Special Edition on the Environment

Making LCA More Efficient

Junichi KANAZAWA*, Nobuyuki SATO**

Abstract

Life Cycle Assessment (LCA) has gained attention because it enables quantitative evaluation of the burden a product places on the environment. However, acceptance of LCA has proceeded slowly because a large amount of work is required to gather the environmental burden data used in the evaluation.

To shorten this work time, we utilize readily-accessible databases both internal and external to the company and have established "Effective LCA" procedures for calculating the environmental burden data for LCA.

Past methods for evaluating the environmental impact of products and their problems

Throughout their life cycle, which extends over the long period from the production stage to the stage when they are disposed of as waste, products have an impact on the environment. To provide products which have a small impact on the environment, the burden they place on the environment throughout their life cycle—their characteristics in regard to energy savings, resource savings, recyclability, hazardous material content, etc.—must be evaluated at the design stage, and improved as much as possible.

For this reason, our company and other manufacturers of electric and electronic products have introduced "product assessment" as a method of evaluating issues of "environmental burden" at the product design stage. With this tool, product models currently being designed can be compared to models of the past in regard to specified evaluation criteria (such as "quantity reductions," energy savings, recyclability, etc.) and enable an evaluation of the degree of improvement in environmental burden. However, because this evaluation method, for each evaluation criterion, is based on comparisons between products, it has the following problems:

1. It is not possible to analyze at which stage of a product's life cycle its environmental burden is largest, and that makes it difficult to come up with effective countermeasures.
2. Evaluation data is shown as relative values, so it is not possible to make comparisons to products not included in the data (such as the products of other makers).

As a method of solving the disadvantages of this kind of product assessment, LCA is receiving considerable attention.

Because LCA is a quantitative method for evaluating environmental burden (for example CO_2 discharge quantities) and because it considers a product's full life cycle, the problems mentioned above in regard to the "product assessment" system are solved.

Problems with LCA

LCA is implemented according to the flow shown in Figure 1.

After determining the subjects to be surveyed, "data gathering" is done. However, at this step of the process, the environmental burden data required by LCA is gathered, from both inside and outside the company, and is organized in a structure which enables LCA.

At the "LCA implementation" step, inventory analysis and impact evaluation are performed, based on the data which has been gathered. In the "inventory analysis" step, environmental burden data generated during the product life cycle—that is, input data (the cost of energy applied and resources consumed) and output data (the discharge quantity of materials which put a burden on the environment)—are calculated across the entire product life cycle. In addition, in the "impact evaluation" step, the results obtained under inventory analysis are classified into categories such as "global warming," "ozone layer destruction," etc., and the degree of environmental impact in each category is evaluated.

The LCA approach started in the 1960's and its foundation was solidified in 1997 with publication of ISO14040, the international standard for LCA. Nevertheless, the fact is that its acceptance afterwards has been slow. That is

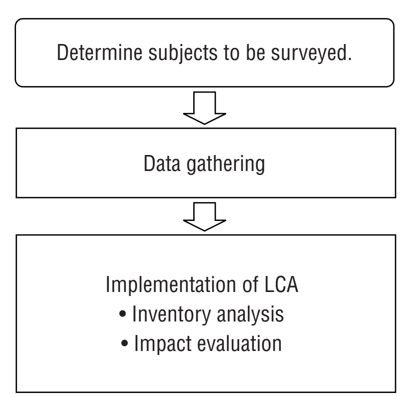

Figure 1: Flow for implementing LCA

* Corporate Global Environment Department.
** Nobuyuki Sato, System Solutions Company, Terminal Systems Div.

because of these problems:

① the theory of LCA is difficult to understand, so it is hard to reach a level of understanding where one can perform evaluations, and

② a huge amount of work is required to gather and/or create the huge amounts of data on environmental burden.

First of all, concerning problem ①, in order for LCA to be widely accepted, it is important that it be easy for designers to implement it. However, the fact that, because the above-mentioned inventory analysis and impact evaluation are hard to understand, it is not easy for designers to understand and use LCA is one of the factors that has inhibited its wide acceptance. Recently, however, "LCA software" which converts inventory analysis and impact evaluation to software, has become fully developed. Through use of this software, it is possible to implement LCA without understanding those difficult parts, and as a result, it seems that this problem will now be solved.

Next, we will explain problem ②. For example, for automatic teller machines (ATM's), one of Oki Electric's main products, the number of parts exceeds 10,000 and, moreover, most of those are purchased parts. In order to evaluate the environmental burden of a product over its life cycle, one must even consider the environmental burden of the waste, etc. discharged when these purchased parts are manufactured. To do that, data on those 10,000 parts must be gathered and the amount of their impact on the environment must be calculated, but one problem is that the amount of labor required for that task is huge. In other words, a barrier to greater use of LCA is not LCA itself, but is rather the preparatory stage of "data gathering."

To solve this problem, it is necessary to improve the work of LCA data gathering and reduce the labor involved. Next we will introduce a specific way of doing this.

Our work in making LCA more efficient

Global warming, the world's biggest environmental problem and the increase in CO_2 levels is its primary cause. Here, taking as an example, calculation of the CO_2 discharged by a product, we will explain the general steps for performing LCA.

With the LCA procedure, first we divide the life cycle of a product into the stages shown in Table 1.[1)] After determining the source(s) of CO_2 discharge in each of those stages, we gather and total data on the related energy consumption, etc., and input it into the LCA software. Internal to the LCA software are conversion coefficients (for LCA, they are called basic units) and, using them, the inputted data are automatically converted to CO_2 discharge amounts and totaled.

In Table 1, the activities of manufacturing, distribution, use, and disposal can be grasped within the company, so the input data related to these can be readily obtained.

In contrast, energy consumption data regarding purchased parts such as materials and parts must be obtained from the maker of the purchased parts, but in practice, this is hard to do. In general, an estimating technique is used whereby the amount of CO_2 discharged is calculated from data such as purchase price, weight, etc., using conversion coefficients.

In the past, the required data was gathered from related groups inside and outside the company through manual work and was organized into the format required by LCA. Many man-hours of labor were required for that.

To deal with that, LCA practitioners gather data from databases which can be readily accessed inside and outside the company, using networks, and, through effective use of spreadsheet software, they summarize the data into the format required by LCA. As a result, the time required to gather and summarize data about purchased parts can be greatly reduced. Next, we explain this in detail.

1. Method for estimating CO_2 discharge amount due to purchased parts

   At Oki Electric, a variety of databases are connected via a network and groups in every region, including sales, design, purchasing and manufacturing mutually utilize them. One of those databases is the "parts information database."[2]

   In this database, for each part, information such as the following is recorded:

   - parts management information
     control number, part name, model, maker, purchase price, etc.

Stage	Scope of stage	Main CO_2 discharge sources
Preparation	Purchased items such as materials, parts, and semi-manufactured goods, until they are transported to the next stage.	Energy consumption at factories manufacturing the purchased items.
Manufacturing	The stage where, at the factory, products are fabricated, assembled, inspected, transported, packaged, and shipped	Energy consumption at our company's factories.
Distribution	The stage up to the point the product is delivered to the user.	Energy consumption by trucks carrying shipments.
Use	The stage at which the consumer uses the product. Includes fuel consumption related to maintenance and the environmental burden of the life cycle of the consumables required when the product is used.	Electrical power consumption of the products themselves.
Disposal	The stage of disposing of waste products whose useful life has finished. Covers recovery and breakdown of these used products.	Energy consumption associated with waste disposal.

Table 1: Product life cycle and CO_2 discharge sources

Control number	Part name	Number	Weight (kg)	Price (Yen)
123-0001	Connector A	1	0.001	5
123-0002	Connector B	1	0.002	6
125-0001	Resistor A	2	0.0005	1
125-0002	Resistor B	1	0.0005	2

Table 2: Table of prices and weights of purchased parts

Part type	Total number	Total weight (kg)	Total price (Yen)
Connectors	200	1.2	1000
IC's	100	0.5	10000
Resistors	2000	0.1	2000
Condensers	2000	0.1	3000

Table 3: Purchased parts—"by category" results (quantities in one product)

- parts technical information
  control number, features, weight, shape, dimensions, etc.

At the same time, for the products subject to survey, the following information about the products is listed in the "bills of material":
- the name and control number for all the parts used in the product, and
- quantities.

In the spreadsheet software, this bill of materials and the "parts information database" are connected, and when the required information is selected, results such as those shown in Table 2 are obtained.

When there are few parts in a product, if the results in Table 2 are inputted to the LCA software as is, the software makes a conversion to CO_2 discharge quantity using the "basic units" (conversion coefficients) stored in the software. However, for products where the parts count is 10,000 or more, this inputting task is impractical. Instead, it is effective to group the parts into categories and do the inputting of a smaller number of inputs. In order to confirm parts data categories and classify parts efficiently, a control number associated with each part is used.

For purchased parts, the control number is defined in the following format:
123-4567

The first three digits define the classification of the part according to function—i.e. is this part a structural component?, a connector?, or? In the case of structural parts, the number shows whether it is a screw, a spring, or what. Because the control numbers are unique for each part, this enables parts to be automatically classified into parts categories. If spreadsheet software is used and the connectors, IC's, etc. of Table 2 are classified according to part type, the results will be as in Table 3. Then, by inputting this reduced amount of data into the LCA software, the CO_2 discharge quantity of purchased parts can be calculated.

2. Method for estimating CO_2 discharge amount due to purchased materials
   The amount of CO_2 discharge from purchased materials such as steel and aluminum is estimated from the purchased amount. Information about purchased materials is stored in the factory's "production information database" and the data is available via networks. For example, concerning the contributions of fabrication operations such as turning or forming, for each fabricated part, there is recorded data about:
   - the kind of material, and
   - the weight of the material (including the material in defective parts).

   Using spreadsheet software, the desired information is selected from the database. Afterward, it is categorized by material type, such as steel and aluminum, and Table 4 can be created.

   By the above method, the time required for gathering and organizing data related to purchased products is shortened and LCA can be implemented efficiently. Next we will describe an example of application of this method.

Example of implementing LCA

To evaluate the amount of CO_2 discharged due to a product, we perform LCA "inventory analysis" utilizing databases internal and external to the company and LCA software. Here we explain this example.

<Assumed conditions>
- Products addressed:
  We compare old and new model ATM's (automated teller machines). In each case the number of constituent parts is over 10,000.
- The LCA software used:
  JEMAI-LCA (JEMAI: Japan Environmental Management Association for Industry)
- The environmental burden factor evaluated:
  Inventory analysis of CO_2

<Steps in implementing LCA>
- Product life cycle is broken into stages according to the standard divisions of Table 1.
- In each stage, the sources of CO_2 discharge such as amount of energy consumed, etc. are surveyed and converted to "per product unit" amounts.
- The above-mentioned data is inputted into the LCA software and the CO_2 discharge amount is calculated and summarized.

The surveyed sources of CO_2 discharge for each stage are as follows.

Material name	Amount used (kg)
Stainless steel	10
Copper	5
Aluminum	3
Polyethylene	0.5

Table 4: Material required for product–weight/product unit

1. Sources of CO_2 discharge in the "preparation" stage
   The items considered in this stage are the materials and parts which Oki Electric purchases. Here, the CO_2 discharge sources relate to the electrical power and fossil fuel consumed in the manufacture of these products by the manufacturer. Because the parts count in the subject products is 10,000 or more, it is difficult to obtain all this environmental impact data from the various parts makers. Therefore, to solve this problem, we use the above-mentioned databases and adopt the approach of estimating CO_2 discharge amount from the price and weight of the materials and parts purchased.
   The "base units" and the intra-company database we used are as shown in Table 5
2. Sources of CO_2 discharge in the "production" stage
   At the product production stage, the main sources of CO_2 discharge are the electrical power and fossil fuel consumed at our own factories. By surveying the number of products produced, and the factory's total consumption of electrical power and fossil fuel, a "per product produced" allocation can be made.
3. Sources of CO_2 discharge in the "distribution" stage
   At the distribution production stage, the main source of CO_2 discharge is the fuel consumed by the trucks hauling products from factories to destinations. By surveying the distance traveled by the trucks, the number of products loaded on each truck, and the fuel consumed, a "per product produced" allocation can be made.
4. Sources of CO_2 discharge in the "use" stage
   At the product use stage, the main source of CO_2 discharge is the electrical power consumed by the product in operation. In addition, we considered the fuel consumption of maintenance vehicles. The energy consumption data was allocated on a "per product produced" basis.
5. Sources of CO_2 discharge in the "disposal" stage
   At the used product disposal stage, the main sources of CO_2 discharge are the following:
   - fuel consumed by the trucks used in hauling used products for recovery,
   - electrical power consumed at the decomposition (breakdown) factories,
   - fossil fuel consumption, and
   - energy consumed in the pulverization and landfill steps after the breakdown process step.

   Here, we examined the fuel consumed by the trucks hauling used products as part of the recovery operation and the energy consumed by the breakdown factories. We surveyed these and allocated them on a "per product" basis.
   Note that, because the recycle ratio of Oki Electric ATM's exceeds 96%, we ignored CO_2 discharge amounts after the process step of breaking down waste products.
6. Through the above steps, we obtained the LCA results (inventory analysis results) shown in Figure 2. It is clear from this figure that most of the CO_2 discharge amount occurs in the "product use" stage. It is also clear that our "measures to reduce electrical power consumption" have produced the largest improvement.

	Base unit	Database
Materials	Base units incorporated in the LCA software	Production information database
Parts	CO_2 discharge amount base units which utilize industry relationship tables (input/output tables)	Product information database

Note: These "CO_2 discharge amount base units which utilize industry relationship tables (input/output tables)" are the "energy and CO_2 discharge amount base units '95, according to industry relationship tables" published by National Institute for Environmental Studies and Kyoto University. We obtained these over the Internet and input them into the LCA software.

Table 5: The "base units" and database used

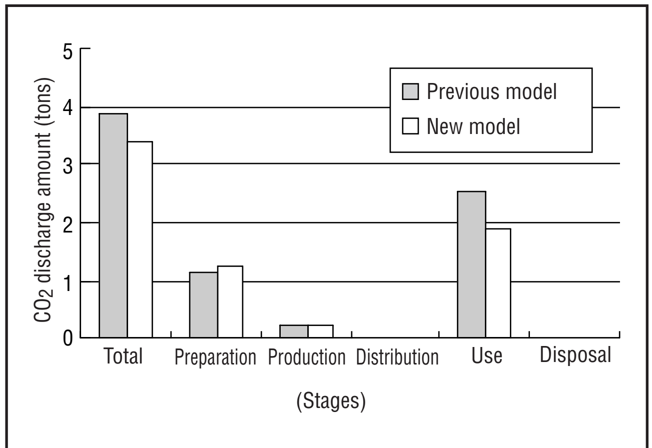

Figure 2: LCA results for ATM's

Conclusion

In spite of the advantages of LCA, its wide acceptance was delayed because "a huge amount of time was required for gathering / organizing data on environmental burdens for use in evaluation." As a means of solving this problem, we tried a method of "making LCA more efficient" in calculating environmental burden data, by utilizing internal/external databases which can be conveniently accessed through networks. The results were good and we have essentially succeeded in establishing procedures for implementing simple and easy LCA.

References

1. JEMAI Program Implementation Guidebook, Japan Environmental Management Association for Industry (non-profit).
2. Himeno, Oikawa: "Information Weapons for the Electronic Equipment Manufacturing Industry," Electronic Mounting Technology, Vol. 16, No. 10, October 2000.