AWARE: Providing Consumers with Environmental and Social Performance of Products and Producers to Influence Purchasing Decisions

Katie Kerfoot

ME 490

April 28, 2005

Executive Summary

The AWARE project is focused on providing consumers with information on the social and environmental impacts of their purchases at the point of sale. This report addresses what type of information should be displayed to users and in what form so that it is credible, transparent, and easy to understand. The result is a three-tiered set of increasingly detailed product-specific environmental information. The most detailed level is product-specific Life Cycle Inventory data recording environmental impact of the product for its entire life. The second level displays the weighted impact of the product on various environmental categories. Users may choose the metrics of Eco-Indicator 95, EDIP, or EcoPoints 97 to calculate this level. The third level is a color rating indicating the aggregate impact, according to the selected metric, of the product relative to other products in its class.

This system is designed for implementation on a PocketPC with a compatible scanner, allowing users to simply scan product barcodes to receive the information. It is presented in a clear and simple manner to allow for ease-of-use and also includes enough detail to be transparent. The greatest limitation of this method is the scarcity of available product-specific Life Cycle Inventory data. Government incentives will have to be created to encourage corporations to collect and release such data. If this data is made available, the use of AWARE could create significant market incentives to improve social and environmental performance.

1 Introduction

1.1 Definition of Need

The United States is a large market with frequent purchases of innumerable products. Generally, purchasing choice is based on differentiation of product features, price, brand, and packaging, which drives suppliers to meet consumer preferences of these characteristics. Surveys show that consumers will also consider environmental and social performance of products if they are made aware of these characteristics [I]. Currently there is no reliable, convenient, and simple method of presenting this information to consumers and very few attempts at such a method in the United States.

The AWARE project is focused on developing a system of presenting product-specific environmental characteristics and producer-specific social responsibility and environmental characteristics in an easily understood, convenient, and credible manner to allow consumers to consider these factors when choosing among competing products. Widespread use of this system would drive corporations to lower the environmental impact of their products and implement socially responsible principles to stay competitive. The greater goal of the project is to extend considerations of the environment and social responsibility to every stage of product life, from initial designs to product purchase, use, and disposal.

1.2 Concept

To allow consumers to use AWARE at the point of purchase, it will need to be available in a convenient manner. Labels are commonly used to convey relevant information such as price and important product characteristics such as nutrition and life, Figure 1, but may not be suitable for environmental and social responsibility information. A very limited amount of information can be presented on a label and companies may not wish to advertise such information. To avoid these problems, AWARE is available on a program for a PocketPC and a compatible scanner, Figure 2. Users will only need to scan a product, and environmental and social responsibility characteristics of the product and brand will be displayed.

Figure 1. Consumers in developed markets are typically bombarded with a large number of products that have few fundamentally differentiating factors, and hence make decisions based mostly on price, brand, and packaging alone.

Figure 2. Handheld computers (PDAs) oufitted with UPC barcode scanners could function as an effective means to providiing additional information, such as environmental characteristics, to consumers at the point of sale.

1.3 Background

1.3.1 Environmental and Social Labels

Numerous labeling methods have emerged that attempt to solve the problem of providing environmental and social information of products and producers to consumers. Examples of these labels include Energy Star and Fairtrade in the United States and Eco-Label and Energy Label in the European Union. In general, the labels are maintained by independent organizations that set their own criteria for certification based on their specific concerns. Criteria are generally tailored to product classes, either based on a general life cycle assessment of that class, or determined subjectively by the organizations' knowledge and experience with the issue.

Energy Star was started by the EPA as a voluntary labeling program to encourage energy efficiency and is now also partnered with the DOE. Currently, Energy Star is used on a very limited range of general-consumer products, mostly focused on high energy-consuming appliances such as clothes washers, refrigerators, computers, and televisions. Standards for Energy Star are specific to each of these product classes [II].

Fairtrade labels seek to provide information on social responsibility regarding treatment of workers. TransFair USA certifies coffee, tea, and cocoa in the United States and bananas, sugar, honey and orange juice in Europe. To be certified the product must be grown from cooperatives of small farmers that provide a fair minimum price for workers. Farms are annually visited by Fairtrade labeling inspectors who report their findings to a committee that determines accept or deny certification of the fair trade label. Inspectors also review financial records of the farms and interview members of each producer group [III].

The Eco-label is regulated by the Eco-labeling Board, which is a group of representatives from industry, environment protection groups, and consumer organizations who review and set the criteria for the label. The criteria are focused on reducing the product phase of greatest impact and are based on a general life cycle assessment for each product class. The criteria for each product class are revised every 3 years to account for technological improvements and changes in the market. Products carrying the Eco-label are sold in 37 countries, but none in the United States [IV].

The EU Energy Label is required by law to be displayed for all refrigerators, freezers, dishwashers, clothes washers and dryers, lamps, electric ovens, and air conditioners. The label rates products on a scale from A++ to G according to product class criteria. The criteria are based on energy consumption during the products' use-phase and various product performance measurements [V].

1.3.2 Life Cycle Assessment

Life Cycle Assessment (LCA) is a method of quantitatively evaluating the environmental impact of a product across its entire life including production, manufacturing, use, and disposal. It is currently being used in industry to identify the product phase of greatest impact, and to modify design, or processes to reduce overall impact. LCA begins with goal definition and scoping that defines the purpose, boundaries, and assumptions of the analysis. The next step is to develop a Life Cycle Inventory (LCI) of quantitatively measured values of impact for various environmental categories (ozone depletion, acidification, global warming, etc.). To account for possible tradeoffs between categories in the improvement stage an impact analysis can apply weights of relative importance to the inventory data. An improvement analysis can then determine how to reduce environmental impact of the product [VI].

1.3.3 Weights of Impact Categories

1.3.3.1 Eco-Indicator 95

Eco-Indicator was developed by PRé Consultants, an independent company in the Netherlands, in conjunction with various Danish corporations. Eco-Indicator 95 provides weights for LCI data based on a distance-to-target method. This method correlates the weight of an impact directly with the magnitude that impact is from a target value. To determine the target values impact was categorized by human fatalities, illness, and ecosystem degradation. The acceptable levels of impact, used as target values, were determined subjectively by the contributors to the project as one fatality per million inhabitants per year, zero illnesses, and 5% ecosystem degradation over several decades [VII].

1.3.3.2 Eco-Indicator 99

Eco-indicator 99 partitions LCI information into three damage categories: human health, ecosystem quality, and resources. Human health is measured in terms of disability adjusted life years (DALYS), representing the years lived disabled and years of life lost for people exposed to harmful substances [VIII]. The units of ecosystem quality are the potentially affected fraction (PAF) of species in relation to toxic substances, determined by the percent of all species present in the affected environment that are living under toxic stress [IX]. Resources are measured by the quality, in mega joules of surplus energy, of the remaining mineral and fossil resources [X].

Weights for each of these three categories were determined so that a comparable, aggregate score of environmental impact could be reported. A written survey of a panel from the LCA Swiss Interest Group was used to determine the weights. The survey directly asked the subjects to rank the comparative importance of each of the three damage categories and assign weights to the categories. The results were 0.40 for human health, 0.20 for ecosystem quality, and 0.20 for resources.

Eco-Indicator 99 has had many criticisms that it is neither quantitative nor credible. The conversion of LCI data into ecosystem quality in terms of PAFs is problematic and does not accurately represent ecosystem impact. Also, relative weights of the categories were determined from only 82 people from one group, which does not represent the importance of environmental impacts to society as a whole.

1.3.3.3 EDIP

Environmental Design of Industrial Products (EDIP) was established by the Danish EPA to guide corporations through Life Cycle Assessments of their products. The EDIP team is composed of representatives from the Technical University of Denmark, Danish industrial companies, the Confederation of Danish Industries, and the Danish EPA. The EDIP method involves applying weights to LCI data, converting them into contributions to emissions, resource use, and potential worker injuries [XI].

The weights for emissions are determined by referencing international agreements and national plans of emission reduction and calculating how much a particular emission will have to be reduced per person to meet these political targets. Resource consumption weights are influenced by the comparative scarcity and rate of regeneration of each resource. Weights for potential worker injuries consider the probability that a category will result in injury of a worker and the seriousness of the consequences of the injury to the worker. EDIP weights are more quantitative and socially representative than

Eco-Indicator, but many categories are specific to Denmark and so should be cautiously applied to other regions.

1.3.3.4 EcoPoints 97

EcoPoints was developed by the Swiss Ministry of the Environment (BUWAL). The weighting method is similar to Eco-Indicator 95, determined by the distance-to-target principle and intended to be applied to LCI data. However, the targets set by EcoPoints is based on critical targets set by the Swiss government unlike Eco-Indicator 95 where targets are determined subjectively [XII].

1.3.3.5 Co-op America

Co-op America's Responsible Shopper program uses aggregate scores, called insights, to rate the social responsibility of corporations. The program acknowledges that these scores are determined qualitatively, based on the personal value systems of the organization's research staff. While the calculation of these score is not quantitative, the program recognizes implied weights used in rating. Items involving health, safety, and well-being of people are weighted more heavily, especially if children or other vulnerable groups in society are impacted. Violation of what the program calls "basic fairness and honesty" are also weighted more heavily. For example, companies participating in price-fixing schemes or sweatshops will receive more negative scores. Also, the program weighs "personal vices," such as alcohol, gambling, tobacco, and pornography less heavily [XIII].

2 Specifications

2.1 Project Requirements

AWARE must be convenient, credible, and easy to understand to be successful. Users must be able to use AWARE quickly and easily while shopping and understand the information displayed and the metrics behind the display. If the system is not easy to use then it will not be attractive to consumers, and it will not have an impact on purchasing decisions. Similarly, if it is not easy to understand the information presented will not be meaningful. Also, if the information is not credible and transparent then it will not promote true social and environmental performance and will not be trusted by the public. Users should be able to customize AWARE to account for their preferences in both the metrics and the display of ratings and information.

Requirements

- Information displayed must be immediately understood by the general public
- Users must be able to quickly compare competing products
- Data and ratings must be transparent
- Users should be able to customize the presentation and calculation of ratings to include their preferences

2.2 Project Specifications

Product information used for rating the environmental impact will be derived from LCI data as this is currently the most quantitative, respected, and widely used method to measure impact of all product phases. Environmental impact will be displayed in multiple layers of information with increasing complexity. The highest level will be a color-schemed rating system from red to green that allows users to quickly gauge overall impact of a particular product relative to other products in its product class and compare competing products. The lower levels will serve to provide more detailed information of the products' impact and reveal the data behind the higher level ratings. To demonstrate the environmental rating system, LCI data will be gathered for three product classes and the method will be applied to each product within every class.

2.3 Project Challenges

2.3.1 Available Information

Because Life Cycle Assessments are voluntary, there is a limited amount of LCI data available to the public and even less data that reveals what specific brand and product the assessment was carried out on. The National Renewable Energy Laboratory (NREL) has started a Life Cycle Inventory database, but because they are focused on energy, most of the data is from energy sources [XIV]. Environmental Product Declarations (EPD) in Sweden has started a similar database encouraging data from all processes and products [XV]. This database does include products appropriate to use with AWARE but very few products are available for purchase in the United States.

2.3.2 Impact Weights

In order to develop the highest level color-based rating scheme an aggregate score indicating the products' overall environmental impact will need to be determined. This will require either a set of normalization and weights for each impact category or specific cutoff requirements for each color. Either method has drawbacks. Weights can not be determined completely objectively and a weighting system ideally appropriate for AWARE has not yet been developed. Cutoff requirements will require an independent organization to set the criteria for each color rating for each product class and periodically update them to encourage improvement. The organization will receive pressure form influential corporations to set criteria that will not hurt their competitiveness. Also, some weighting factors will be present in the criteria for impact categories even if they are not explicit or even intentional. Most importantly, both weights and cutoff requirements should be representative of society as a whole and not just the members of this project.

2.3.3 Participation

For AWARE to be successful, information must be available for a large amount of products. A voluntary system will not attract enough corporations to collect LCI data and publicly release them, especially for those products that are not environmentally competitive. LCI data could be collected from the corporations themselves with external verification to ensure transparency or it could be collected from an independent organization. Enforcement or incentives for corporations to release this data will need to be established from the government. Such enforcement was created for the EU Energy Label and has been very successful.

3 Ratings and Display

3.1 Levels of Information

The first level of information is the raw LCI data given with appropriate units, Figure 3. This will allow advanced users to see the objective data collected for each product. The second level shows which environmental factors the product has the most impact on, Figure 4. To do this, a system of normalization and weights will have to be applied to the LCI data. Because there is no metric ideal for AWARE, the user instead will be able to choose among a list of possible metrics. It will be up to users to decide which metric they consider most credible, or to compare the results calculated from multiple metric systems. The Life Cycle Assessment software SimaPro contains the normalization and weighting factors for numerous LCA metrics. From this software EDIP, Eco-Indicator 95, and EcoPoints were chosen to calculate the second level of information. The calculation takes the form:

Resources

Non renewable material	269.0 kg
Renewable material	151.4 kg
Non renewable energy	4300.2 kWh
Renewable energy	2554.0 kWh

Emissions

Greenhouse gases	479.0 kg CO_2
Ozone-depleting gases	0.0 kg CFC-11
Acidifying gases	86.1 kg SO_2
Ground level ozone gases	0.3 kg C_2H_2
Eutrophication compounds	8.3 kg PO_4^-

Recyclable Resources

Materials	55.3 kg
Energy	244.0 kWh

Waste

Hazardous waste	0.6 kg
General waste	734.0 kg

Figure 3: Raw LCI data for refrigerator/freezer model 8117

$$\frac{D_{i,n} W_{n,m}}{N_{n,m}} = C_{i,n,m}$$

where $D_{i,n}$ is the measured environmental impact of category n from the LCI data of product i, $W_{n,m}$ is the weight of that category determined by a specific metric m, $N_{n,m}$ is the normalization factor of that category determined by the same metric, and $C_{i,n,m}$ is the weighted impact of the category n, for product i, according to metric m. For example, if LCI data shows that a product causes the emissions equivalent to 2 kg of CFC-11, the weighted impact of ozone depletion can be found using this equation:

$$\frac{(2\ kg\ CFC-11\ eq)(23\ PET_{WDK\,2000})}{(4.95\ kg\ CFC-11\ eq)} = 9.29\ PET_{WDK\,2000}$$

where $PET_{WDK\,2000}$ is the unit for the impact based on weighting relative to global and Danish emission targets by the year 2000. It was determined that this information should be displayed in the form of pie charts. Graphs are easily understood and because the units of the resulting calculation are essentially meaningless to most users, pie charts are more appropriate than bar graphs.

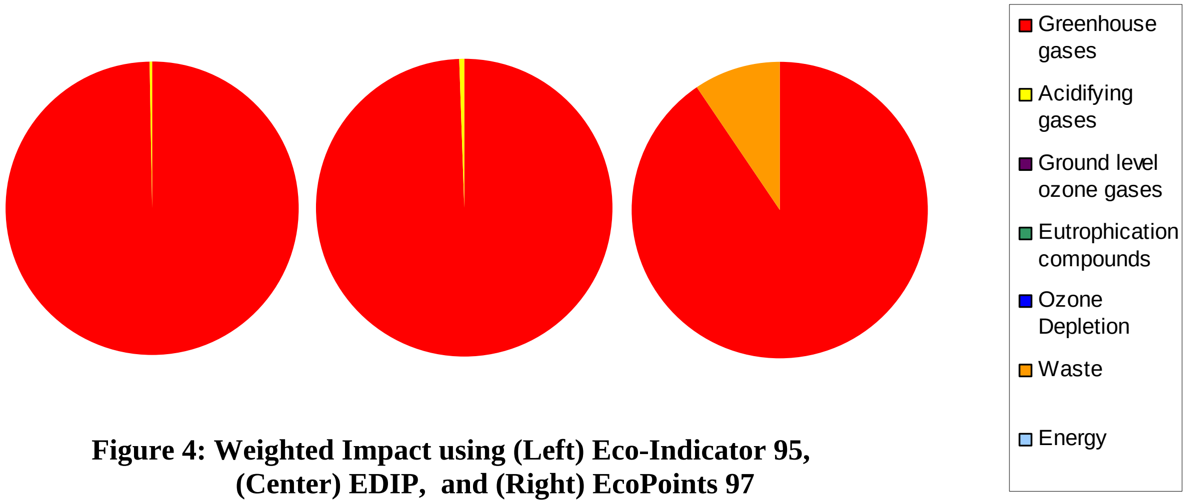

Figure 4: Weighted Impact using (Left) Eco-Indicator 95, (Center) EDIP, and (Right) EcoPoints 97

The third level of information will be a color rating from red to green, red being the highest level of environmental impact and green being the lowest. The rating is determined by summing the products' weighted impact for each environmental category and finding the mean and standard deviation for each product class. Colors are assigned by how far a product deviates from the mean of its class, Figure 5. A product's total weighted impact is described as:

$$T_{i,m} = \sum_{n=1}^{N} C_{i,n,m}$$

where $C_{i,n,m}$ is the weighted impact of the environmental category n, using metric m, for product i with N environmental categories, and $T_{i,m}$ is the total environmental impact of that product according to metric m. The deviation, $R_{i,m}$, of product i from the mean impact of its product class is calculated from:

$$R_{i,m} = \sqrt{(T_{i,m} - \overline{T}_{i,m})^2}$$

where $\overline{T}_{i,m}$ is the arithmetic mean of the product class's environmental impact:

$$\overline{T}_{i,m} = \frac{1}{N}\sum_{n=1}^{N} T_{i,m}$$

The standard deviation, σ_m, of the product class with I products using metric m is defined as:

$$\sigma_m = \sqrt{\frac{1}{I}\sum_{i=1}^{I}(T_{i,m} - \overline{T}_{i,m})^2} \quad .$$

The product rating is determined by the comparison of $R_{i,m}$ to σ_m:

If	$-0.5\sigma_m \geq R_{i,m}$	the product is rated RED;
if	$0.5\sigma_m > R_{i,m} > 0$	the product is rated ORANGE;
if	$0 > R_{i,m} > -0.5\sigma_m$	the product is rated YELLOW;
if	$-0.5\sigma_m \geq R_{i,m}$	the product is rated GREEN.

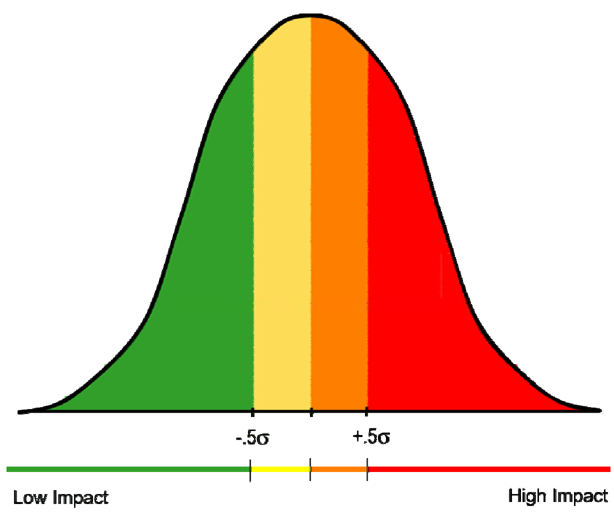

Figure 5: Determination of color rating for the third level of information

The advantage of having the rating calculated from standard deviations is that the market should drive its own incentives for reducing environmental impact. Products entering the market with a green rating will push other products into higher impact ratings, creating competition in the market that does not need to be enforced or updated by government or outside organizations. As corporations improve the environmental performance of their products over time they will force outdated products into the red end of the spectrum creating an incentive to continually lower products' impact without the need to adjust the rating system.

3.2 Display

The symbol of a flower was chosen to represent environmental performance, and the symbol of a boy's head was chosen for social performance, Figure 6. The program displays the third level of information (color rating) once the user has scanned a product. If the user clicks the screen it shows the lower levels of information. Similarly to environmental ratings, the user can choose from a number of "watchdog" organizations that monitor corporations' social responsibility to determine a producer's social rating. The organization used for this demo of AWARE is Co-op America's Responsible Shopper. If the user clicks on the producer rating, the screen will display the positive and negative contribution the producer has made to social responsibility and environmental performance as reported by Responsible Shopper. If the user clicks on the product rating, the screen will display the second level of product-specific environmental impact- the division of overall product impact into specific environmental categories. The user can then click on the pie chart to display the raw LCI data.

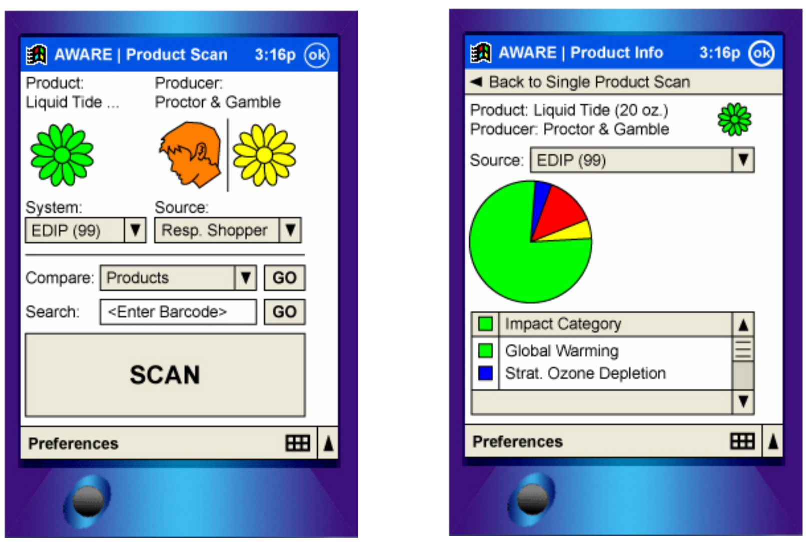

Figure 6: (Left) Highest level of information displaying product and producer color ratings; (Right) Second level of product information displaying the contribution of the product's total environmental impact on various environmental categories

Users will also be able to compare products directly using AWARE. When users select "compare products" the program will allow them to scan multiple products and will display each product's and producer's color ratings, Figure 7. This will allow users to quickly identify the products with the best environmental and social performance and also present possible tradeoffs between either environmental and social performance or product and producer performance.

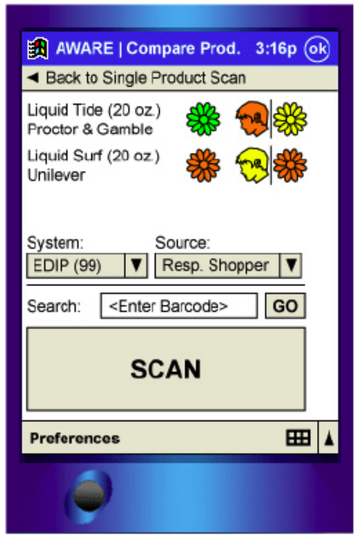

Figure 7: The "Compare Products" screen allows user to quickly compare environmental and social performance of products within a product class

3.3 Application of AWARE

3.3.1 Product Classes

The three product classes chosen to demonstrate AWARE are Electrolux refrigerator/freezer units, Ariel laundry detergent, and Perfect Print toner cartridges for laser printers. Data for the refrigerator/freezers and toner cartridges were found through the Environmental Product Declaration (EPD) program in Sweden. The data for laundry detergent was found from a case study conducted by Proctor & Gamble [XVI]. These products were chosen primarily because they were the only products purchased by individual consumers where LCI data was publicly available and included a brand name. Unfortunately, because of this scarcity of brand and product specific LCI data the demonstration can only compare environmental performance between products but not between brands as the LCI data for each product class is from the same brand. This lack of currently available LCI data is the biggest challenge for the AWARE concept. It is clear that voluntary requests for the data are not enough to meaningfully apply AWARE to the marketplace.

3.3.2 Functional Units

Each product's LCI data is given in terms of a functional unit appropriate for that product. Ideally, the functional unit is chosen so that environmental impact can be compared between products without confounding other product attributes such as life, or capacity. The functional unit given for laundry detergent is the recommended dosage for one wash cycle. This will allow consumers to compare environmental impact of different detergents without needing to consider the number of washes each bag of detergent can be used for.

For refrigerator/freezers, the functional unit is one refrigerator/freezer. While the choice of this unit will allow consumers to easily compare products, it does not account for the capacity of the refrigerator/freezer. Energy Star uses an alternative method of allowing refrigerator/freezers with larger capacities to have a greater environmental impact. This avoids discouraging the reduction of impact of larger refrigerator/freezers but also gives consumers the false impression that a large refrigerator/freezer has a comparable impact as a small one. The functional unit used in AWARE will always encourage consumers to buy smaller refrigerator/freezers, which have a lower environmental impact. To encourage improvement of environmental performance in larger models, multiple product classes could be created for refrigerator/freezers to divide significantly smaller models from larger models.

The functional unit used in the collected LCI data for toner cartridges is one cartridge. Because the different models of toner cartridges have varying print capacities, the data was adjusted to have a functional unit of 1000 pages for AWARE. Without this adjustment, the ratings would encourage consumers to purchase the models with lower print capacities, which are smaller so have a lower environmental impact. The drawback to this incentive is that consumers will need to purchase more of the smaller models to print the same amount of pages and will consequently cause a greater impact than purchasing fewer of the larger models. Using the same amount of pages as the functional unit avoids this issue.

3.3.3 Impact Categories

For all three product classes, global warming potential dominates environmental impact. This causes the product ratings to be consistent regardless of which metric is used. It must be pointed out that in this case, it would be easier to measure environmental impact by carbon dioxide equivalent emissions alone instead of accounting for all environmental categories as AWARE does. However, global warming potential will not dominate impact for every product class, especially for more toxic products such as batteries or bleach. Also, AWARE will still be an appropriate measure of impact as the contribution of these products to global warming is reduced and other categories become more significant.

3.3.4 Location-Specific Use Phase

LCI data assumes a location for the use-phase of each product, usually where the majority of customers live. Changing the assumed location of the use-phase will impact the data for products that consume significant amounts of electricity during use because grid emissions vary by location and provider. Because the ratings used in AWARE are determined from the original LCI data, this can be accounted for. The default of AWARE is to use the location assumed by the LCI data, but users will also have the option of selecting the location where the product will be used. AWARE will then customize the use-phase data by accounting for local grid emissions. This option was implemented for refrigerator/freezers in the demonstration using Ann Arbor, MI and Richmond, VA as example locations [XVII], [XVIII].

4 Conclusions and Recommendations

4.1 Evaluation of AWARE

The current system of AWARE meets the majority of the project goals but some future work will have to be done. The system's ratings and data are presented in a way that is clear and easy to understand, but further research will need to be done to confirm that the vast majority of potential users can immediately and intuitively understand the display. Users can very easily compare the social and environmental performance of competing products either by separately scanning the products or by using the "compare products" option. By presenting three levels of increasingly detailed data, the higher level ratings are more credible and transparent. To ensure this transparency, LCI data collection will also need to be transparent and should follow a regulated system such as EDP. Finally, users can customize the system to account for their preferences by choosing the environmental and social metrics that best represent their values. The current system does not allow for users to customize the display of data, but this could be implemented in future work.

4.2 Potential of AWARE

The greatest limitation to AWARE is the lack of credible, available, product-specific LCI data. Implementation of AWARE could give incentives to producers that promote environmental performance to collect such data but it is unlikely that the majority of producers would participate. If the government created requirements for producers to make LCI data available for their products, then AWARE could have a very real impact on purchasing decisions and environmental impact in the market.

An appropriate place to launch AWARE would be in health food stores. These stores presumably draw consumers who are most concerned about the environmental and social performance of products. Also, producers who supply products to health food stores would be most likely to willingly provide LCI data to the public. This could be the ideal venue for AWARE to be tested on the public to measure potential impact on purchasing decisions and possible marketability of the concept.

4.3 Conclusions

AWARE can be used to provide environmental and social information about products and producers to consumers in an easily understood, credible, and convenient method. If LCI data is made available for many products in a number of product classes, then the use of AWARE will create market incentives for reducing environmental impact and encouraging social responsibility. The ratings can be customized to account for both location of the use-phase and varying user preferences for social and environmental metrics. Further research will have to be done to determine a potential market and test the impact of AWARE on purchasing decisions.

5 References

[1] Jamison, Scott et. al. (2004) *An Analysis of Social and Environmental Impact on Consumer Shopping Behavior.* Survey Design and Analysis Course, Ross School of Business, University of Michigan, Ann Arbor.

[2] Energy Star website, accessed April 21, 2005 <http://www.energystar.gov>.

[3] Transfair USA website, accessed April 21, 2005 <**http://www.transfairusa.org**>.

[4] The European EcoLabel website, accessed April 21, 2005 <**http://www.eco-label.com/default.htm**>.

[5] EU Energy Label website, accessed April 21, 2005 <http://www.est.org.uk/myhome/efficientproducts/energylabel>.

[6] Society of Environmental Toxicology and Chemistry (1993) *A Conceptual Framework for Life-Cycle Impact Assessment*. SETAC, Pensacola, Florida.

[7] Goedkoop, Mark, et. al. (1996) *The Eco-indicator 95: Manual for Designers* PRé Consultants.

[8] Murray, C.J.L., (1996) *Rethinking DALYs. In: Murray, C.J.L., Lopez, A.D., The Global Burden of Disease. A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020.* Harvard University Press, Cambridge.

[9] Meent et. al. (1999) *Quantifying Toxic Stress in LCA by means of Potentially Affected Fraction (PAF).* RIVM Laboratory of Ecotoxicology, Bilthoven; and PRé Consultants, Amersfoort, The Netherlands (to be published)

[10] Chapman P. F. and Roberts F. (1983) *Metal Resources and Energy*, Butterworth, London.

[11] Wenzel, Henrik, Michael Hauschild, and Leo Alting (1997) *Environmental Assessment of Products: Methodology, Tools and Case Studies in Product Development*. Springer.

[12] Goedkoop, Mark, et. al. (2004) *SimaPro 6 Database Manual Methods library*. PRé Consultants, The Netherlands.

[13] Co-op America's Responsible Shopper website, accessed April 24, 2005 <http://responsibleshopper.org>.

[14] NREL's Life-Cycle Inventory Database Project website, accessed April 25, 2005 <http://www.nrel.gov/lci>.

[15] Environmental Product Declaration (EPD) Project website, accessed April 24, 2005 <http://www.environdec.com>.

[16] Van Hoof, Gert, Diederik Schowanek, and Tom CJ Feijtel (2001) *Comparative Life-Cycle Assessment of Laundry Detergent Formulations in the UK*. Strombeek-Bever, Belgium.

[17] DTE Energy Customer Connections Newsletter, January 2005 website, accessed April 25, 2005 <http://my.dteenergy.com/home/pdfs/CustConctJan05.pdf>

[18] Dominion Environmental Report website, accessed April 25, 2005 <http://www.dom.com/about/environment/report/performance>.