INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

Saving the rainforest? Environmental impacts of camelina and crambe

Nils Rettenmaier, Marie Hemmen & Tobias Wagner

PANACEA & MAGIC Value Chain Event on Oilseed Crops, Imperial College London, 27 March 2019

The ifeu

- In 1971, professors and students founded the AGU:

  Working Group on Environmental Protection at the University of Heidelberg

  – Focus on current environmental policy issues, including a report about a proposed nuclear power plant in Wyhl.
- The need for independent environmental research led to the foundation of ifeu as a non-profit organisation in 1978.
- In 1992, ifeu became a GmbH (limited liability company) with non-profit status as of 1999.
- At present, ifeu has a staff of about 60 scientists who work as an interdisciplinary team with a broad variety of expertise on current environmental topics.
- The institute is committed to the goal of a sustainable society.

20 Jahre ifeu-Institut, M. Schmidt, U. Höpfner (Hrsg.), 1998, Heidelberg

ifeu's Areas of Work

- Waste Management and Resource Conservation
- Environmental Education
- Energy (and Renewable Energies)
- Industry and Products
- Food and Biomass
- Sustainability
- Life Cycle Assessment (LCA)
- Risk Assessment
- Environmental Impact Analysis (EIA)
- Strategic Environmental Assessment (SEA)
- Traffic and Transport
- …. and many others

ifeu's Clients (selection)

European Union

European Environment Agency

European Commission

ETC RWM
European Topic Centre on Resource and Waste Management

World Bank, UNEP, FAO, etc.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

iea

UNFCCC

UNIDO

FAO FIAT PANIS

THE WORLD BANK

Non-governmental Organisations

NABU

GREENPEACE

VCD Verkehrsclub Deutschland

BUND für Umwelt und Naturschutz Deutschland e.V.

Departments of Federal, State and Local Governments

- Federal Ministry Department (Environment, Economy, Transport)
- State Departments

Transport and Logistic Service Providers

DB

Deutsche Post

ifeu's Clients (selection)

Industrial Associations

PlasticsEurope

edana

DGfH

ACE Auto Club Europa

petcore

Verband Metallverpackungen

Organisations of Development cooperation

inWent Internationale Weiterbildung und Entwicklung gGmbH

CDG Carl Duisberg Gesellschaft e.V.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GOPA WORLDWIDE CONSULTANTS

Companies

PET CYCLE

Coca-Cola

DANONE

DER GRÜNE PUNKT

SIG

BMW

Shell

BAYER

Red Bull

MVV Energie

P&G

Tetra Pak PROTECTS WHAT'S GOOD

Kimberly-Clark

Schools, Public Services, ASEW, Consumer Advice Centre

Foundations

Portrait of camelina and crambe

Camelina:

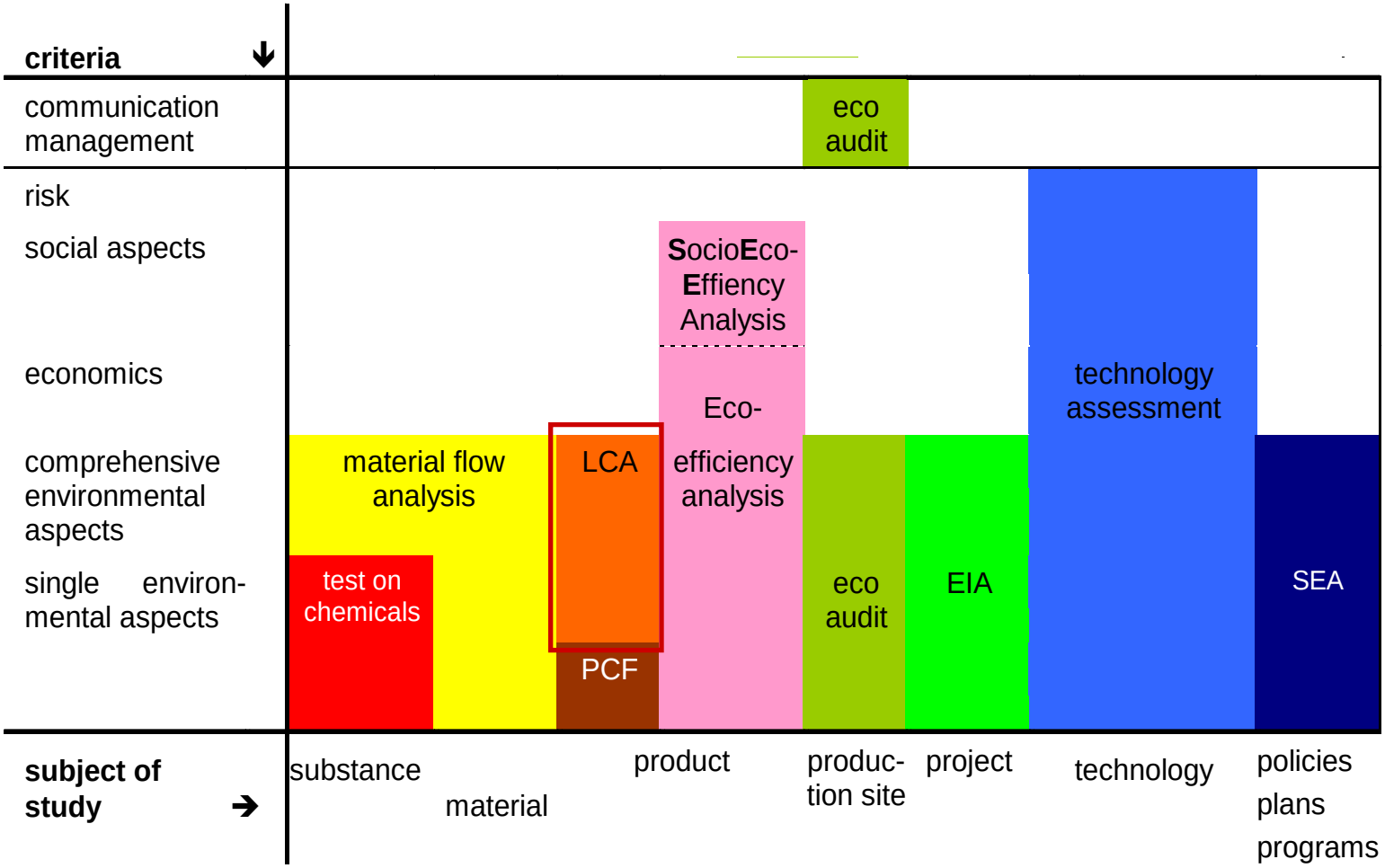
Name(s): camelina, gold-of-pleasure, false flax
(*Camelina sativa* (L.) CRANTZ)
Family: Brassicaceae
Fruit: Capsule (seeds in pods)
Yield in 2025: 1.2 | 2.4 | 4.4 t_{FM} ha^{-1} yr^{-1}

Crambe:

Name(s): crambe
(*Crambe abyssinica* HOCHST. EX R.E.FR.)
Family: Brassicaceae
Fruit: Capsule (seeds in hull)
Yield in 2025: 1.8 | 3.0 | 4.4 t_{FM} ha^{-1} yr^{-1}

Photo credits: Christina Eynck and Debbie Puttick (Linnaeus Plant Sciences), Robert van Loo and Rolf Blaauw (Wageningen UR)

Environmental management tools



Source: IFEU, own compilation

LCA overview: Purpose

LCA addresses

- the environmental aspects and **potential environmental impacts** (e.g. use of resources and the environmental consequences of releases)
- **throughout the life cycle** from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. **cradle-to-grave**)
- of a **product** (*any* good or service).


INTERNATIONAL STANDARD ISO 14040

Environmental management — Life cycle assessment — Principles and framework

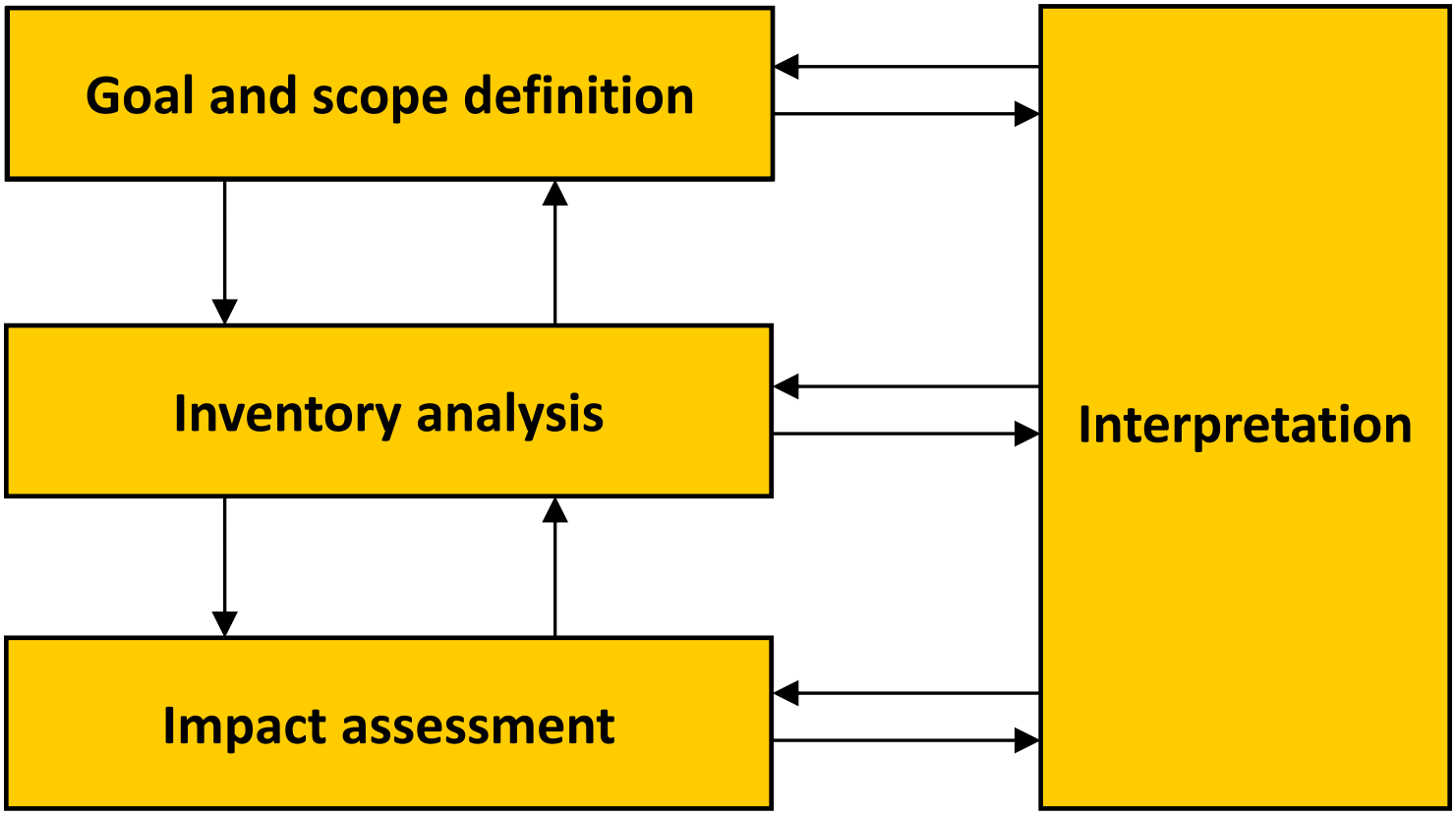

INTERNATIONAL STANDARD ISO 14044

Environmental management — Life cycle assessment — Requirements and guidelines

Source: ISO 14040

LCA overview: The four (iterative) phases

Structure following ISO standards 14040 & 14044

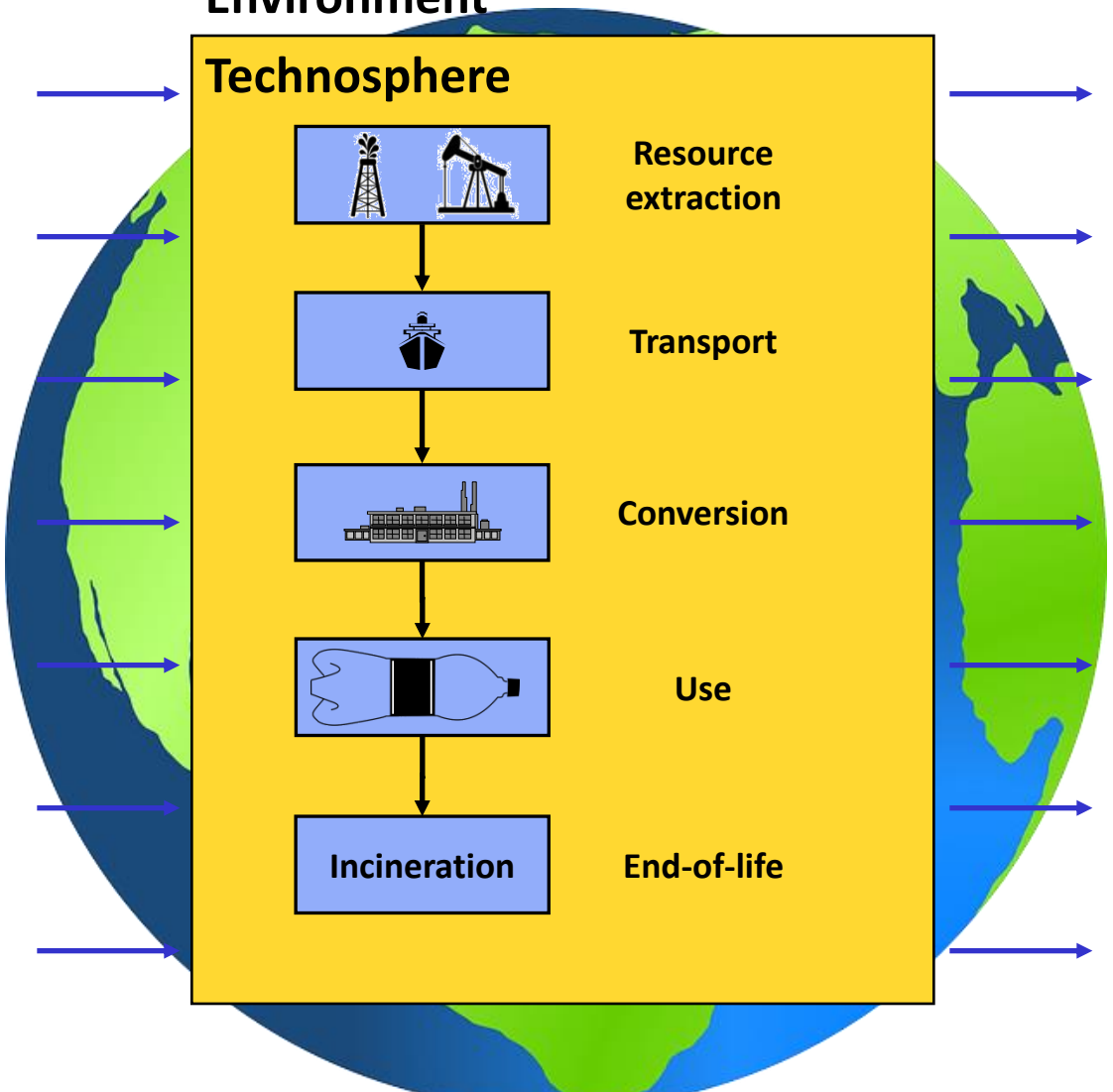


LCA overview: Scope

Resources

e.g.:

- natural gas
- crude oil
- lignite
- hard coal
- uranium
- water
- ores
- minerals

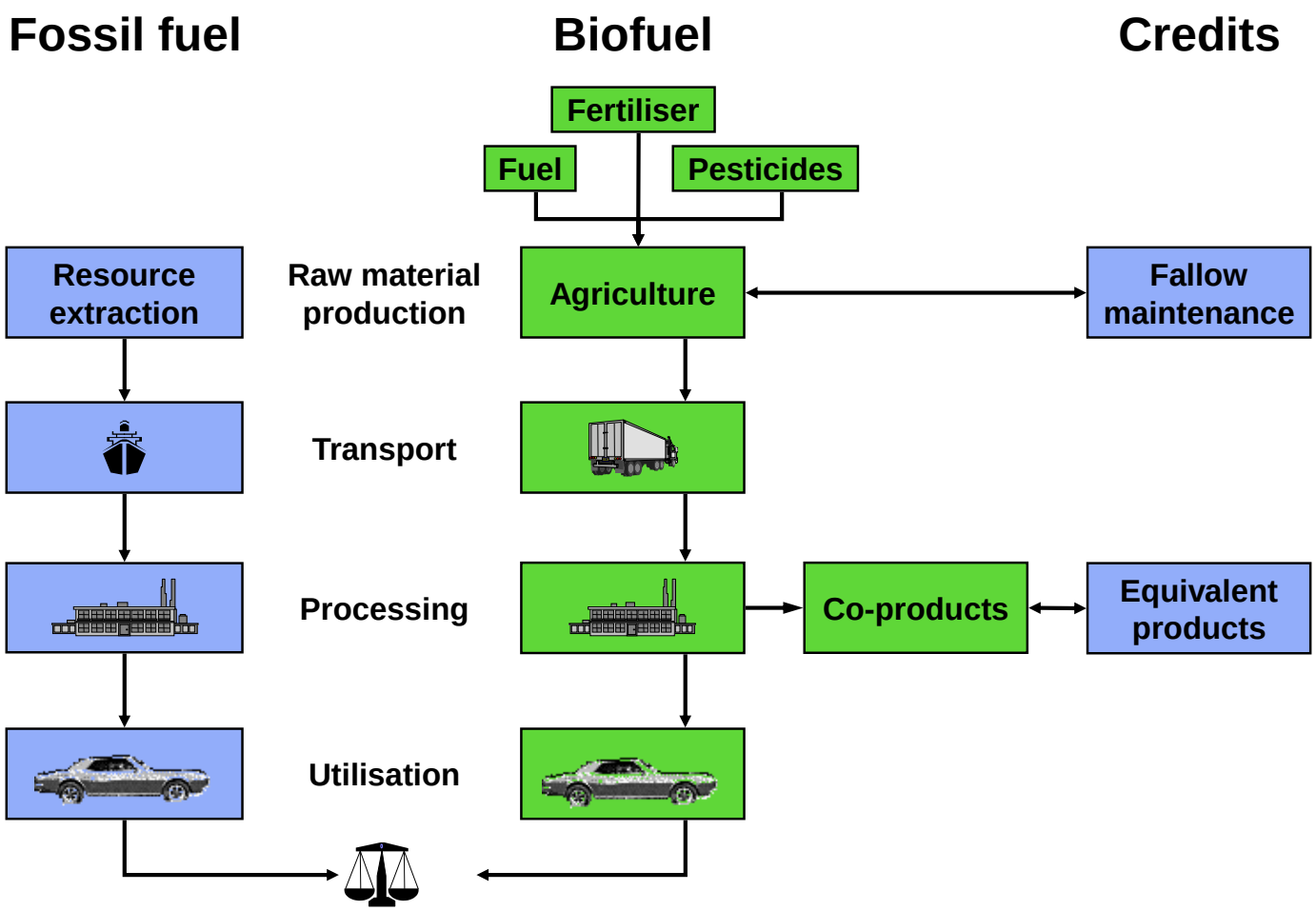


Releases

e.g.:

- CO_2
- SO_2
- CH_4
- NO_x
- NH_3
- N_2O
- HCl
- CO
- C_6H_6
- VOC

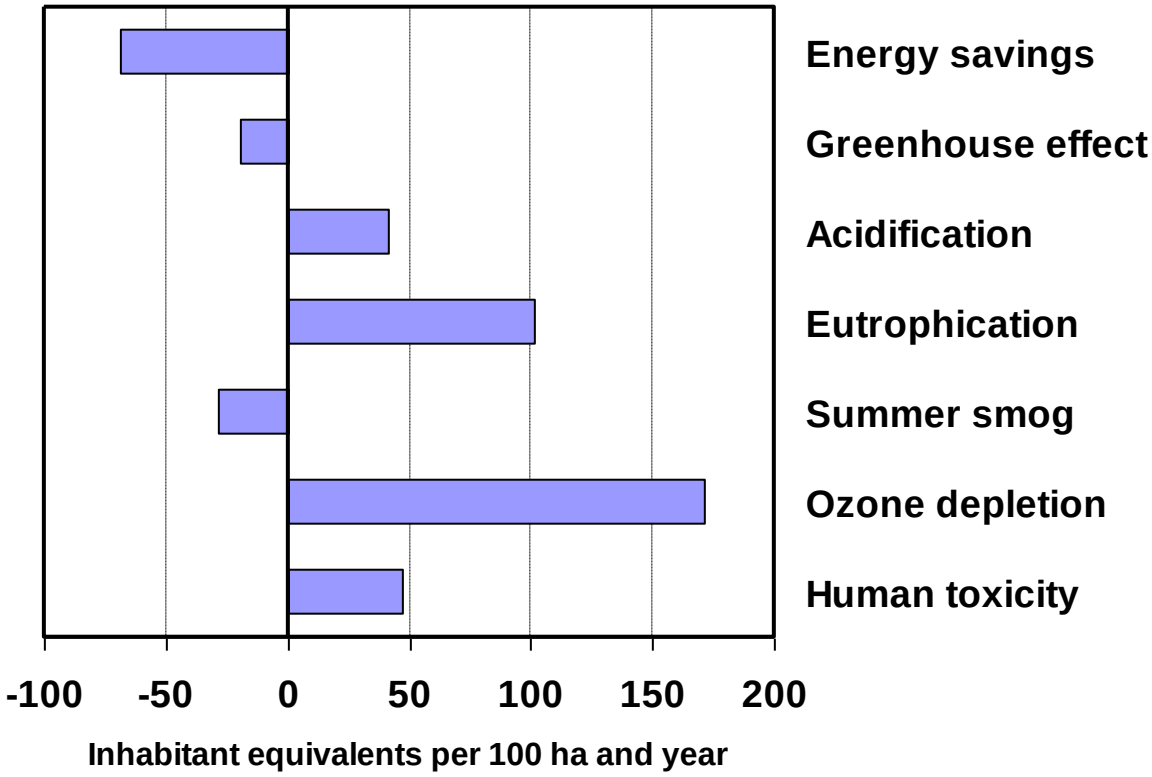
LCA overview: Life cycle comparison



Example: Rapeseed biodiesel vs. diesel

← Advantages for biodiesel Advantages for diesel →

Rapeseed



 Source: IFEU 2017

ifeu and LCA: 25+ years of experience

F + E-Vorhaben des Umweltbundesamtes
Nr. 104 08 508/02

Endbericht

Energie- und CO_2-Bilanz von Rapsöl und Rapsölester im Vergleich zu Dieselkraftstoff

ifeu – Institut für Energie- und Umweltforschung Heidelberg
Fachbereich „Verkehr und Umwelt“

Dezember 1991

First full life cycle assessment on biodiesel in Europe

1991

Agenda

1. Introduction
2. Camelina & crambe for bio-based products (COSMOS)
3. Camelina & crambe for biofuels
4. Conclusions

Main aim of the COSMOS project

To **reduce Europe's dependence on imported tropical oils** (palm kernel, coconut, castor) as sources for medium-chain-length oleochemical surfactants, lubricants, polymers and other high-value products, **by turning camelina and crambe into profitable oilseed crops**.

COSMOS

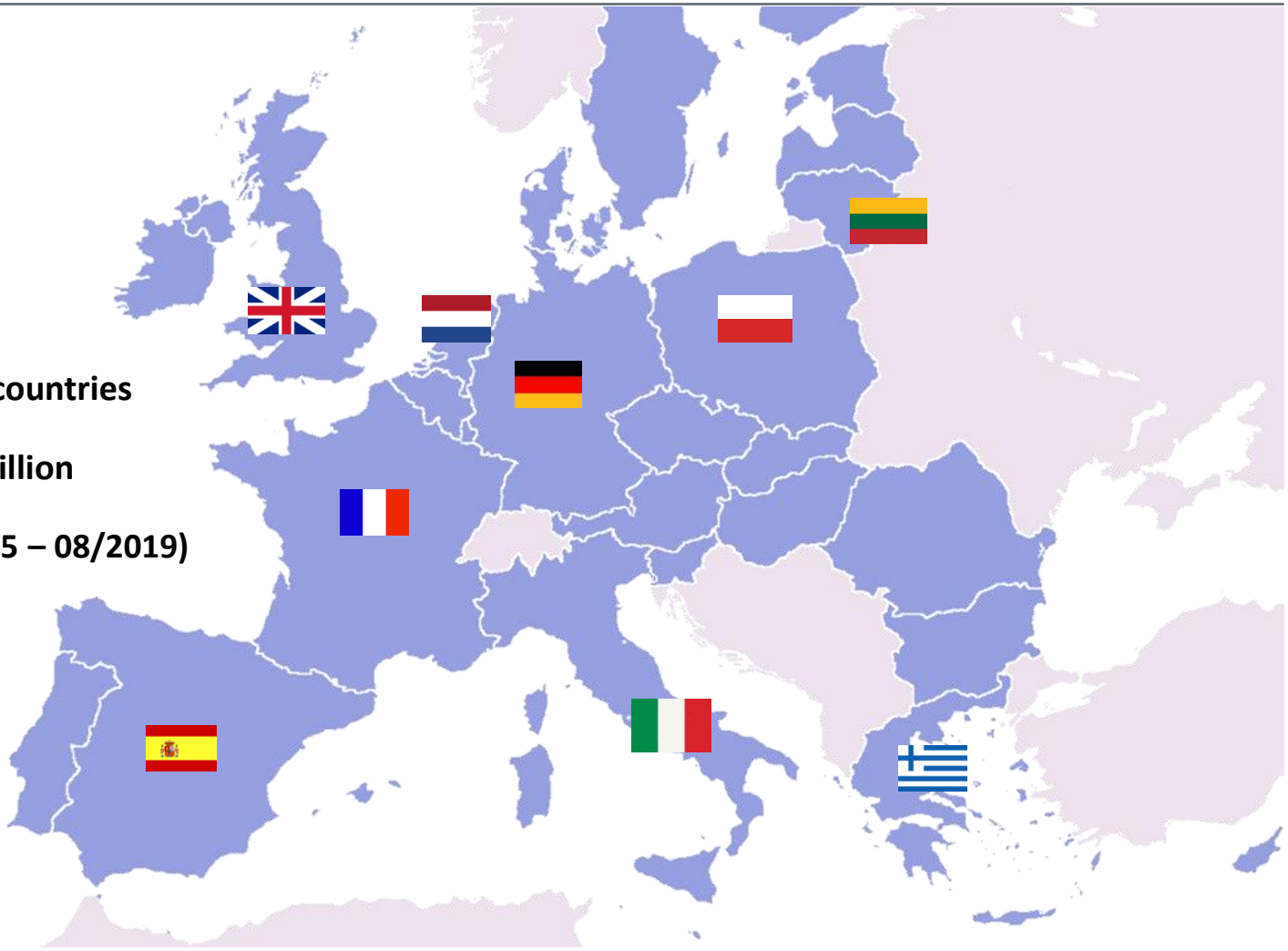
ADDING VALUE TO CAMELINA AND CRAMBE OIL

COSMOS: Partners, budget and duration

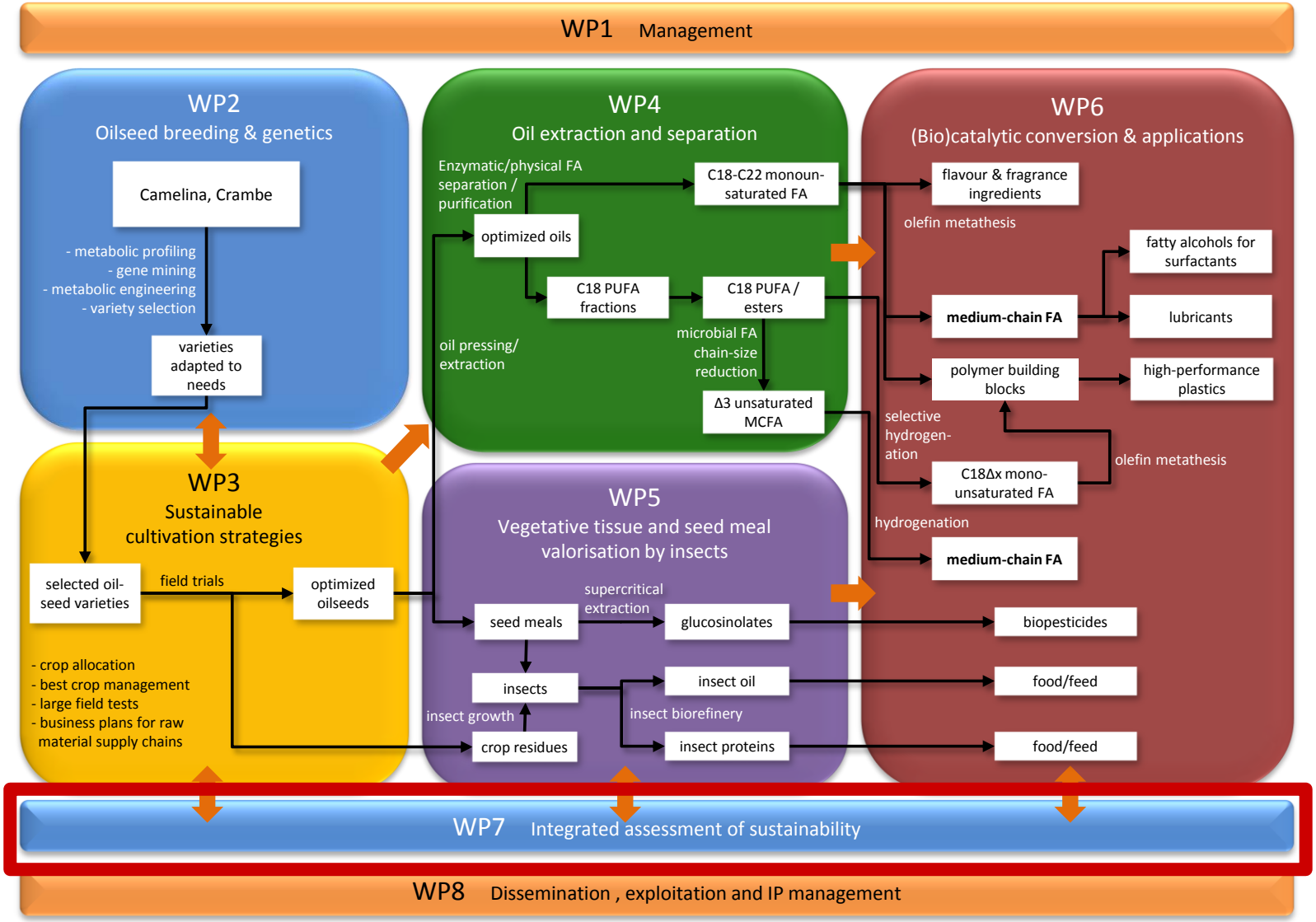
18 partners in 9 countries

Budget: € 10.8 million

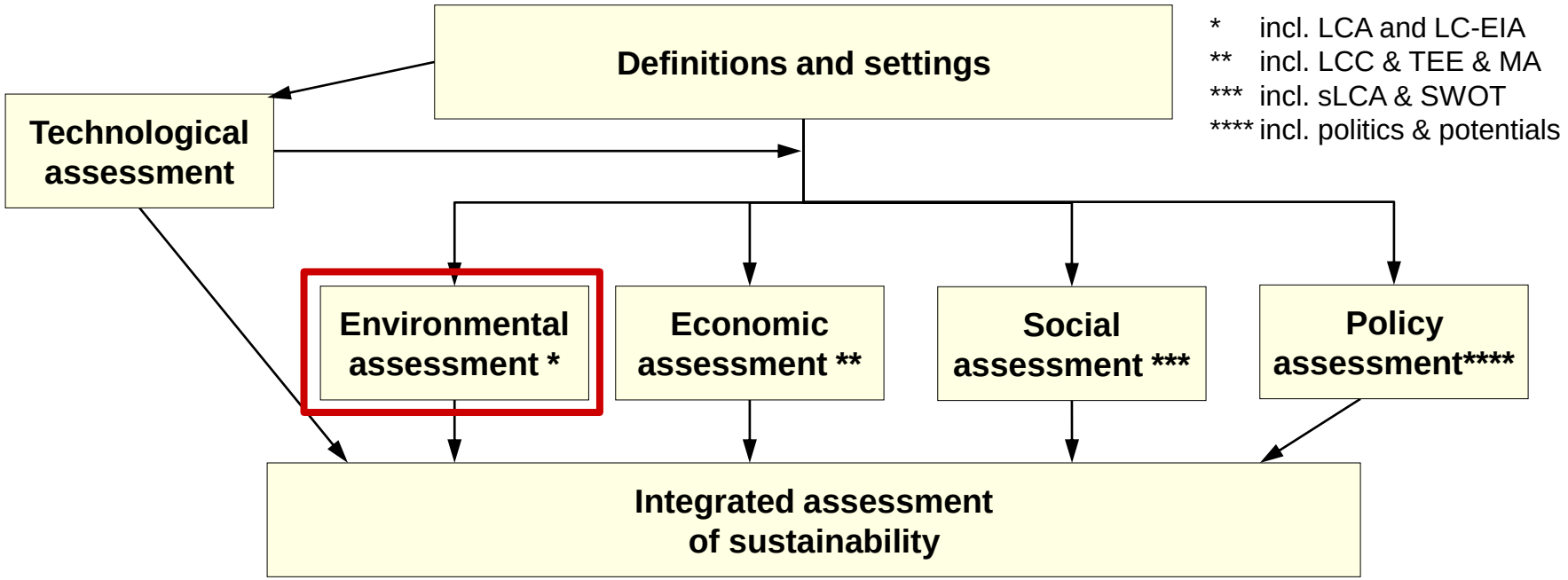
4.5 years (03/2015 – 08/2019)



COSMOS: Project structure

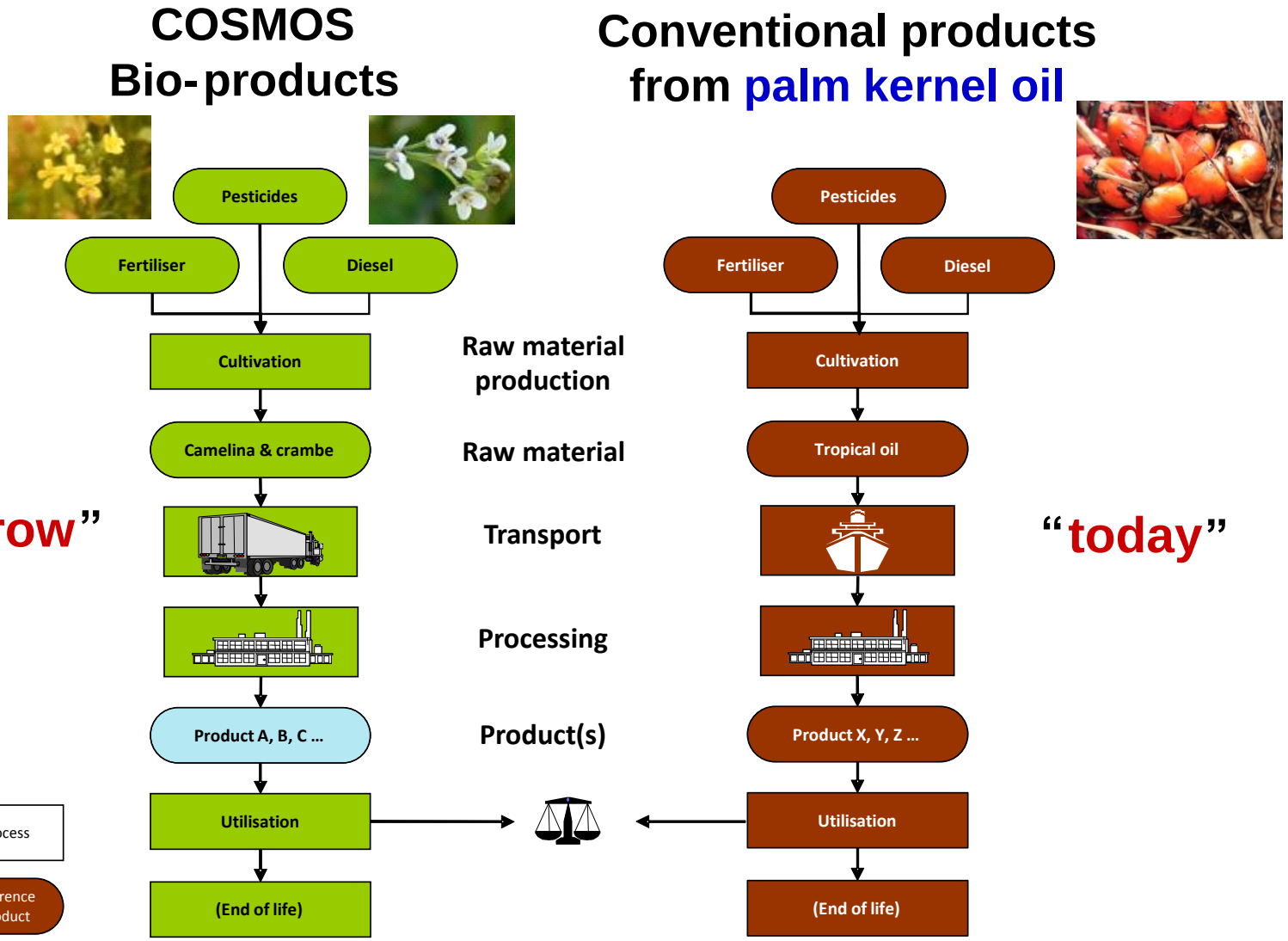


COSMOS: Sustainability assessment

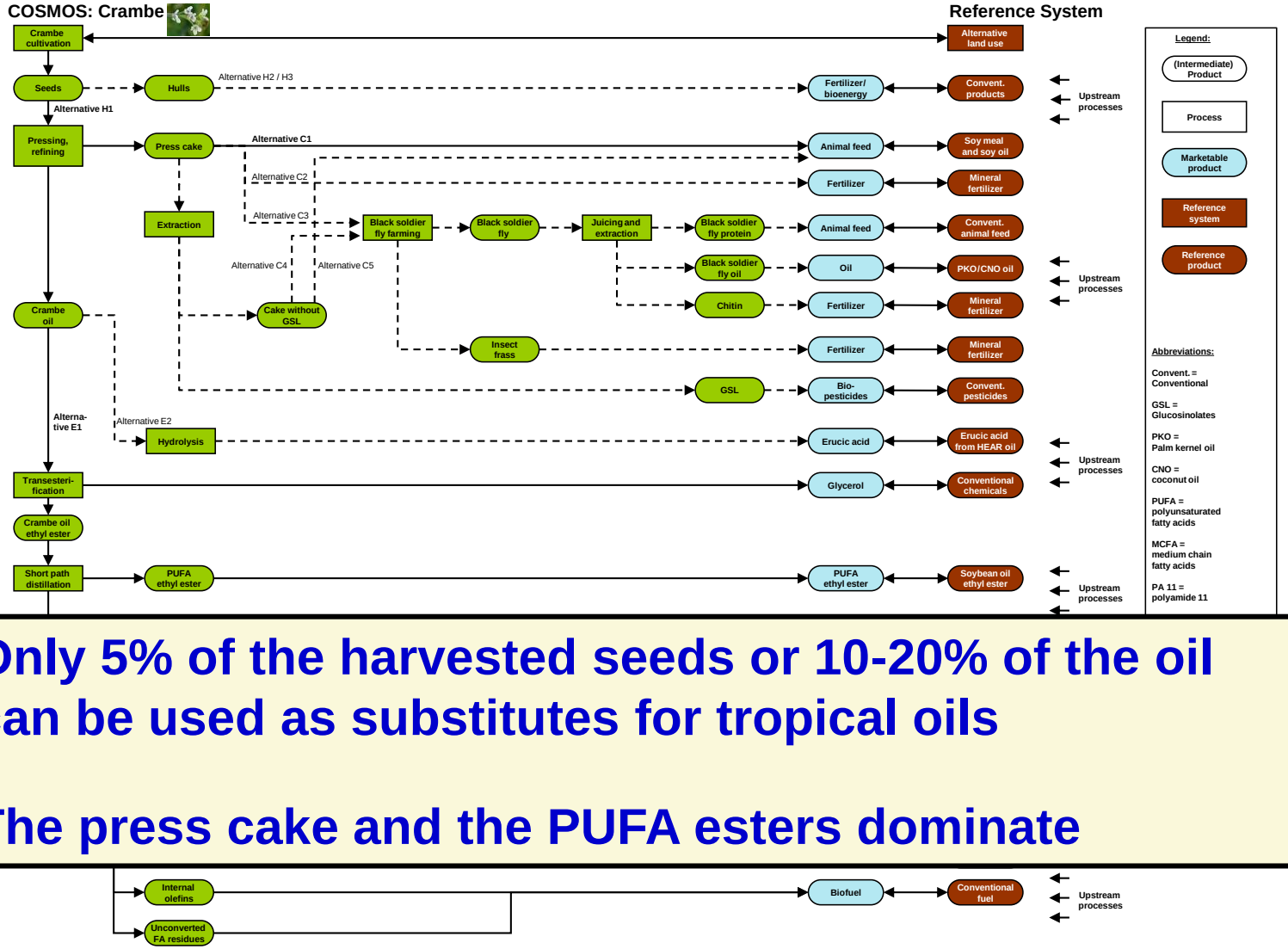


 Source: IFEU, own compilation

COSMOS: Simplified life cycle comparison



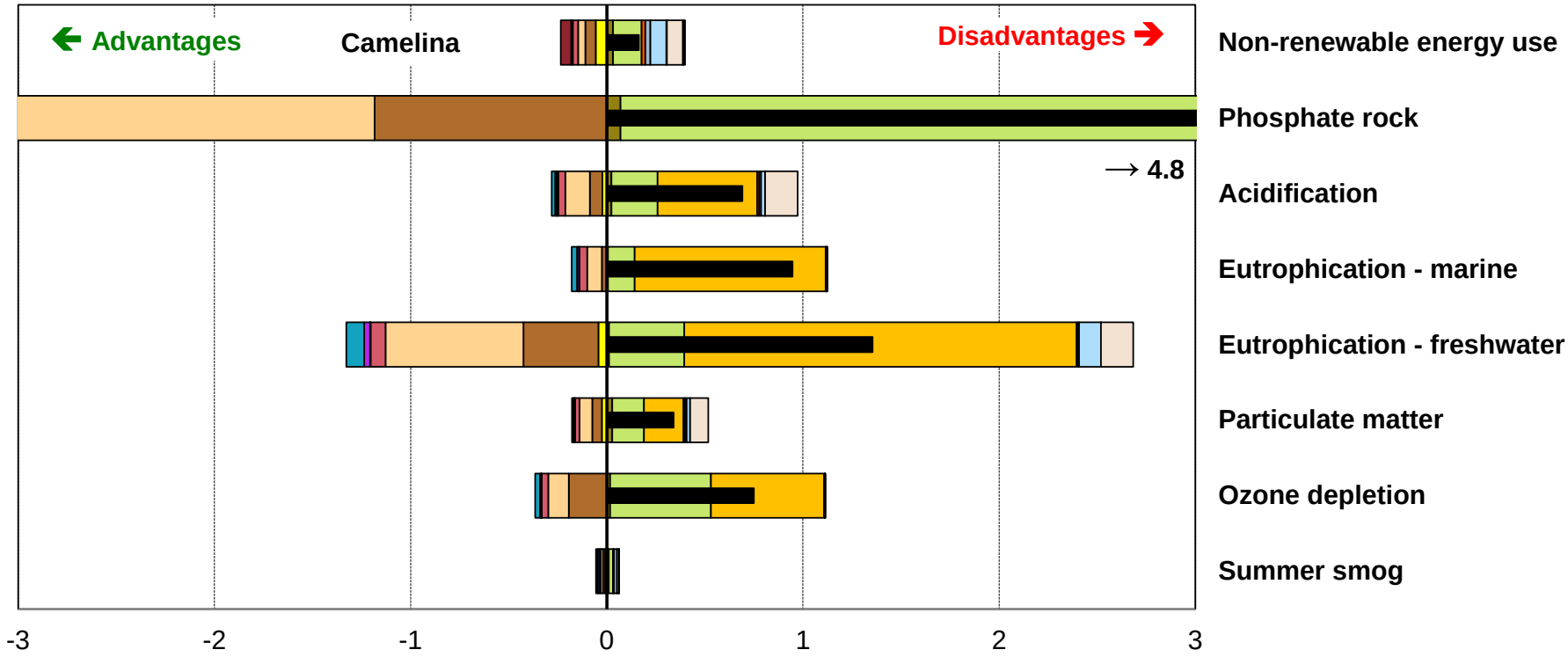
COSMOS: System overview



➔ **Only 5% of the harvested seeds or 10-20% of the oil can be used as substitutes for tropical oils**

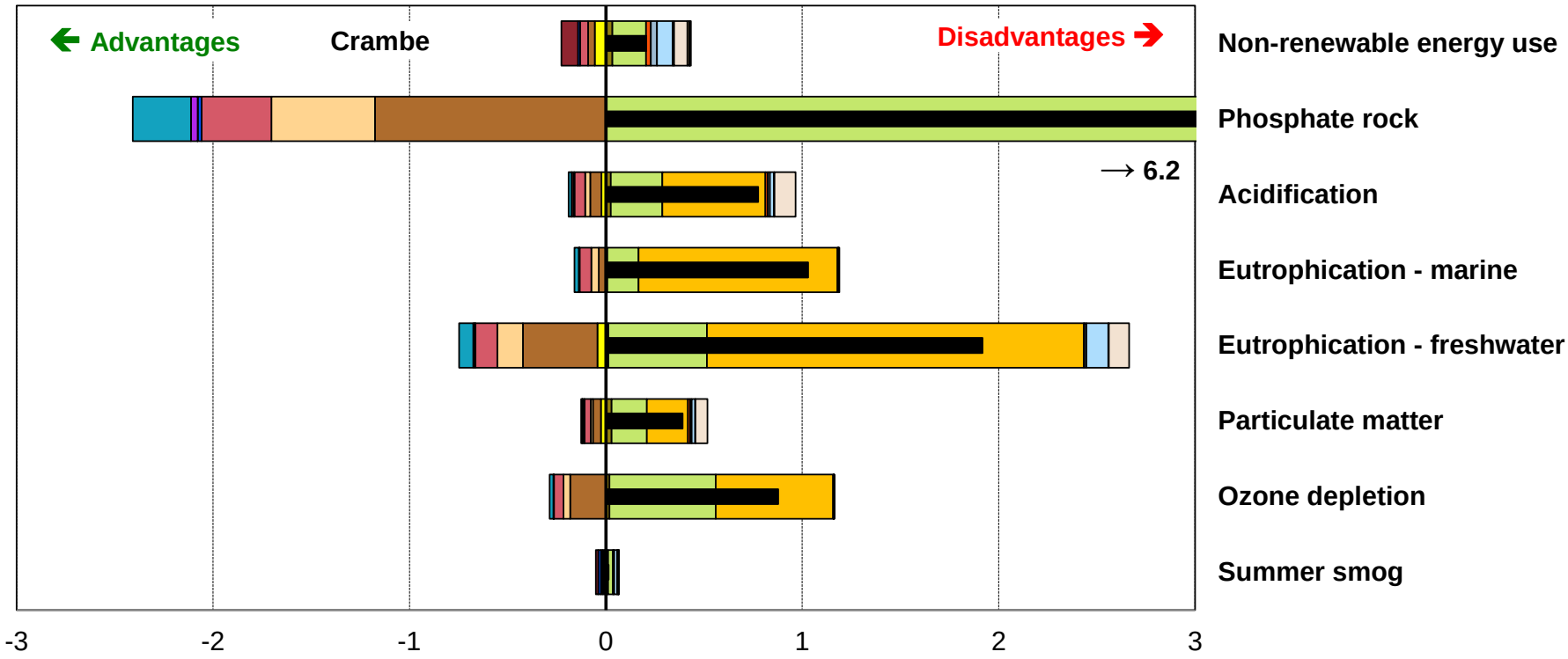
➔ **The press cake and the PUFA esters dominate**

COSMOS: Normalised LCA results for camelina, idle land, 2025



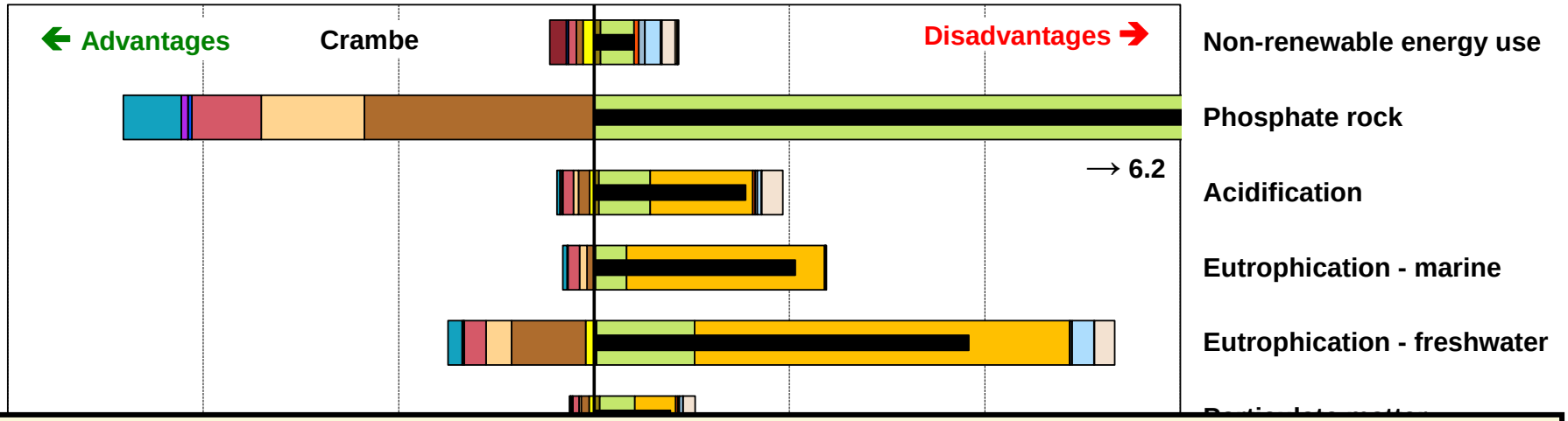
IFEU 2019

COSMOS: Normalised LCA results for crambe, idle land, 2025



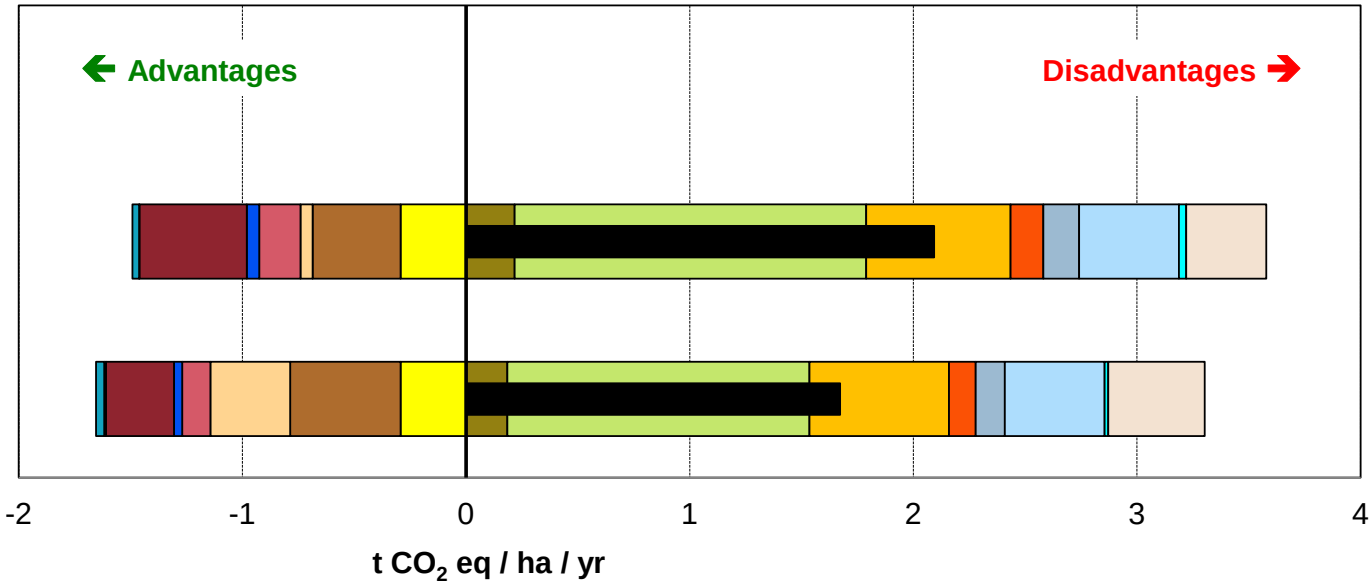
IFEU 2019

COSMOS: Normalised LCA results for crambe, idle land, 2025



- ➔ **Largest burdens due to fertilisers (green and orange bars)**
- ➔ **Largest credits for press cake and (in the case of camelina) PUFA esters**
- ➔ **Minor significance of transports (Asia → Europe), technical processing, etc. compared to the fertiliser-related impacts**
- ➔ **LCA results (for all shown impact categories) tend to be disadvantageous for both camelina and crambe**

COSMOS: Greenhouse gas balance without LUC



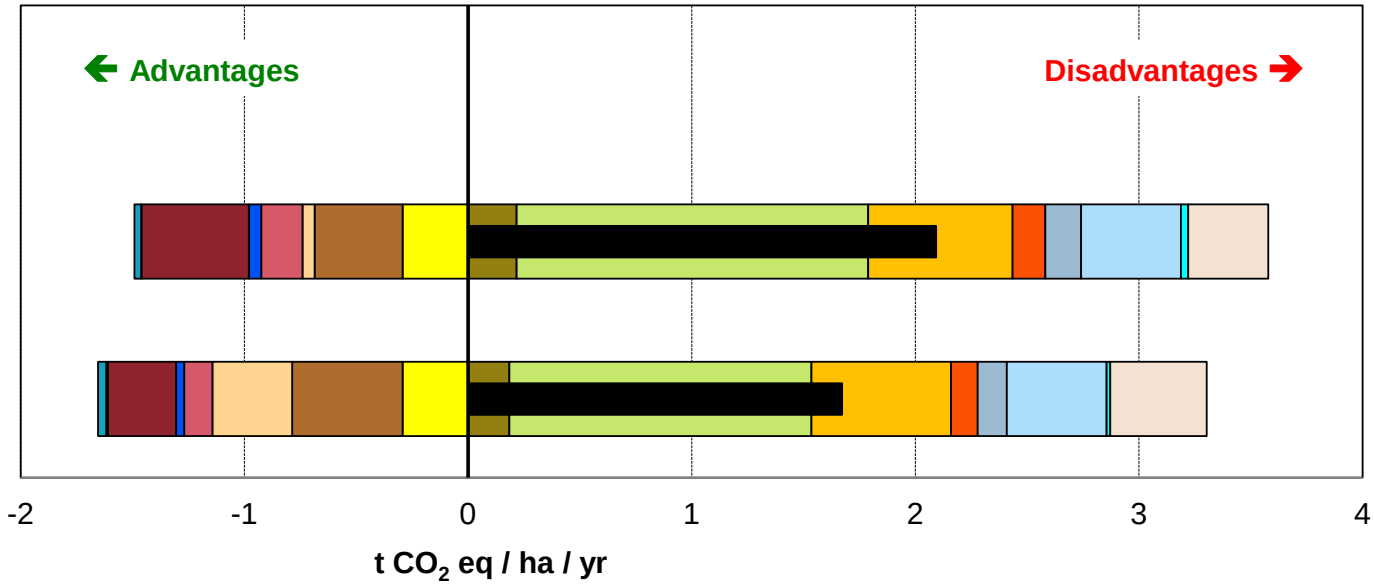
Crambe | No LUC

Camelina | No LUC

- Agriculture: diesel and others
- Agriculture: fertiliser
- Agriculture: field emissions
- Transports and pre-treatment
- Pressing, refining, GSL-extraction
- Conversion: transesterification
- Credits: glycerol
- Conversion: SPD/HVCFE
- Conversion: ethenolysis and hydrogenation
- Credits: cake as animal feed
- Credits: PUFA EE
- Credits: medium chain FA esters
- Credits: lubricants
- Credits: α-olefins
- Credits: saturated FA
- Credits: internal olefins and LCFE
- Net result

IFEU 2019

COSMOS: Greenhouse gas balance without LUC



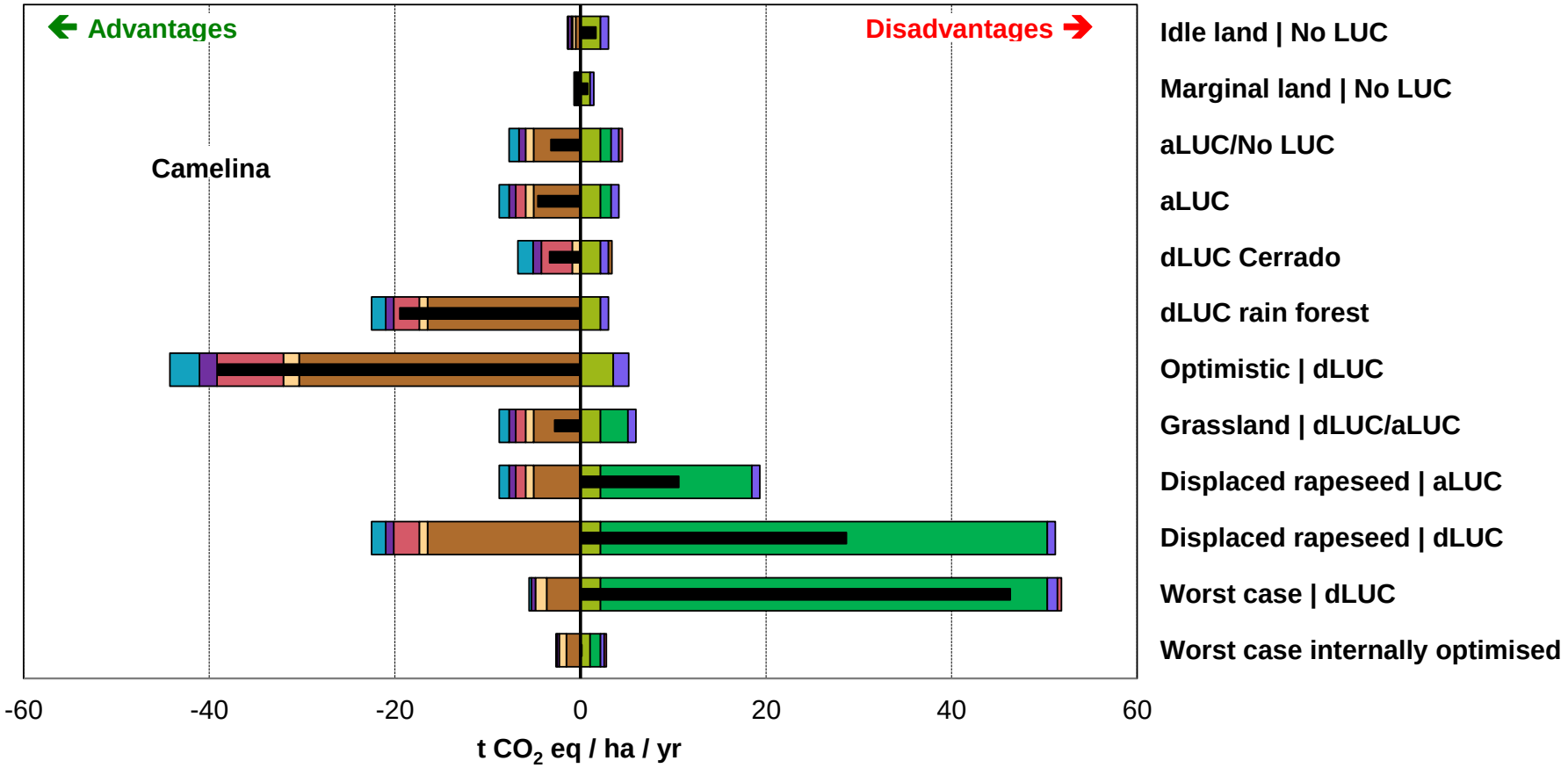
Crambe | No LUC

Camelina | No LUC

- Agriculture: diesel and others
- Agriculture: fertiliser
- Agriculture: field emissions
- Transports and pre-treatment
- Pressing, refining, GSL-extraction
- Conversion: transesterification
- Credits: glycerol
- Conversion: SPD/HVCFE
- Conversion: ethenolysis and hydrogenation
- Credits: cake as animal feed
- Credits: PUFA EE
- Credits: medium chain FA esters

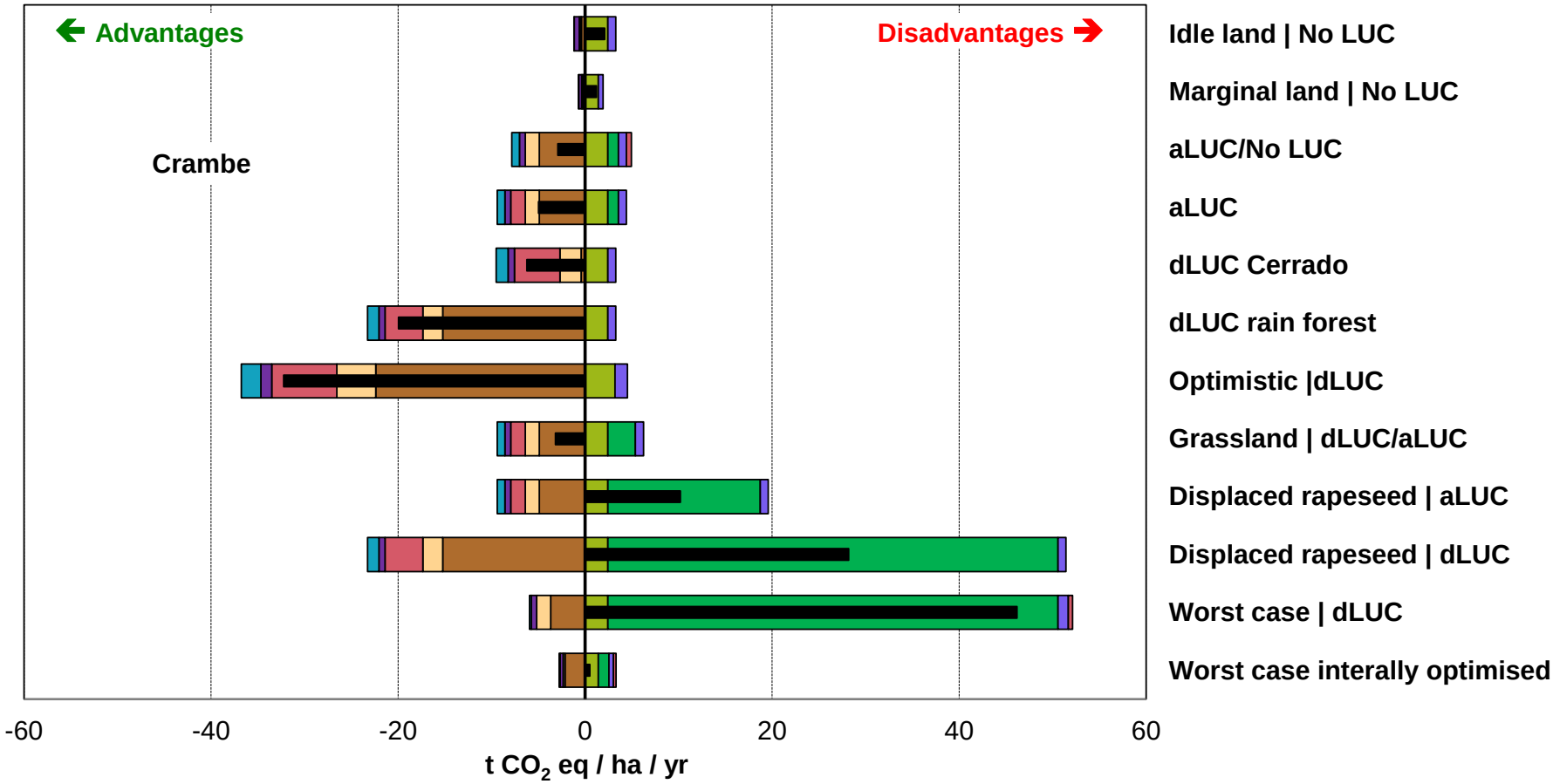
➔ **Without the consideration of land use changes (LUC): net additional GHG emissions**

COSMOS: Greenhouse gas balance with varying LUC



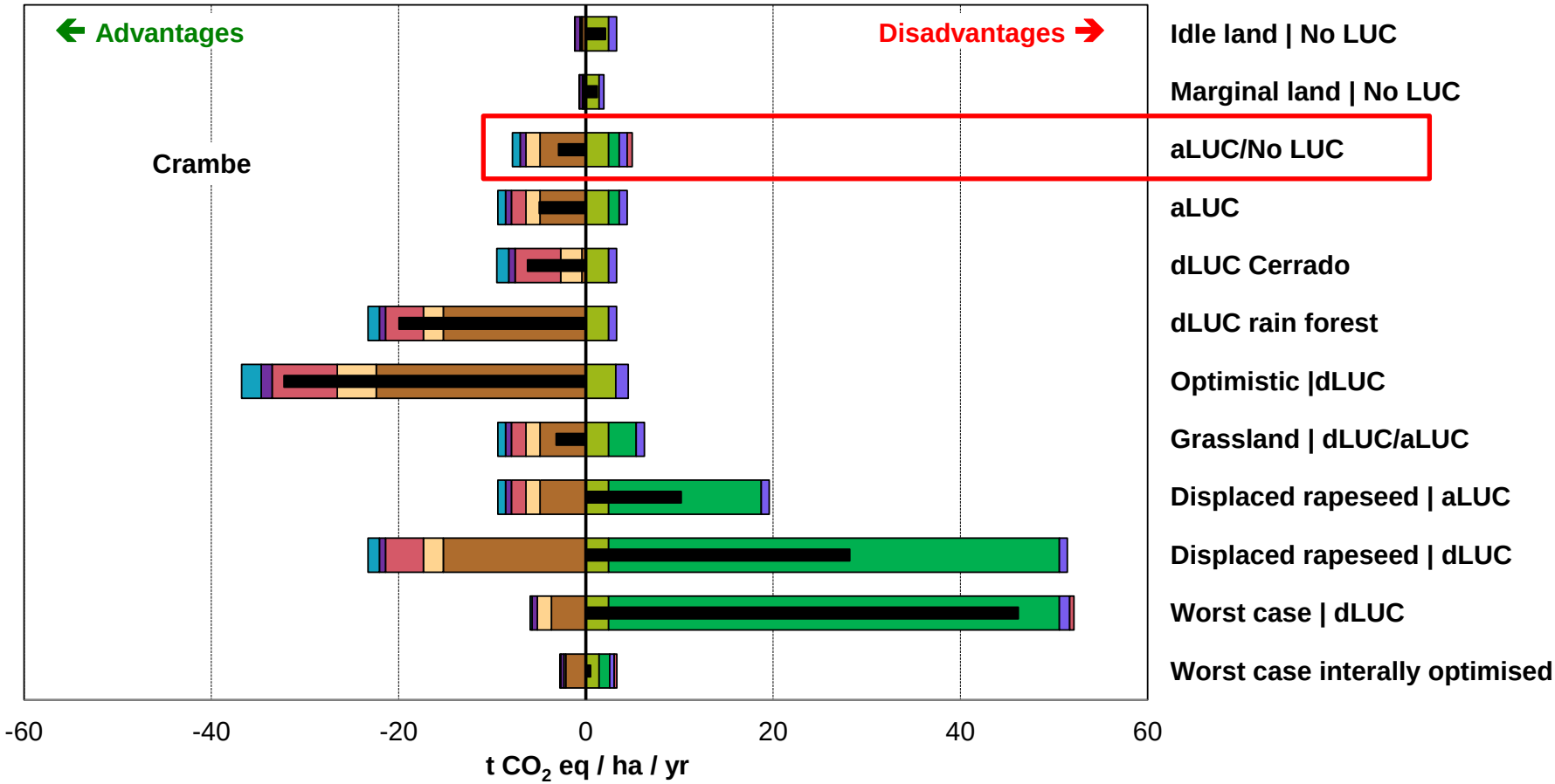
IFEU 2019

COSMOS: Greenhouse gas balance with varying LUC



IFEU 2019

COSMOS: Greenhouse gas balance with varying LUC



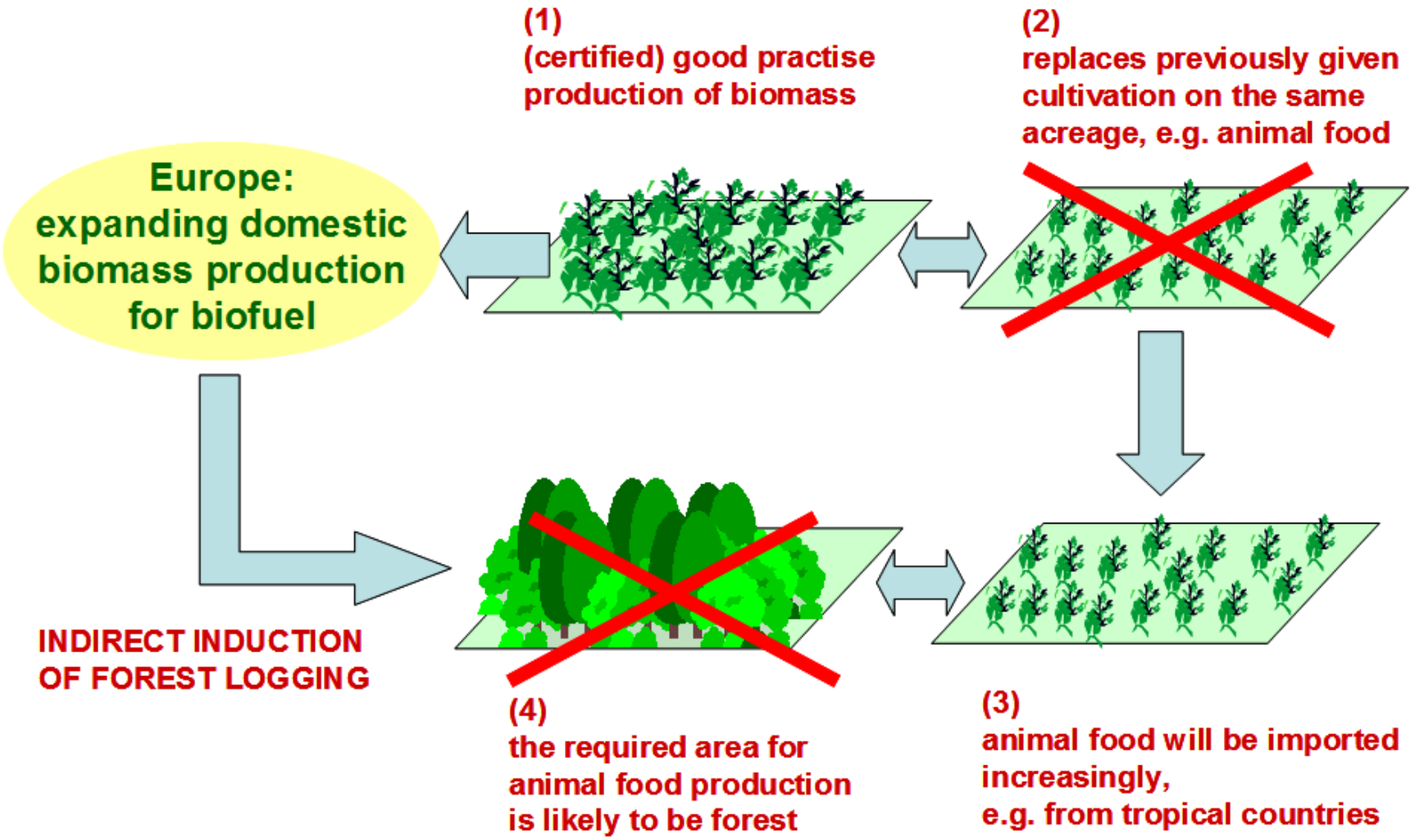
IFEU 2019

COSMOS: Decreased European demand = avoided tropical deforestation?

1. Oil palm plantations are not impacted, but rather coconut palm plantations.
   - Palm *kernel* oil makes up only 15% of an oil palm plantation's turnover.
   - Plans for expansions of oil palm plantation are thus largely independent of palm *kernel* oil demand and prices.
   - Given a balanced product equation, impacts on coconut palm plantations are plausible because the market applications are similar.
2. Decreased coconut oil production does not necessarily avoid deforestation.

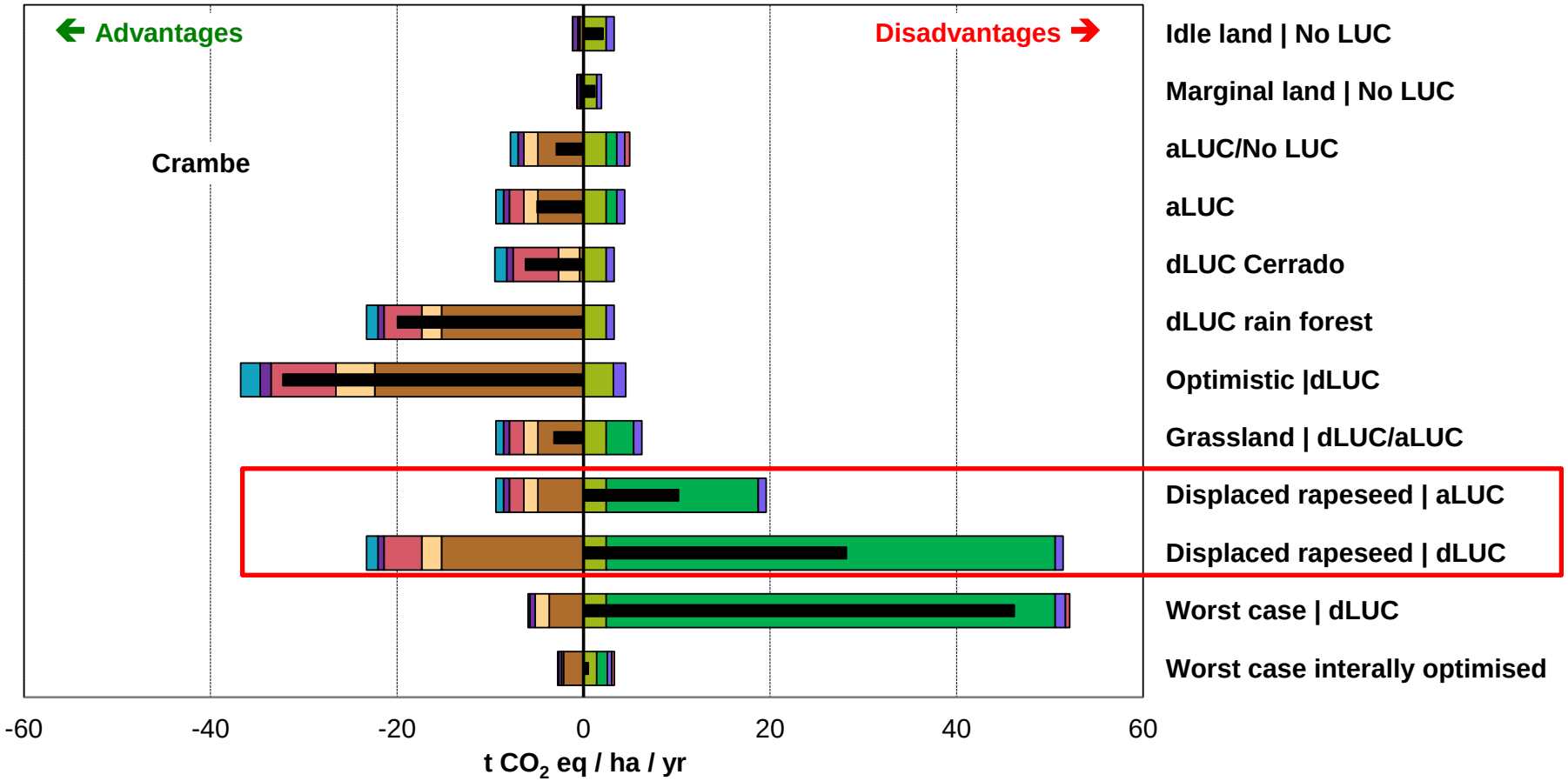
Deforestation is *not* avoided	**Deforestation is avoided**
Little growth of the coconut oil market in the last decade and little deforestation	The clearing of natural areas can be cheaper than the optimised management of existing plantations.
Characterised by smallholder farmers with low fertilisation and old palm trees. → Possible future market growth can be met through optimised management of existing plantations	The introduction of the RED in Europe may lead to a significantly lower demand for palm oil so that large quantities of palm kernel oil could also lack, which might result in stronger expansions of coconut oil plantations.
…	…

COSMOS: Greenhouse gas balance with varying LUC



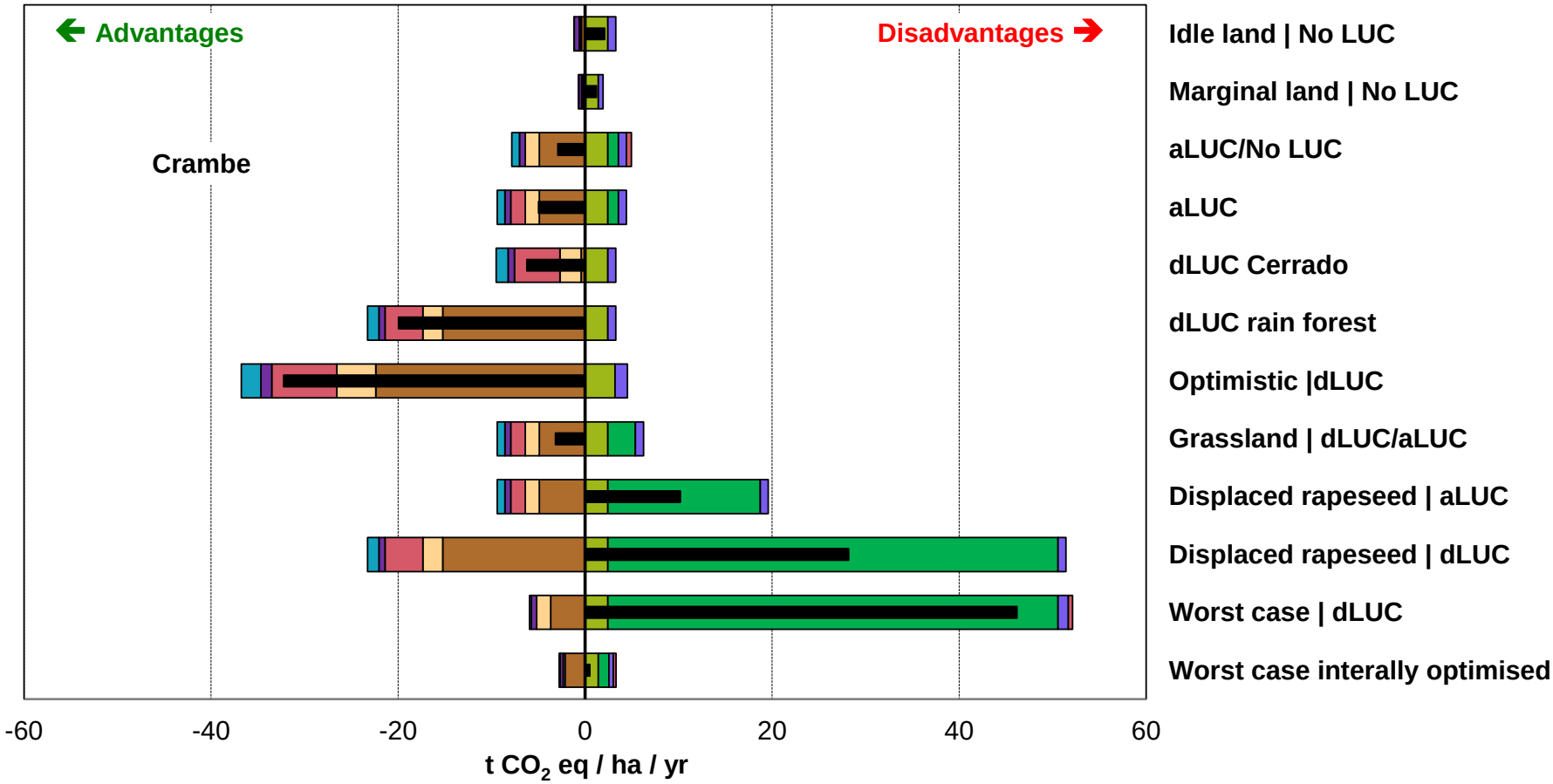
Source: IFEU 2008

COSMOS: Greenhouse gas balance with varying LUC



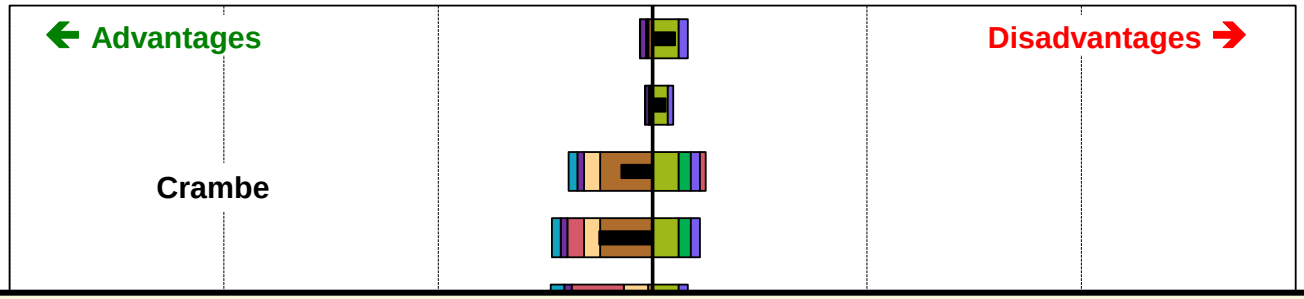
IFEU 2019

COSMOS: Greenhouse gas balance with varying LUC



IFEU 2019

COSMOS: Greenhouse gas balance with varying LUC



- **Greenhouse gas (GHG) balance strongly influenced by land use change (LUC) effects**
- **No objective/'true' results possible**
- **Significant potential for considerable GHG savings at low risks for net additional GHG emissions provided that disadvantageous LUC effects are avoided, especially by**
  - **additional introduction of camelina and crambe into crop rotations without displacement of other crops**
  - **cultivation on marginal sites in EU with still fair yields**

COSMOS: Do camelina and crambe save rainforest?

- In South East Asia: uncertain.
  If so, the effect is not too pronounced.
- In South America: probably yes.

Agenda

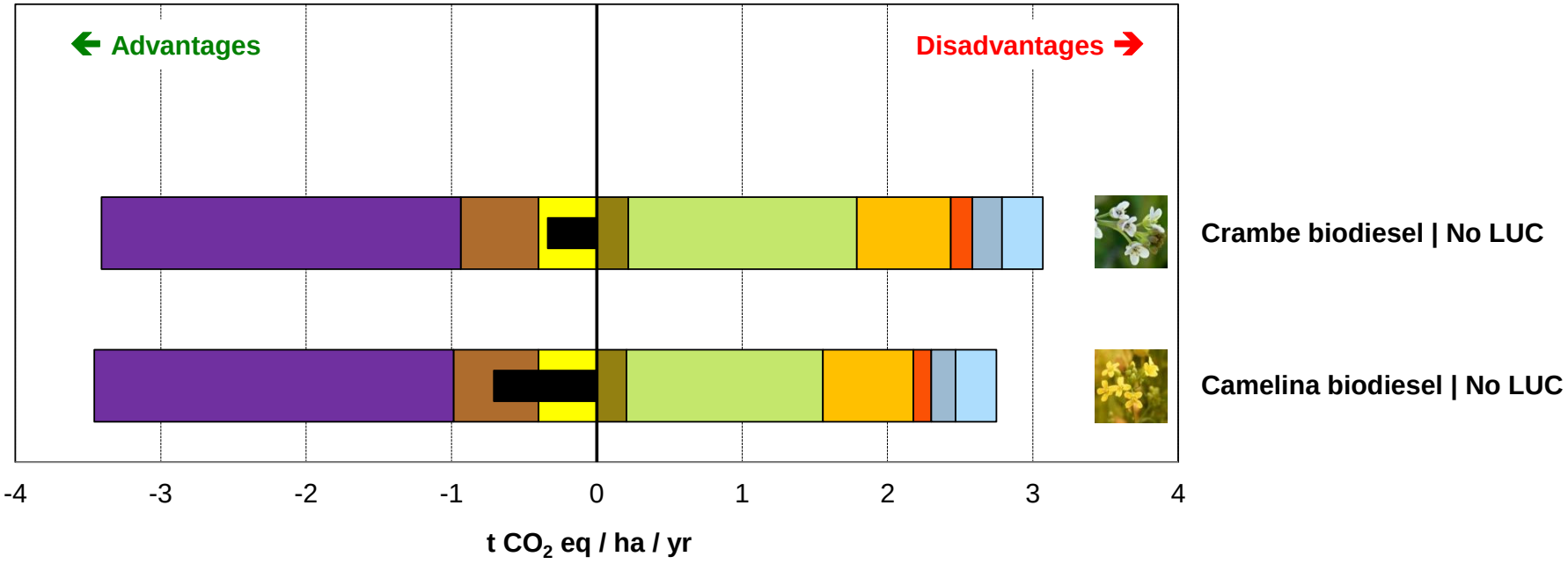
1 Introduction

2 Camelina & crambe for bio-based products (COSMOS)

3 Camelina & crambe for biofuels

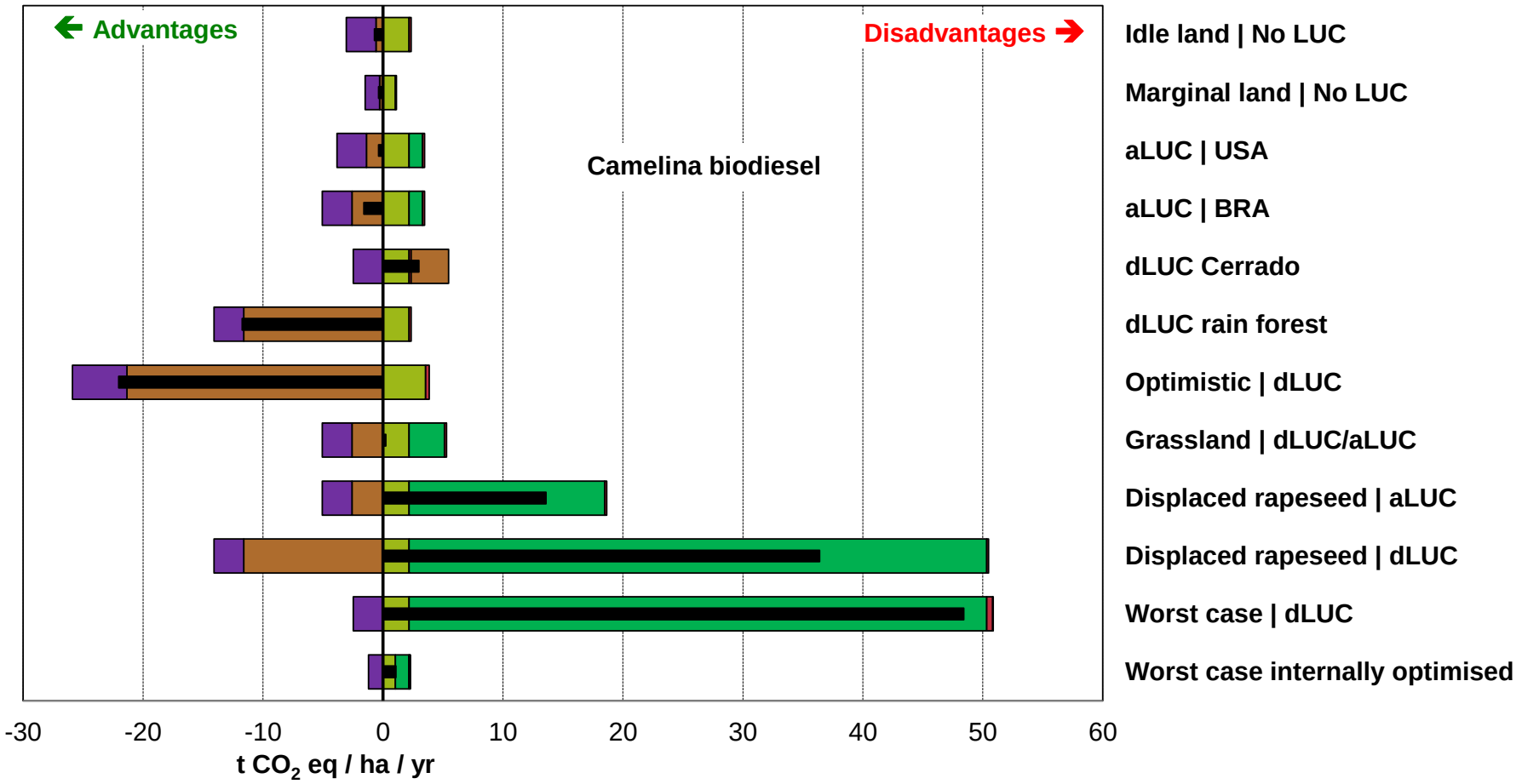
4 Conclusions

Biodiesel from camelina and crambe: Greenhouse gas balance without LUC



IFEU 2019

Biodiesel from camelina: Greenhouse gas balance with varying LUC



Idle land | No LUC

Marginal land | No LUC

aLUC | USA

aLUC | BRA

dLUC Cerrado

dLUC rain forest

Optimistic | dLUC

Grassland | dLUC/aLUC

Displaced rapeseed | aLUC

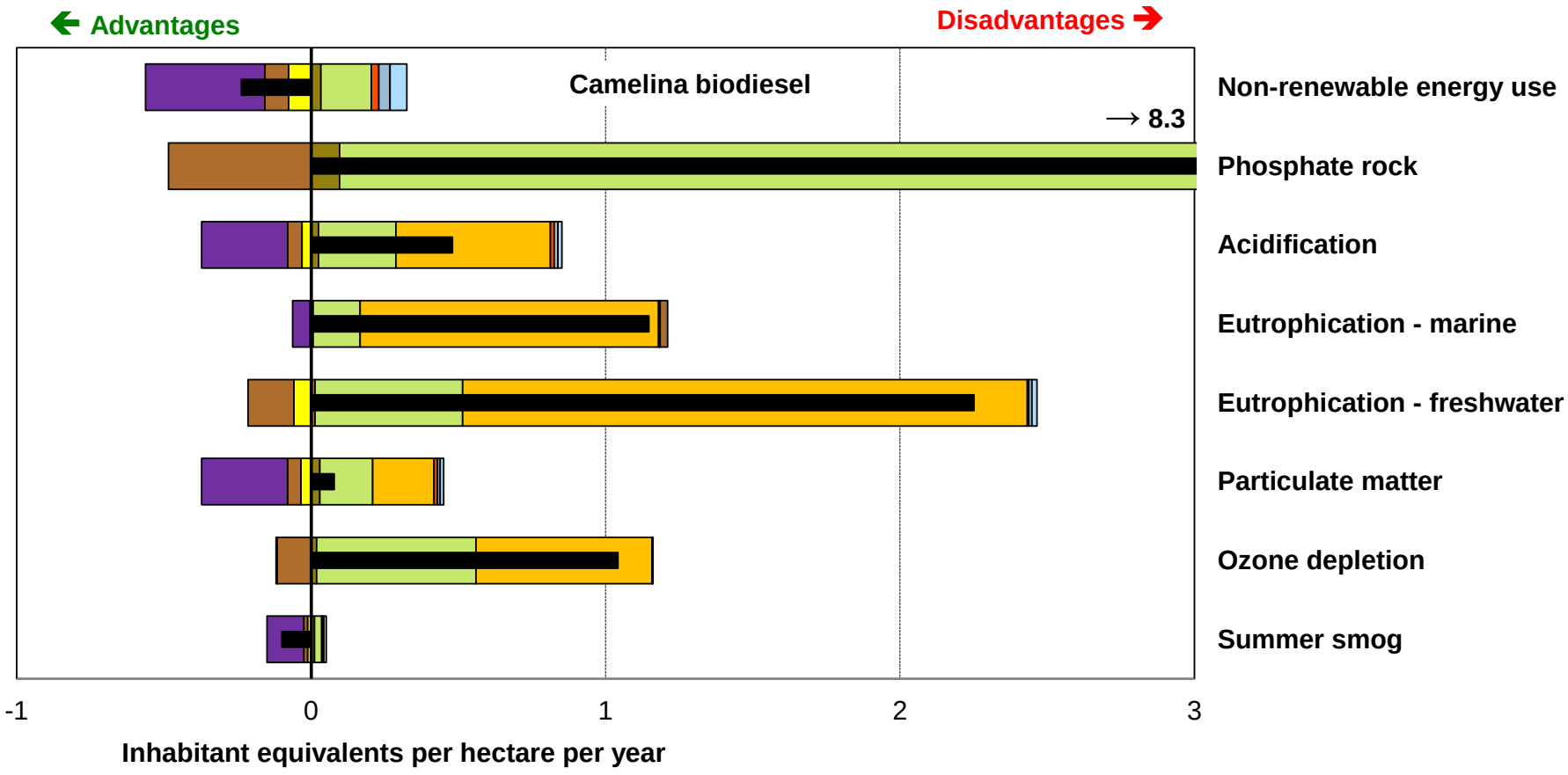
Displaced rapeseed | dLUC

Worst case | dLUC

Worst case internally optimised

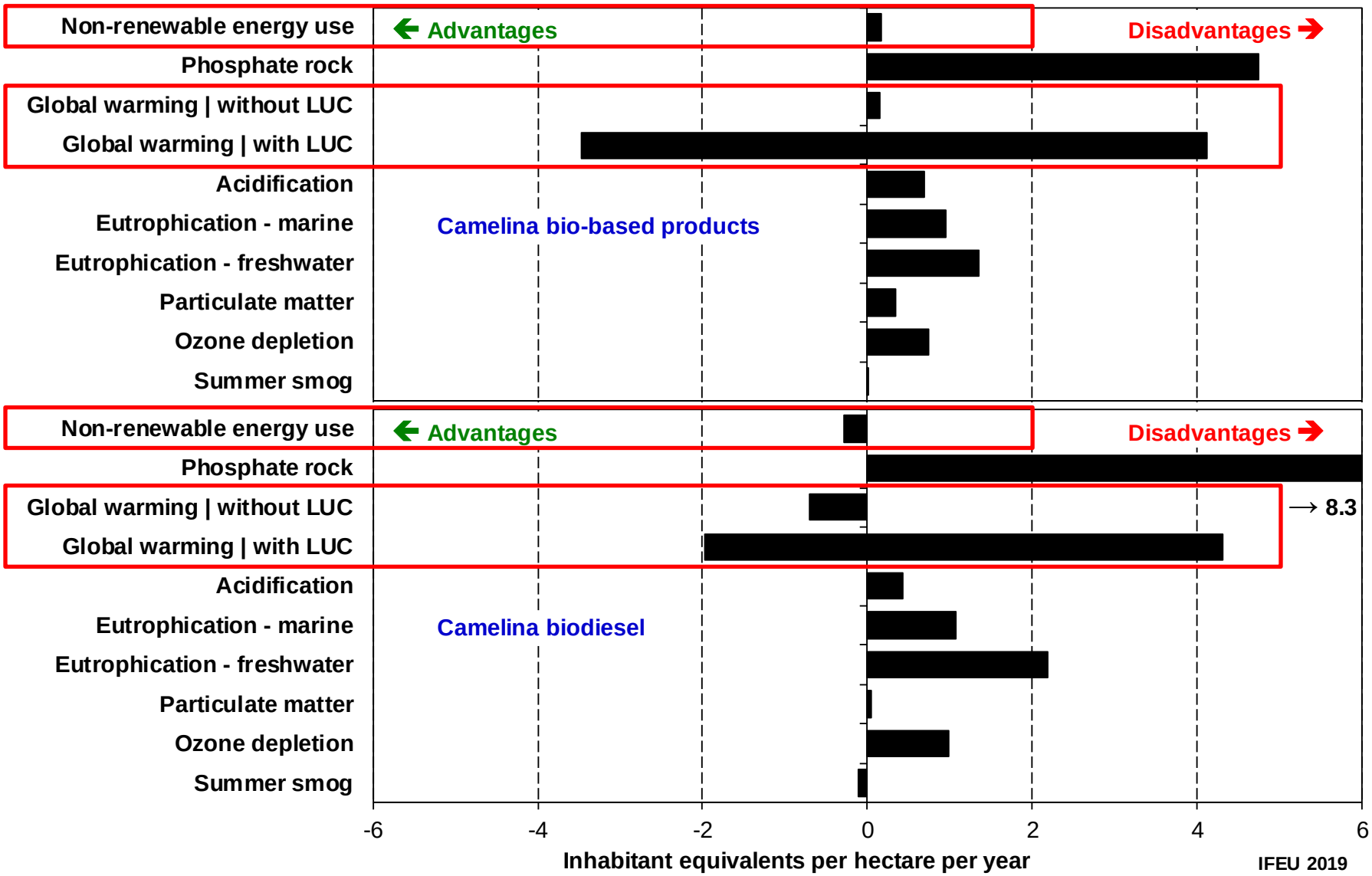
IFEU 2019

Biodiesel from camelina: Normalised LCA results, idle land, 2025



IFEU 2019

Camelina for bio-based products and biodiesel, normalised LCA results



IFEU 2019

Agenda

1. Introduction
2. Camelina & crambe for bio-based products (COSMOS)
3. Camelina & crambe for biofuels
4. Conclusions

Conclusions


1. **Bio-based products from camelina & crambe tend to show environmental disadvantages compared to conventional equivalent products**
   - due to substitution of bio-based products from perennial crops / leguminous crops. These are tough nuts to crack!
   - There is a significant potential for advantages regarding GHG emission savings and land use impacts on biodiversity, but it is uncertain.
2. **Biofuels from camelina & crambe show the same pattern of environmental advantages & disadvantages known from other biofuels**
   - Due to substitution of petroleum-based products
3. **Domestic camelina & crambe *can* reduce pressure on rainforests…**
   - …through avoidance of protein feed and palm oil imports (rather than palm *kernel* oil or coconut oil)
   - …if the corresponding value chains are established in an efficient manner
   - …if they are cultivated without displacement of other crops

Conclusions


4. **LCA is a very suitable tool. However, since LCA is not (yet) able to address local environmental impacts, it needs to be supplemented by a separate life cycle environmental impact assessment (LC-EIA)*.**

5. **For a comprehensive sustainability assessment, economic and social aspects such as job creation, impacts on indigenous people etc. need to be taken into account, too, e.g. by an integrated life cycle sustainability assessment (ILCSA)**.**
   - **Social aspects and other arguments such as reduced import dependency might speak in favour of the COSMOS system**

* Kretschmer et al. (2012): Proceedings of the 20th EUBCE, Milan, Italy

** Keller et al. (2015): Applied Energy 154, 1072–1081, https://doi.org/10.1016/j.apenergy.2015.01.095

Acknowledgement

Part of this work has received funding from the European Union's Horizon 2020 research and innovation programme:

- **COSMOS** project
  under grant agreement no. 635405
- **MAGIC** project
  under grant agreement no. 727698

INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

Acknowledgement: The COSMOS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 635405.

Acknowledgement: The MAGIC project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 727698.

Thank you very much for your attention!

Nils Rettenmaier
nils.rettenmaier@ifeu.de

Wilckensstraße 3 69120 Heidelberg Phone +49-6221-4767 - 24 Fax +49-6221-4767 - 19 www.ifeu.de