Manure management and mitigation of greenhouse gases: opportunities & limitations

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PhD project

- PhD project: ‘Moving beyond manure’
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- Conclusions

Introduction (1/2) Contribution of MM to GHG emissions

- Manure management (MM) = storage, processing, and application of liquid (slurry) or solid manure
- MM contributes
  - ~14% to agricultural greenhouse gas (GHG) emissions in Europe, mainly swine and cattle slurry (IPCC)
  - Up to 53% of agricultural N_2O emissions (Chadwick et al, 2011)
- GHGs: Mainly CH_4 and N_2O, lesser extent CO_2

25 x CO_2

Methano-genisis

298 x CO_2

(de-)nitri-fication

1 x CO_2

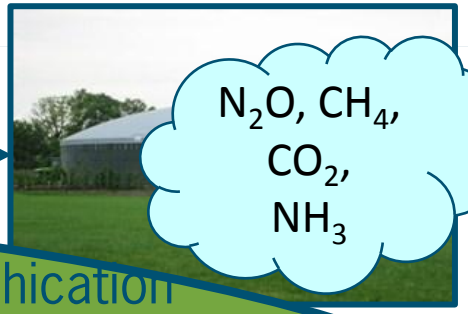
Fossil Energy

Introduction (2/2) Sources of GHG emissions and life cycle perspective

N_2O, CH_4, CO_2 NH_3

Greenhouse gases (CO_2, CH_4, N_2O)

Acidification (NH_3, SO_2, NO_x)



N_2O, CH_4, CO_2, NH_3

Eutrophication (NH_3, NO_x, NO_3)

N_2O CO_2 NH_3

Particulate matter (NH_3, NO_x, SO_2)

Fossil fuel depletion

NO_3

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Aim & methods

- Aim: Show GHG mitigation opportunities & limitations (shifting of emissions and environmental impacts)

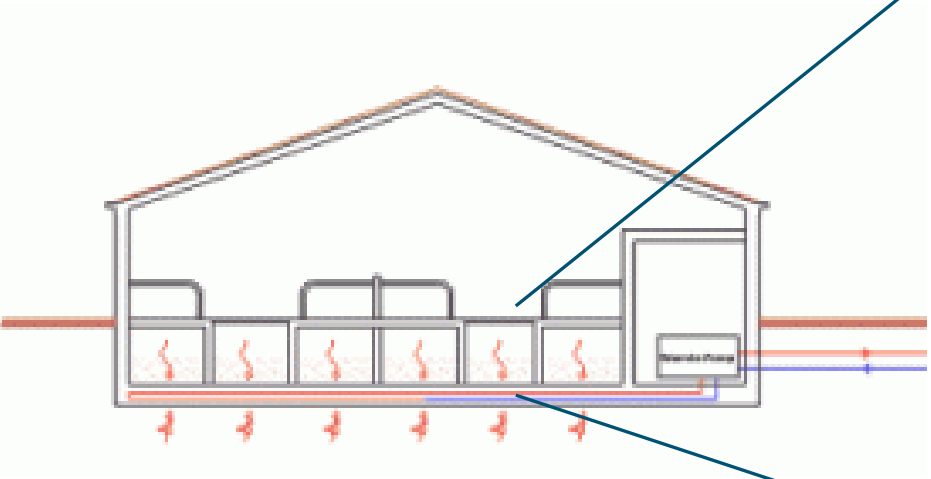
- Methods
  - life cycle assessment (LCA): steady state modelling of environmental impact from cradle to grave
  - Impact categories: GHG emissions, Acidification, Eutrophication, Particulate matter, and Fossil Fuel Depletion

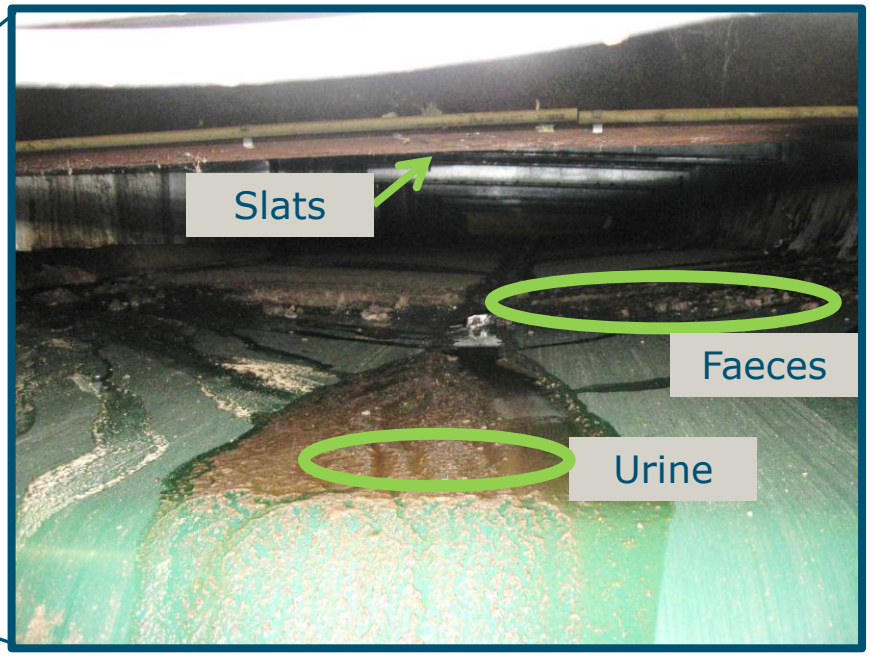
Mitigation opportunities & limitations

1. Don’t make manure
2. In-house/ outside storage
    - Segregating urine and faeces (keeping separate)
    - Cover storages
    - Reduce storage time/ temp
3. Manure processing
    - Anaerobic digestion
    - Separation of liquids and solids
    - Filtration
    - Biological treatment
    - Nutrient removal
4. Field application
    - Broadcast spreading→ not consistent

Mitigation opportunities & limitations

Segregating urine & faeces





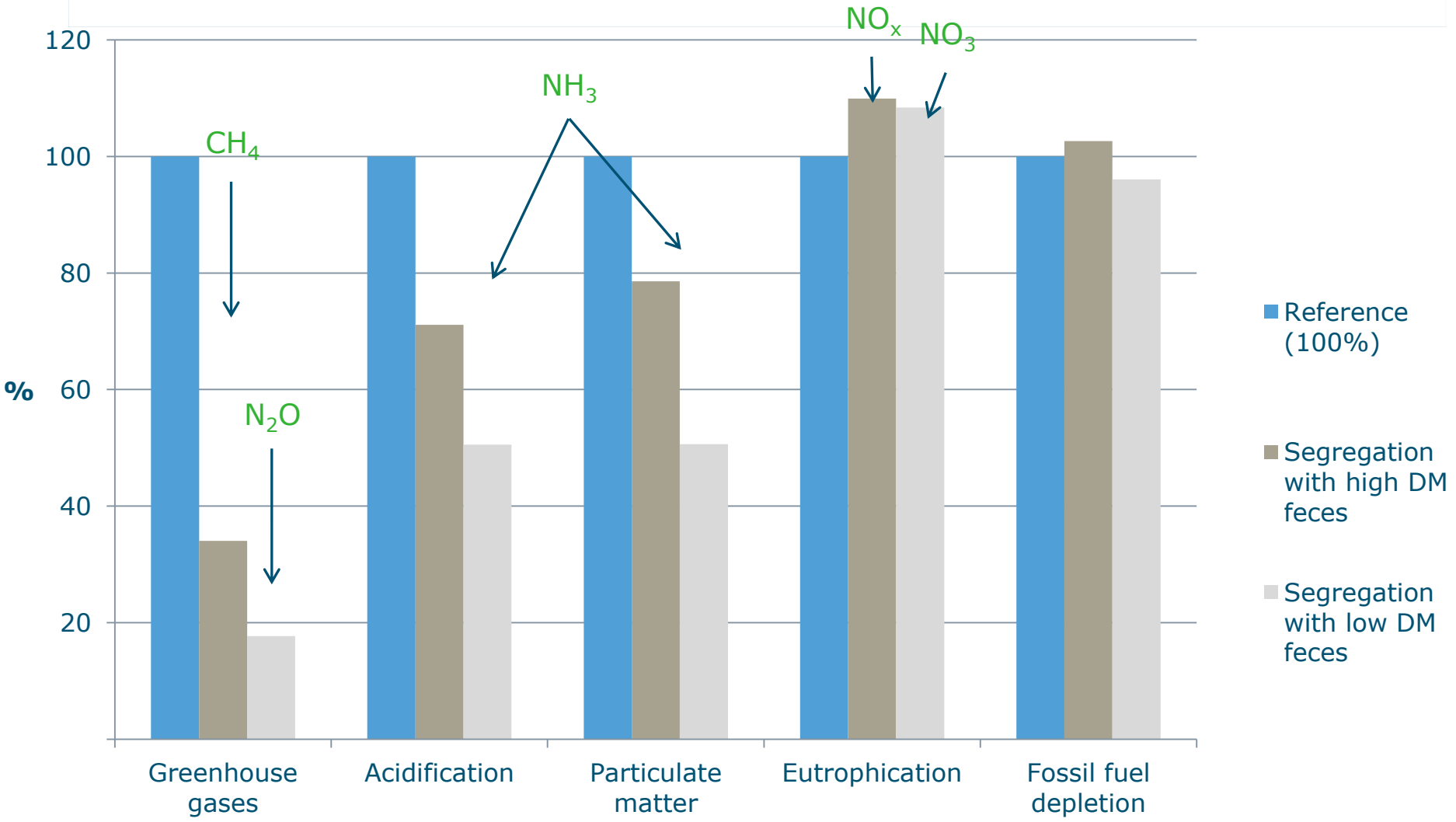
Mitigation opportunities & limitations (1/4)

Segregating urine & faeces

- Scenarios compared
  1. Reference MM
  2. Segregation high DM
     - High DM faeces→ open storage/ spreading + incorporation
     - Urine→ closed storage/ injection
  3. Segregation low DM
     - Low DM faeces→ closed storage/ injection
     - Urine→ closed storage/ injection

Mitigation opportunities & limitations (2/4)

Segregating urine & faeces



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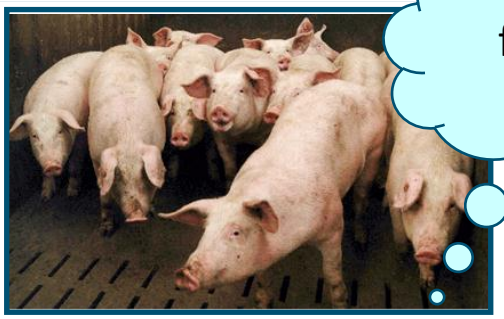
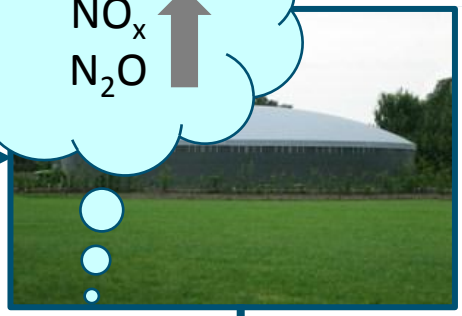
Mitigation opportunities & limitations (3/4)

Segregating urine & faeces



High DM faeces
NH_3 ↓

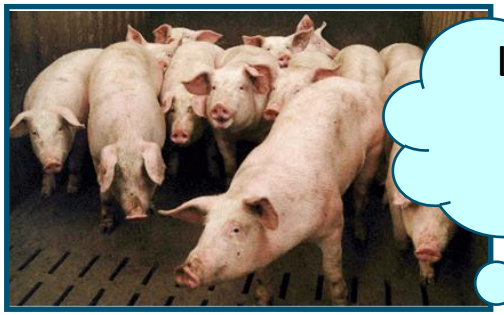
NO_x
N_2O ↑



NH_3 ↑

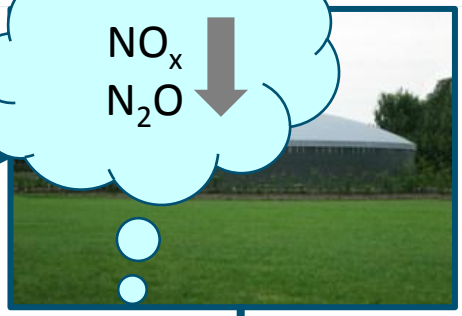
Mitigation opportunities & limitations (3/4)

Segregating urine & faeces



Low DM faeces
NH_3

NO_x
N_2O



NH_3

NO_3

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Mitigation opportunities & limitations (4/4)

Segregating urine & faeces

Main conclusion segregating urine & faeces:

- Opportunity: Keep urine and faeces separate to reduce GHGs
- Further process high DM faeces

- Limitations: Look at all related environmental impact categories and life cycle stages to consider shifting of emissions

Mitigation opportunities & limitations

Anaerobic digestion

Mitigation opportunities & limitations (1/3)

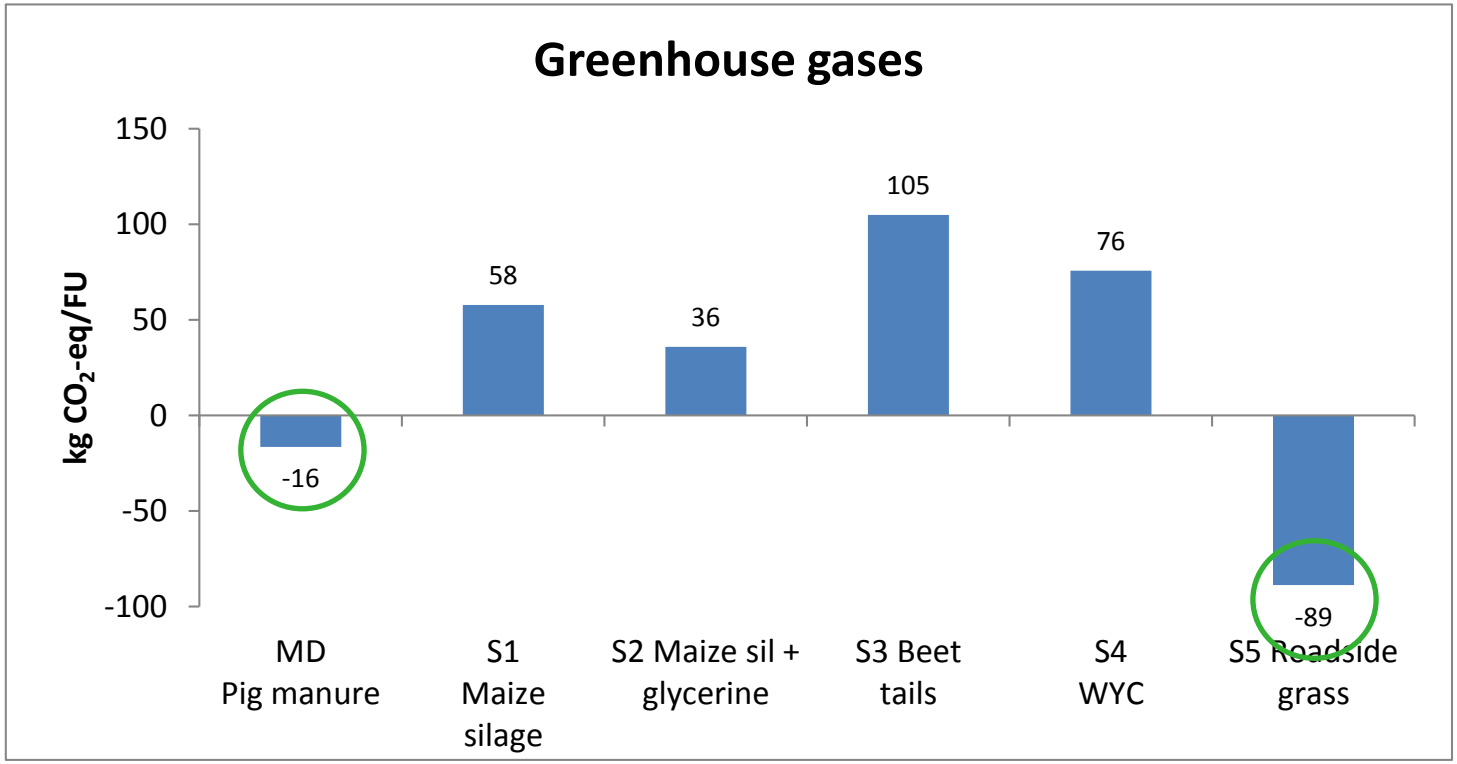
Anaerobic digestion

- Digestion of pig manure:
  - Mono digestion of pig manure
  - Co-digestion of manure with

Substrate		Initial use	(Substitute)
maize silage	→	feed	(land use)
glycerin/ maize silage	→	heat	(gas)
beet tails	→	feed	(barley)
wheat yeast concentrate	→	feed	(soy meal)
roadside grass	→	compost	(fertilizer)

Mitigation opportunities & limitations (2/3)

Anaerobic digestion



- Production of substituting product contributes to land use changes (up to 188 kg CO_2-eq), and increases acidification and eutrophication
- Avoided fossil electricity & heat reduced GHGs (up to 280 kg CO_2-eq)

Mitigation opportunities & limitations (3/3)

Anaerobic digestion

Main conclusions anaerobic digestion:

- Opportunities: Mono-digestion of pig manure reduces some GHGs (~2% of ag GHGs in NL), and produces energy

- Co-digestion with wastes/ residues increases bio-energy and reduces GHGs and other impacts

- Limitation: Co-digestion increases energy production, but also increases GHG emission through LUC when competing with feedstocks; and other impacts

Mitigation opportunities & limitations

Manure processing

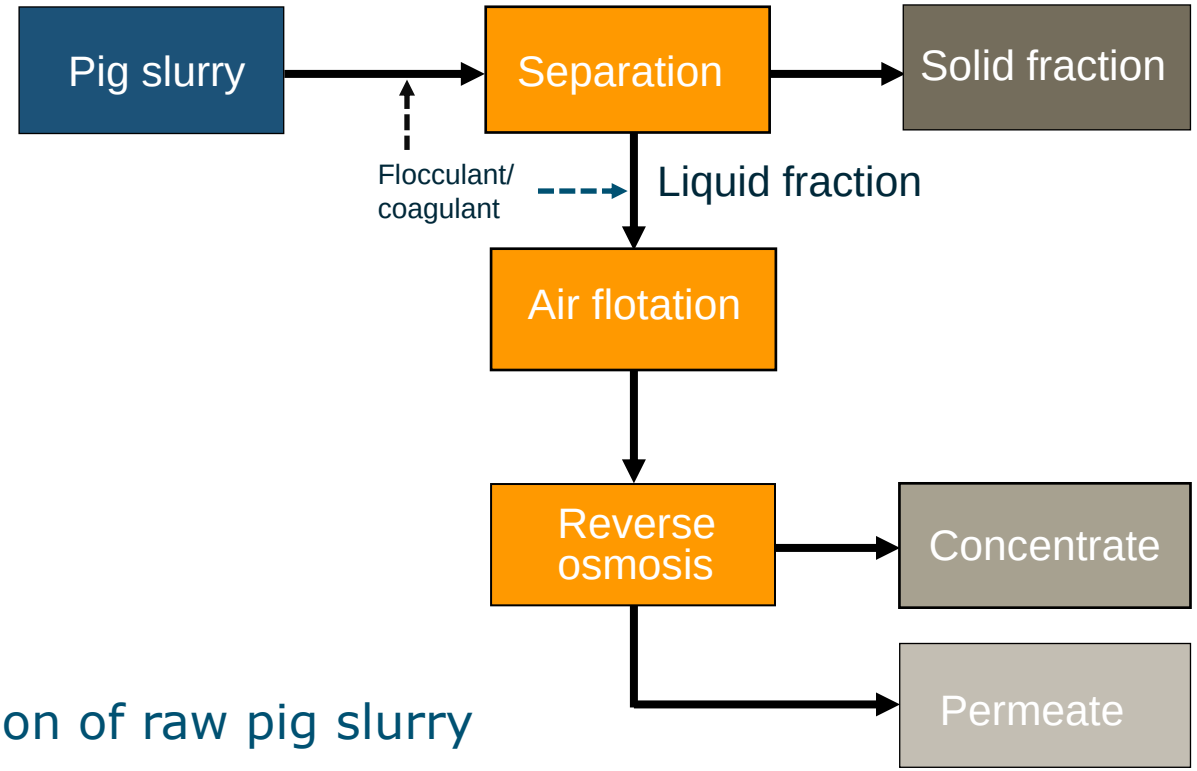
Mitigation opportunities & limitations (1/4)

Manure processing

- Production of mineral N-K concentrate as fertilizer
- Compare environmental consequences to conventional MM
- Scenarios:
    1. Production of concentrate
    2. Including anaerobic digestion of solid fraction

Mitigation opportunities & limitations (2/4)

Manure processing



3 step process:

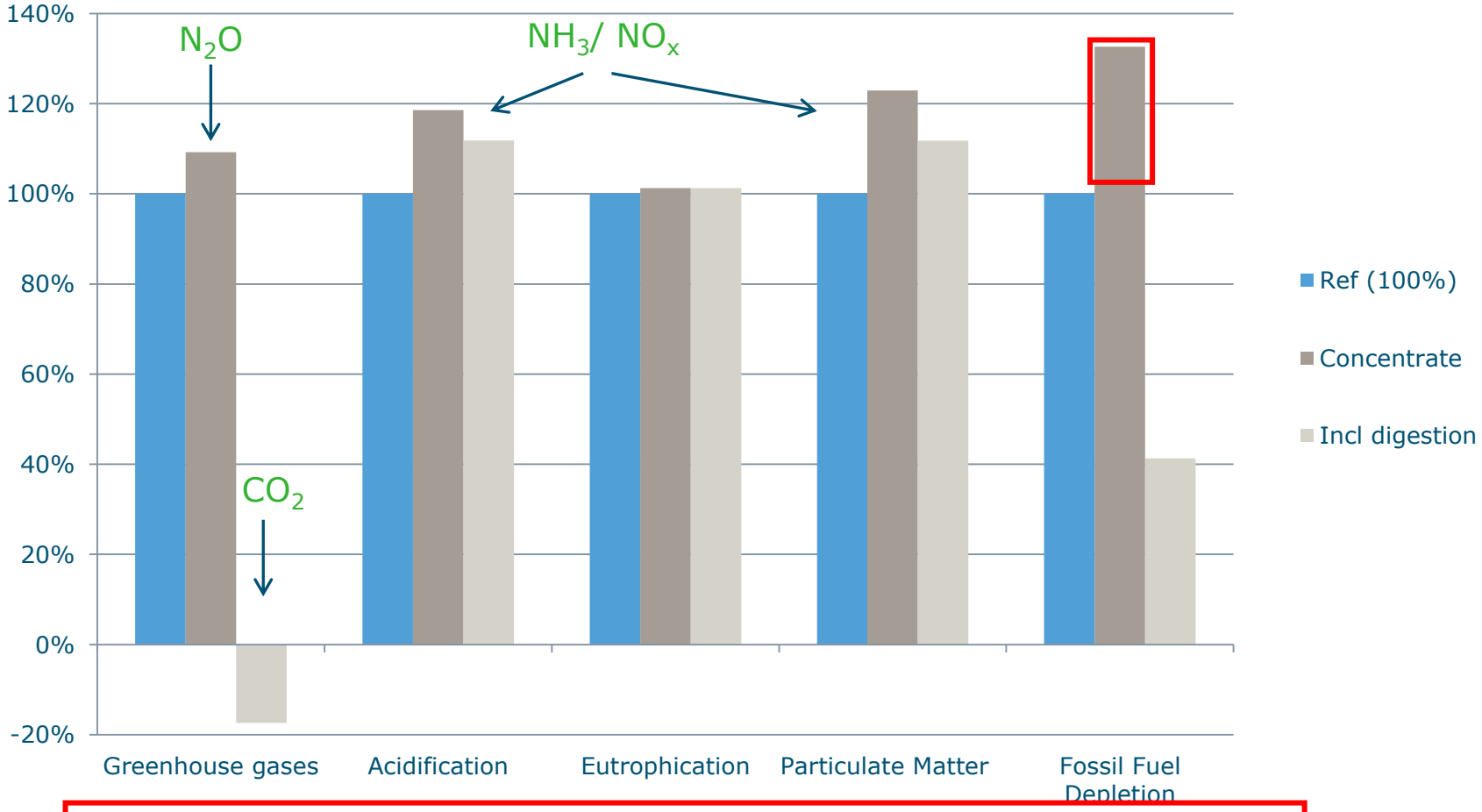
(1) Solid/liquid separation of raw pig slurry

(2) Removal of suspended solids from liquid fraction

(3) Concentration of dissolved minerals

Mitigation opportunities & limitations (3/4)

Manure processing



- Energy for transportation halved, but energy needed for processing
- With anaerobic digestion, energy is produced

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Mitigation opportunities & limitations (4/4)

Manure processing

Main conclusions manure processing

- Opportunity: With anaerobic digestion, processing reduces GHGs

- Limitations: Production of concentrate increased environmental impact through storage and processing

Conclusions Opportunities & Limitations

- LCA essential for showing opportunities & limitations to mitigate GHGs
- Opportunities
  - Segregating urine and faeces reduces GHGs up to 82% compared to conventional MM
  - Anaerobic mono digestion and co-digestion with roadside grass (waste) reduce GHGs
- Limitations
  - Shifting of N emissions to other environmental impact categories/ life cycle stages→ Bias to look only at GHGs
  - Anaerobic co-digestion: competition with feed leading to land use changes and increased GHG emission

Outlook

- Integrate concepts from life cycle perspective to reduce emissions and improve fertilizer products

- Keep it simple

End

'Don't get biased when GHG emissions are the highest'!

Look at all related impacts

Thank you!

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