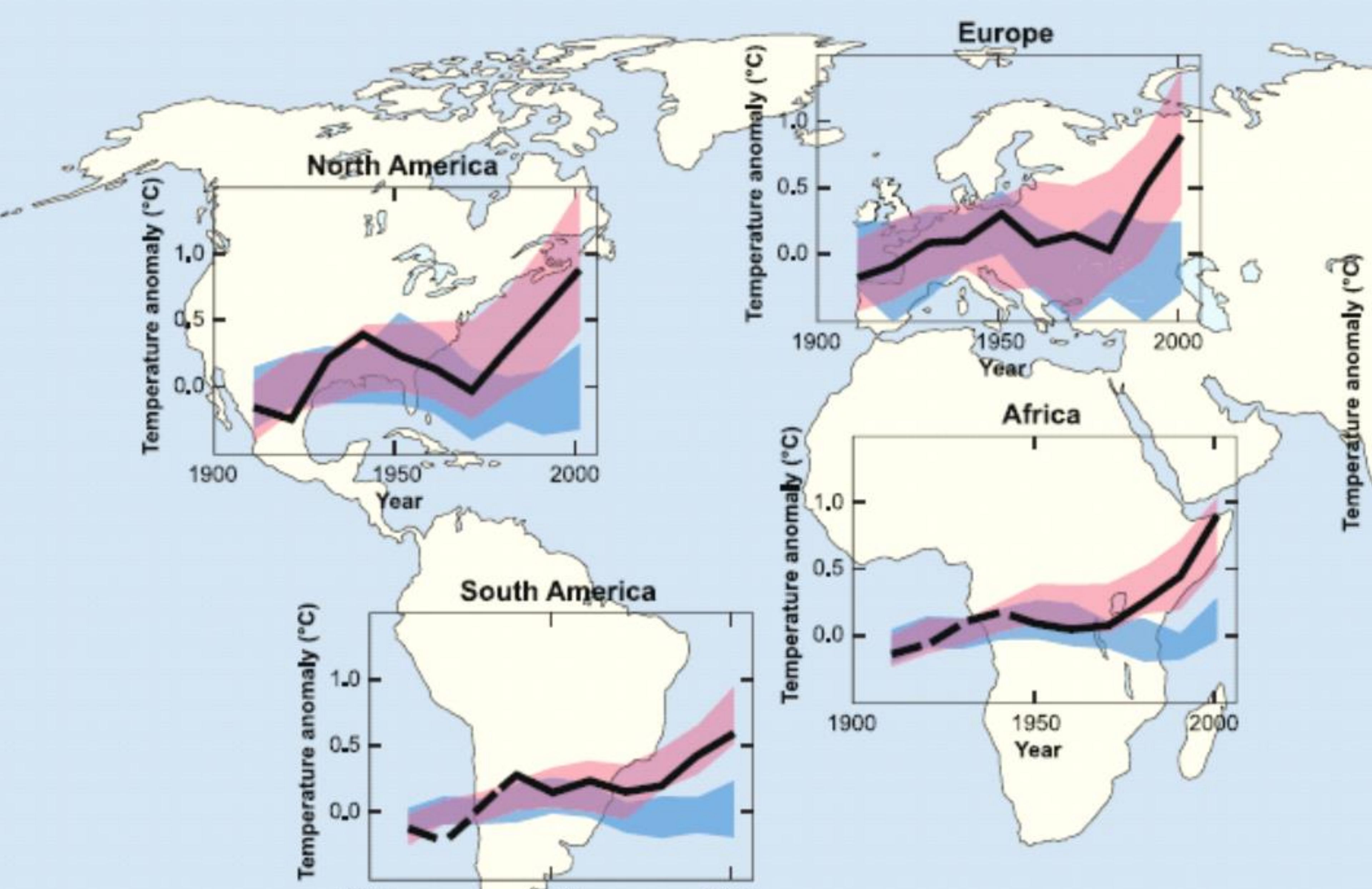
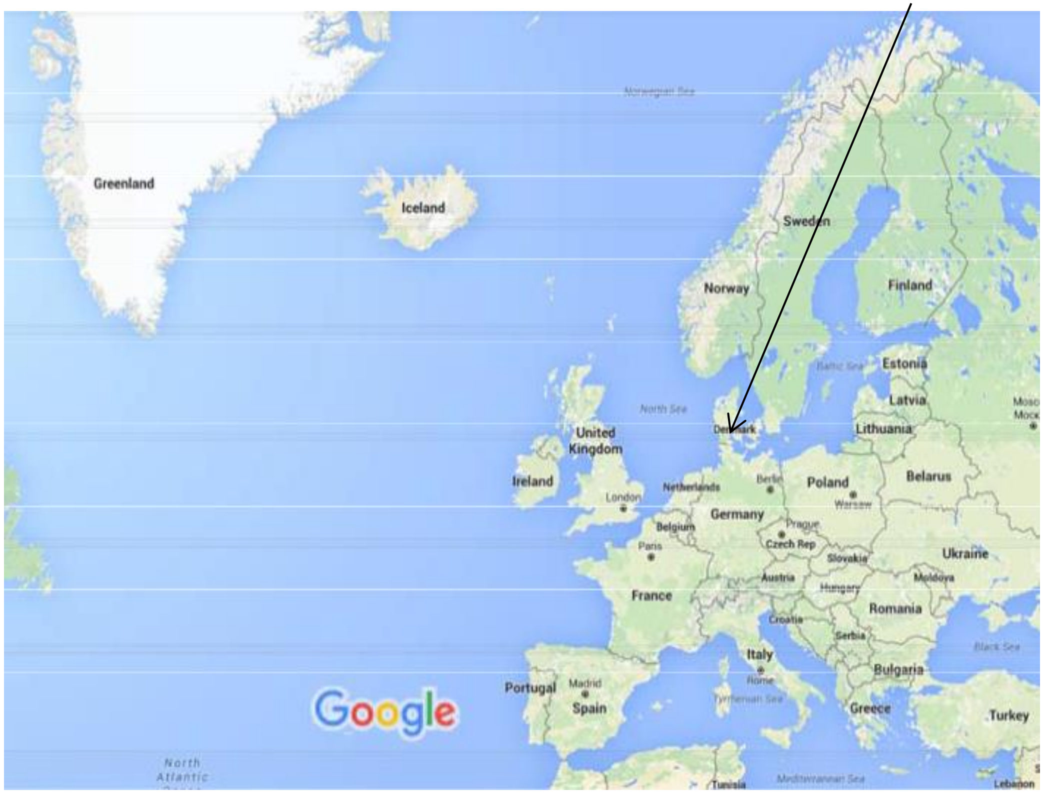
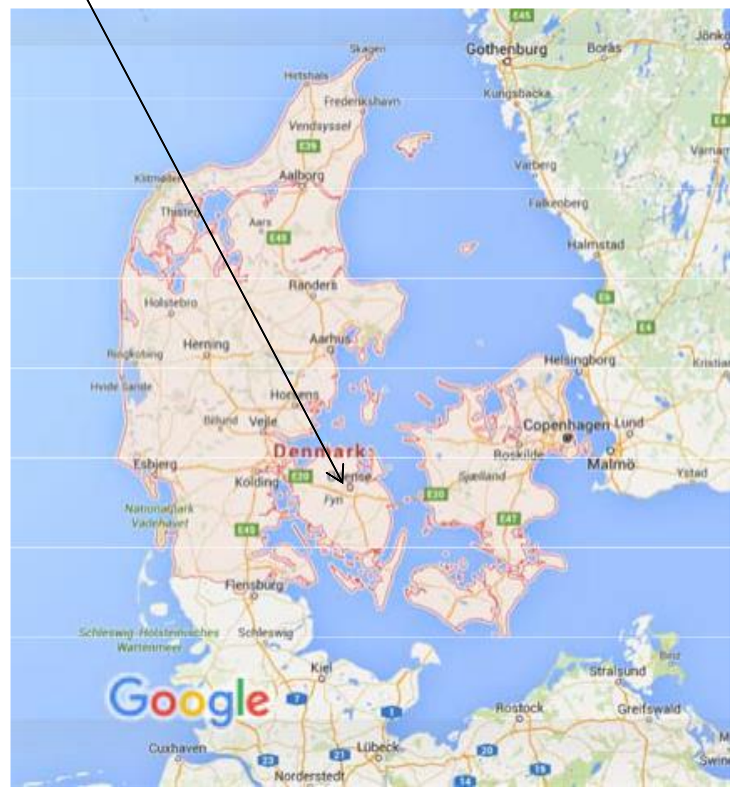


Model of the biowaste management continuum for estimating GHG emission

UNIVERSITY OF SOUTHERN DENMARK





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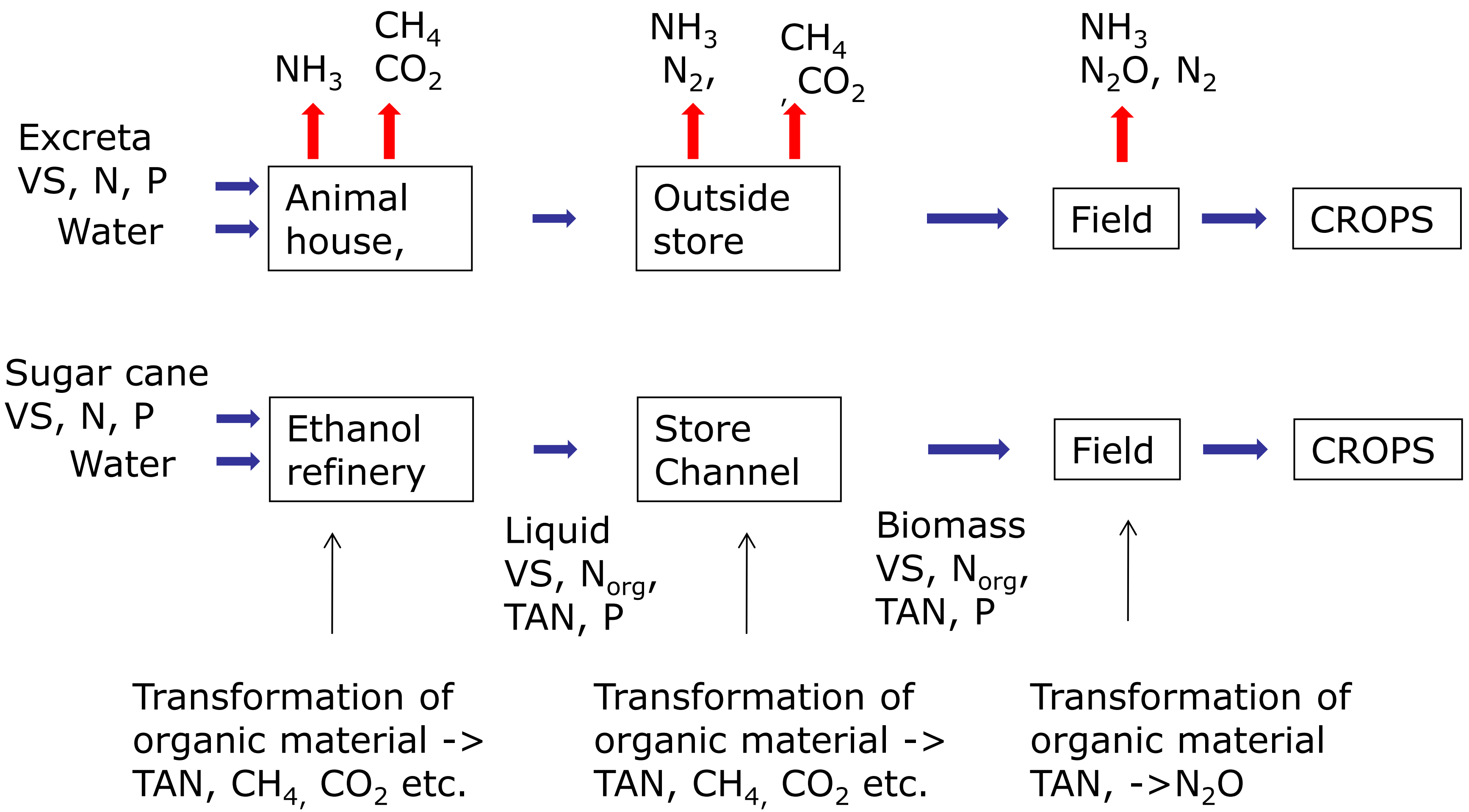
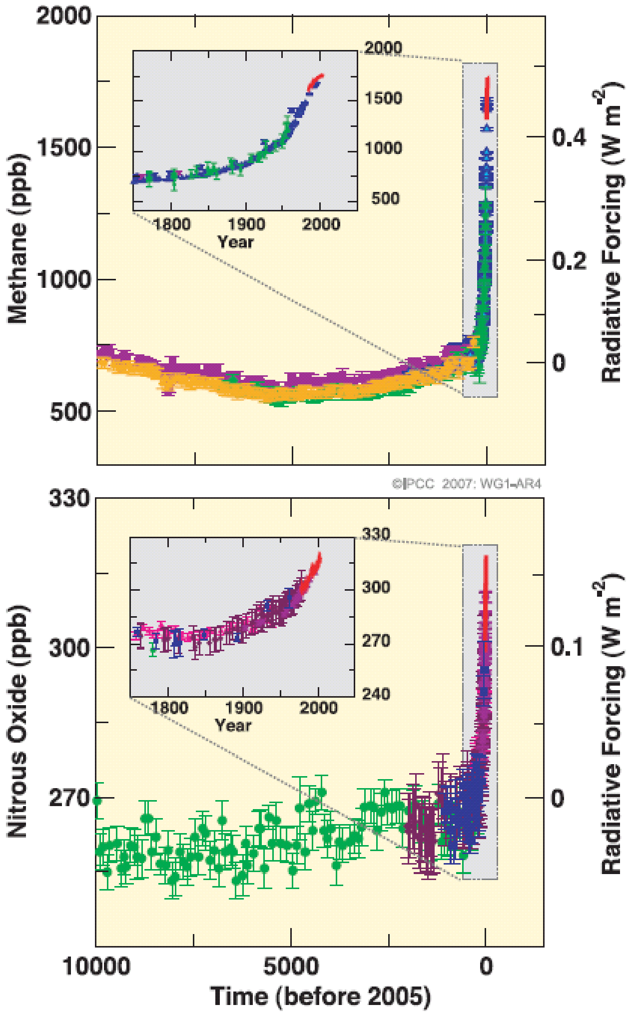
Animal slurry and vinasse management continuum



Greenhouse gas (GHG) emissions from livestock manure

- The rationale for considering manure a significant source of methane (CH_4) and nitrous oxide (N_2O)
- Manure management and GHG emission
- Driving variables, interactions with climate
- Effects of management: Exemplified by anaerobic digestion and separation

Methane and nitrous oxide



Contribution to net global warming (anthropogenic) from:

- Methane 30%
- Nitrous oxide 10%

(IPCC, 2007)

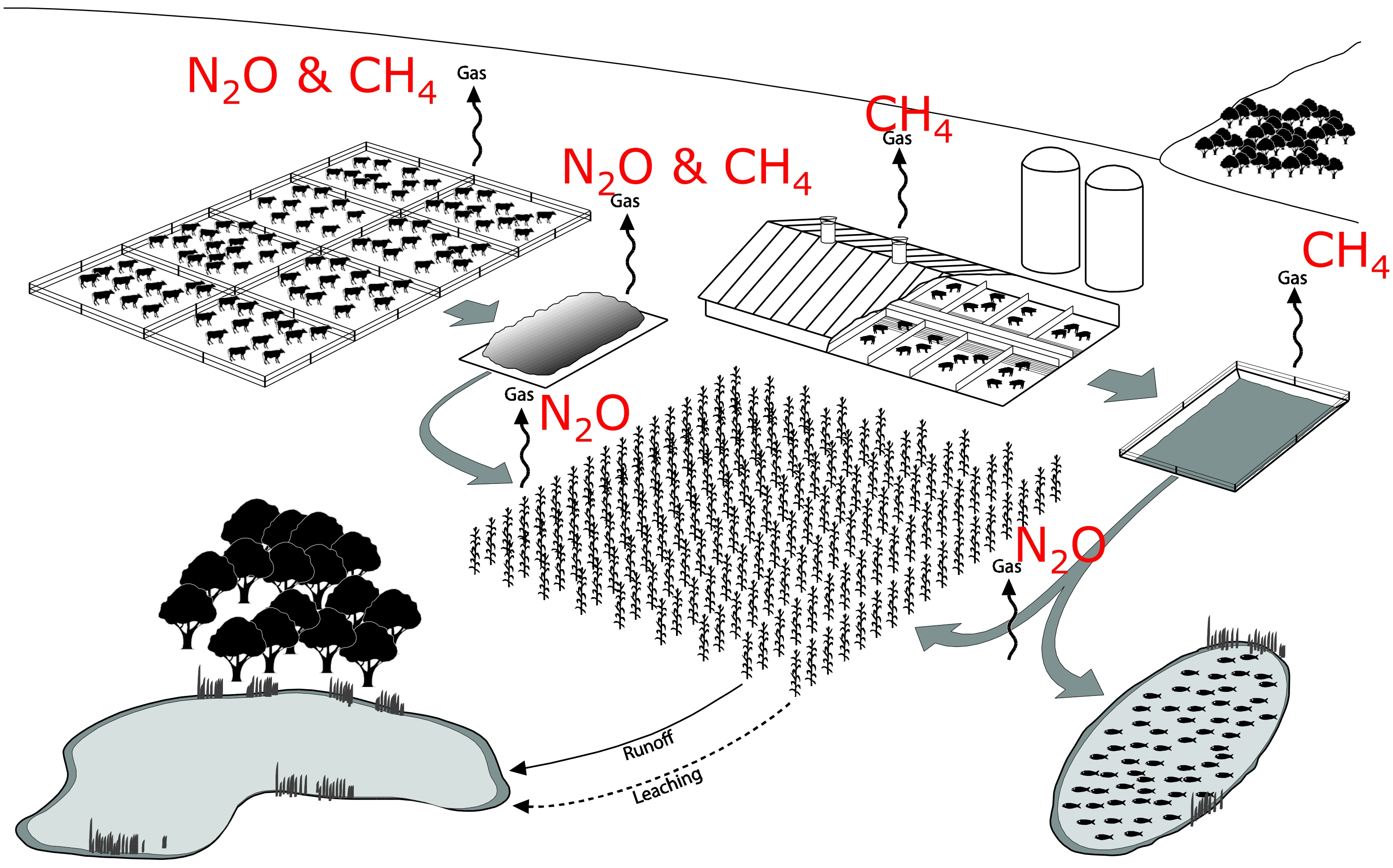
Livestock contributes:

- 37% of global CH_4 emission
- 65% of global N_2O emission

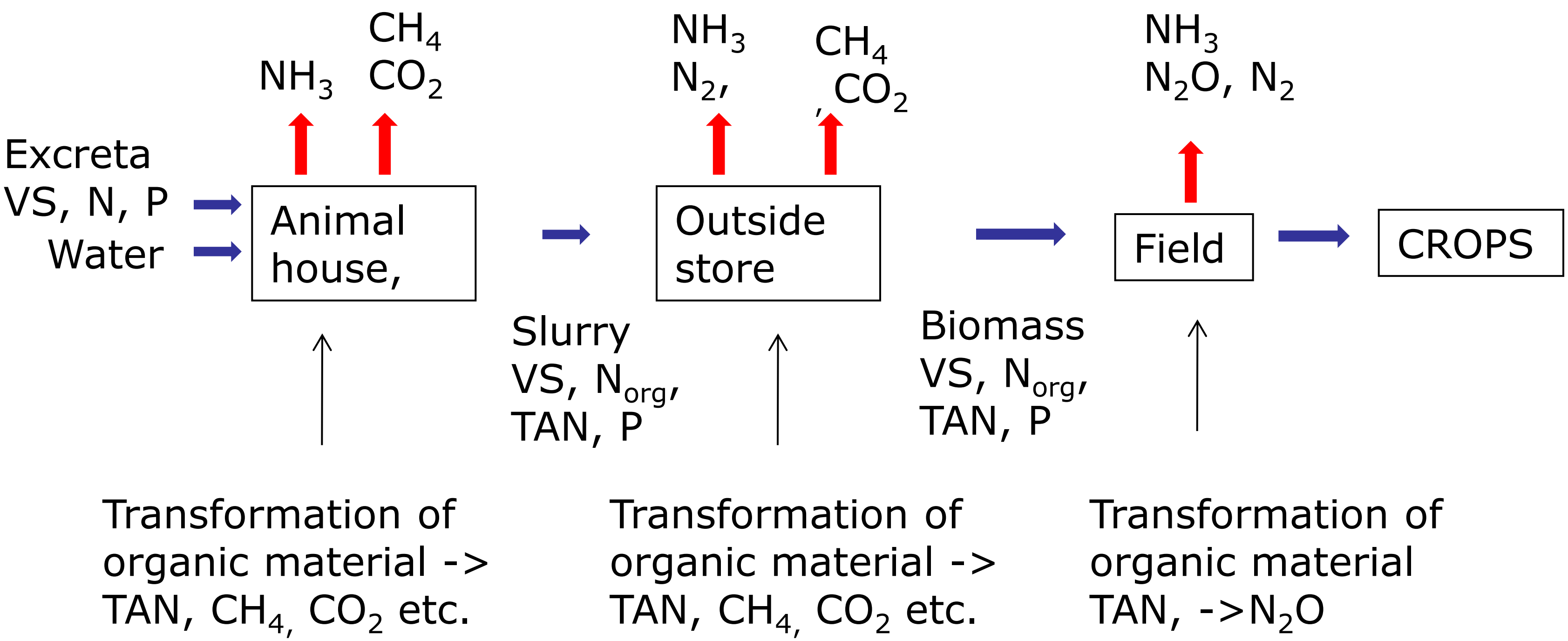
(FAO 2006, Livestock long shadow)

IPCC 2006

Greenhouse gas emission from livestock production

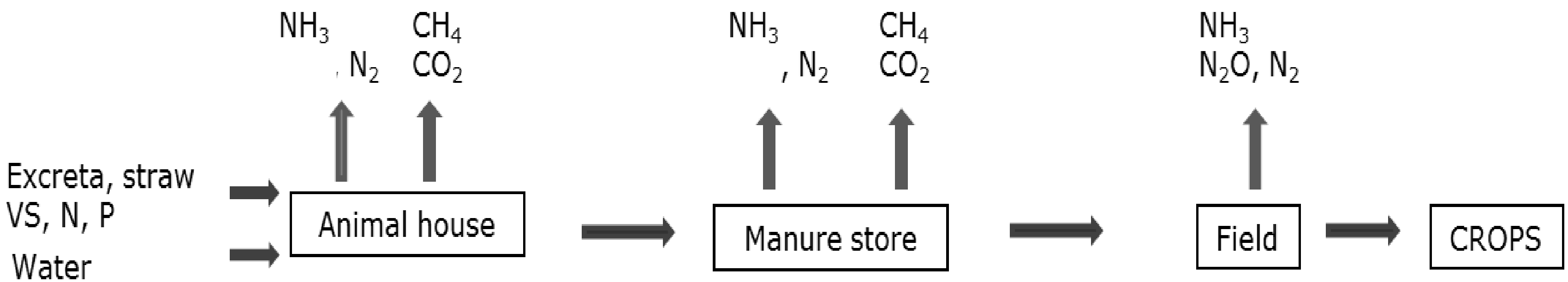


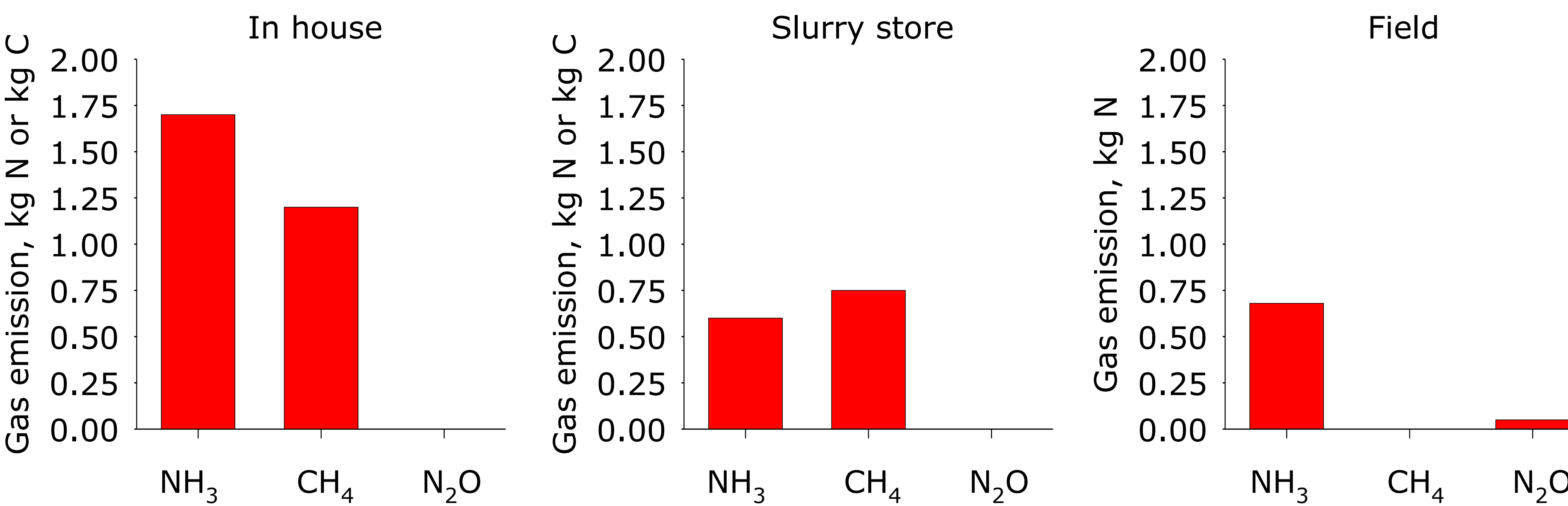
Manure management continuum



Nitrous oxide and methane emission models

Example: Pig slurry from one pig place – 3 fatteners per year (Sommer et al., 2013)





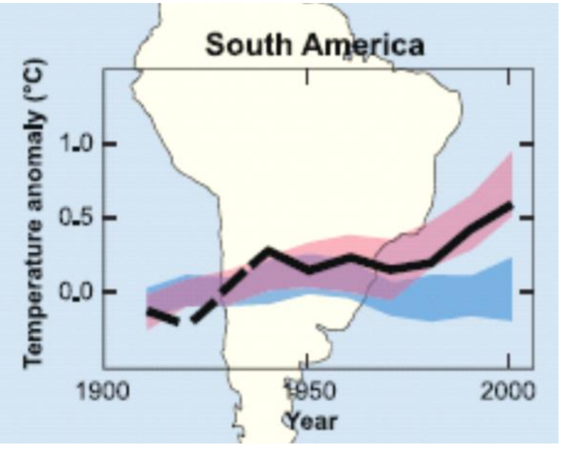
Methane and nitrous oxide

Environmental preconditions:

- Methane (CH_4): anaerobic environment
- Nitrous oxide (N_2O): a mosaic of aerobic and anaerobic sites

Climate warming effect of methane and nitrous oxide (IPCC 2013):

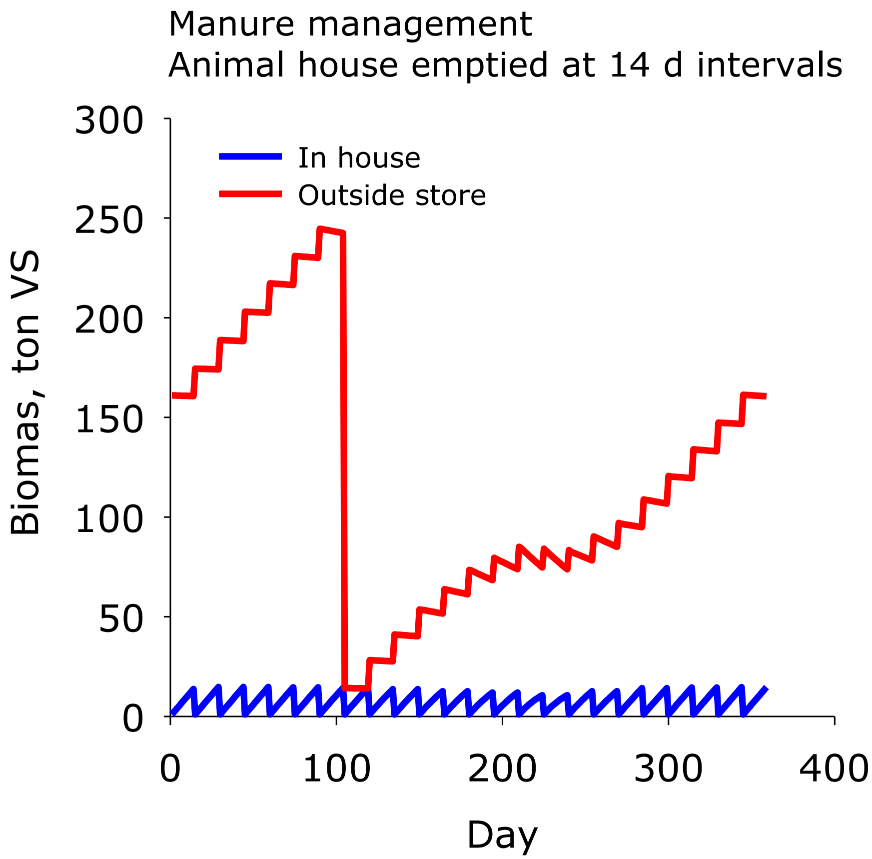
- 1 kg CH_4 equals effect of 34 kg CO2
- 1 kg N_2O equals effect of 298 kg CO_2

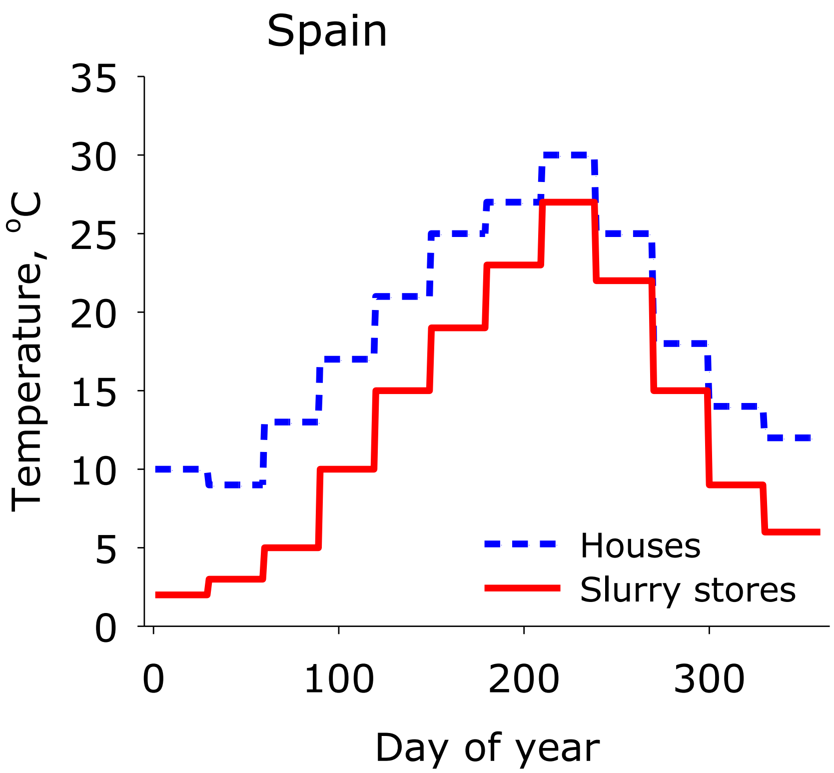


Example: Calculating CH_4 emissions from a Spanish pig barn

Effect of reducing storage time in the barn from 14 d to 1 d
(time until transfer to outside store)

Climate and excretion from pig production

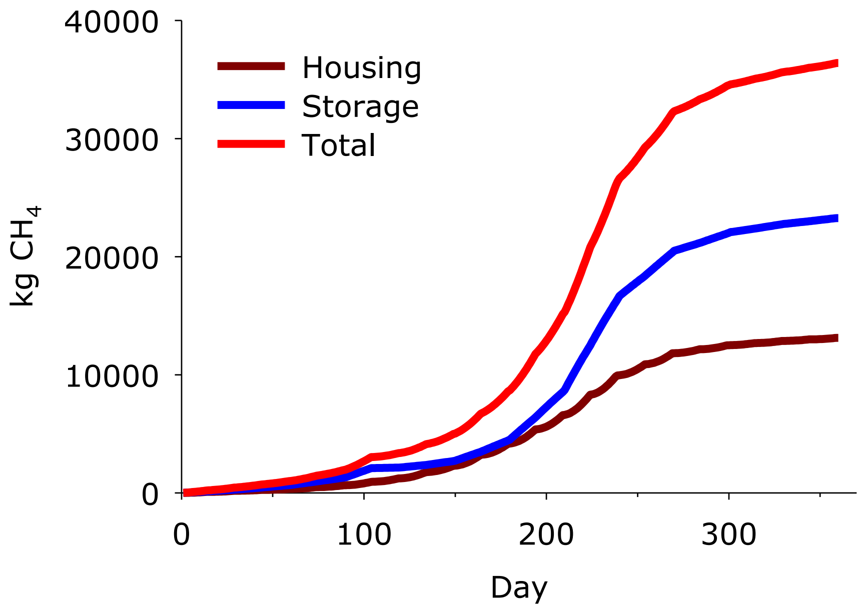




Manure management
Reduce in-house slurry storage in Spain

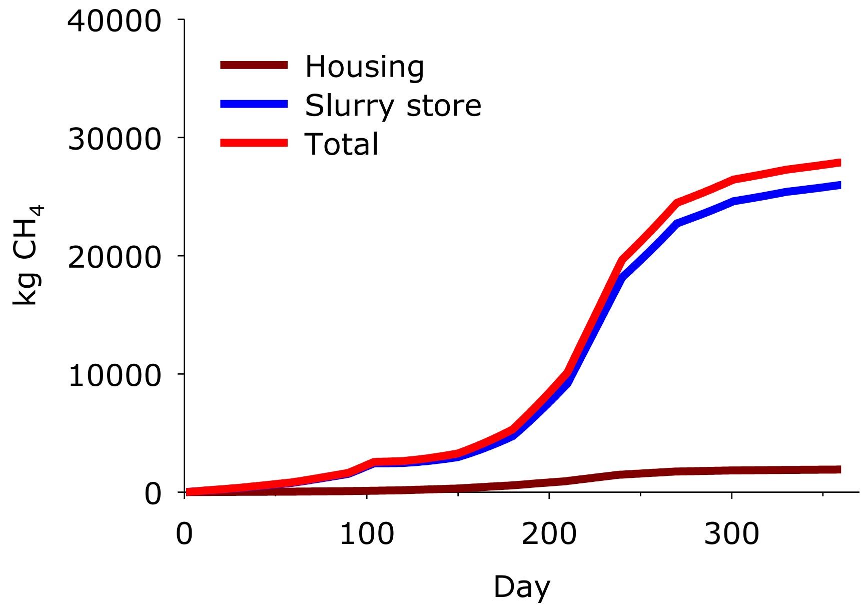
14 d

Fortnightly slurry removal from pig house



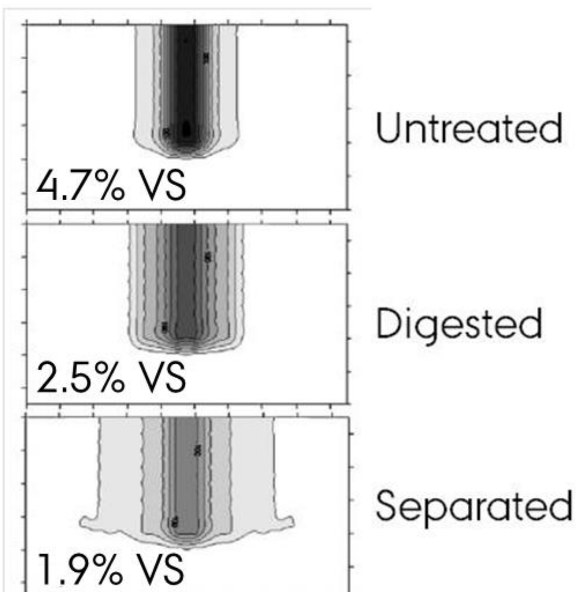
1 d

Daily slurry removal from house



N_2O emission model
Liquid of waste is partly absorbed by the soil

Ammoniacal N after 24 h:



Retention of liquid declines with volatile solids concentration:

$$f_R = 1 - (1 + aVS)^{-1}$$

$$a = 0.063 + 1.33\exp(77.8\psi)$$

f_R is fraction retained
VS is volatile solids
µ is soil water potential

N_2O emission model
Assumptions

- VS_d and TAN is soluble = mobile
  VS_{nd} is particulate = immobile

- Three main sources of N_2O:

Slurry clumps (oxygen limited)

- Nitrification (N_{cl})
- Denitrification (D_{cl})

Bulk soil (well-aerated)

- Nitrification (N_s)

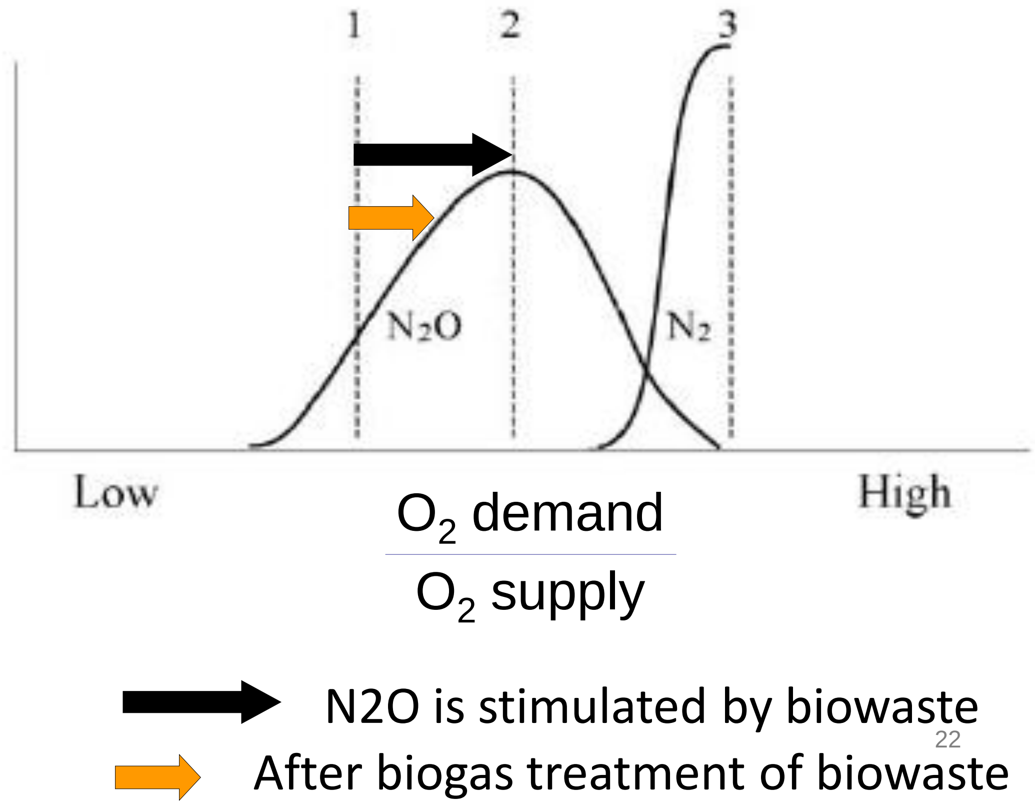
Two compartments:
- wet ”hotspots
- bulk soil

- Degradable VS is a main driver of denitrification, together with oxygen supply from the soil

N_2O emission model
Balance between O_2 supply controls emission potential

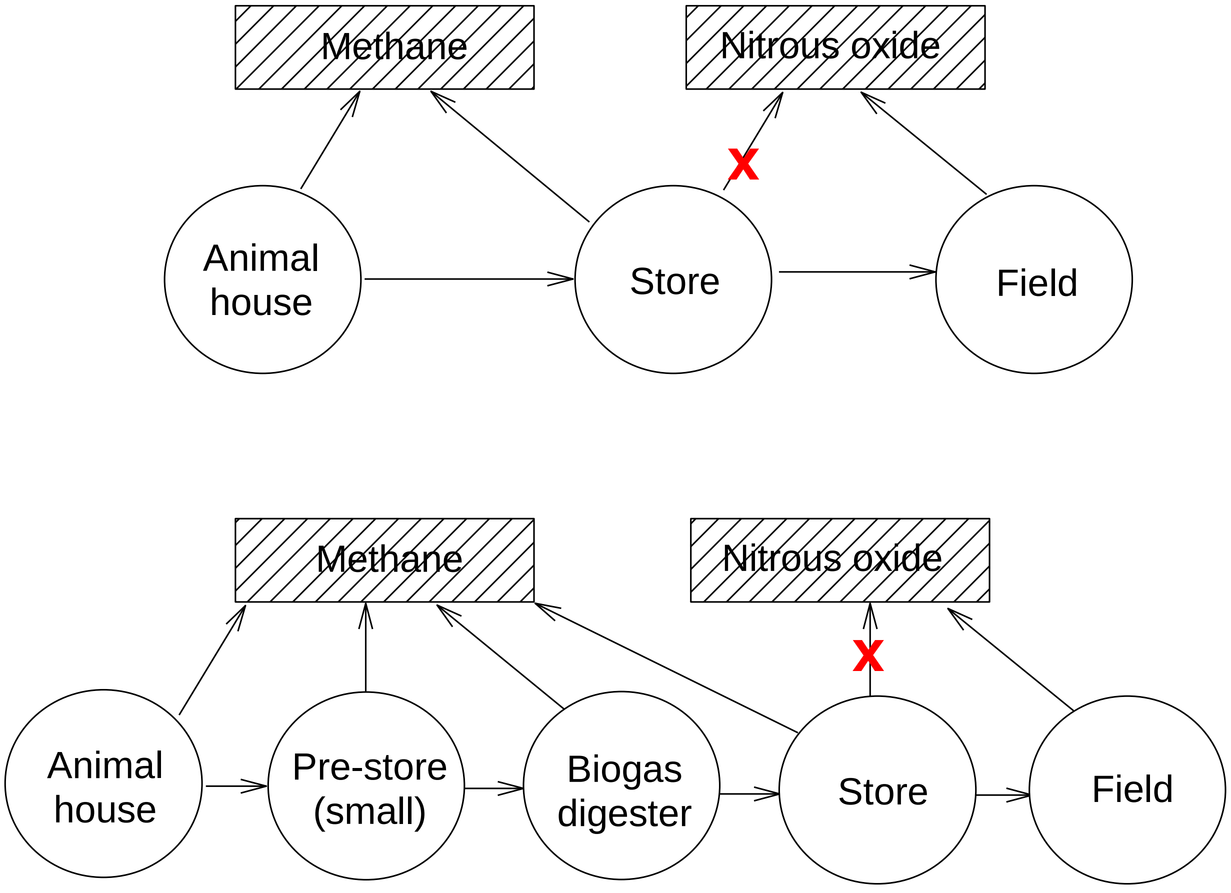
O_2 demand:
- manure VS composition
- slurry redistribution

O_2 supply:
- texture
- compaction
- moisture

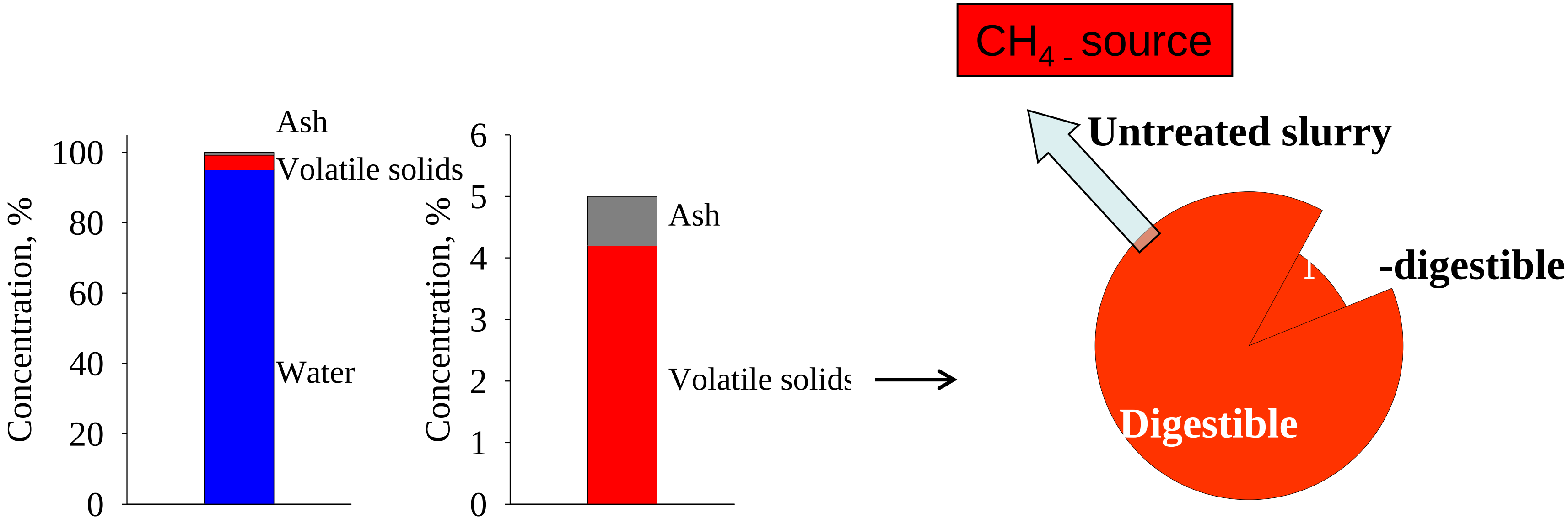


Including biogas treatment in the manure management continuum and methane emission calculations

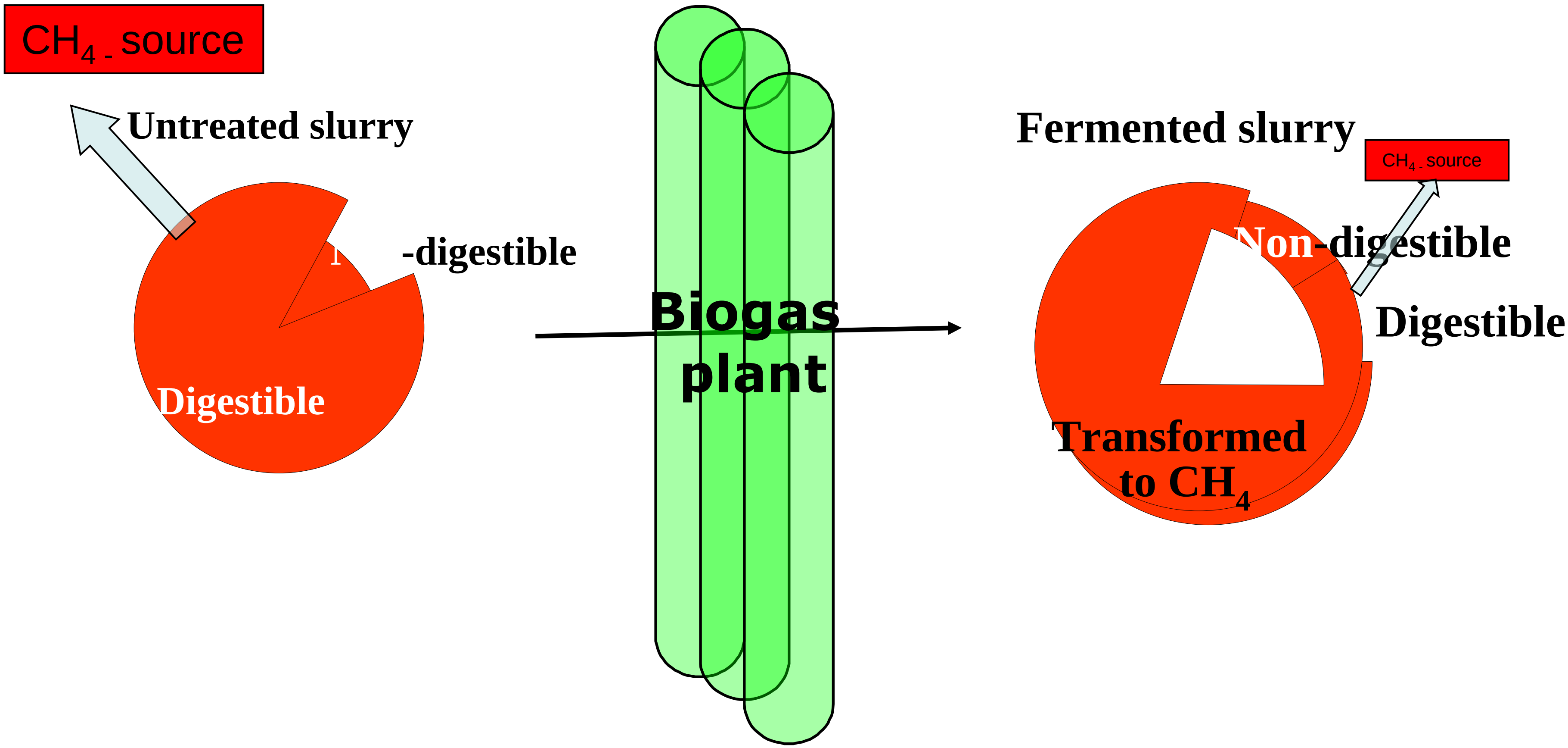
Farming systems with and without anaerobic digestion (AD) producing biogas



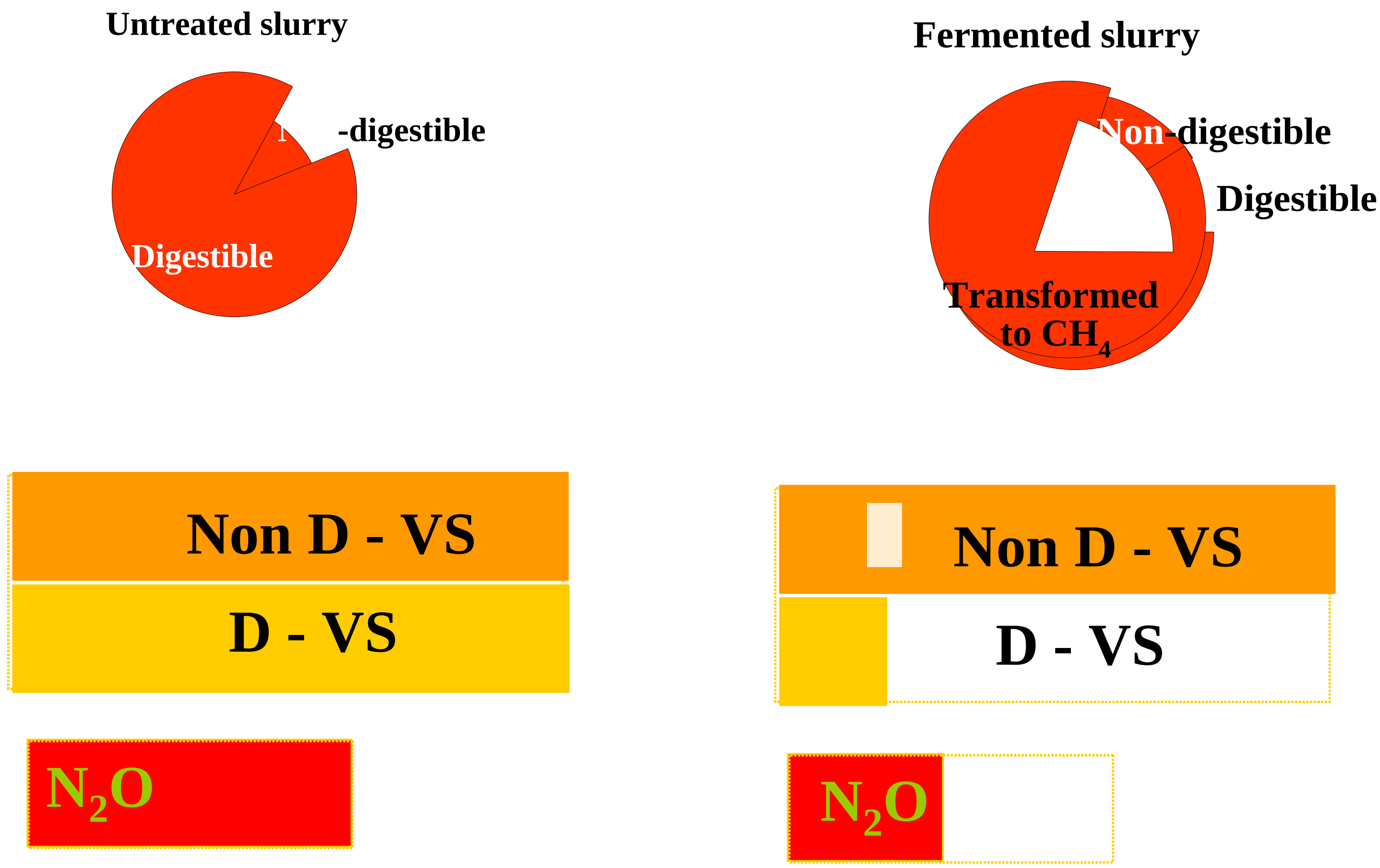
Effects of AD on methane (CH_4) and nitrous oxide (N_2O) emissions



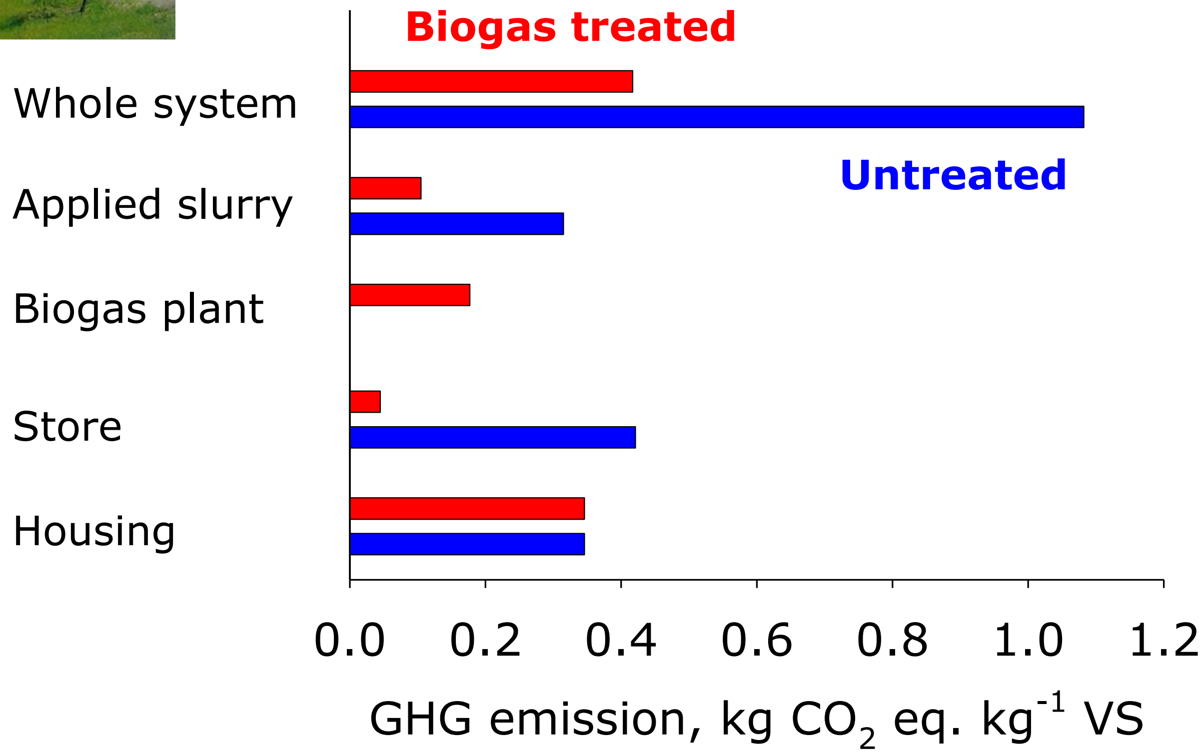
Effects of AD on methane (CH_4) and nitrous oxide (N_2O) emissions



Effect of reducing degradable VS on N_2O emissions after field application



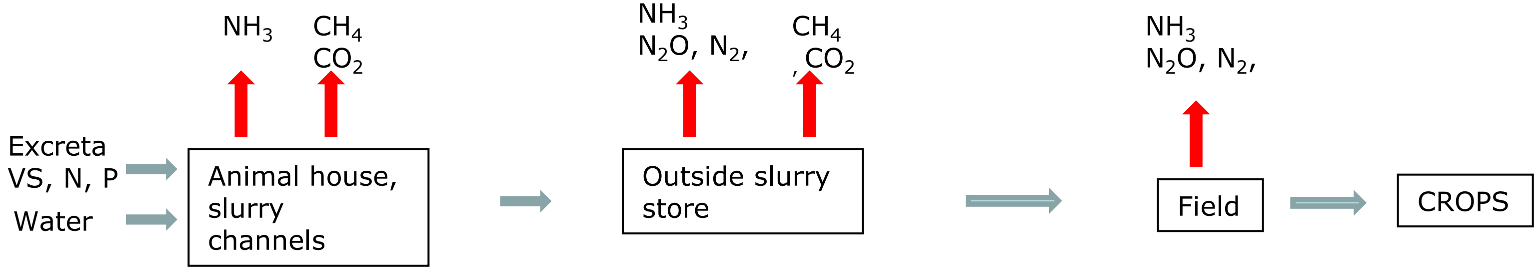
GHG emission - effects of anaerobic digestion of livestock slurry



The effect of separating slurry

Manure management: Four cases

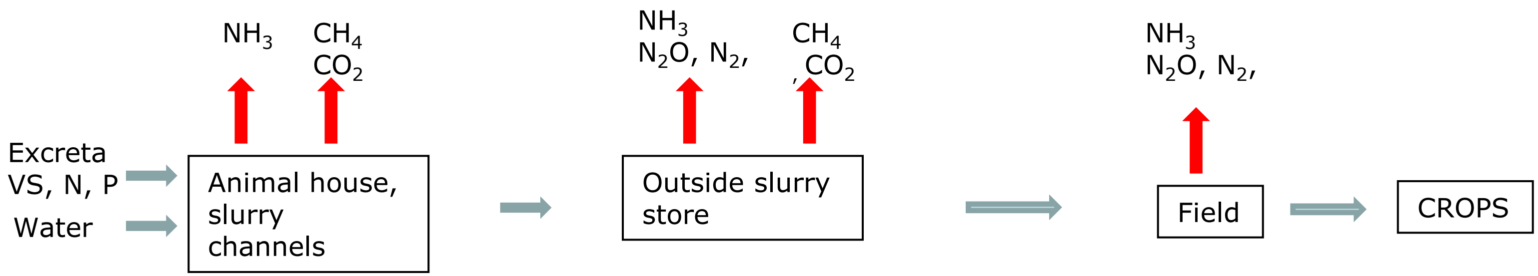
1. Traditional system - Baseline
2. Traditional system - Daily removal of slurry from animal house



GHG emissions and change in soil carbon
Baseline and reduced inhouse slurry storage

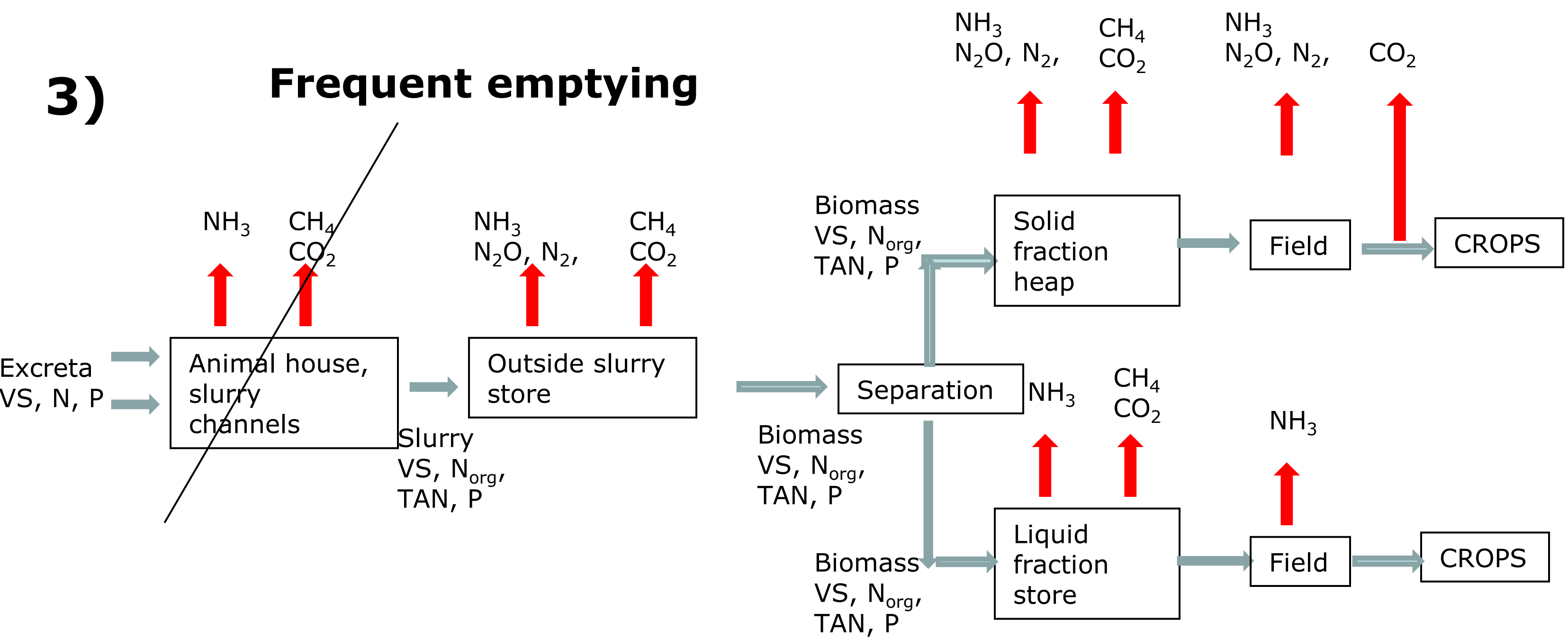
			Baseline	Reduced in-house storage
			Mg CO_2-eq $year^{-1}$	
House	Slurry	CH_4	30	4.5
Store	Slurry/liquid	CH_4	36	39.6
Field	Slurry/liquid	N_2O	60.7	88.8
Soil	Sequestration	C	-28.4	-31.8
	Total		98.2	100.9

Manure management: Four cases



1. Traditional system - Baseline
2. Separatton + Daily removal of slurry

3) **Frequent emptying**



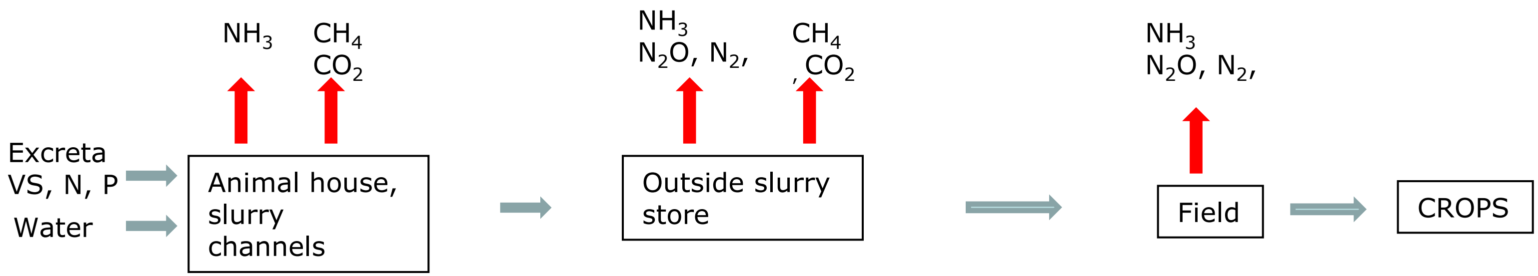
Separation frequent emptying

GHG emissions, energy and change in soil carbon

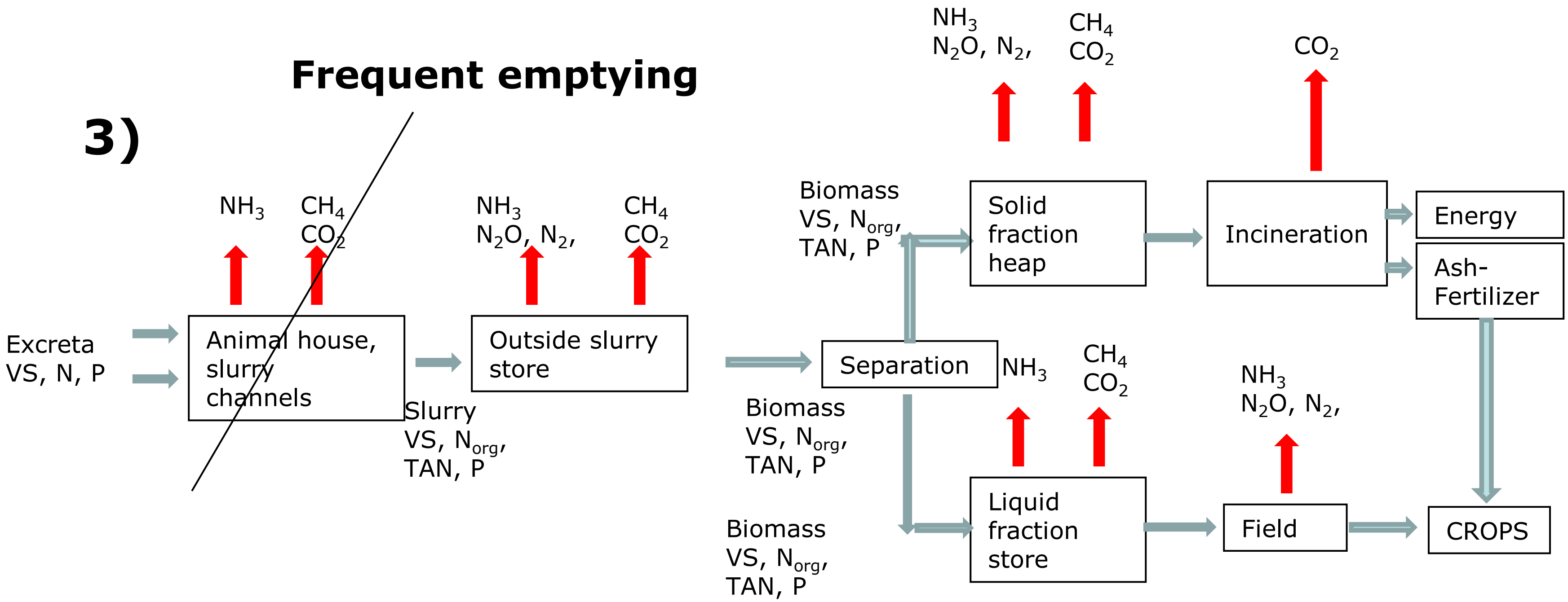
Baseline and separation

			Baseline	Separation
			Mg CO_2.eq year	
House	Slurry	CH_4	30	4.5
Store	Slurry/liquid	CH_4	36	19.4
Field	Slurry/liquid	N_2O	60.7	50.4
Store	Fibre	CH_4	0	8.8
Store	Fibre	N_2O	0	4.7
Field	Fibre	N_2O	0	1
Energy	Consumption		0	2.8
Coal	Substitution		0	0
Soil	Sequestration	C	-28.4	-33.5
Net emission			98.3	58.1

Manure management: Four cases



1. Traditional system – Baseline daily removal
3. Separation & incineration - Daily removal

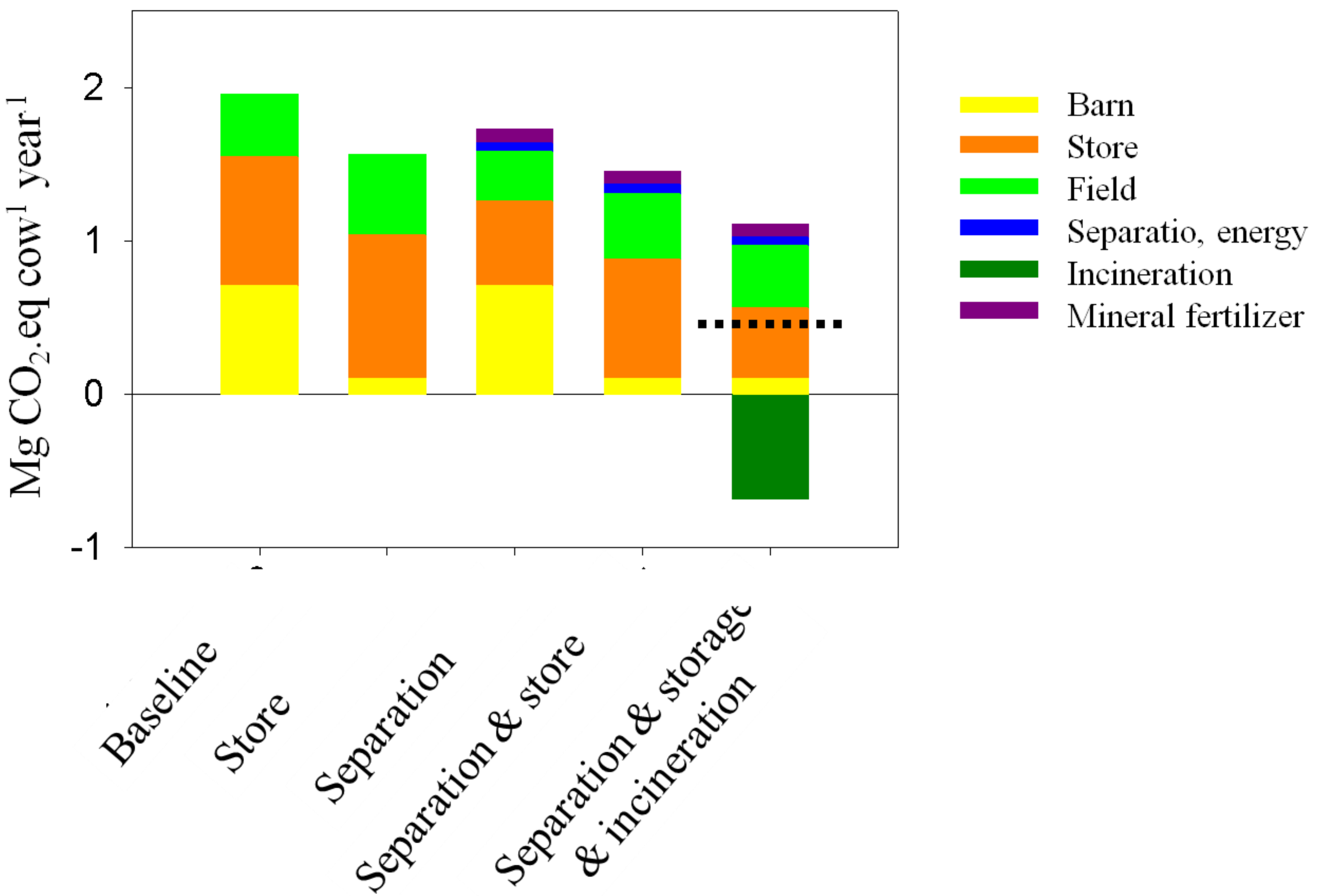


4.

GHG emissions, energy, change in soil carbon
Baseline and separation

			Baseline	Separation and incineration
			Mg CO_2.eq year^{-1}	
House	Slurry	CH_4	30	4,5
Store	Slurry/liquid	CH_4	36	19,4
Field	Slurry/liquid	N_2O	60,7	50,4
Store	Fibre	CH_4	0	0
Store	Fibre	N_2O	0	0
Field	Fibre	N_2O	0	0
Energy	Consumption		0	2,8
Coal	Substitution		0	-29,1
Soil	Sequestration	C	-28,4	-11,7
Net emission			98,3	36,3

GHG balance per dairy cow



Conclusion, potential reductions

- Reducing emissions at one stage in slurry mangagement chain may increase emissions downstream (separation)
- Combining treatments can give positive interactions (synergy) with significant overall reduction in GHG emission
- Manure can be a significant energy source
- There is a potential for reducing GHG emission by fermenting livestock slurry
- The reduction in N_2O emissions highly dependent on soil conditions
- Potential for synergistic effects when combining better manure management with AD