Sustainability Assessment of Advanced Window Systems

PhD Research   PhD student: Nazanin Eisazadeh   Promotor: Prof. Karen Allacker   Co-promotor: Prof. Frank De Troyer

Research Information

Keywords

Window systems, Energy efficiency, Environmental impact, Comfort

Introduction / Context

Using glazing in the building envelope provides daylight, views and ventilation and windows can hence contribute significantly to indoor environmental quality. In order to avoid high energy consumption in buildings, selecting the appropriate size, proportion, shape, location and type of window along with the orientation and shading is a very important issue to address in the early design stage. The challenge is to provide a balance between energy efficiency, occupant comfort and saving resources. This can be achieved by obtaining an integrated performance analysis where the link between various window design parameters and their combined effect on energy consumption, comfort, environmental impact and cost are considered.

Aims and Objectives

Investigating the impact of window systems and design on the energy efficiency, environmental impact and cost of places where occupants spend substantial time inside; patient rooms, elderly housing, etc.

Exploring and determining the relationship between window systems and design on indoor environmental conditions, daylighting, comfort & health.

Question / Goal

- To what extent do window systems influence energy use, environmental impact, cost and comfort?
- How can architects design the optimal window system and geometry regarding energy efficiency and daylighting?

The goal is to create a set of guidelines, an improved design method and a framework to assist architects in the early design stage; recommending optimal window system design and suggesting architectural design scenarios for improving the overall performance.

Hypothesis / Methodology

A screening study was performed with a sample patient room with three window systems and a fixed building, activity and construction scenario to understand the impact of the window systems on the energy efficiency, environmental impact and daylighting and to identify key factors for further research.

The three window systems analysed in the screening study were chosen to represent windows (1) in existing buildings (basic scenario) (2) with improved glazing characteristics in terms of light and UV transmitted and (3) with improved glazing characteristics in terms of solar control and heat resistance. The three window types consist of double glazing composed of two 4 mm glass panes and a 15 mm spacer with argon as gas fill.

1. Basic window: uncoated glazing, base for comparison
2. Low iron window: high light and UV transmission
3. Coated window: solar control and high thermal insulation

The simulations are made for the patient room with the three window systems facing North, South, East and West; with/without shading. The energy and daylighting simulations were conducted using DesignBuilder and environmental impacts were calculated with the KULeuven-MMG tool.

Results

- In Belgium often windows are designed with a focus on reducing the heating loads. The results however show that the effect of the window system on cooling loads should be considered as well.
- The models with the coated window have the best overall performance; showing the importance of glazing characteristics in window design.
- The models with the low iron window have the lowest overall performance; the high solar gains in summer increase cooling energy with ca. 30% compared to models with the coated window. Additionally, the illuminance map shows that the effect of the low iron characteristic does not particularly contribute to optimal daylighting and does not compensate for the high energy consumptions and environmental impacts.
- Shading devices have a major impact on energy saving and daylighting.
- Results show that shading devices can play a major role in retrofitting existing buildings.
- The results indicate that focusing on individual aspects is not sufficient to assess the window systems performance in a comprehensive way and an integrated approach is needed to satisfy all aspects.

Conclusion

The results demonstrate that the window systems have a significant impact on energy loads, environmental impact and daylighting and selecting the optimal system is a very important issue to address in the early design stage.

References

1.Eisazadeh Otaghsaraei, N., Allacker, K. (2016). Nanotechnology and its impact on sustainable architecture. Sustainable Built Environment (SBE) Regional Conference. Zurich, pp. 688-694.

2.Eisazadeh Otaghsaraei, N., Allacker, K. (2016). Sustainability assessment of window design in patient rooms in hospitals. Paper accepted for PLEA 2017

Fig. 1: Sample patient room and double glazing units characteristics

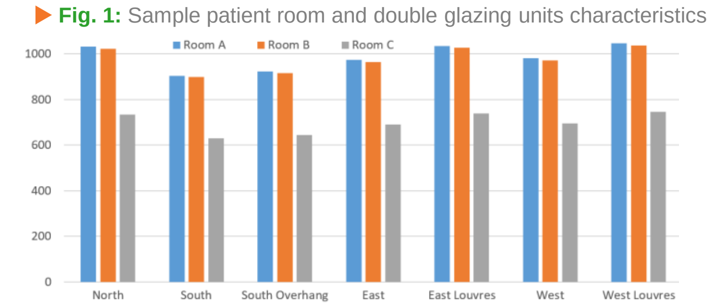

Fig. 2: Annual heating loads (KWh)

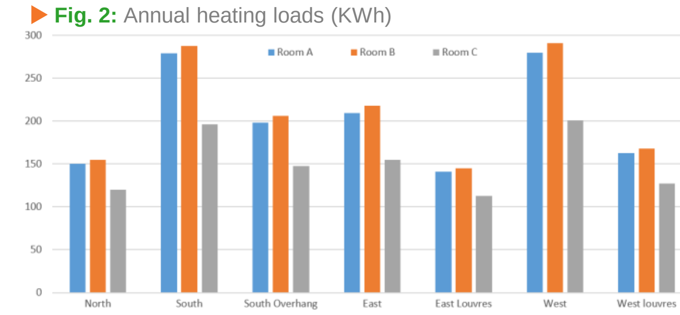

Fig. 3: Annual cooling loads (KWh)

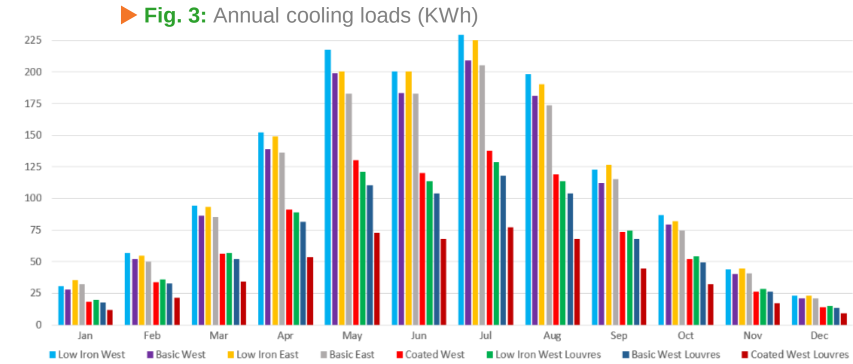

Fig. 4: Solar gains windows (KWh) in East and West with/without shading

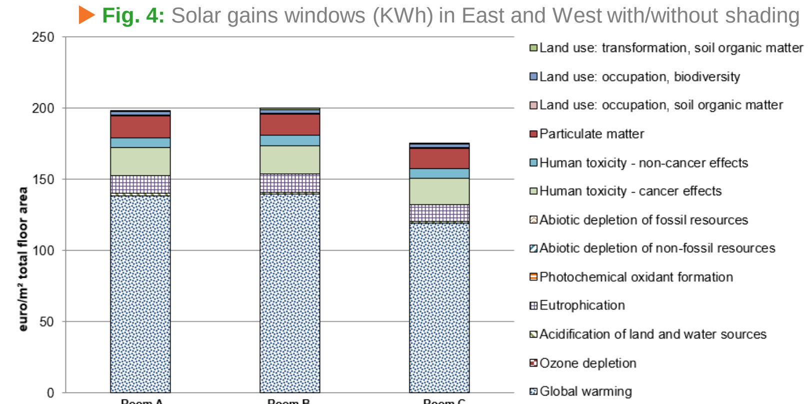

Fig. 5: Patient rooms environmental cost- Impact Indicators

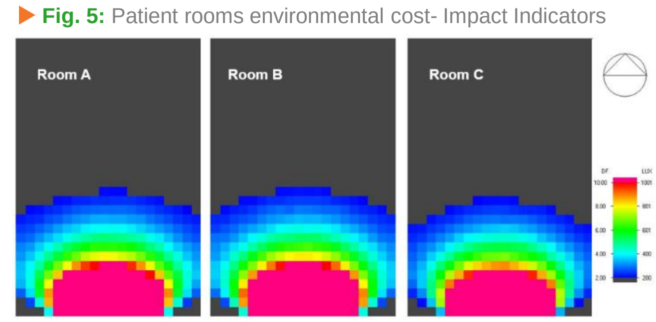

Fig. 6: Illuminance map of south oriented rooms without shading

Average Daylight Factor (%)	Without Shading				With shading		
Orientation	North	South	East	West	South	East	West
Room A (Basic window)	3.77	3.83	3.82	3.79	2.90	1.47	1.51
Room B (Low Iron window)	3.89	3.94	3.96	3,86	2.98	1.53	1.57
Room C (Coated window)	3.22	3.30	3.31	3.26	2.50	1.28	1.31

Fig. 7: Models average daylight factor

Doctoral Seminar on Sustainability Research in the Built Environment
DS²BE 2017

Contact

Nazanin Eisazadeh: nazanin.eisazadeh@kuleuven.be

KU LEUVEN