

A dynamic thermal modelling study of a typical metal clad building to evaluate overheating in the UK

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Authors: Chris Kendrick & Shaun Wang



Summary

A typical modern portal frame warehouse building with in-plane GRP rooflights was modelled using Tas and Lumen Designer software to assess annual heating loads and summertime thermal comfort in the south of the UK. The effects of rooflight area, ventilation strategy and stratification were assessed.

Various combinations of ventilation strategy to reduce internal temperatures in the summer were investigated, including natural ventilation through cargo doors and/or ridge vents, and mechanical ventilation. The effect of ventilation was found to be critical, and by far the greatest effect on overheating risk.

The 'base case' building incorporated 10% rooflights; the effects of increasing rooflights to 14%, or eliminating rooflights were investigated. Use of daylight through rooflights offers major benefits to the internal environment within a metal clad building, as well as potential savings in energy use, running cost and CO₂ emissions. Use of 14% rooflights reduces lighting load by approximately 40% from that of a portal frame building with no rooflights, whilst beneficial solar gain also counteract the additional heat losses from the rooflights, resulting in heating loads only marginally greater. It was found that total CO₂ emissions (heating and lighting) are reduced by 30% (14% rooflights) when rooflights are used with dimmable lighting because the saving in lighting electricity far outweighs the additional heating. However, the daylighting benefit is at the expense of some increase in summertime overheating risk.

Stratification was investigated by assessing temperature on an imaginary mezzanine floor. Temperatures were found to be lower at floor level than at high level, but not to a high extent.

It was found that overheating occurred for the unventilated base case. However, introduction of some natural ventilation just by opening cargo doors and personnel doors was sufficient to avoid overheating, with temperatures kept down to acceptable levels (less than 1% of occupied hours above 28°C) at ground level.

It was found that rooflight area had some effect on overheating risk: eliminating rooflights reduces risk of overheating (although not a viable solution to most practical cases) whilst increasing rooflight area from 10% to 14% did show an increase in internal temperatures. However, this was a secondary effect in comparison to ventilation strategy, which had a far greater effect; a well ventilated building with good daylighting through 10-14% rooflights had lower risk of overheating than a non-ventilated building without rooflights.

Introduction of ventilation by leaving cargo doors open was found to have a significant effect on internal temperatures. Ridge vents had less effect on their own but offered more benefit when used with open cargo doors to allow increased throughput of air. Ridge vents that were left open at night had some effect, although this was minimal. Mechanical ventilation was found to offer some benefit, although less effective than cargo doors in conjunction with ridge vents, whilst plant size and consequent energy consumption is a deterrent to its use in practice.

The Building Regulations Solar Overheating criterion was investigated. ADL2 suggests total internal gains should not exceed 35W/m²K when averaged over a specified period. Application of the approximate method in CIBSE TM37 (Design for Improved Solar Shading Control) indicated that this figure is not exceeded for a metal clad building with either 10% or 14% rooflights. The Tas modelling results agree closely.

However, buildings with higher internal loads, such as retail display lighting and/or much higher occupancy levels, can give risk of overheating unless alternative precautions are taken.

Introduction

The objective of this study was to better understand the extent of overheating likely with current metal clad portal frame buildings when rooflights are used. In particular, the temperature at different levels due to stratification within the occupied space needs to be determined. Various mitigation strategies will also be investigated using natural/mechanical ventilation at high and low level.

1. The Model: Weather, geometry and internal conditions

1.1 Weather/Location

The building is located in Southern England, so that CIBSE Design Summer Year (London DSY) weather file is used for thermal modelling.

1.2. Geometry

The building has two bays, each with a 6° duopitch roof, and is 60m in length, 40m in width and 7m height (floor to eave).

There is an office area in one corner of the building with a floor area of 120m² (6m×20m) with two storeys (floor height is 3m each).

Two cases are modelled: 10% and 14% nominal rooflight area, which are detailed in the table below. A 'frame' (overlap with opaque cladding) of 12.75% area was assumed.

| Case | Nominal | Glazing | Glazing dimensions (m ²) | Number of rooflights |
|------|---------|---------|--------------------------------------|----------------------|
| 1 | 10% | 8.75% | 4.5m×0.925m | 48 |
| 2 | 14% | 12.25% | 6.3m×0.925m | 48 |

Table 1. Rooflight dimensions

Including frames, the total rooflight area for 10% case is 227m², for 14% case is 319m². There are no rooflights on the roof of the office area. External surfaces are all goosewing (mid) grey.

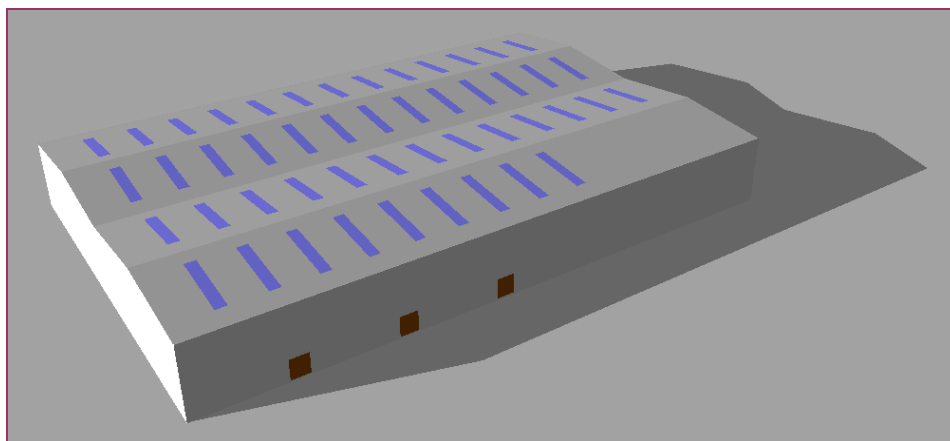


Figure 1. 3-D model of the portal frame building

1.3. Construction

The warehouse is of portal frame construction and is clad with profiled metal sheeting insulated as follows:

| | |
|--------------------------------|------------------------------------|
| Roof cladding: | U-value = 0.25W/m ² K. |
| External wall cladding: | U-value = 0.35W/m ² K. |
| Ground floor (concrete floor): | U-value = 0.25 W/m ² K. |
| Internal wall (office use): | U-value = 0.83W/m ² K. |

The rooflights consist of two layers of GRP with an intermediate insulating layer giving a U-value of 1.3 W/m²K.

Optical properties of rooflight samples have been determined by an independent laboratory and combined by methods set out in BS EN ISO 410 to give properties for the rooflight construction: a visible light transmission of 0.47 and a solar gain factor (g-value) of 0.47 were calculated for the rooflight construction used.

1.4. Internal conditions

Twenty four hour, seven days per week occupation was assumed, with heating to 19°C (no heat mid-June to mid-September). There is no air conditioning. Air infiltration was calculated assuming an air permeability of 7.5 m³/h per square metre total envelope area at 50Pa pressure differential.

1.4.1. Infiltration rate

7.5m³/h/m²@50Pa (Q_{50}/S)

$$I = \frac{1}{20} \frac{S}{V} \frac{Q_{50}}{S}$$

Inner Volume V = 17540m³; Surface area S (excluding floor area) = 3855.2m²
Thus air infiltration I=0.08 air changes per hour (ach). I=0.1 is used.

1.4.2. People

20 people, with heat outputs from CIBSE Guide A below (in table):

| People | 20°C | | 22°C | |
|----------------------------|----------|--------|----------|--------|
| | Apparent | Latent | Apparent | Latent |
| Light bench work (factory) | 130 | 105 | 115 | 120 |
| Medium bench work | 140 | 125 | 125 | 140 |

Table 2. Heat gains from people (CIBSE Guide A)

For twenty people, apparent gain = 2600W, latent gain =2000W.

Portal frame building floor area = 2280m².

An apparent (sensible) heat gain of 1.2W/m² and latent gain of 0.9W/m² is used.

1.4.3. Lighting control

Auto control/dimmed;
 Photocell control dimming;
 Maximum light gain: 5.6W/m²;
 Target Room Illuminance: 350lux.

2. Daylight modelling

Lumen Designer was used to investigate the daylighting (illuminance distribution) on the floor.

2.1. Orientation of the building

There was found to be little difference of average daylight factor across whole building area (excluding offices) between different orientations of the building because of the very shallow slope of the roof. Therefore, thermal modelling was based on the long axis running **east-west**.

2.2. Daylight modelling results

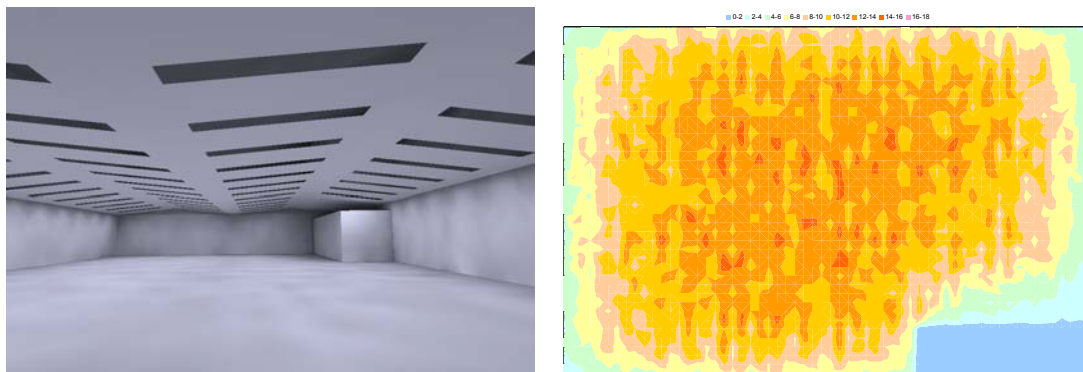


Figure 2. Left - Interior rendering by illuminance levels; Right -Daylight factor distribution on the floor (excluding the office at right bottom corner)

| Nominal rooflight percentage | Average daylight factor (%) |
|------------------------------|-----------------------------|
| 14% | 5.60 |
| 10% | 3.41 |

Table 3. Daylight factor for different rooflight percentages

3. Thermal modelling

3.1. Method

A dynamic thermal model was created using TAS software, integrating daylight analysis results from Lumen Designer. A daylight availability analysis enabled the extent of artificial lighting to be controlled automatically to maintain 350lux. With realistic levels of interior heat gains from people, lights and equipment, and with solar radiation accounted for, the temperatures can be determined throughout the year at ground and mezzanine floor level. Overheating is investigated by graphs showing percentage of temperature excess hours. Both mechanical ventilation and natural ventilation are investigated in this study.

3.2. Natural Ventilation

Natural ventilation includes cargo doors and ridge vents and the combination of these two. The temperature for opening cargo doors is set to 20°C. The dimensions of natural ventilation openings are summarised in the following table.

| Openings | Area (m ²) | Percentage of wall/floor area |
|-----------------|------------------------|-------------------------------|
| Cargo doors | 49.3 | 3.52% (of wall) |
| Personnel doors | 10.8 | 0.77% (of wall) |
| Ridge vents | 40.0 | 1.67% (of floor) |

Table 4. Natural ventilation openings

An additional natural ventilation scheme allowed for ridge vents opening on summer nights.

3.3. Mechanical ventilation

Mechanical ventilation is set at 2.5ach, supplying outside air to the ground floor zone and exhausting from the roof zone.

4. Thermal modelling results for Case 1 (10% rooflights)

4.1. Summary of loads and CO₂ emissions

Table 5. Loads summary (kWh/m² per year): 10% rooflights

| | Heating | Solar | People/ Equipment | Lighting |
|--|---------|-------|----------------------|----------|
| Base case | 22.23 | 34.22 | 10.18 | 29.89 |
| Base case without rooflights | 16.85 | 0.00 | 10.18 | 49.06 |
| Mechanical ventilation | 22.32 | 34.22 | 10.18 | 29.89 |
| Natural ventilation (by cargo doors) | 22.50 | 34.22 | 10.18 | 29.89 |
| Natural ventilation (by ridge openings) | 22.57 | 34.22 | 10.18 | 29.89 |
| Natural ventilation (cargo doors + ridge openings) | 22.69 | 34.22 | 10.18 | 29.89 |
| Natural ventilation (cargo doors + ridge NIGHT) | 22.70 | 34.22 | 10.18 | 29.89 |

Table 6. CO₂ emissions (kg/m² per year): 10% rooflights

| | Heating | Lighting |
|--|---------|----------|
| Base case | 5.39 | 13.21 |
| Base case without rooflights | 4.17 | 21.68 |
| Mechanical ventilation | 5.41 | 13.21 |
| Natural ventilation (by cargo doors) | 5.46 | 13.21 |
| Natural ventilation (by ridge openings) | 5.47 | 13.21 |
| Natural ventilation (cargo doors + ridge openings) | 5.50 | 13.21 |
| Natural ventilation (cargo doors + ridge NIGHT openings) | 5.51 | 13.21 |

4.2. Monthly loads

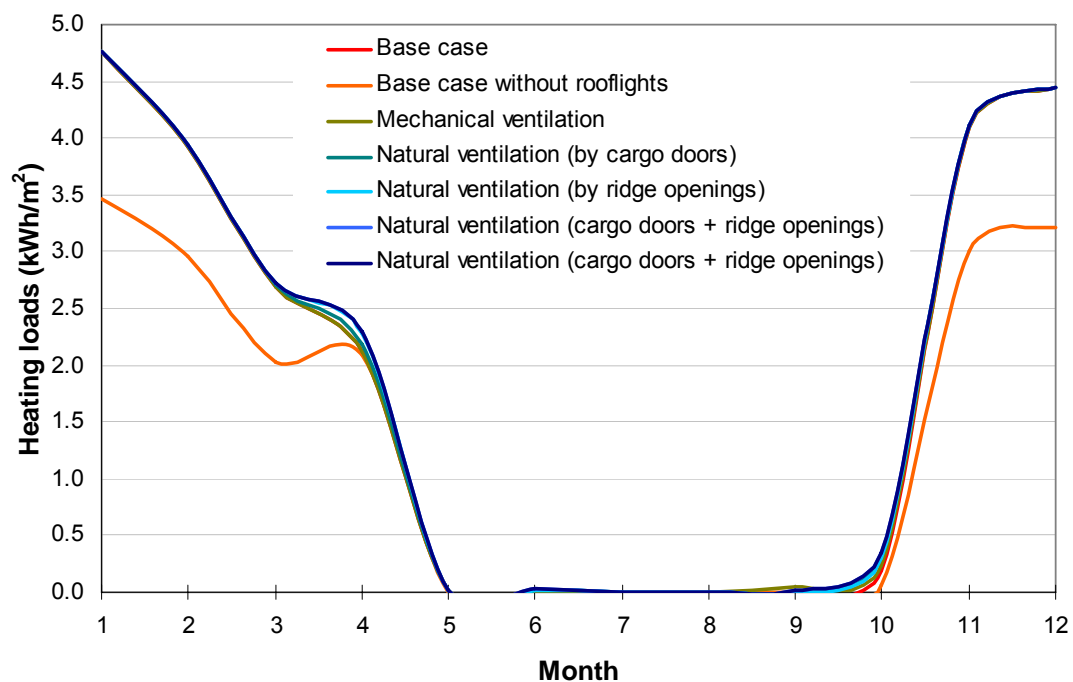


Figure 3. Monthly heating loads for different ventilation schemes: 10% rooflights

Ventilation scheme has little effect upon heating loads, and any variations can be ascribed to lack of optimisation of heating control (some heating may be applied at the same time as ventilation).

4.3. Overheating (ground floor)

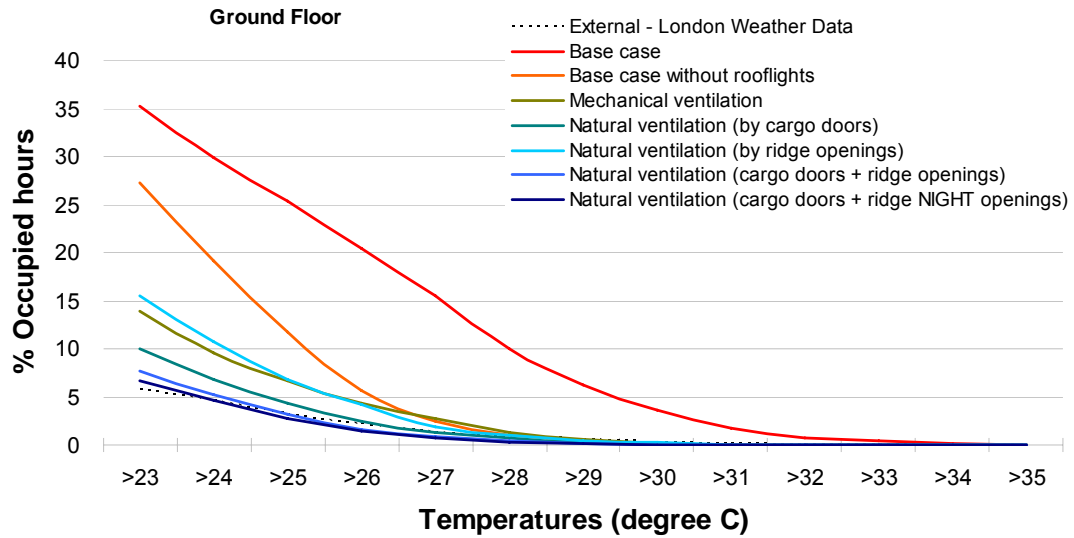


Figure 4. Ground floor overheating: 10% rooflights

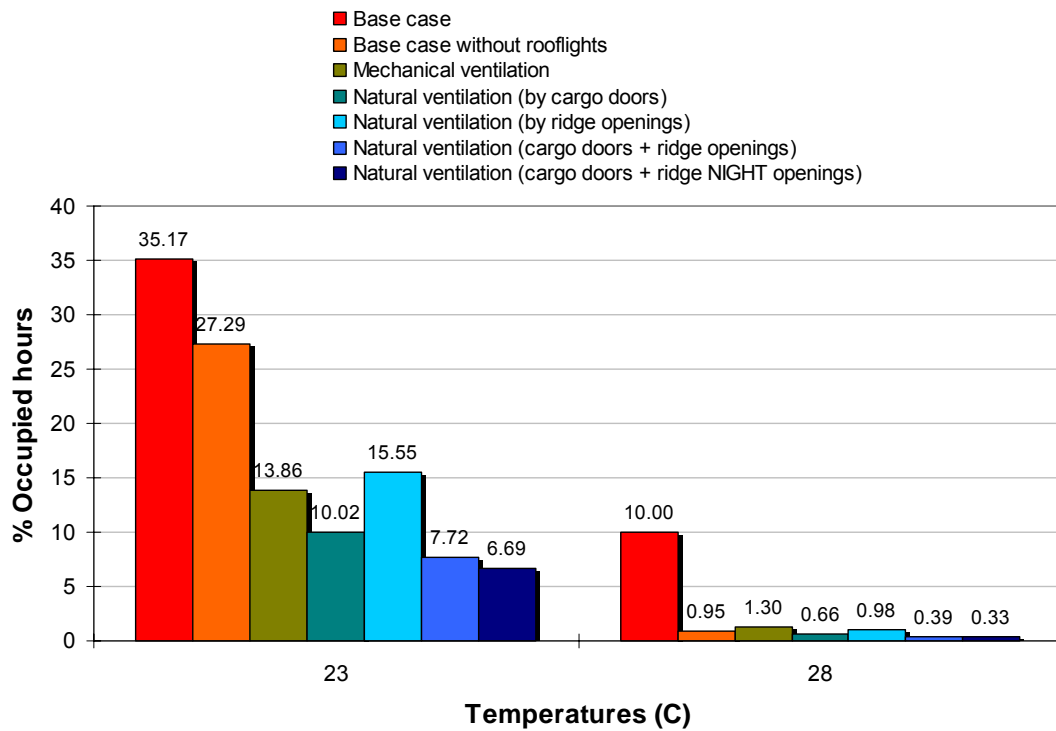


Figure 5. Percentage of occupied hours over certain temperatures: 10% rooflights

The base case shows significant risk of overheating when there is no ventilation. Elimination of rooflights does reduce the risk of overheating, although this would result in a significant increase in energy use, running costs and resultant CO₂ emissions and would have a serious effect upon the internal environment for occupants. Introduction of natural ventilation through open cargo doors has a much greater effect and ensures lower risk of overheating. This example building with 10% rooflights would not exceed 28°C for more than 1% of occupied hours. Ridge vents are less effective on their own, but would also substantially decrease overheating risk. However, ridge vents in conjunction with cargo doors allows cross-flow ventilation and gives the best results.

4.4. Overheating (mezzanine)

The effect of stratification was investigated by analysing temperatures at a notional mezzanine level.

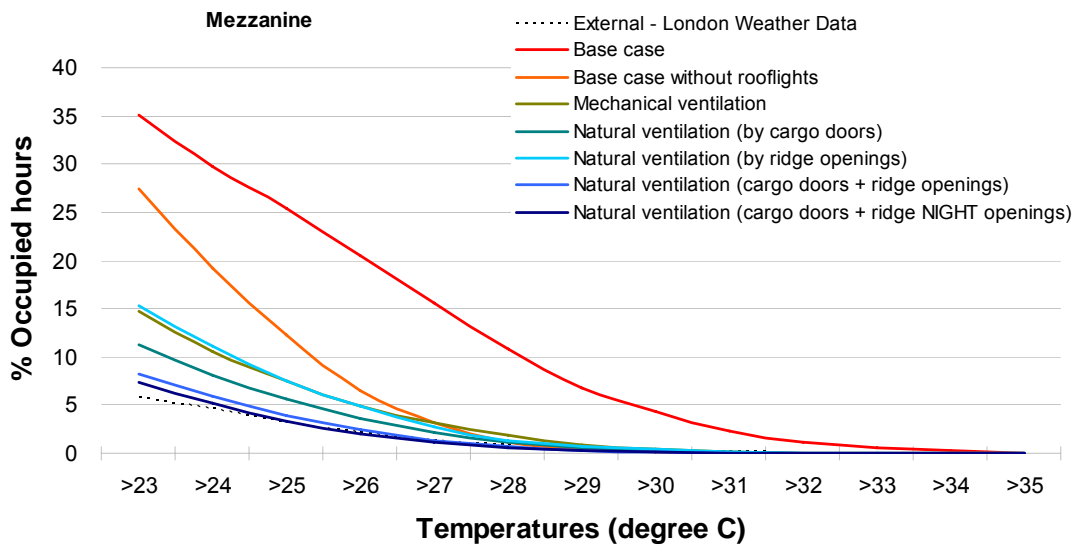


Figure 6. Mezzanine floor overheating: 10% rooflights

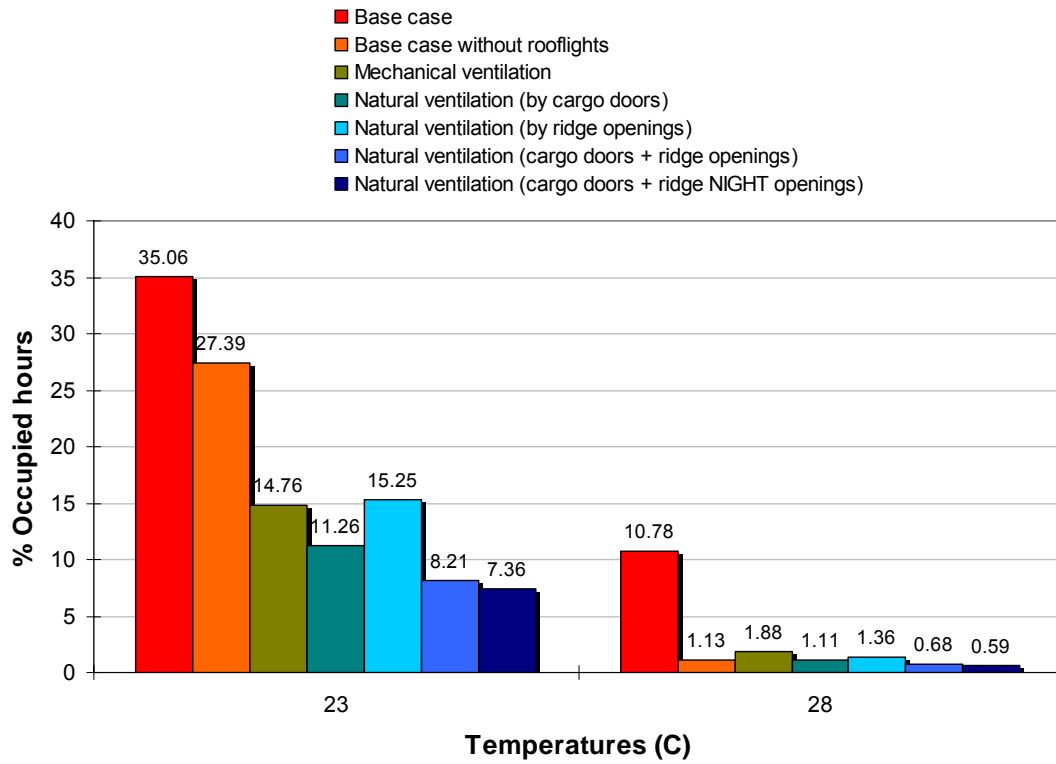


Figure 7. Percentage of occupied hours over certain temperatures: 10% rooflights

The mezzanine floor level is subject to higher temperatures than the ground floor, but thermal comfort remains close to an acceptable level.

4.5. Temperatures for three warmest days

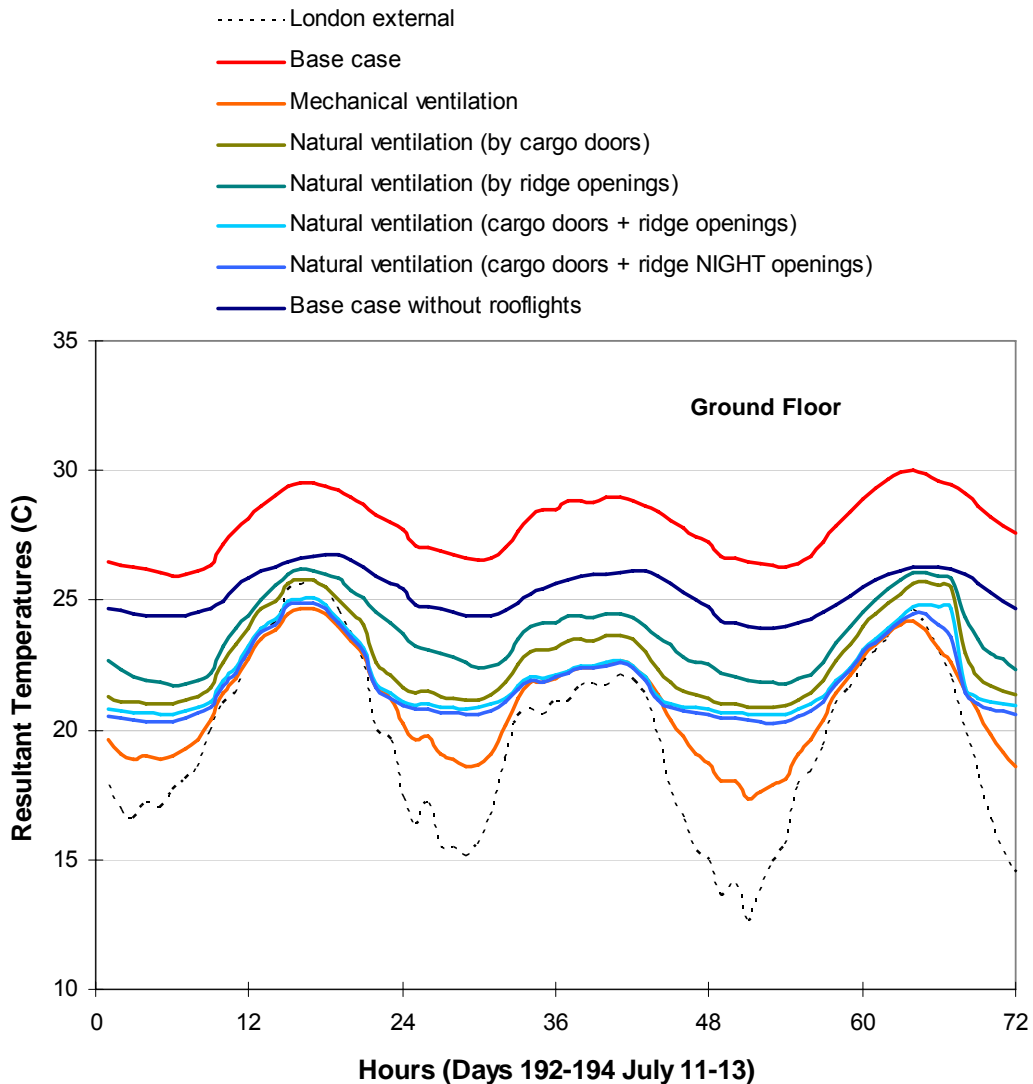


Figure 8. Resultant temperatures on ground floor for three warmest days: 10% rooflights

Mechanical ventilation is most effective at reducing temperatures overnight. However, using natural ventilation (cargo doors and ridge vents) keeps daytime peak resultant temperatures as low as achieved by mechanical ventilation. The unventilated building (with or without rooflights) gets significantly hotter than any of the ventilated cases, demonstrating that ventilation strategy is critical, and is of greater significance than rooflight area (up to a point) in avoiding overheating. The example building with 10% rooflights, ventilated with cargo doors and ridge vents, does not exceed 25°C resultant temperature of any of the three warmest days.

5. Thermal modelling results for Case 2 (14% rooflights)

5.1. Summary of loads and CO₂ emissions

Table 7. Loads summary (kWh/m² per year): 14% rooflights

| | Heating | Solar | People/ Equipment | Lighting |
|--|---------|-------|----------------------|----------|
| Base case | 22.69 | 48.09 | 10.18 | 28.14 |
| Base case without rooflights | 16.85 | 0.00 | 10.18 | 49.06 |
| Mechanical ventilation | 22.79 | 48.09 | 10.18 | 28.14 |
| Natural ventilation (by cargo doors) | 23.09 | 48.09 | 10.18 | 28.14 |
| Natural ventilation (by ridge openings) | 23.19 | 48.09 | 10.18 | 28.14 |
| Natural ventilation (cargo doors + ridge openings) | 23.32 | 48.09 | 10.18 | 28.14 |
| Natural ventilation (cargo doors + ridge NIGHT) | 23.33 | 48.09 | 10.18 | 28.14 |

Table 8.CO₂ emissions (kg/m² per year): 14% rooflights

| | Heating | Lighting |
|--|---------|----------|
| Base case | 5.50 | 12.44 |
| Base case without rooflights | 4.09 | 21.68 |
| Mechanical ventilation | 5.53 | 12.44 |
| Natural ventilation (by cargo doors) | 5.60 | 12.44 |
| Natural ventilation (by ridge openings) | 5.62 | 12.44 |
| Natural ventilation (cargo doors + ridge openings) | 5.65 | 12.44 |
| Natural ventilation (cargo doors + ridge NIGHT openings) | 5.66 | 12.44 |

5.2. Monthly loads

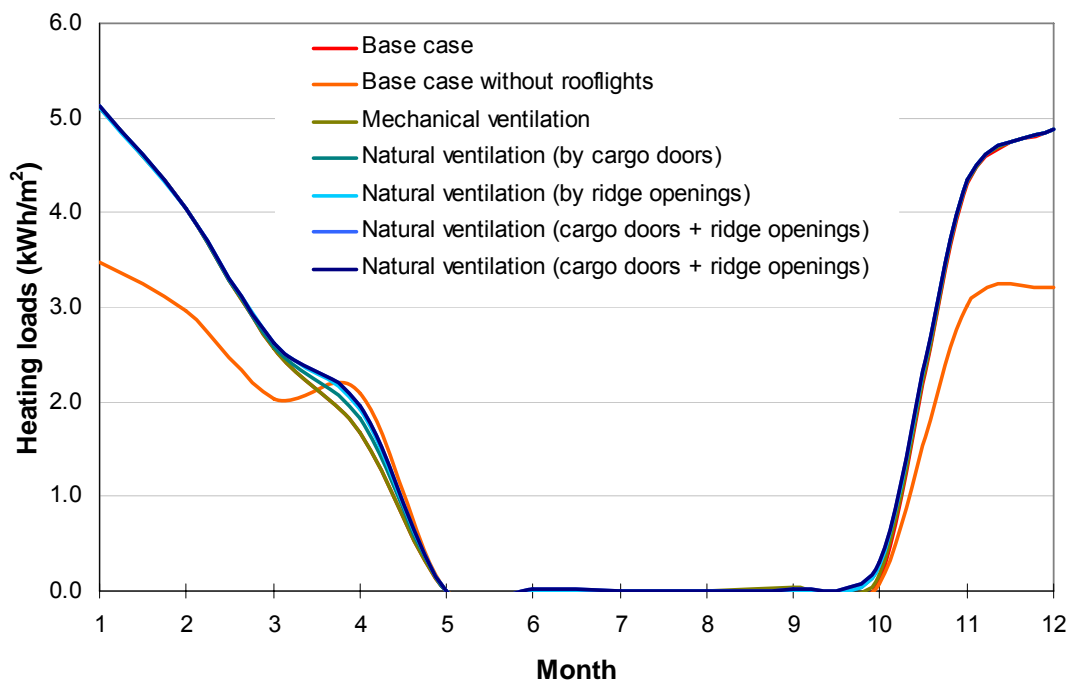


Figure 9. Monthly heating loads: 14% rooflights

This graph shows very similar results to Figure 3 (10% rooflights), as heating loads are not significantly affected by rooflight area.

5.3. Overheating (ground floor)

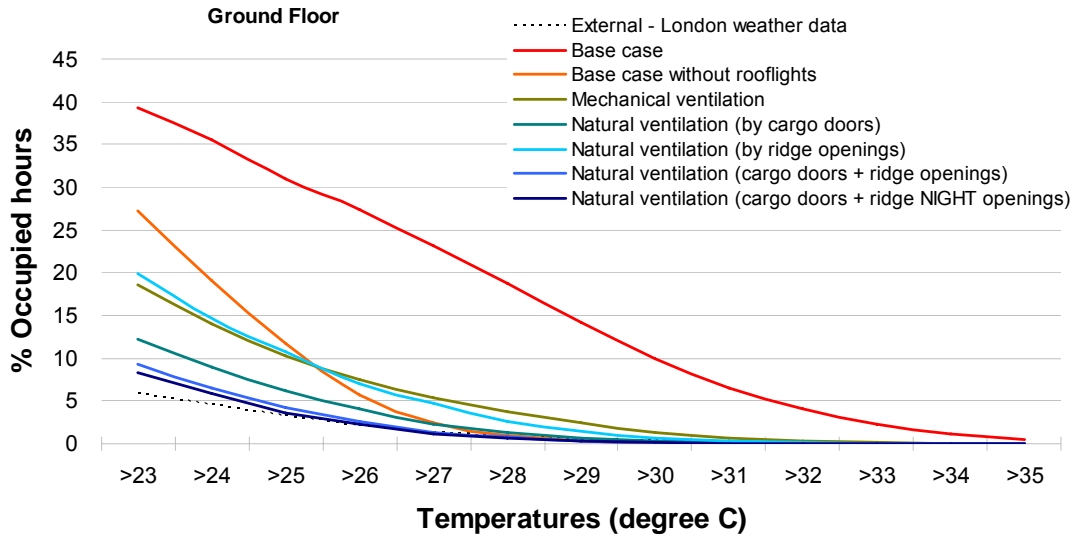


Figure 10. Ground floor overheating: 14% rooflights

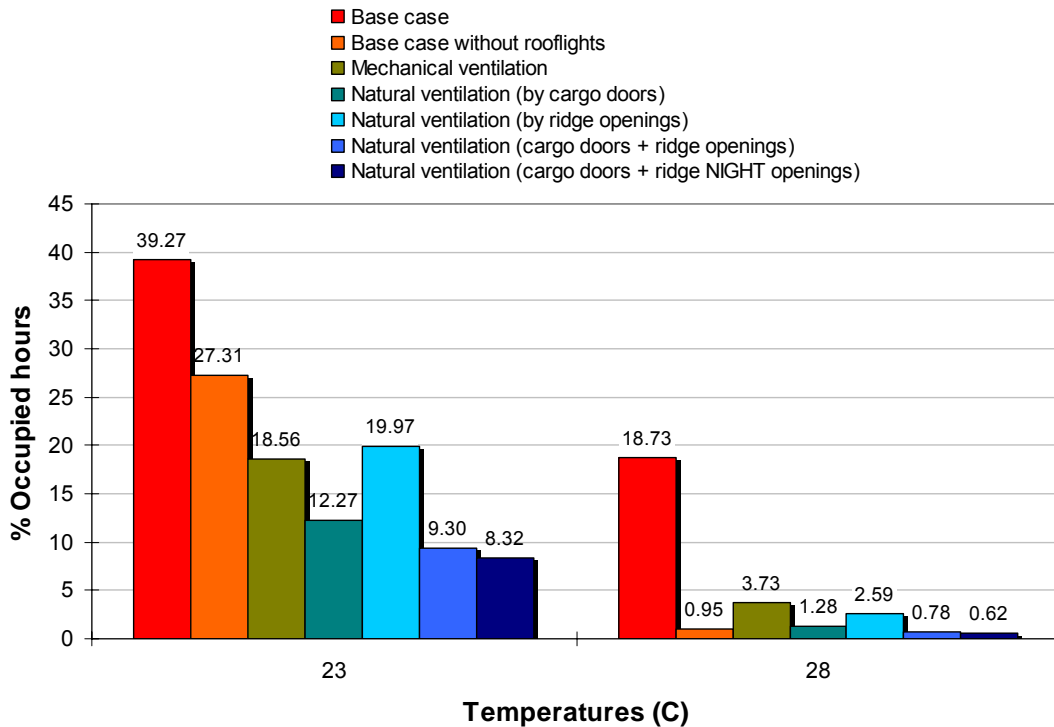


Figure 11. Percentage of occupied hours over certain temperatures: 14% rooflights

These graphs shows similar results to Figures 4 and 5 (10% rooflights). There is a significant risk of overheating in the unventilated base case. Eliminating rooflights does reduce the risk of overheating, but at the cost of increased energy consumption, running costs and CO2 emissions together with a poorer

internal environment. Even at 14% rooflights, natural ventilation through cargo doors has a greater effect and ensures lower risk of overheating. Ridge vents are less effective on their own, but, when combined with open cargo doors, give the best results, and this example building with 14% rooflights would not exceed 28C for more than 1% of occupied hours.

5.4. Overheating (mezzanine)

The effect of stratification was investigated by analysing temperatures at a notional mezzanine level.

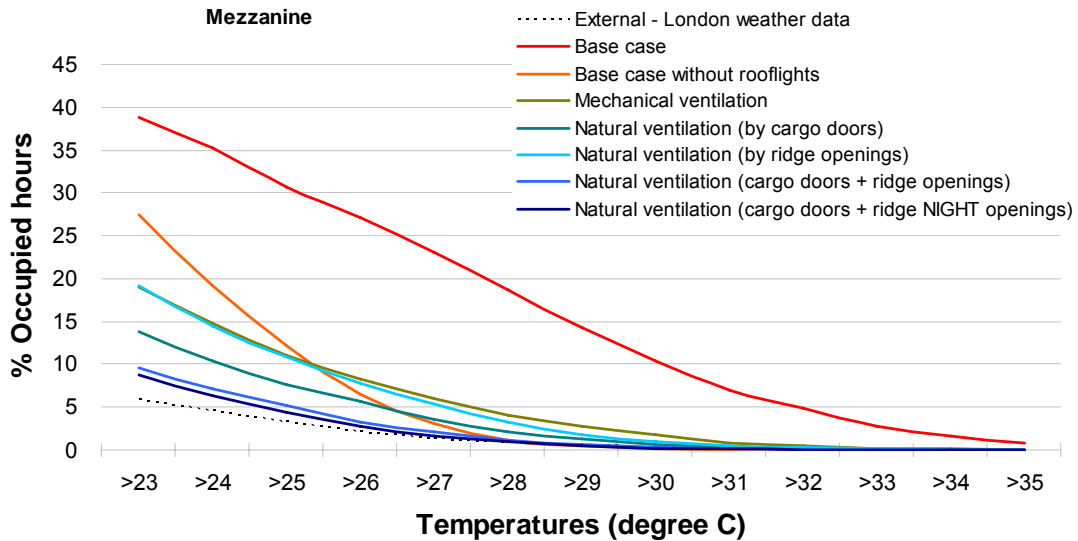


Figure 12. Mezzanine floor overheating: 14% rooflights

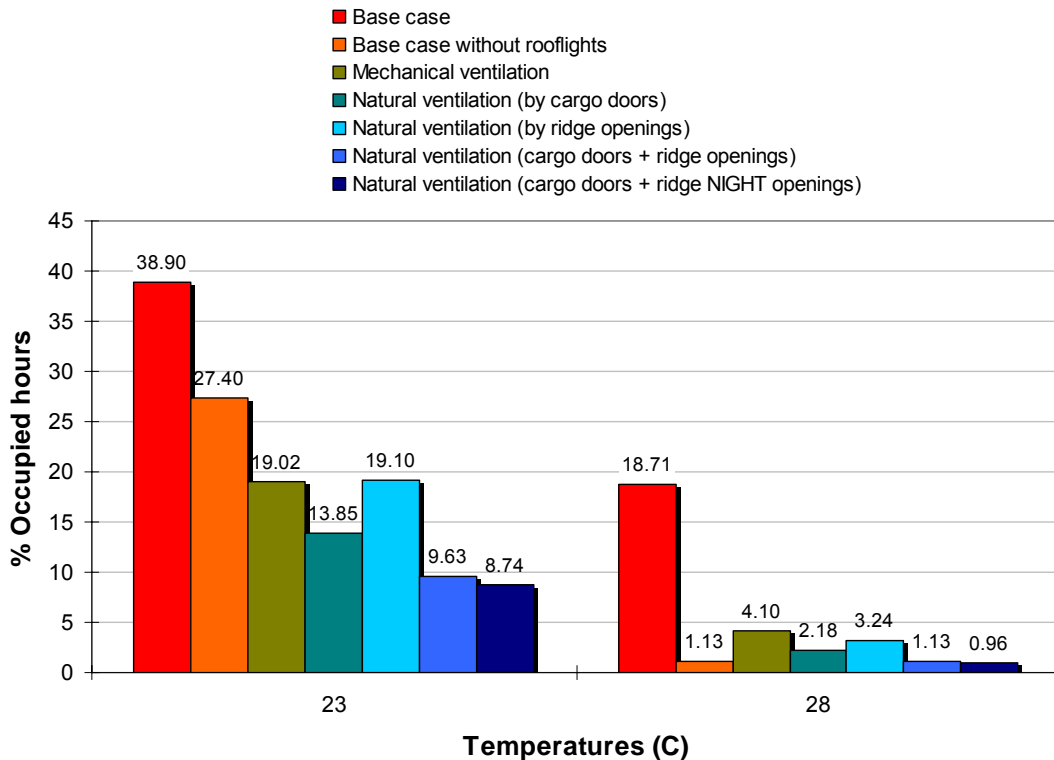


Figure 13. Percentage of occupied hours over certain temperatures: 14% rooflights

The model does show higher temperatures at mezzanine level, indicating some thermal stratification.

5.5. Temperatures for three warmest days

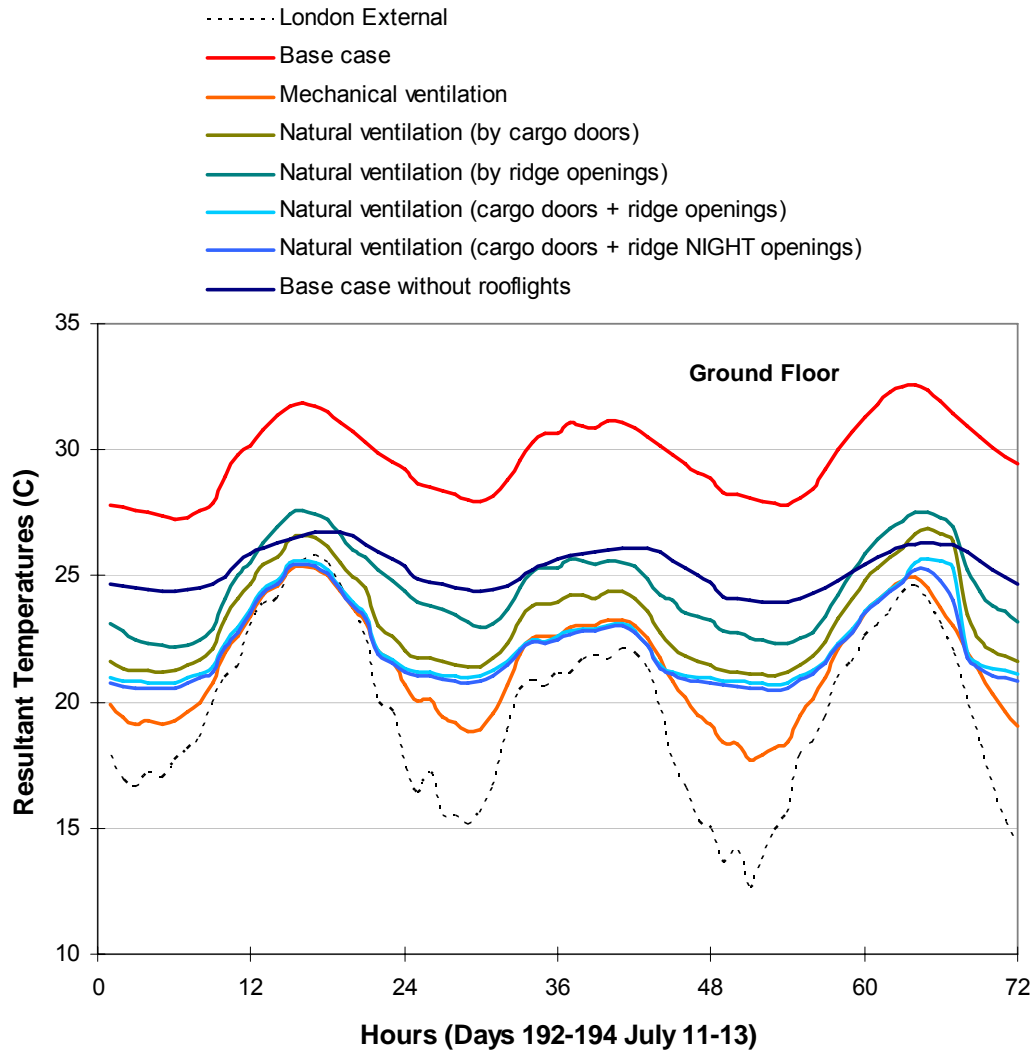


Figure 14. Resultant temperatures on ground floor for three warmest days: 14% rooflights

Mechanical ventilation is most effective at reducing temperatures overnight. However, using natural ventilation (cargo doors and ridge vents) keeps peak daytime resultant temperatures as low as achieved using mechanical ventilation. The unventilated example building gets significantly hotter than any of the ventilated cases, demonstrating that ventilation strategy is critical and of greater significance than rooflight area (up to a point) in avoiding overheating. A building with 14% rooflights does not exceed a resultant temperature of 26°C on any of the three warmest days.

6. Comparison between different rooflight percentages

The comparative analyses are based on cases of no ventilation at all and natural ventilation by opening cargo doors.

6.1. Loads and CO₂ emissions

Table 9. Loads (kWh/m² per year)

| Ventilation schemes | Heating | Solar | People/ Equipment | Lighting |
|---------------------------|---------|-------|----------------------|----------|
| 0% Base case | 17.18 | 0 | 10.18 | 49.06 |
| 10% Base case | 22.23 | 34.22 | 10.18 | 29.89 |
| 14% Base case | 22.69 | 48.09 | 10.18 | 28.14 |
| 10% with cargo doors open | 22.50 | 34.22 | 10.18 | 29.89 |
| 14% with cargo doors open | 23.09 | 48.09 | 10.18 | 28.14 |

Table 10. CO₂ emissions (kg/m² per year)

| Ventilation schemes | Heating | Lighting | Heating+Lighting |
|---------------------------|---------|----------|------------------|
| 0% Base case | 4.17 | 21.68 | 25.85 |
| 10% Base case | 5.39 | 13.21 | 18.60 |
| 14% Base case | 5.50 | 12.44 | 17.94 |
| 10% with cargo doors open | 5.46 | 13.21 | 18.67 |
| 14% with cargo doors open | 5.60 | 12.44 | 18.03 |

6.2. Monthly heating loads

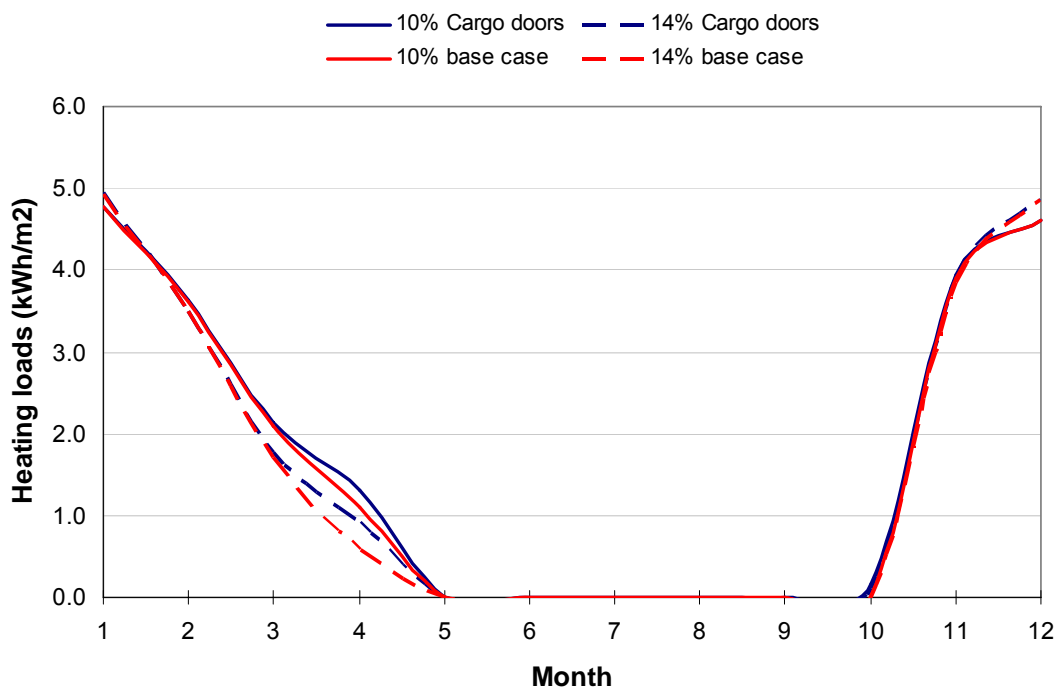


Figure 15. Heating loads for base case and natural ventilation (cargo doors open)

6.3. Overheating (ground floor)

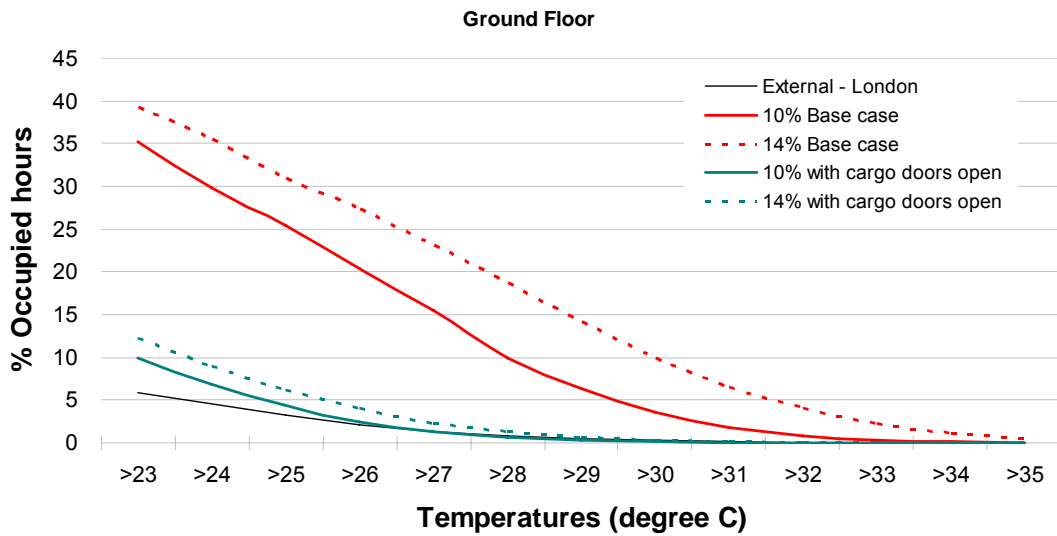


Figure 16. Ground floor overheating

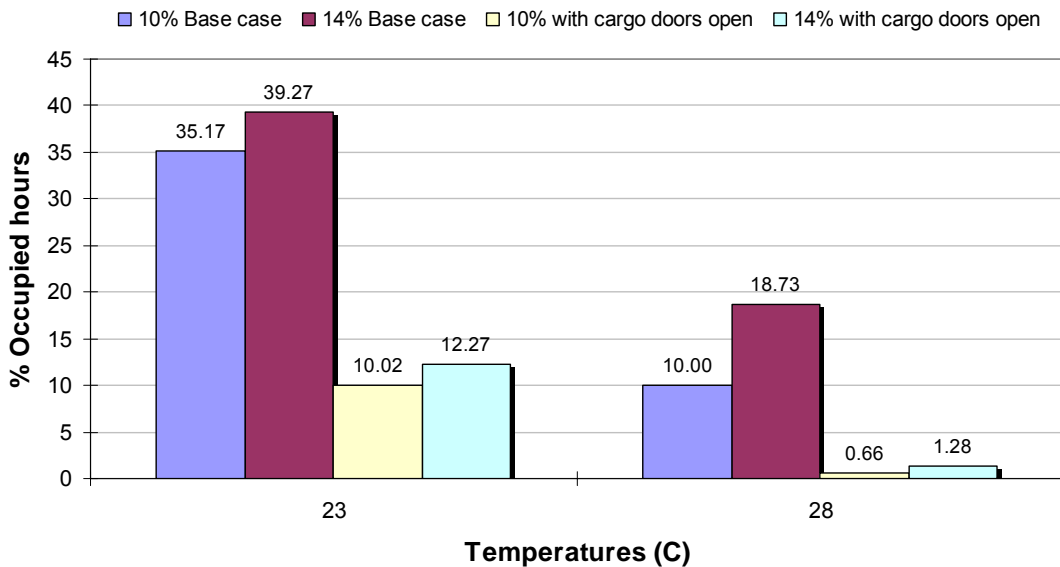


Figure 17. Percentage of occupied hours over certain temperatures

This clearly shows that use of natural ventilation has a very high impact, even when ventilation is only through cargo doors, whilst a change in rooflight area from 10% to 14% has a less dramatic effect upon overheating risk. The modelled building with 10-14% rooflights and effective natural ventilation has a low risk of overheating to uncomfortable levels.

6.4. Overheating (mezzanine)

The effect of stratification was investigated by introducing a notional mezzanine floor level.

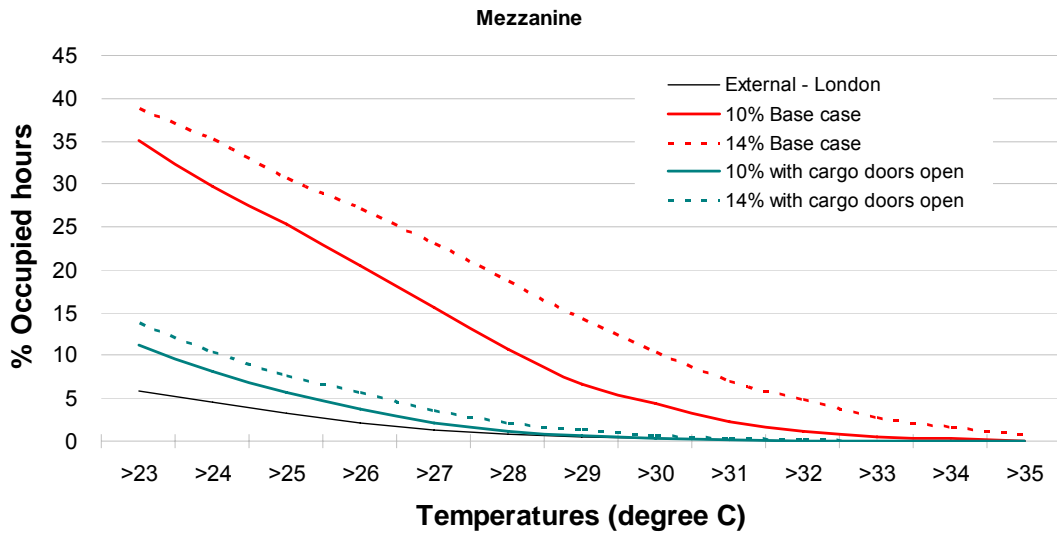


Figure 18. Mezzanine floor overheating

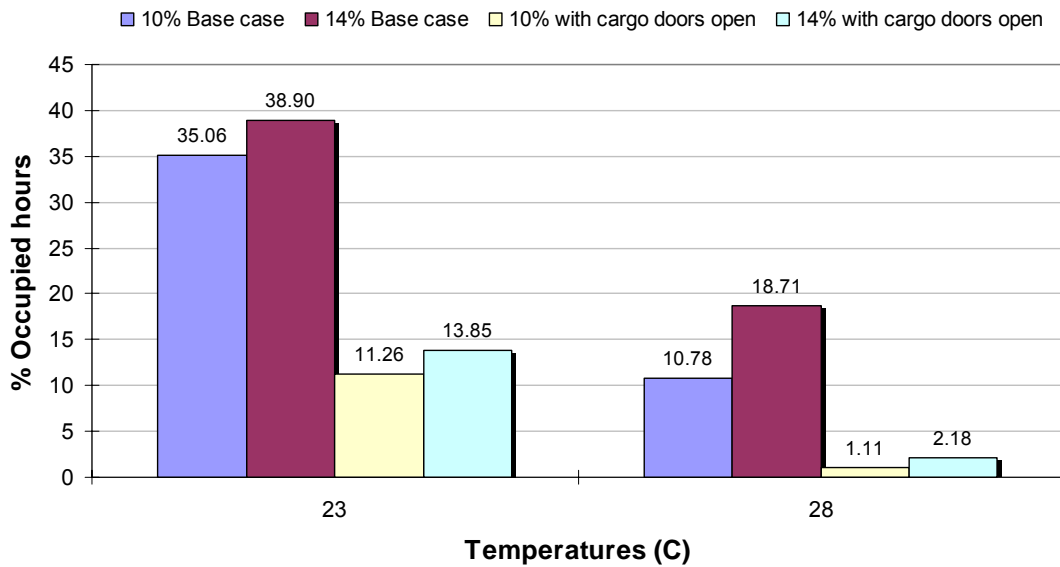


Figure 19. Percentage of occupied hours over certain temperatures

The model shows higher temperatures at the mezzanine level, indicating some thermal stratification.

6.5. Temperatures for three warmest days

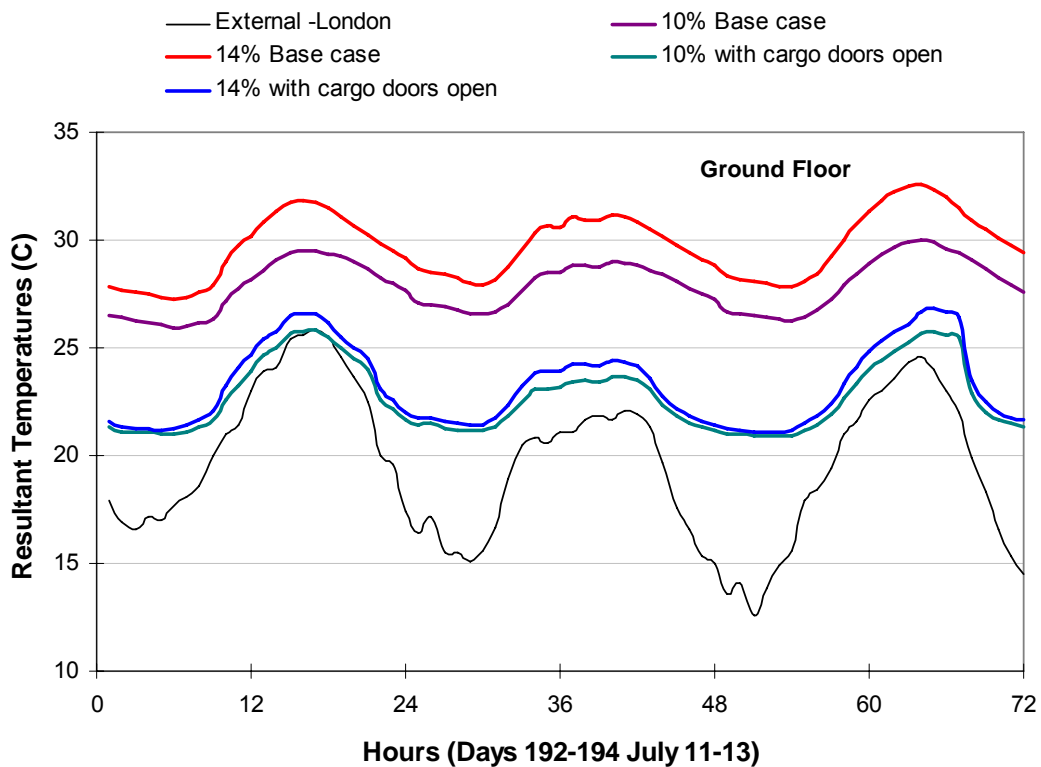


Figure 20. Resultant temperatures on ground floor for three warmest days

This graph shows that at the hottest point on the three warmest days of the year, unventilated buildings may overheat (reaching temperatures of over 30°C) but use of natural ventilation, if only through cargo doors, limits peak temperatures and significantly reduces overheating risk. Rooflight area (10-14% investigated) is a secondary effect for the example building studied, with an increase from 10% rooflights to 14% rooflights making less than 1°C difference to peak temperatures in the ventilated building.

7. Building Regulations Criterion 3: Limiting the effects of solar gains

Building Regulations Approved Document L2A states that reasonable provision could be:

a) when the building is subject to design irradiancies for July given in CIBSE Design Guide A, the combined solar and internal gains per unit floor area should not exceed 35W/m² when averaged between 0630 and 1630 GMT

b) the operative temperature does not exceed a threshold for more than a reasonable number of hours per year when the building is tested against the CIBSE Design Summer Year appropriate to the building location. For offices, a threshold of 1% over 28°C is suggested.

1% over 28°C may be considered unnecessarily onerous for many industrial and warehouse buildings, but it is still met by most of the cases analysed, except those without any ventilation

Analysis of the internal solar gains in the building with the CIBSE Design Summer Weather Year data used for July shows that the total average gains are never near 35W/m², even for 14% nominal rooflight area, as shown in the following graphs.

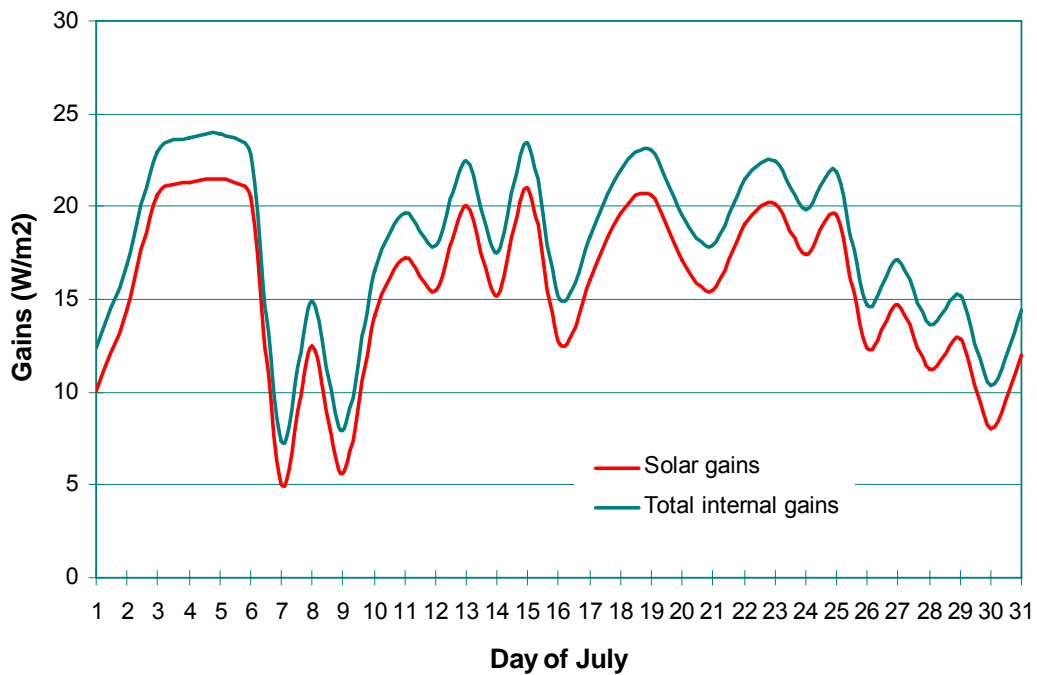


Figure 21. Total and solar gains for July (10% rooflights)

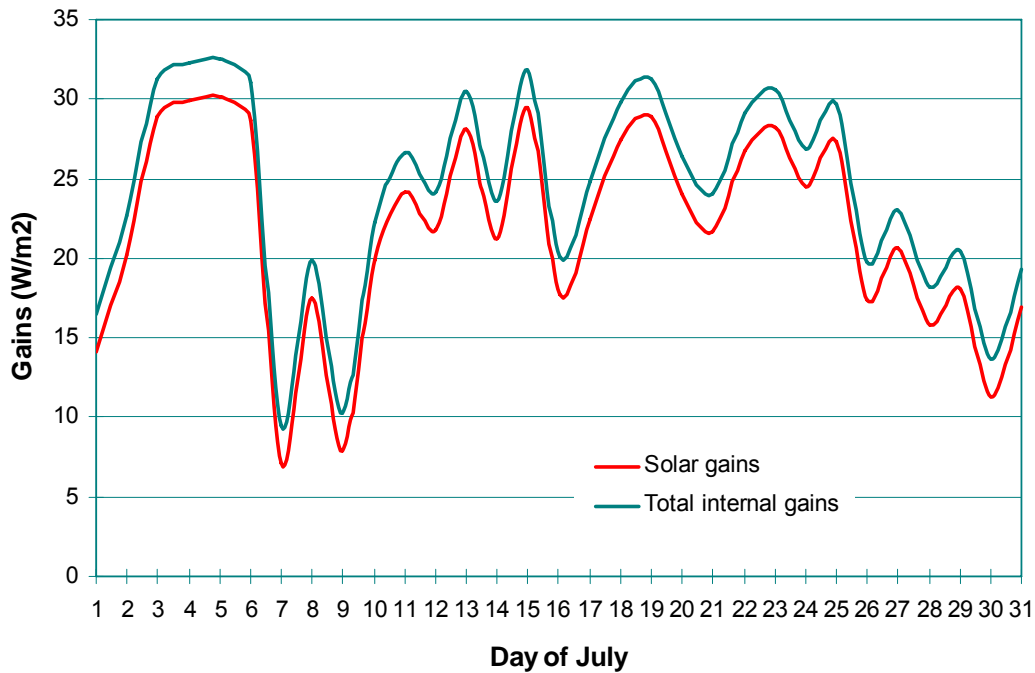


Figure 22. Total and solar gains for July (14% rooflights)

Using CIBSE Technical Memorandum TM37:2006 (Design for improved shading control), as recommended in ADL2, it is possible to calculate the approximate solar gain in a building from the location, the area and orientation of glazing, and the floor area. The solar load per unit floor area is given by:

$$\Phi_{sl} = (1/A_p) \sum (A_g \phi_s g_{eff})$$

Where

- A_p = Perimeter floor area
- A_g = Net area of glazing
- ϕ_s = external solar radiation for the orientation of the opening
- g_{eff} = effective g-value (gain) of the glazing

Applying this equation and using the tables in TM37 with an assumed g-value for the rooflights of 0.47 (as used in the modelling) and for London:

Perimeter area A_p = Total floor area – office area
 = 2400 – 120
 = 2280m²

Glazing area A_g (10%) = 199.8m²
 Glazing Area A_g (14%) = 279.7m²

Average outside solar irradiance for London on horizontal plane (Table 5.2 in TM37):

$$\varphi_s = 655 \text{ W/m}^2$$

$$\text{Effective g-value} = g \times 0.71 = 0.47 \times 0.71 = 0.33$$

| Rooflight percentage | Solar gain (TM37) W/m ² for July 4th | Solar gain (TAS) W/m ² for July 4th |
|----------------------|--|---|
| 10% | 19.1 | 21.3 |
| 14% | 26.7 | 29.9 |

Table 11. Average solar gains for TM37 method and TAS model

Internal gains add approximately 2.5W/m² to these figures, depending upon lighting load, taking the total load to over 23.8W/m² and 32.4W/m² for 10% and 14% rooflights respectively.

8. Conclusions

- Analysis shows there is an overheating risk with buildings that are totally unventilated
- Ventilation strategy and rooflight area both affect the risk of overheating, but ventilation strategy is by far the dominant effect.
- In a large open span metal clad building, cargo and personnel doors can be opened to provide effective cross ventilation as required. Opening cargo doors is common practice and is effectively self-regulating. Roof vents allow air to escape at high level and increase the effect of ventilation. They may also be left open at night to give secure night ventilation.
- Introduction of some natural ventilation (by opening cargo doors) has a significant effect, and ensures there is no overheating risk for buildings of this type incorporating 10% or 14% rooflights.
- The example building with either 10% or 14% rooflights with ridge vents and open cargo doors did not have total solar+internal gains exceeding 35W/m², and did not exceed 28°C for more than 1% of occupied hours, thus complying with both main criteria in Building Regulations Approved Document L2A for demonstrating solar overheating will not occur. Modelling also showed that resultant temperature is not predicted to exceed 26°C on the three warmest days of the year.
- Overheating risk can be reduced by eliminating rooflights altogether, but this would result in significant increases in overall energy use,

running costs, CO₂ emissions, and would give a significantly poorer internal environment inside the building.

- Rooflights save approximately 40% of lighting energy with only a small heating penalty, provided that appropriate controls are fitted to enable dimming in response to available daylight.
- Total CO₂ emissions (heating and lighting) are reduced by 30% (14% rooflights) when rooflights are used with dimmable lighting because the saving in lighting electricity far outweighs the additional heating gas required.
- Investigation of stratification shows this has some effect, particularly at higher rooflight areas, but the modelling suggest this is not a very significant factor.

The work demonstrates that there is no overheating problem at 14% rooflight area, for the warehouse considered. However, if other internal gains are higher (for example from significantly increased occupation density, or retail display lighting), it is possible that overall overheating criteria may be exceeded at lower rooflight areas.

APPENDIX

Base case

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|----------|------------------|
| 1 | 10850.15 | 1568.14 | 9392.38 |
| 2 | 8961.61 | 2678.95 | 7783.01 |
| 3 | 6127.00 | 4806.03 | 7794.03 |
| 4 | 4838.49 | 7283.20 | 6821.25 |
| 5 | 18.96 | 13153.88 | 6446.94 |
| 6 | 0.00 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 0.00 | 6245.05 | 7248.68 |
| 10 | 427.54 | 3638.99 | 8269.09 |
| 11 | 9329.07 | 2114.36 | 8870.12 |
| 12 | 10132.26 | 1078.42 | 9761.11 |
| Total | 50685.07 | 78030.45 | 91355.38 |
| Peak | 43.99 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Base case with no daylight windows

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-------|------------------|
| 1 | 7917.41 | 0.00 | 11440.96 |
| 2 | 6752.57 | 0.00 | 10333.77 |
| 3 | 4616.92 | 0.00 | 11440.96 |
| 4 | 4755.87 | 0.00 | 11071.89 |
| 5 | 12.92 | 0.00 | 11440.96 |
| 6 | 17.37 | 0.00 | 11071.89 |
| 7 | 0.00 | 0.00 | 11440.96 |
| 8 | 0.00 | 0.00 | 11440.96 |
| 9 | 0.00 | 0.00 | 11071.89 |
| 10 | 155.23 | 0.00 | 11440.96 |
| 11 | 6870.72 | 0.00 | 11071.89 |
| 12 | 7319.00 | 0.00 | 11440.96 |
| Total | 38418.02 | 0.00 | 134707.86 |
| Peak | 37.96 | 0.00 | 15.38 |
| Day | 330 | 0 | 1 |
| Hour | 6 | 0 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Mechanical ventilation

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|----------|------------------|
| 1 | 10850.15 | 1568.14 | 9392.38 |
| 2 | 8961.61 | 2678.95 | 7783.01 |
| 3 | 6127.00 | 4806.03 | 7794.03 |
| 4 | 4838.49 | 7283.20 | 6821.25 |
| 5 | 18.96 | 13153.88 | 6446.94 |
| 6 | 0.00 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 94.07 | 6245.05 | 7248.68 |
| 10 | 526.08 | 3638.99 | 8269.09 |
| 11 | 9350.17 | 2114.36 | 8870.12 |
| 12 | 10134.12 | 1078.42 | 9761.11 |
| Total | 50900.66 | 78030.45 | 91355.38 |
| Peak | 44.00 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (by cargo doors)

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|----------|------------------|
| 1 | 10856.48 | 1568.14 | 9392.38 |
| 2 | 8966.30 | 2678.95 | 7783.01 |
| 3 | 6169.56 | 4806.03 | 7794.03 |
| 4 | 4993.74 | 7283.20 | 6821.25 |
| 5 | 25.88 | 13153.88 | 6446.94 |
| 6 | 35.52 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 15.83 | 6245.05 | 7248.68 |
| 10 | 722.32 | 3638.99 | 8269.09 |
| 11 | 9374.88 | 2114.36 | 8870.12 |
| 12 | 10140.75 | 1078.42 | 9761.11 |
| Total | 51301.27 | 78030.45 | 91355.38 |
| Peak | 44.01 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (by ridge openings)

| Value in kWh | | | |
|--------------|----------|----------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 10850.12 | 1568.14 | 9392.38 |
| 2 | 8973.08 | 2678.95 | 7783.01 |
| 3 | 6199.07 | 4806.03 | 7794.03 |
| 4 | 5178.10 | 7283.20 | 6821.25 |
| 5 | 27.59 | 13153.88 | 6446.94 |
| 6 | 44.01 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 5.80 | 6245.05 | 7248.68 |
| 10 | 675.80 | 3638.99 | 8269.09 |
| 11 | 9363.04 | 2114.36 | 8870.12 |
| 12 | 10134.41 | 1078.42 | 9761.11 |
| Total | 51451.02 | 78030.45 | 91355.38 |
| Peak | 44.00 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (cargo doors + ridge openings)

| Value in kWh | | | |
|--------------|----------|----------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 10856.44 | 1568.14 | 9392.38 |
| 2 | 8977.76 | 2678.95 | 7783.01 |
| 3 | 6216.21 | 4806.03 | 7794.03 |
| 4 | 5225.68 | 7283.20 | 6821.25 |
| 5 | 44.52 | 13153.88 | 6446.94 |
| 6 | 88.50 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 20.61 | 6245.05 | 7248.68 |
| 10 | 779.80 | 3638.99 | 8269.09 |
| 11 | 9382.44 | 2114.36 | 8870.12 |
| 12 | 10140.97 | 1078.42 | 9761.11 |
| Total | 51732.93 | 78030.45 | 91355.38 |
| Peak | 44.01 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (cargo doors + ridge NIGHT openings)

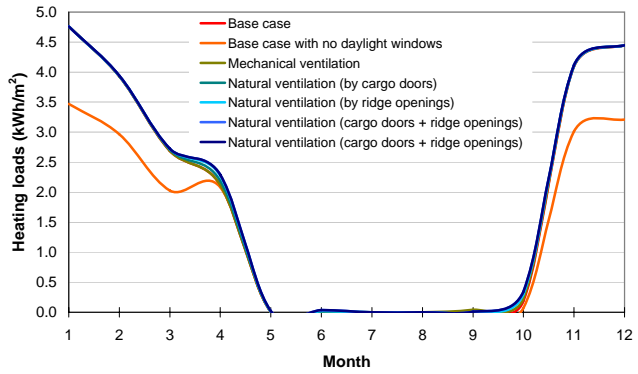
| Value in kWh | | | |
|--------------|----------|----------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 10856.44 | 1568.14 | 9392.38 |
| 2 | 8977.76 | 2678.95 | 7783.01 |
| 3 | 6216.21 | 4806.03 | 7794.03 |
| 4 | 5225.68 | 7283.20 | 6821.25 |
| 5 | 44.52 | 13153.88 | 6446.94 |
| 6 | 88.50 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 34.24 | 6245.05 | 7248.68 |
| 10 | 796.36 | 3638.99 | 8269.09 |
| 11 | 9385.90 | 2114.36 | 8870.12 |
| 12 | 10141.37 | 1078.42 | 9761.11 |
| Total | 51766.97 | 78030.45 | 91355.38 |
| Peak | 44.01 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Shed floor area= 2280 m2

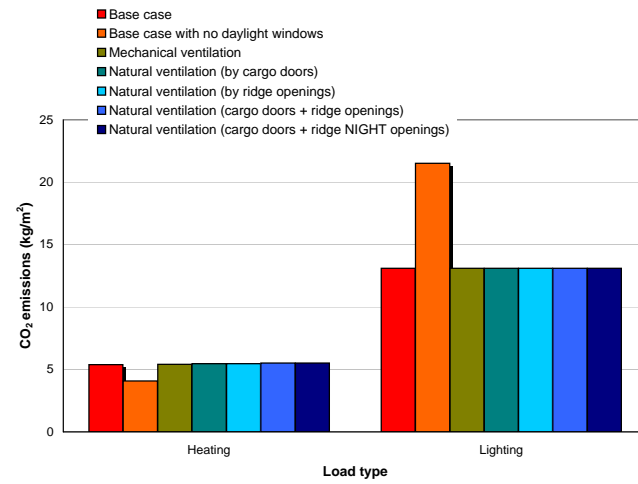
Base case

| Value in kWh | Lighting electri | | 29,642 |
|--------------|------------------|--------------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 4.76 | 0.69 | 4.12 |
| 2 | 3.93 | 1.17 | 3.41 |
| 3 | 2.69 | 2.11 | 3.42 |
| 4 | 2.12 | 3.19 | 2.99 |
| 5 | 0.01 | 5.77 | 2.83 |
| 6 | 0.00 | 5.22 | 2.59 |
| 7 | 0.00 | 5.77 | 2.75 |
| 8 | 0.00 | 4.56 | 2.98 |
| 9 | 0.00 | 2.74 | 3.18 |
| 10 | 0.19 | 1.60 | 3.63 |
| 11 | 4.09 | 0.93 | 3.89 |
| 12 | 4.44 | 0.47 | 4.28 |
| Total | 22.23 | 34.22 | 40.07 |



Base case with no daylight windows

| Value in kWh | Lighting electri | | 48,656 |
|--------------|------------------|-------------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 3.47 | 0.00 | 5.02 |
| 2 | 2.96 | 0.00 | 4.53 |
| 3 | 2.02 | 0.00 | 5.02 |
| 4 | 2.09 | 0.00 | 4.86 |
| 5 | 0.01 | 0.00 | 5.02 |
| 6 | 0.01 | 0.00 | 4.86 |
| 7 | 0.00 | 0.00 | 5.02 |
| 8 | 0.00 | 0.00 | 5.02 |
| 9 | 0.00 | 0.00 | 4.86 |
| 10 | 0.07 | 0.00 | 5.02 |
| 11 | 3.01 | 0.00 | 4.86 |
| 12 | 3.21 | 0.00 | 5.02 |
| Total | 16.85 | 0.00 | 59.08 |



Mechanical ventilation

| Value in kWh | Lighting electri | | 29,642 |
|--------------|------------------|--------------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 4.76 | 0.69 | 4.12 |
| 2 | 3.93 | 1.17 | 3.41 |
| 3 | 2.69 | 2.11 | 3.42 |
| 4 | 2.12 | 3.19 | 2.99 |
| 5 | 0.01 | 5.77 | 2.83 |
| 6 | 0.00 | 5.22 | 2.59 |
| 7 | 0.00 | 5.77 | 2.75 |
| 8 | 0.00 | 4.56 | 2.98 |
| 9 | 0.04 | 2.74 | 3.18 |
| 10 | 0.23 | 1.60 | 3.63 |
| 11 | 4.10 | 0.93 | 3.89 |
| 12 | 4.44 | 0.47 | 4.28 |
| Total | 22.32 | 34.22 | 40.07 |

Natural ventilation (by cargo doors)

| Value in kWh | Lighting electri | | 29,642 |
|--------------|------------------|--------------|------------------|
| Month | Heating | Solar | Internal (L,O,E) |
| 1 | 4.76 | 0.69 | 4.12 |
| 2 | 3.93 | 1.17 | 3.41 |
| 3 | 2.71 | 2.11 | 3.42 |
| 4 | 2.19 | 3.19 | 2.99 |
| 5 | 0.01 | 5.77 | 2.83 |
| 6 | 0.02 | 5.22 | 2.59 |
| 7 | 0.00 | 5.77 | 2.75 |
| 8 | 0.00 | 4.56 | 2.98 |
| 9 | 0.01 | 2.74 | 3.18 |
| 10 | 0.32 | 1.60 | 3.63 |
| 11 | 4.11 | 0.93 | 3.89 |
| 12 | 4.45 | 0.47 | 4.28 |
| Total | 22.50 | 34.22 | 40.07 |

Natural ventilation (by ridge openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 29,642 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 4.76 | 0.69 | | | 4.12 |
| 2 | 3.94 | 1.17 | | | 3.41 |
| 3 | 2.72 | 2.11 | | | 3.42 |
| 4 | 2.27 | 3.19 | | | 2.99 |
| 5 | 0.01 | 5.77 | | | 2.83 |
| 6 | 0.02 | 5.22 | | | 2.59 |
| 7 | 0.00 | 5.77 | | | 2.75 |
| 8 | 0.00 | 4.56 | | | 2.98 |
| 9 | 0.00 | 2.74 | | | 3.18 |
| 10 | 0.30 | 1.60 | | | 3.63 |
| 11 | 4.11 | 0.93 | | | 3.89 |
| 12 | 4.44 | 0.47 | | | 4.28 |
| Total | 22.57 | 34.22 | | | 40.07 |

Natural ventilation (cargo doors + ridge openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 29,642 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 4.76 | 0.69 | | | 4.12 |
| 2 | 3.94 | 1.17 | | | 3.41 |
| 3 | 2.73 | 2.11 | | | 3.42 |
| 4 | 2.29 | 3.19 | | | 2.99 |
| 5 | 0.02 | 5.77 | | | 2.83 |
| 6 | 0.04 | 5.22 | | | 2.59 |
| 7 | 0.00 | 5.77 | | | 2.75 |
| 8 | 0.00 | 4.56 | | | 2.98 |
| 9 | 0.01 | 2.74 | | | 3.18 |
| 10 | 0.34 | 1.60 | | | 3.63 |
| 11 | 4.12 | 0.93 | | | 3.89 |
| 12 | 4.45 | 0.47 | | | 4.28 |
| Total | 22.69 | 34.22 | | | 40.07 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 29,642 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 4.76 | 0.69 | | | 4.12 |
| 2 | 3.94 | 1.17 | | | 3.41 |
| 3 | 2.73 | 2.11 | | | 3.42 |
| 4 | 2.29 | 3.19 | | | 2.99 |
| 5 | 0.02 | 5.77 | | | 2.83 |
| 6 | 0.04 | 5.22 | | | 2.59 |
| 7 | 0.00 | 5.77 | | | 2.75 |
| 8 | 0.00 | 4.56 | | | 2.98 |
| 9 | 0.02 | 2.74 | | | 3.18 |
| 10 | 0.35 | 1.60 | | | 3.63 |
| 11 | 4.12 | 0.93 | | | 3.89 |
| 12 | 4.45 | 0.47 | | | 4.28 |
| Total | 22.70 | 34.22 | | | 40.07 |

Loads summary kWh/m2

| | Heating | Solar | Internal | Lighting |
|-----------------|---------|-------|----------|----------|
| Base case | 22.23 | 34.22 | 40.07 | 29.64 |
| Base case wit | 16.85 | 0.00 | 59.08 | 48.66 |
| Mechanical ve | 22.32 | 34.22 | 40.07 | 29.64 |
| Natural ventile | 22.50 | 34.22 | 40.07 | 29.64 |
| Natural ventile | 22.57 | 34.22 | 40.07 | 29.64 |
| Natural ventile | 22.69 | 34.22 | 40.07 | 29.64 |
| Natural ventile | 22.70 | 34.22 | 40.07 | 29.64 |

CO2 emissions kg/m2

| | Heating | Solar | Internal | Lighting |
|-----------------|---------|-------|----------|----------|
| Base case | 5.39 | 15.13 | 17.71 | 13.10 |
| Base case wit | 4.09 | 0.00 | 26.11 | 21.51 |
| Mechanical ve | 5.41 | 15.13 | 17.71 | 13.10 |
| Natural ventile | 5.46 | 15.13 | 17.71 | 13.10 |
| Natural ventile | 5.47 | 15.13 | 17.71 | 13.10 |
| Natural ventile | 5.50 | 15.13 | 17.71 | 13.10 |
| Natural ventile | 5.51 | 15.13 | 17.71 | 13.10 |

Base case

| | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 4078 | 3656 | 3427 | 3081 | 2614 | 2226 | 1789 | 1361 | 876 | 552 | 313 | 153 | 69 | 35 | 13 |

Base case without daylight

| | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|-----|-----|----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3940 | 3291 | 2976 | 2391 | 1672 | 1026 | 496 | 210 | 83 | 35 | 0 | 0 | 0 | 0 | 0 |

Mechanical ventilation

| | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 2847 | 2157 | 1685 | 1214 | 843 | 590 | 376 | 237 | 114 | 53 | 18 | 4 | 0 | 0 | 0 |

Natural ventilation (by cargo doors)

| | | | | | | | | | | | | | | | | |
|---|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3696 | 2258 | 1270 | 878 | 593 | 384 | 218 | 111 | 58 | 28 | 11 | 4 | 0 | 0 | 0 |

Natural ventilation (by ridge openings)

| | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3749 | 2808 | 1918 | 1362 | 937 | 591 | 367 | 171 | 86 | 43 | 25 | 5 | 0 | 0 | 0 |

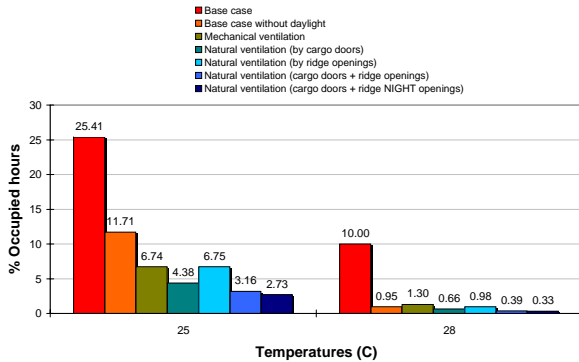
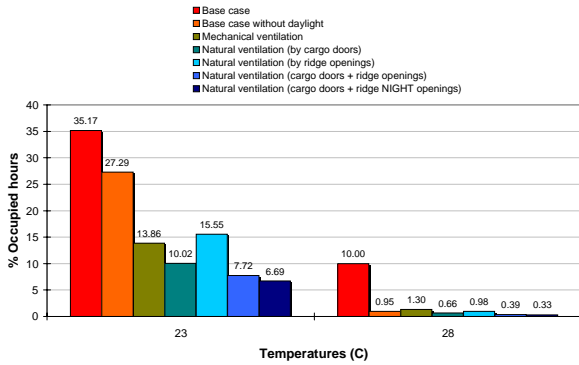
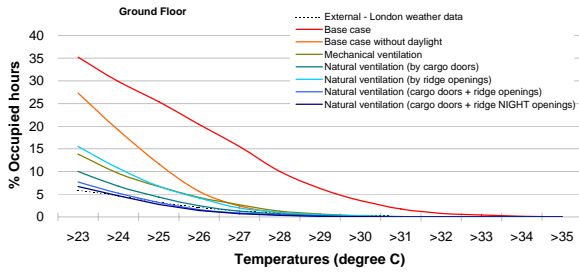
Natural ventilation (cargo doors + ridge openings)

| | | | | | | | | | | | | | | | | |
|---|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3571 | 1772 | 973 | 676 | 458 | 277 | 142 | 72 | 34 | 13 | 5 | 1 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| | | | | | | | | | | | | | | | | |
|---|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 2930 | 1437 | 872 | 586 | 405 | 239 | 125 | 64 | 29 | 12 | 5 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 46.55 | 41.74 | 39.12 | 35.17 | 29.84 | 25.41 | 20.42 | 15.54 | 10.00 | 6.30 | 3.57 | 1.75 | 0.79 | 0.40 | 0.15 | 0.00 |
| Base case + | 44.98 | 37.57 | 33.97 | 27.29 | 19.09 | 11.71 | 5.66 | 2.40 | 0.95 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mechanical | 32.50 | 24.62 | 19.24 | 13.86 | 9.62 | 6.74 | 4.29 | 2.71 | 1.30 | 0.61 | 0.21 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 42.19 | 25.78 | 14.50 | 10.02 | 6.77 | 4.38 | 2.49 | 1.27 | 0.66 | 0.32 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 42.80 | 32.05 | 21.89 | 15.55 | 10.70 | 6.75 | 4.19 | 1.95 | 0.98 | 0.49 | 0.29 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 40.76 | 20.23 | 11.11 | 7.72 | 5.23 | 3.16 | 1.62 | 0.82 | 0.39 | 0.15 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 33.45 | 16.40 | 9.95 | 6.69 | 4.62 | 2.73 | 1.43 | 0.73 | 0.33 | 0.14 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |



Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 4078 | 3656 | 3427 | 3081 | 2614 | 2226 | 1789 | 1361 | 876 | 552 | 313 | 153 | 69 | 35 | 13 |

Mechanical ventilation

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 2847 | 2157 | 1685 | 1214 | 843 | 590 | 376 | 237 | 114 | 53 | 18 | 4 | 0 | 0 | 0 |

Natural ventilation (by cargo doors)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3696 | 2258 | 1270 | 878 | 593 | 384 | 218 | 111 | 58 | 28 | 11 | 4 | 0 | 0 | 0 |

Natural ventilation (by ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3749 | 2808 | 1918 | 1362 | 937 | 591 | 367 | 171 | 86 | 43 | 25 | 5 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

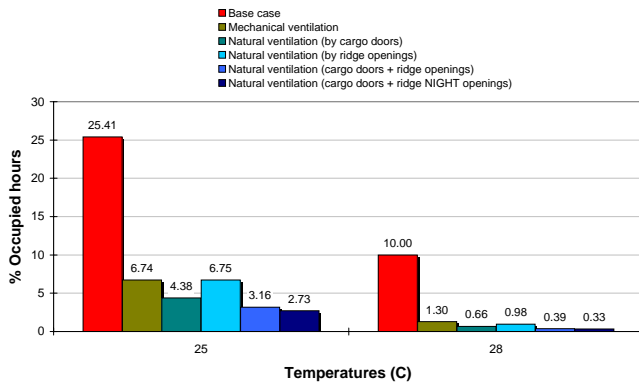
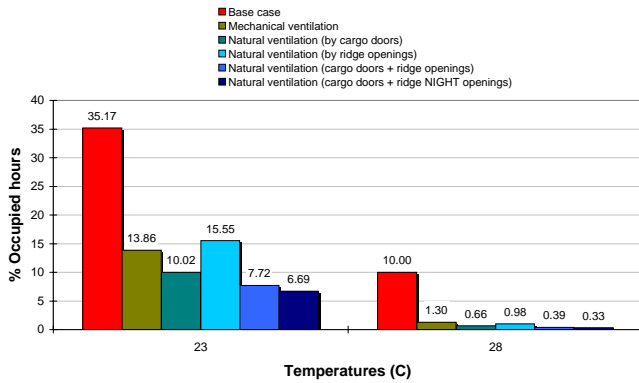
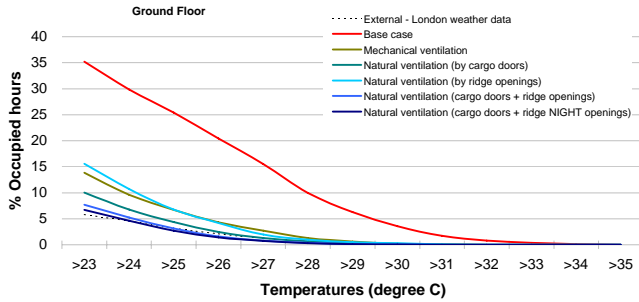
| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3571 | 1772 | 973 | 676 | 458 | 277 | 142 | 72 | 34 | 13 | 5 | 1 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 2930 | 1437 | 872 | 586 | 405 | 239 | 125 | 64 | 29 | 12 | 5 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 46.55 | 41.74 | 39.12 | 35.17 | 29.84 | 25.41 | 20.42 | 15.54 | 10.00 | 6.30 | 3.57 | 1.75 | 0.79 | 0.40 | 0.15 | 0.00 |
| Mechanical | 32.50 | 24.62 | 19.24 | 13.66 | 9.62 | 6.74 | 4.29 | 2.71 | 1.30 | 0.61 | 0.21 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural vent | 42.19 | 25.78 | 14.50 | 10.02 | 6.77 | 4.38 | 2.49 | 1.27 | 0.66 | 0.32 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural vent | 42.80 | 32.05 | 21.89 | 15.55 | 10.70 | 6.75 | 4.19 | 1.95 | 0.98 | 0.49 | 0.29 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural vent | 40.76 | 20.23 | 11.11 | 7.72 | 5.23 | 3.16 | 1.62 | 0.82 | 0.39 | 0.15 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural vent | 33.45 | 16.40 | 9.95 | 6.69 | 4.62 | 2.73 | 1.43 | 0.73 | 0.33 | 0.14 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |



Base case

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 4087 | 3646 | 3397 | 3071 | 2610 | 2221 | 1798 | 1367 | 944 | 589 | 378 | 206 | 96 | 46 | 24 | 4 |

Base case without daylight

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|------|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3914 | 3293 | 2940 | 2399 | 1682 | 1071 | 567 | 273 | 99 | 40 | 14 | 0 | 0 | 0 | 0 | 0 |

Mechanical ventilation

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 2866 | 2197 | 1717 | 1293 | 924 | 653 | 436 | 280 | 165 | 74 | 36 | 14 | 1 | 0 | 0 | 0 |

Natural ventilation (by cargo doors)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3637 | 2268 | 1406 | 986 | 711 | 497 | 322 | 187 | 97 | 54 | 25 | 10 | 4 | 0 | 0 | 0 |

Natural ventilation (by ridge openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3749 | 2647 | 1824 | 1336 | 975 | 660 | 431 | 235 | 119 | 58 | 34 | 15 | 2 | 0 | 0 | 0 |

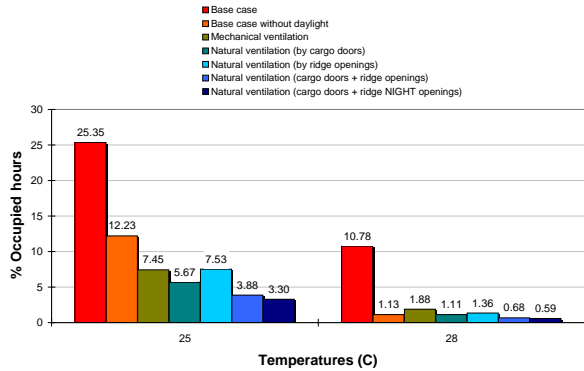
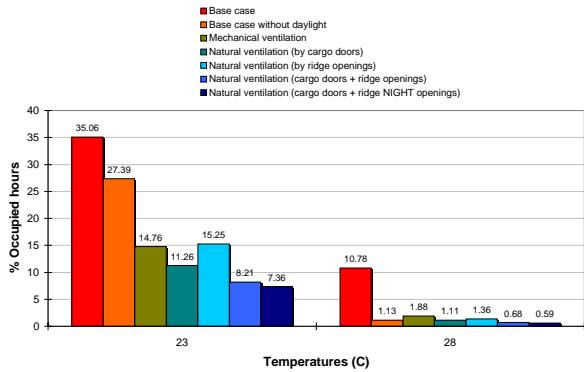
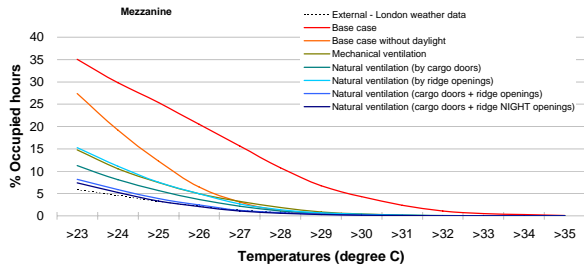
Natural ventilation (cargo doors + ridge openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3468 | 1722 | 1003 | 719 | 518 | 340 | 211 | 108 | 60 | 30 | 11 | 5 | 1 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lc | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 2804 | 1427 | 899 | 645 | 461 | 289 | 183 | 95 | 52 | 23 | 11 | 5 | 0 | 0 | 0 | 0 |

| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| External - Lc | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 46.66 | 41.62 | 38.78 | 35.06 | 29.79 | 25.35 | 20.53 | 15.61 | 10.78 | 6.72 | 4.32 | 2.35 | 1.10 | 0.53 | 0.27 | 0.05 |
| Base case v | 44.66 | 37.59 | 33.56 | 27.39 | 19.20 | 12.23 | 6.47 | 3.12 | 1.13 | 0.46 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mechanical | 32.72 | 25.98 | 19.60 | 14.76 | 10.55 | 7.45 | 4.98 | 3.20 | 1.88 | 0.84 | 0.41 | 0.16 | 0.01 | 0.00 | 0.00 | 0.00 |
| Natural vent | 41.52 | 25.89 | 16.05 | 11.26 | 8.12 | 5.67 | 3.68 | 2.13 | 1.11 | 0.62 | 0.29 | 0.11 | 0.05 | 0.00 | 0.00 | 0.00 |
| Natural vent | 42.80 | 30.22 | 20.82 | 15.25 | 11.13 | 7.53 | 4.92 | 2.68 | 1.36 | 0.66 | 0.39 | 0.17 | 0.02 | 0.00 | 0.00 | 0.00 |
| Natural vent | 39.59 | 19.66 | 11.45 | 8.21 | 5.91 | 3.88 | 2.41 | 1.23 | 0.68 | 0.34 | 0.13 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 |
| Natural vent | 32.01 | 16.29 | 10.26 | 7.36 | 5.26 | 3.30 | 2.09 | 1.08 | 0.59 | 0.26 | 0.13 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |



Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 4087 | 3646 | 3397 | 3071 | 2610 | 2221 | 1798 | 1367 | 944 | 589 | 378 | 206 | 96 | 46 | 24 |

Mechanical ventilation

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 2866 | 2197 | 1717 | 1293 | 924 | 653 | 436 | 280 | 165 | 74 | 36 | 14 | 1 | 0 | 0 |

Natural ventilation (by cargo doors)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3637 | 2268 | 1406 | 986 | 711 | 497 | 322 | 187 | 97 | 54 | 25 | 10 | 4 | 0 | 0 |

Natural ventilation (by ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3749 | 2647 | 1824 | 1336 | 975 | 660 | 431 | 235 | 119 | 58 | 34 | 15 | 2 | 0 | 0 |

Natural ventilation (cargo doors + ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

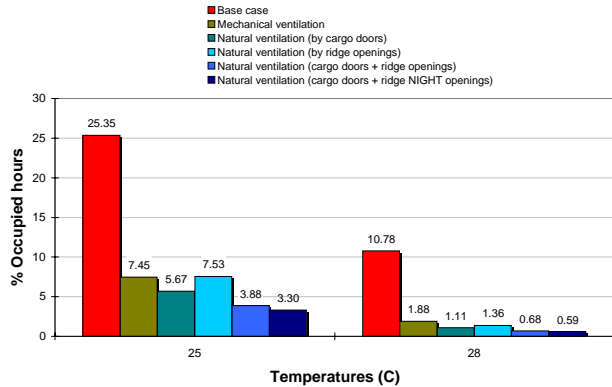
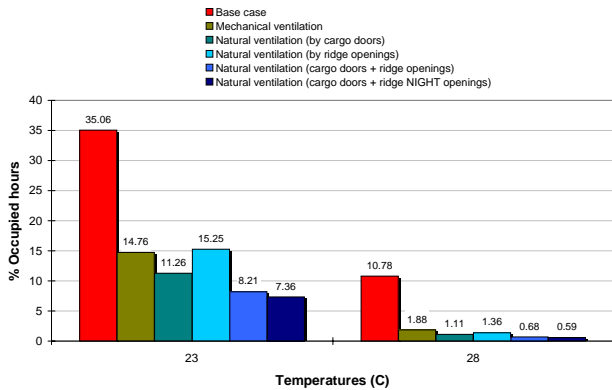
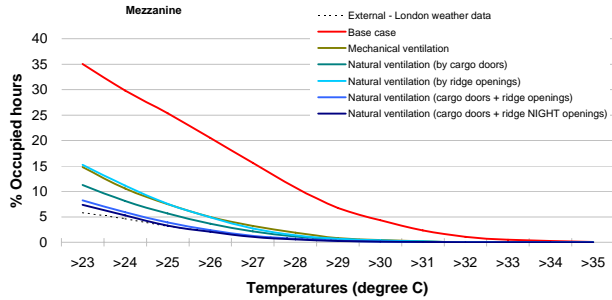
| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3468 | 1722 | 1003 | 719 | 518 | 340 | 211 | 108 | 60 | 30 | 11 | 5 | 1 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

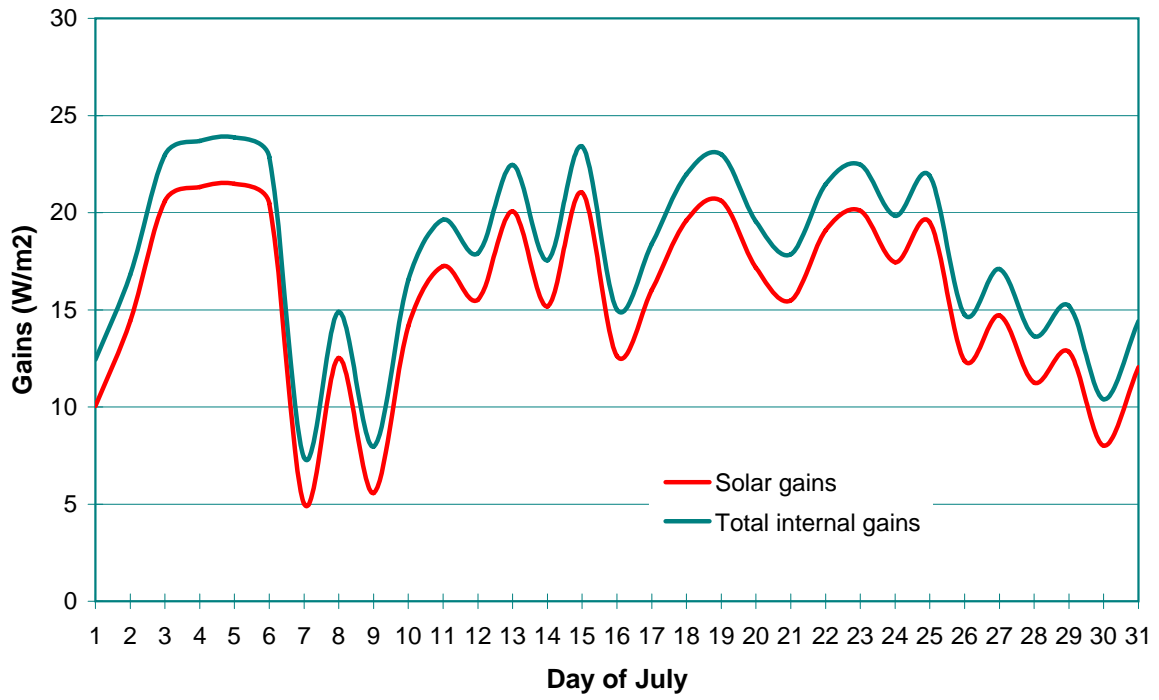
Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 2804 | 1427 | 899 | 645 | 461 | 289 | 183 | 95 | 52 | 23 | 11 | 5 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 46.66 | 41.62 | 38.78 | 35.06 | 29.79 | 25.35 | 20.53 | 15.61 | 10.78 | 6.72 | 4.32 | 2.35 | 1.10 | 0.53 | 0.27 | 0.05 |
| Mechanical | 32.72 | 25.08 | 19.60 | 14.76 | 10.55 | 7.45 | 4.98 | 3.20 | 1.88 | 0.84 | 0.41 | 0.16 | 0.01 | 0.00 | 0.00 | 0.00 |
| Natural ven | 41.52 | 25.89 | 16.05 | 11.26 | 8.12 | 5.67 | 3.68 | 2.13 | 1.11 | 0.62 | 0.29 | 0.11 | 0.05 | 0.00 | 0.00 | 0.00 |
| Natural ven | 42.80 | 30.22 | 20.82 | 15.25 | 11.13 | 7.53 | 4.92 | 2.68 | 1.36 | 0.66 | 0.39 | 0.17 | 0.02 | 0.00 | 0.00 | 0.00 |
| Natural ven | 39.59 | 19.66 | 11.45 | 8.21 | 5.91 | 3.88 | 2.41 | 1.23 | 0.68 | 0.34 | 0.13 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 |
| Natural ven | 32.01 | 16.29 | 10.26 | 7.36 | 5.26 | 3.30 | 2.09 | 1.08 | 0.59 | 0.26 | 0.13 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |

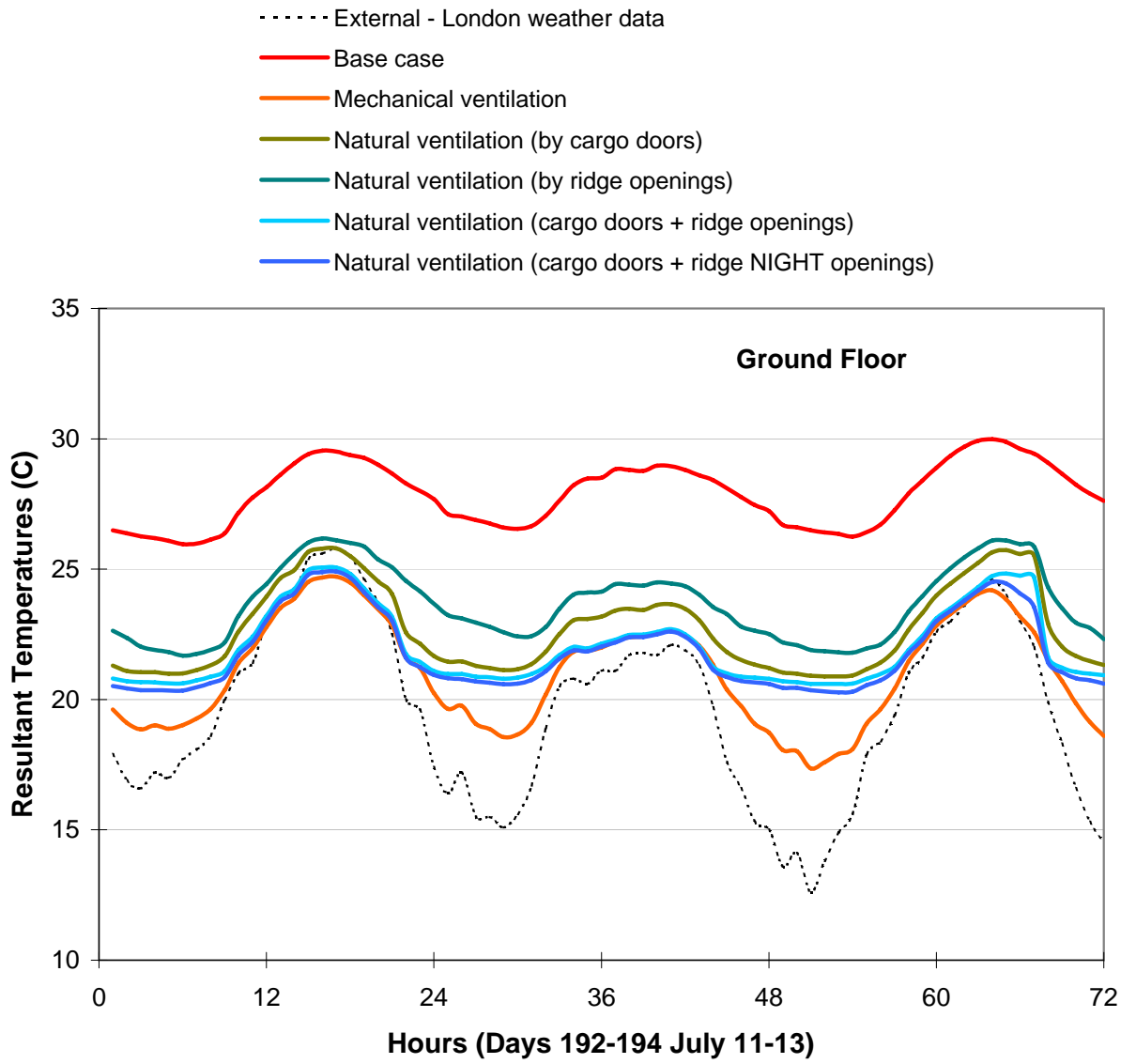


10% Grey thermal results.xls

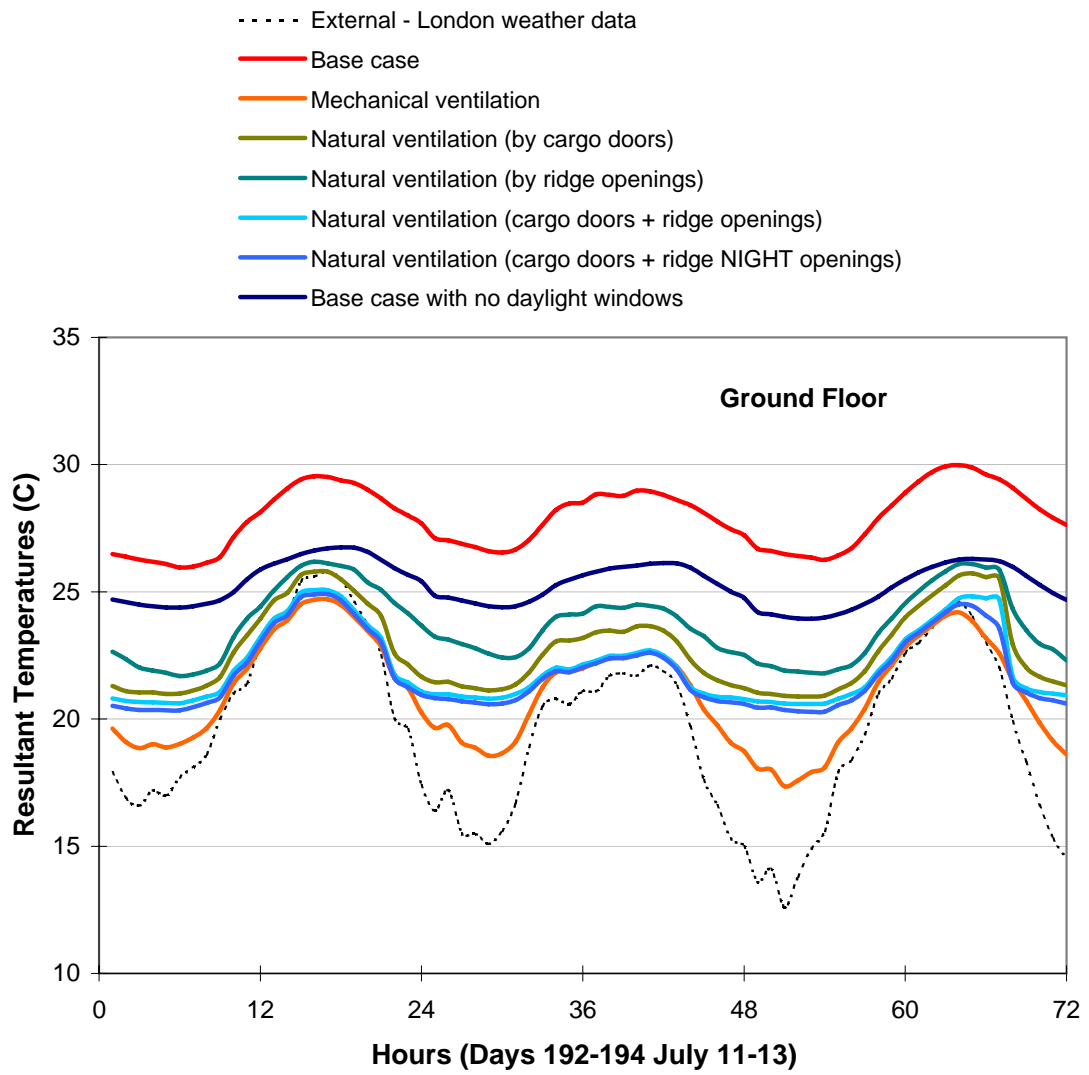


Solar Gains in July (7-17h)

10% Grey thermal results.xls



10% Grey thermal results.xls



Base case

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|--------------|-----------------|------------------|------------------|
| 1 | 11662.80 | 2212.72 | 8928.51 |
| 2 | 9213.82 | 3767.13 | 7461.43 |
| 3 | 5830.31 | 6756.79 | 7493.34 |
| 4 | 3810.10 | 10240.99 | 6554.76 |
| 5 | 0.00 | 18465.93 | 6164.40 |
| 6 | 0.00 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 0.00 | 8781.80 | 6988.91 |
| 10 | 264.61 | 5120.08 | 7991.47 |
| 11 | 9835.13 | 2984.71 | 8436.70 |
| 12 | 11116.60 | 1529.96 | 9223.68 |
| Total | 51733.36 | 109641.38 | 87397.04 |
| Peak | 46.32 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Base case with no daylight windows

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|--------------|-----------------|-------------|------------------|
| 1 | 7917.09 | 0.00 | 11440.96 |
| 2 | 6752.31 | 0.00 | 10333.77 |
| 3 | 4616.67 | 0.00 | 11440.96 |
| 4 | 4753.11 | 0.00 | 11071.89 |
| 5 | 12.91 | 0.00 | 11440.96 |
| 6 | 17.36 | 0.00 | 11071.89 |
| 7 | 0.00 | 0.00 | 11440.96 |
| 8 | 0.00 | 0.00 | 11440.96 |
| 9 | 0.00 | 0.00 | 11071.89 |
| 10 | 155.08 | 0.00 | 11440.96 |
| 11 | 6870.38 | 0.00 | 11071.89 |
| 12 | 7318.68 | 0.00 | 11440.96 |
| Total | 38413.58 | 0.00 | 134707.86 |
| Peak | 37.96 | 0.00 | 15.38 |
| Day | 330 | 0 | 1 |
| Hour | 6 | 0 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Mechanical ventilation

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|--------------|-----------------|------------------|------------------|
| 1 | 11662.80 | 2212.72 | 8928.51 |
| 2 | 9213.82 | 3767.13 | 7461.43 |
| 3 | 5830.31 | 6756.79 | 7493.34 |
| 4 | 3810.10 | 10240.99 | 6554.76 |
| 5 | 0.00 | 18465.93 | 6164.40 |
| 6 | 0.00 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 85.78 | 8781.80 | 6988.91 |
| 10 | 374.74 | 5120.08 | 7991.47 |
| 11 | 9860.06 | 2984.71 | 8436.70 |
| 12 | 11118.61 | 1529.96 | 9223.68 |
| Total | 51956.20 | 109641.38 | 87397.04 |
| Peak | 46.33 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (by cargo doors)

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|--------------|-----------------|------------------|------------------|
| 1 | 11668.48 | 2212.72 | 8928.51 |
| 2 | 9218.60 | 3767.13 | 7461.43 |
| 3 | 5898.78 | 6756.79 | 7493.34 |
| 4 | 4172.31 | 10240.99 | 6554.76 |
| 5 | 13.40 | 18465.93 | 6164.40 |
| 6 | 8.88 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 14.26 | 8781.80 | 6988.91 |
| 10 | 612.22 | 5120.08 | 7991.47 |
| 11 | 9901.93 | 2984.71 | 8436.70 |
| 12 | 11125.59 | 1529.96 | 9223.68 |
| Total | 52634.47 | 109641.38 | 87397.04 |
| Peak | 46.34 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (by ridge openings)

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-----------|------------------|
| 1 | 11662.81 | 2212.72 | 8928.51 |
| 2 | 9232.79 | 3767.13 | 7461.43 |
| 3 | 5957.96 | 6756.79 | 7493.34 |
| 4 | 4376.33 | 10240.99 | 6554.76 |
| 5 | 16.44 | 18465.93 | 6164.40 |
| 6 | 13.30 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 7.00 | 8781.80 | 6988.91 |
| 10 | 584.62 | 5120.08 | 7991.47 |
| 11 | 9893.89 | 2984.71 | 8436.70 |
| 12 | 11119.66 | 1529.96 | 9223.68 |
| Total | 52864.80 | 109641.38 | 87397.04 |
| Peak | 46.34 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (cargo doors + ridge openings)

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-----------|------------------|
| 1 | 11668.47 | 2212.72 | 8928.51 |
| 2 | 9237.07 | 3767.13 | 7461.43 |
| 3 | 5976.64 | 6756.79 | 7493.34 |
| 4 | 4463.31 | 10240.99 | 6554.76 |
| 5 | 19.60 | 18465.93 | 6164.40 |
| 6 | 44.84 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 22.40 | 8781.80 | 6988.91 |
| 10 | 692.81 | 5120.08 | 7991.47 |
| 11 | 9917.13 | 2984.71 | 8436.70 |
| 12 | 11126.07 | 1529.96 | 9223.68 |
| Total | 53168.36 | 109641.38 | 87397.04 |
| Peak | 46.35 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Natural ventilation (cargo doors + ridge NIGHT openings)

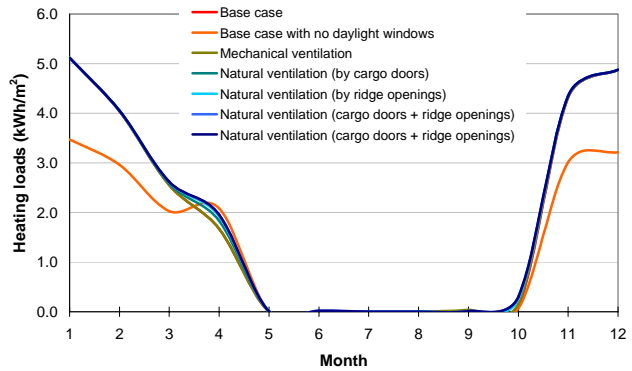
Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-----------|------------------|
| 1 | 11668.47 | 2212.72 | 8928.51 |
| 2 | 9237.07 | 3767.13 | 7461.43 |
| 3 | 5976.64 | 6756.79 | 7493.34 |
| 4 | 4463.31 | 10240.99 | 6554.76 |
| 5 | 19.60 | 18465.93 | 6164.40 |
| 6 | 44.84 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 30.41 | 8781.80 | 6988.91 |
| 10 | 705.87 | 5120.08 | 7991.47 |
| 11 | 9920.33 | 2984.71 | 8436.70 |
| 12 | 11126.35 | 1529.96 | 9223.68 |
| Total | 53192.88 | 109641.38 | 87397.04 |
| Peak | 46.35 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

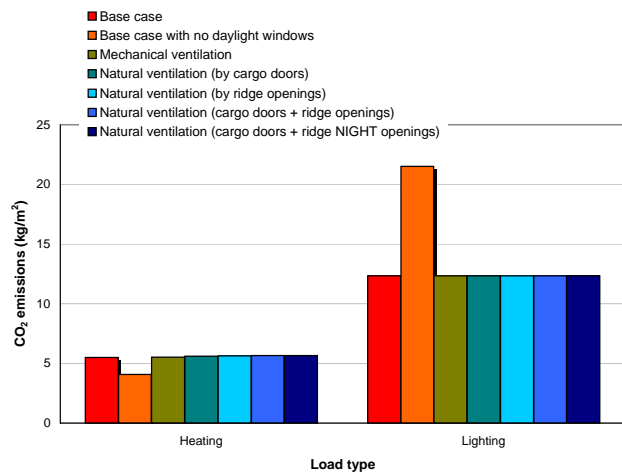
Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Shed floor area= 2280 m2

| Base case | | | | |
|--------------|--------------|------------------|------------------|--|
| Value in kWh | | Lighting electri | 27.906 | |
| Month | Heating | Solar | Internal (L,O,E) | |
| 1 | 5.12 | 0.97 | 3.92 | |
| 2 | 4.04 | 1.65 | 3.27 | |
| 3 | 2.56 | 2.96 | 3.29 | |
| 4 | 1.67 | 4.49 | 2.87 | |
| 5 | 0.00 | 8.10 | 2.70 | |
| 6 | 0.00 | 7.33 | 2.47 | |
| 7 | 0.00 | 8.09 | 2.63 | |
| 8 | 0.00 | 6.40 | 2.86 | |
| 9 | 0.00 | 3.85 | 3.07 | |
| 10 | 0.12 | 2.25 | 3.51 | |
| 11 | 4.31 | 1.31 | 3.70 | |
| 12 | 4.88 | 0.67 | 4.05 | |
| Total | 22.69 | 48.09 | 38.33 | |



| Base case with no daylight windows | | | | |
|------------------------------------|--------------|------------------|------------------|--|
| Value in kWh | | Lighting electri | 48.656 | |
| Month | Heating | Solar | Internal (L,O,E) | |
| 1 | 3.47 | 0.00 | 5.02 | |
| 2 | 2.96 | 0.00 | 4.53 | |
| 3 | 2.02 | 0.00 | 5.02 | |
| 4 | 2.08 | 0.00 | 4.86 | |
| 5 | 0.01 | 0.00 | 5.02 | |
| 6 | 0.01 | 0.00 | 4.86 | |
| 7 | 0.00 | 0.00 | 5.02 | |
| 8 | 0.00 | 0.00 | 5.02 | |
| 9 | 0.00 | 0.00 | 4.86 | |
| 10 | 0.07 | 0.00 | 5.02 | |
| 11 | 3.01 | 0.00 | 4.86 | |
| 12 | 3.21 | 0.00 | 5.02 | |
| Total | 16.85 | 0.00 | 59.08 | |



| Mechanical ventilation | | | | |
|------------------------|--------------|------------------|------------------|--|
| Value in kWh | | Lighting electri | 27.906 | |
| Month | Heating | Solar | Internal (L,O,E) | |
| 1 | 5.12 | 0.97 | 3.92 | |
| 2 | 4.04 | 1.65 | 3.27 | |
| 3 | 2.56 | 2.96 | 3.29 | |
| 4 | 1.67 | 4.49 | 2.87 | |
| 5 | 0.00 | 8.10 | 2.70 | |
| 6 | 0.00 | 7.33 | 2.47 | |
| 7 | 0.00 | 8.09 | 2.63 | |
| 8 | 0.00 | 6.40 | 2.86 | |
| 9 | 0.04 | 3.85 | 3.07 | |
| 10 | 0.16 | 2.25 | 3.51 | |
| 11 | 4.32 | 1.31 | 3.70 | |
| 12 | 4.88 | 0.67 | 4.05 | |
| Total | 22.79 | 48.09 | 38.33 | |

| Natural ventilation (by cargo doors) | | | | |
|--------------------------------------|--------------|------------------|------------------|--|
| Value in kWh | | Lighting electri | 27.906 | |
| Month | Heating | Solar | Internal (L,O,E) | |
| 1 | 5.12 | 0.97 | 3.92 | |
| 2 | 4.04 | 1.65 | 3.27 | |
| 3 | 2.59 | 2.96 | 3.29 | |
| 4 | 1.83 | 4.49 | 2.87 | |
| 5 | 0.01 | 8.10 | 2.70 | |
| 6 | 0.00 | 7.33 | 2.47 | |
| 7 | 0.00 | 8.09 | 2.63 | |
| 8 | 0.00 | 6.40 | 2.86 | |
| 9 | 0.01 | 3.85 | 3.07 | |
| 10 | 0.27 | 2.25 | 3.51 | |
| 11 | 4.34 | 1.31 | 3.70 | |
| 12 | 4.88 | 0.67 | 4.05 | |
| Total | 23.09 | 48.09 | 38.33 | |

Natural ventilation (by ridge openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 27.906 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 5.12 | 0.97 | | | 3.92 |
| 2 | 4.05 | 1.65 | | | 3.27 |
| 3 | 2.61 | 2.96 | | | 3.29 |
| 4 | 1.92 | 4.49 | | | 2.87 |
| 5 | 0.01 | 8.10 | | | 2.70 |
| 6 | 0.01 | 7.33 | | | 2.47 |
| 7 | 0.00 | 8.09 | | | 2.63 |
| 8 | 0.00 | 6.40 | | | 2.86 |
| 9 | 0.00 | 3.85 | | | 3.07 |
| 10 | 0.26 | 2.25 | | | 3.51 |
| 11 | 4.34 | 1.31 | | | 3.70 |
| 12 | 4.88 | 0.67 | | | 4.05 |
| Total | 23.19 | 48.09 | | | 38.33 |

Natural ventilation (cargo doors + ridge openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 27.906 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 5.12 | 0.97 | | | 3.92 |
| 2 | 4.05 | 1.65 | | | 3.27 |
| 3 | 2.62 | 2.96 | | | 3.29 |
| 4 | 1.96 | 4.49 | | | 2.87 |
| 5 | 0.01 | 8.10 | | | 2.70 |
| 6 | 0.02 | 7.33 | | | 2.47 |
| 7 | 0.00 | 8.09 | | | 2.63 |
| 8 | 0.00 | 6.40 | | | 2.86 |
| 9 | 0.01 | 3.85 | | | 3.07 |
| 10 | 0.30 | 2.25 | | | 3.51 |
| 11 | 4.35 | 1.31 | | | 3.70 |
| 12 | 4.88 | 0.67 | | | 4.05 |
| Total | 23.32 | 48.09 | | | 38.33 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| Month | Heating | Solar | Lighting electri | Internal (L,O,E) | 27.906 |
|--------------|--------------|--------------|------------------|------------------|--------------|
| 1 | 5.12 | 0.97 | | | 3.92 |
| 2 | 4.05 | 1.65 | | | 3.27 |
| 3 | 2.62 | 2.96 | | | 3.29 |
| 4 | 1.96 | 4.49 | | | 2.87 |
| 5 | 0.01 | 8.10 | | | 2.70 |
| 6 | 0.02 | 7.33 | | | 2.47 |
| 7 | 0.00 | 8.09 | | | 2.63 |
| 8 | 0.00 | 6.40 | | | 2.86 |
| 9 | 0.01 | 3.85 | | | 3.07 |
| 10 | 0.31 | 2.25 | | | 3.51 |
| 11 | 4.35 | 1.31 | | | 3.70 |
| 12 | 4.88 | 0.67 | | | 4.05 |
| Total | 23.33 | 48.09 | | | 38.33 |

Loads summary kWh/m2

| | Heating | Solar | Internal | Lighting |
|-----------------|---------|-------|----------|----------|
| Base case | 22.69 | 48.09 | 38.33 | 27.91 |
| Base case wit | 16.85 | 0.00 | 59.08 | 48.66 |
| Mechanical ve | 22.79 | 48.09 | 38.33 | 27.91 |
| Natural ventile | 23.09 | 48.09 | 38.33 | 27.91 |
| Natural ventile | 23.19 | 48.09 | 38.33 | 27.91 |
| Natural ventile | 23.32 | 48.09 | 38.33 | 27.91 |
| Natural ventile | 23.33 | 48.09 | 38.33 | 27.91 |

CO2 emissions kg/m2

| | Heating | Solar | Internal | Lighting |
|-----------------|---------|-------|----------|----------|
| Base case | 5.50 | 21.26 | 16.94 | 12.33 |
| Base case wit | 4.09 | 0.00 | 26.11 | 21.51 |
| Mechanical ve | 5.53 | 21.26 | 16.94 | 12.33 |
| Natural ventile | 5.60 | 21.26 | 16.94 | 12.33 |
| Natural ventile | 5.62 | 21.26 | 16.94 | 12.33 |
| Natural ventile | 5.65 | 21.26 | 16.94 | 12.33 |
| Natural ventile | 5.66 | 21.26 | 16.94 | 12.33 |

Base case

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 4407 | 3831 | 3636 | 3440 | 3114 | 2720 | 2393 | 2029 | 1641 | 1246 | 870 | 571 | 352 | 203 | 103 | 44 |

Base case without daylight

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|------|-----|-----|----|----|----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 3940 | 3291 | 2977 | 2392 | 1672 | 1027 | 495 | 211 | 83 | 35 | 0 | 0 | 0 | 0 | 0 | 0 |

Mechanical ventilation

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 3284 | 2440 | 2048 | 1626 | 1227 | 896 | 664 | 471 | 327 | 208 | 113 | 50 | 22 | 10 | 1 | 0 |

Natural ventilation (by cargo doors)

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 4022 | 2670 | 1602 | 1075 | 791 | 544 | 353 | 207 | 112 | 61 | 31 | 11 | 3 | 0 | 0 | 0 |

Natural ventilation (by ridge openings)

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 4075 | 3180 | 2304 | 1749 | 1292 | 938 | 618 | 417 | 227 | 123 | 60 | 35 | 15 | 2 | 0 | 0 |

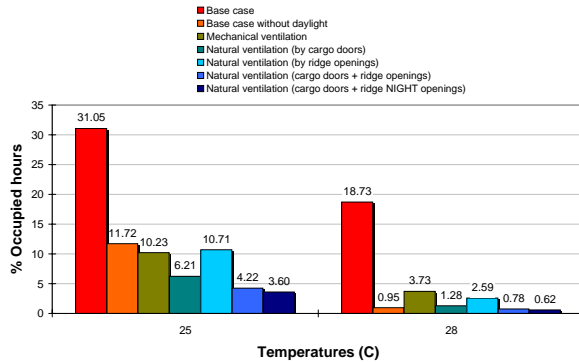
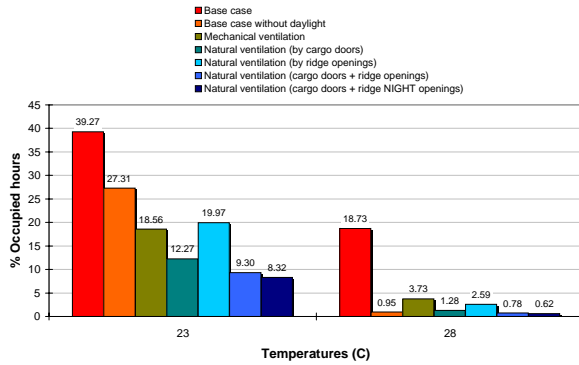
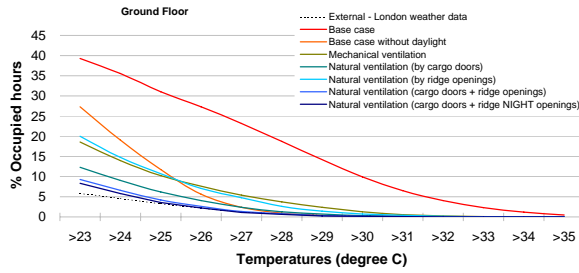
Natural ventilation (cargo doors + ridge openings)

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 3990 | 2243 | 1173 | 815 | 574 | 370 | 228 | 121 | 68 | 30 | 11 | 4 | 0 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| | | | | | | | | | | | | | | | | | |
|---|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|---|
| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Group | 8760 | 3374 | 1878 | 1047 | 729 | 508 | 315 | 193 | 100 | 54 | 23 | 11 | 4 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 | 0.00 |
| Base case | 50.31 | 43.73 | 41.51 | 39.27 | 35.55 | 31.05 | 27.32 | 23.16 | 18.73 | 14.22 | 9.93 | 6.52 | 4.02 | 2.32 | 1.18 | 0.50 | 0.00 |
| Base case + | 44.98 | 37.57 | 33.98 | 27.31 | 19.09 | 11.72 | 5.65 | 2.41 | 0.95 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mechanical | 37.49 | 27.85 | 23.38 | 16.56 | 14.01 | 10.23 | 7.58 | 5.38 | 3.73 | 2.37 | 1.29 | 0.57 | 0.25 | 0.11 | 0.01 | 0.00 | 0.00 |
| Natural ven | 45.91 | 30.48 | 18.29 | 12.27 | 9.03 | 6.21 | 4.03 | 2.36 | 1.28 | 0.70 | 0.35 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 46.52 | 36.30 | 26.30 | 19.97 | 14.75 | 10.71 | 7.05 | 4.76 | 2.59 | 1.40 | 0.68 | 0.40 | 0.17 | 0.02 | 0.00 | 0.00 | 0.00 |
| Natural ven | 44.41 | 25.61 | 13.39 | 9.30 | 6.55 | 4.22 | 2.60 | 1.38 | 0.78 | 0.34 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 38.52 | 21.44 | 11.95 | 8.32 | 5.80 | 3.60 | 2.20 | 1.14 | 0.62 | 0.26 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |



Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 4407 | 3831 | 3636 | 3440 | 3114 | 2720 | 2393 | 2029 | 1641 | 1246 | 870 | 571 | 352 | 203 | 103 |

Mechanical ventilation

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3284 | 2440 | 2048 | 1626 | 1227 | 896 | 664 | 471 | 327 | 208 | 113 | 50 | 22 | 10 | 1 |

Natural ventilation (by cargo doors)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 4022 | 2670 | 1602 | 1075 | 791 | 544 | 353 | 207 | 112 | 61 | 31 | 11 | 3 | 0 | 0 |

Natural ventilation (by ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 4075 | 3180 | 2304 | 1749 | 1292 | 938 | 618 | 417 | 227 | 123 | 60 | 35 | 15 | 2 | 0 |

Natural ventilation (cargo doors + ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

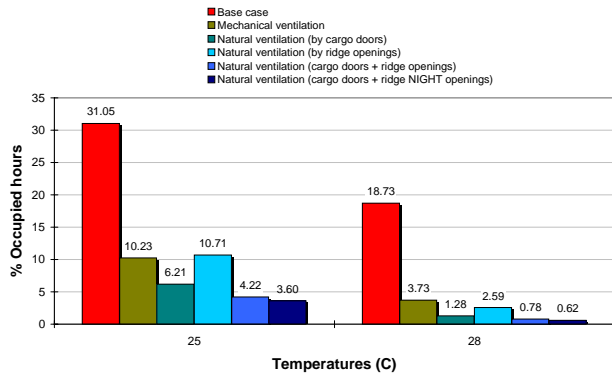
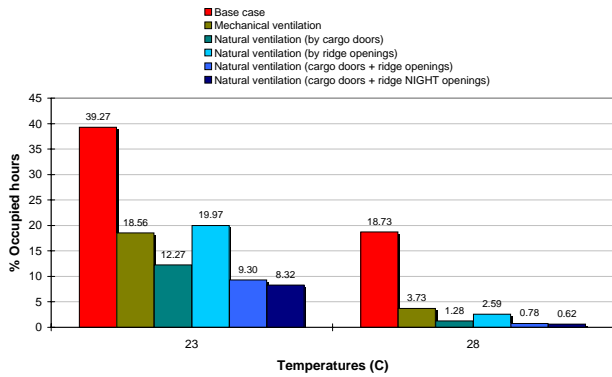
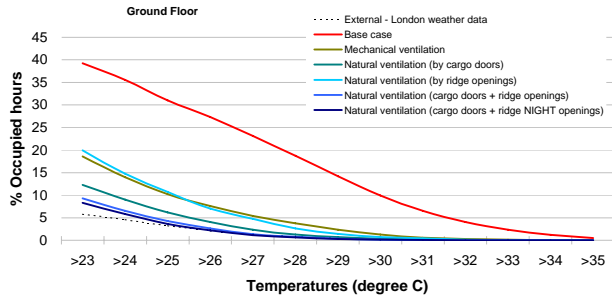
| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3890 | 2243 | 1173 | 815 | 574 | 370 | 228 | 121 | 68 | 30 | 11 | 4 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Group | 8760 | 3374 | 1878 | 1047 | 729 | 508 | 315 | 193 | 100 | 54 | 23 | 11 | 4 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|
| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 50.31 | 43.73 | 41.51 | 39.27 | 35.55 | 31.05 | 27.32 | 23.16 | 18.73 | 14.22 | 9.93 | 6.52 | 4.02 | 2.32 | 1.18 | 0.50 |
| Mechanical | 37.49 | 27.85 | 23.38 | 18.56 | 14.01 | 10.23 | 7.58 | 5.38 | 3.73 | 2.37 | 1.29 | 0.57 | 0.25 | 0.11 | 0.01 | 0.00 |
| Natural ven | 45.91 | 30.48 | 18.29 | 12.27 | 9.03 | 6.21 | 4.03 | 2.36 | 1.28 | 0.70 | 0.35 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 |
| Natural ven | 46.52 | 36.30 | 26.30 | 19.97 | 14.75 | 10.71 | 7.05 | 4.76 | 2.59 | 1.40 | 0.68 | 0.40 | 0.17 | 0.02 | 0.00 | 0.00 |
| Natural ven | 44.41 | 25.61 | 13.39 | 9.30 | 6.55 | 4.22 | 2.60 | 1.38 | 0.78 | 0.34 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural ven | 38.52 | 21.44 | 11.95 | 8.32 | 5.80 | 3.60 | 2.20 | 1.14 | 0.62 | 0.26 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |



Base case

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 4381 | 3847 | 3647 | 3408 | 3086 | 2696 | 2380 | 2015 | 1639 | 1247 | 907 | 608 | 420 | 245 | 148 | 74 |

Base case without daylight

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|------|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3916 | 3294 | 2940 | 2400 | 1682 | 1072 | 567 | 274 | 99 | 40 | 14 | 0 | 0 | 0 | 0 | 0 |

Mechanical ventilation

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3273 | 2481 | 2087 | 1666 | 1292 | 967 | 722 | 520 | 359 | 243 | 163 | 70 | 39 | 15 | 8 | 1 |

Natural ventilation (by cargo doors)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3935 | 2616 | 1752 | 1213 | 916 | 674 | 491 | 311 | 191 | 112 | 62 | 33 | 14 | 5 | 0 | 0 |

Natural ventilation (by ridge openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 4043 | 3020 | 2178 | 1673 | 1268 | 956 | 689 | 470 | 284 | 162 | 89 | 49 | 27 | 12 | 2 | 0 |

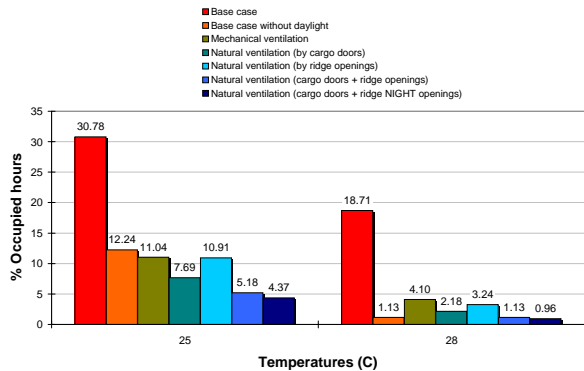
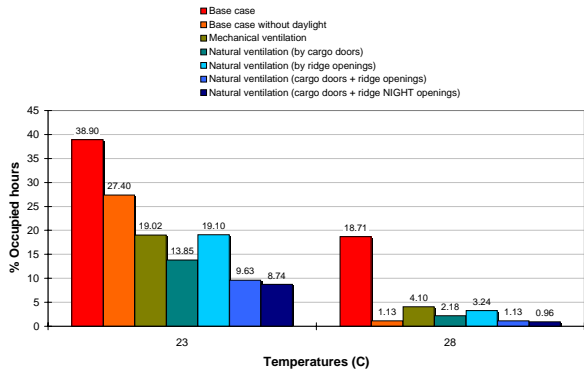
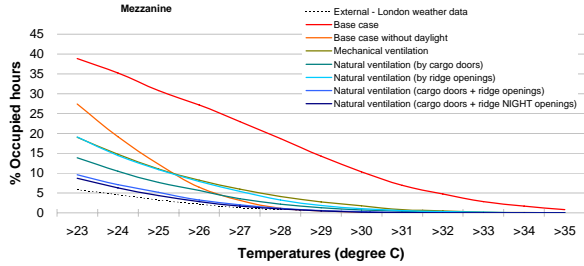
Natural ventilation (cargo doors + ridge openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3788 | 2089 | 1204 | 844 | 620 | 454 | 285 | 180 | 99 | 52 | 26 | 10 | 3 | 0 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

| Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365 | | | | | | | | | | | | | | | | | |
|---|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzzz | 8760 | 3233 | 1799 | 1085 | 766 | 548 | 383 | 244 | 146 | 84 | 42 | 17 | 8 | 3 | 0 | 0 | 0 |

| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|
| External - Lr | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 50.01 | 43.92 | 41.63 | 38.90 | 35.23 | 30.78 | 27.17 | 23.00 | 18.71 | 14.24 | 10.35 | 6.94 | 4.79 | 2.80 | 1.69 | 0.84 |
| Base case v | 44.70 | 37.50 | 33.56 | 27.40 | 19.20 | 12.24 | 6.47 | 3.13 | 1.13 | 0.46 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mechanical | 37.36 | 28.32 | 23.82 | 19.02 | 14.76 | 11.04 | 8.24 | 5.84 | 4.10 | 2.77 | 1.75 | 0.80 | 0.45 | 0.17 | 0.09 | 0.01 |
| Natural vent | 44.92 | 29.86 | 20.00 | 13.85 | 10.46 | 7.69 | 5.61 | 3.55 | 2.18 | 1.28 | 0.71 | 0.38 | 0.16 | 0.06 | 0.00 | 0.00 |
| Natural vent | 46.15 | 34.47 | 24.86 | 19.10 | 14.47 | 10.91 | 7.87 | 5.37 | 3.24 | 1.85 | 1.02 | 0.56 | 0.31 | 0.14 | 0.02 | 0.00 |
| Natural vent | 43.24 | 23.85 | 13.74 | 9.63 | 7.08 | 5.18 | 3.25 | 2.05 | 1.13 | 0.59 | 0.30 | 0.11 | 0.03 | 0.00 | 0.00 | 0.00 |
| Natural vent | 36.91 | 20.54 | 12.39 | 8.74 | 6.26 | 4.37 | 2.79 | 1.67 | 0.96 | 0.48 | 0.19 | 0.09 | 0.03 | 0.00 | 0.00 | 0.00 |



Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 4381 | 3847 | 3647 | 3408 | 3086 | 2696 | 2380 | 2015 | 1639 | 1247 | 907 | 608 | 420 | 245 | 148 |

Mechanical ventilation

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3273 | 2481 | 2087 | 1666 | 1292 | 967 | 722 | 520 | 359 | 243 | 153 | 70 | 39 | 15 | 8 |

Natural ventilation (by cargo doors)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3935 | 2616 | 1752 | 1213 | 916 | 674 | 491 | 311 | 191 | 112 | 62 | 33 | 14 | 5 | 0 |

Natural ventilation (by ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 4043 | 3020 | 2178 | 1673 | 1268 | 956 | 689 | 470 | 284 | 162 | 89 | 49 | 27 | 12 | 2 |

Natural ventilation (cargo doors + ridge openings)

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

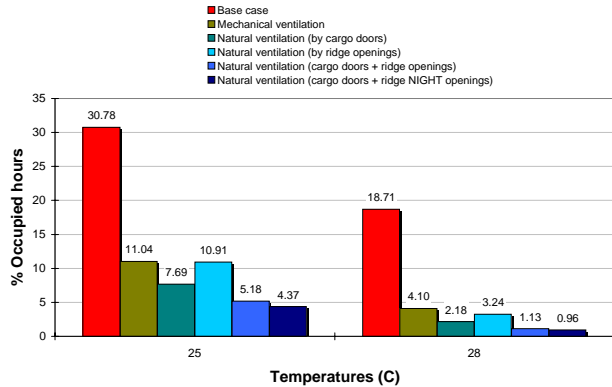
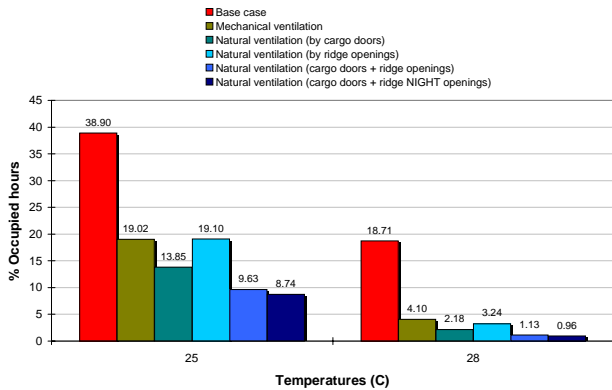
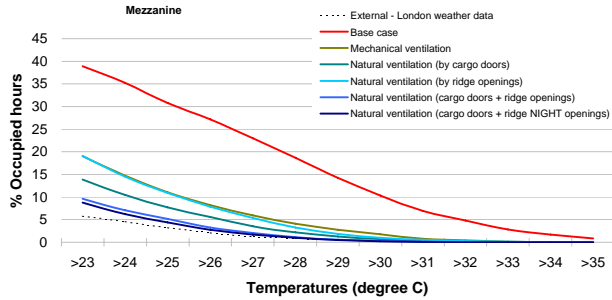
| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3788 | 2089 | 1204 | 844 | 620 | 454 | 285 | 180 | 99 | 52 | 26 | 10 | 3 | 0 | 0 |

Natural ventilation (cargo doors + ridge NIGHT openings)

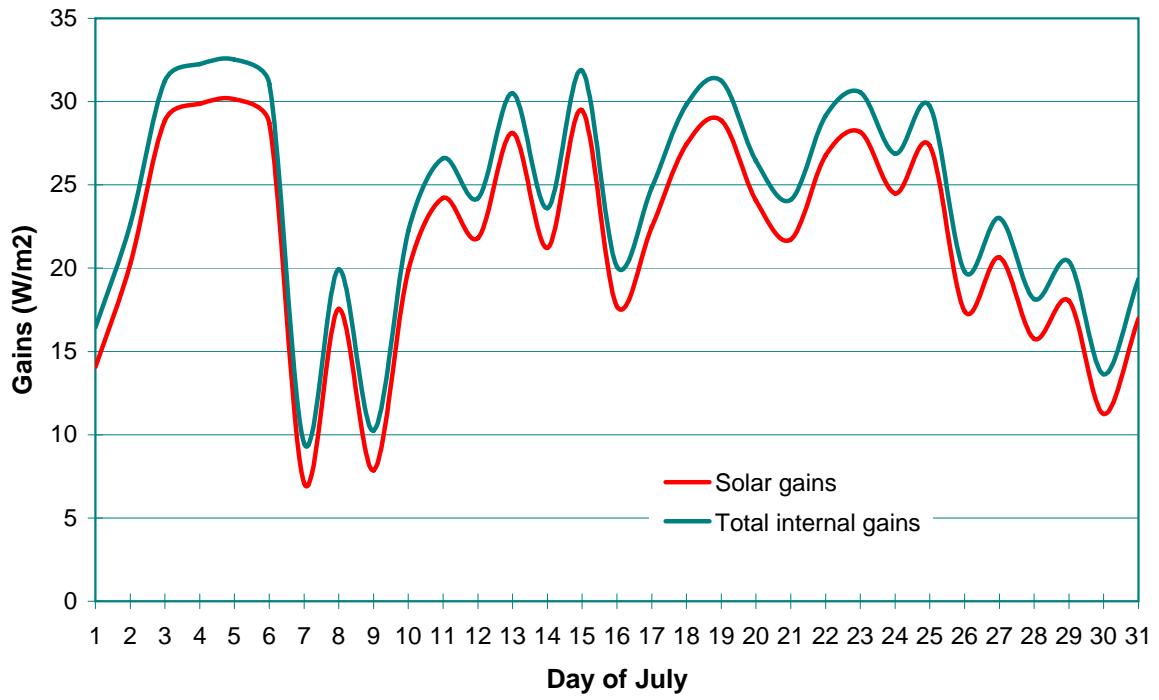
Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| | | | | | | | | | | | | | | | | |
|----------------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| Band (C) Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| External - L | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 |
| Shed Mezz | 8760 | 3233 | 1799 | 1085 | 766 | 548 | 383 | 244 | 146 | 84 | 42 | 17 | 8 | 3 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|
| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
| External - L | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| Base case | 50.01 | 43.92 | 41.63 | 38.90 | 35.23 | 30.78 | 27.17 | 23.00 | 18.71 | 14.24 | 10.35 | 6.94 | 4.79 | 2.80 | 1.69 | 0.84 |
| Mechanical | 37.36 | 28.32 | 23.82 | 19.02 | 14.75 | 11.04 | 8.24 | 5.94 | 4.10 | 2.77 | 1.75 | 0.80 | 0.45 | 0.17 | 0.09 | 0.01 |
| Natural ven | 44.92 | 29.86 | 20.00 | 13.85 | 10.46 | 7.69 | 5.61 | 3.55 | 2.18 | 1.28 | 0.71 | 0.38 | 0.16 | 0.06 | 0.00 | 0.00 |
| Natural ven | 46.15 | 34.47 | 24.96 | 19.10 | 14.47 | 10.91 | 7.97 | 5.37 | 3.24 | 1.85 | 1.02 | 0.56 | 0.31 | 0.14 | 0.02 | 0.00 |
| Natural ven | 43.24 | 23.85 | 13.74 | 9.63 | 7.08 | 5.18 | 3.25 | 2.05 | 1.13 | 0.59 | 0.30 | 0.11 | 0.03 | 0.00 | 0.00 | 0.00 |
| Natural ven | 36.91 | 20.54 | 12.39 | 8.74 | 6.26 | 4.37 | 2.79 | 1.67 | 0.96 | 0.48 | 0.19 | 0.09 | 0.03 | 0.00 | 0.00 | 0.00 |

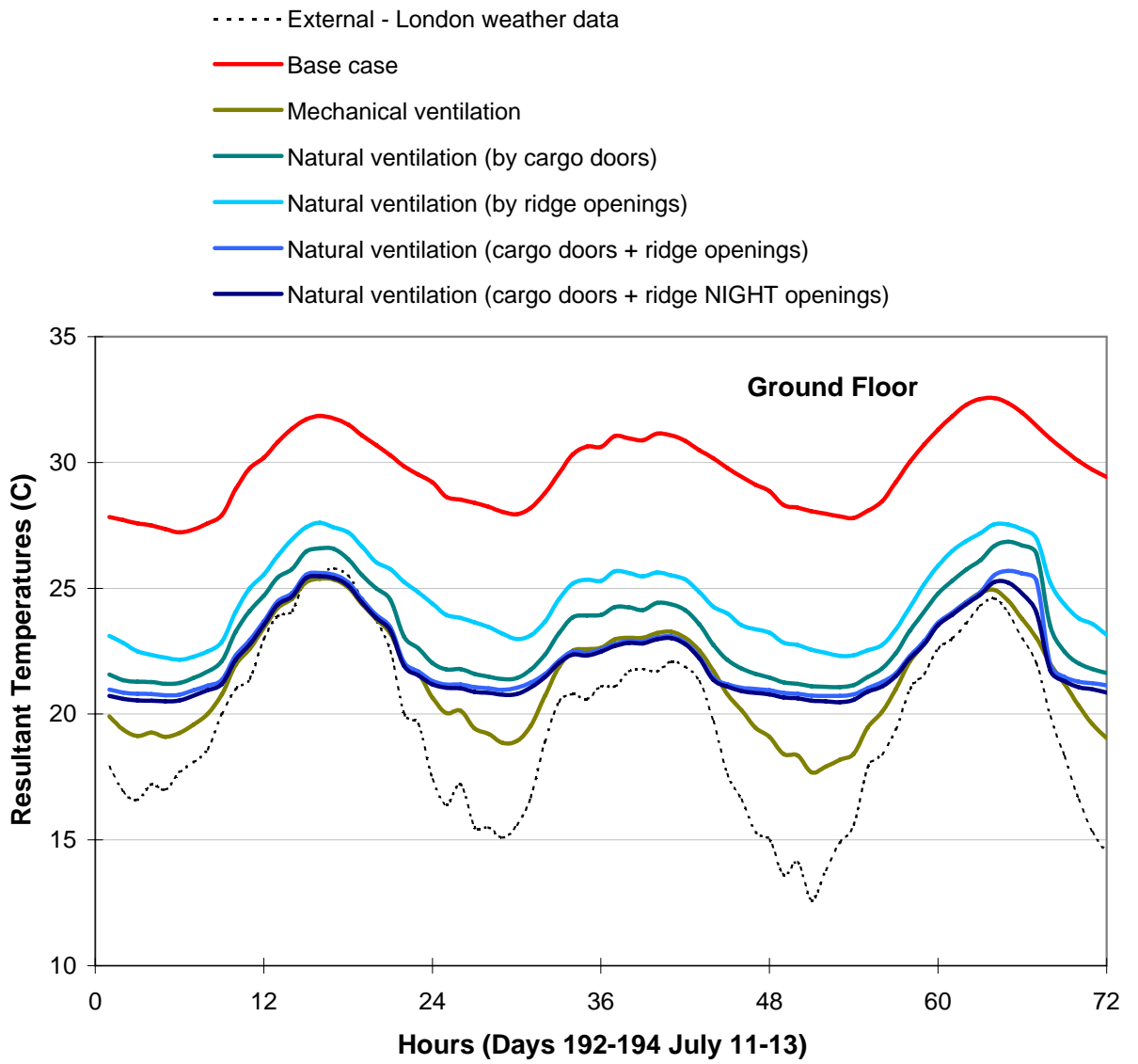


14% Grey thermal results.xls

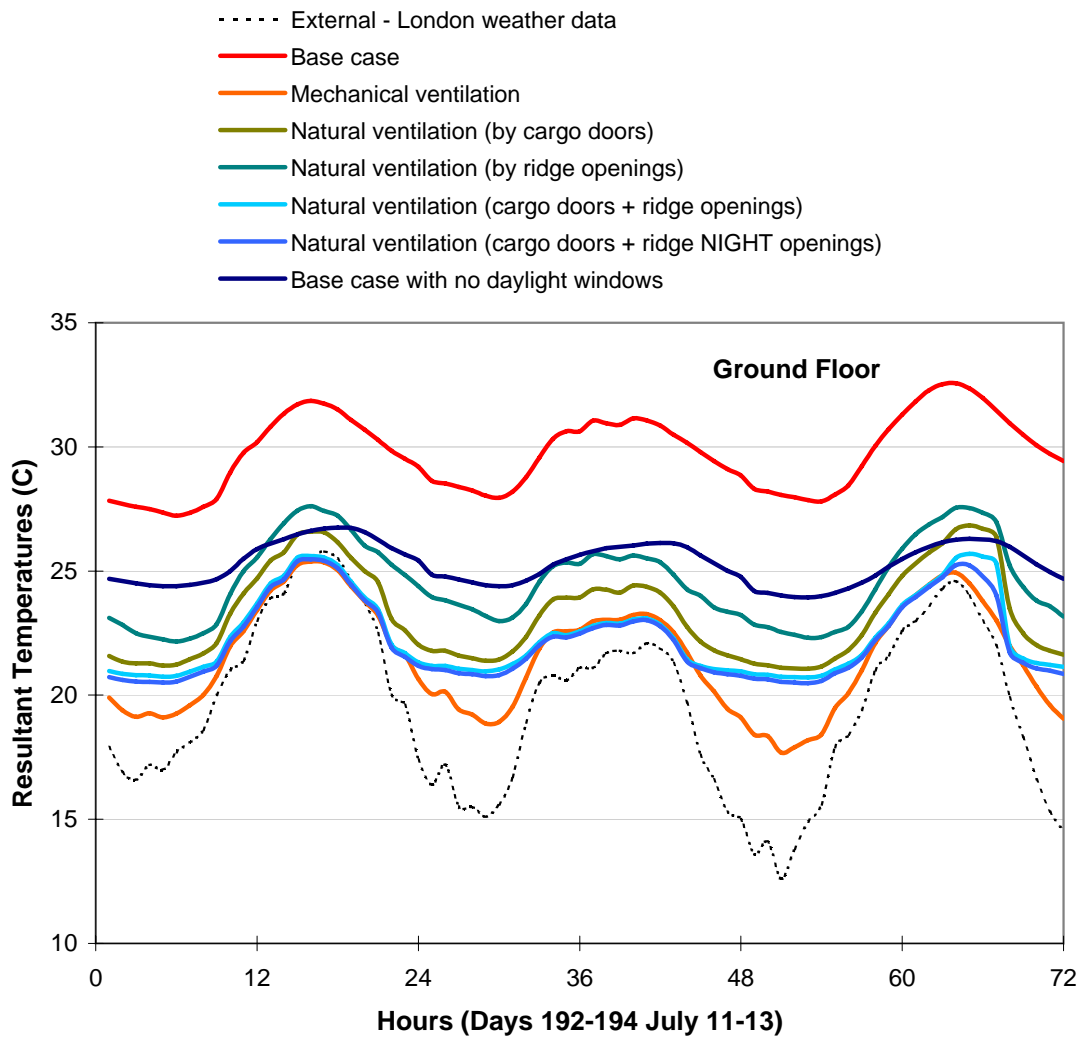


Solar Gains in July (7-17h)

14% Grey thermal results.xls



14% Grey thermal results.xls



10% Base case

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|----------|------------------|
| 1 | 10850.15 | 1568.14 | 9392.38 |
| 2 | 8961.61 | 2678.95 | 7783.01 |
| 3 | 6127.00 | 4806.03 | 7794.03 |
| 4 | 4838.49 | 7283.20 | 6821.25 |
| 5 | 18.96 | 13153.88 | 6446.94 |
| 6 | 0.00 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 0.00 | 6245.05 | 7248.68 |
| 10 | 427.54 | 3638.99 | 8269.09 |
| 11 | 9329.07 | 2114.36 | 8870.12 |
| 12 | 10132.26 | 1078.42 | 9761.11 |
| Total | 50685.07 | 78030.45 | 91355.38 |
| Peak | 43.99 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

14% Base case

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-----------|------------------|
| 1 | 11662.80 | 2212.72 | 8928.51 |
| 2 | 9213.82 | 3767.13 | 7461.43 |
| 3 | 5830.31 | 6756.79 | 7493.34 |
| 4 | 3810.10 | 10240.99 | 6554.76 |
| 5 | 0.00 | 18465.93 | 6164.40 |
| 6 | 0.00 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 0.00 | 8781.80 | 6988.91 |
| 10 | 264.61 | 5120.08 | 7991.47 |
| 11 | 9835.13 | 2984.71 | 8436.70 |
| 12 | 11116.60 | 1529.96 | 9223.68 |
| Total | 51733.36 | 109641.38 | 87397.04 |
| Peak | 46.32 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

10% with cargo doors open

Value in kWh

| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|----------|------------------|
| 1 | 10856.48 | 1568.14 | 9392.38 |
| 2 | 8966.30 | 2678.95 | 7783.01 |
| 3 | 6169.56 | 4806.03 | 7794.03 |
| 4 | 4993.74 | 7283.20 | 6821.25 |
| 5 | 25.88 | 13153.88 | 6446.94 |
| 6 | 35.52 | 11911.41 | 5901.03 |
| 7 | 0.00 | 13154.08 | 6275.40 |
| 8 | 0.00 | 10397.97 | 6792.32 |
| 9 | 15.83 | 6245.05 | 7248.68 |
| 10 | 722.32 | 3638.99 | 8269.09 |
| 11 | 9374.88 | 2114.36 | 8870.12 |
| 12 | 10140.75 | 1078.42 | 9761.11 |
| Total | 51301.27 | 78030.45 | 91355.38 |
| Peak | 44.01 | 65.39 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

14% with cargo doors open

Value in kWh

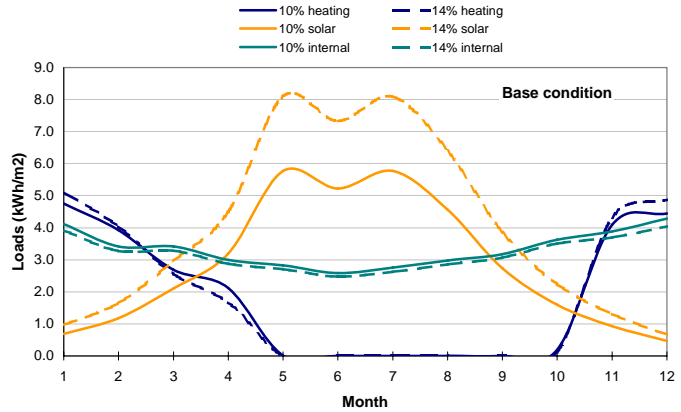
| Month | Heating | Solar | Internal (L,O,E) |
|-------|----------|-----------|------------------|
| 1 | 11668.48 | 2212.72 | 8928.51 |
| 2 | 9218.60 | 3767.13 | 7461.43 |
| 3 | 5898.78 | 6756.79 | 7493.34 |
| 4 | 4172.31 | 10240.99 | 6554.76 |
| 5 | 13.40 | 18465.93 | 6164.40 |
| 6 | 8.88 | 16723.07 | 5639.06 |
| 7 | 0.00 | 18456.22 | 5993.90 |
| 8 | 0.00 | 14602.03 | 6520.90 |
| 9 | 14.26 | 8781.80 | 6988.91 |
| 10 | 612.22 | 5120.08 | 7991.47 |
| 11 | 9901.93 | 2984.71 | 8436.70 |
| 12 | 11125.59 | 1529.96 | 9223.68 |
| Total | 52634.47 | 109641.38 | 87397.04 |
| Peak | 46.34 | 91.46 | 15.42 |
| Day | 330 | 171 | 1 |
| Hour | 6 | 13 | 1 |

Heating Peaks Solar Peaks or Internal (L,O,E) Peaks on Day 1, Hour 1

Shed floor area= 2280 m2

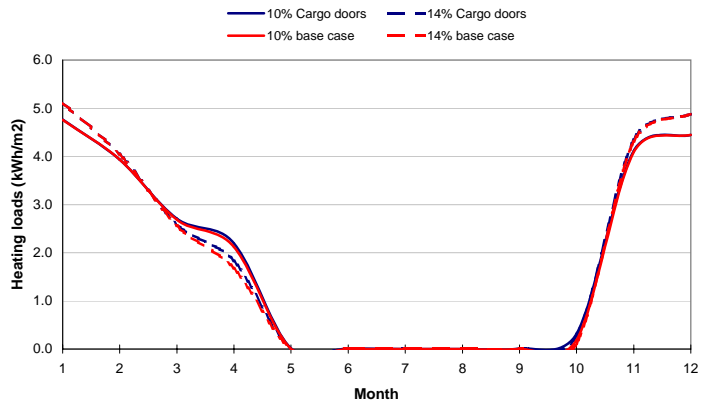
10% Base case

| Month | Heating | Lighting | electrici | 29,642 |
|--------------|--------------|--------------|------------------|--------|
| | | Solar | Internal (L,O,E) | |
| 1 | 4.76 | 0.69 | 4.12 | |
| 2 | 3.93 | 1.17 | 3.41 | |
| 3 | 2.69 | 2.11 | 3.42 | |
| 4 | 2.12 | 3.19 | 2.99 | |
| 5 | 0.01 | 5.77 | 2.83 | |
| 6 | 0.00 | 5.22 | 2.59 | |
| 7 | 0.00 | 5.77 | 2.75 | |
| 8 | 0.00 | 4.56 | 2.98 | |
| 9 | 0.00 | 2.74 | 3.18 | |
| 10 | 0.19 | 1.60 | 3.63 | |
| 11 | 4.09 | 0.93 | 3.89 | |
| 12 | 4.44 | 0.47 | 4.28 | |
| Total | 22.23 | 34.22 | 40.07 | |



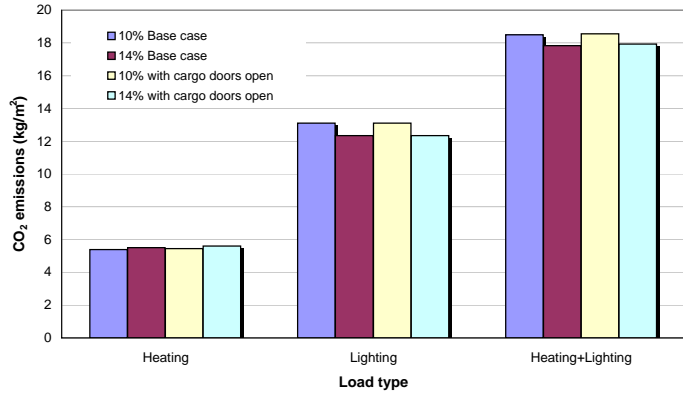
14% Base case

| Month | Heating | Lighting | electrici | 27,906 |
|--------------|--------------|--------------|------------------|--------|
| | | Solar | Internal (L,O,E) | |
| 1 | 5.12 | 0.97 | 3.92 | |
| 2 | 4.04 | 1.65 | 3.27 | |
| 3 | 2.56 | 2.96 | 3.29 | |
| 4 | 1.67 | 4.49 | 2.87 | |
| 5 | 0.00 | 8.10 | 2.70 | |
| 6 | 0.00 | 7.33 | 2.47 | |
| 7 | 0.00 | 8.09 | 2.63 | |
| 8 | 0.00 | 6.40 | 2.86 | |
| 9 | 0.00 | 3.85 | 3.07 | |
| 10 | 0.12 | 2.25 | 3.51 | |
| 11 | 4.31 | 1.31 | 3.70 | |
| 12 | 4.88 | 0.67 | 4.05 | |
| Total | 22.69 | 48.09 | 38.33 | |



10% with cargo doors open

| Month | Heating | Lighting | electrici | 29,642 |
|--------------|--------------|--------------|------------------|--------|
| | | Solar | Internal (L,O,E) | |
| 1 | 4.76 | 0.69 | 4.12 | |
| 2 | 3.93 | 1.17 | 3.41 | |
| 3 | 2.71 | 2.11 | 3.42 | |
| 4 | 2.19 | 3.19 | 2.99 | |
| 5 | 0.01 | 5.77 | 2.83 | |
| 6 | 0.02 | 5.22 | 2.59 | |
| 7 | 0.00 | 5.77 | 2.75 | |
| 8 | 0.00 | 4.56 | 2.98 | |
| 9 | 0.01 | 2.74 | 3.18 | |
| 10 | 0.32 | 1.60 | 3.63 | |
| 11 | 4.11 | 0.93 | 3.89 | |
| 12 | 4.45 | 0.47 | 4.28 | |
| Total | 22.50 | 34.22 | 40.07 | |



14% with cargo doors open

| Month | Heating | Lighting | electrici | 27,906 |
|--------------|--------------|--------------|------------------|--------|
| | | Solar | Internal (L,O,E) | |
| 1 | 5.12 | 0.97 | 3.92 | |
| 2 | 4.04 | 1.65 | 3.27 | |
| 3 | 2.59 | 2.96 | 3.29 | |
| 4 | 1.83 | 4.49 | 2.87 | |
| 5 | 0.01 | 8.10 | 2.70 | |
| 6 | 0.00 | 7.33 | 2.47 | |
| 7 | 0.00 | 8.09 | 2.63 | |
| 8 | 0.00 | 6.40 | 2.86 | |
| 9 | 0.01 | 3.85 | 3.07 | |
| 10 | 0.27 | 2.25 | 3.51 | |
| 11 | 4.34 | 1.31 | 3.70 | |
| 12 | 4.88 | 0.67 | 4.05 | |
| Total | 23.09 | 48.09 | 38.33 | |

Loads summary kWh/m2

| | Heating | Solar | Internal | Lighting |
|---------------|---------|-------|----------|----------|
| 10% Base cas | 22.23 | 34.22 | 40.07 | 29.64 |
| 14% Base cas | 22.69 | 48.09 | 38.33 | 27.91 |
| 10% with carg | 22.50 | 34.22 | 40.07 | 29.64 |
| 14% with carg | 23.09 | 48.09 | 38.33 | 27.91 |

CO2 emissions kg/m2

| | Heating | Solar | Internal | Lighting | Heating+Lighting |
|---------------|---------|-------|----------|----------|------------------|
| 10% Base cas | 5.39 | 15.13 | 17.71 | 13.10 | 18.49 |
| 14% Base cas | 5.50 | 21.26 | 16.94 | 12.33 | 17.84 |
| 10% with carg | 5.46 | 15.13 | 17.71 | 13.10 | 18.56 |
| 14% with carg | 5.60 | 21.26 | 16.94 | 12.33 | 17.93 |

10% Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Groun | 8760 | 4078 | 3656 | 3427 | 3081 | 2614 | 2226 | 1789 | 1361 | 876 | 552 | 313 | 153 | 69 | 35 | 13 | 0 |

14% Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Groun | 8760 | 4407 | 3831 | 3636 | 3440 | 3114 | 2720 | 2393 | 2029 | 1641 | 1246 | 870 | 571 | 352 | 203 | 103 | 44 |

10% with cargo doors open

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

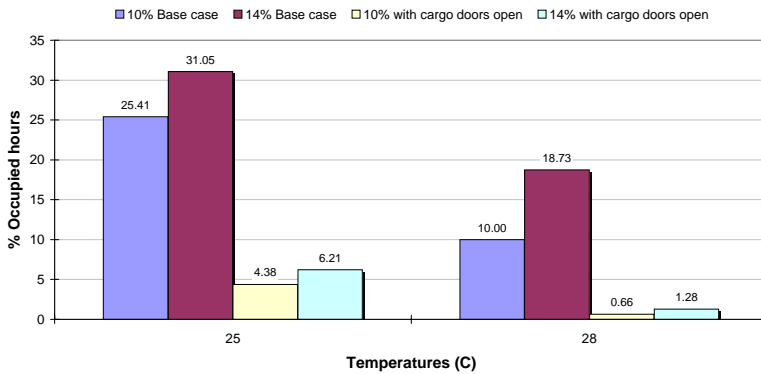
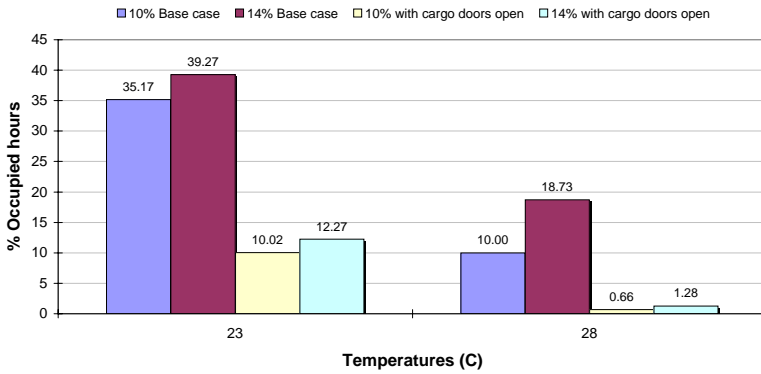
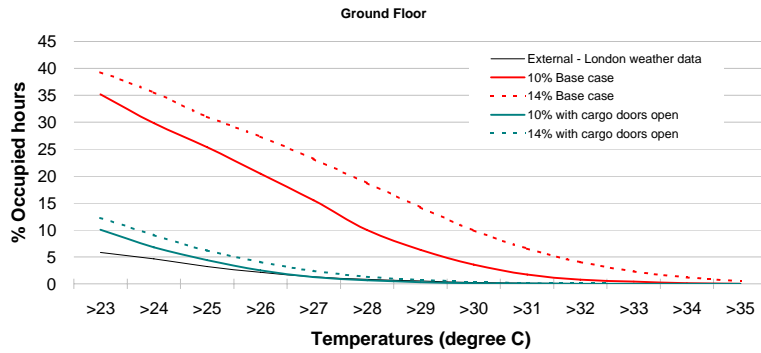
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Groun | 8760 | 3696 | 2258 | 1270 | 878 | 593 | 384 | 218 | 111 | 58 | 28 | 11 | 4 | 0 | 0 | 0 | 0 |

14% with cargo doors open

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Groun | 8760 | 4022 | 2670 | 1602 | 1075 | 791 | 544 | 353 | 207 | 112 | 61 | 31 | 11 | 3 | 0 | 0 | 0 |

| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|
| External - Lr | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| 10% Base c | 46.55 | 41.74 | 39.12 | 35.17 | 29.84 | 25.41 | 20.42 | 15.54 | 10.00 | 6.30 | 3.57 | 1.75 | 0.79 | 0.40 | 0.15 | 0.00 |
| 14% Base c | 50.31 | 43.73 | 41.51 | 39.27 | 35.55 | 31.05 | 27.32 | 23.16 | 18.73 | 14.22 | 9.93 | 6.52 | 4.02 | 2.32 | 1.18 | 0.50 |
| 10% with ca | 42.19 | 25.78 | 14.50 | 10.02 | 6.77 | 4.38 | 2.49 | 1.27 | 0.66 | 0.32 | 0.13 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14% with ca | 45.91 | 30.48 | 18.29 | 12.27 | 9.03 | 6.21 | 4.03 | 2.36 | 1.28 | 0.70 | 0.35 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 |



10% Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzz | 8760 | 4087 | 3646 | 3397 | 3071 | 2610 | 2221 | 1798 | 1367 | 944 | 589 | 378 | 206 | 96 | 46 | 24 | 4 |

14% Base case

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzz | 8760 | 4381 | 3847 | 3647 | 3408 | 3086 | 2696 | 2380 | 2015 | 1639 | 1247 | 907 | 608 | 420 | 245 | 148 | 74 |

10% with cargo doors open

Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

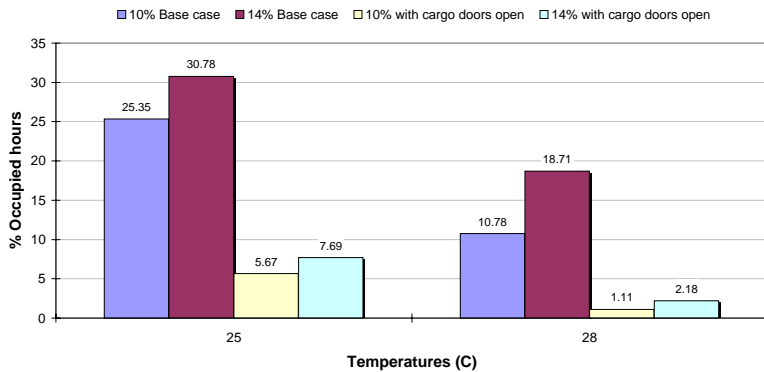
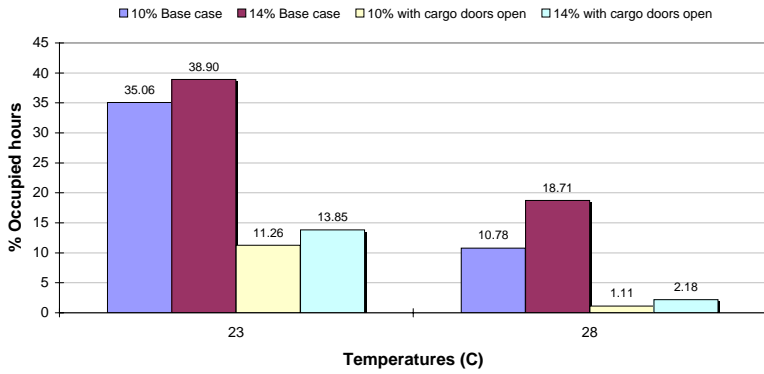
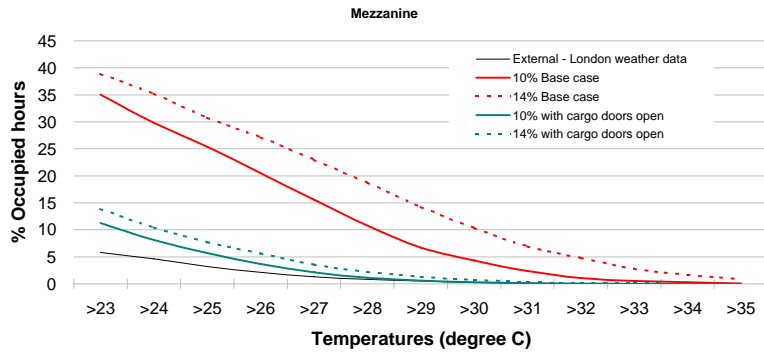
| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzz | 8760 | 3637 | 2268 | 1406 | 986 | 711 | 497 | 322 | 187 | 97 | 54 | 25 | 10 | 4 | 0 | 0 | 0 |

14% with cargo doors open

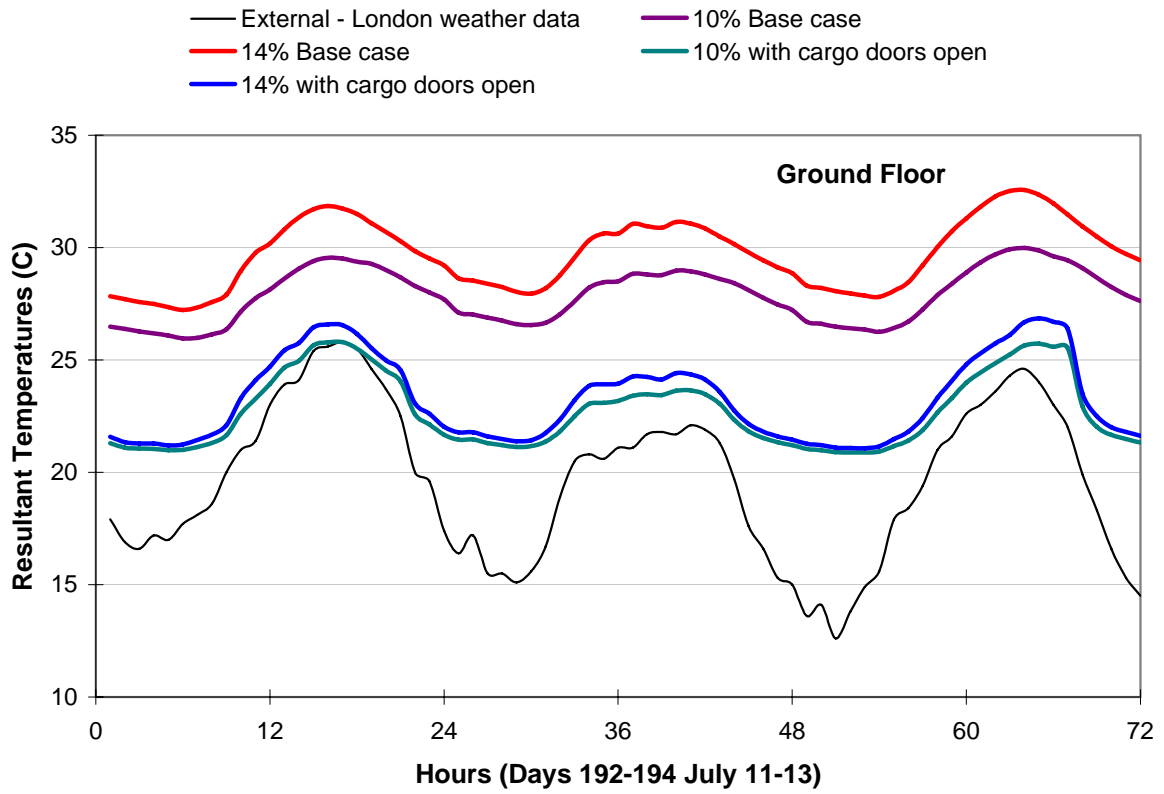
Cumulative Frequency (Hours) of Resultant Temperature for Year, Days 1 to 365

| Band (C) | Total | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---------------|-------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|
| External - Lr | 8760 | 1047 | 840 | 660 | 511 | 405 | 283 | 188 | 112 | 72 | 45 | 22 | 12 | 5 | 3 | 0 | 0 |
| Shed Mezzz | 8760 | 3935 | 2616 | 1752 | 1213 | 916 | 674 | 491 | 311 | 191 | 112 | 62 | 33 | 14 | 5 | 0 | 0 |

| | >20 | >21 | >22 | >23 | >24 | >25 | >26 | >27 | >28 | >29 | >30 | >31 | >32 | >33 | >34 | >35 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|
| External - Lr | 11.95 | 9.59 | 7.53 | 5.83 | 4.62 | 3.23 | 2.15 | 1.28 | 0.82 | 0.51 | 0.25 | 0.14 | 0.06 | 0.03 | 0.00 | 0.00 |
| 10% Base c | 46.66 | 41.62 | 38.78 | 35.06 | 29.79 | 25.35 | 20.53 | 15.61 | 10.78 | 6.72 | 4.32 | 2.35 | 1.10 | 0.53 | 0.27 | 0.05 |
| 14% Base c | 50.01 | 43.92 | 41.63 | 38.90 | 35.23 | 30.78 | 27.17 | 23.00 | 18.71 | 14.24 | 10.35 | 6.94 | 4.79 | 2.80 | 1.69 | 0.84 |
| 10% with ca | 41.52 | 25.89 | 16.05 | 11.26 | 8.12 | 5.67 | 3.68 | 2.13 | 1.11 | 0.62 | 0.29 | 0.11 | 0.05 | 0.00 | 0.00 | 0.00 |
| 14% with ca | 44.92 | 29.86 | 20.00 | 13.85 | 10.46 | 7.69 | 5.61 | 3.55 | 2.18 | 1.28 | 0.71 | 0.38 | 0.16 | 0.06 | 0.00 | 0.00 |



Comparisons between 10% and 14% Grey thermal results.xls



MCRMA

106 Ruskin Avenue
Rogerstone
Newport
Gwent
NP10 0BD

Tel: 01633 895633

Email: info@mcrma.co.uk

Published by:

NARM

National Association of
Rooflight Manufacturers Ltd

Email: info@narm.org.uk

www.narm.org.uk



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