INTERNATIONAL ENERGY AGENCY
Energy conservation in buildings and
community systems programme

# Literature List

# Overview of reports from the EU-RESHYVENT project on residential hybrid ventilation


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# Literature List from the Reshyvent Project

## 1 Description of EC-Reshyvent project

The aim of the EC RESHYVENT project (2003-2005) was to integrate renewables and hybrid technologies in domestic ventilation systems by researching, developing, and constructing four complete hybrid ventilation concepts for different EU climate zones and by delivering generic output to companies in terms of technical specifications and guidelines including market economical and social aspects.

In order to streamline all actions and also for optimisation of the available resources, this 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.


The key elements of the RESHYVENT project were reflected in the work packages titles:

1. State of art review of ventilation techniques in residential buildings, available simulation and calculation models, other related EC and IEA work.
2. Making of a market survey and SWOT analyses and give description of market chances/prospects, restrictions and boundary conditions for the application of hybrid ventilation and study the social aspects of advanced ventilation systems.
3. Integration of renewables (as well as active as passive application of renewables) and integration of hybrid ventilation in heating and cooling concepts
4. Give an overview and analyses of the meaning of current standards and regulations including solutions for equivalent functional requirements, improvement and modifications of regulations with special attention for CEN.
5. Compile design parameters and constraints, making sensitivity analyses.
6. Development of a calculation model for designing hybrid ventilation and for predicting the performance
7. Development of control and ventilation strategies for hybrid ventilation
8. Specifications and terms of references for the development of components for hybrid ventilation systems
9. Development, with active participation of four industrial consortia, of four complete hybrid ventilation concepts (as demonstration-ready products) for different European climates (severe, cold, moderate and mild/warm conditions)
10. Asses the impact of urban environments in EU on hybrid ventilation and its potential solutions

# 2 Deliverables

A list of the major publications issued from the Reshyvent project is given below. The list is sorted by work package and supplemented with the abstracts of the documents if available.

A full set of reports can be found on the AIVC website (www.aivc.org). Information is also given on www.reshyvent.com.

## *2.1 WP 1 - State of the art review*

State of the art review and interpretation of ventilation techniques in residential buildings, available simulation and calculation models, other related EC work.

Schild, P.G. 2002. ***State-of-the-art of low-energy residential ventilation***. EC Reshyvent project. Norway. 113 pp

*Abstract:*
*The document describes the state of art on demand control and hybrid ventilation in dwellings and residential buildings, necessary calculation and simulation models and components as well as possibilities for active application of renewables for support energy and low energy heating and cooling.*

## *2.2 WP 2 - Market support unit*

Making of a market survey and SWOT (strength-weakness-opportunities-threats) analyses and description of market chances/prospects, restrictions and boundary conditions for the application of hybrid ventilation.

Blomsterberg**,** A. 2005. ***Market survey for demand controlled hybrid ventilation in residential buildings***. EC Reshyvent project. Sweden. 145 pp

*Abstract:*
*The ventilation systems in the existing building stock differ very much from country to country due to differences in market forces, building codes, traditions, user preferences, climates etc.. In northern Europe most new dwellings are equipped with mechanical ventilation systems (more and more with heat recovery), while southern countries often rely on window airing. In many countries with mechanical ventilation the building code has required and sometimes still requires this system. Other market driving forces are related to indoor air quality, health, comfort, climate and energy issues. In countries with a predominance of mechanical ventilation systems the older buildings still often have natural or passive stack ventilation. There is not yet a real European ventilation market, the market is mostly national.*

*There are many demands and expectations from the customers as to the performance of ventilation systems. Low noise, low draught, good indoor air quality, low investment costs and manual override for the user are often given a high priority. Other examples are reliability, flexibility, user friendliness, low operation costs and low energy use. Many of these demands and expectations are unsatisfactorily fulfilled by the existing ventilation systems. There is clearly a need for improved systems and there is probably a market for new types of ventilation systems, which can meet the demands and expectations for indoor climate, control, user friendliness, reliability and at the same time the energy use of ventilation. The most promising system to achieve these goals is demand controlled hybrid ventilation. One of the advantages is the likelihood of a positive response from the occupants thanks to less noise from the ventilation systems itself and a higher degree of user control. Hybrid ventilation have access to natural and mechanical ventilation modes and therefore the best ventilation mode*

*can be chosen depending upon the circumstances. A complication for hybrid ventilation can be the need for a more advanced control system. The demand control should result in always adequate ventilation rates, no excess ventilation during winter causing a high use of energy, but enough ventilation to ensure adequate indoor air quality.*

*There are no standards or regulations preventing the implementation of demand controlled hybrid ventilation in dwellings. In some countries the current regulations may complicate the implementation compared with a traditional ventilation system. The new building codes being developed thanks to the EPBD should remove these barriers and become a market driving force. A harmonised European market would increase the potential for demand controlled hybrid ventilation systems. The building codes and standards, and assessment procedures must be harmonised. The assessment procedures must take into account innovative systems like demand controlled hybrid ventilation. An important step in that direction could be the implementation of the requirements of the above mentioned EPBD. With the future more stringent energy performance requirements there will be increased competition from mechanical ventilation systems with heat recovery and energy efficiency measures not related to ventilation systems. The investment cost for hybrid ventilation systems must be lowered by reducing the cost of crucial components like sensors. This would be facilitated with an European market. Demand controlled hybrid ventilation will benefit from a LCC analysis taking into account the energy use. Especially the use of electricity is very low compared with mechanical ventilation.*

*Key interested parties have to be informed as to the benefits of a proper ventilation system and the benefits of demand controlled hybrid ventilation. The system has to be accepted by the end users.*

*Demand controlled hybrid ventilation systems can then be competitive in many European countries, in countries with a predominance of mechanical ventilation systems or natural ventilation systems. A crucial driving force will be the EPBD requiring energy efficient buildings, where an important energy efficiency measure will be to install energy efficient ventilation. There is a market in new construction as well as refurbishment. As to the last the indoor air quality and energy efficiency often need to be improved and installing a complete mechanical ventilation system is often too complicated and costly.*

van Dongen, J.E.F. ***Occupant Behaviour and Attitudes with respect to Ventilation of Dwellings***. EC Reshyvent project. The Netherlands. 29 pp

*Abstract:*
*A very important aspect for the introduction of new advanced technologies, especially in the residential sector, is the acceptance of the occupants and the degree of interaction between a ventilation system and the occupants. This is especially the case for demand controlled ventilation. How much shall the occupant be able to influence the ventilation. Health aspects have to be taken into account, which the user might not always be able to judge. This working document gives information on how occupants use different ventilation provisions and systems, why they ventilate as they do and which moderating factors play a role. Further special attention is paid to promoting and restraining factors for acceptance of new ventilation devices. The method used is a study of literature.*

*With respect to the question how occupants ventilate, among others, has been found e.g. that if air inlets are present, they are used on a variable way, but no difference between summer and winter periods.*

*Reasons why occupants ventilate (or not) are: indoor climate and air quality, outdoor climate and outdoor factors.*

*Further it appears that:*

- *The ventilation by behaviour is only partly related to the type of ventilation system. In*
- *the bedroom the behaviour tends to be independent of the system installed;*
- *There seems to be a relatively constant 'subjectively preferred' amount of total*
- *ventilation from mechanical devices and behaviour taken together.;*
- *Provision related factors who influence the ventilation behaviour are the possibility to*
- *regulate, user-friendliness, (causing) draught , way of hinging and pollution or rust;*
- *The aesthetic quality play a role.*

*As a matter of course the ventilation behaviour also is influenced by the household behaviour and social and personal factors.*

*There are a number of promoting and restraining factors for acceptance of ventilation devices. Factors for acceptance of ventilation systems are:*

- *quality of directions for use;*
- *good performance*
- *fulfilling the expectations*
- *user-friendliness*
- *adaptation, integration with usual daily behaviour*
- *comfort, health, safety promoting*
- *friendliness to install, to repair*
- *maintainability, ability to clean*
- *aesthetics and architectural adaptation*
- *low cost, financial profit (energy saving)*

*Further general conclusions are:*

- *In a substantial proportion of the dwellings the occupants are dissatisfied about their ventilation provisions. This means that there is a market for better ventilation provisions;*
- *Occupants are often not 'average people'.;*
- *Occupants must be able to intervene in a simple way with an automatic system.*

## *2.3 WP 3 - Renewables Integration Support Unit*

Integration (active and passive application) of renewables in relation to support energy and integration in heating and cooling concepts

Antvorskov, S., Winter Andersen, R., Aarø, D., Hendriks, J.W. ***General information on renewable applications for auxiliary energy suitable for use in hybrid ventilation systems***. EC Reshyvent project. 44 pp

*Abstract:*
*The integration of renewable energy technologies in the RESHYVENT project focuses on solar and wind applications to substitute fossil fuel in the operation of hybrid ventilation systems. The term, integration of renewables, covers a very large field of applications. This report only touches upon the application of wind and solar as renewables. On the basis of existing renewable energy technologies this report will give an overview of the possibilities for integration of renewable energy into hybrid ventilation components. The different technologies are not explained in detail, only mentioned as possible options.*

Antvorskov, S., Hendriks, J.W. ***Specifications of applicable renewable sources for integration in possible prototypes***. EC Reshyvent project. 40 pp

*Abstract:*
*This report is part of work package 3 (WP3) within the RESHYVENT project. The main objectives of WP3 are to support and guide four different hybrid ventilation consortia's in*

*issues dealing with development, implementation and integration of renewable energy applications.*

*The integration of renewable energy technologies has focused on solar (Photo voltaic (PV) for electricity supply) and wind (as natural driving force for air movement) applications to substitute fossil fuel in the operation of hybrid ventilation systems. The focus in this deliverable is mainly on the application and integration of PV systems into different components in the different developed hybrid ventilation systems. PV has been chosen as this technology is very flexible and has many implementation possibilities as the PV solution has the possibility to be fully integrated into components and the building.*

Antvorskov, S. ***Impact of Reshyvent concepts on the use of renewable energy for heating, cooling and electricity***. EC Reshyvent project. 26 pp

*Abstract:*
*This report is deliverable D3.3 in the Reshyvent project and deals with the quantification of the impact of hybrid ventilation systems and the impact on limiting and equalising ventilation losses especially on the application of renewables and low valued energy.*

Charvat, P., Jicha, M., Stetina, J. ***Solar chimneys.*** EC Reshyvent project. Brno, Czech Republic. 17 pp

*Abstract:*
*The increasing impact of ventilation and air-conditioning to the total energy consumption of buildings has drawn attention to natural ventilation and passive cooling. Since the indoor air quality is a major concern in ventilation, and natural ventilation does not guarantee acceptable IAQ at any circumstances, an idea of hybrid ventilation has been introduced.*
*The basic idea of the hybrid ventilation is to employ natural forces as long as possible, and to use mechanical ventilation only when necessary. There are three basic concepts of hybrid ventilation:*

- *Alternating or combined natural and mechanical ventilation*
- *Fan assisted natural ventilation*
- *Stack and wind supported mechanical ventilation*

*Solar chimneys can generally be employed in all three concepts if the passive stack ventilation is involved. The passive stack ventilation relies on the stack effect created by the temperature difference between air temperature inside and outside a building. Unfortunately, sometimes there may be an insufficient air change in a building due to the small stack effect.*
*The performance of passive stack ventilation can be, in many cases, improved by means of devices utilizing renewable energies. The most often exploited renewable energy for this purpose is energy of wind. There are different kinds of wind cowls available on the market, which can significantly improve the performance of passive stack ventilation.*
*The attempts to employ solar energy with this objective (e.g. solar chimneys) have been quite rare so far. This report contains some outcomes of the investigations of a solar chimney performance, which were done at the Department of Thermodynamics and Environmental Engineering of the Brno University of Technology.*

## *2.4 WP 4 Standards And Regulations Support Unit*

It gives an overview and analyses of the meaning of current standards and regulations including solutions for equivalent functional requirements, improvement and modifications of regulations with special attention for CEN.

Wouters, P., Heijmans, N., Loncour, X., Delmotte, Ch. 2003. ***Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems - General considerations***. EC Reshyvent project. Belgium. 44 pp

*Abstract*

*During the last decade, there is in general a tendency to pay more attention to indoor climate (thermal comfort, indoor air quality, visual comfort and acoustics) and energy efficiency aspects of buildings and systems. The development of hybrid ventilation systems is clearly linked to this tendency.*

*As part of the increased interest in indoor climate and energy efficiency, and mainly due to the complex interaction between the various aspects, the quantification of these aspects becomes more important. An increased number of countries have standards and regulations concerning the energy efficiency of buildings and the indoor climate performances.*

*Standards and regulations are important boundary conditions in the development, optimisation and evaluation of hybrid ventilation systems:*

- *In case of existing of envisaged regulations which impose certain performances (.e.g. indoor air quality requirements, fire safety,…), it is evident that hybrid ventilation systems have to comply with these specifications.*
- *In case of standards and regulations focusing on the total energy performance of buildings, it is clear that hybrid ventilation systems may represent opportunities for improved energy performance. As a result, they may be become an attractive alternative for other investments in energy efficiency measurements.*

*Often, such standards and regulations are to a large extent written on the basis of the experiences with existing systems. As such, it is not always evident to show the compliance of new and innovative systems with the regulations.*

*In this report, the following issues are discussed:*

- *The various roles for ventilation and the specific features of hybrid ventilation (§3);*
- *Classification of standards and regulations (§4);*
- *Performance oriented versus descriptive standards (§5);*
- *Challenges for translating customers and societal needs in standards and regulations(§6);*
- *Accuracy requirements concerning performance predictions in standards and regulations(§7);*
- *Direct versus indirect performance specifications (§8);*
- *Energy performance standardisation: an open platform for innovation (§9);*
- *Information about related projects (§10)*
- *Overview of standards and working items in CEN TC 156 (§12)*

Wouters, P., Heijmans, N., Loncour, X., Delmotte, Ch. 2004. ***Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems - Standards and regulations concerning indoor air quality and summer comfort***. EC Reshyvent project. Belgium. 66 pp

*Abstract*

*This report aims to specifically analyse the possible barriers to the development of hybrid ventilation systems in residential buildings. It addresses standards and regulations related to indoor air quality (IAQ) and thermal comfort.*

*The document is structured around two levels:*

*1. The first level is focusing on the international level. European standards are treated at this level.*

*2. The second level is focussing on national situation. A country specific analyse is realised in order to evaluate the different existing national standards and regulations.*

Wouters, P., Heijmans, N., Loncour, X., Delmotte, Ch. 2004. ***Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems - Standards and regulations concerning Energy Performance of Buildings***. EC Reshyvent project. Belgium. 62 pp

*Abstract*

*This report aims to specifically analyse the possible barriers to the development of hybrid ventilation systems in residential buildings. It addresses standards and regulations related to Energy Performance of Buildings (EPB).*
*The document is structured around two levels:*
*1. The first level is focusing on the international level. European standards are treated at this level.*
*2. The second level is focussing on national situation. A country specific analyse is realised in order to evaluate the different existing national standards and regulations.*

Wouters, P., Heijmans, N., Loncour, X. 2004. ***Outline for a general framework for the assessment of innovative ventilation systems***. EC Reshyvent project. Belgium. 92 pp

*Abstract*

*This report aims to present some results of the work done by the 25 European Member States in relation with the Energy Performance of Buildings.*
*On the one hand, it highlights the need for the development of a coherent approach, based on a mixture of European measures and national actions. On the other hand, it presents a generic (but not operational) proposal for practical approach for simulating the performances of such systems.*

*This report addresses only the aspect relative to the simulation of the performance of advanced ventilation system. It focuses only on the aspects that can be treated at international level by addressing items as the general philosophy or the work on input data. The link between these simulations and the way to integrate these results within the national regulations is not addressed in this report. For the moment, this link is very country dependant and a specific study (study of equivalence) has to be done in each case for each country.*

## *2.5 WP 5 Design Parameters Support Unit*

Setting up design parameters, making sensitivity analyses and design constrains.

Weber, A., Dorer; V. ***Parameters for the performance assessment of hybrid ventilation systems Performance criteria, target levels and design constraints***. EC Reshyvent project. Switzerland. 42 pp

*Abstract*

*As an introduction, this report describes options and choices for performance assessment criteria, target values and constraints considered to be relevant for the EPBD related performance assessment of ventilation systems, specifically hybrid residential ventilation systems, and to give some background including reference to existing threshold and target values.*
*Based on this outline, the main purpose of the report is to specify in detail the performance assessment criteria to be used for the systems evaluations within RESHYVENT WP6.*

Weber, A., Dorer; V., Maldonado, E., Alexandre, J.L., Vaquero, P., Sousa J.; Blomsterberg; A., Heijmans; N., de Gids; W.F. 2004. ***Description of reference buildings and ventilation systems***. EC Reshyvent project. Switzerland. 54 pp

*Abstract*

*This document defines the reference buildings and boundary conditions for the simulations in WP6. These buildings and boundary conditions are based on the definitions given in the IEA Annex 27 "Evaluation and Demonstration of Domestic Ventilation Systems".*

Dorer, V., Pfeiffer, A., Weber, A. 2005. ***Parameters for the design of demand controlled hybrid ventilation systems for residential buildings***. AIVC Technical Note 59, 120 pp,

*Abstract*

*For the design of demand controlled hybrid ventilation systems for residential buildings, the report gives detailed background information on topics which are not sufficiently covered by existing literature (e.g. wind pressures or thermal comfort evaluation by CFD simulation). The report also gives detailed information on input data necessary to perform computer simulations for the performance analysis of systems.*

## *2.6 WP 6 Performance Assessment Support Unit*

Development of models for performance assessment (a.o. an easy to use calculation model for designing hybrid ventilation and for predicting the performance)

Maldonado, E., Alexandre, J.L., Vaquero, P., Sousa, J. 2004. ***Portuguese Ventilation System*** (IC5) . EC Reshyvent project. Portugal. 170 pp

*Abstract*

*The aim of the present report is to define Reference Ventilation Systems used in Portugal and the new strategies of ventilation in the buildings. The studied ventilation strategies include four different types of ventilation:*

- *Natural ventilation according to the Portuguese standard;*
- *Natural ventilation in wet rooms – old Pt standard;*
- *Mechanical Exhaust Ventilation system in the wet rooms and inlet grids in the other rooms;*
- *Mechanical Exhaust Ventilation System in the wet rooms and self-regulated inlet grids in the other rooms.*

*A single family house located in Porto was used with the different strategies mentioned above. For each case, it is intended to evaluate the impact of those systems in the indoor air quality and in the heating energy consumption.*
*The assumptions done in these simulations tests were based in the recommendations from the Annex 27 handbook and from the RESHYVENT – WP5 – WR – 4, 28th November 2003 report.*

Maldonado, E., Alexandre, J.L., Vaquero, P., Sousa, J. ***Reference buildings – Stochastic Methods.*** EC Reshyvent project, IDMEC, Porto, Portugal. 65 pp

*Abstract: -*

Maldonado, E., Alexandre, J.L., Vaquero, P.,Sousa, J. ***Assessment Performances of the Systems.*** EC Reshyvent project, IDMEC, Porto, Portugal

*Abstract: -*

Maldonado, E., Alexandre, J.L., Vaquero, P., Sousa, J., Teixeira, A. ***REGUI – Reshyvent Graphical User Interface. User Guide - Version 1.0.*** EC Reshyvent project, IDMEC, Porto, Portugal

*Abstract: -*

## *2.7 WP7 Control And Ventilation Strategies Support Unit*

Development of control and ventilation strategies for hybrid ventilation in residential buildings

Husaunndee, A., Jreijiry, D., Millet, J.-R., Villenave, J.G. 2004. ***Ventilation control strategies***. EC Reshyvent project. France. 124 pp

*Abstract: -*

## *2.8 WP 8 Specifications And Terms Of References For Components And Systems*

Specifications and terms of references for the development of components for hybrid ventilation systems

De Gids, W.F. ***Source book for Residential Hybrid Ventilation Development.*** EC Reshyvent project. The Netherlands. 65 pp

*Abstract:*

*The purpose of this Source Book is to review reference data from all work packages in the Reshyvent project for the development and application of residential hybrid ventilation systems. It is concerned primarily with basic data and information for industrial parties who are involved in the development of components for residential demand controlled hybrid ventilation or complete systems for it. It is the intention of the author to help and guide industry with indispensable information in the field of demand controlled hybrid ventilation during the pre phase of the development process.*

## *2.9 WP 9 Development And Construction of 4 Systems*

Development and construction with active participation of four industrial consortia of four hybrid ventilation concepts for four different European climate zones.

## *2.10 WP10 - Urban Impact in the EU*

Niachou, A., Santamouris, M. 2005. ***Urban impact in the EU***. EC Reshyvent project. Greece. 339 pp

*Abstract: -*