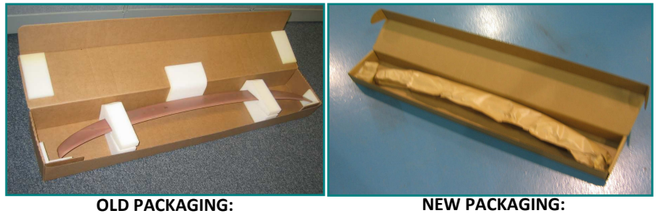
CASE STUDIES

We used EPIC to assess two recently implemented changes in the TMS packaging system— (1) a materials change for the Lexus ES spoiler, and (2) a combination of a route change and the adoption of reusable shipping modules for Sequoia floor mats. Provided below is a brief synopsis of the results from the spoiler packaging analysis.

Lexus Spoiler Packaging: Materials Change

	Package 1	Package 2	Total Savings/Loss for 2006 Lexus ES Spoiler
End of Life	-$0.03	-$0.03	$0
Material Production	$8.28	$4.28	25,044
Transport	$2.19	$2.19	$0
Total	**$10.44**	**$6.44**	**25,044**

Figure 6: Life Cycle Cost comparison between the old and new spoiler packages.



OLD PACKAGING:
- **1400g corrugated cardboard**
- **196g polyurethane foam**
- Standard shipping route in expendable shipping modules

NEW PACKAGING:
- **950g corrugated cardboard**
- **140g coated kraft paper**
- Standard shipping route in expendable shipping modules

Figure 5: Technical specifications of the Old and New Spoiler Packaging

Figure 7 shows results from EPIC for the comparison between the old and new spoiler packaging for TMS' five Areas of Concern: Air Pollution, Global Warming, Human Health and Toxicity, Substances of Concern and Resource Depletion

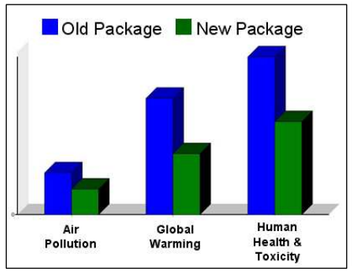


Figure 7.1: Relative environmental impacts for Air Pollution, Global Warming Potential and Human Health and Toxicity.

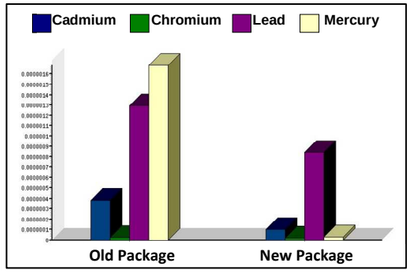


Figure 7.2: Absolute comparison for each of the Substances of Concern (kg.)

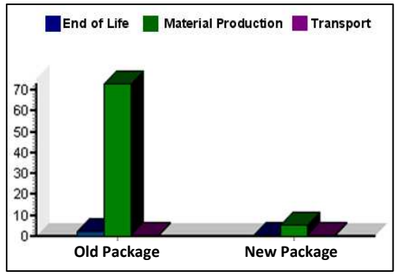


Figure 7.3: Absolute comparison for Resource Depletion (kg), separated by life cycle phase.

CASE STUDY SUMMARY

- **The EPIC tool indicates that the new packaging system is environmentally preferable in all five areas of concern.**
- **Life Cycle Costing (LCC) results from the EPIC tool show that the new package costs almost $4 less, per spoiler.**
- **Each spoiler shipped with the new packaging system emits 1 kilogram CO_2 less than the old system.**

PROJECT SIGNIFICANCE

EPIC will fundamentally change the way TMS packaging engineers approach design decisions. EPIC:

- **Enables packaging designers to make early and informed decisions**
- **Exposes win-wins: reduced environmental impacts *and* cost savings**
- **Bridges the gap between science and management**
- **Provides a model to other companies in the industry**

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GROUP PROJECT BRIEF

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Toyota Motor Sales

INFORMING PACKAGING DESIGN DECISIONS AT TOYOTA MOTOR SALES USING LIFE CYCLE ASSESSMENT

ON THE WEB AT HTTP://WWW.BREN.UCSB.EDU SPRING 2008

OVERVIEW

- We created a tool to **quantify** and **assess** the **environmental impacts** and **financial costs** of packaging systems at Toyota Motor Sales.
- The ***Environmental Packaging Impact Calculator*** (EPIC) provides full life cycle assessment results in minutes.
- EPIC is a **decision support tool** for packaging engineers to use **'on-the-fly'** early in the packaging design process.
- EPIC translates robust **scientific analysis** into **management-actionable** measures.

INTRODUCTION

The Problem with Packaging

The environmental burdens of packaging manifest themselves at all life-cycle stages, from raw material acquisition, to manufacturing the package, to distribution, recycling and land-filling. Each of these stages costs industry money, and generates environmental impacts such as natural resource depletion, energy consumption, and the emission of waste and pollutants. While most consumers associate packaging with creating waste, few people appreciate the impact of its *entire* life-cycle.

Background – Toyota Motor Sales

The packaging designers and logistics experts at Toyota Motor Sales (TMS) are in a unique position to decrease environmental harm by designing better packages and shipping systems. Decisions made early have an impact on material sourcing, transportation costs, and end-of-life treatment. Therefore, informing decisions early on is central to managing impacts and costs at all stages. Our project provides this vital information.

With the goal of minimizing environmental burdens across the life-cycle, TMS recently began implementing changes to its accessory and service parts packaging. The three types of changes they have implemented are:

- ***Dematerialization***: A reduction in materials used and the adoption of environmentally preferable materials
- ***Logistics***: A shortening of shipping routes by switching from "Standard Shipping" to "Direct Shipping"
- ***Reusable Modules***: Adoption of reusable shipping modules

As an extremely metrics-driven company, TMS sought a way to calculate the reduced environmental impacts of the changes they had made, and to predict the impacts of future changes. Specifically, TMS wanted to compare packaging options on the following "Five Areas of Concern" identified in their annual environmental reporting:

1. Global Warming Potential
2. Resource Depletion
3. Human Health and Toxicity
4. Air Pollution
5. Substances of Concern

Life Cycle Assessment

In order to capture all environmental burdens, we used *Life Cycle Assessment* (LCA) methodology to create EPIC. ***LCA quantifies the environmental impacts of a product or system from cradle-to-grave—from natural resource acquisition to disposal, and every step between.*** One of the major strengths of LCA is that it reveals tradeoffs – between environmental impacts, between impacts at life cycle stages, and between environmental and financial considerations.

TMS Part Distribution Center **Photo W.Lee**

In order to get this comprehensiveness, LCA requires significant data collection, expertise, time, and resources; TMS cannot conduct an LCA for every possible packaging alternative. Therefore, EPIC was created to provide the powerful results of a full LCA in a fraction of the time. EPIC will allow packaging design engineers to use LCA to evaluate packaging options in a format that is fast, efficient, and easy to use.

GROUP PROJECT ACHIEVEMENTS

1. Created a fully parameterized model of the TMS packaging supply chain using GaBi4 software. This model allows users to run a virtually limitless number of LCAs, using one model. The model includes:

- All packaging materials, including papers, plastics, and metals
- A complete logistics and distribution network that captures all potential routes
- All shipping modules used by logistics, including metal, plastic, and wood pallets
- End-of-life options, specific to each final destination – recycling, incineration, and landfilling

2. Developed the Environmental Packaging Impact Calculator (EPIC), a decision support tool for TMS packaging engineers and external suppliers to use when designing packaging for TMS parts.

- EPIC allows easy comparison of the environmental attributes and financial costs of proposed packaging options
- EPIC provides full Life Cycle Assessment and Life Cycle Costing results
- EPIC allows TMS management to incorporate LCA into day-to-day decision making

3. Using EPIC, conducted LCAs for two recently implemented packaging system changes.

- *Dematerialization*: Lexus ES spoiler packaging was changed from a larger cardboard box and polyurethane foam padding, to a smaller box and coated kraft paper.
- *Logistics and Shipping Modules*: Sequoia floormats were changed from standard shipping in a wood and cardboard expendable module to direct shipping in a reusable plastic module.

PACKAGING SYSTEM MODEL

The model calculates life cycle environmental and financial costs for *the protection and distribution of one accessory/service part from a supplier to its final destination*.

Working closely with TMS managers, we gathered data on the details of the TMS packaging supply chain through visits to the facilities and in-depth analysis of TMS packaging and facilities data.

Figure 1 shows the three life cycle phases included in the TMS packaging system model. The Life Cycle Assessment includes resource inputs and emission outputs from every step in this chain.

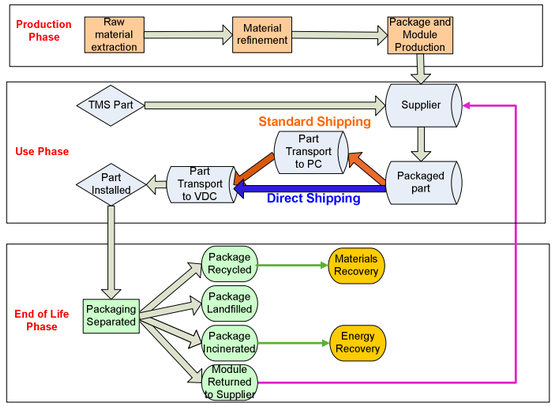

Figure 1: System Boundary of the TMS Packaging System

Using GaBi4 software, we created a heavily parameterized model of the TMS packaging supply chain, which captured everything inside our system boundary (Figure 2). Parameterization allows the model to be flexible; it can calculate a virtually limitless number of LCAs in seconds. This was possible because the network is relatively static, and we were able to pre-program components to be turned on, off, or scaled as necessary.

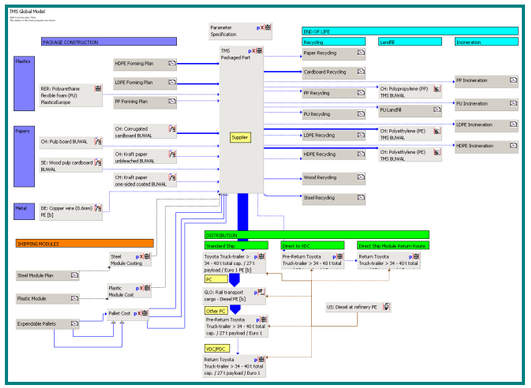

Figure 2: Parameterized 'TMS Model' of the TMS Packaging System.

The TMS Model is separated into the three life-cycle-phases: *Package Construction* (including *Shipping Modules*), *Distribution*, and *End-of-Life*. This model enables TMS packaging engineers to run comprehensive LCAs; however, it was designed to be used in conjunction with a user interface.

EPIC

The *Environmental Packaging Impact Calculator* (EPIC) is an overlay to the TMS Model; EPIC draws upon the parameterized TMS Model to calculate comparative LCA results for two packaging options. This interface allows users unfamiliar with LCA methodology to operate the model and obtain management-actionable results. Some of EPIC's strengths are that it:

- provides a user-friendly interface to the TMS Model
- allows results to be easily exported for TMS management to review, and
- hides proprietary TMS supply chain information from non-TMS packaging engineers.

Using EPIC

Figure 3 shows the welcome screen of EPIC, with the input area on the left side. To operate EPIC, the user enters relevant information for each package: the weight of materials used, whether the package is shipped direct or standard, the type of shipping module used, etc. This process takes only a few minutes, instead of the months necessary to conduct a full LCA.

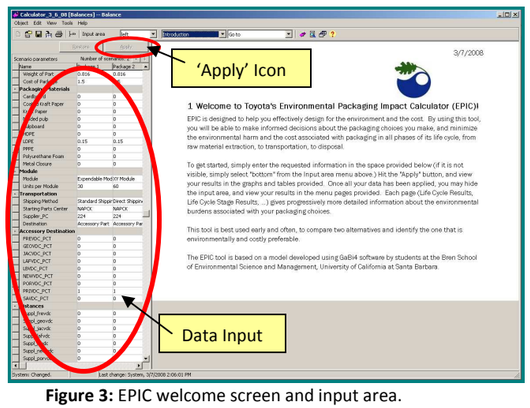

Figure 3: EPIC welcome screen and input area.

To view the comparative results for environmental impacts and financial costs associated with each package, the user simply clicks "Apply" and the results are calculated.

Interpreting the Results

EPIC was designed to be intelligible and actionable to packaging engineers. Therefore, results must be displayed at varying levels of complexity. Figure 4 illustrates the process of translating LCA results from the most detailed, scientifically based level (life cycle inventory) to the simplified, valuation-based level (TMS Areas of Concern) necessary for decision-makers. This last step translates scientific jargon into results that management will understand and use.

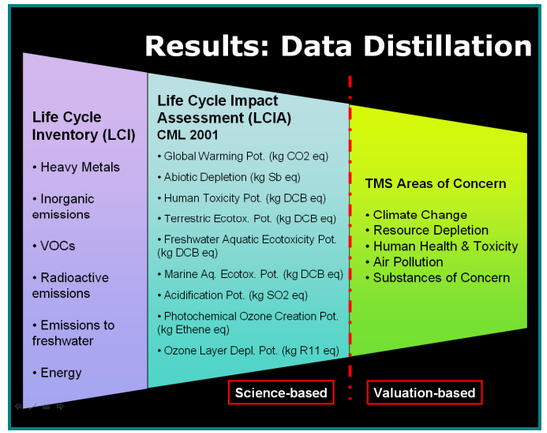

Figure 4: LCA data distillation from detailed to general information.

EPIC provides four results screens, which capture this information distillation process, each revealing progressively more detailed information. The four levels of results provided in EPIC are:

- *Life Cycle Results* – Gives the most basic and easy-to-read results, such as cumulative cost and environmental impact. These results will be used most often. (Green Polygon)
- *Life Cycle Stage Results* – Breaks down the results by life cycle phase (production, transportation, and end-of-life), allowing users to pinpoint where impacts and costs accrue in the system. (Green Polygon)
- *Life Cycle Inventory* – Lists all resources consumed (e.g. trees, energy, minerals, etc.) and emitted (e.g. radioactive emissions, inorganic emissions, etc.) throughout the life cycle of the package system. This level of detail will be used primarily by TMS environmental managers. (Purple polygon)
- *Life Cycle Impact Assessment* – Lists the CML 2001 suite of environmental impact indicators for the entire life cycle. This screen will be used primarily by TMS environmental managers. (Blue Polygon)