The Importance of System Boundaries for LCA on Large Material Flows of Vegetable Oils
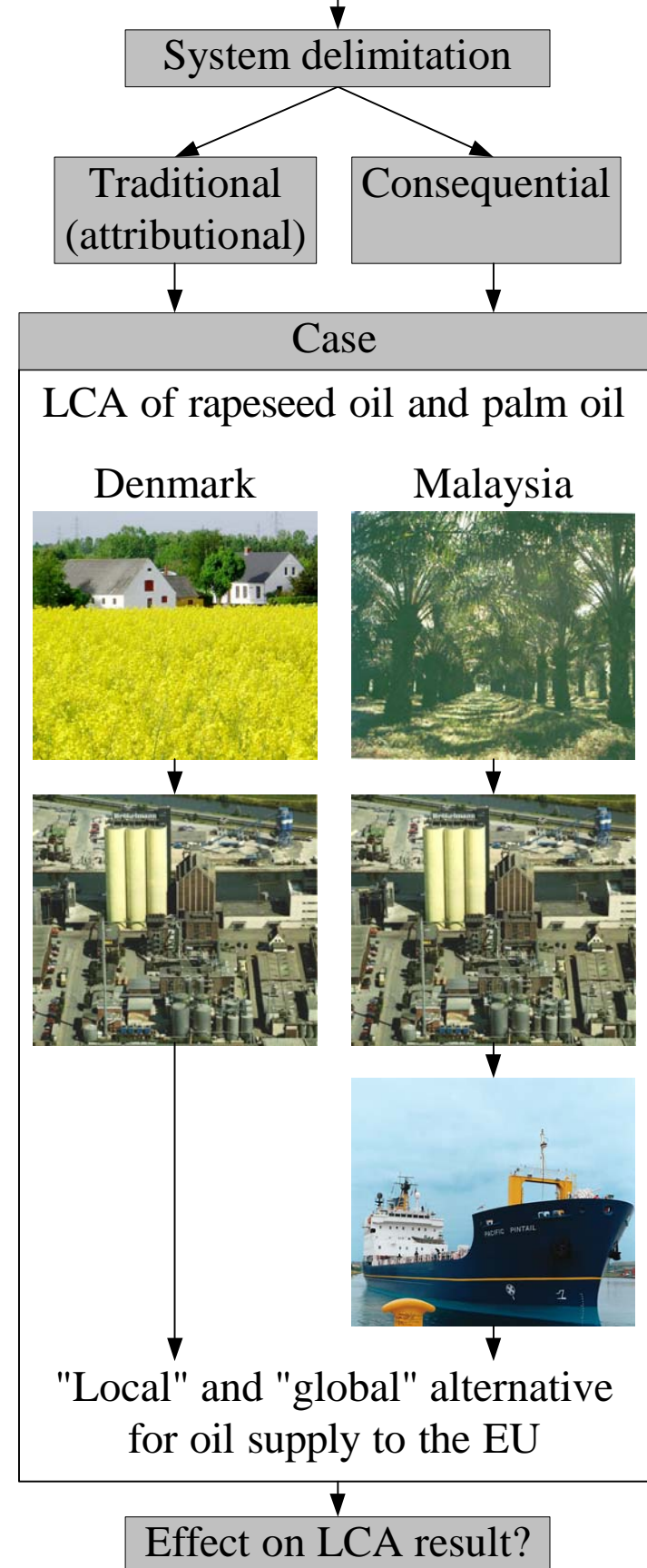
Abstract

In the European Environmental Agency's third assessment of Europe's Environment they conclude that the EU has stabilized its own resource use at the expense of increased resource use outside the EU. I argue, that there is a need for life cycle assessments of different patterns of global production and consumption. This poster discusses the system delimitation of such "global" LCAs on large material flows in the case of agriculture. The two main approaches to system delimitation are; traditional (attributional) LCA versus consequential LCA.

The study of system boundaries is based on a case study of a comparative LCA-screening of rapeseed oil and palm oil. These two commodities represent a global and a local system that can supply the EU with fat. Some essential elements of the product systems are tested for the attributional versus the consequential LCA.

It is concluded that the results of the LCA heavily depend on the approach to system delimitation. The result of the LCA varies with up to a factor 200 depending on the approach to system delimitation. Using the attributional approach, the investigated system only includes the product systems for rapeseed oil and palm oil. Using the consequential approach, the product systems for four oil crops are included. Hence, the attributional LCA may be seen as a too simplified picture of reality, when dealing with decision support to political and regulatory decisions. Thus, applying regulations based on life cycle assessments may lead to undesired effects if not the consequential approach to system delimitation is taken into consideration. Hidden within the goal and scope definition, the attributional approach simply cuts off too many potential important side effects when dealing with global traded large material flows of substitutable commodities. Thus, I see a need for more focus on the approach to system delimitation in the future.

Flowchart (center top):
What is the effect of system delimitation on the LCA result for large material flows of global traded vegetable oils?
→ System delimitation → Traditional (attributional) / Consequential → Case: LCA of rapeseed oil and palm oil → Denmark / Malaysia → "Local" and "global" alternative for oil supply to the EU → Effect on LCA result?

Introduction

Background
- European Environmental Agency indicates that an increasing share of the EU's environmental impact takes place outside the EU. Thus, I argue there is a need for LCAs on global production and consumption patterns
- The approach to system delimitation in LCA may determine the outcome. In recent years system delimitation in LCA has been discussed. Development from attributional (traditional) to consequential LCA. The two approaches are described in Weidema (2003)
- Agricultural commodities are to a large extent traded in the global market and are often substitutable and co-produced with other products. Furthermore these co-products are also often substitutable and traded in the global market
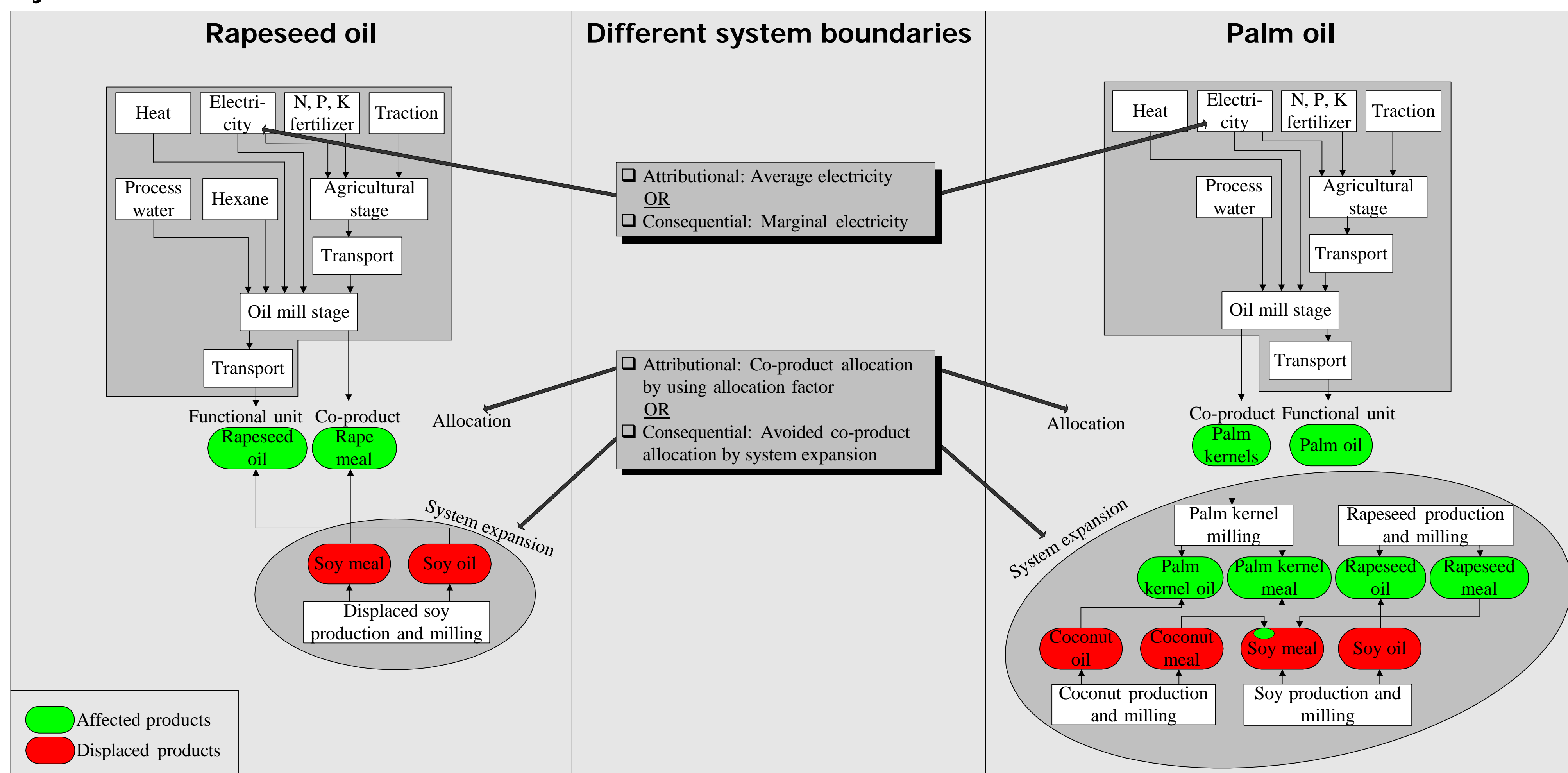
Aim
- What is the effect on the result related to the approach to system delimitation? Attributional and consequential approach
- What are the consequences for the setup of the investigated system - which processes and related product systems are considered as affected?
- What is the added value by adopting the consequential approach in stead of the more traditional approach?

Case
- Comparative LCA-screening of rapeseed oil and palm oil
- The LCA-screening is conducted using both an traditional (attributional) and a consequential system delimitation

System delimitation

Rapeseed oil — processes: Heat, Electricity, N, P, K fertilizer, Traction, Process water, Hexane, Agricultural stage, Transport, Oil mill stage, Transport → Functional unit: Rapeseed oil; Co-product: Rape meal; Allocation; System expansion → Soy meal, Soy oil → Displaced soy production and milling

Different system boundaries
- Attributional: Average electricity OR Consequential: Marginal electricity
- Attributional: Co-product allocation by using allocation factor OR Consequential: Avoided co-product allocation by system expansion

Palm oil — processes: Heat, Electricity, N, P, K fertilizer, Traction, Process water, Agricultural stage, Transport, Oil mill stage, Transport → Co-product: Palm kernels; Functional unit: Palm oil; Allocation; System expansion → Palm kernel milling, Rapeseed production and milling → Palm kernel oil, Palm kernel meal, Rapeseed oil, Rapeseed meal → Coconut oil, Coconut meal, Soy meal, Soy oil → Coconut production and milling, Soy production and milling

Legend: Affected products (green) / Displaced products (red)

Materials and Methods

Applied method
The method used for conducting a comparative LCA-screening of rapeseed oil and palm oil is based on ISO14040-43. Only selected elements of the LCA-screenings are shown on this poster

Goal and Scope
- Functional unit
  The functional unit is chosen as 1 kg crude rapeseed oil and 1 kg crude palm oil. The oils are assumed as completely substitutable
- Scope
  Two differnt approaches to system delimitation are applied (attributional and consequential) in order to assess the effect on the result of the LCA.
- What is traditional (attributional) system delimitation in LCA?
  - Affected processes are assumed to be represented by average data for the specific used product.
  - When one process has multiple product outputs co-product allocation is handled by using allocation factors
- What is consequential system delimitation in LCA?
  - Affected processes are assumed to be represented by marginal processes
  - Co-product allocation is avoided by system expansion

Life Cycle Impact Assessment (LCIA)
The Danish EDIP96 method is used for the LCIA. EDIP does not include land-use. In stead the method for land-use is based on Weidema and Lindeijer (2001)

Data
The inventory is primarily based on existing data from previously LCAs and LCI databases. The primary data are obtained from LCAfood (2003) and Unilever (2004)

Results and Discussions

The result shows significant different results depending on the approach to system delimitation - the result differ with up to a factor ~200 in the case of land-use in the rapeseed production. However, the approach to system delimitation does not change the overall result for any of the included impact categories when comparing rapeseed and palm oil

Key factors related to system delimitation that affect the result
- **Co-product allocation**
  It does not seem like there is coherence between the discplaced system in the consequential LCA and the allocated share in the attributional LCA - the differences vary from a factor of +6.5 to -208.
  In spite of the inconsistency of existing available LCI data, future LCAs on global commodities clearly should assess the importance of adopting either the one or the other approach to system delimitation
- **Energy**
  The approach to system delimitation in the case of marginal versus avarage electricity can not be ascribed to the differences in the result. This is because the emissions that causes global warming, acidification and eutrophication all have their main contributors in the agricultural stage which is not energy related.
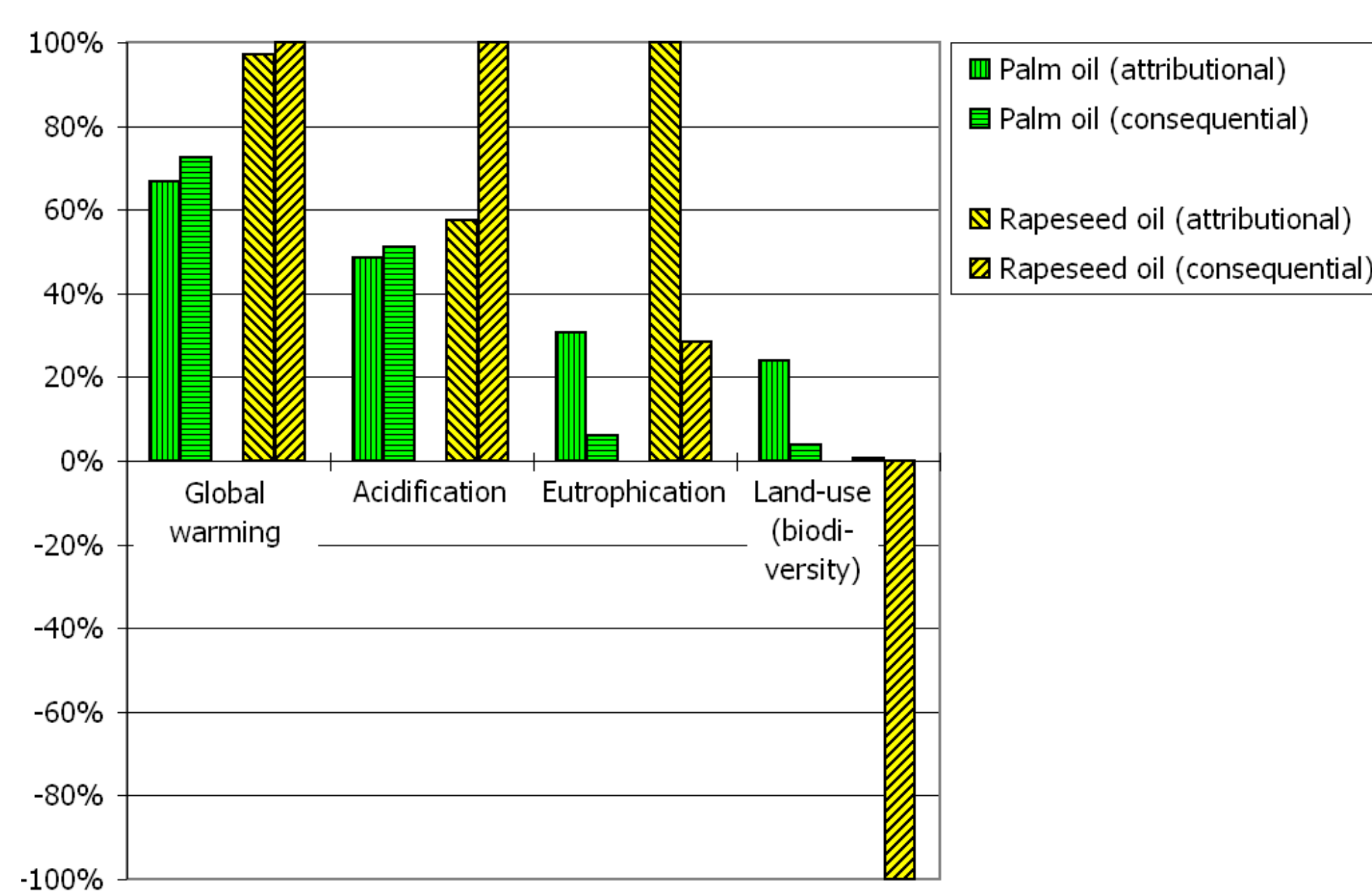 Still, care should be taken in relation to electricity in future LCAs global commodities, especially when dealing with energy intensive products
- **Land-use**
  In the study it is assumed that increase in the production of palm fruits, soy beans and coconuts take place due to transformation of natural forest, while increase in rapeseed production in the EU is met by using additional fertilizer. However, these assumptions can be questioned because they are dependant on the marginal affected land - is it actual natural forest that are transfomed and not grassland, preforests or old rubber plantations?
  Thus, in LCAs of large material flows of global traded substitutable commodities, it may be hard to identify the actual marginal affected land (nature type). Furthermore the agricultural regulation in the affected region may cause some constraints on the production, and thus be of certain importance in relation to the consequential approach

Results

Bar chart — Impact categories: Global warming, Acidification, Eutrophication, Land-use (biodiversity). Series: Palm oil (attributional), Palm oil (consequential), Rapeseed oil (attributional), Rapeseed oil (consequential). Y-axis from -100% to 100%.

Conclusions

The purpose is to investigate the consequences of adopting either the consequential or the attributional approach to system delimitation in a LCA:

What is the consequences for the result of the LCA?
It is concluded that the results of the LCA heavily depend on the system delimitation. However, adopting the one or the other approach does not change the overall conclusion in the actual case; i.e. that palm oil seems like a better environmental alternative than rapeseed oil concerning global warming, acidification and eutrophication, and that the opposite is the case concerning land use. But the contributions to the included impact categories vary up to a factor of 200 depending on the approach to system delimitation

What is the consequences for the setup of the investigated system? - which processes and related product systems are considered as affected?
Using the attributional approach, the investigated system only includes the product systems for rapeseed oil and palm oil. Using the consequential approach, the product systems for four oil crops and five milling processes are included. Keeping the different LCA results in mind, the attributional LCA may be seen as a too simplified picture of reality, when dealing with decision support to political and regulatory decisions. On the other hand market forecasts, which are the prerequisite for system expansion, may also cause uncertainties in the result

What is the added value by adopting the consequential approach?
This study shows that regulation of one commodity may affect several other commodities in the global market. Thus, applying regulations based on LCA may lead to undesired effects if the consequential approach is not taken into consideration. Hidden within the goal and scope definition, the attributional approach simply cuts off too many potential important side effects when dealing with global traded large material flows of substitutable commodities. On this background it is recommended to be extremely aware of the approach to system delimitation in LCA. In this respect it is of great importance to focus on the questions that the LCA is intended to answer. Thus, I see a need for more focus on the approach to system delimitation in the future - especially related to land use

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