

APPROACHES FOR ACTIVE DECISION MAKING AND DESIGNING WITH LIFE CYCLE ASSESSMENT: SIMPLIFYING/STREAMLINING, DIAGRAMMING, AND SEGMENTED SETTING OF THE SYSTEM BOUNDARY

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ABSTRACT

The processes of decision making and development of new products and systems are complex and dynamic. It is not simple to apply current life cycle assessment (LCA) approaches in such processes. This paper presents three LCA approaches that can be applied to enhance the decision-making and design processes: (1) simplifying/streamlining, (2) diagramming, and (3) segmented setting of the system boundary. Each method is briefly described and the advantages of the methods are also discussed.

INTRODUCTION

Life cycle assessment (LCA) is a useful quantitative analytical tool for identifying hot spots of environmental impacts caused by a product or system and to compare and determine which, if any, product or system might cause less environmental impact. However, LCA is not fully utilized in processes of designing a product or system, at least in part because of the practicality of conducting the assessment. Conducting detailed LCAs is costly and time consuming, and often limited in its application (SETAC Europe, 1997; SETAC North America, 1997). Simplifying and streamlining of the LCA process is worth addressing so as to improve the practical use of LCAs. In addition, a simplified methodology is also needed for life cycle sustainability assessment (LCSA) (e.g., Personen & Horn, 2012). A second reason for the limited use of LCAs is a lack of methodologies. Although the ISO 14040 standard supposes that the interpretation of LCA results involves iterative processes and is interrelated to the other phases of conducting LCA, methodologies actively applying LCAs in decision-making processes have not been developed sufficiently.

In an effort to make the decision-making and design process concerning products and systems more effective, this paper examines three approaches: (1) simplifying/streamlining, (2) diagramming, and (3) segmented setting of the system boundary.

SIMPLIFYING/STREAMLINING

The first approach is simplifying/streamlining. Tasaki, Oguchi, Kameya, and Urano (2007) classified existing assessment methods into four types according to their simplicity and then

compared the four types in terms of certainty, relevance, applicability, readiness, and other factors. The results showed that simple and detailed assessments have different advantages and that a simple assessment can be useful in some cases. I categorized simplified and streamlined methods and approaches through a literature review (including those listed in the References) as shown in Table 1. The benefits of a simplified approach include the following: (1) the results are easily understood (simplicity of results), (2) traceability is ensured (simplicity of methods), (3) a reduced amount of time is required to do the assessment, (4) fewer resources are required to do the assessment, and (5) the method is widely distributed and accepted due to its simplicity. The first three reasons benefit decision makers whereas the last two do assessors and developers, respectively.

Table 1. Categorization of simplified/streamlined methods

Characteristics of simplification/streamlining		Quantitativeness			Type of simplicity			
		Qualitative	Semi-quantitative	Quantitative	Simplicity of results	Simplicity of methods	Less time consuming	Fewer resources required to assess
Simplification	Matrices	X	X		X	X	X	X
	Checklists	X				X	X	X
	Diagram	X			X	X	X	X
	Benchmarking against similar assessments		X	X			X	X
	Interview of panel of experts	X	X	X		X	X	X
Streamlining	Focusing/eliminating boundaries and items	-	-	-			X	X
	Focusing changes of impacts, etc.	X	X	X			X	X
	Use of threshold values		X	X			X	X
	Use of qualitative data	X					X	X
	Use of secondary databases or similar data		X	X			X	*
	Use of summary data		X	X			X	*
	Estimation		X	X			X	
	Establishing "showstoppers" criteria	-	-	-			X	X
	Simplifying models	-	-	-		X	X	X
Simple indicators with advanced modeling			X	X		X	X	
Both	Simple or key indicators		X	X	X	X	X	X
	Computation	-	-	-			X	*

*: depends on the situation, -: irrelevant item

DIAGRAMMING—AN APPROACH USING DISCRIMINANT FUNCTIONS

The second approach utilizes an “option diagram”. This diagram is similar to a phase diagram used in chemistry, in which a discriminant line (function) shows conditions under which a substance changes its phase. The difference is that the phases of substances are replaced with options selected by decision making. This type of approach was applied to study consumers as decision makers in judging the appropriateness of replacing products such as TVs and refrigerators with new and more energy-efficient ones (Tasaki, Motoshita, Uchida, & Suzuki, 2013). In this case, the option diagram shows a line dividing two areas where replacing a product respectively either increases or reduces energy consumption. That is, the line shows a

discriminant line on which the environmental loads are equal between different replacement scenarios or cases. Tasaki et al. (2013) called this the “iso-environmental-load [IEL] line”. This approach generally involves three steps as shown in Figure 1. (1) An assessor sets the system boundary and collects Life Cycle Inventory (LCI) data. (2) The assessor then produces a line graph (an option diagram) by taking selected influential variables related to the options as the horizontal and vertical axes and draws discriminant lines. (3) Finally, the assessor plots given scenarios or cases on the graph and decision makers note the location of the plotted area, that is, whether an option increases or decreases an environmental load in each case. An important advantage of this approach is that one can understand how the variables affect the preferability of options just from looking at the line graph. Such insight would facilitate decision making in cases where a variety of scenarios need to be assessed.

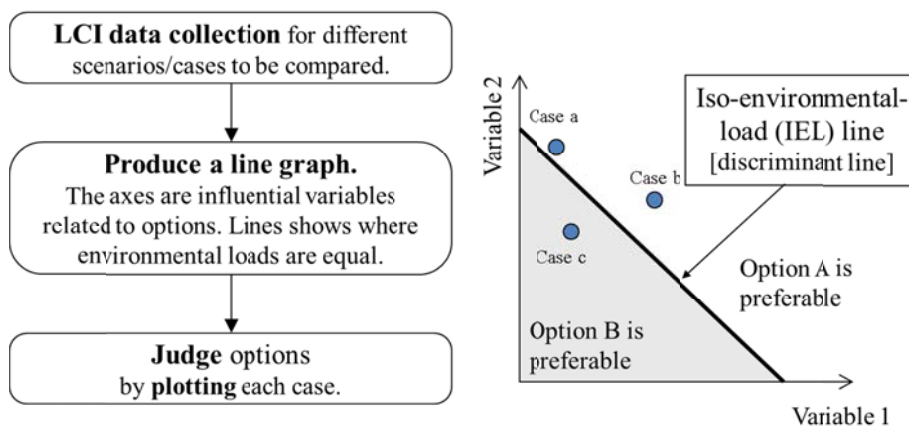


Figure 1. Procedure and outline of a diagramming approach using discriminant functions (lines).

SEGMENTED SETTING OF THE SYSTEM BOUNDARY

The third approach is segmented setting of the system boundary. Usually, a system boundary is set so as to cover the entire system of concern. However, with a segmented approach, an assessor divides the system into two parts and conducts an LCA of one of the subsystems that is relatively established. The assessor then derives the required conditions of the other subsystem from the first results and can develop and design the latter subsystem as shown in Figure 2.

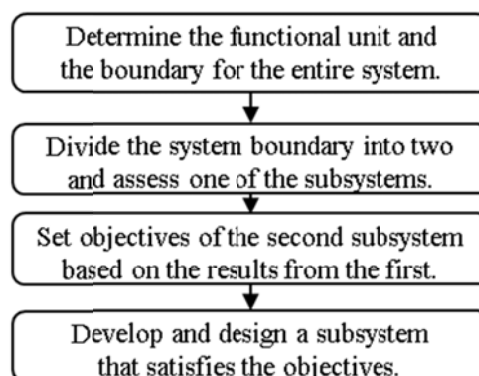


Figure 2. Procedure for segmented setting of the system boundary.

This approach is useful, with the precondition that the entire system consists of multiple subsystems (which complicates the analysis), in two cases: (1) when the system includes undeveloped parts, and (2) when part of the data for the assessment is not readily available. In the first case, the aim is to set goals of developing a relatively-uncertain subsystem based on the results of the assessment of a relatively established, existing subsystem. This should activate and expedite the decision-making process as related to designing a system. In the second case, the aim is to reduce the burden of collecting data by identifying the goals of the subsystem that was not assessed and narrowing the assessment options for that system. This approach would streamline the LCA process and speed up the process of phased management by clarifying the objectives of the second subsystem in the next step.

CONCLUDING REMARKS

In this paper, I addressed three approaches for improving active and effective decision making in the design of products and systems through the use of LCAs. The three approaches were (1) simplifying/streamlining, (2) diagramming, and (3) segmented setting of the system boundary. As these approaches are actually applied, new data will be generated and our understanding of the approaches will deepen. Therefore, the use of these approaches should be promoted.

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