Kan behovsstyrt ventilasjon erstatte lokal varme?

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Kan behovsstyrt ventilasjon erstatte lokal varme?

- Principles
- Challenges
- VABAT Project
Principles

Increased envelope performances

+ Low heating demand
Principles

Increased envelope performances

+ Low heating demand

- Indoor air quality
- Overheating
Principles

Increased envelope performances

- Low heating demand
- Indoor air quality
- Overheating

Energy brought by the ventilation air exclusively
Heating with air: historical perspective

First used in the 70s:
- High heating demand
- High temperature blowing

Poor indoor climate:
- Radiative asymmetry
- Stratification
- Carbonization of particles
Heating with air: historical perspective

- First used in the 70s:
  - High heating demand
  - High temperature blowing

- Poor indoor climate:
  - Radiative asymmetry
  - Stratification
  - Carbonization of particles

→ Bad reputation
Heating with air: nowadays

- Lower heating demand:
  - Low ΔT, hygienic Q
  - Low thermal inertia of air

- Temperature controlled DCV

- Suited for refurbishment

→ Is it possible?
→ Indoor climate?
Supply temperature required (Wigenstad et al., 2012)

\[ P = \dot{V} \cdot c_p \cdot \Delta t \ [\text{kW}] \]

Example

80m² apartment
Outside design T: -20°C
Heating demand (NS 3700):
Passiv: 17 W/m²
ACR: ~1,6 m³/h/m²
Required \( T_{\text{supply}} \): ~50°C
Supply temperature required (Wigenstad et al., 2012)

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Example

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Heating demand (NS 3700):
Passiv: 17 W/m²
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Required \( T_{\text{supply}} \): ~50°C

**Schools:** ACR: ~8 m³/h/m²
**Office:** ACR: ~6 m³/h/m²
Required \( T_{\text{supply}} \): ~26-28°C
Economic impact of Indoor Climate

Operating expense in a typical office building (*REHVA Guidebook 17, 2012*)

- Building related cost
- Salary and employee related cost
- Miscellaneous cost

Thermal comfort/IAQ is the priority!
Ventilation efficiency

- **Contaminant removal effectiveness** *(Sandberg, 1981)*

\[
CRE = \frac{C_{\text{out}} - C_{\text{supply}}}{C_{\text{room}} - C_{\text{supply}}}
\]

- **Temperature efficiency** *(Awbi et Gan, 1993)*

\[
\varepsilon_T = \frac{T_{\text{out}} - T_{\text{supply}}}{T_{\text{room}} - T_{\text{supply}}}
\]
Thermal comfort

EN15251 / ISO7730:

- Operative temperature heating: Top = 21.5°C
- Operative temperature cooling: Top = 25.5°C

- Maximum air velocity heating: Vair < 0.15 m/s
- Maximum air velocity cooling: Vair < 0.25 m/s
- Thermal stratification < 4.2°C between 0.1 and 1.7 m
Overheating

Løvåshagen, Bergen: percentage of dissatisfied by overheating (Berge & Mathisen, 2013)
VABAT Project (2009-2013)

- Low energy buildings
- Is the system relevant?
  - Thermal comfort
  - Ventilation efficiency
  - Airflow patterns
- Energy refurbishment

Methods

Measurements (climate chamber)

CFD simulations
Test chamber

Supply 2,60m

Dummy 3,08m

Exhaust 4,26m
Sensors

~180 sensors

- Occupied zone: 27 stations
- Boundary conditions (walls, supply, exhaust)
Test cases

- Steady-state
- Heating, Cooling
- 0, 1 or 2 occupants

Tested cases

- $P = 1\, \text{W/m}^2$
- $P = 8\, \text{W/m}^2$
- $P = 18\, \text{W/m}^2$

$T_{\text{supply}}(\degree\text{C})$

$\text{ACH}$

- Heating
- Cooling
CFD simulations

- STAR-CCM+
- Turbulence modelling
- Air diffuser modelling

Boundary conditions = experiments
**Heating**

- The warm air jet reaches the opposite wall

- $T_{\text{supply}} = 31.2^\circ\text{C}$
- $\text{ACR} = 1.6 \text{ vol/h}$
The warm air jet reaches the opposite wall

- $T_{\text{supply}} = 31,2^\circ C$
- ACR = 1,6 vol/h

- $V_{\text{air}} < 0,15 \text{ m/s}$
- No discomfort by draught
The warm air jet reaches the opposite wall
• Short-circuiting?
• Thermal stratification?

\[ V_{\text{air}} < 0.15 \text{ m/s} \]

No discomfort by draught
Ventilation efficiency

- CRE close to 1
- $\varepsilon_T \geq 1$

Good ventilation efficiency
Influence of heat sources

C0+ (Ar0=2,9.10^-3)  C1- (Ar0=5,3.10^-3)  C2- (Ar0=4,5.10^-4)  C2+ (Ar0=6,9.10^-5)
Influence of heat sources

- Internal heat sources beneficial
Predicted Mean Vote

Experimental results

- Good values of PMV (EN NS 15251)
Thermal stratification

$\Delta T_{\text{max}} = 1,7^\circ C < 4,2^\circ C$

No discomfort by thermal stratification
Cooling

- Negative buoyancy forces
- Drop of the jet inside of the occupied zone!

\[
\begin{align*}
&\text{ACR} = 3.5 \\
&\text{ACR} = 1.6 \\
&\text{ACR} = 1
\end{align*}
\]
Cooling

- Deflexion of the air jet
- Tridimensionnal airflow

Negative influence of the heat sources on the airflow
Can DCV replace local heating?

Yes!

If:

- Low heating demand (envelope, climate)
- Educational/office buildings/dwellings
- Well functionning DCV
- Refurbishment
- Overheating (active air diffuser)
- Norway: more measurements needed!
Perspectives

- ForKlima (Forenklet behovsstyrt klimatisering av kontorbygg med svært lavt oppvarmingsbehov) – GK miljøhuset
Perspectives

- Noise level
- Distribution losses in ventilation ducts
- Dry air in winter
Thank you!

Questions?