

# Simulation of the indoor climate of livestock buildings: a tool to assess climate change scenarios

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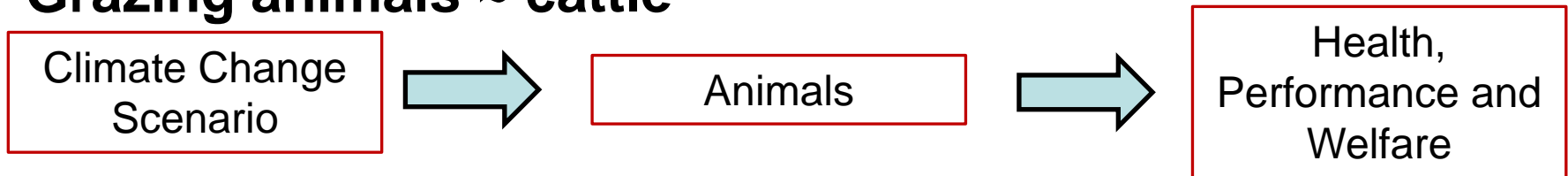


# Objectives

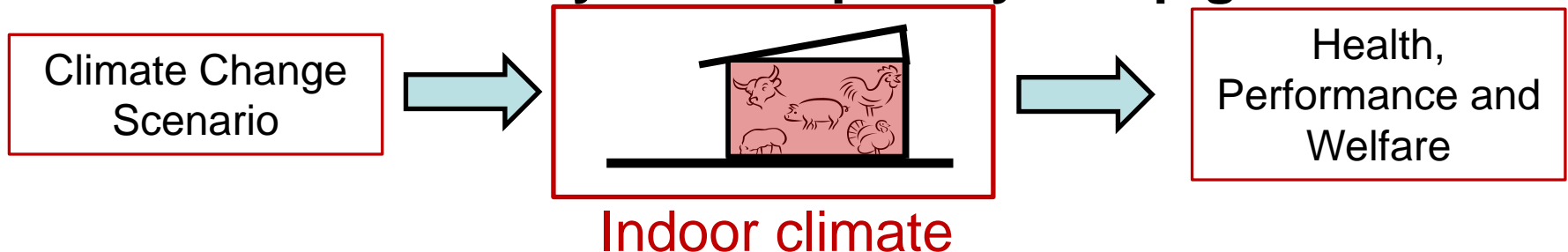
## Background

Impact assessment of climate change scenarios on farm animals in confined livestock buildings

### Grazing animals ~ cattle

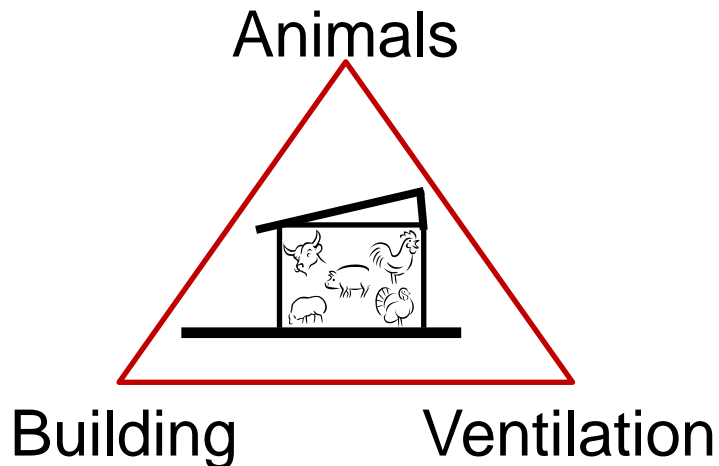


### Confined livestock systems ~ poultry and pig



# Model structure

## Triad



## Balance equations

Sensible heat - Temperature

Latent heat - Humidity

CO<sub>2</sub>

NH<sub>3</sub>

odour

## Temporal resolution

one hour (steady-state)

## Air Treatment

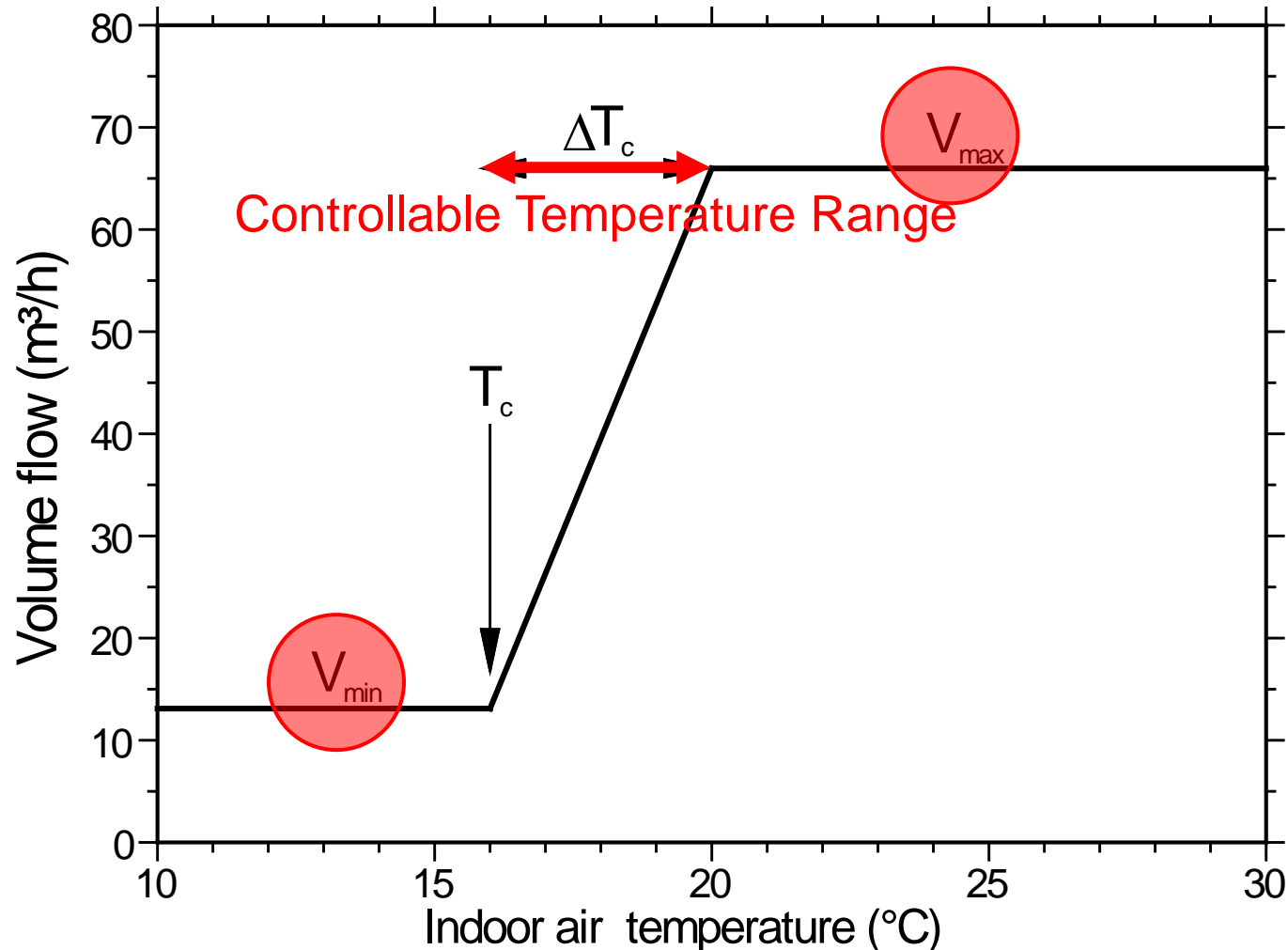
heating, cooling pads, fogging,  
earth tubs, heat exchange

## Limitation

mechanically ventilated building  
no spatial resolution

# Ventilation system

Design parameters ( $V_{\max}$  and  $V_{\min}$ ) and **control unit**

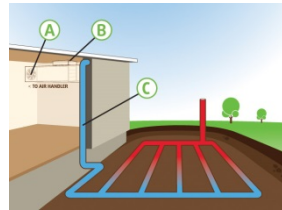


# Air treatment

Heating

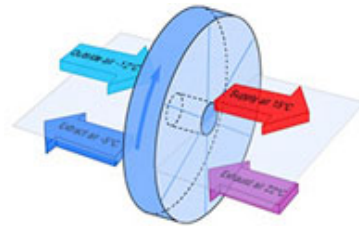


Earth tube systems

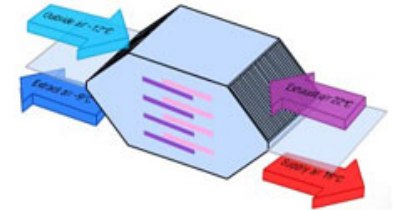


Heat exchanger

regenerative



recuperative



Cooling pads

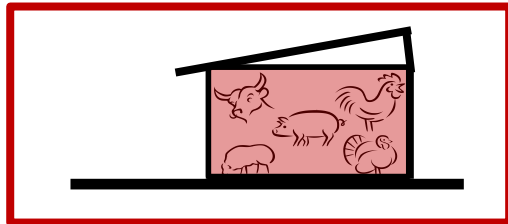
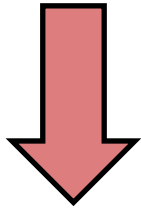


Water fogging systems

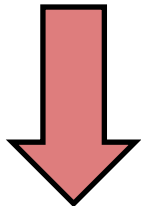


# Application of the model

Meteorological  
data



Indoor climate



Impact on the  
animals

**Reference data** (1985-2010)

**Climate change scenario RCP 4.5**  
(2036-2065)

**Core Module:** Mechanical ventilation

**Air treatment:** cooling pads, fogging, earth  
tube systems, heat exchanger

**Management:** inverted feeding regime,  
animal density

# Output of the simulation

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## Thermal environment

indoor temperature and humidity

condensation

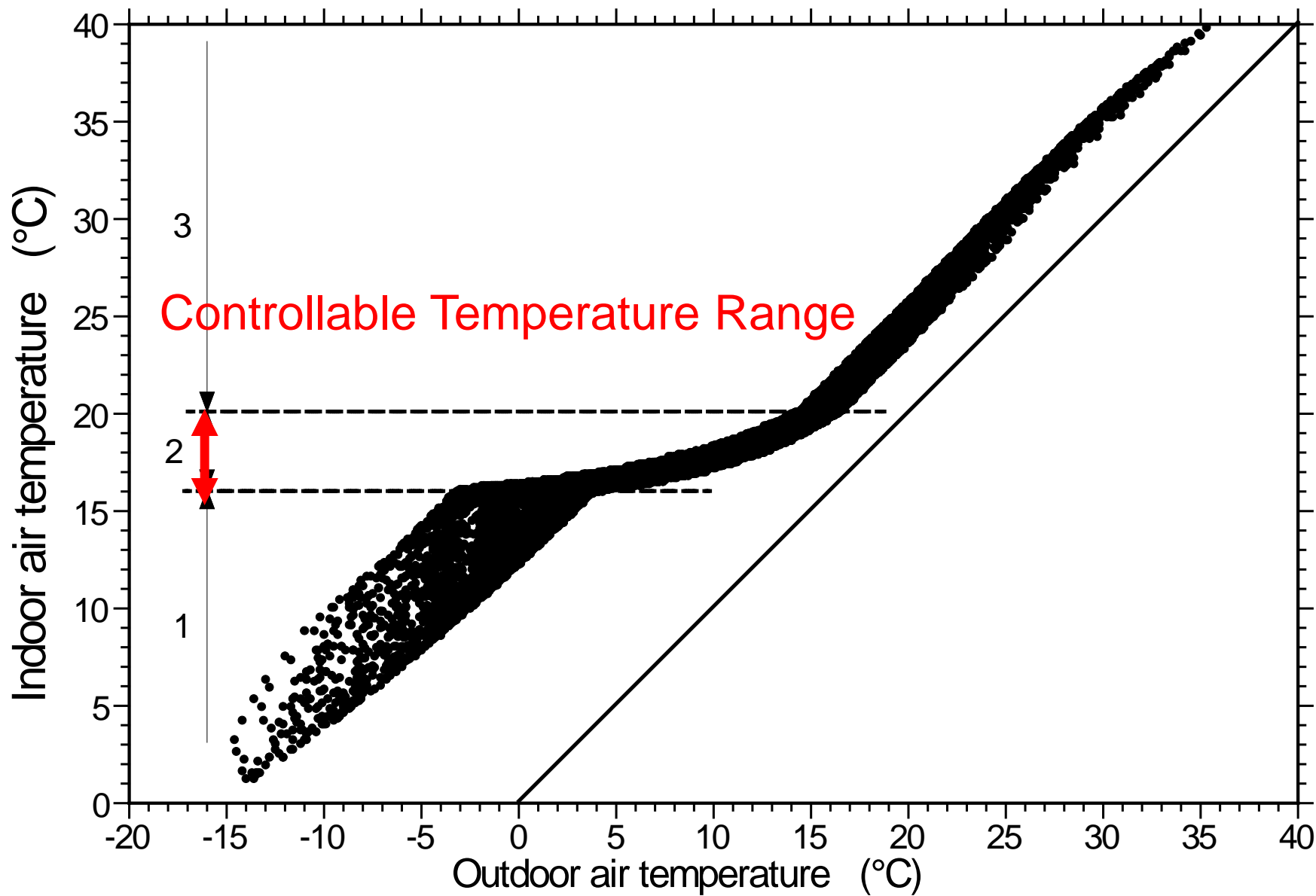
heat stress indices ~ THI

## Indoor air quality = Emission

CO<sub>2</sub> ~ GHG

NH<sub>3</sub> ~ precursor for PM

odour ~ annoyance

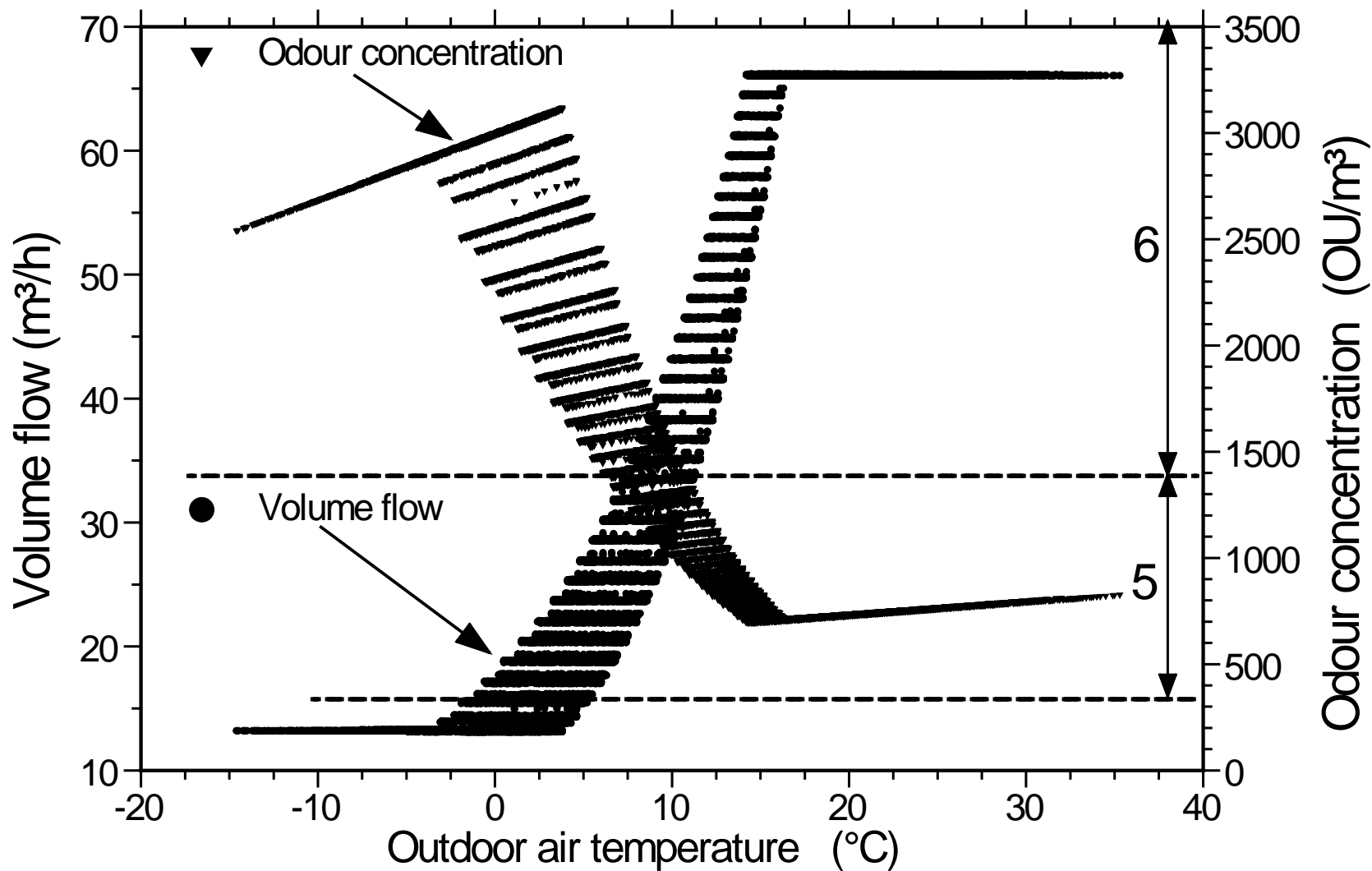


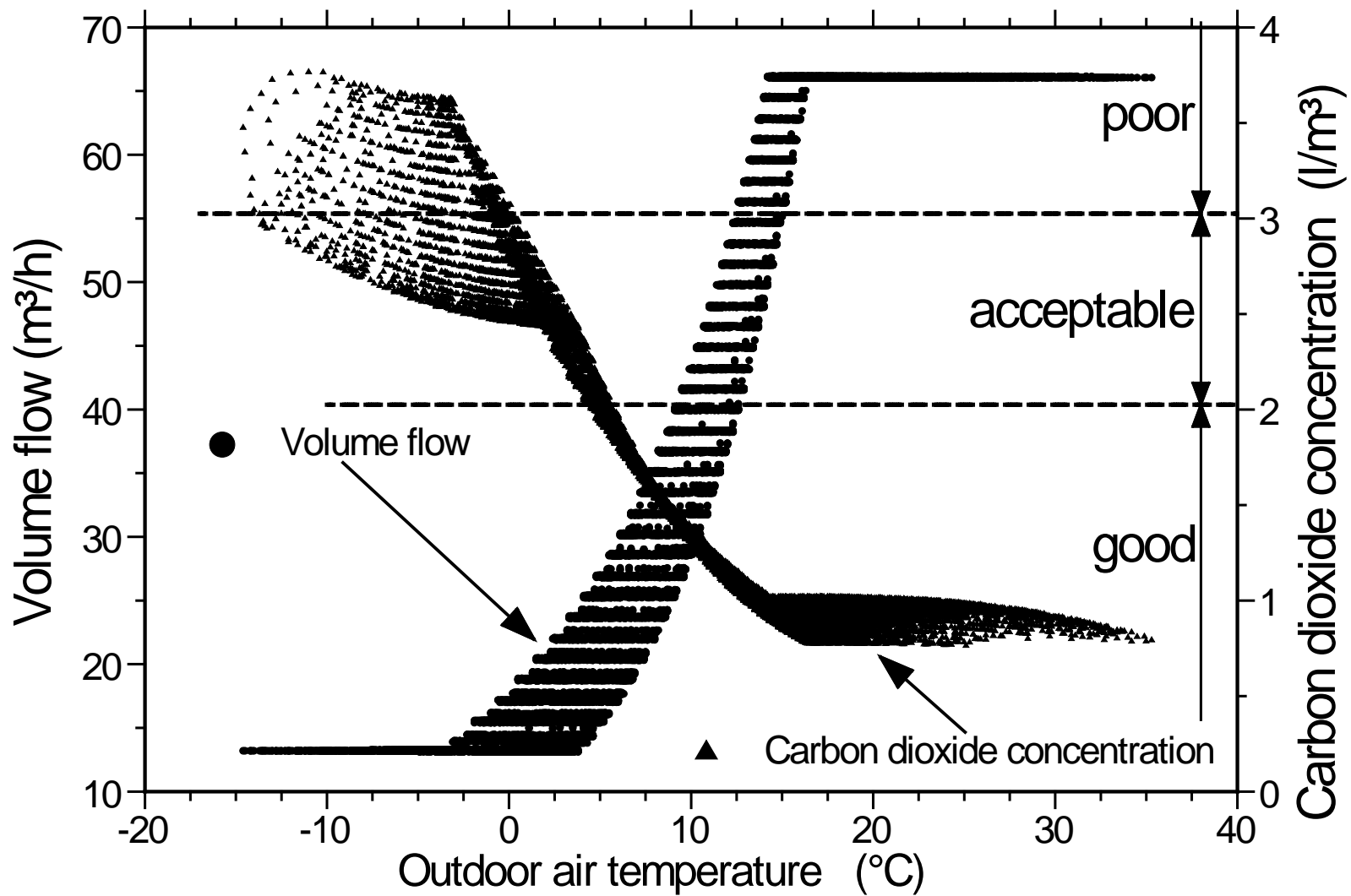


# Thermal indoor climate

Indoor temperature	Relative humidity F (%)			Sum
	< 50	50 - 70	> 70	
<b><math>T_i &gt; 20^\circ\text{C}</math></b>	12.6	10.5	3.9	27.0
<b><math>16^\circ\text{C} \leq T_i \leq 20^\circ\text{C}</math></b>	1.4	16.0	39.0	57.4
<b><math>T_i &lt; 16^\circ\text{C}</math></b>	0	0	16.6	16.6
Sum	14.0	26.5	59.5	100

Optimum





# Impact on animals

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## Holistic indices

THI ~ combination of Temp and rel. Humidity  
exceedance of a threshold for selected parameters

## Performance / welfare / health measures

Daily weight gain

Feed conversion ratio

laying performance, milk production, mortality

? Welfare measures

? Health measures (~ need of medication)

# Model application

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## Climate change: impact on livestock

Business as usual ~ assessment of the resilience  
Adaptation measures ~ cost / benefit  
Vulnerability and adaptive capacity

## Climate change: impact on the environment

CH<sub>4</sub> ~ not relevant for pig and poultry

CO<sub>2</sub> ~ GHG

NH<sub>3</sub> ~ precursor for PM, eutrophication

odour ~ separation distance to avoid annoyance

# Thank you for your attention !

