Sustainable breeding for feed-efficient cows with lower methane emissions

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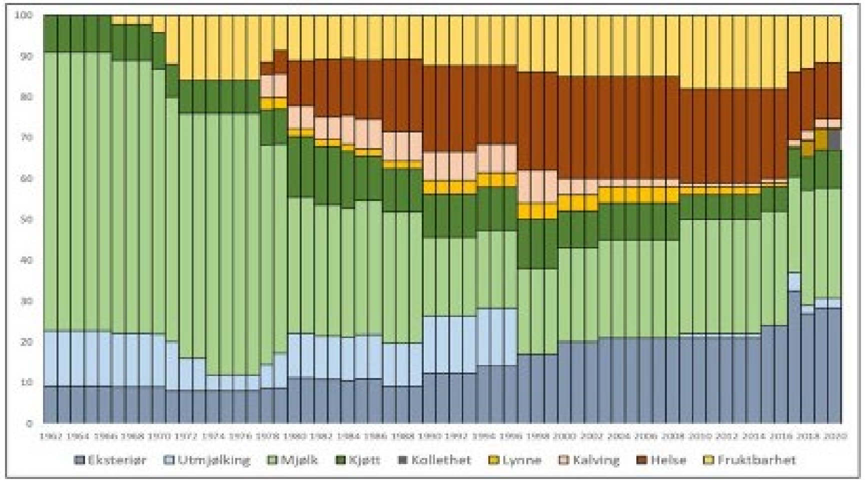
Sustainable breeding for feed-efficient cows with lower methane emissions

Sustainable breeding

- Broad breeding goal
- Balanced weights
- Accuracy of breeding values
- Efficient breeding program
- Control inbreeding

Norwegian Red

- Emphasis on health and fertility since 1970’s
- How to breed a feed efficient climate friendly cow?



Dairy cows in Norway

≈ 200 000 dairy cows

> 90 % Norwegian Red breed

> 50 % of cows in herds with automatic milking system (AMS)

- herd size
- labor costs

Photo: Geno

Breeding feed efficient cows with lower methane emission

AIM
include selection for improved **feed efficiency** and reduced **methane emissions** in the sustainable breeding goal for Norwegian Red

- Phenotyping new traits
- Trait definitions
- Accuracy of genomic breeding values
- Genetic associations to other important traits
  - milk yield, health, fertility…
- Predictions and indicator traits

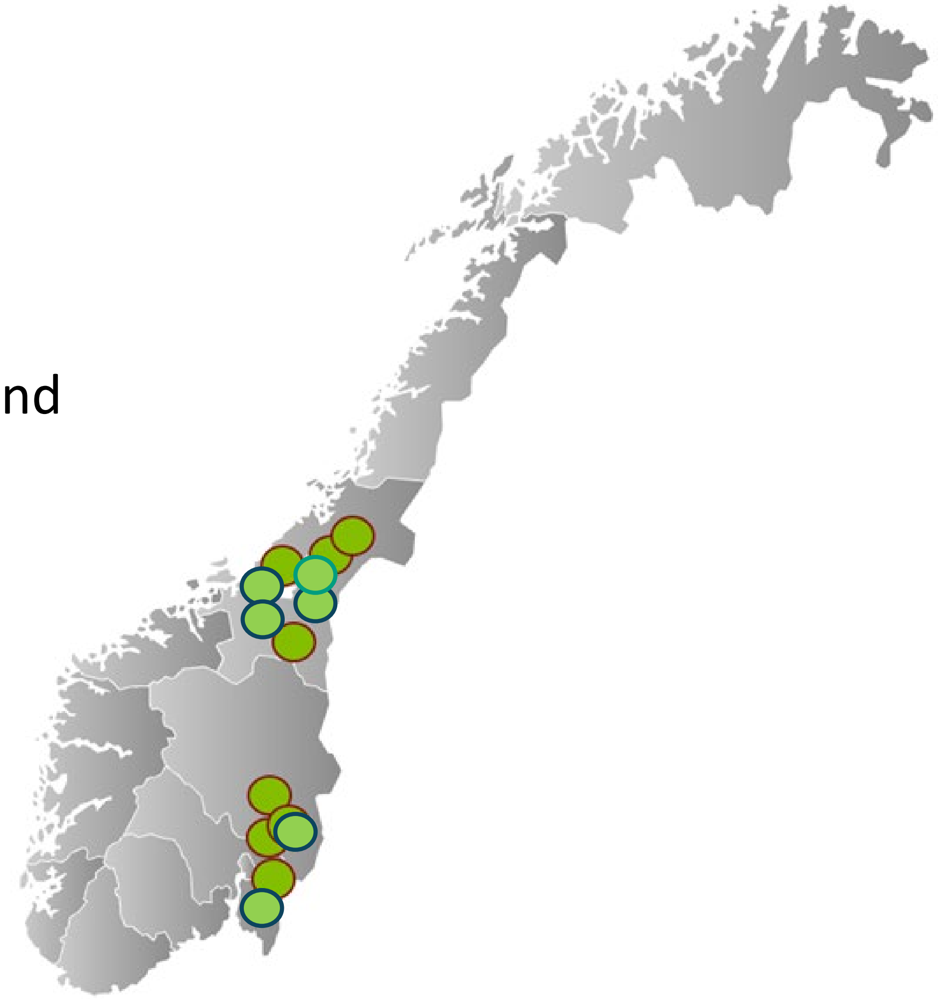
Breeding feed efficient cows with lower methane emission

- New traits – challenging phenotypes
- Traits in the category difficult, costly, time and/or labor-intensive to collect
- Reliable phenotypes crucial for efficient breeding
- Need phenotype on a sufficient number of animals to build a reference population for genomic selection

Breeding feed efficient cows with lower methane emission

- New traits – challenging phenotypes
- Geno established large-scale phenotyping of Norwegian Red cows
- Equipment to measure individual roughage feed intake and methane emission at 14 commercial dairy herds
    - All herds with automatic milking systems
    - All cows genotyped

~ phenotyping **1.000** cows pr. year



Phenotyping methane and feed intake

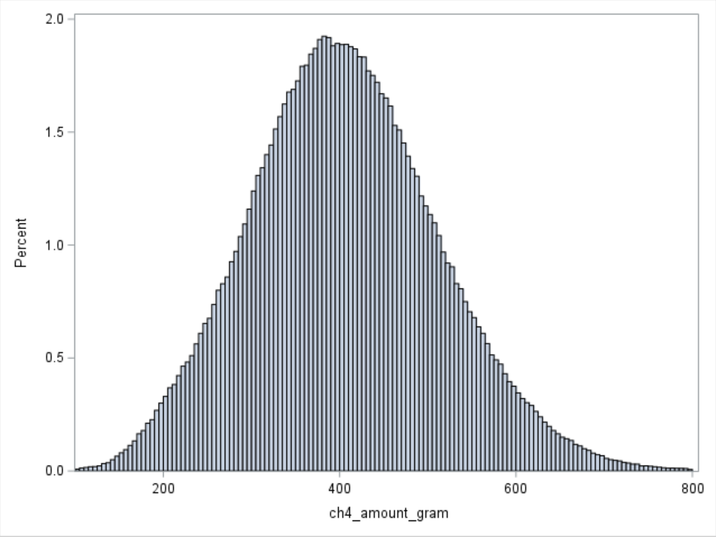
Data collection from the 14 herds ~ 1.000 cows per year

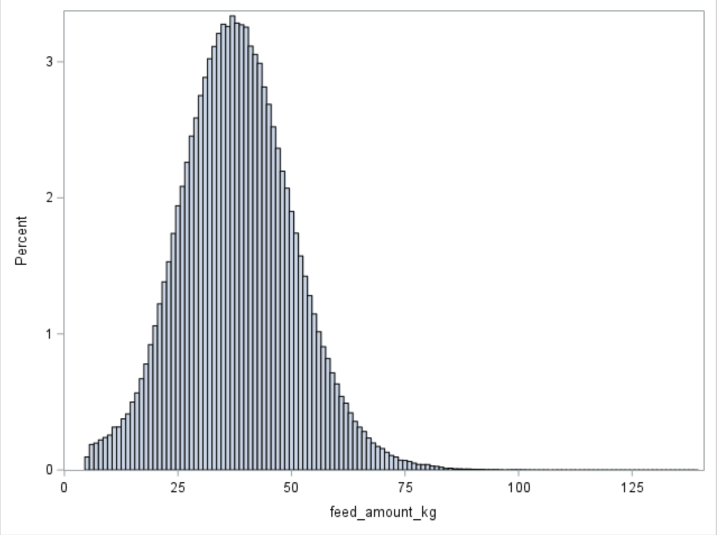
- Methane emission - GreenFeed
- Roughage feed intake – Biocontrol feed bins
- Concentrates feed intake
- Milk yield ++ from AMS
- Body weight
- Body Condition Score camera
- Activity meters
- Other sensors

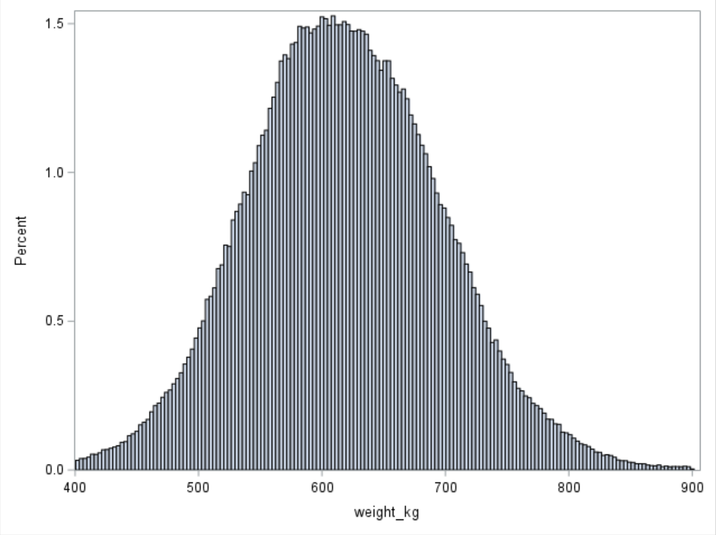
- Genotyping of all cows
- Feed samles for analyses
- Milk samples
- Relevant data from the Norwegian Dairy Herd Recording System

Phenotyping of Norwegian Red

		No of observations (1 record per cow/day)	No of cows with data
Methane from GreenFeed	gram /day (average)	1.126.468	3030
Roughage Feed Intake	Kg/day (sum)	1.183.591	2361







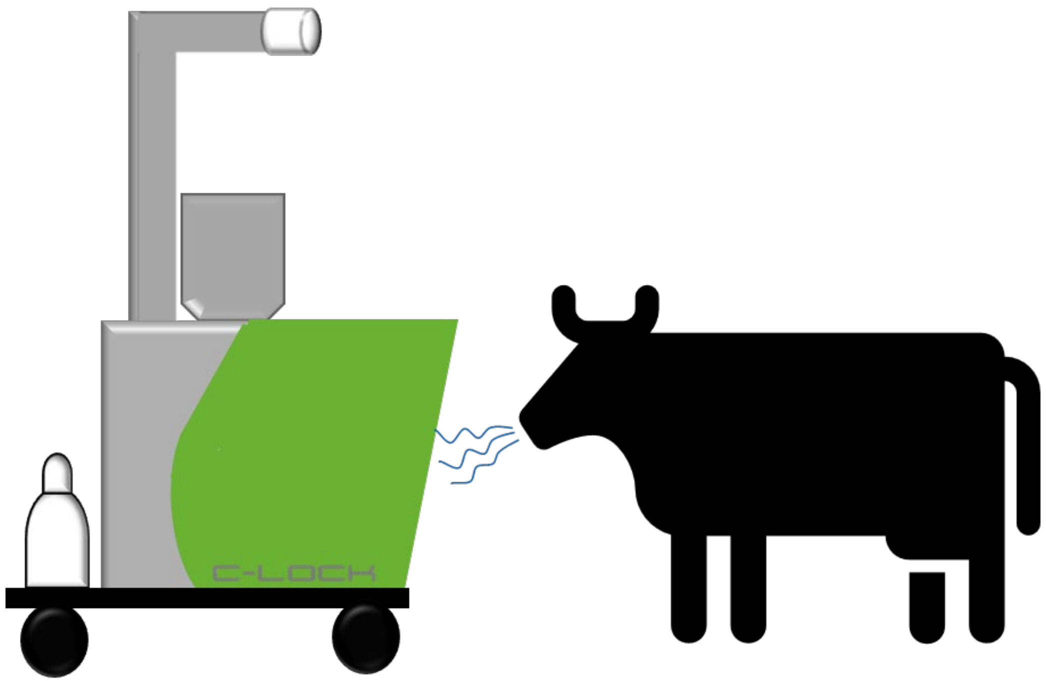
Variable	Mean	Std Dev
CH4	405.2234391	106.3186983
Feed_kg	37.3796641	13.3312148
weight_kg	619.0093114	77.4366873


Methane emission

GreenFeed equipment

Record methane for individual cows

- 2-5 visits per day
- Offer small amounts of concentrates for motivation
- Time restrictions: Minimum time since last visit
- Require minimum 2 minutes with correct head position for good data (accepted record)
- From each visit an estimate of the cow’s methane emission grams per day



From: https://www.c-lockinc.com/

Methane emisson per cow per day

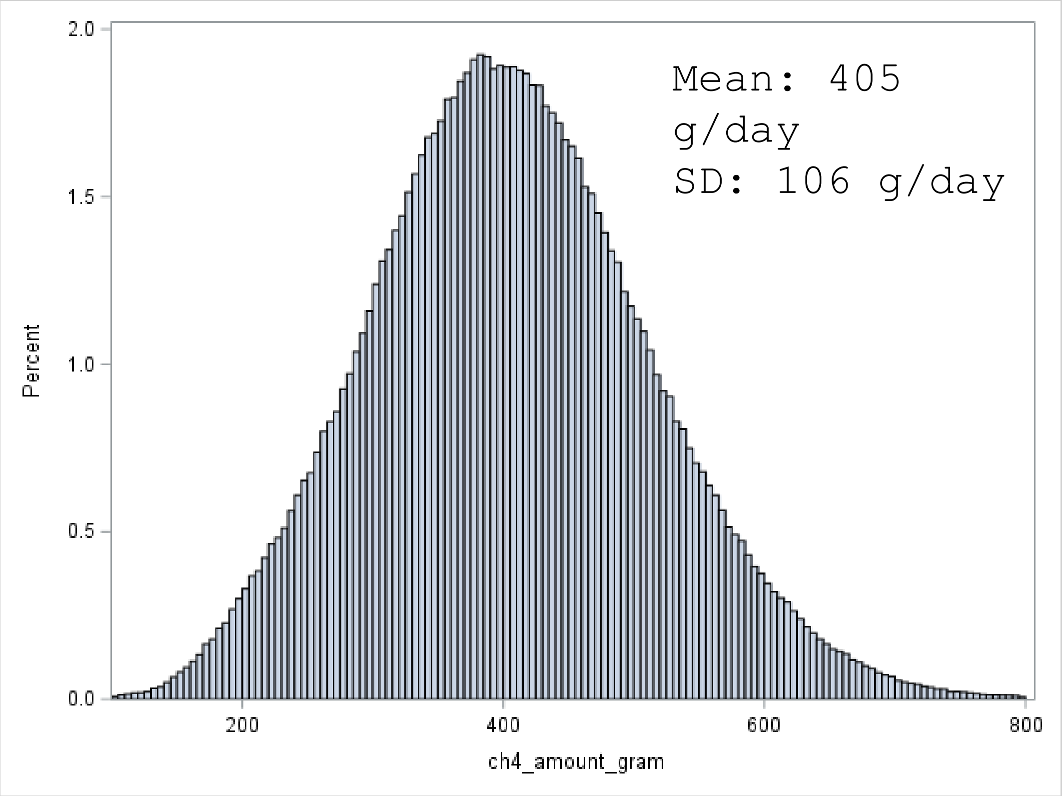
- Methane measures from GreenFeed
- Average per cow per day

Data from

14 GreenFeed units

3030 NRF kyr

> 1 mill CH_4 daily records



Genetic variation for methane emissions

Trait: Methane gram/day

(average per cow per day)

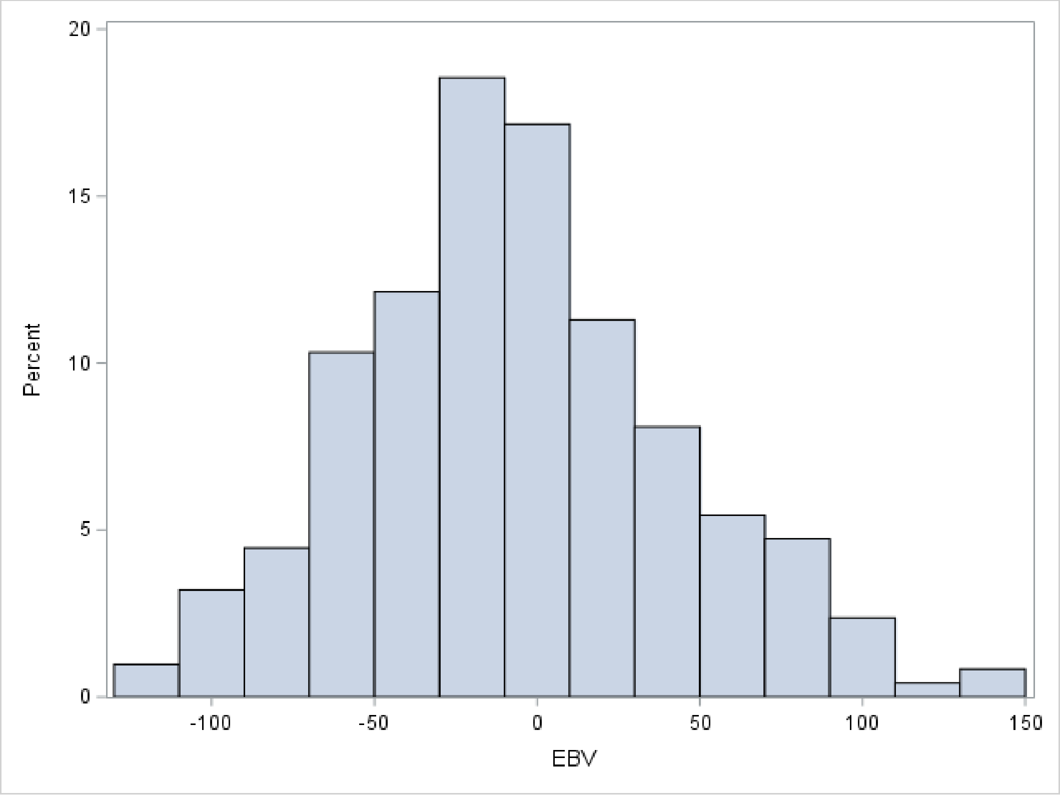
Heritability : **0.34**

(standard error (s.e.) 0.04)

Breeding values range from **-123** to **143**

(s.e. from 22 to 34)

Breeding values (EBV) for cows with phenotype



EBV given as methane gram per day

Methane emissions young bulls

Measuring methane on young Norwegian Red bulls at Geno's test station

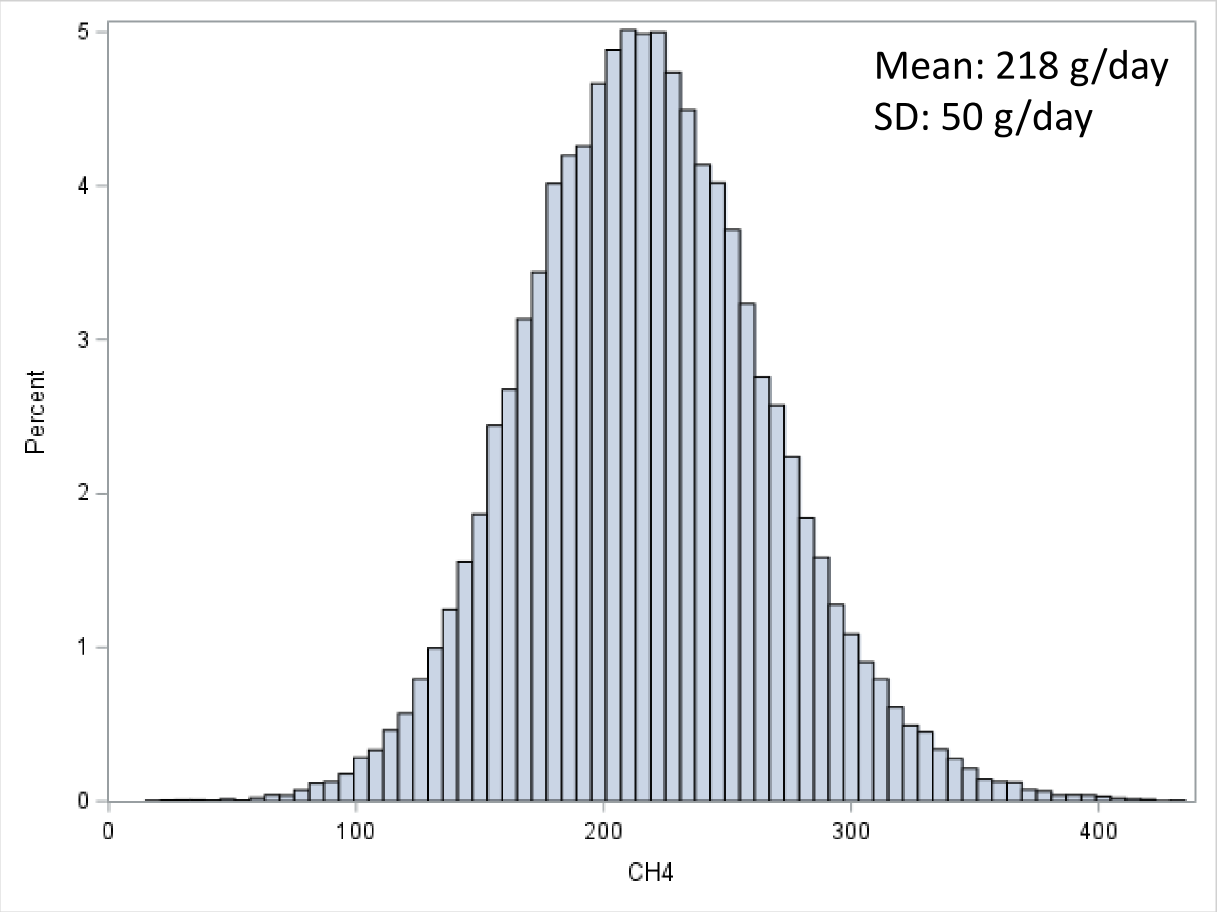
- ≈ 150 bull calves to test station each year
- Arrive 3-4 months old
- Pens with ≈10 bulls
- GreenFeed for methane (CH_4) recording
- Measure methane last month before leaving test station (at 11-12 mo old)
- On average 40 days with methane data
- Phenotype CH_4 data on both selected AI bulls and non-selected

Methane emission young Norwegian Red bulls

Distribution of methane records (g/day)

Data from September 2020 to April 2023

- 76 094 observations (GF visits)
- 212 Norwegian Red bulls



Genetic variation for methane emissions

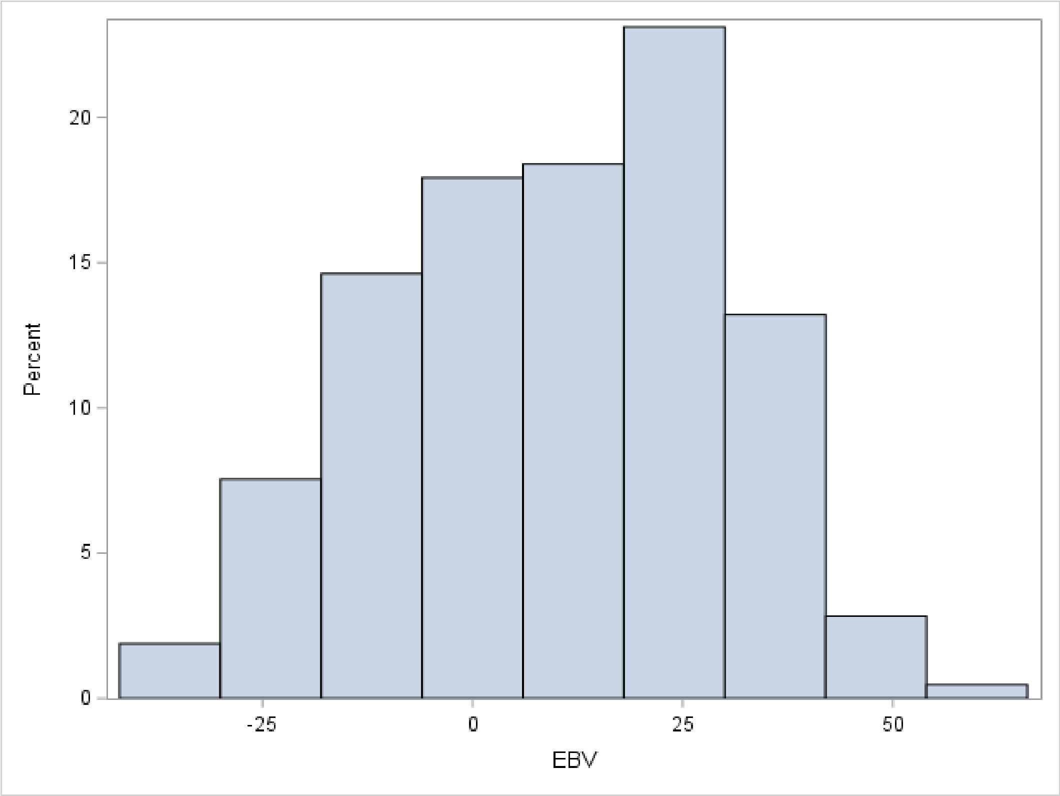
Trait: Methane gram/day
(average per bull per day)

Heritability: **0.56** (s.e. 0.20)

Breeding values range from **-37** to 60

(s.e. between 12 and 15)

Breeding values (EBV) for young bulls with phenotype



EBV given as CH4 g/day

Heringstad and Bakke. 2023. Interbull Bulletin:
https://journal.interbull.org/index.php/ib/article/view/1881/1909

Is methane emission the same trait genetically in young bulls and lactating dairy cows?

Photo:
Geno

Is methane emission genetically the same trait in young bulls and lactating dairy cows?

Data

Methane (CH_4) data from GreenFeed (GF) from

- **14 commercial dairy herds**

  772 000 GF visits from 1 370 cows

- **Geno's test station for young bulls**

  112 000 GF visits from 244 young bulls

Traits

Daily CH_4 emission = average of the GF visits each day:

- gram CH_4 per cow per day
- gram CH_4 per bull per day

Photo: Geno

Connected via pedigree

2 groups from the same Norwegian Red breeding population

90 A.I. sires had offspring in both groups

Among the young bulls with CH_4 data

- 151 had half-sisters with CH_4 data
- 2 had daughters with CH_4 data

Among the cows with CH_4 data

- 598 had half-brother(s) with CH_4 data
- 10 had a sire with CH_4 data

Heringstad, B., and K.A. Bakke. 2025. Journal of Dairy Science Communication (submitted)

Is methane emission genetically the same trait in young bulls and lactating dairy cows?

Results

- Estimated **heritability** (s.e.) of daily CH_4 emissions:
  - **0.39** (0.04) for cows
  - **0.49** (0.15) for young bulls

- Estimated **genetic correlation** (s.e.):
  - **0.63** (0.22)

➢ Large s.e.: Interpret with caution

➢ Strong genetic correlation: Phenotyping young AI bulls is valuable for future genetic evaluation of CH_4

Photo: Geno

Heringstad, B., and K.A. Bakke. 2025. Journal of Dairy Science Communication (submitted)

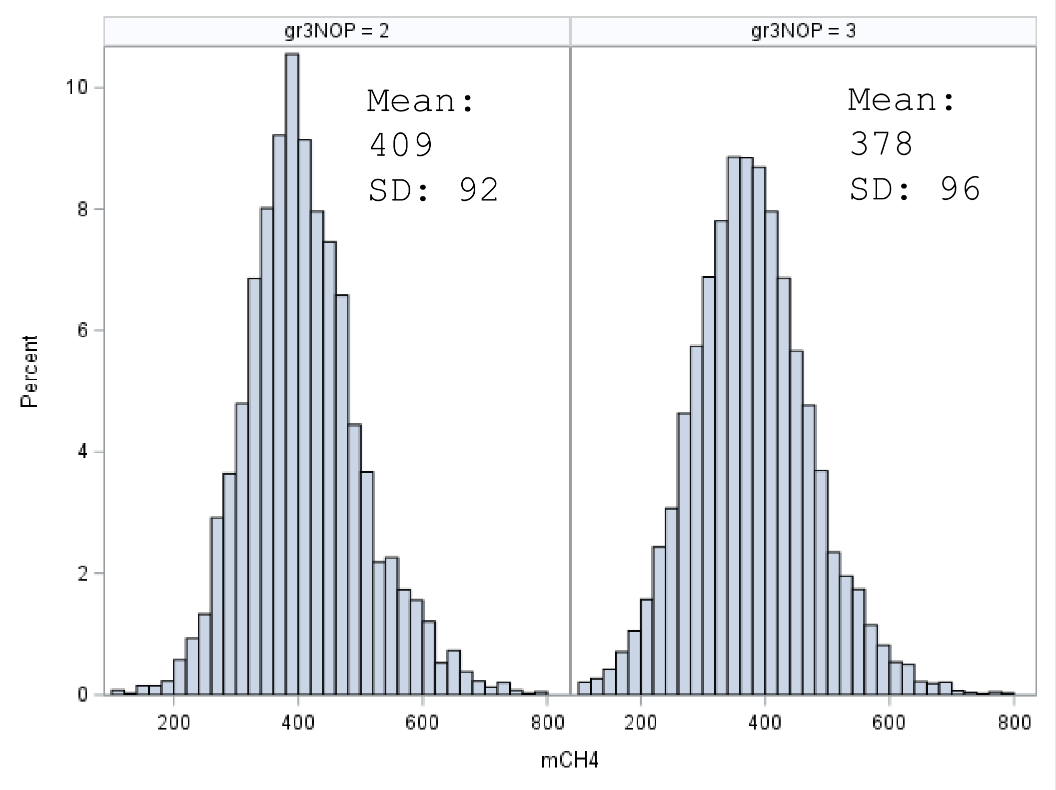
Methane-mitigating feed additives

Genetic variation in the cow's response to methane-mitigating feed additives

AIM: test the CH_4-mitigating effect of 3-NOP (Bovaer®)

- Commercial dairy herd
- 79 Norwegian Red cows
- from June 2023 to June 2024
- CH_4 measured by GreenFeed

  14,166 daily CH_4 measures were analyzed
- Trait: CH_4 gram/day (average of the cows GF visits)
- Cows in 2 groups with 3-NOP and without (control)



Distribution of daily CH_4 measures in control group (left) and the group that received 3-NOP feed additives (right)

MetanHUB

https://www.metanhub.no/

CH_4-mitigating effect of 3-NOP

- Variation between cows?
- Genetic variation?

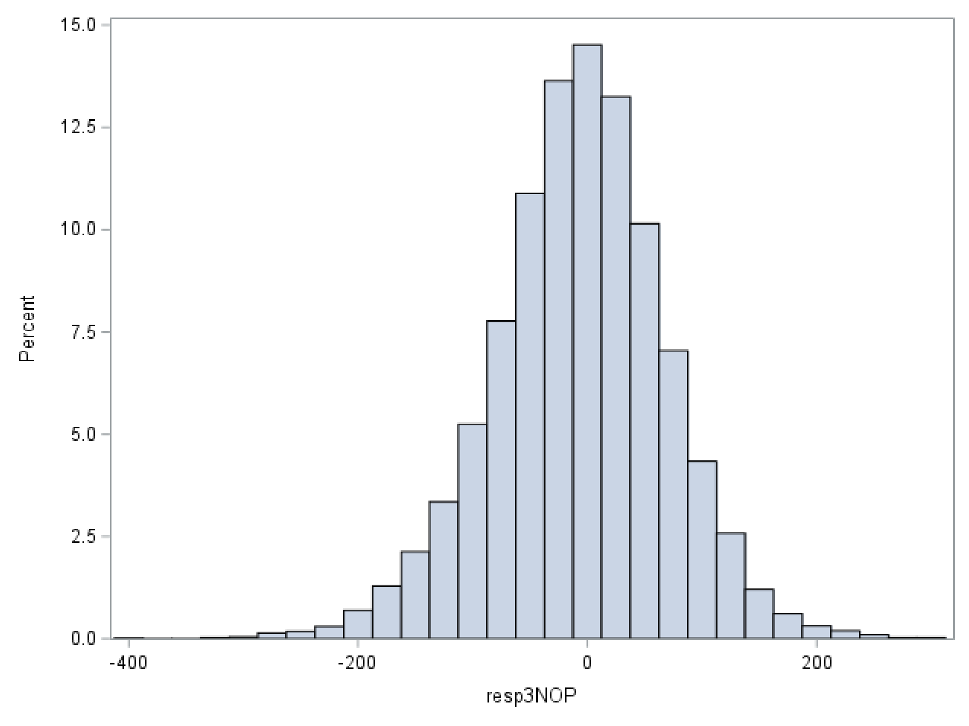
- Response = deviation from base-level CH_4
  defined as the cow's change in CH_4 after introducing 3-NOP in the diet compared to the "base level CH_4" in periods without 3-NOP

- The base level period (no 3-NOP): 3 weeks in September and 4 weeks in January/February

CH_4-mitigating effect of 3-NOP

1. Analyzed daily CH_4 with a linear animal repeatability model
   - Fixed effects: 3-NOP group, parity, lactation week, test-day
   - Random effects: animal genetic, pe, and residual
2. Computed "Yield Deviations" for CH_4 (YD_CH_4)
   - i.e. daily CH_4 corrected for effects of parity, lactation stage and test-day
3. "Base level CH_4" = average YD_CH_4 from the periods without 3-NOP
4. CH_4-response was calculated as YD_CH4_4 minus base level CH_4
   - 7,926 records

Analysis Variable : resp3NOP				
N	Mean	Std Dev	Minimum	Maximum
7293	-7.2543797	75.5029027	-406.7528452	297.2939439



Distribution of CH_4-response, change in daily CH_4 for days with 3-NOP in diet compared to the cow's "base level"

Genetic analysis of CH_4-response

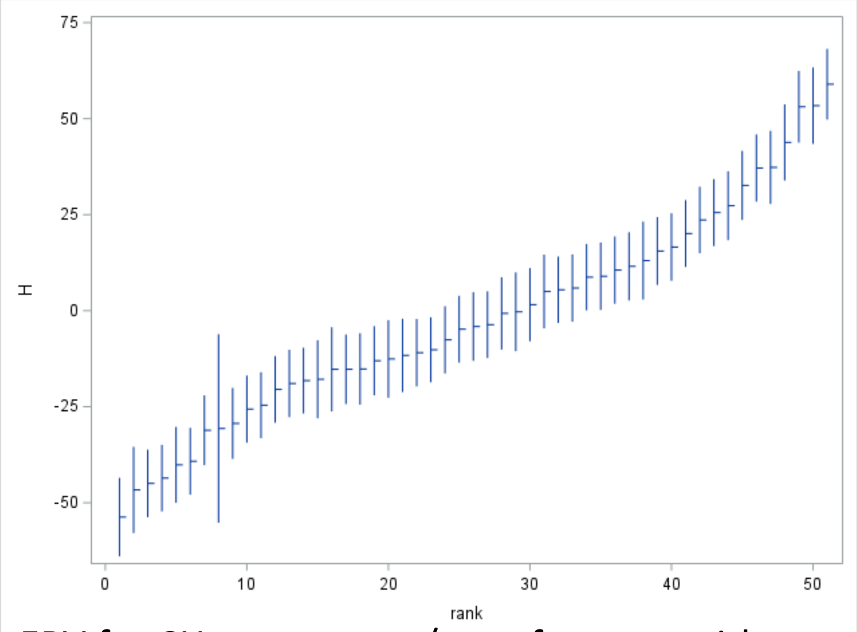
- Trait: CH_4-response (daily records)
- Linear animal repeatability model with fixed effect of testday and random genetic effect of cow
- Estimated variance components using DMU

	estimat	s.e
σ^2_g	852	182
σ^2_e	4933	80

Heritability: 0.15 (0.03)

EBV for cows with CH_4–response records:

N	Mean	Std Dev	Minimum	Maximum
51	-1.8593409	27.3343032	-53.7388000	58.9626000



EBV for CH_4-response +/- s.e. for cows with records, sorted by increasing EBV

Genetic variation in the cow's response to methane-mitigating feed additives

The effect of 3-NOP varies between cows

Part of the variation is genetic


Feed efficiency

Feed efficiency

- Recording roughage intake in 14 herds
- Building reference population
- Predict genomic breeding values for feed efficiency
- Include feed efficiency in TMI

geno NORWEGIAN RED

Traits

- **CH4**: Methane gram/day

  (average per cow per day)

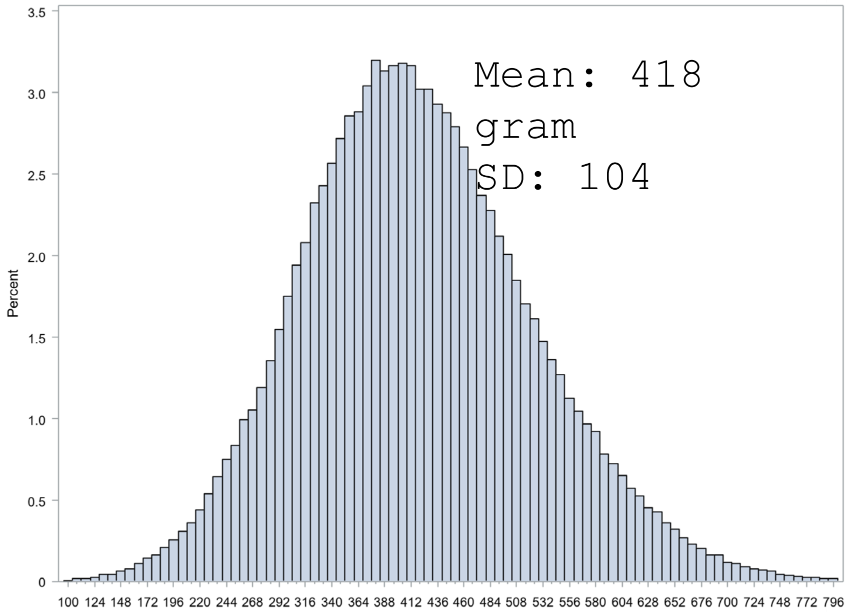
- **BW**: Body weight, kg

  (average per cow per day)

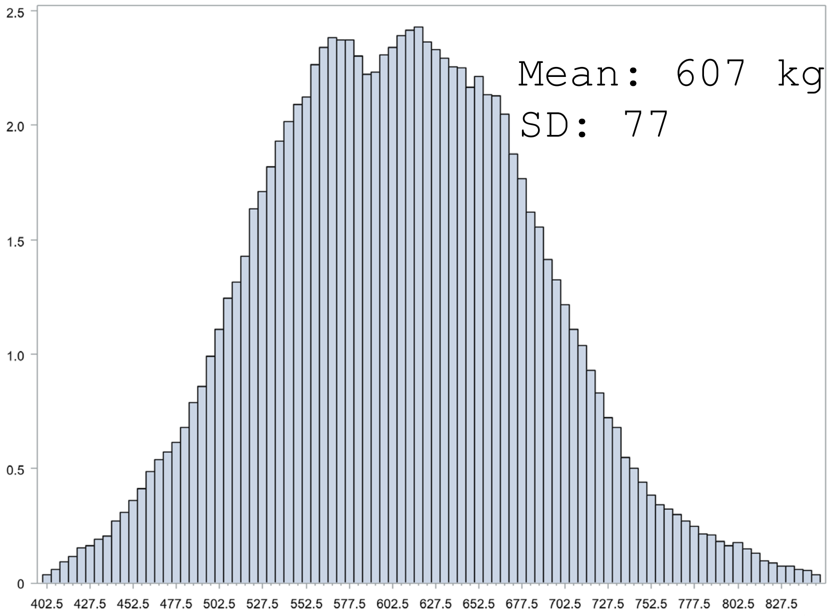
- **dDMI**: sum daily dry matter intake (kg)

Phenotypic distributions

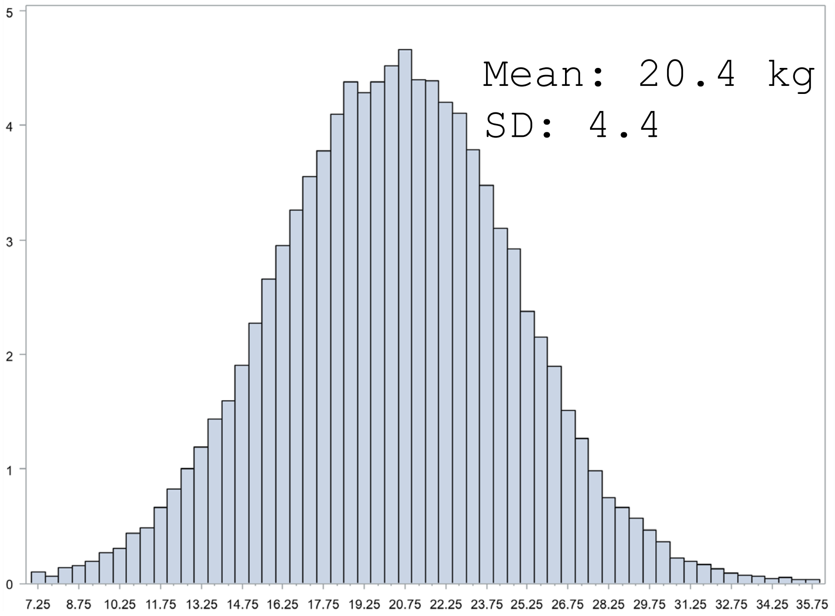
Methane



Body Weight



Daily dry matter intake



Heritabilities (h^2) with standard error (s.e.) on the diagonal and genetic correlations below

Trait	dDMI	BW	CH4
dDMI	0.29 (0.05)		
BW	**0.59** (0.11)	0.57 (0.05)	
CH4	**0.65** (0.10)	**0.50** (0.09)	0.39 (0.04)

dDMI: daily dry matter intake (kg)

BW: Body weight (kg)

CH4: Methane gram/day

h^2 calculated as: $\sigma^2_a / (\sigma^2_a + \sigma^2_{htd} + \sigma^2_{pe} + \sigma^2_e)$

Breeding feed efficient dairy cows with lower methane emissions

Results so far:

- Good data on methane and feed intake
- Genetic variation in Norwegian Red
- Breeding feed efficient cows with lower methane emissions is feasible

- Trait definition feed efficiency?
- Trait definition methane?
- Associations between traits
- Started to analyse traits that are key ingredients of a future feed efficiency and methane traits

Sustainable breeding for feed-efficient cows with lower methane emissions

Sustainable breeding

- Broad breeding goal
- Balanced weights
- Accuracy of breeding values

We aim to **balance** feed efficiency, climate effects, production, health, and fertility in a sustainable breeding goal for Norwegian Red

The work presented here is done together with
dr. Karoline Bakke, researcher, Geno R&D
and **Eli Hveem Krogsti**, project leader of the feed efficiency project, Geno R&D

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Els Korsten