

Today's Environmental Manager's Toolbox: Evaluating the EHS Attributes of Products

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ABSTRACT: In response to the public's interest, companies have expanded their focus on reducing their environmental footprint through designing environmentally preferable products. Corporate environmental managers typically work with product design teams on this effort. This paper explains three tools available to assist in the assessment of EHS attributes of products, namely risk assessment, alternatives assessment, and life cycle assessment. An overview, process appropriate uses, and limitations of each tool are discussed.

KEYWORDS

Alternatives Assessment, Environmental Impact, Life Cycle Assessment, Product, Risk Assessment

I. INTRODUCTION

Now more than ever, companies are realizing the benefits associated with ecodesign concepts, including improved resource and process efficiencies, potential product differentiation, reduction in regulatory burden, and cost savings (Lee). Focus has expanded from the environmental impacts of manufacturing operations to the entire product life cycle, encompassing all operations from cradle to grave. There is significant benefit from integrating environmental aspects into the product as early as possible in the product design and development process. Addressing environmental aspects early allows process and material modifications to be more easily made.

There are three main reasons why the shift has occurred. First, there is a heightened interest by the

public and other stakeholders in the environmental attributes of products. Many customers, including individuals and businesses, consider attributes such as recyclability, use of biobased materials, and energy use when making purchasing decisions. Consumer interest has further expanded from the physical safety to the environmental health of products. For example, consumers are now concerned about the presence of potentially toxic endocrine disruptors and the toxicity of packaging components (Ruoff), whether or not the product can be recycled at the end of life (MarketingCharts), and waste and emissions associated with use of the product (Sunderland). Second, in order to accurately communicate the environmental impact of products and show significant improvement, key retailers and purchasers are developing environmental requirements for suppliers. In order for manufacturers to sell their product on store shelves or be a preferred supplier, they are required to lower their energy use, reduce packaging, or comply with other retailer environmental impact requirements.

Manufacturers are forcing these environmental impact requirements onto their suppliers to ensure their products meet retailer requirements. Lastly, there has been a fundamental shift in thought and the importance of the environmental impact of products throughout their life cycle has been realized. Consumer, retailer, and government focus has shifted from the manufacturing plant to the design, use, and end of life of the product itself. The end of life management strategy is especially important as the impact on the environment can change significantly when the product is landfilled, incinerated, recycled, or remanufactured.

This shift from production based environmental impacts to life cycle thinking has also spawned an increasing number of ecolabels, used to differentiate environmentally friendly products from those of their conventional (i.e., not environmentally friendly) counterparts (Schumacher). Ecolabels are typically developed by independent third party organizations and strive to provide a valid measure of a product's environmental attribute(s). As companies realize the importance of ecolabels, it is critical that product design teams understand the environmental aspects and impacts, the limitations of them, and how to design products to meet their requirements.

In order to respond to the market's request for environmentally friendly products, corporations are incorporating ecodesign concepts into their products now more than ever. Product design teams work to meet these requirements and many have minimal experience designing for the environment. In many corporations, environmental managers are called on to provide vital environmental expertise to the design process.

A plethora of tools have been developed to assist in the evaluation of the environmental health and safety attributes of products. The purpose of these tools ranges from assessing the environmental health and safety attributes of one product,

comparing the attributes of multiple products, and quantifying the attributes throughout the entire life cycle of a product. The depth and breadth of the tools vary as well, from high level screening assessments to in-depth detailed calculations. It is important for today's environmental manager to understand the purpose of tools in order to use them appropriately. The goal of this paper is to provide an overview of three tools used to evaluate the environmental health and safety attributes of products, namely product based risk assessment, alternatives assessment, and life cycle assessment.

II. TOOLS FOR EVALUATING THE ENVIRONMENTAL HEALTH & SAFETY ATTRIBUTES OF PRODUCTS

II.I. PRODUCT BASED RISK ASSESSMENT

Risk is the chance of harmful effects to human health or ecological systems resulting from exposure to some environmental stressor (US EPA). The goal of a product based risk assessment is to understand the potential human health and environmental impacts resulting from use of the product, with consideration for the different types of product users and the levels at which they may be exposed to impacts resulting from the product. Product based risk assessments typically focus on the inherent impacts of the finished product, impacts throughout the entire life cycle of the product, or a selection of life cycle stages.

Product life cycles are divided into six stages: material extraction, material processing, product manufacture, product use, packaging and distribution, and end of life. Product based risk assessment may focus on inherent hazards of the product, potential impact during manufacture, and potential impact at the end of life, as these three phases typically impact total life cycle impact the most.

The first step in conducting a risk assessment, as seen in Figure 1, is to determine the scope and intent of the risk assessment. This includes limiting the assessment to a set of product users or specific life cycle stages. The intent, or purpose, of the risk assessment is then determined and could range from assessing a product for compliance with an environmental performance standard, such as an eco-label, to understanding the potential environmental impact of a product. Once the scope is set, a set of human health and environmental impact criteria included in the assessment are developed as well as the structure of the assessment. Scoping the assessment and developing the criteria is an iterative process, as the scope of the assessment may indicate the criteria to include, and vice versa. When designing the criteria, it is important to consider criteria important to the company/product developer, criteria important to the product user, and criteria important to the greater good of the environment and human health. Threshold levels may be included in the risk assessment such that results are presented on a relative scale, such as high, medium, and low, or risk assessment results may present raw results, allowing the user to prioritize the impacts. In a similar manner, weighting factors may be included in the risk assessment in order to prioritize impacts. The structure of the risk assessment tool can vary, and examples include checklists, matrices, and formal reports. Once the risk assessment tool is developed, the impacts are assessed.

Results show characteristics of the product with high and low impact and can be used many ways. First, allowing product designers to understand the product attributes which contribute significant and

insignificant impact can be used to inform future designs of the same or similar products. Second, the results provide a roadmap to design teams to focus their efforts in order to reduce impact of the highest impact attributes, rather than spending time and resources focused on low impact attributes. Last, the results indicate the environmental and human health attributes that are impacted the most and least. This also provides a roadmap for product designers to concentrate their design efforts to reduce the highest EHS impacts.

The risk assessment process is typically performed by product design teams when developing a new product or redesigning a current product and is integrated in the design process. The role of environmental managers to assist product design teams is threefold. First, design teams are commonly tasked with designing “environmentally preferable” products. The definition of “environmentally preferable” can change from business to business depending on the needs of the customer, behaviors of competitors, and nature of the product manufactured. Environmental managers can help the design team determine what is considered “environmentally preferable” for their situation. In addition, while product designers may understand aspects of eco-design, environmental managers can assist with defining the criteria to be included in the risk assessment. Last, environmental managers can assist in identifying the environmental impacts and aspects of products in order to complete the risk assessment. Defining attributes which are environmentally preferable and placing them on a continuum from less preferable to most preferable will assist the design team in making decisions and



Figure 1: Risk assessment process

understanding environmental impact.

II.I.I. RISK ASSESSMENT IN PRACTICE

Progressive private companies are embracing environmental risk assessment, incorporating it into their current business models. SC Johnson and Walmart have developed internal tools to both assess and numerically score the environmental health and safety risks of their product ingredients. Numerical scores allow companies to prioritize those ingredients with the highest risk and are therefore the priority for substitution or restriction.

II.I.I.I. SC JOHNSON GREENLIST™

SC Johnson developed Greenlist™ in 2001 to more easily classify the environmental and human health impact associated with raw materials used in the company's products. Greenlist™ is a process for rating raw materials on a numerical scale, with 0 "no viable alternatives," 1 "acceptable," 2 "better," and 3 "best" (SC Johnson). As a result, product designers understand from the initiation of the design process which ingredients are "best" to use. Reformulated products must have a higher score than current products in order to move forward with the design process. Greenlist™ has been successful, as SC Johnson has seen an increase in "best" ingredients from 4% in 2001 to 18% in 2010 (SC Johnson). SC Johnson does not disclose the specific environmental and human health impacts integrated in Greenlist™.

Greenlist™ is an example of a tool which translates a significant amount of highly scientific, highly technical information to a format non-environmental experts can use. Furthermore, the goal of Greenlist™ is to support the product research and development function at SC Johnson, further illustrating the emerging importance of environmental and health issues in the product design process.

II.I.I.II. WALMART GREENWERCS

GreenWERCS is a software tool designed to assess the environmental and human health impacts of the composition of chemical products. The tool evaluates data available for individual ingredients, including determining if the ingredient is a persistent, bioaccumulative, and toxic substance (PBT); carcinogen, mutagen, or reproductive toxicant (CMR); potential hazardous waste; and endocrine disruptor. A pre-identified scoring and weighting algorithm is used to translate the ingredient data into more user friendly information. First, each product receives a "green score" or numerical value. Second, a visual analysis shows how the product ranks in relation to others. Lastly, the tool presents ways to reformulate the product without hazardous chemicals (The WERCS).

II.I.II. USES AND LIMITATIONS OF PRODUCT BASED RISK ASSESSMENT

Product based risk assessment at the company level provides a casual, relatively quick method to identify and assess the environmental health and safety risks associated with products to assist with internal decision making. The structure and format of the risk assessment is flexible, allowing the user to determine the scope, boundaries, and impacts included in the assessment. This ensures the assessment meets the needs of the user and the user does not spend time and resources collecting data that does not map back to the goals of the assessment. Flexibility of the risk assessment structure also means that results are typically used for internal purposes only and cannot be used to support marketing claims.

Risk assessment results can be used to (1) identify individual components of a product which contribute significant and insignificant impact and (2) identify the type of environmental and/or

human health impact resulting from the product. This information is invaluable to product design teams as understanding the processes or materials that contribute significant impact and the types of impact occurring can drive future designs decisions to lower those impacts. Results can also be used to educate other business units, such as marketing and manufacturing, about environmental impact of their products.

II.II. ALTERNATIVES ASSESSMENT

A common product risk assessment recommendation is to replace the product or a component with a counterpart with less impact. The difficulty lies in identifying alternatives that are technically feasible, cost effective, and have less impact than the initial component. Whereas risk assessment is used to identify the potential impacts of one product, alternatives assessment is a tool used to compare the environmental, human health, and performance attributes of a set of products which perform the same function to ensure potential replacements are indeed less impactful and that the replacement does not have an unforeseen side effect. It is also used to assess potential alternatives to a toxic or hazardous component of a product to ensure the replacement has a lower impact while performing the same or better than its counterpart. Alternatives assessment can be used in the product design or redesign phases to evaluate alternatives and prioritize them for use.

Alternatives assessment is typically performed in a four step process, as depicted in Figure 2. The first step is to define the problem and understand why an alternative is being sought. The

functional requirements of potential alternatives are identified. At this stage, the alternatives assessment criteria begin to take shape. The assessment team determines which attributes the alternatives will be assessed against and attributes are prioritized. Potential alternatives are then identified through a variety of methods including engineering knowledge, internet research, and benchmarking of competitor products. The number of potential alternatives identified can vary significantly, and will be based on the depth and purpose of the assessment. Potential alternatives are screened by assessing the environmental attributes of each alternative and alternatives are prioritized for implementation. Results of the assessment are used to determine what action, if any, should be taken.

Numerical or relative scoring systems are typically developed to express results of the assessment and prioritize alternatives for implementation. There are two main types of alternatives assessment methods. Screening methods apply decision rules and weighting factors built into the model so the results prioritize the alternatives for implementation. Screening method results are typically expressed as a single numerical score. The advantage of screening methods is that the prioritization of alternatives is subjective, based on requirements built into the assessment method. In contrast, hazard data display methods display the raw results of the assessment. It is the user's responsibility to apply decision methods and weighting factors to rank the alternatives. The benefit of hazard display methods is that the user has control of the data and can apply weighing factors to those attributes which are the most

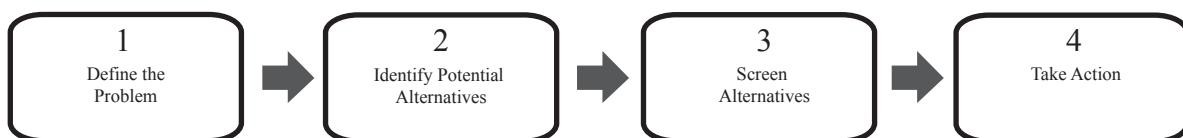


Figure 2: Alternatives assessment process

important (Civie et. al.).

II.II.I. ALTERNATIVES ASSESSMENT IN PRACTICE

In practice, private companies, governments, and non-governmental organizations are developing guidelines and methodologies for performing alternatives assessments. At a minimum, alternatives assessment methods include a set of human health and environmental health impacts. Methods may also incorporate technical feasibility requirements, cost and economic impact, exposure routes, or other attributes specific to the products assessed.

In the last decade, state governments across the country have integrated alternatives assessment into chemical regulation in order to ensure that when a specific chemical is banned, less toxic counterparts not only exist, but will function the same or better than the toxic chemical. Maine and Washington have successfully developed and used alternatives assessment in their legislative process while Massachusetts has used it to focus efforts statewide on reducing high hazard chemicals. At the same time, industry workgroups, such as the Interstate Chemicals Clearinghouse, and non-governmental organizations, such as Clean Production Action, have also developed publically available alternatives assessment methodologies. While many current alternatives assessment processes focus on a specific chemical rather than a product, the process, concepts, and attributes assessed also apply to assessing product alternatives. Winnebeck illustrates how chemical based alternatives assessment methodologies can be modified to assess products when she developed a three step process for identifying and assessing alternative mattresses for a children's product manufacturer.

Winnebeck provides a summary of a number of alternatives assessment frameworks, including those developed by universities

(University of Massachusetts Lowell), government (the Massachusetts Toxics Use Reduction Institute, California Department of Toxic Substances Control), and non-governmental organizations (Clean Production Action, McDonough Braungart Design Chemistry, LLC). While each of these frameworks incorporates a number of environmental and human health effects, the specific attributes included in each framework vary.

In January 2011, University of California at Santa Barbara compiled a number of resources, models, and tools to assist with alternatives assessment and presented it to the California Department of Toxics Substances Control. The UCSB benchmarking paper highlights the process of alternatives assessment, includes practical examples, and is a resource for in-depth alternatives assessment information.

II.II.I.I. FIVE CHEMICALS ALTERNATIVES ASSESSMENT STUDY, MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

In 2005, the Massachusetts government requested the Toxics Use Reduction Institute (TURI) assess safer alternatives for five higher hazard chemicals in Massachusetts. TURI researched potential alternative chemicals for specific uses in Massachusetts and assessed the EHS, performance, and cost attributes of the alternatives and compared them to determine a preferable alternative.

A number of criteria were established for comparison, based on the chemical analyzed. The criteria were grouped into four categories: human health, environment, finance, and performance/technical. The human health and environmental criteria remain the same and unique financial and performance/technical criteria were established for each of the five chemicals. Financial criteria

included cost per unit and performance/technical criteria included availability, appearance, and fire resistance.

II.II.I.II. SAFER CONSUMER PRODUCT ALTERNATIVES, CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)

The California Safer Consumer Product Alternatives proposed regulation outlines a six step process to identify chemicals of concern and identify which consumer products use the chemicals. Manufacturers which use chemicals of concern must complete an alternatives assessment and develop an action plan based on the results.

DTSC is taking a life cycle approach to the assessment as impacts in various stages of the product life cycle must be included in the alternatives assessment. DTSC has identified a total of thirty six criteria under the categories in minerals and resource consumption; public and occupational health impacts, including potential impacts to sensitive subpopulations; environmental impacts; and economic impacts that must be included in the alternatives assessment. The proposed regulations do not include a decision making or prioritization scheme, so it is the manufacturer's decision to implement an alternative.

II.I.I.III. US ENVIRONMENTAL PROTECTION AGENCY DESIGN FOR ENVIRONMENT (DFE) PROGRAM

The US EPA DfE program helps industries choose safer chemicals by researching alternatives and evaluating them for specific applications, such as flame retardants in furniture and bisphenol A alternatives in thermal paper (EPAa). The EPA

has developed a set of assessment criteria and accompanying very low, low, moderate, high, and very high thresholds for each criterion. Results are displayed as a matrix, providing the user with a visual display of the high and low potential impacts and hazards associated with alternatives. Weighting is not incorporated in the method, and it is the responsibility of the user to determine which attributes are more important than others, if any, and ultimately how to prioritize the alternatives for action.

II.I.I.IV. INTERSTATE CHEMICALS CLEARINGHOUSE (IC2) SAFER ALTERNATIVES ASSESSMENTS WIKI

The wiki is a joint project of a number of alternatives assessment experts throughout the US working to assist state technical assistance providers and chemical policy makers in performing alternatives assessment by creating a universally agreed upon process to perform alternatives assessment at the state level. While the wiki seeks to help state governments perform chemical alternative assessments to support regulatory action, the process and a number of criteria are also applicable for manufacturers looking to assess chemicals or products.

II.I.I.V. GREEN SCREEN FOR SAFER CHEMICALS, CLEAN PRODUCTION ACTION

The GreenScreen is an open source method developed by Clean Production Action to rank chemicals using a comparative hazard assessment process which incorporates the twelve Principles of Green Chemistry (see Anastas for more information) in the criteria and the US EPA Design for Environment Program assessment structure. The environmental and human health attributes of a chemical are assessed and based on the results, the chemical falls

into one of four benchmarks: avoid – chemical of high concern, use but search for safer substitutes, use but still opportunity for improvement, and prefer – safer chemical. A set of criteria is defined for each benchmark and the chemical and its breakdown products and metabolites must pass all criteria in order for the chemical to move to the next benchmark. Because multiple criteria exist at each benchmark, multiple alternatives can fall within the same benchmark. The GreenScreen does not provide a method to rank alternatives which fall within the same benchmark, leaving the user ultimately responsible for decision making.

II.II.II. USES AND LIMITATIONS OF ALTERNATIVES ASSESSMENT

Product based alternatives assessment provides a relatively quick method to identify and assess the environmental health and safety risks associated with a set of products which perform the same function. Like risk assessment, alternatives assessment results are used to inform product designers to assist with internal decision making. Alternatives assessment is similar to risk assessment in that the structure and format of both tools is flexible, allowing the user to determine the scope, boundaries, and impacts included in the assessment. This also means that results are used for internal purposes only and cannot be used to support marketing claims.

Alternatives assessment results show which product components contribute significant and insignificant impact as well as the type of environmental or human health impact that results from the product, similar to risk assessment. Whereas risk assessment presents the results for one product, alternatives assessment allows the results from multiple products to be compared in order to select the component with the least environmental impact.

Another main difference between risk

assessment and alternatives assessment is the integration of performance and economic impacts in alternatives assessment that are absent from risk assessment. In alternatives assessment, it is important to consider the performance of each alternative to ensure alternatives are adequately compared. For example, it is not fair to compare the environmental impact of a single use disposable plastic cup to a glass cup, as the glass cup can be used and reused multiple times whereas the plastic cup can only be used once. When evaluating materials or chemicals as alternatives, it is important to determine if alternatives are drop in replacements, or if more of one alternative is needed to perform as well as others, if alternatives meet set durability requirements, and other internal requirements which may affect how the alternatives are compared. It is also important to consider economic impacts associated with alternatives, both internal to the company (ie. increased raw material cost, significant renovations to manufacturing operations required) and to the product user or customer (ie. increased energy usage which translates to increased cost). Cost and performance impacts may outweigh potential environmental and human health benefits of one alternative over others, deeming it inappropriate for use.

Similar to risk assessment, alternatives assessment results can also be an educational tool for other internal business units to understand how changes in processing and raw materials may affect the product's impact. While the results may be presented as a numerical score, alternatives assessment does not quantify the environmental and human health impact of the product throughout its life cycle. Numerical scores are typically used to translate environmental and human health impacts to make results easier to compare, especially for audiences which may not be versed in environmental language.

II.III. LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA) is a tool used to quantify the environmental impact of a product from cradle to grave. LCA results are commonly used to identify environmental improvement opportunities throughout the life cycle of the product or to compare the environmental impact of two products which perform the same function. LCA results are commonly used to validate environmental marketing claims, such as “product x uses less energy than product y.”

The most widely recognized standardized guidelines for LCA have been developed by the International Organization of Standardization (ISO). ISO 14040:2006(E) Environmental management – life cycle assessment – principles and framework and ISO 14044:2006(E) Environmental management – life cycle assessment – requirements and guidelines outline the four step process by which life cycle assessments are performed, as shown in Figure 3.

The LCA begins by defining the goal and scope of the LCA and determining how the results will be used. Any assumptions used in the assessment and limitations of the assessment are also discussed.

The functional unit is a critical component of comparative LCAs and is defined. The functional unit is a measure of the functions of the system to be studied. For example, when comparing the life cycle of a disposable diaper to a cloth reusable diaper, and it is determined that a reusable diaper will last 20 uses, the functional unit is defined as 20 diaper changes. In this example, one reusable cloth diaper will be compared to twenty disposable diapers. At this stage, the life cycle analysts determine which environmental and human health impact categories will be included in the assessment.

Once the goal and scope are defined, the product is divided into six life cycle phases, similar to risk and alternatives assessments. In life cycle inventory analysis, the inputs and outputs of resources, energy, and wastes at each stage (such as pounds of polypropylene used, tons of carbon emitted) are quantified. Figure 4 shows the types of input and output inventory data collected. Life cycle inventory data can be collected either by taking actual measurements of the mass of materials used or through engineering diagrams and product tolerances. In many cases, information from both sources is used. For example, a manufacturer can

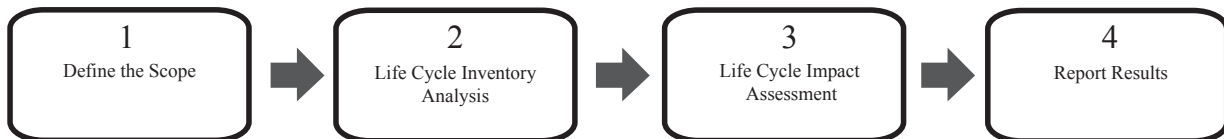


Figure 3. Life cycle assessment process

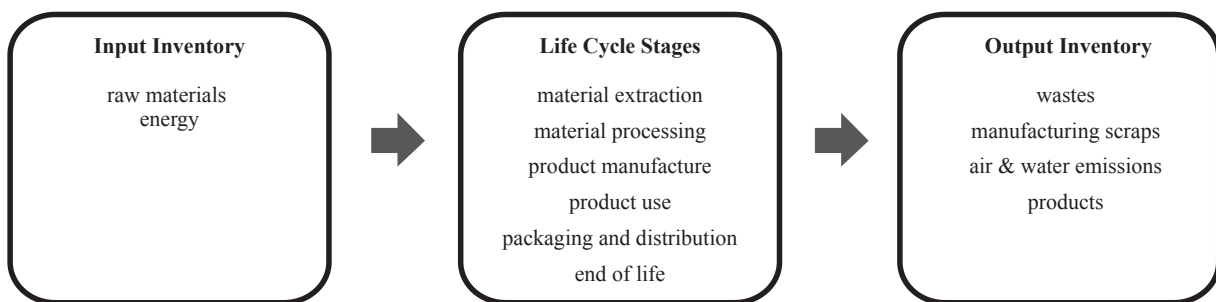


Figure 4: Life cycle inventory process

simply weigh a part to determine how much material is used for the part and scrap rates are normally built in to the manufacturing process, rather than calculated specifically from actual manufacturing operations. The result of the life cycle inventory is a quantified list of inputs and outputs throughout the product life cycle.

In the life cycle impact assessment, raw life cycle inventory data are classified according to the type of environmental impact caused. This is a five step process shown in Figure 5. First, a fate analysis is performed on the inventory data to determine and calculate which environmental compartment the inventory data is most likely to end up. Results of the fate analysis are determined by properties of the chemical and how it degrades in air, water, and soil. An exposure-effect analysis then takes the results of the fate analysis and quantifies potential damage to human health and the environment by exposure

to the chemical at levels determined by the fate analysis. The results of the exposure-effect analysis are called category indicators. Common category indicators include: carcinogens, respiratory organics and inorganics, climate change, radiation, ozone layer, ecotoxicity, acidification/eutrophication, land use, minerals, and fossil fuels. Impact category results are then translated to damage categories which indicate the potential damage caused by the inventory data on specific environmental media, represented by a numerical score. Common damage categories include ecosystem damage, human health, and mineral and fossil fuel resources. Many impact assessment methodologies use weighting factors to convert the damage category results into one numerical score. The environmental impact of products are commonly compared based on the damage category results and single score results.

The life cycle cumulative energy demand

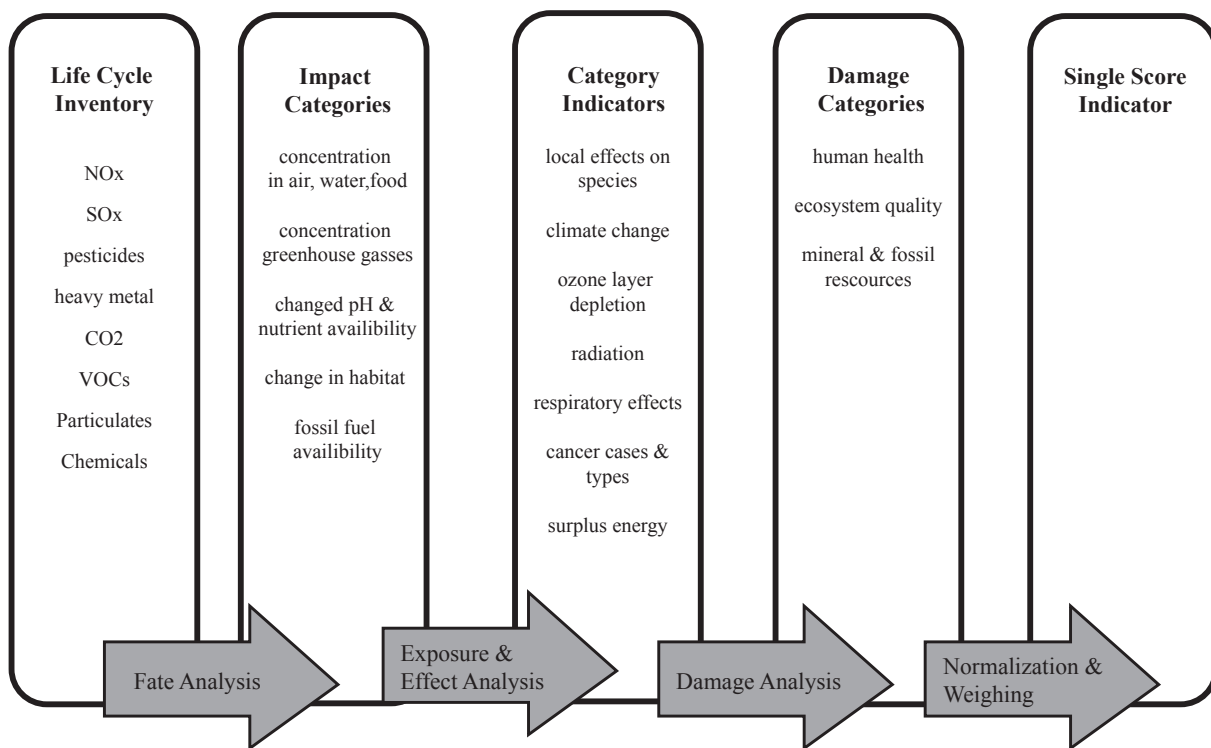


Figure 5: Impact analysis process

(CED) can be calculated in a similar manner. The life cycle inventory is compiled and the associated energy requirement is calculated for each input and output. Energy requirements are summed to determine the CED.

LCAs are typically performed using commercially available software using third party validated data sets. This significantly reduces the amount of data the LCA practitioner must collect to perform the LCA. For example, when performing a LCA of a polypropylene cup, scientifically acceptable data sets exist which identify and quantify the chemical inputs and outputs to polypropylene production; it is not necessary for the LCA practitioner to collect this data. Data sets also exist for polypropylene sent to landfill, incineration, and recycling at the end of life. The availability of this data significantly reduces the workload of the LCA practitioner.

There are instances where a data set does not currently exist for a material or process or the existing data set does not represent what is actually happening in the manufacturing process that is being modeled. For example, if the plastic cup is instead made of polylactic acid (PLA) from corn,

data on the inputs and outputs of materials from PLA production does not exist. In this instance, the LCA practitioner must compile the inventory itself.

LCA results are reported in multiple ways. Total life cycle impact, or single score, is commonly used to compare the environmental impact of two products which perform the same function. Impact of specific life cycle processes allow product designers, supply chain managers, and others involved directly in the manufacturing processes to understand the impact contributed by each process. Understanding the relative impact of processes allows those processes which contribute the most impact to be identified and prioritized for reduction. Specific damage category impact, as shown in Figure 6, allows the manufacturer to understand which environmental compartment will be affected the most as a result of both the life cycle as a whole and the specific processes within the life cycle. Understanding impact throughout the life cycle can help decision-makers ensure the proper environmental indicators are measured over time.

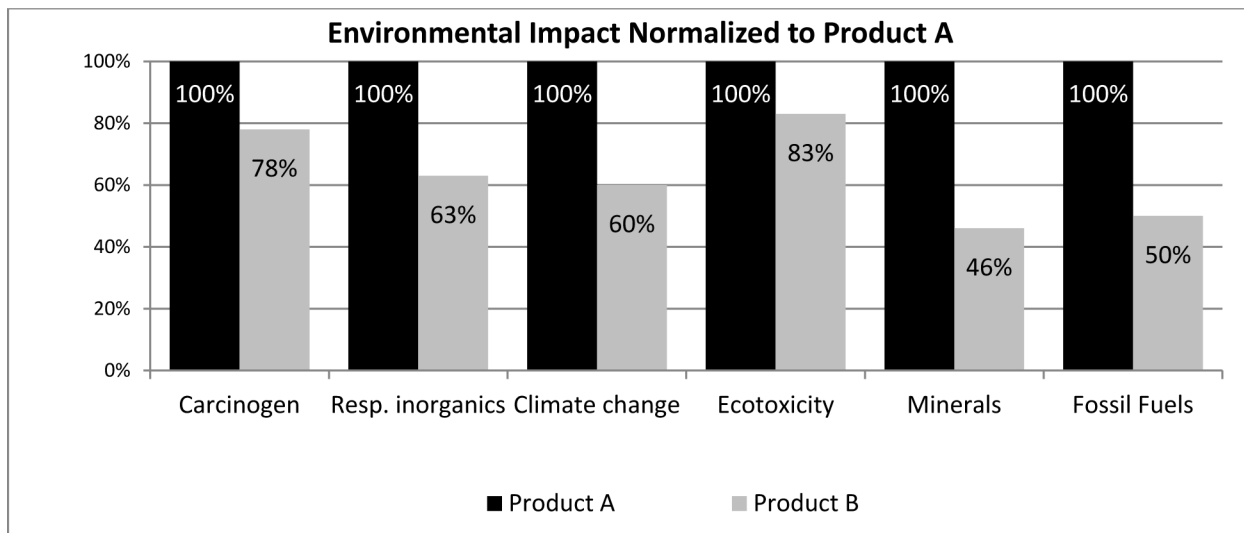


Figure 6: Sample impact assessment results

II.III.I. COMPARATIVE LCAS

Comparative LCAs are those which compare the environmental impacts of multiple products which perform the same function. Results are commonly used to support marketing claims and can also be used to identify impact categories in which the products differ.

For example, the total environmental impact of two products may be the same, but one may have

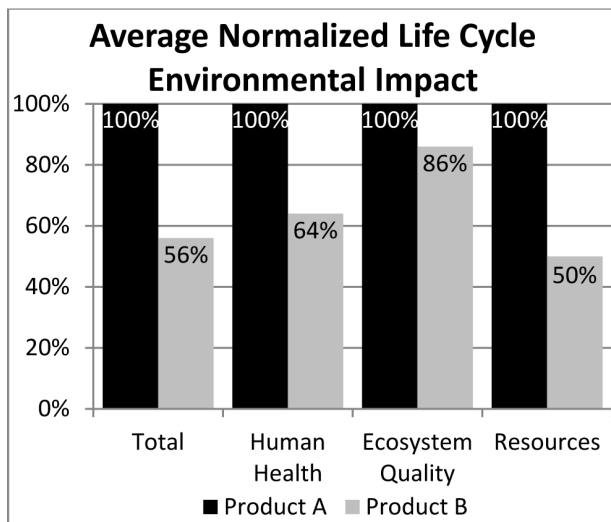


Figure 7: Sample LCA damage category results

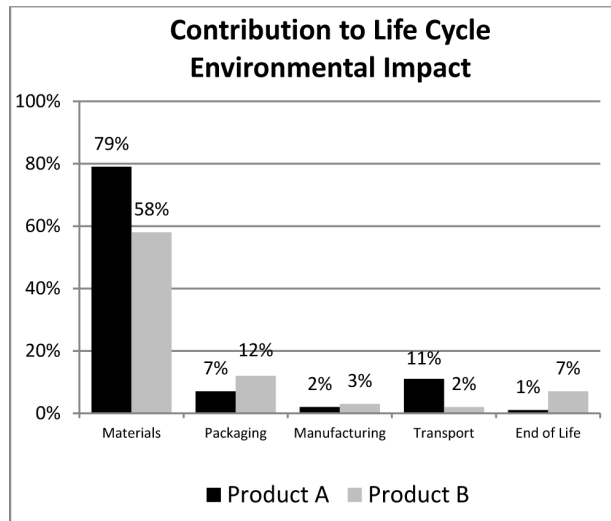


Figure 8: Sample LCA life cycle stage results

significantly less damage to human health than the other. Results comparing the life cycle stage impact of multiple products (i.e., the impact of landfilling two products) pinpoint the contribution of stages to the total impact and help visualize the difference between products.

II.III.II. USES AND LIMITATIONS OF LIFE CYCLE ASSESSMENT

Whereas risk assessment and alternatives assessment are relatively quick tools to identify the potential impacts of a product, life cycle assessment is a resource intense, detailed, rigorous process to quantify the impacts of a product. Risk and alternatives assessment may consider all or a selection of the product's life cycle and life cycle assessment considers all aspects in all life cycle stages of the product.

Life cycle assessment is useful to (1) determine the relative impact of all life cycle stages, processes, and materials to total environmental impact; (2) pinpoint the impact of a specific operation in the life cycle in order to identify opportunities to improve the environmental performance of products; (3) provide credible evidence for marketing claims and compliance with eco-labels; (4) select relevant indicators of environmental performance, and (5) instill life cycle thinking within business (Williamson). Understanding the relative impact of life cycle stages and the ability to pinpoint the contribution of processes to impact allows the user to more accurately understand where efforts should be concentrated to ensure time and resources are spent reducing those processes which contribute the most impact. Furthermore, understanding which indicators are impacted the most can assist the company develop environmental goals. For example, if LCA results show that a product line contributes significantly to water impacts, the company may concentrate its efforts on reducing

water use and wastewater throughout all product lines.

Where risk assessment and alternatives assessment methodologies are flexible, international guidelines for completing life cycle assessments provide a universally agreed upon methodology. Following the guidelines also means that results can and are typically reported externally and can therefore be used by customers to assist in their decision making and can provide credible evidence for marketing claims.

Similar to risk and alternatives assessments, LCA results can also be used to educate decision makers and other business units internally about the contributors to product impact. LCA results can also be used externally to inform decision makers, such as purchasers, about the environmental impact of a business' products.

One important limitation of LCA is that the results are only applicable to the (1) specific product models included in the study (2) based on the boundaries and scope of the study. For example, results of a comparison LCA of a laptop and desktop computer may indicate the laptop has a lower impact than the desktop. These results are only applicable to the two computer models included in the study. While the results may imply all laptops have a lower impact as compared to desktops, this cannot be concluded from the study. Second, the LCA results are representative of the manufacturing operations, wastes, and other operations included in the study and do not apply to future or past product versions where life cycle inventory data varies. For example, a life cycle assessment of a 2010 model laptop not have the same results of the same 2011 model laptop, assuming the 2011 laptop is not an exact replica of the 2010 model.

Another limitation of the LCA is that results from one LCA cannot necessarily be compared to the results of another LCA. For example, if two laptop manufacturers independently perform LCAs of their

laptop models, the results of those LCAs cannot be compared. Each LCA practitioner sets the scope and boundaries of their LCA, so both of the LCAs may be compliant with the ISO 14040 and 14044 LCA guidelines and have different boundaries, rendering a comparison inappropriate.

III. CONCLUSION

With the heightened interest from consumers, the marketplace, governments, policymakers, and other stakeholders around the environmental impact of products throughout the life cycle, the role of the corporate environmental manager is expanding. Environmental managers are not only responsible for ensuring environmental compliance, but are now frequently called upon to provide technical assistance to other functions within the corporation. Now more than ever it is important for environmental managers to be aware of what's going on in the marketplace as corporations respond to the public's request for more environmentally friendly products and environmental information, retailers' environmental impact requirements, and government and other purchaser environmental purchasing policies.

A new set of tools are emerging to help corporations assess the environmental health and safety risks and impacts of products. It is imperative that today's environmental managers familiarize themselves with these tools in order to excel. Table 1 summarizes the uses and limitations of the three product based risk assessment tools presented in this paper. Risk assessment and alternatives assessment are most useful for providing a relatively quick assessment of a product's impacts, modified to the needs of the user. Often times the assessment is performed by collecting a small set of life cycle impact data in order to complete the assessment. In alternatives assessment, the assessment may consist simply of evaluating if the impacts of alternatives are greater, less, or the same as the chemical targeted

Tool	Uses	Limitations
Risk Assessment	<ul style="list-style-type: none"> • Identify potential environmental health & safety risks of products • Identify opportunities to improve the environmental performance of products at various points in their life cycle • Results inform product designers to target aspects for future designs • Results educate business units about environmental impact 	<ul style="list-style-type: none"> • Not used to compare a portfolio of products that perform the same function • Does not integrate performance and economic impacts • Does not quantify impacts
Alternatives Assessment	<ul style="list-style-type: none"> • Identify potential environmental health & safety risks of products • Compare potential environmental health & safety risks of products that perform the same function • Identify opportunities to improve the environmental performance of products at various points in their life cycle • Results inform product designers to target aspects for future designs • Results educate business units about environmental impact 	<ul style="list-style-type: none"> • Does not quantify impacts • May require more time and resources than risk assessment
Life Cycle Assessment	<ul style="list-style-type: none"> • Quantify environmental benefits of products • Provide credible evidence for marketing claims • Identify opportunities to improve the environmental performance of products at various points in their life cycle • Inform decision-makers in industry, government or non-governmental organizations • Select relevant indicators of environmental performance, including measurement techniques • Instill life cycle thinking within businesses • Educate business units about environmental impact 	<ul style="list-style-type: none"> • Detailed analysis is time and resource intense • Not useful as a screening tool • Results are applicable only to the product models included in the study • LCA study results are not comparable as the scope and boundaries vary between studies • LCA experts are needed to accurately and adequately perform assessments • Methodologies and impact assessments are constantly evolving, requiring LCA practitioners to stay up to date

Table 1: Summary of product based risk assessment tools

for replacement. Results are used internally to assist with decision making and the results do not quantify environmental impact.

Life cycle assessment is a resource intense, detailed process involving collecting raw data on the inputs and outputs at each life cycle stage of a product. This raw data is then converted into damage to the environment, human health, and resources typically using mathematical models build into commercially available software packages. Because impact is quantified, the results indicate the amount and type of impact each life cycle process contributes. Life cycle assessment results can also be used to validate marketing claims and may validate compliance with an eco-label. Risk and alternatives assessments are more appropriate as material or product screening tools than LCA, as LCA is resource intense and provides significantly more information which may not be necessary to make the screening decision.

III.I. STUDY IMPLICATIONS

It is crucial that today's environmental manager stay up to date with the industry, government, and public interest in the environmental health and safety attributes of products. Risk, alternatives, and life cycle assessments described in this paper are a set of tools every environmental manager must be familiar with as their responsibilities further expand from industrial operations into the supply chain and life cycle of products. It must be noted that these assessment tools are only three tools in a toolbox spanning any number of tools environmental managers may use regularly. The goal of this paper is to provide an overview of the tools such that environmental managers understand their purpose and when it is appropriate to use each tool.

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