



Using rooflighting for heating

Rooflighting can reduce a building's carbon footprint by minimising heating costs in the colder months – as long as the rooflight area is calculated in such a way to avoid overheating.

In the Southern Hemisphere, the best way to make use of solar gain (the heating effect of the sun) is to design the building so that windows and rooflights mostly point towards the north, while at the same time minimising the number of those that face the cooler south.

When the building also has solid walls and floors (thermal mass), which have an insulating effect, it will act as a heat store, collecting heat during the day and releasing it as the temperature drops in the evening. The result: radical reductions in the building's total energy consumption and associated carbon-dioxide emissions.

Optimising rooflight area for heating

Research conducted by the Institute of Energy and Sustainable Development at Leicester's De Montfort University (DMU) has refuted the widely held view that rooflights offer poor insulation in comparison to the rest of the roof structure.

The fact is that many of a building's characteristics – such as temperature set point, hours of occupancy and internal gains – influence its energy demand, so the effect of installing rooflighting on energy usage can vary from building to building.

That said, as a general rule rooflighting that totals up to 15% of the total floor area will always lead to energy savings, with further energy benefits to be had from up to 20% of rooflighting in certain circumstances. Specifically, the DMU work shows that:

IN BUILDINGS USED PRIMARILY DURING DAYLIGHT HOURS...

- Energy savings is significant in all cases where rooflights constitute 15% of floor area.
- In areas with higher illumination, these benefits are significantly improved by increasing the rooflight area to 20%.
- In areas with low illumination, there is no benefit to increasing the rooflight area beyond 15%.

IN BUILDINGS USED 24 HOURS A DAY...

- Energy savings is significant in all cases where rooflights constitute 15% of total floor area.
- In areas with high illumination, there are minor additional savings to be had by increasing rooflight area to 20%.
- In areas with low illumination, most of the energy savings occur where rooflighting constitutes up to 10% of the floor area. Increasing this to 15% results in minor further savings. However, increasing rooflight area even more, to 20%, actually results in a slight increase in carbon dioxide emissions.

How other heat sources determine rooflight area

Correctly managed solar gain is a benefit that can reduce heating requirements. However, it is an SABS 204 requirement that solar gain is limited to avoid excessive internal temperature rise in summer. This can be achieved by making sure that solar gain and other internal gains – usually stemming from occupants, artificial lighting and internal processes – combined do not exceed 35 watts per square metre (W/m^2). The expected internal gains of a building therefore define the maximum allowable solar gain, which in turn defines the rooflighting area (see table, based on findings by the DMU. Note that figures are based on evenly distributed light).

Internal Gain	Maximum Solar Gain	Equivalent Rooflight to floor area
0 W/m^2	35 W/m^2	21%
5 W/m^2	30 W/m^2	18%
10 W/m^2	25 W/m^2	15%
15 W/m^2	20 W/m^2	12%
20 W/m^2	15 W/m^2	10%

HEAT GAINS DUE TO FACILITY PROCESSES

Any large plant or process facility will produce significant process heat gains, sometimes even in excess of the total limit of $35W/m^2$. In such cases, localised heat extraction or cooling should be used to prevent overheating.

HEAT GAINS DUE TO ARTIFICIAL LIGHTING

Internal gains due to artificial lighting can be significant. Retail outlets, for example, usually require bright lighting that can generate between 15 and $20W/m^2$ – enough to present problems if artificial lighting is used in conjunction with rooflighting of more than 10% or 12% of floor area during times of maximum solar gain.

That said, solar gain is at its highest when daylight illuminance is also at its highest, so if the rooflight area is big enough to provide sufficient light, heat gains through artificial lighting can be

In summary

- Installing rooflights can generate solar gain (heat from the sun), which is usually a benefit in that it reduces heating requirements and associated carbon dioxide emissions.
- Assuming there are no other significant sources of internal heat, rooflight area of 15% of the floor area will always result in reduction in energy usage for heating.
- In instances where there are other significant sources of internal heat (such as facility processes, artificial lighting and occupants), rooflighting will need to be reduced so that total heating gains do not exceed 35 watts per square metre.





greatly reduced (or eliminated) by switching off artificial lighting.

In cases where artificial lighting will be consistently controlled – in other words, where it is done automatically rather than manually – it would be reasonable to disregard the internal gain from artificial lighting when considering rooflighting area because it would only be present when solar gain is minimal (eg at night).

HEAT GAINS DUE TO OCCUPANTS

The heat gains due to the occupants of a building depends largely on the occupant density. In large industrial or storage facilities occupant density is typically low enough to be considered insignificant, so rooflight areas of up to 21% can be used without causing overheating.

One person produces approximately 140W seated or 160W while doing light standing work or walking, rising to 265W when carrying out medium bench work. As a result, where occupant density reaches one person per 30 square metres (m²), as it does in retail shops, for example, internal gains may reach 5W/m². At this occupant density and level of internal gain, rooflight areas of up to 18% will not cause overheating.

Where occupant densities increase further, for instance in offices or classrooms, internal gains should be checked carefully to determine

the appropriate rooflight area. Very densely occupied environments that also contain equipment – call centres, for example – can easily have cumulative internal gains of up to 30W/m². This is too close to the total acceptable internal gain of 35W/m² to allow for much rooflighting without then requiring the use of mechanical cooling.

ENSURING EVEN LIGHT DISTRIBUTION

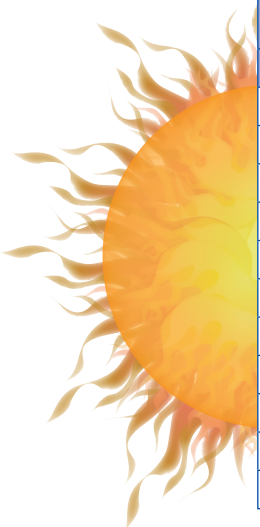
The figures quoted in the table in the previous section assume that light has been evenly distributed throughout the building. This depends on the degree of light diffusion from the rooflights, the height between roof and ceiling and the rooflight layout or distribution. The lower the ceiling, or less evenly spread the rooflights, the greater the level of diffusion required.

If rooflights are clear or do not provide enough diffusion, then the direct light can produce localised overheating directly beneath the rooflights, regardless of rooflight area, in the same way overheating can occur next to a window. This can be resolved by using a rooflight layout that spreads light as evenly possible and selecting the material thickness and colour for optimal levels of diffusion.

Please see our sections on Rooflight design and distribution and Choosing the right material and colour for more information.

Cumulative availability of vertical daylight illuminance

Rooflight to floor area ratio	Total gain Q_{tot} = Computed solar + internal gains (range 0 to 20W/m ²)				
g_{rr}	0W/m ²	5W/m ²	10W/m ²	15W/m ²	20W/m ²
0.10	16.8	21.8	26.8	31.8	36.8
0.11	18.5	23.5	28.5	33.5	38.5
0.12	20.2	25.2	30.2	35.2	40.2
0.13	21.9	26.9	31.9	36.9	41.9
0.14	23.5	28.5	33.5	38.5	43.5
0.15	25.2	30.2	35.2	40.2	45.2
0.16	26.9	31.9	36.9	41.9	46.9
0.17	28.6	33.6	38.6	43.6	48.6
0.18	30.3	35.3	40.3	45.3	50.3
0.19	32.0	37.0	42.0	47.0	52.0
0.20	33.6	38.6	43.6	48.6	53.6



Values of insertion in excess of 40W/m² are shaded blue. The assessment is clearly dependant on the level of expected internal gains. For large-span industrial buildings the usage is likely to remain constant for the lifetime of building (eg storage, retail or manufacture).

Where process-intensive manufacture is intended, the associated high-internal gains may require localised extraction to prevent overheating. This is to be used as a guide only. Full assessment must be done by the professional concern.