# Improving Thermal Energy Performance of UK Built Environment through the Use of Shading Devices

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## Introduction:

The built environment accounts for over 60% of global energy consumption and 55% of greenhouse gas emissions (1). As a large portion of the consumed energy in built environment sectors relate to operational energy, it is evident how vital it is to find novel methods of reducing inherent energy consumption especially for heating and cooling purposes (3). So, as windows are considered one of the main contributors by having considerably high heat loss, it is important to utilise methods such as adding shading devices to reduce heat loss through the window which has also has a direct impact on thermal comfort.

## Methods of Heat Loss:

- **Steady-State Thermal Transfer**: Conduction, Convection and Radiation
- **Transient Thermal Transfer**
  - This method of transfer considers thermal mass as well as thermal resistance of the material.
  - Thermal mass affects the duration that energy is transferred through a surface.
  - If the time between t1 and t2 is omitted, the heat fluxes will not reach the steady-state. In this case, the peaks of heat flux will be different and the time to reach the peak is different as well (2).

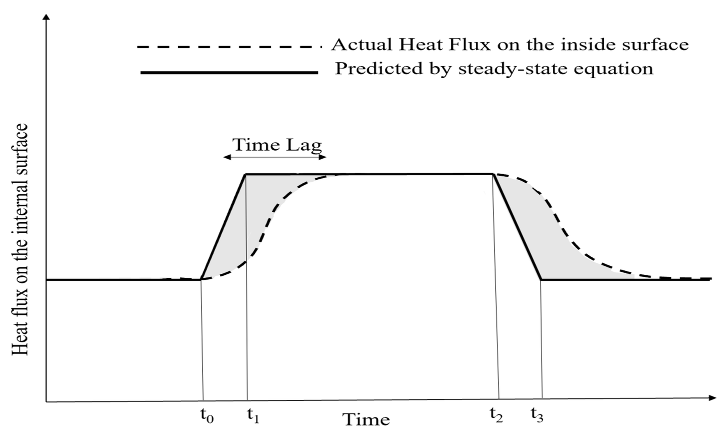

Figure 1: Steady-state vs actual heat flux

- **Dynamic Thermal Performance**

As the weather temperature varies, reaching a steady-state in reality is not possible, so dynamic thermal calculation is required which are commonly calculated using energy modelling software tools. However, a discrepancy between real-time measured data and predicted data have been identified in previous studies.

## Aim:

- Identifying the impact of internal sealed cellular blinds installed in an office, on energy consumption and thermal comfort by reducing heat loss during the cold season both in real-world and dynamic thermal models
- Most of the related studies are based on dynamic models or data collected in a controlled hot-box, so in this case study, the focus was to collect data from a real-world setting whilst having unstable weather conditions

## Methodology:

- Collecting real-time data over night with and without blind scenarios while maintaining internal air temperature at 23 °C
- Predicting surface temperature and energy consumption using EDSL Tas (which is one of the commonly used building energy modelling software tools in the UK) to model the case study
- Compare the predicted results with real-time measured data

## Case Study:

- An office, East faced (110°) within London South Bank University, situated in central London, UK (Figure 2)
- Energy consumption was measured using an energy meter connected to an electric heater
- Calibrated temperature sensors were installed on the window and the blind itself for measuring surface temperature (Figures 3 and 4).

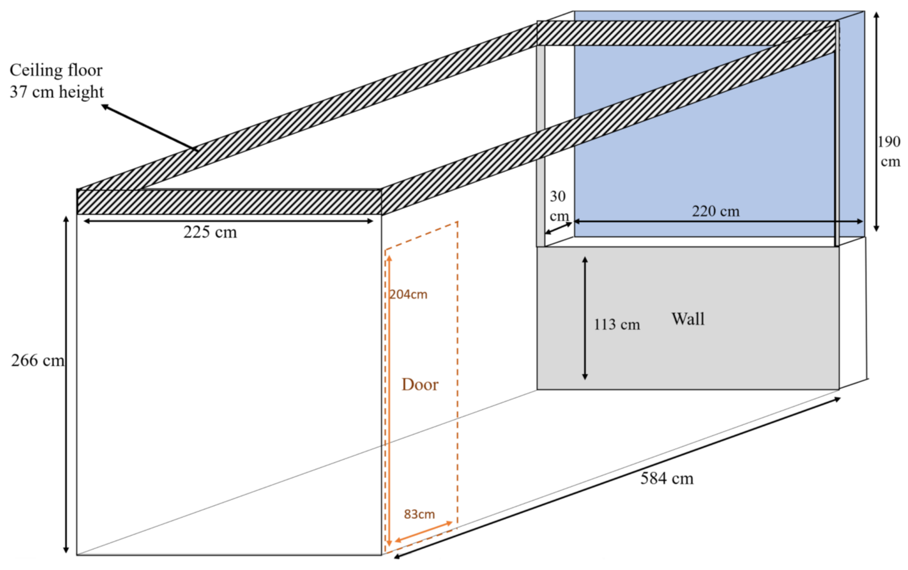

Figure 2: Office room geometry

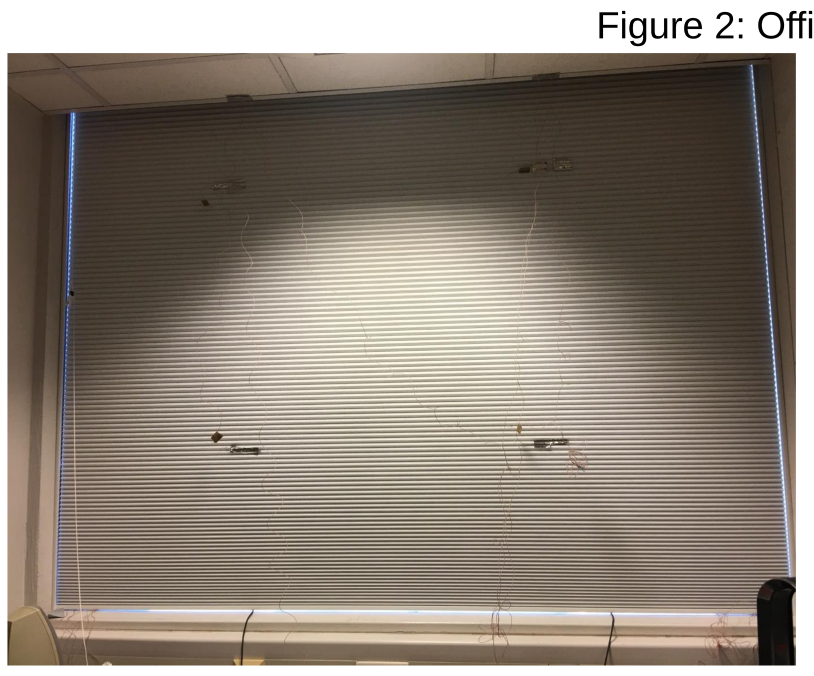
Figure 3: Thermocouples attached to the blind

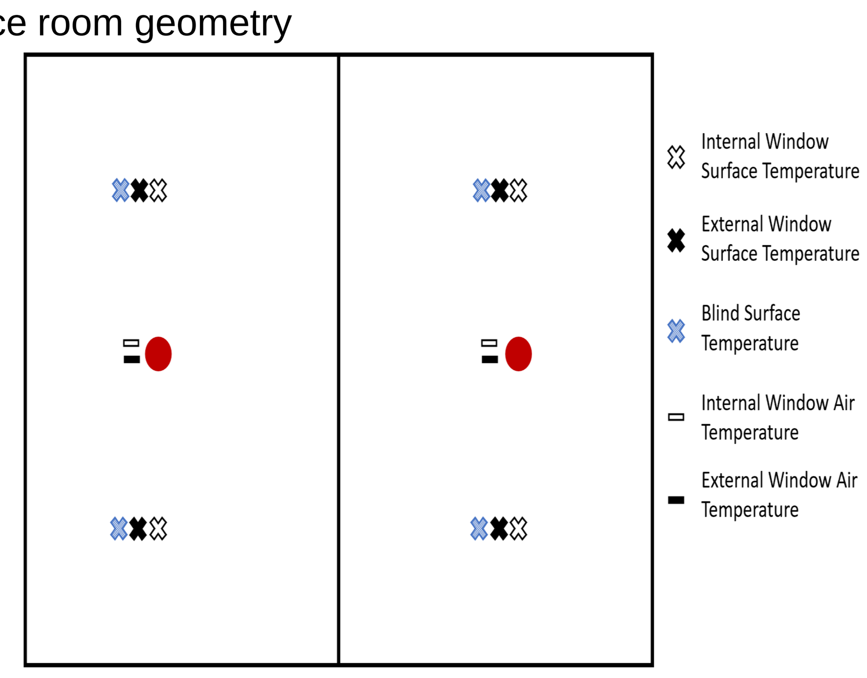

Figure 4. position of sensors installed on the window

- External dry-bulb air temperature, solar radiation and illuminance sensors were positioned on a stand located outside the room to monitor the external weather condition (figure 5).


Figure 5: External weather station

## Results and Conclusion:

- To showcase the results visually, thermal images below were captured by thermal camera model FLIR ONE PRO LT illustrating the effect of blinds on window heat transfer during the cold season (Figures 6 and 7).
- The presence of a blind had increased the inside surface temperature of the window from 13.6°C to 22.5°C.

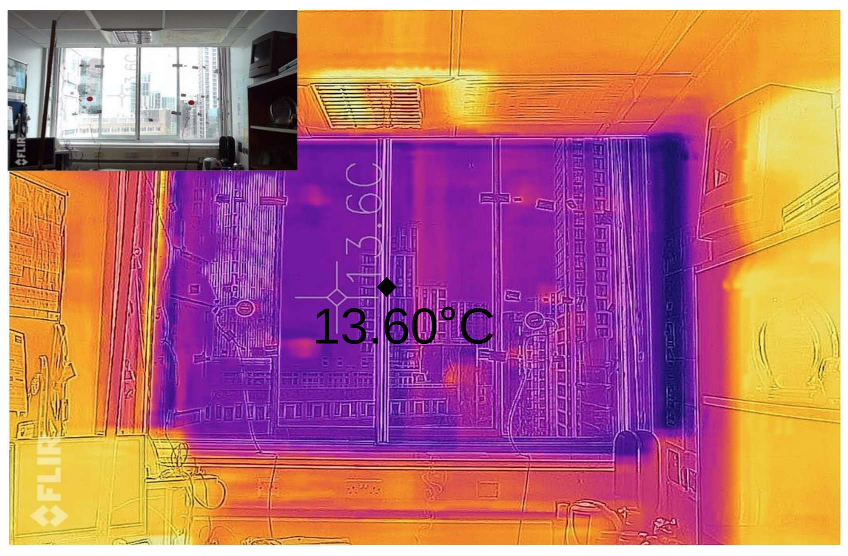

Figure 6: Window surface temperature without blind (glass temperature)

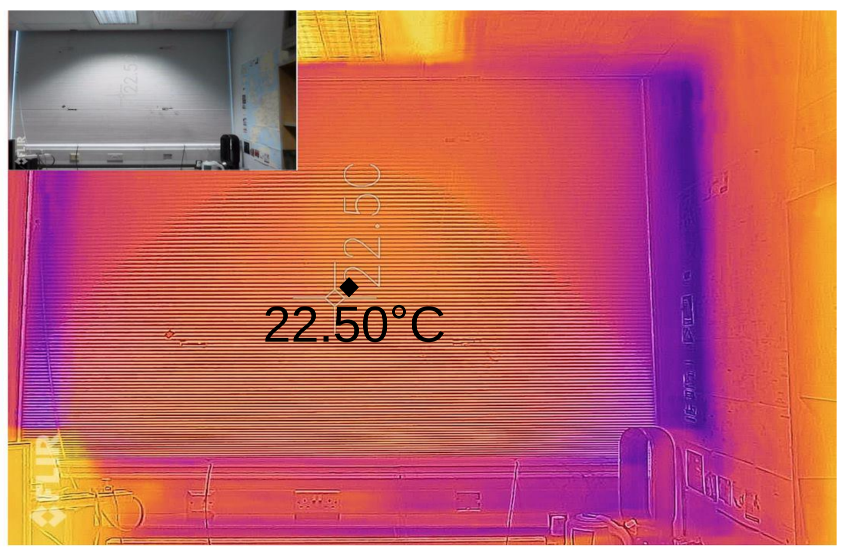

Figure 7: Window surface temperature with blind (blind temperature)

- Thermal comfort: local discomfort can be prevalent when an individual is positioned next to cold glazing via thermal (long-wave) radiant heat exchange which could have a significant impact on how someone feels in addition to the local air temperature.
- Energy Efficiency: reducing heat loss through the window can directly reduce energy consumption for heating purposes.

### Comparison between predicted and measured results:

- Figure 8 illustrates the 3D thermal model generated using EDSL Tas software.
- The hourly predicted results were then compared to real-time data as shown in figure 9.

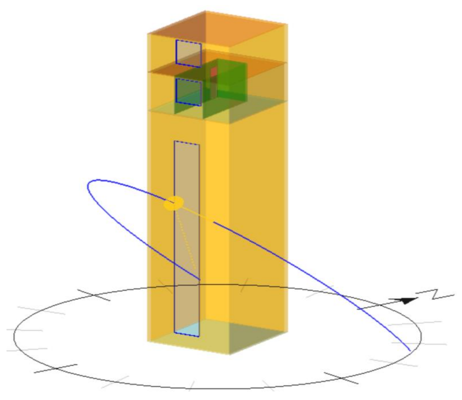
Figure 8: 3D model of the office located on the seventh floor of the building

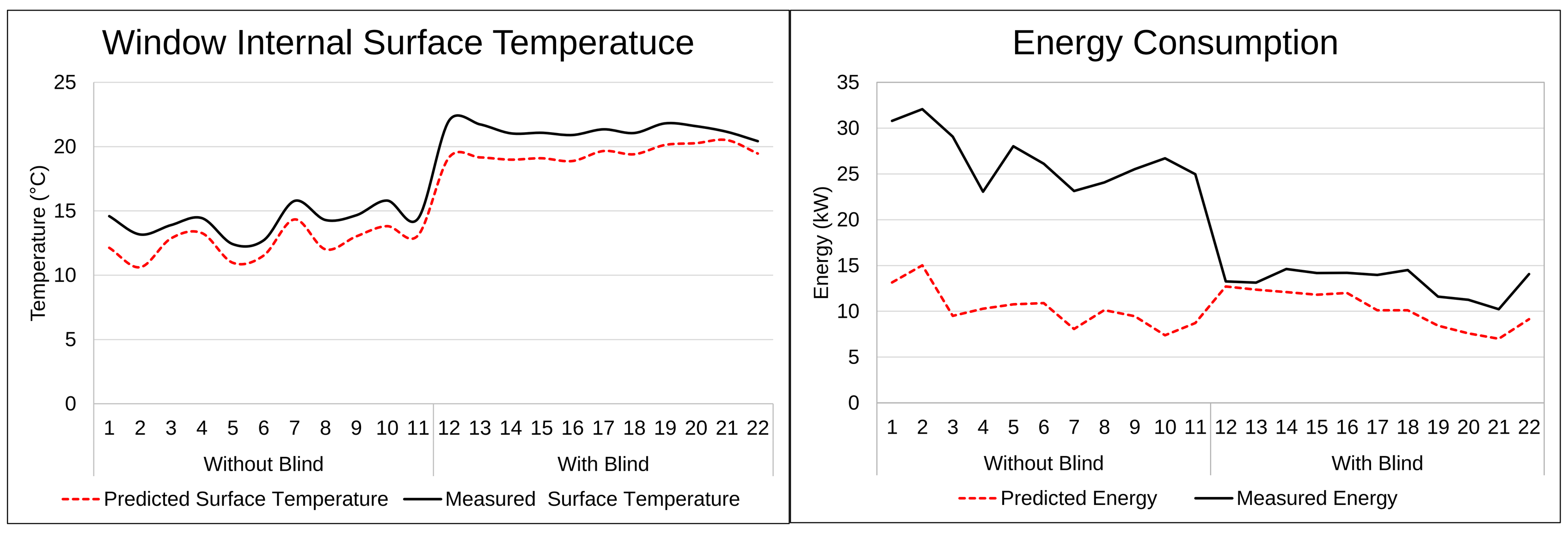

Figure 9: Comparison between real-time measured and predicted simulation results showing window internal surface temperature and energy consumption

- Real-time measured data show that adding a blind can reduce energy consumption for maintaining air temperature at 23°C by 50.59% and the window surface temperature by 33.58%.
- This software was successful in predicting the internal window surface temperature, with the root mean square error (RMSE) of 1.96 and 1.82 in with blind and without blind scenarios, respectively.
- The software was not able to alter energy consumption when using blinds, with RMSE of 3.16 and 16.50 in with blind and without blind scenario, respectively .
- In future, these results will be compared with other commonly used tools in the UK including IES VE , Design Builder and EnergyPlus to identify the most appropriate software for modeling shading devices.

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(2) Childs, K. W., Courville, G. E. & Bales, E. L., 1983. *Thermal mass assessment: An explanation of the mechanisms by which building mass influences heating and cooling energy requirements,* NY: Oak Ridge National Laboratory Tenessee USA, U.S. Department of Energy.
(3) Gledhill, T., Kempton, J., Swan, W. & Fitton, R., 2016. The variability of UK domestic energy assessments. *Journal of Building Survey, Appraisal & Valuation,* 4(4), pp. 264-279(16).

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