Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions.

ADVANCED VENTILATION TECHNOLOGIES

Case Study No 18

RED KITE HOUSE
WALLINGFORD, UNITED KINGDOM

SUPPORTED BY

Intelligent Energy Europe

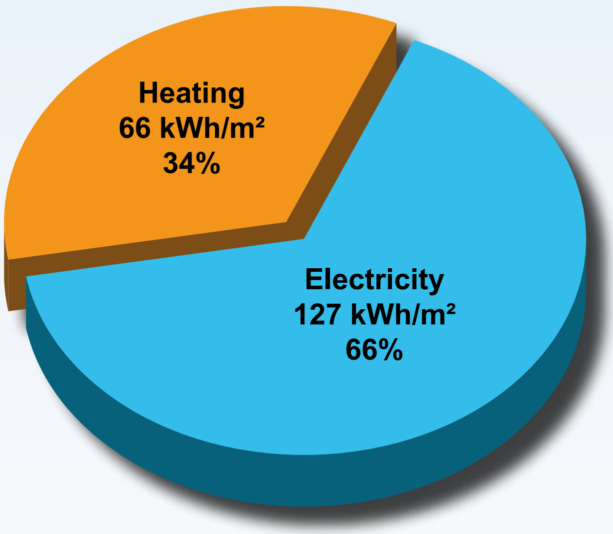
INTRODUCTION

Red Kite House is situated in rural surroundings with no other buildings to limit solar gain or provide wind shielding.

Summary Table of key design parameters.

Building data	
Building type	Office
Total floor area	2 500 m²
Mean occupant density	10 m²/person (overall average)
Occupied hours	2 000 hrs/year
HVAC data	
Ventilation system type	Primarily natural ventilation, with mechanical ventilation for meeting rooms
Heating system	Condensing gas boiler
Cooling system	Not applicable
Total ventilation rate	Not applicable
Heat recovery efficiency	Not applicable
Cooling load	Not applicable
Design heating load	
Building fabric data	
Window U-value	1.8 W/(m² K)
Window g-value	
Exterior wall U-value	0.25 W/(m² K)
Base floor U-value	0.27 W/(m² K)
Roof U-value	0.23 W/(m² K)
Climate data	
Design outdoor temperature for heating	-3°C
Design outdoor temperature and RH for cooling	Not applicable
Heating degree days (include base temperature)	2 033 days (base 15.5°C)
Cooling degree days (include base temperature)	160 (base 18°C)

The building is situated in a climate zone with moderate heating and cooling loads.



Annual energy use.

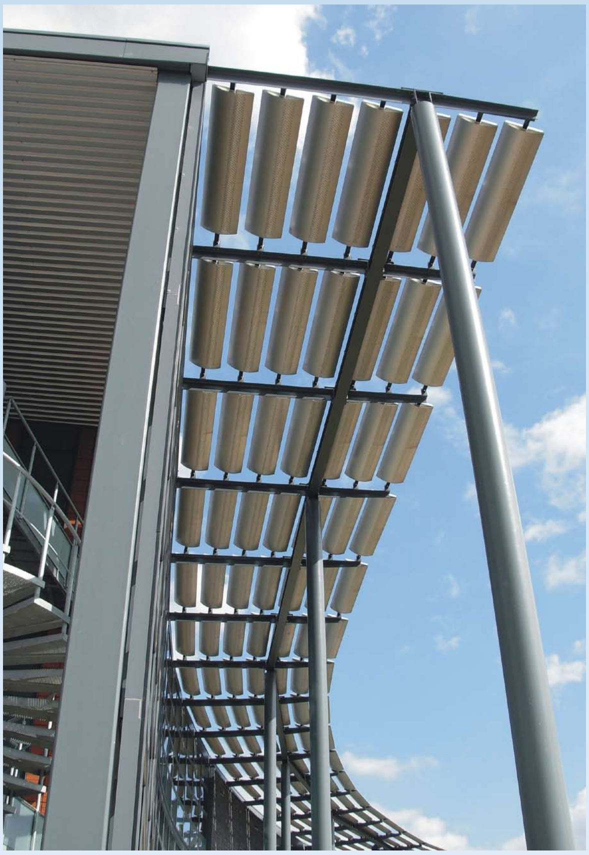
BUILDING DESCRIPTION

Red Kite House is a three-storey office building in South East England with a total floor area of 2 500 m². Each floor is mainly open-plan office area with some meeting and other rooms. Figure 1 shows a plan view of the first floor. The total number of staff is about 250. Some staff are permanently stationed in the building; others spent a proportion of their working time away from the office and are only intermittently present, using a 'hot-desking' arrangement. Principal occupied hours are week days between 08.00 and 18.00.

DESIGN SOLUTIONS

The form of building is designed to ensure that an effective natural ventilation strategy can be achieved and, as a consequence, it has a relatively long, narrow plan on an east-west axis, with a typical depth of 16 m. The limited depth ensures good use of natural lighting. A brise-soleil (Figure 2) is situated at roof level on the south façade and is designed to provide protection from direct solar gain in the summer months but to allow useful heat gains in the heating season. The brise-soleil incorporates photovoltaic cells which reduce the building's electricity demand on conventional grid supply. Roof-mounted thermal solar collectors provide hot water for washrooms.

Figure 1. Plan view of first floor.



The building is naturally ventilated by automatically controlled high-level windows on each floor of the main facades. Larger manually operated windows are also available. The ceiling of each storey is exposed concrete. This thermal mass is used in conjunction with night-time ventilation to reduce peak internal temperatures in summer. In addition to the ventilation strategy, described in more detail later, the building incorporates a number of other sustainable features including rain-water storage system which collects surface water from the roof and recycles it for WC flushing and sustainable drainage measures permeable paving, permeable gravel beds around the building and grass landscaping.

Figure 2. The brise-soleil incorporating PV cells.

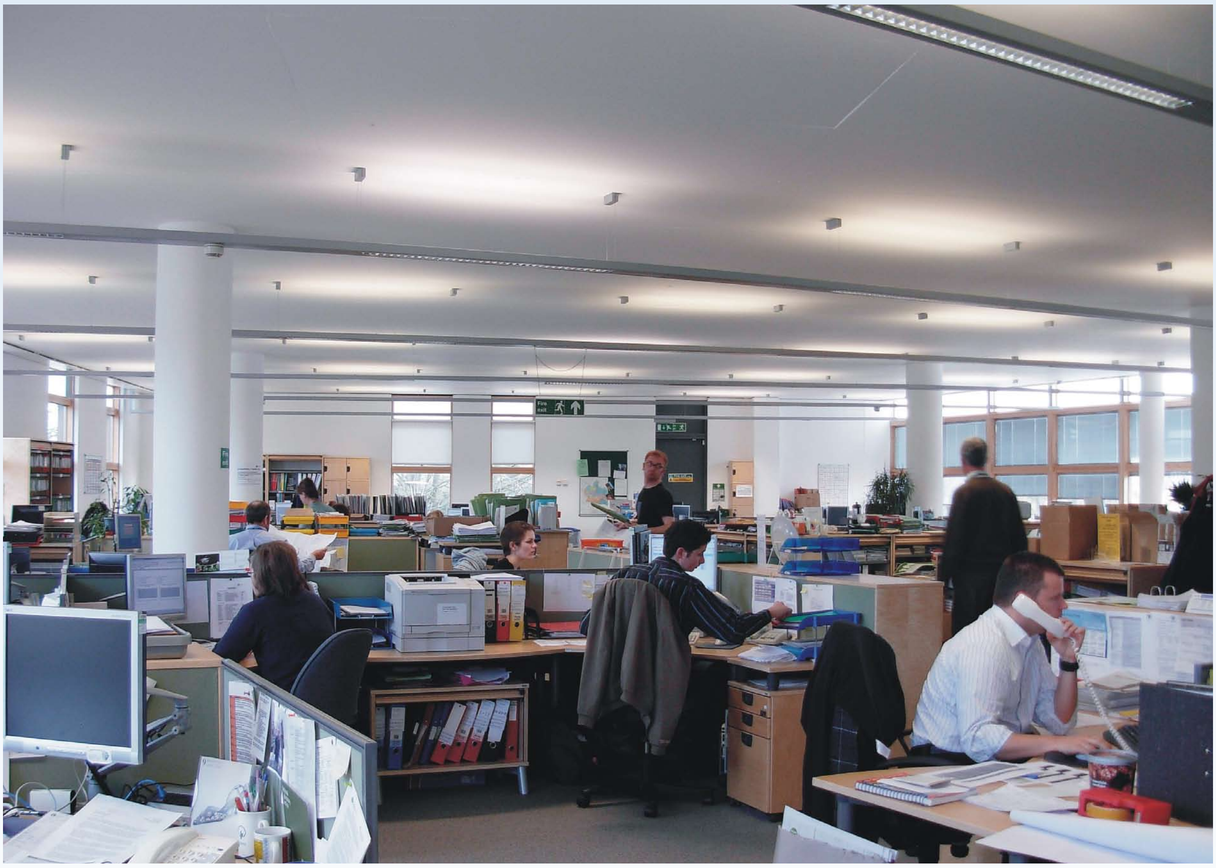


Figure 3. Open plan office showing natural and artificial lighting.

The building achieves an excellent rating based on the UK BREEAM assessment method.

VENTILATION STRATEGY

Except for simple mechanical extract ventilation for the toilets and meeting rooms, the building is fully naturally ventilated by openable windows on the north and south facades. High level top-hung lights on each floor are automatically opened by motorized links. Larger top-hung opening lights are provided at a lower level and these can be manually operated by occupants.

The open plan arrangement (Figure 3) allows free movement of air across the building. Even where partitions are provided, for instance for meeting rooms, these are not carried to the full ceiling height of 3.2 m, again allowing cross flow of air.

There are no suspended ceilings and the concrete soffit is exposed on each floor. This provides substantial thermal mass which, combined with night-time ventilation cooling , acts to minimize peak temperatures during the occupied period and obviates the need for air conditioning.

Operation of the high-level windows is controlled by local temperature measuring devices. When the temperature rises above a set point, determined by the building management team, the windows open and remain open until, either the temperature falls or rain is detected by a roof-mounted sensor.

PERFORMANCE

(i) Energy performance

The monitored energy consumption data for 2006, normalised on unit treated floor area basis yields annual consumptions of 66 kWh/m² for heating and 127 kWh/m² for electricity. These may be compared with benchmarks current at the time of construction given in the UK Energy Consumption Guide 19: Energy Use in Offices (ECG19) for naturally ventilated, open-plan offices. For typical practice, the benchmarks are 151 kWh/m² for heating and 81 kWh/m² for electricity. The good practice values are 79 kWh/m² for heating and 54 kWh/m² for electricity. These are shown in figures 4(a) and 4(b), together with similar benchmarks for a standard air-conditioned building.

Red Kite House has an excellent heating consumption, below the good practice benchmark for naturally ventilated open-plan offices and substantially lower than for air-conditioned offices. The electricity consumption, however is higher than both typical and good practice for naturally ventilated open-plan offices. This is likely to be a result of relatively high density of occupation of Red Kite House and the high computer and office appliances not reflected in current benchmarks. It was not possible to check this as sub-metering of the electricity circuits was not available.

(ii) Indoor climate

(a) Thermal

Initial temperature measurements were made at six locations during the period 15th March to 15th September 2006. These provided an initial overall assessment of performance. Overall results for the six month period are summarised in Table 1, indicating the proportion of occupied hours for which the temperature at five locations exceeded 28°C.

(b) Ventilation

Continuous measurements in two locations in open plan office areas over a two week period in June/July 2008 showed low concentrations of carbon dioxide; always less than 800 ppm , with 700 ppm being exceeded for only thee hours. Measurements made in a two week period in October 2008 yielded slightly higher rates with mean values of 589 ppm and 659 ppm during office hours and occasional peaks above 1000 ppm. Higher concentrations were measured in December 2008 but these may have been atypical because of relatively low indoor temperatures resulting from a problem with the heating system.

(iii) Occupant Assessment of Performance

About 55% of occupants responded to a questionnaire survey to assess satisfaction with the indoor environment. The results are summarised in Table 2.

In general, a significant majority of occupants are satisfied in summer with the overall indoor environment together with specific aspects including thermal comfort, air movement and indoor air quality. In winter, satisfaction with the thermal environment is reduced although detailed analysis of responses indicates that this appears to relate to a local problem with building operation rather than design. As with many open-plan buildings there is some dissatisfaction with internally generated noise. Dissatisfaction with external noise in summer is likely to have arisen from a nearby temporary construction site. There is a very high level of satisfaction with the natural and artificial lighting. This is a benefit of the open-plan design of limited depth with windows provided on two opposing facades.

DESIGN LESSONS

Occupants indicated a high degree of satisfaction with the indoor environment but designers of future buildings using the same principles might

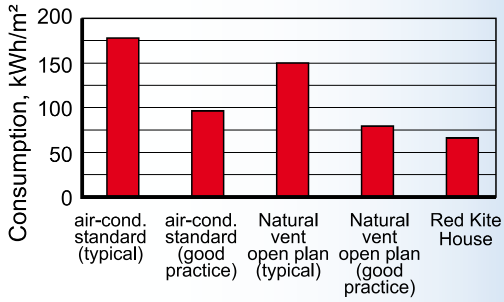


Figure 4(a). Comparison of space heating consumption with UK benchmark values for office buildings.

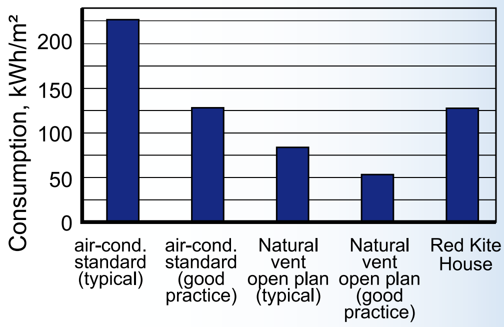


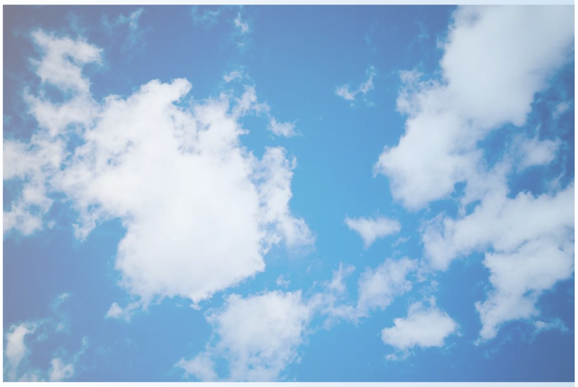
Figure 4(b). Comparison of electricity consumption with UK benchmark values for office buildings..

Table 1. Proportion of occupied hours that air temperature exceeds 28°C.

Ground floor	Level 1 West Wing	Level 1 East Wing	Level 2 East Wing(South)	Level 2 East Wing(North)
1.81%	2.79%	1.76%	2.30%	1.42%

Table 2.
Summary of occupant assessment of the indoor environment.

	Summer %	Winter %
People finding the **overall indoor environment** acceptable	82	69
People finding the **thermal environment** acceptable	77	61
People finding the **indoor air quality** acceptable	93	90
People finding the **acoustic environment** acceptable	51	65
	Natural %	**Artificial %**
People finding the **lighting** acceptable	97	84



Design team information
Designers and contractors

Developer	H R Wallingford
Tenant	Environment Agency (South East)
Architect	Scott Brownrigg
Building Services	Hoare Lea
Structural Engineer	Waterman Partnership
Quantity Surveyor	Davis Langdon
Main Contractor	Moss Construction

consider including monitors within the BEM system to allow windows to be opened if carbon dioxide concentrations reached a set limit. Control algorithms need to be carefully designed where window opening is controlled by several variables (such as temperature, rain, carbon dioxide) to ensure optimal operation.

With the increasing use of computing equipment in offices, it is useful, in order to manage energy use, to meter lighting and other building related electricity consumption separately from other uses.

GENERAL

Key points concerning the design

- **Night-time natural ventilation in common with a thermal sink provided by exposed concrete ceilings limits peak temperatures in summer.**
- **The combination of brise-soleil with solar PV cells both limits unwanted solar gains in summer and provides a useful supply of renewable electricity.**
- **The deliberately limited building width, combined with open plan design, and orientation provide for efficient natural ventilation and day-lighting both of which increase the satisfaction of occupants.**

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Brochure authors: M Kolokotroni and P Warren, Brunel University. UK.

BUILDING ADVENT

Full title of the project: Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions. Building AdVent is funded by the European Commission, Directorate-General for Energy and Transport as part of the Intelligent Energy - Europe Programme.

It is estimated that energy consumption due to ventilation losses and the operation of fans and conditioning equipment is almost 10% of total energy use in the European Union and that about one third of this could be saved by implementing improved ventilation methods. A number of projects have been undertaken under the auspices of the European Union (under the SAVE and ALTENER programmes) and the International Energy Agency (Energy Conservation in Buildings and Community Systems Annexes 26 and 35) to identify and develop improvements in ventilation technology.
The AdVent programme is intended to build on these and has three principal objectives:

- Classification of existing building ventilation technologies as applied in built examples and collection of information on building performance.
- Identification of barriers for future application.
- Preparation of case-studies in a common format, together with training material

BUILDING ADVENT PARTICIPANTS

Coordinator

Buro Happold Consulting Engineers .... UK

Participating Organisations

Brunel University .... UK
National and Kapodistrian University of Athens .... Greece
Helsinki University of Technology .... Finland
Aalborg University .... Denmark
Faculdade de Engenharia da Universidade do Porto .... Portugal
International Network for Information on Ventilation and Energy Performance (INIVE) .... Belgium

Major Sub-Contractors

Federation of European Heating and Air-Conditioning Associations (REHVA) .... The Netherlands
International Union of Architects .... France/Greece
—Architectural and Renewable Energy Sources Work Programme (UIA - ARESWP)

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