Fujitsu's Approach for Eco-efficiency Factor

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Eco-efficiency is one of the many indicators for measuring damage to the environment. The Eco-efficiency Factor is a quantitative indicator that enables us to evaluate changes in service performance and the environmental burdens that are imposed. This paper presents a case study of two notebook personal computers manufactured eight years apart. To evaluate service value, core hardware specifications such as CPU clock speed, memory size, and hard disk drive size were compared. The results show that the more recent notebook has about 24.6 times the service value of the older one. The results of inventory analysis from EcoLeaf, which is a Japanese Type III labeling program based on Life Cycle Assessment (LCA), are used as environmental burdens. Then, we used LIME (Life cycle Impact assessment Method based on Endpoint modeling) to integrate the inventory data of EcoLeaf. The integrated result showed that environmental burdens have dropped about 22%. It is concluded that the Eco-efficiency Factor has increased about 32 times in 8 years. Due to the usefulness of the Eco-Efficiency Factor, it could become an important communication tool between manufactures and green consumers in the near future.

1. Introduction

Nowadays, products tend to be smaller and lighter and consume less electricity. Product manufacturers are giving their products more functions while reducing their environmental burdens by employing Design for Environment (DfE). However, there are not many environmental indicators that consider both a product's service value and its functions. Life Cycle Assessment (LCA), for example, is very useful for assessing environmental burdens but does not consider a product's functions. Eco-efficiency, on the other hand, enables manufactures to express service value and environmental burden at the same time and is a valuable communication tool for customers.

In this paper, we calculate the increase in service value of two of Fujitsu's notebook personal computers (PCs) using their hardware specifications as parameters. Then, we introduce EcoLeaf, which is a Type III environmental labeling program promoted by the Japan Environmental Management Association for Industry (JEMAI). Finally, the results of an EcoLeaf inventory analysis are integrated by using LIME (Life cycle Impact assessment Method based on Endpoint modeling) and presented as a single, comprehensive value. Although the EcoLeaf program and LIME are both well established, this integrated approach is very unique in the field of eco-efficiency computation.

2. Overview of eco-efficiency

2.1 Definition of eco-efficiency

The World Business Council for Sustainable Development (WBCSD) defines eco-efficiency as being achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the Earth's estimated carrying capacity.[1] From this definition, one can see that eco-efficiency is a conceptual framework. In practice, eco-efficiency is often interpreted mathematically as service value divided by environmental burden.

2.2 Fujitsu's activities for Eco-efficiency Factor

Fujitsu is a member of the Eco-efficiency Examination Committee, which is sponsored by the Ministry of Economy, Trade and Industry. We developed the concept of eco-efficiency within this committee and in collaboration with firms such as Matsushita Electric Industrial Co., Ltd. and Mitsubishi Electric Corporation.

The Eco-efficiency Factor is a measure of the improvement of a new product over a previous product in terms of the service value and environmental burden. It is obtained as follows:

$$\text{Eco-efficiency Factor} = \frac{\textit{Service (New product / Old product)}}{\textit{Environmental burdens (New product / Old product)}} \quad (1)$$

The Fujitsu Group has applied this concept to PCs,[2),3)] scanners,[4),5)] and cellular phones,[5),6)] especially focusing on how to quantify the service values, and also contributes to the development of this new environmental indicator.

2.3 Product selection for this case study

In this section, we show the latest method for computing and analyzing the Eco-efficiency Factor, using notebook PCs as an example. To illustrate how the eco-efficiency of Fujitsu's products has increased, we selected two notebook PCs that were manufactured eight years apart: the FMV-5120 NA/X introduced in 1996 and the FMV-830 NU/L introduced in 2004.

3. Quantifying the service

3.1 Background

In the framework of eco-efficiency, the relative improvement of service value (i.e., the numerator of the Eco-efficiency Factor) is a crucial element. However, there is no standard method for calculating the service value at present. One common method is to directly apply a monetary unit.

Customers buy products to obtain certain services. In general, if a product's services satisfy the customer's needs and the price meets the customer's budget, a transaction is made. Therefore, we could use the product price as a proxy for a product's service value. However, prices tend to vary over time and location, especially the prices of IT products. Therefore, it is difficult to obtain a reliable monetary unit since the same data collection method cannot be applied for product price.

Another way of computing the service value is to use the econometrics obtained from a questionnaire survey. By asking customers to rate the relative improvement of a product's services, we can estimate the customers' perceived increase in service value. However, it is not realistic to conduct formal surveys for all products and there is no standard way to calculate the service value at the moment.

3.2 Accepted method for PCs

Our approach for comparing service values is to compare the service values of the core hardware specifications of the old and new product (**Table 1**). This method is especially easy for hardware manufactures to use. For PCs, we first obtain the service value ratios (new to old) for the CPU clock speed (GHz), pre-installed memory size (MB), and hard disk drive (HDD) size (GB). Then, we take the root-mean-squared (RMS) value of these three ratios:

$$\text{RMS of service value ratios} = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} S_i^{\,2}} \qquad (2)$$

S: ratio of new product's service value to old product's service value
n: number of ratios

Hardware itself does not directly deliver the services that customers use; however, hardware is the root element for creating the functions and services of products. Beyond that, the advantage of this method is that it can be easily calculated, even by customers, because the required information is open to the public and can be obtained without a complicated questionnaire survey. However, for consistent, continuous use of this method, it is important to always use the same criteria and parameters.

3.3 Result of service value calculation

When we compared the FMV-5120 NA/X produced in 1996 with the FMV-830 NU/L produced in 2004, we found that the CPU speed, memory size, and HDD size have increased about 13, 32, and 25 times, respectively. Therefore, according to the method shown in the previous section, between these two PCs, the service value has increased about 24.6 times in 8 years.

4. Quantifying environmental burdens

4.1 Background

EcoLeaf is an environmental labeling program promoted by JEMAI that belongs to the Type III category defined by ISO Technical Report 14025.[7] This program was launched in June 2002, and by November 2004 more than 200 labels from 24 product categories were registered in this program. EcoLeaf is based on the Life Cycle Assessment method, which quantifies a product's environmental burden throughout its life cycle, from materials acquisition, product manufacturing, transportation, and usage to disposal and recycling.

Fujitsu has been participating in the EcoLeaf environmental labeling program from its trial stage and in June 2003 was the first manufacturer to obtain the EcoLeaf label for a notebook PC (**Figure 1**). As of January 2005, Fujitsu has acquired 20 EcoLeaf labels for its notebook PCs and 2 labels for its magneto optical (MO) drives. Information about the EcoLeaf certification for these products is available at a Website,[8] and a

Table 1
Service values of PCs.

Service	Unit	FMV-5120NA/X (a)	FMV-830NU/L (b)	s =(b)/(a)	
CPU	GHz	0.12	1.6	13.3	
Memory	MB	8	256	32.0	24.6
HDD	GB	0.81	20	24.7	

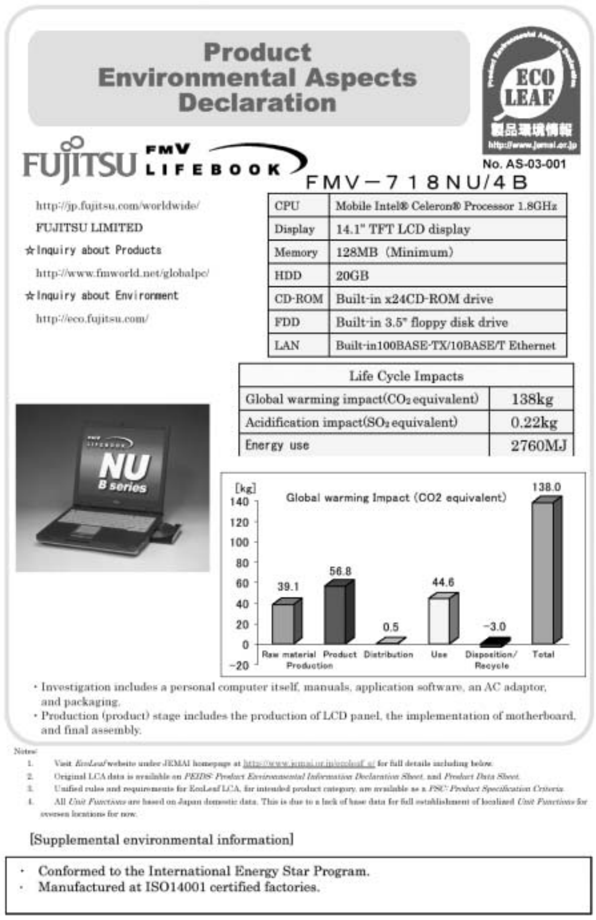

Figure 1
First page of EcoLeaf Type III environmental label.
For an enlargement of this figure, see:
http://www.jemai.or.jp/english/ecoleaf/pdf/AS_03_001_e.pdf

summary of the CO_2 emissions of the first 10 certified products is given in **Figure 2**.

4.2 Outline of EcoLeaf computation

One of the main characteristics of the EcoLeaf program is the Product Specification Criteria (PSC). To ensure the objectivity and consistency of declared information, there are a set of criteria for each product category: for example, the definition of products; requirements and rules of the LCA calculation; scenarios of product use and disposal; methods of data collection, processing, and use; and data to be disclosed. Consumers and purchasers can use these criteria to make solid judgments,[8] and all of the PSCs are available at a Website.[9]

The first PSC for notebook PCs was formulated in 2003 and later modified to include the evaluations of desktop computers and monitors. Some of the key elements of this PSC are as follows:

1) The LCD panel manufacturing, mounting of the main board, and product assembly are set as foreground data.
2) EcoLeaf basic units are set as background data.
3) The distribution stage is modeled as the transportation from the product assembly site to Japanese domestic customers.
4) Three operation modes are considered for the product use phase: active/standby, low-power, and off. Products are assumed to be in use 240 days a year for 4 years.
5) In the disposal and recycle stage, the product collection rate is set to 20% and a deduction is made for product reuse, component reuse, and material recycling.

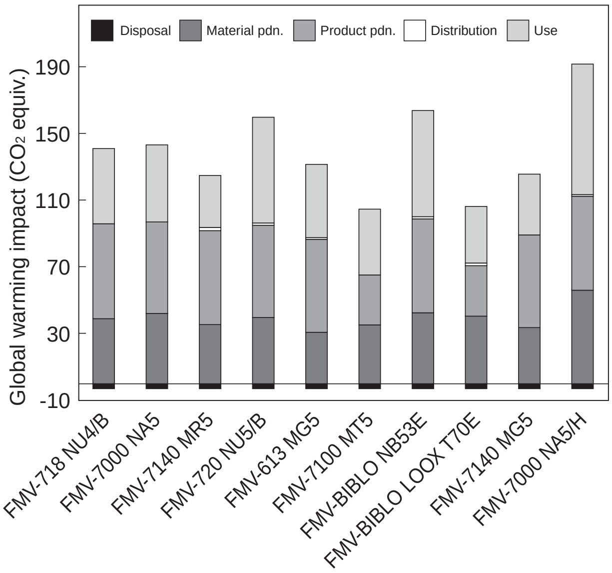

Figure 2
Summary of CO_2 emission for 10 products.

The former product, FMV-5120 NA/X, has not obtained the EcoLeaf label, but we applied the same assumptions and database for the comparison as the ones used for the FMV-830 NU/L. The results of inventory analysis are shown in **Table 2**. A total of 35 inventories are computed in the EcoLeaf label, and Table 2 only shows some of the main ones.

4.3 Application of LIME for integration

In Fujitsu's previous approach, carbon dioxide emissions from the inventory analysis were used as a representative of environmental burden. However, because it is preferable to include other inventories such as material consumption, sulfur and nitrogen oxide emissions, and dust and waste, we applied impact assessment. LIME was developed by the Research Center for Life Cycle Assessment of the National Institute of Advanced Industrial Science and Technology (AIST) in the framework of the LCA National Project of Japan. This is an endpoint-type method of life cycle impact assessment and consists of three parts: characterization, damage assessment, and weighting.[10] In this study, we applied inventory data obtained from EcoLeaf to the LIME methodology and then obtained the integrated environmental burden.

There are three types of integrated indicators in LIME, and we used a non-dimensional indicator based on conjoint analysis in this study.

Table 2
Results of inventory analysis. (Unit: kg/product)

(In)	5120NA/X (old)	830NU/L (new)	(Out)	5120NA/X (old)	830NU/L (new)
Coal	22.5	16.1	CO_2	162	132
Crude oil (fuel)	28.7	22.0	SOx	0.160	0.118
LNG	8.27	6.72	NOx	0.180	0.136
Crude oil (ingredients)	2.33	1.03	N_2O	0.00785	0.00650
Iron ore	2.47	0.931	CH_4	0.00278	0.00231
Copper ore	0.112	0.103	Dust	0.0173	0.0127
Bauxite	0.481	0.195	Solid waste	5.32	4.40
Water	16 900	13 700	Slag	2.81	1.83
etc.			etc.		

The integrated environmental burdens of the two FMV products are shown in **Table 3**. As the table shows, the integrated environmental burden of the new model is about 22% less than that of the older model. This reduction is mainly due to the reduction in material use and energy-saving design of the new product. In fact, the environmental burdens have decreased by about 12% and 40% in the production and use stages, respectively.

Table 3
Integrated environmental burdens.

	FMV-5120NA/X (Points/kg)	FMV-830NU/L (Points/kg)	Reduction (%)
Production	246.4	217.7	11.6
Distribution	7.1	1.8	74.6
Use	122.1	73.5	39.8
Disposal	–2.9	–2.9	0
Sum	372.7	290.0	22.1

5. Result of Eco-efficiency Factor calculation

In the previous sections, we showed that the FMV-830 NU/L has about 24.6 times the service value of the FMV-5120NA/X yet its integrated environmental burden is about 22% lower. Therefore, the Eco-efficiency Factor is as follows:

$$\text{Eco-efficiency Factor} = \text{Service value/Integrated environmental burden} \quad (3)$$

$$= 24.6 / (1 - 0.22) \quad (4)$$

$$= 31.6 \quad (5)$$

Therefore, the Eco-efficiency Factor of this notebook PC has increased about 32 times in 8 years.

6. Conclusion

Transparency and simplicity are the two key elements for any indicators. For the calculation of eco-efficiency and Factor X, we believe that one way to satisfy these requirements would be to use hardware specifications to measure service value and use Type III labels such as EcoLeaf to measure environmental burden. This is because most hardware specifications are readily accessible from product catalogs and the EcoLeaf results are highly trustworthy due to the PSC and third-party inspections. Moreover, environmental burdens can be integrated through LIME and therefore enable us to present a single indicator.

Nowadays, the concept of eco-efficiency has been introduced in many firms and some Japanese firms are already using co-efficiency as a product environmental indicator from the design stage. However, the method and formula differ from firm to firm and these differences can be confusing to customers. Eco-efficiency could become a useful communication tool that helps customers purchase high-quality, environment-friendly products. Therefore, further discussions and collaborations among firms should be conducted.

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