4th one-day symposium of the Animal Task Force & the EAAP Commission on Livestock Farming Systems: *Livestock are more than food*

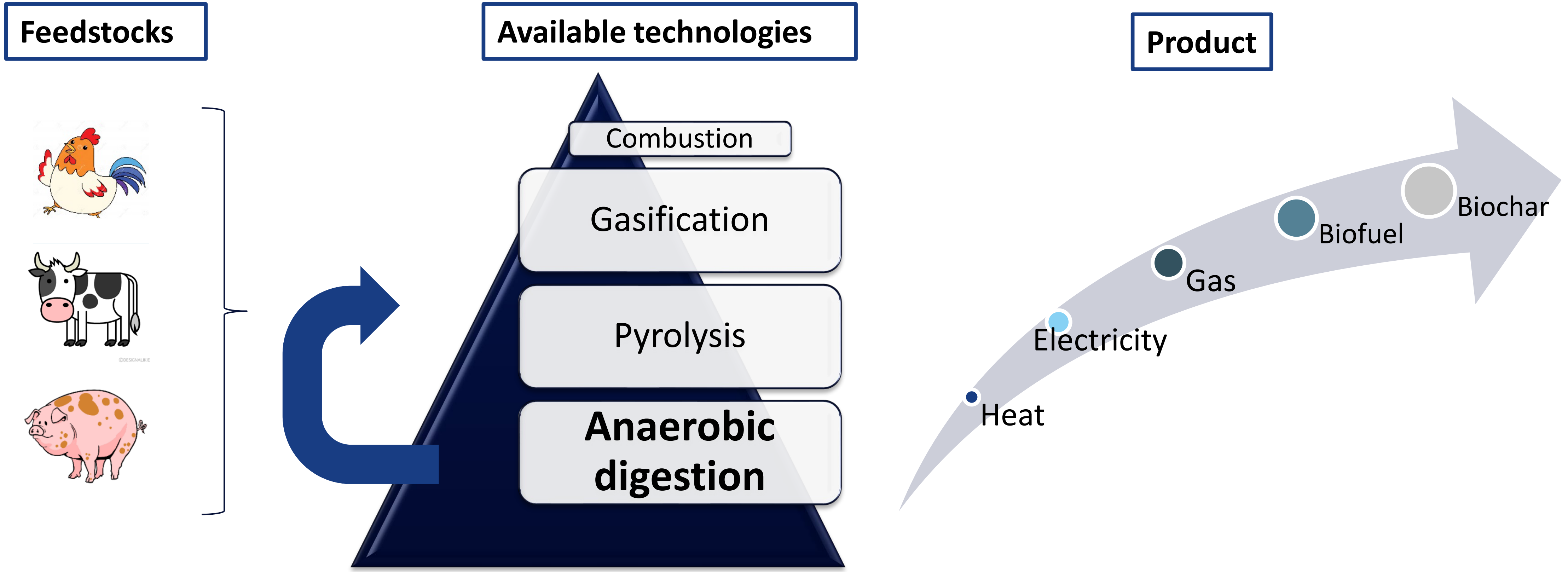
Livestock manure for fertilizer and biofuels

Henrik B. Møller

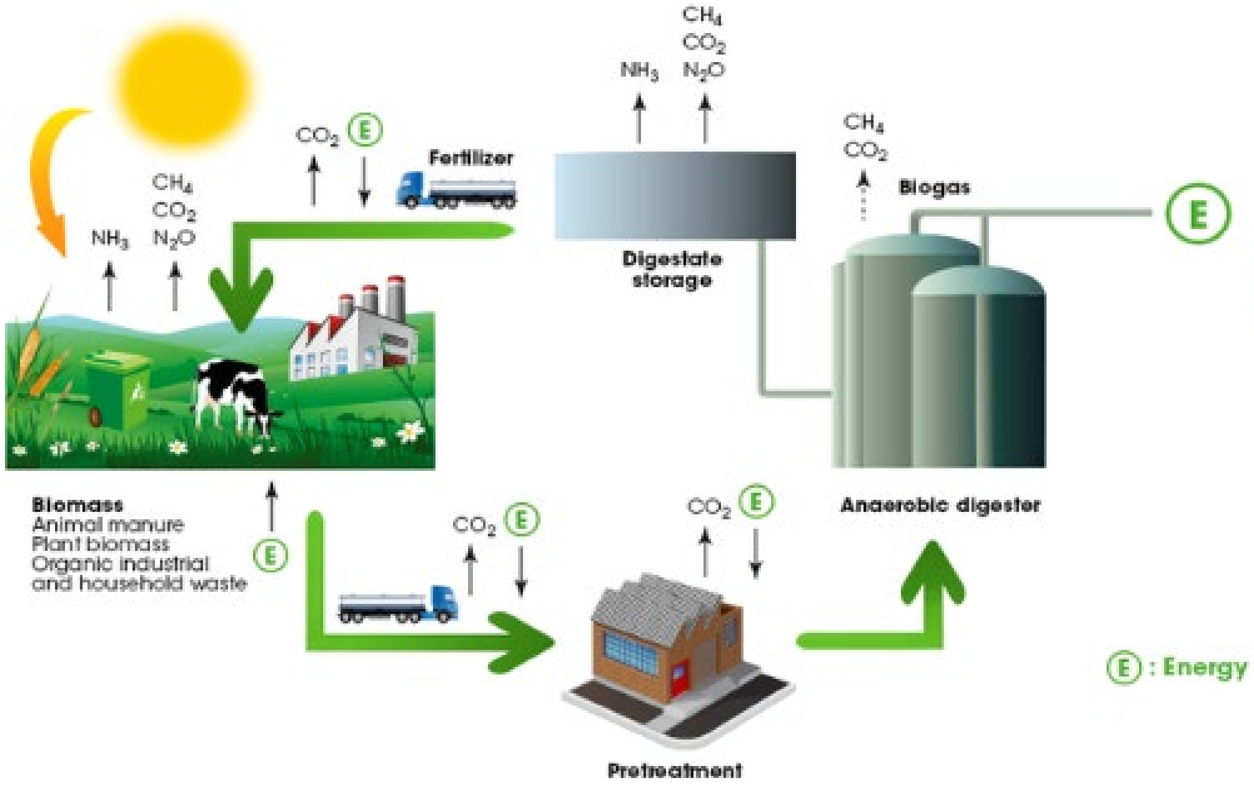
Aarhus University

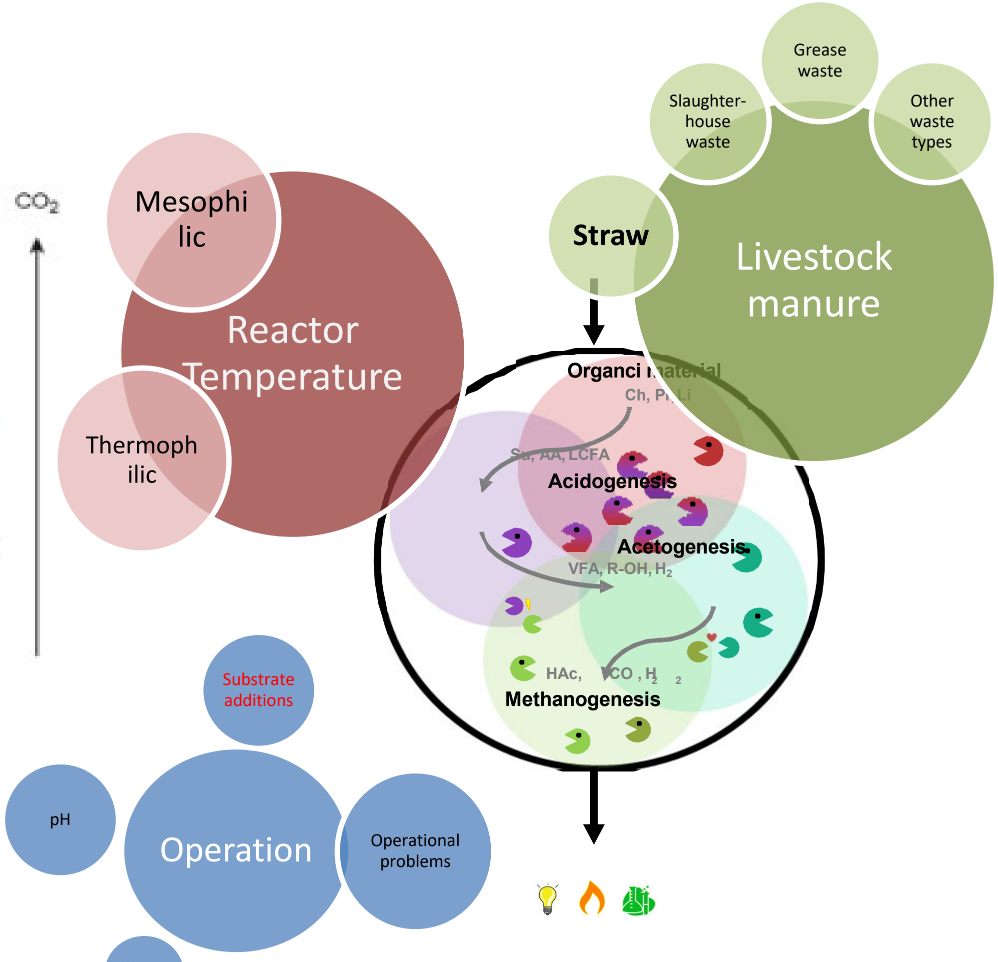
Denmark

LIVESTOCK MANURE FOR BIOFUEL



AD – THE MOST DEVELOPED BIOFUEL





NUTRIENTS IN LIVESTOCK MANURE

Europe (TgN/year)

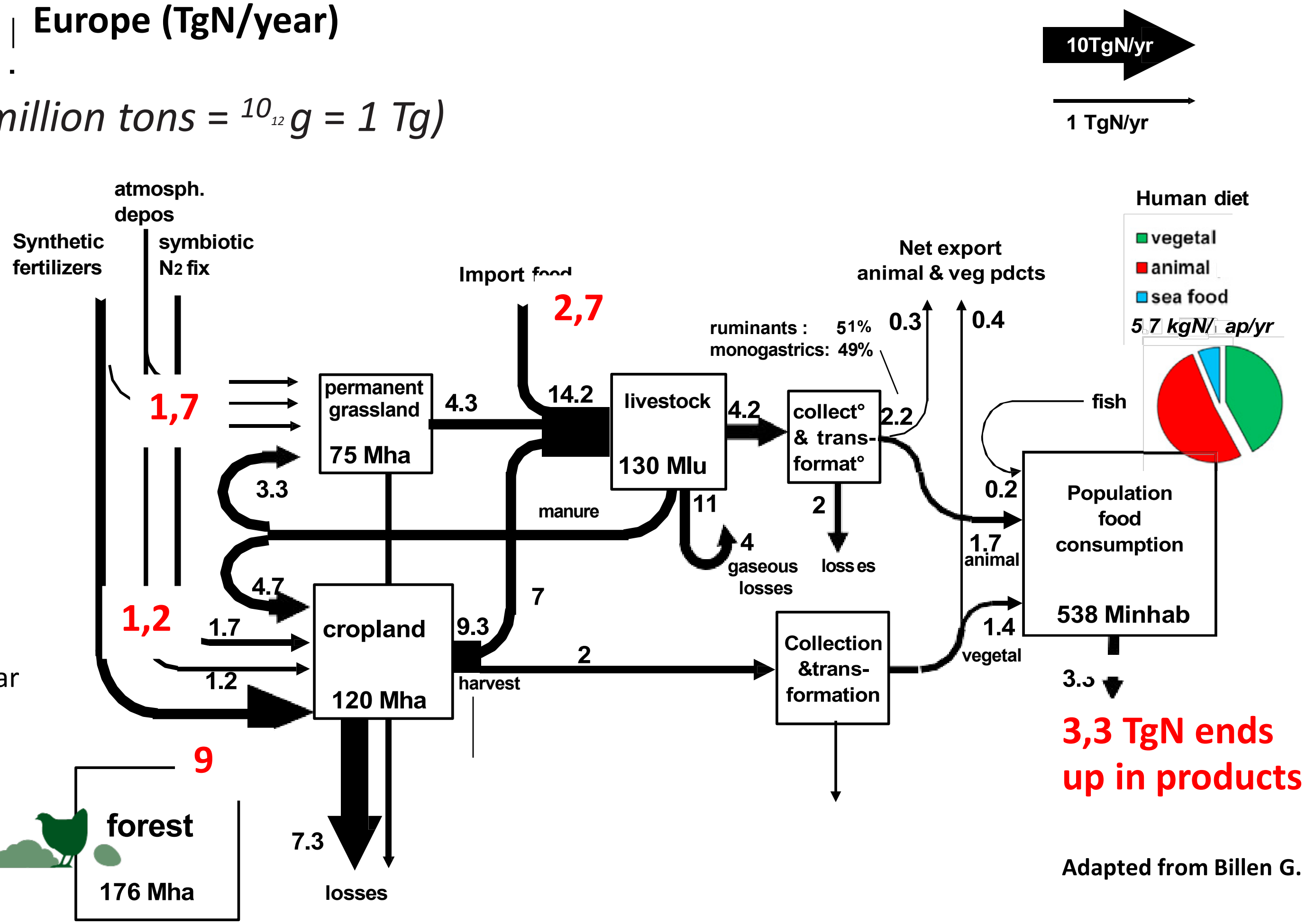
1 Mt = 1million tons = 10^{12} g = 1 Tg)

Total input
14,6 TgN/year

14,2 TgN/year
Goes through animal

8 TgN/year
Ends up in
manure

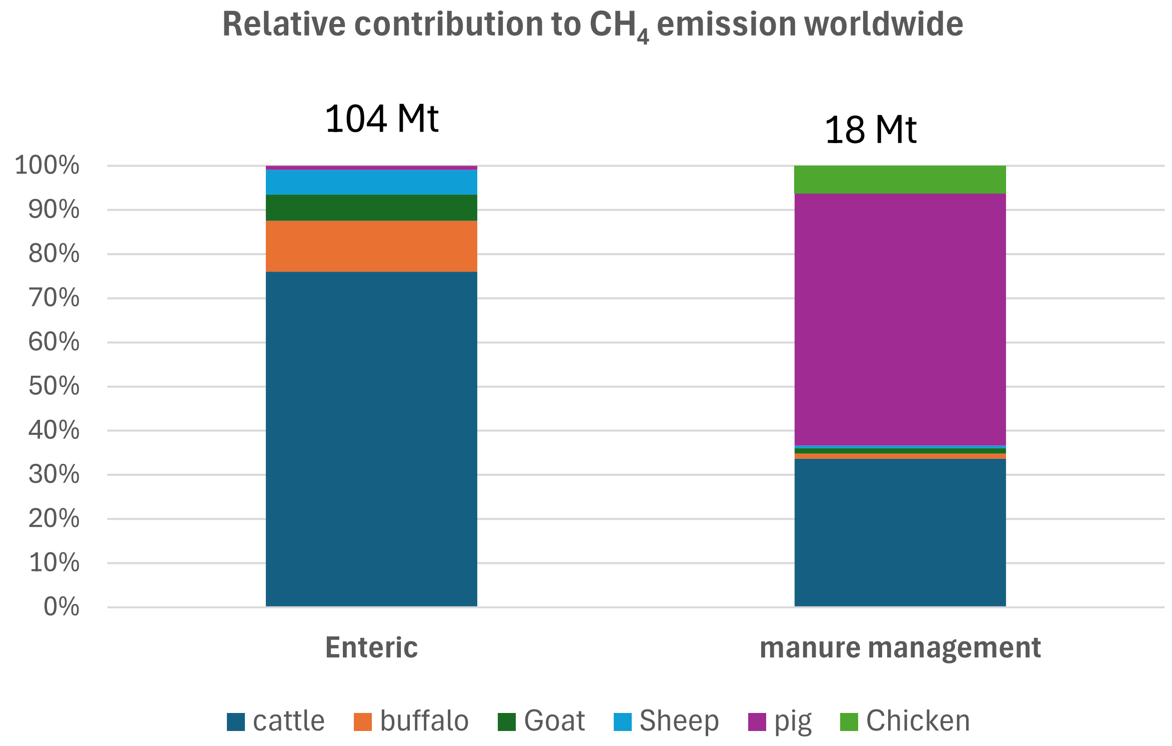
4 TgN/year
Gaseous
losses



3,3 TgN ends up in products

Adapted from Billen G. et al 2021

LIVESTOCK AS A SOURCE OF GHG



CH_4: Hard to capture when it has been *let out of the bottle*!

Global animal population and methane emitted by enteric fermentation and manure management. Data from FAO (2023)

SUSTAINABILITY OF BIOGAS

Transport
Diesel
(2,7 kg CO2/liter)

Electricity
Energimix
(0,150 g CO2/kwh)

CH4 leaks(1-2%)

Biogas produktion

Upgrading
Biogas -> Bionaturgas
Amin

Amine scrubber

Furnace NG

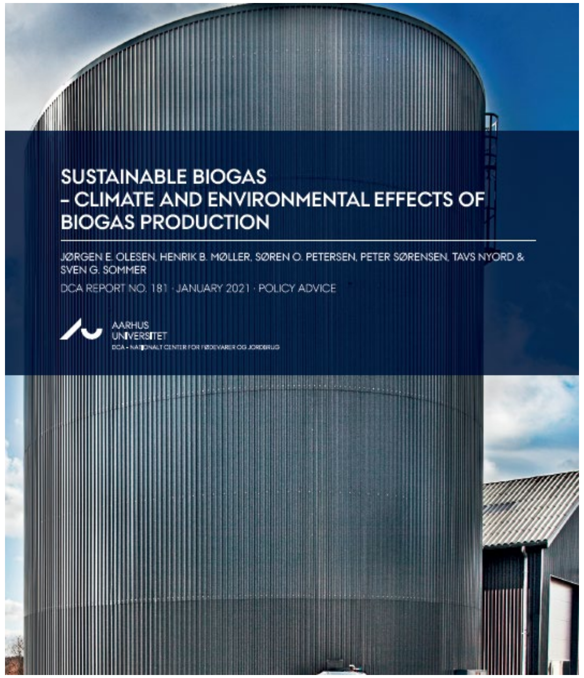
Heat NG

Heat exchanger

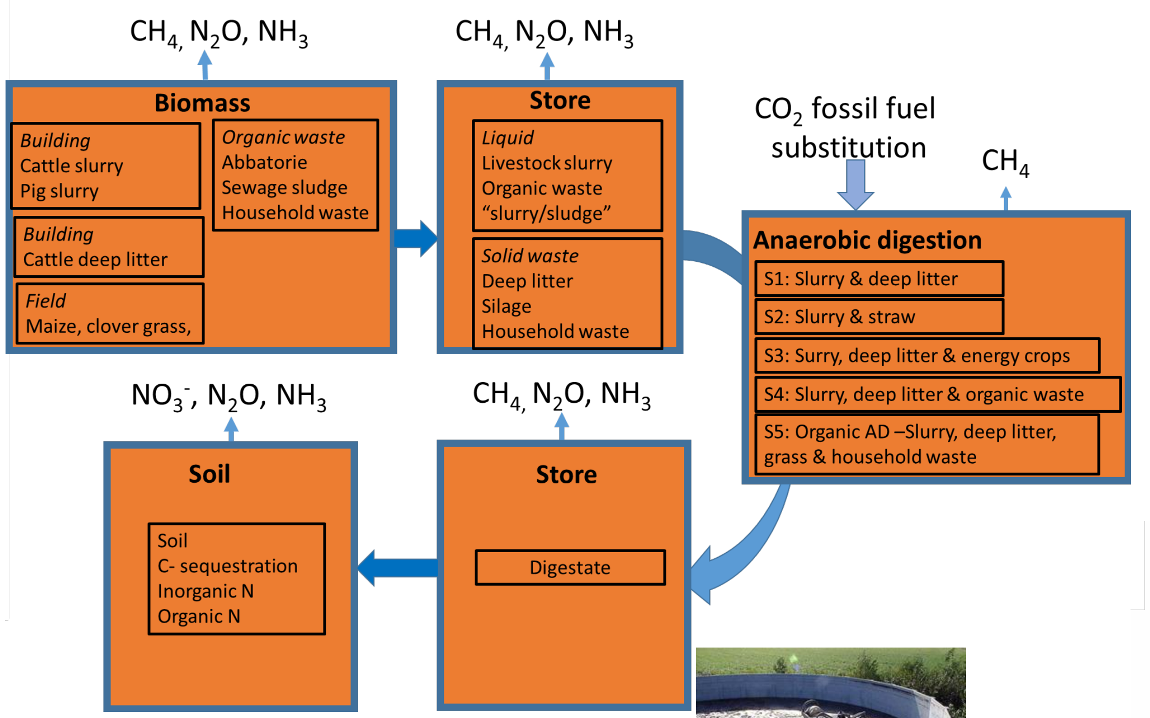
Storage tank

45 days with thermophilic operation (49-55C). + increased retention times of 60 and 90 days. Serial connections of 2 digesters

Digestate is 20° C when it leaves the biogas plant



SUSTAINABILITY OF BIOGAS



$$F(t) = (VS_d + 0.01 \times VS_{nd}) \times \exp(\ln A - E_a/RT)$$

Two VS pools of volatile solids (VS)
•degradable VS (VSd)
•”non-degradable” VS (VSnd)

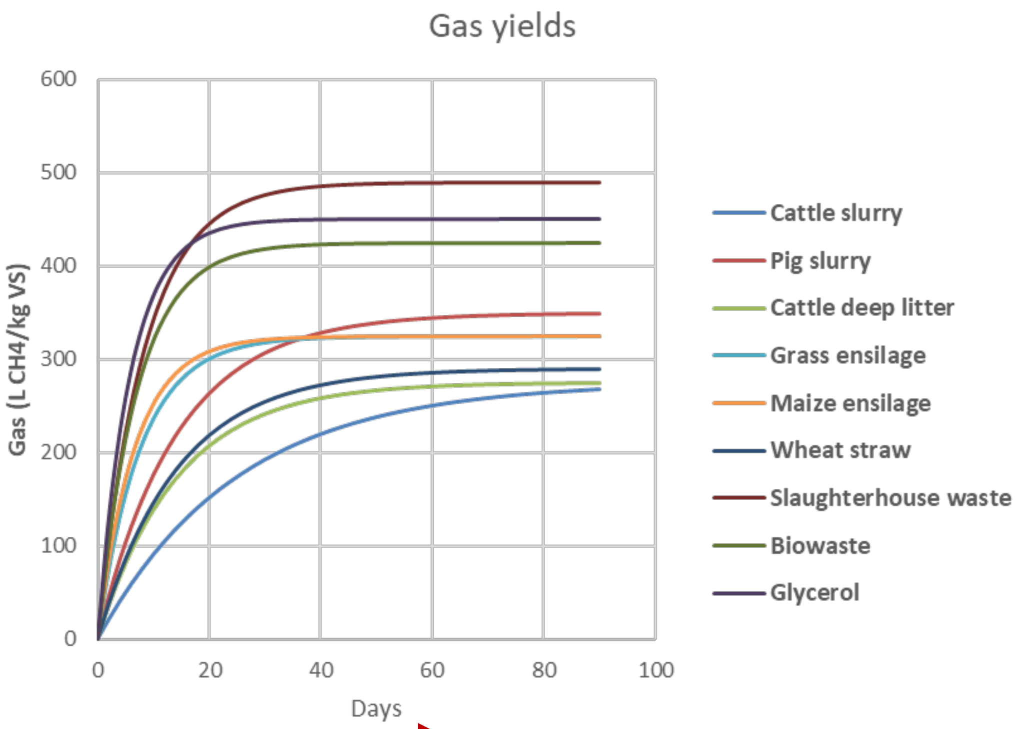
Temperature response of CH4 production expressed *via* Arrhenius relationship

Nutrient Cycling in Agroecosystems **69:** 143–154, 2004.
© 2004 *Kluwer Academic Publishers. Printed in the Netherlands.*

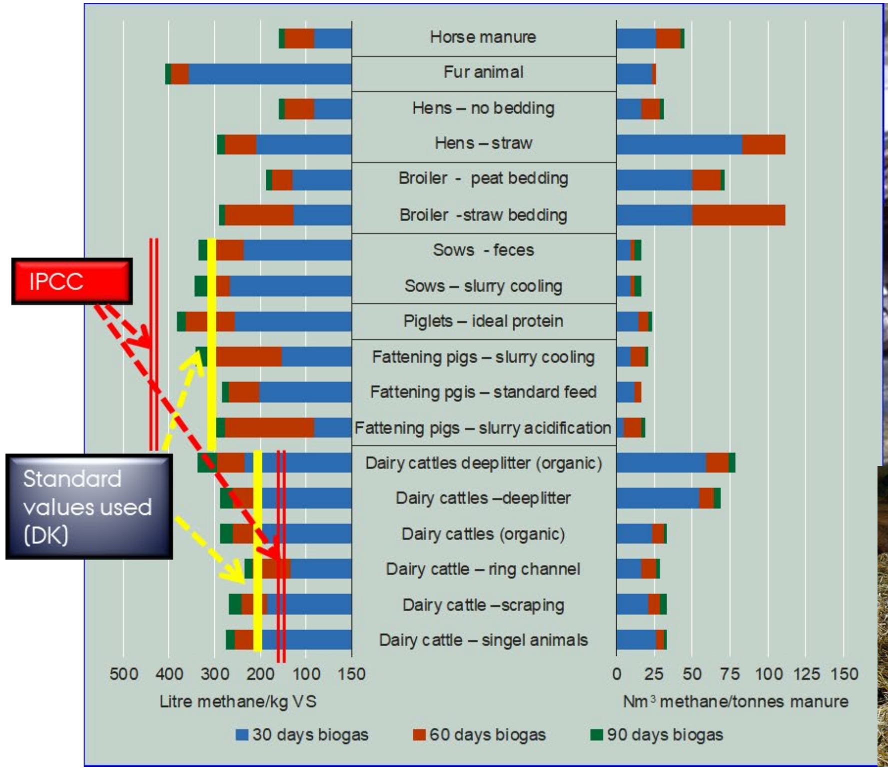
Algorithms for calculating methane and nitrous oxide emissions from manure management

S.G. Sommer[1,*], S.O. Petersen[2] and H.B. Møller[1]

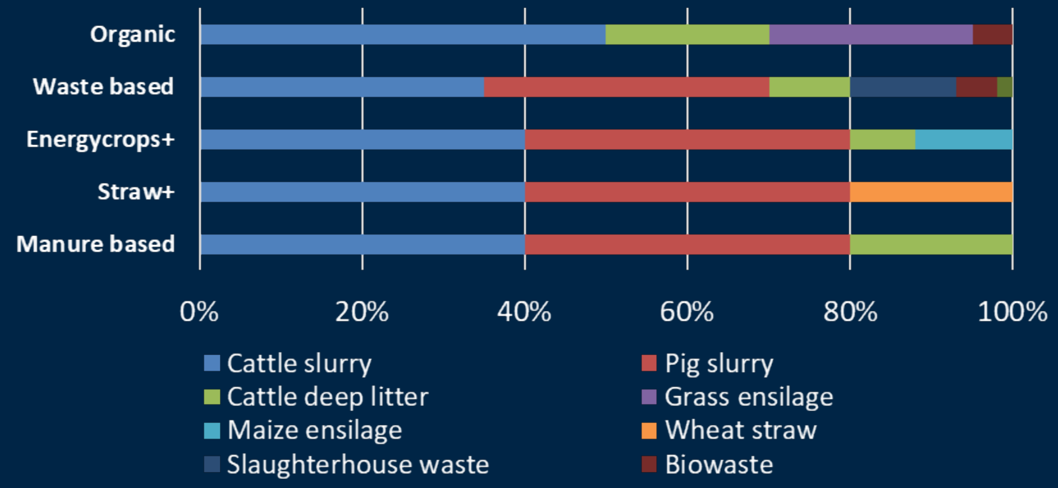
BIOGAS POTENTIAL

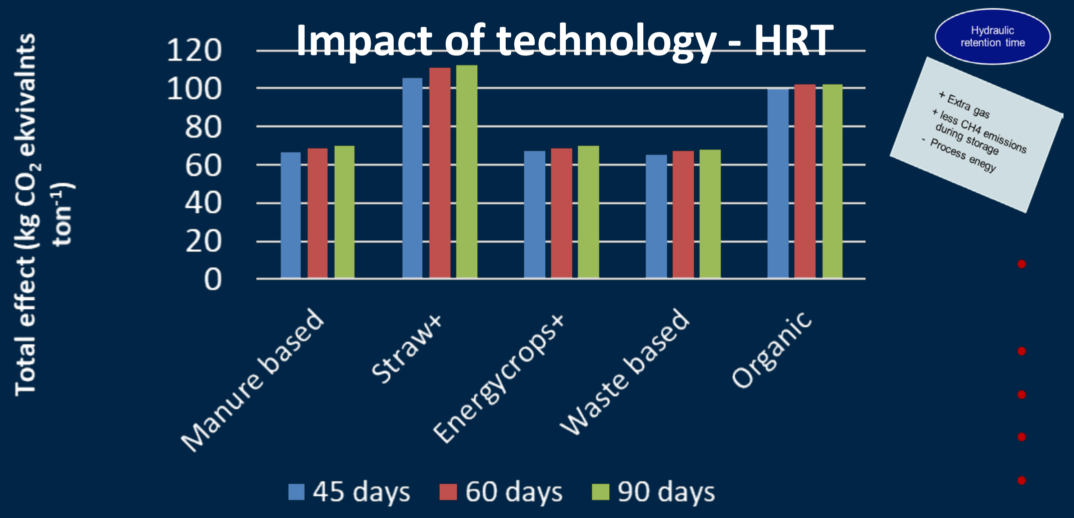


Increasing retention time

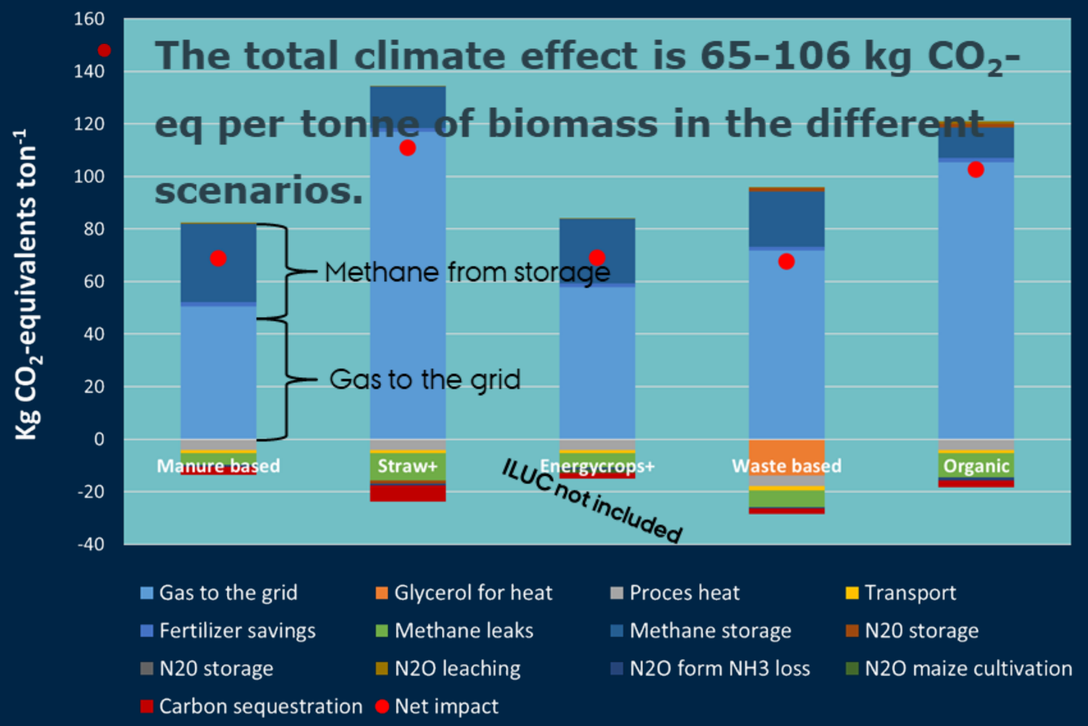


Biomass



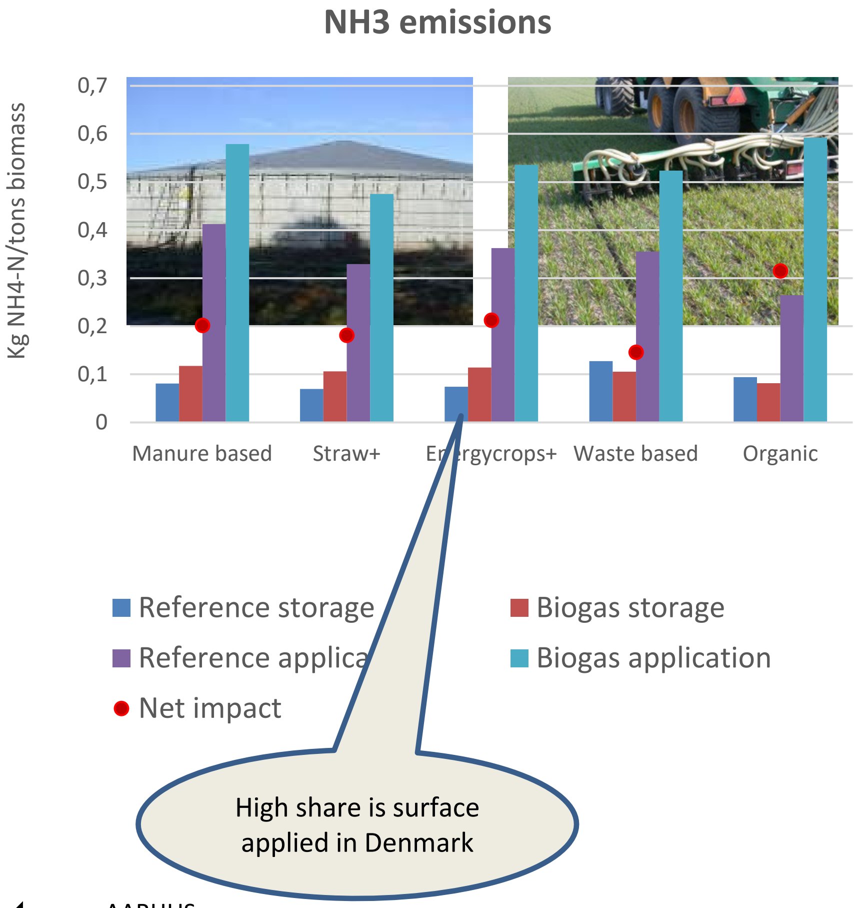


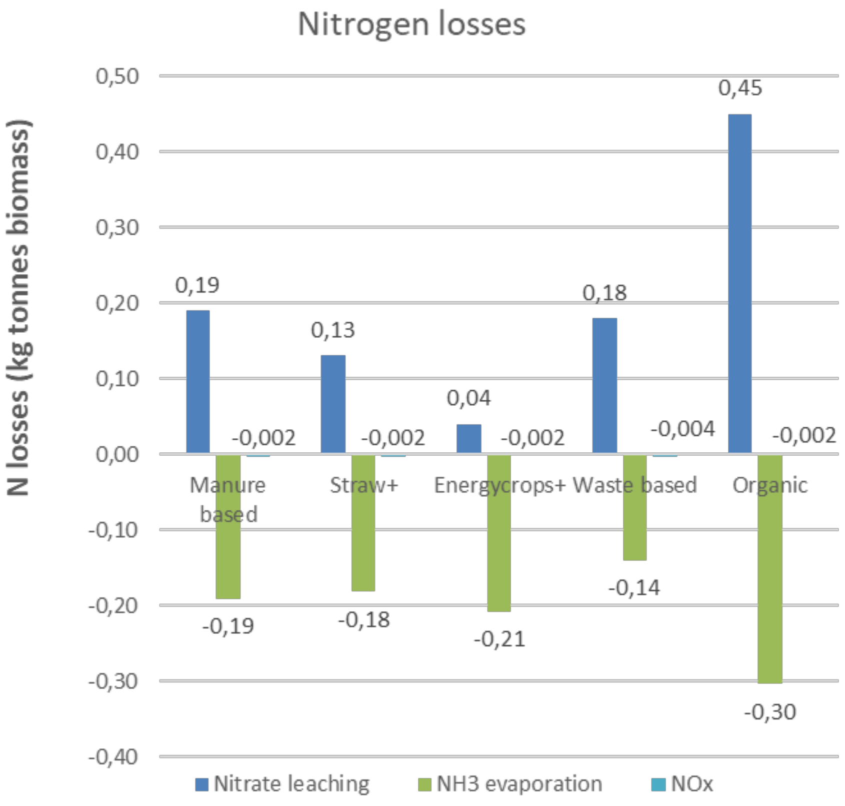
GHG mitigation



- **High positive energy balance for all plants, heat exchangers improve the balance significantly and is needed to reduce storage CH_4 loss.**
- **Straw plant need technology development**
- **The nitrate leaching is reduced with 0,04-0,45 kg/tonnes. Energycrops limits**
- **the positive impact**
- **Emission of NH_3 is higher by AD if digestate is surface applied.**

NITROGEN

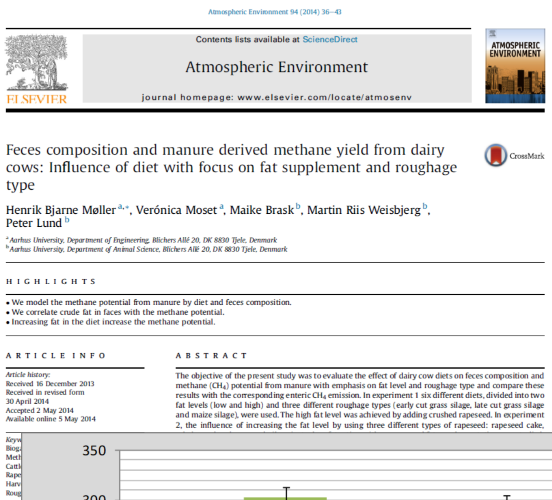




Nitrogen

- The models shows positive effect on NO3 but increased NH3 loss and increased NOX by extra transport

INFLUENCE OF DIET WITH FOCUS ON FAT SUPPLEMENT AND ROUGHAGE TYPE


Atmospheric Environment 94 (2014) 36–43

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Feces composition and manure derived methane yield from dairy cows: Influence of diet with focus on fat supplement and roughage type

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HIGHLIGHTS

- We model the methane potential from manure by diet and feces composition.
- We correlate crude fat in faces with the methane potential.
- Increasing fat in the diet increase the methane potential.

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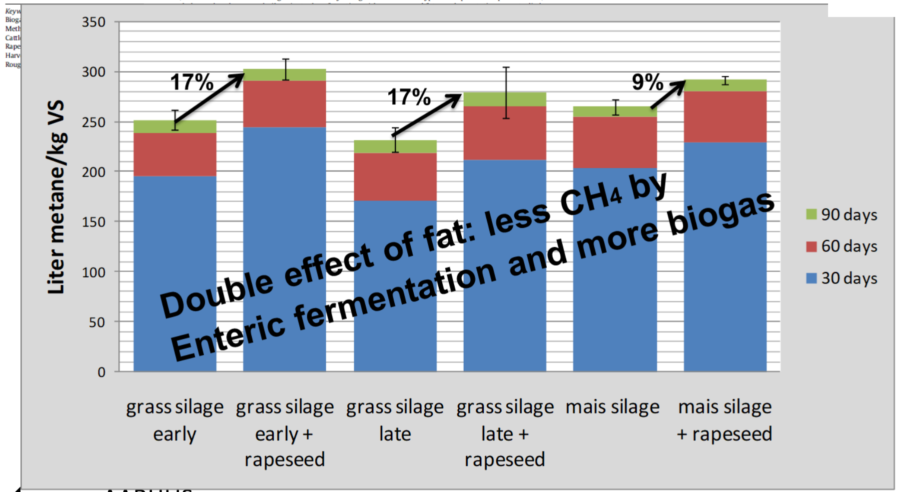
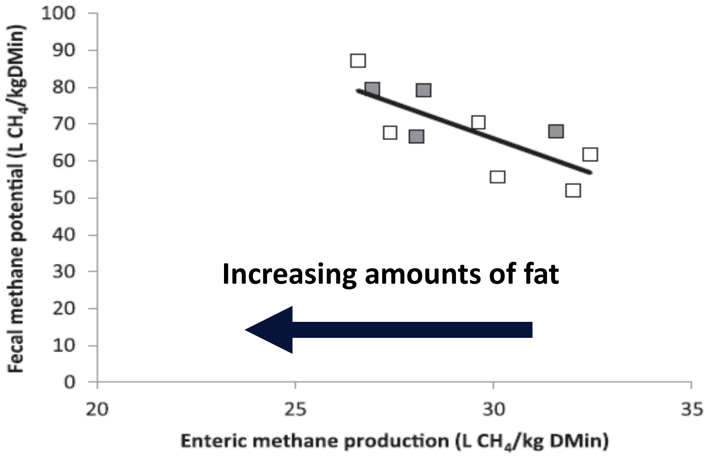
ABSTRACT

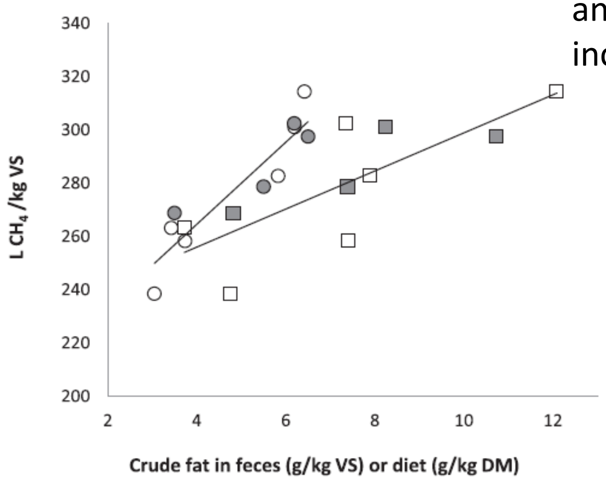
The objective of the present study was to evaluate the effect of dairy cow diets on feces composition and methane (CH_4) potential from manure with emphasis on fat level and roughage type and compare these results with the corresponding enteric CH_4 emission. In experiment 1 six different diets, divided into two fat levels (low and high) and three different roughage types (early cut grass silage, late cut grass silage and maize silage), were used. The high fat level was achieved by adding crushed rapeseed. In experiment 2, the influence of increasing the fat level by using three different types of rapeseed: rapeseed cake,





Win-Win

Increasing amount of fat reduce enteric methane production
and at the same time increase methane potential



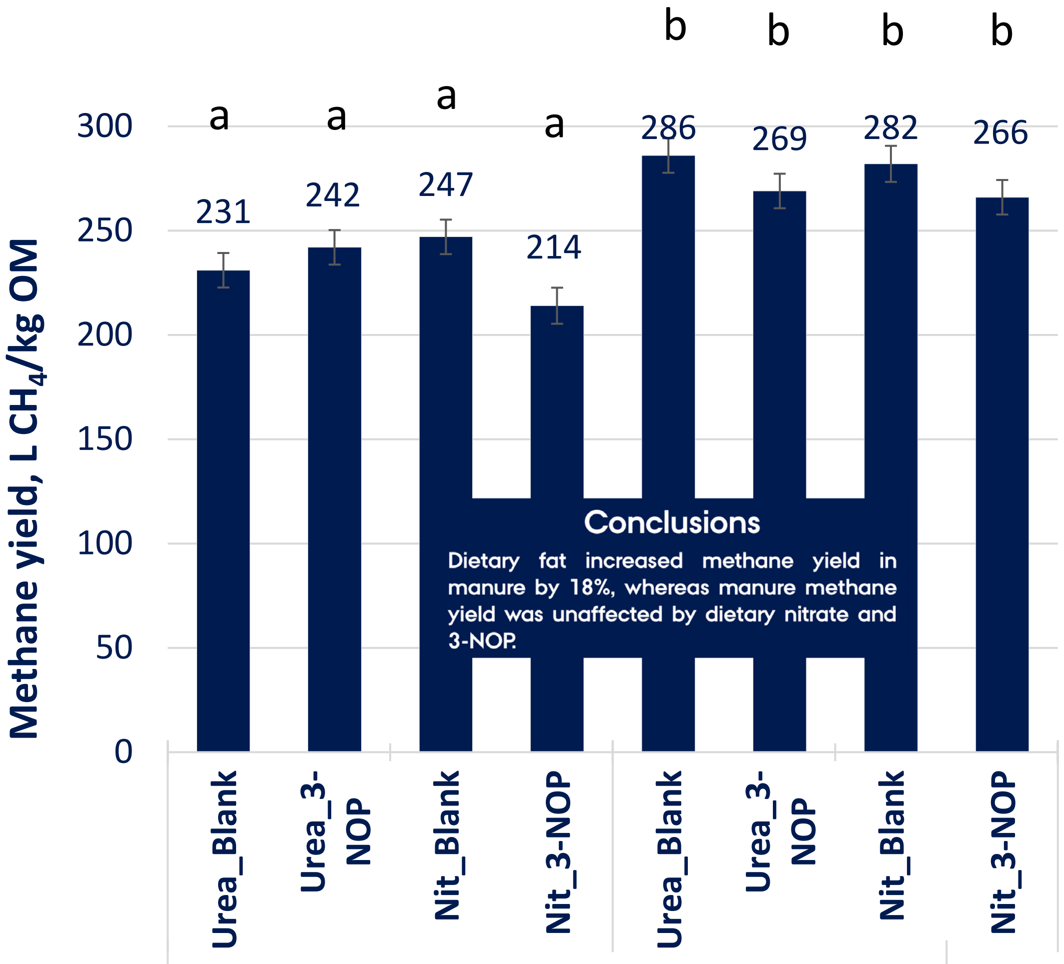
IMPACT OF ADDITIVES

Methane Potential of Manure from Dairy Cows Supplemented with Dietary Fat, Nitrate and 3-NOP

Treatments

Cows were fed ad libitum. Diets were formulated with 50% forage inclusion of dry matter (DM). Forage DM constituted 48% grass-clover silage and 52% maize silage.

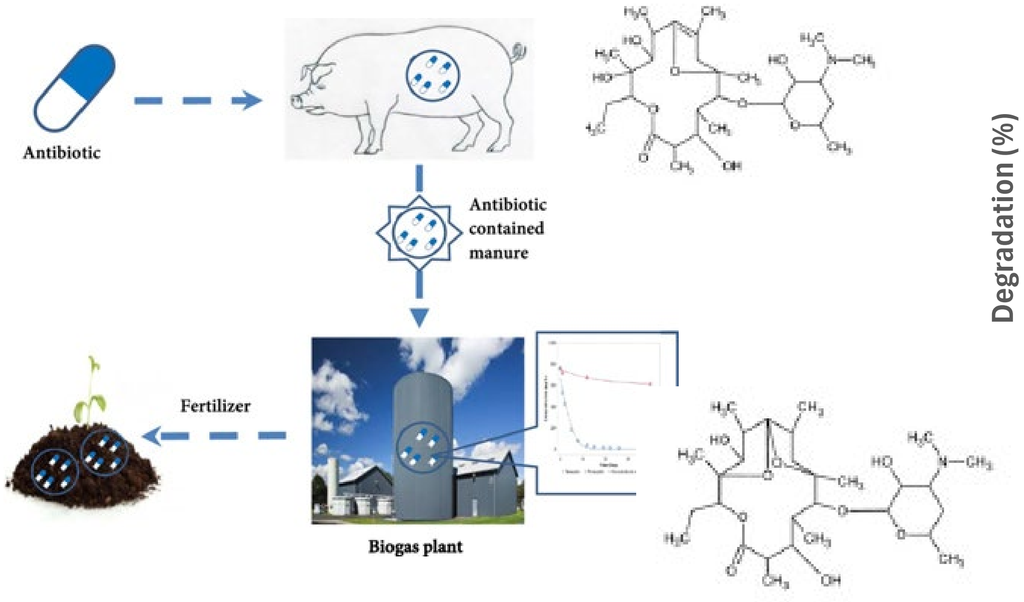
- 2 levels of fat (Low fat (**LF**); 30 g CF/kg DM or High Fat (**HF**); 63 g CF/kg DM)
- 2 levels of nitrate (source: SilvAir®) (0 g/kg DM; **Urea** or 10 g/kg DM; **NIT**)
- 2 levels of 3-NOP (0 mg/kg DM; **Blank** or 80 mg/kg DM; **3-NOP**)

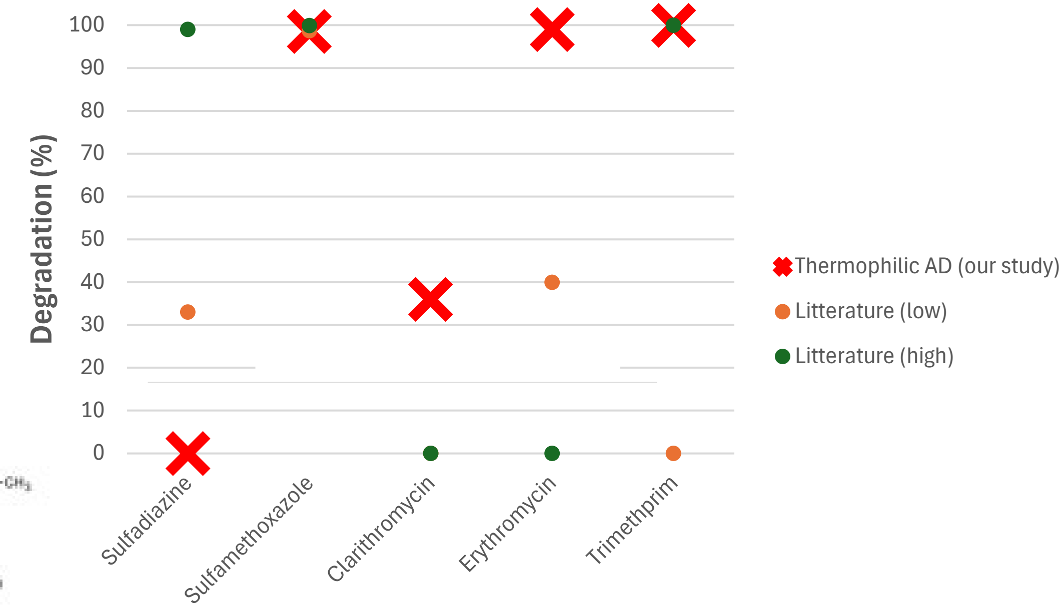


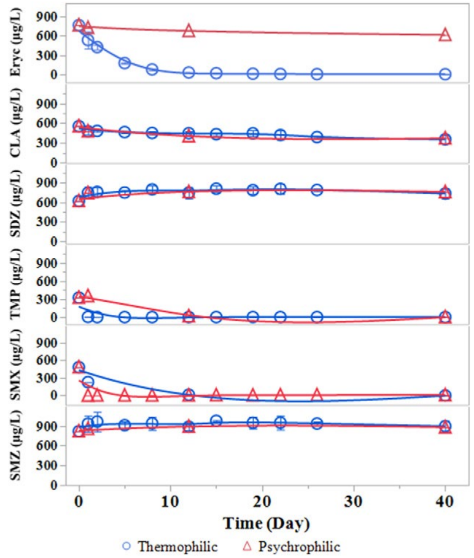
Conclusions

Dietary fat increased methane yield in manure by 18%, whereas manure methane yield was unaffected by dietary nitrate and 3-NOP.

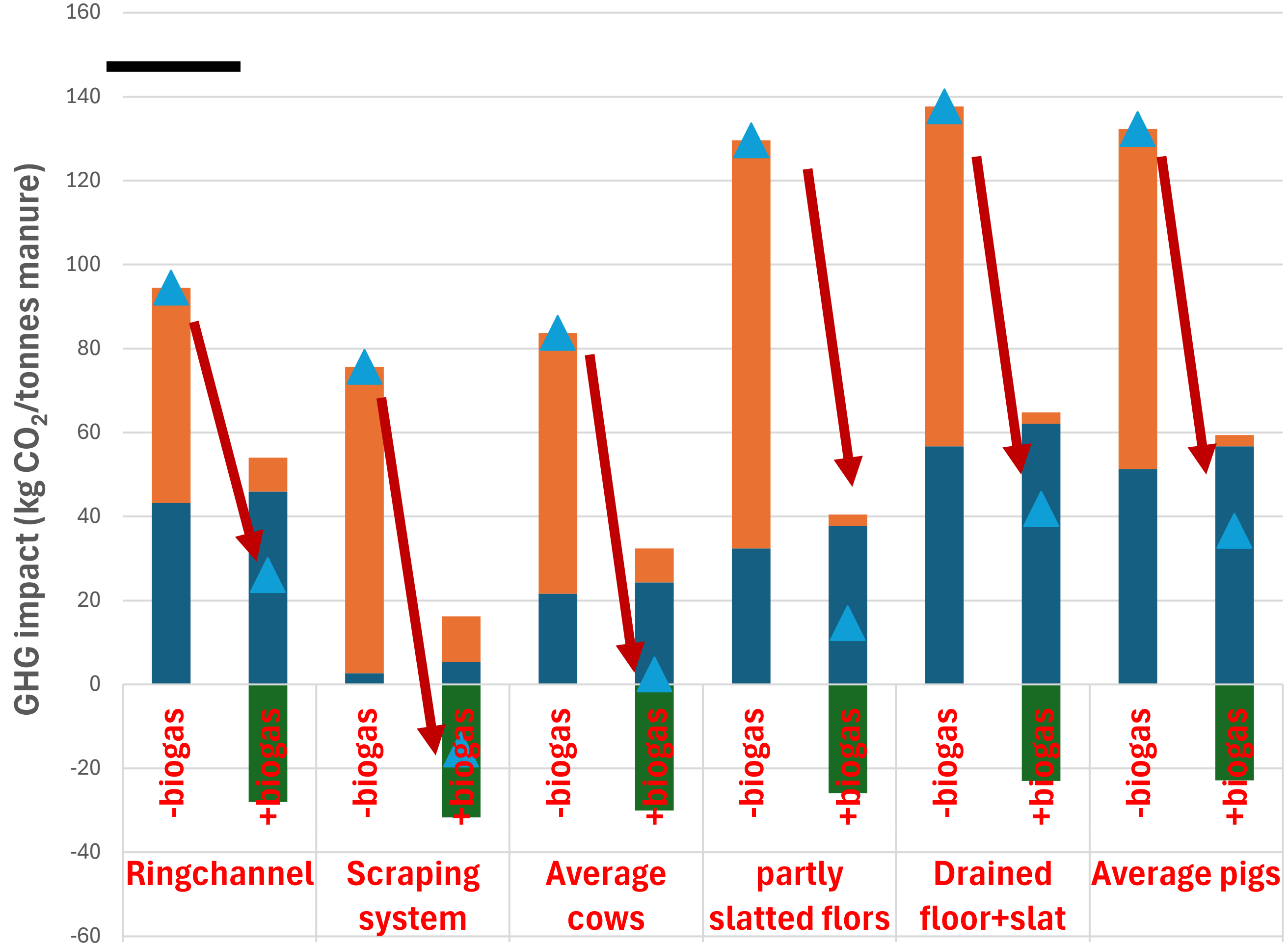
AD AND ANTIBIOTICS!

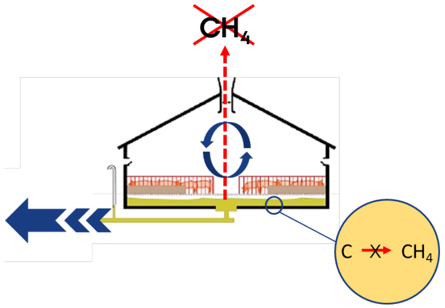






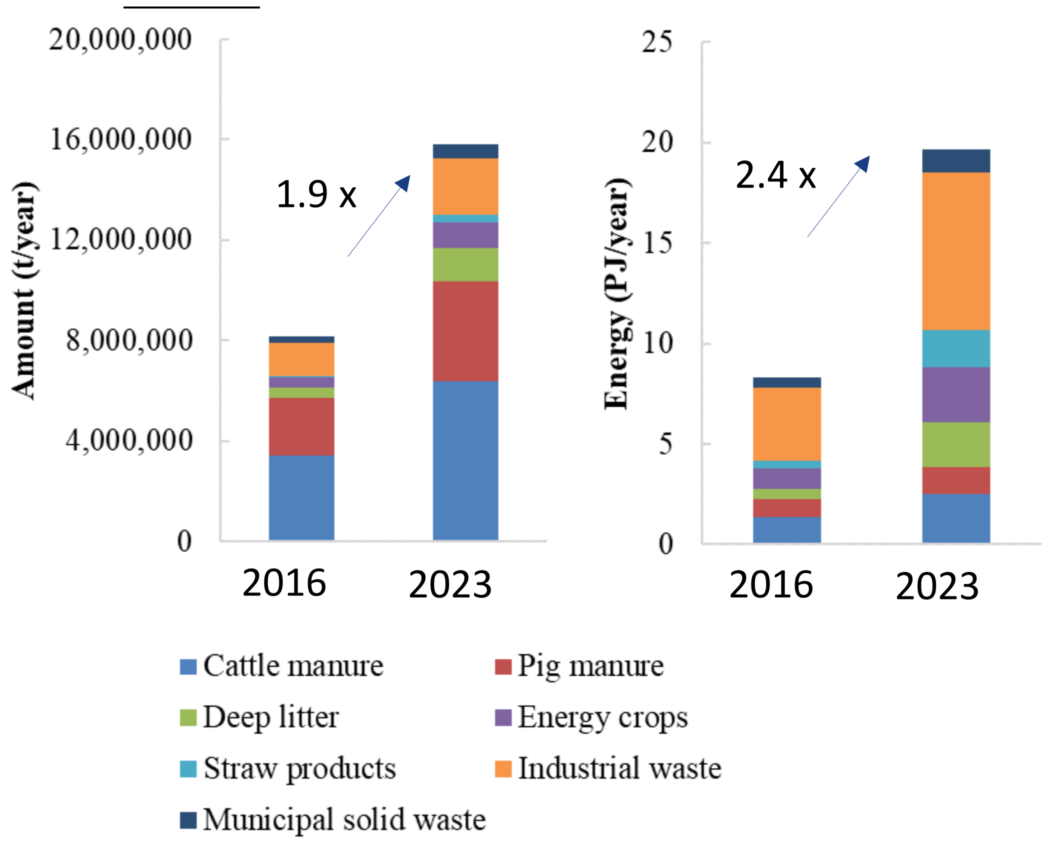
IMPROVED CARBON MANAGEMENT!





- **Frequent discharge** of manure combined with treatment
  - + More degradable carbon for biogas

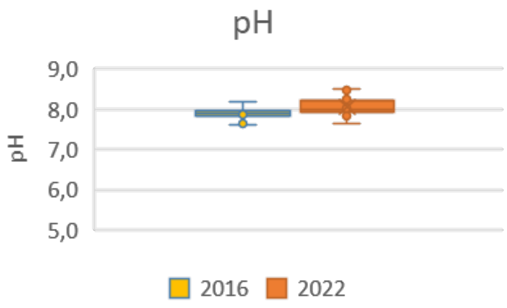
THE DANISH BIOGAS SECTOR

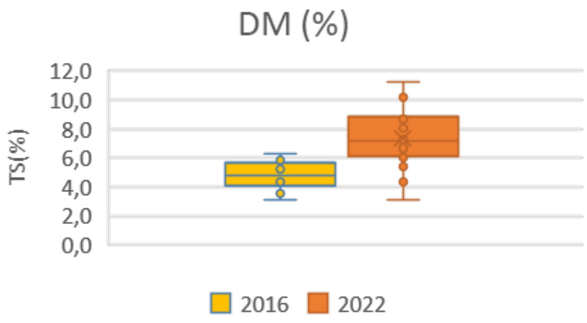


Intensification and changes of the biogas sector in Denmark in recent years

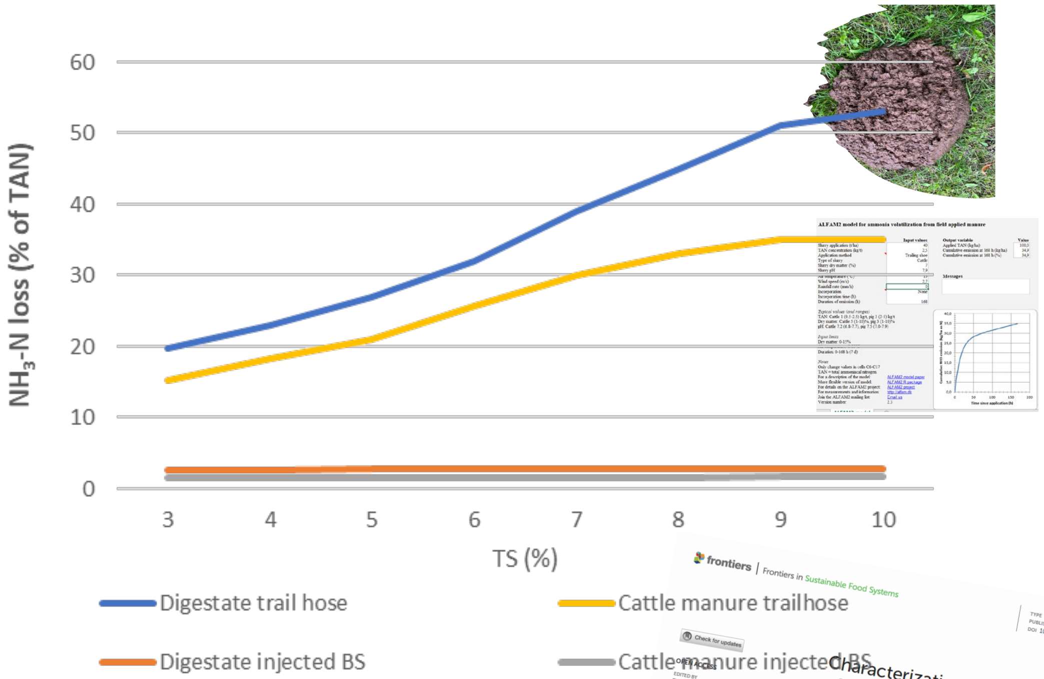
- More than doubling of amount of biomass utilized in anaerobic digestion and energy produced from 2016 to 2024;
- Change on feedstock composition driven by larger utilization of deep litter and straw:
    - Deep litter fraction: 9% of total mass in 2023 → increase of 70%;
    - Straw fraction: 2% of total mass in 2022 → increase of 125%:
    - Some biogas plants operate with up to 25% deep litter + straw!
    - There are new projects with 100% straw

DIGESTATE





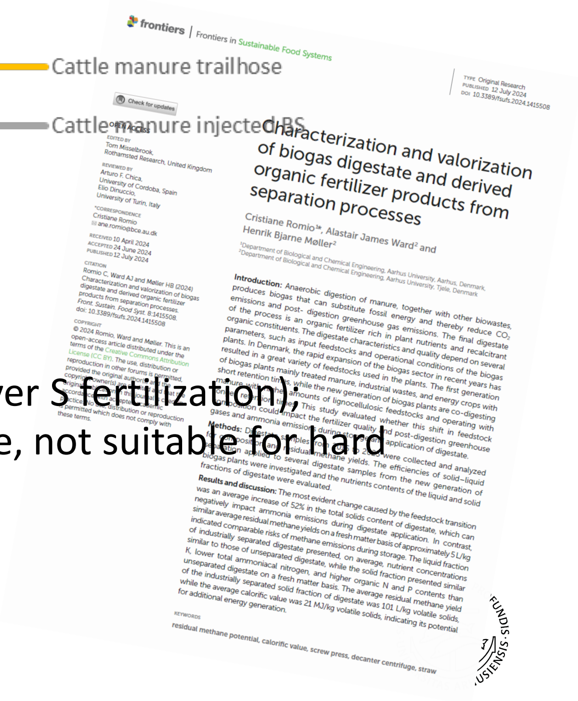
TS increase in by 52% from 2016 until today → slower soil infiltration rate → longer digestate exposition to atmosphere → increased risks for NH_3 emissions during field application.



ALFM2 model

NH_3 emissions mitigation technologies:

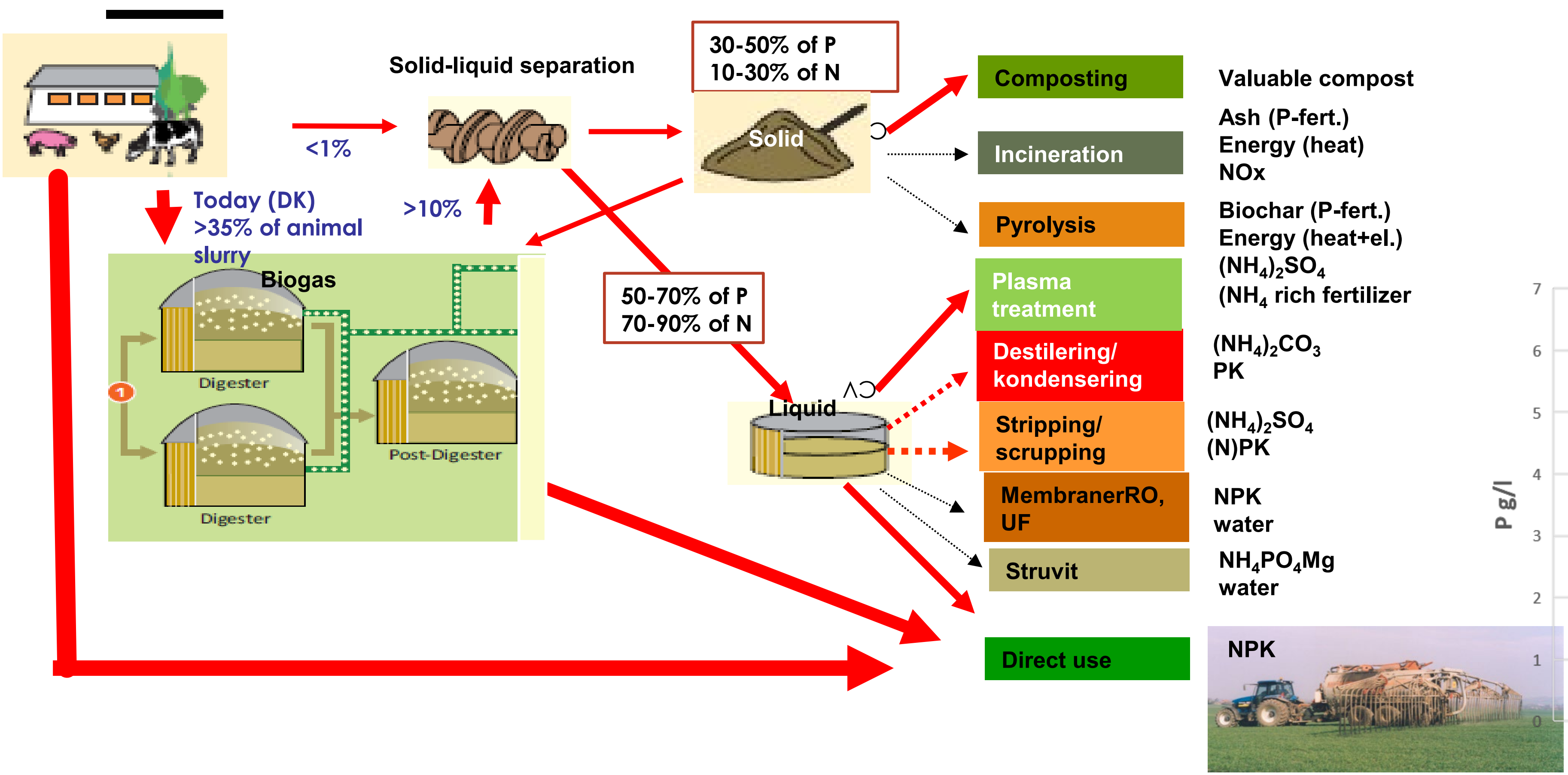
- Acidification with H_2SO_4 (expensive, over S fertilization);
- Soil injection (expensive, crops damage, not suitable for hard soils);
- Plasma treatment
- <u>Solid-liquid separation.</u>

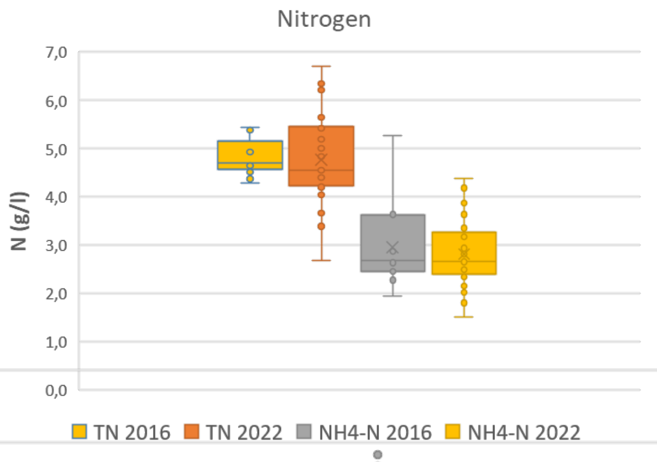

frontiers | Frontiers in Sustainable Food Systems

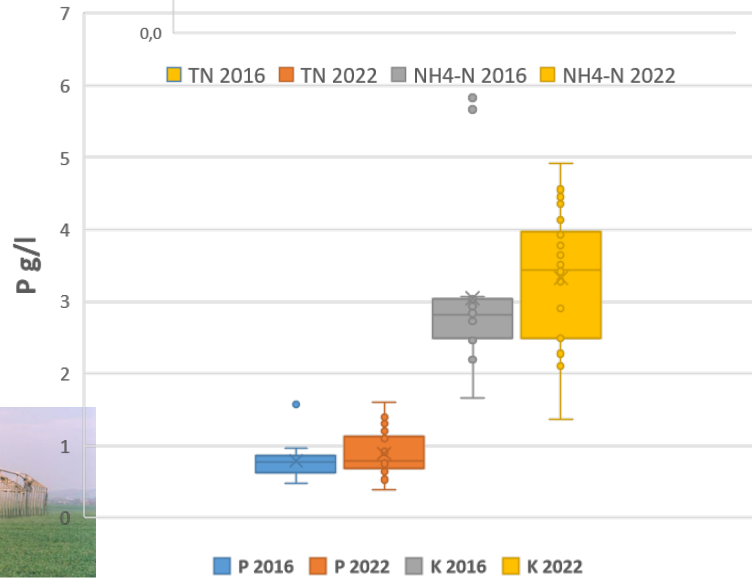
Characterization and valorization of biogas digestate and derived organic fertilizer products from separation processes

Cristiane Romio, Alastair James Ward and Henrik Bjarne Møller

DIGESTATE

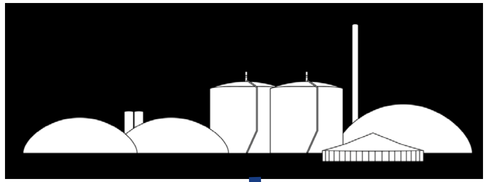






Digestate Rich in nutriens but highly variable

PYROLYSIS OF FIBER FROM AD



60% of drymatter
to fiber fraction

1 tonnes
drymatter

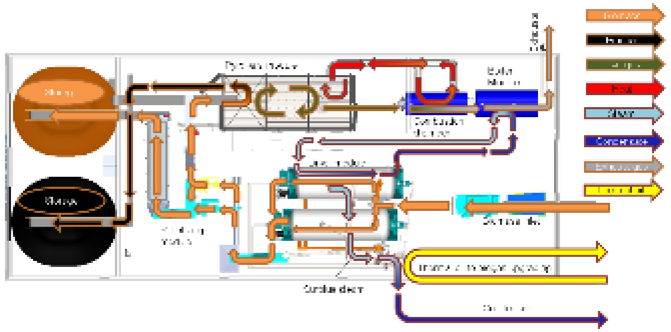
CH4: 165 kg CO2-eq

N2O: 32 kg CO2-ækv

Cabon sequestration :
132 kg CO2 eq.

Drying

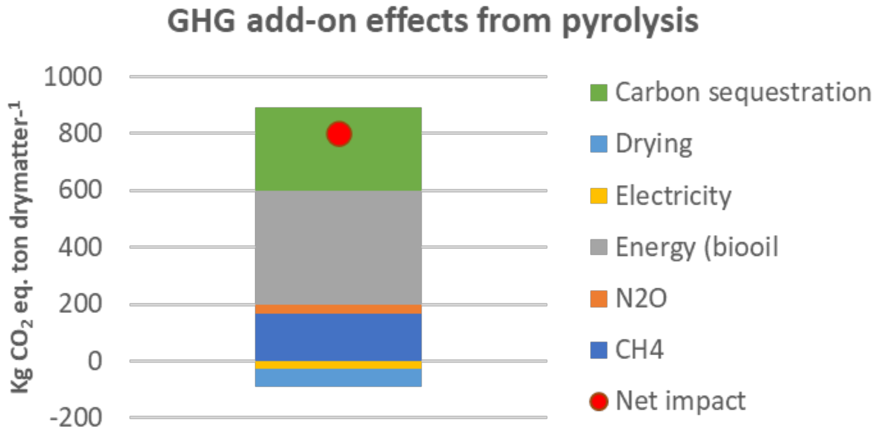
El:ectricity:
27 kg CO2-ækv

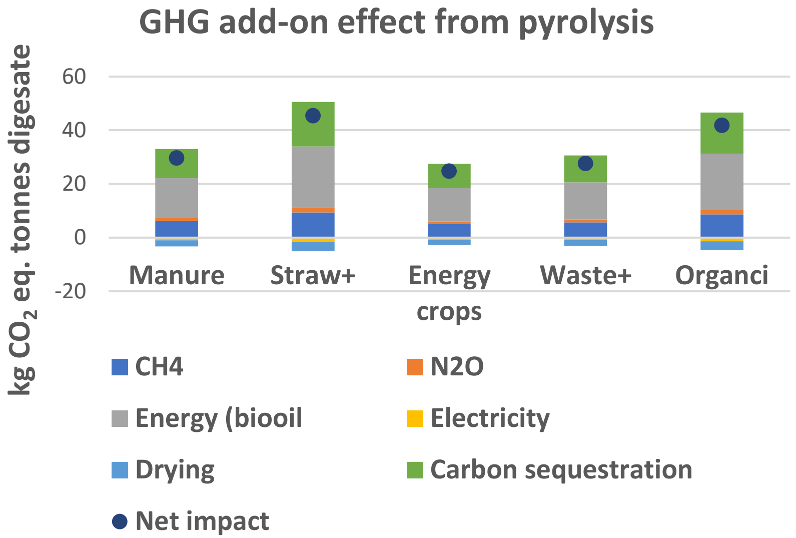


Gas: 400 kg CO2-eq

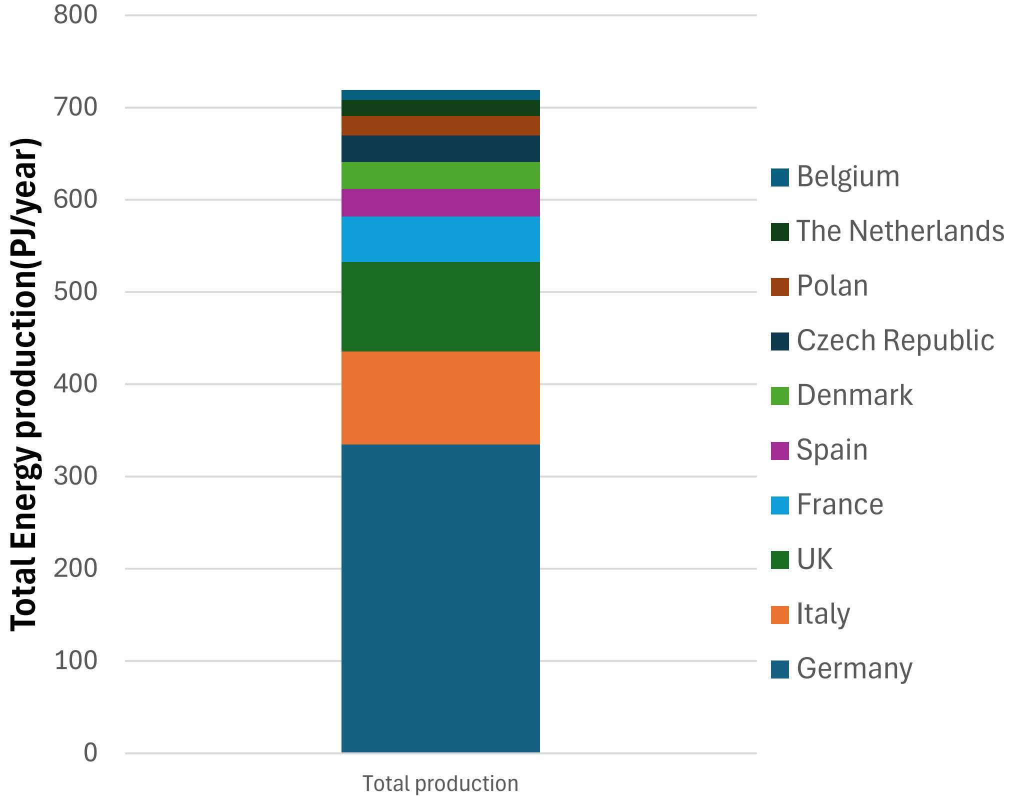
Carbon sequestration:
425 kg CO2 eq

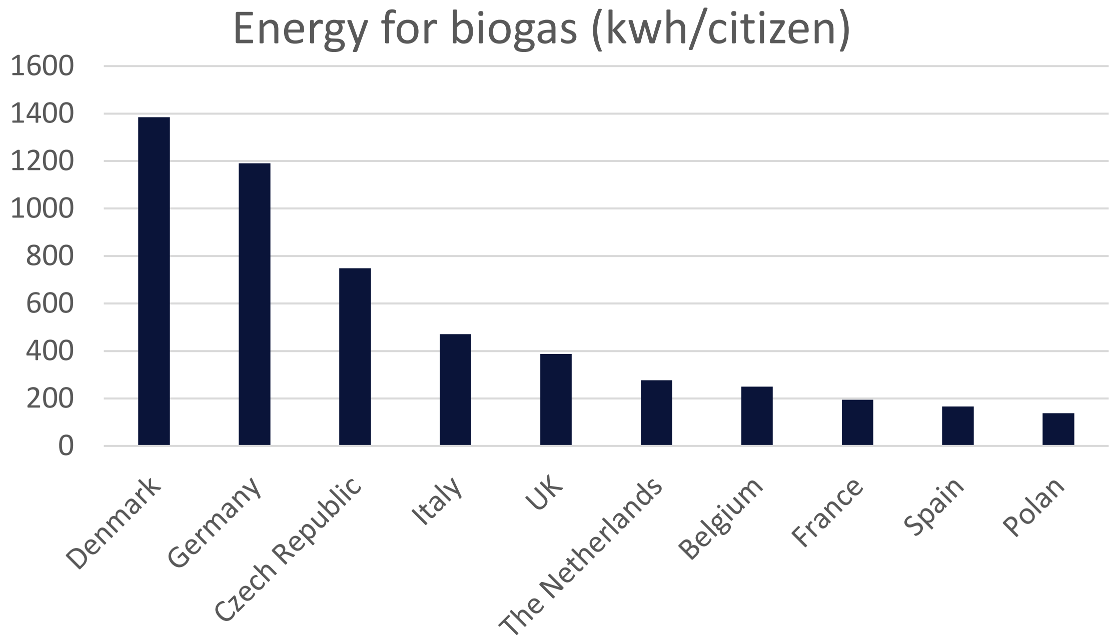
Biochar: carbon stabilization
100 -1000+ years in soil





THE ROLE AND FUTURE OF BIOGAS IN EUROPE

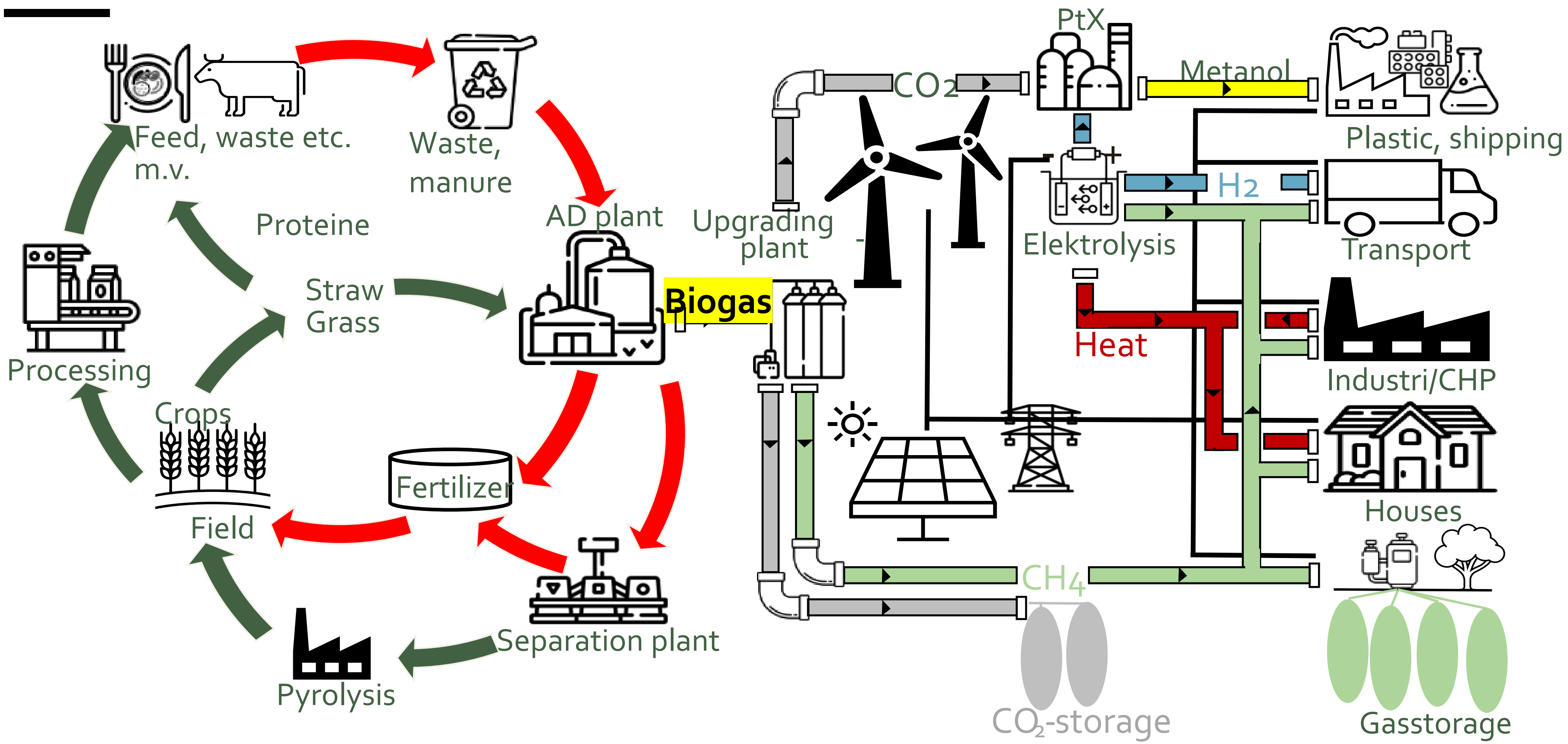




Data from: EBA Statistical Report 2023

EBA: Doubling before 2030

THE ROLE AND FUTURE OF BIOGAS IN DENMARK



CONCLUSIONS

- Animal manure contains large amounts of carbon and nutrients that can be used and transformed into biofuel and fertilizers
- AD is the most developed route for utilization of carbon from animal manure to biofuel
- AD is an important tool to reduce the agricultures carbon foot-print and optimize gain of feed additives, feed and management changes.
- AD can degrade most antibiotics
- AD plays a major role in the transformation of the society to green energy

THANKS FOR YOUR ATTENTION