NATVENT - EUROPEAN PROJECT ON OVERCOMING TECHNICAL BARRIERS TO LOW-ENERGY NATURAL VENTILATION

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Summary
This paper describes the objectives and research methodology of a 30-month research project carried out under the European JOULE programme with the involvement of seven countries with cold or temperate climate. The project aims to contribute to reducing energy consumption and consequent CO_2 emission in buildings by overcoming barriers preventing the wider uptake of technologies for natural ventilation (NV) and low-energy cooling and encouraging and accelerating environmentally-friendly natural ventilation and 'smart' controls as a main design option. The paper provides an overview of the work programme and the methodology adopted for the various research steps and describes the approach of the technical tasks. It also identifies the dissemination routes and the anticipated benefits to the construction industry and the environment.

1. INTRODUCTION

Increased concern over the adverse environmental impact of energy use has encouraged the design and construction of energy efficient buildings, most of which are suited to natural ventilation. Such buildings can provide year-round comfort, with good user control, at minimum capital cost and with negligible maintenance. Current concerns and ethos have produced a climate conducive to the take-up of such a strategy. However, despite this, investors still feel that air conditioning is necessary for many buildings. Many believe that increased heat loads (resulting from wider uptake of computers and office machinery) and intrusion of outside noise, air pollution and dirt makes it necessary to have air conditioning.

The NATVENT project addresses this challenge by providing appropriate natural ventilation technology and guidance for designers of office and institutional buildings who may otherwise contemplate an air-conditioned solution. The 'market' requires confidence that generalised and tested solutions are available to overcome the technical barriers before there can be any significant move towards natural ventilation in new buildings or major refurbishment. It has to be emphasised that successful natural ventilation is not an easy task for designers and, like other aspects of passive environmental design, has much more impact than air-conditioning solutions on the architecture of the building.

Three work packages form the basis of the project. The first will identify perceived barriers through an in-depth study among leading designers, architects, building owners and occupants in seven European Union (EU) countries. The second will monitor environmental and performance parameters of buildings in these countries to provide case studies. The third will develop 'smart' NV technology systems and component solutions to overcome the barriers identified. This project is intended for both new-designs and major refurbishment.

2. TECHNICAL TASKS

2.1 Identifying perceived barriers

It is important to identify the barriers seen by the decision makers e.g. designers, architects, consultants and building owners which restrict the implementation of natural ventilation systems and lead to the decision to install mechanical systems when it may not be strictly necessary. The perceived barriers will be identified in an in-depth study with structured interviews based on questionnaires among leading designers, architects, consultants and building owners or developers in each of the participating countries.

Two types of interviews will be performed:

- interviews focusing on general knowledge, viewpoints, experience and perceived problems with natural ventilation systems in office type buildings
- building project specific interviews concerning the decisions actually taken in the design or refurbishment of office type buildings

The results from the interviews in each country will be compared to identify common issues in implementing natural ventilation systems and to gain experience from each others solutions.

2.2 Performance of naturally ventilated buildings

The aim of this part of the project is to evaluate the performance of existing ad-hoc buildings designed and constructed specifically as energy-efficient naturally ventilated buildings. The main output will be a case-study book identifying the strengths, shortcomings and conflicts of existing natural ventilation together with a video promoting natural ventilation where appropriate.

Initially, the various performance parameters of a building required to be evaluated in the framework of the project will be identified (eg. energy, thermal, acoustical, visual comfort, indoor air quality, maintenance and aesthetics). Cost effective and pragmatic measuring procedures and protocols will be developed for evaluating the indoor environment and energy performance parameters of the buildings. About 20 buildings will be selected for the basic study in which the testing of these procedures will be carried out including interviews among building facility managers and users. Monitoring is likely to be carried out three times during a year; in the winter, the summer and the intermediate seasons.

2.3 'Smart' technology systems and components

The aim of this work package is to develop 'smart' technology systems and component solutions to the conflicts and shortcomings identified by the case studies and the survey. These solutions will be based on laboratory tests, field measurements and simulation studies. It is intended to provide practical solutions to some of these barriers and test their robustness to building construction methods, internal loads and climatic conditions and provide guidelines for their integration with the building and other environmental services.

This part of the project will provide a guide book for energy-efficient natural ventilation applications. This will be aimed at architects and engineers and will have, as one of its aims, the objective of convincing decision makers of the virtues of natural ventilation. A computer design tool will be produced and 'tuned' to evaluate natural ventilation strategies in office-type buildings. The program will address integration of 'smart' natural ventilation components in the building to provide year-around comfort.

Within this sub-programme, five activities will explore specific problems presently thought to be major obstacles in applying natural ventilation in office buildings:

Air and noise pollution in urban areas

At present, vehicle exhaust, other air pollution sources and external noise are seen as a barrier to the general application of natural ventilation in urban areas. To be acceptable, the air supplied internally must be of a sufficiently high quality. Similarly, the levels of external noise internally must be acceptable. The solutions to these problems are likely to be achieved through special filtration and acoustic treatment methods capable of interfacing with other components to achieve optimum comfort conditions.

Provision of 'constant' fresh air

Ventilation provision through natural means depends on external climatic conditions. Changes in wind speed, direction and temperature affect the amount of fresh outside air coming in through openings. An important aspect of natural ventilation design is, therefore, to provide the 'correct' amount of ventilation for occupants in a consistent and robust manner and be relatively independent of short-term external weather fluctuations.

Heat recovery from natural ventilation

Traditional heat recovery systems have high pressure drops. They, therefore, depend on mechanical ventilation systems with high electrical energy consumption for fans. Natural ventilation without heat recovery systems, especially in cold climates, may result in unacceptably high energy consumption. The concept of natural ventilation heat recovery systems will provide the benefits of heat recovery combined with the potential application of natural ventilation in adverse conditions as well as enhancing the internal environment provided in more moderate climates.

Night cooling

Night cooling requires high ventilation rates to effectively cool down the building during the night with relatively colder outside air. This requires a proper design of the ventilation system. Large controllable openings strategically positioned in the façade are needed and in some cases assisting fans could be used. Night cooling with natural ventilation needs predictive control, not only to avoid the risk of overcooling, but also to gain the highest profit from the cooling effect of the colder outside air. At present, design tools and hardware devices to promote night-time ventilation for this type of cooling are not well established and it is the aim of this project to provide such tools.

Integration of systems including reliability and maintenance

Natural ventilation is part of a dynamic system comprising the building and the climate around it. Guidelines for natural ventilation design must therefore be based on experience of the total behaviour of the building and its environment under different climatic exposures and user loads. Good natural ventilation design must integrate the design work of many different systems that work more or less independently of each other. Therefore, it is essential that those involved in building and ventilation design have access to good guidelines if an integrated design procedure is to be feasible, and hence optimise the building's performance. It is anticipated that this project will provide such guidelines.

3. ANTICIPATED BENEFITS

Economic impact

Nearly half of the EU's energy is accounted for in buildings and it is estimated that, of this, about a third is used in non-domestic buildings. The major consumers are those in the **heating-season countries**, i.e. those countries with either moderate or cold climates. It is estimated that these countries comprise about 90% of the total floor area of non-domestic buildings (both public and commercial) in the EU.

Space-heating accounts for about 60% of energy-consumption by end use [1]. Of this, ventilation accounts for 40% and air conditioning (with associated refrigeration and fan power) accounts for another 14%. It can then be estimated that within EU heating-season countries, annual ventilation-related energy consumption accounts for about:

- 57 million tonnes of oil equivalent
- 250 million tonnes of CO_2 emission

Naturally ventilated buildings can typically consume less than half the delivered energy consumed in air-conditioned buildings [2]. Recent estimates suggest that cost-effective energy savings of the order of 20-30% are achievable in office buildings, with evidence of greater savings for major refurbishment projects at some sites. Designing for energy-efficient natural ventilation in new buildings or in major refurbishment (and avoiding the need for air conditioning wherever possible) has the potential to lead to significant reductions in the energy consumed, the CO_2 emitted and avoidance of ozone-depleting refrigerants. A realistic saving of 10% then has the potential to save every year:

- 6 million tonnes of oil equivalent
- 25 million tonnes of CO_2 emission.

However, at the level of individual buildings, there are other economic benefits:

- initial capital cost of naturally ventilated buildings are cheaper in terms of HVAC (heating, ventilating and air conditioning) systems by about 15%. The costs are also different over different time periods since the life of a mechanical plant is usually much less (about half) than the life of the building.
- reduced HVAC system space requirement in naturally ventilated buildings will require less space for plant rooms and service distribution routes
- operating costs of a naturally-ventilated building are typically about 40% less in terms of energy costs than an equivalent (in terms of occupancy and planning) air conditioned building. The maintenance cost is also considerably less - e.g. about 2.5 ECU/m^2 for non air conditioned buildings compared with 10 ECU/m^2 for air conditioned buildings.

Social impact

Today's building user increasingly demands a high quality of the environment in which to work. In a growing service-based economy, commercial success is even more dependant on people. It is therefore a commercial requirement that the working environment meets the needs and aspirations of the occupants.

Over recent years, there has been much debate about the 'sick-building syndrome'. The potential social cost cannot be easily quantified. However, this is of real cost concern because of its impact on staff productivity and absenteeism. Although conclusive evidence is lacking, there is a perception that the prevalence of such conditions is less in buildings that are naturally ventilated than those that are air conditioned. This may be a consequence of fresh air rates in summer being higher in naturally ventilated buildings. This may improve air quality, and combined with the greater potential for individual control, could provide greater occupant satisfaction.

In addition, recent findings [3] showed that the most comfortable naturally ventilated buildings tended to be the most energy efficient. It has been noted that staff satisfaction and comfort could also be linked to better health and productivity. 'Virtuous clusters' tend to emerge, where comfort, control, productivity and energy efficiency all went together and were all positively associated.

Environmental impacts

Member states of the EU have recognised the need for sustainable development. Consequently, building design must seek to satisfy the needs of today's users without leaving a legacy of problems for the next generation.

Buildings and building-services have a number of long term impacts on the environment. There are three key elements:

- use of energy for heating and cooling
- gaseous emissions, in particular CO_2, which contribute to the so-called 'greenhouse' effect
- emissions of ozone-depleting substances from refrigeration systems used in the cooling of buildings

Natural ventilation can make a positive contribution to a sustainable environment by reducing electrical energy use for cooling, and reducing or even eliminating the need for refrigeration in buildings. Well designed provision of ventilation through natural means not only reduces the need for electrical energy to drive chillers but, even more significantly, reduces the reliance on fans and motors. The general arrangement of naturally-ventilated buildings usually helps in increasing the use of daylight thereby minimising electrical costs still further.

4. CONCLUSIONS

The NATVENT project is a collaboration between nine organisations in seven central and north European countries, funded by the EC JOULE programme and national programmes. The UK part of the study is sponsored by the DOE's Construction Directorate through the Partners in Technology (PiT) Programme. The project aims to identify the perceived barriers restricting the application of low energy ventilation in office type buildings, evaluate the performance of existing buildings utilising low energy ventilation and suggest ways of overcoming the barriers by producing technical solutions to specific problems.

Widespread dissemination is considered a key activity within the project. Over the 30-month duration of this project, this will take the form of reports, conference and journal papers. The final products will be a book of case studies, a video to promote natural ventilation, a natural ventilation guidebook and a computer based design tool.

5. ACKNOWLEDGMENTS

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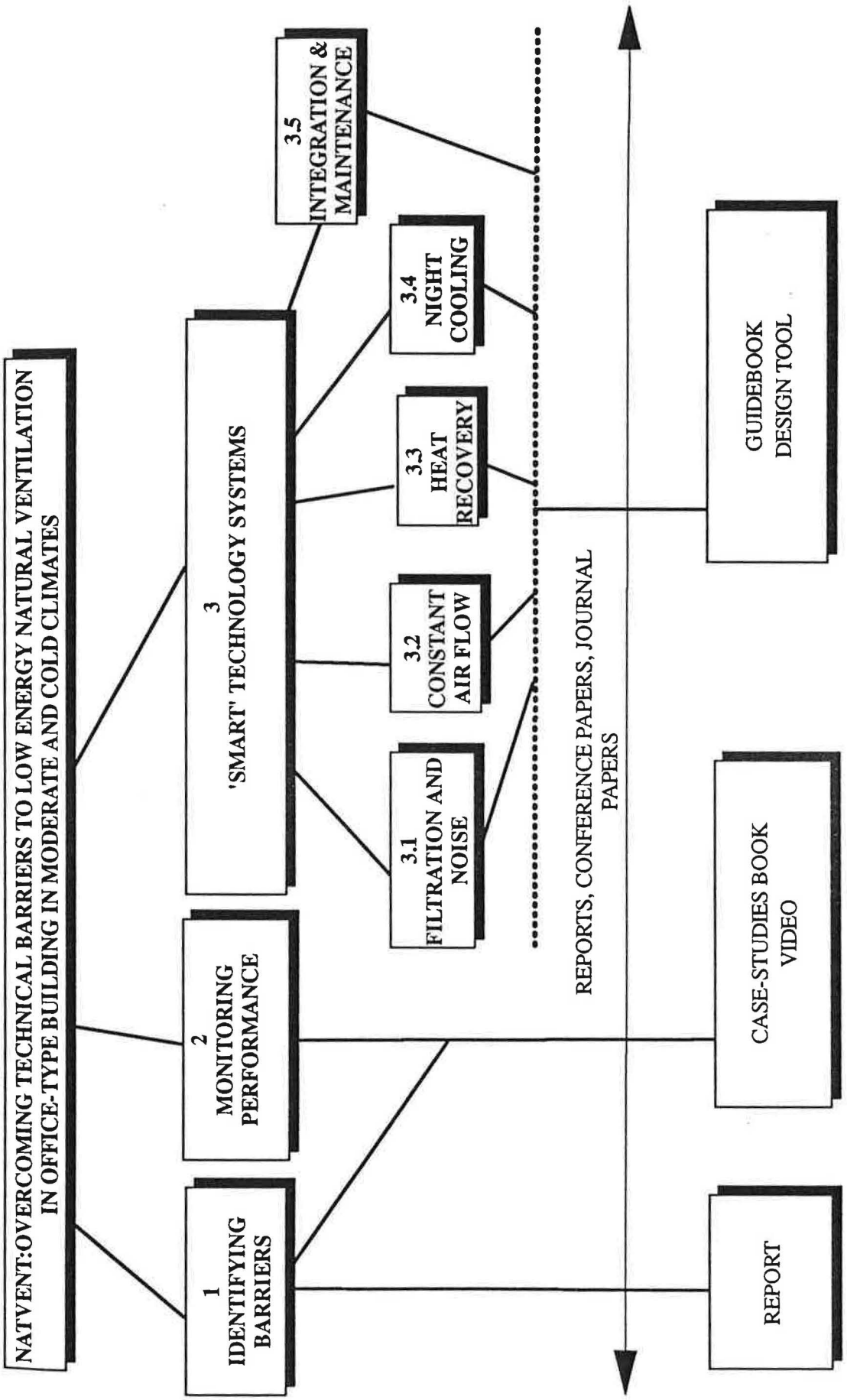

Figure 1: Project Structure Chart

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