New composite products from plastics and fiber waste
Environmental imapacts of a composite pallet

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CIRCWASTE – South-Karelia

- LUT University project
  - Planning for re-materialization: Developing composite fibre products and processing machinery for municipal, industrial and C&D waste fractions
  - Validation of the sustainability of the re-materialization process as a part of the integrated waste management and recovery system
- Wimao Oy project
  - Implementation of re-materialization – Building a pilot plant for waste fraction composite manufacturing
- Lappeenranta city project
  - Coordinating regional co-operation

Waste to fiber-plastics composites

- Fiber-plastics composites
  - Often waste based materials containing fibers and plastics
  - Fiber waste: wood, rock wool, glass wool, cardboard, textiles
  - Plastic waste
  - Demands for material purity not as high as in mono-material recycling

➢ Possibility to recycle e.g. rejects of source separated materials or lower quality mechanically separated materials

➢ Suitable for a number of products

  ➢ Automotive, construction, packing, transport and electrotechnical industry

  ➢ Almost limitless applications, only large-scale 3D products are challenging

➢ Can replace products and components that are made of plastic, metal, glass fibre and wood, and even of rock and concrete

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LUT research on fiber-plastics composites

- Research of materials and composite recipes
    - Fiber Composite research group led by prof. Timo Kärki
- Manufacturing methods for the composite products
    - research group of Production Engineering and Sheet Metal Work Technology led by prof. Juha Varis
- Environmental impacts of the composites (LCA)
    - research group of Waste Management Technology led by prof. Mika Horttanainen
- Chemical engineering research groups involved e.g. in material and product analysis

Wimao Oy: Fiber-plastics composite products from construction and demolition waste

- CIRCWASTE –financing for demonstration plant in Lappeenranta
- The first commercial product is the pallet manufactured of recycled composite material

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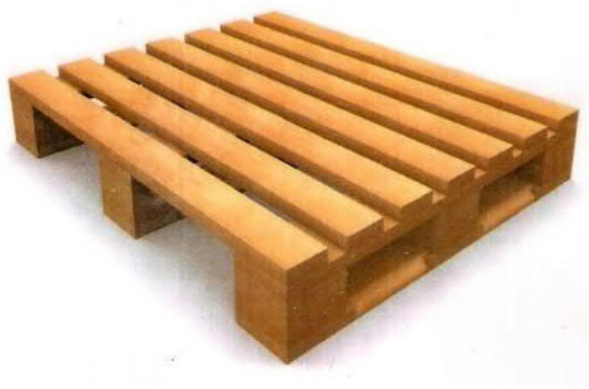
Pallets for logistics

- Globally very widely used in logistics – billions of pallets all the time in use
- Types
  - wooden pallet,
  - plastic pallet,
  - *fibre-plastic composite pallet*



LCA comparison of the environmental impacts of wood-plastics composite pallet to wooden and plastics pallets

Research question

1. What are the environmental impacts of WPC pallets produced from construction and demolition waste (CDW) compared to the wooden pallets and plastic pallets?

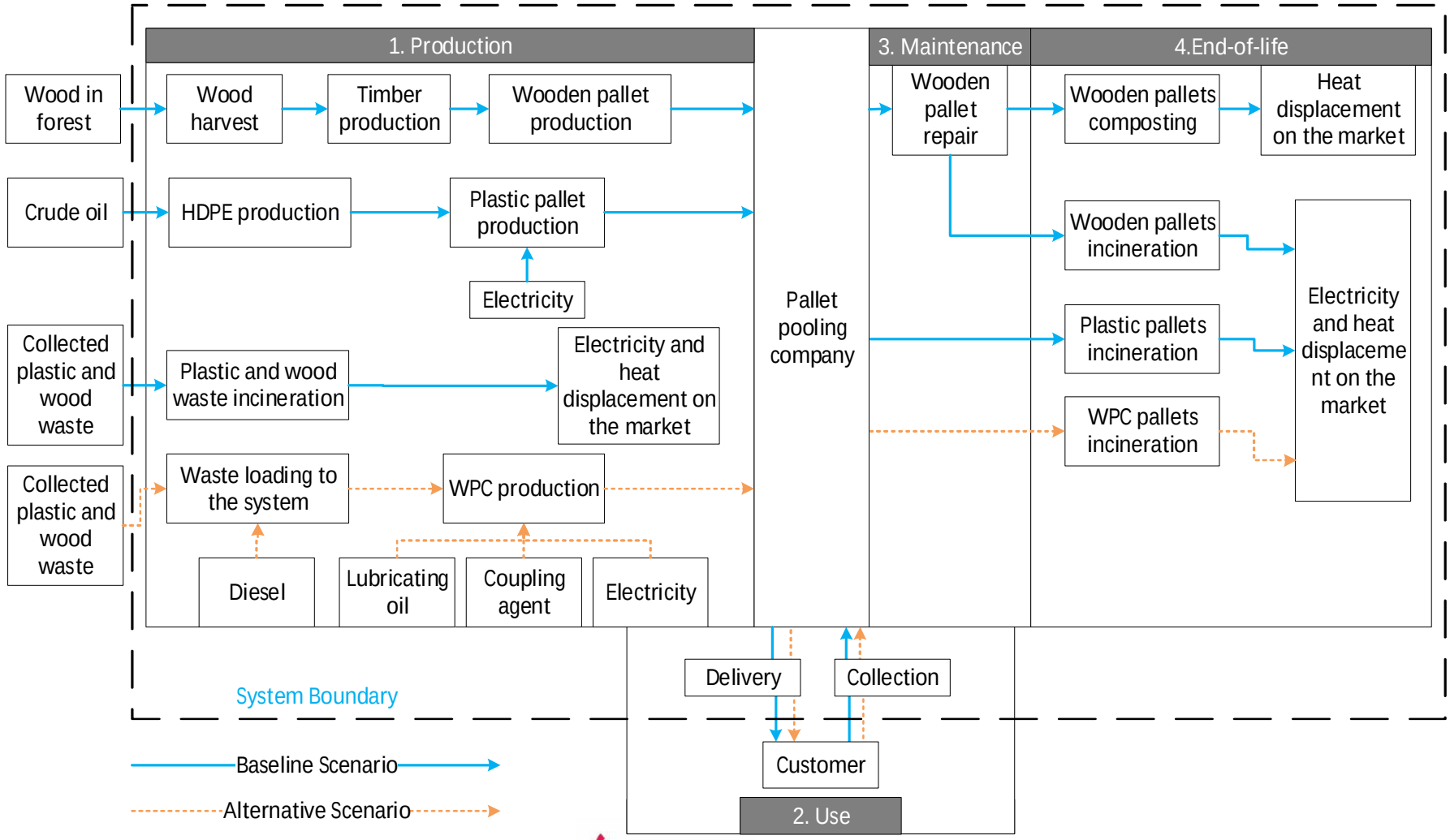
LCA Considerations

	Wooden pallet	Plastic pallet	WPC pallet
Material	Virgin wood	Virgin plastic	Waste wood and plastic composite
Dimensions (mm)	1200 x 800 x 144	1200 x 800 x 144	1200 x 800 x 144
Weight (kg)	21.8	20	14.8
Repair	Every 7 cycles	Not possible	Not possible
Expected lifetime (cycles)	20	66	66
End of life	90% incineration+10% material recovery	100% incineration	100% incineration

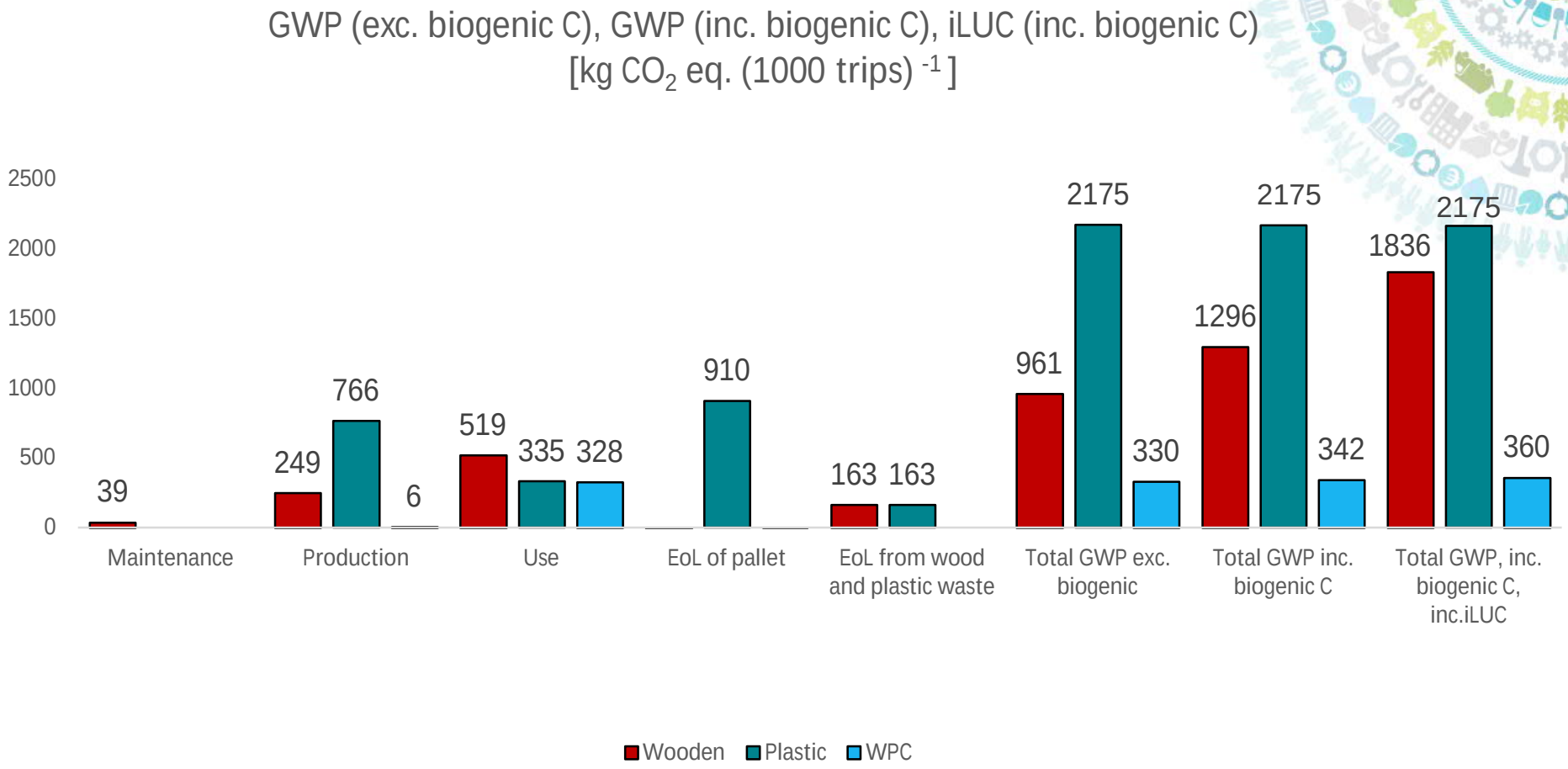
LCA method

- Cradle to grave
- FU: 1000 trips
- End-of-life 0:100 with credit system
- GaBi 8.6.0.20
- CML 2001-Jan.2016
- Consequential LCA (CLCA)

System Boundary for CLCA



Results


GWP (exc. biogenic C), GWP (inc. biogenic C), iLUC (inc. biogenic C)
[kg CO_2 eq. (1000 trips) $^{-1}$]
2500
2000
1500
1000
500
0
39
249
766
6
519
335
328
910
163
163
961
2175
330
1296
2175
342
1836
2175
360
Maintenance
Production
Use
EoL of pallet
EoL from wood and plastic waste
Total GWP exc. biogenic
Total GWP inc. biogenic C
Total GWP, inc. biogenic C, inc.iLUC
Wooden
Plastic
WPC

Summary

- Composite pallet has lowest climate impact
- Energy recovery assumption in the end of life of the pallet is important factor
  - Assumption: Substituting marginal energy (wind and solar power + biomass heat)
  - Recycling of pallets would reduce especially the impact of WPC and plastic pallet
    - WPC pallet recycling is possible but there is no recycling system for composites
- Pallet lifetime (number of usage times) has importance
  - Significant uncertainty
- Weight of the pallet quite important

LUT publications related to environmental impacts of composites

- Khan M., Deviatkin I., Havukainen J., Horttanainen M., **Environmental Impacts of Wooden, Plastic, and Wood-polymer Composite Pallet: A Life Cycle Assessment** Approach. *International Journal of Life Cycle Assessment, 2021.* https://doi.org/10.1007/s11367-021-01953-7
- Khan M., ***Environmental Impacts of the Utilisation of Challenging Plastic-Containing Waste***. Dissertation thesis. LUT University, 2022.
- Sormunen P., Deviatkin I., Kärki T., Horttanainen M., An Evaluation of Thermoplastic Composite Fillers Derived form Construction and Demolition Waste Based on Their Economic and Environmental Characteristics. *Journal of Cleaner production*, Volume 280, Part 2, 20 January 2021.
- Deviatkin I., Khan M., Ernst E., Horttanainen M., Wooden and plastic pallets: A review of life cycle assessment (LCA) studies. *Sustainability 2019, 11(20),* 2019.
- Deviatkin I., Horttanainen M., Carbon footprint of an EUR-sized wooden and a plastic pallet. ICEPP 2019*. E3S Web of Conferences 158*, 03001 (2020).
- Liikanen, M., Grönman K., Deviatkin I., Havukainen J., Hyvärinen M., Kärki J., Varis J., Soukka, Horttanainen M., Construction and demolition waste as a raw material for wood pol-ymer composites – assessment of environmental impacts. *Journal of Cleaner Production*, Vol. 225, 10 July 2019, Pages 716-727.


Thank you
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