Eco-efficiency Factor of Personal Computer Utilizing EcoLeaf and LIME

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ABSTRACT

Eco-efficiency Factor is a quantitative indicator which enables us to evaluate both changes in the service performance and environmental burdens imposed. In this study, two notebook personal computers are selected. In order to evaluate service value, core hardware specifications, such as CPU clock number, Memory size, and HDD capacity are compared and the result shows service value has increased 19 times in 7 years. The results of inventory analysis from EcoLeaf, which is the Type III labeling program in Japan, are employed as environmental loads. Then, in order to integrate inventory data of EcoLeaf, LIME is applied and the integrated result shows the environmental loads have dropped 20%. It is concluded that Eco-efficiency Factor increased 24 times in 7 years.

OBJECTIVE

The development of IT-products is extremely fast; however, there are not many environmental indicators to include the increase in the product services and functions. Nowadays, a product itself tends to be smaller and lighter configuration and achieves less electricity consumption. In other words, suppliers of the product are trying to increase the product functions while reducing the environmental loads by employing the Design for Environment (DfE). Therefore, Eco-efficiency is a useful concept for designer to evaluate service and environment at one time, and also for customers it would be a valuable communication tool.

In this study, the increase in the service of the personal computer is quantified using the hardware specifications as a parameter. Also the result of EcoLeaf environmental label, Type III label promoted by the Japan Environmental Management Association for Industry (JEMAI), is utilized as environmental loads. Finally, the result of EcoLeaf inventory analysis is integrated by LIME and presented as one comprehensive value.

ECO-EFFICIENCY

1. Background

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]. Eco-efficiency Factor in this study is the application of this conceptual framework into the practice.

Eco-efficiency Factor is a quantitative indicator which enables us to evaluate both environmental burdens imposed and changes in the service performance. Service value is applied for the numerator while environmental burdens are applied for the denominator. Particularly, Fujitsu measures the relative improvement in new products to past products as follows:

Eco-efficiency Factor

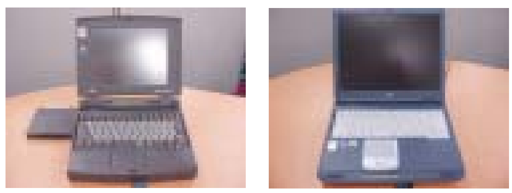
$$= \frac{Service(New\ product / Old\ \ product)}{EnvironmentalBurdens(New\ product / Old\ \ product)}$$

2. Fujitsu's activities for Eco-efficiency Factor

So far, Fujitsu Group applies this concept to the personal computers [2], scanners [3][4], and cellular phones [4][5]. In this paper, we will show and analyze the comprehensive way of Eco-efficiency Factor, employing the personal computer as an example.

3. Targeted products for this study

Two personal computers are selected for the comparison of Eco-efficiency: FMV-5120 NA/X, which are introduced to the market in 1996, and FMV-718 NU4B, which are in 2003. Both are notebook personal computers and time difference of two products is 7 years.



FMV-5120 NA/X   FMV-718 NU4B

Fig. 1: Personal computers of this case study

QUANTIFYING THE SERVICES

1. Background

In the framework of Eco-efficiency, the denominator, the relative improvement of the service, is one of the crucial elements. There is no standard way to calculate the service value at present. One common method to work out the service value is applying a monetary unit directly. The customers buy the products in order to obtain the certain service. In general, when the product services satisfy the customers' demand and when the price meets the customers' budget, the transactions are formed. Therefore, it can be analized that the product price is the proxy of the product service. However, the price tends to be fluctuated, especially the price of IT product is different from place to place and time to time. So a monetary unit is not obtained in the same standard.

Other way of computing the service value would be applying the econometrics based on a questionnaire survey. By asking the relative improvement of the product service to respondents, the service increase which the customer feels can be estimated. Nevertheless, it is not realistic to conduct proper survey for all the products.

2. Accepted method for personal computer

Our proposal for computing the service value of the product is that comparing the value of core hardware specification between old and new product as shown in Table 1. For the parameter of personal computer, CPU clock speed [GHz], pre- installed memory size [MB], and hard disk drive (HDD) capacity [GB] are chosen as core specifications. In order to unite the ratio of the three different specifications, the average of square root is applied at the end.

Hardware itself does not directly deliver the services that customers feel; however, the hardware is the root elements to create the product functions and services. Beyond that, the advantage of this method is that it can be conducted even by a single customer since these information are open to the public and it does not require a questionnaire survey. For the continuous use of indicator, it is important to apply the same criteria and parameters in the same standard.

Table 1: The service value of personal computer

Service	unit	FMV-5120NA/X (a)	FMV-718NU4B (b)	S=(b)/(a)	
CPU	GHz	0.12	1.8	15.0	19.1
Memory	MB	8	128	16.0	
HDD	GB	0.81	20	24.7	

$$\text{Average of square root} = \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} S_i^{\ 2}}$$

S: The ratio of an old and new criterion

n: The number of criteria

3. Result of the service value

Compared to FMV-5120 NA/X produced in 1996 and FMV-718 NU4B produced in 2003, CPU, memory and HDD have increased 15, 16, and 25times respectively. As a consequence of the integration, the service value of personal computer has increased 19 times in seven years as indicated in Figure 2.

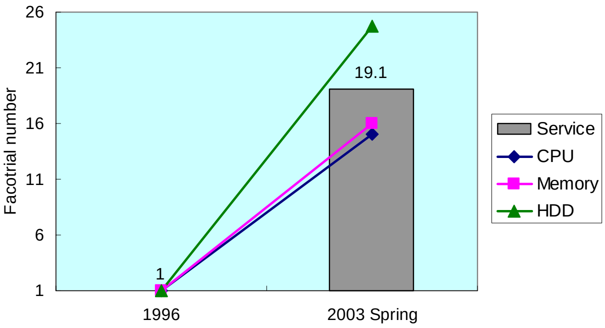


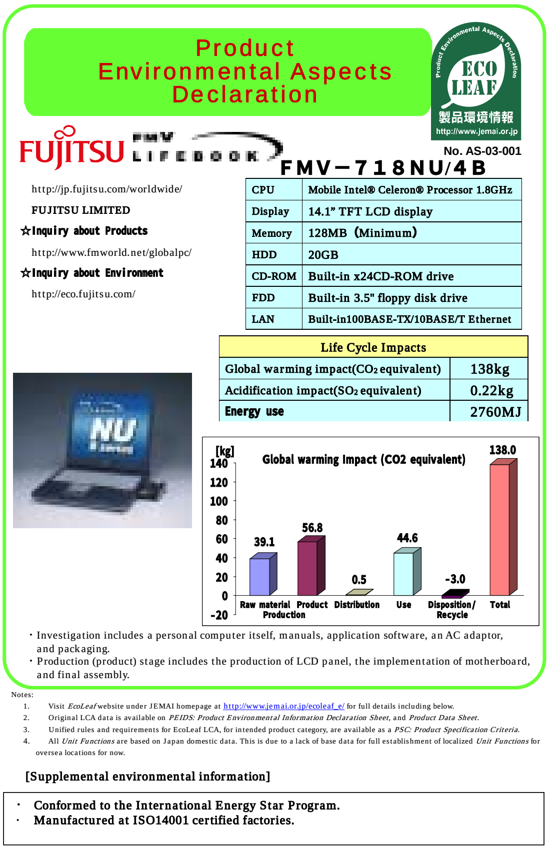
Fig. 2: The comparison of hardware specification and service value

QUANTIFYING THE ENVIRONMENTAL LOADS

1. Background

The EcoLeaf promoted by the Japan Environmental Management Association for Industry (JEMAI) is an environmental labeling program, which belongs to the Type III category defined by ISO TR(Technical Report) 14025 [6]. It has launched in June 2002 and by June 2004 more than 140 labels from 28 product categories are registered in this program.

Fujitsu has been participating in the EcoLeaf environmental labeling program from its trial stage and obtained EcoLeaf label by the notebook personal computer in June 2003, as its first time in PC industry as indicated in Figure 3. Fujitsu acquired 10 EcoLeaf label by the notebook personal computers so far (June 2004) and all the data are open to the public through the website. The summary of these 10 products are shown in Figure 4. [http://www.jemai.or.jp/CACHE/ecoleaf_prodbygrp_groupobj23.cfm]



Product
Environmental Aspects
Declaration

ECO LEAF 製品環境情報 http://www.jemai.or.jp

FUJITSU FMV LIFEBOOK

No. AS-03-001

FMV－718NU/4B

http://jp.fujitsu.com/worldwide/
FUJITSU LIMITED
☆Inquiry about Products
http://www.fmworld.net/globalpc/
☆Inquiry about Environment
http://eco.fujitsu.com/

CPU	Mobile Intel® Celeron® Processor 1.8GHz
Display	14.1" TFT LCD display
Memory	128MB (Minimum)
HDD	20GB
CD-ROM	Built-in x24CD-ROM drive
FDD	Built-in 3.5" floppy disk drive
LAN	Built-in100BASE-TX/10BASE/T Ethernet

Life Cycle Impacts	
Global warming impact(CO_2 equivalent)	138kg
Acidification impact(SO_2 equivalent)	0.22kg
Energy use	2760MJ

・Investigation includes a personal computer itself, manuals, application software, an AC adaptor, and packaging.
・Production (product) stage includes the production of LCD panel, the implementation of motherboard, and final assembly.

Notes:
1. Visit *EcoLeaf* website under JEMAI homepage at http://www.jemai.or.jp/ecoleaf_e/ for full details including below.
2. Original LCA data is available on *PEIDS: Product Environmental Information Declaration Sheet*, and *Product Data Sheet*.
3. Unified rules and requirements for EcoLeaf LCA, for intended product category, are available as a *PSC: Product Specification Criteria*.
4. All *Unit Functions* are based on Japan domestic data. This is due to a lack of base data for full establishment of localized *Unit Functions* for oversea locations for now.

[Supplemental environmental information]

- Conformed to the International Energy Star Program.
- Manufactured at ISO14001 certified factories.

Fig. 3: The first page of the EcoLeaf Type III environmental label (The example of FMV-718 NU/4B)

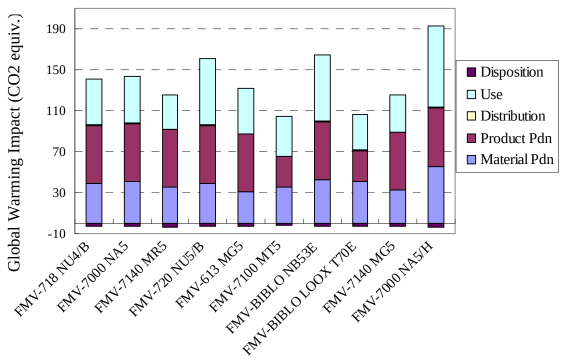


Fig. 4: The summary of CO_2 emission for 10 products

2. Highlight of the EcoLeaf computation

One of the main characteristics of the EcoLeaf program is existence of the Product Specification Criteria (PSC). In order to ensure the objectivity and consistency of the information declared, there are a set of standards for each product categories, such as the definition of products, the requirements and rules of the LCA calculation, the scenarios of product use and disposal, the methods of data collection, processing and use, and the data to be disclosed. Therefore, consumers or purchasers are able to make a solid judgment with these criteria [6].

PSC for notebook personal computer was set in 2003 and accessible by the website.
[http://www.jemai.or.jp/english/ecoleaf/pub_psc.cfm]
Some of the key elements of this PSC are as follows:

・Foreground data are set as LCD panel manufacturing, mounting of main board, and product assembly.

・EcoLeaf basic units are applied for the background data.

・Distribution stage is modeled as the transportation between product assembly site to Japanese domestic customers.

・For the product use phase, three typed of condition are considered such as active/waiting time, lower power time, and off time. Product is used 240 days a year for 4 years.

・In the disposition and recycle stage, product collection rate is set as 20% and deduction is countable for product reuse, component reuse, and material recycle.

The former product, FMV-5120 NA/X, has not obtained EcoLeaf label but we applied same assumptions and database for the comparison. The result of inventory analysis is shown in Table 2. In the EcoLeaf label, total 35 inventories are computed and Table 2 only shows some of the main inventories.

Table 2: The result of the inventory analysis

Unit: kg

(IN)	5120NA/X (old)	718NU4/B (new)	(OUT)	5120NA/X (old)	718NU4/B (new)
Coal	22.5	16.8	CO_2	162	136
Crude oil (fuel)	28.7	22.4	SOx	0.160	0.121
Natural gas	8.27	7.00	NOx	0.180	0.138
Crude oil (ingredients)	2.33	1.14	N_2O	0.00785	0.00635
Iron ore	2.47	1.18	CH_4	0.00278	0.00241
Copper ore	0.112	0.0406	Dust	0.0173	0.0126
Bauxite	0.481	0.228	Soloid waste	5.32	4.35
Water	16900	14000	Slag	2.81	1.64
etc…			etc…		

3. Application of LIME for integration

In the previous approach in Fujitsu, carbon dioxide emission from the inventory analysis is used as a representative of environmental burdens. However, it is preferable to include other inventories such as material consumptions, sulfur and nitrogen oxides emissions, dust and waste; therefore, impact assessment is applied in this time. Life cycle impact assessment method based on endpoint modeling (LIME) is developed by the Research

Center for Life Cycle Assessment of the National Institute of Advanced Industrial Science and Technology (AIST) in the framework of LCA National Project of Japan. This is the endpoint-type method of life cycle impact assessment and consists of three parts; characterization, damage assessment, and weighting [7]. In this study, we apply inventory data obtained from the EcoLeaf to the LIME methodology, and then compute the integrated indicator.

There are three types of integrated indicators in LIME and non-dimensional indicator based on the conjoint analysis is employed in this study. The result of the integrated indicators of two products is indicated in Table 3. Environmental loads are reduced about 20% in the new model. This is mainly due to the reduction of the material use and energy saving design of the latest product. In fact, the environmental loads have decreased 10% and 34% in the production and use stage respectively.

Table 3: The result of integrated environmental loads

	FMV-5120NA/X	FMV-718NU4/B
Production	246.4	220.2
Distribution	7.1	3.0
Use	122.1	80.9
Disposition	-2.9	-7.0
Sum	372.7	297.2

RESULT OF ECO-EFFICIENCY FACTOR

From the computation presented above, it can be seen that the service value has increased 19 time while environmental burdens have dropped 20% between two products; FMV-5120NA/X and FMV-718NU4/B. Therefore, Eco-efficiency Factor becomes as below:

Eco-efficiency Factor
= Service/ Environmental loads
= 19.1 / 0.8
= 23.9

It can be concluded that the Eco-efficiency Factor of notebook personal computer increased 24 times in 7 years.

DISCUSSION

Nowadays the concept of eco-efficiency is introduced to many firms and especially some Japanese firms are employing the Factor X as a product environmental indicator from the designing stage. However, a method and formula differ from firm to firm and it might end up with only confusing the customers.

Transparency and simplicity are the two key essential elements for any indicators. For the calculation of Eco-efficiency and Factor X, we believe that one solution to satisfy these demands is the application of hardware specifications for the measurement of service value and utilization of EcoLeaf Type III label for environmental load calculation as summarized in Figure 6. Most hardware specifications are readily accessible from the product catalogue and the results from the EcoLeaf are highly trustworthy. Beyond that, environmental loads can be integrated through LIME and it enables us to present only one indicator as a consequence. Further discussions are necessary for firms to present the uniformed indicators.

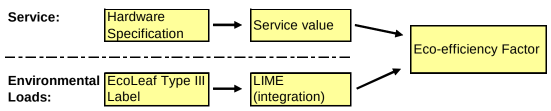


Fig. 6: Flow chart of computation

CONCLUSION

It is essential to evaluate the service value in the framework of Eco-efficiency, especially for IT products, which development are extremely rapid. For the indicator of environmental loads, EcoLeaf Type III label and LIME are helpful for the better and clear understanding for consumers. Finally, Eco-efficiency Factor is a crucial communication tool in order to purchase excellent and environmentally sounds products.

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