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 2

GSIS BUILDING
ATHENS, GREECE

Supported by

Intelligent Energy Europe

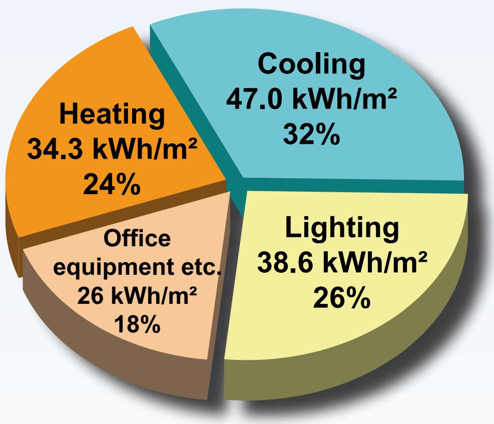
INTRODUCTION

The General Secretariat of Information Systems (GSIS) building is a free standing building located in a central densely-built area of Athens. However, the surrounding buildings are situated at a sufficient distance to ensure that natural ventilation and solar penetration are not obstructed. A tramway running close to the south of the building provides the main external source of noise principally affecting the offices with south-easterly orientation.

Summary Table of key design parameters.

Building data	
Building type	Office building
Total floor area	30 000 m² (including basements)
Mean occupant density	Overall average: 23 m²/person Data entry rooms: 5 m²/person
Occupied hours	3 000 hrs/year
HVAC data	
Ventilation system type	Mechanical ventilation supplemented by openable windows for natural ventilation
Heating system	Low temperature hot water system supplying fan coil heaters
Cooling system	Central cooling plus night cooling by mechanical ventilation
Design ventilation rate	28.8 m³/person

Building fabric data	
Window U-value	2.8 W/(m² K)
Window g-value	0.7
Exterior wall U-value	1.7 W/(m² K)
Base floor U-value	1.85 W/(m² K)
Roof U-value	2.5 W/(m² K)
Climate data	
Design outdoor temperature for heating	2°C
Design outdoor temperature for cooling	34.5°C
Heating degree days (include base temperature)	1 428 days (base 18°C)
Cooling degree days (include base temperature)	186 days (base 25°C)



Annual energy use.

The building is situated in a climate zone with a high cooling load.

BUILDING DESCRIPTION

The building provides offices for the General Secretariat of Information Systems (GSIS), a public administration agency belonging to the Greek Ministry of Economy and Finance. The building was initially constructed in the 1960. An initial retrofit took place in 2000. This was followed by a further retrofit in 2006 under the auspices of the EU 'REVIVAL' programme (Contract No. NNE5/2001/597) with the aim of improving the indoor environment and minimising building energy consumption. The building is rectangular in plan, measuring 115 m in length and 39 m in width and consists of two basement floors, a ground floor, a mezzanine, and four upper floor giving a total floor area of about 30 000 m². Its long axis runs along a south/southeast to north/northwest direction. Figure 1 shows a plan view.

The building is occupied by approximately 1 300 staff, 50% of whom work in the data entry rooms which operate a two shift system (from 08.00 to 13.30 and from 13.30 to 20.00). The data entry rooms (Figure 2) have a high occupancy density (1 person per 5 m² floor area).

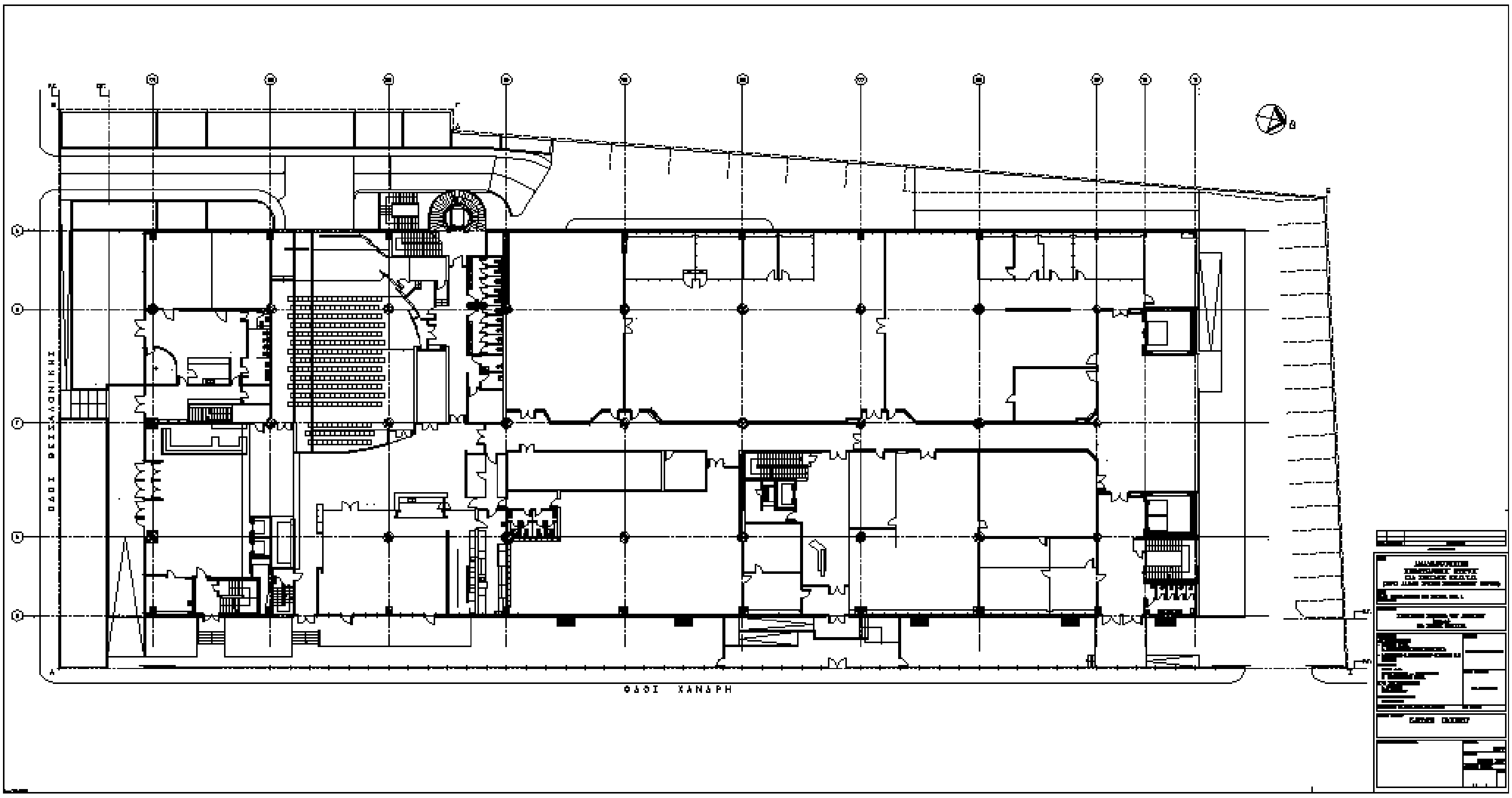


Figure 1. Plan view of the GSIS Building.

DESIGN SOLUTIONS

The following modifications were made during the 2006 retrofit. Shading systems were fitted on the south and west facades of the building to control solar gain both in winter and summer. Double glazing of the north façade was replaced with low emissivity double glazing in order to minimise the thermal losses through the building envelope and to improve thermal comfort in the adjacent office spaces. The HVAC system was upgraded and a new Building Management System (BMS) installed which controlled heating, cooling and a new demand control ventilation system supplying high density office areas (Figure 2). The BMS also records environmental conditions (internal temperatures, relative humidity, lighting levels) and energy consumed for heating and cooling. Energy consumption for lighting was reduced by replacing existing standard luminaires with energy-efficient fluorescent lamps (Osram Lumilux T5 HE) with a luminous efficacy of 104 lm/W. In addition, 26 m^2 of photovoltaic panels were installed to supply auxiliary systems and lighting on the 3rd and 4th floors.

**Figure 2.
High occupancy - data entry room.**

Figure 3. Ceiling fans.

VENTILATION STRATEGY

The ventilation of the office areas is provided by a central mechanical ventilation system incorporating heat recovery and supplemented by openable windows. If required, the mechanical system can provide night-time cooling which, in conjunction with high building thermal mass, assists in limiting daily peak temperatures to below ambient in the summer months. In addition, ceiling fans (Figure 3), controlled either manually or by the BMS, were installed in the densely occupied office areas to extend the thermal comfort envelope to 28.5°C thereby reducing the need for air-conditioning. The supply of outside air to the densely occupied office areas is controlled by the local measurement of CO_2 concentration (Figure 4). Under normal operating conditions air supply is controlled to 30% of full capacity by local dampers. If the CO_2 concentration exceeds a set level, the BMS system increases the air supply to full capacity.

PERFORMANCE

(i) Energy performance

After the building retrofit, the building was monitored using the BMS system for a full

Figure 4. Temperature and CO_2 sensor connected to the BMS.

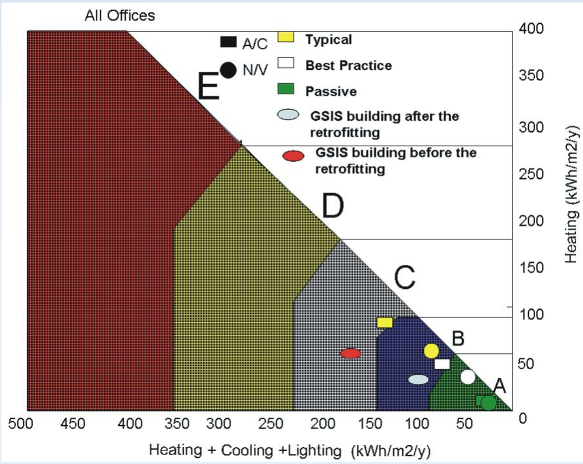


Figure 5.
Energy rating for the GSIS building [using the system included in the EPLabel Project (see references)].

year from April 2007 to March 2008. Total annual energy consumption was 145.9 kWh/m², of which that for cooling was 47.0 kWh/m²; for heating was 34.30 kWh/m²; for lighting was 38.6 kWh/m² and for general electrical use (office equipment etc.) was 26 kWh/m². In comparison with performance before the retrofit, cooling consumption was reduced by 46.5%, heating consumption by 29% and lighting by 16%. Figure 5 shows the performance of the building before and after retrofit using the energy rating system included in the EU-funded EPlabel Project. This demonstrates the considerable improvement, although the rating still falls just below the benchmark for best practice office buildings.

(ii) Indoor environment performance

(a) Thermal

For the majority of the summer period, internal temperatures in all office areas varied between 27.5°C and 28.5°C. The number of hours above 30°C was minimal. Even during extreme external conditions, with ambient temperatures above 41°C, the indoor temperature was constant and below external temperature by at least 10°C. The average temperatures in the most densely occupied areas, the data entry rooms, varied from 24.1°C to 27.7°C for June, 24.5°C to 28.1°C for July and 25.1°C to 28.1°C for August, and were, therefore, within the thermal comfort levels.

(b) Ventilation

The CO_2 concentration in the office areas was recorded by the BMS. Instantaneous values above 1 000 ppm were measured in a high proportion of areas (ranging from 38% in August to 69% in November) but for limited periods. However, even for the most densely occupied offices, the 8-hour mean values varied between 600 ppm and 800 ppm, well within the ASHRAE limit of 1 000 ppm.

(iii) Occupant assessment of performance

An occupant survey of acceptability of the indoor environment was carried out in 2008. In total 74 people, working in a range of office areas with different orientations and occupancy patterns, responded to the questionnaire. The results of the survey are summarised in Table 1. Compared with the situation before the retrofitting, the response showed that the implemented energy measures significantly improved the indoor environmental conditions.

DESIGN LESSONS

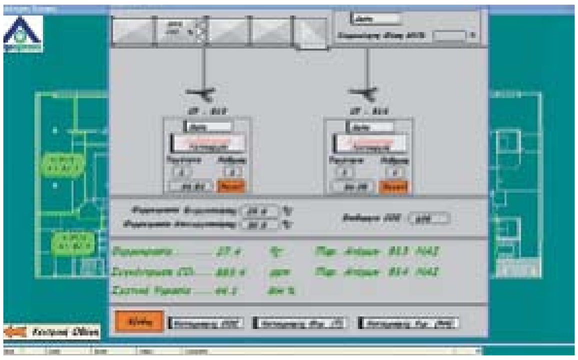
Although the retrofit provided significant energy savings for heating, cooling and ventilation, the post-occupancy comfort survey showed that there is still dissatisfaction regarding the thermal comfort in the densely occupied areas. Further changes could be made to the ventilation system to increase the ventilation rates in each office space. However, this would imply the replacement of the existing system with a new one, a solution much more expensive than the interventions already implemented.

However, the demand control ventilation, based on CO_2 concentration, in conjunction with the use of ceiling fans, provided an excellent solution for maintaining indoor air quality in the densely occupied offices at acceptable levels while at the same time achieving significant energy savings. The BMS also performed well in recording the building energy consumption and detecting any malfunction of the installed systems.

GSIS Building – external view before 2006 retrofit.

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

	Whole year %
People finding the **overall indoor environment** acceptable	72
People finding the **thermal environment** acceptable	61
People finding the **indoor air quality** acceptable	50
People finding the **acoustic environment** acceptable	66
People finding the **lighting** acceptable	83



BMS screen.

GENERAL

Key points concerning the design

The GSIS is an exemplar public building for its energy and environmental performance; the result of a successful retrofitting in the area of heating, cooling, ventilation and lighting despite the restrictions that were encountered due to the ageing and operation of the building.

REFERENCES

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Brochure authors: M Santamouris and I Farrou, National and Kapodistrian University of Athens.

Design team information ***Designers and contractors***	
Tenant	Greek Ministry of Finance
Architect	A.N. Tombazis & Associates Architects
Engineering – Energy	M. Santamouris, Associate Professor, Group Building Environmental Research, National and Kapodistrian University of Athens
Engineering – Structure	Grigoris Pentheroudakis METE A.E.
Engineering – M & E	Bravneboer & Scheers Rijksgebouwendienst, directie Ontwerp & Techniek
Building contractors	Algosystems A.E. (electro-mechanical installations) Lampaditis D. (shading system)

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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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