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 15
RIJKSWATERSTAAT BUILDING
TERNEUZEN, NETHERLANDS

Supported by

Intelligent Energy Europe

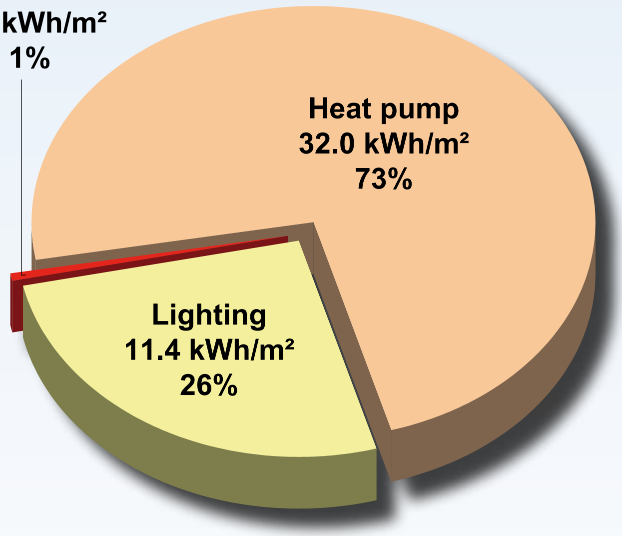
INTRODUCTION

The Rijkswaterstaat building is on a small exposed island site in open countryside close to the coast. There are no other buildings in the vicinity but some shelter by trees to the west.

Summary Table of key design parameters.

Building data	
Building type	Office
Total floor area	1 750 m²
Mean occupant density	30 m²/person
Occupied hours	2 000 hrs/year
HVAC data	
Ventilation system type	Natural ventilation
Heating system	
Cooling system	Natural cooling
Total ventilation rate	Not applicable
Heat recovery efficiency	Not applicable
Cooling load	Not applicable
Design heating load	33 W/m²
Building fabric data	
Glazing U-value	1.6 W/(m² K)
Window g-value	0.65
Exterior wall U-value	0.38 W/(m² K)
Base floor U-value	0.24 W/(m² K)
Roof U-value	0.34 W/(m² K)
Climate data	
Design outdoor temperature for heating	
Design outdoor temperature and RH for cooling	Not applicable
Heating degree days (include base temperature)	2 863 days (base temperature 18°C)
Cooling degree days (include base temperature)	Not applicable

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



Annual energy use.
(Total electricity 43.7 kWh/m²)

BUILDING DESCRIPTION

The building, located in Terneuzen, was completed in 2000 and is occupied staff of Rijkswaterstaat which form part of the Netherlands Ministry of Transport. It is broadly triangular in shape in which the floor levels rise like a snail-shell. In the centre of the building is an atrium with a glazed roof. The building houses 60 employees and has a gross area of about 1 750 m².

DESIGN SOLUTIONS

The design objectives of the building were to develop a sustainable and ecological building, integrated with its surroundings and providing a high level of individual control and comfort for occupants.

Sustainable materials, principally wood, were used in the construction of the building and a high level of insulation was provided. In the absence of a

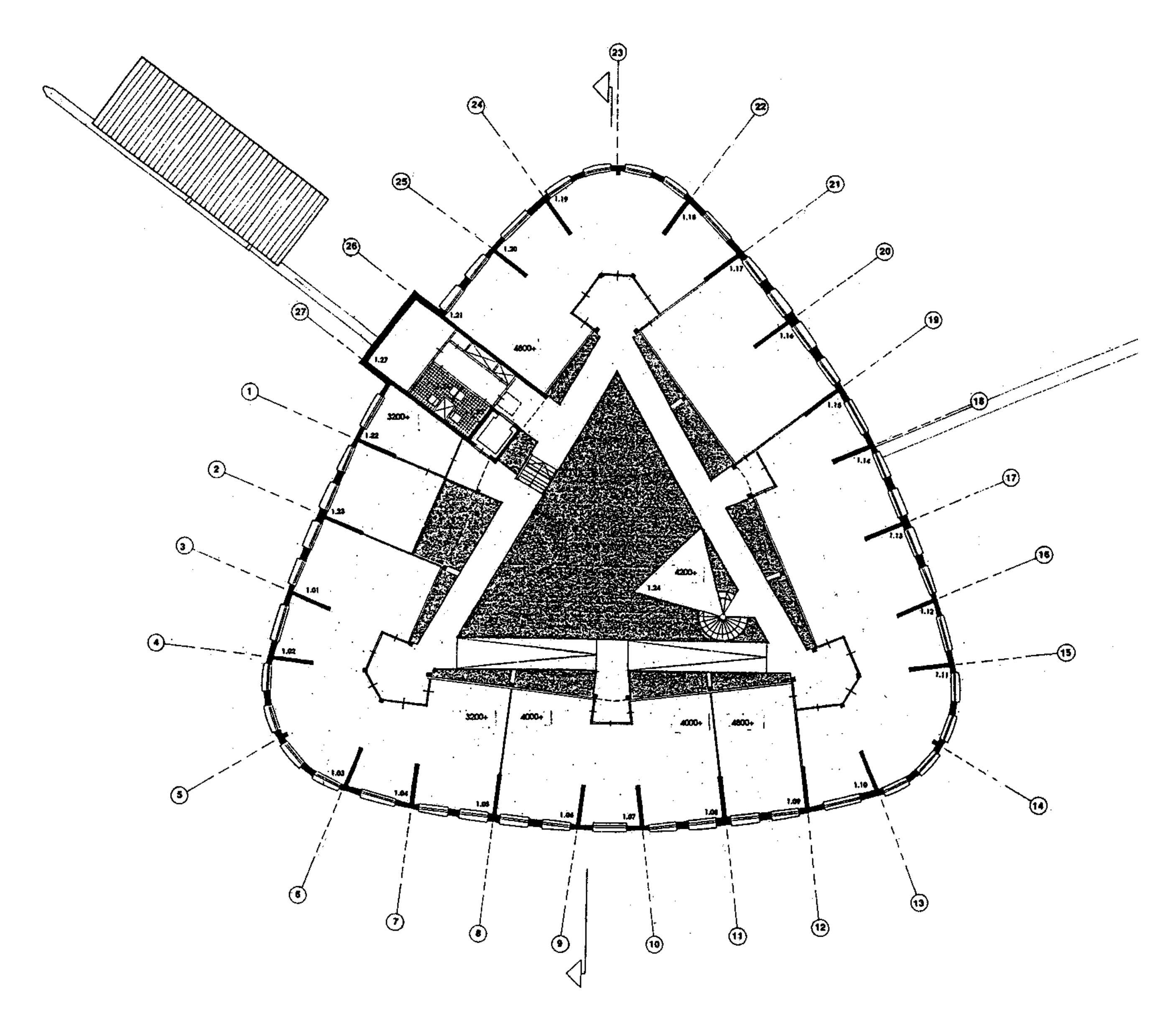


Figure 1. Plan view of the building.

supply of natural gas to the site, the adjacent canal water is used as the source for a heat pump which supplies a low temperature wall and under-floor heating system. The layout of the building is designed to make best use of natural lighting and, in winter, solar gain for passive heating. In summer, heat gain is reduced by the use of external shading and its effects reduced by the provision of thermal mass in the walls and ceilings in conjunction with night ventilation. The building is naturally ventilated, using a system with electronically-controlled inlet openings. Domestic hot water is supplied by a solar collector and 54 m² of photovoltaic cells contribute to satisfying the electrical load.

VENTILATION STRATEGY

An advanced natural ventilation system provides fresh air and assists in controlling thermal comfort in summer. The external walls incorporate openable widows and inlet vents. Sound-proofed openings in the internal walls provide an air flow path to the atrium. Air is extracted from the atrium via a 7 m tall ‘chimney’ with a diameter of 1 m (see Figure 2). There are also openable lights in the glazed atrium roof. The location of the ‘chimney’ in a low wind pressure region, combined with stack effect, is designed to give a flow pattern as shown in Figure 3. In winter, the building management system controls the vents in the external wall to ensure a constant flow rate during occupied hours and to close the vents overnight. Occupants have the facility to over-ride the automatic system if required. The potential for draughts from the inlet vents is reduced by the provision of perforated shelf with 100 mm borders immediately under each inlet. In summer, the flow of air can be increased by the manual opening of windows. The building management system allows the inlets to be open overnight to provide cooling.

PERFORMANCE

(i) Energy performance

The total measured electrical energy consumed by the building over one year was 43.7 kWh/m² per annum. This was distributed as follows: (i) heat pump, for heating – 32.0 kWh/m² per annum; (ii) lighting – 11.4 kWh/m² per annum and (iii) domestic hot water – 0.3 kWh/m² per annum. A comparison may be made with the reference case determined according to the Netherlands Building Code (1998). This sets out the expected performance of an equivalent reference office building constructed to the Code in terms of primary energy consumed per year. Both the measured results and those for the reference building are shown in Figure 4. The performance of the Rijkswaterstaat building with a total primary energy consumption of 730 GJ/annum is substantially better than that of the reference case, 1 270 GJ/annum. Currently, more than 10 years after its design, this building still has the highest Greencalc sustainability score in the Netherlands.

Figure 2. Roof of the building showing the ‘chimney’, atrium glazing and PV cells.

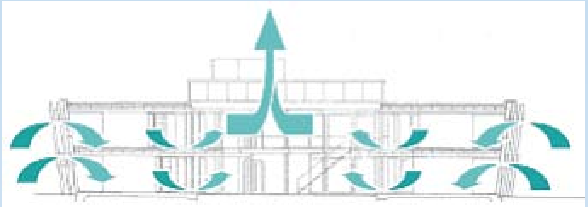


Figure 3. Design air flow pattern.

(ii) Indoor environment performance

(a) Thermal

A monitoring programme was carried out during the summer of 2000 and the winter of 2001.

Thermal comfort measurements were made in seven representative locations.

In summer, no overheating was found for moderate conditions (i.e. external temperature in the range 10–15°C; clouded sky). Some overheating was found in the south orientated offices during the afternoon but this only occurred for a restricted period of time when the shading device in the atrium was not installed. For low occupant activity and light summer clothing, potential discomfort conditions occurred in only one room (PMV < -1.0). For higher activities and warmer clothing, the measurements predicted a high level of satisfaction (-0.5 < PMV < +0.5).

In winter, for medium occupant activity and average winter clothing, the measurements in all office rooms, except one, and the atrium predicted a high level of satisfaction (-0,23< PMV < +0,02). For lower activity levels a higher level of potential discomfort was predicted (-1.72 < PMV < -0.77). A possible explanation is that most employees are outdoor workers who spend only part of their time in the office. Due to their outdoor tasks, most workers are warmly dressed and tend to turn thermostats to a low value.

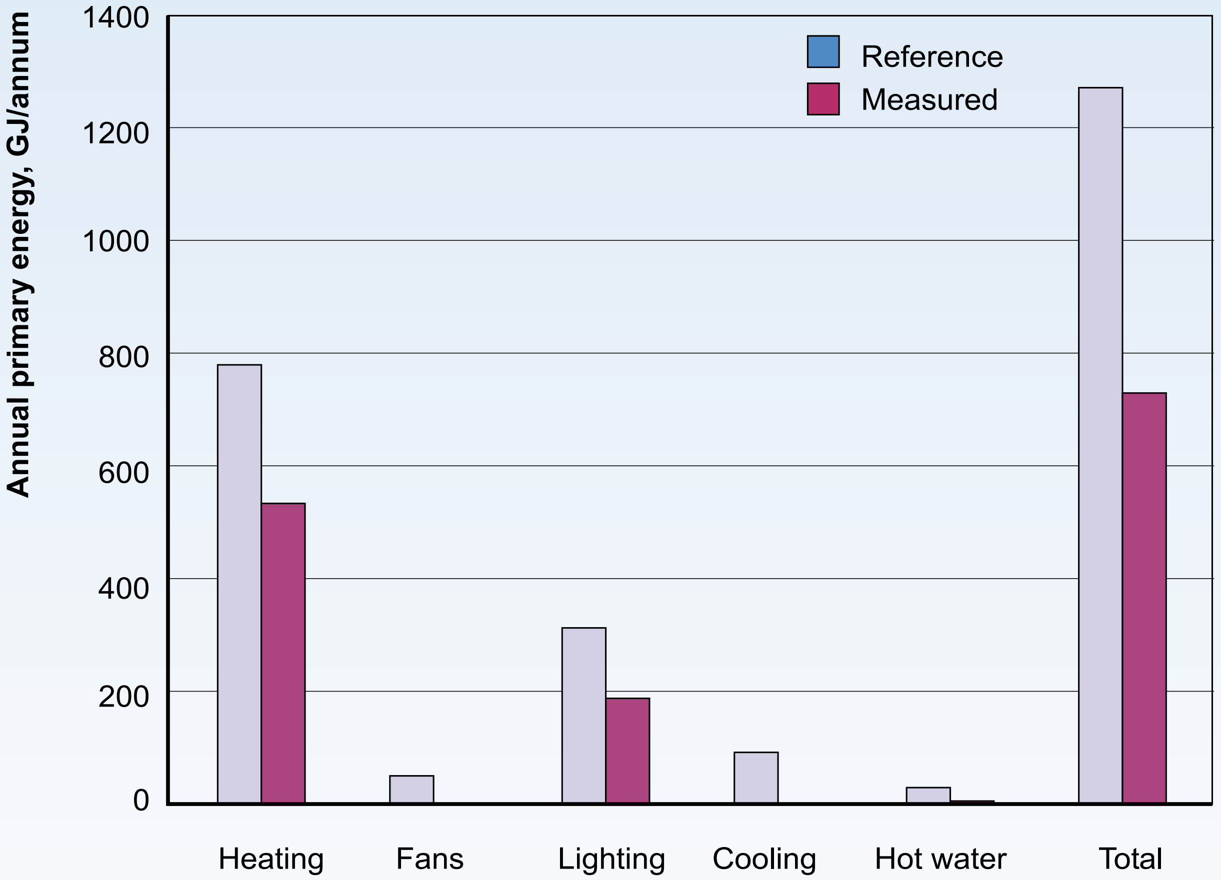


Figure 4. Comparison of the annual measured primary energy consumed by the building with the Netherlands Building Code reference case.

(b) Ventilation

Measurements were made of CO_2-levels in six representative locations during a four-week period in the winter of 2001. During working hours concentrations increased from a baseline level of 360 ppm to between 400 and 600 ppm with occasional peaks of between 700 and 850. These are well within the level of 1000 ppm use as an indicator of good air quality.

External view showing solar shading.

(iii) Occupant assessment of performance

The results of a representative survey of 43% of occupants are summarised in Table 1. In general, occupants were very satisfied with the indoor environment. The high level of satisfaction has been further confirmed by recent surveys.

DESIGN LESSONS

The occupants perceive the building and the indoor climate as pleasant and have substantially fewer complaints than those in other buildings with a similar use.

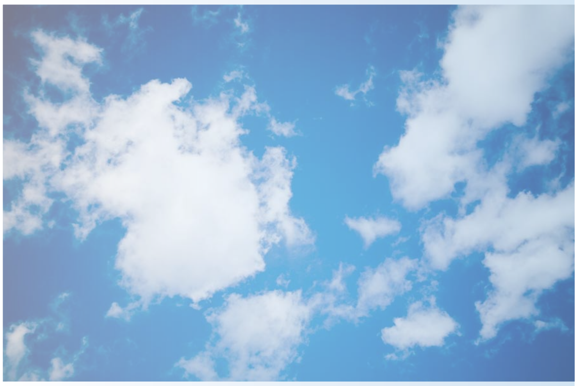
Although the building performs well, with an annual primary energy consumption of 57% of the reference building, energy saving is less than the 46% predicted by simulation at the design stage. This may be result from differences between the building as constructed and the design assumptions or the way that the building is used by occupants. However, despite the time elapsed since its design this building retains the highest 'Greencalc' sustainability score in the Netherlands.

Providing enough daylight on the working surfaces may not be sufficient to avoid artificial lighting

Aerial view showing location and atrium glazing and 'chimney'.

Table 1.
Summary of occupant assessment of the indoor environment.

	Summer %	Winter %
People finding the **overall indoor environment** acceptable	91	91
People finding the **thermal environment** acceptable	67	72
People finding the **indoor air quality** acceptable	85	80
People finding the **acoustic environment** acceptable	100	100
	Natural %	**Artificial %**
People finding the **lighting** acceptable	92	100



Design team information
Designers and contractors

Tenant	Netherlands Ministry of Transport
Architect	opMAAT duurzame architectuur en systeemontwikkeling, Delft
Engineering – Energy	Environmental Design Partnership
Engineering - Construction	Hust –D3BN
Engineering – M & E	Bravneboer & Scheers Rijksgebouwendienst, directie Ontwerp & Techniek
Building contractor	Bliek en Vos bv, Terneuzen

as many occupants will switch on lights if they perceive a dark area within the space.

Difficulties were experienced in sourcing sustainable materials (wool, loam plaster, wood) of a sufficiently high quality.

GENERAL

Key points concerning the design

- **Natural ventilation with electronically controlled openings**
- **Utilization of day light**
- **Good insulation**
- **Minimum of building services**
- **Low temperature heating system**
- **Solar hot water collector**
- **Solar shading**
- **Sustainable materials**

REFERENCES

Cauberg-Huygen R.I. B.V. (2001). Ventilation measurements in an office building using. Passive tracer gas technique. Rotterdam. The Netherlands.

Van der Aa A, Eijdems H H E W, Op ‘t Veld P J(2002). Office building Ministry of Transport at Terneuzen, The Netherlands. Low energy, high thermal comfort and high sustainability in one concept. Proceedings of Indoor Air 2002, Monterey, USA. Vol 3. pp706-711.

Boestra A. (2003). Hoe gezond is het. Duurzaam bouwen. Binnenmilieuprestatie van4. p.16-18, March 2003.

http://www.architectenwerk.nl/hulst-d3bn/PF_Terneuzen.htm

http://duurzaambouwen.senternovem.nl/projecten/40-rijkswaterstaat_kantoor/samenvatting.html.

Brochure authors: P Heiselburg and O Kalyanova, Aalborg University.

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)

Supported by

Intelligent Energy Europe