Annex 35: Hybvent

Hybrid ventilation in new and retrofitted office buildings

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Presented at BCS-SHC Joint Meeting, Port Douglas, November 3-4, 1997

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DECEMBER 1997 ISSN 1395-7953 R9749

Printed at Aalborg University

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ANNEX 35
HYBVENT - HYBRID VENTILATION IN NEW AND RETROFITTED OFFICE BUILDINGS

by

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DESCRIPTION

The Annex was accepted at the ExCo Meeting in Washington June 1997. The first year, starting August 1 1997, is a preparatory year. A project definition workshop has been held in Aalborg, Denmark, in October 1997 with 24 participants from 15 countries: Australia, Canada, Denmark, Finland, France, Germany, Italy, Norway, Poland, Portugal, Sweden, Switzerland, The Netherlands, United Kingdom, USA.

Background

Soon after the energy crisis in 1973 everybody focused their attention on thermal insulation, airtightness of buildings and heat recovery to decrease energy consumption for heating (and cooling) of buildings. Buildings were designed to be isolated from the outdoor environment with an indoor environment controlled by artificial lighting, mechanical ventilation and heating and cooling systems.

Today, in the design of new buildings and retrofit of old buildings, the attention has been turned towards a more integral energy design with focus not only on thermal insulation, airtightness and heat recovery but also on optimal use of sustainable technologies as passive solar gains, daylight and natural ventilation. The buildings are designed in an interplay with the outdoor environment and are utilising it to create an acceptable indoor environment whenever it is beneficial.

The extent to which sustainable technologies can be utilised depends on outdoor climate, building use and building location and design. Under optimum conditions sustainable technologies will be able to fulfil the demands for heat, lighting and fresh air, while in some cases supplementary mechanical systems will be needed and in other cases it will not be possible to use sustainable technologies at all.

In well thermally insulated office buildings, which are more and more frequent in IEA countries, ventilation (and cooling) account for more than 50% of the energy requirement, and a well-controlled and energy-efficient ventilation system is a prerequisite to low energy consumption. Natural ventilation and passive cooling are sustainable, energy-efficient and clean technologies as far as they can be controlled, (that is if well modelled and understood). They are well accepted by occupants and should therefore be encouraged wherever possible.

Unfortunately, the design of energy-efficient ventilation systems in office buildings is often turned into a question of using either natural ventilation and passive cooling or mechanical ventilation and cooling. This prevents a widespread use of sustainable technologies because a certain performance cannot be guaranteed under all conditions. In fact in the large majority of the cases a combination of systems, hybrid ventilation, would be beneficial depending on outdoor climate, building design, building use, and the main purpose of the ventilation system.

The number of office buildings to be retrofitted in most IEA countries is now much larger than the potential for new buildings. In many cases there is a large potential for use of sustainable technologies either as a supplement to the existing mechanical systems or as the main part of solutions in cases where classic ventilation systems are impossible to install in an existing building. Innovative hybrid ventilation systems should be developed or improved for that purpose.

Hybrid Ventilation

Hybrid ventilation systems can be described as systems providing a comfortable internal environment using both natural ventilation and mechanical systems, but using different features of the systems at different times of the day or season of the year. It is a ventilation system where mechanical and natural forces are combined in a two mode system. The basic philosophy is to maintain a satisfactory internal environment by alternating between these two modes to avoid the cost, energy penalty and consequential environmental effects of full year round air conditioning. The operating mode changes with the seasons, and within individual days, such that at any point in time the current mode reflects the external environment and takes maximum advantage of ambient conditions.

Hybrid ventilation should dependent on building design, internal loads, natural driving forces, outdoor conditions and season fulfil the immediate demands to the indoor environment in the most energy-efficient manner. The control strategies for hybrid ventilation systems in office buildings should maximise the use of ambient energy with an effective balance between the use of advanced automatic control of passive devices and the opportunity for users of the building to exercise direct control of their environment. The control strategies should also establish the desired air low rates and air flow patterns at the lowest energy consumption possible. Figure 1 shows the definition of hybrid ventilation as agreed on in the Annex 35 project definition workshop.

Definition of Hybrid Ventilation

Hybrid Ventilation is a two mode system which is controlled to minimise the energy consumption while maintaining acceptable indoor air quality and thermal comfort. The two modes refer to natural and mechanical driving forces.

Purpose of Ventilation

All hybrid systems have to provide air for indoor air quality purposes, but some in addition to that also provide air for thermal conditioning and thermal comfort during working hours.

Purpose of Control System

The purpose of the control system is to establish the desired air flow rate and air flow pattern at the lowest energy consumption possible.

Figure 1. Definition of hybrid ventilation in Annex 35.

Objectives

The Annex 35 research project is aiming at a better knowledge of hybrid systems and focusing on development of control strategies and performance prediction methods for hybrid ventilation in new and retrofitted office buildings. Its main objectives are:

- to develop control strategies for hybrid ventilation systems in new and retrofitted office and educational buildings
- to develop methods to predict ventilation performance in hybrid ventilated buildings
- to select suitable measurement techniques for diagnostic purposes to be used in buildings with hybrid ventilation systems
- to promote energy and cost effective hybrid ventilation systems in office and educational buildings

Strategy and Approach

To fulfil the objectives the work is divided in the following tasks:

A) State-of-the-art review of hybrid ventilation, control strategies and algorithms.

B) Development of control strategies for hybrid ventilation in new and retrofitted office buildings.

C) Development of decision tool for hybrid ventilation applications.

D) Implementation and demonstration of hybrid ventilation.

E) Reporting.

An overview of the approach can be seen on figure 2, which is showing a matrix of annex tasks and the research methods that will be used.

Task	Research Method		
	State-of-the-art Review	Theoretical and Experimental Studies	Pilot Studies
Development of Control Strategies	• Survey of existing strategies • Local versus central control	• Requirements and evaluation criteria for control strategies • Switching between ventilation modes • Combination of automatic and manual individual control • Control system design	• Demonstration of control strategies
Development of Decision Tool	• Survey of available tools	• Better understanding of hybrid ventilation, air flow control • Integration of air flow and thermal simulation models • Development of probabilistic approach	• Application of analysis and decision tools
Implementation and Demonstration of Hybrid Ventilation	• Survey of existing systems and solutions to specific problems • Market survey on components • Survey on building codes	• Analysis of hybrid ventilation components • Analysis of barriers for hybrid ventilation • Analysis of cost-benefits	• Demonstration buildings • Technology transfer

Figure 2. Approach of Annex 35 divided into different tasks and research methods.

"State of the art" review

A state-of-the-art review of the potential and usefulness hybrid ventilation systems will be carried out. The review will among other things focus on the impact of differences in climate (including seasonal differences as winter heating and summer cooling), building design, building use and internal loads on energy performance, indoor air quality and comfort. The review will provide examples of existing systems and show solutions to specific problems (fresh air supply, excess heat removal, etc.) in a particular building located in a certain outdoor climate.

The review will include a study of the existing office building stock in each participating country and will classify it according to its potential for hybrid ventilation. In this way the viability of hybrid ventilation systems in both new and retrofitted buildings can be demonstrated.

A market survey will be carried out on commercially available ventilation components. In addition, a review of control strategies and algorithms being used in hybrid ventilated buildings will be carried out together with a critical view of their integration in the building energy management system (BEMS). A parametric analysis will be carried out to examine the effects of local versus building driven control of the various ventilation components.

Development of control strategies

Integration of sustainable ventilation technologies and classic mechanical systems in a common hybrid ventilation system requires development of new control strategies. By these strategies the hybrid ventilation system should at any time and for a certain combination of internal loads, outdoor conditions and comfort requirements be able to fulfil the immediate demands to the indoor environment in the most energy-efficient manner. The demands to the indoor environment also include the ability of the hybrid ventilation system to create optimum air flows and air flow patterns in the building.

Different control strategies will be developed dependent on climate and main purpose of the ventilation system (indoor air quality, thermal conditioning). The focus of development will be on the problem of switching between natural and mechanical modes and how to establish an effective balance between the use of advanced automatic control and the possibility for users to exercise direct control of their environment.

The cost effectiveness of different ventilation and control strategies will be investigated by comparing capital and operational costs against a typical refurbishment or new build in each participating country.

Theoretical and experimental studies

A better understanding and a better control of the natural ventilation process is a prerequisite for successful hybrid ventilation and can be obtained by theoretical and experimental studies that must go hand in hand.

There do not exist any directly applicable models for analysis of hybrid ventilation. Such analysis models requires an integration of models for air flows and thermal simulation. This will in the annex be achieved by combining existing models and developing the necessary additional modules.

Another possibility is to use a probabilistic approach in the development of analysis models. Such models should be able to predict statistical occurrences of heat and air flow rates as well as contaminant removal efficiency and are models in which data are input together with their uncertainties, and whose output is frequency distributions. The statistical model will be developed by combining physical models of the phenomena involved (air, heat and contaminant transfer, occupant behaviour, meteorological data, interaction between wind, environment and building, etc.) with stochastic models.

In the case of hybrid ventilation it is necessary to take a range of new considerations into account in the analysis. Some of these are: translation of meteorological data from weather stations into urban data, occupant behaviour and perception, pressure distribution on buildings and time-dependent ventilation capacity.

Development of decision tool

In the implementation of hybrid ventilation in office buildings the very first stages of the design process is very important, because a lot of the decisions taken here are very important for the success of hybrid ventilation.

Architects therefore need tools to help them estimate the critical parameters for application of hybrid ventilation, evaluate if hybrid ventilation can be an option and to make the right choices if it is.

Development of a decision tool for hybrid ventilation will be based on theoretical analysis, laboratory experiments and pilot studies.

Implementation and demonstration of hybrid ventilation

Hybrid ventilation is a relatively new concept and an effective way to promote the use of this concept is to implement and demonstrate it in real office buildings.

Therefore, pilot studies will be monitored to collect data on the performance (indoor air quality, thermal comfort, energy consumption, etc.) and environmental impact of hybrid ventilation systems and to evaluate corresponding control strategies. Pilot studies will include both retrofitted and new-built designs in all participating countries to highlight similarities and differences in climatic (including seasonal differences), institutional and cultural (developers and occupants), and technology transfer issues. The pilot studies will concentrate on success stories of hybrid ventilation but will also critically highlight problematic cases and can be a powerful tool to demonstrate to both legislators, developers, brief specifiers and occupants the relative merits of the applicability of hybrid ventilation.

Valuable measurement methods in mechanical ventilation diagnostics are not automatically applicable for natural ventilation systems. Suitable measurement techniques will be selected and refined for these experiments.

Reporting

The state-of-the-art review will be summarised in a report, first in an internal report for use by annex participant and later in a public version. Three additional reports summarising results of the individual tasks will be made.

The report "Principles of hybrid ventilation" will be drafted on the basis of experience gained as well as from previous research (state-of-the-art), from theoretical and experimental studies mentioned above, and from the monitored pilot studies. It will be written for architects and engineers. Therefore, architects should be in the editorial team.

Expected Results

The expected results of the annex are:

- "Principles of Hybrid ventilation", including solutions for efficient, energy and cost-effective hybrid ventilation systems. Recommendations on control strategies
- Analysis tools for predicting the performance of hybrid ventilation. Decision tool for application of hybrid ventilation
- Refinement and recommendations of suitable measurement techniques for diagnostics and commissioning of hybrid ventilation systems
- Demonstration of principles through pilot studies

Annex Beneficiaries

The target audience for "Principles of Hybrid Ventilation" will be both architects and engineers, while the decision tool will be targeted towards architects only.

The reports and developed analysis tools will be available for engineering offices, helping them to provide advice to architects and to design systems.

ANNEX ORGANISATIONAL STRUCTURE AND PROGRAMME PLAN

Figure 3 shows the organisational structure of Annex 35 that was defined at the project definition workshop.

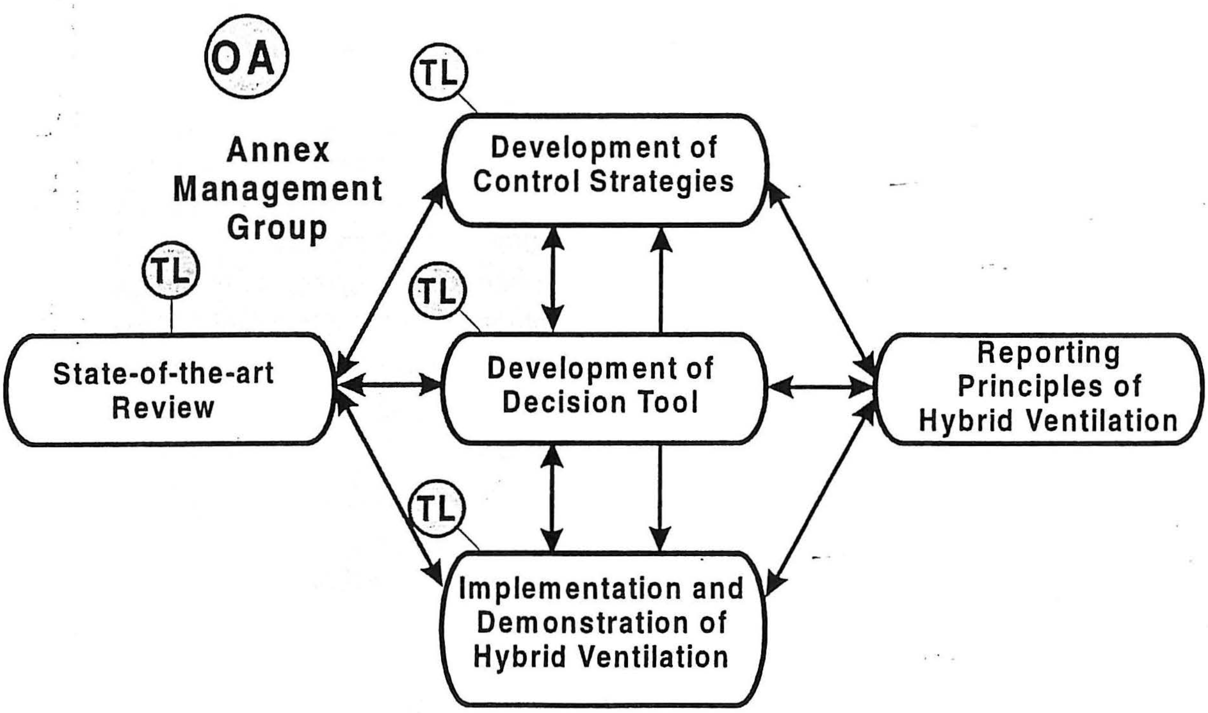

Figure 3. Organisational structure of Anne 35 HybVent

The annex is divided in five tasks with a task leader each except for the reporting task. The operating agent and the four task leaders form the Annex Management Group. In the reporting task different editorial groups will be formed for the different reports.

All countries are required to participate in Task A and in minimum one additional Task of B through D. The minimum level of commitment is to be decided at a later meeting.

Figure 4 shows the Annex timeschedule that was agreed on at the project definition workshop. The three year working phase will begin August 1, 1998 and end July 31, 2001. The reporting phase is scheduled to last one year after the working phase and end July 31, 2002. In this way it is possible to include all results in the reports. At the workshop there was a great concern about the timeschedule for pilot studies. In the case of new build or refurbished buildings planning, construction and a one year measuring period requires tight correspondence between annex and pilot study timeschedules that can be difficult to achieve. Any decisions regarding this are postponed until specific pilot studies are available for the annex.

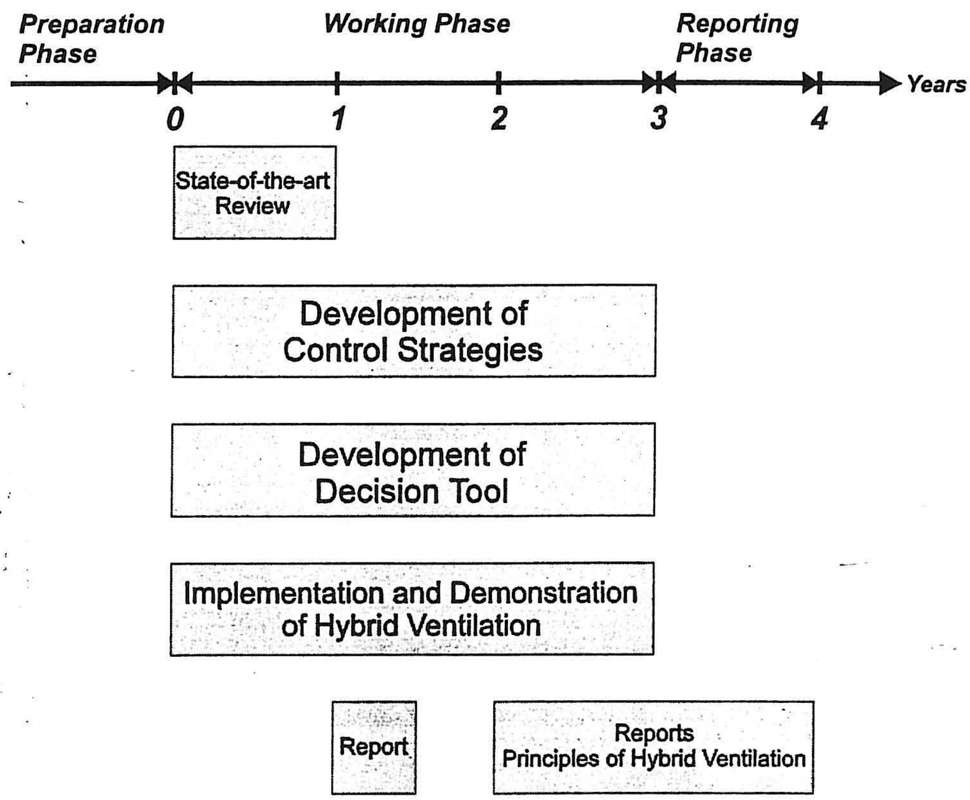

Figure 4. Timeschedule Annex 35 HybVent.

FUTURE ACTIONS

Before the next meeting the OA will make a draft of the annex text (project definition) and a small editorial group will review it. The final draft will be discussed at the next meeting.

As the timeschedule for pilot studies are very tight, it is important to search for suitable projects or buildings and as soon as possible have some available for the annex.

Next meetings

Kick-off Meeting

Location and time: Italy, March 25-27, 1998.

Host: ENEA, Energy Saving Department ERG SIRE, Roma, Mr. Marco Citterio

Objectives:

- Information on Annex 35 for all interested persons; observers welcome
- Presentation of draft of Annex text
- Information on available Pilot Studies
- Nomination of Task Leaders
- Confirmation of Preparation Phase participation

1st Expert Meeting

Location and time: Oslo, Norway, October 2-4, 1998 (After AIVC Conference)
Host: NUST, Norwegian University of Science and Technology, Trondheim, Dr. Per Olaf Tjelflaat.