TREES **Training for Renovated Energy Efficient Social housing**

Intelligent Energy Europe

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Section 1 Techniques

1.3 Ventilation

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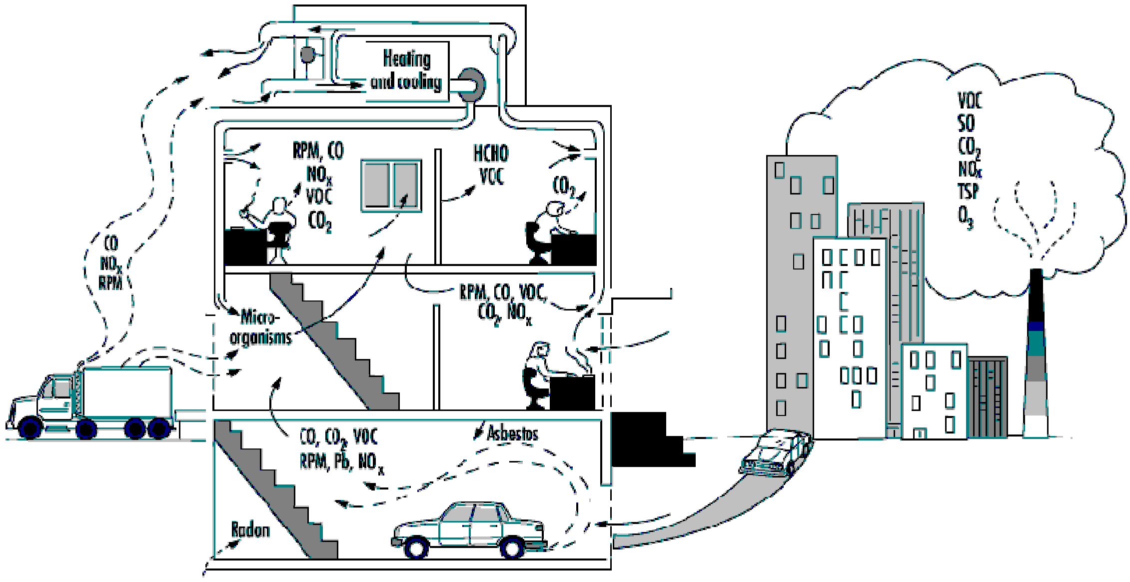
1. Why ventilation

Over the past decades many new building techniques have been developed in effort to reduce energy consumption. Unfortunately, this may result in buildings being so airtight that only little natural ventilation could occur. The result is an increase of indoor air pollution.
Air pollution may also increase by materials used for construction and furnishing and by indoor activities as cooking, heating, smoking, sleeping.

Nowadays we spend about 90% of our time indoors. Air pollution concentrations in the average homes are usually 2 to 5 times worse than outdoors. Inadequate ventilation may cause polluted indoor air. Air pollution could cause discomfort and health problems such as headaches, airborne infections, wheezing, coughing etc, especially for sensitive people.

The solution to these problems is proper ventilation. Ventilation removes indoor air pollutants and thereby improves the quality of indoor air.



Source: www.worksafe.ca

2. Ventilation principles

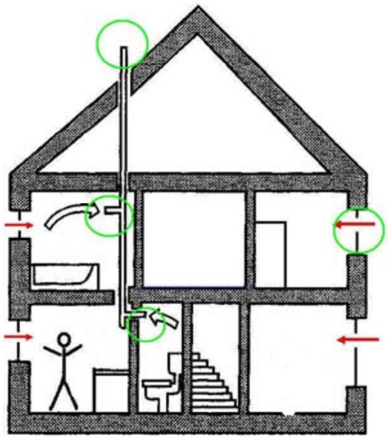
Ventilation is the process of supplying and removing air by natural or mechanical means to and from any space. Cleaner (outdoor) air is used to dilute the polluted (indoor) air that people are breathing. Besides the indoor air quality aspects, ventilation can be used for cooling and heating the building.

Three are 2 basic principles to ventilate a building:

- Natural ventilation: this principle makes use of the natural air exchange through open doors and windows, vents and stacks
- Mechanical ventilation: this system exchanges air by force through an installation with ducts and a fan. In general there are three mechanical ventilation systems:
    1. Exhaust ventilation, with natural supply
    2. Supply ventilation, with natural exhaust
    3. Balanced ventilation

3. Ventilation systems

3.1 Natural ventilation



Natural ventilation

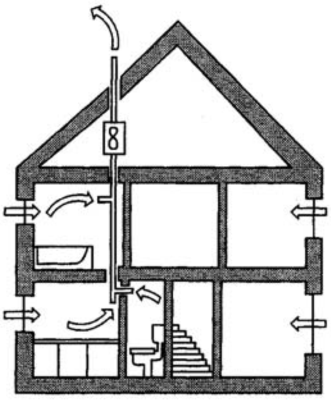
The term ‘natural ventilation’ covers both the uncontrolled air-leakage through cracks and interstices (infiltration) and the air through opened windows, doors and vents. Infiltration is caused by the weather of other pressure-difference forces exerted on building.

Advantages
- Silent, except for fierce wind
- No electrical energy needed
- Simple system and maintenance
- Low investment costs

Disadvantages
- Ventilation is dependent on wind forces, sufficient capacity is not guaranteed
- Risk of burglary through open windows
- Low energy efficiency, heat-recovery is impossible
- Risk of feeling draft close to windows
- Risk of unwanted spread of damps and odours
- Risk of unwanted spread of noises from outside (e.g. traffic).
- Exhaust air ducts demand extra space in the design.
- Not suitable for high buildings.

Application
Only natural ventilation is generally not used anymore due to disadvantages named above.
Possible improvements
- Prevention of burglary: using ventilation vents (fig. 1)
- Noise control: using noise reducing vents (fig. 2a/b)
- Quantity control: using constant-flow vents with a self-regulating system dependent on wind pressure. By fierce wind, less air will be let through (fig. 3)
- Draught prevention: 1) ventilation with grille and not with windows; 2) valve at inner side of the grille to direct the air stream from outside to the ceiling in order to spread the air stream more evenly; 3) minimal height of grille 1,80 m.
- natural supply, mechanical exhaust

3.2 Natural supply, mechanical exhaust



Exhaust ventilation, with natural supply

This ventilation system is based on a fan that exhausts indoor air. There is a natural air supply by windows and/or vents.

The air exchange (by exhaust fan) is mainly extracting air from kitchen, bathroom and toilet. The amount of ventilation can be controlled by the occupant, normally indicated with high, middle and low ventilation rates: The lowest will often be specified as energy-saving/night rate.

Advantages

- Quantity of ventilation can be controlled.
- Direct exhaust (no spreading) of moisture and odours out of sanitary rooms and kitchen.
- Less ducts compared with balanced ventilation.
- Simple system and widely known.
- Possibility of Individual control per room.

Disadvantages

- Risk of draft close to windows;.
- Possible inconvenience of noise from fan especially in apartment buildings.
- Building envelope must be made airtight.
- Extra space needed for exhaust air ducts.

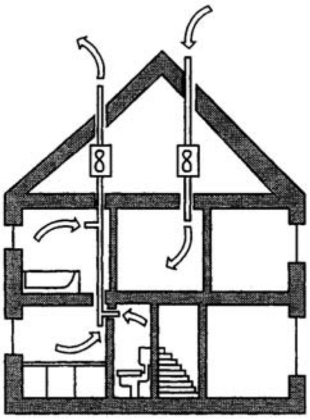
Application

Mechanical exhaust with natural air supply is commonly applied in housing.

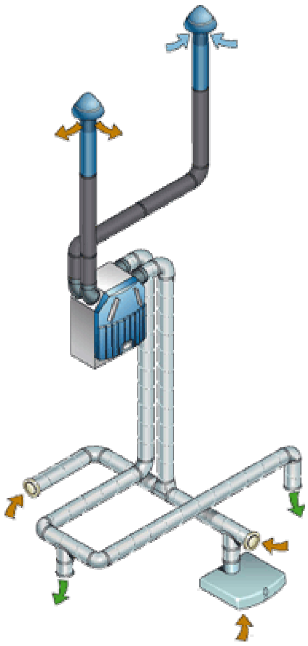
Possible improvements

- Demand regulated system to program ventilation and save energy (see also section ventilation rates).
- Draft can be limited by self-regulating vents.
- Springy fixation and covering of fan to reduce noise nuisance.

3.3 Mechanical supply, mechanical exhaust



Balanced ventilation system



Balanced ventilation system with heat recovery

Balanced ventilation controls the air exhaust and the air inlet by a ventilation system. The system consists of a ventilation unit with 2 fans (supply and exhaust), a heat-recovery unit and 2 duct systems.

The system generally is based on:
- Air supply to bedrooms and living room.
- Air exhaust from kitchen, bathroom and toilet.
- The amount of supply and exhaust air are the equal: in balance.
- Fresh air from outside will be preheated by exhaust air. This means that heat from exhaust air is recovered.

Advantages
- Fully adjustable system.
- Risk of draft is reduced as cool air from outside is preheated by exhaust air.
- Energy saving due to heat-recovery from exhaust air.
- Reduction of noise pollution from outside as air supply is more indirect. Acoustic vents are unnecessary for facades with high noise intensity.
- Possibilities to filter polluted outside air in ducts.

Disadvantages
- Possible noise pollution from fans and air movement in ducts.
- System needs proper, sensitive adjustment. An audit of air exchange rates and noise control is strongly recommended.
- Exhaust air ducts demand a lot of extra space.
- Adequate and frequent maintenance required, especially cleaning and replacing of filters (every other week)
- Building envelope must be made airtight. Air leakages may not occur.

Application
Balanced ventilation is commonly applied in housing and is especially suitable for timber constructions, where airducts can more easily be placed within the construction.

Possible improvements
- Extra inlet vents will reduce air speed and draught.
- Extra air tightness of the building will prevent suction from air out of the crawl space. This air may be polluted with Radon, see also sheet on 'Radon'.
- Instructions for use and maintenance will help to keep the installation work properly. Regular cleaning of filters (every other week with vacuum cleaner) is needed to prevent pollution of fresh air by the filters.
- Use of (mechanical) HEPA-filters to filter 95% of all airborne pollutants, including bacteria, dust, animal hair, dust mites, mildew, lint, fungus, smoke, cooking grease, bacteria and even many viruses. The HEPA filter should be replaced about once a year. (HEPA=high efficiency particulate air)

4. Ventilation rates

4.1 Ventilation standards

There are numerous standards and guidelines recommended by international health associations, industry organizations, government, and private programs and researchers.

Ventilation standards normally quote either the outdoor air supply requirements (volume per time per person), or the outdoor air exchange-rate (per hour). The outdoor air exchange-rate is defined as the ratio of the volume of outdoor air entering an enclosure per hour of the effective volume of the enclosure.

International used standards for ventilation are, the American guideline: ASHRAE standard 62-1989, and the European guideline: CEN1752.

Building codes are often very minimal, and generally do not guarantee good indoor air quality. For high air quality it is assumed that ventilation rates in building codes should be multiplied with 1,5 or 2.

Focus on CO2
The aim of ventilation is to improve indoor air quality. One important variable is CO2-concentration. A concentration of 1000 ppm will result in 20% dissatisfied persons. Above 1200 ppm complaints on tiredness, headache, irritation of eyes increase fast. In The Netherlands a limit of 1200 ppm is advised, in Scandinavian countries 800 ppm [Hass 1998].

Focus on humidity
The aim of ventilation is to improve indoor air quality. One important variable is humidity. Between 40 and 65% there are little complaints. Limits are generally set between 35 and 70%. Indicative levels of relative humidity:
Very good: 35 - 45%
Good: 45 - 55%.

Problems
High levels of humidity will increase growth of moulds, mite-population and vermin. It may lead to a higher risk on allergic reactions caused by pollutants that prefer humid conditions. Complaints on dry air may not be related to humidity, but may be caused by irritating substances [Hass 1998].

Smoking
Ventilation rates should in general be doubled when people are smoking indoors. Per cigarette is 50m3 of fresh air needed per person per hour, and 120m2 to avoid nuisance of smell. [Hass 1998],

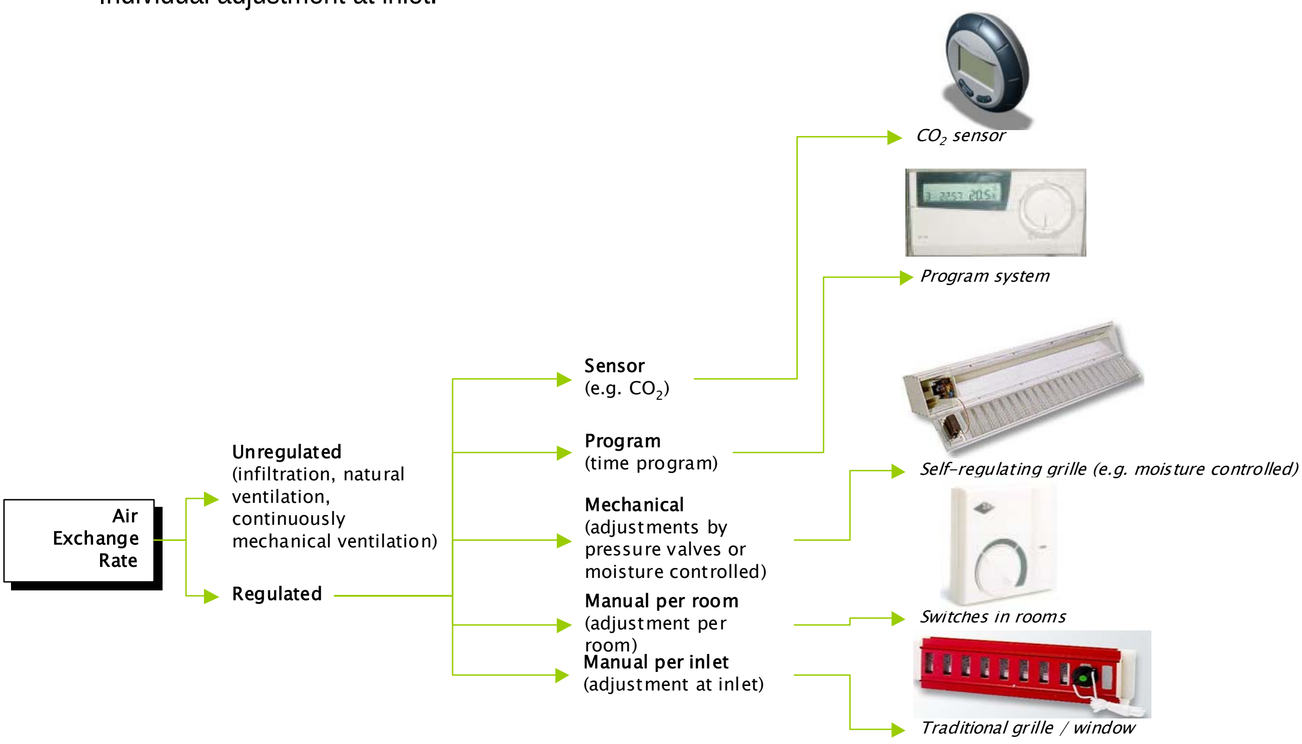
4.2 Regulation of ventilation

The quantity of ventilation is traditionally unregulated. To improve indoor air quality and save energy, ventilation rates can be optimized by using automatic systems:

- Sensor that measures air quality.
- Programs that regulate the fans.
- Temperature dependent regulation.
- Self-regulating vents.

Ventilation rates can also be changed by manual adjustments:

- Switches per room to change fan capacity for exhaust (or even supply), resulting in a higher ventilation rate for a specific room (e.g. kitchen, bathroom).
- Individual adjustment at inlet.



5. Ventilation for heating and cooling

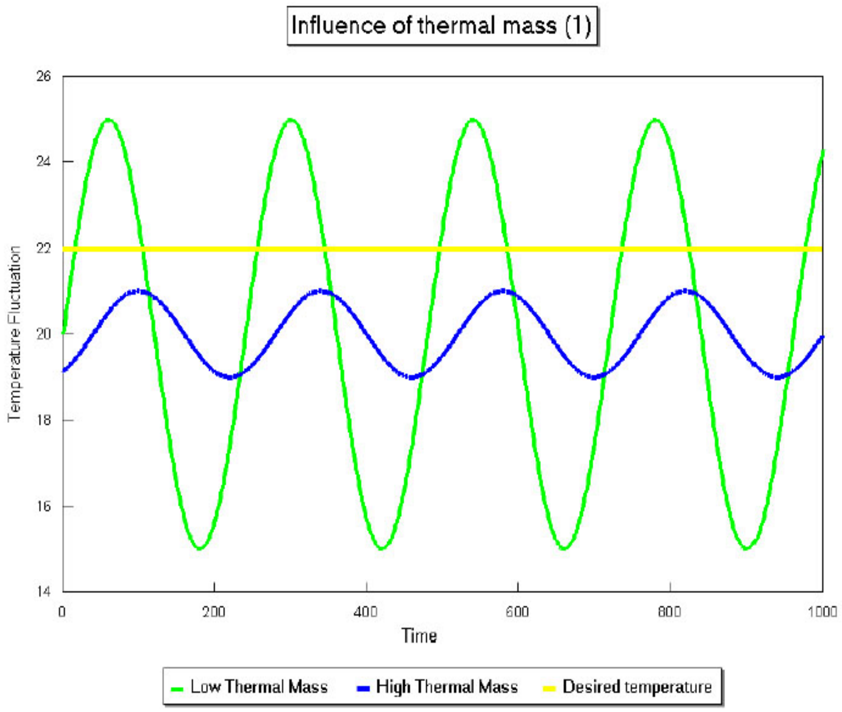
5.1 HVAC

Besides achieving good indoor air quality, ventilation can be used for cooling and heating the building. The three functions of HVAC (heating, ventilation and air-conditioning) are closely interrelated. All seek to provide thermal comfort, acceptable indoor air quality, and reasonable installation, operation, and maintenance costs.

5.2 Night cooling

Night ventilation during summer ensures that during the hours of the night cold outdoor air is supplied that replaces the hot indoor air in so far as possible. For night cooling, ventilation rates during the night are up to an air-exchange rate of 4 per hour, with can be gained by opening windows or equivalent.

High thermal mass materials, like brick and concrete, act as storage for both heat and cold as they heat up and cool down relatively slowly. The thermal capacity of the building's elements delays the heat transfer to the interior of the building, by soaking up excessive heat for several hours. During the night, when the external temperature is lower, the stored heat is slowly expelled to the environment by radiation and by convection.



Thermal mass helps avoid the daytime heat and keep the night-time coolness inside the building for a longer period.

6. Ventilation systems on the market

6.1 Heat recovery units

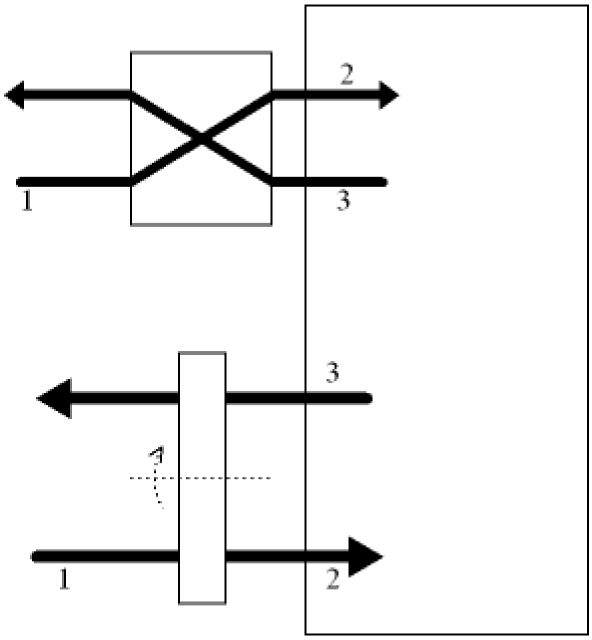
Air-to-air heat recovery
A heat recovery unit, suitable for a balanced ventilation system, has a efficiency of about 70 to 90%. It has two ventilators, one for the heat supply, and one for the heat exhaust.

Heat recovery unit (source: www.jestorkair.nl)

Heat recovery units used in ventilation and air condition systems are based on some common principles:

- Return air
- Rotating heat exchangers
- Air-Fluid-Air exchangers
- Cross flow exchangers
- Heat pumps

Cross flow and rotating heat exchangers are illustrated below:



cross flow and rotating heat exchanger (source engineeringtoolbox.com)

Return Air Recovery Units

With a return air recovery unit - used air is mixed in to the make up or supply air. Energy in outlet air is supplied directly in to the make up air. Both sensible and latent (moisture) heat is transferred.

Rotating Heat Exchangers

With a rotating heat exchanger outlet air heats (or cools) the exchanger when the wheel passes through the outlet airflow. The energy is transferred to the make up air when the wheel passes through the make up air.

Both sensible and latent heat may be transferred. Latent heat when moisture in the outlet air condensates on the wheel. Moisture may be transferred with heat exchangers using hygroscopic wheels. For exchangers without hygroscopic wheels, the condensate is drained out.

Air-Fluid-Air Exchangers

With an air-fluid-air heat recovery unit heat is transferred in an heat exchanger from the outlet air to a circulating fluid. The fluid is circulated to a heat exchanger in the make up air where the heat is transferred to the supply air.

Both sensible and latent heat may be transferred. Latent heat when moisture in the outlet air condensates on the heat exchanger. Moisture is not transferred.

Cross Flow Heat Exchangers

In a cross flow heat exchanger heat is transferred directly from the outlet air to the make up air through the separating walls of the heat exchanger.

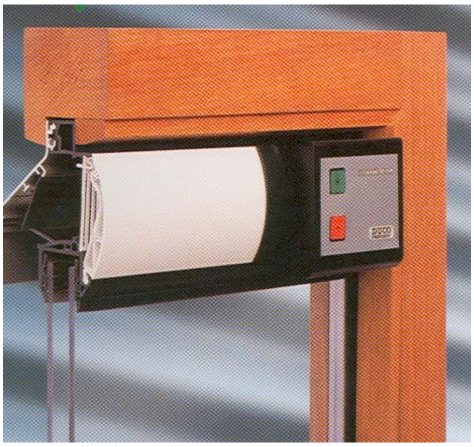
Both sensible and latent heat may be transferred. Latent heat when moisture in the outlet air condensates on the heat exchanger. Moisture is not transferred.

Air-to-water heat recovery

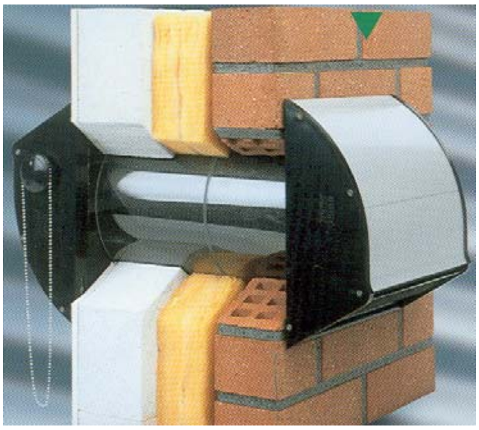
With a heat recover unit a heat pump extracts heat from extracted air to heat tapwater. This system has to be combined with a mechanical exhaust. It cannot be used with a balanced system with air-to-air heat recovery because than the heat is already extracted to preheat supply air. A combination with a balanced system is possible, but without energy saving.

6.2 Ventilation vents

Nowadays, many different types of ventilation systems are available on the market. Ventilation vents can be self-regulating, noise-reducing, of preheating ventilation supply air.



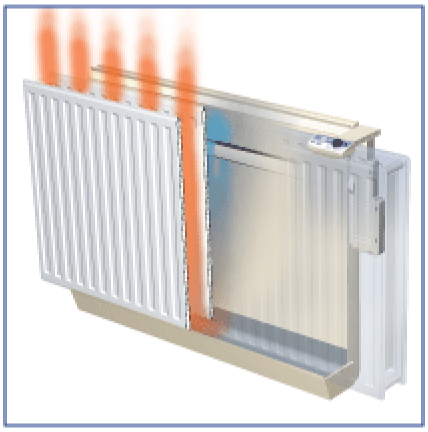
Self-regulating vent



Noise-reducing vent in exterior wall

6.3 Preheating/cooling ventilation air

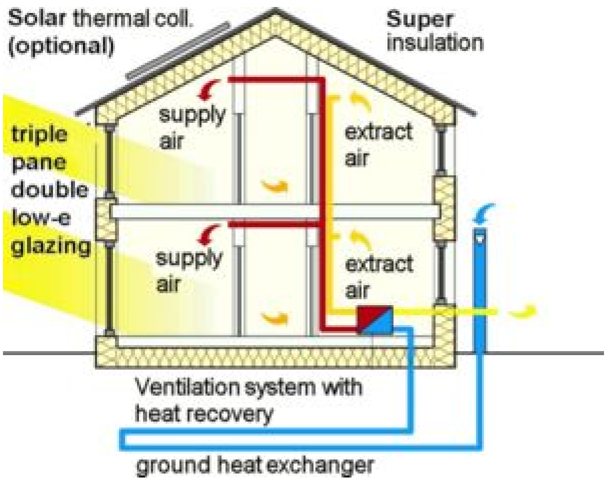
To avoid draught preheating of ventilation supply air can be a solution. Preheating the supply air can be achieved with a balanced ventilation system with heat recovery. A possibility by using a natural supply system is an integrated heating radiator within the ventilation system.



Ventilation integrated with heating radiator, for a natural supply system

Earth-to-air heat exchanger

The air coming into the heat exchanger should be at least be above 0 degrees Celsius. Otherwise, the condensed water from the outgoing air would freeze and block the outgoing air. Therefore, it is necessary to warm the incoming air to at least 0 degrees C. This can be done by an earth-warming pipe, usually about 10 m long and 20 cm in diameter. It is buried about 1.5 m below ground level. In Germany and Austria this is a common configuration for earth to air heat exchangers.



Preheating of ventilation air with advanced glazed balconies

Glazed balconies are often applied as an architectural attractive renovation concept.
The energy concept of glazed balconies is interesting where it replaces traditional renovation measures, e.g. insulation of thermal bridges, concrete renovation, and window frame maintenance. Glazed balconies with preheating of ventilation air save lots of energy and comfortable ventilation can be achieved.