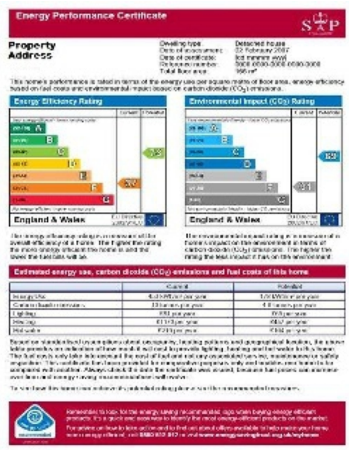
EU ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD) AND SOLAR SHADING

INTRODUCTION

The EU Energy Performance of Buildings Directive came into force in the UK in 2002 and was revised in 2010 to include improved energy performance targets.

Buildings account for 40% of total energy consumption in the EU and with the sector increasing it is a key area for the EU to begin reducing energy consumption. The EPBD provides measures to reduce energy consumption in the EU and also aid compliance with the Kyoto Protocol, the EU's long term commitment to maintain global temperature rise below 2°C and meet the EU commitment to lower greenhouse gas emissions of 20% by 2020.

> "Building strategies should be focus on measures which avoid overheating, such as shading… and passive cooling techniques"
>
> *Energy Performance of Buildings Directive, 2010*



KEY FEATURES

- Develop a method to rate the energy performance of buildings
- Set national minimum energy performance requirements for new and existing buildings that undergo major renovation.
- Introduce an energy performance certificate for buildings
- Put in place regular inspections of heating and air-conditioning systems.

EPBD AND SOLAR SHADING

In the 2010 revision of the EPBD solar shading is referred to in:

Recital 9

Requires that the energy performance of buildings should be calculated on the basis of a methodology that includes, in addition to thermal characteristics, factors that play an increasingly important role such as passive heating and cooling elements, **shading**, adequate natural light and design of the building.

Recital 25.

Covers the increase in the number of air-conditioning systems installed in European countries in recent years. It requires that priority should be given, during building design, to strategies that enhance the thermal performance of buildings during the summer period.

Annex I

Provides a framework for the calculation of energy performance of buildings and a list of the aspects that should be included into the calculation as a minimum standard including *(g)***passive solar systems and solar protection**

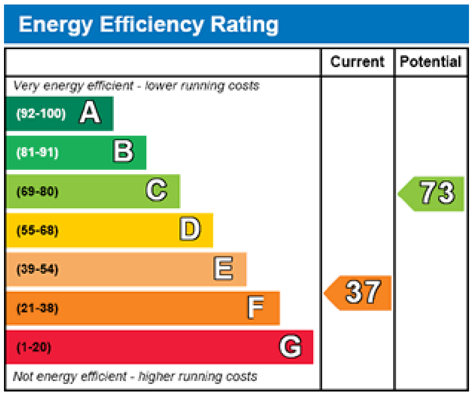
EU ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD) AND SOLAR SHADING

BUILDING REGULATIONS OF EPBD IN THE UK

The minimum energy performance targets for buildings in England and Wales are contained in Part L of the Building Regulations. Part L covers the Conservation of Fuel and Power in buildings. Limiting the effects of solar gain (with shading i.e. blinds) was one of the main elements of the revision on the 1st of October 2010.

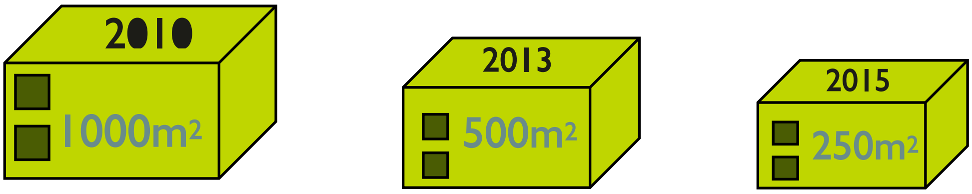
Energy Performance Certificates (EPC's)

- EPCs are required by all buildings when they are constructed, sold or rented.
- EPCs assess the capability of the building to be energy efficient and give the building a rating from A to G ('A' being very efficient and 'G' begin inefficient).



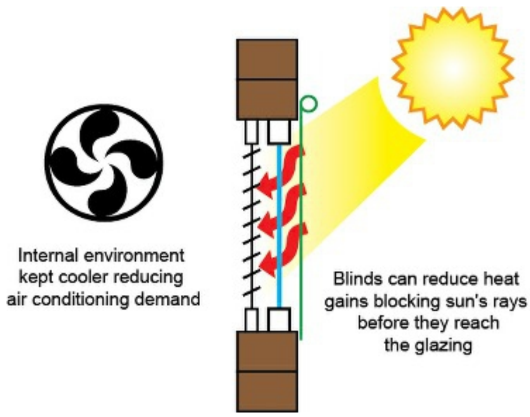
Display Energy Certificates (DECs)

- DECs are required by buildings that have a total useful floor area of greater than 1000m^2 that are occupied in whole or part by public authorities and by institutions providing public services to a large number of people. In 2013 DECs will be required by public buildings greater than 500m^2 and by 2015 this will be changed to buildings with a total useful floor area of greater that 250m^2.



Inspections of air-conditioning systems

- Required for all systems with a rated output over 12kW at least every 5 years.
- The aim of the inspection is to provide building owners and users with advice about the performance of their buildings and cooling plant and to identify opportunities to save energy and cut operating costs.



Building Regulations

Part L - What to do with solar shading?

INTRODUCTION

On October 2010 the Department for Communities and Local Government (DCLG) released 2010 Building Regulations

These were amended in 2013 to comply with the modified European Energy Performance of Buildings Directive. The Part L that concerns to shading is contained in the Part L associated to Conservation of Fuel and Power in buildings. The regulations are split into 4 documents:

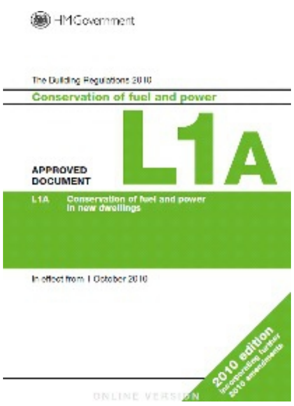
L1A: Conservation of fuel and power (New dwellings)

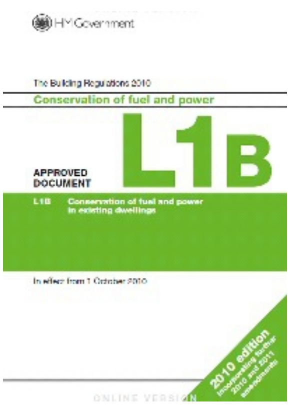
L1B: Conservation of fuel and power (Existing dwellings)

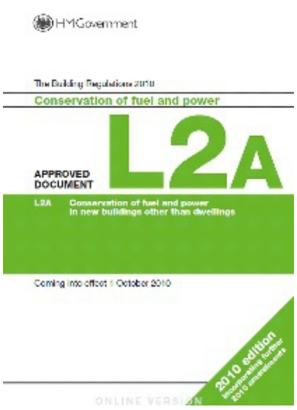
L2A: Conservation of fuel and power (New buildings other than dwellings)

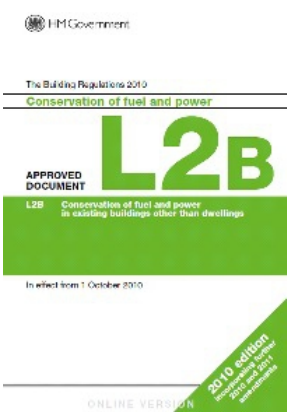
L2B: Conservation of fuel and power (Existing buildings other than dwellings)

> To limit the effects of solar gain an appropriate combination of window size and orientation, solar protection and other solar measures should be considered.
>
> *Part L Building Regulations*









IMPORTANT CONSIDERATIONS

There is a requirement that all new buildings must reduce their annual CO_2 emissions rate by 25% relative to the 2006 standard. This means that buildings must be designed to use less energy during construction and during use. To meet this target the energy efficiency of the heating, cooling and lighting of the building must be taken into consideration.

The energy performance of a building is calculated using the Standard Assessment Procedure (SAP) for domestic buildings and the Simplified Building Energy Model (SBEM) for non-domestic buildings. The energy performance of a building once it is built is represented by an Energy Performance Certificate (EPC), which since 2008 is required for all new buildings.

In addition, all new buildings must undergo the regulations compliance calculations to ensure that the building will not exceed the target CO_2 emissions rate and this can be achieved by ensuring that a building will not be subject to high internal temperatures along with other measures.

Building Regulations

Part L - What to do with solar shading?

CONSERVATORIES

In the 2010 regulations all conservatories that are installed at the same time as the construction of a new dwelling must comply with the energy efficiency targets of the building regulations. But, when a conservatory is installed as an extension to an existing dwelling an exemption applies:

- Which are at ground level
- Where the floor area is less than 30m²
- Where existing walls, doors and windows are retained or replaced with elements that meet the energy efficiency requirements
- Where the heating system for the dwelling does not extend into the conservatory

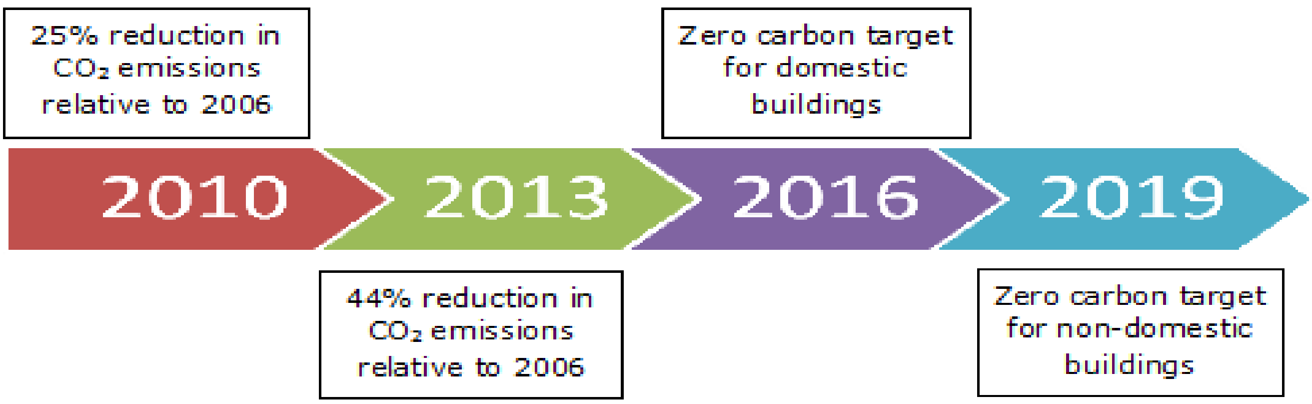
U-VALUE OF WINDOWS

Depending on the type of building, domestic or commercial, whether new or existing building windows have to comply with different minimum standards concerning the heat loss of windows (U-value). See Guidance Note C4 to find out more about this value.

Part L	Reference limits	U-value
L1A	New dwellings	2.0 W/m²K
L1B	Existing dwellings	1.6 W/m²K
L2A	New buildings non-dwellings	2.2 W/m²K
L2B	Existing buildings non-dwellings	1.8 W/m²K

2013 AMENDMENT PART L

The amended regulations require that all Energy Performance Certificates include a recommendation report which includes cost-effective measures that can be connected to major renovation (more than 25% of the total surface area) of walls, floors, roofs, windows, doors and roof lights of the building. They also require that when renovation of thermal elements (wall, floor, roof) take place, they must make a reasonable provision for limiting heat gain and loss in the building through the same thermal elements or other parts of the building fabric. In building refurbishment blinds and shutters can be considered as a remarkable contributor for keeping or rejecting heat efficiently.



THE IMPORTANCE OF SOLAR GAIN FOR BUILDINGS

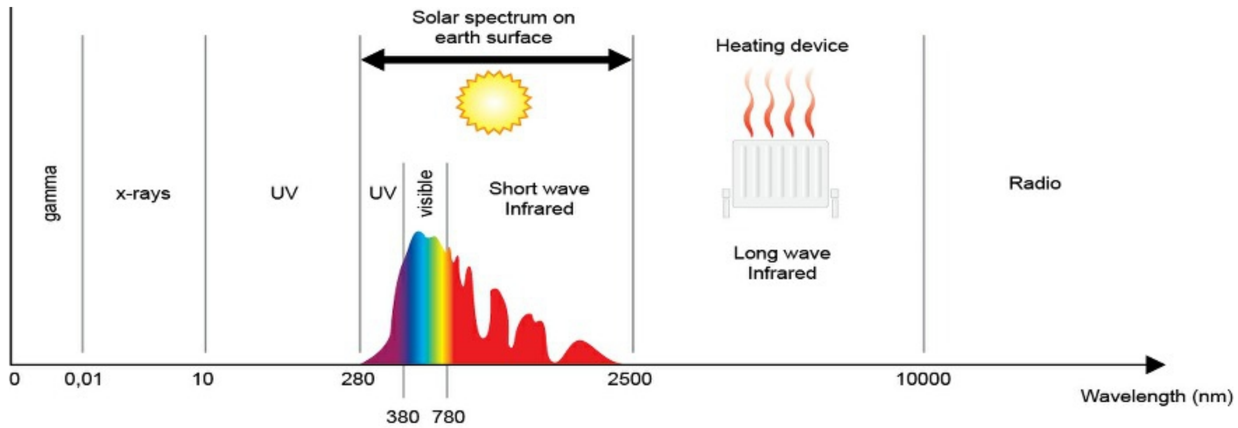
INTRODUCTION

Our Sun produces an enormous amount of energy. Harnessing this powerful source can provide valuable energy for winter heating but without shading it can mean that energy costs are required for cooling in summer.

To understand the need for shading we need to understand how the Sun's rays work. The Sun is constantly flooding the Earth with its energy. But the amount of energy reaching the surface can vary. Under optimal conditions solar radiation reaches the Earth's surface at up to 1000 W/m^2. However, even though the Sun's energy is changing we require a relatively constant and comfortable temperature inside our buildings. This constant internal temperature can be achieved using insulation in the roof, walls and through shading with blinds and shutters.

Blinds and shutters can prevent excessive solar gain by blocking some of the incoming light and retain heat by not allowing it to pass back to the outside.

To know how the solar radiation of the sun works it is necessary to look at the solar spectrum. Incoming solar radiation is made up of three main bands: UV radiation (320nm-380nm), visible light (380nm-780nm) and IR radiation (780nm-2500nm). The Earth's atmosphere absorbs a large proportion of the incoming UV and IR radiation before it even reaches the surface. The radiation that reaches the Earth's surface is predominantly visible light with only 5% being UV.



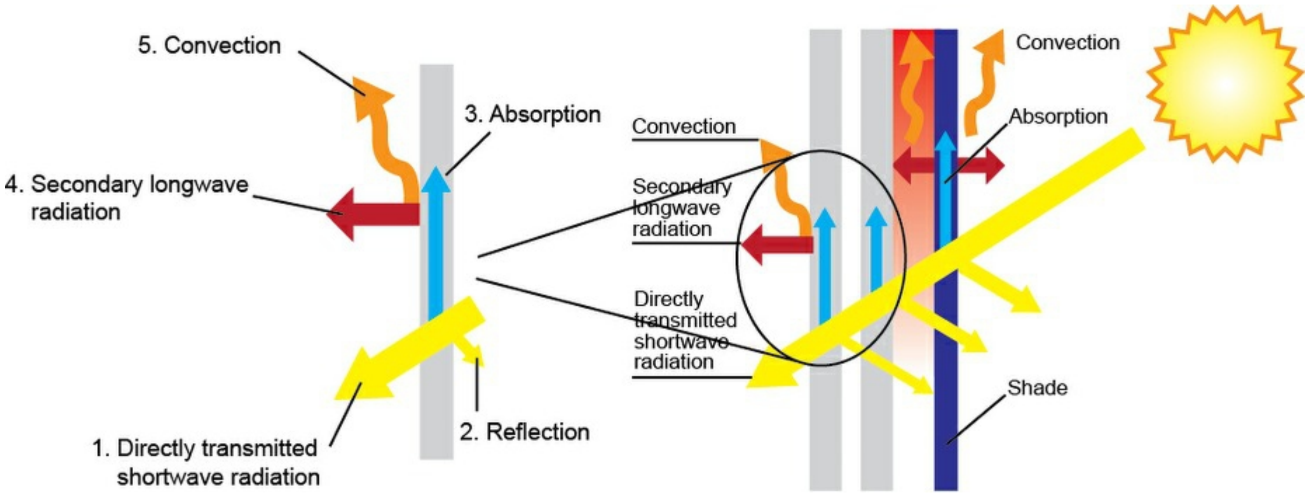
GLASS AND SOLAR RADIATION

Glass allows visible light and shortwave infrared radiation to pass through into a building. The glass reflects some of the shortwave radiation (mostly light) back to the atmosphere however a large percentage is transmitted into the building. For single glazing around 87% of the energy hitting the window is transmitted to the inside.

Once the radiation is in the building it is then absorbed by objects such as walls, floors, chairs, desks, people etc. These objects absorb and convert radiation into longwave (mostly heat) that is re-radiated. The radiation that is transmitted through the window is at wavelengths of 780 – 2,500nm and when it is re-radiated it is between 5,000 – 25,000nm.

THE IMPORTANCE OF SOLAR GAIN FOR BUILDINGS

Solar radiation enters a building by passing through the glass in the windows. Glass is transparent to the shortwave visible light from the Sun but it is opaque to the longwave heat which is not allowed to pass back. The glass and shading device when affected by solar radiation, present the following behaviour:



1. Directly transmitted shortwave radiation. The glass allows visible light and shortwave infrared radiation to pass. Some of this radiation passes straight through the glazing and shading.
2. Reflection. At each layer in the window system some of the incoming shortwave solar radiation is reflected, this may then be absorbed by other layers or reflected back to the outside.
3. Absorption. Also at each layer some of the incoming solar radiation is absorbed. Some materials absorb more radiation than others for example darker colours are more absorbent.
4. Secondary longwave radiation. Objects are constantly absorbing and re-radiating energy as heat. Glass does not allow these to pass back and so the heat is unable to escape and temperatures increase in the room.
5. Convection. It refers to the movement of warm air across the pane of glass as the temperature changes due to solar gain and the cooler surrounding air.

HOW SOLAR SHADING CAN PREVENT BUILDINGS FROM OVERHEATING

Blinds and shutters can prevent excessive solar gain by blocking some of the incoming visual light radiation. External blinds are very effective at this as they prevent the radiation from even reaching the window.

Internal blinds can also reduce solar gain especially fabrics that have a reflective coating facing the window which will reject some of the incoming shortwave radiation, therefore not allowing it to be absorbed and turned into heat.

To find out more about the measures that assess the solar gain, take a look at the next Guidance Note C4 about How solar shading prevents overheating in buildings.

How solar shading prevents overheating in buildings?

INTRODUCTION

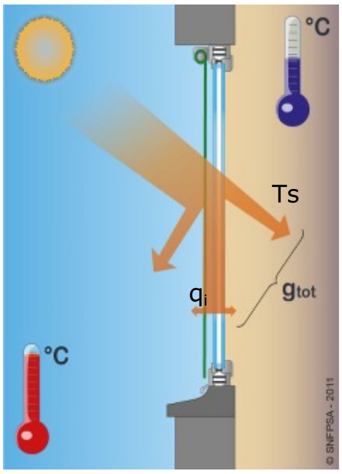
Solar radiation has the power to heat buildings but this energy can also be excessive at certain seasons.

External blinds are very effective at blocking the incoming radiation because they prevent the radiation from even reaching the window. The absorbed re-radiated energy does not pass through the glass being trapped between the blind and the outer pane of glass. The measure that allows us to assess the solar gain of a building is called g-value.

The shading property of blinds and shutters in the UK has been under estimated. They effectively prevent solar gain by blocking some of the incoming solar radiation.

WHAT IS THE G-VALUE AND THE GTOT?

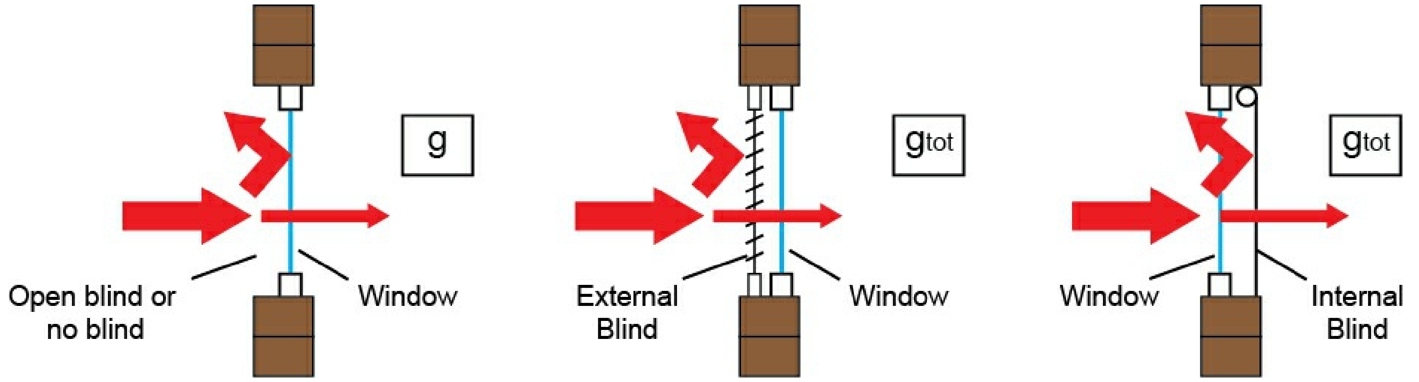
This refers to the total solar energy transmittance through a building element, for example a window when exposed to solar radiation. The g-value is also called the Solar Heat Gain Coefficient (SHGC) and the Solar Factor. It is the sum of the solar transmittance (Ts), and the secondary internal heat transfer factor (qi), i.e. g = Ts + qi, the latter term arising from absorption of solar radiation in the glazing and subsequent re-radiation at thermal wavelengths to both the outside and the inside of the enclosure. The recommended procedure for calculation of the total solar energy transmittance is indicated in the standard EN 410.



The total solar energy transmittance through a window and shading device combined is the g_{total}, colloquially known as g_{tot} in the shading industry.

WHAT DOES THIS MEAN?

The g_{tot} is expressed in values from 1 to 0 where 0 means no radiation is transmitted and 1 means all radiation is transmitted. The lower the value, the lower the heat gain. For example, 0.87 is the g-value of a single piece of float glass. This value can also be expressed in percentages, so that in the example 87% is transmitted thus only 13% of solar energy is rejected. So the lower the transmitted percentage, the better the glass and fabric to reject heat gain. It is important to use accurate data for the energy performance of glazing. Data is available



HOW SOLAR SHADING PREVENT OVERHEATING IN BUILDINGS?

Shading is one of the most effective natural ways to limit overheating in buildings. This property is particularly important in Passive and Active house buildings which aim to reduce total energy consumption and CO_2 emissions. This is also important in large glazing buildings which in summer risk to gain excessive solar radiation. Typically external shading has much more impact on g_{tot} than internal shading because they stop part of the solar radiation that initially hits the window. Therefore, this property should be highly considered when the building is in construction.

In an office building one of the highest energy costs is air-conditioning, effective shading can reduce the need for air-conditioning and save money.

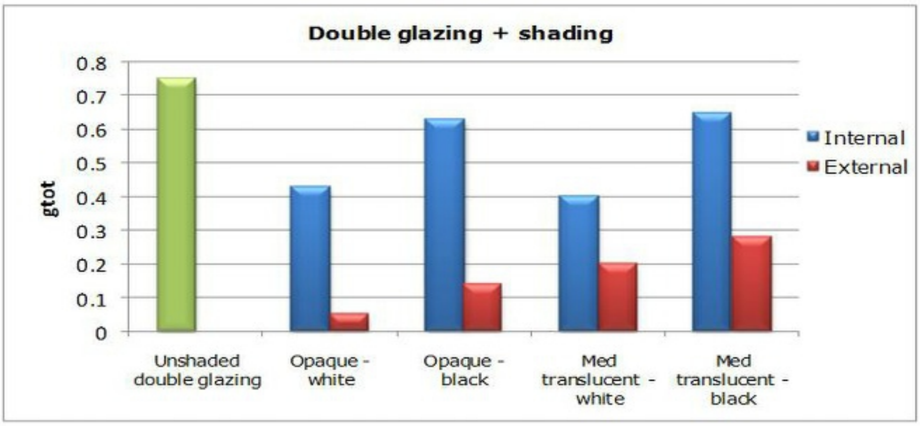
WHAT IS THE IMPORTANCE?

- Blinds are never used without glazing so g_{tot} is the most relevant measure
- g_{tot} should be included in building information modelling
- Reducing energy use reduces carbon emissions and energy costs
- Reducing energy and carbon emissions help you comply with Building Regulations

HOW COLOUR OF THE FABRIC AFFECTS SOLAR ENERGY TRANSMITTANCE

The following data was obtained from the BBSA's Shade Specifier Database, 2008. White colours fabrics are more reflective and therefore have a lower g_{tot}.

Blind fabric	Double glazing (g = 0.75)		Solar control glazing (g = 0.32)	
	Internal blind	External blind	Internal blind	External blind
Opaque -white	0.43	0.05	0.24	0.02
Opaque -black	0.63	0.14	0.30	0.07
Medium translucent -white	0.40	0.20	0.26	0.10
Medium translucent -black	0.65	0.28	0.3	0.14



The graph shows that heat gain can be remarkably reduced by using external shading. Even using a better glazing system such as a solar control, shading will always improve heat gain.

THE EFFECT OF SOLAR SHADING ON AIR-CONDITIONING REQUIREMENTS IN EXISTING BUILDINGS

INTRODUCTION

Domestic and non-domestic buildings account for 45% of the UK's carbon emissions.

Energy consumed in constructing, maintaining and using the built environment is a significant contributor to greenhouse gas (GHG) emissions. In addition, UK has the oldest housing stock in the developed world 8.5 million properties are over 60 years old. This is why refurbishment should have an important role when reducing carbon emissions.

"Selection of solar shading should always be one of the first steps in the design of HVAC systems"

Eolli Seppannen, REHVA

In some refurbishment cases it may be possible to meet the cooling demand of a building without mechanical means. Passive* cooling measures can be employed such as solar shading and natural ventilation. A study by Lund University in Sweden states that savings of between 23-89% in cooling energy use can be achieved from installing shading.

WHY BUILDINGS NEED SHADING?

Buildings with large glazing façades can:

- Generate overheating problems through solar gain
- Contribute to an increase in cooling demand
- Yield visual problems through direct and reflected glare (Dubois, 2001)

Solar shading can help to solve all these problems!.

This makes shading a necessity in buildings with large amounts of glass. In many cases an external solar shade can counteract the overheating problems by blocking solar radiation from entering the building. However, an internal blind may also be required to provide additional glare control particularly in the winter months when solar gains should be maximised but glare is still a problem.

Air-conditioning can also deal with the problem of overheating in a building. However, it can be very expensive, it may give rise to compliance issues over energy use in the building. It also generates carbon emissions and it will not deal with visual discomfort from glare.

*Passive: It refers to a measure that does not require energy

Dubois (2001).*Solar shading for low energy use and daylight quality in offices*

THE EFFECT OF SOLAR SHADING ON AIR-CONDITIONING REQUIREMENTS IN EXISTING BUILDINGS

AUTOMATED SHADING

One of the criticisms of to mechanical shading is that energy savings cannot be quantified as these depend on human behaviour. So, a solution would be the installation an automated system. A study by BRE showed that automatically controlled shading will give extra 3% of CO_2 savings compared with manual of fixed shading systems. Automated solar shading can operate on timers, light and heat measurements that ensure the shading is operating in the most energy efficient way. Automated solar shading will also mean that blinds in unoccupied rooms are being used in the correct way to achieve energy savings.

REDUCTIONS IN COOLING DEMAND WITH SOLAR SHADING

The Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) in Guidebook 12 have analysed the difference in cost to install, run and maintain an HVAC unit for an office with and without shading.

	Without shading	**With shading**	**Overall reductions**	
	HVAC investment cost (£)	HVAC investment cost (£)	Reduction in HVAC investment cost (%)	Reduction in electricity required for cooling (%)
Stockholm	1,555	1,258	19%	38%
Amsterdam	1,520	1,251	18%	30%
Madrid	1,657	1,375	17%	40%

These calculations were carried out for a test office with a floor area of 18m^2 and a glazing percentage of 60%. For the without shading case a solar control glass was used whereas for the calculations with shading a low-e glass was installed. There is a difference in price between these two glazings. In this case solar control glass was assumed to be 108 £/m^2 while low-e glass was assumed to be 60 £/m^2.

The results show that for all three locations an overall reduction in HVAC investment cost and electricity required for cooling is achieved when shading is installed. The results also show that when shading is installed on low-e glazing which is cheaper than solar control glass, improved results can be seen.

A RIGHT BALANCE BETWEEN HEATING AND LIGHTING

Specification of solar shading needs to be carefully considered to achieve overall energy savings in a building. Solar shading can reduce the daylight in a building therefore increasing the electricity requirement for lighting. In the winter months heating requirement increases although this can be balanced by internal and external shading which can reduce heat loss. Dynamic solar shading systems will also optimise beneficial winter solar gains.

Large energy savings in the cooling load can be made but these must be balanced with changes to heating and lighting demands.

PRODUCTIVITY AND SOLAR SHADING

INTRODUCTION

> "By maximising the use of daylight without glare and providing daylight responsive lighting control a productivity benefit of 4% was found in a workplace".
>
> *Carenergie Mellon University*

A good quality internal environment typically has a positive effect on productivity.

It is widely known that the visual and thermal comfort of an internal environment will affect people's relative comfort and therefore how they work within that environment. This can be true in schools, offices, factories and any other building where the efforts of the employees can be affected by an uncomfortable working environment.

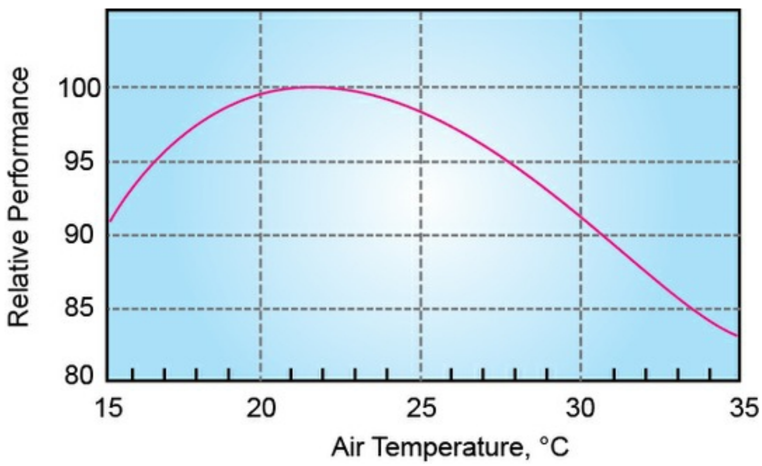
OPTIMAL TEMPERATURE COMFORT

A correct temperature in a building has a significant impact on employee productivity. However, building designers often do not consider this thermal comfort as a priority and argue that it is more important to reduce construction and operating costs of the building. But when the whole lifetime of a building is assessed it is clear that employees salaries and associated costs are significantly higher than building operating costs. This can be seen in the diagram on Page 2 of this guidance note. Relatively minor productivity increases have a large economic impact and provide a valid case for organisations to invest in improving the quality of their indoor environments.

Issues associated with incorrect indoor thermal conditions in a workplace include:

- High indoor temperatures increase the prevalence of sick building syndrome symptoms which include sensory irritations of eyes, nose and throat; neurotoxic and general health problems.
- High temperatures in classrooms are harmful to performance of school work.
- Low temperatures in rooms reduce the dexterity of hands and may affect performance of manual tasks. (REHVA Guidebook No 12)

Therefore, the ideal range of temperature in work rooms is between 20 to 24°C. Above and below these temperatures there is a sharp drop of productivity as people become too hot or too cold, uncomfortable and find it difficult to concentrate.

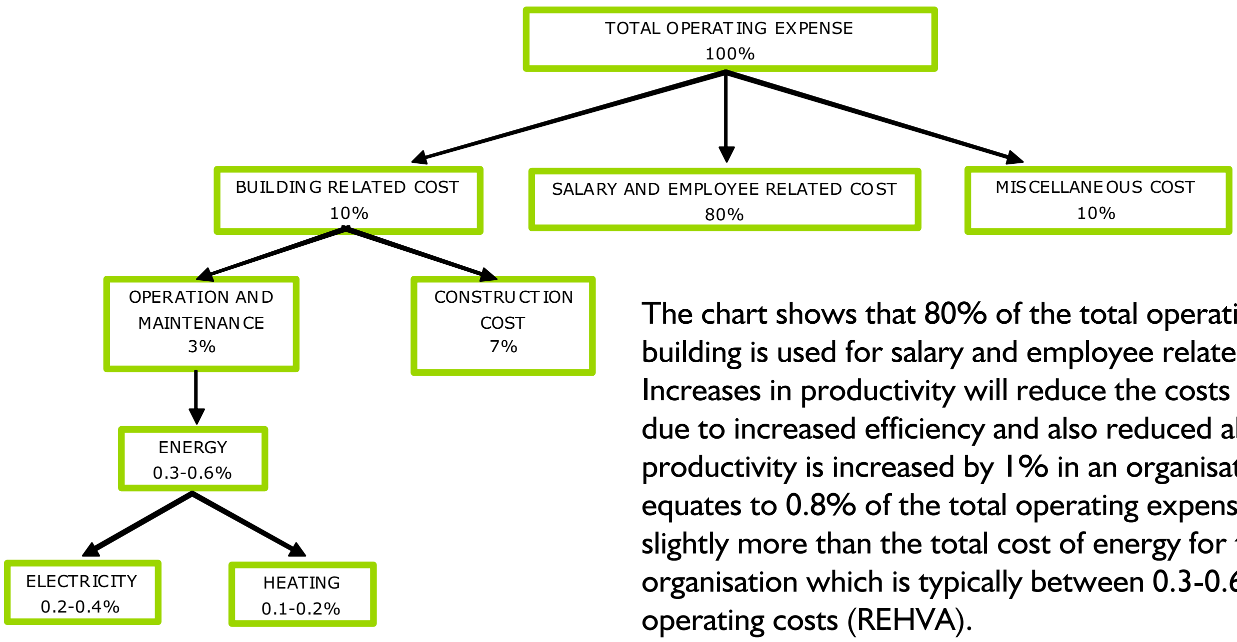


PRODUCTIVITY AND SOLAR SHADING

VISUAL COMFORT

People prefer natural daylight to electric lighting in buildings. It is clear that visual contact with the outside world affects people's state of mind and it is proven that it will increase productivity as people will feel happier. The CIBSE code for lighting states that for a general office (tasks such as computer work, writing, drawing) a recommended lux level is 500 lux*. And a range of 300 to 500 lux for places with less light requirements to have comfortable conditions.

OPERATING EXPENSES IN A TYPICAL OFFICE



The chart shows that 80% of the total operating cost of a building is used for salary and employee related costs. Increases in productivity will reduce the costs in this section due to increased efficiency and also reduced absenteeism. If productivity is increased by 1% in an organisation this equates to 0.8% of the total operating expense. This 0.8% is slightly more than the total cost of energy for the organisation which is typically between 0.3-0.6% of the total operating costs (REHVA).

SOLAR SHADING AND IMPACT OF PRODUCTIVITY

Solar shading can provide a cost-effective and simple solution to improving temperature and light comfort. Through blocking solar radiation external and internal blinds can reduce the build up of heat gain within a building, therefore increasing comfort and productivity for the occupants and reducing the need for air-conditioning.

All types of shading can also reduce glare in buildings. Correctly specified and operated blinds provide the user with the ability to reduce glare, control the amount of natural light and solar gain entering a building.

Blinds and shutters not only improve the quality of an indoor environment and consequently productivity but they will also reduce the energy costs of an organisation through reduced heating and cooling requirements and reduced use of artificial lighting.

*Lux: The amount of illumination on a surface.

REHVA Guidebook No 12*Solar Shading. How to integrate solar shading in sustainable buildings*