

Environmental Impacts of Biobased Products Compared to Conventional Ones - An Overview -

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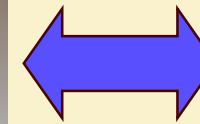
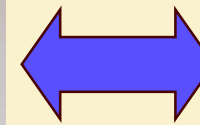
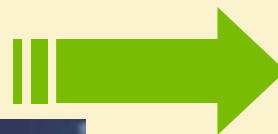
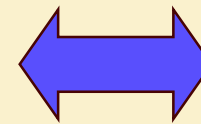
ifeu - Institute for Energy and Environmental Research Heidelberg

Non-Food Crops: From Agriculture to Industry

Bologna, Italy, May 15 - 16, 2003



Products from industrial crops compared to conventional ones



Products from industrial crops

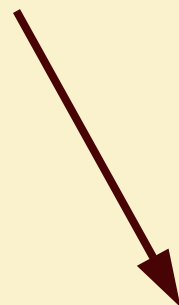
Environmental advantages and disadvantages:

+

- CO₂ neutral
- Save energetic resources
- Biodegradable
- Less transport
- etc.

-

- Land use
- Eutrophication of surface water
- Water pollution by pesticides
- Energy intensive production
- etc.

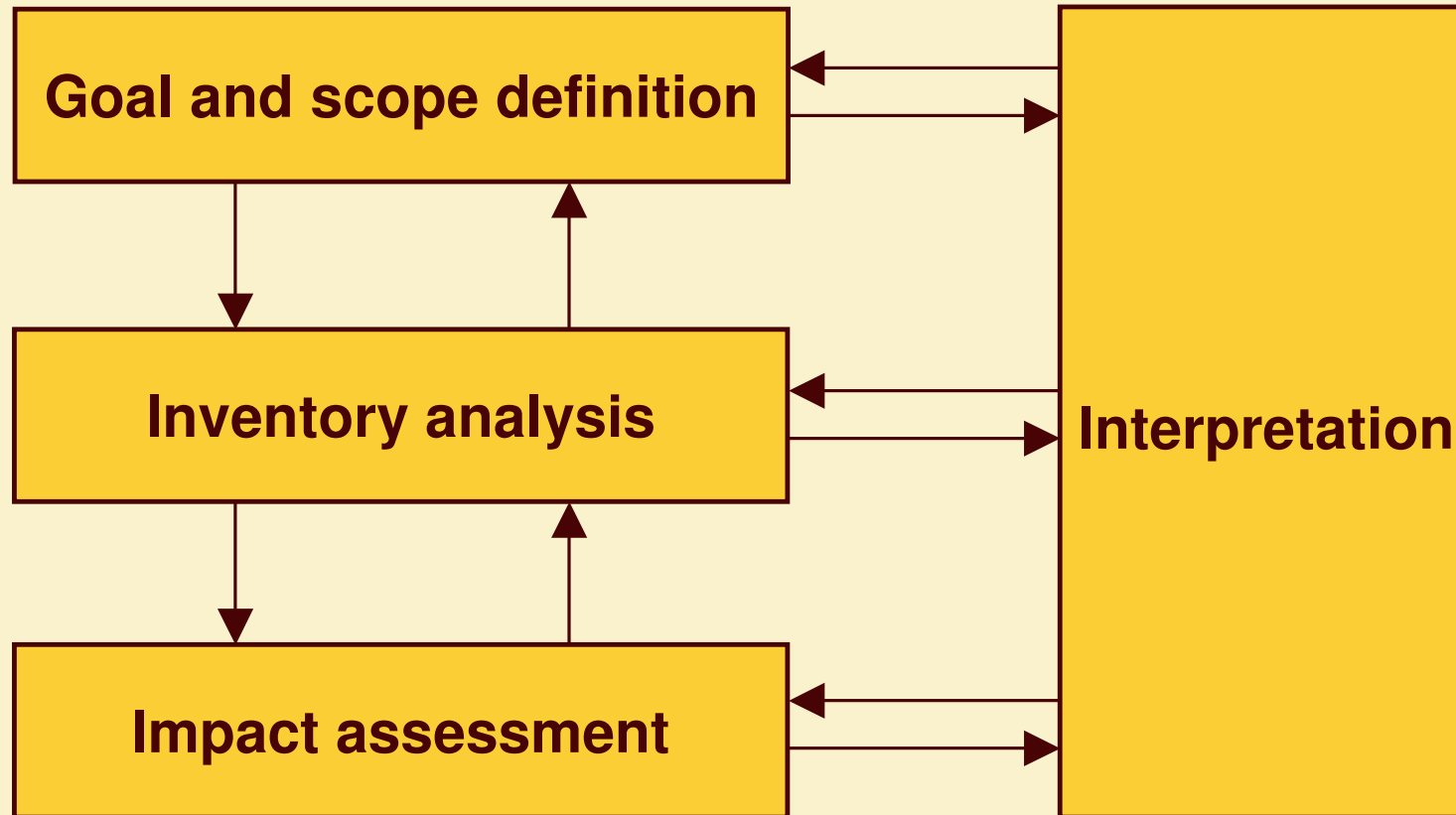


Total:
positive or negative

?

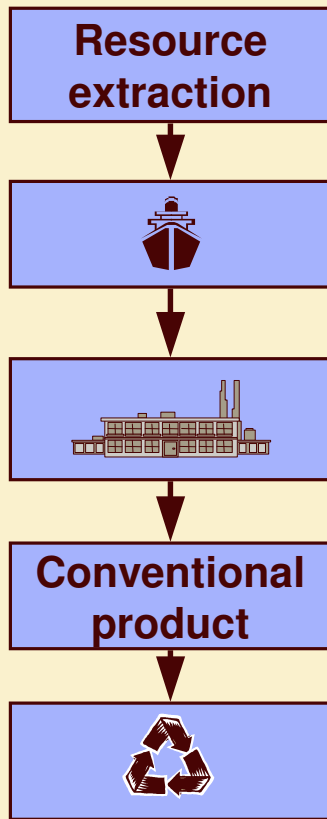
Life cycle analysis (LCA)

ISO 14040-43



Goal and Scope definition

Conventional production system



Raw material production

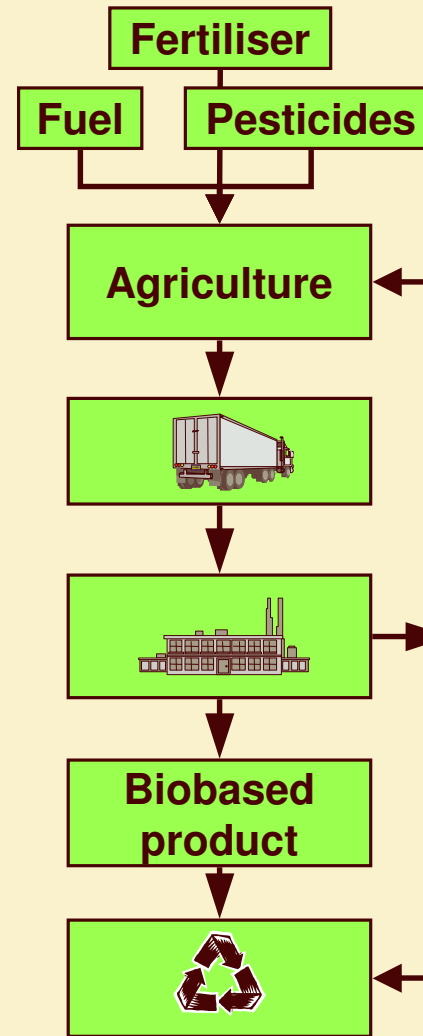
Transport

Processing

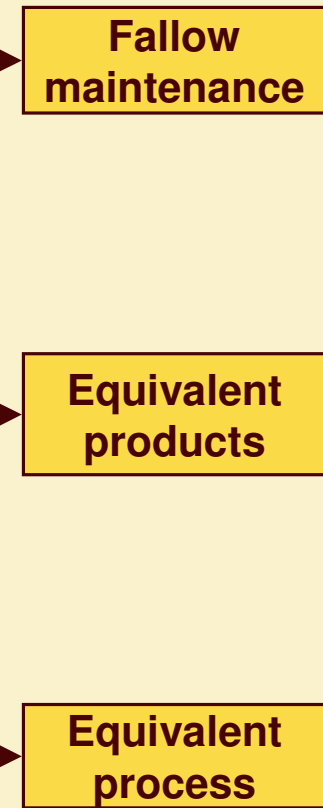
Utilisation

Disposal

Biobased production system



Environmental credits for the biobased product



Hydraulic oil from rape seed

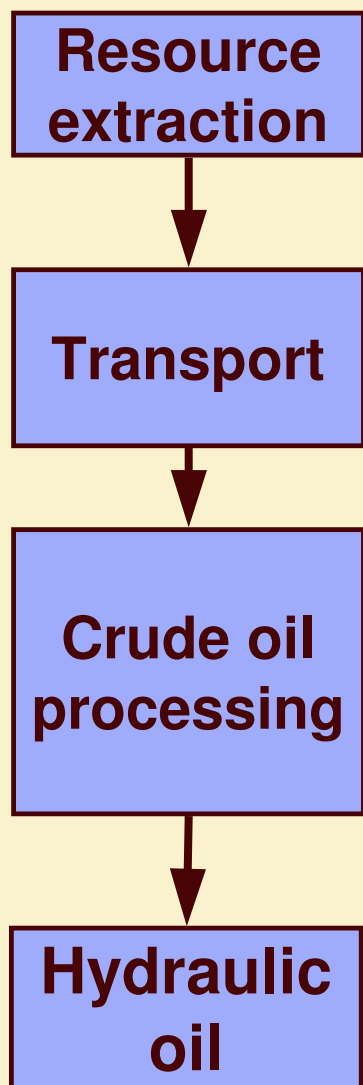
compared to

conventional hydraulic oil

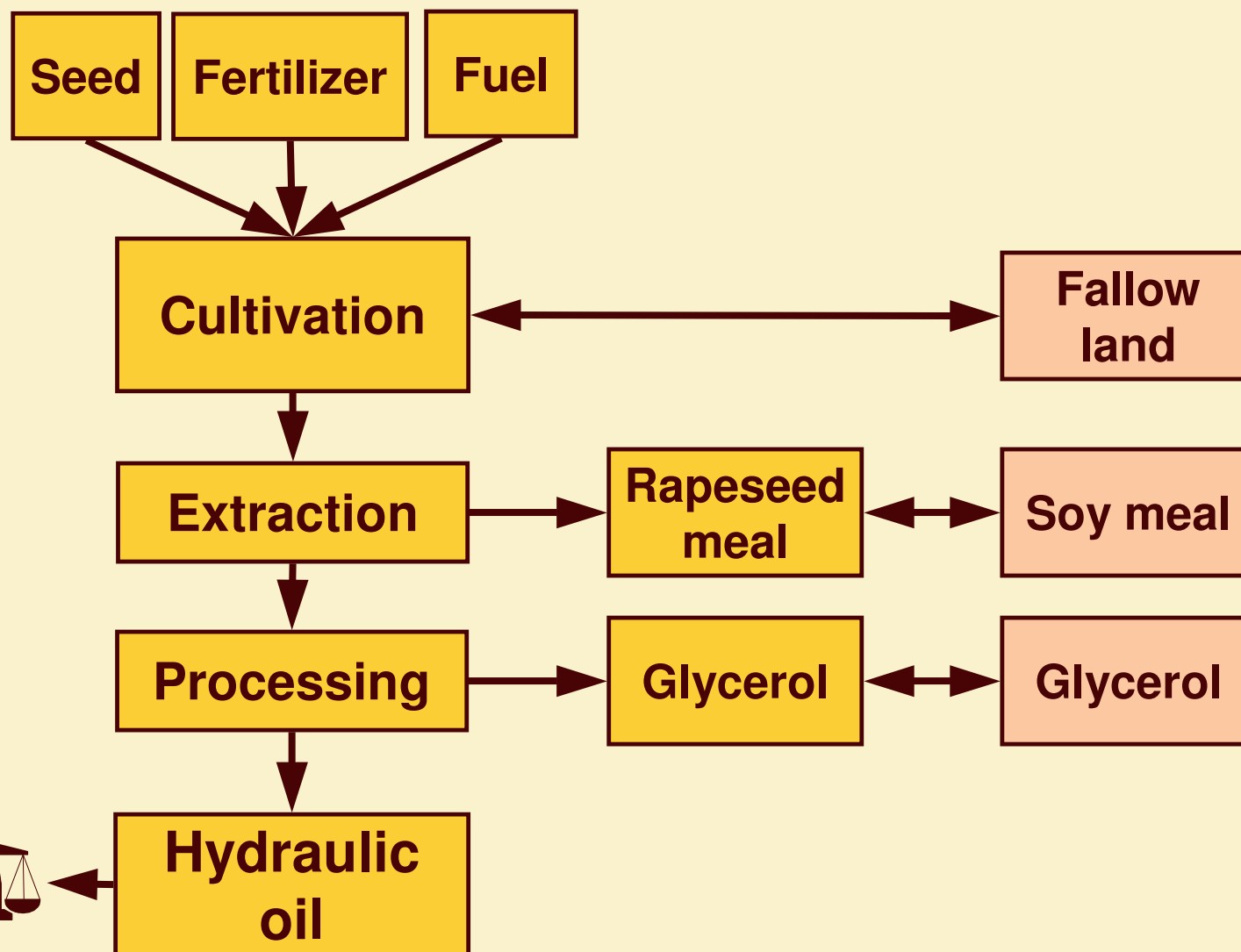


Hydraulic oil – life cycle

conventional



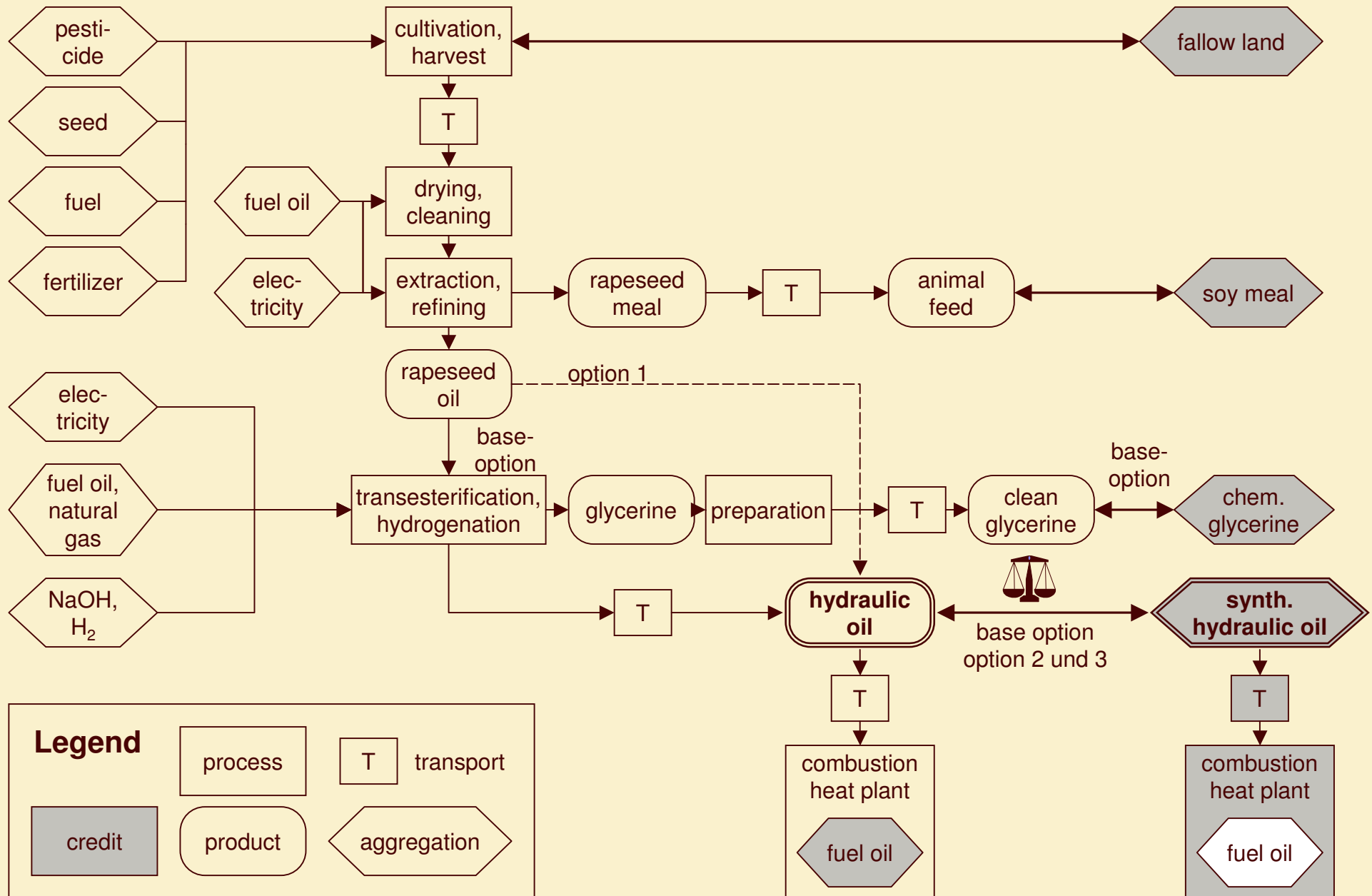
from rapeseed



credits



Hydraulic oil – life cycle

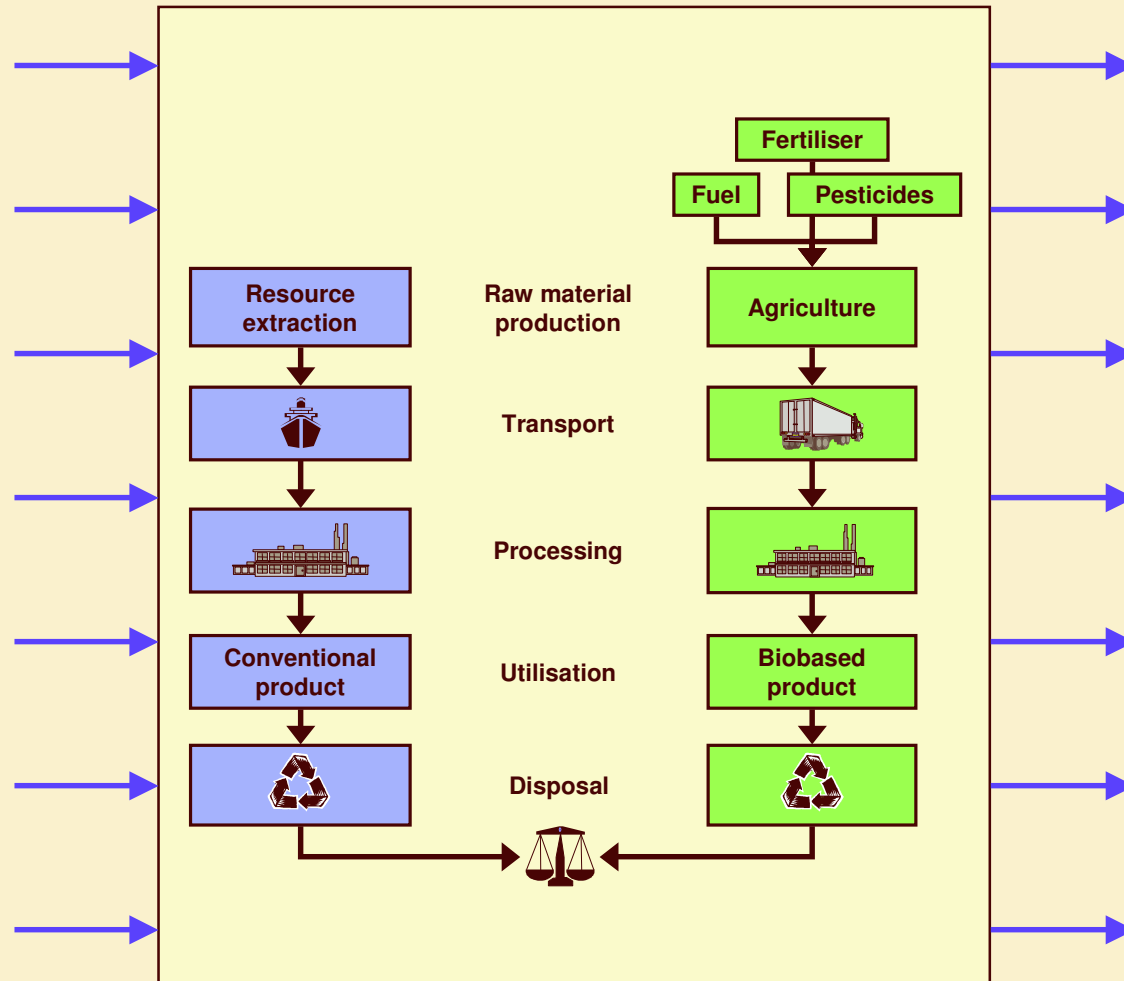


LCA: Inventory analysis

Inputs

e.g.:

- natural gas
- crude oil
- brown coal
- hard coal
- uranium
- water



Outputs

e.g.:

- CO₂
- SO₂
- CH₄
- NO_x
- NH₃
- N₂O
- HCl
- CO
- C₆H₆
- VOC



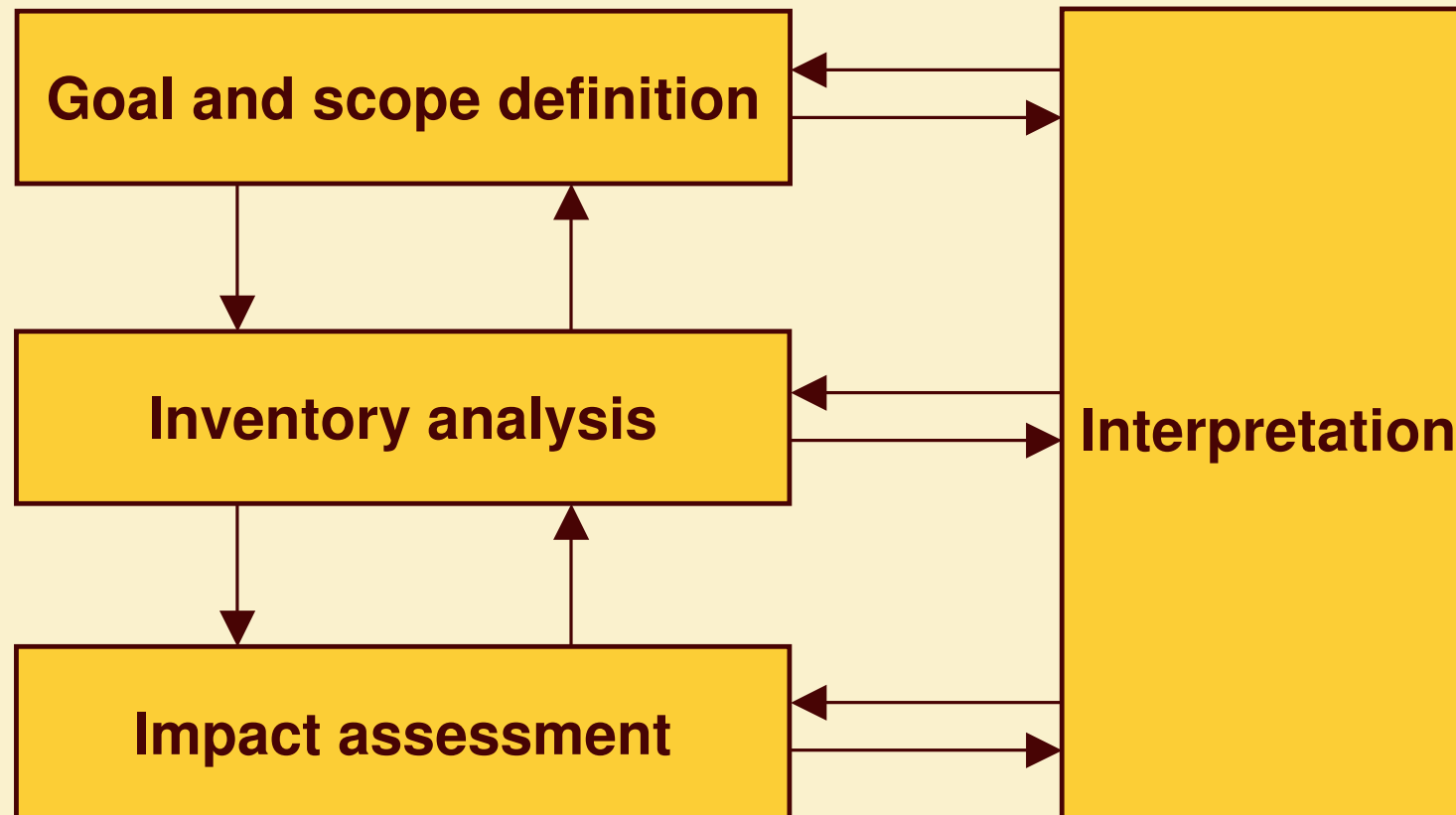
Life Cycle Inventory (LCI)

Inventory parameters	Unit	Rapeseed oil	Rapeseed oil
		Standard	Modified
per (ha·a)			
Crude oil	MJ	-62.279	-71.783
Natural gas	MJ	5.697	6.052
Hard coal	MJ	313	-1.768
Lignite	MJ	-148	-2.589
Urane	MJ	-74	-2.530
Water	MJ	7	-309
Chalk	kg	45	81
Raw phosphate	kg	126	228
Sulfur	kg	8	15
Potassium	kg	811	1.475
Rock salt	kg	0	0
Clay	kg	0	0
CO2 (fossile)	kg	-3.987	-4.847
CH4	kg	1	0

Inventory parameters	Unit	Rapeseed oil	Rapeseed oil
		Standard	Modified
per (ha·a)			
N ₂ O	kg	5	5
SO ₂	kg	2	4
NO _x	kg	5	22
HCl	g	-10	131
NH ₃	kg	4	7
CO	kg	2	6
NMHC	g	-2.044	-2.145
Diesel particulate	g	-405	-417
Dust	g	-362	761
Formaldehyde	g	29	70
Benzene	g	-30	17
Benzo(a)pyrene	mg	2	1
TCDD	ng	-394	-21

Life cycle analysis (LCA)

ISO 14040-43

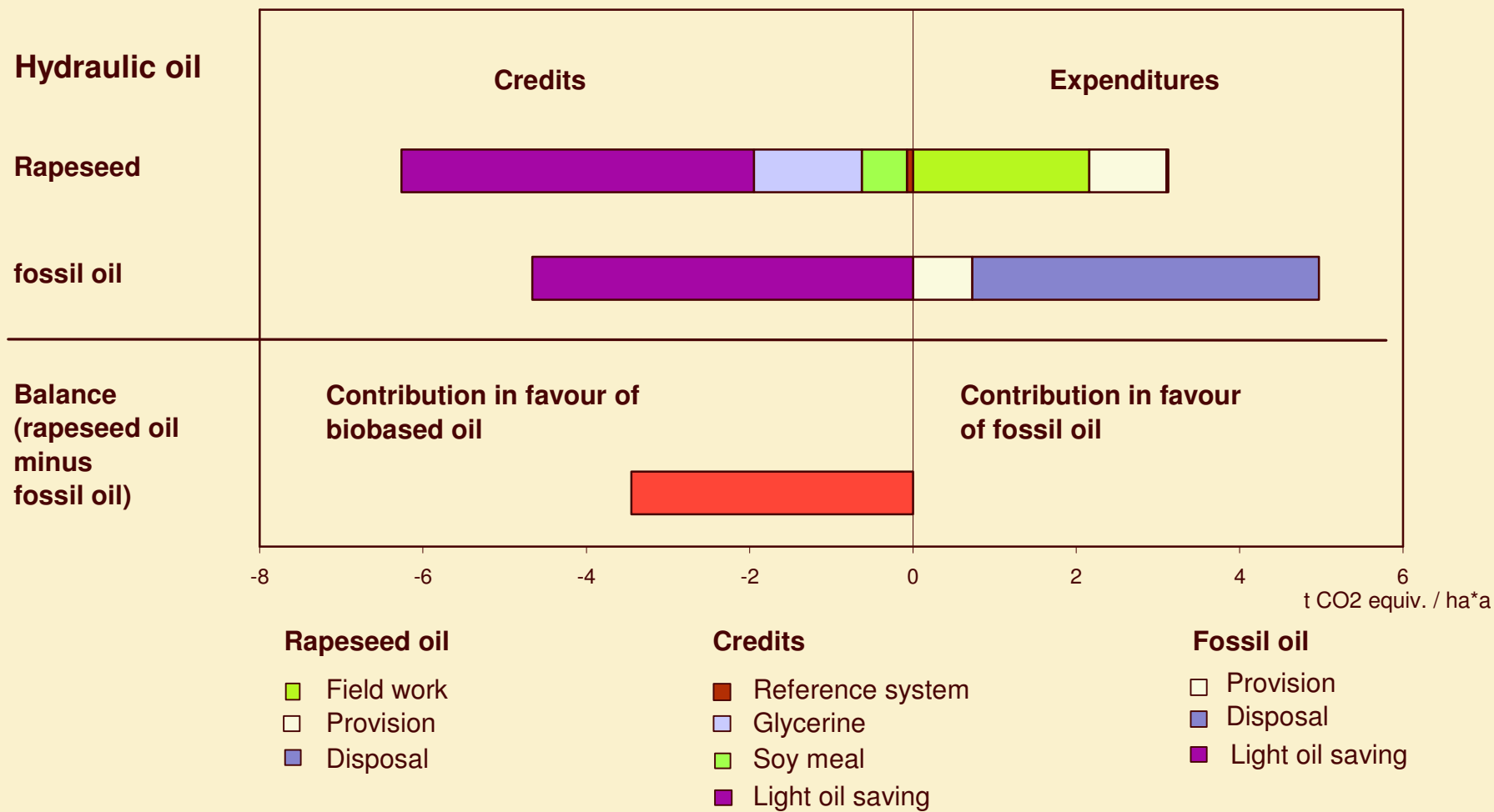


Impact assessment

Impact category	Parameter	Substances (LCI)
Resource demand	Cumulated finite energy demand	Crude oil, natural gas, coal, uranium ore , ...
	Mineral resources	Limestone, clay, metal ores, rock salt, pyrite, ...
Greenhouse effect	CO ₂ equivalents	Carbon dioxide, nitrous oxide, methane, HCFCs, CFCs, methyl bromide, ...
Ozone depletion		Nitrous oxide, HCFCs, CFCs, halons, methyl bromide, ...
Acidification	SO ₂ equivalents	Sulphur dioxide, hydrochloric acid, nitrogen oxide, ammonia, hydrofluoric acid, ...
Eutrophication	PO ₄ equivalents	Nitrogen oxides, ammonia, phosphate, nitrate
Summer smog	Ethene equivalents	Hydrocarbons, nitrogen oxides, carbon monoxide, HCCs, ...
Human and eco toxicity		Nitrogen oxide, carbon monoxide, hydrochloric acid, diesel particulate, dust, ammonia, benzene, benzo-a-pyrene, sulphur dioxide, Dioxines (TCDD), ...

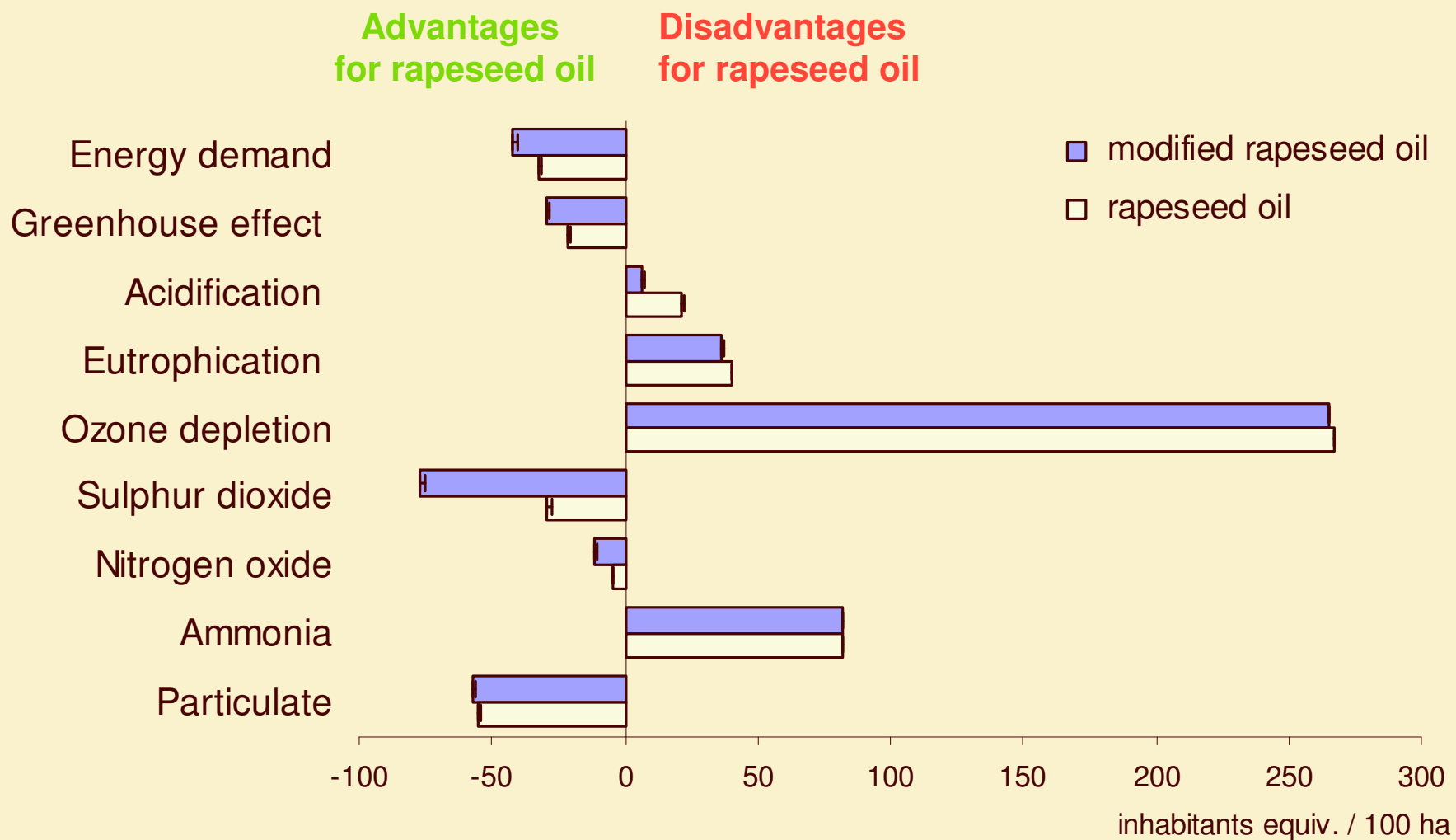


Hydraulic oil – Greenhouse effect





Rapeseed oil – environmental effects



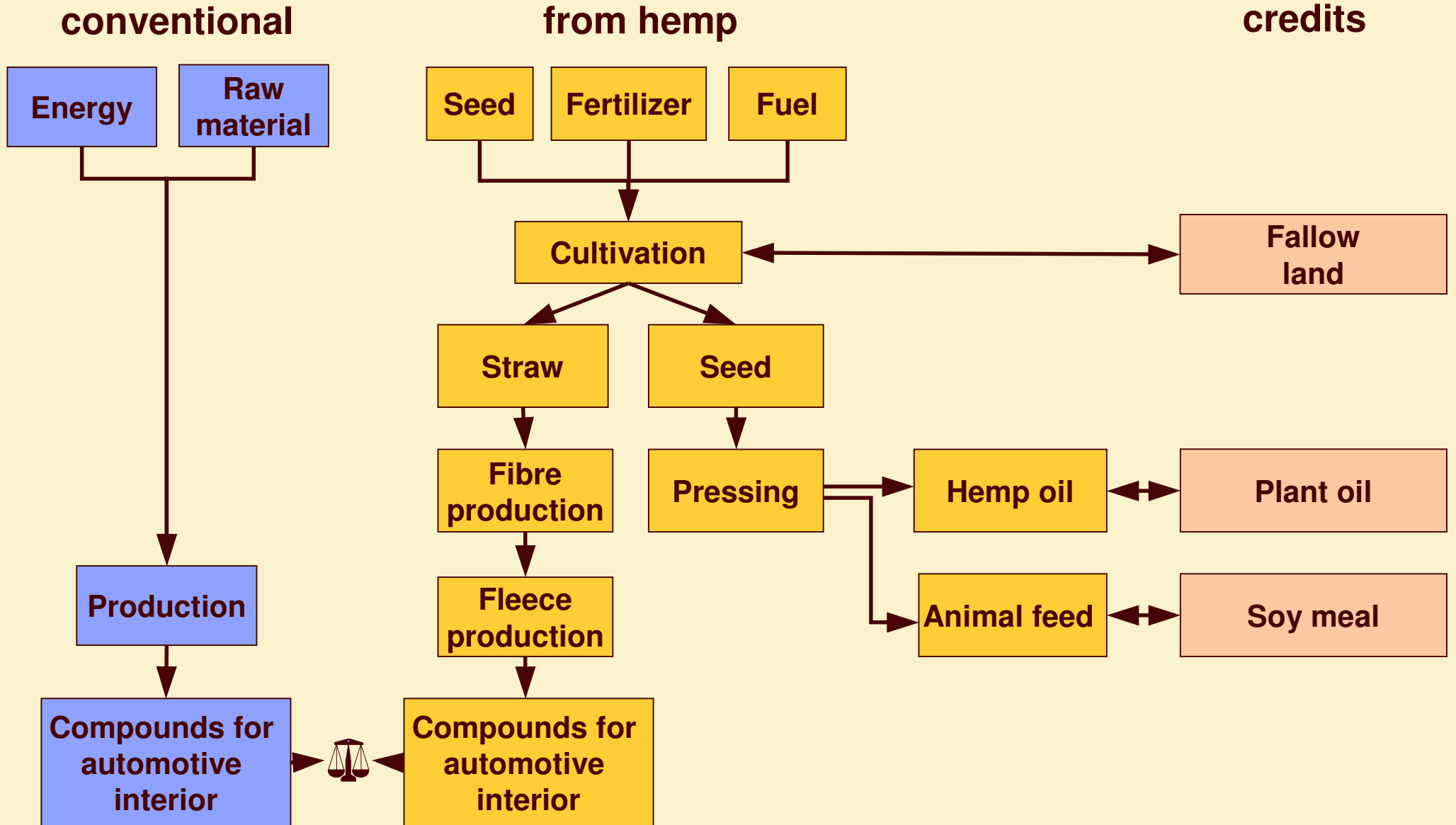
**Automotive interior from
hemp compound**

compared to

conventional polymer

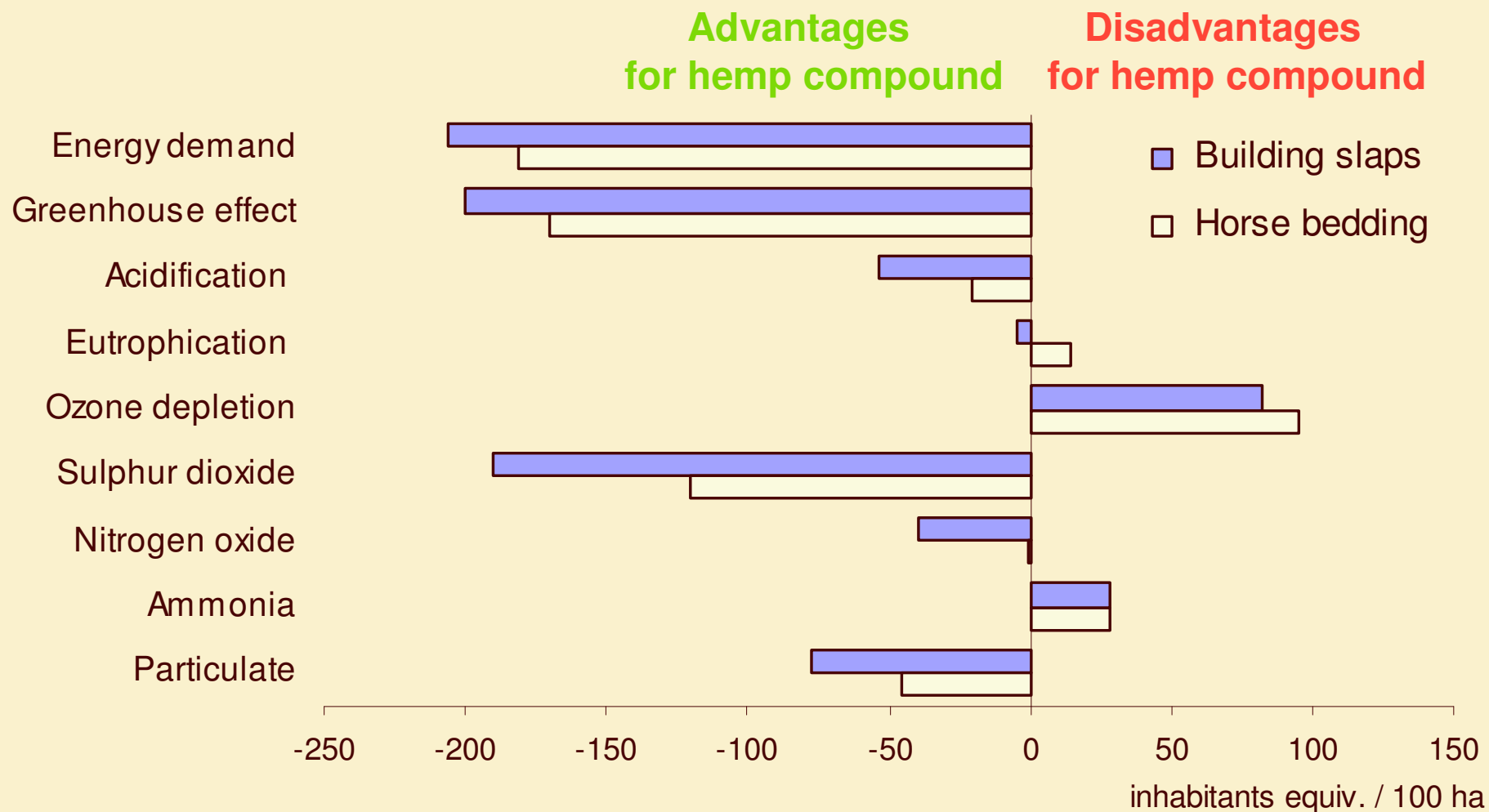


Automotive interior – life cycle



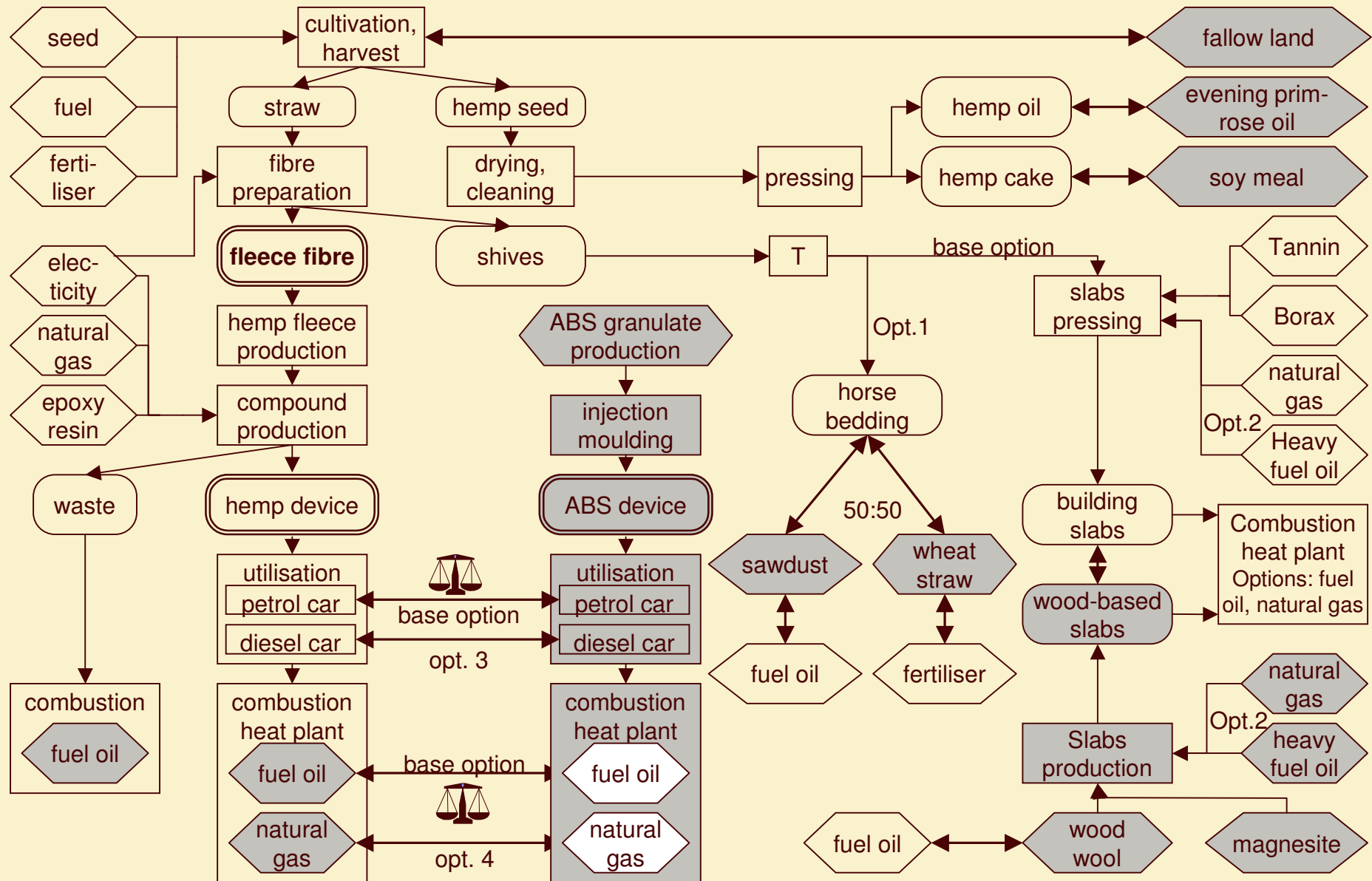


Hemp compound – environmental effects

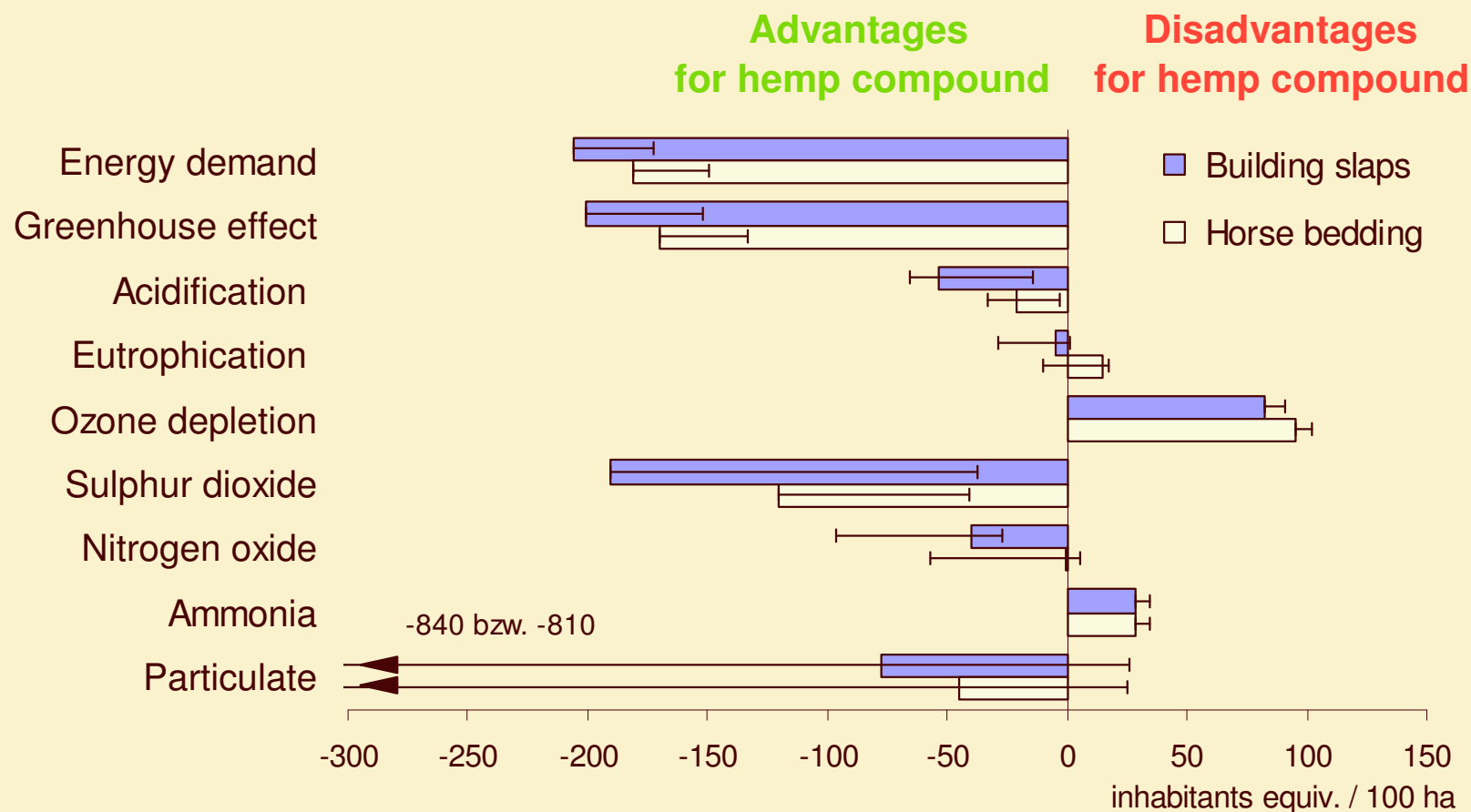




Automotive interior – life cycle



Hemp compound – environmental effects



Scenaria

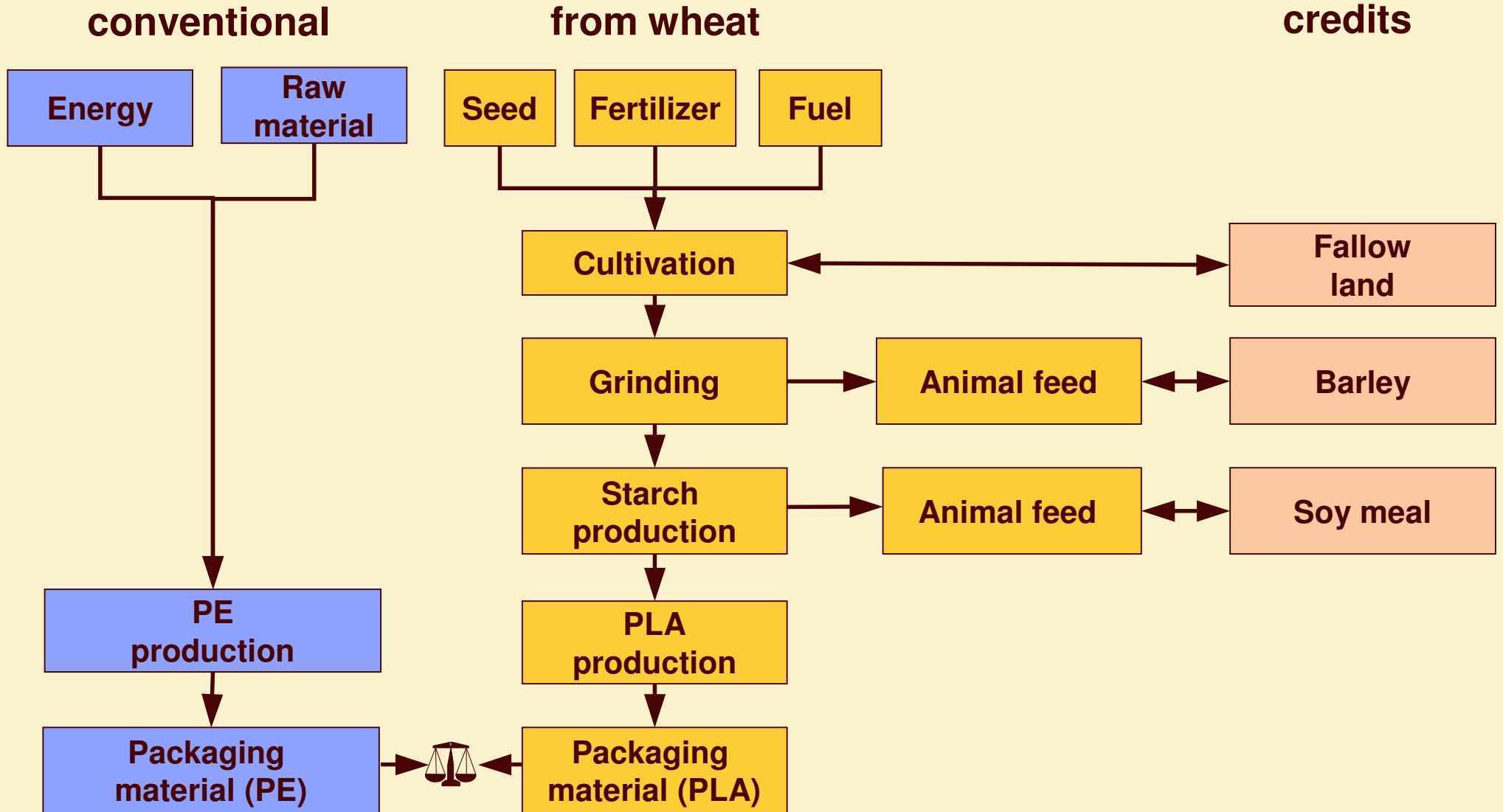
- use of the shives as animal bedding
- drying of lightweight building slabs by natural gas
- use of the product in diesel engines
- use of the product with disposal of the product replacing natural gas

Packaging material from wheat

compared to

conventional polymer

Packaging material – life cycle

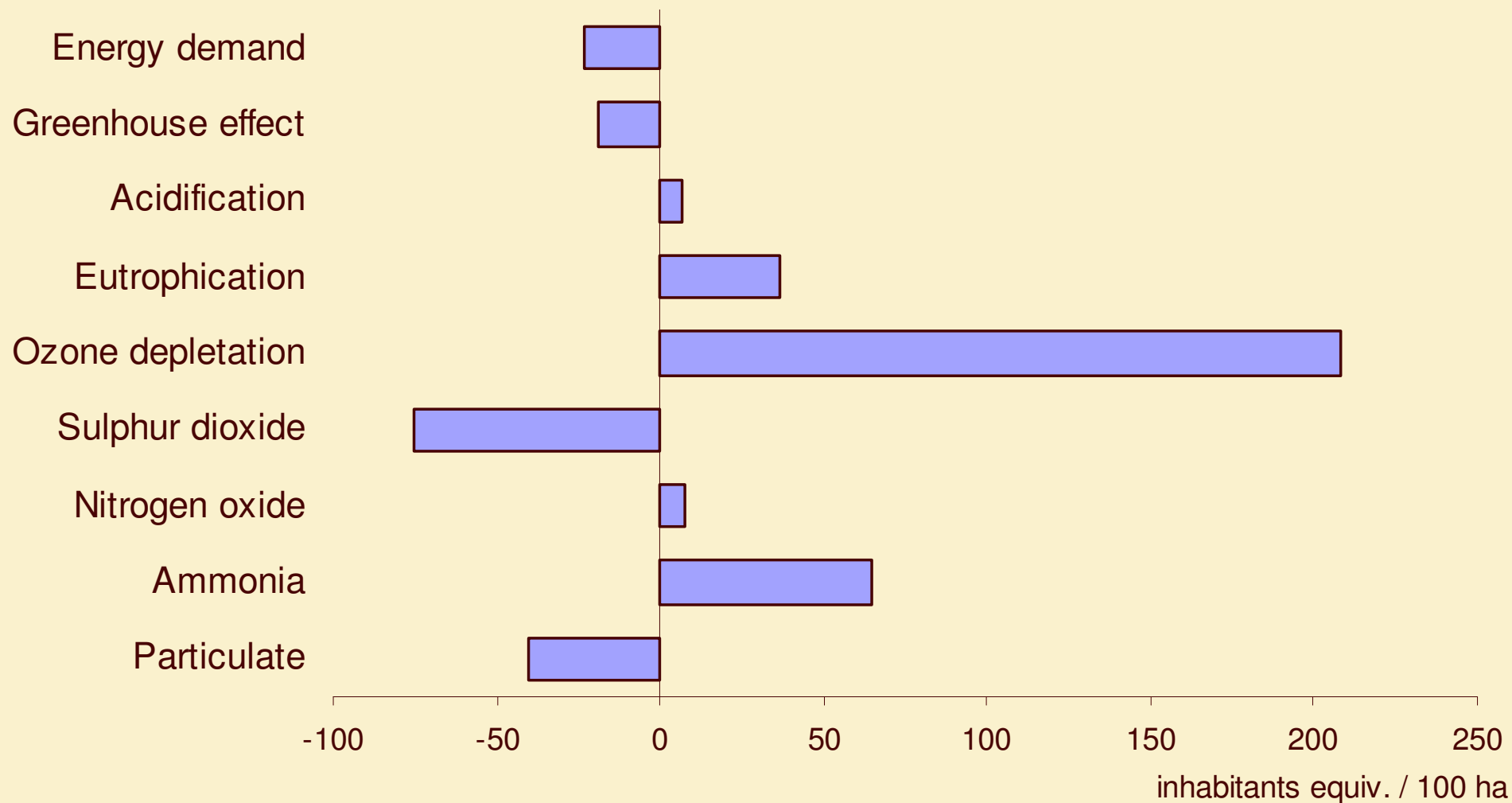




Wheat PLA – environmental effects

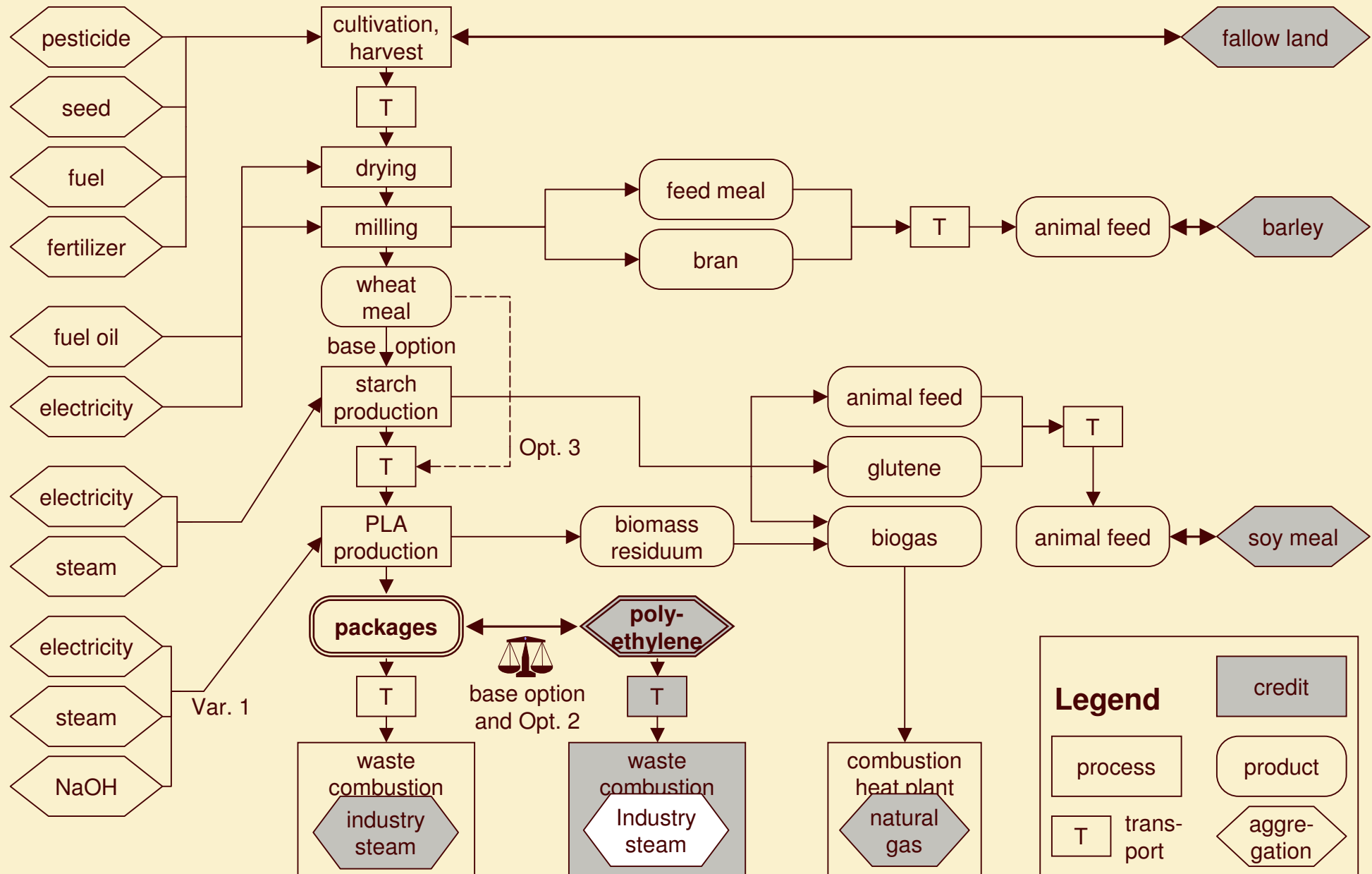
Advantages for wheat

Disadvantages for wheat



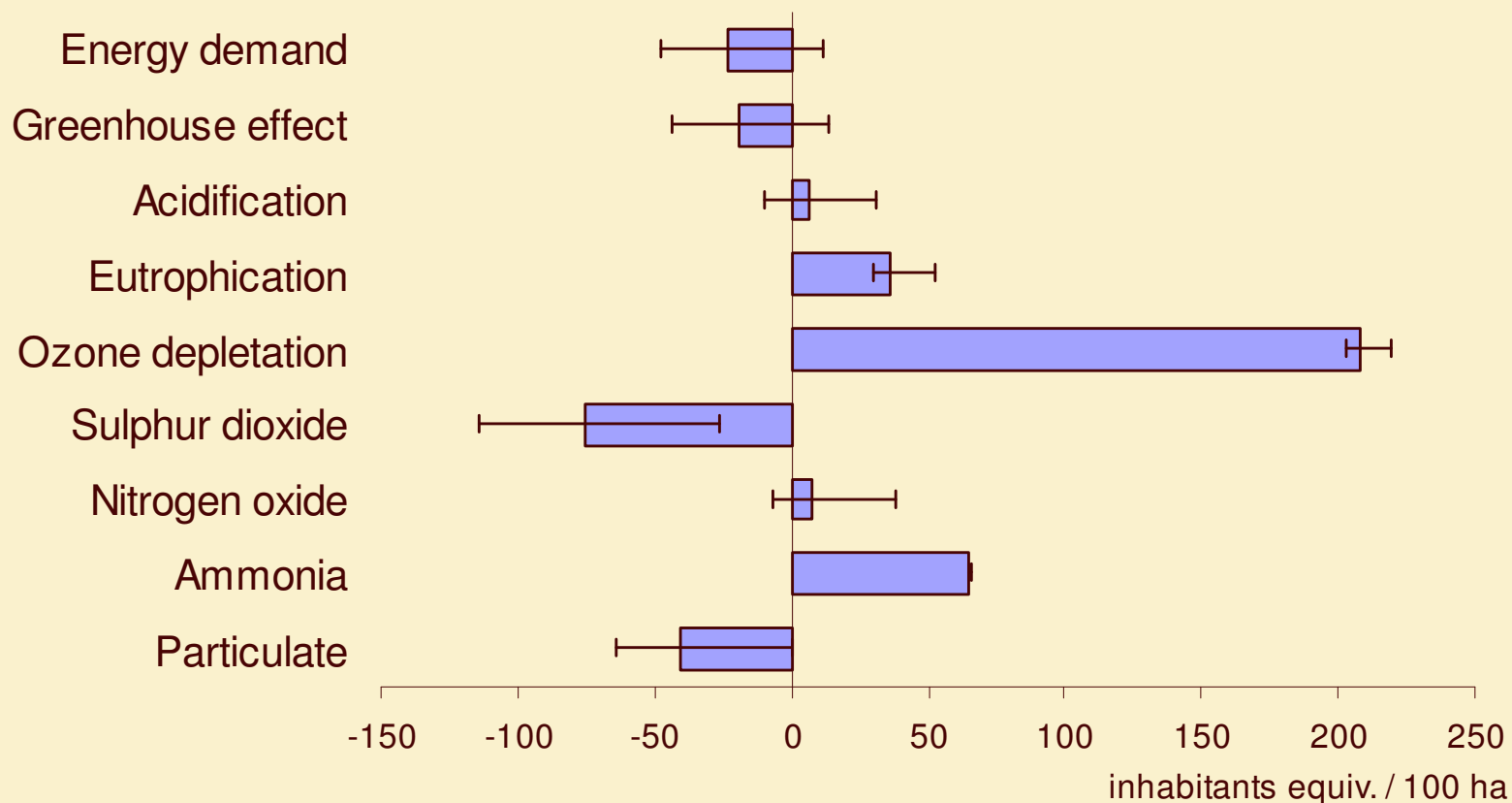


Packaging material – life cycle



Wheat PLA – environmental effects

Advantages for wheat Disadvantages for wheat



Scenaria

- double / half the energy demand for PLA production
- more / less weight of the reference product
- direct utilisation of wholemeal wheat
- conventional packaging from polypropylene instead of polyethylene

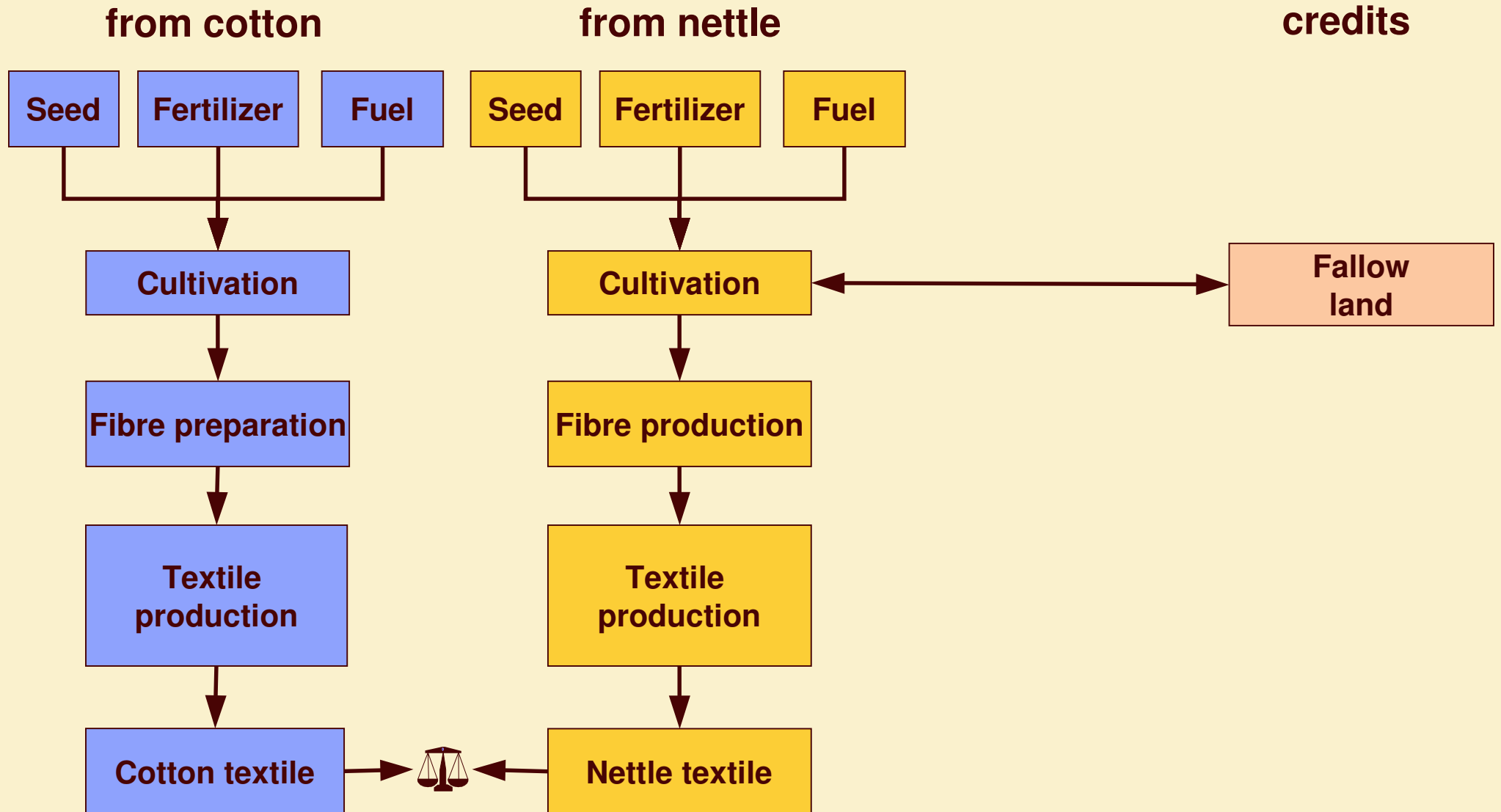
Nettle textile



compared to

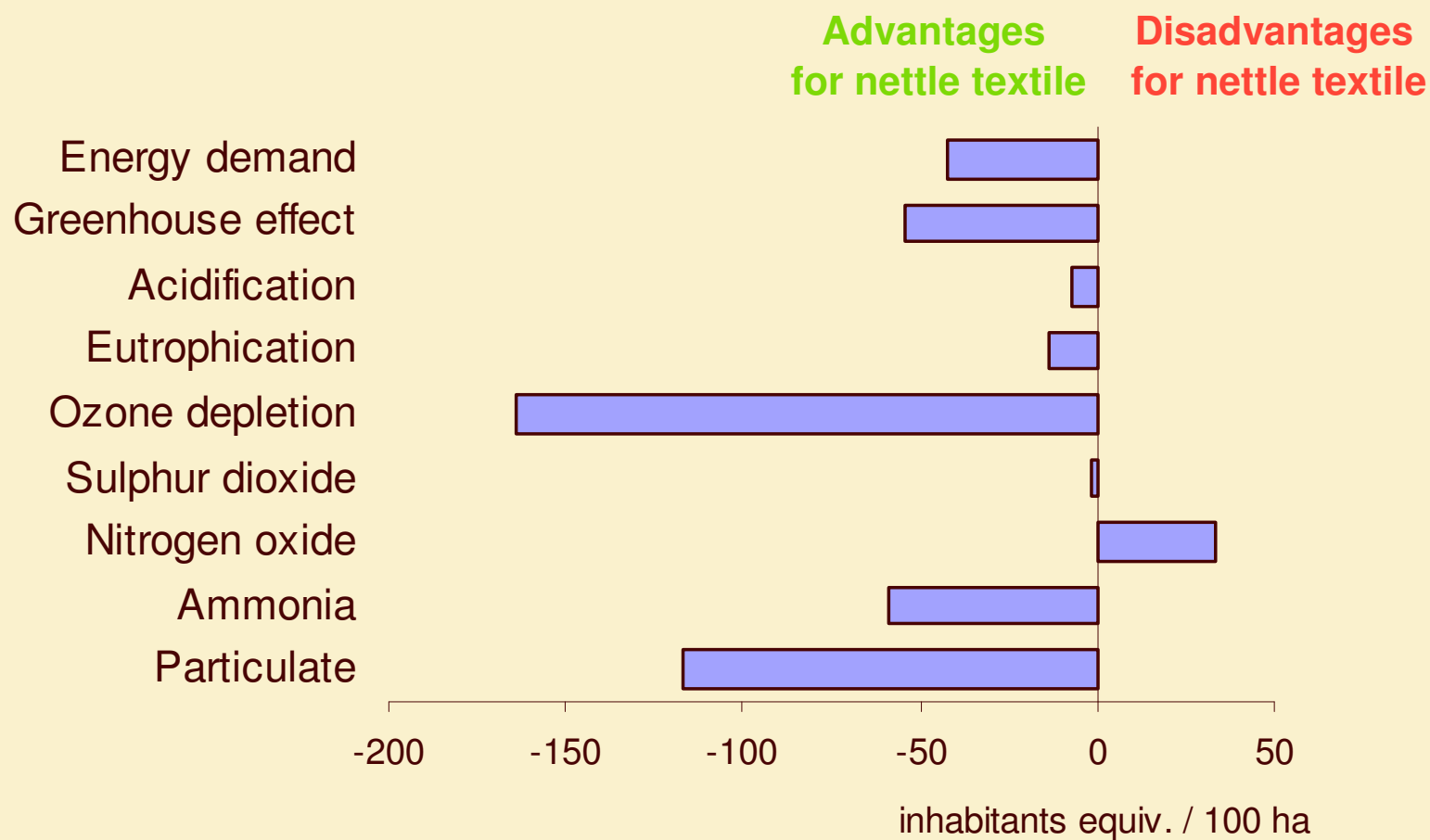
Cotton textile

Textile – life cycle

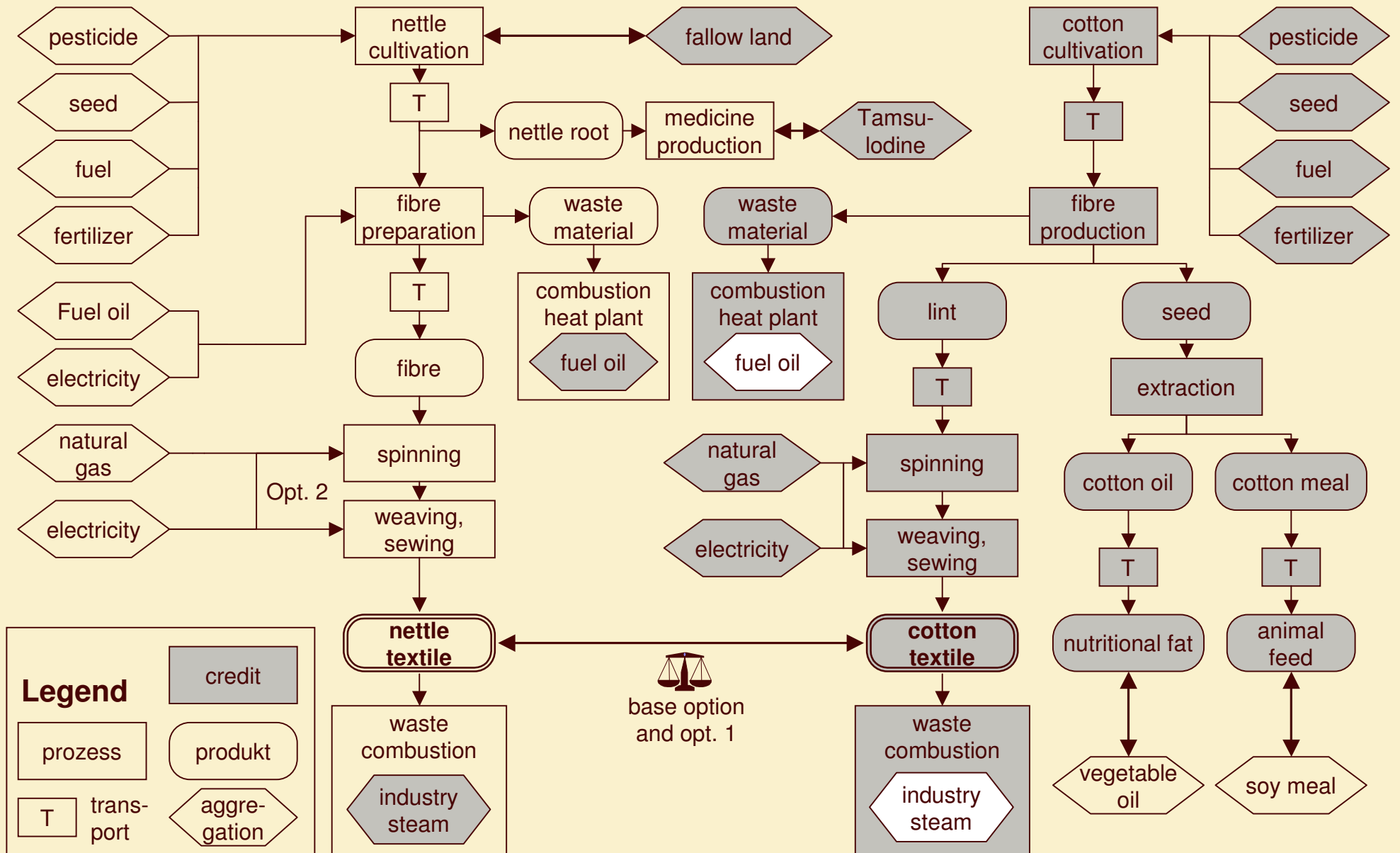




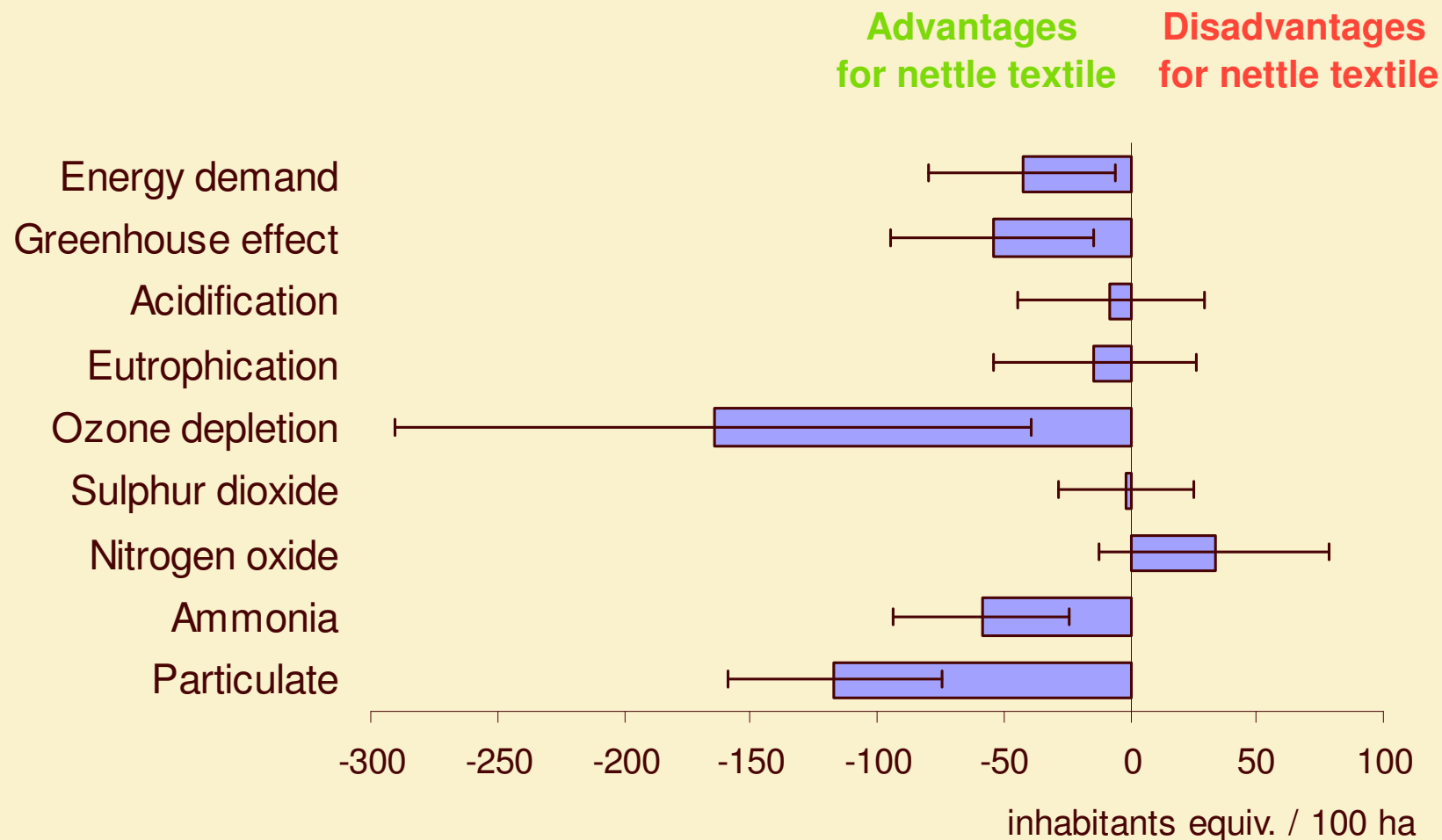
Nettle textile – environmental effects



Textile – life cycle



Nettle textile – environmental effects



Scenaria

- more / less durability of nettle versus cotton
- more / less energy demand for production

Results

- In many cases, biobased products save fossil energy resources and greenhouse gases compared to conventional products.
- But often, this comes along with certain environmental disadvantages, especially acidification, eutrophication or ozone depletion.
- Biodegradability is by no means a synonym for being environmental friendly.

Conclusions

- Due to new, quickly developing technologies, in certain cases the results depend heavily on the process conditions.
- The utilisation phase may constitute the part of the life cycle with the largest impact.
- Co-products are in many cases important factors for the advantage of a product from industrial crops.

Conclusions

- No general conclusions for all industrial crops in contrast to biofuels
- No general conclusions neither for any industrial crop nor for any biobased material as the total life cycle results depend strongly on
 - ❖ agricultural production
 - ❖ usage pattern of biobased products
 - ❖ use of byproducts
 - ❖ kind of disposal or reuse

Conclusions

- LCA is a powerful tool to determine the environmental implications associated with biobased products compared to conventional products.
- It helps to point out the environmental bottlenecks and helps to optimise the whole life cycles especially highlighting
 - ❖ agricultural production
 - ❖ usage pattern of biobased products
 - ❖ use of byproducts
 - ❖ kind of disposal or reuse

to optimise the environmental benefits and minimise the negative implications.



Thank you – Mille grazie !



Sven Gärtner



Guido Reinhardt