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Comparative field tests of an electrochromic shading device - thermal and visual comfort

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Abstract. Electrochromic devices (EC), or Smart Windows, are amongst the most promising technologies to increase users' wellbeing in buildings. A comparative test of EC windows performance was realised in the ZEB Test Cell Laboratory in Trondheim, Norway. Two identical rooms were used for the comparative tests. One of the rooms was equipped with EC devices. The other room was equipped with a traditional insulated glazing unit (IGU) with external solar shading device. Three automatic control strategies were tested in this experiment. The EC device demonstrated a good impact on the thermal and visual comfort when compared to a traditional IGU without moveable shading and a traditional IGU with an external screen.

1. Introduction

An Electrochromic (EC) glass differs from conventional ones because its optical characteristics are not fixed in time but change when a small DC voltage is applied (usually between 1 and 5V) [1]. EC devices can work as a solar shading while allowing the view of the surroundings [2,3]. The two main effects are the improvement of internal comfort and the energy saving potential [4].

Some specific aspects related to the use of EC devices are still not fully investigated. Among those the impact of the switching time which is longer than any other shading device, the user perception of the device itself and the user preference with regards to the manual or automatic switching [5]. This work presents the first step towards a more complete testing campaign.

2. Test Procedure

2.1. EC devices

A commercial model of EC glass was tested. The main characteristics are summarised in Table 1. The parameters indicated are the light transmission, the g-value, the g-value when the incident light is at an angle of 60° and the U-value.

Table 1. Main characteristic of the EC glass.

State	LT [%]	g [%]	g_{60}[%]	U_g[W/m^{2}K]
Bright	58	44	30	0.59
Dark	15	11	7	0.59

2.2. The ZEB Test Cell Laboratory

All the measurements were conducted in the ZEB Test Cell facility, located in Trondheim, Norway. The facility contains two identical cells suspended in a guard room. The façade is located on the southern side and it is the only part of the room envelope exposed to outdoor weather. Further information on the facility can be found in [6].

Table 2. Instrumentation of the Test Cell.

Sensor	Type	Accuracy	Position
Cell Temperature (A + B)	Pt100 black globe	± 0.3 °C	Centre of the cell
Solar Radiation (A + B)	Pyranometer	II class	Window
Illuminance (A + B)	Luxmeter	± 5%	Desk
Outdoor Temperature	Weather Station	± 0.3 °C	Facility roof
Outdoor solar radiation	Pyranometer	II class	Facade
Imaging (A + B)	Camera	Logitech	Rear of cell

2.3. Instrumentation
The main sensors used are reported in Table 2. Both cells are monitored by cameras, that take a photo every 4th second, and combines these to a 6-minute film for each day. White balance and exposure of the cameras were similar, to make it possible to compare the film for both cells.

2.4. Control strategies
Three different control strategies have been considered:
- *Desk illuminance:* The control of the EC and the screen is performed using as parameter the illuminance from the sensor placed on top of the desk. The chosen threshold is 1000 lx. Since the EC has a much longer switching time, the introduction of a buffer zone was necessary. The EC is activated above 1500 lx and deactivated below 700 lx.
- *Indoor globe temperature:* The temperature control was implemented based on the temperature measurement from the black globe inside each cell. The threshold was set to 23°C.
- *Outdoor impinging solar radiation:* The outdoor solar radiation is measured on the external surface of the façade. The activation of the screening devices starts above 200 W/m^2.

3. Results


Figure 1. Results of the measurements in the test cell from July 27th to August 2nd.

Figure 1 shows a screenshot of the custom control and monitoring interface developed for the measurements giving a view from inside the cells on two days (August 18th and September 29th) to show two situations in which the EC is active, and the integrated screen is respectively fully deployed and undeployed. The figure also contains the parameter of interest measured at that time by the sensors. A first visual analysis suggests how the EC device can reduce the internal illuminance in a sunny day, while still letting the occupants have a view of the surroundings.

In Figure 2 some of the parameters are reported, namely the outdoor and indoor temperature, the solar radiation measured at the glass and the switching signal.

4. Conclusions
EC glass proves to be an effective device for solar screening acting to reduce the internal illuminance and the overheating. The integrated screen can offer a better performance in terms of avoiding overheating although it limits the view of the surroundings. The temperature in the room is, in both cases, very high, but this is due to the high insulation of the cell, that can exchange heat only through the facade.

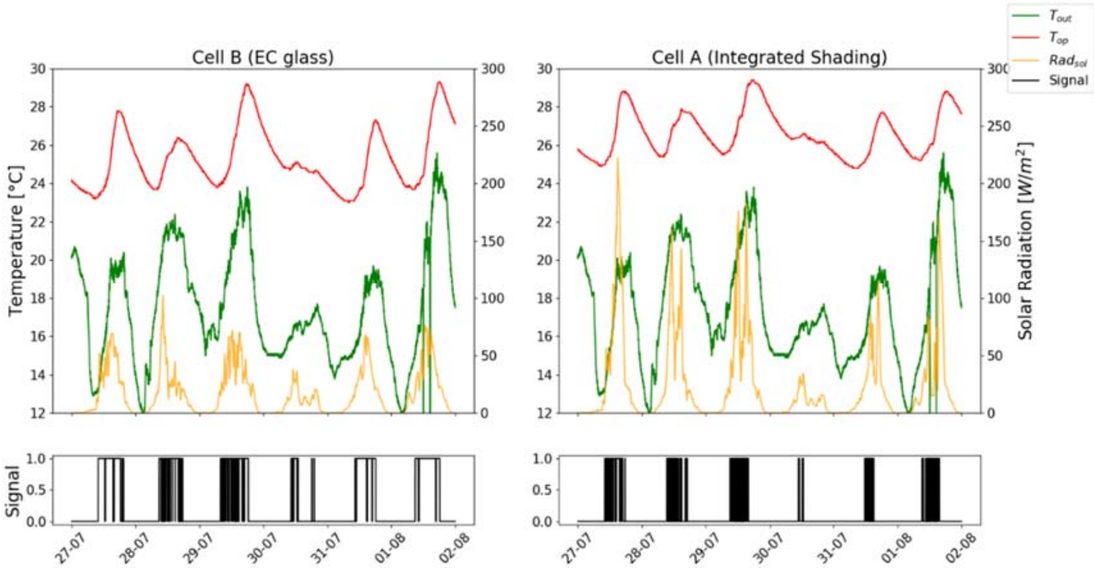

Figure 2. Results of the measurements in the test cell from July 27th to August 2nd.

Although the integrated screen has a higher impact on the solar radiation, the illuminance results in Fig. 2 are higher. This is explained by the fact that the controls act differently: in the EC case by modulating the transition from bright to dark, in the other case by modulating the position of the blind. Since the radiation is measured in the lower part of the window, this is high when the blinds are not fully deployed. This situation, typical of the integrated device, could lead to a stronger contrast and therefore an increase in visual discomfort, and this characteristic must be considered when evaluating the internal comfort.

The experimental campaign is in progress. Next steps involve the inclusion of natural and mechanical ventilation, the presence of occupants, the evaluation of users' satisfaction, the use of manual and automatic switching and several laboratory test to measure the exact switching time and the exact optical characteristics of the two shading systems.

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