IMPACT OF VENTILATION ON AMMONIA AND ODOUR EMISSIONS FROM PIG HOUSING

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4th plenary meeting of "European pigmeat reflection group"
September 12th 2022

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PRESENTATION OUTLINE

- Introduction & objectives
- Methodology
- Results & conclusions
- Lessons learned

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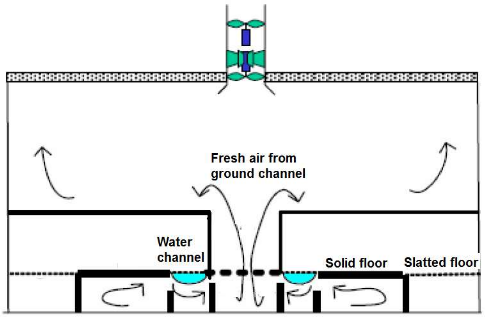
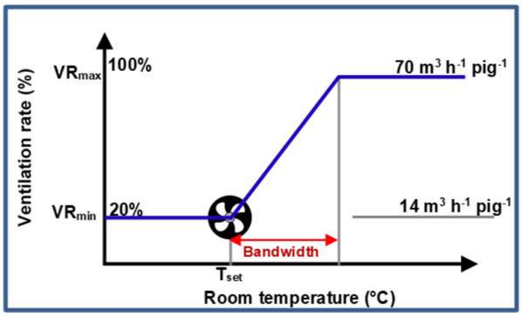
INTRODUCTION: VENTILATION SYSTEM





Bandwidth = 5 °C

Under Floor Air Distribution = UFAD

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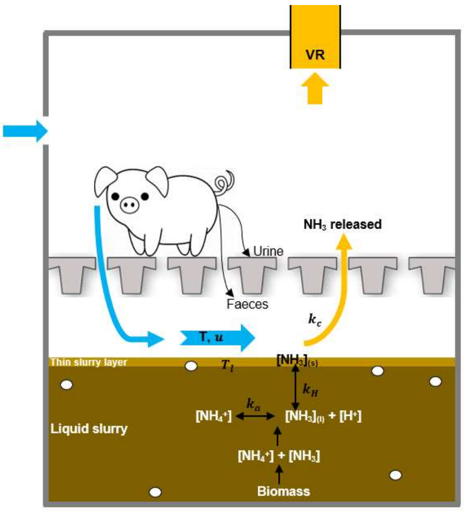
INTRODUCTION: AMMONIA EMISSION



Constant processes with changing dynamics & many influencing parameters

$$NH_3\ release = k_c\left([NH_3]_s - [NH_3]_n\right)$$

Yearlong perspective needed for policy purposes

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INTRODUCTION: EU REGULATIONS

- Implementing EU regulations (NEC, NATURA2000, “Industrial Emissions Directive” 2010/75/EU)
- Odour is permit regulated in Flanders

- Need for emission reduction systems **with proven performance under practice conditions**
- Existing LAES (> 50% emission reduction) are ‘expensive’

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INTRODUCTION: LOW HANGING FRUIT?

- Farmers less familiar with the climate controllers risk poorly tuning.
- Simulations show optimal ventilation control settings (VCS) can reduce NH_3 and odour emissions without additional costs
- Huge methodological challenges

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OBJECTIVES

- Acquire knowledge on the effect of ventilation on NH_3 and odour transport behaviour in pig buildings with UFAD systems.
- Test and optimise VCSs to promote optimal climate, animal production and to reduce emissions in UFAD systems.
- Apply and evaluate the VERA sampling strategy for calculating NH_3 and odour emission reductions from fattening pig buildings.
  https://www.vera-verification.eu/

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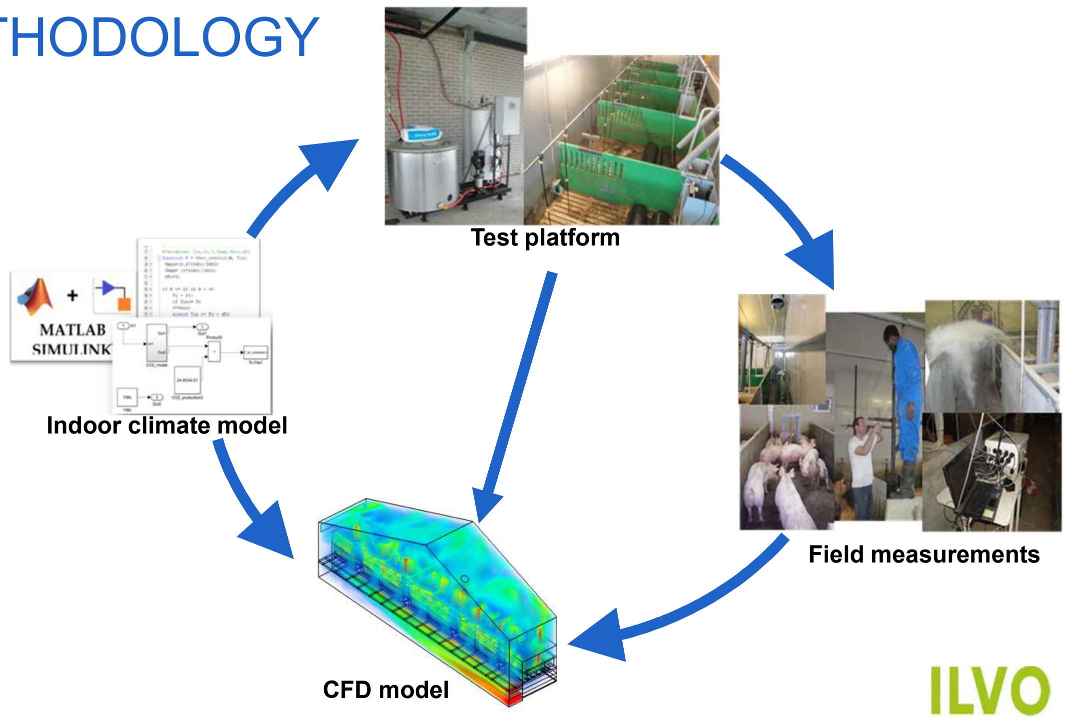
METHODOLOGY



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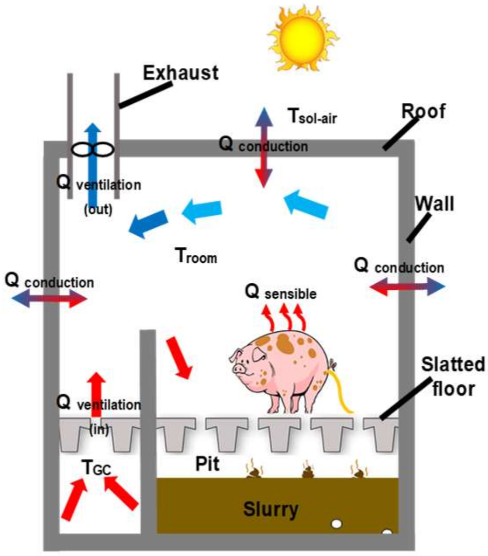
METHODOLOGY: INDOOR CLIMATE MODEL

Steady-state simulation of the impact of ventilation control settings (VCS) on indoor climate

Input:

- **Compartment**
  48 pigs, 6 pigs per pen
  0.83 m² pig^{-1}
- **Weather data**
  2.5 years dataset
  15-minute time step
- **Assumption**
  Perfect air mixing
- **Validation**
  With farm data



Output:

- Ventilation rate (VR)
- Indoor temperature (T_i)
- Relative humidity (RH)
- CO_2

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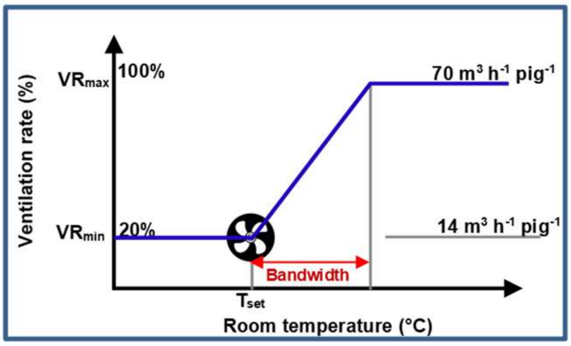
METHODOLOGY: INDOOR CLIMATE MODEL

Promising ventilation control settings



Bandwidth = 5 °C

VCS	T_{set} (°C)	VR_{min} ($m^3\ h^{-1}\ pig^{-1}$)	VR_{max} ($m^3\ h^{-1}\ pig^{-1}$)	V_{phase} (day)
T1	2 °C + T_{CON}	14.0	70.0	0 – 120
T4	T_{CON}	7.0	63.0	0 - 120
T5	24	***3.5***	***56.0***	0 – 28
	23	***7.0***	***59.5***	29 – 48
	22	***10.5***	***63.0***	49- 77
	21	***14.0***	***70.0***	79 - 120

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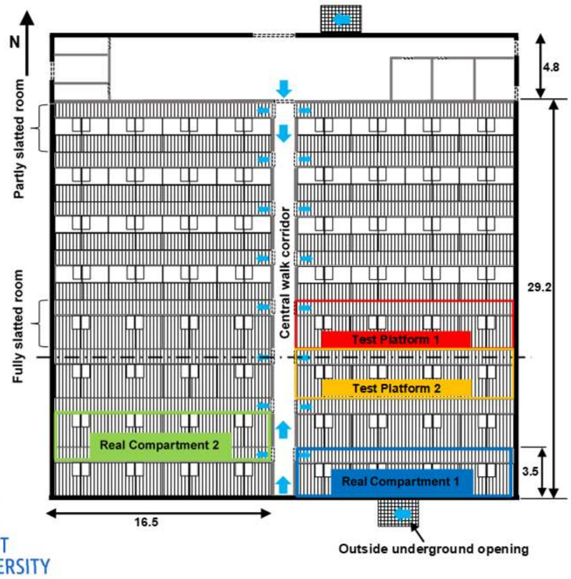
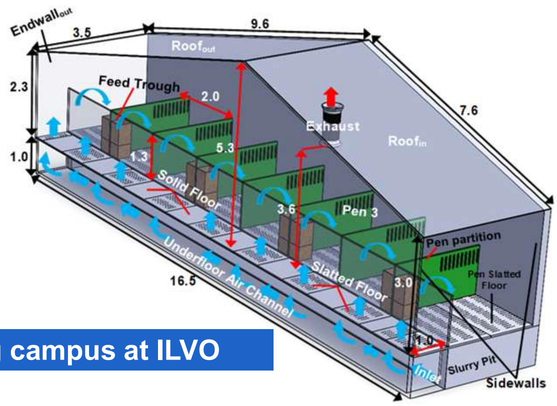
METHODOLOGY: TEST PLATFORM & FIELD SCALE





Pig campus at ILVO

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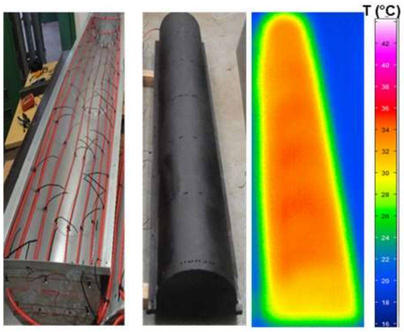
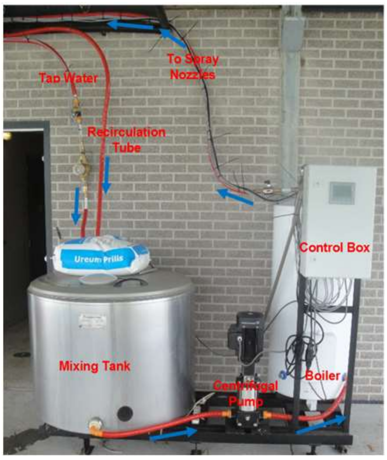
METHODOLOGY: TEST PLATFORM



2.3 kW from mock-up pigs



Urea solution: 0.2 mol L^{-1}
Temperature: 37 °C
Spray frequency: 12 L; 3 h; 0.99 L min^{-1}

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METHODOLOGY: FIELD MEASUREMENTS

- 4 ventilation (CON, T1, T2, T3) regimes in fully-slatted compartments
- 3 fattening rounds (August 2016 – November 2017)
- Duplicate treatments per round (8 compartments)
- NH_3, CO_2, CH_4, N_2O (FTIR) + odour concentrations
- Monitored pig performance

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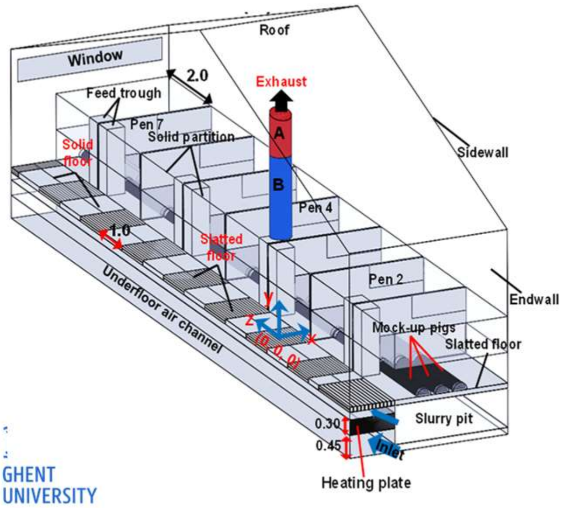
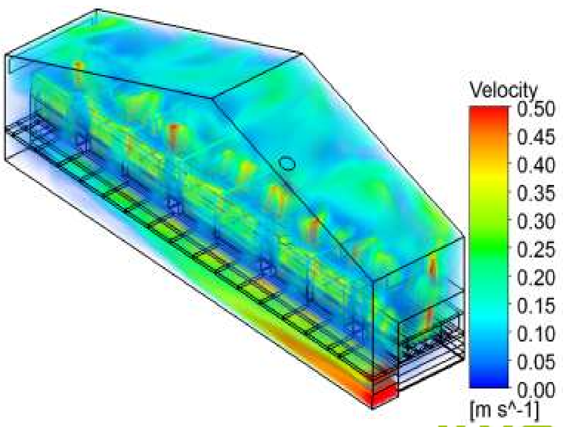
METHODOLOGY: CFD MODEL

Spatial distribution of T, air velocity and NH_3 concentrations





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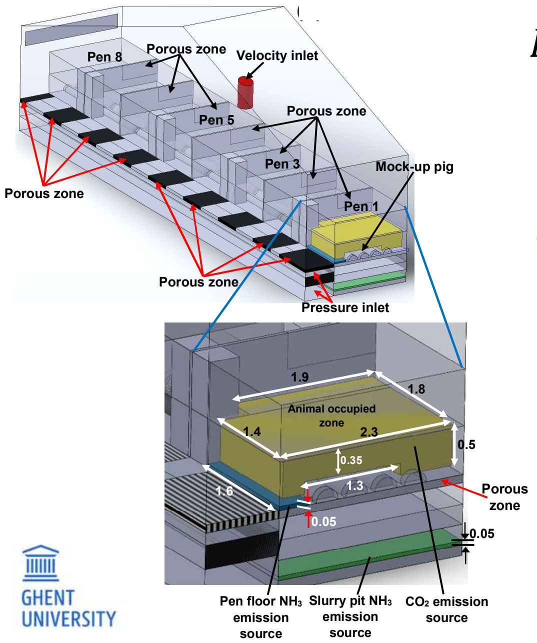
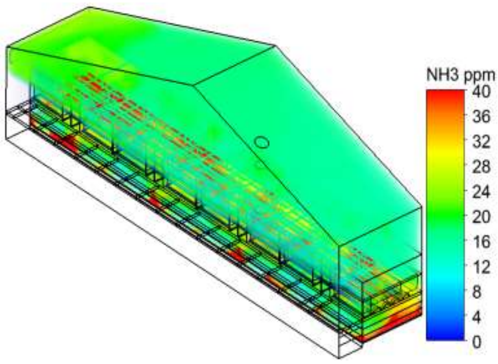
METHODOLOGY: CFD MODEL



$$NH_3\ release = k_c\ ([NH_3]_s - [NH_3]_n)$$

$$NH_3\ release = \frac{k_c \times f \times [TAN]}{H \times 0.05}$$

Spatially extract air velocity & T as NH_3 UDF inputs



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❑ Introduction & objectives

❑ Methodology

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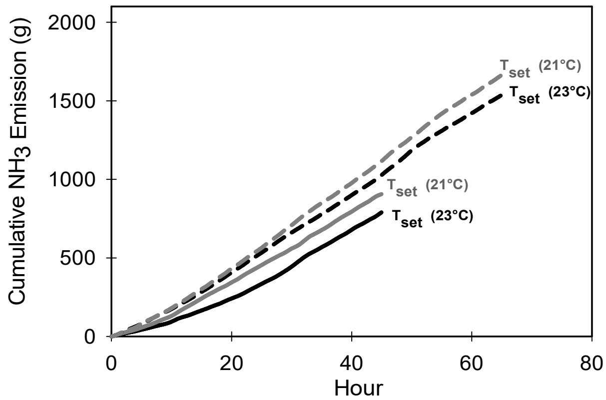
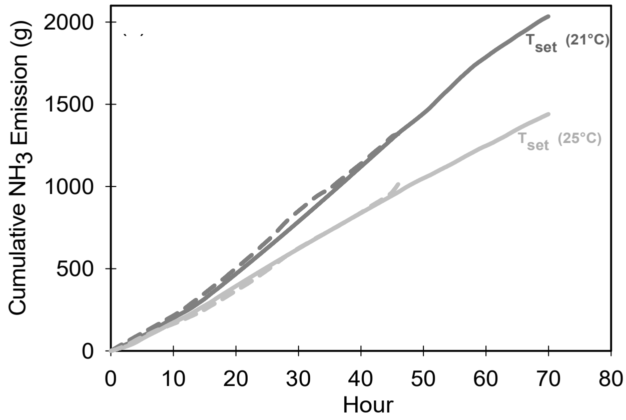
RESULTS

Increasing T_{set} by + 2 °C reduced the NH_3 emission in the test platform.





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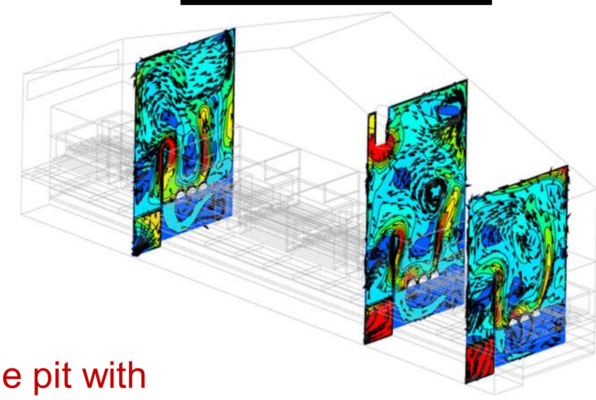
RESULTS

Test Platform

Field measurements

CFD model



Importance of T_{GC}!
Supply air going into the pit with displacement of ammonia

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CONCLUSIONS

- T_{GC} was a key factor affecting NH_3 emissions. It interacted with T_{set} to influence NH_3 emission.
- Increasing the T_{set} by +2 °C (T1) significantly reduced odour emission by 34%.
- All three new VCSs did not substantially reduce the hourly average NH_3 emissions.
- No significant difference in pig rearing performance.
- Calculating annual NH_3 emission based on the VERA protocol showed the potential of T1 to reduce NH_3 emissions by 11% **BUT…**

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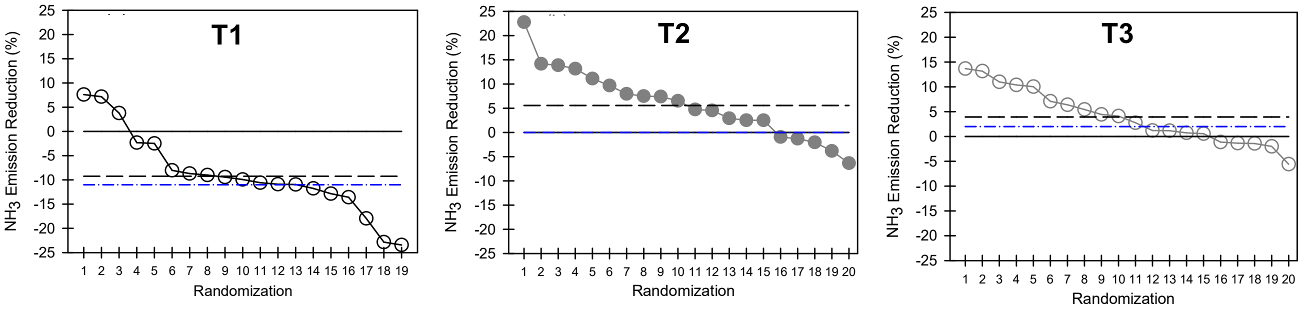
CONCLUSIONS

Large variations in calculated yearly average NH_3 emission reductions based on the VERA test protocol



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LESSONS LEARNED

- Avoid air exchange with manure storage
- Rethink pig building design & manure management (currently going on in The Netherlands: https://www.rvo.nl/subsidies-financiering/innovatie-en-verduurzaming-stallen)

- Power of combined methodology
- Emission measurement strategies should be carefully designed in order to obtain technologies with proven yearlong performance under practice conditions

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Acknowledgments

Funding:
Flanders Innovation & Entrepreneurship (VLAIO LA).

PhD Promotors:
Prof. dr. ir. Bart Sonck, UGent & ILVO
Dr. ir. Peter Demeyer, ILVO
Prof. dr. ir. Michel De Paepe, UGent
Prof. dr. ir. Jan Vierendeels, UGent (†)

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