RESHYVENT
Cluster Project on Demand Controlled Hybrid Ventilation in Residential Buildings with Specific Emphasis on the Integration of Renewables

Contract No: ENK6-CT2001-00533

Report:

Market survey for demand controlled hybrid ventilation in residential buildings

RESHYVENT report No: RESH-WP2-D2.1 2005-02-25

RESHYVENT Work package: WP2 Market support unit: tasks 2.1 and 2.2: SWOT analyses and market survey

Status: Final report. For public use

Prepared by:
Editor Åke Blomsterberg, WSP Environmental
National contributions from:
Belgium: Nicolas Heijmans and Xavier Loncour, BBRI
Czech Republic: Miroslav Jicha, BTU
Denmark: Signe Antvorskov, Esbensen
France: Jean-George Villenave, CSTB and Marc Jardinier, Aereco
Germany: Åke Blomsterberg, WSP Environmental and André Meester, Alusta
Great Britain: Åke Blomsterberg, WSP Environmental
Greece: Katerina Niachou and Mat Santamouris, NKUA
Netherlands: Peter Op't Veld, CH and Willem de Gids, TNO
Norway: Kari Thunshelle and Peter Schild, NBI
Portugal: Eduardo Maldonado, IDMEC
Sweden: Åke Blomsterberg, Stina Holmberg, WSP
Switzerland: Viktor Dorer and Andreas Weber, EMPA

0 Executive Summary

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.

1 Content

2 Introduction
This report constitutes the summary of the work carried out within the framework of the work package 2 Market support unit of the Reshyvent project. The results were used as inputs to the work packages 6 (Performance assessment support unit), 7 (Ventilation and control strategy support unit), 8 (Specifications and terms of reference for the development of components and systems) and 9 (Development and construction of four hybrid ventilation systems).

The main target group is the ventilation industry.

For each country there is an independent chapter incl. a national summary and conclusion subchapter. There are also conclusions for the whole report.

3 Description of task

3.1 Aim
The overall aim of this work package is to get an overview of opportunities, barriers and boundary conditions for hybrid ventilation systems in residential buildings including the following issues:

- Market analysis emphasising needs and demands on demand side and end users
- Indoor air quality and thermal comfort
- Energy and environment issues
- Fire and safety issues
- Acoustic issues
- Behavioural and social aspects
- Expected market penetration in EU

The market survey has three aims:

- To survey the market for hybrid ventilation systems and determine whether there is a market for demand controlled hybrid ventilation in dwellings or not. Any market barriers for the introduction of hybrid ventilation should be commented on with proposals as to how to overcome these.
- To constitute a basis for determining the properties of future energy efficient ventilation systems. Predetermined is however *the use of* demand control and hybrid ventilation.
- To constitute a basis for a market plan (not included in WP2)

3.2 Methods
The task is divided into

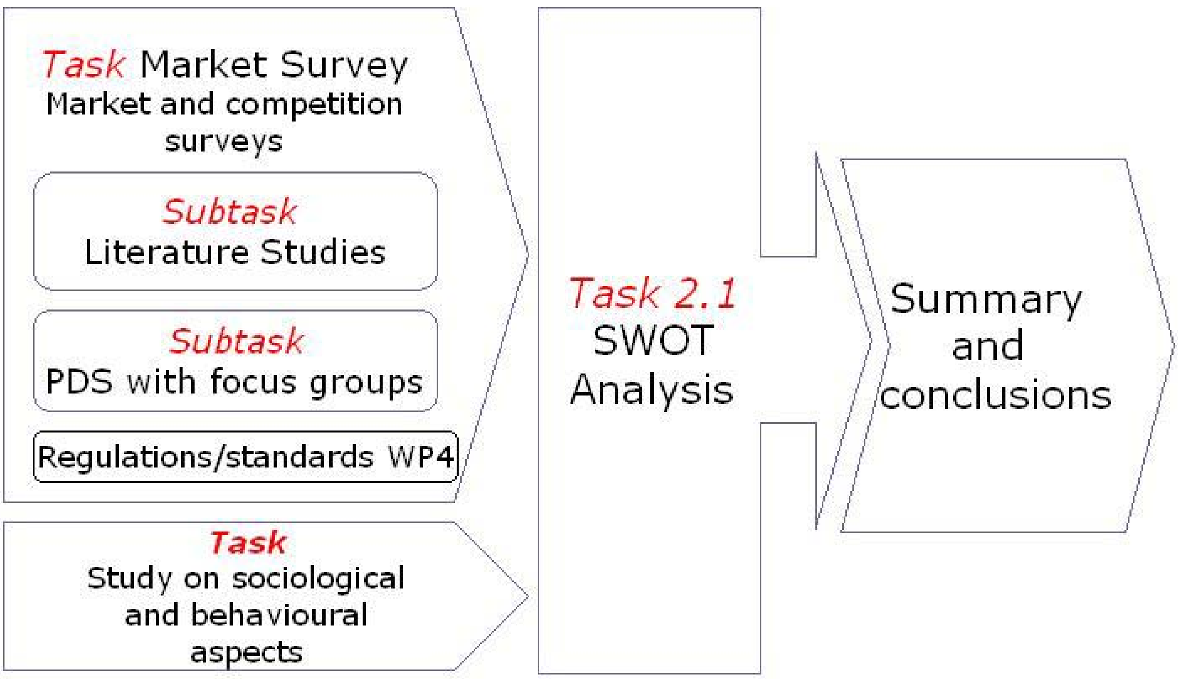
- a market survey (market and competition survey): literature study, PDS with focus groups, input from WP4
- a study on sociological and behavioural aspects.
- concept test (only the participating countries developing demand controlled hybrid ventilation concepts)

The results from these surveys and studies were used in a SWOT analysis on demand controlled hybrid ventilation. The outlined market survey approach has been followed by all participants, however not by Germany and Great Britain, as they have not participated in the RESHYVENT project. The procedure has been followed exactly by Sweden and very well by

Switzerland and Norway. For different reasons it has not been possible for the other participants to follow the procedure in every detail e.g. due to information not being available.

The test methodology was evaluated by Visus Market Research (www.visusab.se) (Hedberg 2004). "The Literature study is an adequate choice of method for this project. It is a cost efficient way of arriving at an overall picture of structural prerequisites such as e.g. the existing building stock, the market penetration of competing ventilation systems and current patents. The PDS is an adequate choice of method, as such a study contribute to a deeper understanding of the structure of the customer needs. Even if the method is not capable of completely surveying the demand structure of the respondents in the selected population, the PDS usually gives the picture of the problems the target groups perceive when using a product. The results can thus constitute a basis for measures aiming at increasing the competitiveness of a product."

In the Annex I of the contract "Description of work" a PDS with focus groups was not foreseen. Planned was workshops and questionnaires. During the first year of the project questionnaires were abandoned, because it determined to be rather difficult to get relevant answers to the questionnaire due to the fact that the knowledge of the hybrid ventilation systems is very limited within the business. It is also time and effort consuming task to carry out a structured questionnaire survey. Professional support is needed and recommended. A PDS-study was therefore chosen as a means of improving the quality of the work and also as a more efficient method.



.

3.2.1 Literature study

The following questions were to be answered:

CUSTOMER AND MARKET CHARACTERISTICS

1) How many are the customers today?
   (Number of one family dwellings + number of property owners + number of member organisations in tenant-owner associations)
2) What are the demands and expectations of the customers?
   a) How does a hybrid ventilation system meet these?
3) Can the customer segment be divided into small / large or low / high cost customer groups?
   a) How does this influence the marketing / selling / etc process?
4) What is the price sensitivity of the customers?
5) Which are the interested parties and how do they influence the market possibilities for and design/function of a hybrid ventilation system?
6) Who in the customer organisation is responsible for purchase of ventilation systems?
7) Which are the marketing channels for reaching the customers?
8) What does the purchasing process look like?
9) Information on standards and regulations in terms of their impact on product development
10) Information on relevant institutes, organisations and contact persons for ventilation related matters

MARKET SEGMENTS

11) Which are the market segments?
    A: Owners of one family houses, property owners (multifamily houses), tenant-owners associations
    For new construction / refurbishment

MARKET PRESENT AND FUTURE STATE

12) What is the size of the total market?
    a) Size of existing housing stock
       Whereof
       i) natural / passive stack ventilation
       ii) Mechanical exhaust ventilation
       iii) Mechanical supply and exhaust ventilation

    b) What is the prognosis for new construction and modernization of housing? Time perspective?
13) What is the potential for hybrid ventilation systems in these buildings? (Number of buildings and percentage of total)
    a) In existing buildings (refurbishment)
    b) In new construction
14) What is the time perspective for implementation of hybrid ventilation systems in the aforesaid market?
15) What are the key factors for market growth in the ventilation business (taxes, subsidies etc)?
16) Why has the market developed the way it has developed?
17) How will the market develop in the future?
18) Which are the driving forces for the market?
19) Information on price levels for ventilation systems

20) Vision about the development in Europe with regard to EPBD
21) Which components need to be further developed resulting in a lower price?

COMPETING SYSTEMS
22) Which are the ventilation systems competing with hybrid ventilation today?
23) How much of the market is held by each of the competing systems today?
24) How are the competing systems marketed today? IC
25) Which patents within the ventilation business exists today?
    a) How do these influence the market introduction and design of the hybrid ventilation system?
26) What counter moves can be expected from producers of competing ventilation systems?
27) What is the risk for other innovative systems being developed in the near future?
    a) How will this influence the possibilities for hybrid ventilation?

3.2.2 PDS with focus groups

Why carry out a problem detection study with focus groups?
- Difficult to evaluate new, untried system for uninitiated parties
- Focus groups requires little effort and time for the interested parties (ca 3 hours) -> sufficient participation likely
- Easy way of determining which features are most important for each category of interested party
- Focus groups is a means of generating information on public understandings and viewpoints

Who should participate?Scientific partner
- ❑ Interested parties:
    - Property owners
    - Consultants
    - Architects
    - Contractors
    - SuppliersProperty managers
    - Operations engineers/technicians
    - End users
    - Building code authorities
    - Health authoritiesOther?The meetings should be led by an impartial facilitator/controller.

The PDS method (Engvall 2003) is a structured approach to estimate and determine existing problems with and basic requirements on a product, building, organization etc.. The method has previously been used in connection with market analysis's of different kinds but has been further developed by the city of Stockholm in connection with the evaluation of the built environment e.g. living for elderly, living with allergies, feedback from new construction, before reconstruction as well as for renewal of city districts. The method is distinguished from traditional questionnaires by the fact that the planned target group itself takes part in the choice and formulation of problems.

The method works mainly according to the description given below and in the following flow chart – here adapted to ventilation projects.

STEP 1:

A group of experts on the subject is brought together, e.g. ventilation consultants, installers, operations engineers, architects, property owners, users for a **first meeting** in order to highlight the **problems of today's existing ventilation systems** seen from their own perspective.

From this first meeting an **interview guide is compiled** with the areas of problems and connecting keywords, which has been brought up during the first expert meeting. This interview guide is then sent to the expert group, who checks that everything has been included and evaluates from their own perspective what is most important to highlight. It is also possible for the members of the expert group to add areas of problem, which were thought of after the meeting.

STEP 2:
With this interview guide as a starting point, **one or several focus group meetings (second meeting)** are carried out with persons from different areas of activity with ventilation as a common denominator. Each focus group meeting is with a different group of people involved in the same area of activity e.g. one focus group meeting with only property managers/owners, one with only architects. The aim of the group meetings is *to have* the experts more or less theoretically formulated problems expressed in daily words of people working with ventilation systems.

The **compilation of problems**, which is the result of the group meetings, is formulated as problem statements, which are presented and discussed in a second meeting with the expert group, which is the **third meeting**.
In the end the final results from the expert and focus group meetings are interpreted by the Scientific Partner and industry or IC for each of the high-priority features/problems

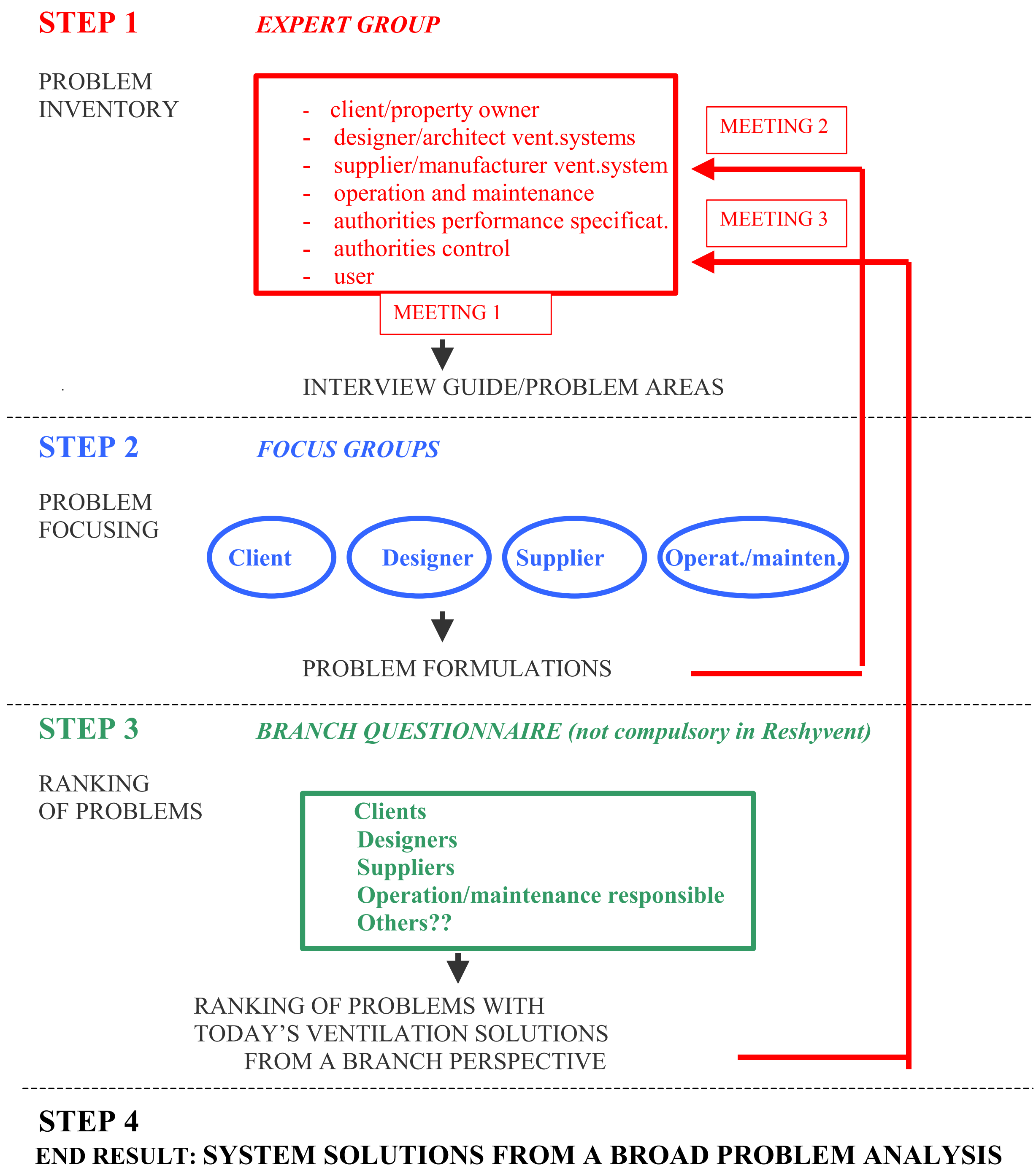
- Does a Hybrid Ventilation system have this feature or solve this problem?
- How well does Hybrid Ventilation compare with traditional ventilation systems for this feature/problem?This evaluation is done using a questionnaire with a ranking

system (see annex 1). Most of the areas of problems from the PDS study should correspond to the aspects in the questionnaire.
STEP 3:
The confirmed problem statements are then sent as a **questionnaire to a larger target group** in order to determine which problems most interested parties agree with. The result is analysed with respect to different basic requirements on a good ventilation system. It can also be analysed with respect to the opinion of different interested parties or be divided according to the different functions of a ventilation system etc. This step ensures that the results are widely supported. Carrying out step 1 and 2 combined with the expertise of the participants was considered by the participants to meet the aim of the task. Therefore this step was not carried out as it was considered beyond the scope of Reshyvent.

This form of problem inventory can reveal additional needs and solutions and give an impartial and detailed description of requirements on ventilation solutions and design. The problems will also be ranked. The ranking within Reshyvent was carried out in step 2.

STEP 4:

System solutions are developed from the above mentioned problem analysis. This step was carried out in WP9 Development and construction of four hybrid ventilation systems and also included the outcome of the SWOT analysis.



3.2.3 Study on sociological and behavioural aspects.

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. Information is given 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. Because of the availability of literature the information is mainly based on Dutch studies on ventilation behaviour, added with information from studies in other countries (especially Sweden). It is assumed that the results of the Dutch studies can be generalised to other countries in Europe.

3.2.4 SWOT-Analysis

SWOT analysis are a good tool for structuring information and data prior to the preparation of a market plan. In a SWOT analysis questions are put enabling companies and project groups to assess and determine whether a new product will have real possibilities on the market and which are the limitations/barriers obstructing an market establishment. The SWOT analysis is therefore considered to be the right choice of method.

Prior to the elaboration of a market plan one should preferably carry out several different SWOT analyses aiming at a complete foundation for the market plan. A crucial step is to compare the new product with competing products.

SWOT is an abbreviation of “Strengths”, “Weaknesses”, “Opportunities” and “Threats”.

The SWOT-analysis is a means to conclude the most important advantages and disadvantages of a product/business idea on the market. Selecting the top few aspects of each category help focusing on a few but important issues to stress in the marketing process (if positive) or improve/plan for (if negative).

Focusing Questions:

How can the STRENGTHS of the product be maintained and improved?

How can the WEAKNESSES of the product be minimised?

How can the OPPORTUNITIES for the product be utilized?

How can the THREATS to the product be forestalled and neutralized?

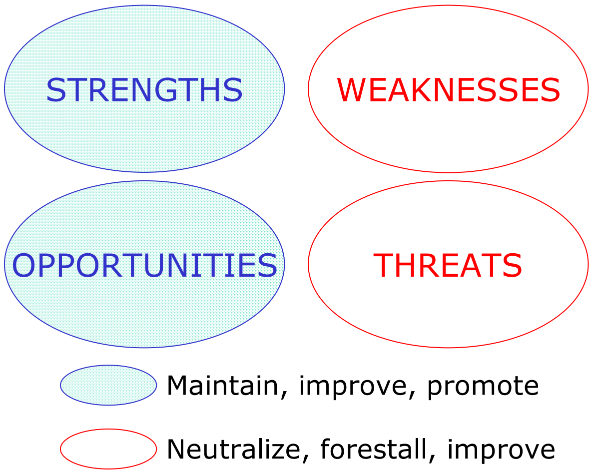


Figure 3.1 SWOT-analysis principle

"Strengths"* and *"Weaknesses" studies internal resources of the product (in this case a hybrid ventilation system) by comparing it with other products of the same kind (in this case other ventilation systems).

Key questions are:

What are the main advantages of hybrid ventilation compared to traditional ventilation?

What are the main disadvantages of hybrid ventilation compared to traditional ventilation?

Issues addressed concerns financial, physical, human and technical resources, processes and brand.

"Opportunities" and "Threats" focuses on external resources beyond the immediate control of the manufacturer e.g. opportunities and barriers posed by the surrounding world, such as the market, interested parties, sociological and behavioural aspects, regulations, political influence etc.

Key questions are:

What are the major opportunities posed by the outside world for hybrid ventilation?

What are the main threats to hybrid ventilation from the outside world?

Issues addressed concerns influence by the industrial structure, interested parties outside the client – manufacturer supply chain as well as the surrounding world.

This SWOT-analysis is based on prior studies "Market and Competition surveys" and "Study on sociological and behavioural aspects"

3.2.5 Concept test

Information as to the interest of the market for the new demand controlled hybrid ventilation systems developed by the four industrial consortia (Belgium, the Netherlands, Norway and Sweden) is needed in order to be able to determine to what extent the system will satisfy the customers demands.

The aim of a concept test is to give deeper knowledge concerning the assessment of the market of the developed concepts. The test should also result in how the market views the concept relative to other relevant ventilation systems.

Examples of issues that can to be elucidated in the concept test are
- Reactions to and interest in the concept
- Strengths and weaknesses related to the concept, additional features compared with competing systems
- Appreciation of specific properties/performance relative to existing solutions
- Further improvements
- How to promote the concept

The concept test can be arranged as a workshop with participants representing e.g. the following interested parties:
- End users
- Property owners/developers
- Architects
- Contractors
- Technical consultants
- HVAC suppliers/developersReferences

Engvall, K., Blomsterberg, Å., 2003. Reshyvent WP2 Market Survey – Guidelines problem detection study incl. focus group meetings.

Hedberg, E., Lundh, K., 2004. Survey of WP2 work, March 2004, Visus Market Research AB.

4 Results

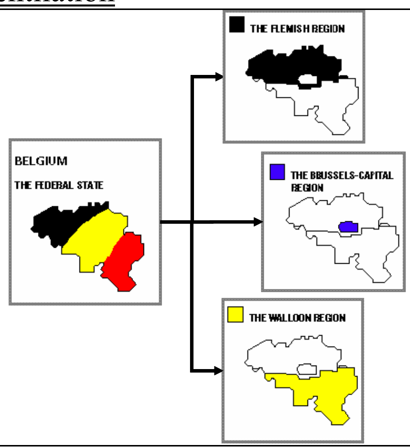
4.1 Belgium

4.1.1 Overview of customer and market characteristics

To have a good overview of the Belgian market, two important facts have to be mentioned:
- Belgium is a federal state; ventilation of dwellings is a competence of the regional states,
- there is a lack of public awareness about ventilation.

<u>Overview of the Belgian situation related to the residential ventilation</u>

Belgium is a federal state composed of three regions: the Flemish region, the Walloon region and the Brussels Capital Region.
Each region is competent to establish requirements relative to ventilation in (residential) buildings. At the moment to write this report, requirements about residential ventilation in new and in refurbished buildings have been imposed only by the Walloon Region. There are no explicit requirements into the two other regions, but the Flemish Region will impose some in the future.



The way residential buildings have to be ventilated in Belgium is described into the Belgian standard NBN D50-001. This standard is legally considered in Belgium as a rule of good practice and should always be applied, whatever explicitly required by a regional regulation or not. The SENVIVV study has shown that, without explicit requirement, this is surely not the case.
Residential ventilation is a relative new topic in Belgium. The Belgian ventilation standard (NBN D 50-001: Ventilation systems for housings) was published in 1991. The requirements about residential ventilation in the Walloon Region were only introduced in 1996. Due to this relatively recent introduction of residential ventilation in Belgium, very few studies are available describing the current situation relative to residential ventilation. In particular, the authors are not aware of specific market studies relative to residential ventilation in Belgium. The lack of requirements in two of the three Belgian regions reduces the application of residential ventilation and makes it difficult to describe the market. For two of the three regions, this lack of requirements doesn't really have created favourable market conditions yet. Answering question as 'system competition' is therefore difficult due one on hand to the small size of the existing market and on the other side due to the lack of studies about this topic.
The PDS study realised in the scope of the RESHYVENT project is, as far as the authors are aware, one on of the first studies realised on this topic in Belgium. This study was however done with limited resources. The reader should keep these remarks in mind when reading the rest of the description of the Belgian situation.

<u>Lack of awareness</u>
An important fact to mention before to detail the market characteristics is that in Belgium, there is a huge lack of awareness about ventilation of residential buildings. This has been shown by various studies (SENVIVV, Test-Achats), and confirmed by the expert invited to the focus group. Many property owners do not yet understand very well why ventilation is required. They usually believe that a house must be very well insulated and that therefore it is not logical to lose energy due to ventilation. Very often, people consider that opening the windows when leaving a room is a good way to ventilate it. This wrong message is even distributed by some professional, as can be seen in the figure below.

La VMC n'est cependant envisageable que pour les maisons neuves. En rénovation, la ventilation est possible notamment par les grilles de ventilation prévues sur certains châssis ou par le système d'ouverture oscillo-battant qui permet de laisser entrouvert le châssis de fenêtre. Retenons toutefois qu'ouvrir en grand les fenêtres pendant 3 minutes est plus efficace que laisser une fenêtre entrouverte toute la journée, et ceci sans refroidir significativement la maison, ni la surchauffer en été.

Mechanical ventilation with heat recovery is however possible for new dwellings only. In case of retrofitting, ventilation is possible with window vents placed in the window frame or with pivot-hung windows that makes possible to leave it half-opened.
Let us retain however that to fully open the windows during 3 minutes is more effective than to leave a half-opened window all the day, and this without cooling the house significantly, nor to overheat it in summer.

Grâce à toutes ces techniques, les maisons bioclimatiques en bois peuvent atteindre un coefficient d'isolation de K20, alors que les recommandations de la Région wallonne sont de K55. Imaginez les économies! En outre, ce système d'isolation respirant épargne aux occupants l'installation d'une ventilation mécanique puisqu'une ventilation naturelle s'opère à travers les parois en bois.	Thanks to all these techniques, the bioclimatic wooden houses can reach a coefficient of insulation of K20, whereas the recommendations[1] of the Walloon Region are of K55. Imagine the economies! Moreover, this system of breathing insulation saves to the occupants the installation of mechanical ventilation **since natural ventilation takes place through the wooden walls.**

Newsletter of an energy supplier, delivered by post to all his clients.

The focus group has also highlighted that people who intend to build a new house are most of the time not willing to pay (a lot) for a ventilation system. When the total price of the dwelling raises up, the user will often cut the ventilation system to reduce the total budget. Furthermore, they prefer to spend their too low budget in more "visible" facilities as nice kitchen and bathrooms. This could be prevented if there were in situ controls (at least in the Walloon region, where ventilation is required by law). The region organises such controls, but they are too seldom to be really threatening to the trespassers.

If they can not avoid a ventilation system, property owners very often look for the cheapest solution – whatever the quality.
Noise and aesthetics are considered by users as serious drawbacks.

<u>Building park size</u>
In Belgium, there are 4.22 million dwellings (year 2001) for about 10.3 million inhabitants. 75 % of the dwellings are single-family houses; 83% of the population live in single-family houses. Other key figures of the building park are available (Heijmans 2004).
Every year, building permits are delivered for ±45.000 new dwellings. The proportion of building permits for apartments is increasing every year (45% in 2001).

<u>Design process</u>
There are three ways a new house can be designed in Belgium.

1. The "traditional way", which was predominant in the recent past. The future owner selects an architect and explain him his wishes. The architect designs the dwelling according to the client's wishes and finds all required building contractors (i.e. all craftsmanships, from the building structure to the plumber…).
   In this case, the architect is responsible to design the ventilation system.
2. The "key-on-carries" (translation of the commonly used French expression "clé-sur-porte") or "all-in". This term designs a general building contractor who takes responsibility of the whole building process. The future owner selects such a general contractor, who generally presents him a catalogue of typical houses. The owner has still some liberties in the design, even if limited. As an architect is required by law, the owner has to take one; it will often be one presented by the "key-on-carries" company. The owner has only one contract with the "key-on carries" company.
   In this case, the "key-on-carries" company (and its architect) is responsible to design the

[1] By the way, the insulation level of K55 is not a recommendation of the Walloon Region, but is required by law!

ventilation system .
The share of the "key-on-carries" companies in the recent years[2].
3. The third way is when a company construct a dwelling in advance, even before it is sold. This is common in The Netherlands, where hundreds of identical houses are constructed and sold, but very rare in Belgium for single-family houses.
In this case, the company (and its architect) is responsible to design the ventilation system.

Demand and expectations from the customer

The demands and expectations of the customers are:
- costs are as low as possible (due to the lack of awareness, most customers are not willing to pay for a ventilation system – they do it only if they have no choice),
- beautiful, aesthetic view, minimum impact on the building design and outlook,
- possibility to manually overrule the ventilation system,
- no drawbacks of the system: noise, draught, condensation,
- maintenance is possible and as low as possible.

These conclusions are mainly based on the market information of RENSON gathered by about 50 people who daily visit the customers, as well as during commercial fairs.

How does then a hybrid ventilation system meet these demands and expectations?

The customers are for residential buildings people with higher incomes. The air handling producers AERECO as well as RENSON are looking for low cost and aesthetic products to use in the hybrid ventilation system and:
- manually overrule will be integrated
- noise: components with low noise levels are looked for
- draught can be strongly reduced by using self-regulating inlets
- condensation is not expected since the humid rooms (bath room and kitchen) will be controlled on relative humidity and this humid air is directly let out.
- all electronic and motorisation will be accessible for maintenance or repair

Market segmentation

The size of the one-family houses varies from 1 room to more than 8 rooms. The average size is 4.3 rooms per house and the floor area is 81 m². 75 % of the occupants own their dwelling and 24 % are leaseholders. There is no strong national tenant association.
However the market is small and relatively unknown, the following segmentation can be done[3]:
- A quarter of the occupants have "high incomes" (can freely chose their house without any problem),
- Almost half of the occupants have "middle incomes" (can choose their house according to the current general economic situation)
- The remainder has "low incomes" (can not easily own a house).

This division, however, could have changed during the last few years due to higher ground and house prices in combination with the actual economic situation.

As the price sensitivity of the customers is high, the price must be as low as possible.

[2] No statistics are available about the current share of the "key-on-carries" companies. Estimations vary between 15% and 50% of the new single-family houses.
[3] Source: George Verscheure, Fonction sociale et dimension économique du logement en Belgique, Bureau du Plan, Bruxelles, 1989

Interested parties and marketing channels
There are some main interested parties concerning ventilation. The architect has to design the ventilation system according to the Belgian standard NBN D50-001. Responsible for the purchase of the ventilation system is most of the time the buildings contractor.

The marketing channels to reach the customers are the architects, the building contractors and the commercial fairs.

Ventibel (www.ventibel.be) is the Belgian association of ventilation system manufacturers. The Belgian Building Research Institute (www.bbri.be) is a major source of dissemination about ventilation to Belgian contractors.

Requirements that apply to ventilation system
Most of the requirements of the Belgian standard NBN D50-001 apply to the ventilation system, but some of them apply to the ventilation system component, mainly to the natural inlets and outlets. For instance, natural inlets and outlets must have at least five operable positions: totally closed, totally open and three intermediate positions; natural exhaust duct must be (mainly) vertical; the height of roof cowls above the roof is specified.

4.1.2 The present and future market

Present potential market
The present potential market can be divided in new dwellings and renovation[4].

In the recent past (2000-2003), 25.000 building permits were delivered per year for new residential buildings. This includes 22.725 single-family houses and 20.125 buildings with in average 8.5 apartments, which means 42.850 new dwellings.

The existing housing stock was 4.22 million dwellings in 2001, whereof 75 % in one-family houses. Studies have shown that 14 % of the housing stock needed to be renovated in 1991 (without that a clear definition of renovation was given).

30% of the Belgian dwellings are not equipped with double glazing. In the Walloon region (as well as in the Flemish region when the new legislation will be in force), when you change the window frames, you have to partially apply the standard NBN D 50-001: only air inlets are required. This could clearly be a marketing channel for traditional natural ventilation systems, but probably is less relevant for hybrid ventilation systems.

It has to be mentioned that in two of the three regions in Belgium, the lack of requirements and the lack of public awareness about residential ventilation doesn't have created favourable market conditions yet. This has been confirmed by the experts invited to the focus group.

Nowadays, experts from ventilation industries have estimated that the market potential for hybrid ventilation in these buildings is very limited (about 0.1% of the existing and new dwellings only) and restricted to the people with the highest incomes.

Within the present market conditions, the industries do not see much potential for (huge) innovations. Indeed, the market is small and very sensitive to price. Besides, the impact of the EPBD is difficult to estimate and therefore innovation is quite risky.

Future potential market

[4] Sources of the figures given here: National Institute for statistics, based on the survey 2001.

The key factors for market growth in the ventilation business (in general) are:

1. Creating public awareness about ventilation
2. Real obligation by law to install a ventilation system and in situ controls
3. A good assessment of the ventilation system regarding the impact of the energy performance directive (see below).

➔ **Those three points are task for the regional governments.**

4. Reduction of the drawbacks: noise, draught, energy recuperation

Market growth, however, can induce price reductions, which means that the total turnover or profit of the ventilation business doesn't increase in accordance.

The coming implementation of the new Energy Performance of Buildings Directive could drastically change the potential future market, after 2006. This will be the case if the regulations allow to correctly evaluate the performances of innovative systems. In other words, if the regulations allow to show that the total energy consumption of the house can be reduced due to the hybrid ventilation system. The real market potential, however, is strongly determined by the required maximum energy consumption per dwelling and the energy gain of the hybrid ventilation system. At the moment, the latter can not be determined, which makes it impossible to predict the future market. Eventually, the ratio of energy gain to costs of a ventilation system, will determine the market.

4.1.3 Market competition

The ventilation systems competing with hybrid ventilation today are all other ventilation systems, since at present hybrid ventilation doesn't exist.

The shares of the market held by competing systems today are most of the time natural supply ventilation, while the market of mechanical exhaust grows when compared with natural exhaust. Balanced ventilation systems in dwellings are rare[5], but its share is probably increasing. It must also be noticed that manufacturers advertises more and more for air conditioning systems for dwellings.

As to patents within the ventilation business today the following can be said: Some Belgian ventilation devices companies protect their products via patents on the control mechanism of the ventilation device (flap), on the design of acoustic devices… while other companies don't have patents at all. It seems that abroad, the ventilation companies (Germany, The Netherlands) pay more attention to patents than in Belgium. According to some Belgian ventilation industries, the patents don't significantly affect the market introduction or design of a hybrid ventilation system.

The following counter moves can be expected from producers of competing ventilation systems: exhaust fans with very low energy consumption, so that the fans can run continuously without remarkable energy consumption. If that kind of exhaust fan becomes a common product, hybrid ventilation (according to the very strict definition of it) will probably never arise.

[5] [5] According to a survey in 1000 Flemish dwellings, only 2.7% of the Belgian (Flemish) dwellings are equipped with a exhaust or balanced mechanical ventilation system. Source: "Enquête naar het energiegebruik en energiegedrag bij Vlaamse gezinnen - In opdracht van :Ministerie van de Vlaamse Gemeenschap Afdeling Natuurlijke Rijkdommen en Energie", Septembre 2003.

4.1.4 Today's ventilation system in comparison with hybrid ventilation systems

An estimation of the costs of the currently applied ventilation systems has been done. These costs are dependant on the size of the dwelling since ventilation has to be foreseen in every room. Raw estimates are made for relatively big houses which are, according to the authors, the only ones where, under the present market conditions, hybrid ventilation has a potential market. For a dwelling with four bedrooms, one living room, one office room, one kitchen, a bathroom and two toilets, the authors have made the following estimates:

Ventilation system	Low estimates	Average estimates	High estimates
System A (Natural ventilation)	430 €	1600 €	3400 €
System C (Fan assisted exhaust ventilation)	780 €	2000 €	3800 €
System D (Fan assisted balanced ventilation) with heat recovery	2600 €	3300 €	4800 €

These prices are including components, installation costs and taxes (VAT). The important difference between the low and the average estimates for natural supply is due to different solutions currently used on the market (inlet grilles placed upon the glazing or frame-integrated systems allowing a controlled window opening). Whatever the system used, it has to fulfil the requirements of the NBN D50-001 standard. The cost of the hybrid system is not yet clear for the moment but should be in the same order of magnitude as the system D.

See also SWOT analyse.

4.1.5 SWOT-analysis

For the SWOT-analysis a hybrid ventilation system and a traditional ventilation system had to be chosen. The reference hybrid ventilation system is the IC3 concept. The reference traditional system is a natural ventilation system (called "system A" in Belgium) or a mechanical exhaust ventilation system (called "system C" in Belgium).
The IC3 concept can be described as a system C where all the components of the exhaust have been dimensioned to be able also to work only with natural driving forces. The assistance-fan has been specially developed to allow natural ventilation even when it is switched off. The whole ventilation system is centrally piloted by a control system. The system integrates sensors that are determining the ventilation needs at level of each room. The ventilation devices (inlets, outlets) are motorised. The control system determines in function of the needs and based on other parameters the status of all the ventilation components (fan speed, opening of the inlets and of the outlets) in order to realise the requested airflows. The system also integrated components for intensive natural ventilation aimed to realise night cooling.

Potential internal Strengths	**Potential internal Weaknesses**
1 Energy savings	1 Cost
2 Better IAQ	2 Aesthetics/Noise
3 Better summer comfort	3 Maintenance/Repair

Potential external	**Potential external**

Opportunities	Threats
1 EPR	1 Present Belgian market
2 Principle of Equivalence	2 Principle of Equivalence

4.1.5.1 Potential internal strengths

1 – **Energy savings**: compared to traditional systems, hybrid ventilation should offer more possibilities to save energy, thanks to a better control strategy (less energy for preheating by reducing airflow when possible, less energy for fan by running in natural mode when possible).
2 – **Better Indoor Air Quality**, thanks to a better control.
3 – **Better summer comfort**, thanks to intensive night cooling: this aspect is usually not included in traditional systems.

4.1.5.2 Potential internal weaknesses

1 – **Costs:** hybrid ventilation is expected to be more costly, as it requires more sensors, actuators, control units… The market is very sensitive to price, at least today.
2 – **Aesthetic aspects and noise** are, at the present time, some of the main concerns of user
3 – **Maintenance** is expected to be more difficult compared to traditional systems, as there are more components in a hybrid system. Also the occurrence of errors (and needed repair) can increase since the system is more complex.

4.1.5.3 Potential external opportunities

1 – **Energy Performance Regulations (EPR)** to be implemented according to the Energy Performance of Buildings Directive (EPBD). Such a regulation has been adopted by the parliament of the Flemish Region (± 67% of the Belgian building permit demands). The two other regions should follow later. The EPR developed in the Flemish Region includes requirements about ventilation and energy, and should be accompanied by intensive controls.
2 – **Principle of Equivalence (PoE)**: The EPR includes a standard calculation procedure to evaluate the EP of a building. When an innovative system is used, if it is not possible to assess its performance thanks to the standard procedure, it will be necessary to prove them with a calculation specific for the innovative systems; this is the PoE. According to the way the PoE is organised, it can be a serious opportunity or a huge barrier for innovative systems, including hybrid ventilation. It will be an opportunity if it allows to properly (honestly) evaluate the performances, in a similar way for all EU countries.

4.1.5.4 Potential external threats

1 – **Present Belgian market**: as shown in the literature study and by the expert focus group meeting, ventilation systems are not well applied in Belgian dwellings, due to the fact that this topic is relatively new in Belgium, the fact that property owners are not yet convinced of their utility. For many people, ventilation can perfectly be done by opening the windows. However, this changing slowly and should dramatically change with the EPR.
2 – **Principle of Equivalence (PoE)**: will be a barrier if the industries do not know exactly and in advance how to evaluate their products, and/or if it varies a lot from countries to countries. This is why RESHYVENT should work on that subject.

4.1.6 Summary and Conclusions

Nowadays in Belgium, people are not sufficiently aware of the need to have a ventilation system in dwellings. Very often they consider that opening the windows when leaving a room is a good way to ventilate it. *Awareness* is a first problem for the implementation of ventilation systems in dwellings.

The *lack of requirements* is another possible source of problem. Belgium is a federal state and ventilation of (residential) buildings is a regional competence. At the moment, there are only requirements in the Walloon region. The Flemish region will introduce similar requirements soon (with the Energy Performance Regulations, in 2006). Both existing Walloon and coming Flemish requirements are based on the Belgian standard about ventilation in dwellings (NBN D 50-001). However, as standards are considered by the law as "rule of good practice", they should be applied even if no regulations explicitly required it. Studies (like the SENVIVV and Test-Achats studies) have shown that this is not the case.

The Belgian standard NBN D 50-001 is mainly descriptive. It is not a barrier for hybrid ventilation, as far as such system is designed as a natural ventilation system.
Other problems that prevent the good application of ventilation in residential buildings are (according to the experts invited to the focus group):

- the lack of knowledge of some architects,
- the total price of the building, which leads the user to cut the ventilation system to reduce the total budget,
- the heavy competition, that lead the suppliers/installer to deliver a system for the lowest price possible, whatever the quality,
- the lack of knowledge or attention paid by the installer,
- the absence of control when the house is achieved. As the owner does usually some works himself to reduce the total budget, the end of the works can be years after the start.
- ….

As the share of the "key-on-carries" or "all-in" companies is increasing, this could be a possible marketing channel for hybrid ventilation system. However, under the present conditions, only the people with high incomes could be a market.

However, the Flemish Region has just adopted (April 2004) an Energy Performance Regulation (EPR), which includes requirements for indoor climate and indoor air quality. In this regulation, intensive controls and sanctions are foreseen. The introduction of the EPR could dramatically change the present conditions and promote innovative/hybrid systems, as it is the case in The Netherlands. The two others regions (Walloon Region and Region of Brussels-Capital) will have to adopt an EPR too, as it is required by the EPBD.

The demands and expectations on ventilation systems of the customers are:

- costs should be as low as possible,
- beautiful, aesthetic view, minimum impact on the building design and outlook,
- possibility to manually overrule the ventilation system,
- no drawbacks of the system: noise, draught, condensation,
- maintenance is possible and as low as possible.

A hybrid ventilation system will meet these demands and expectations by including low cost and aesthetic products and by:

- integrating manual overrule
- using components with low noise levels
- strongly reducing draught by using self-regulating inlets

- avoiding condensation in humid rooms (bath room and kitchen) by controlling relative humidity and letting the humid air out.
- making all electronic and motorisation accessible for maintenance or repair

The target investment price of a demand controlled ventilation system is the price level of fan assisted balanced ventilation with heat recovery.

The present market potential is 2 000 new dwellings and 2 000 refurbished dwellings. The future market potential is likely to be much higher, but difficult to estimate currently.

4.1.7 References

Literature for the market survey and PDS study using focus groups

Standard	NBN D 50-001, Ventilation systems for housings, 1991
SENVIVV	Rapport CSCT n°4, Enquête sur l'isolation, la ventilation et le chauffage dans le logement neuf, 1999
Test Achats	Lesage O., Vanparys R., Maisons à tous vents ?, Test Achats Magazine n°453, 2002.
Concours « Maisons Solaires »	Loncour X., L'heureux D., Van Orshoven D., Wouters P., Concours Maison Solaire n°1 – rapport final, CSTC, 1999
Reshyvent	WP 4 'Standards and Regulations support unit' (STAR-SUN) - Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems - PART 1 : Standards and regulations concerning indoor air quality and summer comfort Heijmans N., Loncour X., Pollet I., Present situation in Belgium in regard to hybrid ventilation (Task 2.2.1 Literature studies), RESHYVENT project report, 2004
Others	For detailed references for facts and figures given in this report, the reader is invited to consult the literature review report mentioned here above.

4.2 Czech Republic

4.2.1 Overview of customer and market characteristics

The end customers of ventilation systems for new construction and refurbishment, if every dwelling owner or renter is taken into account, was 3.73 million (apartments in total as at 1999), out of which 39.9% , i.e. 1.49 million dwellings in single family houses. Average number of occupants is 3.7 per dwellings. 46% of dwellings are private ownership, 19% cooperative ownership, and 35% community ownership.

Since 1999 new construction represents around 24000 dwellings per year, from which 43% in multifamily multi-storey houses. That means that there are approximately 13680 single family houses built every year. Concerning multifamily houses, there is an average number of 10 apartments per house and we can estimate an average of 5 houses belonging to one developer and locality. Then we can assume about 200 decision makers. In total we can estimate 4000 decision makers every year in new houses.

Concerning the existing buildings, from total of 3.73 million of dwellings there are 704,000 cooperative owned buildings, 1,219,000 tenement houses and 1,722,000 privately owned buildings. In case of tenement houses, there are mostly municipality owned houses and in this case a City company charged with the management of buildings is the decision maker. In case of cooperative owned buildings this is the cooperative who decides, i.e. a representative of each apartment has one vote. In this situation we can estimate the number of decision makers to be about 190,000. In privately owned houses the situation is more complicated, but keeping again the average number of occupants per dwelling 3.7, then we have about 465,000 decision makers.

In the Czech republic, ventilation systems in general are underestimated and still considered as a sort of higher standard. People are concern primarily about energy savings for heating. Ventilation is something extra.
Main demands of the customers would be:

- possibility to overrule the system (chance to open windows)
- low noise, draft and no condensation
- must be reliable, requiring minimum running and maintenance cost and energy

Good IAQ is not a very much concern because people generally know a little about it (mostly they know about odours and smoke, much less about relative humidity and even less about CO_2).

In the last decade, the behaviour of people living in apartment houses has changed. Before, when energy was very cheap, the houses were overheated and the most “popular” way how to reduce the impact of high temperature on a human was to wear short sleeves and pants at home. This was accompanied by wide open windows even in winter for long day periods. Since early 90th, the energy cost has drastically increased, thermostatic control was installed in most of apartment houses and behaviour of residents has changed. But even though, the average temperature people are used to set up is 24 to 26°C in living rooms.

How does hybrid ventilation system meet the demands and expectations of the customers? When compared to mechanical systems (but these are very rare, so this comments are based rather on “what if”.) In general, if the hybrid ventilation system meets demands mentioned above, then the system could be given preference. Life cycle could be a concern (CO_2 sensors and their regular calibration).

Slowly a class of rich people develops and these people, if positively influenced (architect, consultant) may be considered as customers that would prioritise a good and advanced ventilation system in single-family houses. Generally, people don’t know very much about ventilation systems, except natural ventilation and mechanical kitchen exhaust. Mostly, if architect recommends a ventilation system, customer accepts or not. But architect doesn’t decide, except public buildings. On the other hand, there are about 1 million of prefabricated multifamily multi-storey houses in the Czech Republic and this is a big market for retrofit including ventilation systems.

In public buildings (schools, libraries, hospitals etc), the market for ventilation systems could be promising as IAQ is a concern. Due to the fact that in the Czech Republic the ventilation systems are rare, the new hybrid ventilation system has probably a bigger chance because this system enters the market in relatively same time as other mechanical systems with heat recovery. In family houses and residential houses, investment and running and maintenance costs will be judged as priorities.

The price sensitivity of the customers is high.

At the moment the prise is a leading factor. Architects and consultants may suggest, but the cost of the system decides.

Who in the customer organisation is responsible for purchase of ventilation systems?
In principles it is the property owner in coordination with manager of the property. Architects and consultants advise them.

The marketing channels for reaching the customers are mostly architects, contractors but mainly specialized fairs ("For habitat" and "For Arch" as two biggest and several others smaller in the Czech Republic).

The purchasing process may differ, but in general, the ventilation system (if any) is designed as an integral part of the building and property owner accepts or not the designed solution.

Ventilation related matters are mainly handled by the following organisations:
- Society of Environmental Engineering (member of Federation of European Heating and Air-conditioning Associations REHVA)
- Association of installation companies
- Chamber of chartered technicians and engineers

When introducing a new ventilation system on the market one has to be aware of the following national requirements:
The key Czech legislation in the field of energy use is the Energy Management Act No. 406/2000 Coll. This act determines which thermo-technical parameters of buildings and constructions must be evaluated in order to accomplish the corresponding effective energy use. The Decree No. 291/2001 Coll. issued according to this act, determines the particular criteria to be met. However, this principle is valid for construction and modernisation of buildings with consumption of heat higher than 1500 GJ/year if they are financed by public financial means. The whole construction and modernisation of apartment houses and public buildings must then only observe the National Technical Standards (see list of references below). In all cases however, only the thermal input for heating is being evaluated.

Concerning private buildings sector, which is out of the rules of Energy management Act and Decree no. 291/2001 Coll, there is necessary to proceed according to the National technical standard CSN 73 05 40. This standard gives the content and form of the Energy Passport of Building and the method of approaches in creation of the definition of energy demand of buildings.

Energy Management Act No. 406/2000 Coll.
Decree No. 291/2001 Coll.
CSN 734301 - Residential buildings, issued 1.1.1989, harmonized 1997, currently under revision, (only in Czech)
CSN 730540 - Thermal protection of buildings, Part 2: functional requirement, issued 1.6.1994, harmonized 1999, currently in fundamental revision that will take into account ventilation of rooms, (only in Czech)

CSN 060210 - Calculation of thermal losses of buildings for central heating systems, (only in Czech)
Circular of the Czech Ministry for regional development 137/1998, (only in Czech)

4.2.2 The present and future market

The size of the total market i.e. the size of the existing housing stock is 3.73 million dwellings in total (as at 1999), out of which 40 % , i.e. 1.49 millions are dwellings in single family houses.

The existing housing stock is equipped with the following ventilation systems[1]:

Single family houses			Apartment buildings		
Natural/-passive	Mechanical exhaust	Mechanical balanced	Natural/-passive	Mechanical exhaust	Mechanical balanced
97 %	2 %	1 %	98 %	1 %	1 %

[1] Figures come from a qualified guess resulting from a discussion with some experts in ventilation and construction. There are no official statistic data about ventilation systems available.

In 1999 new construction represents around 24000 dwellings. Each year from 1998 approximately 24000 new dwellings were built, 43% in multifamily multi-storey houses. About 1 million of multi-storey multifamily are prefabricated residential houses and need to be refurbished.

It is very difficult to estimate the market potential for hybrid ventilation systems in these building, but the potential might be mainly in refurbished prefabricated residential houses (mostly community and cooperative owners, in last years private ownership is more expanding) that are currently being thermally insulated thus becoming air tighter. As a consequence, condensation and mould begins to be a serious problem. If hybrid ventilation system offers positive features compared to mechanical systems with heat recovery, then hybrid ventilation system may have a good potential.

The time perspective for implementation of hybrid ventilation systems in the aforesaid market is estimated to be around 10 years before the system will be well marketed.

The key factors for market growth in the ventilation business are changes in the legislation, establishing demands on IAQ. Also see above concerning mould and condensation. Cost of the system (investment and running costs) is of primary concern.

We can expect some changes in the market since 2006, when new EPBD directives will be implemented. Future energy saving potential depends on what we compare. If we compare hybrid ventilation system with opening windows there are potential savings. How much? No one is able to specify as everybody open windows differently – pressure difference, number of windows, position of windows etc. When we compare with standard ventilation systems designed according the existing standards that require ventilation by constant airflow, the savings can be estimated to a minimum 50%, if we roughly reduce by 50% the time needed for the ventilation. So far all ventilation systems in residential houses must be designed according national standards, i.e. they must ensure the specified amount of airflow for different kind of spaces no matter if this is necessary or not.

More correct information on saving potential with hybrid ventilation will result from demonstration houses which should be considered as most appropriate source for such data.

Only more expensive residential houses that are not affordable for most of population are equipped with ventilation systems, mostly standard systems with heat recovery. As for family houses, the same applies. The main weak point is that there is no national manufacturer in CZ of any system except heat recovery system (e.g. firm ATREA) and so far no manufacturer of any hybrid ventilation system has entered the Czech market. Dissemination is thus the main task to be done, because the investment price and operational and maintenance cost of hybrid ventilation system could be relatively low compared to heat recovery systems.

Mainly companies manufacturing heat recovery systems will be against the hybrid ventilation systems.

4.2.3 Market competition

The ventilation systems competing with hybrid ventilation today are all other ventilation systems. hybrid ventilation system is unknown system so far, better known are mechanical systems with heat recovery, which are considered as most advanced. Otherwise, natural ventilation by opening windows is a “most popular system”.

There is no official statistics as to how much of the market is held by each of the competing systems today. Estimation is that about 98% of ventilation systems are natural systems (windows) assisted with kitchen and/or bath mechanical extract.

There is no information available as to how are the competing systems marketed today. Typically architects and consultants recommend, manufacturers advertise and there are specialized fairs.

A search on www.upv.cz doesn’t show any patent that relates to residential ventilation and that could be considered as a competitor to hybrid ventilation system.

4.2.4 Today’s ventilation system in comparison with hybrid ventilation systems

In the Czech republic, currently the majority of ventilation systems are natural ventilation system consisting simply of opening windows. Most of dwellings are equipped with kitchen cooker hood and to a lesser extent with bath extract. More sophisticated ventilation systems are rare (mechanical with extract, mechanical balanced, with heat recovery). The major drawback for ventilation systems to be installed is the price and then the feeling of most of customers that ventilation systems are super standard and are not necessary. This feeling is very slowly changing mainly in situations when houses are refurbished (by only putting better thermal insulation and new windows) and occupants face problems with condensation and mould. If any ventilation system is to be installed, then price, noise, draft, maintenance and running costs will be a major concern.

The investment cost for a traditional ventilation system for a new building is difficult to specify as the traditional ventilation system is just opening windows accompanied by kitchen and bath extract. If we go a little further, then newly installed systems are mainly mechanical systems with heat recovery (recuperators) and their cost for an average single-family house is about 4 000 Euro. The hybrid or IC2 system is expected to be cheaper (about 3000 Euro) without heat recovery, i.e. by about 25 % cheaper. The investment costs for mechanical system with heat recovery include the basic recuperator with two fans, but exclude ducting and installation works. The same applies to IC2 system, but this one includes complete control system. The ducting for IC2 system is simpler then ducting for mechanical system with heat recovery.

4.2.5 SWOT-analysis

In the SWOT analysis we assume a hybrid ventilation system according to the IC2 concept and as traditional concept natural ventilation that is the most frequently used system in the Czech republic. IC2 system consists of self-regulating inlets, low power fan and control system. The system can be operated in either time-control or sensor-controlled mode, this latter based on CO2 concentrations.

Potential internal Strengths	Potential internal Weaknesses
1 Energy savings	1 Cost
2 Better summer comfort	2 Aesthetics/Noise
3 Better IAQ	3 Maintenance
4 Removal of vapour content	4 Design of hybrid ventilation system

Potential external Opportunities	Potential external Threats
1 New national building regulation	1 Present Czech market
2 Architects and consultants positive approach	2 High price sensitivity.
3 Need of refurbishment	3 Customers attitude
4 Decrease waste of heating	

4.2.5.1 Potential internal strengths

1 – **Energy savings**: Energy savings might we considered as strengths of the hybrid ventilation system but only when compared to traditional natural ventilation system because almost the only systems used in the Czech republic are natural ventilation. This potential could become a real strength only if customers begin to consider ventilation of dwellings as a necessary tool to improve IAQ.
This requires big efforts in dissemination of information about IAQ and necessity of ventilation systems. When compared with mechanical systems with heat recovery, the hybrid ventilation system shows strength in its simplicity and certainly in energy consumption.
2 – **Better Indoor Air Quality**, can be expected due to better control.
3 – **Better summer comfort**, due to intensive night cooling which is usually not included in traditional systems.
4 – Removal of vapour content, from indoor air more effective with humidity controlled ventilation system

4.2.5.2 Potential internal weaknesses

1 – **Costs:** hybrid ventilation is expected to be more costly, compared to natural ventilation systems. It requires more sensors, actuators, control units… The Czech market is very sensitive to price.
2 – **Aesthetic aspects and noise.** Again when compared with natural ventilation, the hybrid ventilation system might be a concern of users due to higher noise level.
3 – **Maintenance** is expected to be more difficult compared to traditional systems, as there are more components in a hybrid system. Calibration of CO2 sensors might be a real problem for larger spread of hybrid ventilation systems.
4 - **Design of hybrid ventilation system**, problem that relates to hybrid ventilation system with preheating or without preheating. In the continental climate of the Czech republic the average annual temperature is lower than in countries on the Atlantic rim, therefore preheating might be necessary to avoid draft risk. But monitoring on a demo site is required before making conclusions.

4.2.5.3 Potential external opportunities

1 – **New national building regulation. Energy Performance of Buildings Directive (EPBD)** are planned to be implemented in the Czech legislation by January 2006 with the aid of EU experts. By determining requirements on ventilation of dwellings may help increasing possibilities of hybrid ventilation systems to be installed. Technical standards should be modified. When designing hybrid ventilation system today, the energy consumption for ventilation is calculated for permanent required exchange of air. Demand control and thus ventilation only on demand is not taken into account. Such approach results in very high energy consumption for ventilation without heat recovery.
2 – **Architects and consultants positive approach.** Architects and consultants mostly have positive approach towards using hybrid ventilation systems if the benefit of the system is well explained.
3 - **Need of refurbishment.** About 1 million of dwellings in the Czech republic in prefabricated residential multifamily multi-storey houses are expected to resolve the problem of IAQ. After being thermally insulated and after exchange of windows the dwellings become very airtight and condensation and mould is a concern.
4 - **Decrease waste of heating.** Demand control can save energy for heating compared to natural ventilation without control.

4.5.2.4. Potential external threats

1 – **Present Czech market**: Ventilation systems in the Czech republic are not well applied in dwellings, due to the fact that property owners are not yet convinced of their utility. For most of customers, the only and sufficient ventilation is by opening the windows. However, this attitude can slowly change after implementing EPBD and after customers become aware of the IAQ.
2 - **High price sensitivity.** The Czech market is very price sensitive and ventilation is still considered as a super standard.
3 - Customers attitude. Unless the IAQ becomes a real concern of customers, or regulations will enforce ventilation, any ventilation system except natural (by opening windows) will be considered expensive and something what is considered as luxury.

4.2.6 Summary and Conclusions

Ventilation systems in the Czech Republic are not well applied in dwellings, due to the fact that property owners are not yet convinced of their utility and there are no requirements for or on ventilation systems. For most of customers, the only and sufficient ventilation is by opening the windows. However, this attitude can change after implementing EPBD and after customers become aware of the IAQ.

The key factors for market growth in the ventilation business are changes in the legislation, establishing demands on IAQ. Also concern about mould and condensation is important. Cost of the system (investment and running costs) is of primary concern.

The main demands on ventilation systems of the customers would be:

- possibility to overrule the system (chance to open windows)
- low noise, draft and no condensation
- reliable, requiring minimum running and maintenance cost and energy

Based on the analysis carried out for this report the following conclusions may be drawn:

- hybrid ventilation systems must be reliable, cheap, user friendly and at low running costs.
- most of customers still consider any sophisticated ventilation system as luxury equipment. This attitude can change as new directive EPBD enter into action from 1 January 2006.
- hybrid ventilation system is also well suited for retrofit of older buildings as ducting is relatively simple.

Information about any ventilation system, including hybrid ventilation needs be broadly disseminated and attention must be paid to IAQ and its relation to human health. In this area, Czech customers "wait" for more intense information campaign.

The target investment cost for a demand controlled hybrid ventilation system is to be lower than a balanced mechanical ventilation system with heat recovery.

4.2.7 References

List of experts - interviewees for the focus group study

Representing interest	Participant	Company
Property owner	Zdenek Jerabek	Infram
Consultant	Jiri Sedlak	Sedlak consultancy
Authorities	Vladimir Macek	Brno University investment department
Architect	Ladislav Vrana	Atelier 2000
Architect	Josef Horny	Horny architects
Developers	Ladislav Cevela	Cevela developing, Ltd. Prague
Research institution	Jitka Mohelnikova	Brno University of Technology, Faculty of Civil engineering

Energy Management Act No. 406/2000 Coll.
Decree No. 291/2001 Coll.
CSN 734301 - Residential buildings, issued 1.1.1989, harmonized 1997, currently under revision, (only in Czech)
CSN 730540 - Thermal protection of buildings, Part 2: functional requirement, issued 1.6.1994, harmonized 1999, currently in fundamental revision that will take into account ventilation of rooms, (only in Czech)
CSN 060210 - Calculation of thermal losses of buildings for central heating systems, (only in Czech)

Circular of the Czech Ministry for regional development 137/1998, (only in Czech)
http://www.mmr.cz (web pages of the Ministry for Regional Development)

4.3 Denmark

4.3.1 Overview of customer and market characteristics

The end customers of ventilation systems for new construction and refurbishment are owners of one-family houses, owners of apartment buildings and tenant-owner building societies. The number of one-family dwellings are 1.27 millions based on 1999 figures. The property owners are 449,000 based on 1999 figures and the members of the Danish tenant owner associations are 741, based on 2000 figures. All figures are gathered from The Danish Ministry of Housing and Urban Affairs. The total number of customers for ventilation systems in dwellings adds up to 1.72 millions.

The customer segment in the field of ventilation in Denmark can be divided into three major market segments.

Category 1: Public organisations subsidising dwellings
Category 2: Private organisations letting out dwellings
Category 3: Property owners residing in own dwellings

The general level of capital available for the customer groups varies and those influence the market characteristics for hybrid ventilation systems. Based on a preliminary market survey conducted by Esbensen Consulting Engineers A/S in the year 2002, the price of a hybrid ventilation system is the deciding factor for further implementation of hybrid ventilation for category 1 and partly category 2 as opposed to passive/mechanical ventilation only. For category 3 and partly category 2 the price of the hybrid ventilation system will have to be in accordance with the life span of the product and how much capital can be saved compared to passive/mechanical ventilation. In general the customer group of hybrid ventilations systems has a varied perception of demands and expectations of a hybrid ventilation system.

Based on interviews of a focus group, it can be concluded that the customer groups have individual demands and expectations to a hybrid ventilation system, but agree as a whole that it is of utmost importance that a hybrid ventilation system is reliable and user friendly.

The focus group was asked to rank the different elements of a hybrid system compared to a mechanical- and natural ventilation systems. The finding of this survey is:

- The components used in a hybrid ventilation system are valued higher than mechanical ventilation, but worse than natural ventilation.
- The design of a hybrid ventilation system are valued almost the same as mechanical and natural ventilation systems.
- The performance of a hybrid ventilation system is valued higher than natural ventilation, but mechanical ventilation is overall higher valued. It is seen, that the noise factor and energy saving potential are the major factors to why hybrid ventilation systems are ranked worse than both mechanical and natural ventilation.
- The control of a hybrid ventilation system is valued higher than natural ventilation but lower than mechanical ventilation.

- The cost of a hybrid ventilation system is ranked below both mechanical and natural ventilation. Hybrid ventilation can only compete with cost of a natural ventilation system in retrofit buildings.

Based on the received material from the focus group, it is seen that suppliers generally have a negative attitude towards hybrid ventilation, and would not recommend the use of hybrid ventilation to reduce costs of fan electricity. On the contrary, both architects and consultants generally have a positive attitude towards recommending hybrid ventilation to obtain better indoor climate and reduce costs.

The responsible personal for purchasing ventilation systems differs depending on the market segment. In the segments of public and private organisations, it is the property owner who is responsible of the purchase of ventilation system, but often relies on the advice of the consultant (consulting engineer or main contractor) hired by the building owner. In the segment of property owners it is solely decided by the property owner, which ventilation system to purchase.

The process of purchasing a hybrid ventilation system is in general that a consultant analyse different ventilation systems and gives advice to the property owner, which approves a certain solution and invites contractors to submit bids. Hereafter, the property owner chooses a contractor depending on price, quality etc. The contractor orders the ventilation system at the supplier or directly at the manufacturer.

The marketing channels for hybrid ventilation systems are for the customers in the segment of public and private organisations the consulting engineers and main contractors. In the segment of property owners the marketing channels are suppliers and small contractors.

In general ventilation related matters are mainly handled by the Danish building and Urban research institute (www.by-og-byg.dk) and by Danish society of HVAC engineers (www.danvak.dk . These two organisations cover a large part of the companies and the people involved in the process of designing and developing ventilation strategies and systems.

When introducing a new ventilation system on the market one has to be aware of the following national requirements. The current Danish building regulation requires a certain minimum air change and does not state requirements for the IAQ. If natural ventilation is used there are minimum requirements for the sizes of the openings to the outside. If the air change is provided from a balanced system a heat recovery system is compulsory.

4.3.2 The present and future market

In 1975-84 the Danish Parliament presented subsidies for energy savings in buildings. Two of the schemes were focused on sealed glazing units and cavity insulation and resulted in major replacements in these two areas in building stock. This caused an overall change in indoor climate in Danish buildings, and the Danish Energy Agency launched an information campaign on correct ventilation (Hansen, K. H). This, combined with tightening the demands in the building regulations on air change rate in buildings with natural and mechanical ventilation, resulted in an increased use of and interest in mechanical ventilation. Since the eighties all new multi-family buildings have been equipped with mechanical ventilation, and the number of balanced ventilation in new single family buildings has also increased remarkably (2002, Danish Statistics).

In the Danish building code of 1995 the demands of ventilation was tightened again. The only type of ventilation allowed in multi family buildings is mechanical ventilation. This combined with an added knowledge of IAQ, e.g. resulting in DS 474: Code of Practice for Ventilation Installations, has resulted in present market.

The present market

The market can be divided into manufacturers, owners of one-family houses, property owners and/or developers (apartment buildings) and tenant-owners building societies.

The size of the total market i.e. the size of the existing housing stock is 2.52 million dwellings in all, where 47 % is rental dwellings and 53 % is owned dwellings (2002, Danish Statistics)

The existing housing stock is equipped with the following ventilation systems:

Single family houses			Apartment buildings		
Natural/-passive	Mechanical exhaust	Mechanical balanced	Natural/-passive	Mechanical exhaust	Mechanical balanced
97 %	1 %	2 %	75 %	25 %	0,1 %

The future market

Refurbishment:

During the period of 2002-2005 the renovation of dwellings financially supported by the government will be reduced from 2 billion price in Euro to 1,25 billion price in Euro. This will, according to the government, reduce the number of dwellings that are granted benefits from 2,690 (year 2001) to 1,650 (year 2005). (The Danish Federation of Small and Medium-Sized Enterprises, April 2002). This is in accordance with the suggestions in the recent budget from the Government. Based on the numbers and distribution of existing ventilation systems a rough estimate of the potential for hybrid ventilation systems in existing buildings (refurbishment), is set by the author to 1-5% of existing dwellings in Denmark (25,000 – 125,000 systems) in total. This figure is however very uncertain as many factors influence the market.

New construction:

According to the suggestions in the recent budget from the government (August 2002), investments in additional dwellings will primarily be dedicated to young people under education and enhanced amount of private organisations letting out property privately.

The dwellings for young people will be financed with an additional 1 billion DKK between 2003-2007 and is estimated to create 3,500-4,000 new dwellings, mainly college residences, for young people in that time period owned by private organisations. Furthermore, 2,500 new dwellings dedicated for young people owned by public organisations will be erected in that same period of time. The public subsidies for new construction will be at the expense of investments in modernisation of existing dwellings. As the new construction mainly will be focused on accommodation for young people, it is unlikely that this segment of new dwellings will be willing to add to the cost per square meter necessary in order to implement hybrid ventilation, unless the savings for the clients are considerable compared to the life span of the system. On the contrary implementation of hybrid ventilation is easier in new constructions compared to existing buildings, which can be an advantage.

The time perspective for implementation of hybrid ventilation systems in the aforesaid market is 3-10 years, but will depend on the time for release of a new Danish building regulation. A real market penetration is not expected within the near future mainly due the actual share of mechanical ventilation systems, which are dominating the market.

The key factors for market growth in the ventilation business are changes in the legislation and hybrid ventilation suppliers to diversify the market.

4.3.3 Market competition

The ventilation systems competing with hybrid ventilation today are passive/natural ventilation, mechanical exhaust and balanced mechanical ventilation. In this context passive/natural ventilation includes kitchen hoods and extracts from bathrooms.

The market shares held by each of the competing systems are difficult to estimate, however, the current distribution of the ventilation systems in percentage of the total market can be seen in the table below.

Type of Housing	Passive Stack	Exhaust	Balanced
One-family	97%	1%	2%
Multi-family	75%	25%	0

Market shares of ventilation systems in Denmark 2002. (The Danish Statistics 2002)

Systems aiming at products for property owners in own dwellings are typically marketed in newspapers, fairs and on Internet sites. Products for property owners letting out dwellings are marketed in professional journals, direct mail campaigns, catalogues, leaflets and on web sites.

A search on "Residential ventilation" in the international database of patents (www.espacenet.dk) gives 47 patents, but none of these are Danish.

Counter moves that can be expected from producers of competing ventilation systems are lobby-work influencing standardisation and legislation as well as increased marketing actions. On a longer time perspective development of similar products can be foreseen.

Future changes in legislation can reduce or even eliminate the need for a specific innovative ventilation system. This introduces a risk in the near future and can postpone development of new systems until new or adjusted regulation is known.

4.3.4 Today's ventilation system in comparison with hybrid ventilation systems

In the following the advantages and disadvantages comparing today's ventilation system with hybrid ventilation, according to interviewees, are presented[6]:

Advantages:
- The reduced noise levels compared to strictly mechanical ventilation.
- The reduced energy consumption compared to mechanical ventilation.

[6] The list of interviewees is presented in the reference list

- To save energy for ventilation is necessary, therefore hybrid ventilation has a great potential as it has the possibility to increase the comfort and lower the energy consumption.
- More reliable compared to natural ventilation, as there are times during a summer situation where there are no natural driving forces.
- In principle there is a greater possibility for obtaining a satisfactory indoor climate when using hybrid ventilation compared to both natural and mechanical ventilation systems.
- A larger degree of freedom for the user. There is more manual control, which is in line with the demands today, as the user can regulate the inlet/outlet flow volume.
- There is a possibility for cross ventilation.

The reduction of energy use in combination with reliability is viewed as the largest advantage for hybrid ventilation.

Disadvantages:
- The experience with both natural and mechanical ventilation is larger and they therefore have an advantage over hybrid ventilation.
- The natural ventilation in winter within the hybrid ventilation might be a problem as preheating is hard (not possible) and the control of the system becomes difficult.
- It is hard to control the air streams especially in night cooling modes.
- The investment compared to both mechanical and natural ventilation is viewed as higher.

The lack of experience with hybrid ventilation is view as the largest disadvantage.

From the interviews the most dominating barrier for hybrid ventilation today, is the lack of practical experience, both in construction and in operation of the system in actual dwellings.

The other identified main barrier, is the lack of awareness of the hybrid ventilation concept and the potentials it has for implementation in dwellings.

The investment cost (including material but excluding installation and VAT) for a traditional ventilation system for a new building is 700 Euro (5 000 DKr) [7] for an apartment with a floor area of 80 m^2. A traditional ventilation system for dwellings consists of exhaust from the kitchen and bathroom. A hybrid system is expected to be approx. 40 % more expensive.[8] The investment costs include flow and temperature sensors, heating coil, fan, filter and motor controlled dampers.

In the future with higher demands for a low heating consumption, it is likely that balanced ventilation systems with heating recovery will become more widespread. The investment cost (including material but excluding installation and VAT) for a ventilation system with a heating recovery unit for an apartment is approx. 2 000 Euro (15 000 DKr).
It is expected that the cost of installation is higher for a traditional ventilation system, than for a hybrid ventilation system.

[7] The price is for a standard system from the Danish manufacture Exhausto
[8] The price is for an Airmaster Navent100 from the Danish manufacture Airmaster

4.3.5 SWOT-analysis

In the following a short SWOT analysis is carried out for a hybrid ventilation system. The assumed hybrid ventilation system (HV) is a demand controlled natural ventilation system with mechanical backup in the exhaust, placed in kitchen and bathrooms.

The analysis is based on a comparison to traditional mechanical balanced or exhaust ventilation system. The below table gives an overview of the issues identified in the SWOT.

Potential internal Strengths	**Potential internal Weaknesses**
1. Less maintenance	1. Low level of experience
2. Demand controlled, resulting in larger satisfaction	2. Limited possibilities for heat recovery
3. Energy savings (electricity and heat)	3. Hard to control the air flows correctly
4. Reduced noise level	4. Higher initial cost
5. Freedom for the user, because of manual control	
Potential external Opportunities	**Potential external Threats**
1. Architects and consultants positive attitude	1. Individual demands and expectations
2. Government financial support.	2. High price sensitivity
3. New national building regulation	3. Negative supplier attitude
4. The energy performance directive	4. Reduced financial support for refurbishment
5. Need of refurbishment in communities in Denmark	
6. High cost for electricity in Denmark	

The issues listed in the SWOT table is explained in more detail in the following sections.

4.3.5.1 Potential internal strengths

1 – Less maintenance

Less maintenance is expected as a hybrid system usually has less components and ducts and filters.

2- Demand controlled

The demand control used for the hybrid ventilation results in a higher degree of user satisfaction, as the ventilation is fitted to the ventilation needs within the home.

3- Energy savings (electricity and heat)

By using the natural driving forces a large part of the fan energy can be saved. The demand control of the ventilation results in savings of the heat demand.

4- Reduced noise level

The internal noise level is reduced as the fan is places in the attic and most of the duct system is omitted.

5- Freedom for the user, because of manual control

There is a larger degree of freedom for the user of a hybrid ventilation system as the option for manual control exists.

4.3.5.2 Potential internal weaknesses

1 – Low level of experience

The experience with hybrid ventilation is in general low; this is especially true for hybrid ventilation for residential buildings.

2- Limited possibilities for heat recovery

Due to the demand for low pressure loss in the ventilation system the possibilities for heat recovery are small and will therefore in some cases represent a weakness in the system.

3- Hard to control the air flows correctly

The monitoring and regulation of the airflow can be difficult to obtain and therefore represents a weakness in the system.

4- Higher initial cost

Due to the rather expensive sensors and control system, a hybrid ventilation system requires, the initial system is typical valued higher than the traditional mechanical ventilation systems.

4.3.5.3 Potential external opportunities

1- Architects and consultants positive attitude

Architects and consultants have positive attitude towards using hybrid ventilation systems company.

2- Government financial support.

Government financial support in the next 5 years devoted towards increasing number of private organisations letting out property.

3- New national building regulation

New national building regulation could be favouring use of hybrid ventilation systems. In the near future the Danish building regulation is renewed, and the content of the changes is at present (2004) being discussed. One of the issues discussed is the primary energy factor for electricity consumption, currently it is foreseen that all electricity consumption should be calculated as primary energy with a factor of 2.5 to 3. There will also be a demand to the energy performance for different types of ventilation systems (Aggerholm, S. 2001). These stricter demands will probably give hybrid ventilation a market advantage because of the low energy consumption compared to common mechanical ventilation.

4- The energy performance directive

The implementation of The Energy Performance Directive in Denmark is well under way. The directive is being worked into the new building regulation which is to be implemented in 2005. Furthermore an energy performance certificate is being prepared thus The Energy Performance Directive will be fully implemented in Denmark in 2006. The directive is foreseen to have an impact on the energy demand in dwellings, as more strict demands on energy consumption and energy performance for ventilation systems is introduced (Aggerholm S., 2001).

5- Need of refurbishment in communities in DK

High percentage of elderly apartments needs refurbishment in the near future.

6- High cost for electricity in Denmark

The high price of electricity in Denmark is a strong driving force for hybrid ventilation. The price for 1 kWh is anno 2004 approximately 0,244 Euro/kWh.

4.3.5.4 Potential external threats

1 - Individual demands and expectations

According to questionnaire, customer groups have individual demands and expectations to hybrid ventilation

2- High price sensitivity

Research proves high price sensitivity in general for all customer groups as long as performance is not improved.

3- Negative supplier attitude.

Suppliers have negative attitude towards hybrid ventilation systems.

4- Reduced financial support for refurbishment.

National government is reducing financial support for refurbishment.

4.3.6 Summary and Conclusions

In the late seventies and early eighties subsidies for energy savings in buildings were introduced. This caused an overall change in indoor climate in Danish buildings, and an information campaign on correct ventilation was launched. This, combined with tightening the demands in the building regulations on air change rate in buildings, resulted in an increased use of and interest in mechanical ventilation. Since the eighties all new multi-family buildings and an increasing number of new single family house have been equipped with mechanical ventilation.

In the Danish building code of 1995 the demands on ventilation was tightened again. The only type of ventilation allowed in multi family buildings is mechanical ventilation. This combined with an added knowledge of IAQ, e.g. resulting in a Code of Practice for Ventilation Installations, has resulted in the present market.

Hybrid ventilation for dwellings is a rather new area, there is no real experience in the field and thus the demands and expectations are not completely defined yet. However, based on the analysis carried out for this report the following conclusions may be drawn:

- Hybrid ventilation systems must be reliable and user friendly.
- Many customer groups currently are very doubtful about the benefits of the hybrid ventilation in dwellings, perhaps because of lack of information.
- The potential for installation of hybrid ventilation is estimated to 1-5 % (25,000 – 125,000) for existing buildings, and for new buildings the potential depends on the type of building being build i.e. expensive high prestige private buildings have a larger potential than cheap public building.
- The Danish building legislation is an important issue for the installation of hybrid ventilation in the future.

Hybrid ventilation has access to both natural and mechanical ventilation modes in one system and exploits the benefits of each mode and thus creates opportunities for further optimisation and improvement of the overall quality of ventilation. The main strength/opportunities of the hybrid system are that it fulfils the high requirement for indoor environmental performance i.e. high user comfort and air quality at the same time as both electrical and thermal energy is saved. The main weaknesses/threats are the low practical experience with hybrid system types. A result hereof is a general negative attitude from some suppliers.

The price sensitivity of the customers is relatively high but is depending on the market segment. In the segment of property owners the price sensitivity can be related to feasibility in terms of pay-back time assessing energy savings and a subjective value of indoor climate. This means that an increased cost can be accepted in this market segment if it can be justified by a similar increase in energy saving or as an improvement of indoor climate.

The cost comparison between hybrid and mechanical systems should be done on a life-cycle cost basis rather than simply on an initial capital cost basis, because of the different design approach, and hence the different balance between initial, running and maintenance and disposal costs. During this the hybrid system might be cheaper than a mechanical system in the long run. The high price of electricity in Denmark is a strong driving force for hybrid ventilation.

However, in the future with higher demands for a low heating consumption, it is likely that balanced ventilation systems with heating recovery will become more widespread. The energy performance directive is foreseen to have an impact on the energy demand in dwellings, as more strict demands on energy consumption and energy performance for ventilation systems are introduced. These aspects are likely to result in implementation of several types of ventilation system (demand controlled hybrid ventilation, balanced ventilation with heat recovery etc.)

4.3.7 References

Literature for the market survey

Aggerholm, S. 2001. Oplæg til energibestemmelser I Bygningsreglementet år 2005 og skitse til bestemmelser I år 2012. By og Byg, Denmark.

Danish Statistics 2002

The Danish Ministry of Housing and Urban Affairs

The Danish Federation of Small and Medium-Sized Enterprises, April 2002

Hansen, K. H. unknown year. Understanding ecological changes in the Danish Building Tradition. Dept. of Construction Management, Technical University of Denmark

Interviews with experts for the market survey

Exhausto	Henning Holm Sørensen
J. Orbesen Teknik	Johannes Orbesen
Plan 1	Troels Lergaard
Danish Building and Urban Research	Søren Aggerholm

List of interviewees for the focus group study

Representing interest	*Participant*	*Company*
Property owner	Rolf Andersson	Boligkontoret Danmark
Consultant	Per Monby	Birch og Krogboe
Consultant	Rolf Djurtoft	Birch og Krogboe
Architect	Jacob Brønsted	KHRS
Architect	Frans Drewniak	HLT
Architect	Rasmus Pedersen	HLT
Authorities	Søren Aggerholm	By og byg
Research institution	Per Heiselberg	University of Aalborg

4.4 France

4.4.1 Overview of customer and market characteristics

Ventilation of residential building

Before 1958 there was no specific ventilation system in residential building (windows airing and combustion products ducts). However the need of new building due to the post war period and the "baby boom" and the possibility to use shunt duct (since 1955) result in the introduction of ventilation system (passive stack) in a lot of new buildings.
In 1958, the French regulation made mandatory the use of a ventilation system (passive stack with collective ducts). They have to provide fresh air in the service rooms and exhaust stale air in the same service rooms; the main rooms are ventilated by windows airing (and building permeability).
Since 1969, In France, the ventilation is based on a general and continuous air renewal (about 1 vol/h of the dwelling); the fresh air comes into main rooms (living room and bedrooms) by air inlets (or air supply) and the stale air is drawn out to exhaust vents in the service rooms. In the same time the mechanical extract only ventilation system came into being.
In 1982 a new regulation allowed the possibility to reduce airflows; so the air change rate is about 0.5 volume/hour of the dwelling with a possibility to a highest airflow rate during cooking period. At the same time the control ventilation systems are authorized.

Ventilation systems.

In new buildings
From 1958 to 1969 only passive stack ventilation system.
Mechanical ventilation systems appear at the end of the sixties and since the beginning of the eighties more than 90 % of the new multi family buildings are equipped with this system; today all the new multi family buildings are equipped with mechanical system and an important part (about 50 %) have hygro controlled systems.

In the eighties some experiments are made with balanced system (mechanical supply and extract) generally interfaced with air/air heat pump; but a lot of maintenance problems (heat pump and/or supply ducts) lead to the relinquishment of these technologies.
In the new single family house more than 75 % (of which 50% with hygro controlled system) are equipped with mechanical ventilation system and 1 % of them are equipped with balanced system (mechanical supply and extract).

In retrofitted buildings
An important part of the buildings built between 1955 and the end of the seventies have to be refurbished. These buildings are in their major part equipped with passive stack ventilation system: when refurbished the airtightness of the envelope is generally improved (changing the windows) so the passive stack ventilation can be inadequate. The French industry has developed motorized cowls which permit both to improve the airflows when the natural forces are insufficient (detection by means of thermostat on outdoor temperature) and to give a complementary flow when cooking (timer).

In France we note a poor sensitivity of the dwelling occupants to ventilation system (although they show interest on IAQ, thermal comfort, acoustic). So the occupant (owner or buyer and owner-to-be) don't suggest any particular ventilation system.
Without market demand, the property developer put in the cheaper and easier to install ventilation system: the mechanical extract only ventilation system. To take into account energy problems (due to thermal regulation), this ventilation system can be hygro-controlled.

The demands and expectations of the customers are:
- respect of regulation (airing and thermal)
- low cost ; in new buildings (multi family or single family) the cost of the ventilation system is less than 500 Euros
- low building impact : the cost of the area of ventilation shaft in a multi storey dwelling (in urban area) is similar to the cost of ventilation system itself)
- sometimes, avoidance of condensation hazards in existing buildings

The problem is quite different in social dwellings.
The social owner has interest in a good ventilation system:
- to give to the occupants a good IAQ,
- to protect his building against condensations,
- to save energy (⇒ and money) ;

but, the majority of new buildings are equipped with mechanical extract only ventilation system.

Ventilation related matters are mainly handled by the following organisations:
- Ministry for housing (regulation for health and energy)
- Ministry for health (regulation for health)
- Ministry for industry (regulation for energy)
- Technical agreement commission (delivers the Technical agreement)
- AFNOR (product certification)
- Industry (often plays a role in design and dimensioning of products)
- Building owners, especially the public sector (….

When introducing a new ventilation system on the market one has to be aware of the following national requirements:

- Compliance with the sanitary regulation (which in France makes mandatory to install a specific ventilation system)
- Compliance with the energy regulation (which includes energy for ventilation)
- Compliance with other regulations as safety, fire, noise
- If the system can be considered as innovative, the Technical agreement is a possible way to assess its performances……

4.4.2 The present and future market

The size of the market is related to the existing housing stock; we give hereafter the total number of dwellings (main home only) in millions versus the year of construction:

	before 1948	1949 to 1974 *	since 1975	total
single family houses	5.476	3.223	4.847	13.546
multi family buildings	2.822	4.354	3.089	10.264
Number of buildings	0.552	0.435	0.269	1.257

* *The first thermal French regulation was in 1975. From this date the insulation is obligatory*

We can estimate the number of buildings built between 1955 (beginning of passive stack ventilation systems with shunt duct) and the end of the seventies (generalization of mechanical extract only ventilation systems) to about 0.5 millions buildings (0.2 in social buildings) representing about 5 millions of dwellings. These dwellings, equipped mainly with passive stack ventilation system have to be refurbished.
When refurbished the airtightness of the envelope is generally improved (changing the windows) so the passive stack ventilation can be inadequate. The French industry has developed motorized cowls which permit both to improve the airflows when the natural forces are insufficient (thermostat on outdoor temperature) and to give a complementary flow when cooking (timer).

Furthermore it seems that there is a demand for new ventilation system ; the idea is to have a building ventilation system giving the basis airflow rate, and a complementary system (movable ?) to give additional flow when necessary (cooking hood).
This kind of demand can be solved by a hybrid ventilation system which doesn't exist today on the French market.

4.4.3 Market competition

We have to distinguish the new buildings and the retrofitted buildings (built between 1955 and the middle of the seventies).
For new buildings the ventilation system competing with hybrid ventilation is mechanical extract only system ; note that today we don't have in the French market an hybrid ventilation system which have respect for both airing regulation and thermal regulation.
For retrofitted buildings equipped with collective passive stack ducts, the French industry has developed motorized cowls which permit both to improve the airflows when the natural forces are insufficient; this system is competing with passive stack (only) ventilation systems.

4.4.4 Today’s ventilation system in comparison with hybrid ventilation systems

In France <u>THE</u> ventilation system in new buildings is a mechanical extract only system with extract flows in service rooms (given by airing regulation) depending on the number of main rooms. The thermal regulation takes into account the energy losses (thermal and electric) due

to ventilation: so the hygro-controlled systems (which reduce flows in inoccupancy) are widely used.
In existing buildings some refurbishment are made with a specific hybrid ventilation system.

So in the French market the choice is very poor:

- new buildings almost exclusively mechanical extract only system
  hygro controlled system if energy constraints
- retrofitted buildings
  with existing mechanical system ⇒ mechanical system
  could be hygro controlled
  with existing passive stack system ⇒ do nothing
  PSV retrofitted
  PSV hygro controlled
  hybrid system (motorized cowl)

The investment cost for a traditional ventilation system for a new building is about 500 €. The traditional ventilation system is a mechanical exhaust system with passive air inlets. Now the part of humidity controlled system is increasing, with a cost of about twice that price (it depends if only outlet, or both inlet and outlets are humidity controlled .

4.4.5 SWOT-analysis

In the SWOT analysis we assume a hybrid ventilation system based on the existing hybrid system used in refurbishment (described above).

Potential internal **S**trengths	Potential internal **W**eaknesses
1 - IAQ	1 - Cost
2 - Energy saving	2 - Space (⇒cost) for ducting
3 - Summer comfort	3 - Design and dimensioning
4 - Existing system in refurbishment	4 - No commercial offer in new buildings

Potential external **O**pportunities	Potential external **T**hreats
1 - Social owners positive approach	1 - Present French market
2 - New IAQ regulation	

4.4.5.1 Potential internal strengths

1 – Good IAQ can be expected due flows value of the French airing regulation

2 – Energy can be save (electricity due to fans)

3 – The French hybrid system has a possibility of an higher flow (time controlled) when cooking. This flow can be used to passive night cooling in summer.

4 – This hybrid system exists on the French market. It will be however adapted to be used in new buildings.

4.4.5.2 Potential internal weaknesses

1 – The mechanical extract only system generally used in France is very cheap (about 500 €uros for one dwelling). The existing hybrid system is more expansive (in retrofitted buildings about 500 €uros for one dwelling but the duct are existing).

2 – Passive shunt ducts take more space than ducts used in mechanical systems.

3 – We have French rules (standard DTU 68.1) for design and dimensionning the mechanical extract only systems. Equivalent rules don't exist for PSV (and hybrid) systems.

4 – The existing hybrid system have to be adapted to new buildings.

4.4.5.3 Potential external opportunities

1 – Social owners will be interested by an hybrid ventilation system

2 – The new airing regulation would help the development of new ventilation systems.

4.4.5.4 Potential external threats

The French market is not ready for new ventilation systems (except if there is an opportunity of thermal gains).

4.4.6 Summary and Conclusions

The French ventilation market differs when existing or new buildings are considered.

For new building, both the health regulation and the energy regulation are the driving forces. This led to the development of mechanical exhaust system, with now an increasing market for humidity controlled systems. These system proved to comply with both regulations, at a quite low price (about 500 € par apartment or house for a complete system).

Nevertheless, there is an increasing interest (though at a low level) for reducing the fan energy, and having systems robust again failure (e.g. providing a minimum amount of air flow through natural forces only). These demands could more lead to basic hybrid systems as the one used in refurbishment than to more complex ones. Another point of weakness for hybrid ventilation systems in new buildings is the lack of design and dimensioning rules (which exist for mechanical systems).

The introduction of the EPBD should not change this situation, as these hybrid system are already taken into account in the actual regulation (RT 2000) and no major change is planned in the new one (RT 2005).
It is also planned to revise the health regulation regarding ventilation. This could lead to a better assessment of hybrid ventilation for new buildings, and can therefore modify the balance IAQ/ energy in the future.

One difficulty for introducing hybrid ventilation in new buildings is the investment cost compared to mechanical systems, the space needed to install them, and the fact that the gains (as running costs and IAQ) are not obvious again compared to mechanical systems. Nevertheless, the increasing interest for green buildings and passive and bioclimatic design could offer opportunities even if at the beginning not on a large scale. It can be noticed that the French industry in the field of natural/hybrid ventilation is willingly to enter the field of new building, and is already a driving force for this development.
A larger development would require for hybrid systems in new buildings:

- Compliance with regulations (health and energy)
- Design and dimensioning rules and/or technical agreement
- Cost effectiveness (investment cost and running costs)

In existing buildings, the situation is quite different and the refurbishment of passive duct systems in apartment buildings is often done with hybrid concept (fan assisted cowl, and sometimes change of air inlets (self regulated or humidity controlled) and outlets (self regulated or humidity controlled). The concepts applied are nevertheless less sophisticated than the one developed in Reshyvent.

4.4.7 References

Focus group

The study was conducted with only one group with:

- state authorities
- manufacturers of ventilation systems
  (motorized cowls and passive stack hygro controlled systems)
- social buildings owners.

The users were not present but the other participants suggest what should be their answer.
The group focus mainly on multi family buildings

Dwellings data (census 1999)
http://recensement.insee.fr

4.5 Germany

4.5.1 Overview of customer and market characteristics

In Germany, there were in 2002 approx. 39 million dwellings. 35% of the dwellings were single unit dwellings, and 65% were dwellings in multi-family houses (Eurostat).

Most of the dwellings, approx. 90%, do not have any ventilation system i.e. air exchange is created by window airing (windows often have a special airing position) and air infiltration/exfiltration through air leakage paths in the buildings envelope. One reason for this is that there are no requirements for having it. In the future, there will be requirements since houses with low energy use will be built.

4.5.2 The present and future market

In Germany, a single-unit dwelling is often ordered by its future owner. This means that the future owner decide whether to have a ventilation system or not.

The kind of ventilation system in multi-family houses are ordered by the builders, influenced by the architect.

The prognosis for new construction is approximately 260 000 new dwellings yearly (see table below)

Specification	Unit	2001	2002	2003 [1]

Germany				
Permits for building construction				
Buildings/ costruction work	Number	289 794	278 340	298 779
Dwellings, total	Number	290 978	274 117	296 854
Living floor space	1 000 m^2	33 846	32 694	36 055
Estimated costs of buildings and other structures	EUR mn	74 438	69 970	70 748
Incl.: Construction of new buildings				
Buildings/ costruction work	Number	201 112	195 389	212 341
Dwellings	Number	262 037	248 411	267 589
Living floor space	1 000 m^2	29 358	28 554	31 436
Estimated costs of buildings and other structures	EUR mn	61 536	58 406	59 169
[1] Preliminary result.				
Last updated on 12 May 2004				

http://www.destatis.de/basis/e/bauwo/bauwotab4.htm

4.5.3 Market competition

There exists no official statistics over ventilation systems of dwellings. In Germany, mechanical ventilation system in dwellings is very unusual. However, an increased tendency towards low-energy houses and passive-solar houses supports the small sector of ventilation industry in Germany.

Approx. 90% of the dwellings has no ventilation system. The rest have balanced, 5%, or mechanical ventilation, 5%.

There is a developed market for balanced ventilation with heat recovery. Also the use of air-conditioning (ventilation and cooling) is quit popular and climate control units for winter gardens. Next to that there is quit a market for the so called mechanical supply units. These are de-central placed units which force air from outside directly into a room. Because of the high noise-reduction performance these units are especially popular in noisy urban areas.

4.5.4 Today’s ventilation system in comparison with hybrid ventilation systems

Today there are hardly any ventilation systems, apart from the small, but established market for balanced ventilation systems with heat recovery.

4.5.5 Summary and Conclusions

The total number of dwellings in Germany is 39 million dwellings. Over 90% of these do not have any ventilation system, mainly relying on window airing and air infiltration/exfiltration through leaky building envelopes. No requirements demand the owners of the dwellings to have a ventilation system. In the future, there will and must be requirements on ventilation.

The EC Energy Performance of Buildings Directive will have an influence on the ventilation market.

4.5.6 References

Personal contact with Dr. Wolfgang Feist at Passivehaus Institut, Damstadt, Germany
Personal contact with Professor Heidt, Fachgebiet Bauphysik & Solarenergie, Universität Siegen, Germany.

Personal contact with Andre Meester, Alusta, the Netherlands.

4.6 Great Britain

4.6.1 Overview of customer and market characteristics

Decisions concerning the choice of ventilation system depend on the type of dwellings. For single dwellings and small multi-family dwellings the decision will normally be made by the architect. For large multi-family dwellings or very large and expensive single-family dwellings a building services engineer may be employed.

4.6.2 The present and future market

In 2001 in the United Kingdom (Great Britain and Northern Ireland), there were about 23.3 million dwellings, of which 82 % were single family houses and 18 % apartments. After 1991 (?), local mechanical exhaust ventilation was required in bathrooms and kitchens, although this usually only operates intermittently. Since 1995, passive stack ventilation has been allowed as an alternative for kitchens and bathrooms and also trickle vents are required. There is currently no UK requirement for whole house ventilation systems, except openable windows. Passive stack and whole house mechanical systems each represent less than 1 % of the whole stock. In addition probably no more than 10 – 15 % of the whole stock would have some form of local extract.

4.6.3 Market competition

The prognosis for new construction is estimated to be yearly new construction of 188,000 dwellings.

The shares of the market held by systems, that would compete with hybrid ventilation are: Passive stack and whole house mechanical systems each represent less than 1 % of the whole stock. In addition probably no more than 10 – 15 % of the whole stock would have some form of local extract.

4.6.4 Summary and Conclusions

Most dwellings do not have any ventilation system today, so there should be a big market for ventilation systems like demand controlled hybrid ventilation, especially taking into account the predominance of natural ventilation in dwellings, offices etc.

The EC Energy Performance of Buildings Directive will have an influence on the ventilation market.

4.6.5 References

Interviews with:
Malcolm Orme, Oscar Faber
Kevin Pennycook, BSRIA

4.7 Greece

4.7.1 Overview of customer and market characteristics

The total number of dwellings is 5.48 millions, based on data from the National Statistical Service of Greece from the year 2001. From these the 3.53 millions are permanent residences, while the rest corresponded to country houses, houses for selling /renting or to houses not inhabited temporarily. From the permanent dwellings 74% is private, 20% is rented and 6% has another property. A total number of 4.56 millions of customers has been estimated.

The demands and expectations of the customers for ventilation systems are mainly, that they provide:

- Optimum IAQ and comfort levels
- Effective reduction of outdoor noise
- Moisture control
- Provision for natural ventilation when the climate and outdoor local environment are suitable
- Simple in use and easy in maintenance
- Reliable and energy efficient system
- Reasonable system cost
- Easily installed and compatible with building in which the system is installed

A hybrid ventilation system is characterized by low system noise, moisture control and controlled ventilation rates with lesser use of air conditioning and higher use of natural ventilation (when the appropriate provisions have been made).

The customer segment could be divided according to the type of dwellings, the customers' prosperity or the location of buildings. Thus, the following classification is suggested:

- Detached/semidetached buildings and apartments
- New and refurbished dwellings
- High and low cost customers
- Expensive and inexpensive regions

The customer segment is expected to have a strong impact on the marketing/selling due to the difficult design and high cost of the hybrid ventilation systems (compared to traditional ventilation systems).

Price is one of the significant parameters that influence the customer's decision for the choice of the ventilation system especially in the private residential sector. Cost and energy effective systems are a major expectation.

The hybrid ventilation market is minor for the time being. However, in a future perspective architects / mechanical engineers, building contractors and ventilation suppliers will mostly influence the market possibilities.

Mechanical engineers or architects undertake the design of the ventilation system and after market research they inform the building contractor for the total system cost (purchasing and installing). The building contractor is mainly responsible for the purchase of ventilation system.

The most marketing channels for reaching the customers are:

- Architects and mechanical engineers
- HVAC providers/developers
- Contractors
- Advertisements in technical journals

What does the purchasing process look like? The mechanical engineer or architect is asked by the building contractor to perform a study for the design and the sizing of the ventilation system. Afterwards, he makes a market research and collects the quotes for the purchase and installing of the systems. Finally the building contractor (or the building owner in single family buildings) decides the market of the ventilation system.

Ventilation related matters are mainly managed by the Technical Chamber of Greece (http://portal.tee.gr/). However, indoor air quality aspects are framed by the Ministry of Social Employment and Protection (http://www.ypergka.gr/) and the Hellenic Institute for Occupational Health and Safety (http://www.inegsee.gr/enimerwsi-39-doc4.htm).

When introducing a new ventilation system on the market one has to be aware of the following national requirements:

According to the Thermal Insulation Regulation, for residential buildings and when there is no provision for a ventilation system a minimum of 0.8 ACH should be achieved for hygienic reasons by infiltration. Thus, windows and doors should not be very well- tight insulated.

In simple air –conditioning installations a number of recommended empirical values of air changes for different use spaces are given in the Technical Guide of the Technical Chamber of Greece (2423/1986). A number of 5-8 ACH is recommended for bathrooms.

A minimum and a recommended quantity of fresh air per person for different spaces is also presented in the Technical Guide of the Technical Chamber of Greece (2423/1986). Either in detached houses or in block of flats the minimum demanded ventilation (per person) is 8.5 m^3/h in the bedrooms and sitting rooms and 34 m^3/h in the bathrooms and kitchens.

Innovative ventilation techniques have not yet been introduced in the vocabulary of the legislative text and there not yet guidelines for special constructions that promote natural ventilation (solar chimneys, ventilations chimneys) or hybrid ventilation.

In case of the residential buildings the minimum ACH that has to be adopted inside a single-family house or an apartment, when there is no provision for ventilation system is $0.8h^{-1}$. That means that there is no obligation or need for a building contractor or a mechanical engineer to design an innovative ventilation system. The minimum ACH can be ensured by infiltration rates. The use of natural ventilation is the most common ventilation technique in Greek dwellings, since it is also cost effective. Besides, in the existing regulation innovative ventilation techniques do not exist. Furthermore, there is no knowledge or techno structure for innovative ventilation systems in the Greek ventilation market. In retrospect, the most important reasons for the market ventilation in the residential sector is except for the cost, the absence of legislation and culture on hybrid or other innovative ventilation systems.

4.7.2 The present and future market

The market segments in the residential sector could be classified in:

- Detached/ semi-detached buildings and apartments

- Property and tenant owners
- New and refurbished dwellings

The size of total market i.e. the size of existing housing stock was a total number of dwellings in 2001 of 5.48 millions, while the permanent residences corresponded to 3.53.

Based on the data from the National Statistical service of Greece [6], the total number of dwellings built in the period 1990-2001 according to permits issued for new buildings and extensions are**:**

a) 1991-1995: 389.414 dwellings, where 193.734 were owner occupied and 195.680 had another type of ownership.

b) 1996-2001: 390.085 dwellings, where 168.229 were owner occupied and 221.856 had another type of ownership.

Thus, an average prognosis for the new construction in the residential sector is 36200 dwellings/year for private buildings and 78000 dwellings/year for buildings with any type of ownership, private or no.

The market potential for hybrid ventilation systems for new construction and modernization is:

In existing buildings (refurbishment):
The potential for hybrid ventilation in existing buildings is very small especially in apartments, where exhaust fans (with constant airflow) usually exist in the Kitchen or in the bathroom.

In new buildings:
In case of the new buildings the situation would be more optimistic since the design of the ventilation system would have been foreseen. In detached/semi-detached houses the stack effect could be assisted by exhaust fans with variable airflow rates based on the pressure differences. In apartments the exhaust fans could be replaced with demand control exhaust ventilation systems.

Despite the difficulty in design in existing houses (retrofit) the potential for hybrid ventilation systems could be enhanced if public subsidies or tax exemptions could be offered to the customers.

The time perspective for implementation of hybrid ventilation systems depends on the percentage of the implementation of hybrid ventilation systems in the market. An optimistic estimation is that 5-10% of the market in the residential sector could be implemented in 10 years. This scenario presupposes the attribution of financial motives to the customers or the introduction of a mandatory ventilation study in the existing legislative frameworks.

The key factors for market growth in the ventilation business are:
- Introduction of energy and cost effective systems in the ventilation market.
- Incorporation of innovative ventilation systems in the energy performance regulation.
- Attribution of subsidies and tax exemptions to the users.
- Dissemination of information for hybrid ventilation systems to engineers, architects,

IAQ aspects, reduction of outdoor noise and limitations of the natural ventilation in the urban environment are the most important driving forces. New regulation imposing higher air change rates is needed in the existing legislative framework in order to favor the use of mechanical and hybrid ventilation systems.

4.7.3 Market competition

The ventilation systems competing with hybrid ventilation today is the most common used ventilation system in dwellings i.e. natural ventilation, which is sometimes combined with an exhaust fan in the kitchen or in the bathroom. More than 99% of the Greek dwellings use natural ventilation.

Mechanical ventilation systems are marketed mainly by advertisements in newspapers, in technical journals in catalogues/leaflets or via Internet.

The following counter moves can be expected from producers of ventilation systems competing with hybrid ventilation:

- Reduction of prices with regard to existing mechanical ventilation systems.
- Introduction of energy effective mechanical ventilation systems.
- Exception of hybrid ventilation systems from the new building codes.

The risk for other innovative systems being developed in the near future is small. In Greece natural ventilation is used in 99% of the dwellings. The promotion of innovative systems would require certain steps like public subsidies, demonstration projects and introduction of these systems in the building codes.

This would influence the possibilities for hybrid ventilation. System cost and introduction of standards and regulations will be crucial factors for the predominance of the hybrid over the innovative ventilation systems.

4.7.4 Today’s ventilation system in comparison with hybrid ventilation systems

A group of experts with representatives from architects, operations engineers, ventilation consultants and property owners were brought together and highlighted the most important problems of today’s existing ventilation systems, as seen from their own perspective. The different areas of problem were summarized as follows:

- Integration of ventilation systems with building structure: new buildings, refurbished buildings, detached/semi-detached, apartments
- System performance: noise (from the system, from the outdoor environment), moisture control, air quality assurance, draught, controllability (for the entire building, for each room), reliability
- Design: air terminal devices (maintenance/cleaning/technical life span), fans/ducts (maintenance/cleaning/aesthetics), sensors/actuators (accessibility, reliability, technical life span), installations (accessibility, maintenance/cleaning/aesthetics)
- Energy efficiency: fans, heat recovery units, compliance with standards
- Choice of ventilation system: type of dwelling, climate, sizing of ventilation system
- System costs: capital, installation, running, maintenance, cleaning costs
- Knowledge: architects/engineers, building contractors, ventilation suppliers, property owners
- User friendliness: automation, manual use

- Ventilation strategies: indoor air quality, thermal comfort, moisture control in kitchens and bathrooms, provision of fresh air to occupied spaces
- Compliance with building regulations: energy, ventilation, IAQ, comfort

The expert group focused on the integration of ventilation systems during the building structure and discussed the difficulties in the ventilation system design for different types of dwellings, namely, new and existing buildings and single and multi-family houses. Besides, they pointed out the importance of performance and design, as well as the required standard of knowledge from the interesting parties (etc. architects, engineers, ventilation suppliers). The client group emphasized on the choice, the performance and the cost of the ventilation system. The group of facility management engineers put forward the consideration of design, ventilation strategies and compliance with the building regulations. They put a high priority on the design, choice of the ventilation system, knowledge and a low priority on the user friendliness.

Compared to a traditional natural ventilation system, a residential hybrid ventilation system was rated higher on performance and reliability levels but lower in the area of maintenance operation and user friendliness. For indoor air quality and reduction of outdoor noise the hybrid ventilation system is better than natural ventilation. Controllability, draft is rated higher for the hybrid ventilation systems but system costs are higher in comparison with the traditional ventilation system. However energy savings and air quality aspects were highlighted by the focus group and considered as of the most important features of the hybrid ventilation systems.

The investment cost for a traditional ventilation system for a new dwelling covering a surface of 100 m^2 consisting of four rooms is in the range of 2800 to 4000 Euros. The traditional ventilation system is a mechanical supply/exhaust system with heat recovery. The investment costs include purchase and installation of the ventilation system. The hybrid system is expected to be more expensive due to the additional sensors IAQ and presence sensors, fans, control units and cabling. These will result in a medium extra cost of 800-1000 Euros with installation cost included.

4.7.5 SWOT-analysis

For the SWOT-analysis a hybrid ventilation system and a traditional ventilation system had to be chosen. The reference hybrid ventilation system is a system based on the principle of fan assisted natural ventilation with variable flow rates according to demand. The reference traditional system is a natural ventilation system.

Potential internal Strengths	**Potential internal Weaknesses**
1. Better IAQ	1. Costs
2. Better indoor comfort conditions	2. Noise generated by the system
3. Reduction of outdoor noise levels	3. Maintenance and cleaning
4. Controllability	4. Design
5. Energy savings	5. User friendliness

6. Reduced risk of draft	6. Technical life span
7. More independent of the climate	7. Aesthetics
Potential external Opportunities	**Potential external Threats**
1. Financial Motives	1. Non-Existing regulation
2. New legislative framework	2. Lack of information
3. Cost effective systems	3. Limited Market
4. Energy savings	4. System costs
5. Energy performance directive	

4.7.5.1 Potential internal strengths

1. Better IAQ
In urban areas where the outdoor pollutants' concentration is increased, the introduced fresh air has to be filtered. This provision can be implemented more easily by hybrid ventilation rather than a conventional natural ventilation system.

2. Better indoor comfort conditions
A hybrid ventilation system is able to meet users' requirements even if the natural driving forces (wind and stack effect) are not sufficient. This is much more appreciative during the cooling period of the year.

3. Reduction of outdoor noise levels
Natural ventilation in noisy areas is not recommended. A hybrid ventilation system can be more efficient with the reduction of the outdoor noise when provision for installing soundproofing filters is made in the inlet/exhaust grilles.

4. Controllability
Ventilation rates can be controlled either by the user or by the system.

5. Energy savings
RHV systems are more energy efficient systems in comparison with mechanical ventilation due to lower electricity demands for fans and also because of the controlled ventilation rates.

6. Reduced risk of draft
The variation of the driving forces can result in undesirable wind effects. This can be avoided with controlled ventilation rates provided by self-regulated supply/exhaust air grilles.

7. More independent of the climate
Since ventilation rate is depended on the variability of wind and thermal forces, natural ventilation is not applicable in all climates. In a hybrid ventilation system provision is made for controllable openings to adjust to different climates and meet users' demands.

4.7.5.2 Potential internal weaknesses

1. Costs
Hybrid ventilation systems are certainly more expensive due to increased capital (dampers, fans, sensors, actuators, ducts, etc.), operational and maintenance costs.

2. Noise generated by the system
The noise from the ventilation system (supply/exhaust fans, etc) cannot be avoided. However, it can be limited up to possible level.

3. Maintenance and cleaning
Regular cleaning and maintenance is required to retain system's reliability and technical life span.

4. Design
The good design of a hybrid ventilation system requires certain knowledge by the architects/engineers. Sometimes special requirements are needed during the construction phase of the building, which makes it more difficult or complex compared with the design of a traditional natural ventilation system.

5. User friendliness
A hybrid ventilation system requires certain handling or management. That's why its operation is considered more difficult and thus less user friendly.

6. Technical life span
The technical life span of a hybrid ventilation system is smaller in comparison with a traditional (natural/mechanical) ventilation system because of the systems components (sensors, actuators, fans, ducts). Besides, because of the small experience of hybrid ventilation in the ventilation market the components will be improved in the future

7. Aesthetics
The design of a hybrid ventilation system requires often rearrangement of the internal spaces or installation of the systems components (sensors, grilles, ducts, etc) in easily displayed places.

4.7.5.3 Potential external opportunities

1. Financial Motives
The attribution of public subsidies or tax exemptions will promote the purchasing of hybrid ventilation systems by the customers segment.

2. New legislative framework
The introduction of stricter energy requirements together with standards and regulation for innovative ventilation systems will assist the market of hybrid ventilation systems.

3. Cost effective systems
Low running costs and reasonable capital costs will favour the use of hybrid ventilation systems over traditional ventilation systems.

4. Energy savings
Energy saving for heating/cooling and electricity is a crucial factor for the potential of hybrid ventilation systems in the ventilation market and it could compensate for the relative high cost of these systems.
5. The energy performance directive
The new Energy Performance Directive emphasizes on energy performance of buildings and sets minimum energy requirements either for new buildings or large existing buildings. The European member counties will have to adapt to this directive in order to ensure the

appropriate air change rates. This will promote the use of ventilation systems and especially of energy efficient innovative systems.

4.7.5.4 Potential external threats

1. Non-Existing regulation
The absence of regulation and standards for innovative ventilation systems from the legislative framework is a negative factor for the use of these systems.

2. Lack of information
The present knowledge about hybrid ventilation is very small and thus architects and mechanical engineers do not recommend the use of hybrid ventilation systems.

3. Limited Market
The existing market is very small and the concept of hybrid ventilation is not widespread yet.

4. System costs
Hybrid ventilation systems have grater capital and maintenance costs compared with traditional ventilation systems. Considering that the high price sensitivity of the customers' segment this constitutes a significant barrier towards the dissemination of these systems in the ventilation market.

4.7.6 Summary and Conclusions

The use of natural ventilation is the most common ventilation technique in Greek dwellings. More than 99% of the Greek dwellings use natural ventilation, which is sometimes combined with an exhaust fan in the kitchen or in the bathroom. The hybrid ventilation market is minor in the residential sector in Greece. According to the existing legislative texts, the minimum ACH that has to be adopted inside a single-family house or an apartment, when there is no provision for ventilation system is $0.8h^{-1}$. That means that there is no obligation or need for a building contractor or a mechanical engineer to design an innovative ventilation system. The minimum ACH can be ensured by infiltration rates. The most important aspect of the ventilation market in the residential sector is the absence of legislation and culture on hybrid or other innovative ventilation systems, as well as, the cost of these systems.

The potential for hybrid ventilation in existing houses is very limited and the exiting knowledge is very small. In case of the new buildings the situation might be more optimistic since the design of the ventilation system will have been foreseen. Hybrid ventilation systems have greater capital and maintenance costs compared with traditional ventilation systems.

The use of hybrid ventilation systems could be favourable in dwellings located in urban areas where the outdoor pollutants' concentration is increased and the introduced fresh air has to be filtered. Also when the natural driving forces (wind and stack effect) are not sufficient and then the hybrid ventilation system would be more effective than the traditional natural ventilation by the window airing. A hybrid ventilation system can be more efficient with the reduction of the outdoor noise, when provision for installing soundproofing filters is made in the inlet/exhaust grilles.

IAQ aspects, reduction of outdoor noise and limitations of the natural ventilation in the urban environment are the most important driving forces. Besides, new regulation imposing stricter limits for the air change rates is needed in the existing legislative framework in order to favor the use of mechanical and hybrid ventilation systems. Finally, government must provide customers with incentives like tax exemptions or other financial motives.

The new Energy Performance Directive emphasizes on energy performance of buildings and sets minimum energy requirements either for new buildings or large existing buildings. The European member counties will have to adapt to this directive in order to ensure the appropriate air change rates. This will promote the use of ventilation systems and especially of energy efficient innovative systems.

For the present time, there is no culture in the Greek ventilation market for hybrid or other innovative ventilation systems. Increased concern on indoor air quality aspects will promote the use of ventilation systems. The limited use of conventional or natural ventilation systems must be considered not only due to the reduction of outdoor noise or outdoor pollution levels but also due to the insufficient driving forces that will result in lower air change rates. Demonstration buildings will increase the public awareness about the performance of hybrid and innovative ventilation system and will enhance existing knowledge of engineers, architects and buildings contractors.

4.7.7 References

1. General Constuction Regulation (Law Number 1577/1985, modified by the law No 1647/1986, 1722/1988, 1892/1990).
2. “Source book of Legislation on passive solar energy and energy conservation: Europe-Greece-Italy”, Energy Conservation in Buildings, CIENE, EC DGXVII.
3. Technical Guide of the Technical Chamber of Greece, 2423/1986: “Installations in Buildings: Air-conditioning of buildings”.
4. Technical Guide of the Technical Chamber of Greece, 2425/1986: “Installations in Buildings: Calculation of air-conditioning load in buildings”.
5. Thermal Insulation Regulation, Athens, 1980.
6. National Statistic Services, Athens, Greece (www.statistics.gr).
7. Technical Chamber of Greece (http://portal.tee.gr/).
8. Ministry of Social Employment and Protection (http://www.ypergka.gr/).
9. Hellenic Institute for Occupational Health and Safety (http://www.inegsee.gr/enimerwsi-39-doc4.htm).

4.8 Netherlands

4.8.1. Overview of customer and market characteristics

Characteristics of the housing stock:
In The Netherlands in 2002 the number of dwellings was 6.710.900 as the number of households was 6.930.000.
The building stock in 2004 will be about 6.8 million dwellings, of which about 29 % are apartments and 71% single family dwellings.
20% is built < 1940
27% is built between 1945 and 1970
53% is built > 1970
In total 45.8% is rented; 54.2% is owned. The % of owned houses is increasing (1947: 28%, 1971: 35%, 1990: 45% 2002: 54%)
The prognoses for the need of the number of dwellings in the future is as follows:

2005: 7.1 million
2020: 7.4 million
For 2005 to 2009 the needed extension of the building stock is 283.000 units; the need of replacement of the existing building stock is 80.000 units. So in total 363.000 units, estimated on 72.600/year.

Characteristics of the customer:
The main demands and expectations of the customers are a good (or even better) indoor air quality and comfort at a lower energy use. These demands and expectations will be met by the IC2 concept mainly through DC fans, demand control and low pressure ducting.

The customer segment can not really be divided into small/large or low/high cost customers, in fact only a developer or architect decides about the ventilation system. There are almost no small customers. I practice, installers can also have an influence on the selection of ventilation systems. More particular, often if an installer is not acquainted with a new innovative technology (such hybrid ventilation), he will give a negative advice to avoid risks.

The introduction of hybrid ventilation at this very moment is only suitable for the top of the market and the so called front runners. Price is at this moment almost the determining factor, initial costs and energy performances in the energy performance regulations (i.e. the EPC) must be competitive with balanced ventilation with high efficiency heat recovery. After January 2006, when the EPC is sharpened to 0.8, the EPC will be the main driver.

The interested parties for ventilation of dwellings are architects, ventilation industry, ministry of housing and developers. The Ministry of Housing will sharpen the EPC from1,0 to 0,8. Which requires in almost all cases an improved performance of the ventilation system. In fact demand control is with this sharpening almost a requirement.

The key interested parties for new ventilation systems are:
Project developers: ventilation systems that contribute in EPR and have competitive price
Architects: not really, only when facilitating architectural design (no major impact on facade)
End users: indifferent but:
End users organisations:
Owners (VEH): very much interested in all kinds of developments; they want alternatives (especially for balanced ventilation with heat recovery), reliable and user friendly systems. They have support for DC Hybrid ventilation!
Tenants (Woonbond): as VEH, but also interested in systems that are maintenance friendly, solutions for poor IAQ and moisture. They also support DC Hybrid ventilation!
Regional Health Organisations: some of these organisations are quite active in the field of ventilation because they recognise the link with health. They play a role in providing information and education!

Responsible for purchase of a ventilation system is in most cases the architect or developer.

Industry is marketing ventilation systems to the customers at this moment through their regular channels.

The purchasing process means selling systems to installers, but only because it is described in the specifications. Installations are in most cases just the balancing item on the budget of buildings.

Ventilation related matters are mainly handled by the following organisations:
"Stichting HR-ventilatie" (Foundation for High Efficiency Ventilation) is a branch organisation of manufacturers of mechanical ventilation with heat recovery promoting the application of energy efficient ventilation and particularly heat recovery.

ISSO (Building Services Research Institute) is a non-profit organization that co-ordinates research and the transfer of knowledge for the benefit of the installation sector within the building environment.

Uneto-VNI is the Netherlands association of contracting installing companies and technical retailers, uniting both electro technical contractors, mechanical engineering companies, sanitary installers as well as technical retailers.

When introducing a new ventilation system on the market one has to be aware of the following national requirements:

Building decree:
The Dutch Building Decree is mandatory for new buildings. Every building permit is checked with the Building Decree. Also for existing buildings there are some basic requirements.
The Building Decree has four chapters:

Chapter Health:
In this chapter the presence of ventilation provisions is regulated, concerning:

- nominal capacity
- performance criteria for
  - thermal comfort
  - controllability
  - direction of flow
  - air quality (positioning of intake in relation to exhaust and flue gasses)

Also the presence of airing provisions (openable windows, doors) is regulated. For airing provisions there are only requirements for the capacity.
Determination method for capacity, thermal comfort, controllability, direction of flow and air quality is regulated in NEN 1087.

Chapter Energy:
In this chapter requirements are given for:

- Air tightness
  Determination and measurement method: NEN 2686
- Energy performance (EPR): the Building Decree gives a marginal value for the energy performance of buildings, depending on the building function (Energy Performance Coefficient – EPC).
  Determination method: NEN 5128
  In NEN 5128 following ventilation related matters are taken into account in the calculation of the energy performance:
  - air tightness
  - ventilation type
  - heat recovery
  - fan energy and fan controls

4.8.2. The present and future market

The existing market (till 1988) can be divided as follows:

Dwelling type	**no. of total**	**% of total**	**Private property**		**Social rent**		**private rent**	
			number	**%**	**number**	**%**	**number**	**%**
Detached house < 1965	500.000	8.0%	415.000	83%	30.000	6%	55.000	11%
Two semi-detached houses <1965	380.000	6.0%	247.000	65%	84.400	23%	41.800	11%
Terrace house <1945	600.000	9.5%	360.000	60%	150.000	25%	90.000	15%
Terrace house 1945-1965	735.000	12.0%	257.250	35%	441.000	60%	29.400	4%
Gallery flat <1965	125.000	2.0%	18.750	15%	81.250	65%	25.000	20%
Apartment with porch <1965	490.000	8.0%	73.500	15%	220.500	45%	171.500	35%
Downstairs/upstairs apartment <1965	230.000	3.5%	46.000	20%	92.000	40%	80.500	35%
Detached house 1966-1988	325.000	5.3%	292.500	90%	11.375	4%	11.375	4%
Two semi-detached houses 1966-1988	280.000	4.5%	238.000	85%	28.000	10%	11.200	4%
Terrace house 1966-1975	650.000	10.5%	325.000	50%	260.000	40%	65.000	10%
Terrace house 1976-1979	230.000	3.7%	115.000	50%	103.500	45%	16.100	7%
Terrace house 1980-1988	540.000	8.7%	243.000	45%	243.000	45%	59.400	11%
Gallery flat 1966-1988	240.000	3.9%	21.600	9%	180.000	75%	36.000	15%
Apartment with porch 1966-1988	175.000	2.8%	14.000	8%	131.250	75%	26.250	15%
other apartments 1966-1988	150.000	2.4%	19.500	13%	97.500	65%	30.000	20%
>1988	1.000.000							

The existing housing stock is equipped with the following ventilation systems:

Single family houses			Apartment buildings		
Natural/-passive	Mechanical exhaust	Mechanical balanced	Natural/-passive	Mechanical exhaust	Mechanical balanced
49 %	49 %	2%	37 %	61 %	2%

The main driving force in the ventilation market is the building regulations. A standard on domestic ventilation (NEN 1087 was published in 1974. This standard required mechanical exhaust in high rise residential buildings and living rooms with "open kitchen". The standard was mandatory in most of the local building codes. From 1974 market penetration of mechanical exhaust in new dwellings from a few % early 70's to 90% end 90's.

In 1981 the Noise Nuisance Act was enforced, stipulating that a facade should have a certain defined noise reduction in noise loaded areas with ventilation provisions in open position. This has led to the development and application of a wide range of sound proofed ventilation grilles. These specific grilles are standard in all noise loaded areas except in dwellings with mechanical ventilation with heat recovery.

In 1992 the Dutch Building Decree is enforced replacing all local building regulation by one national regulation. Strict determination methods and requirements for controllability, thermal comfort, flow direction, capacities and IAQ of supply air.

From 1996 Energy Performance Regulations; sharpened in 1998 and 2000. This leads to an increase in new dwellings of mechanical ventilation with heat recovery from 0.5 % to 50% in 2003. At the same time many requests from the market (end-users, project developers, architects etc.) for other competitive systems for mechanical ventilation with heat recovery (same performances in EPR, price, thermal comfort IAQ). For existing residential buildings no market yet for advanced ventilation systems. From 1999 to 2003 Energy grants for mechanical ventilation with heat recovery and demand controlled ventilation in existing buildings but appeared to be no incentive for market penetration. From 2004 no more grants on energy saving measures. This has lead to a dramatic decrease in application of solar energy , thermal/PV, and advanced ventilation systems in renovation of existing building stock.

Project developers select ventilation system not because of its quality and performances in terms of energy, IAQ, TC but in comparison with other energy reducing measures in the EPR (solar systems, thermal insulation, etc.)
End users organisation see health and (thermal) comfort and absence of noise as main decision factors, not energy! They ask for systems developed from this angle and not from energy point of view.

The number of new constructed houses is about 70,000 a year. About the same size of houses will have renovation or refurbishment which includes improvement of the ventilation system.

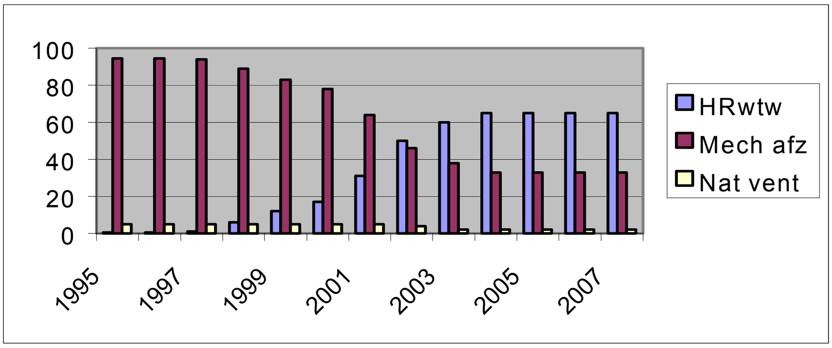
As to the potential for hybrid ventilation in these buildings, hybrid ventilation is only applicable in the top price housing market, which is about 10% of the total market, regardless new of refurbishment. Up to thousand each year of the existing "Hybrid" systems are sold today.

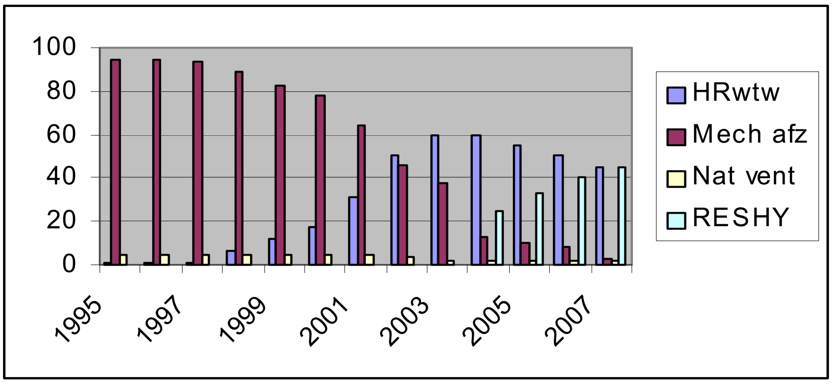
New built dwellings

The building production showed a decrease over the last years with a lowest point of 60000 units in 2003. The building scenario for the next years is as follows:
2004: 66000 units
2005: 70000 units
2006 and 2007: 76000

and then again a slight decrease

In next figures the market development of domestic ventilation systems (mechanical ventilation with heat recovery, Mechanical Exhaust and Natural ventilation (PSV)) is given, based on the market shares in new dwellings till 2003 and expected scenarios for the coming 5 years. The second figure gives the expected market penetration including “RESHYVENT-like” systems assuming that these systems are competitive in price and performances with mechanical ventilation with heat recovery.





Existing dwellings
For a description of the Dutch existing building stock see Annex 1
Retrofitting including new ventilation systems is applied in following cases:
- moisture and mould problems (15% of housing stock)
- new casements/glazing

Some experiments and demonstrations are going on for existing dwellings:
- mechanical ventilation with heat recovery with simplified (prefab) ductwork
- “Plug & play facade” for retrofitting including high level of thermal insulation, heating and advanced ventilation.

The time perspective for implementation of hybrid ventilation systems will be influenced by the sharpening of the Dutch Requirement for energy performance from an EPC of 1 to an EPC of 0.8 at Jan 1, 2003. The potential application of hybrid systems will be stimulated.

An additional factor for market growth, especially for hybrid ventilation, are subsidies, which only play a role because the ministry wants to stimulate the building and installation sector when sharpening the EPC.

The following components have to developed in order to lower the price for DC Hybrid ventilation: sensors.

Also price reduction in (avoiding) wiring can be expected
For mechanical ventilation with heat recovery: application of prefabricated components in ducting,
In general: price reduction by:
- scale enlargement
- using IFD principles in building (Industrial Flexible Demountable)

4.8.3. Market competition

The ventilation systems competing with hybrid ventilation today are mainly mechanical exhaust and balanced ventilation.

The shares of the market held by competing systems today are about 25 % balanced mechanical ventilation and 70 % exhaust only, and the remainder natural ventilation.

Competing ventilation systems:

Mechanical ventilation with heat recovery
Strong points mechanical ventilation with heat recovery in relation with demand controlled hybrid ventilation:
- preheating by heat recovery few degrees below room temperature (thermal comfort)
- no substantial energy penalty in case of increased air flows for better IAQ
- high impact in Dutch EPR

Weak points in relation with demand controlled hybrid ventilation:
- noise (!)
- supply ducts necessary (problem in existing dwellings)
- useful part of heat recovery in mid season (Tout 10….15^0)
- overheating bedrooms in mid season
- appreciation by occupants (=poor)
- many problems and failures during mounting and installing
- maintenance

Local mechanical ventilation with heat recovery systems integrated with radiators (“Climarad”)
Strong points:
- preheating by heat recovery few degrees below room temperature (thermal comfort)
- no substantial energy penalty in case of increased air flows for better IAQ
- high impact in Dutch EPR
- Good solution for existing dwellings (no supply ducts), real competitor for DC Hybrid ventilation

Weak points:
- price
- in total concept mechanical exhaust is necessary, temporary unbalance.

Multifunctional appliances (heating, DHW, mechanical ventilation with heat recovery combined in one appliance)
Strong points:
- three functions combined in one appliance
- high impact in Dutch EPR
- less ductwork (from appliance to outdoors) then combination mechanical ventilation with heat recovery with condensing boiler

- interesting solution for existing dwellings except for limitation for supply ducts

Weak points:

- see mechanical ventilation with heat recovery

Competing in EPR:

- thermal solar energy, solar boilers
- high level of thermal insulation
- heat pumps

At this moment for all these alternative options mechanical ventilation with heat recovery is very favourable in price; this means that DC hybrid ventilation should be positioned in the same price range as mechanical ventilation with heat recovery.

4.8.4. Today's ventilation system in comparison with hybrid ventilation systems

Traditionally there were two types of ventilation systems in the Dutch housing stock: natural supply with passive stacks and natural supply with mechanical exhaust. During the last 5 years more new built dwellings have mechanical ventilation with heat recovery (50% in 2003).

The Dutch National Monitoring ventilation (2002-2003) showed that in general occupants in the Netherlands are satisfied about their ventilation:

- natural supply/mechanical exhaust: 87% are (very) satisfied
- mechanical ventilation with heat recovery: 76% are (very) satisfied

Occupants are more satisfied about the supply then about the exhaust

Supply part:

- natural supply/mechanical exhaust: 93% are (very) satisfied
- mechanical ventilation with heat recovery: 84% are (very) satisfied

Exhaust part:

- natural supply/mechanical exhaust: 78% are (very) satisfied
- mechanical ventilation with heat recovery: 76% are (very) satisfied

The satisfaction with ventilation systems mainly depends on the noise of the system and the indoor air quality ("freshness of air")

The scores of the monitoring could lead to the conclusion that there are no real motives to improve the quality of ventilation i.e. to develop hybrid ventilation systems.

However, there is a need for energy efficient ventilation systems, to comply with the EPC (this explains the 50% market share of mechanical ventilation with heat recovery in 2003). At the same time there is a clear need for alternatives for mechanical ventilation with heat recovery.

A comparison of prices can be made for the Dutch market as shown in next table. However, For new dwellings mechanical ventilation with heat recovery is often needed to comply with the EPC and prices of mechanical ventilation with heat recovery (but also hybrid ventilation) should be compared with other energy saving measures like more thermal insulation, solar boilers, PV, etc.

Dwelling type	single family			multi family		
Basic quality	poor	average	best practice	poor	average	best practice
NWA natural supply		350			275	

PSV natural supply passive stack **total**	 300 450 750	 350 450 800	 500 1) 450 950	 225 350 575	 275 350 625	 400 1) 350 750
ME natural supply mechanical exhaust **total**	 300 500 800	 350 550 900	 500 1) 700 1200	 225 400 625	 275 425 2) 700	 400 1) 800 1200
mechanical ventilation with heat recovery **Total**		2000 4)	2200 5)		2000 3) 4)	2200 5)
Demand Programmed Ventilation 6) **Total**		2000			1800	
demand controlled hybrid ventilation RESHYVENT			2300			2100

1) including self regulating inlets
2) central mechanical extract
3) individual mechanical ventilation with heat recovery
4) including cross flow heat exchanger 90%
5) including bypass
6) active controlled inlets coupled with mechanical exhaust and ventilation programme

4.8.5. SWOT-analysis

Potential internal Strengths	**Potential internal Weaknesses**
1. Low energy consumption (and hence possible score in EPC)	1. Thermal comfort in winter more critical then with mechanical ventilation with heat recovery
2. Supply directly from outside (important issue for occupants)	2. Occupants very sensitive for noise of servomotors of supply grilles
3. Users friendly	3. Quality of sensors
4. No ducts for supply	
5. Easy maintenance (no supply ducts/grilles)	
6. Optimal controlled air quality	
Potential external Opportunities	**Potential external Threats**
1. Alternative for mechanical ventilation with heat recovery	1. Assessment in EPC and EPBD
2. Score in EPC and EPBD	2. Customer attitude to innovations
3. Combination with Domotica possible	3. Critical mass for scale enlargement necessary, (prices sensors)
4. Customers are more or less acquainted with demand controlled programmable ventilation	4. Reality of the building scenario presented by ministry of Housing
	5. No real incentives for existing housing stock

4.8.5.1 Potential internal strengths

The most important strength regarding the potential market (and the decision makers) is the low energy consumption, "translated" in a positive score in the Dutch Energy Performance Regulations (so called EPC score). Also important is that occupants prefer supply directly from outside and the user friendliness. No ducts for supply is an advantage for both new as existing dwellings, hover for the latter demand controlled hybrid ventilation appears to be a more attractive solution then mechanical ventilation with heat recovery. Lack of supply ducts avoids problems with duct cleaning.

4.8.5.2 Potential internal weaknesses

Thermal comfort in winter appears to be more critical then with mechanical ventilation with heat recovery as the supply temperature is outdoor temperature; for high efficiency mechanical ventilation with heat recovery supply temperature does not drop below 17^0C. First experiences with motor controlled inlets (as to be used in the IC2 concept) show that occupants are very sensitive for noise of servomotors of supply grilles especially at night in bedrooms. (Additional measures have been taken).
Quality of CO_2 sensors is still critical.

4.8.5.3 Potential external opportunities

At this moment mechanical ventilation with heat recovery is more and more dominating the market for new dwellings (50% in 2003). At the same time the number of complaints from about mechanical ventilation with heat recovery is increasing. Decision makers, principals are very reluctant to apply mechanical ventilation with heat recovery despite the score in the EPC. At the same time there is a growing need for alternative energy efficient user friendly systems such as demand controlled hybrid ventilation ventilation.
It is expected that hybrid ventilation will also be rewarded in the EPBD which could lead to an expanding of the market in Europe. Combinations with domotica can easily be made and offer extra opportunities and selling points.

4.8.5.4 Potential external threats

At the same time it still unsure if all national EPBD directed calculation methods provide a good and similar rewarding of demand controlled hybrid ventilation ventilation. On national scale the reality of the building scenario presented by ministry of Housing. This scenario is needed to reach a critical mass for scale enlargement necessary especially the prices of sensors.
Another threat is that for existing housing stock there are still no real incentives.

4.8.6. Summary and Conclusions

The Dutch ventilation market is traditionally standards and regulation driven. Since 1974 in most local building codes mechanical exhaust ventilation systems are required in high rise residential buildings. Since 1981 sound proofed ventilation grilles are required. After the introduction of energy performance regulations in 1996 mechanical ventilation with heat recovery showed an increase in market share to 50% in 2003.

The main demands and expectations of the customers are a better indoor air quality and comfort at a lower energy use. These demands and expectations will be met by the IC2 concept mainly through DC fans, demand control and low pressure ducting.

With regard to the introduction of the EPBD for new dwellings and residential buildings no major change is foreseen as the Netherlands already have an Energy Performance Regulation enforced. For existing residential buildings more attention for energy efficient and advanced ventilation systems is foreseen. For existing single family dwelling (= < 1000 m2) no direct impact of EPBD is expected

For the time being the investment cost of IC2 *concept of demand controlled hybrid ventilation* is slightly higher than the competing systems (mechanical ventilation with heat recovery). The cost of the sensors and wiring for the IC2 system is expected to drop due to product development and manufacturing in large numbers.

The expected market penetration of demand controlled hybrid ventilation systems is 20 000 to 40 000 systems/ from 2006 when EPC is sharpened. New ventilation systems in 15 % of existing dwellings with moisture problems or need of new windows could also be an interesting market.

As to social and behavioural aspects, results from a workshop on demand controlled hybrid ventilation (participants from end-user organisations, health services, ministry of housing, industry, social scientist and ventilation experts):

- all participants expect that demand controlled hybrid ventilation has high market potential, without any restriction for new built dwellings (EPR) and is interesting option (better then mechanical ventilation with heat recovery) for existing dwellings
- products/market implementation will only e successful with information and education (wide scale, national, not on product scale)
- health is the most important driving force for demand controlled hybrid ventilation
- Demand control should not be on building level but on room level; differentiation in place, time and person
- Signal on required ventilation, not on perception
- Boundary conditions for quality level of the components
- demand controlled hybrid ventilation is custom made work (perhaps a market problem?)

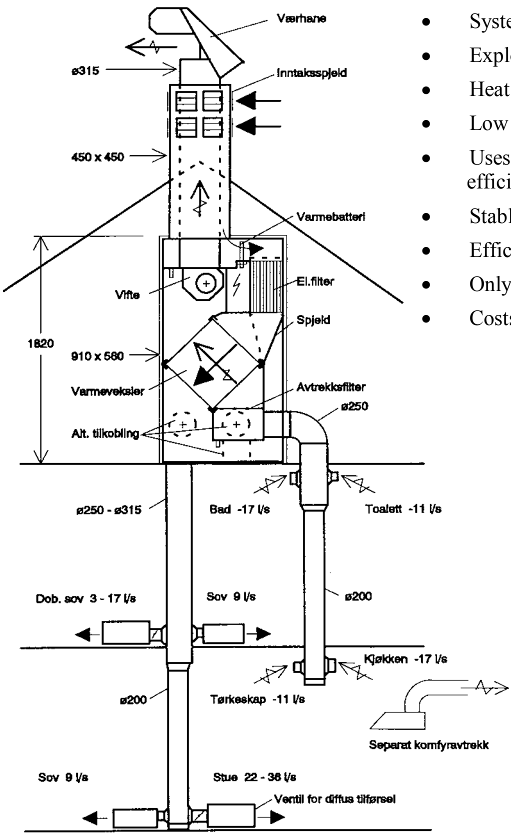
4.8.7. References

Op't Veld, P., 2004, Dutch market survey
De Gids W. , Op't Veld, P., 2003, Dutch National Monitoring Ventilation
Op't Veld, P., AIR 1995, Decision making on domestic ventilation systems
Figures and facts about living 2004 Ministry of Housing, Planning and Environment the Netherlands

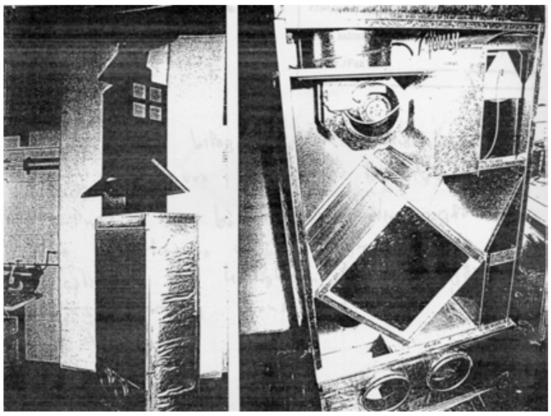
4.9 Norway

4.9.1 Short description of RESHYVENT concept

The box below describes the first prototype system, developed in 1994, which was to be further developed in RESHYVENT. The improvements include: EC-fans, rotary heat exchanger, improved wind turret; demand-controlled hybrid ventilation using CO_2 or RH sensor in extract; IR-sensor controlled motorized damper for automatic night/day mode.



- System developed by NBI and Flexit AS in collaboration in 1994
- Exploits both wind and stack-effect. Assisting fan power is 30-40 W
- Heat recovery efficiency 70-80% efficient
- Low pressure drop (10-40 Pa) and very quiet (23dBA in bedroom)
- Uses displacement ventilation which ensured high ventilation efficiency and has good thermal comfort characteristics
- Stable flow rate
- Efficient electrostatic filter
- Only vertical ductwork. Short length. Easily cleaned
- Costs slightly more than a conventional balanced ventilation system



4.9.2 Overview of customer and market characteristics & driving forces

Norway has 2 million dwelling units. 56% of these are detached houses, followed by 20% in multiple family houses (i.e. semi-detached and terraced houses), the remainder being apartments. Half were built before 1970 [See Figure 4.9a]. The vast majority are owner-occupied. There are approx. 230,000 dwellings in housing cooperatives (mostly apartment buildings). There are approx. 4000 housing cooperatives (estates), and approx. 100 organisations for tenant owner associations.

The median dwelling size for detached houses is 170m², whilst multiple-family homes (semi-detached / terraced, and apartments are all smaller.

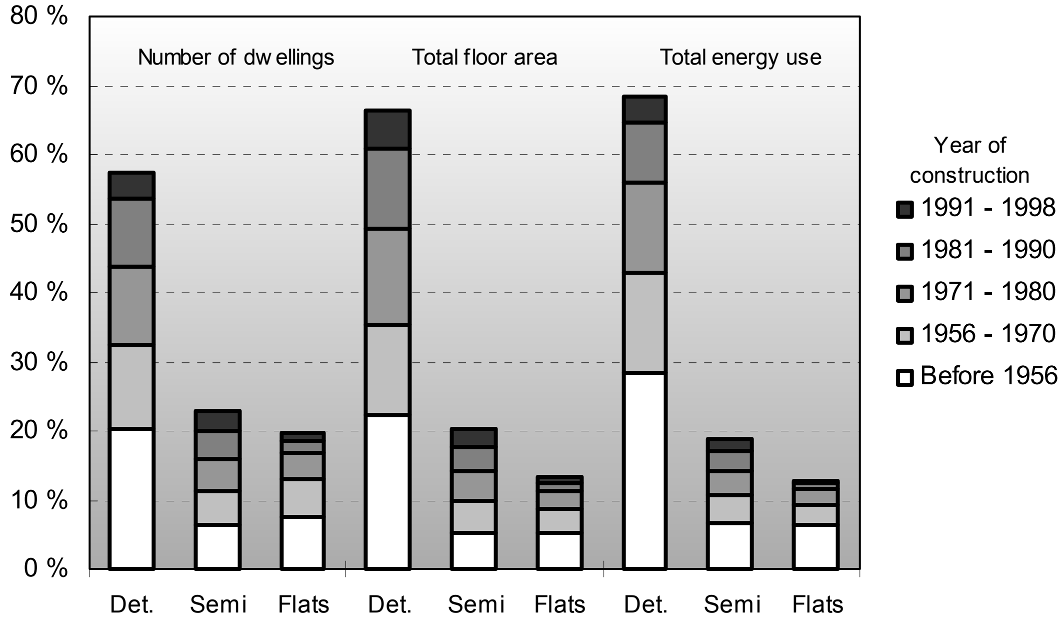


Figure 4.9a *Distribution of no. of dwellings, floor area, and energy use, according to age, for detached houses (***Det.***), semi-detached & terraced multi-family housing (***Semi***), and apartment buildings (***Flats***).* [Source: L.Myhre, NBI]

In the context of this report, we define the "customers" as the dwelling occupiers (end users). The customers' demands and expectations concerning ventilation are:

- Lower energy consumption
- Good indoor air quality: No uncomfortable draughts, filtration wherever necessary to reduce pollutant particles (e.g pollen), no smells
- Smarter technology: demand control, moisture control
- Easier maintenance

Thus the proposed hybrid system, IC4, will thus have to have a very low noise level, and will have to be controlled automatically according to moisture level (maybe also CO_2) and will have to be draught free.

It is thought that the most motivated and actively interested costumers for hybrid ventilation will be: people who are concerned about energy, especially if there is increased awareness about increasing energy prices and the new Energy Directive for dwellings; people who are concerned about health e.g. families with small children, and people with allergies (asthma); families living in trafficated areas; and people interested in technology and good technical performance, and of course also people with an ideological interest in a "green" ventilation system that exploits natural ventilation. This will be the leading group into the mass market.

The customer segment can be divided into customers for detached houses, multi-family houses (i.e. semi-detached/terraced) and apartments. Further it can be divided according to new building/refurbishment, and normal/low energy buildings. The products can be defined as:

- Products for "everybody"
- Products for people with technical interests and knowledge
- Products for people concerned with low energy use, environment friendly, good indoor climate.

The price sensitivity is very high for all types of building. Unless there are considerable savings on energy, a new low energy/hybrid ventilation system can only be permitted to be slightly more expensive than a conventional system. The system is included in a "package" of the complete house. Husbanken (State Housing Bank) gives low rate loans for installation of balanced ventilation with heat recovery (compared to central vacuum-cleaner and control systems for light and heating).

The government body for energy issues, ENOVA, is interested in the outcome to the RESHYVENT project. Information from them can promote interest in this kind of system. Evaluation of the system, recommendations, etc., from them can be a useful result of this project. The new EU energy directive for housing will undoubtedly also act to promote balanced ventilation systems with heat recovery. The state housing bank (Husbanken) has certain conditions for awarding loans for building (regarding house size, energy efficiency, etc), and thus may be interested in aiding the promotion of more energy efficient ventilation systems in new houses. Building contractors have a very significant influence on their costumers in the decision phase. A positive attitude and recommendations from them can certainly influence on the house owners choice of system. Some housing builders are innovative and interested in new solutions. They can offer better standard solutions than the building regulations require.

The most significant driving force for the market growth of balanced ventilation in Norway seems to be interest in indoor air quality and its related health issues, particularly asthma. Norway's second largest city, Bergen, requires new town-houses to have balanced ventilation with filtration, due to outdoor pollution. IAQ issues appear to be more important than energy saving — balanced ventilation with heat recovery does not necessarily lead to a drastic reduction in energy consumption, because it ensures a larger air change rate.
The second most important driving force for the market growth of demand-controlled balanced ventilation with heat recovery is the building regulations, both (i) the tightening of the EPR requirements, and (ii) requirement for 7 l/s per person in bedrooms, which can not be guaranteed with mechanical exhaust ventilation.

The house producer has the greatest influence in the choice of ventilation system, but sometimes also the end user (especially for retrofitting).

The marketing channels for reaching the customers (end user) are:

- The most important channel is through house producers, who are the main contact point for house buyers.
- Respected impartial purveyors of advice: architects, literature from NBI, Husbanken, ENOVA, etc.
- Literature (magazines, newspaper supplements) for homeowners
- Manufacturers of the hybrid system trough their sales department. (though potential customers may interpret marketing information as biased)
- Trade shows for homeowners (where the homeowner can meet the manufacturers)

The house producer, who bears the greatest decision power as regards the ventilation system, should themselves be the target of various marketing tactics. Marketing channels for the house manufacturers are:

- Direct contact through their sales department.
- Direct contact to the individual franchises in the house producer chain (meetings)
- Targeted marketing in building trade journals, trade shows, conferences

Other channels to give information that influences the choice of ventilation system (AIDA - Attention, Interest, Decision, Action):

- Information from the government on energy/economically good solutions.
- Information from Husbanken who give loans and economical contributions (criteria for awarding loans & support).

The purchasing process depends upon the type of contract, whether it is turnkey contract, general contract, or selling of single houses. House producers have traditionally concentrated on turnkey projects, developing large housing estates, where the buyer has little or no influence on the house design or its ventilation system. House producers have thus bought ventilation systems in bulk from a preferred manufacturer, with a significant discount. The vast majority of residential ventilation systems have been sold this way. In recent years, the market for turnkey contracts has stagnated slightly.

When introducing a new ventilation system on the market one has to be aware of the building regulations. These are referenced and discussed RESHYVENT report WP4.

Ventilation related matters are mainly handled by the following organisations:

The professional body for HVAC engineers in Norway is *Norsk VVS Energi- og Miljøteknisk Forening* (Norwegian Society of HVAC Engineers, NORVAC, **www.vvs-foreningen.no,** equivalent to ASHRAE in USA or CIBSE in UK), which is the national representative of REHVA (Federation of European Heating and Air-conditioning Associations, **www.rehva.com**), and SCANVAC, the federation of associations in the Nordic countries and Baltic states (**www.scanvac.net**)

Norwegian manufactures of HVAC equipment can be members of NVEF (*Norsk Ventilasjon og Energiteknisk Forening*, The Norwegian Association for Ventilation and Energy Technology, **www.nvef.no**), which is the national representative of EUROVENT-CECOMAF (European Committee of Air Handling and Refrigerating Equipment Manufacturers, **www.eurovent-cecomaf.org**)

4.9.3 The present and future market

The market can be divided into detached, multi-family houses, and apartment buildings. Another categorization is whether it is a new building or refurbishment.

The size of the total market, i.e. the size of the existing housing stock, is 1.96 million dwelling units, of which 1.1 million are detached, 403,000 are multi-family houses, 355,000 are apartments, and the remaining 95,000 are non-specified.

The number of new dwellings each year is approximately 25.000 [Table 4.9a]. Typically half of these are detached. The rate of construction is slightly increasing, especially apartment buildings (The historical rate of new construction has been: approx 20.000 per year in 1995-1999, and 23.600 in year 2000). The growth in the number of apartments is due to demographic changes: the need for apartments in the Oslo, where an increasing part of the working population is single, and special apartments for the increasing elderly population etc.

Table 4.9a *New dwellings in year 2001* [source: Prognosesenteret]

Detached houses	9,100
Semi-detached/terraced (multi-family)	5,800
Apartment dwellings	7,500 (38.5% increase from 2000)
Total	25,100

Approximately 80% of the existing dwelling stock has natural ventilation (e.g. passive stack). Very approximately 15% has mechanical exhaust ventilation, and the remaining has balanced ventilation. The younger a building is, the more likely that the ventilation system is mechanical. Virtually all houses built in the last 20 years have mechanical ventilation, due to increased awareness the limitations of passive stack ventilation, and stricter interpretation of the building regulations. Since the 1970's the number of family houses with balanced ventilation has grown steadily at 25% per year (i.e. doubling every 3 years). Today, half of all new detached houses have balanced ventilation with heat recovery; the other half has mechanical exhaust.

The market for refurbishment was NOK 29.500 million in 2001. This is an increase of 10% compared to the previous year. Fewer households have been refurbished, but the individual investments have increased. There are no reliable statistics available on how many old houses that have installed mechanical ventilation during refurbishments. However, we know that a third of all installations of residential balanced ventilation are retrofits in existing houses, the remaining $^2/_3$ being in new buildings. It is simpler to retrofit balanced ventilation in houses that earlier had mechanical exhaust ventilation, than in naturally ventilated houses.

There is significant potential for installing low energy ventilation systems incorporating RESHYVENT concepts in new houses that today get balanced mechanical systems (ca. 10,000/year). The market for refurbishment is thought to be much lower, due to problems with finding space for the wider ducts and larger ventilation unit. Naturally, there is nothing to preventing installing a hybrid ventilation system in an old house; it is it is just more complicated than designing it into a new house.

The main focus of the ventilation industry today, is to shift their market from mechanical exhaust ventilation to balanced ventilation. This process takes time, but much can change in 5 years. The next step will be to make people choose 2nd generation balanced ventilation systems, incorporating some RESHYVENT concepts. Nevertheless can such a system compete with existing products in some years? Cost will be a decisive factor.

The key factors for growth and change in the ventilation business are:

- The construction rate of new buildings is slightly increasing
- The need for more apartment buildings in cities, especially Oslo.
- The present building regulations can be fulfilled by mechanical exhaust ventilation in dwellings, with no heat recovery. If the regulations are tightened, then heat recovery will become more popular, thus the market for RESHYVENT concepts will grow too. This is an ongoing discussion.
- Financing rules & loans. The availability of financial incentives for choosing more energy efficient ventilation systems is important, and Husbanken defines a max allowable building size (technical plant rooms are presently included in the max allowable m², and are thus not popular, so there is little space for technical equipment).

4.9.4 Market competition

The ventilation systems competing with hybrid ventilation today are mechanical exhaust ventilation and balanced ventilation, both of which occupy half of the market in new houses.

The most modern competing system (balanced) is marketed though the same channels, and with many of the same arguments, as would be a RESHYVENT ventilation system (see chapter 4.9.1 on Overview of customer and market characteristics). Important sales arguments are energy conservation, good IAQ (health) throughout the whole dwelling, preventing humidity problems.

As to patents within the ventilation business, there are no patents specifically related to the IC4 hybrid system, though it may incorporate patented off-the shelf components. There are also no other patent infringing on the IC4 system.

The IC4 hybrid ventilation system will be competing with ordinary mechanical ventilation systems, and no counter measures are expected from the producers of these systems.

4.9.5 Today's ventilation system in comparison with hybrid ventilation systems

The results of the focus group study are mostly for use in IC4, especially questions on design. Only the main conclusions of the work are documented here.
The comparison of today's ventilation system with hybrid ventilation i.e. the IC4 concept resulted in conclusions as to why we ventilate, success factors for ventilation, success factors for design and costs.

The arguments for ventilating a dwelling are:

- Avoid moisture problems
- Ventilate away emissions from building materials
- Exhaust of excess moisture from kitchen and bathroom
- Temperature control
- Better air quality

The arguments for filtration and balanced ventilation:

- Filtration avoid pollutants, especially in urban areas
- Avoid pollen (allergic persons, persons with small kids)
- Energy savings
- Some scepticism to balanced ventilation

For ventilation of dwellings the following matters are important:

- Avoid noise from the ventilation installation, and between rooms (especially bedrooms)
- Good temperature control
- Different temperature demand in different kind of rooms (cool bedrooms and warm living room, but sometimes also other rooms)
- Fresh air and avoid different kinds of smells
- Good comfort (no draught, temperature control)
- Avoid draught especially by the bed and by the sofa in the living room.

The success factors for design are:

- User interface must be simple
- The installation must be easy to maintain

- Air terminal devices must be placed out of the way from where you want to place paintings, furniture etc. Not too big size, it should be integrated in ceiling or wall.
- Ventilation unit should be placed out of the way, but not take valuable space from storage rooms. It is acceptable that it will take some space.
- Demand-control might be of interest, but must be easy to handle and maintain.
- Control units are acceptable (on the wall, near ceiling), but need an indicator that shows if it is working
- Noise control
- Easier control/more service for elderly people.
- Pay attention to people's existing habits for ventilation. This varies with age, family situation, life style, owner/renter.

It seems that a hybrid ventilation system must not be considerably more expensive than existing balanced systems. This may be problematic, due to the additional investment costs of low energy fans and demand-control sensors and actuators. Nevertheless, it is likely that dwellings will in future cater for a higher standard of living with more technical facilities.
A modern balanced ventilation system installation in a detached house typically costs NOK 35,000~45,000 (VAT included) as of 2001. The ventilation unit itself typically costs about NOK 21,000, optional extra equipment (e.g. remote control panel) typically costs an additional NOK 2,000, and the duct system costs at least NOK 16,000. Alternatively a basic mechanical exhaust system costs NOK 12,500 or more.

4.9.6 SWOT-analysis

The assumed hybrid ventilation system is the IC4 concept. The traditional system is a mechanical ventilation system, either exhaust only or balanced.

Potential internal Strengths	Potential internal Weaknesses
1 Low energy consumption 2 Demand control 3 Low noise level 4 Easier maintenance (washable filters etc) 5 Best air quality 6 "Green" solution	1 Space for ductwork 2 Loft location 3 Type of dwelling 4 Prototype
Potential external Opportunities	**Potential external Threats**
1 More balanced systems in dwellings 2 Recommendations	1 Customers attitude 2 Low cost projects

4.9.6.1 Potential internal strengths

1 Low energy consumption system
Energy savings in dwellings is an important topic in cold-climate countries such as Norway, which is predominantly subarctic. The primary energy source for space heating in Norway is electricity from hydroelectric power. The cost of electricity in Norway has rose dramatically in the autumn of 2002 due to lack of precipitation. This has lead to a much greater awareness

of energy conservation. Energy efficiency has therefore been good sales argument. However, the prices have fallen again to their normal cheap levels (0.65~0.70 NOK/kWh) due to normal precipitation. The proposed hybrid ventilation system will hopefully be the most energy efficient of all products presently on the market. Even if the investment costs will be somewhat higher than for existing systems, it is hoped that the energy savings will give the product a reasonable payback time.

2 Demand control

Demand control is a very effective means of improving ventilation efficiency. This type of regulation can give both energy savings and better air quality. All in all, this means that the total volume of ventilated air during the year can be lower, reducing the ventilation heat loss. Ensuring an optimal air distribution and ventilation rate, according to use, combined with temperature control (automatic bypass to prevent heat recovery in summer for comfort) ensures good air quality. Existing ventilation systems normally only have very crude demand control (manually regulated flow rate: low/medium/max). Simplicity, functional robustness and efficiency are important success criteria.

3 Low noise level

Noise is a very important issue. Low noise level is mentioned as a qualification for a good ventilation system both by the manufacturer's sales force and by the focus group. Most dwellings today have natural or mechanical exhaust ventilation. A third of modern balanced ventilation systems give noticeable noise in bedrooms. The IC4 proposed product should be the quietest on the marked, and thus be attractive to the user.

4 Easier maintenance:

Not all users have an interest in technical things or the capability to maintain a ventilation system. A domestic ventilation system must be able to function well with a minimum of maintenance. The necessary maintenance should be simple and without high expense. This ensures a robust working ventilation system, and a system that does not diminish the air quality. Our proposed system, with shorter ductwork of larger diameter, should be easier to inspect and clean. The filter can hopefully be cleaned easily by the homeowner, so no components need regular replacement. We also hope to give easy access to the system and its components.

5 Best air quality

The system makes use of displacement ventilation, cascade-flow between rooms, moisture recovery during dry winter months, and temperature control. Combined with demand control, the air quality should be better than with any other product on the market.

6 Environmentally correct "green" image

The fact that the system exploits natural driving forces (and can switch off the fans at times) should earn it a "green" kudos akin to a fully natural ventilation system. Its other low energy characteristics will probably be associated with an environmentally friendly solution. This is a "correct" image that helps the popularity of the product on the market, both to the end user and to the producer of the dwellings.

4.9.6.2 Potential internal weaknesses

1 Space for ductwork and unit
The larger dimension of ductwork to reduce pressure drop poses a special problem for the architect and the property developer. There are normally no or very few technical shafts in houses. Large duct risers will take valuable area from the total. This is a problem both in terms of costs and regulations. Horizontal shafts can be a problem for the floor height. Larger dimension ducts necessitate good planning at an early stage of the building project, and good coordination with the architect.

2 Loft location
The nature of the ventilation concept (exploiting natural driving forces) means that the ventilation unit will have to be placed in the loft. The large size of the ventilation unit (to minimise pressure drop) will be another reason for putting it in the loft. Lofts generally have poor access, which poses a potential maintenance problem. Modern balanced ventilation units are increasingly being placed in accessible rooms in the dwelling (cabinet models) as opposed to the loft. This makes inspection and maintenance much easier.

3 Type of house
The proposed product will be most suitable to houses (detached or multi-family) because of the chimney for exploiting wind energy. It has been suggested to make the product modular: one module for air handling (placed in the loft), and an optional rooftop module for exploiting wind. The main module (without the wind module) could used for apartment dwellings, though it might be too large since apartment dwellings lack a loft space.

4 Prototype
The product will still only be a prototype after the end of RESHYVENT, even though it will have undergone thorough testing in real family houses. It may be necessary with further operational experience after further adjustments have been made before the product goes into mass production. This may therefore not be at standard product on the market for a few years.

4.9.6.3 Potential external opportunities

1 More balanced systems in dwellings
Manufacturers of ventilation systems, some building contractors and authorities, are all becoming increasingly positive about the benefits of balanced ventilation systems with heat recovery. This general growing positive attitude towards balanced ventilation systems will undoubtedly embrace the proposed hybrid ventilation system where we have tried to make small improvements upon balanced ventilation systems in terms of energy efficiency, noise level and automation.

2 Recommendations
ENOVA, a public enterprise in Norway concerned with promoting energy efficiency and renewable energy, is interested in the project. ENOVA is helping to support the development financially. Sufficient results from the first year with operation in test dwellings, can give the product support and recommendations from ENOVA. This will be a valuable support to the product in the market.

4.9.6.4 Potential external threats

1 Customers attitude

The end users, and therefore also some building contractors, have traditionally been sceptical to balanced ventilation system. Exhaust systems have been considered as the preferable solution. This scepticism also has backup in the national building regulations, which permit exhaust ventilation. As the advantages of balanced ventilation systems are getting more widely known and understood, the hybrid ventilation system will hopefully get more preferable attention.

2 Low cost projects

All residential building projects have a certain cost limit, in line with the restricted income of normal families. The Norwegian residential housing marked is very competitive, with many builders competing for business with slim profit margins. Building contractors are thus forced to keep costs at a minimum. The price difference between a balanced ventilation system and a normal exhaust system is an important argument, especially when the building regulations permit mechanical exhaust systems. Exhaust systems have a lower installation cost. Home buyers are may prefer to invest . It is necessarily to increase awareness about LCC for balanced systems, to give it priority in the total restricted budget.

4.9.7 Summary and conclusions

Over 60% of new dwellings in Norway have balanced ventilation with heat recovery (2004) [62% in detached houses, 59% in terraced housing, 52% in apartments]. These are almost entirely air-to-air heat recovery. This might be the world’s highest market penetration. The number of dwellings with HRV (heat recovery ventilators) has increased at a steady rate of 25% each year since the late 1970s. The market growth has been partly driven by interest in energy conservation, and but has mostly been driven by an interest in improved air quality and reduced draughts. The standard of living in Norway has improved greatly since the 1970s, partly as a result of the oil industry. People’s expectations about the quality of the environment in their homes has increased accordingly. There has been a parallel increase in prevalence of asthma among the population. Now approx. 30% of Norwegians have suffered allergy. Many households invest in balanced ventilation because they have asthmatic family members. Balanced ventilation seems to be very beneficial for people with such complaints. People wish their ventilation system to provide good IAQ, be draught-free, quiet, reliable and low-maintenance. In 2004, 56% of households who purchased a new house say that ‘good indoor climate’ was a criterion for choosing the type of ventilation system in their new home; similarly 21% had ‘comfort’ as a criterion. In 2002, the percentages were only 29% and 7% respectively – which clearly shows that there is growing interest in IAQ and comfort. These expectations are being fulfilled to a degree with well-designed conventional balanced ventilation systems, so hybrid ventilation does not necessarily have an immediate perceived market advantage. Nevertheless, recent research by NBI on many Norwegian schools with hybrid ventilation, has revealed two factors:

- Pupils in modern schools with hybrid ventilation have less SBS symptoms and are more satisfied with the IEQ (indoor environmental quality) than modern schools with conventional balanced ventilation from packaged AHUs.
- Bag air filters in ventilation systems do not improve the perceived air quality or SBS symptoms, especially among pupils with asthma/allergy (outside the pollen season).

This tells us that hybrid ventilation systems have a potential IAQ benefit in housing, especially if it is possible to avoid using bag air filters in the ventilation system. The fact that hybrid ventilation systems are more robust (are less affected by poor maintenance) is also a great advantage.

The SWOT analysis revealed that a major perceived weakness of some hybrid ventilation systems is that they occupy a large space (for air handling components and ductwork). The best solution to this problem is to develop ductless solutions. A major benefit of ventilation systems not requiring supply ductwork is that fresh air supply filter is no longer needed (to prevent sedimentation in the supply ductwork). This could have an added benefit in terms of IAQ, lower cost, lower pressure loss, maybe even lower risk of noise problems. However it is a challenge to implement air-to-air heat recovery in ductless systems.

Norway's predominantly performance-oriented building regulations are largely accommodative to innovative ventilation systems, so long as they fulfil all the normal criteria for healthy indoor environment etc. The main statutory barrier is that the regulations do not overtly encourage innovative solutions - i.e. by not having a more stringent energy consumption limit, and simply by not mentioning their benefits, such as the fact that total fresh air flow rates can be reduced with demand-control, displacement and cascade ventilation. It is not a problem to get planning approval for buildings with hybrid ventilation technologies. The implementation of the EPBD in Norway will eventually catalyse a tightening of the energy performance regulations (EPR). This will promote RESHYVENT technologies such as demand controlled ventilation, heat recovery, and lower fan power. For example, it is suggested that the Norwegian EPR should be updated in 2006 to include the fan power (SFP) for the first time.

The state housing bank (Husbanken) has financial incentives for features such as heat pumps and heat recovery. Nevertheless, the most dominating barrier to innovative technologies is still cost and market forces. Housing is built mostly by large property developers concerned almost only with capital costs, not LCC, and who try to just meet minimum regulatory requirements. This is a challenge facing the product that the Norwegian consortium is developing. The stiff competition in the housing market is in part a result of the buying habits and attitudes of the general public. In order to sell new technology to home-buyers, it must be competitive with other investment priorities, such as larger floor area or a garage, so it has to be attractive with respect to their conceived concerns on comfort, health and safety as well as running costs and investment return when they move house. Having said that, new housing in Norway is generally more energy-efficient, with a higher level of comfort, than housing further south in Europe.

With regards to the building regulations, we recommend the following:

- The EPR energy consumption limit should be made stricter [It might be tightened slightly in 2006 (not yet decided as of December 2004), but should be tightened further].
- The EPR should explicitly include fan power in the calculations [This will be introduced in 2006].
- The two existing alternatives to the EPR, namely (a) specified level of insulation, or (b) heat loss limit, represent a possible loophole in the present regulations, and should be removed [This might occur in 2006].
- There should be more financial incentives for energy efficient technologies in buildings.

– The building regulations must set clearly defined requirements on ventilation of bedrooms (e.g. 7 ℓ/s per occupant), such that poor ventilation systems will disappear from the market.
– The building regulations on airtightness should be tightened. Today's requirement for houses is n_{50} = 4 ach, and 1.5 ach for apartment buildings. NBI has recently recommended that the regulations for houses be reduced to n_{50} = 2 ach. NBI has shown that this is easy to achieve on standard manufactured houses. This will further promote the use of effective mechanical ventilation.

The Norwegian market survey has shown the following key facts:
– Balanced ventilation with air-to-air heat recovery has become the *de facto* standard system in houses. RESHYVENT concepts are a natural next step in this progress.
– Most of the general public know nothing about, or have misconceptions about, hybrid ventilation. Many people who are aware of hybrid ventilation, have a positive attitude to it a potentially simple and environmentally friendly means of providing better IAQ than conventional ducted balanced ventilation, and better thermal comfort than exhaust systems (with fresh air vents in rooms).
– Many people in the ventilation industry are sceptical about hybrid ventilation (i.e. exploitation of natural driving forces), due to its cost and infancy as a technology, but technological aspects such as DCV and energy-efficienct fans have wide acceptance as inevitable future developments.
– House producers are the biggest potential customers. They are extremely cost conscious, often choosing second-rate solutions that just comply with minimum building regulations. The most innovative house producers are the most positive towards new ventilation systems. This is especially the case for apartment buildings where only 6% of households who buy a brand new apartment get to choose the type of ventilation system in their home. For houses, the situation is different, as 61% of households who buy a new house get to choose the type of ventilation system. Only 25% of households have 'energy conservation' as a criterion for choosing their ventilation system; more households are concerned with the IAQ and comfort as decisive factors.
– The proposed IC4 concept has many of the good features that the focus group were preoccupied with, including: good IAQ (ensured by demand-control), filtration, moisture control, draught free, low noise, low energy consumption, and no-fuss automation and maintenance (no need for filter replacement – all washable).
– However, the target price for a RESHYVENT system should not noticeably higher than a conventional balanced ventilation system with air-to-air heat recovery (NOK 35,000~45,000 in yr 2001, which included installation cost), and any additional costs lead to lower LCC. This may be the greatest limitation. EC fans, CO_2 sensors, and a wind cowl, are especially costly, and need to reduce in price. Also, the increased need for advanced automation significantly increases the cost of development, testing and manufacture of the ventilation unit's controls. There will have to be cost reductions in terms of lower energy consumption, ductless solutions, and similar.
– The exploitation of natural ventilation in combination with heat recovery creates a number of design limitations (size of unit and ducts, unit location) that may limit the practicability of the product. Inspection & maintenance may be problematic in the loft.
– It is important to keep in mind that exploitation of natural driving forces does not necessarily make economic sense. Compared to a conventional ventilation system, the reduction in fan energy in a hybrid ventilation system is predominantly attributed to the reduction in friction losses in the air distribution system (e.g. duct system with very low pressure drop). Exploiting natural driving forces (which can for example be 10 Pa on

average for a 2-storey building) enables a further reduction in fan power. The savings in fan energy attributed to exploiting the natural driving forces is generally much smaller than the savings attributed to reducing duct friction losses in the air distribution system. Hybrid ventilation strategies are usually demand-controlled strategies, which constitutes also a large potential reduction in fan power. All this does not mean that one should not bother exploiting natural driving forces; it is sensible try to exploit its full potential as long as it makes sense economically and environmentally. Similarly, exploitation of natural driving forces does not reduce energy consumption for ventilation preheating or space conditioning — it is other measures, such as demand control, heat recovery and exploitation of thermal mass for thermal cooling, that provide a significant reduction in energy for preheating/conditioning.

- Most Norwegians practice window airing of bedrooms at night. We suspect that this is not only to provide fresh air, but also to achieve a comfortably low room temperature (approx. 15°C) since Norwegians use thermally insulating duvets. We also know that air at low temperature is perceived to be fresher. Some who have balanced ventilation report that window airing is no longer necessary. However, of the room is too warm, then they will still feel a need to use window ventilation. This has detrimental consequences for the energy efficiency of hybrid ventilation systems with heat recovery.

4.9.8 References

Literature for the market survey

SSB (Statistics Norway) – StatBank Norway, Folke- og boligtellingen 2001

Prognosesenteret AS – Boligprodusentenes bransjeanalyse 2004: “Energi, oppvarming & ventilasjon I nye norske boliger”

Husbanken (The Norwegian State Housing Bank) – statistics available on WWW

Interviews with experts for the market survey

Flexit	Knut Skogstad, Stian Martinsen, Jon, Villy Bolsøy
Byggforsk	RTD-department housing, the built environment and society Lars Myhre, Peter G. Schild, Eimund Skåret,

Literature for the SWOT-analysis

RESHYVENT	Present situation in Norway in regard to hybrid ventilation, Task 2.1.1.
RESHYVENT	PSD study with focus groups on ventilation in Norwegian dwellings, Task 2.2.2

Participants involved in the SWOT-analysis

Flexit AS	Technical director, development department, marketing department, sales department
Byggforsk	Norwegian Building Research Institute, RTD-department Building services (also Byggforsk pensioner Eimund Skåret, developer of first generation prototype in 1994)
Mesterhus	One of the largest building contractor groups in Norway
ENOVA	A public enterprise concerned with energy efficiency and new renewable energy
Husbanken	The Norwegian State Housing Bank

4.10 Portugal

4.10.1 Overview of costumer and market characteristics

In 2004, Portugal has about 3.5 million residential units. In historical terms, about 50% were built before 1980, and the rest since then. There has been a large boom in construction since 1980, when the national economy surged ahead, with the corresponding demand for new residential and non-residential units. Quantity rather than quality was the rule for the new construction in the 1980's. Buildings had to be made available quickly and with basic services but without any significant sophistication. The situation has improved since the mid 1990's, when the building market evolved towards beginning to also satisfy an increasing demand for quality as well as a significant portion of second homes, for weekend and vacation purposes.

The typologies of the buildings also changed at about the same time. In 1980, about 90% of the buildings were single-family residences. As the population moved from the countryside to the cities, the share of multifamily residential units significantly increased. However, single-family residences still represent a majority of all new construction. Table 1 shows the building permits issued in 2002, where this new trend is clear: although 8,161 multifamily buildings accounted for 80,476 residential units, the number of single family units amounted to 34,290, i.e., 81% of the total new buildings.

Table 8.1. New construction in the year 2002 in Portugal [1]

Building Typology	**Number of Buildings**	**Number of Dwelling Units**
Residential	42,451	
Single Family	34,290	34,290
Multifamily	8,161	80,476
Nonresidential	7,481	
Total	**49,932**	**114,766**

Thus, overall, 85% of all the existing residential buildings in Portugal are single-family residences, and the rest of the residential units are in multifamily apartment buildings. However, this smaller number of multifamily buildings houses an increasing share of the population, currently at about 60%, as construction space becomes scarcer and the rural population decreases.

Most of the residential buildings are the property of their occupants. The rental market is quite small and concentrated in the older portion of the building sector (buildings from 1970's and earlier). There are no firm statistics about the number of rental units because most rentals are informal and no contract is signed.

Retrofitting represented a small percentage of the building industry. Most old building were simply demolished and replaced by new ones, except if they had a special architectural or historical value. The rehabilitation market has however started to increase during the late 1990's and projections by the sector associations indicate a growing importance of that market over the next decade. Table 2 shows the evolution of the construction market since 1995 and the projections until 2010, where this trend is clear, along a slowdown of new construction. The retrofit market is expected to become larger than the new construction by 2008.

Table 8.2 - Residential Buildings - New and Retrofit market projection, year 2000 [2].

Year	Dwellings (total)	Unoccupied	New	Retrofit	Growth
1995	2 762 000	4 500	50 000	3 000	45 500
1996	2 812 500	4 500	55 000	3 500	50 500
1997	2 878 000	4 500	70 000	4 000	65 500
1998	2 953 500	4 500	80 000	4 650	75 500
1999	3 029 000	4 500	80 000	5 320	75 500
2000	3 099 000	5 000	75 000	6 120	70 000
2001	3 154 500	5 500	61 000	7 050	55 500
2002	3 197 500	6 000	49 000	8 100	43 000
2003	3 230 000	6 500	39 000	9 300	32 500
2004	3 252 000	7 000	29 000	10 700	22 000
2005	3 270 500	7 500	26 000	12 300	18 500
2006	3 285 500	8 000	23 000	14 150	15 000
2007	3 298 000	8 500	21 000	16 300	12 500
2008	3 307 000	9 000	18 000	18 700	9 000
2009	3 313 500	9 500	16 000	21 500	6 500
2010	3 317 500	10 000	14 000	24 750	4 000

The vast majority of single-family residences are naturally ventilated. There are very few such buildings with any ventilation at all, except mechanical extraction over the stove in the kitchen, which is present everywhere. National regulations only require that all rooms must have operable windows for airing, and interior spaces without windows need to have an entry and an exit point for outdoor air, e.g., through pipes with appropriate diameter, e.g., 10-15 cm.

In apartment buildings, the situation is mixed. Most of the older buildings, built prior to 1980, will also be fully naturally ventilated, using the exact same principles as single-family homes. Since then, most apartment buildings have mechanical extraction in kitchens, bathrooms and toilets. Air inlet takes place through cracks in window and door frames. These mechanical extraction systems are now taken for granted and demanded by consumers. They are often automatically switched off during the night by clock controllers for acoustical comfort, a recurring problem due to non-optimized (low-cost) systems.

Balanced ventilation systems are extremely rare, and heat recovery is also not common in residential systems. From a strict economic point of view, due to the mildness of the Portuguese climate, heat recovery can only be justifiable in larger buildings located in the coldest zones. In many regions in Portugal, namely near the coast and towards the south, degree-days are lower than 1000 ºC.days/year and often even lower than 500 ºC.days/year, thereby resulting in low savings and high payback periods. In the coldest zones, though, they can be easily justified if balanced ventilation systems were used. A major change in construction practice would be needed for this option to become viable.

Existing apartment buildings that undergo a major rehabilitation usually adopt this same type of mechanical extraction system or keep the original natural ventilation option, depending on cost and space availability.

Cost and tradition are the main causes for this situation. People are used to regularly opening windows during days with mild weather conditions, i.e., most of the year in Portugal. Other more advanced mechanical systems have always had a difficulty to obtain a significant market share because they require higher costs, as well as higher and more costly maintenance. When designing new buildings and major rehabilitations, architects and engineers simply go along these trends: they select and specify the systems that costumers expect and have the lowest cost for all market segments (natural ventilation for single family residences and central mechanical extraction for large apartment buildings).

4.8.6 Today's ventilation systems in comparison with hybrid ventilation systems

Natural ventilation systems are hard to compete with. The Portuguese climate allows natural ventilation during most of the year. Thus, ventilation systems in residential buildings must be low-cost, though effective, during the two to three months of the year when natural ventilation is usual difficult due to cold outside air temperature.

It will be easier for hybrid systems to compete as an alternative to central extraction systems. Provision of controlled inlets and smarter controls may provide sufficient improvements in indoor air quality, operational cost (electricity consumption and heating/cooling needs deriving from treatment of the ventilation air) and noise reduction to make them interesting.

4.10.2 The present and future market

The present market for hybrid systems is practically non-existing. There are no known buildings with such systems, except a few select demonstration cases.

The potential market for hybrid ventilation systems consists of the new construction and refurbishment, averaging 30,000 to 40,000 new systems every year till 2010 (see table 2). New regulations (see WP4 reports) are coming into effect in 2005 that will require proof of minimum ventilation rates in buildings and, thus, mechanical extraction systems will become the favourite option. Provision of controlled inlets will be a positive point and, thus, an incentive for better ventilation systems in dwellings. Hybrid systems are specifically mentioned in the new regulations and, thus, they may have favourable conditions for faster market penetration.

Even so, in the near future (e.g., within five years), the most positive forecasts can not be higher than just a few percent of the total market. Manufacturers must invest some effort to make these systems better known among designers and to make them aware of the advantages that they offer.

More demanding regulations in the future, in the medium to long term, may change this situation and further increase the potential of hybrid systems, but it is hard to forecast such a development at present.

4.10.3 SWOT-analysis and market competition

Natural ventilation in single family houses and central extract systems in apartment buildings are the common current solution and, unless some major development takes place, these are the base systems that all others must compete with for market share. Central extraction in single family housing is slowly starting to obtain a share, but it is still very small, though with a tendency for increasing.

As these system satisfy indoor air quality requirements and national regulations, there is little incentive for change. Better performance may become an added incentive on the basis of the following points, as suggested by an inquiry on a few selected designers that have been selected for a panel to address the issue of hybrid versus conventional ventilation systems:

- *Cost* - a system that meets regulations and has a lower cost will certainly get a good market share.
- *Space* - architectural pressure to reduce the space needed for ventilation systems will certainly be a positive feature for any innovative ventilation system;
- *Noise* - this is one of the most important reasons for complaints from building occupants. Even if at a slightly larger cost, a "silent" system will be preferred for the segment of the market corresponding to the best quality or luxury.
- *Certification category* - again in the top segment of the market, there may be a role and a market share for any ventilation system that may have a better energy performance and thus contribute to a better class in the certification system. Certification must be introduced by the end of 2005, as demanded by the new European Directive on the Energy Performance of Buildings.

The panel also identified a few additional issues that must be addressed by new systems to be competitive and enter the market:

- *Safety* - the system must be able to coexist with gas-burning water heaters and stoves that are used by many Portuguese residences and are usually installed in the kitchens. The system must be able to supply enough outdoor air for combustion during its operation, as well as always preventing reverse flow in the heater chimney.
- *Aesthetics* - The entry grilles on the façade (or window frames) must be integrated in a way that architects find pleasant and acceptable.
- *Operation* - the controls must be flexible and simple. Anything requiring more intervention by the user than a simple switching on and off as the current extraction systems will have a hard time to be widely accepted. Total automation is the preferred solution.

4.10.4 Summary and Conclusions

Most of the three and a half million dwellings in Portugal have either a fully natural ventilation system or a central mechanical extraction with exhausts from the wet rooms (kitchens, bathrooms and toilets). The national regulation only stipulates operable windows for airing in buildings with natural ventilation, and rooms without windows must have either inlet and outlet openings in natural ventilation or mechanical extraction. Since the mid nineties the demand for quality has increased. Balanced systems and heat recovery are, however, extremely rare and hard to justify in most of the country.

The annual market for new and retrofit units will be between 30,000 to 40,000 per year till 2010. The most common present typologies for ventilation systems should remain so, but there is an opening for hybrid systems because new regulations coming into force in 2005 will provide a significant incentive for better ventilation systems, including hybrid systems. The new European Directive on the Energy Performance of Buildings may play a relevant role in this context through the introduction of more demanding regulations, information in the certification process, and improved inspections of the built reality.

Several barriers, such as higher cost, different aesthetic characteristics, space constraints and higher control complexity may hinder penetration of hybrid systems in the Portuguese market, and, by 2010, at best, only a few percent of the available market can adopt them. Currently mechanical extraction systems are taken for granted and demanded by most consumers.

4.10.5 References

1 - National Statistics Institute, Lisbon, 2003.

2 - Ricardo Aguiar. National Plan for Energy Efficiency in Buildings: impact on CO_2 emissions. INETI, 2002.

4.11 Sweden

4.11.1 Overview of customer and market characteristics

The end customers of ventilation systems for new construction and refurbishment are owners of one-family houses, owners of apartment buildings and tenant-owner building societies. The number of one-family dwellings is estimated to be 1,806,000. For apartment buildings the number of property owners are 8,004 and the number of tenant-owner building societies are 21,760. The total number of customers today adds up to 1,835,000.

The demands and expectations of the customers (based on a focus group meeting with five major apartment building owners/developers) are related to the performance of the ventilation systems, which means:

- few complaints on sound and draft, which are common reasons for complaints in indoor climate questionnaires among tenants

The system should have the following features:

- good controllability,
- built by competent contractors,
- competent operations supervision,
- flexibility (adaptable to individual needs)
- reliable regarding the air flow.

The design should result in:

- robust, aesthetic and easy to maintain and clean air terminal devices and ducts.

The fan/plant rooms should be:

- accessible and easy to maintain.

The cost is of course important, mostly referring to investments costs.

How does then a hybrid ventilation system meet these demands and expectations of the customers? The IC1 hybrid ventilation (see short description in the beginning of the chapter on SWOT-analysis) concept is designed for apartments, but could also be adapted for installation in one-family houses. The concept aims to have the following performance compared with the existing ventilation systems, mostly mechanical ventilation systems:

- less generation of internal noise by the ventilation systems,
- same level of transmission of internal noise (between rooms and apartments) via the ventilation system,
- the same level of transmission of external noise via the ventilation system as for mechanical exhaust ventilation but probably higher than for balanced mechanical ventilation,

- lower risk of draft,
- less central controllability than for mechanical ventilation but higher than for natural ventilation
- higher user controllability of air flows and temperatures of the ventilation system
- less influence on the flexibility of building use by ventilation system
- higher reliability of ventilation system
- slightly less robust, aesthetic and easy to maintain and clean air terminal devices and ducts
- higher investment, but lower life cycle cost

Many of the demands and expectations of customers will be met by the IC1 concept.

The customer segment can on a general level not be divided into small/large or low/high cost customer groups, but different kinds of demands are likely to divide the customer e.g. hygienic functions or high demands on controlled systems. Building costs, choice of building design and maintenance budget also influence a diversion of customers e.g. the new apartment buildings of Bo01 (500 apartments to begin) in Malmö and Hammarby Sjöstad (8000 apartments) in Stockholm. These areas are mostly for high cost customers e.g. the couple with a nice one-family house and the children have left home. The marketing is of course different, emphasizing the design of the buildings and the attractive surroundings.

The price sensitivity of the customers is rather high. Often the system bought is the one with the lowest investment cost, unless there are some added worthwhile features. The high cost customer (among end customers for ownership or co-operative dwellings) is of course less price sensitive, but are not likely to prioritise a better and more energy efficient ventilation systems. According to a study of what the end user is prepared to pay for as to smart solutions/functions in a new dwelling: extended/improved bathroom, cleaning friendly and advanced alarm system (Friedman 2001).
There are a number of interested parties concerning ventilation, ranging from tenants through contractors to clients. The most influential interested party as to choice of ventilation system is often the contractor, but can also be the client (property owner/manager). The contractor is often mainly concerned with the cost of the system. The clients are primarily interested in the performance of the ventilation systems e.g. few complaints on sound and draft, which is likely to be the case for hybrid ventilation according to the IC1 concept. The cost (usually the investment cost) is of course always very important to the clients.

Responsible for the purchase of a ventilation is usually the project team, project leader or in some cases the purchasing manager within the real estate company. For one-family houses the purchaser is often the manufacturer of prefabricated houses.

The most important marketing channel for reaching the customers is the tendering procedure. Sending out information, advertising in specialist press, events and sponsoring agreement are other used channels.

The purchasing process is different for apartment buildings and one-family houses:
Apartment buildings: The tendering procedure often results in the procurement of a contractor not a ventilation system. The system is often chosen by the contractors and therefore based on their knowledge of different systems. Performance requirement limits the contractor's choice in an all-in contract. In a general contract the contractor are often given a required system or in rare cases specific brands.

One-family houses: These houses are often prefabricated. The manufacturer includes a ventilation system of his choice.

Ventilation related matters are mainly handled by the Swedish Association of Air Handling Industries (www.svenskventilation.se) and The Swedish Society of HVAC Engineers (www.siki.se). These two organisations cover a large part of the companies and the people involved in the process of designing and developing ventilation strategies and systems.

When introducing a new ventilation system on the Swedish market one has to be aware of some requirements of the current building code. The current Swedish building regulations require a minimum ventilation rate and not directly a certain specified level of IAQ. In principle any type of ventilation systems can be chosen. Innovative systems like hybrid ventilation systems can be implemented, although they are not really covered by the procedures in the current regulations and standards. For a hybrid ventilation system, it has to be proven to the local building committee that the indoor quality and/or air flows are likely to fulfil the requirements. This can be done in different ways e.g. simple calculations or that if necessary the fans alone can fulfil the requirements. More work is likely to be required to get approval for a hybrid ventilation system than for a mechanical one.

The specific air flow rate (l/s,m2) in the IC1 concept is occupancy dependent. This may lead to low specific air flow rates in large flats e.g. lower than the requirement of the current building regulations of 0.35 l/s,m2.

In the current building regulations heat recovery on the ventilating air is required if the energy demand for heating of the ventilating air exceeds 2 MWh/year and if the heat energy requirement is substantially supplied by oil, coal, gas or peat, or is wholly or partly supplied by electricity during the period November to March inclusive. For most apartment buildings this does not apply as they typically are connected to a district heating system relying mainly on renewables.

4.11.2 The present and future market

The market can be divided into manufacturers and owners of one-family houses, property owners and/or developers (apartment buildings) and tenant-owners building societies.

The size of the total market i.e. the size of the existing housing stock is 4.3 million dwellings whereof 42 % are one-family houses, 40 % are rental apartments, 18 % are tenant-owner society apartments. (2002)

The existing housing stock is equipped with the following ventilation systems:

One-family houses			Apartment buildings		
Natural/-passive	Mechanical exhaust	Mechanical balanced	Natural/-passive	Mechanical exhaust	Mechanical balanced
75 %	17 %	8 %	40 %	44 %	16 %

Since 1975 almost all ventilation system being installed are mechanical ventilation systems. The main reason is that the building code of 1975 was the first building code to require a mechanical ventilation system for dwellings, the exception being one-family houses and apartment buildings with not more than two storeys, where passive stack ventilation was allowed. Recommended air flow rates are given as well. Already the commonly used VVS AMA 1972 (HVAC job descriptions of 1972) states that adjusting and testing of air flows should be done in the finished building, which can be rather difficult for passive stack ventilation.

The building code of 1980 states a certain minimum ventilation rate, and give as examples of acceptable solutions only mechanical ventilation systems with recommended exhaust air flows from e.g. bathroom and kitchen. In 1989 the requirement on heat recovery on the ventilating air was introduced in the building code. A few years later the above mentioned loophole for heat recovery, if the heat energy is mainly supplied by renewable energy, was introduced.

During the nineties the mechanical exhaust only ventilation systems increased their market share. The main reason is that balanced ventilation with heat recovery and forced air heating got a bad reputation for poor performance. For many apartment buildings connected to district heating there was no requirement for heat recovery anymore.

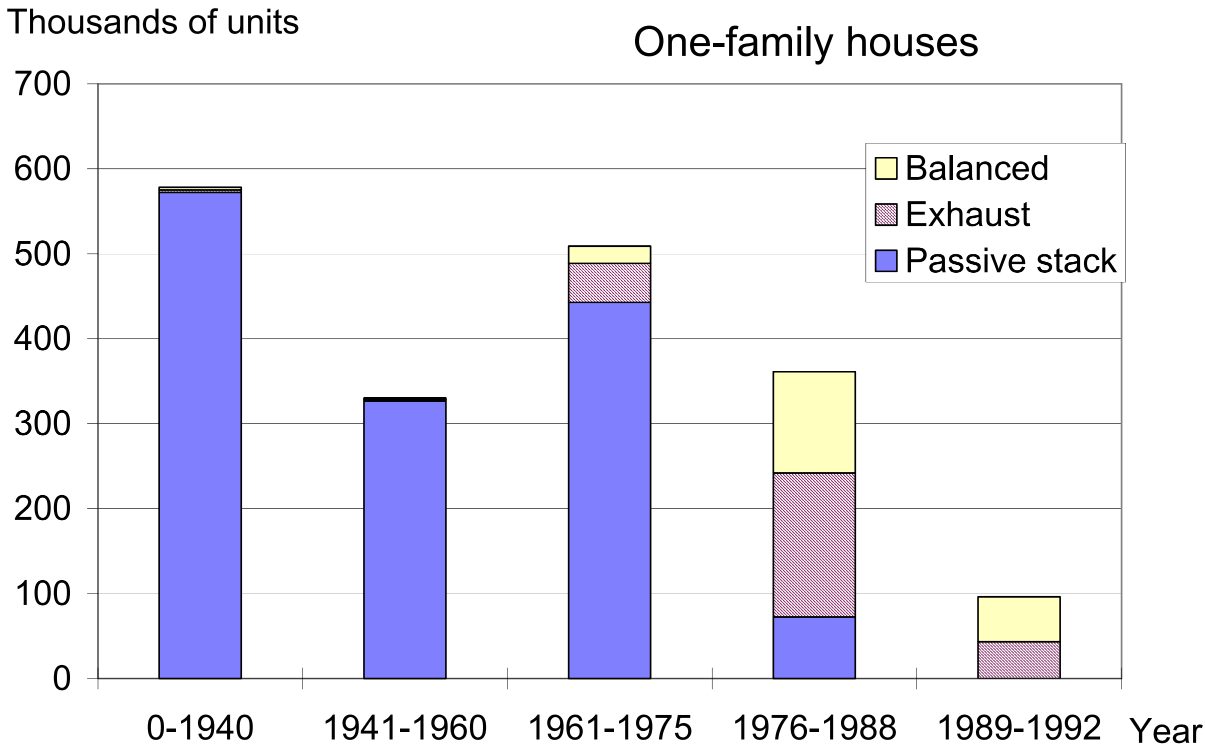


Figure 4.11.1. Ventilation systems in the one-family housing stock as a function of year of erection.

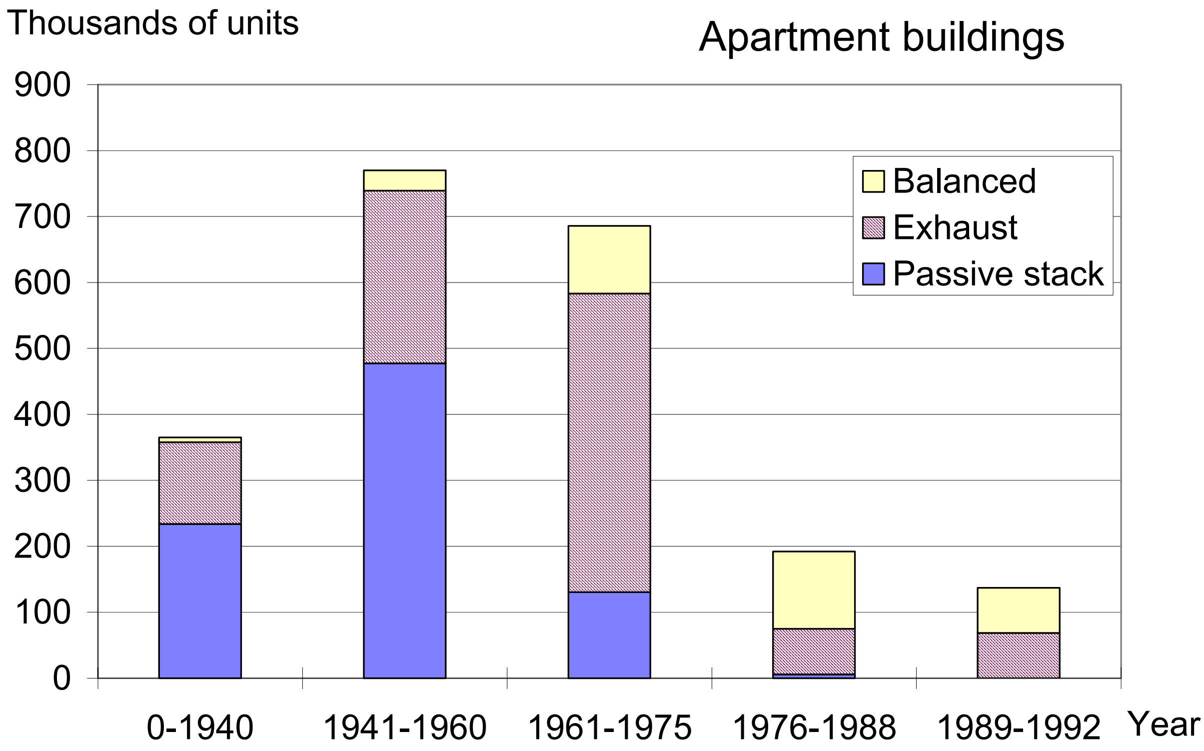


Figure 4.11.2. Ventilation systems in the apartment building housing stock as a function of year of erection.

The main driving force for the ventilation market has been and still is the building regulations. Often the most inexpensive system, which fulfils the requirements are chosen.

The ventilation systems competing with hybrid ventilation today are:
In multifamily dwellings: Mechanical exhaust ventilation, often without heat recovery
In some very specific cases where demands on acoustics and outdoor air quality are very high: mechanical supply/exhaust.
In one-family dwellings: mechanical exhaust ventilation, very often with heat recovery
In some very specific cases where demands on acoustics and outdoor air quality are very high: mechanical supply/exhaust with heat recovery.

The shares of the market held by competing systems today *and since several years* are the following:

- Most of the new multifamily buildings are equipped with mechanical exhaust ventilation without heat recovery. There are at least two reasons for this, the system fulfils the building code (see end of chapter on Overview of customer and market characteristics) and the property owners/developers prefer simple systems to mechanical exhaust or balanced ventilation systems with heat recovery, which are considered to have many problems in operation and to be too expensive in investment and operation (somewhat reduced cost for heating and increased cost for electricity, but higher maintenance costs).
- Some 90 % of the new one-family houses are equipped with mechanical exhaust ventilation incorporating an exhaust air heat pump. To fulfil the building code (see end of chapter on Overview of customer and market characteristics) one-family houses have to be equipped with heat recovery. Thanks to a successful technical procurement

of heat pumps for one-family houses the common heat recovery system is a heat pump.

The competing systems are today mainly marketed to contractors building multifamily houses. Ventilation systems for one-family houses are marketed to manufacturers of prefabricated houses.

A search on “ventilation” in the Swedish database of patents gives 19 hits. A search on “residential ventilation” in the international database espacnet, shows 49 patents whereof one is Swedish. The conclusion is that patents are no barrier for the implementation of hybrid ventilation systems.

Examples of counter moves, which can be expected from producers of competing ventilation systems, are trying to influence legislation and standardisation work. The risk for other innovative systems being developed in the near future is difficult to determine. However there is some general interest in developing demand controlled ventilation for multifamily buildings, mostly coupled to mechanical exhaust ventilation. The interest has been generated by a technical procurement, which was started in 1998, of demand controlled ventilation for new apartment buildings. The technical procurement was initiated by the client group of Hammarby Sjöstad, a new district with 8 000 sustainable apartments in Stockholm. The major apartment building developer within this client group often argues for demand controlled ventilation “Why ventilate as if you are showering 24 hours a day?. Some manufacturers use the argument, demand controlled ventilation, in their marketing. This may make it difficult to sell a hybrid ventilation system on its own merits, it probably has to be packaged as demand controlled ventilation.

The prognosis for new construction and modernization of housing is:
New construction:
Year 2002: 7,500 one-family houses, 13,500 apartments (rental/tenant-owner)
Year 2003: 7,600 one-family houses , 14,200 multi-family houses
Year 2004 – same as year 2003 or increasing dependent on trade outlooks.
Modernization: 37 000 apartments need modernization per year until year 2010

The potential for hybrid ventilation systems in these buildings is:
In existing buildings (refurbishment): roughly estimated to be 25 % of the multifamily buildings in need of renovation or 9,000 apartments/year if emphasis is put on the demand control aspect. It is very difficult to estimate for one-family houses. If subsidies were introduced some of the 500 000 electrically heated (baseboard heaters) one-family houses are likely to be upgraded to demand controlled hybrid ventilation. Many of these one-family houses were built during the seventies.
In new buildings: roughly estimated to be 50 % of the multifamily buildings or 7000 apartments/year if emphasis is put on the demand control aspect. The potential for one-family houses is small, as exhaust fan ventilation with heat recovery is a very established product on the market.

Hybrid ventilation systems are today, however, relatively unknown in the Swedish market. The existing mechanical ventilation systems are well-established on the market, although they are considered to have some problems e.g. draught and noise. This implies that the implementation will progress quite slowly, unless intense marketing is started.

The key factors for market growth in the ventilation business are:

- Energy cost is considered to be the primary key factor.
- Changes in laws relating to the regulation of IAQ or ventilation and thermal comfort, also influence the market.
- Trends in building design and building proprietors willing to invest in innovative projects is also of importance.

A new building code requiring stringent overall energy performance, where the means of achieving energy efficiency can be chosen freely, would encourage the development of new systems.

The investment cost (including material and installation, but excluding taxes) for a traditional ventilation system for a new building is 1 800 Euro (16 000 SEK) for an apartment with 2 bedrooms, a living room, a kitchen and a bathroom. The floor area is 80 m^2. The traditional ventilation system is a mechanical exhaust fan ventilation system (see short description in the beginning of the chapter on SWOT-analysis) ventilating 8 apartments. The outdoor air enters through Z-ducts behind the radiators in the façade. The IC1 system is expected to be 50 % to 100 % more expensive. The higher price includes individual climate control and energy metering. In the future with more stringent energy requirements it is likely that balanced ventilation systems with heat recovery will be the main competitor to demand controlled hybrid ventilation. The investment cost today of such a system is 4 100 Euro (37 000 SEK) i.e. higher than the IC1 system.

The IC1 system is however likely to become cheaper the more units are being produced (see table). The expensive parts of the system are the supply convector, the EC fan, the control panel and the programming. The supply convector does not contribute to any major energy savings, apart from the fact that if there is no supply convector the occupants might perceive draught and raise the indoor temperature. The supply convector must be made more production friendly. The other expensive components are likely to be cheaper once they are produced in bigger numbers, but of course requiring some product development.

Table 4.11.3 Investment cost for the demand controlled hybrid ventilation system, IC1. The costs include material and installation.

Number or apartments	40	300	300	1 200	10 000
Supply convector	652	598	598	435	326
Z-duct	185	152	152	136	130
EC fan	292	277	277	270	253
Control panel	543	435	435	380	272
Hygrostat	65	65	65	65	43
Room control	163	163			
Cables	272	250	174	163	130
Program, configuration etc.	543	326	326	326	76
Miscellaneous	715	592	533	466	299
Sum	3 430	2 858	2 560	2 241	1 529

The target investment cost for IC1 should be lower than the balanced system with heat recovery and preferably close to the investment cost of a mechanical exhaust fan ventilation system without heat recovery as long as this is the main competitor.

The straight payback period taking into account the complete IC1 system and comparing with mechanical exhaust ventilation without heat recovery is appr. 4 years for the energy savings.

4.11.3 Today's ventilation system in comparison with hybrid ventilation systems

Today's ventilation system is a central mechanical ventilation system i.e. either supply/exhaust or exhaust only ventilation system supplying an outdoor air flow not controlled by the users(see also 4.10.2 The present and future market). The user can, however, usually operate a cooker hood i.e. force the ventilation during e.g. cooking. For an exhaust only system the outdoor air is usually not preheated.

The hybrid system is the IC1 concept i.e. a passive stack assisted exhaust fan system with a separate ventilation system for each apartment. The system incorporates a built-in control system, which always ensures the desired air flow independent of boundary conditions. The desired air flow is set by the user from a control board in the apartment, but is also automatically controlled by humidity and outdoor temperature. The outdoor air is preheated in a supply air convector.

An "expert group" with representatives from authorities, clients, architects, HVAC engineers, facility management engineers and users discussed and agreed upon which problems should be discussed when dealing with future ventilation systems for dwellings. The following aspects were considered to have the highest priority:

- Design: air terminal devices (quality, maintenance/cleaning/cleanability), ducts/shafts (maintenance/cleaning, accessibility), fan/plant rooms (accessibility, maintenance/cleaning)
- Performance: sound (from the system, cross transmission), draft (air terminal devices), controllability (the entire building, per apartment), competence (installer, BEMS), reliability (air flow), system (flexibility)
- Building process: co-ordination (different participants, ventilation designer too weak, need of space), quality assurance,
- Knowledge (ventilation consultants, clients, buyers)
- Information: occupants (understanding of function, comprehension of consequences of their handling), operations staff (operations instructions, changes in operation)
- Contradictions and target conflicts between different requirements: health and energy efficiency

The problems mentioned above can be perceived or actual problems. For some of the actual problems there might already exist solutions, which for some reason are not used, e.g. lack knowledge or too expensive. Some of the perceived or actual problems might be solved with information.

The expert group emphasised first of all the importance of how ventilation is handled during the building process, then the importance of design and performance, but also the importance of information. A client group emphasised first of all the performance, then the design and choice of system. One area of problem the client group brought up, which was not really brought up by the expert group was the role of the market when choosing a ventilation system. A group of facility management engineers brought up the area of design, but also the question of responsibility as having the highest degree of priority. Of course the overlap between the different areas and the sometimes small differences between the different groups can be discussed, but an idea as to differences in opinions are given between the different groups as to what is important to improve in today's ventilation systems. That the client group put a low priority on information quite contrary to the expert group with different representatives and the facility management engineers is also worth noting.

Table 1. The different groups' assessment of the degree of priority for the different problem areas, presented in ranking order (1 is highest) and average values for each group (from 1 = low degree of priority to 5 = high degree of priority)

	Experts		**Clients**		**Facility management engineers**	
Area of problem:	Ranking	Points	Ranking	Points	Ranking	Points
Design	4	3.3	2	4.5	**1**	**4.4**
Performance	2	3.8	**1**	**4.8**	3	4.0
Responsibility	5	3.0	3	4.3	**1**	**4.4**
Building process	**1**	**4.0**	3	4.3	5	3.6
Economy	5	3.0	4	4.0	6	3.4
Information	3	3.7	5	2.5	4	3.8
Regulations and standards	5	3.0	4	4.0	4	3.8
Choice of system	6	2.7	2	4.5	2	4.2
Target conflicts	5	3.0	4	4.0	2	4.2

The client group and the facility management engineer group were asked give their opinion as how well today's solution solve different problems (see table 2). The facility management group were reasonably satisfied with the design of air terminal devices and ducts/shafts/fan rooms. The client group is more satisfied with the performance than the facility group. None of the groups are very satisfied with the information.

Table 2. Marking of the performance of today's solutions on the different problems (from 1 = low mark to 5 = high mark).

Area of problem	Clients	Facility management engineers
Design:		
- air terminal devices	3.0	**3.4**
- ducts/shafts/fan rooms	**3.8**	**3.4**
Performance:		
- noise	-	2.8
- draft	3.2	2.8
- controllability	3.0	**3.6**
- competence	**3.5**	2.8
- reliability	3.3	3.2
- system	3.3	**4.0**
Responsibility:		
- authourity	3.0	3.4
- architect/designer	3.0	3.4
- craftsman	3.0	3.4
- hand over phase	3.0	2.8
Building process:		
- co-ordination	2.8	2.8
- quality control	**2.5**	3.2
- quality assurance	**2.5**	3.2
- knowledge	**2.5**	3.0
- type of contract	-	3.0
Economy:		
- investment costs	3.3	3.2
- operations costs (LCC)	**2.5**	**2.6**
Information:		
- users	**2.5**	**2.2**
- operations phase	**2.5**	2.4
- design phase	**2.5**	3.2
Regulations and standards:		
- general	**4.0**	3.2
- air flows	**2.3**	3.4
- energy use	-	**2.8**
Choice of system:		
- simple systems	4.5	3.4
- complex systems	**1.3**	3.4
- energy requirements	**3.5**	3.0
Target conflicts:		
- sustainable development	**2.0**	3.2
- energy and health	**2.0**	**3.4**

A comparison of hybrid ventilation with mechanical and natural / passive stack ventilation for a number of different aspects was done by the IC1 team and the hybrid ventilation system used as a reference was the IC1 concept.

For aspects categorised as system/components issues the IC1 concept is rated higher than the existing ventilation systems in the area of reliability, user friendliness of the system, operation and service, but rated lower in the area of maintenance and technical life span. The aspects with high relevance/priority according to the expert group is reliability, user friendliness and operation and service, and maintenance. As to aspects categorised as design issues the IC1 concept rated on the same level as mechanical exhaust ventilation and both systems are rated higher than balanced mechanical and natural ventilation. However for the aspect with high relevance such as influence on the design the IC1 concept is rated lower.

The overall performance is rated somewhat higher for the IC1 concept than for the existing ventilation systems. For the aspects with high relevance/priority the IC1 concept is rated better for risk of draft i.e. less risk of draft. For generation of internal noise by ventilation systems it is better than mechanical ventilation, but not as good as for natural ventilation.

Central controllability of the IC1 concept is rated better than natural ventilation but worse than mechanical ventilation. However user controllability is best for the IC1 concept. Both aspects were considered important by the expert group.

4.11.4 SWOT-analysis

For the SWOT-analysis a hybrid ventilation system and a traditional ventilation system had to be chosen. The reference hybrid ventilation system is the IC1 concept (see beginning of chapter on Today's ventilation system …..) The reference traditional system is a mechanical ventilation system i.e. either central supply/exhaust or exhaust only ventilation system. The most common traditional ventilation system is a mechanical exhaust fan ventilation system with a centrally located pressure and frequency controlled fan ventilating 8 apartments. The outdoor air enters through slot vents above the windows or Z-ducts behind the radiators in the façade.

The potential internal strengths and weaknesses and the potential external opportunities and threats are presented below and then commented.

Potential internal Strengths	Potential internal Weaknesses
1. User controllability	1. Small market
2. Low internal noise	2. High initial costs
3. Draught freeness	3. Requires low-emitting materials
4. Energy efficiency	4. Technical life-span
5. Expected low LCC-costs	5. Sensitivity to outdoor noise
6. User friendliness	6. Air flow rate stability uncertain in individual rooms
7. Fault detection ability	7. Accessibility to service in apartments
Potential external Opportunities	**Potential external Threats**
1. Reputation	1. Present governmental aim to build cheaper apartments
2. Prognosis for increasing energy costs	2. Knowledge / Information / Mental barriers
3. The energy performance directive	3. Present legislation
4. Growing LCC awareness	4. Need for new Maintenance/Service organisations
5. Future performance oriented legislation / standards	5. Reputation
6. Low running costs	
7. Acquisitive clients	

Comments
Strength 2 From fan and between dwellings
Strength 3 Supply of pre-heated outdoor air

4.11.4.1 Potential internal strengths

1 - User controllability

The IC1 concept allows a high degree of user control of the ventilation, if the user is interested, otherwise the control will be automatic. It is a strong point in the marketing to clients (assuming they care about the end users), as users like to be given a freedom of choice e.g. to be able to override an automatic control.

2- Low internal noise

The noise level from the IC1 ventilation system (fan, duct) will be low thanks to a quiet fan and low pressure drops. The transmission of noise through the IC1 ventilation system between apartments will also be low as each apartment has its own ventilation system. Both measures are improvements compared with traditional ventilation systems, where these noise sources often are the cause of complaints from the occupants. It is a strong point in the marketing to clients assuming they care about the end users.

3- Draught freeness

The IC1 concept means pre-heating of the supply air, which is not common in dwellings. The occupants often complain about a draughty ventilation systems. It is a strong point in the marketing to clients assuming they care about the end users.

4- Energy efficiency

The IC1 concept will improve the energy efficiency of dwellings, which will be a strong point when LCC cost analysis will be applied in the future and the energy requirements will be more stringent, thereby a strong point in the marketing to clients.

5- Expected low LCC-costs

See energy efficiency.

6- User friendliness

The IC1 concept requires some minimum interaction from the user to function properly. For this interaction the system has to be user friendly, which is the aim of the concept.

7- Fault detection ability

The fault detection capability of the IC1 concept will/should appeal to property owners/managers.

4.11.4.2 Potential internal weaknesses

1 – Small market

The IC1 concept can be difficult to apply on existing buildings. Most renovations in Sweden today are made with as little change as possible to the building structure.
The total potential market for the IC1 concept is 58 000 dwelling units p.a., whereof 13 000 are considered possible for the IC1 concept. This limited market will influence the price for the system. Parts of the concept may be used in existing buildings. Interest has been noted for demand controlled ventilation in particular. However an increased international market may enhance the possibilities.

2- High initial cost

The initial costs for the IC1concept are high compared to most existing systems. The investment cost still has a very high priority when deciding which system to use. However growing LCC awareness on the property market may help focusing on the total costs over time which will enhance the market possibilities for the IC1 concept.

3- Requires low-emitting materials in the dwelling

Since the specific air flow rate for the dwelling at times can be quite low, e.g. when the dwelling is empty, there may be a build-up of uncanny odours and harmful pollutants. This fact needs to be communicated to the different parties in the process e.g. design, construction as well as to the end users.

4- Technical lifespan

The IC1 concept involves new and partly complicated components. Future systems are likely to be more robust as experiences from the first few projects are implemented in the development.

5- Sensitivity to outdoor noise

The air supply convector is difficult to design with a very high degree of noise reduction, e.g. Class A according to the Swedish standard for sound classification of dwellings. This excludes implementation of the IC1 concept in the most noisy surroundings.

6- Air flow rate stability uncertain in individual rooms

The IC1 concept is based on very low pressures, which makes it sensitive to disturbances in wind. It can however be noted that the sensitivity is lower than for a conventional passive stack ventilation system and exhaust-only system. The users perception of this shortcoming is in most cases negligible.

7- Access

Access to apartments is needed for service of air supply convector and control unit. The user can be informed and instructed in how to clean and change filters in the air supply convector. There are also property managers arguing that they would like to get access to apartments to be able to inspect the state of the apartments.

4.11.4.3 Potential external opportunities

1- Reputation

The system is expected to be well-reputed. The IC1 solves many of the problems of today's ventilation systems. If the concept lives up to the expectations and is well promoted, then in the long run it should acquire a good reputation.

2- Prognosis for increasing energy costs

The higher the energy cost the more interesting the IC1 concept will be, especially if more stringent energy requirements are enforced and LCC analysis are applied.

3- The energy performance directive

The European energy performance directive, which is to be implemented in 2006, will further promote energy efficient systems. The implementation of the directive is being investigated, therefore it is difficult at this stage to have a more detailed opinion of the impact in Sweden. The aim of the investigation is to draw up a proposal for suitable organisation and necessary changes in statutes in order to implement the directive. Proposals as to suitable follow-up and possible measures to facilitate the implementation are also to be made. An overhaul of the building code will take place. The deadline for the investigation is November 2004.

4- Growing LCC awareness

Everybody, more or less, is today aware of the benefit of LCC considerations, but very few are applying such considerations in practice. For many developers there is no or only little business connection between producing units and facility management units of the same company. However the general trend over time is favourable for LCC considerations in practice, but the development is rather slow.

5- Future performance oriented legislation / standards

As more and more national and international standards are developing in a more performance oriented manner, the opportunities for the system will be growing over time.

6- Low running costs

The IC1 concept includes good monitoring, little need for adjustment of air flows, low use of energy etc. This will be an advantage especially when LCC analysis become more widely used.

7- Acquisitive clients

The complete IC1 concept should in the beginning be of particular interest to the high end of the market i.e. clients interested in IT, advanced technologies etc.. This market is rather small, but does exist. A study investigating smart houses, by interviewing customers of one-family houses, revealed that of high interest, taking investment costs into account, were extended/improved bathroom, advanced alarm systems and cleanability. Improvements like smarter room temperature control was of a lesser interest.

4.11.4.4 Potential external threats

1 - Present governmental aim to build cheaper apartments

In Sweden, at least, there is a heavy, politically-posed pressure on the real-estate market to produce many and cheap flats "for the ordinary people". It is clearly pronounced that it is the initial costs that are to be minimised. Today few, if any, stress the life cycle costs.

2- Knowledge / Information / Mental barriers

Knowledge of involved parties is limited. This causes an initial threshold for the implementation of new ventilation concepts. Information measures are needed to motivate the stakeholders. Mental Barriers for different parties in the building and facility management process, e.g. developers, clients, consultants, architects, contractors, facility management staff; ("We have never tried this before, we'd better keep to the well-known and well-tried"), ("It is far too complicated; we aim at simple and cheap solutions." etc)

3- Present legislation

The specific air flow rate (l/s,m2) in the IC1 concept is occupancy dependent. This may lead to low specific air flow rates in large flats e.g. lower than 0.35 l/s,m2.

The requirement for heat recovery on ventilation (see WP4) is normally not fulfilled with the IC1 concept.

4- Need for new Maintenance/Service organizations

The IC1 concept will require some maintenance and service in the apartment, but it will be possible to monitor air flows, temperatures etc. in the apartment from a remote location e.g. using Internet. The traditional maintenance/service organisation will have to work in different way compared with today.

5- Reputation

The future potential is depending on the outcome of demonstration projects.

4.11.5 Summary and Conclusions

Since 1975 the main driving force for the ventilation market with regard to dwellings has very much been and still is the building regulations. Often the most inexpensive system (investment cost), which fulfils these requirements and other basic requirements (see next paragraph) are chosen. These two driving forces are likely to remain. However, nowadays there are trends towards LCC instead of only investment costs. The importance of energy costs will become more important and as well as key trendsetters and creating a distinctive image.

The main demands and expectations of the customers (apartment building owners/developers) as regards ventilation systems are: low sound and draft level, good controllability, reliability, robust, aesthetic and easy to maintain and clean. Noise and draught are common sources of complaints from occupants. The demand controlled hybrid ventilation system being developed, IC1, aims to meet these demands and expectations, and to be energy efficient.

The IC1 system will be designed to be more reliable, more user friendly, better in operation and service than the existing ventilation systems. The overall performance is expected to be better. The ventilation system will be quieter than mechanical ventilation systems.

A SWOT-analysis of the IC1 system compared with a traditional mechanical ventilation, mainly exhaust fan ventilation, resulted in:

- potential internal strengths: user controllability, low internal noise, draught freeness, energy efficiency, expected low LCC, user friendliness, fault detection ability
- potential internal weaknesses: small market, high initial costs, requires low-emitting materials, risk of short technical life span initially, sensitive to outdoor noise, uncertain air flow rate stability in individual rooms, accessibility to service in apartments
- potential external opportunities: expected good reputation, prognosis for increased energy costs, the energy performance directive, growing LCC awareness, future more stringent performance oriented legislation/standards, low running costs, acquisitive clients
- potential external threats: present governmental aim for cheaper apartments, insufficient knowledge and information, mental barriers, present legislation, need for new maintenance/service, future reputation depending on successful demonstration

Comments regarding the potential internal strengths:

- user controllability: should be a strong point in the marketing to clients, assuming they care about the end users
- low internal noise: should be a strong point in the marketing to clients, assuming they care about the end users
- draught freeness: should be a strong point in the marketing to clients, assuming they care about the end users
- energy efficiency: strong point when LCC is stressed and the energy requirements have become more stringent
- expected low LCC: see energy efficiency
- user friendliness: a must to ensure that the aim of IC1 is fulfilled
- fault detection ability: should appeal to the property owners/managers

Comments regarding the potential external opportunities:

- reputation: if IC1 lives up to the expectation and is well promoted, it should acquire a good reputation
- prognosis for increasing energy costs: the higher the energy cost the more interesting IC1 will be
- the energy performance directive: will promote IC1
- growing LCC awareness: is beneficial for IC1
- future performance oriented legislation: gives better opportunities for IC1
- low running costs: advantageous when LCC analysis become more widely used
- acquisitive clients: the high end of the market might be small, but does exist.

To overcome the potential internal weaknesses the following suggestions are made:

- small market: an increased international market
- high initial cost: lower the cost of e.g. the supply convector, the EC-fan, and focus on LCC and in the beginning on high cost customers
- requires low emitting materials: information to the building process
- technical life span: thorough testing before market introduction
- sensitivity to outdoor noise: avoid implementation in noisy surroundings
- access: involve the occupant in the cleaning and changing of filters

To overcome the potential external threats the following suggestions are made:

- present governmental aim to build cheaper apartments: stress the LCC
- knowledge/information/mental barriers: demonstration projects to show the feasibility and information to contractors and clients
- present legislation: lobby for changes in the legislation
- need for new maintenance/service organisations: training of traditional maintenance/service organisation
- reputation: successful demonstration projects.

Modern ventilation systems must ensure the performance during the life time of the system and at the same time minimize the demand for specialist competence for installation and service.

Modern ventilation systems must ensure a good indoor climate, low operating costs (including service) and be simple to commission (compare with a modern car which has 20000 km service interval, apart from change of tyres).

The ventilation systems, which will compete with demand controlled hybrid ventilation in the near future, are mainly mechanical ventilation systems. In apartment buildings these systems are very often exhaust fan ventilation without heat recovery and for one-family houses with heat recovery. This is due to the current building code.

The European energy performance of buildings directive, which is to be implemented in 2006, will further promote energy efficient systems and facilitate the implementation of innovative systems by stressing the overall energy performance of buildings. The implementation of the directive is being investigated in Sweden. An overhaul of the Swedish building code will take place. The deadline for the investigation is end of 2004.

The energy requirements are likely to be more stringent once the EC energy performance directive is implemented. This will mean that balanced ventilation systems with heat recovery or exhaust fan ventilation systems with exhaust air heat pumps will be the main competitors for the demand controlled hybrid ventilation system, especially for new apartment buildings. As to new one-family houses the competitor is already exhaust fan ventilation systems with heat recovery, but balanced ventilation systems with heat recovery might be the new competitor.

The IC1 system incorporates individual metering of space heating. This to ensure that the occupants are motivated to operate the ventilation system in an energy efficient way e.g. using the low ventilation rate when no one is at home. However for apartment buildings today there are some problem: the cost of heating today is typically included in the rent and the current rental legislation might make it difficult to implement individual metering . The cost of space heating in apartment buildings is on average 15 % of the total operating cost (80 Euro/m^2year in year 2000).

For the near future a demand controlled hybrid system with equivalent indoor climate and operating costs as mechanical exhaust fan systems has the possibility to be an established technology if the total costs are lower. The target investment cost for demand controlled hybrid ventilation is therefore not too much above the one for exhaust fan ventilation. The life cycle cost is however likely to be lower for demand controlled hybrid ventilation thanks to lower energy use. After the implementation of the energy performance directive the target price will be the price of balanced ventilation systems with heat recovery or exhaust fan ventilation systems with exhaust air heat pumps. The estimated investment cost of the IC1 concept is lower than the two last mentioned systems.

The big market for demand controlled hybrid ventilation systems could be retrofitting of existing building, where it is often difficult and expensive to upgrade to balanced ventilation and/or heat recovery.

The yearly potential for demand controlled hybrid ventilation is estimated to be 50 % or 7000 of new apartments and 25 % or 9000 of the refurbished apartments, if demand controlled ventilation is emphasized and intense marketing takes place towards clients, contractors and key trendsetters. Key trendsetters can be architects, developers etc. Meetings with the organisation responsible for the building code and standards are probably also necessary. Otherwise the implementation is likely to progress quite slowly. It is very difficult to estimate the potential for refurbishment of one-family houses, as most one-family houses are individually owned. If subsidies were introduced some of the 500 000 electrically heated (baseboard heaters and passive stack or exhaust fan ventilation) one-family houses are likely to upgrade to demand controlled hybrid ventilation. The potential for new one-family houses is likely to be small, as exhaust fan ventilation with heat recovery is a very established product on the market.

The following has to be fulfilled to ensure that a ventilation system is accepted by the occupants:
- Good guidelines of use, information and maintenance to occupants about the possibilities and function of the ventilation system
- The system must:
✓ be perceived by the occupants as useful
✓ function as expected
✓ give freedom of choice e.g. to override an automatic control
✓ be user friendly
✓ be introduced to the occupants

4.11.6 References

Holmberg, Stina; Nilsson, Anna; Blomsterberg, Åke, 2003. Present Situation in Sweden in regard to hybrid ventilation (WP2 task 2.2.1 Literature studies) WSP Environmental, Building Physics, Malmö, Sweden.

Blomsterberg, Åke, Engvall Karin 2003. PDS Study with Focus Groups on Ventilation in Swedish Dwellings (WP2 task 2.2.2 Questionnaire/focus group)

Holmberg, Stina; Kronvall, Johnny; Blomsterberg, Åke, 2003. SWOT Analysis on Hybrid Ventilation in Dwellings in Sweden (WP 2 Task 2.1 SWOT Analysis)

<u>Literature for the market survey</u>
Housing and housing policy in Sweden, Ministry of finance, 2002 (in Swedish).

ELIB - The technical properties of the Swedish housing stock, Swedish institute for building research, ELIB-rapport nr 6, 1993 (in Swedish).

Prognosis: Indicators January 02, The National Board of Housing, Building and Planning (Boverket), 2002 (in Swedish).

Orestål, Ulla, 1996. Ventilation formerly and nowadays – A handbook and summary of regulations for the compulsory ventilation checks, Svensk Byggtjänst.

Friedman, T., Malmberg, A., 2001. Smart dwellings – a study of customer values for different solutions/functions. Master thesis, Royal Institute of Technology, Stockholm.

<u>Interviews with experts for the market survey</u>
AB Svenska Bostäder, Bengt Johansson

JM Bostäder, Johnny Kellner

Systemair, Mats Sandor

WSP Systems, Ulf Lilliengren,
WSP Management, Christer Harrysson

<u>Literature for the focus group</u>
Engvall, K., Blomsterberg, Å., 2003. Problem inventory using focus groups concerning new solutions for ventilation systems in dwellings. Working document, WSP (in Swedish)

Engvall, K., Blomsterberg, Å., 2003. Guidelines problem detection study incl. focus group meetings RESHYVENT WP2 Market survey report

4.12 Switzerland

4.12.1 Overview of customer and market characteristics

The end customers of ventilation systems for new construction and refurbishment are private persons, property owners/managers, residential owner co-operatives and other owner types. There is only one big owner association in Switzerland with about 270,000 members, whereof about 170,000 own single family houses and 70,000 own multi family houses and 60,000 own apartments. As some have more than one of these types the sum is more than the total number of members. The total number of customers is less than 3.14 millions. The distribution of the building stock to the different owner types is well documented:

Statistics from 1990	
total number of occupied dwellings	3'140'353
whereof *lived-in*	2'800'953
whereof owned by:	
– private persons	1,868,355
whereof inhabited by owners	877,892
– property companies (Bau- und Immobiliengesellschaften)	212,419
– residential owner co-operatives (Wohnbaugenossenschaften)	140,381
– other owner types (institutional investors, local authorities and state)	579,798
2000	
total number of occupied dwellings	3,574,988
whereof lived-in	~ 3,000'000

The demands and expectations of the customers as to the performance of a ventilation system are:

- Good thermal comfort and IAQ
- Humidity within acceptable limits
- Good outdoor noise suppression
- No noise annoyance from system (very low levels for system generated sound are expected)
- System which allows for natural ventilation (window airing)
- Easy to understand, to manually control and to override of system

How will then a hybrid ventilation system meet these demands and expectations? What can be said is that:

- Functioning (fans on/off) of the system may not always be obvious to occupant. This may lead to more manual control/override of system.
- Natural ventilation mode will be appreciated as long as no draught sensations occur.

The customer segment can on a general level not be divided into small/large or low/high cost customer groups, but public building owners and co-operatives may issue more stringent energy requirements, than given by the building code. More sustainable energy standards lead in consequence to the installation of more sophisticated ventilation systems.

The price sensitivity of the customers is normally quite high. This is due to the fact that all type of mechanical ventilation systems are compared to pure natural ventilation by window airing, the by far most widespread ventilation technique in the Swiss residential sector.

There are at least three categories of interest parties with different preferences:
- Building owner: Energy standard of building, ease of control, low investment and operation cost
- Architect: Ventilation concept and principles
- Ventilation engineer: Ease of design, costs, reputation of component and system producer

Responsible for the purchase of a ventilation system for single family houses is mainly the architect and for apartment buildings mainly the ventilation/ HVAC planner engineer or design office.

The most important marketing channel for reaching the customers can be split into technical, commercial and journals:

Technical
- Publications, conferences and technical events organised by HVAC engineering and producer associations
- Publications, guidelines and conferences issued and organised by state or federal departments of energy,
- Campaigns, and information material issued by MINERGIE association
- Dissemination activities of technical universities, and of EMPA

Commercial
- Personal contact
- Reference buildings and architects
- Fairs

Journals

The purchasing process is different for apartment buildings and one-family houses:
Multifamily houses, development site: Contracts with supplier are negotiated for the whole package of units for the whole construction site
One-family houses: Individual purchase from Swiss representative or producer

Ventilation related matters are mainly handled by the following organisations:
SIA, Swiss engineers and architects association
SWKI, Swiss HVAC engineers association
Suissetec, Swiss HVAC manufacturers association
MINERGIE association

When introducing a new ventilation system on the market one has to be aware of the following national requirements:
Standardisation and especially regulation is quiet complex in Switzerland. Public law and regulations are issued on federal, state and municipality level and show a wide spread from national to very local approaches. There is a national harmonisation effort for energy

legislation. Standards are mostly developed and issued by publicly acknowledged or authorised associations (e.g SIA, Swiss engineers and architects association) and commissions, on behalf of the Swiss standards association, and apply throughout the country. There is a long tradition for energy standards and regulations, but IAQ is much less covered. Most standards are in the process to be adapted to CEN standards. The SIA standard for mechanical ventilation systems (SIA 382/1) is in review process. Presently the draft version is in public enquiry. For the meantime the SIA guidance document 2023 for residential ventilation has been published. The aim is to establish a general standard for ventilation with specific chapters for specific applications, like residential ventilation. The pr EN 13779 and several CEN standards on residential ventilation will be implemented.

In recent years innovation in residential ventilation has been pushed by the introduction of low energy certificates for buildings. The MINERGIE certificate has been introduced in order to distinguish buildings with a very high standard concerning energy performance and comfort. The newly introduced MINERGIE-P label goes even beyond this level and is equivalent to the German "Passivhaus" certificate, but compliance has to be assessed according the method defined in the Swiss standard SIA 380/1 Energy use of buildings.

4.12.2 The present and future market

The market can be divided into new construction and refurbishment, but also divided according to investor group.

Total investments in residential buildings were (1998) Fr. 16.4 Mrd./year divided into:
new/retrofit:

- new construction 75 %
- refurbishment 25 %

investor groups:

- private companies (excl. property companies) 42.7 % apartments
- private persons and other customers 32.8 % single family houses
- property companies 16.6 %
- pension funds 4.2 %
- public budget 1.5 %
- insurance companies, banks 2.3 %

The size of the market i.e. the size of the existing housing stock is:
A total of 1 090 000 residential buildings (residential and mixed residential use) with 3 140 500 dwellings, whereof 670 000 are single family houses (1999).

A rough estimation gives the following distribution of ventilation systems in these buildings:

Single family houses			Apartment buildings		
Natural/-passive	Mechanical exhaust	Mechanical balanced	Natural/-passive	Mechanical exhaust	Mechanical balanced
83 %	15 %	2	83	15	2

The prognosis for new construction and refurbishment is:

- New construction: 30 000 – 35 000 dwellings per year until 2010 [W&P]
- Refurbishment: 11,000 – 18,000 dwellings per year

The potential in existing buildings (refurbishment): multifamily buildings: is high for demand controlled exhaust systems. The potential for hybrid systems cannot be determined (topic is no big issue in Switzerland). (2001) 400-600 existing dwellings per year get equipped with a mechanical supply/exhaust ventilation system during refurbishment (3...5 % of the refurbished dwellings)

In new buildings i.e. for MINERGIE buildings, mechanical exhaust systems are one of the systems allowed/recommended. The potential for hybrid solutions in single family houses: pressure augmentation by stack pressure in shaft.

In new multifamily buildings: Individual exhaust shafts are needed due to fire/smoke spread and acoustics requirements. Stack effect leads to different driving pressures at different floor levels. (2001) 3 000 – 3 500 new dwellings per year have a mech. supply/exhaust ventilation system (8...12 % of the new dwellings). An estimate has been made that MINERGIE will reach a share of 20...40 % of the new buildings and 5 – 10 % of the retrofit market within the next 10 years.

In conclusion for new and retrofit: An estimated total of 19 000 – 23 000 dwellings per year will get equipped with a mech. supply/exhaust ventilation system during the next 10 years, whereof 12 000 per year for the protection against outdoor noise and another 5000 for the protection against pollen allergy (are hybrid systems suitable for that?)

Hybrid ventilation is at this time little known in Switzerland. That means there is only a slow market penetration.

The key factors for market growth in the ventilation business are:
- Higher long term value of energy efficient buildings. This is clearly confirmed e.g. by lower mortgage interest for houses with MINERGIE certificate, granted by several banks.
- Higher thermal comfort and better IAQ.
- Outdoor noise protection
- Architects and investors whish to build innovative building types.

4.12.3 Market competition

The ventilation systems competing with hybrid ventilation today are:
- In multifamily dwellings: Mechanical exhaust ventilation systems, continuous operation, time or demand controlled and mechanical supply/exhaust ventilation systems with heat recovery, central system per dwelling or per building.
- In one-family dwellings: Mechanical supply/exhaust ventilation systems with heat recovery (for buildings according to the MINERGIE or the passive house label requirements).

MINERGIE buildings are strongly promoted and partially subsidised by federal and state administrations. Some banks offer reduced mortgage rates. Public building owners have declared the MINERGIE label as the upper quality level for their buildings (for both new and retrofit buildings).

Mechanical residential ventilation systems are still little used in Switzerland. A first aim is, to promote mechanical ventilation systems in general and especially supply/exhaust systems. Only in a next step hybrid ventilation systems can be issued.

4.12.4 Today's ventilation system in comparison with hybrid ventilation systems

Due to the good mixture of the group, representing different players in ventilation, also the opinions and judgements varied quite much. However, this lead to the results that the averaged values are really average, that means the average voting quite often is somewhere in the middle of the marking range.

Within the expert group, the following items were considered to be the most problematic topic (marking 5)

- Design: access for maintenance and cleaning
- Performance: noise emissions and inter-apartment noise transmission, contractor competence

Many of the other topics gained a 4 in the marking, expressing such the view, that many issues have to be considered to get a ventilation system which satisfies the user needs.

Compared to a balanced mechanical supply/extract system with heat recovery, residential hybrid ventilation (residential hybrid ventilation) was considered about the same on component level, same or worse in many system aspects, same or worse in system performance except for adaptability to user needs and to window opening, and better in cost aspects and electricity demand of the system.

Compared to window opening, residential hybrid ventilation showed advantages in many aspects except of course in the efforts for design and in cost.

The most important factors (performance of today's systems) identified by the focus groups are: design, responsibility, regulations and standards

In regard of the performance of today's systems, controllability and reliability were judged most problematic. Air quality and energy saving were seen as most favourable aspects.

Due to the good mixture of the focus group, representing different players in ventilation, also the opinions and judgements varied quite much. However, this lead to the results that the averaged values are really average, that means the average voting quite often is somewhere in the middle of the marking range.

Within the expert group, the following items were considered to be the most problematic topic (marking 5):

- Design: access for maintenance and cleaning
- Performance: noise emissions and inter-apartment noise transmission, contractor competence

Many of the other topics gained a 4 in the marking, expressing such the view, that many issues have to be considered to get a ventilation system which satisfies the user needs.

Compared to a balanced mechanical supply/extract system with heat recovery, residential hybrid ventilation (residential hybrid ventilation) was considered about the same on component level, same or worse in many system aspects, same or worse in system performance except for adaptability to user needs and to window opening, and better in cost aspects and electricity demand of the system.

Compared to window opening, residential hybrid ventilation showed advantages in many aspects except of course in the efforts for design and in cost.

Performance of today's systems:

- The most important factors identified by the focus groups are: design, responsibility, regulations and standards
- In regard of the performance of today's systems, controllability and reliability were judged most problematic. Air quality and energy saving were seen as most favourable aspects.

The investment cost for a traditional ventilation system for a new single family house of medium size is in the range of 5 000 to 8 000 Euro (8 000 to 12 000 SFr). The traditional ventilation system is a supply/exhaust system with heat recovery (heat exchanger) or an exhaust system with exhaust air – hot water storage heat pump. The investment costs include material and installation. The hybrid or IC2 system is expected to be more expensive due to the additional sensors (CO2, presence), control unit and the advanced exhaust fan. These components need to be developed resulting in a lower price level in order to be competitive with a traditional system. On the other hand the IC2 system is expected to be cheaper because of the omitted exhaust air – hot water storage heat pump respectively supply fan and ducts and heat exchanger.

4.12.5 SWOT-analysis

The assumed hybrid ventilation system is a system mostly comparable to the IC2 concept. The SWOT analysis is made in comparison with two reference systems:

A) A state-of-the-art mechanical supply/exhaust ventilation system.
B) Manual airing driven by user controlled window opening

A) SWOT-analysis in comparison with mechanical supply/exhaust ventilation system

Potential internal Strengths	Potential internal Weaknesses
1. Air quality	1. Definition and implementation of control strategies
2. Suitability for retrofit	2. User friendliness may be more challenged
3. Lower investment and running costs	3. Difficult design
4. Decreased electricity use of fan	4. Investment reduction may be small
5. Allowance for and lower sensitivity to windows airing	5. Higher risk for outdoor noise transmission and draught
6. Controllability by users	6. Little possibilities to provide filtered supply air
	7. Unintended flow variability
Potential external Opportunities	**Potential external Threats**
1. Promotion and subsidisation of MINERGIE labelled buildings	1. Higher energy prices for heating
2. High long term value of energy efficient buildings	2. Need for protection from outside noise and outdoor air pollution
3. Retrofit is an important issue	3. Small market
4. Possibility to get a good reputation with innovative building concepts	4. Little knowledge about innovative ventilation solutions
5. Stronger emphasis on IAQ in future national legislation/standards	5. No design guidelines and advice available
6. Social and behavioural aspects	6.
7. Occupant sensitivity to running costs	7.

4.12.5.1 Potential internal strengths

1 – Air quality

Many mechanical systems are operated at constant flow rates. As many homes are occupied by one or two persons only today, in cold climate, this low occupancy leads to too low indoor air humidity levels. Therefore, a RHV system may be especially advantageous, if it is demand controlled.

2 – Suitability for retrofit

In retrofitted residential buildings, with more airtight windows and building envelope, there clearly is a need for mechanical ventilation in order to provide sufficient ventilation. In many cases, shaft and exhaust ducts in wet rooms already exist, but the installation ductwork for the distribution of supply air often impose major problems. Therefore, an exhaust system may prove to be the optimal solution.

3- Lower investment and running costs
Compared with a balanced mechanical system both investment and running costs of a residential hybrid ventilation system are lower, because of the smaller air distribution system and the lower operating hours of the fan. On the other hand, if outdoor air transfer devices are equipped with filters, the efforts for maintenance may be higher, as many filters have to be replaced.

4 – Decreased electricity use of fan
residential hybrid ventilation concepts have the potential to be more energy efficient compared to mechanical or natural systems. The electricity use for fans which could be an argument against mechanical ventilation can be kept lower. The reduced heat energy use of a mechanical system with heat recovery has to be weighted against the lower electricity demand of the hybrid system.

5- Allowance for and lower sensitivity to window airing
In Switzerland mechanical ventilation is not very widespread until today. Therefore window airing is still strongly applied and many people do not want to miss the option for window opening and airing. A system which properly reacts to and accounts for window opening certainly has great advantages.

6- Controllability by users
The possibility for the user to interact with the ventilation system and to have the option to override it, are important aspects for user acceptance. Hybrid systems may inherently react more flexible to users and also provide more options to the occupants than a balanced mechanical system.

4.12.5.2 Potential internal weaknesses

1 - Definition and implementation of control strategies
The flexibility of residential hybrid ventilation can be seen as advantage of residential hybrid ventilation, but may also be an important negative factor, if control strategies and not appropriately defined and implemented. Competent installers, easy to understand user interfaces and system descriptions are necessary.

2- User friendliness may be more challenged
Systems with high complexity tend to be less user friendly. Compared to a simple conventional mechanical system the user friendliness of a residential hybrid ventilation system may be lower due to the increased complexity.

3- Difficult design
The design of a residential hybrid ventilation system requires substantial more knowledge than conventional systems. At the present, designer and architects do not have this knowledge.

4- Investment cost reduction may be small
Investment cost reduction may be small, because of the costs for the outdoor air transfer devices, the control and the possible need for still quite costly sensors.

5- Higher risk for outdoor noise transmissions and draught
With the use of outdoor air supply terminals there is a higher risk for outdoor noise transmissions and draught. This risk can be minimised by directing the air properly into the room (upwards, sidewards along walls) and by the use of acoustic dampers with low flow resistance.

6- Little possibilities to provide filtered supply air
With the use of outdoor air supply terminals and low pressure system, the possibilities to filter supply air appropriately are quite limited. However, in some Swiss building regulations, for mechanical system, the filtering of the supply air is mandatory. This may conflict with the low pressure design constraints.

7- Unintended flow variability
As residential hybrid ventilation concepts are based on low pressure differences, the variation of the natural driving forces will have a big influence on the flow rate. Application of these concepts to multi-storey buildings may be limited. Influence of wind and cross-flow effects may be limited by the use of self-regulating air transfer devices.

4.12.5.3 Potential external opportunities

1- Promotion and subsidisation of MINERGIE labelled buildings
MINERGIE is a label for low energy buildings, issued in Switzerland by the MINERGY agency. MINERGIE is strongly promoted and partially subsidised by federal and state administrations. Some banks offer reduced mortgage rates for certified buildings. Public building owners have declared the MINERGIE label as the upper quality level for their buildings (for both new and retrofit buildings). Furthermore has MINERGIE already gained a very good reputation. The MINERGIE certificate requires a controlled ventilation system either mechanically or naturally driven. A residential hybrid ventilation concept is well suited for this requirement.

2- High long term value of energy efficient buildings
Energy efficient buildings are considered to be of higher long term value. This is clearly confirmed e.g. by customer interest for such buildings and e.g. also by lower mortgage interest for houses with MINERGIE certificate, granted by several banks.

3- Retrofit is an important issue
Retrofit is an important issue and is becoming an important market segment in the future. Ventilation systems which are suitable for building retrofit such as some residential hybrid ventilation concepts will have a good market opportunity.

4- Possibility to get a good reputation with innovative building concepts
Some architects and investors endeavour to get a good reputation with innovative building concepts. residential hybrid ventilation systems offer a possibility for that.

5- Stronger emphasis on IAQ in future national legislation / standards
With the review process of the national building legislation and standards, IAQ will become a more important issue than in the current editions. Mechanical ventilation might then be more

considered as a standard solution for ventilation in residential buildings, which is not the case today.

6- Social and behavioural aspects
The acceptance of mechanical systems by the occupants has been investigated in several studies. For 25% of the tenants interviewed, mechanical ventilation was an argument for the selection of the apartment. Most of the tenants in buildings with mechanical ventilation are very satisfied with the performance of the systems. The pro arguments mostly stated are protection against outdoor noise and pollutants, and better indoor air quality. Complaints are mostly related to system noise and internal odour transmissions.

7- Occupant sensitivity to running costs
Sensitivity to running costs is normally quite high. This is due to the fact that all types of mechanical ventilation systems are compared to pure natural ventilation by window airing, the by far most widespread ventilation technique in the Swiss residential sector. Compared with a balanced mechanical system the running costs of a residential hybrid ventilation system might be lower, because the number of operating hours of the fan is lower. However this may be jeopardised by higher maintenance cost, if any filters are to be regularly replaced in the outdoor air transfer devices.

4.12.5.4 Potential external threats

1- Higher energy prices for heating
Higher energy prices for heating may give preference to systems with heat recovery (heat exchanger in supply/exhaust systems or exhaust air – hot water storage heat pump).

2- Need for protection from outdoor noise and outdoor air pollution
The need for protection from outdoor noise and air pollution is one main key factor for mechanical ventilation, besides energy efficiency and is judged by architects and investors as one of the most important advantages of mechanical ventilation systems. For some residential hybrid ventilation systems this advantage does not apply, or not in the extent the supply/exhaust system does.

3- Small market
At present only about 3000 to 3500 mechanical ventilation systems per year are installed in dwellings in Switzerland (small exhaust fans in wet rooms for temporary operation not considered). Only a minor proportion of this number could be realised as residential hybrid ventilation system. In addition, residential hybrid ventilation is still quite unknown to investors and architects today, see item 4 below.

4- Little knowledge about innovative ventilation solutions
The present knowledge of designers and architects and investors about innovative ventilation is generally quite limited, although this is changing now quite rapidly. However, knowledge on residential hybrid ventilation is still very limited

5- No design guidelines and advice available
As there are very limited experiences with residential hybrid ventilation systems in Switzerland, there are no guidelines and recommendations available at present for residential hybrid ventilation. Also basis information on advantages/disadvantages of such systems,

compared to balanced supply/exhaust systems, is not available. This lack of information material forms a barrier for the introduction of such system on a broader basis.

B) SWOT-analysis in comparison with manual airing driven by user controlled window opening

Potential internal Strengths	Potential internal Weaknesses
1. Improved indoor air quality and improved moisture control	1. Higher investment and running costs
2. Reduced draft risk and reduction of outdoor noise	2. Lower user friendliness
3. Suitable for building retrofit	3. More difficult design
4. Safety and insect ingress	
5. Reduced ventilation losses	
6. Allowance for and low sensitivity to window airing	
7. Controllability by users	
Potential external Opportunities	Potential external Threats
1. High long term value of energy efficient buildings	1. Small market
2. Promotion and subsidisation of MINERGIE labelled buildings.	2. Little knowledge about residential hybrid ventilation
3. Retrofit is an important issue	3. High sensitivity on investment costs
4. Stronger emphasis on IAQ in future legislation / standards	4. No design guidelines and advice available
5. Possibility to get a good reputation with innovative building concepts	

4.12.5.5 Potential internal strengths

1 – Improved indoor air quality and improved moisture control
With any mechanical system, air quality and moisture can be much better controlled. residential hybrid ventilation is ideally positioned to provide good IAQ considering also natural driving forces for ventilation.

2- Reduced draft risk and reduction of outdoor noise
With the use of purpose provided outdoor air transfer devices, outdoor noise transmission can be significantly reduced and draught risk better controlled.

3- Suitable for building retrofit

In retrofitted residential buildings there is clearly a need for controlled ventilation in order to provide sufficient ventilation. In many cases, shaft and exhaust ducts in wet rooms already exist, but the installation ductwork for the distribution of supply air imposed often major problems. Therefore, an exhaust system may prove to be the optimal solution for a mechanical system. However, for exhaust systems, the building must be very air tight in order to limit unintended air flow by infiltration.

4- Safety and insect ingress
With the use of outdoor air transfer devices, there is no need to close the supply opening due to burglary concerns, and due to the risk of ingress of rain and insects.

5- Reduced ventilation losses
Even if there is no heat recovery installed, with residential hybrid ventilation losses can be reduces due demand controlled operation, and due to adapted ventilation rates and better air distribution.

6- Allowance for and lower sensitivity to window airing
Window airing is still very strongly used by occupants in Switzerland and many people do not want to miss the option for window opening and airing. A system which properly reacts to and accounts for window opening certainly has great advantages.

7- Controllability by users
residential hybrid ventilation may offer the same control and interaction possibilities for the user without the inherent problems of user driven window opening like lack of flow rate control, produce unnecessary ventilation losses with windows left open, to produce too high flow rates due to cross ventilation and to deal with problems of unwanted ingress of people and animals. The possibility for the user to interact with the ventilation system, and to have to option to override it, are important aspects for user acceptance. Hybrid systems may inherently react as flexible to users and window opening but also can provide sufficient indoor air quality independently from the user.

4.12.5.6 Potential internal weaknesses

1 - Higher investment costs
As windows must be installed anyway, any installation of a mechanical system leads to significantly higher investment cost. This is one of the major arguments against mechanical ventilation. Therefore, to keep investment cost low is one of the major elements for a successful market penetration of residential hybrid ventilation systems.

2- Lower user friendliness
The operation of windows is very easy and the ventilation effects of airing are obvious to the user. Although there is in general little knowledge on the quantitative effects of window opening in regards to pollutants and humidity levels (which can be seen by the broad range of window opening behaviour), from the users perspective, the situation may not be improved by a more complex residential hybrid ventilation system. Systems with high complexity tend to be less user friendly.

3- More difficult design

The design of a residential hybrid ventilation system requires certainly much more knowledge than the simple installation of windows. At the present, designer and architects do not have this knowledge.

4.12.5.7 Potential external opportunities

1 - High long term value of energy efficient buildings
Energy efficient buildings are considered to be of higher long term value. This is clearly confirmed by the market success of such buildings, but also e.g. by lower mortgage interest rates, granted by several banks for houses with MINERGIE certificate.

2- Promotion and subsidization of MINERGIE labelled buildings
The MINERGIE certificate requires a controlled ventilation system either mechanically or naturally driven. A residential hybrid ventilation concept is well suited for this requirement. MINERGIE is strongly promoted and partially subsidised by federal and state administrations. Some banks offer reduced mortgage rates for certified buildings. Public building owners have declared the MINERGIE label as the upper quality level for their buildings (for both new and retrofit buildings). Furthermore has MINERGIE already gained a very good reputation.

3- Retrofit is an important issue
Retrofit will become more important in future. Ventilation systems which are suitable for building retrofit such as some residential hybrid ventilation concepts will have a good market opportunity.

4- Stronger emphasis on IAQ in future national legislation / standards
With the review process of the national building legislation and standards, IAQ will be a more important issue than in the current editions. Controlled or even some kind of mechanical ventilation might then become a standard in residential buildings which is not the case today.

5- Possibility to get a good reputation with innovative building concepts
Some architects and investors endeavour to get a good reputation with innovative building concepts. residential hybrid ventilation systems offer a possibility for that.

4.12.5.8 Potential external threats

1- Small market
At the present only about 3000 to 3500 mechanical ventilation systems per year are installed in dwellings. Only a few of them could be realized as residential hybrid ventilation system because residential hybrid ventilation is unknown to investors and architects today.

2- Little knowledge about residential hybrid ventilation
The present knowledge of designers and architects and investors about residential hybrid ventilation is very small.

3- High sensitivity to investment costs
Price sensitivity is normally quite high amongst most of the players in the building sector (builders and owners). Due to the fact that natural ventilation is still the by far most widespread ventilation technique in the Swiss residential sector, all types of mechanical ventilation systems are compared to pure natural ventilation by window airing. In a survey cost was mentioned as the most important disadvantage of a mechanical ventilation system (46% of the Investors and 56% of the architects).

4- No design guidelines and advice available
There is a lot of information material available on mechanical ventilation in general, also on advantages/disadvantages of such systems compared to natural ventilation. However, there are no guidelines and recommendations available at present for residential hybrid ventilation systems, due to the very limited experiences with residential hybrid ventilation systems in Switzerland. This lack of information material forms a barrier for the introduction of such system on a broader basis.

4.12.6 Summary and Conclusions

In Switzerland, around 10% of new or retrofitted buildings are equipped with mechanical ventilation systems, a large extend of which are balanced supply/exhaust systems with heat recovery. These systems are promoted mainly for low energy buildings or for buildings needing protection from outdoor noise or air outdoor air pollution.

There is a long tradition for energy standards and regulations, but IAQ is much less covered. A standard for mechanical ventilation systems is in review process. In the meantime a guidance document for residential ventilation has been published. The aim is to establish a general standard for ventilation with specific chapters for specific applications, like residential ventilation.

Most users are very satisfied with mechanical systems, mainly due to the outdoor noise and pollutant protection and the enhanced indoor air quality. Complaints are mostly related to system noise, to internal odour transmission, and to low humidity at cold weather and low occupancy conditions (if system is not demand controlled).

Residential hybrid ventilation systems are still very little known in Switzerland, however some technology transfer can be observed form the application of hybrid ventilation in schools, hotel rooms, elderly homes etc.

The demands and expectations of the customers as to the performance of a ventilation system are:

- Good thermal comfort and IAQ
- Humidity within acceptable limits
- Good outdoor noise suppression
- Low noise levels from the system
- System which allows for natural ventilation (window airing)
- Easy to understand, to manually control and to override of system

How will then a hybrid ventilation system meet these demands and expectations? What can be said is that:

- Functioning (fans on/off) of the system may not always be obvious to occupants.
- Natural ventilation mode will be appreciated as long as no draught sensations occur.

Market options for RHV in this segment can be identified mainly for retrofit buildings, although they are judged to be still quite limited. Market acceptance and penetration can be increased by low cost and by good information material for architects and ventilation planners. The hybrid or IC2 system is expected to be more expensive, than a traditional balanced ventilation system with heat recovery, due to additional sensors, control unit and advanced exhaust fan. These components need to be developed resulting in a lower price level. On the other hand the IC2 system is expected to be cheaper because of the absence of heat recovery unit, supply fan and ducts.

Compared to the still very widespread natural ventilation by window opening, RHV systems have good market opportunities if prices can be kept low and if all the advantages of such systems in term of air quality, noise transmission, ingress protection and energy are well documented and widely disseminated amongst the building community. Demonstration buildings play an important role in such knowledge dissemination processes.

Switzerland is not an EU member, but the European energy performance directive may be adapted and introduced also in Switzerland in the future, as the national standards are harmonized with the CEN standards anyhow.

4.12.7 References

Literature for the market survey

BFS (2001) Statistisches Jahrbuch der Schweiz, Bundesamt für Statistik

Dorer Dorer V., Meierhans R., Steinemann U. (1994): Ventilation: The Situation in Switzerland, AIVC, Air Infiltation Review Vol 15, No.3 June 1994

Frauenfelder Frauenfelder S. (2002): Maktpotentiale und Marktstrategien für MINERGIE und Passivhaus, Tagungsband: Bauen, Sanieren, wirtschaftlich Investieren, p. 75–86, Verlag Rügger 2002, Zürich

Furter Furter R., Huber H., Helfenfinger D. (1999): Prüfung von Kompaktlüftungsgeräten mit Wärmerückgewinnung oder Abluftwärmepumpe, Hochschule für Technik + Architektur Luzern

MINERGIE I (2002) MINERGIE Geschäftsbericht 2001, Verein MINERGIE

MINERGIE II (2002) Referenzliste der MINERGIE Bauten, Verein MINERGIE

MINERGIE III (2002) MINERGIE Standard-Lüftungssysteme, Verein Minergie

Peters Peters M. (2002): Akzeptanz von Komfortlüftungen, Tagungsband: Bauen, Sanieren, wirtschaftlich Investieren, p. 61–74, Verlag Rügger 2002, Zürich

PHPP (2002) Passivhaus Projektierungs Packet, Passivhaus Institut Darmstadt

W & P Wüest & Partner (1999): Immo-Monitoring 2000, Band 1 Wohnungsmarkt, Band 3 Baumarkt, Verlag W & P, Zürich

Literature for the focus group

Weber A., Dorer V. (2002) Present situation in Switzerland in regard to hybrid ventilation (Task 2.2.1 Literature study). RESHYVENT Working report No: RESHYVENT-WP2-WR-x.V1 EMPA 31-Oct-2002

MINERGIE: Info material of the Minergie association. (MINERGIE: Swiss low energy building label). See also www.minergie.ch

Gerber D. (2000). Befragung zur kontrollierten Wohnungslüftung in der Überbauung ‚Hagenwiesen', Dällikon.
Metron AG, Brugg
(User evaluation in 70 apartments)

Fregnan F. (1995). Umfrage in einem Mehrfamilienhaus mit kontrollierter Wohnungslüftung. Wohnsiedlung 'Im Niederholzboden', Riehen. Metron AG, Brugg
(User evaluation in total 34 apartments)

Technomar. (2002)."Derzeitiger und zukünftiger Markt der Wohnungslüftung in Deutschland unter besonderer Berücksichtigung der luftdichten Bauweise (EnEV) und Möglichkeiter der Systemintegration"
Neue Gemeinschaftsuntersuchung der Arbeitsgemeinschaft

TECHNOMAR GmbH, München
TU-Dresden, Institut für Thermodynamik und Technische Gebäudeausrüstung ,
Summer 2002

Interviews with experts for the market survey

Basler & Hofmann, Zürich
Baudirektion Zürich, AWEL Amt für Abfall, Wasser, Energie und Luft, Zürich
Belimo Automation, Hinwil
Bundesamt für Energie, Bern
Bundesamt für Gesundheit, Bern
Helios Ventilatoren AG, Urdorf
Hochschule für Technik + Architektur Luzern, Horw
Mercier, Epalinges
Minergie Agentur Bau , Bern
Siegenia-Aubi, Uetendorf
SM-HEAG, Effretikon
Suissetec, Zürich
Viridén Partner, Zürich

References and background material for the SWOT-analysis.

Weber A., Dorer V. (2002). *Present situation in Switzerland in regard to hybrid ventilation* (Task 2.2.1 Literature study). RESHYVENT Working report No: RESHYVENT-WP2-WR1.EMPA.V1- 31-Oct-2002

Dorer V., Weber A. (2003). *PDS study with Focus groups on ventilation in Swiss dwellings* (Task 2.2.2 Questionnaire/Focus group). RESHYVENT Working report No: RESHYVENT-WP2- WR2.EMPA.V1-31-March-2003

Suissetec (formerly Clima Suisse) (1998). *Leitfaden Kontrollierte Wohnungslüftung*. (Controlled residential ventilation guide) Suissetec (Swiss HVAC manufacturers association), Zuerich

MINERGIE (2003). *Uebersicht Lueftungssysteme* (Overview on ventilation systems). MINERGIE Agentur.
see http://www.minergie.ch/download/Themenblatt_Lueftung.pdf

Dorer V., Pfeiffer A. (2002). *Energieeffiziente und bedarfsgerechte Abluftsysteme mit Abwärmenutzung* (Energy efficient and demand controlled extract ventilation systems with heat recovery). Final report, EMPA Duebendorf, Switzerland, May 2002.
see also http://www.empa-ren.ch/ren/ENABL.htm

Müller V., Peters M. Gubler M., Maillard S., Keller L. (2001). Akzeptanz von Komfortlüftungen im Wohnungsbereich. IPSO, Dübendorf, Switzerland

Merkblatt SIA 2023 (2004). Lüftung in Wohnbauten. Swiss society of engineers and architects (SIA), Zürich. www.sia.ch

5 Study on sociological and behavioural aspects

5.1 Summary

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.
The complete results are described in a full report (Dongen 2004).

With respect to the question **how** occupants ventilate, among others, has been found that:

- If air inlets are present, they are used on a variable way in about 25-30% of the living rooms, and in about 15% of the bedrooms. In the other cases they are whether (nearly) always closed (varying from 5-20%) of the cases, or (nearly) always opened (in about 50-80% of the cases);
- Except in kitchens, in the newly build highly air tight dwellings the (slot)vents are used and opened more than in the mean (moderately) air tight dwellings;
- The use of slot vents do not differ largely between summer and winter periods;
- During a mild winter period in nearly all dwellings (90% at least), independent of the air tightness, one or more windows are used for additional airing during some time;
- If mechanical exhaust ventilation is present, in the mean air tight dwellings the ventilation system is not used (off) in about 17% of the dwellings during daytime and in about 23% during the night.
- Inside doors (to the hall or staircase) are opened (nearly) always in about 50% of the living rooms, 75% of the kitchens (including ‘open’ kitchen rooms) and in 60% of the bedrooms.

Reasons **why** occupants ventilate (or not) are:

- Indoor climate and air quality, e.g. temperature, experienced wetness (condensation), dryness, freshness, odour and draught;
- Outdoor climate, e.g. temperature, sunshine, wind speed and wind direction;
- Outdoor factors (noise, odour, pollution, risk of burglary)

Further it appears that:

- The ventilation by behaviour is only partly (especially in the living room) 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. This amount of ventilation (air flow) appears to be higher than the regulated (and assumed as sufficient) air flows in dwellings with balanced ventilation systems;
- 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 (argument for removing) and architectural factors of dwellings (dwelling plan, volume of rooms, air tightness) play a role.

As a matter of course the ventilation behaviour also is influenced by:

- The household behaviour: presence at home, cleaning activities, cooking, bathing, drying clothes and renovation activities;
- Social and personal factors: smoking, visits, number of persons, pets, plants, attitudes with respect to energy use, health, education, age and gender.

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, information and maintenance to the occupants, as well as to installation firms and architects;
- good performance (reliability, ironing of bugs, sustainability, low damage risk)
- coming up with expectations
- user-friendliness for all (young and old)
- 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)

And, provided above quality aspects:

- multifunctional, party aspects (air flow-, temperature regulation, energy monitoring)
- adaptation and integration with other technical, monitoring and automatic control systems (domotica devices)

Further general conclusions are:

- In a substantial proportion of the dwellings (25-50%), whether newly built and highly air tight, or old and moderately (mean) air tight, 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'. Ventilation provisions need to be very flexible in use because there are a number of moderating personal and social factors who lead to different preferred ventilation rates at different circumstances (including phases of a households 'lifecycle');

- Occupants must keep freedom of choice, so must keep possibilities to intervene into an automatic system. This intervention possibility must be simple (off – on) and good designed;
- In general health problems are not directly related to the type of ventilation system, but if occupants perceive health problems, these problems are often associated to those perceived indoor air and climate problems, which are often especially related to balanced ventilation systems;
- Insufficient information to the occupants about the ventilation system in their dwelling may promote health problems.

5.2 References

Dongen, J., 2004. Occupant behaviour and attitudes with respect to ventilation of dwellings. Reshyvent report RESH-WP2-D2.2.

6 Conclusions

6.1 The European ventilation market as of today

The ventilation systems, in the building stock, differ very much from country to country. There are many reasons for this, differences in market driving forces, building codes, traditions, user preferences, climate,… (see table 6.1). In northern Europe most new dwellings are equipped with mechanical ventilation systems, while southern countries often rely on window airing. More and more mechanical ventilation systems also include heat recovery. The starting point is therefore very different. In countries like Belgium, Czech Republic, Germany, Great Britain and Greece there is among many decision makers a lack of awareness of the need of and insufficient requirements for any kind of ventilation system in dwellings and therefore simply installing some kind of ventilation system is an improvement. In these countries the installation costs for the applied ventilation strategy are usually very low, as there is usually no real ventilation system, only opening windows. In countries with mechanical ventilation systems a certain installation cost for ventilation is unavoidable and accepted by the market, however often an inexpensive ventilation system is assumed to fulfil and surely not exceeding the existing requirements is installed. Often the investment budget is also separated from the operating budget, resulting in sub optimised ventilation systems. The benefit of LCC analysis is being at least more and more discussed, but rarely applied in real projects.

Table 6.1 Current differences in building ventilation regulations, climate and types of existing ventilation systems, sorted by climate. Natural ventilation means relying mostly on infiltration and window airing.

Country	Market driving forces	Climate	Most common ventilation in old dwelling stock	Most common ventilation in new dwelling stock
Denmark	Building regulations	Cold	Passive stack	Mechanical/natural
Norway	IAQ, health, regulation on ventilation	Cold	Passive stack	Mechanical
Sweden	Regulation on ventilation, IAQ and heat recovery, performance checks	Cold	Passive stack	Mechanical
Switzerland	Regulation on ventilation and energy	Cold	Passive stack	Mechanical
Belgium	Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system, but in new buildings building regulations	Moderate	Natural	Natural
France	Regulation on health and energy	Moderate	Passive stack	Mechanical
Great Britain	Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system	Moderate	Natural	Natural
Netherlands	Regulation on ventilation and energy. Energy Performance Regulation.	Moderate	Passive stack/ mechanical	Mechanical
Czech Republic	Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system	Moderate/cold	Natural	Natural
Germany	Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system	Moderate/cold	Natural	Natural/some mechanical
Greece	IAQ, outdoor noise, limitations of natural ventilation. Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system.	Warm	Natural	Natural
Portugal	Insufficient awareness of and insufficient requirements for a minimum of ventilation necessitating a ventilation system	Warm	Natural	Natural

In countries where mechanical ventilation systems have become common, usually a building code that requires mechanical ventilation has been developed e.g. in Denmark, France, the Netherlands, Norway and Sweden. Interestingly, countries with a moderate climate as France and the Netherlands have a large market share for mechanical exhaust ventilation systems in new buildings, while Great Britain, Germany, the Czech Republic and Belgium with rather similar climatic conditions often rely on natural ventilation. A major difference between these two groups of countries are the requirements. For the Netherlands, Denmark and Sweden mechanical ventilation systems were required for apartment buildings for some years, but not any more. The market for mechanical ventilation had however already been developed and established, and didn't disappear. Other common ventilation market driving forces on the European market are IAQ, health, comfort, climate and energy (see table 6.1).

A common solution in cold climates to recover heat from the ventilating air is to install a mechanical balanced ventilation system, to obtain controlled ventilation, with a heat recovery unit. It is rather difficult to recover heat from natural or passive stack ventilation. Most systems for recovering heat from the ventilating air introduce pressure drops in the ventilation system, which are higher than the natural driving forces for ventilation, thereby making natural ventilation difficult.

The existing housing stock (see table 6.2) has a variety of ventilation systems. Most countries, apart from France, the Netherlands and to some extent Norway and Sweden, have a pre-dominance of installed natural or passive stack ventilation systems. In countries with a predominance of mechanical ventilation systems the older buildings still have natural or passive stack ventilation.

In new construction more advanced ventilation systems often compete with other features in a dwelling. End users are often more interested in investing in e.g. larger floor area, extended/improved bathroom, cleaning friendliness or advanced alarm system.

Table 6.2 Ventilation systems in the European building (dwellings) stock*, %,* according to chapter 4 Results.

	Single family houses			**Apartment buildings**		
Country	**Natural/-passive, %**	**Mechanical exhaust**	**Mechanical balanced**	**Natural/-passive, %**	**Mechanical exhaust**	**Mechanical balanced**
Belgium	97	2	1	97	2	1
Czech republic	97	2	1	98	1	1
Denmark	97	1	2	75	25	0,1
France	70	30	0,1	60	40	0,1
Germany	90	5	5	90	5	5
United Kingdom²	95	5		95	5	
Greece	99			99		
Netherlands	60	40		40	60	
Norway	81	14	5	81	14	5
Portugal	99			75	25	
Sweden	75	17	8	40	44	16
Switzerland	83	15	2	83	15	2

The present regulations regarding energy performance, indoor air quality and summer comfort (if any regulations) in residential buildings do not constitute any major barrier to the application of demand controlled hybrid ventilation in Belgium, the Czech Republic, Denmark, Finland, Germany, Greece, Italy, the Netherlands, Norway, Portugal, Sweden, Switzerland and United Kingdom (Wouters 2004-1 and 2004-2). Although the regulations do not constitute any barriers, many countries e.g. Belgium, Greece, Norway and Portugal have regulations which do not promote innovative systems. The fact that the regulations and standards are different in different countries can cause a problem when developing new systems e.g. that the requirements are specified more or less in terms of solutions, that the ventilation target is expressed in different ways or when air flow rates are required they vary from country to country (Tipvent 2001) . A system developed in one country will probably not fulfil the regulations in another country and/or will not receive the same benefit. This however do not only apply to demand controlled hybrid ventilation systems, but to all ventilation systems. An additional problem is the barrier to the development, optimisation and application of innovative systems in general and in particular demand controlled hybrid ventilation caused by the lack of transparent and efficient procedures for assessing the performance of innovative systems.

The total number of dwellings, in the existing building stock, has been estimated to be 126 million (see table 6.3).

Table 6.3 The total number of dwellings, thousands. The total number of dwellings dated 2001 are from Eurostat (Eurostat 2003).

Country	**One-family houses**	**Dwellings in apartment buildings**	**Total number of dwellings**	**Year**
Belgium	3 421	855	4 276	2001
Czech republic	1 488	2 242	3 730	1999
Denmark	1 271	1 160	2 431	2001
France			24 599	2001
Germany	13 710	25 461	39 171	2001
United Kingdom	21 354	4 687	26 041	2002
Greece			5 480	2001
Netherlands	3 128	3 823	6 951	2001
Norway	1 486	469	1 955	2001
Portugal	1 500	2 039	3 539	2001
Sweden	1 806	2 494	4 300	2002
Switzerland	670	2 905	3 575	2000
Total	49 833	46 136	126 048	

There is not yet a truly European ventilation market, the market is mostly national (see chapter 4). However, some manufacturers market and sell components for ventilation systems in more than one country. The components are then often modified according to the national needs or requirements This is a major barrier for cost optimisation.

Some recent ventilation market trends are:
- Passive houses since 5 – 10 years in e.g. Germany, Switzerland, Austria and since a couple of years in Sweden, Belgium, ... Passive houses are mostly terraced houses, but also multi-dwelling blocks, which are very airtight and very well insulated with no traditional heating system, but with mechanical balanced ventilation systems with highly efficient heat recovery units. Recently school and office buildings have been built as passive houses.
- Exhaust air heat pumps since 5 – 10 years in Sweden. Almost all new single family houses have this system i.e. the ventilation system is a mechanical exhaust only system.
- Controlled inlets since 10 years in France and the Netherlands. The control can be based on pressure, humidity or air velocity.
- Since 10 years energy efficient fans have been developed in e.g. Germany, Sweden.

The first two market trends constitute energy efficient ventilation systems or sub systems competing with demand controlled hybrid ventilation. The two last ones are components, which are included in competing energy efficient ventilation systems, but which also can be useful for demand controlled hybrid ventilation systems.

6.2 Why demand controlled hybrid ventilation

There are many demands and expectations of the customers for refurbishment and new construction as to the performance of ventilation systems:

The following aspects often receive the highest priority:
- ❑ Low noise
- ❑ Low draught
- ❑ Good indoor air quality
- ❑ Manual override for the user
- ❑ Low investment costs (often resulting in systems meeting, but not exceeding the requirements as the investment budget is often separated from the operation budget)

Other important demands and expectations are:
- ❑ Good thermal comfort
- ❑ Moisture control
- ❑ Good control
- ❑ Reliable
- ❑ Flexible
- ❑ Aesthetic
- ❑ User friendly
- ❑ Low running costs
- ❑ Low maintenance costs
- ❑ Low energy use
- ❑ Natural ventilation

Between the countries, the demands and expectations are often different and are prioritised differently, but the universal ones are low noise and low draught.

Many demands and expectations are unsatisfactorily fulfilled by the existing ventilation systems. Mechanical ventilation systems tend to often be unsatisfying as to manual override for the user, noise, draught, flexibility, user friendliness and use of electricity, while natural/passive stack ventilation systems tend to often be unsatisfying as to indoor air quality, reliability (ventilation rates), flexibility and energy use (heating). There clearly is 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 can reduce the energy use for ventilation (energy for operation and space heating). One of the most promising system to achieve these goals is demand controlled hybrid ventilation.

Natural and mechanical ventilation have been developed separately over many years. Mechanical ventilation systems has been improved by implementing extensive heat recovery and low pressure systems. Over the same period natural ventilation has developed from being considered only as a largely uncontrolled ventilation system relying on air infiltration through cracks and airing through windows to passive stack ventilation systems with controlled inlets. For classical natural ventilation systems one of the major disadvantages is the variability in performance, which can result in increased risk of draught problems in cold climates and a risk of unacceptable thermal comfort during warm/hot periods. One of the advantages is the likelihood of a positive response from the occupants (Heiselberg 2002) thanks to less noise from the ventilation system itself and a higher degree of user control. One of the advantages of mechanical ventilation is that it is for such systems in principle easier to predict and control the air flows. However the occupants often complain about draught and noise from mechanical ventilation systems and occupants often have less possibilities to understand and influence the ventilation. Moreover, often the operation and maintenance of mechanical ventilation systems is poor or at least not optimal.

Hybrid ventilation systems have access to both ventilation modes and therefore allow the best ventilation mode to be chosen depending on the circumstances (Heiselberg 2002).

The use of electricity has become more and more an issue of concern. This is beneficial for hybrid ventilation systems as they are likely to have a lower use of electricity thanks to low pressures drops in the system and the fact that the fans are not always in operation.

A complication for hybrid ventilation is the need for a more advanced control systems, in comparison with traditional mechanical ventilation systems.

The demand control applied to residential hybrid ventilation systems should result in at all times adequate ventilation rates, no excess ventilation during winter causing high use of energy, but enough ventilation to ensure an adequate indoor air quality.

6.3 SWOT- analysis for demand controlled hybrid ventilation

A SWOT analysis of hybrid ventilation was carried out for all the participating countries. The analysis was based on different traditional ventilation systems and different ideas of a hybrid ventilation system. Some **potential internal strengths** are valid for several countries (see table 6.4) and by these countries also considered very important:

- Energy savings
- Better IAQ

- Low noise level
- Better comfort

A **potential internal weakness** of hybrid ventilation systems is the (higher) investment costs. The investment costs still has a very high priority when deciding which system to install. The life cycle cost for demand controlled hybrid ventilation systems is, however, likely to be lower than mechanical ventilation systems without heat recovery and similar to systems with heat recovery. A life cycle cost approach must be implemented among clients and property developers. Product development and optimisation in combination with a large scale production are needed to lower the costs for demand controlled hybrid ventilation systems. In countries with energy performance requirements (e.g. the Netherlands and France but in the future all EU countries in the context of the energy performance directive) the economic discussion is more complex since energy efficient ventilation systems will compete with other energy efficient technologies. This means that when a certain energy use for space heating is required the energy target can be met by different combinations of energy efficiency measures, where one measure can be energy efficient ventilation or heat pump or improved thermal insulation or ….. . Besides cost reduction the advantages of demand controlled hybrid ventilation have to be communicated to the key interested parties.

Other common potential internal weaknesses are the design challenge of hybrid ventilation (lack of design methods or knowledge) and potential noise problems (compared with natural ventilation i.e. from e.g. fans or electric motors) from hybrid ventilation system. However, the last one is also a potential internal strength, especially compared with mechanical ventilation systems.

Common **potential external opportunities,** which are considered very important, are future national building regulations and the implementation of Energy Performance of Buildings Directive (see also chapter 6.4 on the Energy Performance of Buildings Directive). Some countries believe in subsidies. The **potential external threats** differ from country to country, however some countries cite present national market, high price sensitivity, lack of information/knowledge and system costs as important.

Some examples of expected trends in future national building regulations:
- Requirements on ventilation and energy use in the Czech Republic
- Primary energy factor for use of electricity in Denmark
- Energy performance for different types of ventilation systems in Denmark
- New ventilation requirements in France
- Introduction of stricter energy requirements and standards and regulation for innovative ventilation systems in Greece
- More performance oriented standards and regulations in Sweden
- Stronger emphasis on indoor air quality in Switzerland

Examples of external threats from the market:
- Lack of awareness of the need for and requirements for a ventilation system in Belgium and the Czech Republic
- Not ready for a new ventilation system in France, except if there is a potential for energy savings

Examples of external threats caused by high price sensitivity:
- A ventilation system is still considered as a luxury in the Czech republic

- The price sensitivity is high unless the performance is improved in Denmark
- Compared with the most common ventilation system i.e. natural ventilation in Switzerland

Examples of external threats caused by lack of information/knowledge:
- The present knowledge about hybrid ventilation is very low and thus architects and mechanical engineers do not recommend this system in Greece.
- Knowledge of involved parties is limited resulting in initial barriers to the implementation of new ventilation concepts in Sweden and Switzerland.

Examples of external threats caused by system costs:
- High system cost compared with the existing traditional systems in Greece
- The residential housing market is very competitive in Norway

The external threats from the market, high price sensitivity, lack of information/knowledge should be dealt with by information to interested parties like end users, property owners/developers, architects, contractors, consultants and HVAC suppliers/developers, concerning the need for proper ventilation systems and what demand controlled hybrid ventilation means.

Table 6.4 Summary of SWOT analysis on demand controlled hybrid ventilation systems for dwellings in different European countries. The strengths, weaknesses, opportunities and threats are listed in order of frequency.

Potential internal strenghts	**Country**	**Potential internal weaknesses**	**Country**
Energy savings	BE, CZ, DK, FR, GR, NL, NO, SE, CH	High costs	BE, CZ, DK, FR, GR, SE,
Better IAQ	BE, CH, CZ, FR, GR, NL, NO	Design of hybrid ventilation	CZ, FR, GR, CH
Less noise	DK, GR, NO, SE, CH	Noise from system	BE, CZ, GR, NL
Better comfort	BE, CZ, FR, GR,	Aesthetics	BE, CZ, GR,
Less/easier maintenance	DK, NL,NO,	Maintenance	BE, CZ, GR,
Controllability	GR, SE, CH	User friendliness	GR, CH
Less draft	GR, SE, CH	Technical life span	GR, SE
User friendliness	NL, SE	Space for ductwork	FR, NO
Removal of humidity	CZ	Sensitive to outdoor noise	SE, CH
User satisfaction	DK,	Uncertain air flow stability in rooms	SE, CH
Manual override	DK,	Low level of experience	DK
Less climate dependence	GR,	Less controllability	DK,
Demand control	NO,	Small market	SE
Fault detection	SE	Requires low-emitting materials	SE
Suitability for retrofit	CH	Accessibility to apartments	SE
Lower investment and running costs	CH	Control strategies	CH
Compatible with window airing	CH	Difficult to filter supply air	CH
Supply directly from the outside	NL	Thermal comfort in winter	NL
Exists in refurbishment	FR	Quality of sensors	NL

Potential external opportunities	**Country**	**Potential external threats**	**Country**
Future national building regulations	CZ, DK, FR, GR, SE, CH	National market	BE, FR, CZ
EPD	BE, DK, GR, SE	High price sensitivity	CZ, DK, CH
Subsidies	DK, GR, NO, CH	Lack of information/knowledge	GR, SE, CH
Need of refurbishment	CZ, DK, CH	System costs	GR, NO, SE
Positive attitude of architects and consultants	CZ, DK	Customer attitude	CZ, NO
Energy savings	CZ, GR,	Small market	CH, NL
More balanced systems	DK, NO	Principle of equivalence	BE,
Reputation	SE, CH	Individual demands and expectations	DK,
Low running costs	SE, CH	Supplier attitude	DK,
Principle of equivalence	BE,	Reduced refurbishment subsidies	DK,
Costs	GR,	Non-existing regulations	GR,
Increasing energy costs	SE,	Present legislation	SE
Growing LCC awareness	SE	Maintenance need	SE
Acquisite clients	SE	Reputation	SE
Higher value of building	CH	Increasing energy costs	CH
Alternative to balanced ventilation with heat recovery	NL	Protection from outdoor noise and pollution	CH
		Assessment in EPD	NL

6.4 Impact of the Energy Performance of Buildings Directive on the market for demand controlled hybrid ventilation

The Energy Performance of Buildings Directive contains five basic requirements out of which four are of interest for the marketing of demand controlled hybrid ventilation:

- Establishment of a general framework of a common, integrated methodology for calculating the energy performance of buildings.
- Application of minimum requirements on the energy performance of new buildings
- Application of minimum requirements of the energy performance of large existing buildings that are subject to major renovation
- Certification of the energy performance of buildings when constructed, rented out or sold.

The Directive requires all EU countries to have a new building regulation by 4 January 2006 and to revise it minimum every 5 years.

The establishment of a general framework of a common, integrated methodology for calculating the energy performance of buildings, could facilitate the creation of an European market for demand controlled hybrid ventilation systems. This methodology will include, among many aspects, ventilation and natural ventilation and will also include single-family houses of different types as well as apartment blocks. However, it is not evident to expect in the short term the appearance of European common assessment methods.

Introducing more stringent energy requirements is likely to make demand controlled hybrid ventilation systems more attractive on the market of many countries, because natural ventilation will not be sufficiently energy efficient and demand controlled hybrid ventilation will be a promising alternative to balanced mechanical ventilation system with heat recovery (see chapter 6.2 Why demand controlled hybrid ventilation)

Today the majority of European countries do not have a framework for assessing innovative systems (ENPER 2003). The implementation of the Energy Performance of Buildings Directive will increase the need for appropriate assessment procedures. The energy performance will be of greater importance thanks to the EPBD. In order to be able to compare the energy performance of existing and new innovative systems there will be a need for appropriate procedures for assessing the energy performance. Systems for which these procedures do not exist might disappear from the market.

Many countries are still preparing the national implementation. As an example, the Netherlands seem to be very close to an implementation and foresee a possible positive influence on the market for demand controlled hybrid ventilation systems. Most countries foresee an increased demand for energy efficient ventilation systems.

6.5 Vision of the European market for demand controlled hybrid ventilation

Most of the **demands and expectations** of customers (see chapter 6.2) as to the performance of ventilation systems can in principle be **met by demand controlled hybrid ventilation systems.**

Basically, there are **no standards or regulations preventing the implementation** of demand controlled hybrid ventilation systems in dwellings. In some countries the current regulations can complicate the implementation compared with the traditional ventilation systems. **The new building codes** being developed thanks to the EPBD (see chapter 6.4) should remove these barriers and become **a market driving force** (see table 6.5).

Table 6.5   Market driving forces for demand controlled hybrid ventilation in the future.

Belgium	The mandatory use of Ventilation systems in new dwellings Introduction of cost effective control systems. Energy Performance Regulation in 2006 as part of the implementation of the EPBD
Czech Republic	Regulation on IAQ, mould and condensation EPBD
Denmark	Building regulations. High cost of electricity. EPBD
France	Regulation on ventilation. EPBD
Greece	Financial incentives. EPBD
Germany	Regulation on ventilation EPBD
Great Britain	EPBD
Netherlands	Regulation on ventilation and energy. EPBD
Norway	IAQ, health, regulation on ventilation
Sweden	Regulation on ventilation and energy. EPBD
Netherlands	Regulation on ventilation and energy. EPBD
Norway	IAQ, health, regulation on ventilation. Energy Performance Regulations. Financial incentives
Sweden	Regulation on ventilation and energy. EPBD
Switzerland	Regulation on ventilation and energy
Portugal	EPBD

The European ventilation market of today is not very homogenous due to differences in building regulations, market driving forces, traditions, user preferences and climate as well as types of existing ventilation systems (see table 6.1). **A European harmonised market** would increase the potential for demand controlled hybrid ventilation systems. Such a market would be sufficiently big and important to facilitate and make it worthwhile to carry out the development of improved and competitive systems i.e. as to performance and costs. In order to create such a European market, **the national building codes and assessment procedures must be harmonised**. The **assessment procedures** must take into account **innovative systems** like demand controlled ventilation systems. An important step in that direction could be the implementation of the requirements of the above mentioned EPBD.

The systems competing with hybrid ventilation in new construction and refurbishment are passive stack/natural and mechanical ventilation (se table 6.6). In Denmark, France, the Netherlands, Norway and Sweden the main competition is from mechanical ventilation systems sometimes with and sometimes without heat recovery.

Table 6.6 Ventilation systems competing with demand controlled hybrid ventilation and for some countries their share, %, of the market today. X = competing system with unknown market share.

Country	**Passive/-natural**	**Mechanical exhaust**	**Mechanical exhaust w heat recovery**	**Mechanical balanced**	**Mechanical balanced w heat recovery**
Belgium	X	X	0	0	0
Czech republic	98	1		0	1
Denmark	X	X	0	X	X
France	0	90	0	1	0
Germany	X	X	0	X	2
United Kingdom	X	0	0	0	0
Greece	X	0	0	0	0
Netherlands	5	70	0	0	25
Norway	0	40	0	0	60
Portugal	0	100	0	0	0
Sweden	0	45	45	0	X
Switzerland	0	X	0	0	X

The expected more stringent future energy requirements **will increase the competition from mechanical ventilation with heat recovery**, especially in the countries where mechanical ventilation is already common and accepted. There will also be competition from energy efficiency measures not related to ventilation systems.

In many cases, demand controlled hybrid systems will have a higher investment cost than traditional systems without heat recovery, but likely to have a lower LCC. The more stringent future energy requirements will in many countries create a market for mechanical ventilation systems with heat recovery, which probably will have similar costs to demand controlled hybrid ventilation systems. Today, the investment cost is in most countries a very important criterium in the decision process, as the customers are very price sensitive. Therefore, **the investment costs for hybrid ventilation systems should be lowered**. Product development and large scale production are needed to lower the costs by **reducing the cost of crucial components like sensors**, which would be facilitated by a truly European market. A fair comparison between different ventilation systems can only be done if the life cycle cost is calculated and used as the basis of comparison. The LCC analysis must then include environmental impacts as well. However with the future energy performance requirements the cost comparison will not be made only with mechanical ventilation with heat recovery, but also with other energy efficiency measures.

To begin with in countries like Germany, Great Britain and Greece there is a general lack of knowledge concerning the need of a ventilation system at all. In the other countries mentioned in this report there is obviously a lack of knowledge concerning demand controlled hybrid ventilation. **Information concerning the need for a proper ventilation system and what demand controlled hybrid ventilation means** has to be spread to interested parties like end users, property owners/developers, architects, contractors, consultants, HVAC suppliers/developers etc. The key interested parties may differ from country to country. The important interested parties as to the market possibilities for and design/function of hybrid ventilation systems are typically property owners/developers, architects and contractors. Other interested parties can be consultants, suppliers and end user organisations.

The following has to be fulfilled to ensure that a demand controlled hybrid ventilation system is **accepted by the end users**:
- Good guidelines regarding use, information and maintenance to occupants about the possibilities and function of the ventilation system
- The system must:
✓ be perceived by the occupants as useful
✓ be adapted to households routines
✓ function as expected (very important to avoid getting a bad reputation from the beginning and means that good quality assurance is a must)
✓ give freedom of choice e.g. to override an automatic control (stressed in many countries)
✓ be simple to turn on and off
✓ give time to occupants to get used to
✓ be introduced to the occupants

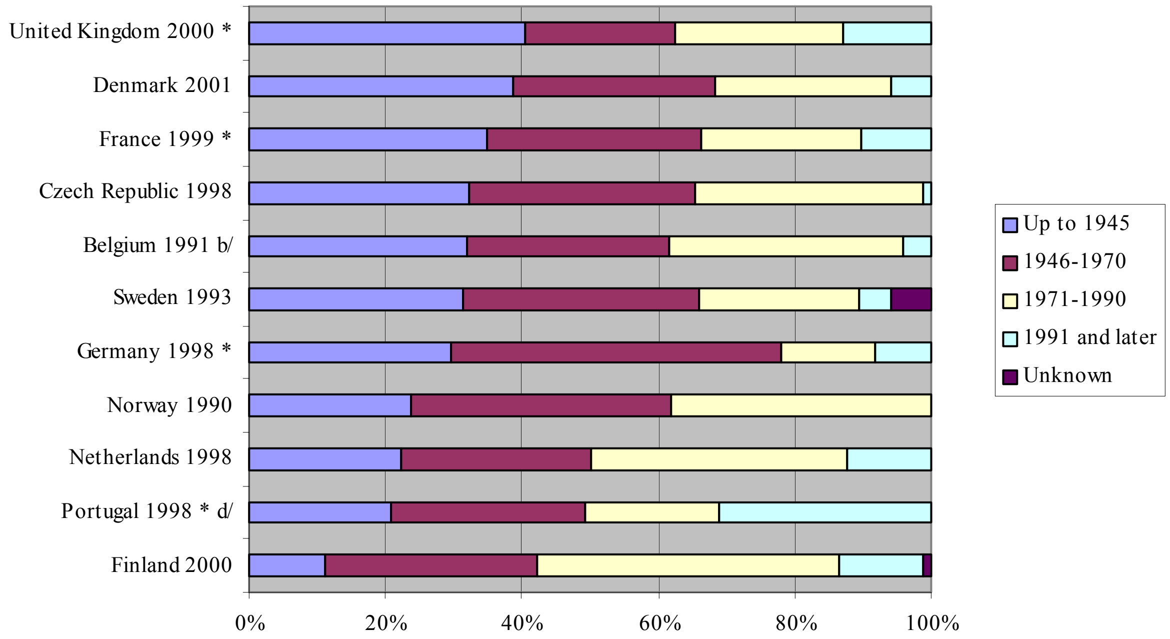
Summing up the vision of the market for demand controlled hybrid ventilation:
- Some national barriers will probably still exist
- The European market will be harmonised
- Demand controlled hybrid ventilation systems will be competitive in many countries
- EPBD will be a crucial market driving force
- The market will be: new construction and refurbishment (mainly of passive stack or exhaust fan ventilation systems)
- The refurbishment market will be for IAQ and energy improvement, as mechanical systems are too complicated and costly in comparison

Recommendations
- Inform the key interested parties about the need for a ventilation system, in order to remedy the lack of awareness in some countries
- Inform the key interested parties about demand controlled hybrid ventilation, in order to remedy the lack of knowledge
- Create a European co-operation, to create a bigger market
- Lower the costs of demand controlled hybrid ventilations, in order to be competitive
- Create a framework for innovative systems (see chapter 6.4), to enable assessment of the performance of demand controlled hybrid ventilation systems and thereby enabling a fair comparison with traditional systems
- Implement a Life Cycle Cost approach, to enable a fair comparison between different systems.

6.6 Market potential for demand controlled hybrid ventilation

In the existing building stock there should be a large market potential. There are e.g. 38 million dwellings built before 1945 (see table 6.7), most of them with poor natural ventilation and high energy use. Demand controlled hybrid ventilation is likely in many cases to be a suitable retrofit, improving the indoor air quality and reducing the energy use for space heating. In these buildings it will be rather complicated and expensive to upgrade to balanced mechanical ventilation with heat recovery, while demand controlled hybrid ventilation will in comparison be simple and inexpensive to install. This is especially true for passive stack or exhaust fan systems, where the vertical exhaust shafts can be used and inlets can be incorporated in the window frame.

Table 6.7a Dwellings by construction period (UNECE Environment and Human Settlements Division, Housing database, 2003)



b/ Data refer to dwellings started.
d/ Data refer to occupied dwellings only.
* Changes in construction periods:

Table 6.7b Dwellings by construction period, thousands (UNECE Environment and Human Settlements Division, Housing database, 2003)

	Total	Up to 1945	1946-1970	1971-1990	1991 and later	Unknown	Remark
Portugal 1998 * d/	3 539	741	1 003	690	1 105	0	
Netherlands 1998	6 951	1 548	1 947	2 605	850	0	
Norway 1990	1 955	466	744	746	0	0	
Germany 1998 *	39 171	11 603	18 909	5 454	3 204	0	
Sweden 1993	4 300	1 355	1 488	997	211	249	
Belgium 2001	4 227	1 028	964	803	384	1 048	See ch. 4.1
Czech Republic 1998	2 730	880	902	918	30	0	
France 1999 *	24 599	8 588	7 734	5 754	2 524	0	
Denmark 2001	2 431	939	723	627	140	2	
United Kingdom 2000 *	26 041	10 677	5 729	6 510	3 385		
	115 944	37 825	40 143	25 105	11 833	1 299	

The potential for demand controlled hybrid ventilation systems in new construction and refurbishment, within the near future, is rather small unless the potential internal weaknesses and end external barriers are removed or lowered and the potential internal strengths and external opportunities are utilized (see table 6.8). The estimated number of yearly new constructions is 1.09 million dwellings and the estimated number of dwellings in need of refurbishment is 3.29 million units . The estimated potential for demand controlled hybrid ventilation in new construction is 48 – 64 thousand dwellings and yearly refurbishment with demand controlled hybrid ventilation is 93 – 129 thousand dwellings, in total 131 – 193 thousand dwellings. These estimates are based on national estimates, where the low number is the potential within 5 to 10 years and the high numbers are beyond 5 to 10 years, assuming that barriers and threats are dealt with seriously, and strengths and opportunities are utilized.

Table 6.8a Expected market penetration in EU, thousands of dwellings in refurbishment. Low potential – within 5 to 10 years, High potential – beyond 5 to 10 years, barriers and threats are dealt with seriously, and strengths and opportunities are utilized.

		Demand controlled hybrid ventilation potential/year		
Country	**Yearly refurbish-ment**	**Low**	**High**	**Remark**
Belgium	599	2	2	Refurbishment need
Czech republic	1 000	0	0	Refurbishment need
Denmark	125	25	50	
France	450	5	15	Actual refurbishment
Germany	0	0	0	
Great Britain	0	0	0	
Greece	0	0	0	
Netherlands	1 043	52	52	Refurbishment need
Norway	17	0	0	Ventilation refurbishment
Portugal	10	0	1	
Sweden	37	9	18	Refurbishment need
Switzerland	14	0	0	
Total	3 294	93	129	

Table 6.8b Expected market penetration in EU, thousands of dwellings in new construction.

			Demand controlled hybrid ventilation potential	
Country	**Total number of dwellings**	**Yearly new construction**	**Low**	**High**
Belgium	4 276	43	2	2
Czech republic	3 730	24	0	0
Denmark	2 431	15	1	1
France	24 599	280	0	5
Germany	39 171	270	0	0
Great Britain	26 041	188	0	0
Greece	5 476	90	0	0
Netherlands	6 951	70	30	40
Norway	1 955	25	5	5
Portugal	3 539	26	0	1
Sweden	4 300	22	7	11
Switzerland	3 575	35	4	4
Total	126 045	1 088	48	64

The time perspective of implementation of hybrid ventilation systems varies from country to country. Within a couple of years implementation is expected in the Netherlands. For the Czech republic, Denmark, France, Norway, Sweden and Switzerland implementation is estimated to occur beyond five years. The situation in the remaining countries is difficult to estimate.

6.7 References

Official Journal of the European Communities, Directive 2002/91/EC of the European parliament and of the Council of 16 December 1992 of the energy performance of buildings.

Dongen, Jef van. Occupants behaviour in existing systems in dwellings. TNO Inro, Draft report 2003-82 Delft, The Netherlands, march 2003.

ENPER (www.enper.org), Energy Performance of Buildings – Assessment of innovative technologies, 2003.

Eurostat, 2003. Eurostat yearbook 2003 – People in Europe. http://www.europa.eu.int/comm/eurostat/.

Heiselberg, P., 2002. Principles of hybrid ventilation. IEA Annex 35 Hybrid Ventilation in New and Retrofitted Office Buildings, Hybrid ventilation Centre, Aalborg University.

Tipvent, 2003. Source book: Towards the improved performances of mechanical ventilation systems. European commission in the framework of JOULE IV.

UNECE, 2003 (United Nations Economic Commission for Europe) Environment and Human Settlements Division, Housing database. http://www.unece.org/stats/publ.htm

Wouters, P., Heijmans, N., Loncour, X., Delmotte, Ch., 2004-1. Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems – Part 1: Standards and regulations concerning indoor air quality and summer comfort. RESHYVENT WP4 Standards and Regulation support unit.

Wouters, P., Heijmans, N., Loncour, X., Delmotte, Ch., 2004-1. Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems – Part 1: Standards and regulations concerning energy performance of buildings. RESHYVENT WP4 Standards and Regulation support unit.

7 Annexes

7.1 Questionnaire ranking ventilation systems

Questionnaire for comparing (ranking) different ventilation systems. The filled in ranking numbers do not represent real systems.

KNOWLEDGE	*Please check one box*				Good	Averag e	Poor
1. Knowledge on mechanical ventilation in dwellings							
2. Knowledge on natural/passive stack ventilation in dwellings							
3. Knowledge on hybrid ventilation in dwellings							
4. Experience of hybrid ventilation in new construction of dwellings							
5. Experience of hybrid ventilation in retrofit of dwellings							
Comments:							
INFORMATION SOURCE *Please check relevant boxes*	None	Standards	Guidelines	Building studies	Own design	Articles in technical journals	Other (please state which)
1. Source of knowledge on hybrid ventilation systems							
Comments:							

In this part of the questionnaire the interviewee is asked to compare hybrid ventilation with mechanical and natural / passive stack ventilation for a number of different aspects. In the last column the level of relevance/priority of the aspect is given, which is the result of the problem detection study. This will serve as an aid in determining what the demands of the interested parties are. Together with the comparison this will help in determining the advantages and disadvantages of hybrid ventilation on the market.

SYSTEM / COMPONENTS	*COMPARISON BETWEEN SYSTEMS* *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE /PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust fan only	Hyb vent	Natural	
1. Reliability*) of ventilation systems	1	1	5	1	
2. User friendliness of ventilation systems	1	1	5	1	
3. Operation and Service 3.1. Access for service of ventilation systems	1	1	5	1	
3.2. Control intervals of ventilation systems (high frequency is bad)	1	1	5	1	
3.3. Possibility for automatic fault detection of ventilation systems	1	1	5	1	
3.4. Ease of operational monitoring of ventilation systems	1	1	5	1	
Average	1,0	1,0	5,0	1,0	
4. Maintenance 4.1. Ease of cleaning of ventilation systems	1	1	5	1	
4.2. Availability of components for ventilation systems	1	1	5	1	
Average	1,0	1,0	5,0	1,0	
5. Service life (technical life span) 5.1. of a ventilation system	1	1	5	1	
5.2. Of ductwork of ventilation systems in dwellings	1	1	5	1	
5.3. Of fans of ventilation systems in dwellings	1	1	5	1	
5.4. Of air inlet / exhaust devices of ventilation systems	1	1	5	1	
5.5. Of control system of hybrid ventilation systems in dwellings compared to	1	1	5	1	
Average	1,0	1,0	5,0	1,0	
Comments:					

* Reliability is the probability that the ventilation system is working in an acceptable way (or better).

DESIGN	COMPARISON BETWEEN SYSTEMS *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE/PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust fan only	Hyb vent	Natural	
1. Ease of design of ventilation systems	1	1	5	2	
2. Availability of design guidelines and advice on ventilation systems	1	1	5	1	
3. Availability of products for ventilation systems	1	1	5	1	
4. Influence on the design of the building caused by ventilation systems (1 = very high, 5 = very low)	1	1	5	1	
5. Influence on the flexibility of building use (f ex change of building design etc) by ventilation system (1 = very high i.e. reduced flexibility, 5 = very low i.e. increased flexibility)	1	1	5	1	
6. Aesthetics (appearance) of ventilation system components	1	1	5	1	
7. Influence on safety issues by ventilation systems (1 = very high, 5 = very low)	1	1	5	1	
8. Influence on fire planning by ventilation systems (1 = very high, 5 = very low)	1	1	5	1	
Average	1,0	1,0	5,0	1,1	
Comments:					

PERFORMANCE	COMPARISON BETWEEN SYSTEMS *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE /PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust fan only	Hybrid ventilation	Natural ventilation	
1. Ability to remove odours and pollutants of ventilation systems	1	1	5	2	
2. Ability to prevent supply of odours and pollutants from outside or neighbours of ventilation system	1	1	5	1	
3. Risk for draught (from f.ex air inlets) in dwellings with ventilation system (5 = very small risk, 1 = very high risk)	1	1	5	1	
4. Ability of ventilation systems to regulate indoor air temperatures	1	1	5	1	
5. Unintentional flow variability of ventilation systems (5 = small variability, 1 = high variability)	1	1	5	1	
6. Sensitivity to airing by dwelling occupants etc of ventilation systems (5 = low sensitivity, 1 = high sensitivity)	1	1	5	1	
7. Ability to remove humidity from bathroom and other wet areas of ventilation systems	1	1	5	1	
Average	1,0	1,0	5,0	1,1	

PERFORMANCE	*COMPARISON BETWEEN SYSTEMS* *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE /PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust only	Hyb vent	Natural	
8. Transmission of external noise of ventilation systems (5 = very low transmission, 1 = very high transmission)	5	2	3	2	3
9. Generation of internal noise of ventilation systems (5 = very low level, 1 = very high level)	2	4	3	5	5
10. Transmission of internal noise (between rooms or apartments) of ventilation systems (5 = very low transmission, 1 = very high transmission)	2	4	3	3	5
12. Balancing of ventilation and heating system of ventilation systems (5 = very easy, 1 = very difficult)	4	4	3	2	
13. Energy saving potential of a dwelling with ventilation 12.1. electricity for fans	2	3	4	5	3
12.2. space heating	5	4	4	3	3
Comments:					

CONTROL	*COMPARISON BETWEEN SYSTEMS* *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE /PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust fan only	Hybrid ventilation	Natural ventilation	
1. Central controllability of ventilation systems	1	1	5	1	
2. User controllability of air flow and temperatures of ventilation systems	1	1	5	1	
Average	1,0	1,0	5,0	1,0	
Comments:					

COSTS	*COMPARISON BETWEEN SYSTEMS* *Rating 1 to 5, where 5 is very good, 3 OK and 1 bad*				*RELEVANCE /PRIORITY* *Please fill in 5=high, 1=low*
	Balanced ventilation	Exhaust fan only	Hybrid ventilation	Natural ventilation	
1. Initial investment of ventilation systems (5 = very low, 1 = very high)	1	1	5	1	
2. Running costs of ventilation systems (5 = very low, 1 = very high)	1	1	5	1	
3. Maintenance costs of ventilation systems (5 = very low, 1 = very high)	1	1	5	1	

Please check one box	Yes	No
4. Would you recommend/invest in hybrid ventilation for dwellings in order 4.1. to obtain a better indoor climate (air quality and thermal comfort)?		
4.2. decrease the costs for fan electricity by XX % annually as well as obtain a better indoor climate? *(translate into costs for your country)*		
4.3. decrease the energy use (cost) for ventilation and space heating with XX % annually as well as obtain a better indoor climate?		
4.4. decrease the LC-cost with XX % calculated on XX years?		
4.5. to enable individual monitoring of energy use (*to what cost?)*		
4.6. to enable web based monitoring and information		
Comments:		

7.2 New construction during the nineties

Annual number of dwellings completed, 1990-2000

	Notes	Total dwellings (1 000)						
		1990	1992	1994	1996	1998	2000	Average
Belgium		43,1	49,7	56,4	46,3	…	…	48,9
Czech Republic		45,2	36,5	18,2	14,9	22,6	25,4	27,1
Denmark		27,0	16,4	13,8	14,2	17,1	15,6	17,4
Finland		65,0	37,0	27,0	21,0	30,0	33,0	35,5
France		336,0	299,0	399,0	356,0	337,0	…	345,4
Germany		256,5	374,6	572,9	559,5	500,7	…	452,8
Greece		120,2	85,1	80,6	86,7	97,4	89,4	93,2
Netherlands		101,4	90,5	92,3	95,0	95,5	74,8	91,6
Norway		27,1	17,8	17,8	17,9	20,7	19,5	20,1
Portugal		…	55,0	62,0	…	…	…	58,5
Sweden		58,0	57,0	21,6	17,9	14,1	15,9	30,7
United Kingdom	a	203,4	179,4	193,4	188,9	179,7	179,2	187,3
Switzerland		42,5	39,2	52,0	44,2	35,2	32,9	41,0
Total		1325,4	1337,2	1607,0	1462,4	1350,0	485,7	1449,6

Source: UNECE Environment and Human Settlements Division, Housing database

a/ Permanent dwellings completed.

Remarks: New construction according to Eduardo Maldonado is for Portugal 26 000 dwellings.