Evaluation of Ecolabelling Criteria

Using Life Cycle Assessment

by

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ABSTRACT

Ecolabels are the main driving force of consumer knowledge in the realm of sustainable product purchasing. While ecolabels strive to improve consumer's purchasing decisions, they have overwhelmed the market, leaving consumers confused and distrustful of what each label means. This study attempts to validate and understand environmental concerns commonly found in ecolabel criteria and the implications they have within the life cycle of a product. A life cycle assessment (LCA) case study of cosmetic products is used in comparison with current ecolabel program criteria to assess whether or not ecolabels are effectively driving environmental improvements in high impact areas throughout the life cycle of a product. Focus is placed on determining the general issues addressed by ecolabelling criteria and how these issues relate to hotspots derived through a practiced scientific methodology. Through this analysis, it was determined that a majority the top performing supply chain environmental impacts are covered, in some fashion, within ecolabelling criteria, but some, such as agricultural land occupation, are covered to a lesser extent or not at all. Additional criteria are suggested to fill the gaps found in ecolabelling programs and better address the environmental impacts most pertinent to the supply chain. Ecolabels have also been found to have a broader coverage then what can currently be addressed using LCA. The results of this analysis have led to a set of recommendations for furthering the integration between ecolabels and life cycle tools.

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INTRODUCTION

According to the Global Ecolabelling Network (2004), an environmental label, or ecolabel, is a label which identifies the overall environmental preference of a product based on life cycle considerations. Ecolabels are produced with three objectives in mind. The first objective is to protect the environment by bringing about environmental improvement. The second objective is to encourage environmentally sound innovation and leadership. And the final objective is to heighten consumer awareness of environmental issues.

Ecolabels originated mainly as environmental declarations and claims which were used to attract consumers who were looking for ways to reduce adverse environmental impacts through their purchasing choices (GEN, 2004). The increasing number of these claims, and lack of guidance or standards around their use, lead to consumer confusion and decreased the credibility of the claims. This has since lead to third party labeling being provided by private and public organizations at the national and regional level. Hybrids of ecolabelling have also emerged. These include third-party labeling systems which have a narrower focus than typical ecolabelling programs, i.e., they focus on a single sector, or only one environmental issue or life cycle phase (GEN, 2004). Programs have also emerged which address additional issues beyond environmental performance, such as social and animal welfare issues.

Three major types of voluntary environmental performance labels have been standardized and defined by the International Organization for

Standardization (ISO): Type 1, Type II, and Type III. Type I, or environmental labeling, is defined as a voluntary, multiple-criteria based, third-party program that awards a license which authorizes the use of environmental labels on products. The label indicates overall environmental preferability of a product within a product category based on life cycle considerations. This type of label has the ability to identify leadership products in the market place, and replaces the need for requiring consumers to undertake their own comparative analyses (GEN, 2004). Type II labels are defined as informative environmental self-declaration claims. Type III, or environmental declarations, are defined as voluntary programs that assess quantified environmental data for a product, under pre-set parameters. The parameters are set by a qualified third party and based on life cycle assessment, and verified by that or another qualified third-party. For the purposes of this study, focus will remain with Type I ecolabels.

An effective and credible ecolabelling program typically considers a set of guiding principles which have been developed based on work complied by ISO (GEN, 2004). According to these ten principles ecolabels should be voluntary, independent, and flexible. Ecolabel criteria should be also based on sound scientific principles, and distinguish leadership in products which are legislatively compliance and fit for purpose. Criteria must be credible, attainable, and verifiable. Also the program should be transparent and consistent with ISO guiding principles.

The development of Type I ecolabels begins with the development of criteria for a specific product category. This process utilizes an independent organization and assistance from a technical advisory group. Once the criteria are determined, companies who wish to participate in the label can apply and submit products for third-party verification (GEN, 2004). Multiple stakeholders typically participate in the initiative including governments, program managers, industry associations, retailers, and consumers.

According to the Global Ecolabelling Network, success of a Type I label is measured with respect to acceptability (2004). Industry participation is one such indicator of success as it indicates that producers see the advantage of displaying the ecolabels on their product. Consumer recognition and demand in the form of purchasing changes is also an important indicator (GEN, 2004). Improvement in the environmental quality of a labeled product is a third indicator of success, but is typically long term and can be difficult to demonstrate.

COSMETIC PRODUCT CATEGORY

Cosmetics are a group of consumer products designed to improve the health, cleanliness, and physical appearance of the human exterior and to protect a body part against damage from the environment (Cosmetics, 2000). This group of products is distinct from pharmaceutical or drug products, as they lack claims of pharmacological activity by any one of the constituents of the product (Cosmetics, 2000). Seven categories of cosmetics exist: skin care and maintenance, odor improvement, shaving products, hair removal, hair care and maintenance, decorative cosmetics, mucous membrane care. Lotions, sunscreens and anti-wrinkle creams are considered skin care and maintenance products. Soaps and shampoos are considered to be part of the cleansing category. The category of odor improvement includes products such as fragrances, deodorants, and antiperspirants. Shaving products are considered part of the hair removal category and styling products or conditioners part of the hair care and maintenance category. Beautifying eye, lip, and skin products are part of the decorative cosmetics category.

As an industry, the Beauty and Personal Care Sector is widespread, representing 4.5% of the global retail market (Euromonitor, 2012). Worldwide in 2010, $208 was spent on average per household on beauty and personal care products. In North America alone, $519 per household was spent on these products in 2010. The market is dominated by Procter& Gamble, who owns the highest percentage of beauty and personal care brands (11.6%), L'Oréal (9.8%), and Unilever (6.9%) (Euromonitor, 2012).

Information relating to the environmental impacts of cosmetic products can be found from different sources. Skin Deep, a database developed by the Environmental Working Group, provides practical solutions to protect consumers from everyday exposures to chemicals. (Skin deep, 2012) The database was developed in 2004 and includes easy-to-navigate safety ratings for a wide range of products and ingredients on the market. (Skin deep, 2012) The database provides users with product specific safety information including cancer risk, toxicity, allergies and overall hazard. The analysis is completed on an ingredient basis and the reliability of the sourced data is also provided. Each product is given an overall hazard score between 0 and 10; a higher score represents a higher hazard.

The information provided allows for a ranking of products and information relating to the behavior of the product's ingredients. The analysis also considers neurotoxicity, endocrine disruption, environmental persistence, and biodegradability. The products classified by the skin deep database include sunscreens, makeup, skin care, hair products, nail care, fragrances, and oral care.

The GoodGuide is an online database also focusing on rating everyday household products including, personal care, household chemical, and food products (GoodGuide, 2012). The overall product rating is derived from three different subcategories: health, environment, and society. The research focuses on rating the ingredients of the products, as well as, company level indicators of social performance and transparency. Product ratings are based on a 0 to 10 scale with a higher value product performing better overall. Data is sourced from a multitude of different outlets, including scientific journals and government agencies, and is organized in a structural framework for scoring. The environmental assessment found within GoodGuide is limited to company practices and policies and does not identify potential areas of product improvement beyond the ingredient level.

Life cycle assessment literature on cosmetics products is also a valuable source for information relating to the environmental impacts of products and identification of areas of improvement in a products life cycle. Product life cycle assessments give insight into environmental impacts throughout the entire supply chain. The information tends to be quantitative in nature, and environmentally focused. In this way, LCA literature provides a contrast to both the Skin Deep and

GoodGuide reference databases. LCAs are uncertain in nature and rely on data which is typically unavailable or protected. They also typically do not capture the social and economic pillars of sustainability.

GOAL AND PURPOSE

The primary goal of this study is to compare the common indictors used by ecolabels to drive environmental impacts reduction to the impact category hotspots determined using a life cycle assessment (LCA). The main driver behind this analysis is the lack of transparent, scientifically backed, information supporting the policies and requirements made by ecolabelling criteria. The intended audience includes interested members of the public who wish to have a better understanding of what is driving environmental impacts in products they use and how it can be reduced, as well as, stakeholders involved in the indicator development process for personal cosmetic products, and manufactures that strive to lower the impact of a product by adhering to ecolabel criteria.

This study will provide the industry with recommendations for beginning to integrate life cycle thinking and life cycle assessment into the ecolabel criteria development process. These recommendations provide guidance and standardization to the application and integration of LCA during the ecolabel criteria development. A case study of cosmetic products is used to illustrate how LCA can be used to indentify hotspot and impact drivers, and how those hotspots align with common ecolabel indicators.

The proceeding chapters explore the potential use of LCA in informing sustainable purchasing and present recommendations on how integration with ecolabels can best occur. Chapter 2 includes a literature review on ecolabel programs, focusing specifically on how ecolabels are evaluated and how LCA has been used in past criteria development processes. Chapter 3 explains the methodology behind the cosmetics case study, providing details about the development of an LCA and the determination of common ecolabel criteria. Chapter 4 presents the results, which includes hotspots found using the LCA procedure and a derived list of common cosmetic ecolabel indicators. The two sets of results are compared to provide insight into the life cycle coverage of current cosmetic ecolabels. Chapter 5 provides a set of recommendations for the future development of ecolabel criteria using a life cycle assessment approach.

Chapter 2

LITERATURE REVIEW

This chapter will provide a review of the literature related to ecolabels, the assessment of ecolabels, and life cycle assessment. General issues related to ecolabels, such as their limitations and consumer perception, will be discussed. The review will include a detailed look at literature which evaluates ecolabel criteria. The literature review will also cover literature relevant to life cycle assessment, and LCAs connection and use within ecolabelling programs. LCAs specific to cosmetics and other similar consumer chemicals products will also be discussed.

ECOLABELS

Type I ecolabelling has two main objectives: (i) to provide consumers with more information about the environmental effects of their consumption, generating a change towards more environmentally friendly consumption patterns, and (ii) to encourage producers, governments and other agents to increase the environmental standards of products/services (Gallasteguil, 2002). These goals are achieved by raising consumer awareness about product impact, eventually leading to acceptance and finally to behavior change (Leire & Thidell, 2004). Table 1 gives a summary of a few ecolabelling programs, many of which are relevant to cosmetics.

Table 1

List of Ecolabels

Organization	Country	Year
Australian Certified Organic	Australia	2002
B Corporation	U.S., Canada	2007
BASF Eco-Efficiency	Germany, US	2002
Brazilian Association of Technical Standards	Brazil	1993
Certified Wildlife Friendly	Africa, U.S.	2007
COOP Naturaline	Switzerland	1993
COSMetics Organic Standard	Europe	2008
Cradle to Cradle	International	2005
Degree of Green	U.S., Canada	2008
Earthsure	U.S., Canada	2006
EcoCert	International	1991
EcoLogo	North America, UK	1988
Ecomark: India	India	1991
Environmental Choice New Zealand	New Zealand	1990
Environmental Product Declaration	International	1999
Global Packaging Protocol on Sustainability	Global	2011
Good Environmental Choice	Australia	2001
Green Crane: Ukraine	Ukraine	2002
Green Good Housekeeping Seal	U.S.	2009
Green Seal	International	1989
Green Tick	U.S, Australia, New Zealand	2001
GreenTag Certified	Australia	2010
International Organic and Natural Cosmetics Corporation	Germany	2001
Italian Association for Organic Agriculture	Organic Agriculture	unknown
Leaping Bunny	International	1998
Natrue	International	2007
Natural Products Association	U.S.	2008
Naturally Sephora	International	unknown
Nordic Ecolabelling	Nordic Countries	1989
NSF Sustainability Certified	U.S.	2010
OASIS	U.S.	2008
SustentaX	Americas	2008
U.K. Soil Association "Organic"	UK	1973
USDA "Organic"	U.S.	2002
Whole Trade™ Guarantee	U.S., Canada, UK	2007

Many studies have identified issues and limitations related to ecolabel programs and their criteria (Horne, 2009; Erskine and Collins, 1997; D'Souza et al., 2006). Concerns include an overload of information provided to consumers, avoidance of product groups which cause a large portion of consumer impact, and a lack of credibility among stakeholders. Other issues include the lack of objectivity in setting performance criteria, difficulties in setting system boundaries, and the short validation periods for commenting on criteria (Gallasteguil, 2002). Another main concern when it comes to ecolabelling is the lack of consumer understanding of the meaning of a symbol or logo and the factors which are considered as part of the label (D'Souza et al., 2006). In contrast, it has also been suggested that the simplicity of ecolabels overshadows the deep understanding of the environmental impacts of product consumption as a whole (Horne, 2009).

Another important aspect of ecolabels to understand is their impact on the market. A number of studies have attempted to understand this impact, as well as, the consumer perspective on labeled products (D'Souza, 2004; Mattoo and Singh, 1994; Hemmelskamp and Brockmann, 1997). It has been suggested that ecolabelling has the potential to reduce the output of unfriendly products on the market in certain situations. Success is expected when a consumer can expect a personal advantage from utilizing the ecolabeled product. Consumer participation, in terms of purchases, and industrial participation, in terms of reporting criteria, are also both factors in measuring success (GEN, 2004). On the other hand, the success rates of ecolabelling programs have not been high. The low success rate of some programs could potentially be due to the misunderstanding of label information and a lack of emphasis on the right segments of consumers.

EVALUATION OF ECOLABELS

While a substantial amount of literature exists which focuses on the evaluation of ecolabels with respect to their effectiveness in terms of consumer acceptance, the evaluation of the impact reduction an ecolabel program creates is less common. As discussed in the previous section, the success of an ecolabel or labeling program is determined by whether or not consumers are changing behavior and purchasing a greener product. According to the Global Ecolabelling Network, (2004) consumer recognition, in the form of trust and willingness to make purchasing decision based on the given information, is a major indicator for success.

Only a handful of studies have evaluated ecolabels with respect to the criteria they employ to create change. In 2004, a study examined the adequacy of three types of ecological labels according to the ISO 14020 series (Lavallee, 2004). Criteria for Type I ecolabels was found in certain cases to be established without any product life cycle assessments or consideration of the impacts from the perspective of the entire life cycle. The article suggests that, even though the ecolabels analyzed lacked objectivity, transparency, and often relied on a semi-qualitative approach to develop criteria, they were still capable of underpinning and influencing public policy on sustainable development as ecolabels are the most direct link between products and consumers. The author also suggests solutions for making the ecolabel process more credible, as it plays an important role as a catalyst in sustainable development (Lavallee, 2004). A second assessment of 36 ecolabelling programs was performed by Horne in 2009. This assessment categorized the schemes based on success criteria, including indicators such as: the number of criteria, quality of the criteria development method, and environmental significance of the product being labeled. It was found that a wide range of methods are used to established ecolabel criteria and the products being labeled are not the most impactful. Horne concluded that it is unclear whether ecolabelling actually leads to reduced impact and sustainable consumption (Horne 2009).

An assessment of ecolabelling criteria from the perspective of sustainability has also been performed on two well-known ecolabelling schemes. The aim was to investigate the gaps in their criteria development processes with respect to sustainability objectives, as the criteria development process had been identified as the core element of effective ecolabels. Through the use of a five level generic framework for strategic sustainable development (FSSD) previously published by one of the authors (Robért, 2000), ecolabelling was found to not be currently as effective a contributor to sustainable production and consumption as it could be. The selection and prioritization of criteria for these two programs was found to not be clearly presented and lacked guidelines which ensure a broad representation of the different aspects of sustainability. It was also found that, while programs strive for a life cycle perspective, LCA is not an obligation of the programs and there is no clear way to ensure the complete life cycle is considered.

INDUSTRY SPECIFIC ECOLABEL ASSESSMENTS

Evaluation of ecolabelling programs has also occurred in a few industry case studies. A case study of paper products was used to assess whether ecolabelling is an effective means of improving the environment (Erskine and Collins, 1997). The authors suggests that ecolabelling programs have not worked to date because they have not fully achieved their aim of promoting products with reduced impact and providing consumers with better information about the environmental impacts of a product. Environmental benefit is believed to not occur until these aims are met. The study also suggests that while the concept of ecolabelling is solid, the practical application of the concept is complicated and there is little evidence that ecolabels are currently benefitting the environment.

Ecolabels for the agriculture industry have also been evaluated. A 1999 article by Snoo attempts to answer the question of whether ecolabels stimulate the development of sustainability practices and improve environmental quality with respect to agriculture (de Snoo 1999). Focusing on the cultivation of ware potatoes on arable farms, the study compared the five Dutch environmental labels with common themes relevant to Dutch environmental policy. The study found that themes which are highly relevant to the environmental impacts had little attention in ecolabelling criteria analyzed, implying that sustainable agriculture is not guaranteed through certification with current ecolabels. Also, the study suggests that due to the lack of a scientific framework for analyzing environmental issues, the effectiveness of the criteria cannot be properly evaluated. A study in 2007 attempted to analyze five Dutch environmental labeling schemes for arable farming with respect to a developed yardstick on biodiversity of agricultural landscapes (Van Amstel, 2007). The yardstick broke down the idea of agrobiodiversity into ten categories of farming activities which were then compared to the standards of the labeling schemes. The study concluded that ecolabels do not guarantee agrobiodiversity, as the measures of the yardstick are not very well represented in the labeling schemes. It was also discovered that the current ecolabels differ in the particular aspects of the agrobiodiversity with which they focus. The author does not see improvement on this issue in the near future due to the fact that agrobiodiversity is not a prominent theme in society or government policy. In a more specific agricultural case, an empirical assessment of eco-certification for banana production in Ecuador has also been performed (Melo, 2005). Contradictory to the results from other studies, the assessment found evidence to support the notion that eco-certified products have a lower ecological risk as farms that were certified significantly outperformed noncertified farms.

The construction industry has also questioned the effectiveness of eco-labeling and its ability to achieve sustainability within the industry. Ball (2001) criticizes the emphasis within ecolabel criteria on politically driven value judgments rather than scientific data, as well as their lack of credibility, representativeness, and stringency (Ball 2001). The study finds that the adoption of ISO 14001 standards would be more successful in steering the construction industry toward environmental improvement as ecolabels do not react to the situation of global environmental destabilization, thereby ignoring wider issues of sustainability.

Some industries have struggled to even evaluate ecolabels because data is lacking for pre-ecolabel conditions. For example, the seafood industry lacks a completed assessment on the impact certification implementation has on seafood production. Empirical modeling is relied on to explore the major factors which cause improvement (Tlusty 2011).

The current status of ecolabel evaluation brings to light many problems related to ecolabel criteria development. Many ecolabels suffer from a lack of scientific rigor during their development stage. This leads to cases where product ecolabels may not adequately cover important impacts related to the product and its supply chain. The absence of strict methodology can also lead to the nonexistence of transparency in the details of the criteria development. It is therefore important to consider the application of additional tools which could be used to develop or evaluate ecolabel criteria.

LCA AND ECOLABELS

The application of life cycle assessment (LCA) methods to a product or industry has been identified as a way to reduce the current issues of criteria development, including transparency and lack of sound scientific methodology. In 1993, the challenges that occur during the use of LCA to define ecolabel criteria were identified (Clift 1993). Primary issues cited include defining a functional unit and setting proper cradle and grave boundaries. The use of LCA in the creation of environmental labeling criteria has since been supported. Neitzel discusses many different ways in which an LCA approach can be applied to ecolabels including to define scope, prioritize life cycle phase and impacts, and to check for completeness of criteria (Neitzel 1997). A specific example of fresh milk packaging is explored, in which LCA was used as a completeness test. The major LCA impacts were found to not directly align with labeling criteria.

Another study performed a LCA on shrimp aquaculture to gain insight on the potential and limitations of utilizing an LCA approach when selecting ecolabelling criteria. The study found the life cycle framework to be the best available basis for analyzing product performance on environmental issues (Mungkung 2006). It was also determined that even though LCA is not capable of quantifying all important impacts, it can provide insight on important qualitative impacts, such as loss of biodiversity and land use impacts in this case. LCA has since been used to create specific ecolabel criteria, such as for the Catalan ecolabel for leather (Mila I Canals 2002**)**. The completed LCA allowed for relevant hotspots to be detected and translated into environmental criteria in combination with other types of data. The assessment of the leather life cycle found three areas of focus: agriculture, cattle-raising, and tannery wastes. The analysis determined a difficulty in establishing criteria for agriculture as it may lie outside the scope of a leather ecolabel, and highlighted shortcoming to the LCA approach for impact categories such as animal welfare and biodiversity.

LCA AND COSMETICS

Although some industries have begun to utilize life cycle assessment as a tool for ecolabel criteria development, this has not yet been seen in the beauty and personal care industry. A complete, publically available, life cycle analysis of a cosmetic product is rare, mainly due to the fact that product formulations are proprietary information. Researchers have thus used other types of assessments to explore and understand the impact of cosmetics. Risk assessment is one of the more common tools utilized due to the chemical nature of these products. The majority of this work focuses on the health and exposure aspect of these types of products, as many formulations contain know allergens in the form of preservatives or fragrances (Schnuch et al., 2007; Rastogi et al., 2001; Johansen, 2003; Houlihan et al., 2002).

Another major area of concern around cosmetic products is their disposal. Many articles have investigated the behavior of cosmetic chemicals when they enter the wastewater stream at end of life; particular focus is placed on biodegradability and ecotoxicity potential (Omil et al., 2004; Ternes et al., 2004; Berger, 1997; Ankley and Burkhard, 1992; Baghel et al., 2008). A third area for concern regarding cosmetics is the utilization of palm oil as part of the chemical formulations. Both environmental and social issues surround the production of palm oil in areas such as Malaysia and Indonesia. Increasing demand for the product has led to deforestation and biodiversity loss, as well as, social unrest, conflict, and limited worker rights (Teoh, 2011; Brown and Jacobson, 2005)

Insight into the life cycle of cosmetic products can also be drawn from LCA studies completed on products of similar composition. Laundry detergent has been extensively researched from a LCA perspective and multiple articles and inventories are available (Dewaele et al., 2006, Henkel, 2008; Koehler and Wildbolz, 2009; Van Hoof et al., 2003). Surface cleaning products have been analyzed using life cycle assessment methodology and been made publically available by Procter & Gamble (AFISE, 2004). In addition, a range of home-care and personal-hygiene products were assessed using LCA by Koehler and Wildbolz, whose study included laundry detergent, kitchen cleaner, window cleaner, liquid soap, and bar soap (Koehler & Wildbolz, 2009).

The limited amount of published LCA research for consumer chemicals is in part a result of the uncertainty of assessing the impacts related to the production of the chemical raw ingredients. Due to the vast number of chemicals, the numerous techniques used to produce them, and the potential cogeneration of different chemicals in one process step, primary impact data is difficult to acquire. Primary data is typically only available for the production of one final major chemical or similar group of chemicals; otherwise data tends of be in an aggregated form due to multiple co-product generation (Klopffer 2005). Methods have been developed to better estimate the impact of chemical production of both high volume and specialty chemicals for use in LCA (Bretz and Frankhauser, 1996; Geisler et al., 2004; Kim and Overcash, 2003). A methodology was also developed for creating LCIs of chemicals for the ecoinvent database. The methodology includes instructions for three distinct conditions: good primary data availability, weak data availability, and aggregated data (Hischier et al., 2005).

SUMMARY

The literature for both ecolabels and life cycle assessments portrays the challenges, benefits, and limitations of each tool. Ecolabels are contingent on consumer adoption and behavior changes. LCA is uncertain in nature and lacks social and economic factors in the impact analysis. In general, the literature around the assessment of ecolabel effectiveness highlights the lack of standardized criteria assessment methodology and the need for the use of tool, such as LCA, to their full potential.

Due to the significant impact ecolabelling programs can have in decision making, it is imperative that the current lack of assessment and divergent program methodologies across products and industries be addressed. The proceeding chapters will assess the extent to which ecolabels are effectively driving environmental improvements throughout the life cycle of a product. Focus will be placed on determining how the general issues found in ecolabels relate to hotspots derived through a practiced scientific methodology.

Chapter 3

METHODOLOGY

There is a need to take a detailed look at the criteria used to produce ecolabels. While many ecolabelling programs employ a multi-stakeholder approach during criteria development, a life cycle analysis may not always be used to determine relevant impacts. Evaluation of the improvement a criterion generates is also a high priority after a label is established. Therefore, in order to fill this gap for cosmetic products, a life cycle assessment will be used to compare ecolabel criteria to the main supply chain impacts. This chapter will describe the methodology and assumption made for an LCA of two cosmetic products, as well as, the methodology for the assessment of the ecolabel program criteria.

STREAMLINED LCA

scope. Cosmetic products can be classified into a few distinct categories based on how they are used. This analysis will include representative products from the leave-on category. Leave-on products are those which remain on the body during use and do not require immediate rinsing. These products are typically absorbed through the skin or are worn off throughout the day. Examples include: lotion, make up, deodorant, and sunscreen. The representative products will include one leave-on product which is expected to be packaging intensive and one which is material intensive, cream foundation and deodorant respectively. Each of these products has a distinct function as a beauty product. Deodorant provides daily odor and wetness protection to the underarm area. Foundation, in cream form, evens out facial skin tone and provides a flawless complexion. In this study the functional unit considered is the amount of cosmetic product required to satisfy its given function for one adult female, over a 1 year period.

system boundaries. This study will include a cradle-to-grave assessment of each of the representative products. Impacts will be assessed from raw material extraction through product manufacturing, use and disposal. The analysis will consider a geographical boundary of the United States; products are manufactured, transported, used, and disposed of with U.S boundaries. Due to data availability, European data may be used as a substitute when U.S. data is unavailable.

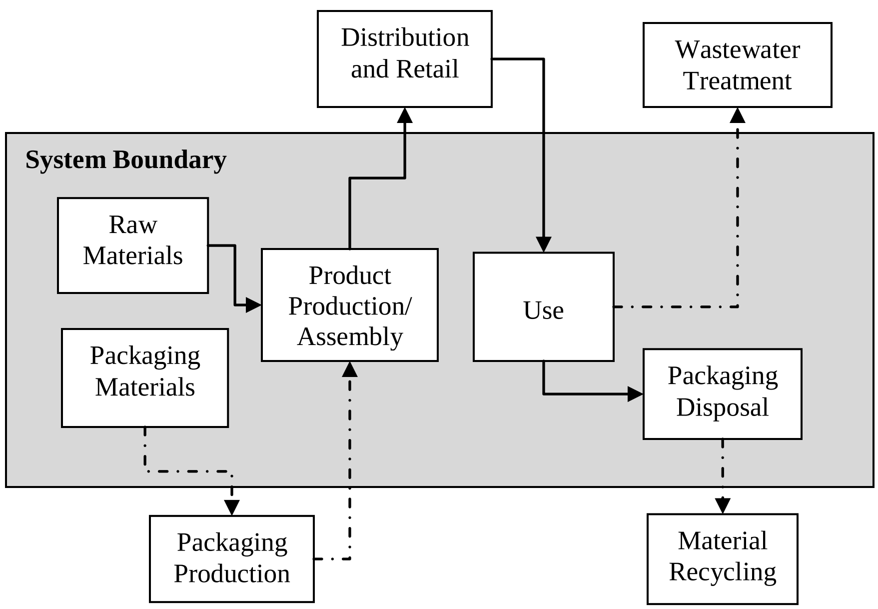

Figure 1: System Boundary Diagram. Processes found outside the gray box are not included in this analysis. Transport is included between phases with solid lines.

The indirect excluded impacts are the same for each of the products being considered. This includes infrastructure and capital goods. For example, impacts from roads which are required for transportation, machinery used during production, and electricity infrastructure are excluded. Also excluded in the inventory of each product are the requirements of storage in a distribution center, retail stores, and at home during the use phase.

allocation procedures. Allocation will occur on an as needed basis when co-products are formed. Any allocation performed in this analysis will be determined on the basis of weight of material. During the final production of cosmetic products no co-products are produced.

LCIA methodology and types of impacts. The ReCiPe impact assessment method using the midpoint impact categories with hierarchist uncertainty perspective and worldwide scale were used in this study to complete the impact assessment (Goodkeep et al., 2009). The impacts were normalized based on data available from worldwide emissions, as U.S. data is not currently available. The analysis will consider 17 ReCiPe midpoint categories which include: Climate Change, Ozone Depletion, Human Toxicity, Photochemical Oxidant Formation, Particulate Matter Formation, Ionizing Radiation, Terrestrial acidification, Freshwater and Marine Eutrophication, Terrestrial and Freshwater Eco-toxicity, Agricultural Land Occupation, Urban Land Occupation, Natural Land Transformation, Metal Depletion, and Fossil Depletion (Goodkeep et al., 2009). Due to the large uncertainty and lack of normalization values within the ReCiPe methodology, the Water Depletion midpoint impact category will be excluded from the analysis. Focus will be placed on the top five most impactful categories according to both the characterized and normalized results.

data requirements. The SimaPro software package was used to complete the analysis of the model (SimaPro, 2012). Input data was sourced from literature references and is supported by generic datasets found in ecoinvent. The data represents an average or baseline value for the inputs of the products being considered. The best publicly available and representative data was used to determine the input values for each product. This required the sourcing of values from literature and linear conversion into the appropriate reference flow. A reference will be cited representing the source of the original value when this is the case. All other input values were determined using average data from an in-house product sampling procedure. This process included the collection and measurement of market representative samples of each of the two products. Values determined using this method represent the average values of this process.

This study was limited by the use of secondary average data. Because the goal of this study is to get a basic picture of the environmental impacts associated with cosmetic products, secondary data is sufficient. In order to get the most accurate picture of the life cycle footprint of a given product, primary data is needed. Primary data would need to be sourced from product manufactures and material suppliers. Uncertainty in the analysis is also increased by the use of European based datasets. In order partially circumvent this uncertainty and get a more accurate picture of the impact relative to the United States, the typical European electricity grid mixed used in the ecoinvent datasets was rerouted to the

U.S. average electricity grid mix. The modification, which involves applying U.S. electrical conditions to the ecoinvent database, was performed by Sylvatica on behalf of EarthShift. (Earth Shift, 2009).

uncertainty analysis. A Monte Carlo simulation was used within the SimaPro software to provide an uncertainty value to the results. This simulation captured the uncertainty inherent to the dataset, as well as, uncertainty of the input values and their representativeness to the corresponding dataset. Inherent uncertainties are only applicable to unit process dataset, and have been predetermined through the use of multiple measuring during sampling or assigned pedigree matrix values. Uncertainties in the input values have been determined using the pedigree matrix embedded in the SimaPro software. Values are assigned to matrix categories including: reliability, completeness, temporal correlation, geographical correlation, technical correlation, and sample size (Goedkoop et al., 2010). The assigned matrix values are then used to determine a standard deviation for each input value. A list of pedigree matrix values applied to each input can be found in Appendix B. The uncertainty of the results will be displayed using error bars in the graphs of the results which represent the standard deviation of the final value.

life cycle inventory. Due to the similarity of the products under consideration, many of the assumptions made in this analysis apply across both product categories. When considering the Raw Materials, Production and Packaging phases, each product's assumptions vary. Assumptions related to Transportation and Disposal are relevant across the different products.

The deodorant product being studied was assumed to be a solid stick which holds 75 g of product per package. Based on consumer survey data, it is estimated that 0.61 g of deodorant is used per application of deodorant and applications occur an average of 1.3 times a day (Loretz et al., 2006). Due to the design of deodorant stick packaging, it is also assumed that 10% of the product in the package is unavailable for use. On a yearly basis, a woman will apply deodorant 474.5 times for a total use of 289.5 g. In order to fulfill this demand, 4.29 packages are required.

The cream foundation being studied was assumed to be found in a small round glass container which holds 0.79 fluid ounces or 22.2 g of product. Based on survey data, it is estimated that a woman applies 0.54 g of foundation per application and that foundation is typically applied 1.24 times a day (Loretz et al., 2008). A 1% product a loss during use is assumed. On a yearly basis, a woman will apply foundation 452.6 times a year for a total use of 244.4 g. In order to meet this demand, 11.11 packages will be required.

raw material extraction and processing. The inventory of raw materials was determined using the ingredient formulations of the respective products. The mass percent of each chemical was used to determine the amount needed to satisfy the functional unit. Chemicals were then matched to appropriate preexisting datasets. When an exact chemical match could not be found, a proxy chemical was chosen. Similar chemicals, or chemicals which could be substituted for one another, where chosen as proxies. In a limited number of cases, the chosen chemical was represented by a general dataset. The chemical formulations, mass percent's, and dataset selections for deodorant and foundation can be found in Table 2 and 3 respectively.

Table 2

Deodorant Formulation and Dataset Pairings

Ingredient	Percent of total mass	Dataset
Cyclopentasiloxane	23%	Sodium metasilicate pentahydrate, 58%, powder, at plant/RER WITH US ELECTRICITY U
PPG-14 butyl ether	9.50%	Propylene oxide, liquid, at plant/RER U
BHT	0.05%	Chemicals organic, at plant/GLO WITH US ELECTRICITY U
Dimethicone	1%	Glycerine, from palm oil, at esterification plant/MY S
C12-15 Alkyl Benzoate	15%	Benzyl alcohol, at plant/RER U
Steareth-100	0.50%	Ethoxylated alcohols, unspecified, at plant/RER WITH US ELECTRICITY U
Stearyl Alcohol	18%	Ethoxylated alcohols (AE3), palm kernel oil, at plant/RER WITH US ELECTRICITY U
Hydrogenated Castor Oil	3.50%	Rape oil, at regional storage/CH WITH US ELECTRICITY U
Polyethylene Wax	1%	Low-density polyethylene (LDPE) virgin resin production/US
PEG-8	2%	Ethylene glycol, at plant/RER WITH US ELECTRICITY U
Fumed silica	0.75%	Silica sand, at plant/DE U
Aluminum	20%	Aluminum, primary, at plant/RER U
Chlorohydrate sunflower oil	0.50%	Rape oil, at regional storage/CH WITH US ELECTRICITY U
Fragrance	1.20%	Chemicals organic, at plant/GLO WITH US ELECTRICITY U
Water	4%	Water, completely softened, at plant/RER WITH US ELECTRICITY U

Table 3

Cream Foundation Formulation and Dataset Pairings

Ingredient	Percent of total mass	Dataset
Cyclopentasiloxan	20%	Sodium metasilicate pentahydrate, 58%, powder, at plant/RER WITH US ELECTRICITY U
Glycerin	12%	Glycerine, from palm oil, at esterification plant/MY S
Water	36.6%	Water, completely softened, at plant/RER WITH US ELECTRICITY U
Dimethicone Cross polymer	5%	Sodium metasilicate pentahydrate, 58%, powder, at plant/RER WITH US ELECTRICITY U
Dimethicone	4%	Glycerine, from palm oil, at esterification plant/MY S
Methicone	5%	Glycerine, from palm oil, at esterification plant/MY S
Benzyl alcohol	0.50%	Benzyl alcohol, at plant/RER U
PEG/PPG-18/18 Dimethicone	2.00%	Ethylene glycol, at plant/RER WITH US ELECTRICITY U
Ethylparaben	0.10%	EDTA, ethylenediaminetetraacetic acid, at plant/RER WITH US ELECTRICITY U
Methyparaben	0.10%	EDTA, ethylenediaminetetraacetic acid, at plant/RER WITH US ELECTRICITY U
Propylparaben	0.10%	EDTA, ethylenediaminetetraacetic acid, at plant/RER WITH US ELECTRICITY U
Disodium EDTA	0.10%	EDTA, ethylenediaminetetraacetic acid, at plant/RER WITH US ELECTRICITY U
Titanium dioxide	6%	Titanium dioxide, production mix, at plant/RER WITH US ELECTRICITY U
Iron oxides	1.50%	Pigments (general) I
Sodium chloride	2%	Sodium chloride, at plant NREL /RNA
Niacinamide	5%	Sulfur, at plant/kg/RNA

production. Product specific production data is currently not publicly available for cosmetic products. In order to estimate the requirements of production, a top-down approach was taken. Production requirements per ton of cosmetic product are available at a company level and where utilized in this analysis. These requirements specifically included electrical energy, gas, water, and an output of effluent for cosmetic production (Oriflame Cosmetics, 2009). The company level values represent the average requirements for the production of multiple products and can be found on a per ton produced basis in Table 4. As this is the best available information on cosmetic production, the impacts of producing deodorant and foundation were assumed to follow a linear relation.

Table 4

Cosmetics Production Requirements

Required Materials	Per ton of production	Dataset
Electrical energy	348 kWh	Electricity, high voltage, at grid/US WITH US ELECTRICITY U
Gas	43.5 Nm^3	Natural gas, at long-distance pipeline/RER WITH US ELECTRICITY U
Water	6.8 m^3	Water, completely softened, at plant/RER WITH US ELECTRICITY U
Effluent	6.12 m^3	Treatment, sewage, to wastewater treatment, class 4/CH WITH US ELECTRICITY U

packaging. The impacts of packaging are represented by the material used and, in the case of plastic, processing steps required to create the final package. The determination is based on the weight of the material being used. Weight was determined through the disassembly and measurement of a group of representative products currently available on the market. An average value was used to represent the product analyzed in this study. When necessary, i.e., when processing is not included within the chosen dataset, a processing or molding dataset was added to the analysis. Injection molding of the plastic material is one instance in which this occurs.

Table 5

Packaging Inputs per Regularly Packaged Product

Deodorant Packaging	Grams Per Package	Dataset
Cap (PE)	5.53 g	Polyethylene, LDPE, granulate, at plant/RER WITH US ELECTRICITY U
Barrel (PE)	32.67 g	Polyethylene, LDPE, granulate, at plant/RER WITH US ELECTRICITY U
Platform (PP)	3.47 g	Polypropylene, granulate, at plant/RER S
Protective cover (PP)	1.3g	Polypropylene, granulate, at plant/RER S
Foundation Packaging	**Grams Per Package**	**Dataset**
Lid (PP)	8.58 g	Polypropylene, granulate, at plant/RER S
Bottle (Glass)	74.1 g	Packaging glass, white, at plant/RER WITH US ELECTRICITY U

The assumed deodorant package in this study weighs a total of 43 g. This includes the barrel: in which the main product is contained, the outer cap, the platform: which lifts the product, and the protective cover: which protects the product during retail. According to deodorant packaging patents, the container for a stick deodorant is typically produced from a thermoplastic polyalkylene, such as polyethylene or polypropylene (Batchelor, 2009), which is injection molded into final form (Rego et al., 2005). It was assumed that the platform and protective cover are produced from polypropylene and the outer cap and barrel from polyethylene. The weight of each material is listed in Table 5. The packaging apparatus is also expected to create a product loss of about 10%, as deodorant remains attached to the sides, bottom of the barrel and platform. In accordance with the functional unit, 4.29 packages are required per year.

The assumed packaging for a cream foundation in this study weights a total of 82.6g. This includes a short glass container, which holds the product, and a hard plastic screw-on lid. The plastic material which forms the lid was assumed to be injection molded polypropylene. The packaging apparatus was assumed to create a 1% product loss, as it is difficult to completely empty the container. In accordance with the functional unit, 11.11 packages are required for one woman for one year.

transport. In the Transportation phase, products and materials are assumed to be transported the same distances. In each model, unless otherwise stated, transportation is assumed to be completed by a diesel truck that is fully loaded. It was also assumed that the transportation impact of the product is only associated with a one way trip. This assumption is due to the fact that many trucks will not run empty directly back to the place of origin; they may take a back hall or head to a new location.

Both models assume that the raw materials travel an average of 700 km to reach the production facility. This includes a transport distance of 600 km by rail and 100 km by truck (Frischknecht and Jungbluth, 2002). Transportation steps prior to the transport of a final raw material are assumed to be embedded within the corresponding LCI dataset assigned to the input. After manufacturing, the product was assumed to be transported by truck a total distance of 520 km from the manufacturing site, through a distribution center, to a retail store (Koehler & Wildbolz, 2009). The distance between retail store and consumer's home for each product was assumed to be a roundtrip of 6.5 km, as a consumer travels an average of 2 miles each way to the store (Laraia et al., 2004; Koehler & Wildbolz, 2009). Because a typically shopping spree results in the purchase of more than one product, the impact of this transportation step was allocated by weight to the total amount of products purchased on an average trip, 20 kg (Henkel, 2008). The final transportation step in the products life cycle is from a consumer's home to its end of life location. This distance was assumed to be traveled by an average garbage disposal vehicle a distance of 4.3 km (Hite et al., 2001). These assumptions are summarized in Table 6.

Table 6

Inventory of Transportation

Transport Type	Distance	Dataset
Raw Materials to Production Facility: Truck	100 km	Transport, freight, rail, diesel/US WITH US ELECTRICITY U
Raw Materials to Production Facility: Rail	600 km	Transport, lorry 16-32t, EURO3/RER WITH US ELECTRICITY U
Production facility to Retail: Truck	520 km	Transport, lorry 16-32t, EURO3/RER WITH US ELECTRICITY U
Retail to Consumer: Car	6.5 km	Transport, passenger car, petrol, fleet average/RER WITH US ELECTRICITY U
Consumer to Disposal: Truck	4.3 km	Transport, municipal waste collection, lorry 21t/CH WITH US ELECTRICITY U

consumer use. Both deodorant and foundation are considered leave-on cosmetic products. This is reflected in the use phase behavior of both products. Deodorant is applied directly to the underarms from the container, where it remains for an entire day. The majority of the product is then absorbed into the skin. Small traces of product are transferred to clothing or are washed off in a shower at the end of the day. Foundation has a similar application. It is applied directly to the face or neck area by hand or with an applicator device, typically a brush, pad, or sponge. Since an applicator device is not mandatory for application, its impact has been excluded in this analysis. The foundation remains on the skin for the duration of the day, a considerable amount of it being absorbed. Similarly to deodorant, a small fraction of product is transferred to clothing or rinsed off with water at the end of the day. Due to the leave-on characteristics of these products, no impacts from the consumer use phase are included in this inventory.

end of life. The disposal or end of life phase also includes many assumptions which are applicable to both cosmetic products. Because cosmetic products are typically used by consumers at home, it was assumed that the remaining product packaging is disposed of through an average U.S. municipal waste curbside service. Due to the low incineration rate of U.S. waste, 11.9% (U.S. EPA, 2011), waste will either be recycled or landfilled. The recycling rate was determined by the type of material the packaging was composed of and how that material is utilized within the packaging. This analysis did not take into consideration corporate take-back programs for cosmetic packaging

The ability of the deodorant and foundation packages to be recycled varies from product to product. Products can be recycled when proper markings can be found on the label. None of the deodorant products considered in this analysis contained a recycling label; therefore it was assumed that resulting deodorant packaging is landfilled. The glass container of the foundation product is more likely to be recycled. The U.S. municipal waste recycling average for glass containers, 18%, was assumed to be the recycling rate for this product (U.S. EPA, 2011). As it is more likely for the package to remain as a whole, the same rate was applied to the polypropylene lid. The remaining material was assumed to be landfilled. Impacts related to recycling are excluded in this analysis as these impacts or credits are allocated to the new function the material will have after being recycled. The inventory of end of life impacts can be found in Table 7.

Table 7

End of Life Inventory, Product Packaging Only

Deodorant	% landfilled	Dataset
Platform	100%	Disposal, polypropylene, 15.9% water, to sanitary landfill/CH U
Protective Cover	100%	Disposal, polypropylene, 15.9% water, to sanitary landfill/CH U
Cap	100%	Disposal, polyethylene, 0.4% water, to sanitary landfill/CH WITH US ELECTRICITY U
Barrel	100%	Disposal, polyethylene, 0.4% water, to sanitary landfill/CH WITH US ELECTRICITY U
Foundation	% landfilled	Dataset
Lid	82%	Disposal, polypropylene, 15.9% water, to sanitary landfill/CH U
Bottle	82%	Disposal, inert material, 0% water, to sanitary landfill/CH WITH US ELECTRICITY U

ECOLABEL CRITERIA ASSESSMENT

Many ecolabels claim to be developed using life cycle thinking and multi-stakeholder input. Often this is not the case, and in addition, once the criterion is developed it undergoes no evaluation step to determine the labels effectiveness. This section will describe the methodology for the categorization of criteria from relevant ecolabelling programs. The goal is to produce a set of indicators which occur most frequently among labels. The outcome of this categorization will be compared with the hotspots determined from the LCA in order to determine if ecolabels are indeed addressing the most important impacts related to the complete cosmetic supply chain.

criteria assessment methodology. This assessment only considers Type I ecolabel programs. These ecolabels must be relevant to cosmetic products, i.e., likely for any cosmetic product on the market to display the label. Availability of the labeling criteria was the main driver in the determination of which programs to consider. It was required that each Type I label considered had publically available documentation which described, in detail, all requirements for certification with the program. This selection process resulted in 11 labels being identified for analysis.

The next step in the method was to compile the criteria for each program from the original documentation. Once compiled, criteria were grouped into categorizes based on the targeted improvement area or impact of the criteria. The grouping lead to the categorization into the following themes: Ingredients, Packaging, Transparency, Aquatic Issues, Natural/Organic, Social Issues, Human Health, Animal Testing, Compliance, Manufacturing, Waste, Energy, Water, and Transport.

Each of these 14 themes represents a targeted area of impact improvement addressed by the criteria. 'Ingredients' targets specific impacts related to the chosen formula of the product and implications of their production. 'Packaging' targets improvements that can be made with respect to packaging to reduce impact. 'Social Issues' refer to issues related to workers of the supply chain. 'Human Health' refers to reduction in consequences to humans during product manufacturing and use. 'Animal Testing' captures the ethical issues related to product testing. Improvement to the overall manufacturing process is considered by the ‘Manufacturing’ category. ‘Waste’ targets the reduction of wastes at all stages of the supply chain. ‘Energy’ targets overall energy reduction in manufacturing. Criteria related to ‘Water’ target the reduction of impacts related to water use throughout the supply chain. ‘Aquatic Issues’ targets the reduction of chemicals which may be harmful to aquatic life at the product’s end of life. Criteria related to reducing transport impacts are captured in the ‘Transport’ theme. The remaining three themes are not directly tied to impact reduction. They are related more to facilitating the improvement of general issues. Improvements made to the overall openness and transparency of a company are captured in the ‘Transparency’ and ‘Compliance’ categories. Requirements for natural or organic claims are captured in the ‘Natural/Organic’ category.

In order to facilitate accurate categorization of the criteria, a reliability assessment was performed. The reliability assessment was implemented on a subset of the criteria, 50 total criteria. An outside source was asked to categorize each criterion into one of the 14 themes, based on provided definitions of each of the categories. The resulting classification was compared with the original, and the harmonization was captured as a percent. The process was repeated until the percent harmonization was greater than 90%.

The category groups were then analyzed and compared in order to determine the areas with the highest coverage. This determination was made with respect to the number of criteria and number of programs for which the criteria was found. Common indicators were determined to be those in which a criterion was found in a similar fashion in multiple labels, or where multiple criterions were found within a few labels. These common indicators were aggregated into a single list as a result of this analysis. These results are used in a subsequent chapter to further evaluate the effectiveness of ecolabelling schemes.

relevant ecolabelling programs. The realm of ecolabelling programs is very diverse, even within the same product category. Labeling schemes are sometimes focused on specific areas of concern for a particular product type, while sometimes they promote general product sustainability. Criteria and labeling also varies from country to country and product category to product category. This has created the possibility for products to be certified under multiple labeling schemes. In order to get an accurate portrayal of the potential of labeling, programs will be considered as a whole rather than individually.

Eleven ecolabelling programs related to cosmetics were identified. Of these schemes, three are directly related to labeling cosmetics for overall sustainability purposes: Nordic Ecolabelling, Green Seal, and Good Environmental Choice Australia. Other labels are interested in the specific natural or organic aspect of cosmetic products: Natrue, COSMetics Organic Standard, and Natural Products Association. The remaining ecolabels are indirectly related to cosmetics, as they cover broad issues which are relevant to the cosmetic supply chain. These labeling schemes include Leaping Bunny and the Global Packaging Protocol on Sustainability.

Each label includes a distinct set of criteria or requirements for certification and the ability to place a label on a product. Each set of criteria is also development with a different set of methodological requirements. These requirements can include multi-stakeholder approaches, life cycle assessments, public input, industry input, etc. A list of each of the ecolabelling schemes addressed in this analysis can be found in Table 9. Also included in this table is a brief description of the goals of each label and the criteria which were met during development. Additional information about the details of each label can be found in Appendix A.

Table 8

Ecolabelling Schemes Included in Analysis

Ecolabelling Scheme	Criteria Development	Description
Leaping Bunny	Single Stakeholder	Provides assurance that no new animal testing is used throughout the production development stages of cosmetic producing companies
Nordic Ecolabel	Single Stakeholder, sent out for review	Guarantees minimal amounts of environmentally hazardous substances, strict requirements on biodegradability and reduced packaging
Green Seal	Multi-Stakeholder, life cycle approach	Guidelines for performance, sustainability, and social responsibility
Good Environmental Choice	Multi-Stakeholder	Defines good environmental performance benchmarks for personal care products
COSMetics Organic Standard	Single Stakeholder	Ensure transition of technical advances to promote the development of cosmetics ever more natural and organic
Natrue	Single Stakeholder	Guarantees products with natural and organic ingredients, soft manufacturing processes and environmental friendly practices
Brazilian Association of Technical Standards (ABNT)	Single Stakeholder	The goal to support an effort of improving and maintaining environmental quality via reduced energy and material consumption, along with the minimization of pollution impacts
ECOCERT	Multi-Stakeholder	Define a quality level for cosmetic which will safeguard a real enhanced value of the natural substances used, and respect for the environment
Natural Products Association (NPA)	Multi-Stakeholder	Guidelines related to natural ingredients, safety, responsibility, and sustainability
Ass. of Industries and Trading Firms (BDIH)	Multi-Stakeholder	Marks the makers of cosmetic products who use natural raw materials with limited ecological impact
Global Packaging Protocol on Sustainability (GPPS)	Multi-Stakeholder	Enables the consumer goods industry to better assess the relative sustainability of packaging

Chapter 4

RESULTS

This chapter will present the results for the completion of the methodology described in chapter 3. These results include both the hotspots determined from the life cycle assessment and the common criteria of the ecolabel assessment. A comparison between these two sets of results will also be provided. It is important to keep in context the limitations of each of these sustainability tools. LCAs are typically environmental in scope, and quantify the maximum impact potential of a specific product. Each ecolabelling program varies in scope and may have distinct goals or areas of focus.

LIFE CYCLE ASSESSMENT RESULTS

The purpose of this LCA is to determine the supply chain's most important hotspots. The results presented are meant to give a general idea of the impacts related to each life cycle phases in the cosmetic product supply chain rather than a definitive value of impact.

The impact assessment resulted in the majority of the characterized impact of both foundation and deodorant to be found in the following impact categories (Figure 2): Climate Change, Fossil Depletion, Agricultural Land Occupation, Human Toxicity, and Ionising Radiation. Climate change was seen to have the highest impact. The cause of this impact was different between the two products (Figure 3a). The Climate Change impact for deodorant was split equally between the raw materials, which contribute 43% of the impact and the packaging materials, which contribute 46% to the impact. For foundation, the Climate Change impact was mainly caused by the packaging materials, which represents 65% of the impact. In particular, the climate change impacts related to glass manufacturing for use as the bottle are high.

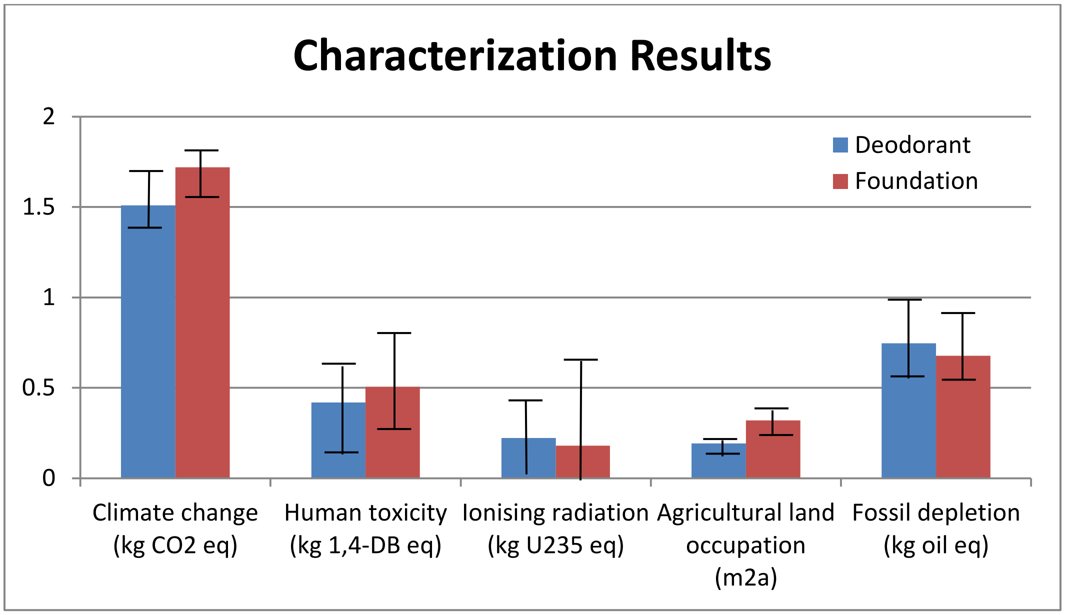

Figure 2. Top five impact categories based on characterized results.

The same relationship can be found within the other impact categories. Fossil Depletion was dominated by packaging materials (72%) in the foundation supply chain, the driver of this impact again being glass production. In the deodorant supply chain, Fossil Depletion was split evenly between chemical raw materials (48%) and packaging materials (45%). Specific materials do not stand out as major drivers of this impact as many of them contribute to it.

A different trend can be seen with respect to two other impact categories. In these cases, the impact of deodorant is found mainly in the raw material phase and the impact of foundation is found in the packaging phase. Human Toxicity is one of these impact categories with raw materials contributing 83% with respect to deodorant and packaging contributing 66% with respect to foundation (Figure 3d). Agricultural Land Occupation again follows the same trend (Figure 3c). In this category, the palm oil derivate ingredients drive the raw material impact for deodorant (88%) and glass again drives the packaging impact for foundation (66%).

The impact category of ionizing radiation has a different dynamic in terms of the highest contributing life cycle phases (Figure 3c). Within both product supply chains, foundation and deodorant, the major impact lies in the raw material phase (62% and 91% respectively). Two specific chemicals drive the impact for deodorant, Propylene oxide and Benzyl alcohol, while the driver for foundation in this case is Titanium dioxide.

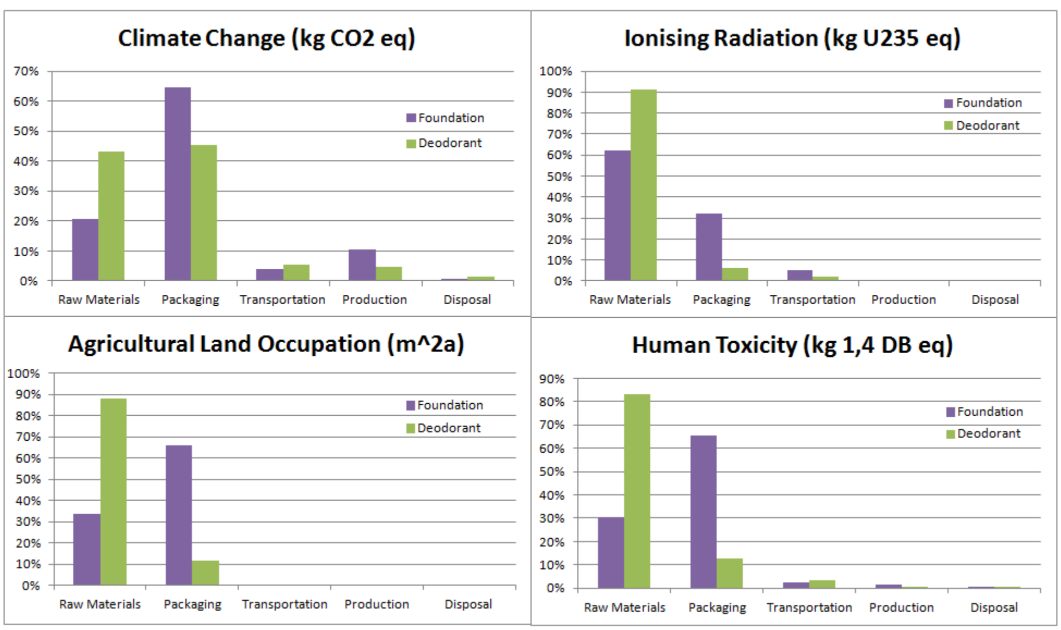

Figure 3. Detailed results of the characterized impact assessment of the product inventory by life cycle phase.

The top five impacts categories shift when impacts are normalized to worldwide levels (Figure 4). Marine Ecotoxicity becomes the most impactful category followed by Freshwater Ecotoxicity, Human Toxicity, Terrestrial Ecotoxity, and Freshwater Eutrophication. These impact categories are ones which had a smaller characterized value, but are known to cause impact at a lower value.

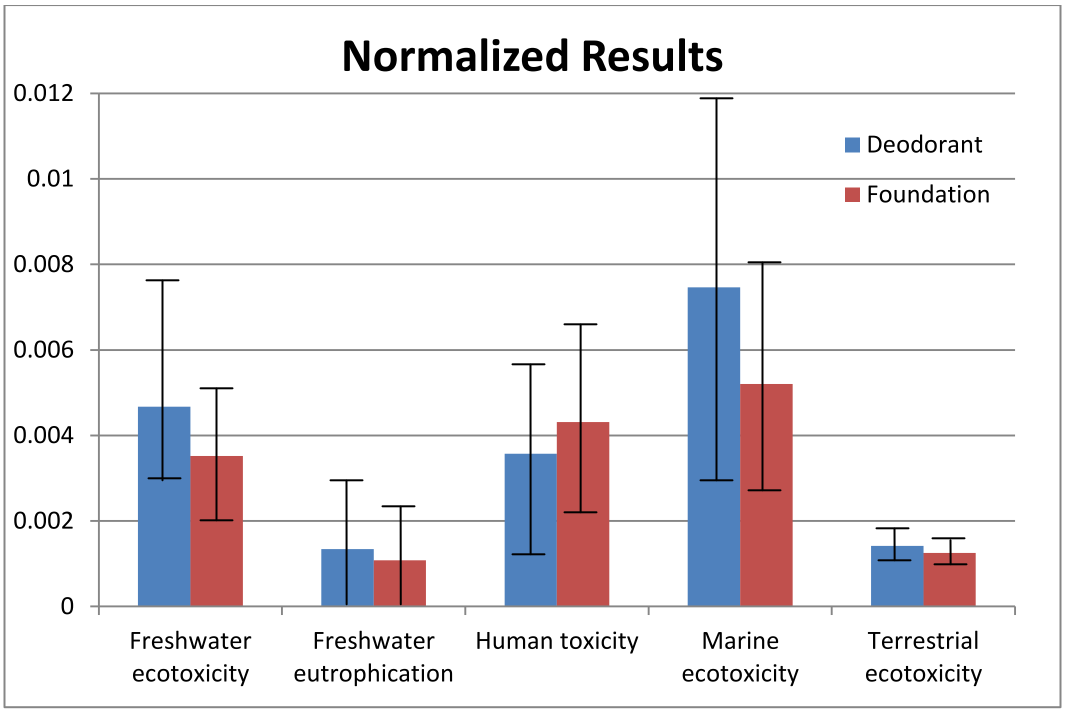

Figure 4. Top five impact categories based on results normalized to world impact.

In the deodorant analysis, Freshwater and Marine Ecotoxicity are both dominated by the raw material phase (72% and 73% respectively). With respect to foundation, Marine Ecotoxicity is dominated by impacts from packaging (62%) and Freshwater Ecotoxicity impacts are split between both raw materials (50%) and packaging (44%). Terrestrial Ecotoxicity is dominated by the raw material phase for both foundation (97%) and deodorant (100%). Many of the raw materials in both these products add to the impact of this category, but the hydrogenated oils and palm oil derived chemicals have the highest impact.

The outcome of the life cycle assessment gives insight into the hotspots within the supply chain of cosmetics which drive the most impact. In this case, the most important impact categories can vary depending on the methodology considered. In the case of the characterized results, climate change was found to create the most impact, followed by Fossil Depletion and Agricultural Land Occupation. When the results are normalized to worldwide reference values, Ecotoxicity impacts and Human Toxicity impacts become significantly more important. These five impacts (Table 8) will be compared to the common indicators found in ecolabels in order to analyze their effectiveness in reducing impacts.

Table 9

Summary of Hotspots Derived from Life Cycle Assessment

Hotspots
Climate Change impact of raw material manufacturing and packaging production
Fossil Depletion potential of raw material manufacturing and packaging production
Agricultural Land Occupation of palm oil derivatives and packaging production
Terrestrial, Freshwater, and Marine ecotoxicity potential of raw materials at disposal
Human Toxicity potential of raw ingredient and packaging materials.

One of the most prevalent trends found in the life cycle assessment results is the relationship between the impacts of the raw materials versus the impacts of the packaging. For the majority of the impact categories, the impact of deodorant was driven by the raw materials and the impact of foundation was driven by packaging. This is an important relationship to consider when generalizing impacts for the cosmetics category as a whole. It is likely that if this analysis is expanded to include additional cosmetics, many will be driven by the impacts of the raw materials, and many by the impacts of their packaging.

ECOLABEL CRITERIA ASSESSMENT RESULTS

Ecolabelling criteria of 11 different programs related to cosmetic products were collected and categorized. A total number of 253 criteria indictors where considered. Each criterion was categorized into one of 14 themes. The majority of themes chosen represent the impact which is being targeted or reduced when the criteria is met. A few categories are not linked directly to an impact improvement, but rather to improvement of general issues. The categorization of each criterion was validated using reliability assessment. The assessment resulted in an 84% category match in the first progression. After modifications to the categorization, the reliability assessment results increased to a 97% match in a second progression. In Table 10, the number of criteria found for each theme and the number of labels which included those criteria can be found.

The theme ‘Ingredients’ was found to have the greatest number of criteria, and representation in a largest number of labeling schemes. The impact reduction found when changing or modifying ingredients can be related to raw material production, as well as, other impacts related to disposal or amount used per application. The majority of the criteria found in this theme involve lists of substances which are prohibited from inclusion in the product formulation. Other criterion involved specific requirements for components such as fragrances, preservatives, mineral, dyes, and nanomaterials. A few criteria were also found which related to the requirements for the extraction of raw materials.

Table 10

Criteria Categorization Results

Category	Number of Criteria	Number of Ecolabels
Ingredients	62	7
Packaging	48	8
Natural/Organic	22	7
Transparency	16	8
Social Issues	16	4
Aquatic Issues	10	4
Manufacturing	12	6
Human Health	12	2
Animal Testing	9	6
Compliance	6	4
Waste	5	4
Water	4	4
Energy	4	3
Transport	3	3
Others	25	7

Criteria related to ‘Packaging’ were the next abundant, with 48 criteria from 8 separate labels. The criteria within this theme related to a reduction in the impacts of packaging. Many labels focused on the use of recycled or secondary materials for packaging, prohibited substances/materials and types of packages, limited amounts of packaging, and increased recyclability of final product packaging.

Another category with a large amount of criteria within 22 different labels is ‘Natural/Organic’. These criteria communicate the requirements for natural or organic claims found on a label. In general these criteria relate to the percent content requirements for such claims and prohibited use of non-natural ingredients whenever possible.

‘Transparency’ contained the fourth largest amount of criteria. This theme includes criteria which deal mainly with consumer goods manufacturing practices and consumer communication. Proper use labeling, proper disposal labeling, and formulation disclosure are all important criteria which belong to this category. Compliance with environmental regulations and performance requirements are examples of indicators found within the ‘Compliance’ theme.

‘Social Issues’ are another important topic covered within ecolabels. The criteria within this theme relate to the issues faced by labors throughout the supply chain. These issues including forced labor, wages, working conditions, and discrimination. The ‘Aquatic Issues’ theme represents potential impacts to aquatic life. Issues of concern in this area include the use of biodegradable, non-bioaccumulating, or toxic substances in the product formulation. Standards related to animal testing policies and avoidance were also prevalent in six of the labels.

‘Human Health’ issues were represented by 12 criteria, but only found in two ecolabels, Green Seal and Good Environmental Choice. The criteria in this category included the exclusion of carcinogenic or reproductive toxins, mutagens, or substances which can cause skin or respiratory sensitization.

Additional themes related to the impacts of manufacturing, waste, energy, water, and transportation. These themes where represented in fewer schemes, and fewer criteria were found as a whole. Common standards found related to continued energy and water consumption reduction, as well as, simple non-pollution manufacturing processes. The remaining criteria not covered by one of the previous schemes were categorized into the category ‘Other’. These criteria include issues that were only of a concern of a single label, impacts related to specific products within the broad scope of cosmetics, or impacts related to smaller and more specific aspects of the supply chain, i.e. storage.

This analysis permitted the compilation of a set of indicators which are most commonly found in ecolabelling criteria. This list of common indicators can be found in Table 11 and includes a list of the ecolabels where the criteria can be found. The majority of the criteria found in this list have coverage in many ecolabels, while a few only have coverage in one scheme with multiple standards existing. The list of common indicators represents, on a broad level, the overall impact coverage of cosmetic ecolabels as a whole.

Table 11

Common Indicators

Common Criteria	Category	Labels
Cosmetic products and ingredients may not be tested on animals	Animal Testing	Leaping Bunny, Green Seal, COSMOS, EcoCert, NPA, ABNT
All products and ingredients must exhibit ready biodegradability	Aquatic Issues	Natrue, Nordic, Green Seal, ABNT
Products should not present acute toxicity to aquatic life	Aquatic Issues	Green Seal, Nordic, ABNT
Exclusion of components that bioaccumulate or are known to form degradation products that bioaccumulate	Aquatic Issues	Green Seal, Nordic
Product should not include an components which are carcinogens or reproductive toxins	Human Health	GECA, Green Seal
The products should not be a skin sensitizer, or cause skin irritation or corrosion	Human Health	Green Seal
All fragrance components shall have been produced following the code of practice of the International Fragrance Association (IFRA).	Ingredients	Green Seal, Nordic, ABNT
Nanomaterials are forbidden.	Ingredients	Green Seal, Nordic, COSMOS
Lists of ingredients which are prohibited or considered environmentally hazardous	Ingredients	GECA, Green Seal, Nordic, EcoCert, NPA, ABNT, COSMOS
Lists of ingredients which are prohibited or considered environmentally hazardous	Ingredients	GECA, Green Seal, Nordic, EcoCert, NPA, ABNT, COSMOS
There shall not be discrimination such that it affects the opportunity or treatment in employment	Social Issues	GECA, Green Seal, ABNT, GPP
Products shall show a list of the ingredients contained in the product	Transparency	Green Seal, COSMOS, ABNT
The label shall include proper disposal instructions	Transparency	GECA, Green Seal, GPP, NPA
All of the formula components shall be disclosed to the certifying body	Transparency	Green Seal, Nordic, EcoCert, NPA
The manufacturer shall establish a plan for continuous reduction of energy and water Consumption	Energy	Green Seal, EcoCert, ABNT, GPP
An environmental management plan must be put in place which addresses the whole manufacturing process and all the residual products and wastes	Manufacturing	COSMOS, GPP, ABNT

Table 11 Cont.

Common Criteria	Category	Labels
The manufacturing processes must be simple, non-polluting, and preserve raw materials	Manufacturing	Green Seal, COSMOS, EcoCert, Natrue
If any reference to organic or natural products or ingredients must comply with the appropriate rules	Natural/Organic	Green Seal, Nordic, COSMOS
Synthetic non-natural ingredient can be used only when there is not a readily available natural alternative ingredient	Natural/Organic	NPA, EcoCert
Requirements for the percentage of natural/organic ingredients for products labeled as such	Natural/Organic	NPA, COSMOS, EcoCert
Recyclable formats, with a feeble energy consumption shall be used for packaging	Packaging	GECA, Green Seal, Natrue, COSMOS, NPA, ABNT, EcoCert, GPP
Lists of prohibited packaging materials and types	Packaging	GECA, Green Seal, Nordic, Natrue, COSMO, ABNT,
It must be ensured that any environmental information or claims on packaging are clear, truthful and accurate.	Packaging	Green Seal, COSMOS, ABNT
As far as possible packaging must be kept to a minimum.	Packaging	Nordic, Natrue, GPP

The results of the ecolabel criteria assessment yielded a set of indicators which are common amongst cosmetic labeling schemes. These criteria cover areas of concern such as animal testing, aquatic issues, human health, ingredients, social issues, transparency, energy, manufacturing, natural/organic, and packaging. The life cycle coverage of these criteria will be investigated in the next section. The results from the LCA will be used to determine how well the common criteria found in cosmetic ecolabels address the important impact concerns from a complete supply chain point of view.

COMPARISON

The analysis in the previous section provides a starting point from which ecolabels can be critiqued. The criteria assessment presents and summarizes the current issues addressed by ecolabelling schemes. The streamlined LCA provides a platform from which to critique the effectiveness of the labels as a whole by indicating the supply chain's most impactful activities. In terms of environmental impacts, it has been found that ecolabels give decent coverage of the top impacts found through the use of life cycle assessment, but gaps do exist. Four of the five LCA hotspots were found to have some coverage in the ecolabel criteria.

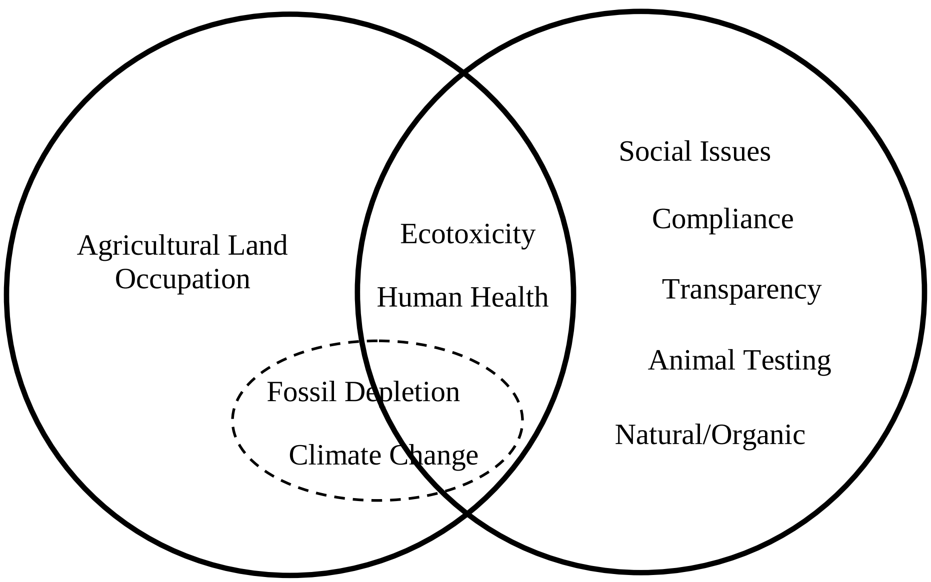

Figure 5. Cosmetic hotspot and ecolabel common criteria comparison.

coverage as a whole. In general, good alignment is seen between the normalized LCA results and the common indicators. The impact categories of ecotoxicity: terrestrial, freshwater, and marine, are examples of this. The 'Aquatic Issues' theme includes three criteria found in ecolabels which help to reduce this impact. In one such criterion, in order to be labeled, products must be readily biodegradable in aerobic and anaerobic conditions. This requirement is found in four of the eleven programs considered. Criteria also require assurance that the product itself or ingredients used to formulate the product are not toxic to aquatic life. Bioaccumulation is also an ecotoxicity risk which is reduced by the use of labeling a product. Many labels prohibit the use of components which are known to bioaccumulate or which produce degradation products which bioaccumulate. In total, these criteria are covered in four of the programs analyzed. Additional reduction in ecotoxicity can be achieved through the elimination or prohibition of ingredients which are considered environmental hazardous, and with other common criterions classified under the 'Ingredients' theme.

The Human Health impact category is another one of the top five impacts derived from the LCA which has significant coverage within the common criteria of cosmetic ecolabels. The 'Human Health' theme includes two indicators which aid in the reduction of this impact upon labeling a product. The first is the prohibition of ingredients which are known carcinogens or reproductive toxins. The second ensures products are not sensitizers to skin or skin/eye irritants. Additional criteria related to 'Transparency' also exist within the ecolabelling schemes which may also reduce human health impacts. These criterions relate to ingredient and formula disclosure of a product. When companies become required to include ingredients on the label, they may be more willing to avoid controversial and potentially harmful ingredients, thus reducing human toxicity and potentially ecotoxicity impacts.

The impact of Climate Change, which resulted from the characterized LCA results, did not have as direct and complete coverage as Ecotoxicity and Human Health, but criteria were found which may reduce this impact indirectly. Criteria relating to packaging improvements are examples of this indirect reduction. Keeping packaging to a minimum and increasing the use of recycled materials which have reduced energy requirements may have an effect on the reduction of CO_2 and other greenhouse gas emissions. Also prohibiting packaging types and materials may also indirectly reduce these emissions. The criteria related to packaging are represented in six of the programs. Additional common criteria also exist within the ‘Manufacturing’ and ‘Energy’ themes which may counteract the Climate Change impact as well. The use of non-polluting, simple manufacturing processes has this potential, as well as, the reduction of energy and water consumption during production and raw material refining.

Fossil Depletion is covered by both direct and indirect criteria within the common ecolabel criteria. The ‘Energy’ theme includes a requirement for continuous reduction of energy use. In a majority of cases, this would create a reduction in fossil use. Also, the use of simple manufacturing processing which preserve the quantities of raw materials will also reduce the Fossil Depletion impacts. Indirect reduced can also be achieved with the criteria mentioned previously for Climate Change reduction. Minimizing packaging or changing packaging and material types can lead to Fossil Depletion reduction, especially for a packaging intensive product such as foundation. Increasing the recyclable content also decreases the amount of natural non-renewable resources used.

Agricultural Land Occupation, the fifth hotspot determined through the life cycle assessment, is not well covered by any of the ecolabel schemes. The driver of this impact tends to be palm oil derived chemicals and other plant based chemicals which require large amount of land for growth and harvesting. Other plant based chemicals also add to this impact. The ecolabelling schemes seem to ignore this impact, as no land use criteria were found in the programs analyzed by this study.

The analysis also uncovered many areas of coverage within ecolabels that go beyond the typical LCA impact categories. Social issues are typically not covered by LCA, as it is typically an environmental tool. Social LCA impact categories are currently under development and may be used in the future to perform a similar analysis. Issues related to animal testing are also very common in ecolabelling programs. Six of the schemes in this analysis prohibited animal testing of final products or product ingredients. Natural and Organic claims is another area which is not covered in traditional LCA. These types of requirements can be found in the following Type I programs: Green Seal, NPA, EcoCert and Natrue.

packaging intensive verse material intensive. It is important to remember the distinctive outcomes which arose for the LCA of foundation and deodorant. In the deodorant LCA, the majority of the impact categories were driven by an impact in the raw material phase, which related to the chemical formula and production of those ingredients. In the foundation LCA, the majority of the categories were driven by impacts in the packaging phase, which related to packaging materials and packaging production. It is not unlikely that this pattern will be seen in other types of cosmetic products. Since most ecolabels cover the general scope of cosmetic rather than individual products, the differences between the impact drivers of these products must be considered when developing ecolabel criteria. For example, if an ecolabel places heavy weight in the area of packaging, it may not be as effective for a material intensive product such as deodorant. The reverse can be an issue for a packaging intensive product labeled under an ecolabelling program which places a strong emphasis on the materials used. Due to the wide variety of cosmetic products, some being packaging intensive while others material intensive, it is imperative for general cosmetic labels to be have sufficient cover in both areas.

coverage by program. Green Seal is the label with the greatest coverage of the life cycle impacts of cosmetics. The ecolabel has criteria which cover 19 of the common criteria, and the majority of the themes. It has the strongest coverage of Climate Change and Fossil Depletion, as well as Ecotoxicity. Green Seal is also very strong in the Human Health impact category, with 10 different criteria. These criteria include requirement on acute toxicity, carcinogens, asthma causing components, skin absorption, skin irritation, respiratory sensitizers, endocrine disruptors, and mutagens. Green Seal also has many transparency requirements, and criteria which are specific to different types of products.

The Nordic ecolabel covers nine of the common criteria in five of the themes. Its coverage includes ‘Aquatic Issues’, ‘Transparency’, ‘Natural/Organic’, and ‘Packaging’. Packaging is one of the major areas of emphasis in the scheme. Nordic is also strong in the area of ‘Ingredients’, as it has criteria which contain specific requirements for the many types of chemicals used for a particular function. One of the largest gaps in this program is that of ‘Human Toxicity’. ‘Energy’, ‘Manufacturing’, and ‘Social Issues’ are also important impacts which are not covered.

The Australia Good Environmental Choice Australia (GECA) program covers six of the common criteria found in five of the themes. These five themes include: ‘Human Health’, ‘Ingredients’, ‘Social Issues’, ‘Transparency’, and ‘Packaging’. ‘Aquatic Issues’ is one of the many gaps of this Type 1 label, as well as, ‘Natural/Organic’ or ‘Manufacturing requirements’.

ABNT covers 12 of the common criteria. ABNT has strong coverage in areas such as ‘Ingredients’, and ‘Aquatic Issues’. It also has coverage in areas including ‘Waste’ and ‘Energy’, which are only seen in a few other schemes. COSMOS covers 11 of the common criteria, but lacks coverage in important impact areas such as ‘Aquatic Issues’ and ‘Human Health’. NPA covers seven of the common criteria, but again misses some of the major impact areas according to the LCA. EcoCert has coverage in eight themes and is strongly focused on ‘Ingredients’ and ‘Natural/Organic Standards’.

improving coverage. All the schemes analyzed in this study have room for improvement. While overall coverage is seen in most of the impact areas identified by the LCA, some impacts are covered more indirectly and Agricultural Land Occupation is not covered at all. As a whole, there is still room for improvement across the five important categories. Green Seal, the most comprehensive with respect to the common criteria and other programs have the potential to benefit from improvement in many of the already covered categories.

One possible addition that can be made to the ecolabels is additional criteria related to material sourcing. This could include the use of sustainable sourcing and organic farming principles. One specific example would be the addition of criteria which insists on sourcing palm oil derived chemicals from groups which adhere to the Roundtable of Sustainable Palm Oil. These types of chemicals are common across many cosmetic products. Another example specific to the deodorant products is the addition of criteria related to aluminum sourcing. These additions can add impact reduction around areas like Agricultural Land Occupation

Another area where additional criteria could be added in to labeling is with respect to emissions measurements and direct reduction criteria. This could improve the Climate Change impact for many cosmetic products. Ecolabels could require emission values to be publically reported or require adherence to an emission reduction plan. Additional criteria could also include requirements for the use of best practices around air quality control or the use of cutting edge emission reduction technology.

Ecolabels can also be improved in many cases by placing a stronger emphasis on certain categories which were found to be important in the LCA. Human Toxicity is not strong in many of the labels analyzed in this study. Adding additional criteria related to the prohibition of carcinogens can improve this in many of the labels. Also the precautionary principle can be employed to better prevent against chemicals which have not yet been shown to cause effects in humans, but are likely too due to their similarity with other known toxins. This type of criteria was only found in two programs: Green Seal and COMOS.

Energy reduction is another area which can gain an advantage from adding additional criteria. In order to fill this gap, additional criteria could include requirements for a certain percentage of energy use to come from renewable sources. The use of green chemistry principles could also be required for labeling, which would encourage simpler manufacturing process, requiring less energy, and producing less waste. Product packaging take back or refilling systems can also be employed to reduce the energy requirements of packaging.

comparison with consumer trends. The common criteria list can be also be compared to consumer trends and insights. Global and national surveys found that 28% of Americans frequently purchase personal care products containing non-toxic ingredients, while 35% of Americans do so occasionally (Yankelovich, 2007). It was also discovered that 20% of Americans will frequently purchase products with recycled or reduced packaging, with 38% doing so on occasion. Natural products are also important to consumers with 14% of Americans frequently purchasing natural personal care products, and 35% doing so on occasion (Yankelovich, 2007). Following price, the inclusion of ingredients which are linked to harmful side effects, and chemical and hazardous free are the most important areas driving consumer purchasing. Avoidance of animal testing, environmentally friendly production, and organic products are also important drivers of consumer decisions.

These areas of consumer concern can all be found within the common ecolabel criteria. Criteria reducing the use of non-toxic ingredients can be found in the ‘Human Toxicity’ theme. Packaging reduction and recycling has a strong emphasis in the majority of the programs. Natural product requirements can be found as well in at least five of the labels. Animal testing is also one of the common criteria, and the ‘Manufacturing’ theme helps ensure a simpler and environmentally friendly production processes.

Chapter 5

DISCUSSION

The cosmetics case study analyzed this paper provides a starting point for improved utilization of life cycle assessment, and other scientific based methods, into the ecolabel criteria development process. With this example, it is possible to better understand how this integration can occur and which best practices should be followed to ensure acceptability of the results. This chapter provides recommendations on how an ecolabelling programs can increase credibility by integrating LCA into the criteria development process.

RECOMMENDATIONS

The first recommendation for incorporating life cycle thinking and analysis to an ecolabel program is for the involved parties to fully understand all aspects of the supply chain. Thinking should be done beyond the basic system boundaries of a product to ensure areas of potentially high impact are not neglected. Variations within the product category being studies should be considered. This can include variations at the product level, variations with respect to packaging, as well as, variations in manufacturing practices or procedures. A solid understanding of the underlying supply chain is imperative to the success of creating a label which addresses the most important issues related to a product.

Secondly, stakeholders in the criteria selection process should consider developing a full LCA model or streamlined LCA to support criteria decisions.

This model should be reflective of products which can be certified under the label, and should strive to be as complete and accurate as possible. In the case that primary data is not easily available or time constraints limit their use, secondary data from generic databases should be considered. The use of this data can provide a model which is acceptable enough to draw general conclusion in a timely manner. Focus in this model can also be narrowed, by having advanced knowledge of the supply chain by emphasizing areas which are likely to cause large impacts. For chemical based products, focus should be placed on capturing the direct raw materials of the product and packaging, and production requirements. The use and end of life phases should be consider when applicable or when information is available.

When an LCA is developed it is important to understand the uncertainties associated with the assessment. Especially when using secondary data, it is important to remember that the results have uncertainty associated with them, and in some cases it may be high enough to change the outlook of the results. Along the same lines, it is also important to interpret the results in the proper manner. This should be done using an impact assessment and identification of the product hotspots. A hotspot is an area or process in the supply chain which is most relevant in influencing the impact footprint. Especially when using a streamlined LCA, hotspots should be considered potential areas of high impact, and should be researched further. Other areas of concern should not be disregarded when not found to be a hotspot, but rather time and energy should be spent to a less extent in these areas.

Once an LCA model is complete, the results can be used in a few ways. Utilizing the LCA hotspot as areas of focus for criteria development is one example. While in the beginning phase of development, emphasis should be placed on the hotspots of the supply chain. The stakeholders involved in the process should dig deeper into each hotspot and attempt to determine and understand the drivers of the impact and how they can be improved or reduced. This will allow criteria to more accurately address important issues and create a product with a reduced footprint.

The hotspots of an LCA can also be integrated later in the development process or into programs which have already developed label criteria. In this case, the hotspots are used to evaluate the effectiveness of the label's criteria in addressing the most important supply chain impacts. By comparing the labels criteria with hotspots, similarly to what has been shown for cosmetics, gaps in the environmental criteria can be discovered. Once gaps or areas of limited coverage are discovered, steps can be taken to add additional criteria into the label. This leads to an overall more robust and credible program.

Another recommendation for this process is to be mindful of other tools, sources, and advancements which may add value to the criteria development process. All available sources and tools should be considered as part of the ecolabel development process. These tools could include items such as published LCA articles, risk assessments, multi-criteria decision analysis, economic analysis and forecasting. It is also important to keep in mind work and research completed by non-governmental organizations (NGO) on social and labor issues, as well as, issues which are important to the consumer of the product. This implies that tradeoffs should be balanced. A single tool, such as LCA, should not be the sole focus of the decision making process. All applicable viewpoints and tools should be used as a whole in the criteria selection process.

A final recommendation, which is important to a program's credibility, is to increase the level of transparency in the selection and evaluation process. Background documentation should be made available which contains information relating to the tools utilized in the decision making process. If an LCA or other tools are used, the methodology and results should be provided within the background documentation. Making this type of information available is a simple way to increase overall credibility and the success of the ecolabel.

CONCLUSION

The role and success of ecolabels in today's market is important to the promotion of sustainable production and consumption. Ecolabelling literature has uncovered and discussed many of the issue related to the lower than anticipated success of labels as a whole. The case study presented in this paper provides an example as to how environmental measurement tools, such as LCA, can be integrated with the ecolabelling process to ensure adequate impact reduction after certification and improve the overall credibility of the program. While issues related to consumer adoption of labels need further research, utilizing the recommendations presented in this paper is an important step in improving the overall success of environmental labeling.

This study provides an example of the usefulness of integrating life cycle assessment into the ecolabel criteria development process. Implementation of the recommendations offered by this study will increase the transparency of ecolabel programs and place an added emphasis on criteria derived from scientific conclusions. This case study provides a solid example as to how LCA can be applied to ecolabel development and standardization, as well as, how LCA can be developed in the future into a criteria evaluation tool.

It is important to remember the limitations of both LCA and ecolabels and continue to work in the direction of a complete sustainability assessment. Life cycle assessment is a tool which can handle many environmental issues but is not inclusive of the other issues which may be important to the overall sustainability of a product. Similar tools need to be continually developed which can stand alongside LCA and provide similar scientific support to ecolabel criteria development. One example of such tool is a Social LCA, which can handle important social issues and is currently in development. Additional research is also needed to identify standard evaluations tools for ecolabels to ensure they are reducing impacts as promised.

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APPENDIX A

DESCRIPTION OF ECOLABELLING PROGRAMS

This appendix gives additional details about the 11 ecolabelling programs discussed within the analysis. This information relates to the overall goals of each program and presents their areas of focus and coverage.

LEAPING BUNNY

The Leaping Bunny Program is a cruelty-free standard from the Coalition for Consumer Information on Cosmetics (CCIC) for companies producing cosmetic, personal care, and household products (Leaping Bunny, n.d.). The label provides assurance that no new animal testing is used throughout the production and development stages of cosmetic production.

The requirements for the label include compliance with criteria around direct and indirect animal testing and the implementation of monitoring systems. Animal testing is defined as testing in which whole non-human animals are the test subjects, including fish, amphibians, reptiles, birds, and non-human mammals. A company must not conduct, commission, or be part of any animal testing of the cosmetic product, or ingredients. A company must also not purchase any ingredients or products from third-party manufacturers or suppliers that conducted, or were part of animal testing. The label also requires a supplier monitoring system in which they must obtain declarations of product and raw material compliance.

NORDIC ECO LABEL

The Nordic Ecolabel is a voluntary scheme that evaluates a product's impact on the environmental throughout the whole life cycle and is the official Ecolabel of the Nordic Countries (Nordic Ecolabelling, 2010). It was established in 1989 by the Nordic Council of Ministers and currently labels 63 product categories. "Cosmetic products" is included as one of these product categories and the Nordic Ecolabel guarantees products with minimal amounts of environmentally hazardous substances, strict requirements on biodegradability, and reduced packaging.

Specific requirements of the label include the use of surfactants that are readily aerobically and anaerobically biodegradable, and preservatives which must not bioaccumulate. Also fragrances must be used in accordance with IFRA guidelines and must not be used in infant or baby products. Packaging must not be more than two layers and it must be possible to separate materials for sorting. Halogenated plastics are prohibited and paper must not be bleached with chlorine. In addition, companies must adhere to a recycling/take-back program.

GREEN SEAL

Green Seal is a non-profit organization who develops life cycle based sustainability standards for products, services and companies (GreenSeal, 2011). Their mission is to use science-based programs to empower consumers, purchasers, and companies to create a more sustainable world. They have developed standard for personal care and cosmetic products which establish environmental, health, and social requirements for such products. Under these guidelines products must meet specific performance, sustainability, and social responsibility requirements.

Specifically the standard prohibits components that are carcinogens, acutely toxic, or cause skin or eye irritation or sensitivity. Animal testing is prohibited. Limitations are made on volatile organic compounds, ingredients with limited biodegradability, and compounds with the potential to bioaccumulate. Colors, photosensitizer and nanoscale components are also restricted. The label requires quality assurance and control practices for all manufacturing processes, and a company must meet social responsibility requirement in categories including freedom of labor, occupational health and safety, and collective bargaining. According to the standard, packaging should contain post-consumer content and potentially be accepted through a take-back program. Heavy metal and chlorinated packaging and applicators are prohibited. The products must also communicate to users, through the product label, information relating to fragrances, proper use, and proper disposal.

NATRUE

Natrue was found in 2007 by several European manufacturers of Natural and Organic Cosmetics with the goal of safeguarding and promoting pure, authentic natural beauty and skin care products (Natrue, 2011). The membership has since been expanded to included companies from the United States. The Natrue label guarantees products with natural and organic ingredients, soft manufacturing processes and environmental friendly practices. Natrue also has a process for certifying raw materials. The cosmetics label exists on three separate levels: natural cosmetics, natural cosmetics with organic portion, and organic cosmetics. The certification works by strictly regulating the following three ingredient groups. Natural ingredients are those found in nature and physical processes are used to obtain them. Derived natural substances are ingredients found in nature but chemically modified through a limited number of approved processes. Nature-identical substances are substances that exist in nature but are produced synthetically and are only permitted when natural substances cannot be recovered. Products classified under the Natrue system must contain no synthetic fragrances, colors, petroleum derived products, silicone oils, and genetically modified ingredients. Products must also not be tested on animals.

The label also has standards related to packaging and packaging materials. Packaging must be kept to a minimum and products should be designed for multiple use. Materials should be recyclable and made from renewable raw materials and cannot include halogenated plastics.

ABNT

The Brazilian Association of Technical Standards (ABNT) Ecolabel Program is a voluntary standard of environmental performance which labels products and services around the world (ANBT, 2008). The goal of the program is to support a continuing effort for improving and maintaining environmental quality via reduced energy and material consumption, and the minimization of pollution impacts. The criteria for personal care products includes regulations on substances used, degradability, bioaccumulation, fragrances, coloring agents, packaging, and product efficiency.

Specifically products must be easily biodegradable, not present acute toxicity, and must not have been tested on animals. Guidelines are also included for substances that are prohibited including aerobic and anaerobic non-biodegradable organic substances. Colorants are also limited and must not bioaccumulate. Fragrance concentration is limited when they present potential effects of dermic sensitivity. Packaging must be designed to not impede material recycling, and designed without the use of halogenated plastics. Environmental requirements for manufacturing include the need for a continuous reduction of energy and water consumption and the use of qualified raw material and service providers.

NATURAL PRODUCTS ASSOCIATION

The Natural Products Association Standard and Certification for Personal Care Products is a set of guidelines developed by the Natural Products Association, a non-profit organization dedicated to the natural products industry (NPA, 2010). The standard is based on natural ingredients, safety, responsibility, and sustainability. Products must include at least 95% natural ingredients made from renewable resources found in nature, and include no petroleum compounds. The standard prohibits certain ingredients such as chemical sunscreens, synthetic fragrances, surfactants, and cleaning agents. Ingredients must also contain no heavy metal or contaminate residue.

Within this program, companies must be fully transparent and display ingredients on product labels. A majority of the packaging materials must be recyclable and produced from post-consumer recycled content. Animal testing of ingredients and products must also be avoided.

BDIH

BDIH, The Association of Industries and Trading Firms for pharmaceutical, health care products, food supplements and personal hygiene products has developed guideline for certified natural cosmetics in correspondence with leading natural cosmetic producers (BDIH, 2006). Using these 1996 guidelines, the testing of the content and production methods of more than 2,000 products has occurred. The “Certified Natural Cosmetics” label marks the makers of cosmetic products who use natural raw materials, i.e. plant oils, fats, waxes, herbal extracts, etc., with limited ecological impact. Specifically the label promotes the objective that nature should be disturbed as little as possible, endangered species protected, genetic manipulation avoided, and as few chemical processes used as possible. The label also promotes renewable and biodegradable materials, natural substances with minimal toxicity potential, and social accountability and responsibility in production. It also expects producers to use environmental-friendly production methods, and minimal packaging.

The label expects raw materials to be obtained from plants under controlled biological cultivation or wild collections. Animals must be protected, therefore no testing of end products may be performed and raw materials may only be used if they have not been tested on animals. The label allows the product of certain components via chemical processes and certain nature-identical preservatives, but rejects organic/synthetic dyes, synthetic fragrances, petroleum products, silicones, and raw materials/products using radioactive radiation for disinfection.

In addition to the label guidelines, BDIH has a list of further goals and requirements relating to raw materials, genetic engineering, ecological compatibility, and social compatibility. Specifically the goals include clear and traceable production processes, consumer education, opposition to genetically modified plants, degradability of raw materials and finished products, and fair trading of raw materials.

GLOBAL PROTOCAL ON PACKAGING SUSTAINABILITY

The Global Packaging Project is an initiative of the Consumer Goods Forum, with an objective to enable the consumer goods industry to better assess the relative sustainability of packaging (GPPS, 2010). Part of the Global Packaging Project includes the development of indicators and metrics for packaging sustainability. In this framework, an indicator is used to describe a concept that will be measured, and a metric is the method used to express or measure this indicator. Examples of the GPP indicators include: total amount of packaging per product; amount of waste generated during production of packaging materials; recycled content; renewable content; water used from water scare areas. The indicators also include the need for an environmental management system and energy audits. It is also important to understand to the recycling, composting, and reuse rate of the packaging, as well as, the transport packaging efficiency. In terms of economic indicators, the total cost and service value and the value of the packaged product lost due to packaging failure are important indicators. In terms of social indicators, it is important to understand the product safety and shelf life. Labor issues, including child labor, collective bargaining, forced labor, discrimination and working hours must also be taken into consideration. Sustainable products will also include end of life communications and community investment.

GOOD ENVIRONMENTAL CHOICE AUSTRALIA

Good Environmental Choice Australia (GECA) is the most recognized labeling program on the Australia market (GECA, 2007). It exists to help people chose products and services that are better for the environment. GECA believes that by making it easier to choose environmental preferable products, the demand on natural resources and risks to the community are reduced. The objectives of the program include: providing incentives for suppliers to reduce the environmental impact of products; providing a clear, credible, and independent guide to consumers; recognizing genuine moves by companies to reduce the adverse impact of their products; and aiming to improve the quality of the environment and sustainable management of resources. GECA develops sets of independent, robust environmental standards and tools through the use of a standardized development method, which includes stakeholder engagement and public review. The coverage of the program includes products such as: adhesives, paints, insulation, carpets, cleaners, computers, furniture, paper, personal care, printers, textiles and toys.

COSMetic Organic Standard

The COSMOS standard is an internationally recognized program for the labeling of natural and organic cosmetics. The main objective of the program is to stimulate processes for sustainable production and consumption (COSMOS, 2011). Four rules are used to promote this objective: promotion of products from organic agriculture and respecting biodiversity; using natural resources respectively; using clean manufacturing process which are respectful to human health; and integrating the concept of green chemistry. The standard distinguishes common cosmetics into five categories to better facilitate the use of the rules: water, minerals, physically processed agro-ingredients, chemically processed agro-ingredients, and other ingredients. The scope of the program includes the origin of ingredients, composition of final product, storage, manufacturing, environmental management, communication, and labeling. The organization itself was founded in 2010 by standards organization in four different European countries.

ECOCERT

ECOCERT is an organic certification organization which was founded in 1991. Originally based in France, the organization certifies products in over 80 countries. The primary focus of the program is around food products, but they label cosmetics and textiles as well (Ecocert, 2003). The certification process is monitored by Ecocert auditors who conduct onsite inspections, certification officers who assess compliance with standard, and a supervisory committee who oversees proper application of the process. The cosmetic standard was developed in 2003 with assistance from multiple stakeholders. The basic principle is to ensure an environmentally friendly cosmetic product. This is accomplished by the use of ingredients from renewable sources, manufacturing by an environmentally friendly process, a minimum threshold of natural ingredients from organic farming, and onsite auditing.

APPENDIX B

UNCERTAINTY ANALYSIS

Table 12

Cream Foundation Input Values and Uncertainty

Input	Value	Pedigree Matrix
Cyclopentasiloxan	4.89E-02 kg	(2,4,2,5,4,4)
Glycerin	2.93E-02 kg	(2,4,2,5,3,4)
Water	8.95E-02 kg	(2,4,2,5,3,4)
Dimethicone cross polymer	1.22E-02 kg	(2,4,2,5,4,4)
Dimethicone	9.78E-03 kg	(2,4,2,5,4,4)
Methicone	1.22E-02 kg	(2,4,2,5,4,4)
Benzyl alcohol	1.22E-03 kg	(2,4,2,5,3,4)
PEG/PPG-18/18 Dimethicone	4.89E-03 kg	(2,4,2,5,4,4)
Ethylparaben	2.44E-04 kg	(2,4,2,5,4,4)
Methyparaben	2.44E-04 kg	(2,4,2,5,4,4)
Propylparaben	2.44E-04 kg	(2,4,2,5,4,4)
Disodium EDTA	2.44E-04 kg	(2,4,2,5,3,4)
Titanium dioxide	1.47E-02 kg	(2,4,2,5,3,4)
Iron oxides	3.67E-03 kg	(2,4,2,5,4,4)
Sodium chloride	4.89E-03 kg	(2,4,2,5,3,4)
Niacinamide	1.22E-02 kg	(2,4,2,5,4,4)
Electrical energy	8.50E-02 kWh	(2,4,3,5,3,3)
Gas	1.06E-02 m^3	(2,4,3,5,3,3)
Water	1.66 kg	(2,4,3,5,3,3)
Effluent	1.50E-03 m^3	(2,4,3,5,3,3)
Lid (PP)	9.53E-02 kg	(3,3,3,5,1,4)
Bottle (Glass)	8.23E-01 kg	(3,3,3,5,1,4)
Plastic Processing	9.58E-02 kg	(2,3,1,5,3,2)
Raw Materials to Production Facility: Truck	2.44E+01 kgkm	(2,5,3,5,1,3)
Raw Materials to Production Facility: Rail	1.47E+02 kgkm	(2,5,3,5,1,3)
Production facility to Retail: Truck	6.05E+02 kgkm	(2,5,3,5,1,3)
Retail to Consumer: Car	3.78E-01kgkm	(2,5,3,5,1,3)
Consumer to Disposal: Truck	3.95 kgkm	(2,5,3,5,1,3)
Lid Disposal	7.81E-02 kg	(2,2,3,5,3,3)
Bottle Disposal	6.75E-01 kg	(2,2,3,5,3,3)

Table 13

Deodorant Input Values and Uncertainty

Input	Value	Pedigree Matrix
Cyclopentasiloxane	6.66E-02 kg	(2,4,2,5,4,4)
PPG-14 butyl ether	2.75E-02 kg	(2,4,2,5,4,4)
BHT	1.45E-04 kg	(2,4,2,5,5,4)
Dimethicone	2.9E-03 kg	(2,4,2,5,4,4)
C12-15 Alkyl Benzoate	4.34E-02 kg	(2,4,2,5,4,4)
Steareth-100	1.45E-03 kg	(2,4,2,5,4,4)
Stearyl Alcohol	5.21E-02 kg	(2,4,2,5,4,4)
Hydrogenated Castor Oil	1.01E-02 kg	(2,4,2,5,4,4)
Polyethylene Wax	2.90E-03 kg	(2,4,2,5,4,4)
PEG-8	5.79E-03 kg	(2,4,2,5,4,4)
Fumed silica	2.17E-03 kg	(2,4,2,5,4,4)
Aluminum	5.79E-02 kg	(2,4,2,5,3,4)
Chlorohydrate sunflower oil	1.45E-03 kg	(2,4,2,5,4,4)
Fragrance	3.47E-03 kg	(2,4,2,5,5,4)
Water	1.16E-02 kg	(2,4,2,5,3,4)
Electrical energy	1.01E-01 kWh	(2,4,3,5,3,3)
Gas	1.26E-02 m^3	(2,4,3,5,3,3)
Water	1.97 kg	(2,4,3,5,3,3)
Effluent	1.77E-03 m^3	(2,4,3,5,3,3)
Cap (PE)	2.37E-02 kg	(3,3,3,5,1,4)
Barrel (PE)	1.40E-01 kg	(3,3,3,5,1,4)
Platform (PP)	1.49E-02 kg	(3,3,3,5,1,4)
Protective Cover (PP)	5.58E-03 kg	(3,3,3,5,1,4)
Plastic Processing Cap	2.39E-02 kg	(2,3,1,5,3,2)
Plastic Processing Barrel	1.41E-01 kg	(2,3,1,5,3,2)
Plastic Processing Platform	1.50E-02 kg	(2,3,1,5,3,2)
Plastic Processing Cover	5.61E-03 kg	(2,3,1,5,3,2)
Raw Materials to Production Facility: Truck	2.90E+01kg	(2,5,3,5,1,3)
Raw Materials to Production Facility: Rail	1.74E+02 kg	(2,5,3,5,1,3)
Production facility to Retail: Truck	2.46E+02 kg	(2,5,3,5,1,3)
Retail to Consumer: Car	1.54E-01 kg	(2,5,3,5,1,3)
Consumer to Disposal: Truck	7.92E-01 kg	(2,5,3,5,1,3)
Platform Disposal	1.49E-02 kg	(2,2,3,5,3,3)
Protective Cover Disposal	5.58E-03 kg	(2,2,3,5,3,3)
Cap Disposal	2.37E-02 kg	(2,2,3,5,3,3)
Barrel Disposal	1.40E-01 kg	(2,2,3,5,3,3)