CARBON FOOTPRINT OF BEEF IN DENMARK
WITH FOCUS ON FUTURE SCENARIOS

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Methodology

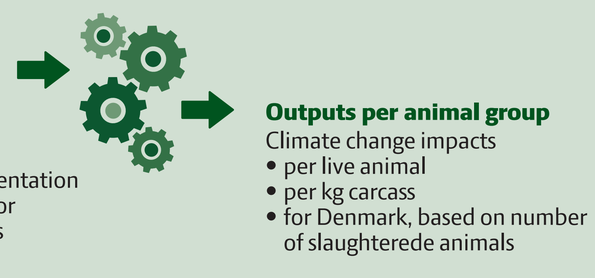
THE MODEL AND THE BACKGROUND DATA

The model, that we propose herein, calculates the GWP impacts of beef production in Denmark. The model differentiates across the impacts from

- **dairy cattle** for large breeds, jersey, crossbreds from large breeds and crossbreds from jersey, from both conventional and organic production systems (i.e., 8 production systems)
- **suckler cattle**, from both intensive and extensive systems (i.e., 2 production systems).

A total of 10 production systems are modelled, and each of them distinguishes between the following animal groups: cows, heifers under 18 months, heifers above 18 months, bulls under 12 months, bulls above 12 months, steers, heifer calves sold to export (0-1 month), and bull calves sold to export (0-1 month). A schematic representation of the model is presented in Figure 1.

FIGURE 1. Schematic representation of the model, per each animal group



BACKGROUND DATA FOR SCENARIO BASELINE:

- Age and the liveweight of the different animal groups: based on slaughter data from *the Danish cattle database*.
- Housing and grazing conditions: based on Gødningsregnskab, 2020.
- N_2O, CH_4 from manure: based on *Normtal 2022/23* (corrected to account for variations in the animal weight and age at slaughter compared with the animal groups defined in *Normtal 2022/23*) and *2019 Refinement to the 2006 Guidelines* (IPCC 2019, v.4, Chapter 10), and the defined housing and grazing conditions.
- Amount of manure to anaerobic digestor: based on Arla Foods' data (Arla Foods Climate Check Report, 2022).
- Feed rations: Optimized in DMS_NorFor (Volden, 2011) based on common feedstuffs used in Denmark.
- GWP impacts from feed cultivation: based on Agri-footprint 5.
- Enteric fermentation: calculated with the NorFor model (Nielsen et al. 2013), based on the "feed rations".

Future scenarios – case study

Scenario 3-NOP: all dairy cows and heifers above 18 months from conventional production systems are fed with 3-Nitrooxypropanol (3-NOP); it is assumed that the use of 3-NOP reduces the emissions of methane connected to enteric fermentation by 30% (based on Kebreab et al. (2022)); heifers are assumed to be fed with 3-NOP from the age of 18 months.
Scenario Shift: based on the current Danish situation, it is assumed that 90% of purebred males are replaced with crossbred males (steer, bulls under 12 months and bulls above 12 months).

References Kebreab, E., Bannink, A., Pressman, E.M., Walker, N., Karagiannis, A., van Gastelen, S., Dijkstra, J. 2022. *A meta-analysis of effects of 3-nitrooxypropanol on methane production, yield, and intensity in dairy cattle. 2022.* J. Dairy Sci. 106.
Nielsen N. I., H. Volden, M. Åkerlind, M. Brask, A. L. F. Hellwing, T. Storlien & J. Bertilsson. 2013. *A prediction equation for enteric methane emission from dairy cows for use in NorFor,* Acta Agriculturae Scandinavica, Section A - Animal Science, 63:3, 126-130.
Volden, H. 2011b. *NorFor: The Nordic feed evaluation system*. Wageningen Academic Publishers

Results and conclusions

TABLE 1. Preliminary Global Warming Potential (GWP) impacts, based on the number of dairy heifers above 18 months and dairy cows in 2021 in Denmark: Scenario Baseline VS Scenario 3-NOP. The impacts refer to the entire lifetime of the animals.

	GWP impacts from manure (incl. grazing, housing and manure tank)		**GWP impacts from enteric fermentation**		**GWP impacts from feed**	
	million kg CO2eq in DK / animals lifetime					
	S. Baseline	S.3-NOP	S. Baseline	S.3-NOP	S.Baseline	S.3-NOP
Large breeds, Heifer o 18 months	17	17	43	41	36	36
Large breeds, Heifer o 18 months crossbreds	2.5	2.5	6.8	6.4	5.8	5.8
Large breeds, cow	960	960	2100	1600	1500	1500
Jersey, Heifer o 18 months	1.9	1.9	4.9	4.7	4	4
Jersey, Heifer o 18 months crossbreds	0.61	0.61	1.6	1.5	1.2	1.2
Jersey, cow	110	110	250	190	180	180
Total	1092	1092	2406	1844	1727	1727

TABLE 2. Number of steers, bulls under 12 months and bulls above 12 months slaughtered in 2021 in Denmark: Scenario Baseline VS Scenario Shift.

	S. Baseline		**S. Shift**	
	n.animals	SUM pairs	n.animals	SUM pairs
Large breed, Steer	964	1496	96	1496
Large breed, Steer crossbreds	532		1400	
Large breed, Bull u 12 months	106742	127772	10674	127772
Large breed, Bull u 12 months crossbreds	21030		117098	
Large breed, Bull o 12 months	23557	29014	2356	29014
Large breed, Bull o 12 months crossbreds	5457		26658	
Jersey, Steer	340	506	34	506
Jersey, Steer crossbreds	166		472	
Jersey, Bull u 12 months	1229	3804	123	3804
Jersey, Bull u 12 months crossbreds	2575		3681	
Jersey, Bull o 12 months	2071	3892	207	3892
Jersey, Bull o 12 months crossbreds	1821		3685	

TABLE 3. Preliminary Global Warming Potential (GWP) impacts, based on the number of steers, bulls under 12 months and bulls above 12 months slaughtered in 2021 in Denmark: Scenario Baseline VS Scenario Shift. The impacts refer to the entire lifetime of the animals.

		S. Baseline	**S. Shift**
FWP cattle males in DK (incl. the entire animal's lifetime	10^6 kg CO_2eq	539	535
Amount of meet produced (based on slaughtered weight)	10^6 kg meat	37.4	40.4
GWP of meat from cattle males	kg CO_2eq / kg meat	14.4	13.2

Scenario 3-NOP: reduction potential from (1092 + 2406 + 1727 =) 5225 to (1092 + 1844 + 1727 =) 4663 million kg CO_2eq, based on the number of dairy heifers above 18 months and dairy cows in 2021 in Denmark.
Scenario Shift: similar GWP impacts when replacing pure breed males with crossbred males (90% replacement rate) compared with the baseline scenario, but crossbred males can generate ~3 million kg additional meat.

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