Aalto University
School of Engineering

MEC-E1070 Selection of Engineering Materials

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School of Engineering

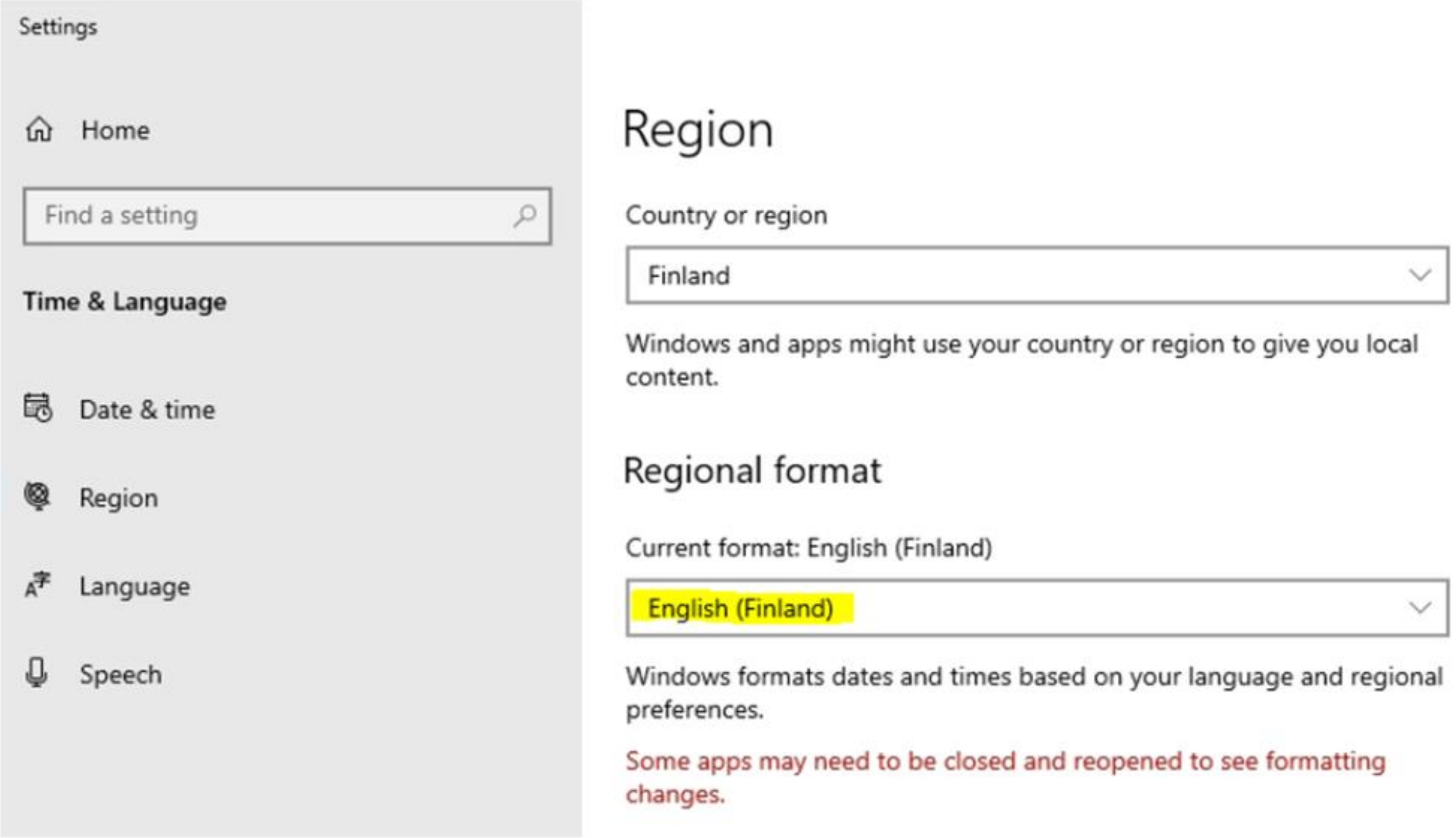
Notes

Fix Eco Audit Crashes

(Remote connection)

This software is picky about the Regional format setting in Windows. Unfortunately at least on our VDI workstations the default format is not working with the Eco Audit feature, and may need to be changed by the user on each session. This is how to do it:

1. Click the Windows Start-menu on the lower left corner of desktop.
2. Seach for "region" by typing it, then choose "Region Settings".
3. Regional format might be Recommended [English (United States)]
   change it to for example:
   English (Finland)

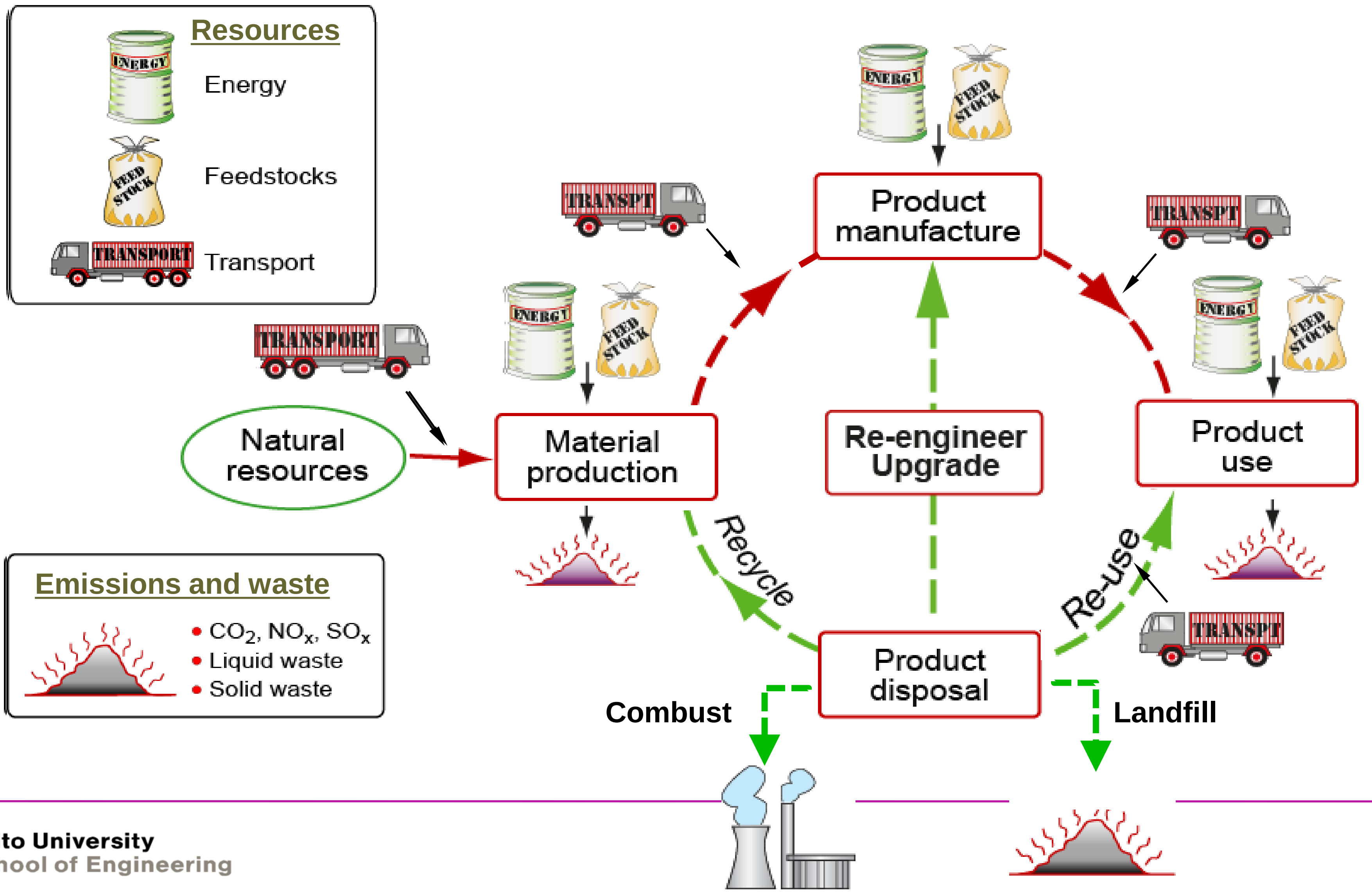


4. Restart EduPack and Eco Audit should work. Remember, you may need to do this again on your next session.

Material and process selection

- Eco-informed selection
- Eco Audits and the Audit tool
- Demo: soft drink containers

The product life-cycle



Eco-informed design

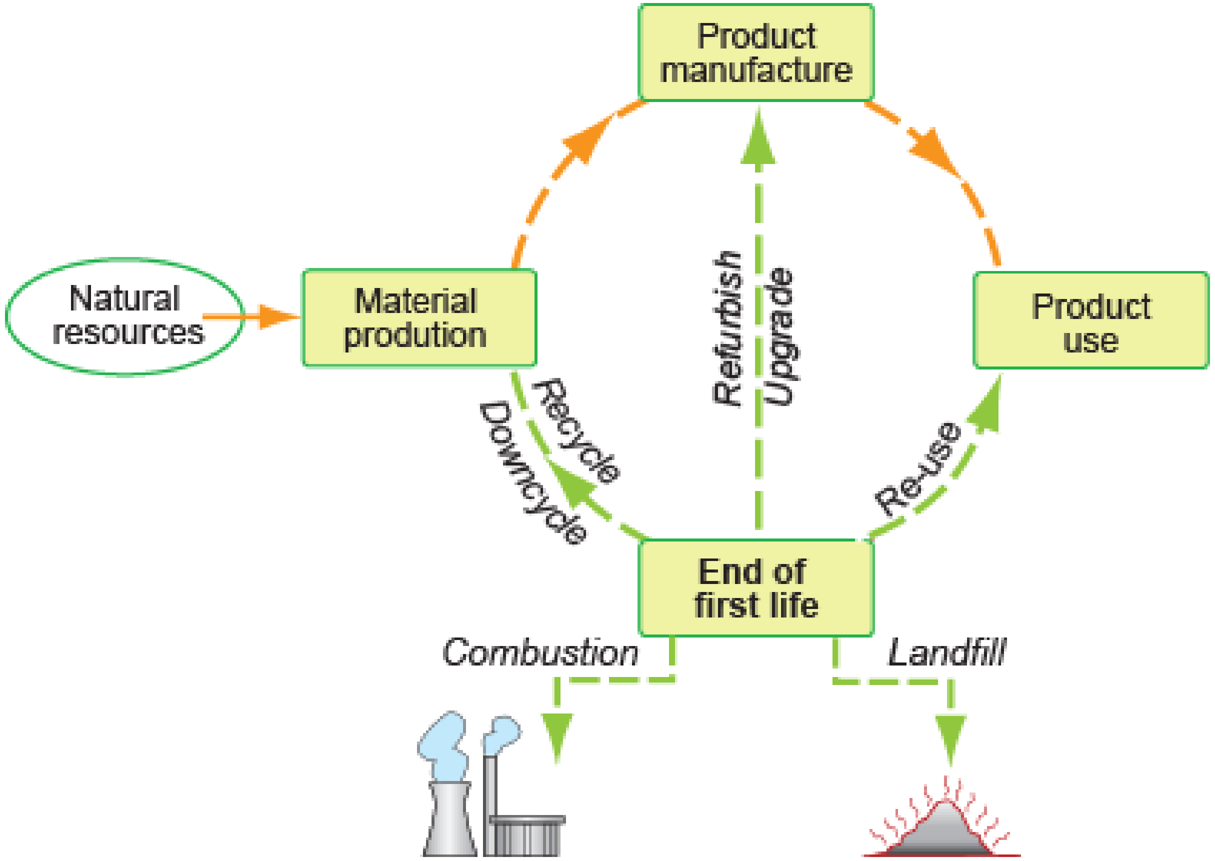
Eco-informed design

- 80% of eco-impact tied in at design stage
- Build-in eco criteria at the design stage

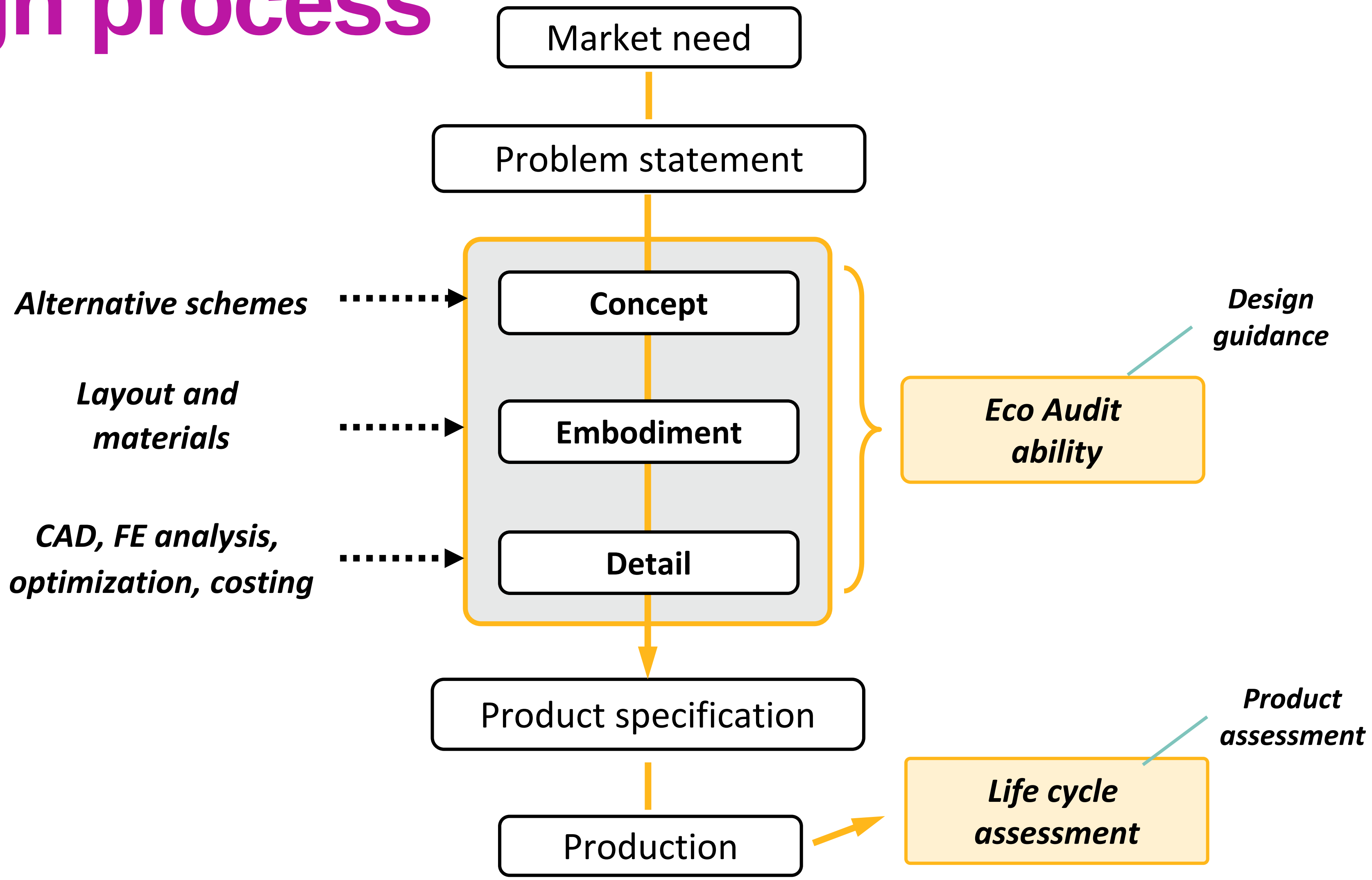
The drivers for eco-design

- Focus on carbon footprint by governments
- Legislation (Carbon taxes, **EuP**, **REACH**)
- Incentives (Subsidies, concessions)
- Urge for “responsible” manufacture
- Doing more with less = $$$

The materials life-cycle



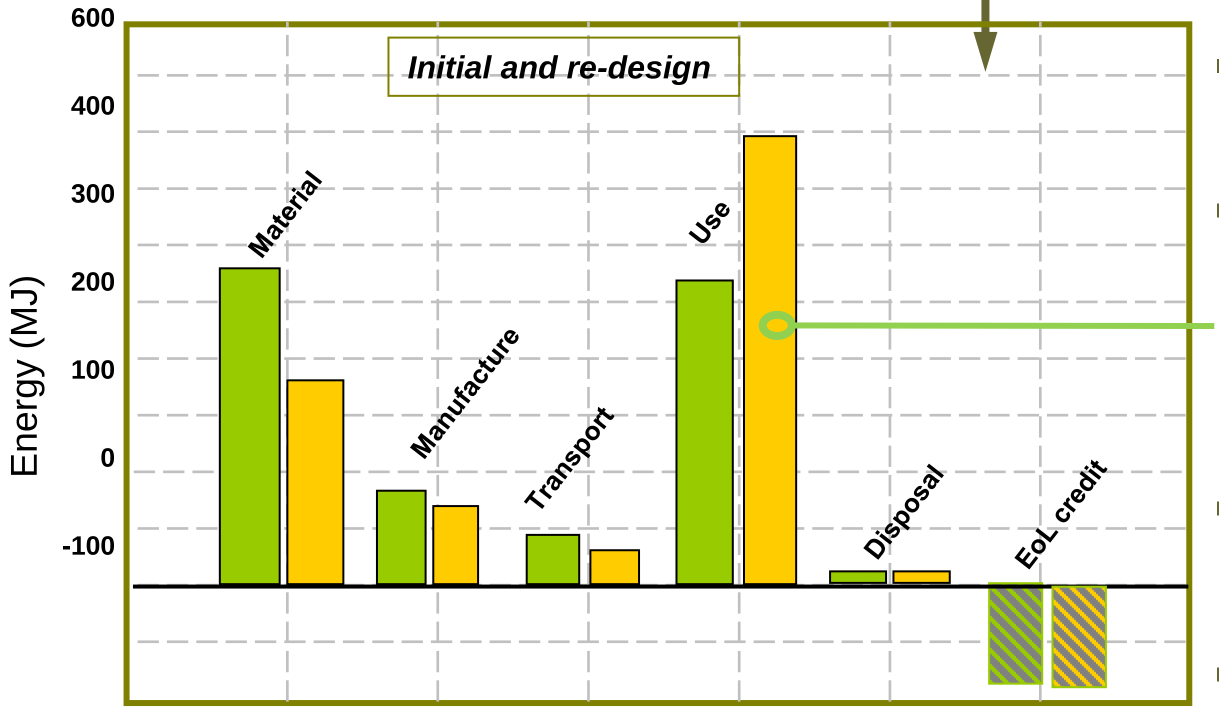
Design process



Eco-informed selection

The steps

Fast Eco Audit	Analyse results, identify priorities	Explore options with "What if…"s	Select new Materials and/or Processes	Recommend actions & assess potential savings



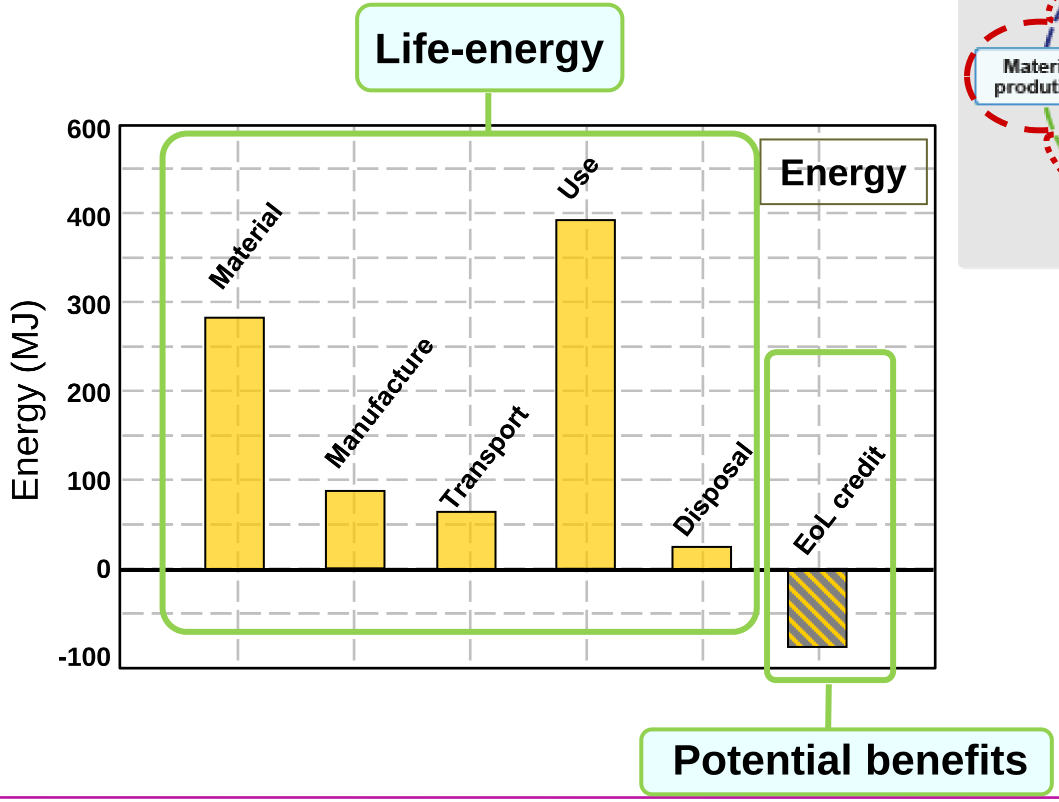
- **With "what if's", make assumptions**
- **Can be better? A systematic analysis**

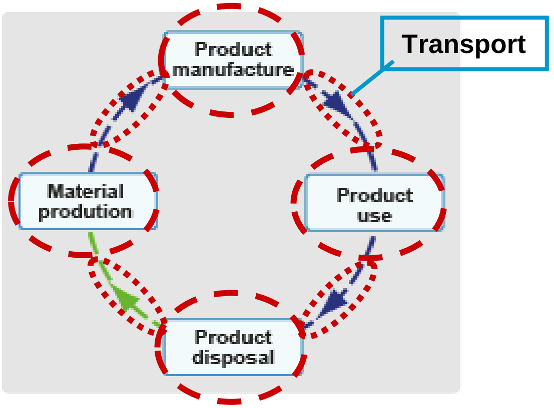
Click on bar for advice

- **Use Eco Audit or other tools to identify design objective**
- **Apply the selection methodology**

Eco Audit for design

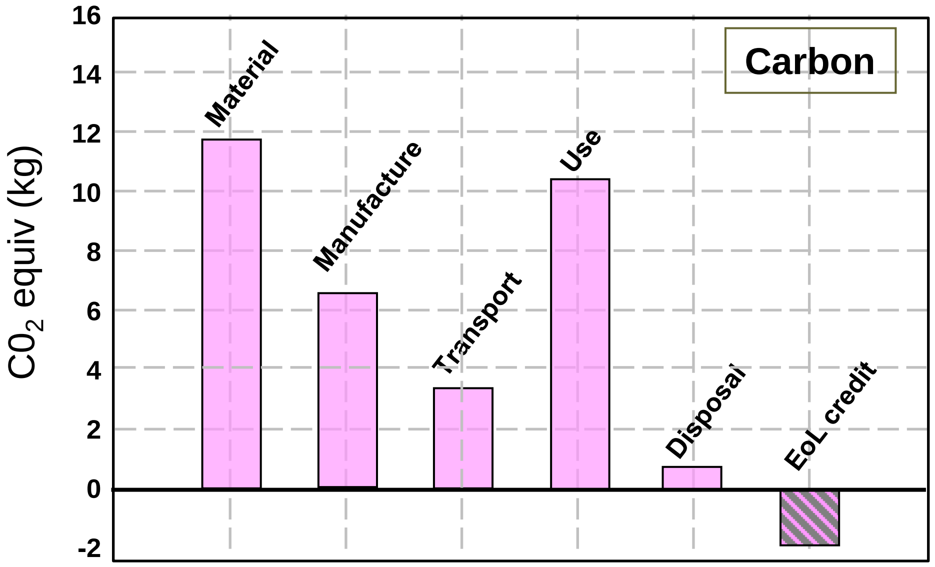
- 1 resource – ***energy*** ***(oil equivalent)***
- 1 emission – ***CO_2 equivalent***
- Distinguish life-phases
- Audit: Energy

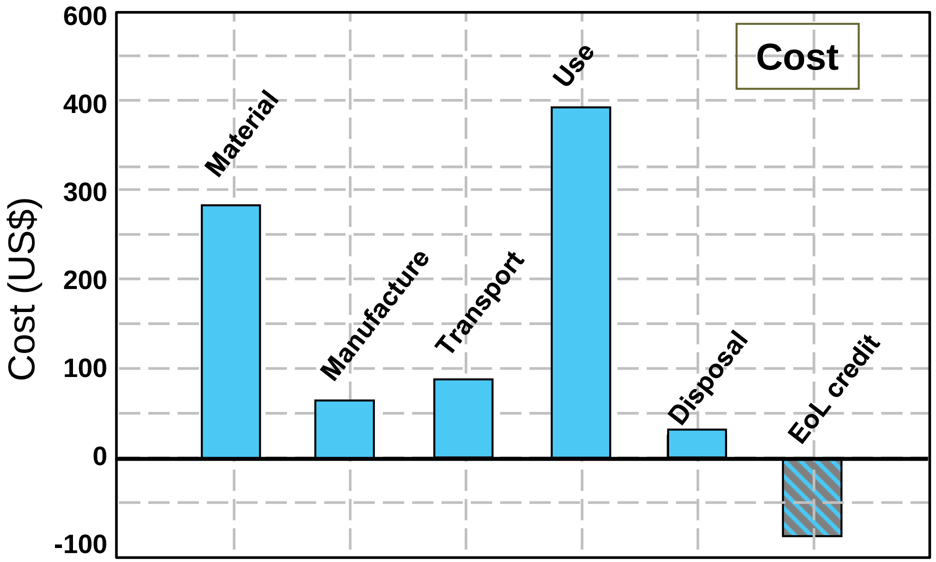




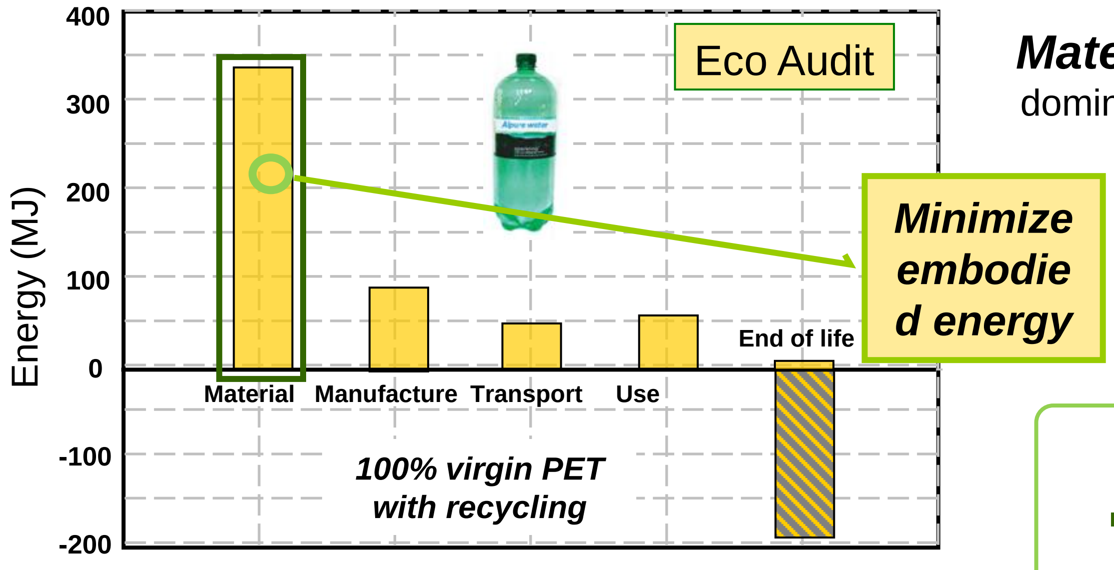
Eco Audit for design

- **1 resource – *energy* *(oil equivalent)***
- **1 emission – *CO_2 equivalent***
- **Distinguish life-phases**
- **Audit: Energy or Cost**





Eco-selection for a soft drink bottle



Material
dominates

Translation

Constraints

- **Able to be molded**
- **Transparent / translucent**
- **Able to contain pressure**

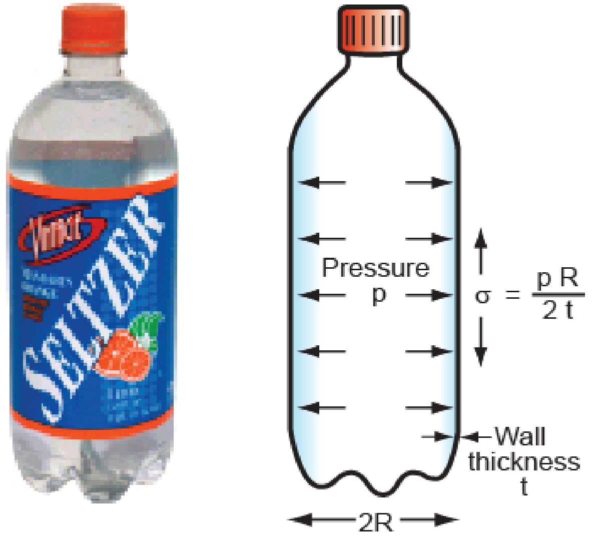
Objectives

- **Minimize embodied energy of bottle**
- **Minimize material cost of bottle**

Design brief

Improve green credentials of bottle

Modelling the bottle



R= Bottle radius
t = Thickness of bottle wall
p = Internal pressure
σ_y = Yield strength of material
ρ = Density of material
H_m = Embodied energy of material/kg
E = Embodied energy/m^2 of wall
C_m = Material cost per kg

Cylindrical pressure vessel

- Circumferential stress $\sigma = \frac{pR}{t} < \sigma_y$
- Embodied energy per unit area of wall

$$E = t H_m \rho = pR \frac{H_m \rho}{\sigma_y}$$

Embodied energy / kg of material

- Find material with lowest energy, seek largest

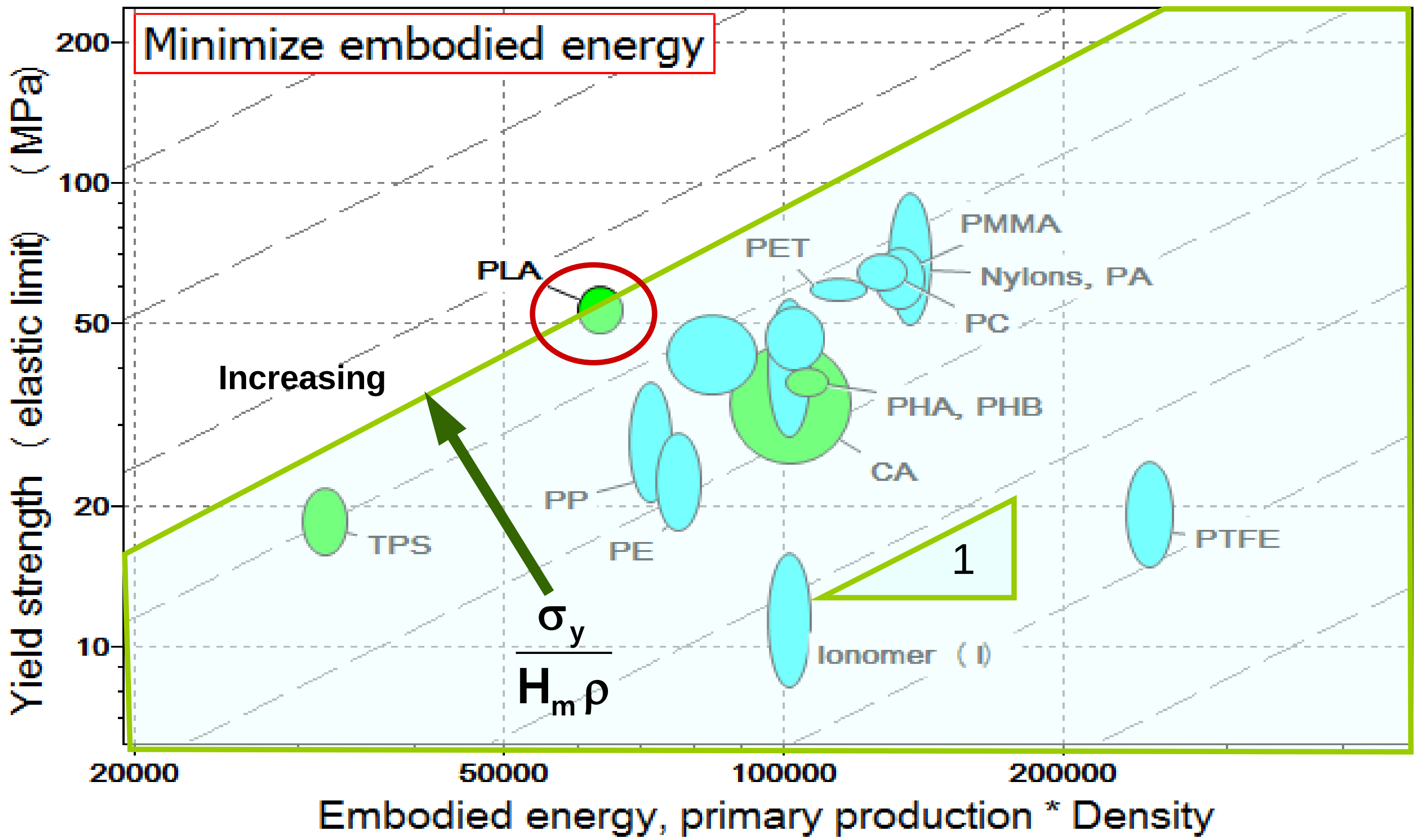
$$\boxed{\frac{\sigma_y}{H_m \rho}}$$

- Find material with lowest cost, seek largest

$$\boxed{\frac{\sigma_y}{C_m \rho}}$$

Price / kg of material

Selection to minimize embodied energy

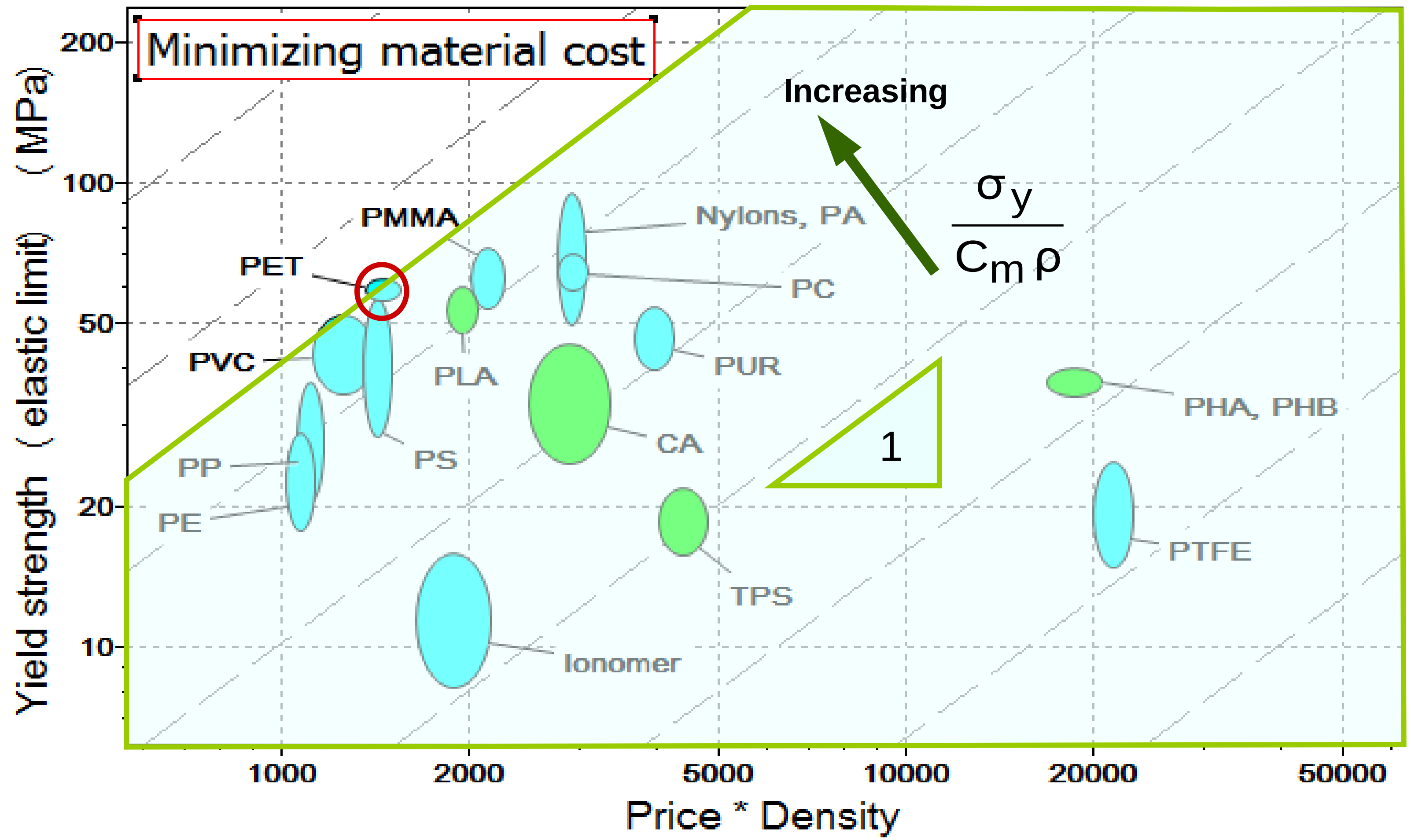


Constraints

- Can be molded
- Transparent / translucent

Bio-polymers are colored green

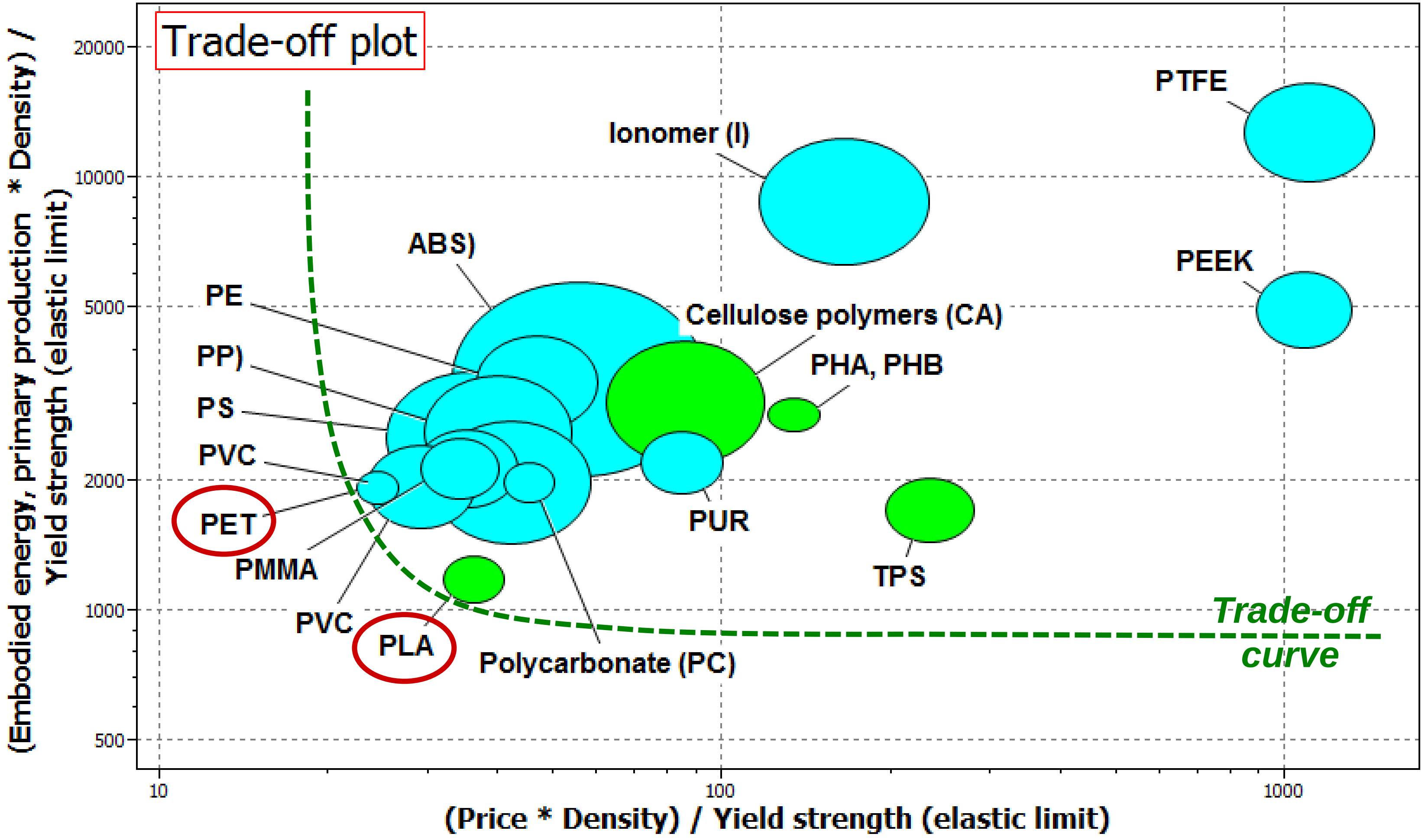
Selection to minimize cost



Bio-polymers are colored green

Trade-off plot

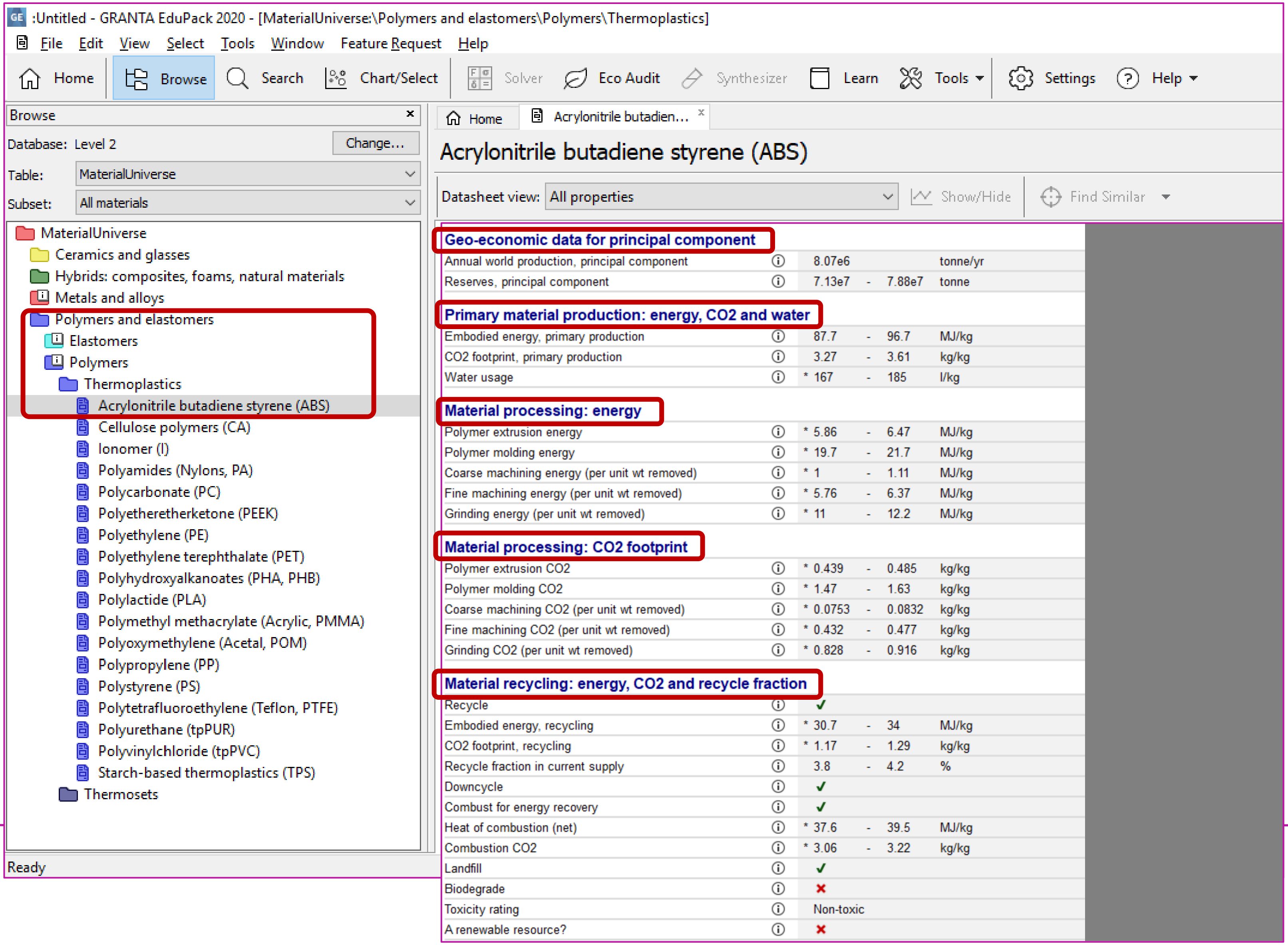
Minimizing both embodied energy and cost



Bio-polymers are colored green

Exchange constant : not established

Eco-property records



Geo-economic data for principal component			
Annual world production, principal component	8.07e6		tonne/yr
Reserves, principal component	7.13e7	7.88e7	tonne
Primary material production: energy, CO2 and water			
Embodied energy, primary production	87.7	96.7	MJ/kg
CO2 footprint, primary production	3.27	3.61	kg/kg
Water usage	* 167	185	l/kg
Material processing: energy			
Polymer extrusion energy	* 5.86	6.47	MJ/kg
Polymer molding energy	* 19.7	21.7	MJ/kg
Coarse machining energy (per unit wt removed)	* 1	1.11	MJ/kg
Fine machining energy (per unit wt removed)	* 5.76	6.37	MJ/kg
Grinding energy (per unit wt removed)	* 11	12.2	MJ/kg
Material processing: CO2 footprint			
Polymer extrusion CO2	* 0.439	0.485	kg/kg
Polymer molding CO2	* 1.47	1.63	kg/kg
Coarse machining CO2 (per unit wt removed)	* 0.0753	0.0832	kg/kg
Fine machining CO2 (per unit wt removed)	* 0.432	0.477	kg/kg
Grinding CO2 (per unit wt removed)	* 0.828	0.916	kg/kg
Material recycling: energy, CO2 and recycle fraction			
Recycle	✓		
Embodied energy, recycling	* 30.7	34	MJ/kg
CO2 footprint, recycling	* 1.17	1.29	kg/kg
Recycle fraction in current supply	3.8	4.2	%
Downcycle	✓		
Combust for energy recovery	✓		
Heat of combustion (net)	* 37.6	39.5	MJ/kg
Combustion CO2	* 3.06	3.22	kg/kg
Landfill	✓		
Biodegrade	✗		
Toxicity rating	Non-toxic		
A renewable resource?	✗		

The EduPack Eco Audit tool

User inputs

User interface

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

2 kW electric kettle

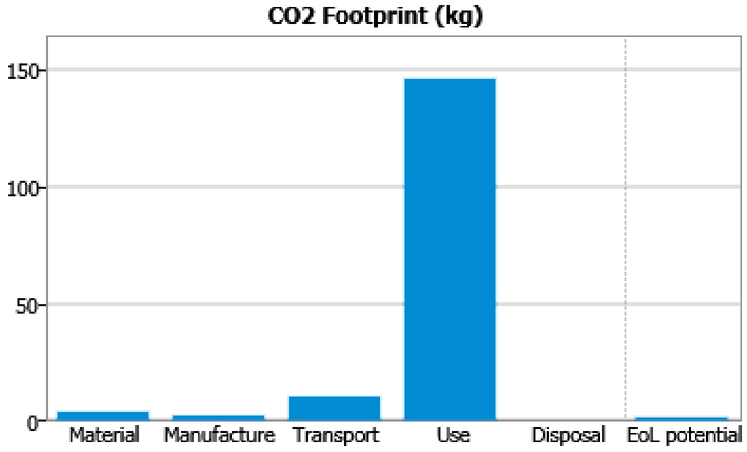
Database

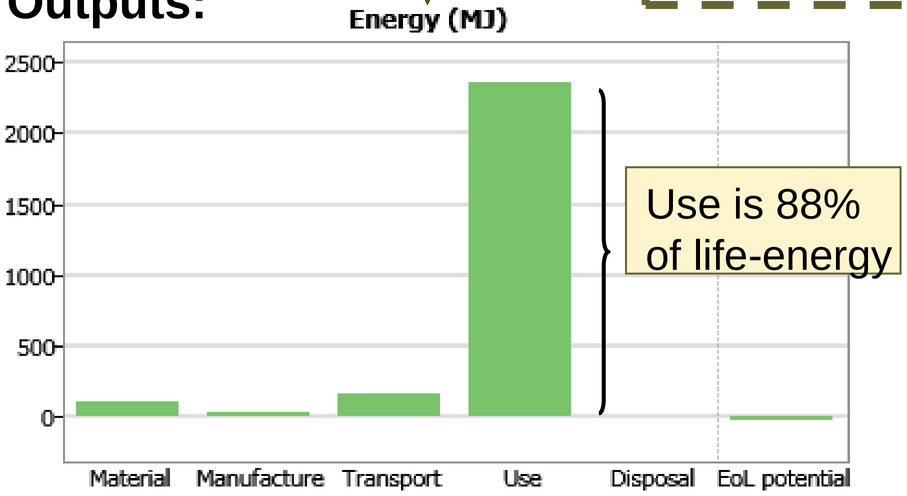
Eco data

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

Eco Audit model

Outputs:

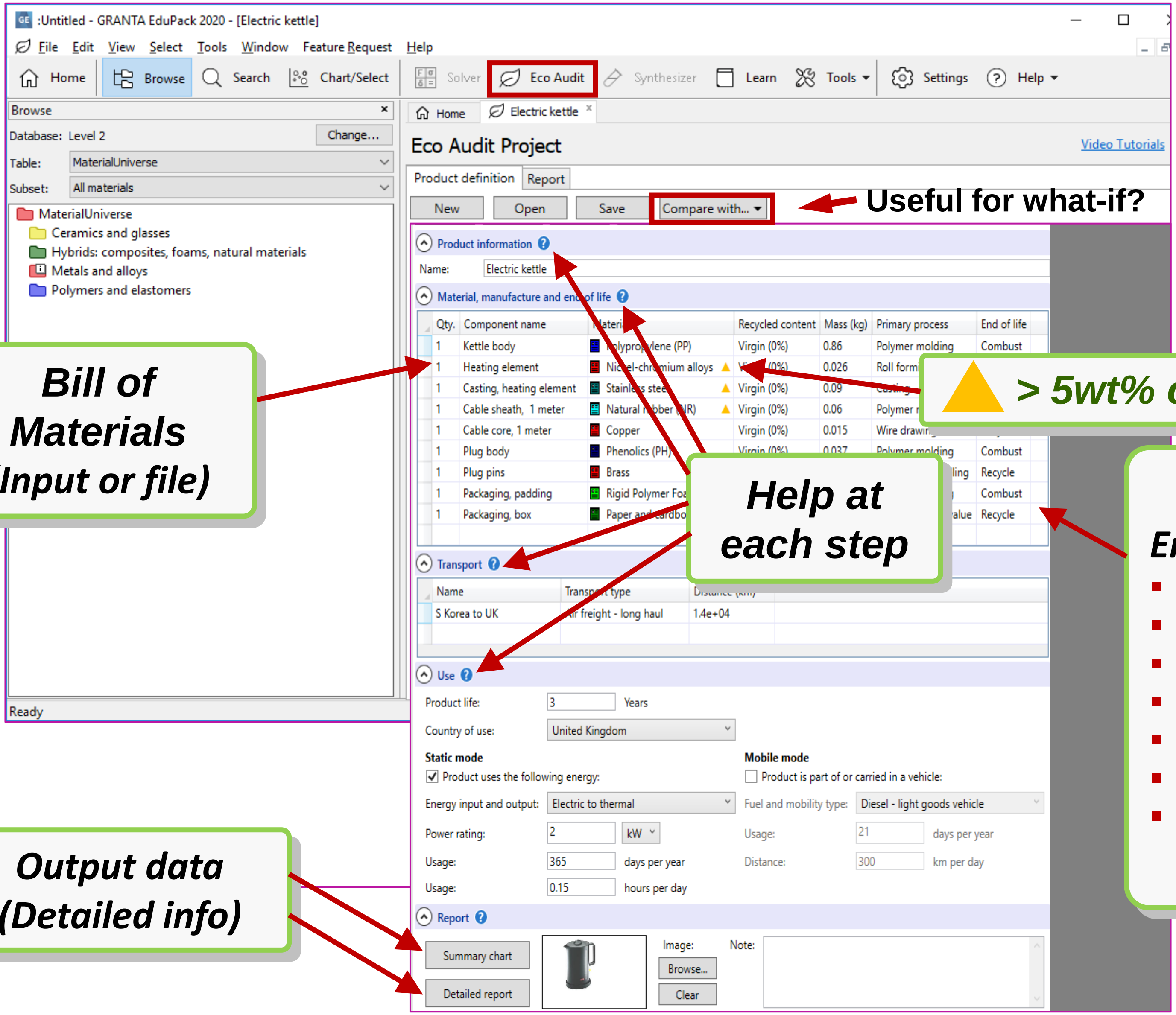




Full report

- ***Data***
- ***Criticality***
- ***Hazard***

The Eco Audit tool at Level 2



Useful for what-if?

Bill of Materials (Input or file)

> 5wt% critical material

Help at each step

End-of-Life

- *Landfill*
- *Combust*
- *Downcycle*
- *Recycle*
- *Re-manufacture*
- *Reuse*
- *None*

Output data (Detailed info)

Task 5.1: Environment

Estimate the amount of energy in different polymers.

Which polymer embodies the least energy during its manufacture when a Young's modulus value of at least 0.8 GPa is required?

Solve the task with level 2 map.

Draw up a map with which you can compare different materials with regard to beam strength (in bending) versus CO2-emissions.

Which material possesses the smallest carbon footprint compared to strength?

Also draw up this map for beam strength versus CO2-emissions when recycled material is used.

Task 5.2: Processes

Essay in approximately 200-300 words with one or two illustrations

Summary

- Eco-informed material choice is part of the eco-design process
- An Eco Audit identifies the most damaging phase of life and identifies strategies for overcoming it
- Systematic strategies, using material indices, optimize material choice to minimize life energy, eco-impact.