Energy Saving in Society by IT Solutions

How to Quantify the Contribution of “Green by IT”

Practical Guide

February 2013

Survey and Estimation Committee

Green IT Promotion Council

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INTRODUCTION

Information technology (IT) is useful for making numerous processes more efficient, manufacturing smaller, lighter, and thinner things, and replacing huge mechanisms with electronic devices and software. Examples abound. IT saves energy in many types of transportation through intelligent transport systems (ITS). Video conferencing, electronic music distribution, e-learning, and other electronic measures reduce the movement of people and wasteful use of natural resources, and effectively lower energy consumption. The building energy management system (BEMS), home energy management system (HEMS), and factory energy management system (FEMS), which measure, optimize, and control energy use in buildings, greatly reduce energy consumption. Therefore, CO_2 emissions across Japan will be greatly reduced by actively using all these IT solutions in various sectors of society.

However, it is hard to quantify the energy-saving effect of IT solutions because they take various forms. Thus, the Survey and Estimation Committee of the Green IT Promotion Council has long discussed how to effectively quantify energy saving in society by IT solutions (“Green by IT”).

Based on these discussions, this document summarizes currently available methods for calculating the effects of Green by IT. Chapter 1, as the opening part, outlines the concept of Green by IT. The calculation methods and their examples with specific values are shown from Chapter 2. Specifically, Chapter 2 explains basic calculation methods; Chapter 3, points to note in calculations; Chapter 4, how to show calculation results; Chapter 5, cases of actual calculations; and Chapter 6, issues to be discussed in the future.

We hope that this document will help readers understand the concept of Green by IT and calculate its effects, thus encouraging the application of Green by IT and reduction of CO_2 emissions.

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OUTLINE

1. Potential of "Green by IT"

1.1 How IT contributes to CO_2 reduction

Reducing greenhouse gas emissions while maintaining economic strength is a tough goal. This cannot be achieved merely by following old ways or with mediocre efforts, but requires innovation in a wide range of areas, such as technology development, social systems, and market mechanisms. IT is expected to play a major role in this innovation.

What can the IT industry do to help curb global warming? The first task is, like all other industries, to reduce greenhouse gas emissions in its own production processes. However, this would contribute little because the IT industry accounts for only 1.5% of the total emissions in Japan. In contrast, making all kinds of widely-used IT and electronic equipment consume less power and raising energy efficiency throughout society by IT solutions will produce far greater spillover effects (Figure 1-1). These are the two roles, i.e. energy saving of IT equipment ("Green of IT") and energy saving in society by IT ("Green by IT") that the IT industry is expected to fulfill. Especially in Green by IT, the IT industry is highly expected to help reduce greenhouse gas emissions in all other sectors, which account for about 98% of total energy use in Japan.

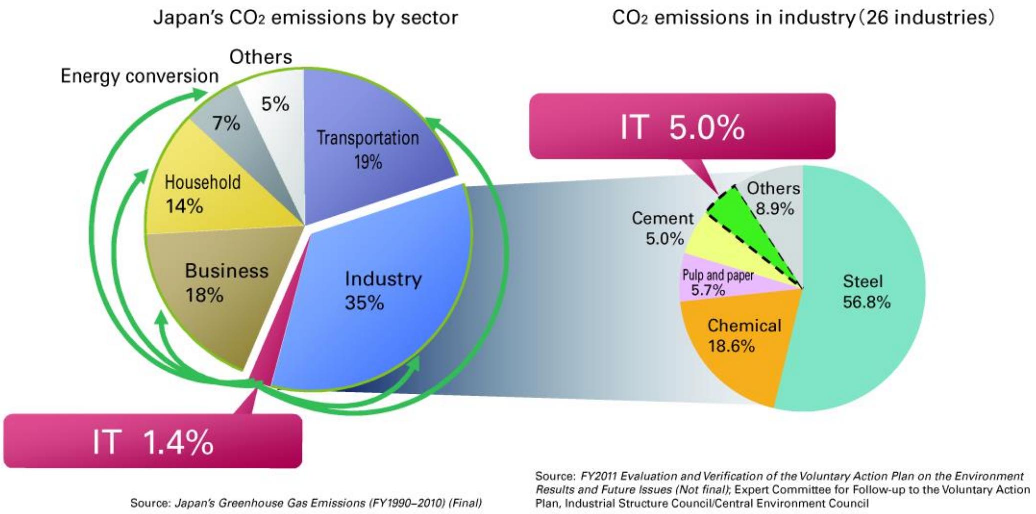

Figure 1-1: IT's contribution to energy saving in society

The main feature of IT is its ability to make numerous processes more efficient, manufacture smaller, lighter, and thinner things, and replace huge mechanisms with electronic devices and software. For example, IT saves energy in many types of transportation through intelligent transport systems (ITS), which are mainly used to control traffic on roads. Video conferencing, electronic music distribution, e-learning, and other electronic measures effectively curb energy consumption by reducing the movement of people and wasteful use of natural resources. The building energy management system (BEMS), home energy management system (HEMS), factory energy management system (FEMS), which measure, optimize, and control energy use in buildings, and optimum control of production processes to increase efficiency, all greatly contribute to the reduction of energy consumption. Actively using all these IT solutions and services in various sectors of society will greatly reduce energy use.

Take video conferencing as an example. Before its introduction, attendees had to travel to the venue of a conference, or to communicate under limited conditions, for instance, over the phone. Video conferencing can eliminate the business trip[1]. Thus, the introduction of video conferencing reduces the energy consumption related to transportation used by attendees, although energy is consumed by the IT equipment that is used for the conference. The net reduction of energy use is the energy-saving effect, or CO_2 emissions reduction by the introduction of video conferencing (Figure 1-2).

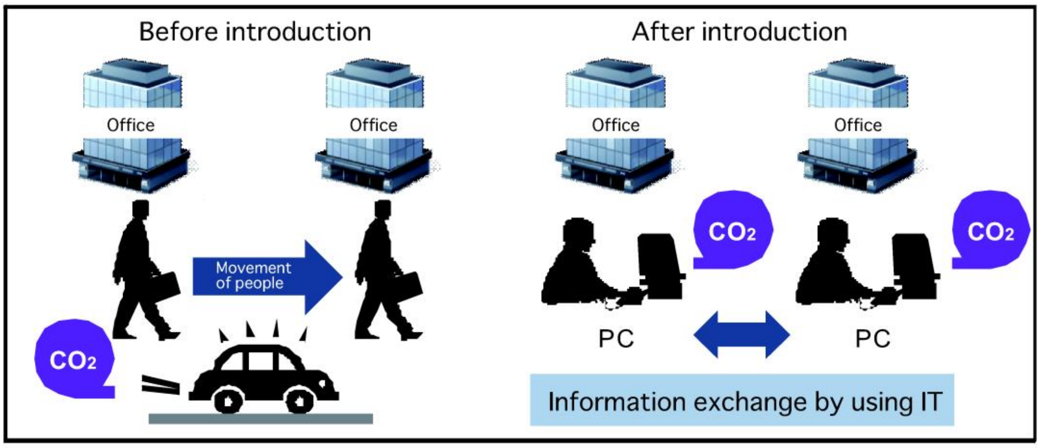

Figure 1-2: CO_2 emissions before and after introducing video conferencing

1 The results of questionnaires show that the main purpose of introducing video conferencing is to “reduce travel expenses,” which suggests that many conferences of less importance are held as video conferences. This response is followed by other reasons such as to “activate communication,” “make quick decisions and share information,” and “improve productivity.” Video conferencing may be regarded as a new means of highly-efficient communication, not merely the replacement of conventional conferences. For details, visit *Findings by Questionnaires on Web Conference Systems*.
(http://www.keyman.or.jp/info/images/sample_report.pdf)

As described so far, IT has great potential to make society more efficient. IT solutions expected to help reduce CO_2 emissions are summarized below.

Table 1-1: IT solutions expected to help reduce CO_2 emissions in society

Category	Subcategory	IT solution
Industry	Production process	FEMS; achieving high efficiency in lighting, air conditioning, motors, generators; and raising efficiency in production processes
Business	Building, indoors	BEMS, electronic tags/logistics, paperless offices, IT for businesses, teleworking, video conferencing, remote medical care/electronic medical charts, and electronic bidding/applications
Household	Building, indoors	HEMS, electronic money, electronic publishing/paper, music/software distribution, and online shopping
Transportation	Infrastructure, activity	Raising efficiency in transportation (railways, air and sea transportation), ITS, and supply chain management (SCM)

1.2 How to measure the CO_2 emissions reduction by IT

When introducing IT solutions, the expected reduction in CO_2 emissions is crucial. To assess the introduction and improve the results further, the effect of the introduction must be quantified.

The effect of introducing IT solutions on CO_2 emissions reduction takes various forms. Therefore, as the first step, all processes in society which will be affected by the introduction must be identified. For example, video conferencing reduces energy consumption related to business trips while increasing the energy consumption of IT equipment. Energy consumption in offices could also be affected. Over the long term, the power consumption of network equipment could change due to an increased burden on the communication network.

To quantify the CO_2 emissions reduction, increases or decreases in CO_2 emissions in each and all of the identified processes are calculated. The result of totaling or offsetting is the net CO_2 emissions reduction by the introduction of IT solutions.

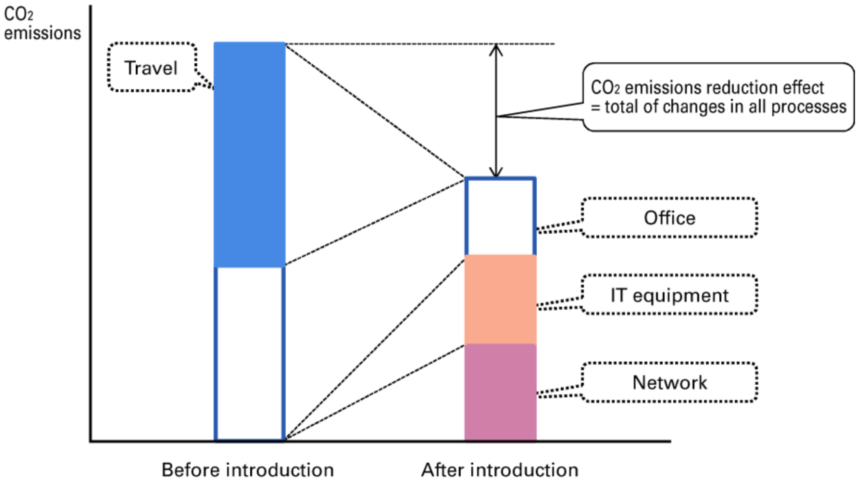

Figure 1-3: Net CO_2 emissions reduction

Figure 1-3 illustrates the net CO_2 emissions reduction by introducing video conferencing. CO_2 emissions related to travel, energy consumption of IT equipment, and energy consumed in offices change after the introduction. The total of all these differences is the net CO_2 emissions reduction. The same result can be obtained by calculating total CO_2 emissions before and after introducing video conferencing and comparing the two totals.

Table 1-2 lists process changes caused by ordinary IT solutions as components of CO_2 emissions reduction effects. The components are changes in the amount of 1) consumption of goods, 2) movement of people, 3) transportation of goods, 4) office space, 5) warehouse space, 6) power/energy consumption (IT/network (NW) equipment), and 7) the use of networks. Processes not categorized into any of these seven items are included in Item 8) "Others" for convenience.

A classification like this makes it easier to identify changes necessary for calculating CO_2 emissions reduction. Table 1-3 shows how and in what form each component leads to the reduction.

Table 1-2: Components and formulas of CO_2 emissions reduction effect by IT solutions

Component	Target	Formula to quantify changes in the component (see Chapter 2)
1) Consumption of goods	Paper, audio CD, book, etc.	Reduced consumption of goods × Basic unit of consumption of goods
2) Movement of people	Airplane, automobile, train, etc.	Reduced travel distance of people × Basic unit of travel
3) Transportation of goods	Truck, railway, cargo, etc.	Reduced travel distance of goods × Basic unit of travel
4) Office space	Space occupied by people (including efficiency at work), space occupied by IT equipment, etc.	Reduced space × Basic unit of energy consumption per space * Reduced space = Reduced number of people × Space occupied per person, or reduced number of pieces of equipment × Space occupied per piece
5) Warehouse space	Warehouse, cold storage warehouse, etc.	Reduced space × Basic unit of energy consumption per space
6) Power/energy consumption (IT/NW equipment)	Power consumption of server, PC, etc.	Change in consumption × Basic unit of grid power * Converting power consumed to CO_2 emissions * Showing energy consumption of IT equipment, not including energy consumption related to manufacturing and disposal
7) NW data communication	NW data communication	Change in data volume × Basic unit of communication * NW communication refers to energy consumption of Internet communication, excluding intranet.
8) Others	Other activities	Change in the amount of activity × Basic unit of change

Table 1-3: CO_2 emissions reduction effect for each component

1) Consumption of goods

Applicable case	• IT solutions eliminate consumption of goods, such as paper and audio CDs.
Change in CO_2 emissions	• Manufacturing consumes energy and emits CO_2. Discontinuing the production reduces CO_2 emissions.
Example	• Electronic distribution of music and books makes audio CDs and paper books unnecessary, which reduces CO_2 emissions during their manufacturing and sales. (Music/software distribution)
Applicable solutions[2]	Paperless offices, electronic medical charts, electronic bidding/applications, electronic money, electronic publishing/paper, music/software distribution, online shopping, etc.

2) Movement of people

Applicable case	• IT solutions reduce the movement of people by car or public transportation.
Change in CO_2 emissions	• Movement of people by car, public transportation, etc. consumes energy. Cutting back on traveling reduces energy consumed in transportation, resulting in CO_2 emissions reduction. • A slight decline in the number of passengers is not quickly reflected in the frequency of trains, etc. There is a time lag until the CO_2 emissions reduction becomes obvious.
Example	• Teleworking makes commuting unnecessary. This reduces energy consumption related to commuting, resulting in CO_2 emissions reduction. (Teleworking)
Applicable solutions	IT for businesses, teleworking, video conferencing, remote medical care/electronic medical charts, electronic bidding/applications, online shopping, ITS, SCM, etc.

[2] Applicable cases differ depending on solutions even in the same category.

3) Transportation of goods

Applicable case	• IT solutions reduce the transportation of goods by truck, railway, etc.
Change in CO_2 emissions	• Like movement of people, this reduces energy consumption related to transportation of goods, resulting in CO_2 emissions reduction. • There can be a time lag until effects become obvious.
Example	• The use of IT solutions and networks makes it unnecessary to transport paper documents, reducing CO_2 emissions. (Paperless offices)
Applicable solutions	Electronic tags/logistics, paperless offices, IT for businesses, electronic bidding/applications, electronic money, electronic publishing/paper, music/software distribution, ITS, SCM, etc.

4) Office space

Applicable case	• IT solutions help reduce office space. • IT solutions improve work efficiency, resulting in shorter hours of use of office space.
Change in CO_2 emissions	• Reduction in office space or working hours lowers energy consumption of air-conditioners, lighting, etc., resulting in CO_2 emissions reduction. • When addressing work efficiency, boundaries (to what extent IT solutions are responsible) must be defined clearly. • When the free-up time, a benefit of improved efficiency, is used for another work, CO_2 emissions do not reduce, but the ratio of CO_2 emissions to total work (productivity) is improved. If the freed-up time is idled away, the benefit of improved work efficiency is wasted.
Example	• When teleworking reduces the number of workers in the office and therefore some lights and air-conditioners are turned off, energy consumption and CO_2 emissions in the office are reduced. (Teleworking)
Applicable solutions	Paperless offices, IT for businesses, teleworking, electronic bidding/applications, etc.

5) Warehouse space

Applicable case	• IT solutions eliminate the need for goods, reducing the storage space.
Change in CO_2 emissions	• If goods are stored near people, they use air-conditioners and lighting. Even if goods are stored in a warehouse, lighting and other facilities consume energy. Smaller storage space consumes less energy, leading to CO_2 emissions reduction.
Example	• When paper documents are digitized by IT solutions, the storage space becomes unnecessary and CO_2 emissions during storage are reduced. (Paperless offices) • Digitizing books frees up the space to store them, promoting effective use of the floor. (Electronic publishing/paper)
Applicable solutions	Electronic tags/logistics, paperless offices, IT for businesses, remote medical care/electronic medical charts, electronic bidding/applications, electronic money, electronic publishing/paper, music/software distribution, SCM, etc.

6) Power/energy consumption (IT/NW equipment)

Applicable case	• IT solutions change the energy consumption of equipment or facilities. • IT solutions change the use of IT equipment or network equipment.
Change in CO_2 emissions	• IT solutions reduce the energy consumption of equipment or facilities, resulting in CO_2 emissions reduction. • The introduction of IT solutions increases the energy consumption of equipment or facilities or requires additional equipment or facilities, resulting in increased CO_2 emissions.
Example	• Implementing IT solutions increases the energy consumption of IT equipment. (All categories) • Teleworking increases the energy consumption of air-conditioners and lighting at home. (Teleworking)
Applicable solutions	FEMS, achieving high efficiency in lighting/air-conditioners/motors/generators, raising efficiency in

	production processes, BEMS, electronic tags/logistics, paperless offices, IT for businesses, teleworking, video conferencing, remote medical care/electronic medical charts, electronic bidding/applications, HEMS, electronic money, electronic publishing/paper, music/software distribution, online shopping, raising efficiency of transportation (railways, and air and sea transportation), ITS, SCM, etc.

7) NW data communication

Applicable case	• The introduction of IT solutions changes the amount of communication on public networks. Equipment of private networks is covered in Item 6) "Power/energy consumption (IT/NW equipment)."
Change in CO_2 emissions	• The introduction of IT solutions increases the amount of communication on public networks, which requires IT equipment to be added to the networks, resulting in increased CO_2 emissions. • The performance and capability of network equipment are improving year by year. This change should be reflected in the basic unit of communication (CO_2 emissions per unit of communication). • An increased amount of communication on public networks does not necessarily increase energy consumption of the network equipment soon. For quantification, however, it is assumed that the increase in energy consumption is proportional to the increase in communication.
Example	• The use of networks increases due to the introduction of teleworking and video conferencing. (Teleworking and video conferencing)
Applicable solutions	FEMS, BEMS, electronic tags/logistics, IT for businesses, teleworking, video conferencing, remote medical care/electronic medical charts, electronic bidding/applications, HEMS, electronic money, electronic publishing/paper, music/software distribution, online shopping, ITS, SCM, etc.

8) Others

• CO_2 emissions reduction effects not covered in Items 1) through 7) are quantified likewise and included in Item 8) "Others."

1.3 Considerations in quantifying the effect of Green by IT

Quantifying the effect of Green by IT on CO_2 emissions reduction requires careful consideration. Not only the IT solutions themselves but also their spillover effects across the whole of society must be covered. Based on discussions by the Green IT Promotion Council so far, the required consideration is outlined below.

First, note that the effect of Green by IT on CO_2 emissions reduction occurs widely in time and space. Take a company that introduces video conferencing. How can it calculate the effect of CO_2 emissions reduction?

The introduction of video conferencing increases the energy which is consumed by IT equipment that would otherwise be left unused. This increase occurs just after the introduction. Meanwhile, even if several attendees stop using trains, the train schedule will not be changed and so there will be no immediate change in CO_2 emissions related to transportation. In this regard, the effect of CO_2 emissions reduction remains a potential until the introduction reaches a critical point ("temporal spread"). In contrast, immediate effects are produced if an attendee stops commuting by car.

Deciding whether realized figures (CO_2 emissions actually reduced) or potential figures (CO_2 emissions reduction achievable but not yet realized) should be used for the calculation depends on the purpose of quantifying the effect of Green by IT. When the purpose is to assess changes already obvious in society, realized figures should be used. To evaluate the potential of IT solutions, potential figures are recommended. By calculating the difference between realized and potential figures and analyzing the reasons behind the difference, more methods of reducing CO_2 emissions may be discovered.

Note that IT solutions are usually introduced within a company but CO_2 emissions are actually reduced outside. Just focusing on changes in the company overlooks changes outside. To calculate CO_2 emissions reduction, it is necessary to encompass relevant changes in the whole of society ("spatial spread").

There are more points to be considered: how theoretical pre-introduction situations should be handled, whether default values or estimates can be used in calculations, and so on. Our current proposals on these topics are shown in Chapter 3, though discussions are still in progress.

DISCUSSION

2. How to Calculate the Effects of Green by IT

2.1 Outline

As described in Chapter 1, CO_2 emissions reduction by IT solutions is calculated by totaling components (Table 2-1). Each CO_2 emissions reduction can be obtained by quantifying the change in CO_2 emissions in a certain field before and after the introduction of IT solutions.

Table 2-1: Components and formulas of CO_2 emissions reduction effect by IT solutions (Same as Table 1-2)

Component	Target	Formula to quantify changes in the component
1) Consumption of goods	Paper, audio CD, book, etc.	Reduced consumption of goods × Basic unit of consumption of goods
2) Movement of people	Airplane, automobile, train, etc.	Reduced travel distance of people × Basic unit of travel
3) Transportation of goods	Truck, railway, cargo, etc.	Reduced travel distance of goods × Basic unit of travel
4) Office space	Space occupied by people (including efficiency at work), space occupied by IT equipment, etc.	Reduced space × Basic unit of energy consumption per space * Reduced space = Reduced number of people × Space occupied per person, or reduced number of pieces of equipment × Space occupied per piece
5) Warehouse space	Warehouse, cold storage warehouse, etc.	Reduced space × Basic unit of energy consumption per space
6) Power/energy consumption (IT/NW equipment)	Power consumption of server, PC, etc.	Change in consumption × Basic unit of grid power * Converting power consumed to CO_2 emissions * Showing energy consumption of IT equipment, not including energy consumption related to manufacturing and disposal
7) NW data communication	NW data communication	Change in data volume × Basic unit of communication * NW communication refers to energy consumption of Internet communication, excluding intranet.
8) Others	Other activities	Change in the amount of activity × Basic unit of change

For example, the introduction of teleworking eliminates the need for office workers to commute and reduces the energy consumed for commuting. In addition, a reduction in the number of workers in an office is expected to lead to reduced office space. Reduced energy is the total of reduction in people movement (Component 1) and office space (Component 2). Meanwhile, the power consumption of electronic appliances and IT equipment at home, networks, etc. is expected to increase (Component 3). As a result, the total energy reduction effect is calculated as: (Component 1) + (Component 2) – (Component 3).

The office space component reflects the reduction in energy consumption (of lighting, air-conditioners, etc.) in the office. This is achieved by the introduction (or use) of IT solutions, which improve work efficiency and thus reduce working hours in the office.

The CO_2 emissions reduction effect by IT solutions is expressed by the combination of effects of the movement of people, transportation and use of goods, energy consumption in space (offices and warehouses), and energy consumption of IT equipment and networks. Each effect is calculated by the change in the amount of activities (reduced movement, consumption, etc.) multiplied by the basic unit of CO_2 emissions.

2.2 How to calculate energy saving (CO_2 reduction) by IT solutions

The energy saving by IT solutions is calculated as follows.

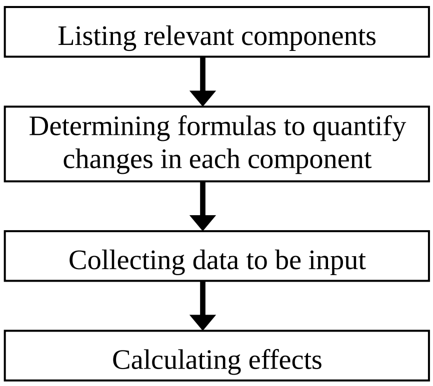

Figure 2-1: Flow of calculating the energy saving by IT solutions

(1) Listing relevant components

First, clearly define situations (scenarios) before and after the introduction of IT solutions. Next, identify which components in Table 2-1 are affected by the introduction, or which components are expected to change after the introduction[3]. In this step, make sure that all components in which energy consumption changes throughout society are listed.

Points to note:

- Not only the reduction in energy consumption (positive effect) but also the increase in IT equipment, communication infrastructure, and so forth (negative effect) must be considered. Although the introduction of IT solutions usually increases the power consumption of IT equipment, the unification of servers, etc. can reduce power consumption.
- Functionally interchangeable situations should be compared: scenarios before and after the introduction of IT solutions may differ from each other in form but must serve the same function.

(2) Determining formulas to quantify changes in each component

Determine a formula to quantify CO_2 emissions (or reduction) in kg-CO_2 or other units for each component. Depending on data availability, each formula listed in Table 2-1 can be modified to enable the calculations to be made. Set the calculation period to one year to allow a comparison of CO_2 emissions in each component. Data availability must be considered before determining each formula.

(3) Collecting data to be input

Collect data to be input into each formula. Two kinds of data are needed to measure the effect of introducing IT solutions.

(i) Amount of activity

Amount of activity means an amount of change in energy or natural resource consumption. In teleworking, this means the amount of fuel saved due to less driving for commuting; in paperless offices, it means the reduction in amount of paper and other reductions.

(ii) Basic unit data

Basic unit data means coefficients to convert amounts of change in energy consumption caused by IT solutions to the amount of CO_2. The amount of saved fuel (teleworking) or reduced paper consumption (paperless office) is converted into the amount of CO_2.

If data cannot easily be obtained or measured, use available existing data such as average values, typical values, or reference values. Appendix 1 shows typical basic units and Appendix 2 lists

[3] If the change before and after the introduction cannot be estimated, quantify the CO_2 emissions before and after the introduction and then determine the difference.

reference values.

When selecting basic units, the following points must be considered:

- When comparing CO_2 emissions reduction effects by different IT solutions, a basic unit that is generally common to these solutions should be selected.
- Some basic units such as the CO_2 emissions coefficient of grid power are subject to change. Select an appropriate basic unit according to the timing and purpose of measurement. When comparing effects by a solution at two different points in time, basic points at respective points in time must be used.

(4) Calculating effects

Based on the collected data, calculate the effect of each component by using the formula determined in (2). Then, total all positive and negative effects.

2.3 Case study: teleworking

This section explains how to calculate the CO_2 emissions reduction effect by teleworking, and some important points.

Setting:

Once-a-week teleworking (52 days a year). The employee usually commutes by car (to and from the station: 6 km) and by train (to and from the office: 40 km). Teleworking at home is 8 hours a day.

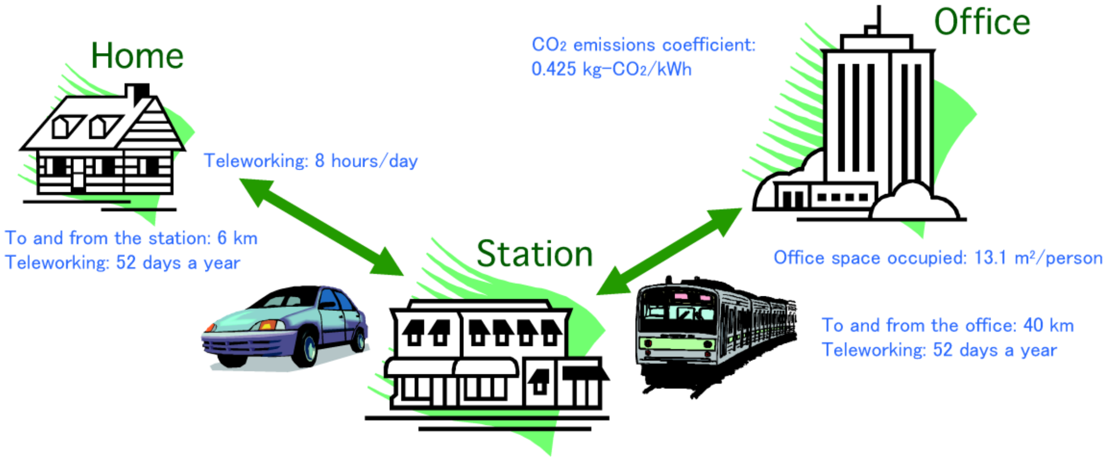

Figure 2-2: Example of teleworking

(1) Listing relevant components

The CO_2 emissions reduction effect by teleworking is related to the six components listed in

Table 2-2.

Table 2-2: Components related to teleworking

Component	Target		Description
2) Movement of people	A	Energy consumption in commuting (by private vehicle)	Teleworking reduces travel by car, lowering the related energy consumption.
	B	Energy consumption in commuting (by public transportation)	Teleworking reduces travel by public transportation such as trains and buses, lowering the related energy consumption.
4) Office space	C	Energy consumption in office	Teleworking reduces energy consumption in the office.
6) Power/energy consumption	D	Energy consumption of IT equipment	Energy consumption of IT equipment used in teleworking
	E	Energy consumption at home	Energy consumption of home appliances used in association with teleworking Example: air conditioners, lighting
7) NW data communication	F	Energy consumption in data communication	Teleworking increases energy consumption in data communication.

For each target, Steps (2) to (4) are explained below.

A: Energy consumption in commuting (by private vehicle)

Target A indicates the amount of energy consumption of private vehicles. This will be reduced by the introduction of teleworking. This positive factor can be calculated as follows.

A = (A1: Reduced travel distance of people) × (A2: Basic unit of travel of a person by private vehicle)

= (A1: Cumulative reduced distance of travel by private vehicle as a result of teleworking)

× (A2: Basic unit of travel of a person by private vehicle)

A1 is the cumulative distance of travel by car which is reduced by teleworking. A2 is the amount of CO_2 emissions for a person to travel 1 km by car (basic unit).

When determining a formula for each target, it may be necessary to modify the formula depending on the availability of basic units and other input data. For example, data on teleworking hours per week are usually available but the number of days is rarely available. In such a case, days of teleworking must be estimated because the commuting frequency (the number of times people commute by car) is one of the input data for Target A. The number of days for teleworking can be estimated by dividing the teleworking hours per week by the assumed average daily teleworking hours. If the basic unit for a person to travel 1 km by car is not available, fuel mileage or other values should be used. In short, formulas should be modified to accommodate the input data available.

As shown in Figure 2-2, when an employee who usually commutes by car for 6 km teleworks for 52 days in a year, the formula of the CO_2 emissions reduction effect is as shown below. The basic unit for a person to travel 1 km by car is 0.047 kg-CO_2/person·km[4]. For details, see the Appendix.

A = (A1: Cumulative reduced distance of travel by private vehicle as a result of teleworking)
× (A2: Basic unit of travel of a person by private vehicle)
= (A1: (Frequency of teleworking) × (Reduced travel distance by car per day of teleworking))
× (A2: Basic unit of travel of a person by private vehicle)
= (52 days/year × 6 km/day) × (0.047 kg-CO_2/person·km)
= 14.7 kg-CO_2/person·year

B: Energy consumption in commuting (by public transportation)

Target B indicates the amount of energy consumption of public transportation such as trains and buses. Like Target A, this reflects the reduction of energy consumption and is regarded as a positive effect.

Even if one commuter stops using public transportation, it will not change the frequency of trains or other public transportation. However, as the number of teleworkers increases, the frequency of public transportation is likely to decrease gradually[5]. This kind of latent capacity of IT solutions does not produce an immediate effect on CO_2 emissions but is expected to do so over time. This is included in the potential of IT solutions.

When an employee who usually commutes 40 km by train teleworks for 52 days in a year, the formula of the CO_2 emissions reduction effect is as shown below.

B = (Reduced travel distance of people) × (Basic unit of travel of a person by public transportation)
= (B1: Cumulative reduced distance of travel by public transportation due to teleworking)
× (B2: Basic unit of travel by public transportation)
= (B1: (Frequency of teleworking) × (Reduced travel distance by public transportation per day

[4] *The Survey on Transport Energy (2001-2002)*; Ministry of Land, Infrastructure, Transport and Tourism
[5] For details, see Section 3.2.

of teleworking)) × (B2: Basic unit of travel by public transportation)

= (52 days/year × 40 km/day) × (0.005 kg-CO_2/person·km)

= 10.4 kg-CO_2/person·year

B2 is the basic unit of an office worker to travel 1 km by train (0.005 kg-CO_2/person·km)[6]. The frequency of trains (public transportation) is assumed to decrease.

C: Energy consumption in office

Teleworking reduces the number of workers in the office. Some lights, air-conditioners, and other facilities are turned off, and thus energy consumption is reduced. Target C indicates this reduction and is categorized as a positive effect.

Although an increase in the number of teleworkers may not immediately reduce energy consumption in the office, this increase is expected to help reduce energy consumption. Like Target B, this is the potential of IT solutions. Assuming the office is used 260 days a year (5 days a week, 52 weeks a year), the reduction of CO_2 emissions for a teleworker can be calculated as follows:

C = (Space occupied by a worker) × (Frequency of teleworking)

× (Basic unit of energy consumption per space)

= (C1: Space occupied by an office worker[7]) × (Frequency of teleworking)

× (C2: Basic unit of energy consumption per office space[7])

= 13.1 m^2/person × (52/260) × 76.0 kg-CO_2/m^2·year

= 199.1 kg-CO_2/person·year

D: Energy consumption of IT equipment

Target D indicates the amount of energy consumption of IT equipment. This value increases due to teleworking and thus is categorized as a negative effect.

In teleworking, teleworkers perform office work at home by using their PC or notebook PC from the company[8]. When a teleworker works at home using a notebook PC (power consumption for 8 hours is 192.1 Wh/day = 0.192 kWh/day), the annual power consumption can be estimated to be

6 *The Survey on Transport Energy (2001·2002)*; Ministry of Land, Infrastructure, Transport and Tourism

7 *Report on ICT Policy for Addressing Global Warming (April 2008)*; Ministry of Internal Affairs and Communications' Study Group

8 Teleworkers usually access the corporate server (or PC) from home. Therefore, it is assumed that the energy consumption of IT equipment in the office remains unchanged.

18,734 Wh/year·unit[9]. If the teleworker lives in metropolitan Tokyo, power is supplied by Tokyo Electric Power Company and thus the CO_2 emissions coefficient is 0.425 kg-CO_2/kWh[10].

D = (Power consumption per piece of IT equipment) × (Basic unit of grid power)
= (D1: Power consumption per notebook PC) × (D2: Basic unit of grid power)
= (D1: Number of pieces of IT equipment × Power consumption per piece
× Time spent per piece) × (D2: Basic unit of grid power)
= (1 × 0.192 kWh/day·piece × 52 days/year) × (0.425 kg-CO_2/kWh)
= 4.2 kg-CO_2/year

E: Energy consumption at home

Teleworking increases the energy consumption of air-conditioners and other home appliances at home. This is a negative effect shown in Target E.

Unlike data on energy consumption in the office, the power consumption of air-conditioners is not available as data per unit area. To obtain the amount of CO_2, calculate the power consumption of the target home appliance based on its running hours in the home environment. Then, multiple the value by the CO_2 emissions coefficient of the relevant grid power.

Assuming that an air-conditioner (with cooling capacity of 2.2 kW for an area of 6 to 9 tatami mats) and fluorescent lights (for an area of 6 to 8 tatami mats) are used during teleworking[11], the power consumption of these appliances is calculated as follows:

E = (Power consumption by teleworking at home) × (Basic unit of grid power)
= {E1: ((Power consumption: air-conditioner) + (Power consumption: lighting))
× (Days of teleworking)} × (E2: Basic unit of grid power)
= {(1.15 kWh/day + 0.54 kWh/day) × 52 days/year} × (0.425 kg-CO_2/kWh)
= 37.3 kg CO_2/year

F: Energy consumption in data communication

Although the Internet helps IT solutions dramatically improve office work and home life, accessing the Internet increases the energy consumption of the relevant equipment. Thus Target F is regarded as having a negative effect on energy consumption.

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[9] Data from the Energy Conservation Center, Japan; average power consumption of a model with a 14-inch or larger LCD (in energy-saving mode). The annual amount assumes usage for 15 hours/week, 52 weeks/year.
[10] Tokyo Electric Power Company, data of FY2007
[11] *The Energy Conservation Center Catalog (2008)*; Energy Conservation Center

Since the energy consumption in data communication changes depending on the increase or decrease in the amount of data communication, the basic unit (0.0025 kg-CO_2/MB[12]) of Internet communication is used.

The latest basic unit values should be used to reflect the rapid improvement in the energy-saving performance of IT equipment and communication infrastructure. The value above is the latest one available at the time of this research.

When a teleworker receives or transmits 10,000 MB of data in a year, the increase in energy consumption related to communication is calculated as follows.

F = (Amount of communication) × (Basic unit of communication)
= (F1: Amount of communication) × (F2: Basic unit of communication)
= 10,000 MB/year × 0.0025 kg-CO_2/MB
= 25 kg-CO_2/year

The availability of the basic unit (CO_2 emissions coefficient) per data communication is limited at present. Since the amount of network communication has been increasing in recent years, this lack of information can cause major uncertainty in measuring the effects of IT solutions.

To determine the total effect of introduced IT solutions, group the targets quantified so far into positive effects and negative effects, and sum up all the values. The calculation results for the example of teleworking (Figure 2-2) are summarized below (Table 2-3).

12 *Reports on the Results Regarding Samples and Calculation Standards of the Eco-efficiency of ICT Services (March 2004)*; Japan Environmental Management Association for Industry

Table 2-3: CO_2 emissions reduction of each target in teleworking

Unit: kg-CO_2/year·person

Item	Target	CO_2 emissions reduction
Positive effects		
A	Energy consumption in commuting (by private vehicle)	14.7
B	Energy consumption in commuting (by public transportation)	10.4
C	Energy consumption in office	199.1
Negative effects		
D	Energy consumption of IT equipment	4.2
E	Energy consumption at home	37.3
F	Energy consumption in data communication	25
	Total (A+B+C−D−E−F)	157.7

3. Considerations in Calculating Effects and Interpreting Results

Chapter 2 described a framework for quantifying the effects of Green by IT. In the actual calculation, however, there are several delicate issues, for example, setting scenarios before and after introducing IT solutions, identifying boundaries, and estimating input data.

This chapter explains two important issues in calculating effects and interpreting results: (a) how to set a pre-introduction scenario and (b) how to define the temporal and spatial spread.

3.1 Pre-introduction scenario

(1) Basic principle

To quantify CO_2 emissions reduction, scenarios before and after introducing IT solutions must be set (see Sections 2.2 (1) and 2.3). A scenario after introduction is normally based on actual results, whereas a pre-introduction scenario is often uncertain mainly due to the following two reasons:

1. A pre-introduction scenario is hypothetical and intangible.
2. Multiple scenarios are possible before introduction; the reason for selection must be clearly noted.

The selection depends on the purpose of the calculation, and so the number of scenarios should not necessarily be limited to one. If an inappropriate scenario is selected, the result of the calculation may not suit the purpose, so the appropriateness of the selection must be assessed thoroughly. For hypothetical scenarios in particular, the reason for selection must be clarified.

A hypothetical pre-introduction scenario is normally based on the practice applicable to a target country where IT solutions are not yet introduced. For example, when calculating the effect of teleworking in Japan, it is assumed that people in urban areas commute by train (see Section 2.3). In some countries, however, commuting by car may be more common. If a pre-introduction scenario is hypothetical, it must be both applicable to a real situation and plausible for the target of IT solutions. Furthermore, the activities defined in the scenario must continue to exist even after introducing IT solutions.

The difference between CO_2 emissions before and after improving IT solutions can also be compared. For example, changes in the amount of CO_2 emissions by replacing old IT systems with new ones can be assessed. A comparison before and after gathering distributed IT equipment into a data center by using cloud technology is another example. When assessing the reduction in CO_2 emissions for a special purpose, it must be explained as needed.

(2) Example: pre-introduction scenario of teleworking

(i) Before and after introduction

Take teleworking as an example. Chapter 2 shows the CO_2 emissions reduction. In that example, changes in CO_2 emissions related to commuting are calculated before and after introducing teleworking. The pre-introduction scenario assumes that people commute by car or public transportation, which is a common way of commuting at present (Figure 3-1).

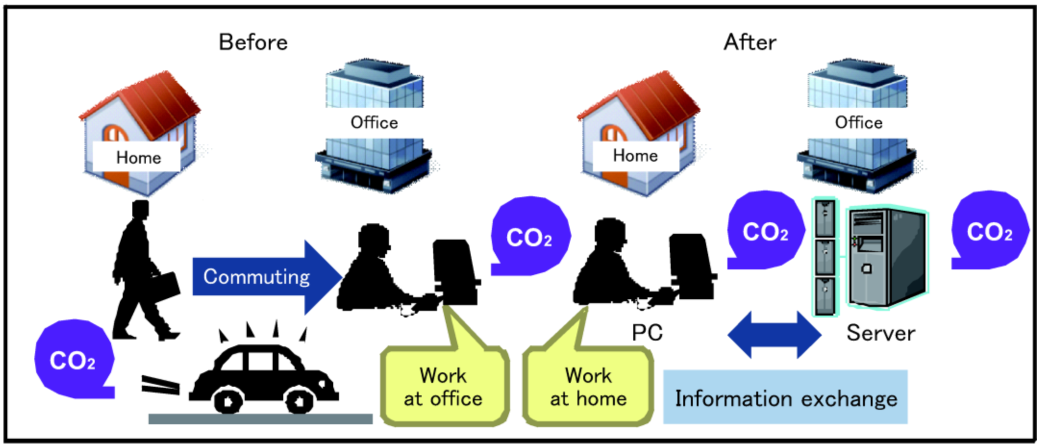


Figure 3-1: Before and after introducing teleworking

Note that commuting methods vary; Chapter 2 assumes the common commuting method in urban areas in Japan, but it may differ in other countries.

(ii) Replacing systems

A particular purpose may require a particular pre-introduction scenario. For example, assume that the purpose is to compare CO_2 emissions in the current situation with those after replacing obsolete teleworking systems with new ones (Figure 3-2). In this case, the major functions for teleworking remain the same, but replacing the systems reduces energy consumption and thus reduces the total CO_2 emissions. Component 6 "Power/energy consumption (IT/NW equipment)" (Table 2-1) is supposed to shrink after introduction.

The timing and IT systems to be compared should also be clearly defined. For example;

- Timing: before and after new IT systems are installed
- IT systems: the latest system rather than an existing general system is installed (hypothetical scenario)

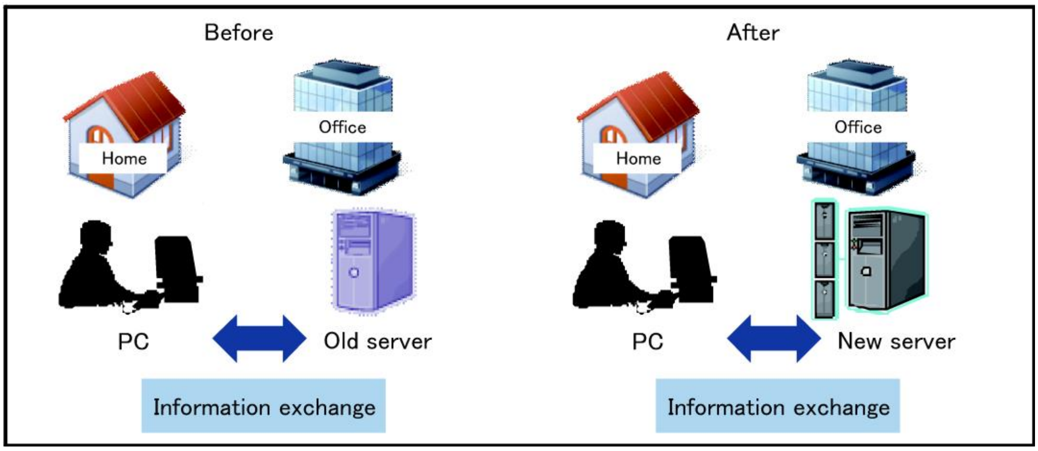


Figure 3-2: Introducing a new IT system for teleworking

(iii) Cloud computing for teleworking

Cloud computing is another example of system replacement described in (ii). CO_2 emissions can be reduced by gathering IT equipment into a single data center by using cloud computing technology. When calculating the effect of doing this, a pre-introduction scenario assumes that many IT devices (servers) are used for teleworking, and an after-introduction scenario assumes that teleworking is supported by cloud computing (Figure 3-3). Again, Component 6 in Table 2-1 will be reduced.

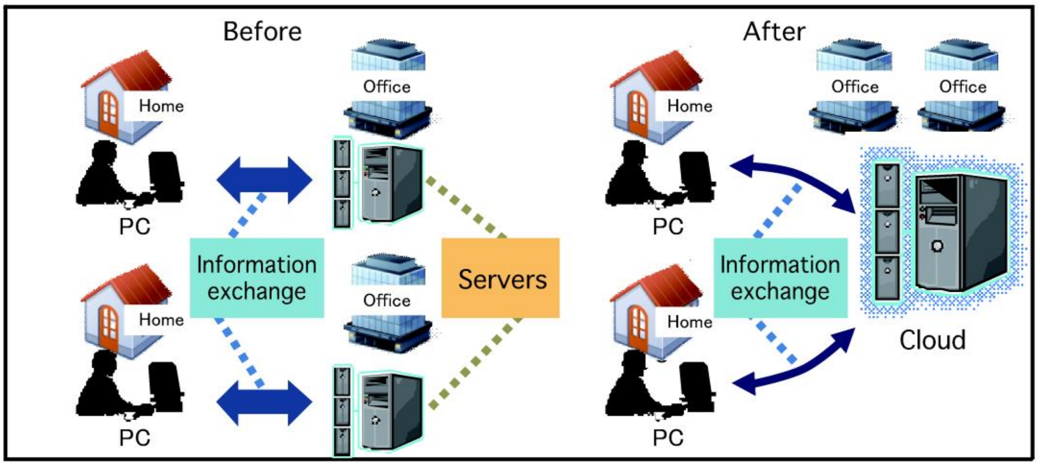


Figure 3-3: Cloud computing for teleworking

It may be possible to compare the situation before introducing teleworking and after introducing cloud computing. In this case, all components in Table 2-1 must be taken into consideration.

3.2 Ranges influenced by IT solutions (temporal and spatial spread)

The reduction in CO_2 emissions achieved by IT solutions is so complicated that the calculated results can be interpreted differently and the amount of reduction can differ greatly. In the following sections, the composite effects of Green by IT are analyzed, which will be useful for calculating and interpreting the reduction in CO_2 emissions achieved by IT solutions.

(1) Concept of temporal and spatial spread

If employees commute by car, introducing teleworking reduces the commuting distance and thus CO_2 emissions. Namely, these effects do not occur in the company that introduces teleworking but among the employees. The effects of Green by IT are not limited to the company itself, but expand to outside the company (Figure 3-4).

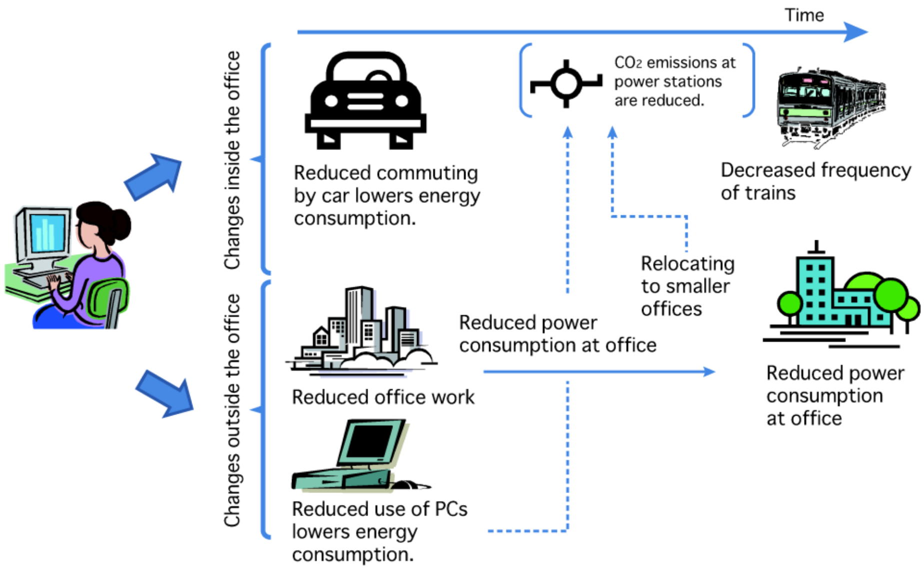


Figure 3-4: How the effects of teleworking spread

To define a spatial boundary, “inside” and “outside” the company should be defined. “Inside” is defined as sectors where energy (electricity, fuel, etc.) and goods (paper, etc.) are consumed, and “outside” is defined as other sectors.

The time lag in the effects should also be considered. Take office space as an example. The required office space may be reduced immediately after introducing teleworking, or the reduction of energy consumption at the office may be delayed. The latter applies to companies which do not relocate to a smaller place or do not introduce measures to save energy even after working hours at the office have been reduced by introducing teleworking.

As in the case above, CO_2 emissions may not be reduced immediately after introducing IT solutions for some reasons. This is defined as “temporal spread,” or a time lag from the introduction of IT solutions until the actual reduction of CO_2 emissions. The temporal spread may also occur when additional measures are necessary (relocation followed by the introduction of teleworking). Considering the temporal spread, CO_2 emissions reduction can be divided into two categories: actual reduction and potential reduction.

(2) Example: temporal and spatial spread

The following sections describe the temporal and spatial spread in the case of teleworking.

(i) Scenarios of introducing teleworking and effects of Green by IT

Table 3-1 summarizes the effects of CO_2 emissions reduction by introducing teleworking. The calculations use the formula described in Chapter 2.

Table 3-1: CO_2 emissions reduction by teleworking

Item	Component	Formula	CO_2 emissions reduction (kg-CO_2/year·person)
Positive effects			
A	Energy consumption in commuting (by private vehicle)	(52 days/year × 6 km/day) × 0.047 kg-CO_2/person·km	14.7
B	Energy consumption in commuting (by public transportation)	(52 days/year × 40 km/day) × 0.005 kg-CO_2/person·km	10.4
C	Energy consumption in office	13.1 m^2/person × (52/260) × 76.0 kg-CO_2/m^2·year	199.1
Negative effects			
D	Energy consumption of IT equipment	(1 unit × 0.192 kWh/day·piece × 52 days/year) × 0.425 kg-CO_2/kWh	4.2
E	Energy consumption at home	(1.15 kWh/day + 0.54 kWh/day × 52 days/year) × 0.425 kg-CO_2/kWh	37.3
F	Energy consumption in data communication	10,000 MB/year × 0.0025 kg-CO_2/MB	25.0
	Total		**157.7**

(ii) Process of CO_2 emissions reduction in teleworking

To help understand the temporal and spatial spread, Figure 3-5 illustrates how and where teleworking is introduced and how CO_2 emissions are reduced for each component listed in Table 3-1.

The process is broken down into four major sub-processes: (a) reduced commuting by car (movement of people), (b) reduced commuting by train (movement of people), (c) reduced office space, and (d) increased use of IT equipment and home appliances at home. In sub-processes (a) and (d), energy consumption is expected to decrease or increase at once. In contrast, the reduction or increase in energy consumption is not clear in terms of reduced frequency of trains (km) (examined items A in Figure 3-5) and reduced office space (examined items B in Figure 3-5).

In the two sub-processes (a) and (d), CO_2 emissions are reduced at employees' homes. In sub-process (b), CO_2 emissions are reduced in the public transport sector. Other reductions take place within the company.

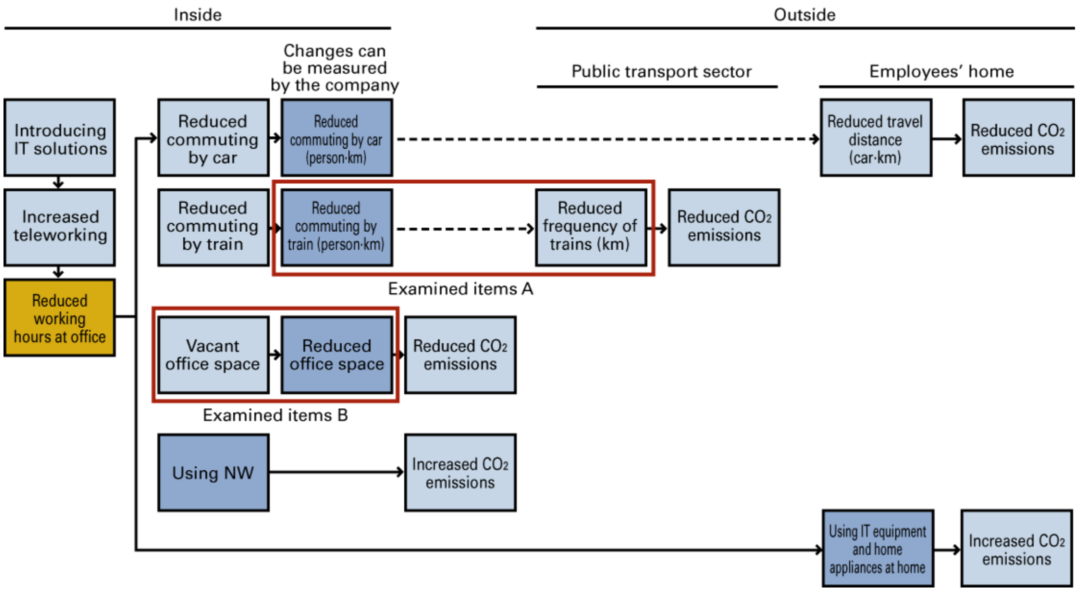


Figure 3-5: Example of process of CO_2 emissions reduction in teleworking[13]

(iii) Summary of spatial and temporal spread

We reviewed the items in areas (A) and (B) which need examining in terms of temporal spread[14]

[13] Spatial boundaries usually spread in line with the expansion of temporal boundaries. Accordingly, both of them are described along the horizontal axis in Figure 3-5. Note that Figure 3-4 shows the spatial and temporal spread two-dimensionally.

[14] For details, see the FY2010 report by the Survey and Estimation Committee of the Green IT Promotion Council.

and assumed that CO_2 emissions can be reduced more easily by reducing the use of public transportation than by reducing office space. While the public transport sector acts relatively more quickly in response to a reduction of commuters (A), reducing office space requires additional measures which may cause a delay (B). In the latter case, therefore, there may be a difference between the potential and actual CO_2 emissions reduction.

In terms of spatial spread, introducing teleworking reduces CO_2 emissions at the office (positive results in Components C, D and F in Table 3-1) while increasing CO_2 emissions at employees' homes (Component E). Furthermore, if the office space is not reduced in accordance with the workload, CO_2 emissions may increase at the office in some cases.

Figure 3-6 shows potential effects broken down in terms of temporal and spatial spread. The bar at the far right indicates the potential CO_2 emissions reduction. The effects (CO_2 emissions reduction) are divided into actions by the company (introducing the IT solution, additional measures) and those by others. Each item can be further divided into sub-items ("inside" and "outside") to show the spatial spread. How much these sub-items contribute to the potential effect is indicated by the lengths of respective bars.

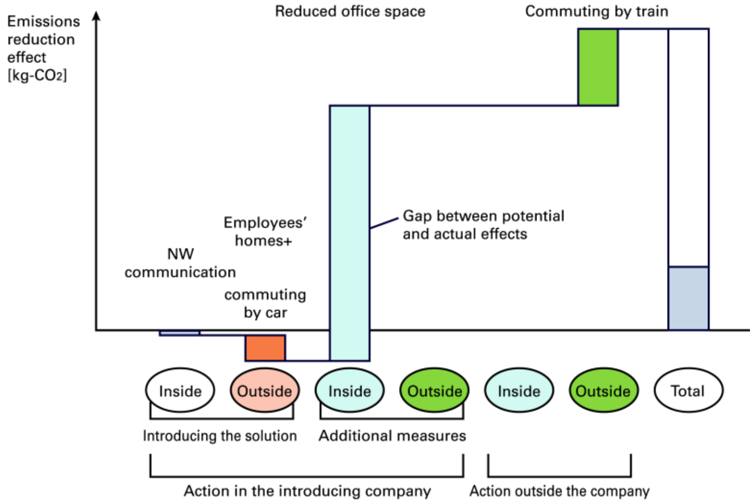


Figure 3-6: CO_2 emissions reduction per sub-item

(3) Actual and potential effects

Sections above examined the breakdown of CO_2 emissions reduction, which is calculated by the formula described in Chapter 2.

Since CO_2 emissions reduction through Green by IT spreads spatially, its contribution must be evaluated across society. For temporal spread, two effects can be defined: actual effects (reduction of CO_2 emissions in the short term) and potential effects (the maximum possible effect by introducing IT solutions).

In Chapter 2, CO_2 emissions reduction by each activity in the seven components (and "Others") was calculated by using the formula:
Change in quantity of activity × Basic unit
However, considering temporal spread, there may be a mixture of potential and actual CO_2 emissions reduction depending on the data and formula used.

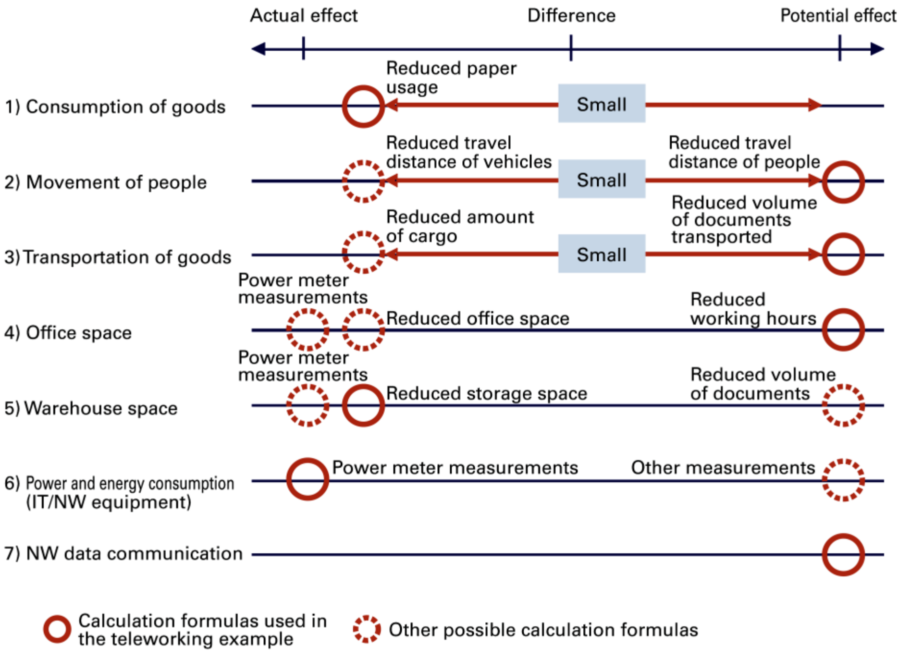


Figure 3-7: Formulas for calculating CO_2 emissions reduction and their positions

Figure 3-7 shows whether the results of calculations for the seven components (see Table 2-1) are close to actual or potential[15]. The results of Component 4 "Office space" show that CO_2 emissions reduction is close to actual when the calculations are based on the measurements by power meters or actual reduction in office space. Meanwhile, the results are closer to potential when CO_2 emissions reduction is calculated based on reduction in working hours. In Component 2 "Movement of people," the difference between CO_2 emissions reduction based on the reduced travel distance of people and the reduced frequency of trains is expected to be small.

[15] The FY2010 report by the Survey and Estimation Committee reviewed the effects of the paperless office and HEMS. Figure 3-7 includes these results.

As shown above, the purpose must be made clear before calculating the effects of Green by IT: to obtain potential effects or actual effects. To obtain actual effects, use a formula closer to the left in Figure 3-7 and actually measured figures. To obtain potential effects, use a formula closer to the right in Figure 3-7 and possible maximum values. This approach will improve the accuracy of calculated CO_2 emissions reduction.

3.3 Summary

(1) Pre-introduction scenario

- If pre-introduction scenarios are inappropriate, the calculation results may not suit the purpose. Thus, the appropriateness of selected scenarios must be assessed thoroughly. In particular, it may be necessary to explain the details of a scenario based on a hypothetical situation.
- A hypothetical pre-introduction scenario is normally based on common practices in the target country before the introduction.
- CO_2 emissions before and after improving IT solutions can also be compared. For example, changes in the amount of CO_2 emissions after replacing old IT systems with new ones or after gathering distributed IT equipment into a data center by using cloud technology can be targeted. When assessing CO_2 emissions reduction for a particular purpose, its framework should be explained in detail.

(2) Temporal and spatial spread

- With an understanding of the temporal and spatial spread of effects, the formula used to calculate CO_2 emissions reduction through Green by IT, the presentation of its results, and thus the quality of the evaluation standard can be enhanced.
- In terms of temporal spread, there are two types of effects of Green by IT: actual effects (left half of Figure 3-4) and potential effects (total of Figure 3-4).
- Actual effects are defined as CO_2 emissions reduction achieved by introducing IT solutions in the short term.
- A potential effect is defined as the maximum CO_2 emissions reduction to be achieved by introducing IT solutions.
- In terms of spatial spread, CO_2 emissions reduction through Green by IT is achieved not only within the company which has introduced IT solutions (lower part of Figure 3-4) but also outside the company (upper part of Figure 3-4).
- The calculated CO_2 emissions reduction should be clearly identified as actual or potential (Figure 3-7).
- The composition of CO_2 emissions reduction can be analyzed based on the above considerations. Figure 3-6 shows that the CO_2 emissions reduction through Green by IT calculated by the

formula described in Chapter 2 can be broken down by actions relating to the temporal spread and to places where the effect takes place. This analysis is useful for both calculating effects and interpreting the results in a consistent manner, and is also useful for promoting Green by IT.

4. Presenting the Results

Based on the above description, the following sections offer some good examples of how to present the results of CO_2 emissions reduction through Green by IT.

4.1 Basic data

(1) Preconditions

As described earlier, the amount of CO_2 emissions reduction through Green by IT depends on the purposes and assumptions. Thus, it is necessary to show what preconditions and scenarios are used for calculation, in addition to the calculation results (Figure 4-1).

The following must be included in the preconditions and scenarios:

1) Conditions for scenarios

- Use quantitative data as much as possible to describe the situation before and after introducing IT solutions. Clearly indicate whether a pre-introduction scenario is hypothetical or actual.

2) Input data

- Describe input data: measured or assumed, the source of data, etc.

3) Boundaries (range influenced by the introduction of IT solutions)

- Indicate the temporal or spatial range that can be influenced by the introduction of IT solutions, thus clarifying the denominator when calculating the reduction ratio.
-

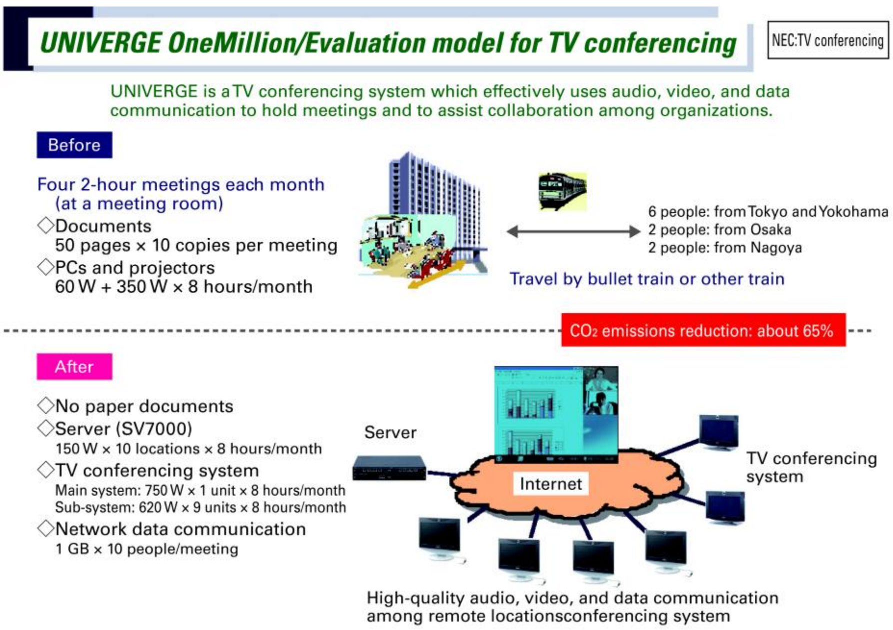


Figure 4-1: Example of presenting scenarios (TV conferencing)

(2) Calculation results

To clarify CO_2 emissions reduction rates, compare the amount of CO_2 emissions before and after introducing IT solutions. Indicating the effects of each component will help understand the features of IT solutions (Figure 4-2).

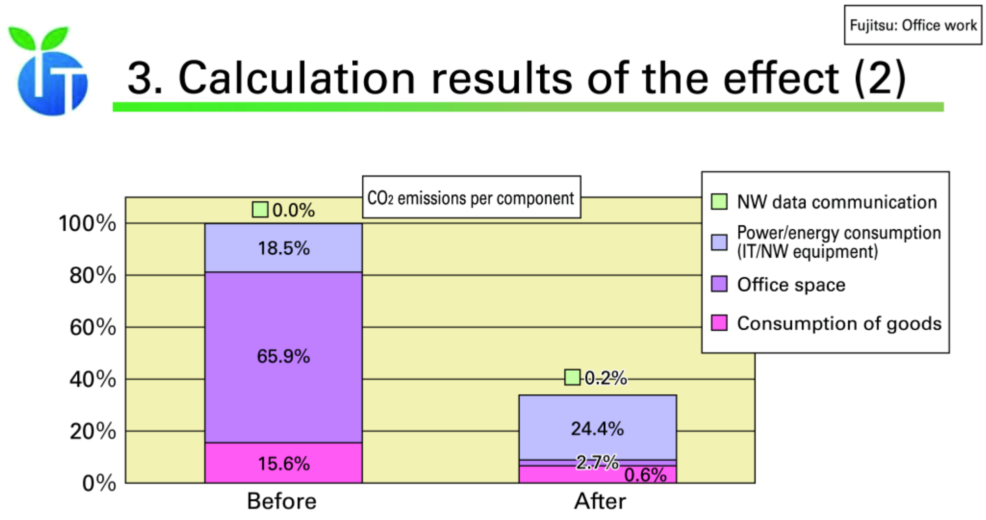


Figure 4-2: Example of presenting calculation results
(introducing IT solutions into office work)

4.2 Additional information

(1) Calculation process and basic unit

To make the calculation process traceable, show the formula and basic units used. This will help readers to understand the results of the calculation (Figure 4-3).

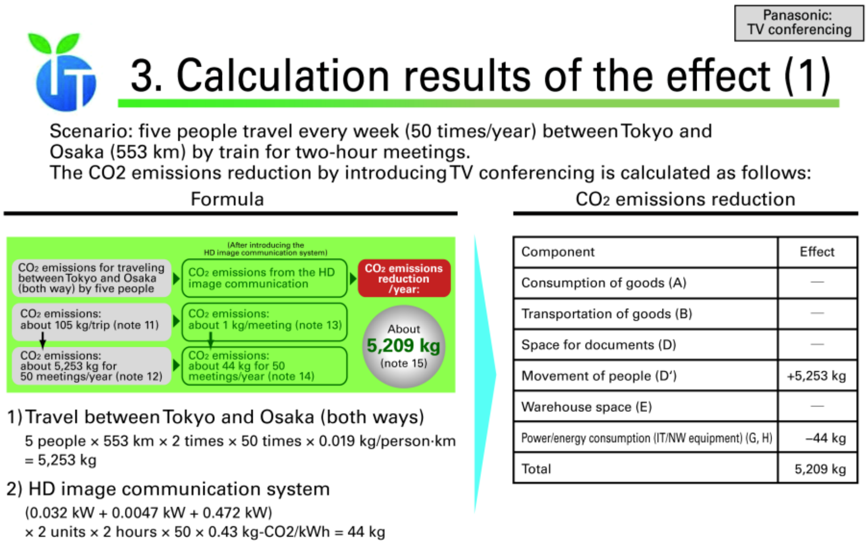


Figure 4-3: Example of presenting the calculation process (TV conferencing)

(2) Analysis results of temporal and spatial spread

Breaking down the effects in terms of temporal and spatial spread is helpful for understanding the features of IT solutions (Figure 4-4).

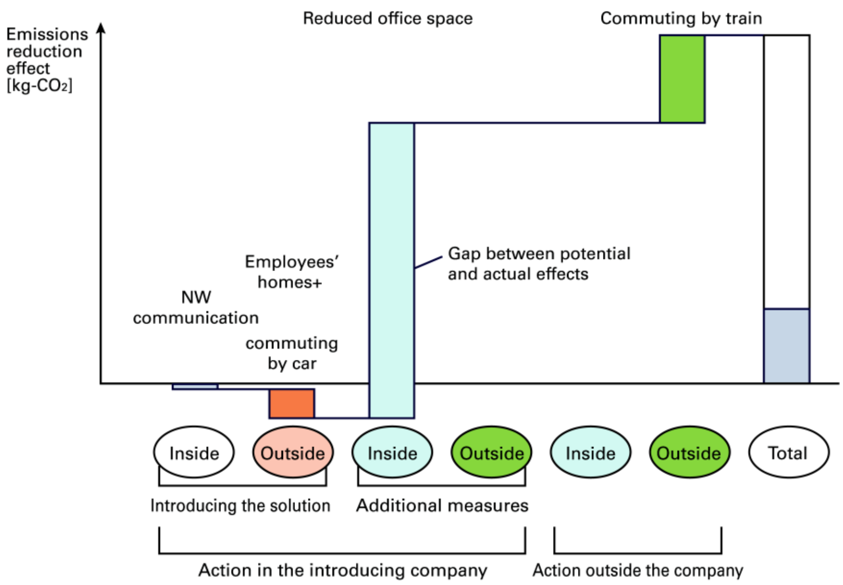


Figure 4-4: Example of analyzing temporal and spatial spread

5. Calculation Cases

5.1 List of calculation cases

The following sections 5.2 to 5.9 show how to calculate the amount of CO_2 emissions reduction by IT solutions in accordance with the methods described earlier. Table 5-1 lists actual calculation cases.

Many other cases are listed in the FY2009 and FY2010 reports by the Survey and Estimation Committee of the Green IT Promotion Council (see Section 5.10). More cases are also introduced in the "Green IT Award" and "Green IT The Best Practices Collection[16].

Table 5-1: List of calculation cases

Classification	Solution	Introducing company	Calculation results	Option
Introducing IT to business	Online acceptance service for account debiting contracts	NTT Data Corporation	✓	✓
	PQTMeister® safety and quality framework for ensuring quality & traceability in the automobile industry	Toshiba Solutions Corporation	✓	
	ASP-type shared online service system for retail securities brokerage firms	Nomura Research Institute, Ltd.	✓	✓
Teleconferencing	HD image communication system	Panasonic Corporation	✓	✓
	Teleconferencing system with the StarBoard electronic whiteboard	Hitachi, Ltd.	✓	✓
HEMS	Carbon Diet: a service for visualizing power saving efforts	NEC Corporation	✓	
Improving transportation efficiency	Logistics support solution (digital tachograph)	Fujitsu Ltd.	✓	✓
Cloud computing	U-Cloud® IaaS (ICT hosting service)	Nihon Unisys, Ltd.	✓	✓

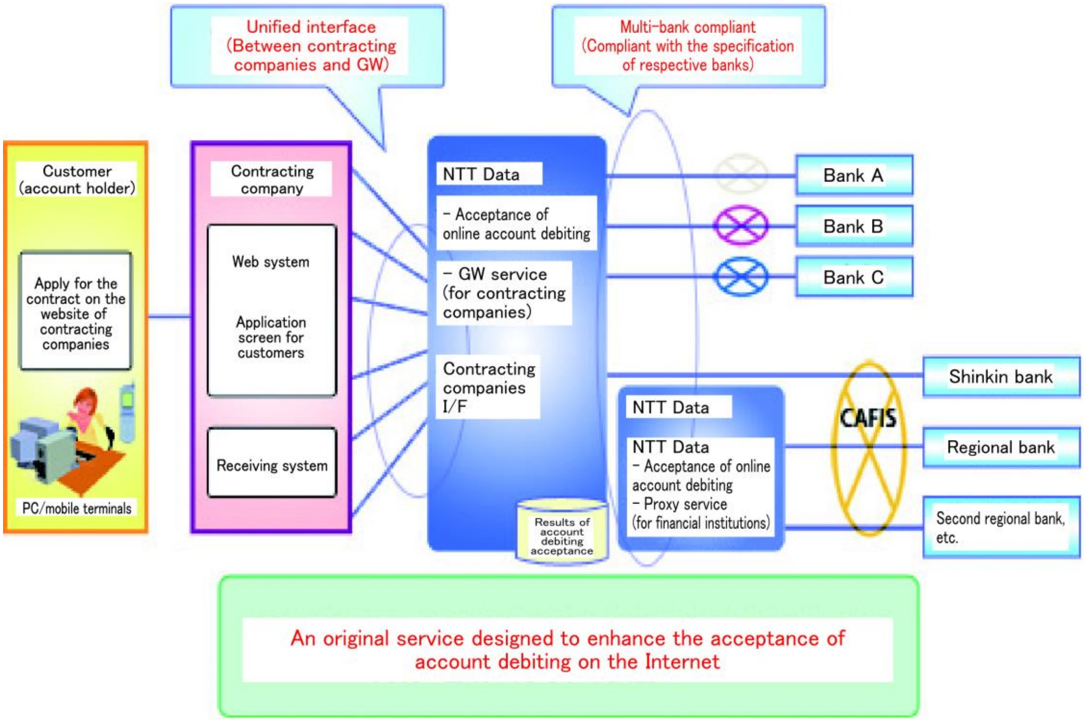
16 Visit the website of the Green IT Promotion Council (http://www.greenit-pc.jp/).

5.2 Introducing IT to business (NTT Data Corporation)

Company name: NTT Data Corporation	Title: Online acceptance service for account debiting contracts

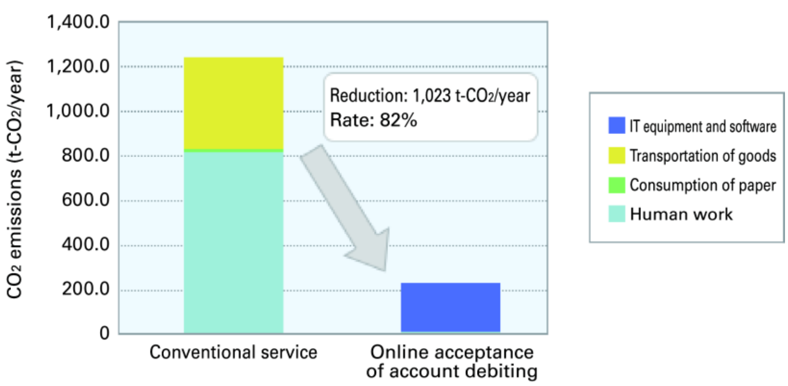
Outline:

An ASP service designed to conclude account debiting contracts on the Internet. This service enables account holders to conclude an account debiting contract on the Internet (paperless, without signature). Such a contract usually requires account holders to fill out and sign forms and both contracting companies and financial institutions to handle these forms.



Overview

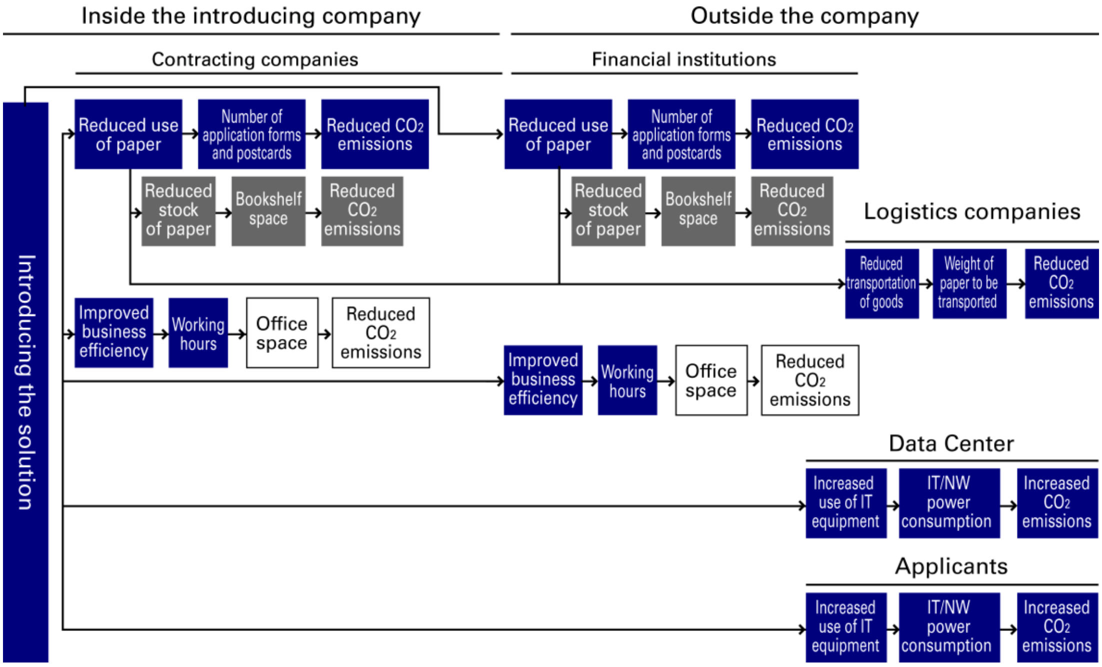
Preconditions for evaluation:	Calculation results:
The amounts of energy consumption before and after introducing the service for 180,000 account debiting applications annually are compared. This covers the process from acceptance of account debiting to notification of the results between contracting companies and financial institutions.	Reduction: 1,023 t-CO_2/year Rate: 82%



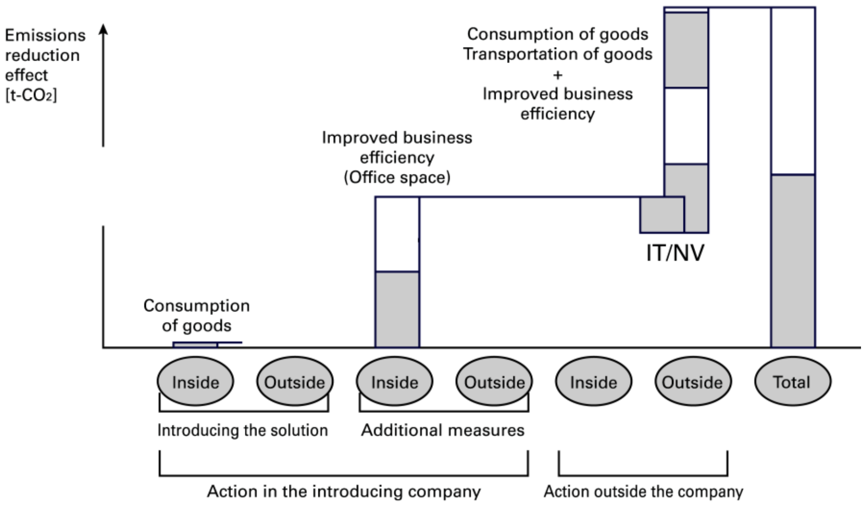
Source: http://www.nttdata.com/jp/ja/green_it/product/index.html

Company name: NTT Data Corporation	Title: Online acceptance service for account debiting contracts

Process of CO_2 emissions reduction



Temporal and spatial spread



Source: http://www.nttdata.com/jp/ja/green_it/product/index.html

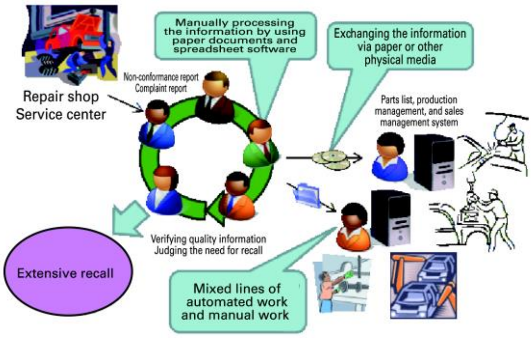
5.3 Introducing IT to business (Toshiba Solutions Corporation)

Company name: Toshiba Solutions Corporation	Title: PQTMeister® safety and quality framework for ensuring quality & traceability in the automobile industry

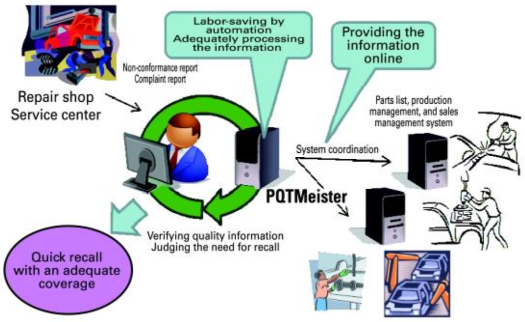
Outline: As customers become increasingly concerned about security and safety with the spread of digitalization of information, companies must quickly respond to defects and troubles in their products. This solution is designed to integrally manage the trace information (paper, data, etc.) on the safety of parts throughout the company, reduce the time required for investigating non-conformance, clarify (minimize) the range of non-conformance to be handled, and reduce the cost of countermeasures or disposal. This is the first package product to provide a quality framework for automobiles which require a high level of safety.

Details of the solution and CO_2 emissions reduction effect:
This solution is the first package product that aims to reduce the development workload in the field of quality management traceability systems, whose framework is usually developed from scratch, and to improve the efficiency of traceability work where many tasks are still performed manually. Improved efficiency will also help decrease the environmental burden during the development as well as traceability work.

Figures 1 and 2 show business models before and after introducing the solution. The business model before the introduction is assumed to be as follows: information was exchanged among factories via physical media such as paper documents and CD-ROMs, and the traceability work was performed by using pen and paper or spreadsheet software. Each factory manages product systems, parts list, and the like by using systems and paper, and they are processed manually upon request. After introduction, the PQTMeister works together with the systems of each factory to automatically obtain information and perform the traceability work. As a result, there is no need for people to do traceability work in terms of data processing. This improved operational efficiency will considerably reduce CO_2 emissions.



Before the introduction



After the introduction

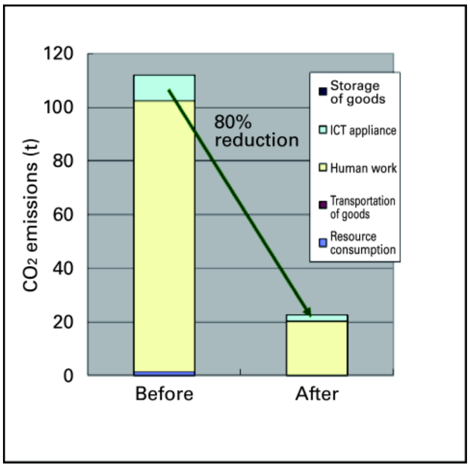
Preconditions for evaluation:
Target work: identifying defect lots (trace-back) and estimating the range of adverse effects (trace-forward). The series of tasks is performed when the maintenance department of a car maker requests an investigation.

Number of requests: 900/year

Departments involved: maintenance dept. (1 person), quality assurance dept. (2 persons), and manufacturing dept. (5 persons)
The traceability work is performed at the head office and a factory.

Range of target work: investigation and estimation only.
The effect of smaller recalls is not evaluated.

Calculation results:



Source:

5.4 Introducing IT to business (Nomura Research Institute, Ltd.)

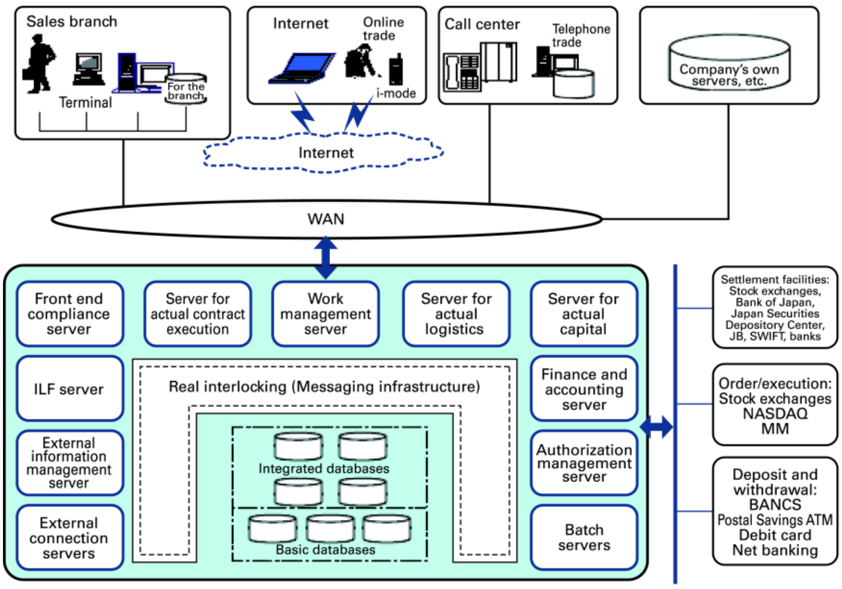
Company name: Nomura Research Institute, Ltd.	Title: ASP-type shared online service system for retail securities brokerage firms

Outline:

A shared system to comprehensively support the back-office work (account management, orders, settlements, etc.) of retail securities brokerage firms. Individual firms do not build and operate a system but share a system on a network, thus reducing CO_2 emissions for system development and operation.

Details of the solution and CO_2 emissions reduction effect:

System configuration



Preconditions for evaluation:

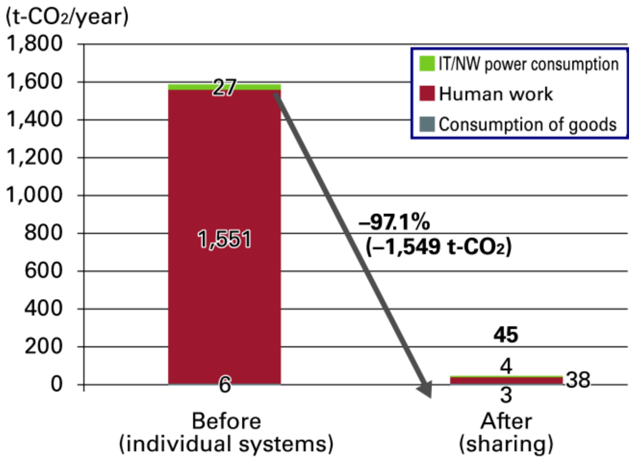
With individual systems:

The assumed system uses 11 servers. A system equivalent to the shared system is built without using package software. Man-hours required for developing this system are estimated to be about 80% of the shared system (the shared system needs to include the components for individual user companies).

With the shared system:

Data in NRI's system is applied to both software and hardware.

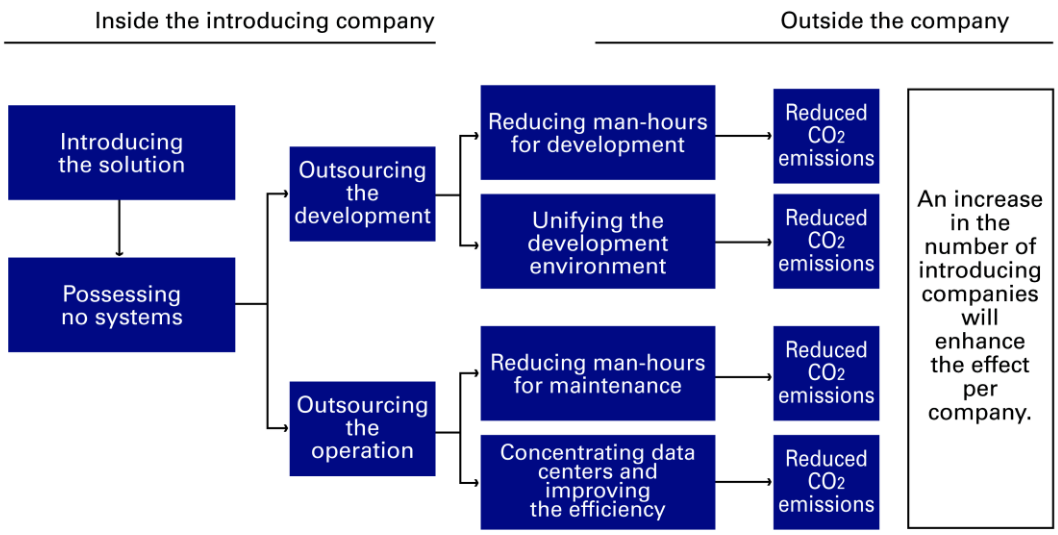
Calculation results:



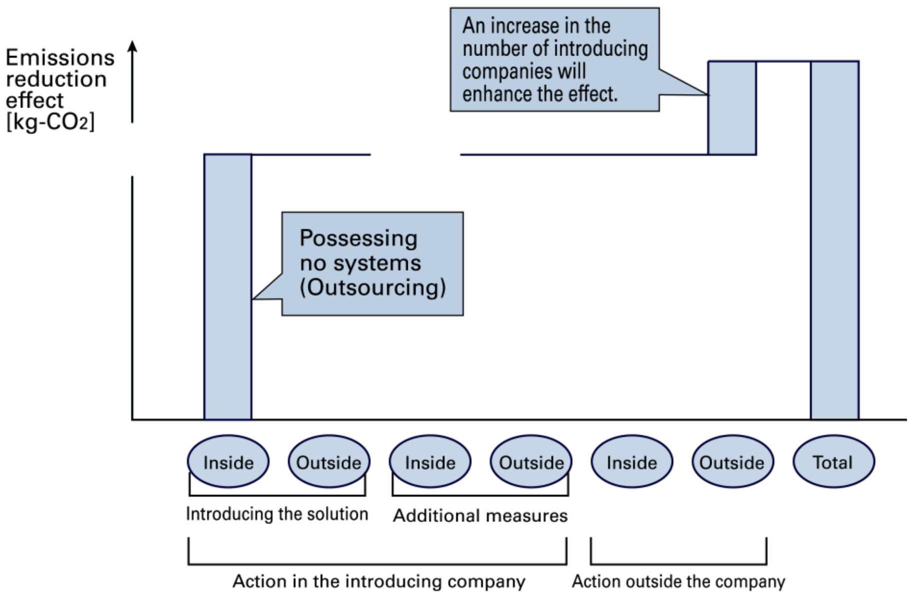
Source:

Company name: Nomura Research Institute, Ltd.	Title: ASP-type shared online service system for retail securities brokerage firms

Process of CO_2 emissions reduction



Temporal and spatial spread



Source:

5.5 Teleconferencing (Panasonic Corporation)

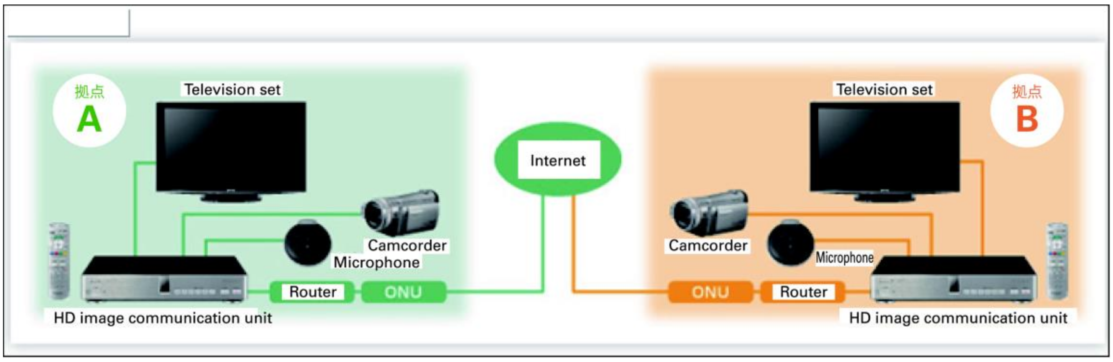
Company name: Panasonic Corporation	Title: HD image communication system

Outline:

Unlike conventional teleconferencing systems, this system offers a variety of communication solutions with high-quality images and sound, so attendees feel like they are holding a usual meeting. They no longer need to gather at one place, which considerably reduces CO_2 emissions related to transportation.

Details of the solution and CO_2 emissions reduction effect:

■ Example of system configuration



■ How to calculate CO_2 emissions reduction effects

The CO_2 emissions related to the movement of people for a meeting and those by using the HD image communication system are compared.

■ Calculation formula

The amount of CO_2 emissions reduction by using IT equipment =

(1) (CO_2 emissions basic unit of a transportation means × travel distance × number of people) – (2) (Power consumption of IT equipment × operating time × number of units × CO_2 emissions coefficient)

Preconditions for evaluation:

▪ CO_2 emissions basic unit of a transportation means[*1]

Railway: 19 kg-CO_2/person·km

▪ Power consumption and CO_2 emissions factor of IT equipment

(1) Unit and power consumption (2 units are used each.)

HD image communication unit: 32 W/unit

Digital high-definition camcorder: 4.7 W/unit

50-inch full-resolution HD plasma television: 472 W/unit

(2) CO_2 emissions coefficient[*2]: 0.43 kg-CO_2/kWh

Calculation results

Scenario: five people travel every week (50 times/year) between Tokyo and Osaka (553 km) by train for two-hour meetings

(1) Business trip (movement of people)

5 people × 553 km × 2 times × 50 times × 0.019 kg/person·km = 5,253 kg

(2) HD image communication (power consumption of IT/NW equipment)

(0.032 kW + 0.0047 kW + 0.472 kW) × 2 units × 2 hours × 50 × 0.43 kg-CO_2/kWh = 44 kg

Factor	CO_2 emissions
Movement of people (1)	+ 5,253 kg
(Power consumption of IT/NW equipment (2)	+ 44 kg
CO_2 emissions reduction effect (1) – (2)	5,209 kg

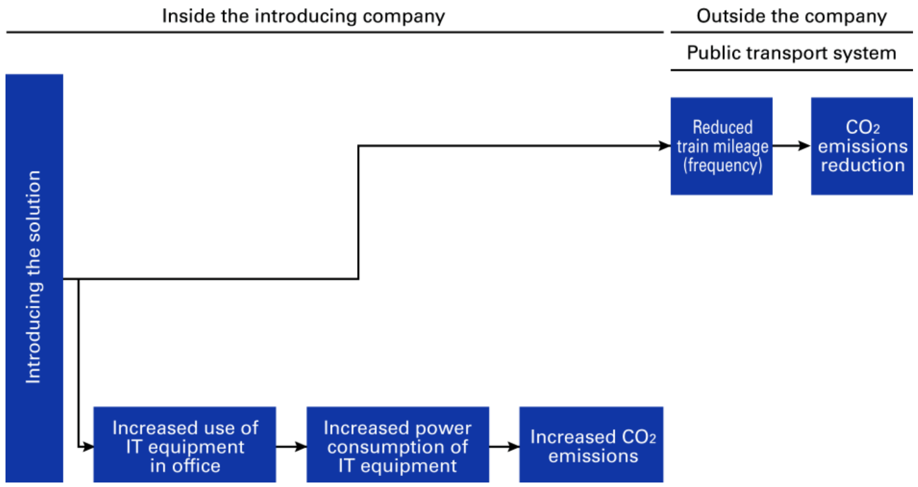
Source:

*1 *Transportation, Traffic and the Environment* (2009); Foundation for Promoting Personal Mobility and Ecological Transportation

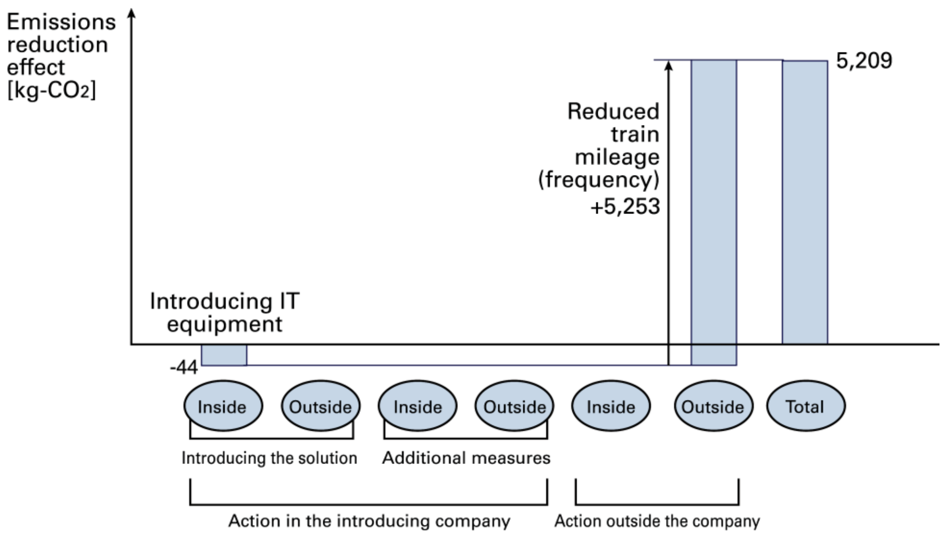
*2 *Household Eco-Account Book* (revised on August 5, 2010); Ministry of the Environment

Company name: Panasonic Corporation	Title: HD image communication system

Process of CO_2 emissions reduction



Temporal and spatial spread



Source:

5.6 Teleconferencing (Hitachi, Ltd.)

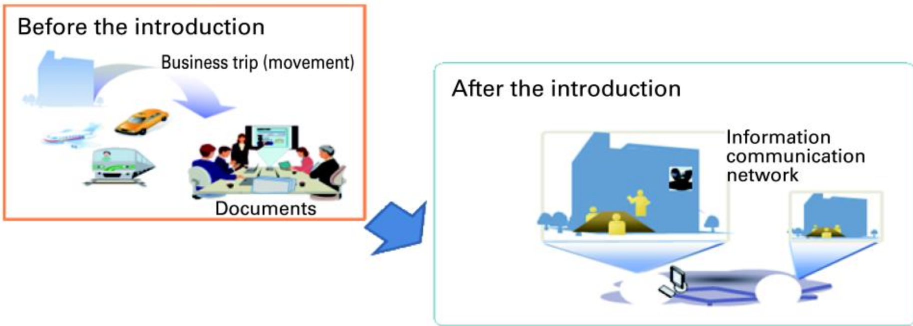
Company name: Hitachi, Ltd. Hitachi Solutions, Ltd.	Title: Teleconferencing system with the StarBoard electronic whiteboard
Outline: StarBoard is an interactive electronic whiteboard on which the PC screen is projected and the PC itself can be operated. Combined with a teleconferencing system, it enables people to share sound, images, and data and hold an effective remote conference.	

Details

(1) Sharing conference data: Attendees of a remote conference can see and share all Word, Excel, PowerPoint, and PDF documents. They can write any comments on the data displayed on StarBoard and save it as it is.

(2) Sharing discussion data: The whiteboard function can be shared by all attendees. Space is automatically added horizontally or vertically if necessary, which enables attendees to write their comments and share them. Multiple locations can be connected simultaneously and existing teleconferencing systems can be used.

StarBoard is a product of Hitachi Solutions, Ltd.



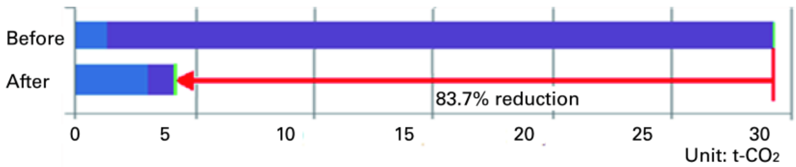
Preconditions for evaluation: A total of 46 meetings are held per year. One meeting lasts one hour with 6 attendees. 3 people come from Osaka by train, and the other 3 people come from around Tokyo.
In the teleconferencing system, 3 people each from Tokyo and Osaka participate. There is no movement of people. StarBoards, PCs, and conferencing systems are installed in both locations.

Preconditions for evaluation:
Introduction of IT equipment and its power consumption increased CO_2 emissions by 493 kg-CO_2 while the elimination of the movement of people decreased CO_2 emissions by 26,416 kg-CO_2.
A considerable reduction effect was confirmed.

Calculation results: Unit: kg-CO_2

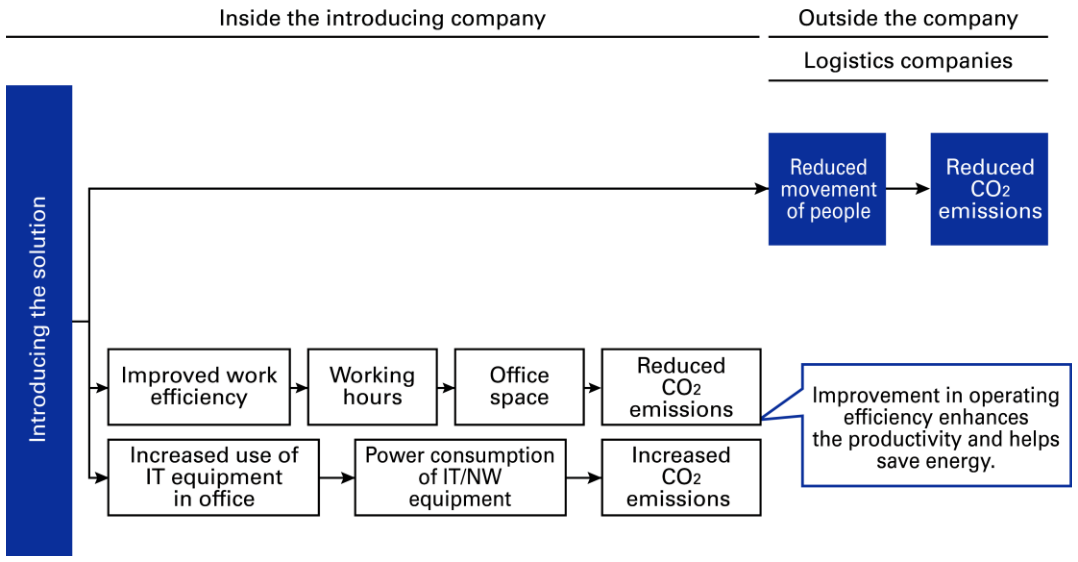
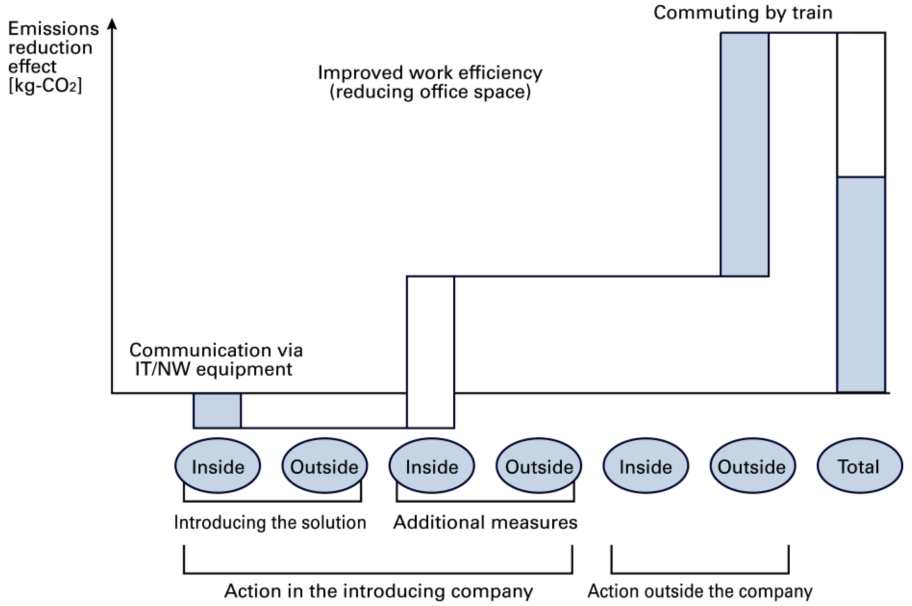
Factor	Effect
Consumption of goods (A)	0
Transportation of goods (B)	0
Document space (D)	0
Movement of people (D′)	26,416
Storage space (E)	0
Power consumption of IT/NW equipment (G, H)	–493
Total	25,923

Reduction effect over the life cycle of equipment from manufacturing to disposal



*The amount of environmental load reduction is evaluated by the SI-LCA method defined in the "Guideline for Information and Communication Technology (ICT) Eco-Efficiency Evaluation (1995)." This evaluation is based on a specific business model; it may vary in other business models.

Source: CV-BI02-001 (CFP certification number)
http://www.cfp-japan.jp/info/p_detail.php?id=24

Company name: Hitachi, Ltd. Hitachi Solutions, Ltd.	Title: Teleconferencing system with the StarBoard electronic whiteboard
Process of CO_2 emissions reduction 	
Temporal and spatial spread 	
Source: http://hitachisoft.jp/products/starboard/support/environment.html	

5.7 HEMS (NEC Corporation)

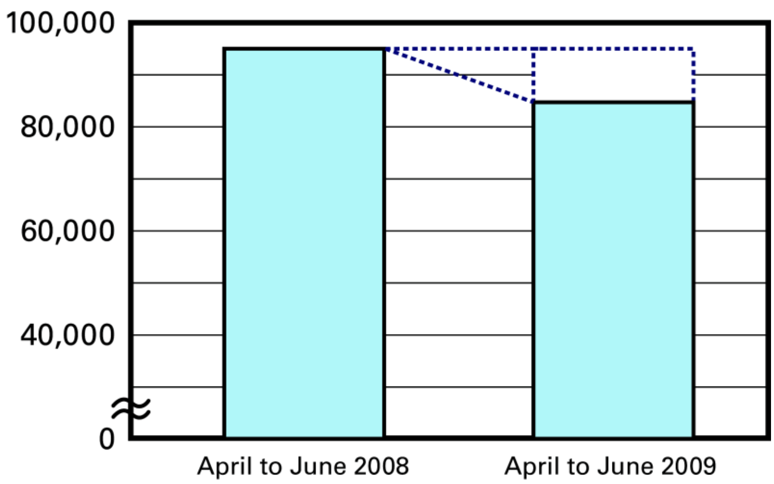
<table>
<tr><td>Company name:
NEC Corporation</td><td>Title:
Carbon Diet: a service for visualizing power saving efforts</td></tr>
<tr><td colspan="2">Outline:
"Carbon Diet" uses an easy-to-install, small unit to measure household power consumption and automatically send the data via short-range wireless transmission to the server, where the consumption is calculated. It enables users to find on the web how they have reduced CO_2 emissions at home and encourages them to continue power-saving efforts while competing with other users.</td></tr>
<tr><td colspan="2">Details of the solution and CO_2 emissions reduction effect:
NEC and NEC Biglobe conducted a trial run of this service with about 100 households of NEC group employees for three months and found that the average household reduced its power consumption by about 10% (April to June 2009: year-on-year change).</td></tr>
<tr><td>Preconditions for evaluation:
The measurement unit can be easily installed by connecting a current sensor to the household distribution board. No special work is required. The measured data is automatically sent to the server through short-range wireless transmission (IEEE802.15.4) which is used in ZigBee wireless networks. Thus, there is no troublesome work for users to participate in this CO_2 reduction activity.</td><td>Calculation results:
100 households participated in a three-month trial run of this service. The year-on-year change showed a reduction of 9,233 kWh, or 9.5%.


Figure: Effect of the visualization service</td></tr>
<tr><td colspan="2">Source: http://www.greenit-pc.jp/topics/release/pdf/green-it-award_091005.pdf</td></tr>
</table>

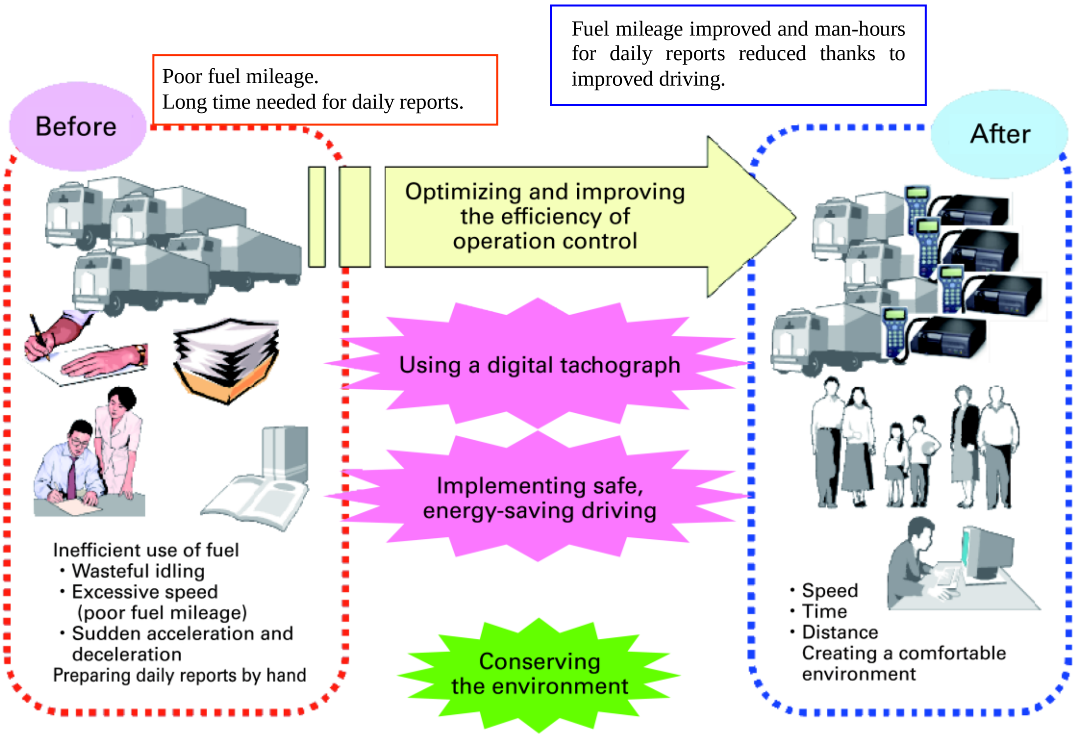
5.8 Improving transportation efficiency (Fujitsu Ltd.)

Company name: Fujitsu Ltd.	Title: Logistics support solution (digital tachograph)

Outline:

This operation control system reduces environmental load and costs through safe, economical driving which is achieved by cooperation among drivers, operation controllers and distribution centers.

Details of the solution and CO_2 emissions reduction effect:

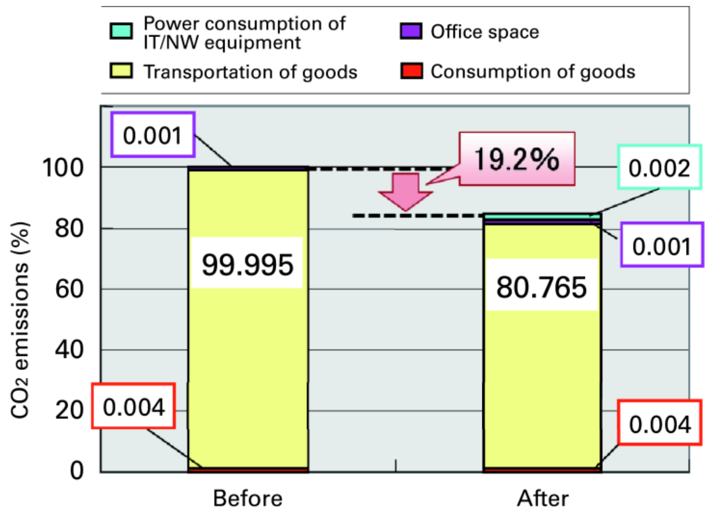


Preconditions for evaluation:

In case of a leading retail and distribution company

- 2000 trucks
- 2000 drivers

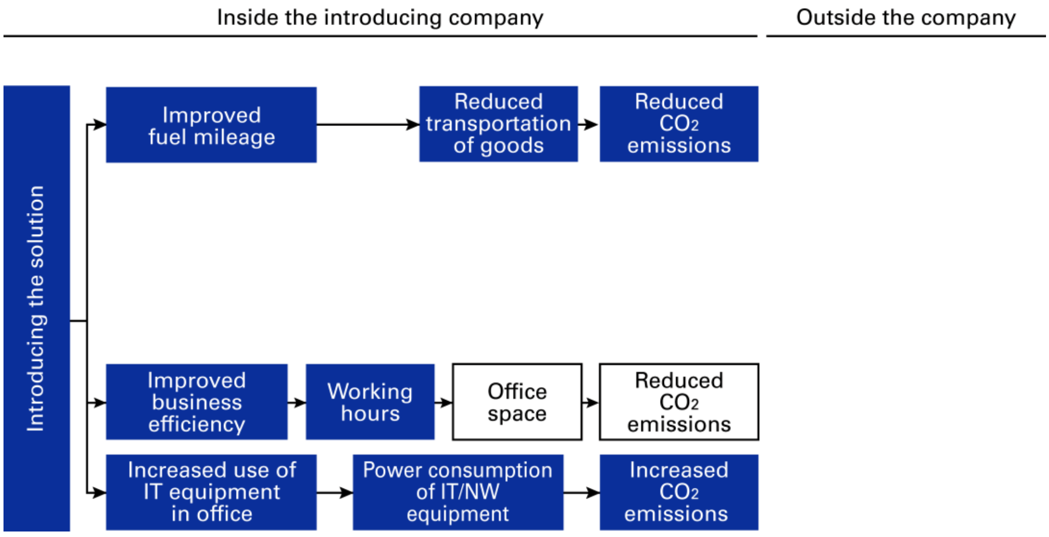
Calculation results:



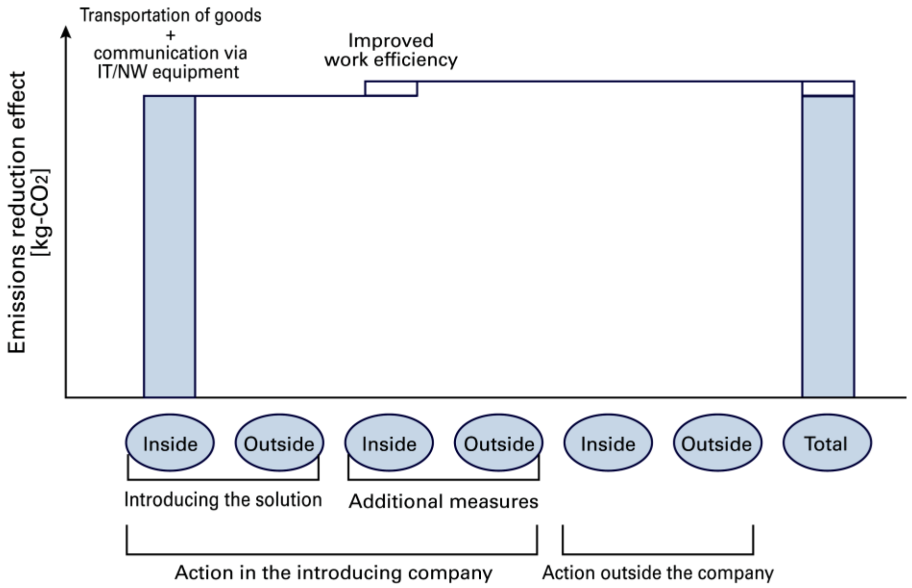
Source: http://segroup.fujitsu.com/its/services/logistics/solution/

Company name: Fujitsu Ltd.	Title: Logistics support solution (digital tachograph)

Process of CO_2 emissions reduction



Temporal and spatial spread



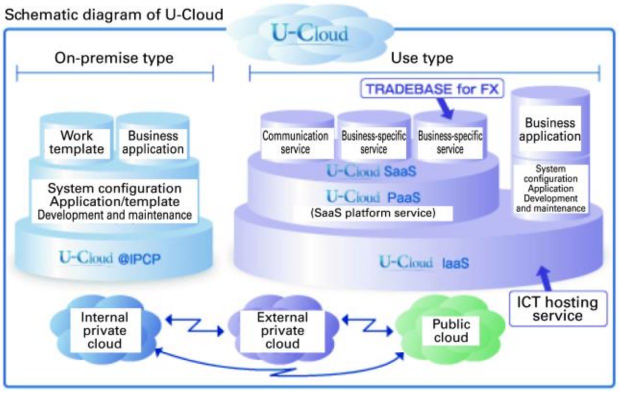
Source: http://segroup.fujitsu.com/its/services/logistics/solution/

5.9 Cloud computing (Nihon Unisys, Ltd.)

Company name: Nihon Unisys, Ltd.	Title: U-Cloud® IaaS (ICT hosting service)

Outline:

U-Cloud is an enterprise cloud service, which provides servers, storage, network resources, and desktops as and when needed.



Selected as the Best Service in "The Fifth Cloud Ranking" of Nikkei Computer (Oct. 11, 2012); Nikkei Business Publications, Inc.

Features

This enterprise cloud service is designed to enhance the migration from an on-premise environment. The service has the following four features:

- A public cloud that can be used like a private cloud
- A one-stop cloud service, leveraging Nihon Unisys's long experience and know-how gained as a system integrator
- A high-quality hybrid cloud is possible in combination with the U-Cloud® IPCP on-premise private cloud package.
- An ICT environment including the client environment is available as a cloud service through the virtual desktop service.

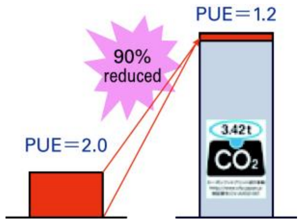
Preconditions for evaluation:

CO_2 emissions of the cloud service and that of the existing data center (PUE=2.0) were calculated as a model case. Power consumption was reduced by about 90%.

Calculation results:

Contribution

Factor	Effect
Consumption of goods (A)	-
Transportation of goods (B)	-
Document space (D)	760
Movement of people (D′)	67,012
Storage space (E)	16,500
Power consumption of IT/NW equipment (G, H)	49,500
Total	

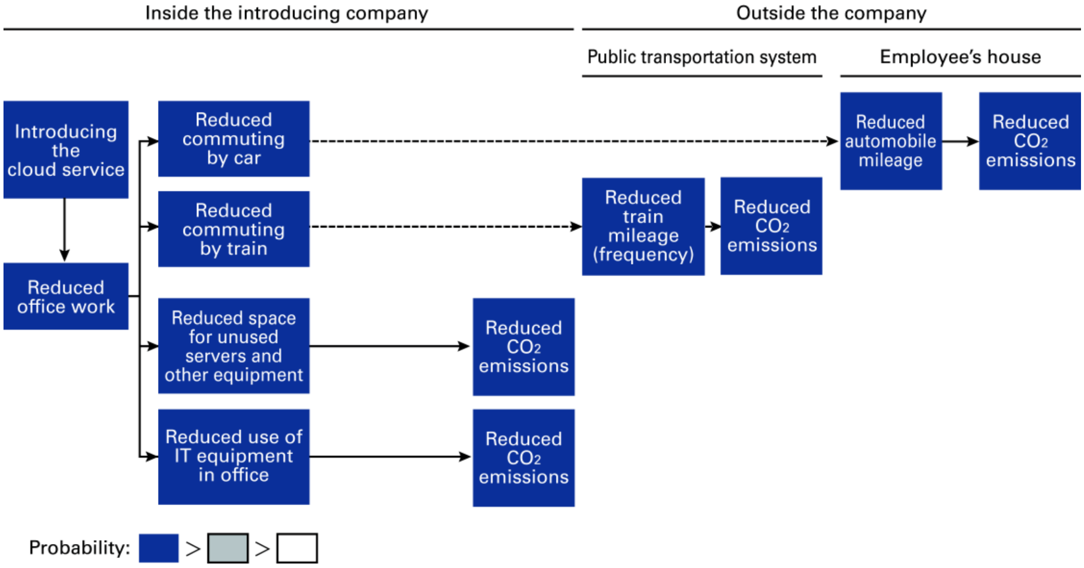


Source: CV-AX02-001 (CFP certification number)

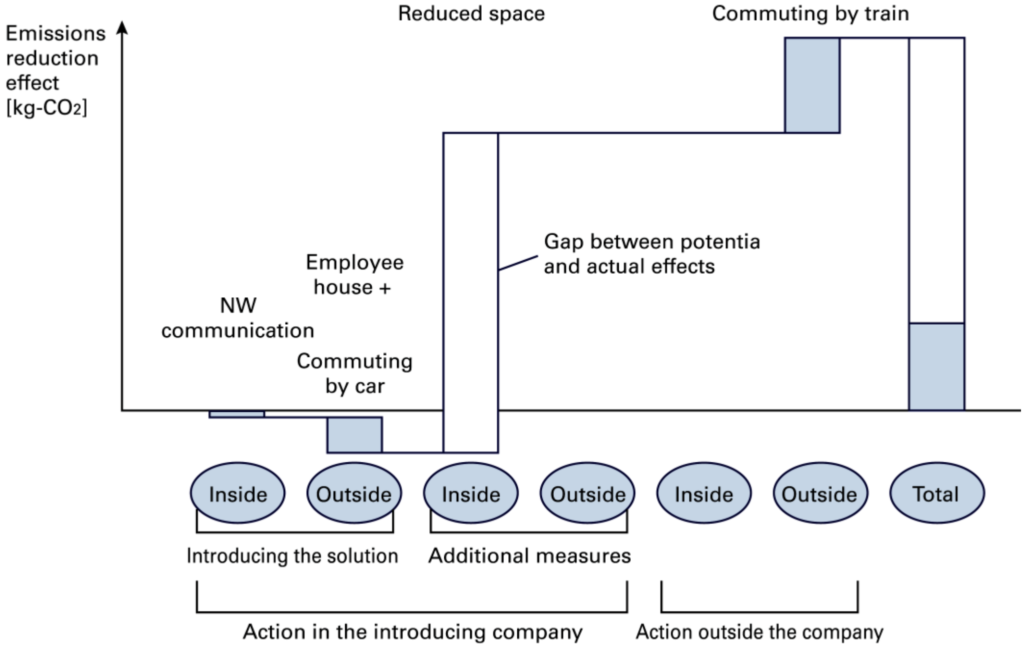
http://www.cfp-japan.jp/info/p_detail.php?id=176

Company name: Nihon Unisys, Ltd.	Title: U-Cloud® IaaS (ICT hosting service)

Process of CO_2 emissions reduction



Temporal and spatial spread



Source: http://www.unisys.co.jp/services/ict/iaas.html

5.10 Other solutions through Green by IT

In addition to those described up to Section 5.9, the Survey and Estimation Committee of the Green IT Promotion Council has collected the solution cases listed in Table 5-2. Their details are described in the previous reports of the committee and other publications.

Table 5-2: Solution cases through Green by IT

Classification	Solution	Introducing company
Improving the efficiency of production process	DEMITASNX design assistance tool for suppressing EMI	NEC Corporation
BEMS	Air-conditioning control system prioritizing comfort	Toshiba Corporation
	Energy conservation system for distribution outlets	Oki Electric Industry Co., Ltd.
	Futuric facilities management system	Fujitsu Ltd.
Paperless office	ICT services for delivering direct mail online	NEC Biglobe, Ltd.
	Working management system	Hitachi Systems and Services, Ltd.
	Administrative information system	Fujitsu Ltd.
	E-form system	Hitachi Software Engineering Co., Ltd.
	Prior notification service for utility charges	NTT Data Billing Service Corporation
	E-paycheck delivery service	Hitachi Software Engineering Co., Ltd.
	Internet Navigware e-learning system	Fujitsu Ltd.
	POS system for mass merchandisers	Fujitsu Ltd.
	Geographical information system (GIS) for farmland	Fujitsu Ltd.
	Integrated internal information solution	Fujitsu Ltd.
	Information leakage prevention measures and PC management	Hitachi Software Engineering Co., Ltd.

	Eliminating paper stock through digitizing documents	PFU Ltd.
	Next-generation office	NTT Data Corporation
	Online service for providing images from earth observation satellites	Fujitsu Ltd.
	Software for reducing the number of prints	Fujitsu Advanced Engineering Ltd.
	ASP business support service for helping financial institutions to liquidize receivables and entrust accounts receivable in bulk	NTT Data Corporation
	Reducing environmental loads using e-form systems (for customer use and in-house use)	Daiwa Securities Co., Ltd. (Daiwa Institute of Research Ltd.)
	Campusmate-J integrated business package for universities	Fujitsu Ltd.
	KOSMO communication web: a web system for health insurance associations	Daiwa Institute of Research Business Innovation Ltd.
Introducing IT to business	Automatic certificate issuing system	Fujitsu Ltd.
	ExchangeUSE workflow system for human resources and general affairs	Fujitsu Ltd.
	SaaS-type simple e-application system	NTT Data Corporation
	Automatic certificate issuing machine	Fujitsu Ltd.
Teleworking	Teleworking (up to 3 days a week)	Fujitsu YFC Ltd.
	Teleworking for reducing commuting and balancing work and private life	Hitachi Software Engineering Co., Ltd.
Tele-conferencing	In-house meeting system	Hitachi Software Engineering Co., Ltd.
	Teleconferencing	NEC Corporation
	Teleconferencing	Fujitsu Ltd.
Remote sensing and management	Analyzing the growth of wheat and estimating the optimum harvesting time	Hitachi Software Engineering Co., Ltd.
	TOREDAS traceable and operational resource and environment data acquisition system	Fujitsu Ltd.

HEMS	Home energy-saving technology using home network	Toshiba Corporation
	Lifinity ECO management system: home energy management system	Panasonic Electric Works Co., Ltd.
Online shopping	"i. market" internet shopping system	Fujitsu Ltd.
Improving transportation efficiency	Stockholm congestion charging system	IBM Japan, Ltd.

6. To Enhance the Use of Evaluation Methods for Green by IT Solutions

This document has described how to calculate energy saving in society by IT solutions ("Green by IT"), which is expected to help reduce CO_2 emissions. We believe that Green by IT has great potential in reducing CO_2 emissions in society. According to one estimate, the energy saving of IT equipment ("Green of IT") in 2020 will be between 21.4 to 42.8 million t-CO_2/year while Green by IT will achieve 68 to 137 million t-CO_2/year[17]. We hope that the methods described here are widely used to quantify the effect of individual IT solutions, thus helping to promote Green by IT and reduce CO_2 emissions.

Meanwhile, many concerns still remain in evaluation methods and calculation tools because the effects of Green by IT are highly diverse. For example, it is difficult to quantify the global effect of Green by IT because global scenarios for calculating the effect of Green by IT are not easily available. In Japan, most business trips are by train while in some countries trips are mainly by plane. Average energy consumption in an office may differ by country. Thus, it is difficult to draw up a scenario applicable to all regions worldwide. To globally promote Green by IT, we must accumulate data on scenarios, representative values, and basic units which are necessary for calculating CO_2 emissions reduction effects.

We must strive to solve these challenges while continuing to accumulate data and cases of evaluation and calculation.

[17] FY2009 Report of the Survey and Estimation Committee of the Green IT Promotion Council

Appendix

Appendix 1 Basic units (for Japan)

The following tables (A 1-1 to A 1-8) list basic units frequently used for calculating the effect of IT solutions on reducing energy consumption. These tables summarize reference values available today[18]. Some items have multiple reference values because they were defined by different organizations at different times; applicable ranges are shown for such items.

Table A 1-1: List of basic units (energy consumption 1/2)

	Item	Reference value	Target range for calculation	Source
Energy consumption	Gasoline	2.75 (kg-CO_2/liter)	Production and consumption	1
		2.75 (kg-CO_2/liter)	Consumption only	2
	Heating oil	2.65 (kg-CO_2/liter)	Production and consumption	1
		2.50 (kg-CO_2/liter)	Consumption only	2
	Light oil	2.95 (kg-CO_2/liter)	Production and consumption	1
		2.60 (kg-CO_2/liter)	Consumption only	2
	Heavy oil	2.81 (kg-CO_2/liter)	Production and consumption	1
	City gas	2.22 (kg-CO_2/liter)	Production and consumption	1
		2.10 (kg-CO_2/liter)	Consumption only	2
	LPG	3.00 (kg-CO_2/kg)	Consumption only	2
		6.50 (kg-CO_2/kWh)	Consumption only	2
	Electricity	0.363 (kg-CO_2/liter)	Production and consumption	3
		0.425 (kg-CO_2/liter)	Consumption only	4
		0.555 (kg-CO_2/liter)	Unclear	5
		0.386 (kg-CO_2/liter)	Unclear	6

Sources:

1) National Institute for Environmental Studies – Environmental load unit (2005)

2) Act on Promotion of Global Warming Countermeasures

3) Ministry of Internal Affairs and Communications – Global warming issues (April 2008)

4) Ministry of the Environment – Summary of reports from power companies

5) Revised Act on Promotion of Global Warming Countermeasures – Default values

6) Global Warming Countermeasure Plan of Tokyo Metropolitan Government (2007 Guidelines)

[18] As of FY2009 when a working group of the Green IT Promotion Council conducted the survey

Table A 1-2: List of basic units (energy consumption 2/2)

	Item	Reference value	Target range for calculation	Source
[Reference] Power generation method	Oil-fired	0.975 (kg-CO_2/kWh)	Production and consumption	7
	Coal-fired	0.742 (kg-CO_2/kWh)	Production and consumption	
	LNG-fired	0.608 (kg-CO_2/kWh)	Production and consumption	
	Solar power	0.053 (kg-CO_2/kWh)	Unclear	
	Wind power	0.029 (kg-CO_2/kWh)	Unclear	
	Geothermal energy	0.015 (kg-CO_2/kWh)	Unclear	
	Hydraulic power	0.011 (kg-CO_2/kWh)	Unclear	
	Nuclear power	0.022 (kg-CO_2/kWh)	Unclear	
[Power] Amount of energy consumption (overseas)	U.S.	0.679 (kg-CO_2/kWh)	Consumption only	8
	Germany	0.660 (kg-CO_2/kWh)	Consumption only	
	U.K.	0.566 (kg-CO_2/kWh)	Consumption only	
	China	1.020 (kg-CO_2/kWh)	Consumption only	
	South Korea	0.535 (kg-CO_2/kWh)	Consumption only	
	Thailand	0.595 (kg-CO_2/kWh)	Consumption only	
	Philippines	0.566 (kg-CO_2/kWh)	Consumption only	
	Vietnam	0.455 (kg-CO_2/kWh)	Consumption only	
	India	1.437 (kg-CO_2/kWh)	Consumption only	
	World average	0.500 (kg-CO_2/kWh)	Unclear	9

Sources:

7) Central Research Institute of Electric Power Industry (CRIEPI) – CRIEPI's newsletter No. 338 (October 2000)

8) Japan Electrical Manufacturers' Association (JEMA) – Investigative report on CO_2 reduction activities by the power sector by country (June 2006)

9) International Energy Agency (IEA)

Table A 1-3: List of basic units (energy consumption by goods and by IT)

	Item	Reference value	Target range for calculation	Source
Consumption by goods	Paper	1.28 (kg-CO_2/kg)	Production and consumption	3
	CD-ROM: Rewritable	0.25 (kg-CO_2/piece)	Production and consumption	10
	CD-ROM: Write-once	0.46 (kg-CO_2/piece)	Production and consumption	10
	Office	76.0 (kg-CO_2/m^2)	Production and consumption	1
	Warehouse	46.2 (kg-CO_2/m^2)	Production and consumption	11
	Data center	2.113 (kg-CO_2/m^2)	Unclear	12
	Office building	657 (kWh/m^2)	Unclear	12
	NW communication	0.002522 (kg-CO_2/MB)	Production and consumption	13
	Fax communication	0.14 (kg-CO_2/hour)	Production and consumption	14
Consumption by IT equipment	Desktop PC	71.4 (kg-CO_2/piece)	Unclear	15
	Notebook PC	27.8 (kg-CO_2/piece)	Unclear	
	CRT display	67.5 (kg-CO_2/piece	Unclear	
	LCD display	21.9 (kg-CO_2/piece)	Unclear	
	Printer	74.7 (kg-CO_2/piece)	Unclear	
	Server (medium-size)	1,066.0 (kg-CO_2/piece)	Unclear	
	Server (workstation)	793.0 (kg-CO_2/piece)	Unclear	
	Mobile communication equipment	1.4 (kg-CO_2/piece)	Unclear	
	Fixed-line phone	14.2 (kg-CO_2/line)	Unclear	
	Facsimile	12.2 (kg-CO_2/line)	Unclear	
	Broadband line	106.0 (kg-CO_2/line)	Unclear	16

Sources:

1) National Institute for Environmental Studies – Environmental load units (December 2002)

3) Ministry of Internal Affairs and Communications – Global warming issues (April 2008)

10) Yearbook of Machinery Statistics (2001)

11) Japan Statistical Yearbook (2005)

12) Energy Saving Chart of the Tokyo Metropolitan Government (2005)

13) Japan Environmental Management Association for Industry – ICT services (2004)

14) WG3 data for environmental efficiency research (2003)

15) Ministry of Internal Affairs and Communications – Research results on the impact of IT on the global environment (2002)

16) Estimation of CO_2 emissions by the broadband network

Table A 1-4: List of basic units (movement of people)

	Item	Reference value	Target range for calculation	Source
Movement of people	Private car	0.0839 (kg-CO_2/person·km)	Production and consumption	11
	Bus	0.0615 (kg-CO_2/person·km)	Production and consumption	
	Airplane	0.1860 (kg-CO_2/person·km)	Production and consumption	
	Train	0.0329 (kg-CO_2/person·km)	Production and consumption	
[Reference] Movement of people	Private car	0.047 (kg-CO_2/person·km)	Unclear	17
	Private light car	0.023 (kg-CO_2/person·km)	Unclear	
	Business vehicle	0.093 (kg-CO_2/person·km)	Unclear	
	Route bus	0.027 (kg-CO_2/person·km)	Unclear	
	Charter bus	0.009 (kg-CO_2/person·km)	Unclear	
	Airplane	0.030 (kg-CO_2/person·km)	Unclear	
	Train	0.005 (kg-CO_2/person·km)	Unclear	
	Subway	0.004 (kg-CO_2/person·km)	Unclear	
	Street car	0.008 (kg-CO_2/person·km)	Unclear	
	New traffic system	0.007 (kg-CO_2/person·km)	Unclear	

Sources:

11) Japan Statistical Yearbook (2005)

17) Ministry of Land, Infrastructure, Transport and Tourism – Handbook of transportation energy (2001-2002)

Table A 1-5: List of basic units (Transportation of goods)

	Item	Reference value	Target range for calculation	Source
Transportation of goods	Truck	0.205 (kg-CO_2/ton·km)	Production and consumption	11
	Freight railway	0.0315 (kg-CO_2/ton·km)	Production and consumption	
	Air cargo	1.410 (kg-CO_2/ton·km)	Production and consumption	
	Cargo ship	0.027 (kg-CO_2/ton·km)	Production and consumption	
	Postal service (letters)	0.0973 (kg-CO_2/ton·km)	Production and consumption	
[Reference] Transportation of goods	Truck for business use	0.049 (kg-CO_2/ton·km)	Unclear	17
	Light truck for business use	0.226 (kg-CO_2/ton·km)	Unclear	
	Private truck	0.098 (kg-CO_2/ton·km)	Unclear	
	Private light truck	0.776 (kg-CO_2/ton·km)	Unclear	
	Train	0.006 (kg-CO_2/ton·km)	Unclear	
	Coastal ship	0.011 (kg-CO_2/ton·km)	Unclear	
	Airplane	0.398 (kg-CO_2/ton·km)	Unclear	

Sources:

11) Japan Statistical Yearbook (2005)

17) Ministry of Land, Infrastructure, Transport and Tourism – Handbook of transportation energy (2001-2002)

Table A 1-6: List of basic units (Others)

	Item	Reference value	Target range for calculation	Source
Transportation of goods	Gasoline car	15.5 (km/liter) Average of gasoline car	Consumption only	18
		0.193 (kg-CO_2/km)	Consumption only	19
	Diesel car	0.146 (kg-CO_2/km)	Consumption only	
	Gasoline hybrid	0.123 (kg-CO_2/km)	Consumption only	
	Diesel hybrid	0.089 (kg-CO_2/km)	Consumption only	
	Fuel cell vehicle	0.087 (kg-CO_2/km)	Consumption only	
	Compressed natural gas vehicle	0.148 (kg-CO_2/km)	Consumption only	
	Electric vehicle	0.049 (kg-CO_2/km)	Consumption only	
[Cases] Fuel mileage	Gasoline car	0.274 (kg-CO_2/km)	Unclear	20
	Diesel car	0.290 (kg-CO_2/km)	Unclear	

Sources:

18) Ministry of Land, Infrastructure, Transport and Tourism – List of fuel mileage (2008)

19) Japan Automobile Research Institute – Report on JHFC Comprehensive Efficiency Research Results (March 2006) (*This is not a regular research.)

20) CDM Project of Bogota Transmilenio PDD

The basic units shown in Tables A 1-1 to A 1-6 indicate (a) the amount of CO_2 emissions generated in both the production and consumption processes (“production and consumption”) and (b) that generated in the consumption process alone (“consumption only”). The former represents the sum of all loads (CO_2 emissions) generated from the production stage to the consumption stage. Meanwhile, the latter targets only the load in the consumption stage.

This document mainly lists numerical data in Japan. When estimating global values, global data must be used. Table A 1-7 below shows the CO_2 emissions coefficients of grid power in some countries as a reference.

In Japan, data on the CO_2 emissions coefficient of power companies is available, and is periodically published by the Ministry of the Environment (Table A 1-8). This indicates how much CO_2 is emitted through electricity generation for supply to the power grid. Basic units differ in each company because of their different ratios of power sources. In addition, the figures may have changed due to the change in ratios following the Great East Japan Earthquake in March 2011.

Considering these factors, an adequate value must be chosen as the basic unit of grid power.

Table A 1-7: CO_2 emissions coefficient of grid power by country

Unit: kg-CO_2/kWh

Country	CO_2 emissions coefficient of grid power	Country	CO_2 emissions coefficient of grid power
U.S.	0.679	Thailand	0.595
Germany	0.660	Philippines	0.566
U.K.	0.566	Vietnam	0.455
China	1.020	India	1.437
South Korea	0.535	Japan	0.425

Sources: Japan Electrical Manufacturers' Association (JEMA) – Investigative report on the CO_2 reduction activities by the power sector by country, version 3 (June 2006)

Note: The value published by Tokyo Electric Power in 2008 is used for the value of Japan.

Table A 1-8: CO_2 emissions coefficient by electric power company in Japan (2010)

Unit: kg-CO_2/kWh

Company	CO_2 emissions coefficient of grid power	Company	CO_2 emissions coefficient of grid power
Hokkaido Electric Power	0.359	Kansai Electric Power	0.311
Tohoku Electric Power	0.429	Shikoku Electric Power	0.326
Tokyo Electric Power	0.375	Kyushu Electric Power	0.385
Chubu Electric Power	0.473	Default value of the Ministry of the Environment	0.559

Sources: Ministry of the Environment – Publication of CO_2 emissions coefficient by electric power company (2010)

Appendix 2 Typical values used for calculating the effects of IT solutions

To determine the effects of IT solutions, data related to activities must be input as shown in Section 2.2.

Although it is preferable to use actual measurement values, they cannot be obtained in some cases, such as when the target is not decided yet or when it is not possible to obtain the data. In such cases, the values in the following table can be used for estimating the amount of activities.

Item	Reference value
Office space per person	13.1 m^2/person
Power consumption of notebook PC for home use (with a 14-inch or larger LCD)	18,734 kWh/year·piece, etc.
Power consumption of notebook PC for office use (with a 14-inch or larger LCD)	33,876 kWh/year·piece, etc.
Power consumption of desktop PC for home use (LCD included)	62,508 kWh/year·piece, etc.
Power consumption of desktop PC for office use (LCD included)	113,568 kWh/year·piece, etc.
Weight conversion coefficient of office paper	0.004 kg/piece (A4 size)
Power consumption of illumination (fluorescent lamp)	25.88 kWh (375 hours a year)
Power consumption of air-conditioners	56.25 kWh (375 hours a year)
Typical size of medical record paper	No. 2 cardboard medical record (270 mm long × 384 mm wide, 220 g/m^2) 2.5 piece/medical record (0.25 m^2/medical record)
Storage space for medical records	Cabinet area needed to accommodate 300 medical records: 0.288 m^2
Weight conversion coefficient of tender documents	0.004 kg/piece (A4 size)
Weight conversion coefficient of office paper	0.004 kg/piece (A4 size)

Appendix 3 Contribution potential of Green by IT

In 2009, the Survey and Estimation Committee of the Green IT Promotion Council estimated the potential of Green by IT to reduce CO_2 emissions ("contribution"). Table A 3-1 shows the contribution by solution, and Table A 3-2 shows the estimated contribution by sector[19].

The extent of contribution depends on the type of IT solution[20]. Due to limited space, the table shows only a part of the contribution through Green by IT. The estimated contribution by sector in 2020 is 70 – 149 million t-CO_2 in Japan and 2.04 – 4.01 billion t-CO_2 worldwide.

Table A 3-1: Potential of Green by IT to reduce CO_2 emissions (major solutions)

Unit: 10,000 t-CO_2/year

IT solution	Japan				Global			
	2005	2020	2025	2050	2005	2020	2025	2050
BEMS	57	546	650	630	549	6524	8,631	20,218
Paperless office	1	14	17	14	10	179	224	340
TV conferencing	140	250	270	220	1,357	4928	5,913	8,970
SCM (Joint delivery)	34	178	222	410	188	1060	1,400	3,555
HEMS	–	157	189	164	–	719	935	1,798
ITS (digital tachograph)	200	730	842	821	1,102	7510	9,491	17,989
Teleworking	19	92	110	142	71	645	924	3,110
Electronic medical records	22	27	28	28	124	392	457	556

* The basic data for this estimation are from actual cases. Thus basic units used are not those in respective years but those currently available.

[19] FY2009 report of the Survey and Estimation Committee of the Green IT Promotion Council

[20] Based on the result and estimation for 2005, 2025 and 2050. For details, see FY2009 report of the Survey and Estimation Committee of the Green IT Promotion Council

Table A 3-2: Estimated contribution through Green by IT (by sector)

Estimated contribution through Green by IT Unit: million t-CO_2/year

Sector	Major solution	GIT introduction effect in 2020 (Japan)	GIT introduction effect in 2020 (global)
Industry	• High-performance boiler, energy-saving equipment • Energy management, energy-saving project, etc.	7 to 14	140 to 276
Business	• Building and energy management system (BEMS) • Teleworking, TV conferencing, paperless office	9 to 18 Including other sectors	122 to 239
Household	• Home and energy management system (HEMS) including digital home appliances • Online shopping, digital contents • Introducing renewable energy, smart grid	16 to 32 Including other sectors	200 to 393
Transport	• Improving fuel mileage of vehicles • ITS (ETC, VICS), Eco-drive • Improving efficiency of logistics (improving SCM, loading ratio, etc.)	36 to 73 Including other sectors	1578 to 3101
Total		68 to 137	2041 to 4009

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