Current status on LCA as applied to the organic food chains

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&

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Life Cycle Assessment (LCA) – methods, models and databases with focus on GHG emission and sequestration potential of organic farming systems and organic food

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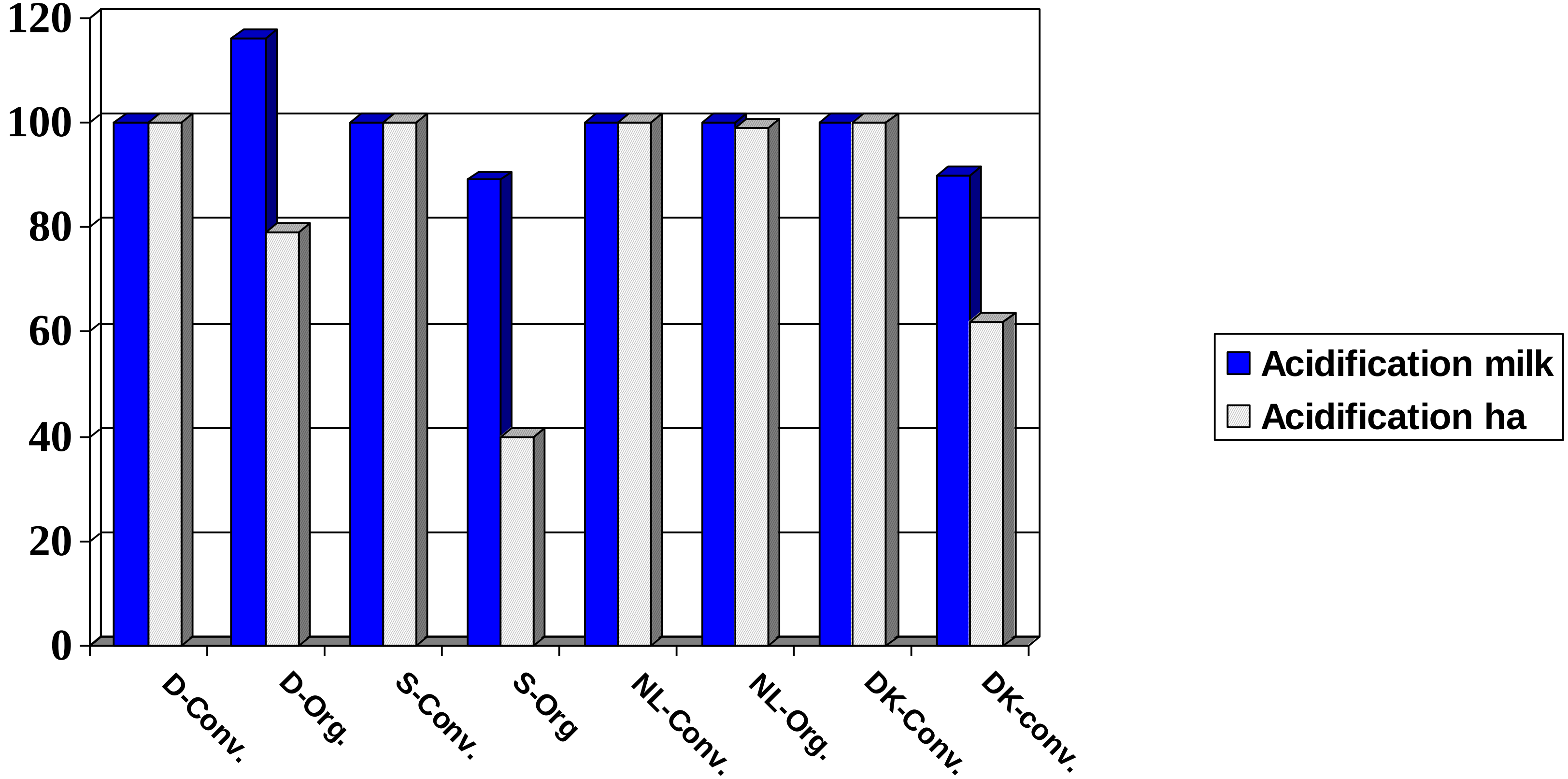
How to assess environmental impacts?

at farm level? or the whole life cycle?

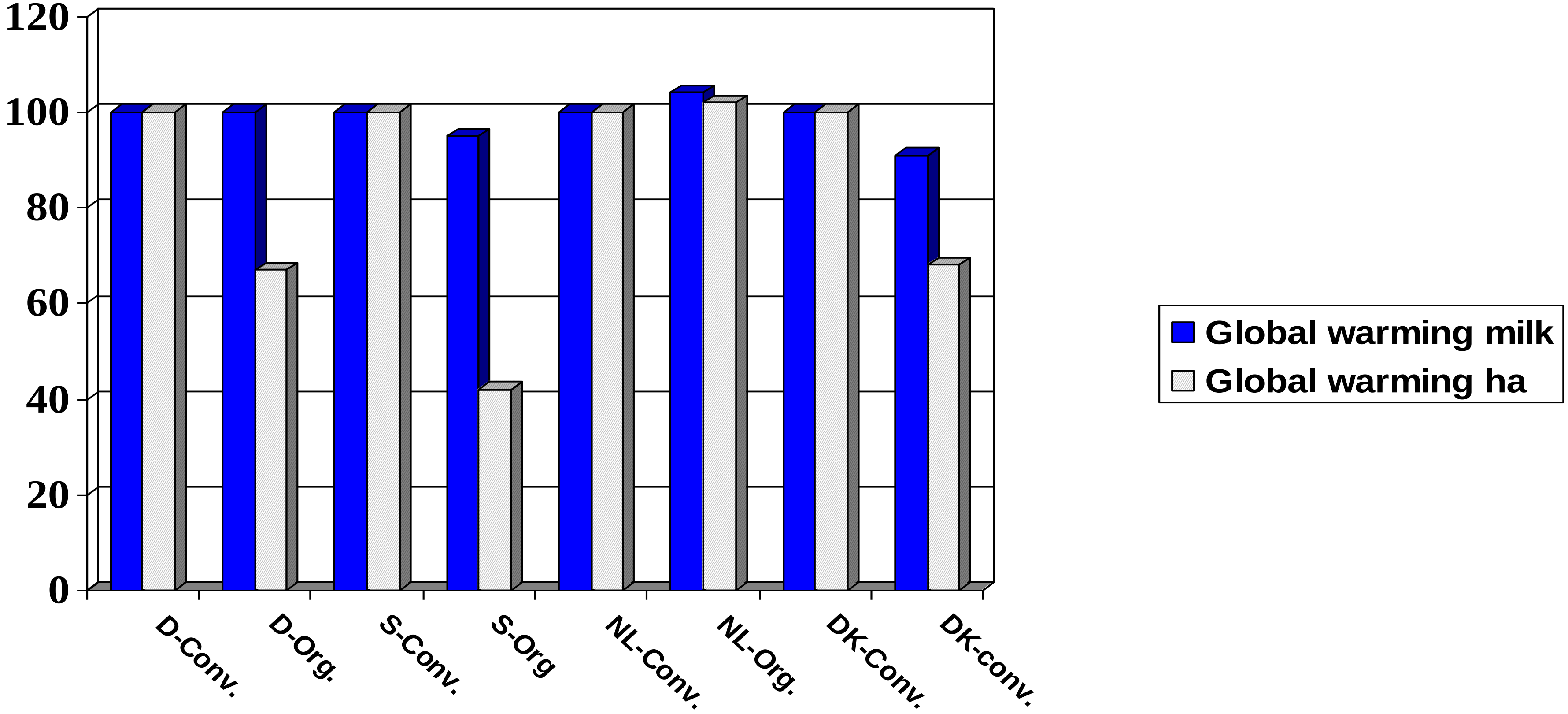
per ha? or per kg product?

Area or product based environmental assesment – acidification dairy production (conv.=100)



Germany, Sweden, The Netherlands, Denmark,
Halberg et al 2005

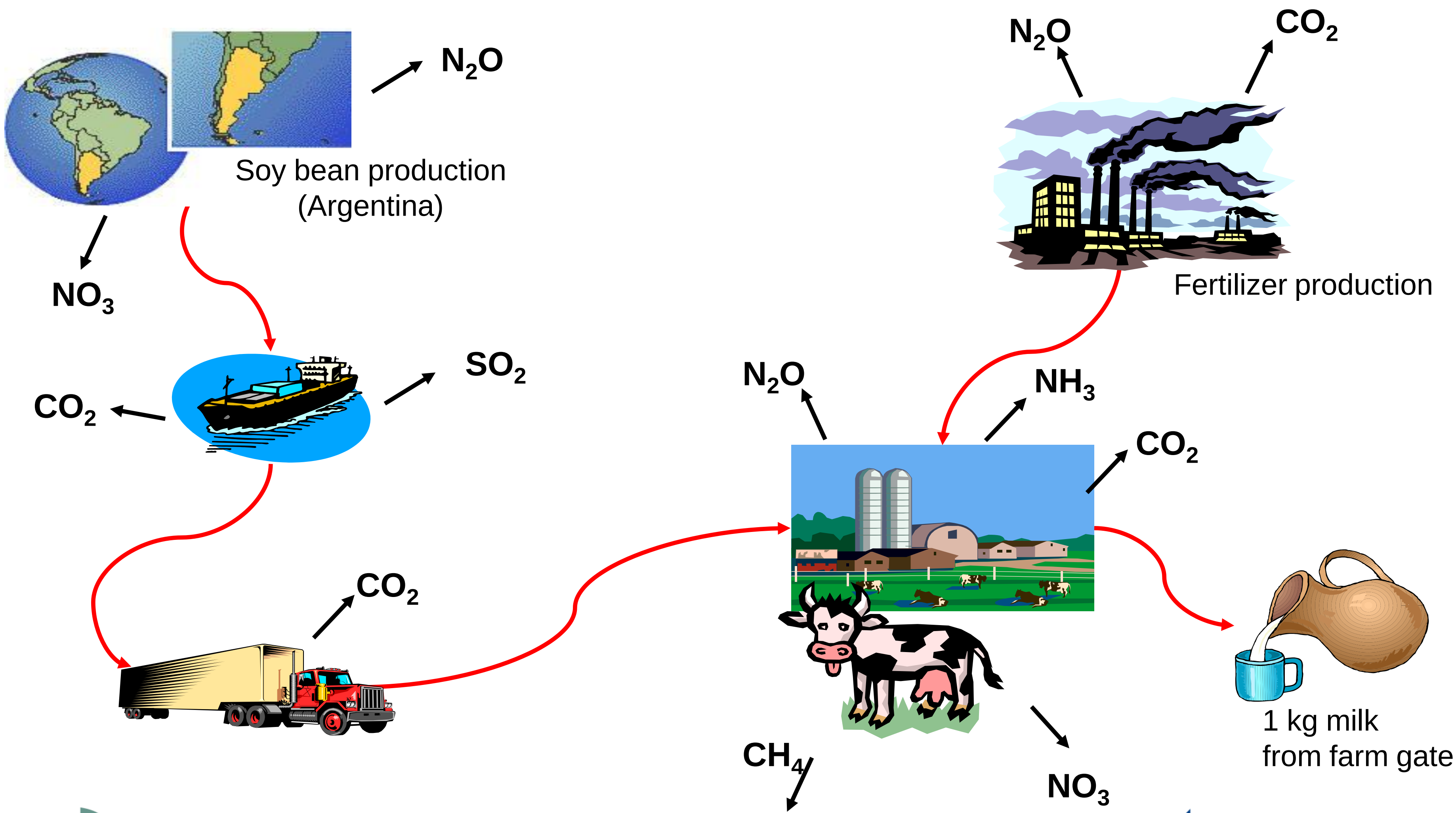
Area or product based environmental assessment - GWP for dairy production (conv.=100)



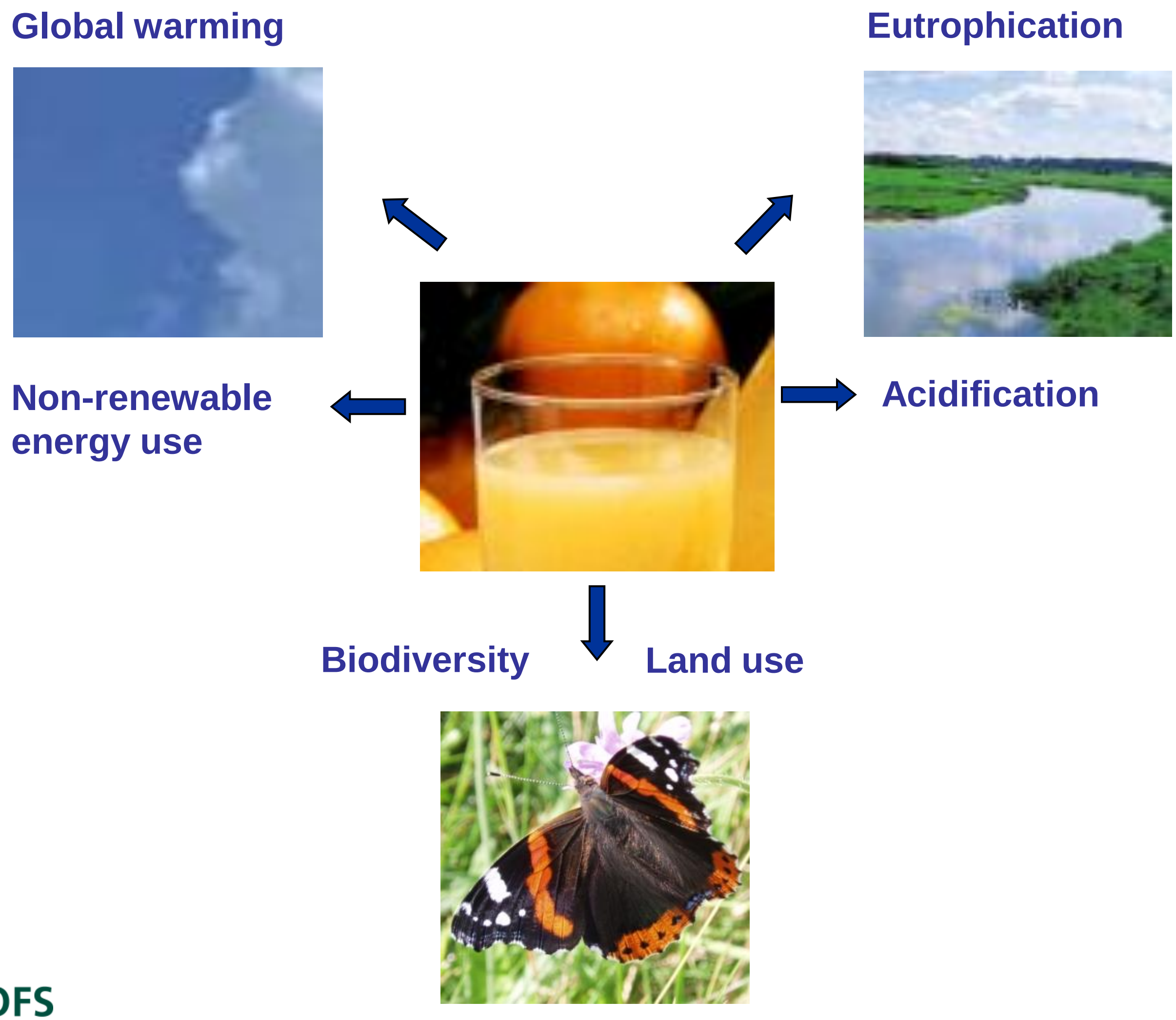
Germany, Sweden, The Netherlands, Denmark,

Halberg et al 2005

How to use an LCA approach?



Method
Life cycle assessment (LCA)



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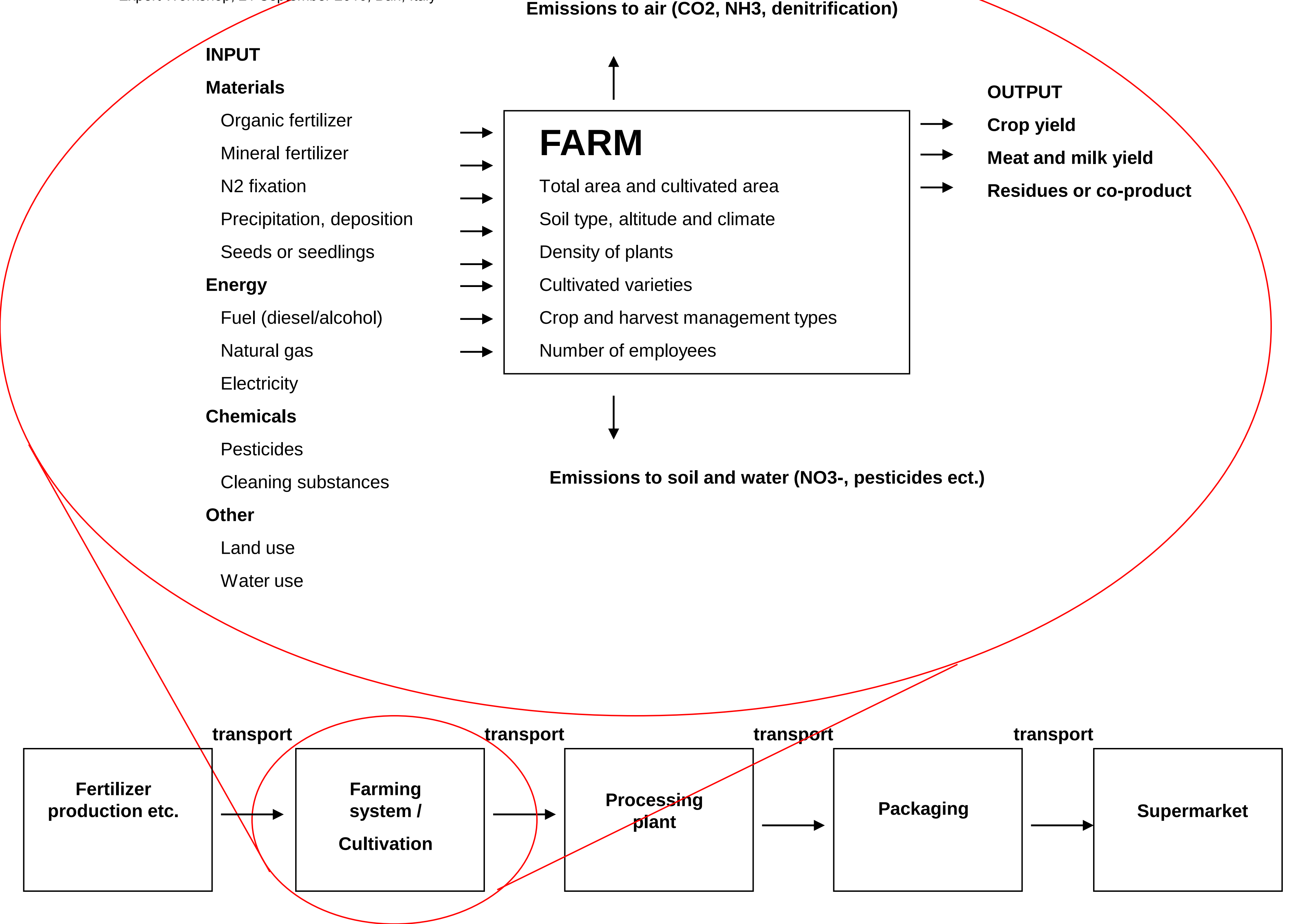
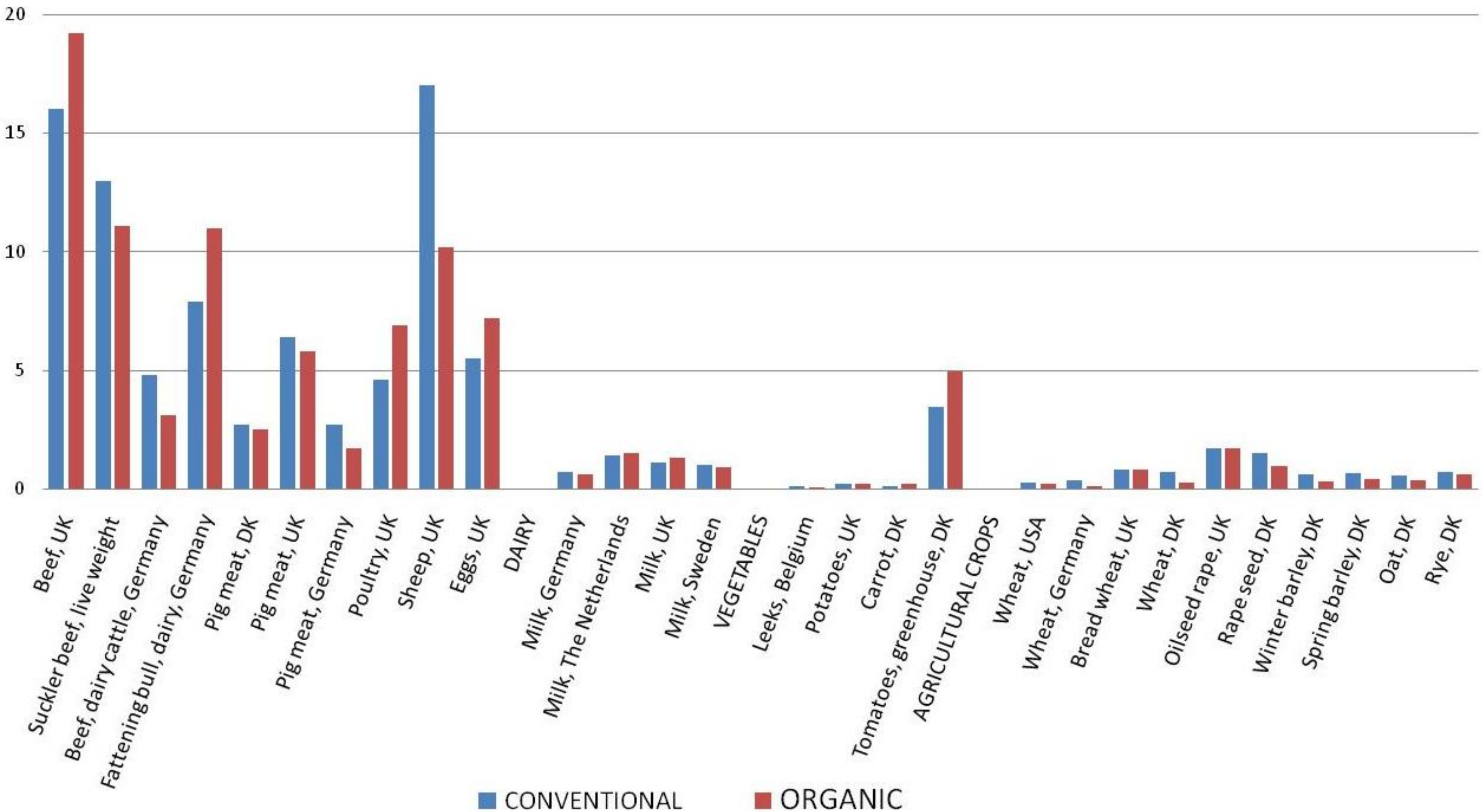
Important environmental impact categories at the farming stage

- Global warming (CO_2, nitrous oxide, methane, etc.)
- Nutrient enrichment (nitrate, ammonia, phosphate etc.)
- Acidification (ammonia, sulfur dioxide, nitrogen oxide etc.)

INVENTORY


Emissions to air (CO2, NH3, denitrification)
INPUT
Materials
Organic fertilizer
Mineral fertilizer
N2 fixation
Precipitation, deposition
Seeds or seedlings
Energy
Fuel (diesel/alcohol)
Natural gas
Electricity
Chemicals
Pesticides
Cleaning substances
Other
Land use
Water use
FARM
Total area and cultivated area
Soil type, altitude and climate
Density of plants
Cultivated varieties
Crop and harvest management types
Number of employees
OUTPUT
Crop yield
Meat and milk yield
Residues or co-product
Emissions to soil and water (NO3-, pesticides ect.)
transport
transport
transport
transport
Fertilizer production etc.
Farming system / Cultivation
Processing plant
Packaging
Supermarket

Comparative values of Emissions of Green House Gasses per kg product in organic and conventional production (After Knudsen, 2010)



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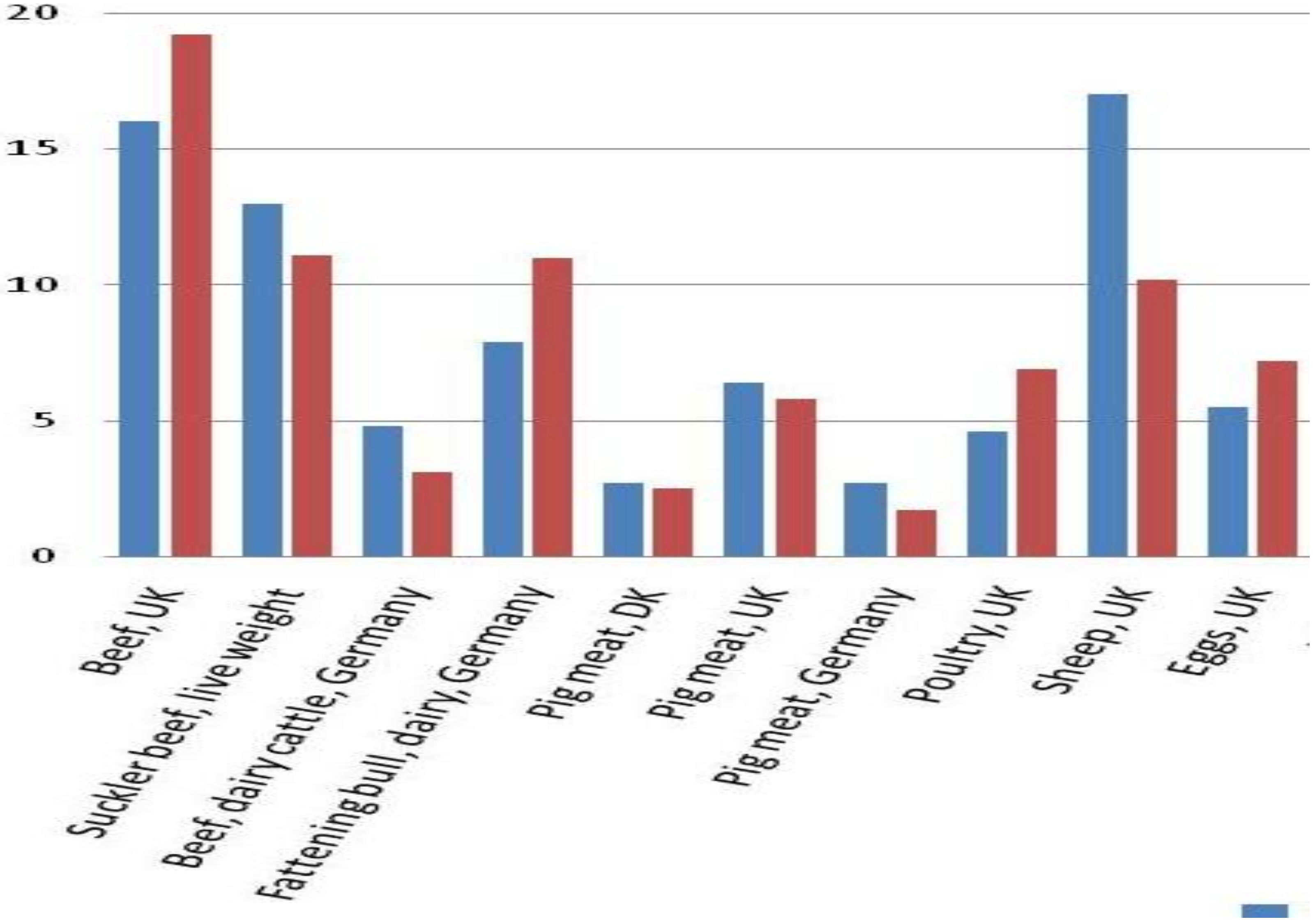

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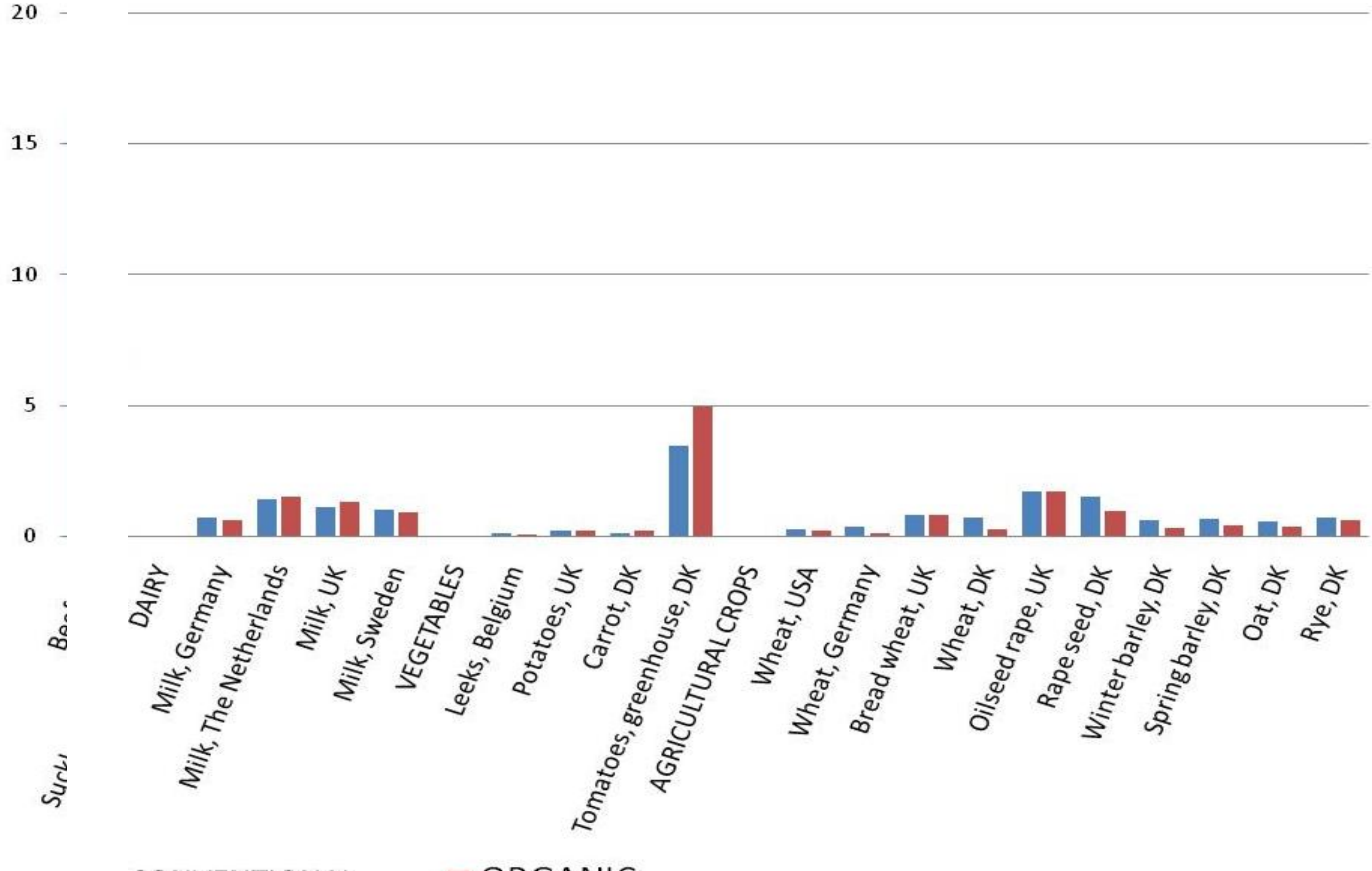


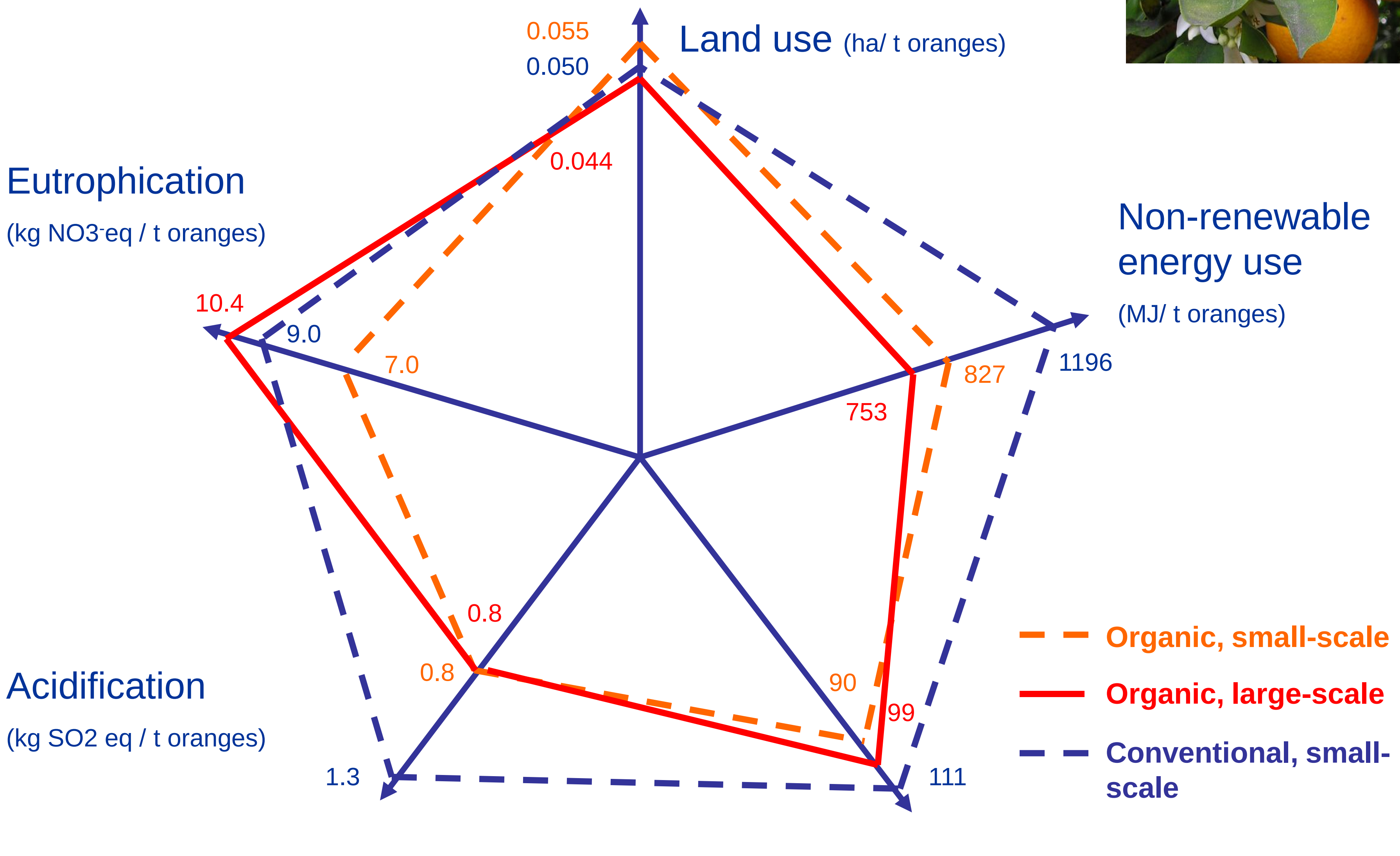
Example from Knudsen et al. (2010) – organic oranges

- To compare the environment impacts in the production of organic oranges at small-scale farms with organic large-scale farms and or small-scale conventional farms in Brazil.

- To identify the environmental hotspots in the product chain of organic orange juice from small-scale Brazilian farms imported to Denmark.

Input production → transport → **Production of oranges** → transport → **Juice concentrate factory, Brazil** → transport → **Juice factory, Germany** → transport → **Import to Denmark**

Environmental impacts at farm gate



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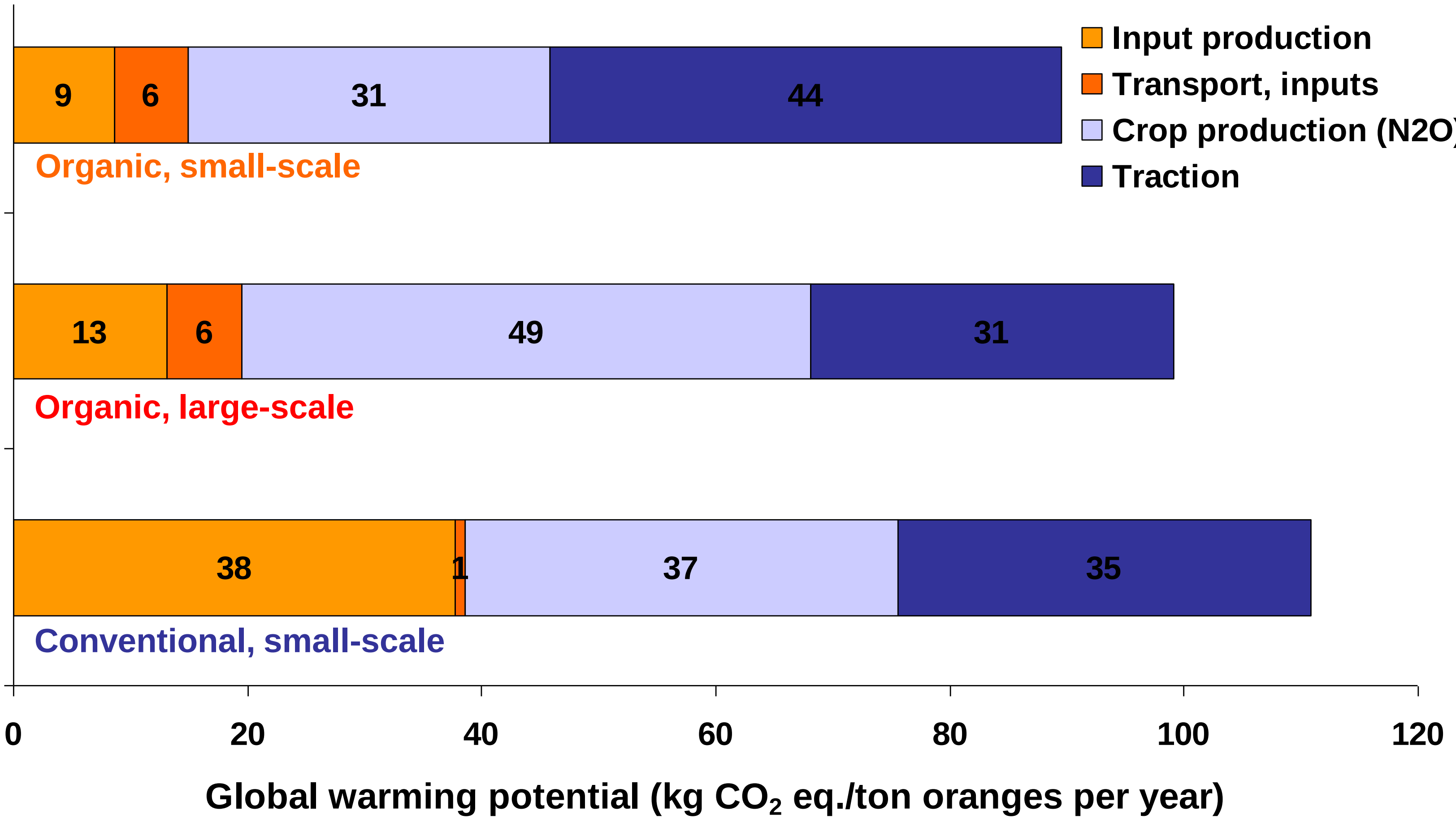
Results at farm gate



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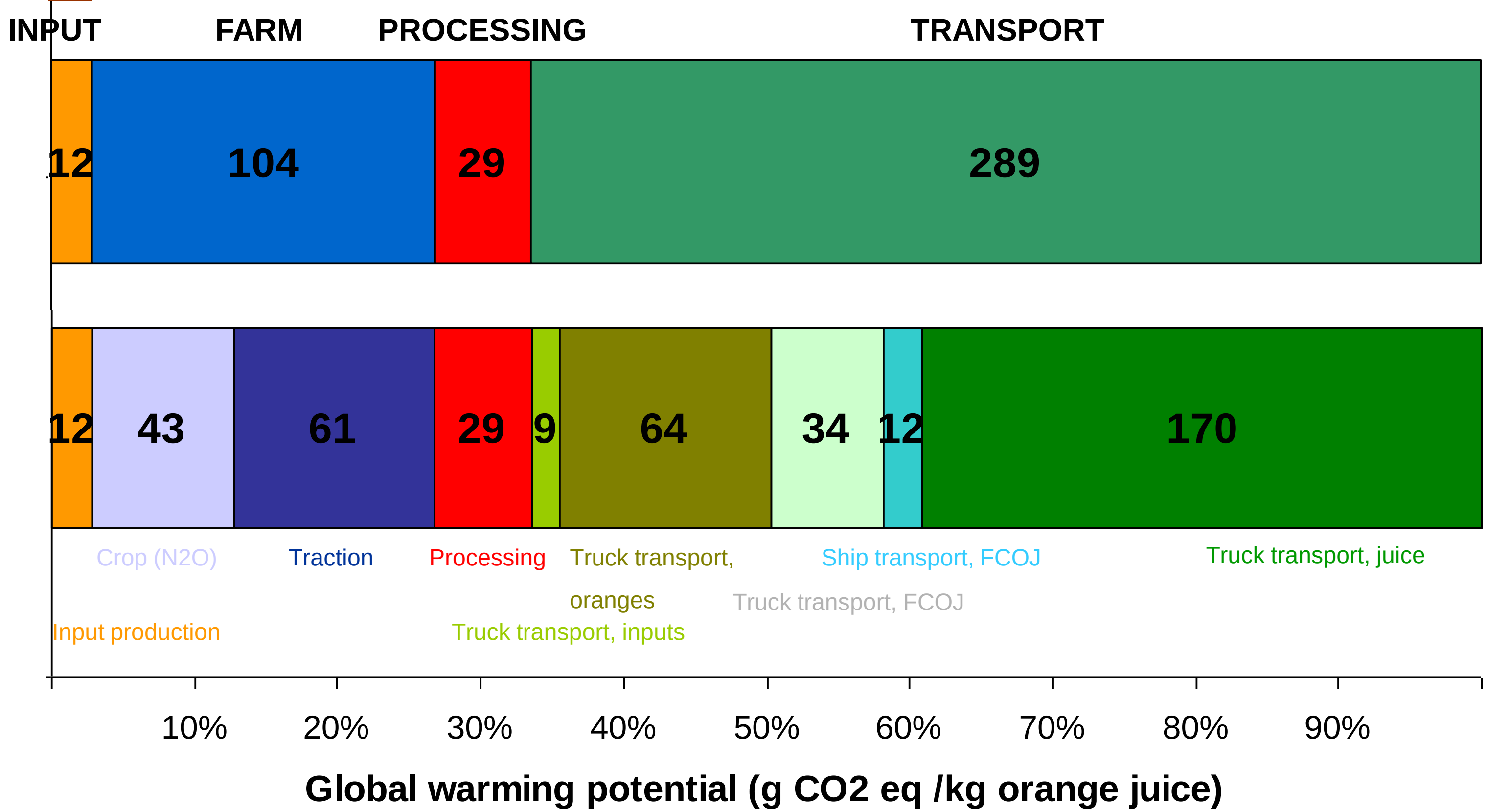
Life Cycle Assessment (LCA) - methods, models and databases with focus on GHG emission and sequestration potential of organic farming syste… organic food.
Expert Workshop, 21 September 2010, Bari, Italy

Results for orange juice



Conclusion
The case study indicates that…

- Organic orange production generally have less environmental impacts per ton orange compared to conventional
  - Inclusion of soil carbon sequestration in the calculations would increase the difference in GWP between organic and conventional even more
- Large organic orange farms have a higher eutrophication potential and less diversity compared to small organic orange farms
- Transport, especially truck transport of fresh oranges and orange juice, contributes approx. 65% to total GWP of organic orange juice from small farms in Brazil

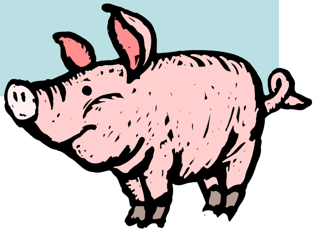
Important aspects when comparing organic and conventional systems

- Difference in carbon sequestration as impacted by differences in crop rotation
- How to account for impacts related to imported nutrients/manure
- How to account for differences in impact on land use/land use change

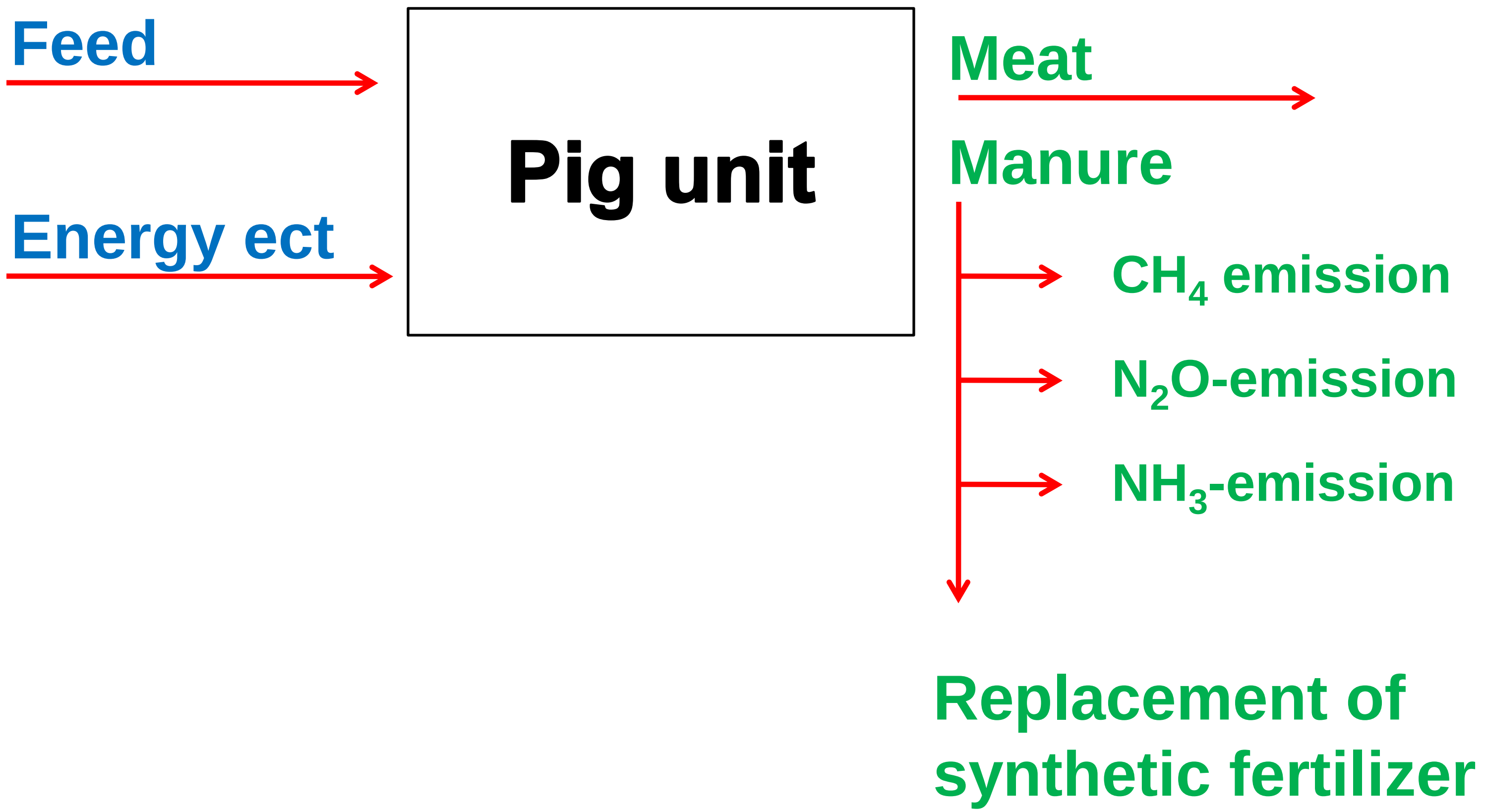
LCA of pork from Danish farm, 1 kg liveweight pig ab farm

Impact category[2]	Organic pig system[1]/unit	Free range sows	All pigs free range	Conven-tional system
Global warming (GWP 100)	g CO_2-eq	2920 [4]	3320 a	2700
Soil C sequestration[3]	g CO_2-eq	-300	-400	0
Acidification	g SO_2-eq	57.3 a	61.4 a	43
Eutrophication	g NO_3-eq	269 b	381 a	230

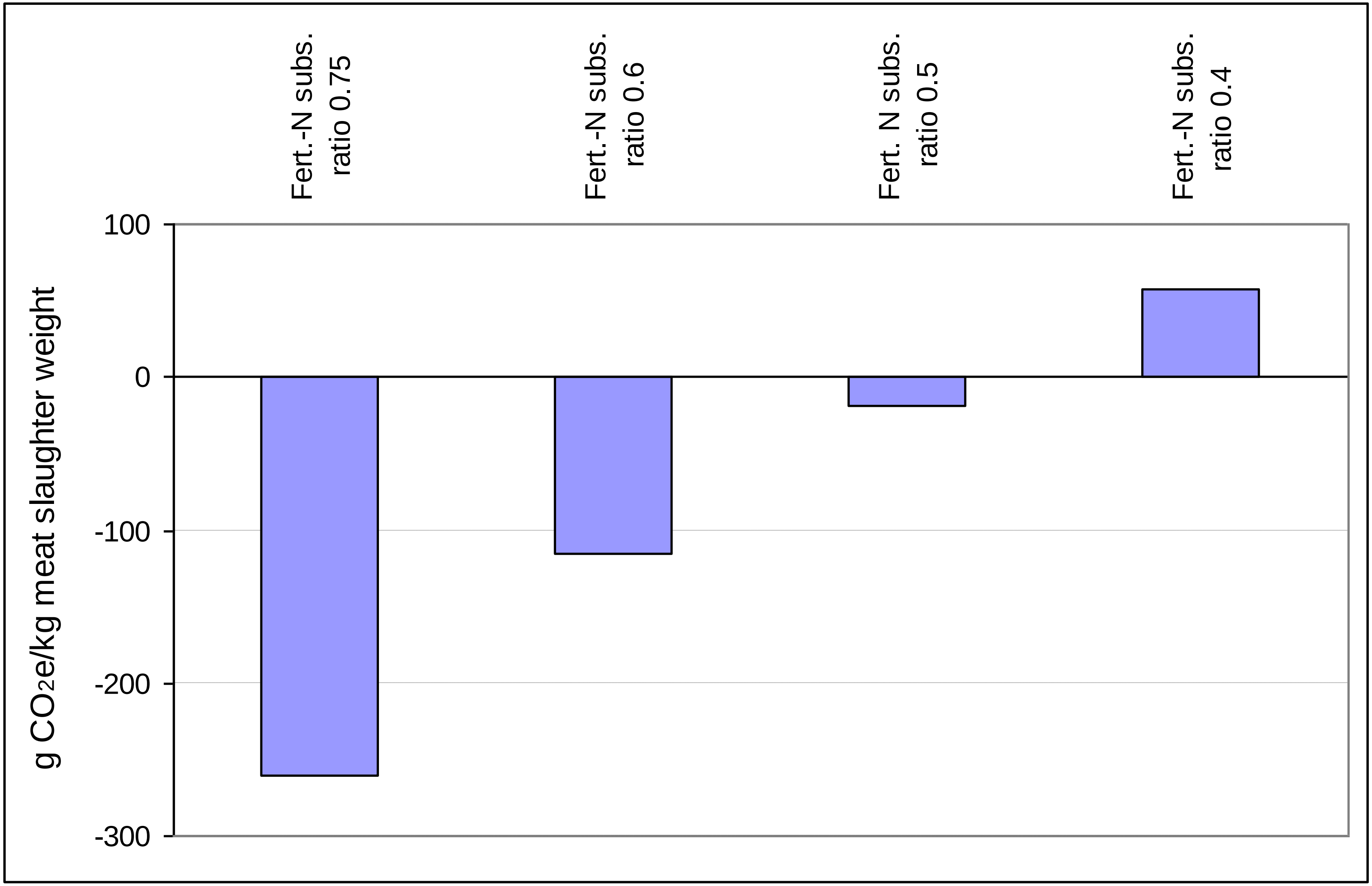
1): Organic systems from Halberg et al., 2007; conventional from Dalgaard et al., 2007.
2): Calculated according to EDIP method (Wenzel et al., 1997; updated 2003)
3): Soil C sequestration: Soil C and N net changes resulting from mineralisation vs. input of organic matter and crop residues modelled with C-tool, Petersen, B. M.; 2007.
4): Statistical tests using Monte Carlo simulations in Simapro.



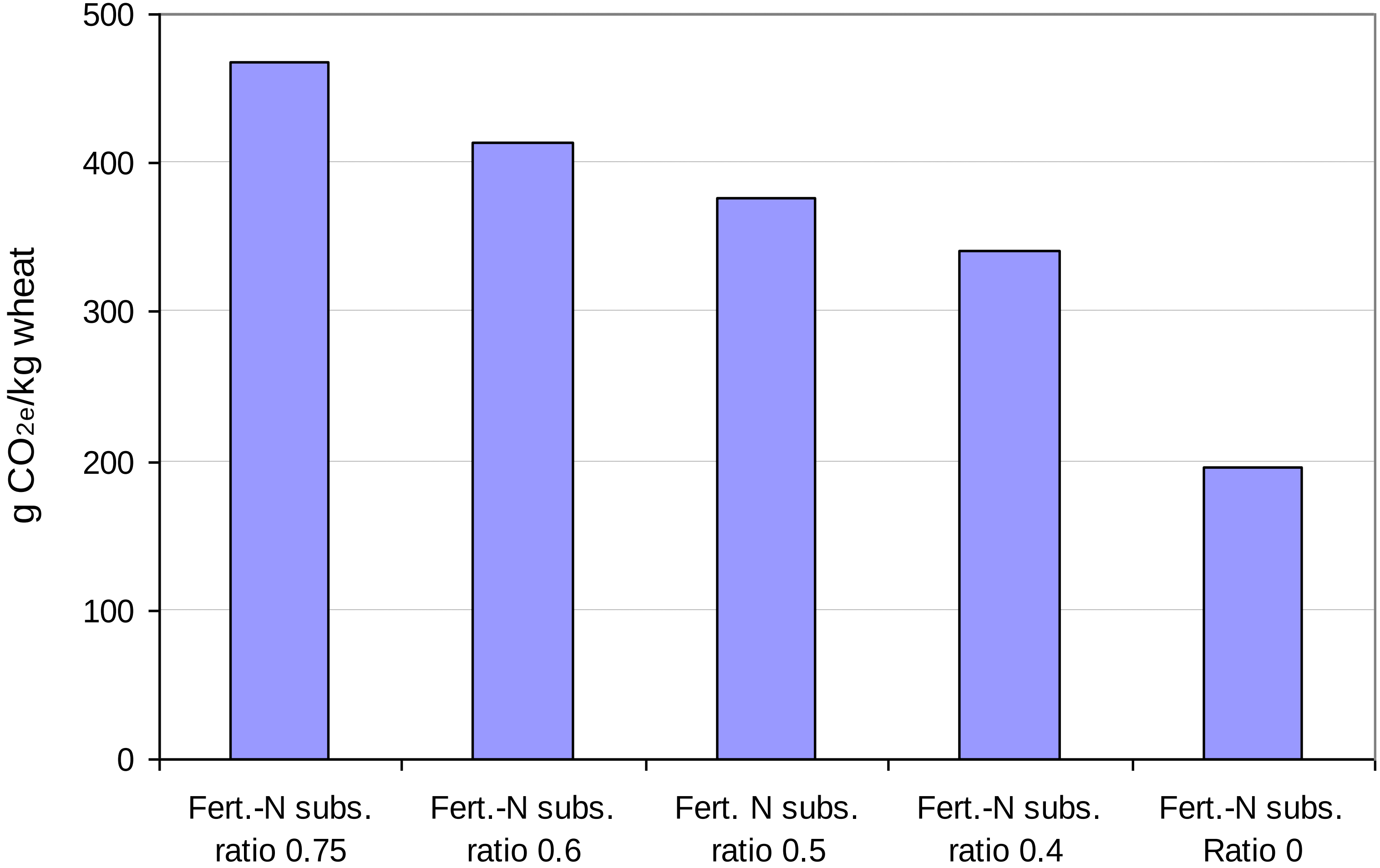
A pig unit has two outputs



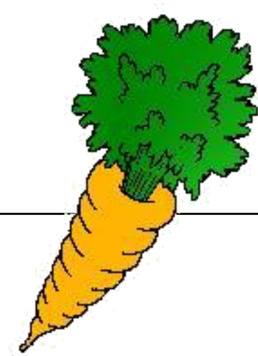
Effect of manure utilization for crop fertilization: Net GHG emissions contribution to the resulting GWP per kg pig meat slaughter weight



GWP of organic wheat as dependent on how the importeret ressource 'manure' has been accounted for, g CO2e/kg



Organic and Conventional Carrot production



	Conventional		Organic	
	Straw	Cooling	Low M.	High M
Fertilizer N, kg/ha	83	83		
Fertilizer P, kg/ha	48	48		
Manure N, kg/ha			135	270
Straw, ton/ha	72	-	72	72
Electricity, kWh/ha	518	1864	518	518
Diesel, GJ/ha	15.0	15.0	15.8	18.8
Yield carrots, ton/ha	61.6	61.6	40.0	52.8
Emissions per kg carrot				
GHG potential, g CO_2 eq.	122	150	193	155
Acidification, g SO_2 eq.	1.00	73	1.06	1.08
Eutrophication, g NO_3 eq.	3.6	3.4	4.0	7.9

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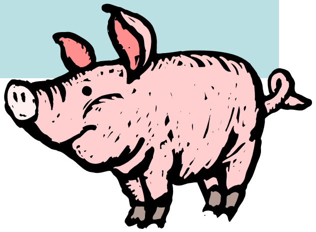

The question of land use and land use change illustrated by organic vs conventional pork

	Organic	Conventional
GWP kg CO_2e/kg LW	**2.6**	**2.7**
Land use m^2a/kg LW	**11.4**	**6.2**
Direct	4.5	0
Indirect ”cereal”	6.8	4.3
Indirect ”soy”	0.1	1.9

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Well accepted relation between land use **change** and GHG to be accounted for:

PAS 2050 recommend the following numbers for assessment in different countries, Kg CO2 e per m2/y

	Grassland to cropland	Forest to cropland
France/Ger/Poland	0.6	2.0
Brazil	1.0	3.7

Nguyen et al (2010) used a worldwide average of 2.2 to 2.8

Reference: **Nguyen TLT**, Hermansen, J., Mogensen, L. Environmental consequences of different beef production systems in the EU. Journal of Cleaner Production 2010; 18 (8) 756–766.
Assumptions: Basic data Searchinger et al. (2008). When forest is converted to cropland, all carbon in vegetation and ongoing carbon sequestration that would take place each year if forest is not cleared, plus **25%** of soil carbon are lost.

The question of land use and land use change (LUC) illustrated by organic vs conventional pork

Effect of LUC	Organic	Conventional
GWP kg CO_2e/kg LW, basis	2.6	2.7
With LUC PAS 2050		
LUC Soy (Brazil)	0.4	7.0
(adjusted total)	(3.0)	(9.7)
LUC cereal (Europe)	13.6	8.6
(adjusted total)	(16.6)	(18.3)
LU – opportunity cost	9	-
(adjusted total)	(25.6)	(18.3)
Nguyen et al. (2010)	35	20

Conclusion

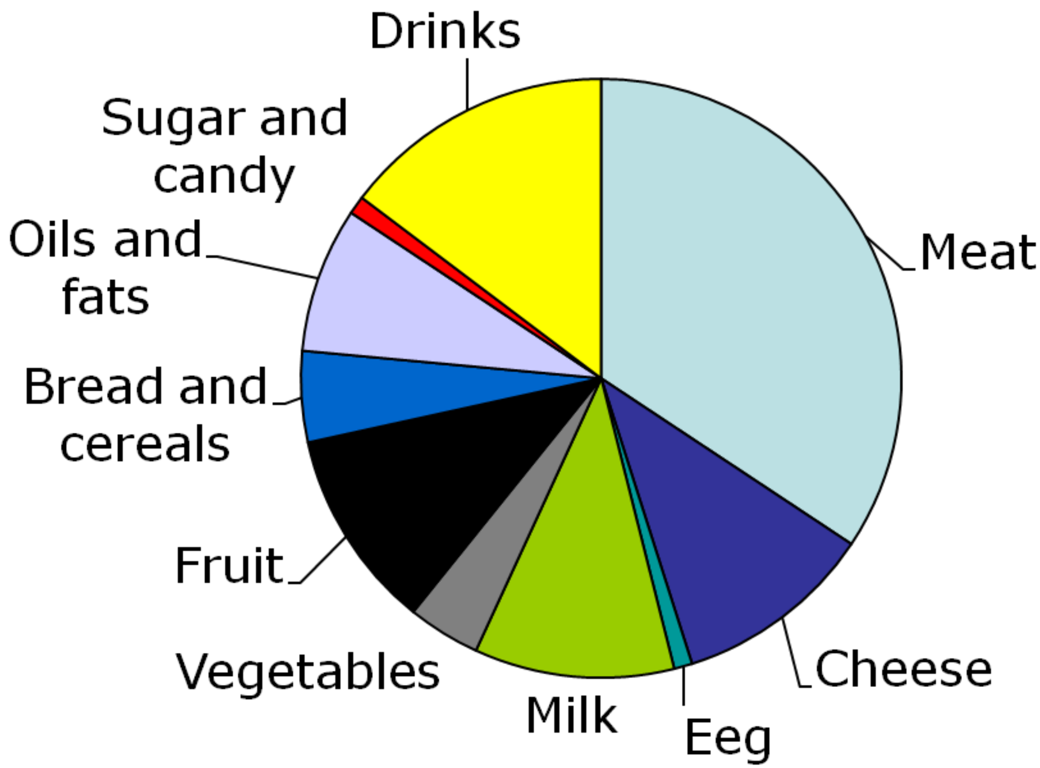
- A wide range of organically produced foods have been compared with foods produced conventionally, and often only small differences is seen in GWP per kg food produced
- The variation within organic production often overshadow differences to conventional production
- It is important to acknowledge and include carbon sequstration related to the (particular) land use pattern in organic farming. While models exist regarding individual fields, models taking into account any effect of soil erosion through a different spatial arrangement of the fields are lacking.
- The GWP of organic food depends very much on how imported manure is considered – it is rarely justified just to consider it as a waste
- The most urgent matter to consider is how the (most often) increased demand for land per unit of food produced in organic production is taken into account (and how it relates to other environmental/cultural impacts of interest) (maybe rephrased to: How to increase total biomass yield and account for it)

Globale warming potential is measured in CO_2-eq.

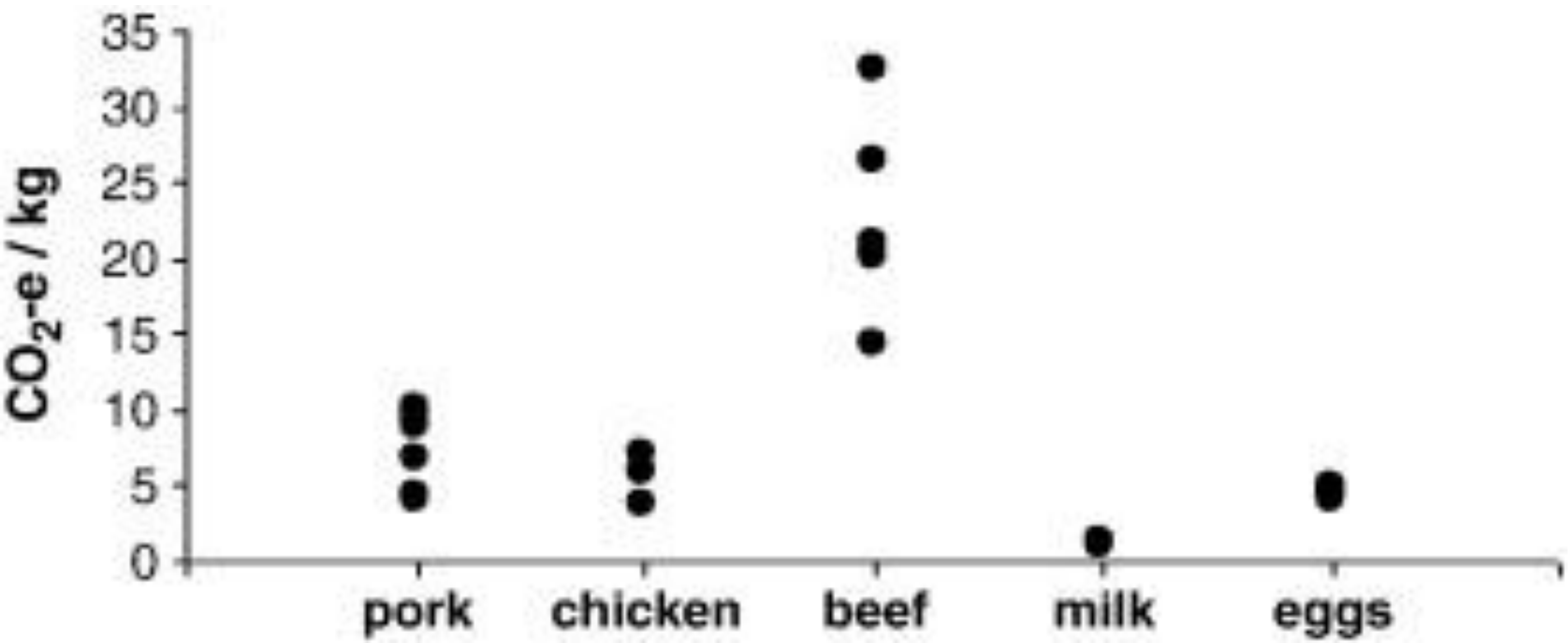
- 1 kg carbon dioxide (CO_2) = 1 kg CO_2-eq.
  - From energy consumption
  - Storage of carbon in soil
- 1 kg Metane (CH_4) = 23 kg CO_2-eq.
  - Ruminants digestion
  - Manure stores
- 1 kg Laughing gas (N_2O) = 296 kg CO_2-eq.
  - From the nitrogen cycle – from soil and manure stores

(100-year, IPCC)

Carbon food print of a typical Danish diet, % of different sources of CO_2-ækv.



Global warming potential of livestock products, in CO_2-e expressed per kg of product (after de Vries & de Boer, 2010)



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