Using the product environmental footprint to strengthen the green market for sustainable feed ingredients; Lessons from a green biomass biorefinery in Denmark

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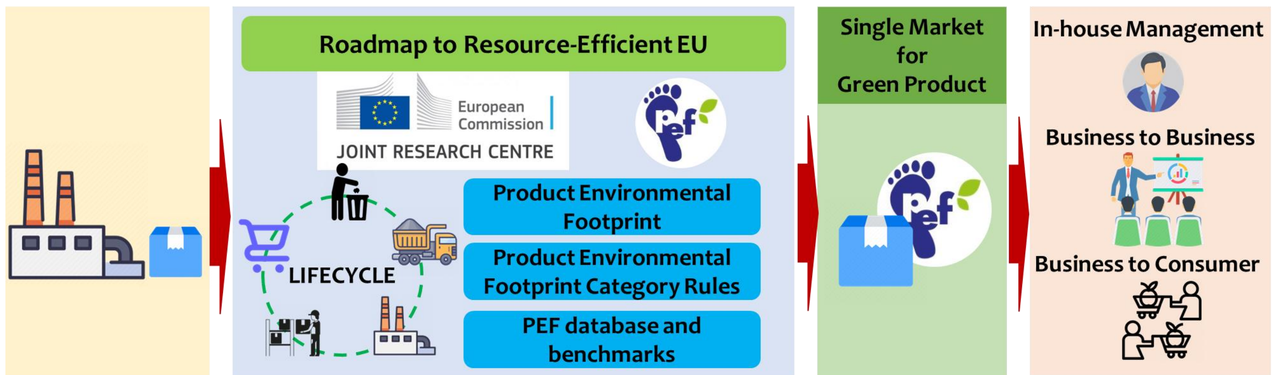
1. Product Environmental Footprint (PEF)



- Developed by the Joint Research Center of the European Commission.
- To transparently assess the environmental impacts of products and services throughout their life cycle.
- To decrease the environmental impacts, and strengthen the European markets for green products.
- To support in-house management, process improvement, business-to-business, and business-to-consumer purposes.

2. PEF within the context of "Græs-Prof"

- **Grass protein concentrate (GPC)**: A feed-grade protein with 90% dry weight and 47% crude protein, extracted from clover-grass, and can partly or fully replace soybean meal in compound feeds. It can be produced locally in Denmark and decrease the import of soybean and soybean meal from abroad and increase Denmark's self-sufficiency in feed protein.
- **Two main Objectives**:
  - To assess the environmental footprint of organic protein concentrate from clover grass.
  - To assess the environmental footprint of compound feed with grass protein concentrate.

Life cycle stage	Short description of the processes included
Organic clover grass cultivation	Organic clover grass, used for GPC, is cultivated in Ausumgaard farm and surrounding farms. The cultivation of organic grass requires the input of manure and biogas slurry as well as energy carriers, water, auxiliary materials and may involve land transformation. The full life cycle of the production of these products, including transport and depreciation of capital goods is in the scope of this PEF study.
Inbound transportation	The delivery of harvested grass to the biorefinery plant is part of the life cycle of GPC.
Production of GPC	GPC production is the core of this PEF study where the delivered grass is processed to the final product and leaves two important co-products namely press cake and brown juice.
Outbound transportation	The transportation of intermediate protein concentrate to the drying facility as well as transportation of co-products are included in the scope of this study.
Processing of coproducts	The processing of the coproducts does not belong to the scope of this PEF study.

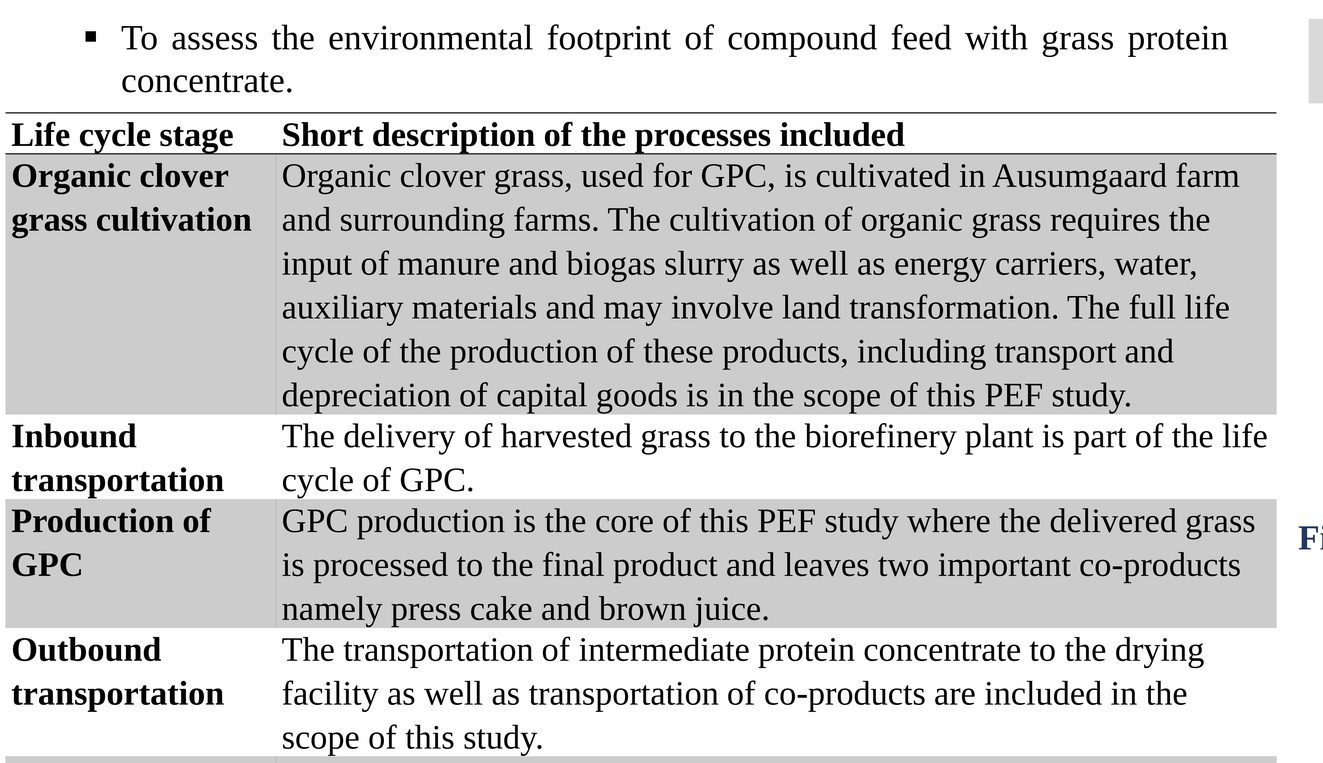


Fig. 1. System boundary for the assessment of organic protein concentrate from clover grass

3. PEF of Grass Protein Concentrate

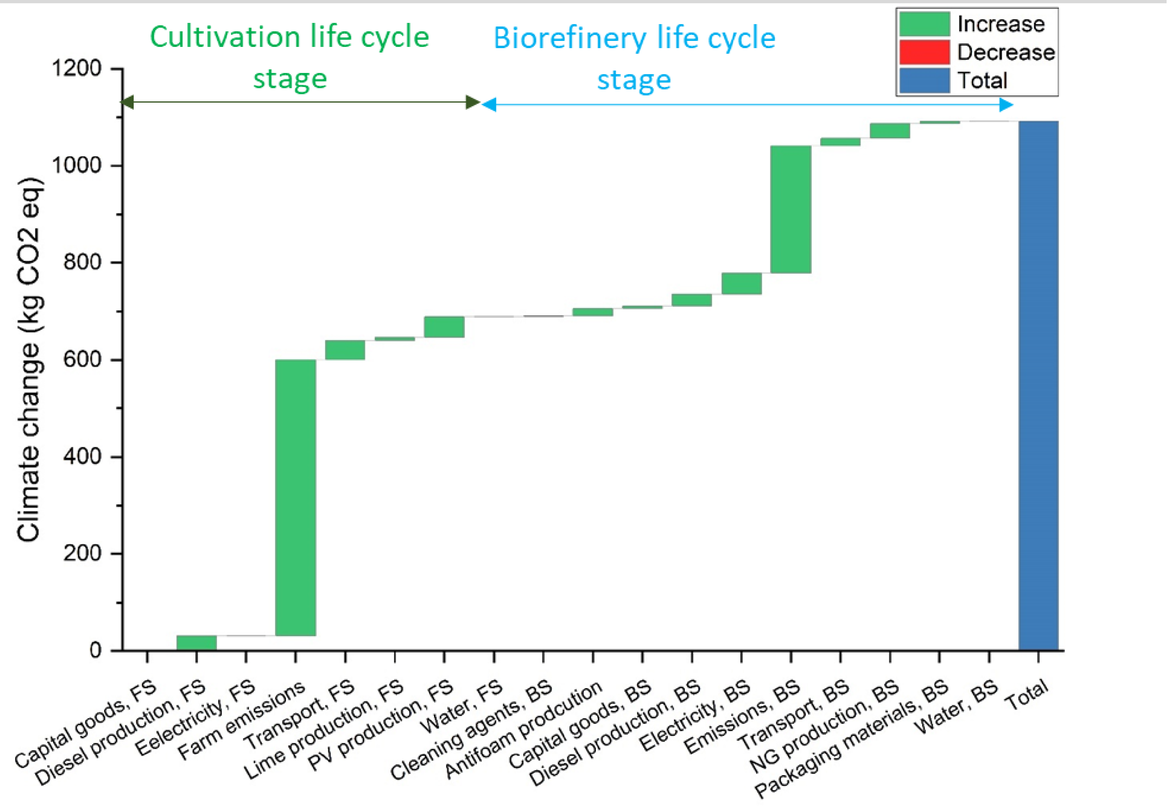


Fig. 2. Climate change impact of 1 tonne of GPC. FS refers to Farm Stage; BS refers to Biorefinery Stage

A Climate change impact of 1091.5 kg CO_2,eq/tonne GPC is achieved. Clover-grass cultivation contributed to 63% of climate change impact (689.1 kg CO_2,eq/tonne). Emissions from the application of manure and lime were the most dominant contributors to the climate change impact. Specifically, 33% of the overall impacts originate from greenhouse gases from manure and slurry applications. For the biorefinery process, emissions from fuel consumption and drying process were the most significant contributors to the PEF of GPC.

PEF of benchmarks on an equal crude protein content with GPC:

Average global soy: 4506 kg CO_2,eq **Average global soymeal**: 2796 kg CO_2,eq

Average EU+28 soy: 1546 kg CO_2,eq **Average EU+28 soymeal**: 3064 kg CO_2,eq

4. PEF compound Feed with GPC

Standard compound feed	Percentage (%)	Unit	Compound feed with GPC	Percentage (%)	Unit
Corn	34.10%		Corn	23.24%	
Wheat	20.00%		Wheat	22.00%	
Sunflowercakes	10.00%		Sunflowercakes	10.00%	
rapeseed cakes	5.90%		rapeseed cakes	5.90%	
Wheat bran	5.90%		Wheat bran	6.00%	
Fishmeal	5.40%		Fishmeal	5.00%	
Oats	5.00%		Oats	15.00%	
Soycakes	4.70%		Soycakes	2.00%	
Grass Protein Concentrate	Na		Grass Protein Concentrate	2.01%	
chalk	7.38%		chalk	7.30%	
Vitamins/minerals etc.	1.62%		Vitamins/minerals etc.	1.55%	
Electricity	0.088	kWh/kg compound feed	Electricity	0.088	kWh/kg compound feed
Heat	0.037	kWh/kg compound feed	Heat	0.037	kWh/kg compound feed

Fig. 3. Formulation of compound feed with and without GPC for PEF assessment

Compound Feed Formulation:

Two compound feed formulations for egg-laying hens are considered; Standard compound feed and compound feed with GPC. GPC contributes to 2% of the modified compound feed substituting part of the soybean meal in the standard feed.

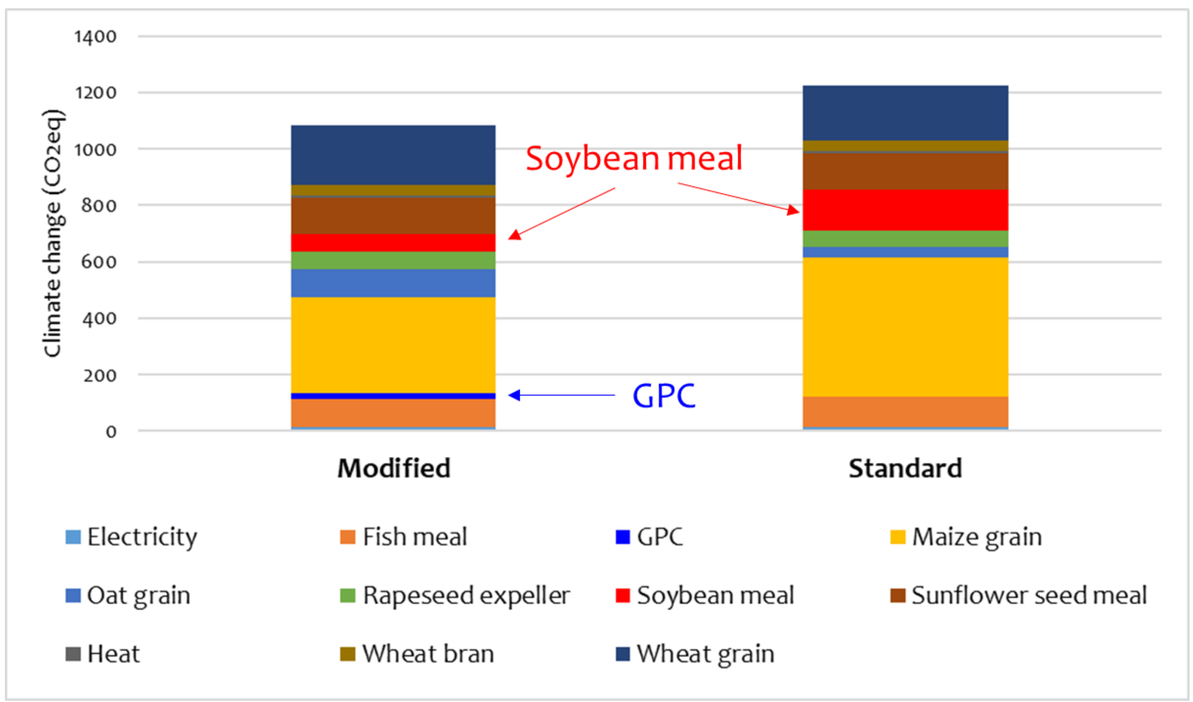


Fig. 4. Climate Change impact of standard and modified compound feed with GPC

Climate change impact of compound feed with GPC was 12.7% lower than standard feed. Other feed ingredients, including maize grain, wheat grain, and sunflower seed meal are the main contributors to the environmental footprint of compound feed with GPC.