World Resources Institute

Sustainable Enterprise Program
A program of the World Resources Institute

ALPHA MOTORS, LTD.:

Integrating Life-Cycle Environmental Concerns into Product Design

Teaching Note

For more than a decade, WRI's Sustainable Enterprise Program (SEP) has harnessed the power of business to create profitable solutions to environment and development challenges. BELL, a project of SEP, is focused on working with managers and academics to make companies more competitive by approaching social and environmental challenges as unmet market needs that provide business growth opportunities through entrepreneurship, innovation, and organizational change.

Permission to reprint this case is available at the BELL case store. Additional information on the Case Series, BELL, and WRI is available at: www.BELLinnovation.org.

The primary teaching objective of this case is to give students a basic understanding of life-cycle analysis and the issues involved when integrating life-cycle tools into the product design process. Experience with a potential life-cycle tool quickly leads students to understand the complications of life-cycle analysis and the problems encountered when they use such tools to inform design decisions. By including a comparison with a different approach to life-cycle analysis in product design, the case can be used to illustrate numerous issues.

The EPS-based spreadsheet can be downloaded for student use at *http://www.wri.org/wri/meb/list.html*

Life-cycle Analysis

A review of the basic steps in a life-cycle analysis (LCA) is a useful way to start the class, to bring all students to the same level of understanding. One way to do so is to work through each step in an LCA and discuss the activities within each category as well as the problems and complications that may be encountered. Going through exercises can also help students see that a company faces many difficult decisions when deciding on a particular approach to LCA. This section raises some of the issues that might be discussed in general and with respect to the Environmental Product Strategies (EPS) system in particular.

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Goal Definition

How and why one might use an LCA can vary greatly and, in turn, influence how an optimal LCA tool should perform. In this case, the company is looking for an LCA tool that can help product designers take account of environmental issues when making materials choices. Firms can also use LCAs to make product-to-product comparisons in house and with competitors (i.e., cloth versus disposable diapers), to illustrate the overall changes in environmental influence of a product (i.e., reducing the amount of plastic in a bottle) and to identify the major environmental problems along the supply chain. In addition, LCAs can be used by consumer groups and policymakers. It is a useful exercise to encourage the students to think about how the ideal LCA tools might differ in these several situations along dimensions such as ease of use, boundary definition, data transparency, consistency in assumptions, and comparability to other LCAs.

Inventory and Categorization

The major issue in this step is access to accurate and usable data. Students should be encouraged to think about the problems involved with setting boundaries in the inventory process, the accessibility of accurate and timely data, and the ways the data are related to the specific technological and geographic assumptions made about activities and wastes throughout the product life cycle.

Valuation

Valuation is one of the trickiest parts of the LCA process and is often not even undertaken in some LCA studies. If you have not already covered it in another section of the class, this may be an appropriate time to discuss major issues involved with environmental risk analysis and the valuation of environmental degradation. Given these issues, how feasible are any attempts at valuation? How context dependent are these valuations?

Valuation is essential when considering the EPS system in particular. The crucial valuation questions arise from two aspects of the EPS scheme: (1) the nature of the economic measures used in calculating the cost of avoiding a unit effect and (2) the assumption that the value of the total environmental impact of an action (the “environmental load”) is equal to the sum of each individual environmental load weighted by the size of each unit effect.

The first of these valuation questions relates to the distinction between cost and worth. Although the theory of competitive markets argues that prices are an object’s worth, the theory rests upon assumptions that are difficult to support in the case of the environment. Perfect markets assume the availability of perfect information to all participants, a situation that is clearly not the case or there would be no need to develop life-cycle analysis in the first place. Furthermore, the theory of markets routinely discusses consumer surplus, which can be defined roughly as the difference in the prevailing market price and the higher price that some consumers would have been willing to pay (recall that demand curves slope downward). In addition, there is the question of how to establish these costs/prices when markets do not exist. Litigators are prepared to place a value on wrongful death or pain and suffering in a civil suit, but markets for pain, or clean air, or future well-being do not exist. Generally, most environmental attributes are external to markets; many of the classic examples of market externalities are based on environmental issues.

When markets exist, EPS uses market prices to establish the costs of avoidance. When market prices do not exist, EPS relies upon two alternatives. If government funds are allocated to resolve specific problems (e.g., funds to protect a particular species), these funds are normalized and extrapolated to obtain a cost figure (e.g., the value of maintaining biodiversity is established by normalizing the Swedish government’s annual budget for species protection). If relevant financial allocations do not exist, then the method of contingent valuation is employed. This method (or set of methods) is based on direct inquiries of representative populations to determine their willingness to pay to avoid specific effects or their willingness to accept compensation for environmental damage. As might be expected, this approach to establishing the appropriate costs of avoidance or acceptance is somewhat controversial because it is hard (both conceptually and practically) to design questions that demonstrably extract the "correct" measure of value.

The second valuation question reflects the fact that the mathematical structure of the value function is a consequence of basic assumptions about the nature of the subject's preferences. The valuation employed in the EPS system is an example of a linear, additive preference structure. Each unit effect is reduced to a monetary value, normalized for risk/exposure and for material quantity. Thereafter, the net impact of each increment in unit effect is the same, regardless of how large the effect is and regardless of the size of any other unit effect. Although such value functions are simple to represent and employ (linear combinations of linear functions), it is difficult to argue that they are an accurate, general purpose formulation of value functions for environmental impacts. Although the appropriate form of the value function may be linear, EPS does not explicitly make this assumption. Rather, the linearity of EPS valuation is based on the assumption that because monetization reduces all effects to a common metric, the resulting metrics should be additive. In fact, most individuals do not even exhibit linear preferences for money, much less for more subjective attributes. (For example, most individuals would consider paying $0.50 to play a game offering a 50:50 chance of winning $1.00 while rejecting out of hand paying $5,000 to get a 50:50 chance of winning $10,000). In practice, preferences usually reflect non-linearities in both individual effects and in substitution between effects.

The first two issues (money as a measure of value and linear additive preferences) are not necessarily crippling assumptions when considering the development of value functions for the environment. Although difficult, it may be possible for someone to establish the dollar value that exactly offsets a particular unit effect. Similarly, linear additive preferences may be able to model the behavior of an individual over a restricted range. However, it is impossible to state that the same dollar value, or the same linearization of preferences, will be agreeable to every individual in the affected population in the case of environmental considerations. And if individuals cannot agree on the value or the structure of their preferences, then no single value or function can be constructed to represent their wants.

Conceptually, value functions are based upon the notion of individual preference, reflecting strategic objectives. Value functions assume that, given two alternatives, the individual decision maker can say one of two things about them: (1) one alternative is better than the other or (2) both alternatives are equally good.

The assumptions underlying the concept of value functions are particularly weak when the problem of establishing group preferences for environmental attributes is under consideration. There are two reasons why: In order to choose between two or more alternatives, one must fully understand the implications of the choice. Otherwise, the choice is meaningless and essentially random. When experts cannot establish the incremental effect of the potential changes in environmental release and resource consumption represented by two alternatives, it is virtually impossible to expect these experts, not to mention the public at large, to say that one is preferable to the other.

Even if all the implications of each choice were completely characterized to the complete satisfaction of all members of the group, there remains the fact that individuals do not have a consistent set of objectives when confronted with environmental choices. For example, some may believe preventing global warming is more important than reducing urban air pollution while others believe that neither of these objectives is as important as maintaining and improving human health. This lack of a consistent set of priorities in the environmental area essentially eliminates the possibility that a useful value function could be constructed.

Although the EPS system is a commendable attempt at simplifying the enormous detail of inventory data to a representative environmental load, the developers of EPS have pointed out that this system is based on their subjective value judgments, which are not necessarily supportable in all situations worldwide. The ultimate goals set out by SETAC (the Society of Environmental Toxicology and Chemistry) and the EPA for improvement analysis based on life-cycle inventories are laudable, but they can be realized only by some kind of consensus on the values for avoiding environmental degradation.

This consideration suggests that achieving the ultimate stage of LCA will require the development of a basis for devising (and revising) a consensus. In the absence of a common strategic objective, LCA cannot possibly be used to designate ways to achieve environmental improvement beyond straightforward pollution prevention/precautionary principle strategies. Clearly, a strategic consensus is required to balance competing environmental, economic, and engineering goals.

Using LCA in a Design Decision

Task 1: The case is designed so that no material choice is obvious and the trade-offs will depend on the students' assessment of the financial, quality, and environmental issues. In general, there is no "correct" answer. However, students should make note of the following issues when defending their material choices:

- The costs of the parts and how the costs should be weighted given the product market segment

- The quality of the materials, i.e., the technical reliability of the materials.

- The end-of-life disposal of the materials. If the material is steel or aluminum, 100 percent recycling is a reasonable assumption. If SMC plastic is chosen, how will it be disposed of at the product's end of life (possibly within a year of initial production of the vehicle). Should Alpha be concerned with landfilling? If students suggest incineration, they should note the associated political and image issues. How should Alpha deal with the current lack of SMC recycling infrastructure and markets? This factor is important because, according to EPS, the general public may not agree that the best option environmentally is the best option.

- The influence of pressures for increased fuel efficiency on the decision. This point raises an interesting question because EPS results are largely influenced by emissions during vehicle use, which are mainly a function of the weight of the part.

- The influence of the company's image and reputation on the decision.

Task 2: This task gives students an opportunity to address the limits of an LCA tool in making DfE (Design for the Environment) decisions. Should Barns use EPS in his decision making? Is it useful? What are its weaknesses? Some points they might address include: What the EPS results mean. What are the ELU (environmental load unit) numbers most sensitive to (material weight)? What are the problems involved with setting boundaries in the inventory process, the accessibility of accurate and timely data, and the relation of data to specific technological and geographic assumptions made about processes throughout the product life cycle? Would the ELUs be different if they used cultural assumptions outside Sweden?

- How the ideal LCA tool would look in terms of ease of use, boundary definition, data transparency, consistency in assumptions, and comparability to other LCAs. When considering the use of EPS as a life-cycle tool, students may wish to consider the level of specificity, ease of use, and overall goals. An appropriate way to end the class session is to brainstorm about the characteristics of an ideal LCA tool. For materials on alternative environmental analysis techniques, the environmental impact evaluation method by EcoBilan provides an interesting comparison to the EPS model.[1]

EPS characteristics

Dimension of Interest	EPS
End Product	Single ELU Number
Ease of Use	Friendly Interface
User	Designers and Experts
Assumptions	Based on Scandinavian Values
Transparency	Difficult- Buried in one number
Underlying Calculations	Complex

Other Issues for Class Discussion

- Does DfE require only a life-cycle tool? What else is required for a full DfE program?
- What else should Mike Barns be thinking about to integrate environmental issues fully into product design decisions? If this tool is successful, what is his next step?
- Where is Barns in the organization? Is his effort likely to encounter resistance? What can he do to reduce resistance to a DfE program?

[1] For further information visit http://www.ecobalance.com/news/newsindx.html#DfE