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

Webinar, 16 April 2021

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Thanks to many co-authors' contributions

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Waste management next level

- Environmental challenges in 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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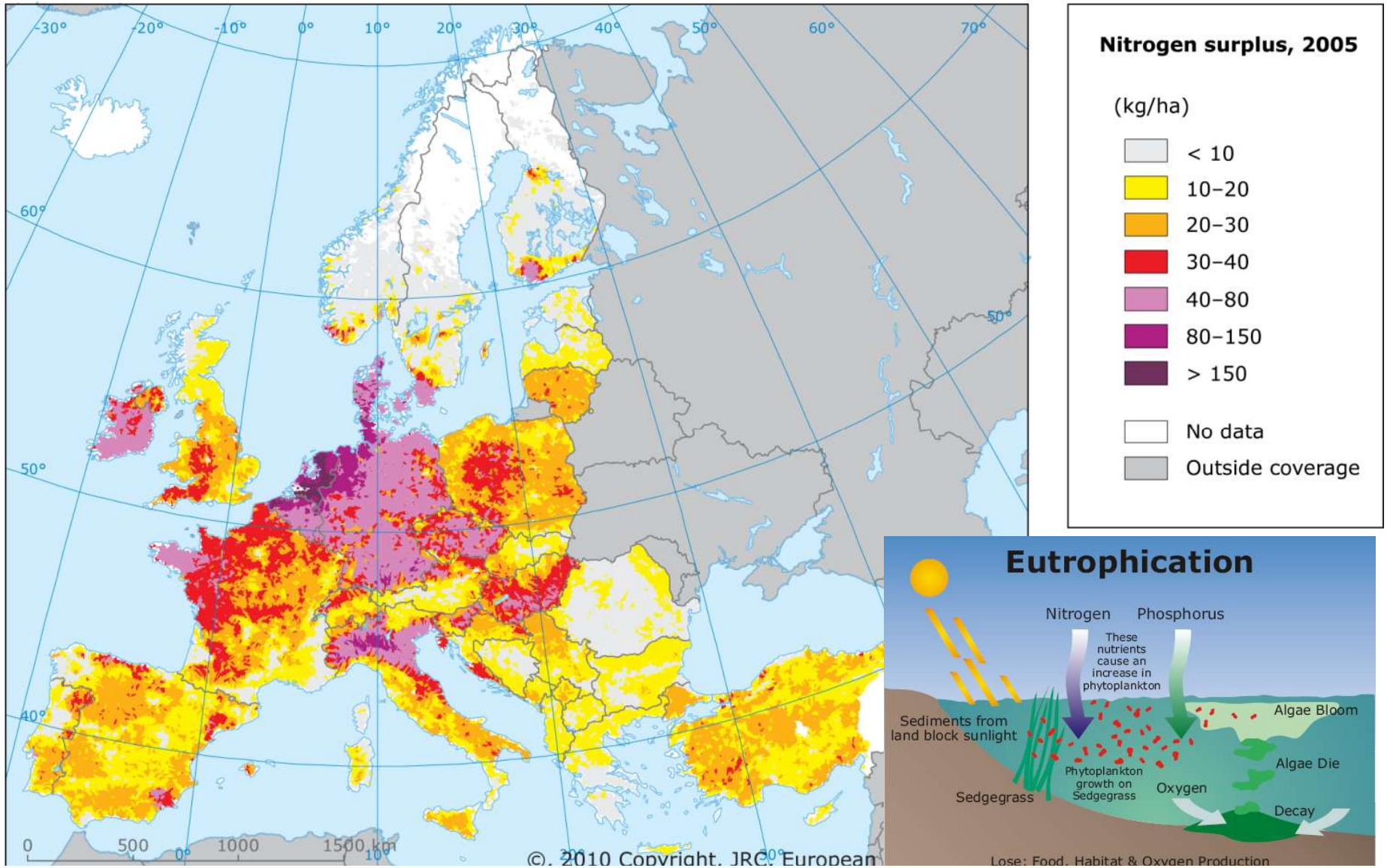
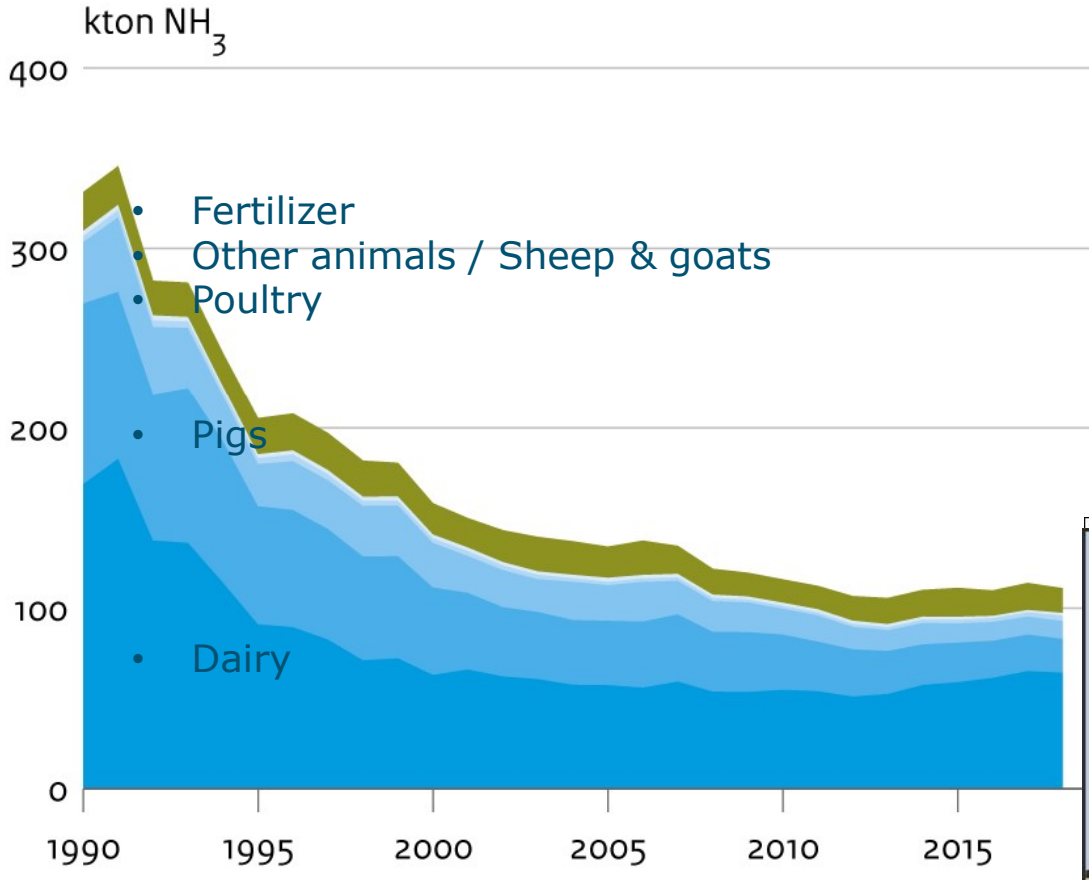
The nitrogen challenge

surplus of N and P

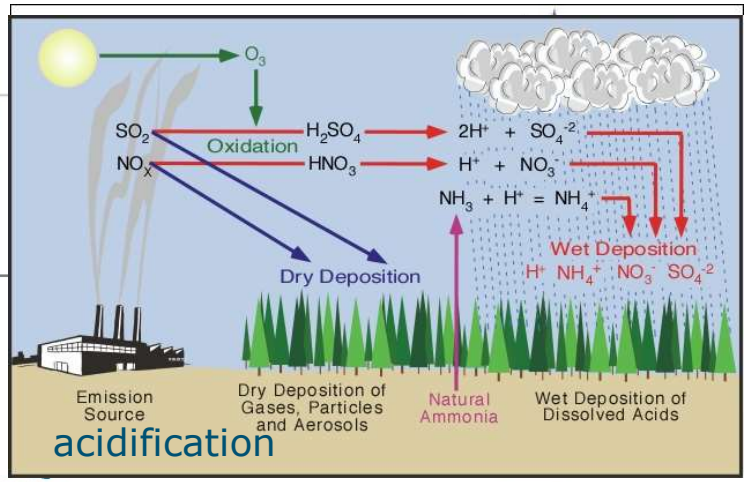


The ammonia challenge

dairy largest contributor, decrease stopped



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

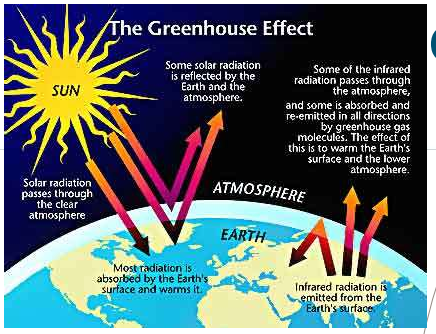


acidification

Bron: RIVM/Emissieregistratie

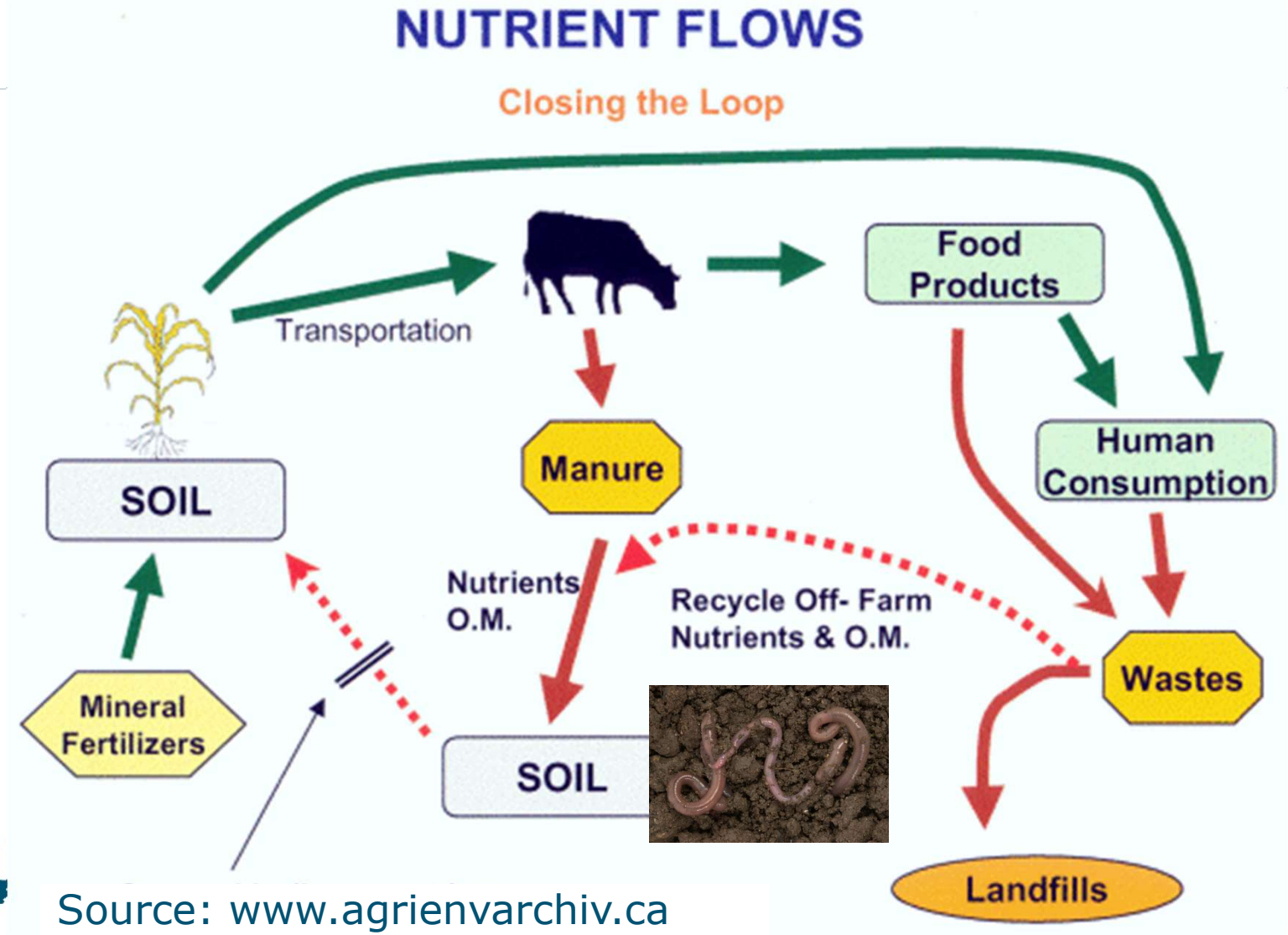
The greenhouse gas challenge

climate neutral agriculture in NL



The soil quality challenge

NPK losses & accumulation, organic matter, compaction



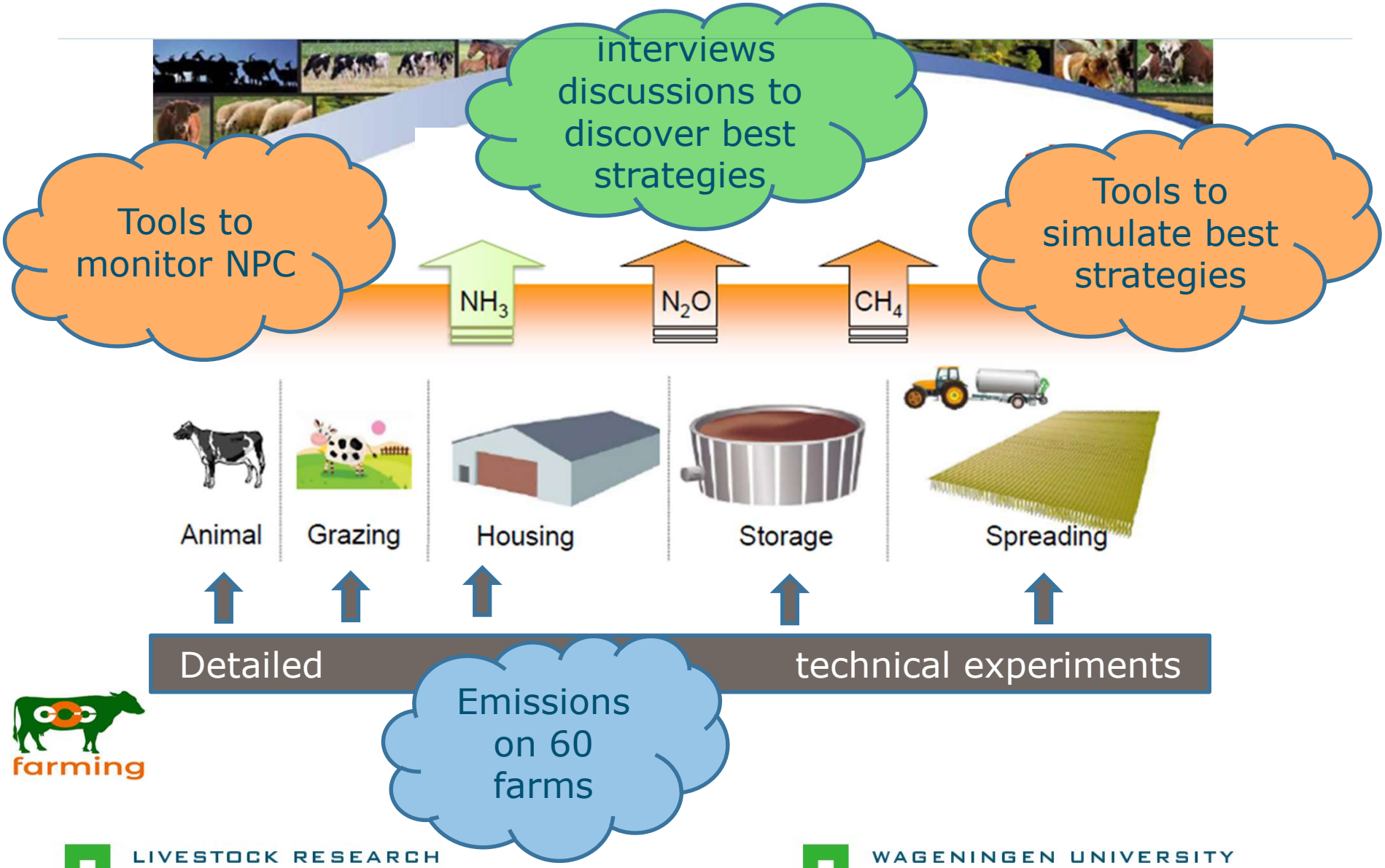
Source: www.agrienvarchiv.ca

Slide 8

pGK1 nog toeveo

peter Groo Koerkamp, 23-10-2017

The Climate Care Cattle farming project



farming

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Need for waste management

… is all handling of waste
from excretion and collection,
storage in & outside the animal house,
any type of processing or treatment,
up to transport and application
in crop production

Applied technology & solutions (1)

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

- Store (enough capacity)

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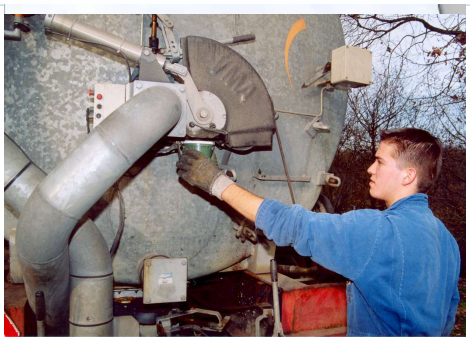
Applied technology & solutions (2)

- 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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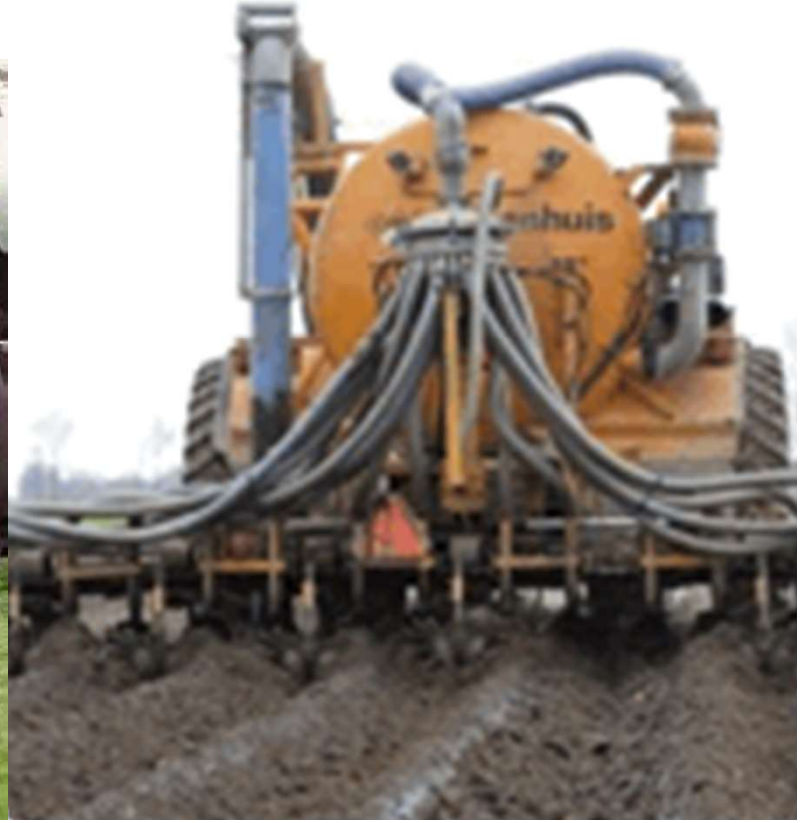
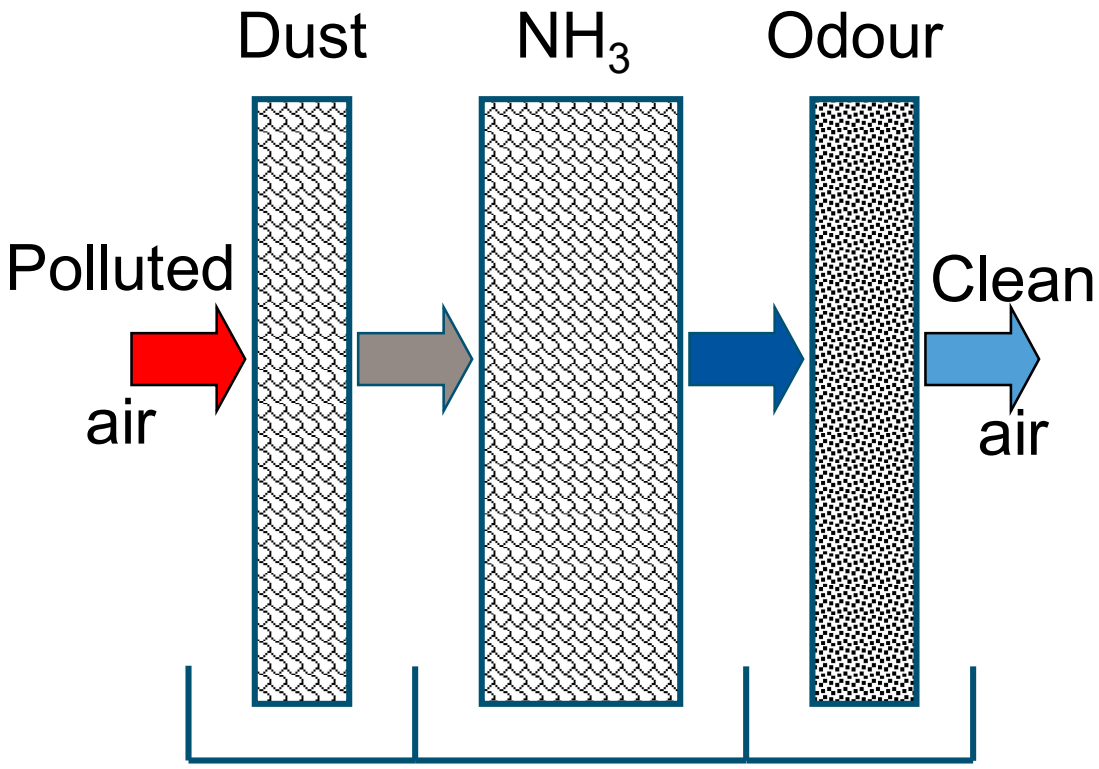
Applied technology & solutions (5)

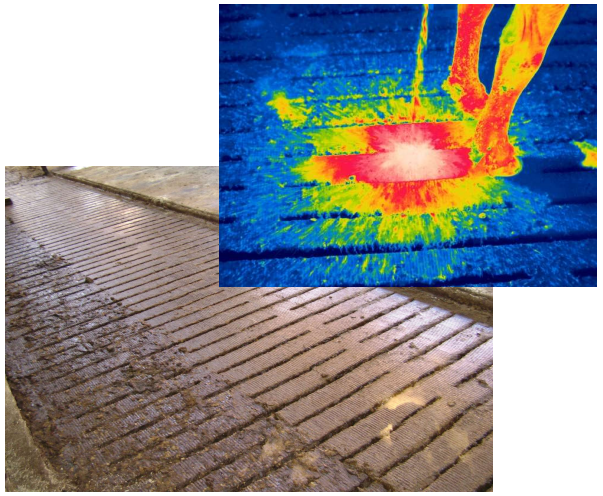
- Modified application to reduce ammonia (NH_3) emissions



Applied technology & solutions (6)

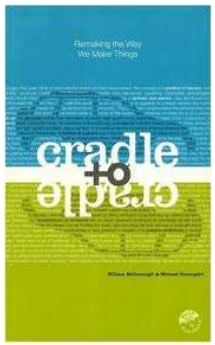
- Air scrubbers and special floors to reduce NH_3 emissions





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

Environmental effects of losses & accumulation

Effect	– Cause
Eutrophication	- loss of N &P
Acidification	- emissions of NH_3 - deposition
Biodiversity loss = loss of species (various scales)	- intensity of production - use of agro-chemicals - transfer nature to crops
Global warming	- emissions of CO_2, CH_4, N_2O,
Reduced water quality: ground & surface water	- loss of N & P, agro-chemicals
Reduced air quality: for worker, animal & neighbourhood	- particulate matter - gases & odour

Eutrophication

Effect of excess nutrients on beaches in France & China

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Environmental effects: other issues

Effect	–	Cause
■ Depletion of natural (limited) sources:		- phosphate as fertilizer - water for irrigation - fossil carbohydrates for energy
■ Reduced soil quality		- low organic matter content - soil compaction

Trade-offs & pollution-swapping (1/3)

- Belt drying, tunnel drying, pelletizing
  - Energy use
  - Costs
  - NH_3 loss
- Storage of solids and farm yard manure (stackable)
  - High N-loss
  - N_2O emission
- Incineration of poultry manure
  - Re-use of P?
  - Loss of OM
- Veal calf treatment
  - Energy use
  - N_2O emission

Trade-offs & pollution-swapping (2/3)

- Digestion of slurry
  - Use of by-products
  - Costs
- Composting
  - High N-loss
- Chemical air scrubbers
  - Energy use
  - Indoor climate
  - N_2O emission
- Biological air scrubbers
- Floor systems
  - Effectiveness questioned
  - Costs
  - Impact animal welfare

Trade-offs & pollution-swapping (3/3)

… 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

Sustainable waste management

- Maximize nutrient recycling in the whole chain
- With no (minimal) undesired environmental impact

First challenge:

Design a waste management system
(from excretion up to application)
that fulfils needs of plant and soil,
and with minimal environmental side-effects

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
- …

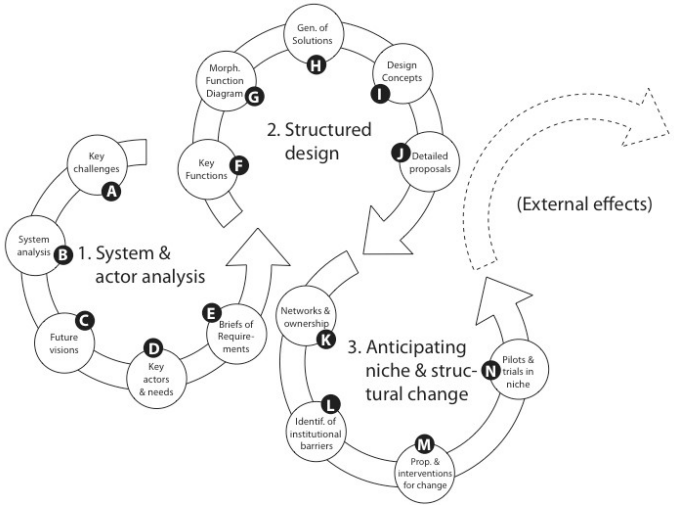
How to solve the first challenge?

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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How to solve the first challenge?

1. Sterilize or dry manure immediately after excretion

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2. Design integrated manure management strategies

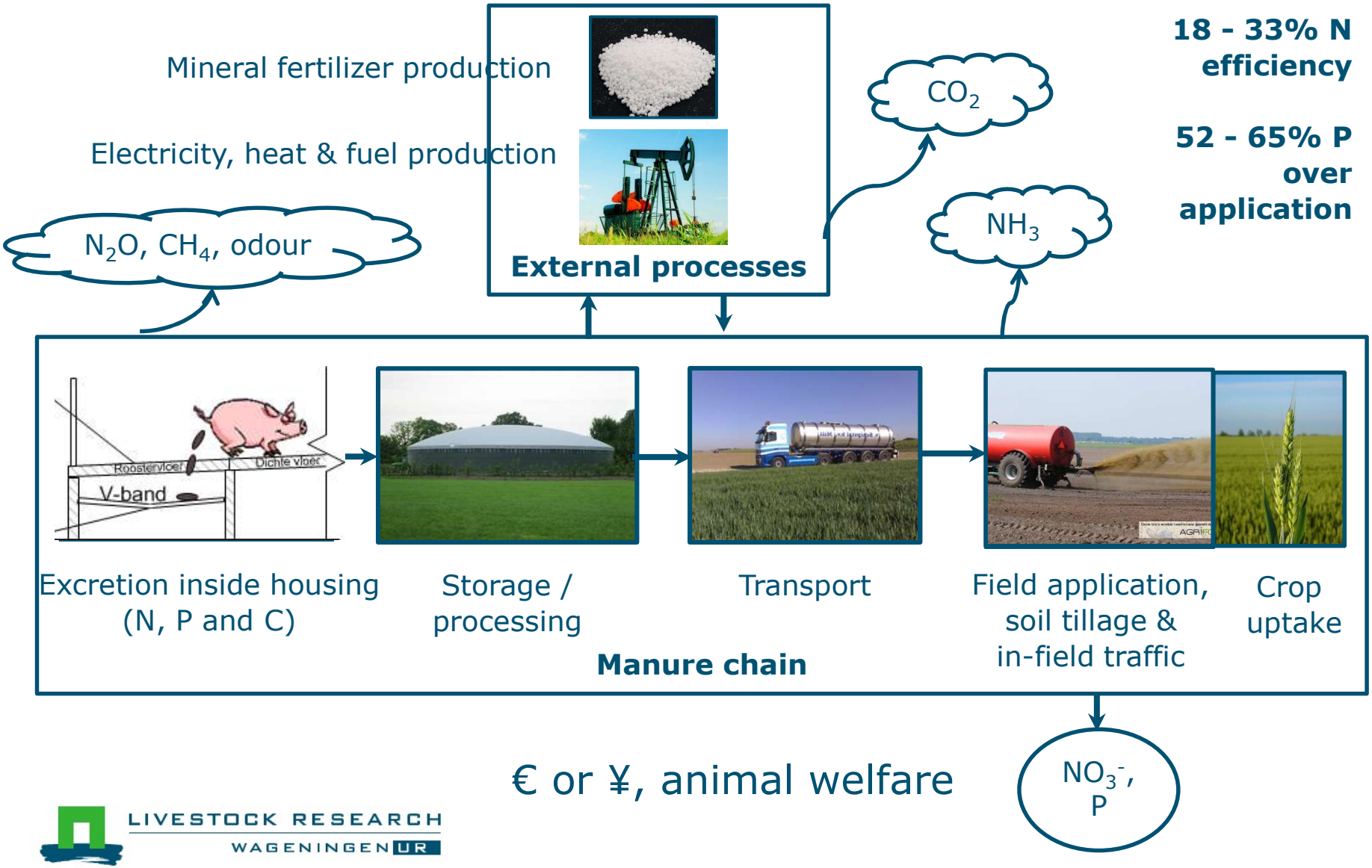
Example: J.W. de Vries et al, 2015. Integrated manure management to reduce environmental impact: I. Structured design of strategies. Agricultural Systems 149: 29-37

Outcome: major environmental impacts reduced by 70%!

Key solutions:

- segregation of feces and urine – keep separated!
- smart combinations/adaptation current technologies
- welfare can be included

Manure management & environment



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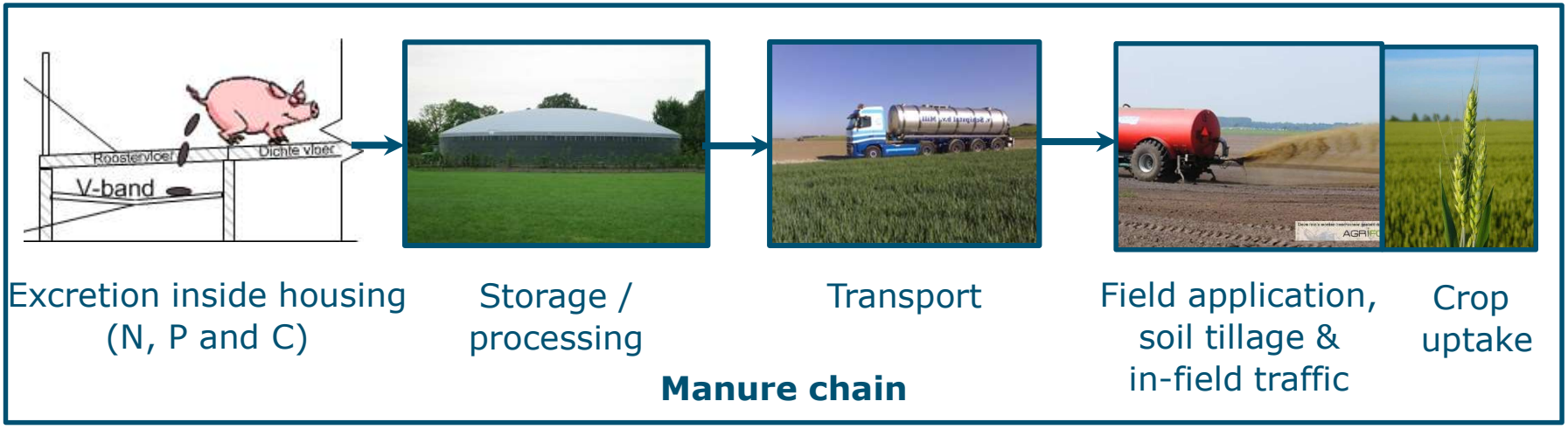

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Selected technical solutions with main effects in brackets

- 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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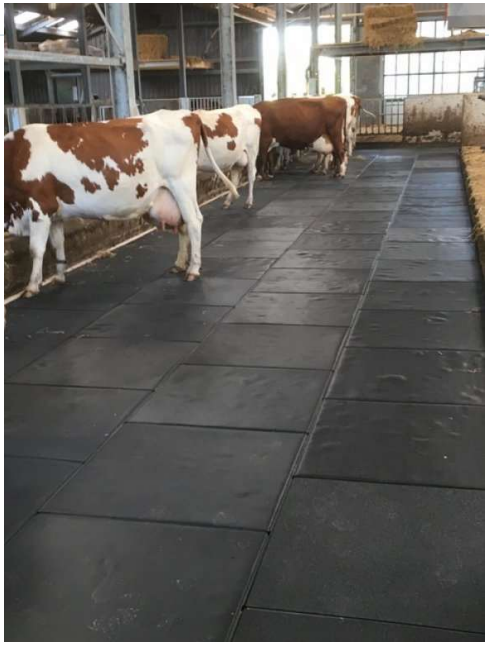
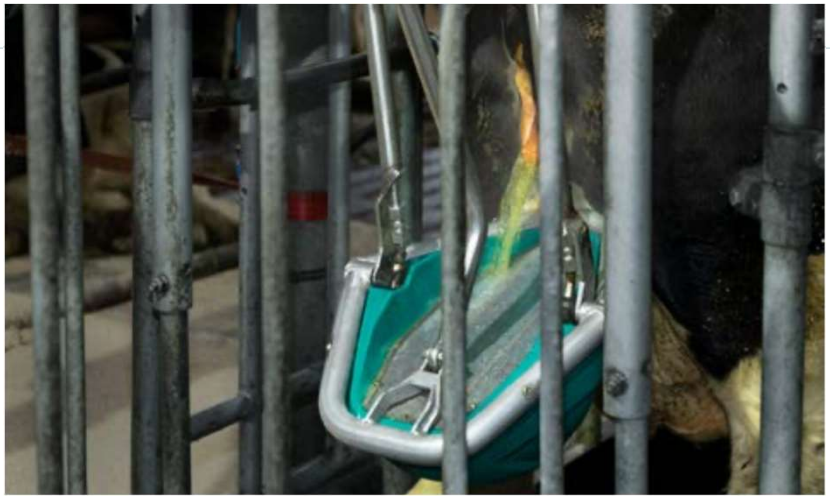
Segregation systems for dairy cows

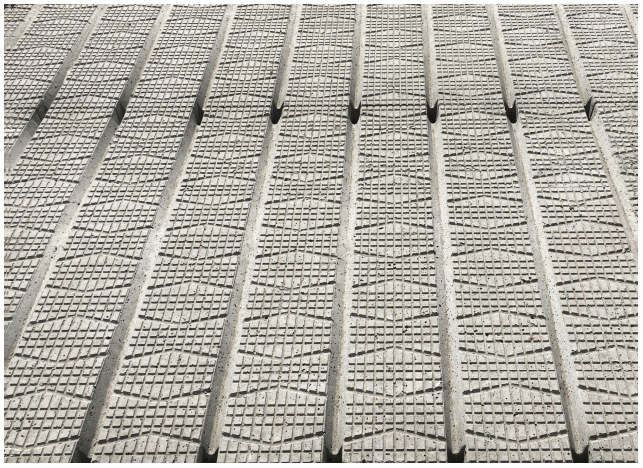


Zeraflex permeable floor



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)
- Ammonia emission reducing application techniques (NH_3)
- Adapted application & tillage (N_2O, fossil energy, N loss)

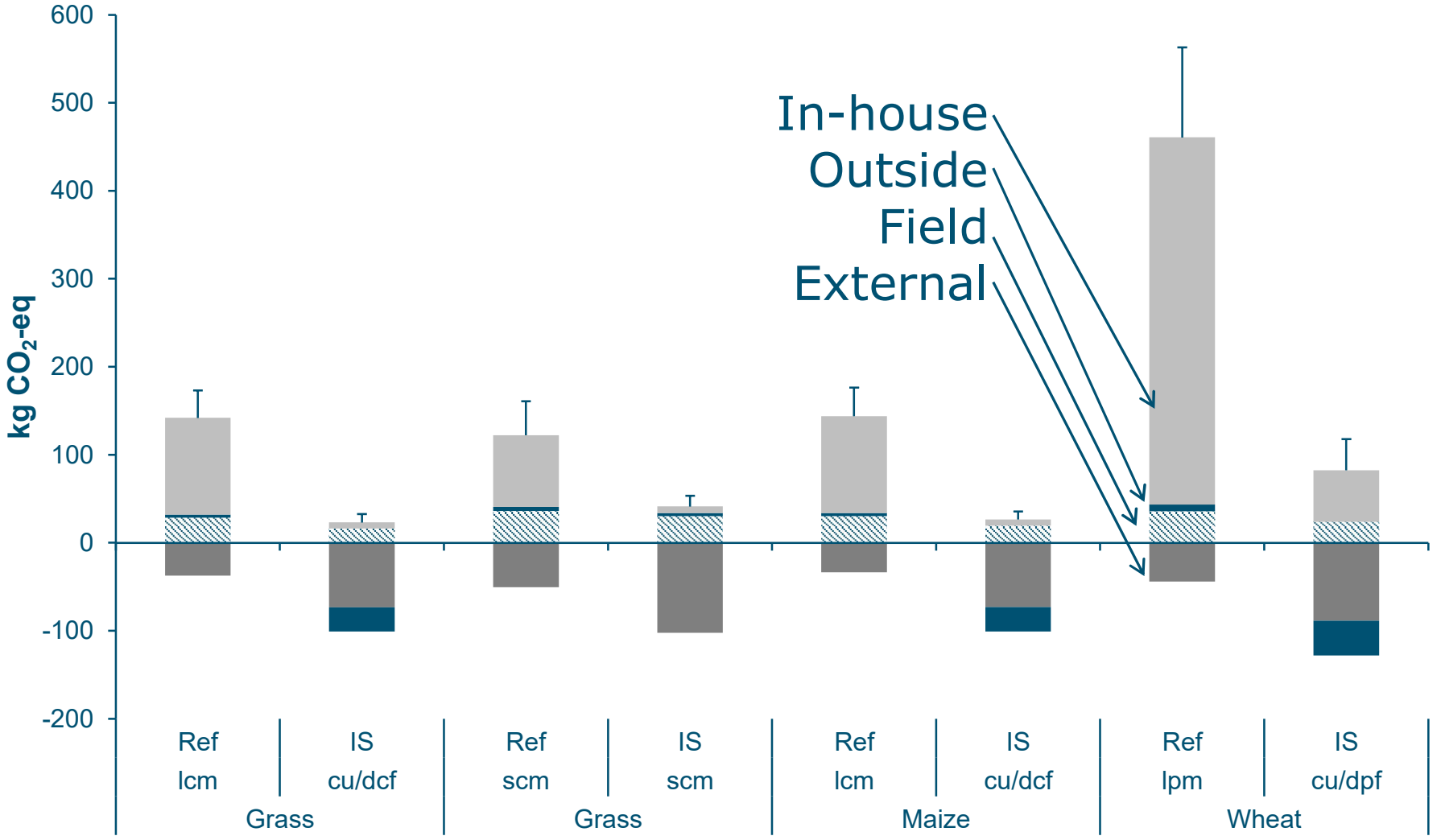
Life Cycle Assessment to asses effects

4 representative crop-manure combinations in NW-Europe:

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

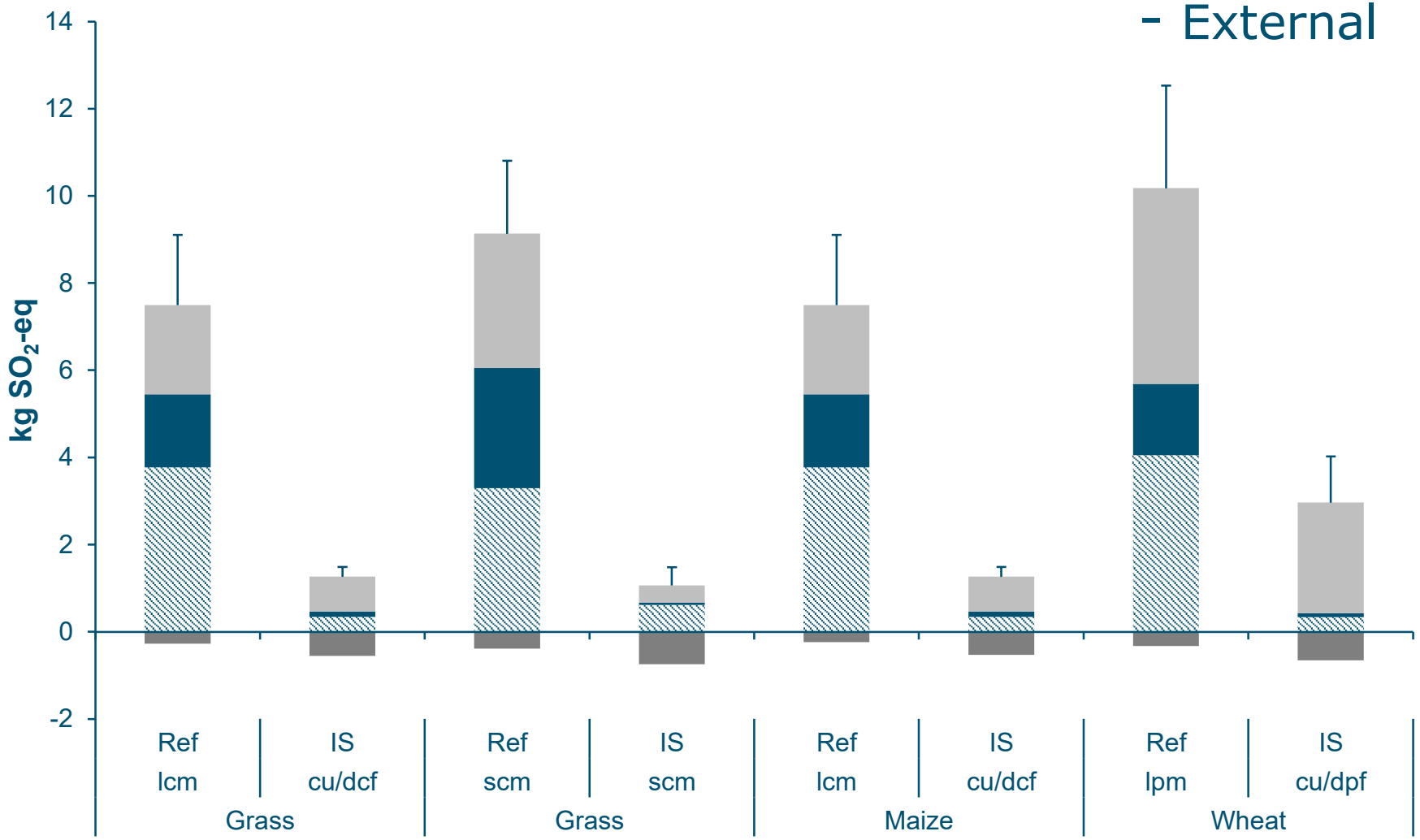
- Reference: house with slats & storage, no storage covers, broadcast spreading, plowing, random traffic
- Monte-Carlo uncertainty analysis on loss coefficients
- Effects: Climate Change, Terrestrial Acidification, NUE

Climate change (CO_2, N_2O and CH_4)

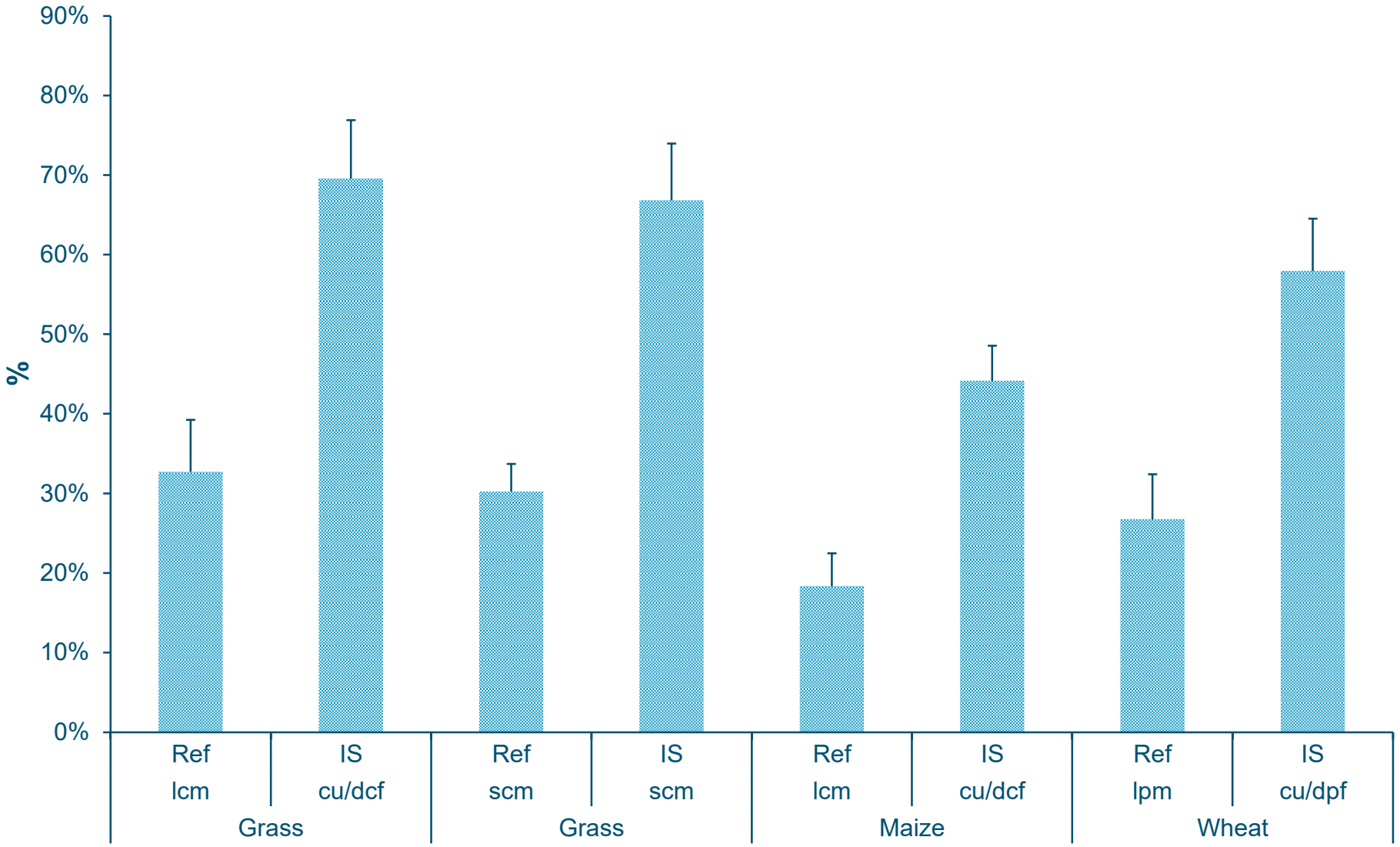


Terrestrial acidification (NH_3)

- In-house
- Outside
- Field
- External



Nitrogen Use Efficiency (crop:excreted)



Sustainable waste management

- Maximize nutrient recycling in the whole chain
- With no (minimal) undesired environmental impact

Second challenge:

Implement in practice such a waste management system
(from excretion up to application)
that fulfils needs of plant and soil,
and with minimal environmental side-effects

Not today

Issues to deal with change & innovation

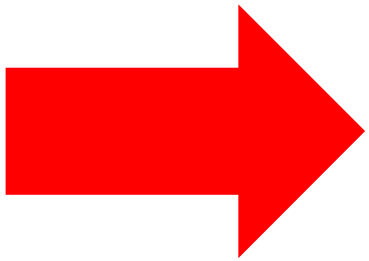
- Investment costs in equipment
- Overall costs of waste management
- Added value of new nutrient products for end user
- Technical complexity of installation (incl. management)
- Contradictions between short and long term
- Legislative mismatch
- No financial reward from the ‘environment’

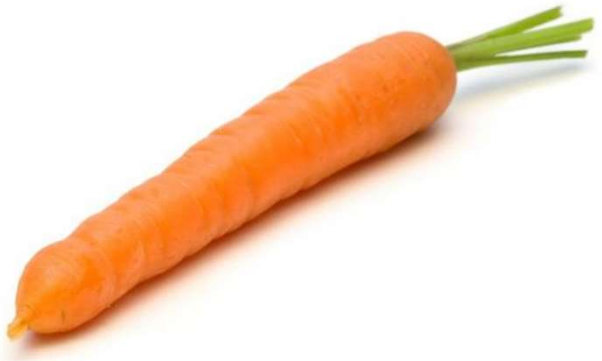
How is this organized?

The ‘stick’:
Enforcement

- EU legislation
- Nat. legislation
- Trade agreement

Organize a new model!





The ‘stick’: Enforcement

- EU legislation
- Nat. legislation
- Trade agreement

The ‘carrot’ Positive incentives:

- €
- Yield/production
- License to produce

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Discussion & conclusion

- Integrated whole manure chain, with ‘simple’ techniques!
- Successful in doubling N-use efficiency and prevention of polluting swapping: reduction >50% on all impacts
- Validate model results of emissions: lab & field
  ongoing with PhD Jihane el Mahdi in EU FertiCycle program
- Economic consequences & practical implementation

Concluding remarks

Sustainable waste management asks for:

- Redesign of the total manure chain,
  starting with the animal house

But above all, more attention for sociological, societal & market aspects:

- Long term vision & agreements between stakeholders
- Well linked to society & regulations
- Demand driven market for fertilizing products

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.
  Integrated manure management to reduce environmental impact: II. Environmental impact assessment of strategies.
  Accepted for publication in Agricultural Systems