INSTITUT FÜR ENERGIE-
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Key findings of LCA study on Tetra Recart

Study title: Comparative Life Cycle Assessment of shelf stable canned food packaging

commissioned by Tetra Recart AB

Stefanie Markwardt & Frank Wellenreuther

Institute for Energy and Environmental Research, Heidelberg, Germany

December 2017

Who is ifeu?

ifeu – Institute for Energy and Environmental Reserach …

…founded in 1978 by a group of scientists from the University of Heidelberg.

Today…

…ifeu is an independent non-profit ecological research institute without any party political and economical influence. Financing solely project-bounded means orders 2/3 from public sector 1/3 from private enterprises.

An important part of the institute…

… is the commitment of its employees to a sustain-able society.

Clients…

… ... include international institutions, federal and state ministries and agencies, governments, well-known companies, business associations, NGOs, public utilities, transport and logistics service providers.

Research and consulting for a sustainable society

70 Scientists working on

Resource protection and waste
Development of policies for a circular economy and assessment of practical recycling solutions and its ecological benefits.

Energy
Evaluation of technologies, development of strategies and policies for a sustainable and efficient energy system , development of climate action plans

Food and Biomass
Environmental assessment and sustainability analyses of foodstuffs, animal feed, bioenergy and all aspects of renewable raw materials from different biomass sources

Industry and Products
Environmental impact assessment, resource and risk analysis of products, processes, technologies, sustainable urban development

Mobility
Analysis of energy consumption and emissions from all motorised transport systems, evaluation of strategies designed to reduce the environmental impact of transport.

Industry and Products

Longstanding experience in

- Life Cycle Assessment (LCA) and GHG emission calculation
- development of methodologies and standards, e.g. German Federal Environment Agency (UBA) and ISO Standards for LCA

In recent years

- LCA of packaging systems and cooperation with packaging producers worldwide
- special focus on beverage packaging systems including many LCA studies
- general environmental consultancy for Tetra Pak and ACE

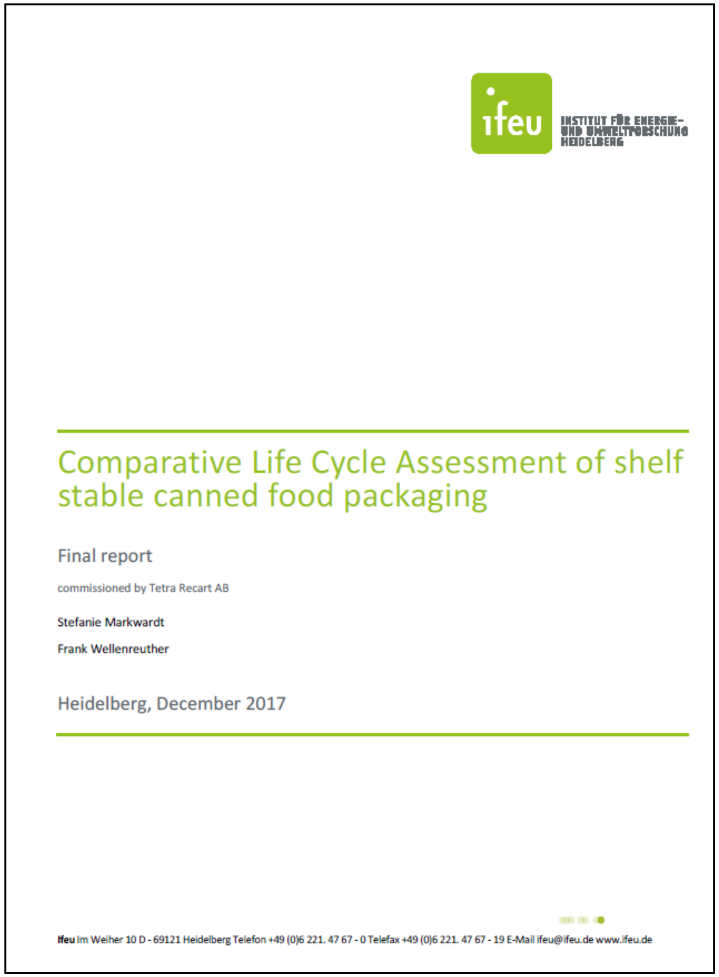
Neutral and independent

- Commissioned also by competitors like bottle or can producers
- Consultancy also for European Commission, ministries and agencies

Content

- Goal and Scope of the study
- Results Germany
- Results Italy
- Results scenario variants European market
- Conclusions and recommendations

Main objectives


Comparative Life Cycle Assessment of shelf stable canned food packaging

Final report

commissioned by Tetra Recart AB

Stefanie Markwardt
Frank Wellenreuther

Heidelberg, December 2017

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- Assessment of the environmental strengths and weaknesses of the Tetra Recart retortable carton.
- Comparison of the environmental performance of Tetra Recart with those of its competing packaging systems in the packed food segment on the markets **Germany, Italy, EU 28+2**.
- Provision of quantitative data to substantiate that the environmental profile is a key sales argument for Tetra Recart, to be used in external communication including comparative claims.
- This study is performed in compliance with the ISO framework on LCA (ISO 14040 and ISO 14044).

LCA framework according to ISO 14040/44

Goal and scope definition

- Functional unit
- System boundaries
- Data requirements

Inventory analysis

- Data gathering and selection
- System model
- Databases

Impact assessment

- Selection of impact categories and indicators
- Quantification of the environmental impacts

Interpretation

- Determination of significant issues
- Evaluations (sensitivity, completeness, consistency)
- Conclusions

Critical review panel of LCA Tetra Recart

Manfred Russ, thinkstep (Germany)

Leigh Holloway, Eco3Design Ltd (United Kingdom)

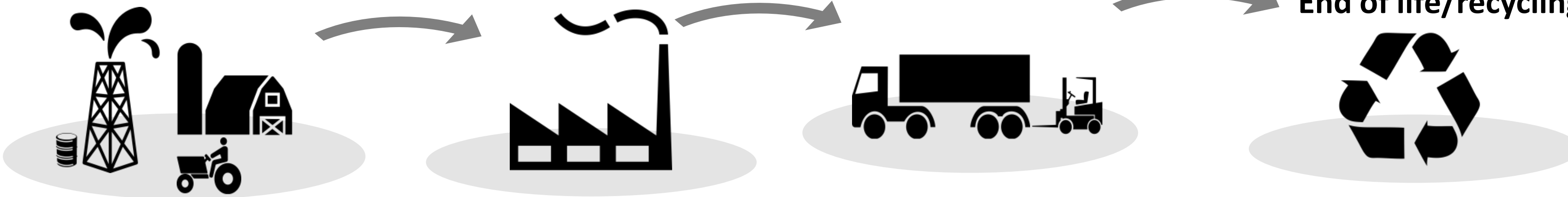
Gian Luca Baldo, Life Cycle Engineering (Italy)

Publication of LCA

System boundaries

'Cradle-to-grave' LCA

Raw materials → **Manufacturing** → **Distribution** → **End of life/recycling**



Raw materials	Manufacturing	Distribution	End of life/recycling
Wood → carton; tray Oil → Polymers Bauxite → Aluminium	Converting Filling	Transport to point of sale	Waste collection and sorting Recycling Incineration, landfilling
Emissions	Emissions	Emissions	Emissions

Environmental impact categories, examples:

- Climate Change / Global Warming Potential (CO_2 equivalents)
- Terrestrial / Aquatic Eutrophication (PO_4 equivalents)
- ...

System boundaries: cradle-to-grave

Included life cycle elements

Base materials	• Extraction, production, converting and transport of the primary base materials used in the primary packaging elements (including chemicals, additives)
Conver-ting	• Converting and transport of primary packaging elements (including closure and label)
Transport packaging	• Production, converting and transport of transport packaging (i.e. stretch foil, pallets, cardboard trays)
Filling	• Transport of materials to filler and filling processes
Distibu-tion	• Transport from fillers to potential central warehouses and final distribution to the point of sale
Recycling & disposal	• Sorting, recycling and disposal processes for primary packaging and transport packaging (including energy recovery)
Credits	• Credits for energy recovery (replacing e.g. grid electricity) and material recycling

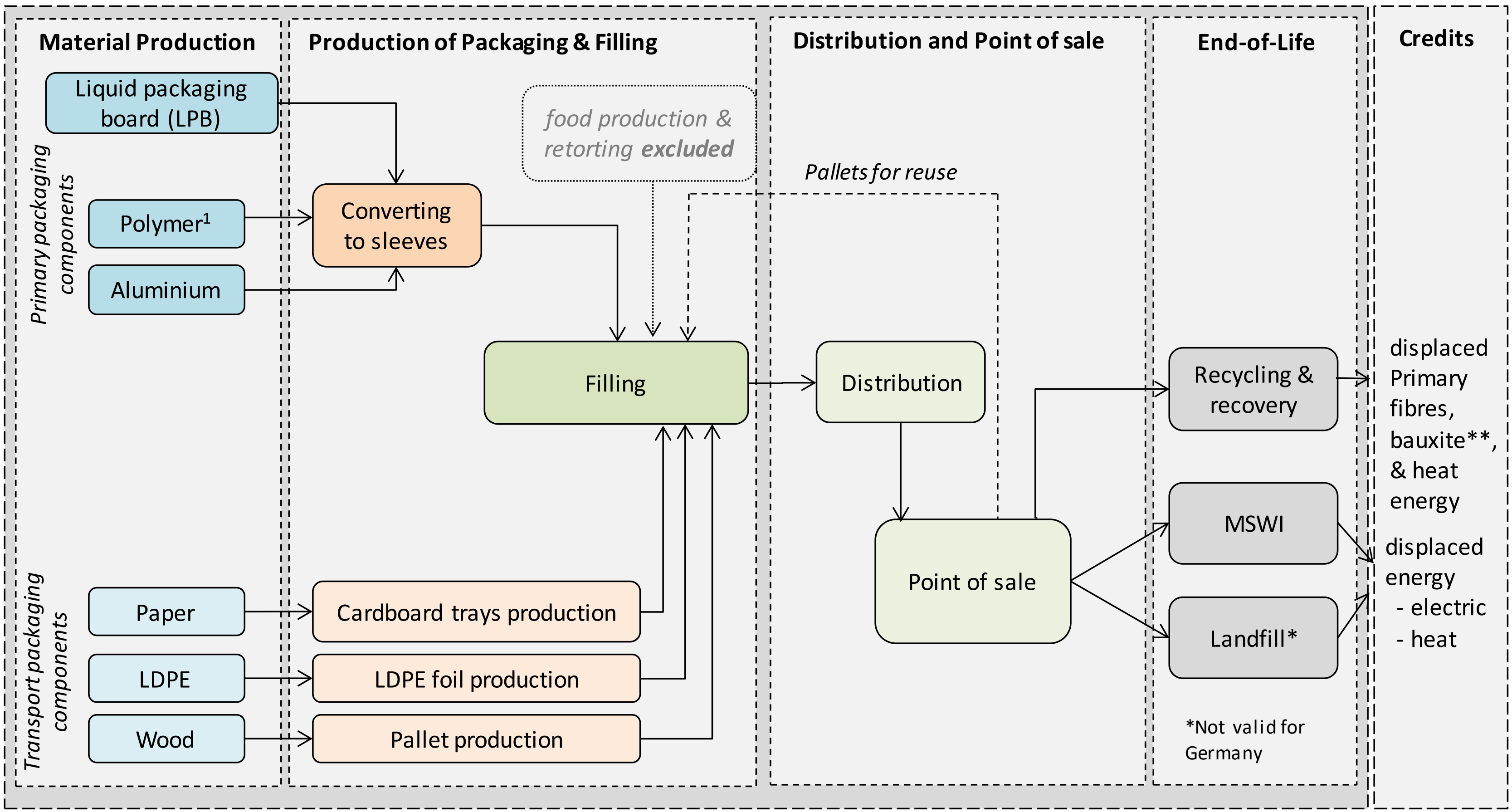
System boundaries: cradle-to-grave

Excluded life cycle elements

- production and disposal of infrastructure and their maintenance
- production of food and transport to fillers
- Retorting
- distribution of food from the filler to the point-of-sale
- environmental effects from accidents
- environmental effects related to storage phases
- losses of food at different points in the supply and consumption chain which might occur for instance in the filling process, during handling and storage
- transport of filled packages from the point of sale to the consumer
- follow up use phase of packages at the consumers (e.g. potential washing processes of the packages by the user after emptying)

System boundaries: flowcharts of systems

Food carton Tetra Recart

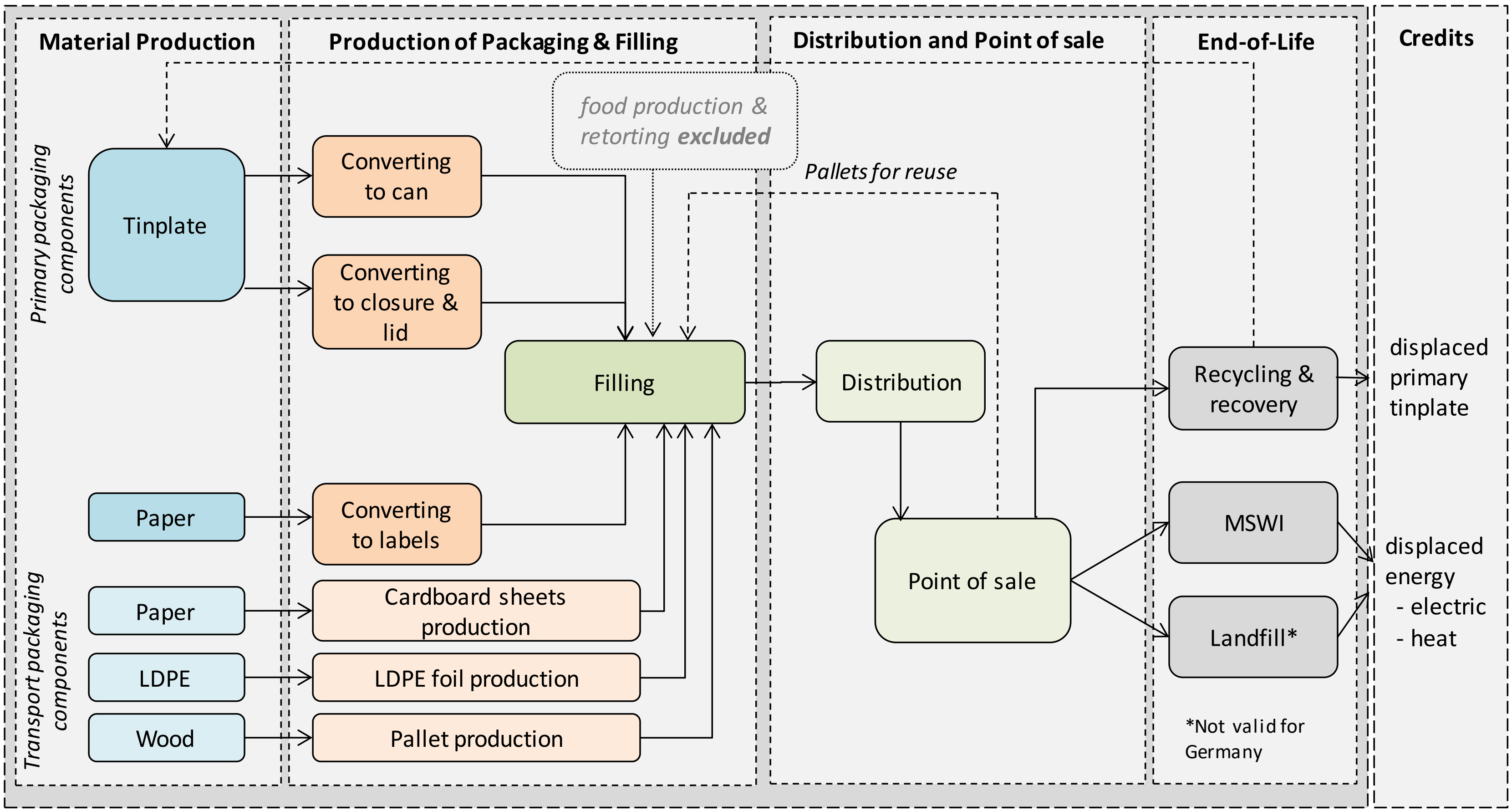


[1] exact composition is aggregated to „Polymer" due to confidentiality..

***only valid* for Germany

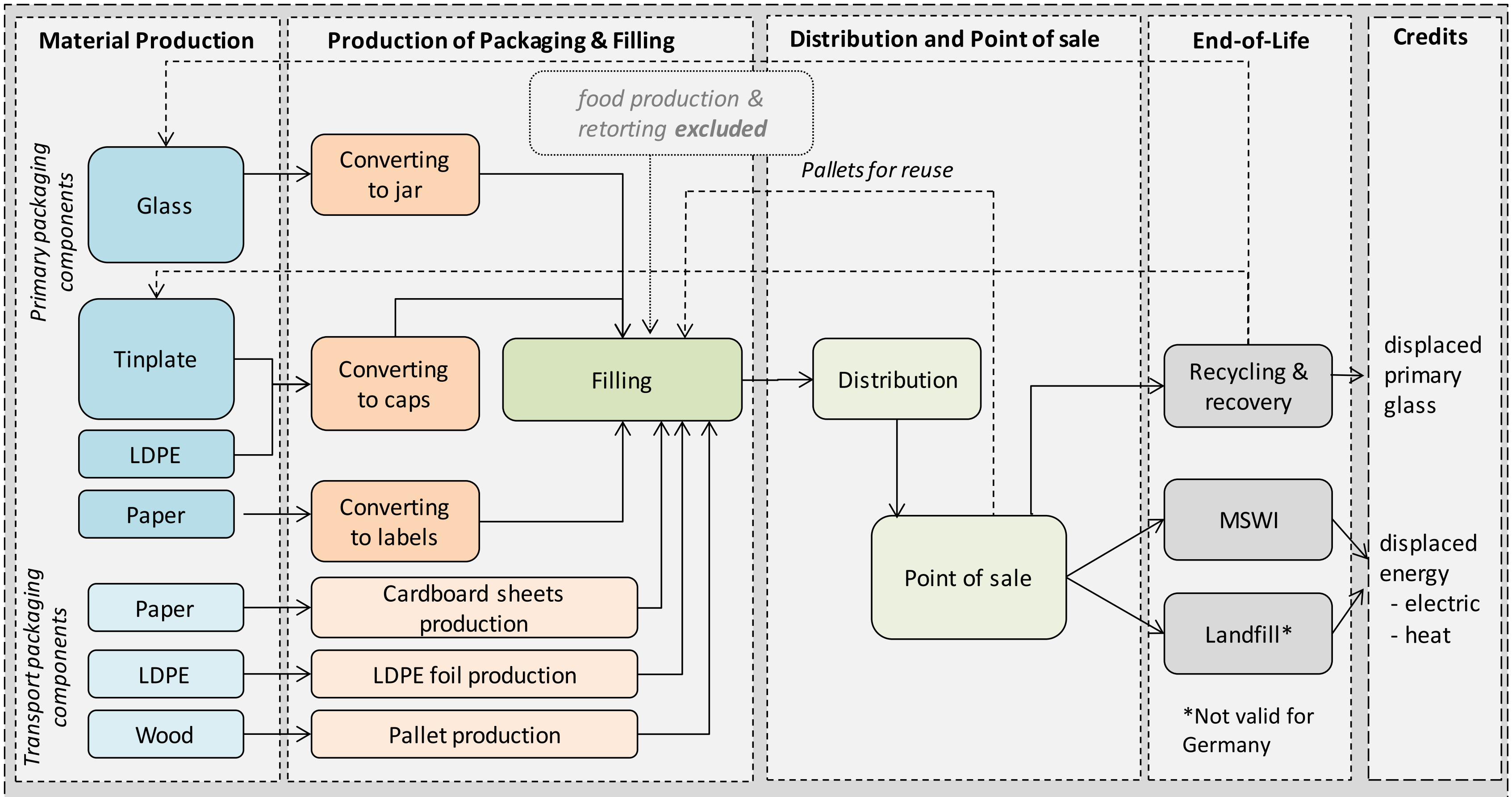
System boundaries: flowcharts of systems

Steel can



System boundaries: flowcharts of systems

Glass jar



System allocation approach

How are the impacts and benefits of recycling and recovery processes considered in the system model?

Base scenarios: Allocation factor 50%

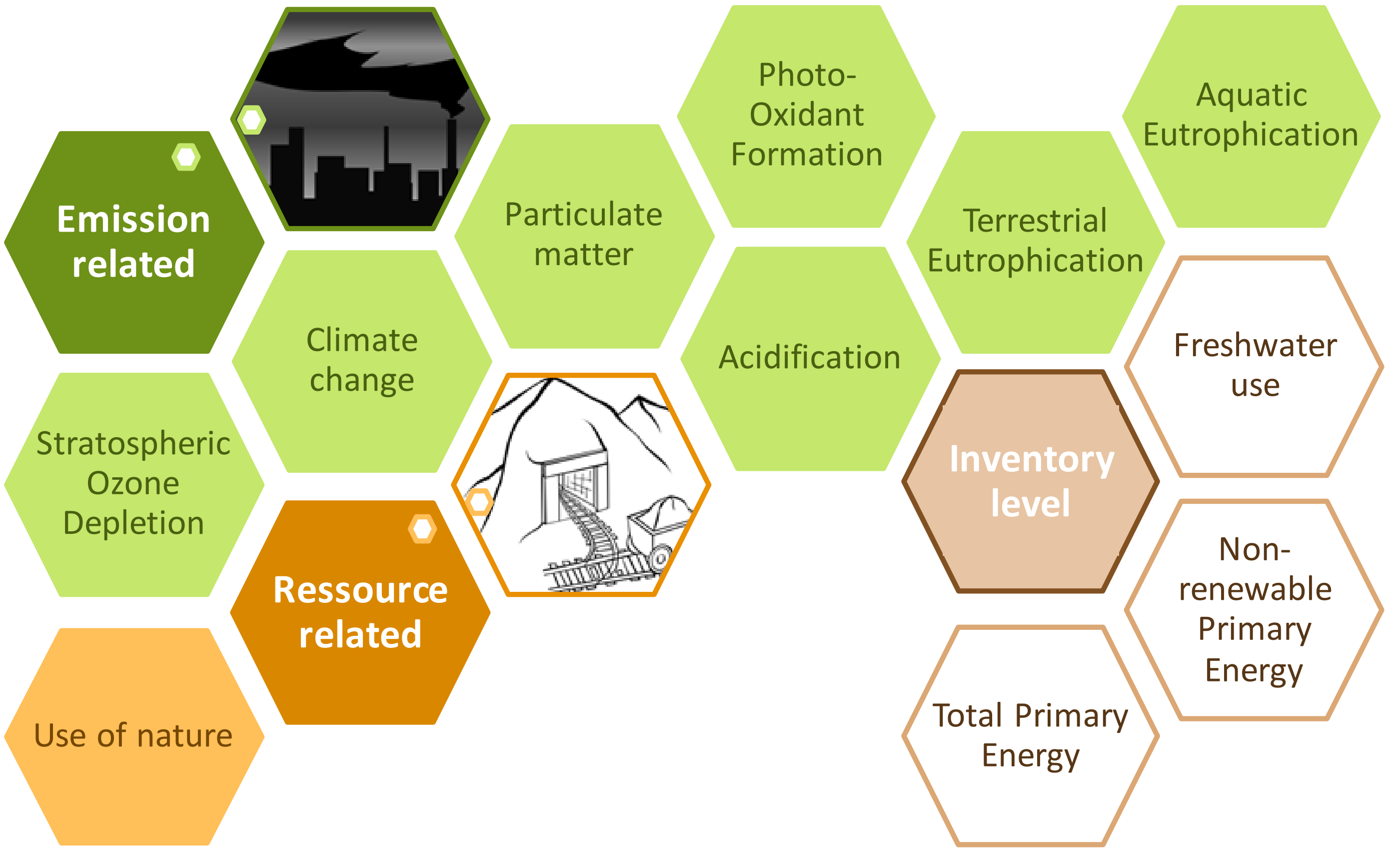
Half of the burdens and credits from recovery and recycling processes are allocated to the system under examination, the other half is allocated to the subsequent system.

Sensitivity analysis: Allocation factor 100%

All burdens and credits are allocated to the system under study.

- **Results of one allocation approach are not more correct than those of another.**
- **ISO requirements: Application of two different allocation approaches to verify the influence of this methological choice on the results.**

Environmental impact assessment



Impact categories **represent the environmental issues of concern**, to which life cycle inventory analysis results per functional unit are assigned,
<u>BUT</u> do not reflect actual environmental damages.

Environmental impact assessment

Impact categories	Description
Climate Change	Addresses the impact of anthropogenic emissions on the radiative forcing of the atmosphere. Greenhouse gas emissions enhance the radiative forcing, resulting in an increase of the earth's temperature.
Stratospheric Ozone Depletion	Anthropogenic impact on the earth's atmosphere, which leads to the decomposition of naturally present ozone molecules, thus disturbing the ozone layer in the stratosphere.
Photo-Oxidant Formation	Also known as summer smog, is the photochemical creation of reactive substances (mainly ozone), which affect human health and ecosystems. This ground-level ozone is formed in the atmosphere by nitrogen oxides and volatile organic compounds in the presence of sunlight.
Acidification	Affects aquatic and terrestrial ecosystems by changing the acid-basic-equilibrium through the input of acidifying substances.
Terrestrial Eutrophication **Aquatic Eutrophication**	Eutrophication means the excessive supply of nutrients and can apply to both surface waters and soils. *terrestrial: eutrophication of soils by athmospheric emissions* *aquatic: eutrophication of water bodies by effluent releases*
Particulate Matter	Covers effects of fine particulates with an aerodynamic diameter of less than 2.5 µm (PM 2.5) emitted directly or formed from precursors as NO_x and SO_2. A correlation between the exposure to particulate matter and the mortality from respiratory diseases as well as a weakening of the immune system exists.
Total Primary Energy	Quantification of the primary energy consumption of a system. It is calculated by adding the energy content of all used fossil fuels, nuclear and renewable energy (including biomass).
Non-renewable Primary Energy	Considers the primary energy consumption based on non-renewable, i.e. fossil and nuclear energy sources.

Environmental impact assessment

Impact categories	Elementary Flows								Unit
Climate Change	CO_2*	CH_4**	N_2O	$C_2F_2H_4$	CF_4	CCl_4	C_2F_6	R22	kg CO_2-e
Stratospheric Ozone Depletion	CFC-11	N_2O	HBFC-123	HCFC-22	Halon-1211	Methyl Bromide	Methyl Chloride	Tetrachlor-methane	kg CFC-11-e
Photo-Oxidant Formation	CH_4	NMVOC	Benzene	Formal-dehyde	Ethyl acetate	VOC	TOC	Ethanol	kg O_3-e
Acidification	NOx	NH_3	SO_2	TRS***	HCl	H_2S	HF		kg SO_2-e
Terrestrial Eutrophication	NOx	NH_3	SOx						kg PO_4-e
Aquatic Eutrophication	COD	N	NH_4+	NO_3-	NO_2-	P			kg PO_4-e
Particulate Matter	PM2.5	SO_2	NOX	NH_3	NMVOC				kg PM2.5-e

* CO_2 fossil and biogenic / ** CH_4 fossil and CH_4 biogenic included / *** Total Reduced Sulphur

Functional unit & Selection of packaging systems

- **The function examined is the packaging of retorted food for retail. The functional unit for this study is the provision of 1000 L packed food to the point of sale.**
- The focus of this study lies on the food carton Tetra Recart.
- The food category canned tomatoes was chosen as this is one of the key categories to Tetra Recart.
- The chosen competing packaging systems glass jar and steel can have a high relevance in the countries Italy and Germany as well as on the European market.
- Specifications of the Tetra Recart and for transport packaging are provided by Tetra Pak.
- The specifications of the competing packaging systems were determined by Tetra Pak in 2016 and are based on existing products and market relevance in the markets of Germany and Italy. Recycled content of steel can and glass jar has been included based on industry references.

Selection of packaging systems

Germany*	Tetra Recart Germany 390 g	Steel can Germany 400 g	Glass jar Germany 400 g
Food content	Canned tomatoes		
Primary packaging	**17.0 g**	**59.5 g**	**223.2 g**
– Glass			217.0 g
– tinplate		50.5 g	
Label paper		2.0 g	1.2 g
Closure / lid-tinplate		7.0 g	5.0 g
Secondary packaging	**62.0 g**	**27.0 g**	
Tray corrugated cardboard			**56.0 g**
Tertiary packaging	**24,462 g**	**24,575 g**	**24,427 g**
- Pallet	24,000 g	24,000 g	24,000 g
- Type of pallet	EURO	EURO	EURO
- Stretch foil per pallet	462 g	575 g	427 g
Pallet configuration			
- Packages per tray	16	12	12
- Trays per layer	8	6	14
- Layers per pallet	16	12	12

Italy	Tetra Recart Italy 390 g	Steel can Italy 400 g	Glass jar Italy 340 g
Food content	Canned tomatoes		
Primary packaging	**17.0 g**	**59.5 g**	**220.7 g**
– Glass			215.0 g
– tinplate		50.5 g	
Label paper		2.0 g	1.2 g
Closure / lid-tinplate		7.0 g	4.45 g g
Secondary packaging	**62.0 g**	**64.85**	**59.2 g**
Tray corrugated cardboard		48.95 g	37.7 g
Stretch foil		15.9 g	21.5 g
Tertiary packaging	**24,462 g**	**24,575 g**	**24,575 g**
- Pallet	24,000 g	24,000 g	24,000 g
- Type of pallet	EURO	EURO	EURO
- Stretch foil per pallet	462 g	575 g	575 g
Pallet configuration			
- Packages per tray	16	12	12
- Trays per layer	8	6	14
- Layers per pallet	16	12	12

*Specifications of German market applied for European scenario

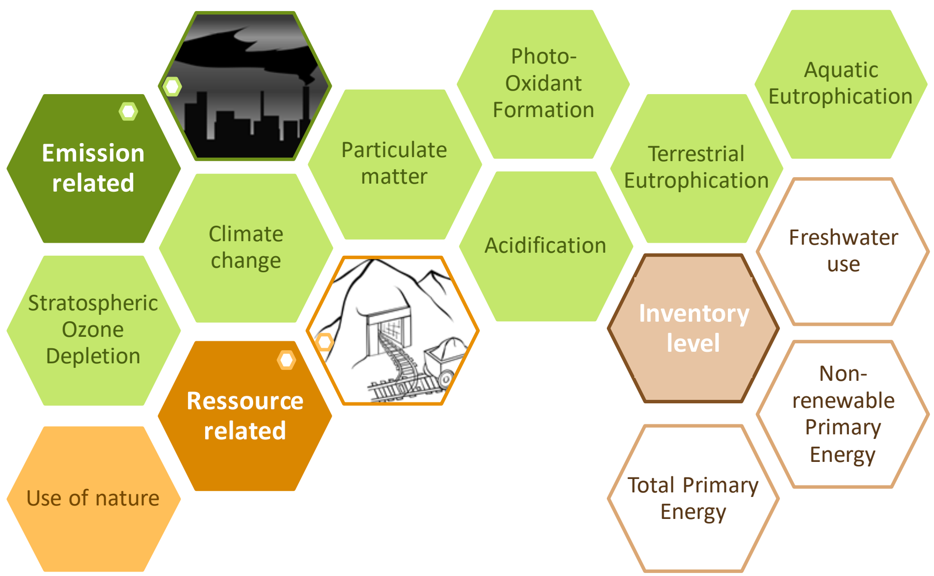
End-of-life

Country	Packaging system	Collection quota	Recovery quota	Reference year	Source
Germany	Food carton	85.3%*	76.8%	2014	[UBA 2016]
	Steel can	99.9%*	95.9%	2014	
	Glass jars	91.1*	88.8%	2014	
Italy	Food carton	28.4%*	25.6%	2015	Tetra Pak
	Steel can	84.5%	73.4%	2015	[Ricrea 2016]; www.consorzioricrea.org
	Glass jars	77.9%	70.9%	2015	[CoReVe 2016]; www.coreve.it
EU28+2	Food carton	48.9%*	44.0%	2015	ACE; www.beveragecarton.eu
	Steel can	79.2%*	76.0%	2014	APEAL; www.apeal.org
	Glass jars	74.9%*	73%	2015	FEVE; www.feve.org; collection quota

*assumption for share of sorting residues

Country	MSWI/Landfill	Quota	Reference year	Source
Germany	MSWI	100%	2014	calculated based on [Eurostat 2016]
	Landfill	0.00%		
Italy	MSWI	42 %		
	Landfill	58%		
EU28+2	MSWI	40%		
	Landfill	60%		

Results Germany



Result graphs – How to read them?

BURDENS – left stacked bar:

- Glass: production and transport of glass including converting to bottle
- Tinplate: production and transport of tinplate
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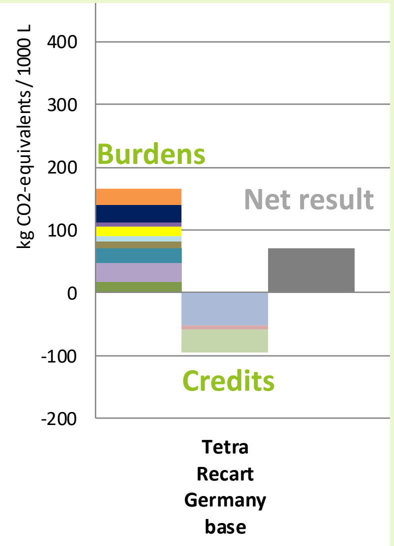
- Plastics for sleeve: production and transport of plastics and additives for carton
- Aluminium foil: production and transport of aluminium & converting to foil
- Converting: converting processes of cartons
- Closure & label: production and transport of base materials for closures and label
- Transport packaging: production and transport of transport packaging: wooden pallets, LDPE shrink foil and corrugated cardboard trays
- Filling: filling process including packaging handling
- Distribution: retail of the packages from filler to the point-of-sale
- Recycling & disposal: sorting, recycling and disposal processes of primary and transport packaging



CREDITS – negative stacked bar:

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- Credits material: credits for material recycling
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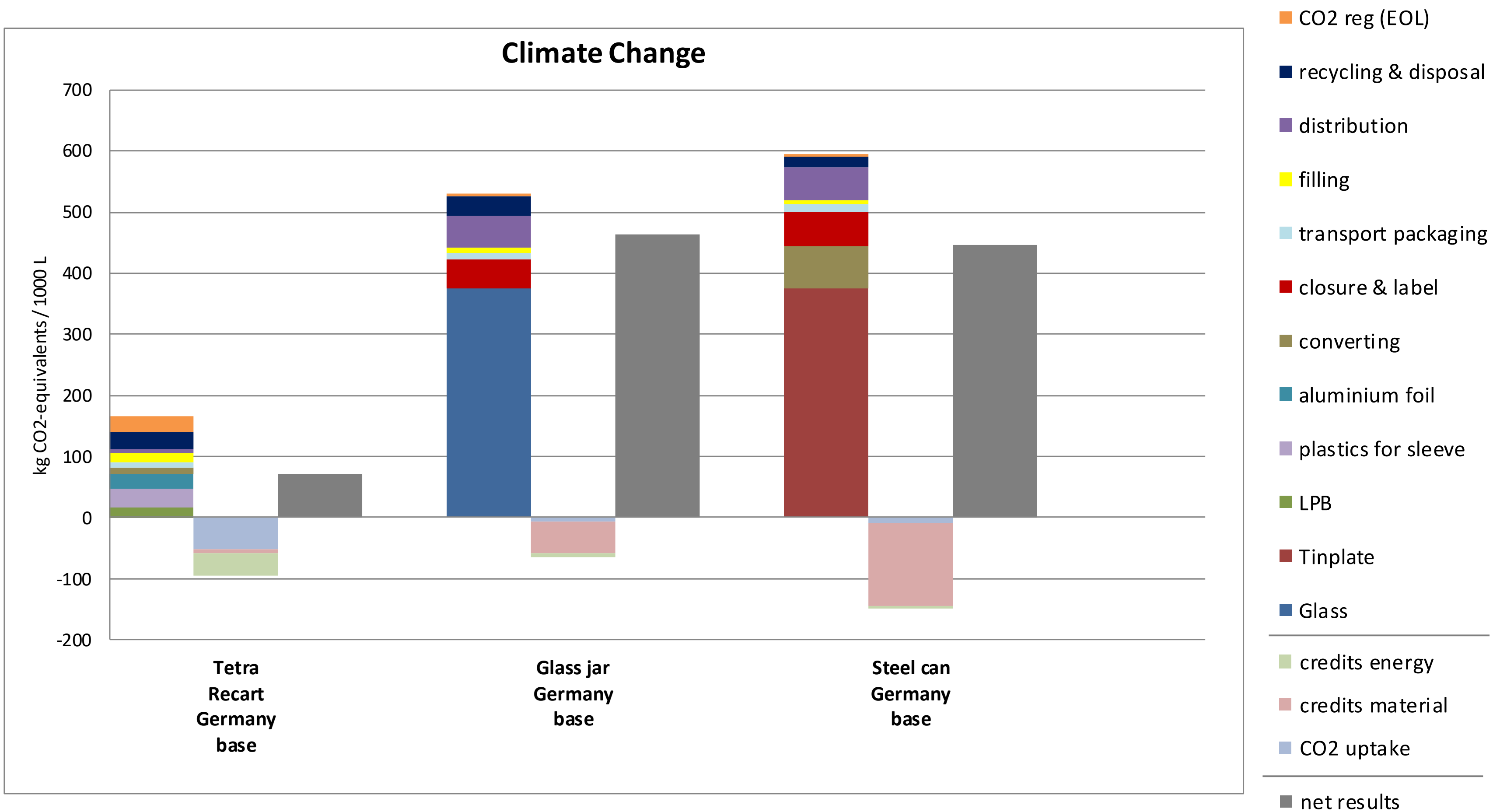
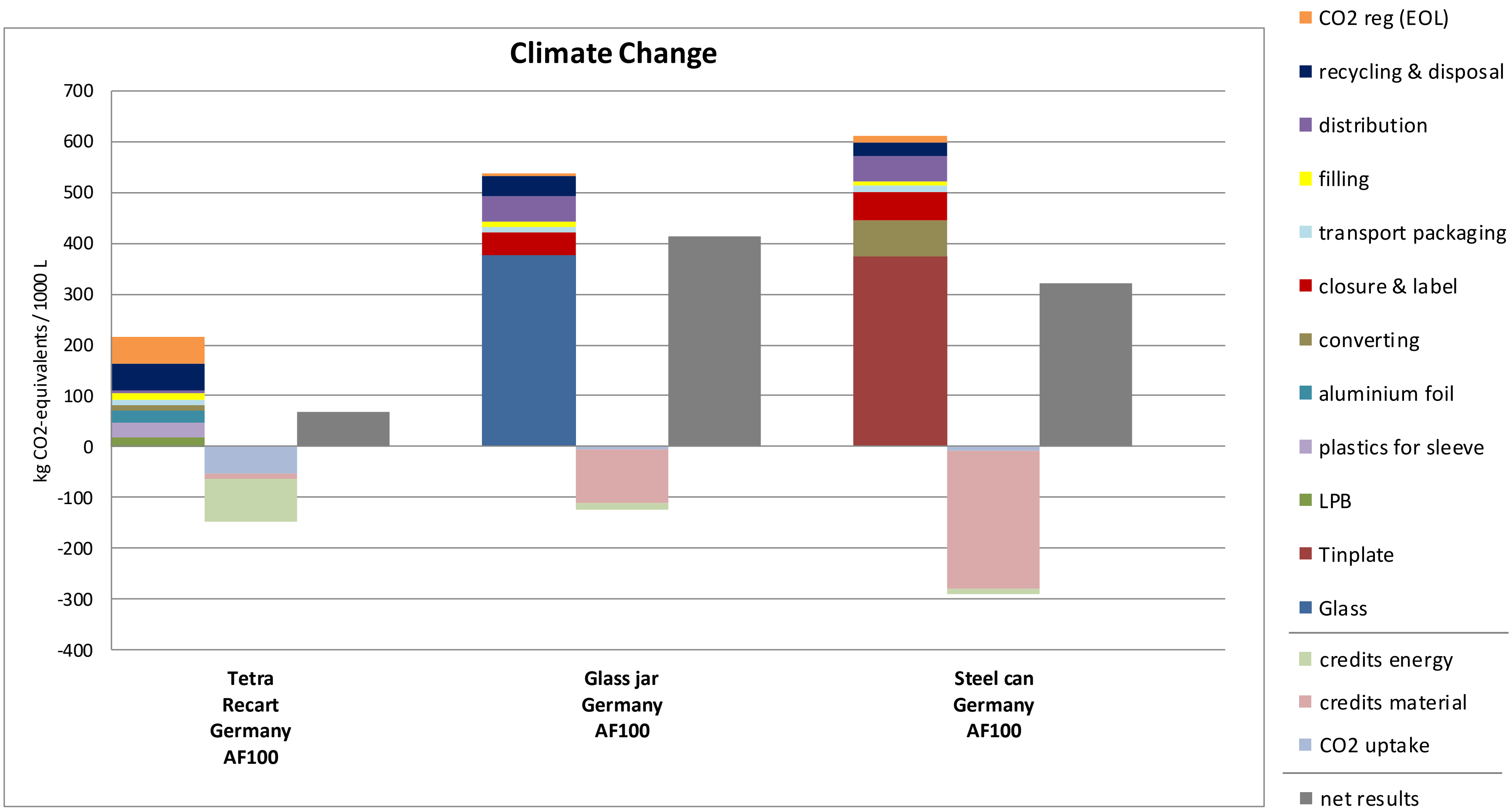
- CO_2-uptake: Uptake of athmospheric CO_2 during the plant growth phase

Results base scenario Germany



Results sensitivity analysis allocation factor 100% Germany



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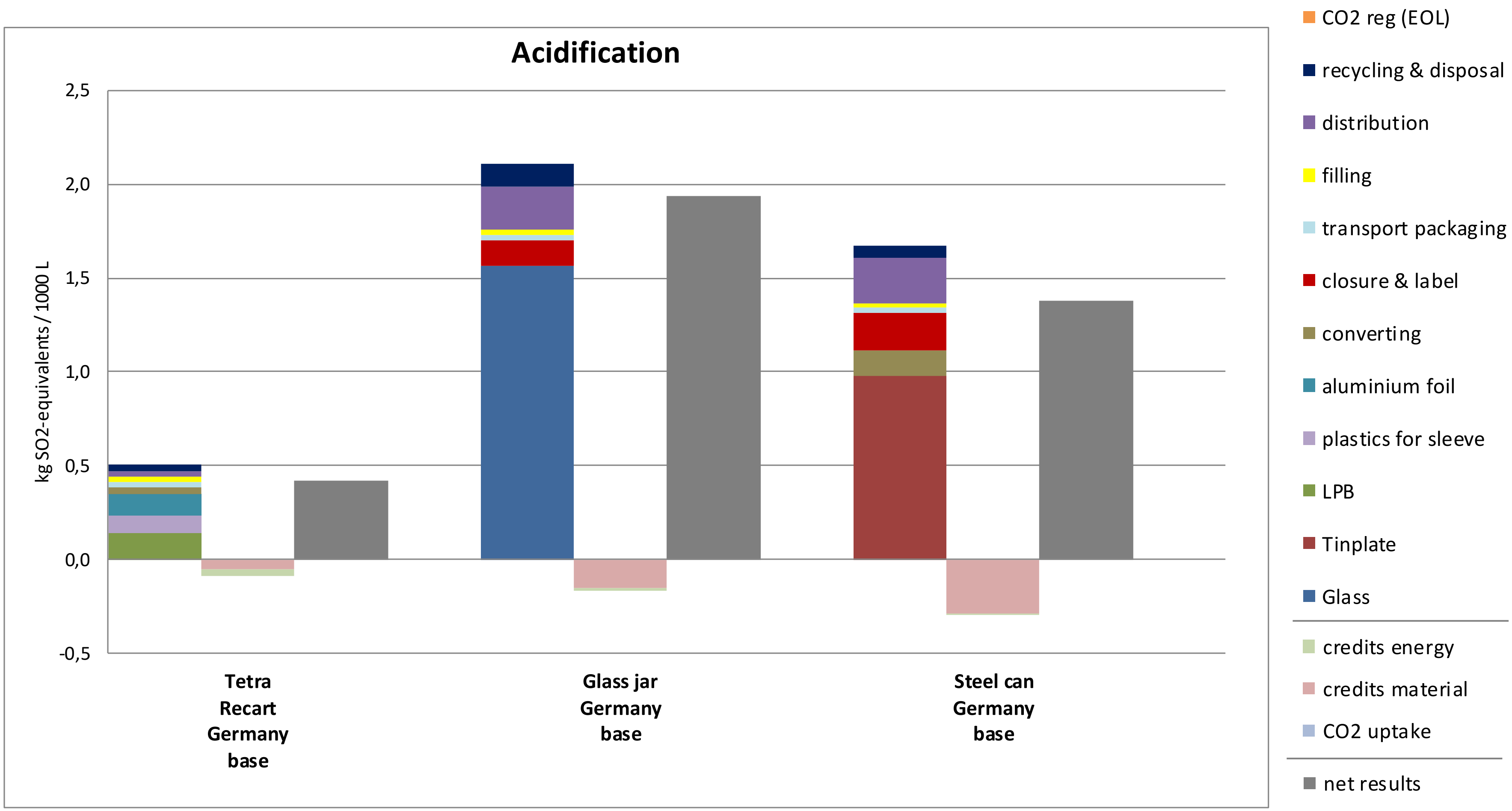

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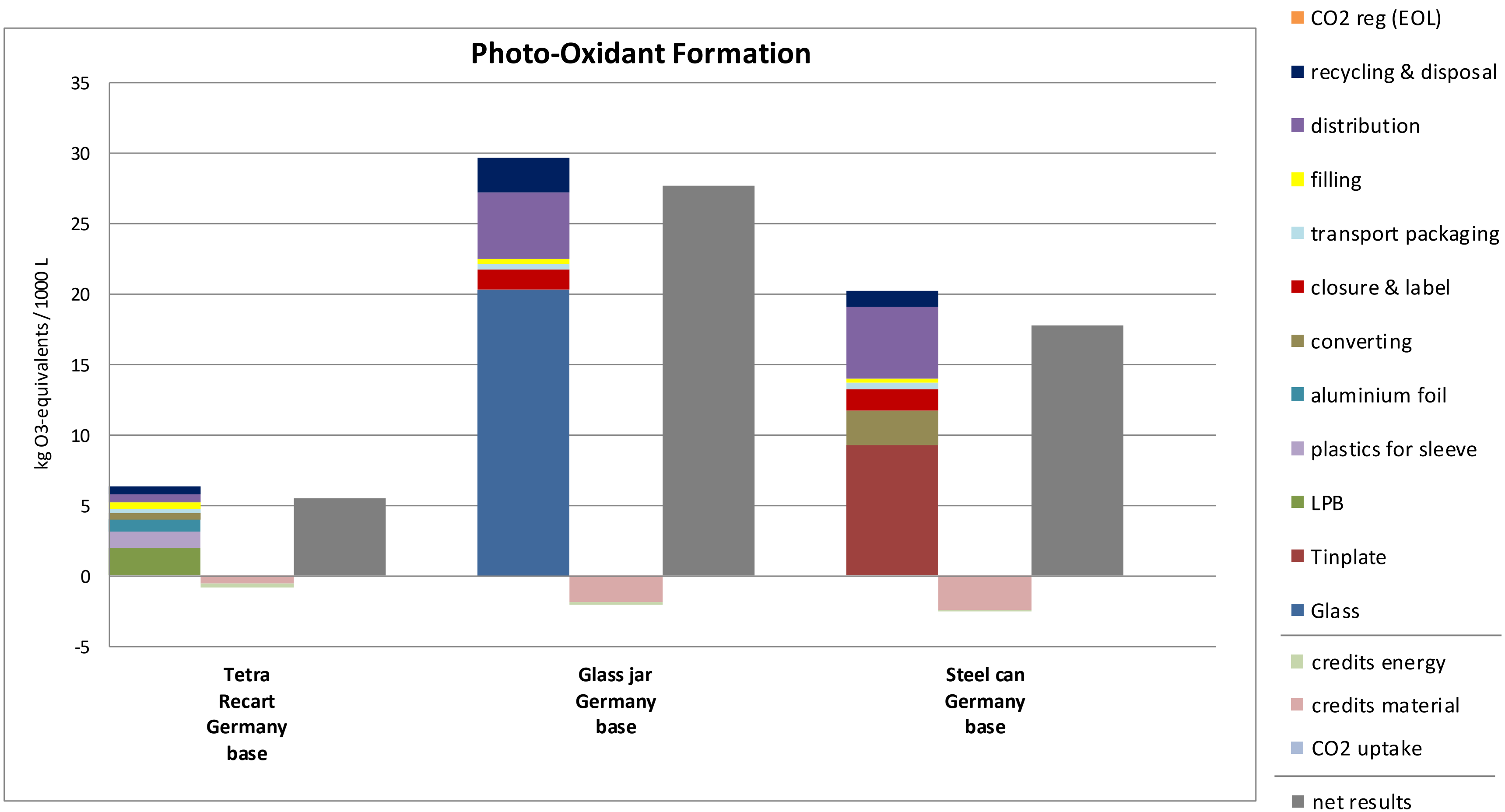

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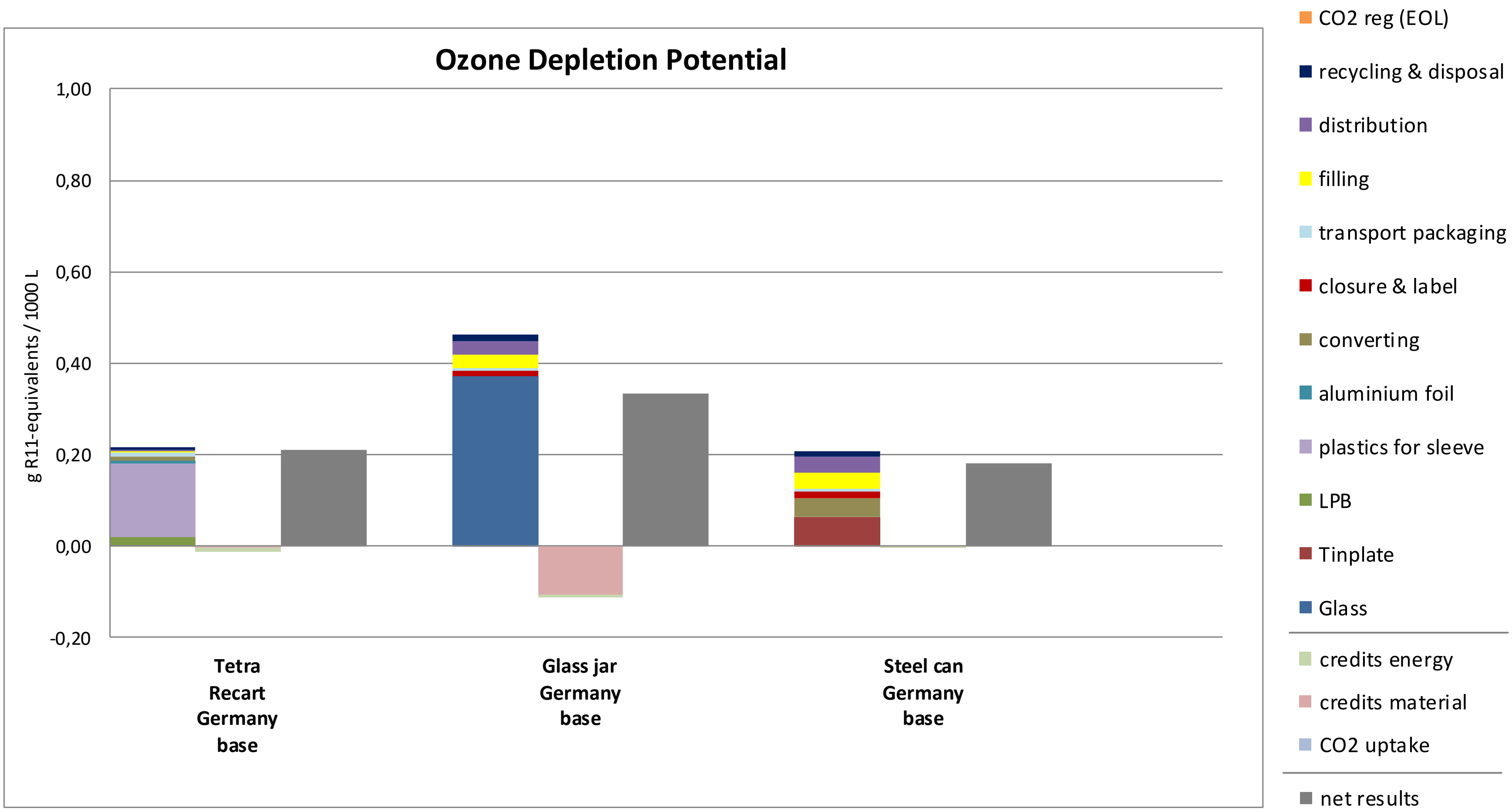

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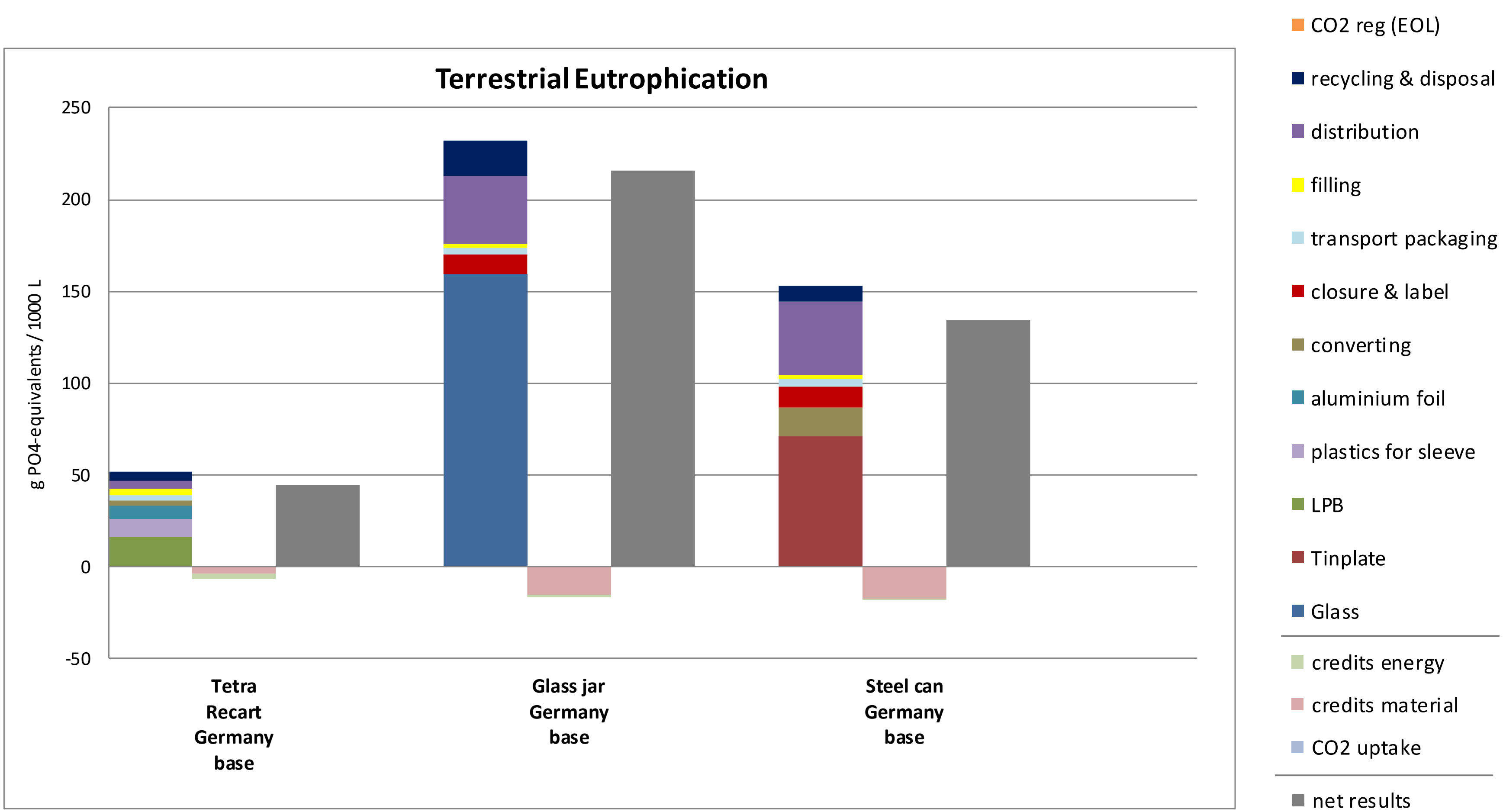

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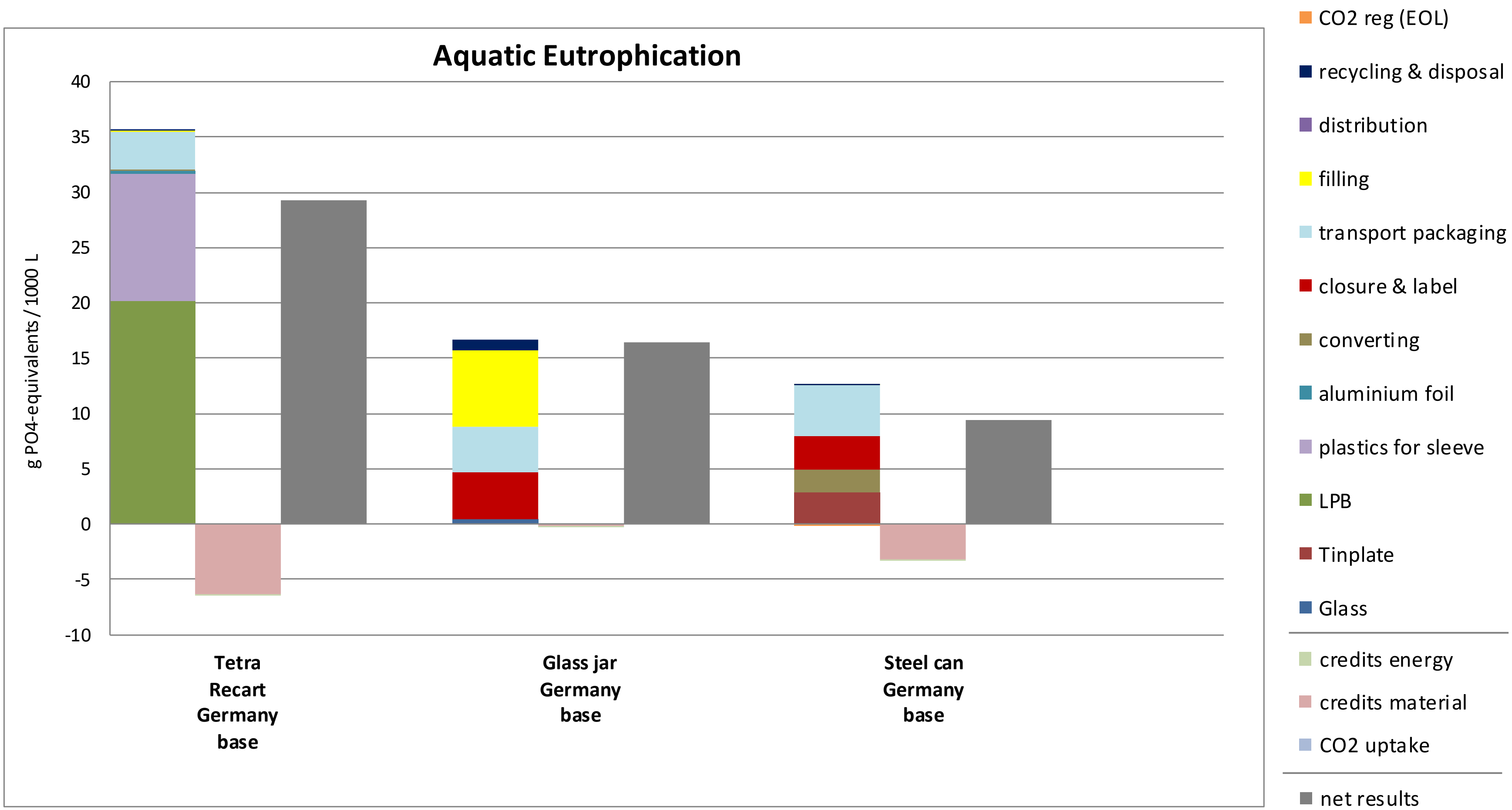

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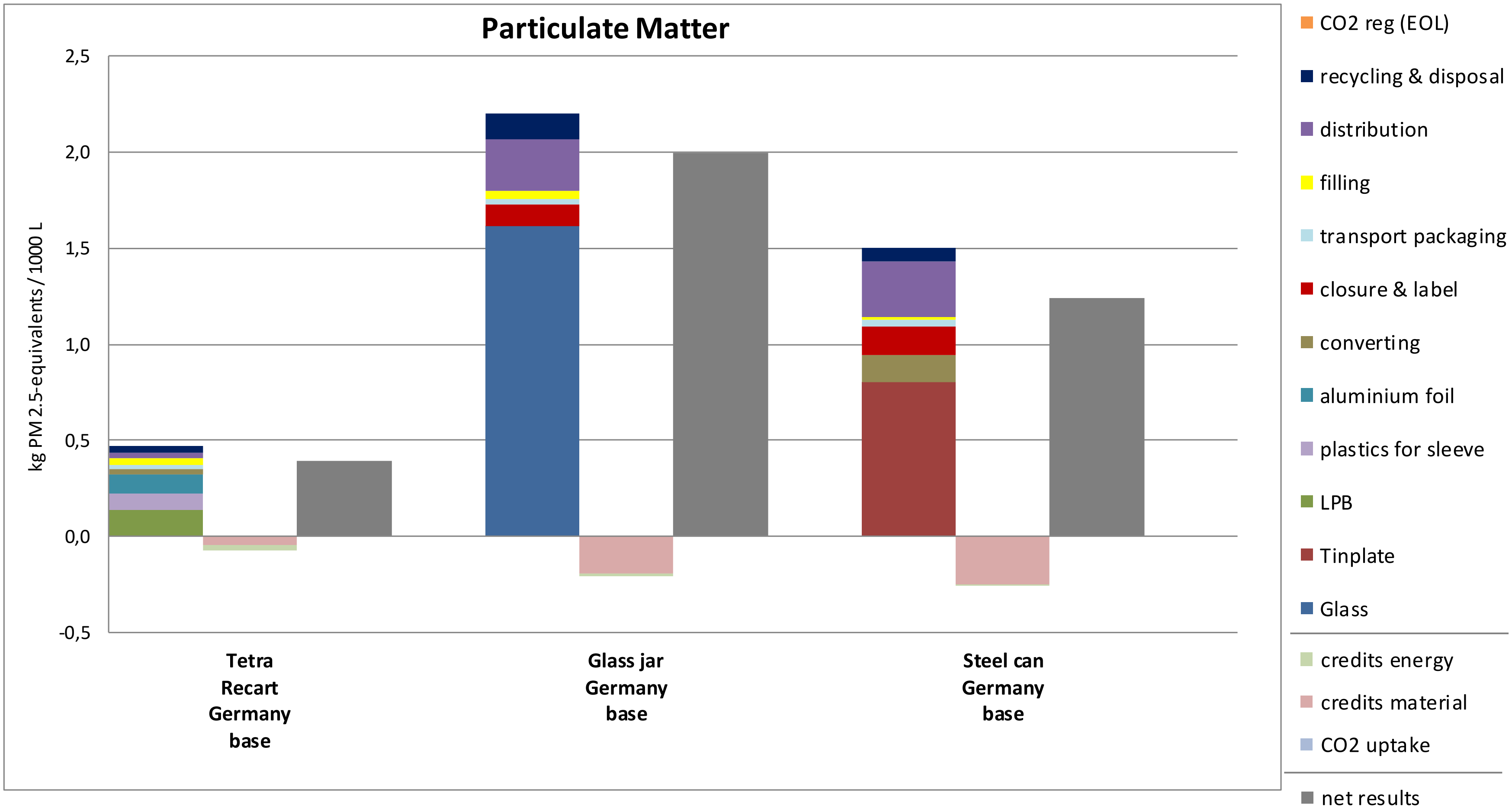

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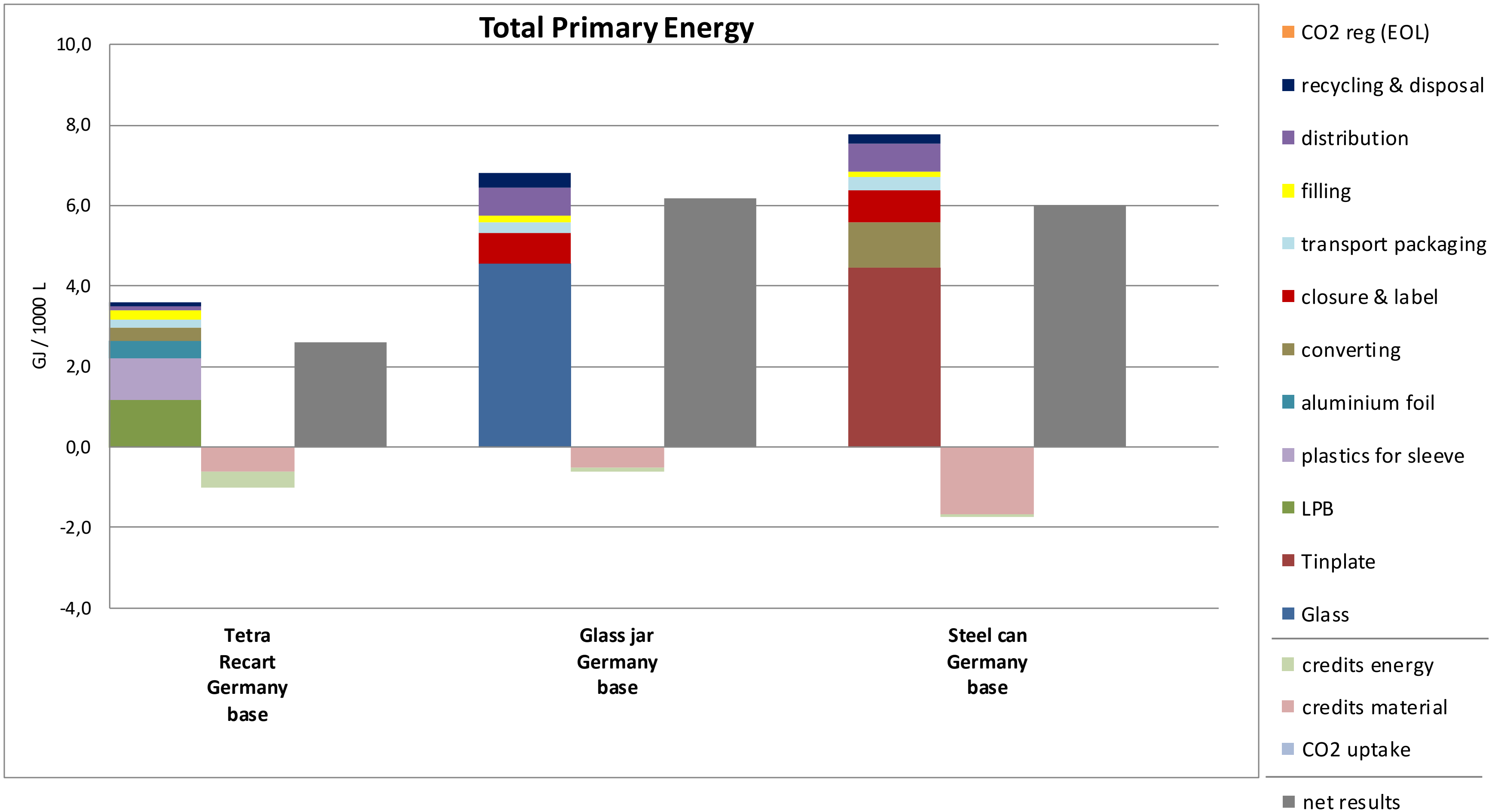

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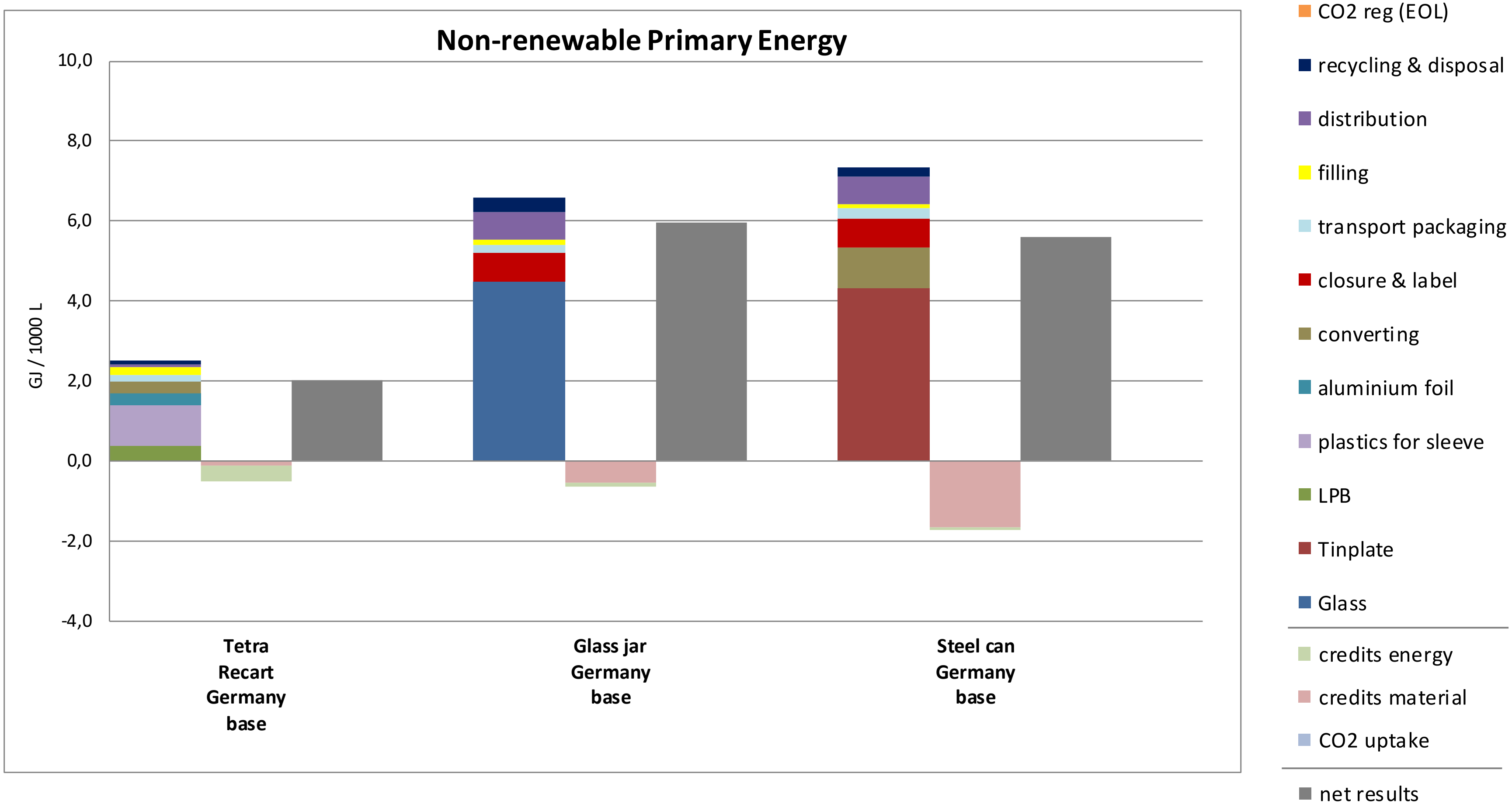

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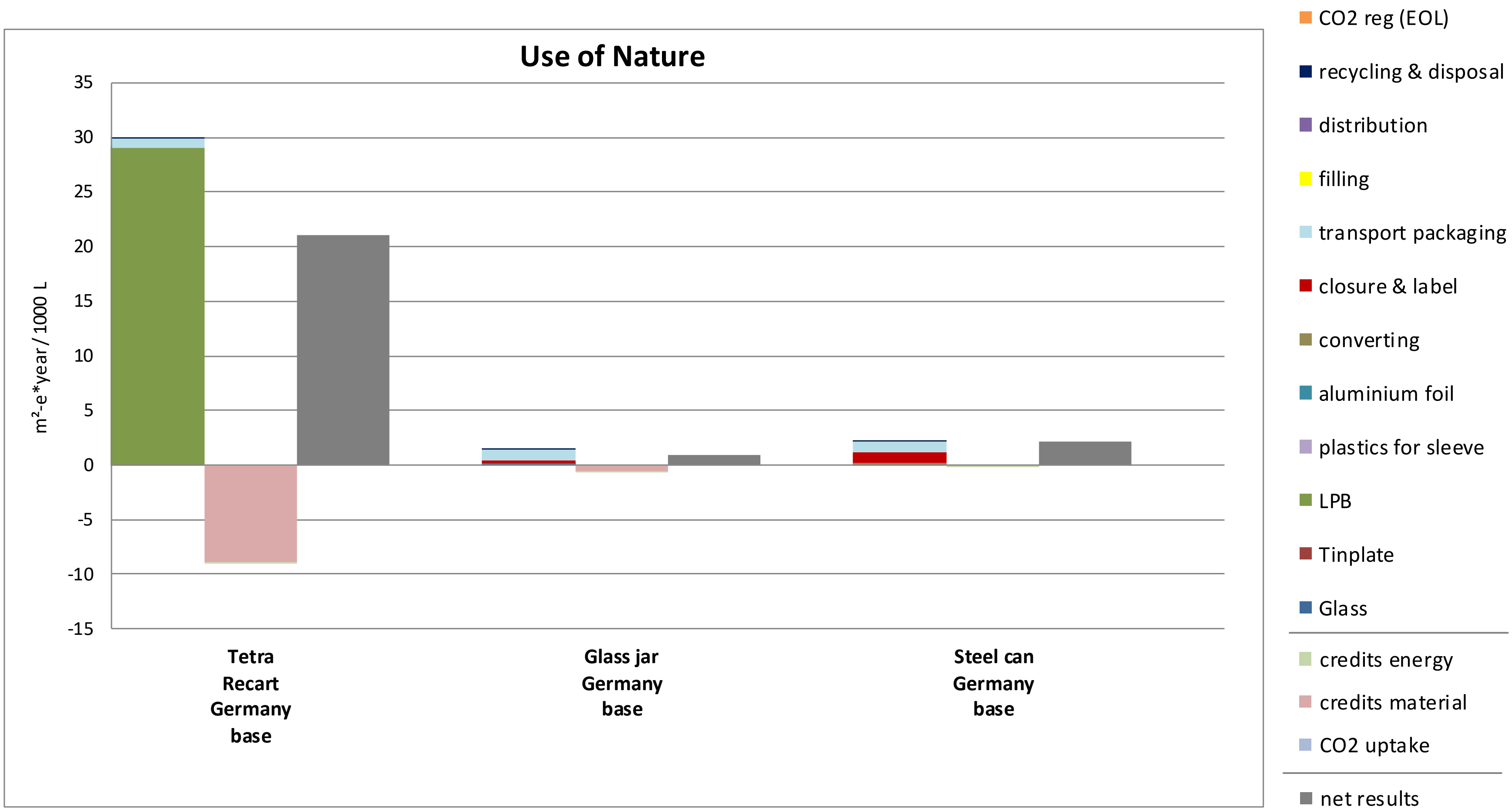

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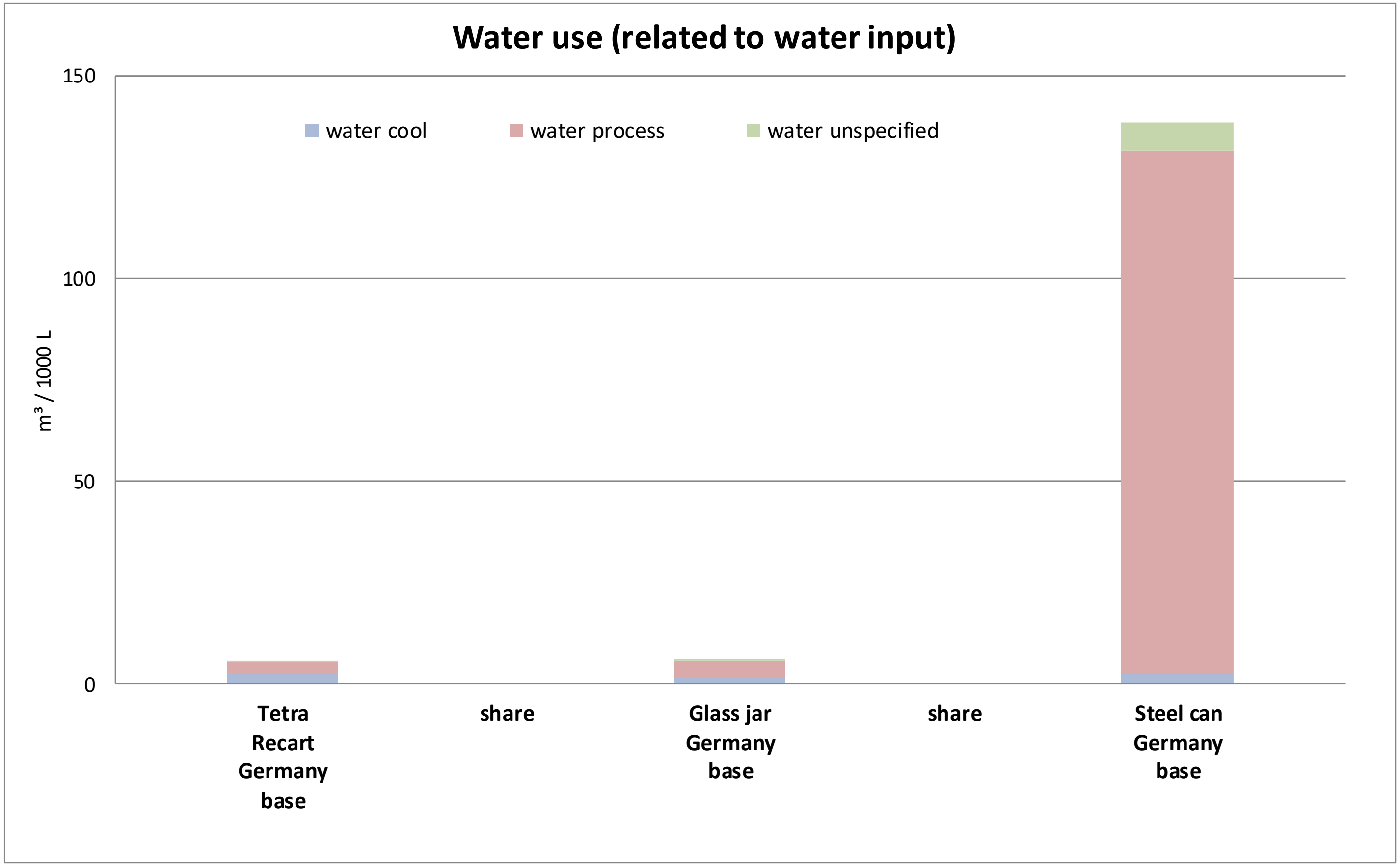

Results base scenario Germany

Comparison of net results: Tetra Recart versus alternative packaging systems in Germany

Tetra Recart 17 g

Glass jar: 223 g

Steel can: 59.5 g

Germany base scenario allocation factor 50%	The net results of **Tetra RecartGermanybase** are lower (green)/ higher (orange) than those of	
	Glass jar	Steel can
Climate Change	-85%	-84%
Acidification	-79%	-70%
Summer Smog	-80%	-69%
Ozone Depletion Potential	-38%	16%
Terrestrial Eutrophication	-79%	-67%
Aquatic Eutrophication	78%	211%
Human Toxicity: PM 2.5	-80%	-68%
Total Primary Energy	-58%	-57%
Non-renewable Primary Energy	-66%	-64%

Applied recycling rates Germany

Tetra Recart: 76.8%

Glass jar: 88.8%

Steel can: 95.9%

The remaining share which is not recycled is disposed according to the European share:

0% landfill

100% MSWI

Results sensitivity analysis allocation factor 100% Germany

Comparison of net results - sensitivity analysis allocation factor 100%:
Tetra Recart versus alternative packaging systems in Germany

Germany allocation factor 100%	The net results of **Tetra Recart Germany AF100** are lower (green)/ higher (orange) than those of	
	Glass jar Germany AF100	Steel can Germany AF100
Climate Change	-84%	-79%
Acidification	-81%	-69%
Photo-Oxidant Formation	-81%	-68%
Ozone Depletion Potential	-15%	8%
Terrestrial Eutrophication	-80%	-66%
Aquatic Eutrophication	34%	264%
Particulate Matter	-82%	-67%
Total Primary Energy	-73%	-65%
Non-renewable Primary Energy	-73%	-63%

The ranking order among Tetra Recart and alternative packaging systems is not affected by the application of a 100% allocation factor, except in the *Ozone Depletion Potential* when compared to the steel can.

By applying an allocation factor of 100% the difference between Tetra Recart and steel can becomes insignificant.

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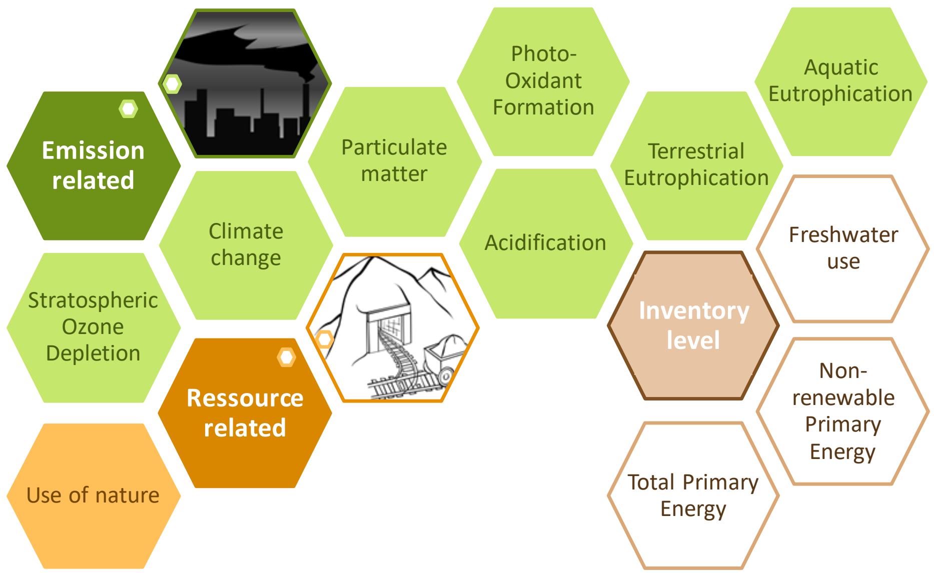
Results Italy



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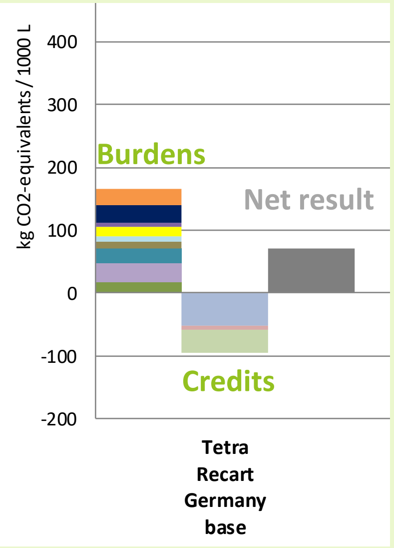

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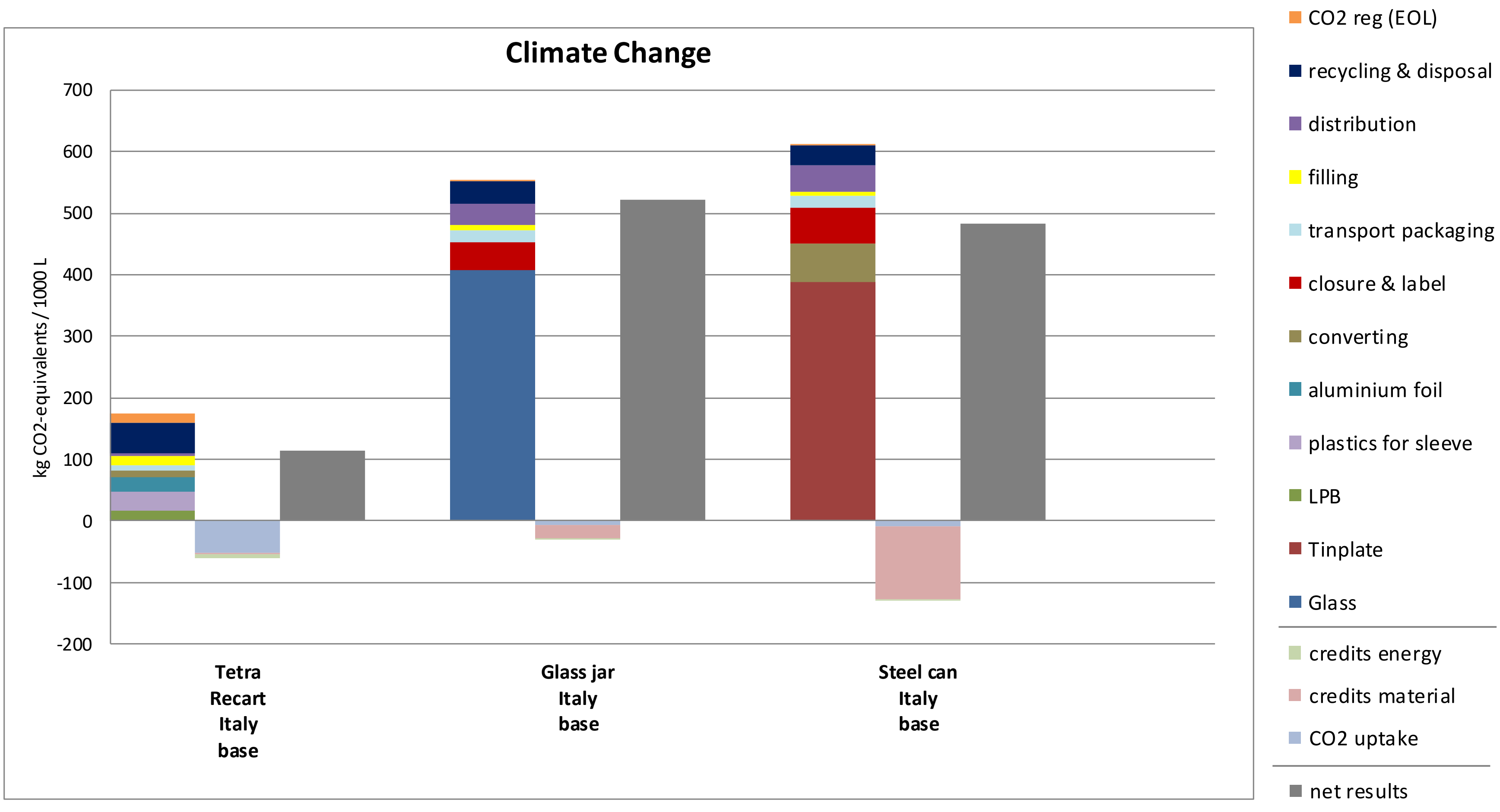
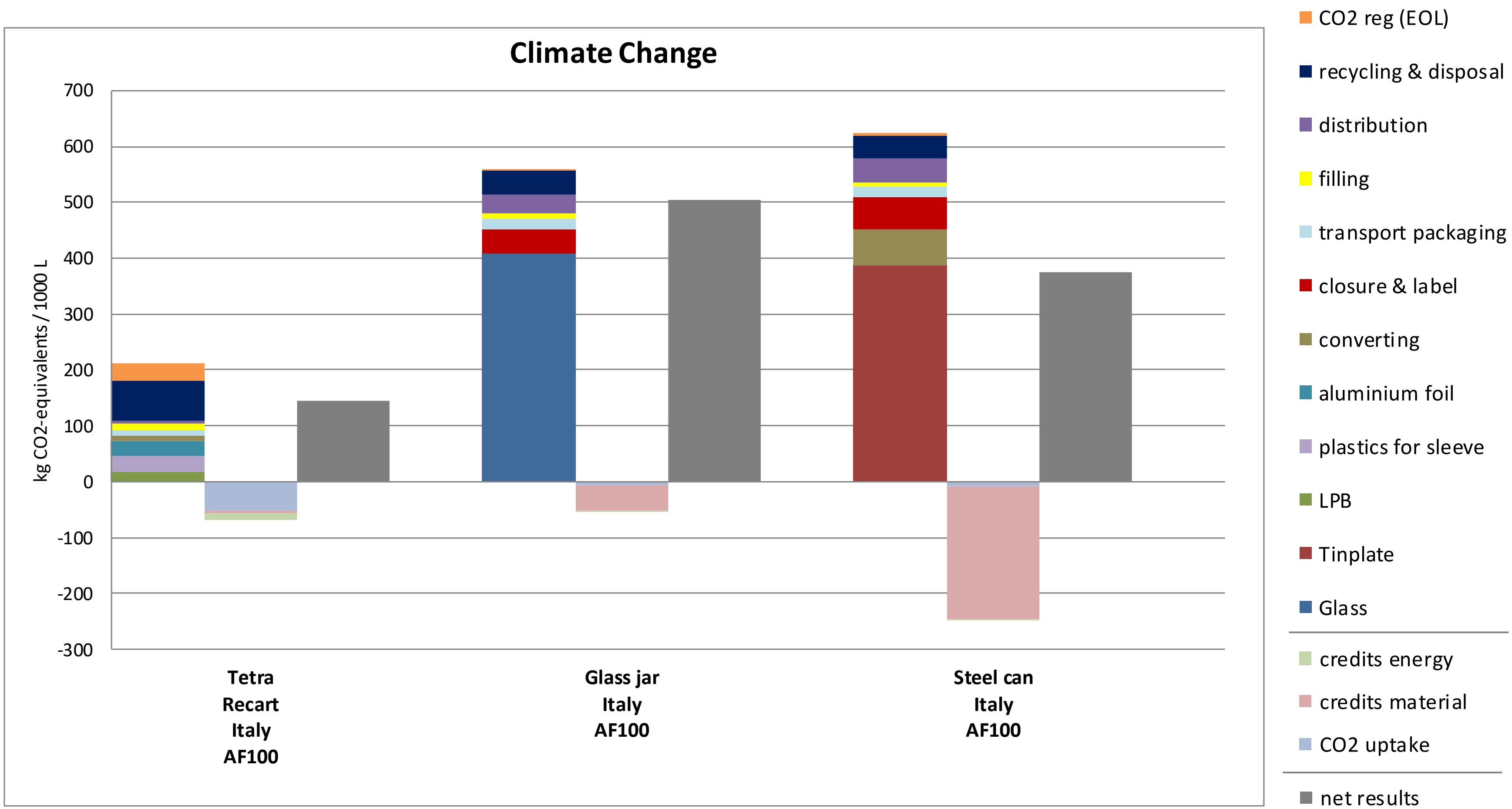
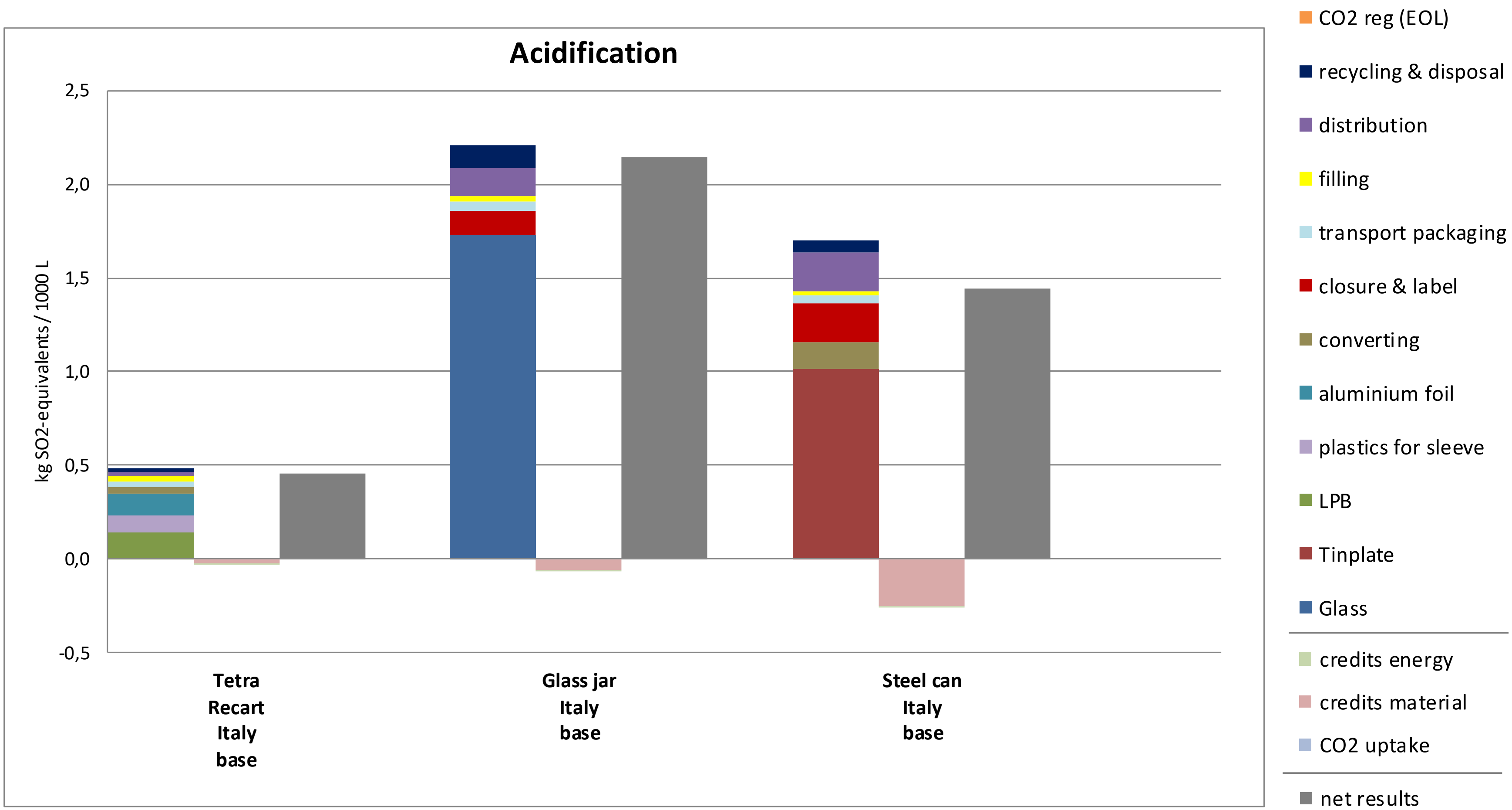
Results base scenario Italy



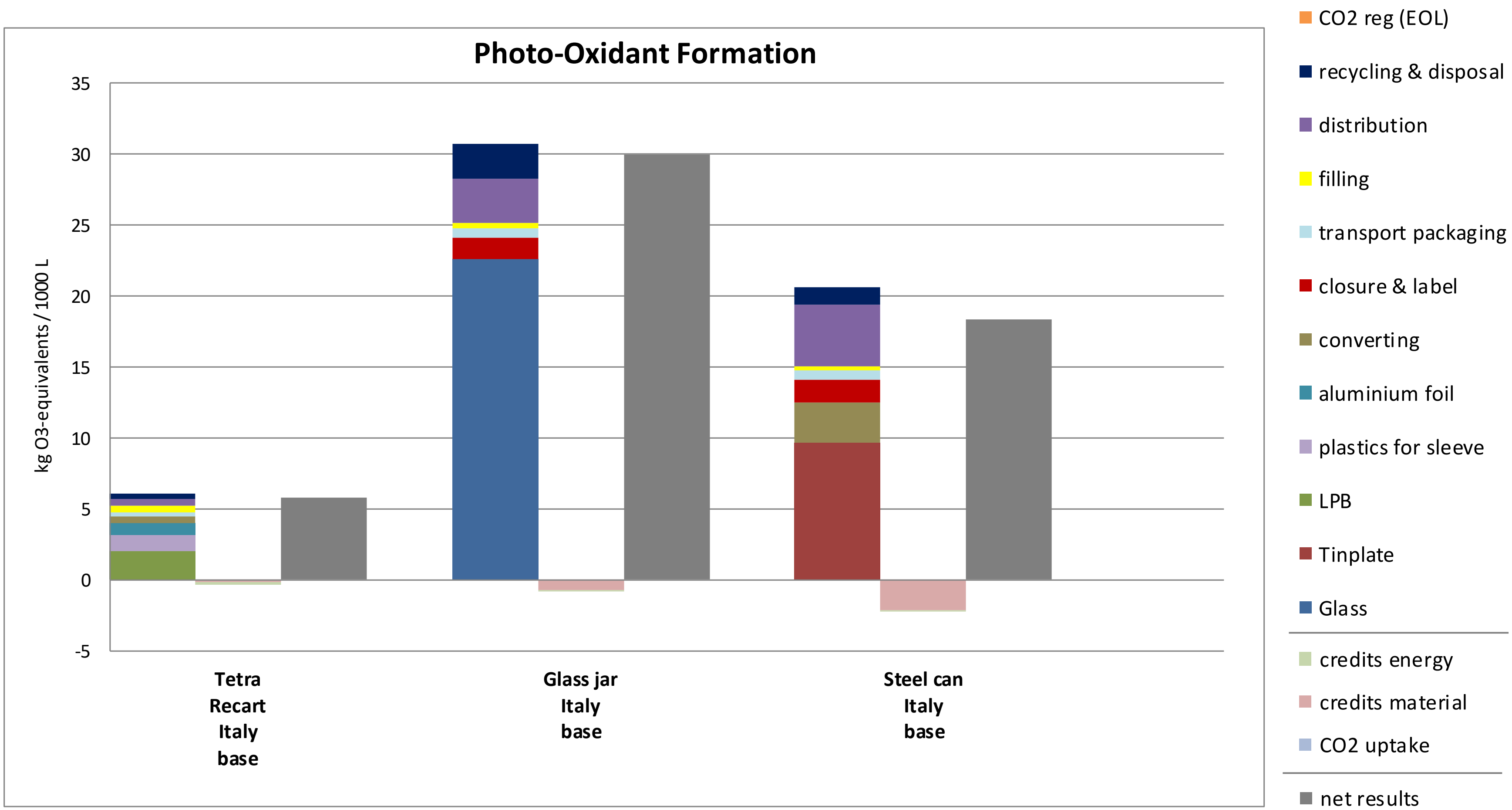
Results sensitivity analysis allocation factor 100% Italy



Results base scenario Italy



Results base scenario Italy



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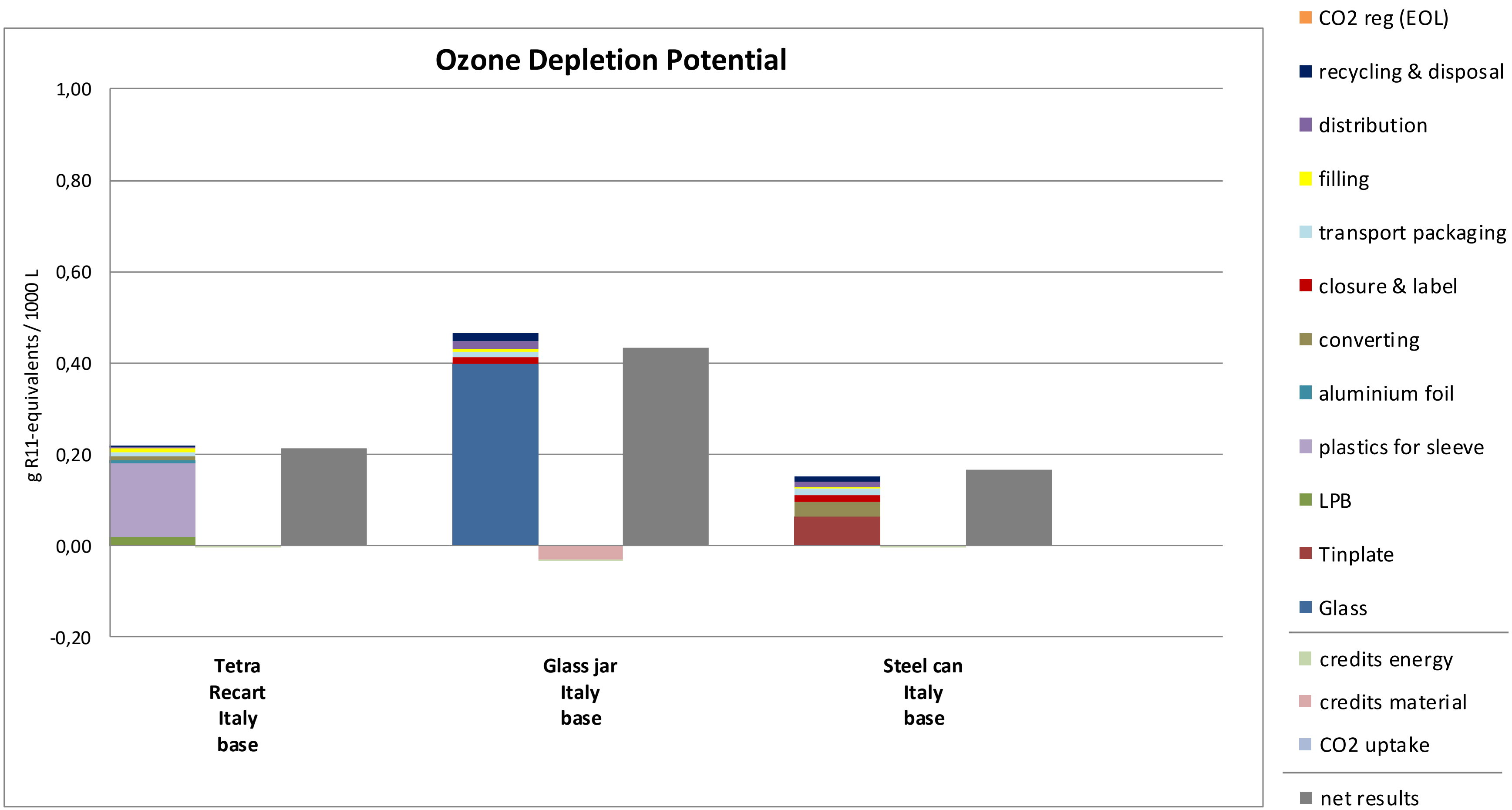

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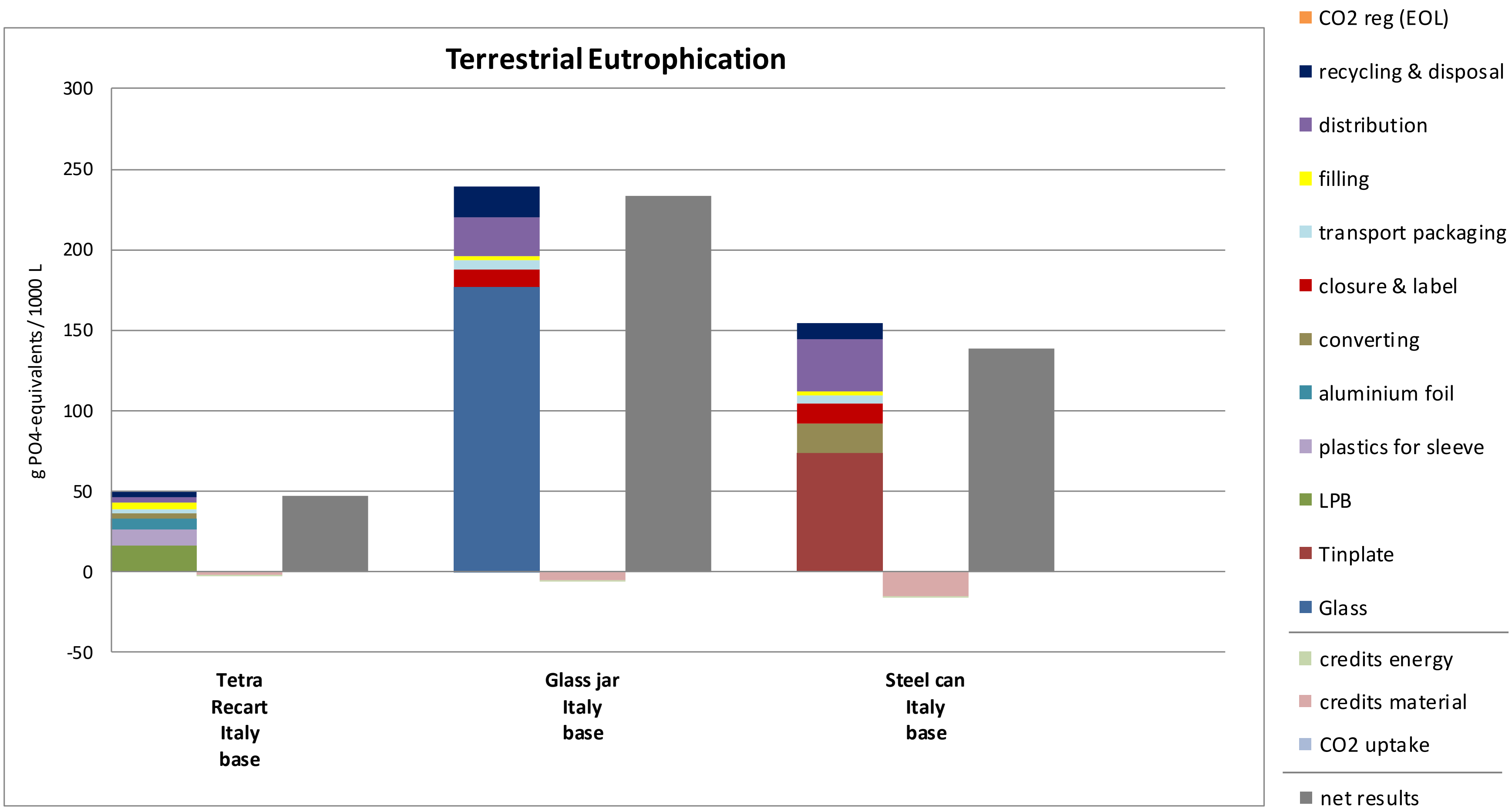

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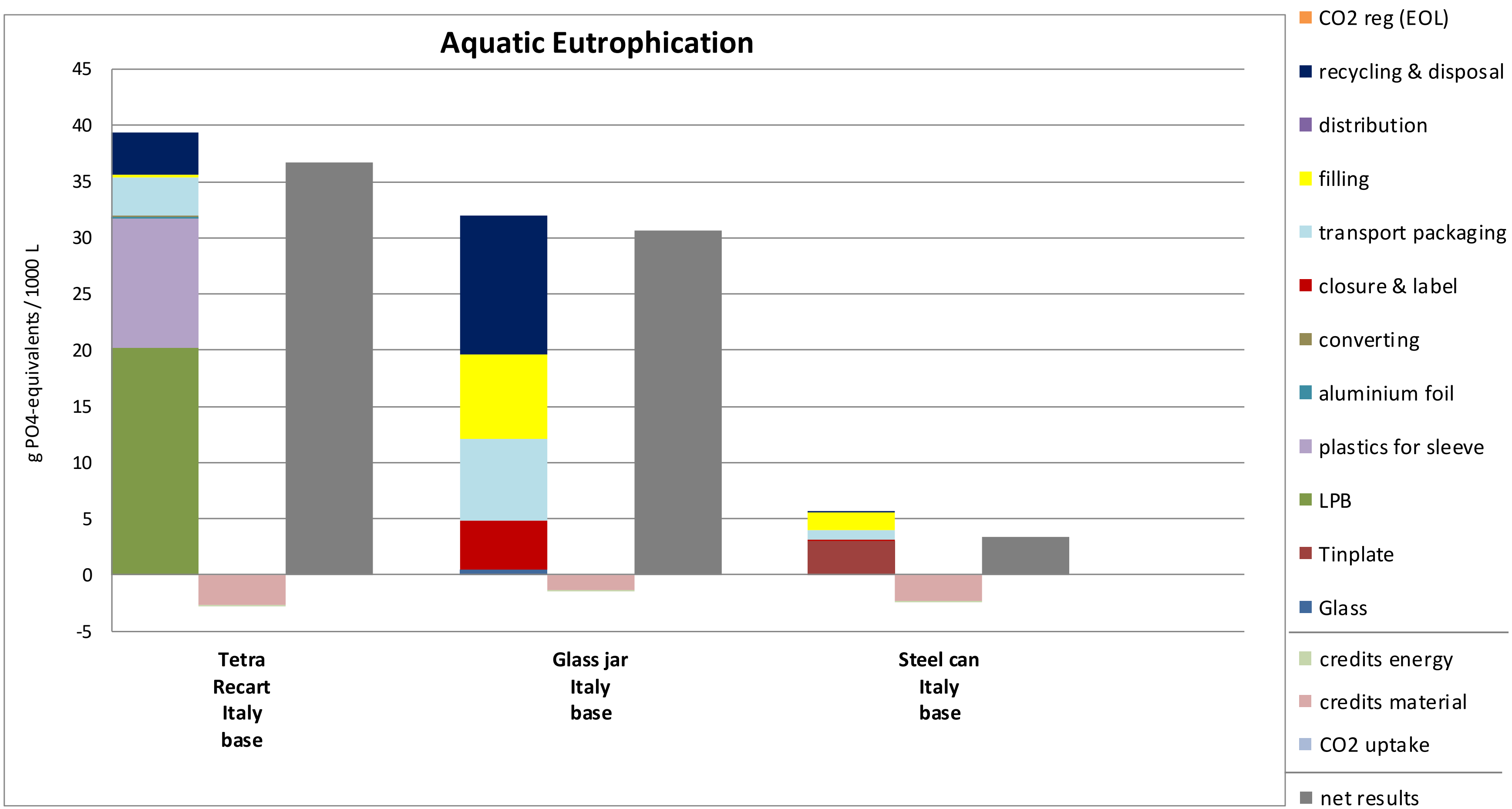

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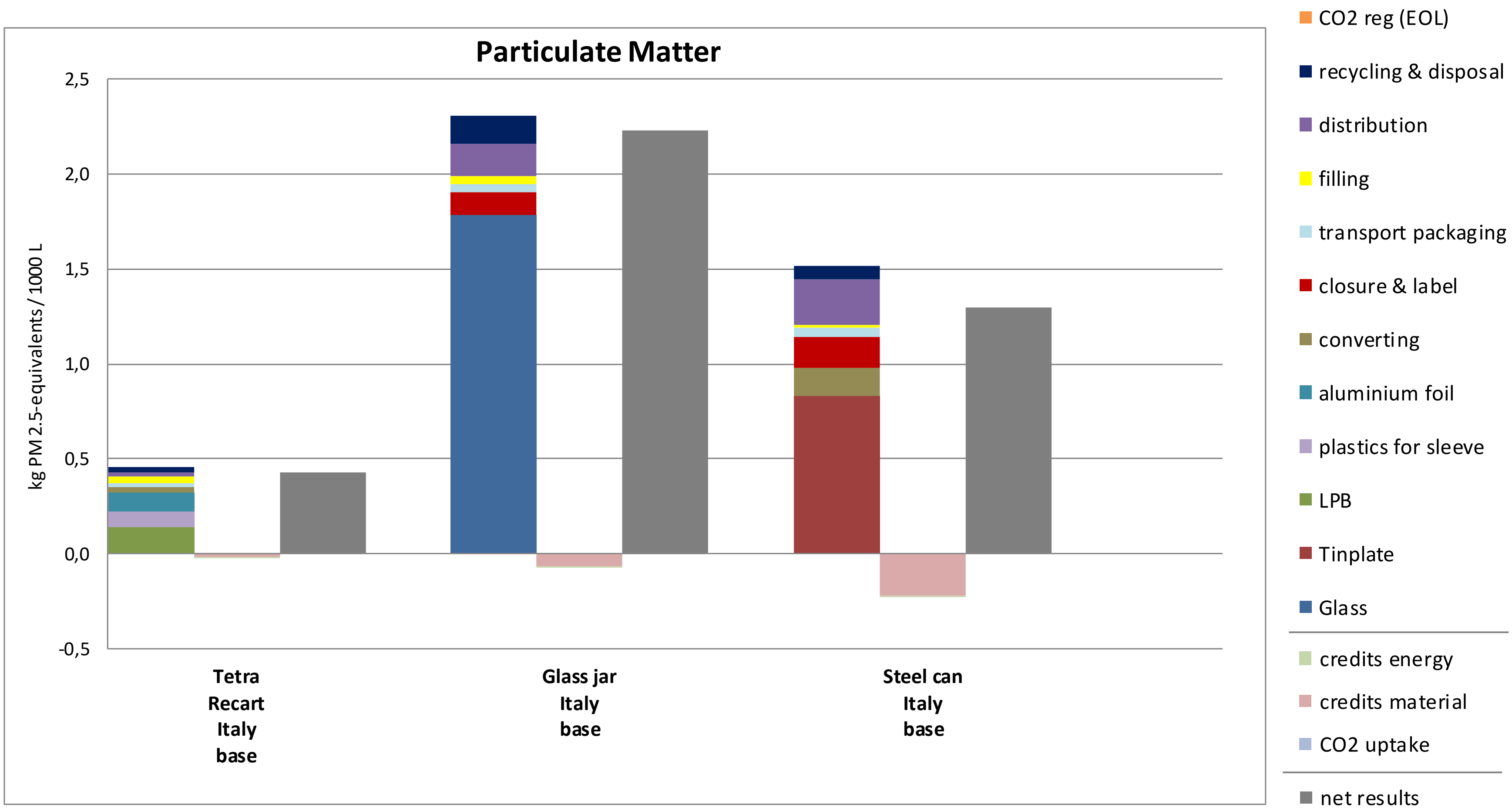
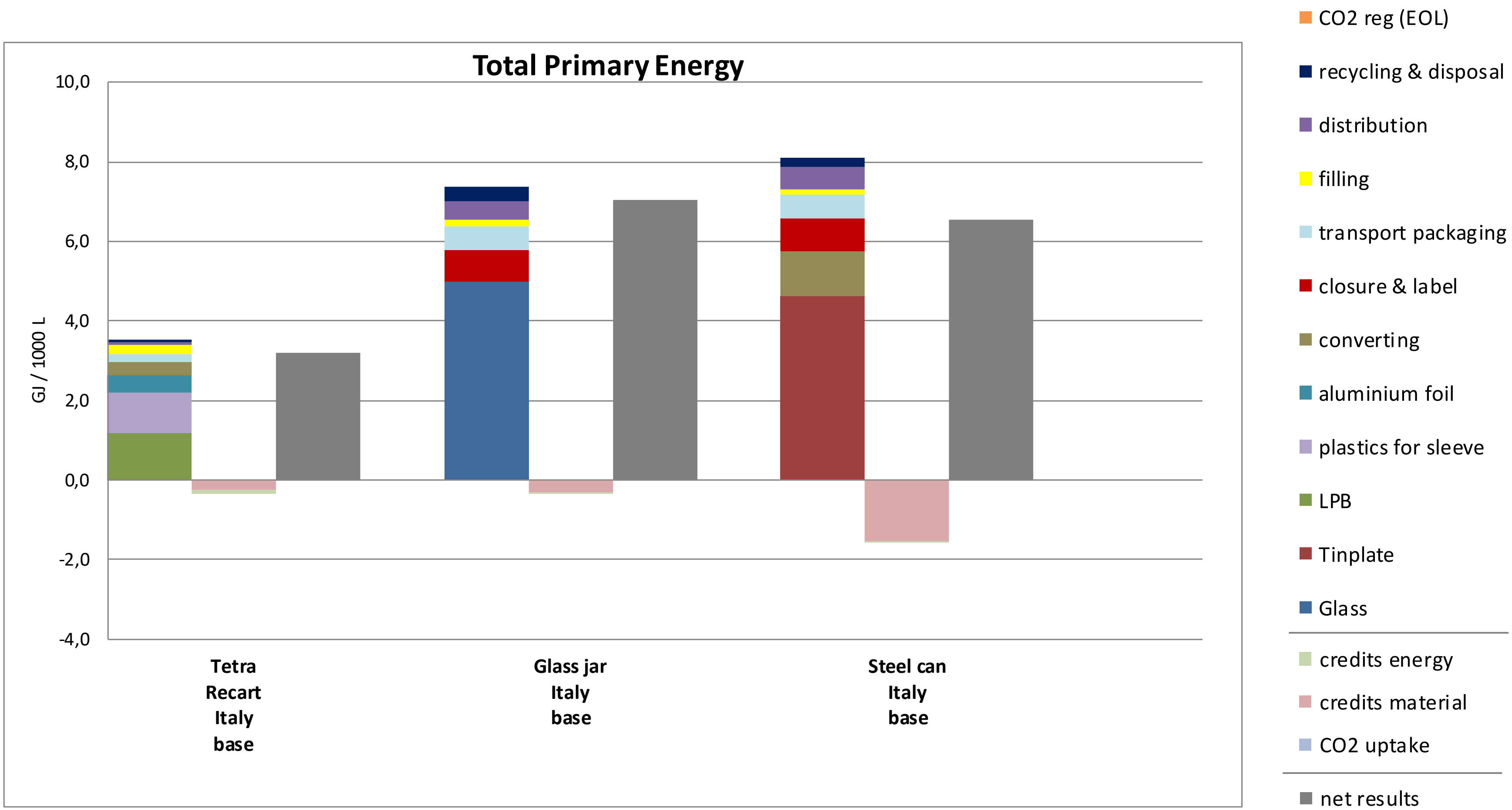
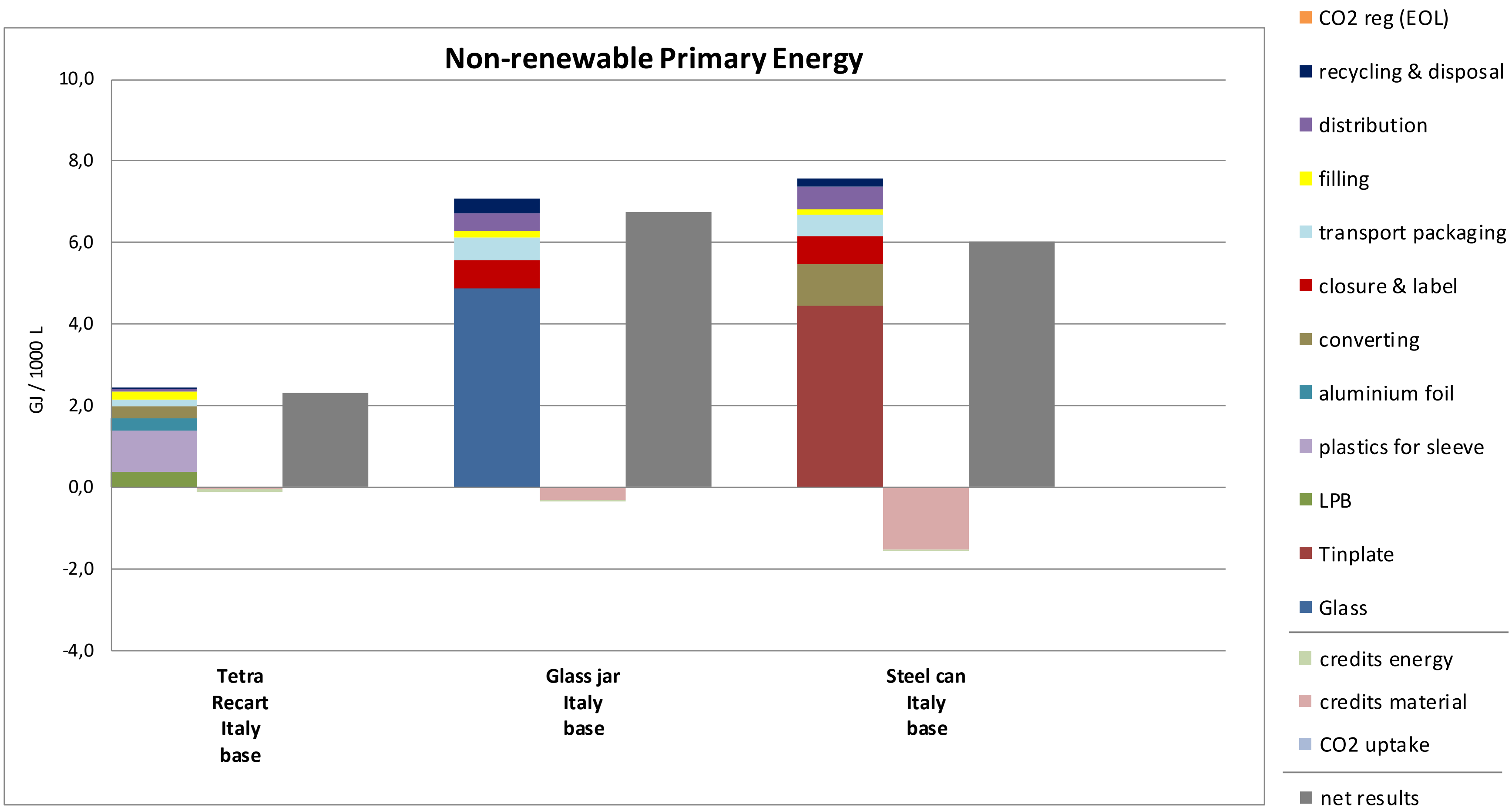


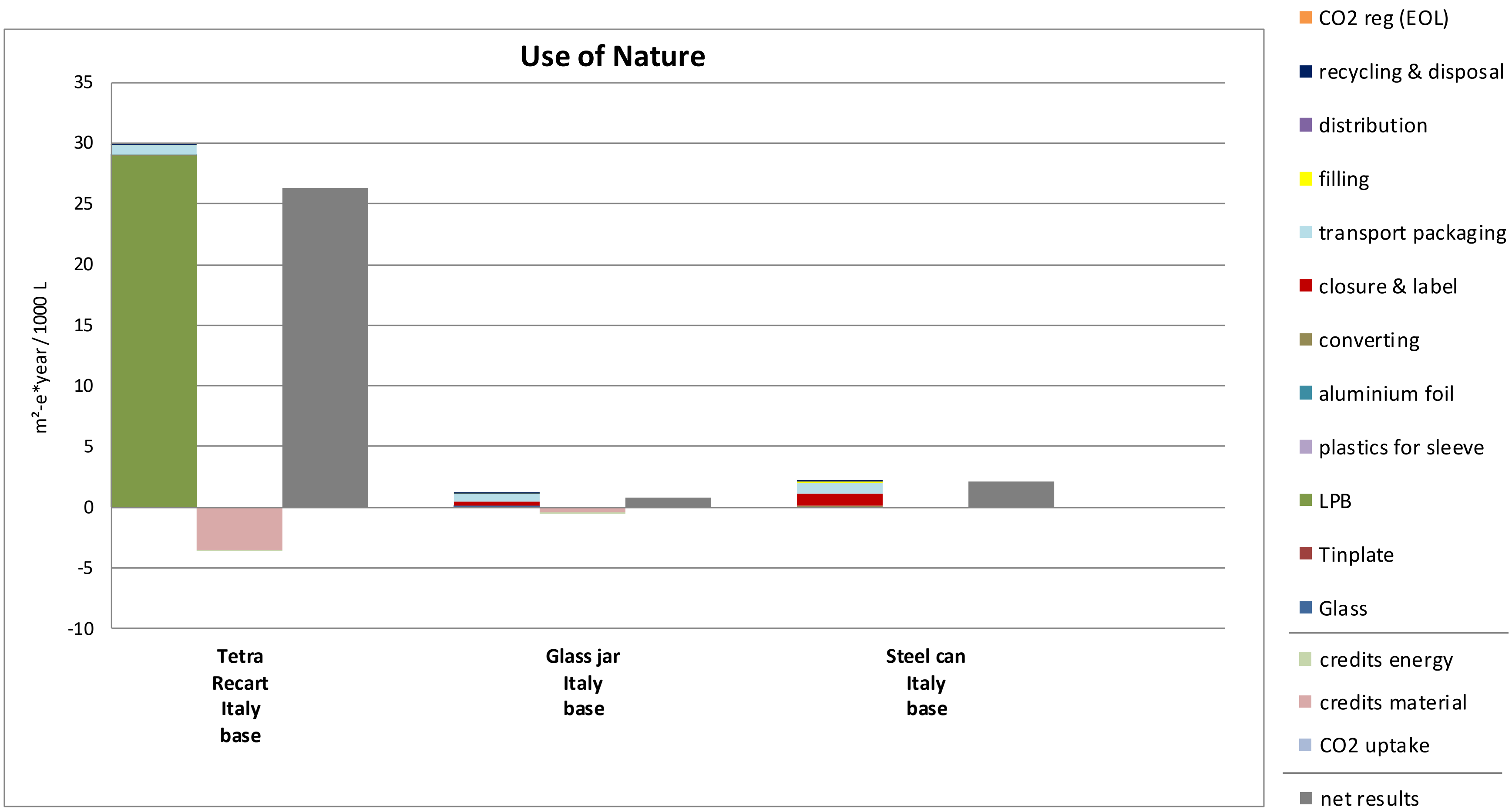
Results base scenario Italy



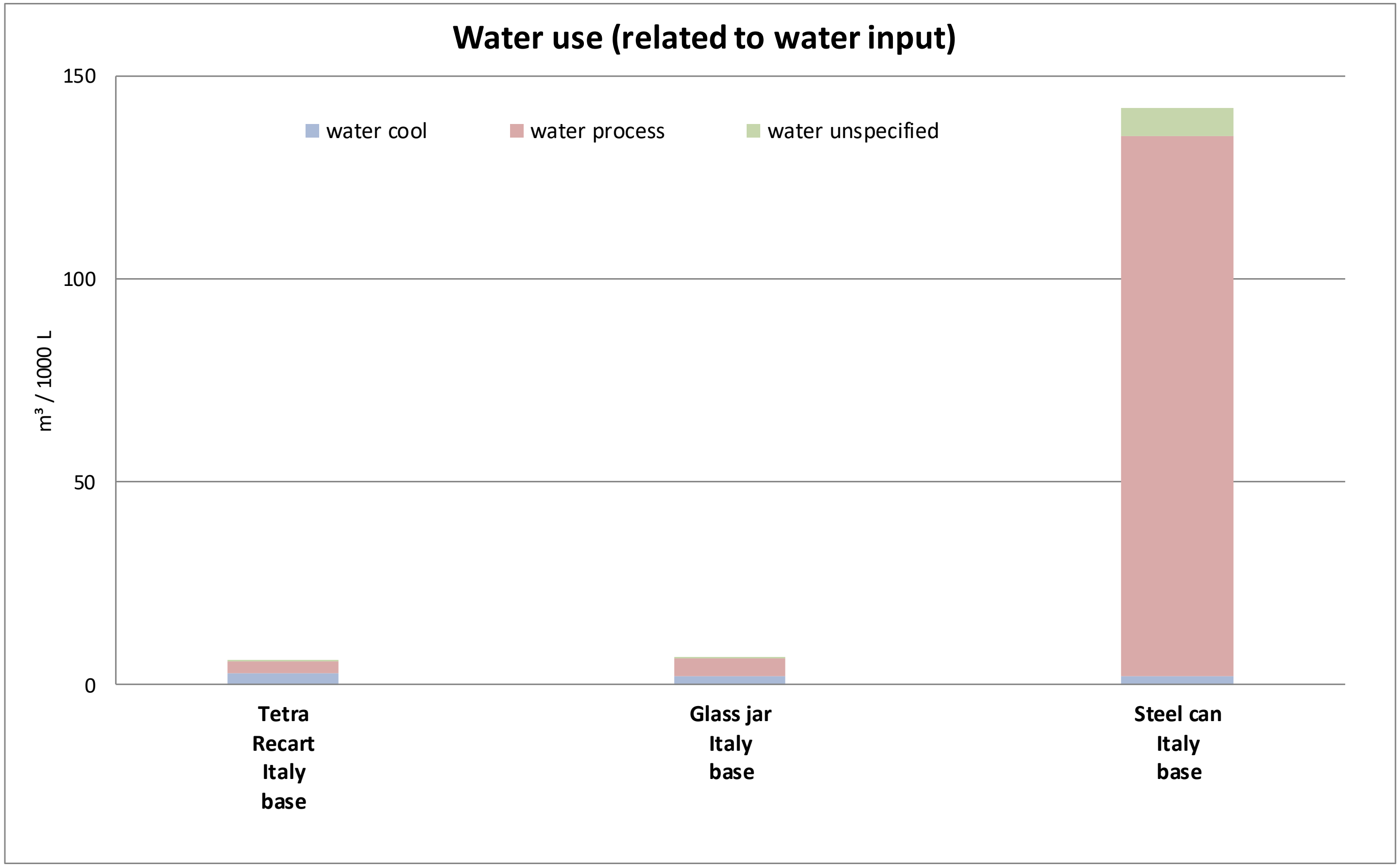
Results base scenario Italy



Results base scenario Italy



Results base scenario Italy



Results base scenario Italy

Comparison of net results: Tetra Recart versus alternative packaging systems in Italy

Tetra Recart 17 g

Glass jar: 221 g

Steel can: 59.5 g

Italy base scenario allocation factor 50%	The net results of **Tetra Recart** are lower (green)/ higher (orange) than those of	
	Glass jar	Steel can
Climate Change	-78%	-76%
Acidification	-79%	-68%
Summer Smog	-81%	-69%
Ozone Depletion Potential	-51%	29%
Terrestrial Eutrophication	-80%	-66%
Aquatic Eutrophication	20%	102%
Human Toxicity: PM 2.5	-81%	-67%
Total Primary Energy	-55%	-51%
Non-renewable Primary Energy	-66%	-61%

Applied recycling rates Italy

Tetra Recart: 25.6%

Glass jar: 70.9%

Steel can: 73.4%

The remaining share which is not recycled is disposed according to the European share:

58% landfill
42% MSWI

Results sensitivity analysis allocation factor 100% Italy

Comparison of net results - sensitivity analysis allocation factor 100%:
Tetra Recart versus alternative packaging systems in Italy

Italy allocation factor 100%	The net results of **Tetra Recart Italy AF100** are lower (green)/	
	Glass jar Italy AF100	Steel can Italy AF100
Climate Change	-71%	-62%
Acidification	-79%	-64%
Summer Smog	-80%	-65%
Ozone Depletion Potential	-47%	28%
Terrestrial Eutrophication	-80%	-63%
Aquatic Eutrophication	11%	91%
Human Toxicity: PM 2.5	-81%	-62%
Total Primary Energy	-57%	-42%
Non-renewable Primary Energy	-65%	-51%

The ranking order among Tetra Recart and alternative packaging systems is not affected by the application of a 100% allocation factor.

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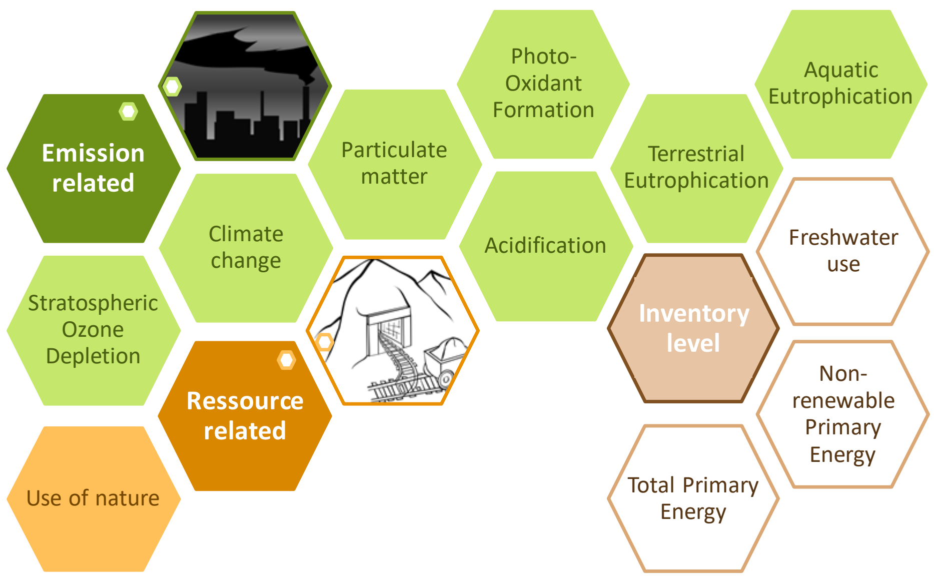
Results Europe



Results scenario variants on the European market

For European scenario specifications of German market were applied for steel can and glass jar*

Glass jar: 223 g

Steel can: 59.5 g

EU 28+2 status quo allocation factor 50%	The net results of **Tetra Recart EU28+2** are lower (green)/ higher (orange) than	
	Glass jar EU28+2	Steel can EU28+2
Climate Change	-81%	-81%
Acidification	-80%	-72%
Photo-Oxidant Formation	-82%	-73%
Ozone Depletion Potential	-50%	5%
Terrestrial Eutrophication	-81%	-71%
Aquatic Eutrophication	19%	60%
Particulate Matter	-83%	-72%
Total Primary Energy	-58%	-57%
Non-renewable Primary Energy	-73%	-72%

*Due to the disproportionate effort to gather data in each European country to derive European average specifications for glass jar and steel can, specifications of German market were chosen as one of the two most relevant market for canned tomatoes in Europe.

Applied recycling rates EU 28+2

Tetra Recart: 44%

Glass jar: 73%

Steel can: 76%

The remaining share which is not recycled is disposed according to the European share:

60% landfill

40% MSWI

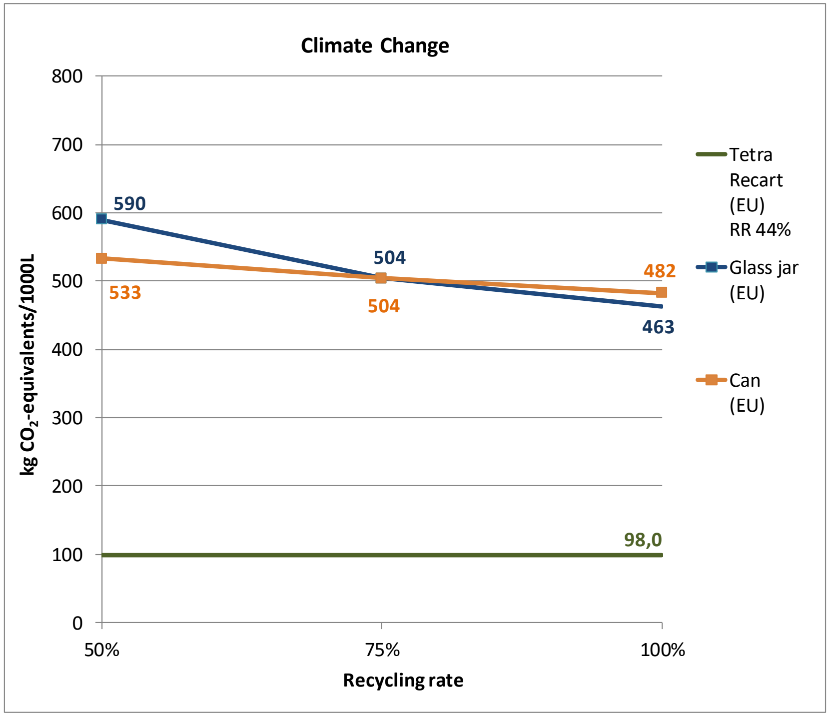
Differences in results compared to Germany result from:

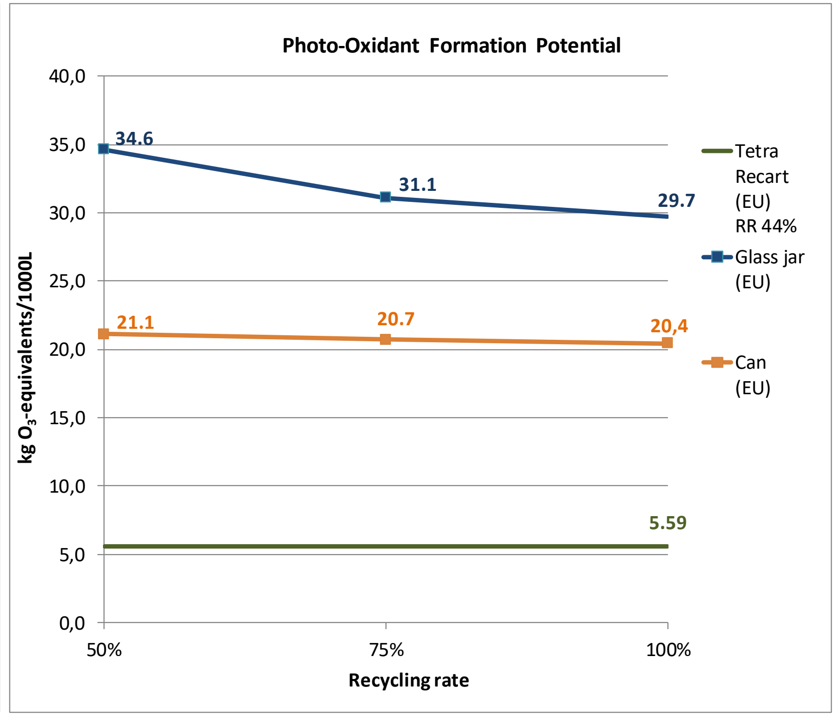
- **lower recycling rates for all systems analysed**
- **higher share of landfill (no landfill in Germany)**
- **different electricity grid mix.**

Results scenario variants on the European market

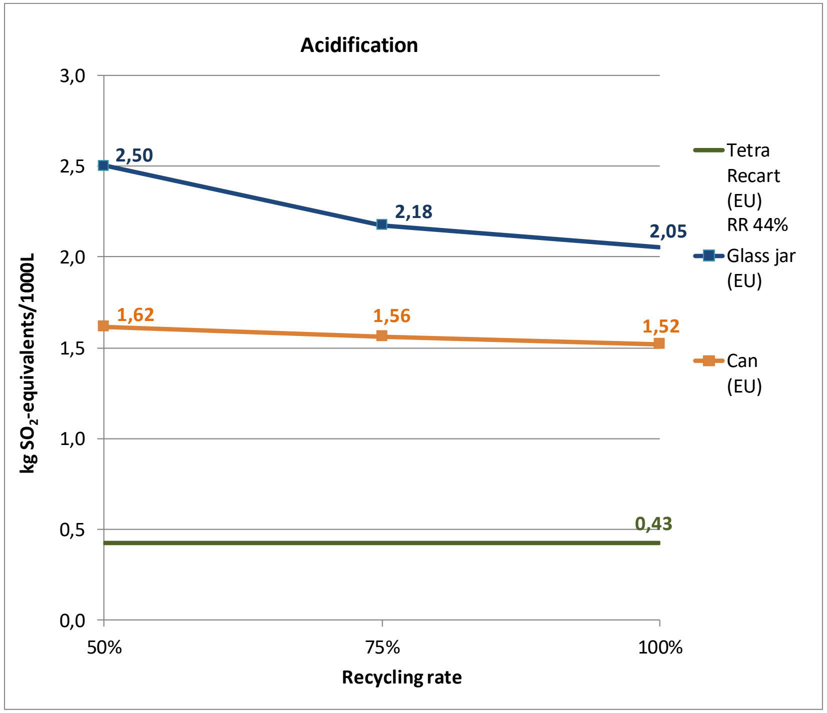
- Effects of varying recycling rates within a certain value range on the results were examined.
- Additional scenarios provide indications about environmental performance of the different packaging systems, <u>if the recycling quota of the competing packaging systems is varying:</u>
  - recycling rate 50%
  - middle range recycling rates (close to 75%)
  - high range recycling rates (100%)
- An allocation factor of 50% is applied.

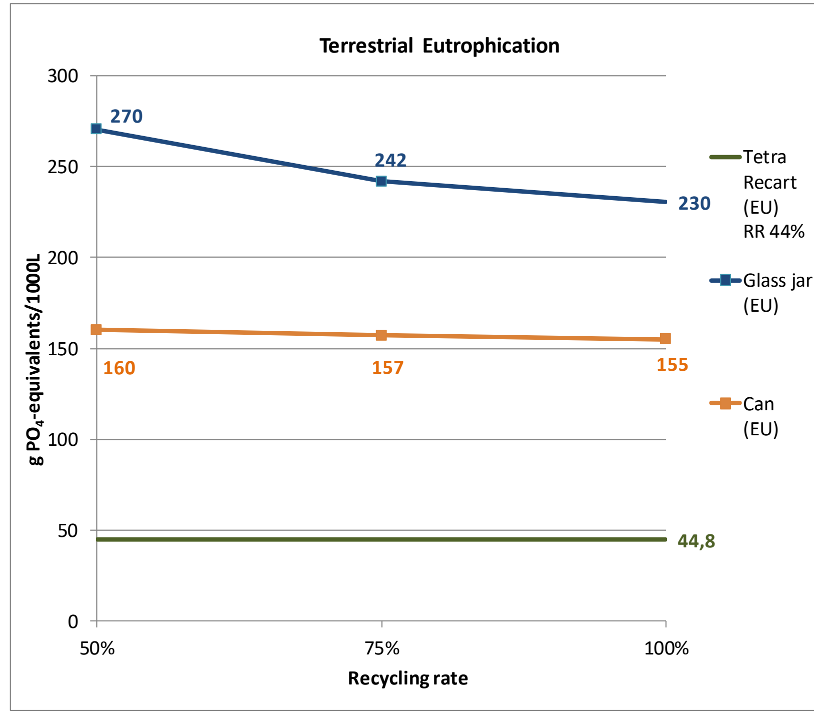
Results scenario variants on the European market



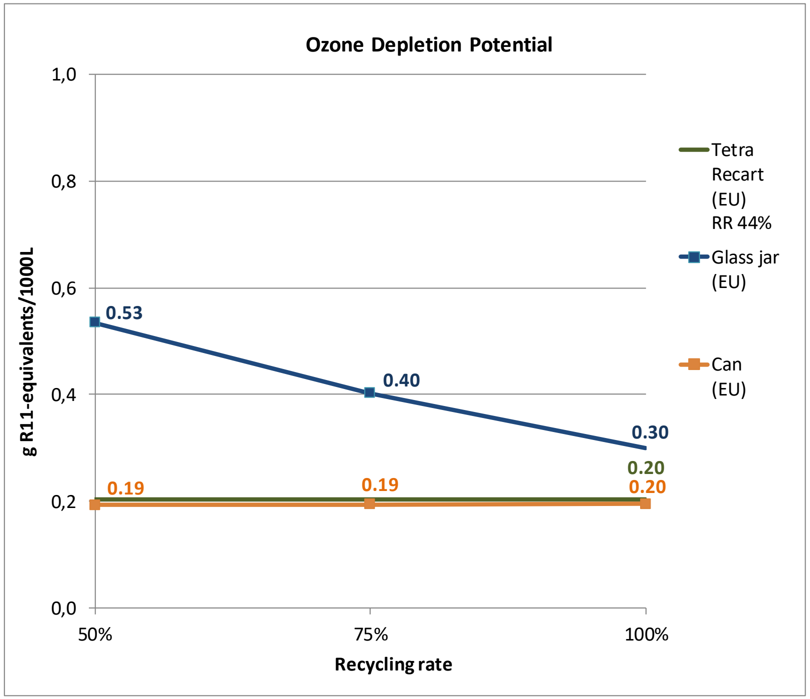


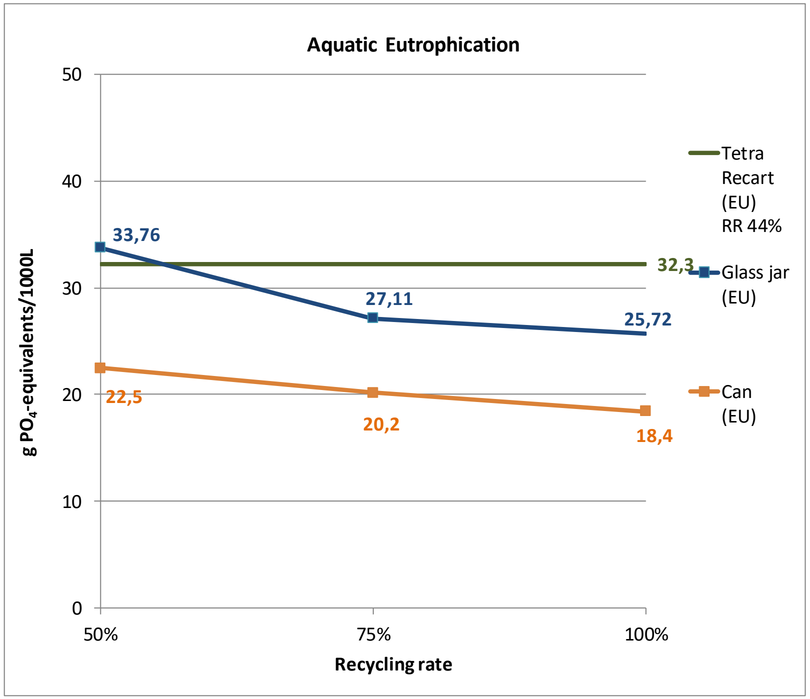
Results scenario variants on the European market



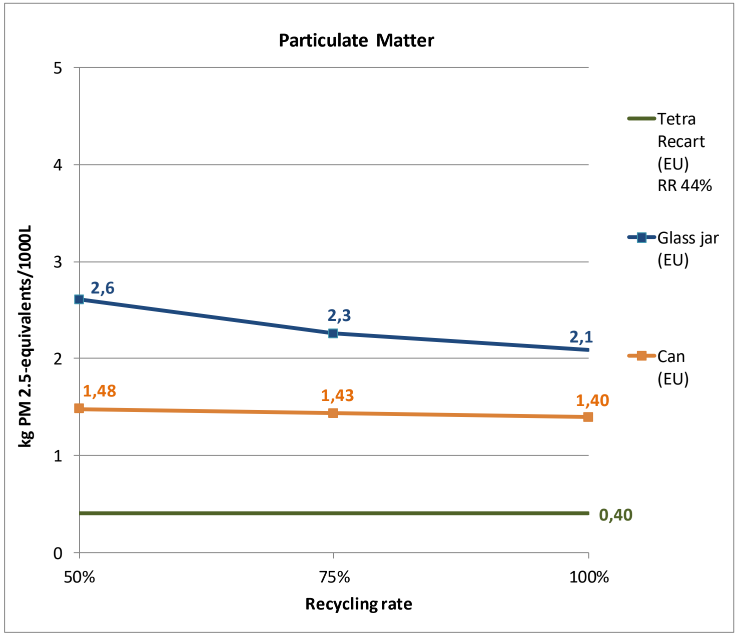


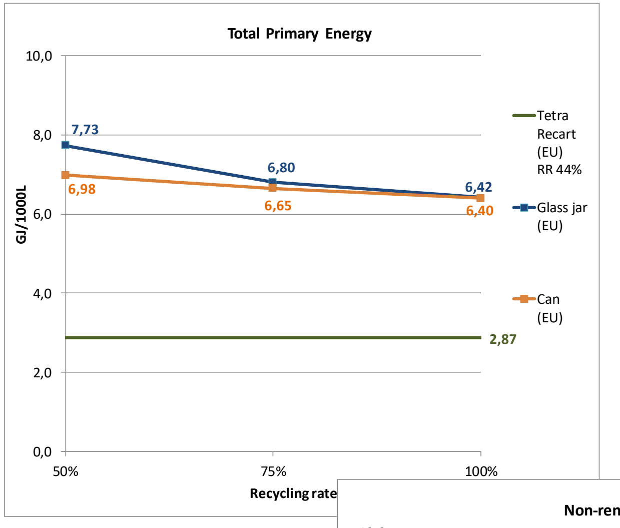
Results scenario variants on the European market

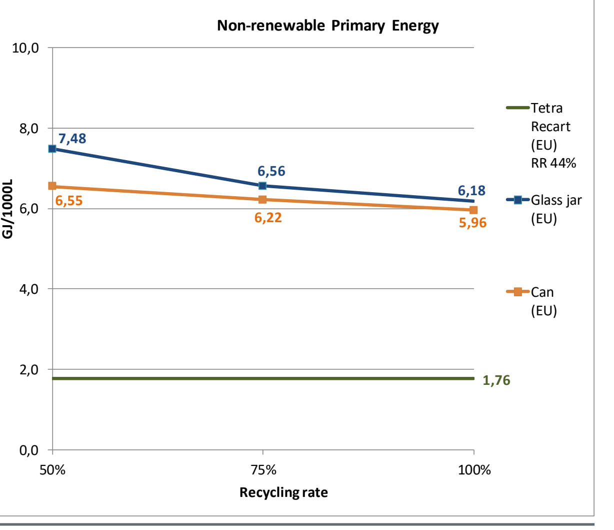




Results scenario variants on the European market







Results scenario variants on the European market

- Scenario variants for the European market confirm the pattern as observed for Italy and Germany.
- The result may be used as an indication on how country-specific parameters may influence overall results, i.e. varying recycling rates.
- Apart from the electricity grid mix, recycling rates are one of the major parameters expected to differ considerably between countries.

Conclusions
Most significant parameters

- Major impact in most of environmental impact indicators in both markets due to the production of base materials, especially the production of plastics, aluminium, tinplate and glass.
- Production of LPB for Tetra Recart plays a less important role in many impact categories.
- But LPB still main contributor to the results of Tetra Recart in *Aquatic Eutrophication, Summer Smog, Acidification, Terrestrial Eutrophication* and *Particulate Matter.*
- Included polymers in Tetra Recart cause high contribution to the *Ozone Depletion Potential*.
- Production of transport packaging of glass jar and steel can shows high contributions in *Aquatic Eutrophication* potential.
- Transport related impacts of glass jar and steel can in *Terrestrial Eutrophication* and *Summer Smog*. Impacts for scope of Germany are higher due to the longer transport distances.
- High share of Tetra Recart and glass jar due to landfilling in Italy: major contribution to *Aquatic Eutrophication*, however to a lesser extent for Tetra Recart.

Conclusions
Comparison of TRC with competing systems

- **Glass jar** shows higher environmental impacts in all impact categories compared to Tetra Recart, except in Aquatic Eutrophication.
- **Steel can** shows higher environmental impacts in all impact categories than Tetra Recart except in *Aquatic Eutrophication* and *Ozone Depletion Potential*: Results of the can match those of the Tetra Recart within the scope of Germany if an allocation factor of 100% is applied.
- The robustness and validity of the results regarding the allocation factor used for open-loop recycling are generally confirmed by the sensitivity analyses.
- The sensitivity analysis with varying recycling rates for the alternative packaging systems on the European market confirms the pattern, when the Tetra Recart is compared with the glass jar and steel can.
- Findings are only valid within this LCA study's framework conditions. Accordingly, several limitations must be considered and are documented in detail in the full report.

Overarching conclusions and recommendations

- Food carton Tetra Recart clearly shows a more favourable environmental performance compared to glass jar and steel can.
- The robustness and validity of the results are confirmed by the applied sensitivity scenarios regarding the allocation factor and varying recycling rates for glass jar and steel can.
- Environmental impacts of Tetra Recart are primarily defined by the production of base materials for primary packaging.
- The share of LPB made of renewable sources, the production of it using a high share of renewable energy sources and the lightweight of Tetra Recart are an advantage.
- Optimisation efforts for the Tetra Recart should be directed towards the weight and type of polymers included in Tetra Recart.

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