Life Cycle Assessment of Particle Board

Urea Formaldehyde vs. MDI as the binding agent

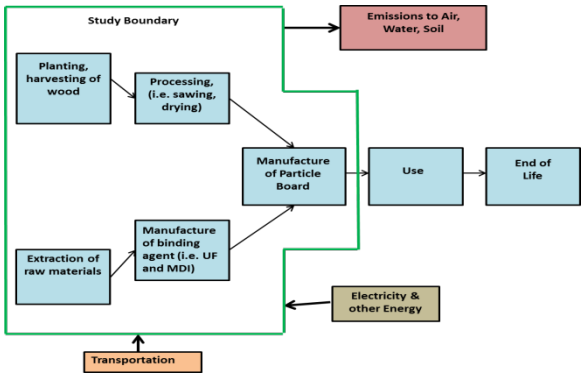
(White Paper)

1. Introduction

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.

2. Goal and Scope

- **System Boundaries:** Cradle-to-Gate includes extraction and manufacture of raw materials, manufacture of particle board and transportation within those phases.



System boundary of the particle board

- **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 $\frac{kg}{m^3}$ [1], or 46.6 $\frac{lb}{ft^3}$.

- **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

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

3. 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.

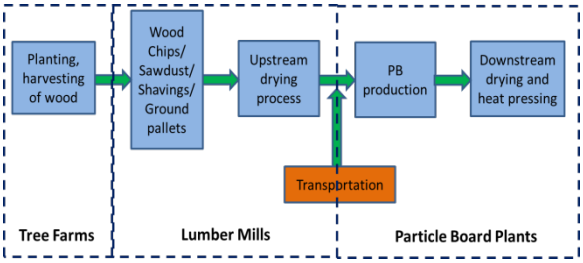
- **Key Parameters and Assumptions:**

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

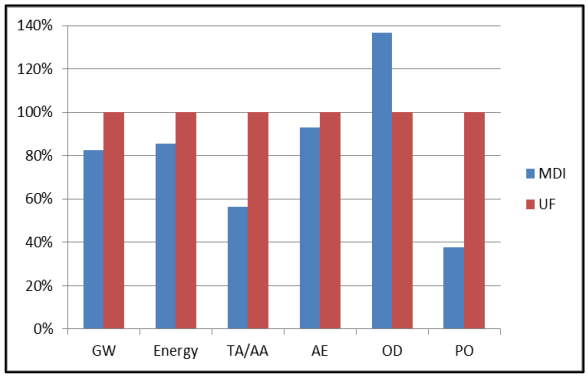
- **Life Cycle Inventory Data Sources:**

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]

- **Modeling Details of Wood Related Processes and Particle Board Manufacture:**



4. Impact Assessment Results



The overall impact assessment results show that UF has higher impacts for all categories except Ozone Depletion. However, since the UF LCI cited in this study does not report any ozone depletion substances, the ozone depletion impact of UF particle board might be underestimated. For example, the Climate Change (sometimes called Global Warming) impact of particle board made using MDI binder is about 82.6% of the impact of particle board made with UF binder.

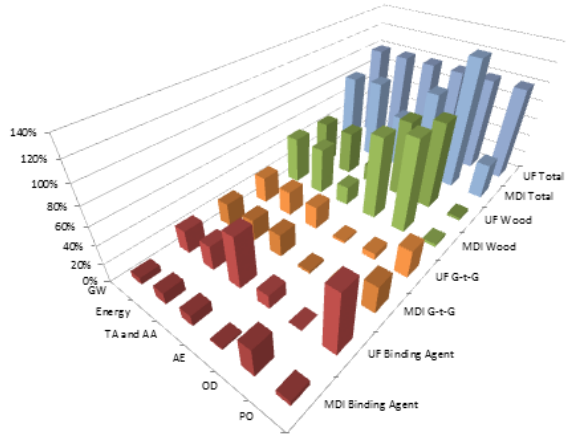
Life Cycle Assessment of Particle Board

Urea Formaldehyde vs. MDI as the binding agent

(White Paper)

Impact Category (Units)	UF Particle Board	MDI Particle Board	Relative Impacts (MDI vs. UF)
Global Warming (kg CO_2e)	1,267	1046	82.6%
Life Cycle Energy (MJ)	22,285	19078	85.6%
Terrestrial & Aquatic Acidification (kg SO_2-e)	27.74	15.59	56.2%
Aquatic Eutrophication (kg PO_4-e)	0.80	0.75	92.9%
Ozone Depletion (kg CFC-11-e)	$1.01x10^{-4}$	$1.38 x10^{-4}$	136.8%
Photochemical Oxidation (kg C_2H_4-e)	0.92	0.35	37.8%

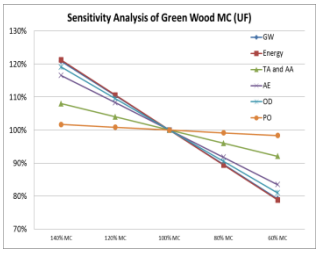
The figure below shows the environmental impacts by life cycle stages. Wood materials contribute the most to GW, Energy, AE and OD in both types of board. Binding agent contributes the most to TA/AA and PO in UF board while the gate-to-gate PB manufacturing process contributes the most for these two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

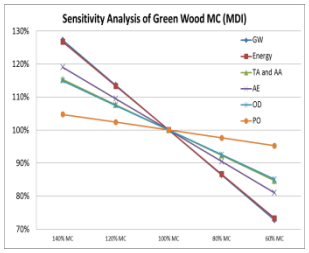


5. Sensitivity Analysis

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

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. Figures below show 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.





6. Conclusions

The life cycle impact assessment results show that particle board with UF has greater environmental impacts versus MDI particle board, except for OD. However, further studies need to be done in order to correct/confirm the inventory for ODSs in UF resin manufacturing.

7. 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.
2. Milota, M., C. West, et al. (2005). "Gate-to-Gate Life-Cycle Inventory of Softwood Lumber Production." Wood and Fiber Science **37**(0): 47-57.
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.
5. Puettmann, M., R. Begman, et al. (2010). "Cradle-to-Gate Life-Cycle Inventory of US Wood Products Production: CORRIM Phase I and Phase II Products." Wood and Fiber Science **42**(CORRIM Special Issue): 15-28.
6. Wilson, J. (2010b). "Life-Cycle Inventory of Particleboard in Terms of Resources, Emissions, Energy and Carbon." Wood and Fiber Science **42**(CORRIM Special Issue): 27.