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Reducing slurry temperature to lower NH_3, N_2O and CH_4 emissions from pig fattening housing

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A study of the TEMPORALIS project supported by the French ecological transition Agency (ADEME)

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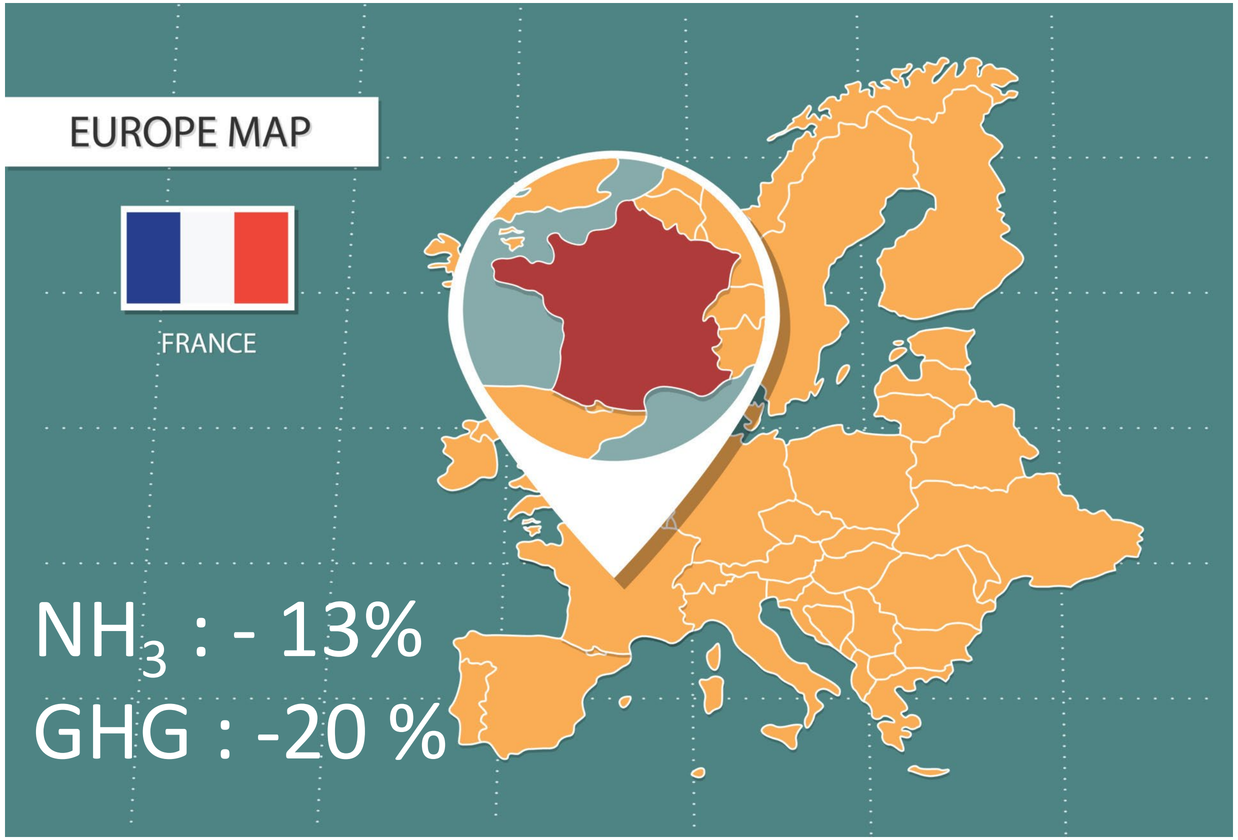
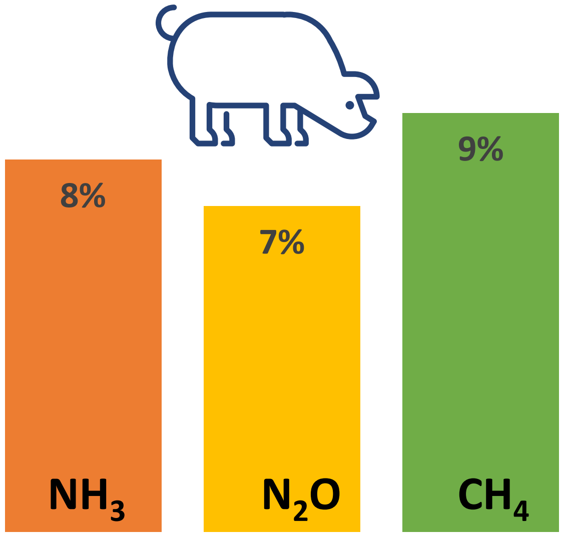
Context



France's committements



(Citepa, 2022)

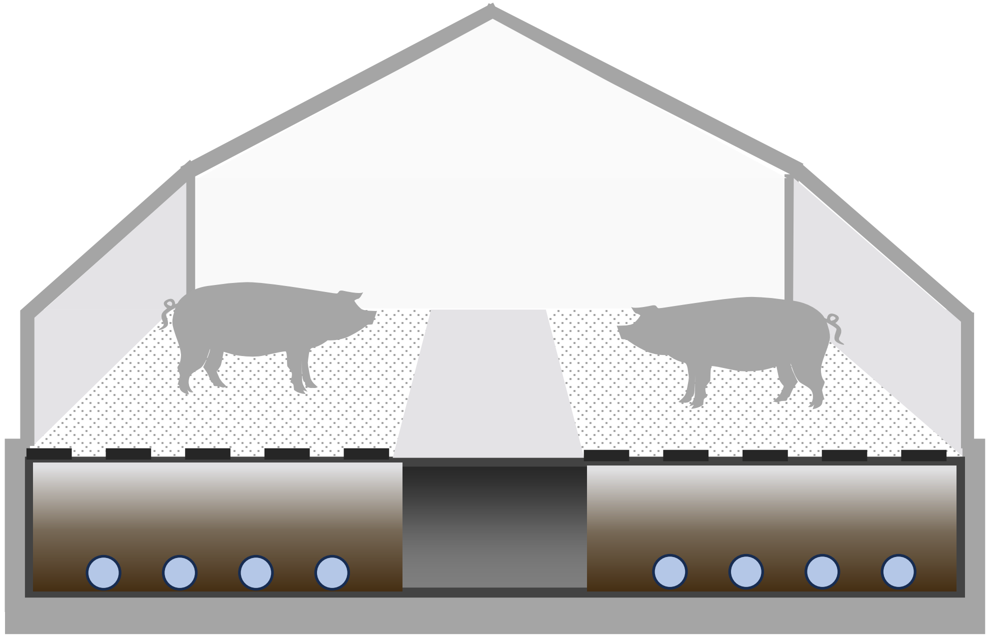
Contribution of the pig sector

IMPLEMENTATION OF TECHNIQUES FOR THE REDUCTION OF GASEOUS EMISSIONS

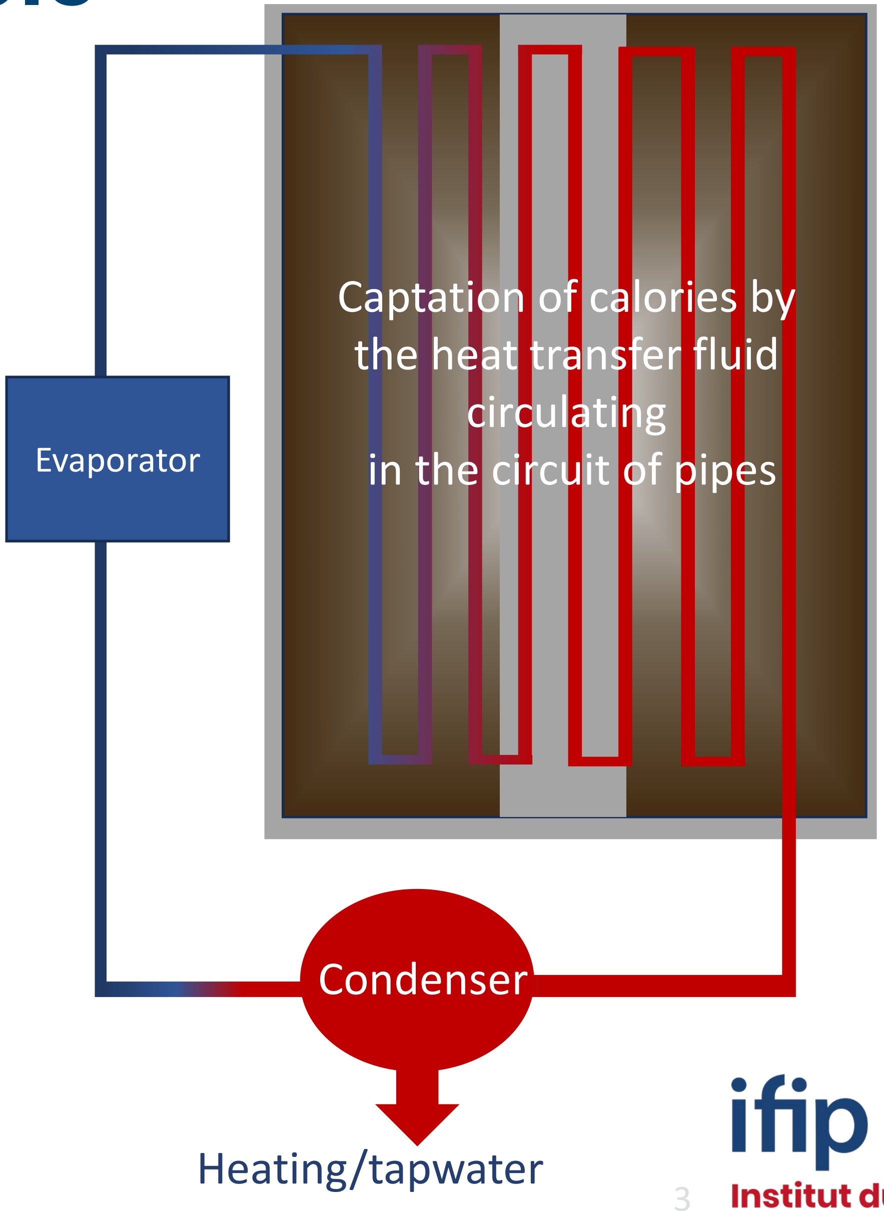
? Effectiveness, applicability

Manure cooling – the principle

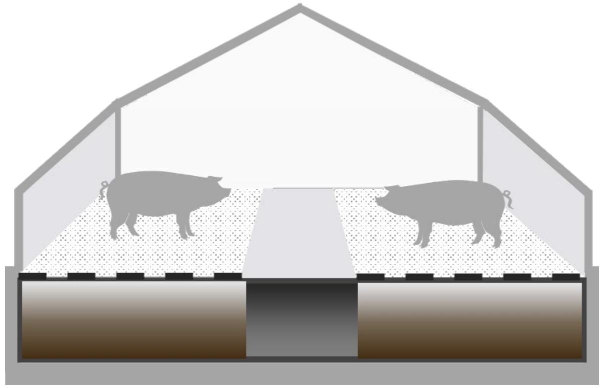
Reduction of the slurry temperature by captation of calories



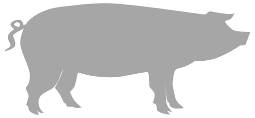
Circuit of pipes installed in the prepit



Experimental design



Reference room

54 

30 to 118 kg

Fully slatted floor

Slurry storage

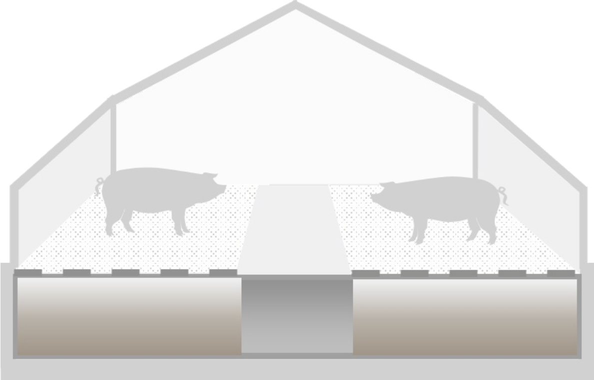
Diffuse ceiling and under-floor extraction

Conventional setpoint temperature (22°C)

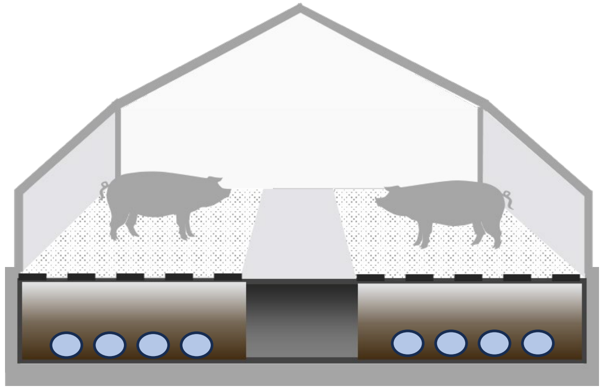
Multiphase dietary strategy

Experimental design

- 30- meter circuit of pipes
- Fixed directly on the pit bottom
- Filled with a heat transfer fluid (33% glycol)
- 20 W.m^{-2}



Reference room



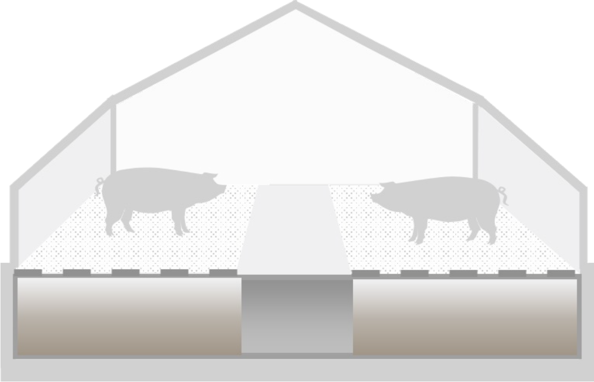
MCS**PB** room

MCS**PB** : Manure Cooling System – **Pit Bottom**

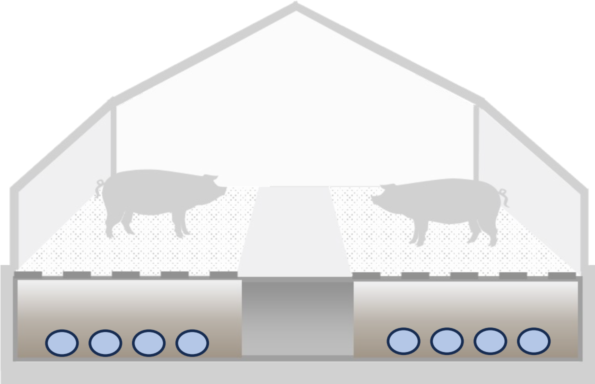
Experimental design

2 consecutive batches between May to December

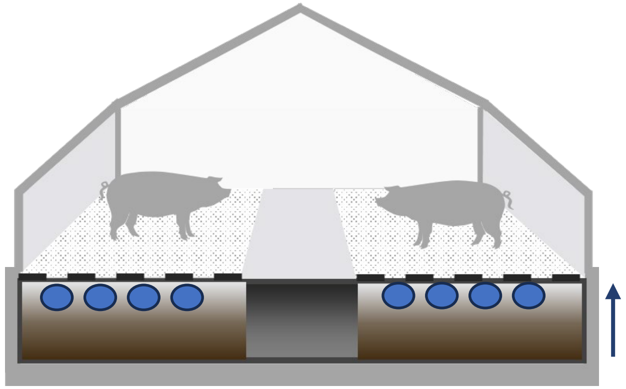
Raft floating on the surface of the slurry



Reference room



MCS**PB** room



MCS**F** room

Same technical design than MCS**PB**

MCSFS : Manure Cooling System – **F**loating **S**ystem

Measurements and recordings

PIG WEIGHING
Entry, feed transition and slaughter + carcass data

FEED WEIGHING
Every day

Zootechnical aspect

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Measurements and recordings

PIG WEIGHING
Entry, feed transition and slaughter + carcass data

FEED WEIGHING
Every day

Environmental aspect

SLURRY
Height every 2 weeks -> volume
Sampling : feed transition + slaughter

GAS (NH_3, N_2O, CH_4)
Ambient air - Every 3 minutes

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Measurements and recordings

PIG WEIGHING
Entry, feeding transition and slaughter+ carcass data

FEEDING WEIGHING
Every day

Ambience

SLURRY
Height every two weeks -> volume
Sampling : feed transition + slaughter

GAS (NH_3, N_2O, CH_4)
Ambient air – every 3 minutes

TEMPERATURE (Ambience and Slurry)
VENTILATION RATE
Every 15 minutes

Results – zootechnical performance

	Reference	Pit Bottom	Floating System	National Value
ADG $g.d^{-1}$	917±186 b	954±103 a	932±91 ab	803
FCR $kg.kg^{-1}$	2,56±0,2 a	2,50±0,1 a	2,50±0,1 a	2,75
Meat lean	60,9±2,2 a	61,3±2,0 a	60,9±1,9 a	60,7

(a,b) : Values accompanied by different letters on the same line indicate a statistically significant difference at the 5% level

Ambience – Temperature in the air

Average values expressed in °C

Air

26,5±1,9 (a)	25,7±2,2 (b)	26,5±2,0 (a)
25,0±0,8 (a)	23,9±1,1 (b)	25,2±1,0 (a)

Set point temperature 22°C

► Reduction of the ambient temperature for the MCS**PB** room

(a,b) : Values accompanied by different letters on the same line indicate a statistically significant difference at the 5% level

Ambience – Temperature of the slurry

Average values expressed in °C

Measures taken at the botton of the pit

Slurry

23,7±0,8 (a)	15,8±2,3 (c)	18,1±1,6 (b)
22,5±0,6 (a)	16,1±3,8 (c)	16,7±2,3 (b)

Impact of ambient temperature on slurry (Guyot et al., 2022 – Guingand et al., 2024)

Good efficiency of both MCS

(a,b) : Values accompanied by different letters on the same line indicate a statistically significant difference at the 5% level

Environmental aspect – NH_3

Average values expressed in kg $N\_NH_3.place^{-1}.year^{-1}$

2,3±1,3	2,0±1,4	2,4±1,4
2,2±1,3	1,9±1,4	2,2±1,3

2,5 – 3

Guingand et Courboulay, 2019
Philippe *et al.*, 2011
Santonia *et al.*, 2017

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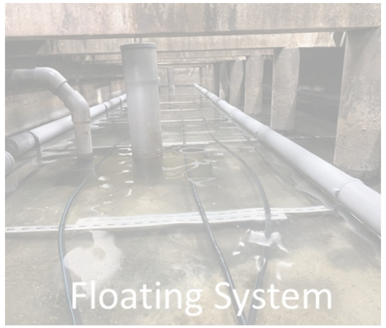
Environmental aspect – NH_3

Average values expressed in kg $N\_NH_3.place^{-1}.year^{-1}$



	Reference	Pit Bottom	Floating System
☀	2,3±1,3	2,0±1,4	2,4±1,4
❄	2,2±1,3	1,9±1,4	2,2±1,3

Reduction lower than 20%
for the « Pit Bottom » System

Environmental aspect – NH_3

Average values expressed in kg $N\_NH_3.place^{-1}.year^{-1}$

☀	2,3±1,3	2,0±1,4	2,4±1,4
❄	2,2±1,3	1,9±1,4	2,2±1,3

No effect of the « Floating System »

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Environmental aspect – NH_3

Average values expressed in kg $N\_NH_3.place^{-1}.year^{-1}$

	2,3±1,3	2,0±1,4	2,4±1,4
	2,2±1,3	1,9±1,4	2,2±1,3

Hansen *et al.*, 2013 : relation between installed cooling capacity and ammonia reduction : 10 % per 10 W/m^2

► In our study : 20 W/m^2 –> 20 % - close to our result

Holm *et al.*, 2016 : Reduction (%) =1,5 x – 0,008x2 with x = Cooling capacity in W/m^2

► In our study : with 20W/m^2 -> 26,8% - higher than our result

Environmental aspect – N_2O

Average values expressed in kg $N\_N_2O.place^{-1}.year^{-1}$

	Reference	Pit Bottom	Floating System
	0,08±0,02	0,08±0,02	0,09±0,02
	0,08±0,01	0,08±0,01	0,08±0,02

0,10 – 0,25

Philippe *et al.*, 2015

IPCC, 2019

No effect of both MCS

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Environmental aspect – CH_4

Average values expressed in kg C_CH_4.place^{-1}.year^{-1}

	Reference	Pit Bottom	Floating System
	**8,5±0,1**	**2,2±0,1**	**3,4±0,2**
	**4,5±0,2**	**1,4±0,3**	**2,0±0,5**

2– 5

Philippe *et al.*, 2011
IPCC, 2019

Environmental aspect – CH_4

Average values expressed in kg C_CH_4.place^{-1}.year^{-1}

	Reference	Pit Bottom	Floating System
Summer	8,3±0,1	2,2±0,1	3,4±0,2
Winter	4,5±0,2	1,4±0,3	2,0±0,5

High efficiency of the Pit Bottom System (70%)

Environmental aspect – CH_4

Average values expressed in kg $C\_CH_4.place^{-1}.year^{-1}$

8,5±0,1	2,2±0,1	3,4±0,2
4,5±0,2	1,4±0,3	2,0±0,5

High efficiency of the Floating System (55%)

Environmental aspect – CH_4

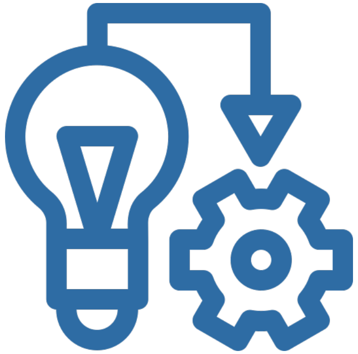
Average values expressed in kg $C\_CH_4.place^{-1}.year^{-1}$

8,5±0,1	2,2±0,1	3,4±0,2
4,5±0,2	1,4±0,3	2,0±0,5

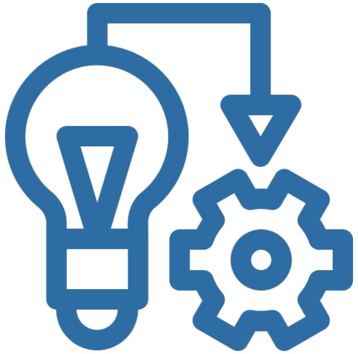
Reduction of the activity of methanogenic bacteria in the cold slurry

Conclusions

Efficiency lower than expected on NH_3…



20 W/m²



40 W/m²

Lower temperature
on the area between slurry
and slatted floor

Degradation
of animal welfare

Consequences on
performance?

Conclusions

Efficiency lower than expected on NH_3…

… but higher than expected on CH_4

High interest in term of National Low-Carbon Strategy

Increased profit through energy recovery from slurry (not yet analyzed)

Implantation in existing building can be difficult (volume of the pit for the MCS**PB** – adaptation for the MCS**F**)

Expensive technique although the save of energy

Conclusions

The MCS**PB** is easier to implement than the MCS**F**

Especially in new buildings

Maintenance of the technique

Evolution of circuit porosity ? Risk of leaks ?.....

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Thanks for your attention !

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TEMPORALIS *

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