BASF
The Chemical Company

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

Incontinence Bed Pads Eco-Efficiency Analysis Final Report – October 2012

Submitted by:

BASF Corporation
100 Park Avenue, Florham Park, NJ, 07932

Prepared by:

Bruce Uhlman, Senior Sustainability Specialist

J. Patrick Harmon, Industry Manager

Robert Drake, Senior Product Steward

T. Steven Wood, President & CEO, Vintex, Inc.

Paul Helsby, VP Sales & Marketing, Vintex, Inc.

Paul Hruska, Mgr. Regulatory Compliance & Mfg. Support, Vintex, Inc.

Kasper Van Veen, VP Research & Prod Development, Vintex, Inc.

Table of Contents

1. Purpose and Intent of this Submission

1.1. The purpose of this submission is to provide a written report of the methods and findings of BASF Corporation's "Incontinence Bed Pads 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 Incontinence Bed Pads Eco-effiicency 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/business/eco_efficiency/index.asp?program=EcoEff or http://www.basf.com/group/corporate/en/sustainability/eco-efficiency-analysis/index

2. Content of this Submission

2.1. This submission outlines the study goals, procedures, and results for the Incontinence Bed Pads Eco-efficiency Analysis (EEA) study, which was 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 energy and resource consumption, emissions, toxicity potential, 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.

3.2. Preconditions:
The basic preconditions of this eco-efficiency analysis are that all alternatives that are being evaluated are being compared against a common functional unit or customer benefit. 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 functional unit and consider both the environmental and economic impacts of each alternative over their life cycle in order to achieve the specified customer benefit. 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. An overview of the scope of the environmental and economic assessment carried out is defined below.

3.2.1. Environmental Burden Metrics:

For BASF EEA environmental burden is characterized using eleven categories, at a minimum, including: primary energy consumption, raw material consumption, greenhouse gas emissions (GHG), 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 yellow represent the six main categories of environmental burden that are used to construct the environmental fingerprint, burdens in blue represent all elements of the emissions category, and green show air emissions.

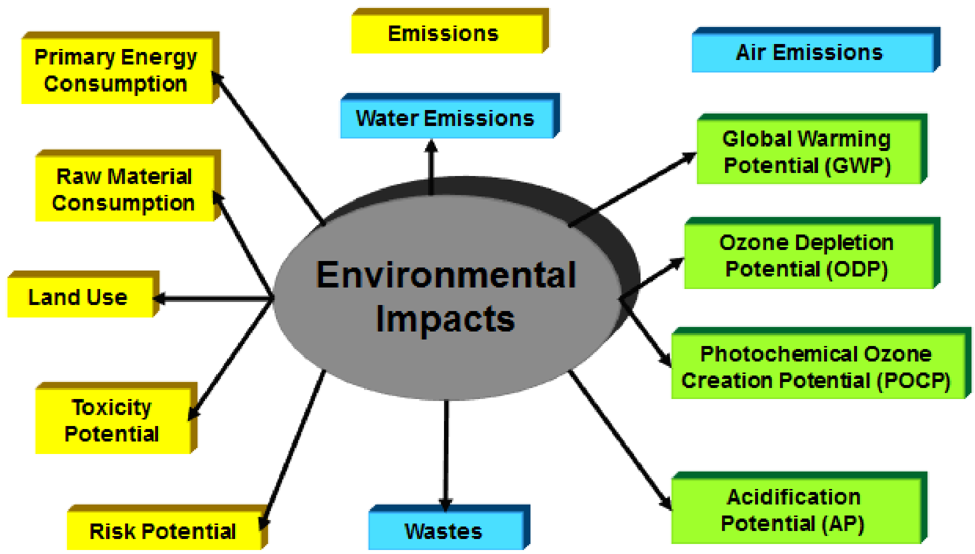

Figure 1: Environmental Impact categories

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. When different production methods are compared, the relevant costs include the purchase and installation of capital equipment, depreciation, and operating costs. The costs incurred are summed and combined in appropriate units (e.g. 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.

3.3 Work Flow:
A representative flowchart of the overall process steps and calculations conducted for this eco-efficiency analysis is summarized in Figure 2 below.

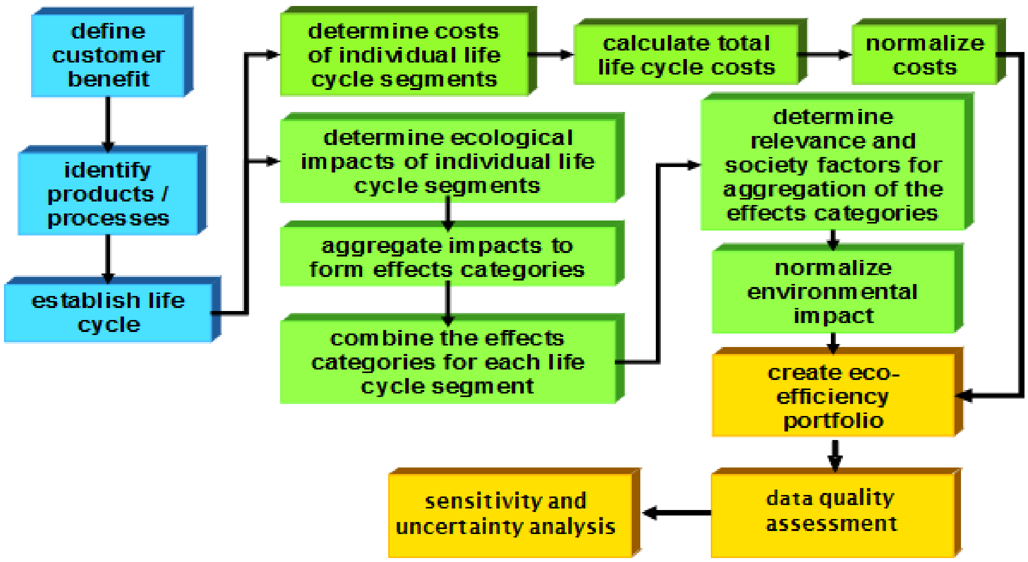

Figure 2: Overall process flow for Incontinence Bed Pad EEA study

4. Study Goals, Decision Criteria and Target Audience

4.1. Study Goals:
Healthcare facilities and hospitals are not alone in their quest to increase the sustainability of their businesses by reducing the impacts of their operations and purchasing decisions on the environment as well as their instituition's financial bottom line. Like many industries, the healthcare industry has long debated the pros and cons between reusable and disposable textiles. Issues around responsible use of resources, energy consumption, laundering activities, total cost of ownership and waste generation have been at the forefront of this debate. The goal of this study will be to holistically and scientifically compare the environmental and economic life cycle impacts of one range of products in this category, incontinence pads used in an institutional environment (e.g. hospital, long-term care facility). Specifically, the study compares two different kinds of domestically produced reusable vinyl technologies with an imported reusable vinyl technology and two kinds of conventional disposable technologies.

The study considered the use of these incontinence pads in the United States market as a whole with no specific focus on one region (e.g. Southwest, Northeast). Thus, average national data was used for key study input parameters such as material costs, average fuel price, etc.

Study results will allow for a comprehensive comparison of the key environmental and economic drivers for each alternative: the initial manufacturing and on-going laundering impacts (environmental & economic) of reusable bed pads and the initial manufacturing and end of life impacts of disposable pads.

Study results will be used as the basis to guide product development in the area of more eco-efficient incontinence pads as well as support external marketing claims around the environmental and economic benefits of the various incontinence pad technologies. The Eco-efficiency methodology will facilitate the clear communications of the study results to key stakeholders in the healthcare and textile industries, their respective trade associations and can also support the overall education and awareness on this topic to the end consumer.

4.2 Decision Criteria:
The context of this EEA study compared the environmental and cost impacts for reusable and disposable technologies for incontinence protection. The study goals, target audience, and context for decision criteria used in this study are displayed in Figure 3.

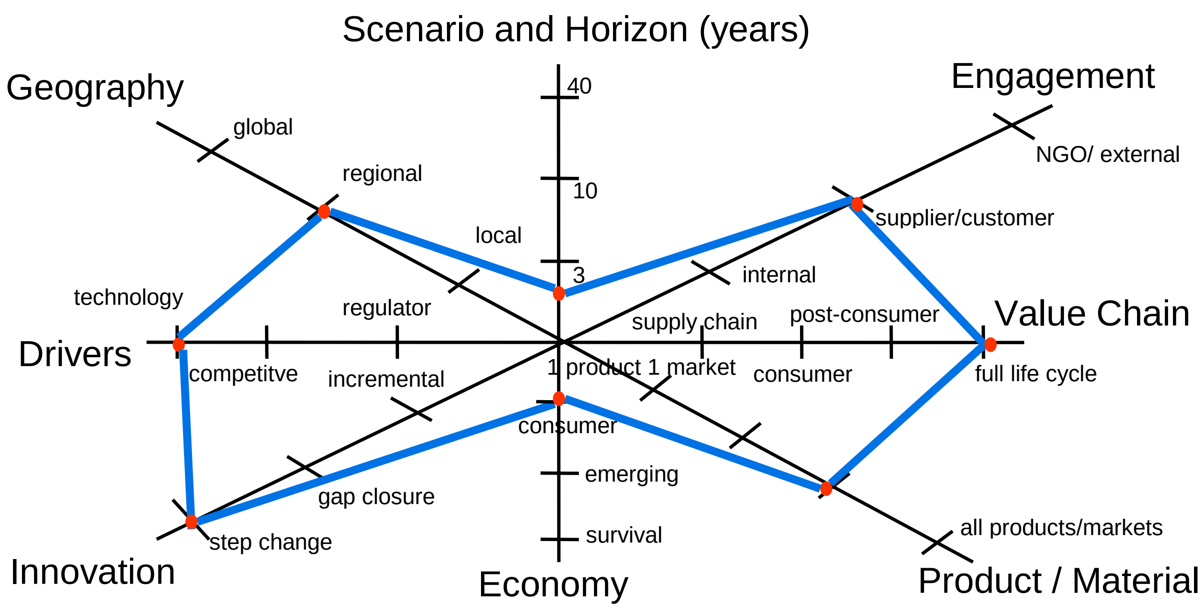

Figure 3: Context of Incontinence Bed Pads Eco-Efficiency Analysis

4.3. Target Audience:
The target audience for the study has been defined as healthcare professionals, hospitals, nursing home and long-term care facility managers, the healthcare textile maintenance industry, related healthcare trade associations and the end consumer. It is planned to communicate study results in marketing materials and at trade conferences.

5. Customer Benefit, Alternatives and System Boundaries

5.1. Customer Benefit (CB):

The Customer Benefit (identified also as CB) or Function Unit (FU) applied to all alternatives for the base case analysis is to provide barrier protection from liquid human voids from an average adult (1,500 ml/day)[1] over 1,000 patient days while additionally providing the ability to reposition/move the patient on the bed.

The above functional unit was selected to best address the actual use of incontinence pads in institutional applications with 1,000 patient days being sufficiently long enough to allow full consideration of the durability of the reusable bed pad alternatives. Other product performance attributes (e.g. wicking, absorption, prevention of bed sores) and physical appearance attributes (e.g. staining, odour, lay flat etc.) were deemed by industry experts as equivalent for all alternatives and thus were outside the study's scope.

5.2. Alternatives:

The product alternatives for incontinence protection defined in the customer benefit and compared under this EEA study cover (1) domestically produced loose back reusable vinyl pads (2) domestically produced bonded vinyl reusable pads (3) imported loose back reusable vinyl pads (4) standard disposable bed pads and patient positioners (5) extra absorbency disposable bed pads and patient positioners.

Specific to the reusable vinyl alternatives, the loose back alternative is the lightest of the three reusable alternatives. The bonded vinyl alternative is about 40% heavier than the domestic loose back while the imported loose back is the heaviest about 55% more than its domestic loose back counterpart. Considering durability relative to the domestically produced loose back reusable vinyl pad, the heavier bonded vinyl alternative shows an improvement of around 25% while the imported loose back reusable vinyl pad has the lowest durability of the reusable alternatives and is 50% lower than the domestically produced loose back vinyl. The improved durability for the bonded vinyl alternative is due to the extra backing/barrier material while the decreased durability for the imported loose back vinyl pad is due to poorer technology and manufacturing quality.

Relative to the standard disposable alternative, the extra absorbent disposable alternative has enhanced design features and materials that allow for improved absorbency and leakeage protection thus allowing for reduced usage relative to the standard option.

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. The system boundary for the reusable incontinence bed pad system is depicted in Figure 4, while the disposable incontinence bed pad system is depicted in Figure 5.

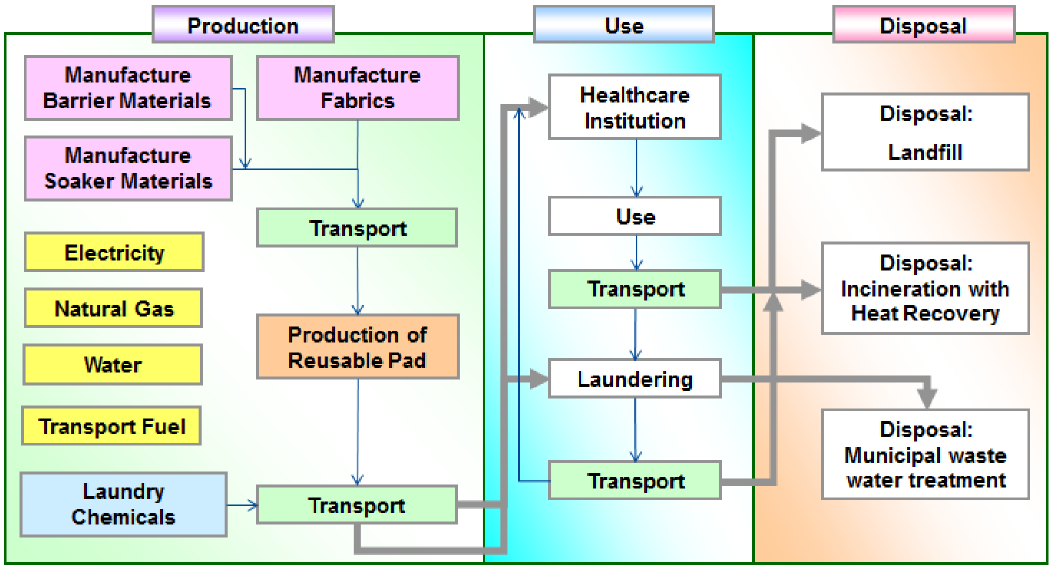

Figure 4: System boundary – Reusable Incontinence Pads

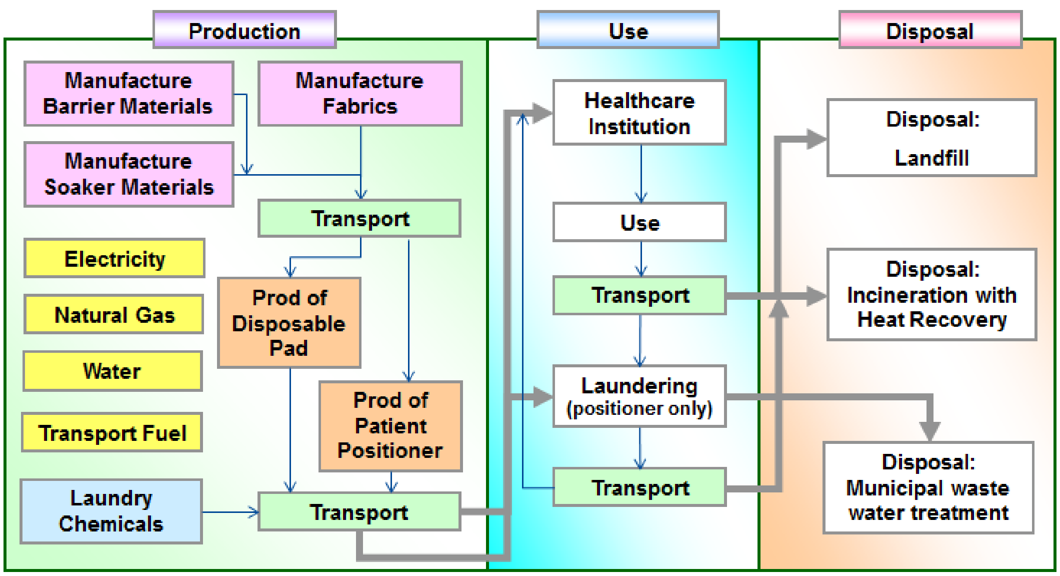

Figure 5: System boundary – Disposable Incontinence Pads (and Patient Positioners)

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:

Adjustment in the durability of the various reusable incontinence pads based on industry expert opinions. Relative durability in comparison to the base case assumptions increases for all reusable alternatives.

5.4.2. Scenario #2:
Removal of the patient positioner from the disposable alternatives.

5.4.3. Scenario #3:
Evaluation of a disposable bed pad that is designed to function as both a barrier protector and a patient positioner.

5.4.4 Scenario #4:
Inclusion of caregiver's/nurse's time in total cost calculations.

5.4.5 Scenario #5:
Sensitivity around purchase price assumptions for alternatives.

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 characteristics. Absolute input values as opposed to differential values were utilized.

6.1.1. Structure and Material Compositions:
The overall structure of both a disposable and reusable incontinence pad is quite similar as the functionality of the various layers are generally the same. Figure 6 depicts the general cross section of a typical incontinence pad. The first layer is the top sheet, which can either be a woven or knit (e.g. polyester, cotton) or non-woven material (e.g. spunbond polypropylene). This layer contacts the patient's skin and thus comfort and its ability to wick liquid away from the skin are important. The surface weight of the material (grams/m^2) can vary depending on the type of material used, with the weight for the reusable alternatives being significantly heavier. The next layer is the soaker material, which is designed to hold moisture. Reusable soakers generally consist of a blend of rayon and polyester, thus allowing them to be reused after cleaning. Soakers of disposable incontinence pads are predominately made up of fluff pulp (cellulose fibers) and super absorbent polymer/fibers, which only allow for a single use. Finally, the backsheet acts as a fluid barrier and is made from PVC coated polyester knit for the reusable pads and either polyethylene film or spunlace polypropylene for the disposable alternatives. Similar to the top sheet, the suface weight of the backsheet for the reusable pads is significantly heavier than for the disposable pads, thus lending to its durability.

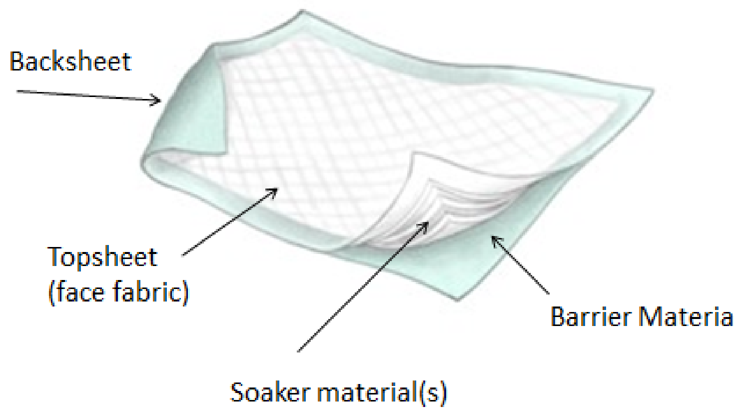

Figure 6: Generic Schematic – Incontinence Pad

Other minor components, which served to either bind the layers together or improve leakage protection to name a few, were also considered in this analysis.

For this study, standard industry sized pads of the following dimensions 31”-34” (L) x 36” (W) were used as basis for comparison.

The actual weights and type of materials used for each alternative were obtained through either detailed Bill of Materials (BOM) or from analytical laboratory reports. Full compositional data was provided to NSF International in support of this verification but are not directly included in this report in order to protect company confidential information. Table 1 shows the indicative weights for the various functional layers of an incontinence bed pad. As to be expected, the more durable reusable pads are significantly heavier and have higher soaker weights than their disposable counterparts.

	Layer Weights (grams / m^2)	
	Reusable Pad	**Disposable Pads**
Layer		
Topsheet	130 - 220	20 – 40
Soaker	240 - 380	120 – 140
Barrier	150 - 350	(included in backsheet)
Backsheet	60 - 90	30 – 40
(indicative) Total Weight	575 - 890	190 – 210

Table 1: Indicative Weights of Incontinence Pad Alternatives

An additional functional attribute that is provided inherently by the reusable bed pad is its ability to assist patient caregivers in being able to perform handling tasks such as the safe movement of the patient while also reducing the risks of injuries to the neck, shoulder or back of the caregivers that could occur during manual repositioning of patients. As the disposable beds are not strong enough to move the patient by themselves, another item must be included in the disposable incontinence pad system in order to compensate for this. The eco-efficiency project team agreed that the most common place item in healthcare facilities that serves this purpose is a standard 51" x 72" draw sheet (i.e., patient positioner), which is comprised of a cotton/polyester blend[2]. This draw sheet is placed over the bottom bed sheet and in addition to assisting the lifting or movement of the patient, it also protects the bottom sheet from potential soiling.

6.1.2. Manufacturing Data:

Surveys were completed for the manufacturing process of the domestically produced reusable incontinence pads. The survey accounted for the manufacturing inputs (raw materials, energy, utilities etc.) as well as outputs (final product, solid waste streams, air emissions etc.) generated during the production phase of the lifecycle for the reusable pads. This information was used to generate the eco-profiles for these end products. This information is confidential to the manufacturer and thus not disclosed here but has been disclosed to NSF International as part of the study verification process.

Though it was not possible to obtain similar primary manufacturing data for the imported loose back vinyl pad, it was conservatively assumed that the manufacturing inputs (e.g. energy, raw materials) and outputs (e.g. emissions streams) data for the imported vinyl reusable incontinence pad were similar to its domestically produced counterpart, as their product structures are similar. This is a conservative assumption as the predominant manufacturing region for these pads is Asia, where the general trends indicate that indicators around our impact categories emissions, energy consumption, risk, etc. for similar products are generally higher than in North America.

Industry average data was used for the manufacuring impacts and emissions for the disposable alternatives.

6.1.3. Usage:

Incontinence pads are used to protect bed linen and mattresses from patient incontinence and other liquid discharges. Equally important is the ability for the incontinence pad to aid the caregiver in patient repositioning several times throughout a 24 hour period to maintain skin integrity. In order to ensure proper coverage and protection, many factors such as the size of the bed pad, the amount and type of soaker material in the incontinence pad, and the functionality of the fabric material related to breathability and its ability to wick moisture away need to be considered.

The nature of and the capacity of the soaker material in the reusable alternatives allows for the incontinence pad to maintain its absorbency and other functionality (e.g. wicking of moisture) even after it has been initially soiled with void material. Due to the absorption characteristics of the soaker materials in the disposable alternatives, disposable bed pads tend to become exhausted upon the initial contact with liquid void material and thus require frequent changing in order to ensure proper protection.

Finally, the basis for the frequency and amount of the average adult void was established at 375 ml of liquid four times per day for a total quantity of 1,500 ml[1]. Based on these considerations the following assumptions were made for the study alternatives usage amounts for the base case analysis:

- Reusable: though individual soaker capacity is sufficient to handle the 1,500 ml daily void amount, a likely scenario is that 2 reusable bed pads will still be used over a period of 24 hours. As such, 2 reusable bed pads are used per patient day.
- Standard Disposable: to ensure proper protection (and compensating for lower absorbency capacity) the standard disposable pads will be applied in tandem on the bed and removed after each void. Thus, 8 standard disposable pads will be used per patient day (i.e. two pads per void x 4 voids per day = 8 total pads).
- Extra Absorbent Disposable: to account for the enhanced absorbency and leakage protection of the disposable "extra" bed pad alternative, only one is required per void. Thus, only 4 disposable extra alternatives are required per patient day.

6.1.4. Durability:

An advantage of a reusable incontinence bed pad is its ability to withstand the repetitive rigors of institutional processing (laundering) and patient movement. How often the resuable pad can be used and still deliver desired performance is determined by many factors such as the type and weight of materials used in manufacturing the components, the quality of manufaturing, and the type of laundering process used, just to name a few. To establish a baseline durability value for the reusable vinyl bed pad, healthcare textile data, which is frequently collected by consultants to the industry, was utilized[2]. Referencing the section for Acute Healthcare Industry Nursing Textile items, a durability of around 47 uses was established for the item: pad, incontinent. This item is equivalent to the "loose back" vinyl alternative identified earlier as alternative 1. Usage data was not available for the other two vinyl alternatives so expert opinions and informal surveys of healthcare professionals knowledgeable about reusable incontinence pads was used to establish their respective durability values. General responses from these experts indicated an overall higher durability value for vinyl bed pads than what was being reported in the Phillips & Associates, Inc. report[2]. The team felt the base case analysis should stay with the more conservative values from the report but address the impact of potentially higher durability in the sensitivity analysis section (Section 10). However, the durability figures provided by the experts were used to scale the durability figures from the Philips & Associates, Inc. report for the other vinyl alternatives. Due to the higher weight of the vinyl backing/barrier material, the bonded vinyl alternative was given a durability of 60 uses, a 25% increase over the loose back vinyl. The imported loose back alternative has been documented to not hold up as well to institutional laundering and thus begins to lose performance signifcantly quicker than the domestically produced loose back vinyl bed pad. An average usage of 24 was selected for the imported vinyl bed pad, a 50% decrease from its domestic loose back alternative. In the same industry report[2], the durability for the draw sheet (item: Sheet, Draw, T-180, Sateen) was given approximately 31 uses.

The usage figures utilized above are based on the reported gross replacement factor, which encompasses more than just the failure of an item but also takes into consideration issues such as unrelated damage, theft, misuse etc. and is thus reflective of real use figures.

6.1.5. Laundering:

6.1.5.1. General Assumptions:
Properly laundering healthcare textiles is essential in order to ensure that they are free of any odours, any micro-organisms have been removed or reduced to acceptable levels and the items are free of stains. In order to achieve this, reusable textiles are washed following specific wash programs that ensure the specific and timely addition of wash chemicals, detergents, potable water, heating, mechanical action and a proper rinse cycle. For the laundering of incontinence pads from a healthcare facility, the common laundering technology and the basis for this study is a tunnel washer. A tunnel washer is a continuous batch washer that is specifically designed to handle large loads while efficiently using water and power.

6.1.5.2. Chemicals:
The overall washing procedure and chemical addition sequence and amounts were provided by a leading manufacturer of specialized laundry chemical products and reflective of institutional laundering conditions (i.e. tunnel washers). They were developed for very heavy soiled textiles such as incontinence pads. Operating cycles (i.e. flush, wash, bleaching, rinse etc.) and individual wash formulas were specified. In general, the chemicals added during the laundering process and thus modeled for this study included: alkali, detergent, bleach, sour and peroxide. The specific addition amounts are referenced in the manufacturer's specification document[3].

6.1.5.3. Energy Usage:
Key lifecycle use phase laundering impacts related to energy and water consumption amounts were based on institutional tunnel washers. Though highly automated, some variability does exist with regards to the energy and water usage amounts. Relevant LCAs, trade association figures, government research projects and expert opinions were evaluated in order to reach consensus on the energy and water usage figures for this study.

An LCA conducted by the European Textile Services Association (E.T.S.A.) in 2008[4] on laundered workwear showed the total consumption of heat energy (oil or gas) for institutional laundering averaging around 6.7 MJ/kg of laundered material (dry weight) with a maximum of 10 MJ/kg. Similarly, a peer reviewed LCA conducted by the Center for Design at RMIT University, which compared laundered and disposable gowns[5], estimated a combined energy consumption of 8.6 MJ/kg of natural gas and 0.4 MJ/kg electricity for a total of 9.0 MJ/kg. Considering these two relevant data sources a conservative value of 10 MJ/kg of laundered material was selected with a split between natural gas usage and electricity at 95/5. For determining the total energy consumption (as well as subsequent chemical usage amounts) the basis for the weight (kg) of laundered material used in the calculations is "dry" weight and does not include bound water or void material, which is normal industry practice and consistent with the basis established from the studies referenced.

6.1.5.4. Water consumption (usage):
The RMIT LCA study referenced above cited a water usage amount of 22 liters/kg of laundered material but includes a 40% water recycle rate, so the actual water consumption figure is slightly above 13 liters/kg. Similarly, a study conducted by the Leonardo Da Vinici Project[6] reported that the water consumption for laundering textiles from operating rooms and clean rooms (similar environments to our application) was between 10 – 20 liters/kg. Expert interviews of laundry professionals also confirmed the figure to be between 0.6 – 0.7 gallons/pound (18.5 liters/kg). The mid point of these values (15 liters/kg) established the basis for the base case analysis.

6.1.5.5. Waste water:
The eco-efficiency methodology accounts for all emissions into water bodies occuring during the production, use and disposal of the various materials used in the study. However, unique to this analysis is a specific and significant waste water stream generated during the use phase, which is the water discharge from the tunnel washers after the laundering of the reusable bed pads and the bed draw sheet. This liquid waste contains water, the chemicals used during laundering and the soiled material cleaned from the bed pad. The project assumed that the waste water flow would initially enter the sewer system and then enter a municipal waste water treatment facility where it would be treated and released into the environment. Due to similarities in the scope considered, the RMIT LCA study[8] was utilized to establish the final composition of the waste water discharged into the environment. Energy required to pump the waste water from the laundry facility into the sewer system was also included and estimated at 1.5 kWhr/ 1000 liters.

6.1.5.6. Frequency:
The reusable bed pads were laundered on a daily basis (two pads are laundered in a 24 hour period) while the draw sheet used for patient positioning for the disposable alternatives was laundered every other day (one sheet every 48 hours). This last assumption was based on expert judgment.

6.1.6. Transportation
The logistical impacts for movement of raw materials, finished products, laundering activities and end of life options were considered. The specific key logistical segments considered and their corresponding assumptions are presented in Table 2.

Life Cycle Phase	Method of Transport	Distance (km)
Production Phase		
Sourcing Basic Raw Materials	Truck	250
Shipment from Manufacturer to Distributor	Truck	250
Shipment from Distributor to Healthcare Facility	Truck	250
Imported Product s	Sea Freight	10,000
Use Phase		
Healthcare Facility to off-site Laundry Facility	Truck	75
Laundry Facility to Healthcare Facility	Truck	75
Disposal Phase		
Municipal Solid Waste Collection and transport to Landfill	Truck	100
Municipal Solid Waste Collection and transport to Incineration	Truck	100

Table 2: Logistical Assumptions for Key Life Cycle Components

6.1.7. Disposal Methods

Both liquid and solid wastes are generated during the various lifecycle stages for the various alternatives. As previously described in section 6.1.5.5 the liquid waste generated during the laundering process (water, void material, and cleaning chemicals) goes directly into the normal sewer collection system for treatment and ultimate discharge from the local municipal waste water treatment plant.

The key solid waste generated comes from the disposable bed pads, which includes both the pad itself and the voided material. Excluding the rare exceptions where the bed pads would be considered a regulated waste, the waste is normally classified as non-hazardous and disposed of in the normal municipal solid waste (MSW) stream. The latest statistics from the U.S. EPA[9], show that almost 12% of the collected MSW goes to combustion with energy recovery with the remainder going to either landfill or recovery. This will form the basis for our modeled disposal method for the alternatives. Specific to the potential energy recovery through incineration, the heating value of the disposable bed pad was estimated at 28 MJ/kg and the heating value for the reusable bed pad was estimated at 45 MJ/kg. As there are limited to no recovery options available for the discarded bed pads, it was assumed then that the remainder (88%) goes to landfill.

For transport considerations at end of life, the voided amount was included in the total weight of the bed pad for the disposable options but was not included for the reusable bed pad alternatives as they are usually ragged out or disposed of after being laundered.

6.2. Life Cycle Costs

The lifecycle cost for each alternative was mostly comprised of material costs, laundering costs and the costs of disposal. User costs for the system components of the bed pad and any required patient positioner (i.e., draw sheet) were utilized and as such fully accounts for all lifecycle costs incurred and profits realized. The key on-going cost associated with the reusable bed pads is the laundering costs. Expert user surveys were conducted and compared against data[13] tracked for the Textile Rental Service Association (T.R.S.A.) of America and both figures were consistent at about $0.55/pound of textile. This expense is all inclusive and includes all overheads and operating expenses for the laundry facility and the costs were similar across the range of facilities (e.g. textile rental service laundries, self-operated hospital laundries etc.).

Costs associated with disposal were based on current rates[12] for transfer and disposal of solid waste at municipal landfills. Costs or savings between the alternatives related to better inventory control and reductions to capital and storage costs were either not considered significant or too difficult to quantify by the project team to be considered in this analysis.

6.3. Further Assumptions

6.3.1. Packaging Systems

The bulk/merchandise packaging systems for the reusable and disposable bed pad alternatives were considered outside of the scope of this study. This is consistent with other studies[8] which compared disposable and reusable textiles in the healthcare industry, as the overall impact of the package relative to the other key lifecycle environmental impacts was minimal.

6.3.2. Pressure Ulcers / Bed Sores

For patients confined to beds for long periods of time, areas of skin can break down when moisture is present and something keeps rubbing or pressing against the skin. This pressure on the skin can cause loss of blood flow and the subsequent formation of ulcers. In addition to the pain and discomfort, the treatment of bed sores can be quite expensive depending on the stage and severity with costs[14] estimated at a few hundred dollars to several thousands per occurrence. Bed pads based on their ability to minimize pressure points and keep the patients skin dry through wicking moisture away could help reduce the likelihood of occurrence or the severity of bed sores and thus could significantly add to the economic value proposition of bed pads. However, given that various face fabric and soaker combinations are available to both reusable and disposable bed pad manufacturers the project team based upon expert opinion concluded that performance attributes (e.g. wicking and absorption) would be equal between reusable and disposable technologies and thus for this analysis this topic was deemed outside the scope of work.

6.3.3. Time and Cost associated with changing frequency

A potential significant cost element that warrants consideration is the labor cost component associated with the healthcare professional's/nurse's time required for the activities related to the changing of the bed pads throughout the day. Intuitively, if a bed pad requires a greater frequency in inspections and related changing activities over the day, the nurse or healthcare professional will need to allocate a larger part of their daily workload to these activities. Thus, bed pads which require less on-going care and oversight could increase the nurse's productivity during their shift which could lead to potential cost savings. Scenario # 4 presented in Section 10 will look at the sensitivity of the study results based on whether an economic value is placed on the extra time per day a nurse must attend to disposable bed pads versus reusable bed pads.

6.3.4. Fluff Production

Previously, bleaching of pulp using elemental chlorine produced and released into the environment large amounts of chlorinated organic compounds. As a result, the industry worked to develop technologies that reduce the amount of elemental chlorine used. Today, over 80% of the bleached fluff pulp is produced using the ECF (Elementary Chlorine Free) process, a more environmentally favorable technology. Only about 5% of the fluff pulp produced uses the TCF (Totally Chlorine Free) process. Thus for this study, the ECF process was modeled for the base case analysis as it best represents the current state of the art production process.

7. Data Sources

The environmental impacts for the production, use, and disposal of the various alternatives were calculated from eco-profiles (a.k.a. life cycle inventories) for the individual system components (e.g. bed pads, draw sheets) and activities (e.g. laundering activities, logistics) occuring over the lifecycle. Lifecycle 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-high 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 3.

Eco-Profile	Source, Year	Comments
Polyester	U.S. Avg., 1996	Most reliable profile available; Boustead database[7]
Cotton	U.S. Avg., 2003	Öko-Institute
Polypropylene	E.U. Avg., 2002	APME (Association of Plastics Manufacturers Europe)
Polyethylene	E.U. Avg., 2002	APME (Association of Plastics Manufacturers Europe)
Fluff (ECF process)	2006	Most reliable profile available; ecoinvent database[15]
SAP	2009	Most reliable profile available; Boustead database[7]
Knit PVC	2011	BASF and External Customer Data
Laundry Chemicals	2011	Ecolab; Boustead database[7]
Natural Gas Usage	US and Canada Avg. 1999	Most reliable profile available; Boustead database[7]
Electricity Usage	US and Canada Avg. 1999	Most reliable profile available; Boustead database[7]
Transport – Truck	Northeast U.S. Avg., 2011	US LCI[16]
Transport – Sea Freight	U.S. Avg., 1996	Most reliable profile available; Boustead database[7]
Waste water	2008	RMIT University[8]
Municipal Waste – Landfill	U.S. Avg., 1996	Most reliable profile available; Boustead database[7]
Incineration with heat recovery	Germany 2006	Most reliable profile available; Boustead database[7]
BASF data sources are internal data, while the others are external to BASF. Internal data is confidential to BASF; however, full disclosure was provided to NSF International for verification purposes.		

Table 3: Eco-profile Data Sources

8. Eco-efficiency Analysis Results and Discussion

8.1. Environmental Impact Results:

The environmental impact results for the Incontinence Bed Pads Eco-effiicency analysis were generated as defined in Section 6 of the BASF EEA methodology. The results for the analysis are presented below in sections 8.1.1 through 8.1.9.

8.1.1. Primary energy consumption:

Energy consumption, measured over the entire life cycle and depicted in Figure 7, shows that the standard disposable bed pad uses significantly more energy over the defined life cycle than all other alternatives. The gross energy consumption for the standard disposable bed pad alternative was almost 67,200 MJ per customer benefit (i.e. /CB). Considering a credit of around 8,400 MJ/CB for heat recovery through incineration the net energy consumption was 58,800 MJ/CB. This is more than double the 24,700 MJ/CB consumed by the disposable extra bed pad with enhanced absorbency and leak protection. For the disposable alternatives, 70 – 80% of the energy consumed went into the manufacture of the bed pad fabric and soaker materials. Heat recovery through incineration reduced the overall energy consumption for the disposable alternatives by between 13 – 21 %.

All the resusable alternatives yielded lower energy consumption than the best performing disposable alternative. The best performing reusable was the domestically produced loose back vinyl with only 13,500 MJ/CB consumed, roughly 55% of the best performing disposable alternative. In addition, the domestic loose back vinyl bed pad consumed about 40% less energy than the worst performing reusable alternative, the imported loose back bed pad. The bonded vinyl alternative performed better than the imported loose back but still almost 25% worse than the best performer. As expected, the key energy consumer for the reusable alternatives was the energy consumed during laundering which constituted between 70 – 80% of the total lifecycle energy consumed. Though the bonded vinyl had the highest durability of all the alternatives considered, the benefit of having to produce fewer items over the lifecycle was not able to overcome the higher energy demand required during the daily laundering activities where it incurred much higher impacts due to its significantly higher overall weight.

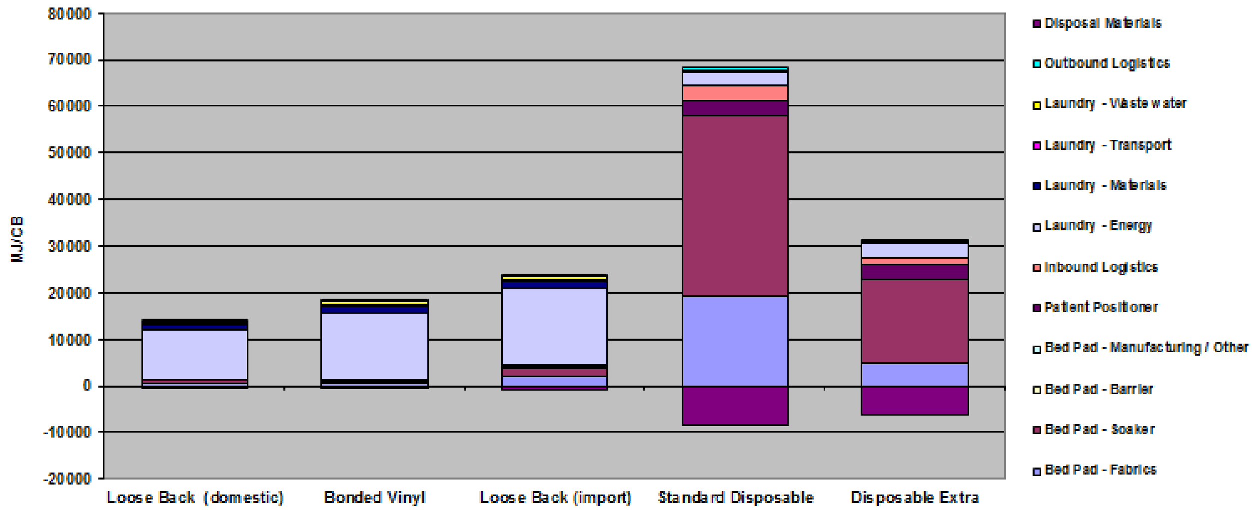

Figure 7: Primary Energy Consumption

8.1.2. Raw material consumption:

Figure 8 shows that the key drivers for raw material or resource consumption are the same as for energy consumption. Resources (fuels) required for laundering dominates the reusable bed pad alternatives, while resources for the fabrics and soaker materials dominates the disposable alternatives. The standard disposable consumed the largest amount of resources, approximately 0.75 kg silver equivalents/CB after a credit of 0.12 kg silver equivalents/CB achieved through heat recovery during incineration. The disposable extra absorbent bed pad had the next highest consumption of around 0.3 kg silver equivalents/CB. The alternative with the overall lowest resource consumption was the domestic loose back alternative, which consumed only 0.15 kg silver equivalents/CB, over 25% better than the next best reusable alternative (bonded vinyl) and 80% better than the amount of resources required to produce the standard disposable alternative.

Since the study results show the impacts during use are more dominant than the impacts incurred during production for the reusable alternatives, designs leading to effective lightweighting of the bed pad without a corresponding drop off in durability are the most energy and resource efficient. This is how the loose back alternative, which was not as durable as the bonded vinyl option, was able to have lower overall energy and resource consumption since it was 25% lighter.

Per the BASF 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 and indicated in Figure 9, oil was the most significant resource consumed for the disposable options, as oil is the main precursor for the production of the synthetic fabric materials (e.g. backsheet and topsheet) and the soaker material. The most significant resource for the reusable alternatives was natural gas and this was related to the energy required to heat the hot water during the laundering process.

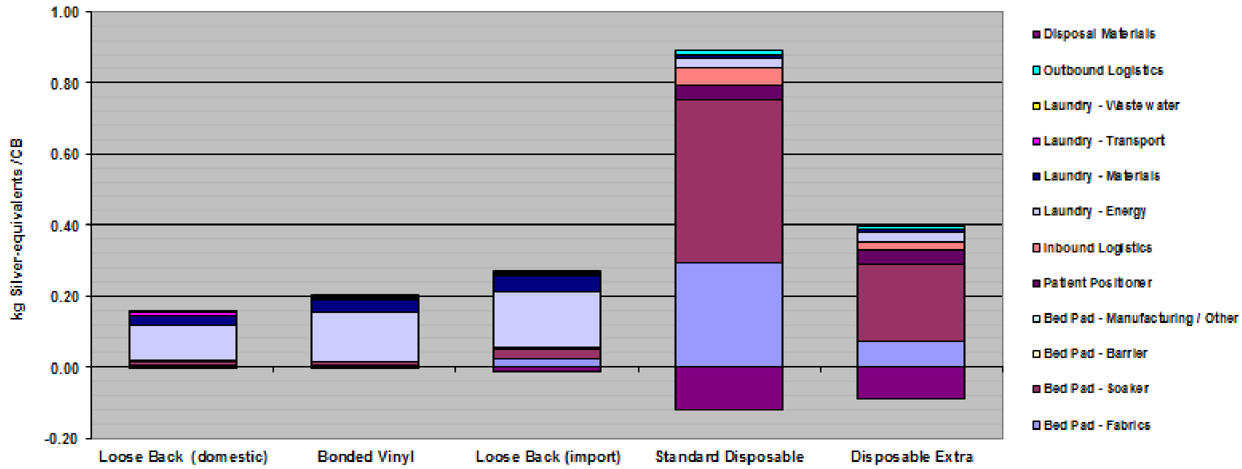

Figure 8: Raw Material Consumption by Module

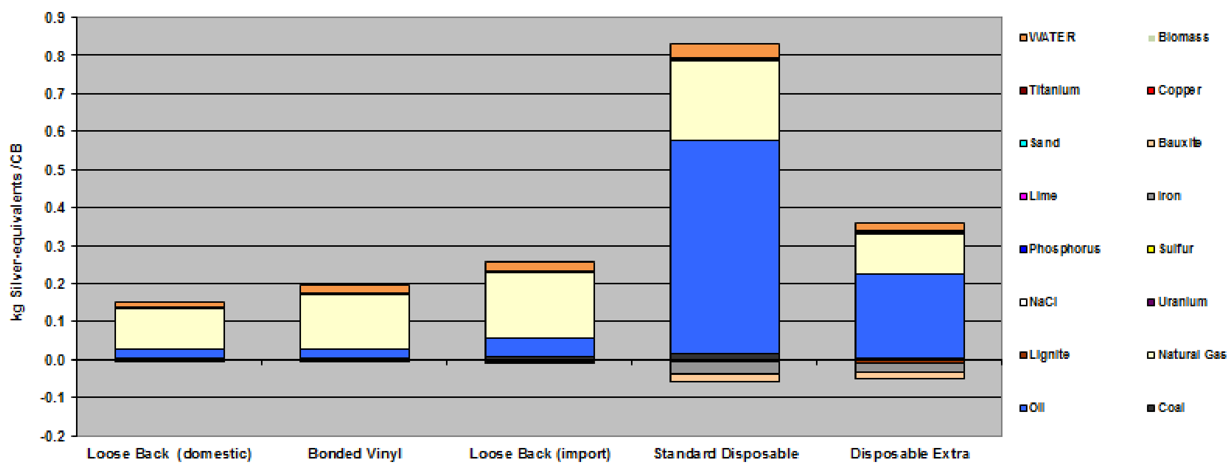

Figure 9: Raw Material Consumption by Type

8.1.3. Air Emissions:

8.1.3.1. Global Warming Potential (GWP):

Figure 10 shows that the highest carbon footprint occurred in the standard disposable bed pad with a value of 3,910 kg of CO_2 equivalents per customer benefit. The disposable extra absorbent alternative was able to reduce this amount by 40% but still had a 35% higher carbon footprint than the worst performing reusable alternative, the imported loose back. The best performing alternative was the domestically produced loose back with a carbon footprint of 874 kg of CO_2 equivalents/CB which, was over 60% less than the best performing disposable alternative. The largest contributor for the reusable alternatives was the combustion of fossil fuels during the laundering process while the largest contributors for the disposable alternatives were the soaker material and the emissions from end of life options (landfill and incineration).

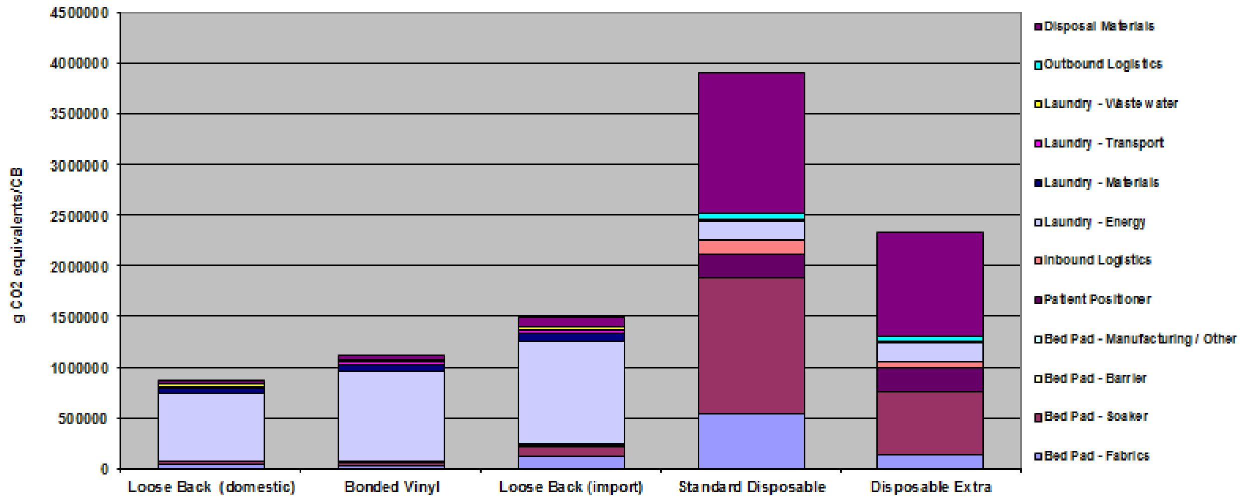

Figure 10: Global Warming Potential

8.1.3.2. Photochemical ozone creation potential (POCP):

The lowest contributor to ground level ozone creation potential (smog) occurs with the bonded vinyl bed pad with a value of around 366 g ethylene equivalents/CB. Then next lowest contributor is the domestically produced loose back vinyl alternative with a value of 375 g ethylene equivalents/CB. Figure 11 shows that POCP is highest for the standard disposable with key contributors being the soaker material and end of life disposal options. As the standard disposable alternative requires the largest amount of materials to be transported, combustion of the additional fuel contributes to the emissions of methane and non-methane VOCs, two key smog contributors. In adddition, nitrogen oxides produced in the emissions of truck exhaust can also contribute to the formation of photochemical ozone (smog).

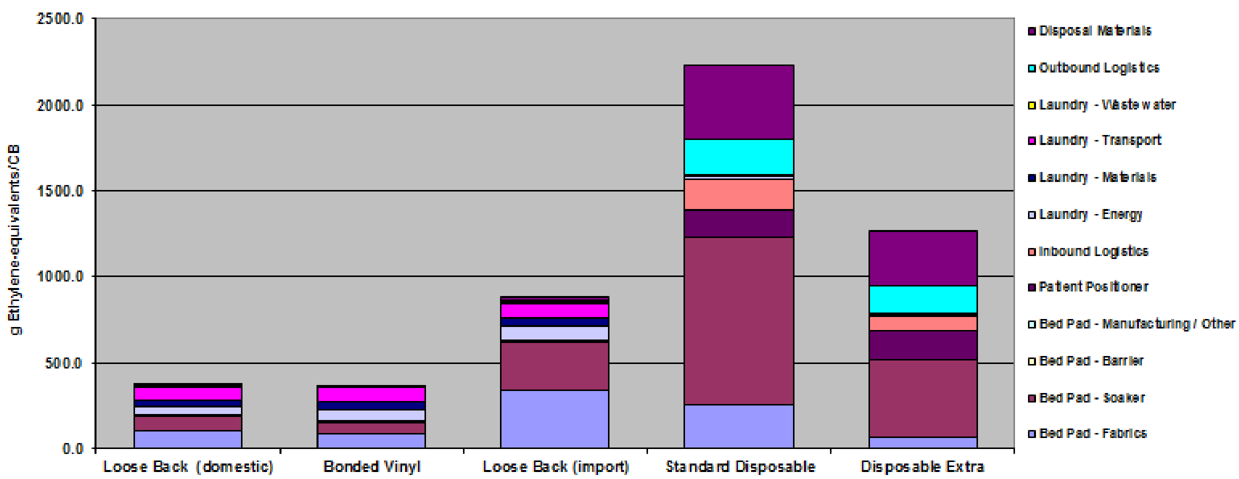

Figure 11: Photochemical Ozone Creation Potential (POCP)

8.1.3.3. Ozone depletion potential (ODP):

All of the alternatives result in minimal ozone depletion potential. The standard disposable bed pad produced the highest level, measured at about 42 mg CFC equivalents/CB. Figure 12 indicates that the ODP comes predominately from the pre-chain chemistries involved in the precursor materials used in the soaker material. Overall, ODP is the least relevant air emission and accounts for less than 0.1% of the total environmental impact for each of the systems.

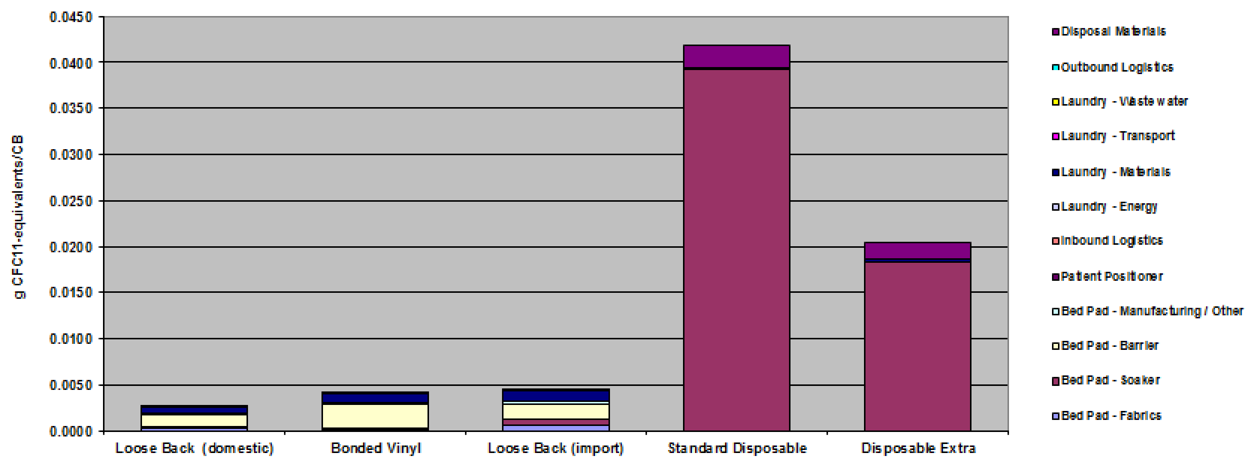

Figure 12: Ozone Depletion Potential

8.1.3.4. Acidification potential (AP):

It can be seen from Figure 13 that the largest contributor to acidification potential was the standard disposable alternative, with a net value of about 11,720 g SO_2 equivalents/CB. The second highest alternative is the imported loose back vinyl followed by the disposable extra absorbent with a value of around 11,200 g SO_2 equivalents/CB. The best performing reusable pad has equivalent impact as the best performing disposable pad. The disposable alternatives impacts are offset somewhat from the heat recovery during incineration. The reusable alternatives impact is predominately NO_x and SO_x emissions generated during the burning of the fossil fuels required for the laundry activities.

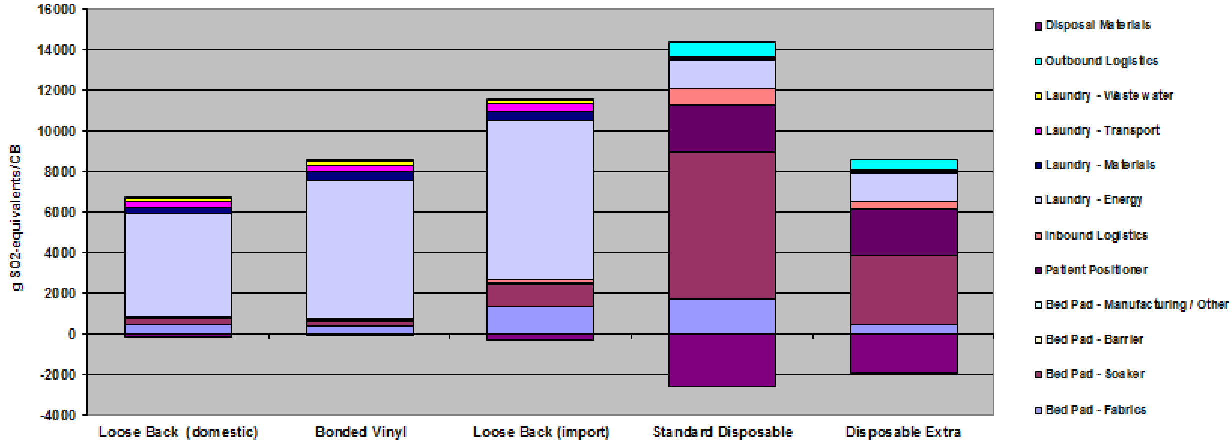

Figure 13: Acidification Potential.

Utilizing the calculation factors shown in Figure 28, Figure 14 shows the normalized and weighted impacts for the four air emissions categories (GWP, AP, POCP and ODP) for each alternative. The standard disposable alternative scored worst in each category while the domestically produced loose back vinyl alternative had the lowest overall air emissions. GWP was the most relevant air emission category followed by AP. The ODP category was not considered relevant for this study.

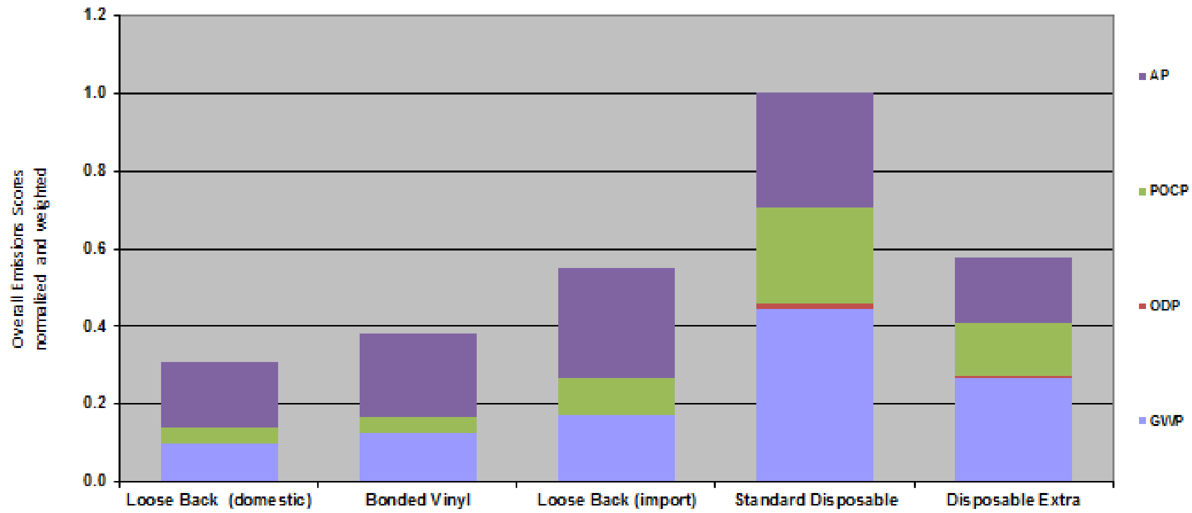

Figure 14: Overall Air Emissions

8.1.4. Water emissions:

Figure 15 displays that the overall water emission is highest for the standard disposable bed pad with almost 1,000,000 liters of grey water equivalents/CB. This is driven by the specific water emissions of COD, chlorides and sulfates attributed to the manufacturing of the soaker material (SAP, fluff) and the overall quantity of pads required over the lifecycle. Improved performance helped the disposable extra absorbent alternative reduce grey water emissions by more than half to 480,000 liters of grey water equivalents/CB. The water emissions from the reusable alternatives were dominated by the impacts from the laundering activities and ranged from 225,000 – 450,000 liters grey water equivalents/CB. The domestic loose back vinyl pad had approximately 55% lower water emissions than the best performing disposable pad. Impacts from laundering contributed between 65% - 75% of the total water emissions impact for the domestically produced reusable alternatives and 50% for the imported vinyl alternative. These results are a good example why a holistic and lifecycle approach must be taken when evaluating environmental impacts. Initially, one would have expected the water emissions from laundering the reusable alternatives would have been the most significant contributor through its direct emissions to the sewer but in reality the cumulative water emissions of the prechain materials used in the disposable alternatives contributed more significantly.

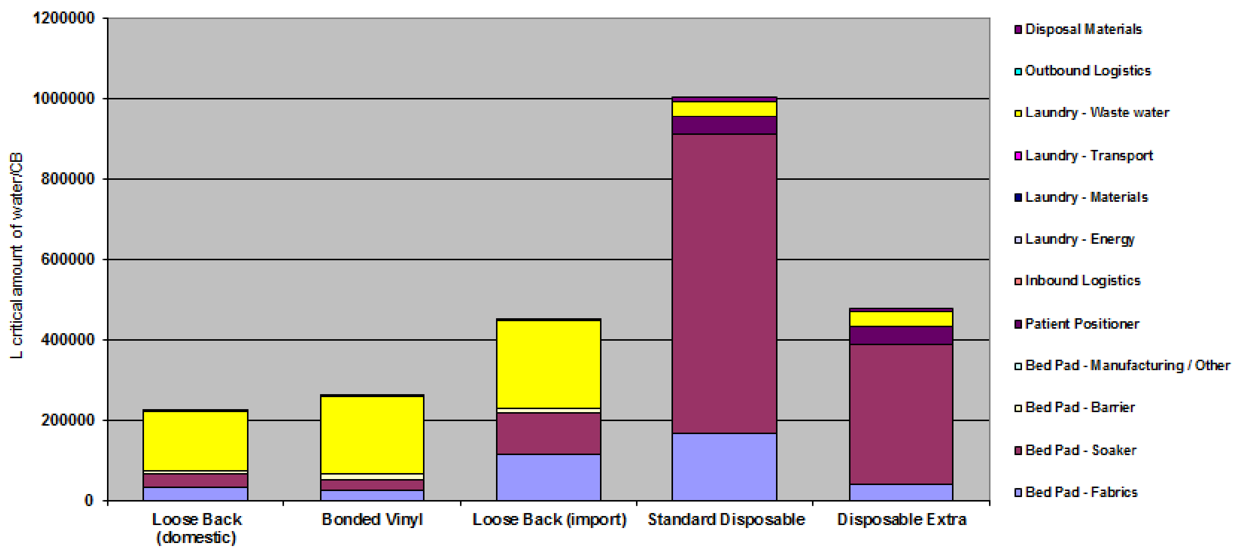

Figure 15: Water Emissions

8.1.5 Solid waste generation:

Solid waste emission categories considered for this study included municipal, special, construction and mining wastes. Solid waste emissions for each alternative are depicted below in Figure 16 and are mostly impacted by the quantity of material going to landfill. The standard disposable bed pad had the highest impact of over 3.5 metric tons of municipal waste (MSW) equivalents/CB followed by the disposable extra alternative with over 2.3 metric tons of MSW equivalents/CB. The best peforming reusable alternative, the bonded vinyl, only accounted for around 2% of the solid waste emissions of the worst performing alternative with an impact over the life cycle of around 0.07 metric tons MSW equivalents/CB. All reusable alternatives generated dramatically less solid waste than the single use disposable alternatives due to their inherent durability and ability to be reused.

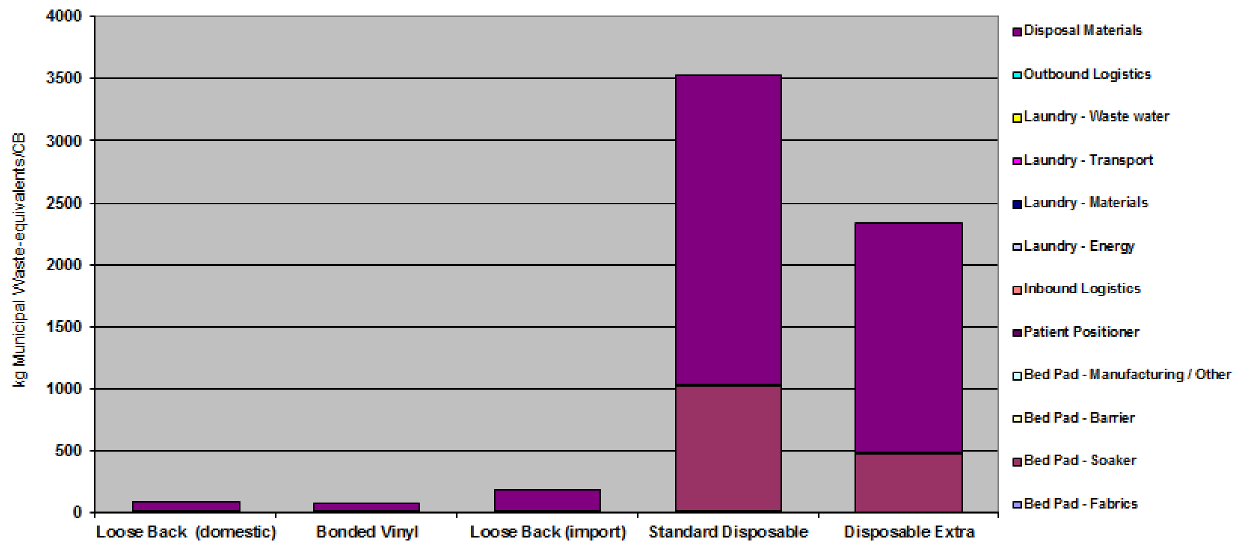

Figure 16: Solid Waste Generation

Utilizing the calculation factors shown in Figure 28, a composite of the cumulative impact of the three main emission areas of air, water and solid waste is depicted in Figure 17. The standard disposable bed pad had the highest impact in each individual category as well as overall. The disposable extra alternative through better absorbency and leak protection was able to reduce overall emissions by slightly more than 40%. The domestically produced loose back pad, the best performing alternative, significantly reduced emissions by over 85% relative to the standard disposable and almost 75% relative to the best performing disposable.

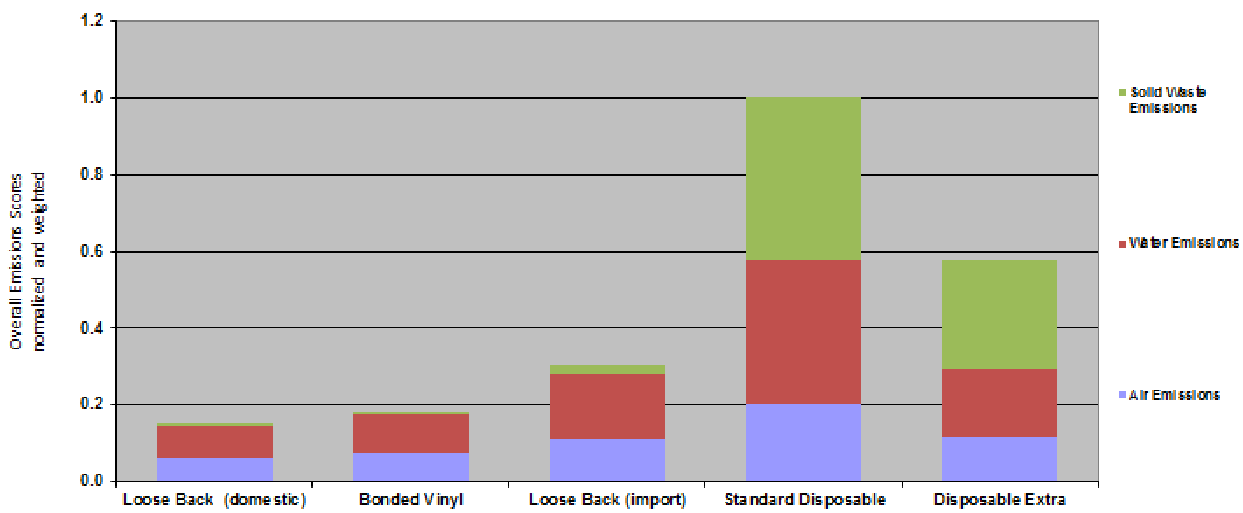

Figure 17: Overall Emissions Scores

8.1.6 Land use:

As displayed in Figure 18, the disposable alternatives had significantly higher land use impacts than the reusable alternatives. This was directly attributed to the land use impacts from the soaker material and the logistics impacts (building/using roads) of transporting the large quantity of material. All three reusable alternatives accounted for very low impact in land use ranging between 65 – 110 m^2*yr per customer benefit compared to over 525 m^2*yr for the standard disposable alternative.

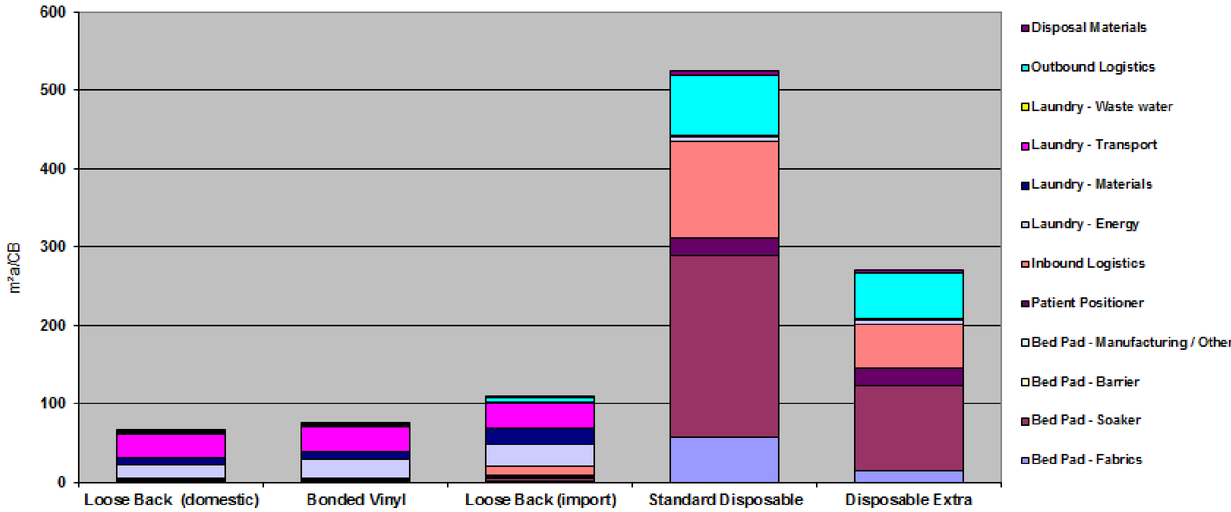

Figure 18: Land Use

8.1.7 Toxicity potential:

The toxicity potential for the various bed pad alternatives was analyzed for the production, use, and disposal phases of their respective life cycles. For the production phase, not only were the final products considered but the entire pre-chain of chemicals required to manufacture the products were considered as well. Human health impact potential in the use phase consists of the use of the bed pads as well as any resulting laundering activities and logistics required to transport and clean the necessary system components. Toxicity potential in the Disposal phase was negligible for the reusable alternatives but not insignificant for the disposable alternatives. Nanoparticles were not included in the chemical inputs of any of the alternatives.

Inventories of all relevant materials were quantified for the three life cycle stages (production, use and disposal). Consistent with BASF's EEA methodology's approach for 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 R-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 19 shows how each module contributed to the overall toxicity potential score for each alternative. The values have been normalized and weighted. The toxicity potential weightings for the individual life cycle phases were production (20%), use (70%) and disposal (10%). These standard values were not modified for this study from the standard weightings.

As to be expected the major influencing factor was the laundering activities for the reusable alternatives while the toxicity potential for the disposable alternatives was relatively equally distributed across the three lifecycle phases. Specifically for the reusable alternatives, the laundry chemicals were the most significant impact category with the impacts for transport being the second most significant impact category. Materials used in manufacturing and the impacts from disposal were negligible for the reusable alternative. All reusable alternatives scored higher in overall toxicity potential than the disposable alternatives. Relative to the domestically produced loose back vinyl, the best peforming reusable alternative, the standard disposable had a 10% lower toxicity potential score and the disposable extra had over a 40% reduction. Key contributors to the toxicity potential of the disposable alternatives were the production of the soaker material, the laundry chemicals required for cleaning the draw sheet and the fuel emissions from transporting the materials to their end of life destination.

Figure 20 shows how the scoring is distributed across the life cycle stages. Consistent with the discussion above, the use phase is the most significant for the reusable alternatives, accounting for almost all of the toxicity potential points. 50% of the impact for the standard disposable was from the materials used in production with the remainder equally distributed amongst laundry activities (use phase) and outbound logistics (disposal phase). A high safety standard was assumed for the manufacturing processes for the raw materials and a closed operating system was assumed for the laundering process. Finally, no reduction in the scores based on exposure conditions was applied for the disposal phase of the materials as the potential for human contact during removal and disposal of the materials is high.

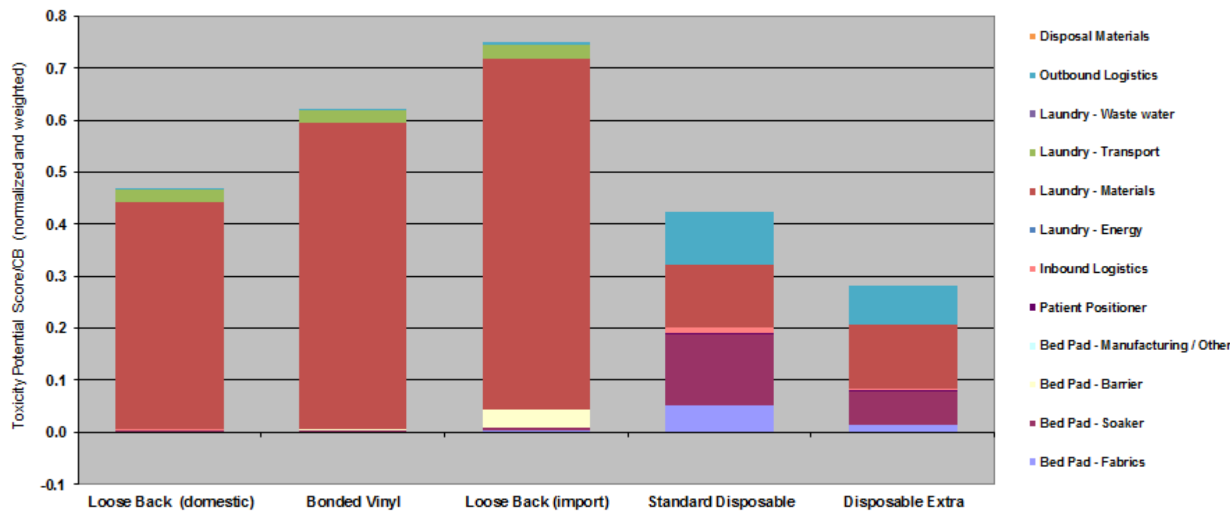

Figure 19: Toxicity Potential – Modules

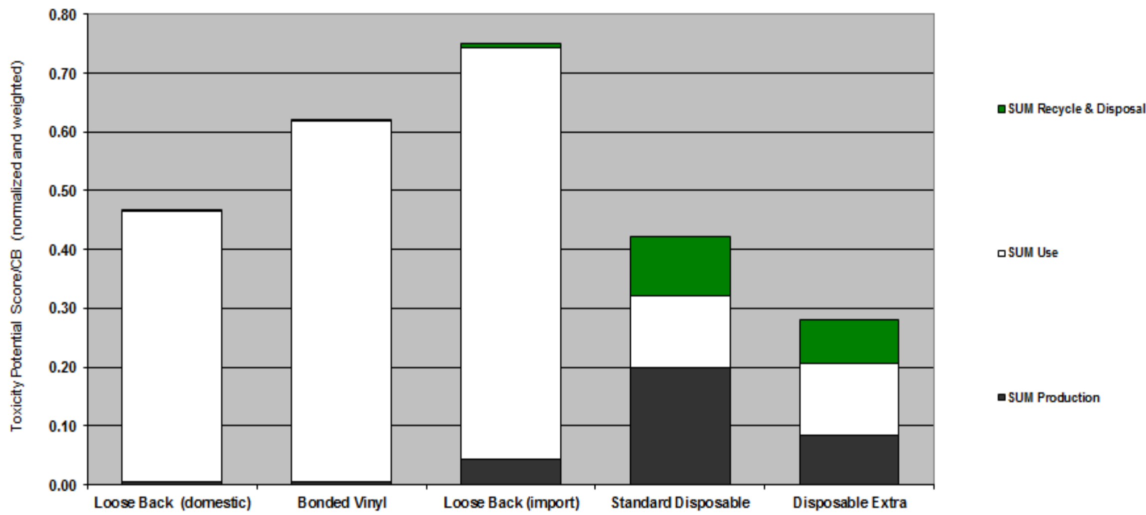

Figure 20: Toxicity Potential- Life Cycle Phases

8.1.8. Risk (Occupational Illnesses and Accidents potential):

All the materials and activities accounted 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.

In Figure 21, the greatest Occupational Illnesses and Accident potential occurs for the standard disposable bed pad alternative. The module, which contributes to the highest risk potential for occupational illnesses and accidents, almost 75% of the total impact, is the soaker materials. More specifically, the manufacturing activities related to the fluff material are the largest contributor to this impact category. The disposable extra alternative is able to reduce the risk potential by almost 50% relative to the standard disposable alternative. The risks associated with the reusable alternatives are mostly related to the laundering activities and materials. However, the likelihood of risks for the domestically produced reusable alternatives is over 85% less than the best peforming disposable alternative. The risks associated with the imported loose back vinyl alternative, though much better than any of the disposable alternatives is over 85% higher than the domestically produced loose back pad.

As depicted in Figure 22, occupational diseases were the most relevant risk category for each alternative. No unique risk categories were identified for this study so the standard weighting between working accidents and occupational diseases was maintained.

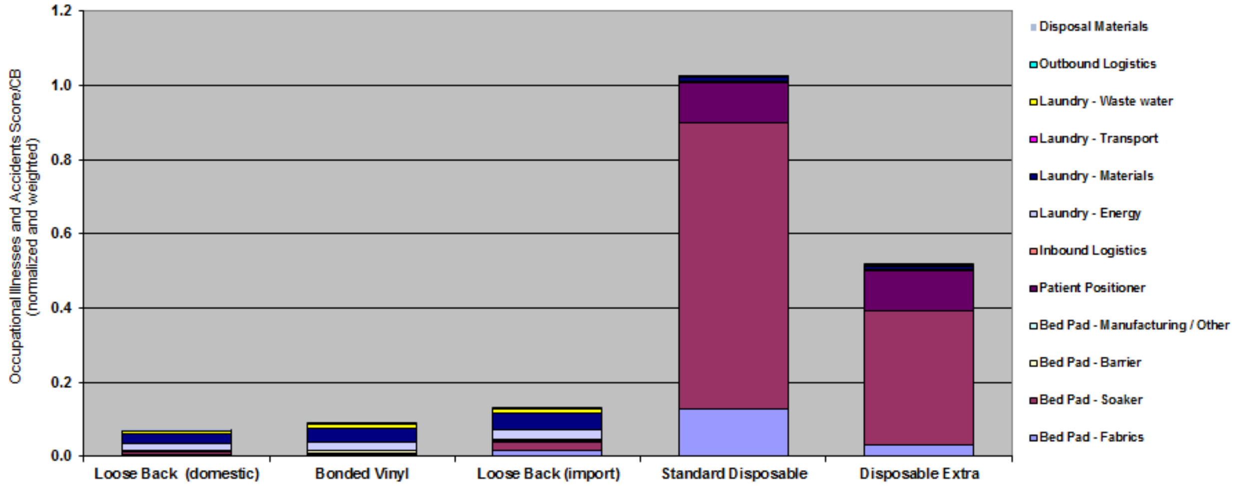

Figure 21: Risk Potential (Occupational Illnesses and Accidents) – per Module

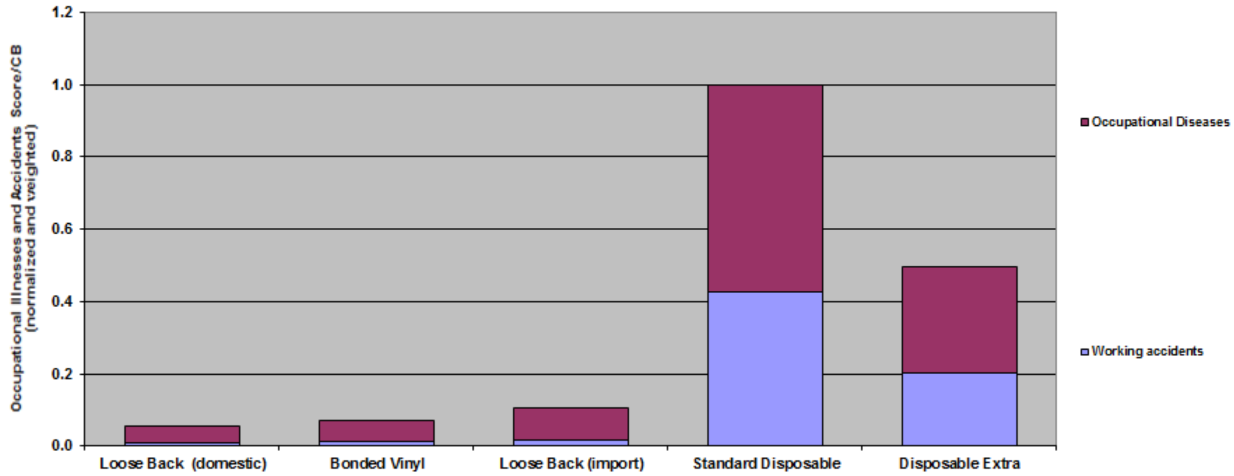

Figure 22: Risk Potential – per Impact Category

8.1.9. Environmental fingerprint:

Following normalization or normalization and weighting with regards to the emissions categories, the relative impact for all six of the main environmental categories for each alternative is shown in the environmental fingerprint (Figure 23). As presented earlier in the discussions around the individual impact categories, the reusable bed pad alternatives demonstrated significantly reduced overall environmental impacts in all categories except toxicity potential. The key factors being their efficiencies in use of natural resources to achieve the desired customer benefit as well as their reduction in the production of solid waste emissions over the defined life cycle. All of the reusable alternatives scored higher in toxicity potential due to the high amount of cleaning chemicals utilized during the laundering activities of the use phase of their life cyle. From an environmental perspective, the environmental impact savings related to being able to reuse the vinyl bed pads significantly outweighs the environmental impacts associated with their laundering. The environmental fingerprint clearly shows that there is a strong environmental value proposition for reusable bed pads. Overall, the domestically produced loose back vinyl alternative had the lowest overall environmental impact. The bonded vinyl's overall environmental impact was about 30% higher than the domestically produced loose back and the imported vinyl's was over 70% higher. The highest overall environmental impact was for the standard disposable alternative, over 3.5 times higher than the best alternative. The disposable extra alternative's overall environmental impact was almost 50% less than the standard disposable but still had almost twice the impact of the best performing reusable alternative.

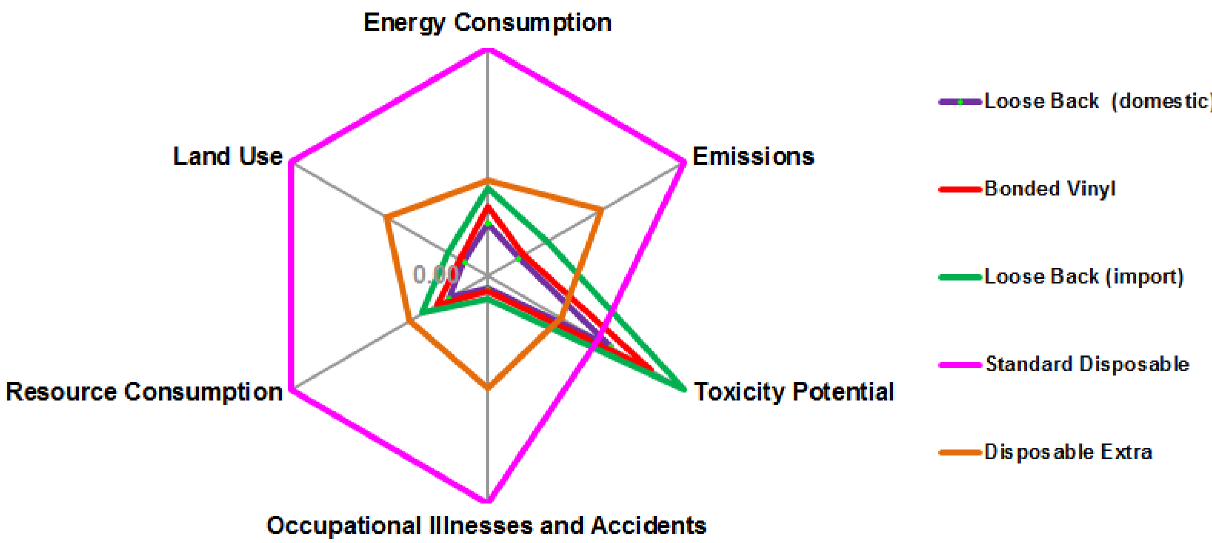

Figure 23: Environmental Fingerprint

8.2. Economic Cost Results:

The life cycle cost data for Incontinence Bed Pads EEA are generated as defined in Section 7 of the BASF EEA methodology and described in Section 6.2 above. The results of the lifecycle cost analysis are depicted in Figure 24 and demonstrate that the alternative with the lowest life cycle costs was the domestically produced reusable loose back alternative. Differences in overall life cycle costs between the reusable and disposable alternatives were driven predominately by the costs associated with laundering for the reusable alternatives and the initial purchase price for the disposable alternatives. For the reusable alternatives, over 85% of the life cycle costs were related to the laundering activities with only about 11-13% of the costs associated with the actual material costs. On the converse, almost 86% of the total life cycle costs associated with the disposable alternatives were related to material costs, with costs for the patient positioner and laundering making up the rest.

The lowest life cycle cost was for the domestically produced reusable loose back alternative with a cost of around $1,275 / CB. The bonded vinyl alternative was 32% higher and the imported loose back was almost 55% higher in life cycle costs relative to the best alternative. Both disposable alternatives had similar life cycle costs with values over $4,700/CB. The reduction in costs associated with requiring fewer items for the disposable extra alternative due to its enhanced performance is offset by its significantly higher purchase price relative to the standard disposable.

Looking at the costs from another perspective, the actual cost for only the disposable bed pads range between $4.30/day (standard disposable) to $4.10/day (extra absorbent disposable alternative). In contrast, the all-in (full life cycle) costs per day for the reusable alternatives were $1.30/day for the domestic loose back pad, $1.70/day for the bonded vinyl alternative and near $2.00/day for the imported loose back alternative. Overall, this study clearly shows that there is significant financial incentive for the use of reusable bed pads with a cost reduction of over 70% when comparing the best reusable and disposable alternatives.

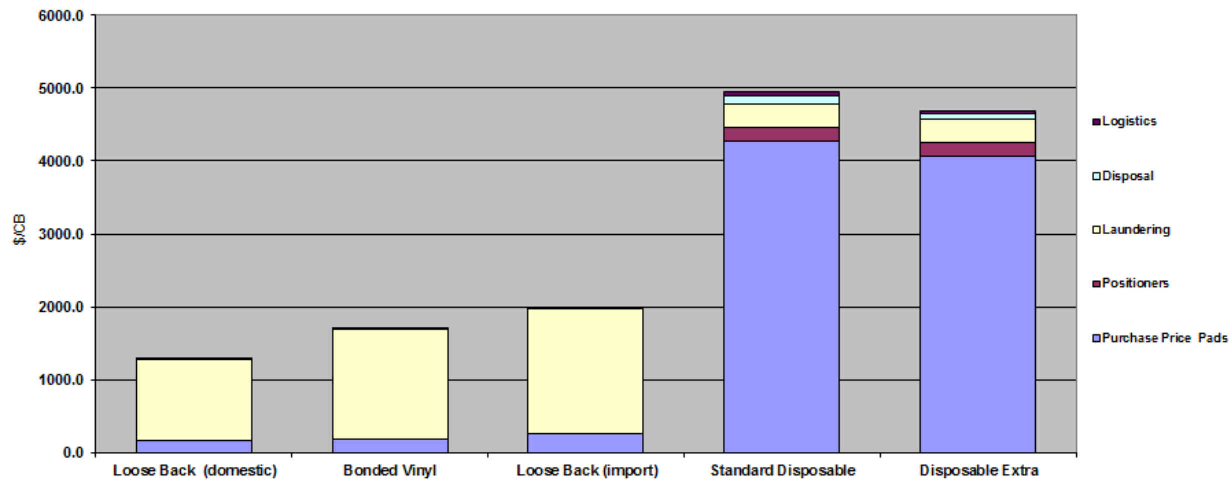

Figure 24: Life Cycle Costs - Modules

8.3. Eco-efficiency Analysis Portfolio:

The eco-efficiency analysis portfolio for the Incontinence Bed Pad 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 a 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 is the target market for the use and ultimate disposal of the materials. The environmental relevance values utilized were last reviewed in 2009 and the social weighting factors were recently updated in 2009 by an external, qualified third party organization.

Figure 25 displays the eco-efficiency portfolio for the base case analysis and shows the results when all six individual environmental categories are combined into a single relative environmental impact and combined with the life cycle cost impact. Because environmental impact and cost are equally important, the most eco-efficient alterative is the one with the largest perpendicular distance above the diagonal line and the results from this study find clearly that the domestically produced reusable loose back pad is the most eco-efficient alternative due to its combination of having both the lowest environmental burden and lowest life cycle cost of all the alternatives. The next best alternative is the bonded vinyl. All three reusable bed pads are significantly more eco-efficient than the disposable alternatives. The least eco-efficient alternative was the standard disposable bed pad. The disposable extra bed pad demonstrated significantly improved environmental and economic performance relative to the standard disposable but still trailed all the reusable alternatives with regards to eco-efficiency.

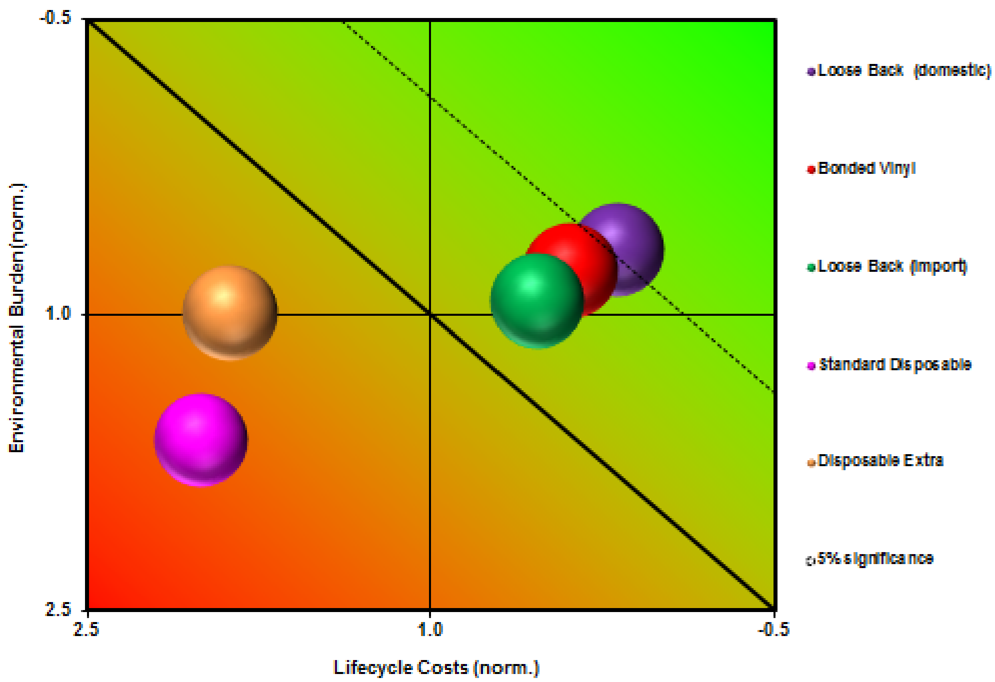

Figure 25: Eco-efficiency Portfolio – Incontinence Bed Pads

9. Data Quality Assessment

9.1. Data Quality Statement:

The data used for parameterization of the EEA was sufficient with most parameters of 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. The Eco-profiles utilized were deemed of sufficient quality and appropriateness considering both the geographic specificity of the study as well as the time horizon considered. Table 4 provides a summary of the data quality for the EEA.

Parameter	Quality Statement	Comments
Alternative's Structure and Material Composition		
Disposable Bed Pad	High	Known formulations from manufacturer. Eco-profiles developed specifically for this study are based on current technologies and company data.
Reusable Bed Pad	Medium High	Lab analysis and industry average data. Eco-profiles developed specifically for this study are based on current technologies.
Patient Positioner	High	Known formulation based on current industry data.
Reusable Alternative Durability	Medium High	Historical trade association data. Data specific to our scope and context of study.
Laundering Activities		
Chemicals	High	Types and amounts supplied by leading laundry chemical supplier. Eco-profiles developed specifically for this study are based on current technologies and company data.
Energy	Medium High	Usage figures based on external, comparable LCA studies. Assumed values are reasonable given study context and goals.
Water Usage	Medium High	Usage figures based on external, comparable LCA study as well as EU commission project. Assumed values are reasonable given study context and goals.
Waste Water	Moderate	Amount and composition based on external, comparable LCA study. Assumed values are reasonable given study context and goals.
Waste Disposal Methods	Medium	US EPA statistics. National average. Assumed values are reasonable given study context and goals.
Costs		
Reusable Bed Pad	High	Current price for region of study. Provided by material supplier(s).
Disposable Bed Pad	High	Current price for region of study. Provided by material supplier(s).
Patient Positioner	High	Current price for region of study. Provided by material supplier(s).
Waste Disposal	Medium High	Value is reasonable given study context and goals. Regional price.

Table 4: Data Quality Evaluation for EEA Parameters

10. Sensitivity and Uncertainty Analysis

10.1 Sensitivity and Uncertainty Considerations:

A sensitivity analysis of the final results indicates that the economic impacts were 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 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). The main assumptions and data related to economic impacts were:

- Material costs (purchase price of final products)

- Laundering activities
- Disposal methods and costs

As the data quality related to these main contributors was of medium-high to high quality, this strengthened our confidence in the final conclusions indicated by the study.

Though the economic impacts were the most significant, environmental impacts still influenced the overall eco-efficiency of each alternative. A closer look at the analysis (see Figure 26) indicates that the impact with the highest environmental relevance was the emissions category (solid wastes and water emissions specifically) followed by toxicity potential and energy consumption. This is to be expected, as the previous discussions showed end of life impacts are quite significant when you evaluate the large quantity of material that goes to landfill for the disposable alternatives. The corresponding weights of each bed pad and assumptions related to their usage quantity are the key assumptions that impact these key categories. Data quality related to this information was also strong at a level of medium-high to high quality.

The calculation factors (Figure 28), which consider both the social weighting factors and the environmental relevance factors, indicate which environmental impact categories were having the largest effect on the final outcome. Calculation factors are utilized in converting the environmental fingerprint results (Figure 23) into the final, single environmental score as reflected in our portfolio (Figure 25). The impacts with the highest calculation factors were the same as those with the highest environmental relevance factors, with regards to the six main impact categories. 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 (Figure 27) had an influence in adjusting the relative weightings of a few impact categories represented in the energy, resource consumption and emissions sub-categories. Higher societal relevance for energy and resource consumption helped increase their respective weighting relative to the other key impact categories. In addition, the impact of solid waste emissions was adjusted lower (impact minimized) due to society's higher weighting given to water and air emissions.

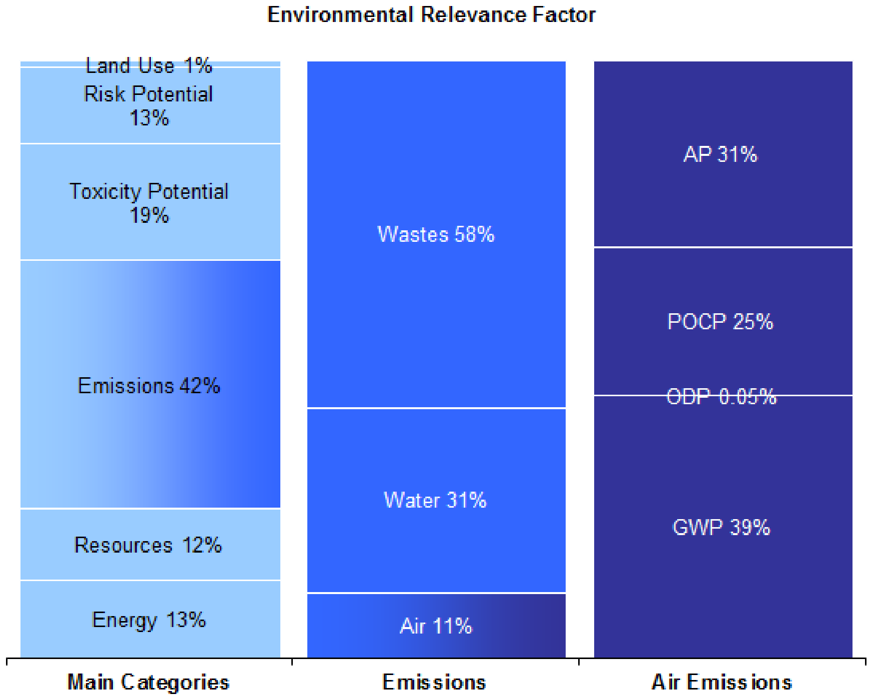

Figure 26: Environmental Relevance Factors that are used in the Sensitivity and Uncertainty Analyses

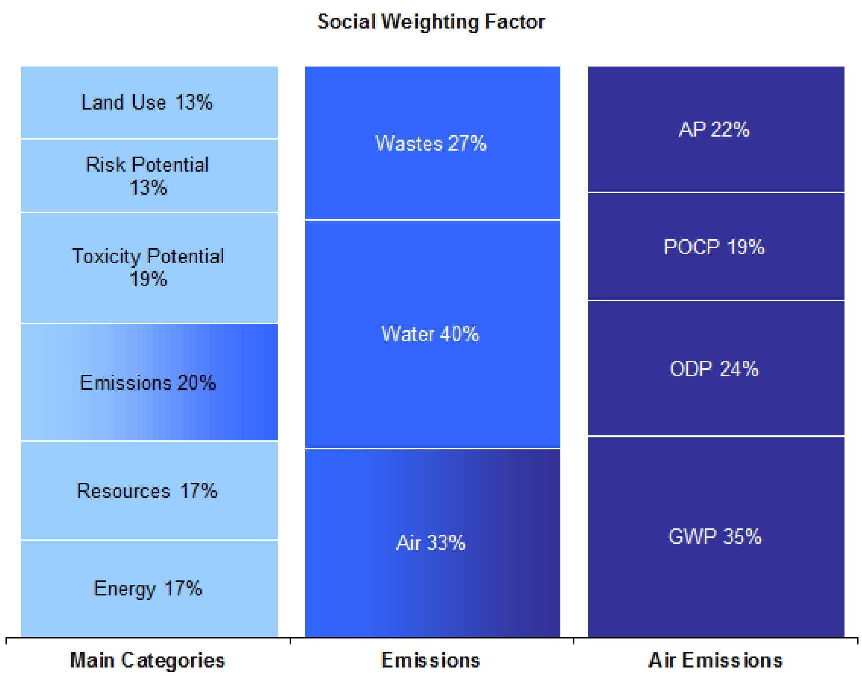

Figure 27: Social Weighting Factors that are used in the Sensitivity and Uncertainty Analyses

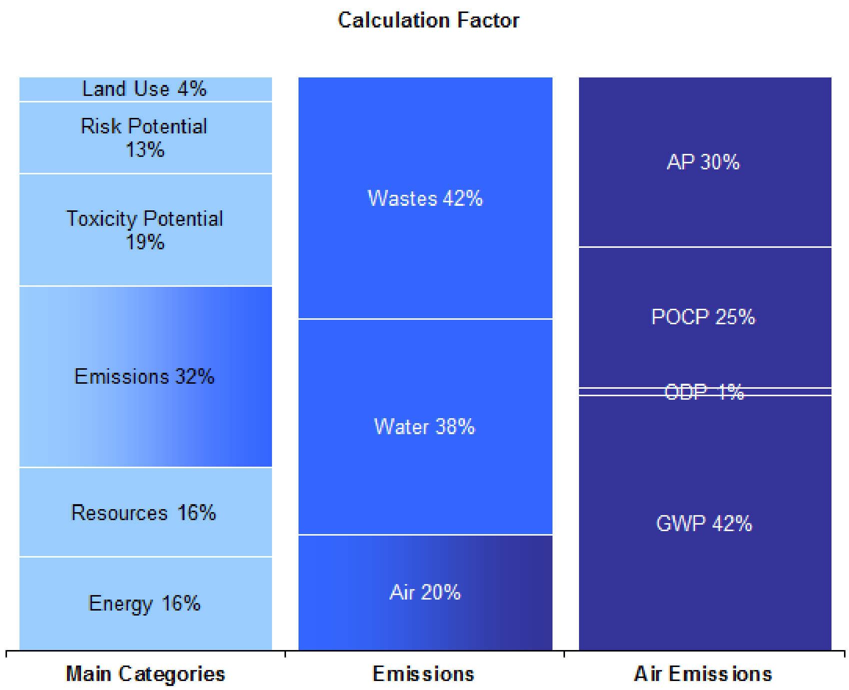

Figure 28: Calculation Factors that are used in the Sensitivity and Uncertainty Analyses

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.

10.3 Scenario Analyses

10.3.1 Scenario #1: Increased Durabilities for all Reusable Bed Pads

This scenario looks at the impact of varying the durability values for each reusable alternative. Specifically, this scenario will show the impact of increased durability for each of the reusable pads. Based on the experience of the project team as well as input from industry experts, the team felt the durability numbers reported in the Phillips and Associates, Inc. report were conservative and not necessarily reflective of likely durability figures for reusable bed pads. Based on expert opinions and customer surveys, the team established new durability values for the reusable alternatives, specifically 125 for the bonded vinyl, 100 for the domestic loose back and 50 for the imported loose back vinyl. The enhanced durability enabled the reduction in the number of reusable pads used per customer benefit (CB) from 42 to 20 for the domestically produced loose back, from 34 to 16 for the bonded vinyl and from 84 to 40 for the imported loose back vinyl. Figure 29 shows the new portfolio results with this new baseline for durability.

Overall, it can be observed that the positioning (eco-efficiency) of all the alternatives remained relatively the same. Relative to the base case, the eco-efficiency for the domestically produced loose back improved by about 5%, the imported loose back improved by around 7% and the bonded vinyl alternative by slightly less than 1.0%.

From the economic perspective, life cycle costs for the reusable alternatives is driven by the laundering costs and not the purchase price so a reduction in the number of reuseable pads over the defined life cycle has minimal effects. From an environmental perspective, there is also only a slight improvement relative to the disposable alternatives

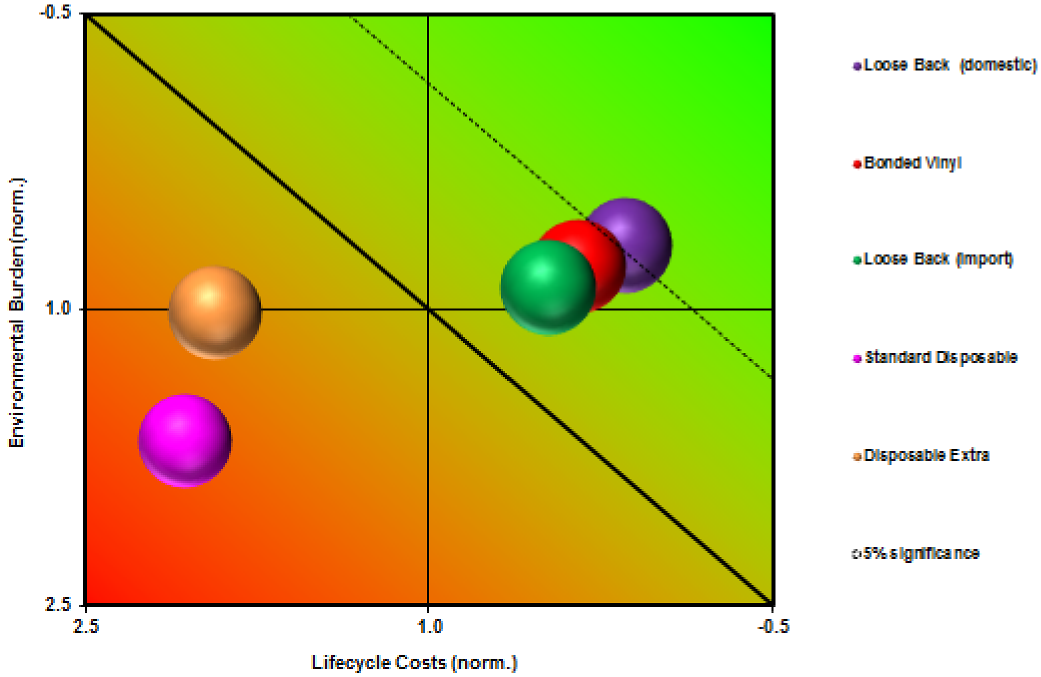

Figure 29: Scenario Analysis #1: Increased Durability for Reusable Bed Pads

10.3.2 Scenario #2: Removal of Patient Positioner for Disposable Alternatives

As discussed in the base case analysis a patient positioner (i.e., draw sheet) is required for the disposable alternatives in order to assist in the safe movement of patients. The positioner has both manufacturing impacts as well as on-going environmental impacts related to the laundering of the positioner. By removing the positioner from the analysis, the relative impact the positioner had on the overall economic and environmental profile of the disposable bed pad systems can be determined. From an economic perspective, the patient positioner is relatively inexpensive and durable and washed only every other day so the economic benefit was only around a 4% reduction in total costs. However, a bigger benefit was realized on the environmental side. As the patient positioner made up a larger portion of the overall impacts for the extra absorbent disposable alternative, removing the patient positioner significantly reduced the overall environmental impact by almost 10%. The benefit for the standard disposable was slightly below 3%. Improvements relative to the reusable alternatives in the key areas of energy and resource consumption were realized. However, from an overall eco-efficiency perspective, all the reusable alternatives still performed significantly better than all the disposable alternatives. A revised eco-efficiency portfolio for Scenario #2 is shown in Figure 30. Finally, it should be reiterated that though the disposable alternatives were able to improve their eco-efficiencies through the removal of the patient positioner, the positioner is a required system component for the disposable alternatives in order to make them functionally equivalent to the reusable alternatives.

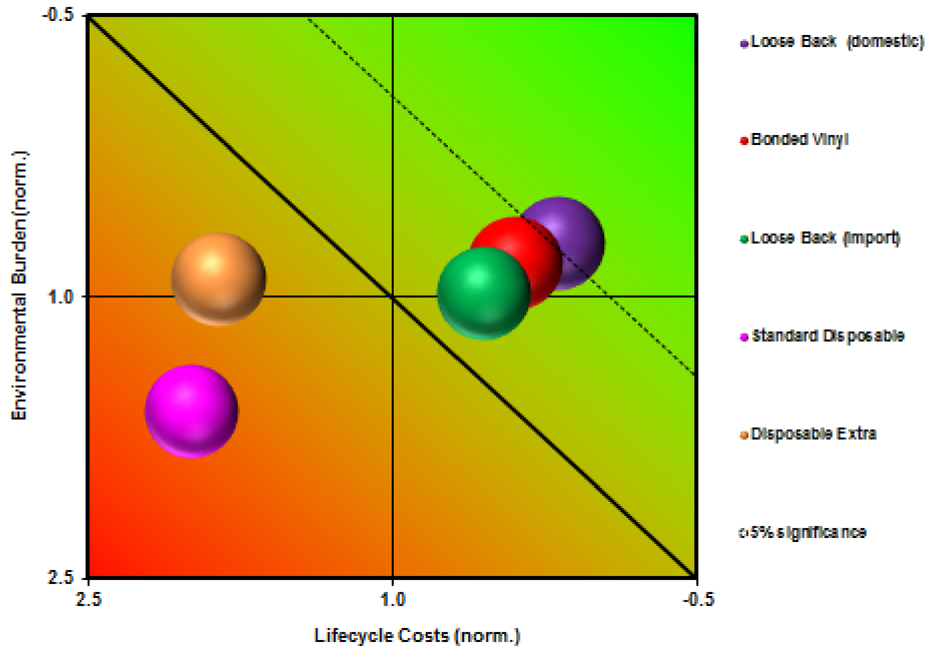

Figure 30: Scenario Analysis #2: Removal of Patient Positioner for Disposable Alternatives

10.3.3 Scenario #3: New Alternative: Combined Disposable Pad & Patient Positioner

This scenario looks at a new alternative, which combines incontinence protection and the ability to (re)position a patient in a single disposable item. The design is a more robust version of the disposable extra pad with a higher strength/heavier back sheet section, which may eliminate the need for an additional draw sheet. All of the other study assumptions and alternatives remained the same as in the base case analysis. Material specifications for the new alternative were adapted from the disposable extra design and supplemented with analytical lab reports and expert judgment. Due to the novelty of design and the increase in material usage required for the enhanced strength, a price premium over the disposable extra alternative is expected. Though for this analysis, a similar price to the disposable extra alternative was assumed.

Compared to the standard disposable, this new alternative is approximately 13 grams/m^2 heavier for a total weight increase of 11 grams/pad. The independent draw sheet which is required for the base case disposable alternatives weighs slightly over 500 grams and can be used approximately 31 times over its lifetime[2]. This allocates about 16 grams of material per use. In addition, and more significant, is the fact that the draw sheet requires removal and cleaning every other day. This burdens the original disposable alternatives with the environmental and economic impacts associated with the various logistical activities and usage of chemicals, water and energy associated with laundering. This alternative outperforms the best performing disposable alternative in all environmental categories and even the imported loose back vinyl pad from an overall environmental perspective. Figures 31 and 32 below reflect the increased eco-efficiency of this new alternative. However, this new alternative still significantly trails all reusable alternatives in terms of eco-efficiency even with the more conservative pricing assumption.

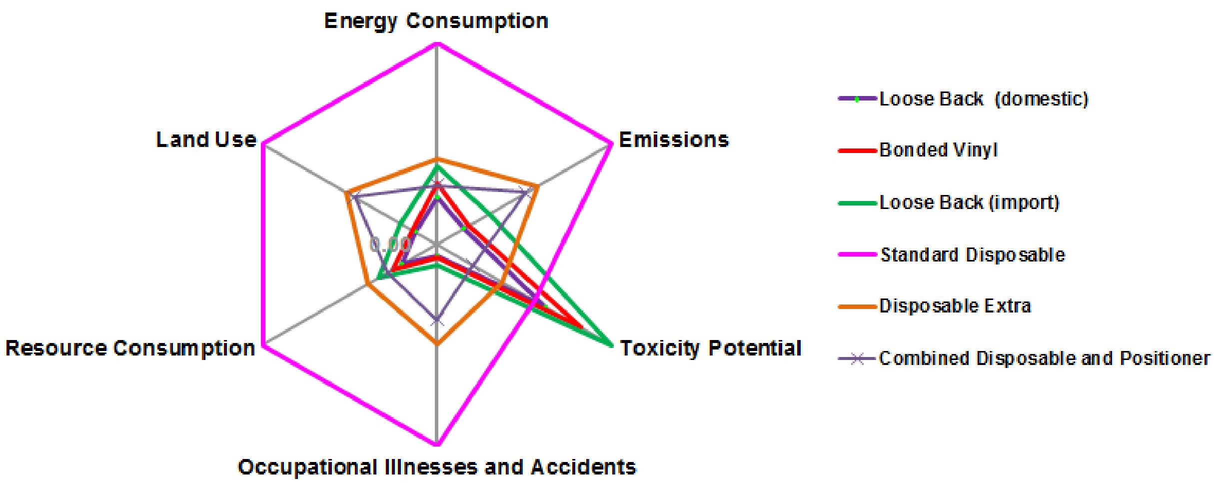

Figure 31: Scenario Analysis #3: Environmental Fingerprint New Disposable Alternative

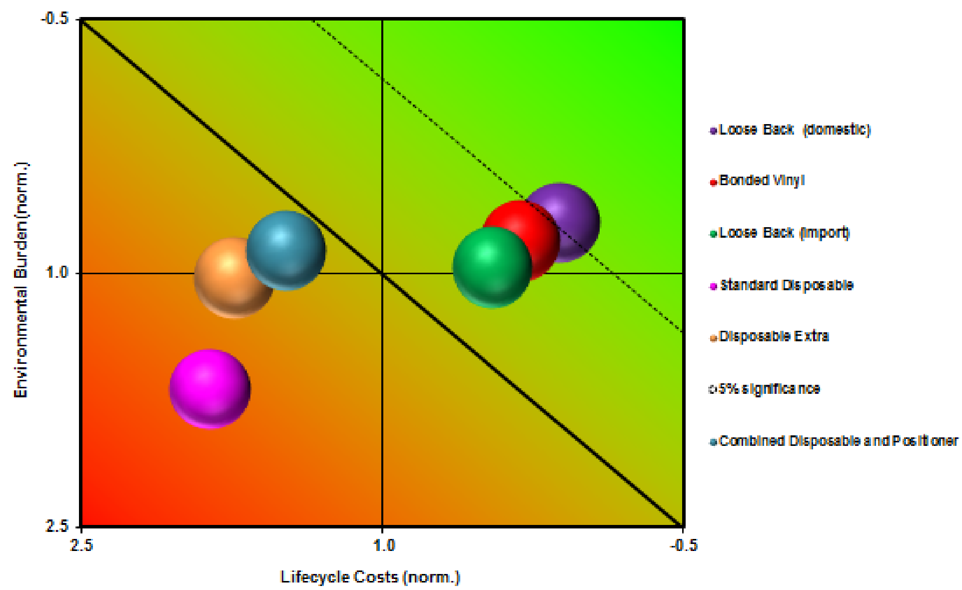

Figure 32: Scenario Analysis #3: Eco-Efficiency Portfolio New Disposable Alternative

10.3.4 Scenario #4: Caregiver's Time included in Financial Calculations

As discussed previously in section 6.3.3, a potential significant cost element that warrants further discussion and analysis is the potential labor cost component associated with the healthcare professional's/nurse's time required for the activities related to the changing of the bed pads throughout the day. Intuitively, if a bed pad requires greater frequency in inspections and related changing activities over the day, the nurse or healthcare professional will need to allocate a larger part of their daily workload to these activities. Thus, bed pads that require less on-going care and oversight could increase the nurse's productivity during their shift which could lead to potential cost savings. This scenario look at the sensitivity of the study results based on whether an economic value is placed on the extra time per day a nurse must attend to disposable bed pads versus reusable bed pads. For the economic comparison, the differential amount of time between the reusable and disposable alternatives was utilized.

External customer feedback as well as an external study[14] were referenced to establish the time requirements for a nurse to inspect and change bed pads for patients who are confined to a hospital bed and suffering from pressure ulcers. A conservative basis of 5 minutes was established for the changing time required. Based on the required 4 changes per day for the disposable alternatives this accounts for 20 minutes of dedicated caregiver's time per day compared to only 10 minutes for the reusable alternatives, which only require changing twice per day. Using an established value of $20/hour for a professional caregiver at a hospital[14] and a differential time per day of 10 minutes, this potentially adds over $3.30 per day in additional overhead costs. This is quite significant when compared to the actual bed pad costs for the day, which range between $4.30/day (standard disposable) to $4.10/day (extra absorbent disposable alternative). In contrast, the all-in (full life cycle cost) per day for the reusable alternatives were $1.30 for the domestic loose back pad, $1.70 for the bonded vinyl alternative and near $2.00 for the imported loose back alternative.

As represented in Figures 32 and 33 below, the economic and eco-efficient advantage of the reusable alternatives is only strenghened when a broader economic analysis is considered.

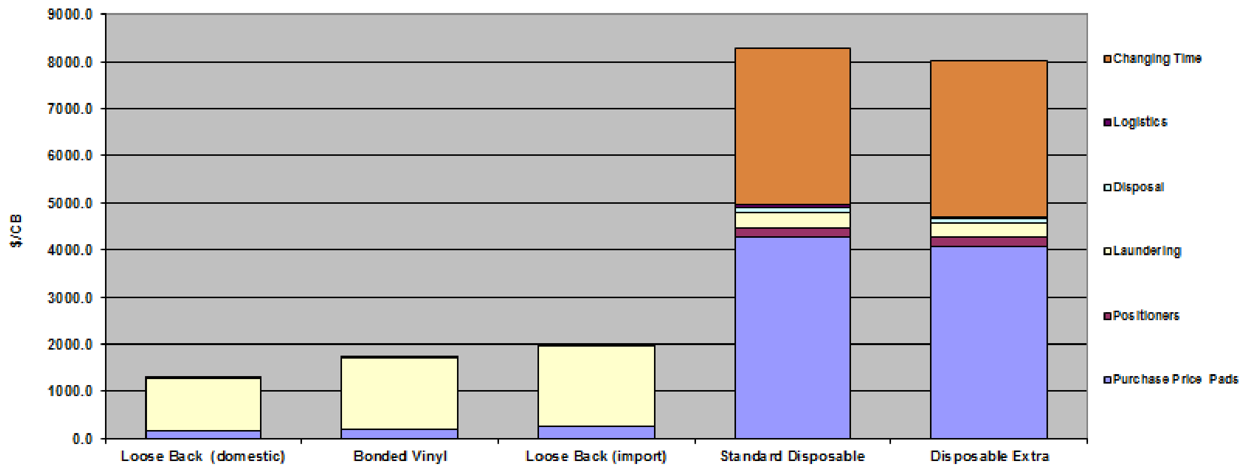

Figure 32: Scenario Analysis #4: Caregiver's time considered in economics

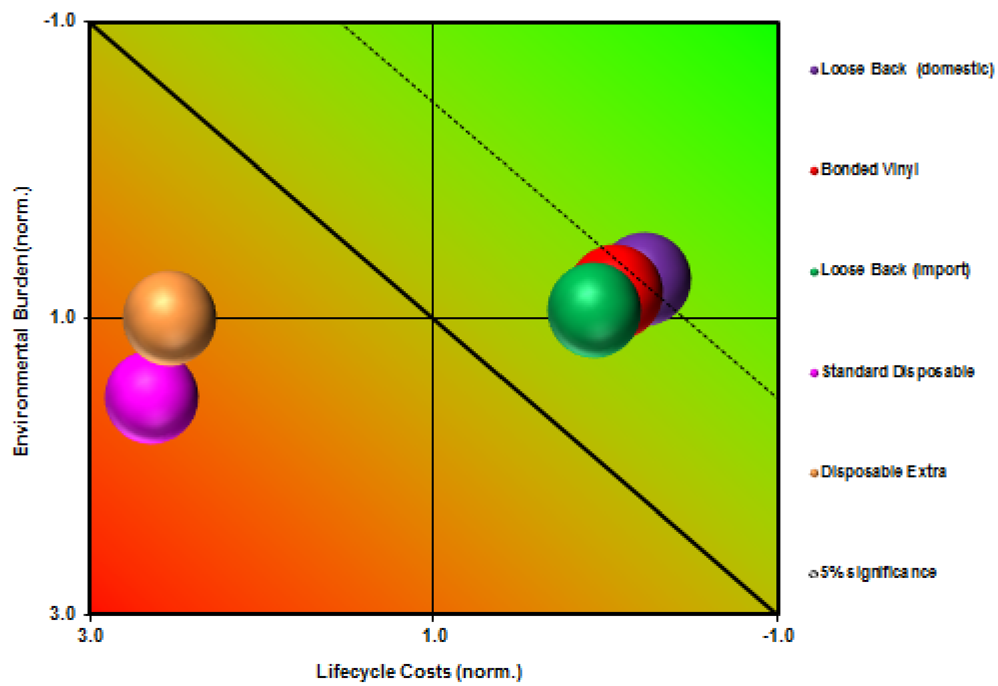

Figure 33: Scenario Analysis #4: EEA Portfolio; Caregiver's time considered

10.3.5 Scenario #5: Purchase Price Changes

This scenario looks at price sensitivities to the purchase price paid for each alternative. As the economic impacts over the lifecyle are more significant contributors to the eco-efficiency of each alternative than the environmental impacts, fluctuations in purchase prices could have a significant impact on the final results.

Even at a purchase price reduction of over 70%, the best performing disposable bed pad is still higher in lifecycle cost and not as eco-efficient as either of the domestically produced reusable alternatives (loose back vinyl and bonded vinyl).

Even a 50% increase in the cost of laundering (the major cost contributor for the reusable alternatives) is not sufficient enough to make the disposable alternatives as cost effective or eco-efficient as the reusable alternatives.

The fact that the same general conclusions can be drawn from the study even when considering these significant economic variations only strengthens our confidence in the study results that show reusable bed pads being more eco-efficient and having lower economic and lifecycle cost impacts than disposable bed pads.

11. Limitations of EEA Study Results

These 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] RN Pedia.com Complete Nursing Notes and Community http://www.rnpedia.com/home/notes/fundamentals-of-nursing-notes/urinary-elimination

[2] North American Edition Comparative Operating Revenues and Expenses Profile for the Healthcare Maintenance Textile Industry. October 30, 2008 collected, compiled and compared by Phillips & Associates, Inc.

[3] Std Tunnel Formulas(ALL).xls Very Heavy Soil. Revision May 4, 2012. Gurtler Industries. 15475 South LaSalle Street South Holland, Illinois 60473

[4] http://www.arta1.com/cms/uploads/E.T.S.A.%20Study%20Gives%20Textile%20Services%20Sustainability%20Advantage.pdf. European Textiles Services Association (E.T.S.A.)

[5] http://www.arta1.com/cms/uploads/Australian%20Industry%20Surgical%20Gowns%20LCA%202008.pdf Carre, Andrew. Centre for Design at RMIT University. "Life Cycle Assessment Comparing Laundered Surgical Gowns with Polypropylene Based Disposable Gowns. November 27, 2008.

[6] Leonardo Da Vinci Project sponsored by the E.U. Commission on Education and Culture; Sustainability in commercial laundering facilities. Module 1 Chapter 2 page 16 Use of Water for washing.

7 Boustead Consulting Ltd UK, The Boustead Model 5.1.2600.2180 LCA database

8 http://www.arta1.com/cms/uploads/Australian%20Industry%20Surgical%20Gowns%20LCA%202008.pdf. Carre, Andrew. Centre for Design at RMIT University. "Life Cycle Assessment Comparing Laundered Surgical Gowns with Polypropylene Based Disposable Gowns. Nov. 27, 2008. Section 4.2.13, Waste Disposal and Appendix E, Nutrient Balance

9 United States Environmental Protection Agency EPA-530-F-010-012 Figure 4 Page 3 December 2010 www.epa.gov/wastes

10 BUWAL 250 Life Cycle Library, 2nd edition, Bundesamt for Umwelt, Wald und Landschaft (Swiss Agency for the Environment, Forests and Landscape)

11 TNS Infratest Landsberger Strasse 338 Munich Germany 80687

12 http://www.lacsd.org/solidwaste/swfacilities/rates.asp

13 North America Healthcare Laundry Industry Revenue and Expense Profile. 2010 Healthcare Conference Las Vegas, NV Sept 28-29 Phillips & Associates, Inc.

14 Shannon, Ronald BS MPH et al., March 2009 Wirtschaftliche Auswirkung von Ultrasorb® AP Premium Krankenunterlag zur Vermeidung von nosokomialen Druckgeschwüren

15 ecoinvent data v2.0. EcoInvent Centre Swiss centre for life cycle inventories. http://www.ecoinvent.org/database/

16 NREL US Life Cycle Inventory (LCI) database. Category: Truck Transportation November 2011 Data Generator: Nathan Hardesty http://www.nrel.gov/lci/database/