Optimierte Luftheizung für MINERGIE-P und Passivhäuser

Ausgearbeitet durch

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Abstract

MINERGIE-P and Passivhaus

The standard MINERGIE-P [MINERGIE], which translates the idea of the German Passive House standard to Swiss boundary conditions, has been introduced while the present project was already running. Therefore, and because there exists much more literature concerning Passive Houses, this project focused on the Passive House standard. However, statements in this report addressing "the Passive House" are valid for MINERGIE-P buildings, too.

Situation

In Passive Houses, the mechanical ventilation system can as well be used as the heating system. Air flow rates are chosen according to hygienic needs. Ventilation and heating have some contradictory requirements for the design and layout of the system. Wood stoves get more and more popular as additional heating system. Problems with heat distribution may result.

Goals

The purpose of the project is to show how a good system would look like, in how far heating by ventilation is suited for houses which only are close to comply with the Passive House standard, how the building mass is to be used for heat transmission and storage, how heat from a wood stove is distributed in the rooms, and which requirements the stoves have to fulfil.

Topics

Aspects of thermal comfort and of the efficiency of air distribution within the room have been evaluated by measurements in the air flow test chamber and by Computational Fluid Dynamics (CFD).

The impact of the air distribution within the dwelling and possibilities to use the building mass for heat transmission and storage have been evaluated with respect to supply air conditions. Requirements for the temporal and spatial distribution of supplementary heat from wood stoves have been determined.

Findings from measurements in P+D-buildings conducted in independent projects, and complementary aspects have been taken into account.

Findings

According to "Passivhaus Qualitätsanforderungen“ [PHQ] published by the Passivhaus Institut, a comfortable indoor climate must be realizable in a Passive House (residential use) without separate heating system, and without air conditioning. This essential condition defines requirements which the building envelope has to fulfil, and which in the end are summed up into the well-known limit of 15 kWh/(m^2.a) (related to net living area) for the heating demand of a Passive House (see section 1.2). The necessary air exchange is guaranteed - at least during the heating season - via a balanced mechanical ventilation system with efficient heat recovery.

Thermal comfort - temperatures

Room temperature

Room temperatures in Passive Houses are in the usual range and show a distribution similar to the one found in conventional dwellings [CEPHEUS].

In contrast to conventional buildings, air and radiative temperature in Passive Houses are almost the same. Surface temperatures on the inner side of external walls are about 0.5 K below room air temperature. The inner surfaces of windows are no more than 3 K below room air temperature if the ambient temperature is around -10°C.

Asymmetries of the radiative temperature

Asymmetries of the radiative temperature need not be compensated for by heating surfaces and are well below the limits (10 K between two walls).

Gradient of the air temperature

The vertical gradient of the air temperature often is hardly measurable, both in the air flow test chamber and in occupied dwellings. Even with heated air supply in the upper part of a room, gradients are often less than 1 K over the entire height of the occupied zone in Passive Houses. Even in two-storey open rooms, no large gradients occur (see section 4.6). According to [SIA 180] between 0.1 m und 1.1 m height above floor a gradient of 3 K/m would be tolerable.

Room temperatures exceeding the comfort range

During summer, the usual measures to avoid overheating have to be taken in Passive Houses, too. In spring and autumn, overheating in Passive Houses without appropriate sunshade is more likely to occur than in conventional buildings (see heating load). However, if modest overheating is permitted (in some parts of the dwelling), better use can be made of passive solar gains.

Thermal comfort – draught risk

High surface temperatures of external walls, together with the required thermal bridge-free construction and the high airtightness of the building envelope, prevent cold air downdraught at external walls. However, if glazings extend over more than one storey, there might be a need for countermeasures.

The air supply to the room does not cause unacceptable draught risks. This is mainly due to the restriction of the air flow rates to hygienic requirements. Type and position of the supply air terminal device (supply ATD) within the room is not restricted by comfort requirements. Other aspects like minimizing the duct length, acoustics or aesthetics etc. may have priority (see sections 4.4 und 4.7).

Air exchange efficiency

The air exchange efficiency, too, is only weakly influenced by type and position oft the supply ATD. However, short-circuiting flow paths should be avoided. Placing supply and transfer ATDs on opposite walls in the same height is more critical than placing them close together on the same wall.

Air exchange efficiencies generally are found to be in the range 0.45 to 0.55, indicating a well mixed room air (see section 4.5 und 4.7).

Temperature zones and night time temperature set-point reduction

Generally, only minor temperature differences are found between the rooms in a Passive House dwelling. The building responds slowly on changes in heating power. Therefore no further energy savings can be achieved by temperature zoning and by reduction of the temperature set-point during night time. A lower temperature in the sleeping room is not necessary from a physiological point of view, either, but sometimes tenants want to have lower temperatures. Section 3.5 explains how intentional temperature differences can be established in a Passive House dwelling.

Air flow rates and air heating

The requirements for a Passive House have been defined so that generally the heating load can be covered by preheating the supply air (max. 50°C flow temperature after heating coils) and with air flow rates according to IAQ requirements.

<u>Air flow rates</u>

Air flow rates are chosen according to IAQ requirements (24 to 30 m^3/h.person). If the necessary heating power cannot be supplied with these flow rates, a supplementary heating source has to be provided (e.g. a small radiator in the bathroom). Possibly, the available heating power is too low if flow rates are reduced to avoid low relative humidity.

Contradictory requirements – higher flow rates to provide enough heating power, lower flow rates to avoid low relative humidity – can be met in Passive Houses in a moderate winter climate (Mittelland). Buildings with less insulation need an additional heating. Systems with recirculation are also possible. However, these systems are more complicated and expensive, and IAQ is more critical because pollution loads may be redistributed (see section 2.2 and chapter 7).

An auxiliary heating may be necessary in a Passive House if heat is delivered with less than 50°C (solar system, heat pump).

Humidity

Surface temperatures below dew point temperature are practically impossible in Passive Houses due to the very small temperature differences between surfaces and room air, and due to the continuous air change provided by the mechanical ventilation. Therefore the main reason for building damages is eliminated.

Outdoor air has usually low humidity content in winter. To avoid uncomfortable dry room air, air exchange rates have to be restricted to the minimum required by IAQ (see above). Air flow rates should be adapted to the actual occupancy. If required, the occupants should be able to further reduce the flow rate, if persons are present to 18 m^3/h.person, if unoccupied to the basic air flow rate (see section 2.3).

Heating load

Solar (and internal) gains cannot be neglected when the heating load of a Passive House is determined. In the "Passivhaus-Projektierungspaket" [PHPP 02/03] a new method has been implemented to calculate the heating load and the available heating power via supply air. The Swiss code "Wärmeleistungsbedarf von Gebäuden" [SIA 384/2] is being revised. This means that at the time being no method compatible with Swiss boundary conditions is available to calculate the heating load of buildings with a very low heating demand.

Therefore the building specifications should explicitly exclude the application of SIA 384/2 until the revised version is available.

During (longer) periods of absence, the heating in a Passive House should not be reduced, because the heating power of the supply air is limited. Energy savings are hardly to achieve by reducing the heating power, and regaining the set-point temperature takes either a long time or requires a larger heating power.

A breakdown of the heating system for about one day constitutes no problem as the room temperature decreases very slowly due to largely reduced losses.

If necessary, auxiliary heating devices may be used to (re)gain the set-point temperature: in most cases it is sufficient to put on the oven for a while. Mobile heating appliances may be used to heat a dwelling before the first occupants move in, or to support drying out a newly erected building (see section 2.2).

Heat transfer (losses) from ducts

Large temperature differences occur frequently between supply air ducts and their surroundings within the thermal envelope with heating by ventilation.

Ducts without insulation may deliver about 1/3 of the heat content of the supply air to the surroundings along the first 5 m. Applying 1 cm of insulation reduces the heat flow to the surroundings by 50%. Nevertheless, the supply air temperature at the supply ATD adapts quickly to changes in the heating power if ducts are mounted on the surface or in hollow ceilings. Imbedding ducts into concrete without insulation results in a delay and a dampening of a temperature step at the air heater both at the supply ATD and at the concrete surface. The air heating system shows a surprisingly high inertia. A decoupling from the building mass can be achieved by applying insulation. The supply temperature in the sleeping room can be lowered and at the same time the bathroom temperature can be risen by leading the respective supply air duct through the bathroom with no insulation (see section 3.3).

Heat distribution in the dwelling, temperature zones

Heat from a room in the supply zone is transferred to a neighbouring room in roughly equal shares via the separating wall and via the transferred air (closed door). Open doors or more general open floor plans allow for natural convection. The heat transfer via natural convection is about one order of magnitude larger than that via transmission or mechanically forced ventilation (see section 3.4).

Under these circumstances, a sophisticated heat distribution system is not necessary. A "simple" heating system will work. On the other hand this means that special measures are necessary to keep rooms at different temperatures if this is required (see section 3.5).

Settings and control

It must be possible to choose air flow rates and set-point temperature independently. Heat supply is adjusted by varying the supply air temperature. The sensor for the room temperature is placed in the central part of the dwelling.

In multifamily houses it must be possible to set the air flow rate, and mostly the room temperature, too, individually per dwelling. The ventilation should have at least the settings "off", "basic", "normal", and "high" (see section 3.6).

Wood stove

The lower limit for the combustion capacity of a wood stove is given by the demand for an efficient combustion with low pollutant emissions. The capacity of heat delivery to the room depends on the combustion capacity and on the heat capacity of the stove. Even the smallest available stoves actually are oversized for dwellings in a Passive House. Stoves which can deliver part of the heat to e.g. the hot water storage with an additional heat exchanger are better suited.

The convection through open doors is essential to distribute the heat from a wood stove placed in the living room. If a Passive House is heated solely by a wood stove for a longer period, temperature differences of 2 to 4 K are established between the rooms. However, to avoid overheating of the living room, a very low capacity is required. The maximum heating power delivered to the room should not exceed 2 kW (in a dwelling with 130 m^2 floor area). Stoves using firewood must either have a very large heat capacity, allowing for a heat delivery for 24 h (or more), or the heat release has to be split into two firing periods per day. Pellet stoves are easier to control, but the small heating load remains a problem (see chapter 5).

Ventilation system

<u>Fans / balance</u>

Fans with speed controlled electronically commutated DC motors are used, which are very efficient. Supply and extract flow rates should be balanced under all operating conditions. This requires mass flow control, which up to now is offered only by few manufacturers. Mostly volume flow control is used. Then the mass flow is temperature dependent: a temperature difference of 10 K gives rise to 3 to 4% deviation in mass flow.

Leakage

Most important are leakages in the heat exchanger, because the actual efficiency of the heat recovery is reduced, and extract air may be recirculated unintentionally.

Increased air exchange rates

Kitchen hoods are not coupled to the ventilation system because they have much higher extract rates and because the extract air has a high pollution load. Kitchen hoods should be operated in recirculation mode.

Hoods with own extract air and own outdoor air supply may be installed, but are not recommended because of the additional leakage introduced into the building envelope.

Intense airing during short intervals (ca. 10 minutes, cross ventilation if possible) is well suited also for Passive Houses if short-term pollution loads are to be removed efficiently (see section 6.1).

Commissioning

There are no special guidelines for ventilation systems with air heating in the existing literature. Basically, the prerequisite for a good performance of the air heating is that the ventilation system itself works properly.

It is especially important to check:

- heat transfer and flow rates at the heat exchanger
- capacity of the air heater
- supply air temperatures at the supply ATDs
- room temperatures in a cold period

(see section 6.8).