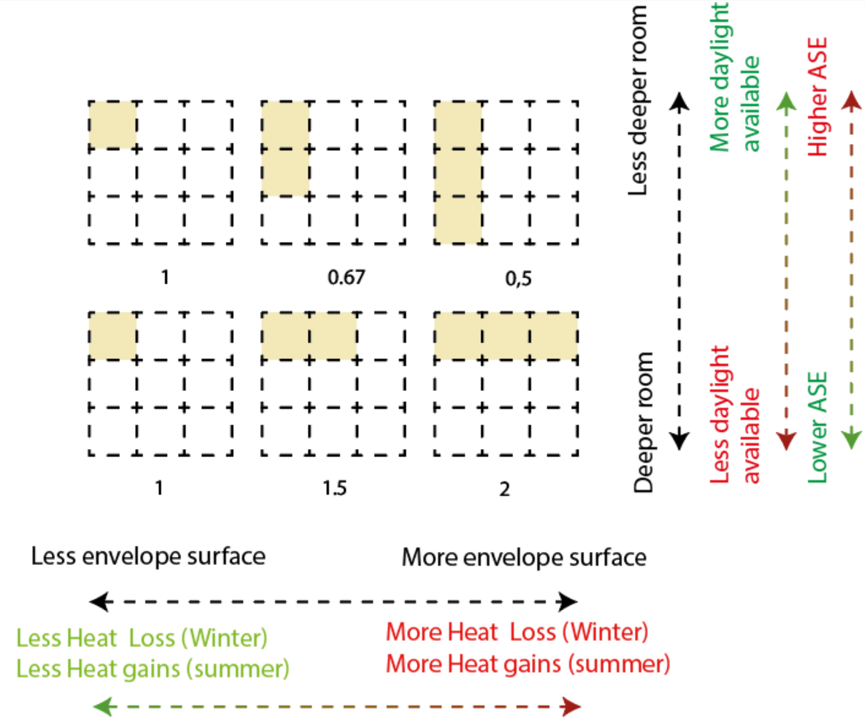
Width/depth ratio





Influential parameters

Width/depth ratio



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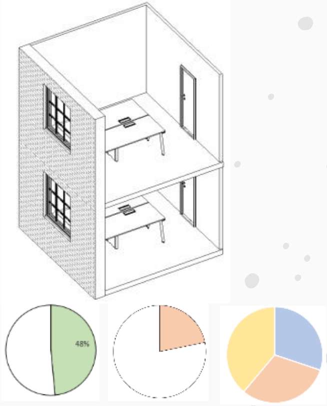
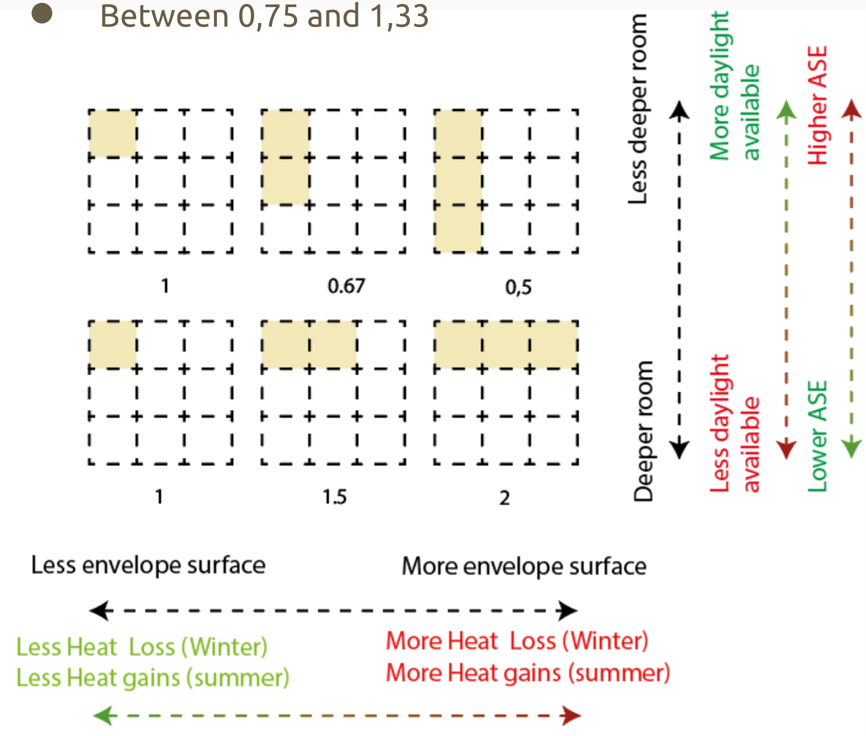
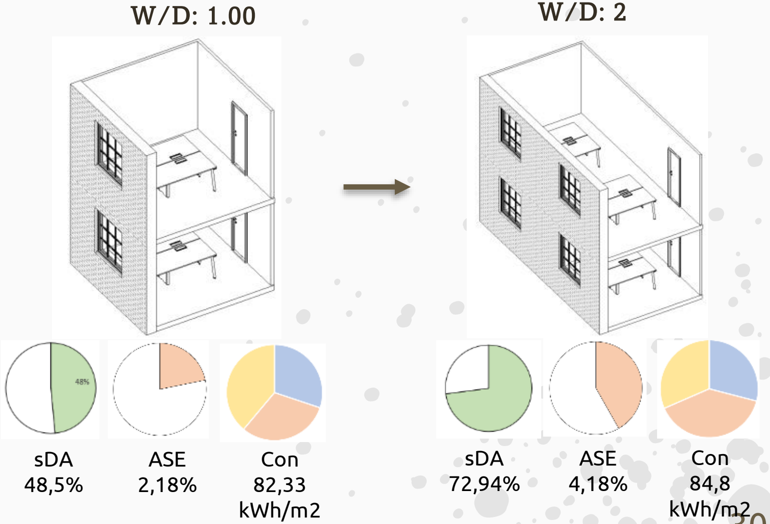


Influential parameters

Width/depth ratio

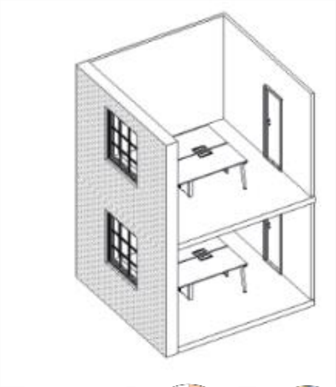
- Between 0,75 and 1,33





Influential parameters

Fixed shading device



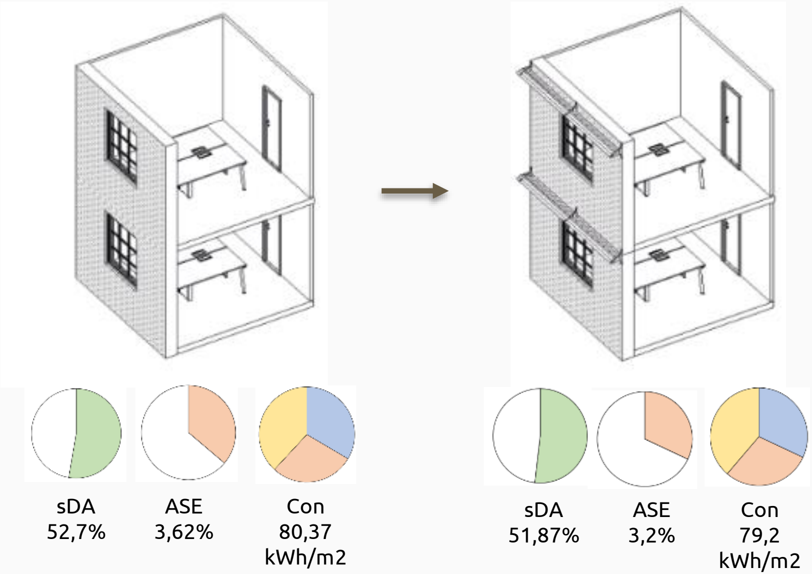
sDA
52,7%

ASE
3,62%

Con
80,37
kWh/m2

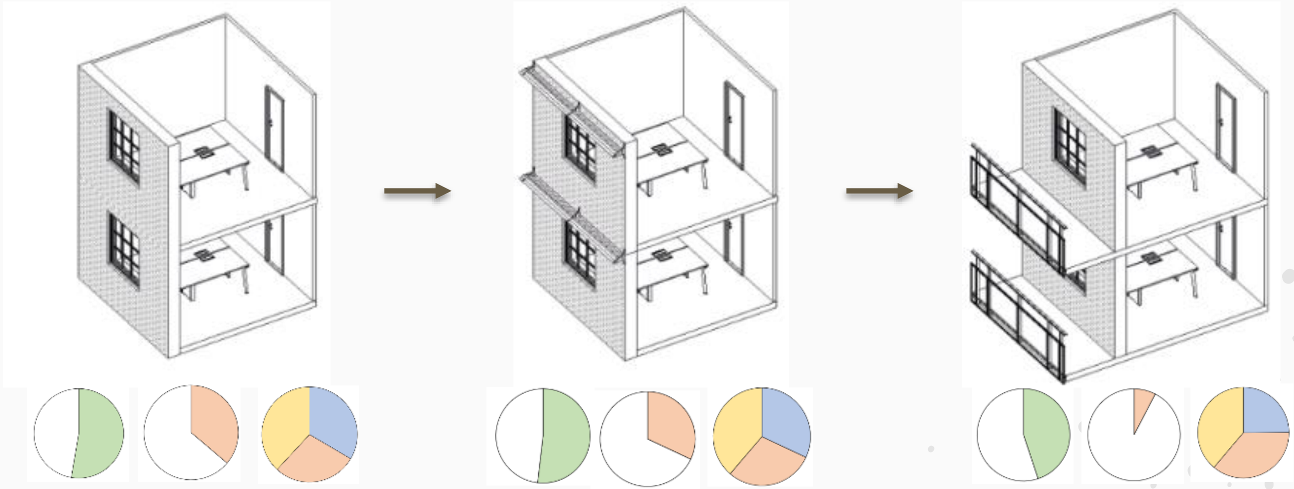
Influential parameters

Fixed shading device



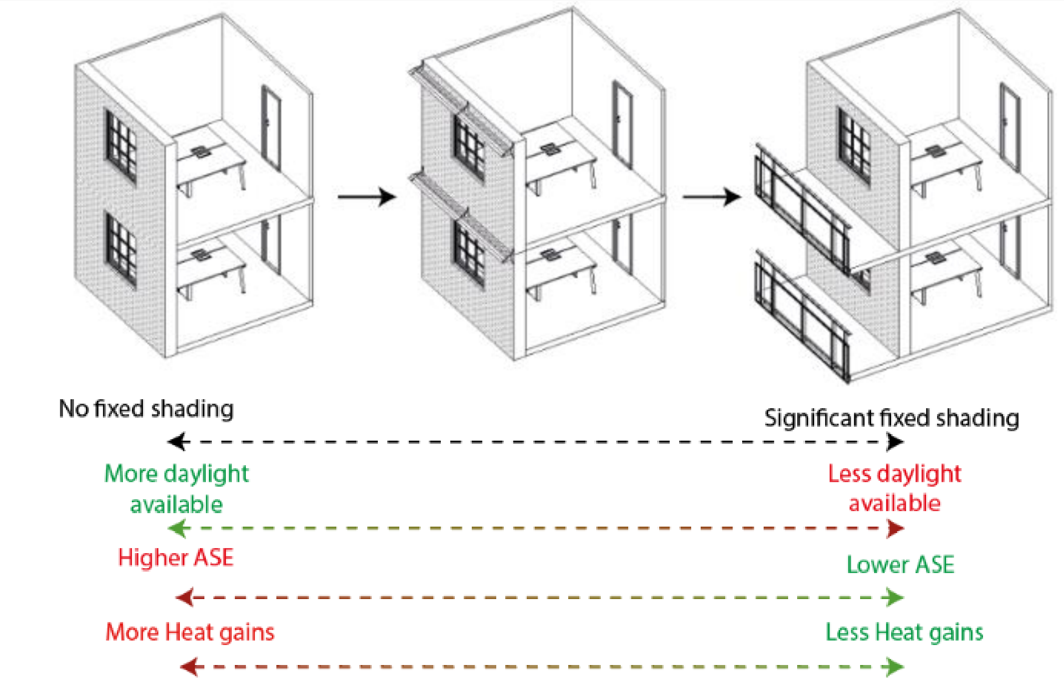
Influential parameters

Fixed shading device



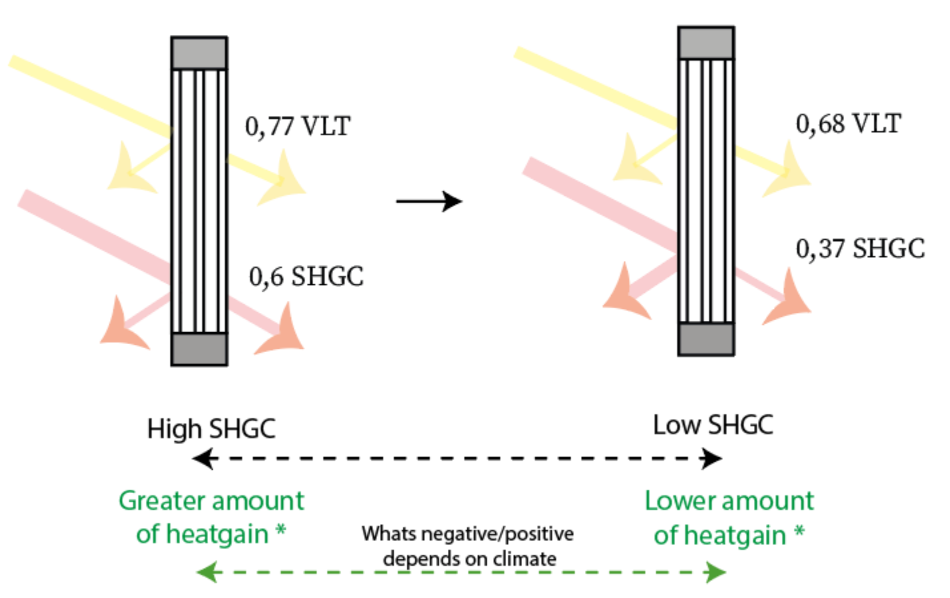
Influential parameters

Fixed shading device



Influential parameters

SHGC and VLT



SHGC = Solar heat gain coefficient

VLT = Visible light transmittance

Conclusion

- If the requirements for daylight provision for the EN 17073 are met, it is still possible to apply for green building certificates
- High recommendation level, energy consumption will increase on average by 8.33 kWh/m2 compared to the minimum recommendation level
- If the optimal orientation for the European norm is used (SE and SW) , energy consumption will be higher
- Blinds will affect the lighting consumption
- For daylight requirement, it does have a positive influence. With medium and high, all points are obtained for daylight for green building certificates. Only pay attention to ASE
- Most important parameters: Window-to-wall ratio and width/depth ratio. Fixed shading device can lower the ASE and cooling consumption in the right scenario