Swapping in Greener Materials: Example 2

by Sarah Dehlinger, Jake Hvistendahl, Joel Kohn, Jessica Papa (2013)

Note: This is a company-anonymized version of the file.

Comments:

Great job, team! You had more than 30 ideas, listed clear arguments for why the winning materials won (actually more verbose than needed), and the winners followed from design brief priorities. You did have two ideas that eliminated parts of the system (conductive polymer and cotton fabric base), but they could have been called out more clearly. Great that you even did estimated LCAs of how much improvement they would provide. (Though remember, a calculated 0.5% improvement is not a real improvement—with our quick-and-dirty estimated LCAs, the uncertainty is easily +/- 30%.) Also, typo: "cycyle".

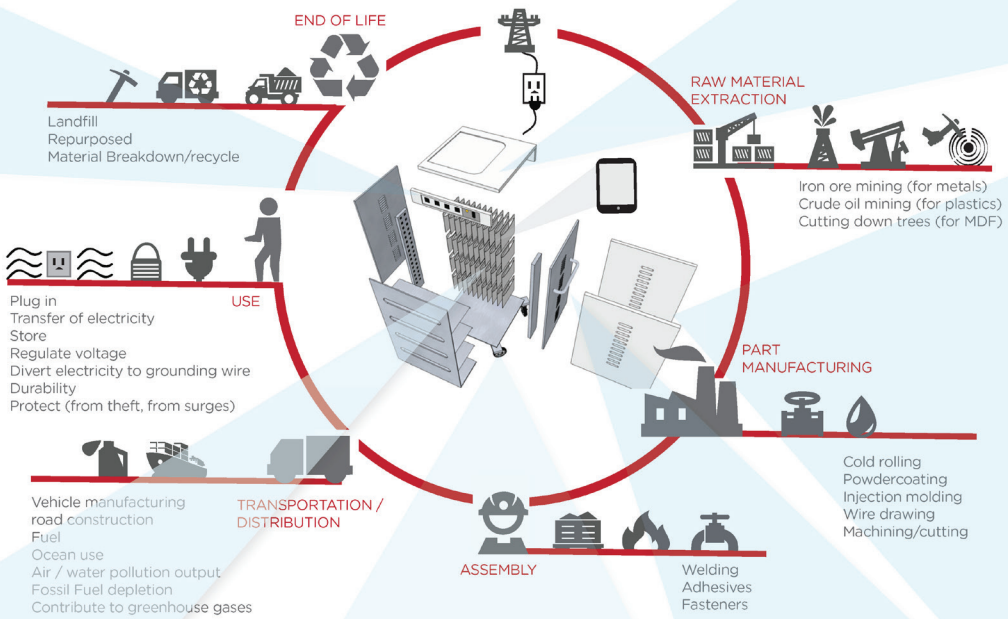
IS COMPRISED OF THE FOLLOWING MATERIALS:

- Steel (sides, bottom, shelves, nuts, bolts, washers, etc)
- MDF (top)
- ABS Plastic (dividers, wheels bumpers, misc components, cord clips)
- Aluminum (Handle)
- Copper & plastic (wires)

In an attempt to utilize more sustainable material options, the following material substitutions were identified:

Part: MDF
- Recycled Glass
- FSC certified wood
- Hemp fibers/Hempboard
- Binderless Coconut Coir
- Fiberboard
- Ecor
- Chicken feather plastic
- Bamboo

Part: Copper & plastic (wires)
- Conductive Polymer [PE DOT:PSS] to replace wires altogether



Part: Steel (doors / shelves)
- Carbon Fibers
- FSC certified wood
- Basalt Fiber
- Cardboard
- Reinforced Concrete
- Recycled rebar cage
- Recycled books
- Recycled tires - woven rubber from tires
- Binderless Coconut Coir Fiberboard
- Brick
- Adobe
- Ecor
- Chain mail created from soda can pop tops class project assembly
- Hemp fibers/Hempboard
- Bamboo
- Chicken feather plastic

Part: ABS Plastic Dividers
- Bioplastic - Mirel from Metabolix and ADM
- HDPE [recycled bottles]
- Chicken feather plastic
- FSC certified wood
- Reclaimed wood

Part: ABS Plastic Wheels
- Bioplastic - Mirel from Metabolix and ADM
- HDPE [recycled bottles]
- Chicken feather plastic
- Cotton fabric base (sliding replacement for wheels)
- Gum sustainably harvested from school desk undersides

Part: Aluminum Handle
- Carbon Fibers
- FSC certified wood
- Basalt Fiber
- Reclaimed wood
- FSC certified wood

Please note: Materials comprised of the same elements contain the same material replacement options. Additionally, some materials are substitutes for more than one material.

Taking into consideration the pre-determined design priorities (table 1) combined with the results from two LCA studies (complete analysis results found on page 4) the following two materials were identified as viable replacement options for steel, and ABS plastic:

Design Priorities	New Material Impacts on Design Priorities
Design for Relevance	Bamboo
Reduce Material Impact	Bioplastic Bamboo
Product Durability	Bamboo
Keep Prices Low	Bamboo
Design for Disassembly	Bioplastic Bamboo

TABLE 1

MATERIAL REPLACEMENT 1: BAMBOO TO REPLACE STEEL

Replacing steel with bamboo gives a 68% performance improvement in a life cycle assessment. Bamboo is more accessible than the hempboard previously identified in assignment 11.1 as an alternative to our most common material, steel. In addition to it's accessibility advantages over hemp, bamboo is more durable, a key design priority. While the material is slightly more expensive than hempboard (assuming 1/2" or 3/4" in thickness), bamboo proivdes more confidence in the long-term availability of the product. Additionally, the bamboo material is more aesthetically pleasing than both steel and hempboard, and would more likely find a life after its intended use. Finally, bamboo is a rapidly renewable alternative to other aesthetically pleasing materials such as wood.

image courtesy ehombuilder.com.au

image courtesy

MATERIAL REPLACEMENT 2: BIOPLASTIC TO REPLACE DIVIDERS, BUMPERS, AND OUTLET PLASTIC

Sourced from renewable stock, Mirel PHA bioplastic delivers a .50% performance improvement in a life cycyle assesment as compared to ABS. The bioplastic manufacturing process is easily interchangeable from the existing ABS material, likely resulting in an easy swap out without much redesign to the existing process. The bioplastic reduces material impact, and drastically increases the likelihood for both recycling and other end-of-life scenarios base on its core properties.

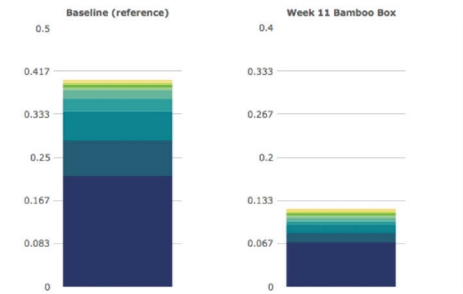
image courtesy

image courtesy designnews.com

It is quite feasible and realistic for to replace two of it's core materials, steel and ABS plastic, with alternatives that are more sustainable. While many options are available, bamboo and bioplastic represent materials that both meet the design priorities and reduce the overall environmental impacts for the lifecycle of the .

MATERIAL REPLACEMENT: BAMBOO

68% Improvement to baseline



Total = 0.41mPts/func unit

Input	mPts/func unit
Material - Steel, converter, low-alloyed	0.214
Material - Cable, three-conductor cable	0.0689
Process - Steel, converter, low-alloyed: Sheet rolling, steel	0.0564
Process - Steel, converter, low-alloyed: Powder coating, steel	0.0236
Transportation - Truck and trailer	0.0169
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00566
Material - Cable, three-conductor cable	0.00536
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00332
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.00317
Process - Steel, converter, low-alloyed: Turning, steel	0.00243

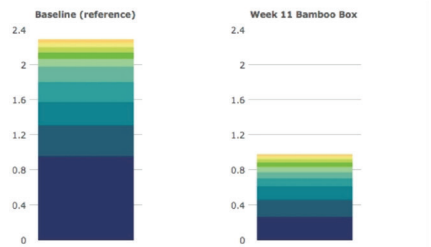
Total = 0.13mPts/func unit

Input	mPts/func unit
Material - Cable, three-conductor cable	0.0689
Transportation - Truck and trailer	0.0145
Material - Glued laminated timber, indoor use	0.0125
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00566
Material - Cable, three-conductor cable	0.00536
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00332
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.00317
Material - Glued laminated timber, indoor use	0.00267
Process - Steel, converter, low-alloyed: Turning, steel	0.00243
EOL - Acrylonitrile-butadiene-styrene copolymer, ABS: Incineration, plastics, mixture	0.00207

Please note vertical axic scales are different

Bamboo:
.13m/Pts/ func unit
1.1 CO2 eq .kg/Fun unit

Baseline:
.41m/Pts/ func unit
2.4 CO2 eq.kg/Fun unit



Total = 2.4 CO_2 eq. kg/func unit

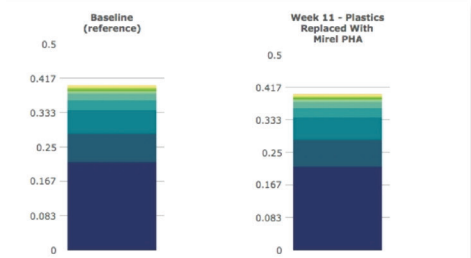
Input	CO_2 eq. kg/func unit
Material - Steel, converter, low-alloyed	0.957
Process - Steel, converter, low-alloyed: Powder coating, steel	0.352
Material - Cable, three-conductor cable	0.266
Transportation - Truck and trailer	0.229
Process - Steel, converter, low-alloyed: Sheet rolling, steel	0.177
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0903
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.0738
EOL - Acrylonitrile-butadiene-styrene copolymer, ABS: Incineration, plastics, mixture	0.0552
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0530
Process - Acrylonitrile-butadiene-styrene copolymer, ABS: Injection molding, plastics	0.0401

Total = 1.1 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Material - Cable, three-conductor cable	0.266
Transportation - Truck and trailer	0.197
Material - Glued laminated timber, indoor use	0.149
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0903
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.0738
EOL - Acrylonitrile-butadiene-styrene copolymer, ABS: Incineration, plastics, mixture	0.0552
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0530
Process - Acrylonitrile-butadiene-styrene copolymer, ABS: Injection molding, plastics	0.0401
Material - Glued laminated timber, indoor use	0.0320
Process - Acrylonitrile-butadiene-styrene copolymer, ABS: Injection molding, plastics	0.0235

MATERIAL REPLACEMENT: BIOPLASTIC

.5% Improvement to baseline (would be higher if more appropriate end-of-ilfe options were available in SM)



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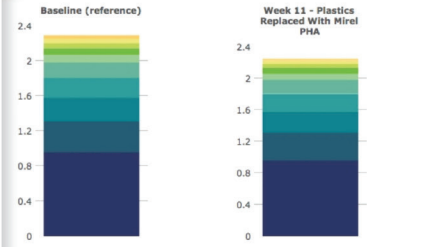
Process - Steel, converter, low-alloyed: Sheet rolling, steel	0.0564
Process - Steel, converter, low-alloyed: Powder coating, steel	0.0236
Transportation - Truck and trailer	0.0169
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00566
Material - Cable, three-conductor cable	0.00536
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00332
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.00317
Process - Steel, converter, low-alloyed: Turning, steel	0.00243

Total = 0.41mPts/func unit

Input	mPts/func unit
Material - Steel, converter, low-alloyed	0.214
Material - Cable, three-conductor cable	0.0689
Process - Steel, converter, low-alloyed: Sheet rolling, steel	0.0564
Process - Steel, converter, low-alloyed: Powder coating, steel	0.0236
Transportation - Truck and trailer	0.0169
Material - Polyhydroxyalkanoates, PHA bioplastic (Mirel)	0.00578
Material - Cable, three-conductor cable	0.00536
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.00332
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.00317
Process - Steel, converter, low-alloyed: Turning, steel	0.00243

Bioplastic:
0.41 CO2 eq.kg/Fun unit
2.4 m/Pts/ func unit

Baseline:
.41m/Pts/ func unit
2.4 CO2 eq.kg/Fun unit



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EOL - Acrylonitrile-butadiene-styrene copolymer, ABS: Incineration, plastics, mixture	0.0552
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0530
Process - Acrylonitrile-butadiene-styrene copolymer, ABS: Injection molding, plastics	0.0401

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Material - Cable, three-conductor cable	0.266
Transportation - Truck and trailer	0.229
Process - Steel, converter, low-alloyed: Sheet rolling, steel	0.177
Material - Polyhydroxyalkanoates, PHA bioplastic (Mirel)	0.0785
Material - Aluminum, cast, semi-permanent mold (SPM)/kg NREL /US	0.0738
Material - Acrylonitrile-butadiene-styrene copolymer, ABS	0.0530
Process - Polyhydroxyalkanoates, PHA bioplastic (Mirel): Injection molding, plastics	0.0401
Process - Acrylonitrile-butadiene-styrene copolymer, ABS: Injection molding, plastics	0.0235