Corrugated Packaging Alliance

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# The “Typical Box” LCA Study for Box Makers

## Background, Results, Implications

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March 31, 2009

# Why a Life Cycle Assessment for Corrugated Boxes?

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- Marketplace demands and expectations
  - Wal-Mart Packaging Scorecard
  - Customer needs and inquiries
  - Competing package concepts (e.g., RPCs)
- Packaging now must do more than meet the specs
  - Carbon footprint
  - Recycled content
- Future success will require making and documenting environmental improvements
  - This study will establish a baseline against which progress can be measured
- Corrugated packaging has a great story to tell
  - High recycling rates, high recycled content, integrated material supply, renewable basic raw material

# Key Facts About this Study

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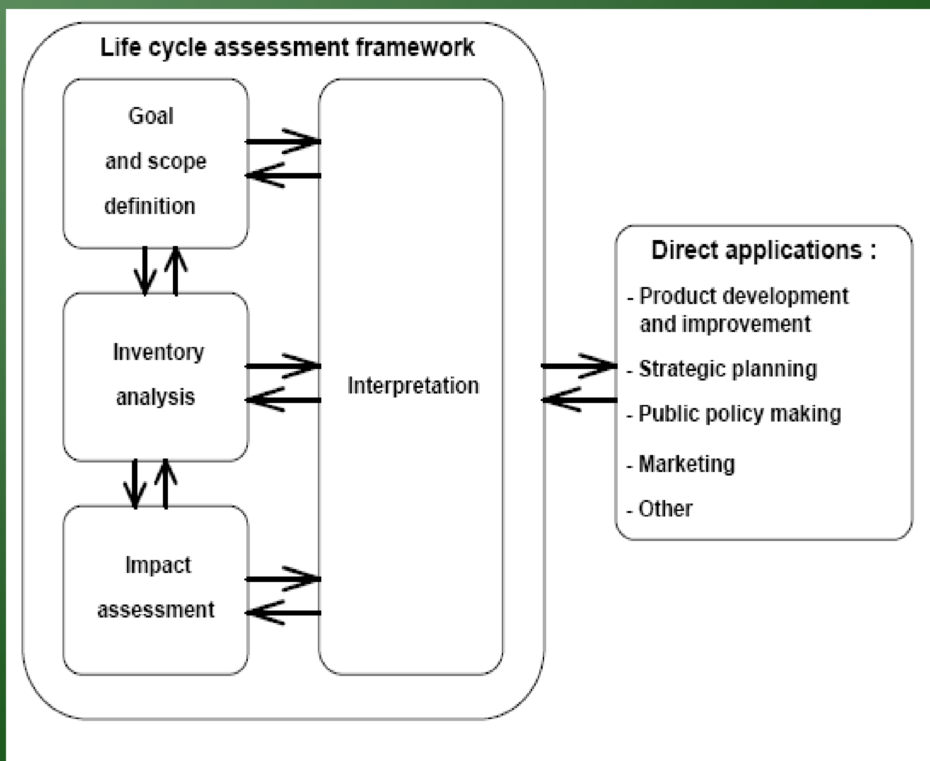
- Industry-wide, covering 56 mills or 95% of containerboard and 162 box and other converting operations or 45% of 2006 production
- Nearly 2 years in the making
- Much of input data from industry surveys, not plant level data collection
- Well recognized and experienced LCA practitioners (Five Winds International)
- Excellent peer review panel

# What is Life Cycle Assessment?




***How LCA can be used:***

- Benchmarking
- Continuous improvement
- Product development
- Comparative assertions
- Product messaging
- Customer inquiry

# Life Cycle Inventory Analysis

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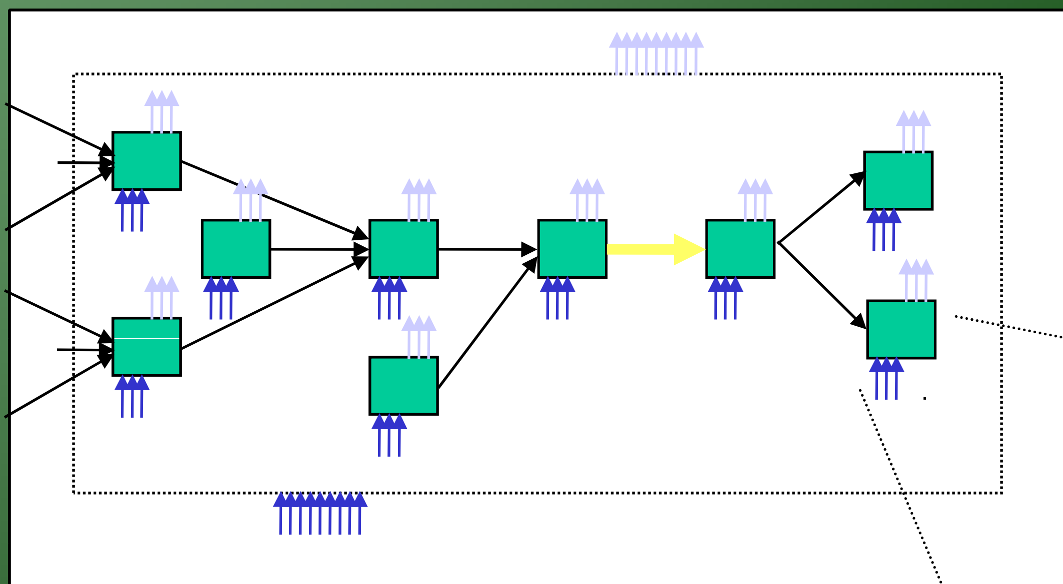

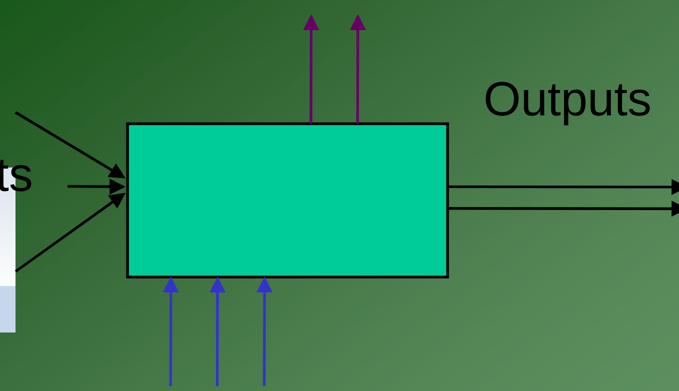


NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

ecoinvent
Swiss Centre for Life Cycle Inventories

# Goal and Scope of Study

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- **Goal is to conduct a Life Cycle Assessment (LCA) for an industry average corrugated box**
  - **to better understand its environmental performance across all life cycle stages**
  - **promote continuous environmental improvement of corrugated packaging products**
  - **respond to customer and public demands for environmental information**
- **The scope of the study is a "cradle-to-grave" life cycle assessment for the U.S. industry's average corrugated product**

# Summary of System Boundaries



| Included | Excluded |
|---|---|
| Raw materials and ancillary inputs; E.g. wood and paper pulp; pulping and bleaching chemicals | Capital equipment and maintenance |
| Energy; E.g. extraction, processing and transportation fuels; purchased electricity | Maintenance and operation of support equipment |
| Processing of materials | Transportation of employees |
| Operation of primary production equipment | |
| Waste | |
| Packaging of products | |
| Transportation of raw and ancillary materials | |
| Overhead (heating, lighting) of manufacturing facilities | |
| Internal transportation of materials | |
| Post use processes [transportation, sorting, baling, etc.] | |

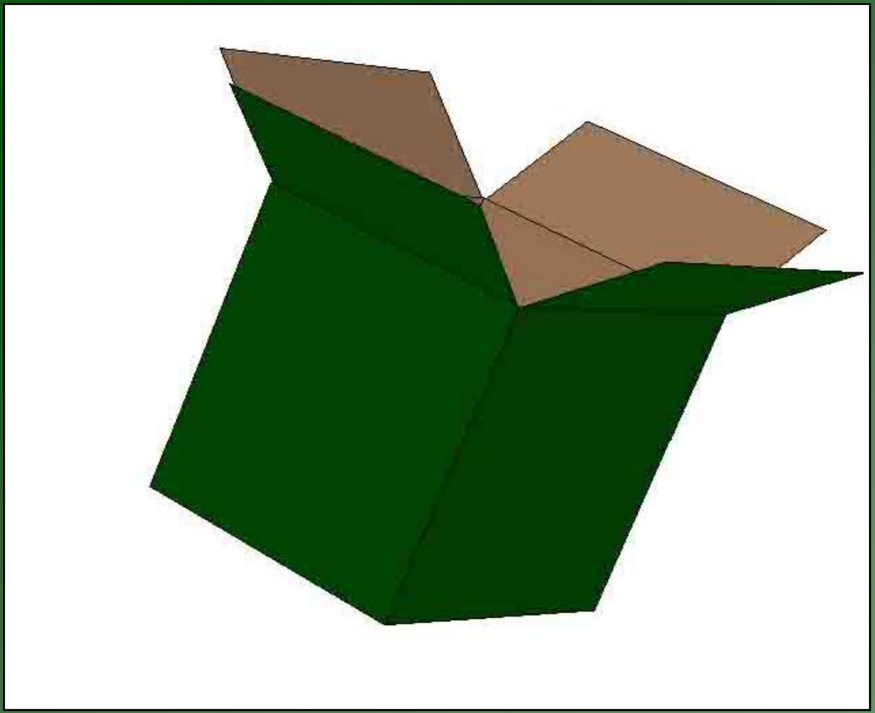
# Functional Unit Concept

- A functional unit is the basis of comparison of different products or processes
  - It assures equivalence between systems:
    - Comparing different milk containers it might be “delivery of one gallon of consumable milk”
- Since in this study we are not comparing the function of a corrugated package to another product designed to deliver the same function, the functional unit “1 kilogram of U.S. average corrugated products” and has been referred to as the “reference flow”

# RSC- ECT 32 = 1 Kilo



| | |
|---|---|
| **Style:** | RSC |
| **ID Dimensions** | 20 x 18 x 20 |
| **Board Weight:** | 35#/26#C/35# |
| **Sq. Ft.** | 20.47 |
| **Basis Wt** | 108.18#/msf |
| **Box Wt** | 2.2 lbs |
| | 1 kg |



# 24-12oz Long Neck Bottles

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| | |
|---|---|
| **Style:** | Die-Cut RSC |
| **ID Dimensions** | 15 5/8 x 10 7/16 x 9 |
| **Board Weight:** | 35#/26#B/35# |
| **Sq. Ft.** | 6.93 |
| **Basis Wt** | 105.3#/msf |
| **Box Wt** | .77 lbs |
| | .35 kg |

# 12” Pizza Box

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| | |
|---|---|
| **Style:** | Die-Cut Self Locking Tray |
| **ID Dimensions** | 12 x 12 x 2 |
| **Board Weight:** | 30#/26#B/30# |
| **Sq. Ft.** | 3.67 |
| **Basis Wt** | 95.32 #/msf |
| **Box Wt** | .39 lbs |
| | .177 kg |

# Scope of Study and Life Cycle Stages

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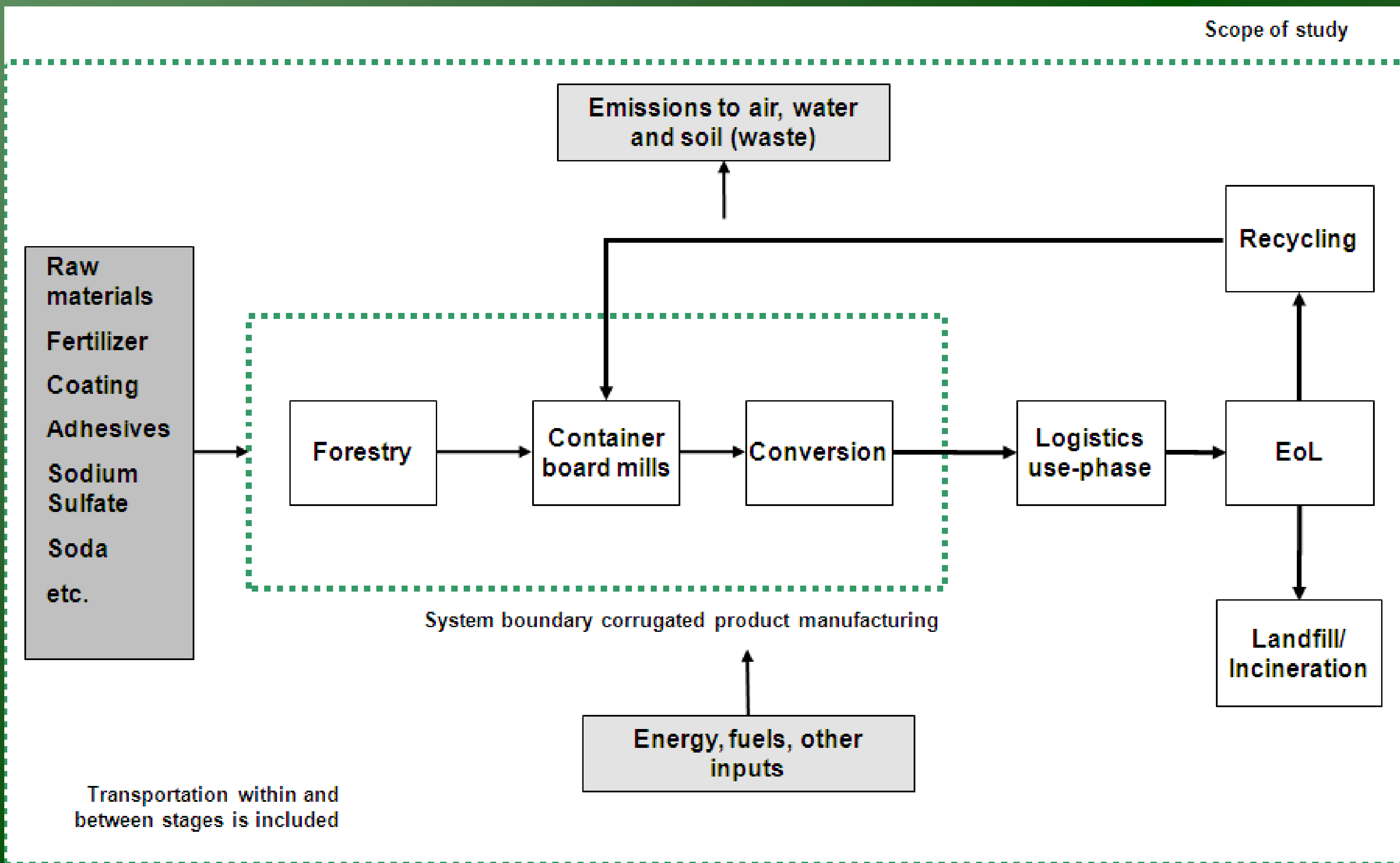

# Study Results

- **Life Cycle Inventory (LCI)**
  - **Full listing of input and output flows**
  - **Includes raw materials, materials from the technosphere, products and coproducts, emissions to the environment**
- **Life Cycle Impact Assessment (LCIA)**
  - **LCI results used in variety of assessment tools to evaluate potential environmental and human health impacts**

# Data Sources



- **CORRIM II report: Virgin fiber manufacturing**
- **Fisher International: Fiber and chemical input for containerboard manufacturing as well as production volume**
- **NCASI: Survey on energy usage as well as selected releases to the environment of Containerboard mills and converting plants**
- **Box plant inventory data from FBA member study participants**
- **GaBi LCI database:**
  - **US transportation model (based on US Census Bureau Vehicle Inventory and use Survey [2002] and US EPA emissions standards for heavy trucks in 2007)**
  - **US paper EoL model (based on 2006 US EPA life cycle assessment of landfill emissions)**
  - **Fuels, energy, and ancillary materials: Regional mixes and data sets from the GaBi LCI data base.**

# Life Cycle Inventory

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| | | | | | |
|---|---|---|---|---|---|
| Input | Energy | Fossil fuels | | | |
| | | | Diesel | 0.07 | kg |
| | | | Fuel oil | 0.04 | kg |
| | | | Gasoline | 5.18E-05 | kg |
| | | | Hard coal | 0.06 | kg |
| | | | Natural gas | 0.06 | kg |
| | | | Propane | 1.11E-04 | kg |
| | | | Old tires | 7.65E-03 | kg |
| | | Renewable | | | |
| | | | Biomass | 0.25 | kg |
| | | Consumed end energy | | | |
| | | | Power | 1.73 | MJ |
| | | | Hydropower | 1.71E-03 | MJ |
| | | | Steam purchased | 0.47 | MJ |
| | Materials | | | | |
| | | | Wood fiber | 1.18 | kg |
| | | | Recovered fiber | 0.46 | kg |
| | | | Sodium carbonate | 8.27E-04 | kg |
| | | | Sodium sulphate | 3.98E-05 | kg |
| | | | Starch | 0.01 | kg |
| | | | Ink | 8.47E-04 | kg |
| | | | Borax | 3.11E-04 | kg |
| | | | Coatings | 7.05E-04 | kg |
| | | | Adhesives | 7.94E-04 | kg |
| | | | wax | 4.74E-03 | kg |
| | | | | | |
| | | | Water | 56.90 | kg |
| | | | | | |
| Output | Prouct | | | | |
| | | | Containerboard | 1.00 | kg |
| | | | Beneficials | 0.01 | kg |
| | Waste | | | | |
| | | | Waste to landfill | 0.05 | kg |
| | | | Incineration good | 0.01 | kg |
| | | | Hazardous waste | 0.00 | kg |
| | | | Land application | 0.01 | kg |
| | Emissions | Air | | | |
| | | | Carbon dioxide | 0.72 | kg |
| | | | Carbon dioxide - biogenic | 1.55 | kg |
| | | | Carbon Monoxide | 1.26E-03 | kg |
| | | | Nitrogen oxide | 1.80E-03 | kg |
| | | | Nitrous oxide (laughing gas) | 6.46E-06 | kg |
| | | | Methane | 1.86E-05 | kg |
| | | | Sulphur dioxide | 2.28E-03 | kg |
| | | | Particulate matter | 5.63E-04 | kg |
| | | | NNVOC | 1.61E-04 | kg |
| | | Water | | | |
| | | | Biological oxygen demand (BOD) [Analytical measures to fresh water] | 1.92E-03 | kg |
| | | | Total reduced sulphurus (TRS) [Inorganic emissions to air] | 7.55E-05 | kg |
| | | | Total suspended solids (TSS) [Analytical measures to fresh water] | 1.96E-03 | kg |
| | | | Chemical oxygen demand (COD) [Analytical measures to fresh water] | 4.90E-05 | kg |
| | | | Waste water | 56.90 | kg |

# Life Cycle Inventory – 2

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| | | |
|---|---|---|
| Main material input | | |
| Wood input | 1.18 | kg |
| Recovered fiber | 0.46 | kg |
| Sodium carbonate $Na_2CO_3$ | 0.0057 | kg |
| Sodium sulfate $Na_2SO_4$ | 0.0055 | kg |
| Average product | | |
| Containerboard | 1.00 | kg |

# Life Cycle Inventory -3

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| | | | |
|---|---|---|---|
| Input | | | |
| | Containerboard | 1.04 | kg |
| | Starch | 0.0118 | kg |
| | Wax | 0.0047 | kg |
| | Ink | 8.47E-04 | kg |
| | Adhesives | 7.94E-04 | kg |
| | Caustics | 7.86E-04 | kg |
| | Coating | 7.05E-04 | kg |
| | Borax | 3.11E-04 | kg |
| | Resins | 2.11E-06 | kg |
| Output | | | |
| | Corrugated product | 1 | kg |

# End of Life Results

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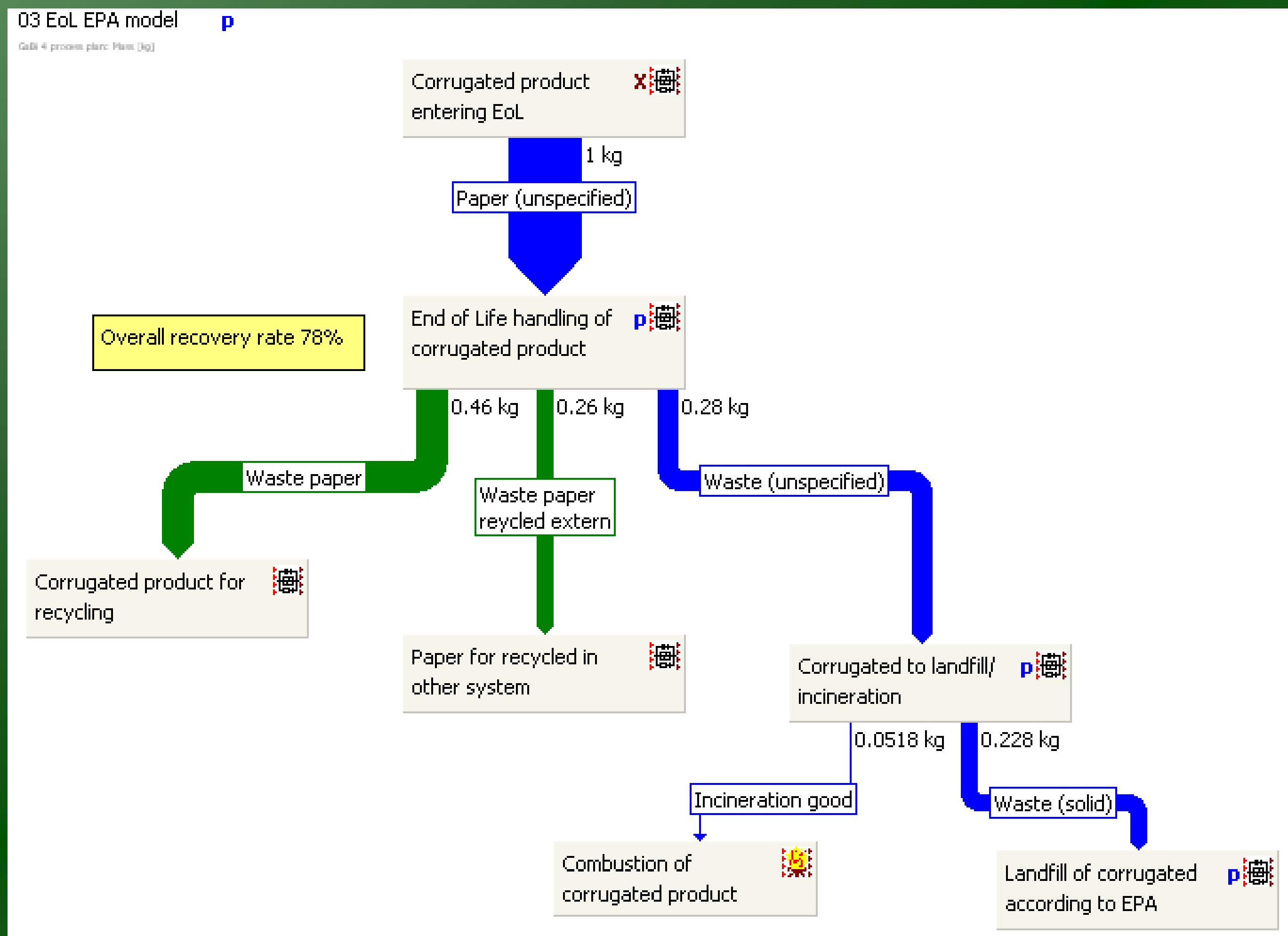

# Life Cycle Impact Assessment

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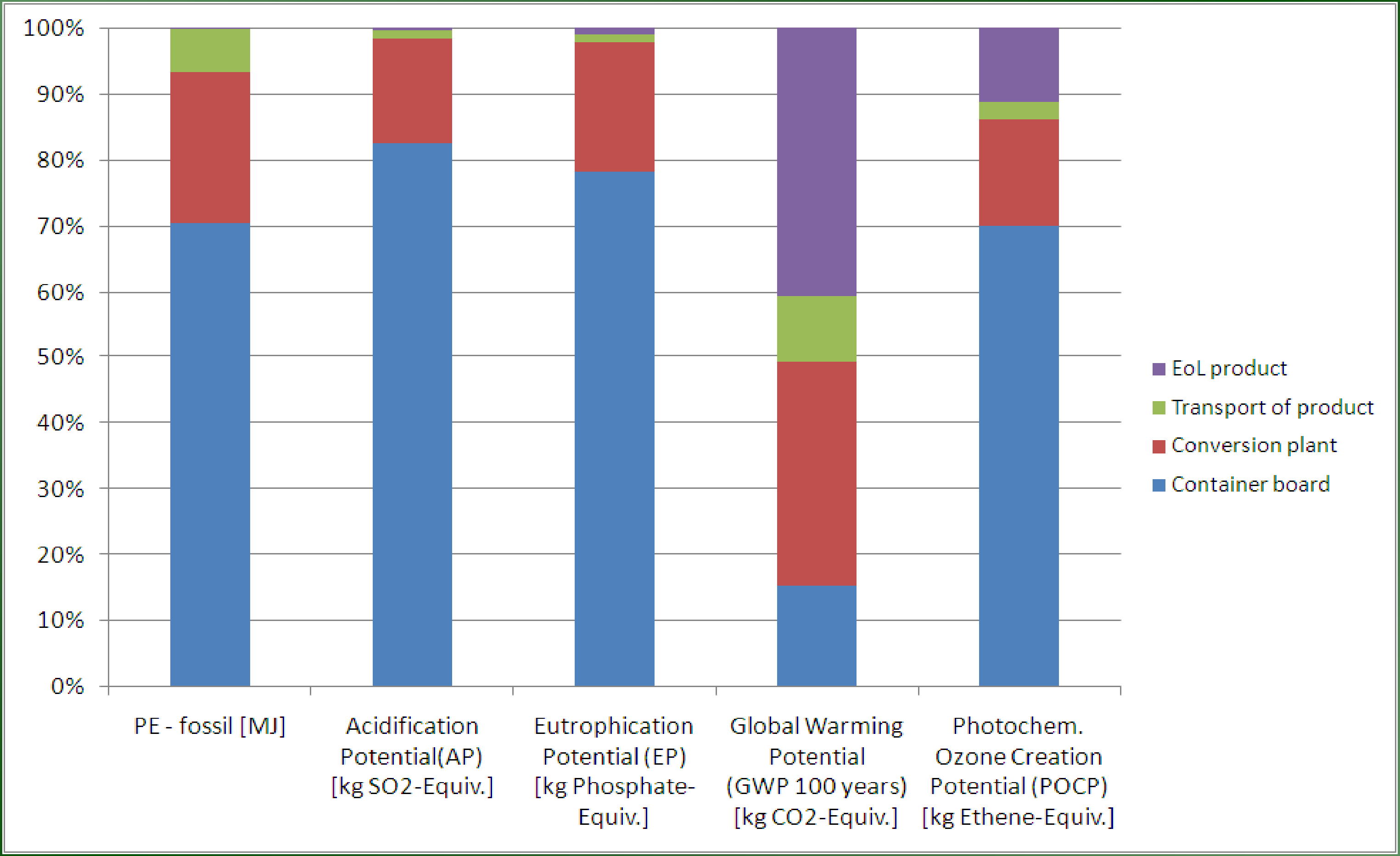
| Category Indicator | Impact category | Description | Unit |
|---|---|---|---|
| Energy Use | Primary Energy Demand (PED) | A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar). | MJ |
| Climate Change | Global Warming Potential (GWP) | A measure of greenhouse gas emissions, such as $CO_2$ and methane. | kg $CO_2$ equivalent |
| Eutrophication | Eutrophication Potential (CML)<br><br>Eutrophication Potential (TRACI) | A measure of emissions that cause eutrophying effects to the environment. The eutrophication potential is a stoichiometric procedure, which identifies the equivalence between N and P for both terrestrial and aquatic systems | kg Phosphate equivalent<br><br>kg Nitrogen equivalent |
| Acidification | Acidification Potential (CML)<br><br>Acidification Potential (TRACI) | A measure of emissions that cause acidifying effects to the environment. The acidification potential is assigned by relating the existing S-, N-, and halogen atoms to the molecular | kg SO2 equivalent<br><br>kg H+ equivalent |




**Share of different life cycle stages per impact category plus Fossil-Fuel Primary Energy Demand (PED) for of 1 kg of corrugated product**

# Study Conclusions-1

- **Paper mills drive the life cycle profiles**
  - **For all impact categories, material and energy flows from paper mills dominate results. Environmental impacts dominated by energy demands at the mill. Bio-based energy (e.g. hog-fuel, liquor, etc.) substantially reduce global warming potential contribution from mills.**
- **Transportation of final product does not define profile**
  - **Long distance transportation scenarios (based on national averages) represent an insignificant change in overall life cycle impacts for all impact categories.**

# Study Conclusions-2

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- **End of Life is only important with respect to GWP & POCP/ Smog potential**
  - **End of Life as modelled (based on 2006 industry average) only important in relation to global warming potential and POCP/ Smog potential.**
  - **Other life cycle impact indicators show little or no contribution from end of life stage.**
  - **Effect on GWP mainly related to noncaptured methane generation from landfill operations.**

# Implications of Results and Conclusions

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- **Most of environmental footprint outside of the box plant**
- **Upstream material and energy choices are key**
- **Box Maker can influence the footprint of his box:**
  - **choice of paper used**
  - **choice of inks, adhesives**
  - **process efficiencies at the plant**
  - **other inputs**
- **Steps at the box plant may be key to marketplace differentiation**

# Next Steps

- Finish this study
- Communicate results within the industry
- Share inventory with GreenBlue, EPA, USLCI
- Plan for a study update with emphasis on more plant level data gathering
- Use results to compare yourselves against industry average and your plants against one an other to find opportunities to reduce your environmental footprint