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The simulation-based performance assessment of an adaptive shading system taking into account occupant behaviour

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Introduction

The energy efficiency of buildings is becoming more and more important these days, resulting in smart building systems to be implemented more often. An example of this are adaptive shading systems, which are shading systems that can change their state to adapt to the outdoor climatic conditions or the needs of the building occupants. Adaptive shading systems have two (sometimes conflicting) goals: improving the indoor comfort and reducing the energy consumption of the building.

The performance of adaptive shading systems can be predicted using simulations. This is already done by different institutes and product developers. However, something that is often not taken into account (properly) is occupant behaviour (OB), even though the influence occupants have on the performance increases as buildings are becoming more and more energy efficient.[1] This can lead to a difference between the predicted and actual performance, which is a problem for product developers of adaptive shading systems. If they use simulations during the design of a product, they might make design decisions based on wrong conclusions by for instance assuming a certain occupant behaviour while in reality occupants behave differently. Another problem that can occur is that the adaptive shading system is not able to achieve the building performance that is expected and promised to the client, due to a performance gap caused by occupants.

Research goal

This research therefore has two main objectives:

1. Determine how to deal with the performance uncertainty of an adaptive shading system due to building occupants
2. Provide practical advice for an adaptive shading system developer

Figure 1: Roller blinds system by Verosol [2]

Methodology

The focus of this research will be on an automatic roller blinds system with a metallised fabric, which is developed by Verosol (figure 1). Three different control strategies are investigated (table 1). Strategy 2 is based on the baseline control strategy of Verosol's PLUG&PLAY system, strategy 3 is based on the newer FourC control strategy (developed by Verosol, SolarSwing and TU/e) and strategy 1 can be seen as the basic control strategy, which makes it possible to evaluate the benefit of making the control strategy more complex/intelligent.

Table 1: Different control strategies for the Verosol roller blinds system

Strategy 1	Strategy 2 [2]	Strategy 3 [3]
Irradiance threshold (horizontal on roof)	Irradiance threshold (vertical on façade)	Overcast sky detection
Manual override possible	Manual override possible	Manual override possible
Two states: up & down	Variable height (manually adjustable)	Two modes: energy & comfort
		Glare safe height (automatic)

The performance of the system is assessed for each control strategy using EnergyPlus. A slightly modified version of the reference office building of IEA SHC Task 56 is used for this.[4] Different OB models are used, with different levels of complexity. Only relevant OB model types (occupancy, shading interactions) are included. High resolution comfort evaluation is necessary to determine whether indoor comfort is achieved, which can be used to evaluate if manual overrides might occur that aren't taken into account in the used OB model. Based on the results, the sensitivity or robustness of the system (with different control strategies) for OB is evaluated. Based on this it can be determined how to deal with the performance uncertainty due to OB for the Verosol system. To evaluate whether the study is also applicable to another system, a case study is conducted for a different type of adaptive shading system: Kindow.[5] This is a vertical blinds system that tracks the sun and has more complex physical properties and a different control strategy.

References

[1] Clevenger, C.M.; Haymaker, J. (2006). The impact of the building occupant on energy modeling simulations. Computing and Decision Making in Civil and Building Engineering.

[2] Verosol (2017). https://verosol.com/

[3] SolarSwing (2017). https://solarswing.nl/project/veroplay/

[4] D'Antoni, M.; Bonato, P. (2017). Reference office description (draft). IEA SHC TASK 56.

[5] Kindow (2017). http://kindow.nl/