Submission for
Verification of Eco-Efficiency Analysis Under
NSF Protocol P352, Part B

Retail Shopping Carts
Final Report – January 2015

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1. Purpose and Intent of this Guidance Document

1.1. The purpose of this submission is to provide a written report of the methods and findings of BASF Corporation's Retail Shopping Cart Eco-Efficiency Analysis, with the intent of having it verified under the requirements of NSF Protocol P352, Part B: Verification of Eco-Efficiency Analysis Studies.

1.2. The Retail Shopping Cart Eco-Efficiency Analysis was performed by BASF according to the methodology validated by NSF International under the requirements of Protocol P352. More information on BASF's methodology and the NSF validation can be obtained at http://www.nsf.org/info/eco_efficiency.

2. Content of this Guidance Document

2.1. This submission outlines the methodology, study goals, design criteria, target audience, customer benefits (CB), process alternatives, system boundaries, and scenario analysis for the Retail Shopping Cart EEA study, which will be conducted in accordance with BASF Corporation's EEA (BASF EEA) methodology. This submission will provide a discussion of the basis of the eco-analysis preparation and verification work.

2.2. As required under NSF P352 Part B, along with this document, BASF is submitting the final computerized model programmed in Microsoft® Excel. The computerized model, together with this document, will aid in the final review and ensure that the data and critical review findings have been satisfactorily addressed.

3. BASF's EEA Methodology

3.1. Overview:

BASF EEA involves measuring the life cycle environmental impacts and life cycle costs for product alternatives for a defined level of output. At a minimum, BASF EEA evaluates the environmental impact of the production, use, and disposal of a product or process in the areas of cumulative energy demand, resource and water consumption, emissions, toxicity and risk potential, and land use. The EEA also evaluates the life cycle costs associated with the product or process by calculating the costs related to, at a minimum, materials, labor, manufacturing, waste disposal, and energy consumption.

3.2. Preconditions:

The eco-efficiency methodology utilized in this study has been validated to the requirements of Part A of NSF P252 Validation and Verification of Eco-Efficiency Analyses. In addition, all alternatives that are being evaluated are being compared against a common Functional Unit (FU) or Customer Benefit (CB). This allows for an objective comparison between the various alternatives. The scoping and definition of the Customer Benefit are aligned with the goals and objectives of the study. Data gathering and constructing the system boundaries are consistent with the CB and consider both the environmental and economic impacts of each alternative over their life cycle or a defined specific time period in order to achieve the specified CB. An overview of the scope of the environmental and economic assessment carried out is defined in this report. Cut off rules applied to data collection and for material and process evaluation were consistent with our approach defined in Section 6.11 (De Minimis Levels) of our Part A Methodology submittal.

3.2.1. Environmental Burden Metrics:

For BASF EEA environmental burden is characterized using twelve categories, at a minimum, including: cumulative energy demand, abiotic depletion potential (a.k.a. raw material or resource consumption), water consumption, global warming potential (GWP), ozone depletion potential (ODP), acidification potential (AP), photochemical ozone creation potential (POCP), water emissions, solid waste emissions, toxicity potential, risk potential, and land use. These are shown below in Figure 1. Metrics shown in light blue represent the seven main categories of environmental burden that are used to construct the environmental fingerprint, while burdens in green represent all elements of the emissions category, and pink show the specific air emissions.

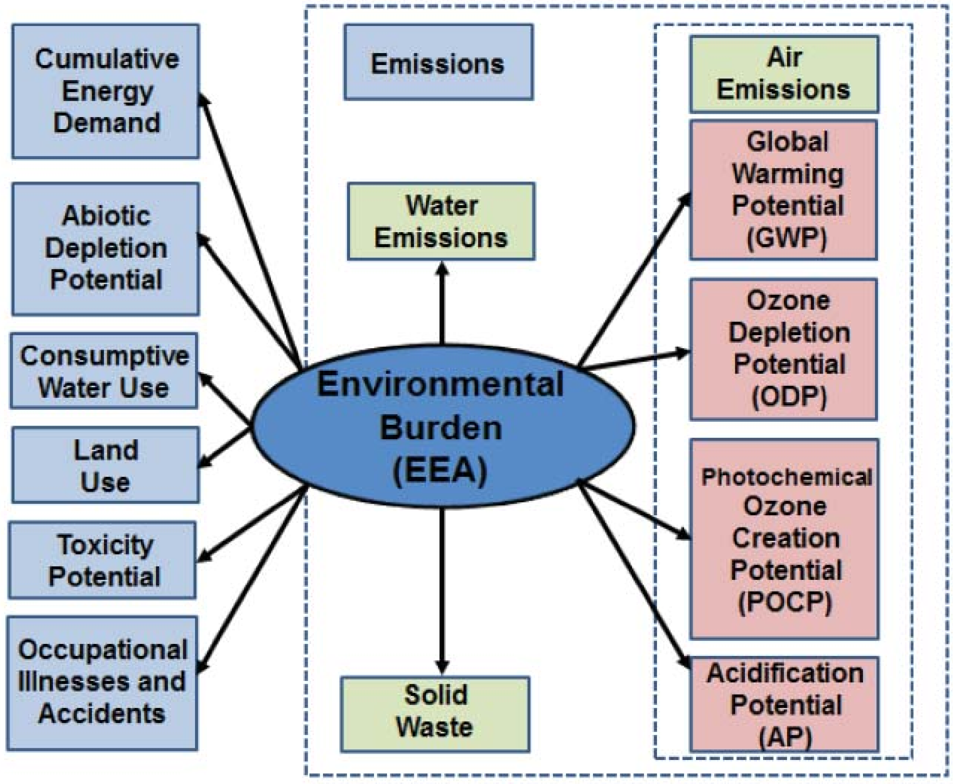


Figure 1. Environmental impact categories

3.2.2. Economic Metrics:

It is the intent of the BASF EEA methodology to assess the economics of products or processes over their life cycle and to determine an overall total cost of ownership for the defined customer benefit ($/CB). The approaches for calculating costs vary from study to study. When chemical products of manufacturing are being compared, the sale price paid by the customer is predominately used followed by any subsequent costs incurred by the product's use and disposal. When different production methods are compared, the relevant costs include the purchase and installation of capital equipment, depreciation, and operating costs are analyzed. The costs incurred are summed and combined in appropriate units (e.g. U.S. dollar or euro) without additional weighting of individual financial amounts. The BASF EEA methodology will incorporate:

- the real costs that occur in the process of creating and delivering the product to the consumer;
- the subsequent costs which may occur in the future (due to tax policy changes, for example) with appropriate consideration for the time value of money; and
- costs having ecological aspect, such as the costs involved to treat wastewater generated during the manufacturing process.

3.2.3. Work Flow:

A representative flowchart of the overall process steps and calculations conducted for this Eco-Efficiency analysis is summarized in Figure 2 below.

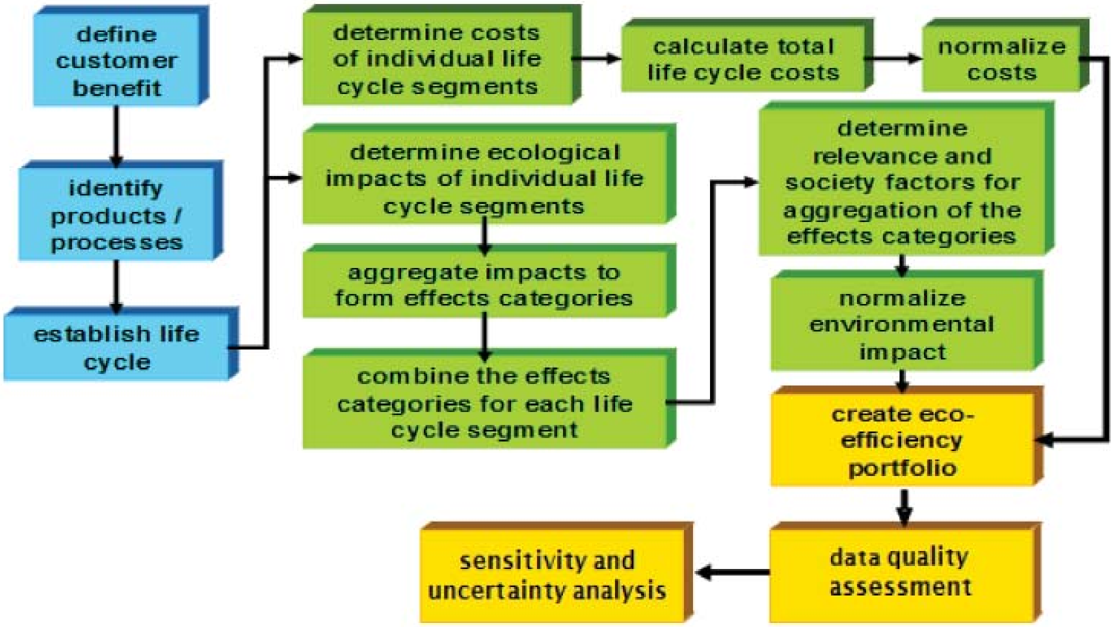


Figure 2. Overall process flow for Retail Shopping Cart EEA study

4. Study Goals, Context and Target Audience

4.1. Study Goals:

Americans are gradually incorporating broader environmental criteria into their retail purchasing decisions. Consumers are becoming increasingly more aware of the environmental impacts of the products they purchase. In addition to the products they buy, they are also considering other aspects of their shopping experience (packaging, eco-labels, nutrition label, ingredients etc.). One popular topic that has gotten a lot of scrutiny is the benefits and trade-offs of the various bags consumers use to carry their merchandise. Plenty of life cycle assessment studies have been completed on the various types of bags (i.e. paper, plastic, and reusable) consumers can use and how they compare from an environmental perspective. However, one area that has not been fully understood or evaluated from the retail and consumer level is the environmental and economic impact of the shopping carts consumers use when they go shopping.

Shopping carts are an essential part of the shopping experience. Consumers require that the carts they use are clean, safe, and easy to operate while retailers expand upon those basic requirements to include features such as durability, reliability and the overall life time costs to maintain their fleet of carts. Store owners are well aware of the significant first time costs to purchase their fleet of carts but they may be less knowledgeable about the magnitude of their ongoing ownership costs. In addition, they may also be unaware of the environmental impacts required to produce and maintain their fleet of carts till their end of life.

There are currently between 30 – 35 million shopping carts in use in the retail sector in the United States with over 1,250,000 carts being replaced every year[9]. Just based on these numbers, a significant amount of money as well as resources are invested each year into our national shopping cart inventory. Thus innovations in making shopping carts more durable, easier and less expensive to maintain, and overall more enjoyable for consumers to use will benefit not only store owners but the environment and the end consumer alike.

This life cycle assessment will evaluate a new shopping cart technology and compare it against an established retail solution. More specifically, the existing metal shopping cart which dominates the retail landscape will be compared against a new all plastic shopping cart developed and manufactured by Bemis Retail Solutions™. Each of these solutions have their corresponding economic and environmental trade-offs and benefits, which will be objectively evaluated and compared in this study. For example, the metal cart is manufactured from steel, an extremely recyclable material, has a lower initial purchase price but higher on-going maintenance costs. On the other hand the more expensive plastic cart has longer durability and lower maintenance requirements. Impacts to produce, maintain and recycle the carts will be considered in a holistic manner taking into account both the financial costs as well as a broad list of environmental impact categories. These factors will be considered together to determine which retail cart solution is more eco-efficient.

The results of this study will be used as a basis to guide retail store owners in making informed purchasing decisions for retail carts that consider both the full total cost of ownership (not just initial price) as well as a balanced life cycle environmental impact. The results will also support manufacturers of shopping carts to focus on the relevant economic and environmental impacts of their product and thus drive improvements in these areas with new innovations and designs.

This study will analyze the customary shopping cart requirements of a standard retail store over a 15 year timeframe. The store requirements will be for 300 carts with a 60/40 distribution between full size carts and convenience size carts.

4.2. Design Criteria:

The context of this EEA study compared the environmental and cost impacts for the production, use and end of life disposition of the shopping cart requirements for a large scale retail shopping center over a 15 year time frame. The goals, target audience, and context for decision criteria used in this study are displayed in Figure 3.

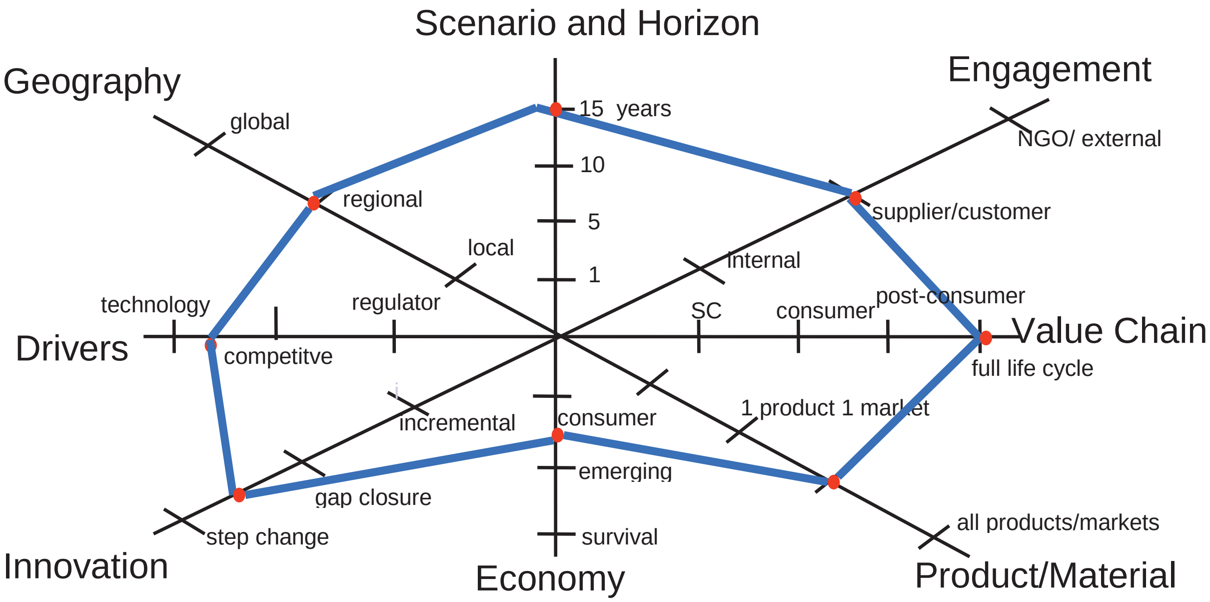


Figure 3: Context for Retail Shopping Cart Eco-Efficiency Analysis

4.3. Target Audience:

The target audience for this study has been defined as owners of retail shopping centers product developers and to lesser degree consumers. It is planned to communicate study results directly to retail store owners, in marketing materials and at industry trade conferences.

4.4. Allocation Method:

Except where noted in section 6, Input Parameters and Assumptions, allocation procedures recommended by ISO 14040 were followed. Of specific note were the allocation of impacts for the plastic cart manufacturing process (physical allocation) and the End of Life recycling of steel (World Steel Report[8]).

5. Customer Benefit, Alternatives and System Boundaries

5.1. Customer Benefit:

The Customer Benefit (identified also as CB) or Function Unit (FU) applied to all alternatives for the base case analysis is the production, use, maintenance and end of life impacts of maintaining a fleet of 300 shopping carts including both full size and convenience size carts at a large scale retail shopping center over a 15 year time frame. The above customer benefit was selected to best represent the potential benefits and trade-offs for various solutions for providing shopping carts at a retail store.

5.2. Alternatives:

The alternatives for retail shopping cart EEA to be analyzed and compared are: (1) Bemis™ innova™ full size and convenience size plastic shopping carts and (2) standard industry metal full size and convenience shopping carts (Metal Cart).

The key differences between the alternatives are the base material of construction (plastic vs. steel), the respective durability of the carts (8-12 years on avg. for plastic vs. and a 5–7 year durability range for metal), the required repairs, the initial purchase price and the cost of maintenance activities.

5.3. System Boundaries:

The system boundaries define the specific elements of the production, use, and disposal phases of the life cycle that are considered as part of the analysis. For both alternatives the starting point for the analysis is the extraction of the basic raw materials required for the production of the carts as well as the cleaning materials and fuels for transport. For both materials the incorporation of recycle content into their basic manufacturing processes is considered as both the steel and plastic components are highly recyclable and the infrastructure exists for its collection. For both alternatives the impacts for producing the required amount of cleaning solution as well as replacement parts are included. The “use” phase of both alternatives includes the cleaning and repair of the existing shopping cart fleet and the replacement of the carts which can no longer achieve their desired function. The “disposal phase” includes the end of life treatment of all components of the shopping cart as well as all wastes generated during the cleaning and repair of the carts. For the plastic cart, the entire cart will be collected and returned to the manufacturer for recycling while the steel carts will also be predominately recycled with only a small portion of their components going into the municipal solid waste stream. Inputs and wastes generated during the cleaning operations will be addressed at the store level with the waste water going to the municipal collection system. The generic life cycle of the shopping cart is represented in Figure 4.

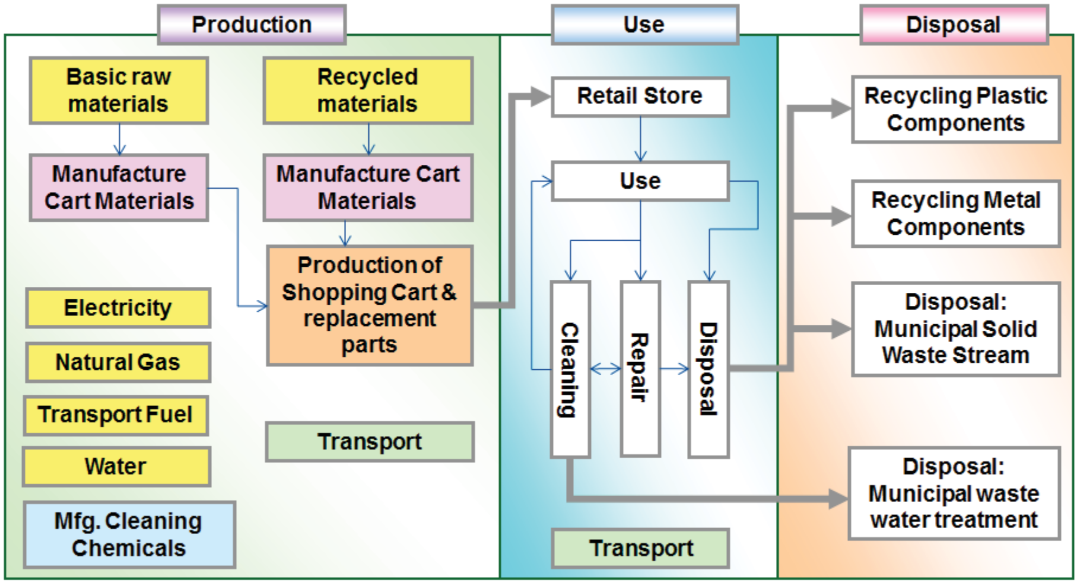


Figure 4. System Diagram for generic life cycle of retail shopping cart

5.4. Scenario Analyses:

In addition to the base case analysis, several additional scenarios were evaluated to determine the sensitivity of the study's final conclusions and results to key input parameters as well as to help focus the interpretation of the study results. Results will be presented and discussed in section 10.

5.4.1. Scenario #1:

Variability to study results based on expected durability of alternatives.

5.4.2. Scenario #2:

Cleaning frequency of the carts.

5.4.3. Scenario #3

Percentage of metal carts which get refurbished rather than fully replaced.

5.4.4. Scenario #4:

Wheel replacement frequency for the metal retail cart.

6. Input Parameters and Assumptions

6.1. Input Parameters:

A comprehensive list of input parameters were included for this study and considered all relevant material and operational characteristic for the supply and use of shopping carts at a retail shopping facility.

6.1.1. Cart Design

Retail stores generally carry two different size shopping carts for their customers: full size and convenience size. This study will assume that a standard retail store will have 60% full size and 40% convenience size shopping carts.

The full size cart will have a nominal basket capacity of 11,510 in^3 with a total shopping capacity of almost 19,000 in^3 (includes under basket storage). In addition, the full size cart will have a built in child seat. Other performance or cosmetic features (i.e. cup or flower holders, graphics, etc.) were not specifically considered in this analysis and were not deemed essential to influencing the study results.

The convenience cart will have a nominal combined basket capacity of 5,000 in^3 and a total shopping capacity when considering the lower tray of around 8,200 in^3. Similar to the convenience cart, features such as cup or flower holders, coupon holders etc. which are not critically important components of the functionality of the cart and the overall customer experience, where not specifically considered in this analysis.

Figures 5 and 6 depict representative images of the plastic and metal shopping cart designs considered for this analysis.

Figure 5. Bemis™ innova™ full size and convenience shopping carts

Figure 6. Indicative metal full size and convenience shopping carts

6.1.2. Cart Durability

Industry research[1] as well as the expert opinion of the team established the relative durability of the two alternatives. Cart durability can be influenced by many factors such as climate, quality of construction, and the repair/maintenance frequency. The average durability of the metal cart was established at 5 years while the average durability for the Bemis™ innova™ carts was established at 10 years. Both values assume the carts are part of a quality cleaning and preventive maintenance program. Impact of these assumptions on the final eco-efficiency results for each alternative are explored further in Scenario #1 of Section 5.4.1 (Scenario Analyses).

6.1.3. Material Composition and weights

As noted above, standard industry sized shopping carts were assessed for this analysis. The actual weights and type of materials used for the production of the Bemis™ innova™ shopping carts were supplied by the manufacturer. Full compositional and construction data was provided to NSF International in support of this verification but is not directly included in this report in order to protect company confidential information.

Material composition and weights for the generic metal shopping carts were provided by Bemis Retail Solutions™. Table 1 depicts the components and their respective weights for both the full size and convenience metal shopping cart.

Part	Description	Full size cart (weight - lb.)	Convenience cart (weight – lb.)
Frame	Steel Tubing	18.5	13.2
Handle	Steel Tubing	3.1	2.2
Basket (upper)	Steel wire	15	7.1
Basket (lower)	Steel wire	NA	6.7
Child seat	Steel wire	9.3	
Lower tray	Steel wire	3.6	2.2
Wheels	Front/Rear	4.6	4.6
Belts	Polyester / Nylon	0.4	
Miscellaneous (covers, caps, seat)	Plastic	0.5	0.4
Casters	Steel	4.8	4.4
TOTAL		**59.8**	**40.8**

Table 1. Cart components and weights: metal shopping carts

6.1.4. Required Number of Carts

On average a large retail store or shopping center requires around 300 active shopping carts on the premises, with 60% being full size carts and 40% being convenience carts. Carts will be replaced over the considered 15 year life cycle based on their defined durability (section 6.1.2.) and in the case of the metal carts consideration will be given to how many carts are fully refurbished rather than being recycled. Expert opinion of the project team established that the industry average for refurbishment of steel shopping carts at their end of life is around 40%. When the durability of a cart is not evenly divisible into the required life cycle, the multiplier for the required number of carts will be rounded-up to the next whole number in order to better reflect the actual purchasing practice of the retail store.

During normal use, shopping carts can be lost, stolen or damaged beyond repair. Full size carts being that they can be taken into parking lots and exposed more to traffic and theft will have a higher likelihood for losses. For this analysis, the full size carts were assigned a loss / damage rate of 3% for the metal cart and 2% for the plastic cart. The lower value for the plastic cart is mostly due to the plastic frame and side panels being more resilient to collisions and damage than the more rigid steel frames. The rates are lower for the convenience cart since they are predominately for in store use only. The metal convenience cart has a 2% rate of theft/damage while the plastic convenience cart is 1%.

6.1.5. Cart Manufacturing

A detailed accounting for all raw materials, emissions and energy usage including impacts of fully recycling the plastic carts (i.e. collection, transport and disassembly/regrinding) at the end of their useful life were considered for the Bemis™ innova™ carts. A detailed questionnaire was provide to Bemis Retail Solutions™ in order to account for all inputs (energy, water, etc.) and outputs (water emissions, air emissions etc.) required during the manufacturing and recycling of the plastic carts. Physical (mass) allocation method was utilized to distribute the entire plants manufacturing impacts to the plastic retail shopping cart.

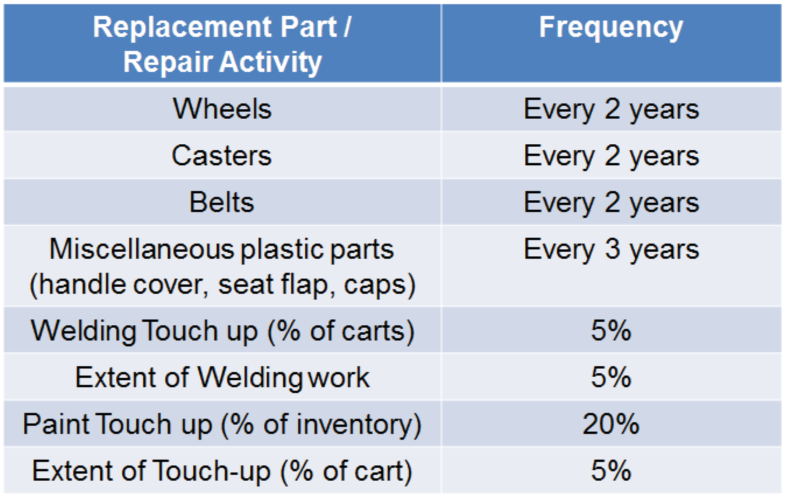
6.1.6. Cart Refurbishment & Cleaning Requirements

Proper preventive maintenance is essential in order to keep shopping carts looking and functioning properly. These programs help carts achieve their desired durability, reduce the frequency of breakdowns and repairs and generally help store owners minimize the total cost of ownership of their shopping cart fleet. Frequent cleanings help maintain carts that are safe and aesthetically pleasing for the customers.

6.1.6.1. Refurbishment & Repair

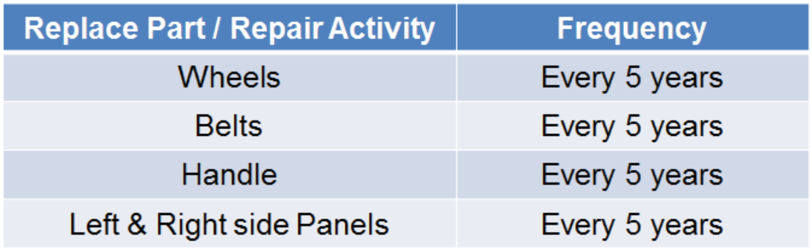
Table 2 indicates the required preventive maintenance schedule for metal shopping carts while Table 3 indicates the program for the plastic carts. Generally, any required repair / preventive maintenance is done at the store location during the on-site cleaning visits.

As described in section 6.1.2, each shopping cart technology has its defined durability range. Specific for the metal carts, at the end of life, some carts can be fully refurbished and enter back into service rather than being recycled for scrap. Refurbishing a cart as opposed to producing one from virgin/recycled material generally saves resources, reduces energy consumption and reduces emissions. For this analysis, it was conservatively assumed that 40% of the metal carts are refurbished when they reach their end of life. Full refurbishment provides the cart with a new durability similar to that of a new virgin cart.



Replacement Part / Repair Activity	Frequency
Wheels	Every 2 years
Casters	Every 2 years
Belts	Every 2 years
Miscellaneous plastic parts (handle cover, seat flap, caps)	Every 3 years
Welding Touch up (% of carts)	5%
Extent of Welding work	5%
Paint Touch up (% of inventory)	20%
Extent of Touch-up (% of cart)	5%

Table 2. Preventive maintenance schedule – metal shopping carts

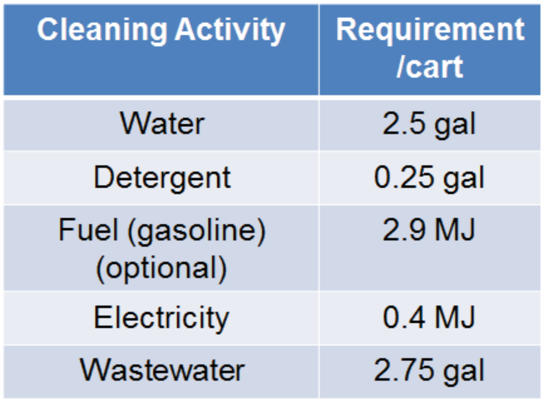


Replace Part / Repair Activity	Frequency
Wheels	Every 5 years
Belts	Every 5 years
Handle	Every 5 years
Left & Right side Panels	Every 5 years

Table 3. Preventive maintenance schedule – Bemis™ innova™ plastic shopping carts

6.1.6.2. Cleaning Requirements

Generally, carts are cleaned several times per year in order to keep them clean and free of dirt and germs. Cleaning is normally done at the store location and involves the use of high pressure power washing unit as opposed to shipping the carts off-site for cleaning or cleaning them locally utilizing an automated cleaning system. The cleaning requirements as well as waste generation were extracted from the specifications for a standard commercial grade power washer[2] and are depicted in Table 4.



Cleaning Activity	Requirement /cart
Water	2.5 gal
Detergent	0.25 gal
Fuel (gasoline) (optional)	2.9 MJ
Electricity	0.4 MJ
Wastewater	2.75 gal

Table 4. Shopping cart cleaning requirements

It was assumed that both the plastic and metal shopping carts are cleaned at the same frequency which was established at 3 times/year. In addition, the same type and quantity of detergent is used to clean both alternative shopping carts. For the base case, heating of the water was not included. If heated water is utilized the required energy was estimated at 2.9 MJ/cart.

6.1.7. Transportation - Logistics

The logistical impacts for movement of basic and recycled materials for manufacturing of the finished shopping carts for use by the retail store as well as the logistics for activities associated with the cleaning, repair and disposal/recycling of the shopping carts were considered. The specific key logistical segments considered and their corresponding assumptions are presented in Table 5. Data sources related to the logistic profiles utilized in this study can be found in Table 9, Life Cycle Inventory Data Sources.

Life Cycle Phase	Method of Transport	Distance (km)
Production Phase		
Sourcing Basic & Recycled Raw Materials	Truck	10 – 3680
Sourcing of Basic Raw Materials	Rail	2770
Sourcing of Basic Raw Materials (imported)	Ship	7,400 – 11,520
Shipment from Manufacturer to Retail Store	Truck	1,600
Use Phase		
Replacement Parts	Truck	1,500
Cart Cleaning and Refurbishment	NA	At store
Disposal - Recycling Phase		
Solid Waste Collection & transport to Landfill or Incineration	Truck	160
Bemis Retail Solutions™ cart service location	Truck	1,600
Return to Bemis Retail Solutions™ from service location	Truck	1,600
Local metal recycling	Truck	50

Table 5. Logistical assumptions for retail shopping cart EEA

6.1.8. End of Life - Recycling

Both plastic and metal are highly recyclable materials though programs and infrastructure need to be in place in order to make these recycling efforts effective. World Steel Association[3] provided the EoL (end-of-life) recycling rates for the types of steel material utilized in this analysis. The key material (finished cold rolled coil and wire rod) had an established recycling rate of 85%. The impacts and credits for recycling were directly incorporated into the life cycle inventory data provided by World Steel Association.

Bemis Retail Solutions™ has a high recycle rate of plastic materials and by-products within their manufacturing facility as well as for their products. For this analysis, the Bemis innova™ shopping cart when it reaches its end of life or becomes damaged so that it can no longer be utilized is collected and sent to a regional service location where carts are collected over time and then returned to Bemis Retail Solutions™ where they are disassembled and recycled. Plastic is reground in incorporated back into the shopping cart or other Bemis™ products (open loop recycling). The only products which do not get recycled are the seat belts and wheels which enter into the standard municipal waste stream.

6.2. Life Cycle Costs

The life cycle costs for each alternative included a full cost accounting for all aspects of the production, use and end-of-life of the shopping carts. In addition to the purchase price of the cart which covers all upstream costs, the costs for cleaning, maintenance and repair, refurbishment, replacement and disposal were considered for both alternatives. Any necessary freight charges were also considered for all logistic activities.

Table 6 summarizes the cost assumptions associated with the purchase price and on-going cleaning and repair costs of the carts.

Item	innova™ full size cart ($/unit)	Standard metal full size cart ($/unit)	innova™ convenience cart ($/unit)	Standard metal convenience cart ($/unit)
Purchase Price	$180	$110	$120	$90
Replacement items				
Wheel (full set)	$18.50	$17	$18.50	$17
Handle	$7	$5	$7	$5
Seat belt	$15	$5		
Side panels	$10		$10	
Rust/finish touch up		$14		$12
Weld repair		$7.5		$5
Realignment		$5		$5
Full refurbishment		$75		$60
Cleaning	$1.75	$1.75	$1.75	$1.75

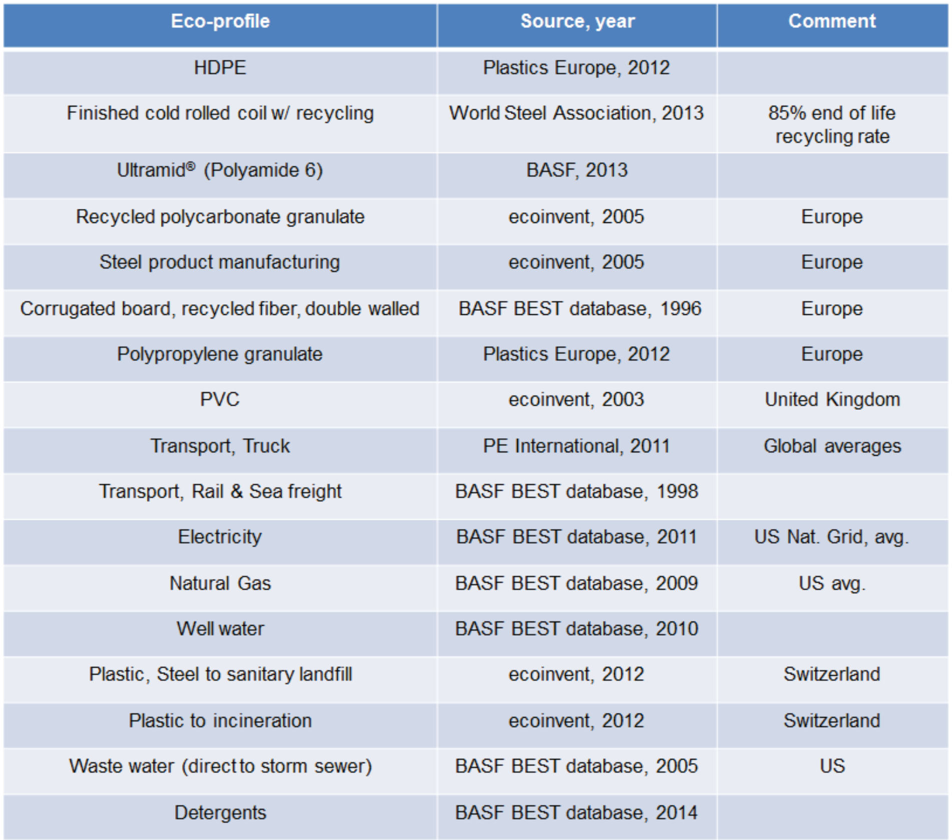
Table 6. Cost assumptions for retail shopping cart EEA

Current national average fuel costs[4] were utilized to calculate fuel costs for material disposal and recycling efforts. Finally, national average data was used for the tipping fees for municipal solid waste ($50/ton)[6] and the incineration tipping fee ($68/ton)[5].

7. Data Sources

7.1. Environmental:

The environmental impacts for the production, use, and disposal of the various alternatives were calculated from eco-profiles (e.g. life cycle inventories) for the individual system components (e.g. wire rod, cart frame and side panels, handles, seat belts etc.) and activities (e.g. cleaning, welding, injection molding) occurring over the life cycle defined for this analysis. Life cycle inventory data for these eco-profiles were from several data sources, including BASF and customer specific manufacturing data. Overall, the quality of the data was considered medium to high. None of the eco-profiles data was considered to be of low data quality. A summary of the eco-profiles is provided in Table 7.



Eco-profile	Source, year	Comment
HDPE	Plastics Europe, 2012	
Finished cold rolled coil w/ recycling	World Steel Association, 2013	85% end of life recycling rate
Ultramid® (Polyamide 6)	BASF, 2013	
Recycled polycarbonate granulate	ecoinvent, 2005	Europe
Steel product manufacturing	ecoinvent, 2005	Europe
Corrugated board, recycled fiber, double walled	BASF BEST database, 1996	Europe
Polypropylene granulate	Plastics Europe, 2012	Europe
PVC	ecoinvent, 2003	United Kingdom
Transport, Truck	PE International, 2011	Global averages
Transport, Rail & Sea freight	BASF BEST database, 1998	
Electricity	BASF BEST database, 2011	US Nat. Grid, avg.
Natural Gas	BASF BEST database, 2009	US avg.
Well water	BASF BEST database, 2010	
Plastic, Steel to sanitary landfill	ecoinvent, 2012	Switzerland
Plastic to incineration	ecoinvent, 2012	Switzerland
Waste water (direct to storm sewer)	BASF BEST database, 2005	US
Detergents	BASF BEST database, 2014	

Table 7. Eco-profile Data Sources

8. Eco-Efficiency Analysis Results and Discussion

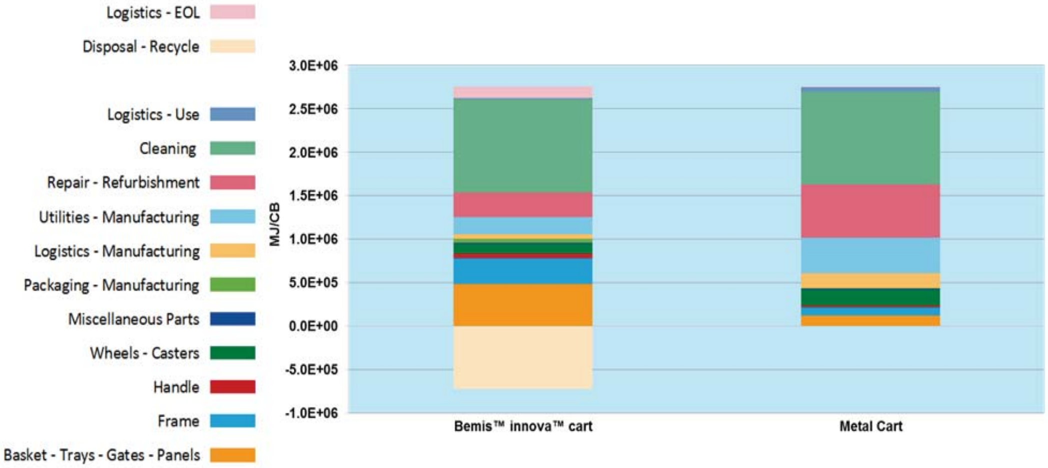
8.1. Environmental Impact Results:

The environmental impact results for the Retail Shopping Cart Eco-efficiency analysis were generated as defined in Section 6 of the BASF EEA methodology. The results discussed in Section 8.1.1 through 8.1.9 are for the Base Case only and do not represent any of the scenarios.

8.1.1. Cumulative Energy Demand:

Cumulative energy demand, measured over the entire life cycle and depicted in Figure 7, shows that the metal shopping cart uses a greater amount of energy over the defined life cycle than the comparable plastic shopping cart. The gross energy consumption for the metal shopping cart alternative was about 2.8 million

MJ per customer benefit while the Bemis™ innova™ shopping carts consumed about 30% less energy or around 2.04 million MJ/ customer benefit (after credit for recycling is considered). For both alternatives, the largest contributor to energy consumption (between 40-50%) is the cleaning operations. Additionally, for both alternatives if heated water is utilized for cleaning the overall energy demand for cleaning increases by 4% with the full life cycle energy demand for each alternative increasing between 1.5% - 2.0%. Both alternatives are significantly minimizing energy consumption through high recycling efforts of their products. A credit for recycling the majority of the plastic components of the Bemis™ innova™ cart saves about 25% of the life cycle energy requirements. The metal cart also saves a lot of energy through an 85% recycling rate for the metal components of the cart. This credit for steel recycling is applied not as an end of life credit but is incorporated directly in the life cycle inventory of the steel and thus the benefit is realized through lower impacts in the production modules. Finally, energy consumption during manufacturing as well as during repair / refurbishment activities is about double for the metal cart than for the plastic cart.



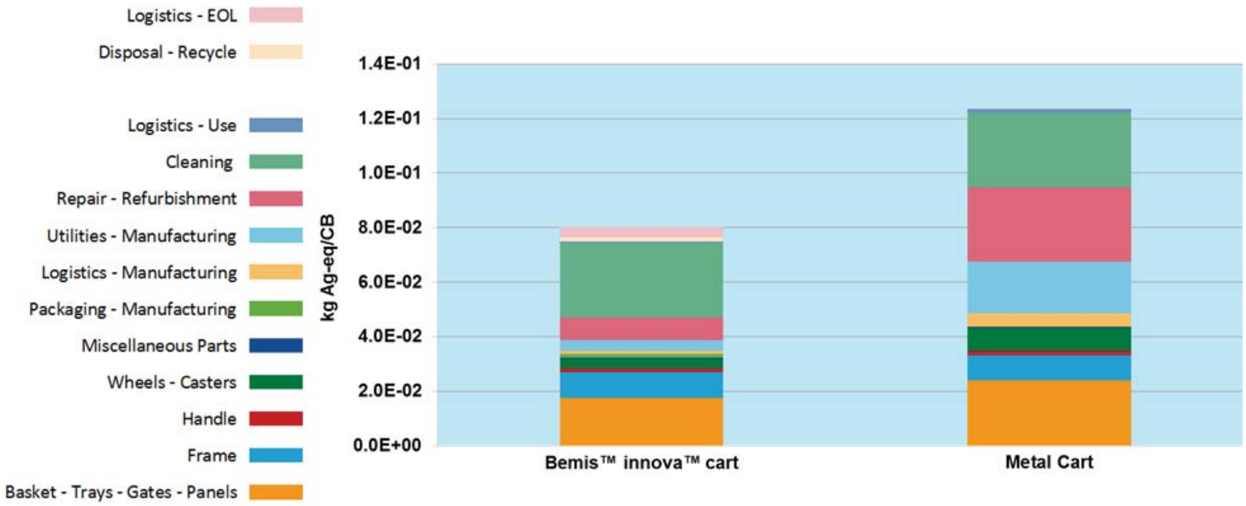
Environmental Relevance: **HIGH** – Contributes 22% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance factors.

Figure 7. Cumulative energy demand

8.1.2. Abiotic Depletion Potential (Resource Consumption):

Figure 8 shows that the key drivers for Abiotic Depletion Potential (a.k.a. raw material or resource consumption) are similar to those for energy consumption. For the plastic cart, the main contributors are the basket, tray and frame as well as the cart cleaning activities. For the metal cart, the main contributors are the basket and trays, the utilities used during manufacturing and the cleaning and repair activities.

Per BASF's EEA Methodology, individual raw materials are weighted according to their available reserves and current consumption profile. These weighting factors are appropriate considering the context of this study. As to be expected the main resources consumed by each alternative are oil and natural gas. In addition, the metal cart also had appreciable consumption of manganese, vanadium and iron important elements in the production / manufacturing of steel.

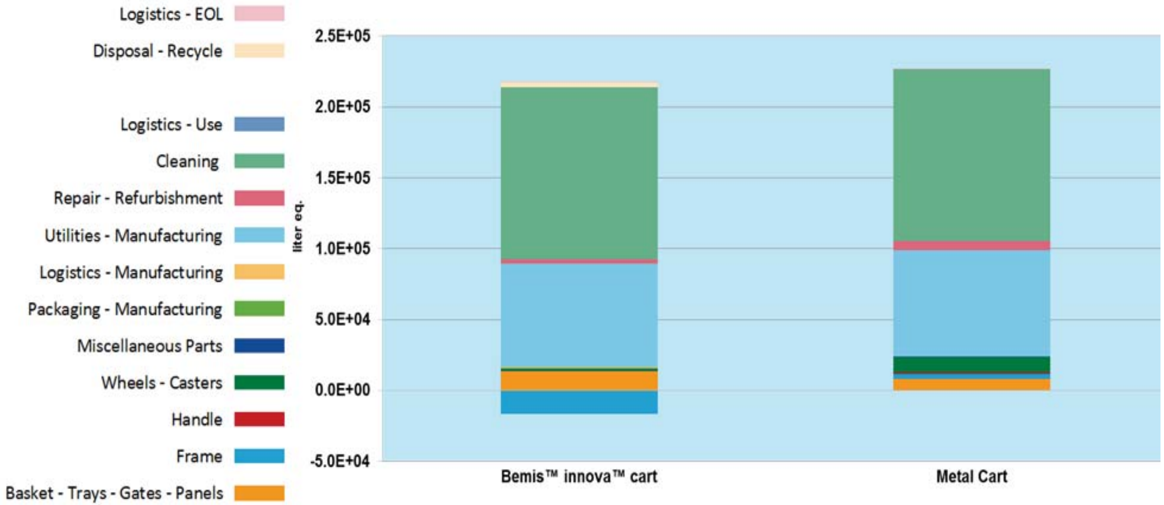


Environmental Relevance: **MEDIUM** – Contributes 9% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance factors.

Figure 8. Raw material consumption by module

8.1.3. Consumptive Water Use

As expected, Figure 9 shows the largest contributor to consumptive water use for this study is the cart washing activities where approximately 2.5 gallons of water are used to clean each cart. Water usage during manufacturing is also a significant contributor for each alternative. Overall, the Bemis™ innova^{TM} cart had about 10% lower consumptive water use.



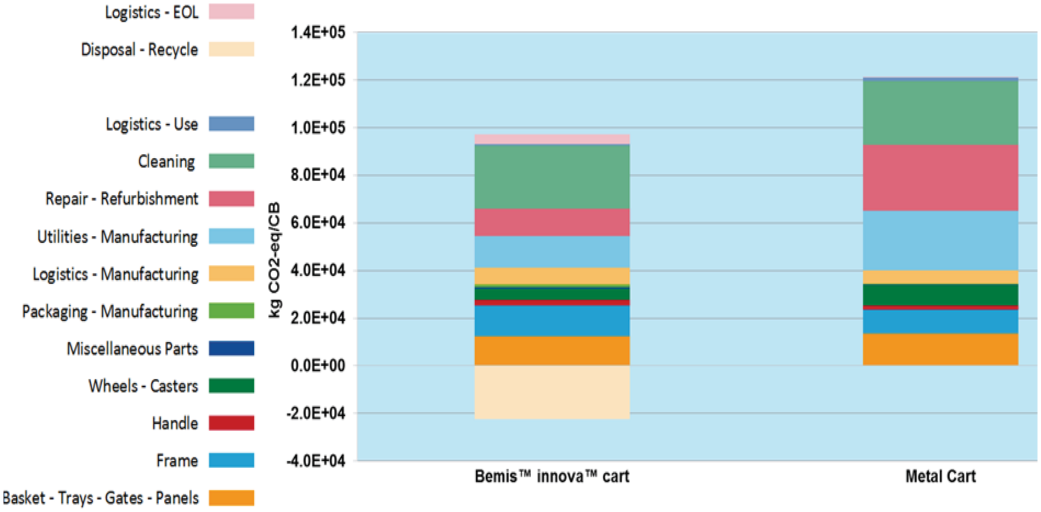
Environmental Relevance: **LOW** – Contributes 3% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance factors.

Figure 9. Consumptive water usage

8.1.4. Air Emissions:

8.1.4.1. Global Warming Potential (GWP):

Figure 10 shows that the highest greenhouse gas emissions or carbon footprint occurred in the metal shopping cart alternative with a value of 122 mtons of CO_2 equivalents per customer benefit. The Bemis™ innova^{TM} shopping cart alternative had a carbon footprint of 75 mtons of CO_2 equivalents per customer benefit, a reduction of almost 40%. The largest contributor to global warming potential for the metal cart alternative was in the cleaning, repair and manufacturing operations. The largest contributor to the plastic cart carbon footprint was also the cleaning operation. GWP is the most relevant air emission in this study.

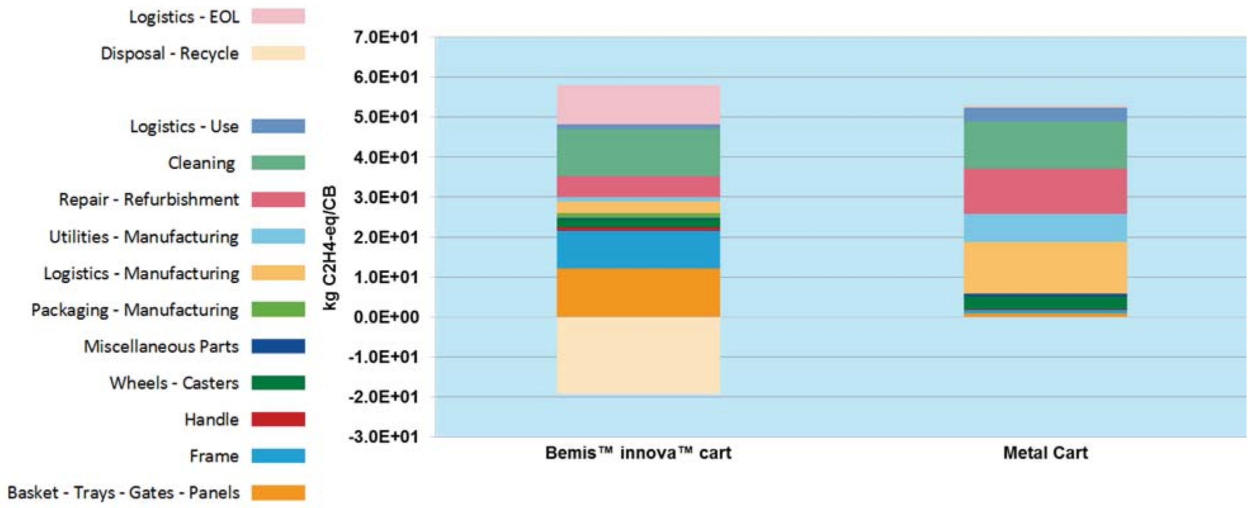


Environmental Relevance: **HIGH** – Contributes 15% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 10. Global warming potential (GWP)

8.1.4.2. Photochemical ozone creation potential (POCP, smog):

Emissions with Photochemical Ozone Creation Potential (POCP) are dominated in both alternatives by the impacts of manufacturing, repair/refurbishment and cleaning. As depicted in Figure 11, the Bemis™ innova^{TM} cart benefits significantly from its recycle strategy at end-of-life where all carts are collected and disassembled and the various plastic components are sorted, reground and reincorporated into finished products thus off-setting POCP emissions that would have occurred during pre-chain manufacturing activities. Overall, the Bemis™ innova™ cart has around a 25% lower emission rate of components which contribute to POCP / summer smog.

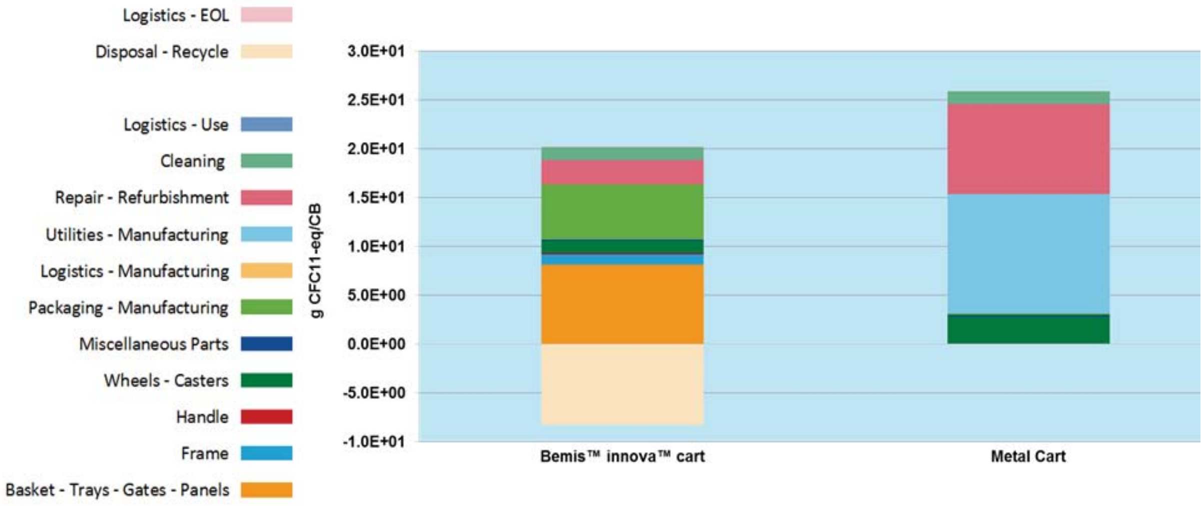


Environmental Relevance: **HIGH** – Contributes 7% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 11. Photochemical ozone creation potential (POCP)

8.1.4.3. Ozone depletion potential (ODP):

Both alternatives result in negligible ozone depletion potential. ODP is the least significant environmental emission and has an environmental relevance factor less than 1%. The Bemis™ innova^{TM} cart alternative produced the lowest level, measured at about 12g CFC equivalents/CB.

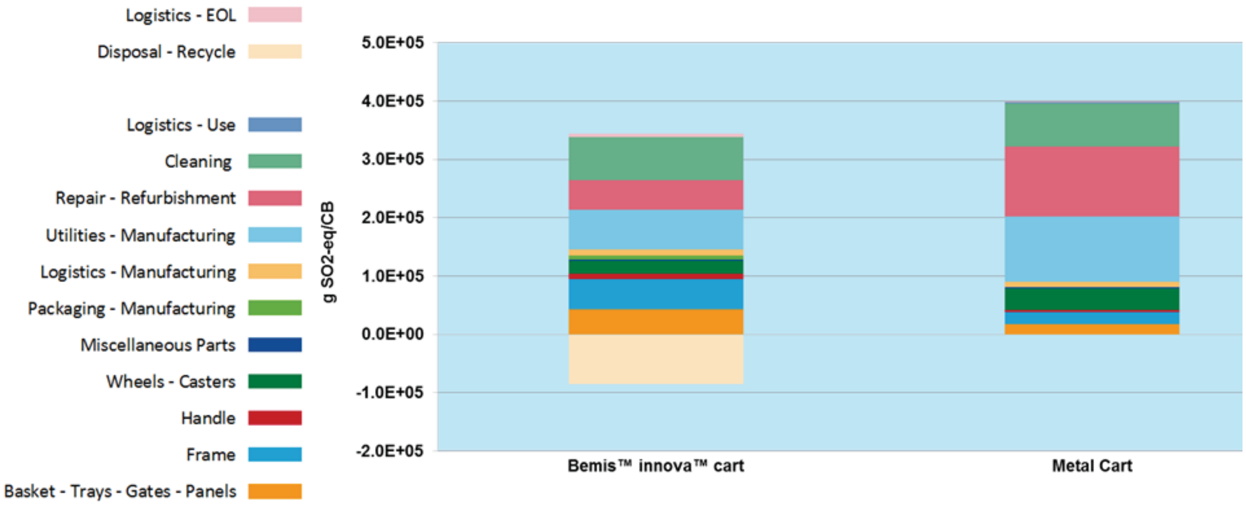


Significance: **LOW** – Contributes less than 1% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 12. Ozone depletion potential (ODP)

8.1.4.4. Acidification potential (AP):

It can be seen in Figure 13 that the largest contributor to acidification potential was the metal shopping cart alternative with a value of around 0.4 metric tons SO_2 equivalents/CB, mainly due to manufacturing operations, repair / refurbishment and cleaning. The Bemis™ innova^{TM} cart alternative's value of around 0.26 metric tons of SO_2 equivalents/CB was almost a 35% reduction.



Environmental Relevance: **HIGH** – Contributes almost 12% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 13. Acidification Potential

Utilizing the calculation factors show in Table 10, Figure 14 shows the normalized and weighted impacts for the four air emissions categories (GWP, AP, POCP, and ODP) for each alternative. Overall, the metal shopping cart alternative had the greatest air emissions, over twice those of the Bemis™ innova^{TM} cart. The metal cart scored highest in each of the four air emission categories.

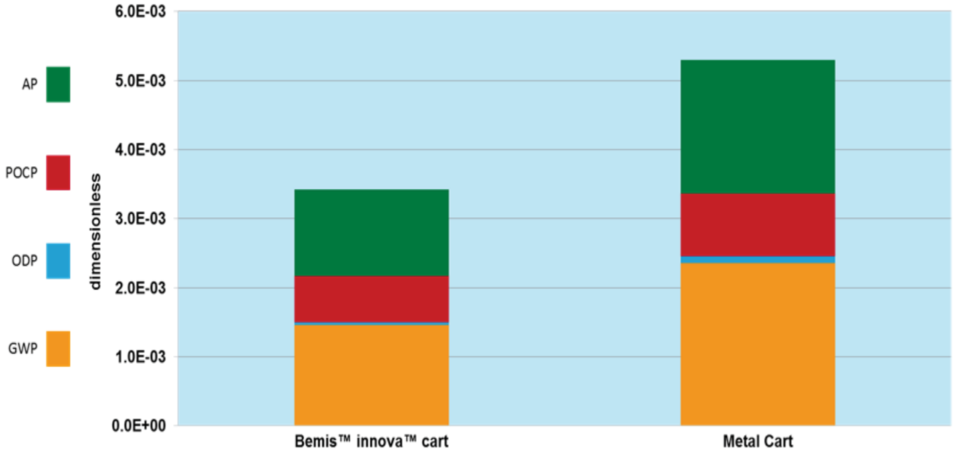
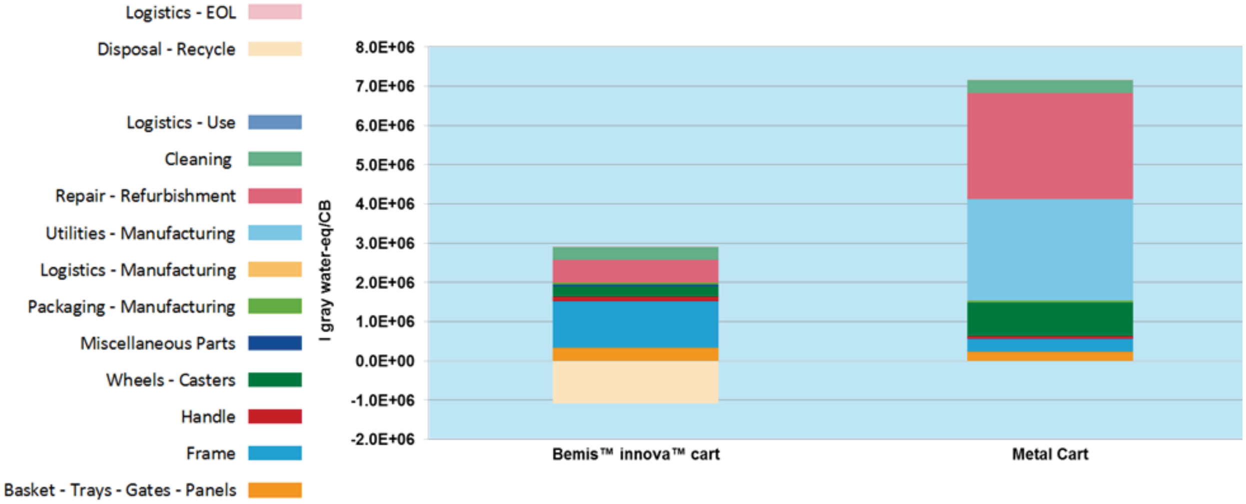


Figure 14. Overall air emissions

8.1.5. Water emissions:

Figure 15 displays that the overall water emission is highest for the metal cart with over 7,000 m^3 of grey water equivalents/CB. This is driven by the specific water emissions of phosphates and trace metal emissions Zn, Ni and Cr from the metal manufacturing processes (initial production / replacement parts). Actual water emissions over the Bemis™ innova^{TM} shopping cart life cycle are over 50% less than the corresponding metal cart. Surprisingly, water emissions from the cart cleanings, though a large contributor to consumptive water usage does not place a large environmental load on the POTW/storm sewer. Water emissions are the highest rated environmental impact category.

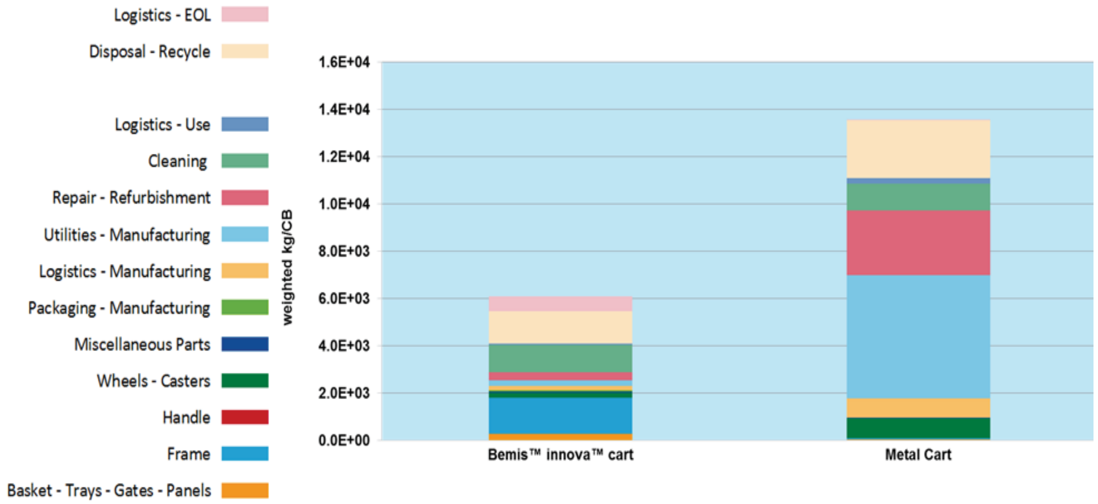


Environmental Relevance: **HIGH** – Contributes 24% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 15. Water emissions

8.1.6. Solid waste generation:

Solid waste emissions were dominated by the solid waste generation associated with the cart manufacturing and repair/refurbishment activities. Solid waste emissions are depicted below in Figure 16 and show that the metal cart generates almost twice the solid waste generation as the Bemis™ innova^{TM} cart.

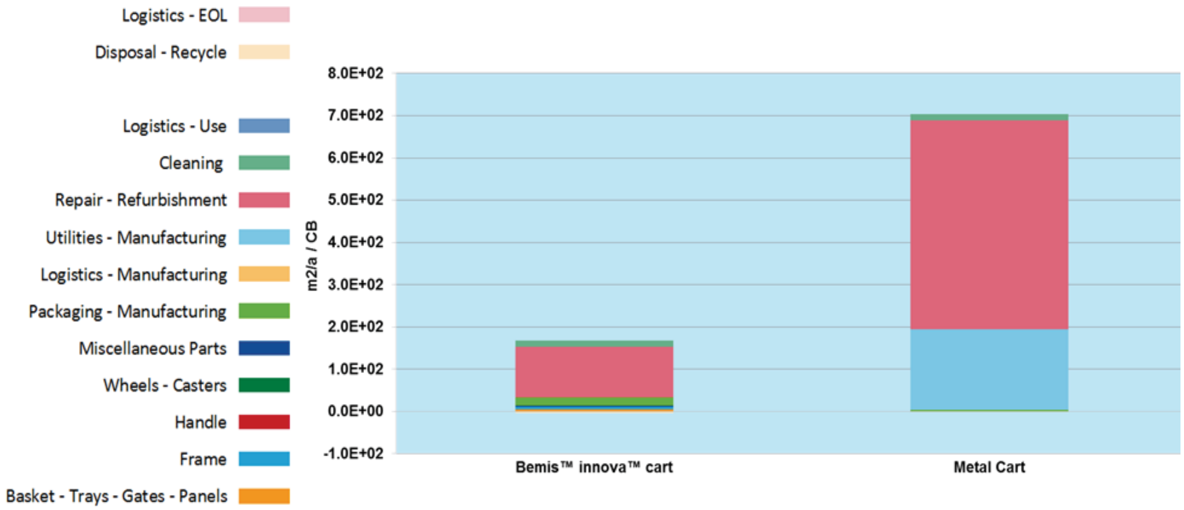


Environmental Relevance: **MEDIUM** – Contributes 8% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 16. Solid waste generation

8.1.7. Land use:

Land use is assessed for each alternative and is based on the assessed impacts of land occupation and transformation. As displayed in Figure 17, the land use impacts are mostly influenced by the cart repair and refurbishment activities for both alternatives. Through increased overall durability as well as requiring less frequent replacement of key wear items (i.e. wheels), the Bemis™ innova^{TM} plastic cart achieves a significantly lower overall impact to land use.



Significance: **LOW** – Contributes less than 1% to the overall environmental impact. See Table 10 for summary of environmental impact relevance / significance.

Figure 17. Land use

8.1.8. Toxicity potential:

The toxicity potential of the various materials and components required to produce the retail shopping carts as well as any associated activities with their use, maintenance and disposal/recycling were analyzed for each alternative over their respective life cycle. Analysis of final products (i.e. full size and convenience carts; replacement parts etc.) included a full analysis of the entire pre-chain of chemicals and raw/recycled materials required during their manufacture and transport. During the use phase of the life cycle the human health impact potential consisted of the use of the carts, the cleaning activities as well as any required repair and refurbishment. Toxicity potential at the end of life considered impacts from disposal, recycling and the associated logistics.

Nanoparticles were not included in the chemical inputs of any of the alternatives and were not evaluated in this study.

Inventories of all relevant materials were quantified for the three life cycle stages (production, use, and end-of-life). Consistent with BASF's EEA Methodology's approach of assessing the human health impact potential of these materials (ref. Section 6.8 of Part A Submittal), a detailed scoring table was developed for each alternative broken down per life cycle stage. This scoring table with all relevant material quantities considered as well as their H-phrase and pre-chain toxicity potential scores were provided to NSF International as part of the EEA model which was submitted as part of this verification. Figure 18 shows how each life cycle module contributed to the overall toxicity potential score for each alternative. The values have been normalized and weighted.

The module which influenced toxicity potential to the largest degree for both alternatives was the cart washing activities. For both alternative shopping carts the same type and quantity of cleaning detergent was used. In addition, as the plastic and metal carts were washed with the same frequency the environmental impacts associated with the cleaning activities were equal for both alternatives. Cart washing activities contributed between 35% -50% to the overall toxicity potential. The next significant contributors to the toxicity potential scores were the cart components required for the initial manufacturing or required during repair/refurbishment. Logistics activities contributed about 15% to the overall score for both alternatives. Overall, the Bemis™ innova™ cart had a 35% lower life cycle toxicity potential score than the comparable metal retail shopping cart alternative. End-of-life impacts were minimized due to the high recyclability of both alternatives and in fact the toxicity potential scores were reduced through the reuse / recycling of many of the cart components back into finished products. When incorporated into the final environmental scoring, toxicity potential contributes 19% to the overall score. This is a significant contribution.

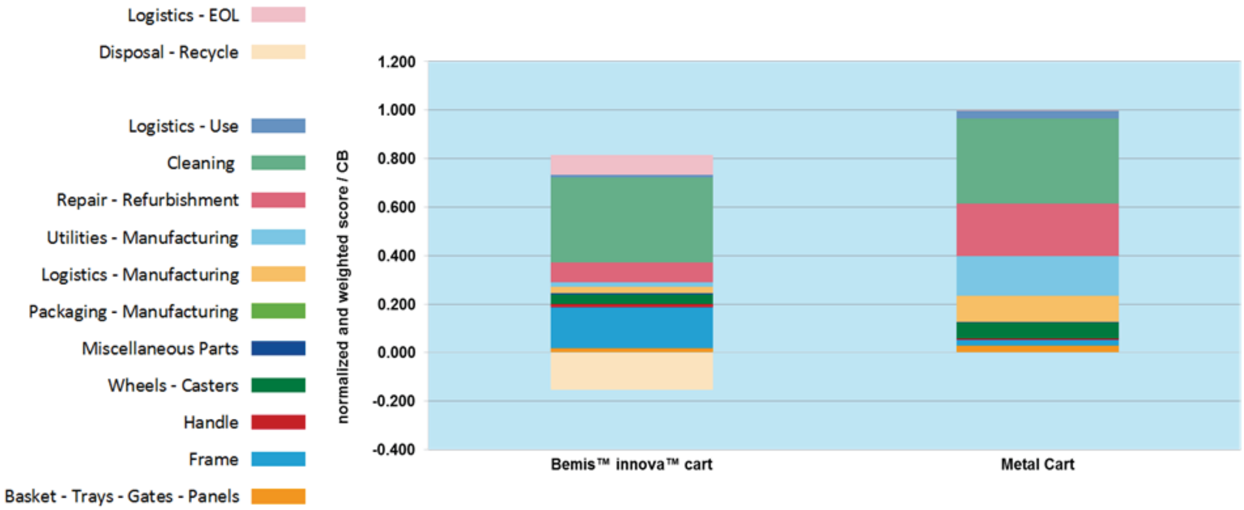


Figure 18. Human toxicity potential – modules

8.1.9. Risk potential (Occupational Diseases and Accidents potential):

The risk category in BASF EEA, includes assessment of the physical hazards during the production, use and disposal phases of the defined life cycle as well as consideration for the risk of explosions, flammability, storage accidents, worker illnesses and injury rates, malfunctions in product filling/packaging, transportation accidents and any other risks deemed relevant to the study. The risk potential is established using quantitative government and industry data (e.g. working accidents and occupational disease using industry related data) as well as expert judgment. All the materials and activities account for in the various life cycle stages were assigned specific NACE codes. NACE (Nomenclature des Activities Economiques) is a European nomenclature, which is very similar to the NAICS codes in North America. The NACE codes are utilized in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the business economy and is broken down by specific industries. Specific to this impact category, the NACE codes track, among other metrics, the number of working accidents, fatalities, illnesses, and diseases associated with certain industries (e.g. chemical manufacturing, petroleum refinery, inorganics, etc.) per defined unit of output. By applying these incident rates to the amount of materials required for each alternative, a quantitative assessment of risk is achieved.

Figure 19 shows that the risk category for this study is dominated by the risks associated with the manufacturing and fabrication of metal components as well as the risks associated with the manufacturing of the wheels/casters. This is to be expected as steel manufacturing and fabrication have significantly higher accident and incident rates than chemical (plastic) manufacturing. Due to the less frequent replacement of the wheels on the Bemis™ innova^{TM} cart (5 years vs. 2 years), the innova™ cart has a lower risk impact in the wheels/caster category. Overall, working accidents contributed about 60% to the risk category score while occupational diseases contributed around 40%. No unique risk categories were identified for this study so the standard weighting between working accidents and occupational illnesses was maintained.

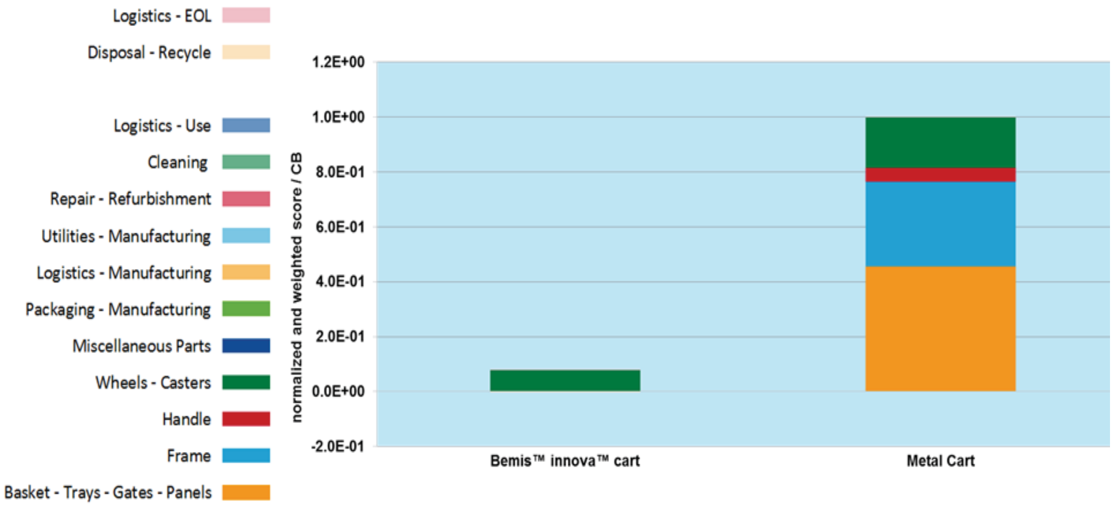


Figure 19. Risk potential (occupational illnesses and accidents) – per module

8.1.10. Environmental Fingerprint:

Following normalization or normalization and weighting with regards to the emissions categories, the relative impact for all seven of the main environmental categories for each alternative is shown in the environmental fingerprint, Figure 20. A value of “1.0” represents the alternative with the highest impact in the referenced category; all other alternatives are normalized against this value and given a normalized value less than 1.0. Positions closer to the center of the fingerprint reflect lower impact in that specific environmental category.

As presented in the previous discussions of the individual impact categories and depicted in the environmental fingerprint, the Bemis™ innova^{TM} retail shopping cart demonstrated reduced overall environmental impacts in all environmental categories for the base case analysis. The key factors influencing the reduced overall environmental impact are the cart’s longer durability, lower manufacturing impacts and reduced maintenance/repair requirements.

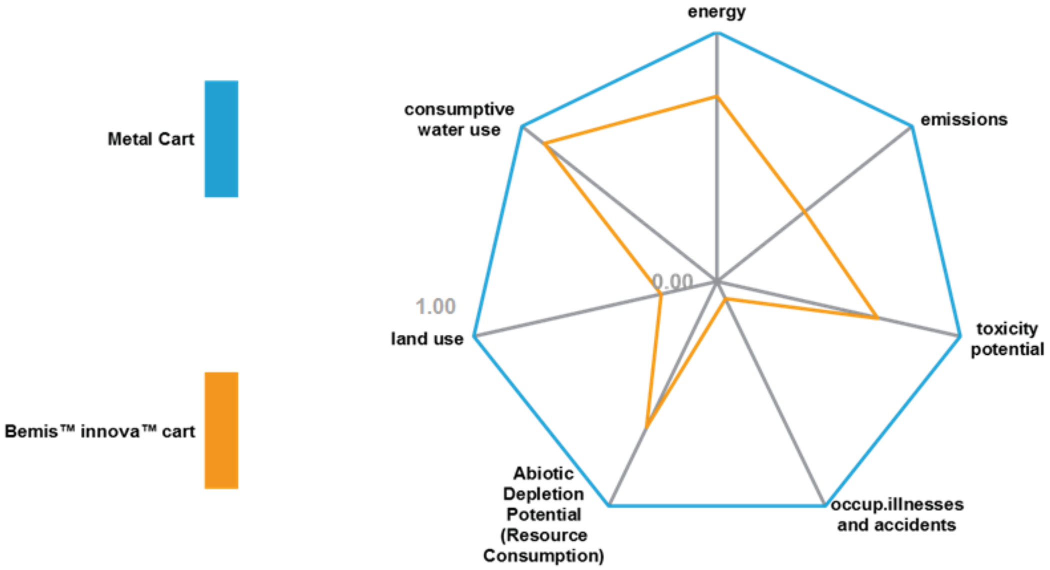


Figure 20. Environmental fingerprint

8.2. Economic Cost Results:

The life cycle cost data for the retail shopping cart EEA are generated as defined in Section 7 of the BASF EEA methodology and described in Section 6.2, above. The results of the life cycle cost analysis are depicted in Figure 21 and demonstrate that the alternative with the lowest life cycle costs was the Bemis™ innova$^{\text{TM}}$ shopping cart alternative. This difference was driven by the fact that the Bemis™ innova™ cart is more durable and has less on-going maintenance and repair costs. From an initial purchase price, the Bemis™ innova$^{\text{TM}}$ full size cart is about 65% more expensive than the metal cart and the Bemis™ innova$^{\text{TM}}$ convenience cart is about 33% more expensive than its metal counterpart. However, from an ownership perspective, the life cycle costs for maintaining the defined fleet of innova$^{\text{TM}}$ shopping carts is over 15% less expensive than the fleet of metal shopping carts. Being twice as durable (10 years vs. 5 years) means less plastic shopping carts need to be purchased over the 15 year life cycle. Though the purchase price of the Bemis™ innova$^{\text{TM}}$ cart dominates its total cost of ownership (70% of the cost), the metal cart incurs high expenses with maintenance and refurbishment (almost 45%). Specifically, the maintenance and repair requirement for the metal cart is over 5x the cost for the Bemis™ innova$^{\text{TM}}$ shopping carts. Both carts have the same expenses related to cart cleanings.

The base case analysis for this study shows that there is financial incentive for a retail store to purchase and maintain a fleet of Bemis™ innova$^{\text{TM}}$ shopping carts than metal shopping carts.

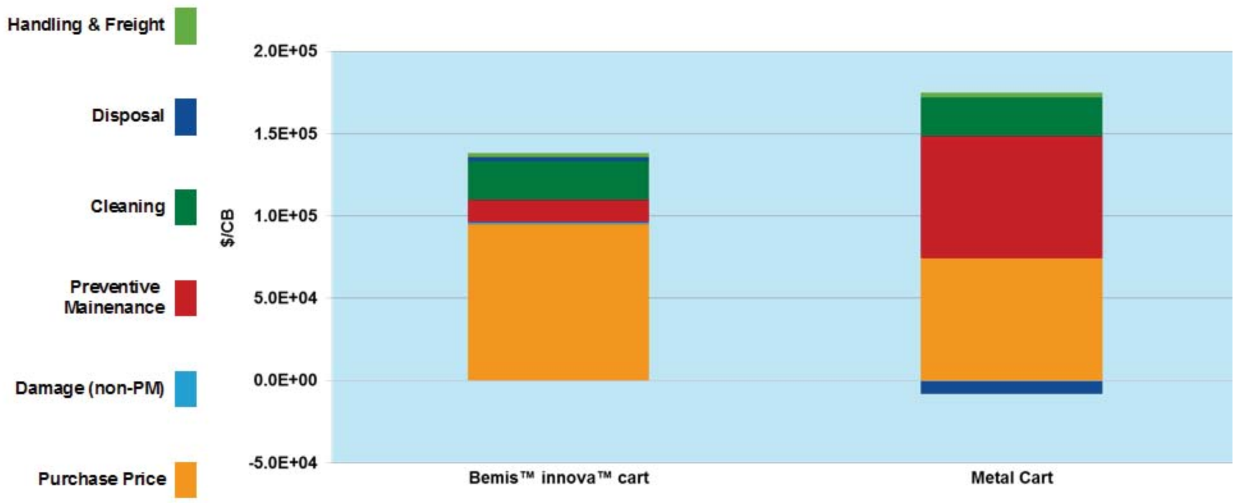


Figure 21. Life cycle costs - modules

8.3. Eco-Efficiency Analysis Portfolio:

The eco-efficiency analysis portfolio for the Retail Shopping Cart EEA has been generated as defined in Section 9.5 of the BASF EEA methodology. Utilizing relevance and calculation factors, the relative importance of each of the individual environmental impact categories are used to determine and translate the fingerprint results to the position on the environmental axis for each alternative shown. For clearer understanding of how weighting and normalization is determined and applied please reference Section 8 of BASF's Part A submittal to P-352. Specific to this study, the worksheets "Relevance" and "Evaluation" in the EEA model provided to NSF as part of this verification process should be consulted to see the specific values utilized and how they were applied to determine the appropriate calculation factors. Specific to the choice of environmental relevance factors and social weighting factors applied to this study, factors for the USA (national average) were utilized, as this was the intended target market/audience for the use of the materials. The environmental relevance values utilized were last updated in 2013 and the social weighting factors were last updated in 2011 by an external, qualified third party organization.

Figure 22 displays the eco-efficiency portfolio for the base case analysis and shows the results when all seven individual environmental categories are combined into a single environmental score and combined with its respective life cycle cost impact. Because environmental impact and cost are equally important, the most eco-efficiency alternative is the one with the furthest perpendicular distance above the diagonal line moving in the direction of the upper right hand quadrant. The results from this study find that the Bemis™ innova^{TM} shopping cart was more eco-efficient solution when compared to the standard metal shopping cart. Combining both its life cycle cost benefit with its superior environmental profile enabled the innova^{TM} carts to be the most eco-efficient solution for a retail shopping center. The eco-efficiency advantage was over 30%.

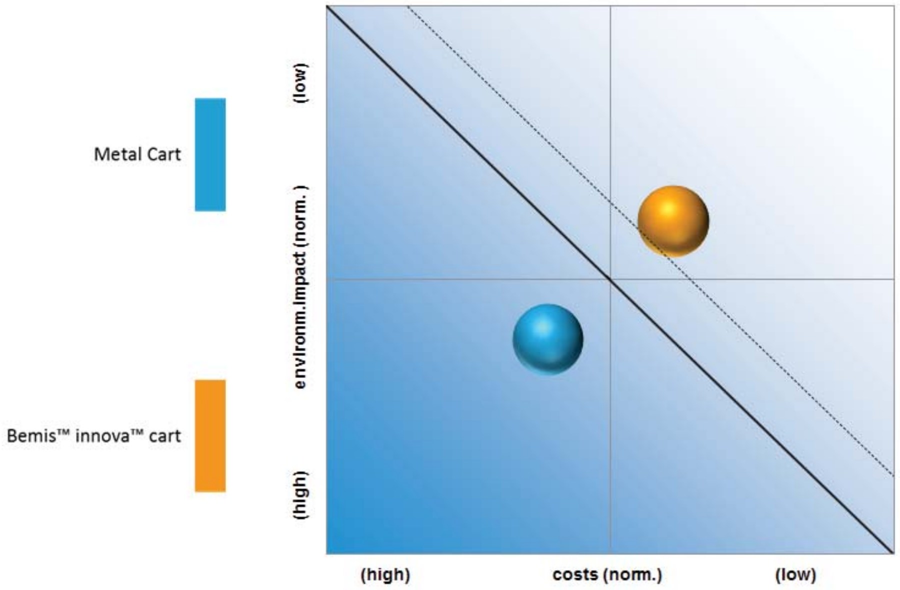


Figure 22. Eco-efficency portfolio base case analysis – retail shopping cart

8.4. Scenario Analysis:

8.4.1. Scenario 1: Influence of product durability

This scenario looks at the impact of product durability on the overall economic and environmental impact of the alternatives. For the base case analysis industry averages and expert opinion was used to establish the respective durability of the carts to be 10 years for the Bemis™ innova^{TM} cart and 5 years for the metal cart.

Keeping all other assumptions constant, Figure 23 reflects the revised portfolio when the durability of the metal cart is increased by 50% to 7.5 years. This change to durability improves the metal carts environmental and economic position relative to the plastic cart by over 25%. As reflected in the portfolio, both alternatives are almost equivalent with regards to eco-efficiency with the Bemis™ innova™ cart having about an 8% advantage. The metal cart has a 2% cost advantage but trails in environmental performance by almost 35%. Impacts related to cart production and refurbishment are minimized with the increased durability. Finally, decreasing the number of new carts that need to be purchased over the 15 year life cycle helps decrease the metal cart's overall total cost of ownership.

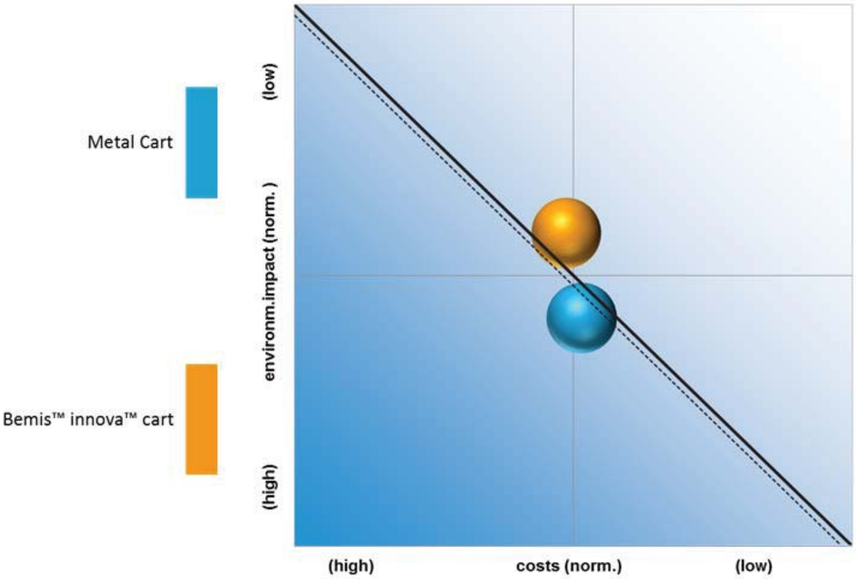


Figure 23. Scenario 1: durability increase of metal cart by 50% to 7.5 years

The last durability scenario looks at the case where the metal cart achieves its maximum durability (7.5 years) and the Bemis™ innova™ cart achieves its lowest expected durability (7.5 years). In this case the eco-efficiency of both alternatives is equivalent. Figure 24 shows that the 11% economic benefit of the metal cart is off-set by the 35% environmental advantage of the Bemis™ innova™ cart

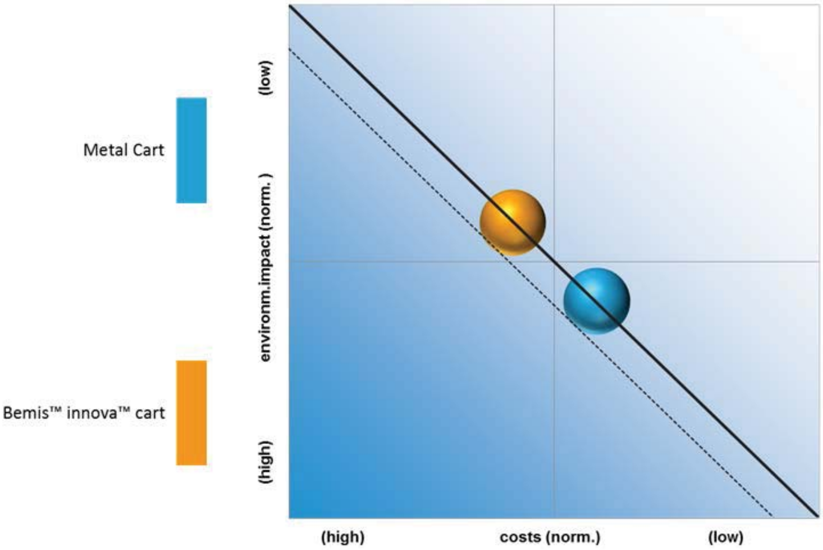


Figure 24. Scenario 1: both carts with durabilities of 7.5 years

8.4.2. Scenario 2: Cleaning frequency of carts

This scenario analysis evaluates the impacts of cleaning the carts. Cart cleanings have a significant impact on the key environmental impact categories of energy consumption, consumptive water use and greenhouse gas emissions. A single reduction in cart cleanings/year for an alternative can have significant impact on its environmental profile. In addition, cart cleanings contribute about 15% to the life cycle cost of a cart. Thus, reductions in cart cleanings while still maintaining the cleanliness of the cart will enhance a carts eco-efficiency.

By reducing cart cleanings by one time per year, both carts were able to reduce their environmental impacts by 6% and decrease their respective life cycle costs by around 5%.

8.4.3. Scenario 3: Refurbishment rate of carts

This scenario looks at the refurbishment rate for the metal carts. Rather than purchase a new metal cart which would require additional resources, energy and emissions, existing carts can be refurbished to an almost "as-new" condition. This scenario looks at the impact of increasing the base case refurbishment rate from 40% to 75%. As shown in Figure 25 the overall eco-efficiency of the metal cart alternative increases but still trails the Bemis™ innova^{TM} cart by over 25%.

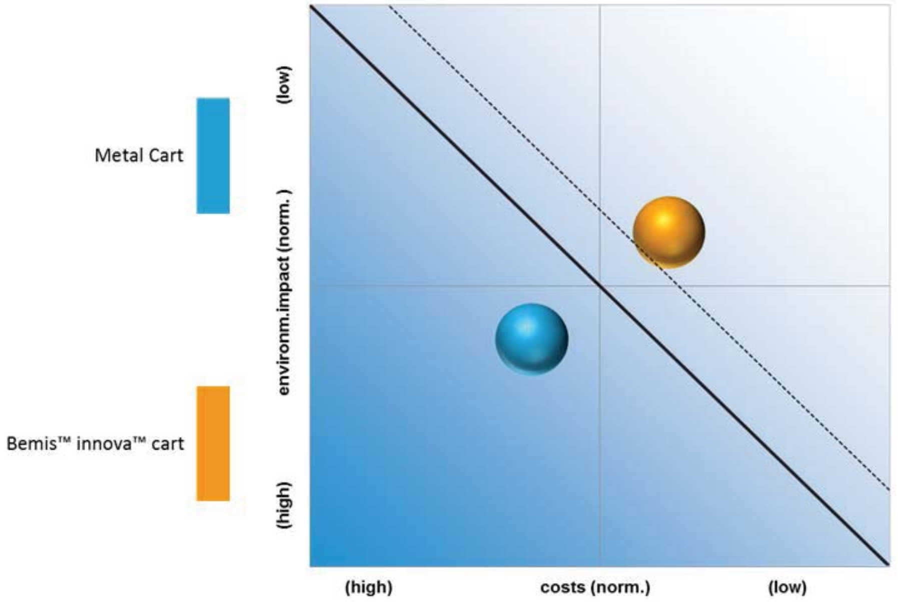


Figure 25. Scenario analysis 3: Increase refurbishment rate of metal carts to 75%

8.4.4. Scenario 4: Wheel replacement frequency for metal cart

As was discussed in the previous sections, the economic and environmental impact of the wheels is a significant contributor to the overall impact of the cart. This scenario looks at increasing the durability of the wheels for the steel cart from 2 years to 5 years. Thus, the wheel replacement costs and durability will be equivalent for both alternatives. Figure 26, shows the significant improvement of the metal cart alternative in both the economic and environmental areas. The metal cart improves its relative eco-efficiency and now only trails the Bemis™ innova™ solution cart by around 10%.

Even with an increase from 2 years to 3 years, the eco-efficiency of the steel cart can be improved. With a three (3) year durability, the metal cart improves both its overall economic and overall environmental profile by over 10%.

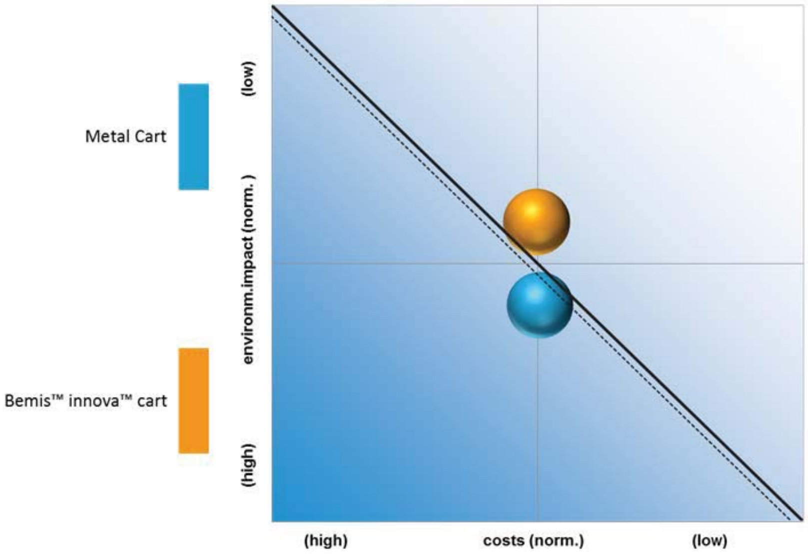


Figure 26. Scenario analysis 4: Increased durability of steel cart wheels to 5 years

9. Data Quality Assessment

9.1. Data Quality Statement:

The data used for parameterization of the EEA was sufficient with most parameters of medium to high data quality. Moderate data is where industry average values or assumptions pre-dominate the value. No critical uncertainties or significant data gaps were identified within the parameters and assumptions that could have a significant effect on the results and conclusions. Table 8 provides a summary of the data quality for the EEA while Table 9 lists the data sources for the life cycle inventory

Parameter	Quality Statement	Comments
Polyamide 6	High	Known formulation based on BASF company data.
HDPE, PP, PC resins	Medium - High	Industry average; Plastics Europe, 2012
Butadiene rubber	Medium – High	Industry average; Boustead database
Metal cart tubing and wire rod	High	Manufacturer's data for weights and dimensions; World Steel Association, 2013
Steel product manufacturing, welding, bending and coating	Medium	Manufacturer's data for weights and dimensions. Industry average; region Europe
Plastic cart Manufacturing	High	Bemis manufacturing plant data for impacts and emissions
Cart wheels	Medium – High	Known material construction and weight from mfg.
Seat belts	Medium – High	Known material construction and weight from mfg.
Impacts of material at disposal	Medium - High	Specific landfill and incineration profiles for plastic and steel. Industry average. Region Europe
Waste water	Medium	Industry data. Assumed values are reasonable given the scope and goals of the study.
Logistics	Medium – High	Specific supply chain routes
Cart Cleaning	Medium – High	Standard industry equipment
Cart durability	High	Industry data; industry expert opinion
Cart repair requirements	High	Industry expert opinion
Cart purchase price and on-going repair / cleaning costs	High	Manufacturer's data
Landfill / Incineration Costs	Medium – High	National average data report by government agencies and trade industry data

Table 8. Data quality evaluation for EEA parameters

Eco-profile	Source, year	Comments
Ultramid 8233	BASF, 2013	
HDPE, PC, PP resins	Plastics Europe, 2005-2012	
Finished Cold rolled wire rod/coil, with recycling	World Steel Assoc. 2013	
Steel product manufacturing, bending, welding, coating	ecoinvent, 2005	Region Europe
Butadiene rubber	BASF BEST database, 2001	
Transport, Truck	Global / PE International, 2011	
Transport, Rail	US Average / 1998	
Transport – Sea Freight	US Average / 1998	Most reliable data available
Detergent	BASF BEST database, 2014	Typical institutional cleaning detergent
Well Water	BASF BEST database, 2010	
Natural Gas	BASF BEST database, 2009	US Average
Electricity	BASF BEST database, 2011	US national grid
Gasoline - use	BASF BEST database, 2012	United States, 2002
Plastic / Steel to Landfill	BASF BEST database, 2012	ecoinvent 2012; sanitary landfill
Plastic to incineration	BASF BEST database, 2012	ecoinvent 2012; municipal
Waste water (direct to storm sewer)	BASF BEST database, 2005	US

Table 9. Life cycle inventory data sources

10. Sensitivity and Uncertainty Analysis

10.1. Sensitivity and Uncertainty Considerations:

A sensitivity analysis of the final results indicates that the economic impacts were slightly more influential or relevant in determining the final relative eco-efficiency positions of the alternatives. This conclusion is supported by reviewing the BIP Relevance (or GDP-Relevance) factor[7] calculated for the study. The BIP Relevance indicates for each individual study whether the environmental impacts or the economic impacts were more influential in determining the final results of the study. For this study, the BIP Relevance indicated that the economic impacts were more influential in impacting the results than the environmental impacts (reference the “Evaluation” worksheet in the Excel model for the BIP Relevance calculation).

As the data quality related to the main cost contributors identified in Table 8 were of medium to high quality, we were confident in the final conclusions indicated by the study.

Though the economic impacts were the most significant, the environmental impacts still influence the overall eco-efficiency of each alternative. A closer look at the analysis (Table 10) indicates that the impacts with the highest environmental relevance were cumulative energy consumption, water emissions, global warming potential and acidification potential. This is to be expected, as cart production, cleaning and refurbishment are energy and resource intensive. The durability of the carts, their expected repair/refurbishment requirements and the frequency of cleaning are the main assumption that impacts these key categories. Data quality related to this information was also strong at a level of medium to high quality.

The calculation factors (Table 10), which consider both the social weighting factors and the environmental relevance factors, indicate which impact categories were having the largest effect on the final outcome. Calculation factors are utilized in converting the environmental fingerprint results (Figure 20) into the final, single environmental score as reflected in our portfolio (Figure 22). The impacts with the highest calculation factors were cumulative energy demand, water emissions, abiotic resource depletion and toxicity and risk potential. The input parameters that were related to these impact categories have sufficient data quality to support a conclusion that this study has a low uncertainty.

The social weighting factors had an influence in adjusting the relative weightings of a few impact categories namely air emissions (GWP, AP), consumptive water use and water emissions. Higher societal relevance for consumptive water use and resource consumption helped increase their respective weighting relative to the other key impact categories. In addition, the lower social weighting values for water emissions, global warming potential and acidification potential helped to decrease their overall weighting compared to the other key impact categories.

Environmental Impact Category	Environmental Relevance Factor	Social Weighting Factor	Calculation Factor	Significance
Toxicity Potential	NA	19.3%	19.3%	HIGH
Cumulative Energy Consumption	22.1%	13.8%	17.5%	HIGH
Water Emissions	23.5%	7.6%	13.4%	HIGH
Abiotic Resource Depletion	8.6%	15.0%	11.3%	HIGH
Risk Potential	NA	10.6%	10.6%	HIGH
Consumptive Water Use	3.2%	15.4%	7.0%	MEDIUM
Solid Waste	8.3%	5.0%	6.5%	MEDIUM
Global Warming Potential	14.7%	1.6%	4.9%	LOW
Acidification Potential	12.0%	1.6%	4.4%	LOW
Summer Smog (POCP)	6.6%	1.4%	3.0%	LOW
Land Use	0.2%	7.4%	1.1%	LOW
Ozone Depletion Potential	0.8%	1.3%	1%	LOW
TOTAL:	100%	100%	100%	

Scale:

> 10%	HIGH
5 – 10 %	MEDIUM
< 5%	LOW

Table 10. Environmental relevance factors, social weighting factors, calculation factors and significance used in the sensitivity and uncertainty analysis

10.2. Critical Uncertainties:

There were no significant critical uncertainties from this study that would limit the findings or interpretations of this study. The data quality, relevance, and sensitivity of the study support the use of the input parameters and assumptions as appropriate and justified.

11. Limitations of EEA Study Results

11.1. Limitations:

The eco-efficiency analysis results and the conclusions are based on the specific comparison of the production, use, and disposal phases, for the described customer benefit, alternatives, system boundaries and specific study assumptions. Transfer of these results and conclusions to other production methods or products is expressly prohibited. In particular, partial results may not be communicated so as to alter the meaning, nor may arbitrary generalizations be made regarding the results and conclusions.

12. References

[1] Shopping Carts Preventive Maintenance: Important things to consider; Roche, Jesse, Sales & Marketing Dir.; Jimco Maintenance Inc. http://www.jimcos.com/case_for_pm.html

[2] Delco Cleaning Systems; Delco Versa Super Skid rev 8-09. 2009 www.delco-cleaning.com

[3] LCI data for steel products; Sebastian, Brandi M.; World Steel Association. 2014

[4] http://www.eia.gov/petroleum/gasdiesel/

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