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UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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UAB Universitat Autònoma de Barcelona

INIA Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

MITIGATION OF GREENHOUSE GASES IN LIVESTOCK VIA GENETIC SELECTION: INCORPORATION OF METHANE EMISSIONS INTO THE BREEDING GOAL IN DAIRY CATTLE UNDER DIFFERENT SCENARIOS

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CO2
FOOTPRINT

- **At present, CH_4 emissions are not included into the breeding goals in any livestock specie**

"The primary goal of most livestock producers is, very simply, to make money"

(Harris, 1970)

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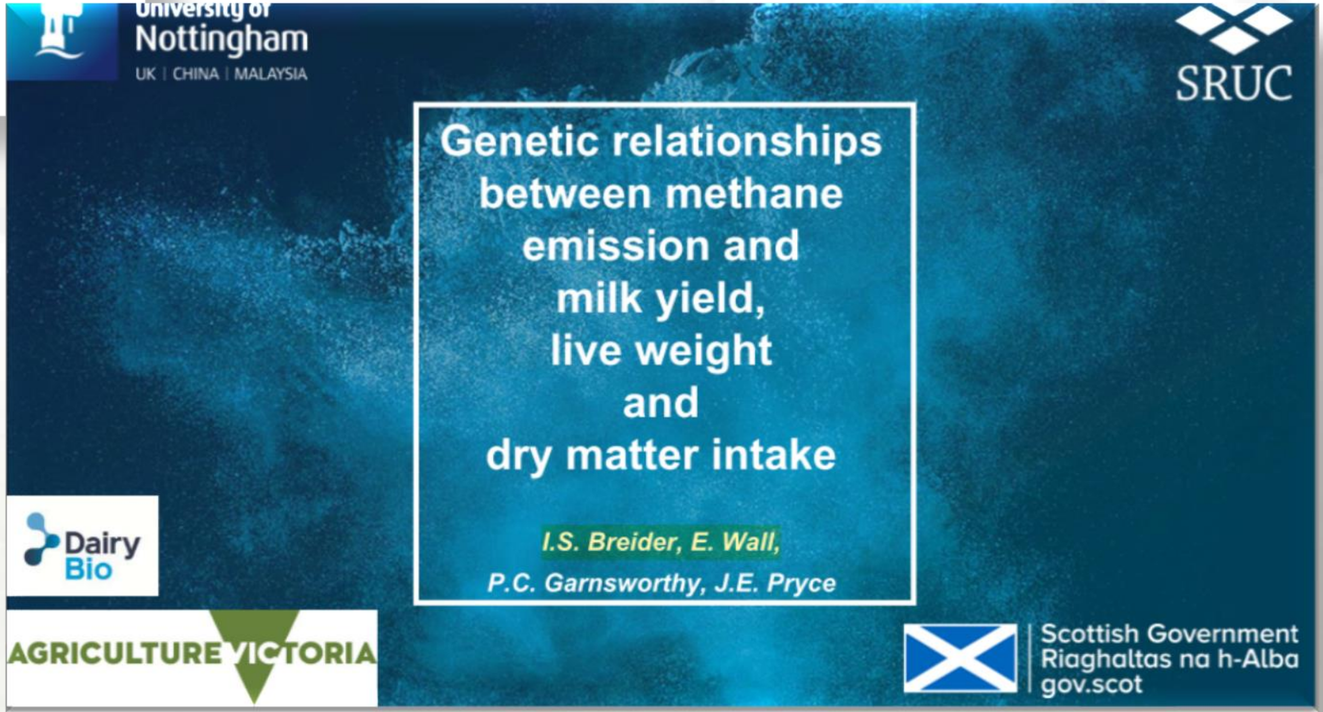
Bell, Matthew J. and Pryce, Jennie and Wilson, Paul (2016) A comparison of the economic value for enteric methane emissions with other biological traits associated with dairy cows. American Research Journal of Agriculture, 2 . pp. 1-17. ISSN 2378-9018



01 To estimate the economic value of enteric CH_4 emissions

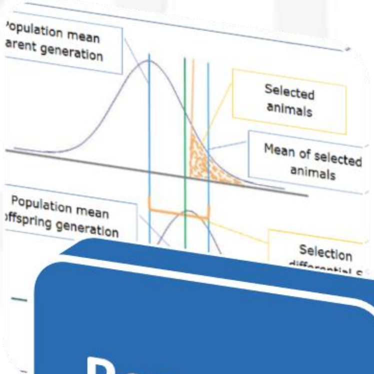
02 To include enteric CH_4 into the breeding goal in Spanish dairy cattle

03 To evaluate the expected genetic and economic response of traits in the selection index under different scenarios

Bio economic model

Economic value derivation

VCE CH_4

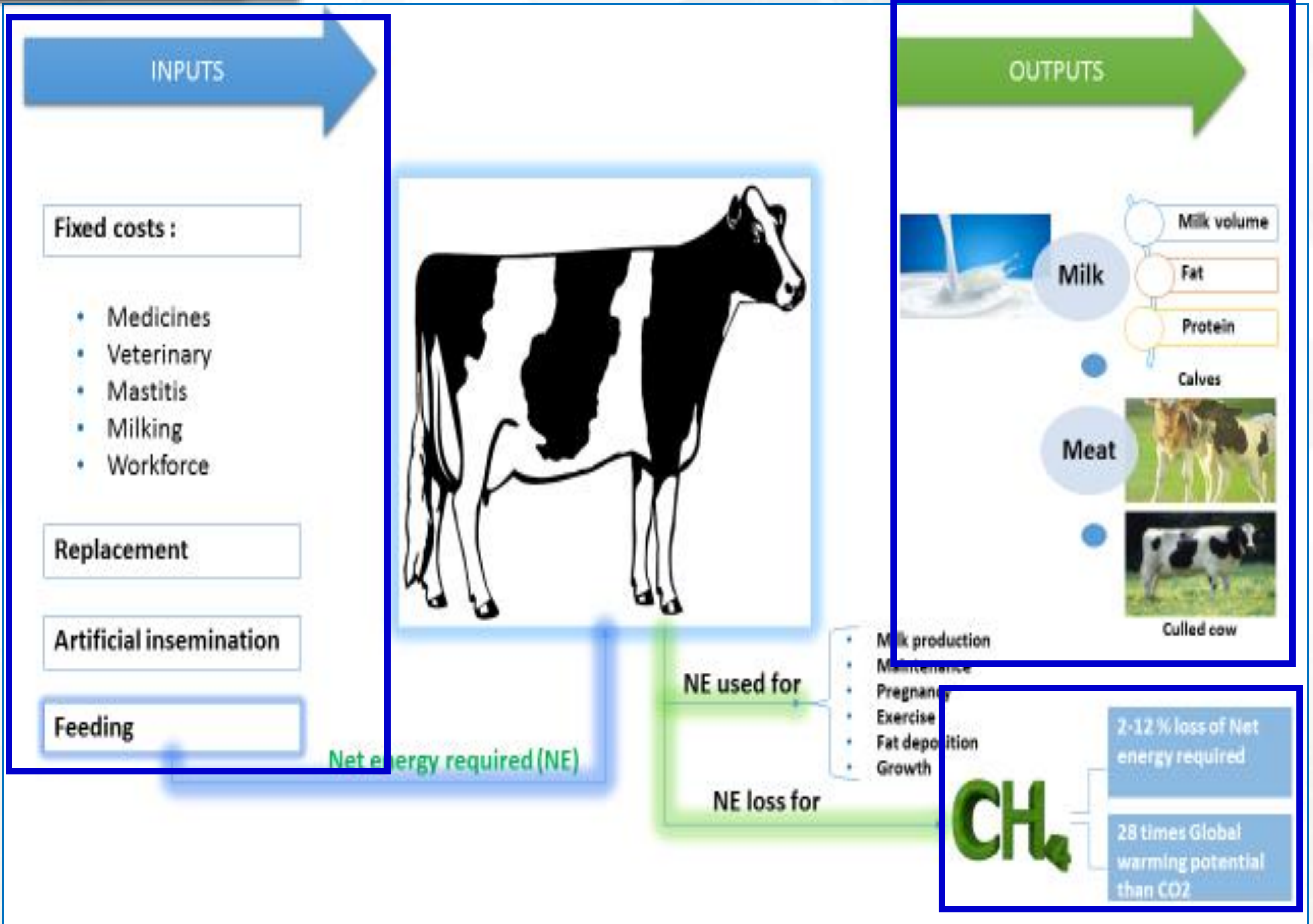


Response to selection

Bio-economic model (profit function)

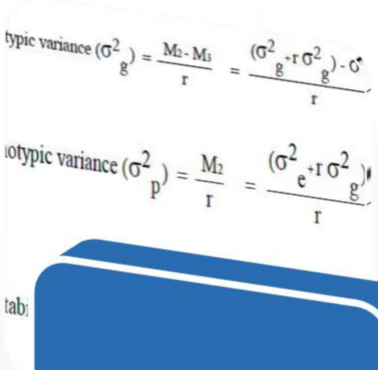
$$B\left(\frac{\frac{€}{cow}}{yr}\right) = R - C - C_{CH_4}$$

- ✓ **B** : benefit €/cow/yr,
- ✓ **R** : revenues,
- ✓ **C** : costs,
- ✓ C_{CH_4} : CH_4 emissions cost
- ✓ **R** and C are functions of any number (*n*) of traits

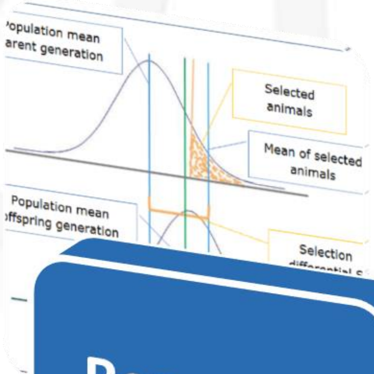


Bio economic model

Economic value derivation



VCE CH_4



Response to selection

03
Scenario
CH_4 as a loss of net energy

02
Scenario
Carbon tax on CH_4 emissions

01
Scenario
Current ICO as benchmark

Economic values

Estimated as **partial derivatives of the benefit (B)** with respect to **the trait** keeping all other traits constant.

1 Benchmark:

$$ev_{xi} = \frac{\partial(B)}{\partial_{xi}} = \frac{\partial(R)}{\partial_{xi}} - \frac{\partial(C)}{\partial_{xi}}$$

2 CO2 tax:

$$ev_{xi} = \frac{\partial(B)}{\partial_{xi}} = \frac{\partial(R)}{\partial_{xi}} - \frac{\partial(C)}{\partial_{xi}} - \frac{\partial(C_{CH_4})}{\partial_{xi}}$$

4 NE loss:

$$ev_{xi} = \frac{\partial(B)}{\partial_{xi}} = \frac{\partial(R)}{\partial_{xi}} - \frac{\partial(C)}{\partial_{xi}} - \frac{\partial(C_{CH_4})}{\partial_{xi}}$$

Emission cost:

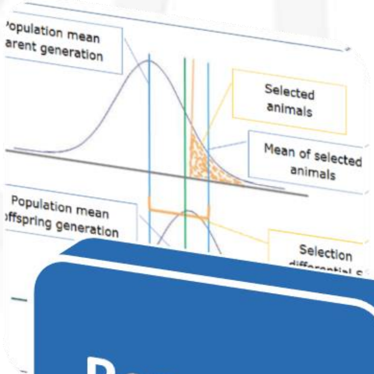
$$CH_4\ cost\ \left(\frac{€}{\frac{cow}{yr}}\right) = CO_2\ cost\ \left(\frac{€}{kg}\right) * 28 * CH_4\ production\ \left(\frac{kg}{yr}\right)$$

$$CH_4\ cost\ \left(\frac{€}{\frac{cow}{yr}}\right) = TNEL\ (\%) * TNER\ (Mcal) * 1\ Mcalorie\ cost\ \left(\frac{€}{Mcal}\right)$$

Bio economic model

Economic value derivation

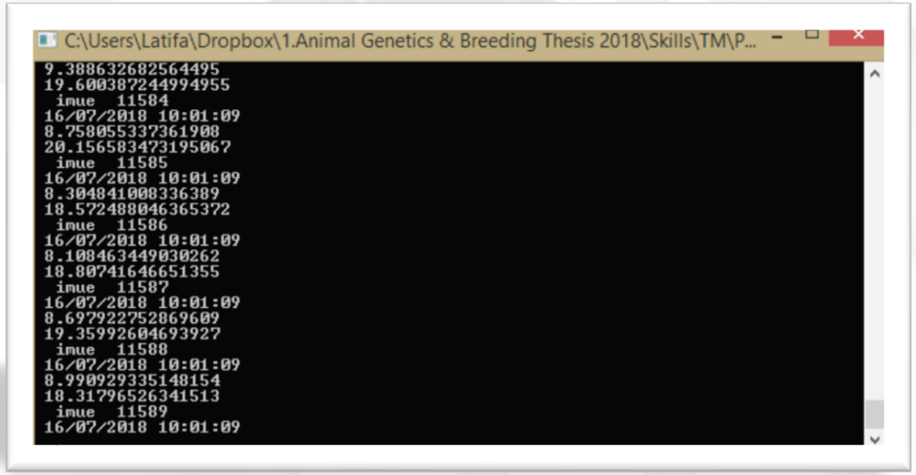
VCE CH_4



Response to selection

VCE

- One trait model
- TM software *(Legarra et al., 2008)*



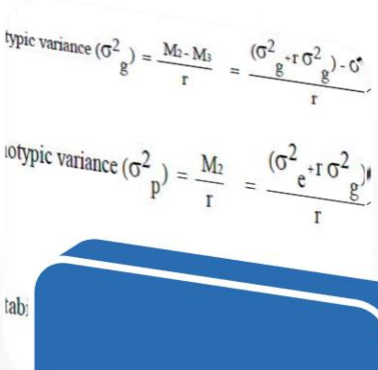
$$CH_4 = \mu + hd + par + rt + wk + dim + hd * wk + hd * rt + p + a + e$$

Genetic correlations between CH_4 and ICO

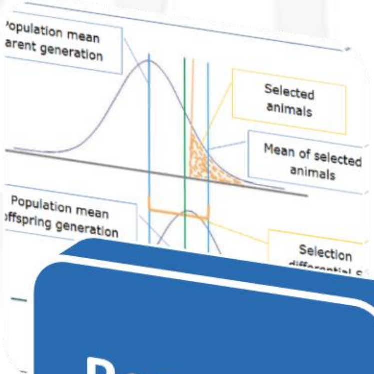
- Sire EBVs correlation: CH_4 EBVs and the official EBVs for traits in the ICO, from official CONAFE evaluation
- 475 sires evaluated with methane EBVs

Bio economic model

Economic value derivation



VCE CH_4

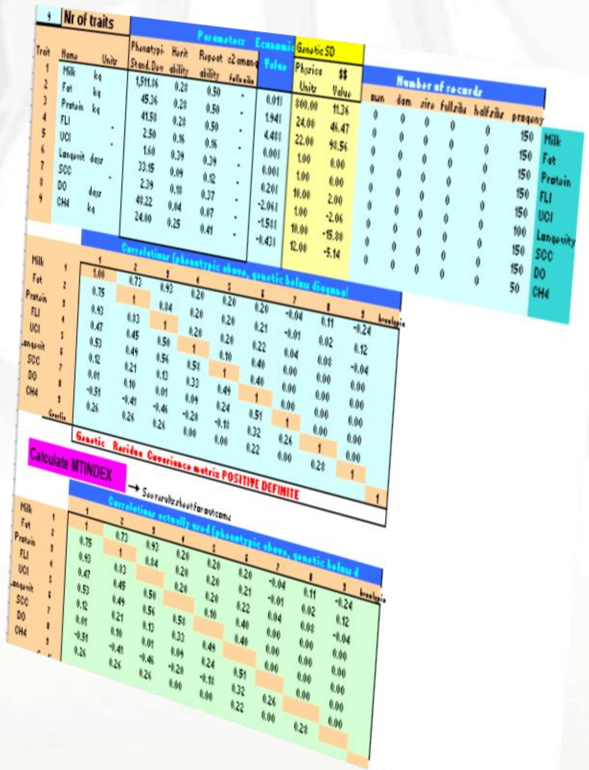


Response to selection

Response to selection

Selection index theory *(Hazel, 1943)*

- Genetic parameters,
- Economic values,
- Expected number of observations of the progeny,
- Multi-trait selection objectives



J. van der Werf

Data

- Productive and economic parameters
- (co)variance matrix between traits
- Genetic evaluation database

Traits	Units	Mean	Standard deviation	Num obs
CH_4	g/d	224.00	126.4	1386
Milk yield	kg/d	36.15	9.08	1382
Milk fat	%	3.50	0.90	1382
Milk protein	%	3.10	0.40	1382

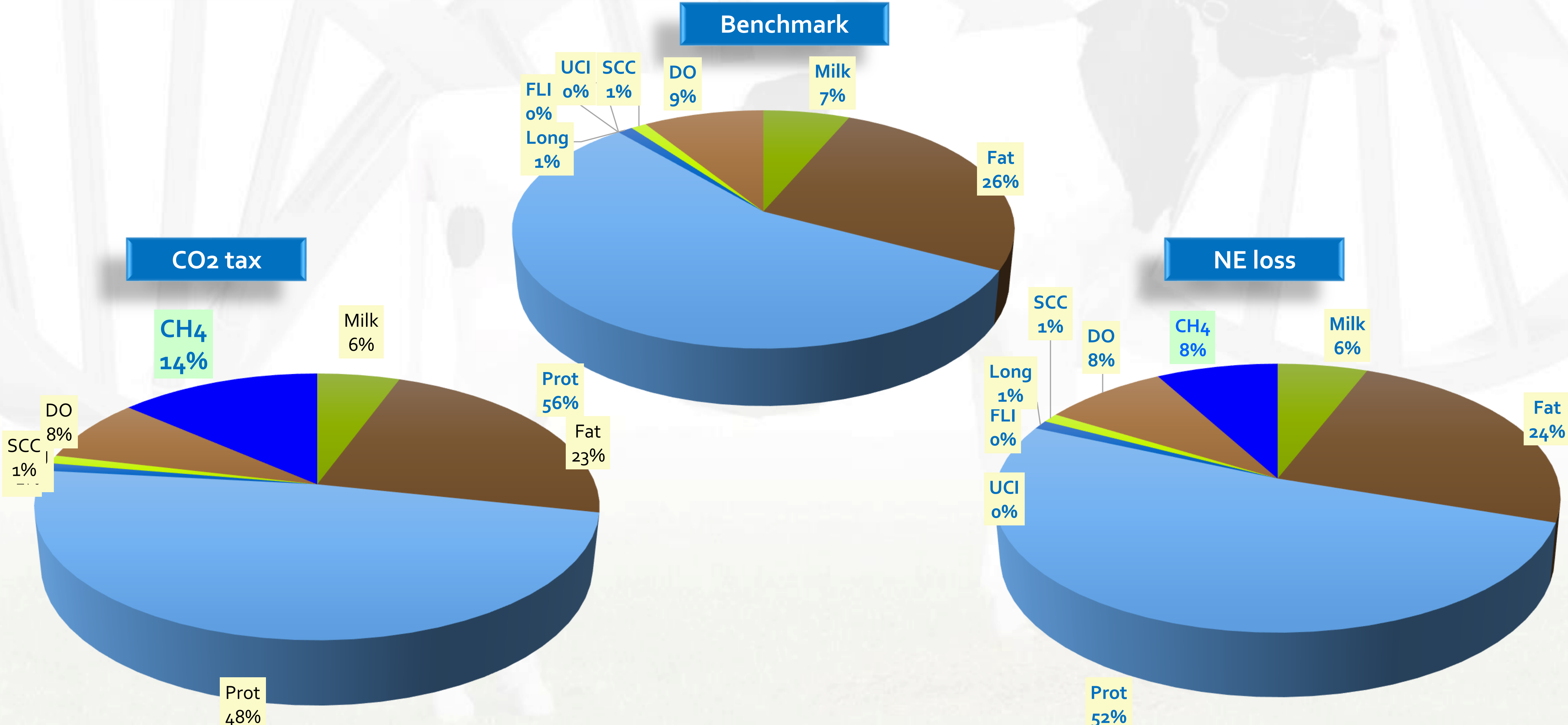
Economic values (€/unit)

Traits	Units	Benchmark	CO_2 tax	NE loss
Milk	kg	0.01	0.01	0.01
Fat	kg	1.94	1.94	1.94
Prot	kg	4.48	4.48	4.48
FLI	-	-	-	-
UCI	-	-	-	-
Long	days	0.20	0.20	0.20
SCC	-	[illegible]	[illegible]	[illegible]
DO	days	[illegible]	[illegible]	[illegible]
CH_4	kg	0.00	-1.21	-0.67

Bell et al., (2016) :
-1.68 £ /kg of CH_4 (≃ -1.77 €/kg of CH_4)

FLI: Feet and Legs Index; **UCI**: Udder Composite Index; **DO**: Days Open; **CH_4**: Methane

Relative importance of traits (%)



Genetic parameters

h^2 CH_4 = 0.37 ± 0.16

rg (ICO-CH_4) = -0.21

Trait	Rg_CH4	p-value
Milk	-0.17	0.00065
Fat	-0.10	0.04400
Protein	-0.14	0.00560
FLI	-0.16	0.00049
UCI	-0.22	0.00000
Long	-0.10	0.04376
SCC	-0.08	0.06911
DO	-0.06	0.16960

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Response to selection

Item	Units	Benchmark scenario		CO_2 tax		NE loss	
		Units	€	Units	€	Units	€
Production traits							
Milk	kg	198.75	2.82	195.89	2.78	198.58	2.82
Fat	kg	6.05	11.72	5.83	11.28	5.97	11.56
Protein	kg	5.94	26.62	5.77	25.87	5.89	26.38
Functional traits							
FLI	-	0.145	0.00	0.149	0.00	0.15	0.00
UCI	-	0.17	0.00	0.17	0.00	0.17	0.00
Longevity	days	0.53	0.11	0.57	0.11	0.55	0.11
SCC	-	0.0184	-0.038	0.0234	-0.048	0.021	-0.04
DO	days	1.17	-1.84	1.14	-1.80	1.16	-1.83
Environmental traits							
CH_4	kg	-1.24	0.00	-3.25	3.94	-2.40	1.62

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Response to selection

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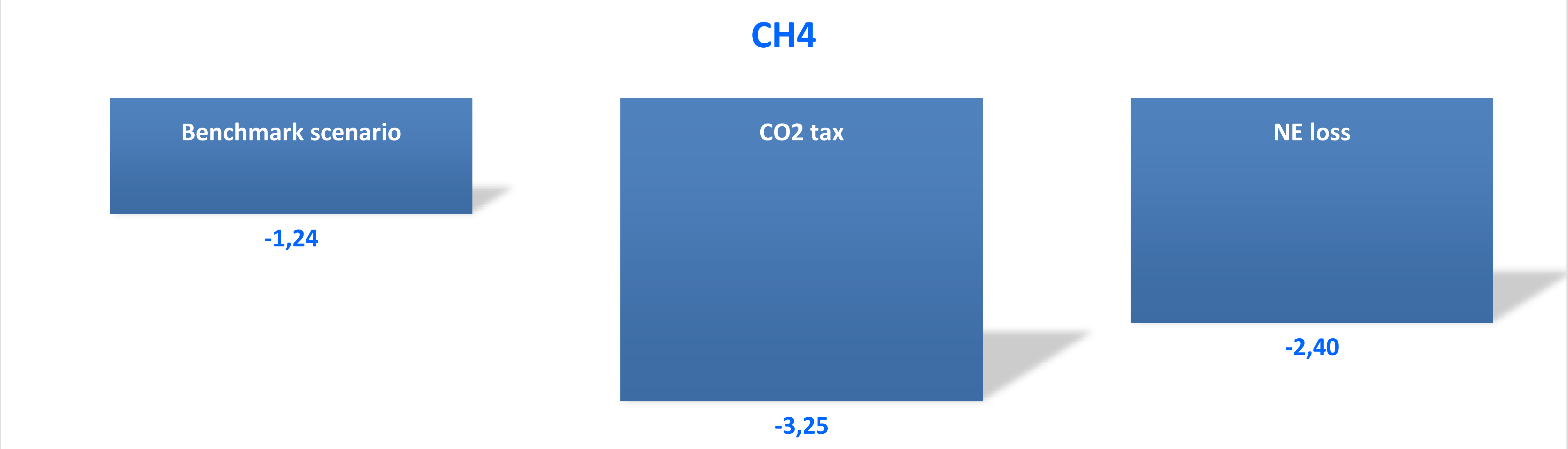

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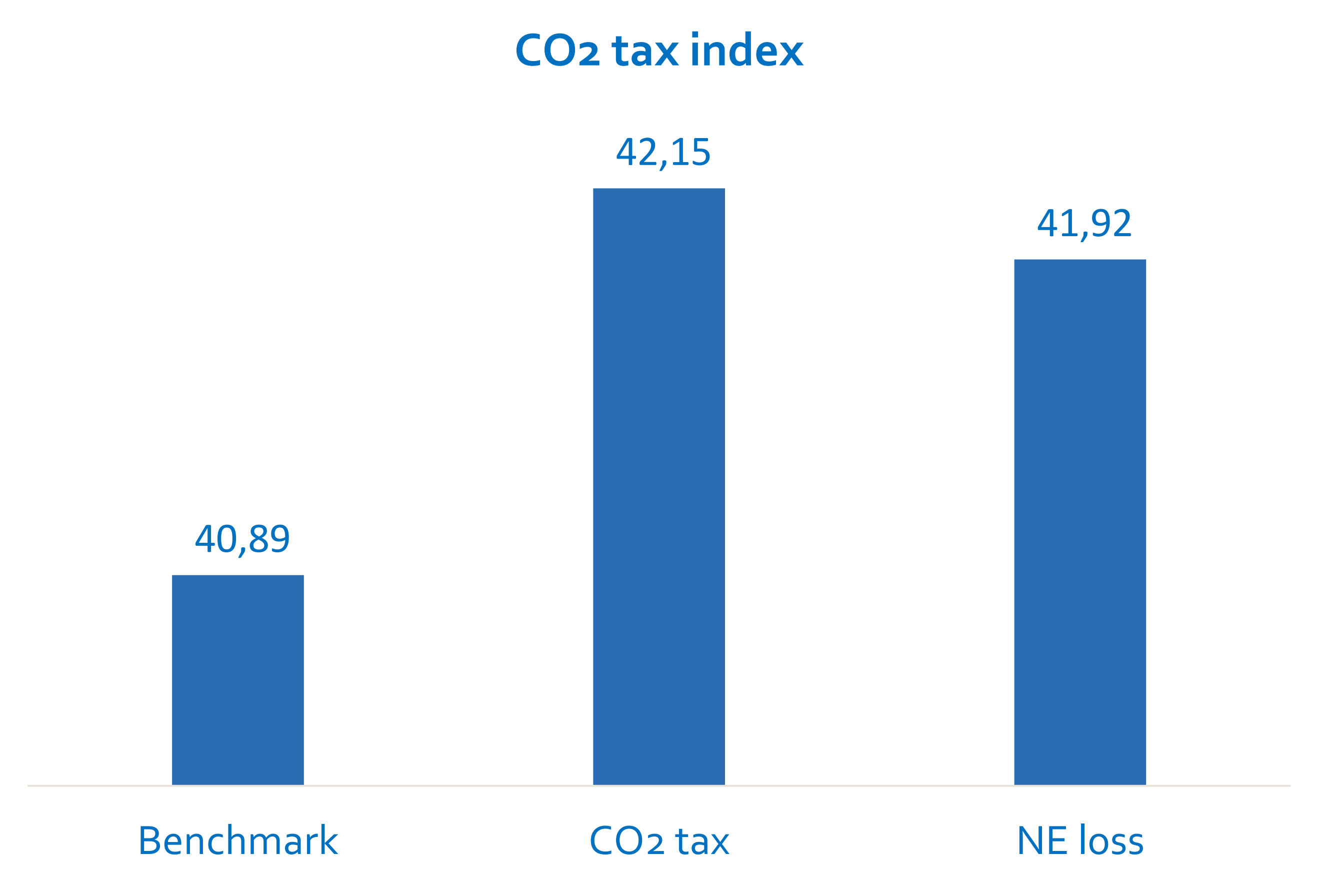
Response to selection



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				0.17	0.00	0.17	0.00
				0.57	0.11	0.55	0.11
				0.0234	-0.048	0.021	-0.04
				1.14	-1.80	1.16	-1.83
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Response to selection

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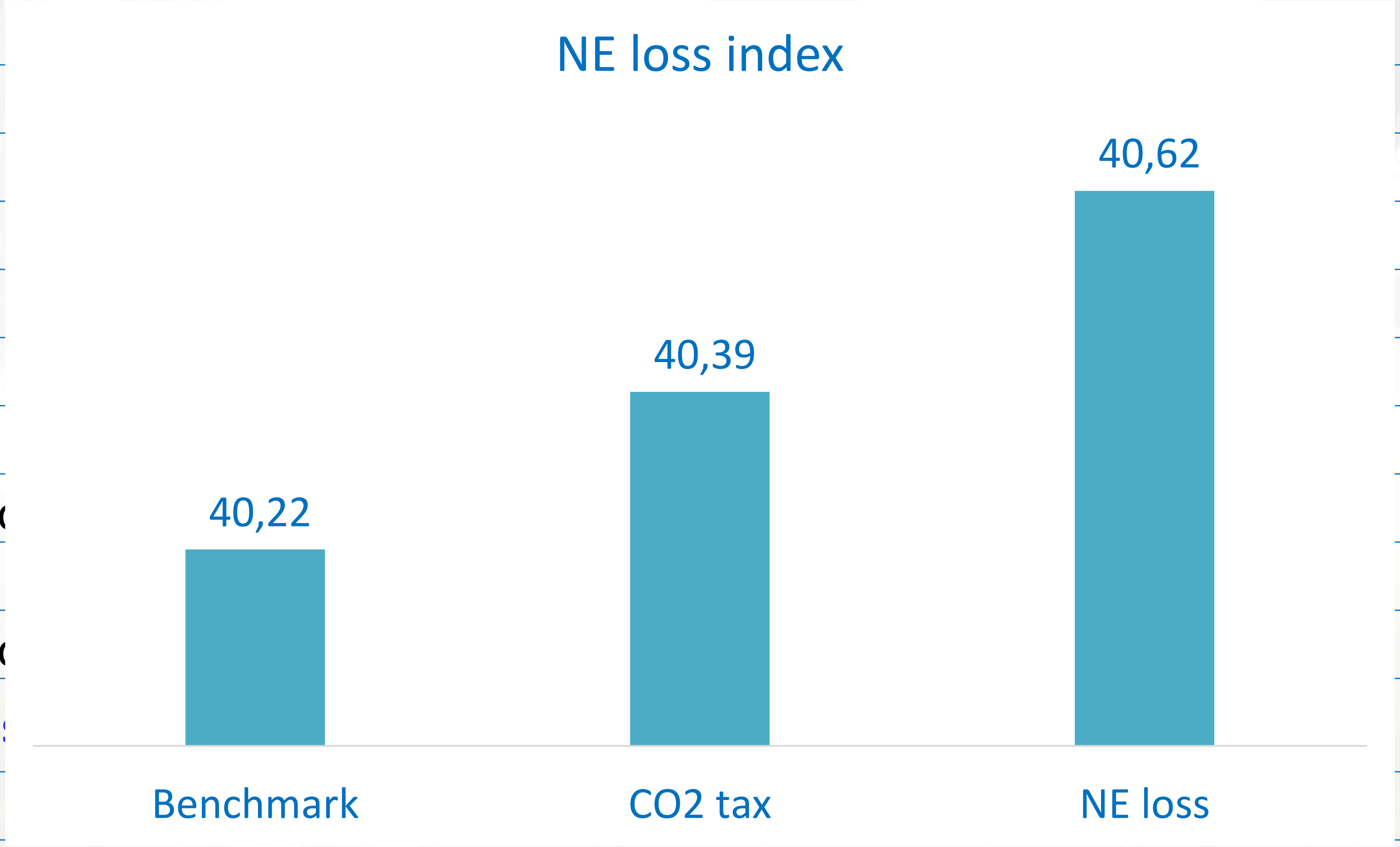
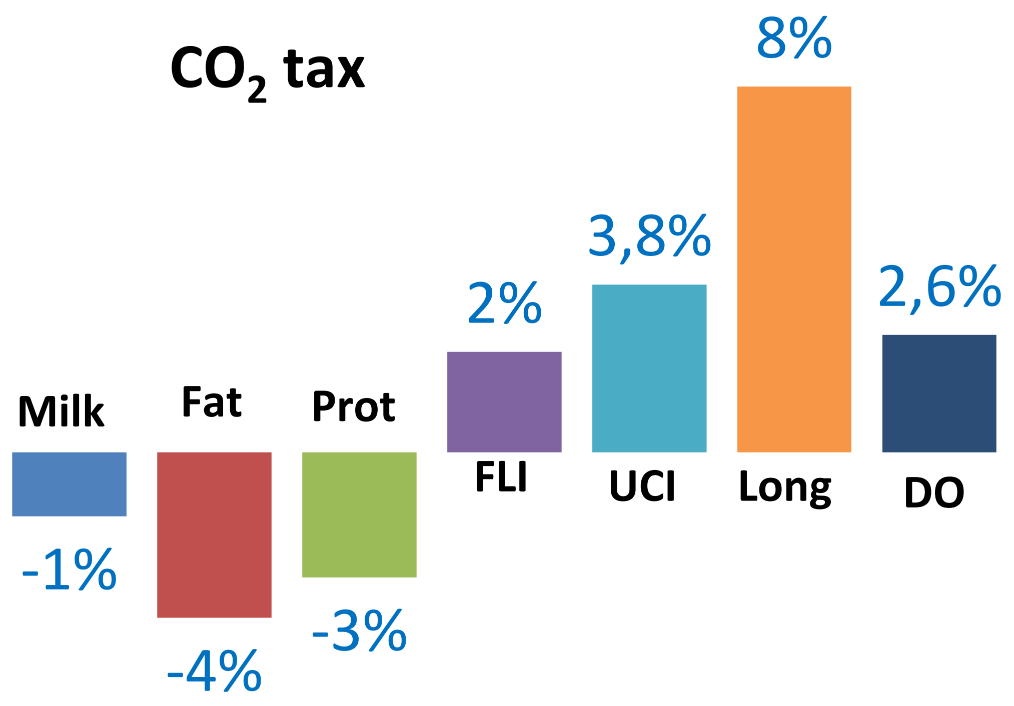


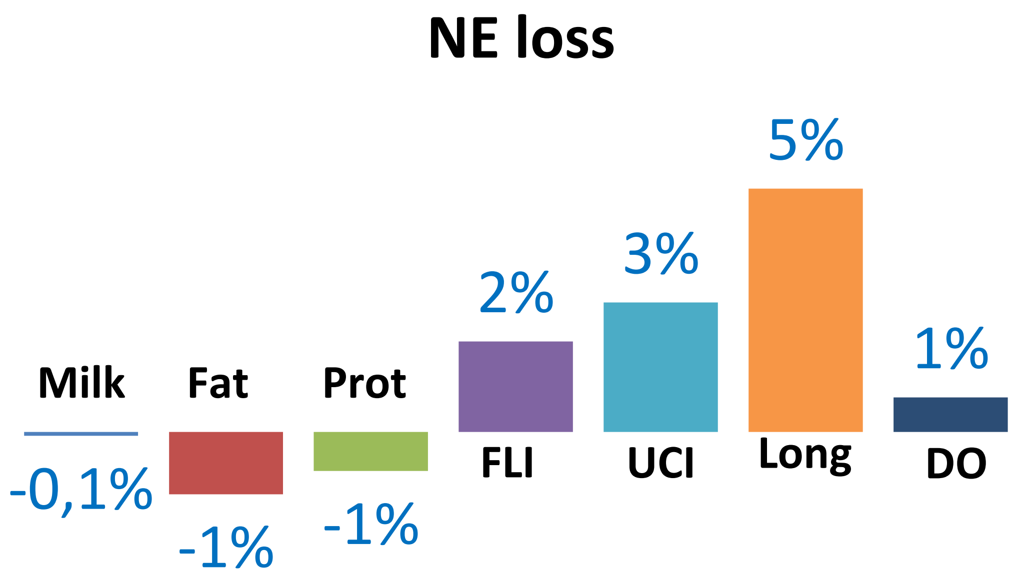
FLI: Feet and Legs Index; **UCI**: Udder Composite Index; **DO**: Days Open; **CH_4**: Methane

Response to selection

Item	Units	Benchmark scenario		CO_2 tax		NE loss	
		Units	€	Units	€	Units	€

Production and functional traits





FLI: Feet and Legs Index; **UCI**: Udder Composite Index; **DO**: Days Open; **CH_4**: Methane

1. The genetic analysis showed that enteric CH_4 is a heritable trait in dairy cattle
2. Selection for better efficiency leads to lower CH_4 emissions
3. A small impact on production traits and an improvement in functional traits when CH_4 was included as NE loss and CO_2 tax in the breeding objective
4. Incorporating CH_4 has impact on total benefits
5. There is a potential in mitigating CH_4 emissions in dairy cattle through genetic selection
6. GC estimates between CH_4 and other traits are low with large CI : need of robust genetic correlation estimates with other biological traits


Acknowledgments
Thank you!
Hvala!
CIHEAM
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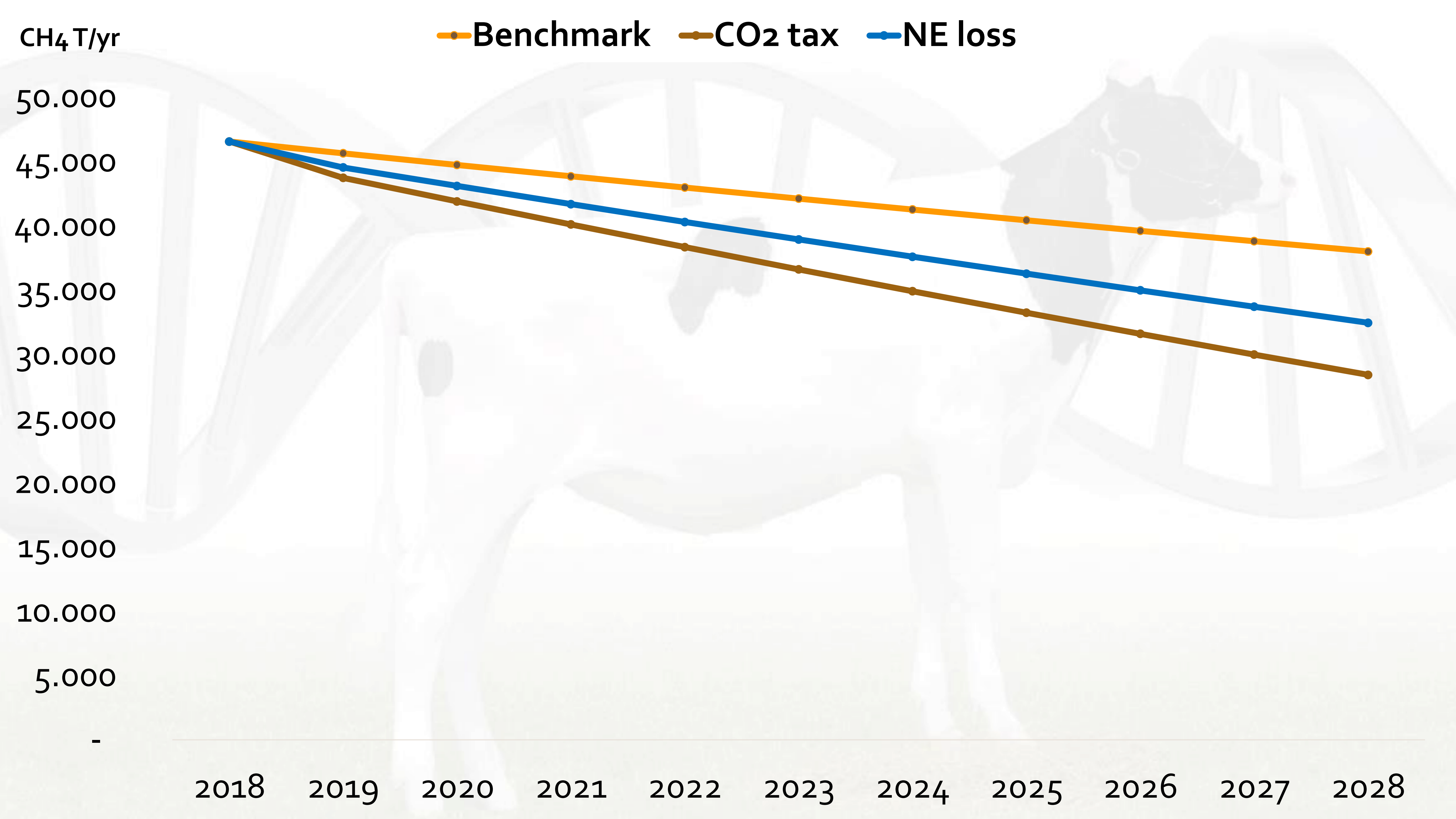
Production
CH4 emissions reduction
CH4
Economic weight


CH4 T/yr
Benchmark
CO2 tax
NE loss
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
-
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028

World GHG Emissions Flow Chart