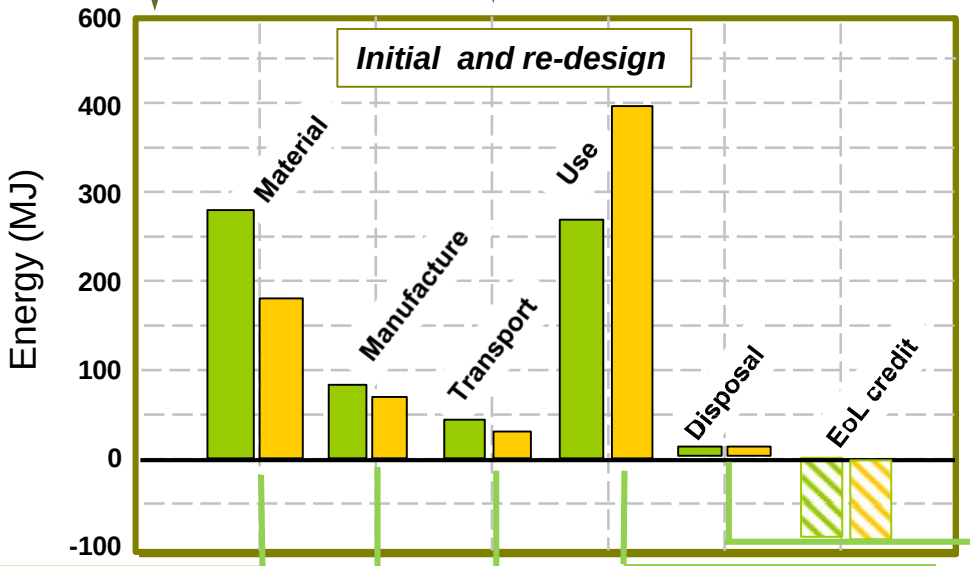
Eco-design: the strategy (1)

The steps

Fast eco-audit → Analyse results, identify priorities → Explore options with "What if..."s → Use CES to select new Materials and/or Processes → Recommend actions & assess potential savings



Use eco-audit to identify Eco-design objective

Material
Minimize:
- material in part
- embodied energy
- CO_2 / kg

Manufacture
Minimize:
- process energy
- CO_2/kg

Transport
Minimize:
- mass
- distance
- transport type

Use
Minimize:
- mass
- thermal loss
- electrical loss

End of Life
Select:
- recyclable materials
- non-toxic materials

The CES Eco-audit tool

User inputs

User interface

- *Bill of materials*
- *Manufacturing process*
- *Transport needs*
- *Duty cycle*
- *End of life choice*



Data from CES

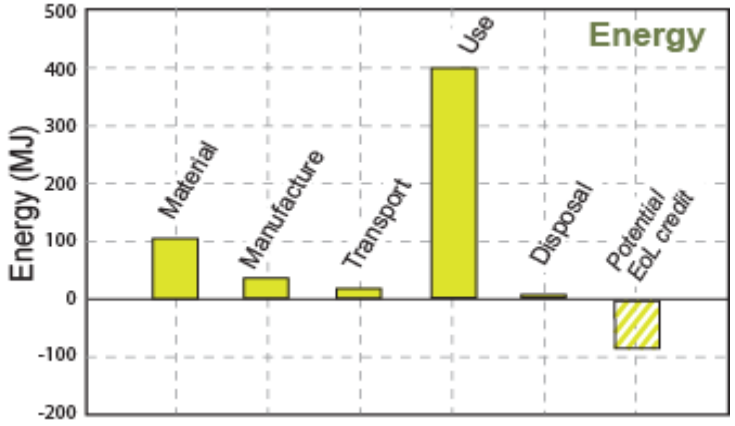
Eco database

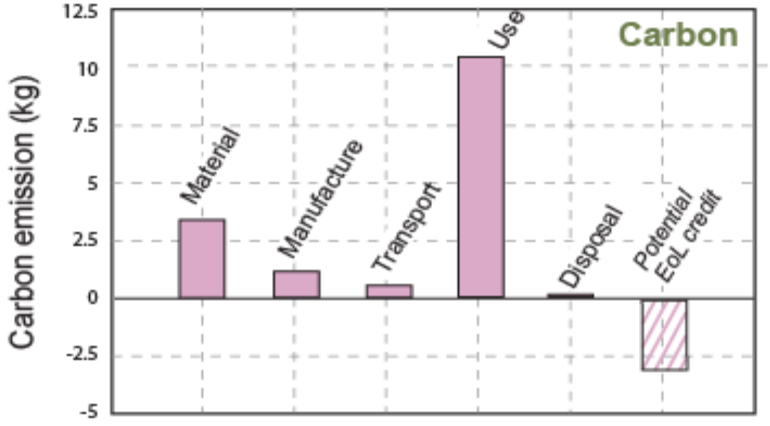
- *Embodied energies*
- *Process energies*
- *CO_2 footprints*
- *Unit transport energies*
- *Recycling / combustion*

Eco audit model

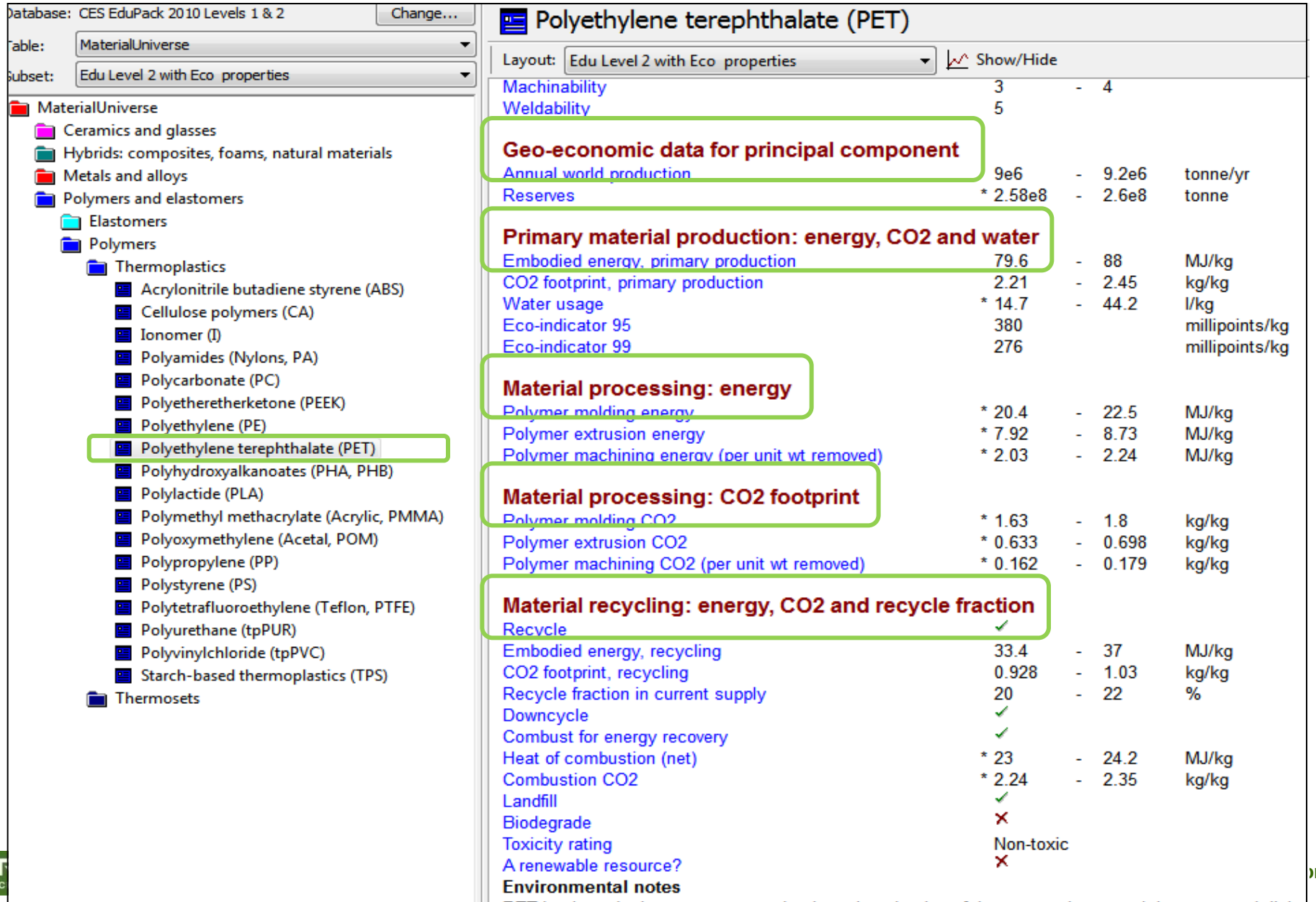
Outputs

(including tabular data)





Typical record showing eco-properties



The CES EduPack Eco-audit tool

User inputs

User interface

- *Bill of materials*
- *Manufacturing process*
- *Transport needs*
- *Duty cycle*
- *End of life choice*



Data from CES

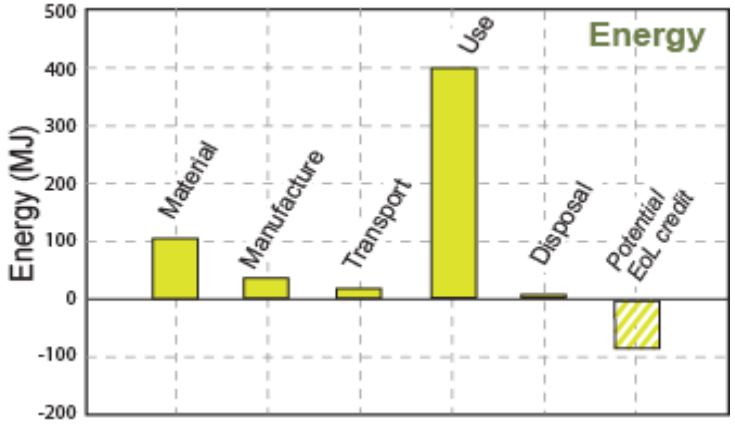
Eco database

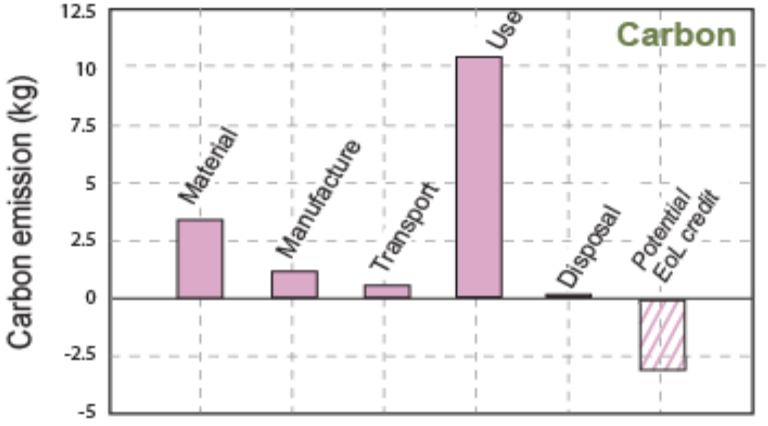
- *Embodied energies*
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- *CO_2 footprints*
- *Unit transport energies*
- *Recycling / combustion*

Eco audit model

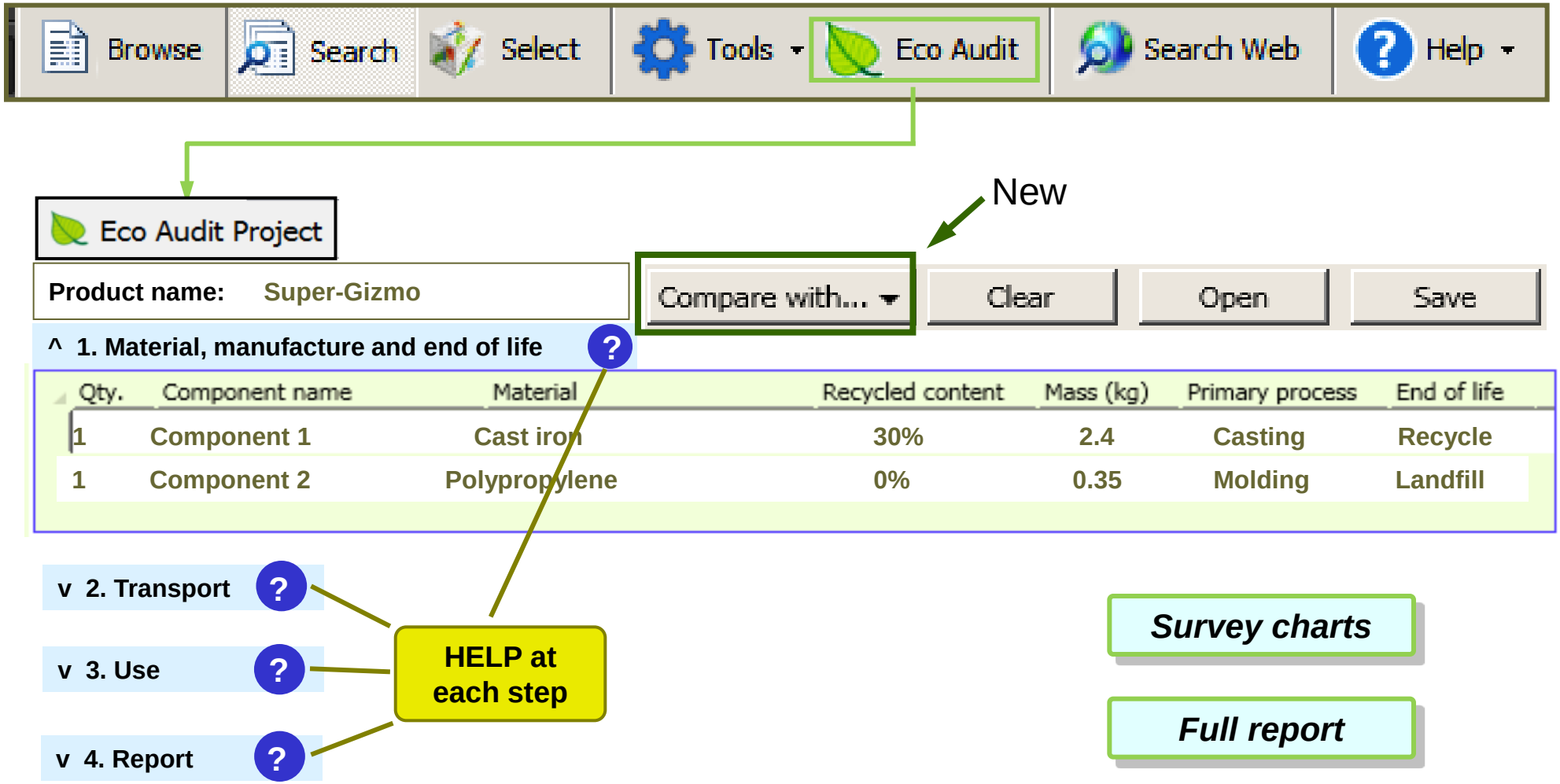
Outputs

(including tabular data)





The simple Audit tool: Levels 1, 2 and 3



Step 1. Material and process energy / CO_2

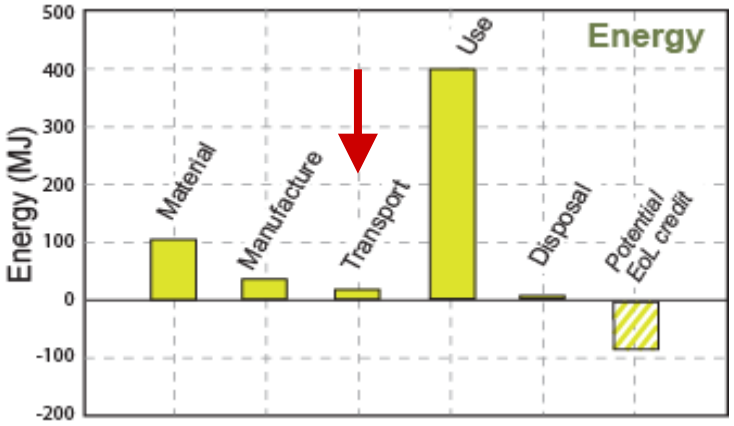
Component name	Material	Process	Mass (kg)	End of life
Component 1	Aluminum alloys	Casting	2.3	Recycle
Component 2	Polypropylene	Polymer molding	1.85	Landfill
Component 3	Glass	Glass molding	3.7	Reuse

Step 2. Transport

Transport stage	Transport type	Distance (km)
Stage 1	32 tonne truck	350
Stage 2	Sea freight	12000

Transport energy

Transport CO_2



Step 3. Use phase – static mode

Energy input and output *Fossil fuel to electric*

Power rating *1.2* *kW*

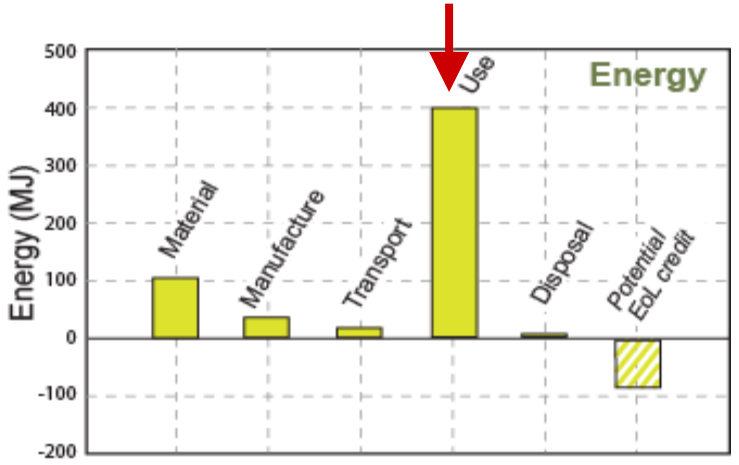
Usage *365* days per year

Usage *0.5* hours per day

Energy conversion path

- Fossil fuel to heat, enclosed system
- Fossil fuel to heat, vented system
- **Fossil fuel to electric**
- Fossil fuel to mechanical
- Electric to heat
- Electric to mechanical (electric motor)
- Electric to chemical (lead-acid battery)
- Electric to chemical (Lithium-ion battery)
- Electric to light (incandescent lamp
- Electric to light (LED)

Total energy and CO_2 for use



Bottled water (100 units)



- 1 litre PET bottle with PP cap
- Blow molded
- Filled in France, transported 550 km to UK
- Refrigerated for 2 days, then drunk

Product name: *PET bottle*

Compare with... | Clear | Open | Save

Number	Name	Material	Process	Mass (kg)	End of life
100	Bottles	PET	Molding	0.04	Recycle
100	Caps	Polyprop	Molding	0.001	Landfill
100	Water			1.0	

Transport

Stage 1	14 tonne truck	550 km

Survey charts

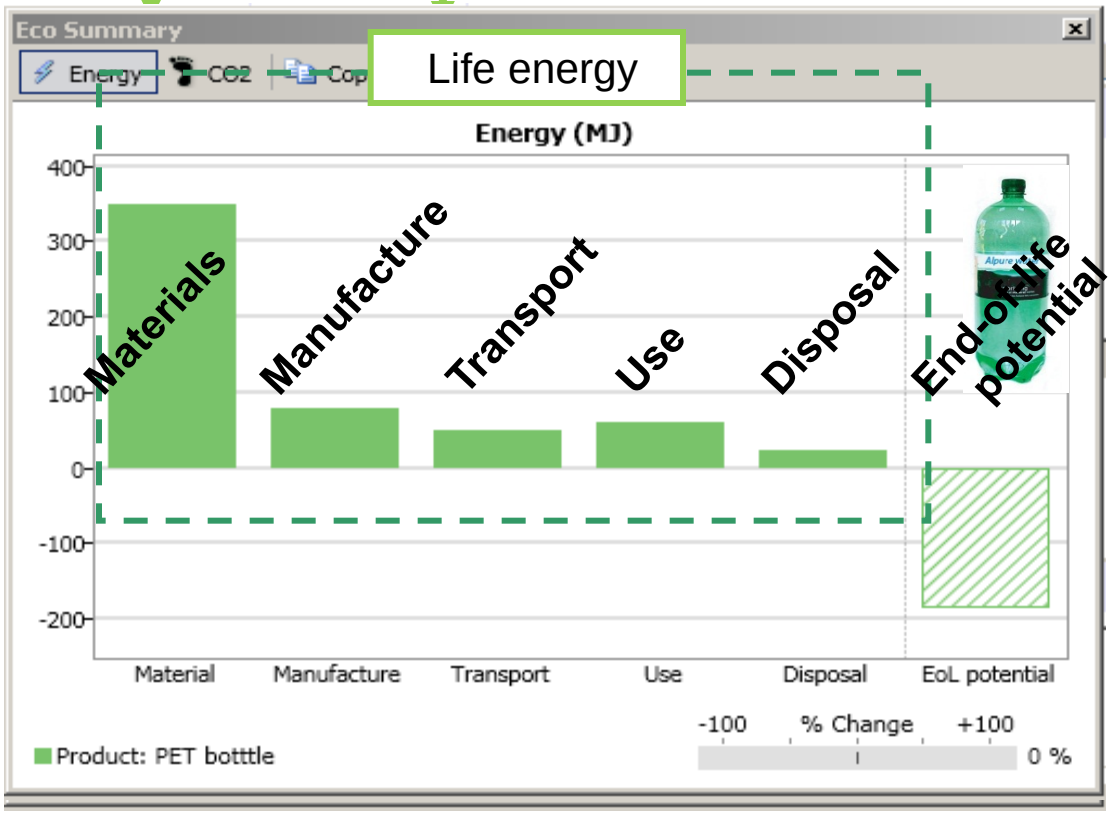
Use - refrigeration

Fossil to electric	0.12 kW	2 days	24 hrs/day	Full report

Output: summary charts

Toggle between energy *and* carbon footprint

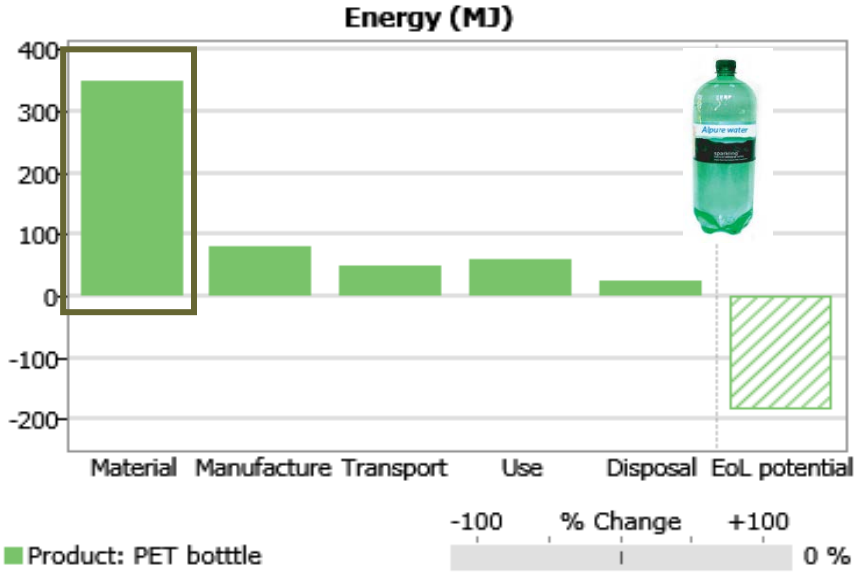
Copy *or* print the chart

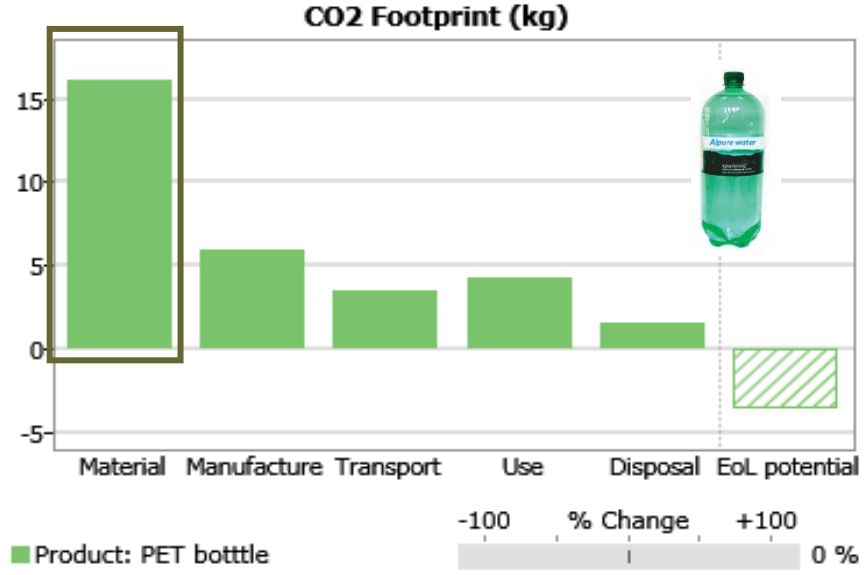


Which phase has the largest impact?

Materials

Actions and comparisons





The audit reveals the most energy and carbon intensive steps…

… and allows rapid "What if…"



PET ***Glass ?***

Change the materials



- 1 litre **glass bottle** with **aluminum cap**
- **Glass molded**
- Filled in France, transported 550 km to UK
- Refrigerated for 2 days, then drunk

Product name: *Glass bottle*

Compare with... | Clear | Open | Save

Number	Name	Material	Mass (kg)	End of life
100	Bottles	Soda glass	0.45	Recycle
100	Caps	Aluminum	0.002	Landfill
100	Water		1.0	

Copy of current project
New project
Saved project

Transport

Stage 1	14 tonne truck	550 km

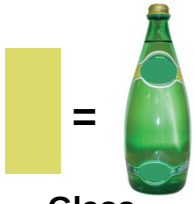
Use - refrigeration

Fossil to electric	0.12 kW	2 days	24 hrs/day

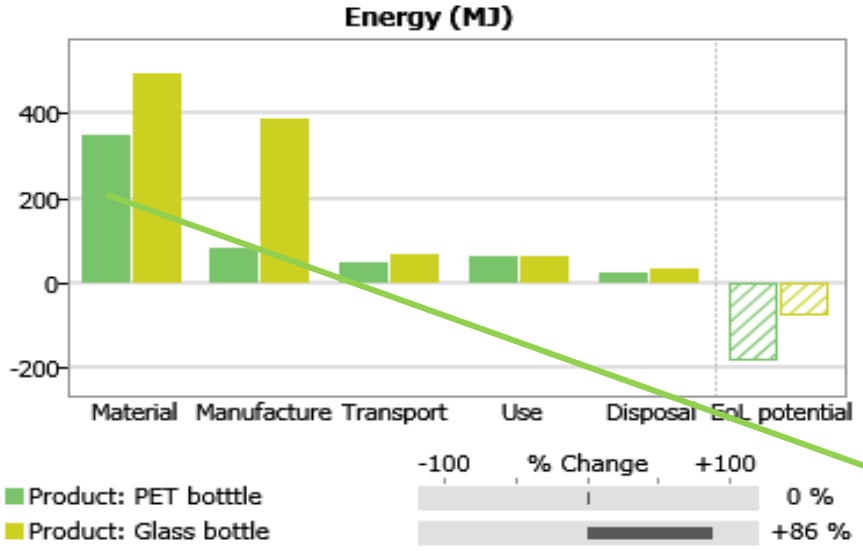
Actions and comparisons

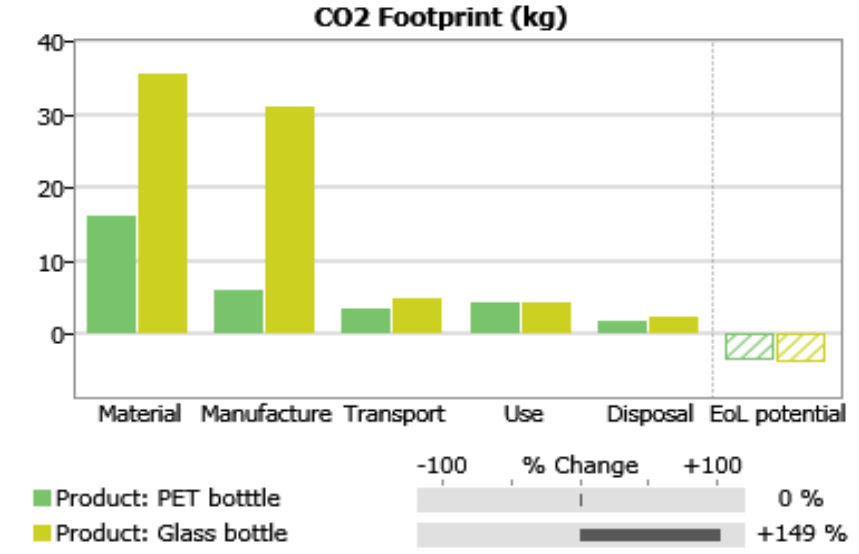


Virgin PET



Glass





The fast comparison allows design decisions on-the-fly

Reducing impact

Actions

- **Use as large a 'recycled content' in the material as possible.**

What if…….
100% recycled PET?

Energy balances with recycling

Material	Recycled fraction in current supply[(1)] (%)	Embodied energy, virgin material (MJ/kg)	Embodied energy, recycled material (MJ/kg)	H_r/H_p Ratio of recycled to virgin energies (%)
Aluminum	36	210	26	12
Steel	42	26.5	7.3	27
Copper	42	58	13.5	23
Lead	72	27	7.4	27
PET	21	85	39	46
PP	5	74	50	67
Glass	24	10.5	8.2	78
Paper	72	45	20	44

H_p — Primary production energy

H_r

The recycling of Al is much easier than that of glass

Reusing glass cullet implies risks of poor quality of products (defects)

Updated manufacturing energy $H_p^* = H_p \cdot (1-r) + r \cdot H_r$

Manufacturing energy with recycled material, at **constant product quality**

Energy saving $\Delta H_p = H_p - H_p^* = H_p - H_p \cdot (1-r) - r \cdot H_r = r \cdot (H_p - H_r)$

Actions and comparisons

Click
Compare with….
Copy of current content

Set* Recycle content *to 100%



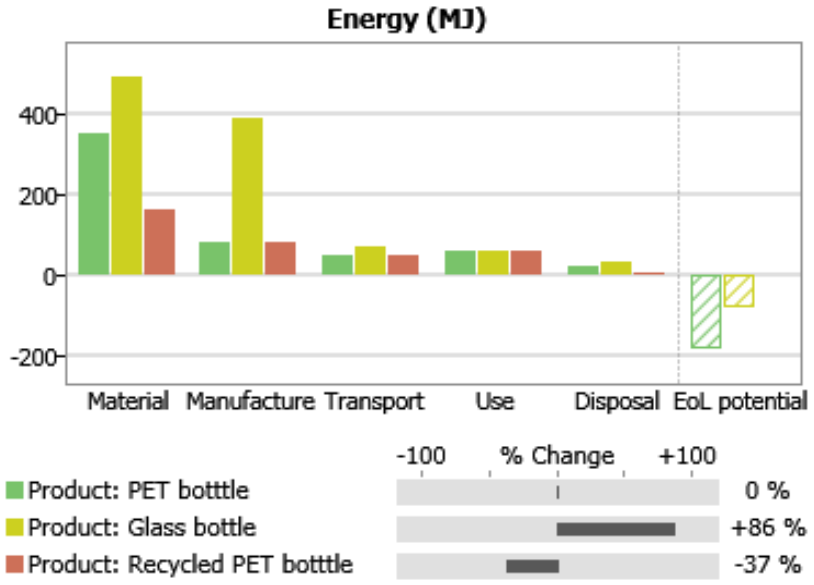
Virgin PET

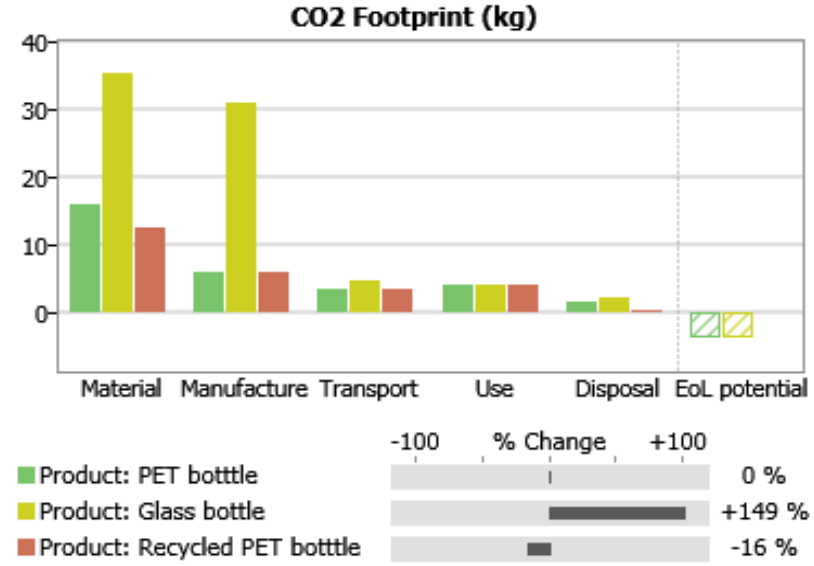


Glass



Recycle PET

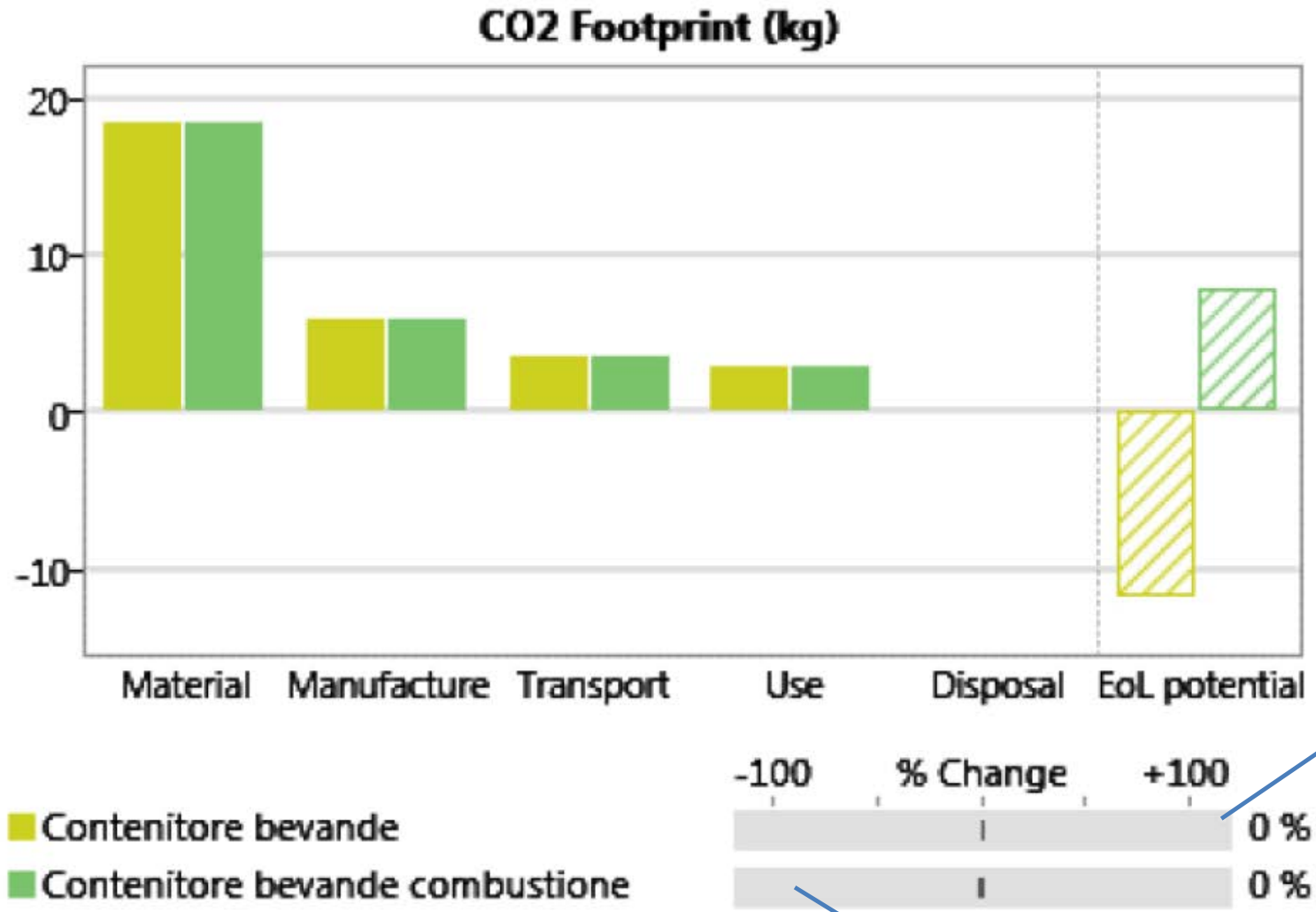




Can explore:

- Material choice
- Recycle content
- Transport mode
- Transport distance
- Use pattern
- Electric energy mix
- End of life choice

Many projects available as project files.

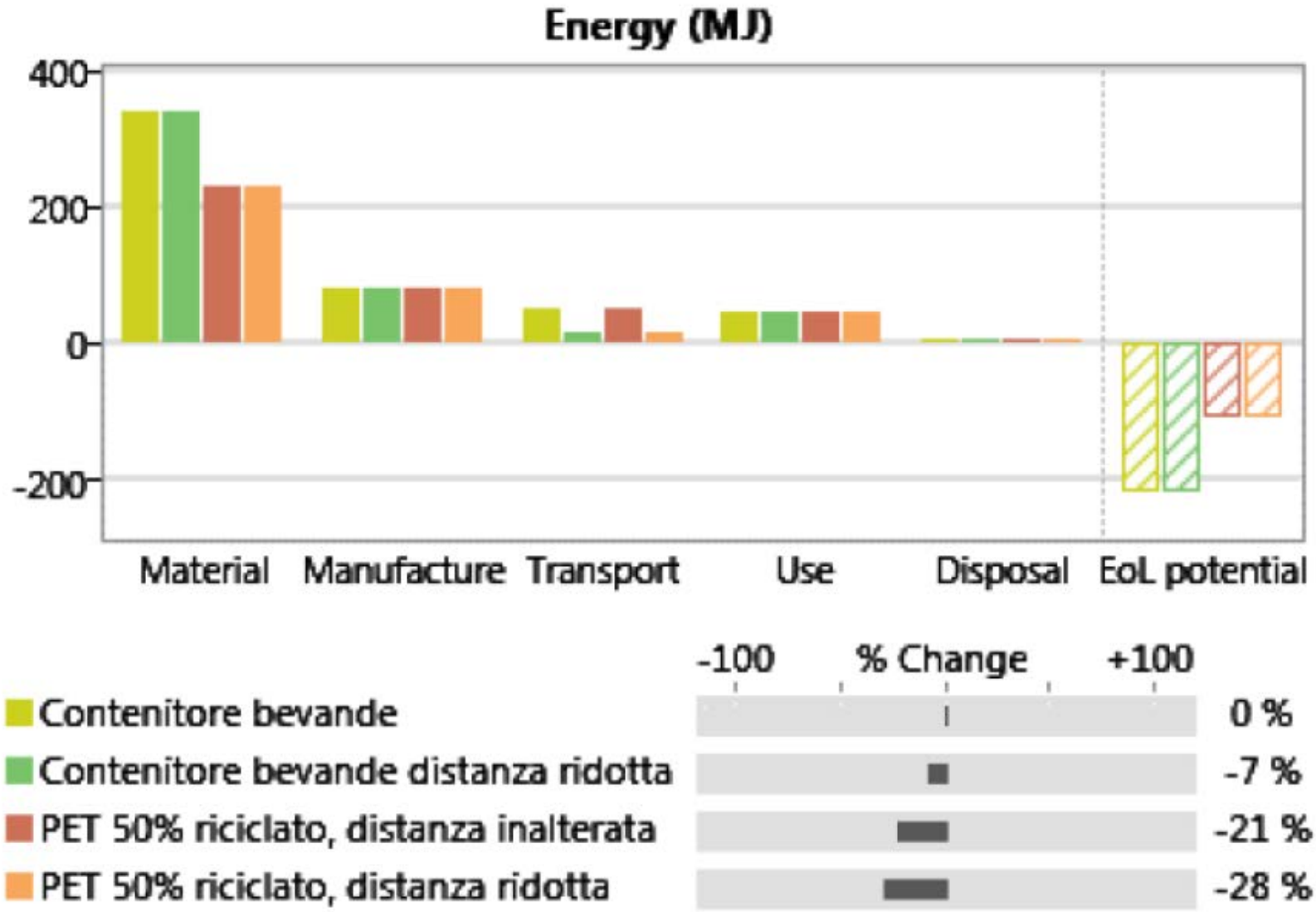


b

Combustion of cap (PP), Recycling of bottle (PET)

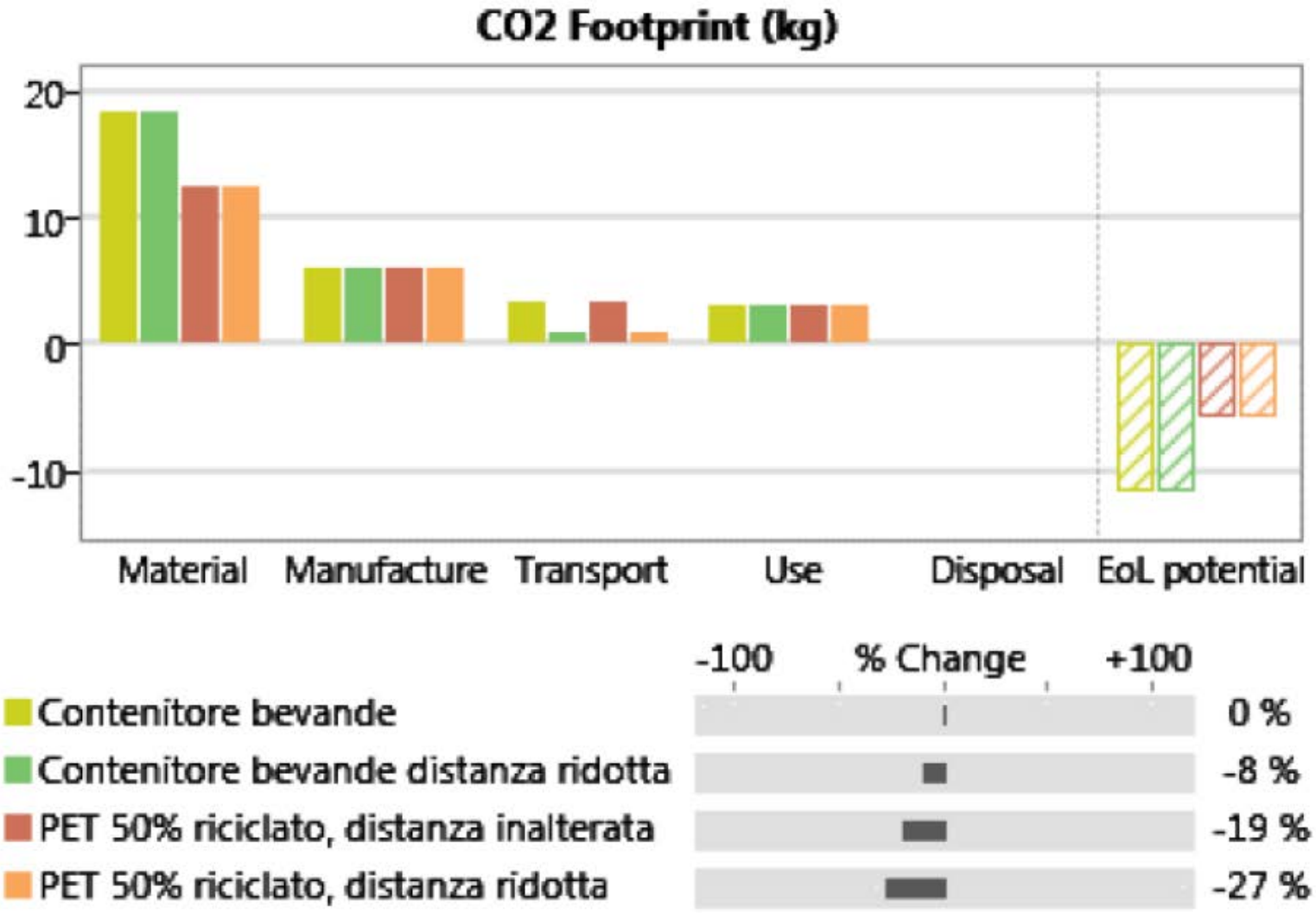
Combustion of both cap and bottle

Evidence of negative impact on CO_2



Synergistic effects:

- Reduced distance (150 km, instead of 550 km)
- **Introduction of 50% recycled PET (feasible?)**



Synergistic effects:

- Reduced distance (150 km, instead of 550 km)
- **Introduction of 50% recycled PET (feasible?)**