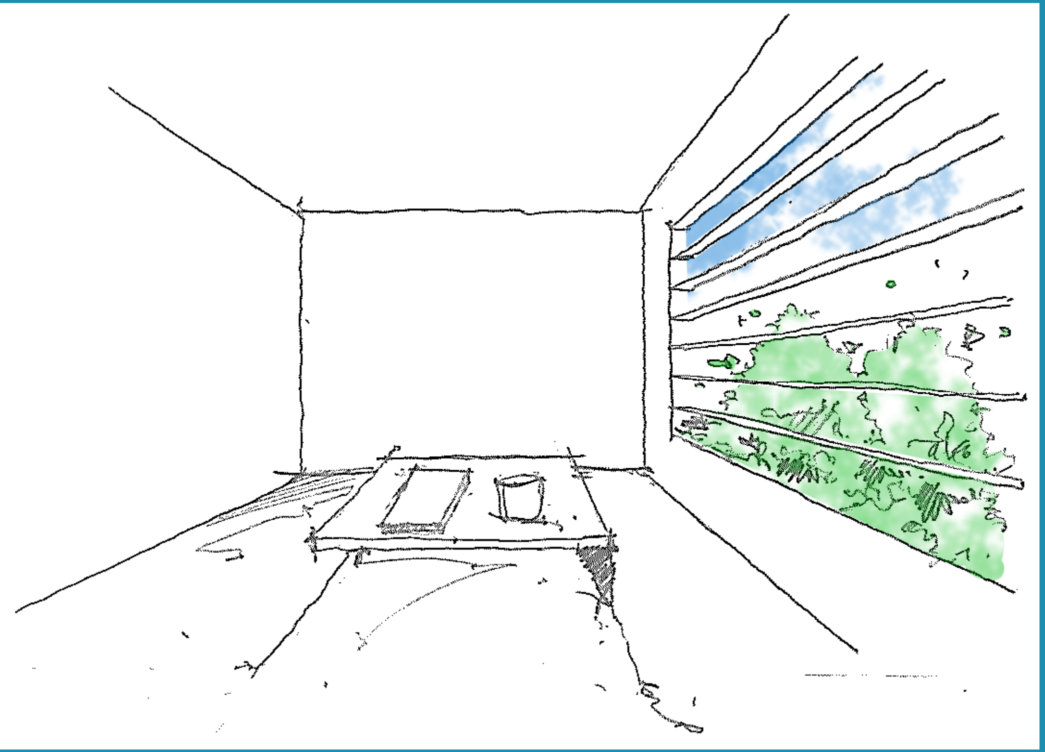
Environmental performance of window systems in patient rooms: a case study in the Belgian context



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Importance of Window Systems

- Energy consumption
- Heat flow
- Environmental impact
- Solar gains
- Indoor environmental quality
- Aesthetics
- Health and productivity

→ Daylight

View

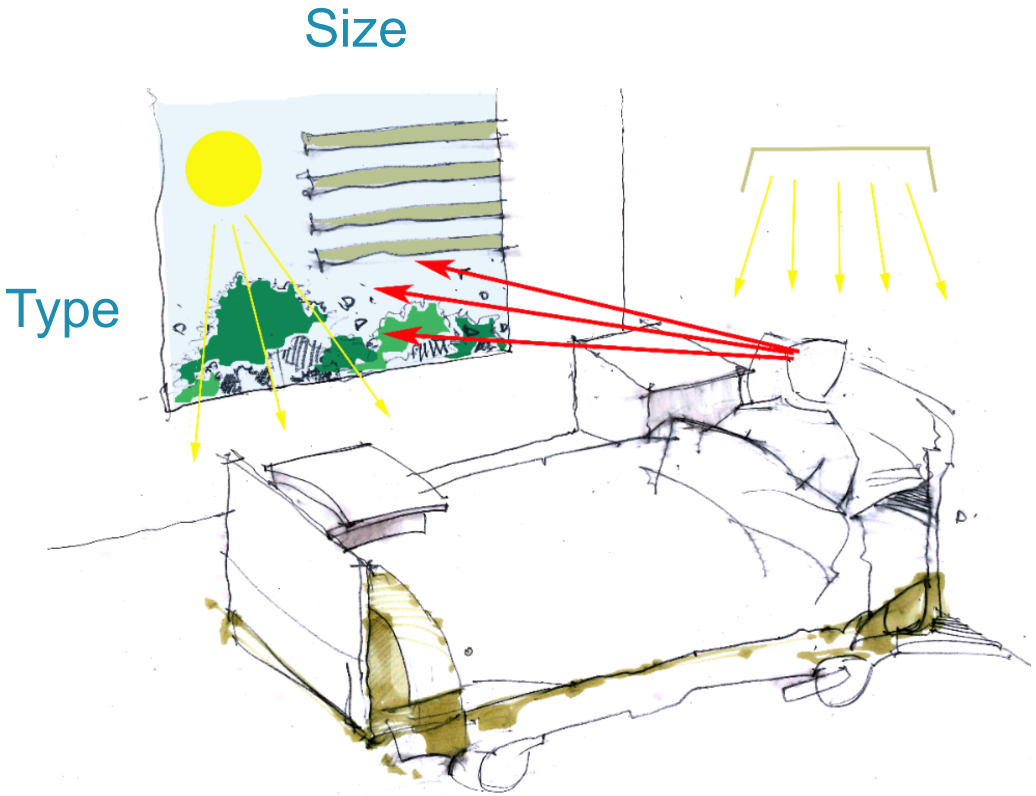
Design geometry

Building function

Climate

Orientation

Occupants needs



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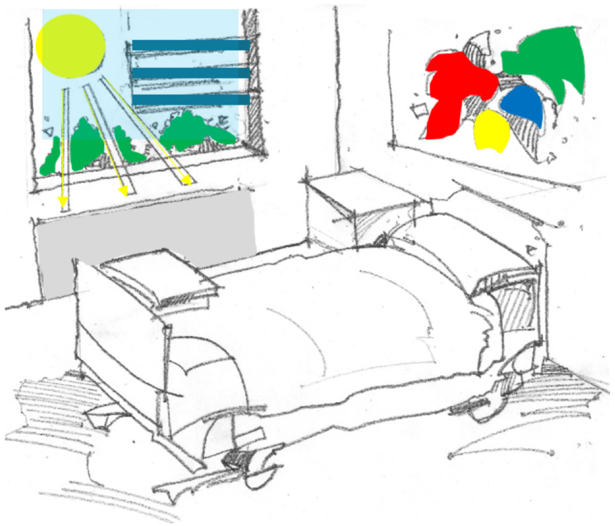
Aims and Objectives

Integrated performance analysis of window systems in patient rooms

- Energy use/cost
- Life cycle environmental impact
- Daylighting

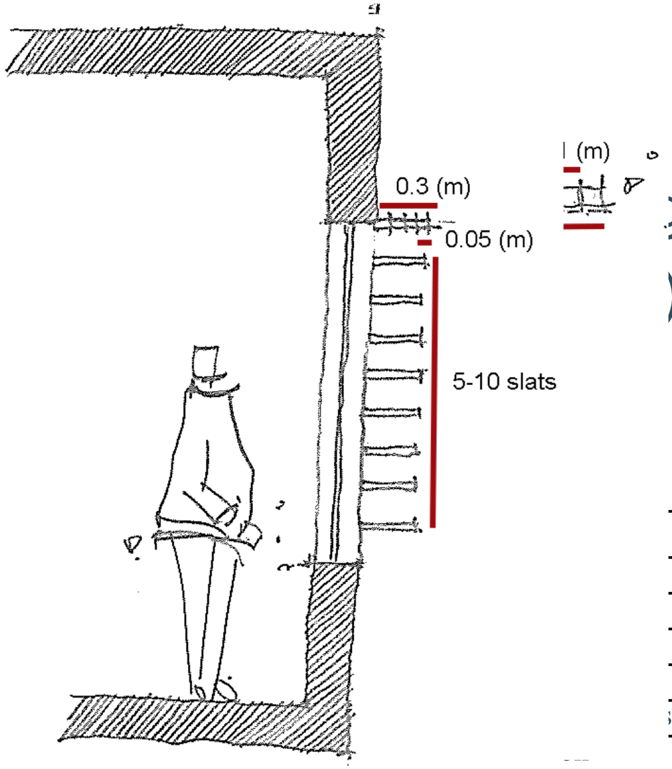
Type of glazing

Shading device



Simulation Model Description

- Location: l
- One exter g window
- External v)

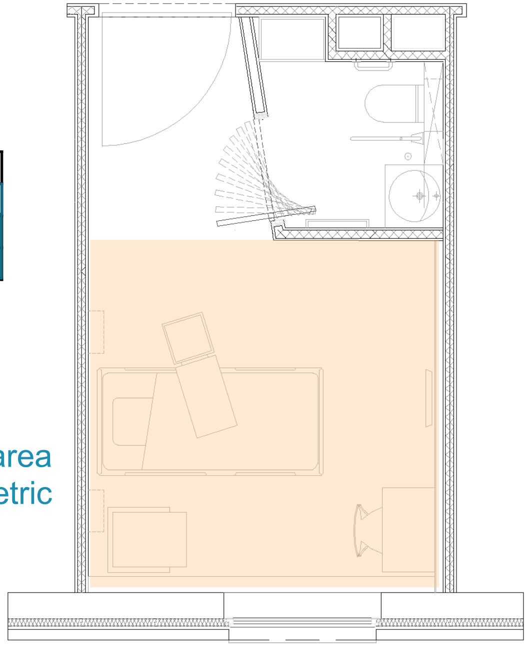


Value of parametric variables

Variables	Minimum	Maximum	Step
Overhang depth	0.5 m	1.0 m	0.10 m
Slat depth	0.1 m	0.3 m	0.05 m
Number of slats	5	10	1

GLZ [Tvis/g-value]	C		U-value (W/m²K)
GLZ1 [0.82/0.80]	4-		2.50
GLZ2 [0.73/0.41]	4-		1.10
GLZ3 [0.61/0.31]	6-		1.10
GLZ4 [0.76/0.74]	4-		1.70
GLZ5 [0.75/0.53]	4-	sion + g-value)	0.60
GLZ6 [0.68/0.38]	4-		0.60

The patient room area considered for parametric model dimension



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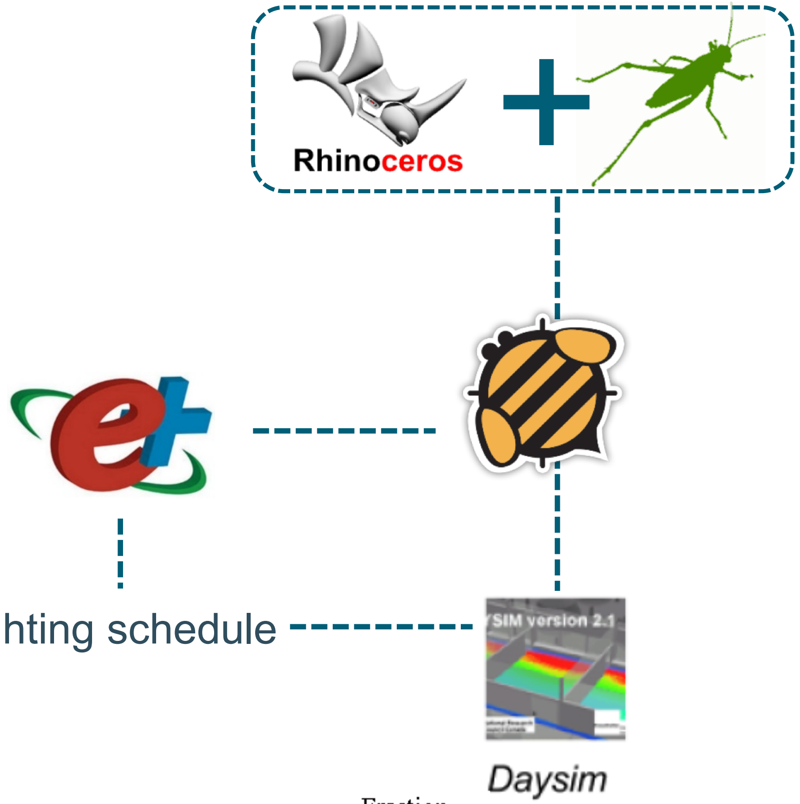
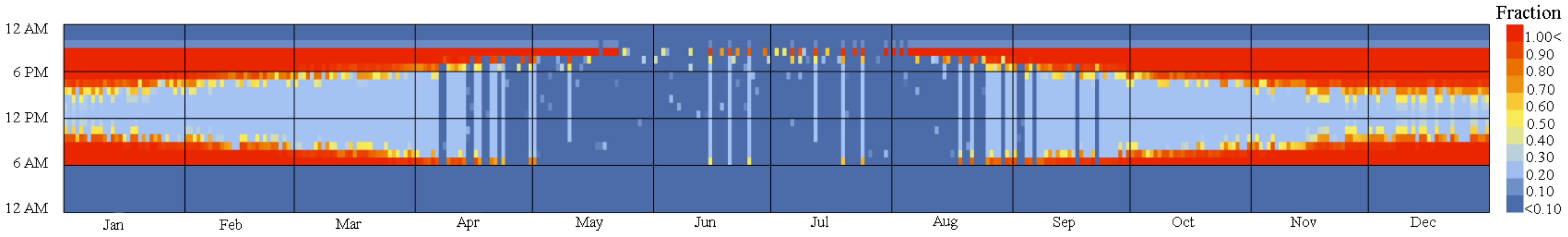
Methodology: Energy Analysis



Simulation engine: EnergyPlus

Patient room:

- One external wall
- Adiabatic internal walls and floors
- Ideal load system
- Daylight-linked control lighting
- Detailed glazing system modelling (WINDOW 7.6 software)



Lighting switch profile
Fraction - Hourly

Sample daylight-linked control lighting annual schedule map

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Methodology: LCA

MMG+_KU Leuven tool

MMG* method

Quantify the environmental performance of building elements for the Belgian context

LCI data from Ecoinvent are adapted to the Belgian context

'Cradle-to-grave' LCA
Production, construction, use, end of life

*Milieugerelateerde Materiaalimpact van Gebouwelementen

MMG+_KU Leuven tool

Excel-based calculation tool

Calculates the impacts and shows the results in a graphical way

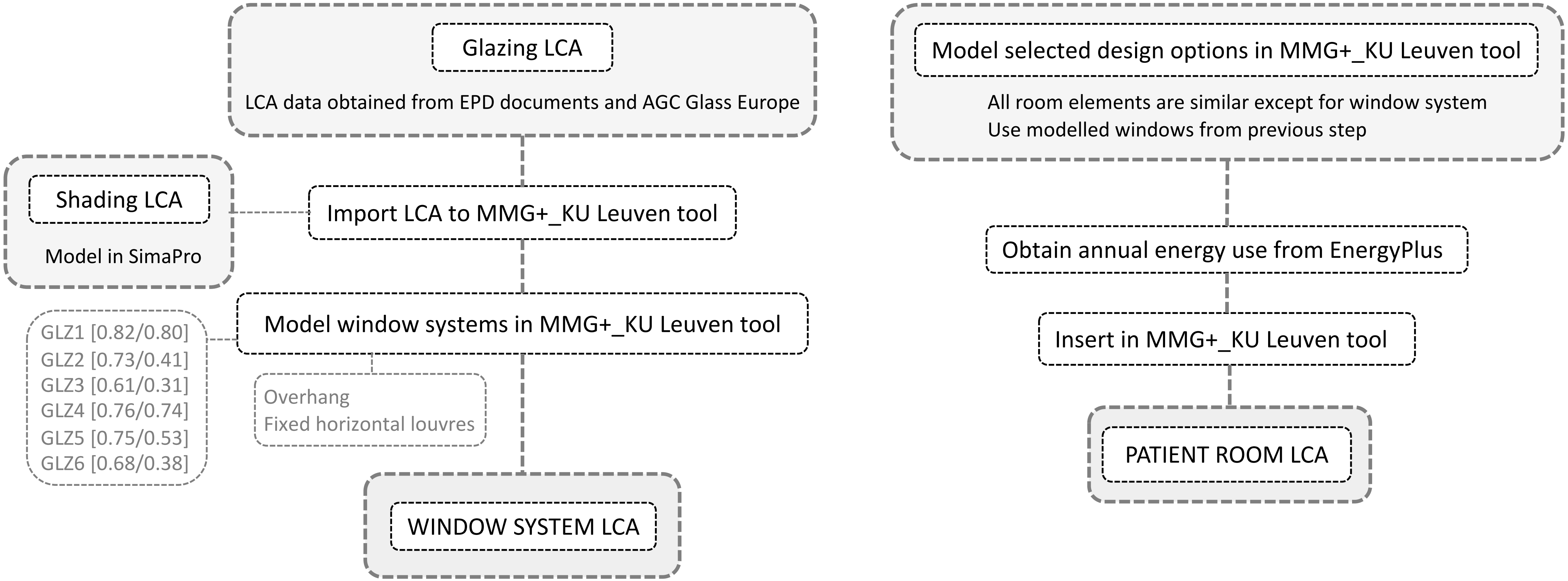
Environmental indicators
CEN & CEN+

For each impact category the results are expressed as characterised results (equivalents) and as environmental costs (monetary values, €)

CEN+ Indicators
Human toxicity
Particulate matter
Ionising radiation: human health
Ionising radiation: Ecosystems
Ecotoxicity
Water scarcity
Land occupation
Land transformation

CEN Indicators
Global warming
Ozone depletion
Acidification for soil and water
Eutrophication
Photochemical ozone creation
Abiotic depletion resources - elements
Abiotic depletion - fossil fuels

Methodology: LCA



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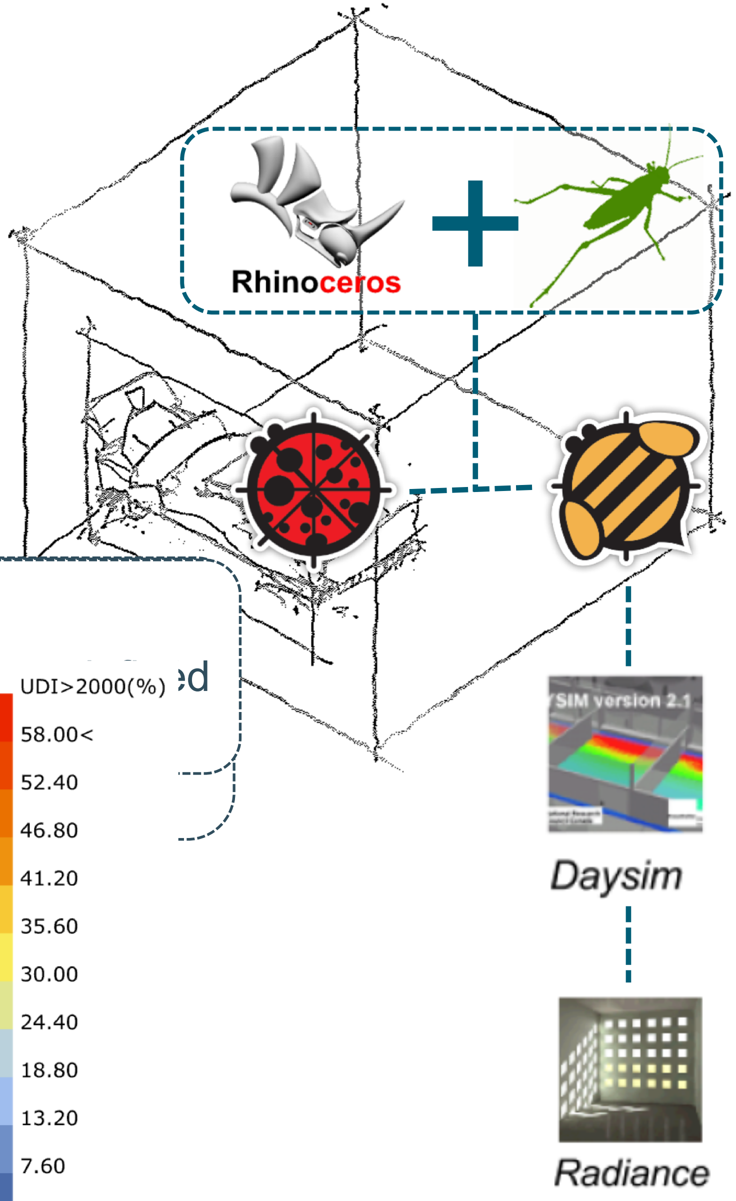
Methodology: Daylighting & Visual comfort



Daylighting & visual comfort metrics

- sDA (spatial Daylight Autonomy)
- UDI (Useful Daylight Illuminance)

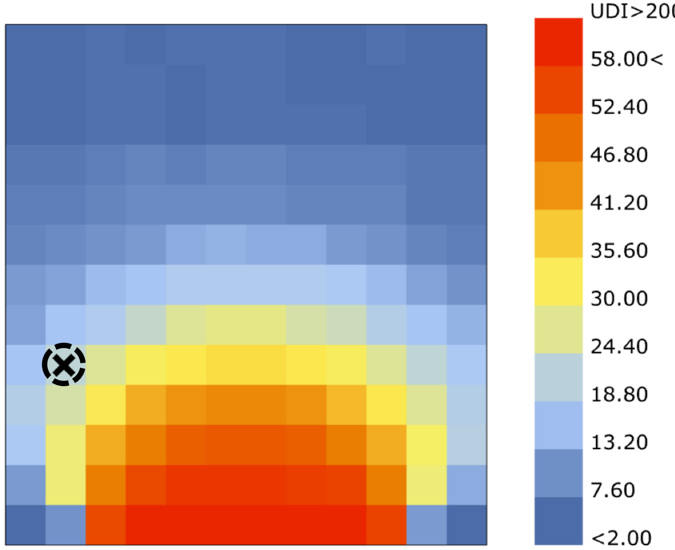
$UDI_{100\text{-}2000lux}$

The day ... ed
as *usefu*
least 50

Daylighting simulation model:

- Analysis points (sensors): 0.3 m spacing grid
- Task plane: 0.90 m (bed surface)
- Reference sensor: patients position in bed

Patients position



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Methodology

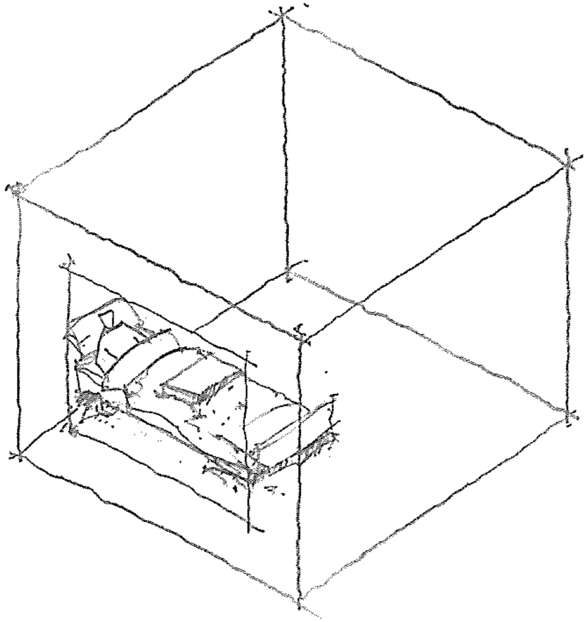
Design performance evaluation criteria:

- Lower energy and environmental costs
- Minimum sDA value of 50% (sDA ≥50%)
- Higher visual comfort

Step 1: design options with no shading — Benchmark design

Step 2: design options + shading device — Select best performing options

Step 3: side-by-side comparison — Selected design options + Benchmark design



Result and Discussion: Step 1

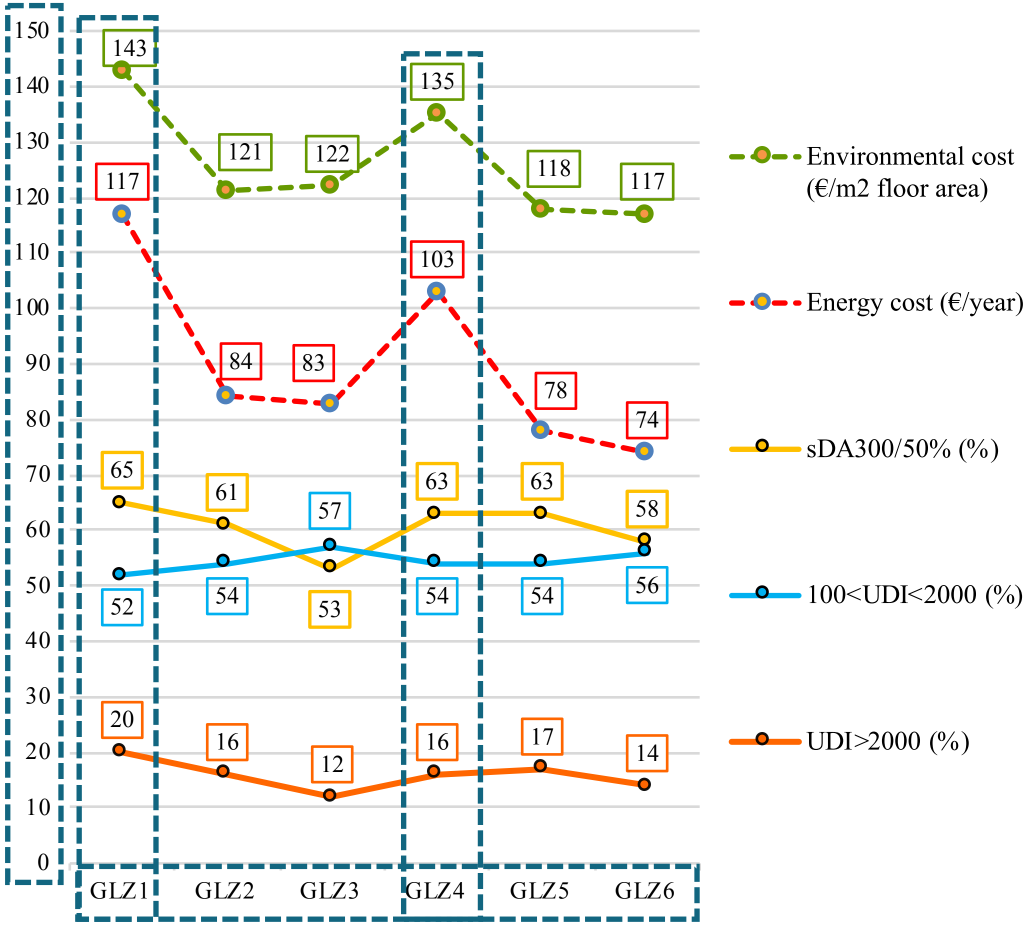
No shading – Benchmark designs

Highest energy and environmental cost

- uncoated glazing (GLZ1, GLZ4)
    - Higher heating and cooling loads

Least energy and environmental cost

- Coated triple pane glazing
    - Lower cooling and heating loads



Benchmark designs performance without shading device (40% WWR – South orientation)

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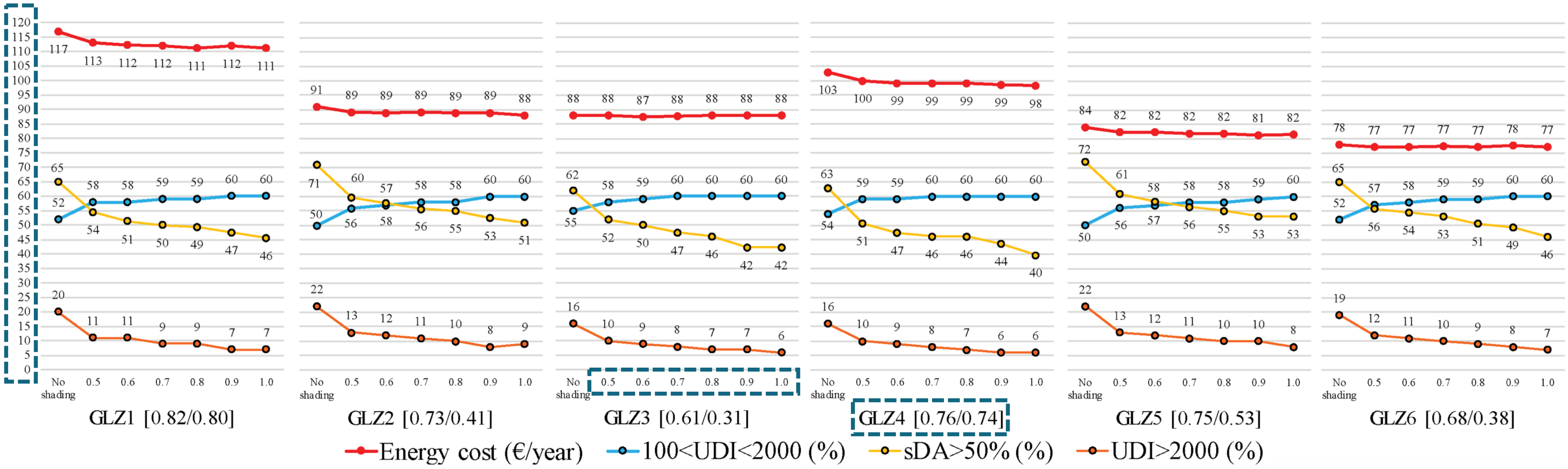
Step 2: Overhang



- Decreases daylighting levels ($sDA_{300/50\%}$>50%)
  - Increase the useful daylighting levels and visual comfort (lower UDI>2000lux)

Step 2: Overhang

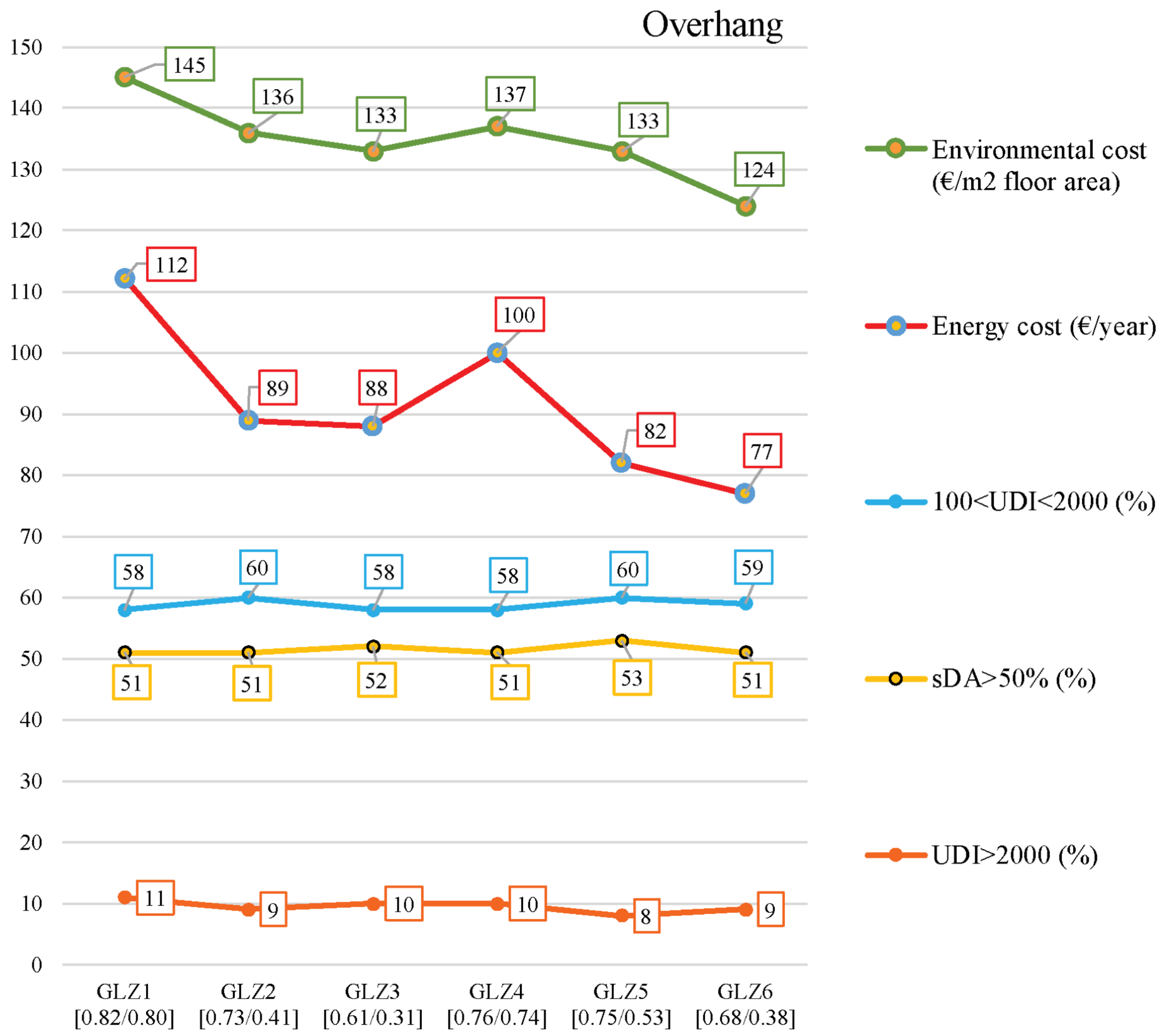
Selected design options

Highest life cycle environmental impacts

- uncoated glazing (GLZ1, GLZ4)
    - High operational energy use

Lowest life cycle environmental impacts

- GLZ6 (TG, lowest U-value, g-value: 0.38)
    - Lower cooling load



Coated glazing:

Environmental costs > Benchmark design

- Increase in window size (50% WWR)
    - Higher quantities of shading material and energy loads

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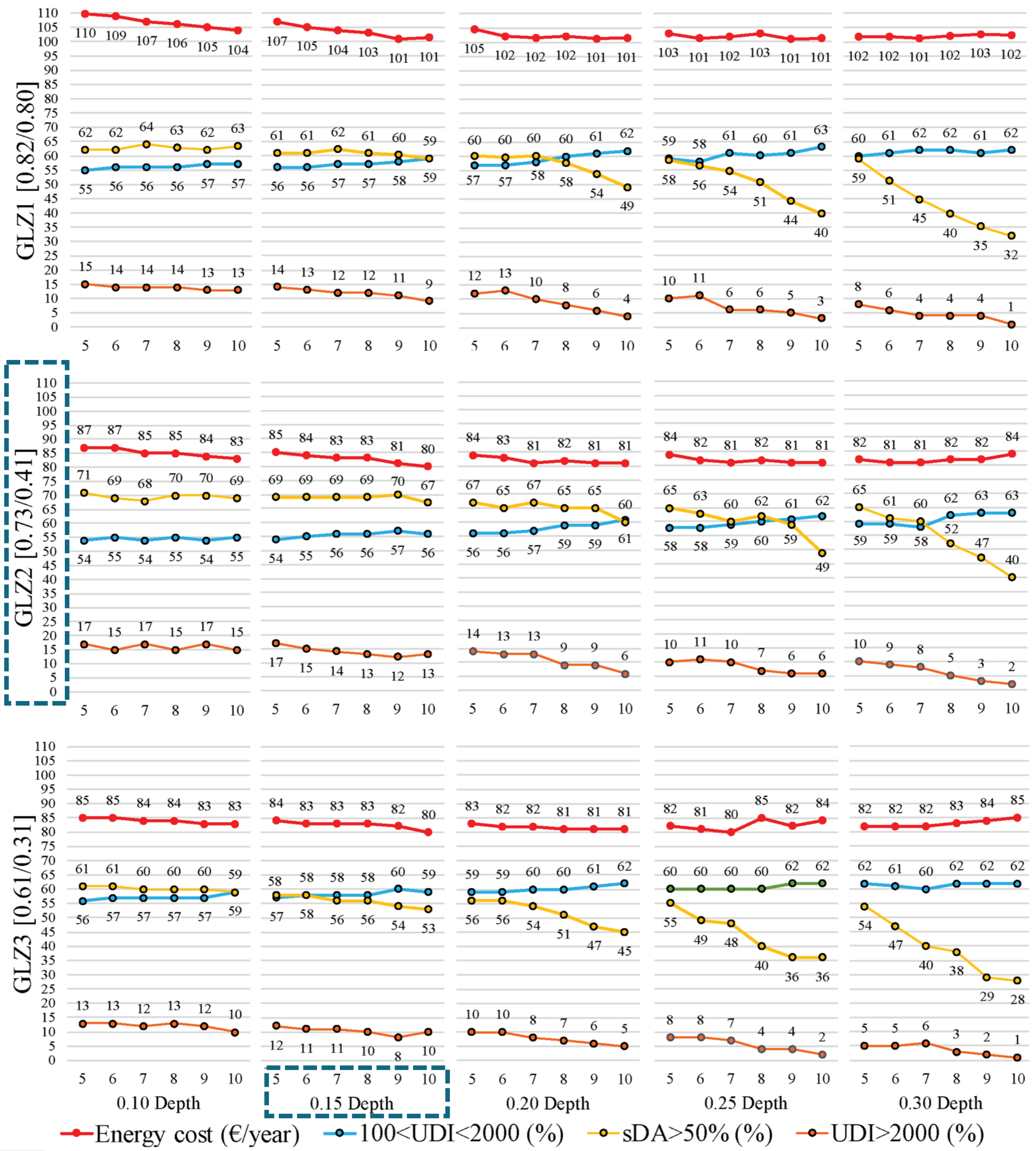
Step 2: Horizontal Louvres

Main difference (each glazing type):

- Daylighting levels
- $UDI_{>2000lux}$

- Energy cost is similar



Step 2: Horizontal Louvres

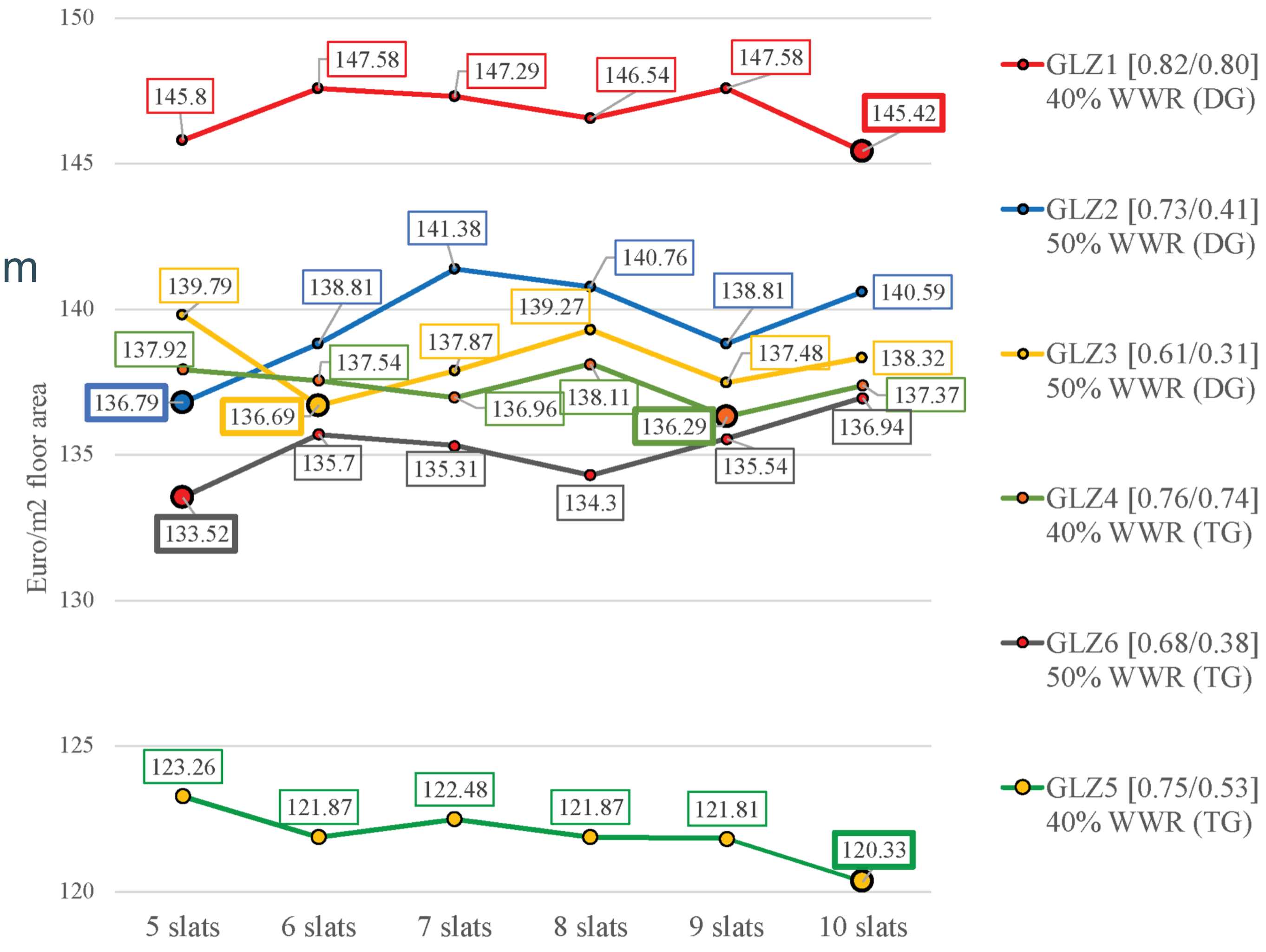
Selected design options

Environmental impact

- Quantity of material used for the shading system

Optimal design option

- Differs based on the project goals



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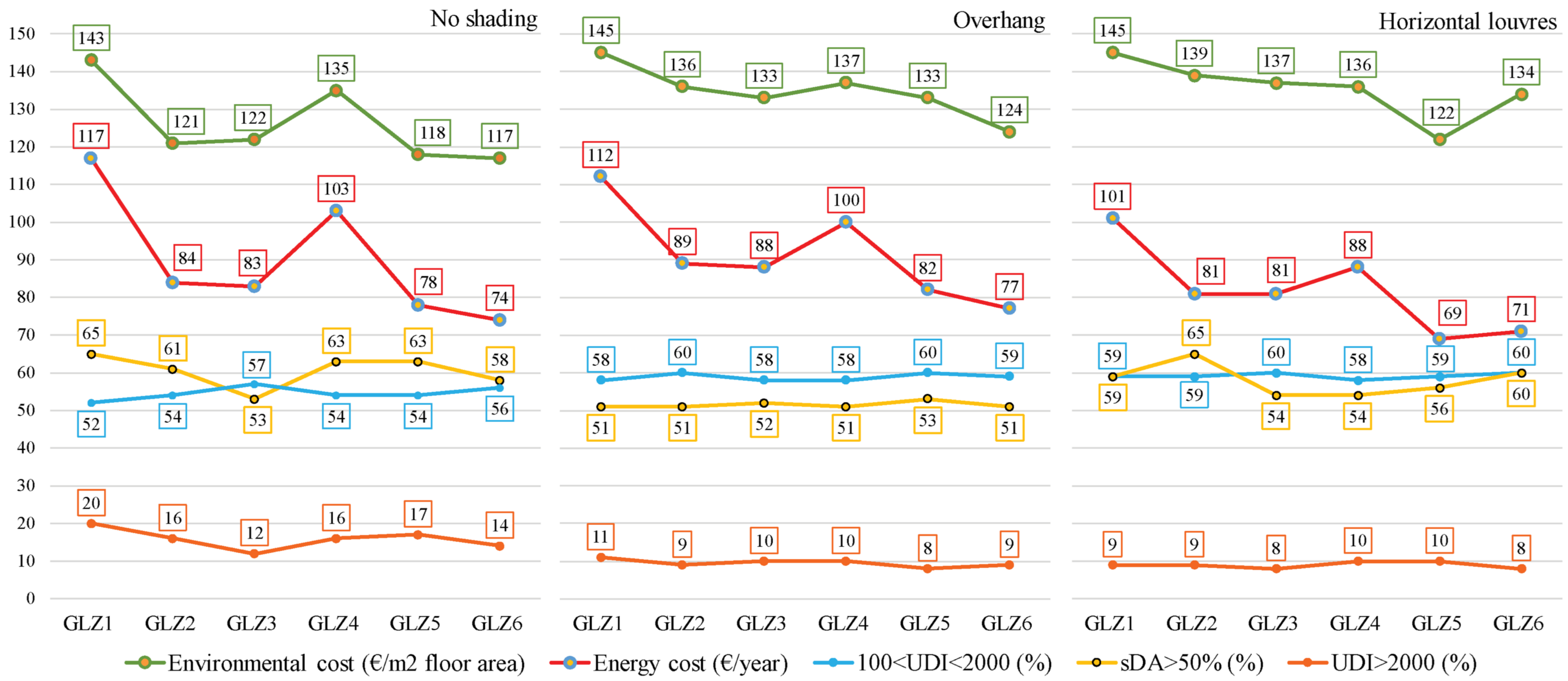
Step 3: Side-by-side comparison



Fixed horizontal Louvres show higher UDI>2000 interval values (compared to) environmental cost

- Reduce likely appearance of glare and increase visual comfort.

- environmental cost

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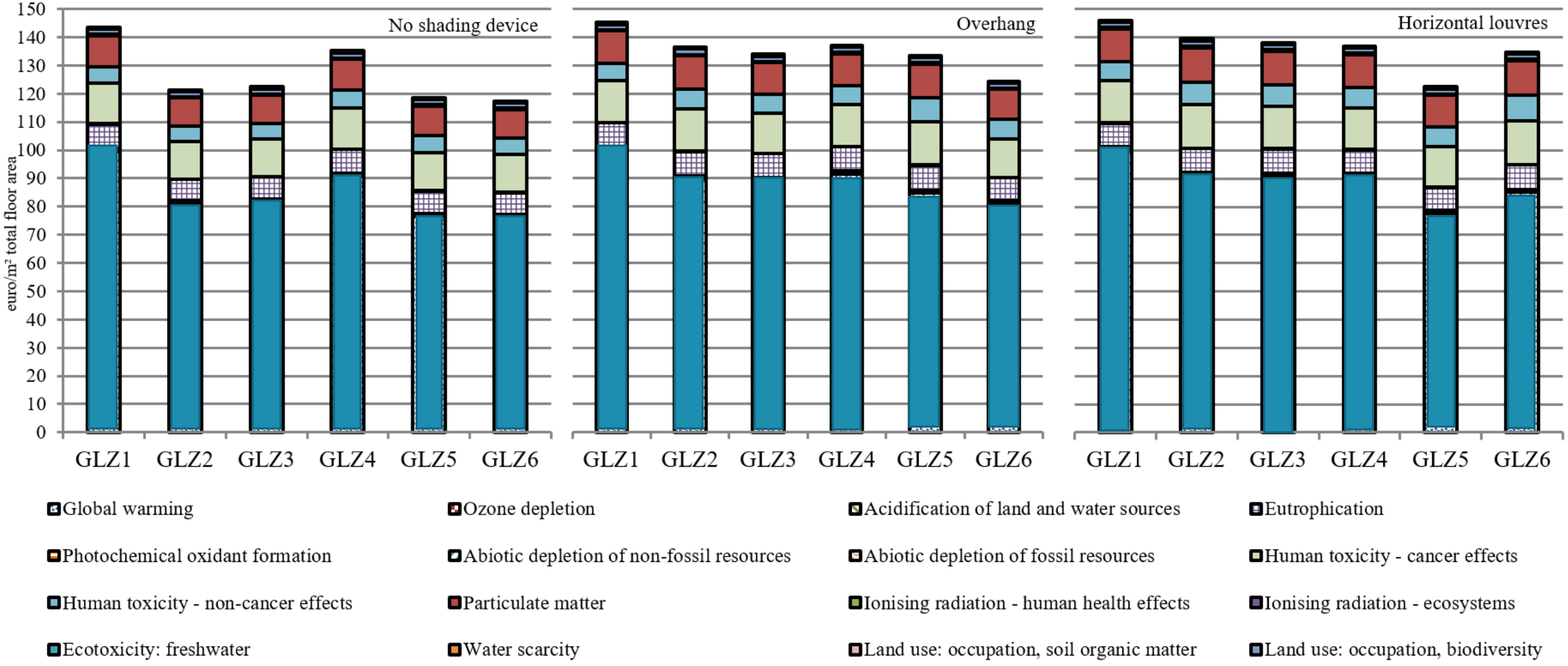
Step 3: Side-by-side comparison



Global warming has the highest impact in all cases

Least environmental impact: Coated triple pane glazing (GLZ5 and GLZ6)

- Lower operational energy use for heating and cooling

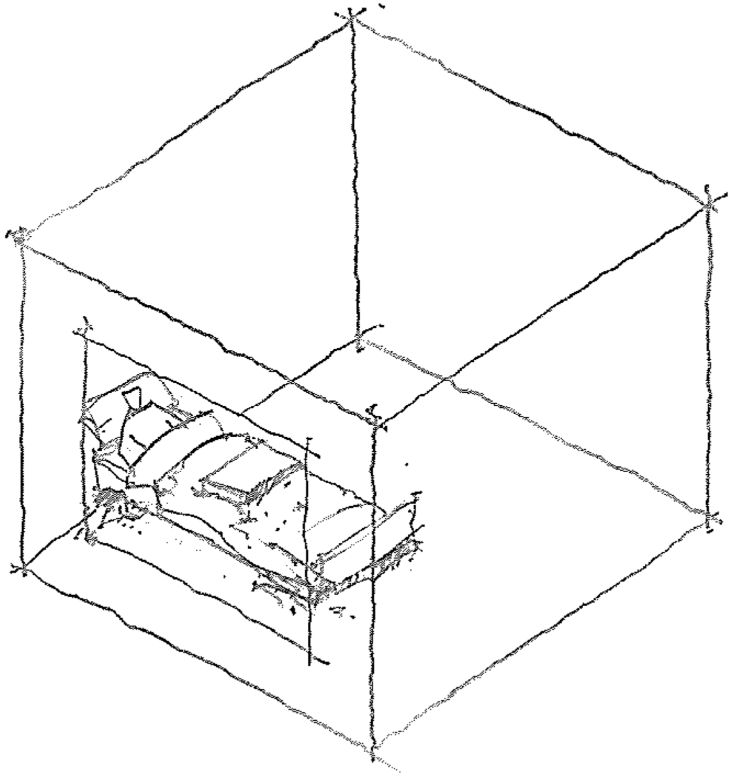
Conclusion

- Major impact of glazing characteristics and window system configuration on performance
  - Careful selection during the early design process

- Environmental impacts > window size + quantity of shading material

- Environmental impacts: Coated glazing < Uncoated glazing

- Most significant environmental impact indicators:
  - Global warming
  - Particulate matter formation
  - Human toxicity (cancer effects)



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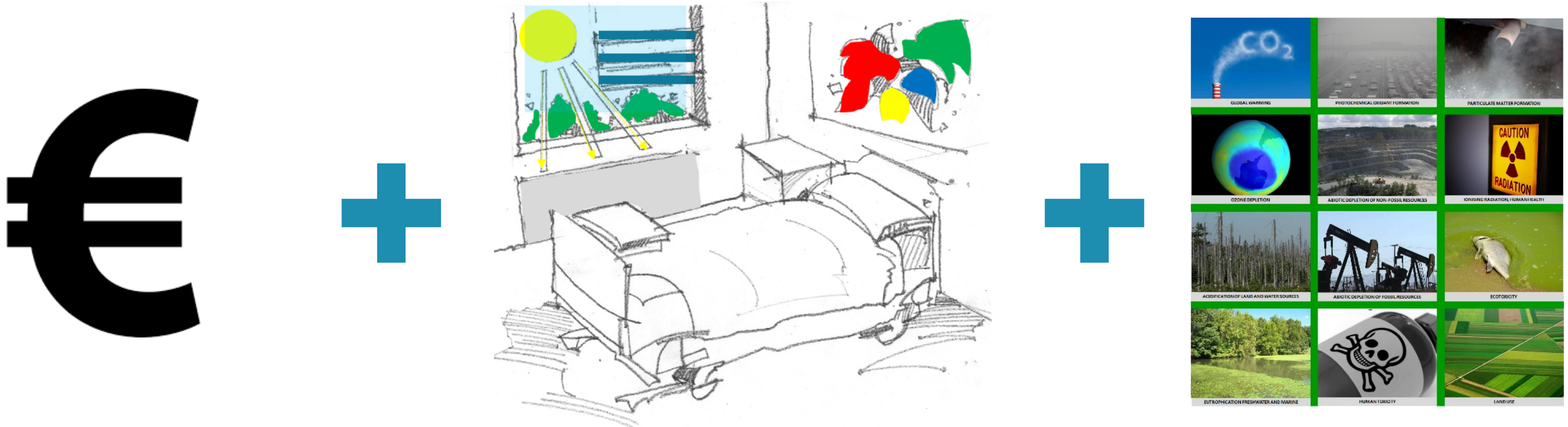
Conclusion

- An **integrated approach** is necessary to obtain a correct insight into the windows performance.
- A parametric study which considers the effect of different metrics on the design options can **support architects** in understanding the cross effects.
- This approach can support the choice of the most preferred window system design solution based on the **project goals**.



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Thank you for your attention!

Questions and comments?

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