Life Cycle Assessment(LCA)

of paper packaging products

EcoPaperLoop - Final Conference

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Poland

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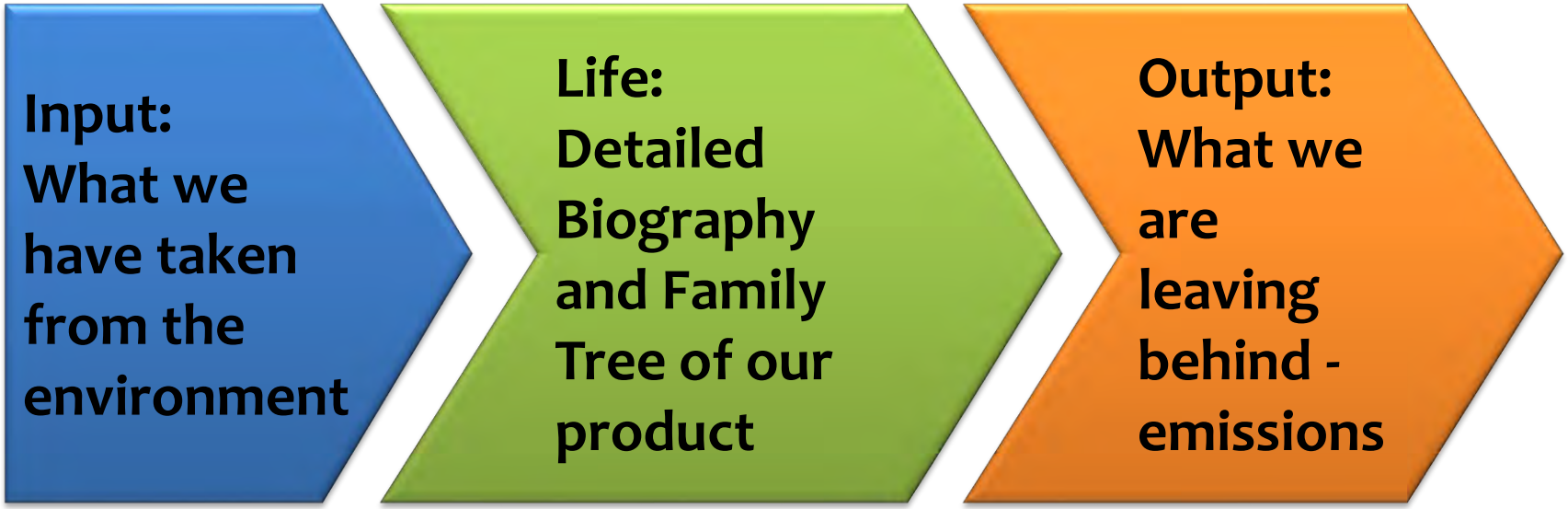
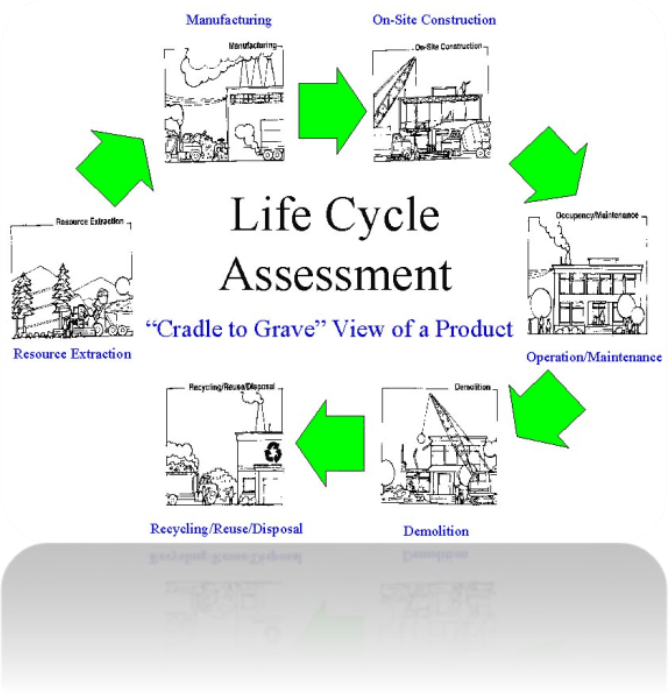
What is LCA ??


Input:
What we have taken from the environment
Life:
Detailed Biography and Family Tree of our product
Output:
What we are leaving behind - emissions

What is LCA ??

- LCA = Life Cycle Assessment
- Probably the most popular standardised sustainability and environmental assessment methods
- 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.

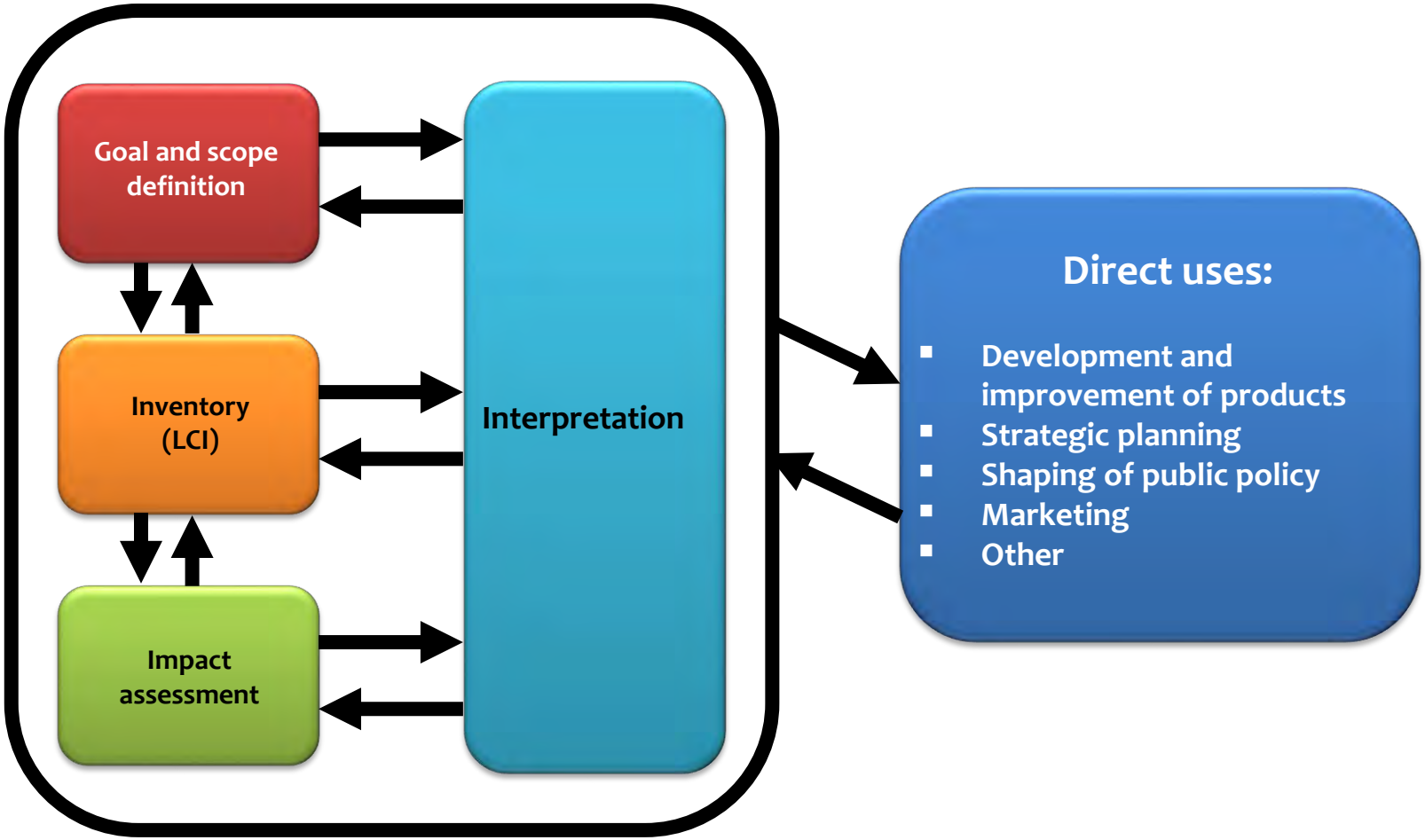


What is LCA ??

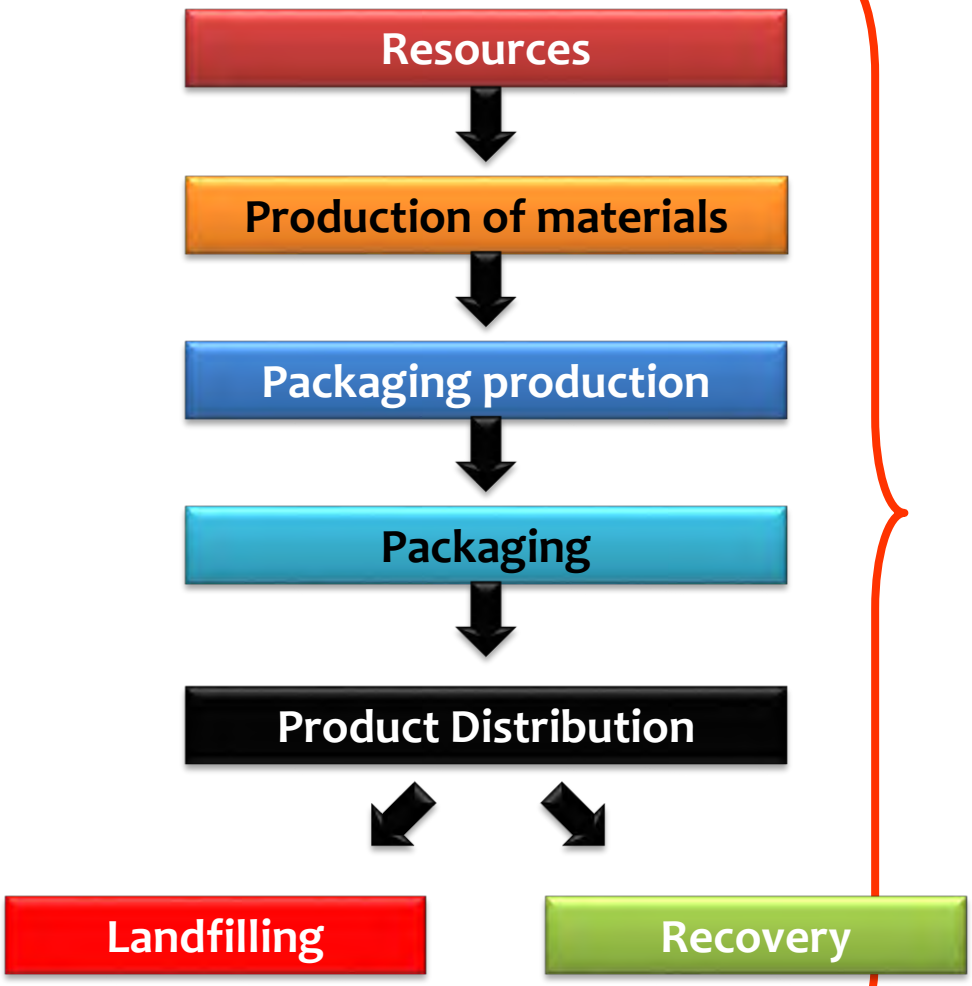
LCA method can be used to rate and compare a product with another products of similar function.

- LCA method consists of different criteria of evaluation in all life cycle stages of a selected product.
- Potential environmental influence of every life cycle process of a chosen product is quantitatively recorded in different impact categories

LCA in 4 steps



LCA of Packaging



- Natural resources utilisation
- Environmental damage
- Energy utilisation
- Gas emissions
- Liquid waste
- Solid waste
- etc

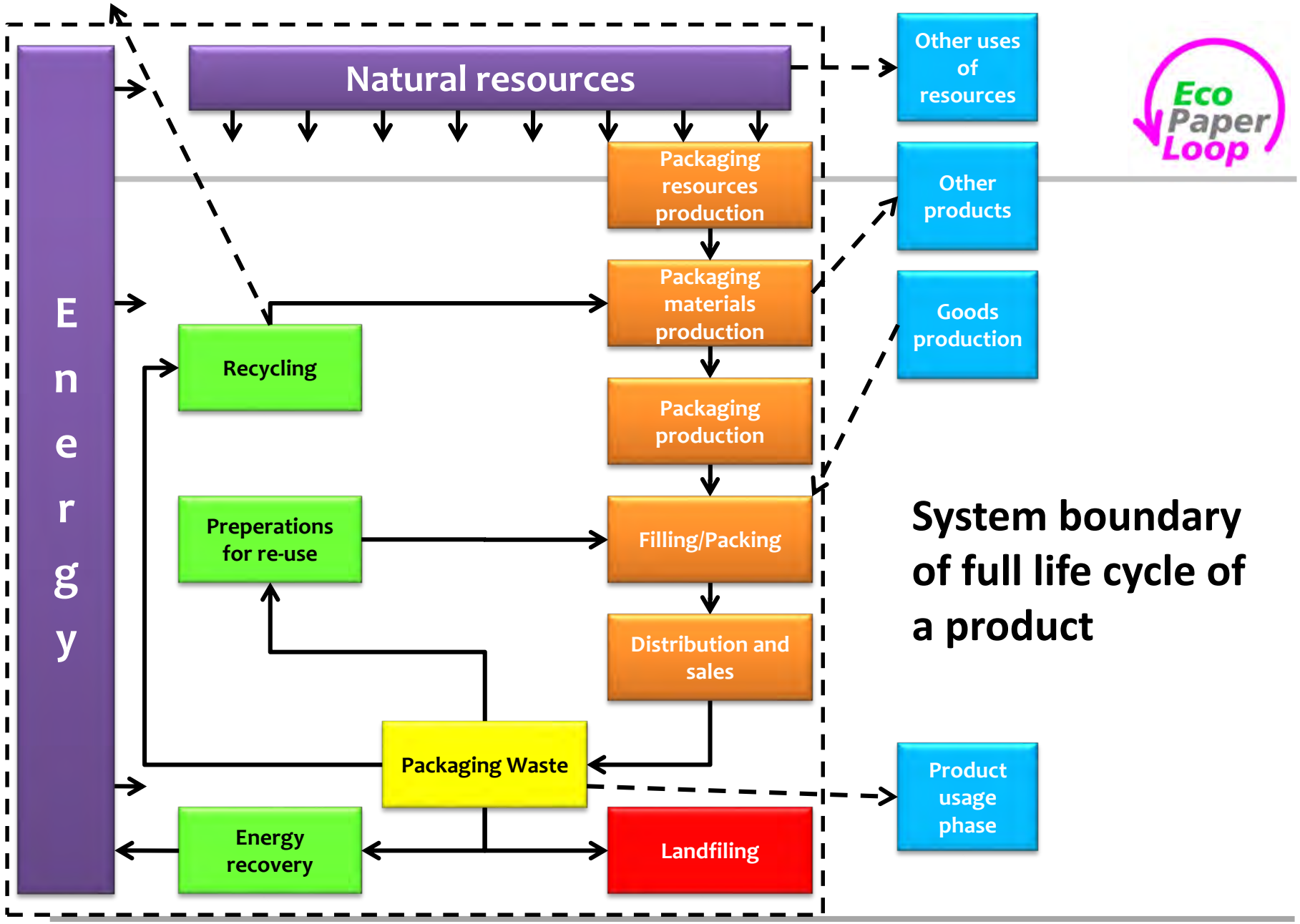
WP5 - Eco-design for recycling

In ECOPAPERLOOP we look at the end of life of paper products – especially the step of recycling.

LCA will allow us to compare eco-design environmental impacts in recycling.

Assumptions:

- **For better clarification and comparison potential LCA results will be shown in 2 modes:**
  - Full life cycle of the product
  - Focus on the end-of-life processes – showing only emissions in end-of-life scenarios



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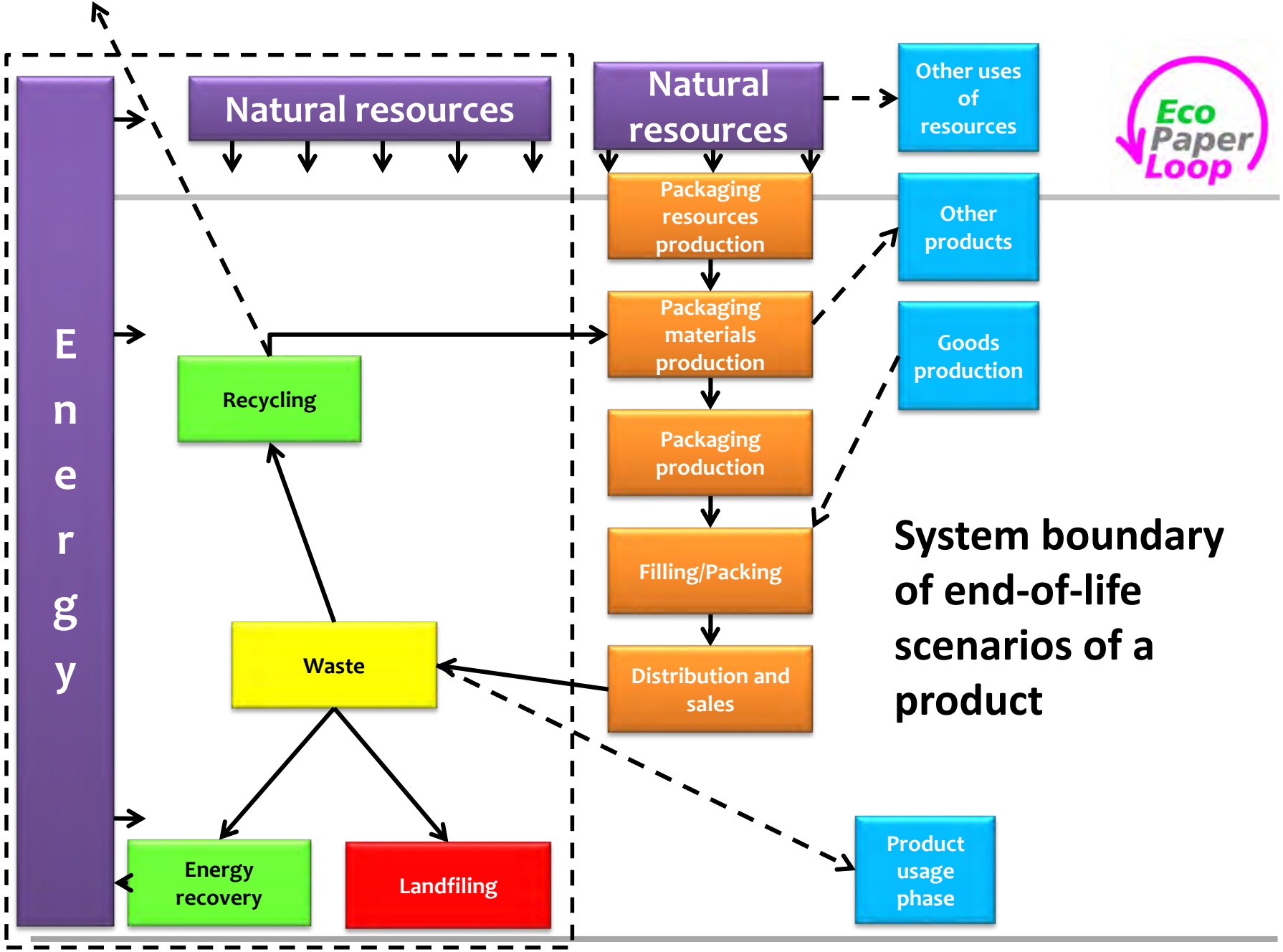

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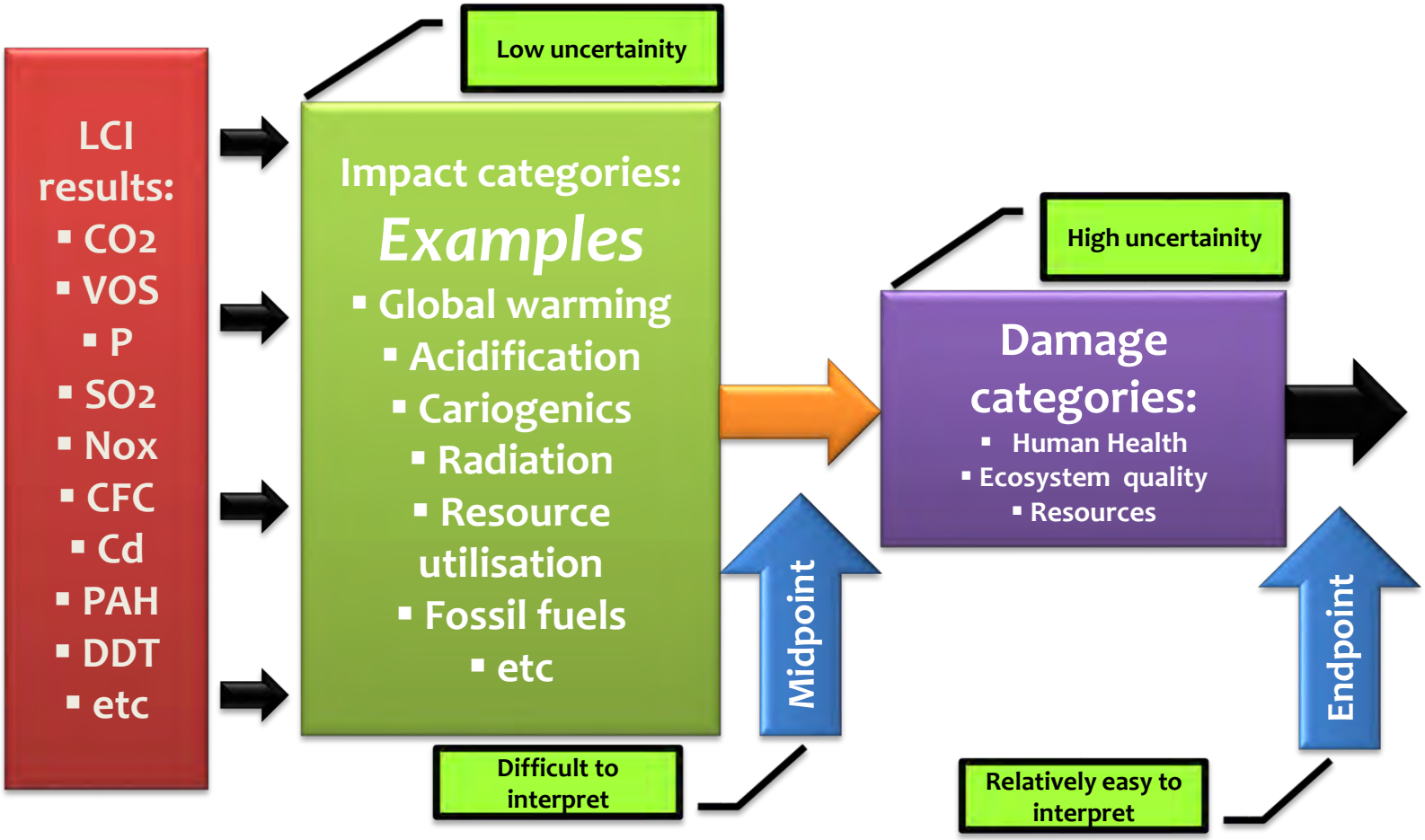
Choice of products for LCA

Total of 4 LCA's – 2 for packaging and 2 for graphic products:

- Two general packaging and graphic products demonstrating issues easy to understand by all project stakeholders
  - *Comparison of flexo and offset newsprint*
  - *Comparison of pure paper bag and laminated paper bag*
- Two technical LCA's – specific packaging and graphic products demonstrating particularities of paper and direct linkage of recyclability benchmark score to environmental impacts
  - *LCA of Italian magazines*
  - *LCA of Polish paper packaging*

Impact Assessment Method



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Impact Assessment Method

Proposed method

- **ReCiPe**
  - **ReCiPe** is an impact assessment method which comprises harmonized category indicators at the midpoint and the endpoint level.
  - It is an improvement on CML 2000 and Eco-indicator 99. The main contributors to this project are **PRé consultants, CML** and **RIVM, Radboud University**.
  - ReCiPe allows the environmental load of a product to be expressed in a single score.

Impact Assessment Method

Relevant impact categories – mid-point:

- **Agricultural and urban land occupation** (in particular for Paper Production process) - The amount of either agricultural land or urban land occupied for a certain time. The unit is m2*yr.
- **Climate change** - The characterization factor of climate change is the global warming potential. The unit is yr/kg CO2 equivalents.
- **Fossil fuel and minerals depletion** (for all the processes) The characterization factor of fossil depletion is the amount of extracted fossil fuel extracted, based on the lower heating value. The unit is kg oil equivalent (1 kg of oil equivalent has a lower heating value of 42 MJ).

Impact Assessment Method

Relevant impact categories – end-point:

- **Human Health**, expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World bank and WHO. The unit is years.
- **Ecosystems**, expressed as the loss of species over a certain area, during a certain time. The unit is years.
- **Resources** surplus costs, expressed as the surplus costs of future resource production over an infinitive timeframe (assuming constant annual production), considering a 3% discount rate. The unit is 2000US$.

LCA – Paper Bags

Comparison of pure paper and plastic laminated shopping bag.

- **The scope**: to assess the full life cycle of shopping bags:
  - pure paper bag
  - paper plus plastic lamination

- **End-of-Life scenarios:**
  - **Pure Paper Bag**: Recycling of pure paper bag in a standard recycling plant
  - **Laminated Paper Bag Scenario A**: Recycling of laminated paper bag in a standard recycling plant
  - **Laminated Paper Bag Scenario B:** Recycling of laminated paper bag in a specialized plant for the treatment of composite and laminated paper grades
  - **Laminated Paper Bag Scenario C:** Disposal without recycling.

LCA – Paper Bags

Methodology:

A typical product with standard properties and typical conditions of printing and recycling.

- Calculatated with **SimaPro version 8.0.3**
- **ReCiPe Endpoint V1.10** was used as an impact assessment method
- Most of the processes and data for the calculation were taken from **Ecoinvent v.3 Database**.

LCA – Paper Bags

Assumptions:

- **Paper**: Same paper grade was considered for both pure paper bags and plastic laminated bags:
  - **50% kraft bleached** cellulose from wood and,
  - **50% recycled fibres**.

- The functional unit for the calculation is **1 kg** of ready to use bags.

LCA – Paper Bags

Assumptions:

- **Lamination:** 20% w/w of polypropylene.

  The case of 20% plastic lamination can be considered as the maximum level of plastic fraction normally used in high quality bags available on the market.

  Reference: Information from contacted laminated bags producers.

- **Total mass** of the bag and all the other packaging elements (like adhesive application, handles and finishing) are supposed to be the same for both pure paper bag and laminated bag

LCA – Paper Bags

End-of-life scenarios assumptions:

- **Pure Paper Bag**
  - all the product is recycled back to the same packaging paper stream, for manufacturing of the same paper grade.
  - The recycling yield is assumed to be 100%, that mean no coarse reject is generated in the recycling.

- **Laminated Paper Bag - Scenario A**
  - the end of life option is recycling as mixed packaging paper for recycling in a standard plant, not specifically equipped for managing high amount of composite materials.
  - It is supposed that the coarse reject after the pulping stage is 50%, because not all the cellulose fibres can be recovered and an important part of them is rejected together with plastic.

LCA – Paper Bags

End-of-life scenarios assumptions:

- **Laminated Paper Bag - Scenario B**
  - The end of life option is recycling as selected packaging paper for recycling in a specialized plant, equipped for managing high amount of composite materials.
  - An average transport distance of **500 km** by truck from the place where the paper is collected to the mill where it is recycled is assumed.
  - It is supposed that the coarse reject after the pulping stage is 25%, some fibres are rejected together with the plastic but most of the paper fraction can be recovered (75%).
  - Part of the plastic waste (50%) is supposed to be recycled.

LCA – Paper Bags

End-of-life scenarios assumptions:

- **Laminated Paper Bag - Scenario C**
  - the end of life option is **final disposal** of the used product, for instance if the local regulation doesn't allow recycling for this kind of products in the paper fraction.

- **Laminated Paper Bag – coarse pulping reject waste**
  - The coarse pulping reject is supposed to be disposed as for the MSW, **60% landfill** and **40% incineration**.
  - There are no specific data available at EU level for the disposal of recycling waste, so it is considered the same ratio as for MSW.

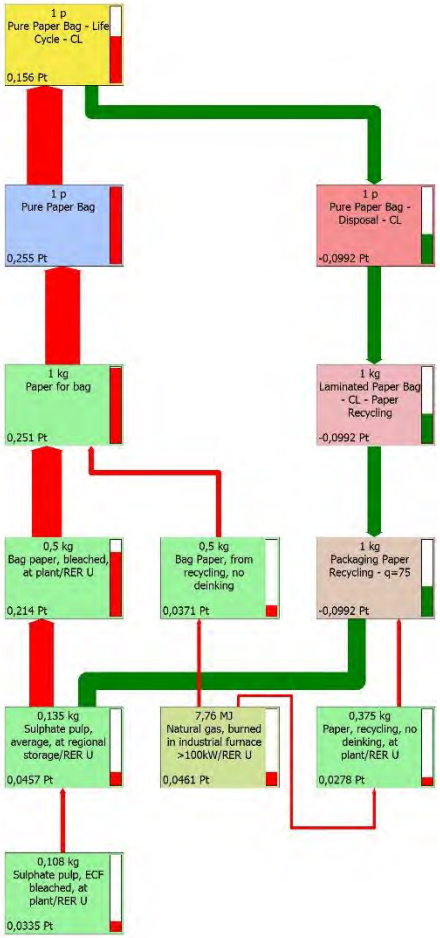
LCA – Paper Bags

End-of-life scenarios assumptions:

- **Closed Loop Approach:** The recycled fibres obtained are supposed to replace the raw material used for bags manufacturing:
  - 50% of recycled fibres replace the recycled raw material,
  - 50% of recycled fibres avoid the usage of virgin cellulose pulp.

- **Quality Factor:** quality of recycled fibres is normally lower than virgin cellulose fibres.
  - The quality factor was set to 75%, which means that only 75% of the original quality and properties can be obtained by using recycled fibres.
  - In order to include this reducing quality factor in the LCA calculation, it was considered that only 75% of available recycled pulp is used back into the loop for replacing the virgin pulp fraction
  - The determination of the most suitable value for the quality factor need to be studied more precisely, taking into account new developments of the Product Environmental Footprint rules under discussion in Europe.

LCA – Paper Bags – Process Tree



Pure Paper Bag: The green arrow shows the benefit of recycling into the same loop.

- The arrow is linking to the sulphate pulp which production could be avoided with recycling into the same loop.

Recycling can avoid the major impact of pulp production from virgin wood, but the environmental impacts of the recycling process and paper formation are still accounted.

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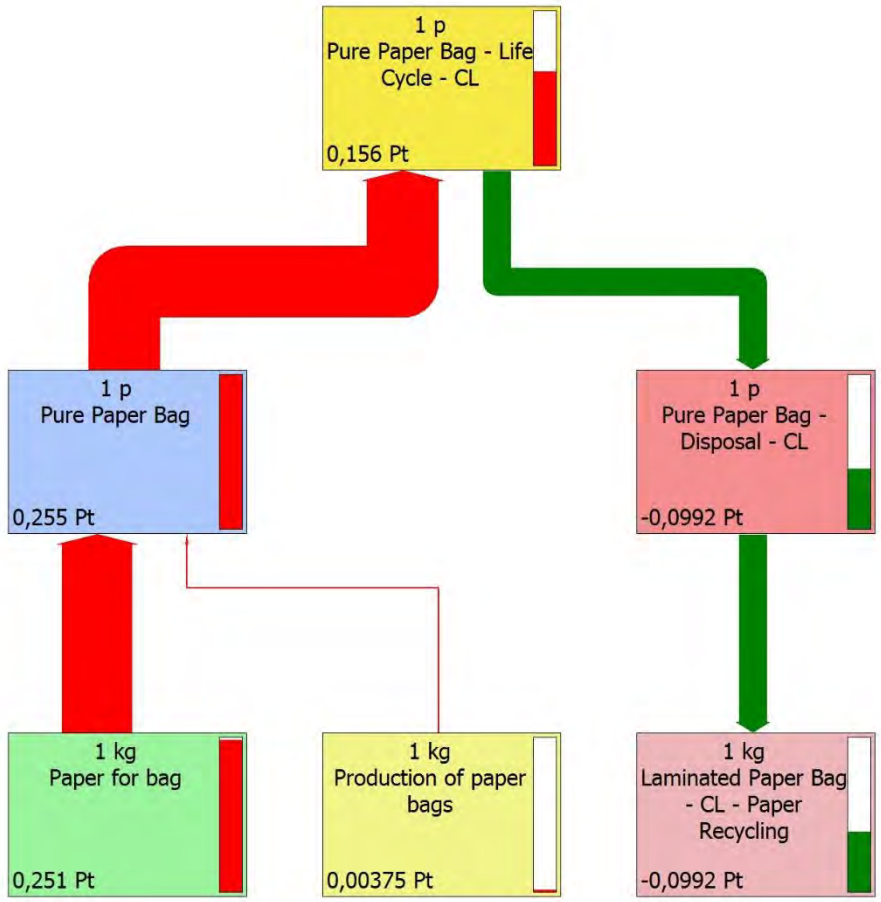
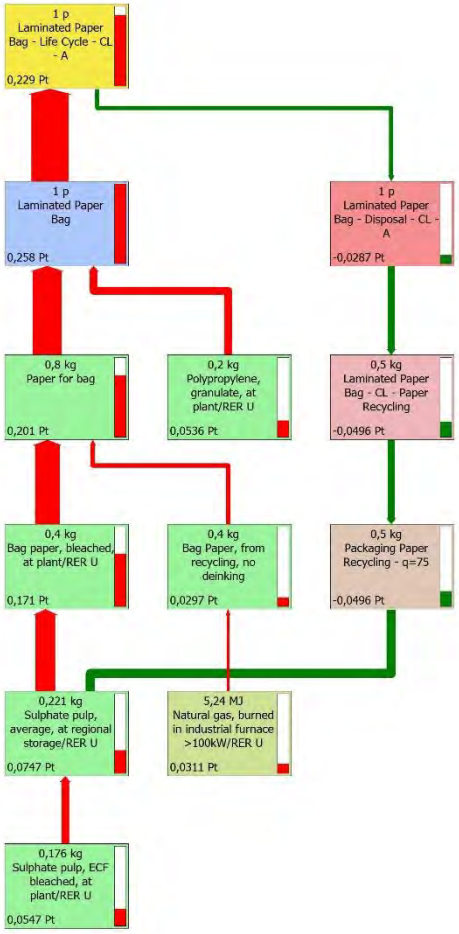
LCA – Paper Bags - Process Tree



LCA – Paper Bags - Process Tree



Laminated Paper Bag - Scenario A: The green arrow shows the benefit of recycling into the same loop.

- The arrow is linking to the sulphate pulp which production could be avoided with recycling into the same loop.

Recycling benefit is smaller than in **Pure Paper Bag** due to smaller amount of paper being recycled

- The amount of paper recycled is equivalent to 50% of the overall bag mass.

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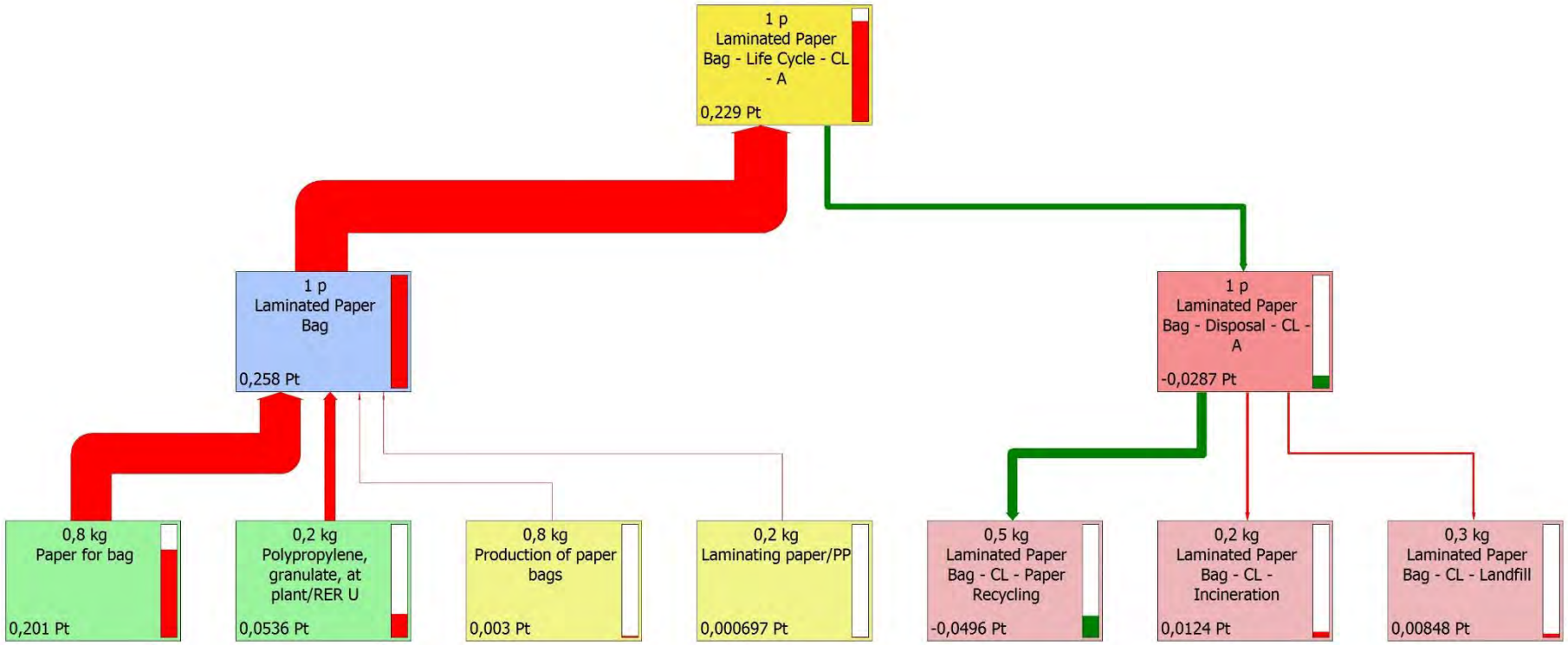
LCA – Paper Bags - Process Tree



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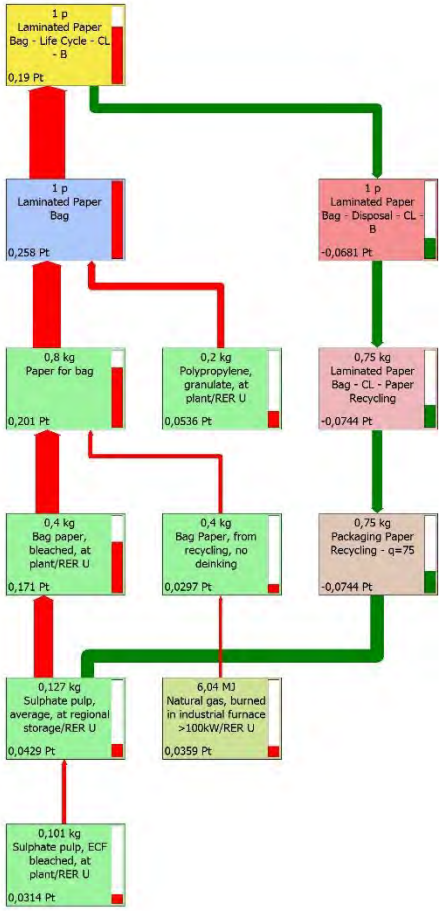
LCA – Paper Bags - Process Tree



Laminated Paper Bag - Scenario B: The green arrow shows the benefit of recycling into the same loop.

- The arrow is linking to the sulphate pulp which production could be avoided with recycling into the same loop.

Recycling benefit is bigger than in **Laminated Paper Bag - Scenario A** due to larger amount of paper being recycled.

- The amount of paper recycled is equivalent to 75% of the overall bag weight.

Note: The recycling process also includes bigger transport environmental costs, due to the fact that there are not many specialised recycling plants in Europe that can successfully recycle laminated paper bags with high efficiency.

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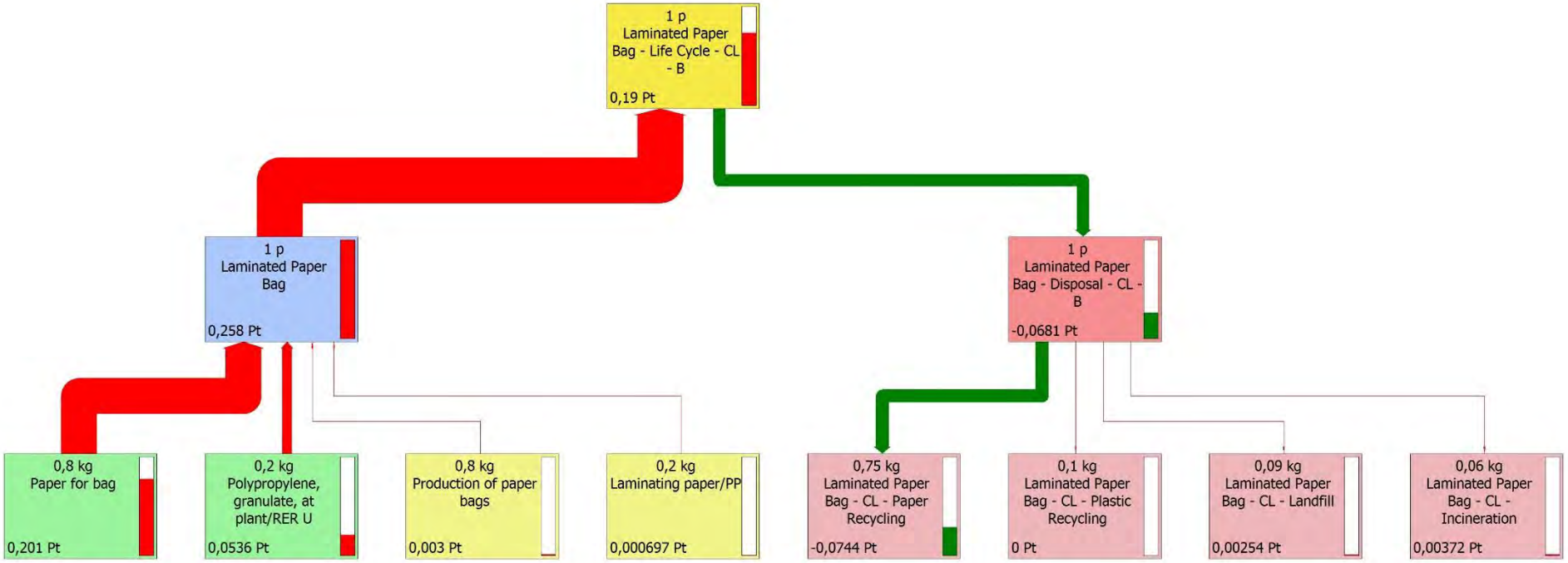
LCA – Paper Bags - Process Tree



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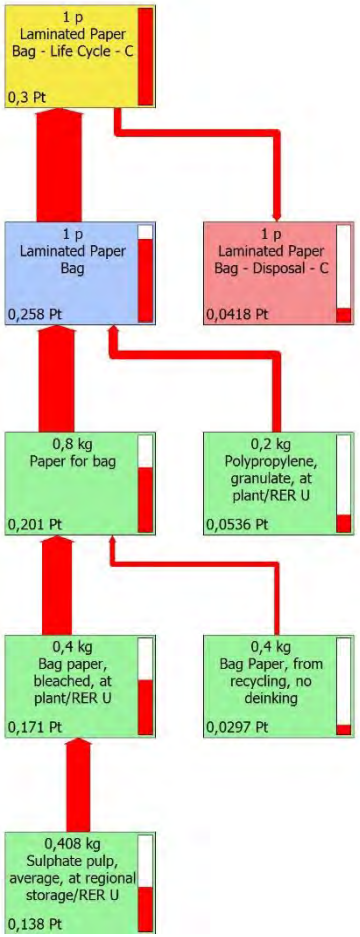
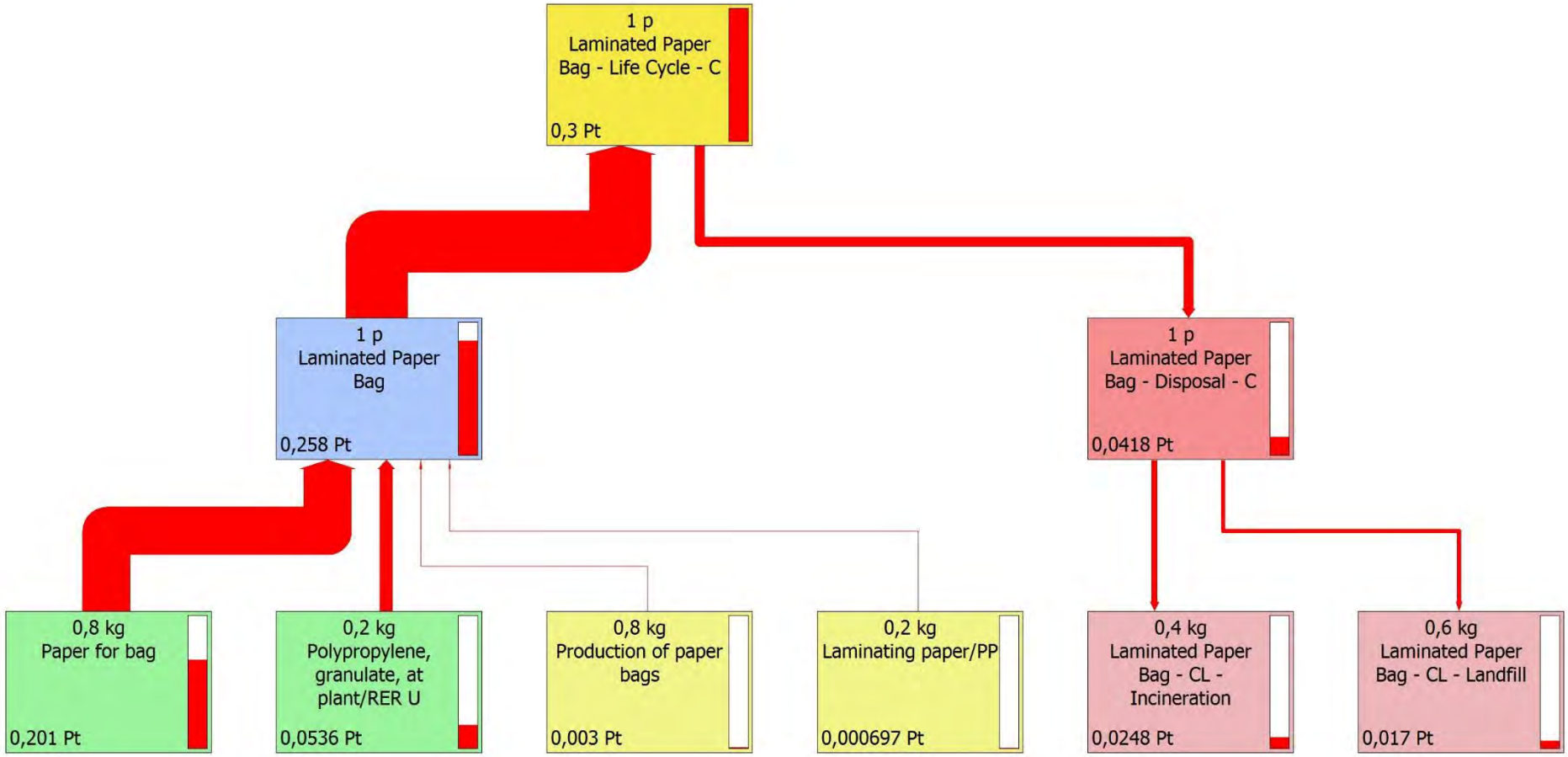


Laminated Paper Bag - Scenario C:

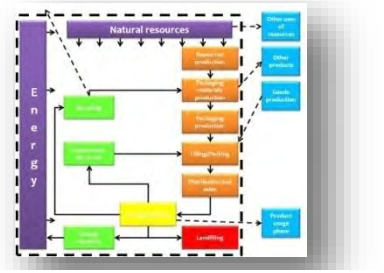
no recycling is taking place - all of the laminated paper bag is considered as a waste and is disposed in landfill and incineration

- This is a scenario specific to countries where laminated paper bags usually do not go to any recycling plant.

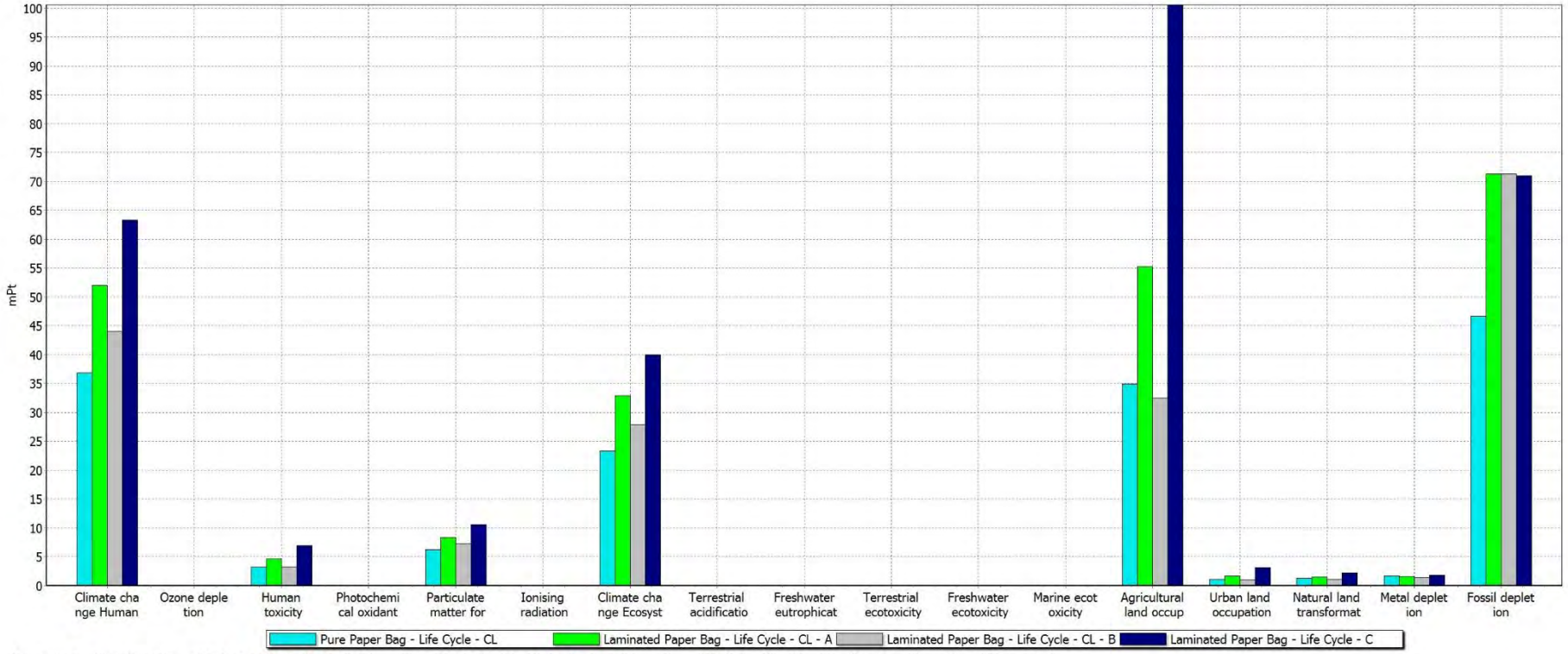
LCA – Paper Bags - Process Tree



LCA – Paper Bags – Impact Assessment

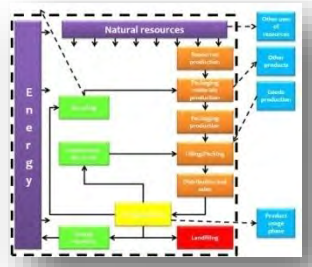


Full life cycle – Mid-Point Results

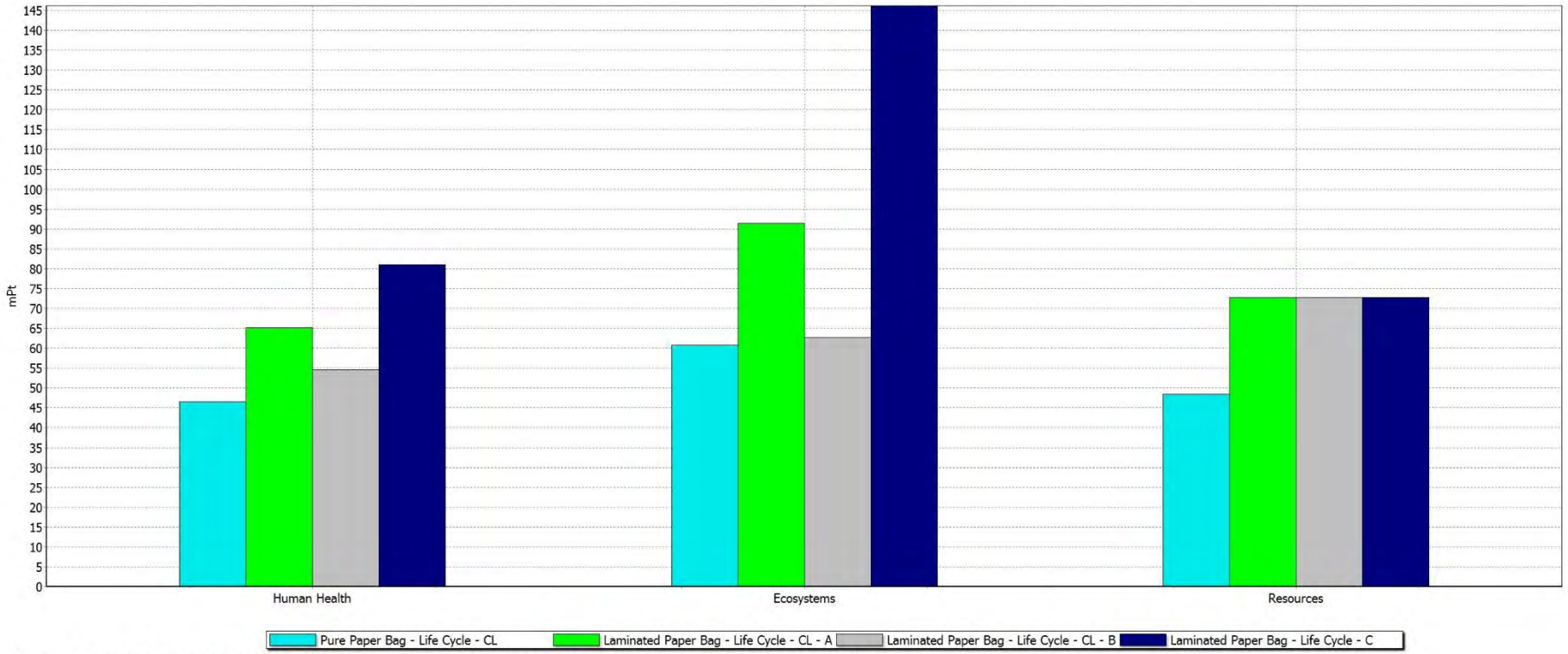


Comparing 1 p 'Pure Paper Bag - Life Cycle - CL', 1 p 'Laminated Paper Bag - Life Cycle - CL - A', 1 p 'Laminated Paper Bag - Life Cycle - CL - B' and 1 p 'Laminated Paper Bag - Life Cycle - C';
Method: ReCiPe Endpoint (H) V1.10 / Europe ReCiPe H/A / Weighting

LCA – Paper Bags – Impact Assessment



Full life cycle – End-Point Results



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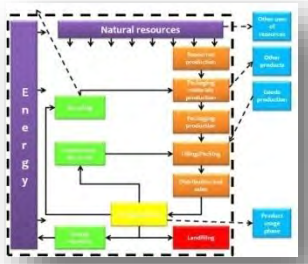
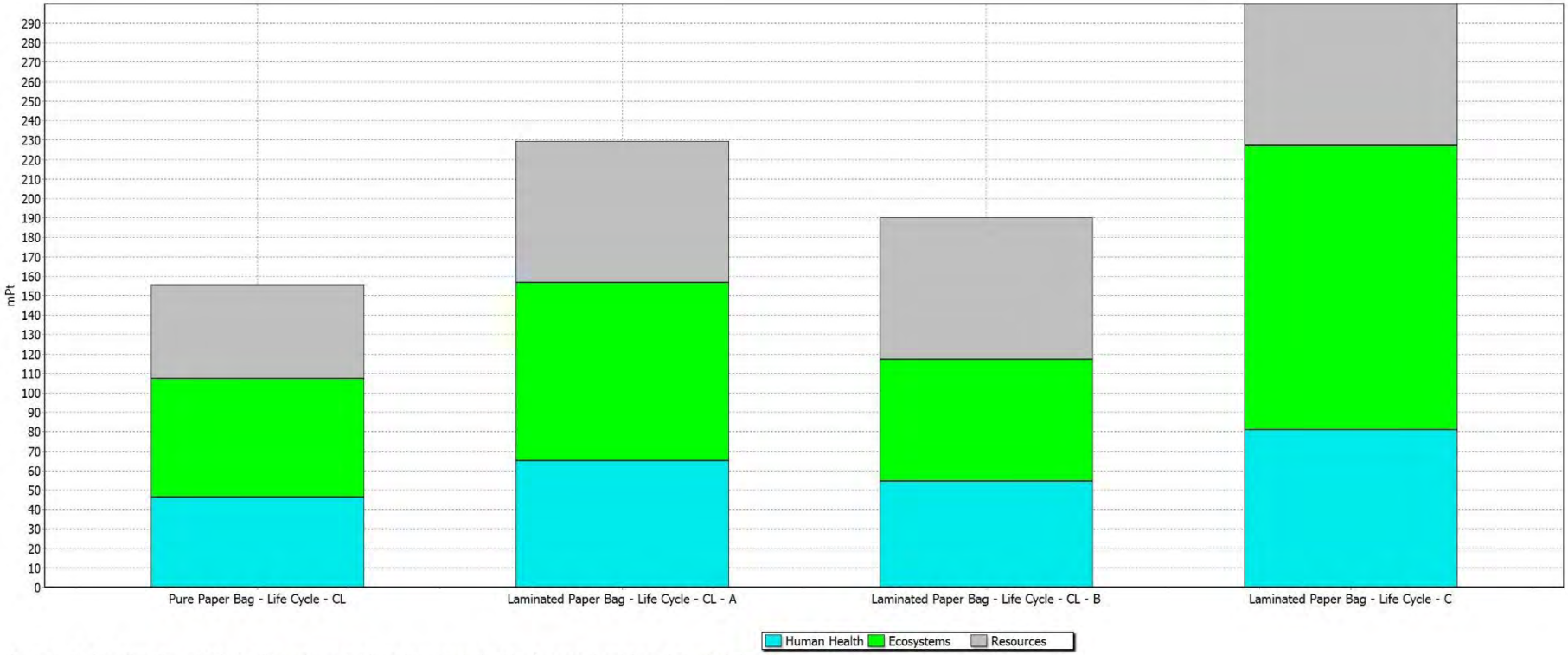


Full life cycle – Single Score Results



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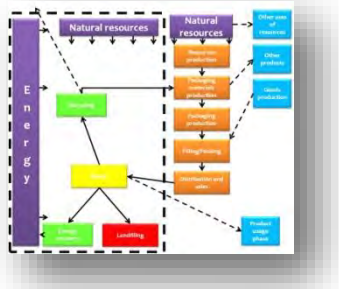
Method: ReCiPe Endpoint (H) V1.10 / Europe ReCiPe H/A / Single score

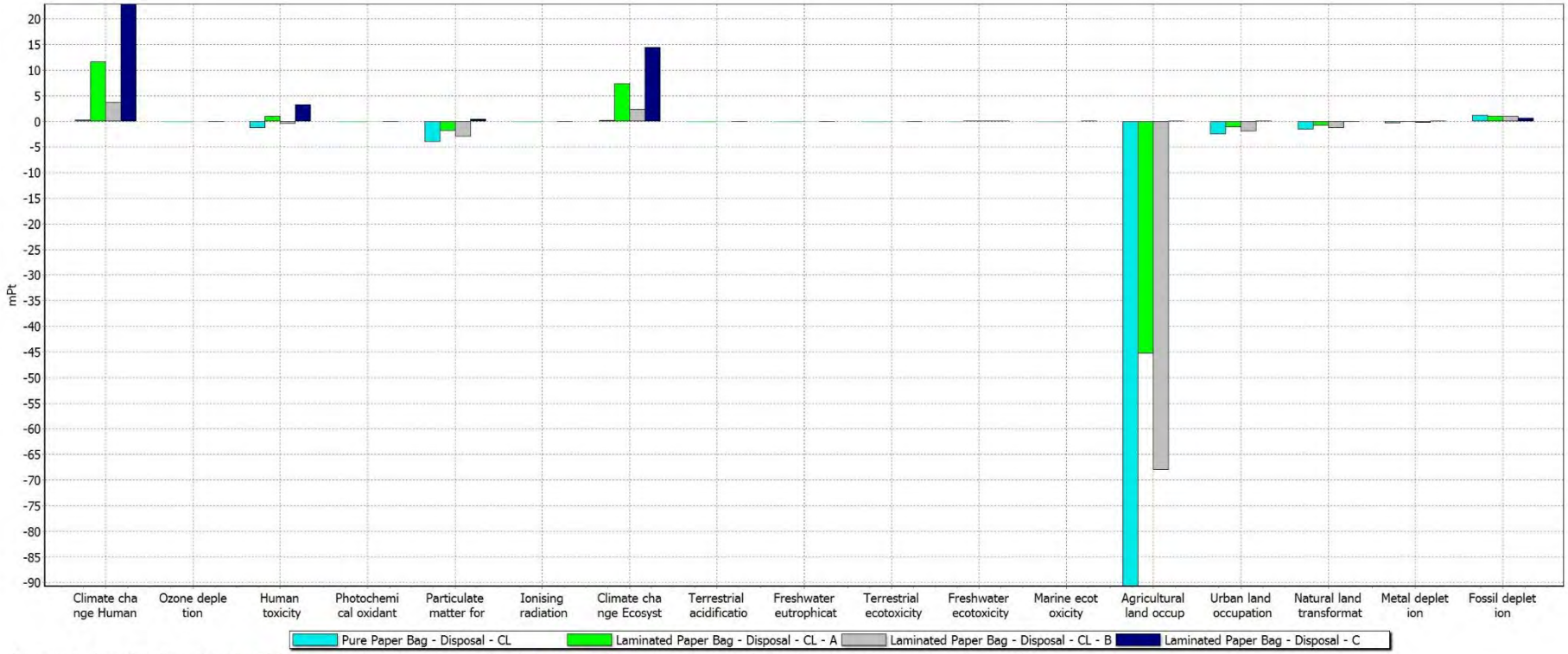
LCA – Paper Bags - Impact Assessment

- **Pure paper bag** shows the lowest environmental impacts in all categories, as 100% of the material is recycled.
- In **scenarios A** the level of recycling is 50% and in **scenario B** raise up to 75%.
- For all these scenarios the recycled fibres are used for replacing the cellulose pulp with a **quality factor of 75%.**
- Scenario C assumes no recycling at all – all the material goes to waste.
- The benefit of recycling is especially prevalent in agricultural land occupation impact category, which is directly linked to the feedstock material of pulp and paper production.

LCA – Paper Bags – Impact Assessment



Disposal only – Mid-Point Results



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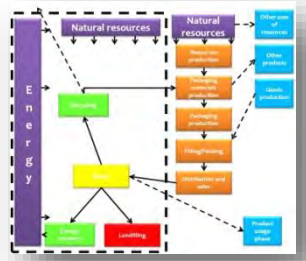
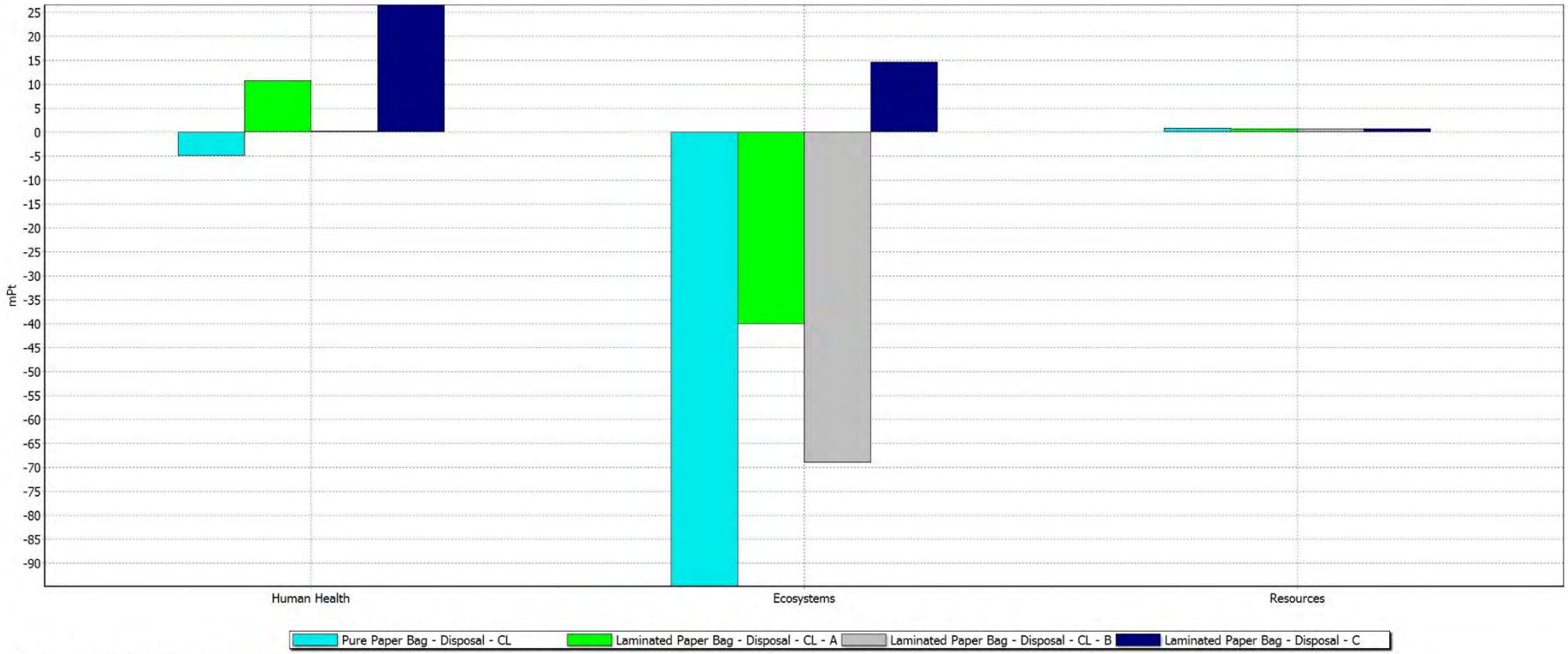
LCA – Paper Bags – Impact Assessment

Disposal only – End-Point Results





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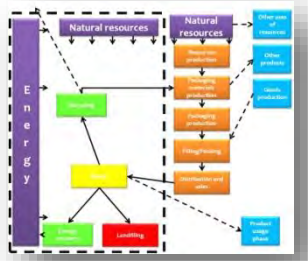
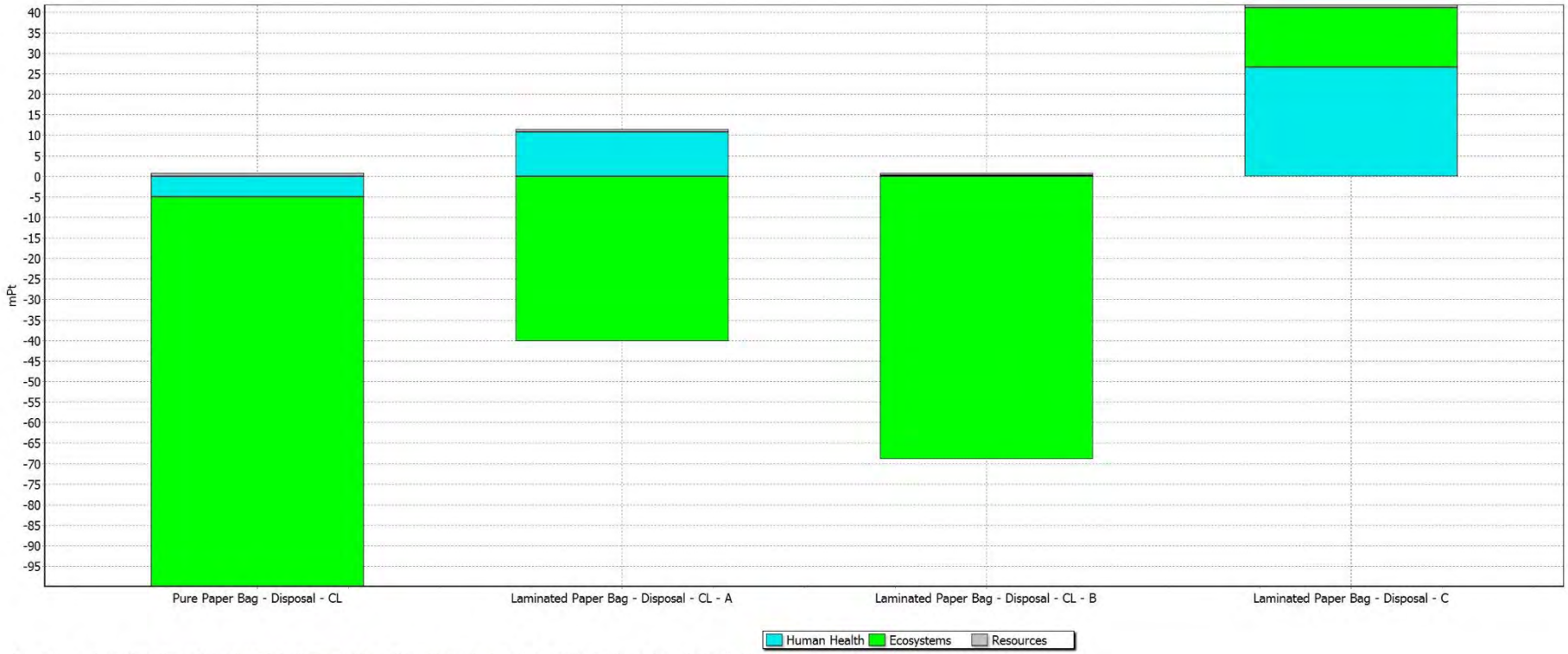


Disposal only – Single Score Results



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Method: ReCiPe Endpoint (H) V1.10 / Europe ReCiPe H/A / Single score

LCA – Paper Bags - Impact Assessment

- The impact of disposal scenario in the category of agricultural land occupation is negative for **pure paper bag** and **scenario A** and **B** of **laminated paper bag** due to recycling processes present, constituting an environmental benefit.
- This category in weighted presentation shows that recycling is most relevant and crucial process in the considerations of disposal scenario processes.
- **Laminated Paper Bag Scenario C** – as there is no recycling present – the impact of this category is zero. All impacts of **scenario C**, are related to landfilling of laminated paper bag.

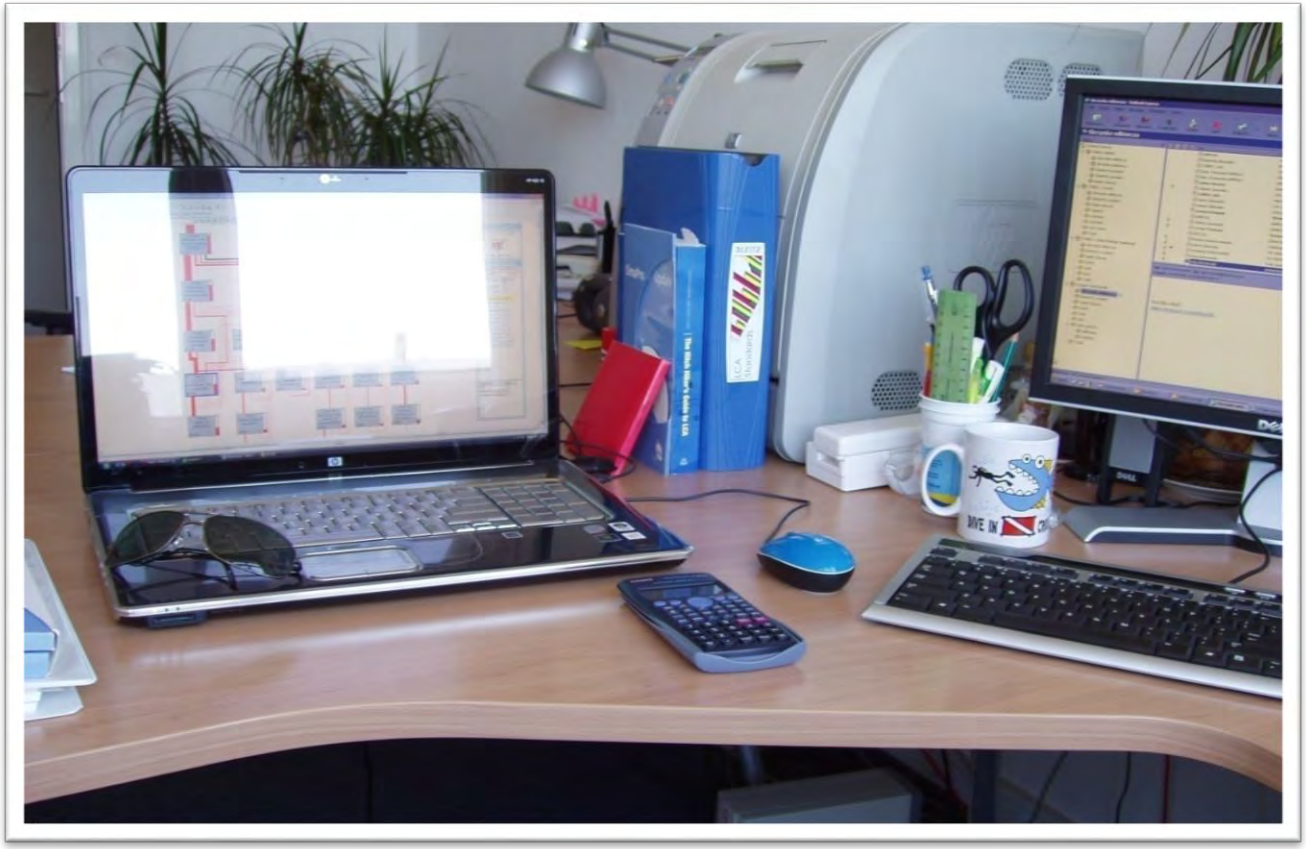
LCA – Paper Bags - Conclusions

- The main impact for the manufacturing of all bags is due to the **pulp and paper production** from virgin cellulose fibres.
- The polypropylene accounts for 27 % of the total weighted environmental costs for the **laminated paper bag**.
- the most important environmental advantage is the possibility of **recycling** the paper at the end of life in the **same production loop**, for producing the same paper grade used for the bag.
- This option enable to reduce the amount of virgin raw material pulp for the manufacturing of the bags, although taking into consideration a reducing **quality factor of 75%.**
- In the case of laminated **paper bag - Scenario C** , the lack of recycling make it necessary to supply all virgin fibres for the production and to dispose the product at the end of life.

LCA – Paper Bags - Conclusions

- The case of **pure paper bag** with complete recycling in the same paper cycle has the best behaviour in all impact categories.
- **Laminated paper bag – Scenario A** is worse than the **pure paper bag**, because of the impact of polypropylene and the low amount of recycling rate, 50% of the total bag mass.
- In **Scenario B** the results for most of the impact categories are better than **Scenario A.**
- The **Scenario C** is generally the worse one, especially for agricultural land occupation which is directly linked to the pulp feedstock supply.
- The determination of the most suitable **quality factor** value need further investigation in the future, taking into account new developments of the Product Environmental Footprint rules under discussion in the EU.

Thank you!!



LCA Workstation