RESHYVENT- A EU CLUSTER PROJECT ON DEMAND CONTROLLED HYBRID VENTILATION FOR RESIDENTIAL BUILDINGS

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ABSTRACT

In January 2002 the EU RESHYVENT project started, a three-year project within the EU Fifth Framework Programme on the investigation and development of demand controlled hybrid ventilation systems in residential buildings. The project is a clustering of four industrial consortia with a multi-disciplinary scientific consortium. Each of these industrial consortia will develop a working prototype of a hybrid ventilation system for a specific climate. A scientific group with 12 partners from research institutes, consultants and universities will carry out the scientific research work for the development of these systems.
This paper gives a summary and update of the work carried out so far.

KEYWORDS

Demand Controlled Hybrid ventilation, Sensor Technolgies

INTRODUCTION

Energy use by ventilation losses and fans accounts for almost 10% of total energy use in EU. As dwellings represent about 25-30% of all energy used in EU countries, new innovative energy efficient ventilation technologies for residential buildings could give an important contribution to the EU objectives on energy and CO_2 reduction. More over, indoor air quality and thermal comfort (winter and summer conditions) could be improved. The most promising development in ventilation systems is based on demand-controlled hybrid technologies. These are two-mode system using natural forces as long as possible and electric fans only if necessary. Sensor technologies are used to establish the exact required airflow for indoor air quality and thermal comfort to a minimal energy demand. When using hybrid ventilation systems, the expected energy saving on long term within EU is approximately 64 PJ/year for residential buildings, giving a reduction of 3.6 Mton CO_2-eq./year.

THE EU RESHYVENT PROJECT

The key elements of the RESHYVENT project are reflected in the subtitle of the project “Cluster Project on Demand Controlled Hybrid Ventilation in Residential Buildings with specific emphasis of the Integration of Renewables”, i.e.:

Hybrid Ventilation
Hybrid ventilation is defined in accordance with the IEA Annex 35 project “Hybrid ventilation for offices and schools” as a two-mode system that 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. Hybrid ventilation systems must provide air for indoor air quality, thermal conditioning and thermal comfort. A control system

has to establish the desired air flow rate and pattern at the lowest energy consumption possible. This means:

- air flows will be exactly controlled to the actual needs, based on thermal comfort and IAQ;
- using natural driving forces as long as possible, using mechanical forces when necessary

Although this definition of hybrid ventilation is clear, there is lots of misunderstanding. A first classification of hybrid ventilation was proposed in IEA Annex 35 “Hybrid Ventilation” (P. Wouters):

- Alternate use of natural and mechanical
- Fan assisted natural
- Stack and wind supported mechanical

A more sophisticated classification is proposed by W. de Gids, discriminating 18 different types in 9 development stages. This classification is used in the RESHYVENT project. An advantage of this classification is that for new hybrid ventilation concept it is instantly clear in which stage of development they are.

Demand Controlled Ventilation

Ventilation is exactly tuned to the demands of the users, in terms of IAQ and thermal comfort under all climatic conditions. This means in general the use of sensors and developing ventilation and control strategies. The control system is the heart of the whole system.

Integration of Renewables

Within the RESHYVENT project there is specific emphasis on the application of renewables. Despite the hybrid character of the system auxiliary energy is needed for running the fans, the sensors and the control system. This energy will be, as far as possible, be generated by sustainable technologies, such as PV and wind energy. Besides that renewables energy will be used for optimising wind and solar effects. In this case wind-optimised cowls and solar chimneys are technologies to be developed.

Residential Buildings

The scope of the project is residential buildings, single family houses as well as multifamily houses in the new build sector and the existing sector. The hybrid ventilation systems will be developed for different climates, ranging from (sever) cold, moderate, mild to warm. Specific attention will be paid to the thermal comfort conditions during winter (draught) for the cold and moderate climates and for the thermal conditions during summer (overheating) for the mild and warm climates.

Cluster Project

The RESHYVENT project is a cluster project with four independent industrial consortia from Norway, Sweden, The Netherlands and Belgium/France, with in total 10 industrial partners. Each of these industrial consortia will develop a working prototype of a hybrid ventilation system for a specific climate. A scientific group with 12 partners from research institutes, consultants and universities will carry out the scientific research work for the development of these systems.

The Structure of RESHYVENT

The project is a clustering of four industrial consortia with a multi-disciplinary scientific consortium. The industrial consortia are served and supported by scientific Support Units corresponding with the defined tasks in the work packages. Each of the four Industrial

Consortia has a "scientific coach". Their task is to coach the industries in their RTD work and to operate as an intermediary to the scientific partners and the co-ordinator.

RESHYVENT has the following partners:

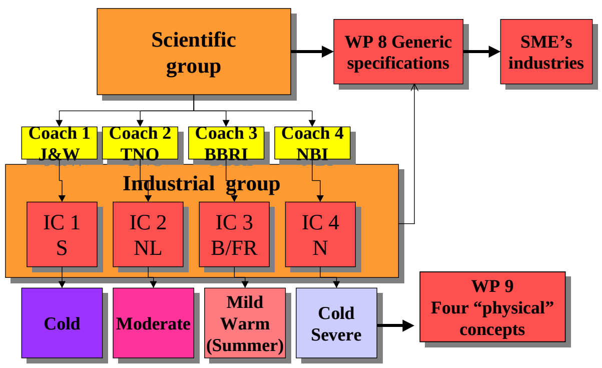
Scientific Group		**Industrial Consortium 1: coach WSP**	
Cauberg-Huygen Raadgevende ingenieurs	NL	Systemair AB	SE
TNO Building and Construction Research	NL	Thermopanel AB	SE
Belgium Building Research Institute (BBRI)	BE	Stigberget Driftteknik AB	SE
Swiss Laboratories for Materials Testing and Research (EMPA)	CH	**Industrial Consortium 2: coach TNO**	
WSP Environmental	SE	Bergschenhoek BV	NL
Centre Scientifique et Technique de Bâtiment (CSTB)	FR	Aluminium Handelmij Alusta BV	NL
Esbensen Consulting Engineers	DK	J.E. Stork Ventilatoren BV	NL
Instituto de Engenharia Mecânica (IDMEC)	PT	Cox Geelen BV	NL
Norwegian Building research Institute (NBI)	NO	**Industrial Consortium 3: coach BBRI**	
National and Kapodestrian University of Athens (NKUA)	GR	Aereco SA	FR
Gaia Solar	DK	Renson NV	BE
Brno University of technology (BUT)	CZ	**Industrial Consortium 4: coach NBI**	
		Flexit AS	NO

The RESHYVENT project has two types of deliverables:

- A practical part, i.e. the development and construction of components, products and systems, to be demonstrated after completion of the project and, later, commercially exploited and launched on the market by industries.
- A generic part, i.e., all developed knowledge, (technical, economical, social etc.) as well as all supporting tools, instruments and documents will be disposable for EU industries

To come to the final output and deliverables of the **practical** and **generic** part a number of supporting research activities will be undertaken in the scientific support units.

Organisation structure of RESHYVENT



The scientific research work is organised in a number of work packages. The industrial partners can consult the work packages. It is the task of their scientific coaches to structure these questions, to identify the relevant work package and to match the questions with the scope of the work programme and the objectives of the work packages.
RESHYVENT has following work packages:

WP 1 State of art review - *WP leader NBI* : State of art review and interpretation of ventilation techniques in residential buildings, available simulation and calculation models, other related EU work. Within this work package an extended database is collected on all available literature and research work in the field of advanced ventilation. This data base will be accessible: www.byggforsk.no/prosjekter/Reshyvent/

WP 2 Market Support Unit - WP leader SWP: Making of a market survey and SWOT (strength-weakness-opportunities-threats) analyses an give description of market chances/prospects, restrictions and boundary conditions for the application of hybrid ventilation. Also the social aspects of new innovative ventilation systems in relation to occupants will be addressed.

WP 3 Renewables Integration Support Unit - WP leader Esbensen:
Integration (active and passive application) of renewables in relation to auxiliary energy in ventilation concepts. Integration in heating and cooling concepts. This WP will focus on the application of PV for running fans, controls, sensors, etc. In addition, the application of solar chimneys will be tested.

WP 4 Standard and Regulations Support Unit - WP leader BBRI:
An overview and analyses will be given of the meaning of current standards and regulations including solutions for equivalent functional requirements, improvement and modifications of regulations. An important development within this work package is the support for the implementation of European Energy Performance Directives (EPD). Within this work package a uniform approach and method will be developed for the performance assessment for innovative ventilation systems and innovative technologies in general, based on equivalence principles.

WP5 Design parameters Support Unit - WP leader EMPA:
Setting up design parameters, making sensitivity analyses and design constrains. This WP will focus on essential elements like wind effects in the built environment and modelling air flows in spaces. An inventory is made of all necessary boundary conditions for hybrid ventilation systems.

WP 6 Performance Assessment Support Unit - WP leader IDMEC:
Development of models for performance assessment on "concept-level" (ventilation system in relation to the building). All the (generic) simulations and calculations are carried out within this work package.

WP 7 Control and Ventilation Strategies Support Unit - WP leader CSTB:
Development of control and ventilation strategies for hybrid ventilation; i.e. developing the "heart" of every demand controlled hybrid ventilation system.

WP 8 Specifications and ToR for components and systems - WP leader TNO:
Specifications and terms of references for the development of components for hybrid ventilation systems. All research work carried out in the different work packages as well as the developments for the four specific hybrid ventilation systems (within WP 9) will be "translated" to generic terms and specifications. Ventilation industries and designers for development of hybrid ventilation systems can use these specifications.

WP 9 Development and Construction of four systems - WP leader Cauberg-Huygen R.I.:
In this work package the four industrial consortia actively participate with their scientific coaches on the development and construction of four hybrid ventilation concepts for four

different European climate zones. The performances of these four concepts have to comply with a number of design objectives. These objectives are listed in table 1.

Table 1. Design objectives for the RESHYVENT hybrid ventilation systems

	Market average 2001	RESHYVENT targets (2012)
energy use for domestic ventilation[)] severe climate cold climate moderate climate mild climate	GJ/dwelling 43 33 22 9	GJ/dwelling 7.5 5.8 4.9 1.2
indoor air quality CO_2 hours > 700 ppm CO_2 hours > 1400 ppm	 2000 (kppm.h) 500 (kppm.h)	 500 (kppm.h) 100 (kppm.h)
thermal comfort (% of room PD < 15%; $T_{out} = 0^0C$)	50-75%	85-95%
Noise levels	>35 dB(A)	< 35 d(BA)
airflow stability % of time according design	6- 12 % (poor)	25-50% (good)
Maximal additional costs and payback time severe climate cold climate moderate climate mild climate	 -	Additional Costs/dwelling (euro) / Payback time (y) 2000 / 5.6 1800 / 6.6 1500 / 8.8 1500 / 19.2
Total energy use for domestic ventilation in EU	EU: 2797 PJ/year EU+candidate EU: 3850 PJ/year	EU: 2733 PJ/year EU+candidate EU: 3784 PJ/year
Total CO_2 emission ventilation related energy	EU: 153 Mton/year EU+candidate EU: 215.6 Mton/year	EU: 149.4 Mton/year EU+candidate EU: 211.9 Mton/year
Total energy saving (total market penetration EU ~ 2% candidate EU ~ 0,25%)	-	EU: 64.1 PJ/year EU+candidate EU: 65.6 PJ/year
Total CO_2 saving (total market penetration EU ~ 2% candidate EU ~ 0,25%)	-	EU: 3.6 Mton/year EU+candidate EU: 3.7 Mton/year

Each industrial consortium will focus on a specific application field (climate, building and application of renewables). This has consequences on the significance of thermal comfort in summer and winter conditions and ventilation components for supply and exhaust, see table 2.

Table 2. Application fields

	IC 1 – S	**IC 2 – NL**	**IC 3- B/FR**	**IC 4 – NO**
Climate	Cold	Moderate	Mild and warm	Severe
Building type	Apartments	Dwellings Apartments	Dwellings	Dwellings
Renewables	PV, Wind. Heat recovery optional	PV Wind	PV	Wind Heat recovery
Summer Comfort	No	Limited	Crucial	No
Winter Comfort	Important	Important	Important	Crucial
Supply	Crucial	Important	Important	Crucial
Exhaust	Crucial	Crucial	Crucial	Crucial

WP 10 Urban impact - WP leader NKUA: Identifying the impact of the urban environment on natural ventilation in relation to hybrid ventilation. The urban environment has a major impact on natural ventilation but also on application of PV. Urban conditions in EU can give barriers

for natural ventilation and cooling (especially in Southern regions). Hybrid ventilation can provide a solution without the necessity of applying fully mechanical systems. Also barriers and solutions for PV application in EU urban areas will be taken into account as well as the impact of traffic on ventilation (noise and pollution).

WP 11 Dissemination, Steering and Management - WP leader Cauberg-Huygen R.I.: Continuous dissemination, exploitation and monitoring of project results.
Information of the project can be found on the RESHYVENT website: www.reshyvent.com

DEVELOPMENT OF FOUR HYBRID VENTILATION SYSTEMS

The Swedish concept addresses apartments in cold climates. As in these climates ventilation demand corresponds often with the heat demand the ventilation supply is integrated in a combined hybrid supply convector. Air collectors can preheat supply air. Exhaust system is a fan assisted passive stack. The Dutch consortium is elaborating two concepts one for 2004 (ready at end of the project) and one for 2010. The 2004 concept is a fully hybrid demand controlled system with decentral supply from the facade and a coupled hybrid central mechanical extract. A characteristic development in this concept is an extreme low-resistance ductwork (< 2 Pa at 56 dm^3/s) based on the experiences and components developed within the EC TIPVENT project. A special fan is developed using 2 Watt at 56 dm^3/s at 20 Pa. This extreme low fan power is possible by a combination of the low pressure duct work and wind optimised cowls (<1 Pa at 56 dm^3s).. Supply grilles are actively controlled with compensation for cross flow and infiltration. The prototype is tested in 2003 and 2004 in Czech Republic by Brno University of Technology. The French/Belgium consortium is working on the integration of renewables (i.e. PV application) in combination with hybrid ventilation. Like the Dutch concept, this concept is also based on a fully hybrid demand controlled system with decentral supply from the facade and a coupled hybrid central mechanical extract. PV provides the auxiliary energy for the fan. There is special attention for the summer comfort en the application of free cooling during the night. The Norwegian concept is entirely different from the others. For extreme cold climates heat recovery is necessary for preheating. The combination of hybrid (natural) ventilation with heat recovery is innovative. A supply system with low-pressure ducts with displacement ventilation is used. This enables to reduce airflows because of a better ventilation efficiency, while maintaining the required level of indoor air quality.

COLLABORATION WITH NEWLY ASSOCIATED STATES

One of the features of the RESHYVENT project is a narrow collaboration with NAS partners. The Brno University of Technology BUT is contributing in WP 3 by testing the application of a solar chimney, WP 10, impact on pollution by traffic in relation to air quality for ventilation. BUT will also test the ventilation concept of the Dutch Industrial consortium, especially for application in Czech Republic.

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