A Life Cycle Assessment of Particle Board: UF vs. MDI as the Binding Agent

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Background

Particle board is widely used as a building material component and in furniture, as its durability, strength and cost make it desirable for many applications. Particle board is made primarily by pressing wood chips or sawdust together with a binding agent to keep the wood particles together. The widely used conventional binding agent is Urea Formaldehyde (UF). The use of other substances as binding agent, such as 4, 4'-diphenylmethane diisocyanate (MDI), can have lower impacts to the environment. This study uses the Life Cycle Assessment (LCA) methodology to compare potential environmental impacts associated with particle board manufactured using UF versus MDI binding agents.

(Photo source: images.google.com)

Figure 1. Samples of Particle Board and Application

Goal and Scope

- System Boundaries: Cradle-to-Gate includes extraction and manufacture of raw materials, manufacture of particle board and transportation within those phases.
- Functional Unit: an industry-standard size of particle board, 1000 square feet by ¾ inches. The density of this board is assumed to be 746 *kg/m*↑3 [1], or 46.6 *lb/ft*↑3 .
- Particle Board Composition (weight %):

  UF board: 9.2% resin (65% solids), 90% wood and 0.8% others for compound

  MDI board: 3% resin, 97% wood and trace amount of other compounds

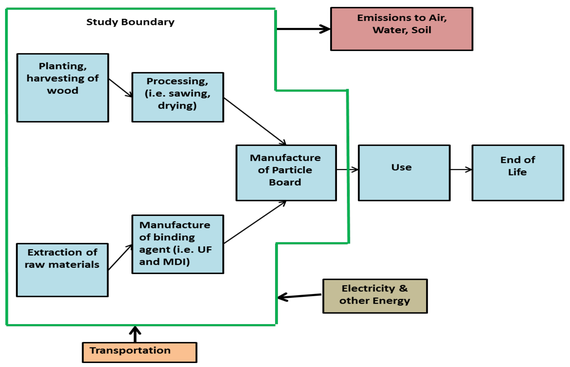

Figure 2. System boundary of the particle board LCA

- Software: Excel for modeling the overall system. Gabi 5 Life Cycle Inventory database for energy sources and transportation.

Life Cycle Inventory Analysis

Cut-off criteria

Exclusion: A flow contributes to less than 1% of the total cumulative mass/energy. The sum of the neglected material flows may not exceed 5% of mass, energy or environmental relevance.

Key Parameters and Assumptions

Table 1. Key parameters and assumptions

Key Parameters/Assumptions	Value	References
Density of board	746 kg/m^3	[1]
Resin used (UF)	202 kg (131 kg solid)	Calculated
Resin used (polymeric MDI)	43.8 kg	[1]
Wood content (UF board)	1,286 kg	Calculated
Wood content (MDI board)	1,374 kg	Calculated
Moisture Content (MC)	100%	[2]
Woodchips/sawdust entering PB plant	25.7%	[2]
Final board moisture content	4%	[1]
Total Sand-off in the PB manufacturing process	0.06 inch	Critical Review Panel
UF furnish moisture content before heat press	4%	Critical Review Panel
MDI furnish moisture content before heat press	9%	Critical Review Panel

Table 2. Life Cycle Inventory Data Sources

Key Processes	Data Source
Urea Formaldehyde (65% solids)	[3]
MDI resin	[4]
Tree planting and harvesting	[5]
Lumber sawing process	[2]
Drying and Processing at PB plant	[1]
Transportation distances	[6]

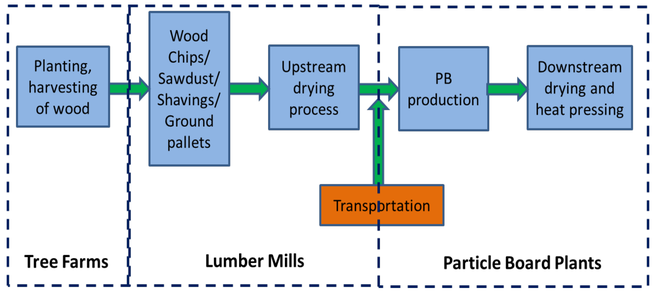

Figure 3. Modeling details of wood related processes and particle board manufacture

Impact Assessment Results

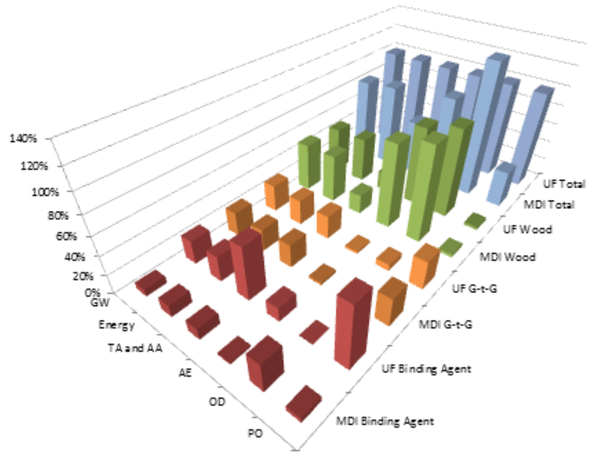

Figure 4. Relative environmental impacts by life cycle stages (UF vs. MDI, UF PB total as the baseline)

Wood materials contribute the most to GW, Energy, AE and OD in both types of board. Binding agent contributes the most to TA/AA and PO in UF board while the gate-to-gate PB manufacturing process contributes the most for these two categories in MDI board, which indicates the relative lower impacts of using MDI compared to UF as the binding agent.

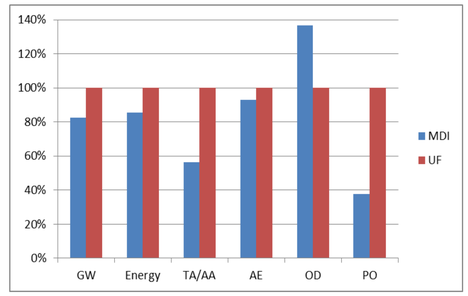

Figure 6. Total relative impacts (MDI vs. UF)

Sensitivity Analysis and Conclusions

$$Moisture\ Content\ (MC) = Mass\ of\ water\ in\ wood / Mass\ of\ Dry\ wood \times 100\%$$

MC in green wood is one of the major variables since it determines the amount of energy needed to dry green wood to 25.7% MC before going into the PB manufacturing plant. Figure 5 shows the impact of green wood MC to the final results. The higher the initial MC, the higher environmental impacts occur. MDI PB is more sensitive due to the relative lower total environmental impacts except OD compared to UF PB. Figure 6 shows the MDI PB has lower impacts per functional unit than UF board except OD which is due to the lack of data in the UF resin LCI study [3].

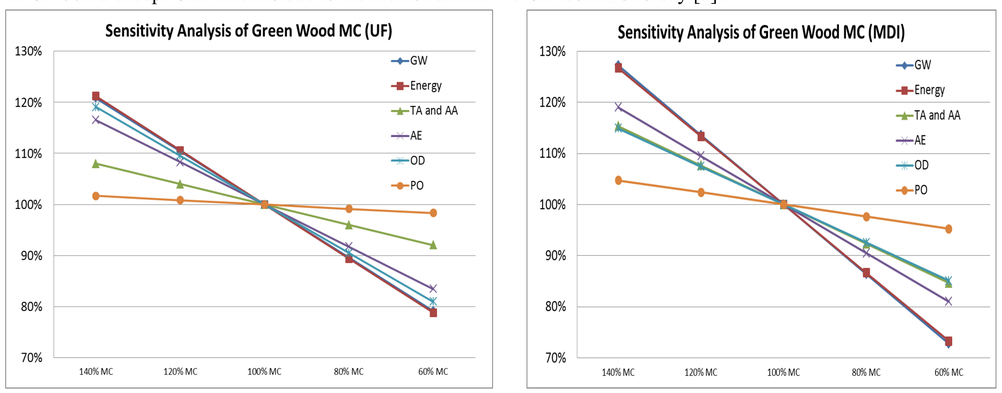

Figure 5. Sensitivity analysis of moisture content in green wood. Left: UF PB, Right: MDI PB

Critical Review

This report has passed an external critical review by three LCA and industrial experts. The critical review summary concluded this work was conducted per ISO14040/14044 standard.

References

1. Wilson, J. B. (2008). Module F, Particleboard: A Life-Cycle Inventory of Manufacturing Panels from Resource through Product. CORRIM: Phase II Final Report.
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3. Wilson, J. B. (2010a). "Life-Cycle Inventory of Formaldehyde-Based Resins Used in Wood Composites in Terms of Resources, Emissions, Energy and Carbon." Wood and Fiber Science **42**(0): 125-143.
4. American Chemistry Council (2010). Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors. F. Associates. Prairie Village, KS.
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