atf animal task force

A European Public-Private Partnership

LIÈGE université
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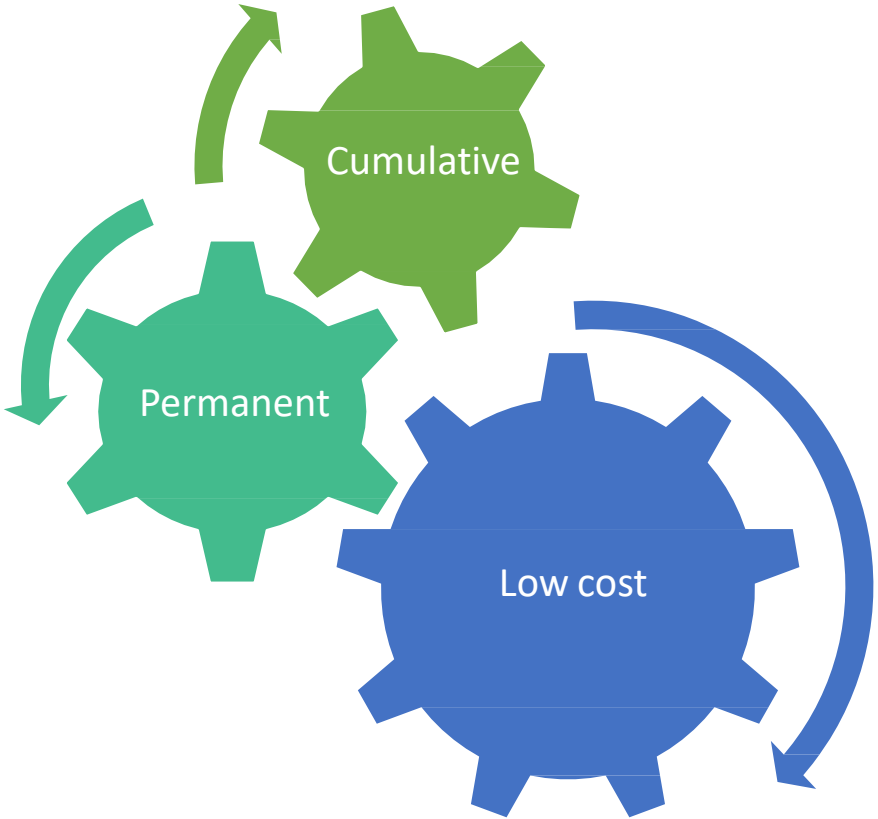
Agro-Bio Tech

Strategies in practice: Input from the field

Animal Genetics

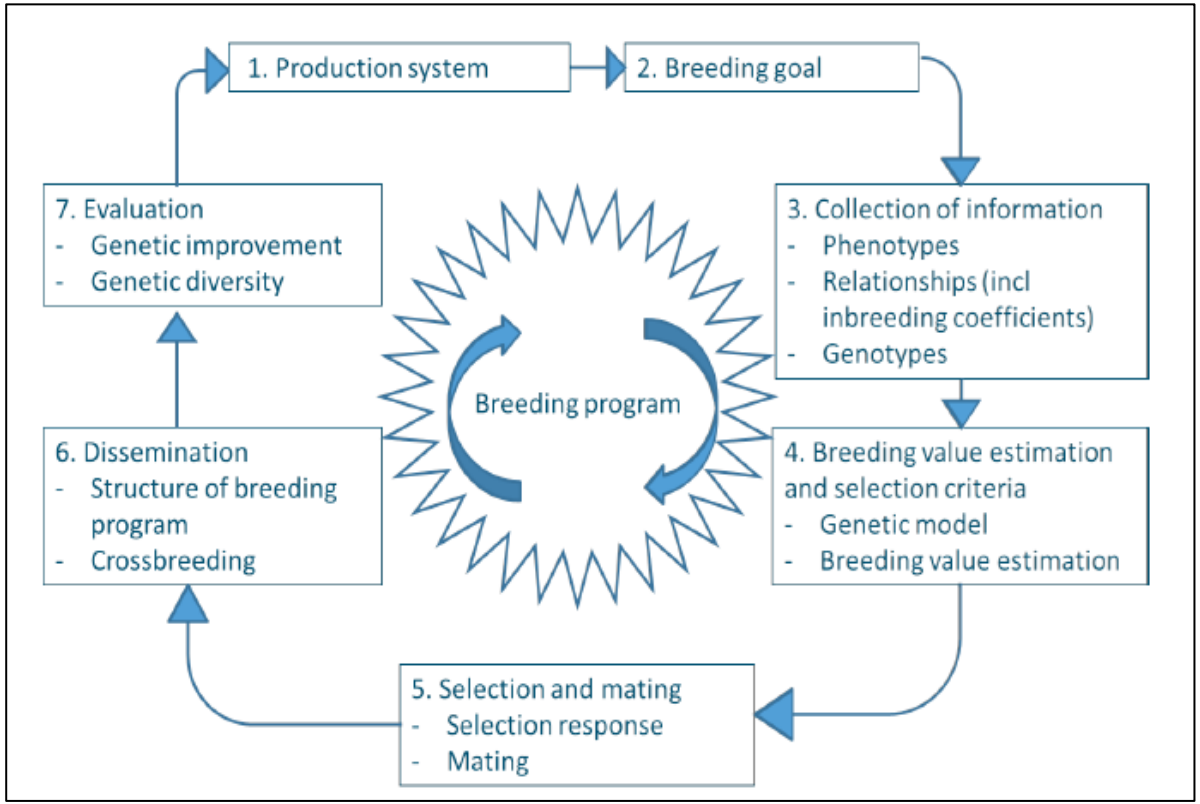
Nicolas Gengler

Genetic Improvement → Promising Tool…



Genetic Improvement → Breeding Program

http://www.wcgalp.org/system/files/proceedings/2014/how-teach-animal-breeding-and-genetics-undergraduate-students-presentation-thinking-process.pdf



Breeding Program → Breeding Goal

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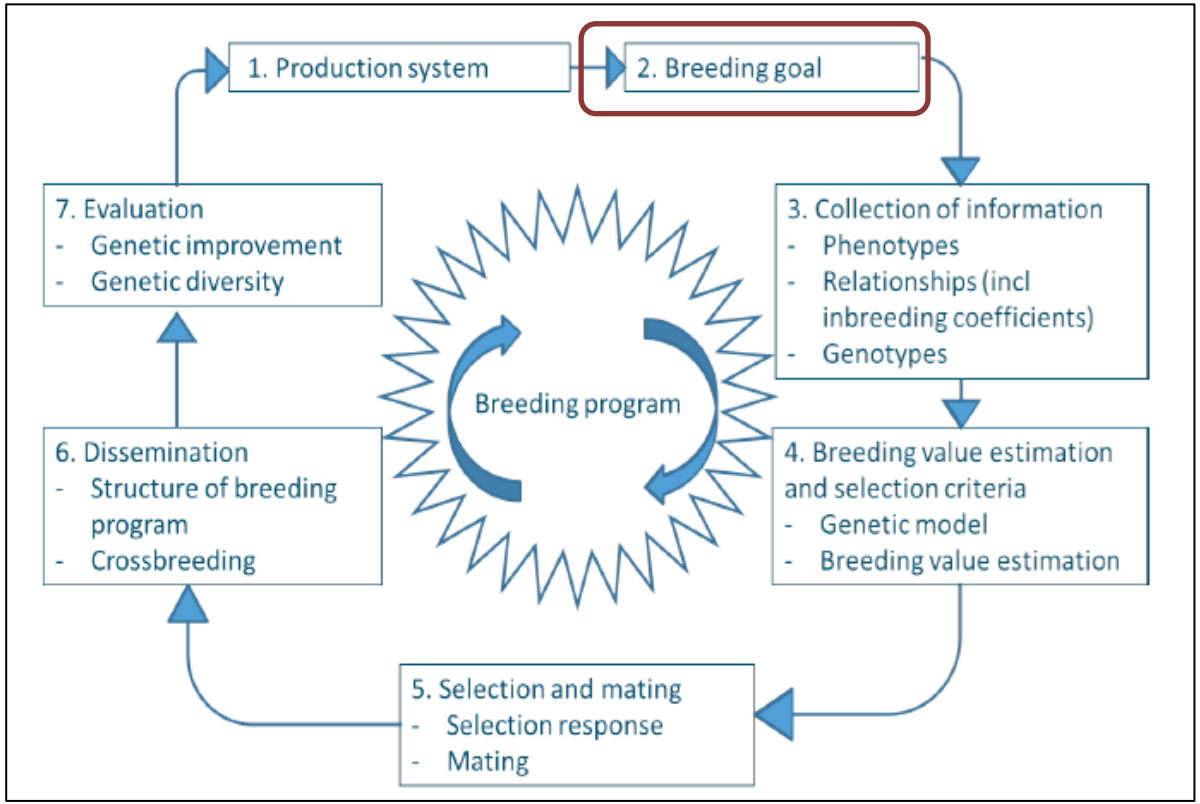
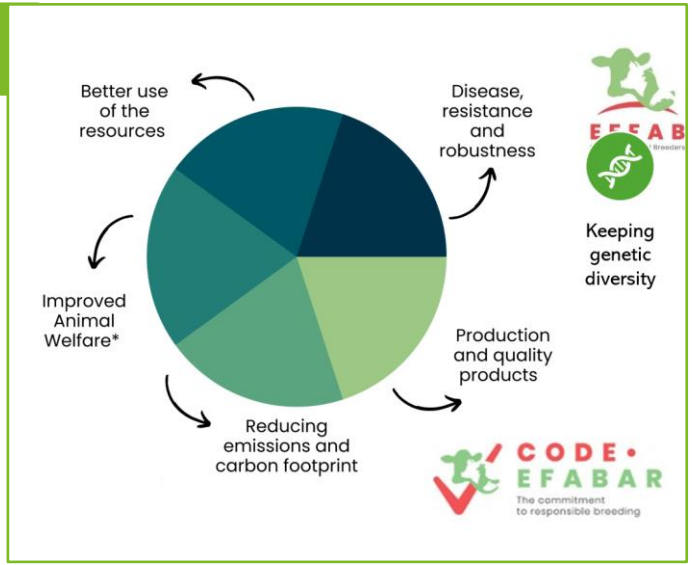


What is a “Breeding Goal”?

- In short: “What we want to achieve by breeding”
- In long: A function of the traits to be improved
  - Considering the emphasis (weight) given to each “breeding goal trait”

➔ direction in which we want to improve animals

- Crucial to create **Genetic Improvement (GHG ↘)**
- Developing appropriate **Selection Indexes**
- And keeping **breeding balanced**



Breeding Program → Phenotypes

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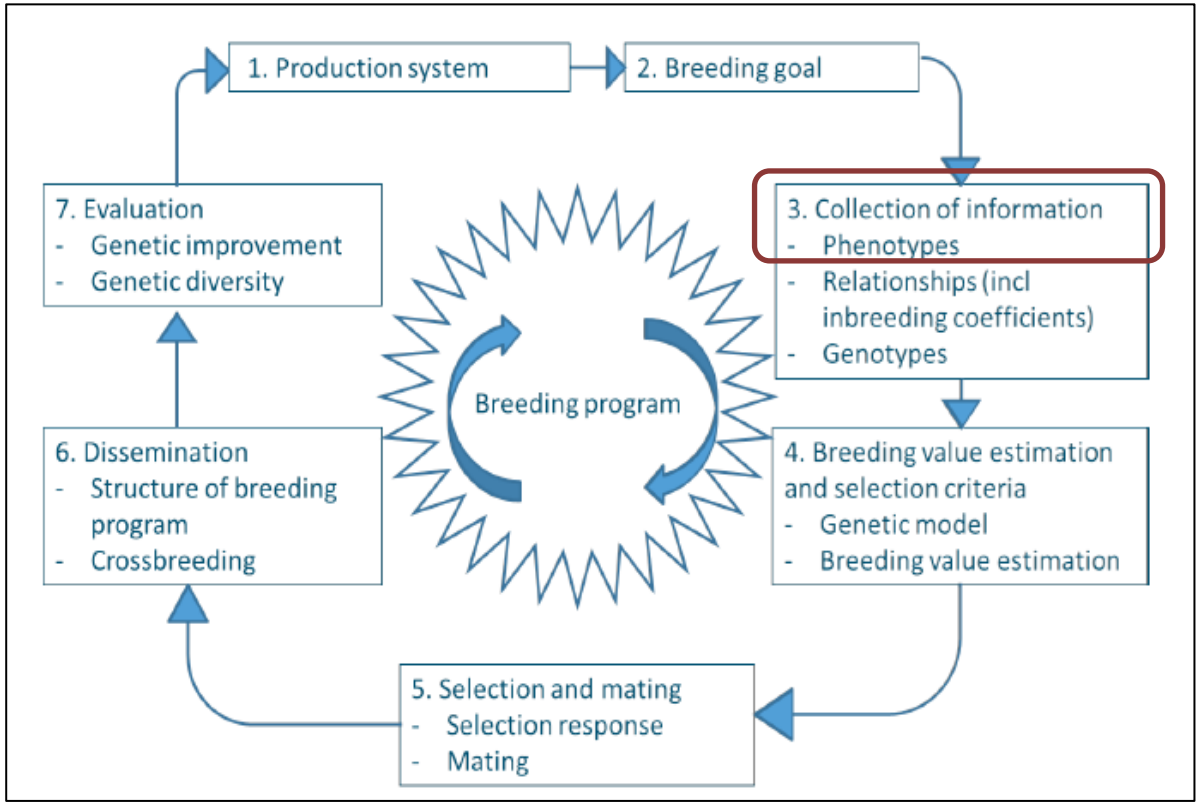


Acquiring GHG related phenotypes…

- **High investments** needed in measuring emissions
- Often associated also to (feed) **efficiency** ← also costly
  - **Energy**  → **CH_4**
  - **Nitrogen use efficiency (NUE)**  → **N_20**
- Direct measurements of **CH_4** 

Measuring CH_4 → difficult and expensive

Table 1. Summary of the main features of methods for measuring methane output by individual animals [1].

Method	Purchase Cost [2]	Running Costs [2]	Labour [2]	Repeatability	Behaviour Alteration [3]	Throughput
Respiration chamber	High	High	High	High	High	Low
SF_6 technique	Medium	High	High	Medium	Medium	Medium
Breath sampling during milking and feeding	Low [4]	Low	Low	Medium	None	High
GreenFeed	Medium	Medium	Low	Medium	Low	Medium
Laser methane detector	Low	Low	High	Low	Low-Medium	Medium

[1] Consensus views based on experiences of METHAGENE WG2 members. [2] Per measuring unit or group of animals. [3] Compared to no methane recording: low = measuring in situ; medium = some handling, training or change in routine; high = confinement. [4] Medium if using FTIR analyser.

Comparison of Methods to Measure Methane for Use in Genetic Evaluation of Dairy Cattle

animals

by Philip C. Garnsworthy [1,*], Gareth F. Difford [2,3], Matthew J. Bell [1], Ali R. Bayat [4], Pekka Huhtanen [5], Björn Kuhla [6], Jan Lassen [2], Nico Peiren [7], Marcin Pszczola [8], Diana. Sorg [9,10], Marleen H.P.W. Visker [3] and Tianhai Yan [11]

Animals **2019**, *9*(10), 837; https://doi.org/10.3390/ani9100837

Selection Index to the rescue…

- What is a "**Selection Index**"?
  - Definition: best (linear) predictor of the **breeding goal**
  - Combination of information from many traits
    - NB: concept of "**information**" vector
  - Many variants here important "**Desired Gain SI**"
    - **Forced** response of GHG
- Concept of "**selection index traits**"

➔ **what we really measure and select to improve our animals**

  - Weighted into a single "combined" **index** value

Selection Index to the rescue…

- Important disclaimer:

"Breeding goal traits" can be ≠ from "Selection index traits"

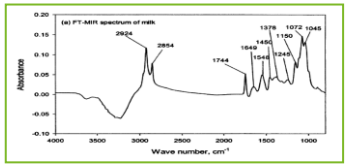
- Therefore (illustrating by our context):
  - Direct CH_4 / N_20 emissions in breeding objectives
    ➔ few thousand records CH_4, "none" for N_20 ← outside animal
  - But proxies for CH_4 emission, NUE (i.e., based on milk composition)
    ➔ tenth of millions of records
- Strong interest to find appropriate indirect proxies

➔ Importance of international collaboration

Possibility: Use of Mid-Infrared Spectrometry

Milk samples
(milk payment, milk recording)

MIR spectrometry analysis



Raw data = MIR spectra

Calibration equations

Quantification:

Existing and new traits

MIR-CH_4 and MIR-Nitrogen Use Efficiency (NUE)

- Use of milk mid-infrared (MIR) spectra based proxies
  - MIR-CH_4

J. Dairy Sci. 98:5740–5747
http://dx.doi.org/10.3168/jds.2014-8436

***Hot topic*: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra**

A. Vanlierde,*[1] M.-L. Vanrobays,†[1] F. Dehareng,* E. Froidmont,‡ H. Soyeurt,† S. McParland,§ E. Lewis,§ M. H. Deighton,# F. Grandl,‖ M. Kreuzer,‖ B. Gredler,¶ P. Dardenne,* and N. Gengler†[2]
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  - MIR-NUE

J. Dairy Sci. 103:4435–4445
https://doi.org/10.3168/jds.2019-17910

Potential of milk mid-infrared spectra to predict nitrogen use efficiency of individual dairy cows in early lactation

C. Grelet,[1] E. Froidmont,[1] L. Foldager,[2,3] M. Salavati,[4] M. Hostens,[5] C. P. Ferris,[6] K. L. Ingvartsen,[2] M. A. Crowe,[7] M. T. Sorensen,[2] J. A. Fernandez Pierna,[1] A. Vanlierde,[1] N. Gengler,[8] GplusE Consortium,† and F. Dehareng[1]‡
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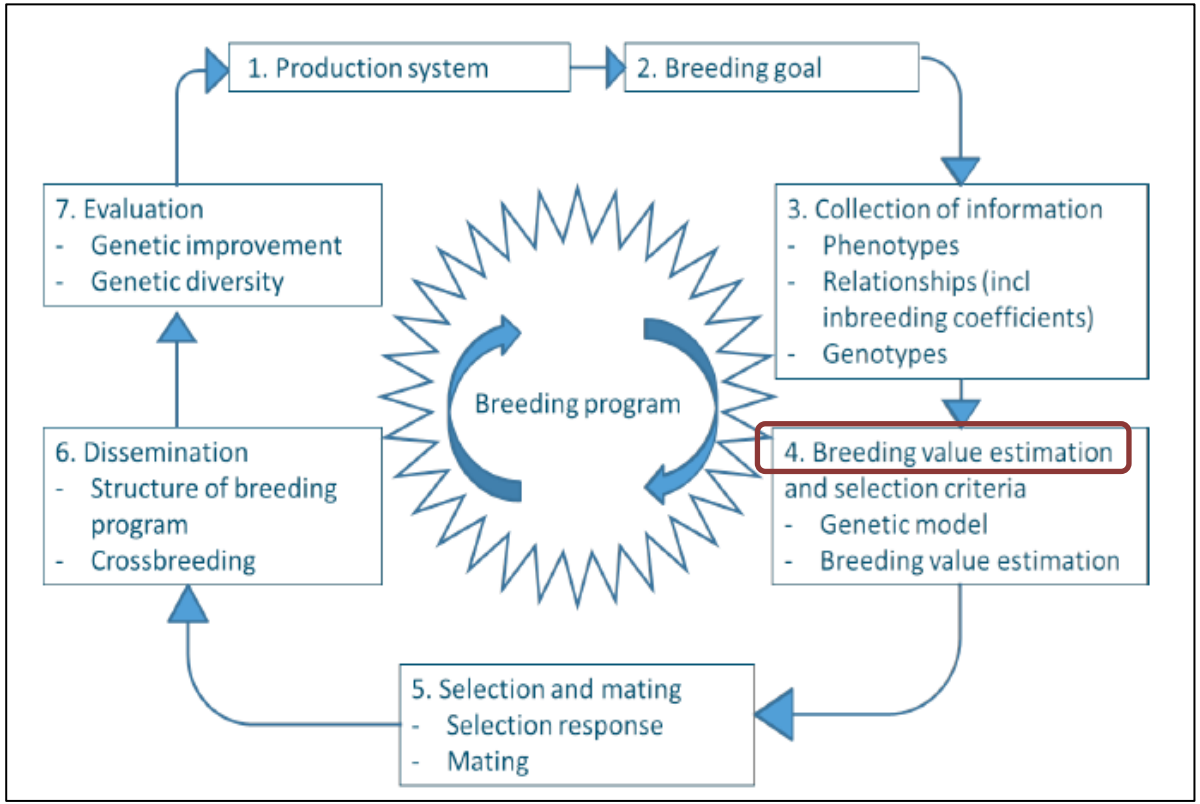
Near IR (NIR) on feces

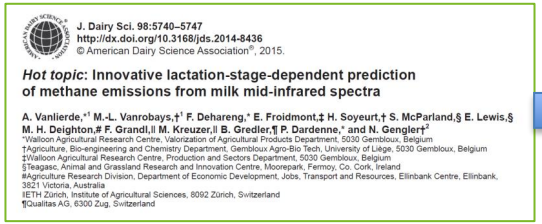
Breeding Program → Routine Breeding

http://www.wcgalp.org/system/files/proceedings/2014/how-teach-animal-breeding-and-genetics-undergraduate-students-presentation-thinking-process.pdf



Selecting on MIR-CH_4 and MIR-NUE possible?

- Use of milk mid-infrared (MIR) proxies ➔ Estimated Breeding Values?
  - MIR-CH_4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J. Dairy Sci. 100:5578–5591
https://doi.org/10.3168/jds.2016-11954

Genetic parameters of mid-infrared methane predictions and their relationships with milk production traits in Holstein cattle

P. B. Kandel,* M.-L. Vanrobays,* A. Vanlierde,† F. Dehareng,† E. Froidmont,‡ N. Gengler,* and H. Soyeurt*[1]
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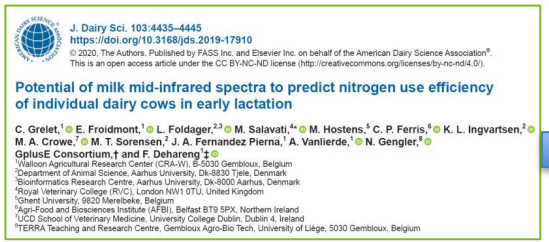
‡Department of Production and Sectors, Animal Nutrition and Sustainability Unit, Walloon Agricultural Research Centre, 5030 Gembloux, Belgium

  - MIR-NUE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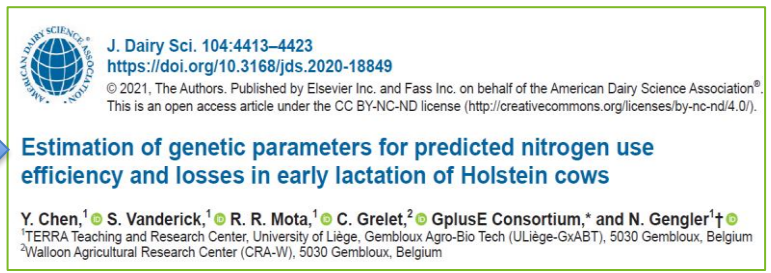

J. Dairy Sci. 104:4413–4423
https://doi.org/10.3168/jds.2020-18849

Estimation of genetic parameters for predicted nitrogen use efficiency and losses in early lactation of Holstein cows

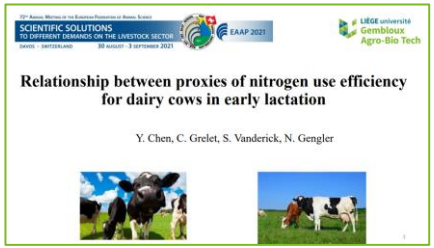
Y. Chen,[1] S. Vanderick,[1] R. R. Mota,[1] C. Grelet,[2] GplusE Consortium,* and N. Gengler[1]†
[1]TERRA Teaching and Research Center, University of Liège, Gembloux Agro-Bio Tech (ULiège-GxABT), 5030 Gembloux, Belgium
[2]Walloon Agricultural Research Center (CRA-W), 5030 Gembloux, Belgium

➔ **Heritability in ~ 0.10 – 0.20 range, similar to somatic cells**

And Routine Breeding → only starting…

- Disclaimer:
  - A lot of movement
  - Here especially dairy cattle situation, uncertainty about next steps
- CH_4, very different approaches:
  - All taking advantage of **genomics** → increased **reliabilities of EBV**
  - **Indirect** through feed efficiency: NLD, AUS, USA…
  - Only **direct CH_4** or **indirect (MIR)**: CAN, IRL (?)…
- N_20 → use of **Urea** as a proxy for NUE, some doubts

→ Importance of international collaboration



Breeding Program → Genetic Improvement

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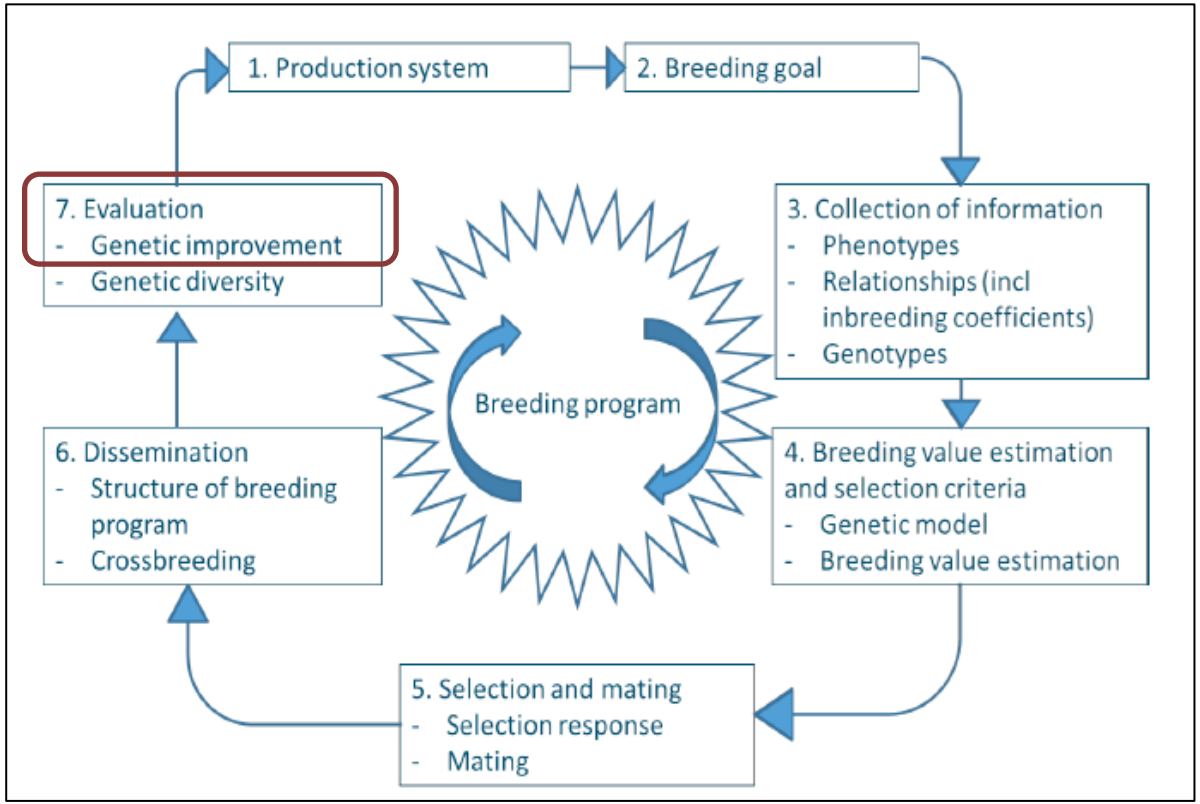

CH_4 example presented @ ATF-EAAP 2022 event

J. Dairy Sci. 103:7210–7221
https://doi.org/10.3168/jds.2019-17598

Mitigation of greenhouse gases in dairy cattle via genetic selection: 2. Incorporating methane emissions into the breeding goal

O. González-Recio,[1,2*] J. López-Paredes,[3] L. Ouatahar,[1] N. Charfeddine,[4] E. Ugarte,[5] R. Alenda,[2] and J. A. Jiménez-Montero[4]
[1]Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Crta. La Coruña km 7.5, 28040 Madrid, Spain
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[4]Spanish Holstein Association (CONAFE), Ctra. Andalucía km 23600 Valdemoro, 28340 Madrid, Spain
[5]Department of Animal Production, NEIKER—Tecnalia, Granja Modelo de Arkaute, Apdo. 46, 01080 Vitoria-Gasteiz, Spain

Total methane reduction from dairy cattle in Spain under considered scenarios

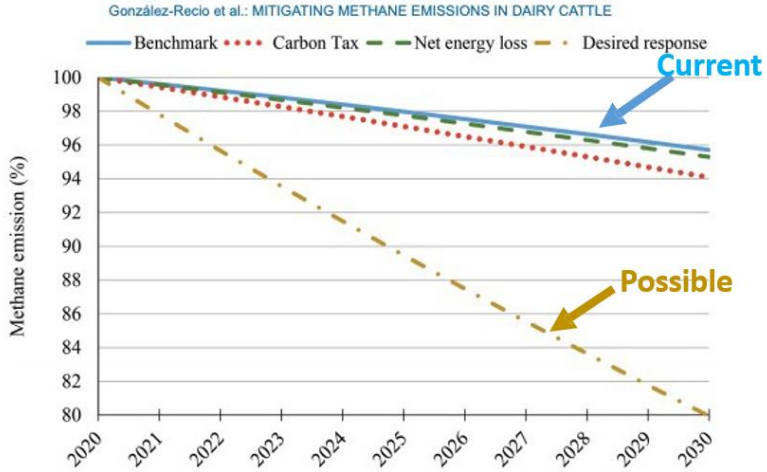

Figure 2. Expected reduction in percentage from current levels in methane emissions produced by Holstein cows in Spain based on gain in methane emissions (MET; t/yr) under the 4 scenarios: benchmark, carbon tax, net energy loss, and desired response (i.e., nu cows × MET genetic gain × time/1,000). A decrease of 1.5% in the number of dairy cows was considered each year, following census da the Spanish Holstein association: (http://www.conafe.com/VisorDocs.aspx?pdf=estadisticas_CENSO_DE_ANIMALES.pdf).

Projected enteric methane per billion liters of milk in Spain

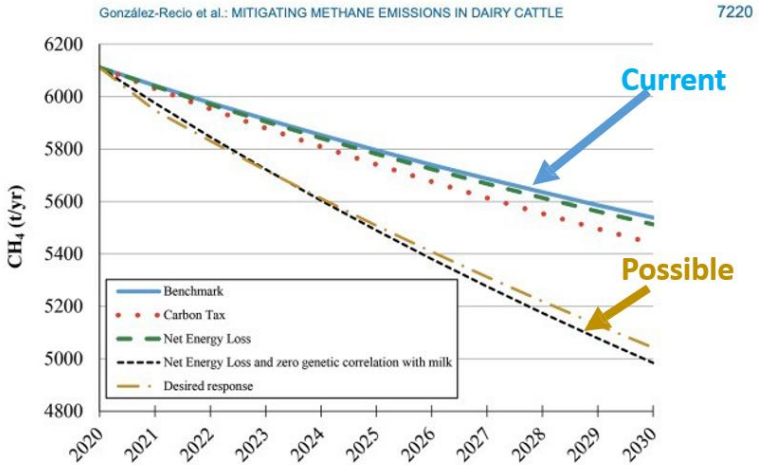

Figure 3. Estimated methane production (t/yr) per billion liters of milk from the expected genetic gain obtained under the 4 scenarios: benchmark, carbon tax, net energy loss, and desired response.

CH_4 example presented @ ATF-EAAP 2022 event

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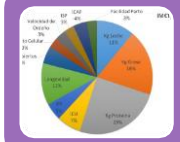


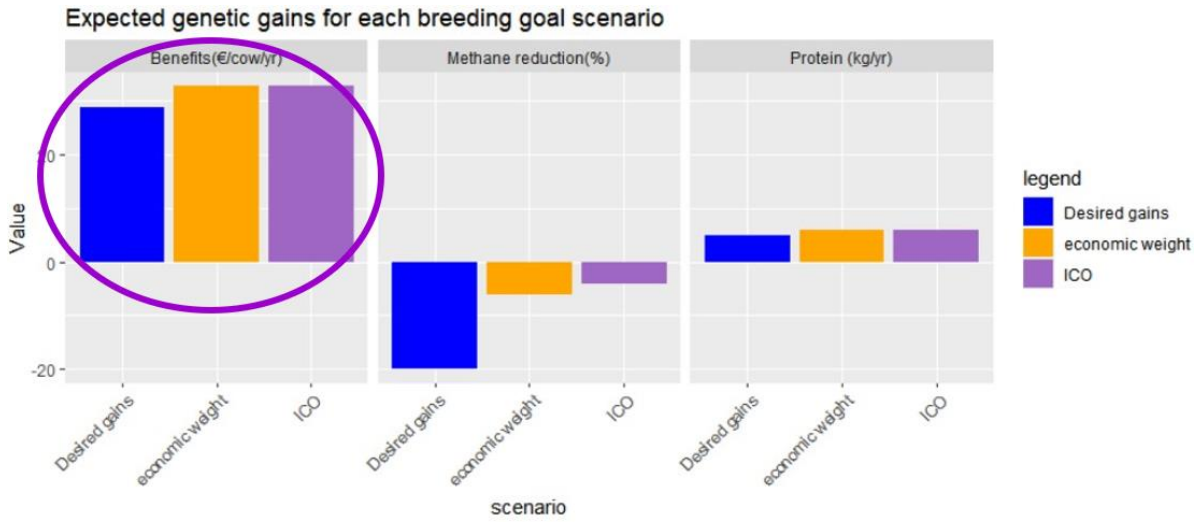
Benchmark - current ICO

Carbon prices

- €43.37/t of CO_{2e}
- Moderate scenario from BEIS, (2017)

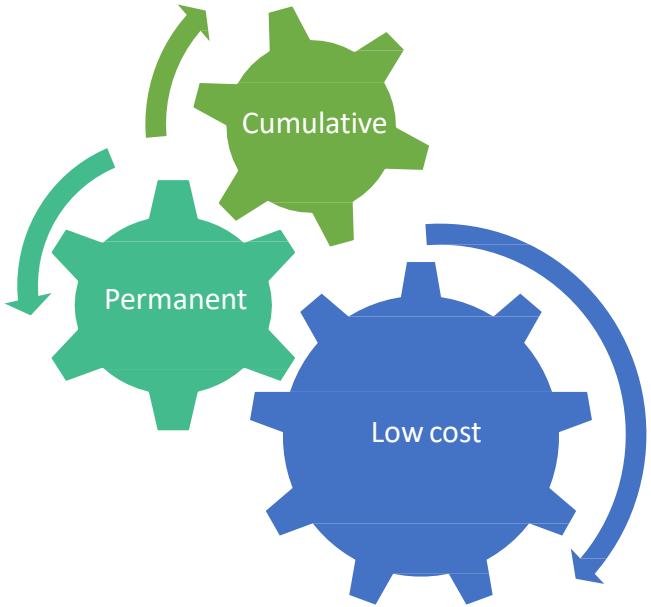
Desired gains

- 20% reduction of CH_4 in 10 years



Take Home Messages

- Many approaches exist to mitigate GHG
  - Genetics → potential to be an **excellent tool**
- But: **practical implementations** needed!
  - **First progress** in the field
- Also: **international collaborations key-issue**
  - Acquisition data
  - Genomic selection → reference populations



→ Needed: support for international collaboration (EU?)

Thank you for your attention!

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- Support throughout the Futurospectre partnership
  - AWE – Comité du Lait – CRA-W – ULiège-GxABT
- CECI Consortium for computational resources
- Service Public de Wallonie (SPW – DGO3, Belgium)
- National Fund for Scientific Research
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A European Public-Private Partnership