Comfort ventilation - a key factor of the comfortable, energy-efficient building

Ruedi Kriesi
Dr. sc. Tech.
Zehnder Group Management AG
Senior Project Leader
ruedi.kriesi@zehndergroup.com

Ruedi Kriesi is the owner of the Kriesi-Energie GmbH, vice-president and head of strategic group of Minergie association and technology-consultant of Zehnder Group. Until 2000 he was head of the energy office of Zurich Canton. In this function, he developed concept and brand Minergie with the economist Heinz Uebersax. Until 2010 he was head of Technology at Zehnder Group, where he introduced the comfort ventilation business. For 12 years he was member of the Swiss Commission for Energy Research and he is a single member of the Swiss Academy of Technical Sciences. Since 1990 he lives in Wädenswil in a zero heating energy dwelling, which he built with the architect Ruedi Fraefel.

1. Introduction

Passivhaus in Germany and Austria, MINERGIE® in Switzerland, Klimahaus in Italy – for all these brands heat recovery ventilation is mandatory thanks to its positive effect on energy consumption. Thus, these brands are important drivers for the introduction of this new technology. Whereas Passivhaus has reached just a few percent of the total new-build volume in Germany, about 25% of the total new-build volume in Switzerland is certified by MINERGIE®, creating a very important market for all energy efficient technologies.

In Holland, heat recovery ventilation is a cost effective means to fulfill the building code both for ventilation and energy efficiency. But whereas in Germany and Switzerland the image of heat recovery ventilation is good and improving further thanks to its broad promotion with its user benefits, its reputation is clearly inferior in Holland, where investors often apply the technology without approval by the users. The positive perception becomes clearly visible with its denomination in Switzerland, where it is called Comfort Ventilation.

Houses are built more and more tightly for air infiltration, in order to reduce energy needs for heating and cooling and to increase their effect as barriers to external noise. This means, however, that interior air quality requires additional attention – by frequent manual operation of windows during short periods or by installation of an automatic air exchange system.

2. User benefits of comfort ventilation - driver for its fast introduction

The main driver for comfort ventilation is the improvement of indoor climate:

- Many people suffer from increasing traffic noise - the automatic air exchange allows keeping the windows closed most of the time, maintaining their function as effective noise barriers, especially at night, when the inhabitants are asleep and manual operation of windows is not possible (**Figure 1**).
- Thanks to the automatic air exchange, no bad odours can accumulate and no mould can build up in a cold climate, even with users who are often absent for work or vacation with no possibility to

1 plane with window closed: 30 dBA in room.

1 plane with window inclined: 45 dBA in room. Equal to 32 planes with window closed!

Figure 1. Fresh air with windows closed - noise-absorbing windows can properly perform only when closed.

regularly operate the windows for humidity control, or with tenants who don't care about air quality and keep windows continuously closed.
- Comfort ventilation also protects against dust through open windows. For people with hay fever it can even be equipped with pollen filters.

For the user, these advantages are clearly more important than the reduced energy consumption. Thanks to the increased comfort the value of an apartment may be increased by 10%, amounting to 1 000 €/a at an annual rent of 10 000 €, whereas the effect on the energy consumption for space heating thanks to the heat recovery amounts to about 25% or 400 kg oil/a and is worth about 300 €/a only at today's oil cost of -.75 €/kg.

Besides higher rents the investors can benefit from a higher long-term value of their building. Since it is equipped with the latest technology, which will become standard equipment within only a couple of years, the building will provide a modern standard for a longer period of time.

Comfort ventilation increases the benefit of a noisy construction site, because the building can be operated with closed windows most of the time. And again, the higher value of the site in many places outweighs the extra investment for the better technology.

3. Reduced energy consumption thanks to comfort ventilation

Reducing energy consumption by thermal insulation and heat recovery ventilation costs much less than providing renewable energy for space heating, down to very low consumptions. This experience was made with the Wädenswil zero-heating dwellings, built by the author with the architect Ruedi Fraefel as early as 1990, where the author has lived ever since.

With the improvement of thermal insulation of buildings the proportion of air exchange on the energy consumption has continuously increased. In the 70's, it may have counted for 10% of total demand for space heating of a single-family home, while it has risen to 35% today and up to 70% in apartment buildings.

Comfort ventilation reduces energy consumption by transferring heat from the return air to the fresh supply air. This is done by a heat exchanger, in which thin membranes made of plastics or aluminium separate the two airflows. About 85% of the heat contained in the return air is recovered, heating the cold supply air. In addition, the automatic ventilation helps to reduce the air exchange in the apartment, because the fresh air is supplied to the bedrooms and reused in the hallway, in many cases also in the living room and finally in the bathrooms and kitchen, from where it is returned to the ventilation unit. If manual ventilation through windows is the only way to get fresh air, the windows often remain open during long periods, increasing the air exchange far above an optimum value.

To move the two air streams, two small fans are operated, consuming electricity. To assess the energetic quality of comfort ventilation, the amount of heat recovered must be compared to the electricity consumed by these fans, as is common to qualify heat pumps. For heat pumps, an annual or seasonal performance index (API or SPF) is defined as the ratio of the annually delivered amount of heat and the annual consumption of electricity, reaching 3 to 5 for modern installations. An equal index can be defined for comfort ventilation systems, by comparing the annually recovered amount of heat with the annual electricity consumption. Table 1 shows that the corresponding values of Comfort Ventilation are much better.

Obviously, if the unit is operated all year round, the resulting annual performance index, API, is inferior to a resulting seasonal performance index, SPF, for seasonal use. Indeed, most users operate the units all year round to profit from improved protection against outside noise, dust, pollen and pests such as spiders, insects or snails, also in spring and fall, when temperatures outside and inside are very similar.

As shown in **Table 1**, exhaust ventilation reduces the heat demand of a flat with good performance indices as well, but to a much smaller degree than heat recovery ventilation. This technology extracts air from bathrooms and kitchen by a central fan. Fresh air is pulled into the bedrooms through openings in the window-frames by the slight under-pressure created by the fan. This reliably avoids mould in most cases, but it does not offer a good barrier against outside noise and no effective filter can be placed in the window openings. Additionally, wind will often create larger pressure differences around the house, resulting in very different air supply rates or even negative air flow directions in the bedrooms and living room.

4. Early home market in Switzerland with MINERGIE®

The standards for MINERGIE®-buildings all require an automatic air exchange. Since a very low consumption of non-renewable energy is required at the same time and all forms of renewable energies tend to be expen-

Table 1. Energy gain of Comfort Ventilation (or Heat Recovery Ventilation, HRV) compared to ventilation through windows and by exhaust fans.

		Window ventilation	Exhaust ventilation	HRV, 85% recovery	Gain compared to window vent.	
					Exhaust v.	HRV
Air exchange rate	$m^3/h - h^{-1}$	190 – 0.5	135 – 0.35	135 – 0.35		
Energy demand for heating air exchange:						
- Zurich (3400 HDD)	kWh/a	5170	3670	550	1500	4620
- Milano (2200 HDD)	kWh/a	3340	2370	360	970	2980
Energy demand fans			(15W)	(30W)		
- Year round operation	kWh/a	–	130	260	-130	-260
- Seasonal operation (4 500 h/a)	kWh/a	–	62	135	-62	-135
Performance Indices API/SPF Zurich	–				11/24	18/34
Performance Indices API/SPF Milano	–				7/15	11/22
Net energy gain						
- annual/seasonal oper. Zurich	kWh/a*				1240/1380	4100/4350
- annual/seasonal oper. Milano	kWh/a*				710/850	2460/2710

* 1 kWh_{el} = 2 kWh_{therm}

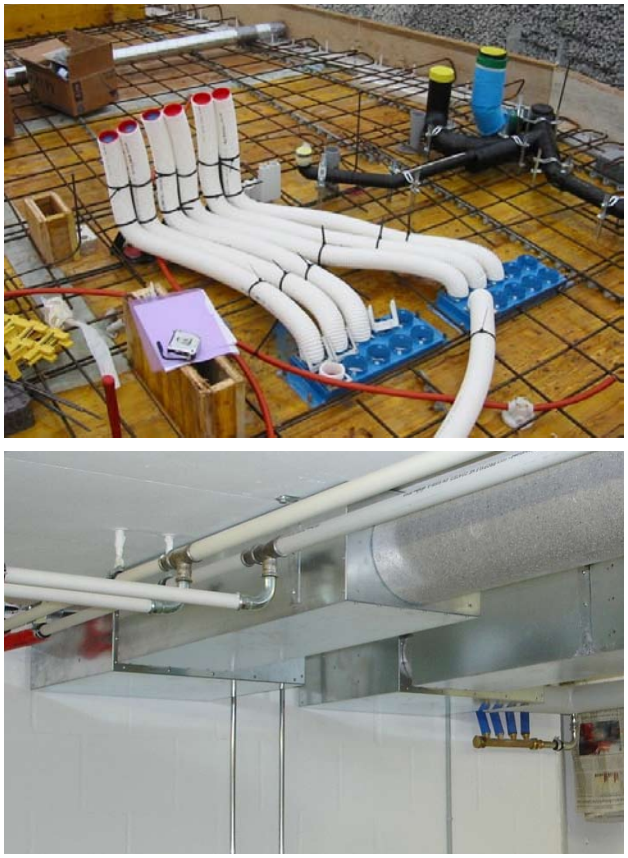

Figure 2. Two blue mounting plates (top) are nailed to the wooden formwork and connected to the ComfoTube ducts, later covered by liquid concrete. Once the formwork is dismounted, the distribution casings can be bolted to the mounting plates, then visible on the ceiling. Below right both the distribution casings for fresh and return air can be seen, connected to the sound absorbers in front of them.

sive, 97% of all MINERGIE®-buildings are equipped with Comfort Ventilation. Thanks to the 20 000 certified MINERGIE®-buildings existing today, the brand therefore offers a perfect platform for the continuous improvement of ventilation systems.

Zehnder entered the Comfort Ventilation business by buying the ComfoHome-concept from UC Uebersax Consulting in the year 2000 and only two years later the Dutch manufacturer of heat recovery ventilators Storkair. Consequently, Zehnder was the first company to offer complete standardized home ventilation systems with its own products (**figures 2 to 4**). These systems can be combined with all types of heating systems, such as with gas boilers, wood stoves or wood boilers or heat pumps.

Its central component are the 90% efficient ComfoAir heat recovery units for the application in homes, manufactured by Storkair since 1995. Another key component is the flexible, double wall, all plastic ComfoTube duct, which has become the dominant way of air distribution for home ventilation first in Switzerland, later in Germany and Italy. This is thanks to the good air tightness of the required small duct diameters and the easy installation of the low-weight ducts. With ComfoHome Zehnder also introduced central air distribution casings, from which all ducts supply the air to the rooms in parallel. This results in small differences between the air flows, even without any adjustments, and in a good noise barrier between connected rooms. Zehnder also became the first to apply a standardized soil heat exchanger, ComfoFond, to avoid freezing of the heat ex-

changers at very low outside temperatures, using renewable energy. In the mean time, Zehnder has patented a soil heat exchanger on the basis of an anti freeze loop, heating the supply air of the ventilator unit with a traditional brine to air heat exchanger. This concept avoids frequent mistakes with the buried air ducts.

Kitchen hoods normally evacuate additional exhaust air over the hood. Since houses with Comfort Ventilation are normally very air tight, a special air supply duct must provide additional air when the hood is in operation, or a window must be opened. In both cases a lot of cold air will make the kitchen uncomfortable during hood operation. Types with active charcoal filters avoid cold air, but the filters must be replaced frequently, since the coal also absorbs humidity, abundantly available above the cooker. Zehnder has developed a third solution in cooperation with V-Zug, leading Swiss manufacturer of white wear. The hood is optimized for minimal use of return air, so that it can be coupled to the heat recovery ventilator. This results in a very low noise level of the hood, no cold intake air and infinite use of the same filter, which can be cleaned in the dishwasher.

5. Some myths on Comfort Ventilation

As all new technologies, Comfort Ventilation is opposed by traditionalists with experience from bad installations but often also with entirely incorrect arguments:

a) In homes with Comfort Ventilation it is not possible to open windows: Balanced ventilation applies two independent fans for the air in and out. Hence open windows do not affect it. Obviously the energy requirement of the building will increase with open windows. In a good installation, bad air quality will occur very rarely. Hence the desire to open windows will be rare as well. But if the air is bad or if there are other reasons for opening windows, such as listening to outside noise or dumping something to the garden, it is always possible.

b) Air ducts are unhygienic and microbes will develop: The air distribution system is positioned within the thermal envelope of the building. Therefore it is as warm as the rooms and the air in the system cannot condense any water. In dry ducts, no microbes can develop. Additionally, correctly built systems use filters both in the supply duct and in the vents of the return air, and the systems must be accessible for cleaning according to German and Swiss regulations. Tests on many installations have shown lower concentrations of microbes in the supply air than in the air intake, because a part will remain in the filter. The only source of microbes can be a dirty filter in the air intake, ahead of the heat recovery unit, where the air is still as cold and humid as outside, for example in autumn.

c) The systems are noisy: Correctly dimensioned systems apply very low air velocities in the distribution system to keep pressure drops low. Thus the fans will run at low speed, creating little noise. This remaining noise must be lowered to the severe maximum limit of 25dBA by noise absorbers, according to German and Swiss regulation.

d) The system will create unpleasant draft: Comfort Ventilation in a dwelling for 3 to 5 people or 100

Figure 3. Each country has its own construction principles. Whereas in Switzerland and Austria most concrete ceilings are poured on site onto site built wooden formwork, in which round ComfoTube ducts can be mounted, prefab hollow ceiling-elements are applied in Northern Germany, on which flat ComfoTubes are positioned in the layer of the impact noise insulation.

Figure 4. Comfortable energy efficient homes often are equipped with standardized combined units: A Zehnder ComfoBox provides not only heat recovery ventilation to the building on the left, but also space heating, space cooling and domestic hot water by an energy efficient soil to water heat pump, reducing cost for planning and installation.

to 200 m² moves 100 to 200 m³/h only, since it has to remove bad odours and excess humidity only and it is not used for heating or cooling purposes. Thus airflows are so low that it can only be sensed by holding the hand in front of a grill or close to a passage under a door, but never in the room at some distance from grills and passages.

e) Comfort Ventilation means air heating with dry hot air near air vents: The great majority of homes with home ventilation apply water systems for the distribution of heat, hence radiators or floor heating. The ventilation system is used for hygienic purposes only and the fresh supply air is heated by heat recovery only. Hence the temperature of the supply air always remains slightly below room temperature when it is cold outside and slightly above, when it is hot. Only traditional smaller Passivhouses apply air heating in order to keep cost low.

f) Comfort Ventilation means dry air: The systems will always reuse the supplied air in several rooms, thus reducing the amount of air required for a given level of air quality. Fresh air is brought into the bedrooms. It is then lead through the hallway and often through living rooms as well before it is returned from bathrooms and kitchen to the heat recovery unit. Since less air is required, the apartment is less dehumidified by dry outside air in winter. If houses with correctly dimensioned Comfort Ventilation still are too dry, it is due to a leaky envelope or to insufficient or entirely missing source of water vapor in the apartment. Enthalpy recovery exchangers, returning not only heat from the exhaust air but also humidity, can reduce the problem in many situations. However, a relative humidity inside of 35% at temperatures below freezing is sufficient. High indoor humidity favours mite growth and increases the risk of mould close to heat bridges of the thermal insulation.

g) Comfort Ventilation leads to bad air quality: The automatic and continuous air exchange leads to better air quality than with manually operated windows. However, Comfort Ventilation cannot solve the problem of hazardous emissions from building materials, such as formaldehydes from glues or paint. Many such gasses are harmful or just annoying in concentrations over several orders of magnitude. Comfort Ventilation can constantly reduce the level of all gasses a bit, but it would be very costly and most uncomfortable to increase the air exchange rate to such an extent. Gas emissions from materials must be avoided at the source; there is no other solution to this.

6. Conclusion

Comfort ventilation is an effective technology not only to increase indoor comfort but also to reduce the energy consumption for space heating and cooling of buildings. This double advantage is recognized in a growing number of countries. The only reason its application is not spreading even faster is the traditional thinking of both planners and users – air has always come into the buildings through windows, why should this be changed? But also wooden wheels had been used for centuries and resistance to these "modern rubber tyres" on horse trailers had been intensive.

MINERGIE® - brand that created a large market for comfortable, energy-efficient buildings

The first 200 buildings were certified according to the MINERGIE®-standard in 1998 in Zurich. In 2010, about 25% of the total new-build market in Switzerland and a total of 20'000 buildings with close to 20 mill. m² of heated floor area were certified by this brand, lifting it within 15 years to the by far cheapest and most effective instrument for energy policy in the country.

This huge success was possible thanks to a pragmatic technical approach and to promotion on the basis of the user-benefits:

- MINERGIE®-technology: With the zero heating-energy dwellings built in Wädenswil in 1990, it was shown that an air tight and well insulated building envelope, combined with heat recovery ventilation can reduce the energy demand for space heating to a very low level at reasonable cost. At this low level, it doesn't really matter, if still fossil fuels are used and, if more expensive renewable energies are applied, they can be afforded thanks to the low requirement.

- MINERGIE®-promotion: Traditional promotion for energy saving measures in all industrialized countries asked for contributions from users and investors to reduce the countries' energy dependency. But when an individual investor spends a lot of money in a new home, he cannot afford any risk and he would invest in a proven concept only, hence in a traditional home with high energy consumption.

  This learnt with long lasting fruitless efforts, MINERGIE®-promotion was based on user benefits, also learnt with the Wädenswil zero energy dwellings: The airtight and well-insulated building envelope protects the user from external noise. Thanks to Comfort Ventilation, the windows can remain closed most of the time, keeping dust and pests outside and avoiding any risk of mould.

  For the investor, these advantages of the energy efficient building actually are worth more than the energy savings. Once the building industry had understood that the investors would listen to this kind of promotion, planners, installers and system suppliers copied the arguments and sent them to the market with their means of communication.

Accordingly, MINERGIE® was defined as the combination of increased quality of life, increased competitiveness and reduction of non-renewable energy to a sustainable low level. This new philosophy has entirely changed the image of energy efficiency in Switzerland. Whereas it was a subject reserved for the green corner of society before, it now is accepted by all parties and by all types of investors in the country.

MINERGIE® was developed by the author, who at that time was the head of the Zurich canton energy office, together with Heinz Uebersax, a marketing consultant who was the initial owner of the brand and who developed it privately at first. Today the brand is owned and managed by the MINERGIE® association, with all the Swiss cantons, the federal government, system manufacturers, planners and professional building investors as the main members. A strong position is held by the cantons, which are responsible for the building regulations in the country. The fact that their information to the market is supporting the MINERGIE® philosophy has accelerated the acceptance of the brand.

Another important early support for the brand was provided by the bank of the canton of Zurich: In 1998 already they offered a special mortgage rate for MINERGIE®-buildings with the arguments, that these houses would maintain their value better thanks to their high comfort and that they would not be affected by a sudden increase in energy price, hence that they present a smaller risk for the bank. In the meantime, it has been shown by the University of Zurich, that the resale value of MINERGIE®-homes indeed is higher than of comparable buildings.

The brand is applied on a broad scale in Switzerland and Liechtenstein. There is a licensee in France. In 2011, it is planned to create an organization for the export of the brand and the related knowledge for any organization who wants to install a similar brand in its home country.

For more information: www.minergie.ch