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Indoor Environment and Ventilation in Sustainable Buildings

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Outline

- Indoor environment requirement.
- Particulates and human health.
- Sustainable buildings characteristics.
- Problems in renovated buildings.
- Solutions
  - Central ventilation
  - Local ventilation
  - Ventilation in sustainable buildings
- Conclusions

Indoor environment quality requirement

For normal living quality condition in occupied spaces different standards and regulations (WHO[1]) required the following parameters to be fullfiled:

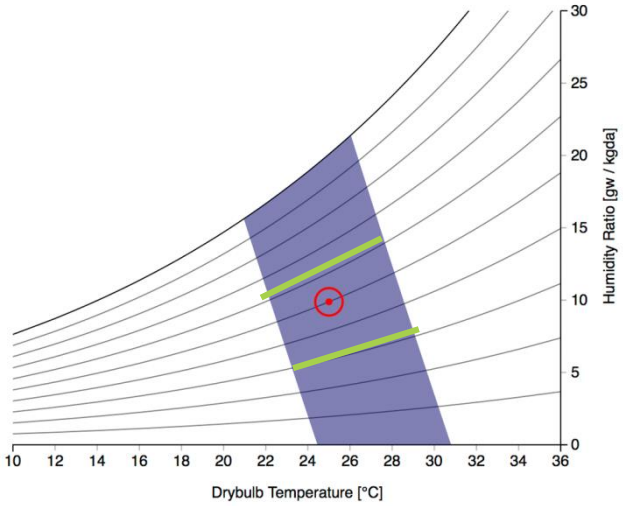
Air temperature:	20 ÷ 24°C in winter; (18°C WHO min.)
	22÷26°C in sommer
Floor temperature:	19 ÷29 °C

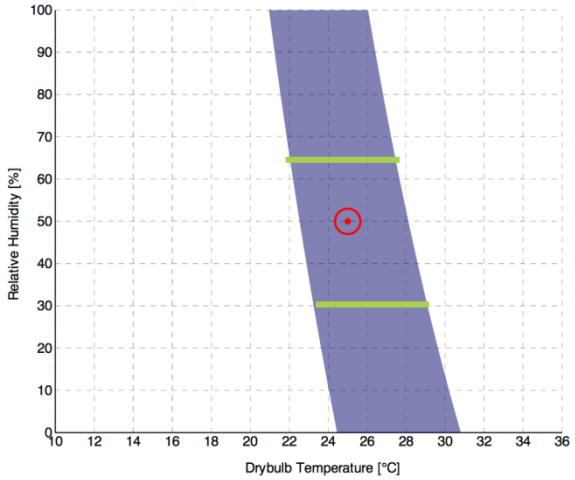
Radiant temperature asymmetry : +5°C for celing, +23°C for wall

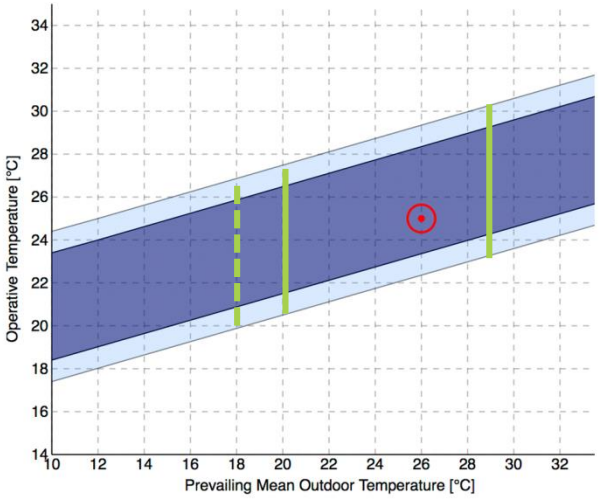
Temperature stratification: 3 ÷ 4 °C

Relative air humididty:	35 ÷ 60%
Air movement:	0,1 ÷ 0,8 (1,2) m/s – air temperature depending
Noise level:	20÷35 dB(A)

Indoor environment chart for less than 5 % dissatisfied occupants (PPD, or 95 % PVM)







Temperature-relative humidity chart
Two alternative representations of thermal comfort for the PMV/PPD method
Air velocity: 0,2 m/s to 0,8÷1,2 in summer times
Lines provide optimum comfort zone

Adaptive chart for indoor operative temperature to oudoor temperature according to ASHRAE Standard 55-2010, ISO 7730, EN 15251

Indoor air pollution limitations

Air cleanless:

- Particulates: PM10 < 50 μgm^3
  PM2,5 < 25μgm^3
- Formaldehyde < 0,1 ppm
- NO_2 < 40 ppb
- VOC: LCI defined for each organic component
- CO < 7 ppm (24h exp.)
  < 35 ppm (8h exp.)
- CO2 < 800 ÷1100 ppm
- Radon < 300 Bq/m^3 (~10 mSv/y)

[1]Problems of indoor air quality are recognized as important risk factors for human health in both low- and middle- and high-income countries. Indoor air is also important because people spend a substantial proportion of their time in buildings.

Air exchange – ventilation - is „conditio sine qua non“ in buildings with tight envelope (renovated buildings and sustainable buildings).

[1]WHO guidelines for indoor air quality: selected pollutants (WHO, 2005, 2010)

Particulates and human health

The exposure to airborne particulate matter is one of the most significant environmental risks for people.

Based on the studies in the analysis[1] it can be concluded that overall, the main origin of home PM10 and PM2.5 is outdoor air.

This means that indoor sources of these particle mass fractions are not as significant compared to the outside concentrations, and that in-creased ventilation (**without filtration**) can lead to increase in indoor concentrations and exposures.

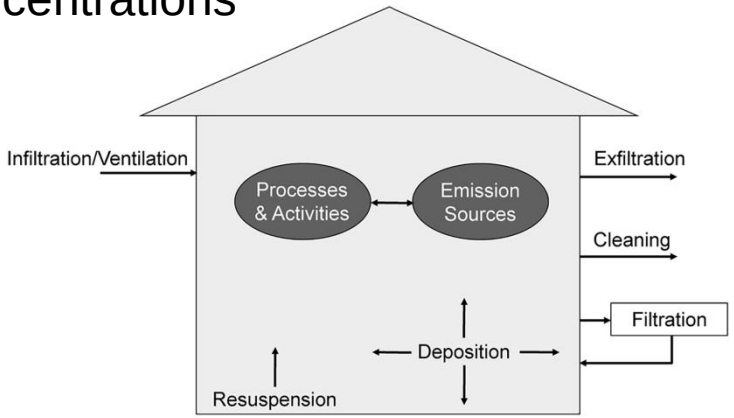
Control of exposure therefore requires that focus is placed on outdoor PM10 and PM2.5 of the urban environment surrounding homes, and particularly on any local sources of the particles.

In some cases (indoor sources of pollution: fireplaces, cooking, etc) indoor air pollution can be as more as 6 time ower the outdoor pollution.

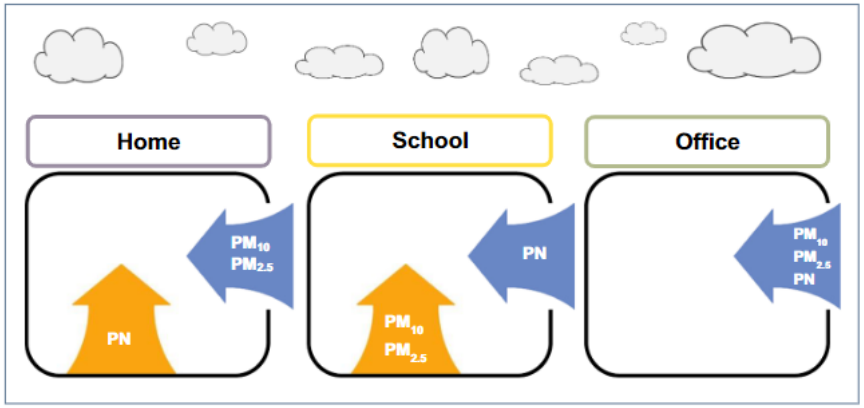
[1]Airborne particles in indoor environment of homes, schools, offices and aged care facilities, https://doi.org/10.1016/j.envint.2017.07.025

Indoor exposures to particulates

Schematic *diagram* of the key factors influencing indoor air particle concentrations



Recent 'Global Burden of Disease' (GBD) assessments placed exposure to $PM_{2.5}$ (mass concentration of particulate matter with aerodynamic diameter < 2.5 μm) among the top ten risks leading to worldwide lower life expectancy and/or lives with disease . Most of the PM exposure occurs **indoors**, because this is where people spend a large fraction of their lives.



Dominating processes influencing the concentrations in given environments. It should be kept in mind that the ilustrated processes are not the only ones to be taken in to account for efficient indoor particle concentration control strategy.

Sustainable building

Sustainable buildings main characteristics are:

- Build from sustainable and recyclable materials (wood, bricks,...);
- Low exergy (energy) consumption by building, operation and dismantling;
- Tight envelope;
- Appropriate windows area on S; W; E; N;
- Mechanical ventilation with heat recovery;
- Use passive and active solar energy (zero fossil exergy building);
- Satisfying indoor environmental requirement in all seasons – over the year;
- Easy to maintenance;
- Long life of the structures, mechanical and electrical equipments;
- Smart building - IT connected;
- Etc.

Problems

Buildings

- In real world millions of existing buildings are far from sustainable one;
- EU Energy efficiency Directive is driving the countries to effective and massive existing building thermal renovation;
- Existing building have low thermal insulation;
- Windows with single or double glazing in frames with large croaks;

Outdoor environment

- Increased air pollution;
- Noise pollution;

People

WHO 2018 Report:

- 9 from 10 people breath highly polluted air;
- 7 million premature death because of exposure to small particulates, smoke;
- WHO is warning, that 91 % of world population is living in rooms with lower air quality, as proposed by WHO recommendations.

Problems at existing buildings renovation

Missing of integrated renovation approach, because:

- Lack of capital;
- Unsatisfactory planning;
- Ownership in multifamily housing;
- Inconsistent subsidies

Most common problem:

Windows renovation without installation of mechanical ventilation in time of renovation.

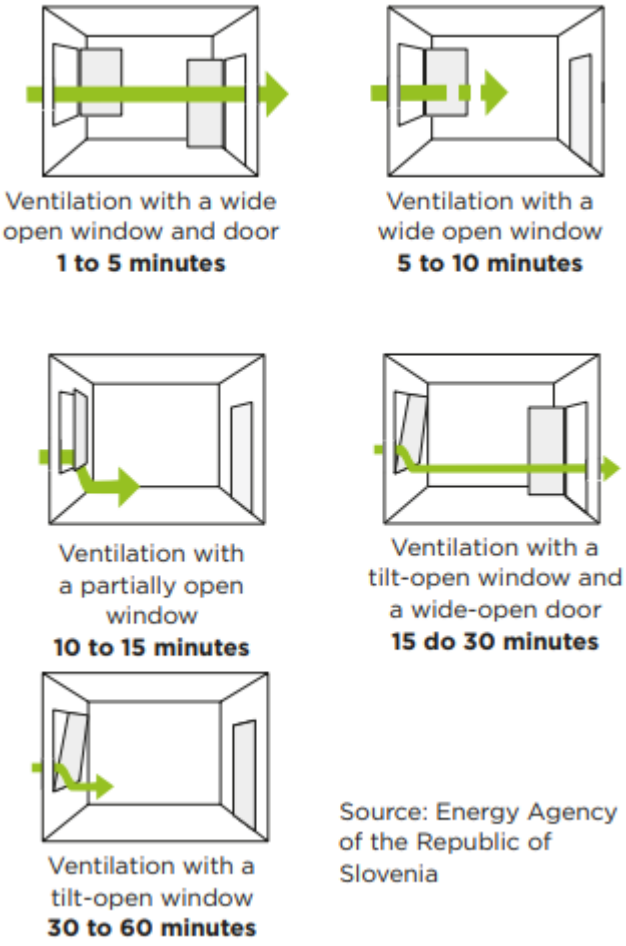
Results:

- Sick buildings syndrome, low quality indoor environment and a relative small exergy saving for heating.
- Increased relative humidity in the space, growth of fungi's, etc.
- Increased concentration of VOC, CO_2 and particulates.

Solutions with ventilation

Ventilation is the only way to prevent further negative impact of polluted indoor environment. There are two basic concept of ventilation:

- Natural ventilation with opening of windows
  - Wasting the heat in winter (intended to be saved by change of old windows);
  - Time consuming, intermittent.
- Artificial - mechanical ventilation
  - Central ventilation (standard by new and some older office buildings with air conditioning)
  - Local ventilation (most usual solution by existing building renovation)



Source: Energy Agency of the Republic of Slovenia

Ventilation principles comparison

Central ventilation

Central ventilation we consider when designing the house or building, and include the investment costs and location of air ducts in the design itself. Central systems offer good thermal efficiency and are usually distinguished by quieter operation, however, such systems require more installation space and come at a higher investment cost. Problem is the maintenance of the ducts (dirt deposition), room air supply control and noise transfer trough the duct system.

Local ventilation

An undisputed fact, also recognized by numerous experts, is that local ventilation systems provide a healthier and more efficient ventilation compared to central ventilation systems. They can be installed practically anywhere, in each and every room. As the path of air is shorter, air distribution costs are significantly lower, while users can adjust the unit's operation in each room according to their current needs. Due to simple installation, maintenance and cleaning, as well as its suitability for different-sized apartments and buildings, local ventilation system are gaining popularity and are now becoming even more popular than central ventilation systems.

Local ventilation advantages

Comparing this two ventilation system in application by building renovation and sustainable buildings, the advantage is going to local ventilation, because:

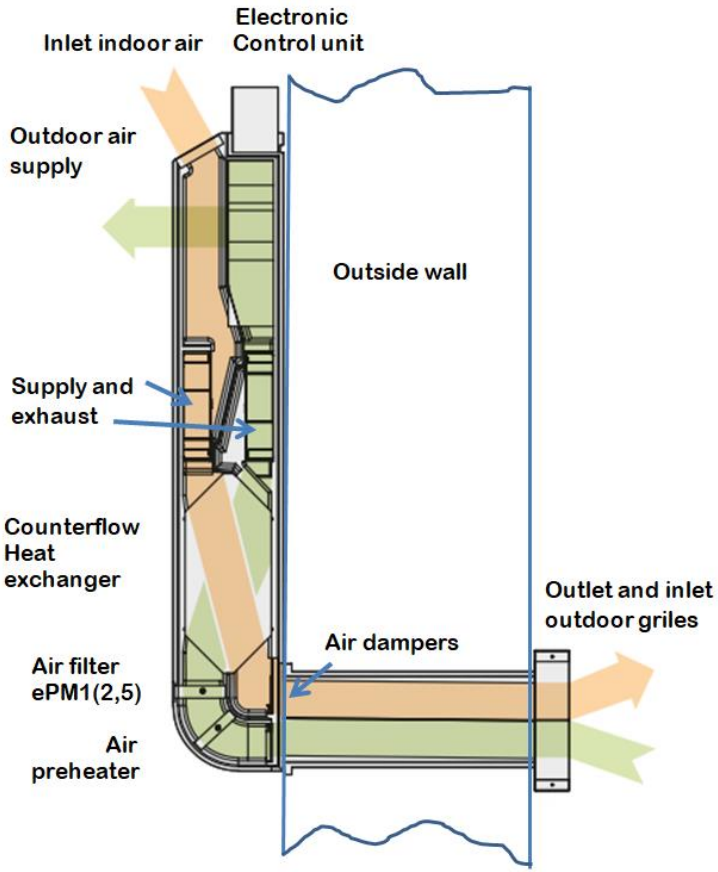
- No needs for duct work
- Simple installation in different room, according to the user needs
- Operation flexibility
- Cost efficient
- High quality of product
- Functionality

In modern sustainable building design both system can be applied. Decisions are more based on the behavior of the users, as from the quality of chosen system.

Funktions of modern local ventilation units

Modern local, compact ventilation unit consist of

- Outdoor grilles;
- Motorized damper for closing the building envelope in standby time;
- High efficiency outdoor air filter ePM2,5 with efficiency of 50-70%;
- Counter flow heat exchanger (HEX) with efficiency 70÷95%
- Supply and exhaust low noise fans;
- Indoor air filter ePM10
- Control units with IT capability for : fan speed control, indoor and outdoor temperature and humidity sensors, VOC or CO_2 sensor, radon sensor (on request), WiFi, remote control with timer, movement sensor or video camera.



Operation of modern local ventilation units

- The units can by operated locally by remote control or via WiFi with Aps by mobile, tablet or PC.
- Units are most advanced equipment in house and prepared for present and future smart building. Some of them have also electric air preheater to prevent freezing in HEX in cold days and high indoor humidity.
- Units can operate auto and as exhaust or supply air unit. The last function is important for summer night cooling of the rooms.
- Operational advantage of local ventilation units in apartments, office buildings, hotels, motels etc. is in their flexibility and independibility of operation by hours, days, weeks.
- Units are in operation when we need to have fresh and clean air in the room.

Exergy consumption

- With new standard prEN13142:2017 specific power input (SFI) for local ventilation units is limited between 0,11(Class 0) to 0,40 (class 6) W/m^3/h.
- Thee best unit of class 0 yearly exergy consumption will be less than ~964 W/m^3,y and for the class 6 will be ~3500 W/m^3,y; (24/7/12 operation h).
- The needed amount of outdoor air depend from occupation in the room and air pollution.
- With the electronic air purifier and new indoor air scrubber modul[1] for chemical washing of the indoor air the volume can be going down for 60 to 80%.
- The scrubber remove safely all molecular contaminants, including CO2, formaldehyde and full range of VOCs.

[1] enVerid System‘ Indoor Air Scrubber, ASHRAE J. March 2019, pg.12.

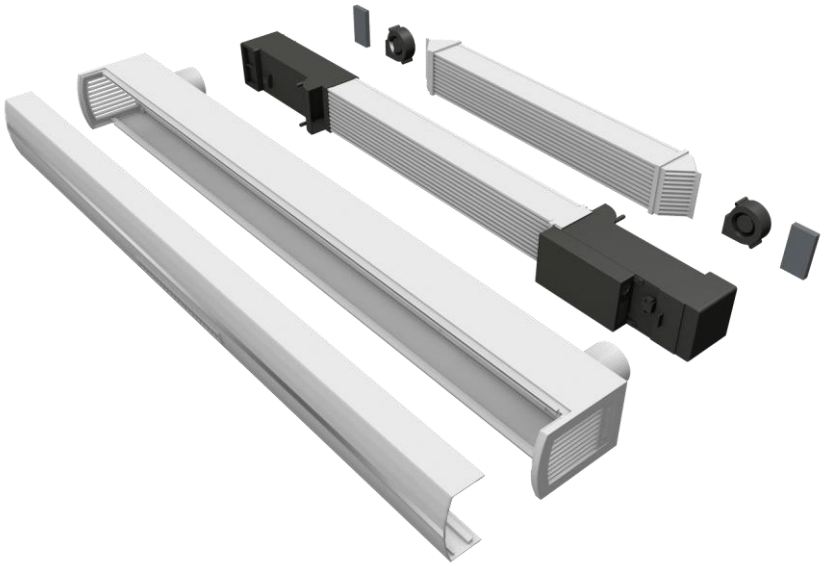
Ventilation in sustainable buildings

- Most of sustainable buildings are of new design .
- Exergy consumption is 20 -10 kWh/m^2 including ventilation loses.
- Most of exergy needed for building operation is renewable energy.
- All equipment have highest possible thermal and mechanical efficiency.
- Ventilation air is in the range 30 to 40 m3/h, occupant
- Local and central ventilation are chosen according to owner decision and building design (single family house, multifamily housing, office buildings, etc.).
- Multystory buildings with air conditioning have always central ventilation system.
- By renovation of multistory and single story buildings to passive or zero fossil exergy buildings, the local ventilation bring lot of advantages.
- All sustainable building are designed to be smart buildings and present state of the art technology of local ventilation respond to all IT requirement.

Conclusions

- Renovation of existing building make them more tight, similar to modern sustainable, low exergy or zero fossil exergy buildings . Both needs artificial ventilation, to provide the occupant healthy environment.
- Between central and local ventilation principle authors prefer local ventilation system, because of high flexibility, simple installation, energy efficiency, low investment costs and high quality of the product on the market.
- The new product for local ventilation are a new stone into direction to smart buildings with there connectivity and flexibility.

MIKrovent - local ventilation unit



MIKrovent Home 30

MIKrovent Office 60 & Professional 120

Ljubljana Declaration Statement

Indoor Environment and ventilation in sustainable buildings