Shading Study – Thermal Impact Assessment of External Shading

for

East Sussex Healthcare NHS Trust
Eastbourne District General Hospital
Endoscopy Unit, Room F30 Office

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Document Revision Sheet

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Contents

Executive Summary

Overheating in buildings has a direct impact on the health and wellbeing of the building occupants and users. In the warming climate of today we are now at an ever increasing risk. One of the most common causes of overheating is excessive solar gains through windows. This report provides a summary of the performance of external roller screen as a passive cooling device.

This document reports on the thermal impact of an external shading installation at Eastbourne District General Hospital. A study was conducted with the aim to determine the shading effect of a retrofitted external roller screen. The shading device was supplied and installed by Enviroblinds. The temperature monitoring, thermal modelling and analysis was carried out by AMA.

The real time monitoring demonstrates that the use of external screen improved the thermal comfort with regularly reducing the air temperature by around 2°C. The maximum temperature difference was 2.5°C. Therefore, it can be concluded that under the test conditions external screen has demonstrated potential to improve thermal comfort and reduce overheating.

The dynamic thermal analysis results indicate a consistent reduction in internal temperatures and a reduced risk of overheating with the use of external shading. The peak summertime internal air temperature was reduced by 5°C.

Frequency analysis shows that the use of external shading moderates the temperature peaks and results in significantly lower frequency of high temperatures; the risk of overheating was reduced from 12% of annual occupied hours to 2%.

Overheating in buildings impacts occupant health and wellbeing and reduces productivity. Installing passive measures, such as external shading, first is more cost effective than installing active cooling. Capital cost of installing external shading is typically 25% of the cost of installing air conditioning. Annual running and maintenance cost of external shading is negligible in comparison to air conditioning. The use of external shading achieved a 52% reduction in potential cooling energy demand and the results suggest the possibility of avoiding the requirement for active cooling.

Due to global temperature rise extreme hot weather will become more common, external shading can be used to mitigate the negative impact of high temperatures, keeping in line with the NHS Net Zero target.

1.0 Introduction

Overheating in buildings has a direct impact on the health and wellbeing of the building occupants and users. In the warming climate of today we are now at an ever increasing risk of buildings suffering with prolonged periods of overheating. One of the most common causes of overheating is excessive solar gains through windows.

Controlling solar gains is a key consideration in maintaining indoor comfort and implementing low energy 'passive' building design. Solar gains can be limited with effective external shading; shading can reduce peak internal air temperature, regulate swings in temperature and reduce the building cooling load. It is lower cost for buildings to install passive cooling options first, before installing active cooling.

This document reports on the thermal impact of an external shading installation at Eastbourne District General Hospital. A study was conducted with the aim to determine the shading effect of a retrofitted external roller screen. The shading device was supplied and installed by Enviroblinds, the temperature monitoring, thermal modelling and analysis was carried out by AMA. The installation set up is described and the temperature monitoring results are presented. Further analysis is carried out by the means of a computer simulation model to predict the long term thermal impact of the shading installation.

Figure 1. Shading study location

2.0 Benefits of External Shading

2.1 Passive Cooling

External shading is a passive design measure that can be used to regulate internal air temperature and reduce the need for mechanical cooling. This is in line with delivering the net zero NHS target.

The direct impact of passive cooling is that it can avoid or reduce the need for active cooling and associated running costs. Every 1°C of temperature reduced by passive measures can save about 5% of power required for cooling. The capital cost of installing external shading is typically 25% of the cost of installing air conditioning. Annual running and maintenance cost of external shading is negligible in comparison to air conditioning. Installing passive cooling first is more cost effective.

2.2 Health and Wellbeing

Exposure to extended periods of high temperature can cause a range of direct and indirect health impacts in addition to discomfort and heat stress. The most vulnerable occupants are elderly people, young children and those with pre-existing health problems who are likely to suffer most as a result of higher internal temperatures. Overheating can affect the productivity in work place through reduction in work intensity and increase in breaks; for example, report writing has been found to be 16% slower in overheating offices.

2.3 Future Climate

The UK has already experienced changes to its climate due to global temperature rise; summers are set to get hotter, last longer and extreme heat will become increasingly common. Climate projections suggest that a 'hot' summer such as 2021 will become the average summer by 2050. This will have a direct impact on the requirement to install and run active cooling in buildings.

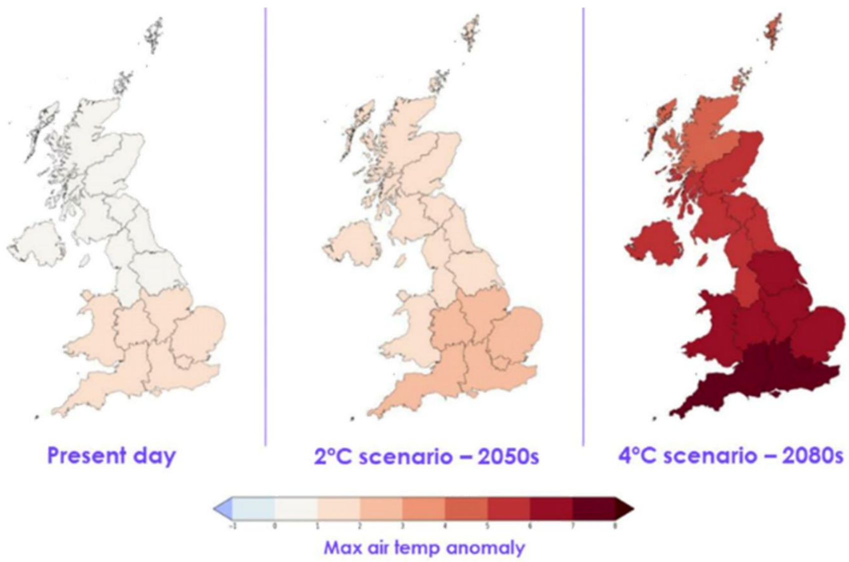

Figure 2. Change in maximum summer air temperature (Met Office UKCP18)

3.0 Shading Study

A live temperature monitoring was carried out for an external shading installation at Eastbourne District General Hospital in August 2023. The 'Test Room' assessed is the Endoscopy Unit office (F30) on the first floor. This room has historically suffered with overheating and does not have air conditioning at present. For purposes of comparison, the adjacent office (F29) was set up as the 'Control Room'.

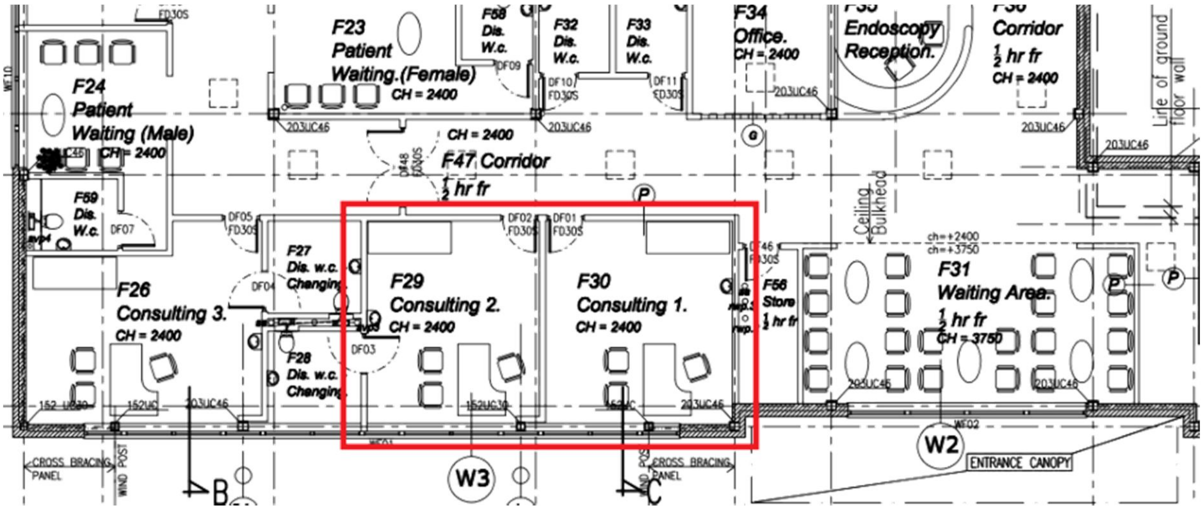

Figure 3. Shading study location; Control Room F29 and Test Room F30

3.1 Introduction

The room assessed is on the first floor, with a total internal floor area of approximately 25m^2 and a 3.9m^2 window facing southwest. An external roller blind is installed to this window and the room air temperature is monitored with the use of a calibrated data logger from 2nd to 24th August 2023.

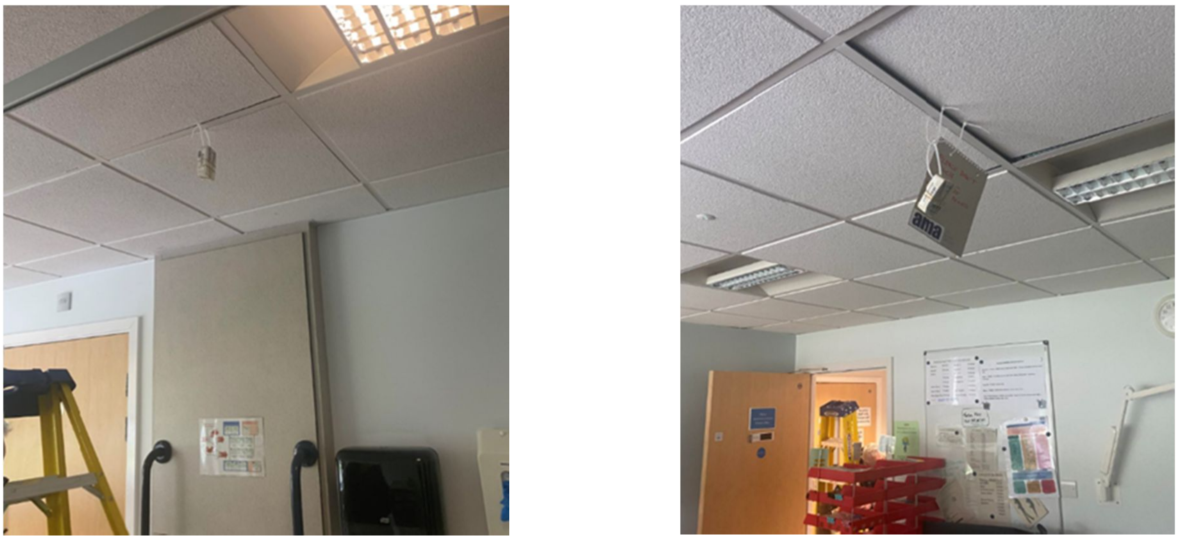

Figure 4. Shading study location; Control Room F29 (left) and Test Room F30 (right)

For purposes of comparison, the adjacent consulting room that does not have external shading is also fitted with a data logger to record internal air temperature in five-minute intervals. This data is compared to establish the impact of external shading. Further analysis is carried out by the means of a dynamic thermal model of the room. This model is verified with the use of the recorded temperature data and used to predict how the assessed room may perform in the future.

The shading study is a collaborative piece of work between AMA Building Services Consulting Engineers and Enviroblinds for the East Sussex Healthcare NHS Trust.

3.2 The Setup

The window of a southwest facing room was fitted with an external roller screen, whilst the adjacent room had an existing internal roller blind in operation. AMA carried out internal air temperature monitoring in both rooms and the mean radiant temperature was recorded at five-minute intervals. Both rooms were in use during the temperature monitoring period and the occupants were free to open and close the blinds as required.

3.3 External Shading

The shading device was supplied and installed by Enviroblinds. The system is a mesh type screen fabric with an openness factor of 5%, retaining the view to the outside, with a solar transmittance of 15.5% and visible light transmittance of 13.7%. The double glazing and screen total solar energy transmittance is G 0.09.

The system is externally wall mounted on brackets with cable guides to allow the outward opening of windows. Operation by motor and internal remote control with sun and wind sensor.

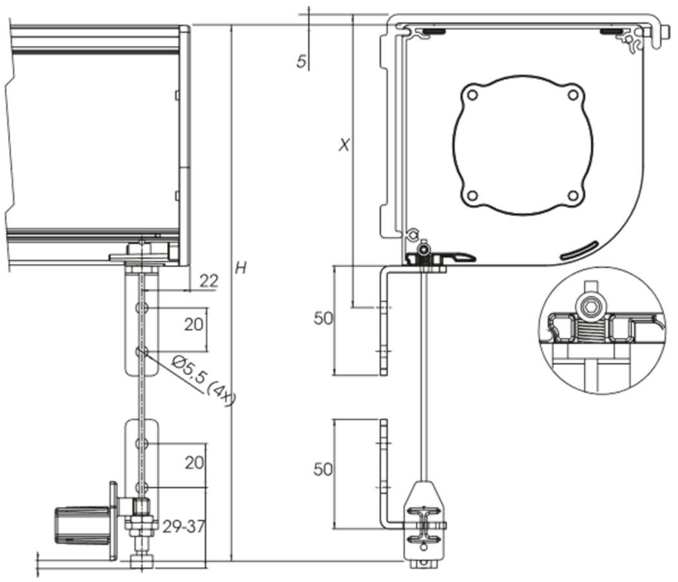

Figure 5. Shading system on cables

3.4 Temperature Data

The temperature data shows that room with external blind had a lower temperature than the room with an internal blind. The temperature peak was typically 2°C lower with the use of the external blind, the maximum temperature difference was 2.5°C.
The results show that the office with external shading has a consistently lower temperature than the room with internal shading.

- Maximum temperature with external blind 27.6°C
- Maximum temperature with internal blind 29.0°C

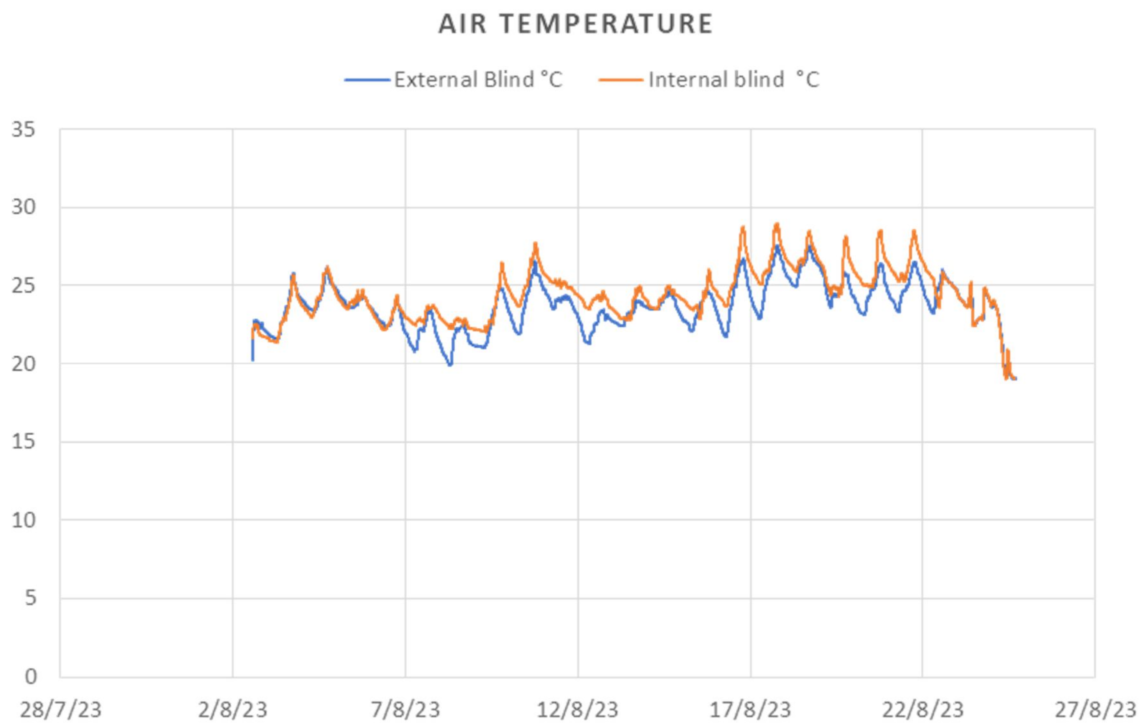

Figure 6. Temperature monitoring data graph

4.0 Computer Thermal Modelling and Simulation

Dynamic thermal simulation was carried out using IES Virtual Environment software to predict the impact of an external roller blind on cooling and heating loads. The simulation parameters are based on the temperature monitoring setup.

Integrated Environmental Solutions Virtual Environment (IES VE) thermal dynamic software is used to model the building. The environmental modelling is carried out by the means of creating a 3D model with building specific parameters. The model is based on drawings provided by the Trust, Google Earth and assumed information as stated.

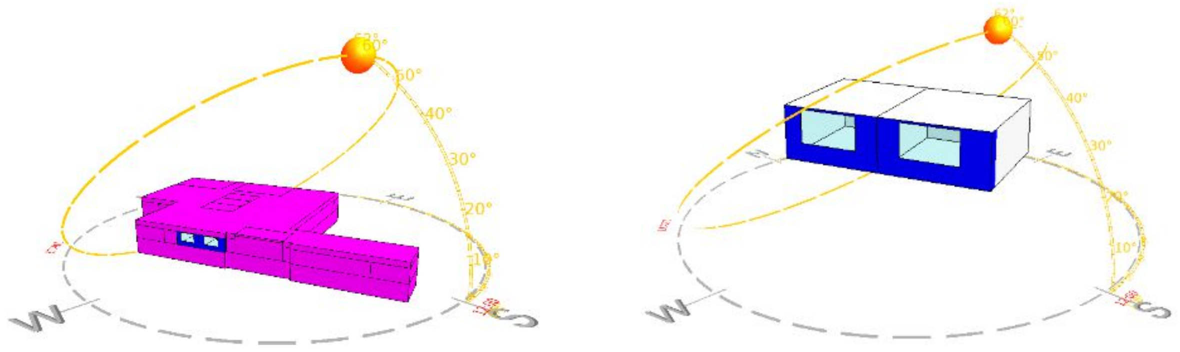

Figure 7. IES model with sun path (21st June 12.00)

4.1 Simulation Parameters

The following U-values are used:

- Roof 0.18 W/m2.K
- External wall 0.26 W/m2.K
- Glazing 1.60 W/m2.K g-value 0.4
- Ground floor N/A (first floor location)
- Internal partition 1.79 W/m2.K
- Internal ceiling/ floor 1.09 W/m2.K

The following parameters are used:

- Hours of occupation, 8am – 6pm weekdays
- Internal gains included
- Infiltration 0.25ach, windows assumed shut
- Infiltration 1.0ach, window and door open
- IES design weather data Herstmonceux (max 28.5°C)
- IES simulation weather file SouthamptonDSY05.fwt (design summer year)
- Cooling set point 23°C

4.2 Validating the Model

To validate the IES model a simulation to reflect the test situation was carried out. The aim is for the simulation temperature profile to be similar to the recorder temperature data. This validated model can then be used to carry out further simulations.

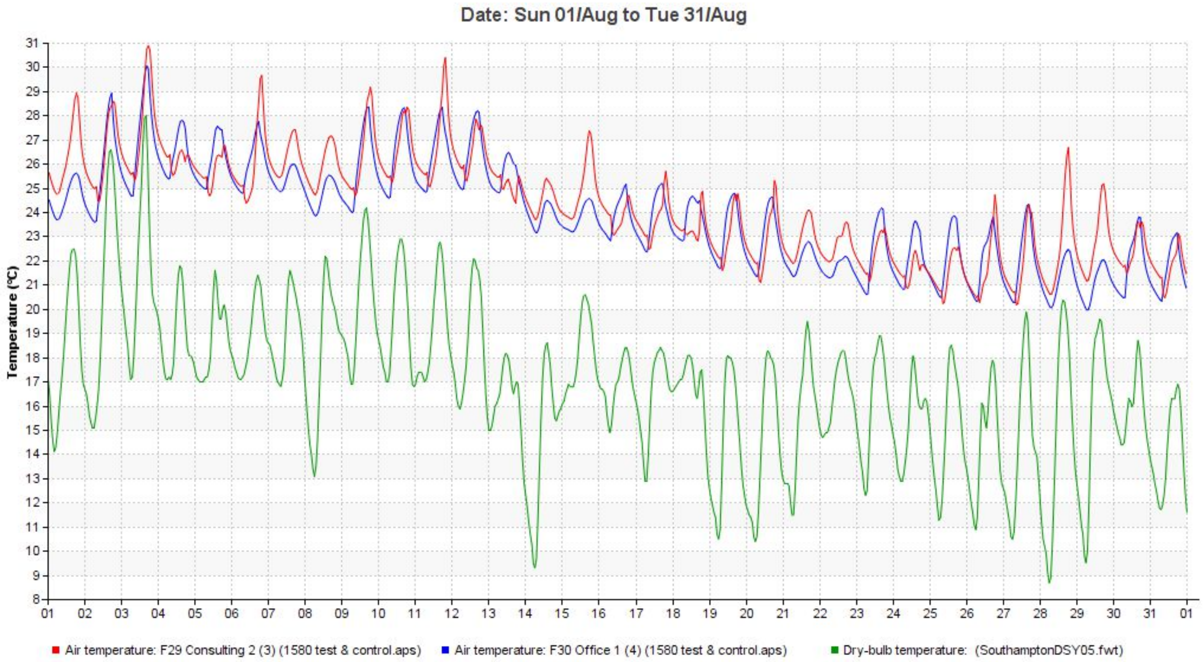

Figure 8. IES temperature graph (external blind blue, internal blind red, external green)

The IES external air temperature profile is compared to real time data from the local (Herstmoceux) weather station to confirm it corresponds.

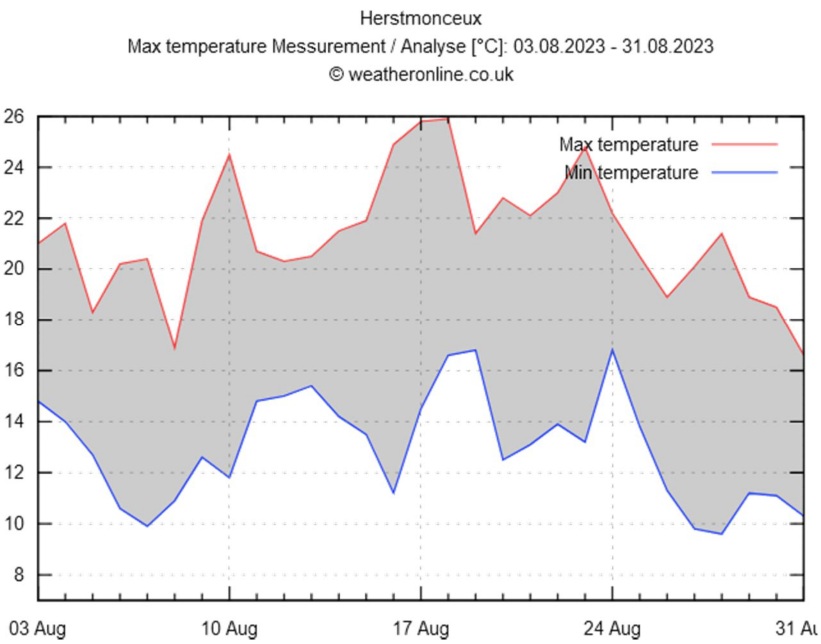

Figure 9. Herstmonceux weather station temperature graph for August 2023

4.3 Simulation Results

Further simulations are carried out for F30 Office to assess the impact of the external shading on predicted temperature range and overheating risk. The impact of the external shading is also referenced to the potential cooling load in the room.

4.3.1 Predicted Temperature Range

HTM-03 recommends thermal modelling to be undertaken to assess the risk of overheating and take into account the maximum values and the time component. Commonly used overheating benchmark in offices is 26°C (CIBSE Guide A), extended periods above this temperature can result in overheating and negative impact on health and wellbeing. Temperatures above 28°C should not occur for more than 1% of annual occupied hours.

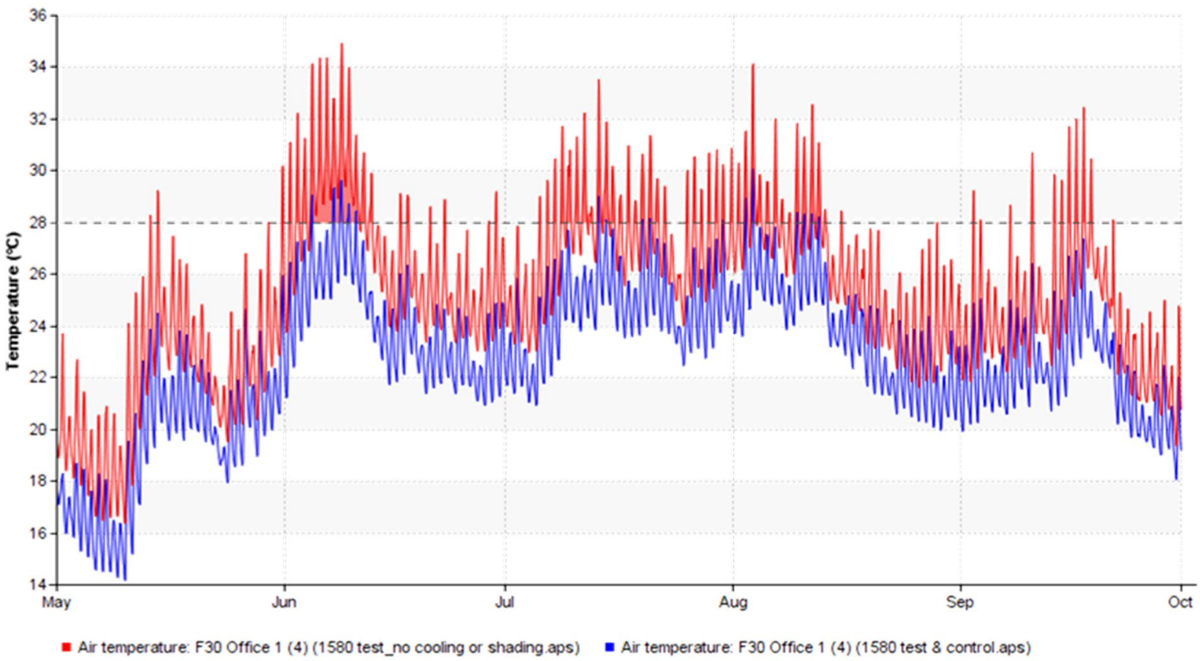

Figure 10. Predicted internal air temperature (external blind blue, internal blind red)

The results show that the room with external shading has a consistently lower temperature than the room with internal shading. The simulation predicts a 5°C lower maximum air temperature with the use of external shading.

- Maximum temperature with external blind 30°C
- Maximum temperature with internal blind 35°C

Frequency of temperatures above the office comfort criteria of 26°C (CIBSE Guide A) are assessed for occupied hours. The use of external shading is predicted to result in a reduced frequency of high air temperatures and risk of overheating.

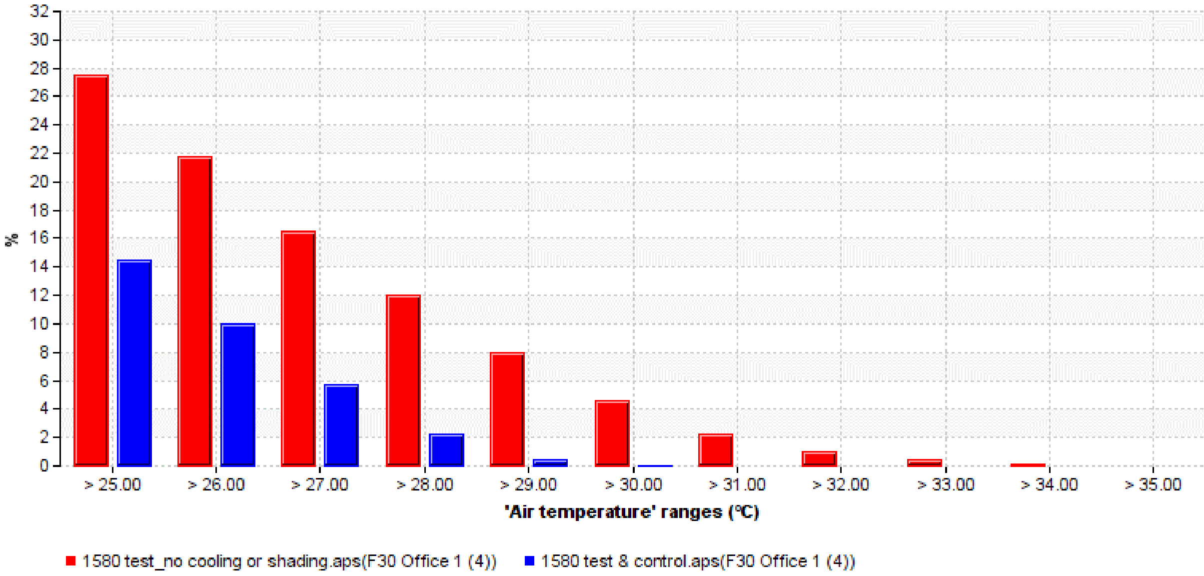

Figure 11. Predicted frequency of temperatures (external blind blue, internal blind red)

The results show that the room with external shading has a lower frequency of overheating than the room with internal shading.

- External blind – 2% frequency of temperatures above 28°C
- Internal blind – 12% frequency of temperatures above 28°C

4.3.2 Predicted Cooling Energy Savings

The results show that office with external shading has a consistently lower cooling demand than the room with internal shading, the annual cooling load is 52% lower.

- Annual cooling load with external blind 0.2078MWh
- Annual cooling load with internal blind 0.4332MWh

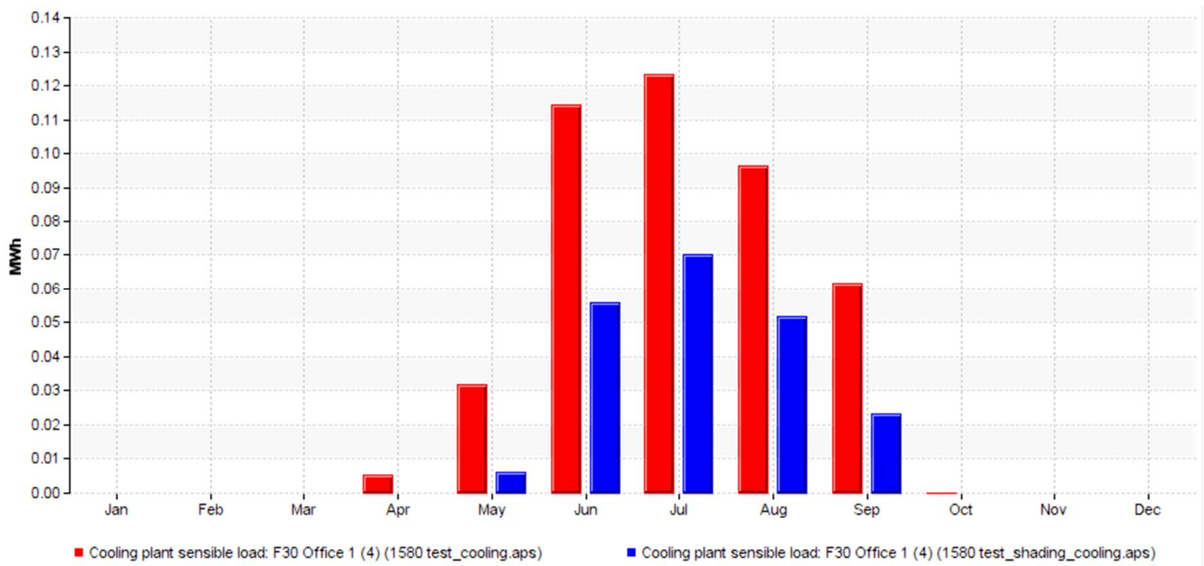

Figure 12. Predicted cooling load (external blind blue, internal blind red)

4.4 Discussion of Results

There is a growing demand for strategies to combat excessive solar gains in buildings. This report provides a summary of the performance of external roller screen as a passive cooling device.

The real time monitoring demonstrates that the use of external screen improved the thermal comfort with regularly reducing the air temperature by around 2°C. The maximum temperature difference was 2.5°C. Therefore, it can be concluded that under the test conditions external screen has demonstrated potential to improve thermal comfort and reduce overheating.

The room set up was somewhat limited as the test room and control room do not have identical use and ventilation profiles or internal gains, it may be useful to carry out further temperature monitoring to record the impact in more similar rooms. The test situation solar gain was not the 'worst case scenario' as the room orientation is not due South and the window to wall ratio is relatively low, a change to these two factors would likely result in a greater difference between the rooms.

The dynamic thermal analysis results indicate a consistent reduction in internal temperatures and a reduced risk of overheating with the use of external shading. The peak summertime internal air temperature was reduced by 5°C and the risk of overheating was reduced from 12% of annual occupied hours to 2%.

The use of external shading achieved a 52% reduction in potential cooling energy demand and the results suggest the possibility of avoiding the requirement for active cooling.

5.0 Appendices

Calibration certificates (BSRIA)

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Certificate of Calibration

Issued by:	BSRIA Instrument Solutions - A division of BSRIA Limited
Date of issue:	14 April 2023

Certificate number
STD_143107

Page 1 of 2 pages

BSRIA

Laboratory address:
Old Bracknell Lane West, Bracknell,
Berkshire RG12 7AH
T: +44 (0) 1344 459 314 | 0800 254 5566
E: instruments@bsria.co.uk
W: www.bsria.com/uk/instrument/

MARTIN TROTTER

Approved signatory

Customer: Instrument Solutions
Old Bracknell Lane West
Bracknell Berkshire RG12 7AH

Date received: 22 March 2023

Instrument:

BSRIA I.D.:	201707
Description:	Temperature data logger
Manufacturer:	Testo
Model:	175-T1
Serial number:	37582709/706
Procedure version:	U58F19V4

Laboratory conditions:

Temperature:	20 °C ± 4 °C	Relative humidity:	< 75 %rh
Mains voltage:	240 V ± 10 V	Mains frequency:	50 Hz ± 1 Hz

Comments:

Instrument calibration conducted as found - no adjustments undertaken.

Calibration information:

The instrument was calibrated by comparison against laboratory reference equipment whose values are traceable to recognised National Standards. This is an electronic document that has been signed digitally.

The uncertainties quoted refer to the calibration only and are not intended to indicate any long-term instrument specification/performance. This certificate only relates to the items calibrated and was performed at the above laboratory address.

Calibrated by: K. Shipman **Date of calibration:** 13 April 2023

This certificate provides traceability of measurement to recognised National Standards, and to the units of measurement realised at the National Physical Laboratory or other recognised National Standards laboratories.

 This certificate complies with the requirements of BS EN ISO 10012:2003.

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Certificate of Calibration

As Found Results

Certificate number STD_143107
Page 2 of 2 pages

Reference equipment used in the calibration:

Instrument description	Serial number	Certificate number	Last cal. date	Cal. period
Temperature & Humidity Standard (ZZPDL03)	KS0614005	UK_48043	11/05/2022	12 Months

Calibration uncertainties:

The reported measurement uncertainty values shown have been calculated taking into account the device resolution and stability at the time of calibration.

Instrument setup:

Unless otherwise specified the instrument has been setup with the following parameters:-
Logging interval = 5 minutes; Duration = Open ended; Wrap around = Off; START MODE = Key start.

TO START THE INSTRUMENT USING THE KEYPAD (Only applicable for START MODE = Key start)
Press and hold the GO button until RECORD is shown on the display. NOTE: The logger can only be stopped using the software.

Calibration procedure:

The instrument was placed within an environmental chamber alongside a series of reference resistance thermometers of known and traceable uncertainty. The average of the readings are reported within this certificate as the applied value. At each calibration point shown, the instrument was left for a period of time to acclimatise before any results were recorded. All instrument readings were taken from the internal memory.

Calibration results:

	Applied	Indicated	Correction	Specification	% of Spec.	Uncertainty
Test point 1	9.6 °C	9.7 °C	-0.1 °C	±0.5 °C	20.0 %	±0.31 °C
Test point 2	19.8 °C	19.9 °C	-0.1 °C	±0.5 °C	20.0 %	±0.31 °C
Test point 3	29.8 °C	29.9 °C	-0.1 °C	±0.5 °C	20.0 %	±0.31 °C

Any test points marked with a * do not comply with instrument specification.

End.

Certificate of Calibration

Issued by: BSRIA Instrument Solutions - A division of BSRIA Limited

Date of issue: 23 March 2023

Certificate number
STD_142673

Page 1 of 2 pages

BSRIA

Laboratory address:
Old Bracknell Lane West, Bracknell,
Berkshire RG12 7AH
T: +44 (0) 1344 459 314 | 0800 254 5566
E: instruments@bsria.co.uk
W: www.bsria.com/uk/instrument/

MARTIN TROTTER

Approved signatory

Customer: Instrument Solutions
Old Bracknell Lane West
Bracknell Berkshire RG12 7AH

Date received: 14 February 2023

Instrument:

BSRIA I.D.:	202158
Description:	Temperature data logger
Manufacturer:	Testo
Model:	175-T1
Serial number:	37629831/911
Procedure version:	U58F19V4

Laboratory conditions:

Temperature: 20 °C ± 4 °C — Relative humidity: < 75 %rh
Mains voltage: 240 V ± 10 V — Mains frequency: 50 Hz ± 1 Hz

Comments:

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Calibrated by: K. Shipman — **Date of calibration:** 14 March 2023

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Certificate of Calibration

As Found Results

Certificate number
STD_142673
Page 2 of 2 pages

Reference equipment used in the calibration:

Instrument description	Serial number	Certificate number	Last cal. date	Cal. period
Temperature & Humidity Standard (ZZPDL03)	KS0614005	UK_48043	11/05/2022	12 Months

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Test point 1	9.7 °C	9.7 °C	0.0 °C	±0.5 °C	0.0 %	±0.31 °C
Test point 2	19.8 °C	19.8 °C	0.0 °C	±0.5 °C	0.0 %	±0.31 °C
Test point 3	29.9 °C	29.7 °C	0.2 °C	±0.5 °C	40.0 %	±0.31 °C

Any test points marked with a * do not comply with instrument specification.

End.