Environmental evaluation of bio-composites using LCA

Comparison of two different applications

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Outline

1. Study background and previous work
2. Environmental evaluation of bio-composite applications
3. Results for two types of products
4. Conclusions and future work

Background I

- Södra's case for producing a bio-composite
  - Timber and market pulp are their biggest products
  - New application for wood fibre $\rightarrow$ Bio-composite of wood fibre (70%) and poly-lactic acid (PLA) (30%), *DuraPulp*
  - *DuraPulp* is commercially produced

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  - Decreased dependence on non-renewable fossil-based polymers with similar qualities
  - Minimization of non-degradable plastic waste
  - Reduction of fossil CO_2 emissions

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  - Carbon neutrality vs. climate neutrality
  - Land use and land use change

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- Challenges of using renewable resources[2]
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  - Land use and land use change
- Application of bio-composite $\rightarrow$ Long life span vs. short life span
  - Car door panel vs. packaging unit

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  - Polymer matrix $\rightarrow$ Poly-lactic acid[4], bio-polyethylene[5]

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  - Car door panel → Mass of the material (per functional unit), use phase[6]
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- Comparison of long vs. short life span applications are lacking
  - Different materials, same functional unit
  - How can the bio-composite best be applied?

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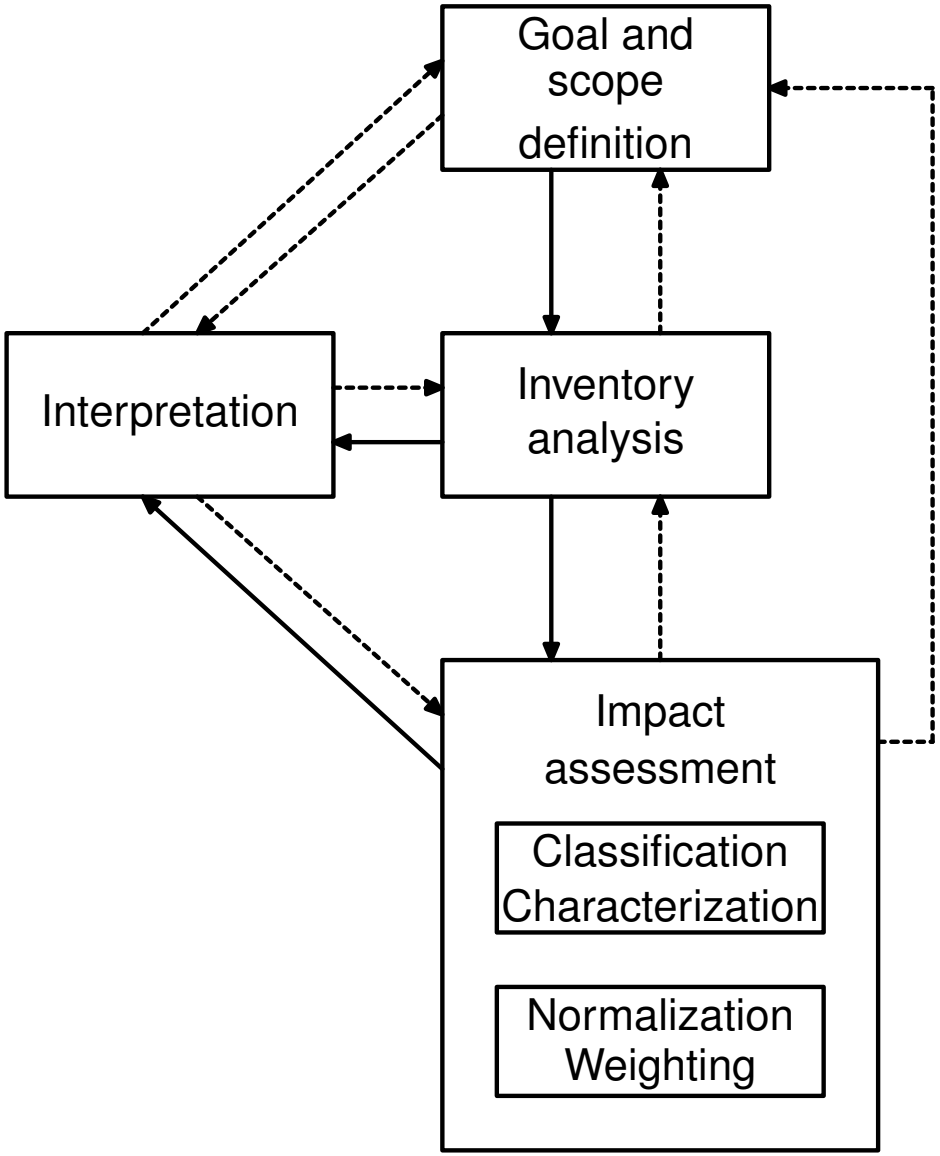
The LCA framework



Environmental loads e.g.
- MJ fossil energy
- g SO_2
- g NO_x
- kg waste

Environmental potential effects, e.g.
- resource depletion
- global warming potential
- acidification potential

Final assessment e.g.
- one-dimensional index

Goals of the study

- To compare bio-composites with bio-based polymer matrices and fossil-based polymer matrices
- To identify the main factors for the environmental impact
- To suggest methodological choices to enable the comparison of long life span products to short lifespan products

Scope of the study I

- Functional unit
  - Long life span $\rightarrow$ 1 car door panel
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  - 17 years for car door panel
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- Time span
  - 17 years for car door panel
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  - Normalization of reference flow in order to compare long lifespan to short lifespan
- Geographical system boundaries → Manufacturing (except for polymers), use phase and end of life assumed to take place in Sweden

Scope of the study II

- Data sources
  - Primary data from Södra, e.g. pulp production, DuraPulp production
  - ecoinvent database, e.g. polymer production, electricity mix
  - Literature sources, e.g. PLA production[8]

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- Impact categories
  - Global warming potential (GWP)
  - Eutrophication potential (EP)
  - Acidification potential (AP)
  - Photochemical ozone creation potential (POCP)
  - Depletion of abiotic resource potential (DAP)

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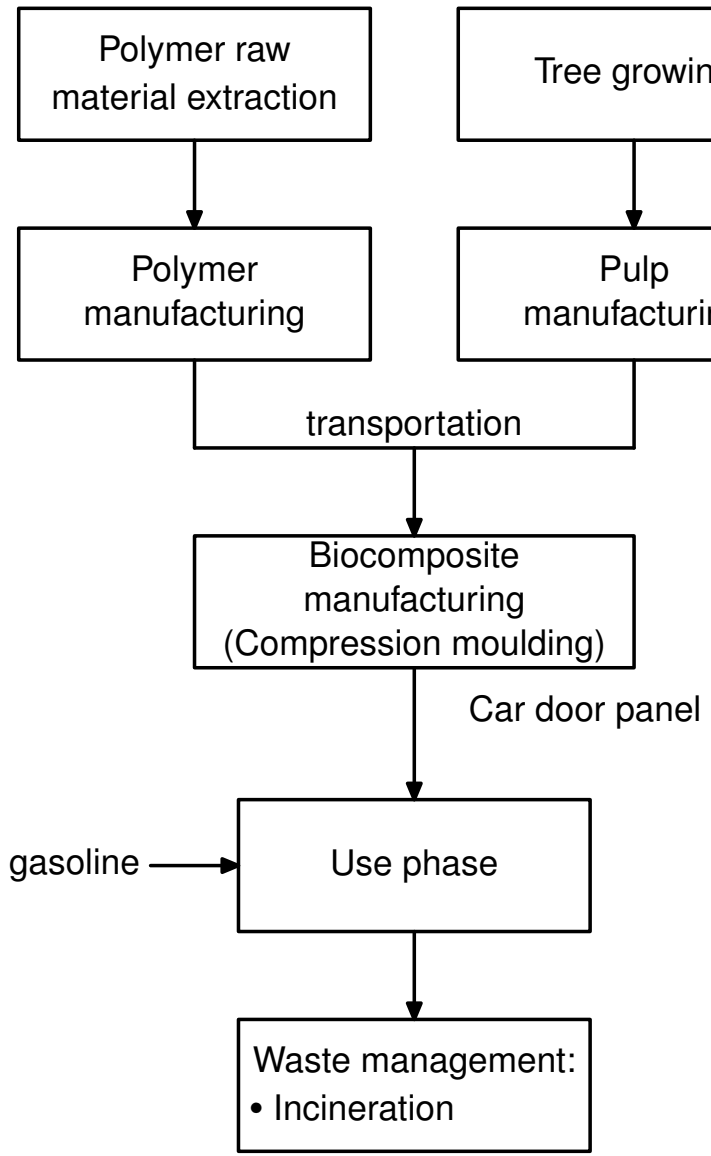
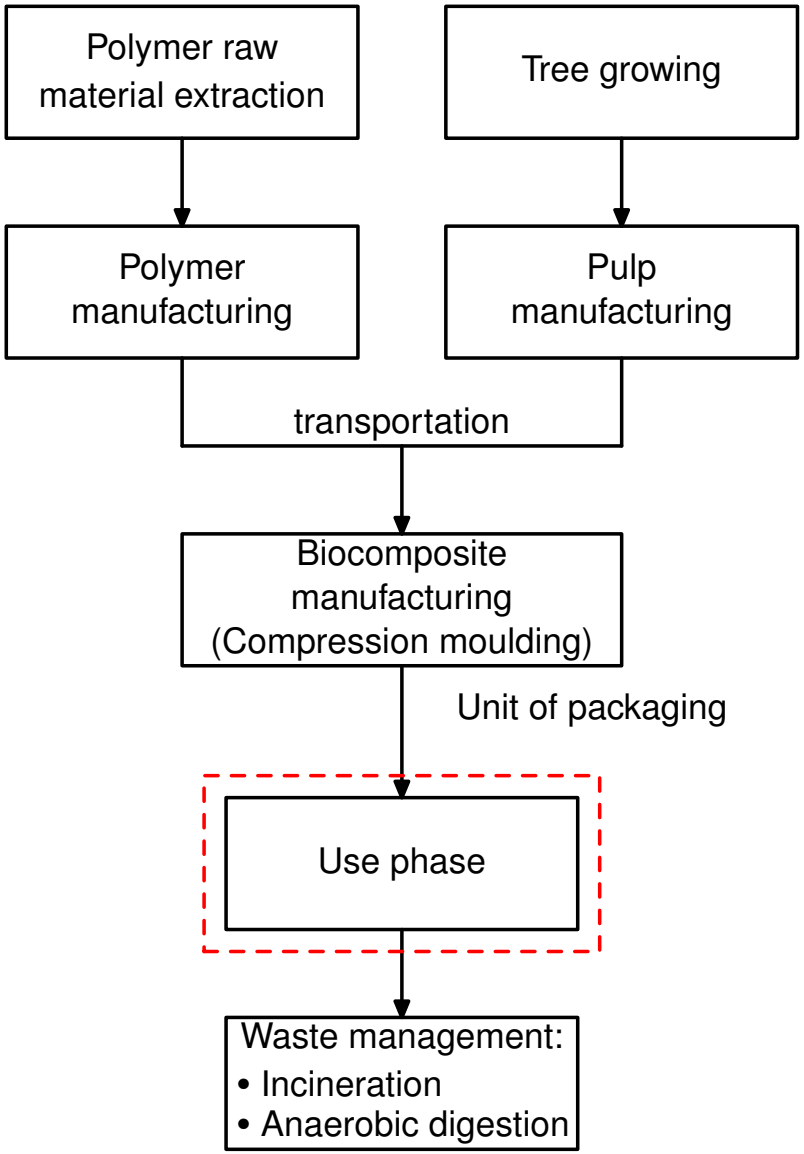
Flow chart of the car door panel life cycle



Flow chart of the packaging unit life cycle

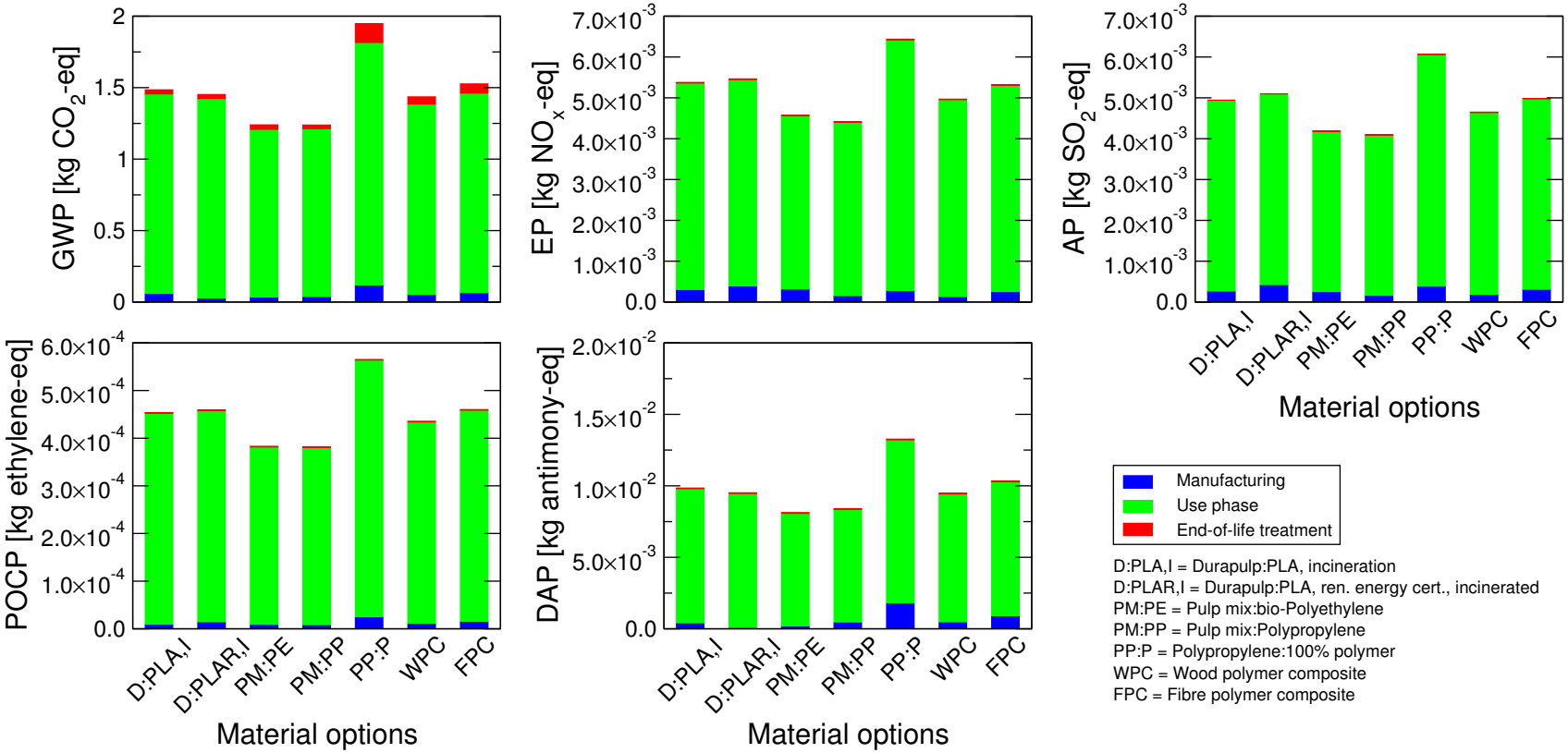


Results and sensitivity analysis

- Results for the car door panel life cycle
  - Reference case → Average European car
  - Changing the use phase → Electric car
  - Site location of the polymer manufacturing
- Results for the packaging unit life cycle
  - Reference case → No recycling
  - Change in waste collection rate
  - Site location of moulding the packaging units

Environmental impact of the car door panel

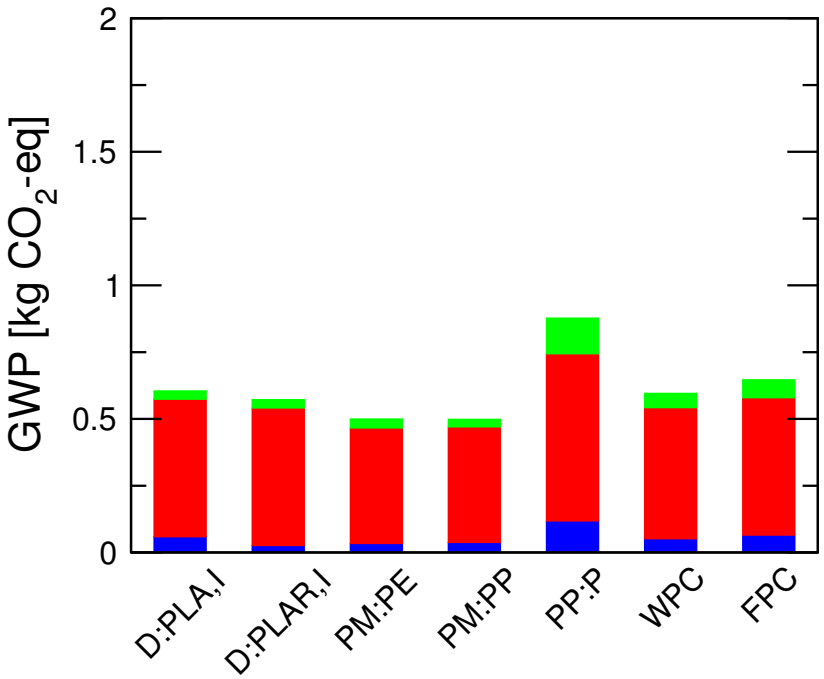
Reference case



- Use phase is by far the dominating life cycle phase
- Variations are due to the mass of the panel → Lower fuel use

Environmental impact of the car door panel

Changing the use phase



D:PLA,I = Durapulp:PLA, incineration
D:PLAR,I = Durapulp:PLA, ren. energy cert., incinerated
PM:PE = Pulp mix:bio-Polyethylene
PM:PP = Pulp mix:Polypropylene
PP:P = Polypropylene:100% polymer
WPC = Wood polymer composite
FPC = Fibre polymer composite

- The manufacturing phase has a larger share of the total life cycle impact
- Actor's perspective[9] $\rightarrow$ Consider Södra's sphere of influence

[9] B. Löfgren, A.-M. Tillman, and B. Rinde. *Journal of Cleaner Production* 19.17-18 (2011), pp. 2025–2033.

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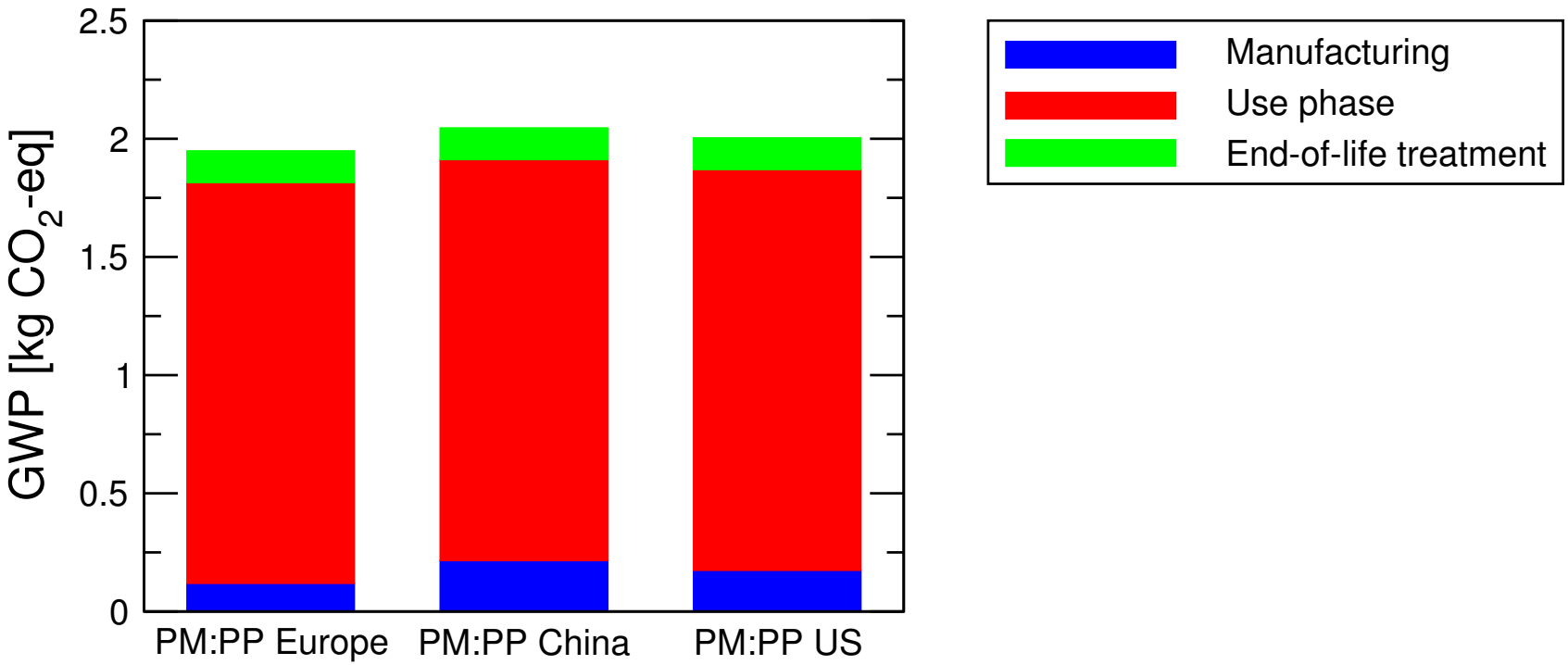
Site location of polypropylene manufacturing



- Location of polymer manufacturing does not have a large influence on the car door panel's total impact

Environmental impact of the car door panel

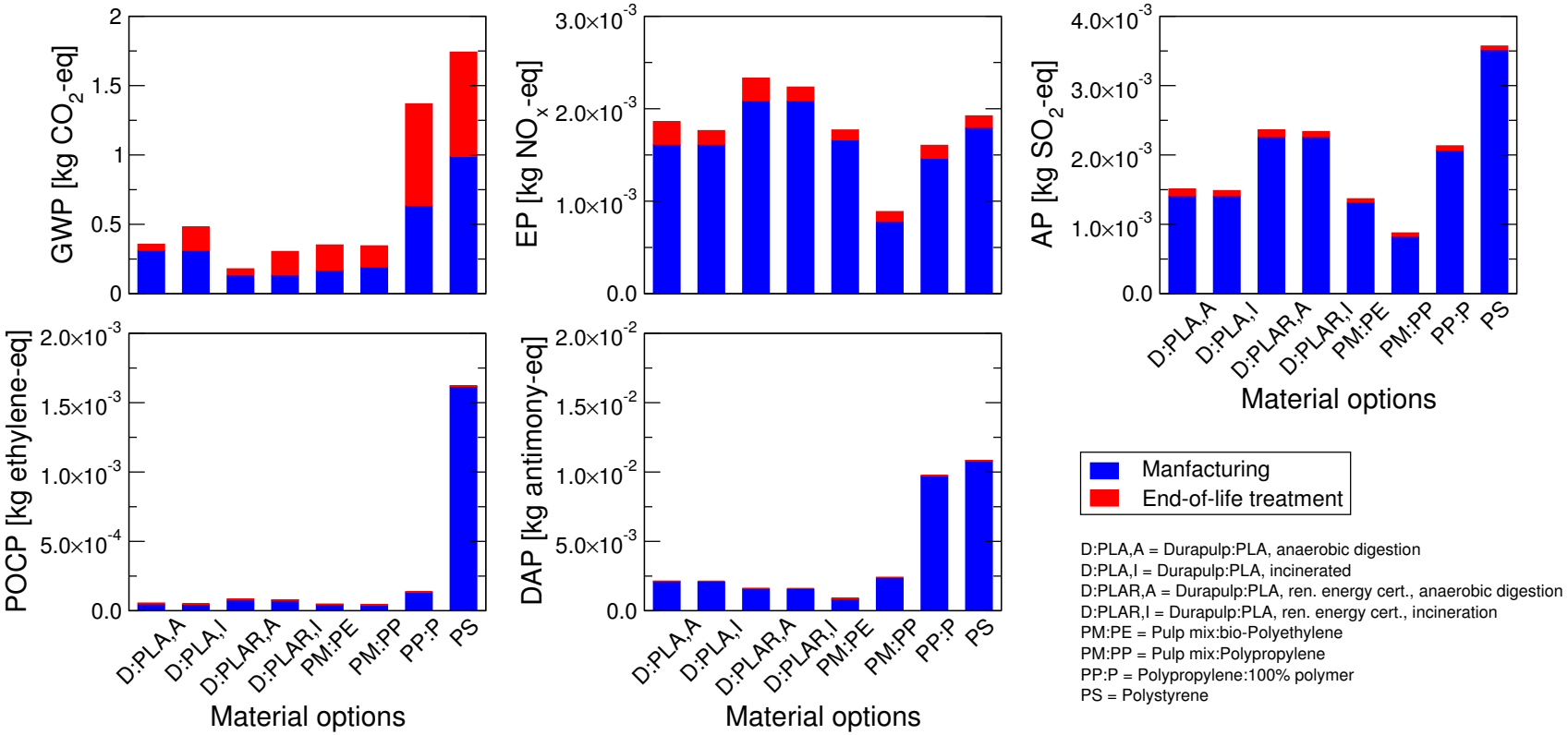
Conclusion

- The use phase has the largest influence and depends on the weight
- Changing the use phase to an electric car will decrease the environmental impact
- Manufacturing impact does not matter significantly from a conventional "products or services" perspective
- Currently, no reuse or recycling of car door panels
  - Non-metallic materials are shredded and landfilled or incinerated[10]

[10] C. Jensen et al. Tech. rep. Swedish Environmental Research Institute (IVL), 2012.

Environmental impact of the packaging unit

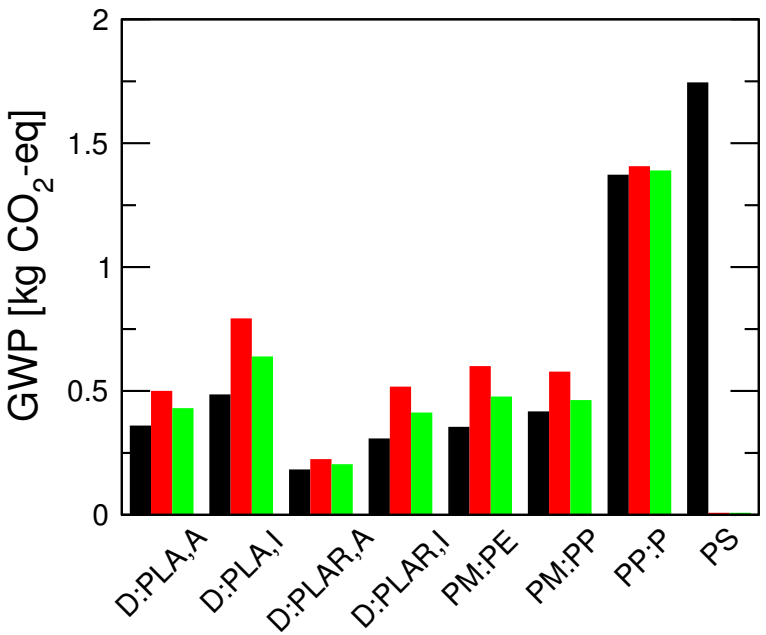
Reference case

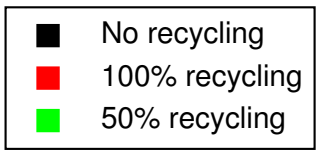


- Global warming potential is reduced when using pulp fibre
- Eutrophication potential is higher for the bio-composites due to fertilization

Environmental impact of the packaging unit

Change in waste collection rate





Number of uses:
- No recycling: 1
- 100% recycling: 11
- 50% recycling: 2

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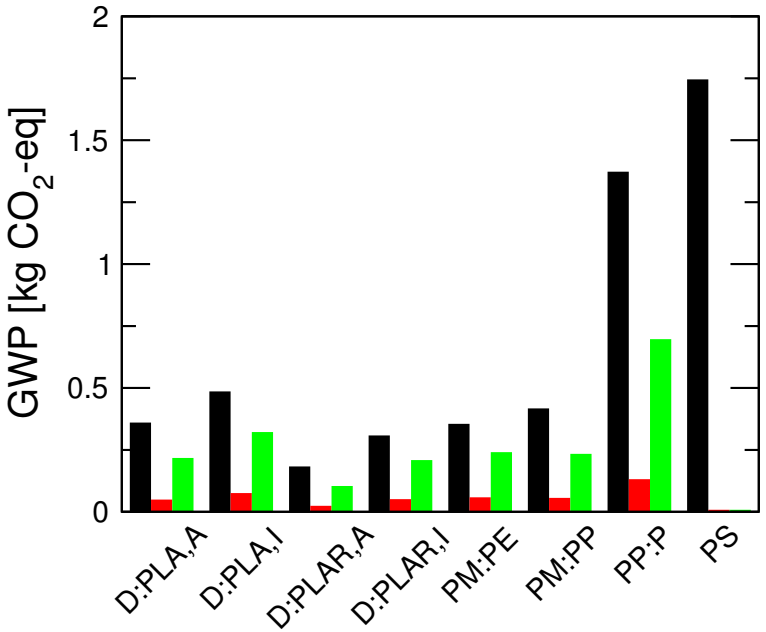

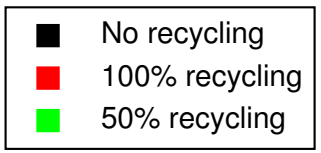

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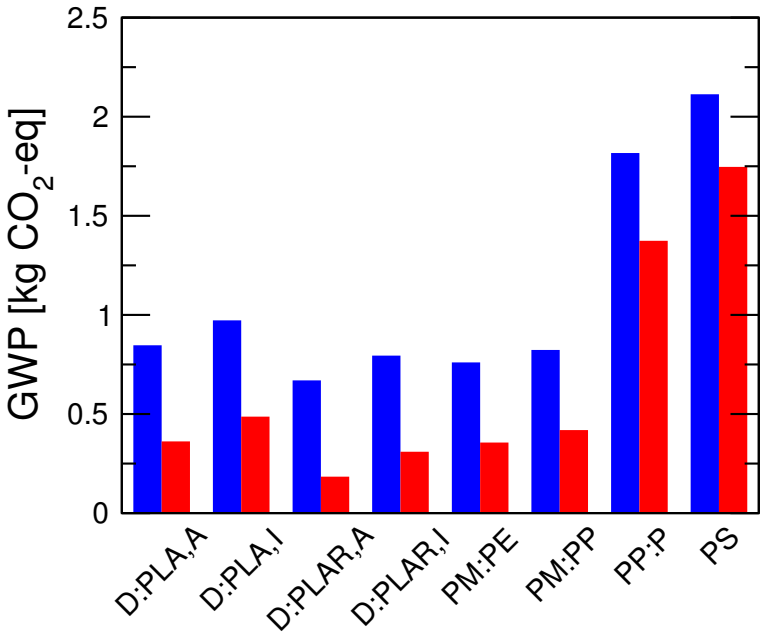

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- The moulding location influences the total life cycle Impact

Environmental impact of the packaging unit

Conclusion

- Waste collection and recycling has a positive influence life cycle impact of the packaging unit
  - Recycling decreases the environmental impact per use
  - In this particular case, the addition of virgin (fossil) polymer has a significant influence
- The choice of moulding site can have a large influence

Methodological choices

- The mass of the reference flow has been normalized with regards to life span
  - Higher need of material input for the short lifespan product
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- The mass of the reference flow has been normalized with regards to life span
  - Higher need of material input for the short lifespan product
  - Lower need of material input for the long lifespan product
- Results indicate that the preferable application for DuraPulp is the short lifespan product

Impact category	Car Door panel	Packaging unit
GWP	1.31	2.84
EP	1.20	0.91
AP	1.23	1.44
POCP	1.25	2.84
DAP	1.35	4.56

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- Findings suggest that DuraPulp is preferred in a short lifespan application
- The car door panel life cycle is dominated by the use phase due to the difference in density between the materials
  - Change the use phase
  - Change the polymer
- The packaging unit's impact depends mostly on the choice of polymer and location of manufacturing
  - Choose a "clean" electricity mix for manufacturing
  - Higher waste collection rate leads to a higher input of polymer
  - If the material is recycled once, it needs to be continued to be recycled for it to be a reasonable alternative

Future work

- Methodological
  - To investigate how large-scale bio-polymer production affects land use and carbon balance
  - To investigate how outcomes of an actor-based LCA may affect decisions
  - To investigate further how to compare products with different life spans under recycling scenarios

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  - To investigate further how to compare products with different life spans under recycling scenarios
- Practical
  - To investigate the recycling processes and connected impacts more closely
  - To investigate what happens when the expected lifespan changes

THANK YOU

Any questions?