STØTTET AF
mælkeafgiftsfonden

INKLUDERING AF JORDENS KULSTOFÆNDRINGER I LIVSCYKLUSVURDERINGER (LCA)

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Hvordan kan jordens kulstofændringer inkluderes i LCA?

Nogle landbrugssystemer bidrager mere til kulstoflagring i jorden end andre…

Anvendte metoder til modellering af jordens kulstofændringer LCA

- IPCC guidelines til estimering af jordens kulstofændringer
  - Fordele: Simpel
  - Ulemper: Ikke præcise, kun fire kategorier for kulstof input

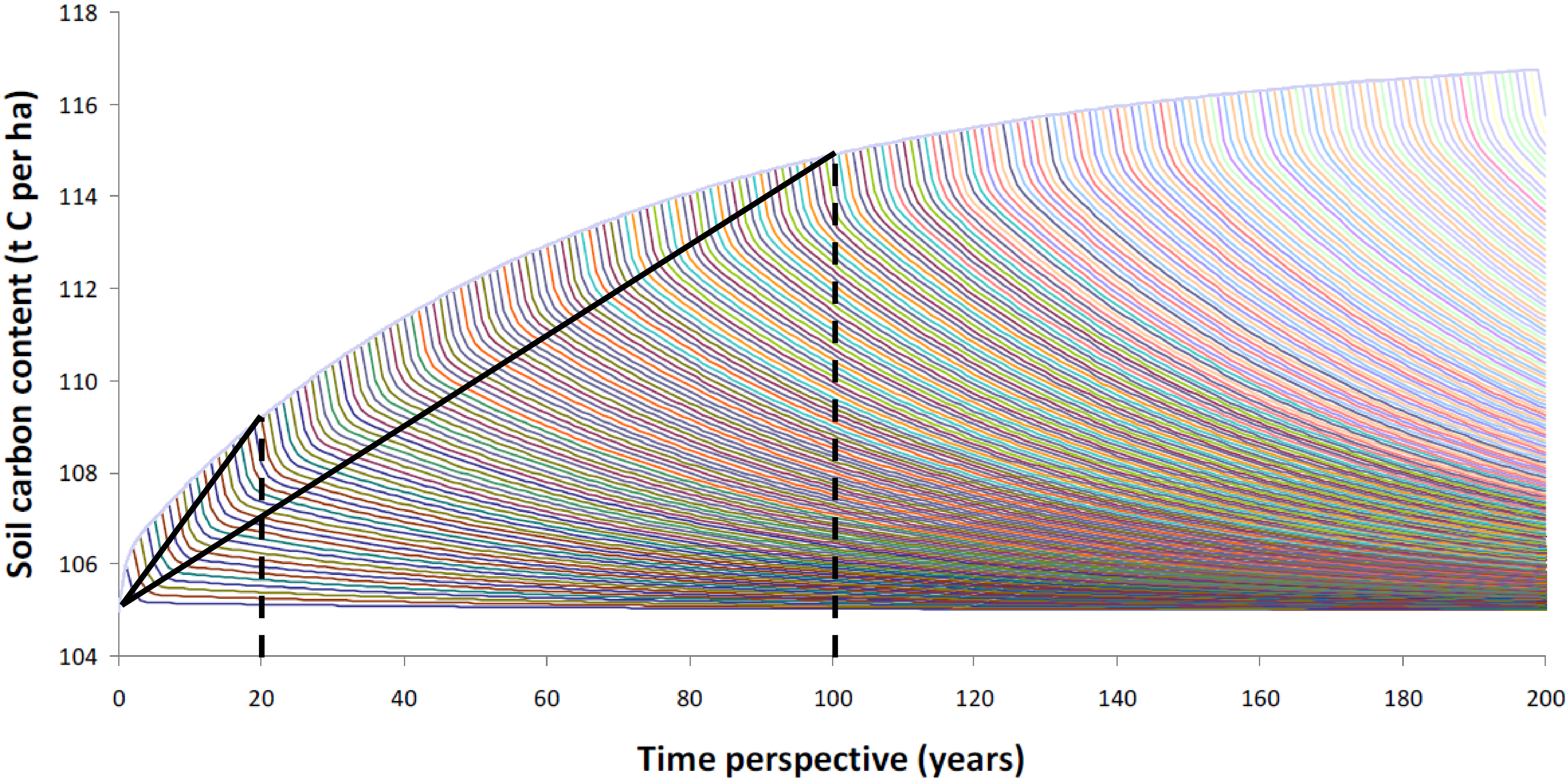
- Anvende jord-kulstof modeler som Roth C, ICBM eller C-TOOL direkte
  - Fordele: Mere præcise end IPCC
  - Ulemper: Inkluderer ikke til tidsdynamikken af emissionerne og klimaeffekten. Fokuserer ikke på effekten af én afgrøde/aktiviteten i ét år i et vist tidsperspektiv, hvilket der er brug for til LCA

Udfordringer ved modellering af jord C i LCA

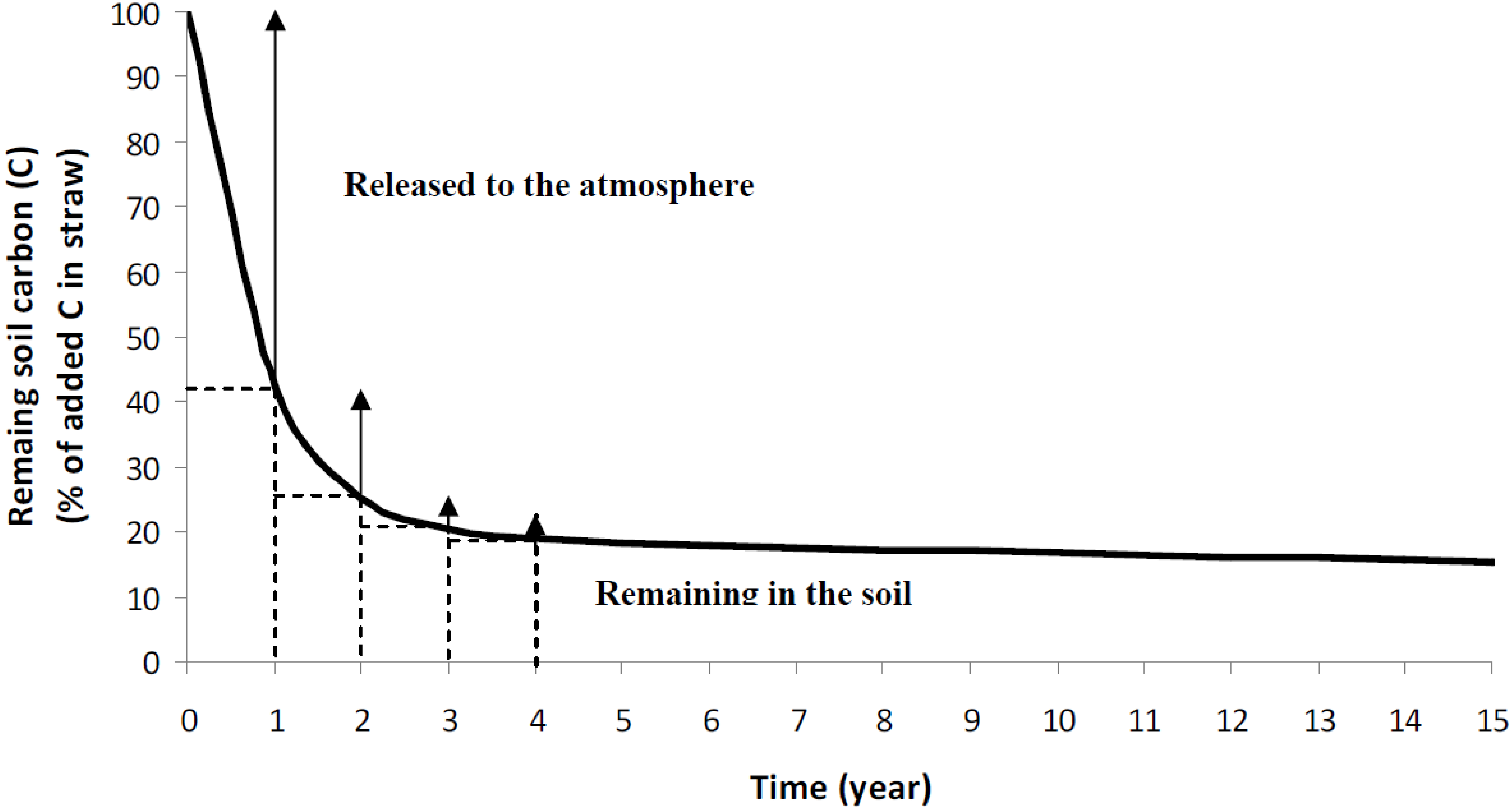
- En typisk LCA af fødevarer estimerer emissionerne fra ét år
- MEN, tilført kulstof til jorden bliver frigivet over en længere periode, hvilket skal tages hensyn til i metoden
- Vigtigt at inkludere kulstofdynamikken i jorden
- Forskellige bredt accepterede jord-kulstof modeller, såsom RothC, ICBM eller C-TOOL, kan anvendes
- Udgangspunkt i C-TOOL

Opbygning af jord kulstof mod en ny ligevægt

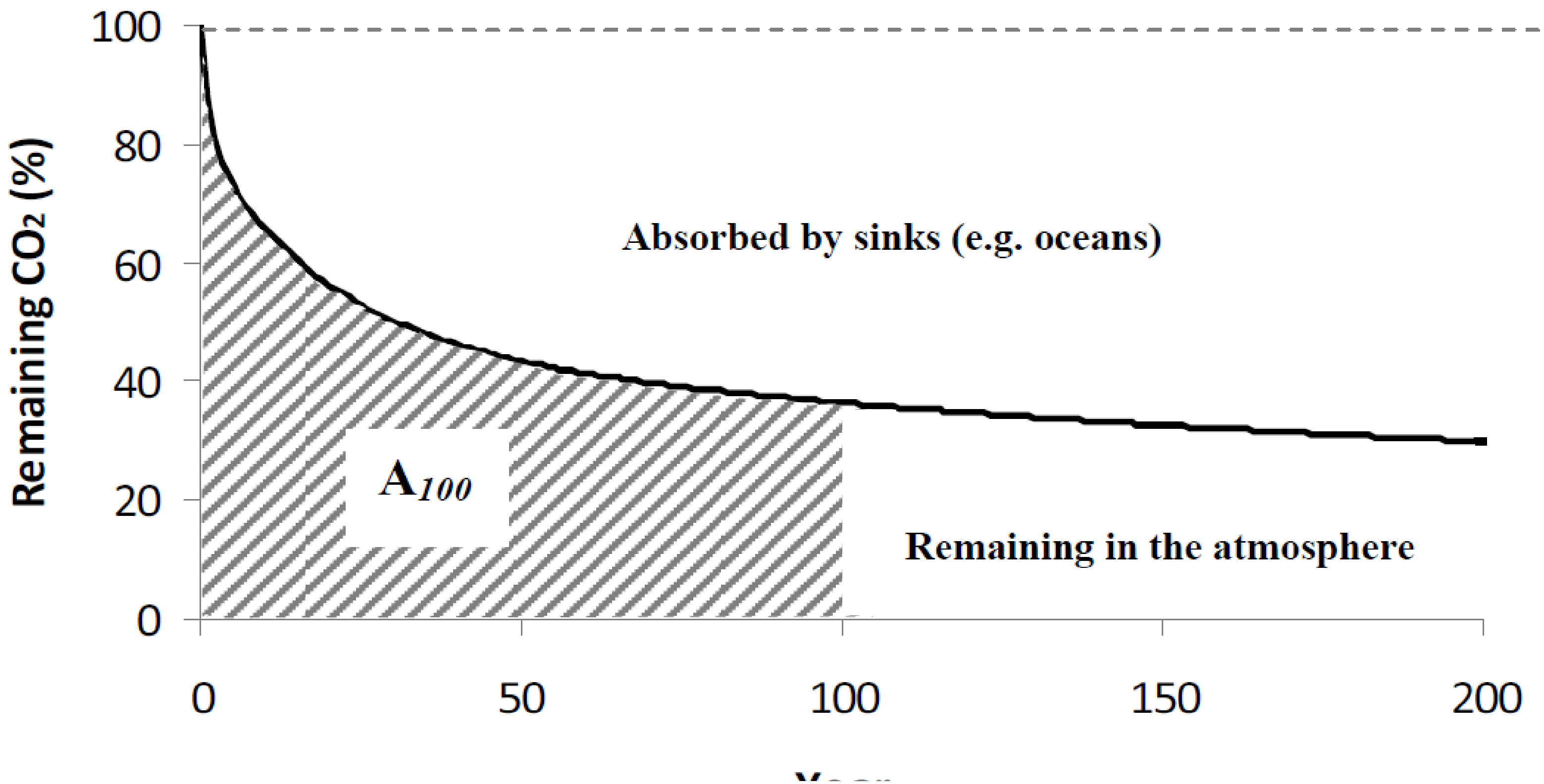
– baseret på nedbrydningskurver fra tilførsler af C



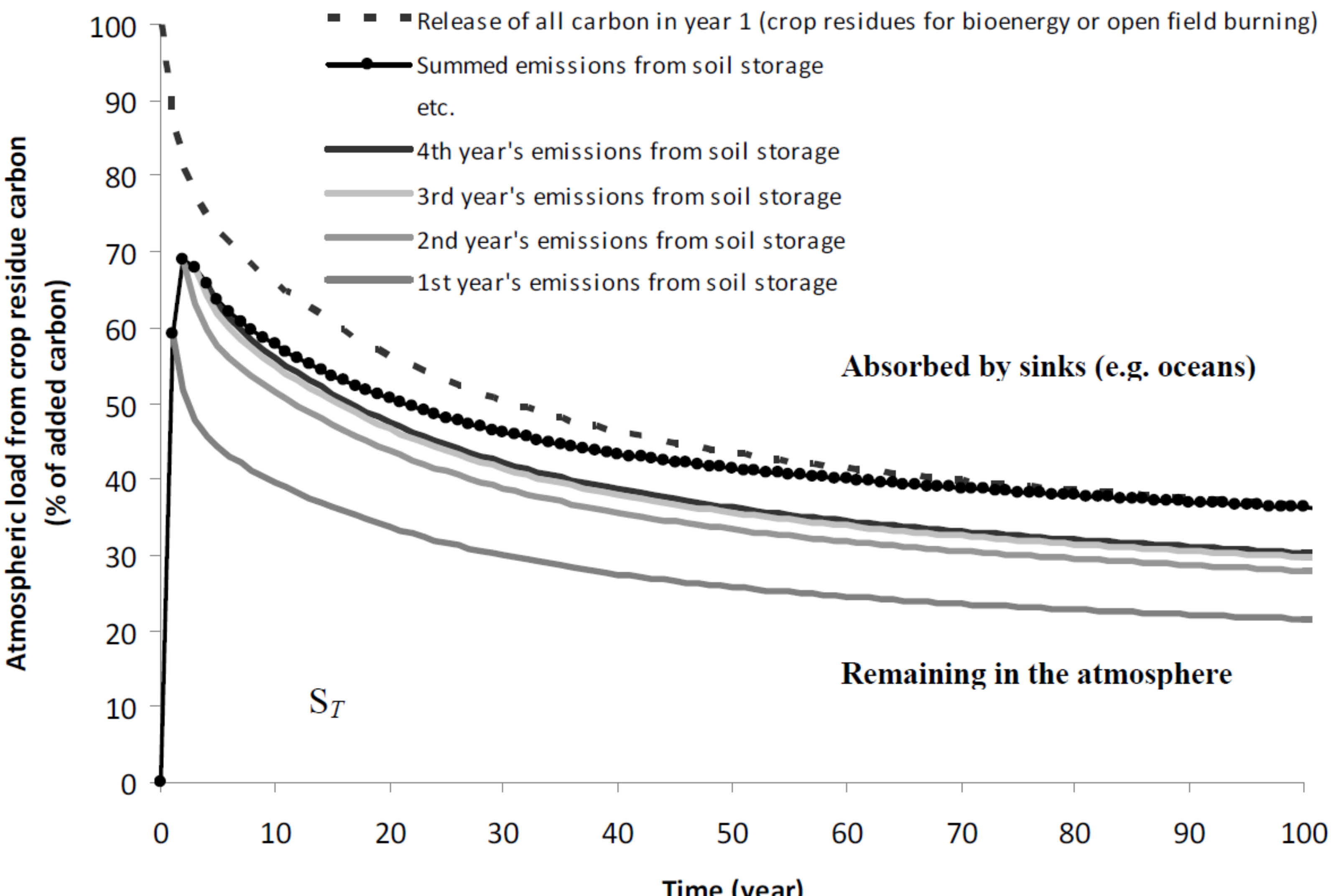
Nedbrydning af biomasse kulstof tilført til jorden



Bern Carbon Cycle Model



Klimaeffekt fra biomasse kulstof – tilført til jorden vs. brændt



Ideen i metoden

Baseret på et års tilførsel af kulstof til jorden (fra afgrøderester mv.)

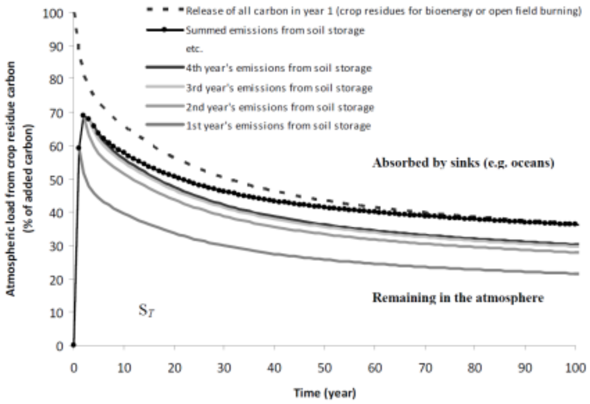
- **Jord-kulstof dynamikken af dette kulstofinput er modelleret via enten C-TOOL, RothC eller en anden jord-kulstof model**

- **i kombination med Bern Carbon Cycle modellen for at tage hensyn til de tidsafhængige emissioner**

Estimering af en 'sequestration factor'

1. Emissionerne fra jordens nedbrydning af tilført C – kombineret med Bern Carbon Cycle Model – for at estimere arealet under den summerede kurve, S_T.

2. Beregne emissions reduktionen eller sequestration factor: $$R_T = \frac{A_T - S_T}{A_T}$$



DK	Tidsperspektiv (år)		
	20	100	200
R_T (%)	21	10	5

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An approach to include soil carbon changes in life cycle assessments

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ABSTRACT

Globally, soil carbon sequestration is expected to hold a major potential to mitigate agricultural greenhouse gas emissions. However, the majority of life cycle assessments (LCA) of agricultural products have not included possible changes in soil carbon sequestration. In the present study, a method to estimate carbon sequestration to be included in LCA is suggested and applied to two examples where the inclusion of carbon sequestration is especially relevant: 1) Bioenergy: removal of straw from a Danish soil for energy purposes and 2) Organic versus conventional farming: comparative study of soybean production in China. The suggested approach considers the time of the soil CO_2 emissions for the LCA by including the Bern Carbon Cycle Model. Time perspectives of 20, 100 and 200 years are used and a soil depth of 0–100 cm is considered. The application of the suggested method showed that the results were comparable to the IPCC 2006 tier 1 approach in a time perspective of 20 year, where after the suggested methodology showed a continued soil carbon change toward a new steady state. The suggested method estimated a carbon sequestration for the first example when storing straw in the soil instead of using it for bioenergy of 54, 97 and 213 kg C t^{-1} straw C in a 200, 100 and 20 years perspective, respectively. For the conversion from conventional to organic soybean production, a difference of 32, 60 or 143 kg soil C ha^{-1} yr^{-1} in a 200, 100 or 20 years perspective, respectively was found. The study indicated that soil carbon changes included in an LCA can constitute a major contribution to the total greenhouse gas emissions per crop unit for plant products. The suggested approach takes into account the temporal aspects of soil carbon changes by combining the degradation and emissions of CO_2 from the soil and the following decline in the atmosphere. Furthermore, the results from the present study highlights that the choice of the time perspective has a huge impact on the results used for the LCA. For comparability with the calculation of the global warming potential in LCA, it is suggested to use a time perspective of 100 years when using the suggested approach for soil carbon changes in LCA.

1. Introduction

Climate change is increasingly regarded as a major problem and mitigation options are discussed (e.g. IPCC, 2007). Carbon sequestration, which is removal or temporary storage of carbon from the atmosphere for example in vegetation or soil, is seen as a way of mitigating climate change by temporarily avoiding some radiative forcing (Brandão et al., 2013). Soil carbon sequestration is the temporary storage (or release) of carbon in the soil and is in agricultural soils expected to hold a ...

global warming mitigation potential to reduce agricultural emissions and increase C sequestration. Thus, Smith et al. (2007) estimated soil C sequestration to contribute about 89% to the global mitigation potential from agriculture. However, the importance of soil C sequestration is poorly reflected in current LCA's (Koerber et al., 2009), since the majority of studies have not included soil C sequestration in the overall greenhouse gas estimations mainly due to methodological limitations ...

Kulstoflagring ved udvalgte foderafgrøder

x 0.10 - 397 x 44/12




Foderafgrøde	C input til jorden ($kg\ C\ ha^{-1}\ year^{-1}$)
Byg, 100% halm fjernet	177
Barley, 0% halm fjernet	265
Hvede, 100% halm fjernet	345
Hvede, 0% halm fjernet	468
Kløvergræs, ensilage	595
Kløvergræs, afgræsset	674
Majsensilagee	137

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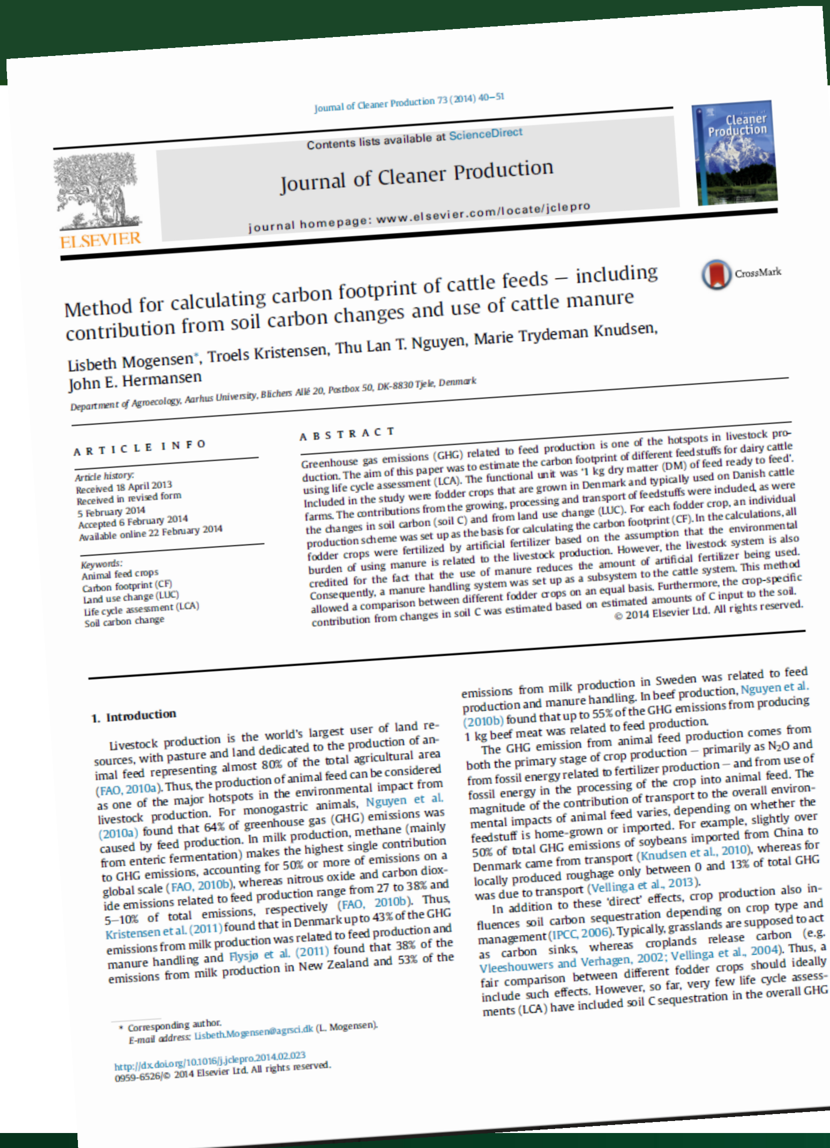

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Method for calculating carbon footprint of cattle feeds – including contribution from soil carbon changes and use of cattle manure

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ABSTRACT

Greenhouse gas emissions (GHG) related to feed production is one of the hotspots in livestock pro- duction. The aim of this paper was to estimate the carbon footprint of different feedstuffs for dairy cattle using life cycle assessment (LCA). The functional unit was '1 kg dry matter (DM) of feed ready to feed'. Included in the study were fodder crops that are grown in Denmark and typically used on Danish cattle farms. The contributions from the growing, processing and transport of feedstuffs were included, as were the changes in soil carbon (soil C) and from land use change (LUC). For each fodder crop, an individual production scheme was set up as the basis for calculating the carbon footprint (CF). In the calculations, all fodder crops were fertilized by artificial fertilizer based on the assumption that the environmental burden of using manure is related to the livestock production. However, the livestock system is also credited for the fact that the use of manure reduces the amount of artificial fertilizer being used. Consequently, a manure handling system was set up as a subsystem to the cattle system. This method allowed a comparison between different fodder crops on an equal basis. Furthermore, the crop-specific contribution from changes in soil C was estimated based on estimated amounts of C input to the soil.

1. Introduction

Livestock production is the world's largest user of land re- sources, with pasture and land dedicated to the production of an- imal feed representing almost 80% of the total agricultural area (FAO, 2010a). Thus, the production of animal feed can be considered as one of the major hotspots in the environmental impact from livestock production. For monogastric animals, Nguyen et al. (2010a) found that 64% of greenhouse gas (GHG) emissions was caused by feed production. In milk production, methane (mainly from enteric fermentation) makes the highest single contribution to GHG emissions, accounting for 50% or more of emissions on a global scale (FAO, 2010b), whereas nitrous oxide and carbon diox- ide emissions related to feed production range from 27 to 38% and 5–10% of total emissions, respectively (FAO, 2010b). Thus, Kristensen et al. (2011) found that in Denmark up to 43% of the GHG emissions from milk production was related to feed production and manure handling and Flysjø et al. (2011) found that 38% of the emissions from milk production in New Zealand and 53% of the emissions from milk production in Sweden was related to feed production and manure handling. In beef production, Nguyen et al. (2010b) found that up to 55% of the GHG emissions from producing 1 kg beef meat was related to feed production.

The GHG emission from animal feed production comes from both the primary stage of crop production – primarily as N_2O and from fossil energy related to fertilizer production – and from use of fossil energy in the processing of the crop into animal feed. The magnitude of the contribution of transport to the overall environ- mental impacts of animal feed varies, depending on whether the feedstuff is home-grown or imported. For example, slightly over 50% of total GHG emissions of soybeans imported from China to Denmark came from transport (Knudsen et al., 2010), whereas for locally produced roughage only between 0 and 13% of total GHG was due to transport (Vellinga et al., 2013).

In addition to these 'direct' effects, crop production also in- fluences soil carbon sequestration depending on crop type and management (IPCC, 2006). Typically, grasslands are supposed to act as carbon sinks, whereas croplands release carbon (e.g. Vleeshouwers and Verhagen, 2002; Vellinga et al., 2004). Thus, a fair comparison between different fodder crops should ideally include such effects. However, so far, very few life cycle assess- ments (LCA) have included soil C sequestration in the overall GHG

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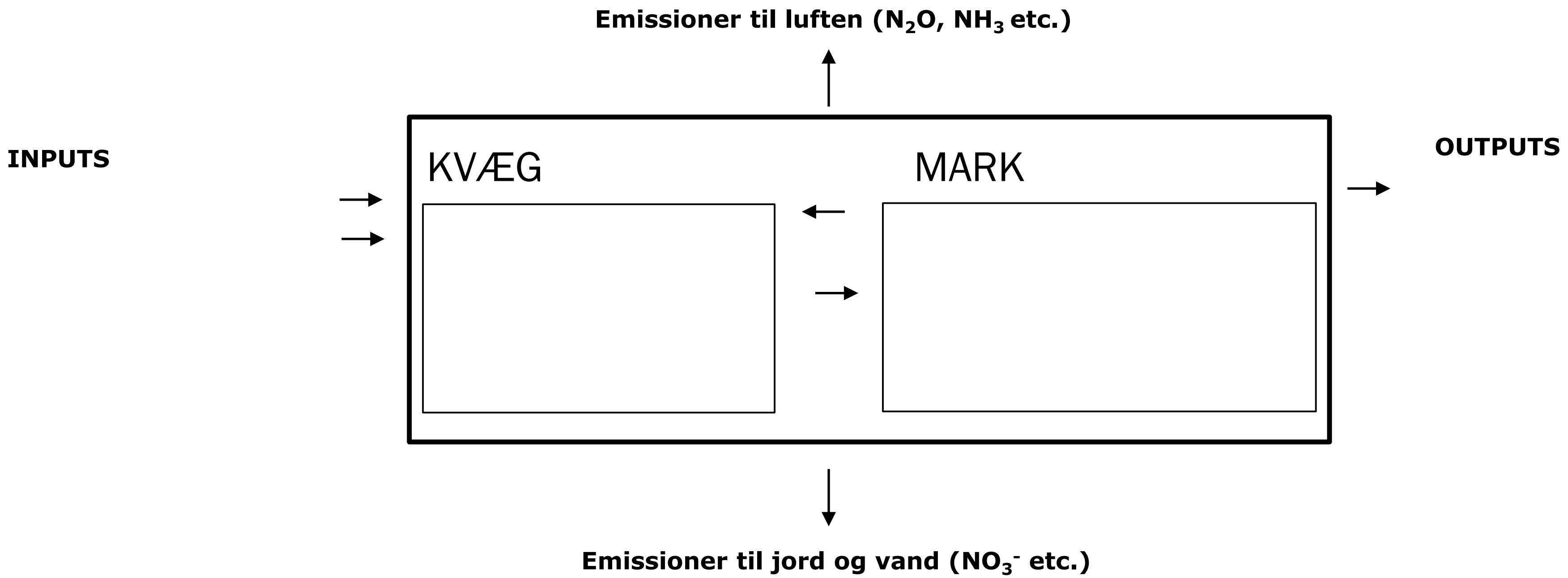
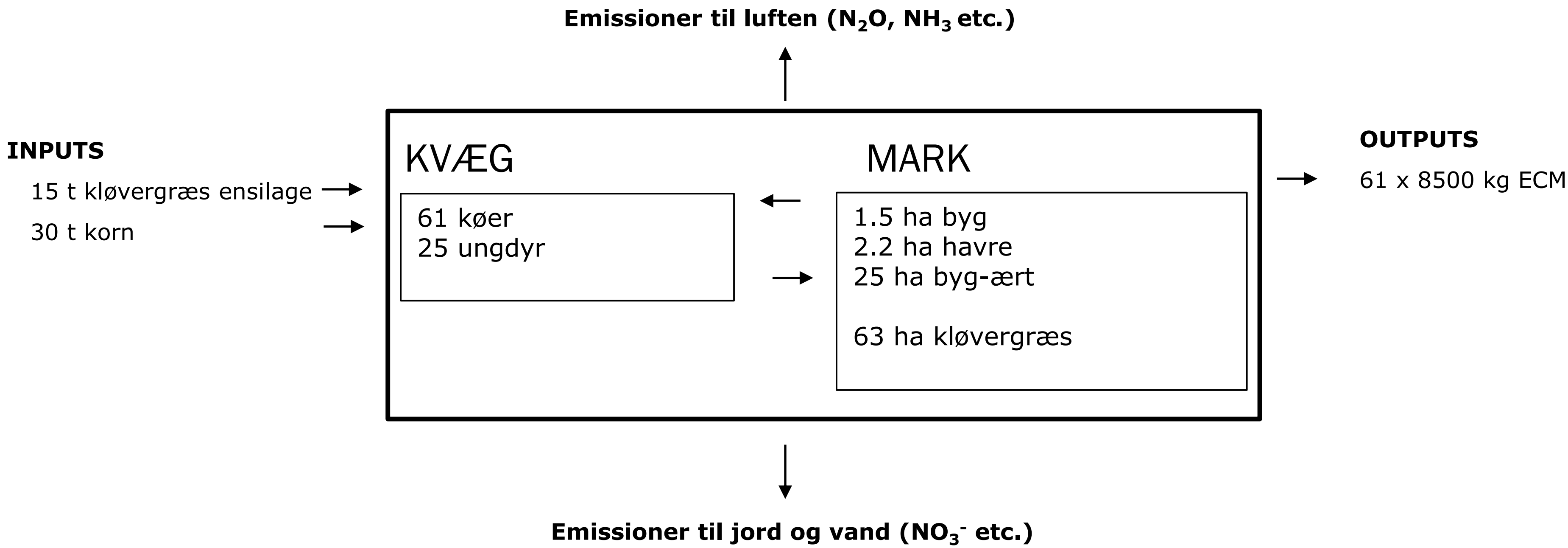
Praktisk eksempel: økologisk mælkeproduktion



Praktisk eksempel: økologisk mælkeproduktion



Simplificerede værdier for kulstoflagring

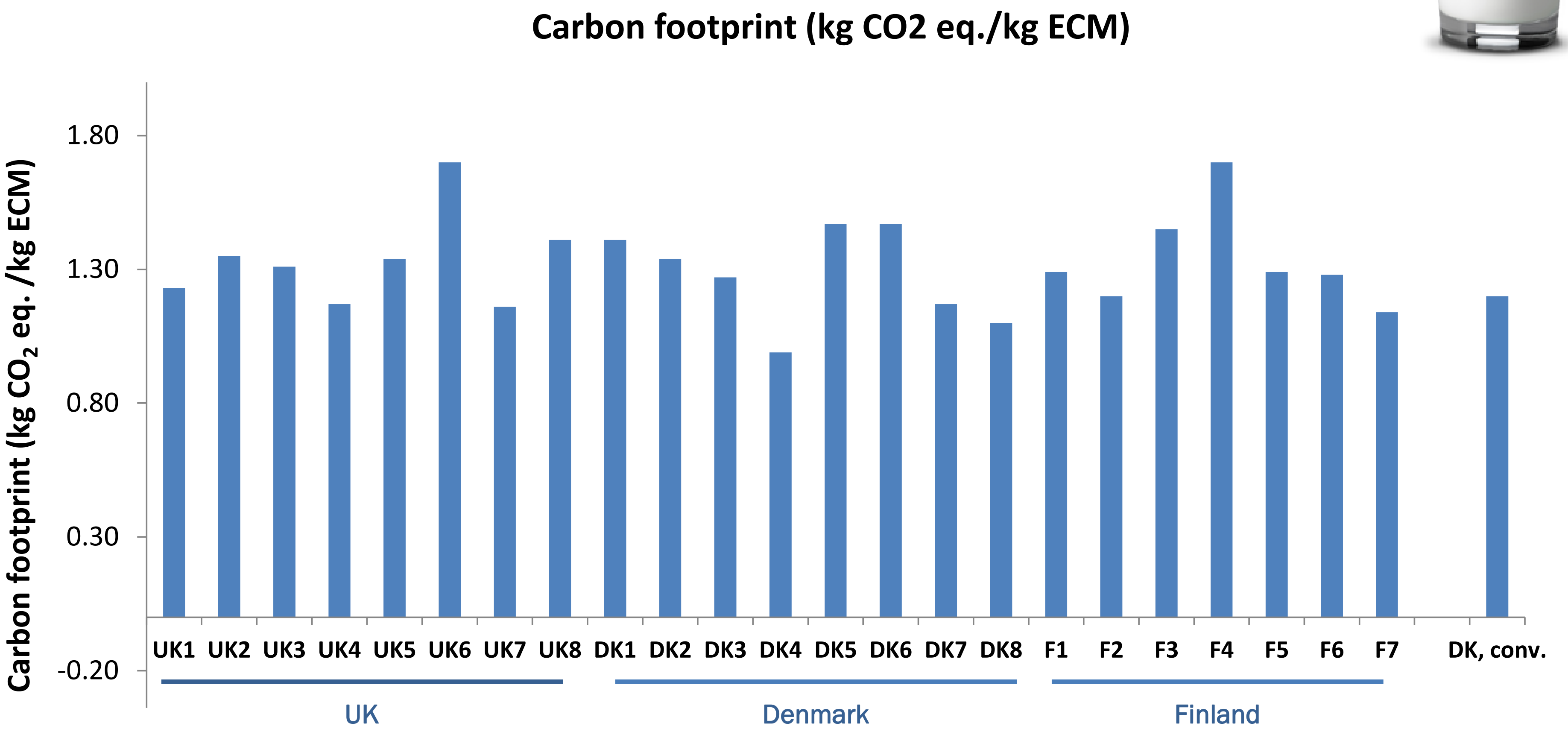


	Carbon sequestration (kg CO_2/(ha year)
Korn (halm nedmuldet)	100
Korn (halm fjernet)	-500
Kløvergræs	850

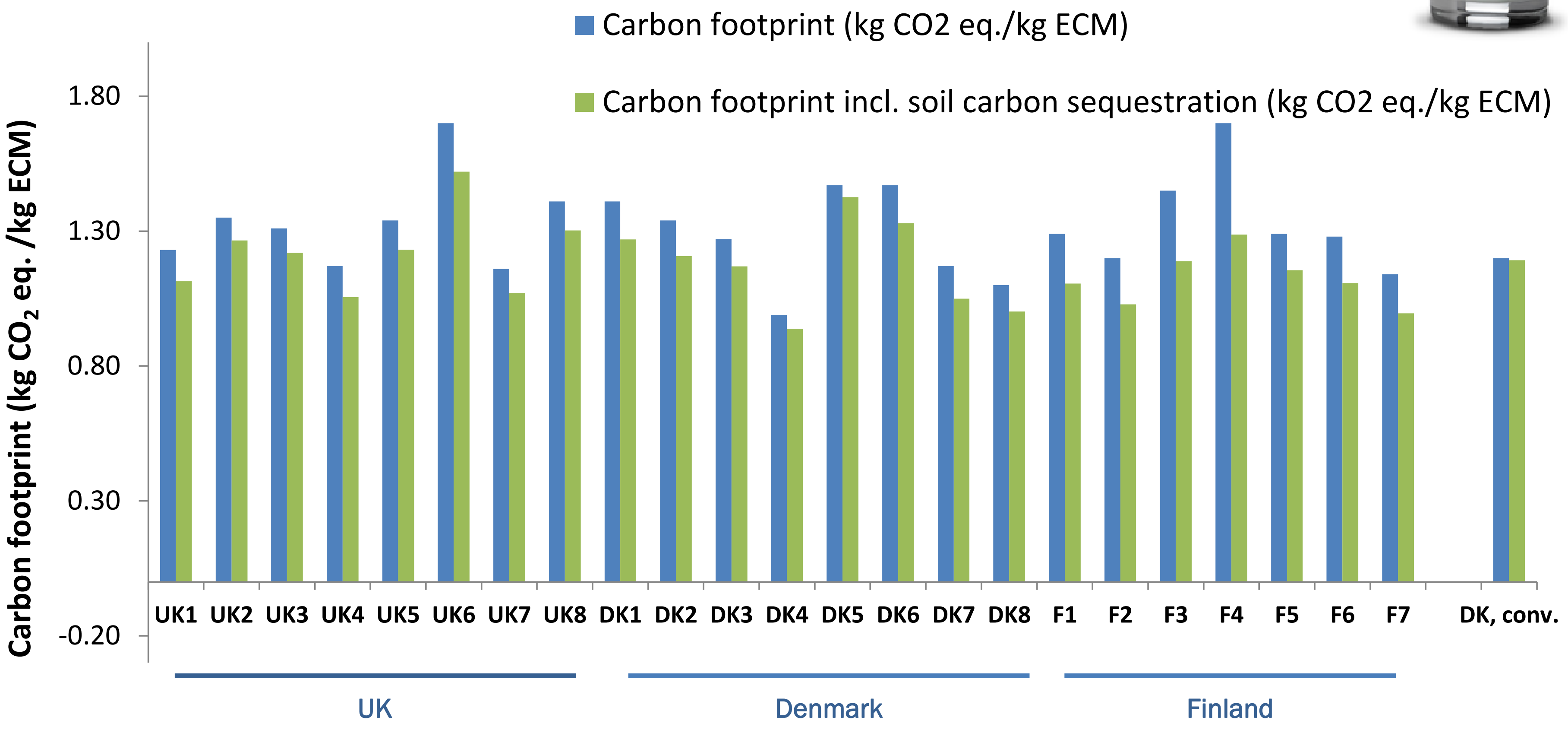
Praktisk eksempel: økologisk mælk
Beregning af kulstoflagring

Areal (ha)	kg CO_2/ha	Carbon sequestration (kg CO_2)
29 ha kornafgrøder	x 100 kg CO_2/ha	= 2900 kg CO_2
63 ha græsarealer	x 850 kg CO_2/ha	= 53550 kg CO_2
Importeret foder		
15 t kløvergræs ensilage (8.3 t/ha) = 2 ha	x 850 kg CO_2/ha	= 1700 kg CO_2
30 t korn (4.5 t/ha) = 7 ha	x 100 kg CO_2/ha	= 700 kg CO_2
TOTAL		= 58850 kg CO_2
		≈ 582 kg CO_2/ ha
		≈ 0.10 kg CO_2/kg ECM

Klimaaftryk af mælk fra 23 økologiske kvægbedrifter



Klimaaftryk af mælk fra 23 gårde
- inclusive jordkulstof-ændringer



Karakteristika ved metoden

- Baseret på aktuelle data på kulstofbidrag fra afgrøderester mv.

  (alle aktiviteter, der ændrer kulstofbidraget til jorden, er inkluderet)

- Kulstofbidraget til jorden er multipliceret med en ‘sequestration factor’

- Hvis den er brugt til afgrøder, er kulstofbidraget skaleret til kulstofbidraget fra en referenceafgrøde

- Tidsperspektivet er 100 years (men kunne være 20 years eller andet)

Tak for jeres opmærksomhed!