Practical LCA for Short Shelf Life Products

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Manufacturers in the electronics industry are faced with product shelf life counted in months. This fact creates many challenges for product designers. Often, for example, product designers are asked to improve the environmental performance of their products. With a few exceptions this request is like asking for "more likeable" products. What is environmental performance? How do you measure it? How do you know that you haven't traded one environmental impact for another? And worst of all, how do you do it in time for the next product release?

Life Cycle Assessment (LCA) is a well-established method of looking at the environmental impacts of a product from raw materials extraction through disposal. This technique has been standardized through ISO (standards 14040 - 14045) and is considered credible and scientific for analyzing a product, evaluating potential improvements and, with special consideration, comparing competing products. Traditionally however creating an LCA takes a significant amount of time -- weeks or even months, so has been an impractical tool for designers, especially for products with shelf lives counted in months.

The traditional solution for design tools is to hide the complexity of the real world behind simplistic rules of thumb or coarse indicators. The problem with rules of thumb is that they do not always apply and may even contradict one another. For example, one rule for reducing impacts states that you should minimize material use. This could guide designers into thinking high-tech fiber-reinforced materials are a good thing. The next rule tells designers they should use materials that can be easily recycled, which indicates they should not use fiber-reinforced materials. These types of design rules do not help designers in making tradeoffs, a core challenge in environmentally-conscious design.

The other traditional solution is to develop simple indicators per type of material, per process, or per unit of process output. This solution does a much better job in helping designers to make trade-offs. The problem here, however, is that creating these indicators is not always straightforward. For instance how do you express limited recyclability as an indicator? One could choose only relatively simple indicators, like embodied energy, but then you only cover part of the environmental problem. Once you have identified the indicators and determined how to calculate them you still need to be able to meaningfully compare one indictor with another. At what point do you consider global warming over toxicity, for example?

A new concept will allow even designers of short shelf life products take advantage of the benefits of LCA. This method allows specialists in things other than LCA to rapidly create a full-scale LCA model, to view results, and to generate and compare "what-if" scenarios. These industry-specific "wizards" are built around a similar set of products and can be rapidly updated or customized to a particular manufacturer or process type. Results can be used both internally and externally: internally for decision-making, for example, and externally for environmentally-preferable purchasing submissions, eco-labels, etc.

The tool solves the aforementioned problem elegantly:

- The designer is guided step by step through the system, the risk for incorrect application is small
- The tool is ideal for clarifying tradeoffs
- The tool can use simple or broad scope indicators, but it can also produce detailed results that could be used for specific stakeholders or for environmental product declarations (EPDs); because the detail behind the analysis is maintained, the source of the results is transparent

Benefits Of LCA Elude Manufacturers Because Of Unacceptable Time/Cost

The time to market for many electronics components averages six months.1,2 Once they reach the shelves products are retired after less than six months. For many companies the process of creating an initial LCA and then modifying it each time the product changes has seemed overwhelming, both in terms of cost and of manpower. In some industries the constant introduction of proprietary materials with unknown impacts compounds the difficulty of applying LCA. On the other hand a thorough understanding of the life cycle impacts of any product is one of the best ways to ensure that design for environment (DfE) goals are met, and impacts are not simply shifted around.

A clear example of how LCA can be used to improve DfE begins with the impact of semiconductors and semiconductor-intensive products, such as cell phones, at various stages of their life. For nearly all energy-using products, the easiest way to reduce environmental impacts is to reduce energy use during the use phase of the product. Unlike nearly all other energy-using products, however, the materials extraction and manufacturing of semiconductor-intensive products produce more impacts than the use phase.3 This is in part because designers have already minimized use-phase energy impacts because of the need to minimize heat generation and to meet the demand for longer battery life in mobile products.4 Understanding where the highest impacts occur ensures that the manufacturing phase is not ignored in DfE efforts. Unfortunately it is often in the materials and manufacturing phases that LCA becomes cumbersome.

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[1] "Back to the Future,", Electronic News, July 21, 2003
[2] "Smart Design," Goeing, R. EETimes, November 1, 2004
[3] "Application of Eco-Efficiency Factor to Mobile Phone and Scanner," K. Fuse et al, EcoDesign, 2003
[4] "Green Design For Electronic Device Components – Implementing A Design For Environment, Health And Safety (Dfehs) Program For Semiconductor Products," S Hermanns et al, Going Green – CARE INNOVATION 2002

New Methodology Uses Automated Tools To Address The Issues

Other industry sectors face similar issues. To address them, a methodology was developed around automated software tools, or "wizards," with built in "rules" to ensure consistency in data quality as well as consistency in assumptions.5 In addition to applications in the US, there have been several applications in Europe:

- Member companies of the European cardboard manufacturers, FEFCO, have a wizard-based tool that helps them to discuss the environmental load of proposed cardboard box packaging solutions
- The European car tire producers have a jointly-developed wizard solution that allows them to test alternative compositions and use phase or disposal scenarios for car tires
- The Dutch cement industry association has a wizard-based tool to analyze the environmental impacts of concrete products

The methodology starts by addressing the issue of expertise. Designers understand the materials/components selection process and the manufacturing process for their products. Rather than providing a blank slate, as traditional LCA tools do, the wizard offers lists of commonly-used materials and/or components while walking the user through the manufacturing process. For common processes the wizard offers default data that the user can choose to use or can change to reflect a unique process. To make the system flexible for the truly-innovative designer the user can choose to ignore any of the predefined lists and choose one from the entire database of materials and components.

Energy use and emissions are handled in two ways. For each step in the manufacturing process the user can enter energy and, in some cases, emissions data. Optimally default information is included in the wizard for typical processes. Alternatively the user can zero out the energy usage and emissions for each step and instead enter data for the whole factory, along with an allocation to this particular product. This allows the use of the best available data for a whole product analysis, but also allows an understanding of the impact of reducing energy use or emissions during particular processing step.

Development of the wizard requires education of an LCA expert on the specific manufacturing process, but this education only needs to happen once for a multitude of similar products. Once the wizard is developed a designer, or manufacturing expert, can create life cycle models for endless products, or potential products, without having to know much about LCA. Since wizards are modular complex manufacturing processes with multiple options can be created. Figs. 1 - 5 show portions of a simple wizard developed for a packaging coalition (FEFCO) in Europe.

[5] "A Practical Method for Life Cycle Review of Products and Services for Manufacturers and Purchasers," G. Norris. Final report prepared for the International Design Center for the Environment in connection with their eLCie web tool, September 13, 2004

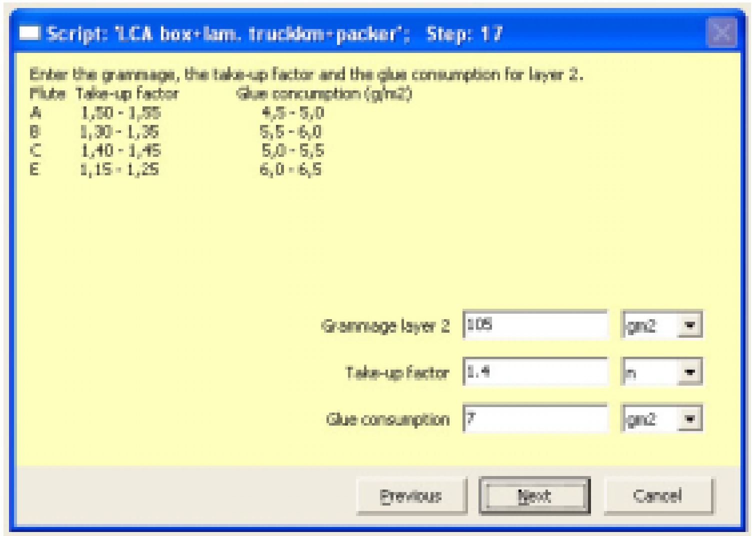

Fig. 1: The Wizard Walks Through Manufacturing Process A Step At A Time, Offering Default Data That Can Be Accepted Or Modified Reflecting Actual Process Conditions. The User Enters Data About The Product, The Process And Waste, Translated Into Mass Of Input Materials, Energy Use And Waste

Transport is a huge environmental impact that is easy to forget. Choosing a more benign component that is shipped twice as far may result in a less benign product. The wizard asks for transport data at every logical point to ensure that this factor is considered. The designer can also choose to skip over details like this when they are known to have no significant bearing on the analysis.

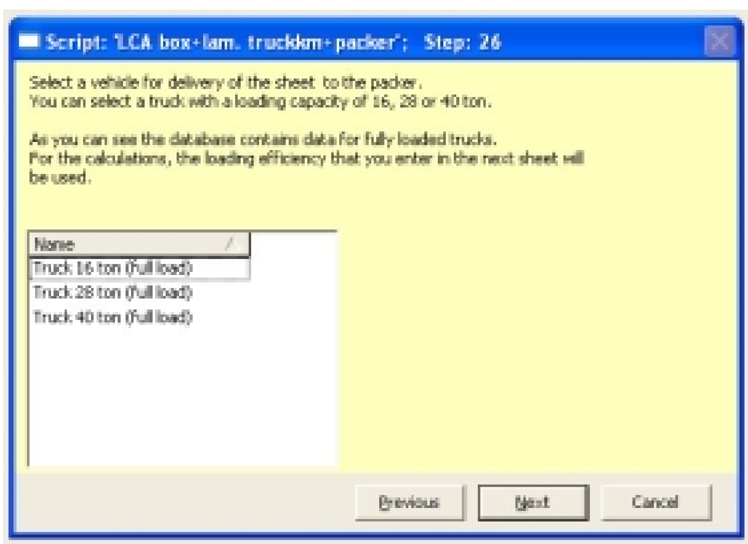

Fig. 2: Fuel Used In Transportation Impacts The Environment, Increasing Global warming And Pollutants (Nitrous Oxides, Sulfur Dioxides, Particulates Plus Others. Information Pertinent To Transportation Ensures All Impacts Are Accounted For

The designer can specify the percentage of product disposed of in different ways (Fig. 3) and the analysis can be used to understand the true impacts of different types of disposal helping a manufacturer design an effective, low impact take-back system, for example.

He can also see the potential liability resulting from the inevitable improper disposal. When designed to provide information as part of an environmentally-preferable product purchasing system the purchaser can become an active player in the analysis. If they choose "recycle" as the end of life instead of "incinerate," for example, they can see how their product disposal decisions will impact the environment. When possible, the same end of life scenario is applied to all the products in a comparison.

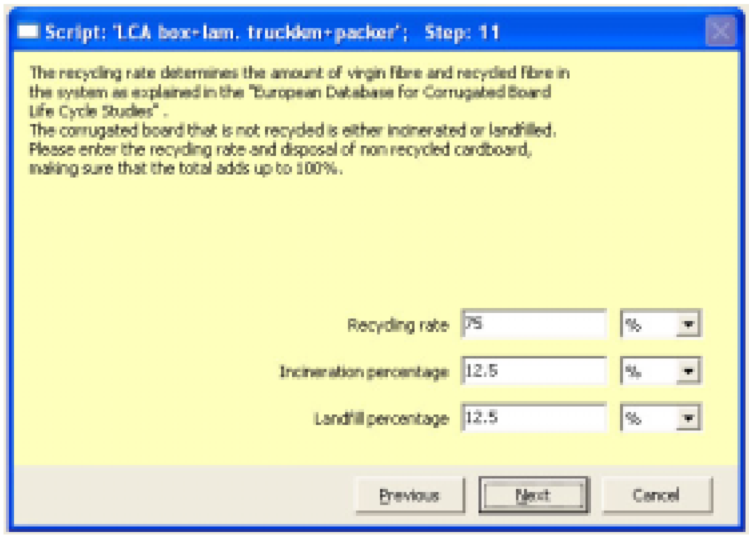

Fig. 3: Questions For Use And End Of Life Allows Industry Expert To Create LCA

The completed wizard displays the impacts that are important to the user with the automation on top of a full-featured LCA software tool and he can now use all of the analysis capability inherent in the tool and beyond what is programmed in the wizard.

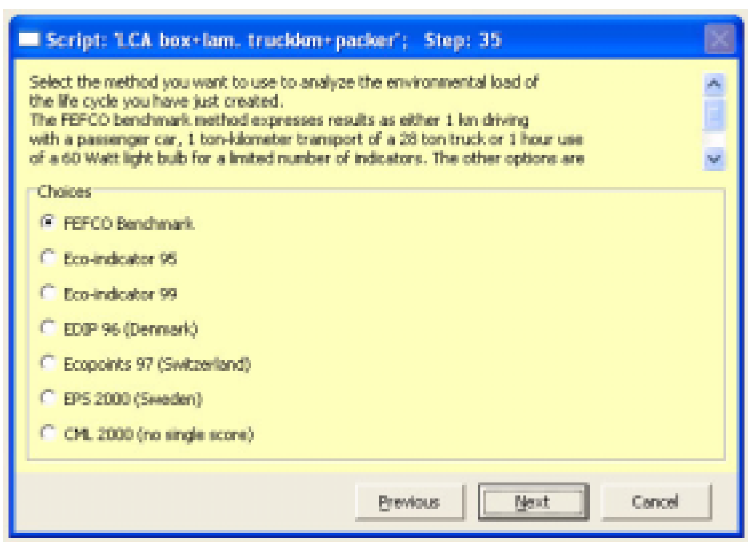

Fig. 4: Many Ways Exist To Analyze/Weigh Environmental Impacts. For Example, Water Use In Southwest Desert Of US Has Greater Impact Than In Pacific Northwest. User Standardizes OnOne Method Or Chooses From Several Methods To See Bigger Picture

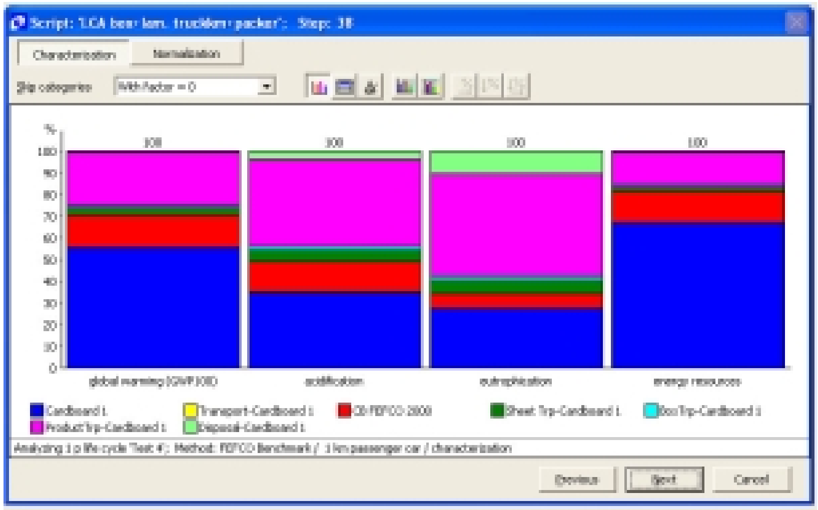

Fig. 5: Reports Can Be Shown Automatically In Wizard. Here Are Contributions Of Various Parts Of Packaging To Four Different Environmental Impacts. First Cardboard Layer Accounts For Most Global Warming/Energy Use

The completed wizard allows a user to rapidly generate a new LCA model which can be saved and modified. This feature is helpful in comparing similar products, to test for sensitivity to changes, or to assess the impact of a process or material change.

Another feature built into some wizards is the ability to generate the life cycle model for a number of nearly identical products at once. When the only differences between the products are one or two quantities, for example, the wizard can collect the data for both and generate two life cycles concurrently. This eliminates the need for the user to go back through the wizard for each product separately. This feature could be used to model a number of different cables, identical except for the length.

To date, most wizards have been developed for consortia. This approach allows the development costs to be shared among several manufacturers and ensures that a broad range of manufacturing techniques is represented. When these wizards are peer-reviewed and verification procedures are in place they can be used for environmentally-preferable product programs in compliance with ISO standards.

Wizards can also be created for a single company producing many products that use similar manufacturing processes. In either case the wizard can be customized to reflect a company’s proprietary processes.

Interestingly, once a number of companies within a consortium have completed the wizard analysis these data can be used to generate LCA results for a "generic product" which can then be used by designers up the supply chain for initial analyses and, later in the process, can then replace the generic product with specific products to see how the impacts compare.

Using Data Wisely

When new data gathering is required, this becomes the most time-intensive part of the LCA. To standardize on data usage and limit the amount of data collection required the methodology specifies primary and secondary datasets. For the electronics industry both the US Life Cycle Inventory database (available at http://www.nrel.gov) or the more extensive European ecoinvent database (http://www.ecoinvent.ch) may be applicable, depending upon the manufacturing location. In cases when the material or components are not in either of those databases, the US Input/Output database, which includes sector-based impact data based on dollars spent in a particular sector (such as "communication equipment" or "electronic computers") can be used. This last database provides life cycle information for a comprehensive set of roughly 500 commodities (goods and services) produced in the US. Its advantage is its comprehensiveness, while its limitation is the coarseness of its treatment of the commodities. Input/Output databases as well as process-level LCI databases are being generated for other countries and regions as well. Materials that are not adequately represented by the input/output data may require a unique solution. These are materials that the input/output-based data indicate may be very important in the final results. The reason for concern is that the input/output-based data are not sufficiently precise. If the material is in widespread use the wizard creation may include gathering specific data for that material. Alternatively the wizard itself could facilitate collection of factory data from which to construct more appropriate impact estimates.

Conclusions

A methodology has been developed to make LCA practical for designers of short shelf life products such as electronics. The methodology standardizes assumptions and datasets to allow for valid comparisons. Two commercially-available LCA software tools support the automation required to implement this methodology, ensuring longevity and applicability across a broad range of manufacturing techniques. Once implemented this methodology can lead to a better understanding of the environmental impacts of existing products and processes, improve DfE, and enable sound environmentally-preferable purchasing decisions. OEMs can use the tool to understand and manage the impacts of their supply chain.

Further Reading

There really hasn't been much written about wizards at all -- but there is a lot more general LCA material on the Sylvatica web site. http://www.sylvatica.com A large compilation of all the LCA articles on the web, plus an LCA search engine can be found at http://www.pre.nl/LCAsearch/default.htm

About The Authors

Greg Norris founded and directs Sylvatica, a life cycle assessment (LCA) research consulting firm. He is Program Manager for the United Nations' Environment Program's (UNEP) global Life Cycle Initiative, directing the Program on Life Cycle Inventory Analysis, teaching courses on LCA and Industrial Ecology at the Harvard School of Public Health, where he also advises graduate students and visiting research fellows from abroad. He consults on LCA and sustainable consumption to UNEP, to federal and state agencies in the US, and to the private and non-profit sectors. Norris is founder and executive director of New Earth http://www.newearth.info a global foundation for grass-roots sustainable development. He has developed several software tools to assist analysis and decision-making related to LCA and sustainable enterprise. Research integrates socio-economic pathways to human health within the LCA framework and human need-based approach to sustainable consumption analysis. He is Adjunct Research Professor at the Complex Systems Research Center, University of New Hampshire, Program Associate in the Center for Hazardous Substance Research at Kansas State University, and editor at the International Journal of Life Cycle Assessment. gnorris@sylvatica.com

Mark Goedkoop goedkoop@pre.nl earned an MSc in industrial design engineering from Delft University of Technology. He worked as an independent design consultant until he moved his focus to the field of ecodesign establishing PRé consultants and pioneering the field of LCA. PRé has become a well established LCA consultancy with partners in many parts of the world with thefocus on the development of practical, yet scientifically sound tools to improve the environmental performance of products and services:

- The Eco-indicator projects resulting in a methodology that is used to translate the many different environmental impact of a product into a single score
- The Product services project, that resulted in tools that can be used to combine the environmental assessment both on lifecycle and societal level
- The dematerialisation assessment tool
- The development and marketing of the market leading LCA software SimaPro

Lise Laurin founded EarthShift to focus on supporting businesses that help the earth. EarthShift http://www.earthshift.com supports and sells life cycle assessment (LCA) and total cost assessment (TCA) software and supports Sylvatica with LCA, and TCA consulting. Prior to EarthShift Lise consulted with a number of high tech and environmental organizations, providing market research and marketing strategy. Lise uses skills developed through twenty years in the electronics and semiconductor industries, enabling rapid communication of manufacturing ideas into LCA. She began her professional life as a process engineer at Intel. She earned a BS in Physics from Yale University. llaurin@earthshift.com