Application of Eco-Efficiency Factor to Mobile Phone and Scanner

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Abstract

The concept of Eco-efficiency, coupling with the stimulation of services and the effort of environmental load reductions, is beneficial to indicate the state of IT-products, which the developments are extremely rapid. This paper shows two comprehensive case studies, mobile phones and scanners, especially focusing on how to quantify the service values. As a result, the service value of the mobile phones increases 2.50 in one and half years, Eco-efficiency factor as 2.07. Also the service value of the scanners goes up 2.47, and Eco-efficiency Factor as 2.13 in two years.

In addition, utilizing core hardware specifications is proposed when quantifying the service value of multi-functional products, such as personal computers, PDAs and mobile phones. Core hardware evaluation enables us to quantify the service value of multi-functional products, which the availability and perception of services differ from person to person. Beyond that, core hardware evaluation allows us to correspond to new unexpected product's functions in the future. In contrast, uni-functional products such as scanners in this case study can be evaluated as their product functions that customers perceive.

1. Introduction

There are at present, many specified indicators which deliver the environmental performance of products that of Type I, II, and III labels defined by the ISO 14000 series, Life Cycle Assessment (LCA), Eco-efficiency, Factor X, and etc. Fujitsu is currently partaking in the Eco-efficiency Examination Committee sponsored by METI and is in the process of developing a new approach for a specialized environmental indicator, Eco-efficiency Factor. Application of the Eco-efficiency Factor has been demonstrated in personal computers by Fujitsu [1]. In this paper, the applications to mobile phones and scanners are discussed focusing primarily on how to quantify the service values.

2. 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 [2]. Eco-efficiency Factor in this study is the application of this conceptual framework into 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

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

3. Application to mobile phone

3-1. Product selection

For the examination of this study, two types of mobile phones, A and B, are selected: A was first introduced to the market in Feb. 2001 and B was then introduced in Oct. 2002. Both A and B are straight type figures and do not carry the digital photo function. Attached accessories, manuals, battery chargers, and packaging materials are not included in this study in order to specify the system boundary to the phone itself.

3-2. Quantifying the environmental burdens

The selection of carbon dioxide (CO_2) emission over the entire product life cycle is suggested as the amount of environmental burdens. CO_2 emission is considered as a proxy for energy consumption and a major factor of global warming effect, so at the moment we apply CO_2 emission as a representative of the environmental burdens. Life cycle inventory analysis has conducted with functional unit set as two years use of a mobile phone.

Product life is divided into the five stages as shown in Table 1. Metals, plastics, glass, and rubbers are classified in the "Materials and parts" stage. Besides these, semiconductors and liquid crystal panel (LCD) are classified and calculated as different entities because the energy consumption of manufacturing these parts is considered to be significant. The scopes of other stages are summarized in Table 1.

The result of inventory analysis for CO_2 emission is shown in Figure 1. One can see that most of the CO_2 emission stems from the product itself, which contains raw materials acquisition to manufacturing, but not from the product use. In addition, CO_2 emission of Product B increased 21% compared to Product A due to the increase in number of crucial semiconductors.

Table 1: Life cycle stage and scope

Stage	Scope
Materials and parts (battery included)	Raw materials (metals, plastics, glass and etc.) Semiconductors, LCD panel [3]
Assembly	Implementaion of mother board, final assembly
Transportation	Assembling facility to end user
Use	Calculate on the electricity use during the charge. Battery charge as 30min/day for total 2 years
End of life	Not investigated

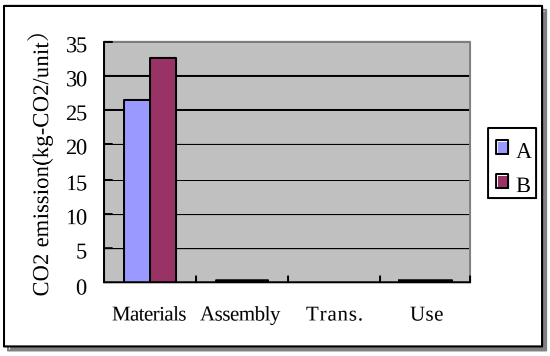

Figure 1: CO_2 emission of the mobile phones

3-3. Quantifying the service value

There is no definitive answer for the service value. Especially, in case of the multi-functional products such as personal computers and mobile phones, the perception of services differs from person to person. For instance, some people use mobile phones for only receiving calls and others use it as an emailing tool, morning alarm, game media during the commuting hours, digital camera, remote controller, and etc… Furthermore, the demands and requirements of the mobile phone between past, present, and future are expected to be very different.

[Accepted method]

Therefore, hardware specification of the mobile phone is employed in order to evaluate the service value as shown in Table 2. Four big items [namely Item X] are identified: computing speed, memory, Liquid Crystal Display (LCD), and battery. First two items are considered to be the basis for the performance even in the past and future. When one new function is added, some of these items need to be improved correspondingly. For instance, the function of digital photo and movie will increase the memory size dramatically. Second two items are regarded as peculiar to the mobile phone; the clearness of LCD and battery durability are essential for most users.

In order to calculate each Item X, several criteria are chosen. Then the ratio of new and old product is computed. The average of square root is utilized in order to unify the Item Y as well as the Item X as below:

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

S: the ratio of an old and new criterion
n: the number of criteria

Table 2: Service value as hardware specification

Services (Item X)	(Item Y)	Ratio of new/old S=(b)/(a)	={1/n Σ S^2}^0.5	
Computing speed	CPU clock 1	1.67	2.64	2.50
	CPU clock 2	3.33		
Memory	Memory	1.61	1.61	
LCD	Brightness	6.20	3.78	
	Size	1.13		
	Resolution	1.78		
Battery	Battery capacity	1.10	1.05	
	Electricity consumption	1.00		

[Other considerable methods]

During the brainstorming stage, several other methods have been developed for quantifying the services. Given below is a breakdown of these four methods.

Table 3: The breakdown of other methods

	Method	Item X
Accepted	Hardware spec.	CPU, Memory, LCD, Battery
Others 1	Calling function	Indication, Input, Storage, Power supply, Portability
Others 2	Usage state	Telephone, Email, Portability
Others 3	CPU, Memory	Only CPU and Memory
Others 4	Scoring system	Scoring semi-quantitatively for 15 items

3-4. Results

From the information above, Eco-efficiency Factor is given by the following equation.

Eco-efficiency Factor

$$= \frac{Service(\sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} S_i^{\ 2}})}{CO2emission(B/A)} = 2.50 / 1.21 = 2.07$$

Figure 2 describes the transitions of service, Eco-efficiency Factor, and CO_2 emission values. Despite CO_2 emission has increased in the newer model, Eco-efficiency Factor becomes almost double. That is because increase in service value compensates increase in CO_2 emission as a total.

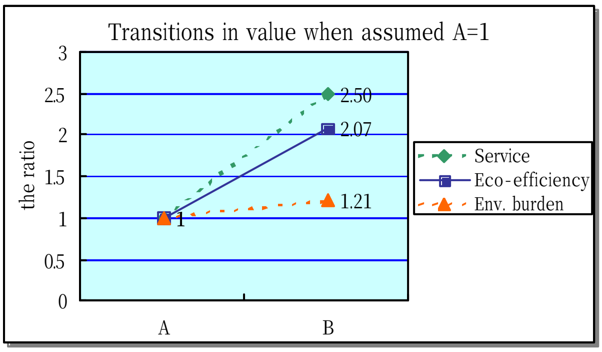

Figure 2: Eco-efficiency Factor of mobile phone

Beyond that, Eco-efficiency Factors for all the methods (See Table 3) are indicated in Figure 3. It can be seen that the results differ from method to method due to the change of the evaluation viewpoints.

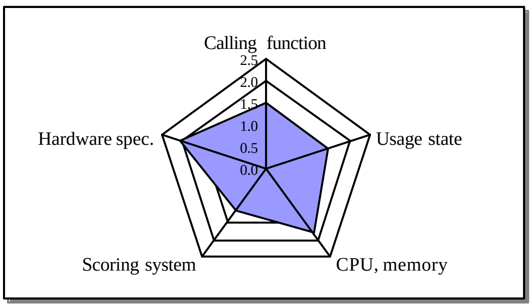

Figure 3: Eco-efficiency Factor of various methods

4. Application to scanner

4-1. Product selection

Two types of scanners, fi-4110C and fi-4120C produced by PFU, are selected for this case study. fi-4110C was first introduced to the market in spring 1999 and fi-4120C was then released in spring 2002. Both models are compact A4 two-sided color document scanners weighing less than 4 kg. Packaging materials and manuals are included in this study.

4-2. Quantifying the environmental burdens

CO_2 emission over the product life cycle is utilized as the proxy of environmental burdens (See 3-2). Functional unit of this inventory analysis is defined as 5 years use of a scanner. The life cycle stage and scope are summarized as shown in Table 4. Again, semiconductors are categorized independently and calculated as a different entity in the "Materials and parts" stage.

The result of CO_2 emission is given in Figure 4. CO_2 emission has increased in "Materials and parts", "Transportation", and "Use" stages in total 16%.

Table 4: Life cycle stage and scope

Stage	Scope
Materials and parts	Raw materials (metals,plastics,glass,and etc.) Semiconductors
Assembly	Final assembly
Transportation	Assembling facility to end user
Use	Operation: 2hours/day, Stanby: 6hours/day Use of 240 days/year for total 5 years
End of life	Not investigated

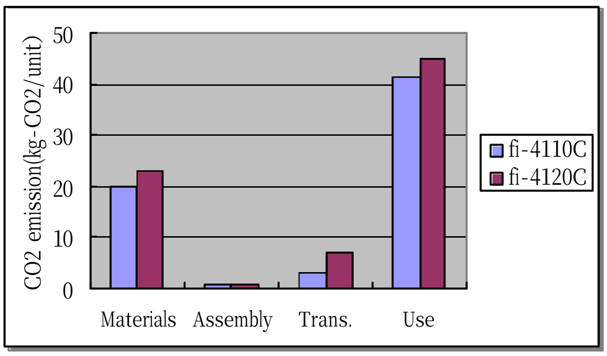

Figure 4: CO_2 emission of the scanners

4-3. Quantifying the service value

Hardware specification is applied for the case study of personal computers [1] and mobile phones since services cannot be specified in a simple way for these multi-functional products. Unlike personal computers and phones, scanners carry only one definitive function, which is "scanning"; customers know what to do when faced with scanners. This characteristic enables us to evaluate the service from the product functional point of views, in this case, scanning function.

In order to define the product function, three types of performance are selected: the optical, media processing, and data processing performances (namely Item X). For each Item X, several criteria (namely Item Y) are selected. Optical performance consists of two criteria, such as basic resolution and readout speed. Then the ratio of new and old product is computed. The average of square root is utilized in order to unify the Item Y as well as Item X. In consequence, the service value in terms of scanning function increased 2.47 as shown in Table 5.

Table 5: Service value as product function

Services (Item X)	(Item Y)	Ratio of new/old S=(b)/(a)	={1/n ·S S^2}^0.5	
Optical performance	Basic resolution	2.00	3.81	2.47
	Readout speed	5.00		
Media-processing performance	Max. media size	1.00	1.24	
	Media thickness	1.44		
Data-processing performance	Program numbers (pre-installed)	1.50	1.50	

4-4. Results

Eco-efficiency Factor is calculated as 2.47/1.16 =2.13. The transition of these three values, service, Eco-efficiency Factor, and CO_2 emission, are shown in Figure 5. One can see the same trend in mobile phones presented in Figure 2. Although both service and CO_2 emission have increased, Eco-efficiency Factor appeared to be positive due to the higher increase in the ratio of services than to the increase in the ratio of CO_2 emission.

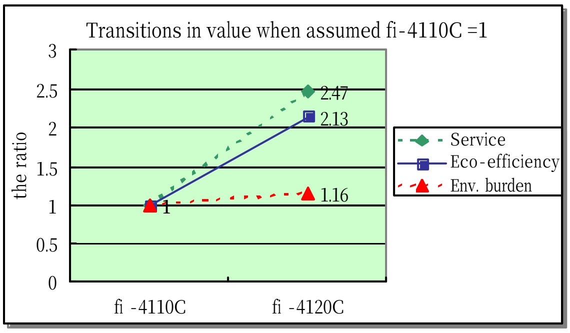

Figure 5: Eco-efficiency Factor of Scanner

5. Discussions

1. In accordance with product characteristics, it is pivotal to select quantifying methods of services.

Product Type	Example	Method
Multi-function	PC, PDA, phone ⇨	Core Hardware Specification (Indirect evaluation)
Uni-function	Scanner ⇨	Product Function (Direct evaluation)

2. For the life cycle CO_2 emission of products, product use phase is not always the largest factor. (See Figure 1) Electronic equipment tends to be considered that the use phase is the most significant on emitting CO_2. However, our result of mobile phones shows the product itself emits greater quantities of CO_2 than other phases.

3. The designer's data are the key to calculate the service value. (See Table 2) When quantifying the service value of mobile phones, we have attempted to gather all the information from product catalogs. However, it seems to be not enough since the product catalog not always carry the same information. The information are rather based on products characteristics. Therefore, it was necessary to check the specifications that designers keep.

4. Evaluation criteria for services have to be fixed. (See Figure 3) Even in the same product comparison, the service value fluctuates a lot by the changes of evaluation viewpoints. It would be crucial to fix the evaluation method for each product group.

6. Conclusions

Due to the extremely rapid developments of IT-products, the improvement of services cannot be excluded in the framework of Eco-efficiency. It is necessary to select two different methods when quantifying the service value. For the multi-functional products including personal computers, PDAs, and mobile phones, it would be preferable to evaluate from their core hardware specification. Core hardware evaluation allows us to compare even in the different time scale with the same parameters and also enables us to correspond to the new product's functions. On the other hand, uni-functional products such as scanner in this case study can be evaluated as their product functions.

7. References

[1] Fujitsu Limited (2002) 2002 Fujitsu Group Environmental Report. p.23

[2] World Business Council for Sustainable Development. http://www.wbcsd.ch accessed in Aug 2003

[3] Yamaguchi, H. et al (2002) A Life Cycle Inventory Analysis for Liquid Crystal Displays. Proceeding of The Fifth International Conference on EcoBalance, S1-76