The Handbook

The “eco-efficiency” and “factor” concepts were proposed about ten years ago, the study and application for the definition and formulae of indicator and for the and other specific methods has barely begun in Japan. These concepts are definitely at the early stage, when companies where they have already been introduced are working to increase their staff's awareness and encourage their staff to apply them to their practical work experiences. But interest in the concept of eco-efficiency that aims to reduce the environmental impact and increase the value is growing steadily as a concept essential for corporate management. This handbook responds to this growing interest by introducing outlines of the significance of the eco-efficiency and factor concepts and of the benefits of their application by explaining practical application methods.

Who are the target readers of this handbook?

It is assumed to be primarily business sectors. It is sure to be of practical use when staff of manufacturing divisions (development and design divisions, quality control divisions etc.) and environment divisions in particular apply it to their work.

What are the target industries of this handbook?

The contents of the handbook are primarily concerned with electrical and electronic products, but the methods it describes can be of use to other industries.

Please give us your comments

We wish to respond to the comments of anyone who is interested in this topic. We would like to improve this handbook to distribute it more widely. Please send us your feedback and your questions regarding our activities on the eco-efficiency and factor concepts.

(Please direct them to the telephone and fax numbers and the E-mail address on the last page)

Contents

What do we expect from eco-efficiency and factor?

1.1 What is the target of eco-efficiency and factor application?

Transformation of ideas — to find new wealth and value

In the twentieth century, technology advanced far more rapidly and economic activities expanded far more than ever before, providing people with social lives that are extremely convenient and abundant. But the lifestyle we now enjoy thanks to mass production, mass consumption, and mass disposal has placed a heavy impact on the environment, resulting in a variety of critically dangerous circumstances referred to collectively as global environmental problems, and including atmospheric pollution, water quality deterioration, waste problems, global warming, and harmful chemical substances. This trend intensified rapidly in the last half of the twentieth century, and it is now doubtful that, unless it is reversed, sustainable development of the economy and society can be guaranteed in the twenty-first century.

The German professor, Dr. Ernst-Ulrich von Weizsaker and et al have responded by proposing Factor Four as a method of achieving abundance while considering the earth's limitations. Factor Four, a way of doubling wealth,halving resource use in order to achieve sustainable development of the globe is a sharp departure from the twentieth-century concept of reliance on mass production and mass consumption.

The factor concept originally had a global scale perspective, but it is a concept that can be applied effectively to national level evaluations to achieve higher GDP (abundance and value) accompanied by a lower environmental impact (energy consumption for example), and also to corporate level evaluations to achieve higher sales and corporate profits (social benefit that is provided by the company)while creating a lower environmental impact (CO_2 emissions for example). If this concept is further developed, it can be applied to products. This handbook is intended to be used as a guidebook to its application to products.

Mechanism to act promptly and to respond flexibly to change

The role of eco-efficiency and factors in helping transform ideas is the support and popularization of eco-products that encourage the creation of sustainable society.

The age when the goal was only lowering the environmental impact is over. In a business environment that demands the pursuit of diverse wealth, corporations must constantly respond flexibly as they transform themselves so that they can always anticipate and act promptly to react to change. Businesses must adopt new concepts and system creation so they can revise their procedures without being bound by established ideas to meet the needs of a new age.Eco-efficiency and factor are new ideas that can be applied effectively to achieve these goals.The use of these indicators enables us to measure progress in efforts to lower the environmental impact while increasing value. Two types of improvement—lower environmental impact and increased value—will probably provide the motivation to develop products that provide greater value and are kinder to the environment than earlier products. We are counting on the readers of this handbook to fully understand its content and apply it in a positive manner to product development.

1.2 What is the meaningful “efficiency” to measure the environmental performance?

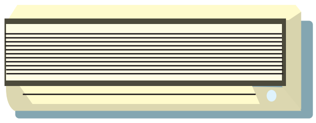
Familiar examples of efficiency

Isn't eco-efficiency a concept similar to the idea of “efficiency” that is used in daily life?

Examples of efficiency that immediately come to mind are energy-consumption efficiency, electric power generation efficiency, fuel consumption efficiency (fuel consumption), investment efficiency, work efficiency, and so on. The Iwanami Dictionary of the Japanese Language defines efficiency (Japanese word, koritsu) as, “the ratio of the quantity of work performed by the effective operation of a machine and the total energy supplied to it.” The following are a few familiar examples.

① Energy consumption efficiency of an air conditioner (COP)[1]

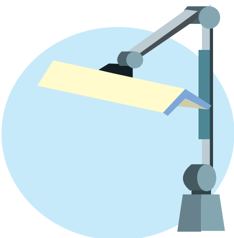
This is calculated by the following formula.



(Cooling or heating capacity [kW])/(Electric power consumption [kW])

This measurement method is stipulated by JIS(Japanese Industrial Standards). The COP (=Coefficient of Performance) listed in a catalog is data obtained by a measurement method stipulated under the Energy Conservation Law, and recently products with a COP of 6.0 or more have appeared.

② Energy consumption efficiency of a lighting fixture[1]



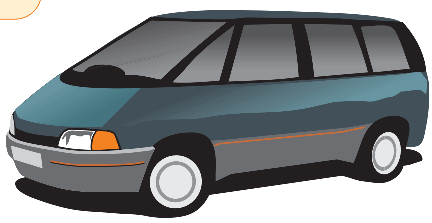
It is represented by the following formula.

(Brightness of the light [lm (Lumen)]/(Electric power consumption [W])

Lighting fixtures should provide adequate brightness using a small quantity of electric power. For example, because the brightness of a 60W incandescent bulb can be obtained with a bulb type fluorescent lamp of about 15W, fluorescent lamps can be defined as energy-saving products

③ Fuel consumption efficiency (fuel consumption)

The fuel consumption efficiency that is an important point when purchasing a car is represented by the following formula.



(Distance driven [km])/(Quantity of fuel consumed [L])

Data measured by the 10･15 mode (a driving mode that simulates the average driving patterns in a city and on an expressway, it is used for testing to confirm exhaust gas) is generally obtained.

In these ways, “efficiency” can probably be defined as “ratio of effective output to the input.” Eco-efficiency too can be understood as a type of efficiency if it is considered to represent the ratio of various values (=effective output) that are obtained by a product to the equivalent value, input, that refers to the impact on the environment.

Efficiency includes cases where the numerator and denominator are the same type of yardstick as shown in ①and cases such as ② and ③ where they are not the same. When representing eco-efficiency, it is necessary to present not only the numerical values, but to also show the units in order to avoid misunderstandings and confusion, because as shown by the explanation of the method of defining indicators in the next chapter, generally the numerator and denominator are different yardstick.

1 Energy Conservation Capacity Catalog — Summer 2003 by the Energy Conservation Center, Japan

1.3 Start to calculate eco-efficiencies and their factor — in the case of refrigerators

Formulas of eco-efficiency and factors

The "fuel consumption efficiency" case described in the previous section can be defined as an efficiency that is increased when a vehicle can drive further while consuming less fuel. The eco-efficiency concept is similar. In this chapter, the eco-efficiency of a refrigerator made ten years ago and that of a new refrigerator are calculated as an example. So that this example is easier to understand, the environmental impact that is the denominator used is the electric power consumed during use that is the heaviest impact during a refrigirator's life cycle. The numerator is the capacity that is assumed to be the product value that is a user's top priority. High (eco-) efficiency is the ability to cool more goods with less electricity. It was not stipulated in advance just what kinds of data (calculation range for example) would be used to define what kinds of environmental impact and product value. There are actually a variety of concepts.

● Example: Basic data for the calculation of eco-efficiency and its factor (refrigerators)

	Refrigerator made 10 years ago	New refrigerator
Capacity (L)	150	300
Electric power consumption (kWh/year)	1000	200

● Eco-efficiency of the refrigerator made 10 years ago

$$\frac{\text{Capacity (numerator)}}{\text{Electric power consumption (denominator)}} = \frac{150\ \text{L}}{1000\ \text{kWh/year}} = \text{Eco-efficiency } 0.15$$

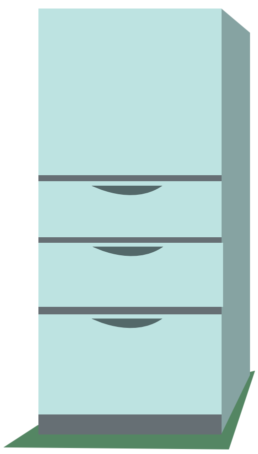
The eco-efficiency obtained is 0.15 (unit omitted for simplicity) but, it is not clear how to asses its environmental impact based only on this value. The eco-efficiency of the present refrigerator is calculated as follows

● Eco-efficiency of the new refrigerator

$$\frac{\text{Capacity}}{\text{Electric power consumption}} = \frac{300\ \text{L}}{200\ \text{kWh/year}} = \text{Eco-efficiency } 1.5$$

The eco-efficiency of the new refrigerator obtained is 1.5. It is a value that is 10 times the eco-efficiency of the refrigerator made 10 years ago. Although its capacity is about twice as great, technological progress achieved during the past 10 years has improved energy conservation design, lowering its total electric power consumption to 1/5 of its former value.

Next, the ratio of the eco-efficiency of the 10-year old refrigerator to that of the new refrigerator is obtained.



● Factor

$$\frac{\text{Eco-efficiency of the evaluated product (new)}}{\text{eco-efficiency of the yardstick product (10 years old)}} = \frac{1.5}{0.15} = \text{Factor of 10}$$

This is a factor. It shows that its eco-efficiency is 10 times that of a refrigerator made 10 years ago. If no technological progress had been achieved, in order to use a refrigerator with doubled capacity using 10 year old technology, it would probably consume almost 2,000kWh of electric power. When a producer wishes to increase refrigerator capacity (product function), but also wishes to lower electric power consumption (environmental impact), a factor allows such an ideal to be quantitatively expressed.

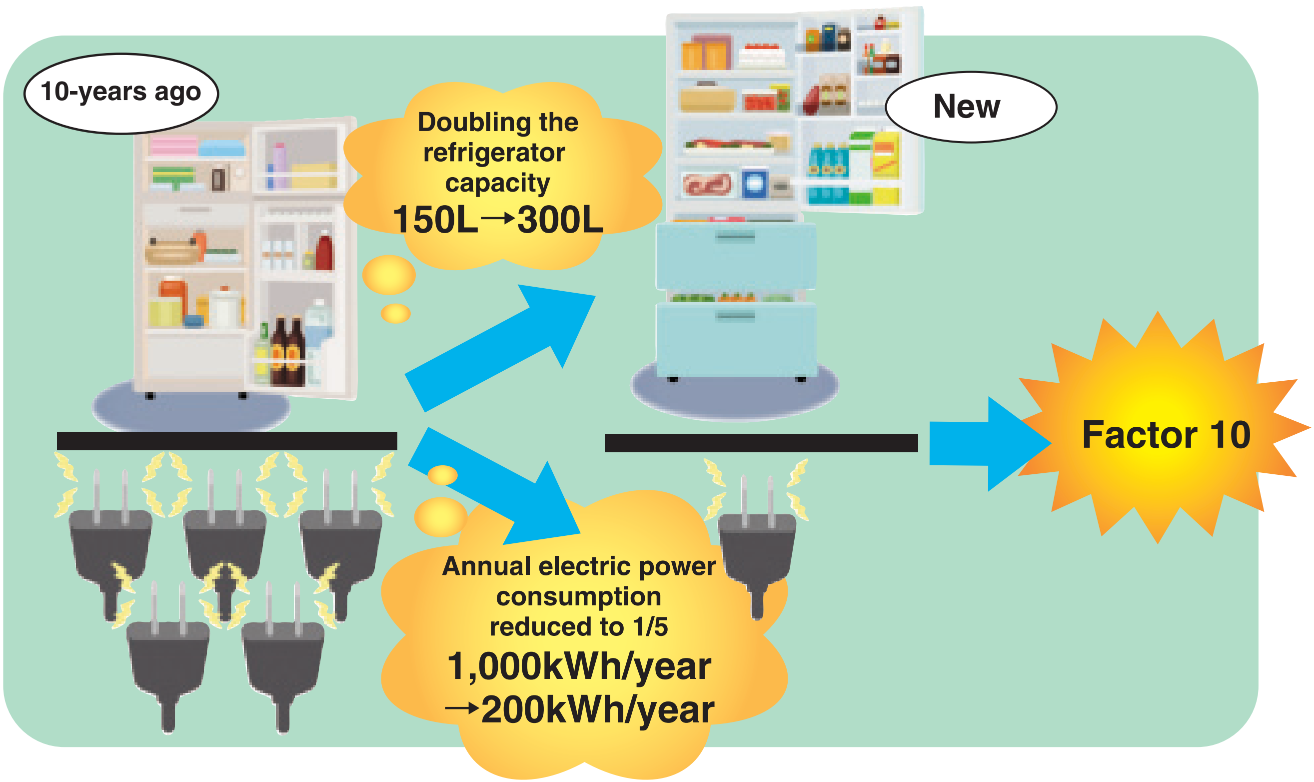
Eco-efficiency and factors can be improved by lowering the environmental impact and maximizing the product value. This means that it is a positive indicator that can be used not only to assess a product from the perspective of environmental impact reduction but also more progressively, assess the technological progress that improves its performance and other product values.

This concludes the explanation of the refrigerator example. Eco-efficiency and its factor can be generally represented as follows[2].

$$\text{Eco-efficiency} = \frac{\text{Products value}}{\text{Environmental impact}}$$

$$\text{Factor} = \frac{\text{Eco-efficiency of the assessed product (new)}}{\text{Eco-efficiency of the yardstick product (old)}}$$

The following figure schematically explains operation of the eco-efficiency and factor approach by taking the refrigerator as an example.



2 The numerator of the eco-efficiency is presented as product value, but “product” as used in this handbook, means “products and services.” The same applies in rest of the handbook.

How do we calculate eco-efficiency and factors and present them ?

2.1 How to calculate eco-efficiency

The previous section explained the method of calculating eco-efficiency and a factor using refrigerators as an example, but in this section, the eco-efficiency and factor calculation methods are explained in general.

Eco-efficiency numerator (product value)

The product value, or in other words, product functions, performance, quality, service life, and so on are clarified. It is also possible for the numerator to be quantified accounting for physical quantities, economic value, and so on (see Figure 1), but in Japan it is often considered to be functions and performance. It is probably best to use those that have been disclosed to the public through product brochures or catalogs in order to guarantee transparency and reliability.

Figure 1. Example of Product value (Numerator)

Item	Product examples	Examples of items applied
Physical quantities	- (common)	Production volume (units, kg, tons, etc.)
Economic value	- (common)	Amount of sales, profits or income (currency)
Functions and performance	Refrigerators	Capacity, cooling speed, freezing speed
	Personal computers	MPU processing capacity, hard disk capacity
	Scanners	Optical performance, media processing performance, data processing performance
	Washing machines	Washing capacity, product service life
	Printers	Printing speed, image quality
	Radiators	Ease of disassembly, product service life, number of parts
	Cell phones	Calculation speed, memory, LCDsize, battery life

As shown by the above examples, a wide range of items are treated as values of a product (numerator). It is necessary to carefully study each case to decide which items to consider.

It is possible to integrate multiple items when converting them to numerical values to obtain an integrated representation. Below a number of examples of cases where integration was done in line with the concept of multiple values to represent them as a single value are explained.

(Note: the following is only one example of the concept of numerator integration.)

Example 1. Integrating multiple functions by averaging the sum of squares

Averaging the sum of squares, $=\sqrt{\frac{1}{n}\sum_{i=1}^{n} s_i^2}$, is used to integrate multiple performances.

The average of the sum of squares is obtained and returned based on the average of the squares

[Example of an indicator from Fujitsu]

Figure 2. Data to Calculate the Product Value [numerator: function] (Scanner)[3]

Functions/performance		Unit	Old (a) fi-4110C	New (b) fi-4120C	Comparison of new and old functions/performance (b)/(a)	
Optical performance	Basic resolution	dpi	300	600	2.00X	3.808X
	Reading speed (Color, both sides)	ipm	5	25	5.00X	
Media processing performance	Max. document size	mm	210×297	210×297	1.00X	1.240X
	Document thickness	kg/ream	45-90	45-110	1.44X	
Data processing performance	creen processing/ contraction function (Yardstick equipment)	Program numbers (pre-installed)	4	6	1.50X	1.500X

[Definition and calculation of the numerator]

Optical performance

$$3.808=\sqrt{\frac{1}{2}(2^2+5^2)}$$

Media processing performance

$$1.240=\sqrt{\frac{1}{2}(1^2+1.44^2)}$$

Data processing performance

$$1.500=\sqrt{\frac{1}{1}(1.50^2)}$$

Integration of product value (numerator)

$$2.469=\sqrt{\frac{1}{3}(3.808^2+1.240^2+1.500^2)}$$

The numerator is calculated by applying numeric aspects from major functions of scanner.The ratio of new/old products is represented by averaging the sum of squares.Thus,the improvement of each function can be expressed.

In order to obtain total value,multiple functions are integrated and averaged again.

Example 2. Multiplying product service life and product functions

Figure 3. Data to Calculate the Product Value [numerator: function] (Washer)

	New product	Old product
Product service life	10 years	10 years
Product functions (washing capacity)	8 kg	6 kg

[Sample indicator from Matsushita Electric Industrial Co., Ltd. and Hitachi Corp.]

[Definition and calculation of the numerator]

Product value (numerator) = product service life × product functions

numerator of new product = 10 × 8 =80

numerator of old product = 10 × 6 =60

3 In this example, the factor was not calculated by obtaining the eco-efficiency of a yardstick product and an evaluated product; the degree of improvement of the product value (nominator) of the yardstick product and of the evaluation product were calculated in advance as a comparison of the old and new products.

Example 3. Weighting and totaling product functions

(1) Setting the product functions
(2) Calculating coefficients according to degree of customer satisfaction (examples frequency of use, average unit price, etc.)
(3) Calculating the functions (capacity of the functions) according to absolute values
(4) Making the performance of the old and new product dimensionless with the performance of the yardstick product as the yardstick. (adding the unit)
(5) Adding by multiplying the coefficients.

Figure 4. Data to Calculate the Product Value [numerator: function] (IH cooking heater[4])

Functions	Coefficient	Product in 2002 (new product)				Product in 1995 (old product)			
	Function provided/not provided	Performance (W)	Dimensionless	Coefficient addition	Coefficient addition	Function provided/not provided	Performance (W)	Dimensionless	Coefficient addition
Right IH heate	1,825	1	2,000	1.00	1,825	1	2,000	1.00	1,825
Left IH heater	1,825	1	3,000	1.50	2,738	1	2,000	1.00	1,825
Radiant heater[5]	209	1	0.36	1.00	209	1	0.36	1.00	209
Roaster	150	1	0.20	1.00	150	1	0.20	1.00	150
Total product functions					4,922				4,009

Performance in 2002/performance in 1995 =3000/2000＝1.5

With/without function is represented as 1 or 0

Figure 5. Concept of Coefficient (Frequency of Use)

Functions	Formula	Frequency of use	Coefficient
Right IH heater	5 times/day × 356 days × 10 years	18,250	1,825
Left IH heater	5 times/day × 356 days × 10 years	18,250	1,825
Radiant heater	209 times/year × 10 years	2,090	209
Roaster	150 times/year × 10 years	1,500	150

[Definition and calculation of the numerator]

Product value (nominator) [heating capacity = right IH heater + left IH heater + radiant heater + roaster]
Nominator of new product = (1,825 × 1.0)+(1,825 × 1.5)+(209 × 1.0)+(150 × 1.0)=4,922
Nominator of old product = (1,825 × 1.0)+(1,825 × 1.0)+(209 × 1.0)+(150 × 1.0)=4,009
[Sample indicator from Matsushita Electric Industrial Co., Ltd.]

4 IH (Induction Heating) cooking heater = hot plate used in kitchens
5 A radiant heater refers to a heater for an aluminum pot, copper pot, or small pot not equipped with an IH heater

Eco-efficiency denominator (environmental impact)

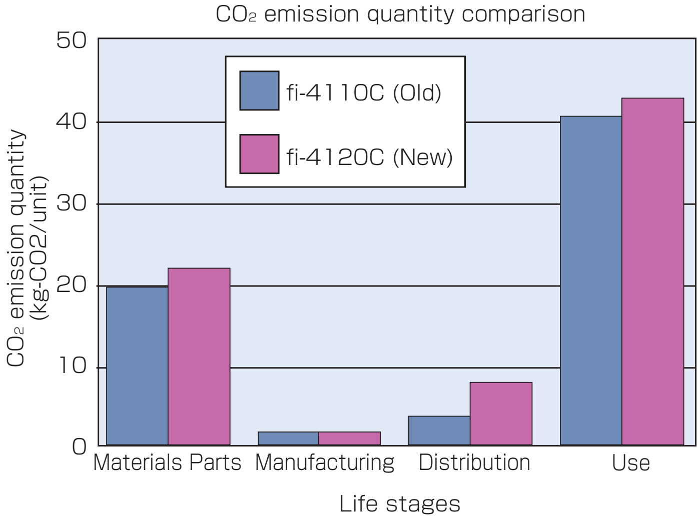
It is clarified based on the environmental impact. This impact includes global warming, resource use (electric power, water consumption, iron ore consumption, etc.), and the effects of the use of harmful substances (lead, toluene, mercury, etc.). Also the overall life cycle of his product should be clarified.Refer to the following environmental impact items and calculation example Note) The following is just an example.

Figure 6. Example of Environmental impact (Denominator)

Major items	Items	Examples of items	Unit
Input	Energy consumption	Energy consumption (electric power, fossil fuels, etc.)	W, kg
	Resource consumption	Materials(raw materials, solvents, intermediate products, etc.),water,etc.	kg,m^3
	Natural resources consumption	Water	m^3
	Chemicals	Lead, toluene, mercury, etc.	kg, g
Output	Quantity of outputs	Quantity of output of substances harmful to the ozone layer	Converted to kg of CFC
		Quantity of output of greenhouse gasses	Converted to kg of CO_2
		Acidification coefficient	Converted to kg of SO_2
		Waste material	kg

Example 1. Quantity of CO_2 emissions during the life cycle

Figure 7. Data used to calculate the [Environmental impact (denominator)] (Scanner)



The quantity of CO_2 emissions through the life cycle of the product is used as the environmental impact.

- Manufacturing: final assembly site
- Distribution: from final assembly site to user
- Use: hypothesized as in use 2 hours/day and stand-by for 6 hours/day for 240 days/year for 5 years.

*Disposal and recycling are not considered by the calculation, because it is assumed that there is little difference between the old and new product.

[Example of indicator from Fujitsu]

[Definition and calculation of the denominator]

Environmental impact (denominator) = total CO_2 emissions during the life cycle (kg-CO_2/unit)

= materials ・ parts + manufacturing + distribution + use (kg-CO_2/unit)

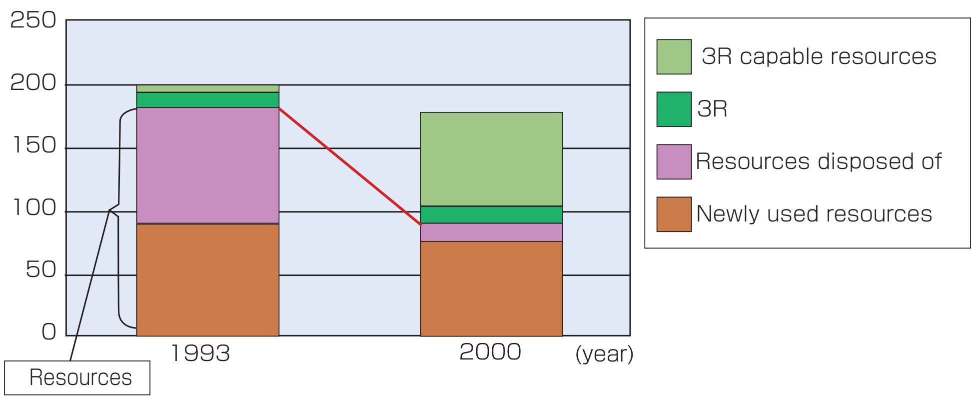
Denominator of new product (fi-4120C) = 23.02+1.1+7.21+45.2=76.53 (kg-CO_2/unit)

Denominator of old product (fi-4110C) = 20.34+1.1+3.3+41.4=66.14 (kg-CO_2/unit)

Example 2. Quantity of resources during the life cycle

Quantity of resources not recycled is used as the environmental impact .

Figure 8. Data Used to Calculate the Environmental impact (Denominator) (TV)



[Definition and calculation of the denominator]

Environmental impact (denominator) = Resources that do not circulate over the entire life cycle

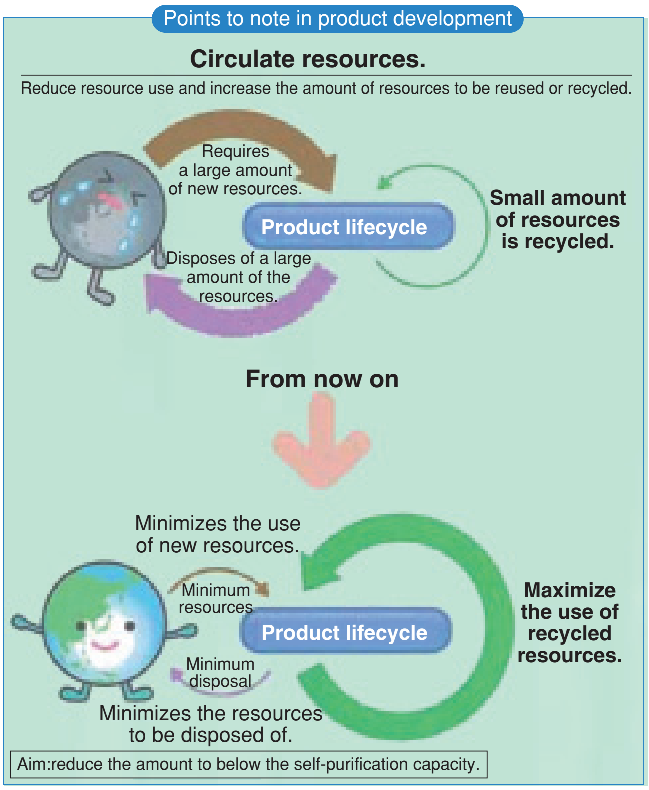
* Resources not circulared = Newly used resources +Resources disposed of

= Used resources-reused or recycled resources + Used resources-reusable or recyclable resources

Denominator of new product (2000 product): (87.77-9.10)+(87.77-72.24) = 78.68+15.54 = 94.22 (kg)

Denominator of old product (1993 product): (100.10-10.48)+(100.10-8.28) = 89.63+91.82 =181.45 (kg)

[Example of an indicator from Matsushita Electric Industrial Co., Ltd.]



If this indicator is used, 3R (reduce (resource conservation, long use), reuse, and recycle) can be assessed.

Products in a recycling-oriented society should be used as resources to the greatest possible degree. At the same time as quantity of resources newly input as raw materials etc. should be reduced, the quantity of resources discarded should also be reduced.

In this example, if both are not reduced, the environmental impact is not minimized.

[Image and indicator from Matsushita Electric Industrial Co., Ltd.]

Example 3. Integrating multiple environmental impacts

Because a method of integrating environmental impacts as a single indicator has not been established, they may be represented separately for multiple environmental impacts (global warming, resource consumption, etc.). Or integrating data so that the persons viewing the information will find it easy to understand as shown in the following example (Figure 9) is also considered.

(Example) Case where the environmental impacts of a comparison product are calculated and integrated as the sum of their vectors when the denominator (environmental impact) consists of three factors, global warming (energy consumption), resource consumption, and specified chemical substances, these are integrated and the result treated as a single environmental impacts, and each of the environmental impacts of the yardstick product are considered to be 1:

Figure 9. Data to Calculate Environmental impacts (denominator) (cell phone)

	M:Effective use of resources	E:Efficient use of energy	T:Reduce use of substances potentially harmful to the environment
1991 year model (yardstick product)	**1**	**1**	**1**
2002 year model (Evaluation product)	**0.42**	**0.24**	**0.82**
Details of the improvements	Reduction of of virgin resources **58**% Reduction In non-recyclable resources **60**%	Electricity consumption Reduction at time of regular use **66**% Reduction at standby time **96**%	Reduction in lead of solder **18**%

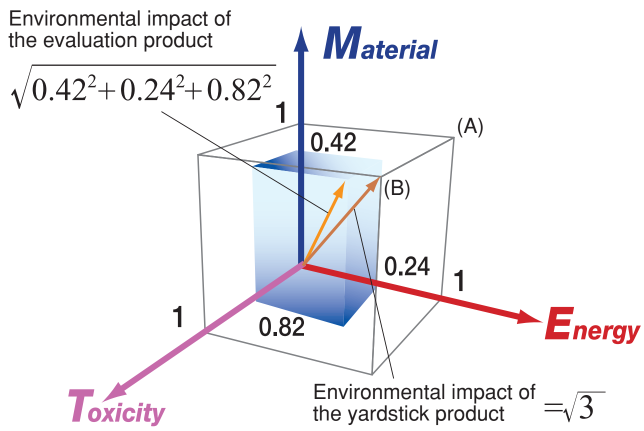
[Definition and calculation of the denominator]

Environmental impact (denominator) $=\sqrt{(M^2+E^2+T^2)}$

Denominator of the yardstick product $=\sqrt{1^2+1^2+1^2}=1.73$

Denominator of the evaluation product $=\sqrt{0.42^2+0.24^2+0.82^2}=0.95$

Figure 10. Schematic of Integration of Environmental impact



[Example of indicator from Mitsubishi Electric Corporation]

In the above example (Fig. 10), the environmental impact is represented by three-dimensional space in MET. The environmental impact of the yardstick product is clarified as the length of the diagonal line of the cube (A), and the environmental impact of the evaluation product is clarified as the length of the diagonal line of the rectangular parallelepiped (B). And the direction of the diagonal lines can be viewed as the environmental impact with the greater impact, so that the degree of the improvement of the environmental impact can be understood at a glance. But if well balanced reduction is not done, one side will lengthen so that the value representing the environmental impact (length of the vector) will not be small. This method provides a way of representing integration, by for example, clarifying the total environmental impact even when one of the MET has become zero.

Integration of the denominator,numerator of eco-efficiency

As already stated, there are various methods of calculating eco-efficiency and its factor. It is necessary to note that each method has its merits and demerits. The methods should be combined considering the elements of the product value, characteristics of the environmental aspect that is selected as the indicator, and the purpose of its use.

Figure 11. Advantages and Disadvantages of Integrating and Unifying the Factors and Using Them Separately (as Multiples)

	Advantages	Disadvantages
Single factor that has been integrated	• It is easy for non-experts (parties using the information) to instantly understand the overall degree of improvement	• Is the integration method fully appropriate? • It is difficult to let people understand the concept of the integration.
Separate (multiple) factors	• It is easy for a corporation (party disclosing the information) to create • It is easy for non-experts (parties using the information) to separately understand the degree of improvement of each environmental impact	• It is impossible to understand the total degree of improvement. • If only one factor has sharply improved,it would be necessary to check each,item to specity the most inflnential one

Representing multiple evaluation items by a single indicator has the merit that it is easily understood, but it also has a demerit; concentrating multiple items make it difficult to understand individual environmental problems and inducting factors. And it is predicted that if a weighting coefficient is used during the integration process, coordination between concerned parties necessary to set the common rules is difficult.

Calculation of factor

Above, the ratio of the eco-efficiency of a yardstick product and that of an evaluation product was treated as the factor. In the above examples, the eco-efficiency of a past product (yardstick product) and a present product (evaluation product) were compared. It is probably also possible to set a factor that should be the target by comparing the present eco-efficiency and the eco-efficiency that should be achieved in the future.

2.2 Presentation of eco-efficiency and facotrs

It is necessary to correctly explain what eco-efficiency and the indicator of a factor mean and the purpose of introducing the concepts and indicator, to gain understanding and thereby, increase the value of eco-efficiency and factors as tools in the market. It is necessary to avoid misunderstanding by, for example, explaining that the formulae were not created by defining them in a way that benefits corporations in particular. The following are basic precautions to be followed when using eco-efficiency and a factor to disclose information to the public. Refer to these when examining eco-efficiency or factors and when explaining them to people in other departments of your company and in other companies

(1) Clarify definition of eco-efficiency and disclose

The definition of eco-efficiency should probably be clarified by presenting a specific indicator and formulae concerning the denominator of eco-efficiency (environmental impact) and the numerator (product value).

(2) Select items of eco-efficiency to guarantee transparency and reliability

The value can fluctuate according to the indicator selected as the numerator of eco-efficiency (product value). Consequently, transparency or reliability should be obtained by, for example, using those disclosed in product brochures or catalogs.

(3) Clarify the definition of a factor

A factor reveals the degree of improvement of the eco-efficiency between an old and a new product to clarify their eco-efficiency relationship. Because a method of integrating multiple environmental impact with differing dimensions with a single indicator has not been established, there are cases where a factor is defined for each environmental impact. In such cases, it should be clarified which aspects of environmental impact each factor represents.

(4) Clarify the baseline year or the product model name that is the yardstick when disclosing a factor

When disclosing a factor, the yardstick year or the product model name that is the yardstick is clarified. At this time, it is a common concept that a factor is treated as a relative indicator that represents the degree of improvement of a new product over an old product made by the same company, but because their definitions, the yardstick products, and formulae differ between companies, it is impossible to compare them. It should be clarified that it is a comparison between internal products.

(5) Clarify the definition of a factor that discloses eco-efficiency calculation data for both the numerator and denominator

When factors are disclosed, the values of the numerator/denominator are represented at the same time. It is not correct to disclose only the value of a factor. It is necessary so that, for example, two questions can be answered. Was the factor raised by improving the environmental impact (denominator) or was the factor raised by increasing the product value (numerator)?

2.3 Steps to apply eco-efficiency and factors

Example of application of eco-efficiency and factors

It can be stated that the most important reason for calculating eco-efficiency and factors is to obtain quantitative indicator in order to develop products with higher product value while producing less environmental impact. It is important to perform continuous evaluations based on eco-efficiency and factors to improve them. The following example of an application method is based on this fact (Fig. 12).

(1) First the products whose eco-efficiency and factor are evaluated are selected.

(2) What is the purpose of evaluating this product? Compliance with laws and regulations, demands by concerned parties etc. and other elements are considered. It is more effective to set specific numerical targets that should be achieved.

(3) After the evaluation items are determined, the evaluation methods are specified.

a) Which items appropriately represent necessary information? Measurement items suitable as indicator are selected, For example, it is necessary to decide if the quantity of production, value of production, quantity of sales, or value of sales and other items appropriately represent necessary information. As the environmental impact, the most appropriate item, electrical power or quantity of energy used for example, is selected.

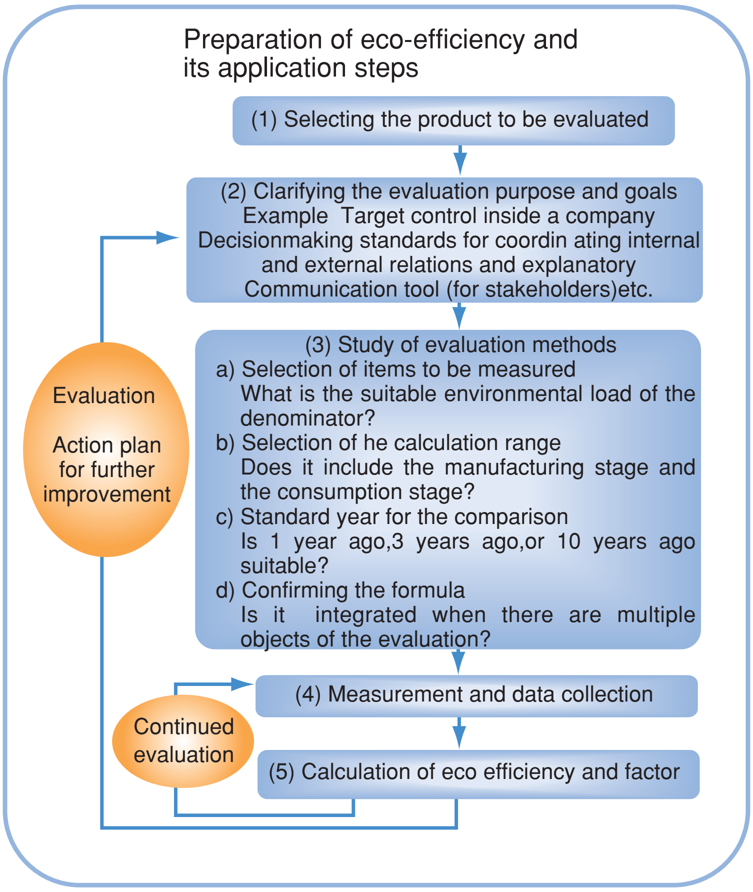
b) A study is done to determine, according to the purpose, if the calculation range should be only the production stage or if it should be the life cycle. It is also necessary to decide whether or not to deduct the recycling portion.

c) It is decided what year to set as the yardstick year for the calculation of the indicator. Because the priority of the stipulated yardsticks differs according to the period, it is necessary to consider the number of years in the past to be the basis for evaluating improvement by, for example, taking care that it is not impacted by laws, regulations, and other outside concerns.

d) In a case where formulae are integrated or weighted, it is necessary to clarify the setting method so that it is not done arbitrarily.

(4) (5) After the evaluation method has been established, the actual measurement and calculation is done. Continuously clarifying and evaluating the state of improvement in this way reveals the location of the causes of impacts so they can be easily dealt with to set targets for further improvement.

Figure 12. Eco-efficiency and Factors: Purposes and



2.4 Effective use of eco-efficiency and factors

(1) Incentives for design technologists

Eco-efficiency indicator, or factors, are compared with LCA, but LCA is a method of quantitatively clarifying environmental impacts, and the calculation result of LCA should be as small as possible. On the other hand, an eco-efficiency indicator, or factor, not only clarifies the lower limit of environmental impacts, but also shows the degree of improvement of product value and degree of improvement of quality. A factor differs from LCA in that it should be as high as possible. It can also be stated that eco-efficiency and factor evaluate the skills of product technologists from multiple perspectives. Therefore, it is an "indicator with bright future orientation," and is counted on to provide incentives to technologists.

(2) Driving force behind the creation of eco-products

The eco-efficiency indicator, or factors, are starting to attract interest both inside and outside of Japan as indicator that can make an effective contribution to the creation of a sustainable society. The use of these methods can become the driving force behind the creation of genuine eco-products. Corporations have begun to devise ways to effectively use factors, by for example, adding the degree of improvement of a factor indicator to product assessment evaluation items, constructing an LCA implementation data base (calculating factors based on LCA implementation data) or using them as action target values in corporate voluntary plans. If the degree of performance improvement and degree of improvement of environmental impact can be quantified, it will be possible to use them as targets that should be achieved in the future. The eco-efficiency value of products, or factors will be improved annually, and this is clearly what is called "Sustainable improvement" in ISO14001.

(3) Communication tool for responding to customers' requests for environmental information about products

Customers request the disclosure of environmental information concerning products. These demands for the information access can be satisfied by using factors as one kind of environmental label. In fact, there are many issues to be resolved to use factors as a communication tool.

It would be necessary to fully explain a number of facts: a factor is a value calculated based on a company's in-house yardstick to compare its new and old products; in order to release the values of the environmental indicator, factors, it is necessary to be willing to completely reveal the prerequisite conditions, models compared, formulae, indicator, and the weighting and integration methods in order to disclose eco-efficiency indicator that are numerical factors; and finally, they are values calculated by comparing a company's new and old products but not a comparison with another company's products. It would, therefore, be necessary to educate recipients of this information so that people who examine the values (customers) will understand that eco-efficiency and factors have the above characteristics.

Figure 13.1 Examples of Eco-efficiency and Factor PR (Covers of explanatory pamphlets)

Figure 13-2. Examples of Eco-efficiency and Factor PR

(Left : small ad in the Nikkei Sangyo Shimbun.
December 2000 right : Special Environmental Issue
of Fobes. August 2002)

Figure 13-3: Example of Eco efficiency and Factor PR(product brochure)

Which direction should we take to implement eco-efficiency and factors?

Conclusions

Recent years have seen a conspicuous trend to use indicator to quantitatively evaluate progress in environmental management. Although trial and error is still a major feature of this process, an increasingly large number of companies are interested in indicator as common evaluation yardsticks for environmental sectors, technology developers, administrators, and other concerned parties. And the trend to this use of indicator is not limited to internal management. Indicators are used to rapidly and effectively inform outside organizations of the superiority of the results of environmental impact reduction, and interest in the use of eco-efficiency as a method is growing.

As already stated, there is no uniform eco-efficiency and factor calculation method. It is at the stage where the race has just begun according to the basic concept of reducing environmental impactand increasing value. In order to develop and apply methods of quantitatively evaluating both the denominator and numerator, many problems have to be resolved and an open debate should be carried to establish these as common indicator.

There are various product conditions including products that are expected to rise in value rather than to reduce environmental impact, and others whose environmental impact should be reduced while maintaining a constant value. Setting calculation rules for the environmental impact (denominator) and product value (numerator) for each group of products is, therefore, a shortcut to mutual understanding. Many items and calculation methods concerning eco-efficiency and factors are being tried out, and the direction has been becoming clearer. Attention often focuses only on differences between calculation methods, but at corporations that have aggressively undertaken this task, they have become an important foundation for determining the orientation of indicator.

There are still many unresolved challenges concerning eco-efficiency and factors, but it is important to begin. These challenges will not be overcome quickly. When Japan that specializes in the creation of new products has constructed indicator guided by consciousness of both reducing environmental impact and increasing value, it will obtain both products and a powerful tool for disseminating information around the world. One of the most effective way to actually construct and implement tools called indicator is for all concerned parties to participate actively in their creation.

We hope that this will be a valuable reference for corporations developing products that benefit the environment by introducing indicator in order to achieve abundance unlike that possible in the past

Reference documents

Refer to the following documents to learn more about eco-efficiency and factors.

(1) Report on a survey of the promotion of the introduction of environmental harmony type product activities (eco-efficiency) contracted by the Ministry of Economy, Trade, and Industry in 2002

(2) Report on a survey of the promotion of the introduction of environmental harmony type product activities (eco-efficiency) contracted by the Ministry of Economy, Trade, and Industry in 2001

(3) World Business Council for Sustainable Development: Measuring eco-efficiency as a guide to reporting company performance.

(4) Schmidt-Bleek, translator Sasaki Ken et al.: Factor X, Springer - Verlag Tokyo,

(5) Yamamoto Ryoichi: Eco-design best practice 100, Daimond-sha

(6) Pamphlet, National/Panasonic: Factor X, yardstick for products that achieve new abundance

(7) Pamphlet, Product eco-efficiency at Hitachi (Factor X)

(8) Mitsubishi Electric Group: Report on the environment and society, 2003

(9) Mitsubishi Electric Group: Report on the environment, 2002

(10) Mitsubishi Giho, May 2003, Vol. 77 No. 5

(11) Report on environmental management by the Matsushita Electrical Industrial Group, 2003

(12) Report on environmental management by the Fujitsu Group 2003

(13) Report on environmental management by the Hitachi Corp. 2003

Eco-efficiency and factors are the themes of an exhibit at Lake Biwa Environmental Business Messe 2003 held in November 2003.

http://www.biwako-messe.com/topics/01.htm

"Japan Forum on Eco-Efficiency(JFEE)"

Leading companies in Japan and JEMAI have established the Japan Forum on Eco-Efficiency(JFEE)in October, 2004.
About 100 companies and research institutes,which are interested in Eco-Efficiency,are participating to this forum now.

http://www.jemai.or.jp/english/ecobiz/forum.cfm

Appendix 1 Model case eco-efficiency and factors

Examples of the disclosure of actual eco-efficiency and factors are shown below. Only part of the disclosure process is described.

Mitsubishi Electric Corporation

Basic Factor Computaion df Mitsubishi Electric Group

- Computaion is made with standard product (fundamentally manfactured by company in 1990)
- Product performance improvements are taken into account＊1
- Based on MET environmental improvement concepts (effective use of resources＊2,efficient use of energy, and reduce use of substances potentially harmful to the environment)synthesized into a vector length.

Product Eco-efficency＝Product Perfomance /Negative environmental impact
Factor ＝Eco-efficency of present product/ Eco-efficency of standard product

＊1 If the degree improvement in product perfomance cannot be reduce numerically,the value givenis is 1
＊2 Index for effective use of resources
＝Virgin resource volume ＋weght of non-recycable resources(volume disposed of being recycled)
＝(product weight—weight of recycable materials and parts)＋(Product weight—Weight of recyclable resource)

Case of Indication of Definitions
Definitions and basic concepts of eco-efficiency and factor

Example **Cell-phone: Factor 1.82**

		Material: Effective resource utilization	Energy: Effective energy use	Toxicity: Environmentally harmful substance content
Yardstick product	1991 model **Analog Mova D**	1	1	1
Evaluation product	2002 model **Mova D 251i**	0.42	0.24	0.82
	Improvements	Reduction of virgin resources 58% Reduction In non-recyclable resources 60%	Electricity consumption Reduction at time of regular use 66% Reduction at standby time 96%	Reduction in lead solder 18%

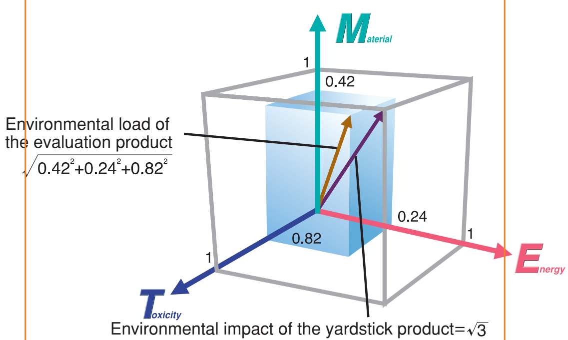
I_{91}(Environmental impact of yardstick product)

$$=\sqrt{1^2+1^2+1^2}=1.73$$

I_{02}(Environmental impact of evaluation product)

$$=\sqrt{0.42^2+0.24^2+0.82^2}=0.950$$

Factors＝ Eco-efficiency of evaluation product/ Eco-efficiency of yardstick product
＝$(1/I_{02})/(1/I_{91})$
＝(1／0.950)／(1／1.73)
＝**1.82**



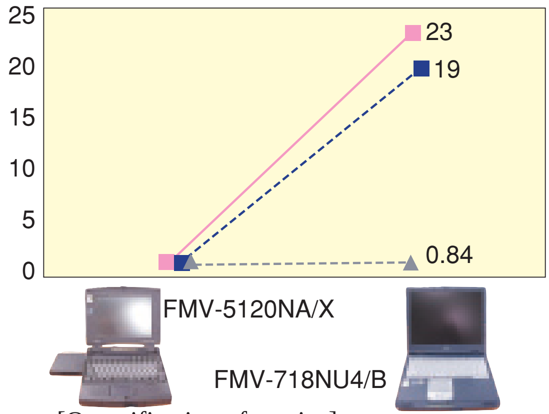
Disclosure of calculated data (numerator/denominator) and formula
Eco-efficiency of yardstick product (A) = 1/0.950
Eco-efficiency of evaluation product (B) = 1/1.73
Factor = (B)/(A) = 1.82

Indicating the ground for the calculation
Items used to calculate the environmental impact (denominator): energy, resources, environmentally harmful substances

(Source: Mitsubishi Electric Group: Environmental Sustainability Report p. 18, 2003)
For details concerning this example, see: http://global.mitsubishielectric.com/company/eco/index.htm

Fujitsu Ltd.

Factor values were calculated by comparing the eco-efficiency of the notebook size personal computer FMV-5120NA/X first sold in 1996 with the FMV-718NU4/B, a product awarded the Ecoleaf Environmental Label when it went on sale in 2003. The results achieved Factor 23 (converted to global warming impact) over 7 years.



Factor = 19/0.84 = 23X
Environmental impact reduction of 16%

Case where the yard-stick year, product model, etc. are clearly indicated

Disclosure of calculated data (numerator/denominator) and formula

Improvement of product value (numerator) (A) = 19/1

Improvement of environmental impact (denominator) (A) = 0.84/1

Factor = (A)/(B) = 23

[Quantification of service]

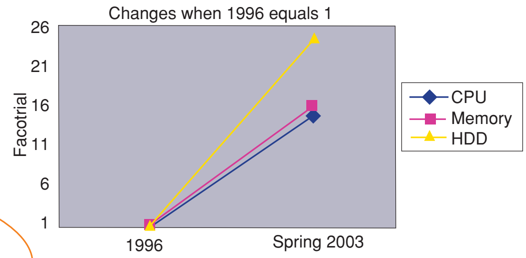
The following formula was used to quantify service. The calculation was done by averaging the sum of the squares to summarize the various services: CPU, memory, and HDD.

Averaging sum of squares

$$= \sqrt{\frac{1}{n} \cdot \sum_{i=1}^{n} S_i^{\,2}}$$

Functions/ performance	Unit	FMV-5120 NA/X (a)	FMV-718 NU4/B (b)	S=(b)/(a)
CPU	GHz	0.12	1.8	15.0
Memory	MB	8	128	16.0
HDD	GB	0.81	20	24.7

19.1X



Indicating grounds for the calculation

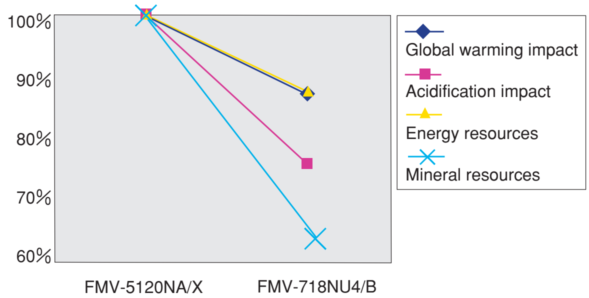
Product value (numerator): integrated CPU, memory, and HDD

Environmental impact (denominator): global warming impact

[Calculating the environmental load]

The environmental load was calculated based on the notebook size personal computer product classification yardstick (PSC) in the Ecoleaf Environmental Label program.

Machine name	Old product	New Produ	
Global warming impact (converted to kg of CO_2)	164	138	Reduction
Acidification impact (converted to kg of SO_2)	0.286	0.217	Reduction
Energy resources (converted to kg of crude oil)	61.7	52.2	Reduction
Mineral resources (converted to kg of iron ore)	136	89.8	Reduction



The old product (FMV5120NA/X) was considered under the Ecoleaf Environmental Label Program based on the following hypotheses.

The old product (FMV5120NA/X)was considered under the Ecoleaf Environmental Label Program based on the following hypotheses.

- Concerning the manufacturing site, it was assumed that the 10.4 inch flat panels were made at the present FDTC Yonago, and the main board was mounted and assembled by Shimane Fujitsu.
- It was assumed that it was distributed using the same impacting method and impacting rate as now.
- It was assumed that when it is used, the time when it is suspended state is lower power time.

For other cases and details see the following two home pages
http://eco.fujitsu.com/jp/info/downloads/Eco/rep2003/report19_23.pdf
http://journal.fujitsu.com/267/greenlife/

Improving the quality of life

Minimizing environmental impact

New Prosperity

"New Prosperity" indicators: "Environmental Efficiency" and "Factor X"

Matsushita has defined two New Prosperity indicators: "environmental efficiency" and "Factor X."
These indicators assess products and services over their entire life cycles.
They represent our corporate vision and one of our basic policies for product development.
At the same time, they serve as a set of uniform indices to help people around the world choose products and services.

Example of indication of definition
Definitions and basic concepts of eco-efficiency and factor

"Factor X" = Environmental efficiency improvement factor = Improvement in "quality of life" / Reduction on "environmental impact"

"Quality of life" is a measure for assessing product longevity and product function. "Environmental impact" measures effects in terms of global warming, resources, and chemical substances. Together these define "environmental efficiency"

Global warming — GHG* efficiency = Product life × Product function / GHG emissions over the entire life cycle

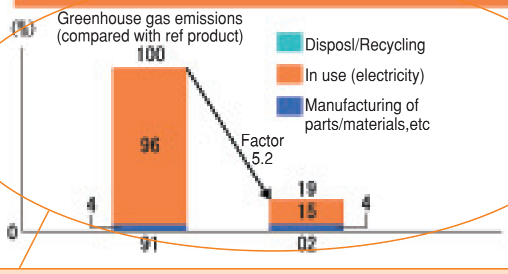
Resources — Resource efficiency = Product life × Product function / Non-circulating resources over the entire life cycle
(Non-circulating resources : Resources newly extracted from the earth + Resources disposed of)

Chemical substances — Non-use of hazardous chemicals
(Lead, cadmium, mercury, hexavalent chromium specified brominated flame retardants, and PVC resin)

* GHG: greenhouse gas

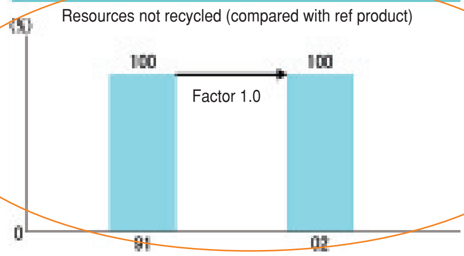
The non-fluorocarbon refrigerator

GHG Factor: 5.2



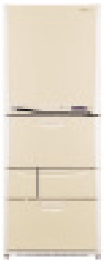
Calculation data (numerator/denominator)
Eco-efficiency of yardstick product (A) = 1/100
Eco-efficiency of evaluation product (B) = 1/19
Global warming prevention factor = (B)/(A) = 5.2

Resource factor 1.0 — 1.0



Calculation data (numerator/denominator)
Eco-efficiency of yardstick product (A) = 1/1
Eco-efficiency of evaluation product (B) = 1/1
Resource factor = (B)/(A) = 1.0

Natural Fluid Refrigerator



At the Matsushita Electric Group Factor X (eco-efficiency) was introduced as the authorized yardstick for Green Products (low environmental impact products) in 2002. Inside the company, the development of Green Products has been accelerated by applying the yardstick to evaluations of performance, while outside the company, Green Products have been promoted with the Type II Environmental Label (p16,13-3) application yardstick.

http://matsushita.co.jp/eco/en/factor_x/

Hitachi Ltd.

Lets look at a Factor X calculation example actually applied to washing machines.

Washing Machine

Outline of the products compared

Item / Product		Yardstick	Evaluation
Year manufactured		1990	2002
Model No.		KW-B438	NW8BX
Product service life *6 (designated usage time (years))		6	
Product functions	Washing capacity (kg)	4.5	8.0
	Cleaning power *7	0.83	0.9
Washing conditions		Yardstick course *8	
Product weight (kg)		34.0	41.0
Electric power consumption *9 (W)		–	310
Quantity of electric power consumed *10 (W-h)		125	54
Yardstick quantity of water used (liters)		197	125/32 (inserted)

Example of the clarification of the yardstick year and product model etc.

＊6. Product service life is stipulated under Notification No. 230 of April 1974 of the Director of the Machinery and Information Industries Bureau of the Ministry of International Trade and Industry, ✗Revision to the Minimum Retention Time for Repair Use Performance Parts for Household Electronic Appliances.

＊7. Cleaning power is set by the cleaning performance test stipulated by JIS C 9811-1999 Methods of measuring performance of household use electrical washing machines. Stipulated soiled cloths are washed under the stipulated test conditions, and the degree of the cleanliness of the soiled cloths is measured by their reflectivity. The degree of cleanliness of the specimen washing machine is compared with that of a stipulated yardstick washing machine, to set the cleaning performance as the cleanliness ratio that was obtained.

＊8 The yardstick course is a course that satisfies a degree of cleanliness ratio of 0.8 or more, and it is stipulated in JIS C9606.

＊9, 10, Electrical power consumption and quantity of electric power consumed are values measured when the machine has been operated continuously at the rated voltage of the rated frequency and the two values are almost equal (JIS C 9606-1993 Electrical washing machine)

＊11. the total emission of global warming gasses is based on the Hitachi LCA (Hi-PLCA ver. 3).

- Example where th transparency and reliability of all calculated items are assured.

Results of the evaluation of the global warming prevention factor

◆ Results of calculation of total emission of global warming gasses *11

Unit: (kg/unit)

Life cycle stage		Yardstick	Evaluation
	Product	Yardstick	Evaluation
	Year of manufacture	1990	2002
	Model name	KW-B483	NW-8BX
Made	Materials manufactured	52	76
	Manufactured	4	4
Transported	Transportation	4	6
Used	Utilization (Electricity, water)	175	68
Returned	Recovered/recycled	11	16
Total	Total life cycle	246	169

◆ Content of calculation of global warming prevention

		Yardstick	Evaluation
Product service life (designated usage time (years))		6	
Product functions	Washing capacity (kg)	4.5.	8.0
	Cleaning power	0.83	0.9
Emissions of global warming gasses throughout its life cycle per unit washing capacity (kg/kg)		54.7	21.1
Global warming prevention rate		0.41	2.05
Global warming prevention factor			5.0

- Increase in materials to increase the washer-capacity (4.5 to 8 kg)
- Reduction in operating electric power by adopting PAM control and DD camera method (125 to 54 W·h)
- Use of recycled plastic for the outer tank and PP base
- Increased capacity of the washing machine
- Increase in cleaning performance

Yardstick model NW-B483

Evaluation model NW-8BX

Calculated data (numerator/denominator

Eco-efficiency of yardstick product (A) =6 X 4.5 X 0.83/54.7

Eco-efficiency of evaluation product (B) =6 X 8.0 X 0.9/21.1

Factor = (B)/(A) = 5.0

Indication of grounds for calculation

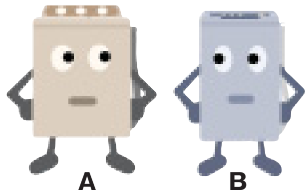
Environmental impact (denominator) calculation items: quantity of global warming gasses emitted

Product value (numerator): product service life X product functions

Source: Hitachi Corporation's Product Eco-efficiency (Factor X) pamphlet, p. 4, May 2003)
For details see the home page http://greenweb.hitachi.co.jp/pdf/kouritsu.pdf

Appendix 2 FAQ about eco-efficiency and factors

Q Can we compare the factors for products manufactured by different companies?



A No, you cannot compare them.

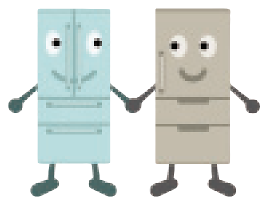
Because the definition of eco-efficiency and factors, baseline for products, and formulae all differ between companies, they are not intended for comparisons of products made by different companies. Factors are commonly treated as relative indicator that indicators the degree of improvement of new products over old products from the same company. It is necessary that they be used only to "compare new and old products." In order to prevent causing misunderstandings when disclosing information about eco-efficiency and factors, it is important that the numeric values are transparent, or in other words, that the form of the numerator/denominator is disclosed numerically at the same time. ⇒See Page 13 (4) of this handbook.

Q Does the environmental impact of eco-efficiency make LCA mandatory?

A LCA are preferable, but they do not have to be LCA.

The ultimate purpose of a factor is to improve numerical values. It is a concept of improving values, or in other words, environmental impacts, by continuous improvements based on reassessing product development and manufacturing flow. Attempting improvements from the life cycle perspective is important, but there are cases where it is not necessarily possible to clarify values based on a life cycle. It must be decided specifically what to improve and, according to the purpose of the evaluation, whether or not the range of activities that are the object of the calculation should be the life cycle. ⇒See page 8 of this handbook.

Q Will eco-efficiency indicators and factors result in new standard for each type of product?



A They can be common, but further discussion is necessary.

Indicator should be common so they can be used as criteria for purchasing, but further study is necessary before they can be applied this way. It is necessary to discuss ways to apply an effective utilization that increases awareness of the significance of the factors and eco-efficiency, rather than only focusing on the number of factors. ⇒See page 17 of this handbook.

Appendix 3 Overseas trends in eco-efficiency and factors

What is the original factor, Factor10?

A concept proposed by Professor Schmidt-Bleek of the Wuppertal Institute in Germany, Factor X represents long term target values to guarantee the sustainability of the globe.

The grounds for setting targets are not strictly specified.

It is explained as a method of achieving sustainable economy by reducing the flow of resources on the earth to one-half. To count on fairness, consideration must be given to the achievement by developing countries of the yardstick of living of developed countries where only 1/5 of the world's people live. This shows that the citizens of the developed countries must reduce the quantities of resources and energy they consume to 1/10 of its present level (= increase productivity by 10) in a single generation (approximately 50 years).

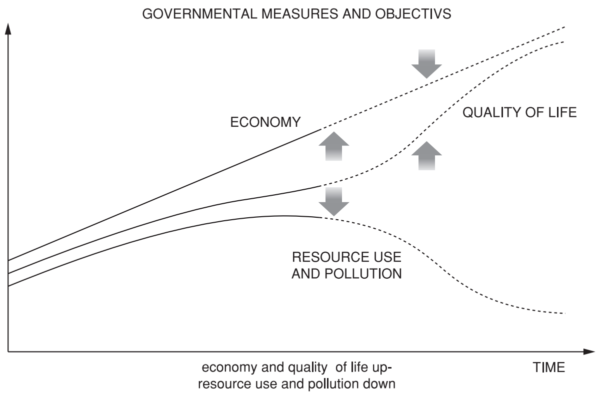
$$\frac{\text{Value of present services} = 1}{\text{Present environmental impact} = 1} \Rightarrow \frac{\text{Value of services in 50 years} = 5}{\text{Environmental impact in 50 years} = 1/2} = \text{Factor10}$$

The point that should be the issue is not the value 10. If the population rises, increasing the per capita consumption in the developed countries, the factor that should be the target will also rise, forcing an increase in eco-efficiency and resource productivity. This is because the environmental capacity of the world is limited. Efforts are now being made to develop various technologies needed to achieve Factor X. In order to improve factors at the social level, it is necessary to focus on a method of transforming the structure of society to provide adequate services with the minimum quantity of resources of energy by altering existing consumption patterns instead of relying on new products and technologies.

What is eco-efficiency?

Eco-efficiency was originally proposed at a United Nations conference (Earth Summit) concerning the environment and development held in Rio De Janeiro in 1992. Later the World Business Council for Sustainable Development (WBCSD) defined it as follows. “Eco-efficiency is 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. The supply of goods and services should be considered from the life cycle perspective. And the impact of this supply must be reduced to a level at least in line with the earth's estimated carrying capacity.” The WBCSD has proposed seven elements to improve eco-efficiency.

1. A reduction in the material intensity of goods or services;
2. A reduction in the energy intensity of goods or services;
3. Reduced dispersion of toxic materials;
4. Improved recyclability;
5. Maximum use of renewable resources;
6. Greater durability of products;
7. Increased service intensity of goods and services.



WBCSD image of eco-efficiency improvement.

The WBCSD recommends the application of eco-efficiency indicator to measure the degree of achievement of the above goals. Later the Organization for Economic Co-operation and Development (OECD) positioned eco-efficiency as a concept important for achieving sustainable development. The OECD defines it as, “dividing the value of products produced by a corporation, an industry, or an economy by the total environmental load.”

Please send your comments and questions about this handbook to the following.
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Eco-efficiency and Factor Handbook

for Products

Creation of Indicator for a "Sustainable Society"

——Toward greater value and reduced environmental load——