A SIMPLE SPREADSHEET MODEL FOR ESTIMATION OF METHANE EMISSION FROM PIG AND DAIRY COW BARNS AND EXTERNAL STORAGE OF MANURE

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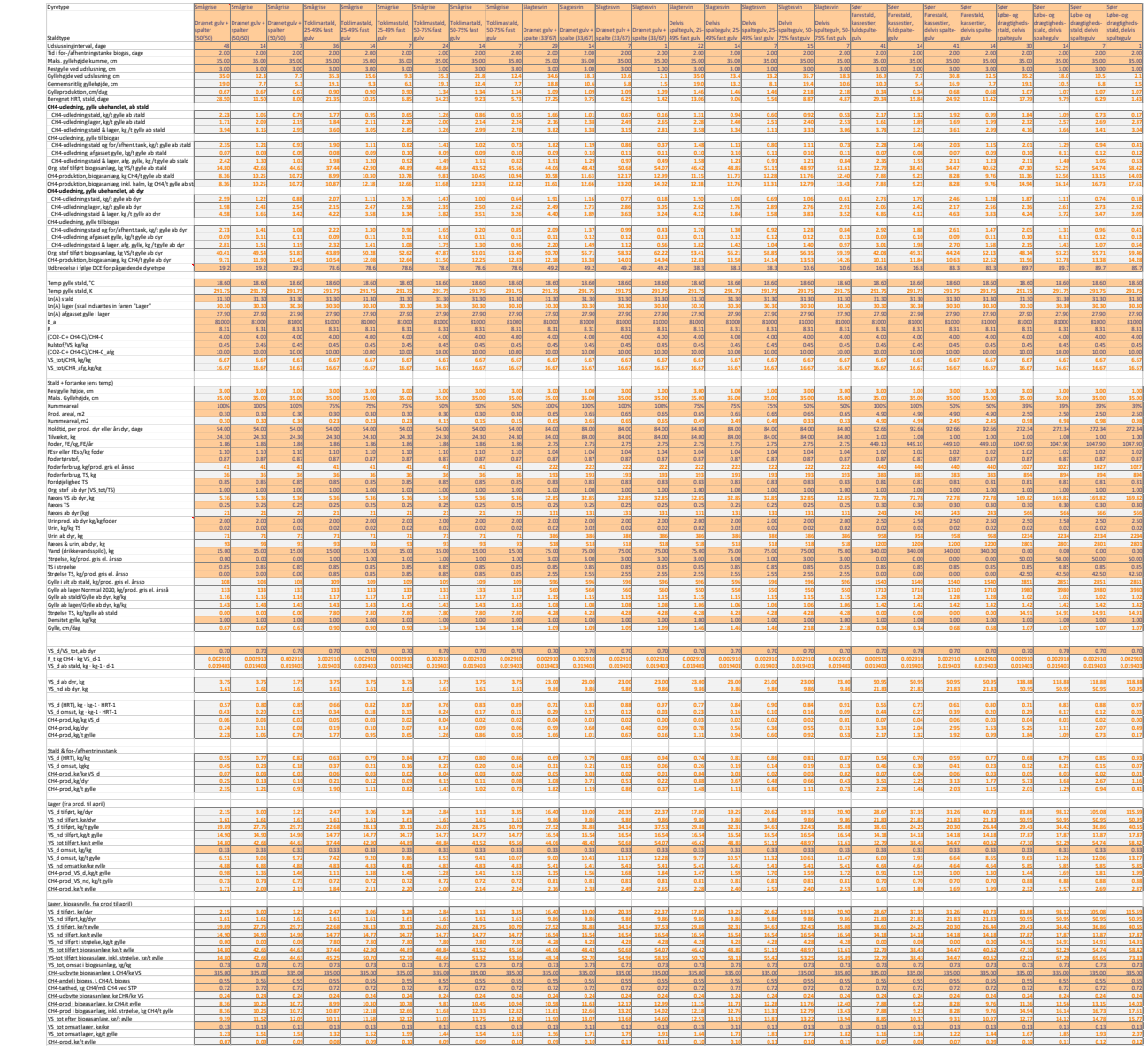
OBJECTIVES

- To make a simple and transparent model
- give estimates of methane production and emission from slurry in the barn and storages
- does not include enteric CH_4 production from the animals
- easy to change parameters

THE MODEL

Includes the common barn types for:

- sows
  - farrowing unit
  - gestation unit
- piglet
- finishing pigs
- dairy cows
  - solid floor
  - slatted floor with slurry pits



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EXCRETION OF ORGANIC MATTER AND SLURRY AMOUNT

- Excretion of organic matter is based on the Danish normative system for animal manure (used for calculation of N, P and K in slurry ex tank):
  - feed intake of the animal
  - digestibility of organic matter

- The slurry amount is estimated from:
  - dry matter content of faeces
  - dry matter content of urine
  - bedding materials
  - water wastes

RETENTION TIMES OF SLURRY

The hydraulic retention time (HRT) is estimated as:

- slurry pits area, height at flushing (emptying)
- average slurry volume divided with produced faeces and urine
- includes residual slurry (proxy for inoculum with methanogens)

HRT = V / Q

- where V is the average volume
- Q is the input of faeces and urine

METHANE PRODUCTION AND DEGRADATION OF ORGANIC MATTER

Based on the Arrhenius equations:

$$F_t = (\mathrm{VS_d} + 0.01\mathrm{VS_{nd}})\, e^{(\ln A - \frac{E_a}{RT})}$$

- where F_t is production of CH_4
- VS_d and VS_{nd} are degradable and non-degradable matter, respectively
- lnA and E_a are Arrhenius parameters based on lab experiments of various slurries

Based on CH_4/CO_2 ratios, the degradation of organic matter is calculated using an annuity equation:

$$VS_d = (1 - \Delta VS_d)^{HRT}$$

This approach is used in the Danish National Inventory Report as an IPCC tier 2 method

METHANE EMISSION FROM EXTERNAL STORAGE

The CH_4 emissions from external storage tanks are calculated using:

- amount of organic matter of slurry leaving the barn
- monthly average temperatures of the slurry
- separate ln(A) parameters for slurry during storage
- the emptying of the storage tanks
  - pig slurry – ones a year
  - cattle slurry – that the slurry are used during summer with average storage times of 2 months until September

INCLUSION OF AD, SLURRY COOLING AND FREQUENT EMPTYING THE SLURRY PITS

Biogas production (AD) is included with:

- an additional reception tank (pretank)
- a fixed degradation of the organic matter from the slurry
- additional biomass added on the biogas plant is not included

Slurry cooling

- just change the slurry temperature

Frequent emptying (flushing) the slurry pit

- change the maximal slurry height

RESULTS – SOME EXAMPLES

Methane emission from

- finishing pig, 30 – 110 kg
- 100% slurry pit, 0.65 m^2 per pig
- flushing interval, 29 days
- residual slurry after flushing, 3 cm
- slurry temperature is 18.6 °C
- the slurry in the external storage is kept from April to April
  - average HRT, 180 days
  - monthly average slurry temperatures

RESULTS – SOME EXAMPLES 2

Parameter	Unit	Finishing pigs fully slatted floor (1/3 with smaller slats)			
Temperature	°C	18.6	18.6	16.2	18.6
Flushing interval	days	29	7	29	29
Residual slurry	cm	3	3	3	10
HRT	days	17	10	17	24
CH_4 barn	kg / ton	1.7	0.7	1.3	2.2
CH_4 slurry tank	kg / ton	2.2	2.4	2.3	2.0
CH_4 slurry tank w/ AD	kg / ton	0.1	0.1	0.1	0.1

The model is used for estimation in the Climate Technology Report for Agriculture prepared for the Danish ministries in 2023

STRENGTHS AND WEAKNESSES

Strengths

- Simple and transparent – built in a spreadsheet
- Easy to change parameters and get the results
- Anaerobic digestion is included

Weaknesses

- Static model using average values
- Assumes that all degradable organic matter is alike
- Fixed ratio between CH_4 and CO_2 → calculation of degraded organic matter

CONCLUSION

- The model is simple and transparent
- Estimates methane based on
  - excretion of organic matter
  - hydraulic retention times (flushing intervals and residual slurry after flushing)
  - the Arrhenius equation
- Methane abatement technologies can be included
- Technologies that reduces the CH_4 from the barn often increases the emission from the external storages
- Important to include the whole chain, barns, external storages, and abatement technologies

ALTERNATIVE MODEL

Dr. Frederik Dalby has presented a more advanced and dynamic model earlier on this conference

The spreadsheet model as well as further explanations can be obtained from:

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