Heat Recovery Ventilation

Higher Education Package for Nearly Zero Energy and Smart Building Design

Barna Edit PhD

Budapest University of Technology and Economics

HI-SMART

Erasmus+

Co-funded by the Erasmus+ Programme of the European Union

MŰEGYETEM 1782

STU

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

ENERGIAKLUB
CLIMATE POLICY INSTITUTE
APPLIED COMMUNICATIONS

Buildings today…and EPBD

https://nepszava.hu/3068763_mindent-megigertek-de-csak-nem-jon-a-berlakasepitesi-hullam

https://www.kalohirek.hu/ - Zsiga Ferenc / KALOhírek

http://pestbuda.hu/ -Bukovszki Péter/pestbuda.hu

https://nlc.hu/otthon/20141014/kadar-kocka-haz-videk-magyar/

Caution!

https://renew.org.au/wp-content/uploads/2020/09/interior.png/

https://pingvinpatika.hu/pub/media/wysiwyg/Blog/faradt_almos_asit_tavaszifaradtsag_118436882_1200px.jpg

Effects of airtightness!

https://napidoktor.hu/wp-content/uploads/2020/06/poli-farbe_1.jpg

HI-SMART

Erasmus+

Caution!

https://kanizsaujsag.hu/

http://www.kondenzacioskazan.eu/wp-content/uploads/2016/02/baxi_duo-tec_combi_28_he.jpg

For traditional, open combustion gas-appliances:
Sufficient ventilation air has to be provided for proper operation and to avoid accidents.

https://scotlandhomesafe.co.uk/products/honeywell-xc70

HI-SMART

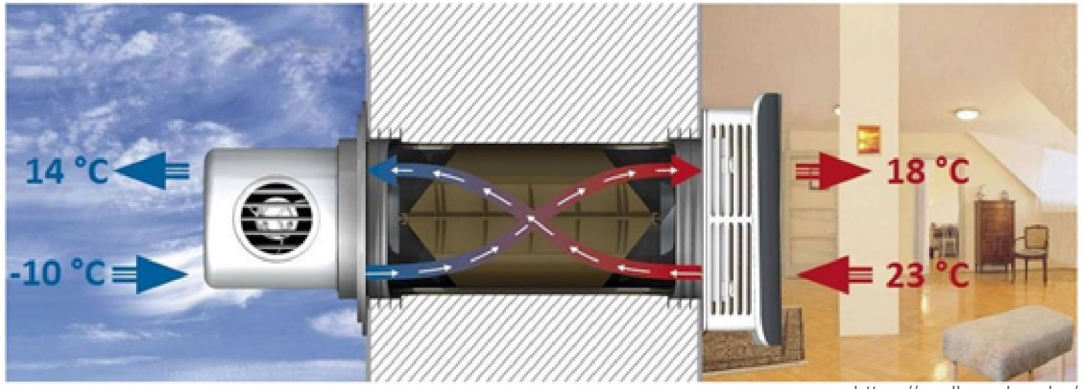
Erasmus+

Means of ventilation

https://kep.index.hu/1/0/3193/31933/319339/31933931_2449911_1740c1f1d7433c5157ba499ee6429ec9_wm.jpg

https://klimatrend.eu/higroszabalyzas-aereco-legbevezetok/

https://ezermester.hu/cikk-5792/Parasodo_ablakok



https://szellozoshop.hu/

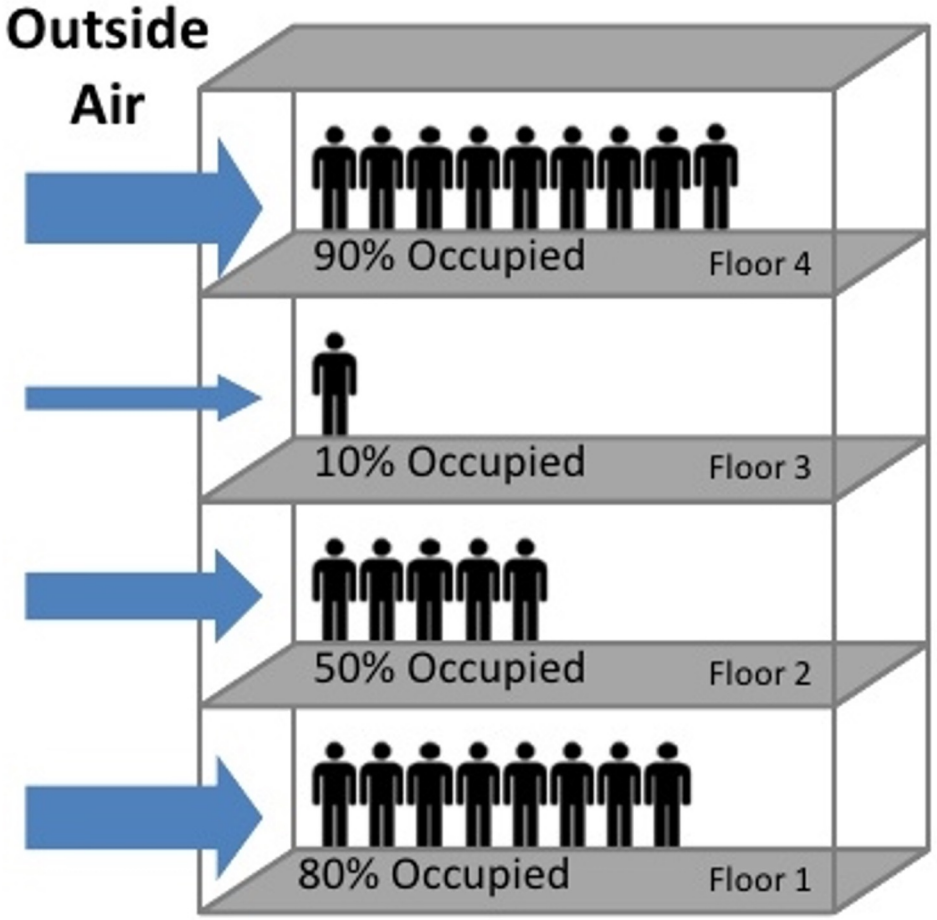
Energy demand of ventilation

In EPBD, among other aspects, ventilation of buildings and it's energy demand is of concern.

Energy demand for ventilation can be reduced by:

- Adjusting ventilation according to the actual demand; and/or
- Recover the energy from ventilation.

Demand controlled mechanical ventilation



https://www.horizon-engineering.com/uncover-hidden-energy-savings-using-demand-control-ventilation-and-building-pressure-control

- Ventilation need is detected and operation time is reduced with the time when ventilation is not needed.
- Minimum ventilation rate is still necessary depending on the occupancy and the building needs (insufficient ventilation could cause damage to the building, or harm on health)
- This ventilation air is heated in winter and sometimes cooled in summer.
- To save this thermal energy **heat recovery** should be used in the ventilation system.

Role of heat recovery ventilation

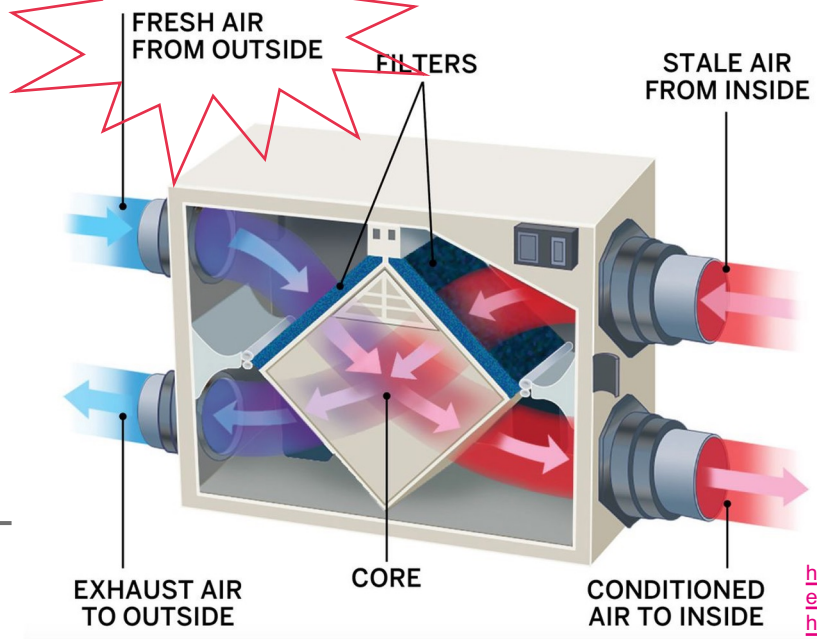
In highly insulated, air tight buildings the role of ventilation is crucial:

- at least 50% of heat losses are caused by the ventilation
- heat recovery ventilation is a necessity in order to meet the target set by EPBD

The role of heat recovery is to:

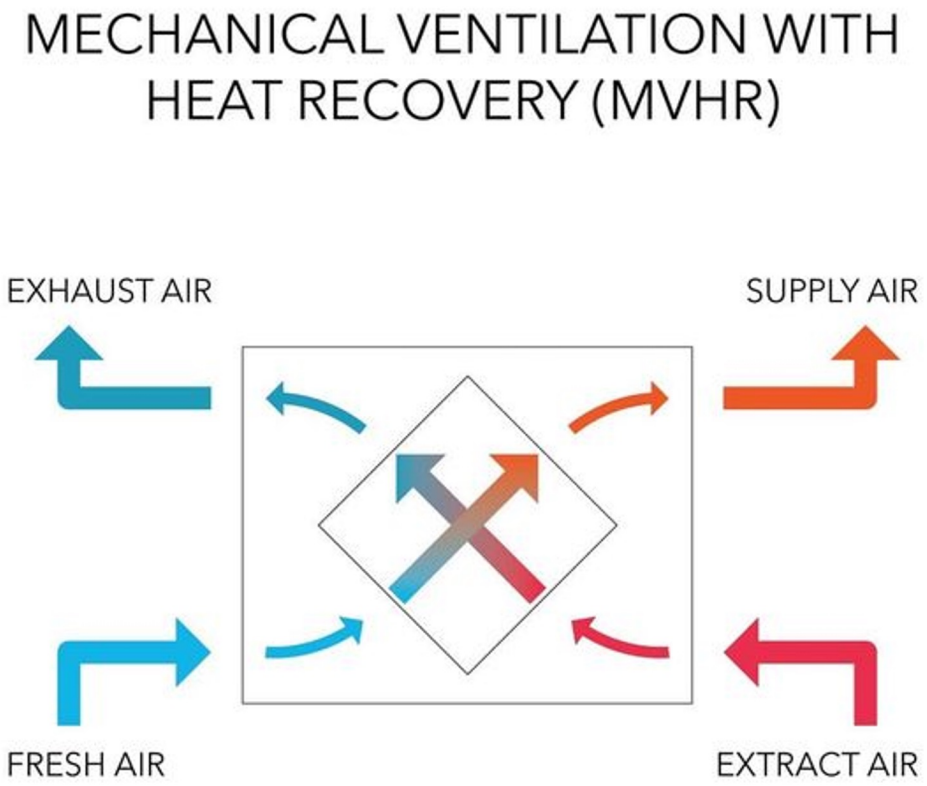
- Contribute to energy savings
- Provide fresh air for occupants
  - Maintain IAQ and thermal comfort

www.freeimageslive.com



https://www.thisoldhouse.com/green-home/21124887/healthy-home-clearing-the-air - Ian Worpole

Operation of HR…in winter



passivehouseschool.com

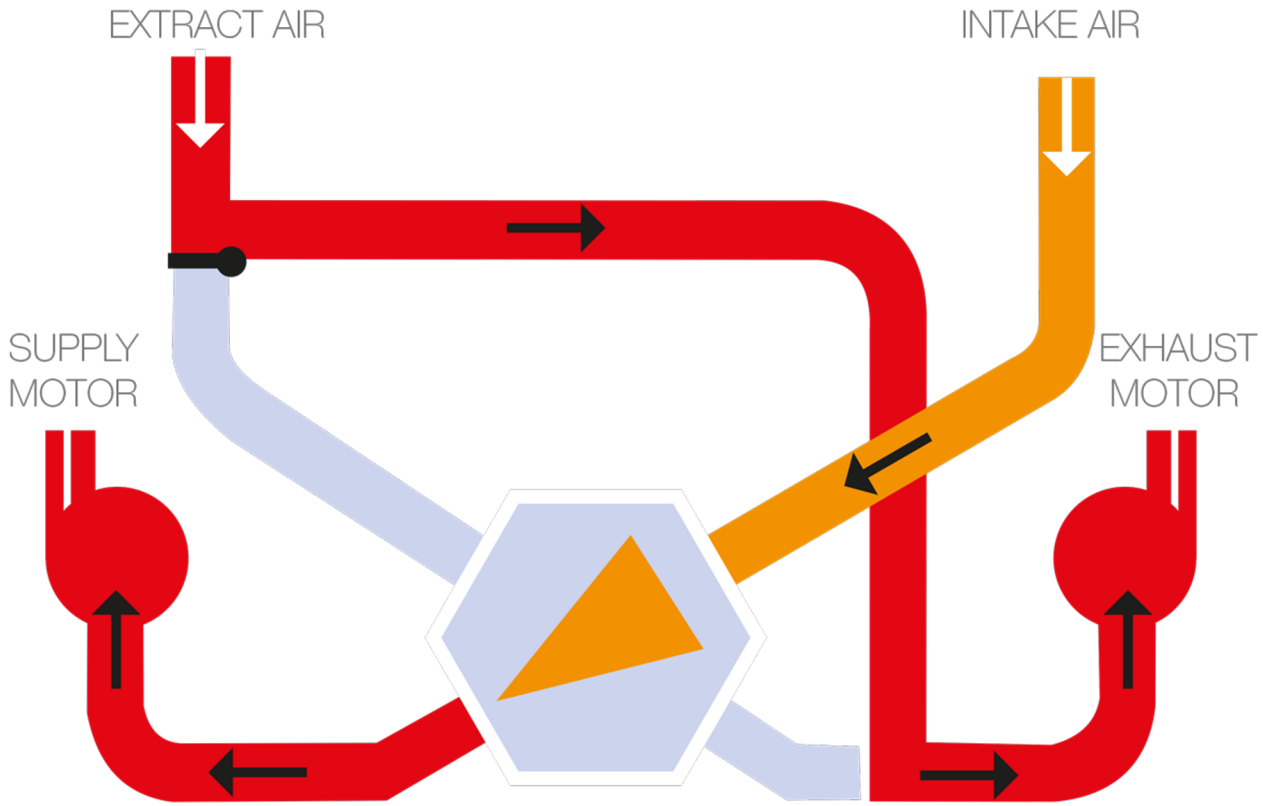
By recovering the residual heat in the extract air, the fresh air is pre-heated, and the supply air enthalpy is increased before it enters the rooms. MVHR units typically recover about 75–95% of the heat in the extract air.

Operation…in summer

Recovery operation: Hot fresh air enters the unit, cools down in the heat exchanger and a fan moves the air to the room.

From the wet rooms of the flat, the humid exhaust air is removed. This cools down the incoming air in the heat exchanger.

If weather is cooler outside **a bypass** can be used – no heat exchange occurs between supply and exhaust.



https://www.zehnder.co.uk/summer-bypass

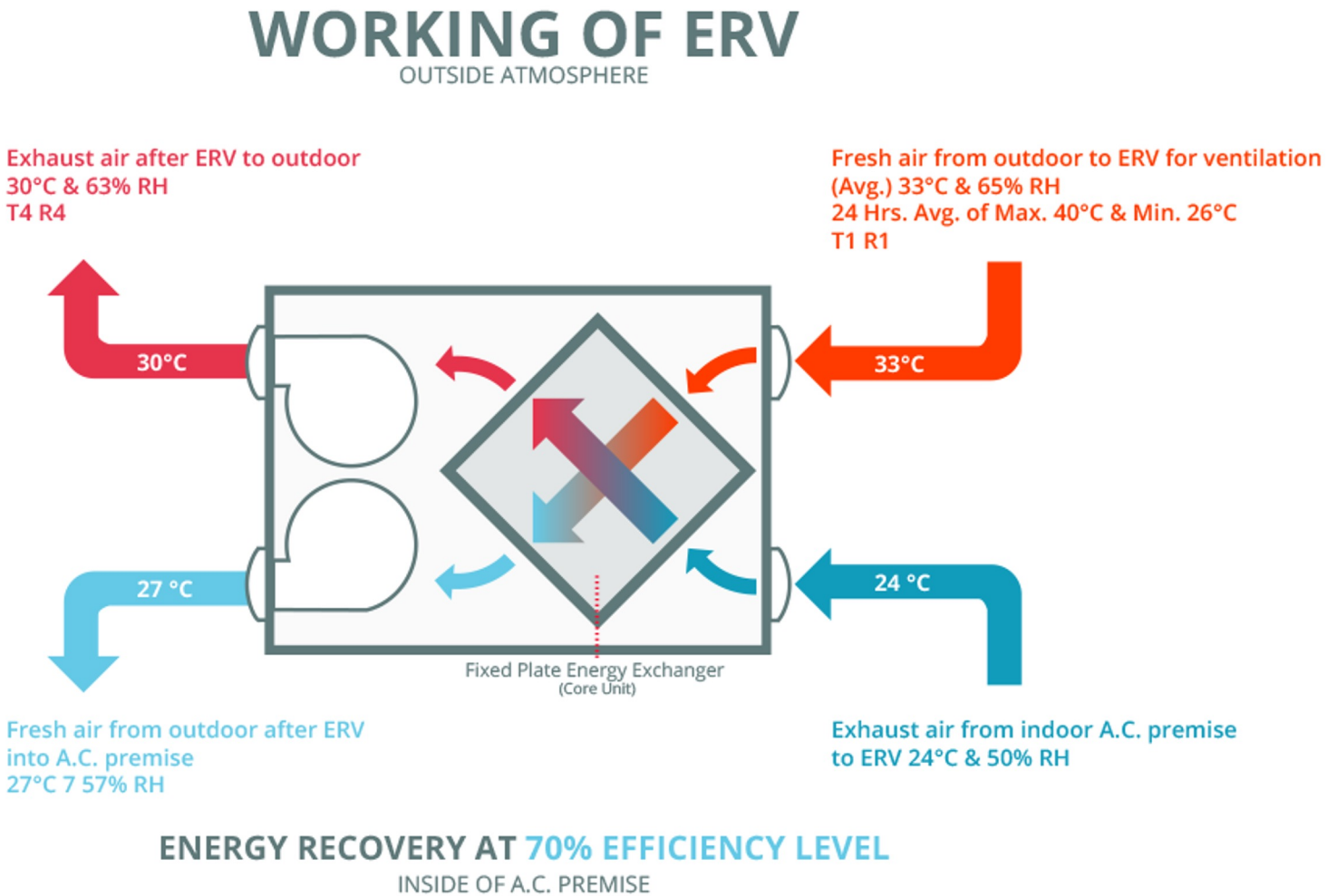
Humidity recovery/ energy recovery

Enthalpy heat recovery is when humidity from the exhaust air is also recovered besides heat.

Cold and dry winter outdoor air is heated and its moisture content is increased with the recovered moisture from the exhaust.

Internal moisture emission is needed!

In summer, the unit can decrease the moisture content of hot and humid supply air.

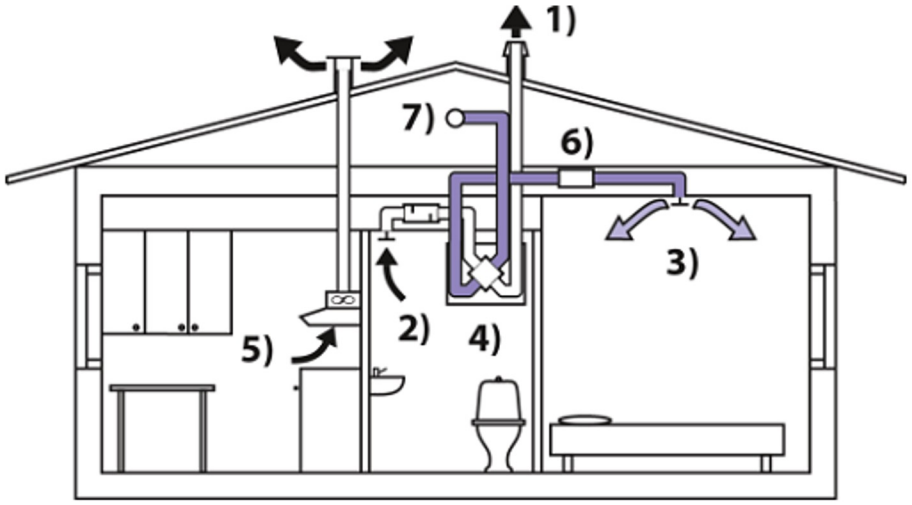


https://zeroenergyproject.org/wp-content/uploads/2016/05/erv_zero_energy.png

Mechanical exhaust and supply system

In mechanical supply and exhaust systems the air is supplied

- via ducts and fans
- to bedrooms and living rooms,
- and typically exhausted from the kitchen, bathrooms and toilets.



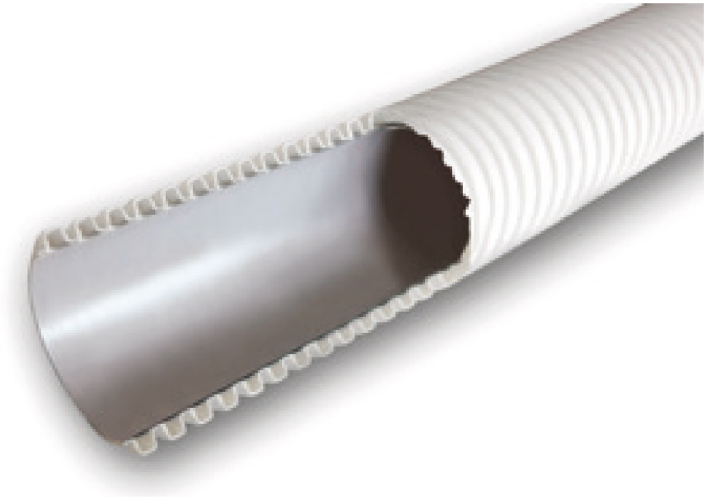
Principle of mechanical exhaust and supply system in a house. 1) Exhaust air 2) Extract air 3) Supply air to the bedroom 4) Ventilation unit with heat recovery 5) Kitchen exhaust 6) Sound attenuator 7) Outdoor air intake for ventilation.

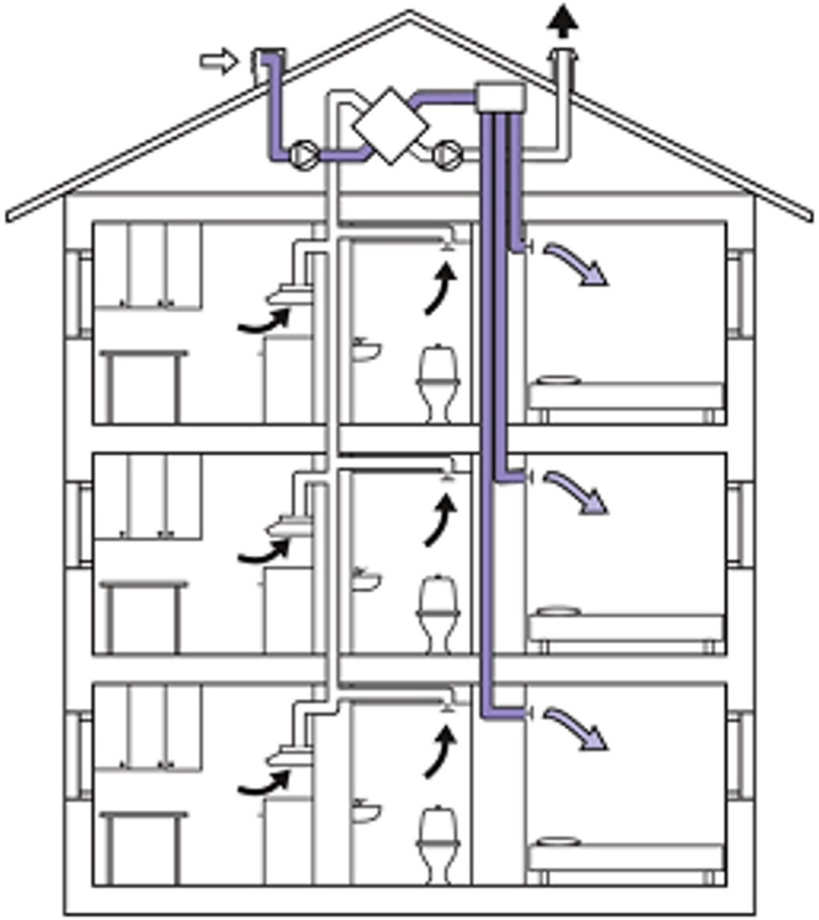
REHVA Guidebook 25 - Residential Heat Recovery Ventilation

In apartment buildings…

Mechanical exhaust and sup
system can be: **centralized**

https://helios.hu/

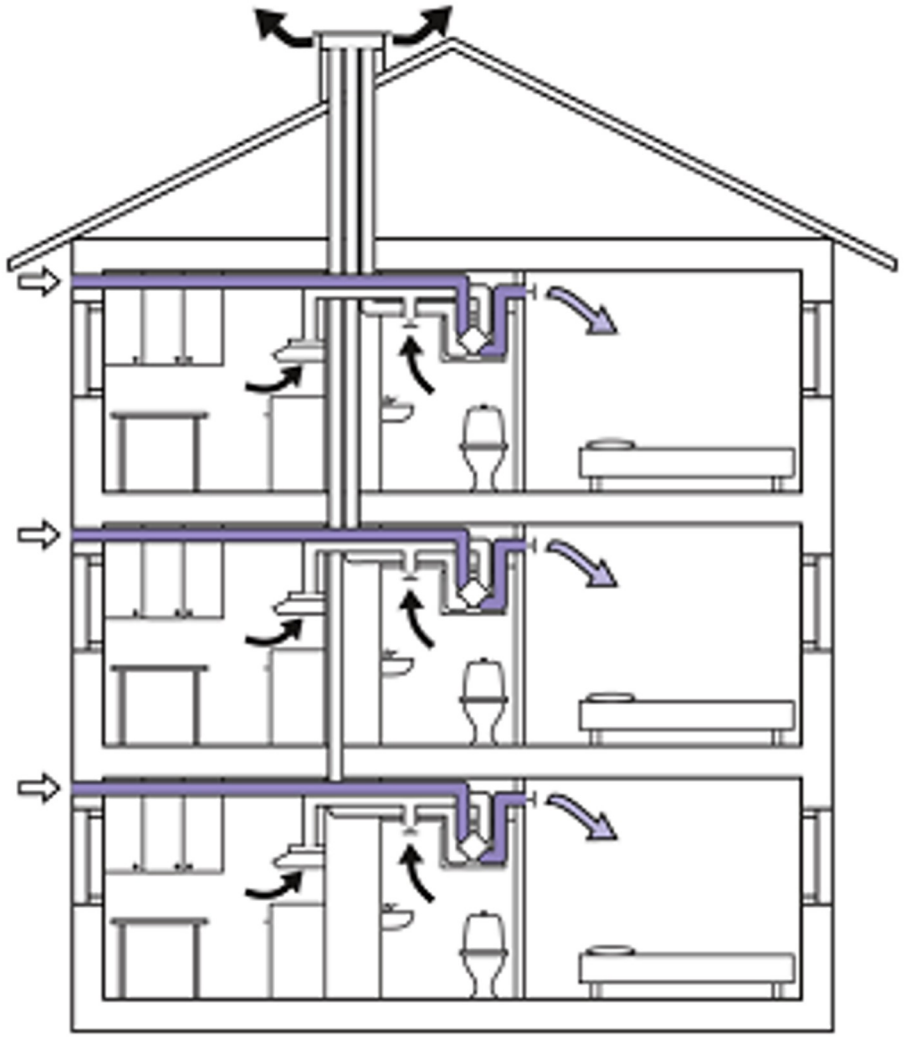




REHVA Guidebook 25 - Residential Heat Recovery Ventilation

In apartment buildings…

Mechanical exhaust and supply system can be: **decentralized**



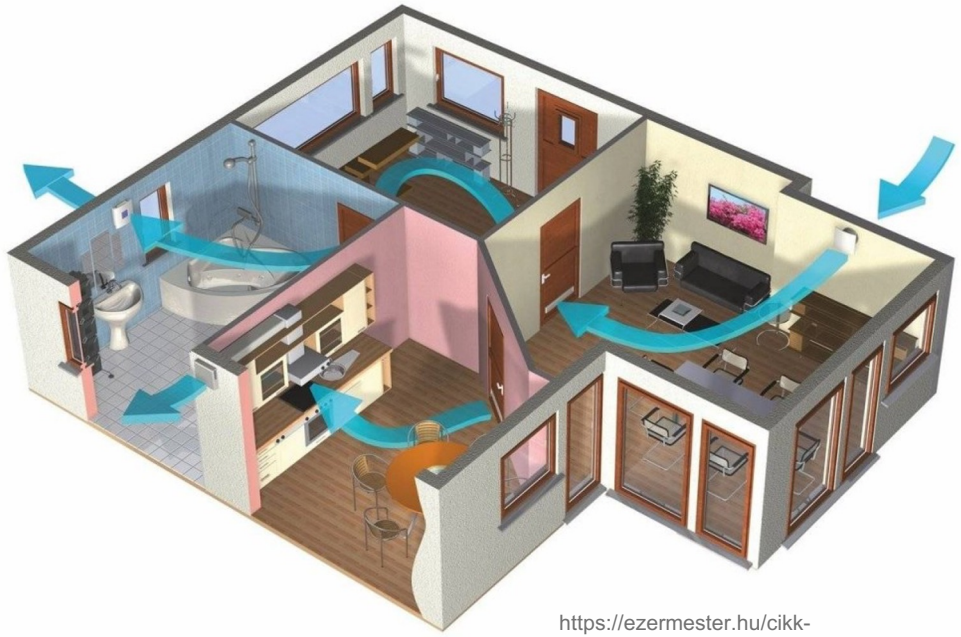
REHVA Guidebook 25 - Residential Heat Recovery Ventilation

Room ventilation units

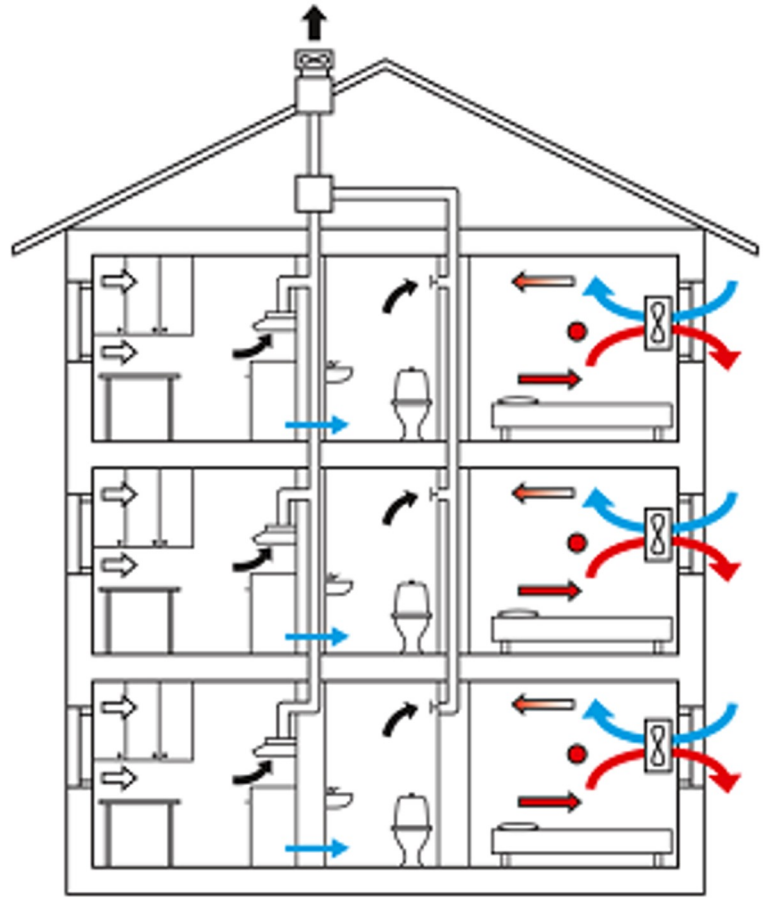
Can be applied when buildings are renovated.

Combines existing mechanical supply and exhaust and room ventilation units

Less efficient



https://ezermester.hu/cikk-9326/Rendszerbe_foglalt_decentralis_lakasszellozte tok



REHVA Guidebook 25 - Residential Heat Recovery Ventilation

Parameters to consider

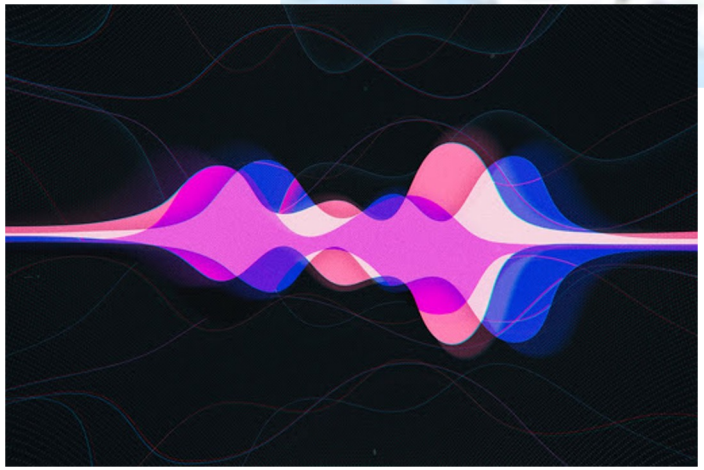
Air flow rates

- For indoor air quality in homes
- To remove humidity and pollutants

Electric energy consumption

Noise and draught

https://actmedia.eu/



http://www.echonoisecontrol.com/

Air flow rates

EN 16798:1 specifies the required amount of air per person

- Category I : 10 l/s
- Category II: 7 l/s
- Category III: 4 l/s

- 1 l/s=3.6 m3/h

Average air change rate in residences (from practice): 0.5 (1/h)

Revision - The path of air

Outdoor air is supplied to living rooms, bedrooms.

The ventilation air for the kitchen, bathroom and toilet has to be transferred from the bedrooms and living rooms.

From wet rooms extract airflows are needed to remove pollutants and humidity.

https://helios.hu/

Minimum design supply and extract air-flow rates

	Supply (l/s)	Extract (l/s)	Air velocity (m/s)
Living rooms >15m^2	8+0.27 l/s,m^2		0.1
Bedrooms >15m^2	14		0.1
Living- and bedrooms 11-15m^2	12		0.1
Bedrooms <11m^2	8		0.1
WC		10	
Bathroom		15	
Kitchen/with cooker hood		8 / 25	

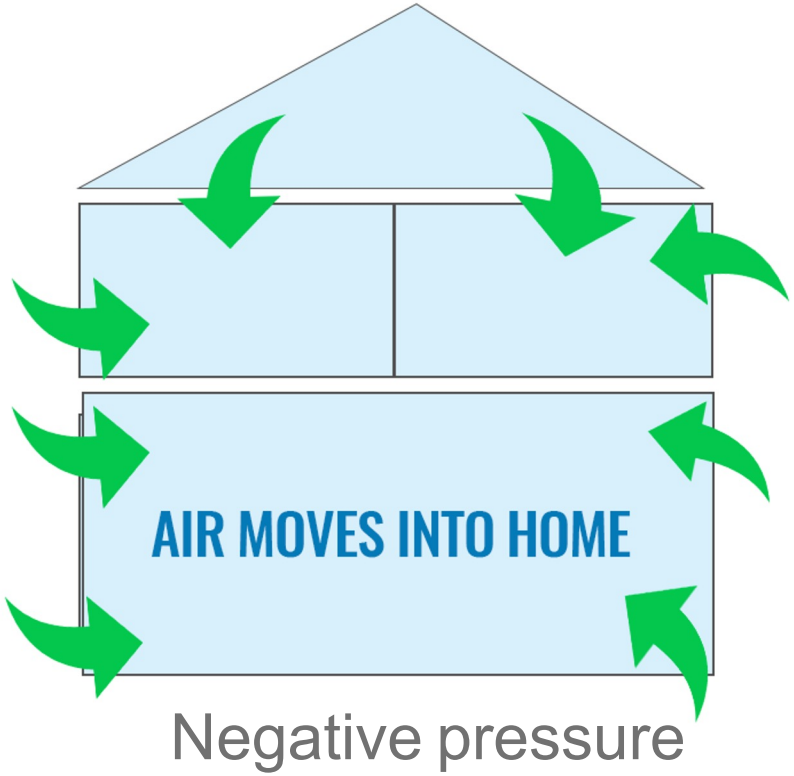
HI-SMART
Erasmus+

Cooker hood airflow

In new airtight buildings the cooker hood airflow has to be compensated:

https://www.klarstein.hu/Hasztartasi-cikkek/Paraelszivok/Fali-paraelszivok

- the total extract and supply airflow rates should be approx. equal in order to avoid excessive negative pressure in the building.



Negative pressure

https://yellowbluetech.com/2019/04/10/clearing-home-negative-air-pressure/

Draught

The sensation of draught depends on the air velocity, air temperature and variation of air speed which is expressed as turbulence intensity.

A maximum mean air velocity of 0.1 m/s is recommended as the design criterion. (DR max. 10%)

In summer higher velocities are allowed.

$DR=(34-t_a)(v-0.05)^{0.62}(0.37 \cdot v \cdot Tu+3.14)$

Where,

DR – is draught rating, i.e. the percentage of people dissatisfied due to draught, in per cen (%)

t_a – is the local air temperature ($19<t_a<27°C$), in degrees Celsius (°C)

v – is the local mean air velocity, in metres per second (m/s)

Tu – is the local turbulence intensity, in per cent (%).

ISO 7730

Noise

People are more sensitive to noise in a quiet residential environment compared to an office environment.

Design equivalent continuous sound level, LAeq,nT	dB (A)
Bedroom	25
Living room	30
Wet room	35

REHVA Guidebook 25 - Residential Heat Recovery Ventilation

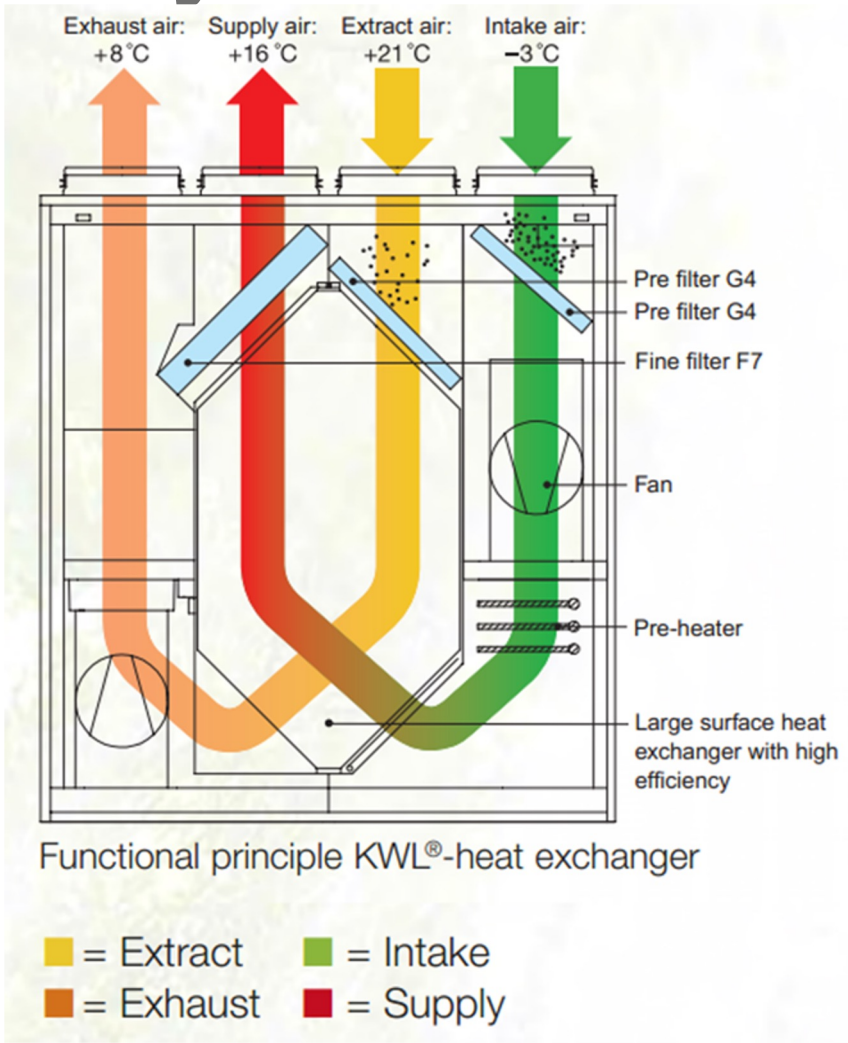
The noise level should not be more that 45 dB(A) at the balcony or at the neighbour's window.

System elements -Heat recovery unit

Heat exchanger types used in residential ventilation units:

- plate heat exchangers (recuperative) and
- rotary heat exchangers (regenerative)

- COVID-19 info: plate heat exchangers hold no risks (no contamination of incoming air), rotary heat exchangers have to be investigated for air leaks – cannot be more than 5 %.



Functional principle KWL®-heat exchanger

www.heliosventilatoren.de

Selection of the heat recovery unit

Selection parameters

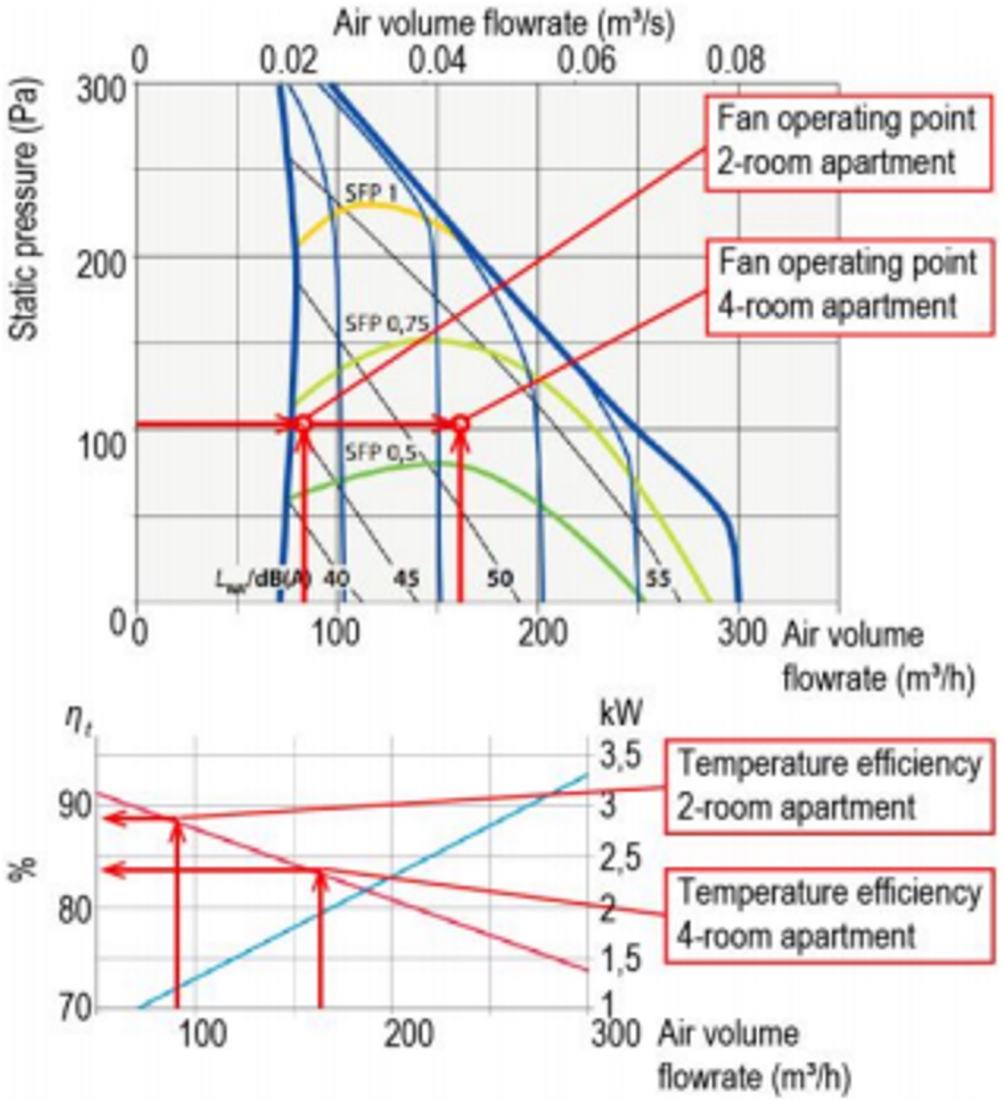
design air-flow rate of the air handling unit = sum of room airflow rates.

ductwork pressure drop must be assumed

- initial value of 100 Pa can be used for smaller apartments
- initial value of 200 Pa can be used for apartment buildings
- 50 Pa should be added to take into account the increase of pressure drop of filters during operation

(acutal pressure drop to be calculated in later design stage)

Example of diagram for specific fan power



HI-SMART
Erasmus+

System elements -air terminal units

Supply air must reach the occupied zone without causing draught.

The pressure drop of diffusers and grilles must not be too high.

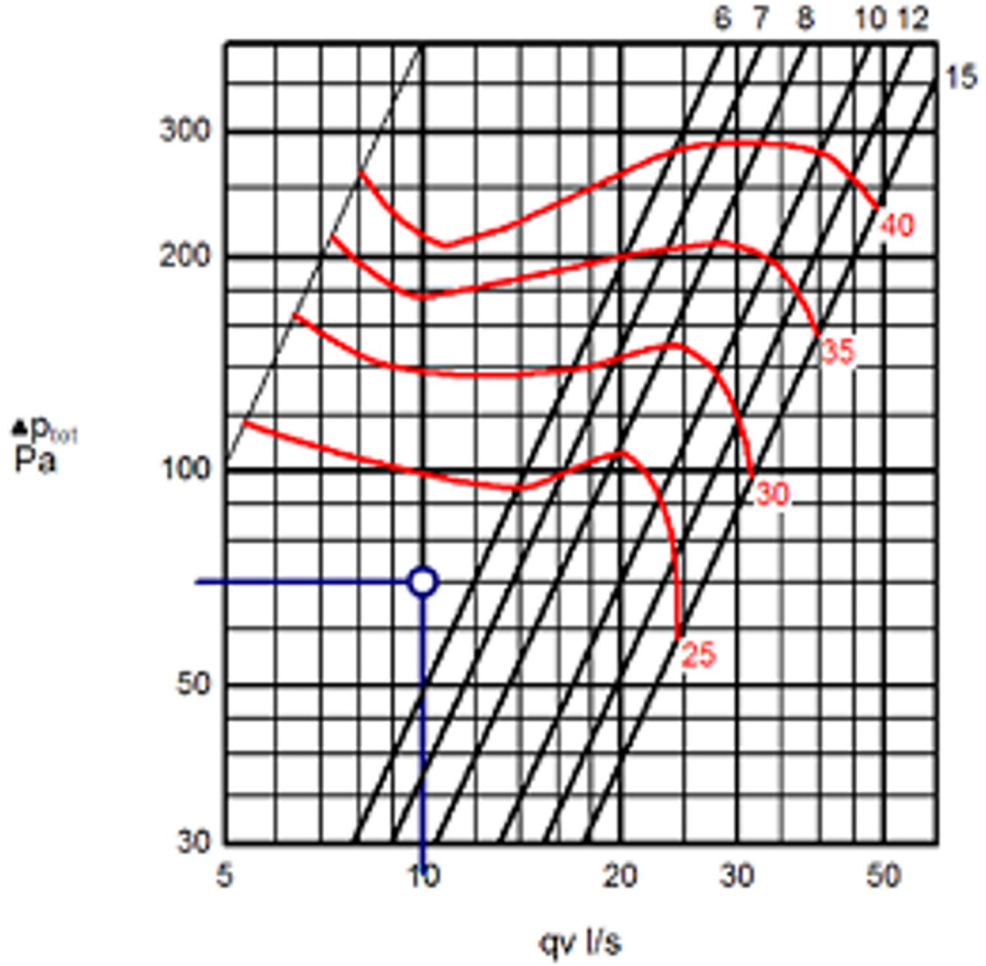
Diffusers and grilles should have pressure drop adjustment possibilities.

The diffusers and grilles must not cause noise.

www.primexvents.com

Selection diagram of a supply diffuser

- Different sound pressure levels indicated with red,
- Based on flow and pressure drop the adequate diffuser can be selected.



REHVA Guidebook 25 - Residential Heat Recovery Ventilation

Positioning of units and ductwork

Place the air handling so that it will be convenient to connect it with ducts, electricity and the condensate drain and with enough space and access for future maintenance. Units should be placed indoors (e.g. kitchen, corridor, bathroom).

Place the air terminal devices (supply & exhaust) in rooms with effective air exchange.

Positioning of units and ductwork

Ducts should be large enough to ensure air velocities that are within allowed limits.

https://helios.hu/

Thermal insulation should be positioned correctly (depending whether the unit is inside or outside).

Pressure drop calculation

The ductwork pressure drop consists of:

- Pressure drop due to friction
- Pressure drop of ductwork elements such as bends, branches, air terminals, dampers

Pressure drop due to friction:

- Depends on duct dimensions and air velocity
- Ducts should be dimensioned so that friction pressure drop does not exceed 0.6 to 1 Pa/m,
- Air velocities must be checked for noise.

Pressure drop calculations

Pressure drop from duct elements depends on:

- air velocity,
- pressure loss coefficients of ductwork elements.

$$\Delta p = \xi \cdot p_d$$

where, Δp – pressure drop (Pa); ξ – pressure loss coefficient, p_d – dynamic pressure

System elements - Filters

Aim according to EU Directive 2008/50

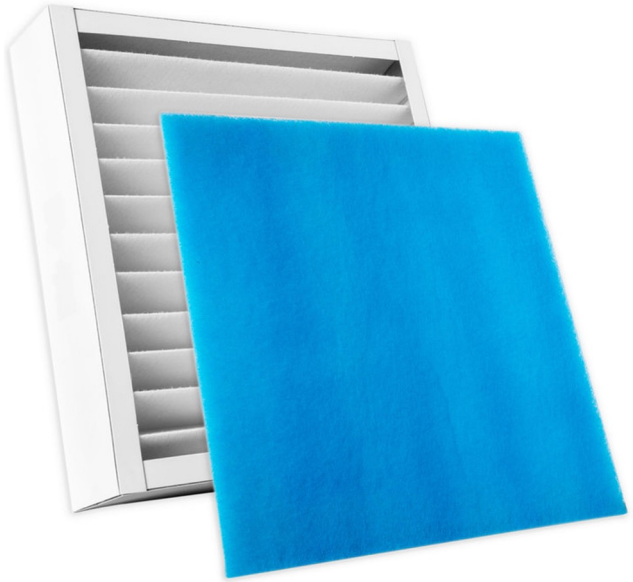
- the annual average of PM10 should be < 40 µg/m³ and for PM2.5 it should be <25 µg/m³ indoors

WHO guideline

- target for the annual mean value for
- PM2.5 is <10 µg/m³ and for PM10 <20 µg/m³.

With today's filtration technology it is feasible to meet the WHO target

Filters



https://www.kwl-filteronline.de/

Local outdoor values for PMx can be found in WHO's database: Ambient (outdoor) air pollution database

It is recommended to change filters when the initial pressure drop is doubled or at least once in a year.

Specific fan power and fan electricity use

Pressure drop calculations enable accurate specific fan power calculations.

50 Pa should be added to take into account the increase of pressure drop of filters during operation.

Annual electricity use of the fan:

$$Ev = SFP \cdot q_v \cdot \tau$$

Where: Ev – electricity use (kWh), SFP – specific fan power (kW/(m^3/s)), q_v – air flow rate (m^3/s), τ – time (h – 8760h)

Heat recovery efficiency

Also known as temperature ratio

Together with specific fan power they describe the thermal and electrical efficiency of ventilation units.

$$SFP=P/q_v$$

where, P - the total power input of the ventilation unit incl. fans, actuators and controls, kW, q_v – design air flow rate (m^3/s)

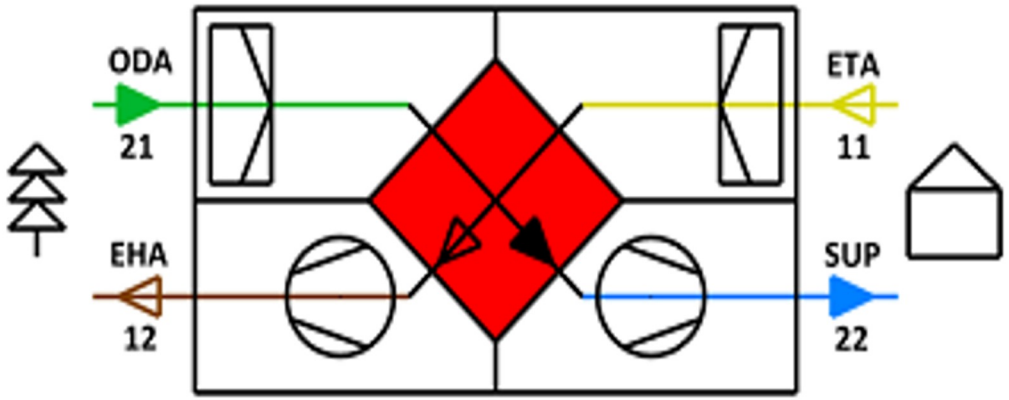
Heat recovery efficiency

Heat recovery efficiencies are determined according to EN 13141-7 for residential ventilation units.

On the supply and extract air side:

$$\eta_{t,su} = \frac{t_{22} - t_{21}}{t_{11} - t_{21}} \cdot \frac{q_{m22}}{q_{m11}}$$

$$\eta_{t,ex} = \frac{t_{12} - t_{11}}{t_{11} - t_{21}} \cdot \frac{q_{m11}}{q_{m22}}$$



t_{22} is the supply air outlet (supply); t_{11} is the extract air inlet (extract);

t_{21} is the supply air inlet (outdoor); t_{12} is the extract air outlet (exhaust);

q_{m22} is the supply air mass flow;

q_{m11} is the extract air mass flow;

HI-SMART
Erasmus+

Annual energy efficiency

It is based on recovered energy and the heating demand of the ventilation:

$$\varepsilon_{sup} = 1 - \frac{Q_{coil}}{Q_{off}}$$

ε_{sup} - is the annual efficiency of the heat recovery,

Q_{coil} is the annual heating energy of supply air including defrosting, kWh

Q_{off} is the annual heating energy of supply air without heat recovery, kWh

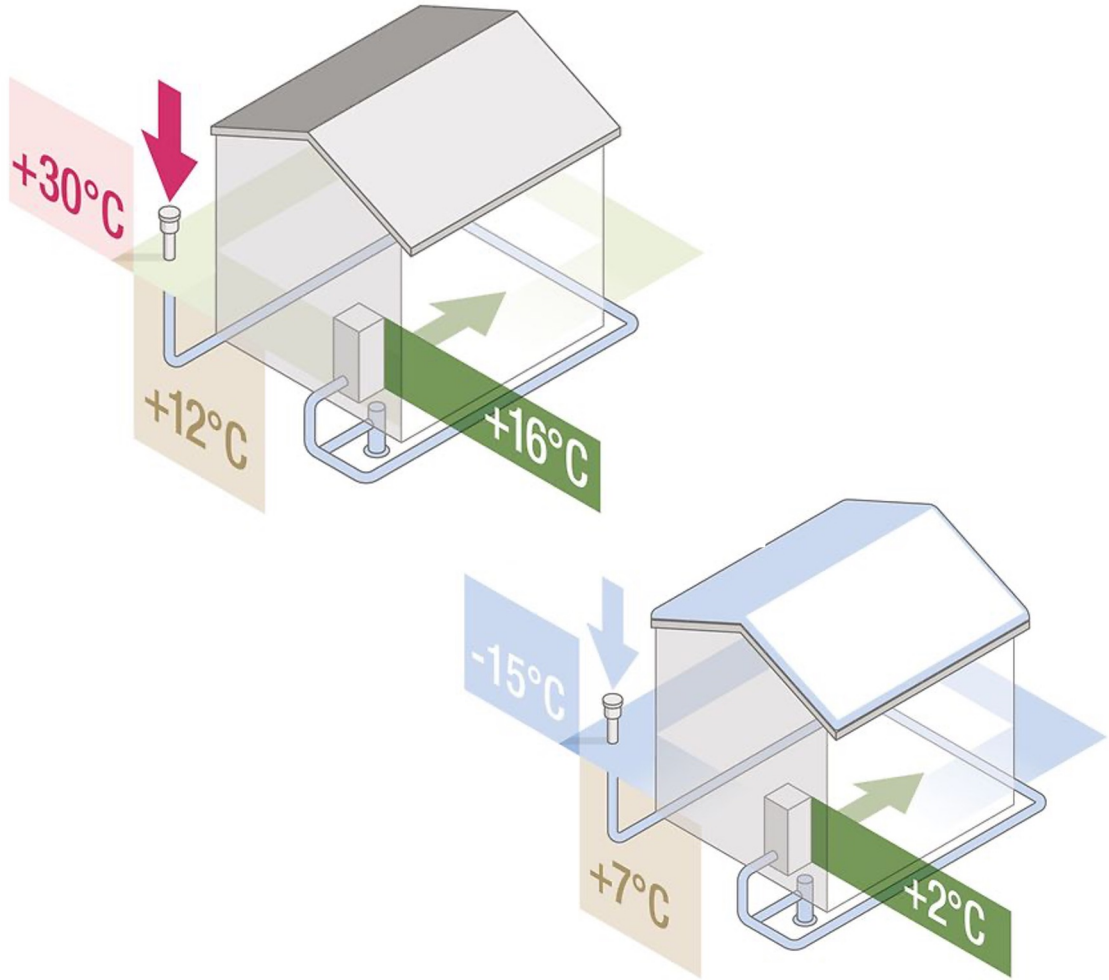
Use of ground heat exchangers as supplements

1-1.5 m below ground level the effect of weather is not significant

In winter it does not cool that much, in summer it does not heat up

With ground heat exchanger it is possible to pre-heat or pre-cool the ventilation air.

Can be useful in more extreme climates.



https://www.rehau.com/uk-en/ground-heat-exchanger

Thank you for your attention!

Barna Edit PhD
Barna.edit@epget.bme.hu

Budapest University of Technology and Economics
Department of Building Services and Process Engineering

Erasmus+

The views and opinions expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission.

Co-funded by the Erasmus+ Programme of the European Union

STU

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

ENERGIAKLUB
CLIMATE POLICY INSTITUTE
APPLIED COMMUNICATIONS