

Energy savings from **controlling solar shading**

Dr Paul Littlefair, Environmental Consultancy Centre, BRE

Eurling Jose Ortiz and Dr Claire Das Bhaumik, Sustainable Energy Centre, BRE

This paper examines the energy and thermal comfort implications of installing solar shading, including automatically controlled shading. In air conditioned buildings in England, shading can reduce carbon dioxide emissions and energy cost. Automatic control of shading can give extra savings. Modelling of an automatically controlled shading system (internal or external) in an air-conditioned office gave building energy cost savings of around 10% in the London area, compared to the no shading case. In a naturally ventilated hospital, automatically controlled external shading significantly reduced summer overheating, which could avoid the need to install cooling in some areas.

Previous work at BRE has highlighted the benefits of solar shading (refs 1,2) in controlling overheating and glare. But shading can have energy benefits too. A BRE case study (ref 3) estimated that installing solar shading (either mid-pane or external) and night ventilation in a typical 1960s open plan office would save around 55kWh/m²yr in air conditioning, cutting running costs by £15/m²/year. Even in a building where cooling had already been installed, the shading could pay for itself in under five years.

A literature review by Dubois (ref 4) quoted studies giving savings of between 23 and 89% in cooling energy use from installing shading. Dubois also showed large energy savings (around 12 kWh/m²yr) by using a simple seasonal awning in a south facing office. However this was almost completely offset by extra heating and lighting use if the awning was fixed and remained in place year-round. This indicates that moveable shading (ref 5) is especially appropriate. But the shading should be appropriately controlled.

This paper sets out to quantify the benefits of shading control. It describes environmental modelling of two example buildings with an automatic shading control system, and comparison with the same buildings with no shading, with fixed shading, and with manual control of blinds. The buildings chosen were an air conditioned office (figure 1) and a naturally ventilated hospital block (figure 2).

The modelling procedure

The buildings were modelled using the sophisticated dynamic thermal model DOE 2. Each building was simulated for a year using

weather data from London, Manchester, and Edinburgh.

Each building was modelled with five different types of shading:

- A** Internal shading (roller blinds), manually controlled.
- B** Internal shading as above, automatically controlled with manual override.
- C** External shading, fixed (a simple one metre deep overhang).
- D** External shading, moveable, automatically controlled with manual override. These are external venetian blinds, mid coloured. The slats are assumed to be closed when lowered.
- E** No shading (base case).

Manual control

To assess the way people use blinds, BRE developed a model of blind movement from surveys of office buildings (ref 5). Sunshine is the main factor affecting lowering of blinds. People are more likely to raise their blinds at the beginning or end of the day.

In the hospital wards, blinds were assumed to be shut at the end of the day then opened at the start of the day unless it was sunny. Blind changes were then modelled in the same way as for offices. Offices and consulting rooms in hospitals were assumed to have the same blind use patterns as office buildings.

Automatic control (with manual override)

The automatic control, based on Somfy's ANIMEO system, was assumed to work in the following ways. If a room was unoccupied at night, blinds were lowered to reduce heat loss, except if the

Solar Control

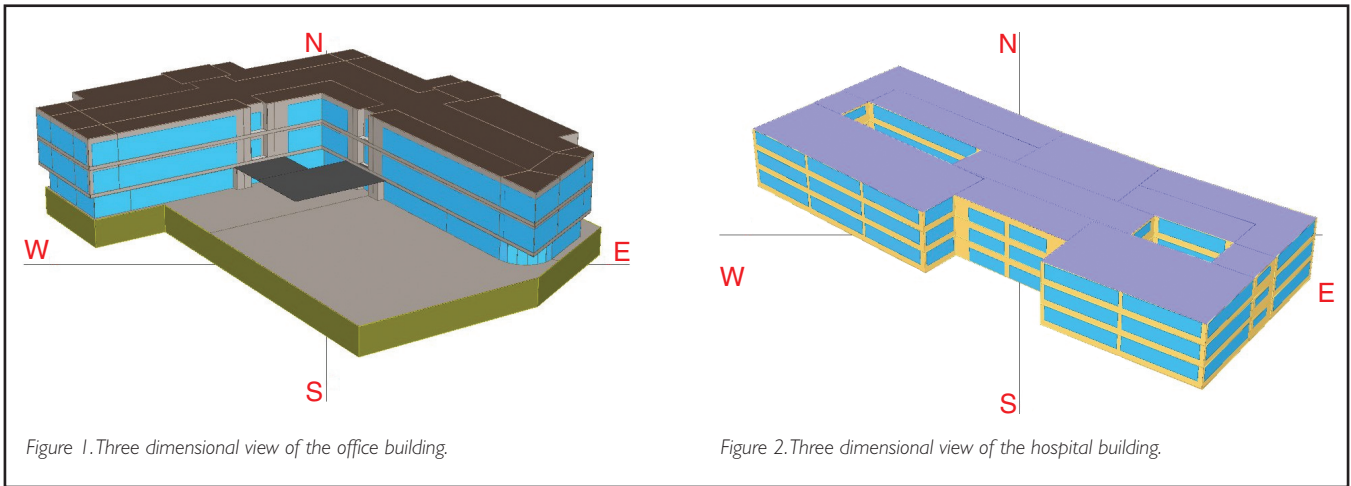


Figure 1. Three dimensional view of the office building.

Figure 2. Three dimensional view of the hospital building.

previous day had been warm. If a room was unoccupied during the day, blinds were lowered to reduce heat loss and unwanted solar gain, except on cold days when the solar gain would be useful.

If a room is occupied, then the automatic system sends the blinds up just before the start of occupation, except in summer (June, July, August), when the system sends the blinds down if there is sun on the façade, to prevent possible overheating.

In spaces like offices and hospital wards occupants value having control over their environment. They may also want to alter blind position so that they can have a view out or to control glare or provide privacy. Accordingly, in the analysis users were taken to be able to override the blind position at any time. The system reset the blind position to its initial value three times a day if the sunshine level was appropriate, but users could reset them back again if required.

In hospital wards occupied at night, users were assumed to close the blinds.

Results

For the office building, figure 3 gives calculated energy cost for the five shading strategies. Costs were assumed to be 2p/kWh for gas

and 6.5p/kWh for electricity. These are approximate costs and will depend on tariff and supplier, so should be taken as indicative only.

For the hospital building, figure 4 gives calculated energy cost for the same five cases. No cooling energy is used as the hospital is assumed to be naturally ventilated. Figure 5 gives overheating data in terms of the number of hours key temperatures are exceeded. The 'maximum' bars give the data for the worst affected zone in the building; the 'average' bars give the average data for all the zones in the building.

DISCUSSION

In the analysis, installing shading always reduces cooling demand but increases artificial lighting and, nearly always, heating. The only exception is in the hospital where adding internal blinds slightly reduces the heating load. This is due to reduced heat loss through windows during cold nights.

Air conditioned office

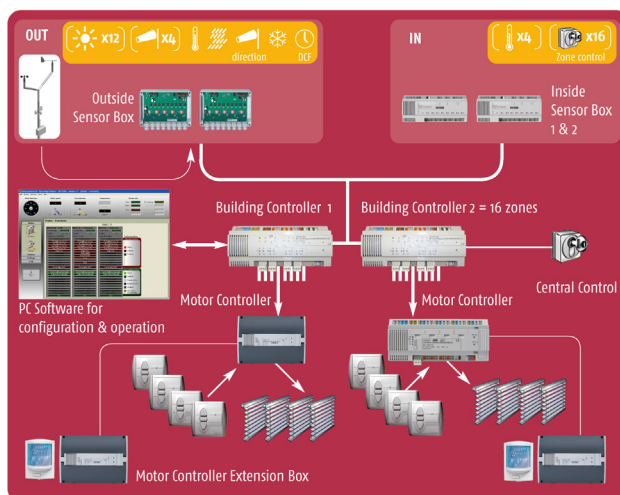
The results for the office building show that substantial cooling savings are possible. External automatic shading control (option D) achieves the biggest savings in cooling. Compared to the no shading case (option E) it gives a 66% reduction in London, 77% in

Manchester and 85% in Edinburgh. This strategy can therefore reduce cooling requirements in air conditioned buildings (or even avoid the need to install cooling in some locations). Cooling savings are best achieved with external devices that prevent additional solar gains.

Even when cooling savings are balanced against the increases in heating and lighting energy use, providing shading saves energy overall compared to the no shading case. Predicted savings are up to 10% in energy cost in London if an automatically controlled system is used. For London, there is very little difference between the energy performance of internal and external

> Extended solution

Local control with Radio Technology Somfy.



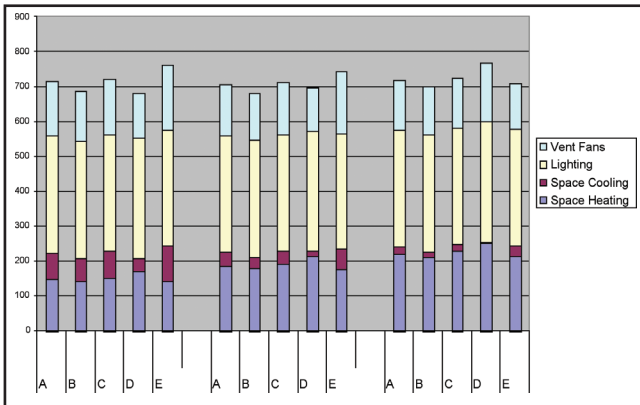


Figure 3. Energy cost (pence per square metre) for the office building for the five cases: A: Manually controlled internal blinds; B: Automatically controlled internal blinds; C: Overhang; D: Automatically controlled external shading; E: No shading.

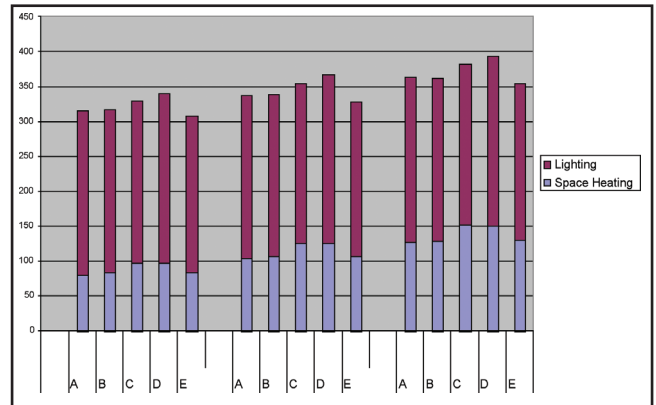


Figure 4. Energy cost (pence per square metre) for the hospital building for the five cases: A: Manually controlled internal blinds; B: Automatically controlled internal blinds; C: Overhang; D: Automatically controlled external shading; E: No shading.

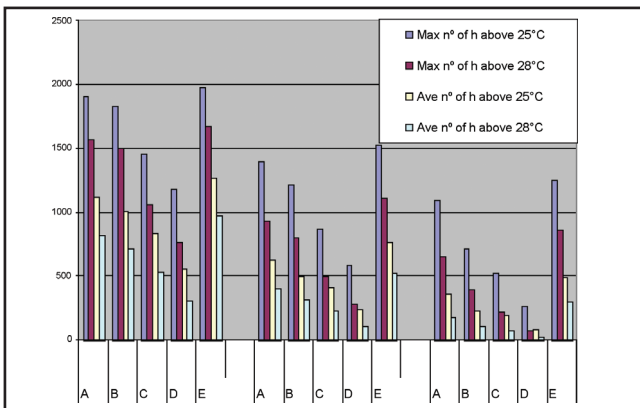


Figure 5. Hours of overheating for the five cases: A: Manually controlled internal blinds; B: Automatically controlled internal blinds; C: Overhang; D: Automatically controlled external shading; E: No shading.

shading systems.

However, latitude is a critical factor for shading systems. At high northern latitudes additional shading does not generally achieve energy savings, although it may increase user comfort by reducing glare.

For internal blinds, introducing automatic control (option B) always gives a saving of around 3% in total energy use compared with manual control (option A), for all locations. Both heating and cooling energy are reduced, but lighting energy use increases marginally, because the blinds are lowered more in summer.

Comparison of the automatically controlled external shading (option D) with the simple fixed overhang (option C) shows that the controlled shading gives a 5% reduction in energy cost in London and 2% reduction in Manchester. However in Edinburgh there is a 6% increase in energy cost. This is due to the increase in space heating costs in winter, because the occupants are modelled to use the moveable

external shading like blinds to reduce glare. The fixed overhang does not control glare from low angle sun in winter, so would be unlikely to be acceptable on its own as a shading device.

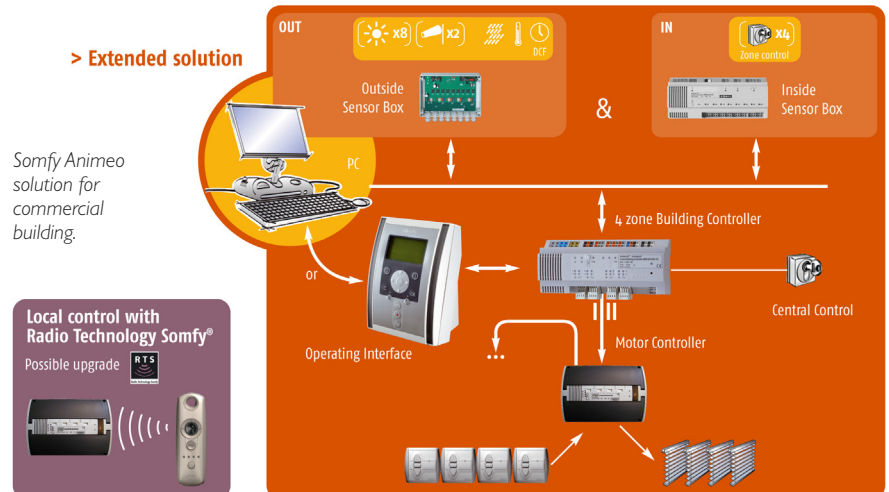
A combination of automatically controllable internal shading (winter) and external shading (summer) could be the best strategy for energy savings and comfort levels in an air conditioned building.

Naturally ventilated hospital

As the hospital does not have cooling installed, adding any form of shading will increase the energy use. Internal shading results in an energy penalty of 1-3%, and external shading a penalty of 7-12%, compared to the no shading case.

With internal shading, automatic control (option B) gives similar energy use to manual control (option A). For external shading, the moveable automatically controlled system (option C) gives energy use 1-4% higher than the simple fixed overhang (option D).

However energy use is not the only important issue here. Thermal comfort is critically important too. Figure 5 shows that the hospital design is particularly prone to overheating, especially in Southern England. Taking the hospital as a whole, a very high temperature of 28°C is exceeded 11% of the year with no shading.



Adv - Blinds & Awnings

continued from page 23

Internal shading reduces the temperatures slightly. Fixed external shading gives a further reduction, but the most effective system uses the moveable automatically controlled shading. Even with this system there is a tendency for the building to overheat, so it would need to be applied as part of a package of measures, for example improved ventilation and maybe cooling of the hottest zones.

Further north the overheating is not so marked if suitable shading is installed. With the moveable automatically controlled solar shading, overheating is limited to a few 'hot spots' in the building. There is a substantial difference in thermal comfort between the different shading options.

Moveable shading also helps to provide privacy, which is important in hospital buildings. Options C (fixed overhang on its own) and E (no shading) would not be acceptable in most areas in hospitals for this reason.

Conclusions

In air conditioned buildings in England, shading can result in significant reductions in carbon dioxide emissions and energy cost. There are extra savings from installing automatic control of shading. Overall, an automatically controlled shading system (internal or external) in an air-conditioned office gave building energy cost savings of around 10% in the London area, compared to the no shading case. In a naturally ventilated hospital, automatically controlled external shading resulted in significant reductions in summer overheating, which could avoid the need to install cooling in some areas.

ACKNOWLEDGEMENTS

The analysis described here has been funded by the shading control manufacturer Somfy. However the views expressed here are those of the authors and not necessarily those of Somfy SAS. We would like to thank Serge Neuman and Geraldine Mostachfi of Somfy for providing details of their systems.

REFERENCES

1. Littlefair P J, 'Solar shading of buildings' BRE Report BR 364. Garston, Building Research Establishment, 1999.
2. Littlefair P J, 'Retrofitting solar shading' BRE Information Paper IPI 1/02, Garston, Building Research Establishment, 2002.
3. Energy Efficiency Best Practice Programme 'Comfort without air conditioning in refurbished offices', New Practice Case Study 118, Garston, BRECSU, 2000.
4. Dubois M-C, 'Solar Shading for Low Energy Use and Daylight Quality in Offices. Simulations, Measurements and Design Tools.' Report No TABK—01/1023, Department of Construction and Architecture, Lund University, Lund, Sweden, 2001.
5. Littlefair P J, 'Controlling solar shading' BRE Information Paper IPI 2/02, Garston, Building Research Establishment, 2002.