'New estimates of the CF of the total Danish beef production'

Martin Øvli Kristensen og Mogens Vestergaard,
Seges Innovation

Kvægkongres d. 27. februar 2024, kl. 10.15-11.00
Session 45

AARHUS UNIVERSITY

Kvægafgiftsfonden

Innovation Center for Organic Farming

SEGES INNOVATION

STØTTET AF Kvægafgiftsfonden

:

The presentation relates to the project:

Vejen[e] til en mere klimavenlig dansk kalve- og oksekødsproduktion udgår fra malkekvægholdet

Mogens Vestergaard, Arne Munk, **Martin Ø Kristensen**, Alberto Maresca, Henrik Martinussen, Nicolaj I Nielsen, Anne Mette H Kjeldsen, Anders Fogh, SEGES Innovation

Morten Kargo, Aarhus Universitet

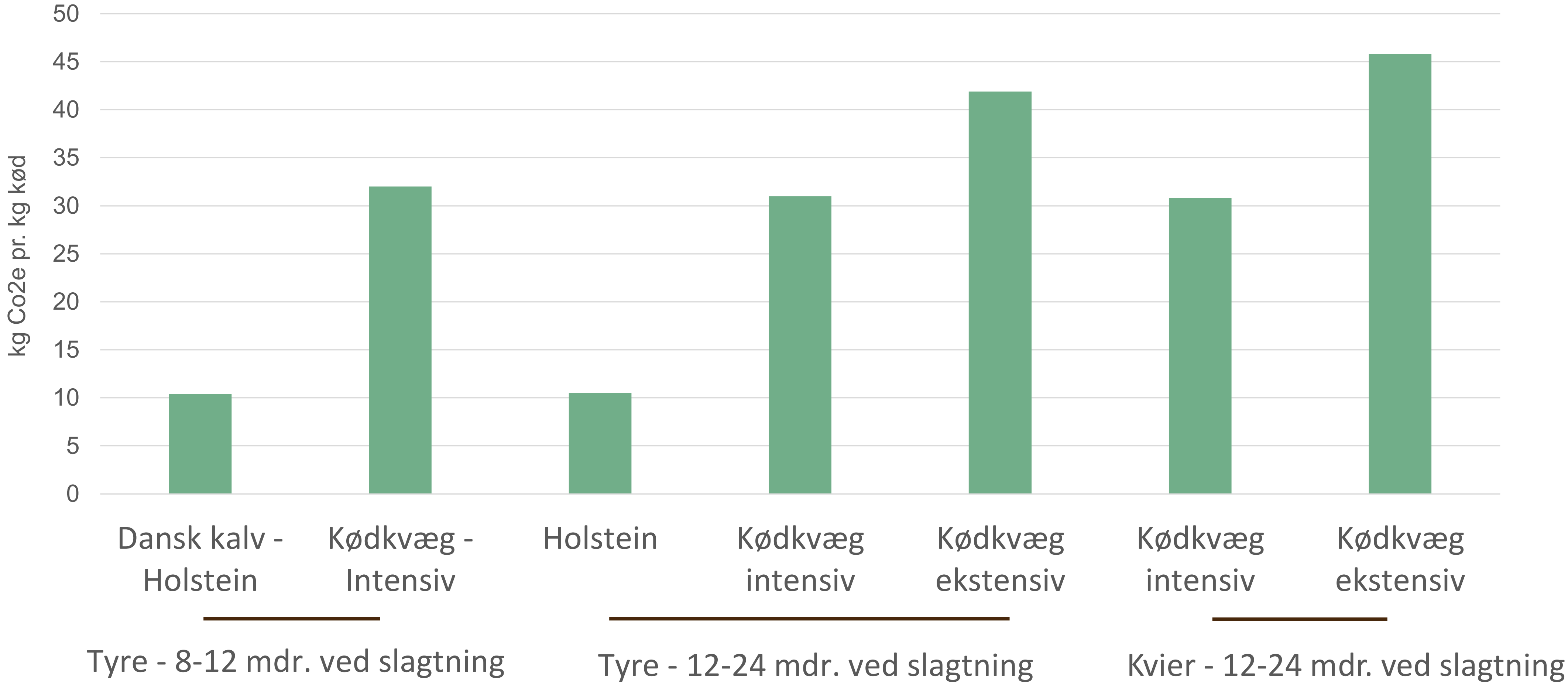
SEGES INNOVATION

Objective – the project

- Show that we can reduce CF of beef without reducing the total amount of beef produced in Denmark
- Solutions include:
  - Changes in beef production systems
  - Genetic improvemnet of beef animals (i.e., reduced CH_4 production?)
  - Feeding related changes (i.e., feed ration and mitigation of CH_4)
- We intend to show scenarios as how to reduce the climate impact of the entire beef production
- We will define economically sustainable production systems based upon utilizing all calves born in the dairy herds, including those currently being exported early in life or as pregnant heifers

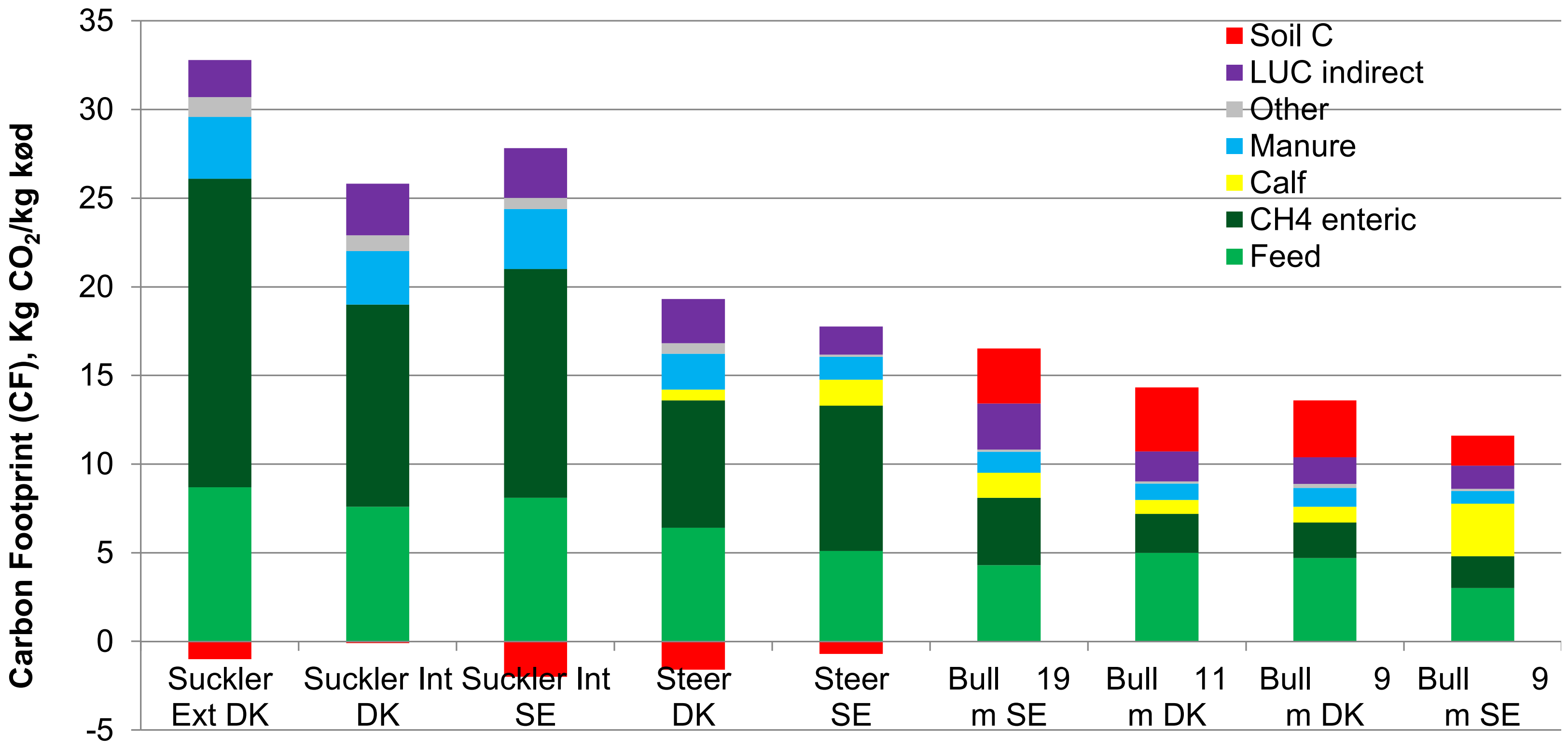
SEGES INNOVATION

Aarhus Universitet – klimaaftryk pr. kg kød for forskellige systemer



MØK0

Klimaaftryk (CF) fra svenske og danske kødproduktions-systemer – Store forskelle



SEGES INNOVATION

Mogensen, Kristensen, Nielsen, Henriksson, Svensson, Vestergaard, Spleth, Hessle & Lindahl, 2015, LIVEST

Slide nummer 5

MØK0 Holstein ØKO ungtyre vil ligge på 15-17 kg CO2 og krydsnings ØKO ungtyre på 13-16 kg CO2/kg

Martin Øvli Kristensen; 2024-02-07T10:56:44.954

Can we change the production systems?

- Can we change the distribution among the various production systems?
  I.e.,
  - Produce more animals (or tons of carcass) in the more climate efficient systems
  and
  - Produce less animals (or tons of carcass) in the less climate efficient systems?

SEGES INNOVATION

We got inspiration from: Modelling CF of the NZ beef production

NZ has 9 times as many dairy cows and 13 times as many suckler cows compred with DK

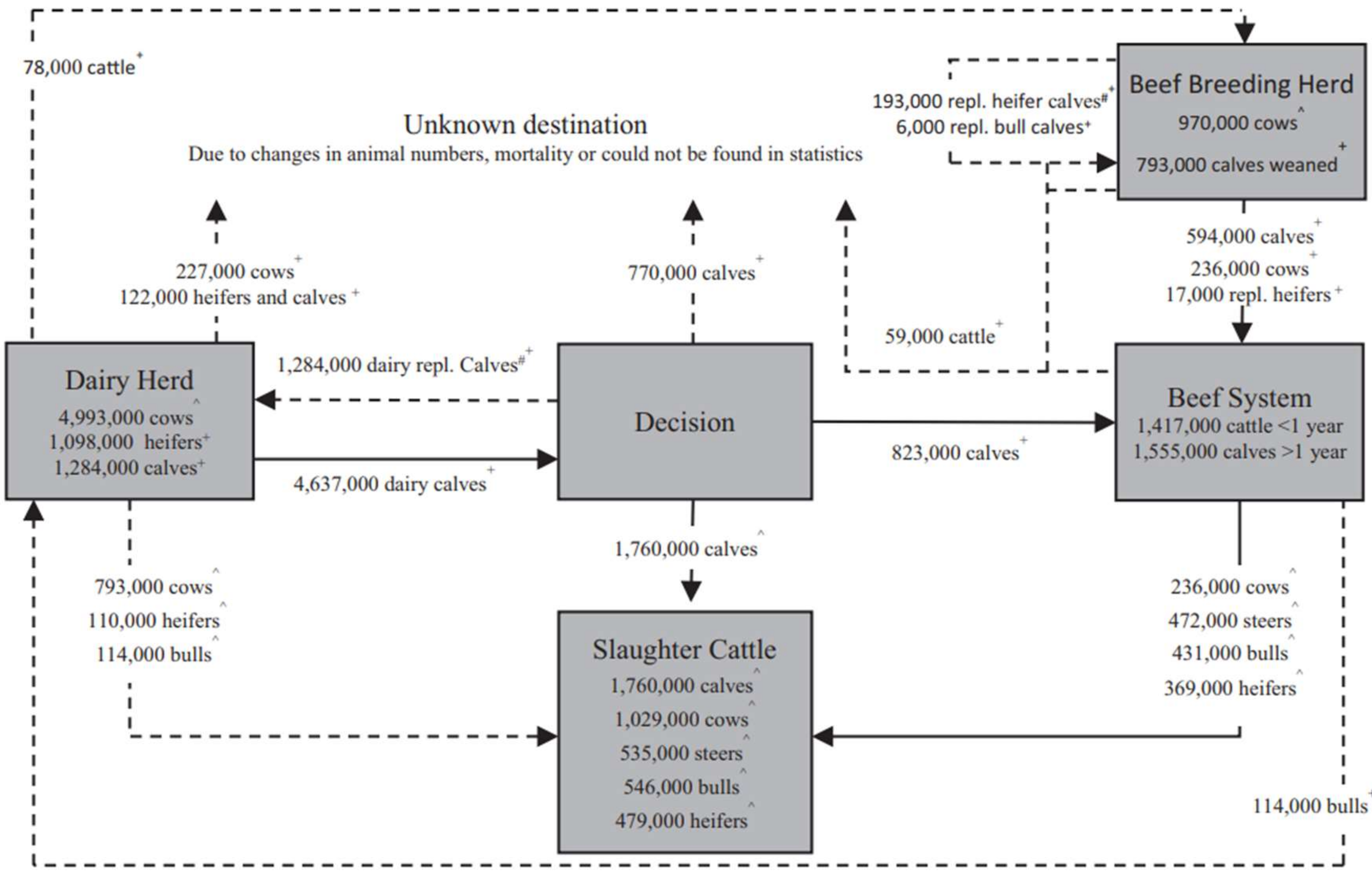


Fig. 1. Population dynamics of the NZ beef and dairy sectors (Beef + Lamb New Zealand Economic Service, 2018b; Dairy, 2018a; Ministry for Primary Industries, 2018) (Numbers may not add up due to rounding).
^ values based on statistics, + values based on calculations, * bulls were of dairy and/or beef origin, # a portion of these animals don't enter the beef/dairy herd due to mortality/failure to get in-calf.

:S
ON

A dramatic scenario:
If New Zealand culled all suckler cows and instead increased number og dairy cows and ONLY produced beef based on beef x dairy calves born in the dairy herds, NZ could reduce the entire CF by 22% (GWP

B. van Selm, et al.

Agricultural Systems 186 (2021) 102936

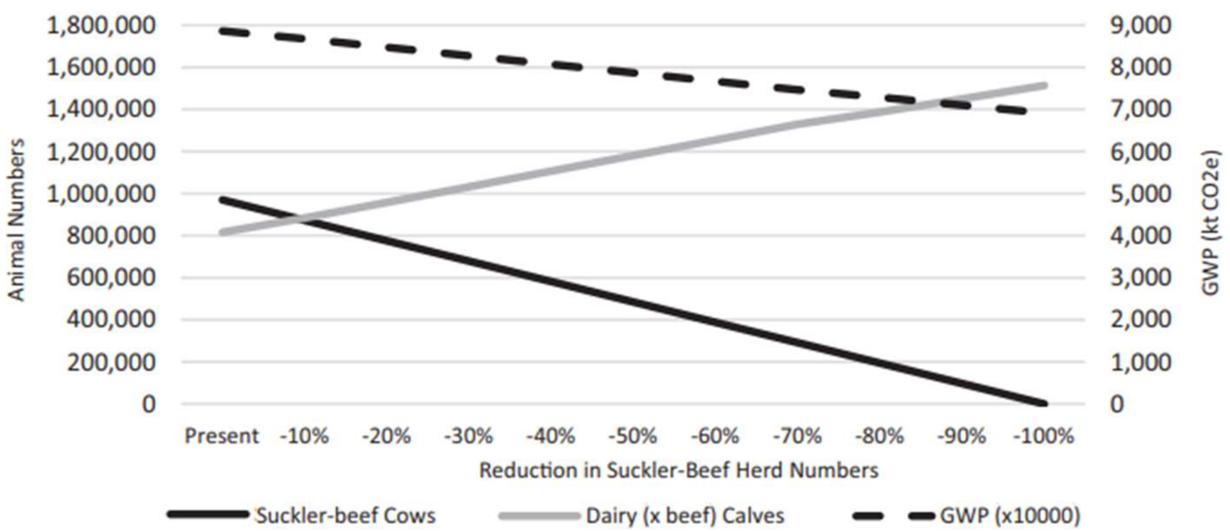


Fig. 2. Consequences of decreasing beef breeding cows and calves on GHG emissions and dairy beef calves entering the beef sector when CW beef output remains constant. GWP: global warming potential.

SEGES INNOVATION

Before being able to reduce CF of the Danish beef production, we need to know how the current production is (and how it is compossed)

- Thus, we need to know the amount of beef produced in the various categories, the sizes of the carcasses, and the CF of the individual production systems/categories

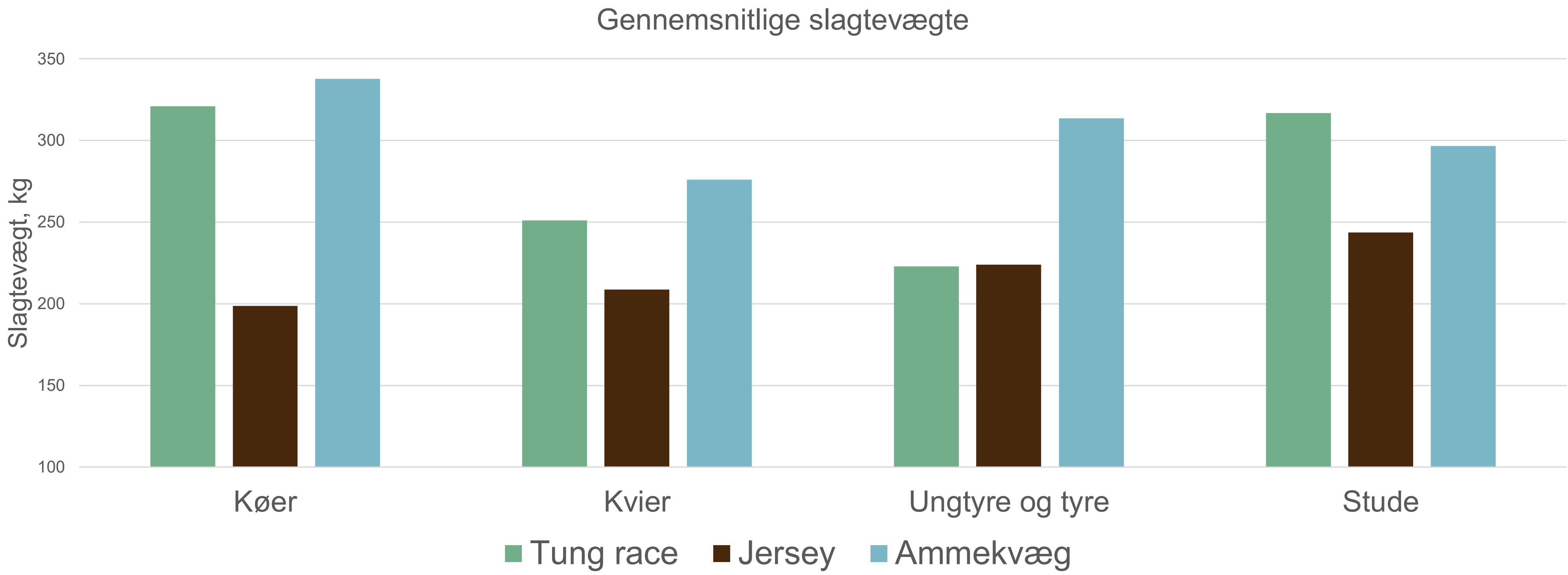
SEGES
INNOVATION

Building the model – INPUTS
Number of animals slaughtered (2021) – divided into categories

	Dairy	Suckler
Heifers		
u. 18 mo.	32.687	10.557
a. 18 mo.	23.586	10.119
Bulls		
u. 12 mo.	131.651	3.124
a. 12 mo.	33.720	28.239
Steers	4.927	2.042
Cows	158.552	17.634
Total	385.123	71.715

SEGES INNOVATION

Carcass weights, Large breeds, Jersey, and suckler cattle



Background data to build a dynamic model to describe the total CF of Danish beef

- Slaughter data
  - Age, carcass weights, number of cattle
- Barn type (Deep-bedding, slathered etc., manure storrage etc)
- Feeding plans - Standard feeding plans optimized in DMS_NorFor

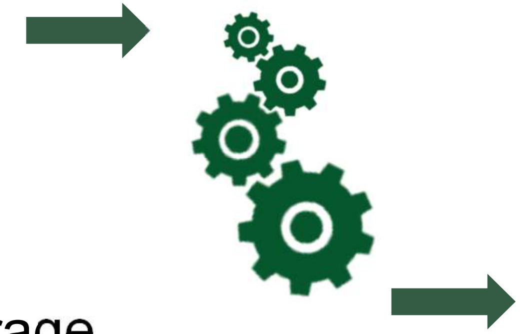
- National and international emission factors (ICCP)

The model

Input data pr. group

- Age
- Carcass weight
- # animals

- Barn type
- Manure handling/storage
- Feed ration
- Grazing/non-grazing



Output data pr. group

- Carbon Footprint
  - Manure related
  - Feed production
  - Methane from digestion etc

- CF pr kg CWT
  - For dairy cattle a part of the CF is allocated to milk

Model development and testing: Alberto Maresca, Arne Munk, Martin Ø Kristensen, Henrik Martinussen

This is just one of 15 folders with equations and calculations !

```
D118    =HVIS($C$83="D"; J118 * (M118) / 55.65 * (D$123*D72/365+D$122*D73/365);"")
```

Enteric Fermentation | **Feed cultivation**

Feed rations from DMS_NorFor (daily weighted averages, calculated based on the defined feed rations during grazing and non-grazing)

		antal dage	DML_c feed intake of concentrate in kg	DML_f feed intake of forage in kg dm	rd_NDF rumen digested NDF in g/day	FA_intake fatty acid intake in g/da	Ash_intake ash intake in g/day	DMI feed intake in k	FA_DM fatty acid in g / kg dm	NDF_DM neutral detergent fiber in	GEFtot gross energy MJ per kg DM	Korn (vårbyg), kg ww	Rapsskrå, kg ww	Raps-kager, kg ww	Majs-ensilage, middel FI
Køer	grazing	150	8.95	13.09	4754	652	1289	22	30	332	19	4.8	0.2	5.2	21.4
Køer	non-grazing	215													
Kvier u. 18. mdr.	grazing	180	0.20	6.49	1732	123	562	7	18	398	18	0.0	0.1	0.0	6.9
Kvier u. 18. mdr.	non-grazing	185													
Kvier o. 18. mdr.	grazing	180	0.11	6.34	1743	113	542	6	17	415	18	0.0	0.0	0.0	6.5
Kvier o. 18. mdr.	non-grazing	185													
Tyre u. 12 mdr.	non-grazing	365	3.52	2.30	1138	153	328	6	26	301	19	3.1	0.0	0.9	4.7
Tyre o. 12 mdr.	non-grazing	365	3.49	2.53	1203	172	348	6	29	307	19	2.8	0.0	1.1	5.3
Stude	grazing	180	0.33	6.17	1775	128	660	7	20	420	19	0.3	0.0	0.0	0.0
Stude	non-grazing	185													
Kalve 0-3 mdr.	non-grazing	365	1.00	0.20	168	139	126	2	82	152	0	0.7	0.2	0.2	0.0
Kalve 0-1 mdr.	non-grazing	365	0.00	0.00	0	0	0	0	0	0	0	0.1	0.1	0.1	0.0

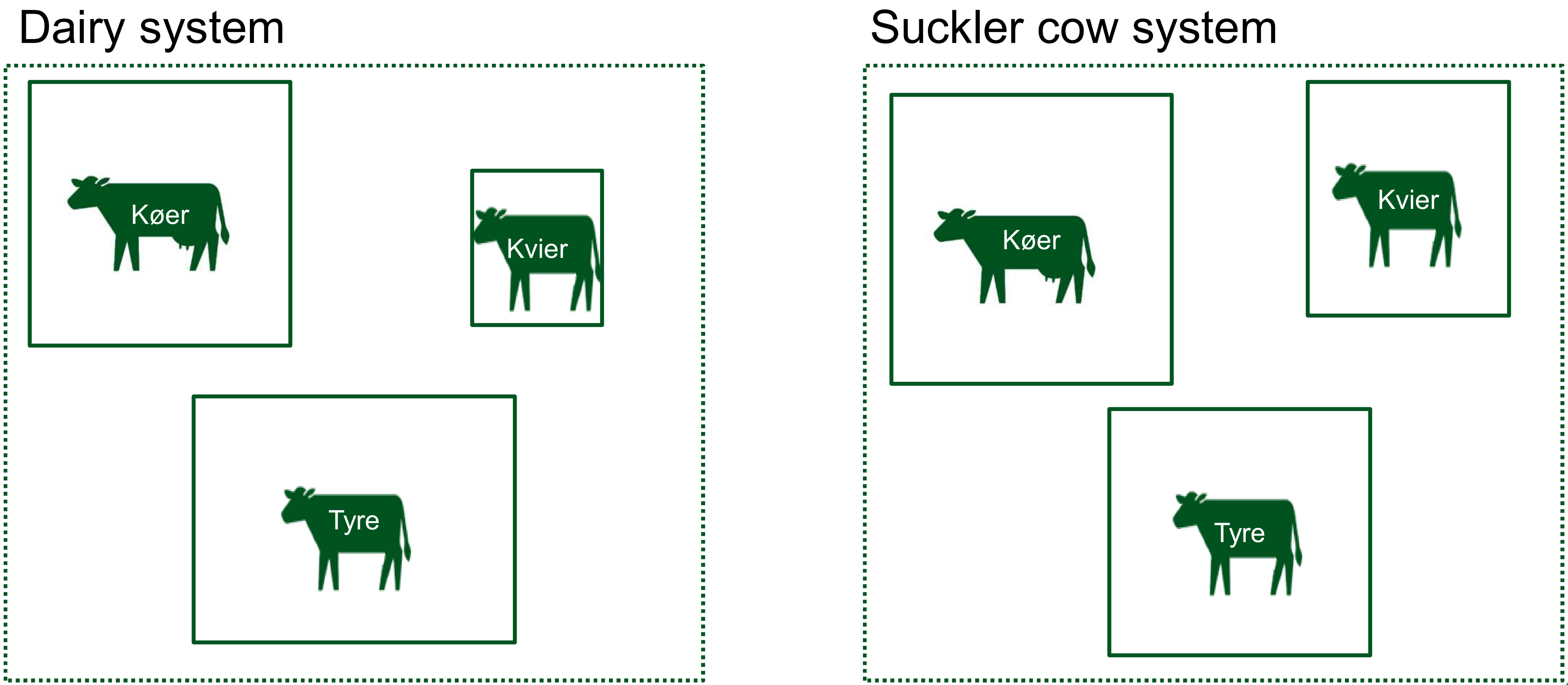
		antal dage	DML_c feed intake of concentrate in kg	DML_f feed intake of forage in kg dm	rd_NDF rumen digested NDF in g/day	FA_intake fatty acid intake in g/da	Ash_intake ash intake in g/day	DMI feed intake in k	FA_DM fatty acid in g / kg dm	NDF_DM neutral detergent fiber in	GEFtot gross energy MJ per kg DM	Korn (vårby ww	Rapssk ww	Raps-kag ww	Majs-ensilage, middel w
Køer	grazing	150	7.65	11.35	4102	546	1051	19	29	333	19	4.7	1.0	3.2	18.0
Køer	non-grazing	215													
Kvier u. 18. mdr.	grazing	180	0.13	4.31	1232	34	365	4	21	426	19	0.1	0.0	0.1	2.0
Kvier u. 18. mdr.	non-grazing	185													
Kvier o. 18. mdr.	grazing	180	0.02	4.76	1402	90	390	5	19	450	19	0.0	0.0	0.0	2.2
Kvier o. 18. mdr.	non-grazing	185													
Tyre u. 12 mdr.	non-grazing	365	3.00	1.26	695	88	148	4	21	250	19	2.7	0.9	0.0	3.6
Tyre o. 12 mdr.	non-grazing	365	2.19	2.44	903	87	160	5	19	300	19	1.9	0.6	0.0	6.6
Stude	grazing	180	0.05	4.79	1391	95	396	5	20	442	19	0.0	0.0	0.6	1.5
Stude	non-grazing	185													
Kalve 0-3 mdr.	non-grazing	365	0.80	0.40	122	94	90	1	79	156	0	0.4	0.2	0.2	0.0
Kalve 0-1 mdr.	non-grazing	365	0.00	0.00	0	0	0	0	0	0	0	0.1	0.1	0.1	0.0

enteric fermentation calculated based on NorFor formulas (dairy cattle; D) or manual input suckler cattle; S)?	D
D	
S	

Barley grain, dried, at farm	Rapeseed meal (solvent), at processing	Rapeseed expeller (pressing), at processing	Maize silage, at farm
0.5313	0.4470	0.5786	0.0848

	enteric fermentation - NorFor	Y kg CH4 / day	DMI_c feed intake of concentrate in kg dm	DMI_f feed intake of forage in kg dm	rd_NDF rumen digested NDF in g/day	FA_intake fatty acid intake in g/day dm	Ash_intake ash intake in g/day	DMI feed intake in kg dm	FA_DM fatty acid in g / kg dm	NDF_DM neutral detergent fiber in g / kg dm	GEFtot gross energy MJ per kg DM	/day Korn (vårbyg), kg ww /day	Rapsskrå, kg ww /day	Raps-kager, kg ww /day	Majs-ensilage, middel FK, kg ww /day
Malkekøer, tung race Kalve 0-1 mdr												0	0	0	0
Malkekøer, tung race Kalve 0-3 mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.000	1	0	168	139	126	2	82	152	0	1	0	0	0
Malkekøer, tung race Kalve 0-6 mdr.															
Malkekøer, tung race Kvier u. 18. mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.130	0	6	1732	123	562	7	18	398	18	0	0	0	7
Malkekøer, tung race Kvier o. 18. mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.125	0	6	1743	113	542	6	17	415	18	0	0	0	6
Malkekøer, tung race Stude	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.130	0	6	1775	128	660	7	20	420	19	0	0	0	0
Malkekøer, tung race Køer -tk (1year)	Y = (1,230 x DMI - 0,145 x FA_DM + 0,012 x NDF_DM) / 55,65 x 10	0.444	9	13	4754	652	1289	22	30	332	19	5	0	5	21
Malkekøer, tung race Tyrekalve 0-1 mdr.												0	0	0	0
Malkekøer, tung race Tyrekalve 0-3 mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.000	1	0	168	139	126	2	82	152	0	1	0	0	0
Malkekøer, tung race Tyrekalve 0-6 mdr.															
Malkekøer, tung race Tyre u. 12 mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.118	4	2	1138	153	328	6	26	301	19	3	0	1	5
Malkekøer, tung race Tyre o. 12 mdr.	Y = (1,6105 + 0,5615 x DML_c + 1,3511 x DML_f + 0,000309 x rd_NDI	0.122	3	3	1203	172	348	6	29	307	19	3	0	1	5

Illustration of the categories of cattle in the model



SEGES
INNOVATION

Example: CF of a Holstein bull (average)

- Slaughter age = 10.2 mo.
- Carcass wt (CWT) = 210 kg

	Manure	Feed production	Methane digestion	Total
Kg CO_2e	936	1166	360	2463
Kg CO_2e pr. kg CWT	4.4	5.6	1.7	11.7

- # bull calves slaughtered in 2021 = 106.742

	Manure	Feed production	Methane digestion	Total
Mio. kg CO_2e	100	124	38	263

SEGES INNOVATION

The average Carbon Footprint of the total Danish beef production as calculated by the model

17.9 kg CO_2e/kg carcass weight
→ 2.2 mio. tons CO_2e

And how does this then relate to comparable estimatations?
No comparable estimation for other countries available, but in New Zealand total production was estimated to 21.3 kg CO_2e/kg CWT (van Selm et al. 2021).
A calculation from 4 states in USA reports 18.3 kg CO_2e/kg CWT (Rotz et al. 2015)

SEGES INNOVATION

How can we reduce the total CF from Danish beef production? – Scenario calculations

- **Feed additives (scenario 1)**
- Feeding strategies
- Biogas
- Management strategies
  - **More crossbred calves (scenario 2)**
  - Finishing feeding of culled dairy cows
- Choice of and changes in categories of cattle with lowest CF

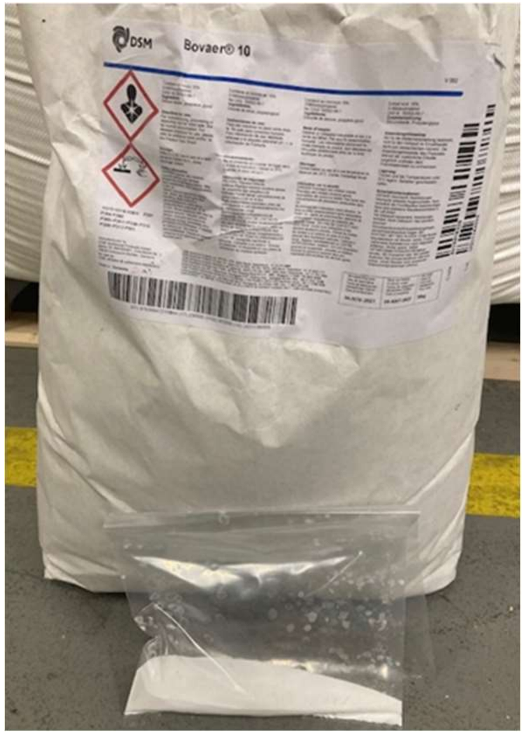
  →**Reduce groups/categories with the highest CF (scenario 3)**

  →**Close down all suckler cow herds (scenario 4)**

SEGES INNOVATION

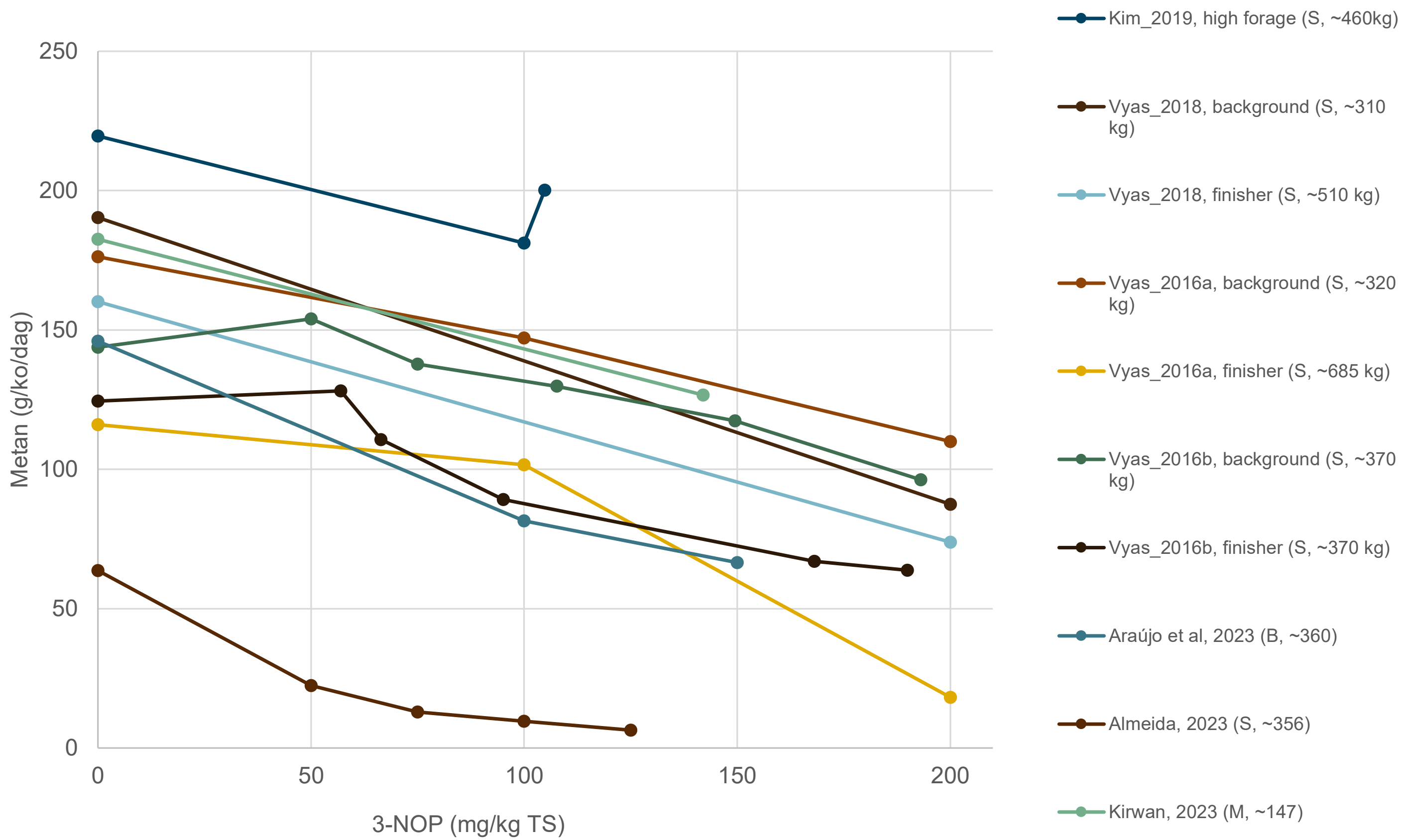
Scenario 1 - Bovaer

- How large a reduction can be achieved by feeding Bovaer (3NOP) on total CF?
- Bovaer supplied to dairy cows (only conventional) and heifers above 18 mo.
  - Assumed a 30% reduction in enteric methane



SEGES
INNOVATION

What can we expect form feeding 3NOP to slaughter calves?



On average a reductioner of 30% in methane production
By feeding 120 mg 3-NOP/kg DM

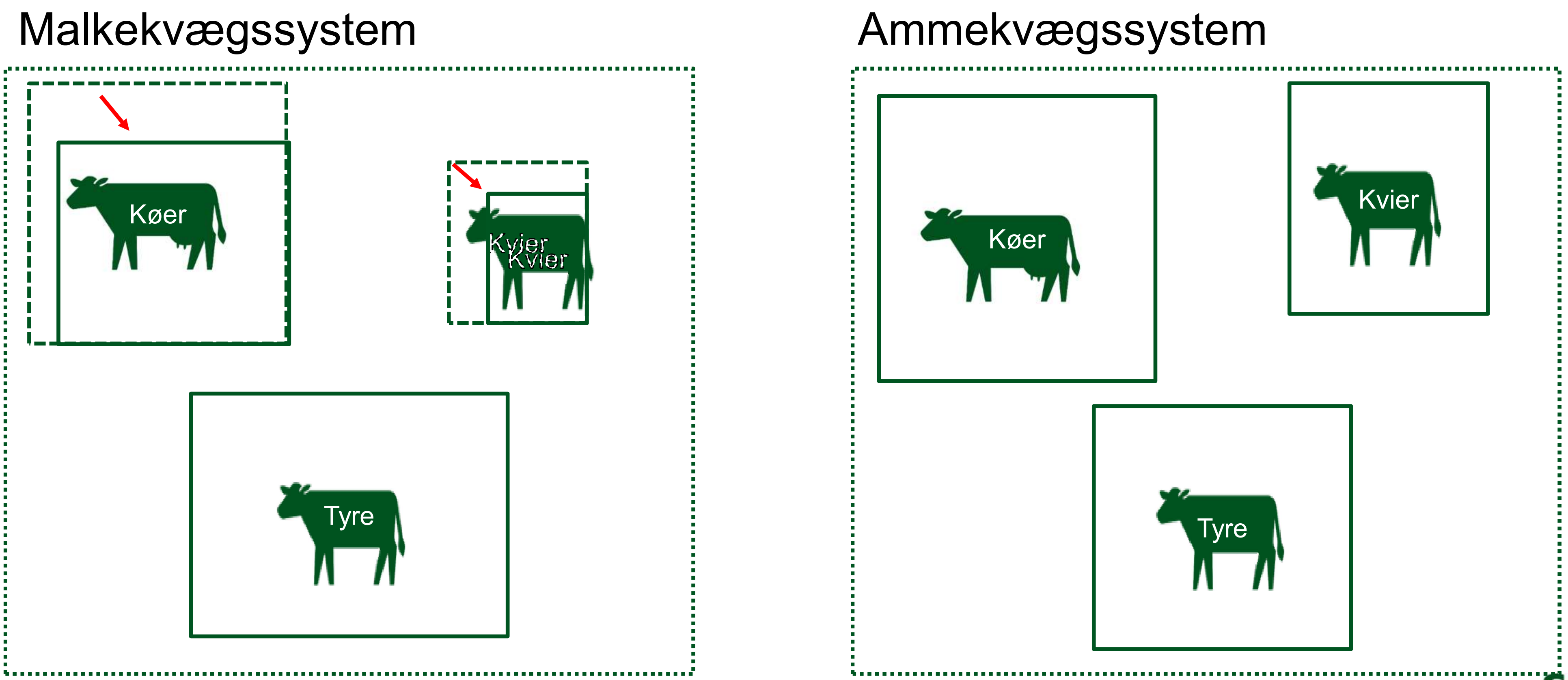
Same feed intake and growth rate

The relation between dosage of 3-NOP/kg TS and g CH_4 output/animal/day

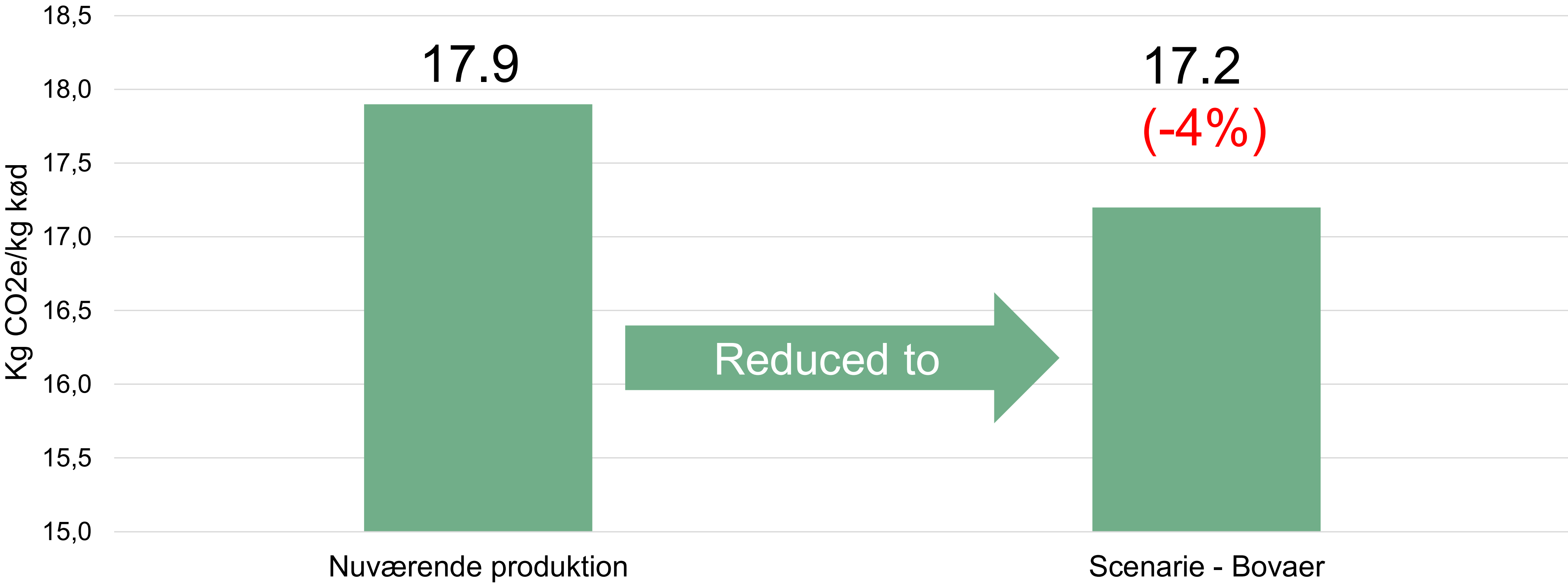
SEGES INNOVATION

Lau-Jensen, Nielsen, Vestergaard, 2023

Scenarie 1 – Bovaer to dairy cows and heifers > 16 mo.



Supplying Bovaer to conventional dairy cows and heifers above 18 mo.



SEGES INNOVATION

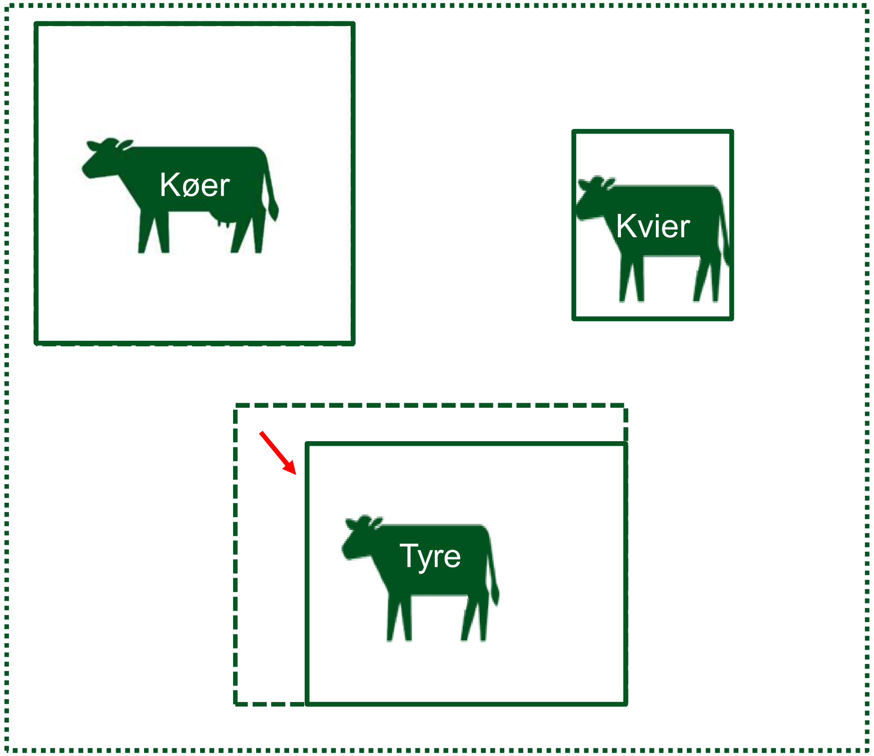
Scenario 2 – More crossbred calves (beef x dairy)

- 90% of all slaughter calves are crossbreds (compared to 30% at present (2021))
  - Steers, bulls above and below 12 mo.

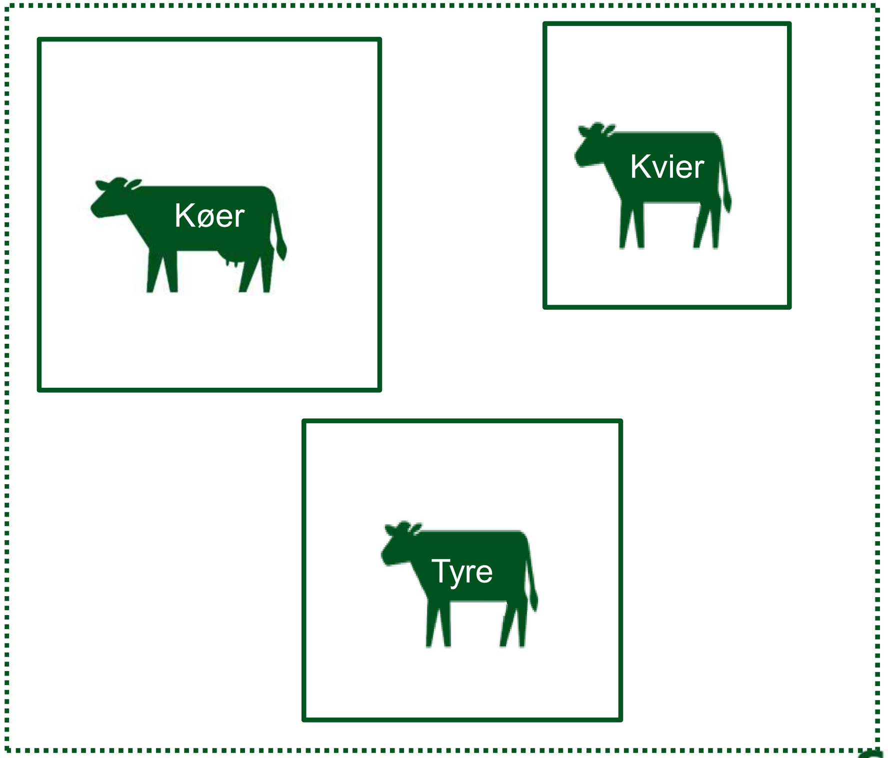
SEGES INNOVATION

Effect of using crossbred calves instead of purebreds

Dairy system

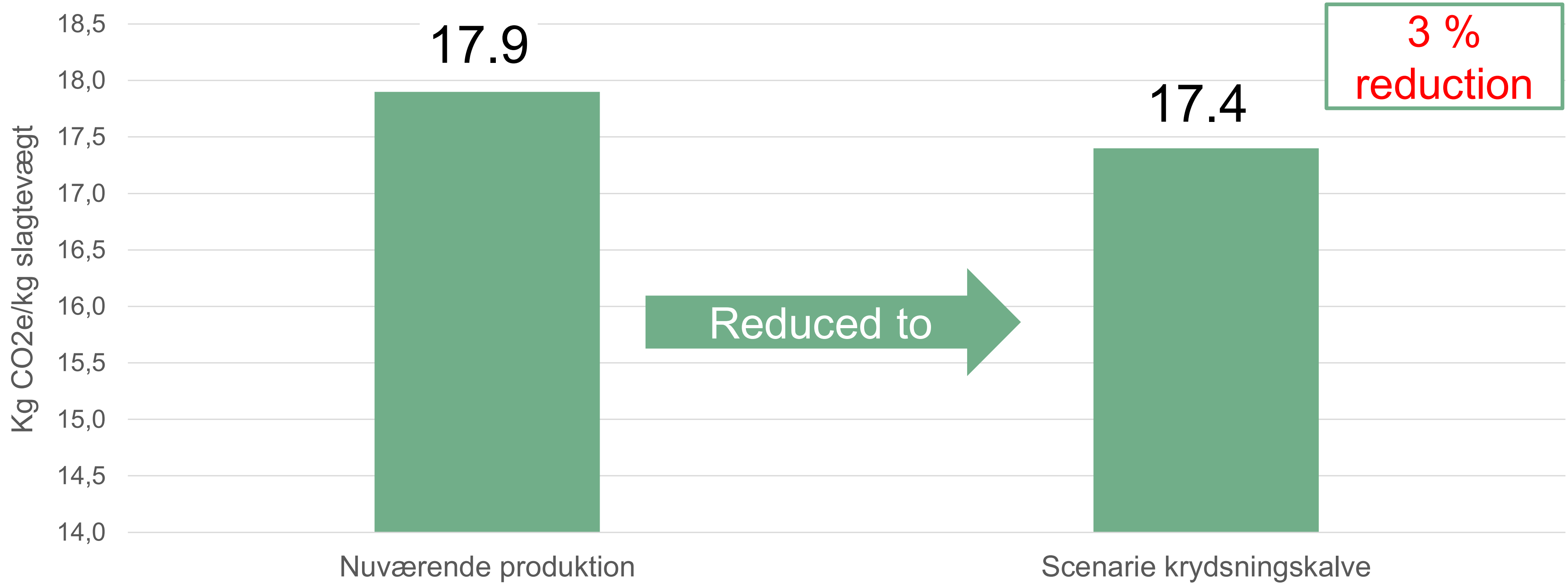


Suckler cow system



SEGES INNOVATION

Scenario 2: Effect of 90% crossbred calves used for slaughter calf production



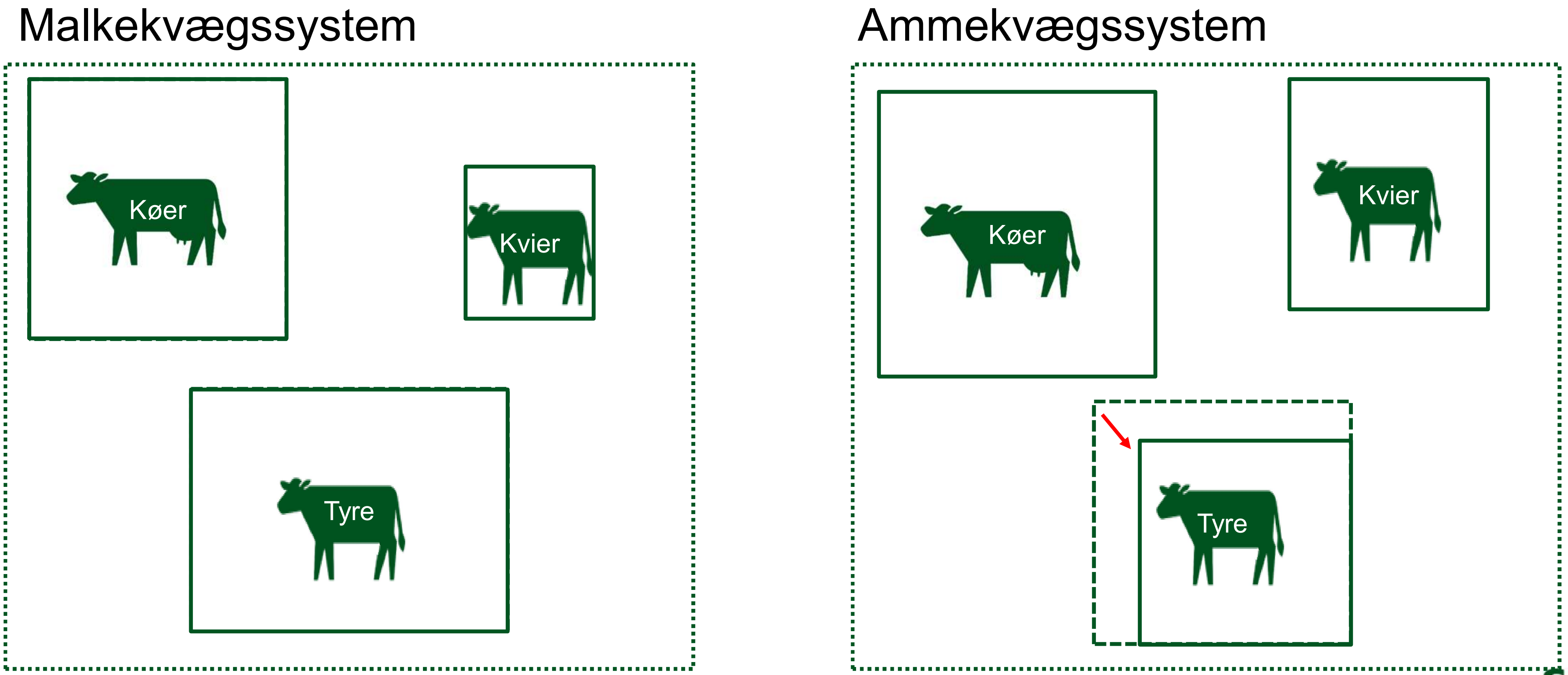
BUT more total beef produced, thus the reduction is closer to -5%

SEGES
INNOVATION

Scenario 3 – Higher carcass weight for slaughter calves and a concomitant reduction in number of suckler cows (same total amount of beef produced)

SEGES
INNOVATION

Scenario 3: Higher carcass weight for slaughter calves and a concomitant reduction in number of suckler cows (same total amount of beef produced)



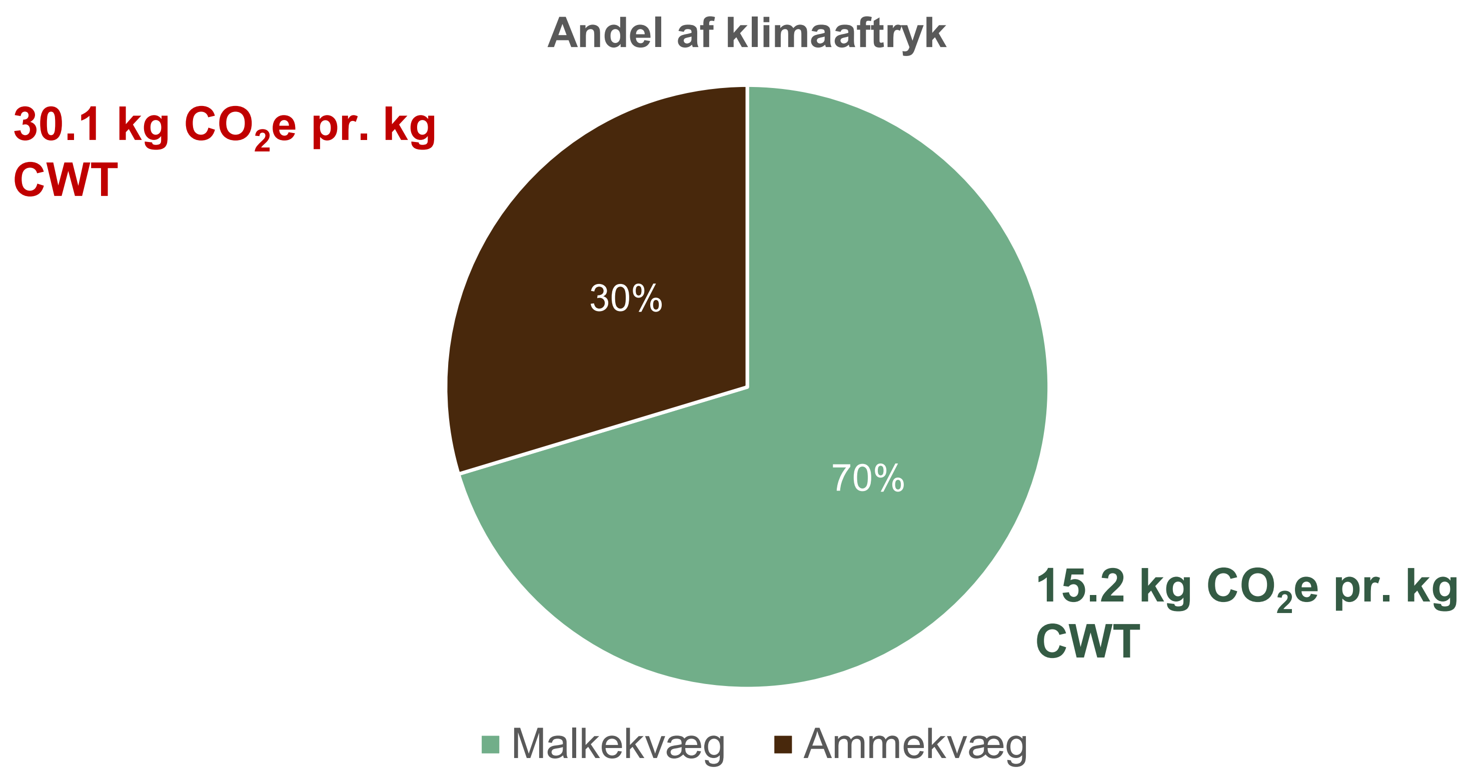
SEGES INNOVATION

Scenario 3 – higher carcass weight of slaughter calves (i.e., more beef x dairy crossbreds of same age) AND a concomitant reduction in the suckler cow production (same total amount of beef produced)

The reduction is equivalent to 0.20 mio. tons of CO_2e

SEGES INNOVATION

CF for Danish beef in 2021 – ALL animals born in dairy herds vs. ALL animals born in suckler herds

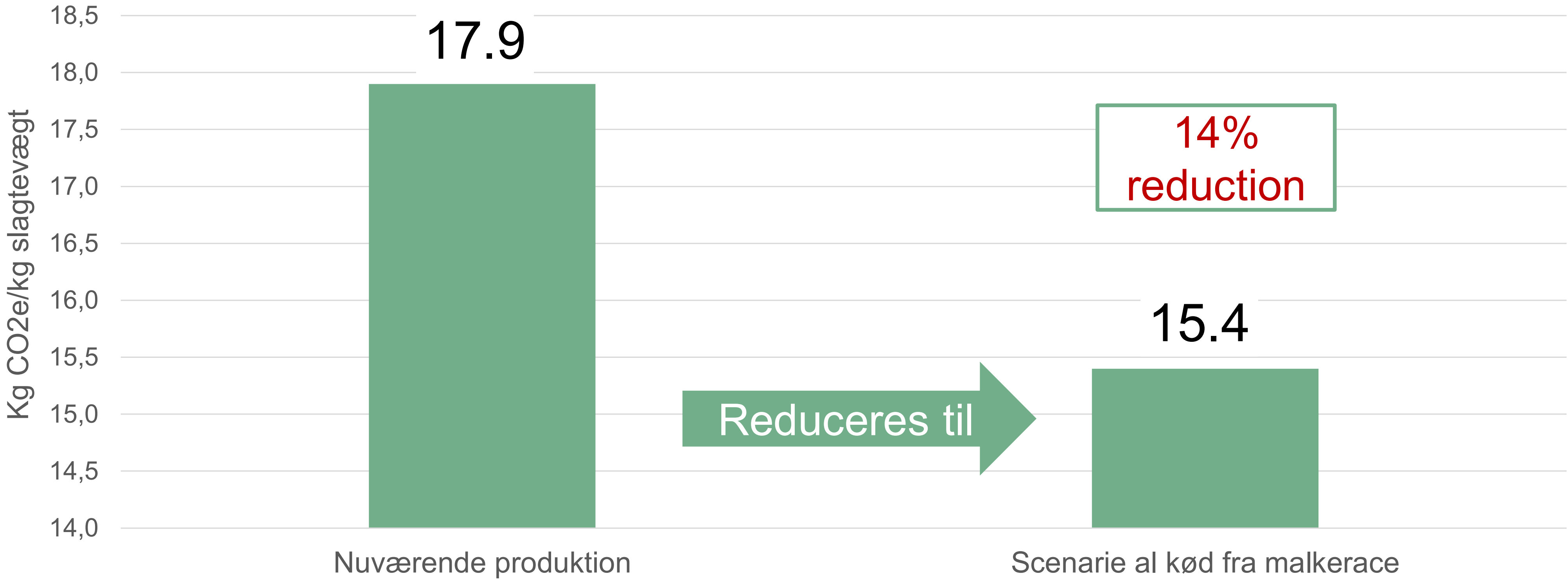


SEGES INNOVATION

What happens if all suckler cow herds are closed and the beef replaced by beef coming from the dairy system?

SEGES INNOVATION

Scenario 4 – If all beef from the suckler cow system is replaced by beef arising from calves born in dairy herds



Equivalent to 0.37 mio. tons of CO_2e

SEGES INNOVATION

Scenario 4+: What happens if we replace all beef from suckler cow herds with beef from catle born in dairy herds?

- Beef from suckler cow herds amounts to 22,100 tons of beef

↘

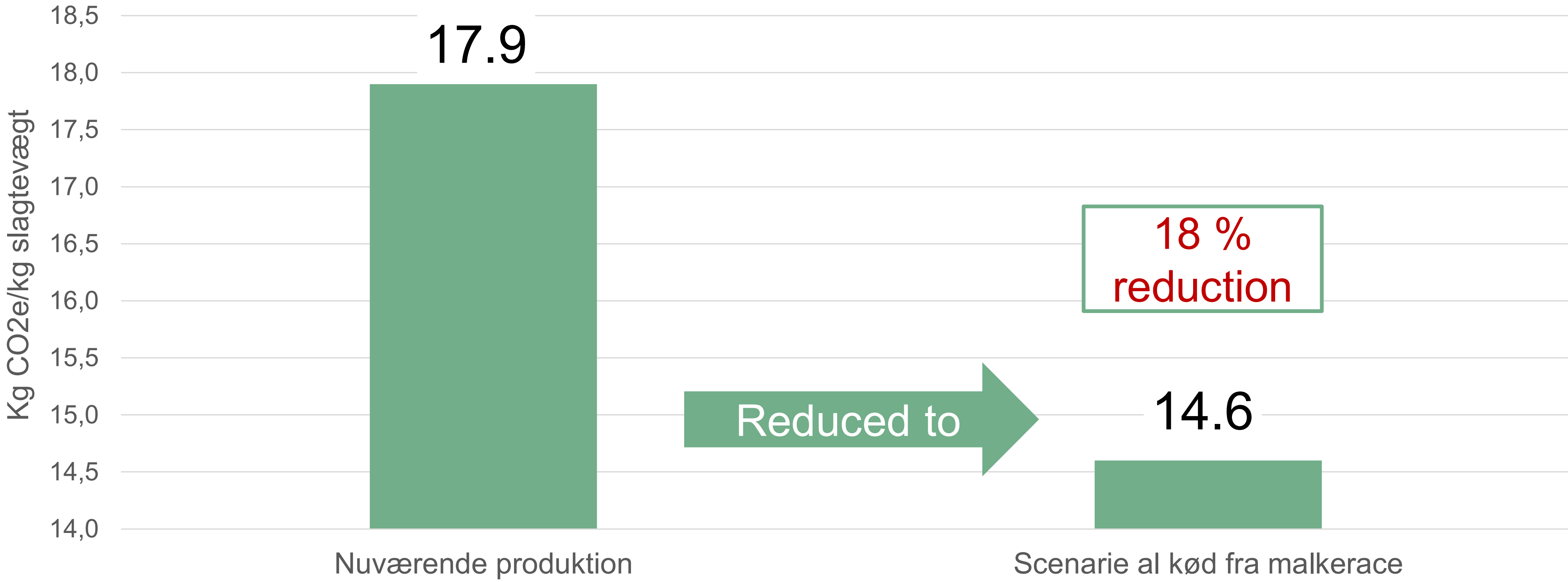
- This can be replaced by 88,000 slaughter calves with a carcass weight of 250 kg

- If we consider a situation where already 90% of the slaughter calves are beef x dairy crossbreds, we will only need an extra 46,200 slaughter calves of a carcass weight of 250 kg

(DK exports 50,00 one-month old calves anually, and many pregnant dairy heifers, so these calves could be used for a domestic beef production)

SEGES INNOVATION

Scenario 4+ – If all beef from suckler cow herds = 0 and is replaced by beef produced from crossbred slaughter calves



Equivalent to 0.41 mio. tons of CO_2e

SEGES INNOVATION

Other scenarios which can contribute to a reduction in CF of the Danish beef production

- Finishing feeding of culled cows?
- ….?
- ….?

- We are currently calculating 2-3 more scenarios, to be available late 2024.

SEGES INNOVATION

Take home messages – so far…

- ✓ Our model can calculate CF of the total Danish beef production
- ✓ Our model can estimate the effects of changes among the various production categories (see 4 examples of scenarios)
- ✓ The preliminary scenario-calculations have shown reduction potential of 2-8% for the individual scenarios
- ✓ We expect (within a 10 year time frame) a further 5%? reduction in CF due to genetic improvemnets
- ✓ Vwe expect the combinned reduction potential will end at 20-30% depending of how drastic changes are impossed and how many catle will be fed 3NOP (or similar efficient products)
- ✓ Our overall estimates will be ready ultimo 2024/primo 2025.

SEGES INNOVATION

But, does it all have to be that efficient and having the lowest CF? Or will we make room for grazing of natural areas, use more crossbred heifers for red meat etc - and who is going to do the job?

Foto: Camilla Kramer

Foto: Mogens Vestergaard

Foto: Iben Alber Christiansen