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NatVent™: Aims and Vision

V Kukadia and M D A E S Perera

Building Research Establishment Ltd
Garston
Watford
Hertfordshire
WD2 7JR
UK

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ABSTRACT

This paper gives an overview of the EC NatVent™ project on 'Overcoming Technical Barriers to Low Energy Natural Ventilation in Office Type Buildings in Moderate and Cold Climates' which has been carried out under the European Commission Joule Programme 1994-98. The project was targeted at countries with low winter and moderate summer temperatures where summer overheating from solar and internal gain can be significantly reduced by low-energy design and good natural ventilation. In addition, the project addressed natural ventilation solutions to buildings located in urban areas where external air pollution and noise levels are usually regarded as being high. In this paper, the background to the project together with the objectives have been outlined and a brief account of the various research areas studied, solutions provided and products resulting from each area have been given.

1. BACKGROUND

Concerns over the adverse environmental impact of high-energy usage required for mechanical ventilation and air-conditioning have been growing over recent years. As a result, the design of energy efficient buildings employing natural ventilation strategies has been encouraged.

Natural ventilation is not just about openable windows. It is rather a holistic design concept, which according to Cook and McEvoy (1996) is now being used in the architectural design of large offices and other building types. Design is centred on using passive ventilation, based on the 'stack' (temperature) effect and wind pressure differentials, to supply fresh air to building interiors even when the windows are closed. As part of this process, designs incorporate atria or internal stairwells which, in some instances, use low-energy fans to provide 'assisted natural ventilation' (ie low-energy ventilation).

Buildings incorporating such strategies can provide year-round comfort, with good user control, at minimum capital cost and with negligible maintenance. In addition, naturally ventilated buildings can typically consume less than half the energy consumed in air-conditioned buildings. It is estimated that even a modest 10% take up of these strategies could save about six million tonnes of oil equivalent and 25 million tonnes of avoided CO_2 emissions every year within the EU. In addition, a survey (Ellis, 1994) carried out in the UK a few years ago, concluded that 90% of senior management preferred buildings without air-conditioning. Making the best use of natural ventilation and daylighting were at the top of the occupiers' most important design features in both urban and out-of-town offices.

However, despite this many investors have felt that air-conditioning is still necessary for many buildings, in particular where there is an increase in heat load (for example, from computers and office machinery) and in areas where there is an intrusion of external air and noise pollution. At an Experts' workshop in January 1995, the European Network of Building Research Institutes (ENBRI) working group on environmental issues identified solutions to these problems as one requiring priority action. Arising from this and other decisions, the NatVent™ project on 'Overcoming Technical Barriers to Low Energy Natural Ventilation in Office Type Buildings in Moderate and Cold Climates' was set up within the EC Joule Fourth Framework Programme 'Rational Use of Energy in Buildings'. The main action was to address the above issues, provide natural ventilation solutions and carry out effective dissemination.

2. OBJECTIVES OF NatVent™

The main objective of this pan-European project was to reduce primary energy consumption (and consequently CO_2 emissions) in office type buildings without compromising indoor air quality and comfort. This main objective has been achieved through two specific objectives:

- To identify and overcome technical barriers which restrict the implementation of natural ventilation and low-energy cooling in countries with moderate and cold climates.
- To provide practical solutions and guidance and thus encourage the wider uptake of natural ventilation technologies.

The project targets countries with low winter and moderate summer temperatures (i.e. Central and Northern European countries) where summer overheating from solar and internal gain can be significantly reduced by low-energy design and optimum natural ventilation. An additional priority was to develop natural ventilation solutions to buildings in urban areas where external air pollution and noise levels are regarded as being high. The project was aimed at both new-designs and major refurbishments.

3. The NatVent™ Consortium

The NatVent™ Consortium consists of the following:

- Building Research Establishment (BRE) from the United Kingdom as the overall Co-ordinator of the project.
- Belgian Building Research Institute (BBRI)
- Danish Building Research Institute (SBI)
- Dutch Building Institute (TNO)
- AB Jacobson and Widmark (J&W) from Sweden
- Technical University of Delft (TUD) from The Netherlands
- Willan Building Group (WILLAN) from the UK
- Norwegian Building Research Institute (NBI)
- Sulzer Infra Laboratory (SULZER) from Switzerland

All Consortium members are at the forefront of current ventilation technology and most are involved in national and CEN activities (developing codes and regulations). The vision of the Consortium was for NatVent™ to play a catalytic role in promoting common natural ventilation strategies and technologies within the European Union.

4. KEY TECHNICAL ACTIVITIES

The above objectives have been addressed by carrying out the key technical activities as shown in Figure 1.

Activity 1: Identification of technical barriers to natural ventilation

This activity was led by the Danish Building Research Institute (SBI) with the aim of identifying perceived barriers as seen by building professionals that restrict the implementation of natural ventilation and lead to the decision to install mechanical ventilation systems. Barriers were identified by carrying out in-depth structured interviews based on questionnaires among leading designers, architects, consultants, building owners and developers in each of the participating countries. A European-wide questionnaire was produced with input from all nine Partners within the NatVent™ consortium. In total about 105 interviews in the seven countries were carried out.

The survey identified that, with varying degrees, there is a significant lack of knowledge and experience on specially designed natural ventilation strategy in office buildings compared with that on mechanical ventilation. In addition, there is a lack of source material on natural ventilation knowledge in standards, guidelines and building studies throughout Europe. There was also a universal requirement for new design tools on natural ventilation including calculation rules as well as computer programs, which are numerically advanced but still simple to use by the non-specialist. As a result of this activity, a number of published papers and reports have been produced comparing country specific barriers as well as common barriers amongst the participating countries (Aggerholm, 1998).

Activity 2: Monitoring the performance of buildings.
The Belgian Building Research Institute (BBRI) and Sulzer Infra Laboratory (SULZER) led this activity. Its aim was to establish pragmatic innovative design strategies by monitoring the performance of existing low-energy buildings and providing case studies of current best practice. It is recognised that ultimately it is important to demonstrate the viability of natural ventilation in both performance and competitiveness if it is to succeed in the market place. Therefore, performance criteria and cost are important parameters when choosing between natural ventilation and alternative solutions.

To this end, cost effective and pragmatic measuring procedures and protocols were developed and used to evaluate the performance of existing ad-hoc buildings that were designed and constructed specifically as energy-efficient naturally ventilated buildings. Nineteen buildings within the seven EU countries were monitored in detail during the winter and summer periods (Ducarme, 1996). Figure 2 shows that the buildings cover a wide spectrum of shape and size yet they all use low-energy ventilation technology.

During monitoring, parameters such as room temperatures, humidity, carbon dioxide levels and ventilation rates were measured. In one building that was located in a highly polluted area, levels of pollutants such as carbon monoxide and traffic noise were also monitored.

Possible shortcomings and advantages from the ventilation strategies used during the summer and winter monitoring periods were identified. At its most basic level, for example, some users experienced difficulty in operating or understanding the control strategy. In general, these problems have mostly been such that they can easily be rectified. However, it is important that these experiences are disseminated to designers to prevent future problems in other buildings. Therefore, recommendations for achieving overall successful natural ventilation in buildings have been identified and short summary reports as well as a major detailed report on the findings have been produced. In addition, details of all the monitoring activities together with the results and recommendations are also available on the NatVent™ CD-ROM. Further details of this activity may be found in Demeester (1998)

Activity 3: Providing solutions to technical issues.
This third activity co-ordinated by BRE, was aimed at developing 'smart' naturally ventilated technology systems and component solutions to overcome the technical barriers identified in

Activity 1. This was done through the following five key tasks:

(i) ***Low-energy air supply components for use in buildings in urban locations.***
This task was led by the Willan Building Services. Its aim was to develop components and strategies for natural ventilation in non-domestic buildings located in urban areas with high external pollution and noise loads.

As part of this work, existing systems have been evaluated and current standards, performance and specifications compiled. A checklist has been developed which summarises all the pollution problems attributed to urban areas to provide guidance on the location of inlets and outlets. In addition, a spreadsheet based design tool has been developed that determines adequate air inlet sizes depending upon the ventilation requirements for a building. A low pressure drop inlet which is capable of damping noise levels and filtering particles has also been developed. In addition, a number of publications on this work have produced. Further details of this activity may be found in Ajiboye (1998).

(ii) ***Controlled airflow inlets to account for variability in weather.***
This area has been led by the Dutch Building Research Institute (TNO) with the aim of identifying and specifying conditions under which newly-developed natural ventilation 'smart' controlled air flow inlets can provide acceptable indoor air quality for occupants' health and comfort in offices.

Natural ventilation depends upon external climatic conditions and therefore changes in the wind speed, direction and temperatures affect the amount of fresh air which flows through the openings. An important aspect of a controlled airflow strategy is thus to provide an optimum quantity of fresh air for occupants in a manner that is generally independent of short-term external weather fluctuations.

To ensure a controlled flow rate, especially during the winter, when high driving forces could result in excessive heat loss, usually require active and quite complex control strategies. As an alternative, 'passive' vents have been developed which provide a measure of pressure independent flow without the need for mechanically controlled actuators. The breakthrough has been the development of vents that operate at extremely low driving pressures of a few Pascals (say upto 20 Pa). Such a device has been developed under this activity. In addition, to demonstrate their viability, an interactive user-friendly software program was developed. This gives visual indication of ventilation, air quality and thermal parameters for many ventilation and weather configurations. Further details of this activity may be found in De Gids (1998).

(iii) ***Natural ventilation with heat recovery.***
This task was led by the Norwegian Building Research Institute (NBI). Its aim was to develop natural ventilation systems with heat recovery. In very cold climates, an acceptable assumption is that natural ventilation without heat recovery could result in unacceptably high consumption of energy. Therefore, natural ventilation systems with heat recovery provides an energy efficient system for the colder climates where traditionally mechanical ventilation (with high energy consumption fans) has been

used to overcome the high pressure drops associated with such systems.

The study here has included determining the distribution of available driving pressure at key locations within each participating country. An advanced low-energy fan assisted natural ventilation system with heat recovery has been developed. The fan is extremely energy efficient and consumes approximately 0.25W for each l/s of air flowing through the system. Further details of this activity may be found in Brunsell et al (1998).

(iv) ***Low-energy cooling***

The Dutch Technical University of Delft (TUD) led this task to develop low-energy cooling strategies. An important aspect of natural ventilation design is to prevent the need for refrigerative cooling. In much of Northern Europe, excessive external temperature and humidity rarely present a problem. Instead, buildings tend to overheat as a consequence of high internal heat loads and solar gains. Hardware and control algorithms have been developed to minimise these problems.

The control strategy for night cooling has focused on:

- predictive control;
- cooling day control;
- set-point control;
- slab temperature control;
- degree-hours control.

Hardware window prototypes for controlled night cooling have been developed. Associated with this is a graphical tool for designing effective window openings. Further details of this activity, its findings and products may be found in van Paassen and Leim (1998).

(v) ***Integration of 'smart' systems for optimum year-round performance.***

This area was led by AB Jacobson and Widmark. A simple but reliable design tool, integrating all the elements of NatVent™ was developed so that an optimum solution for any building could be found. Key features in the design tool included the following:

- driving forces (wind and temperature);
- air flow through components;
- solar radiation; and a
- thermal model.

These components have been incorporated into a visual basic model with a simple user interface. Behind this is an extensive numerical database and pre-selected default data. Output includes air change rate, heat losses and related data. Further details may be found in Kronvall et al (1998).

5. DISSEMINATION ACTIVITIES

Effective and widespread dissemination and communication of the results has been a key activity in the NatVent™ project. Results have been disseminated to a wide spectrum of the construction industry, to building designers, architects, researchers and services engineers through national and international conferences and workshops. Successful workshops in all the participating countries have been held and a network of European architects has been established to provide advice to the Consortium. A conference on NatVent™ (Kukadia, 1998) has also recently been held. Further dissemination activities are being carried out through publication of the NatVent™ Guide, CD-ROM and various design tools.

6. PRODUCTS FROM THE PROJECT

The following is a summary of the products that are available from the project:

- Individual country reports on Technical Barriers
- European report on Technical Barriers
- Building case studies reports
- Design tools
  - Spreadsheet based tool for the determination of inlet size and location
  - An interactive user-friendly algorithm which gives visual indication of ventilation, air quality and thermal parameters
- Components
  - Inlet which is acoustically treated and deals with particle attenuation
  - Controlled air flow inlet to compensate for the variations in external climate
  - Low pressure heat recovery system
  - Night cooling devices and controls
- NatVent™ Guidebook
- CD_ROM: This contains all the details about the project and its participants, full information about and reports on all the technical areas covered, design tools and also information on hardware developed from the project.

7. CONCLUSIONS

The aim of the NatVent™ project was to reduce primary energy consumption by overcoming the technical barriers that prevent the implementation of natural ventilation in countries with moderate and cold climates. This has been achieved by providing solutions and disseminating the results to a wide audience in order to encourage and accelerate the use of low energy ventilation systems as the main design option.

NatVent™ has been successful in identifying the technical barriers that exist amongst building professionals. It has established innovative design strategies by monitoring existing low-energy buildings throughout Europe and thus provided case studies of current practice with recommendations. It has provided the following technological solutions to the issues identified in the project:

- A low pressure drop inlet for attenuating external air and noise pollution in urban areas together with a design tools for the sizing and location of inlets.
- A very low pressure drop vent with controlled incoming air flow to account for variable external weather conditions.

- A low energy fan assisted system to recover heat for use in the colder climates
- Hardware window prototypes and control algorithms for controlled night cooling to minimise summer overheating.
- A simple design tool integrating all the elements of NatVent™ giving an optimum solution.

In particular, NatVent™ has contributed significantly to the dissemination of results and promoting the use of natural ventilation strategies throughout the participating countries. As a result, it has raised the interest in many of the EU countries who are now looking at low energy ventilation technology as a first design option.

Therefore, in conclusion, it is our view that NatVent™ has combined 19th and 20th century strategies with late 20th century technologies to provide low-energy ventilation for the new millennium.

7. REFERENCES

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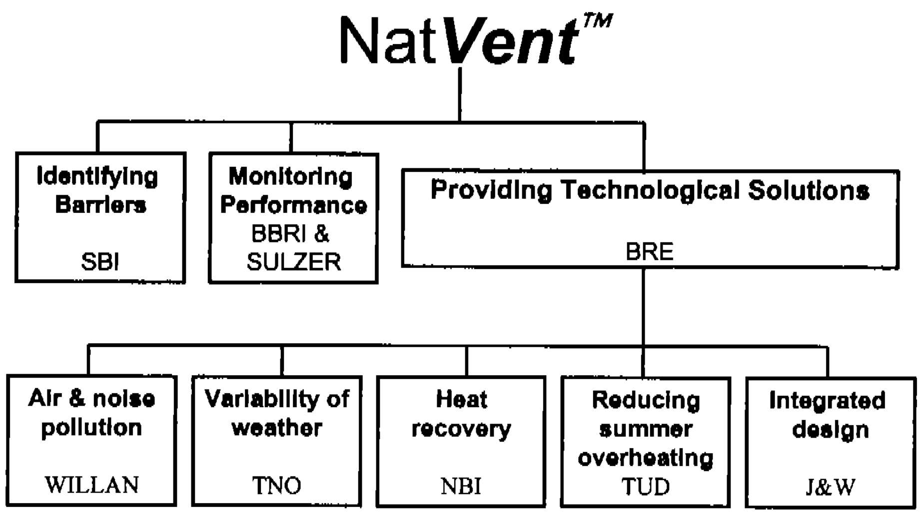

Figure 1: Overview of activities for the NatVent™ project.

Figure 2. NatVent™ Monitored Buildings