How much can we achieve by feeding and what types of feed additives are available?

rebecca.danielsson@slu.se
Dept. of Animal Nutrition and Management

2022-06-15 KSLA

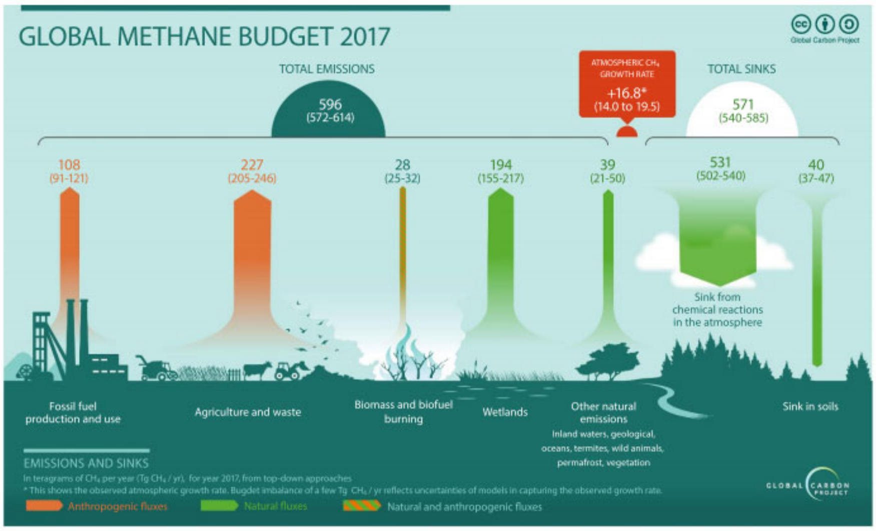
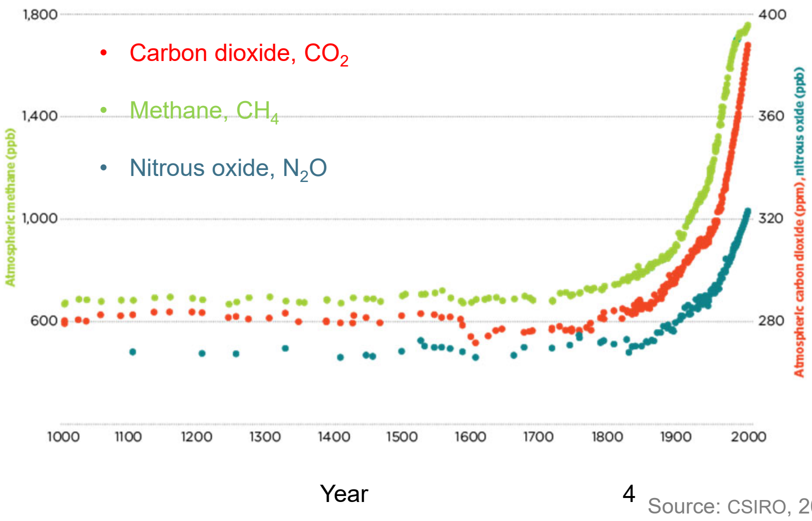


Figure 1. The global methane budget for year 2017 based on top-down methods for natural sources and sinks (green), anthropogenic sources (orange), and mixed natural and anthropogenic sources (hatched orange-green for 'biomass and biofuel burning').

Saunois et al. 2020, ESSD (Fig. 6)

https://www.globalcarbonproject.org/methanebudget/ 3

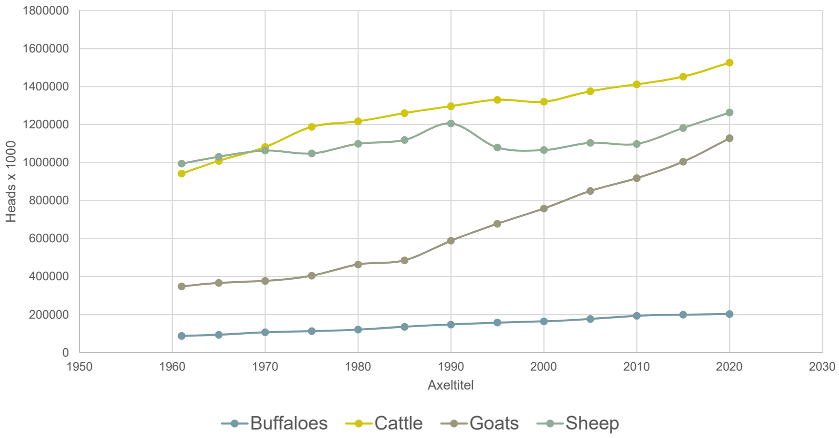
GHG - concentration in atmosphere over time



4 Source: CSIRO, 2012

SLU

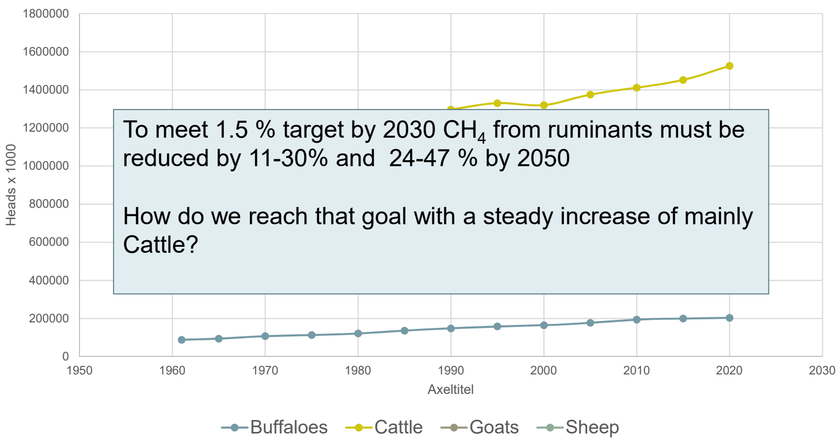
Number of ruminants over time



Source: FAOstat

SLU

Number of ruminants over time

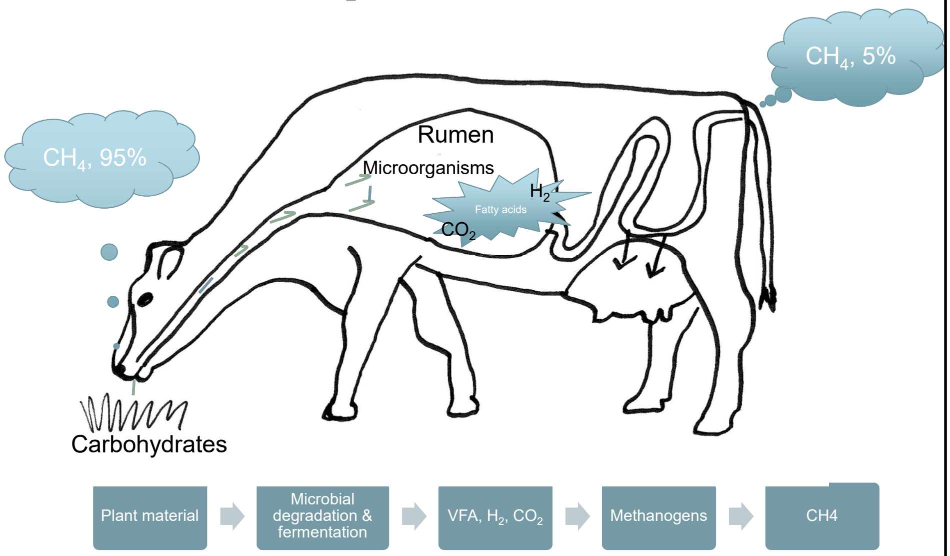


To meet 1.5 % target by 2030 CH_4 from ruminants must be reduced by 11-30% and 24-47 % by 2050

How do we reach that goal with a steady increase of mainly Cattle?

Source: FAOstat and IPCC 2018

Methane production in cow



7

Methanogenesis

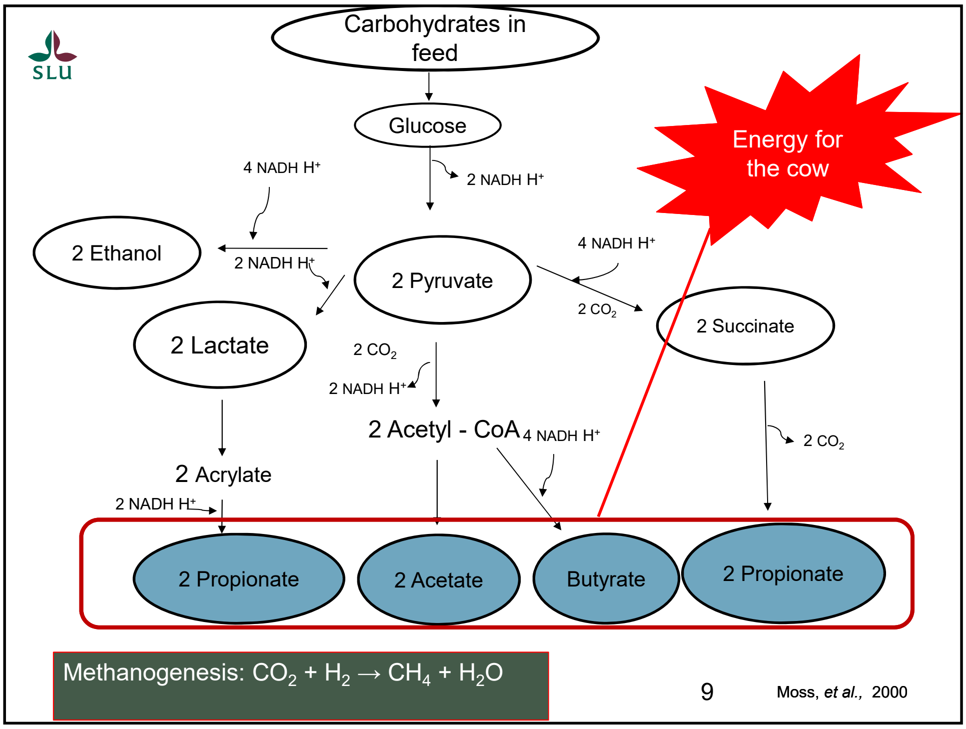
From fermentaion:

Acetate + Propionate + Butyrate + CO_2 + H_2

Methanogenesis, major pathway:

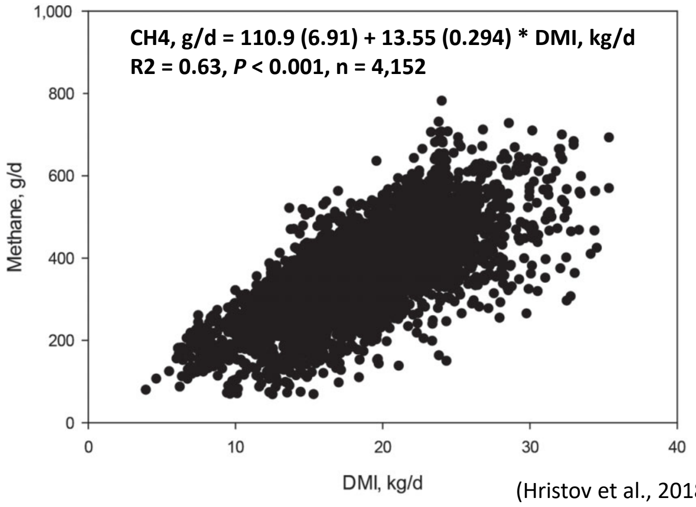
$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$

Volatile fatty acids (VFA) ratios different amounts of CH_4 is produced



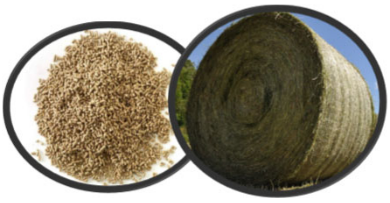
SLU

Effect of feed intake



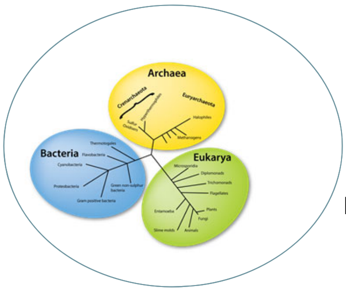
(Hristov et al., 2018)

Variation in methane production, due to?



Type of feed

Genetics



Microbial community structure

11

Type of feed

- Proportions of forage:concetrate
  - Increase of starch reduce CH_4 / kg DM (change ratio of FA), has not been observed in nordic studies

J. Dairy Sci. 96:2476–2493
http://dx.doi.org/10.3168/jds.2012-6095

Development of equations for predicting methane emissions from ruminants

M. Ramin[1] and P. Huhtanen[1]
Department of Agricultural Research for Northern Sweden, Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden

Type of feed

- Proportions of forage:concetrate
  - Increase of starch reduce CH_4 / kg DM (change ratio of FA), has not been observed in nordic studies
  - Rather small effect up to 70 % inclusion. If the diet contain 90 % concentrate GE loss is around 3 %
    - negative impact on rumen environment

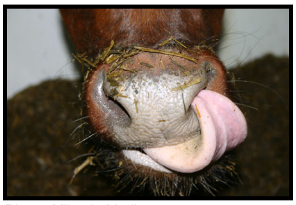


Photo: Mikaela Lindberg

- Type of forage
  - Sugar content,
  - Digestibility

Individual variation

CH_4 production differ between individuals

- Genetic potential for selecting animals with a lower ability to produce methane
- Differences in feed efficieny

Individual variation

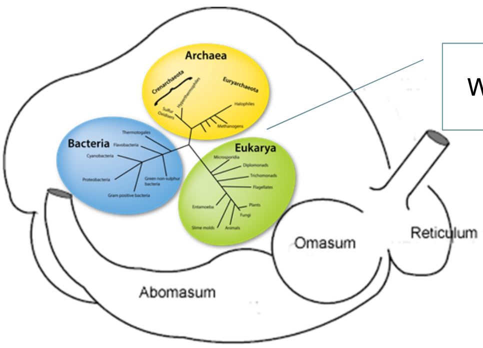
CH_4 production differ between individuals

Can be due to:

- Physiology – rumen size (turn over time of digesta)
- Type of microbiota in rumen – heritable?

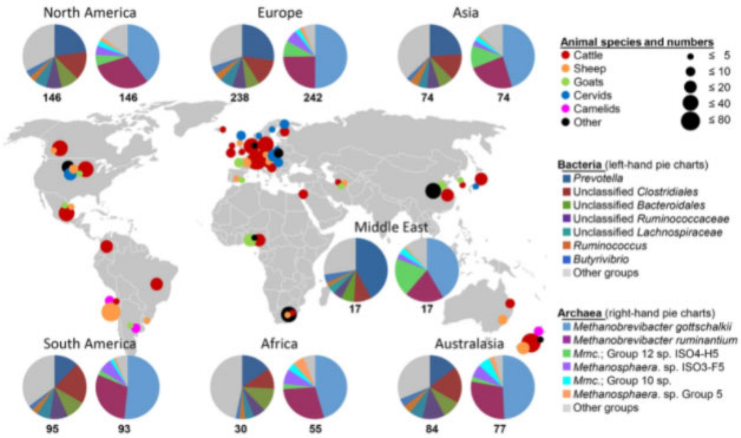
Individual variation

- Differences in microbial community structure



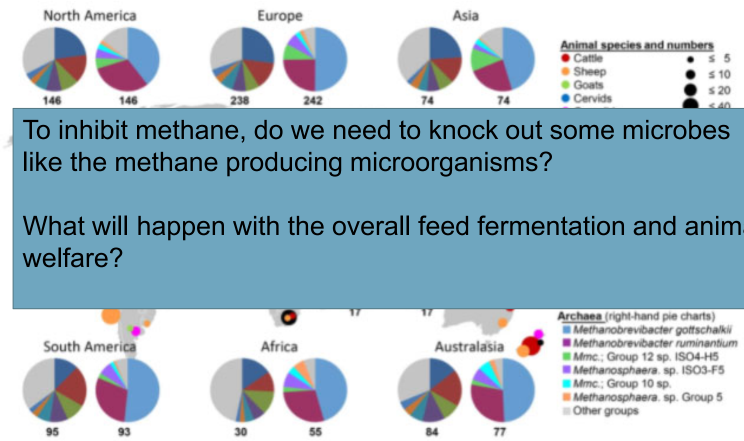
Who are there??

Core rumen microbiome



(Henderson et al., 2015)

Core rumen microbiome



To inhibit methane, do we need to knock out some microbes like the methane producing microorganisms?

What will happen with the overall feed fermentation and animal welfare?

(Henderson et al., 2015)

Feed and feed additives – an overview

Arndt et al., 2022. A meta analysis study including 430 peer reviewed publications including 98 mitigation strategies:

- Animal and feed management
- Diet formulation
- Rumen manipulation


PNAS RESEARCH ARTICLE | SUSTAINABILITY SCIENCE OPEN ACCESS

Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 °C target by 2030 but not 2050

To meet the 1.5 °C target, methane (CH_4) from ruminants must be reduced by 11 to 30% by 2030 and 24 to 47% by 2050 compared to 2010 levels. A meta-analysis identified strategies to decrease product-based (PB; CH_4 per unit meat or milk) and absolute (ABS) enteric CH_4 emissions while maintaining or increasing animal productivity (AP; weight gain or milk yield). Next, the potential of different adoption rates of one PB or one ABS strategy to contribute to the 1.5 °C target was estimated. The database included findings from 430 peer-reviewed studies, which reported 98 mitigation strategies that can be classified into three categories: animal and feed management, diet for-

Significance

Agricultural methane emissions must be decreased by 11 to 30% of the 2010 level by 2030 and by 24 to 47% by 2050 to meet the 1.5 °C target. We identified three

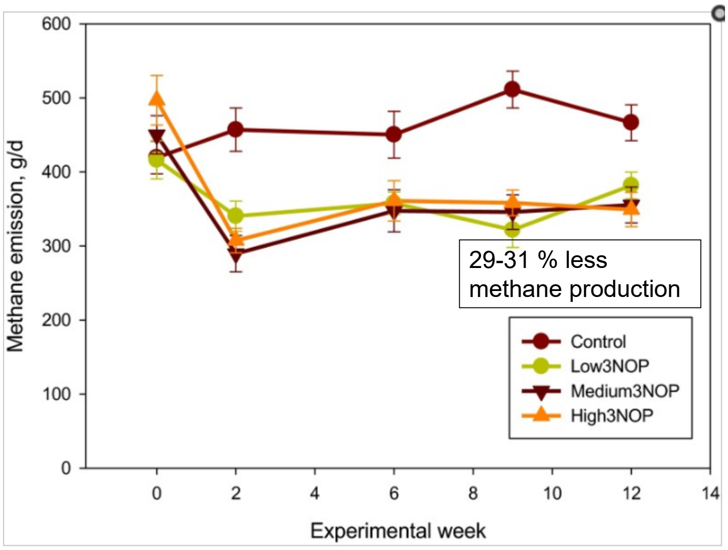
Rumen manipulation substrates

- 3NOP (Nitrooxypropanol) or Bovaer - Small molecule inhibitors that block the final step in methanogenesis.
  - Approved in EU for dairy cows spring 2022
- Red algae, inhibits methanogens in similar way as 3NOP.

- What happens with the hydrogen?

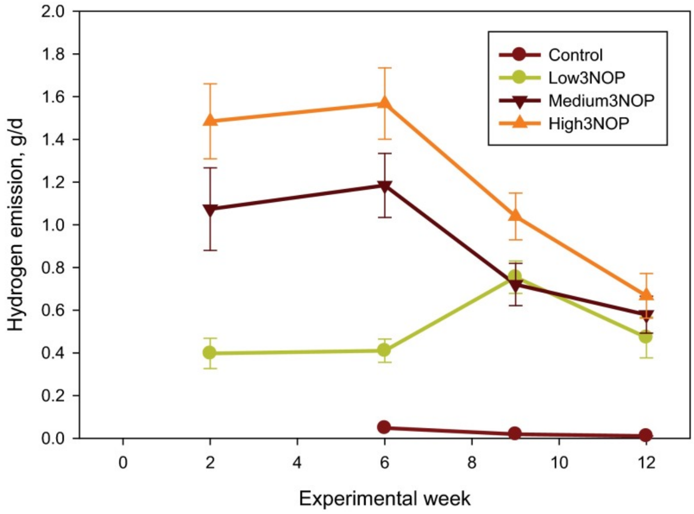
- Cost

3NOP methane production



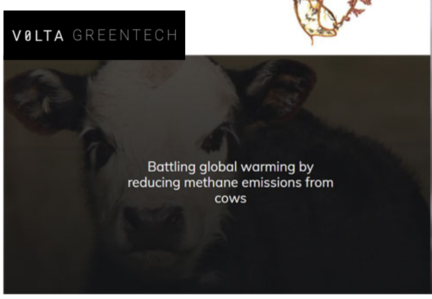
Hristov et al., 2015

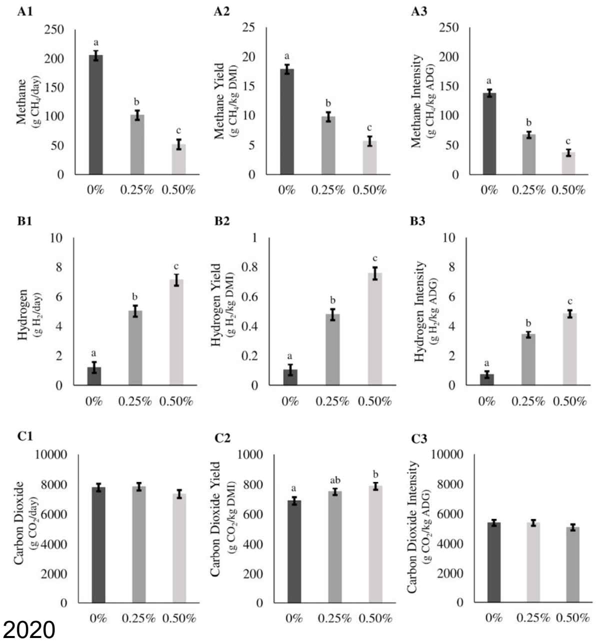
3NOP hydrogen production



Hristov et al., 2015

Algae– *Asparogopsis spp.*





Rouque et al., 2020

A. Taxiformis to dairy cows, Umeå 2022

30 early lactation dairy cows in three groups, inclusion level of AT at organic matter basis:

- Control, 0 %
- Low, 0.15 %
- High, 0.3 %

SLU

Analysis to be performed

- Digestibility of the feed
- Bromoform and bromine in milk (+iodine), urine and faeces
- Volatile fatty acids, total and proportions in rumen fluid
- Microbial composition –of bacteria and archaea and quantification of methanogens in rumen fluid and faeces
- Blood parameters – markers for inflammation for i.e.

SLU

Diet and feed additives

Intervention	Effect	Comment
Concentrate:Roughage	Low - medium	Some effect with > 70%. Negative for the rumen environment.
Fat	Medium	<5 % otherwise risk for inhibiting fermentation in the rumen
Nitrate	Medium	Toxicity, needs to be carfully added
Tanniferous forages	Low	To high inclusion in diet reduce digestibility
3-nitrooxypropanol	Medium-high,	Approved by EU 2022 for dairy cows. Cost? In which systems?
Seaweed	Medium-high?	Cost? Iodine and bromine levels, need long term study on dairy cows.

Diet and feed additives with some numbers

Mitigation strategy	Daily CH_4 n	Daily CH_4 Mean	Daily CH_4 P-value	CH_4 g/day n	CH_4 g/day Mean	CH_4 g/day P-value
Animal and feed management	205	4.6%	0.004	131	-2.1%	1.000
Feeds						
Decreasing forage-to-concentrate ratio	95	-1.6%	0.330	69	-12.6%	< 0.001
Increasing feeding level	42	17.9%	< 0.001	31	-8.1%	0.001
Increasing forage quality	31	10.6%	0.033	25	-2.3%	0.975
Diet formulation						
Oils and fats	63	-19.5%	< 0.001	52	-14.8%	< 0.001
Rumen manipulation						
3-nitrooxypropanol	11	-38.5%	< 0.001	12	-36.8%	< 0.001
Tanniferous forages	42	-11.6%	< 0.001	39	-10.0%	< 0.001
Nitrate	39	-16.9%	< 0.001	38	-16.3%	< 0.001
Secondary plant compounds	87	-5.9%	< 0.001	71	-8.4%	< 0.001
Probiotics	36	-0.8%	1.000	33	-1.6%	0.789

Table, based on data from Arndt et al., 2022

What do we know today?

How methane is formed - which organisms that are responsible for the formation of methane, but not the connection between different groups and how different substrates affect the entire microorganism community.

The focus is on trying to reduce methane production by;

- Various substrate that inhibit methane-producing microorganisms (inhibit H_2 formation or block methane formation, or stimulate other electron sinks)
- Choice of feed - effect throughout the chain
- Breeding for more efficient feed utilization and less methane
- Increased productivity

Thank you for listening!

Questions?

rebecca.danielsson@slu.se