FACULTY OF BIOSCIENCE ENGINEERING

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# Model-based analysis of greenhouse gas emission reduction potential through farm-scale digestion

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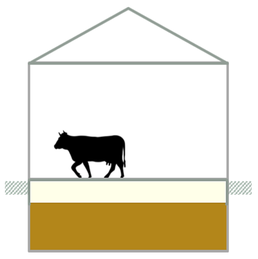
## Problem statement

Can the carbon footprint of dairy farms be reduced through farm-scale anaerobic digestion?

## Scenarios

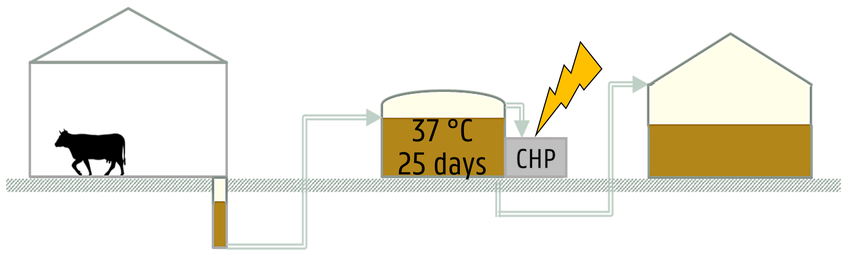
### 1 Manure pit



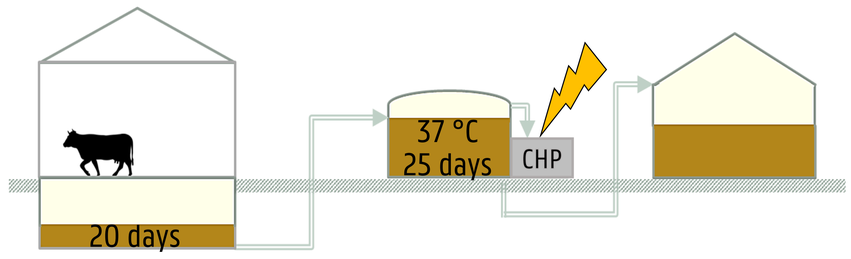
$CH_4$

Long-term manure storage
=
Unwanted **methane** formation

### 2 Fresh manure digestion




### 3 Pre-stored manure digestion




$CH_4$ **Farm-scale anaerobic digestion =** Renewable energy production from **methane**

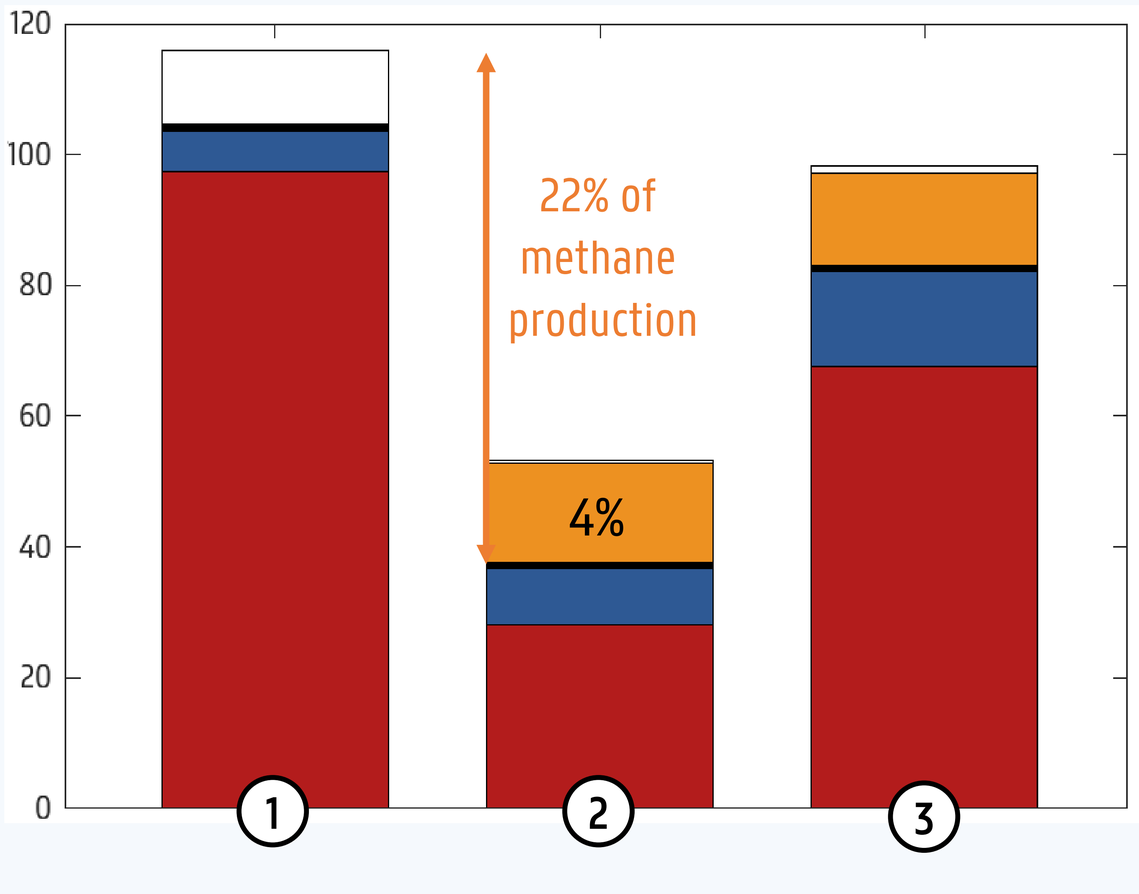
$CH_4$ BUT ALSO: Digester **methane** losses
**Methane** emissions from (pre-storage of manure and) long-term digestate storage

## Method

**Fit-for-purpose anaerobic digestion model** based on simplification of ADM1 assuming **hydrolysis as the rate-limiting step**.
Inclusion of **temperature dependency** and **constraints for storage** for dynamic simulation of methane emissions and production.

## Results

Carbon footprint (kg $CO_2$-equivalents per $m^3$ of manure)




- **$CH_4$ from storage (simulated)**
- $N_2O$ from storage
- $CH_4$ from spreading
- $N_2O$ from spreading
- Digester $CH_4$ losses
- Emissions from electricity production

## Conclusions

### Methane emissions from storage

- Up to **70% reduction** through fresh manure digestion at a digester retention time of 25 days
- Digestion of pre-stored manure or decrease in digester retention time = more **methane** emissions and less energy production from **methane**

### Carbon footprint of dairy farms

- Over **80%** related to **methane** emissions from manure storage, under relatively warm conditions and without controlled digestion
- Up to **50% reduction** through fresh manure digestion (compared to a default dairy farm with a manure pit) assuming that digester methane losses are 4% of the methane production in the digester
- Possible reduction **completely offset** (no reduction compared to a default dairy farm with a manure pit) if digester methane losses are 22% of the methane production in the digester

**Farm-scale anaerobic digestion can reduce methane emissions and the overall carbon footprint of default dairy farms with a manure pit if the digester is correctly dimensioned, properly managed and frequently monitored.**

**Further reading**: Vergote et al. (2019). Model-based analysis of greenhouse gas emission reduction potential through farm-scale digestion. *Biosystems Engineering*, 181, 157-172.

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