Ventilation with heat recovery is a necessity in "nearly zero" energy buildings

Claus Händel
Dipl.-Ing., Tech. Secretary
European Ventilation Industry Association (EVIA), Brussels
www.evia-ventilation.eu
haendel@fgk.de

With between 30% and 40% of the EU's annual energy consumption caused by the building sector, we appreciate that the target laid down in the Energy Performance of Buildings Directive (EPBD) to install a "Nearly Zero Energy Building" is a must for the coming years.

Although this type of building is not yet completely defined, we can be sure that the first priority is to reduce energy demand, whilst the second is to increase renewable energy in buildings.

However, the basic objective of a building is not to save energy, but rather to provide the right balance between heating and cooling, to provide good indoor air quality, and to achieve these objectives at acceptable standards and in an efficient manner to proved high user productivity.

We all know that in new buildings the thermal insulation and air tightness of buildings has reached high levels in the northern EU Member States, and further improvements will only bring few benefits at a high cost.

This reality will soon also be valid in the other Member States. That means that the issue of energy demand in terms of ventilation is increasingly occupying the minds of building designers. In principle, there are two ways to reduce energy demand for ventilation:

- Lower the ventilation rate; and/or
- Recover the energy from ventilation.

On the other hand, there are three emission sources in buildings which have to be considered:

- Human emissions (CO_2, humidity, odours);
- Emissions created by humans (water in kitchen, bathrooms etc.); and
- Emissions of buildings (pollutants, solvents, odours, VOC etc).

This means that, depending on the use of the building, different emissions sources will have greater prominence. This also means that the ventilation rate cannot be lowered under a certain limit, because this will cause several problems with the building (e.g. the potential deterioration of the material) or the user (e.g. bad air quality). Demand-controlled ventilation is a strategy to detect the ventilation need and to reduce "needless" ventilation (see Rehva March 2011, Mari-Liis Maripuu), but in the end there is a need for a certain ventilation rate depending on the individual and the building needs in order to prevent the building from being damaged by insufficient ventilation and to ensure the provision of good indoor air quality with a high level of comfort. This ventilation rate has to be heated up in Winter and cooled down in Summer. There is no other means to save this thermal energy than by introducing heat recovery in the ventilation system.

Heat recovery in ventilation systems

This means that in the near future the heat demand for ventilation will achieve a dominant percentage of the energy requirements for residential and non-resi-

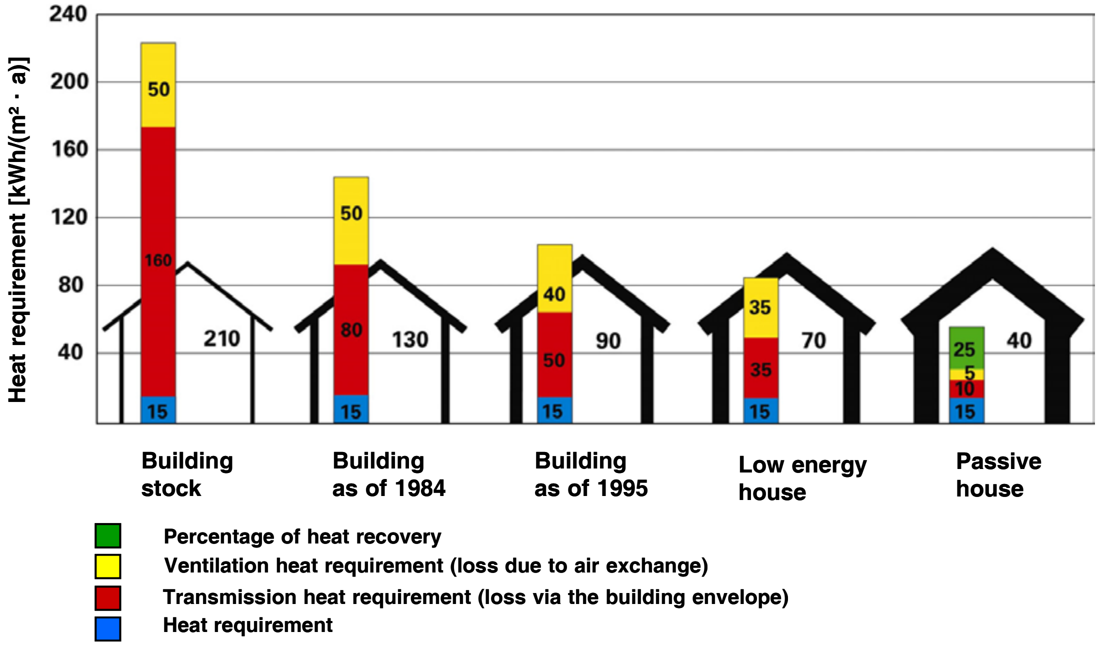

Figure 1. Percentage of ventilation heat demand of residential buildings in Germany.

dential buildings due to the high thermal insulation standards.

In low energy and passive houses, at least 50% of the thermal heat is caused by the ventilation. The example of passive houses shows that the thermal heat requirement can only be significantly reduced by using heat recovery in ventilation systems (**Figure 1**).

Coming back to the "Nearly Zero Energy Building", we have to discuss first the definition of heat recovery. The reduction of energy is commonly understood to be characterized by passive systems such as thermal insulation, building tightness, sun protection, among others, and to make up the rest a building should use renewable energies for heating and cooling systems. Ventilation does not fit strictly into this, because theoretically it can be realized in many cases, and, in the opinion of many people, without a machine, and we have to compare a passive system (such as window airing) with an active system (ventilation with heat recovery). This leads to the question: does heat recovery reduce energy demand or when used in ventilation is it a renewable energy source?

Initially it is not straightforward to answer, and it is always a matter of chosen boundaries (e.g., energy balance boundaries). The following points can, however, be stated:

1. The heating source of outside air is usually to be seen as a renewable energy source (for example, an outside air heating pump for heating).

   Thus the outside air is energy from an environmental source, and the exhaust air of a ventilation system becomes outside air once it leaves the building. The use of exhaust air as a heat source is, due to the higher temperature, more efficient than the use of outside air.

2. A large part of the internal heating sources in buildings comes from renewable sources:

   a. Passive solar gains via windows (100% renewable);

   b. Persons (100% renewable);

   c. The renewable percentage of the power electricity from the grid (currently approximately 10%, and increasing); and

   d. The renewable part of the space heating, for example, biomass, geothermal energies, and environmental energies (currently approximately 10% and increasing).

Therefore the ventilation heating losses of up to approximately 40% come from renewable sources. With heat recovery, this heat can be almost completely recycled. In addition, the heat recovery can once again make the energy available that the heat recovery system has already retrieved and conveyed into the building.

So heat recovery is a revolving process and keeps the energy in the building, and we need at least a machine, a heat recovery unit, to realize this. So the conclusion is:

Heat recovery in ventilation systems is a renewable energy source in analogy with a heat pump.

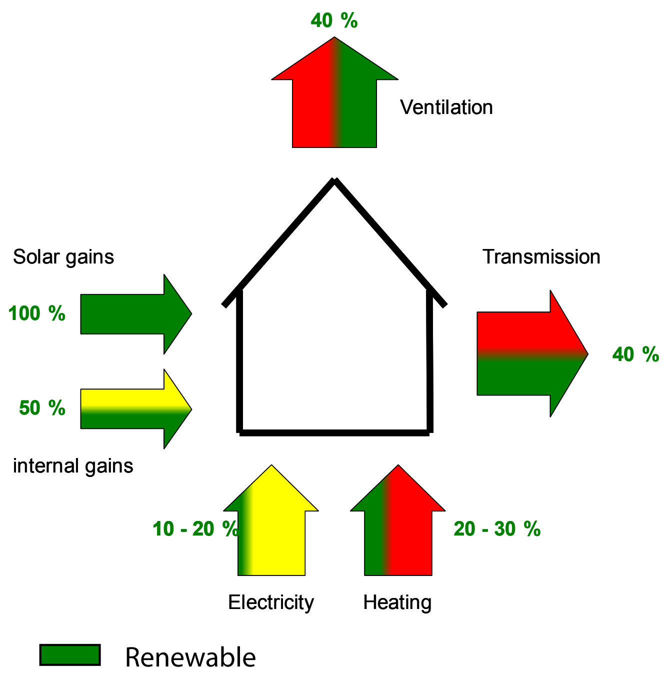

Figure 2. Regenerative percentage of the heat recovery.

Looking at the market for heat recovery systems, we need to divide up the different segments into residential buildings, non-residential buildings, and industrial systems.

Heat recovery in Non-Residential Buildings

Sometimes, it is hard for an expert to understand why efficient heat recovery is not generally accepted and used in ventilation systems of non residential buildings, because the cost efficiency of heat recovery is in most cases outstanding.

Table 1 shows the impact of legal and normative aspects in the energy efficiency of buildings and the result on heat recovery systems.

Before 2007 no legal aspect defined minimum heat recovery in non-residential buildings in Germany. As a result fewer than 50% of units had heat recovery. The impact of EPBP and its target to reduce the energy demand of technical building systems in EnEV 2007 and 2009 by 2010 gave rise to a significant increase in heat recovery units.

Table 1. Heat recovery in Non-Residential Buildings [2].

Year	Turnover Mio €	Export Mio €	Percentage	Units	With heat recovery	Percentage
2008	431	111	25,8%	42.236	15.569	46%
2009	379	97	25,5%	33.476	15.148	55%
2010	390	103	26,4%	36.476	19.791	67%

If we look into the near future and the target of a "Nearly Zero Energy Building", we cannot see any possibility other than efficient heat recovery. This does not mean that the temperature ratio or the humidity ratio of a heat recovery unit must have the maximum possible values. Depending on the use, the climate, and the thermal loads of a building, a detailed yearly calculation of an optimized efficiency is necessary.

Heat recovery offers some other opportunities which help to reduce energy demand for cooling in Summer. Firstly, heat recovery in Summer during the cooling period reduces the chiller capacity and the chiller consumption in the same manner as in the heating period.

In most European climate zones, the energy recovered in Summer will be relatively small in relation to the possibilities in winter, but heat recovery systems can be upgraded with indirect humidification systems in the exhaust air stream.

Indirect evaporative cooling

In connection with efficient heat recovery, the cooling effect of evaporated water can be used for cooling the supply air in the central air-handling-unit (AHU). The cooling effect is mainly used indirectly in European climate zones, thereby ensuring that the supply air does not increase the humidity in the rooms. A basic need is to improve thermal conditions.

Indirect evaporation cooling with exhaust air

The **exhaust air** is cooled down as much as possible by being sprayed with water depending on exhaust air conditions. With an efficient heat recovery system the "cold" is then transferred to the supply air side. These systems are highly suitable when, after evaporation, the exhaust air temperature is, in cooling mode, lower than the outside air temperature. For example, when rooms in a building remain relatively cool via the storage or additional room cooling systems, and the humidity load is low.

Indirect evaporation cooling with outside air

For these systems, the **outside air** is cooled as much as possible by being sprayed with water. The "cold" is then transferred to the supply air or to recirculation air.

Table 2. Ventilations rates in Residential Buildings EN 15251 [4].

Category	Total air exchange rate house		Air exchange rate habitable rooms (living, bedrooms, study)		Related exhaust airflow from wet rooms		
	Per m² dwelling 1 [l/s/m²]	Ach (at ceiling height of 2,5m)	Per person 2 [l/s/pp]	Per m² 3 [l/s/m²]	Kitchen 4a [l/s]	Bathroom 4b [l/s]	Toilet 4c [l/s]
I	0,49	0,7	10	1,4	28	20	14
II	0,42	0,6	7	1,0	20	15	10
III	0,35	0,5	4	0,6	14	10	7

These systems are highly suitable when in cooling mode after the evaporation the outside air temperature is lower than the room temperature. For example, when the thermal room load is relatively high in a building (i.e., in industry).

These examples show that a heat recovery system is more than a simple unit to reduce energy demands. Instead, it can be a kind of energy generator providing renewable energy.

Heat recovery in Residential Buildings

In general we can state that the same principles for non residential buildings are also valid for residential buildings. There is however some differences that must be taken into account:

- Fewer people per square meter
- Lower thermal loads
- Higher water emissions
    - o Risk of mould
- Multiple use (living rooms, bedrooms, kitchen, bathroom) with different ventilation demands in small systems
- Typical ventilation systems are different:
    - o Balanced systems with heat recovery
    - o Exhaust systems
    - o Positive ventilation systems
- Relative small air-change rate compared to other buildings (**Table 2**)
- Predesigned systems with serial ventilation units
- Significant interaction with the tightness of the building envelope.

We also need to note that inhabitants are used to opening windows for airing, with the result that in some cases the ventilation rate is too high (resulting in high energy losses) or too low (resulting in a risk of mould), depending on the individual. So in all cases we have to compare window airing with fan assisted systems.

The supplementary study on Ecodesign Lot 10 shows the possible energy savings of ventilation systems with heat recovery [3]. Although the typical design criteria for residential ventilation are different within the EU Member States, the resulting ventilation air change rates are rather similar at an average rate of approximately 1.3 m³/(h m²).

This results in a total EU-average amount of 369 TWh per year of thermal energy in the heating season for the ventilation rate needed. These high values show that a focus on electrical energy for fans is completely misleading and that this thermal energy can only be recovered with heat recovery systems. If we consider that heat recovery is widely installed in EU Member States, nearly 80% of this energy can be saved.

A scenario made in Germany for Residential Ventilation show the potential of energy savings if we consider, that up to 2020 HRV will be present in 10, 20 or 30% of the building stock (**Figure 3**). This will result in a CO_2-Savings potential of approx 6 Mio to/year. If we expand these values on EU 27, we can expect a CO_2-Savings potential of approx 18 Mio to/year or 3% of the total 20-20-20 target of Europe. A significant value.

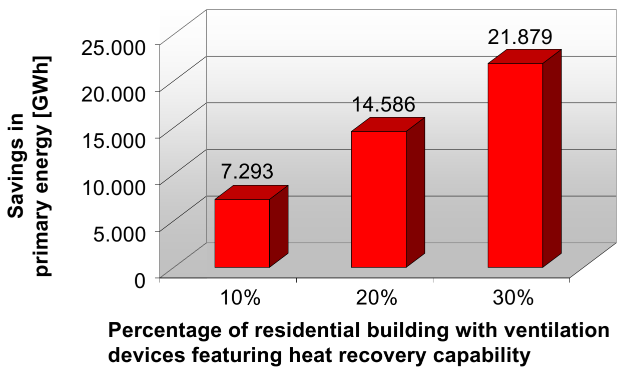

Figure 3. Primary energy savings potential by using ventilation systems with heat recovery in residential buildings.

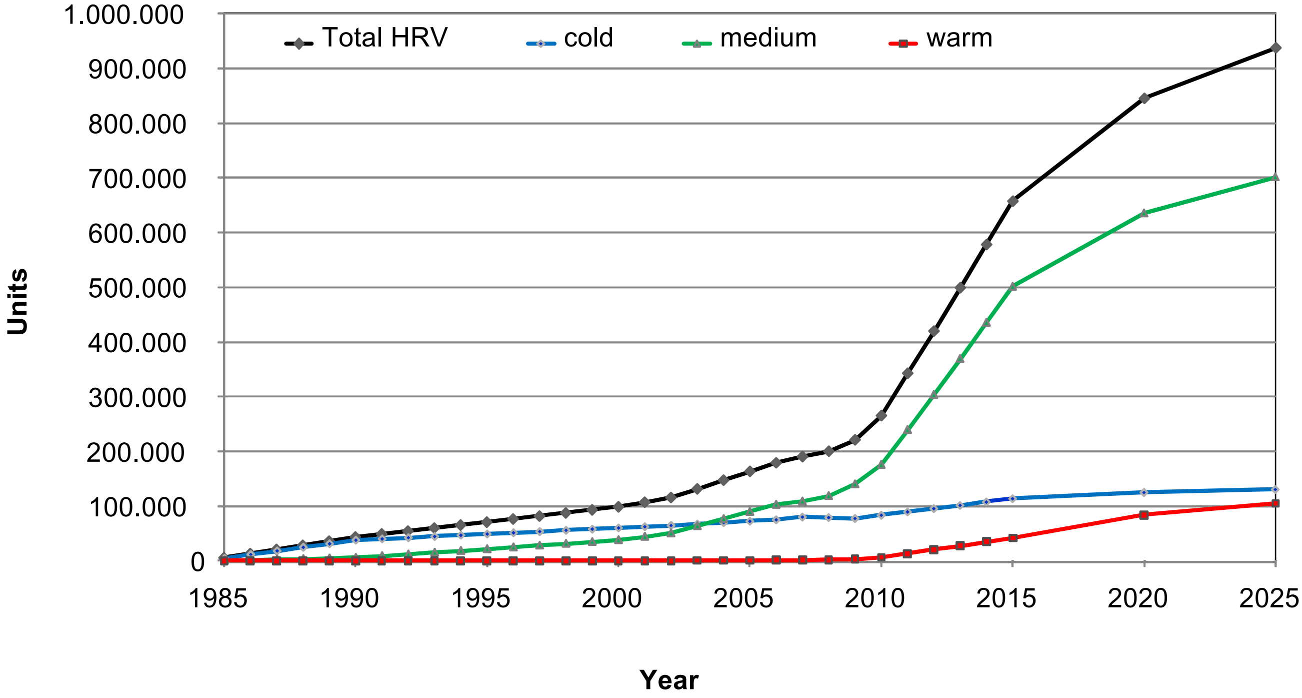

Figure 4. Estimated market for single dwelling ventilation units with heat recovery [3] and EVIA.

In Non-Residential Buildings we can expect the same amount of CO_2-Savings, so in total we talk about reaching 6% of the EU targets.

If we review the European market, we can see that the market for HRV started in the 1980s in the Scandinavian and Dutch markets, dominating them until 2000. This is a direct result of regulation and the climate impact.

From 1995, the market in medium climate countries began developing in the bigger countries such as Germany, the UK, and France, and we are currently seeing a dramatic rise in all the medium climate countries with their high populations and a degree of saturation in the cold climates. This results from the energy discussions and a changing perception from the building owners with regard to energy, health & comfort, and special promotion programs.

Countries in warmer climates do not yet have any significant markets for HRV. Up to now, heat recovery systems have not been mandatory in most of the EU Member States. This must change, because otherwise the energy targets for 2020 will not be reachable.

The mission of EVIA is to be a thought-leader on ventilation issues, helping to profile it in the political discussion, taking into account the significant impact of ventilation on energy, hygiene, health, and comfort. It is important to learn from the countries with considerable experience in ventilation systems and solutions to avoid mistakes made elsewhere in the past.

EVIA supports the goals of Ecodesign to establish a transparent European market for ventilation units with heat recovery without artificial barriers.

References

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[4] EN 15251 Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics, May 2007 (see Rehva journal March 2011).