UiT The Arctic University of Norway

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Indoor Environment

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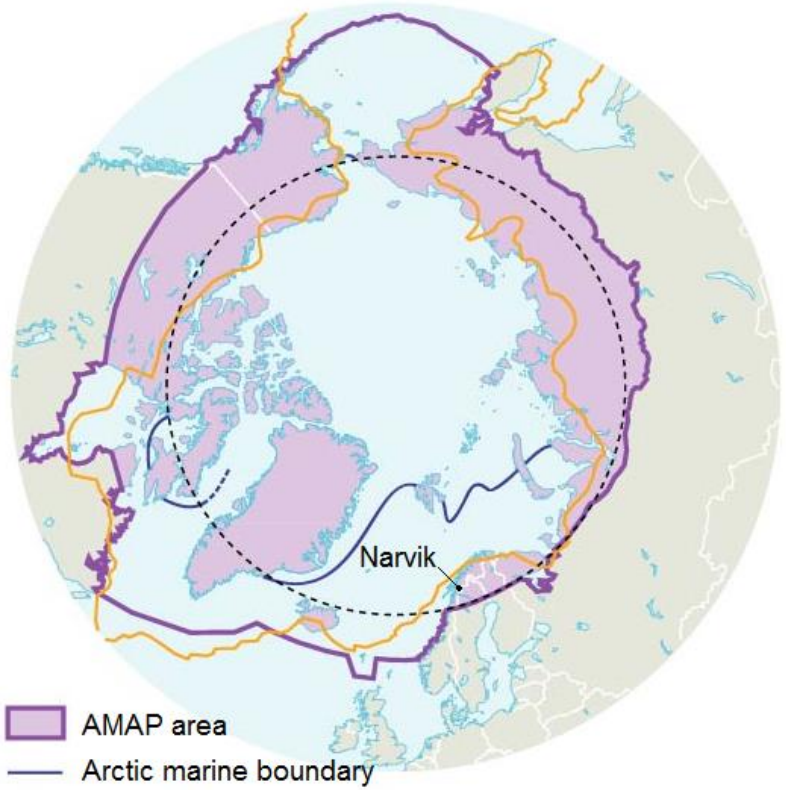
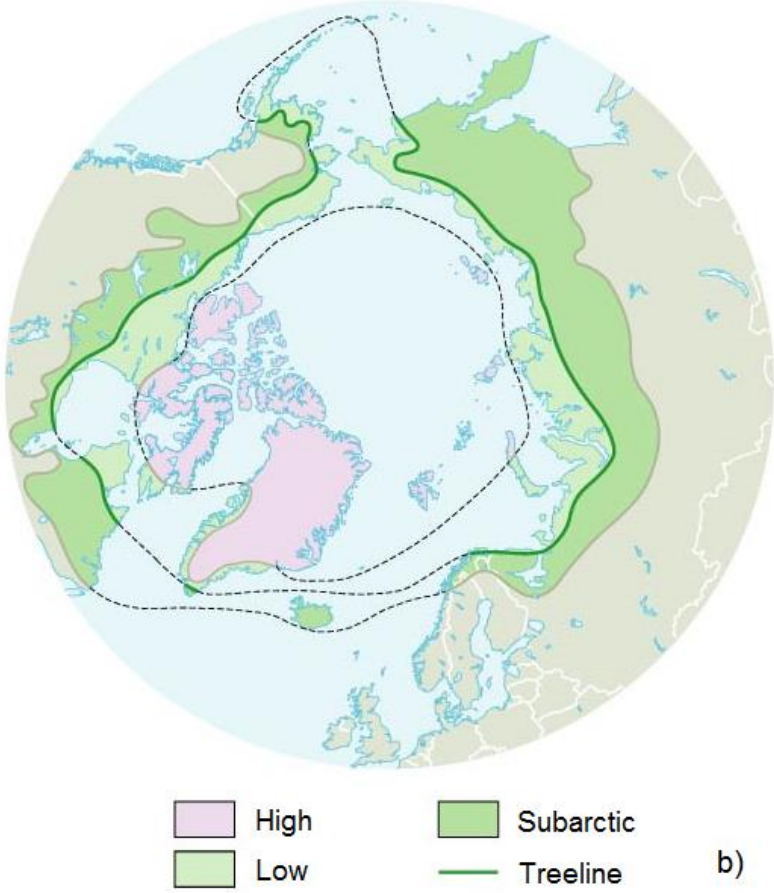
Introduction

The Arctic – definitions

By region or temperature



By treeline or fauna



AMAP – Arctic Monitoring and Assessment Programme (1998)

Introduction

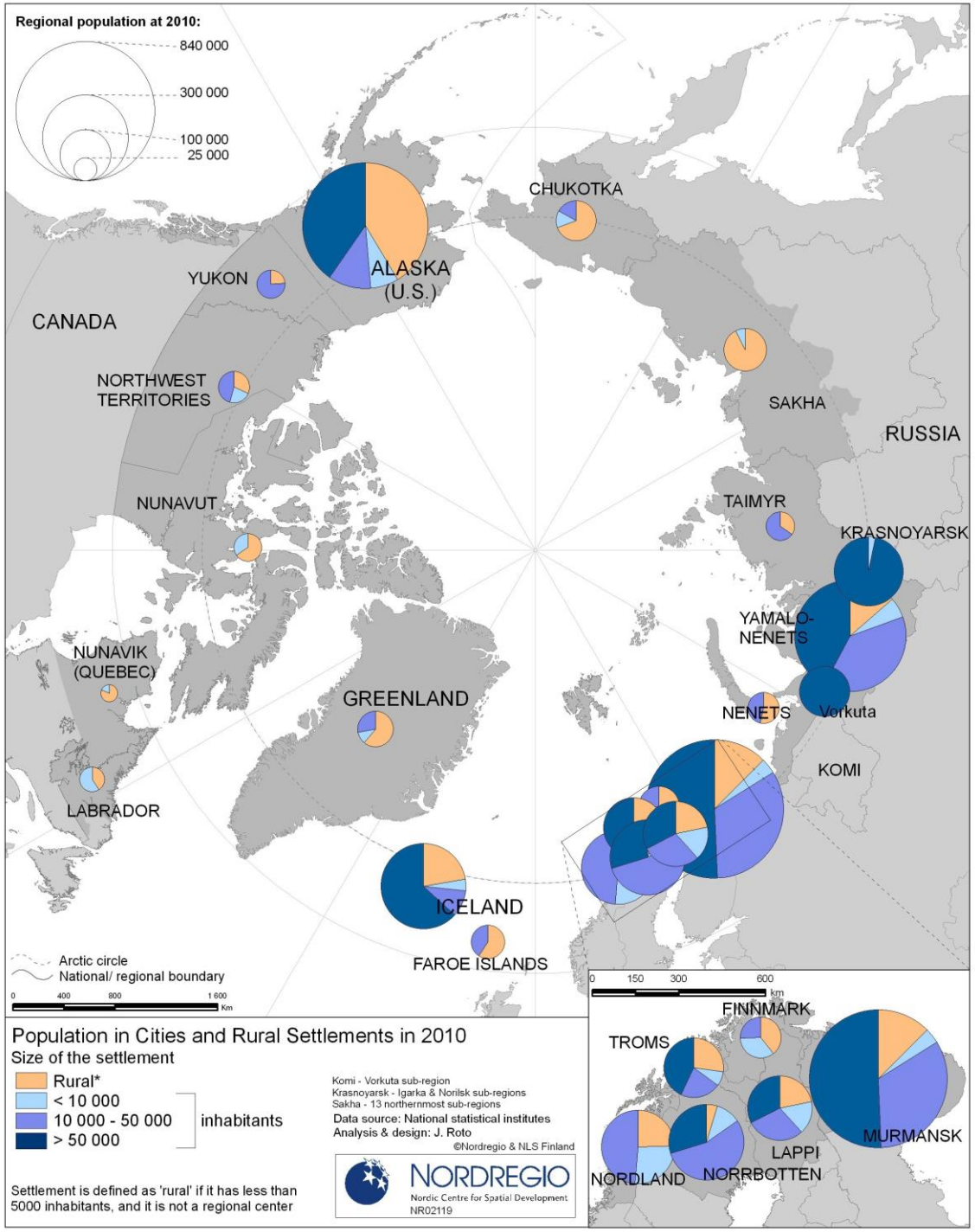
Arctic climate

- Warmest monthly mean temperature > 10^{o}C and lowest < −3^{o}C
- Large seasonal variationsprecipitation
  - cold, dark winters (polar nights)
  - short, bright summers (midnight sun)
- Arid, dry, little precipitation
  - snow and ice
  - frost action
  - seasonally frozen ground and permafrost
- Shifting between easterly polar winds and Westerlies

Introduction

Population in the Arctic

- Less than 5,5 million people within AMAP borders
- Largest concentrations of people in Scandinavia, NW-Russia
  - declining in Russia
  - generally stable elsewhere
- Concentrated in small towns along cost lines and in rural areas
- Large portion of indigenous people or of indigenous descent



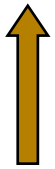
Indoor environment

Definition

Indoor climate

Indoor environment

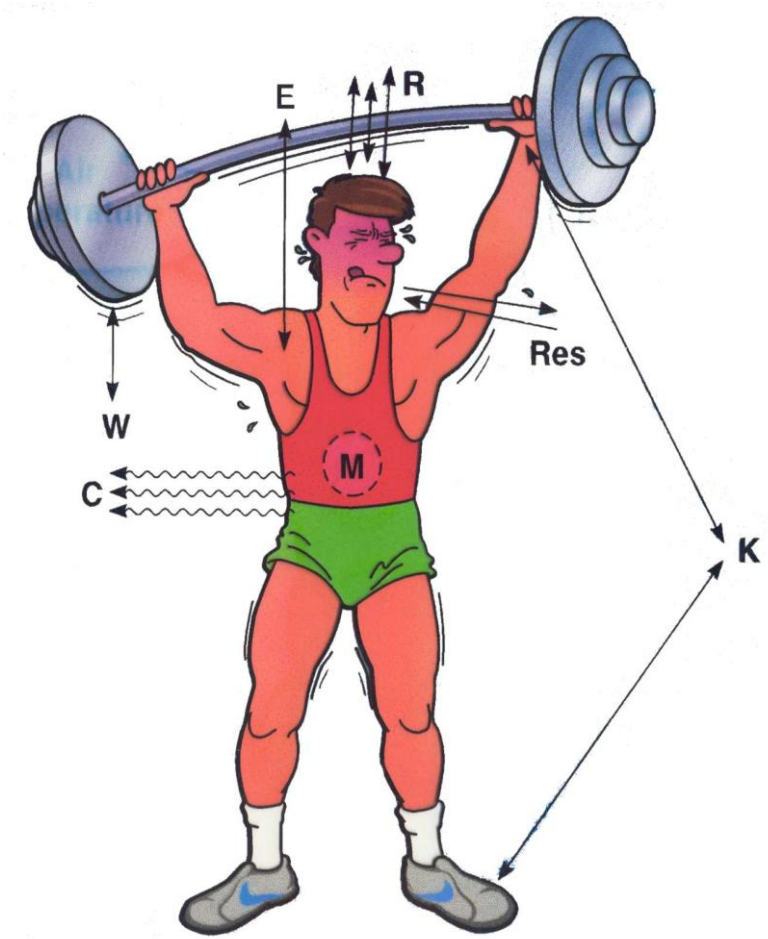
Type	Description
Thermal	Energy balance, temperature, thermal comfort
Atmospheric	Air quality, pollutants (gases), fibres and particles
Acoustic	Sound perception, noise and vibrations
Actinic	Electromagnetic (light) emission, glare, radon radiation
Mechanical (physical)	Perception of touch, pain, safety, ergonomics
Psychosocial	Inter-human relations
Aesthetic	Aesthetics



WHO – World Health Organization’s definition

Thermal climate

Heat generation and losses



- **R and C**: heat loss from **radiation and convection**
  - approx. 60-70 % depending on clothing
- **E**: heat loss from **evaporation**
  - approx. 25 % with moderate activity
- **K and RES**: heat loss from **conduction and respiration**
  - negligible, normally omitted in calculations
- **M**: heat generation (metabolism)
  - varies with activity level (**W**)
  - humans are ineffective “machines”
  - less that 20 % efficiency factor

Thermal climate

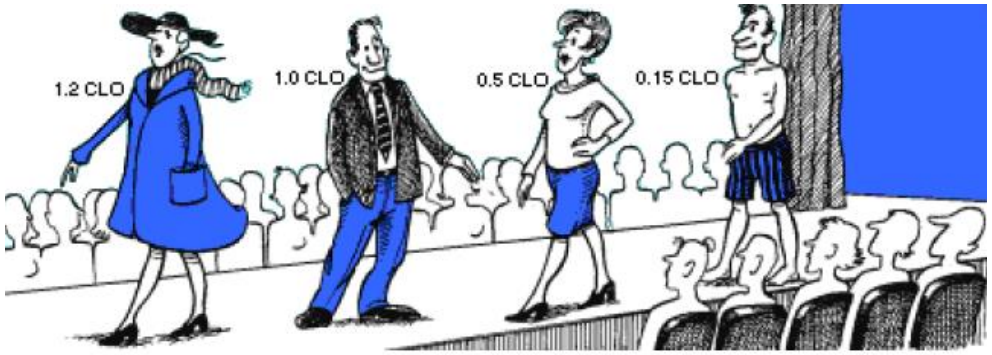
Metabolism, activity level and insultation (clothing)

1 met = 58 W/m^2

1.1 Met

2.5 Met

6.5 Met



Insulation for the entire clothing: $I_{clo} = \sum I_{clo,i}$ (m^{2}K/W)

0.19
+
0.04
+
0.11
+
0.02
+
0.02
0.38

a) Summer

0.28
0.25
0.04
0.25
0.05
0.04
0.91

b) winter

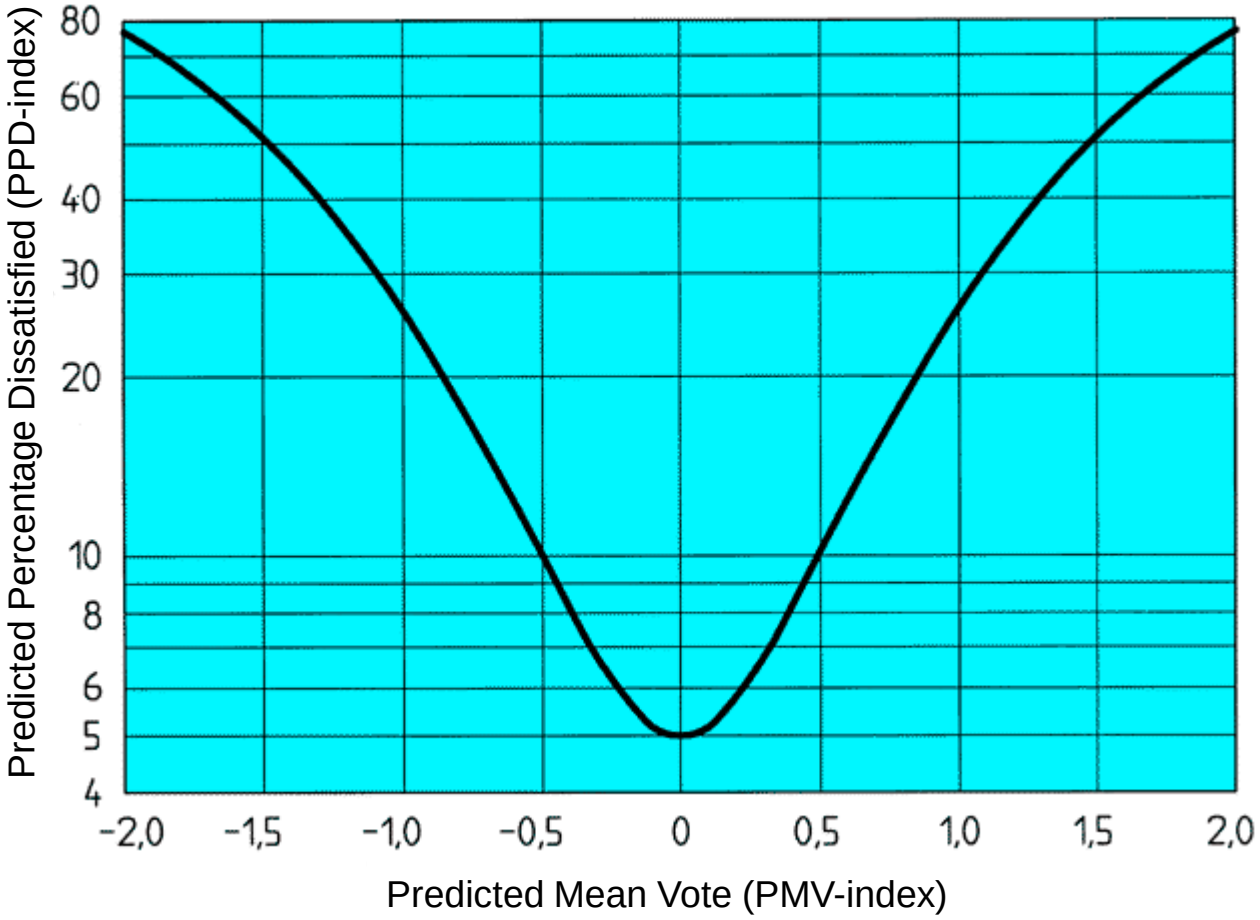
Thermal climate

Various temperature terms

Term	Description
Air temperature (t_a)	Temperature measured in air (stagnant or in motion).
Operative temperature (t_o or t_{op})	Combines the effects of air temperature and heat radiation from surrounding surfaces. In well-insulated buildings: $t_o \approx t_a$ $t_o = A \cdot t_a + (1 - A)\bar{t}_r$ (*A is an impact factor*) v_{ar}: < 0,2 | 0,2-0,6 | 0,6-1,0 A: 0,5 | 0,6 | 0,7 where relative air speed (v_{ar} in m/s) is defined as: $v_{ar} = v_a + 0{,}3(M - 1)$, ved $0{,}8 < M < 4{,}0\ met$ or $v_{ar} = v_a + 0{,}005(M - 58)$, ved $46 < M < 232\ W/m^2$
Equivalent temperature (t_{eq})	Same as operative temperature when the air speed (v_a) is zero.
Mean radiant temperature ($\bar{t}_r$)	Mean radiant temperature from all surfaces in a room, affecting a human inside.
Comfort temperature (t_{co})	The equivalent temperature needed for achieving thermal comfort (*PMV* = 0) at a given activity and clothing level, and at a given relative humidity.

Thermal climate

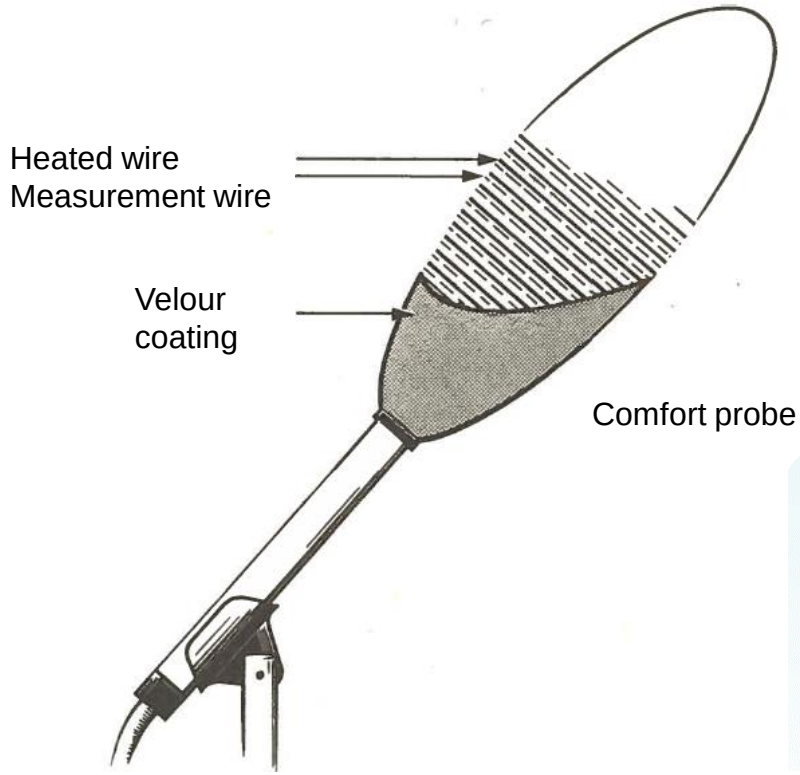
Thermal comfort – user assessment

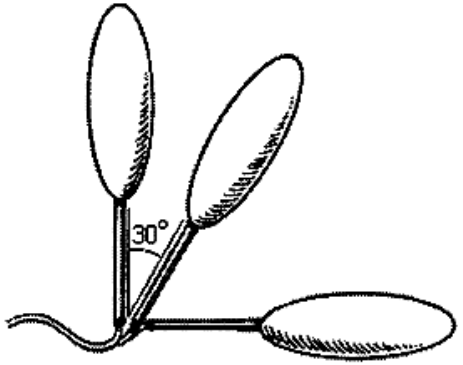


PMV	PPD
−3: cold	100 %
−2: chilly	77 %
−1: somewhat chilly	27 %
0: neutral	5 %
1: somewhat warm	27 %
2: warm	77 %
3: hot	100 %

Thermal climate

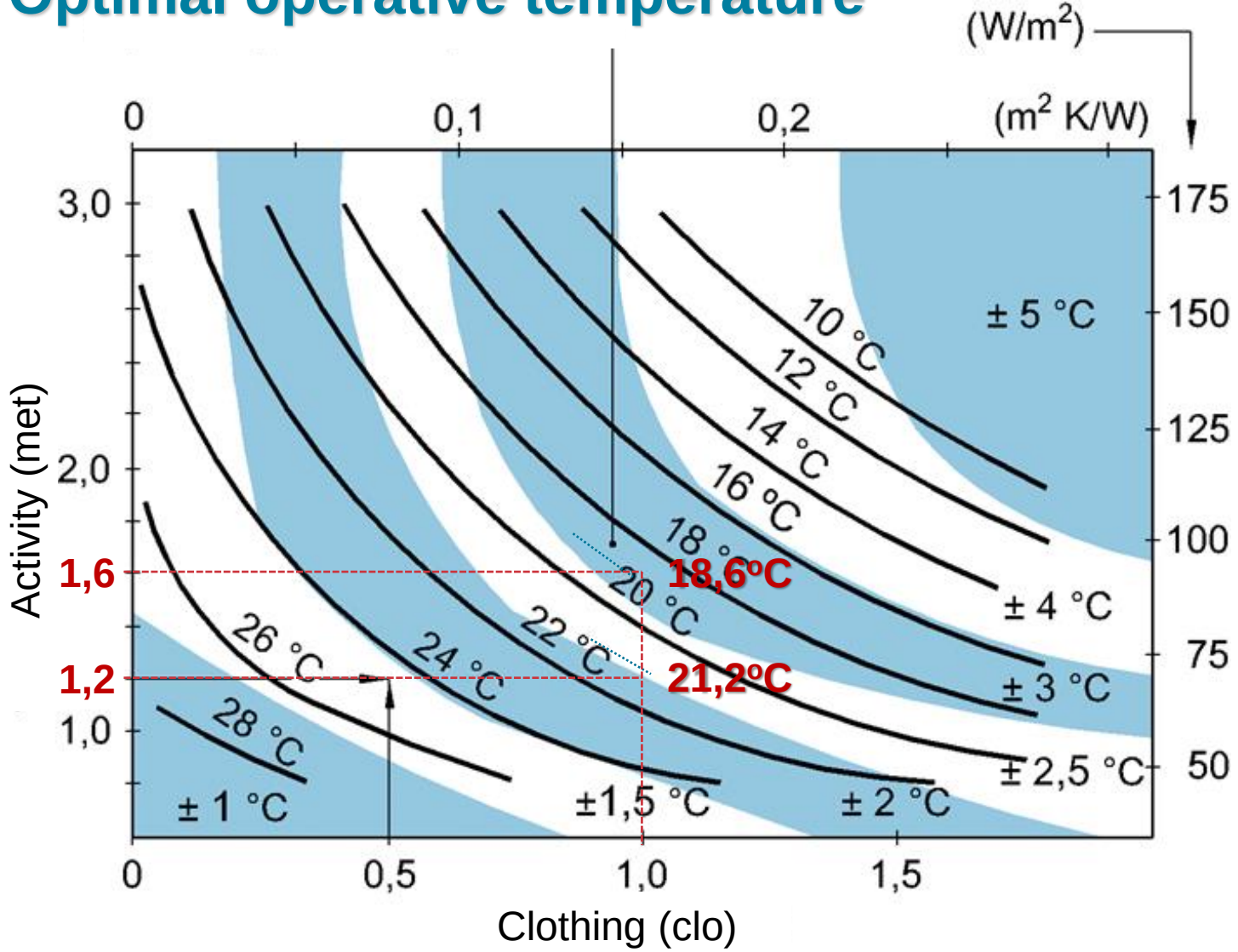
Thermal comfort – measurements





Thermal climate

Optimal operative temperature

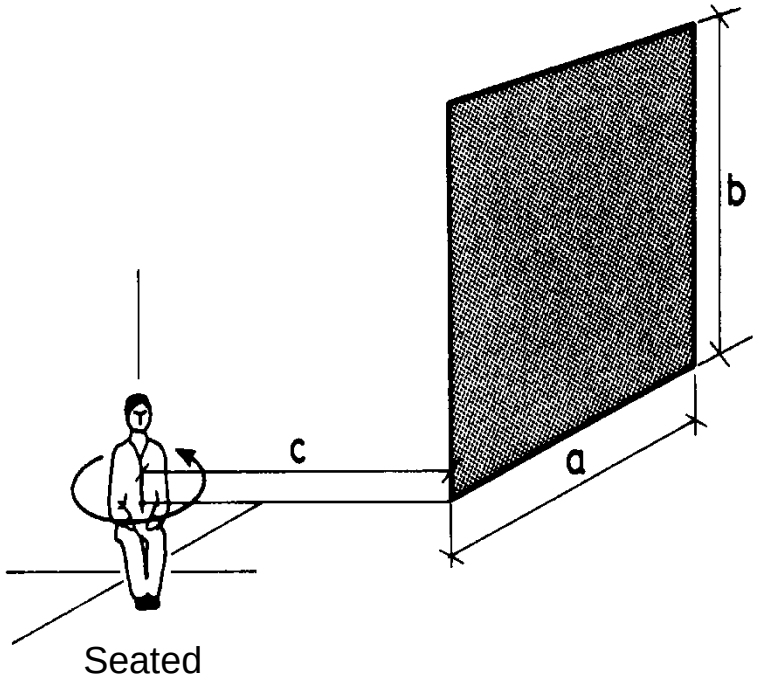


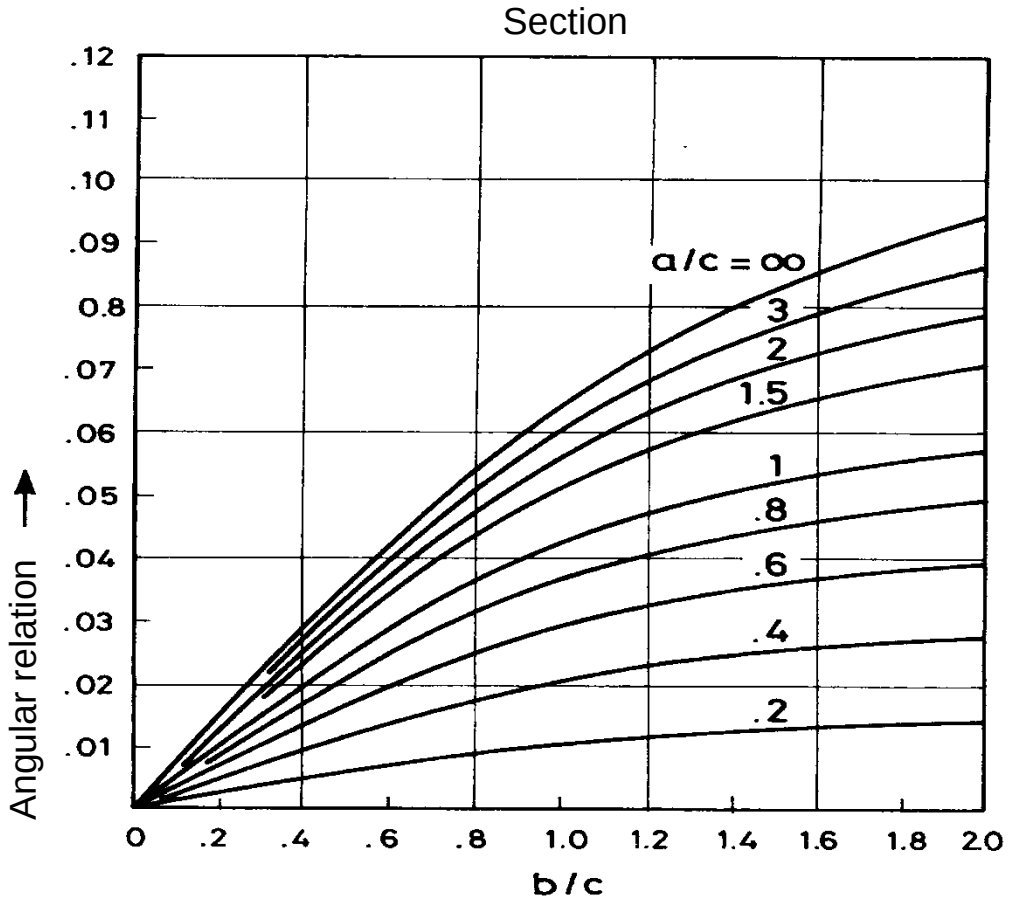
The blue and white regions represents intervals around optimal operative temperature where PMV is ± 0,5.

This translates to a PPD less than 10 %.

Thermal climate

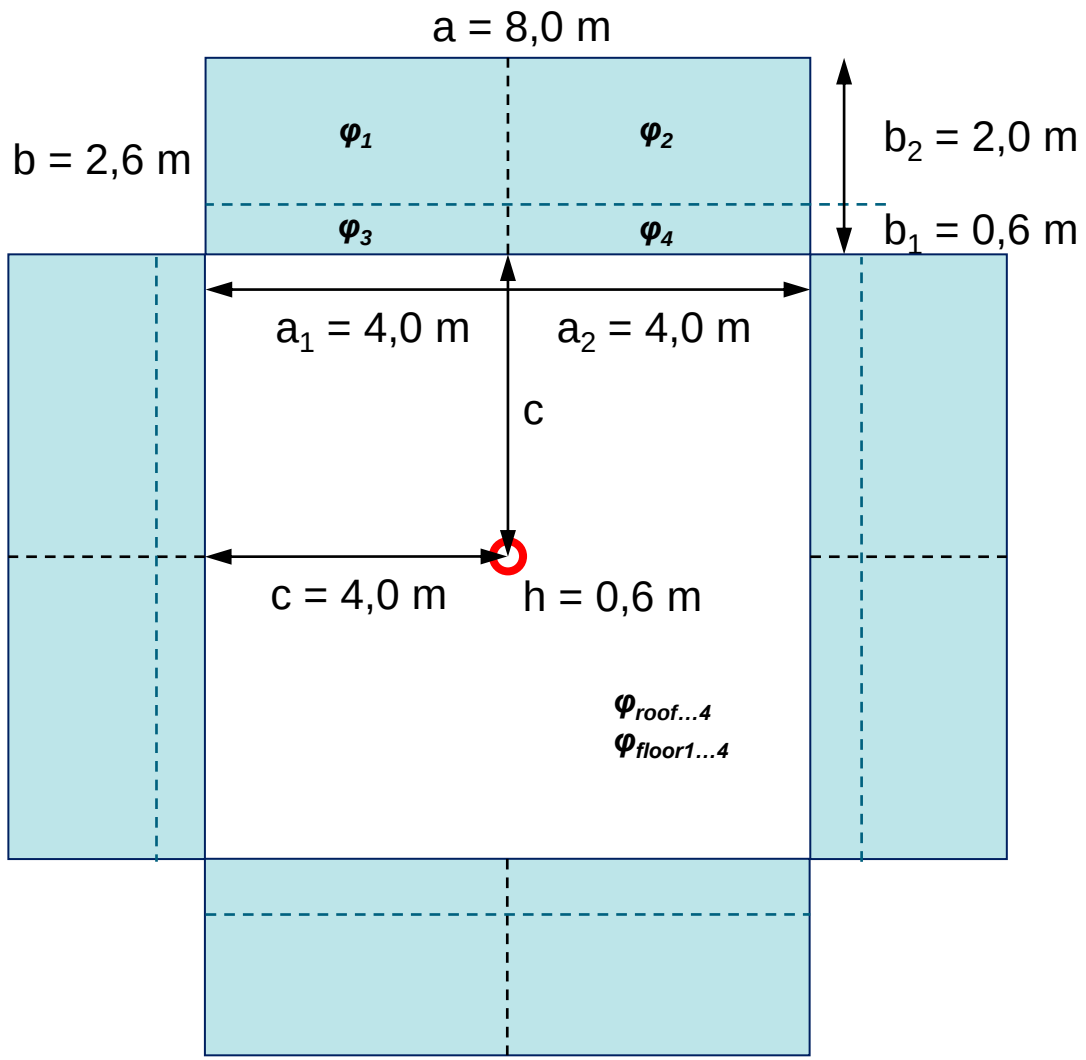
Heat radiation – angular relations





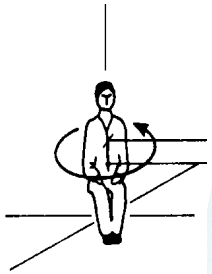
Thermal climate

Heat radiation – angular relations



	Wall		Roof	Floor
	upper	lower		
a	4	4	4	4
b	2	0,6	4	4
c	4	4	2	0,6
a/c	1	1	2	6,67
b/c	0,5	0,15	2	6,67

	Wall		Roof	Floor
	upper	lower		
tab	A.01.06, p. 473		A.01.06, p. 474	
φ	0,026	0,009	0,067	0,113
#	8	8	4	4
$\Sigma\varphi$	8(0,026+0,009)+4·0,067+4·0,113			
	1,0			



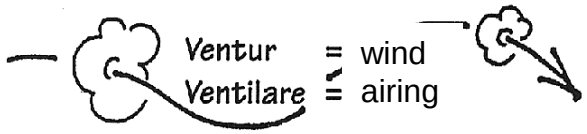
Thermal climate

Heat radiation – surface temperatures

Atmospheric climate

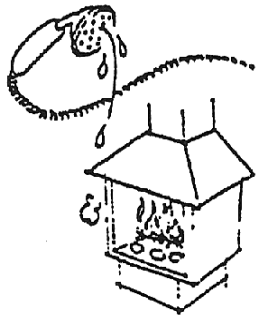
Air quality – ventilation

Why ventilate?



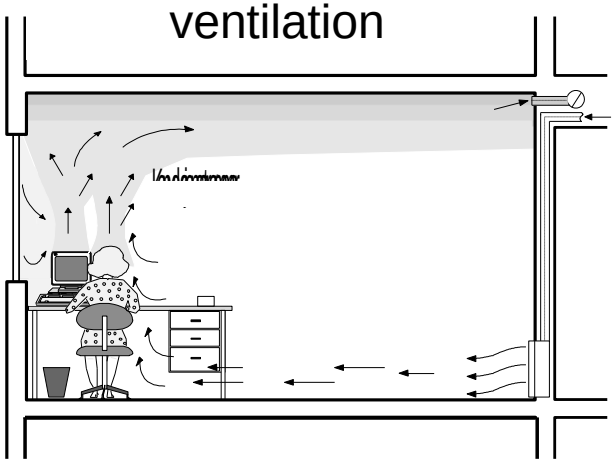
- CO_2

- Emissions

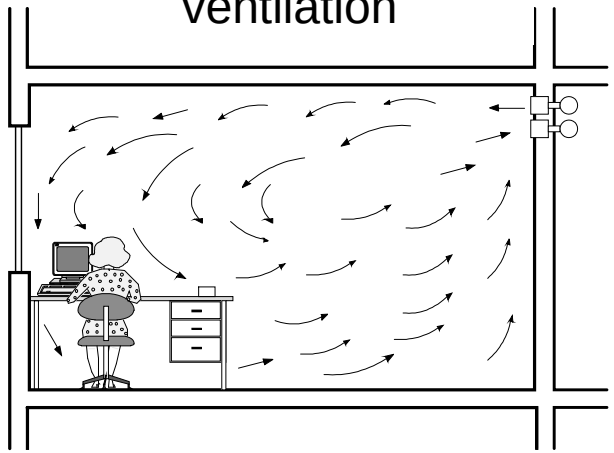


- Moisture
- Heat

Displacement ventilation

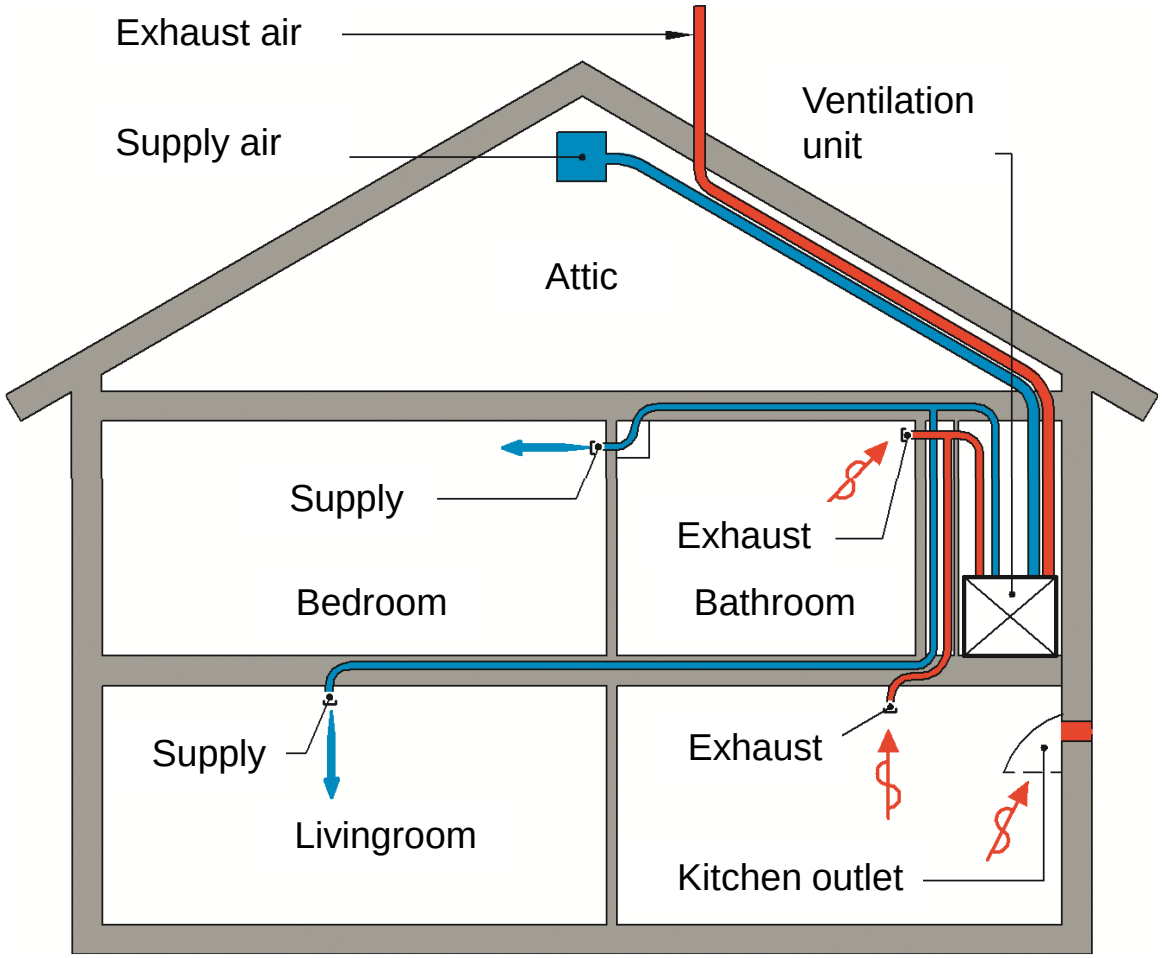


Mixing ventilation

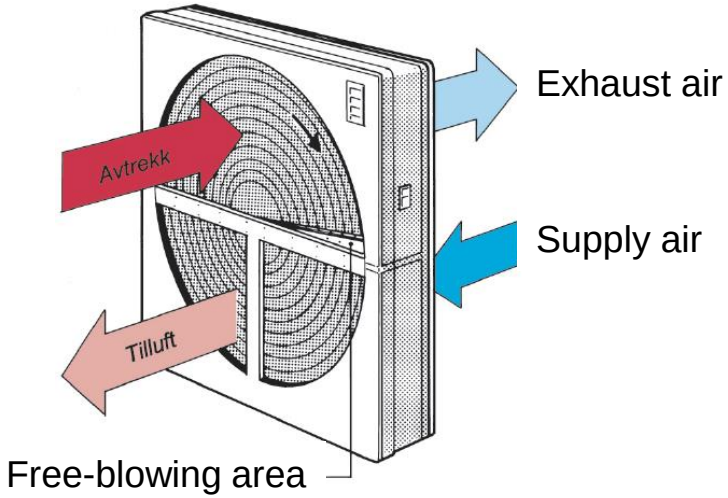


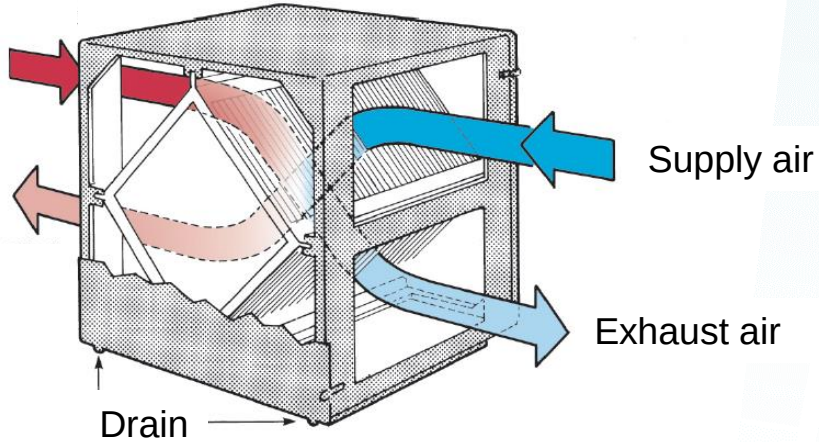
Atmospheric climate

Balanced ventilation in dwellings



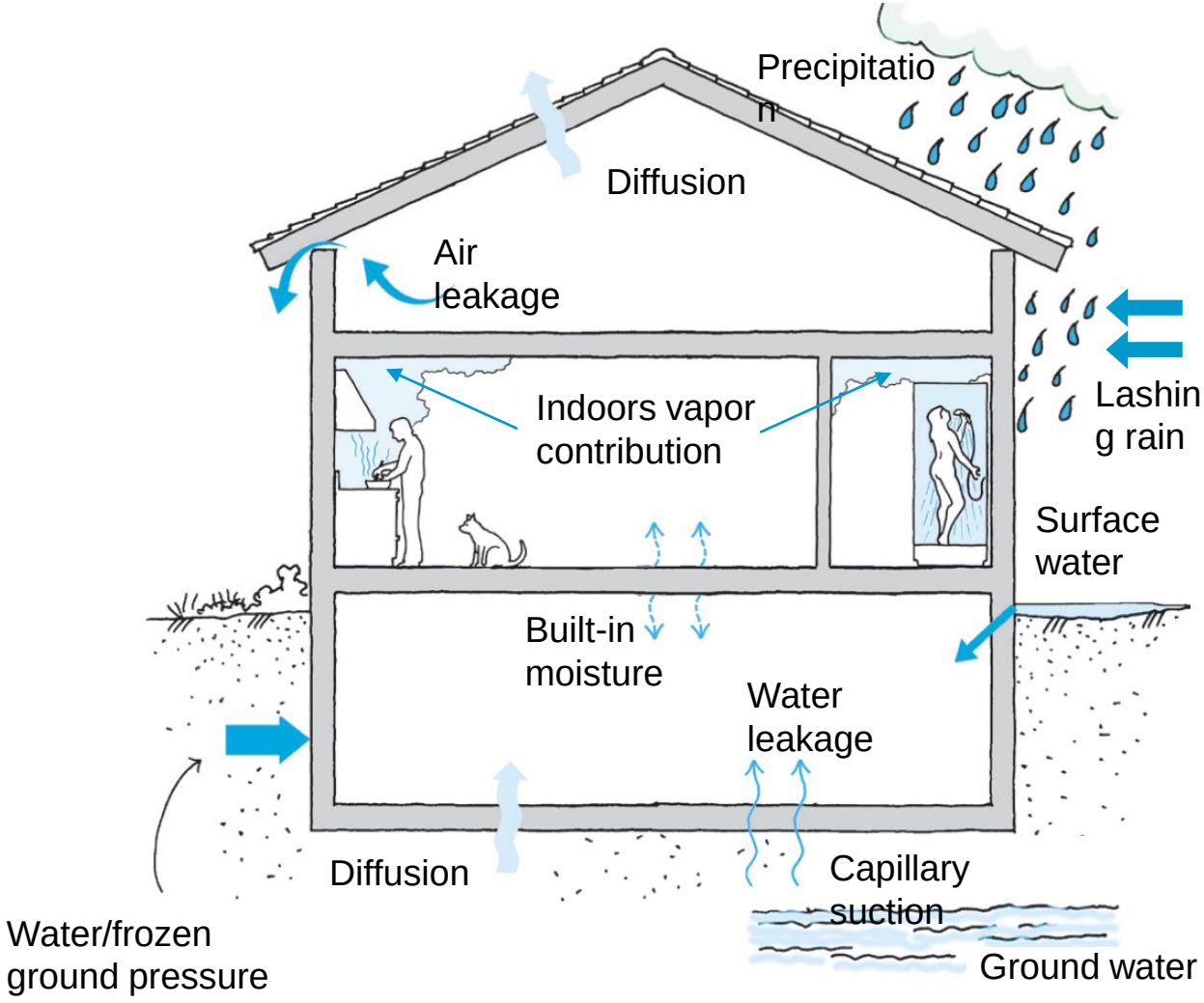
Heat recovery



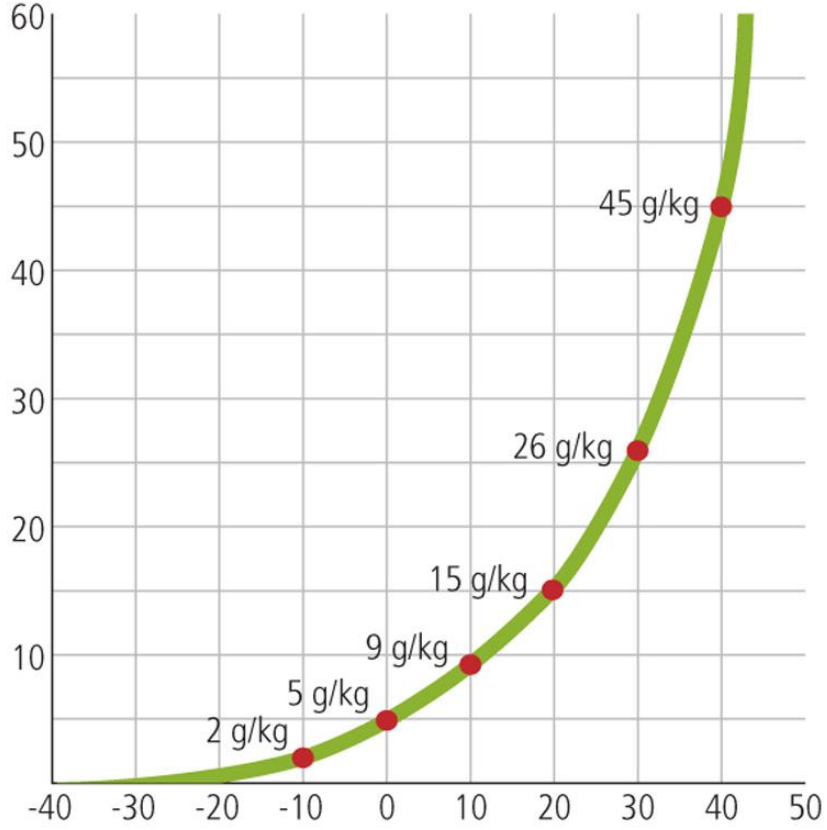


Atmospheric climate

Sources of water and vapour

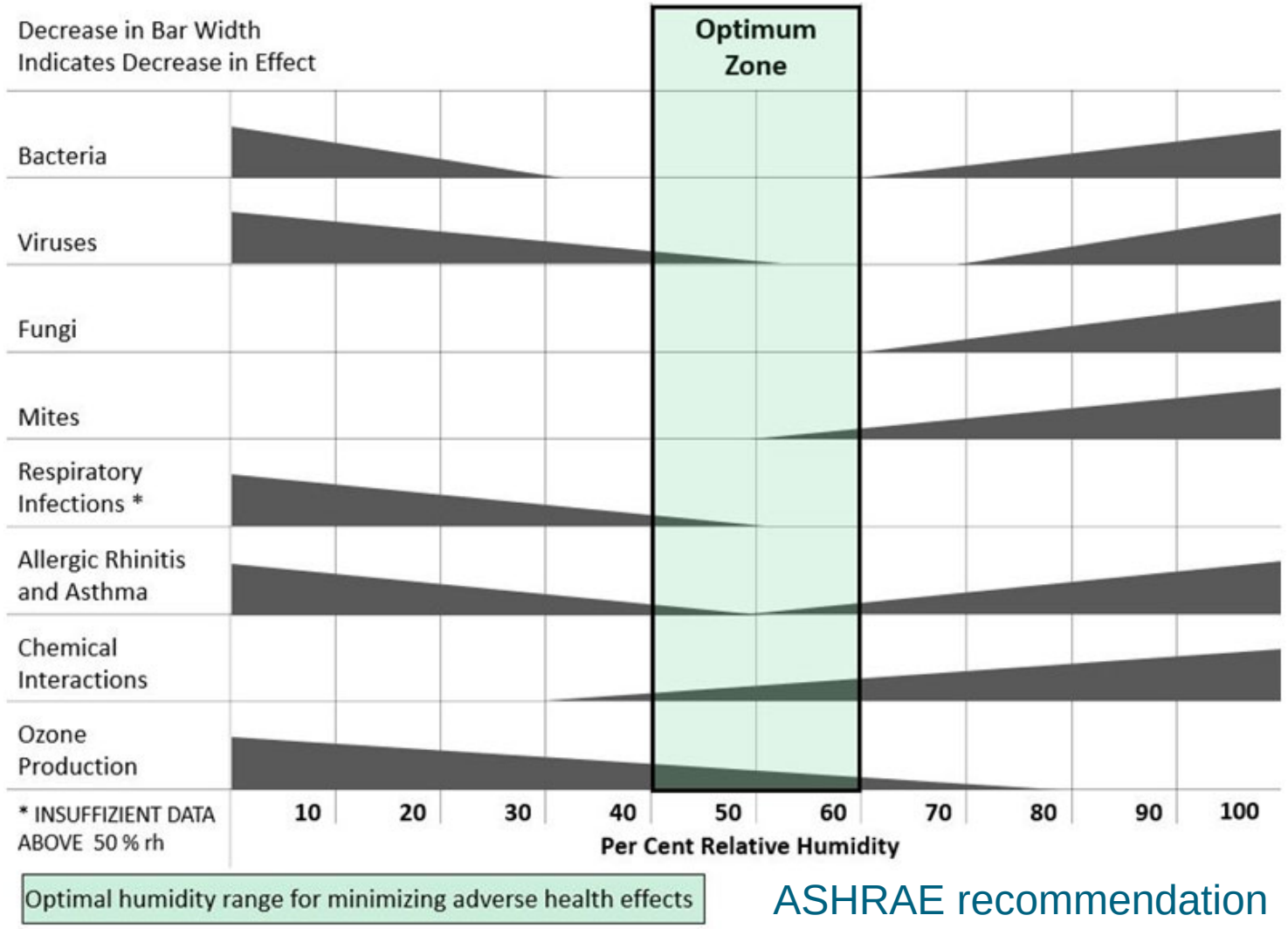


Maximum water content air can hold at various temperatures



Atmospheric climate

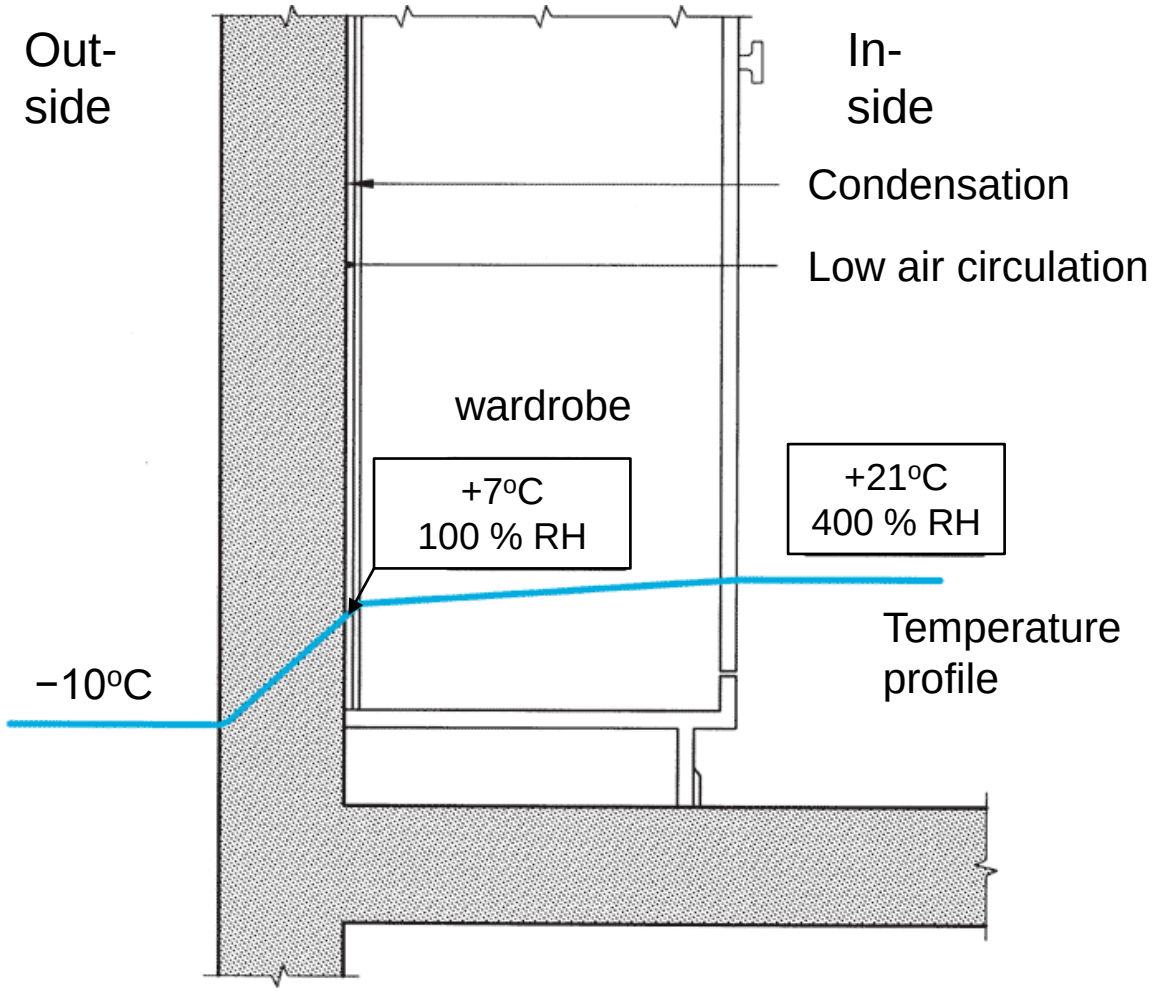
Relative humidity

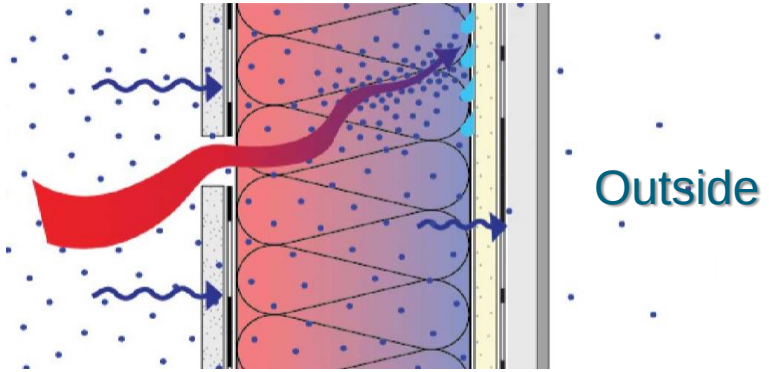


ASHRAE recommendation

Atmospheric climate

Relative humidity – condensation

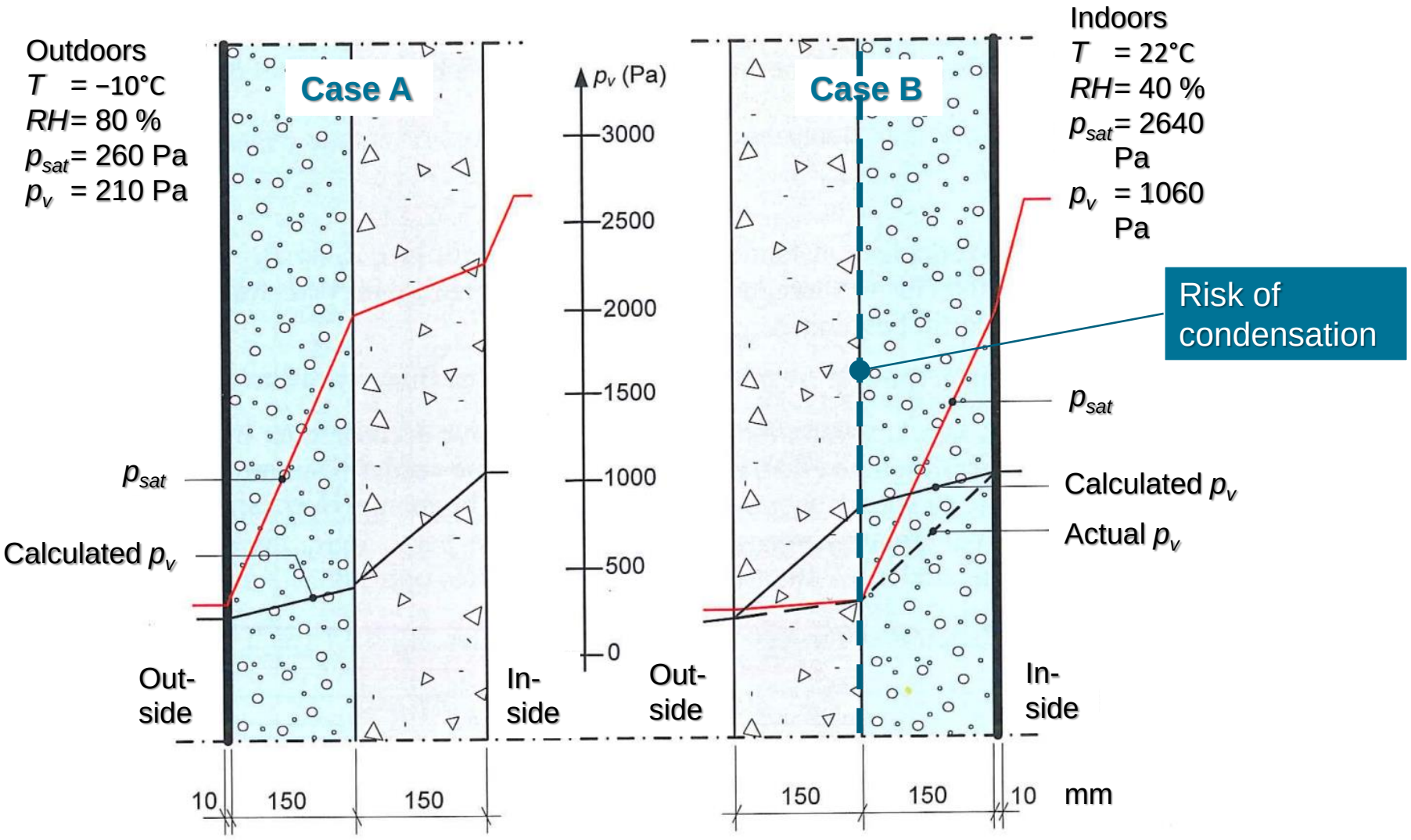




Diffusion through a wall assembly with a discontinuity in the vapor barrier

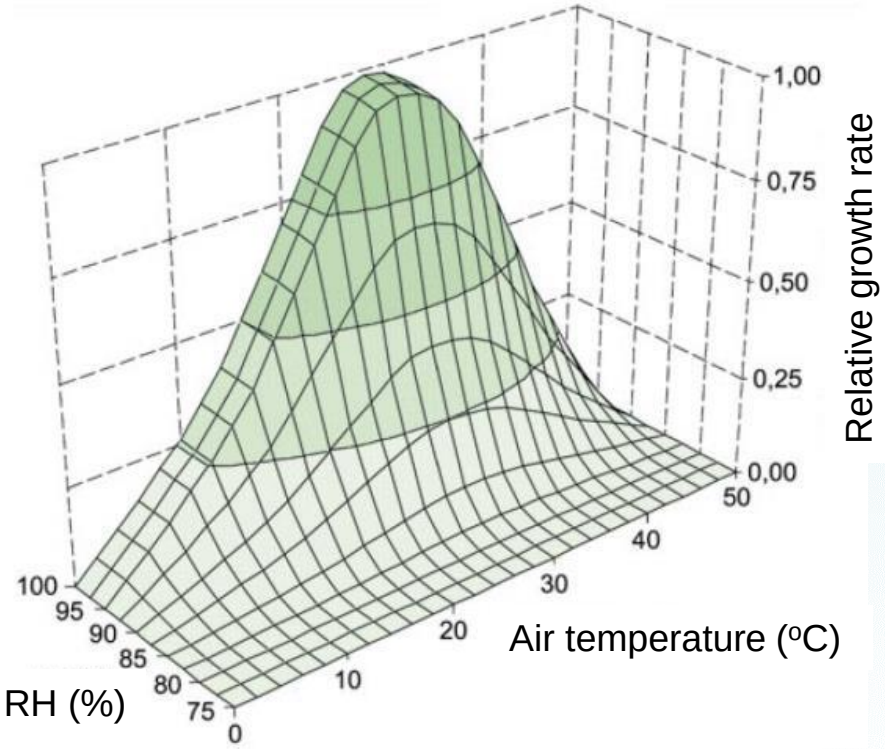
Atmospheric climate

Relative humidity – condensation risk



Atmospheric climate

Relative humidity – mould growth



Thank you for your attention

Photo: Raymond Riise (UiT)