Guideline for Information and Communication Technology (ICT) Eco-Efficiency Evaluation

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1. Preface

This guideline includes the general framework, principles, and requirements relating to evaluation of environmental impact of Information and Communication Technology (ICT), the eco-efficiency evaluation of ICT as well as the comparative evaluation of the environmental impact of ICT. The purpose of this guideline is to provide an objective tool in evaluating environmental impact caused by individuals, businesses and the whole of society relevant to ICT: to be concrete, it mainly focuses on assessing the CO_2 emissions that lead to global warming. The evaluation targets are ICT services and solutions in general, provided through the system combined with devices, software and associated services for improvement in business and lifestyle. The guideline is a manual for ICT providers, while it is open to the public and available to everybody.

The following is the structure of this guideline: Framework of ICT environmental impact assessment (Chapter 2): Outline of ICT eco-efficiency assessment (Chapter 3): Framework of comparative evaluation of ICT environmental impact, eco-efficiency and Factor X (Chapter 4): and examples of evaluation based on the guideline (Chapter 5).

For assessment of ICT environmental impact, Chapter 2 can be referred. Chapter 2 and 3 for evaluation of ICT eco-efficiency, Chapter 2 and 4 for comparative evaluation of ICT environmental impacts, and Chapter 2, 3 and 4 for the comparative evaluation of eco-efficiencies. However, be aware that the comparative evaluation may be too difficult to be assessed for some types of ICT. In the case of applying this guideline for ICT comparative evaluation, the reminders in Chapter 4. 3, which aim at comparative evaluation, not among ICT, but between ICT and the alternative way, should be referred in advance.

2. Framework for Evaluation of ICT Environmental Impact

2.1 General

As a general rule, ICT environmental impact should be assessed based on the Life Cycle Assessment (LCA), which is explained in detail in ISO14040 series.[1] This chapter explains the framework on how to apply LCA for ICT. This section deals with the general notices for assessing ICT environmental impact. The detailed explanation on functional units and system boundaries is available in the following sections.

As shown in ISO14040, the outline of the LCA implementation consists of the following four stages.

(1) Definition of goal and scope
(2) Life cycle inventory analysis
(3) Life cycle impact Assessment
(4) Life cycle interpretation

For ICT environmental impact assessment, in stage (1) "definition of goal and scope", the functional unit and system boundary also should be set in the beginning. In LCA, the environmental impact of a product is quantified from the viewpoint of its life cycle, from raw material acquisition to production, use, disposal and recycling.

In stage (2) "inventory analysis", inputs and outputs considered as environmental impact (e.g. fuel oil, CO_2) should be calculated along the lifecycle of the product. It is essential to specify data collection and allocation, data quality requirement of the process that might have enormous impact on its consequence and the reference data used for the calculation in the analysis.

Stage (3) "impact assessment" consists of three stages, that is, classification, characterization and weighting. Classification and characterization are essential parts of the life cycle impact assessment. The process of classification and characterization, essential part of impact assessment, are scientific, leaving relatively little room for subjective values. Note, however, there is some difference of scientific knowledge accumulation and data availability among each impact category. Aggregating is another process of life cycle impact assessment. By aggregating the results of multiple indicators through weighting, the trade-off among various environmental aspects can be considered and then comprehensive evaluation is possible. Aggregated indicators, on the other hand, mutually compare and relatively assess environmental factors with different standpoints: the assessment depends greatly on social values and preferences. As environmental concerns vary industry by industry, some aggregated indicators are favorable to a specific industry, and others are unfavorable. Moreover, an aggregated indicator favorable to a specific product/service might be unfavorable to another in the same industry; therefore, the comparative evaluation with aggregated indicators should be done carefully and used appropriately. ISO14040 series provide that in the case of comparative assertions disclosed to the public shall not contain aggregated data.

Stage (4) "interpretation" is the phase of confirming whether LCA in which the finding from the

[1] ISO14040, 14042 and 14043 will be revised when they are integrated into ISO14040 and ISO14044 in the first half of FY2006. In this document, ISO14040 is used as the general term for LCA standards.

inventory analysis and the impact assessment are implemented, in order to reach conclusions and recommendations, and digesting the results. This stage may involve the iterative process of reviewing and revising the nature and quality of the data collected consistent with the defined goal. The findings of the interpretation phase should reflect the results of any sensitivity analysis that is performed.

2.2 Functional Unit

ISO14040 series define the functional unit as the “quantified performance of a product system for use as a reference unit in life cycle assessment study (ISO14040. 3.5).” Specifically, it means the “quantitative representation of the main performance/function of an evaluated product in a certain numerical unit.” [1)] The term of “product” is considered to include the whole product system as well as service system.

A function of the assessed product/service system, that is, a functional unit, should be specified when the environmental impact is evaluated. It is important to set the functional unit in advance, specifically and quantitatively.

Functional units may be defied as follows:

(1) Environmental impact assessment of “system of application/authorization to personnel/general affairs division”
Annual number of applications/authorizations at the personnel/general affairs division of A corporation: 5 million
(2) Environmental impact assessment of “online shopping system”
Annual number of sales through the system: 7,000 copies of books, 2000 copies of software

As shown in the examples above, a functional unit should be selected and disclosed with attention to its fairness, representativeness and accuracy, consistent with the goal and scope of the study.

The functional unit for the ICT environmental impact assessment is generally defined as the “quantification of annual activity,” presuming customers would like to know the annual change (improvement) triggered by the new ICT introduction. As many ICT have more than one year of product age, the environmental impact induced by production and disposal/recycling generally needs to be divided (distribution) by the years of service or .legal durable years

【Reference】
1) “JIS Handbook vol.58 Environmental Management 2005” (edited by Japan Standards Association) January 2005

2.3 System Boundary

System boundary is an interface between a product system and the environment or other product system. Generally, product system consists of complex connected unit processes. The system boundary determines which unit processes shall be included within the study of the LCA.

Ideally, the system boundary should be defined, involving the whole unit processes from raw material acquisition to emission into the environment, covering consumption of material and energy through the entire life cycle of product. In many cases, however, there is not enough time, data, and resource to carry out a comprehensive study: It would be worthwhile to examine the appropriate degree of detail regarding the study. Extra elaboration is not necessary for negligible activity and unit process that may little impact on the result of the study. The most critical part is the defined system boundary should be disclosed clearly in order to keep the transparency and consistency with the goal of the study.

This section deals with life cycle of ICT, activities to be considered in each stage.

2.3.1 Life Cycle of ICT

For determining the system boundary of ICT, it is necessary to consider that the system is a combination of a number of devices, software products, and services. Figure 2.3.1-1 shows an example of the stages regarded as the life cycle stages from production to disposal/recycling, which is specific to ICT. To make them relevant, the assessed stages can be determined each time with modification, e.g. the addition and/or exclusion of the stages.

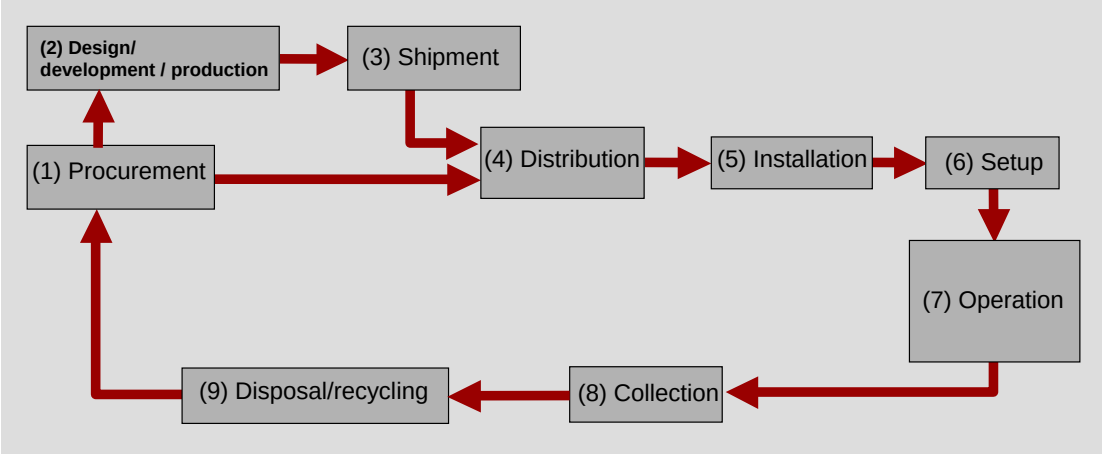


Figure 2.3.1-1 Example of life cycle stages

The following is the explanation of each stage shown in figure 2.3.1-1. The activities to be considered at each stage will be described in section 2.3.2 and figure 2.3.2-1.

(1) Procurement
At this stage, personal computers, server devices and software, and materials as well as packaging for devices and papers for the product manual are considered. The upper stages like raw

material/natural resource acquisition are also contained at this stage.

(2) Design/development/production
At this stage, manufacturing devices and software as a final product is categorized, as well as designing and developing.

(3) Shipment
At this stage, the devices and software are shipped. This stage also includes installation of software into recording media, preparing manuals, and packaging products.

(4) Distribution
At this stage, the devices and software are delivered to the users through the following method of transportation.

- Transport from the manufacturing factory to the warehouses of the distributors
- Transport from the warehouses of the distributors to shops
- Transport from the shops to the destination of users

If necessary, distribution within a stage or between stages should be considered, e.g. the transportation of materials and parts of products and the automobile driving accompanied with installation or setup.

(5) Installation
At this stage, devices are installed on site to be available for operation.

(6) Setup
At this stage, ICT is set up to be available for users.

(7) Operation
At this stage, ICT is in operation. This stage also includes maintenance of devices and the updating of versions of software during operation.

(8) Collection
At this stage, used devices and recording media are transported to recycling plants and/or disposal facilities.

(9) Disposal/recycling
At this stage, devices and recording media are recycled at recycling plants, or industrial waste is disposed at disposal facilities.

2.3.2 Target Activities of the Assessment

2.3.2.1 General

The target of the ICT environmental impact evaluation includes activities by individuals, businesses or the whole of society, involved in any stage of the life cycle. Activities to be assessed include "goods/energy consumption," "use of ICT devices,", "use of network infrastructure," "use of software" "shipping ~transport substitution," "traveling ~transport substitution," "storage," and "workforce." The target of the assessment can be selected from among these activities in each life cycle stage of the product system. Figure 2.3.2-1 is an example table of the relevance between life cycle stages and target activities of the assessment.

Table 2.3.2-1 Relevance between life cycle stages and target activities of the assessment

Life cycle stages / Target activity	(1) Procurement	(2) Design/ development/ production	(3) Shipment	(4) Distribution	(5) Installation	(6) Setup	(7) Operation	(8) Collection	(9) Disposal/ recycling
1) Material/energy consumption									
2) Use of ICT devices									
3) Use of network infrastructure									
4) Use of software									
5) Shipping ~transport substitution									
6) Traveling ~Transport substitution									
7) Storage									
8) Workplace									

1) Goods/energy consumption

The activities that occur and are relevant to the life cycle of material/energy input/output to the product system, excluding activities included in 2) – 8). The "material" includes information paper, information media like CDs and toner cartridge for printers, water and compressed air. Also, the "energy" includes fuel (e.g. gasoline and fuel oil) and electricity.

2) Use of ICT devices

The activities that occur and are relevant to the life cycle of devices used in the system for the ICT, especially related to energy consumed by the devices. In the operation stage, the target of the evaluation is limited to the activities relevant to the life cycle of energy consumed by using ICT devices.

3) Use of network infrastructure

The activities that occur and are relevant to the life cycle of facilities used in network infrastructure, especially related to material and energy consumed by the facilities. The network infrastructure aforesaid means the facilities providing ICT-related services for the assessed ICT, e.g. telephone communication, ISP (internet service provider) connection, and data offer at data centers. (See 2.3.2.2 for details).

4) Use of software infrastructure

The activities that occur and are relevant to the life cycle of materials and energy consumed in the design, development and use of software. The software aforesaid includes individual software, packages, middleware, and OSs (operating systems). (See 2.3.2.2 for details.)

5) Shipping ~transport substitution
The activities that occur and are relevant to the life cycle of various types of shipping, especially related to material (including pallet and secondary material) and energy used for transportation.

6) Traveling ~ transport substitution
The activities that occur and are relevant to the life cycle of various types of traveling, especially related to material and energy used for the transfer including public transportation.

7) Storage
The activities that occur and are relevant to the life cycle of material and energy required to keep relevant goods in storage without losing its quality.

8) Work force
The activities that occur and are relevant to the life cycle of material and energy required for work force at office or working place.

2.3.2.2 Network Infrastructure

(1) Purpose of targeting network infrastructure in the assessment

As shown in the following figure 2.3.2-1, ICT is provided based on a hierarchy composed of three layers: AP (application), information sharing platform, and network infrastructure.

Application (AP)
Information sharing platform*
Network Infrastructure

* The layer composed of various middleware mutual to various AP

Figure 2.3.2-1 Hierarchy layers of ICT [1)]

The layer "network infrastructure" is a foundation necessary for providing ICT and exist as layers in a physical form. The "information sharing platform" is the middle layer connecting the network infrastructure and application, and the "application" layer means individual application of ICT. The hierarchy shows that the application layer exists supported by the lower two layers.

Therefore, the environmental impact by network infrastructure should be included in the eco-efficiency evaluation of ICT. This section describes the ideas necessary for the assessment of environmental impact by network infrastructure.

(2) Evaluation methods for network infrastructure

A process-sum method is appropriate for the evaluation of the environmental impact by network infrastructure. If a process-sum assessment is not available, macro statistical estimation based on various data can also be made applicable e.g. for the environmental impact per certain amount of information.

A) Functional unit for the evaluation of network infrastructure

It is necessary to set up a functional unit for the assessment of the environmental impact by network infrastructure. The functional unit should be set up based on the following method, matching the functional unit for the assessment of the environmental impact of ICT described in the section 2.2.

(a) Firstly, the functional unit (e.g. annual environmental impact (Lnw) per line) is established for the environmental impact assessment of network infrastructure, and the environmental impact per unit is estimated.

Incidentally, the life cycle of network infrastructure cannot be generalized with terms such as from cradle to grave," as the infrastructure has been developing in various forms since the first telephone network was established in Japan in 1890. Consequently, each communication facility composing the infrastructure necessary for providing ICT is regarded as a system, which is the target of the environmental impact assessment. The total environmental impact by each facility is divided by its legal life years, in order to calculate the environmental impact per year.

(b) The environmental impact of network infrastructure is presented in the functional unit for the environmental impact assessment of ICT. (If the ICT requires 2 lines, for example, its

environmental impact per year is Lnw×2.)

B) Life cycle stages of network infrastructure
There are five life cycle stages: production, installation, use, removal, and disposal/recycling

C) Grouping of network infrastructure and basic rules for the addition of environmental impacts
Network infrastructure at present is grouped into (a) the wired network, (b) IP network and (c) mobile network. Each network consists of subscriber station (e.g. terminal equipment, terminating equipment and protector), access facilities (e.g. telephone poles, conduits, changer, local switches and base station) and transfer facility (e.g. router and transmitter）. Figure 2.3.2-2 shows a typical sample of communication equipment used in network infrastructure.

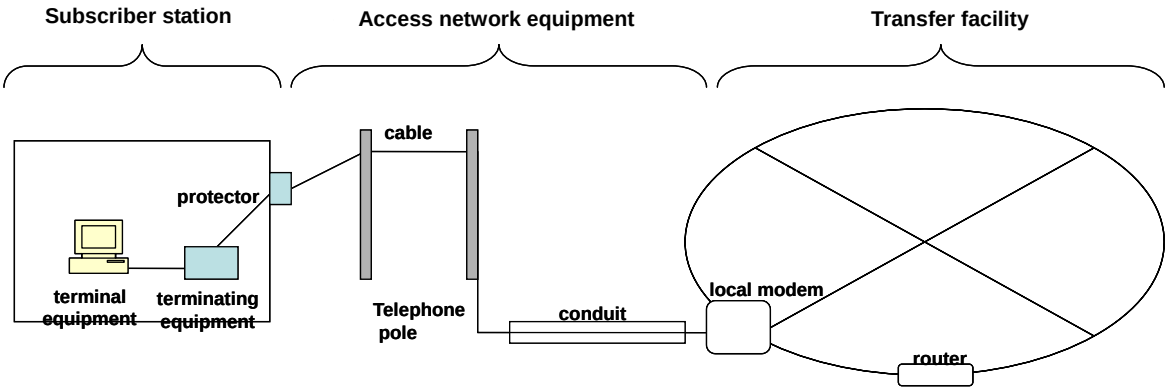


Figure 2.3.2-2 Sample of communication equipment used in network infrastructure

In the evaluation of network infrastructure, environmental impacts per year in terms of total equipment (including (a), (b) and (c)), which is used for the assessed ICT, was calculated by the method shown in 1).

D) Allocation
As shown in Figure 2.3.2-3, there are various types of applications used for operating ICT. For calculating the environmental impact of each application, the target of assessment should be allotted among all the applications used in network infrastructure, although the total number and scale cannot be specified. The environmental impact of network infrastructure used for operating ICT, instead, is estimated as follows: calculate the environmental impact per unit (e.g. communication time or amount of information) by the infrastructure, then multiply the functional unit by the unit quantity used for operating ICT.

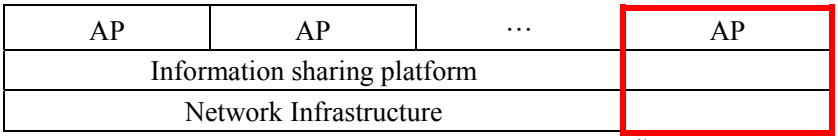


Figure 2.3.2-3 Functional structure of AP[1)]

(a) Information network systems are grouped into two types: line communication and

packet-switching. The former type is assessed per communication time, the latter per amount of information.

(b) Regarding subscriber station (Cf. Figure 2.3.2-2) used for operating ICT, the environmental impact of the equipment is estimated based on its use situation, and the allotment for the ICT is calculated based on the communication time or amount of information used.

NOTE: Sample estimation of the environmental impact by subscriber station [terminal devices]
The following is the estimation of environmental impact of PCs, included in subscriber station.
[Annual environmental impact per PC [kg-CO_2/(unit·year)] x [Number of used units (unit)] × [Operation hours for the ICT service (hours/service)] x [Frequency of use of the ICT service (times/year)]] ÷ [[Total operation hours of the PC (hours/year)]
(The assessed item of environmental impact = CO_2)

(c) For the assessment of access equipment (Cf. Figure 2.3.2-2), a fixed unit (e.g. environmental impact per subscriber) is applied regardless of its usage situation, as the subscribers always occupy the equipment whether or not they are using it. When the equipment is used for several purposes, the allotment of environmental impact for the target ICT is calculated.

(d) Unlike access equipment, transfer facility (Cf. Figure 2.3.2-2) is occupied only when used. Therefore, the environmental impact for operating ICT is allotted among the environmental impact by the equipment corresponding with the usage time or amount of information.

(e) For the evaluation of environmental impact of terminal equipment, its operation rate corresponding the traffic situation can be taken into account.

(3): Example of evaluation of network infrastructure

The assessment of B FLET'S (business type) is described as a sample assessment based on the methods above in Chapter 6.

【Reference】

1) "Reports on effectiveness regarding samples and standards of the calculation of ICT eco-efficiency" (March 2004, the Japan Environmental Management Association for Industry)

2.3.2.3 Evaluation method for software

(1) Definition and scope of software

As shown in Table 2.3.2-2, software equipped with ICT is grouped into four types in the guideline. Type 2, 3, and 4 (general-purpose software) are collectively referred to as “software infrastructure.”

As type 1 is exclusively produced for a specific customer, the environmental impact of software composing ICT is counted as 1/1 (=all of the environmental impact in terms of production). The environmental impact of type 2, 3, 4 that are mass-produced for multiple customers, on the other hand, is expressed as 1/number of shipped/operated units (divided by the “number of shipped/operated units).” Considering the characteristics of programming, the volume of the “number of shipments/operation” of type 2 (L), 3 (M) and 4 (N) is usually L＜M＜N. The term of L stands for the number of shipped business packages, the term of M stands for the number of middleware. N represents the number of operating system.

Table 2.3.2.3-1 Classification of ICT software and the environmental impact of each type

Type	Classification	Category	Environmental impact through production
1	Individual software (for individual part)	Software customized for users	1
2	Software infrastructure (for general purpose)	Business packages (e.g. system software for electronic application)	1/L
3		Middleware (e.g. information system management, database and others)	1/M
4		Operating system (e.g. Unix and Windows*)	1/N

* UNIX is a registered trademark of The Open Group in the United States and other countries. Microsoft is a registered trademark of Microsoft Corp. in the U.S. and other countries.

(2) Calculation Method for Environmental Impact of Software

1) Process-sum method

The environmental impact of the whole system is calculated by totaling the environmental impacts of individual software. Even if all of the actual data for the environmental impact is not available, the entire environmental impact of ICT can be estimated by using the volume (ex. Price) and the environmental impact if a part of software can be is available. In the case of estimating the entire impact by using environmental impact from a part of software, it is appropriate to deal with numbers within the same class of software category.

$$\text{[Total } CO_2 \text{ emission (kg-}CO_2\text{) by software]} = \frac{\text{[Gross amount used for software size]}}{\text{[Amount used for the volume (ex. Price) of software using the process-sum method]}} \times \text{[Unit amount of } CO_2 \text{ emission by the software products estimated using th process sum method (kg-}CO_2\text{)]}$$

(2) Input/output table

Based on input/output table, the environmental impact is calculated by multiplying the unit amount of CO_2 emission (kg-CO_2/yen) for the information service industry together with the gross amount spent for the assessed software infrastructure.

[Total CO_2 emission (kg-CO_2) by software infrastructure]	=	[Gross amount used for software infrastructure]	x	[Unit amount of CO_2 emission for information service industry (kg-CO_2/yen)]

NOTE: The years spent developing software infrastructure is not a term in the formula above. Even in the case it takes two years for development, the unit amount of CO_2 emission does not need to be doubled, as the gross amount is for two years. As it takes longer for the development, naturally, the gross amount increases.

When sales volume or CO_2 emission is available for the evaluation, the precision for the total emission from the software will be raised. Less error occurs if the amount for information service sector (including operation services) and software (including individual software), when the first type software, individual software, described in the table 2.3.2.3-1 is considered.

Error could be categorized into (a) Error estimated from the data of information service and software sector in input/output tables8) and (b) error derived from the total amount of data that accumulated data of a part of product. Less error occurs when the data for software is calculated by using (b). In either case, when the data is handled by using process- sum methods, it is possible to calculate both input/output table data and the way of (a) and to compare in order to raise the precision.

2.3.2.4 Evaluation method for traveling

(1) Classification of facilities for traveling

The following are the facilities used for traveling influenced by the introduction of ICT.

(a) Railway (train, subway, new transit system, monorail linear-motor train, and others)
(b) Bus
(c) Ship
(d) Airplane
(e) Automobile (including taxi)

(2) Assessment method for traveling

The environmental impact of traveling related to the ICT introduction is estimated as follows.

Example of calculation:

[Total CO_2 emission (kg-CO_2) by traveling] =

【Number of passengers[persons] 】x [distance (km)] x [generic data(reference unit) of CO_2 emission for transportation (kg-CO_2/person・km)]

2.3.2.5 Evaluation for storage and workforce

(1) Evaluation methods for the environmental impact induced by storage

The environmental impact e.g. CO_2 emission (kg-CO_2/year) induced by storage is calculated by multiplying the generic data (reference unit) (annual CO_2 emission) together with the operating years as follows:

[Environmental impact of storage] =

[Environmental impact induced by storage per year] x [Operating years]

(2) Evaluation method for the environmental impact induced by workforce

The environmental impact e.g. CO_2 emission (kg-CO_2) induced by the use of an office is calculated by multiplying the generic data (reference unit) (annual CO_2 emission) together with the operating years as follows:

[Environmental impact of workforce] =

[Environmental impact induced by the use of an office per year] x [Operating years]

3. Outline of ICT Eco-efficiency Evaluation

The previous chapter describes the methods for calculating the environmental impact of ICT. While ICT contributes to the creation and development of value (benefits) e.g. the efficiency in industry and our life, it also increases the environmental impact by consuming resources and energy through the production and operation of infrastructure. Therefore, the idea of "eco-efficiency" is necessary to compare the environmental impact with the value produced by ICT. This chapter describes the eco-efficiency of ICT.

It is at the stage where the discussion has just begun according to the basic concept of reducing environmental impact and increasing value. It is probably the most critical issue to ensure transparency and improve reliability of the method of eco-efficiency evaluation.

It is appropriate to avoid misunderstanding by, for example, using the common principles and explaining that the formulae were not created by defining them in a way that benefits corporations in particular.

3.1 The definition of eco-efficiency

The following is the general formula to calculate the eco-efficiency of ICT,

$$\text{Eco-efficiency} = \frac{\text{Value provided by ICT}}{\text{Environmental impact of ICT}}$$

3.2 ICT value

The evaluation method for environmental impact (denominator of eco-efficiency) per functional unit of ICT is explained in the previous chapter. The value (numerator), which cannot be expressed in the functional unit, rather, is, for instance, the quantification of value brought by ICT.

The indicator which stands for value can be expressed by various index in line with the target level (product, company, country and others) or purposes. The following are the principles for defining value indicators

1) To clarify the target (nation, industry, product and others) to be evaluated, the audience to be reported and the purpose

2) To consider which items appropriately represent as the numerator, together with the system boundary for environmental impact assessment

3) To define clearly evaluation items and the reasons to be selected; the numerator can be set by taking physical indicator, sensory component indicator, and economic indicator. Physical indicator means communication speed, sensory indicator means the level of comprehension, conformity, and economic indicator includes price and added value.

4) The indicators for value should have no dependency with the environmental impact.

5) The indicators for value should use publicly available data and information in product brochures or catalogs in order to keep transparency or reliability.

It is well explained that price indexes (economic indicator) of product or service stand for the value of the product or service in a hedonic approach. A complete free market let the consequence work. However, when government intervention like regulation, oligopoly situation, informational imbalance between product/ service providers and consumers, price is not appropriate indexes. Considering the facts, it is important to evaluate the appropriateness of using economic indicators

3.3 Examples of value indicators

Examples are provided in Table 3.3-1

Table 3.3-1 Examples for index of numerator

Application	Level	Target of users	Purposes of using indicators	Items for numerator
TV conference	Product	Business person	Assessment of product quality (value) and environmental aspects	Labor productivity
		Conference organizer		Accomplishment of conference, conformity, comprehension, satisfaction (sensory value)
Internet access	Product	Consumers	Assessment of product quality (value) and environmental aspects	Internet connection speed (physical value)
	Product	Consumers	Assessment of product quality (value) and environmental aspects	Accessibility of connection (sensory value)
Supply chain management	Company, business place	Business person	Profitability and environmental impact	Labor productivity, stock turnover rate (economic value)
Document management system	Company, business place	Business person, administrator (system administrator)	Assessment of product quality (value) and environmental aspects	Information security (physical and sensory value) Achievement of high hit rate for search information (sensory value) Accessibility of connection (sensory value)
Multimedia learning system	Company, business place	Business person, administrator (system manager)	Assessment of product quality (value) and environmental aspects	Learning level (sensory value)
			Evaluation of expansibility and environmental aspects	
Library management system	School, municipality, business place	Business person, enterprises, administrator	Assessment of service improvement and environmental improvement	Rotation frequency of books (physical value)
Electric paper (poster) system	Company, office	Business person, enterprises	Assessment of product quality (value) and environmental aspects	Viewability (sensory value)

4. Framework of ICT Comparative Evaluation

Based on the assessment of environmental impact/eco-efficiency of ICT explained at the Chapter 2 and 3, this chapter describes the general principles necessary for comparing more than one ICT evaluation, results and/or comparing ICT with existing means (e.g. the comparison between TV conferences and face to face meetings that require traveling).

4.1 Principles of Comparative Evaluation

In order to make a quantitative assessment of ICT, the system boundary shall be equivalent. The following are the principles of comparative evaluation for ICT:

4.1.1 Comparative evaluation of Environmental Impact

1) The functional unit is identical.
2) The system boundary is clearly defined.
3) 1) and 2) should be defined in detail for ensuring the transparency and objectivity of the comparative evaluation.

4.1.2 Comparative evaluation of Eco-Efficiency

1) The functional unit applied for environmental impact evaluation (denominator of eco-efficiency) is identical.
2) The system boundary is clearly defined.
3) The value which responds to the functional unit of environmental impact should be evaluated.
4) The unit of value is identical

NOTE: Points to remember for the eco-efficiency evaluation and the comparative evaluation

***** For the comparative evaluation of eco-efficiency, the unit of value (quantified value) should be identical

<Inappropriate examples> Japanese Yen (monetary value) and kbps, kbps and Mbps

* For the comparative evaluation of eco-efficiency, the system boundary should be consistent.

<Inappropriate examples> One covers all stages, manufacturing the system, operation and disposal stages as the system boundary. The other covers only operation as the system boundary

$$\text{Eco-efficiency of ICT (A)} = \frac{\text{Value provided by ICT (A)}}{\text{Environmental impact per functional unit of ICT (A)}}$$

$$\text{Eco-efficiency of ICT (B)} = \frac{\text{Value provided by ICT (B)}}{\text{Environmental impact per functional unit of ICT (B)}}$$

Consistency in the unit of value

*Consistency in the functional unit

*Clear explanation of the system boundary

4.2 Methods for Comparative Evaluation

Comparative evaluation of ICT is grouped into the comparative evaluation of environmental impact and the comparative evaluation of eco-efficiency. Either of the following two methods can be applied according to the purpose of assessment:

4.2.1 Comparative Evaluation of the Environmental Impact

In comparative evaluation of environmental impact of the targeted ICT, the baseline ICT or conventional way (baseline service) should be configured. Below are the formulas for comparing the environmental impact of ICT: (See the chapter 2 for evaluation of ICT environmental impact)

[Quantitative change in environmental impact] =

[Environmental impact of the targeted ICT] - [environmental impact per functional unit of baseline (conventional) service]

[Rate of change in environmental impact] =

[Change in environmental impact] ÷ [Volume of environmental impact per functional unit of baseline service]

The terms “quantitative change in environmental impact” and “rate of change in environmental impact” defined above can be reworded as follows:

- When the quantitative change is a positive value, the terms are reworded as “quantitative increase in environmental impact” and “increasing rate in environmental impact.”
- When the quantitative change is a negative value, the terms are reworded as “quantitative decrease in environmental impact” and “decreasing rate in environmental impact.”

They may be reworded so as to fit for each purpose.

4.2.2 Comparative Evaluation of Eco-efficiency

Below is the formula for the comparative evaluation of eco-efficiency of ICT (See the chapter 3 for the assessment of eco-efficiency by ICT):

[Comparative evaluation of eco-efficiency] =

[Eco-efficiency of the targeted ICT] ÷ [Eco-efficiency of baseline service]

Comparative evaluation of eco-efficiency may be expressed as “Factor X evaluation” accordingly.

4.3 Reminders

In comparative evaluation of ICT, there are some activity items to be assessed helpful for better understanding its potential, other than the items considered in the assessment of environmental impact or eco-efficiency described in Chapter 2 and 3.

NOTE: Activity items to assess the potential of ICT
Examine TV conference system as an example of ICT.
In the assessment of environmental impact of the TV conference system, the following are the major items to be assessed based on Section 2.3.2.
*Use of ICT devices
*Use of network infrastructure
*Use of software
In the comparative evaluation of the TV conference (targeted ICT) with the face to face meeting requiring business trip (baseline service), however,
*Traveling by transportation
should be also assessed.
In such case, the evaluation should follow the procedure described in section 2.3.2.4..
Even if the TV conference system could be more helpful to reduce traveling by transportation, compared with the face to face meeting requiring business trip, the timetables of public transportation at the moment may not be influenced by ICT immediately, while substantial reduction of fuel like gasoline could be expected in the case of private vehicle for transportation. When ICT including the TV conference becomes more popular in the future, however, it will cause a drastic change in the social structure, inducing the actual reduction in traffic.
It is desired that such activities will be considered in the comparative evaluation of ICT with the baseline service as a potential for inducing a change in environmental impact.
Other activity items with a similar potential include,
* Storage
* Workforce

4.4 Additional Note

This chapter does not necessarily show a negative view to the invention of different types of ICT comparative evaluation, including one in which setting up a baseline service is difficult. However, the validity of any method for comparative evaluation should be examined by critical reviews.

5. Examples

This chapter introduces examples that are evaluated based on the content of the guidelines. Generic data used in each example are not in common usage; each method may be referred to by different names in different examples. Those data are neither standardized data nor recommended data. The data each company selected are explained within each example.

5.1 <Nippon Telegraph and Telephone Group> “FLET’S Service”

►Outline/overview of FLET’S Service

FLET’S Service offers communication lines to provide internet connections with flat monthly charge. The following is the outline of services.

* FLET’S ISDN: services of offering communication lines to provide internet connections via ISDN (Integrated Services Digital Network) lines
* FLET’S ADSL: services of offering communication lines to provide internet connections via ADSL (Asymmetric Digital Subscriber Line) lines
* B FLET ’ S Service of offering communication lines to provide high-speed internet connections via optical fiber

► Overview of evaluation

This section describes the following studies for FLET’S Service (FLET’S ISDN, FLET’S ADSL, [MORE], B FLET’S [Family Type]) provided by Nippon Telegraph and Telephone East Corp. (NTT East).

* Environmental impact evaluation
* Eco-efficiency evaluation
* Comparison of eco-efficiency evaluation (Factor evaluation)

(1) Environmental impact evaluation

► Functional unit

Functional unit is that a customer uses FLET’S Service to access the Internet for two hours and transmits/receives 50MB of data each day throughout the year.

► System boundary

Evaluation model is described in Figure 5.1-1. The model includes foundational equipment and devices for providing the services. That is, equipment for users (e.g. personal computers (hereafter called PC), , ADSL modem and), access equipment (e.g. , , , , optical cable, telephone poles, manholes, and conduits), and transfer facility (e.g. LAN switches, routers, power/air-conditioning facilities and others). These models are established based on the actual network facilities in the Tokyo metropolitan region. Equipment for maintenance operation and user management is not included, as its environmental impact is quite small. User’s terminal is supposed to be desktop PC and notebook PC. Average data is used for the evaluation. It is assumed that terminating equipment for subscribers, ADSL modem, optical networks is energized 24 hours a day.

The life cycle stages to be assessed include production (including constructing equipment and cabling), use, and disposal/recycling (including removal) in the life cycle of each facility. (Figure 5.1-2)

"Recovery by recycling" means the effect of recycling on reducing environmental impact in the society: it is indicated as a negative quantity in the assessment. When the metal in a product is recycled as pig iron, for example, the environmental impact of the recycling is added to the "disposal/recycling" stage, while the base unit for pig iron production is expressed as a negative value gained through "recovery by recycling".

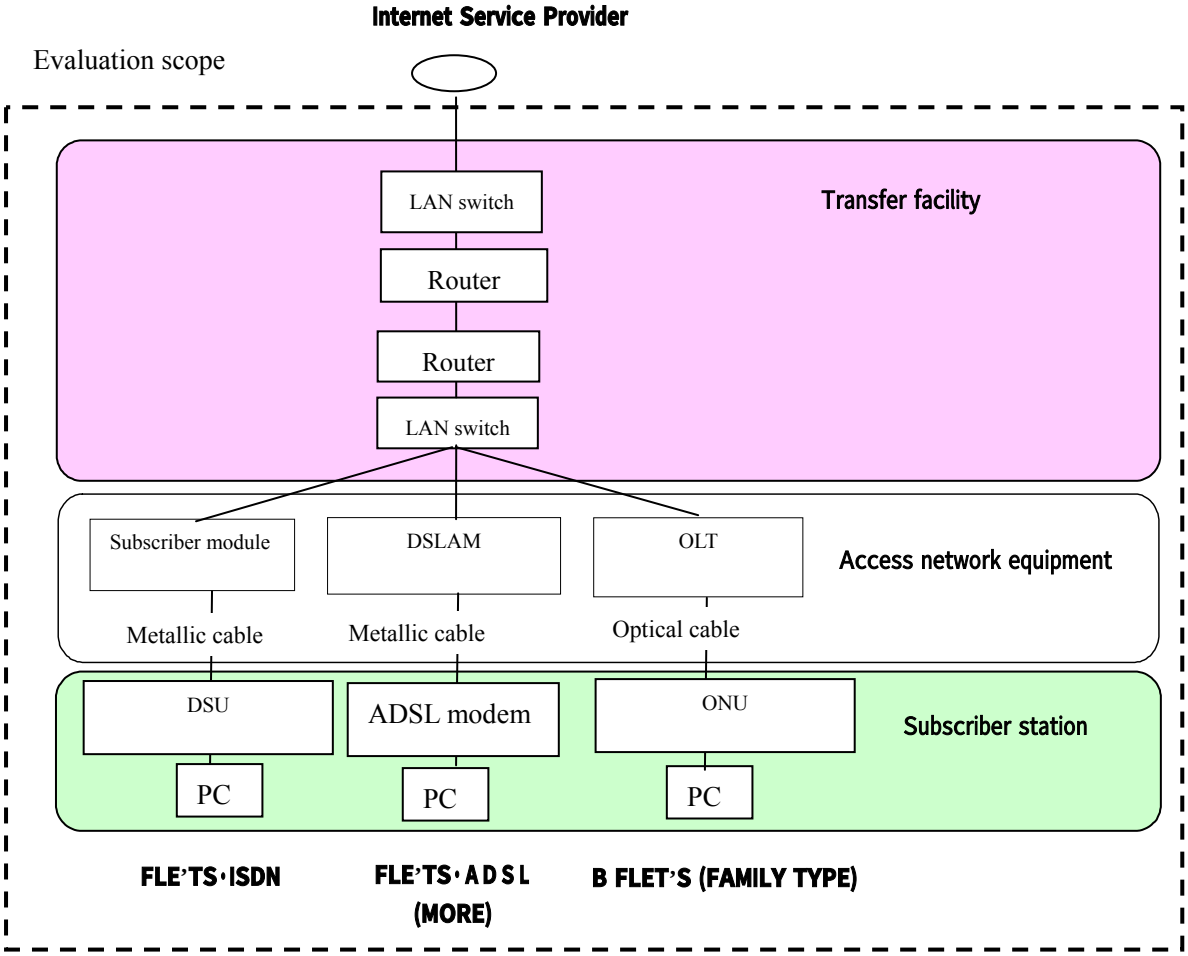


Figure 5.1-1 Evaluation model of FLET'S Service

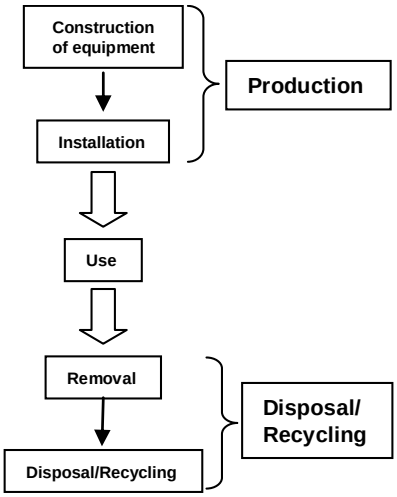


Figure 5.1-2 Life cycle stages

Table 5.1-1 shows relevance between the life cycle stages and evaluation targets/activities shown in "2.3.1 life cycle of ICT".

Table 5.1-1 Relevance between the life cycle stages of B FLET'S and the target items/activities of LCA

[Explanatory note: (○: assessed / – : not assessed)]

	Procurement*2	Design/ Development/ Production*3	Shipment	Distribution*3	Installation*3	Setup	Operation	Collection*3	Disposal/ Recycling
Use of ICT devices*1	○	–	–	–	–	–	○	○	○
Use of network infrastructure*1	○	○ *4	–	○	○	–	○	○	○

*1: "Use of ICT devices" means equipment for users (subscribers) in Figure 5.1-1. "Network infrastructure" is equivalent to transfer facility and access equipment

*2: The "procurement" stage in the cycle of "use of ICT devices" covers the "production" in Figure 5.1-2 since the procurement is considered to include the purchase of ICT devices, e.g. PC, by the users of FLET'S Service, which is a prerequisite before use. Meanwhile, the "procurement" stage in the cycle of "use of network infrastructure" is equivalent to the "construction (of equipment)," as it means the procurement of communication facilities by NTT, the provider of network infrastructure.

*3: In the cycle of "use of network infrastructure," "production," 'distribution," and "installation" stages are equal to the "construction (of equipment)"in Figure 5.1.2, while the "collection" corresponds to the "removal (of equipment) "in Figure 5.1-2.

*4: Design and development are not included for this study.

► Evaluation method

The environmental impact evaluation of each FLET'S service is based on "2.3.2.2.2 Network infrastructure" in the guidelines.

* Equipment for subscribers: The environmental impact is based on the functional unit; a customer uses PC to access the internet for two hours and uses DSU, ADSL modem and ONU for 24 hours each day throughout the year.

* Access equipment: The environmental impact is allocated by the number of subscribers within a equipment and computed the environmental impact per user throughout the year.

* Transfer facility: Based on the functional unit, the environmental impact is calculated for the operation of transmitting/receiving 50MB of data each day throughout the year.

► Results of environmental impact evaluation

Figure 5.1-3 shows the results of environmental impact evaluation for FLET'S Service.

* FLET'S ISDN: The environmental impact throughout its life cycle is 89.1kg-CO_2/year/user. If it includes recovery by recycling, the impact is 83.2 kg-CO_2/year/user. Approximately 22% of the total environmental impact was produced in the production stage, 76% in the use stage, and 2% in the disposal/recycling stage.

* FLET'S ADSL (MORE): The environmental impact throughout its life cycle is 112.6kg-CO_2/year/user. If it includes recovery by recycling, the impact is 106.6 kg-CO_2/year/user. Approximately 18% of the total environmental impact was produced in the production stage, 80% in the use stage, and 2% in the disposal/recycling stage.

* B FLET'S (Family Type): The environmental impact throughout its life cycle is 63.2kg-CO_2/year/user. If it includes recovery by recycling, the impact is 57.4 kg-CO_2/year/user. Approximately 33% of the total environmental impact was produced in the production stage, 63% in the use stage, and 4% in the disposal/recycling stage.

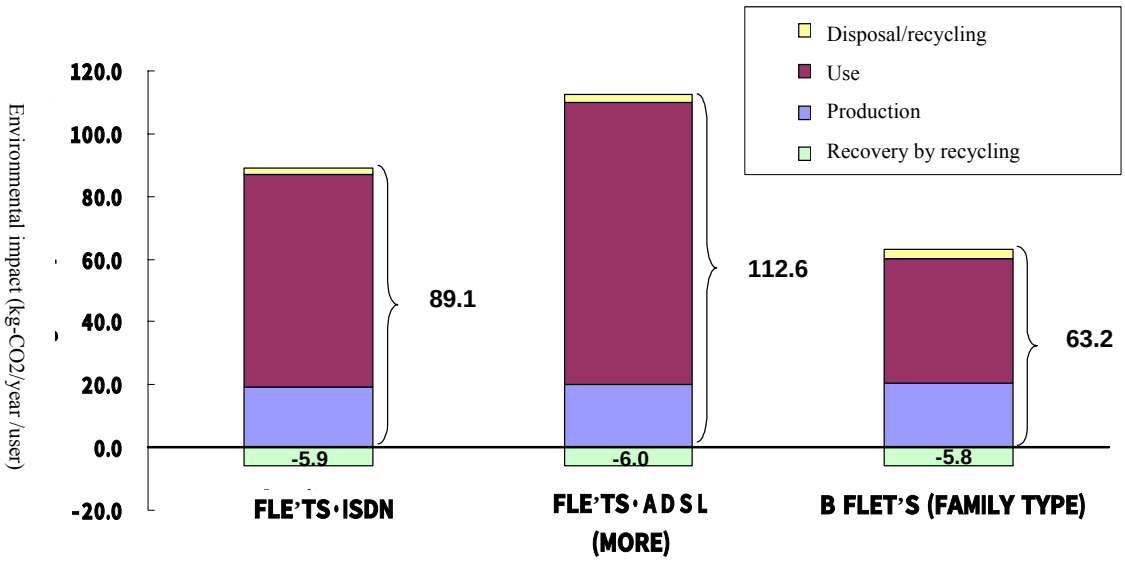


Figure 5.1-3 Environmental impact by internet access service (FLET'S Service)

Recovery by recycling
(2) Eco-efficiency evaluation

► Evaluation method
Each environmental impact evaluation of FLET ' S Service follows the content of "3. outline of ICT Eco-efficiency Evaluation" in the guidelines.

► Target audiences and purposes for eco-efficiency evaluation
For subsequent evaluation of eco-efficiency, some details are mentioned.
The targets of eco-efficiency evaluation are FLET ' S Service (FLET'S ISDN, FLET'S ADSL [MORE], B FLET'S [Family Type]). The scope covers NTT East business area. The target audience is customers within the business area. The purpose of evaluation for eco-efficiency analysis is to provide the information so that customer can select favorable service.

► Value brought by ICT
The value is defined as communication speed of transmitting/receiving data, which can be quantified as physical value. When the communication speed of transmitting data is different from that of receiving data, the average data is applied. The unit is kbps (kilo bits per second) (refer to table 5.1-2). Other document that includes the above evaluation is NTT group CSR report 2005.

► Results of eco-efficiency evaluation
In case of defining communication speed of FLET ' S Service as the value of eco-efficiency, the results are 0.769 kbps/kg-CO_2 with FLET'S ISDN, 61.0 kbps/kg-CO_2 with FLET'S ADSL (MORE), 1740 kbps/kg-CO_2 with B FLET'S (Family Type). The highest eco-efficient service is B FLET'S (Family Type), which performs with the smallest environmental impact and with the highest communication speed (Table 5.1-2).

(3) Comparison of eco-efficiency evaluation
► Evaluation method
Comparative evaluation of eco-efficiency follows the content of "4. Framework of ICT Comparative Evaluation", setting the value of FLET'S ISDN as its baseline. The functional unit of each FLET'S service is consistent with the functional unit defined in environmental impact evaluation (refer to (1) environmental impact evaluation). Similarly, the system boundary is consistent with the definition in the environmental impact evaluation (refer to (1) environmental impact evaluation).

► Generic data
Generic data used in the evaluation is the data of communication equipment that is composed of ICT equipment and network infrastructure or materials used. Generally, data is calculated in process-sum method. In case of being difficult, the data is obtained from EASY-LCA made by Toshiba or LCA SUPPORT made by NEC.

► Results of eco-efficiency evaluation

Evaluation of comparing eco-efficiency (Factor) results in 79.3 in case of FLET'S ADSL (MORE), 2,260 in case of B FLET'S (family type), setting the value of FLET'S ISDN as a baseline (Table 5.1-2).

Table 5.1-2 Relevance between the life cycle stages of B FLET'S and the target items/activities of LCA

Index items	Unit	FLET ' S Service		
		FLET'S ISDN	FLET'S ADSL (MORE)	B'FLET'S (family type)
Value	kbps	64.0	6500	100,000
Environmental impact	kg-CO_2	83.2	106.6	57.4
Eco-efficiency	kbps/kg-CO_2	0.769	61.0	1740
Comparison of eco-efficiency (Factor evaluation)	-	1	79.3	2260

►Reference

1) NTT group CSR Reports (2005) http://www.ntt.co.jp/csr_e/2005report/index.html

5.2 <NEC Corp.> “GreenGlobe – Next Generation Environmental Information Management Solution”

1) Outline of GreenGlobe

Figure 5.2-1 describes the outline of GreenGlobe, the solutions for constructing the advanced eco-management system. It is based on the intensive system of environmental information (e.g. data on environmental impact and environmental accounts) management, utilizing the intranet for collecting data dispersedly managed on each site either inside or outside the country. It is the solution that provides the one-stop services from consulting and system construction to its operation and maintenance.

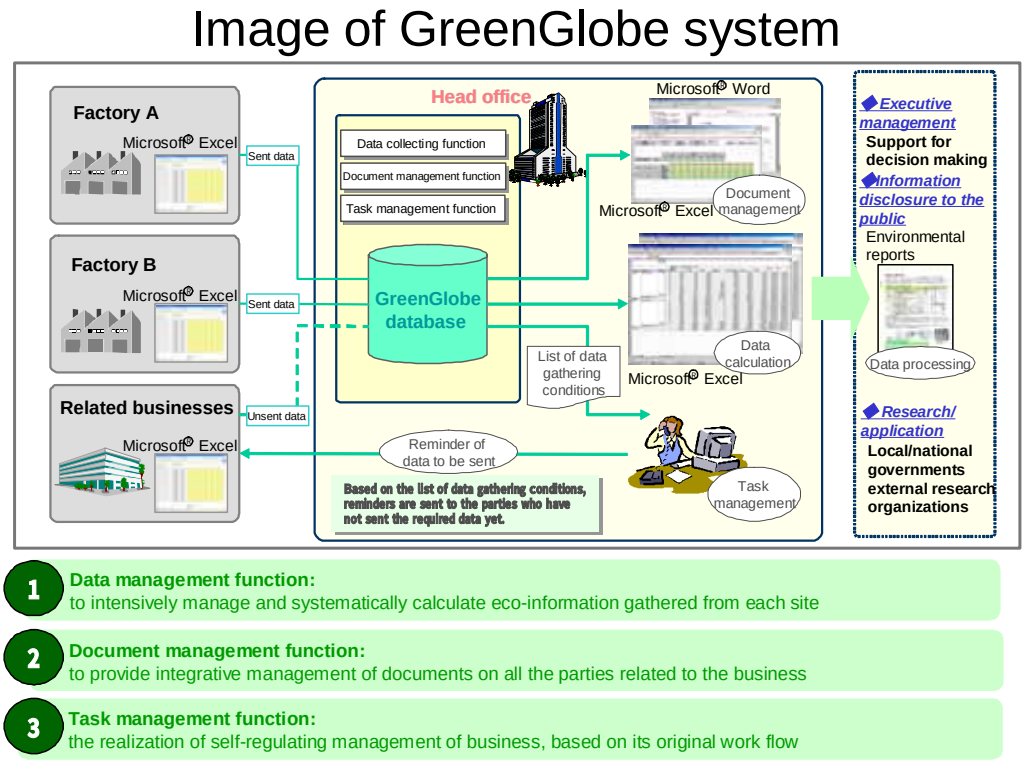


Figure 5.2-1 Outline of GreenGlobe

2) Environmental impact evaluation of GreenGlobe

► Purposes of evaluation

Environmental impact evaluation is focusing on GreenGlobe, which provides solution services, aiming at letting customers, especially corporate clients, to learn the effect of environmental impact reduction through the solution services.

► Functional unit

The functional unit is a set of GreenGlobe systems with the following functions:

- Data management function capable of managing data simultaneously from seven business establishments
- Document management function capable of managing documents equivalent to one million sheets of A4 size paper

● Task management function capable of giving simultaneous directions to seven business establishments

► System boundary

Figure 5.2-2 shows the evaluation models, which are based on the following conditions:

A) Evaluation model (before the introduction of GreenGlobe)

a) Data calculation

For the simultaneous calculation of various environmental data from 7 business establishments, 300 sets of PCs and monitors are used for 60 hours per year.

b) Data collection / business management

For the e-mails to send calculated data to the head office as well as to manage daily works in the environmental management, 300 sets of PCs and monitors are used for 40 hours while 24MB internet access is available throughout the year.

c) Data calculation

For the calculation of gathered data, 5 sets of PCs and monitors are used for 64 hours per year at the head office.

d) Document management

The paper equivalent of a million sheets of A4 size is consumed and 100 units of printers are operated for 8.33 hours per year, for preparing various documents on the information aforesaid required for the eco-management system. Incidentally, parts of the documents equivalent to 330.000 sheets of A4 size paper are transported from business establishments to the head office 60km away.

e) Audit procedure

For the audit of the environmental management system, three auditors traveled six times per year over a distance of 60km by train.

B) Evaluation model (after the introduction of GreenGlobe)

a) Data calculation

Same as before GreenGlobe was introduced.

b) Data collection / business management

As a result of the introduction of the GreenGlobe system, which is used as an alternative method of information exchange using e-mails, just one server is regularly occupied, and the volume of information utilized through the intranet is approximately ten times more than before.

c) Data calculation

As work efficiency is improved by the introduction of the GreenGlobe system, the time spent on data collecting by PC and monitor is approximately 1/5 less than before.

d) Document management

As the management system is computerized by the introduction of the GreenGlobe system, approximately 1/3 of the amount of paper (equivalent to A4 size) is consumed, 1/3 of the time is spent printing, and 1/3 of the amount of paper is transported compared to before.

e) Audit procedure

As the electric audit of the environmental management system is realized by the introduction of GreenGlobe, the auditors travel approximately half the times they used to.

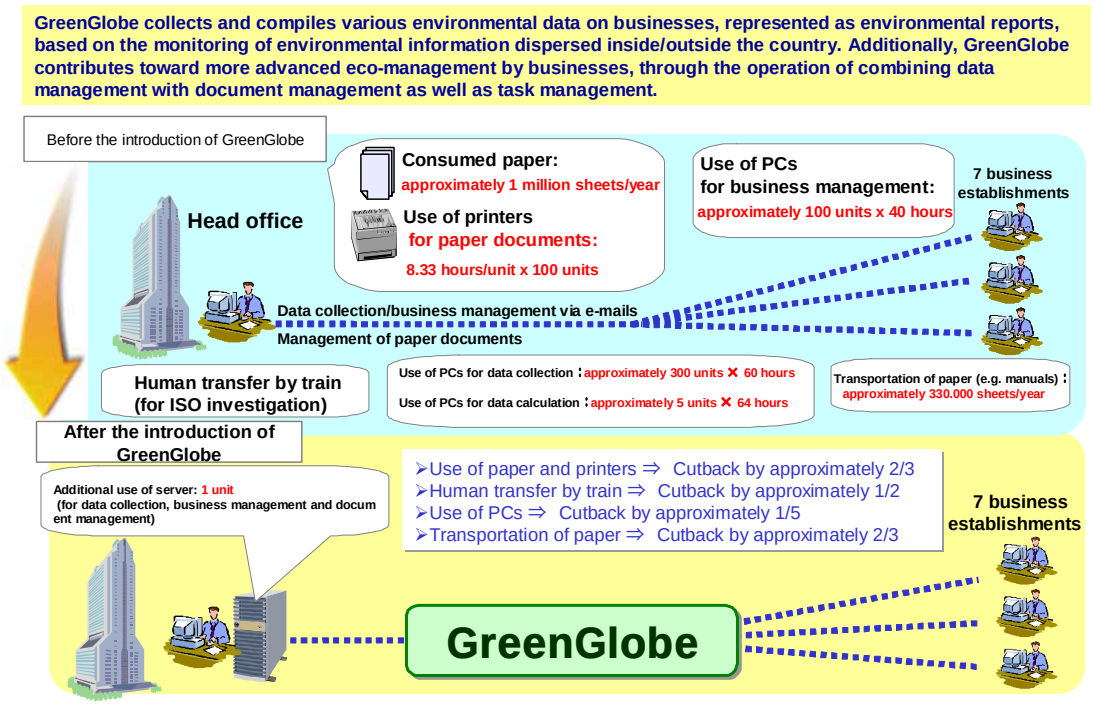


Figure 5.2-2 Environmental impact evaluation model for GreenGlobe

► Evaluation method

The evaluation basically follows the content described in the guideline. Table 5.2-1 shows the relevance between the life cycle stage and the items/activities in the environmental impact assessment. Only the operation stage is assessed because the environmental impact by the other stages in the life cycle is small enough to be disregarded.

Table 5.2-1 Relevance between the life cycle stage and the items/activities in the environmental impact assessment for GreenGlobe

[Explanatory note: ○...assessed, – ...not assessed]

	Operation
Material/energy consumption	○
Use of ICT devices	○
Use of network infrastructure	○
Use of software	–
Shipping	○
Storage	○
Traveling	–
Workforce	–

The actual assessment was estimated with a support tool for eco-solution designing[1)] developed by NEC. The functional unit of CO_2 emission (including the one by electricity) is setup with "LCASUPPORT Database Japan" and "LCA SUPPORT Database: Input-Output Table FY1995." The environmental impact by IP access service is set at 2.5×10^{-3}kg-CO_2/Mbyt, based on reference[2)]. Table 5.2-2 explains basic unit of environmental impact, which are used for GreenGlobe evaluation.

Table 5.2-2 Basic unit of environmental impact, which are used for GreenGlobe evaluation

Target activities	Environmental impact	CO_2 base unit	References
Material/energy consumption	Paper manufacturing and, incinerating	—	Calculation of Paper manufacturing is derived from JEMAI-LCA database, paper incineration is based on data to refer complete burning of cellulose
Use of ICT devices	Generating electricity	—	LCA SUPPORT database, Japan
Use of network infrastructure	Utilizing IP network	0.0025 kg-CO_2/MB	JEMAI "eco-efficiency of ICT services~case study and study reports regarding evaluation rules" (2004)
Shipping-transport substitution	Commercial truck (normal type)	0.176 kg-CO_2/t・km	Ministry of Land, Infrastructure and Transport,(MLIT) " Transportation and Energy Handbook" (2001)
Traveling-transport substitution	Railway	0.018 kg-CO_2/person/km	Ministry of Land, Infrastructure and Transport,(MLIT) " Transportation and Energy Handbook" (2001)

► Results of the assessment

Figure 5.2-3 shows the comparison of CO_2 emission between the models before and after GreenGlobe was introduced: it is assessed that approximately 58% of CO_2 emission was cut by the introduction. In the model without GreenGlobe, approximately 80% of CO_2 emission is induced by material/energy consumption, which is due to the paper used for document management. As GreenGlobe computerizes document management, it can minimize the use of paper and reduce CO_2 emission: as paper documents are decreased, CO_2 emission by shipping due to paper transportation is also cut. CO_2 emission due to traveling also decreases through the introduction of ab electronic audit, which reduces the time of travel by auditors. On the other hand, CO_2 emission through the use of ICT devices as well as network infrastructure increases by the introduction of GreenGlobe, as intranet is utilized more for information exchanges necessary for business management. Nevertheless, the decrease in CO_2 emission on the whole was achieved, as the increased CO_2 emission through the use of ICT devices and network infrastructure is much smaller than the decrease due to other activities.

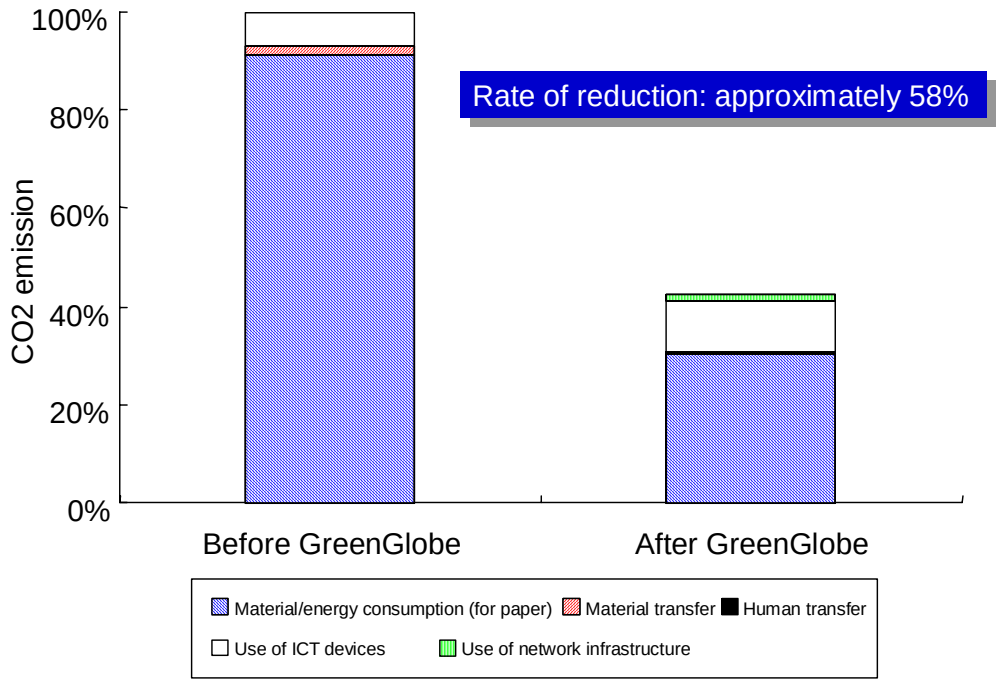


Figure 5.2-3 Environmental impact assessment of the GreenGlobe system (per year of operation)

3) Eco-efficiency evaluation of GreenGlobe

► Purposes of evaluation

Environmental impact evaluation is focusing on GreenGlobe, which provides solution services, aiming at letting customers, especially corporate clients, to learn the effect of eco-efficiency improvement through the solution services.

►Evaluation method

The evaluation method follows the content of this guideline. Regarding "value" which is defined as the numerator of eco-efficiency evaluation, both of values before/after introducing the GreenGlobe is considered as equal, that is one, though it is possible to describe productivity, convenience, operationality, costs and others as value indicators. The denominator of eco-efficiency is derived from the amounts of CO_2 emission that is calculated at 2).

► Results

Figure 5.2-4 shows the comparison of eco-efficiency between the models before and after introducing the GreenGlobe: it is assessed that approximately 2.4 times of eco-efficiency was improved, when the number of the eco-efficiency before introduction is assumed as 1.

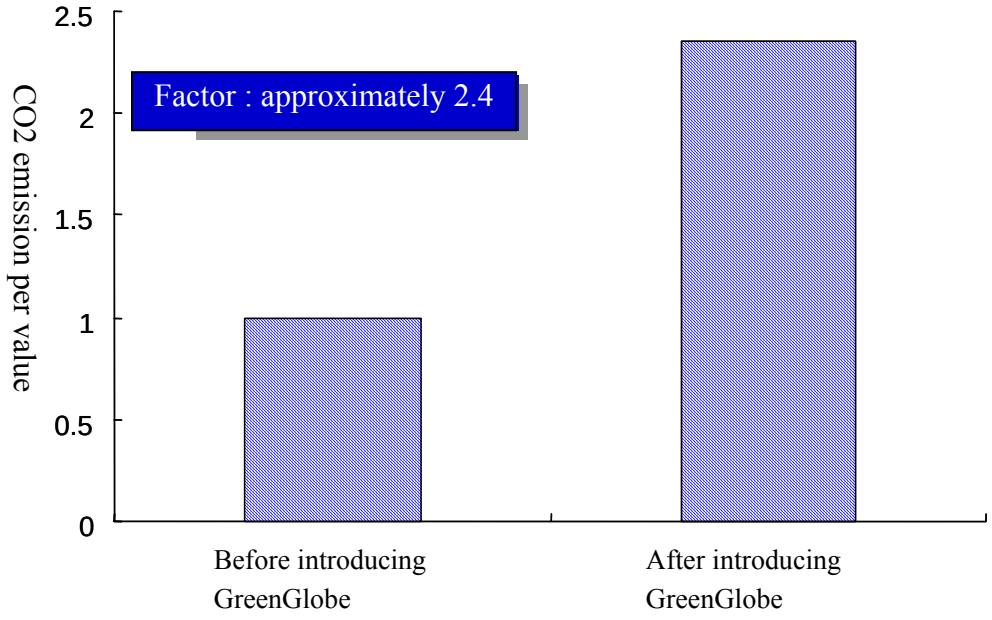


Figure 5.2-4 Comparison of eco-efficiency of the GreenGlobe system (per year of operation)

[References]

1) "Design Support Tool for IT/Network Solutions," Hiroo HARADA and Shigeyuki MIYAMOTO (Summaries of the 1st colloquium of the Institute of Life Cycle Assessment, Japan, 2005)

2) "Reports on the Results Regarding Samples and Calculation Standards of the Eco-efficiency of ICT services," p. 21 (the Japan Environmental Management Association for Industry, March 2004)

5.3 <Hitachi, Ltd.>

Hitachi sets the following common conditions; evaluation method, basic unit of CO_2, life cycle stages, evaluation tools for the two case examples.; since those conditions are explained in the beginning,

1) Evaluation method: each study follows the content of 2.3.2 Target Activities of the Assessment

2) Environmental impact to be assessed: CO_2 emission

3) CO_2 basic unit (example)

Table 5.3-1 Examples of CO_2 basic unit for case studies

Environmental impact	Base unit and others	References
Electricity	0.436kg-CO_2/kWh	Federation of Electric Power Companies（2003）
Paper production	2.339kg-CO_2/kg	Paper pulp handbook 1998 others
Vehicle for delivering ledger sheet	0.145kg-CO_2/t･km	Data Ministry of Land, Infrastructure and Transport white paper（2002）
Environmental impact by transmitting data	2.5g-CO_2/MB	Japan Environmental Management Association for Industry[1]
Number of man power	2.36kWh/person･h	Actual measurement at office

4) Life cycle stages: both studies follow the content of "2.3.1 life cycle stages for ICT". In both case examples, the stages cover procurement, design, develop and production, shipment, distribution, installation, setup, operation, collection, disposal/recycling

5) Evaluation tool: SI-LCA (System Integration –Life Cycle Assessment) developed by Hitachi is applied. [2]

5.3.1 Case example of evaluation "ReportMission" [2]

► Outline of the system

The ReportMission is a system which provides electronic report on the screen and enables automatic search /transmission without outputting paper instead of conventional services which requires the processing results on real paper in order to make forms control.

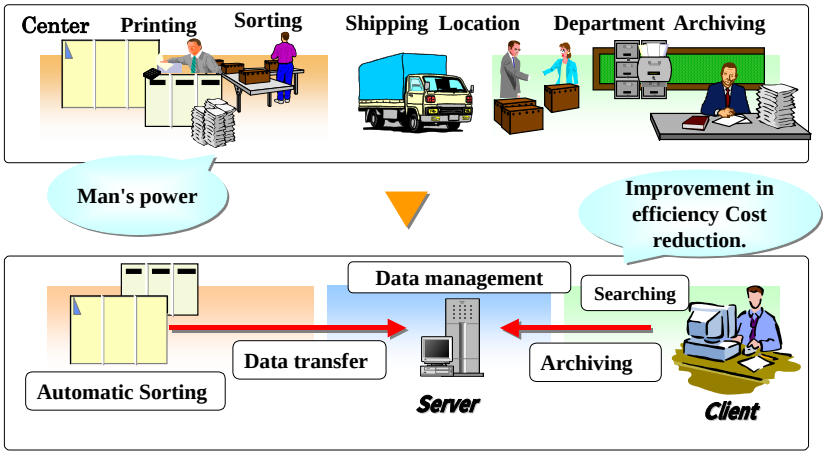


Figure 5.3-1 Outline of the electronic report system "ReportMission"

► Functional unit

ReportMission delivers 48 million reports for a year to 100 departments (10 locations, 10 departments/ location).

► System boundary

Figure 5.3-2 shows an evaluation model before introducing ReportMission system, Figure 5.3.-3 explains the evaluation model after introducing the system. These models assume that report is sent to each location from base center. Before introducing the system, those reports used to be printed and classified into each location and transported into each center, where the reports are sorted and delivered to each department. After the introduction, 10% of reports are still delivered by track, the rest of 90% are searched and viewed through the Intranet. In this evaluation, manufacturing devices (printer, server, PC) , use, sorting, searching / viewing, and transportation. Table 5.3.-2 presents the evaluation targets of each life cycle stage.

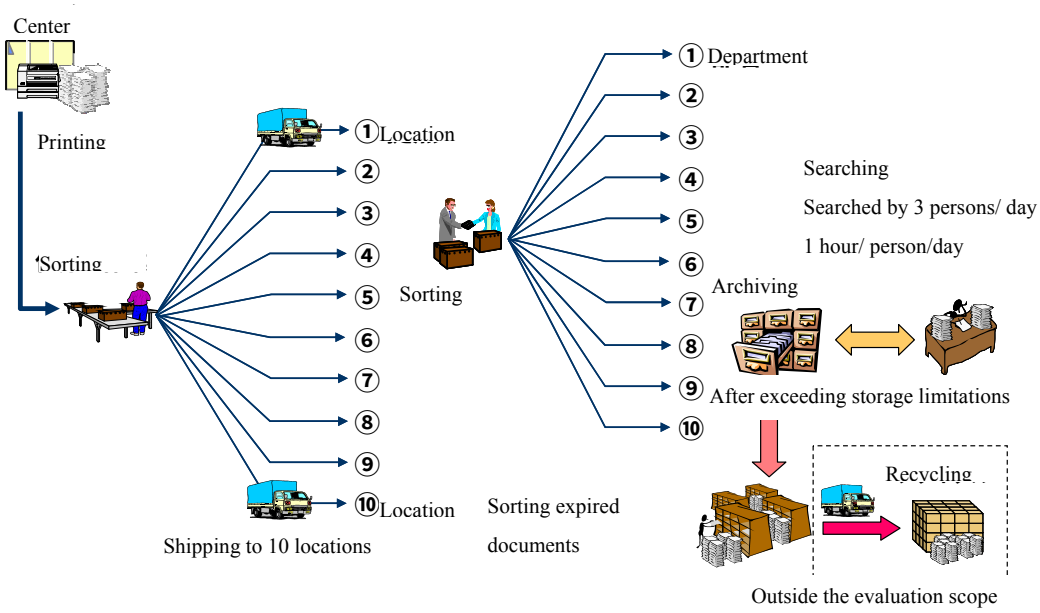


Figure 5.3-2 Model before the introduction of ReportMission

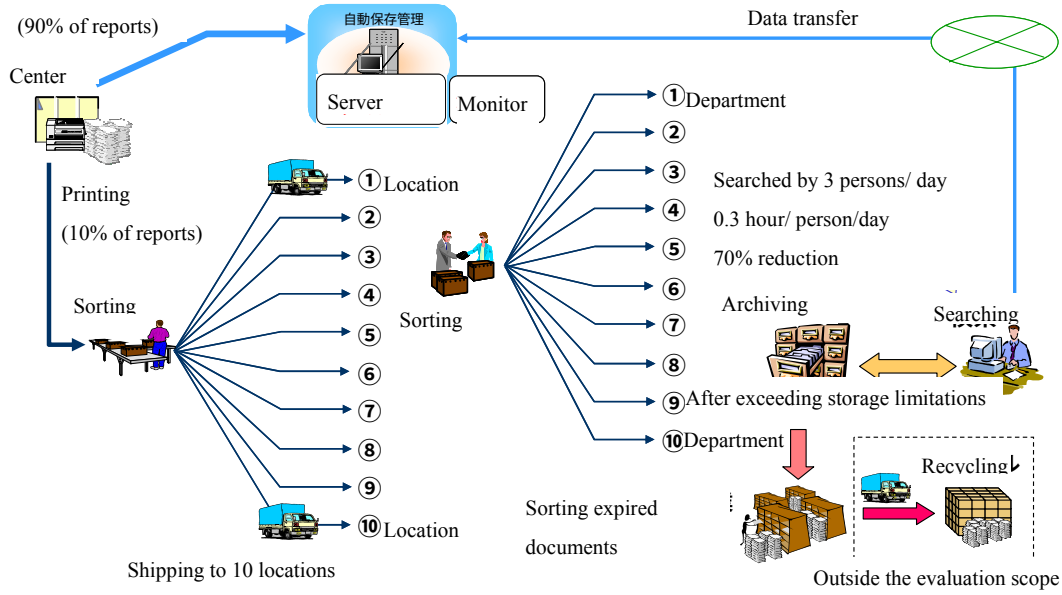


Figure 5.3-3 Model after the introduction of ReportMission

Table 5.3-2 Evaluation targets in each life cycle stage

Life cycle stage		Before the introduction of ReportMission	After the introduction of ReportMission
Procurement		Manufacturing 4 units of printers	Manufacturing printers, servers, monitors, and PCs for clients (The results of LCA with Hitachi eco design assessment tools are utilized.)
Design/development/production(*)			Environmental impact for system design and development
Shipment			CD: 1,, user's manual : 500,, and corrugated carton: 1 CD：1 piece, manual book：paper 500 sheets, packaging cardboard：1 box（carton）
Distribution		Transport of printers (transportation: 4-ton truck / distance: 100km)	Transport of the above equipments (transportation: 4-ton truck / distance: 100km)
Installation(*)		2 days for installation	1 day
Setup(*)			8 persons/ day/ one setup setup covers setup, registering reports, and user guidance
Operation	Paper consumption	48 million sheets/year (A4 size printing paper)	4.8million sheets/year (A4 size printing paper)
	Human work	75 workers/year (sorting)	13 workers/day/year
	Power consumption	Power consumption by printers: 45,000kWh/year	Power consumption by scanners, PCs and servers: 17,946kWh/year
	Shipping	480,000km/year (Transportation for delivering reports)	240,000km/year
	Use of internet infrastructure		Data capacity for considering searching and viewing (6kb/paper)
Collection		Transportation of 4 units of printers from the head office/branches to recycling facilities (full load for 4-ton truck / distance: 50km)	Transportation of printers and servers to recycling facilities (transportation volume: full load for 4-ton truck / distance: 50km)
Disposal/recycling		Printer	Printer, server, monitor, client PC

Eco-efficiency of the business establishment:

"Total sales by the business establishment" ÷ / "environmental impact"

► Assessment method

Table 5.3-3 shows the relevance between the life cycle stages and assessed items/activities in the assessment of environmental impact by ReportMission.

Table 5.3-3 Relevance between the life cycle stages and assessed items/activities in the assessment of environmental impact by ReportMission

[Explanatory note: ○...・・・assessed / ―...・・・not assessed]

	Procurement	Design/ development/ production	Shipment	Distribution	Installation	Setup	Operation	Collection	Disposal/ recycling
Material/energy consumption	○	○	○	○	―	○	○	○	○
Use of ICT devices	―	―	―	―	―	―	○	―	―
Use of network infrastructure	―	―	―	―	―	―	○	―	―
Use of software	―	○	―	―	―	―	― ○	―	―
Shipping	―	―	―	○	―	―	○	○	―
Traveling	―	―	―	―	―	―	○	―	―
Storage	―	―	―	―	―	―	―	―	―
Workforce	―	○	―	―	○	○	○	―	―

► Results

Figure 5.3-4 shows the results obtained from SI-LCA (the CO_2 emission) throughout a year both before and after the introduction of ReportMission Table 5.3.-4 explains the results only for operation stage. Though ReportMission increases CO_2 emission by power consumption in production and operation of server and PCs, it reduces paper consumption in the operation stage and distance for delivery tracks. Additionally, it cuts down man-hourpower, through the significant improvement in searching and sorting speed. As a result, CO_2 emission throughout the life cycle was reduced by approximately 82%.

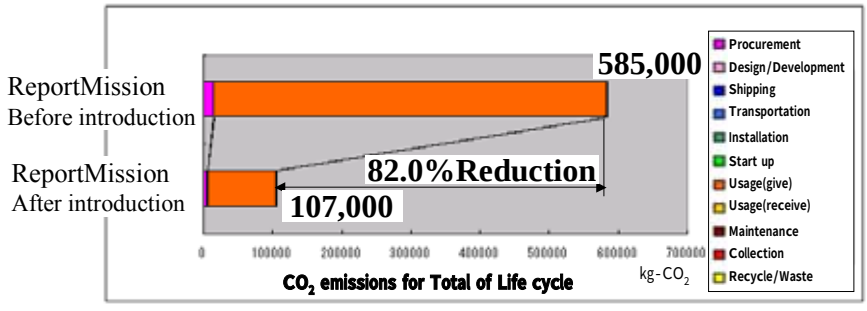


Figure 5.3-4 Results of the Assessment

Table 5.3-4 Evaluation results of operation stage

Environmental impact	CO_2emission（kg-CO_2）		Reduction rate（%）	Evaluation target
	Report Mission Before the introduction	Report Mission after the introduction		
Paper use	449,088	44,909	90	Printing paper
Workforce	12,384	2,206	82	Searching, sorting, disposal of expired reports
Electricity consumption	19,620	7,832	60	Power consumption for Printer, server, monitor , client PC
Automobile run	90,230	45,115	50	Tracks for delivering reports
Other impacts	0	51	—	Impact from network infrastructure with data transfer

► Target audiences of eco-efficiency
Manager (system user)

► Values
The ReportMission ensures high speed data analysis due to swift data transfer from center to each department. However, it is difficult to evaluate the effect quantitatively. Therefore, the values defined in eco-efficiency is considered as 1, “value before introducing the ReportMission=value after introducing the ReportMission=one”.

► Results of eco-efficiency and factor
ReportMission introduction=.1/585 t-CO_2=0.0017
ReportMission introduction=.1/107 t-CO_2=0.0093
Factor =b/a= 5.5

5.3.2 Case example of evaluation (2), library management system “Livre”

► Outline of system
The outline of Livre is shown in the figure 5.3.-5. Livre is a system that supports a wide range of library services; speedy circulation procedure with barcodes, quick search to find a book, computer-assisted information search for library records, books, serials, articles, special materials, quick, easy and systematically. By using the web for reserving a book and asking delivery, users do not have to go to a library. The benefit for users is large. Document management also can be well operated. Circulation work and management work can be implemented only with manager’s personal computer which controls all book databases.

Figure 5.3-5 library management system “Livre”

► Functional unit

Livre controls a library that carries 10,000 books for a year.

► System boundaries

Figure 5.3.6 shows before and after Livre services. In this study, the evaluation assumes application for lending books by using the web function, excluding delivery services.

Before introducing Livre, users are asked to have a borrower card which is required for borrowing. Library has to operate book control by using an inventory book on real paper. After introducing the Livre, lending can be implemented with barcode. Daily management and making an inventory can be done with DB server and personal computers and with barcode.

Table 5.3.5 shows evaluation target of each life cycle stage and values of evaluation.

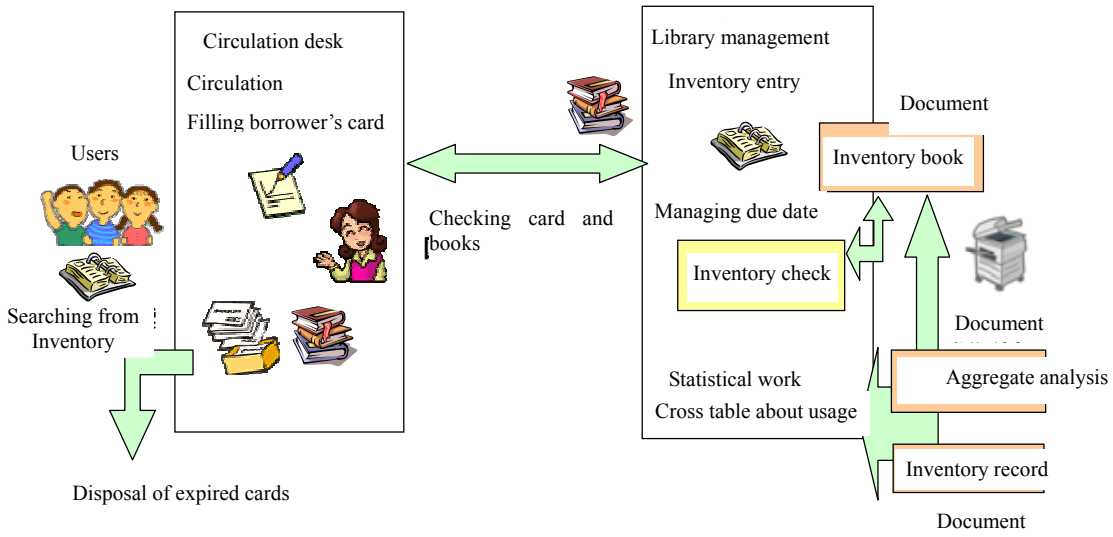


Figure 5.3-6 Model before introducing Livre

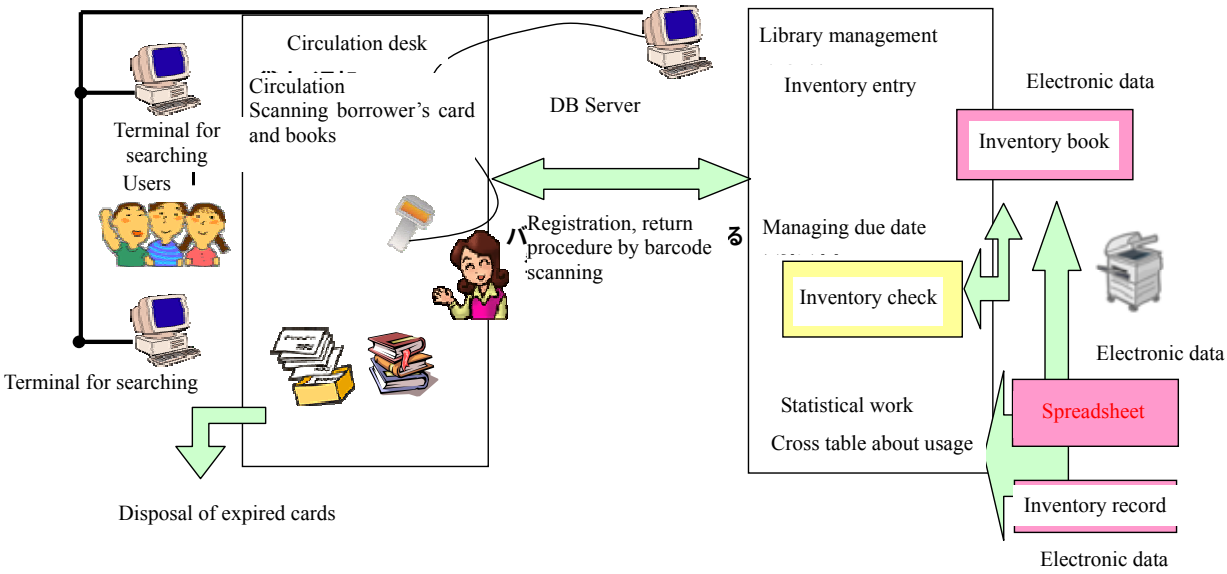


Figure 5.3-7 Model after introducing Livre

Table 5.3-5. Evaluation target of each life cycle stage

Life cycle stages		Before the introduction of "Livre"	After the introduction of "Livre"
Procurement		Copying machine：one (The results of LCA with Hitachi eco design assessment tools are utilized.)（using Hitachi environmental consideration designing assessment tool）	Server, PC, Copying machine：one (The results of LCA with Hitachi eco design assessment tools are utilized.)（using Hitachi environmental consideration designing assessment tool）
Design/development/ production (*)		—	Development cost of Livre（calculating with office eco-efficiency）
Shipment		—	CD：1 piece, manual book：paper 375 piecessheets, packaging cardboard：1 box（carton）
Distribution		100km transportation of copying machine ,with 4 ton truck	100km transportation of server,pc, copying machine with four 4 ton truck
Installation(*)		—	Installation man-hours（calculating with office eco-efficiency）
Setup(*)		—	Setup man-hours（Calculating with office eco-efficiency）
Operation	Paper consumption	9,892 papers per year	751 papers per year
	Workforce	Annual workforce＝48.6 people per day	Annual workforce＝22.4 people per day
	Electric power consumption	Electric consumption of copying machine :11.2kWh/year	Electric consumption of server, PC, copying machine, PC, and others whole system ：567kWh/year
	Other environmental load	User card（plastic）	User card (plastic) Book labeling（paper）
	Maintenance (*)	Maintenance work of copying machine（calculated as office eco-efficiency*）	Maintenance works for whole system（calculated as office eco-efficiency*）
Collection		Transporting copying machine with four ton truck, 100km	Transporting server, PC, copying machine and others with four tones truck to recycling cites 100km away
Disposal/recycling		Copying machine	server, PC, copieng machine etc

* Eco-efficiency of the business establishment:

"Total sales by the business establishment" ÷ / "environmental impact"

► Evaluation method

Table 5.3.6 shows the relation among life cycle stages and evaluation targets and activities at environmental impact evaluation in Livre.

Table 5.3-6 The relation among life cycle stages and evaluation targets and activities at Livre

（○：evaluation target，－：not evaluation ）

	Procurement*2	Design/ Development/ Production*3	Shipment	Distribution*3	Installation*3	Setup	Operation	Collection*3	Disposal/ Recycling
1) Goods/energy consumption	○	○	○	○	○	○	○	○	○
2) Use of ICT devices	－	－	－	－	－	－	○	－	－
3) Use of network infrastructure	－	－	－	－	－	－	○	－	－
4) Use of software	－	○	－	－	－	－	－	－	－
5) Shipping ~transport substitution	－	－	－	○	－	－	－	○	－
6) Traveling ~Transport substitution	－	－	－	－	－	－	－	－	－
7) Storage	－	－	－	－	－	－	－	－	－
8) Workplace	－	○	－	－	○	○	○	－	－

► Results

Figure 5.3-8 explains CO2 emission before and after introducing the Livre with operation for one year.

The Livre introduction increases manufacturing the procurement equipment and power consumption in the operation stage. However, the consumption of paper in the operation stage can be reduced, and the work man-hour by the efficiency improvement of routine works. 41% of the the CO2 emission can be reduced at all life cycles.

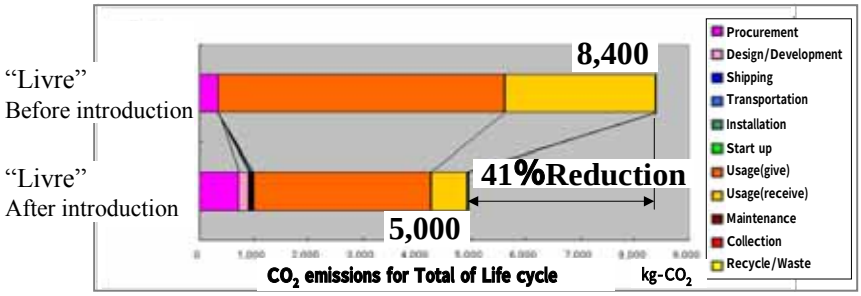


Figure5.3-8 Results of evaluation

► Target audiences of eco-efficiency evaluation

Librarian

► Values

Library books Turnover (number of books per year/ number of book stock

“Livre” may increase the turnover ratio of book stock. But until now, the evidence is yet obtained. Instead, the example is derived from other example at a library, “Bunkyo ward library”, where the online system for searching and reservation was already introduced. According to the announcement of the library, approximately 2.08 times increases for reservation and requesting, 1.07 times increases for lending books. Therefore the number of 1.07 was applied for the potential effect

(Calculation of turnover ratio of book stock) * 900 books was defined as number of lending book per month in this case study.

Turnover ratio of book stock before introducing Livre
=(900books/ month*12 *10,000books) *100=108%

Turnover ratio of book stock before introducing Livre
=(900books/ month*1.07*12 *10,000books) *100=115.6%

► Results of eco-efficiency and factor evaluation
Eco-efficiency before introducing Livre = 108.0/8.4 t-CO2/year =12.9……(A)
Eco-efficiency after introducing Livre =115.6/5.0t-CO2/year=23.1…(B)
Factor=B/A=1.8

► References
1) NISHI, “SI-LCA: Assessment Method for Environmental impact by System Products,” brochure for the speech at the 2nd Conference of LCA Society of Japan, August 2005
2) NISHI et al, “SI-LCA: Assessment Method for Environmental impact by System Products,” Collection of papers for “Eco-design 2004 Japan symposium, pp.268-271, 2004

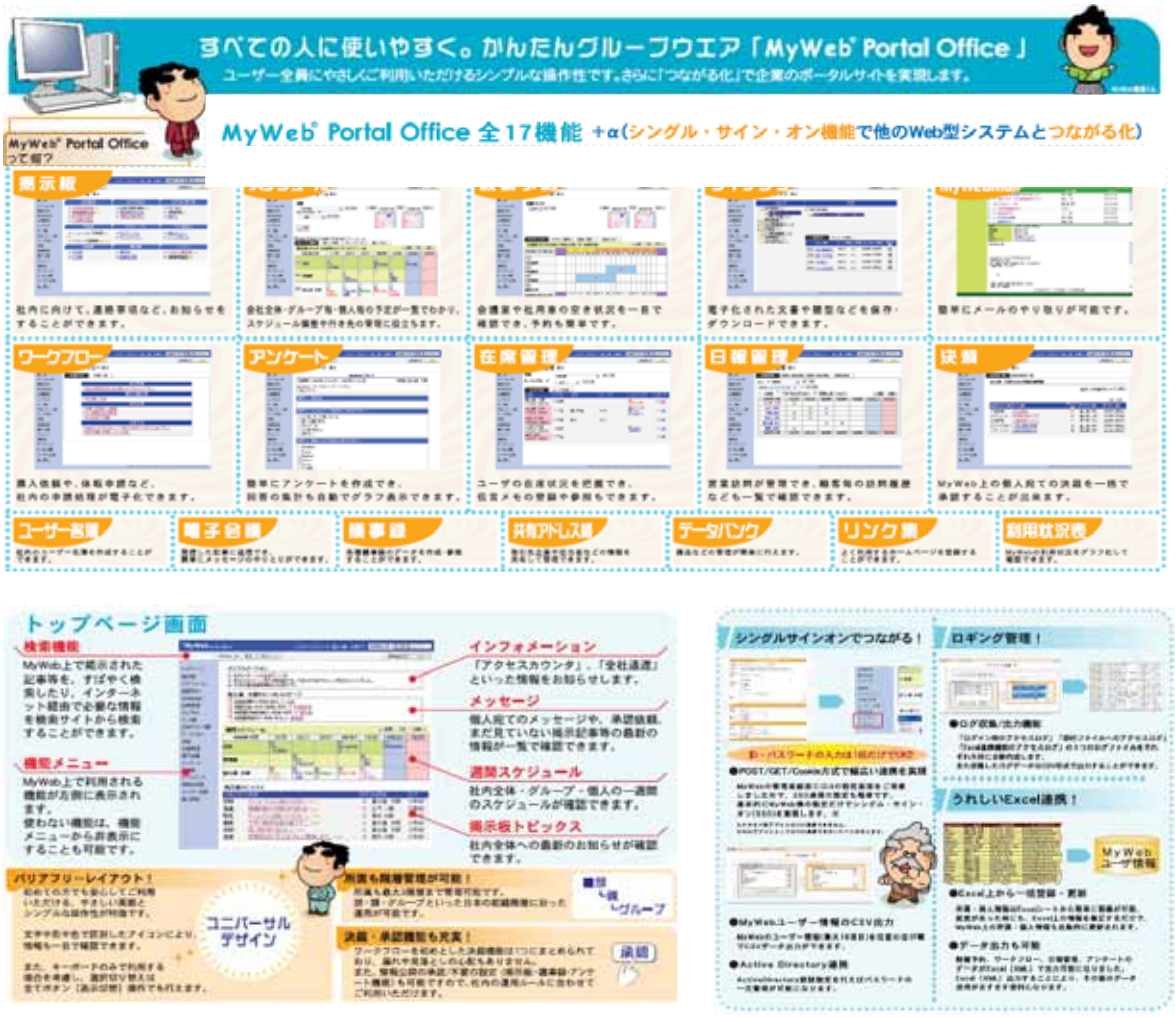
5.4 <Fujitsu Ltd.> “MyWeb Portal Office Groupware Easy-to-operate for Everyone”

1) Outline of system

[Outline of functions]

Figure 5.4-1 describes the outline of MyWeb Portal Office, the groupware for better internal communication and information sharing throughout companies via the intranet.

MyWeb Portal Office is a communication tool well adapted to the “Japanese-style” organization that is easy to operate for everybody on the Web. The standard model has 17 functions, including a bulletin board, scheduling, and approval. It is available for step-by-step use e.g. concealing unnecessary functions on the display. Additionally, MyWeb Portal Office can correspond with mobile terminals (i-mode, EZweb and Vodafone live!) and PDA (PocketPC2002/2003), featuring accessibility from anywhere, anytime.



* MyWeb Portal Office is the registered trademark of Fujitsu Shikoku Ltd.

Figure 5.4-1 Outline of Fujitsu’s Groupware “MyWeb Portal Office”

2) Functional unit

The functional unit, in this case MyWeb Portal Office, is operated for a year, providing the circulation of a bulletin board of documents on a library, schedule management, and management of facility booking for a company with 200 workers.

The list of values and base data used for the assessment is presented in [Assessment method].

3) System boundary

Based on the "2.3.1 Life cycle of ICT" in the guidelines, the "operation" stage is solely chosen as the target of the assessment, as it is significantly effected by the introduction of ICT.

Figure 5.4-2 shows the evaluation models before/after the introduction of MyWeb Portal Office.

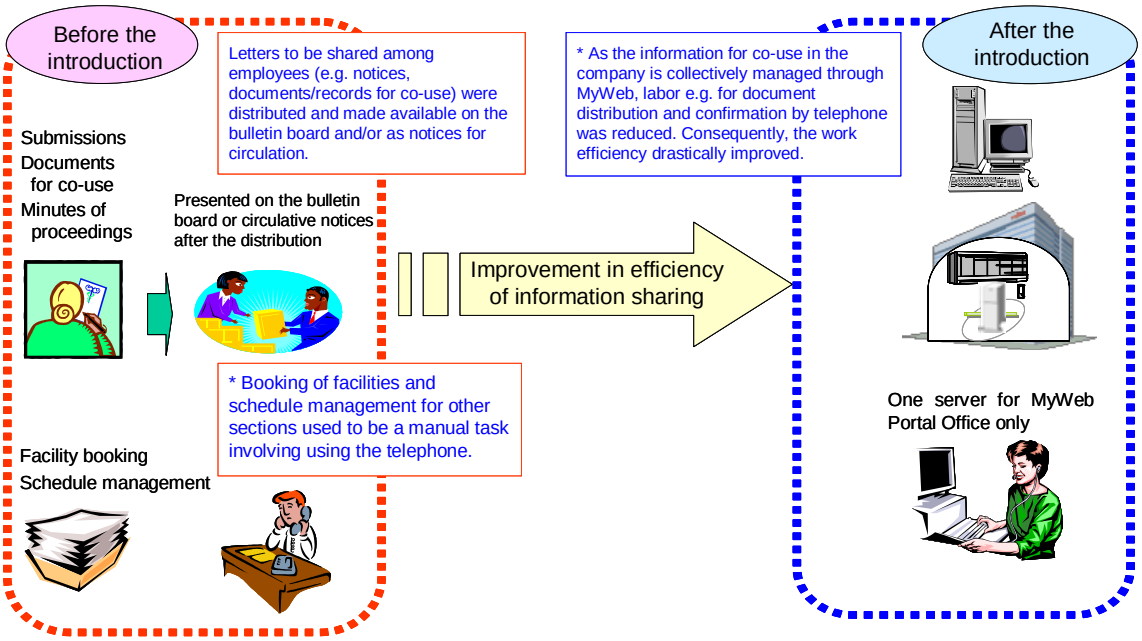


Figure 5.4-2 Models before/after the introduction of MyWeb Portal Office

Before the introduction:

1. Letters for internal co-use in companies (e.g. notices, documents/records for co-use) used to be shared by reproducing the necessary number of copies from the original, and presenting them on the bulletin board and/or as circulative notices.
2. Schedule management used to be performed by employees and the information was presented on a white board and/or in a schedule book.
3. Booking of facilities used to be managed by the administrative section at each site. When an employee needed to make a booking, it was necessary to ask the administrative section or make the booking by him/herself by phone.

After the introduction:

1. As the server collectively manages all the documents on the bulletin board as well as in the minutes/library, it becomes unnecessary to make copies for distribution. Consequently, the volume of paper for documents is significantly reduced.

2. As the server collectively manages schedules of all employees (with an enrollment list and a register of users), the efficiency of internal communication within companies considerably improves.
3. As all the bookings of facilities becomes available on the Web, manual labor for booking by phone or through the use of a schedule book becomes unnecessary.

► Assessment method
The assessment is based on the "2.3.2 Target activities of the assessment" in the guideline.
Table 5.4-1 shows the relevance between the life cycle stages of MyWeb Portal Office and the target items/activities, for while Table 5.4-2 presents the base data used in the assessment. The assessment method for environmental impact by ICT, adapted by Fujitsu, was used.

Table 5.4-1 Relevance between life cycle stages and the target items/activities
[Explanatory note: ○...assessed / – ...not assessed]

	Procurement	Design/ development/ production	Shipment	Distribution	Installation	Setup	Operation	Collection	Disposal/ recycling
Material/energy consumption*							○		
Use of ICT devices*							○		
Use of network infrastructure*							○		
Use of software*							–		
Shipping							–		
Traveling							–		
Storage*							○		
Workforce*							○		

* The target factors of the assessment are as follows, based on the assessment method for environmental impact by ICT adapted by Fujitsu.
Material/energy consumption (paper consumption in this assessment)
Use of ICT devices: power consumption for the target ICT devices
Use of network infrastructure: volume of network data communication
Storage: office/storage space
Workforce: office space

Table 5.4-2 Basic data before/after the introduction of MyWEb Portal Office

Target activities	Effect factor at Fujitsu	Basic data	Before the introduction	After the introduction
Material/energy consumption	Usage amount	Sheets of used paper	46.500 (sheets)	2.200 (sheets)
Use of ICT devices	Power consumption for IT/NW	Server	546 kWh	6,646 kWh
Use of network infrastructure	Volume of data communication on network	Data communication	1,090 Mbyte	58,195 Mbyte
storage	Office space	Space for documents	0.42 m^2	0.02 m^2
		Space for devices	0.0 m^2	0.5 m^2
workforce		Number of man-hour	60 persons/month	20 persons/month

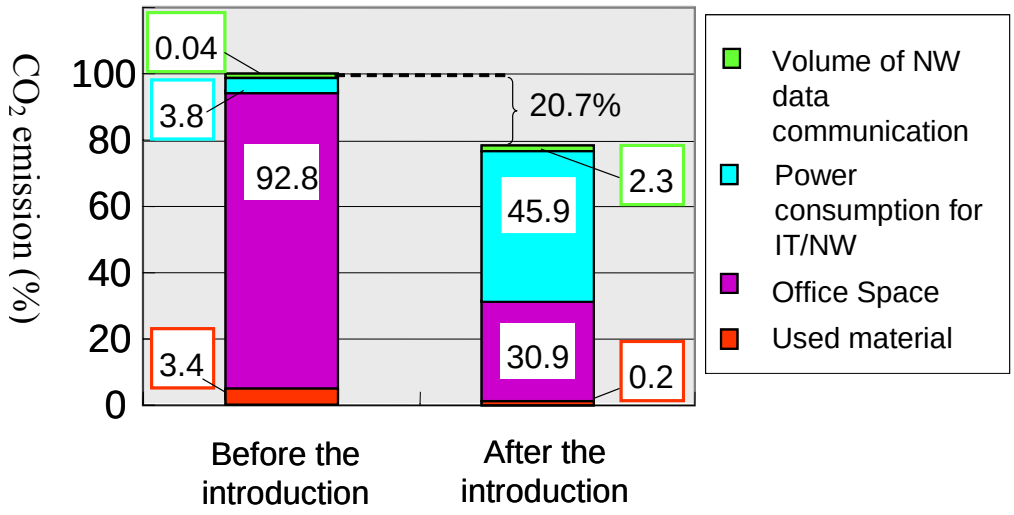
Column: Base unit for office space
Fujitsu sets fundamental base units based on the inter industry tables on FY1995. The base unit for workforce is estimated as follows, by calculating CO_2 emission from an office building necessary for an employee to work for a year.

Environmental impact by the business building[3)]: 87.7kg-CO_2/m^2・year ---- (1)
Required space for a worker[4)]: 13.1/m^2/worker ---- (2)
CO_2 emission from an office building necessary for an employee to work for a year: 1.149kg-C O_2/m^2・year ---- (1)×(2)

4) Results of Assessment
Figure 5.4-3 shows the CO_2 emission from an operation for a year before/after the introduction of MyWeb Portal Office. Following are the effects produced from the introduction of MyWeb Portal Office:

1. As copying documents on data for co-use becomes unnecessary, the consumption of paper is reduced.
Approximately 46.000 sheets/year → 2.000 sheets/year
2. Labor for co-use of internal data and communication within companies is significantly cut down.
Approximately 60 men/month → 20 men/month

While CO_2 emission increases because of power consumption by server and ICT devices, the CO_2 emission by paper consumption and workforce is significantly reduced. Overall, 21% of CO_2 emission is reduced.



* CO_2 emission before the introduction is set at 100%.

Figure 5.4-3 Results of Assessment

5) Target audience for providing eco-efficiency

The target for assessing eco-efficiency is a variety of products. The above data is disclosed tor the clients who purchase MyWeb Portal Office. The purpose of the evaluation is to show environmental improvement by comparing before/after introducing my web portal office to a certain company that has 200 employees.

6) Indicators

In terms of the definition of eco-efficiency in 3.1, values are considered as equal before and after using MyWeb Portal Office, ICT environmental impact (denominator) is defined as CO_2 emission in this study.

Factor is a ratio of eco-efficiency. Then, the factor can be explained as follows;

Factor= 1/(1-0.207)=1.3

7) References

Case studies of ICT solutions, that are expected to show environmental improvement, including My-Web Portal Office, are available from the following;

http://jp.fujitsu.com/about/csr/eco/solutions/envsolutions/list.html

Reference of this example is available from the following web;

a) http://www.myweb-jp.com/portaloffice/

b) http://jp.fujitsu.com/group/labs/business/activities/activities-3/index.html#envtech

c)" Investigation on actual conditions of energy consumption for general use" by NEDO

d) Building Owners and Managers Association, Japan

http://www.birukyo.or.jp

8) Basic unit

For calculation of CO_2 emission, the following reference data were applied.

Table 5.4-3 Table of basic unit

Environmental impact		Basic unit		source
Goods consumption	Paper	$1.6*10^{0}$	kg-CO_2/kg	1995 interindustry table (1999)
	Weight basis factor	$4.00*10^{-3}$	kg/ sheet	Paper, pulp handbook 1998
Office space （use stage only）	Per 1 m^2	$8.77*10^{1}$	kg-CO_2/m/year	1995 interindustry table (1999)
	Workspace per person	$1.31*10^{1}$	M^2/person	Building Owners and Managers Association, Japan
Power consumption of IT, network devices	Electricity	$4.40*10^{-1}$	Kg-CO_2/kWh	1995 interindustry table (1999)
Power consumption of network data communication	Data communication	$2.5*10^{-3}$	Kg-CO_2/Mbyte	Reports about eco-efficiency of ICT servies (JEMAI) (2004)

*Basic units that are derived from input/output table are arranged and converted in Fujitsu's own right.

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