Challenges and vision for climate care cattle farming from a system's perspective

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Thanks to many co-authors' contributions

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Waste management next level

- Environmental challenges (focus the Netherlands)
- Current waste management
- Trade-offs, pollution swapping and side-effects
- Design challenge in sustainable waste management
- Integrated solution and modelling results
- Concluding remarks

The Netherlands (NL) in numbers

250 * 350 km

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The socio-spatial challenge

farming in the backyard of 18M people

	Canada	USA	NL
Cattle (10^6) 	15	96	3.8
Pigs (10^6) 	15	61	11
Poultry (10^6) 	167	2 045	88
People (10^6)	33.5	307.2	16.7
Area (10^6 km^2)	9.98	9.63	0.04
People density (km^{-2})	3.4	31.9	418
Poultry density (km^{-2})	16.7	212.4	2200

- Metropolitan agriculture
- Dutch export: >70% of production to NW Europe

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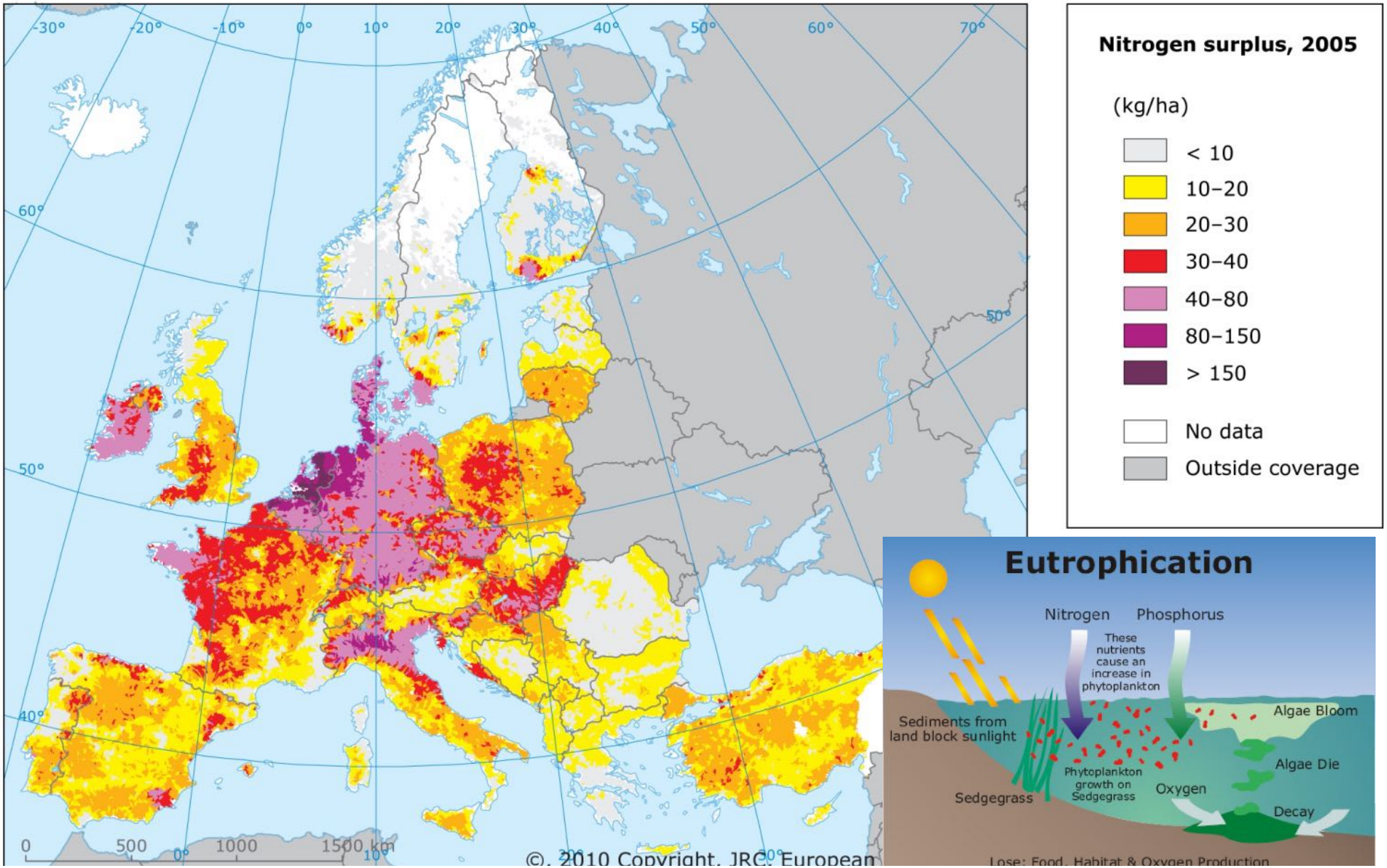
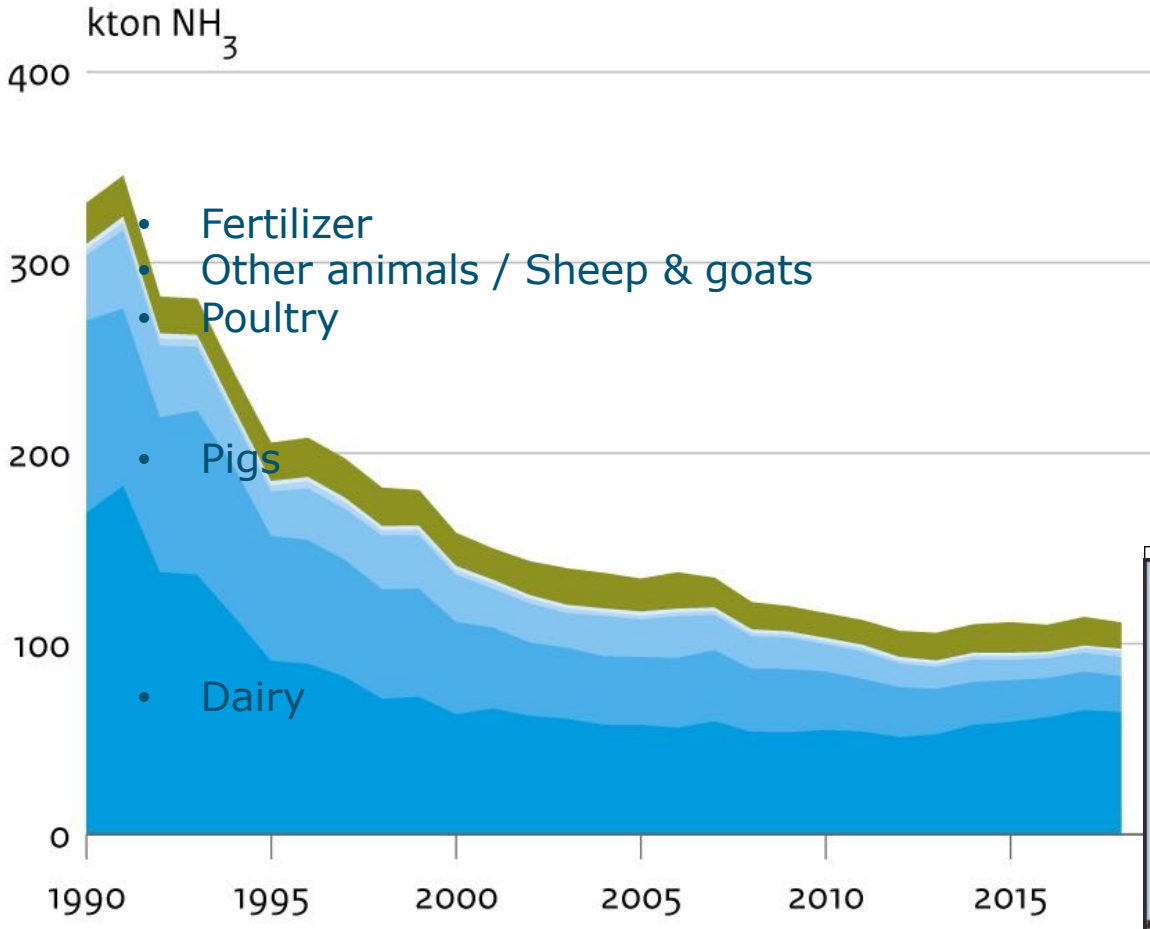
The nitrogen challenge

surplus of N and P



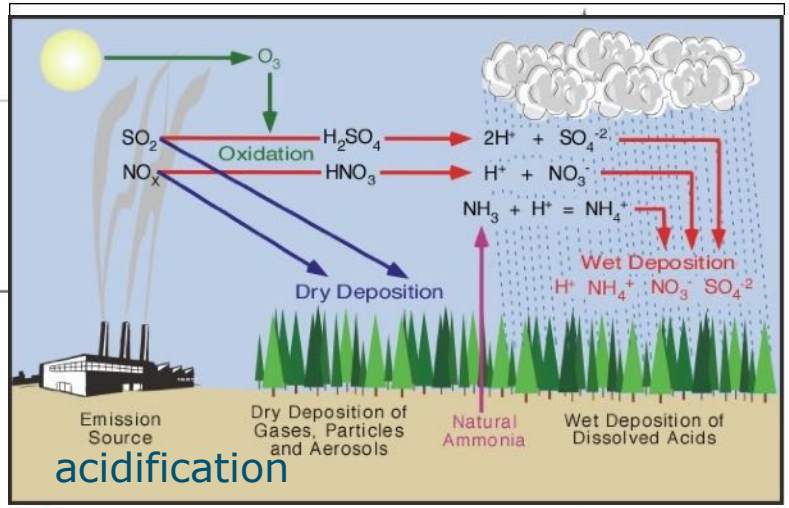
The ammonia challenge

dairy largest contributor, decrease stopped



Bron: RIVM/Emissieregistratie

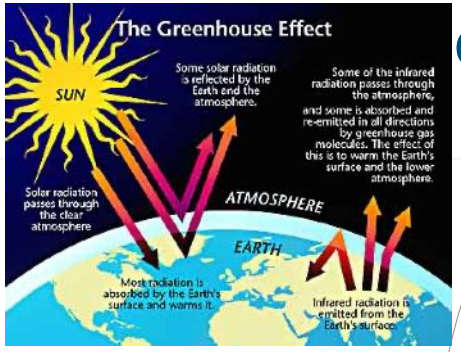
2018: Total 111 kton NH_3
equal to 63 kg NH_3 per hectare



acidification

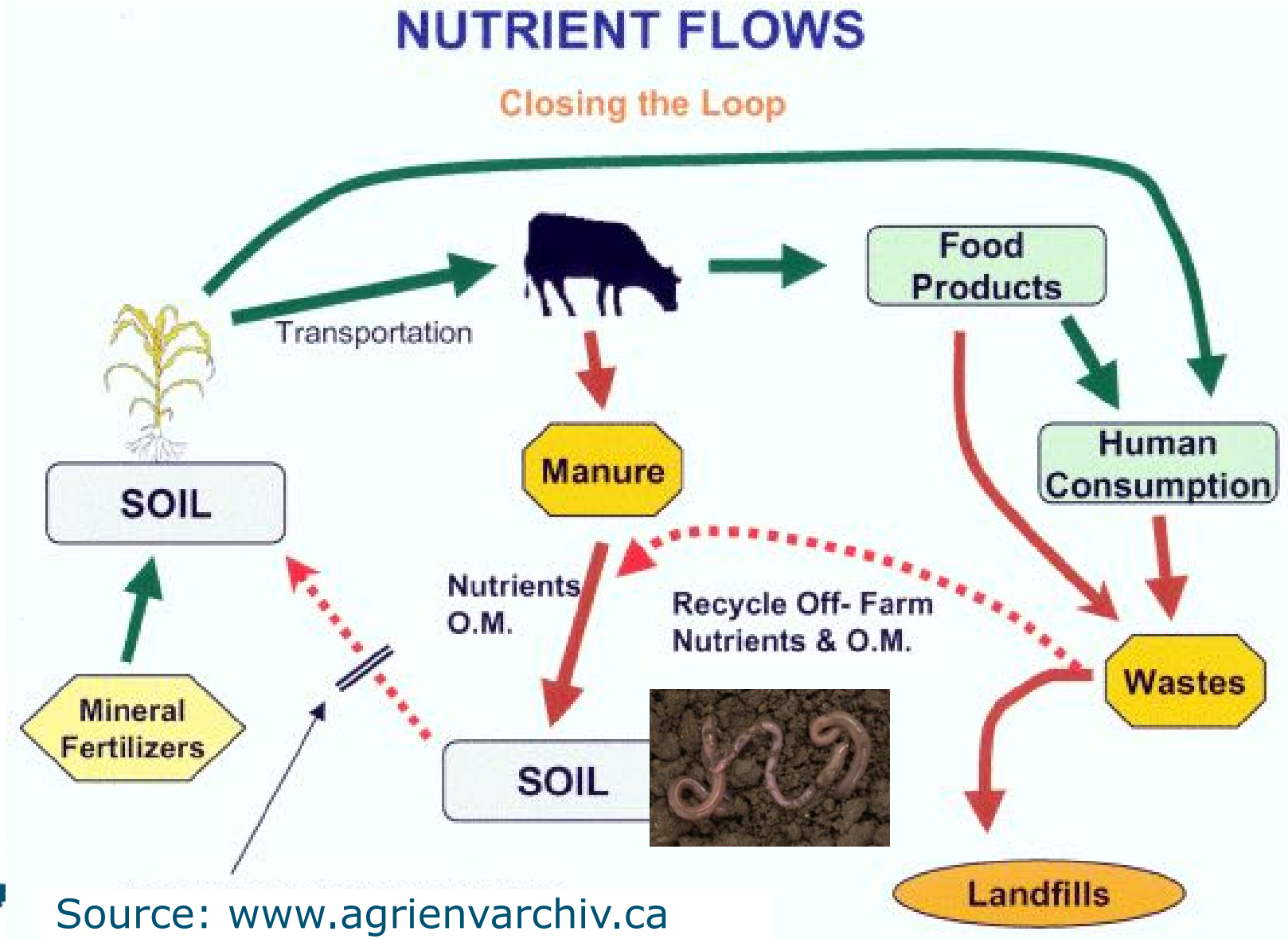
The greenhouse gas challenge

climate neutral agriculture in NL



The soil quality challenge

NPK losses & accumulation, organic matter, compaction



Source: www.agrienvarchiv.ca

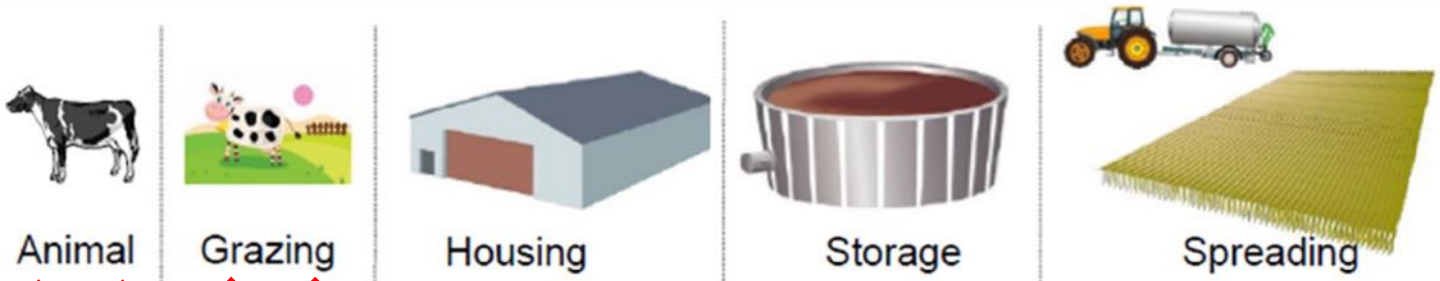
The Climate Care Cattle farming project

interviews discussions to discover best strategies

Tools to monitor NPC

Tools to simulate best strategies

NH_3 N_2O CH_4



Detailed technical experiments

Emissions on 60 farms

farming

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Applied technology & solutions (1)

- Collect all slurry, manure and litter
- Separation of liquid & solid fraction

- Store (enough capacity)

Applied technology & solutions (2)

- Transport of slurry and manure
  - Within NL
  - Export

- Belt & tunnel drying, pelletizing

- Incineration manure at BMC Moerdijk (mainly poultry manure)

Applied technology & solutions (3)

- Nitrification / denitrification (e.g. veal calf slurry)

- Digestion of slurry (dairy & pig slurry)

- Composting

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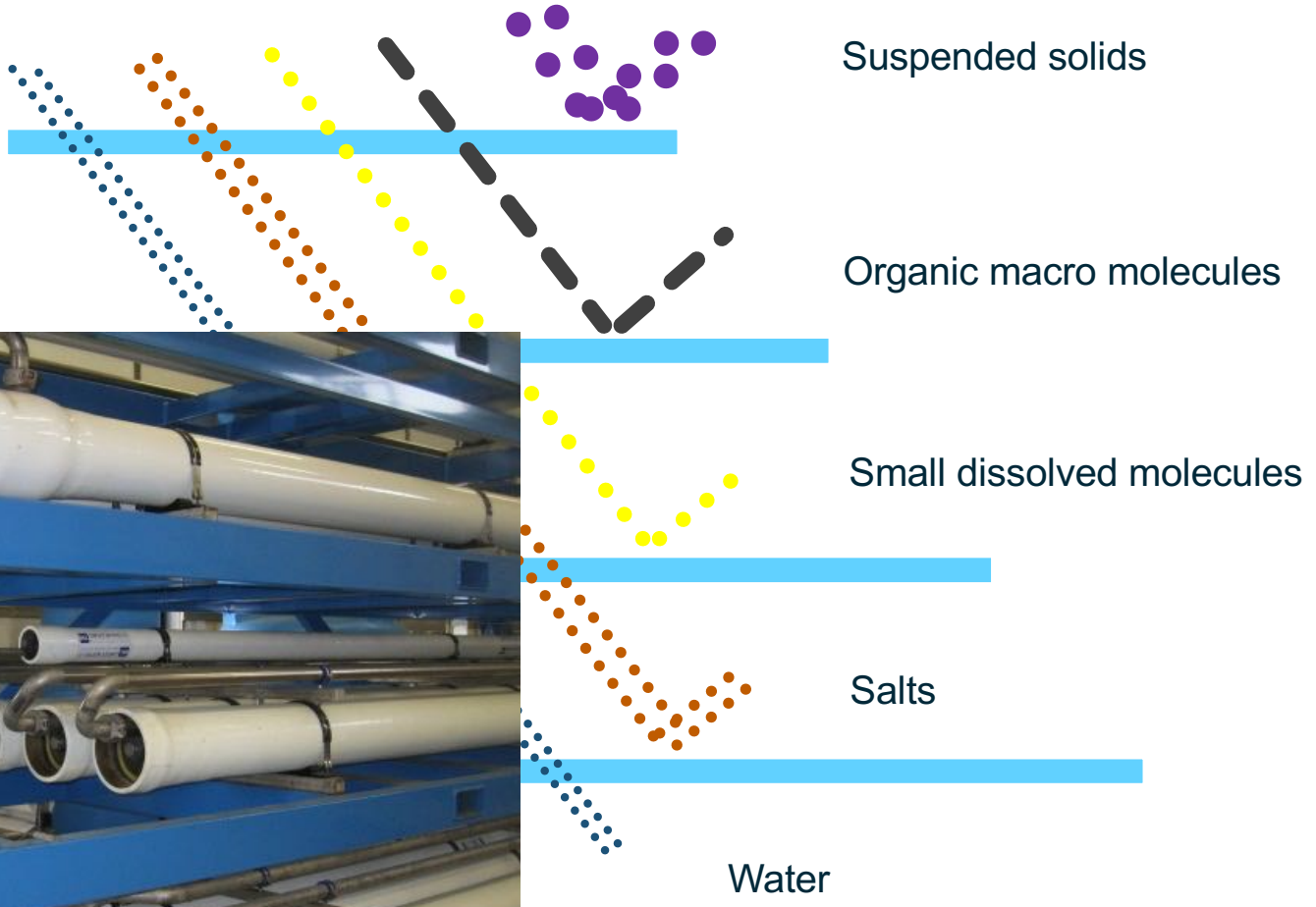
Applied technology & solutions (4)

- Combination into advanced systems



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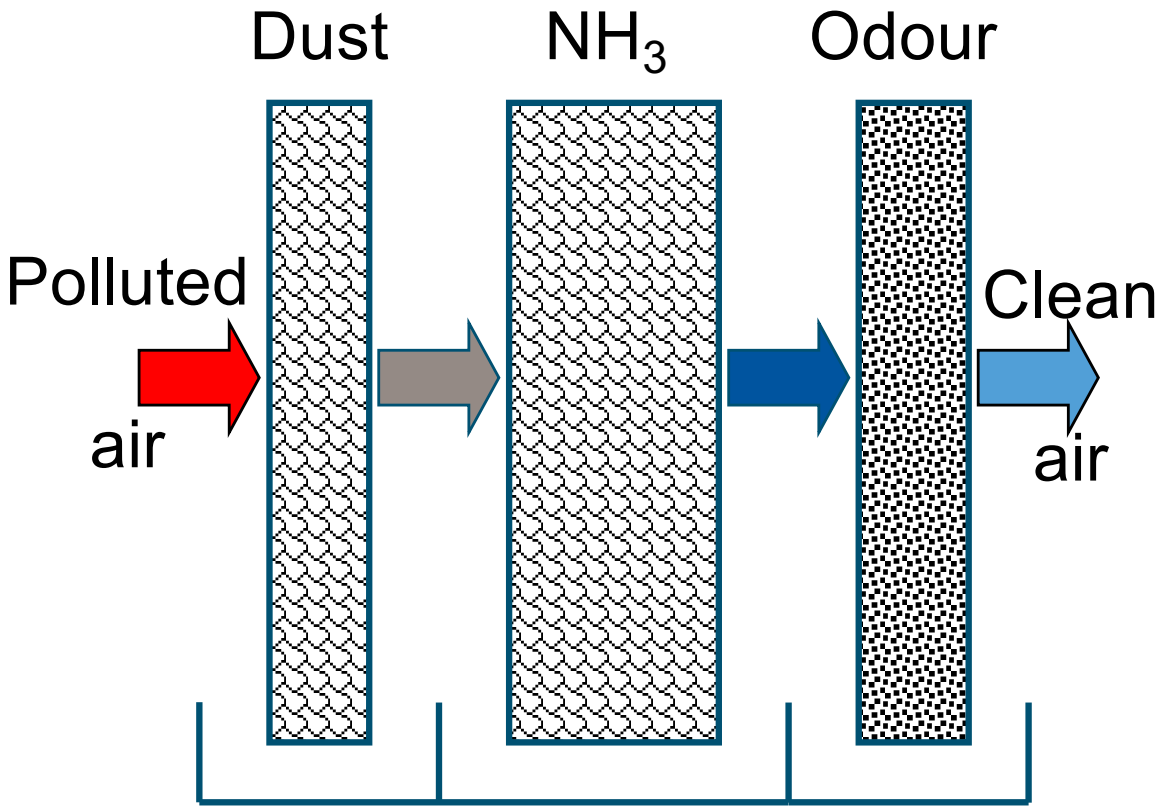
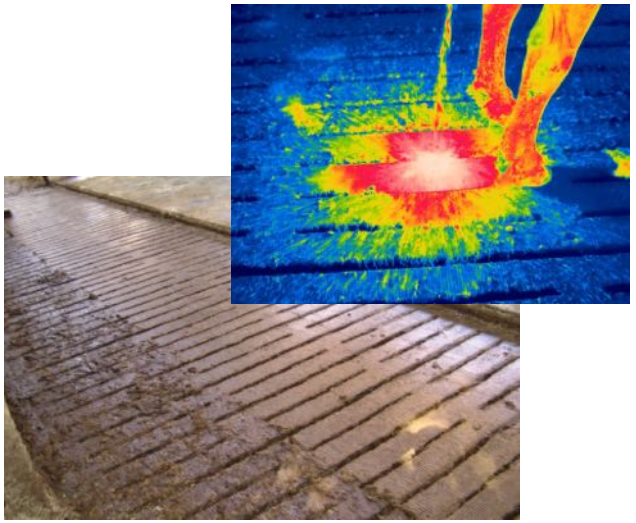
Applied technology & solutions (5)

- Modified application to reduce ammonia (NH_3) emissions

Applied technology & solutions (6)

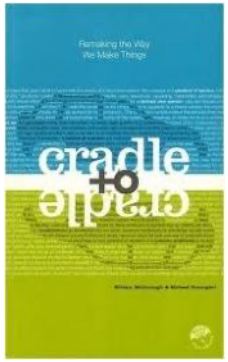
- Air scrubbers and special floors to reduce NH_3 emissions





From slatted floors to drained floors that close the slurry pit

Is this sustainable in the long run?



"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
(People Planet Profit concept)

Taken from *Our common future*, UN report Brundtland committee 1987

How do we love all the children

of all species for all time?

Willam McDonough

UN Sustainable Development Goals

… to end poverty, protect the planet and ensure prosperity for all, in 2030! Enforced by January 1, 2016

Trade-offs & pollution-swapping

- Energy use, N-loss, N_2O emission, high € costs

… and most importantly:

- Effect / impact: reductions and improvements are limited
- Also for combinations of techniques

- Short term environmental goals not met
- Long term environmental goals infeasible

Complexity of processes

- Microbial degradation, conversion, (de)nitrification
- Chemical reactions and equilibria
- Physical processes, e.g. volatilization

Many influencing factors (animal house, waste, soil):

- temperature
- pH
- oxygen concentration
- carbon availability
- air velocity
- water activity / water content
- …

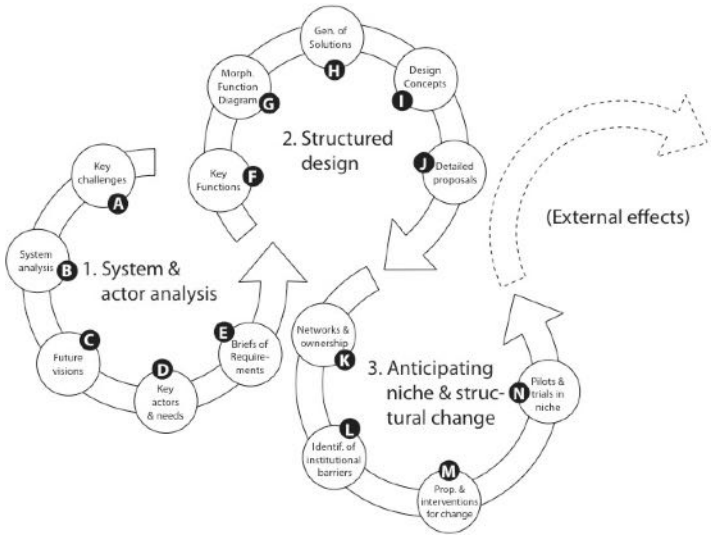
How to solve the design challenge?

1. Sterilize or dry manure immediately after excretion

Or

2. Design integrated manure management strategies

J.W. de Vries et al, 2015. Integrated manure management to reduce environmental impact: I. Structured design of strategies. Agricultural Systems 149: 29-37



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Manure management & environment

Mineral fertilizer production

Electricity, heat & fuel production

External processes

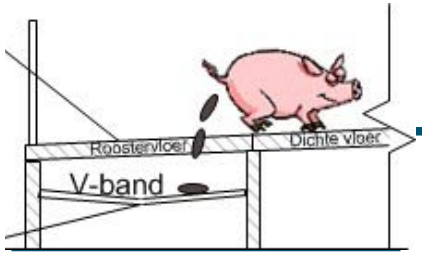
CO_2

NH_3

N_2O, CH_4, odour

18 - 33% N efficiency

52 - 65% P over application



Excretion inside housing (N, P and C)

Storage / processing

Transport

Field application, soil tillage & in-field traffic

Crop uptake

Manure chain

€ or ¥, animal welfare

NO_3^-, P

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Selected technical solutions with main effects in brackets

- Segregation of pig and dairy cattle urine and feces inside the housing system (CH_4 & NH_3 emission)

Belt system for pigs - separates urine and faeces and allows straw!

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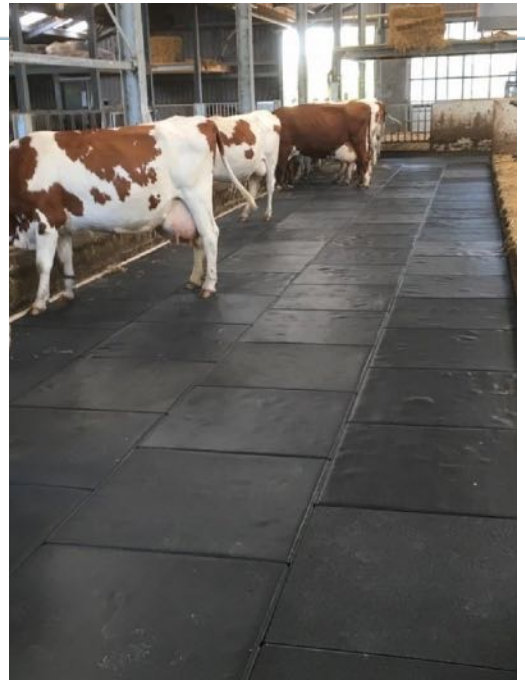
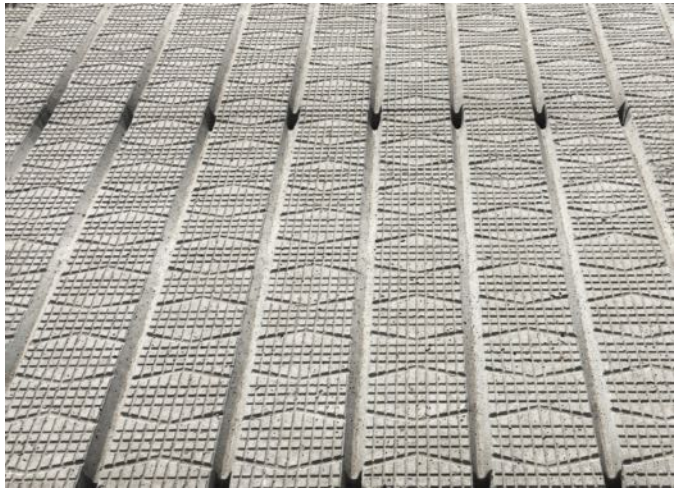
Segregation systems for dairy cows



Zeraflex permeable floor

CowToilet for urine collection - Hanskamp

Lely Sphere with feces collector



Swaans G6 floor with drain holes

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Selected technical solutions with main effects in brackets

- Segregation of pig and dairy cattle urine and feces inside the housing system (CH_4 & NH_3 emission)
- Bio-energy production from feces (fossil electricity/heat)
- Addition of zeolite to solid dairy cattle manure (NH_3)
- Sealed separated storages (volatilization of N and C)
- New field application techniques (NH_3)
- Adapted application & tillage (N_2O, fossil energy, N loss)

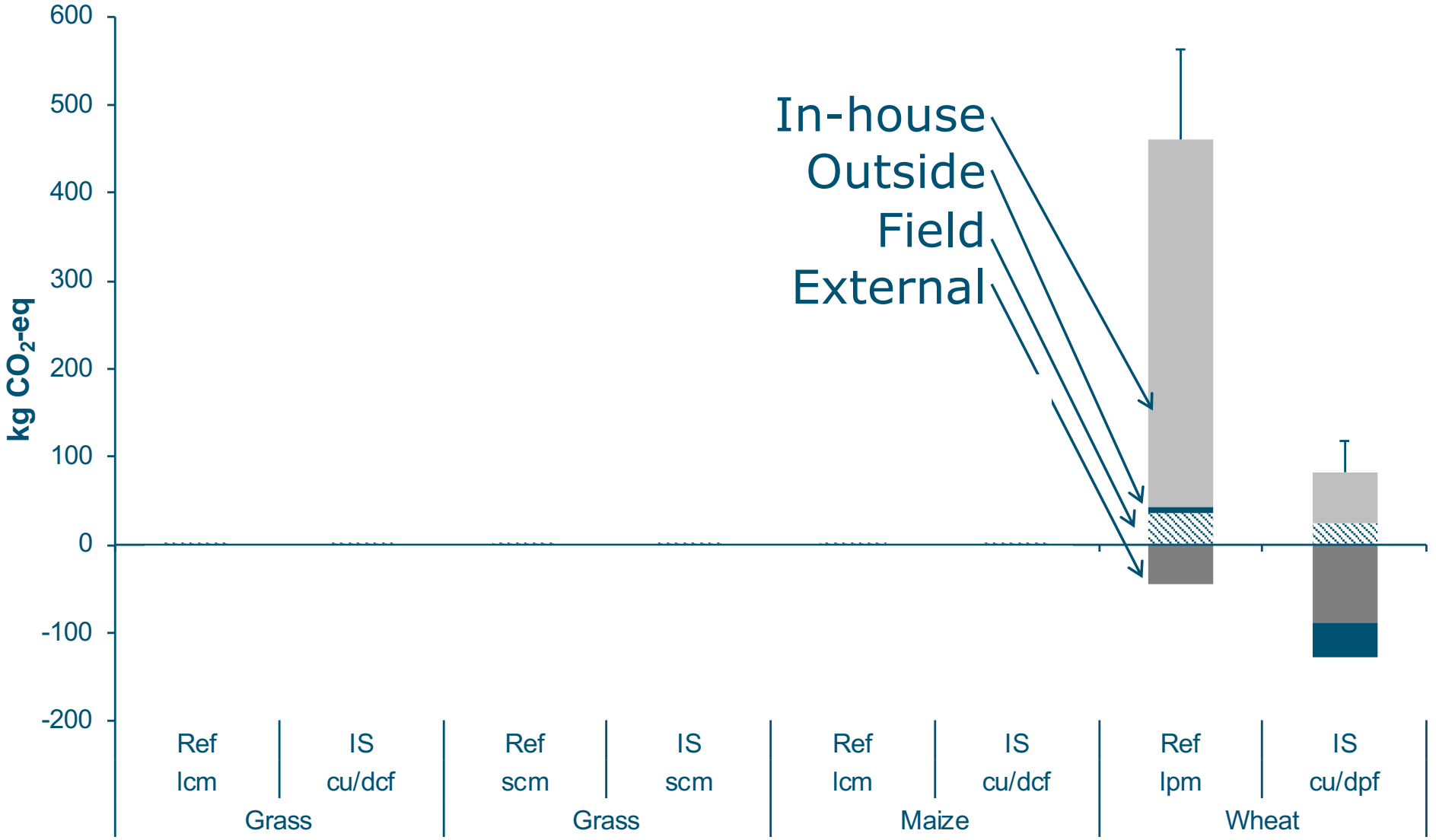
Life Cycle Assessment to assess effects

4 representative crop-manure combinations in NW-Europe:

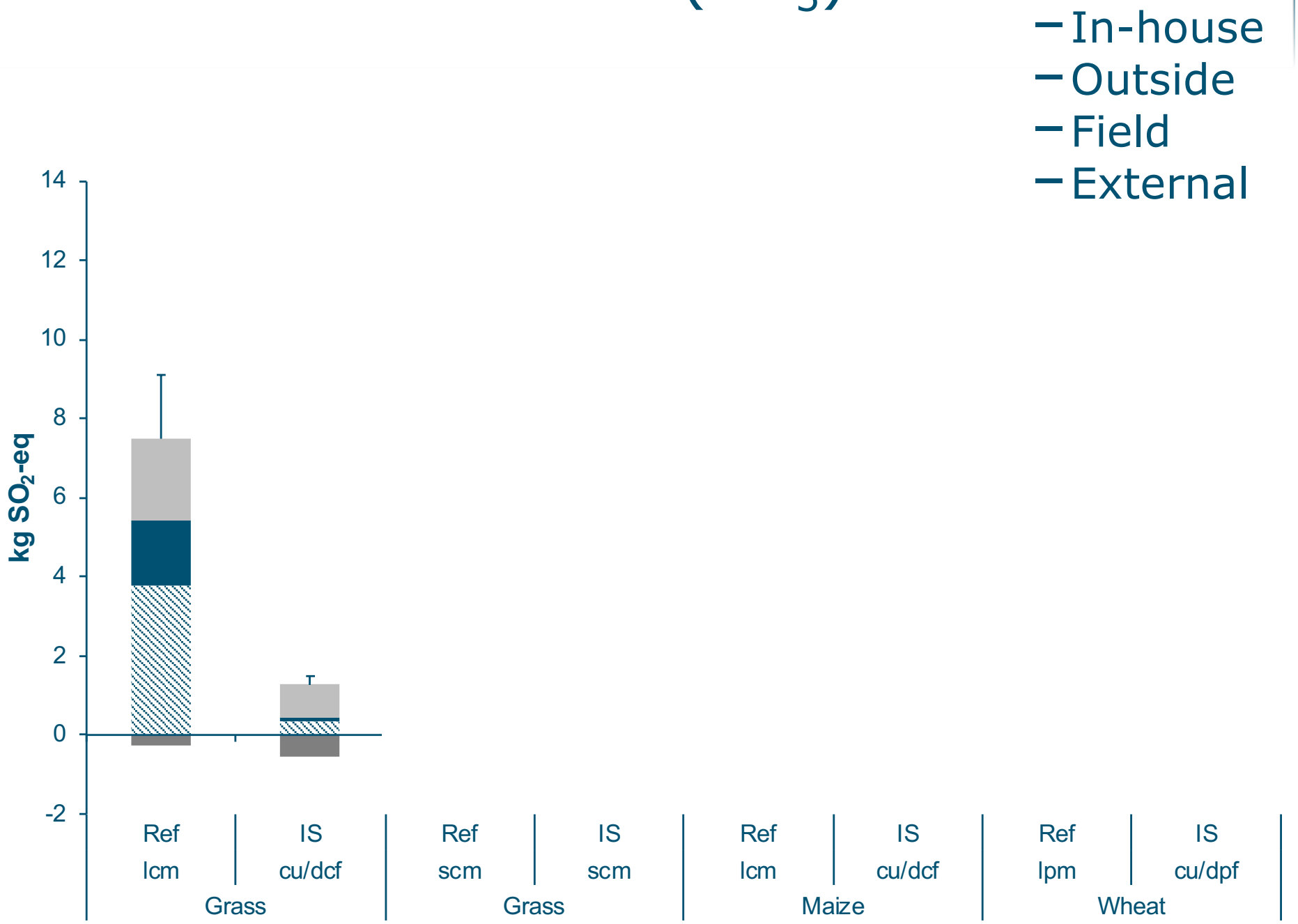
- Gras – liquid cattle manure
- Gras - solid cattle manure
- Maize – liquid cattle manure
- Wheat – liquid pig manure

- Reference: house with slats & storage, no storage covers, broadcast spreading, plowing, random traffic
- Monte-Carlo uncertainty analysis on loss coefficients
- Effects: Climate Change, Terrestrial Acidification, NUE

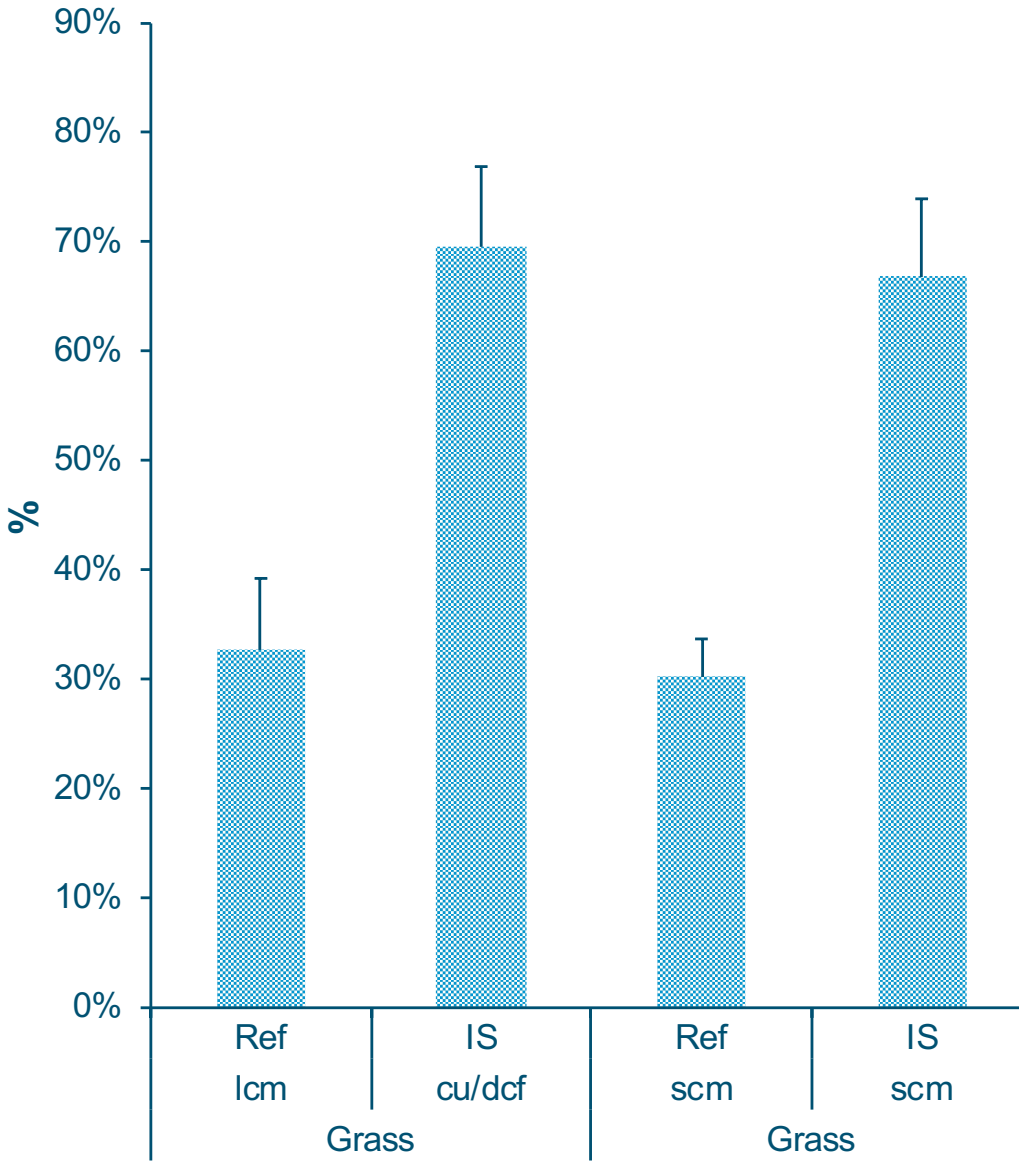
Climate change (CO_2, N_2O and CH_4)



Terrestrial acidification (NH_3)



Nitrogen Use Efficiency (crop:excreted)



Discussion & conclusion

- Integrated manure chain, 'simple' techniques!

- Doubled N-use efficiency
- No polluting swapping
- All environmental impacts reduced >50%

- Validate model results of emissions: lab & field
  ongoing with PhD Jihane el Mahdi in EU FertiCycle program
- Economic consequences & practical implementation

- Segregation is key to success!

End

Photo of a tilted manure belt under a slatted floor to segregate faeces and urine of pigs

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Further reading

- De Vries, J.W., W.B. Hoogmoed, K.M. Groenestein, J.J. Schröder, W. Sukkel, I.J. De Boer, P.W.G. Groot Koerkamp, 2014.
  Integrated manure management to reduce environmental impact: I. Structured design of strategies.
  Accepted for publication in Agricultural Systems
- De Vries, J.W., W.B. Hoogmoed, K.M. Groenestein, J.J. Schröder, W. Sukkel, I.J. De Boer, P.W.G. Groot Koerkamp, 2014.
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