New innovative domestic ventilation systems in the Netherlands

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ABSTRACT

Energy efficient building means automatically extra attention to energy efficient ventilation and air tight building. At this moment there are a number of new innovative domestic ventilation systems in the market as an alternative for the common MVHR systems. The types of systems range from advanced natural and hybrid systems to balanced hybrid systems. All these systems can combine a low energy consumption with a good indoor air quality and thermal comfort and guarantees on reliability and performance. A prerequisite for this is a good design and especially a good construction and commissioning. In the Netherlands a demonstration project is going on in which a number of these new systems are demonstrated and monitored. The first results from practice are very promising.

1. INTRODUCTION

The main purpose of ventilation is to maintain a good and healthy indoor environment.

That need is even launched until the first building regulations in the Netherlands (Housing Act 1902, Accession of "light and air"). In general the pollution sources in or belonging to a dwelling determine the necessary amount of ventilation. Air quality in principle increases with the amount of ventilation. However, the more ventilation, the greater the influence this gives the thermal comfort and energy use.

A good ventilation strategy must therefore ensure that these contradictions are united and optimized. The strategy here should be to provide a good, comfortable and reliable ventilation under all weather and user conditions.

The most important development in domestic ventilation systems over the last years is the improvement of controllability. This controllability was first required from the view of operation and reliability, but later also from the perspective of thermal comfort. With the recent introduction of the EPBD in Europe the controllability is more and more considered from the perspective energy efficiency at one hand, while maintaining a good thermal comfort and a good indoor air on the other hand. Special attention is necessary on well insulated homes where periods with heat demand are relatively short.

The level of building regulations and (mandatory) ventilation standards is always a major driving force on the decision for the type of ventilation system and the quality of the applied ventilation systems. The bulk of the applied ventilation systems perform just at the level required by the building regulations. A better quality, in practice is seldom applied.. In the Netherlands this is clearly reflected in the market penetration of the various ventilation systems. For example, the percentage balanced ventilation with heat recovery in new housing since the introduction of the Energy Performance Regulations has increased from less than 0.5% in 1995 (introduction of the Dutch Energy Performance Standard) to 50% in 2005. Also for the ventilation industry the building regulations is the main reason for the development of new ventilation systems and components.At this moment, especially the influence of ventilation in the Dutch Energy Performance Standard EPN (NEN 5128) is an important motive for new and innovative developments that should lead to reducing energy consumption.

This means reducing energy use by ventilation by limiting the infiltration losses, limiting the ventilation and reducing energy consumption by fans (or other auxiliary energy). Reducing energy consumption is only one motive for product development since the introduction of the Energy Performance Standard by the end of 1995. However, energy efficiency, irrespective of regulation, shows in itself for an occupier no decision criterion.

In principle, all developments and trends aimed at achieving an acceptable indoor environment against a minimally energy. The ventilation system must be of such reliability that the required performance attn indoor environment and energy over a certain percentage of the time of a year will actually be realized. The latter provides a number of preconditions regarding thermal comfort, noise, dependence on weather conditions and reliability.

2. TRADITIONAL CLASSIFICATION OF VENTILATION SYSTEMS

Ventilation systems have been distinguished, both in the rules to the market, according to the nature of the driving force for the supply and exhaust, that is, naturally or mechanically:

- Total natural ventilation: natural supply and PSV, possibly supplemented by local mechanical exhaust (cooker hood, fans for bathroom or toilet);
- Natural supply and mechanical exhaust;
- Mechanically supply and exhaust, in most cases combined with heat recovery.

With regard to this traditional distinction the development of hybrid ventilation systems is a new and distinctive trend. Hybrid demand ventilation means simply: natural ventilation as long as possible and mechanical ventilation if necessary to meet the requirements.This means:

- Air flows exactly regulated and controlled to the actual needs, based on thermal comfort and indoor air quality;

An even further energy reduction can still be achieved if the necessary auxiliary electrical energy is supplied by renewables, for example by photo voltaic energy or wind. The distinction that has been made so far in the regulations between natural and mechanical ventilation is no longer relevant. Other developments in the field of ventilation technology are generally deviated from these developments and classifications. However, the characteristics and performance may differ substantially from the traditional systems.

3. NEW DEVELOPMENTS

For new dwellings with high energy performance in the framework of the EPBD there is a need for an energy-efficient ventilation system to install, in combination with a high level of air-tightness of the building envelope. The known balanced ventilation systems with heat recovery are in themselves a good and tested concept. At the same time from the Dutch market there is a clear need to introduce equivalent alternative ventilation concepts, with equivalent performance with regard to energy, thermal comfort and indoor air quality.

Nowadays, the Dutch ventilation industry developed a number of new advanced energy-efficient ventilation systems that can be applied both in new energy efficient dwellings with as energy efficient retrofitting of existing dwellings. At the same time, also with regard to the traditional balanced ventilation system with heat recovery a number of optimizations and innovations has taken place.

3.1. Hybrid ventilation systems:

The aim of hybrid ventilation is using natural ventilation as long as possible and mechanical ventilation when necessary in order to provide the necessary ventilation rats and ventilation patterns at the lowest possible energy consumption. The exchange between the natural and mechanical ventilation modes is controlled automatically on the basis of an advanced monitoring and control system.

The most important research and development on the field of hybrid ventilation took place in a European research and development project (2002 – 2004): EC RESHYVENT (Cluster Project on Demand Controlled Hybrid Ventilation for Residential Buildings with specific emphasis on the application of renewables). In this project four different industrial consortia developed four totally different hybrid ventilation systems. The Dutch consortium, consisting of Alusta, Bergschenhoek, Cox-Geelen and JE Stork Air, led by TNO Build developed a hybrid demand ventilation system in 2005 which now has been marketed under the name Vent-O-Hybrid. The "Vent-O-Hybrid" concept is a full hybrid, demand-supply system with decentralized supply from the facade on a central room level and (mechanical) exhaust. For apartments it contains individual exhaust ventilation.

A characteristic element of the concept is that a duct work with extremely low resistances (< 2 Pa at 56 dm3 / s) is applied. Especially for this concept an extremely energy-efficient fan is designed with a power of 2 watts at a flow rate of 56 dm3 / s at 20 Pa. The combination of a duct with extremely low pressure, and an optimized cooker hood (resistance < 1 Pa at 56 dm3 / s), make this very low electricity consumption for auxiliary energy possible. The supply and demand flows can be controlled by one or a multiple set of parameters. The actively controlled supply grilles have compensation for infiltration and cross flow ventilation. The system is demand controlled on basis of CO_2 sensors in living room and bed rooms. The exhaust flow is automatically adapted and balanced to the necessary supply flows. This is done by a controlled valve in the outlet. At the time that the valve is fully opened and the flows are still not adequate then the extraction fan is turned on.

3.2. Balanced ventilation systems:

Central balanced ventilation with heat recovery is in the Netherlands now a common known and trusted product.

The system was already introduced in the Netherlands in the early 80's but has only received its market penetration by 1998 after the market introduction of the counter flow heat exchangers in combination with DC fans. The principle is a mechanical system with central supply and exhaust with a duct system providing al habitable rooms of supply, while the exhaust system is a duct system with exhaust devices in at least from the kitchen, the toilet and bathroom .

The most widely used system in the Netherlands is a system with one individual unit per dwelling. The design and execution of balanced ventilation systems in multifamily buildings may vary (individually or collectively) also with regard to the location of the supply and exhaust ducts, fans and the heat recovery unit. Regarding the performances on energy efficiency and impact on the energy performance standards MVHR is at present the main system in the Dutch market. Further energy optimization is to benefit from the following aspects:

- Link with actual ventilation demand, for example by CO_2 control
- Zoning of the system, that is, separate and flow control opportunities for certain areas (bedrooms, living room)
- Link with actual heat demand
- Control of minimum ventilation rates (ensuring disposal of pollutants into the indoor air)

3.2.1. Linking with CO_2 control:

A relatively simple option is a scheme by means of a CO_2 sensor in the runoff. In an earlier experiment commissioned by the Ministry of Housing to the effects of CO_2 control such a system is tested in practice, tested and measured. This experiment showed that this relatively simple way of effective demand.

3.2.2. Zoning:

One disadvantage of a central balanced ventilation system is that the central control regime. In practice shows that at night time systems often operate at the lowest fan position particular because of noise problems. This can lead to too low ventilation rates in the bedrooms. This problem can be solved by the zoning system, i.e., the ability to separate the flow for certain areas. This allows for example in a night situation the bedrooms with nominal flows ventilated while the maximum flow can be halved. This has a positive effect on both the energy and ventilation fans and the noise. Some manufacturers affiliated with the Foundation HR ventilation have investigated the possibilities for zoning in their devices to integrate.

3.2.3. Linking heat recovery with heat demand:

A recent study by TNO Building Research has shown that the effect of the heat recovery should be adapted to the thermal behavior of a dwelling. This particular behavior can be expressed in a new parameter: the turning point temperature. This is to a large extent determined by the façade and the thermal quality of the facade. Well-insulated homes have a relatively low turning point temperature. This means that there are relatively long periods were the heat recovery is not effective anymore. New MVHR units have the ability to regulate its heat recovery. The heat recovery should be off early to avoid overheating (by using a bypass). However, this will reduce the hours of operation and heat recovery. Switching off the heat recovery in the vicinity of the turning point temperature indicates a decline of the recovered heat from 3% (dipped from 30% to 27%) while the thermal comfort is improved (less over heating).

3.2.4. Ensuring minimum flow:

Monitoring a minimum flow rate in balanced ventilation systems is technically feasible and simple. From an energy point of view this has no or very limited impact (because of the heat recovery). Ensuring a minimum is important to maintain a certain air quality guarantee, even in the absence of residents (especially in relation to control CO_2). Mechanical ventilation systems also offer the possibility to a certain pressure level in the house (such as overpressure) for example to avoid air flows from crawl space to the building.

3.2.5. Local balanced ventilation

Local balanced ventilation systems are room bound ventilation systems designed as a compact single unit with mechanical supply and exhaust on room level for one room. They may also be combined with heat recovery and CO_2 control. It can be controlled on a simple level by means of manual control. It may also, incidentally technically simple manner, sophisticated done through presence detection, or controlled by CO_2 and/or relative humidity. However, there is a separate exhaust system needed to toilet, bathroom and kitchen. Therefore, for these systems it is necessary that a balance for the total dwelling is achieved.

At present, a number of products in the market or under development under this principle can be classified:

A specific development is the so called Climarad system, which is based on an integrated unit with a mechanical ventilation system that is combined with a radiator. With the help of CO2 sensor the flow of the ventilation unit is controlled. In addition, a kitchen ventilation unit is applied with a relative RH sensor. The ventilation units are equipped with a heat exchanger with an efficiency of 85%. In addition to these ventilation units, there are also three independent exhaust fans in the kitchen, bathroom and toilet. This exhaust fans are RH controlled to maintain an acceptable humidity in the sanitary rooms.

Another development on local balanced ventilation is the ACC (Air Climate Control) system by Innosource. This is a balanced ventilation system with decentralized supply units and central exhaust, controlled by a central control unit.

The supply consists of mechanical ventilation units, which are placed in the façade of every habitable room. The exhaust devices in the kitchen, bathroom and toilet are connected by a duct to a central mechanical exhaust unit.

The ACC system allows installation in both new construction as in retrofitting (as no supply ducts are necessary). Moreover, the Air Climate Control unit can virtually control an unlimited number of units. This makes the system suitable for residential buildings, offices, schools, hotels.

Because next to CO_2 production by occupants also other sources of pollution in buildings occur (building materials, finishing, furnishing) there is always a minimum ventilation rate maintained. The system consists of hardware (computer, powerline modem, phase linking and CO2 sensors) and software. The sensors are connected to a wall socket on the mains; signals go through the mains so additional wiring is not needed. The air quality can be measured in several areas. The signals are sent via a powerline modem registered in a computer and then analyzed. Signals can also be read remotely.

4. QUALITY OF DESIGN

The quality of the newest ventilation systems, available now on the Dutch market, is as product without doubt excellent. Nevertheless, the quality of the product itself does not imply t yet the guarantee of a good quality of the whole system. In particular the design and implementation are a major role in determining the ultimate quality. The design and realization of ventilation systems for homes is a process in which always feedback is made certain moments to all previously formulated requirements and assumptions.

It is noted that the final choice of an energy efficient ventilation system in energy efficient dwellings must be carefully aligned with the construction and heating (and cooling) concept. For example, in dwellings with heat pumps and low temperature systems not only the ventilation should be limited but also peaks and fluctuations should be avoided. In addition, information and education of residents is needed. Residents should therefore know how to deal with their home and how installations and ventilation should be used. Therefore it is necessary that instruction and information manuals are provided on the use and maintenance.

5. DEMONSTRATION

Currently a number of projects are organized to demonstrate the defined innovation ventilation systems. In a cluster of five projects with a total of approximately 500 homes the following concepts are demonstrated:

- A (simplified) CO_2 demand ventilation system based on the RESHYVENT system (company Alusta) in 80 homes (no hybrid exhaust),
- Local demand balanced ventilation with heat and CO_2 control (company Climarad) in elderly homes and existing apartments.
- Local demand-supply mechanical steering on the basis of CO_2 (company Innosource) in 73 homes
- Optimized central balanced ventilation with heat recovery combined with zoning and demand in two variants, based on CO_2 and on the basis of pre-programming (Brink Climate Systems)
- RESHYVENT system (Vent-O-hybrid)

In all these demonstration a comprehensive monitoring takes place of the performance of the systems with regard to energy, ventilation, indoor air quality and occupants experiences.

Thermal comfort of the systems is measured in the laboratory of Cauberg-Huygen Consulting Engineers with special attention to the combination natural controlled supply in combination with low temperature heating (like floor heating).

Table 1 shows the results of the measurements of CO_2 levels in six homes with the simplified RESHYVENT system.

Table 1: Results CO_2 measurements simplified REHYVENT system

CO_2 concentration [ppm]	*Dwelling*					
	1	*2*	*3*	*4*	*5*	*6*
Minimum	280	386	386	332	307	311
Average	468	502	579	522	446	572
Maximum	1752	899	1692	1392	1148	1171
Standard Deviation	173	99	184	197	116	216
% time < 800 ppm	95%	99%	90%	90%	98%	80%
% time 800.-.1200 ppm	4%	1%	8%	9%	2%	20%
% time > 1200 ppm	1%	0%	2%	1%	0%	0%

6. CONCLUSIONS

Legislation and building regulations always have been the main driving force to stimulate innovations in domestic ventilation systems and especially for the development of advanced energy-efficient ventilation systems. The most recent developments of the European ventilation industry concern new systems and new principles have a certain meaning and impact for the EPBD.

In the long term sustainability will also feature in the housing sector, as well as for new as existing housing. Also indoor air quality, thermal comfort throughout the year and the acoustic environment play more and more an important role.
In the most recent developments all these aspects are included to a greater or lesser extent. It is also notable to mention that there are different alternatives for energy efficient ventilation, not only with regard to manufacturers but also with regard to ventilation principles.

Both in terms of natural ventilation as mechanical ventilation, there are solutions available and there are applications in all possible situations, both for new and existing housing. Regarding the first monitoring results from practice it occurs that the performance of hybrid ventilation (Vent-O-Hybrid) and local balanced ventilations (Climarad system) is significantly better then traditional systems with only exceeding 0 to 2% of the time a CO_2 level of 1200 ppm.

Demand control ventilation shows excellent results however, provided that CO_2 sensors are properly installed and function. Low average air change rates and low CO_2 concentrations are combined in the both measured systems.