Outline of HybVent

Heiselberg, Per

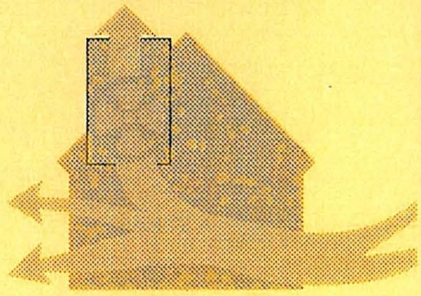
Publication date:
1999

Document Version
Publisher's PDF, also known as Version of record

Aalborg **UNIVERSITY**

Outline of

Outline of HybVent



Per Heiselberg

Paper No 102

Indoor Environmental Engineering

Presented at the First International One Day Forum on
Natural and Hybrid Ventilation, HybVent Forum '99,
Sidney, Australia, September 1999

Printed at Aalborg University

Outline of HybVent

Per Heiselberg

Outline of HybVent

Per Heiselberg
Indoor Environmental Engineering
Aalborg University
Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark
fax: +45 9814 8243
e-mail: ph@civil.auc.dk

1 ANNEX DESCRIPTION

The international project Annex 35 "Hybrid ventilation in New and Retrofitted Office Buildings was accepted by the IEA at the Energy Conservation in Buildings & Community Systems Executive Committee Meeting in Washington June 1997. The first year, starting August 1 1997, was a preparatory year and the four year working phase started August 1998. The Annex have participants from 15 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Norway, Sweden, The Netherlands, United Kingdom and USA.

1.1 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 utilizing it to create an acceptable indoor environment whenever it is beneficial.

The extent to which sustainable technologies can be utilized 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.

1.2 Definitions

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 varies according to the season and within individual days, thus the current mode reflects the external environment and takes maximum advantage of ambient conditions at any point in time. The main difference between conventional ventilation systems and hybrid systems is the fact that the latter are intelligent with control systems that automatically can switch between natural and mechanical mode in order to minimize the energy consumption.

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 maximize 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 Annex 35.

Definition of Hybrid Ventilation

Hybrid Ventilation is a two mode system which is controlled to minimize 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.

1.3 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 build and retrofit of office and educational buildings
- to develop methods to predict ventilation performance in hybrid ventilated buildings
- to promote energy and cost effective hybrid ventilation systems in office and educational buildings
- to select suitable measurement techniques for diagnostic purposes to be used in buildings with hybrid ventilation systems

2 STRATEGY AND APPROACH

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

Subtask A: Development of control strategies for hybrid ventilation
Subtask B: Theoretical and experimental studies of performance of hybrid ventilation. Development of analysis methods for hybrid ventilation
Subtask C: Pilot studies of hybrid ventilation

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

Task	Research Method		
	State-of-the-art Review	Theoretical and Experimental Studies	Implementation and Demonstration
Subtask A Development of Control Strategies	• Survey of existing strategies • Local versus central control	• Definition of requirements and evaluation criteria for control strategies • Development of strategies for switching between and combining ventilation modes • Development of strategies for combination of automatic and manual individual control • Control system design	• Demonstration and evaluation of control strategies
Subtask B Development of Analysis Methods	• Survey of available analysis methods	• Achieve better understanding of the physics of hybrid ventilation (air flow control) • Integration of air flow and thermal simulation models • Development of probabilistic analysis method	• Application and evaluation of analysis methods
Subtask C Pilot Studies	• Survey of existing systems and solutions to specific problems • Market survey of components • Survey of building codes	• Analysis of hybrid ventilation components and systems • Analysis of barriers for hybrid ventilation application • Cost-benefit analysis of hybrid ventilation	• Demonstration of hybrid ventilation performance • Technology transfer

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

2.1 Development of Control Strategies

A hybrid ventilation system, which is integrating both natural and mechanical driving forces in the same ventilation system, requires development of new control strategies. These strategies should ensure at any time and for a certain combination of internal loads, outdoor conditions and comfort requirements that the immediate demands to the indoor environment are fulfilled in the most energy efficient manner. As the function of hybrid ventilation is closely related to the use and function of the building a thorough control of hybrid ventilation requires a completely integrated approach where building design, its technical systems (lighting, heating), occupant behavior, surroundings, climatic and meteorological conditions etc., are taken into consideration.

The participants will as a starting point take a typical case in their own country and climate and by theoretical studies, laboratory experiments and field studies of the performance of different control strategies in a hybrid ventilated building develop the most suitable strategies. The main focus will be on development of strategies for switching between ventilation modes and for combining central automatic and individual manual control.

In the development of new control strategies the focus will be on different issues in the participating countries and will cover a range of hybrid ventilation system and building designs. One of the major tasks will be on development of optimum fuzzy controllers that will enable the implementation of real multicriteria control strategies incorporating expert knowledge and on the development and comparison of smart setting and tuning techniques for these controllers. This will enable a rational operation and improved performance of the fuzzy controllers and is a necessary condition for implementing complex control techniques.

2.2 Theoretical and Experimental Studies of Hybrid Ventilation Performance

Thorough understanding of the hybrid ventilation process is a prerequisite for a successful application of hybrid ventilation, for development of optimum control strategies and for development of analysis methods for hybrid ventilation design. The annex will therefore by theoretical and experimental studies investigate the different elements of the air flow process in hybrid ventilation from air flow around buildings, air flow through openings, air flow in rooms to air flow between rooms in a building. The hybrid ventilation process is very dependent on the outdoor climate as well as the thermal behavior of the building and therefore, it is essential to take all these factors into consideration as well as the air flow process of whole systems.

2.3 Development of Analysis Methods

Suitable analysis methods as we know them for mechanical systems are not available for hybrid ventilation systems. Valid methods would give architects and engineers the necessary confidence in system performance, which in many cases, is the decisive factor for choice of system design.

As the hybrid ventilation process and the thermal behavior of the building are linked the development of analysis methods for hybrid ventilation must take both aspects into consideration at the same time and include efficient iteration schemes. This is the case for all types of analysis methods from simple analytical methods, zonal and multizone methods to detailed CFD analysis methods. The subtask will deal with methods on different levels, but a major focus will be on combining thermal simulation models with existing multizone air flow models. In this way the thermal dynamics of the building can be taken into account and this will improve the prediction of the performance of hybrid ventilation considerably. The combined model will be the most important design tool for hybrid ventilation.

The second major development is a new probabilistic analysis method that makes it possible to evaluate indoor climate, energy consumption and certainty of design solution based on the whole operation period. The method should be able to predict the probability that demands of energy consumption, indoor climate and air flow rates are met in hybrid ventilated buildings. The method will be developed, by combining available physical models of the phenomena involved with stochastic models and will be useful in the early design phase.

2.4 Pilot Studies of Hybrid Ventilation

Pilot studies in different countries are used to implement hybrid ventilation systems and demonstrate their performance. The pilot studies are monitored to collect data on performance (IAQ, thermal comfort and energy consumption) and to evaluate corresponding control strategies and analysis methods. The pilot studies include both retrofitted and new build designs and highlight similarities and differences in climatic issues (including seasonal differences), institutional and cultural issues (developers and occupants), and technology transfer issues. The pilot studies concentrate on success stories of hybrid ventilation but also critically highlight problematic cases.

Buildings with hybrid ventilation often include other sustainable technologies like daylightning, passive cooling, passive solar gains etc, and an integrated approach is used in the design of the building and its technical systems.

The pilot studies have hybrid ventilation systems according to the definition applied in this annex. The performance (IAQ, thermal comfort, energy consumption, etc.) of the hybrid ventilation system with the corresponding control strategies are monitored during a one year period. Measurement data are also provided for evaluation of analysis methods and/or control strategies. An analysis of barriers for hybrid ventilation application and a cost-benefit analysis of the alternatives to ventilation system design are provided as well.

Table 1 shows the pilot studies in Annex 35

Table 1. Annex 35 Pilot Studies

Country	Building name	Location	Year of completion	Building type
Belgium	PROBE	Limelette	1975/1997	Office
Denmark	B&O HQ	Struer	1998	Office
Italy	Palzzina I Guzzini	Recanati	1997	Office
Japan	The Liberty Tower	Meiji	1998	Educational
Japan	Tokyo Gas Earth Port	Tokyo	1996	Office
Japan	Fujita Technical Center		1999	Office
Norway	Grong Primary School	Grong	1997	Educational
Norway	School	Oslo	1999	Educational
Norway	Lavollen	Trondheim	?	Office
The Netherlands	Waterland	Leidschenveen	2000	Educational

2.5 Annex 35 Workgroups

The work in subtasks A and B is organized in a number of workgroups, which deals with some of the most important problems in hybrid ventilation design. Table 2 shows the 12 workgroups functioning at the moment and the titles of their work. The workgroups will be closed, when they have finished their work, and new ones may be formed during the remaining working period of the Annex.

Table 2. Annex 35 Working Groups

Workgroup	*Title*	*Leading Country*	*Countries participating*
WG-A1	**Characterization of Ventilation and Control Strategies**	DK	B, DK, F, FIN, N, NL
WG-A2	**Equivalent Energy Performance Targets in Standards and Regulations**	B	B, DK, F, FIN, NL
WG-A3	**Comfort Requirements and Energy Targets**	NL	AU, DK, F, N, NL
WG-A4	**Application of Analysis Methods in the Hybrid Ventilation Design Process**	N	AU, DK, F, N, NL
WG-B1	**Incorporate Thermal Stratification Effects in Network Modeling**	AU	AU, CAN, F, I, N
WG-B2	**Methods for Vent Sizing**	NL	B, CAN, DK, I, NL, S
WG-B3	**Input Data Bank**	UK	G, S, UK
WG-B4	**Develop Probabilistic Methods**	DK	AU, DK, I
WG-B5	**Wind Flows through Large Openings**	S	AU, CAN, DK, F, I, NL, S
WG-B6	**Evaluation of Analysis Tools – Specification of Data Requirement**	AU	AU, FIN, D, I, N
WG-B7	**Integrate or Implement Control Strategies into Models**	AU	AU, F, FIN, G, S, NL, USA
WG-B8	**Climate Data**	AU	AU, B,G, I

3 RESULTS AND END PRODUCTS

The results of Annex 35 will be summarized in two final reports and specific results of individual subtasks will be reported in technical reports and papers.

3.1 State-of-the-art Review

This report will describe the state-of-the-art of hybrid ventilation technologies, of control strategies and algorithms and of analysis methods. The report will provide examples of existing systems. It will show solutions to specific problems (fresh air supply, excess heat removal, etc.) in particular office buildings located in different outdoor climates and using different commercially available hybrid ventilation components.

The report will 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 thermal comfort.

3.2 Principles of Hybrid Ventilation

This report will describe the principles of hybrid ventilation, including solutions for energy-efficient, comfortable and cost-effective hybrid ventilation and recommendations on control strategies and analysis methods. The report will be written on the basis of experience gained in annex subtasks as well as achievements from previous research (state-of-the-art review).

RECENT PAPERS ON INDOOR ENVIRONMENTAL ENGINEERING

PAPER NO. 86: P.V. Nielsen: *The Selection of Turbulence Models for Prediction of Room Airflow.* ISSN 1395-7953 R9828.

PAPER NO. 87: K. Svidt, G. Zhang, B. Bjerg: *CFD Simulation of Air Velocity Distribution in Occupied Livestock Buildings.* ISSN 1395-7953 R9831.

PAPER NO. 88: P. V. Nielsen, T. Tryggvason: *Computational Fluid Dynamics and Building Energy Performance Simulation.* ISSN 1395-7953 R9832.

PAPER NO. 89: K. Svidt, B. Bjerg, S. Morsing, G. Zhang: *Modelling of Air Flow through a Slatted Floor by CFD.* ISSN 1395-7953 R9833.

PAPER NO. 90: J.R. Nielsen, P.V. Nielsen, K. Svidt: *The Influence of Furniture on Air Velocity in a Room - An Isothermal Case.* ISSN 1395-7953 R9843.

PAPER NO. 91: P. Lengweiler, J.S. Strøm, H. Takai, P. Ravn, P.V. Nielsen, A. Moser: *Dust Load on Surfaces in Animal Buildings: An Experimental Measuring Method.* ISSN 1395-7953 R9844.

PAPER NO. 92: P. Lengweiler, P.V. Nielsen, A. Moser, P. Heiselberg, H. Takai: *Deposition and Resuspension of Particles: Which Parameters are Important?* ISSN 1395-7953 R9845.

PAPER NO. 93: C. Topp, P.V. Nielsen, P. Heiselberg, L.E. Sparks, E.M. Howard, M. Mason: *Experiments on Evaporative Emissions in Ventilated Rooms.* ISSN 1395-7953 R9835.

PAPER NO. 94: L. Davidson, P.V. Nielsen: *A Study of Low-Reynolds Number Effects in Backward-Facing Step Flow using Large Eddy Simulations.* ISSN 1395-7953 R9834.

PAPER NO. 95: A. Nielsen: *VRML Programs for Room Ventilation Applications.* ISSN 1395-7953 R9846.

PAPER NO. 96: E. Bjørn, P.V. Nielsen: *CFD Simulations of Contaminant Transport between Two Breathing Persons.* ISSN 1395-7953 R9809.

PAPER NO. 97: C. Topp, P.V. Nielsen, P. Heiselberg: *Modelling Emission from Building Materials with Computational Fluid Dynamics.* . ISSN 1395-7953 R9915.

PAPER NO. 98: H. Brohus: *Influence of a Cooled Ceiling on Indoor Air Quality in a Displacement Ventilated Room Examined by Means of Computational Fluid Dynamics.* ISSN 1395-7953 R9920.

PAPER NO. 99: P. Lengweiler, A. Moser, P.V. Nielsen: *New Functions to Model Measured Deposition and Resuspension Rates of Particles.* ISSN 1395-7953 R9924.

PAPER NO. 100: P. Lengweiler, A. Moser, P.V. Nielsen, H. Takai: *Modelling Measured Deposition and Resuspension Rates of Particles. in Animal Buildings.* ISSN 1395-7953 R9925.

PAPER NO. 101: P.V. Nielsen: *The Importance of a Thermal Manikin as Source and Obstacle in Full-Scale Experiments.* ISSN 1395-7953 R9932.

PAPER NO. 102: P. Heiselberg: *Outline of Hybvent.* ISSN 1395-7953 R9939.

Complete list of papers: http://iee.civil.auc.dk/i6/publ/iee.html

ISSN 1395-7953 R9939

Dept. of Building Technology and Structural Engineering
Aalborg University, December 1999
Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark
Phone: +45 9635 8080 Fax: +45 9814 8243
http://iee.civil.auc.dk