Cool Coalition | Global Alliance for Buildings and Construction | ES-SO European Solar Shading Organisation

Case Study Title:

A Case Study assessing the impact of Shading Systems combined with Night-Time Ventilation strategies on Overheating within a Residential Property.

s-built building photograph (Please insert only one representative picture in a landscape format, 300 dpi, JPEG)

South-West facing building close to Camden High Street Underground Station

Project Name	**Assessing the impact of Shading Systems combined with Night-Time Ventilation strategies on Overheating within a Residential Property.**
Location	London, United Kingdom
Climate Zone	ASHRAE/ London climate zone
Latitude/Longitude	51.4792N,0.4506W
Building Type	**Commercial building converted into 20 loft residential appartments and 2 penthouses on the top floor. Orientation building south west with heavily glazed facades on the south-west and north-east façade of the building.**
Floor Area [sqm]	**Four rooms were identified within the building to be evaluated, the rooms selected were of similar (if not identical) size, orientation, finish, had the same size glazed area that would be exposed to the same level of solar radiation externally.** **The rooms only differ in room depth; Room A extends to 4.5m in depth and Room B extends to 3.5m in depth. Room A and B are both 3.5m wide.**

Building Height [m]	building height: no info
Number of Storeys	Three floors above ground and one lower (basement) level
Completion Year	2016
Project Team	London South Bank University with Zoe De Grussa, Dr Deborah Andrews, Dr Gordon Lowry, Dr Elizabeth .J. Newton, Kika Yiakoumetti. The British Blind and Shutter Association with Andrew Chalk, David Bush.

*mock-up experiments and other research-based experiments could be included as case study, aside from actual building construction projects if similar information could be provided.

1. Project Description

Project Overview

For this case study, the researchers modelled the behaviour of an occupant who leaves their home vacant between 8am and 4pm, keeping the windows closed for security reasons during the day whilst assessing the thermal impact of closing a blind either internally or externally for the duration of the day and examining what effect this has on the operative temperature increase of a room during the day.

This is then statistically compared with the operative temperature increase of a room without solar shading to identify the temperature reduction that is offered through use of internal and external blinds through reducing the operative temperature increase; which would subsequently impact the level of comfort an occupant would experience on their return to the property.

Different types of external shading and internal shading were used in the testing.

Please describe the project overview, touching upon 1) project background (100 words), 2) passive cooling intervention (100 words), 3) project achievements (100 words). [Max 300 words] (Please write the brief explanation as the detailed info can be provided in the following sections.)

2. Climate & Site Context

Basic Climate Conditions		
Temperature	Annual Average	XX°C
	Annual Range	XX°C (Month) - XX°C (Month)
Relative Humiditiy	Annual Average	XX%
	Annual Range	XX% (Month) - XX% (Month)
Annual Degree-Days (ASHRAE Standard 169-2020)		HDD 18°C: XXX CDD 10°C: XXX
Climate Analysis		
Data collection started in August 2016 and finished in October 2016 which consisted of twenty days' worth of data, four days were discounted due to variations in testing and were discounted due to quality control. The sixteen days of data comprised of six days where the external air temperature was above 25°C, five days where the external air temperature was between 20 - 25°C and five days where the external temperatures were below 20°C at peak each day.		
Site Analysis		

In the design stage of the building lifecycle the building specifier considered the use of external shading but was discouraged by the planning authority on the basis it would not be a necessity and therefore would not justify the impact on the aesthetics of the building. This was further supported by the glazing specifier where the developer was informed the glazing alone would obviate the requirement for solar shading.

Although the glazing system was evidenced to contribute to overheating in this scenario it is important to note that other design decisions during the refit of the building would also contribute to the extent of the building overheating such as the ceiling height, location and orientation, depth of room, insulation and potential for air leakage, thermal mass of the building, single sided design layout for glazing, hot water distribution layout and the lack of ability to cross ventilate the building.

As in the original building specification, no shading was specified, however during the construction it was reported how some of the apartments appeared to be overheating above acceptable comfort levels. This was causing issues for workers carrying out the re-fit, affecting materials and methods during construction and subsequently created issues with the plumbing system. When the building was left un-occupied for 5-6 weeks before it was fully furnished the building manager found that the waste pipe water had evaporated leaving no protection against ingress from the sewage system. The British Blind and Shutter Association were approached to give further recommendations of the impact differing shading strategies could have on comfort levels within the building

Please describe project site conditions that inform your building design (e.g., topography, building density, landscaping, etc.) [Max 150 words]

Passive Cooling Strategies (please tick implemented passive cooling strategies)
☐ Building Orientation & Form (site orientation, building shape, etc.) ☑ Envelope Design (insulation, air-tightness, **shading**, window system, thermal mass, etc.) ☑ Natural Ventilation (cross ventilation, stack ventilation, **night ventilation**, etc.) ☐ Evaporative Cooling (direct/indirect evaporative cooling, etc.) ☐ Ground Cooling (geothermal, ground-coupled systems, basement/underground space,etc.) ☐ Radiative Cooling (cool roof, night sky radiation, radiant barriers, reflective surfaces, etc.) ☐ Nature-based Solutions (green roof/wall, tree shading, etc.) ☐ Others (human behavior, clothing, semi-passive (fans, etc.))
Description (please describe one strategy per box – you can add more boxes below if needed)
The operative temperature increase between 8am and 4pm were statistically compared using a Paired T-Test: to firstly observe whether internal blinds have a significant impact on the operative temperature increase of a room in comparison to a room without a blind;

secondly to compare the impact external blinds have on the operative temperature increase of a room in comparison to a room without a blind; **and lastly if there is a significant difference in the increase in operative temperature between rooms with internal blinds and rooms with external blinds.**
Over a 4 days testing the noise experienced within the room with windows open was averaged to take into consideration work rush hour traffic and periods of times at night where external noise would be reduced. **This resulted in 61Db LAeq,T and 43Db LAeq,T recorded for a room with a window open and a room with the window closed retrospectively.** **Considering that even with the windows closed the values exceed 35Db LAeq,T you can assume that occupants would be inclined to keep windows closed in order to improve their acoustic comfort when they are within the building specifically at night when they are trying to sleep.** *Please describe the feature of the adopted passive cooling strategies [Max 200 words]*
Compared with no blind room operative temperature peaked between 33.5°C and 45°C where the screen fabric and the aluminium venetian blinds were tested on days when the operative temperature was between 24.5°C and 47.5°C.

3. Passive Cooling Design Details

4. Active Components

Active (Hybrid) Cooling Strategies

(please describe one strategy per box – you can add more boxes below if needed)

Different types of exterior and interior shading were used.

It was observed how both the external venetian blind and the external screen fabric blind provide the largest mean difference in operative temperature increase indicating that they protect the interior room effectively from unwanted solar gains.

With an external venetian blind angled at 45° the operative temperature increase has the broadest range as solar gains are able to penetrate the interior of the room dependent on the angle of solar incidence in relation to the blind.

Between the internal blind types the internal screen reflective fabric (which has a higher solar reflectance than the internal aluminium venetian blind and screen fabric blind) was hypothesised to be the most effective at reducing operative temperature increase.
However, results show that the reflective screen blind was less effective at reducing operative temperature increase within the room. Reflecting on the data collected this may be due to the intensity of the testing where the Screen Reflective Fabric was tested on days when the no blind room operative temperature peaked between 33.5°C and 45°C where the Screen Fabric and the Aluminium Venetian blinds were tested on days when the operative temperature was between 24.5°C and 47.5°C.

The extent of the impact of all three internal blinds on the operative temperature : they can significantly reduce the operative temperature increase by 68 - 73% when compared to the operative temperature reduction achieved by external blinds within this building scenario.

Please describe the feature of the adopted energy-efficient active cooling strategies (e.g., mechanical cooling integration (AC, fans), controlled strategies (automated shading/windows), radiative cooling, evaporative cooling, earth coupled heat exchangers, renewables, etc.) [Max 200 words]

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5. Performance Data

Cooling Energy Use

The study described has demonstrated how solar shading when combined with night-time ventilation can be an effective method in reducing operative temperature increase in an urban flat.

Although external shading is observed to be optimal, internal shading in this study demonstrated it can achieve as much as 73% of the operative temperature reduction as external shading.

This means that dynamic shading solutions effectively can reduce the cooling need.

Indoor Thermal Comfort

The starting point for the indoor operative temperature was extremely high (reached 47,5 °C with no blinds) due to the fact that the converted residential building remained unoccupied for several weeks.

If the experiment was to be carried out again and the external conditions affecting the building were within the same parameters, with 95% confidence it can be said that a room with an internal blind and window closed between 8am and 4pm the operative temperature increase within the room would be 8.54°C - 12.88°C lower than a room without a blind.

Equally if an external blind was installed the room would d be 11.27°C - 18.38°C cooler and the difference in operative temperature between a room with an external blind and an internal blind installed would be between 1.99°C and 4.45°C cooler.

6. Financial Data

Cost Benefits

The cost benefits relate to the reduction of the cooling need when using solar shading.

This study demonstrated that a South-West facing flat in an old converted office building in North London was able to reduce indoor temperatures from a scorching 47.5C to a more acceptable 28C by using external solar shading.

On the cost benefits no date were delivered in this project.

Reference is made to the Guidehouse study:
Solar shading – Synergising mitigation of GHG emissions and adaptation to climate change: the potential to disrupt rising cooling demand and overheating in buildings.

In the Guidehouse study, November 2021 :
In terms of energy consumption, an uptake of dynamic solar shading can save up to approximately 60% of electricity for space cooling in Europe by 2050 or approx. 870 TWhel of saved final energy accumulated from 2020 to 2050. A saving that will be made by the end users paying their energy bill.

Automated solar shading also optimises energy performance in winter.

Compared to fixed shading or manually operated dynamic shading, automated dynamic solar shading can also maximise the utilisation of solar gains.

The Guidehouse study explored the cost of implementing more dynamic solar shading and found that up front capital expenditure (CAPEX) is broadly cost-neutral when compared with the equivalent requirement for A/C installation.
On top of this, very significant savings will be made from ongoing operational costs (OPEX).
The conclusion is that switching from more A/C to dynamic solar shading systems could reach some € 285 billion accumulated savings from 2020 till 2050.

https://es-so.com/resources/resource-center/documentation

Please describe the financial benefits due to the introduction of passive cooling measures against baseline (e.g., positive return on investment [incremental cost versus saving operational cost], payback periods, IRR, etc.)[Max 200 words]

*Please try to extract passive cooling cost and savings; however, if it is difficult, please annotate the premise. (e.g., the calculation includes the cost for both passive heating and cooling, etc.)

7. Passive Cooling Operation

Maintenance Requirement

There is little maintenance needed for internal shading.
For external shading normal yearly maintenance is sufficient for a long life cycle.

Please describe the maintenance requirement to sustain the passive cooling performance [Max 150 words]

8. Lesson Learnt / Recommendations

Technical Challenges, Solutions and Achievement

External shading is already widespread in many European countries and is becoming increasingly developed even in regions where internal shading was traditionally more common.
Internal shading solutions can also reduce the cooling load but they need installation attention because of the solar radiation is already entering through the windows.

For an optimum solution it is important to consider shading already from the designing phase, to reduce costs and have a better alignment with the building design.

Please describe the challenges and solutions of passive cooling strategies in the design/construction/operation phase [Max 150].

Financial Challenges, Solutions and Achievement

The financial challenges were not discussed in this paper but reference is made to the Guidehouse study (see above).

For this building retrofit it was the perception of the building designer that no shading was needed and the glazing would be sufficient.

When the retrofitted building converted into flats remained a number of weeks unoccupied the indoor temperature reached 47,5 °C. On that moment the reflex was made that shading was needed. That is when the study started with shading being applied on the outside and inside to see what the results would be. The results were satisfactory as they showed a decrease of the operative temperature, achieving with exterior shading 28 °C.

Please describe the challenges and solutions of passive cooling strategies from the financial perspective (e.g., what are the factors of incremental costs (e.g., imported materials, lack of labor skills, additional analysis cost, etc.), and how could these be mitigated (e.g., tax rebate, preferential loans, subsidies, business incentives, etc.) [Max 150].

Other Challenges, Solutions and Achievement

Perception of the project developer during the design phase convinced that the building will not overheat when not using solar shading.

The opening and closing behaviour of windows and blinds has been documented to be poorly understood and underutilised by occupants, initiation of movements can be confounded by a number behavioural factors particularly in urban areas where noise pollution, security and availability of daylight are often prioritised over thermal comfort.

Automated shading solutions can help to overcome this.

Within unoccupied rooms changes in solar shading and window opening behaviour could have a beneficial impact on the thermal conditions experienced in a living space later in the day and over a period of time on the building fabric of a building.

The benefits in thermal comfort could also considerably reduce the energy requirement from mechanical ventilation systems if users are educated on the best window opening and blind movement strategies.

Please describe the challenges and solutions other than the two above (e.g., capacity of design professionals, material availability, cultural resistance, users' low awareness, etc.) [Max 150].

9. Free Description

Free Description
Please describe the information that could be useful to readers (e.g. replicability of case studies, tips on design and material specifications, cost information, etc.) [Max 300].

10. Annex

Supporting documentations
Attached case study and executive summary Guidehouse

Room left : no blind installed
Room right : 80 mm aluminium venetian blind

Internal Operative Temperature – A black globe thermometer (40mm Ø) was used with a mercury thermometer as the temperature probe. The sensor was set up on a tripod and positioned 1.8m from the glazed façade and set at 1.2m from floor level within all four rooms being monitored. . The size of the globe used closely correlates with measurements of operative temperature within the indoors, which relates to the temperature humans feel when clothed (Humphreys, 1977).

External Air Temperature – A air temperature sensor was situated on the ground floor outside. The handheld air temperature sensor was positioned away from direct solar radiation to prevent the metal probe being affected by radiant heat.

Please insert any complementary visual materials such as drawings, analysis, performance data, thermal fluid simulation imaging, 3D rendering, as well as descriptions to explain those, etc.

11. Citation

Citation
Overheating, Night-Time Ventilation, Internal Blinds, External Blinds, Shading. Please include here the citations/references/links of your project and/or research.

12. Contact

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