Automatic volume flow balancing in ventilation units

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Controlled ventilation with heat recovery plays an increasingly important role not only in new buildings, but also in energy efficient refurbishments due to the high savings potential and better indoor air quality. Basic information on the need for ventilation (indoor air quality, health and comfort) as well as on energy efficient ventilation systems with heat recovery can be found in passipedia.passiv.de *

In practice however, as a result of incorrectly or inadequately balanced systems, the potential for reducing heat losses frequently cannot be fully exploited, a fact that has often been proved through measurements and subsequent examination of new systems. Within the European Project 3ENCULT about energy efficient retrofit different concepts to achieve long term air flow balance have been investigated.

Significance of volume flow balancing

If a ventilation system is operated in unbalanced state (e.g. due to filter clogging) the ventilation heat losses will increase accordingly since some of the air volume (due to the resulting over- or under pressure in the building) enters the building through leaks in the building envelope (thus bypassing the heat recovery system) rather than via the heat recovery system.

A ventilation system with heat recovery should always be operated in a balanced way. This is the only way to ensure long-term heat recovery efficiency of the ventilation unit and thus achieve energy savings compared with exhaust-only systems. Devices with automatically balanced volume flow rates can secure balanced operation on a permanent basis.

Besides reducing the ventilation heat losses, automatic balancing of volume flow rates also has another essential purpose, namely the prevention of structural damage, which plays an especially important role in relation to historical buildings. If warm, humid indoor air penetrates the thermal building envelope towards the outside through leaks, condensation occurs at materials with temperatures below the dew-point temperature and may lead to structural damage.

In terms of building physics, the risk of damage due to moisture in historical buildings is much higher than in the case of new constructions; in historical buildings, it may be difficult to achieve a consistently airtight building envelope which is equally effective all over, on account of problems due to existing structures such as wooden beam ceilings. In order to compensate for these weak points, balanced operation of the ventilation system becomes even more important.

Available practicable methods and accuracies

Large ventilation systems with ventilation performance > 600 m³/h are usually equipped with a system which ascertains the volume flow rate by means of a measurement of the effective pressure at the fan's inlet. With this method, a high rate of accuracy could be achieved; laboratory measurements of ventilation units with air flow rates > 600 m³/h (within the framework of Passive House component certification of ventilation units with ventilation performance > 600 m³/h, see www.passiv.de) prove that at upper and middle air flow rates deviations (between device measurement and laboratory measurement) of less than 3 % are possible (**Figure 1**).

Today smaller ventilation units for single dwellings (< 600 m³/h) frequently also have systems for automatic volume flow balancing. Constant volume flow fans utilise the relationship between the rotational frequency (rpm) and power consumption of the fans and the volume flow rate. In the case of fans that have forward-curved blades, the volume flow rate can be clearly determined from their

*http://passipedia.passiv.de/passipedia_en/planning/building_services/ventilation.

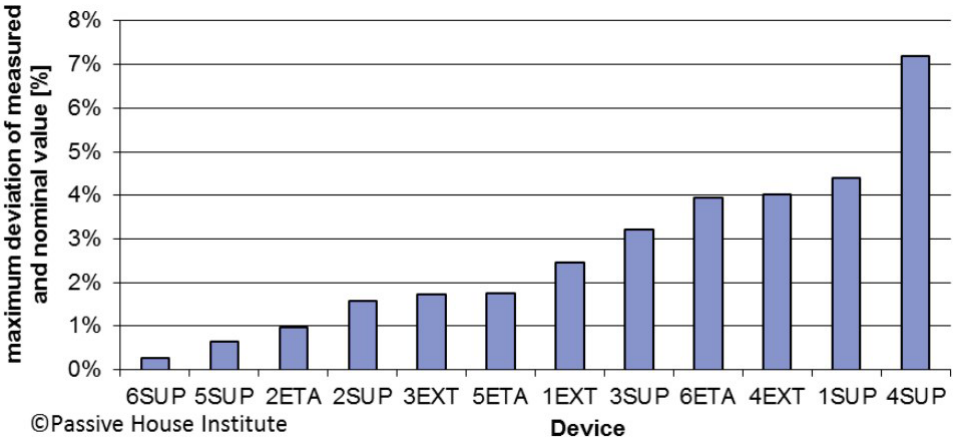

Figure 1. Measured results of volume flow balance with ventilation units > 600 m³/h within the scope of certification as Passive House Component: Maximum deviation of the displayed value (set point) from the measured volume flow rate based on the set point value in the middle operating range.

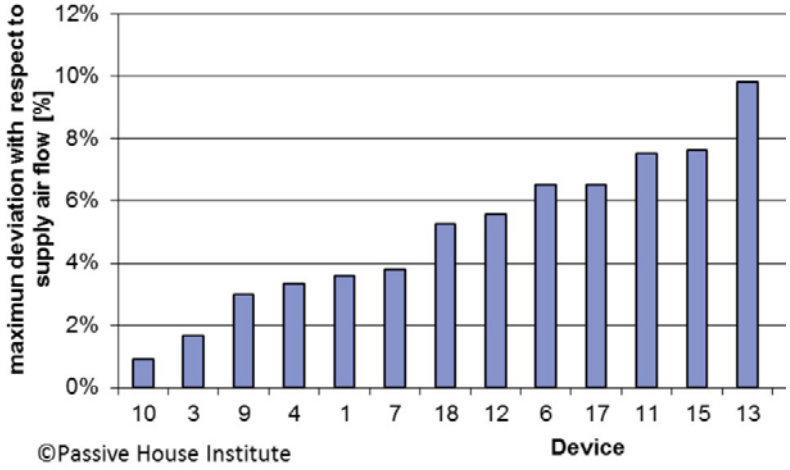

Figure 2. Measured results of volume flow balance with ventilation units < 600 m³/h: Maximum deviation in the supply air and extract air volume flows based on the supply air volume flow in the middle operating range.

characteristic curve only based on the rotational frequency and the power consumption. By comparing the actual and set values and the corresponding readjustment by the fan control, the volume flow rate can be kept constant regardless of the changing pressure drop in the duct work. However, there are still large differences relating to maintenance of the balance (**Figure 2**). Calibration of the flow rate measuring system of the fan to the respective ventilation device in the installed state can lead to significantly improved accuracy of the built-in flow rate measuring system as well as the air flow balance.

Automatic volume flow balancing – practical recommendations

When installing new ventilation systems, it should be ensured that they are equipped with a system for automatic balancing of volume flow rates. In this case, the additional investment provides the following benefits for the user:

- Prevention of structural damage: balanced operation of the ventilation system minimises leakage flows through the building envelope. The potential for structural damage is reduced since lower leakage flow rates also lead to a lower risk of condensation forming inside the building structure.
- Reduction of ventilation heat losses and thus lower running costs for energy: balanced operation of the ventilation system ensures long-term heat recovery efficiency.
- Reduction in maintenance costs: due to a ventilation system which automatically ensures constant volume flow rates. Costs for readjustment of the system (which should be carried out at least every 5 years in the case of a ventilation system without automatic volume flow balance) will not incur.
- Simplified adjustment of the volume flow rates during commissioning

The higher the heat recovery efficiency of the ventilation system and the better the air tightness of the building are, the higher the savings will be with a system with automatic balancing of volume flow rates. Under consideration of the investment costs (manufacturers' estimate of extra costs for end-users: €150 – 200 for separate ventilation units per apartment), in principle this measure will be cost-effective if the air tightness level of the building is 1.0 h^{-1} or better (**Figure 3**). With air tightness values worse than 1.0 h^{-1} advantage in terms of cost can only be achieved with very high heat recovery rates.

In particular for historical buildings, automatic volume flow balancing should still be considered in spite of the mostly rather moderate levels of air tightness. In this regard, priority should be give.n to preservation of the building substance and thus preservation of the cultural heritage.

The following points should be kept in mind when choosing the system:

- As far as possible, devices with built-in systems should be used, as these do not depend on oncoming flow conditions in the duct and require no extra effort for installation. In addition, one source of error is avoided due to the fact that the volume flow measurement device is usually integrated into the fan system.
- Ventilation systems with ventilation rate over 600 m³/h are usually equipped with a system for automatic balance adjustment in any case. A high quality is essential; this can easily be checked by means of a test stand measurement by comparing the test measurement result with that of the built-in volume flow rate measuring device.
- Today smaller ventilation units (< 600 m³/h) frequently also have systems for automatic volume flow balancing. However, there are still large differences relating to maintenance of the balance. Calibration of the flow rate measuring system of the fan to the respective ventilation device in the installed state can lead to significantly improved accuracy of the built-in flow rate measuring system as well as the air flow balance.

Attention should be given to the following points when adjusting the balance:

- The balance between the outdoor air flow and exhaust air flow should always be adjusted as accurately as possible.
- **In the case of historical buildings:** If it is not possible to improve air tightness to a high standard during the retrofit, a small amount of extract air surplus (maximum of 10%) can be set when adjusting the ventilation system in order to protect the building structures, as the risk of structural damage due to supply air surplus is much higher than it is in new constructions.

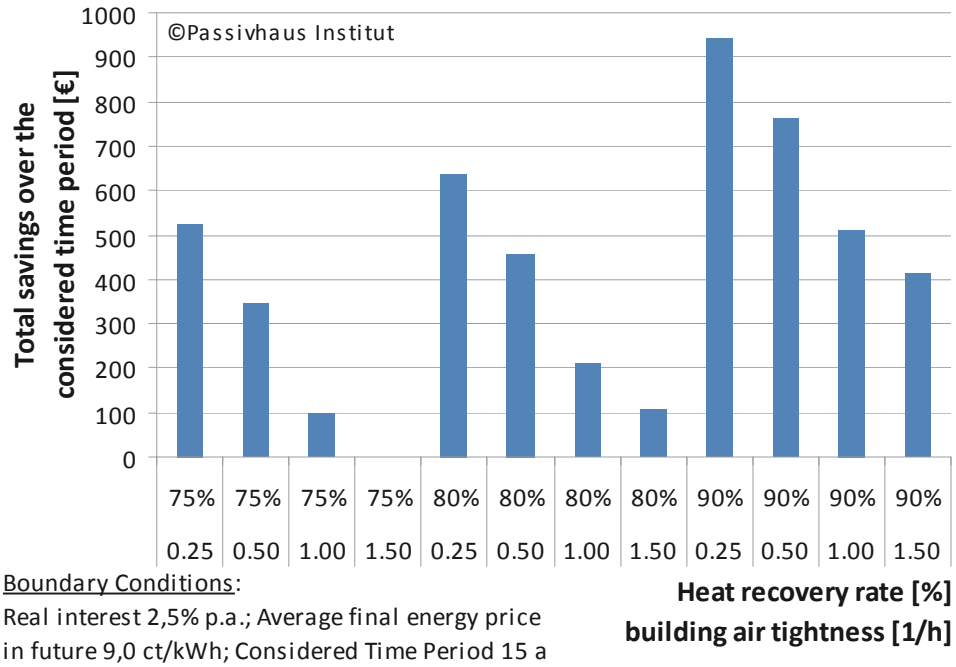

Figure 3. Overall savings achievable with automatic volume flow balancing throughout the period under consideration in comparison with non-balanced systems (assumptions: degree of balance of the non-balanced system = 65%, degree of balance with automatic volume flow balancing = 100%). Boundary conditions: ventilation device for one dwelling 120 m³/h; air change rate 0.35 h⁻¹.

However, in order to maintain the extract air surplus, here also it should be ensured that the ventilation system provides a system for automatically keeping the adjusted air flow rates constant. Control of the extract air surplus in dependence on the pressure difference between critical rooms and the outside by means of suitable sensors is desirable. Due to the thermal lift, critical areas are mainly the upper floors. Therefore measuring the pressure difference towards outside at least there in order to keep a slightly lower pressure inside is recommended. ■

Source

Analysis of the cost-effectiveness of automatic volume flow balancing in ventilation units with heat recovery; report within 3ENCULT project, Passive House Institute, Darmstadt 2014