Life Cycle Assessment(LCA)

of active and intelligent packaging

COST FP1405 Workshop
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COBRO – Packaging Research Institute

COBRO

ActInPak

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EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

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Horizon 2020

COST Action FP1405

Active and intelligent fibre-based packaging – innovation and market introduction **(ActInPak)**

ActInPak is a pan European (COST) network of the leading experts in active and intelligent packaging of over 150 institutes, universities and companies from 37 countries. Main goal of action is to develop a knowledge-based network on sustainable, active and intelligent fibre-based packaging in order to facilitate its introduction on the market.

http://www.actinpak.eu
http://www.cost.eu/COST_Actions/fps/Actions/FP1405
https://www.linkedin.com/groups/COST-FP1405-ActInPak-8254568/about

COBRO – PACKAGING RESEARCH INSTITUTE

State, self-supporting research institution subordinated to the Ministry of Economy, founded in 1973.

Member of:

- World Packaging Organisation,

- International Association of Packaging Research Institutes,

- Polish Chamber of Packaging,

- European Bioplastics.

- **Packaging R&D Department:**
  - ✓ Packaging and Environment Department
  - ✓ Laboratory for Packaging Materials and Consumer Packaging Testing
- **Laboratory for Transport Packaging Testing**
- **Certification Centre**
- **Standardization Department**
- *Packaging Spectrum* Magazine

Sustainable Development

To use the traditional definition, sustainable development is:

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs", in other words ensuring that today's growth does not jeopardize the growth possibilities of future generations.

Sustainable development thus comprises three elements - economic, social and environmental - which have to be considered in equal measure at the political level. The strategy for sustainable development, adopted in 2001 and amended in 2005, is complemented inter alia by the principle of integrating environmental concerns with European policies which impact on the environment.

- source: http://europa.eu

Sustainable Development

Sustainable development is about integrating the goals of a high quality of life, health and prosperity with social justice and maintaining the earth's capacity to support life in all its diversity. These **social, economic and environmental** goals are interdependent and mutually reinforcing. Sustainable development can be treated as a way of expressing the broader expectations of society as a whole.
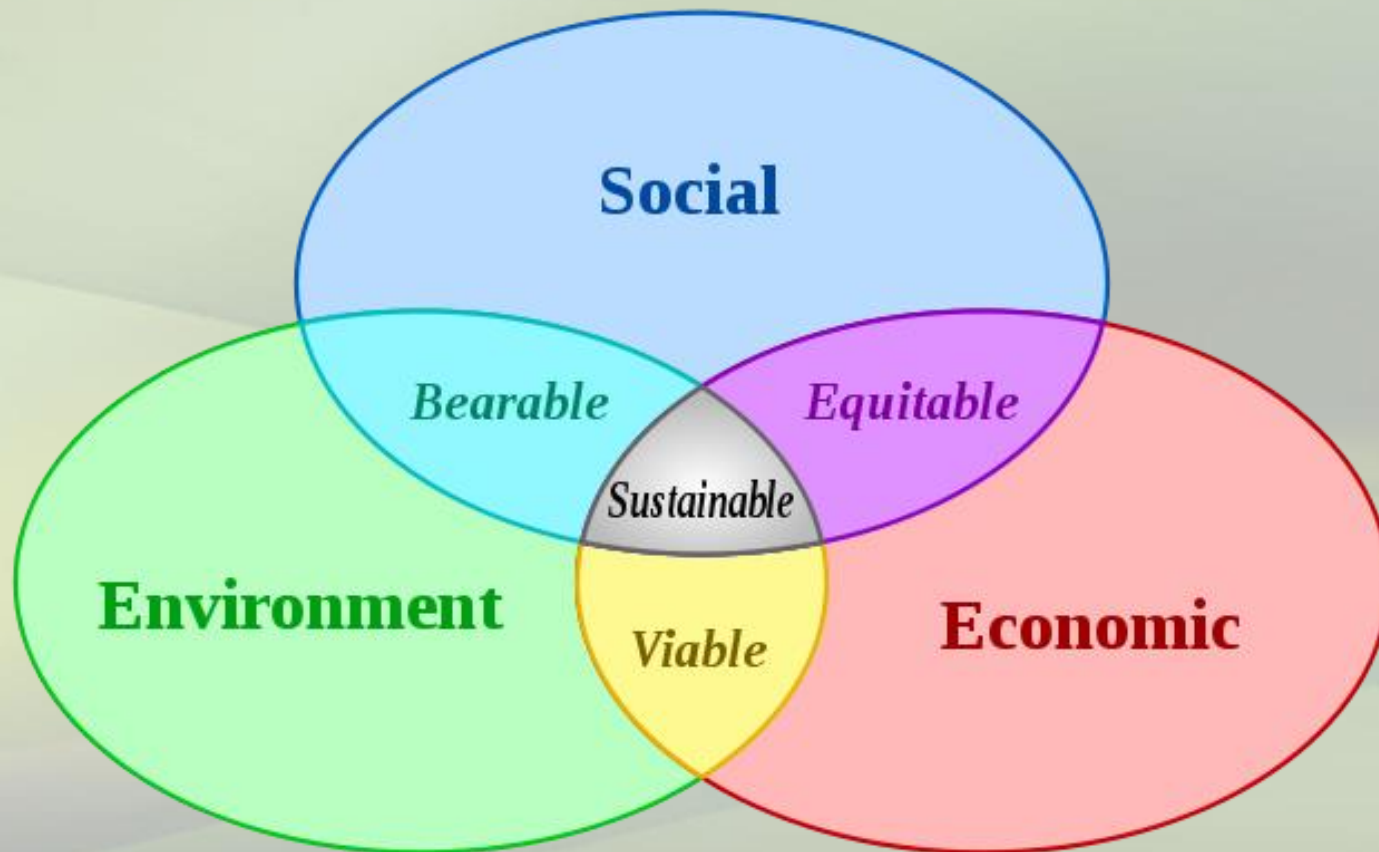
- source: ISO 26000:2010

Sustainable Development

Sustainable development concept for business, consists of taking into consideration widely understood **economic, environmental and social** issues in the **daily and long term operations of a company**.
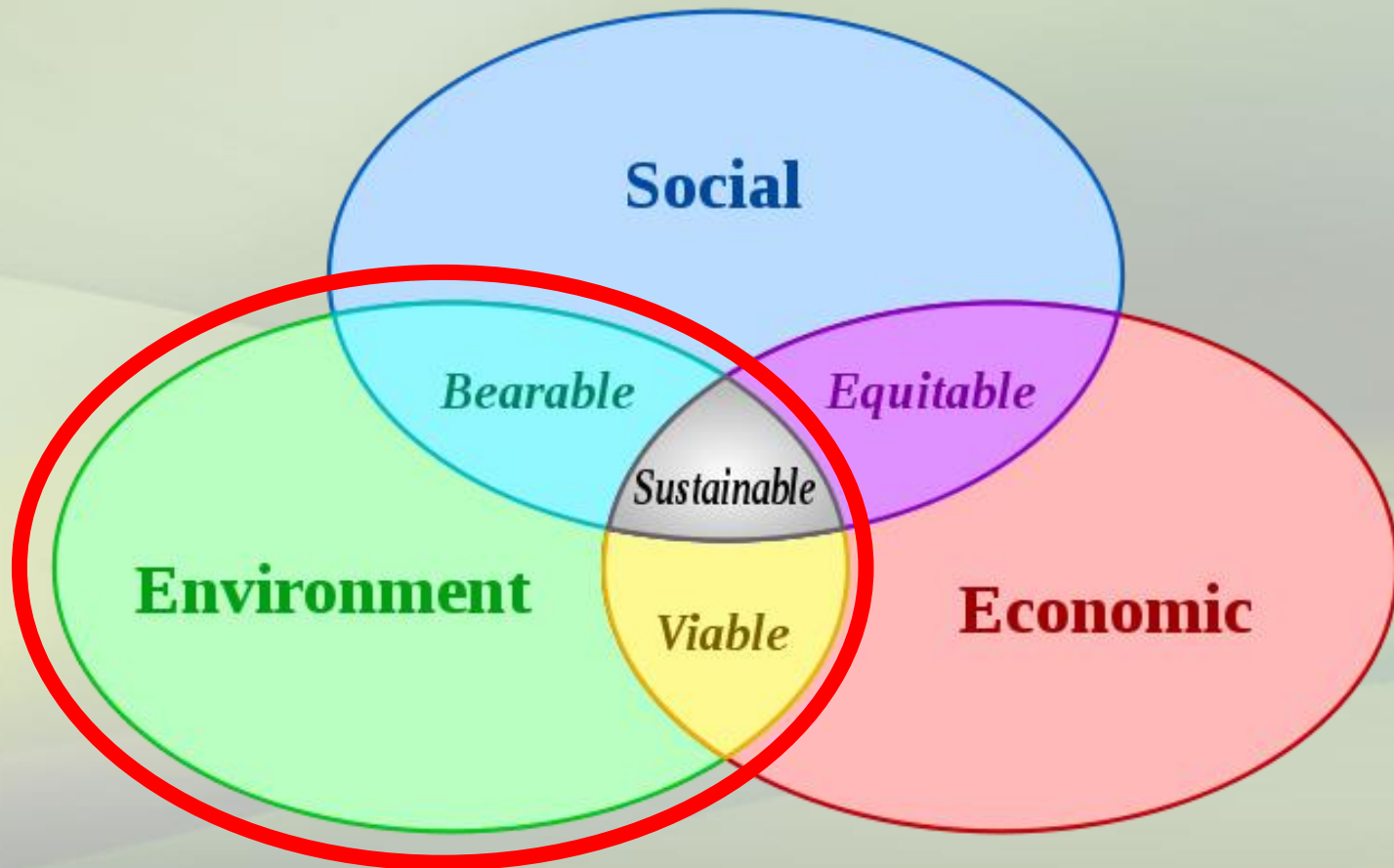
Sustainable Development

Sustainable Development

Sustainable development has to be present in **all product life cycle stages:**

- production processes,
- processing methods,
- delivery chain,
- packaging,
- distribution,
- usage and
- waste management including transport.

At the same time sustainable products should match up or exceed conventional products by functional and quality properties, fulfil todays environmental protection standards, and also contribute to waste management system.

Sustainable Development
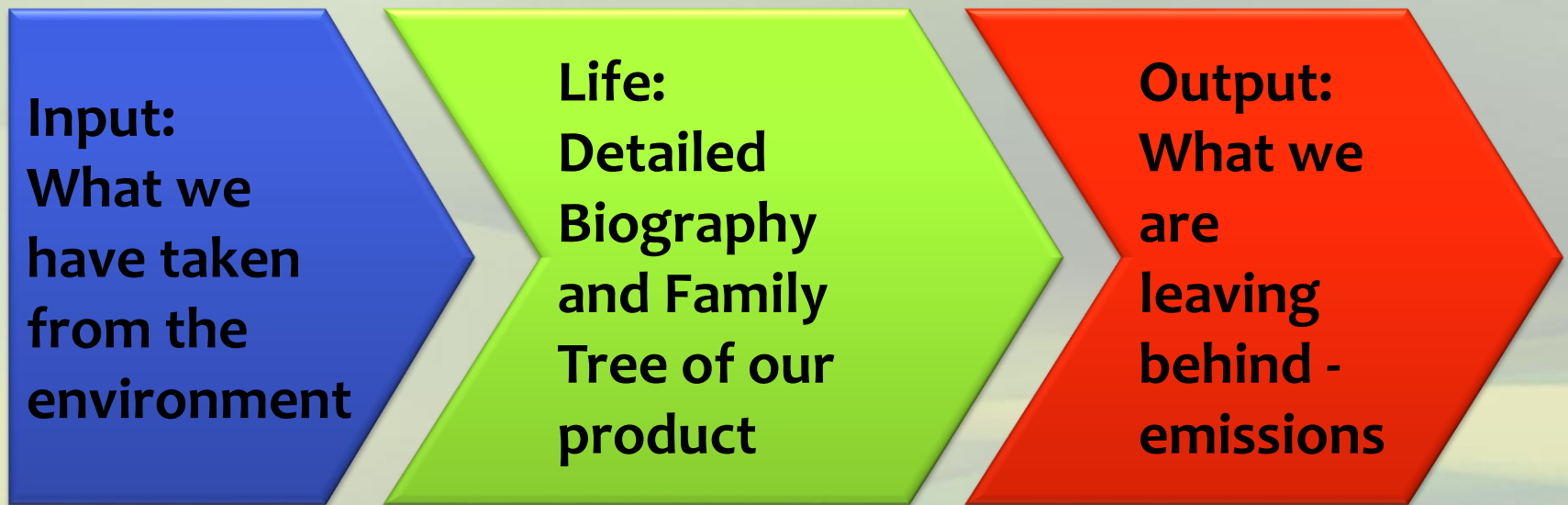
Sustainable Development
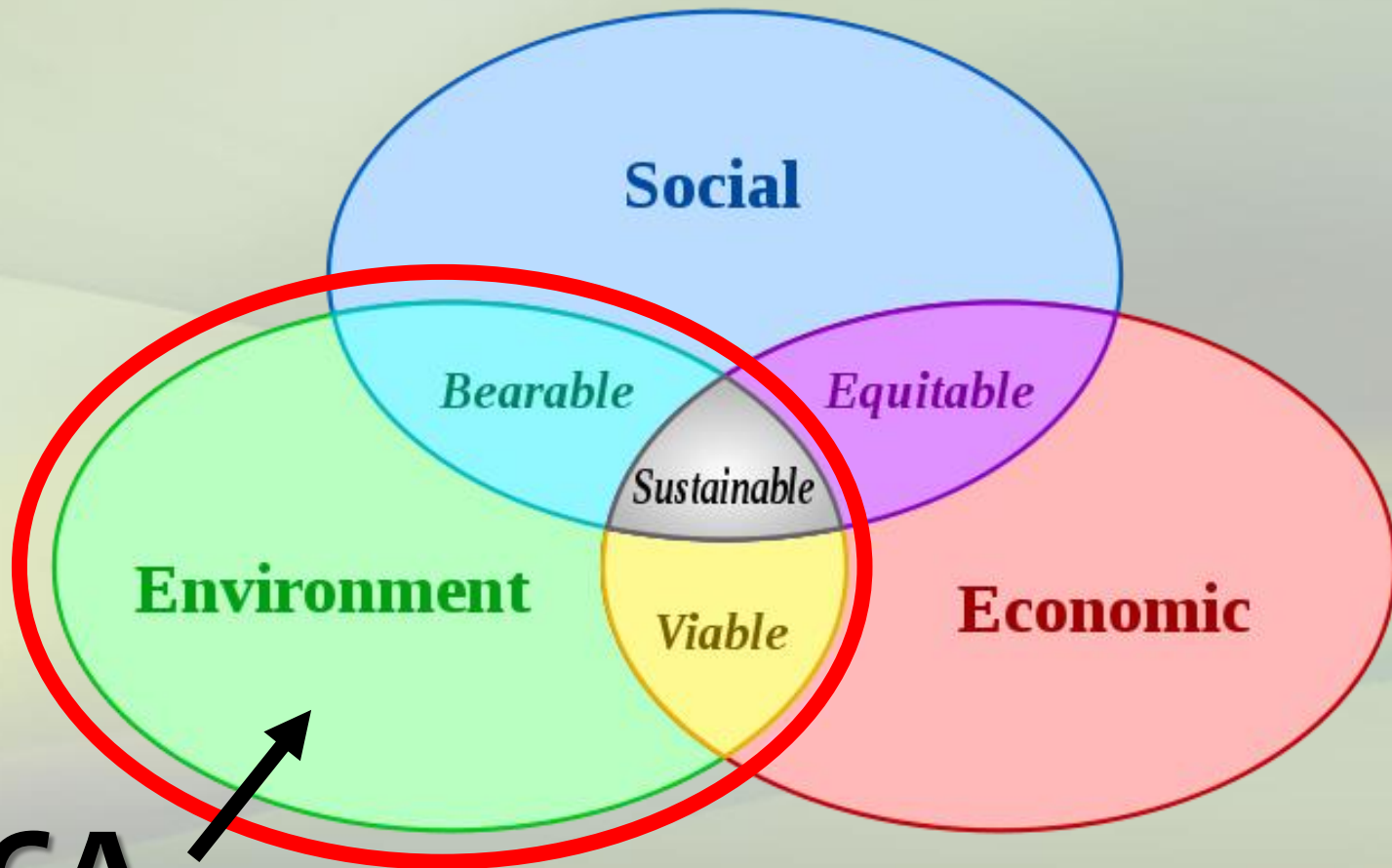
What is LCA ??

- LCA = Life Cycle Assessment
- The most popular sustainability assessment tool
- Can be used to assess products, value chains, processes, whole companies, economy and even socio-cultural implications
- Its main goal is to assess the aspects of environmental impacts in whole life cycle of selected subject matter.
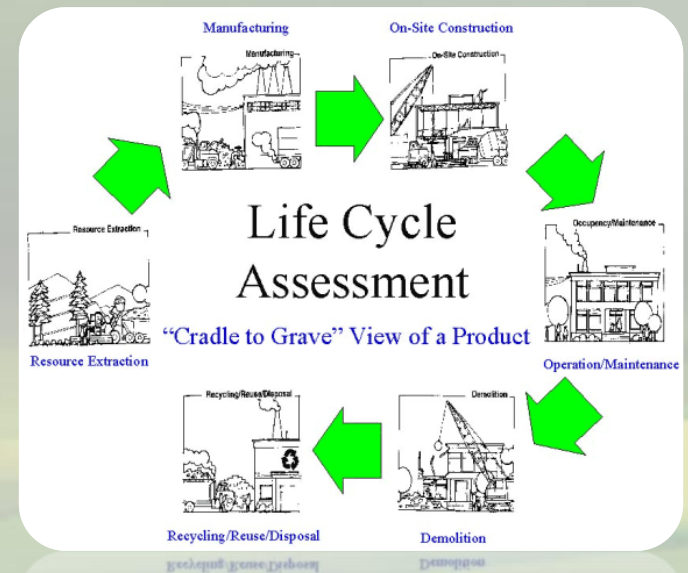
What is LCA ??

- LCA consists of different criteria of evaluation in all life cycle stages of a selected product.

- Environmental influence of every life cycle process of a chosen product is quantitatively recorded in different impact categories

- **LCA method can be used to rate and compare a product with another products with similar functionality.**

What is LCA ??

Input: What we have taken from the environment

Life: Detailed Biography and Family Tree of our product

Output: What we are leaving behind - emissions

LCA as a description of reality

LCA is used to *model* **complex** reality

+

Each *model* **simplifies** the reality

=

Contradiction – simplification distorts the reality

Main goal of LCA – **minimise this distortion**

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How to use LCA

- Internal LCA – used by enterprises
  - 'knowing your product', identification of 'hot spots', strategic management goals
  - Marketing / Benchmarking
  - PR
  - Preparation for legislation changes, arguments for lobbying
- External LCA – full public reports
  - Published by public institutes/research institutes
  - Need to be peer reviewed
  - Not often used by enterprises due to bad experiences in the '90 (benchmarking backfire)
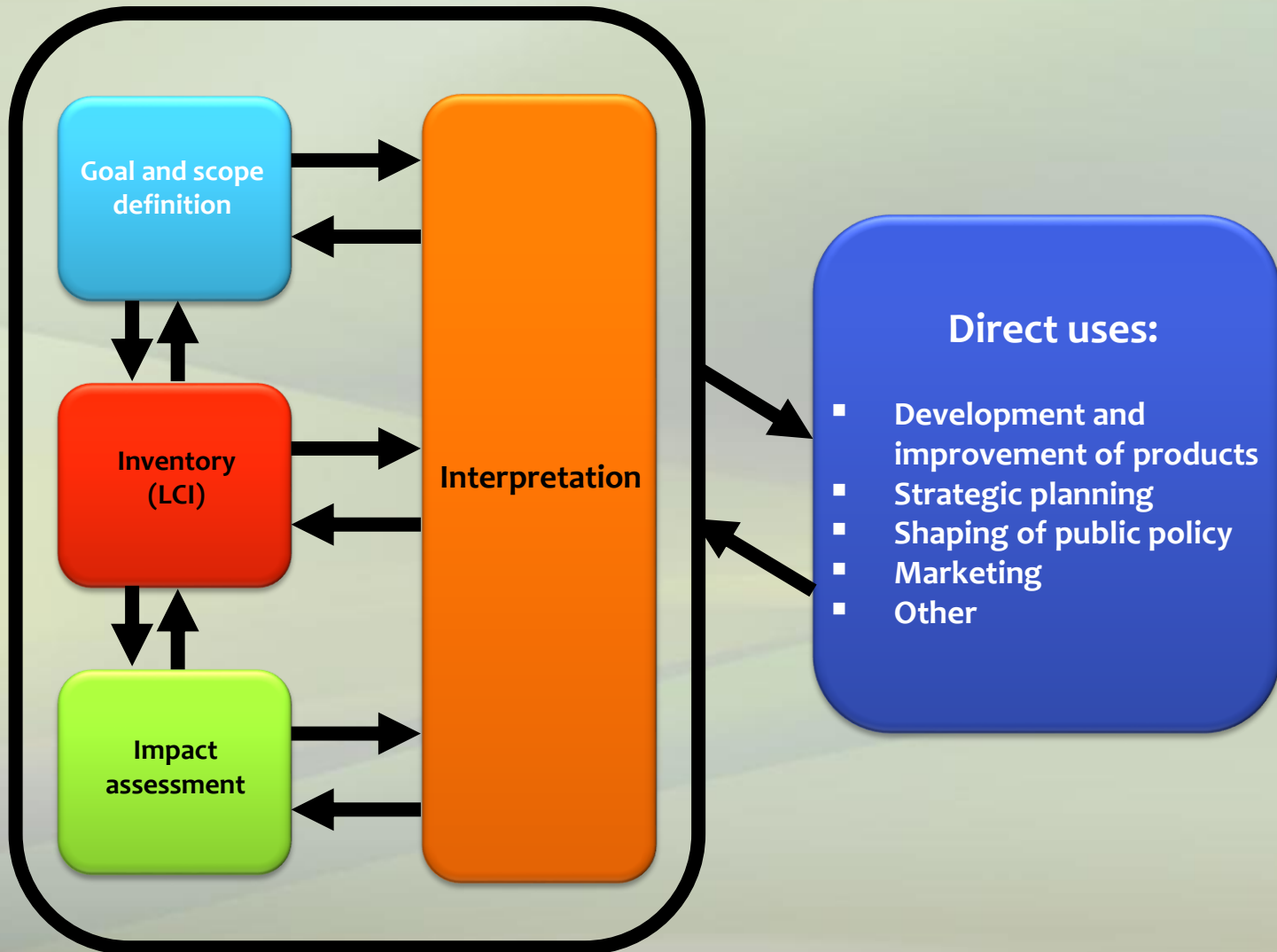
LCA Standards

- 2 main standards:
  - EN ISO 14040 – main concept
  - EN ISO 14044 – details

- Other relevant standards:
  - EN ISO 14020 series – Environmental labels and declarations
    - 14021 – Type II
    - 14024 – Type I
    - 14025 – Type III
  - 14064 – GHG emissions – *due soon*
  - 14067 – Carbon Footprint calculation – *due soon*

LCA CEN Reports

- **2 CEN Reports for packaging:**
    - CR 12340:1996 – Recommendations for LCI of packaging systems
    - CR 13910:2009 – Criteria and methods for packaging LCA
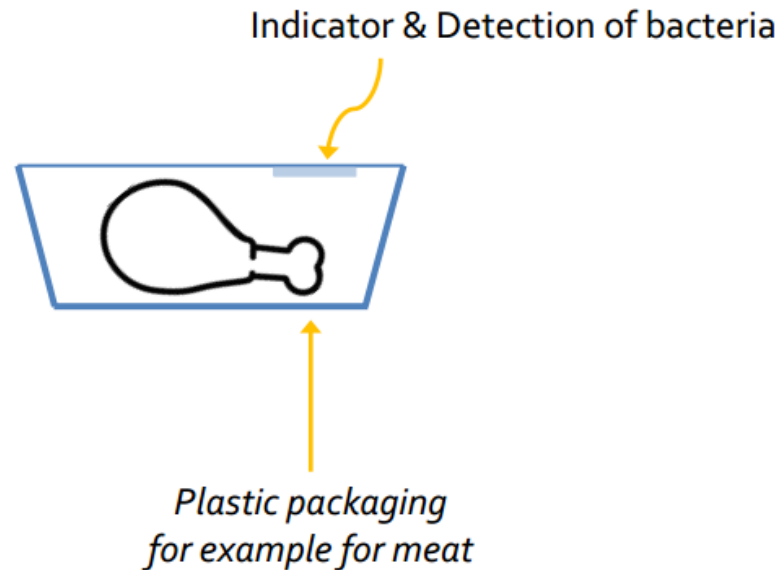
LCA in 4 steps

Goal and scope definition

Inventory (LCI)

Impact assessment

Interpretation

Direct uses:

- Development and improvement of products
- Strategic planning
- Shaping of public policy
- Marketing
- Other

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Goals of the meeting

1. Determine the target (beneficiary) of our LCA
2. Determine the scope of the LCA
3. Determine the functional unit for intelligent demonstrator
4. Determine the functional unit for active demonstrator
5. Choose demonstrator solutions that we have LCI data on

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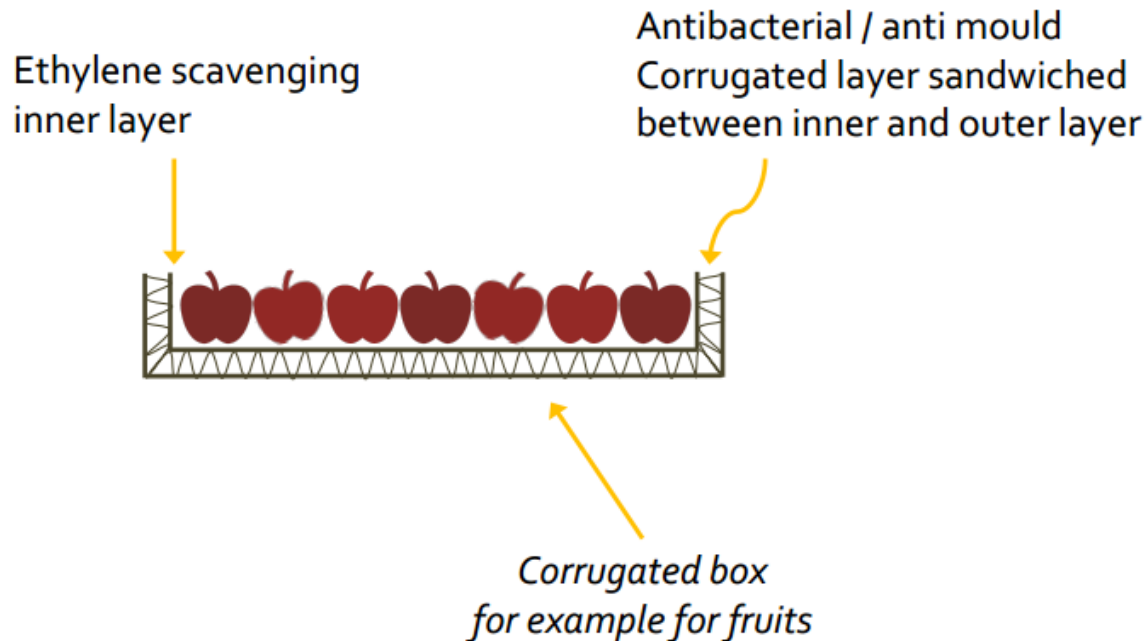
ActInPak Demonstrators

Demonstrator 1 – Intelligent

Indicator & Detection of bacteria

Plastic packaging
for example for meat

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ActInPak Demonstrators

Demonstrator 2 – Active

Modified atmosphere

Oxygen scavenger applied as a label on interior of packaging

Plastic packaging
for example for pre baked bread

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ActInPak Demonstrators

Demonstrator 3 – Active

Ethylene scavenging
inner layer

Antibacterial / anti mould
Corrugated layer sandwiched
between inner and outer layer

*Corrugated box
for example for fruits*

Step 1 – Goal and Scope

Life Cycle

How does it look like ??

Product

Goal

What/Why/For Whom
We need LCA

Scope

- Functional Unit
- System Boundaries

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Step 1 – Goal and Scope

Life Cycle

How does it look like ??

Product

Goal

What/Why/For Whom
We need LCA

Scope

- Functional Unit
- System Boundaries

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Group Brainstorm 1
Goal of our LCA

Who is our target?? We need ONE!!
- Consumer
- Retailer
- Wholesale / Logistics
- Policy Makers
- NGO's
- Academia
- Or maybe someone else??

Discuss, write down benefits and risks of having each of those targets, and then choose one.

Time: 20 minutes

Step 1 – Goal and Scope

Natural resources

Other uses of resources

Energy

Packaging resources production

Other products

Packaging materials production

Product to be packed

Recycling

Packaging production

Preperations for re-use

Filling/Packing

Boandary includes packaging production loses

Distribution and sales

Emptying

Use phase of the packed product

Energy recovery

Landfiling

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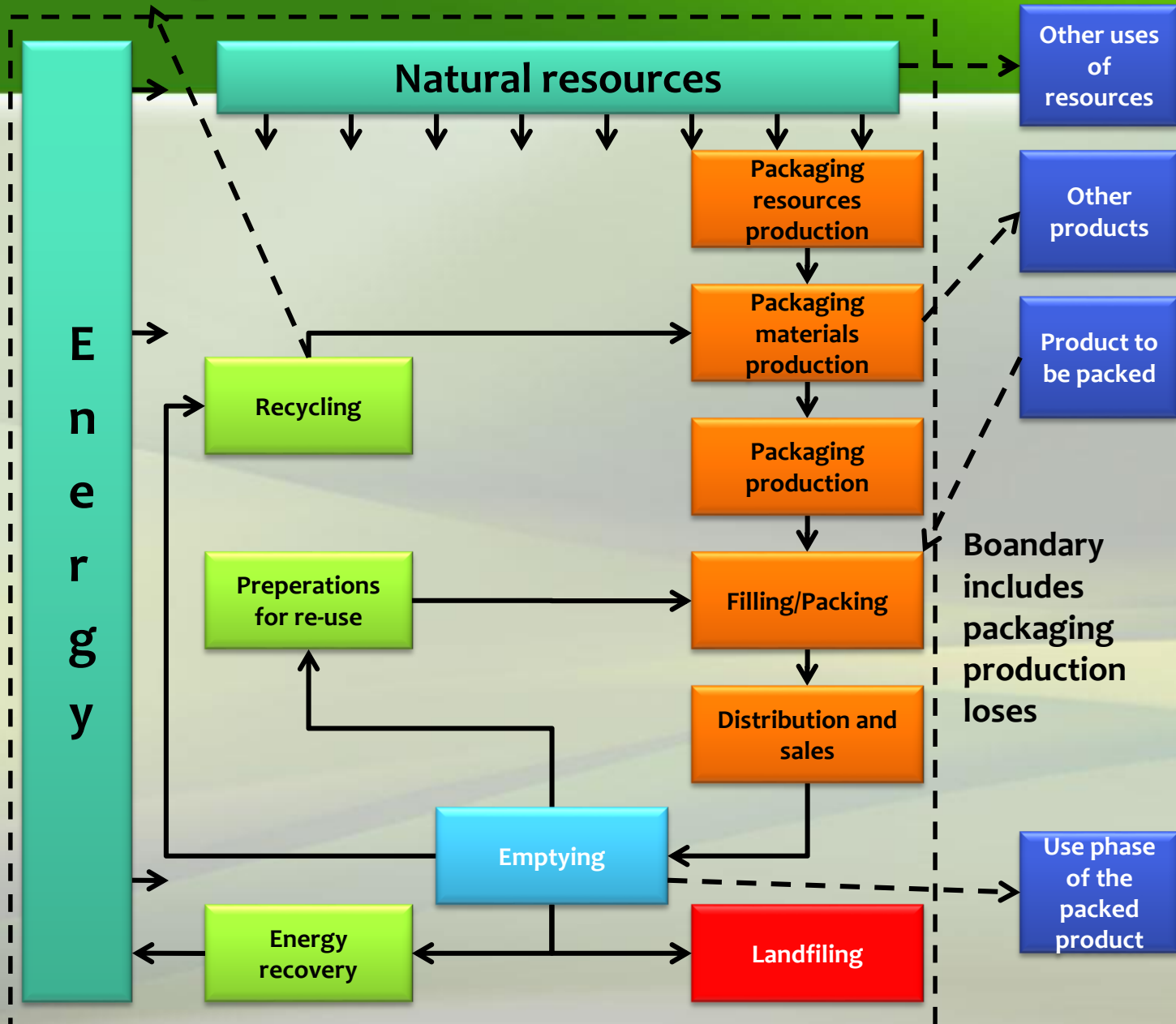
Group Brainstorm 2
Scope of our LCA

Taking into account our chosen target, what should be the scope of our studies:
- Cradle to grave – Packaging only
- Cradle to grave – Packaging + product
- Cradle to gate – Packaging
- Cradle to gate – Packaging + product
- Other scopes (gate to grave)??

Discuss, and then choose one.

Time: 20 minutes

Step 1 – Goal and Scope
Functional Unit

- Unit of reference
- Quantitative system effect – unit has to measure same effect when comparing 2 or more products
- All data should be referenced to the functional unit

Functional Unit examples:

- Paint: 20 m² area coverage for 20 years
- Ice-cream: kcal / mass / leisure time
- Beverage packaging: volume of beverage
- Public transport: person-kilometer
- Packaging waste: kg
- Shopping bags: 5 kg of shopping carried for 500 meters
- Hand towels: 10 000 washed hands

Step 1 – Goal and Scope
Functional Unit

STEP 1: DESRIBE THE PRODUCT BY ITS PROPERTIES

Obligatory properties:

Positioning properties:

Market irrelevant properties:

PROPERTIES THAT AFFECT REFENCE FLOWS

MARKET REQUIREMENTS

ALL OBLIGATORY PROPERTIES

STEP 2: DETERMINE THE RELEVANT MARKET SEGMENT

A C E H

B D F G

RELEVANT, SIGNIFICANT AND REPRESENTATIVE PRODUCTS

STEP 4: DEFINE THE FUNCTIONAL UNIT

STEP 3: DETERMINE PRODUCT ALTERNATIVES B D F G

TRANSLATE FUNCTIONAL UNIT TO PRODUCT FLOWS

STEP 5: DETERMINE REFENCE FLOWS FOR EACH PRODUCT SYSTEM B D F G

PRODUCTS TO BE COMPARED

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Group Brainstorm 3
Functional unit – Active Packaging

List possible functional units for active packaging solutions, taking into account:

- Ease of comparison between active and non active packaging

- Objectivity / Absence of bias

- Fit to chosen target and scope of our study

Time: 30 minutes

Group Brainstorm 4
Functional unit – Intelligent Packaging

List possible functional units for intelligent packaging solutions, taking into account:

- Ease of comparison between active and non active packaging

- Objectivity / Absence of bias

- Fit to chosen target and scope of our study

Time: 30 minutes

Step 2 - LCI

Data collection – depends on the goals and scope of our research.

- What shall be taken into account:
    - System boundaries
    - Geography
    - Time of data collection
    - Functional Unit
    - Allocation methods
    - But most importantly: **Time and Money!!**

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Step 2 - LCI

Step 2 effect – Process Tree

- Process Tree includes all LCI results in the form of inputs and outputs emissions from and to soil, atmosphere, water etc.

- Examples of quantitative results of LCI: CO_2, CFC, P, SO_2, NOx, DDT used/emitted during different stages of life cycle.

Step 2 – Process Tree
PET bottle – recycling 30%

70% PET Landfill

30% PET recycling

PET Bottle

Injection Blowing

Energy + Transport

PET Granulate

Injection Moulding

Fossil Fuels

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Step 2 – Process Tree
PET bottle – recycling 30%

Meeting Brainstorm
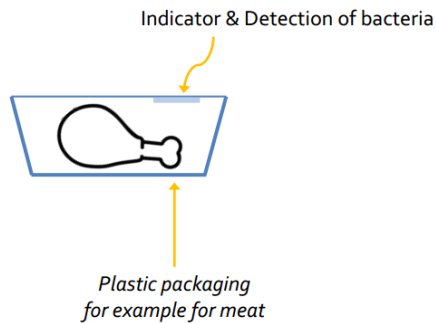## Choice of packaging solutions

- What do we know / don't know?

- Which data can we access / get?

- What can we assume?

- Can we choose a proxy product/component?
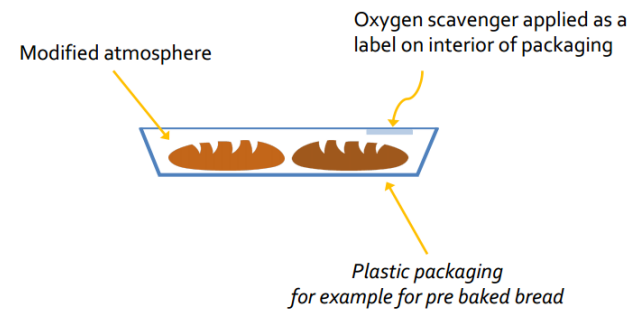
- Who else can we contact / we know that could help?

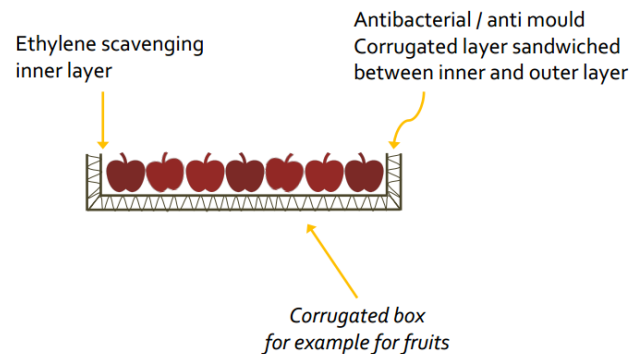fppt.com

Meeting Brainstorm
Choice of packaging solutions

Demonstrator 1 – Intelligent

Indicator & Detection of bacteria

*Plastic packaging
for example for meat*

Demonstrator 2 – Active

Modified atmosphere

Oxygen scavenger applied as a
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*Corrugated box
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Step 3 – Impact Assessment

- LCI results while interesting do not give us any specific information about the environmental impact of a particular product

- LCI results should be interpreted and characterised into impact categories

- There are many characterisation methods available, many of them with normalisation and weighting options
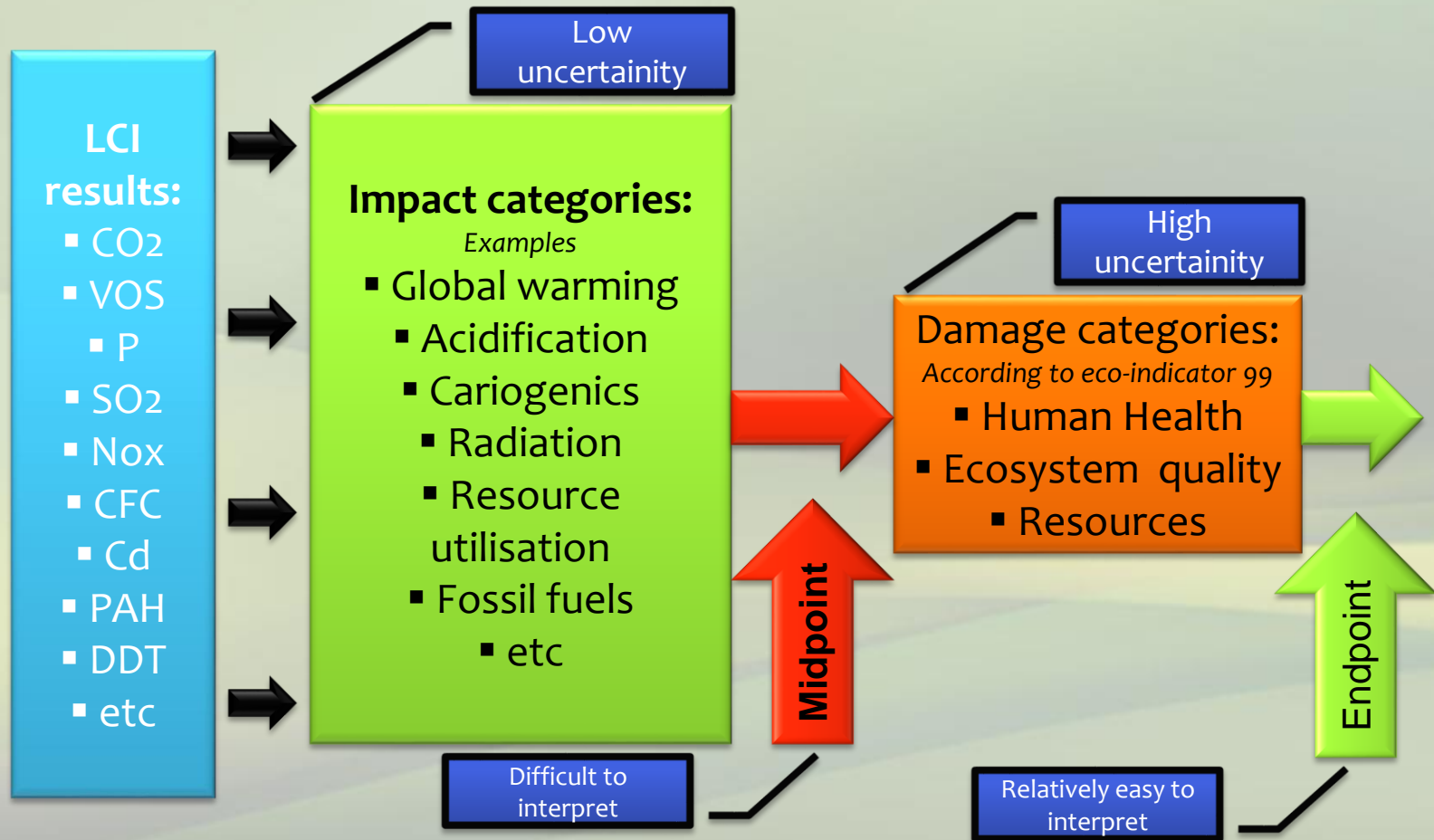
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Step 3 – Method example

CML 2000

LCI result	Climate change	Acidification	Human toxicity
1000 gr CO_2	x 1 = 1000		
10 gr. CH_4	x 23 = 230		
10 gr. SO_2		x 1 = 10	x 9.6E-2 = 0.96
5 gr. NOx		x 0.7 = 3.5	x 1.2 = 6
1E-7 gr dioxine			x 1.3E9 = 130
Total	1230	13.5	136.96

CO_2-eq.

SO_2-eq.

Human toxicity potentials

Step 3 –
Midpoint and Endpoint in a method

LCI results:
- CO_2
- VOS
- P
- SO_2
- Nox
- CFC
- Cd
- PAH
- DDT
- etc

Low uncertainity

Impact categories:
Examples
- Global warming
- Acidification
- Cariogenics
- Radiation
- Resource utilisation
- Fossil fuels
- etc

Difficult to interpret

Midpoint

High uncertainty

Damage categories:
According to eco-indicator 99
- Human Health
- Ecosystem quality
- Resources

Relatively easy to interpret

Endpoint

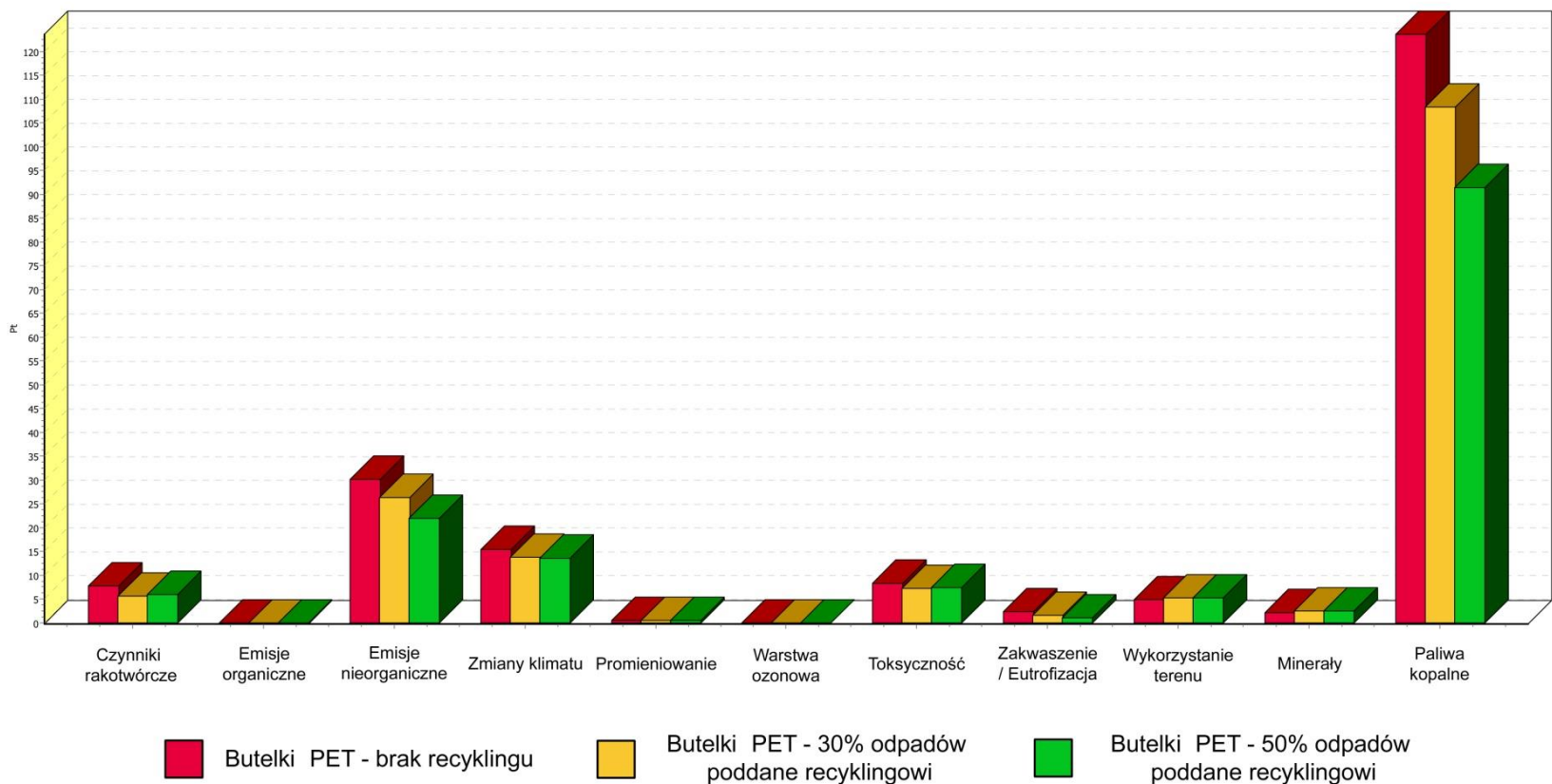fppt.com

Step 3 –
Midpoint and Endpoint in a method

Mid- and endpoints in ReCiPe,
see www.lcia-recipe.net
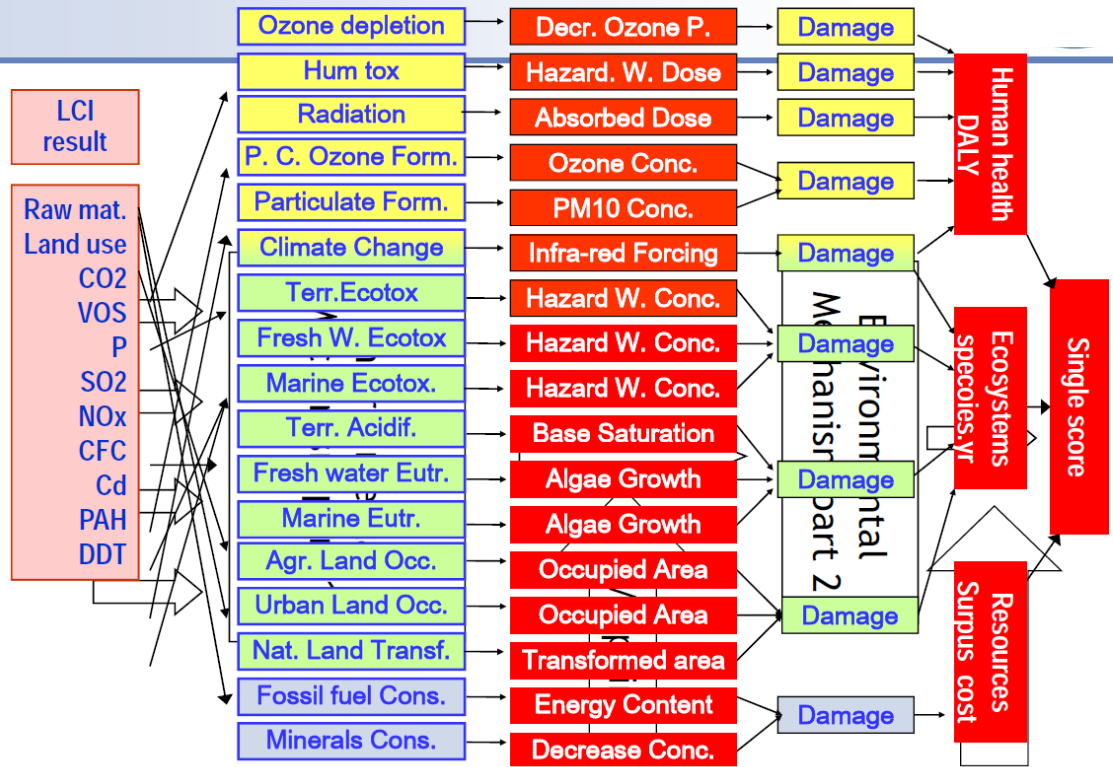
Step 3 – Impact Assessment
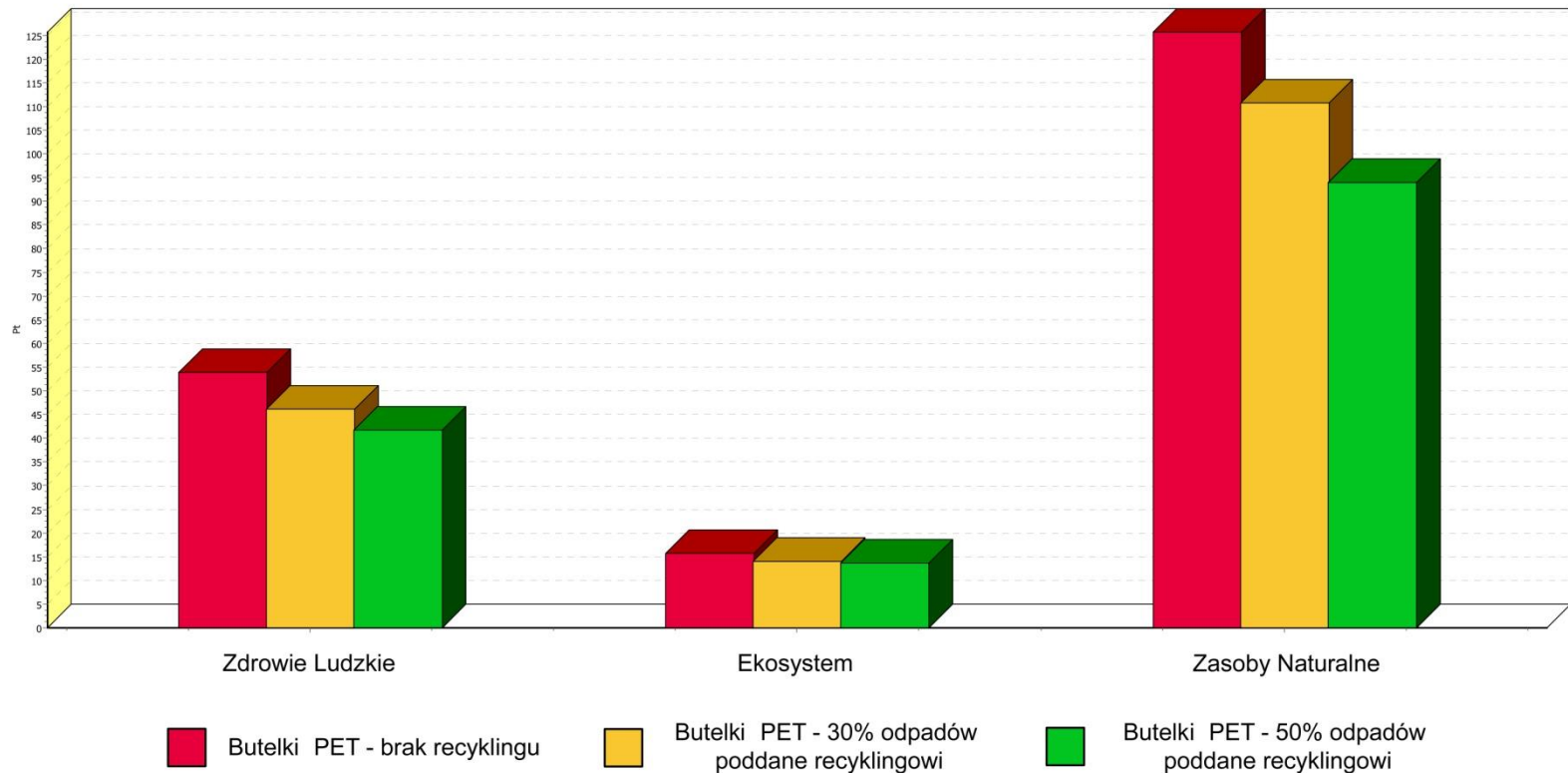## 3 PET bottles – No recyling / recycling 30% & recycling 50%
Method: Eco-indicator 99

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3 PET bottles – No recyling / recycling 30% & recycling 50%
Method: Eco-indicator 99

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Step 3 – Impact Assessment
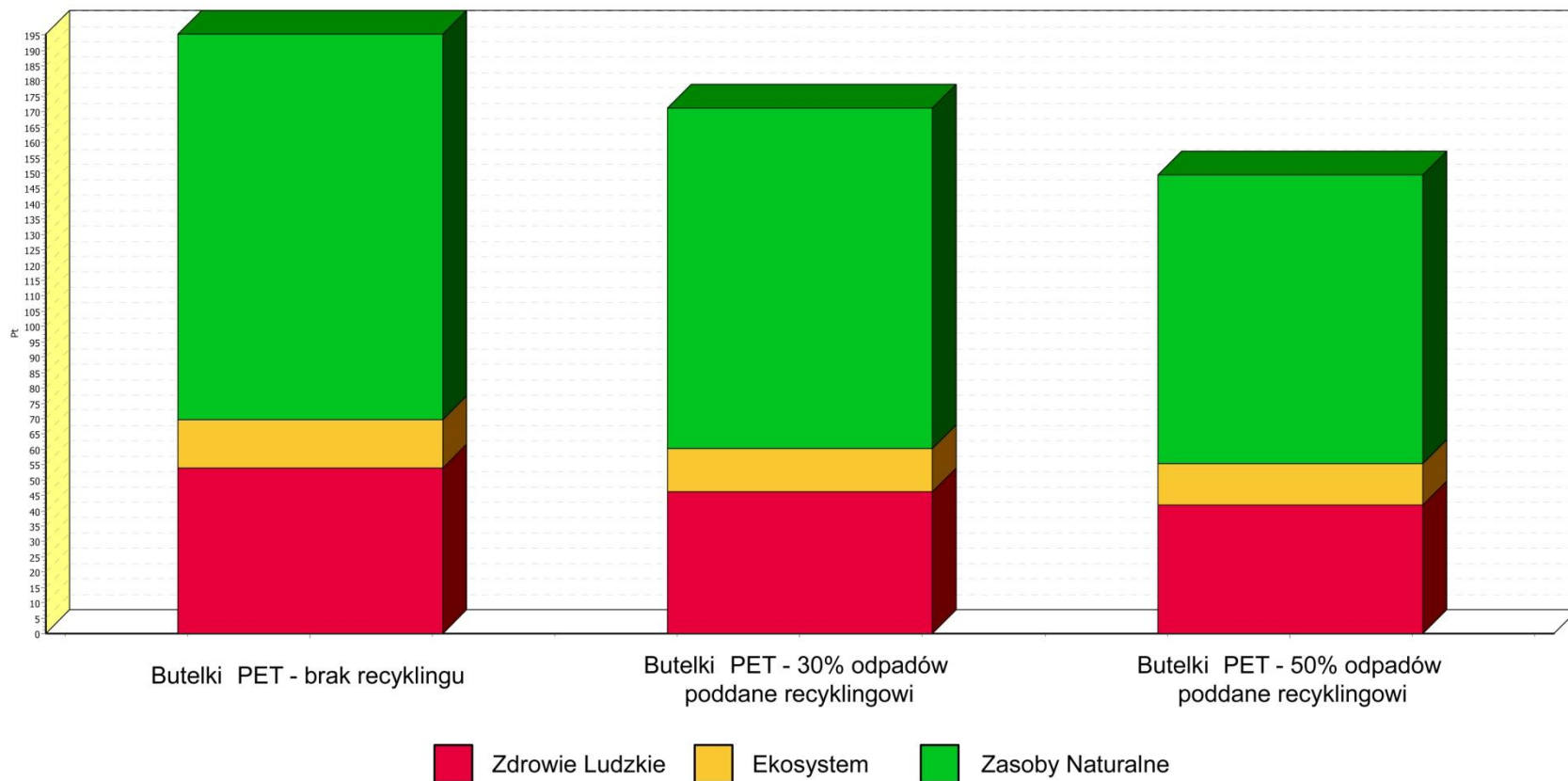## 3 PET bottles – No recyling / recycling 30% & recycling 50%
Method: Eco-indicator 99

Butelki PET - brak recyklingu

Butelki PET - 30% odpadów poddane recyklingowi

Butelki PET - 50% odpadów poddane recyklingowi

Zdrowie Ludzkie   Ekosystem   Zasoby Naturalne

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Step 4 - Interpretation

ISO 14044 standard recommends that before drawing conclusions and preparing a report from 3 previous steps, following elements should be checked:

- Check consistency of results with goal and scope definitions
- Check processes with highest environmental impact
- Check for anomalies (use best judgment)
- Check whether the method is consistent with assessed product
- Some methods omit substances present in the LCI – check whether the number of omitted substances influence the result by choosing a different method
- LCA is not objective, therefore it is helpful to check how the LCA results are dependent on our choices throughout the process.
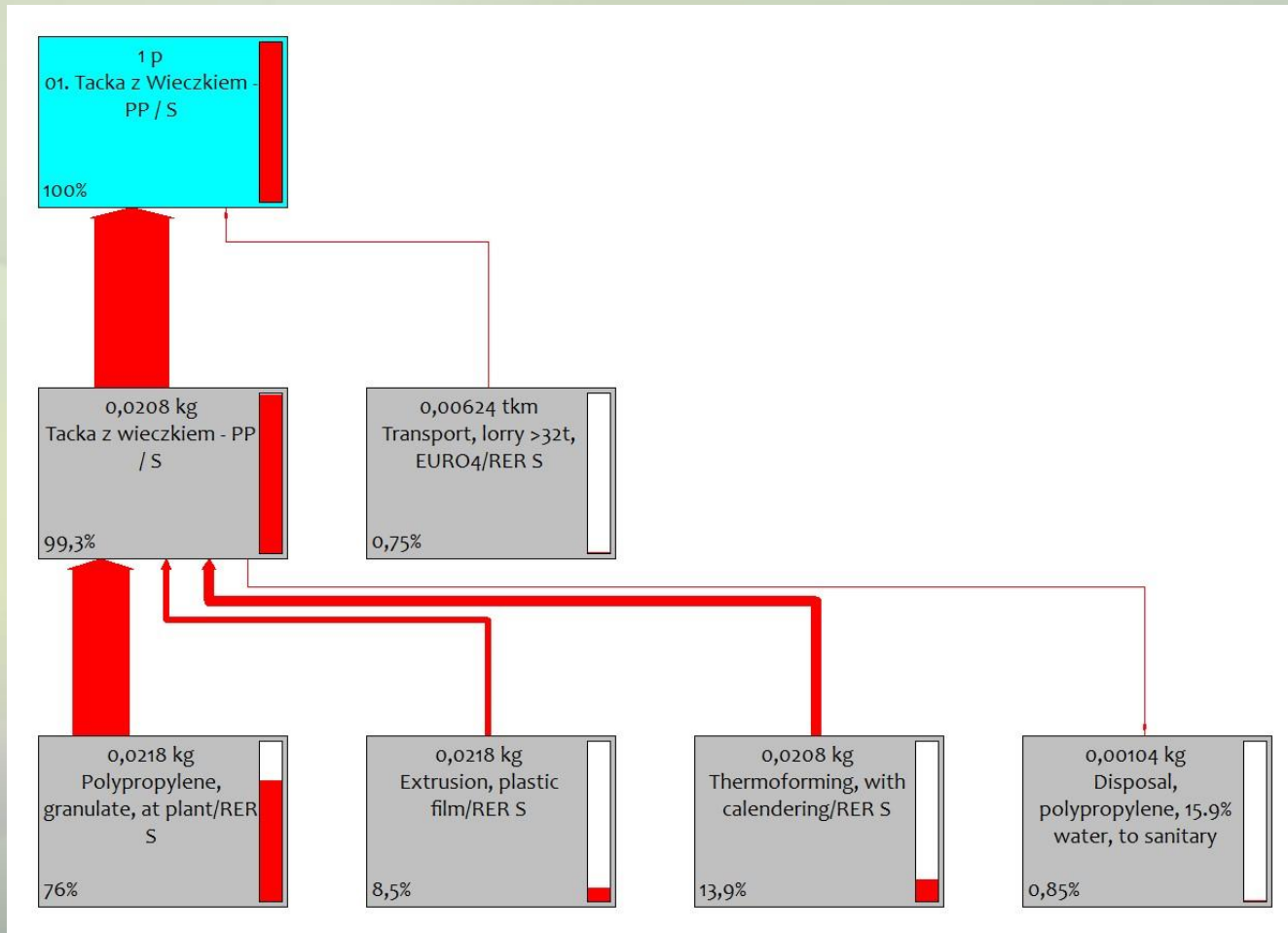- Perform uncertainty and sensitivity analysis where logical and possible. Prepare few scenarios.

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Example

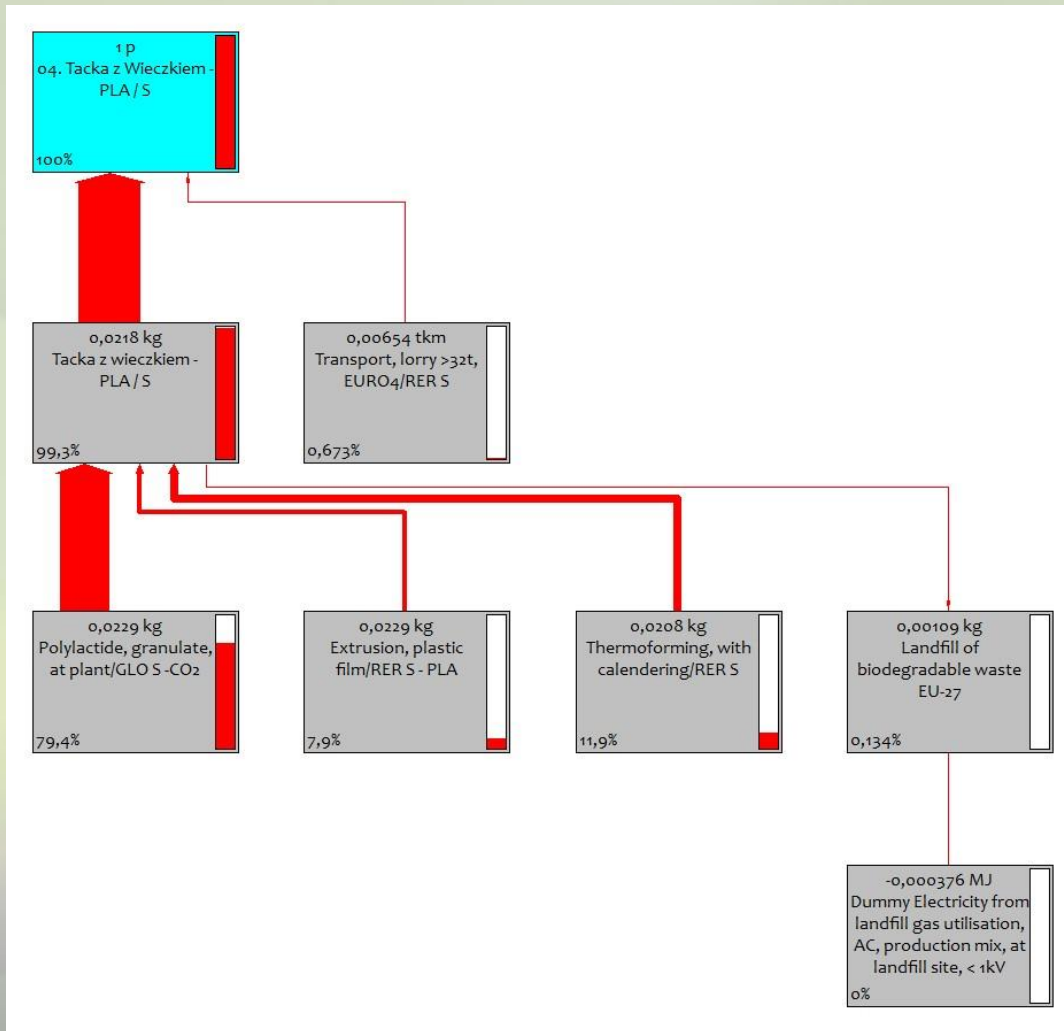**Cheery tomato container from the following materials :**

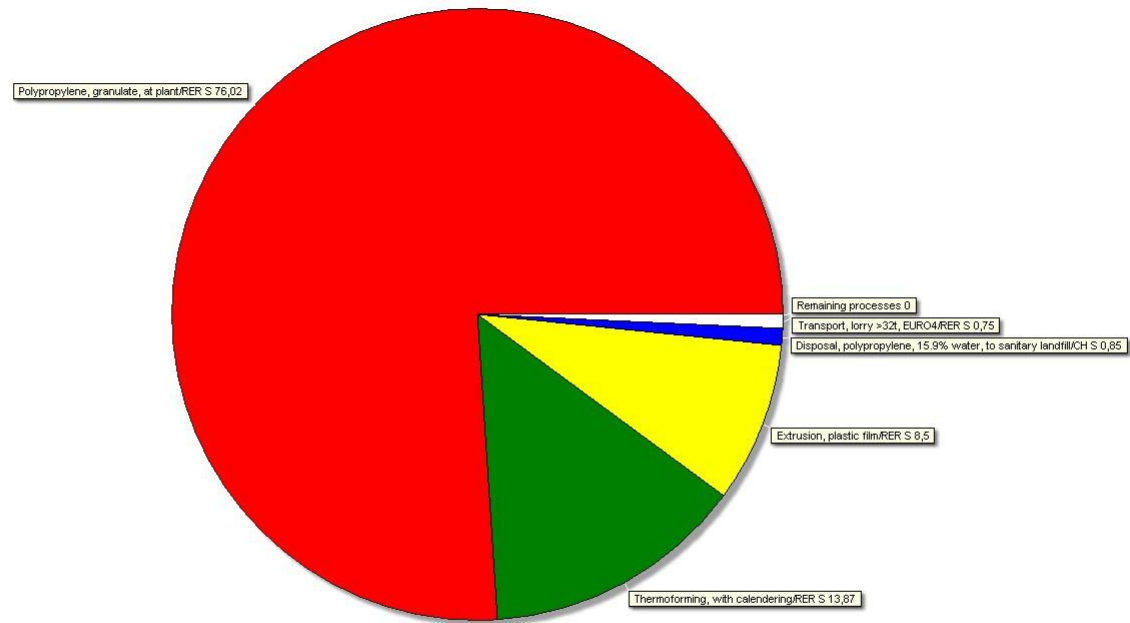1. PP
2. PET
3. rPET
4. PLA

Example

PP container

Example

PLA container

Example

PP container

Polypropylene, granulate, at plant/RER S 76,02

Remaining processes 0
Transport, lorry >32t, EURO4/RER S 0,75
Disposal, polypropylene, 15.9% water, to sanitary landfill/CH S 0,85

Extrusion, plastic film/RER S 8,5

Thermoforming, with calendering/RER S 13,87

- ■ Polypropylene, granulate, at plant/RER S
- ■ Thermoforming, with calendering/RER S
- ■ Extrusion, plastic film/RER S
- ■ Disposal, polypropylene, 15.9% water, to sanitary landfill/CH S
- ■ Transport, lorry >32t, EURO4/RER S
- ■ Remaining processes

Analyzing 1 p '01. Tacka z Wieczkiem - PP / S';
Method: Eco-indicator 99 (H) V2.07 / Europe EI 99 H/A / Single score

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Example

## PLA container

Polylactide, granulate, at plant/GLO S -CO2 0,00676

Remaining processes 0,00001
Transport, lorry >32t, EURO4/RER S 0,00006
Extrusion, plastic film/RER S - PLA 0,00067
Thermoforming, with calendering/RER S 0,00101

| ■ Polylactide, granulate, at plant/GLO S -CO2 | ■ Thermoforming, with calendering/RER S | ■ Extrusion, plastic film/RER S - PLA | ■ Transport, lorry >32t, EURO4/RER S | □ Remaining processes |
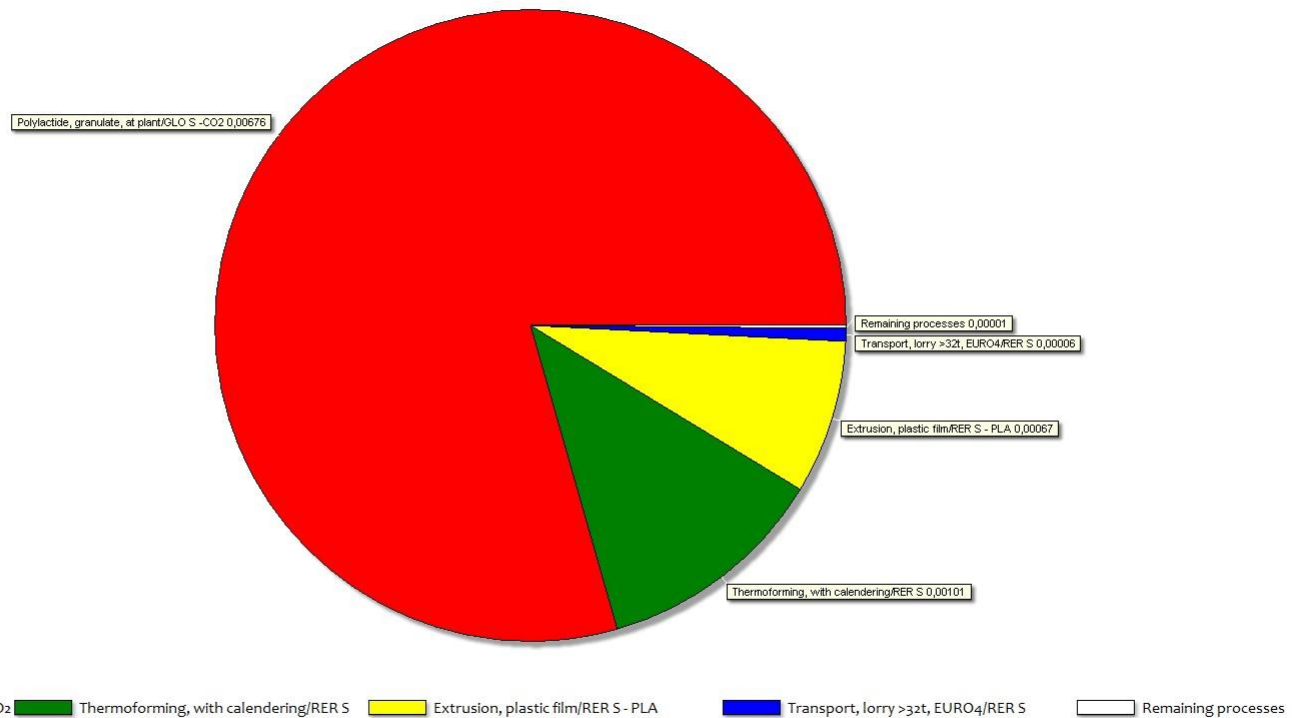
Analyzing 1 p '04. Tacka z Wieczkiem - PLA / S';
Method: Eco-indicator 99 (H) V2.07 / Europe EI 99 H/A / Single score
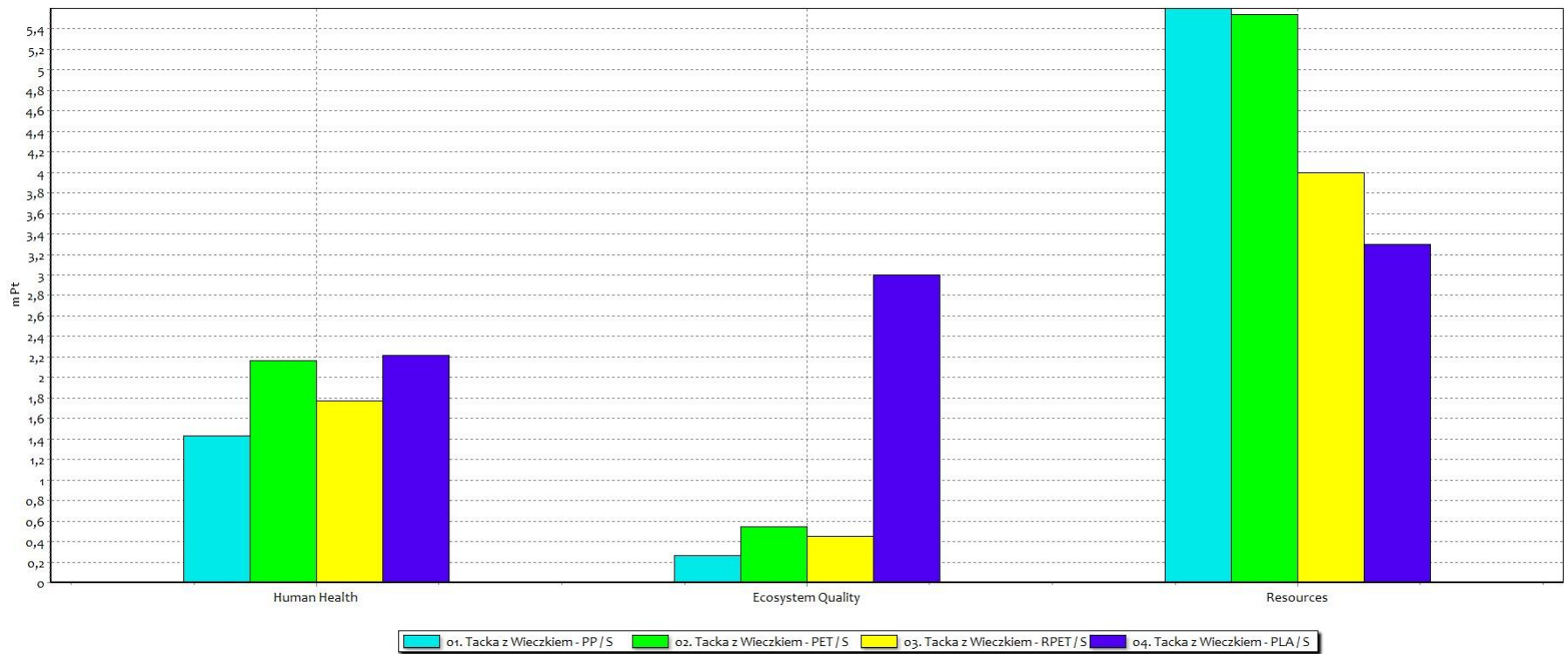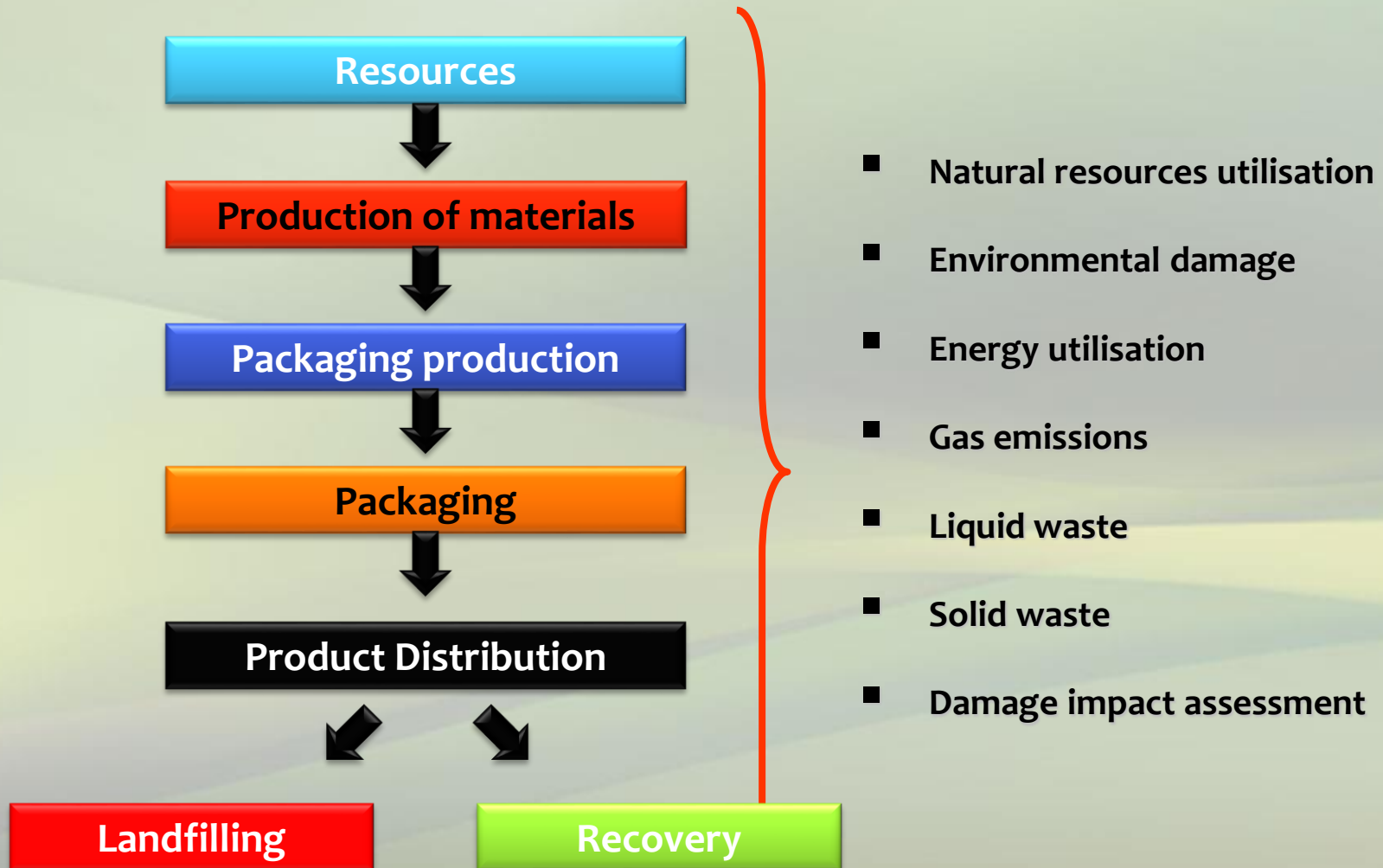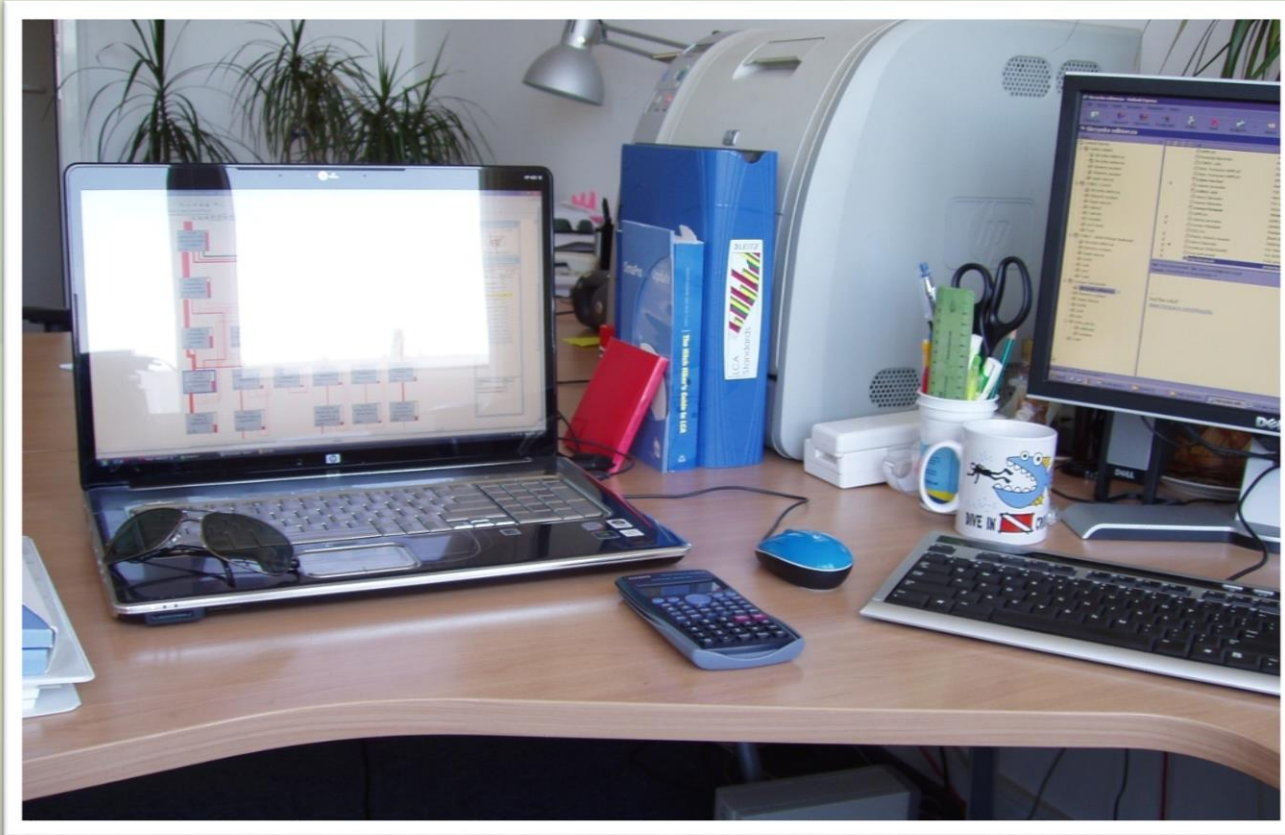
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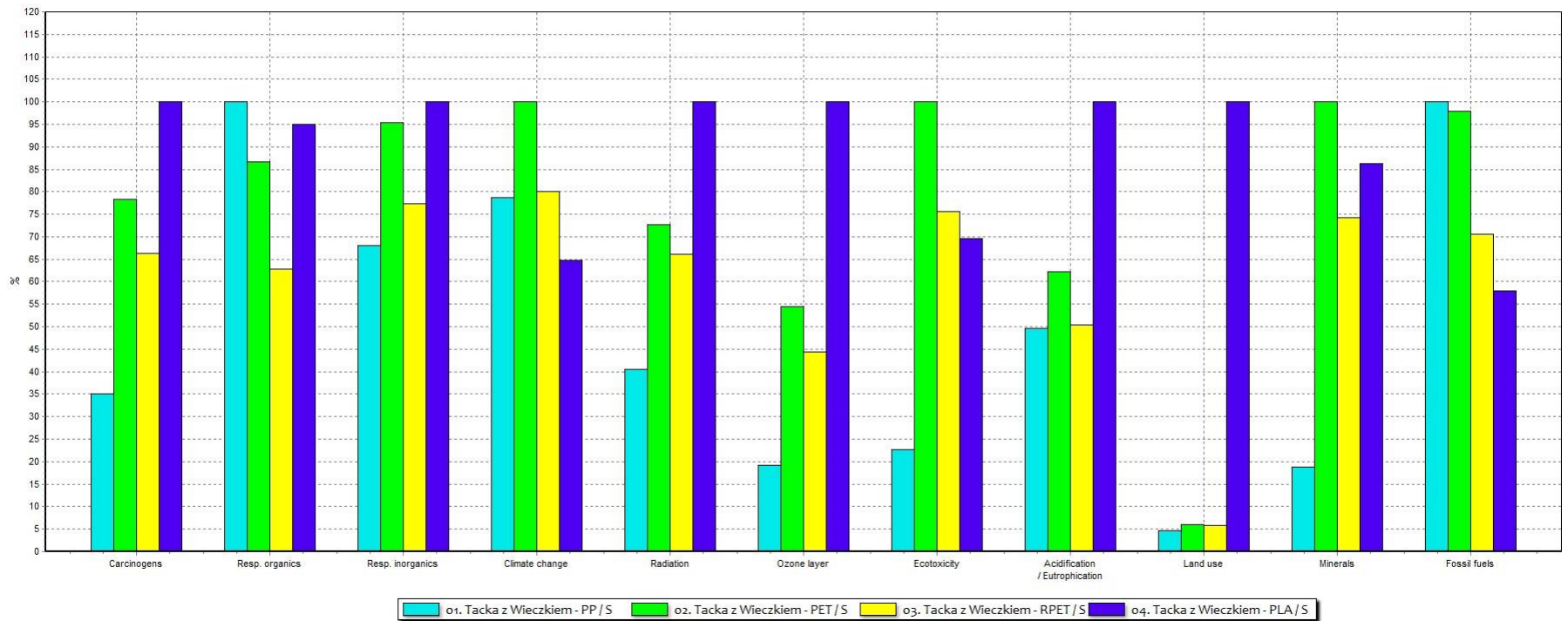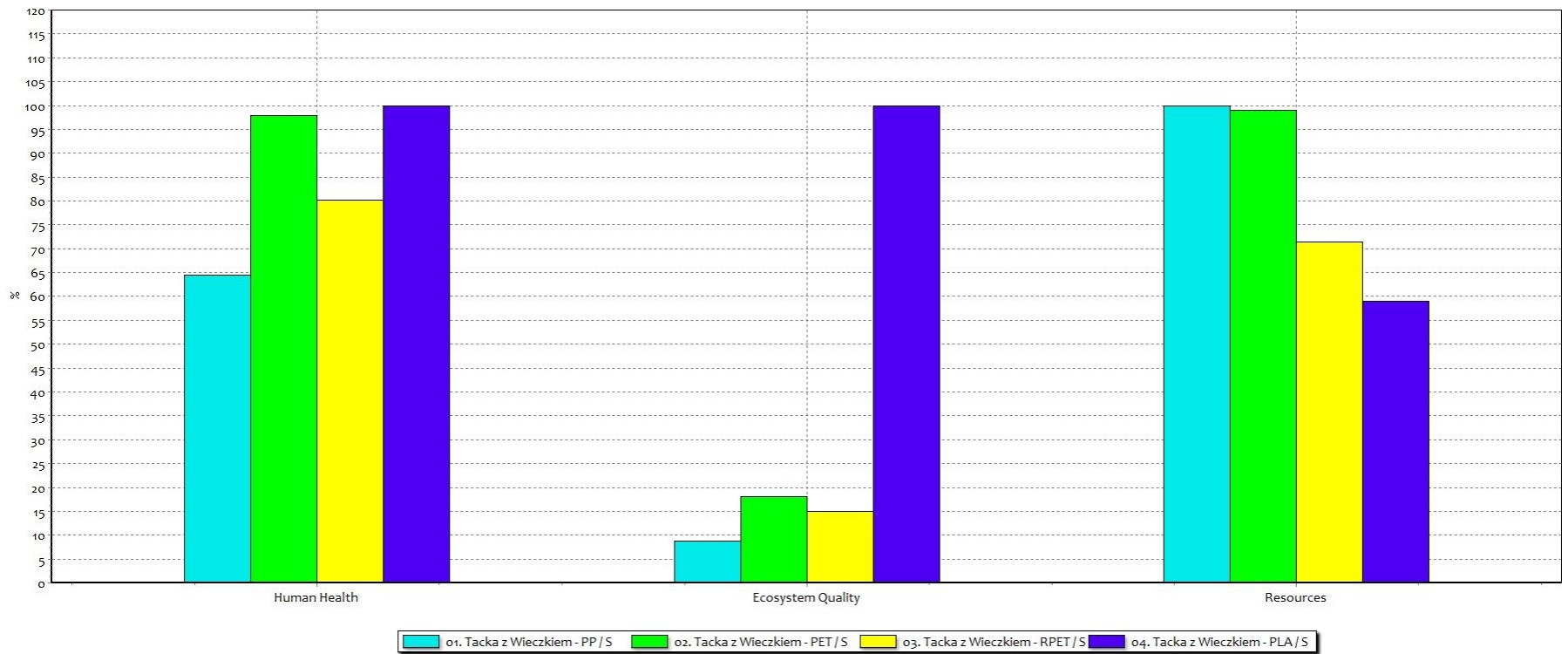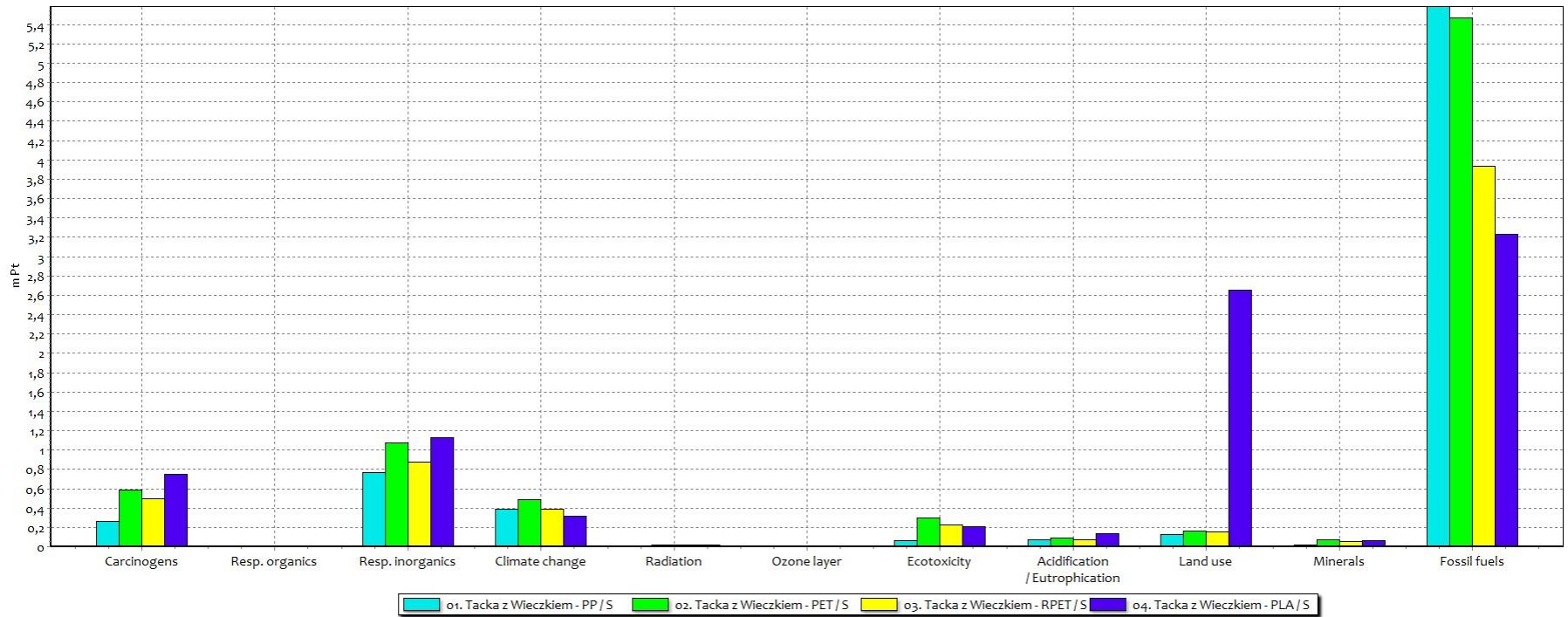
Example

Example

Example

Example

Summary

Thank you!!

LCA Workstation