REHVA

Federation of European Heating, Ventilation and Air-conditioning Associations

Address:
Rue Washington 40
1050 Brussels
Belgium

- **www.rehva.eu**
- **info@rehva.eu**
- **Tel: +32 2 514 11 71**
- **Fax: +32 2 512 90 62**

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Displacement Ventilation in Non-industrial Premises

an old principle with new technology

Rehva Guidebook on Displacement Ventilation

Aimed at:

- **the practising engineer**

Discussing:

- **what is displacement ventilation?**
- **what are the benefits**
- **what are the limitations?**
- **where should it be used (and not used)?**

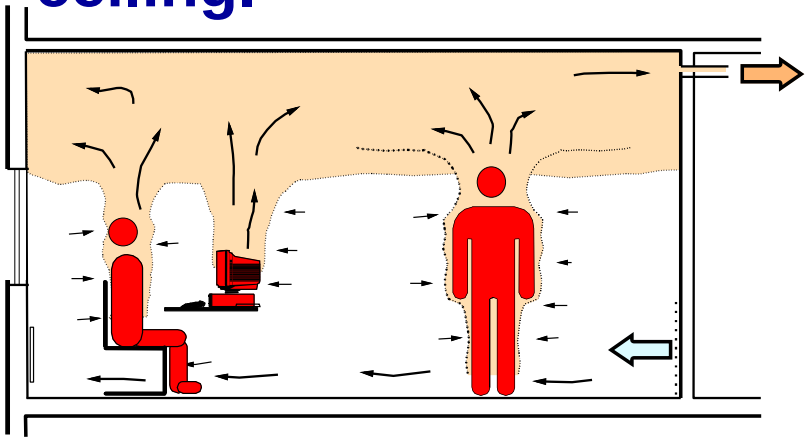
The theory is illustrated by case studies showing how displacement ventilation can be utilised in practice

Contents of the book

- **Disp.vent in a nutshell**
1. **Terminology, symbols and units**
2. **Basic knowledge about displacement ventilation**
3. **Air diffusers**
4. **Design procedures**
5. **Energy aspects**
6. **Automation and control**
7. **Case studies**
   - **Restaurant**
   - **Cell office**
   - **Auditorium**
   - **Meeting room**
   - **Class room**
8. **References**

The basic idea

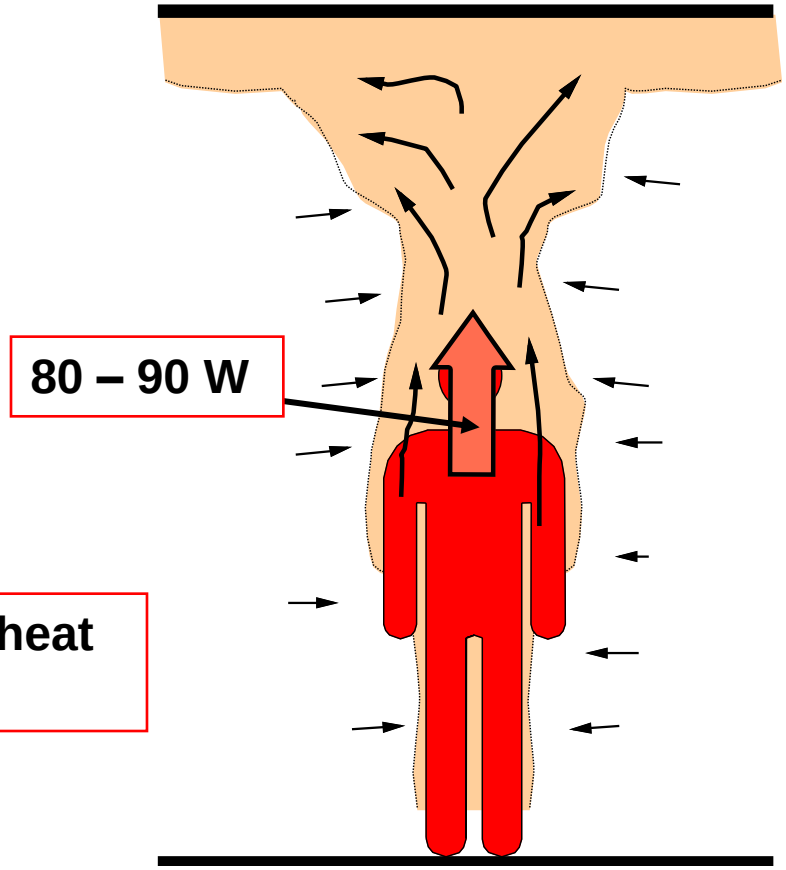
Warm air rises due to buoyancy, and carries the pollutants from people up towards the ceiling.



In industry….

….and non-industrial premises

Man = heat source – in theory



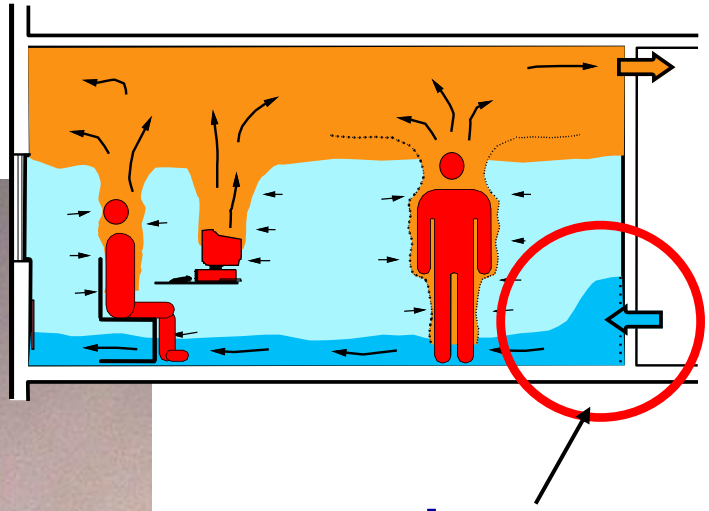
The air rises because of the heat release of the human body

Man = heat source – in practice

- **Warm, polluted air rises due to buoyancy.**

Cigar smoke visualises the rising air, but is is the heat from the body that drives the flow.

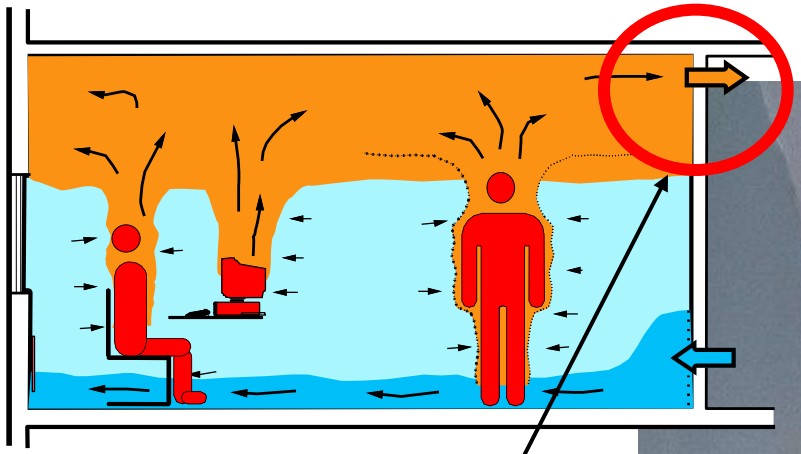
Air supply



Air supply units

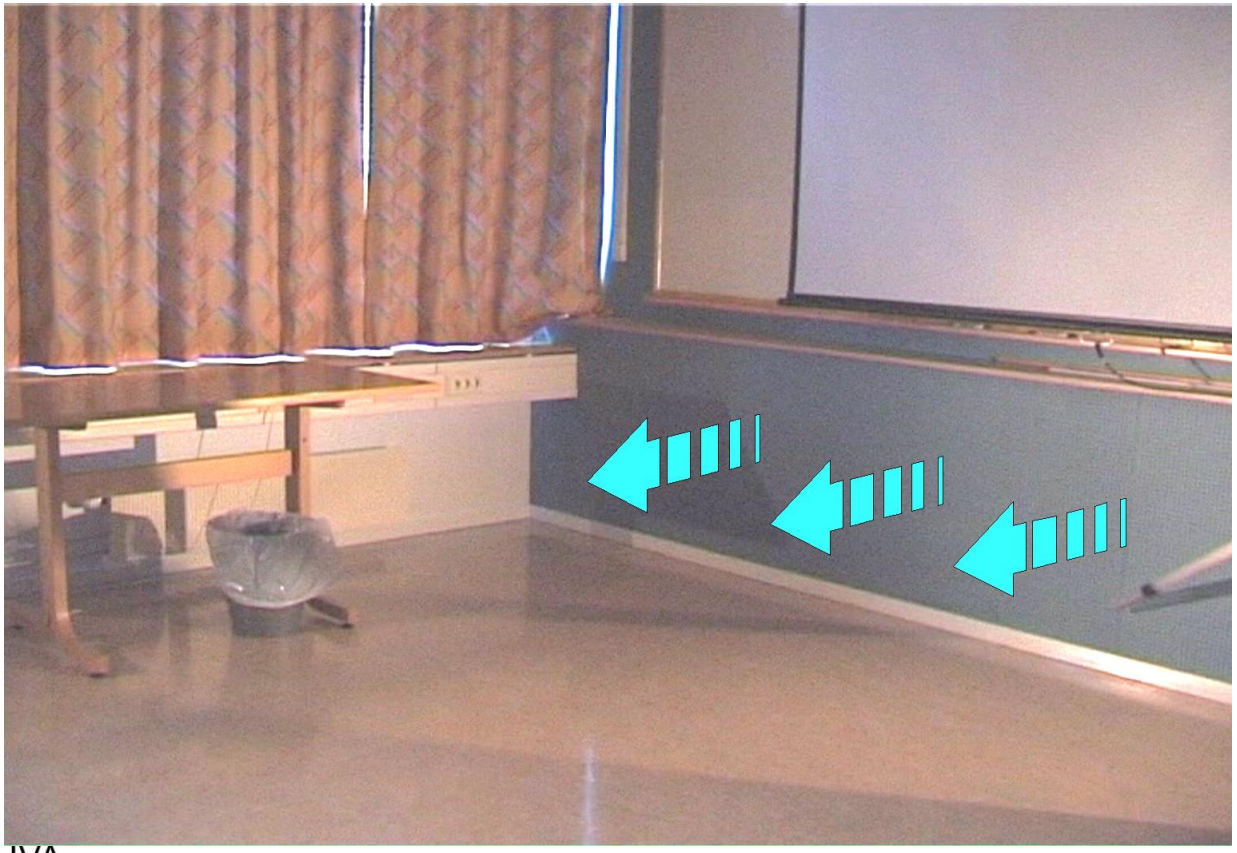
The air floats along the floor like water and fills the room from below

Air is extracted at ceiling level



The extract opening can be located anywhere in the highest part of the room

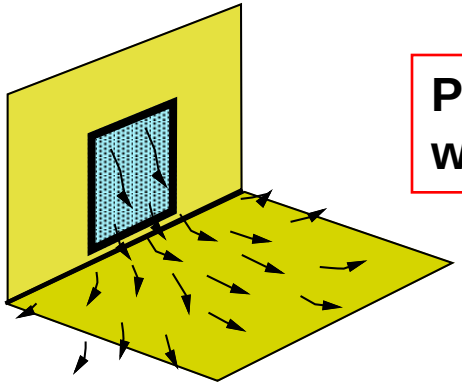
Air supply



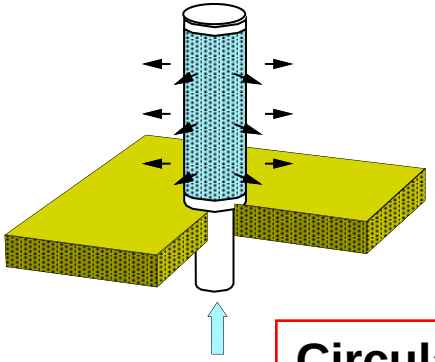
The air is supplied from wall panels with low velocity.

The supply air is colder than the room air.

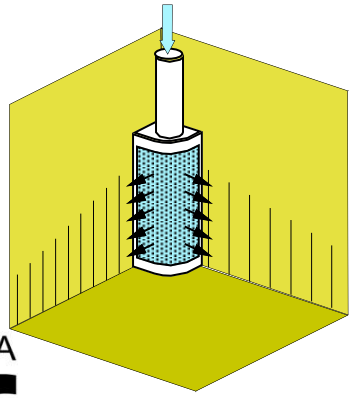
Air supply can be arranged in many ways



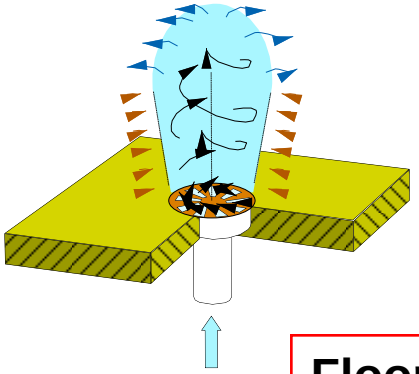
Plane, wall-mounted



Circular, free-standing



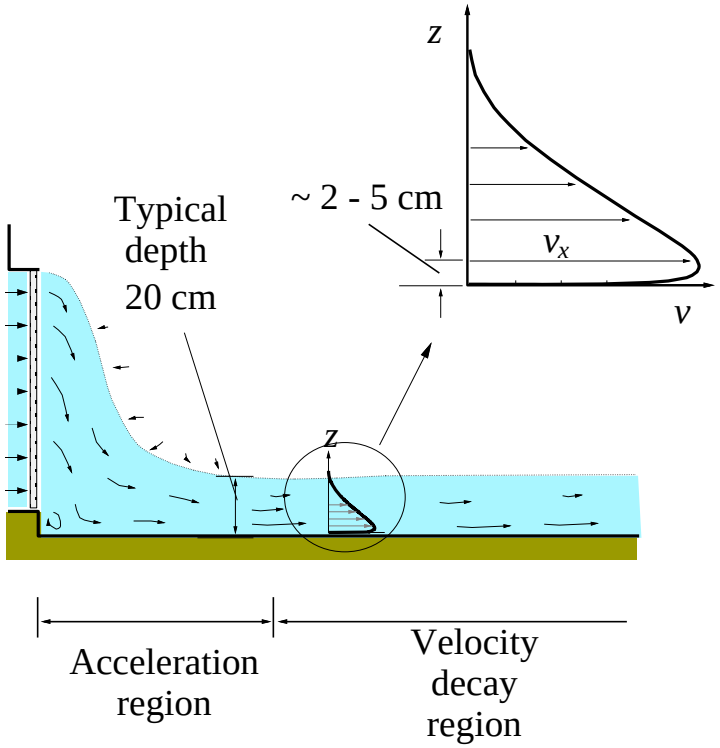
Semi-circular, corner-mounted



Floor-mounted

Be aware of cold draught along the floor!

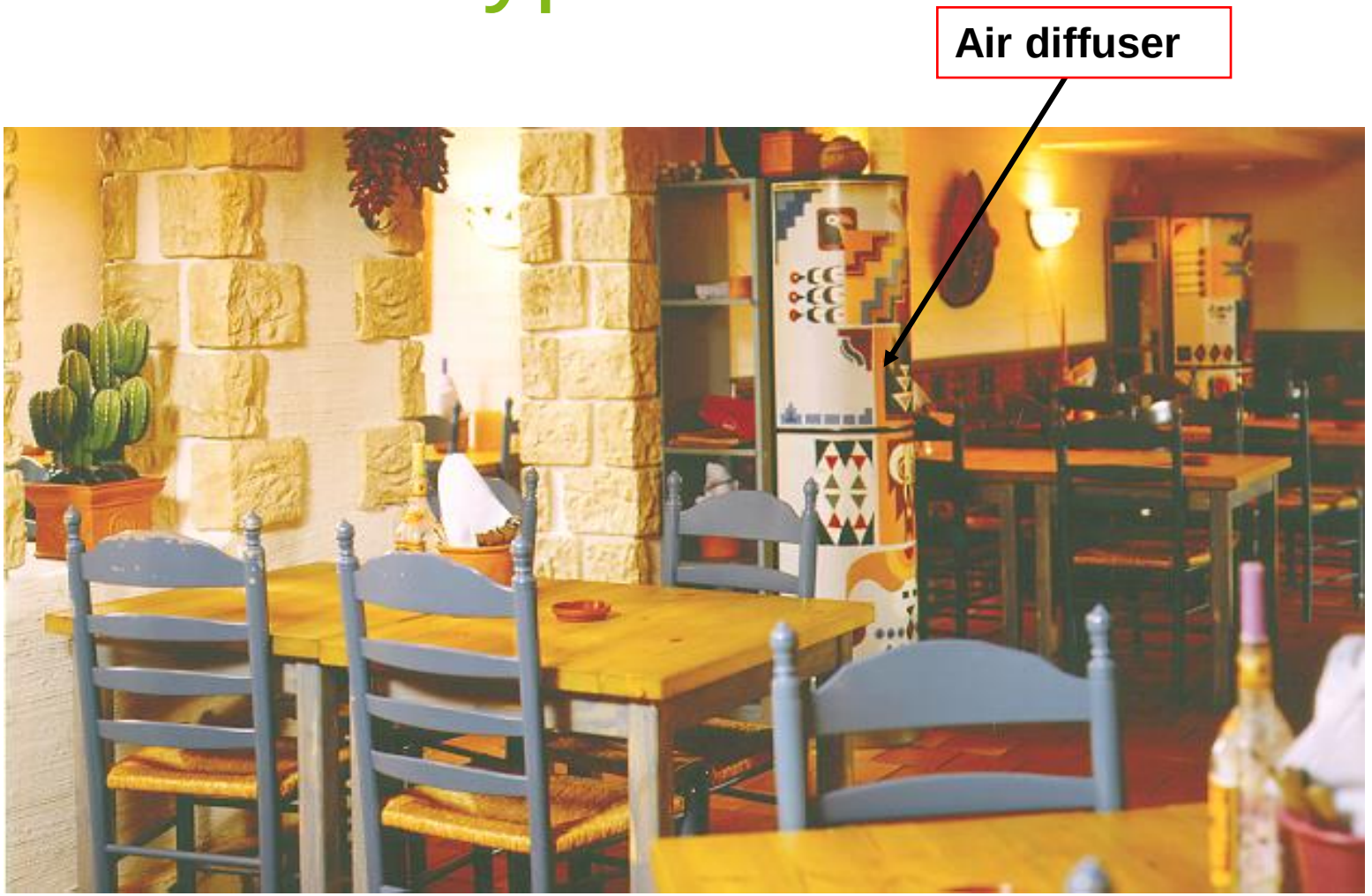
- **When the supply air is colder than the room air, it will fall to the floor, and may cause cold draught.**
- **This may avoided by choosing the right diffuser.**
- **Remember:**
  - Choose a diffuser that is suited for the purpose
  - Make sure that the adjacent zone (the “draught zone”) does reach places where people are located permanently.



Diffuser types - Casino

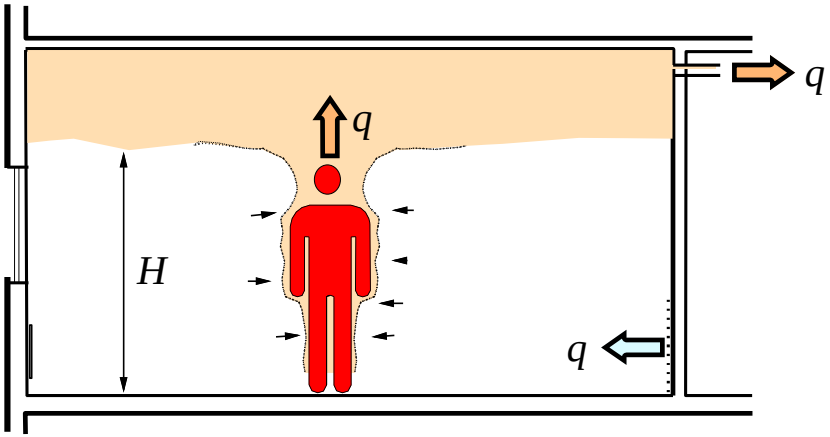
Diffuser types - Atrium

Diffuser types - Restaurant

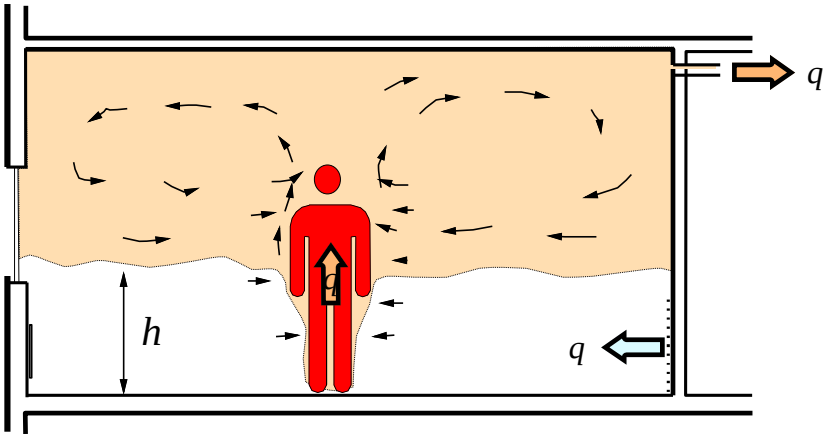


Diffuser types - Department store

Basic principles – Convection currents



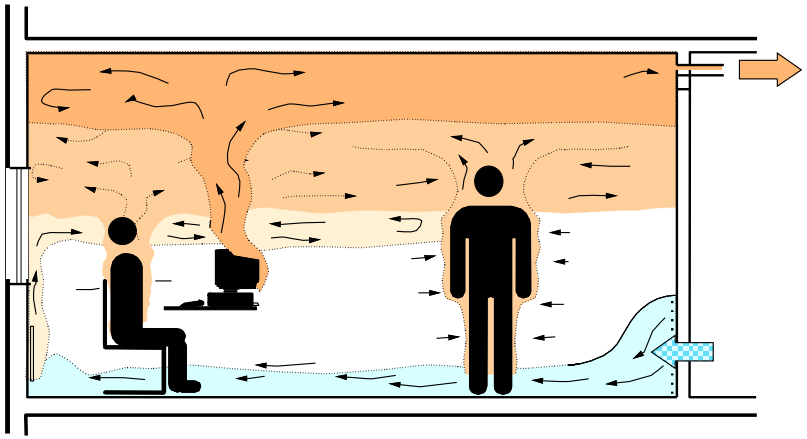
The air that rises in the convection current must be replaced by new air. This makes a two-layer flow, where the polluted, “used” air stratifies in the upper layer.

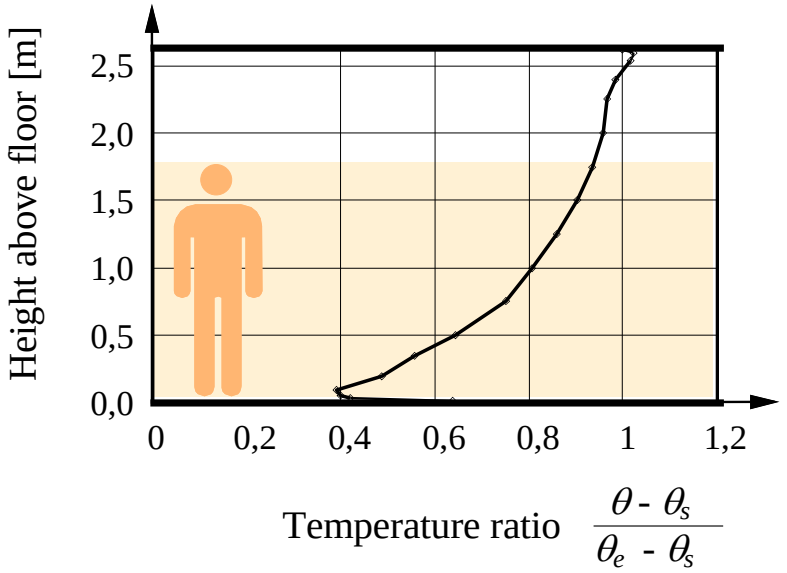


Less supply air lower the interface between the two layers.

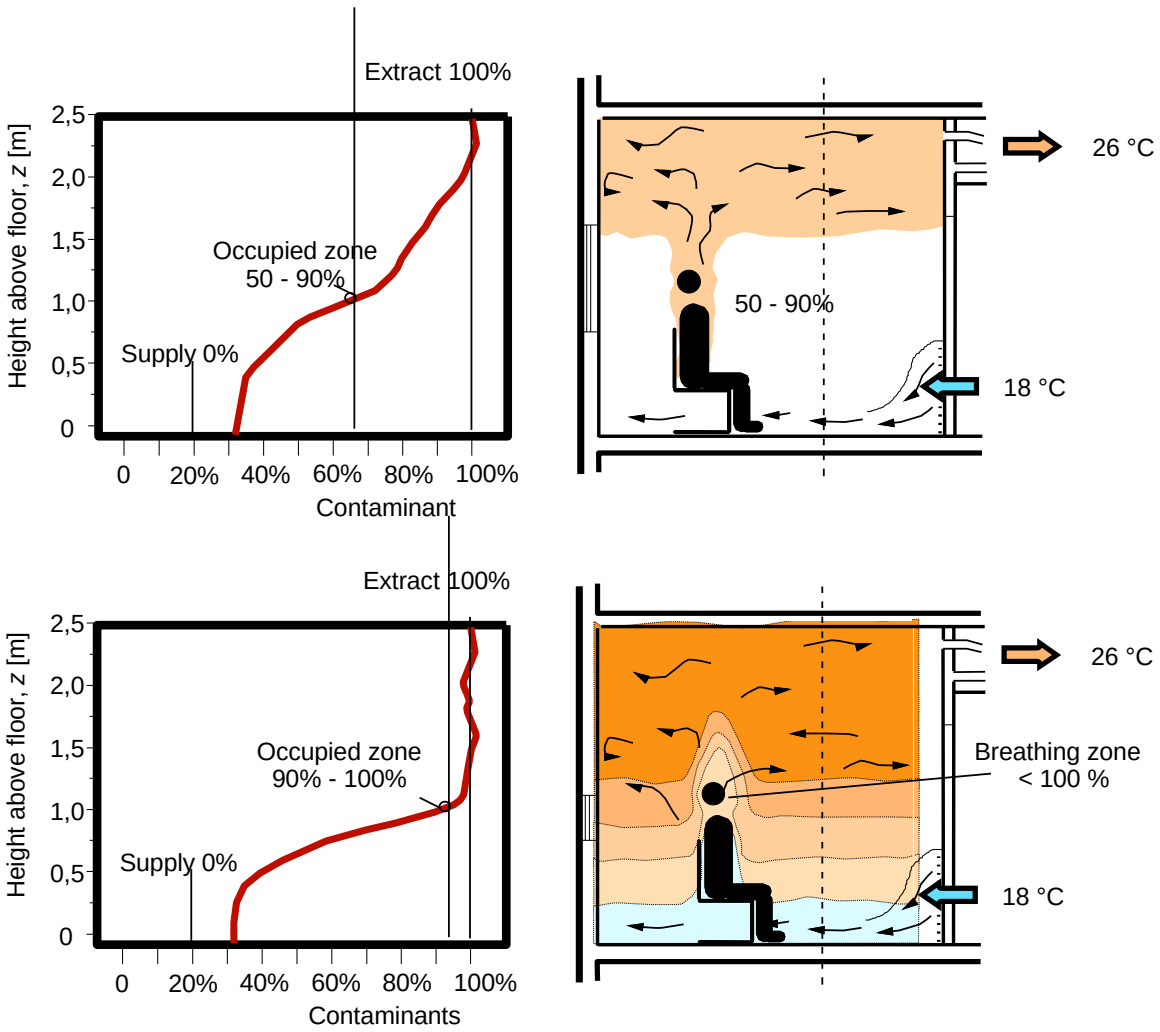
Basic principles – Thermal stratification

In practice, the air will stratify in many layers, making the temperature rise from floor to ceiling.



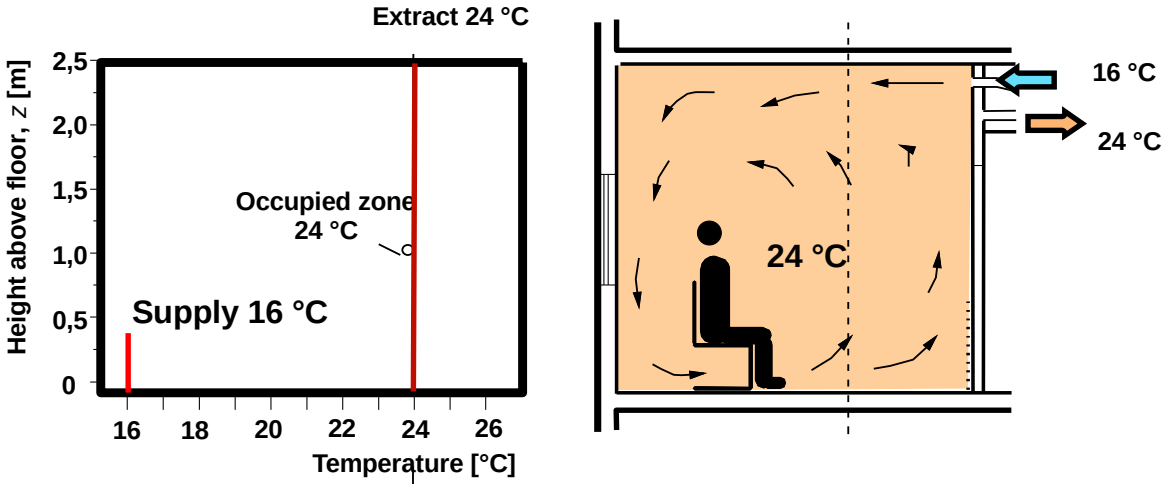


Basic principles – Thermal stratification

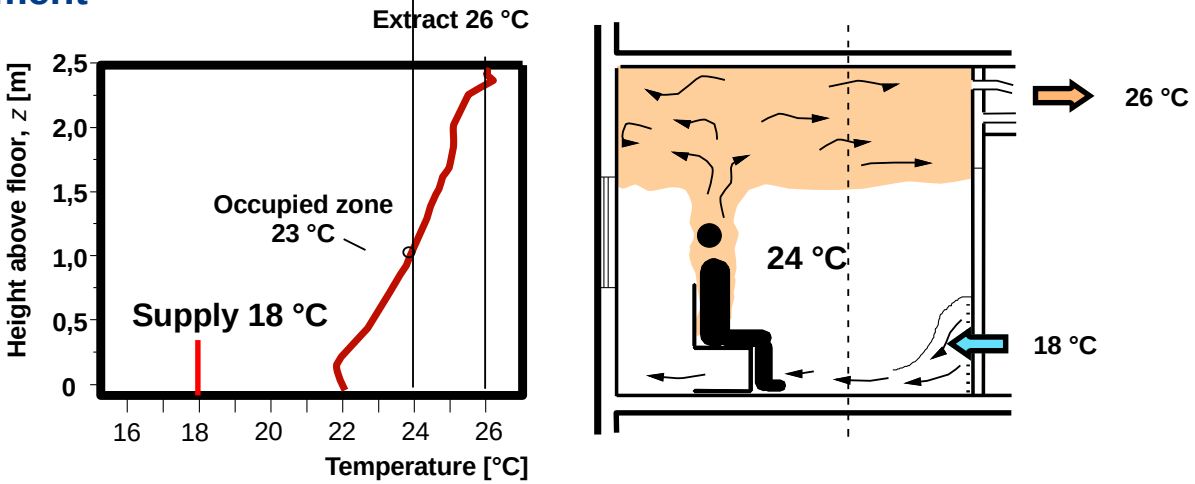


Temperature distribution - normal rooms

Mixing

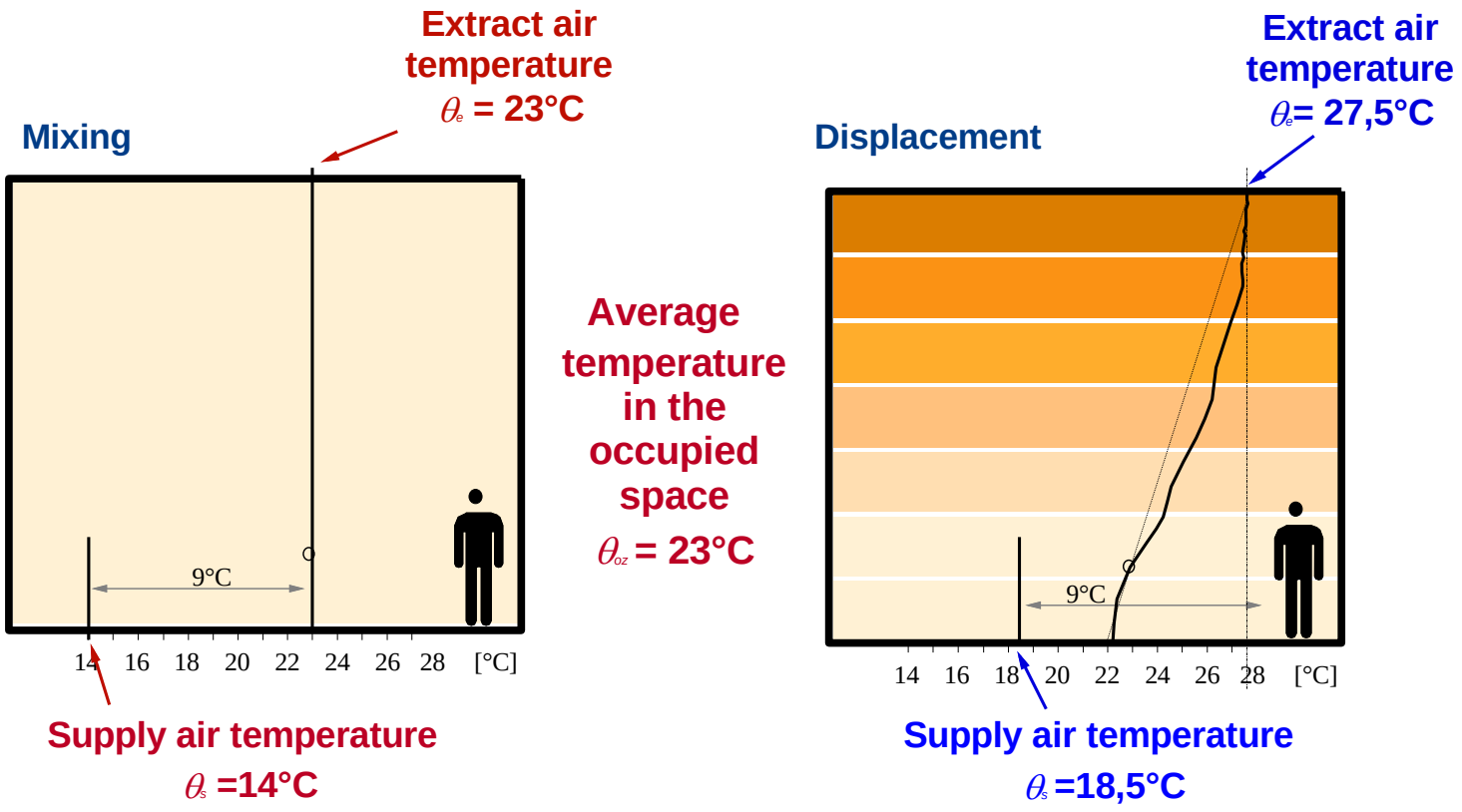


Displacement



Less cooling is needed to obtain the desired temperature in the occupied space

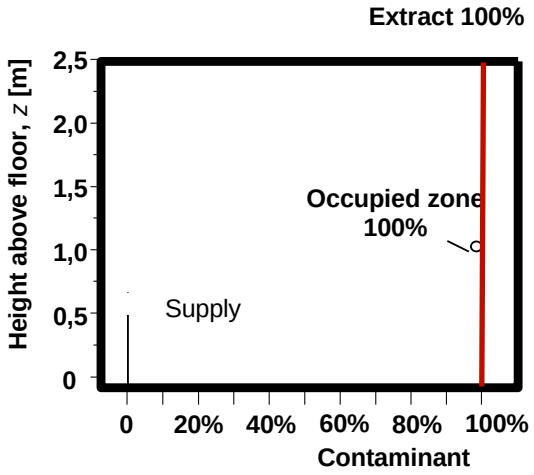
Temperature distribution - Tall rooms

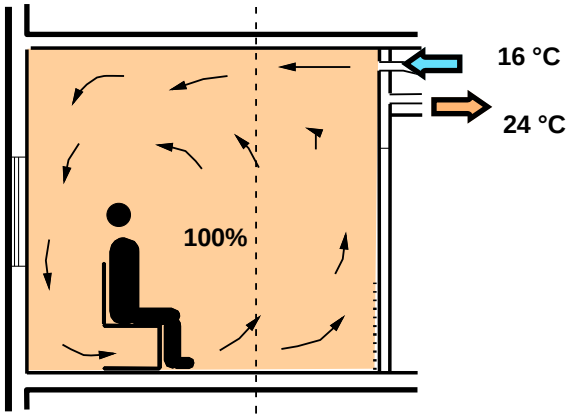


The cooling advantage is most pronounced for tall rooms

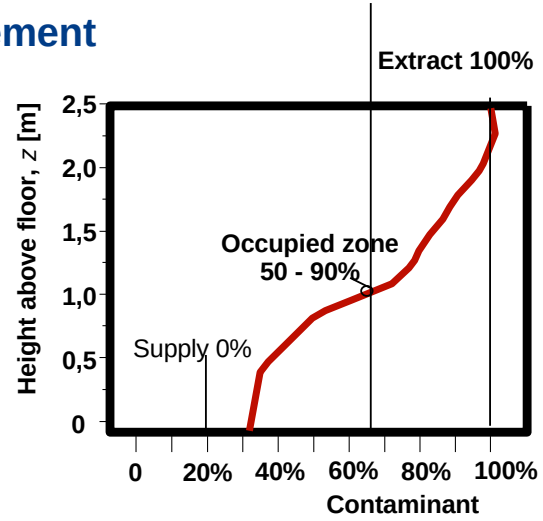
Contaminant distribution in normal rooms

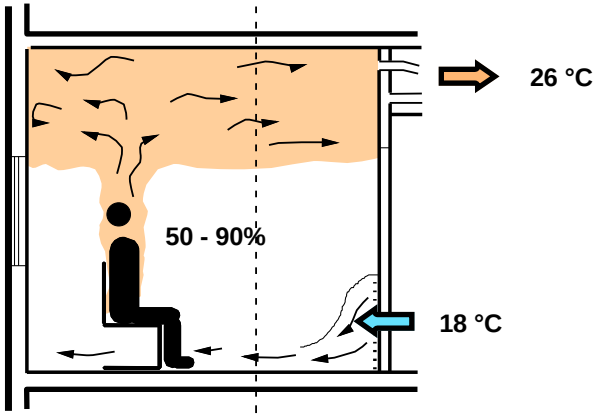
Mixing





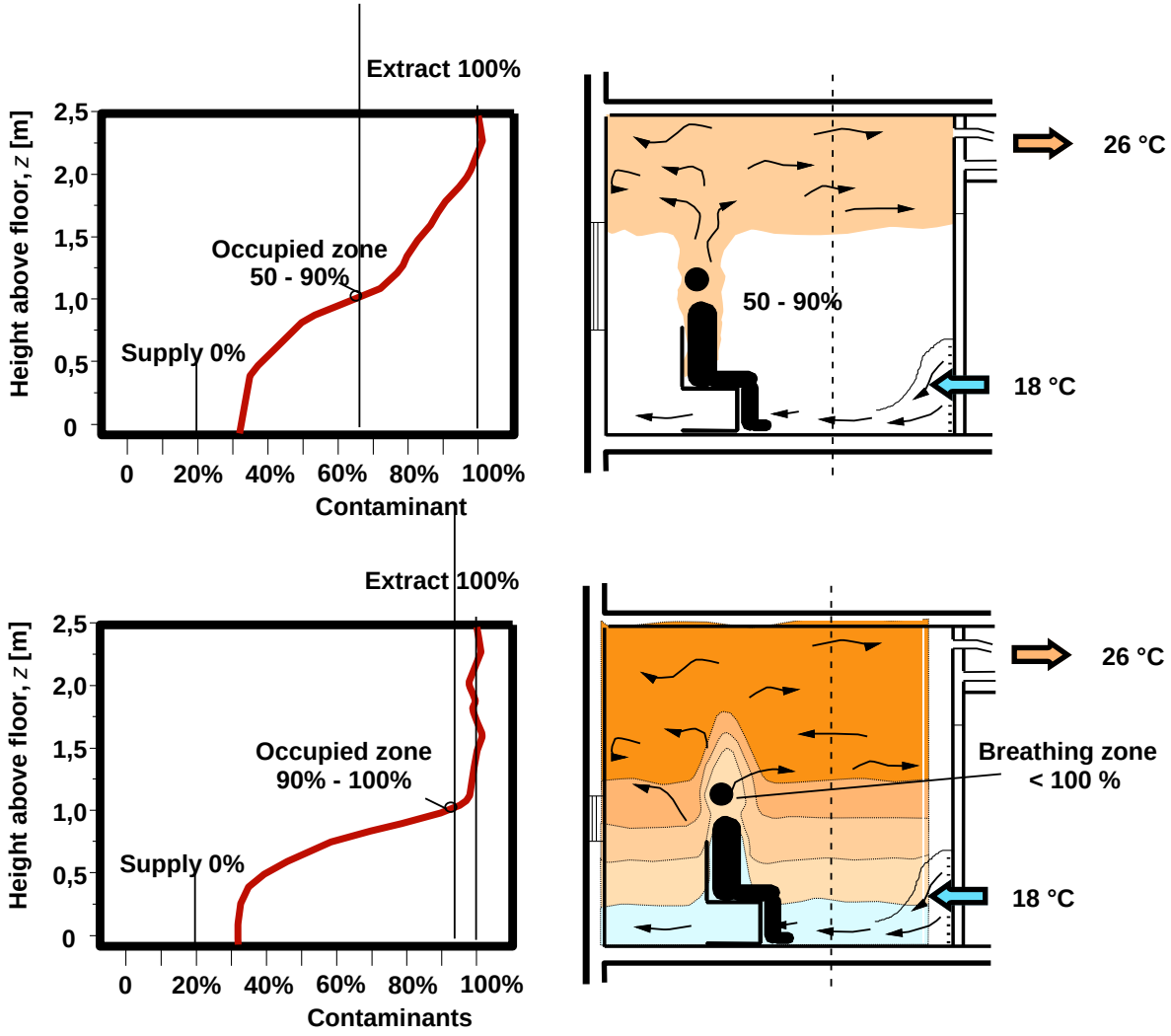
Displacement





For the same ventilation rate, we may get better air quality with displacement ventilation

Little air - less benefit



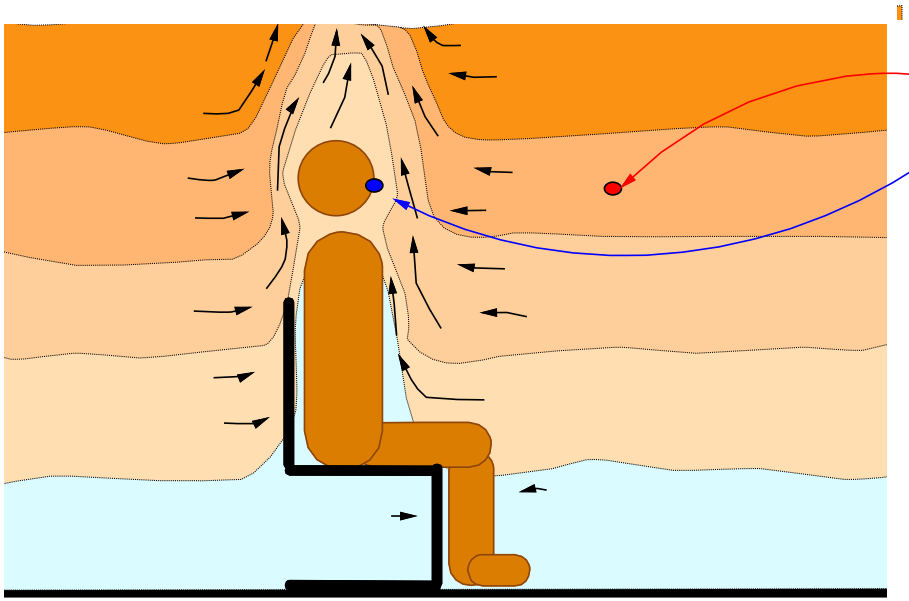
20 l/s per person = very good

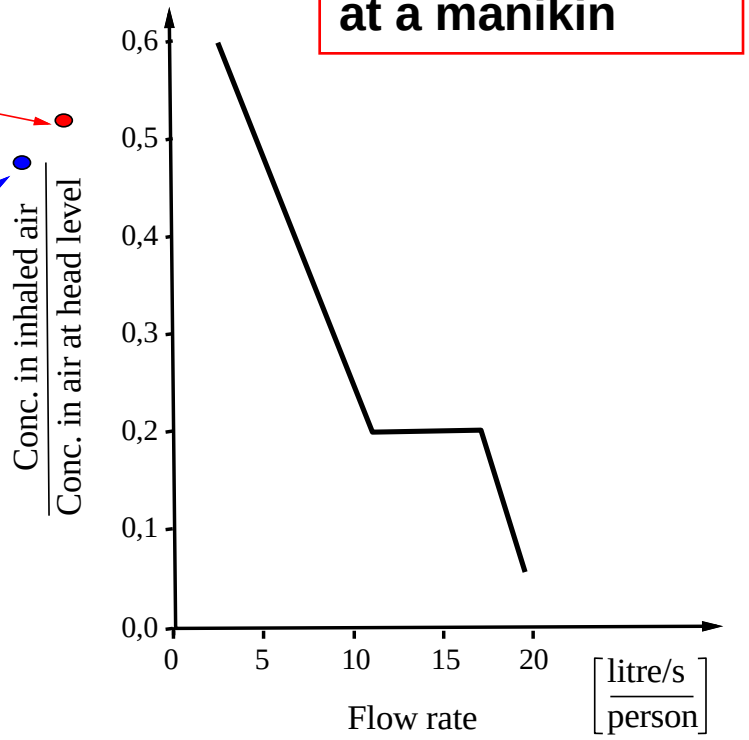
10 l/s per person = acceptable

< 10 l/s per person = insufficient

Contamination in inhaled air

Concentration ratios measured at a manikin



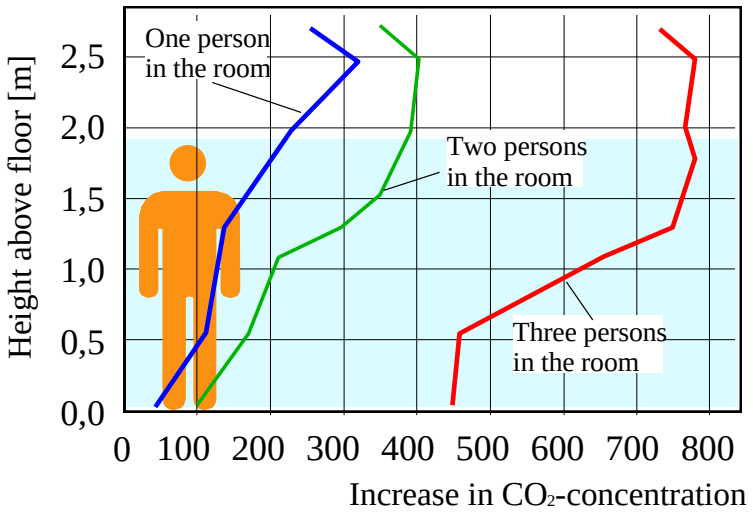


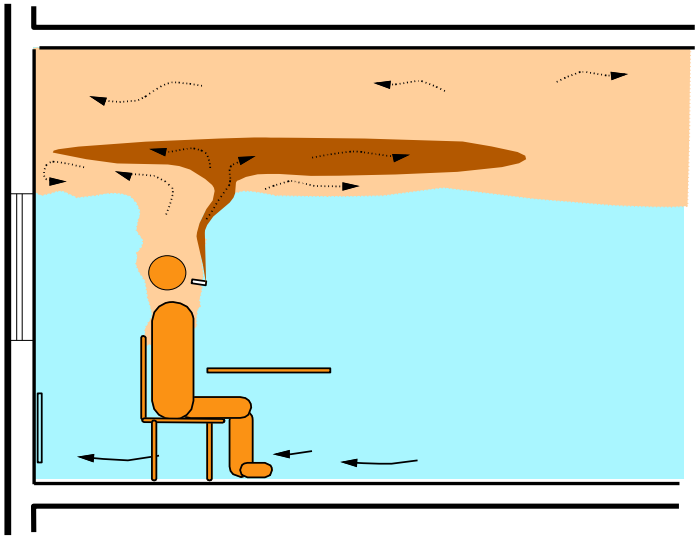
The rising flow around a person brings fresh air to the breathing zone

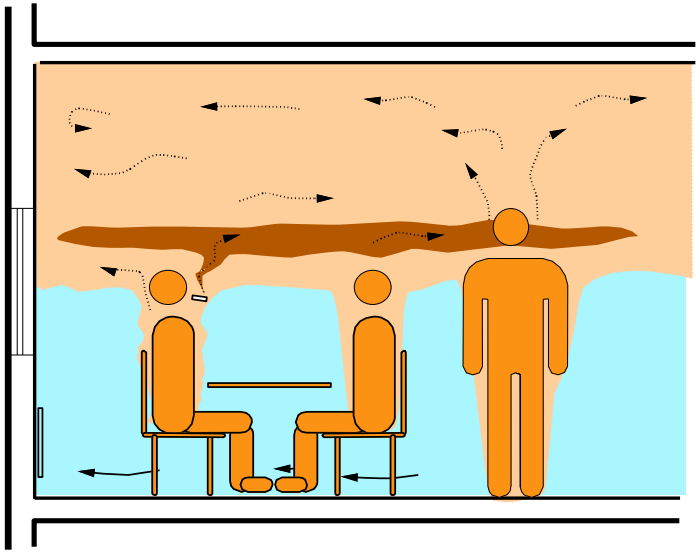
Source:
Mats Sandberg, Sweden

Better air quality: Yes – and No?

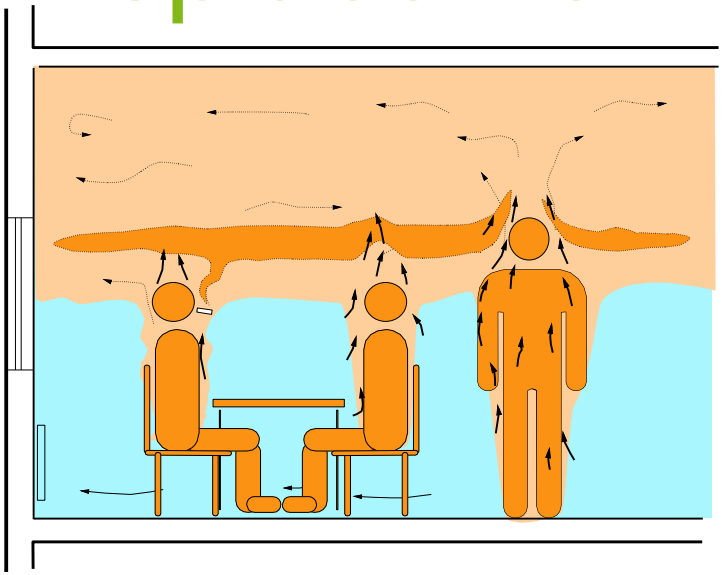
When there are many people, and insufficient air, the contaminants stratify at lower levels

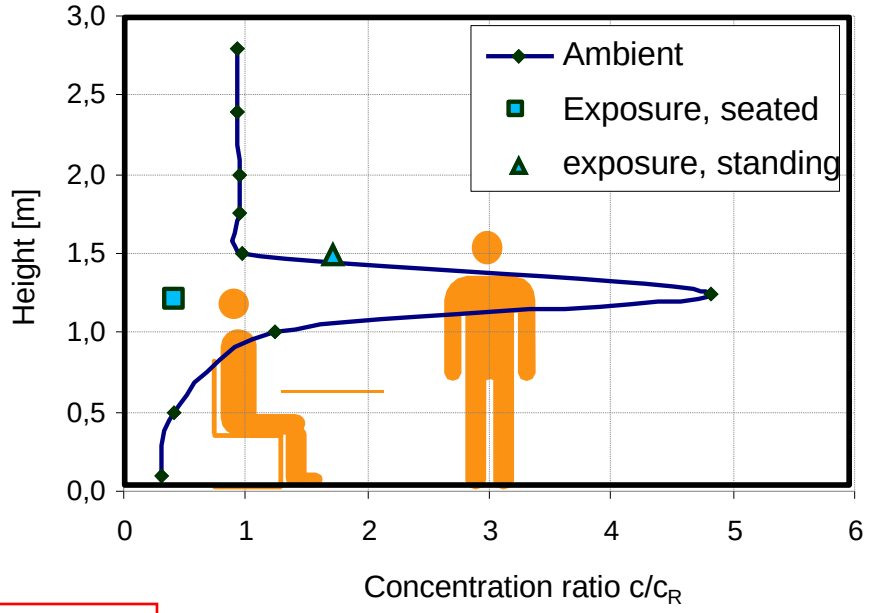






Passive smoking in crowded rooms with Displacement Ventilation

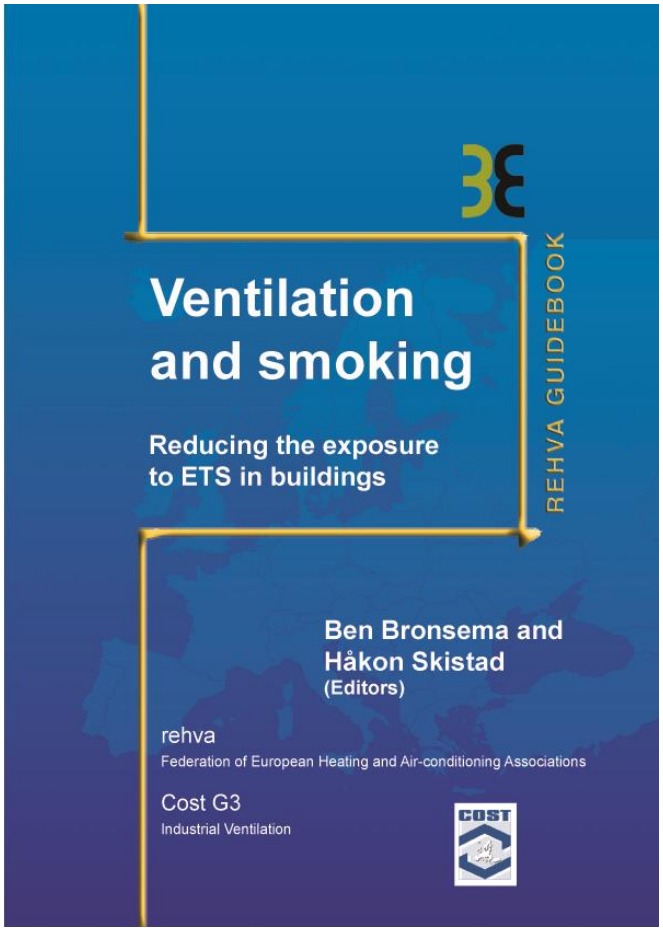




A standing person's exposure may be greater, but people are still protected by the rising air current around themselves

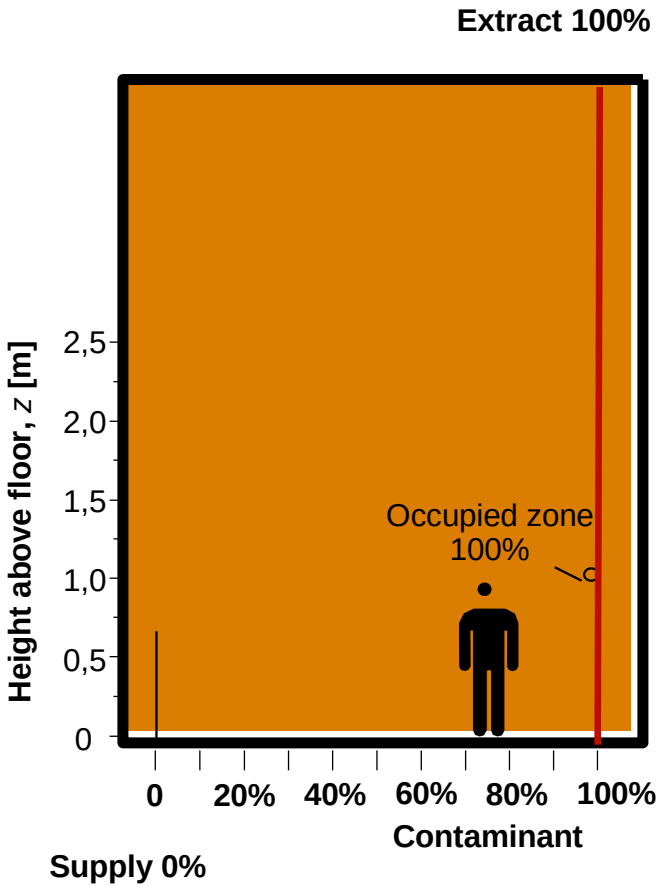
Source:
Peter V- Nielsen, Denmark

For protection against tobacco smoke, see REHVA Guidebook no 4: “Ventilation and Smoking”.

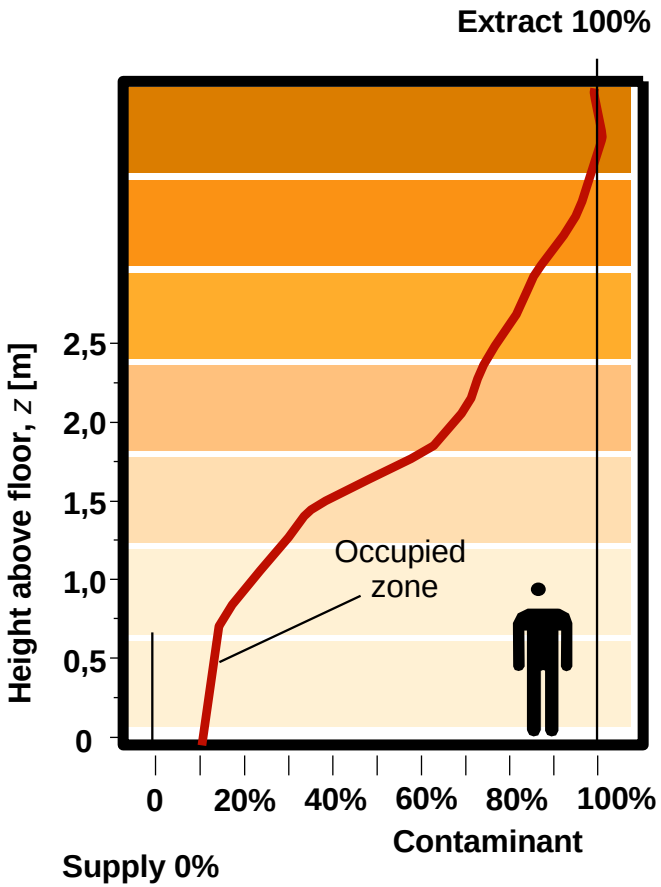


Contaminant distribution in tall rooms

Perfect mixing

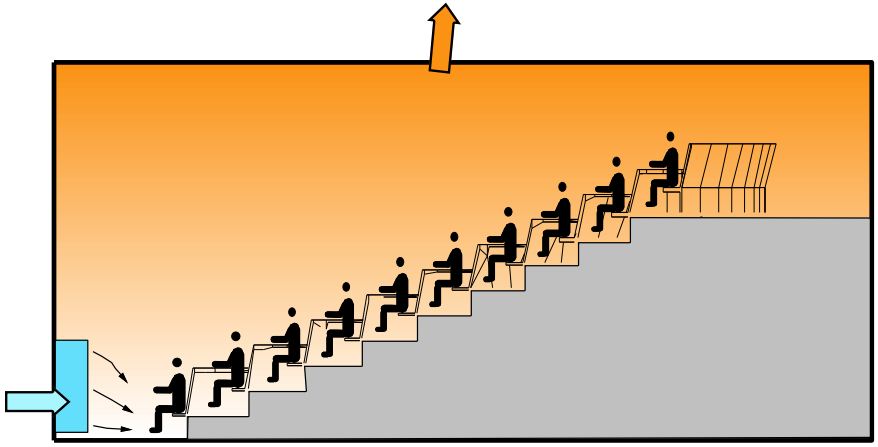


Displacement

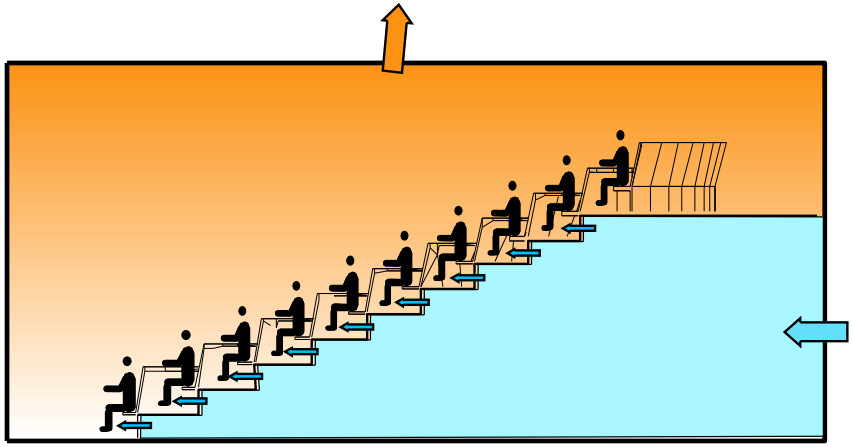


Auditoria – air supply

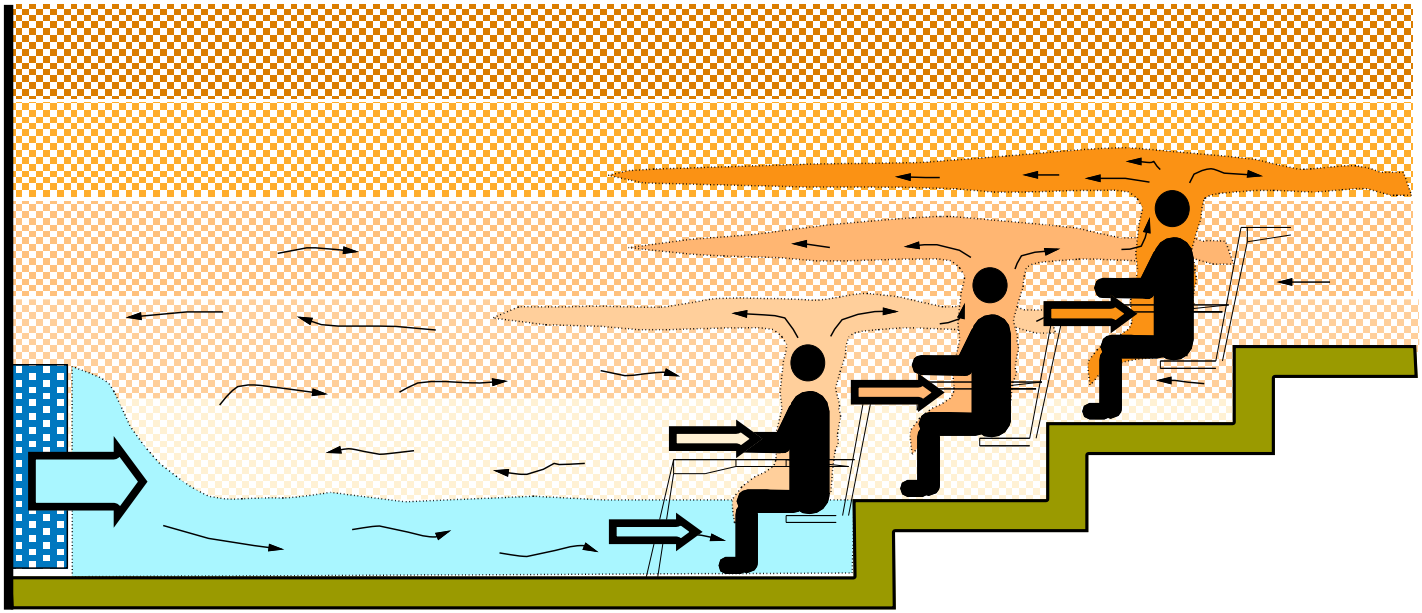
Air supply in front of the room



Air supply under the seats

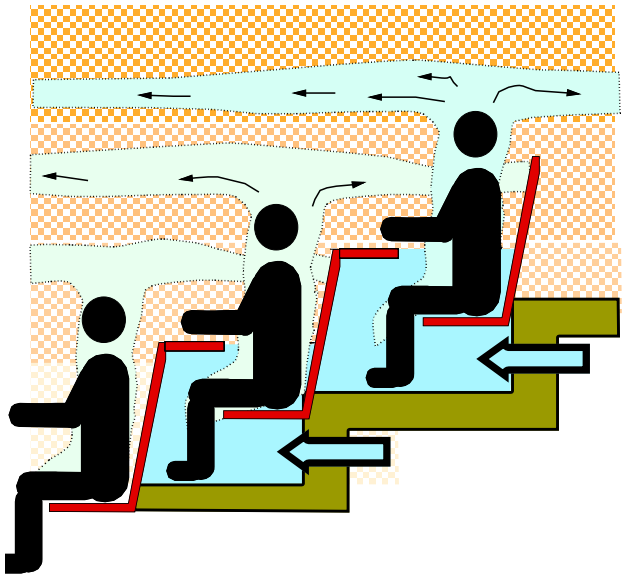


Auditoria – air flow pattern

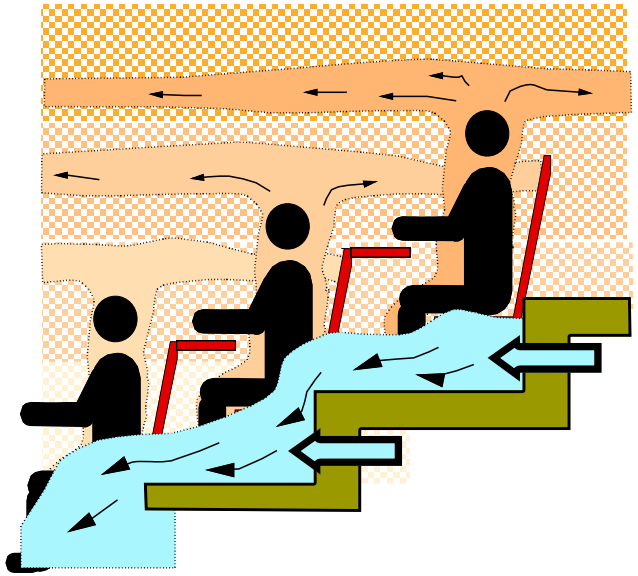


Thermal and contaminant stratification

Auditoria – air flow pattern

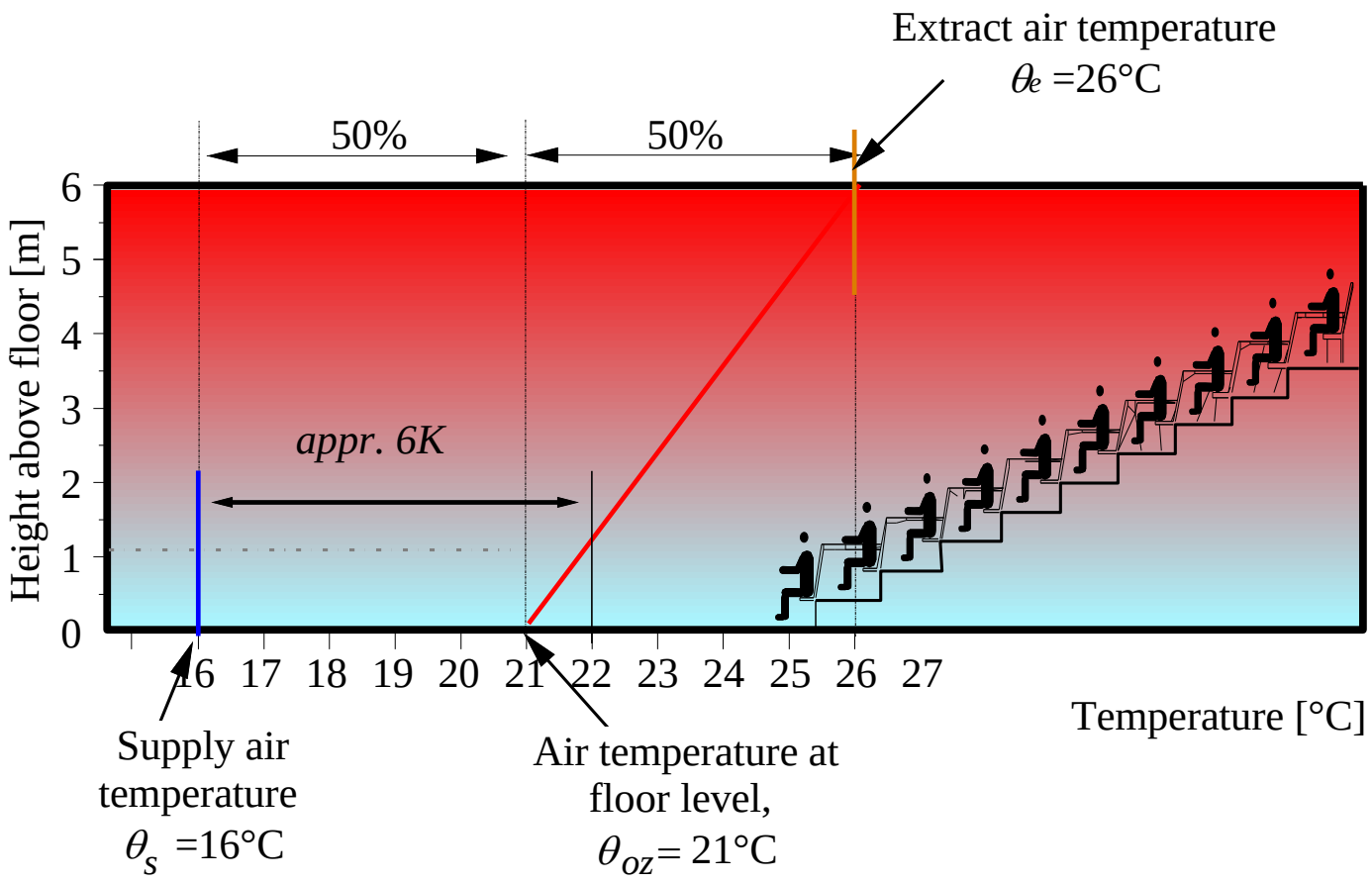


Supply air is contained between the rows.

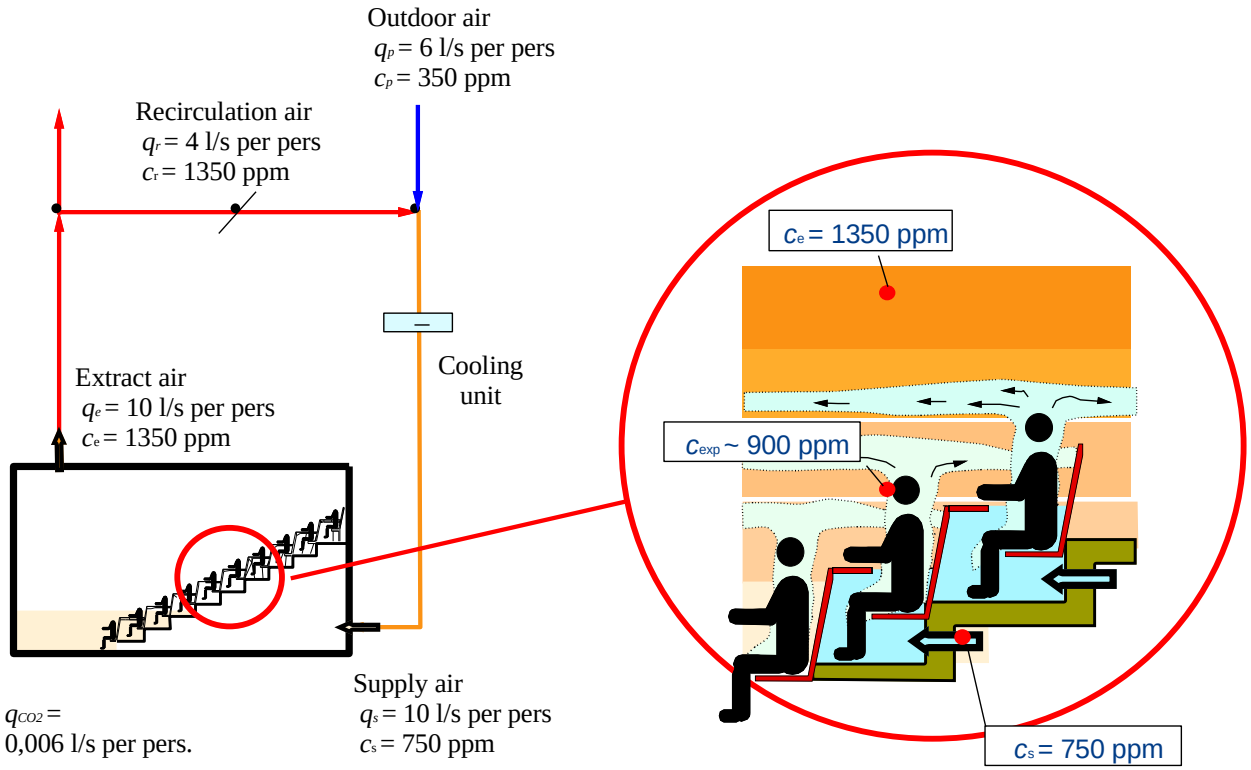


Supply air is floating down the stairways.

Auditoria – temperature distribution

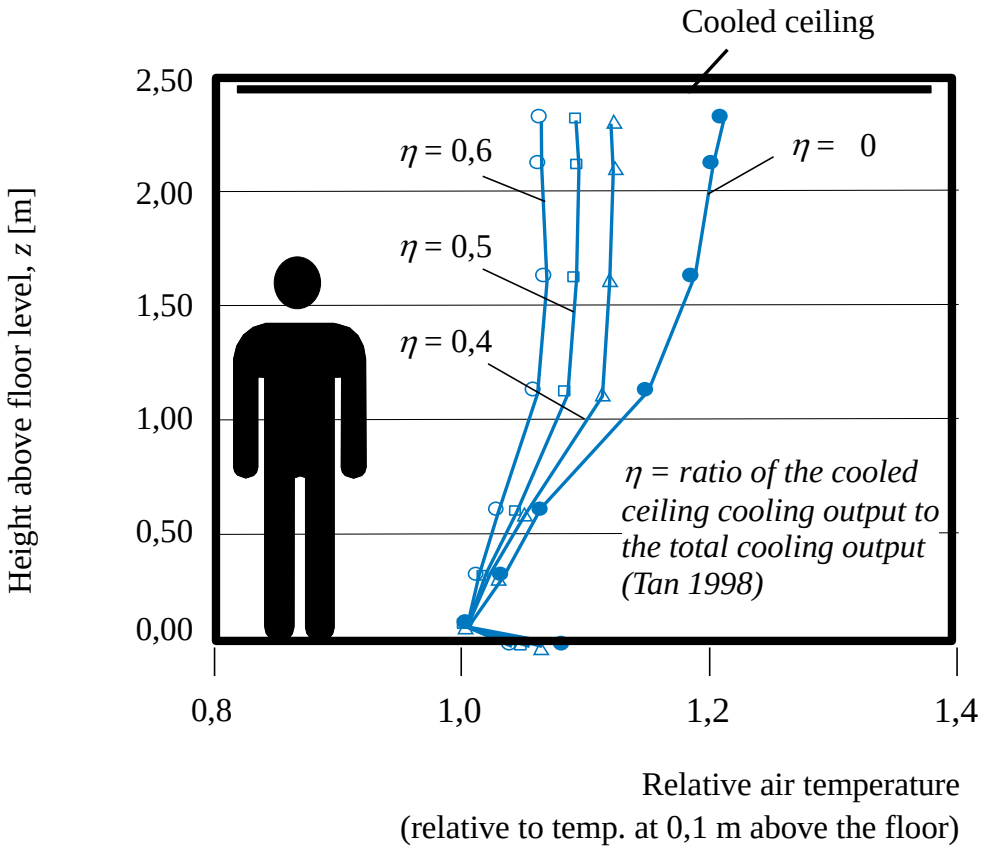


Auditoria – Recirculation



Displacement ventilation gives benefits to recirculation in tall rooms – for details, see the book

Cooled ceiling - high temperature cooling



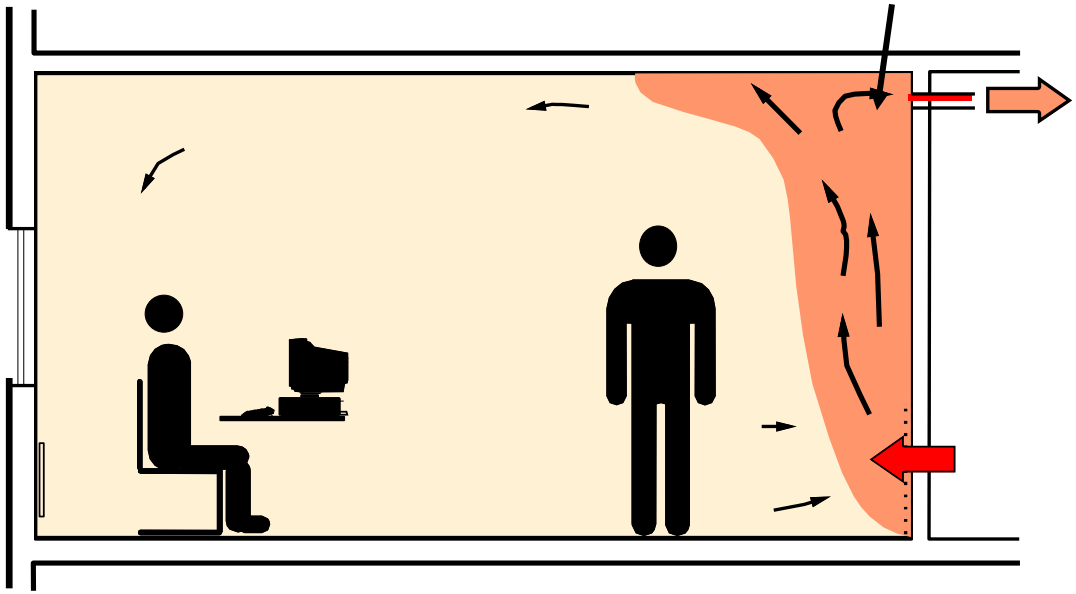
Cooled ceiling is ok when the cooling output of the ceiling is less than 40% of the total cooling.

Cooled ceilings, or cooling convectors, decrease the air quality benefit.

Mixing ventilation should be considered as an alternative.

Room heating

Short-circuiting:
The warm, fresh air is pulled into the extract

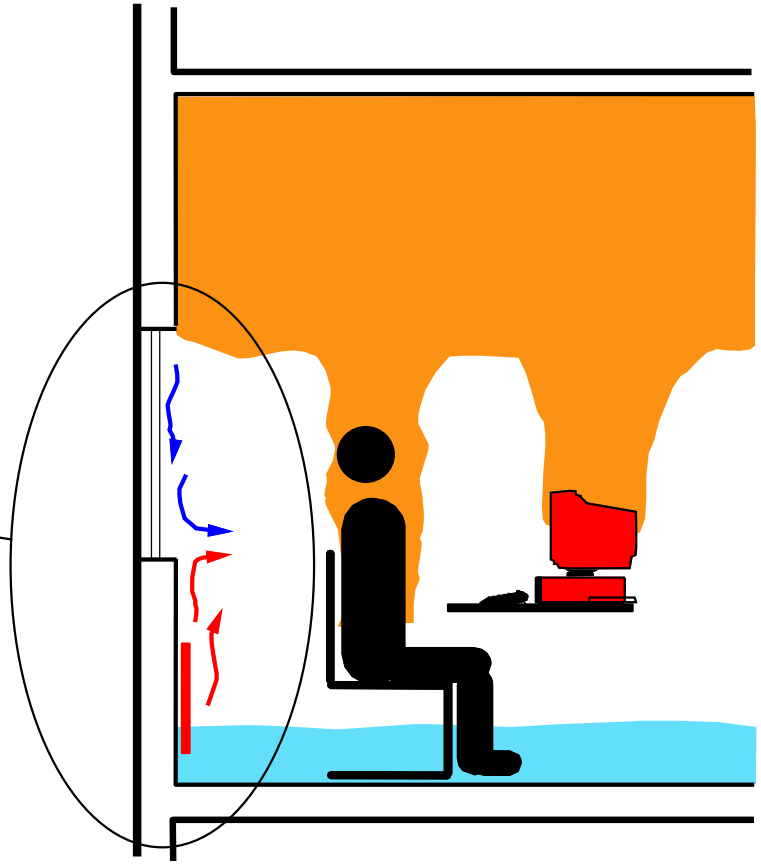


When the room is occupied:
- **Don't heat the room by the ventilation air !**

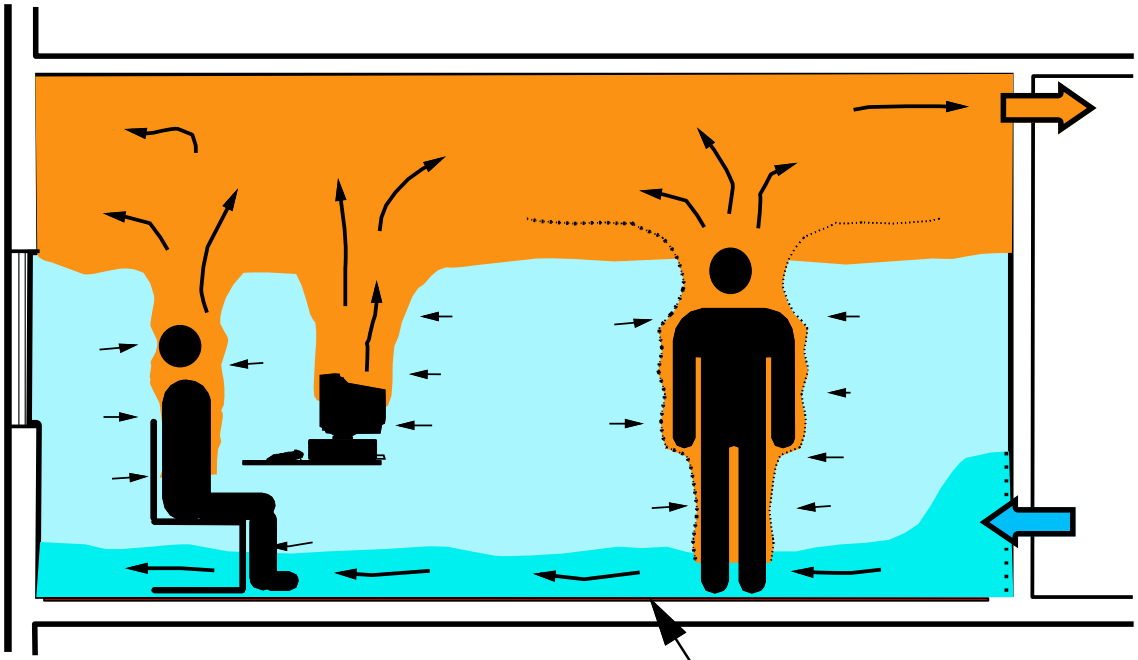
At night:
- **Some people recommend heating by the ventilation air….**

Heating by radiator/convector

Warm air from radiator balances meets the cold air from window/wall



Floor heating - low temperature heating



Floor heating is ok as long as the floor temperature is moderate (i.e. less than appr. 25° C)

Useful or useless?

Best suited for:

- **Restaurants,**
- **Meeting rooms,**
- **Classrooms**
- **Tall rooms:**
  - Conference rooms,
  - Theatres,
  - Supermarkets, etc

Advantages:
- **Improved air quality**
- **Most efficient in tall room**
- **1°C – 3°C lower temperature in the occupied space for a given supply temperature**

Less suited for:

- **Where surplus heat is the main problem, and not air quality.**
- **Where ceiling heights are lower than approximately 2,3 metres.**
- **When the problem is cooling in low rooms (in offices, consider mixing and cooling panels)**
- **Where disturbances to room air flow is strong.**

Where the contaminants are colder/denser than the ambient air.

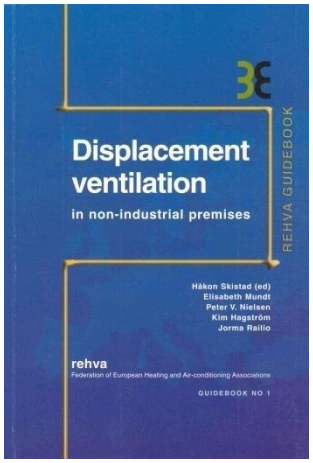
..and please remember:

Displacement Ventilation is no miracle, and should not be used everywhere.

It has lost much of its reputation in several countries due to incompetent or over-optimistic use.

Problems:

- **draught along the floor**
- **diffusers require much wall space**



..but used with skill in the right places, it has definite advantages.

Thank you for your attention

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