# Enrichment of Design for Environment (DfE) and Development of Its Support System

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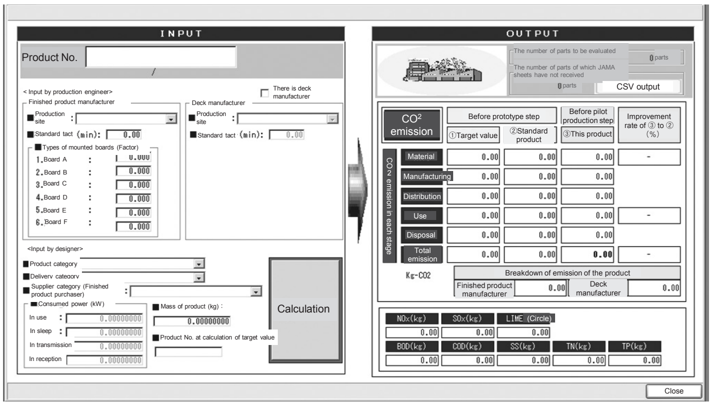



## Abstract

All the products that are the basis of our economic life not only provide their intrinsic value and convenience but also produce by-products of environmental impacts. Not a few companies have introduced the method called "Life Cycle Assessment (LCA)" in order to promote their "Design for Environment (DfE)" as their initiatives on reduction of environmental impacts caused by their products.

Like food calorie calculation, LCA can visualize the environmental impacts caused in the product life cycle, by using indices such as $CO_2$. On the other hand, LCA necessitates complex special knowledge and complicated data collection and calculations, which end up in numerous man-hours.

As its countermeasure, we promoted the development of "information system that can calculate LCA of our products only with the input of our product number." Taking car navigation for example, we used to require 20 hours for the calculation but now the time is reduced to 5 minutes, 240-times faster than before.

This paper presents our DfE support system including LCA calculation and our future prospects.

## 1 Introduction

The 21st century is called "the century of the environment." Many companies have introduced the environmental management system based on ISO 14001. In addition to efforts to reduce and curb environmental impact at sites, many manufacturers have enhanced the design for environment (DfE) to reduce environmental impact caused by their products in order to promote the environmental protection activities in their manufacturing processes.

Recently, many companies have adopted a method called life cycle assessment (LCA) as one of such initiatives.

The method helps understand the environmental impact in each stage of the life cycle of products by using indicators, e.g. $CO_2$. (Refer to **Fig. 1**.) As a result, it is advantageous in terms of the fact that it enables i) analysis to determine, concretely, points to be focused when taking measures for reducing the environmental impact and ii) quantification of improvement levels. Moreover, many companies use the assessment not only for internal use but also as a tool for providing the information of the environmental impact of their products and for advertising their green product development efforts by disclosing the assessment to consumers and their stakeholders[1].

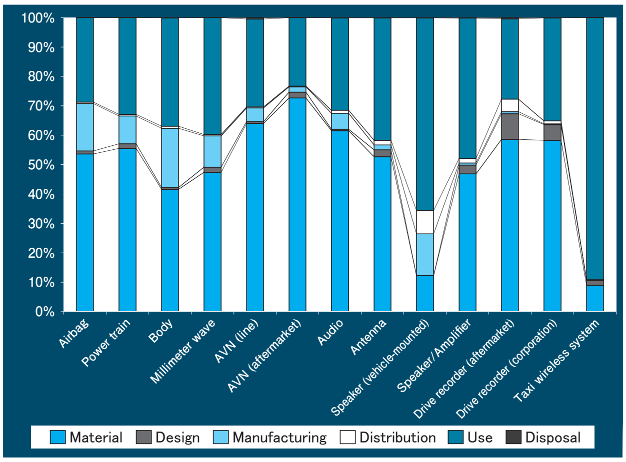


Fig.1 Results of LCA Trial of Our Products

However, LCA necessitates accumulating values calculated in each stage of the life cycle so that a great deal of special knowledge and calculation time is required.

Recently, many calculation tools have been available to reduce the complication of the LCA, and they actually simplify the calculation to some extent. However, troublesome work, such as collecting and inputting information, still remains today.

FUJITSU TEN intends to conduct LCA for all our product categories and to enhance improvement, positioning LCA as an important tool for promoting "the better relationships of people with vehicles and the environment" set forth in FUJITSU TEN Global Environment Charter. To that end, it is necessary to find a method that makes LCA processes easier.

For those reasons, we developed a system that "calculates LCA only with the input of a product number." As a result, the system was recognized as a case example contributing to LCA in Japan at the 7th Life Cycle Assessment Society of Japan Awards, and we received "Incentive Award" (picture in the abstract). This paper explains the outline of our LCA calculation system and our effort for DfE.

## 2 LCA Calculation Method and Necessity of Efficiency Improvement

In order to understand the environmental impact caused by each product, it is necessary to calculate and accumulate both energy (INPUT) amount and the environmental impact (OUTPUT), such as $CO_2$, emitted at each stage of its life cycle (material, manufacturing, distribution, use, and disposal) as a result of the energy consumption. (Refer to **Fig. 2**) The outline of the necessary calculation is herein explained, taking the material stage of a product for example.

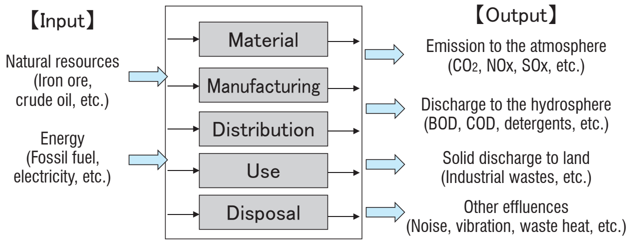


Fig.2 Input and Output for LCA

Various types of energy are input in the material stage starting from procurement of raw materials through manufacturing and processing of parts. Due to advancement of LCA study, environmental impact factors for individual parts and materials per unit weight already exist as literature values. Therefore, companies calculate LCA by multiplying the number of a part and/or material information (type and weight) by the factors. However, it is extremely complicated to understand what and how much materials are included in each part. The process has to be done for a product consisting of some thousand parts. It is easy to assume that even collecting necessary information for the calculation is a painstaking work.

Such an information collecting work has to be implemented for each stage of the life cycle and the amounts of energy and resources input to the part are collected beforehand through the work.

After collecting all the input data, each of the resources and energy is multiplied by its factor and the multiplied numbers are accumulated.

At the time of our LCA trial, all calculations were performed manually for the accumulation. Therefore, it required approx. 20 hours to collect, calculate, and accumulate the data for an AVN (car navigation system), without counting hours required for searching literatures for the factors. If we had been able to use the 20 hours, we could have made much discussion to improve environmental impact. In this context, it is important to improve the efficiency in the calculations for these stages to more firmly promote DfE.

## 3 Outline of LCA Calculation System

FUJITSU TEN tried the LCA for all our product categories in two years. (Refer to **page 40 - page 43, No. 32 of FUJITSU TEN TECHNICAL JOURNAL in English version.**) Based on the trial results, we developed the system that can curb the man-hours for the data input and calculation as much as possible through efforts, e.g., incorporation of the data obtained from the local survey as factors.

We introduce here the deliberated points in the development of the system for the material, manufacturing and use stages which account for much of the environmental impact of our products.

**●Material stage**

In our LCA trial, each part was categorized per calculation unit of quantity, area, length, and material mass, in accordance with its characteristics, and then the LCA values were calculated in each of those units. However, the calculation required much time[2) 3) 4)].

In the course of development of the system, we reviewed and changed the calculation method such that the calculation can be performed based on either quantity or material mass of a part while being careful not to undermine the accuracy. Since the information must be obtained in the course of product development, it is already stored in the information system in FUJITSU TEN. By utilizing the information, we achieved the system that can multiply the information by the LCA factors prepared beforehand and automatically calculate LCA by only inputting a product number. (Refer to **Fig. 3**).

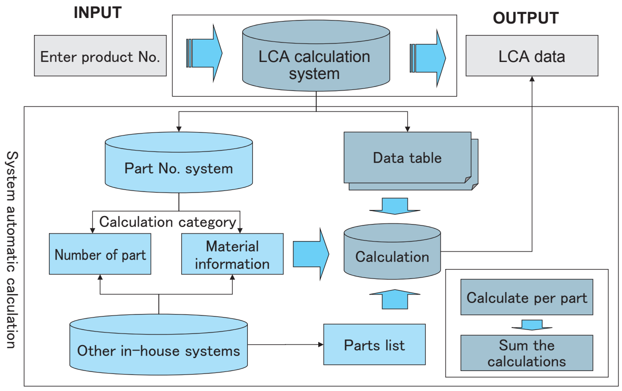


Fig.3 Outline of In-house Systems linking with LCA system

**●Manufacturing stage**

As one of the general methods, it is often used to conduct a local survey once at a manufacturing site to calculate environmental impact data per product, and to deem the data as equivalent to the products manufactured afterwards[2) 3) 4)].

However, actually, even when the same amount of electricity is consumed, $CO_2$ emission may double or triple, depending on manufacturing country. In addition, production efficiency also differs from country to country. Based on those facts, FUJITSU TEN whose manufacturing sites are located globally decided not to adopt the method that uses the data from the local survey as fixed values but to adopt a method that reflects elements having large influences to the LCA values.

Fixing a normally-consumed energy amount as a factor for each of the three varying elements of production site, mounting method for each printed board, and production tact, we introduced a mechanism in our system that reflects eco-friendliness in the manufacturing stage to the LCA values.

**●Use stage**

In this stage, it is important to set a scenario, for example, how often and how long the product will be used in its life cycle. However, once the scenario is fixed, LCA values can be easily calculated, even manually. Therefore, use of the system in this stage does not much contribute to the efficiency improvement. In this text, an example of LCA calculation methods in vehicle-mounted devices is explained.

In the case of household appliances and others, LCA is calculated based on the scenario of average hours of use and consumption current (dark current) occurring in the state where the appliance is plugged in (sleep mode) for a specific time period, such as one day. However, in the case of vehicle-mounted devices, a different approach is required because it is a vehicle that consumes energy.

In the case of our products, the point to be studied is the influence of their weights and power consumption given on the vehicle's consumption of energy such as gasoline. However, actually the energy efficiency of the product varies depending on the fuel efficiency, net weight, etc. of the vehicle on which the product is mounted[7)]. If the LCA is calculated for each vehicle model, the environmental impact caused by, for example, the same car navigation system will vary depending on the vehicle model, and the degree of the improvement made by our DfE effort is not clear.

FUJITSU TEN has set and fixed the scenario based on principle conditions such as fuel, expected weight, life of vehicle, and annual mileage, using the literature values, to visualize the environmental impact reduced by our design for environment (DfE) effort.

The LCA values of power-consuming vehicle-mounted devices, such as car navigation systems, need to be calculated due to their electricity load. Since they are not household appliances, $CO_2$ per kWh conversion factors disclosed by electricity companies and other bodies[8)] cannot be used for them. Therefore, they were out of the scope of the initial LCA survey. However, now we estimate the values based on the scenarios set for the devices by using literature values.

In LCA, not only in the use stage, there is a possibility that LCA values greatly vary depending on scenario setting and survey method. Thus it is not suitable to compare the values among manufacturers. We continue to hope that a standard to be used across the car parts manufacturing industry will be established, as an increasing number of companies in the industry disclose the LCA.

## 4 Effect of LCA Calculation System

**Table 1** shows the effects produced by the LCA calculation system that FUJITSU TEN developed. The system improved the calculation efficiency 240 times as compared with manual calculation, in the case of products consisting of many parts, such as car navigation systems.

A part of advantages of the system are presented below.

Table 1 Effect of Development of LCA Calculation System (per Model)

| Product | Manual calculation | LCA calculation system |
|---|---|---|
| Millimeter wave radar, ITS etc. | 6 hours | 3 minutes |
| Car navigation system | 20 hours | 5 minutes |

### (1) Material and disposal stages

The system most improves the efficiency in these stages. As shown in **Fig. 4**, engineers need to input only part of information on the interface screen. With the input information, the system completely automates the process to multiply and accumulate the data: (1) it multiplies the data already existing in our in-house information system by the environmental impact factors introduced this time; (2) and it accumulates the multiplied values. As for the calculation performed in the material and disposal stages, literally, the system "can automatically calculate LCA values only with the input of the product number."

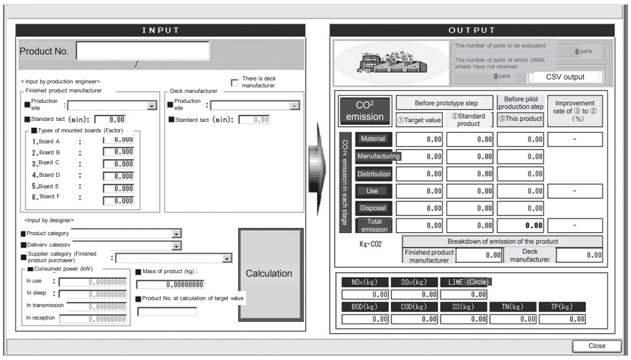


Fig.4 Screen of LCA Calculation System

### (2) Manufacturing, distribution, and use stages

Conventionally, survey across various literatures and actual data were required in order to set scenarios. However, since we set the factors for those data, difference per model will be able to be reflected to the LCA in the future by only inputting varying elements such as production site, production tact, and distribution category.

## 5 Framework for promoting Design for Environment

FUJITSU TEN has promoted the DfE (Design for Environment) activity by adding eco-friendly perspective to the product development process, such that DfE consideration can be given, as much as possible, to designing in the early stage[5][6]. Moreover, in addition to the development of the LCA system as an evaluation criteria and/or a tool for LCA, we have joined the Fujitsu Group Environmental Protection Program and developed our own system using the eco-efficiency factors and the supergreen evaluation. Further, we developed comprehensive DfE systems for task management and database management to make sure to conduct the evaluation. Our DfE-related systems are briefly explained here.

### ●Eco-efficiency factor calculation system

The eco-efficiency factor is a comprehensive indicator of improvement in the values (function and performance) offered by a product while curtailing environmental impact caused by the product. FUJITSU TEN systematized and connected calculation of the indicator to the LCA calculation system. Thus the environmental impact reduction level can be automatically reflected and the eco-efficiency factor can be also automatically calculated by inputting the value offered by the product.

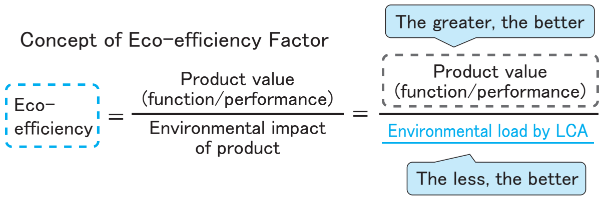


Fig.5 Basic Idea of Eco-Efficiency Factor

### ●Green level evaluation system

Since 1992, we have conducted the environmental assessment that determines eco- friendly level of products in terms of energy saving, miniaturization/weight saving, recycling, and so on. Besides that, LCA and eco-efficiency factor are added as items that can be quantitatively evaluated. Moreover, the evaluation whether products are graded as supergreen product is also conducted at the same time as the assessment. (Refer to **Fig. 6**.)

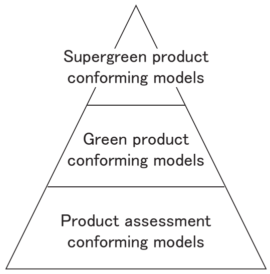


Fig.6 Categorization of Products Based on Green Evaluation

### ●DfE comprehensive system

We have the DfE evaluation tools such as the aforementioned LCA, eco-efficiency factor, and green level evaluation. In addition, we developed a system including a support function such as deadline management, from a viewpoint of comprehensive "DfE" management, rather than separate management based on those tools.

A function of this system enables to roughly determine necessity of DfE evaluation of products, based on the information for issuing product numbers. In addition, the system has a database function that links a representative model to be evaluated to equivalent models, for example, models in different colors, of which LCA values will be the same as one of the representative model so that the LCA value of the representative model is used for all the equivalent models.

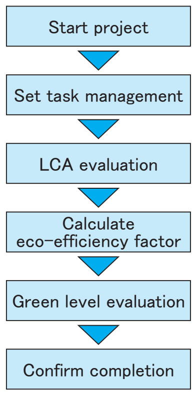


Fig.7 Evaluation Process

Conventionally, there was a problem that the environmental assessment just before the pilot production only served as result checking. Most of the environmental impact of the products is determined in the stream upper than designing[9].

Therefore, we decided to clarify DfE targets of product models in the product planning step and to conduct the DfE evaluation at two steps, using the targets at one step and using actual values at the other step for checking the result. The system has been used since fiscal year 2011 and the models to be evaluated by the system are gradually expanded.

## 6 Simulation System and Future Prospect

Our LCA calculation system automatically calculates LCA results by only inputting a small amount of information such as the product number. Thus the system achieved the drastic cut in man-hours required for the input and calculation. On the other hand, simulation to identify improvement measures was difficult because the calculation process was not visualized. Therefore, we are now developing a prototype system with a function that can simulate what and how should be changed to improve the LCA values and that also can simulate to what extent the LCA value will be improved by the change. Besides, we are also developing an analysis function of clarifying points to be focused to improve. All of those efforts are designed to enrich the support systems that contribute to reduction in environmental impact of products.

In addition to the development of those systems, we are coordinating with related departments to introduce the DfE evaluation process into the concept design (product planning step) that has a greater influence on DfE.

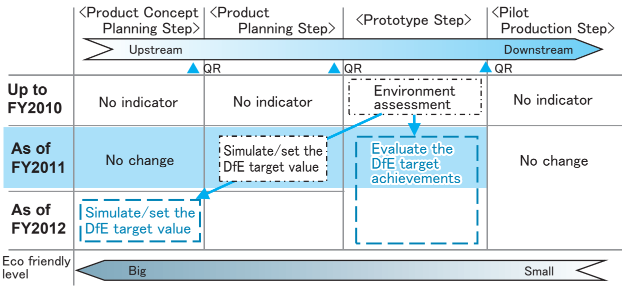


Fig.8 Schedule for Evaluation Process Introduction into Product Planning Step

## 7 Conclusion

With consumers rising their environmental awareness, eco-friendly products are increasing in the market[2)9)]. It can be said that developing and launching better eco-friendly products is a critical theme for manufacturing companies. In such a time, design and development via LCA and other DfE evaluation tools lead to more effective improvement. The DfE evaluation support tools including the LCA calculation system that we developed satisfy needs of the times and they can be deemed as effective and important means for using man-hours of engineers to improve the environment.

Companies possess various types of information which they obtain through the process of manufacturing. If the information is appropriately linked and utilized, the time required for the DfE evaluation can be shorten drastically. The case example introduced herein is focused on our efforts in making the evaluation process more effective. However, as more efforts are accumulated, these efforts will further contribute to the development of future eco-friendly products of FUJITSU TEN.

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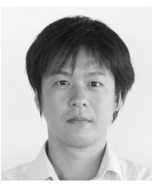

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