Second International Conference Buildings
and the Environment, June 1997, Paris

EC 2000 HIGH PERFORMANCE BUILDINGS THAT REDUCE OR AVOID AIR CONDITIONING.

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Abstract.

This paper outlines progress in the THERMIE Target project Energy Comfort 2000 after three and a half years. Seven of the eight buildings are under construction and the eighth will be starting on site in May 1997. The project covers the design, construction, commissioning and monitoring of the buildings which are offices, university buildings, and public and recreational buildings, together with "horizontal activities" which link the projects together. All buildings have been designed to save at least 50% of the energy consumption of conventional buildings and to avoid or minimise the use of air-conditioning, by passive design methods. Results from monitoring of the first completed building show that it has saved 74% of the energy of an equivalent air-conditioned building, with the majority of the occupants believing that the building provides comfortable internal conditions . The many useful results from EC2000 are being produced for dissemination in the form of "Information Dossiers", subjects to date include fire safety in atria, natural ventilation design, control strategies and windows.

1. INTRODUCTION.

Energy Comfort 2000 brings together eight new non-domestic buildings in six European Countries, which demonstrate energy conservation, reduction or avoidance of air conditioning and environmentally friendly design, whilst aiming to provide good comfort conditions for occupants. The project started in 1993 and includes the design, construction and monitoring of the buildings, together with a series of horizontal activities which are designed to link together the buildings and provide useful output for designers on the lessons learnt during the five years of the project.

EC2000 is a European Commission THERMIE Target Project and includes a large group of building owners, designers and energy experts who meet regularly throughout the project life to exchange ideas and experiences as the buildings develop and to prepare materials to disseminate the results.

2. THE EIGHT BUILDINGS.

There are many similarities, and many differences between the EC 2000 buildings but similar issues, problems and solutions run through all. The range of experiences will hopefully give rise to a wider understanding of energy and comfort issues and many "generic" solutions, applicable to non-domestic buildings throughout Europe.

2 1 Chelmsford, UK. University Learning Resources Centre.

This was the first EC2000 building to be completed and occupied, in September 1994. It is the first building on the new site of Anglia Polytechnic University and comprises 6,000 square metres of library, and offices for university staff. With two central atria, the four storey building is fully passively ventilated and makes extensive use of daylighting. Thermal mass was added to the top storey building to reduce peak temperatures using nightime ventilation and there are other interesting features such as double light shelves. Monitoring is complete and is reported later in this paper.

2.2 Leeds, U.K. Speculative office development.

The second EC2000 building completed was also in the UK and is a speculative office building in the Leeds City Office Park, developed on an old town gas site near the city centre. The highly glazed building has 5,000 square metres of office space, around a central atrium which is also the entrance hall. Mechanical ventilation is used, assisted by the stack effect in the atrium but there is no active cooling. Solar shading and use of thermal mass activated by nightime ventilation, are designed to provide adequate comfort conditions all year round.

2.3 Enschede, the Netherlands. Tax Office Extension.

Completed in November 1996, this 4,000 square metre office was designed in-house by the Rijksgebouwendienst, the Netherlands Government Building Agency (with external energy advice). It makes use of extensive daylighting, with light shelves (incorporating lighting units) and solar shading, and is completely passively ventilated with the aid of a central atrium. Nightime ventilation combined with use of thermal mass is designed to keep temperatures within the Rgd standards. A photovoltaic array has been installed on the roof and a rainwater collection and use system is also operating.

2.4 Athens, Greece. AVAX SA Construction Company Offices.

Due for completion in April 1997, this seven storey head office building is designed to provide pleasant working conditions without using its air-conditioning system, for much of the year despite the climate of Athens. Movable, vertical glass shading devices on the main (eastern) facade are used, combined with use of thermal mass, passive ventilation and room fans. The shading devices allow an almost uninterrupted view across Athens from the building's commanding position, except when needed to provide shading against the morning sun.

2.5 Aix en Provence, Universite des Sciences

There are two buildings forming this project which are both due to be completed by May 1997. The designs come from an architectural competition winner and provide a range of lecture rooms, offices and other facilities for students, researchers and staff within a two and three storey 6,000 square metre development. Arranged round courtyards, the building uses insulation, shading, daylighting and natural ventilation and has an active solar heating system which heats the library floor.

2.6 Lisbon, Portugal. EXPO 98, Multi-purpose Pavilion

This will be the main pavilion on the EXPO site with a capacity 16,000 spectators in the sports arena with a secondary exhibition and conference room. The design was the result of a competition and gives the appearance of an upturned boat in keeping with the "Oceans" theme of EXPO 98. The structure is in laminated wood covered in aluminium. A displacement ventilation system has been designed to minimise energy use, with heating or cooling from the district mains and river water for pre-cooling. Passive ventilation and daylighting are to be used except when there are events.

2.7 Schiedam, the Netherlands. Multi-use Public Building.

Construction of the19,000 square metres of facilities for this major development project is well advanced, and includes a library, offices, archives, a theatre and conference facilities. High insulation levels, daylighting and natural ventilation are all used where possible in different parts of the building.

2.8 Valladolid, Spain. Office Development, Edificios Intecos.

The last EC2000 building to commence construction provides 11,000 square metres of office space on four storeys, designed to provide a working

demonstration of both active and passive solar energy and saving 80% of the normal energy consumption. Technologies to be used include nightime and buried pipe cooling, evaporative cooling and absorption chillers, active solar collectors, natural ventilation and daylighting. Construction is due for completion in 1998.

3. THE DESIGN PROCESS AND CALCULATIONS.

Each building has been designed by its own design team with assistance from various energy experts. All designs have been discussed in open sessions with the EC2000 groups to exchange experience and ideas and look for solutions to common problems. The overall targets for EC2000 are to reduce total energy consumption by at least 50% and to avoid or minimise air conditioning, as well as providing good comfort conditions for occupants. All projects approached this challenge in different ways and during the design process most of the initial design concepts have been developed and included, and energy modeling has indicated that the targets will be achieved or exceeded. The final stage of the projects is the monitoring when the buildings are occupied and it is only then that the actual energy consumptions and conditions will be known.

4. RESULTS OF MONITORING.

The one year monitoring at Anglia Polytechnic University is finished and the final report is complete. This shows that:-

- The building has achieved a 74% energy saving over its traditional air-conditioned counterparts, resulting in an annual energy saving exceeding £62 000. (July '95 - June '96)
- The facade glazing system has proven to be very effective for eliminating glare whilst admitting useful solar gains 7 times greater that the associated losses during the heating season.
- The night cooling has the potential to reduce internal temperatures so that when used during warm weather, windows need not be opened by the BEMS on the following day to avoid overheating.
- Occupants generally perceive that the building provides comfortable internal thermal, visual and aural conditions, and are on the whole satisfied with the environmental control systems.

Despite the success of the project in achieving the targets of EC2000, it is recognised that there remains scope for further improvement to the building's energy and environmental performance. Further investigation and action is intended to be carried out in:-

- Improving the night cooling system
- Reducing lighting energy use
- Providing passive humidification during the winter months
- Improving daylight distribution
- Reducing internal noise levels

5. THE INFORMATION DOSSIERS.

5.1 Description.

In order to disseminate the results of EC2000 a number of Information Dossiers are being produced. These will bring together various aspects of the eight buildings under different subject headings and compare the results achieved on the different sites. The format of the Dossiers is to provide a short description of the subject and then provide information with diagrams, tables and drawings as appropriate on the experiences with each relevant building. The audience for the Dossiers is seen as designers, students, journalists and clients and building owners, depending on the subject matter.

It is intended to produce Dossiers on the following subjects:-

- Fire safety in atria.
- Passive ventilation in new office designs.
- Control strategies for energy conscious and comfortable buildings.
- Windows the key to low energy design.
- Clients and Contracts for Passive and Natural Buildings
- Design Standards for Low Energy Offices
- Summary of Environmental Assessments.
- Climatic Sensitivity of Designs
- Active solar heating and cooling.
- Cost Effectiveness of EC2000 Buildings.
- Energy Consumption of EC2000 Buildings.
- Comfort and Quality in EC2000 Buildings.
- Client and Market perception of finished EC2000 Buildings.

Four Dossiers have been produced so far and others are under way.

5.2 "Fire safety in atria".

This Dossier describes the general principles and reviews three EC2000 buildings with atria and how they were able to satisfy the local building control officers in this respect. At APU the features used were glass down stand curtains to hold a reservoir on each floor at high level; channelling screens to plume the smoke into the atrium; and enlarged hot smoke reservoirs within the roof void on the top floor. At Leeds, an automatic fire detection/alarm system with fire dampers in the supply air ducts was installed and toughened glass placed between the offices and the atrium. At Enschede a sprinkler system was installed together with automatically opening smoke vents in the roof, a costly combination.

5.3 Passive ventilation in new office designs"

The second Dossier describes the opportunities and gives details of systems in five buildings. These include automatically opening vents and windows, trickle ventilation in winter, atrium stack ventilation, self adjusting vents, mechanical back-up, design optimisation using CFD, BEMS control of ventilation, fresh air floor plenum, and single sided ventilation.

5.4 "Control strategies for energy conscious and comfortable buildings".

This Dossier describes the control strategies adopted in all eight EC2000 buildings, for windows, air supply and exhaust, night ventilation, heating, cooling, lighting, and shading. All buildings had BEMS for some control functions, but manual control was used for many. Suggestions are made on how to choose an appropriate system for specific buildings.

5.5 "Windows - the key to low energy design".

The last Dossier currently available describes the available options for windows and glazings and discusses the solutions used in five EC2000 buildings. These include triple glazing with enclosed blinds, vision and daylighting windows, external solar shading, light shelves and roof lights. The use of modeling and visualisation tools is also discussed.

6. ENVIRONMENTAL ASSESSMENTS.

6.1 Background.

Each building is undergoing an environmental assessment based on the UK BREEAM scheme for new office developments[1]. This assesses the environmental impact of the building at the global, local and indoor scales and gives the building an overall environmental rating. The method has been applied broadly to the EC2000 buildings and is not a definitive assessment for two reasons. First, that the buildings are not all offices and thus BREEAM for Offices cannot apply fully, and second that energy consumption standards and related CO_2 emissions are different in the different European Countries, making the "credits" given for CO_2 emissions somewhat inconsistent. A project called BEAM is currently underway to produce guidelines for an assessment tool more applicable to the whole of Europe.

6.2 Preliminary results.

Five buildings have so far been environmentally rated. The Leeds and Enschede offices have both received a rating of "Excellent" partly as a result of getting 8 out of 10 credits for energy use. Anglia Polytechnic University and Expo 98 both received a rating of "Very Good" (the second best rating) helped by 8 out of 10 credits for energy use. The assessment of the Athens AVAX office is not complete but it is likely to achieve a rating of at least "Good".

The assessment methodology allows design teams to improve their design in environmental terms as a result of the preliminary assessment and thus this process is still proceeding on those buildings not yet built.

7. CONCLUSIONS.

EC2000 is an ambitious project since it brings together eight building teams all of whom have their own working methods, financial systems, normal practices, etc. The design and construction of non-domestic buildings, particularly those of novel design, requires input and eventual agreement between many people who often have different and conflicting requirements to satisfy. With the last EC2000 building starting on site in May 1997, the whole process of design, modeling, agreement, construction, occupation and monitoring will be set for completion. There are many important results and conclusions to drawn from EC2000, at many levels and these are starting to come out.

Firstly, the interaction of the design teams of the EC2000 buildings and the experts at the design Workshops, has helped greatly to improve designs, exchange ideas and promote understanding of how low energy buildings can be made to operate successfully. This understanding is a important part of the information contained in the Information Dossiers.

Secondly, the design phases and modelling have indicated that the principles of EC2000 (50% energy saving with full comfort) can be achieved in design, as long as there is cooperation between team members, reasonable flexibility to make changes to original concepts, available finance, experienced and competent energy designers, some flexibility in design standards and a general willingness to explore new options.

Thirdly, the importance of the commissioning phase to set up the building and controls to operate according to the design, has been demonstrated. There are many potential "pit-falls" between the detailed design and the correct functioning of the energy systems, including incorrect programming of the BEMS, misunderstanding of the systems by building operators, malfunctioning of mechanical systems, lack of education and understanding by occupants and users. The first stage of the monitoring is likely to show up problems but these must be expected and solved before full monitoring starts.

Fourthly, the first completed monitoring phase of an EC2000 building, Anglia Polytechnic University, shows that energy predictions have been substantiated in practice and that when the systems are operating correctly, comfort conditions will be good. Monitoring of the other buildings is starting and will hopefully show similar results.

Acknowledgments.

Funding for EC2000 comes from the European Commission THERMIE Programme, which was approved in 1993/4.

References.

1. BREEAM / New Offices, Version 1/93. Building Research Establishment, Garston, Watford, UK.
2. Other publications mentioned (as they become available) obtainable from the EC2000 coordinators.