Carbon footprints of organic dairy farms in Europe

SOLID project

Real farm data analysis of 34 farms from 6 countries

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SEVENTH FRAMEWORK PROGRAMME

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Overview

- LCA and Arla carbon footprint model
- SOLID project organic farm data (here 6 countries included: UK, DK, FI, AT, BE, IT)
- Results
- Conclusions

LCA and Arla carbon footprint model

- Arla carbon footprint model is focusing on one LCA impact; global warming
- Of the full life cycle of dairy production, system boundaries are set from cradle to farm gate
- Emissions from agriculture include CO_2, No_x and CH_4 (carbon dioxide, nitrous oxides and methane)
- Conversion of emissions to CO_2 equivalents by multiplying with characterisation factors (N_2O by 25 and CH_4 by 298)
- Result is given as kg of CO_2 equivalents per kg of Energy and protein Corrected Milk (ECM)

System boudaries overview

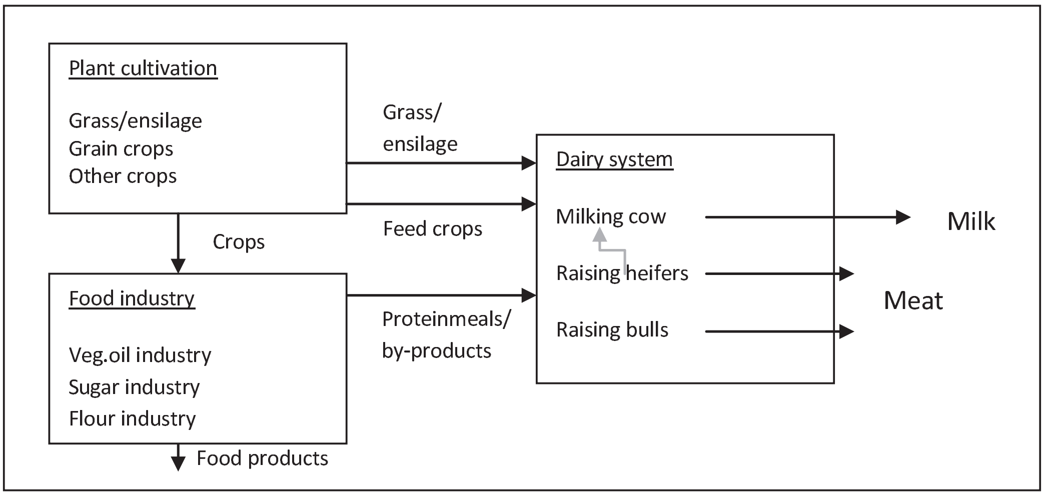

Fig. 1. Overview of system boundaries as used in this study. Modified from Schmidt & Dalgaard (2012a).

In addition to these, transportation, fertiliser production etc. are included

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Arla carbon footprint model data requirements

- Input data needed for model:
  - imp, exp fertilizers (incl. Manure and straw)
  - Energy use: traction diesel, grain drying, electricity
  - Crops produced on farm (ha, yield, fertilizer use)
  - Milk yield
  - Herd details (dairy cows, heifers, calves, bulls)
    - Number of fallen, slaughtered, exported and imported animals + weights
  - Housing system and time indoor
  - Imported feeds
  - Feeds cultivated and used on farm

Arla carbon footprint model

- Based on given data, model estimates feed requirement per farm as required energy

- Inputs of roughage are estimated based on total feed required and data on imported and homegrown feed

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SOLID data and adjusting to Arla model

- The data was collected from organic dairy farms using the Natural England funded PG (public goods) tool developed at the Organic Research Centre

- The PG tool assesses each individual farm across 11 “spurs”:
  - Soil Management, Biodiversity, Landscape and Heritage, Water Management, Nutrient Management, Energy and Carbon, Food Security, Agricultural Systems Diversity, Social Capital, Farm Business Resilience, and Animal Health and Welfare.

- Makes use of information which the farmer will already have available (e.g. farm accounts, cropping records, animal health plan)

Parameter [unit]	Formula	Data collected on-farm
		Number of culled animals and dairy cows
Replacement ratio (RR)	N culled animals / N dairy cows	
Newborn heifers [heads]	0.5 * total N of calves born	
Newborn bulls [heads]	0.5 * total N of calves born	Number of calves born
Deathborn heifers [heads]	0.05 * newborn heifers	
Deathborn bulls [heads]	0.05 * newborn bulls	
		Number of dairy cows
Fallen dairy cows (excl. calves) [heads]	0.02 * total N of dairy cows	
Time from birth of 1st calf to slaughter [months]	12 * (1/RR)	
Average live weight [kg]	A * 0.9	
Weight after birth of 1st calf [kg]	A * 0.8	
Weight per fallen dairy cow [kg]	A * 0.9	
		A = weight per slaughtered dairy cow
Weight per exported dairy cow [kg]	A	
Weight per imported dairy cow [kg]	A * 0.9	
Heifers (average) [heads]	same as N of dairy cows	Number of dairy cows
Fallen heifers [heads]	0.02 * N of total heifers	
Age at birth of 1st calf [months]	27, same for all	
		Time indoor per dairy cow
Time indoor per heifer [%]	estimated as same as for dairy cows	
Average live weight [kg]		Weight per calf + calculated weight before calving
	calf weight + 0.5 * weight before calving	
Weight before birth of 1st calf [kg]	A * 0.8 + (calf weight * 1.7)	
Weight per fallen heifer [kg]	0.8 * live weight	
Weight per exported heifer [kg]	calf weight + weight before calving/2	
Weight per imported heifer [kg]	0.9 * live weight	
Bull calves [heads]	same N as born	
Fallen bull calves [heads]	0.04 * N born	

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Farm characteristics

Attribute [unit]	Austria min	Austria max	Belgium min	Belgium max	Denmark min	Denmark max	Finland min	Finland max	Italy min	Italy max	UK min	UK max
Dairy cows [Number]	10	12	55	78	36	164	9	47	16	41	105	205
Milk yield [kg ECM]	2032	4618	7075	7887	3410	7112	5168	8717	3963	7816	3519	5456
Time on pasture [%]	55	65	55	55	50	65	25	50	25	75	50	65
Imported manure and straw [kg N]	4	37	0	4496	0	7570	0	0	0	0	9	3426
Rotational grassland [ha]	0	0	5	28	4	207	3	33	6	28	4	249
Permanent grassland [ha]	13	24	17	21	3	75	0	5	0	13	32	122

Carbon footprint, average of 34 farms

Table 3. Average carbon footprint of organic dairying in six European countries [a)] per 1 kg ECM, allocated between the processes …, $n_{farms} = 34$.

European average **Direct emissions**	**Dairy cows** [kg CO_2-eq]	**Raising heifers and bulls** [kg CO_2-eq]	**Crop cultivation** [kg CO_2-eq]	**Total** [kg CO_2-eq]
CH_4 enteric fermentation	0.43	0.16		
CH_4 manure handling and storage	0.07	0.02		
N_2O	0.03	0.01	0.25	
Sum of Direct emissions	**0.53**	**0.19**	**0.25**	**0.97**
Emissions outside animal activities				
Feed inputs		0.0003		
Imported feed inputs		0.035		
Manure land application		0.002		
Purchased manure and live animals		0.056		
Fuels		0.061		
Electricity		0.066		
Transport		0.005		
Destruction of fallen cattle		0.0000		
Farm, capital goods and services		0.123		
Sum of Emissions outside animal activities		**0.35**		
Total				**1.32**

a) Austria, Belgium, Denmark, Finland, Italy and United Kingdom

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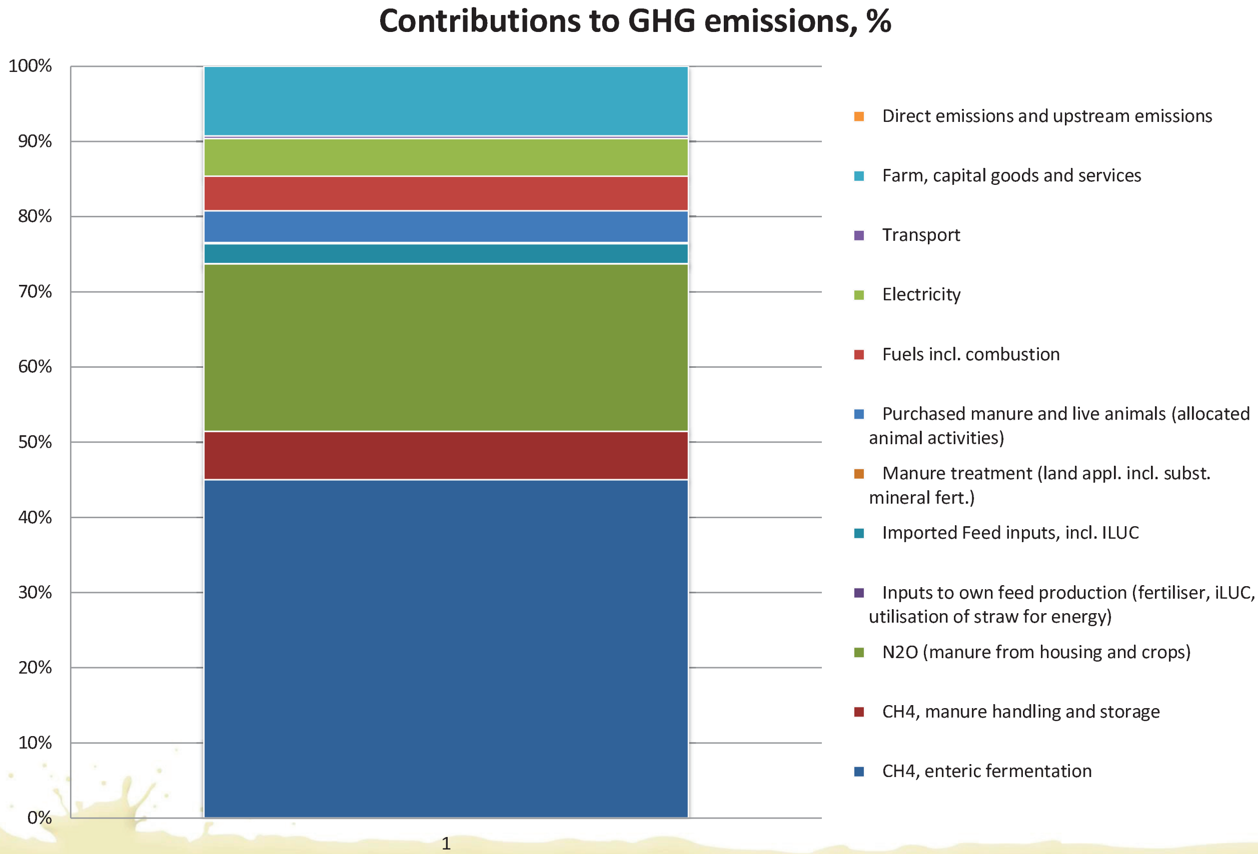
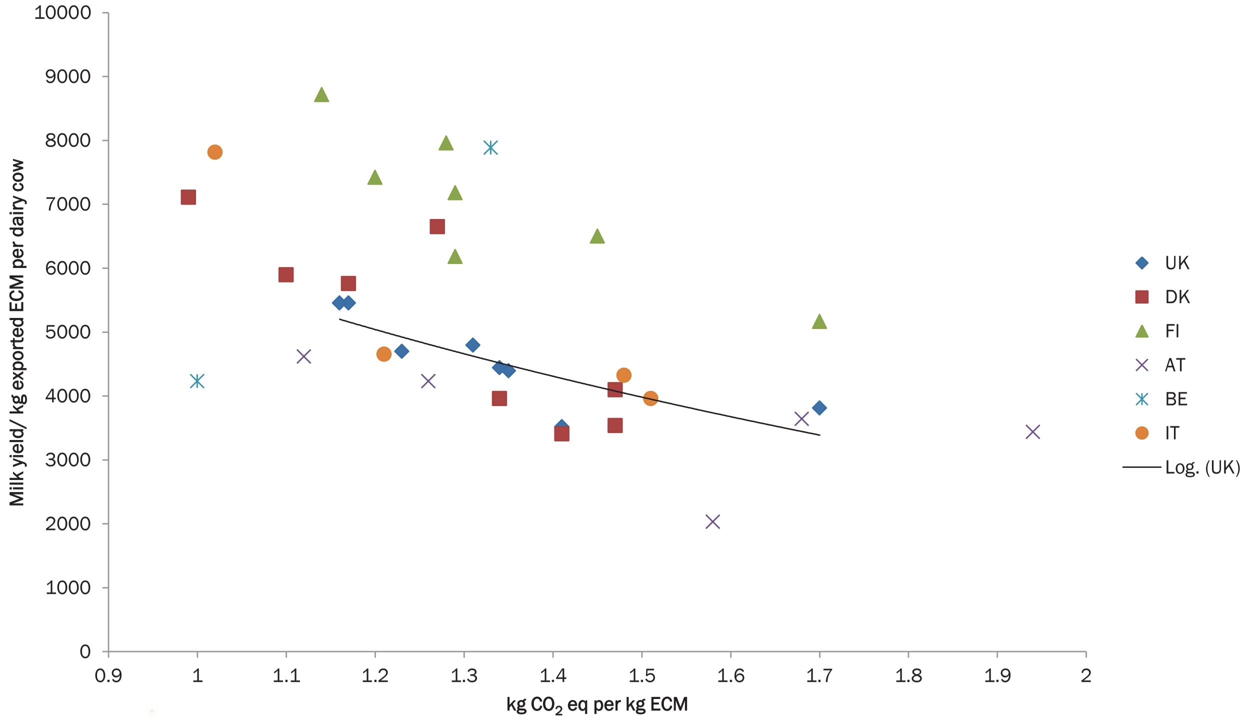


Carbon footprints of 6 countries, smallest and largest (prelim.)

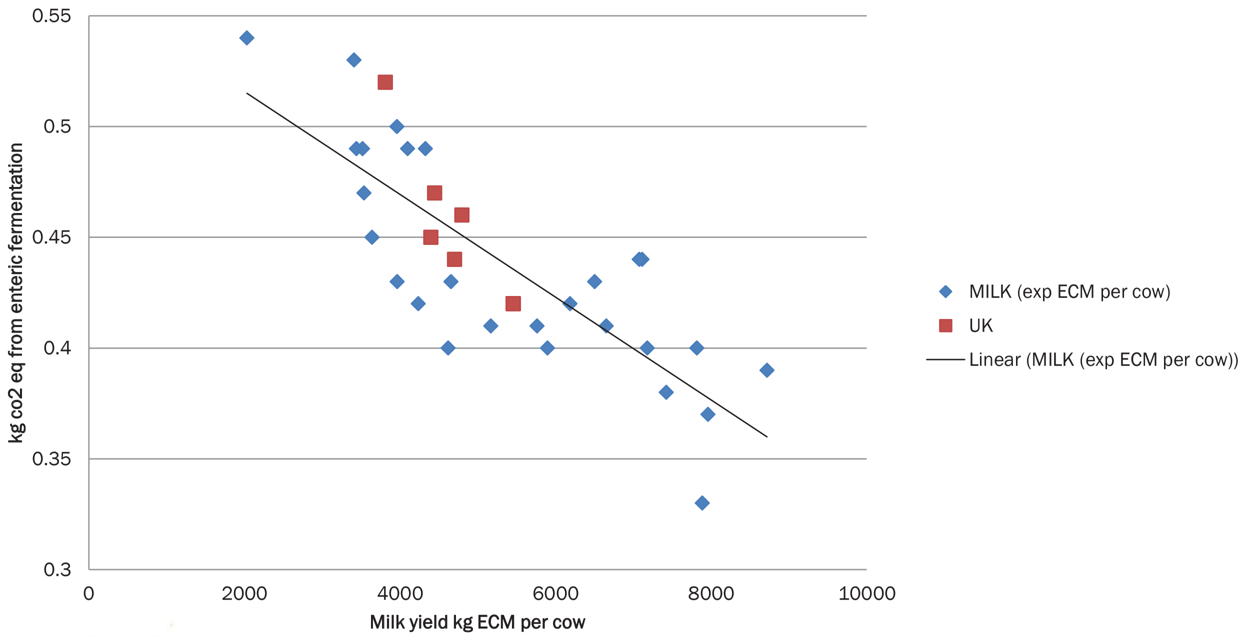
Table 4. Estimated GHG emissions per country. Lowest (Min) and highest (Max) contributors presented.

	Emissions as kg CO_2 equivalents per kg ECM by country											
	AT		BE		DK		FI		IT		UK	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Total GHG per kg ECM	0.92	1.30	0.79	1.12	0.77	1.23	0.84	1.24	0.81	1.25	0.79	1.16
Total share from direct												
CH_4 enteric fermentation	0.56	0.71	0.45	0.51	0.56	0.67	0.49	0.58	0.53	0.63	0.58	0.77
CH_4 manure handling and storage	0.056	0.09	0.072	0.098	0.046	0.055	0.074	0.144	0.071	0.018	0.048	0.134
N_2O	0.023	0.048	0.037	0.05	0.021	0.025	0.037	0.082	0.032	0.1	0.021	0.073
Inputs												
Feeds	0.072	0.137	0.107	0.099	0	0.008	0.022	0.006	0	0.02	0	0.014
Fuel	0.039	0.083	0.03	0.088	0.008	0.008	0.027	0.019	0.061	0.063	0.007	0.001
Electricity	0.048	0.036	0.011	0.06	0.032	0.030	0.101	0.32	0.029	0.153	0.022	0.074
Other	0.123	0.199	0.087	0.217	0.098	0.434	0.086	0.087	0.071	0.186	0.09	0.112

CO_2 equivalents per milk yield



kg CO2 eq from enteric fermentation per exp ECM /cow)



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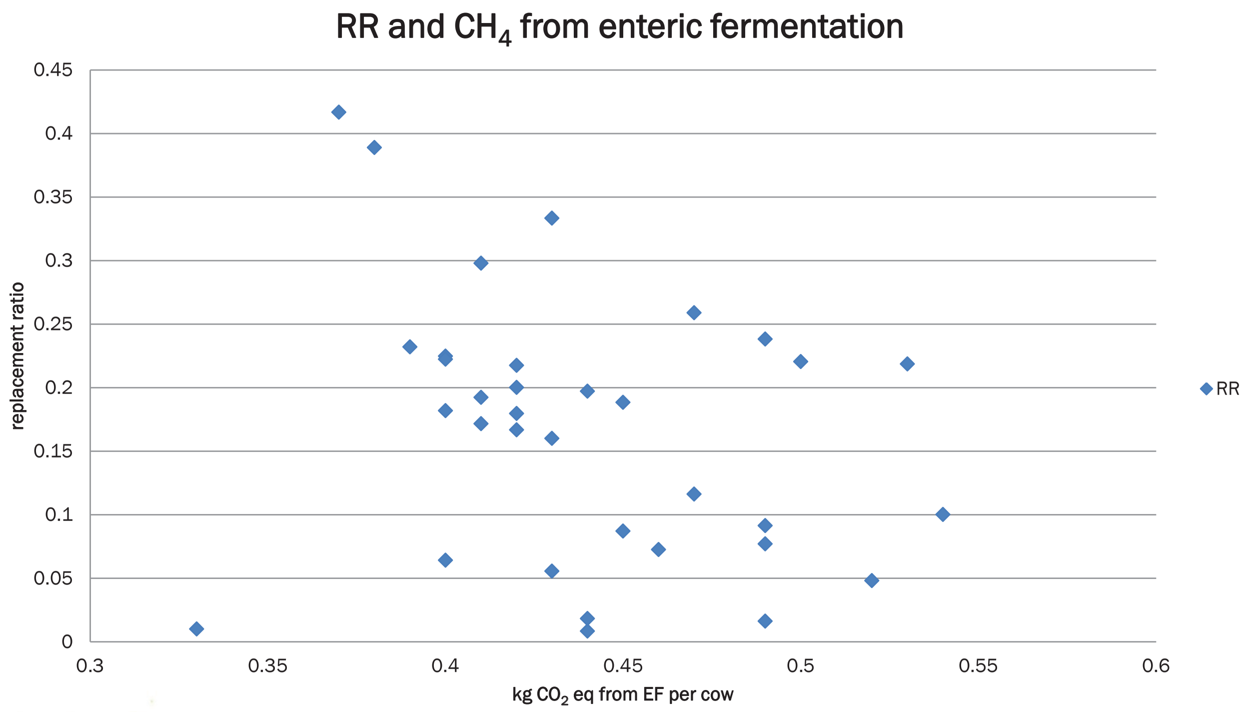

Conclusions

- Largest contributors to GHG is CH_4 from enteric fermentation and N_2O from crop cultivation and fertiliser use
- Variation can be seen between farms in milk yields and CF: by raising milk yields, CF per kg ECM lowers, especially when focusing on enteric fermentation.
- In the model, $CH_4$from enteric fermentation is calculated as a function to gross energy intake. -> high energy -> high methane.
  - Feed design can help in reducing methane from enteric fermentation
- Replacement ratio has an effect, but not clearly shown in this data
- Besides farm activities, the method for calculating the carbon footprint could be improved; this calculation does not yet take account of carbon sequestration– doing so would change the results to the benefit of farms using more grass-based permanent pastures
- Adding carbon sequestration to these CF calculations would provide a more complete picture of GHG emissions from organic dairy farms.
- It is important that mitigation strategies do take into account the other important features of organic dairy production like impact on biodiversity and on changes in soil carbon sequestration. Although enteric fermentation is the largest contributor to GHG emissions, development of more sustainable practises should therefore not only be in feed design, but in overall tactical management on farms.

Thank you!

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