Kan behovsstyrt ventilasjon erstatte lokal varme?

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Seminar 19.11.13

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 assymetry
  - Stratification
  - Carbonization of particles

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- Poor indoor climate:
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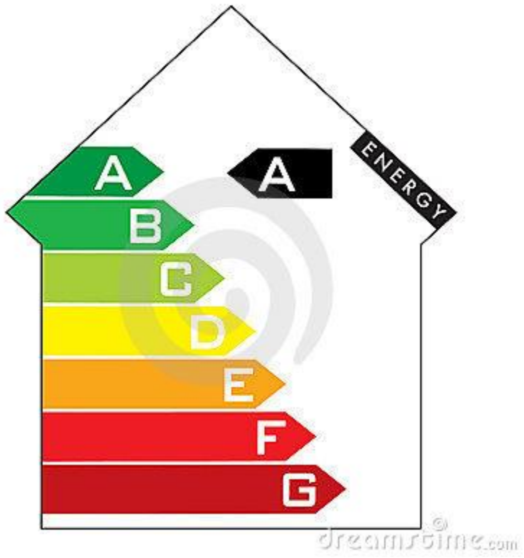
  - Stratification
  - Carbonization of particles

➡ 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

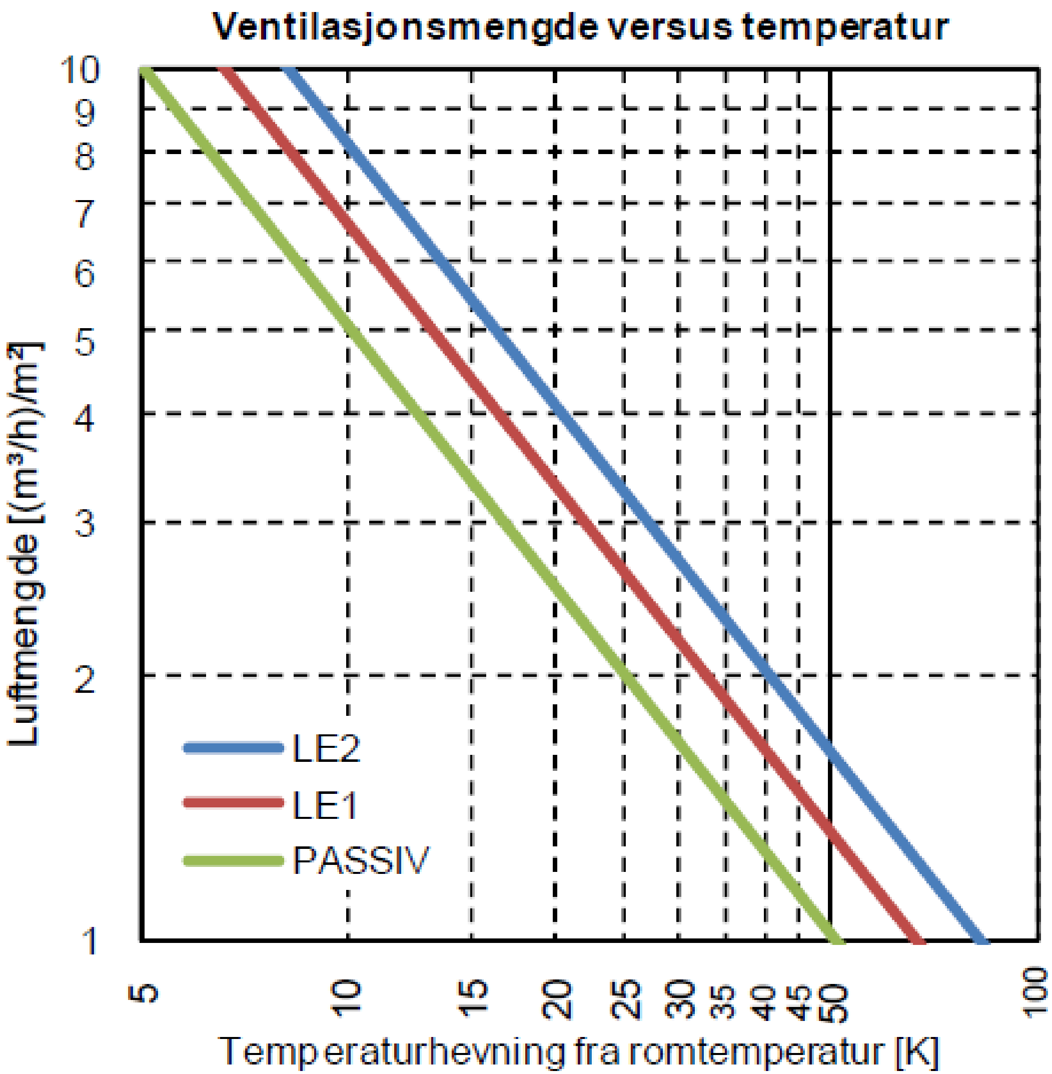
Outside design T: -20°C

Heating demand (NS 3700):

Passiv: 17 W/m²

ACR: ~1,6 m³/h/m²

Required T_{supply}: ~50°C



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

Example

80m² apartment

Outside design T: -20°C

Heating demand (NS 3700):

Passiv: 17 W/m²

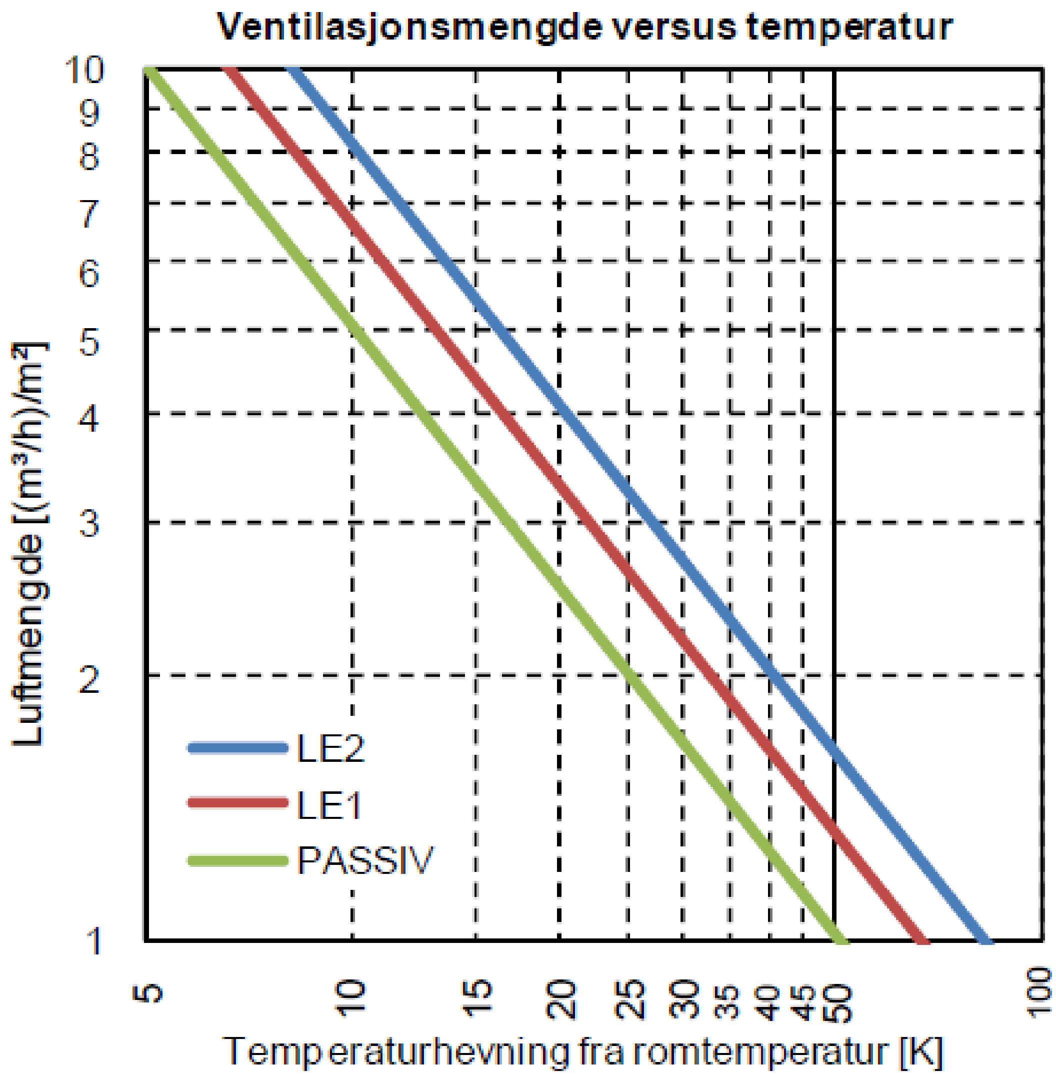
ACR: ~1,6 m³/h/m²

Required T_{supply}: ~50°C

Schools: ACR: ~8 m³/h/m²

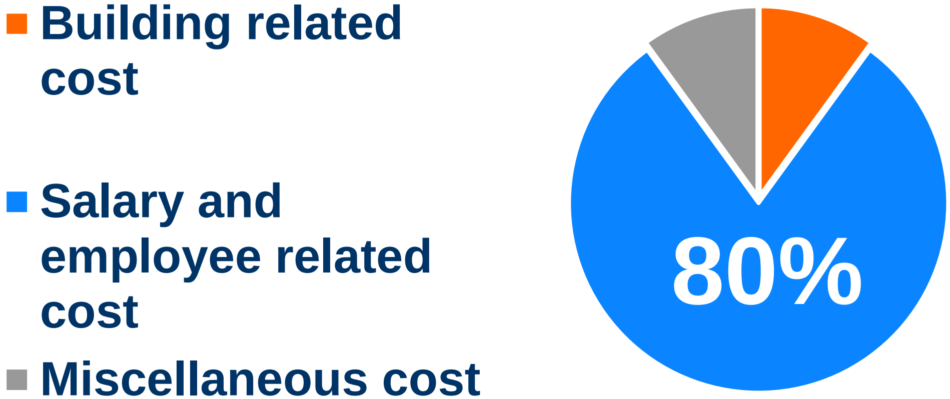
Office: ACR: ~6 m³/h/m²

Required T_{supply}: ~26-28°C



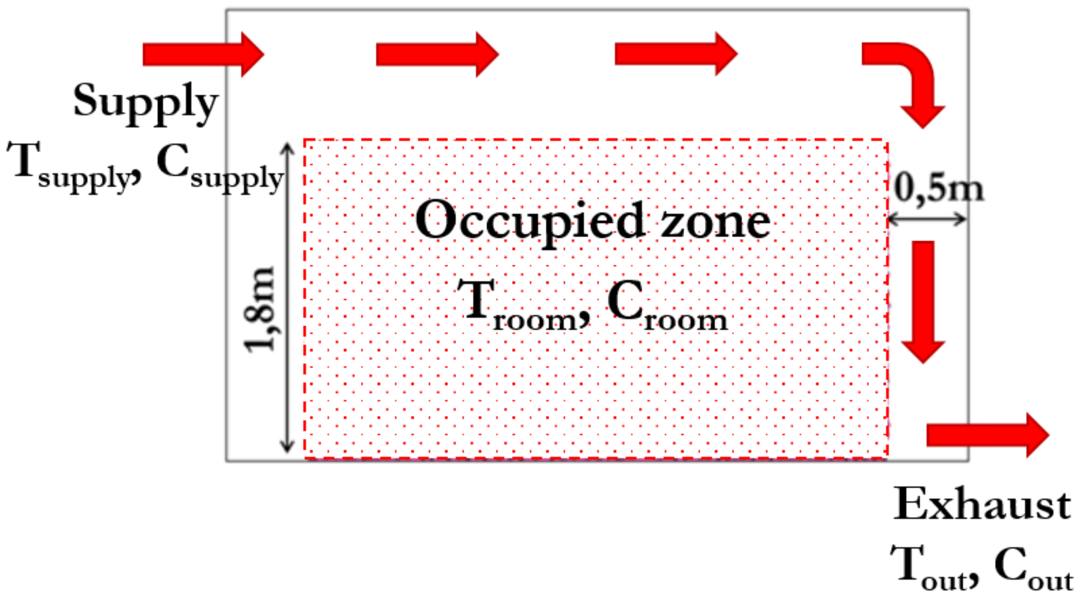
Economic impact of Indoor Climate

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



Thermal comfort/IAQ is the priority!

Ventilation efficiency

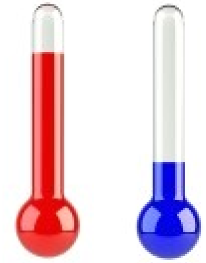


- **Contaminant removal effectiveness *(Sandberg, 1981)***
- **Temperature efficiency *(Awbi et Gan, 1993)***

$$\mathrm{CRE} = \frac{C_{out} - C_{supply}}{C_{room} - C_{supply}}$$

$$\varepsilon_T = \frac{T_{out} - T_{supply}}{T_{room} - T_{supply}}$$

Thermal comfort



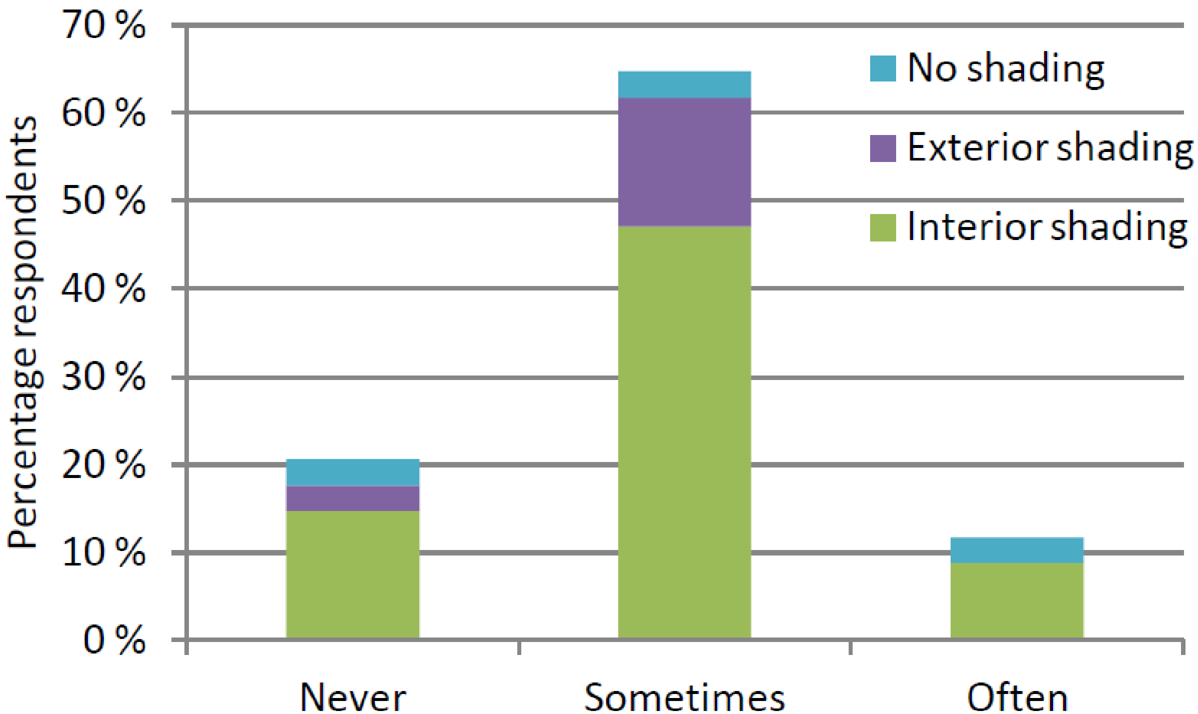
EN15251 / ISO7730 :

- 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 1,7m

Overheating

Løvåshagen, Bergen: percentage of dissatisfied by overheating (*Berge&Mathisen, 2013)*

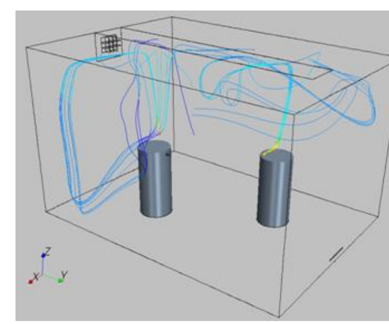


VABAT Project (2009-2013)

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

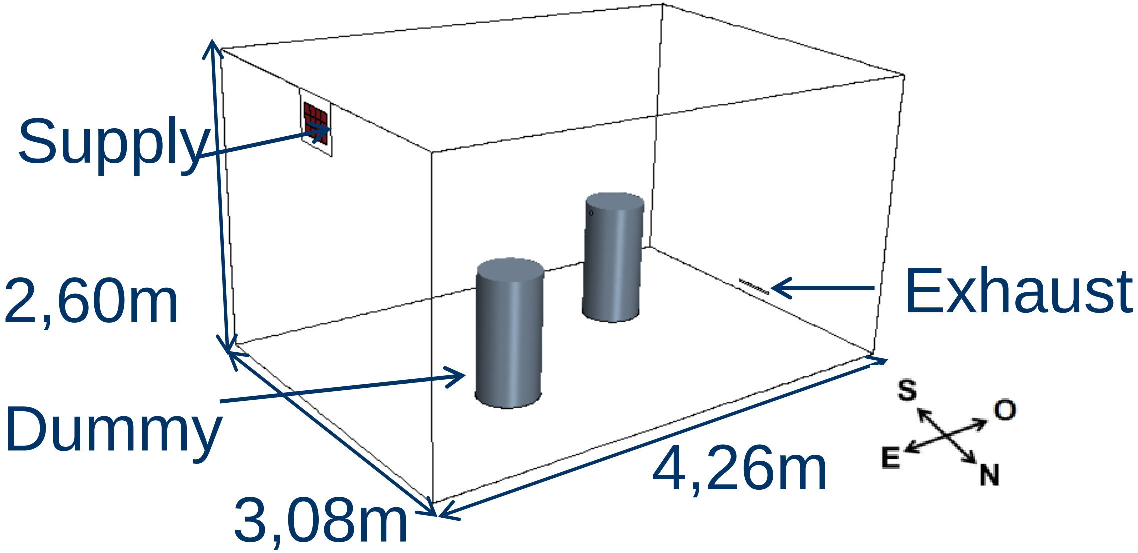
Methods

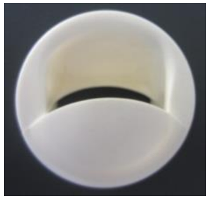
Measurements (climate chamber)

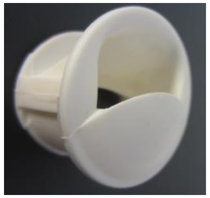


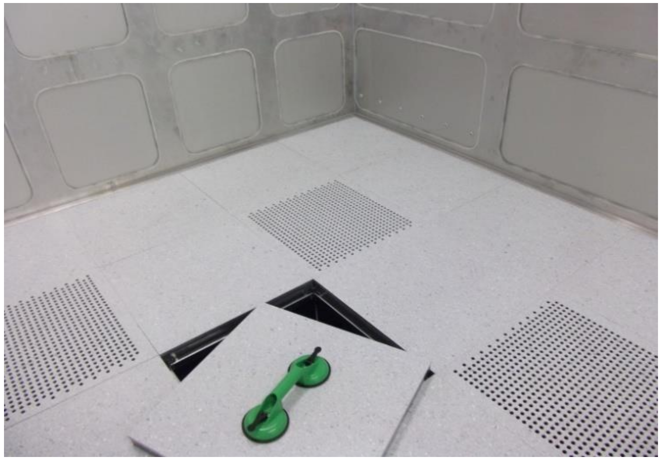
CFD simulations

Test chamber









Sensors

~180 sensors

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

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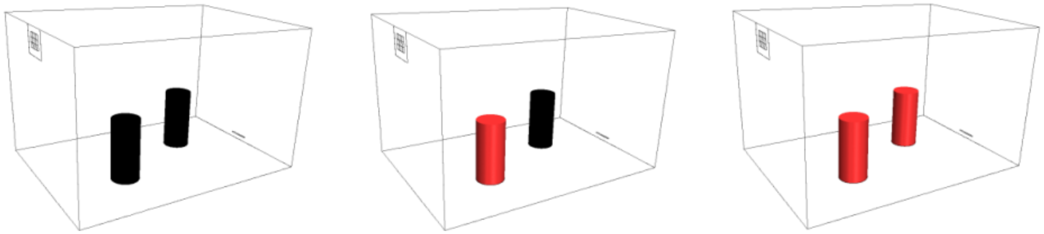
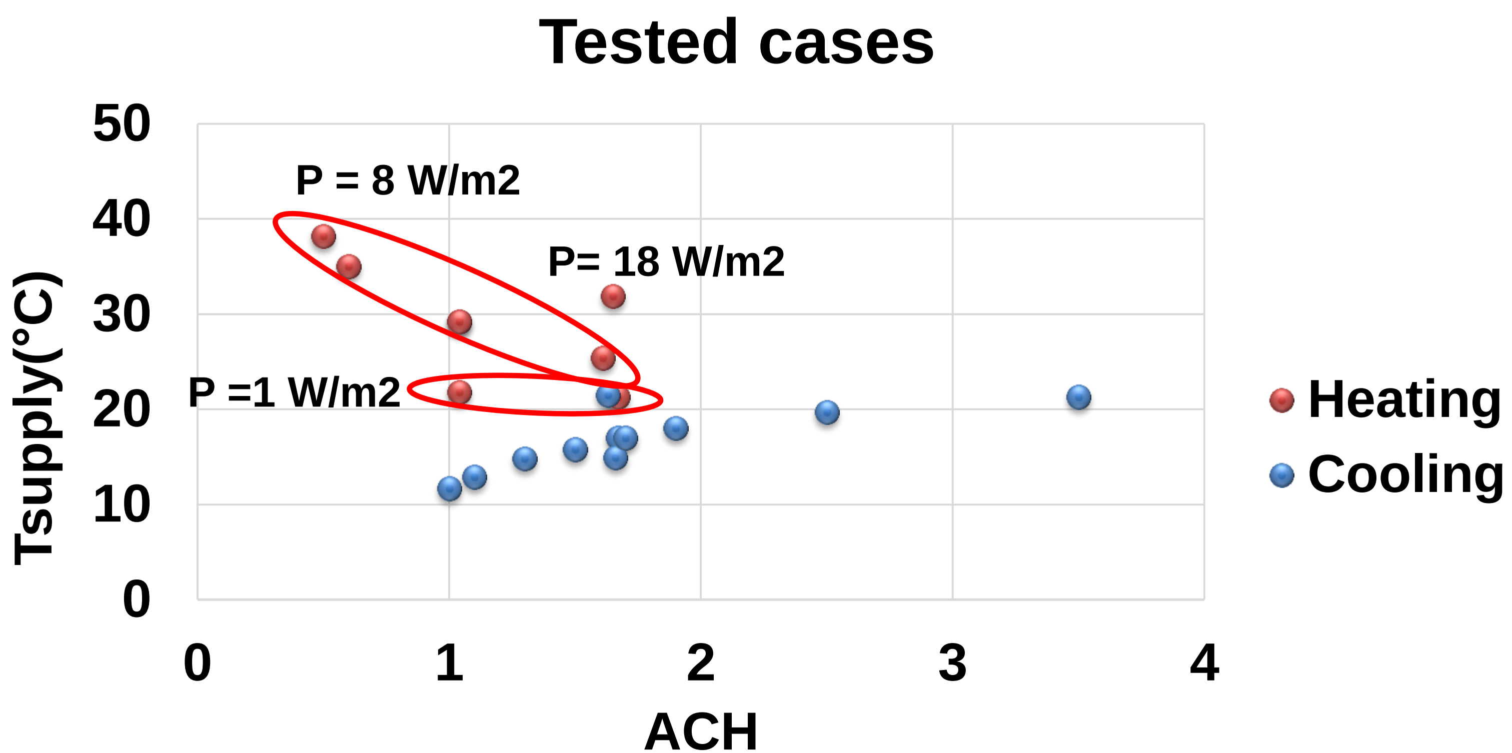
Test cases

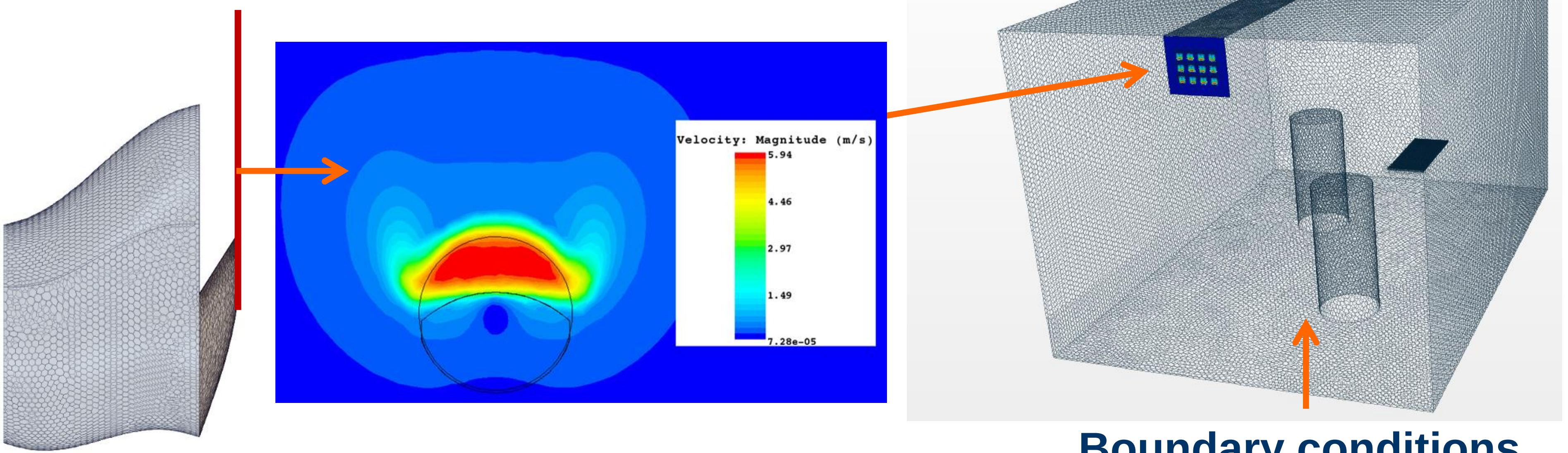
- Steady-state
- Heating, Cooling
- 0, 1 or 2 occupants





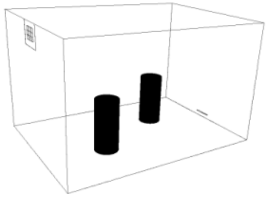
CFD simulations

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

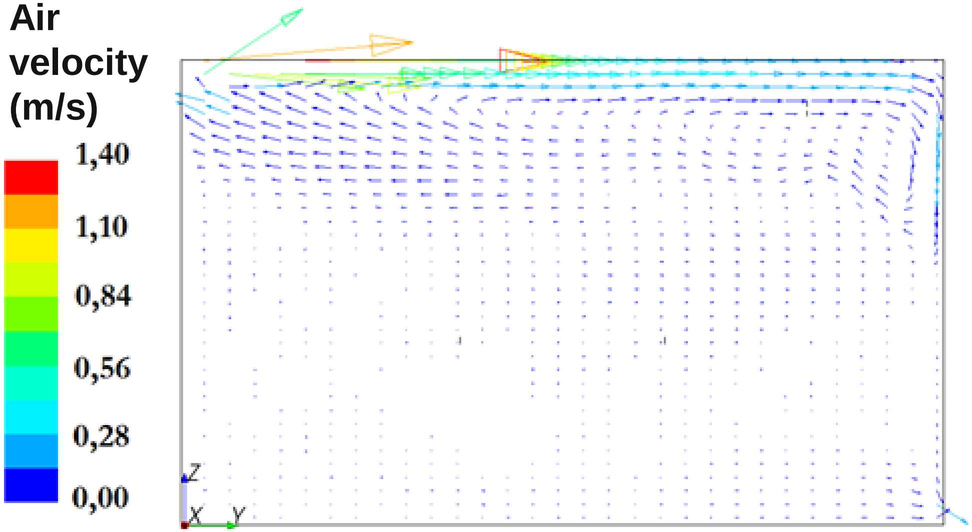


Boundary conditions
= experiments

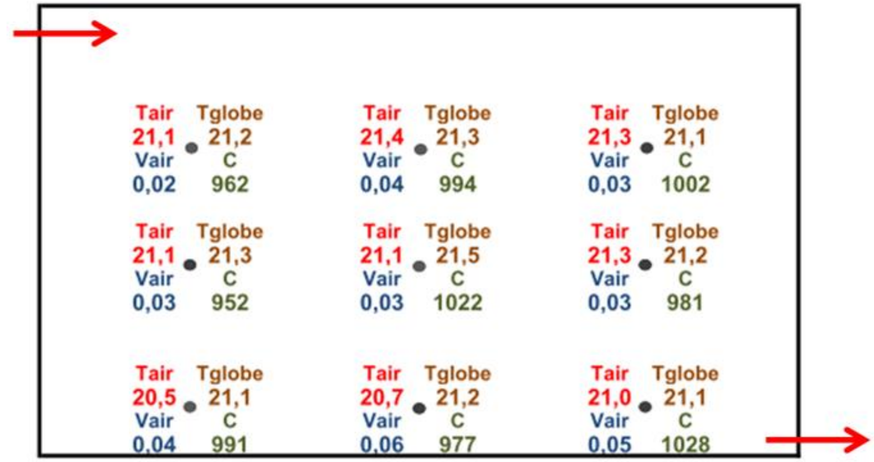
Heating



T_{supply} = 31,2°C
ACR = 1,6 vol/h



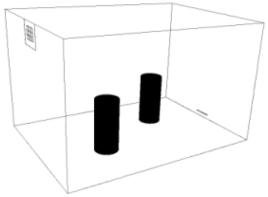
CFD



EXP

- The warm air jet reaches the opposite wall

Heating



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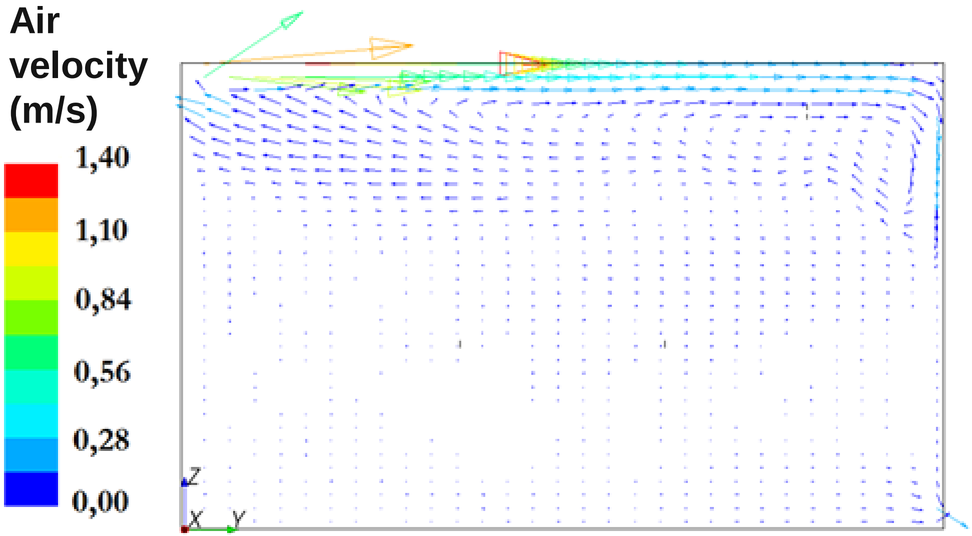

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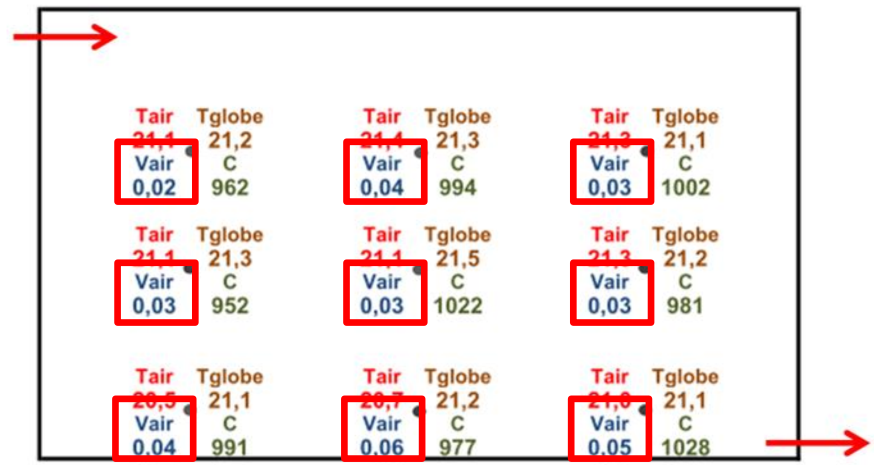
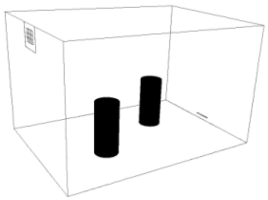


EXP

- The warm air jet reaches the opposite wall

V_{air} < 0,15 m/s
No discomfort by draught

Heating



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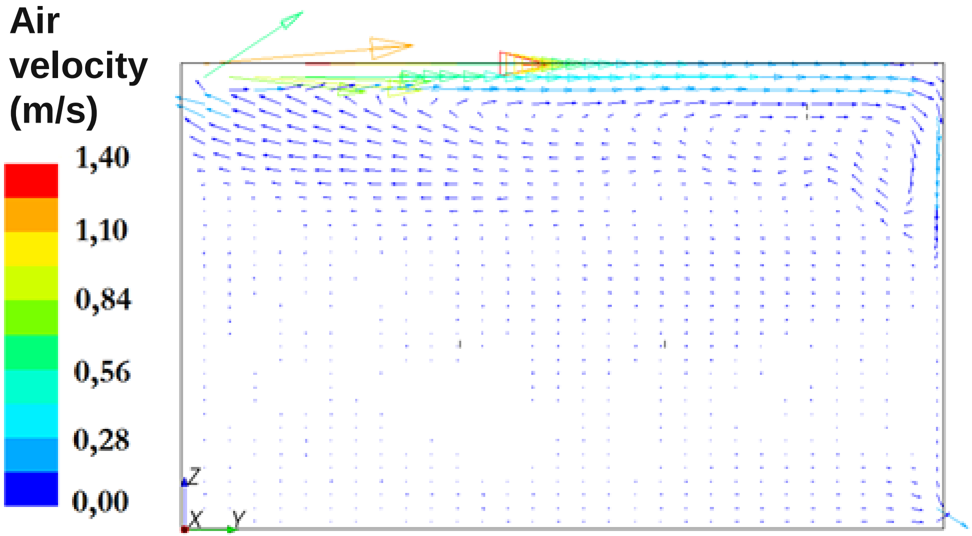
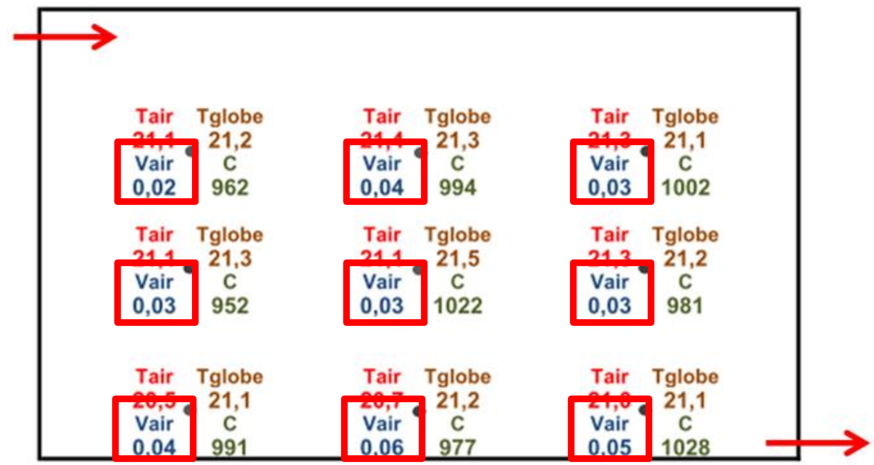


CFD

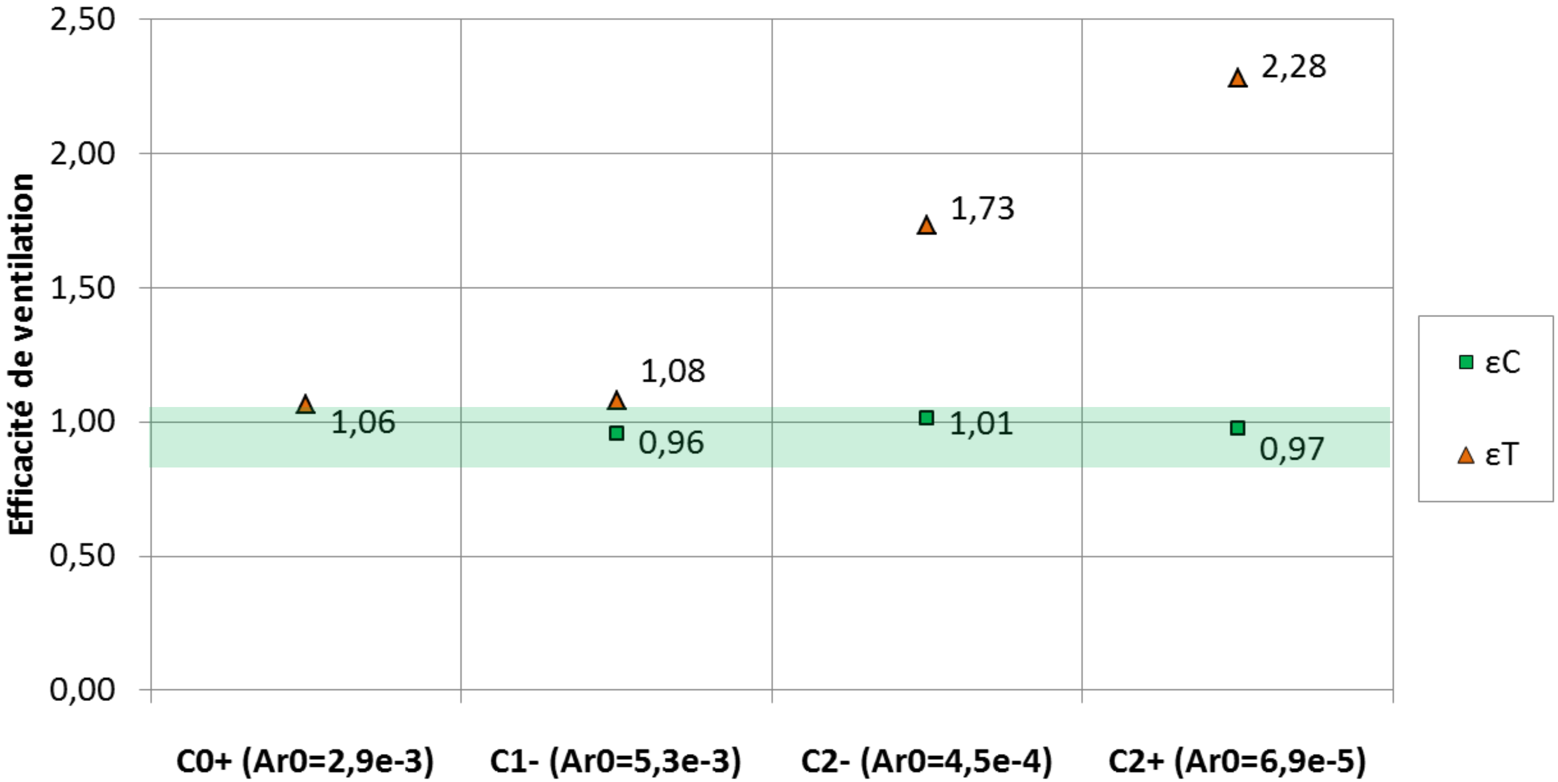


EXP

- The warm air jet reaches the opposite wall
- Short-circuiting?
- Thermal stratification?

V_{air} < 0,15 m/s
No discomfort by draught

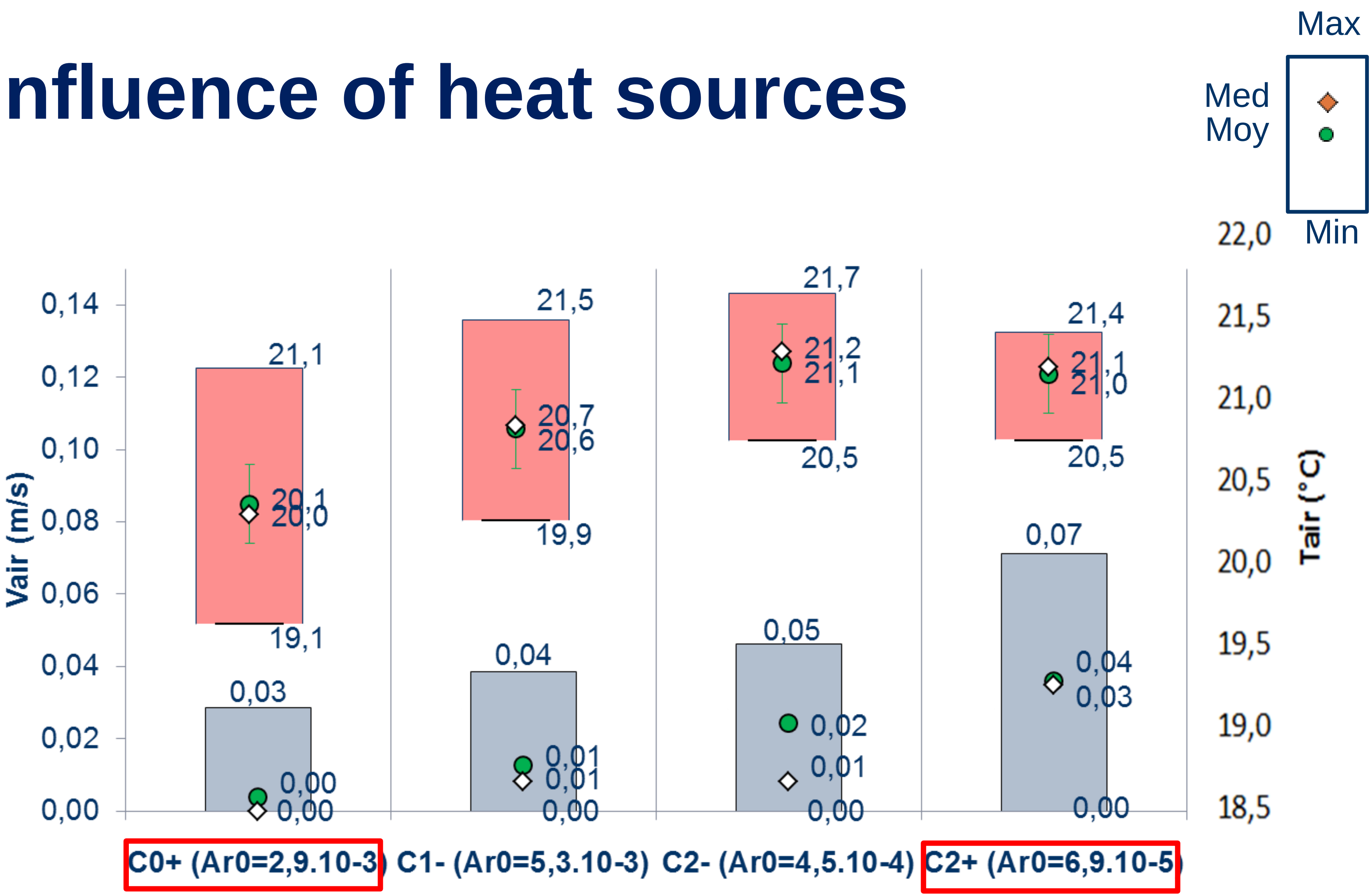
Ventilation efficiency



- CRE close to 1
- $\varepsilon_T >= 1$

Good ventilation efficiency

Influence of heat sources



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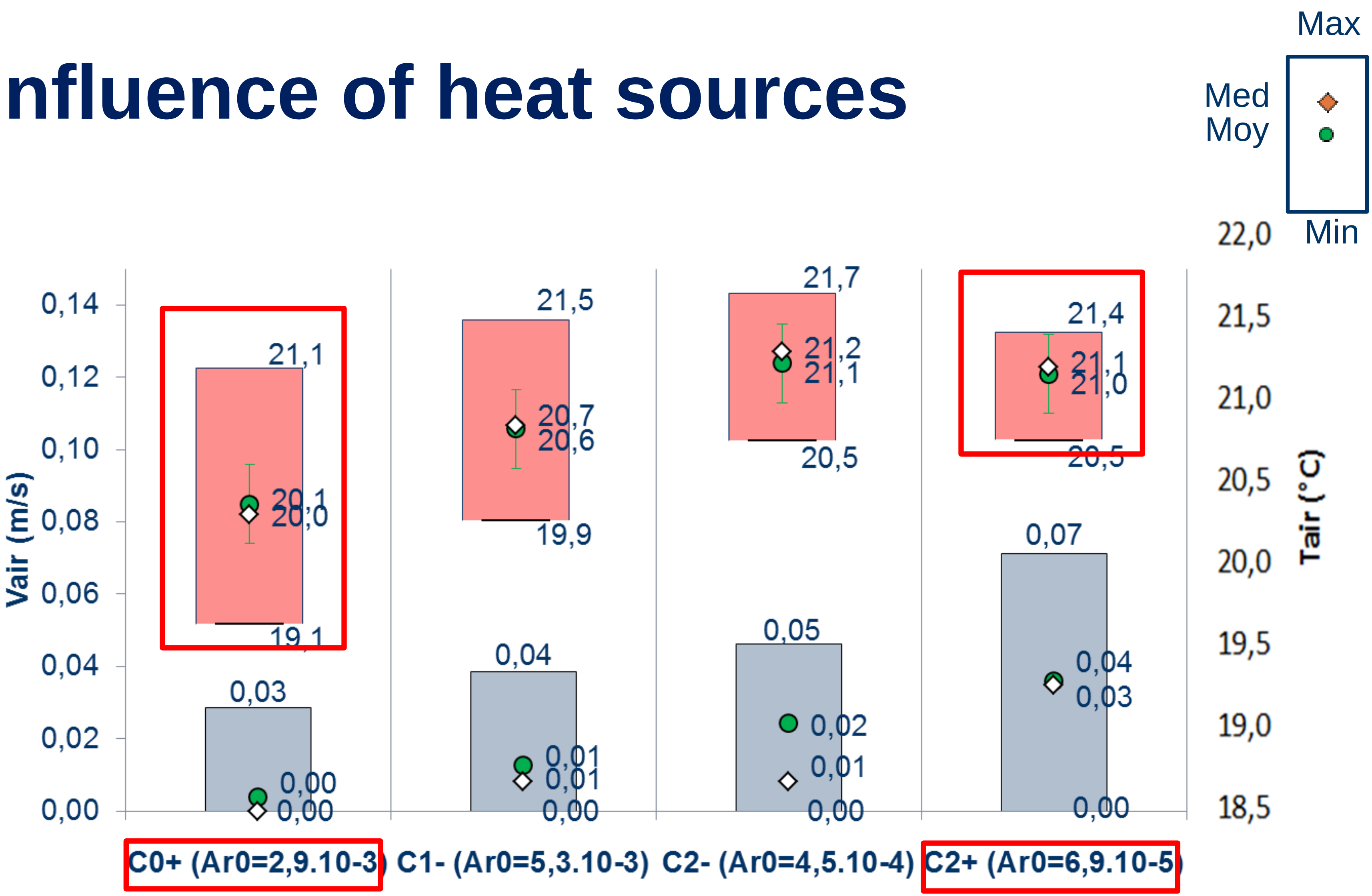
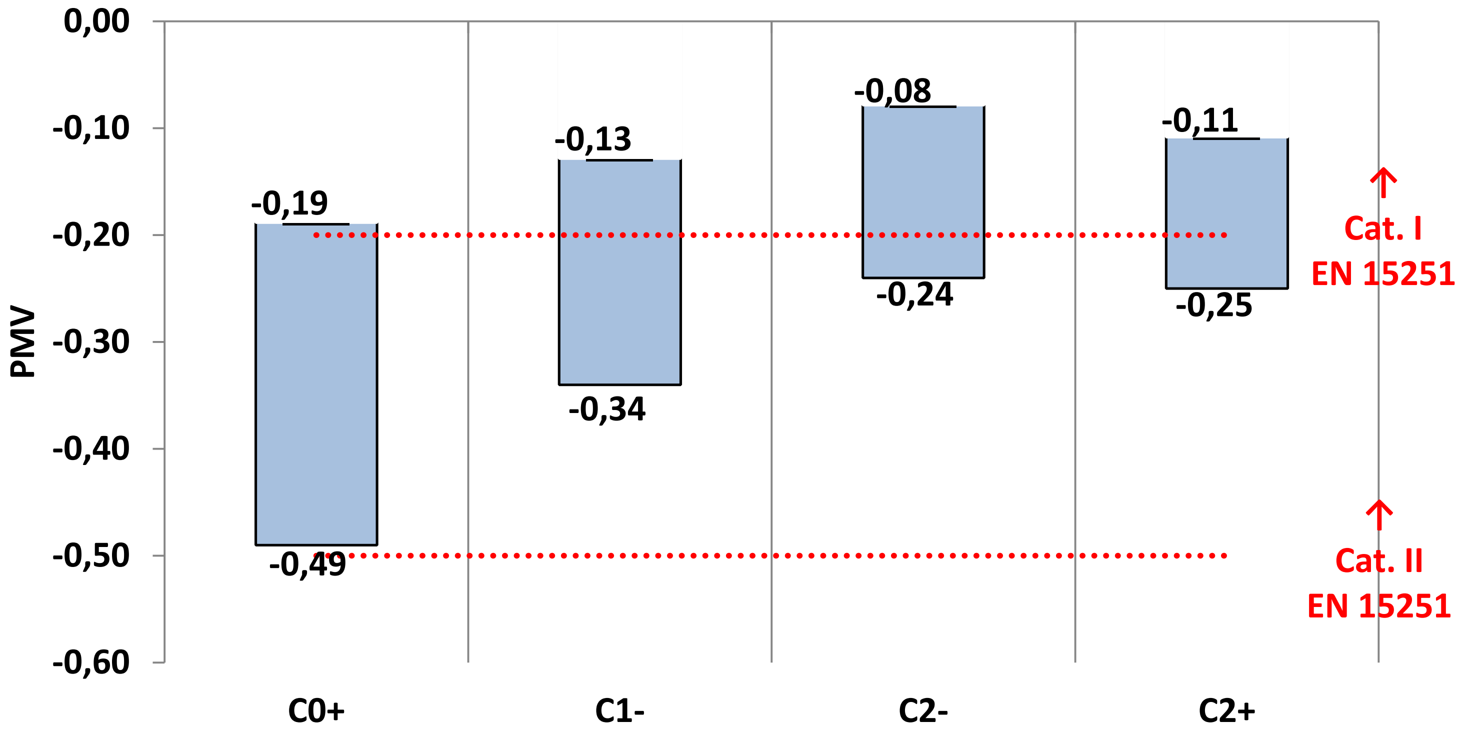
Influence of heat sources



- Internal heat sources beneficial

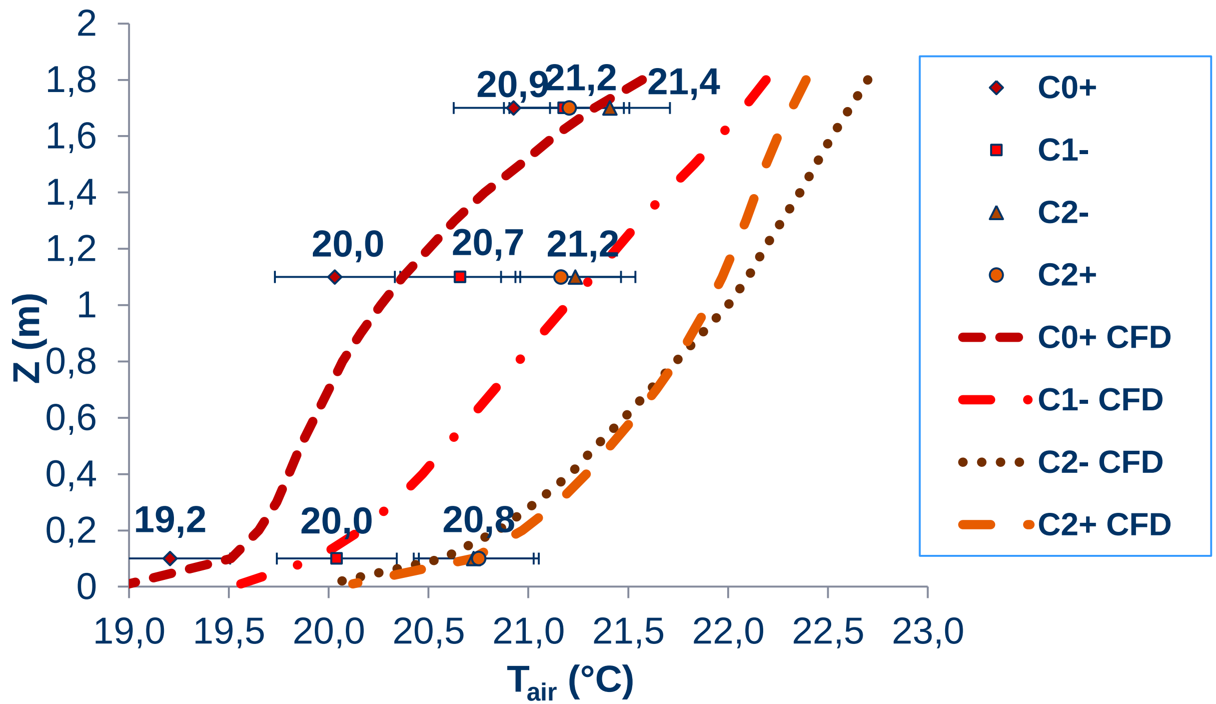
Predicted Mean Vote



Experimental results

- Good values of PMV (EN NS 15251)

Thermal stratification

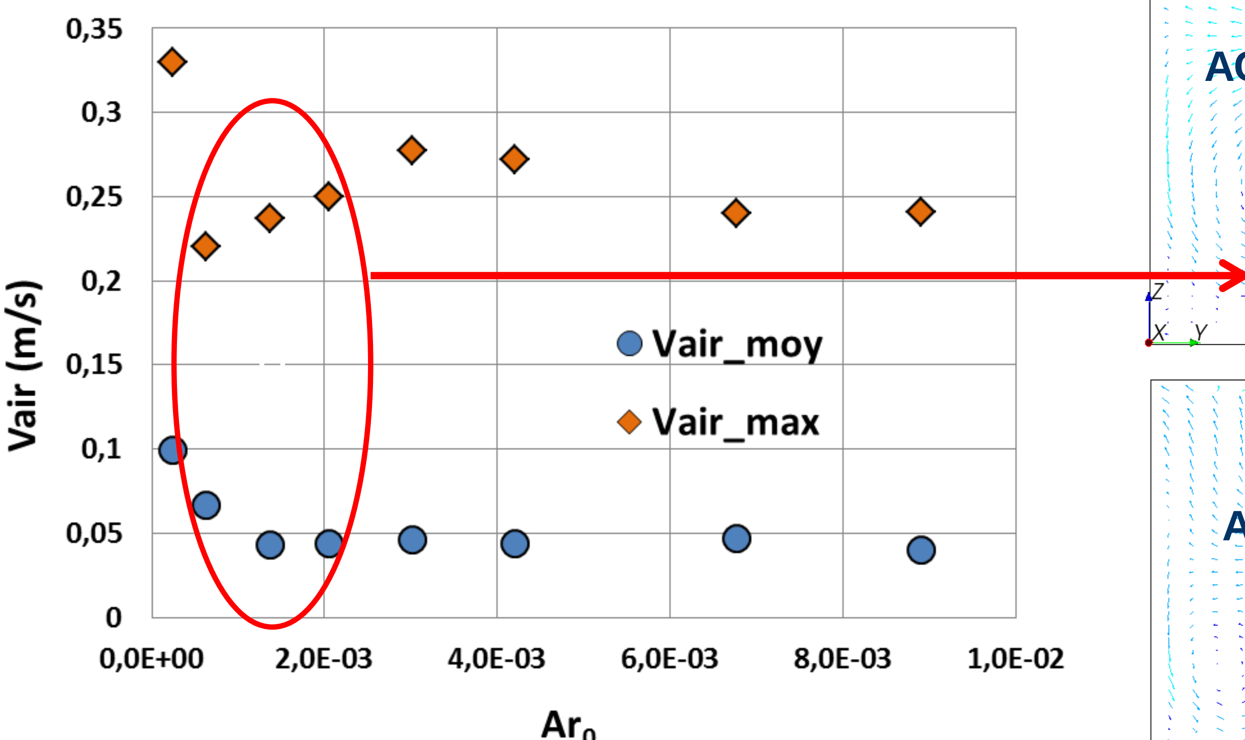


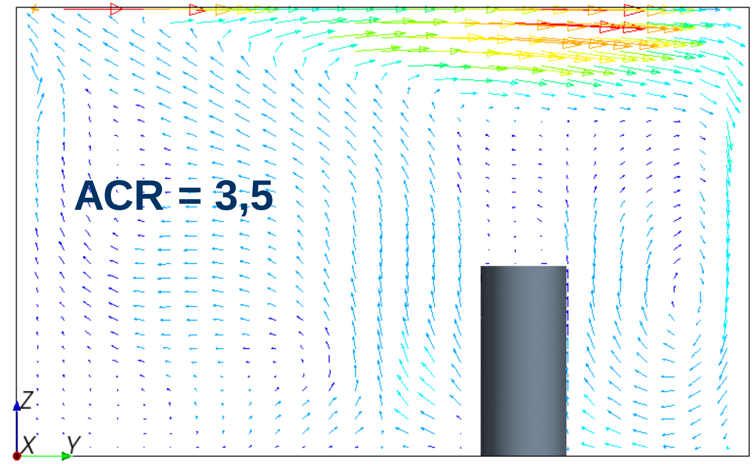
ΔT max = 1,7°C < 4,2°C

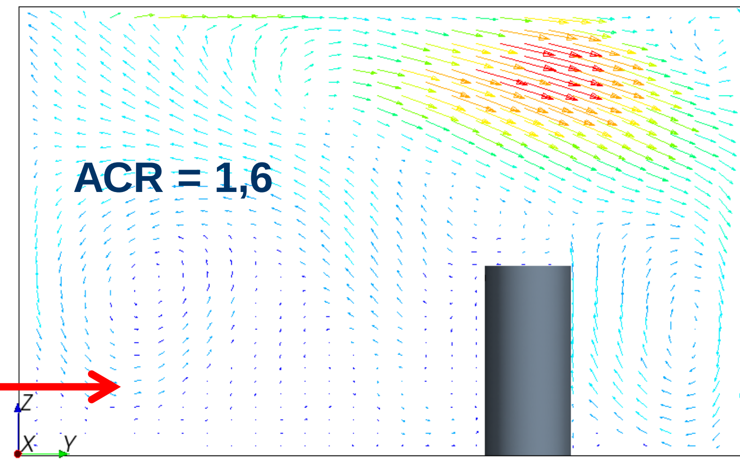
No discomfort by thermal stratification

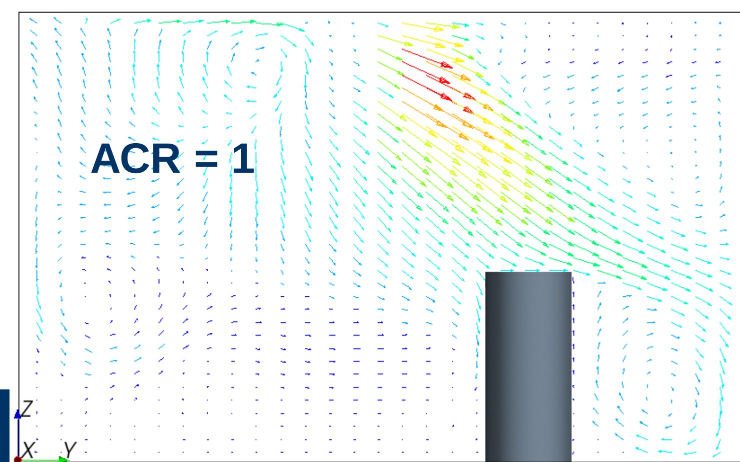
Cooling

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



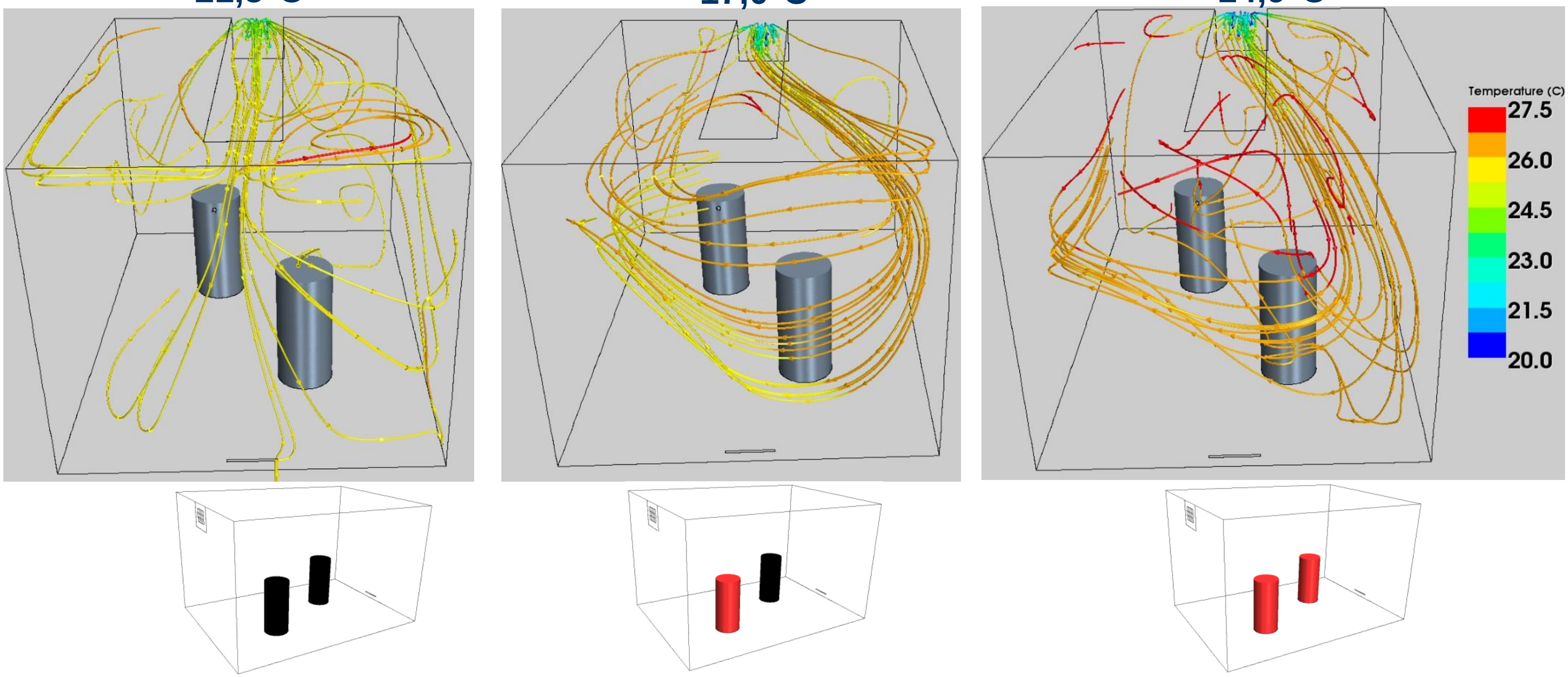






Cooling

T_{supply} = 21,5°C | T_{supply} = 17,0°C | T_{supply} = 14,9°C



- 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?