

## Formulation of Guidelines for ICT Eco-efficiency Evaluation at the Japan Forum on Eco-Efficiency

*Takeshi Origuchi<sup>†</sup>, Takashi Sawada, and Shiro Nishi*

### Abstract

Guidelines for evaluating the eco-efficiency of information and communications technology (ICT) have been formulated at the Japan Forum on Eco-Efficiency (JFEE) by a working group that includes NTT. They provide the first uniform standard for evaluating environmental impacts and eco-efficiency achieved by the introduction of ICT. They enable objective evaluation of the environmental load, eco-efficiency, and environmental impact reduction effect of various ICT services.

### 1. Introduction

In recent years, the rapid spread of information and communications technology (ICT), such as the Internet, broadband access, and mobile communications, has accelerated the paradigm shift from an industrial society to an information society. ICT has a large influence on the environmental, economic, and social aspects of our lives. Accordingly, increased transparency and objectivity is being sought regarding ICT evaluation. Against this background, in March 2006, the “Guideline for Information and Communication Technology (ICT) Eco-Efficiency Evaluation” [1] (hereafter called the Guidelines) was published by the Japan Forum on Eco-Efficiency. This document aims to provide an objective and practical tool for evaluating the ICT-related eco-efficiency of individuals, businesses, and society as a whole. This article provides an overview of these Guidelines and discusses the ideas behind them.

Eco-efficiency is expressed as the value of products and services divided by the environmental load. A more eco-efficient system provides greater value for a given environmental load or the same value for a lower environmental load or ideally both more value and less environmental load. Eco-efficiency embodies the idea that reducing the environmental load can create more value. As an indicator for environmental

management and for managing the development of products designed taking the environment into account, eco-efficiency is coming to be introduced and applied by an increasing number of companies.

### 2. ICT and its environmental impacts

The environmental impacts of ICT can be divided into negative and positive factors, as shown in **Fig. 1**. Negative factors result from the environmental load caused by ICT. They include energy consumption due to the electricity used by ICT devices and networks, the use of natural resources for producing ICT devices and constructing facilities, and the generation of waste from the disposal of ICT devices and dismantling of facilities. Positive factors are associated with the reduction in environmental load achieved by ICT services. These include dematerialization, which refers to the replacement of physical production and distribution of music and video in the form of CDs and DVDs by the delivery of digital information over the network, reduced movement and transportation through the use of videoconferencing, and intelligent transport systems, as well as more efficient industry and living through supply chain management systems, information appliances, etc. We can also expect ICT to be used to enhance environmental awareness and environmental education and to play a role in reducing the environmental load through the use of environmental sensors and environmental monitoring. When thinking about the impact of ICT on the global environment in this way, it is necessary to

<sup>†</sup> NTT Information Sharing Laboratory Group  
Musashino-shi, 180-8585 Japan  
Contact: kansuip@lab.ntt.co.jp

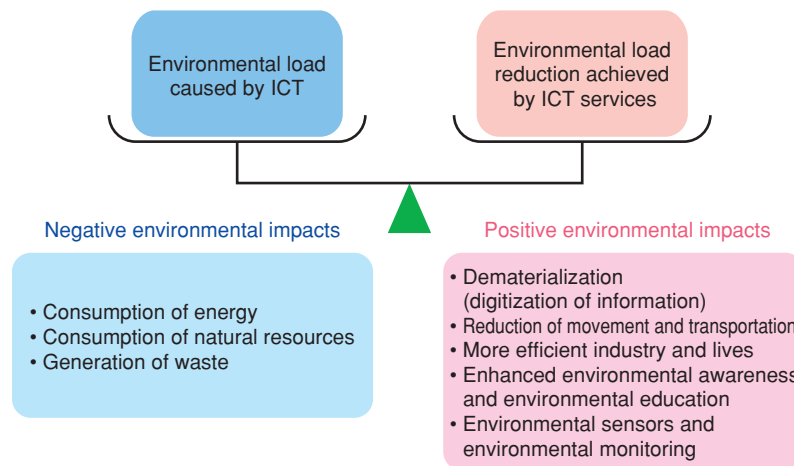


Fig. 1. Environmental impacts of ICT.

quantitatively evaluate which of the two sides—negative or positive—has the greater impact. To date, however, there has been no uniform standard for doing so. Instead, companies have performed trial calculations and presented results by themselves.

### 3. Formulation of the Guidelines

The Japan Forum on Eco-Efficiency (JFEE) was established by the Ministry of Economy, Trade and Industry (METI). The current chairman is Professor Ryoichi Yamamoto of the University of Tokyo and the secretariat is the Japan Environmental Management Association for Industry (JEMAI) [2]. To further its aim of expanding the application of eco-efficiency, JFEE published the Guidelines to provide the first uniform standard for evaluating the environmental load and eco-efficiency associated with the implementation of ICT. The Guidelines were drafted by a working group headed by Dr. Yasunari Matsuno, associate professor, University of Tokyo, and eight ICT corporations (Fujitsu, NEC, Toshiba, Hitachi, Matsushita Electric, Canon, Fuji Xerox, and NTT) participating in JFEE. As a leader in research on technology for evaluating the environmental impact of networks and ICT services, NTT has played an active role in this working group. The Guidelines are divided into four main sections, as described below in sections 4–7.

- Framework for Evaluation of ICT Environmental Impact
- Outline of ICT Eco-efficiency Evaluation
- Framework of ICT Comparative Evaluation
- Examples

### 4. Framework for Evaluation of ICT Environmental Impact

The Guidelines state that the ICT environmental load should be assessed based on life cycle assessment (LCA) conforming to the ISO14040/JISQ14040 series. The LCA technique quantitatively evaluates the environmental impact at each stage in the life cycle of a product or service, from the gathering of raw materials to production, use, and disposal.

#### 4.1 Life cycle stages of ICT

The Guidelines describe the life cycle stages shown in **Fig. 2** as stages particular to ICT that need to be evaluated.

#### 4.2 Activities targeted for evaluation

For each life cycle stage, the Guidelines classify the activities to be evaluated, that is, the activities that have an impact due to the use of an ICT service, into: (1) goods/energy consumption, (2) use of ICT devices, (3) use of network infrastructure, (4) use of software infrastructure, (5) shipping-transport substitution, (6) traveling-transport substitution, (7) storage, and (8) work force. For item (1), we evaluate activities related to materials and energy such as information publications, CDs, fuel such as gasoline, and electricity, excluding materials and energy related to items (2) to (8). For item (2), we evaluate activities related to devices that make up the system that runs the ICT service. Items (3) and (4) are described in detail in sections 4.3 and 4.4. Items (5) and (6) concern the evaluation of activities related to the means of transporting goods and people, respectively. Item (7) concerns materials and energy needed for storing

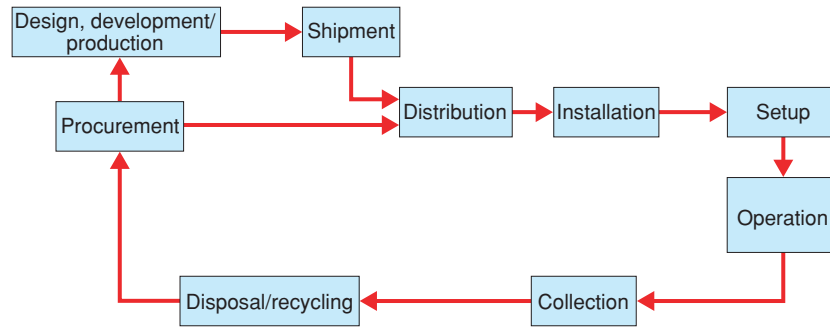


Fig. 2. Example of life cycle stages.

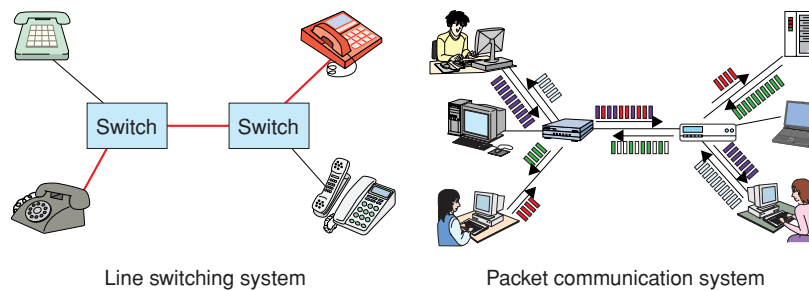


Fig. 3. ICT systems.

goods (e.g., in a warehouse) in a state that maintains their quality. Item (8) concerns materials and energy needed to allow people to perform work in an office or elsewhere.

### 4.3 Approach to evaluating environmental load of network infrastructure

The Guidelines state that the following ideas should be applied when evaluating the environmental load of the network infrastructure.

#### 4.3.1 Units of evaluation

As shown in **Fig. 3**, there are two types of telecommunication systems: circuit switching and packet communication. They have different formats for transferring information, which results in different units for evaluating the environmental load. In a circuit switching system, the circuit is occupied for the duration of the call, so the unit of evaluation is time. In a packet communication system, information to be transmitted is divided into small packets, which means that information from different sources can be carried on the same communication line. In other words, a particular user does not occupy a circuit. For this reason, the unit of evaluation here is the quantity of information.

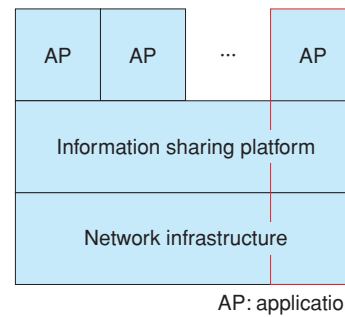


Fig. 4. Hierarchical layers of ICT.

#### 4.3.2 Evaluation period

The network infrastructure consists of many communication facilities having different lifetimes. This makes it difficult to evaluate the life-cycle environmental load of the network infrastructure as a single system. Under these circumstances, the method described in the Guidelines is to divide the environmental load of each facility by the number of years in its service life to give the environmental load per year and then to sum up the values for all facilities to obtain the environmental load of that network infrastructure.

#### 4.3.3. Allocation

Referring to **Fig. 4**, the environmental load of the

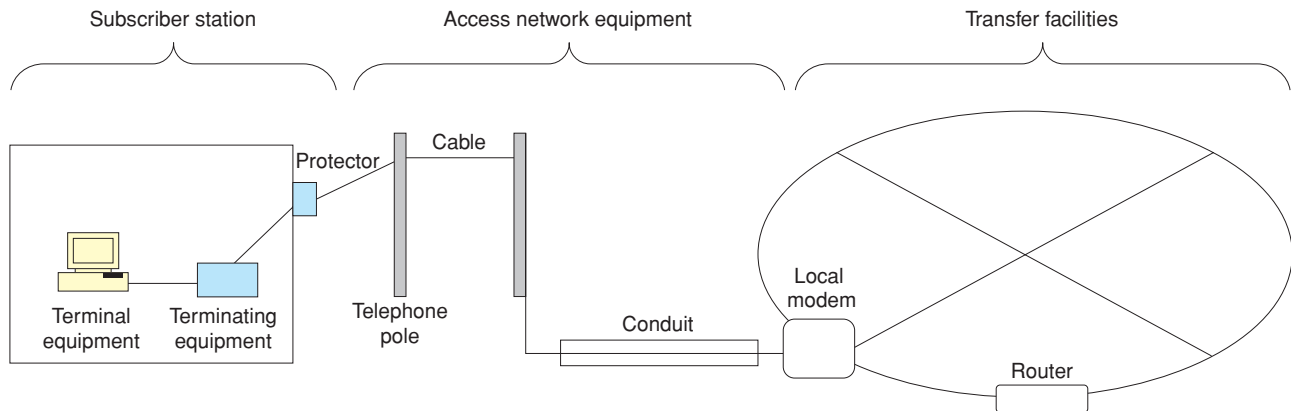


Fig. 5. Example of communication facilities making up the network infrastructure.

lower-layer network infrastructure must be evaluated with respect to the application that drives the ICT service in question. Thus, while it is necessary to allocate to the infrastructure that portion of the whole application load generated by the target application, it is impossible to determine the total number and scale of applications on the application layer above the network infrastructure. The solution to this problem is to calculate the environmental load of the network infrastructure per unit time or unit quantity of information, which corresponds to (1) in section 4.2, and then to multiply that value by the total time of communication or amount of information used by the application for the ICT service. This gives the environmental load of the network infrastructure corresponding to that ICT service.

This approach to load allocation evaluates that portion of the network-infrastructure environmental load corresponding to the application that drives the ICT service. The next step is to allocate to the facilities making up the network infrastructure their portion of the environmental load corresponding to that application. This is done for each of the facility types shown in **Fig. 5**, as described below.

a) Subscriber station

Facilities belonging to a subscriber are allocated a load on the basis of time or quantity of information in accordance with the usage conditions of the ICT service being evaluated.

b) Access network equipment

For landline access facilities as in fixed-line telephone services and IP services, a subscriber always occupies the facilities regardless of the type of use.

This means, for example, that the environmental load of access facilities can be divided by the number of subscribers to give the load per subscriber, i.e., a fixed environmental load unrelated to the usage conditions of the ICT service being evaluated. Furthermore, if the facilities are being used for multiple purposes, the load can be allocated according to the conditions in question. On the other hand, wireless access facilities as used for mobile-phone services and hotspot services feature two key functions: one for registering the subscriber's location and the other for carrying information over radio waves. The location-registration function requires that the channel be occupied, which means that the environmental load in this case can be evaluated as a fixed value, the same as for landline access facilities, regardless of the usage conditions of the ICT service being evaluated. The function for carrying information over radio waves, in contrast, allows communicating users to share the same channel, which means that the environmental load can be evaluated in terms of either time or quantity of information.

c) Transfer facilities

Since facilities of this type are occupied only when they are being used, they are allocated a load on the basis of either time or quantity of information.

#### 4.4. Approach to evaluating environmental impact of software

The environmental load of software can be evaluated in terms of personal computers, servers, and other items that are needed to design and develop the software.

Table 1. Classification of ICT software and allocation of environmental impact.

Classification	Software type
Individual software (for individual part)	Custom software
Software infrastructure (for general purpose)	Business packages (e.g., electronic application system)
	Middleware (e.g., information system management, databases, and others)
	OS (operating system)

#### 4.4.1 Software classification and allocation of environmental impact

The Guidelines classify software in the manner shown in **Table 1**. Individual, customized software is designed for a specific customer and can therefore be evaluated simply in terms of the total environmental load. A software infrastructure, however, implies the use of multiple copies by a number of customers, which means that the environmental load can be divided by, for example, the number of copies shipped. According to this reasoning, the environmental load is generally larger for individual software, so particular attention should be given to this type of software when evaluating the environmental load of software running an ICT service.

#### 4.4.2. Software evaluation method

The Guidelines state that the power consumption or other characteristics of the personal computers, servers, and other devices used for designing and developing various software programs to be evaluated should be surveyed, that the environmental load should be evaluated in conformance with actual conditions (called the process-sum method), and that the values so obtained should be summed up to evaluate the environmental load of the entire system for running the ICT service. However, for software in the software-infrastructure class for which such surveys are difficult, the Guidelines include a method for calculating the environmental load from the price of that software.

#### 4.5 Calculating the potential increase/decrease in ICT environmental load

The Guidelines include a section on evaluating the potential increase/decrease in the ICT environmental load for the purpose of determining the latent capabilities of ICT. To explain this concept, we take as an example the elimination of business trips resulting from the introduction of a videoconferencing system in place of traditional meetings that require partici-

pants to travel (corresponding to activity (6) in section 4.2: the movement of people). If an automobile is normally used as the means of transportation for the business trip, the consumption of gasoline can be eliminated by holding a videoconference. If public transportation such as a train or bus is normally used, there will be no immediate energy saving. However, if videoconferencing becomes popular and many people stop using public transport as a result, then the public-transportation companies will revise their timetables and cut back on services. Thus, a substantial reduction in the amount of movement is possible in an ICT society in the future.

This calculation of the potential increase/decrease or “apparent effect” of the ICT environmental load and the evaluation of what kind of impact would be generated when using ICT in a certain way should lead to an ICT society that takes the environment into account. Other activities that relate to this ICT apparent effect are storage and workplace activities (items (7) and (8) in section 4.2). The Guidelines point out, however, that attempting to achieve a paperless office or labor savings through the application of ICT services will not necessarily result in an immediate reduction in storage facilities for storing documents or in personnel. It will, however, provide an opportunity for changing the way business is performed and for achieving a substantial reduction in the future.

#### 4.6 Necessary entries

The Guidelines also state that, to improve the transparency of an eco-efficiency evaluation, the following items should be clearly described: outline/overview of ICT service, purpose of evaluation, functional unit, system boundaries, relationship between evaluated life cycle stages and activities, evaluation method, reference data, and evaluation results. Here, the functional unit refers to the performance of the ICT service in quantitative terms as a criterion for performing an evaluation. For example, the function-

al unit of an e-learning service might be “100 employees each receiving four lessons at their desktop computer over a period of one year, where one lesson takes two hours”. System boundaries are settings that define the range of evaluation.

### 5. Outline of ICT Eco-efficiency Evaluation

The eco-efficiency of ICT can be calculated by the following expression:

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

The environmental impact of ICT quantifies the environmental load based on the framework for evaluating ICT environmental load described in section 4. As described in the Guidelines, the value provided by ICT can be classified into physical, economical, or emotional value. Physical value refers to the value of an ICT service that can be expressed in terms of physical quantities such as transmission speed. Economical value means a numerical value like price or added value that can act as an economic indicator. Emotional value indicates the degree of comfort, understanding, achievement, etc. that a user receives through an ICT service. There are few concrete examples of this type of value and it is currently being researched.

While eco-efficiency can be calculated by the above definition, the Guidelines state that the following points should be considered and clearly described in the evaluation report as important notes:

- Clarify the target (nation, industry, product, and others) to be evaluated, the intended audience, and the purpose.
- Consider which items appropriately represent the numerator, together with the system boundary for environmental impact evaluation.
- Evaluate the value that corresponds to the functional unit of environmental impact.

### 6. Framework of ICT Comparative Evaluation

The Guidelines discuss a framework for performing a comparative evaluation of ICT services or a comparative evaluation between an ICT service and a traditional means based on an evaluation of the environmental load and eco-efficiency, as described above. Here, “traditional means” refers to an existing means or service that does not use ICT, such as a face-to-face meeting involving a business-trip, that can be evaluated in comparison with videoconferencing. In a

comparative evaluation, we first establish the ICT service targeted for comparison (target ICT service), and then establish another ICT service or traditional means (base service). When performing a comparative evaluation of environmental loads and calculating, for example, the environmental-load reduction effect of an ICT service, we evaluate the difference between the environmental loads of the target ICT service and the base service. When performing a comparative evaluation of eco-efficiency, we divide the eco-efficiency of the target ICT service by that of the base service. The comparative evaluation of eco-efficiency is also called factor evaluation.

### 7. Examples

Section 5 of the Guidelines presents examples from the participating ICT corporations. Among these is a case study by the NTT Group on FLET’S Service.

### 8. Future plans

The “Guideline for ICT Eco-Efficiency Evaluation” issued by JFEE constitutes the first set of guidelines for evaluating environmental load and eco-efficiency under a common standard while achieving objectivity and transparency. Using these guidelines to perform objective evaluations should lead to greater customer confidence, accelerated deployment of ICT services, and the creation of a sustainable ICT society. At the same time, quantification of the value provided by ICT, i.e., the numerator in the eco-efficiency ratio, is still being researched and further progress in this area can be expected.

### References

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### Remarks on topics introduced in this article

As an aid to understanding ICT and the environment, JFEE has issued a pamphlet that describes the convenience of ICT services and their impact on the environment. This pamphlet can be downloaded from the JEMAI site [3].

The Environmental Impact Assessment System for ICT Services [4] developed by NTT Information Sharing Laboratory Group, which was reported in the March 2006 issue of NTT Technical Review, facilitates the evaluation of environmental load in conformance with the JFEE Guidelines.



**Takeshi Origuchi**

Research Engineer, Environmental Management & Provisioning Project, NTT Information Sharing Laboratory Group.

He received the B.S. degree in physics from Nihon University, Tokyo, and the M.S. degree in materials science from the University of Tokyo, Tokyo, in 1995 and 1997, respectively. He joined NTT Access Network Service Systems Laboratories in 1997. He is currently engaged in R&D concerning the life cycle assessment of ICT services, the effects of environmental and social impacts caused by using ICT services, and environmental accounting for promoting environmental management in the NTT Group. He is a member of the Institute of Life Cycle Assessment, Japan.

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**Takashi Sawada**

Senior Research Engineer, Supervisor, Environmental Management & Provisioning Project, NTT Information Sharing Laboratory Group.

He received the B.E. and M.E degrees in electronics science from Nihon University, Tokyo, in 1989 and 1991, respectively. He joined NTT Electrical Communication Laboratories in 1992. He is currently engaged in promoting environmental management in the NTT Group.

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**Shiro Nishi**

Project Manager, Environmental Management & Provisioning Project, NTT Information Sharing Laboratory Group.

He joined NTT Musashino Electrical Communications Laboratories in 1985. Since then, he has been engaged in R&D of optical and thermal polymers, optical adhesives, ionic conductive polymers, polymer recycling, and lifecycle assessment. His current interest is the environmental assessment of ICT services.

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