An introduction to natural daylight design in domestic properties

"Our body uses light as a nutrient for metabolic processes similar to food and water".

Contents

Introduction

The National Association of Rooflight Manufacturers (NARM) represents manufacturers offering a complete cross section of fixed and opening rooflight types, including:-

- modular domes
- pyramids
- flat glass rooflights
- in-plane profiled rooflights
- continuous barrel vaults
- panel glazing systems
- architectural glazing systems for skylights
- lantern lights
- atria.

Together, through NARM, they are able to provide a knowledge base second to none on matters relating to the provision of high quality natural daylight into all types of buildings.

This document provides an overview of factors to consider in the design and specification of rooflights in domestic buildings.

Background

Daylight has been used for centuries as the primary source of light in interiors and has been an implicit part of architecture for as long as buildings have existed. Our most natural resource has been available now for over 4 billion years and yet we still do not take full advantage of its qualities and benefits even though research throughout the ages has proven that it is an essential ingredient for our good health and well-being.

The first architectural guidelines were developed over 2,000 years ago by Marcus Vitruvius Pollio and these acknowledged the importance of daylight in design and provided guidance on how to measure the amount of light coming into a room. He proposed a simple test that consisted of stretching a line from the top of a wall that appears to obstruct light, to the point at which the light enters the proposed building.

If there is a considerable space of open sky above that line then it is deemed that the daylight will not be obstructed. This is referred to as the ‘sky component’ and is still used in modern daylight calculation methods.

We spend most of our time indoors and yet the indoor environment is discussed much less than the outdoor environment. The presumption is that we are safe indoors. Buildings provide shelter, warmth, shade and security; but they often deprive us of fresh air and natural light.

It must be remembered that although we have adapted to living indoors, we are still essentially outdoor animals, with our gene code still designed to live on the savannah.

As outdoor animals therefore, we need to live in a natural environment, not an artificial one and so this need, coupled with the desire to improve the energy efficiency of buildings, requires a change in mind set to encourage and ensure the provision of good daylight and ventilation in the future design of domestic buildings.

Daylight is a freely available natural resource that will significantly improve the environment within the home.

Health and well-being

There are many factors in life that affect our health, not least our lifestyles and the places in which we live and work, but even with the knowledge and technology available today, there is still a lack of consideration on the effects of the indoor environment on the human condition.

There are many ways we can improve our health - exercise, diet and education to name but three - but as we spend up to 90% of our time indoors, we should pay just as much attention to the environment in which we live, rather than just the body in which we live.

In addition, around 30% of all buildings do not contribute to good health and yet the indoor environment is discussed much less than the outdoor environment.

If we look at our health 'journey' through life, it becomes apparent that there are not enough proactive measures in place to prevent ill health, and instead we rely on reactive measures to treat us when we fall ill.

If we could reduce the incidence of poor health by improving the environment around us, we not only reduce the burden on the health service, we improve our own quality of life.

It is not just letting daylight in that is important, the view out is also a major factor to support well-being. In 1997 the Danish Building Research Institute conducted a study with over 1,800 people working in office buildings, asking questions to see how important windows were for the office workers. The ability 'to be able to see out' and 'to see the weather' were considered top priorities. Having a view allows one to tolerate a lot more discomforts in the internal environment than if you do not have a view.

Roof windows at the simplest level provide that connection and give us constant and instant information about time, space and place.

Types of daylight

Daylight in buildings is composed of a mix – direct sunlight, diffused skylight and reflected light. An effective and optimised layout of rooflights or roof windows will not just allow the light into the home, but will also determine the type and amount of light entering the home.

Direct light

This is characterised by very high intensity and constant movement. The illuminance produced on the surface of the Earth can reach as much as 120,000 lux. This light enters straight through the rooflight or roof window without any interference to provide a concentrated beam of light into a given space. Direct light will result in glare on very sunny days and will also create dark corners and shadows.

Diffused skylight

This is characterised by sunlight scattered by the atmosphere and clouds resulting in a soft and diffuse light. This illuminance produced by an overcast sky can be as much as 10,000 lux. This light passes through the rooflight or roof window to provide a less bright but more even distribution of light into the space.

Reflected light

This is characterised by light (sunlight and skylight) that is reflected from the ground, terrain, trees, vegetation, and neighbouring structures etc. The surface reflectance of the surroundings will influence the total amount of reflected light reaching the building façade.

Daylighting is inseparably linked to the energy demand and indoor climate of a building. The size and placement of glazing should be determined together with the total energy use of the building and specific requirements for daylighting.

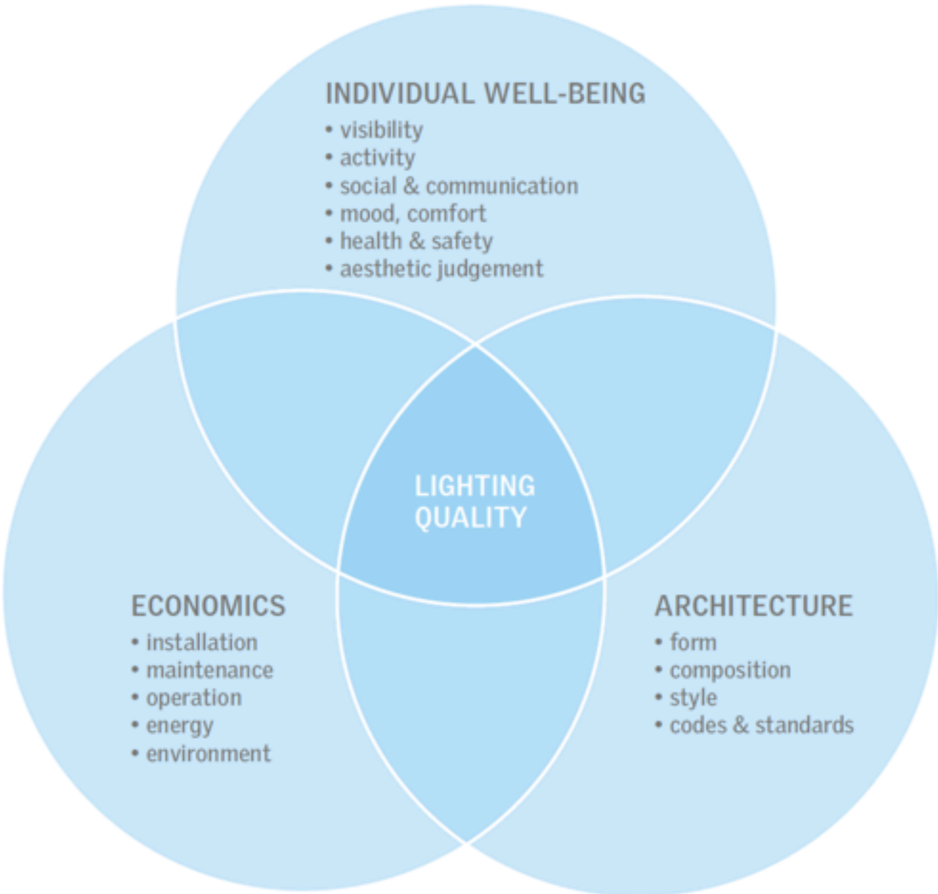
Daylight quality

Daylighting should be designed to provide adequate light levels in the room and on the work plane so that daylight is the main/or only source of light (autonomous) during daytime. Whilst there is little guidance on specific illumination levels in design, there is enough evidence in literature to indicate that illuminances in the range of 100 to 2500 lux are likely to result in significant reduction of electrical lighting usage in the home.

The light variation within your field of view can influence visual comfort and performance. For good visibility, some degree of uniformity of light is desirable. Poor visibility and visual discomfort, such as glare, may occur if the eye is forced to adapt too quickly to a wide range of light levels.

Too high or too low contrasts can also result in tiredness, headaches, discomfort etc. While specific guidelines for dwellings are not available, it is believed that luminance variations around 10:1 are suitable for daylighting design. Generally, the human eye can accept greater luminance variations when spaces are lit by daylight than when they are artificially lit.

Until the late 1990s, lighting recommendations were based primarily on lighting needs for vision. In recent years, the lighting community has adopted a broader definition of lighting quality including human needs, architectural integration, and economic constraints:

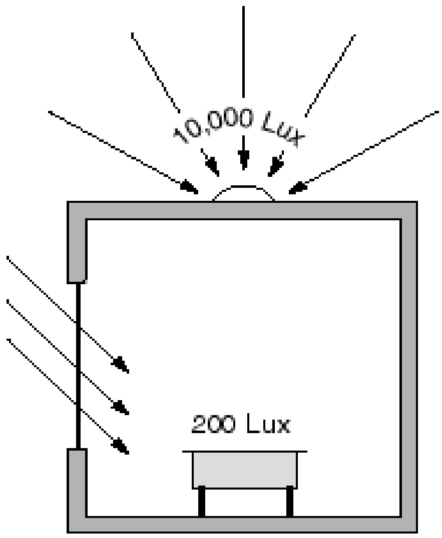


Daylight factor

By using appropriate daylight visualiser software at the design stage, it is possible to simulate the daylight conditions and check the Daylight Factor in a design before committing to a window layout. Daylight is an important consideration when designing any building, but is so often overlooked in the desire to achieve energy efficient homes.

Daylight Factor is quite simply the ratio of interior illuminance at a given point on a given plane set 850mm above the floor, compared to the exterior illuminance and is measured in overcast conditions.

Looking at the figures on the adjacent diagram, an external measurement of 10,000 lux is taken and an internal measurement of 200 lux is taken. If we divide the internal by the external and multiply this by 100, it will give us a percentage. This refers to the Daylight Factor of the given room. In this example the Daylight Factor is 2%.



$$DF = \frac{200}{10{,}000} \times 100 = 2\%$$

Previous design guidelines such as the Code for Sustainable Homes required that in new build houses, kitchens should have a minimum daylight factor of 2%, whilst living areas and home offices should have a minimum daylight factor of 1.5%. There are no guidelines for bedrooms.

As a comparison, research has shown that a 4% daylight factor is perceived as being a daylit room, with lighting levels that can enhance performance and productivity. Using this research, schools and other educational establishments now tend to design to a minimum 4% daylight factor.

However, research also shows that a 5% daylight factor is perceived as being a well daylit room and the small additional glazed area to achieve 5% could have a big impact on the internal environment. But of course there will always have to be a balance between effective glazing area and optimum energy performance of a building.

Most Building Regulations suggest that as a general guide, if the area of glazing is much less than 20% of the total floor area, some parts of the dwelling may experience poor levels of daylight, resulting in increased use of electric lighting. Regulations also tend to restrict the use of glazing in domestic properties to a ratio of 25% glazing to floor area, unless suitable calculations are provided to justify larger glazed areas.

It is therefore recommended that wherever possible, the glazing to floor area ratio should be between 20% and 25% in order to satisfy both the recommendations and the restrictions of the Building Regulations whilst providing the maximum amount of natural daylight without compromising the energy efficiency of the home.

The following guidelines should be considered when designing for daylight factors in housing:

1% DF - should never be acceptable

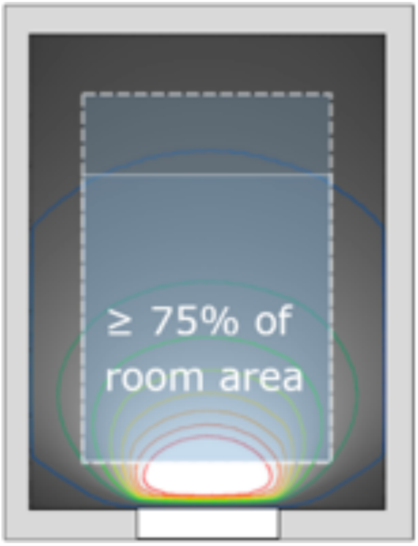
2% DF - room can look gloomy

3% DF - room may still need artificial light

4% DF - is considered daylit

5% DF - is considered well daylit

In addition to the daylight factor, it is recommended that there should always be a minimum level of 300lux for 75% of the room area and 500lux where regular tasks are performed such as cooking or studying.



Benefits of daylight

People enjoy brightly lit spaces which is proven by the huge popularity of conservatories and sun rooms added to homes as a lifestyle choice rather than an increased need for space.

Bringing daylight into buildings is connected to a number of benefits for humans; vision, orientation, productivity, alertness and health. Research has shown that daytime light exposure affects mood and alertness, and influences social behaviours and cognitive performance.

For those of us living in Northern Europe, the benefits of daylight are easily appreciated. A few days of sunny weather helps to boost our spirits and lighten our moods whilst improving our performance and regulating our routine. The right amount of daylight at the right time makes you more productive during the day and helps you to sleep better at night. This is due to the regulation of our circadian rhythms, or body clock, which takes its major cues from the blue spectrum of daylight.

A lack of blue daylight allows a chemical called Melatonin to build up in the blood stream.

Melatonin is a natural nightcap and is secreted as darkness falls to help our bodies regulate the sleep-wake cycle by causing drowsiness and lowering the body temperature. Research has found that the build-up of melatonin is inhibited by blue daylight to the retina. Most standard artificial lighting solutions tend to produce only red/orange or green/yellow light so that the melatonin cannot be inhibited. However, recent research has uncovered an increasing problem where people using tablets or e-readers at night are suffering with sleep disorders due to the screens emitting this crucial blue spectrum of light and therefore delaying the sleep cycle.

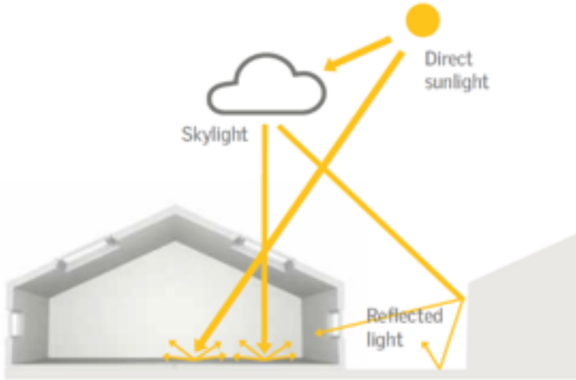
In addition to research on the effects of daylight on melatonin levels, there has been much research over the years into the effects, influence and benefits etc. of daylight, with awareness that it has a positive influence on moods. But this was not fully understood until fairly recently.

In 2001, it was discovered that there is an extra light receptor in the eye which has now raised awareness of the potential positive influence of the non-visual elements of daylight such as photo-biological effects, circadian rhythms and light therapy, but also negative influences such as night-shift work and associated health implications.

As a result, it has been recognised that we not only need new ways of measuring light, but also assessing the impact of light.

Benefits of rooflights

By the very nature of the product, rooflights and roof windows can let in up to twice as much light than a conventional vertical window and up to 3 times as much light as a dormer window because the glazing is pointing directly at the light source with very little diffused or reflected light. Consequently, rooflights and roof windows can supply a great deal more daylight into the heart of the home thereby illuminating areas that might otherwise be quite dark.

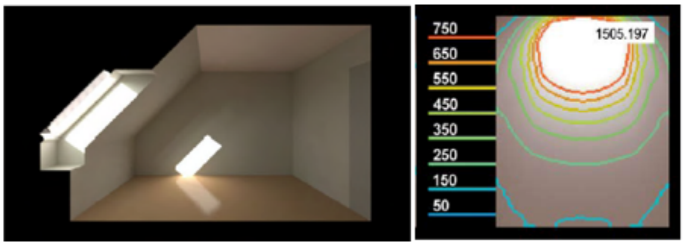


Research by the Danish Building Research Institute in 2006 showed the difference in daylight factors for a standard vertical window, a dormer window and a roof window.

Vertical window simulation:

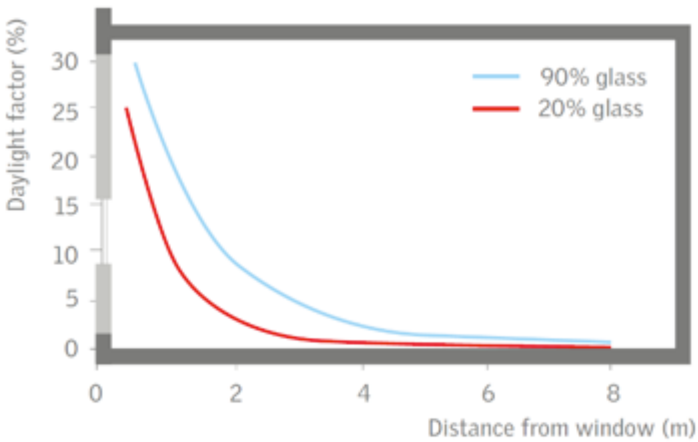
Dormer window simulation:

Roof window simulation:



Note that roof windows and skylights installed in low pitched roofs are likely to receive direct solar radiation even when facing north.

The geometry of a building influences the availability and qualities of daylight in the interior. When the building is deep, providing daylight solely through façade windows has its limitations. No matter how much glass there is included in the façade, it will only be possible to achieve an adequate daylight distribution (DF>2%) a few meters from the façade.



Effects of rooflights and roof windows

The effects of using rooflights and roof windows in residential buildings have been investigated in a climate-based daylight analysis carried out by the Institute of Energy and Sustainable Development at De Montfort University in Leicester. The main goal of the study was to assess and quantify the impact of rooflights and roof windows installed high up, on daylight conditions for various scenarios. In total, ten building designs were evaluated for all combinations of eight orientations and six climate zones. Therefore, there were 480 sets of unique climate-based daylight simulations.

Among the main findings, it was shown that:

- The addition of rooflights invariably improves the overall daylighting performance of the space. For some designs, the addition of rooflights led to a typical increase in daylight availability from 12% to 45% of the occupied year.
- The addition of rooflights results in a significant reduction of periods with too low light levels in the rooms (less than 100 lux) for which electric lighting is likely to be used.
- The addition of rooflights results in an increase of periods with light levels higher than 2500 lux.

Energy efficiency

In Europe today, we spend around 90% of our time indoors, in buildings that consume over 40% of all energy by occupants, of which around 28% of energy use is directly attributable to housing. Of this, energy for lighting accounts for 15% of residential consumption. *(300–1100 kWh/year based on an average of 25-30 light sources and a mix of incandescent lamps, halogen lamps, energy saving bulbs, and high pressure lamps.)*

With the drive towards energy efficient buildings, houses are becoming more airtight with less reliance on the windows opening for ventilation, especially during heating periods. Consequently, some low carbon designs have reduced numbers and sizes of windows to ensure compliance with the strict thermal requirements of the building regulations, but as a consequence has led to a reduction in the amount of natural daylight entering the home. There is evidence to suggest that this has led to the creation of poor indoor environments which in turn leads to an increase in illnesses and ailments.

Not only do rooflights make a positive contribution to the internal environment in a building, research has shown that they also reduce energy use and cost, and contribute to the external environment by reducing the carbon footprint, helping to meet the requirements of Building Regulations.

Of course, we are not able to utilise natural daylight 24 hours a day, so there will always be a need for some form of artificial lighting strategy, especially in the winter months. However, if the designer considers the following key points, then the need for artificial lighting can be substantially reduced:

- The electric light is carbon inefficient in that power from the National Grid is largely generated from burning fossil fuels at modest generation efficiencies
- Where natural daylight levels are low, the lights in the home can often get turned on in the morning and stay on all day, regardless of the need for them
- Natural daylight through rooflights and roof windows is completely free, provides some useful solar gain and creates a pleasant internal environment

By allowing for automatic controls (e.g. motion sensors) where artificial light is generally required 24 hours a day, then the energy requirement for lighting can be reduced.

Daylight control and sun-screening

As with any glazing design, it is necessary to regulate the solar gain whilst considering the control of excessive glare. Solar gain is caused by the suns heat hitting the glazing and too much solar gain may cause excessive heat build-up in the house. Glare is caused by an uncomfortably bright light source or reflection – a form of visual noise – which can impair occupants' enjoyment of the space. Both glare and heat can be controlled by adding sunscreening to the windows.

Internally, pleated and Venetian blinds can be used for adjusting the amount and direction of daylight entering, whereas roller and blackout blinds can provide almost a 100% reduction in daylight entering the space.

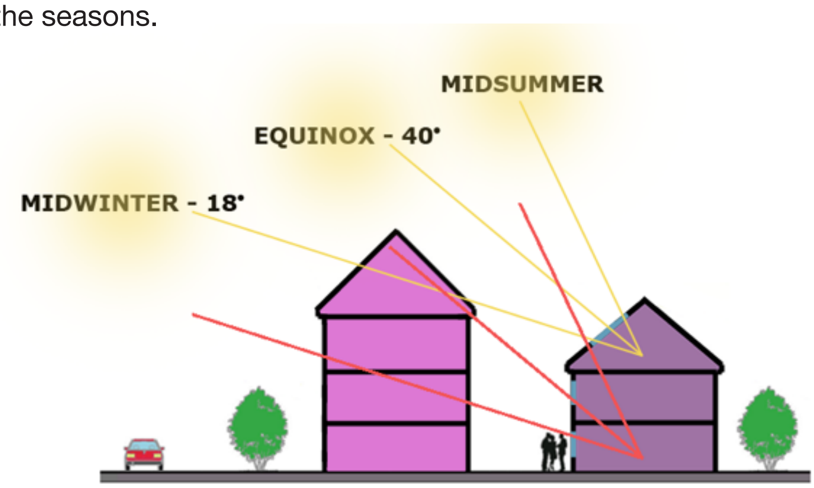
Externally, the most effective way of preventing solar radiation and heat transmittance into the building is by using external shading such as awnings blinds and roller shutters.

Coated glass is also available, but when using coated glass, parts of the solar radiation will be blocked. This may appear to be counterproductive, but it is worth remembering that the highest incidence of solar gain will always be simultaneous with the brightest daylight conditions and so an effective balance can be achieved if designed correctly.

However, it is worth noting that glass coatings can act a bit like sunglasses and will affect the colour perception inside the rooms. This is especially the case in winter months where the room may appear darker.

It is important therefore to not only consider the position of glazing within the home, but also the orientation and location of the building when planning the site setting out, to assess potential shading caused by neighbouring buildings, trees and other obstructions.

In addition, with modern housing developments becoming more dense and three storey housing being used more to increase site yields, this can further restrict natural daylight entering the home and the use of rooflights and roof windows will substantially reduce the impact of neighbouring buildings to provide more daylight throughout the seasons.



How light can affect your design

When planning a project, there are many things to consider to make the finished product all you want it to be. For example, if planning an extension, the design approach could well be influenced by what the space is to be used for and what views are available.

However, thanks to daylight, you have the opportunity to create something special and unique in your home whatever the space is used for and to a large extent, whatever the orientation of the new building will be.

With a new build house, including daylight into the design process provides the opportunity to optimise the window layouts and maximise the benefits that natural daylight brings at the outset.

However, when a new extension is built, this usually means that natural daylight has further to penetrate into the house as the vertical windows are moved further away. All too often, the original room becomes dark and gloomy and even on the brightest days it means that electric lights have to be switched on.

By using rooflights and roof windows you can bring daylight deeper into the living space, which makes the whole room feel brighter, larger and more welcoming.

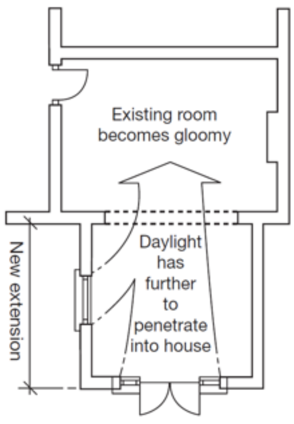
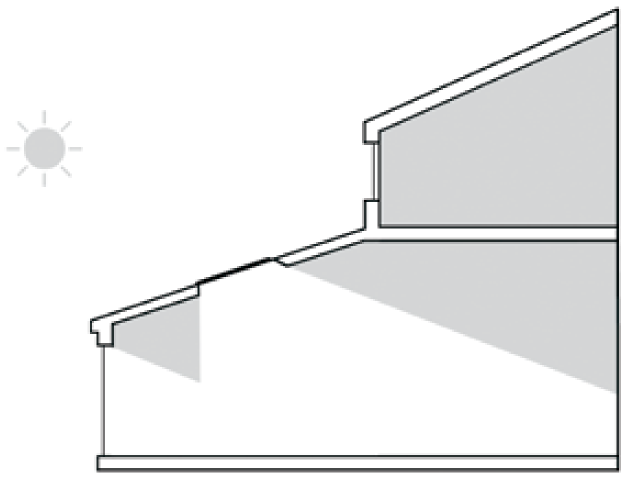
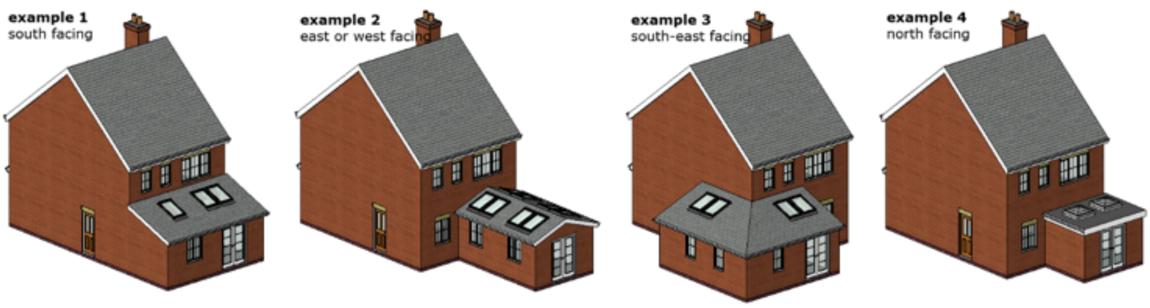


Diagram from Home extension design by Julian Owen, published by RIBA publications, 2008.



The orientation of your house may also determine the type of extension you choose, how the roof pitches to maximise daylight provision and even the use of the space if only north light is available:



Summary

Daylight has a wide range of effects on buildings and their occupants. It influences the demand for electrical lighting, cooling and heating in buildings, and offers an array of comfort and health benefits essential to the well-being of the occupants.

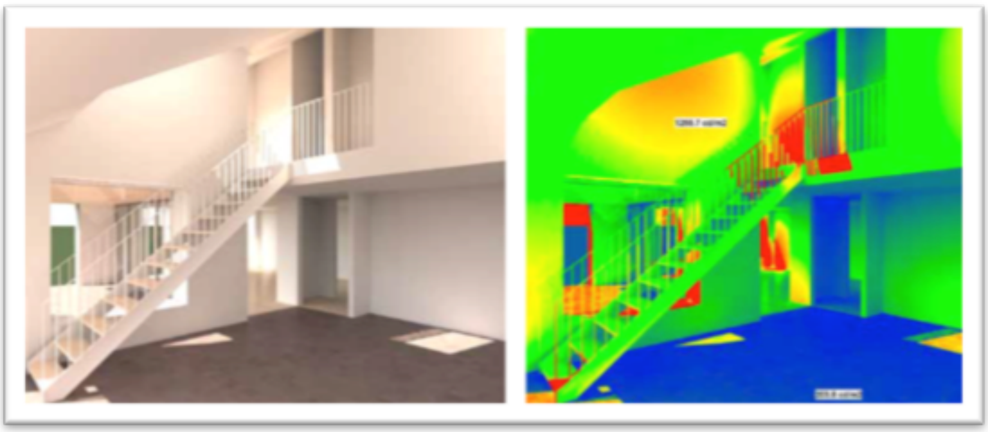
It is important to remember that:

- We spend 90% of our time inside buildings living, working, learning and playing.
- Housing in the UK accounts for around 28% of all energy consumption
- Artificial lighting accounts for around 15% of annual household energy bills
- Utilising natural daylight in design could save 15 million tons of CO_2 every year in Europe
- Around 30% of all buildings do not contribute to good health
- Good daylighting design improves health, well-being and performance

Interiors with an average daylight factor (DF) of 2% or more can be considered reasonably daylit, but electrical lighting may still be needed to perform visual tasks.

A room will appear strongly daylit when the average DF is above 5%, in which case electrical lighting is not likely to be used during daytime.

It is impossible to “optimize” buildings for good daylighting performance with static window solutions alone since daylight intensity varies dramatically. However, the size and placement of windows must always be considered together with the total energy use of the building and specific requirements for daylighting. And it is always important to consider and include proper external and internal solar shading in order to optimize visual and thermal comfort.



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