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SINTEF

Review of HVAC strategies for energy renovation of detached houses towards nZEB in cold climates

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OPPTRE Energy upgrading of wooden dwellings to nearly zero energy level

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Energy upgrading of wooden dwellings to nearly zero energy level

http://opptre.no/

- WP3 on heating, ventilation and energy generation
- Architecture competition will develop design proposals for 5 case houses
- SINTEF NTNU

SYSTEMHUS MESTERHUS HUNTON isola VELUX

RATIO ARKITEKTER AS FLEXIT BEDRE INNEKLIMA ENOVA DIREKTORATET FOR BYGGKVALITET

Detached houses in Norway

- Limited sun in winter
- Cold – mild - wet

- Wood, lightweight,
- Built 1950 – 90
- Electric space heating, little hydronic
- Peak heating from woodstoves

Systemhus-catalogue: «Alstad»

Ventilation

- More airtight after renovation
- 60% of renovations make no changes to ventilation
- Only 9% install balanced mechanical ventilation (Bjørnstad 2015)

Need solutions simple and affordable enough to actually be implemented

Ambitious energy renovation

- Few projects monitored and analyzed
- Few studies on HVAC systems
- Mostly simulation-based

Overhalla
Moltemyr
Isterdalen
SEOPP Bergen
SEOPP Oslo

Photo: Jiri Havran

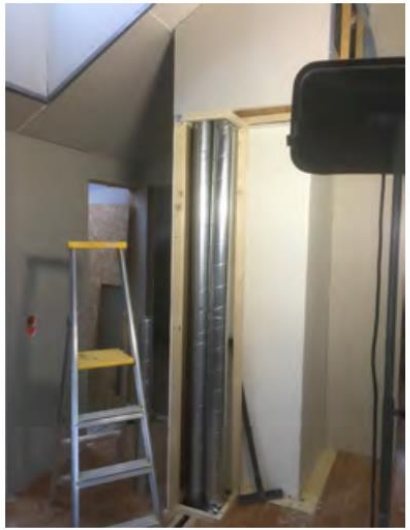
Photo: Jiri Havran

Balanced ventilation with heat recovery

+ Heat recovery
+ IAQ: stable and predictable air change, filtering
+ Thermal comfort: prehat supply air

÷ Retrofitting ducts
÷ **Costs**

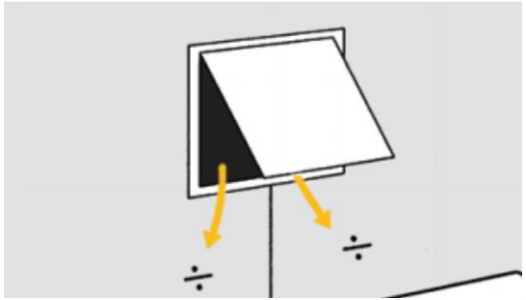
Cool bedrooms?



Kilde:

Ventilation solutions (simple, affordable?)

- Single room ventilators with heat recovery
- Natural ventilation
- Hybrid; window ventilated bedroom



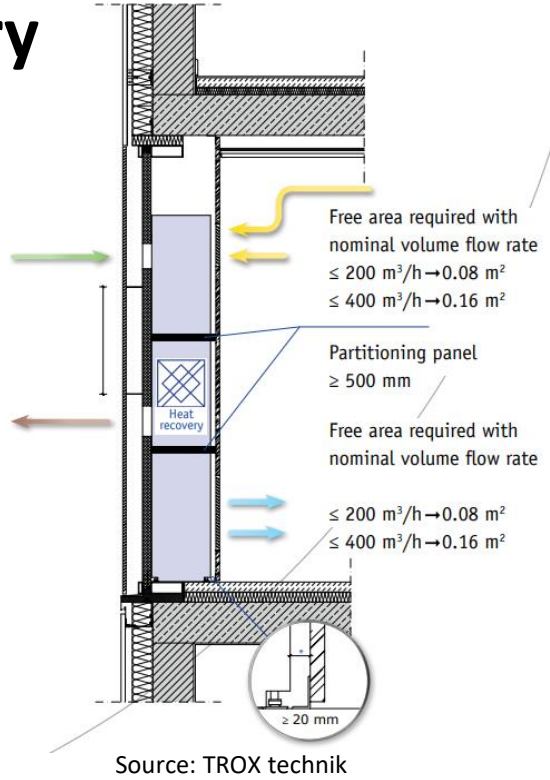
Challenges

- Heat recovery
- Cold draught (no problem in bedrooms)
- Stable and predictable air change

Single room ventilators with heat recovery

+ No ductwork: low fan consumption, easy installation
+ Heat recovery (efficiency?)
÷ Noise
÷ Crude filtering
÷ Sensitive to pressure; wind, stack

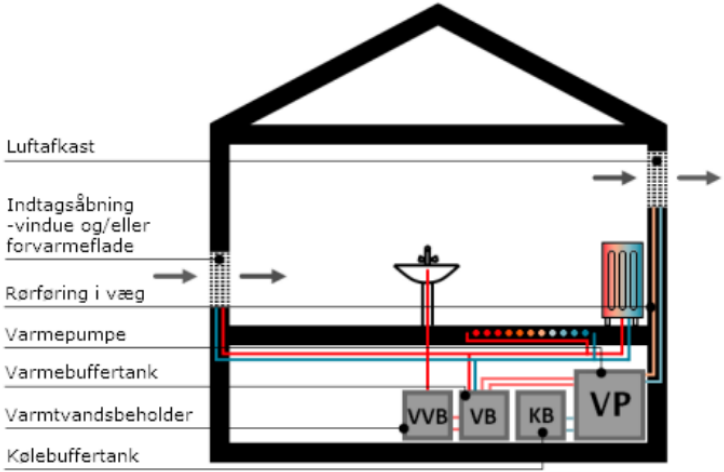
Source: Lunos



Source: TROX technik

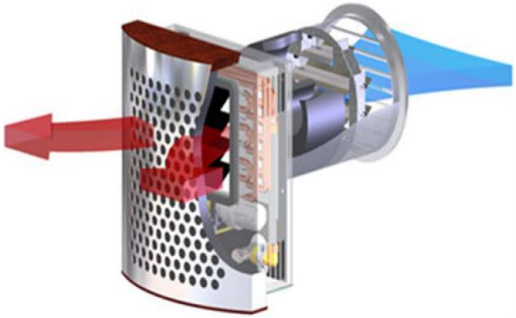
Exhaust air heat pump

- Heat to DHW, or also hydronic space heating
- 4-6 kW heating capacity:
  need good insulation level.
- Challenge: Cold supply air



Source: energiteknologi.dk, EUDP

EAHP had almost as good energy performance as balanced ventilation in a comparison by Gustafsson (2014). This was a renovated semi-detached house, with insulation level of the EnerPHit-standard, in Stockholm climate.

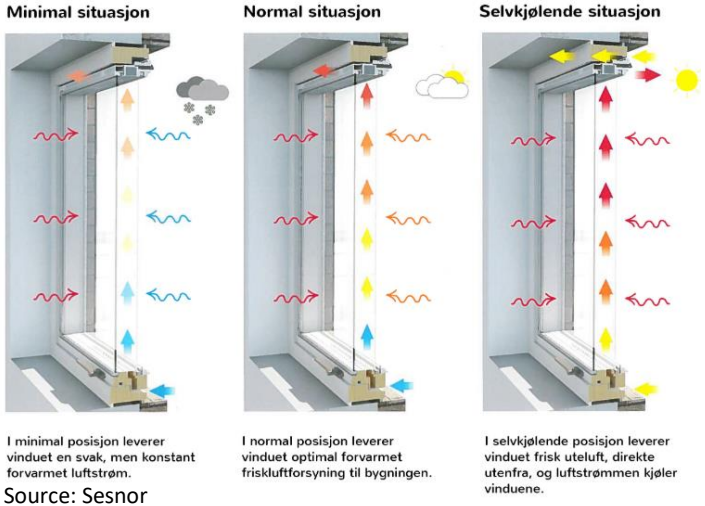


Ventilated window

- Combine with EAHP
- Preheating of 2-5°C at typical airflow rates, most at low outdoor temp

÷ Increases heat loss from window

Korpåsen project, Oslo Photo: Linje Arkitektur AS



Source: Sesnor

Ventilation radiator

- Allows lower water temperature (35-40) than ordinary radiator (Jin 2017)

÷ Need hydronic heating system

In highly-insulated houses, cold draft can occur when the outdoor temperature is near the balance temperature of the house: as the radiators are not heating, supply air will not be preheated.

Source: Purmo

Cool bedrooms

Reports of open windows and reduced energy performance in highly insulated houses, due to warmer bedrooms than occupants prefer. Why, what is new?

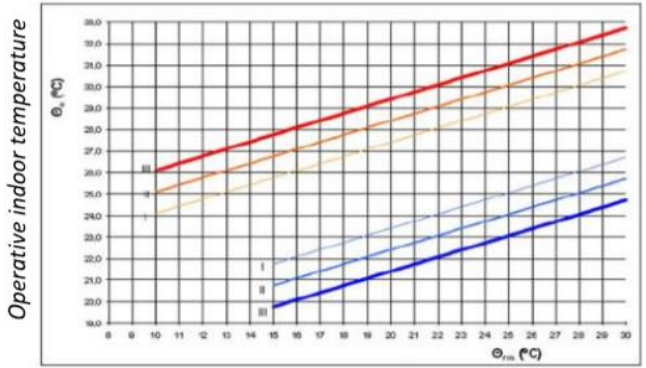
- Balanced cascade ventilation
- Higher bathroom temperature
- Reduced thermal loss through envelope
- People are expected **not** to open windows

Also after renovation?
Klinski reported open bedroom windows in a renovated house where balanced ventilation has been installed.

Cool bedrooms - expanded comfort zone

Special situation under a winter down duvet:

- Extreme Clo (10?)
- Outside scope of comfort models.
- No draught problem.



Exponentially weighted mean outdoor temperature

Source: EN ISO 15251

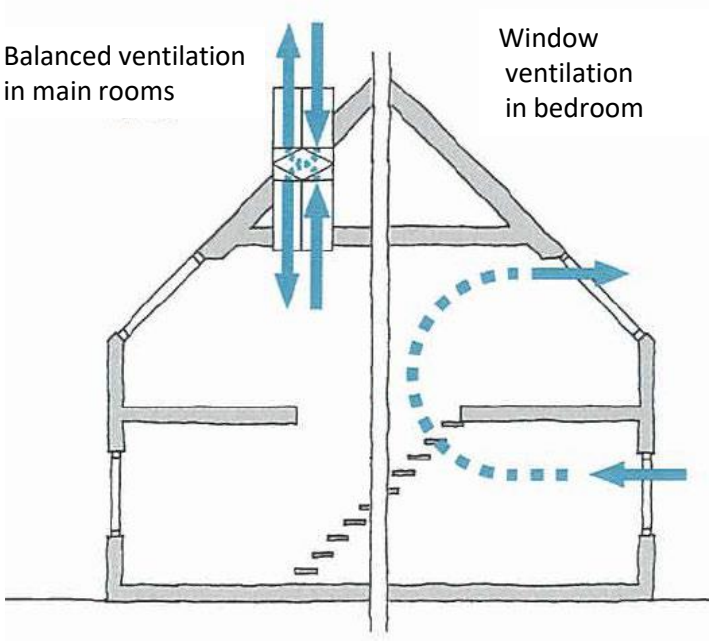
Solutions?

Proposed adjustments to one-zone balanced ventilation:

- Setpoint supply air (Georges)
- Bypass sypply air (Berge)
- Supply and exhaust in bedroom (Selvnes)
- Automatic reduction of supply air to bedroom when window is opened

Investigate:

- Exhaust air heat pump.
- Single room MVHR
- Window ventilated bedrooms, MVHR in other rooms (differentiated ventilation?)



Differences in Scandinavia

In Sweden and Finland:

- More hydronic heating
- More exhaust air heat pumps

For many years EAHP were installed in 90% of all new built detached houses in Sweden.

Norwegian building code focuses on *net energy demand (neglecting the heating system efficiency)*, so only part of the captured energy is accounted for. The Swedish code counts *delivered energy* and thus rewards the heat captured by the EAHP.
Ventilation air flow requirements more strictly specified for different rooms in Norway.

Decision table

Qualitative assessment for planning process

	Energy-efficiency	Investment	Need hydronic	Space for technical	Need ducts	Noise	Filtering	Air quality	Temperature-Zoning	Cold draft?	Occupant sensitive
Balanced ventilation	+ +	÷ ÷		÷	÷ ÷	?	+		÷		
Decentralized balanced ventilation	+	÷				÷ ÷	?		+		
Balanced.ventilation + window ventilation bedroom	+	÷		÷	÷		?		+		÷
Decentral.bal.ventilation + window ventilated bedroom	+	+					?		+		÷
Extract air heat pump, to DHW + ventilated window	+	÷			÷				+	÷	
Hybrid ventilation: balanced winter, natural summer	+ +	÷ ÷		÷	÷		?		?		
Natural ventilation	÷ ÷	+ +		+	+	?	÷	?	+	÷	÷
Extract air heat pump + ventilation radiator	+	÷	÷	÷	?				+		
Compact HVAC-unit	+ +	÷	?	÷	÷	?	+				
Ground source heat pump	+ +	÷ ÷	÷	÷							
Hydronic woodstove			÷	?							?
Solar thermal		÷	÷	?							
Air-air heat pump	+					÷					
Wood stove (not only peak)	+	+									÷
Pellet stove		÷									
Electric resistance heating	?	+ +		+							

Conclusion

- A number of ambitious energy upgrading projects are completed, but few are monitored and evaluated.
- A wider range of concepts and strategies than commonly used in Norway seem to be relevant
- No solution or system appears to be an obvious and universal choice; a number of very different system solutions are relevant, depending on the house and situation.
- Installing hydronic space heating is a major cost and intervention, and (non-)existance of this seem to be crucial for the choice of system.
- Occupant preferences and behaviour seem to be important for choice of system
- Between the Nordic countries, there are differences in commonly used HVAC concepts for renovation not explained by climate only. Energy pricing and building code may be part of the explanation.