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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

ITU-T L.1410 – Case studies

ITU-T L-series Recommendations – Supplement 2

Supplement 2 to ITU-T L-series Recommendations

ITU-T L.1410 – Case studies

Summary

Supplement 2 to ITU-T L-series Recommendations has been developed to provide examples to assess the life cycle environmental impact of ICT goods, networks and services (GNS) based on Recommendation ITU-T L.1410. This Supplement focuses on illustrating the results of reduced greenhouse gas (GHG) emissions that have been achieved through increased efficiency in ICT services. These results represent a small number of the many examples that are expected to supplement Recommendation ITU-T L.1410 in the future.

This Supplement is intended for implementers and organizations developing ICT services, and persons responsible for the deployment of sustainable ICT services, including office workers, policy makers and those in academia.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L Suppl. 2	2013-12-13	5	11.1002/1000/12140-en

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Supplement 2 to ITU-T L-series Recommendations

ITU-T L.1410 – Case studies

1 Scope

Information and communication technology (ICT) has a major role to play in addressing the world's environmental challenges. Indeed, [ITU-T L.1410] and [ITU-T L.1400] have been developed to identify ICT potential to enable significant efficiencies in lifestyle and all sectors of the economy through digital solutions. Such solutions can improve energy efficiency, storage management and business efficiency by reducing travel and transportation, e.g., through teleworking and video conferencing, and by substituting physical products with digital information, e.g., e-commerce.

This Supplement provides examples to assess the life cycle environmental impact of ICT goods, networks and services based on [ITU-T L.1410]. It focuses on illustrating the results of reduced greenhouse gas emissions that have been achieved through increased efficiency in ICT services. These cases represent a small number of the many examples that are expected to supplement [ITU-T L.1410] in the future. To overcome complexity, the case studies adopt a so-called 'hybrid approach' where both process sum and economic input-output are used for the assessment. [ITU-T L.1410] recommends that, as a rule, preference be given to the process sum approach, but acknowledges the use of a hybrid approach to overcome restrictions related to scale and complexity. This approach is explained in [ITU-T L.1410] (see clause 5.2.3.1.1 of [ITU-T L.1410]).

To implement environmental impact assessments based on [ITU-T L.1410] and to utilize the results of such assessments, implementers would need to refer to some best-case practices showing examples of efforts to reduce environmental impact and their related performance assessment.

This Supplement is intended for implementers and organizations developing ICT services, and persons responsible for the deployment of sustainable ICT services, including office workers, policy makers and those in academia.

2 References

[ITU-T L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*.

[ITU-T L.1410] Recommendation ITU-T L.1410 (2012), *Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services*.

[ISO 14040] ISO 14040:2006, *Environmental management – Life cycle assessment – Principles and framework*.

[ISO 14044] ISO 14044:2006, *Environmental management – Life cycle assessment – Requirements and guidelines*.

3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

CO_2 Carbon Dioxide

EoLT End-of-Life Treatment

FEPCO Federation of Electric Power Companies of Japan

GHG Greenhouse Gas

GNS Goods, Networks and Services

JEMAI Japan Environmental Management Association for Industry

ICT Information and Communication Technology

LCA Life Cycle Assessment

LCI Life Cycle Inventory

4 Conventions

None.

5 Framework of case studies

Table 5-1 describes the cases covered in this Supplement. Since these examples cover limited areas, additional examples are expected to reinforce this supplement in the future. Clauses referenced in Table 5-1 are from [ITU-T L.1410].

Table 5-1 – Mapping of case studies

Title of case study	Goal (see clauses 5.2.2.1 and 6.2.2)	Effect of ICT usage (see clauses 5.2.2.3.5 and 6.1.2)	Boundary (clauses 5.2.2.3 and 6.2.2.2)			Used inventory (see clauses 5.2.3 and 6.2.3)		Environmental impact category
			Life cycle stage covered (see clause 5.2.2.3.6)	Category covered (see clauses 5.2.2.3.2 and 6.2.2.3.2)	Assessment period (see clauses 5.2.2.1 and 6.2.2.1)	Primary data	Secondary data	
Office work efficiency	To show an assessment of reduction of greenhouse gas (GHG) emissions through office work efficiency.	Reduction in paper use and increase in work efficiency	All	All except for: – transport – travel	One year	Price of hardware Operating time Office space Weight of end-of-life hardware	CO_2 conversion factors Power consumption	Climate change (GHG)
Supply chain management system	To show an assessment of reduction of GHG emissions in supply chain management systems.	Efficient management system of inventory control and transport	All except for: – raw material acquisition, production and end-of-life treatment (EoLT) of transport	All except for: travel	One year	Transport weight Transport distance Weight of end-of-life hardware	CO_2 conversion factors	Climate change (GHG)

Table 5-1 – Mapping of case studies

Title of case study	Goal (see clauses 5.2.2.1 and 6.2.2)	Effect of ICT usage (see clauses 5.2.2.3.5 and 6.1.2)	Boundary (clauses 5.2.2.3 and 6.2.2.2)			Used inventory (see clauses 5.2.3 and 6.2.3)		Environmental impact category
			Life cycle stage covered (see clause 5.2.2.3.6)	Category covered (see clauses 5.2.2.3.2 and 6.2.2.3.2)	Assessment period (see clauses 5.2.2.1 and 6.2.2.1)	Primary data	Secondary data	
Waste disposal	To show an assessment of reduction of GHG emissions in waste disposal.	Visualization of weight of waste	All except for: – raw material acquisition, production and EoLT of transport – raw material acquisition, production and EoLT of storage of goods	All except for: – travel – work environment	One year	Weight of waste Price of hardware Weight of end-of-life hardware	CO_2 conversion factors	Climate change (GHG)
Building energy management system (BEMS)	To show an assessment of reduction of GHG emissions in building energy management systems.	Automatic power saving control and visualization of office equipment	All except for: – raw material acquisition, production and EoLT of the working environment; the unaltered processes before and after introduction of ICTs	All except for: – consumables and other support products – site infrastructure – transport – travel – storage of goods	One day	Value of electric power consumption Price of hardware Weight of end-of-life hardware	CO_2 conversion factors	Climate change (GHG)

Table 5-1 – Mapping of case studies

Title of case study	Goal (see clauses 5.2.2.1 and 6.2.2)	Effect of ICT usage (see clauses 5.2.2.3.5 and 6.1.2)	Boundary (clauses 5.2.2.3 and 6.2.2.2)			Used inventory (see clauses 5.2.3 and 6.2.3)		Environmental impact category
			Life cycle stage covered (see clause 5.2.2.3.6)	Category covered (see clauses 5.2.2.3.2 and 6.2.2.3.2)	Assessment period (see clauses 5.2.2.1 and 6.2.2.1)	Primary data	Secondary data	
Home energy management system	To show an assessment of reduction of GHG emissions through home energy management system.	Automatic power saving control and visualization of household appliances	All except for: – raw material acquisition, production and EoLT of site infrastructure; the unaltered processes before and after introduction of ICTs	All except for: – consumables and other support products – transport – travel – storage of goods – working environment	One week	Electricity consumptions Value of specification Price of hardware Weight of the end-of-life hardware	CO_2 conversion factors	Climate change (GHG)
NOTE – All clause references refer to [ITU-T L.1410].								

The following areas are covered by case studies:

- General requirements (see clauses 5.2.1 and 6.2.1 of [ITU-T L.1410])
- Goal and scope (see clauses 5.2.2 and 6.2.2 of [ITU-T L.1410])
- Life cycle inventory (see clauses 5.2.3 and 6.2.3 of [ITU-T L.1410])
- Assessment results and analysis (see clauses 5.3 and 6.3 of [ITU-T L.1410])
- Discussion (see clauses 5.4 and 6.4 of [ITU-T L.1410]).

Assessments were carried out on the basis of [ITU-T L.1410], [ISO 14040] and [ISO 14044].

6 Case study 1: Assessment of GHG emissions reduction through improved office work efficiency

6.1 Goal and scope

6.1.1 Goal of the study

The goal of this study was to provide an assessment of the reduction in greenhouse gas (GHG) emissions through work efficiency in the office.

For business entities to implement suitable environmental impact assessments based on [ITU-T L.1410] they would need to refer to best-case practices, used to reduce environmental impact, as well as relevant performance assessments. This case study is intended as an example of the calculation of reduction of GHG emissions on the basis of [ITU-T L.1410]. [ITU-T L.1410] requires the calculation of six GHGs, but only carbon dioxide (CO_2) emissions were calculated in this study, mainly because of the difficulty in acquiring adequate high-quality data.

6.1.2 ICT services

As shown in Table 6-1, this study focused on administrative tasks, financial and contracting tasks, general document management tasks, and business document circulation tasks (refer to Table 1) set at the Nakano Ward Office in Tokyo, Japan, which uses about 2,000 computer terminals operated by 2,281 employees.

The company's old client-server system was replaced by a new web-server system to increase work efficiency and to reduce the amount of paper used. Previously, with the client-server system, the entire book-keeping system was paper-based. This was labour intensive and required storage space for paper documents (i.e., hard copies). A web-server system was installed that made it possible for over 90 per cent of document circulation and approval to be done electronically, thus improving work efficiency. The new electronic archival system also made the retrieval of essential documents simpler and reduced storage space. Replacement of the server and assessment of the results of its installation were conducted from February to March 2012.

Table 6-1 – Subject of the study

Tasks	Example
Administrative	Time management of workers
Financial and contracting	Management of budgets, expenditures and account settlement
General document management	Electronic archival, locating of necessary documents
Business document circulation	Electronic submission and approval of documents

6.1.3 Functional unit

Annual service usage.

6.1.3.1 System boundaries

Table 6-2 shows the assessment range according to the ITU-T L.1410 checklist (see Table 1 of clause 5.2.2.3.2 of [ITU-T L.1410]).

Table 6-2 – Checklist

Category	Items	Raw material acquisition	Production	Use	End-of-life treatment
ICT hardware	Servers, PCs, multifunction printers, network appliances	√	√	√	√
ICT software	Software	√	√	√ See Note 1	√ See Note 1
Consumables and other supportive products	Papers	√	√	See Note 2	√
Site infrastructure	Facilities for client PC and servers	√	√	√	√
Transport (movement of goods)	See Note 3				
Travel (movement of people)	See Note 3				
Storage of goods	Paper	√	√	√	√
Working environment	Office building	√	√	√	√

NOTE 1 – This case study did not consider use and end-of-life treatment of software as it was assumed that this was included in the relevant hardware.

NOTE 2 – The use phase of paper was not counted since there was no emission.

NOTE 3 – The study did not take into account the environmental impact of transportation, as this was considered irrelevant on the basis of the interviews.

6.2 Life cycle inventory

Table 6-3 shows the assessment calculation method and data collected for the calculation of the CO_2 emissions per category, and data sources.

Table 6-3 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions from collected data	Collected data and sources
ICT hardware	<Raw material acquisition and production> Price of hardware (servers, PCs, monitors, network equipment) × emission factor of hardware in CO_2 Number of printers × Emission factor of the printer in CO_2 <Use> Power consumption printer in CO_2 PCs emission factor of electric power in CO_2. <End-of-life treatment> Total weight of the hardware × Emission factor of transportation, fracturing and landfill Number of printers × emission factor of the printer in CO_2	Prices of old and new hardware (source: survey) Emission factor of old hardware in CO_2 (source: Japanese Input-Output Table) (See Note 1) Number of printers (source: survey) Emission factor of the printer (source: EcoLeaf) (See Note 2) Operating time (source: survey) Power consumption (source: catalogue) Emission factor of electric power (source: The Federation of Electric Power Companies of Japan (FEPCO)) Total weight of the hardware (source: survey) Emission factor of transportation (source: Japanese Ministry of Land, Infrastructure, Transport and Tourism), fracturing and landfill (source: Japanese Society of Civil Engineers (an academic society))
ICT software	<Raw material acquisition and production> software prices × emission factors in CO_2	Price of old software (source: survey) Emission factor of old software (source: Japanese Input-Output Table) Price of new software (source: survey) Emission factor of new software (source: Japanese Input-Output Table) (See Note 3)
Consumables and other supportive products	On the basis of interviews, this case study registered the volume of paper consumed before and after the new system was installed. <Raw material acquisition and production> Weight of paper iEmission factor in CO_2 This case study assumed that all paper is incinerated and did not take into account paper recycling. <End-of-life treatment> Total weight of paper × hEmission factor of transportation, combustion and landfill in CO_2.	Weight of paper consumed before installation of new system (source: survey) Weight of paper consumed after installation of new system (source: survey) Emission factor of raw material acquisition and paper production (source: National Institute for Environmental Studies in Japan) Emission factor of transportation (source: FEPCO), combustion (source: Plastic Waste Management Institute and Nomura Research Institute) and landfill. (source: Japan Society of Civil Engineers (an academic society))

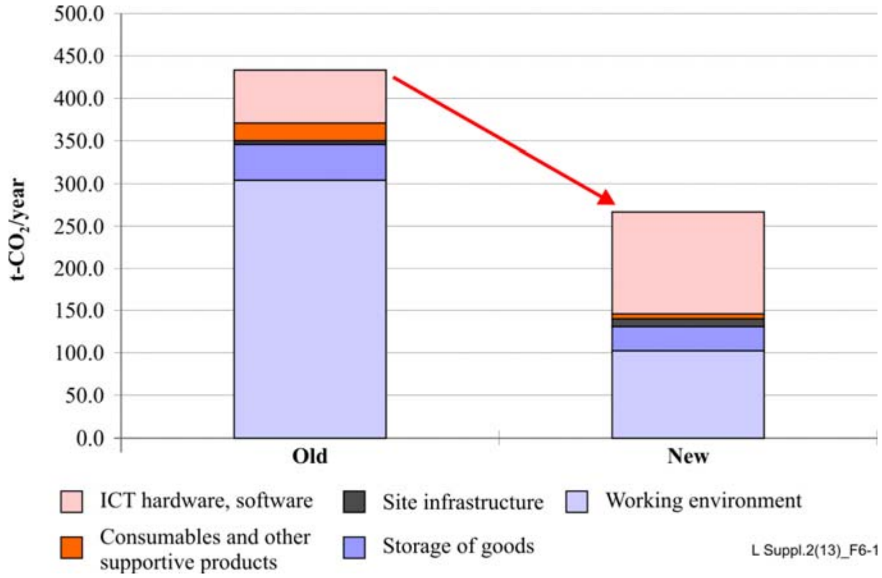
Table 6-3 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions from collected data	Collected data and sources
Site infrastructure	On the basis of interviews, this case study estimated the space used for hardware before and after the new system was installed. <from raw material acquisition to end-of-life treatment> Installation space of the client PCs × annual hours of use × emission factor in CO_2/m^2/year. Exclusive space for the servers × emission factor in CO_2 emission/m^2/year.	Installation space (m^2) of the client PCs (source: survey) Exclusive space (m^2) for the servers (source: survey) Emission factor of office space (m^2/year) (source: Architectural Institute of Japan)
Storage of goods	<from raw material acquisition to end-of-life treatment> Space for storage of papers in the warehouse × emission factor in CO_2/m2/year.	Space (m^2) for storage of papers in the warehouse (source: estimated from volume of paper) Emission factor of office space (m^2/year) (source: Architectural Institute of Japan) * Since warehouse storage exists within the same building in the Nakano Ward Office, this case study used the emission factor for office space
Working environment	This case study assumed that reduction of workload leads to reduction of office space resulting in the reduction of CO_2 emissions from cooling and heating systems and lighting, etc. <from raw material acquisition to end-of-life treatment> Workloads × office space per worker (m^2/man) × emission factor of office space in CO_2/m^2/year.	Workload before new system was installed (source: survey) Workload after new system was installed (source: survey) Office space per worker ((m^2/man) (source: Japan Building Owners and Managers Association) Emission factor of office space (m^2/year) (source: Architectural Institute of Japan).
NOTE 1 – It was difficult to collect process sum data of GHG emission for the old ICT hardware because it was manufactured before 2005 when data to assess environmental impact of the product were not yet available. Although such indices were available for the new system, for the purpose of comparison this case study used the emission factor from the Japanese Input-Output Table where data for both systems are available. NOTE 2 – As for multifunction printers, there were no available LCA data. Therefore, this case study used the data of "EcoLeaf" on RICHO's imagio MP7500RC which were available in the Japanese environmental label and 'EcoLeaf' and have similar function with the printer used in the Nakano Word office. NOTE 3 – It was difficult to collect data process sum data of GHG emission for the old software because it was produced before 2005 when data to assess environmental impact of the product was not yet available. Although such indices were available for the new system, for the purpose of comparison, this case study used the emission factors from the Japanese Input-Output Table where data for both systems are available.		

6.3 Assessment results and analysis

6.3.1 Results

The assessment results showed a 38 per cent reduction when the ICT-based systems is used instead of paper (i.e., 165 t-CO_2/year) at the Nakano Ward Office. From Figure 6-1, it can be seen that the different categories highly influence the volume of CO_2 emission, with the largest reduction in emission through the incorporation of the new system coming from the reduction in consumables (i.e., paper), at 77 per cent.



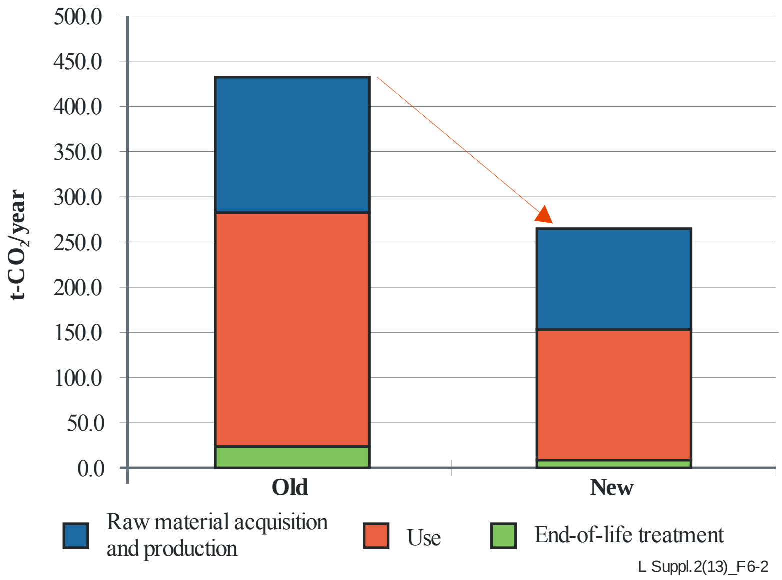
	ICT hardware, software	Consumables and other supportive products	Site infrastructure	Storage of goods	Working environment	Total t-CO_2/year
The old system	61.0	20.4	4.6	43.6	303.7	433.3
The new system	122.5	4.7	9.4	28.3	103.3	268.2
Rate of reduction	–100.8%	77.0%	–104.3%	35.1%	66.0%	38.1%

NOTE – This case study reports only total figures of ICT hardware and software because details of revenue and investment are confidential.

Figure 6-1 – Assessment results by category (unit: t-CO_2/year)

Looking at the results by life cycle phase in Figure 6-2, the reduction rate in the end-of-life phase was the largest at 63 per cent. This is assumed to be influenced by the reduction of paper use. The usage phase had the second-highest reduction and was the result of the decline in the use of electricity in the working environment for amenities such as air conditioning and lighting.

NOTE –Some emission factors include both raw material acquisition and production, and thus the reduction amount due to each life cycle stage is shown by raw material acquisition and production, usage, and end-of-life treatment.



	Raw material acquisition and Production	Use	End-of-life treatment	Total (t-CO_2/year)
The old system	147.6	257.7	28.1	433.4
The new system	110.4	147.4	10.3	268.1
Rate of reduction	25.2%	42.8%	63.3%	38.1%

Figure 6-2 – Assessment results by life cycle analysis (unit: t-CO_2/year)

6.3.2 Sensitivity analysis

Based on interviews with workers, this case study collected data on workload, volume of paper consumption and volume of stored documents. Among these data, workload differs depending on the work type, on the respondent's capability in task processing and even on the worker's subjective perception. Improvement in efficiency as workers become more familiar with system operations is another prevailing factor. Taking these issues into account, this case study compared the old and new systems in two scenarios to analyse the effect of reduction in workload on CO_2 emission reduction rates.

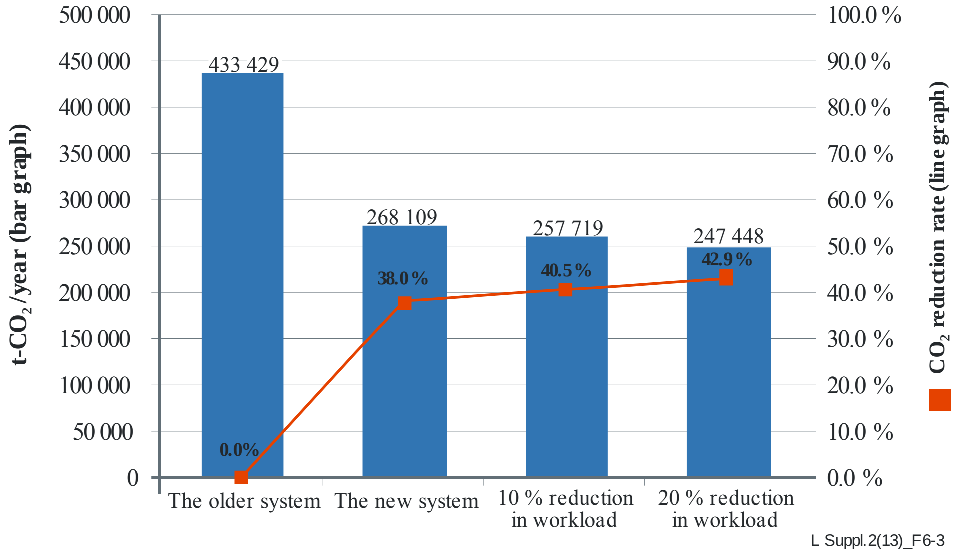


Figure 6-3 – Results of sensitivity analysis

Figure 6-3 shows the volume (blue bar graphs) and reduction rate (red line graph) of CO_2 emissions of the new system as compared with the old system. A ten per cent workload reduction case would reduce emissions by 41 per cent and a 20 per cent workload reduction case would reduce emission by 43 per cent. Based on this, it can been seen that a 10 per cent workload reduction contributes to only a two per cent reduction rate of CO_2 emission. These differences were considered to be insignificant. The results indicate that when changes in the volume of workload are subjectively reported through interviews, they are not a significant influencing factor.

The results may be sensitive to other parameters such as lifetime, but this was not tested.

6.3.3 Cut-off

No definite cut-off rule was taken into consideration and the possibility to avoid cut-offs is one of the advantages of the hybrid approach.

6.3.4 Potential

Table 6-4 shows the potential effect of CO_2 emission reductions in this case study.

Table 6-4 – Potential effect

Potential	Field test and results		
	(1) old system (kg-CO_2/year)	(2) new system (kg-CO_2/year)	Difference (1)-(2) (kg-CO_2/year)
Travel (movement of people)	–	–	–
Transport (movement of goods)	–	–	–
Site infrastructure	Space for client PC 1,183	Space for client PC 1,547	Space for client PC –363
Storage of goods	Paper storage at warehouse and offices 43,465	Paper storage at warehouse and offices 28,299	Paper storage at warehouse and offices 15,166
Working environment	Space for office 303,720	Space for office 103,306	Space for office 200,414

6.4 Critical review

This case study was reviewed internally, as well as by an external panel to ensure the objectivity of the assessment.

6.4.1 Discussion

The following features are noted in the assessment:

- This case study calculated CO_2 emissions based on [ITU-T L.1410] and took into account the life-cycle analysis of the raw material acquisition phase, production phase, use phase and end-of-life treatment phase. A hybrid approach was taken applied to overcome complexity.
- This case study showed a potential 38 per cent reduction when the ICT based systems is used instead of paper at Nakano Ward Office. Emissions under the old system measured 433 t-CO_2/year, whereas those of the new system measured 268 t-CO_2/year; this represents a reduction of 165 t-CO_2/year.
- Japan has approximately 1,700 municipal organizations. If this solution is tailored to 20 per cent of these offices, this could lead to a reduction of 56,134 t-CO_2/year. On the basis that the emission factor of a 4-ton size truck is 0.1502 kg-CO_2/tkm, according to the Japan

Environmental Management Association for Industry (JEMAI) life cycle assessment (LCA) database, this is equivalent to using 779 4-ton trucks/per annum assuming that the average travel distance is 600 km/day and work is performed 200 days per year.

- Proper use of any new system is essential for the realization of system benefits. Based on interviews, under the old IT system, paper materials were usually distributed during meetings (and even after the initial introduction of the new system). However, once people became aware of the usefulness of the new system, paperless meetings (using only computers) were established. Improvements in the skills required for using the new system led to increased work efficiency.
- Although there was a 38 per cent reduction in CO_2 emissions, an increase in emission from the ICT hardware was seen due to implementation of the new system. In the future, there is a possibility of a greater effect emerging through improvements in ICT hardware and increased utilization of more efficient operating ICT resources (e.g., cloud technology).

7 Case study 2: Supply chain management system

7.1 Goal and scope

7.1.1 Goal of the study

The goal of this study was to assess the reduction of CO_2 emissions through a field experiment on an environmental assessment in the supply chain management, with emphasis placed on storage management. The comparative evaluation is a case study intended for the public. [ITU-T L.1410] requires the calculation of six GHGs, but only CO_2 emissions were calculated in this study, mainly because of the difficulty in acquiring adequate high-quality data.

7.1.2 ICT services

The storage management system used prior to this study depended on the skill and experience of staff. Storage shortages occurred frequently at Fukuoka Logistics Centre, requiring additional direct shipments from Yokohama Support Centre by truck or air.

Before the ICT system was introduced, the situation was as follows:

Approximately 2,000 types of goods, with an approximate transport weight of 415 t/year, were transported within the regions of Kyushu, Chugoku and Shikoku; transport of storage to Fukuoka Logistics Centre supported storage management. After the new storage management software was implemented, it became possible to improve the storage management; different types of materials could be stocked at Fukuoka Logistics Centre and with fewer units for each type, and emergency transportation could be reduced by shortening the supply cycle for regular supply from Yokohama Support Centre. Figure 7-1a depicts the reference product system and Figure 7-1b depicts the ICT product system, respectively, for comparison purposes.

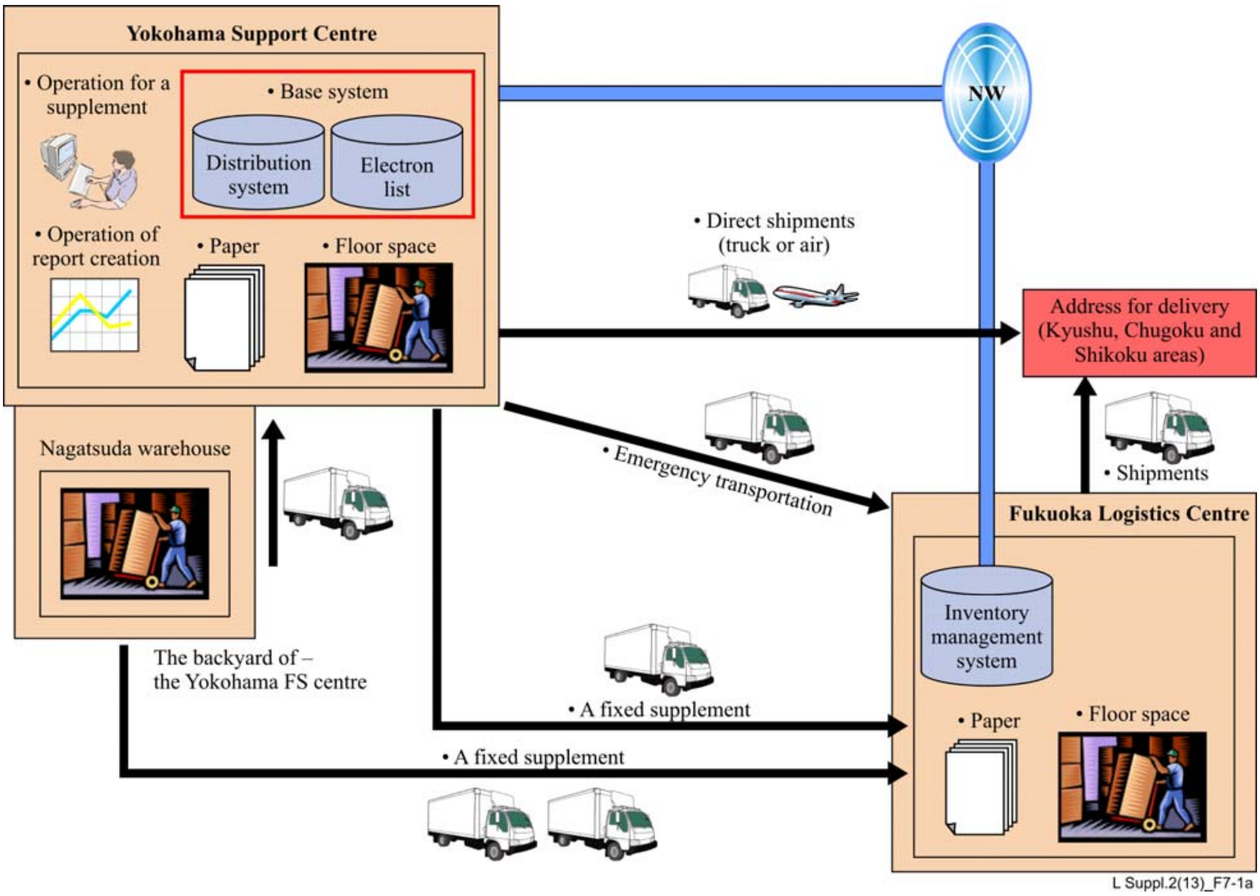


Figure 7-1a – Reference product system

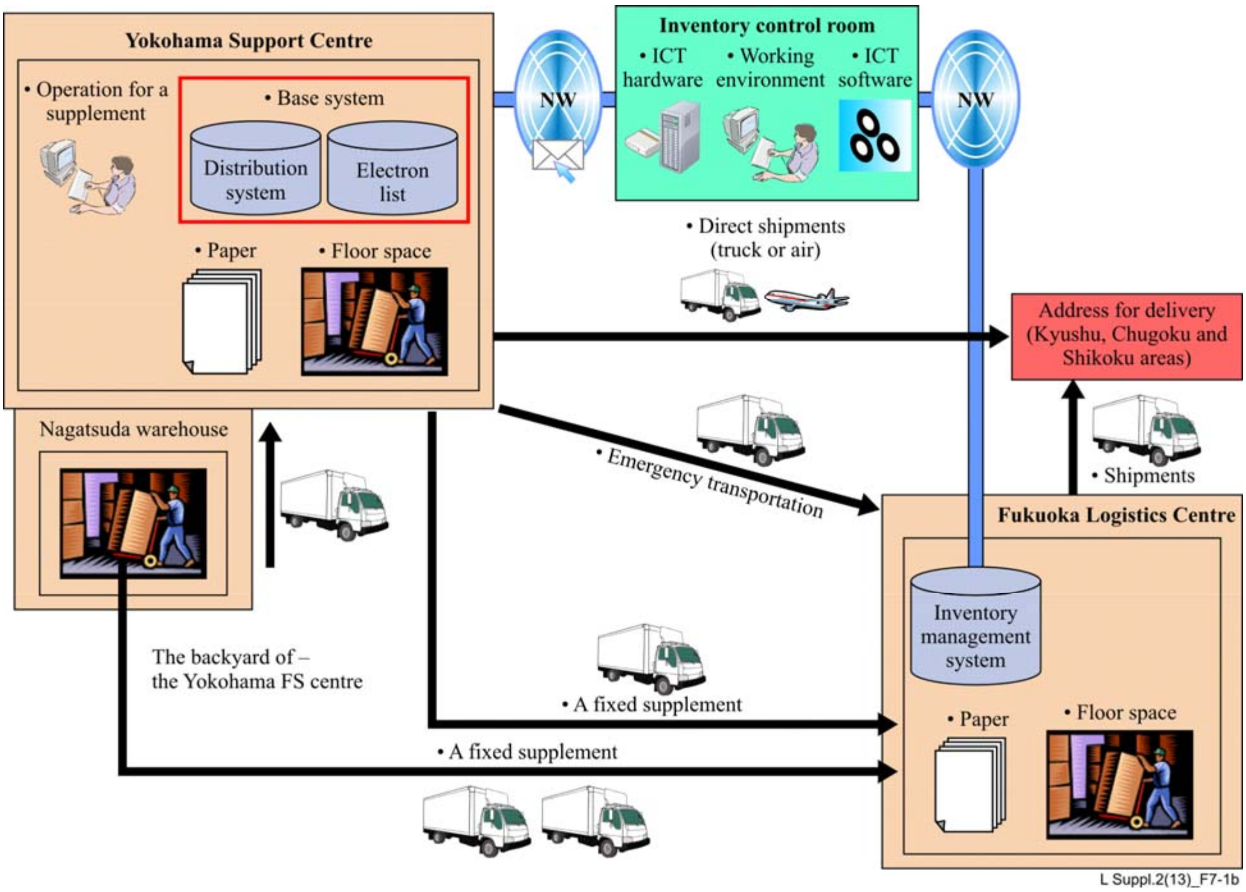


Figure 7-1b – ICT product system

7.1.3 Functional unit

Annual service usage.

7.1.3.1 General

This study evaluated CO_2 emissions generated from the processes of storage management and transportation in a supply chain management system.

The detailed system boundaries are shown below.

Reference product system:

- ICT hardware in the Yokohama Support Centre and the Fukuoka Logistics Centre.
- ICT software in the Yokohama Support Centre and the Fukuoka Logistics Centre.
- ICT network between the Yokohama Support Centre and the Fukuoka Logistics Centre.
- Paper which is used in the Yokohama Support Centre and the Fukuoka Logistics Centre.
- Transportation to the address for delivery, by truck or air, from the Yokohama Support Centre to the Fukuoka Logistics Centre, from the Nagatsuda Warehouse to the Fukuoka Logistics Centre, and from the Fukuoka Logistics Centre.
- Work in the Yokohama Support Centre.
- Floor space of the Yokohama Support Centre and the Fukuoka Logistics Centre.

ICT product system:

- ICT hardware in the Yokohama Support Centre, the Fukuoka Logistics Centre and the inventory control room.
- ICT software in the Yokohama Support Centre, the Fukuoka Logistics Centre and the inventory control room.
- ICT Network between the inventory control room, the Yokohama Support Centre and the Fukuoka Logistics Centre.
- Paper which is used in the Yokohama Support Centre.
- Transportation by truck or air from the Yokohama Support Centre to the Fukuoka Logistics Centre, from the Nagatsuda Warehouse to the Fukuoka Logistics Centre, from the Fukuoka Logistics Centre to the address for delivery, and from the Yokohama Support Centre to the address for delivery.
- The work in the Yokohama Support Centre and the inventory control room.
- Floor space of the Yokohama Support Centre and the Fukuoka Logistics Centre.

7.1.3.2 Eight items to consider and data list

Table 7-1 indicates the system boundaries before and after the ICT systems were introduced, based on eight items considered in the study.

Table 7-1 – Mapping of checklist items for life cycle stages in comparative assessment

Category	Raw material acquisition	Production	Use	End-of-life treatment
ICT hardware	√	√	√	√
ICT software	√	√	–	–
Consumables and other supportive products	√	√	–	√

Table 7-1 – Mapping of checklist items for life cycle stages in comparative assessment

Category	Raw material acquisition	Production	Use	End-of-life treatment
Site infrastructure	√	√	√	√
Transport (movement of goods)	–	–	√	–
Travel (movement of people)	–			
Storage of goods	√	√	√	√
Working environment	√	√	√	√

Table 7-2 depicts the primary data items acquired in this case study to perform the assessment.

Table 7-2 – Data list

Necessary information		Primary data acquisition items
Category	**Items**	
ICT hardware	Server, PC, etc.	Model number (price, weight, electricity used), number of computers, hours used, allocation
	Communication network devices	Volume of network information
	Inventory system	Volume of network information
ICT software	Storage management software	Development work volume, allocation
Consumables and other supportive products	Paper	Quantity used, size
Site infrastructure	Air conditioning for ICT hardware	Volume of network information
	Building	Floor space
Transport (movement of goods)	Truck, air cargo	Transport weight, transport distance, truck/car model
Travel (movement of people)	–	–
Storage of goods	Warehouse	Floor space, building structure
Working environment	Office building	Number of work steps

7.1.3.3 Lifetime

This study assumed that the goods, networks and services (GNS) were used during the statutory useful life in Japan, and were allocated a year's worth of CO_2 emissions.

7.1.3.4 Handling of software

This study calculated the CO_2 emissions of software introduced in the server.

7.1.3.5 System of ICT GNS product system

ICT goods

Table 7-3 indicates the variety of ICT goods introduced.

Table 7-3 – ICT goods

	ICT goods	Yokohama Support Centre	Fukuoka Logistics Centre	Sum total
Reference product system	Server (stand alone)	1	1	2
	Server (SaaS environment)	Because this study has been carried out on the basis of background data, the number of ICT goods.is not specified.		
	PC	37	6	43
	Printer	0	2	2
ICT product system	server	1	1	2
	PC	37	6	43
	Printer	0	2	2

ICT networks

This study calculated the CO_2 emissions of ICT networks using a value of CO_2 emissions per unit amount of data.

ICT services

The software for inventory control is installed in the server of the inventory control room.

7.1.3.6 Life cycle stages

The processes from raw material acquisition to production are calculated together.

7.1.4 Data quality requirements

The data of transportation weight or transportation regions are based on 2011 data.

7.2 Life cycle inventory

Table 7-4 describes the method of data collection and the CO_2 emissions calculation from the data that were used to perform the assessment of this case study.

Table 7-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
ICT hardware	• Server, PC, etc. <Raw material acquisition and production> Price of hardware (servers, PCs, monitors, network equipment) × emission factor of hardware in CO_2. <Use> Power consumption × operating time × emission factor of electric power in CO_2. <End-of-life treatment> Total weight of the hardware × emission factor in	Prices and operating time of the hardware (source: survey) Power consumption and total weight of the hardware (source: catalogue) Emission factor of hardware for raw material acquisition and production and end-of-life treatment in CO_2 (source:

Table 7-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
	CO_2. • Communication network devices <Raw material acquisition and production. Use and end-of-life treatment> Raw material acquisition and production. Use and end-of-life treatment of the communication network devices is included in air conditioning for ICT hardware at site infrastructure. • Inventory system <Raw material acquisition and production> Raw material acquisition and production of the inventory system is included in Use. <Use> Volume of network information × emission factor of data centre in CO_2. <End-of-life treatment> End-of-life treatment of the inventory system is included in Use.	Japanese Input-Output Table) Emissions factor of electric power in CO_2 (source: FEPCO) Volume of network information (source: survey) Emission factor of data centre in CO_2 (source: Society draft)
ICT software	<Raw material acquisition and production> Development work volume ×emission factor of software development in CO_2. <Use and end-of-life treatment> No emission.	Development work volume (source: survey) Emission factor of software development in CO_2 (source: Japanese Input-Output Table)
Consumables and other supportive products	<Raw material acquisition and production> Quantity used and size of paper ×emission factor of paper in CO_2. <Use> No emission. <End-of-life treatment> Quantity of paper used × emission factor of transportation, combustion and landfill in CO_2.	Quantity used and size (source: survey) Emission factor of paper in CO_2 (source: Japanese Input-Output Table) Emission factor of transportation (source: Ministry of Land, Infrastructure, Transport and Tourism), combustion (source: Plastic Waste Management Institute and Nomura Research Institute) and landfill (source: Japan Society of Civil Engineers (an academic society) in CO_2
Site infrastructure	• Air conditioning for ICT hardware <Raw material acquisition and production> Volume of network information × emission factor of communication network devices in CO_2. <Use> Volume of network information × emission factor of communication network devices in CO_2. <End-of-life treatment> Volume of network information × emission factor of communication network devices in CO_2. See Note	Volume of network information (source: survey) Emission factor of communication network in CO_2 (source: Society draft)

Table 7-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
	• Building (facilities for ICT hardware) <Raw material acquisition and production and end-of-life treatment> Floor space × emission factor of the building in CO_2. <Use> Power consumption of the warehouse × emission factor of electric power in CO_2.	Floor space of ICT hardware (source: assumption) Power consumption of the warehouse (source: survey) Emission factor of building for raw material acquisition and production in CO_2 (source: Architectural Institute of Japan) Emissions factor of electric power in CO_2 (source: FEPCO) Emission factor of end-of-life treatment in CO_2 (source: Architectural Institute of Japan)
Transport (movement of goods)	<Raw material acquisition and production> Outside the scope of this study. <Use> Volume of transport weight and transport distance × emission factor of the truck and air in CO_2. <End-of-life treatment> Outside the scope of this study.	Transport weight and transport distance (source: survey) Emission factor of the truck and air in CO_2 (source: IDEA*) * refer to clause 7.3.1.
Storage of goods	<Raw material acquisition and production and end-of-life treatment> Floor space × emission factor of the warehouse in CO_2. <Use> Power consumption of the warehouse × emission factor of electric power in CO_2.	Floor space and power consumption of warehouse (source: survey) Emission factor of the warehouse in CO_2 (source: Architectural Institute of Japan) Emissions factor of electric power in CO_2 (source: FEPCO)
Working environment	<Raw material acquisition and production and end-of-life treatment> Number of work steps × working area per office worker (m^2/person) × emission factor of the office building in CO_2 (kg-CO_2/m^2/year). <Use> Number of work steps × working area per office worker (m^2/person) × electric consumption per unit area of office building (kWh/m^2/year) × emission factor of electric power in CO_2.	Number of work steps (source: survey) The working area per office worker (source: Japan Building Owners and Managers Association) Emission factor of the office building in CO_2 (source: Architectural Institute of Japan) Electric consumption per unit area of office building (source: Architectural Institute of Japan) Emissions factor of electric power in CO_2 (source: FEPCO)
NOTE – In this case study, "Communication network devices" and "Air conditioning for ICT hardware" have been included in this category.		

7.2.1 Data collection

This study used background data from inventory database for environmental analysis (IDEA) for transportation by truck and air. (See NOTE.)

NOTE – Life cycle inventory (LCI) database installed in the LCA software multiple interface life cycle assessment (MiLCA) created by the Japan Environmental Management Association for Industry (JEMAI). (See [b-JEMAI].)

The National Institute for Environmental Studies (NIES) Japan Embodied Energy and Emission Intensity Data (3EID) was used to calculate manufacture and end-of-life treatment (EoLT) of ICT goods and ICT services.

The electricity consumptions of ICT goods installed in the data centre were calculated from the value of specifications. This study adopted the value of 0.413 kg-CO_2/kWh, fiscal year 2010, by The Federation of Electric Power Companies of Japan (FEPCO).

7.2.2 Data calculation

The data calculation was conducted based on the conditions required by [ISO 14040], [ISO 14044] and [ITU-T L.1410].

This study calculated CO_2 emissions from transportation using the equation below:

Transportation weight (t) x transportation distance (km) x environmental load per unit (t-CO_2/tkm)

NOTE – The goods to be transported differed in material, weight, and address of delivery. Therefore, this study prepared background data containing the loading ratio for every vehicle type.

7.2.3 Allocation procedure

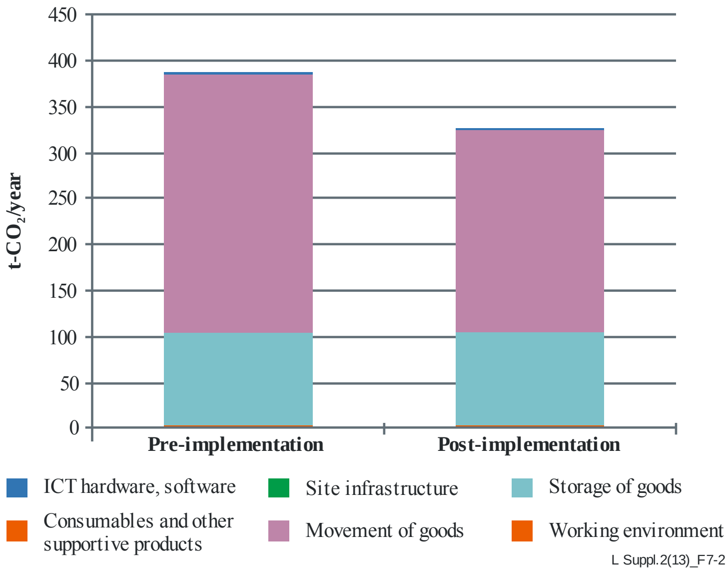
In this field experiment, ICT goods and services were shared with the other services. Therefore, CO_2 emissions were allocated to those services by the amount of management data ratio between them.

7.3 Results of the evaluation and discussion

7.3.1 Results

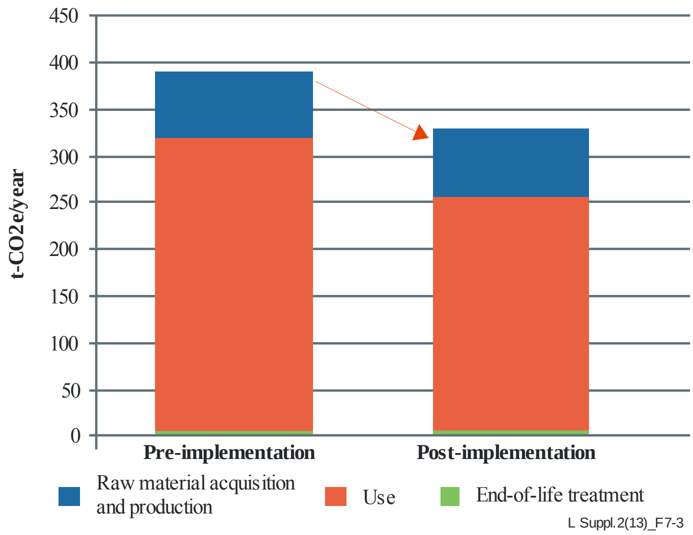
After the ICT system was implemented, the frequency of additional direct shipments, especially by air, diminished. This resulted in an emission reduction of 60 t-CO_2/year (15.4 per cent). Looking at results by category, the reduction was largest for the transportation of goods. The second largest reduction came from work-environment factors.

Looking at results in the life cycle column, the reduction was highest at 19.1 per cent in the use phase, as a result of an increase in efficiency of the transportation of goods. The EoLT phase showed that the effect of reduction in air conditioning and lighting usage was due to reduction in work steps within the working environment. As this study did not consider greenhouse gases other than CO_2, further studies are required in order to make reliable conclusions. Assessment results by category are shown in Figure 7-2. Assessment results by life cycle are shown in Figure 7-3.



	ICT hardware/ software	Consuma-bles and other supportive products	Site infrastruc-ture	Movement of goods	Storage of goods	Working environment	Total
Pre-implementation	2	0.2	0.4	280	102	4	388
Post-implementation	2	0.2	0.4	221	102	2	328
Rate of reduction	–2.6%	0.0%	0.0%	20.9%	0.0%	36.2%	15.4%

Figure 7-2 – Assessment results by category (unit: t-CO_2/year)



	Raw material acquisition and production	Use	End-of-life treatment	Total
Pre-implementation	72	311	5	388
Post-implementation	71	252	5	328
Rate of reduction	0.4%	19.1%	1.6%	15.4%

Figure 7-3 – Assessment results by life cycle analysis (unit: t-CO_2/year)

7.3.2 Sensitivity analysis

After the storage management system was implemented, interviews indicated that the weight of goods requiring additional direct shipments might be reduced in the future by 90 per cent, despite continuation of the air routes to remote, isolated islands. A sensitivity analysis for this scenario was performed, including the same transportation modes and categories used in the main assessment work. The results of this sensitivity analysis are shown in Figure 7-4.

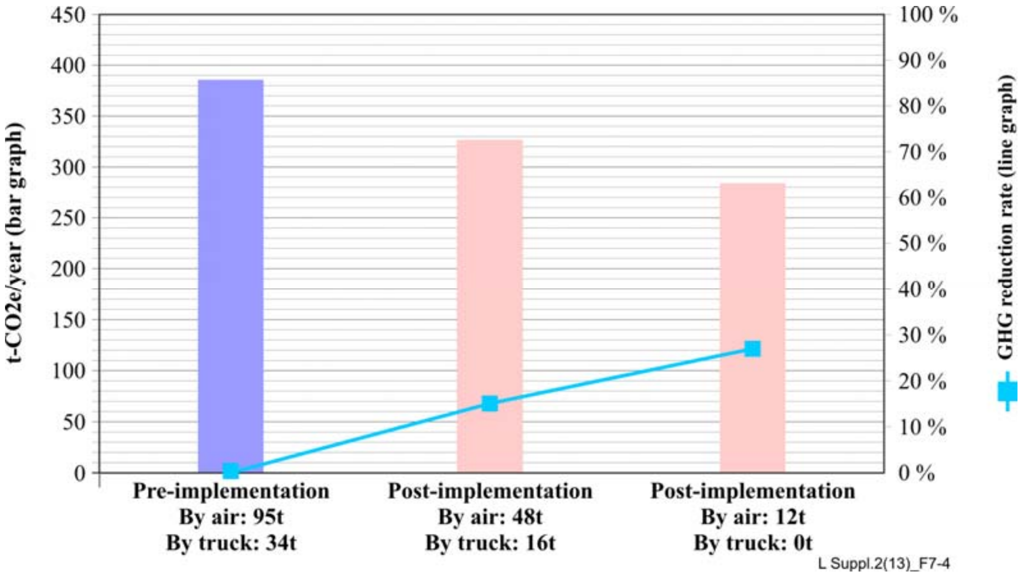


Figure 7-4 – Results of sensitivity analysis

The sensitivity analysis showed a 27 per cent reduction of total CO_2 emissions, (i.e., 103 t-CO_2/year), post-implementation. (See the right-most portion of Figure 7-4.) This showed that the weight of goods to be transported by air has the largest effect.

7.3.3 Cut-off

CO_2 emissions factors below one per cent were used as the cut-off in this case study.

Data for weight of the goods being transported by relay work, such as transport from the Nagatsuda Warehouse to the Yokohama Field Support Centre, included areas not covered in this study. For example, the data available for the route from the Nagatsuda Warehouse to the Yokohama Field Support Centre were for the entire route and were not broken down for the study area. It was estimated that CO_2 emissions for the entire route amounted to approximately 0.03 per cent of the total CO_2 emissions in this case study. Therefore, the weight of the transported goods was cut off because its influence was negligible.

7.3.4 Potential

Table 7-5 displays the potential effect of CO_2 emission reduction in this case study.

Table 7-5 – Potential

Potential	Field test and results		
	(1) Pre-implementation ($t\text{-}CO_2$/year)	**(2) Post-implementation ($t\text{-}CO_2$/year)**	**Difference (1)-(2) ($t\text{-}CO_2$/year)**
Travel (movement of people)	–	–	–
Transport (movement of goods)	Truck run (regular schedule): 25 Air transport:164	Truck run (regular schedule): 31 Air transport: 81	Truck run (regular schedule): –6 Air transport: 83
	Not assessed: acquisition of raw materials, production or end-of-life treatment		
Site infrastructure	Space for ICT hardware Facilities of NW : 0.4	Space for ICT hardware Facilities of NW : 0.4	Space for ICT hardware Facilities of NW : 0
Storage of goods	Warehouse: 102	Warehouse: 102	Warehouse: 0
Working environment	Office: 4	Office: 2	Office: 2

It is not possible to immediately reduce consolidated services such as regular delivery and public transportation or space requirements. This study takes into account this variable, which will not be reduced immediately, but is expected to diminish in the future as ICTs increase in popularity. As a consequence, there will be a reduction in space requirements and facilities such as structures, air conditioning, lighting, etc.

7.4 Life cycle interpretation

In this case study, the environmental impact of the transportation of goods was great. The data were collected in a period of transition, i.e., prior to system implementation to post system implementation. As a result of the sensitivity analysis, a larger reduction of CO_2 emissions is expected when the transition is completed.

7.5 Critical review

An internal critical review was conducted and a blue ribbon panel discussion group was created to ensure the objectivity of the assessment.

8 Case study 3: Waste disposal area

8.1 Goal and scope

8.1.1 Goal of the study

The aim of this study is to assess the reduction of CO_2 emissions by field experiment in the case of combustible waste collection and processing of household waste. This comparative evaluation is a case study intended to be open to the public. [ITU-T L.1410] requires the calculation of six GHGs, but only CO_2 emissions were calculated in this study, mainly because of the difficulty in acquiring adequate high-quality data.

8.1.2 ICT services

Combustible waste was collected from each household twice a week. Combustible waste was incinerated at the waste processing centre and the incinerated ash was placed in landfill. After installation of the visualization software, the volume of combustible waste was visualized and recorded in the Environmental Household Accounting Book; 13 households performed this task at their own home and 37 households at the Visualization House were set up for software use in the neighbourhood. Due to the education effect of this visualization software, the waste reduction action was promoted. As it was assumed that the combustible waste itself was organic and did not lead to any emissions when incinerated, a large part of the total CO_2 emissions was related to the garbage bags used; therefore, the percentage reduction of CO_2 will be covariant with the size of the garbage bags, i.e., the amount of plastics. Figure 8-1a depicts the reference product system and Figure 8-1b depicts the ICT product system, respectively, for comparison purposes.

Combustible waste to be incinerated in this assessment is defined as follows:

Combustible garbage:	Kitchen garbage and other combustible garbage.
Other combustible waste:	Clothes, paper, other (cat litter box sand, pet faeces, disposable chopsticks, shells, futon cushions, pain relief patches, etc.).

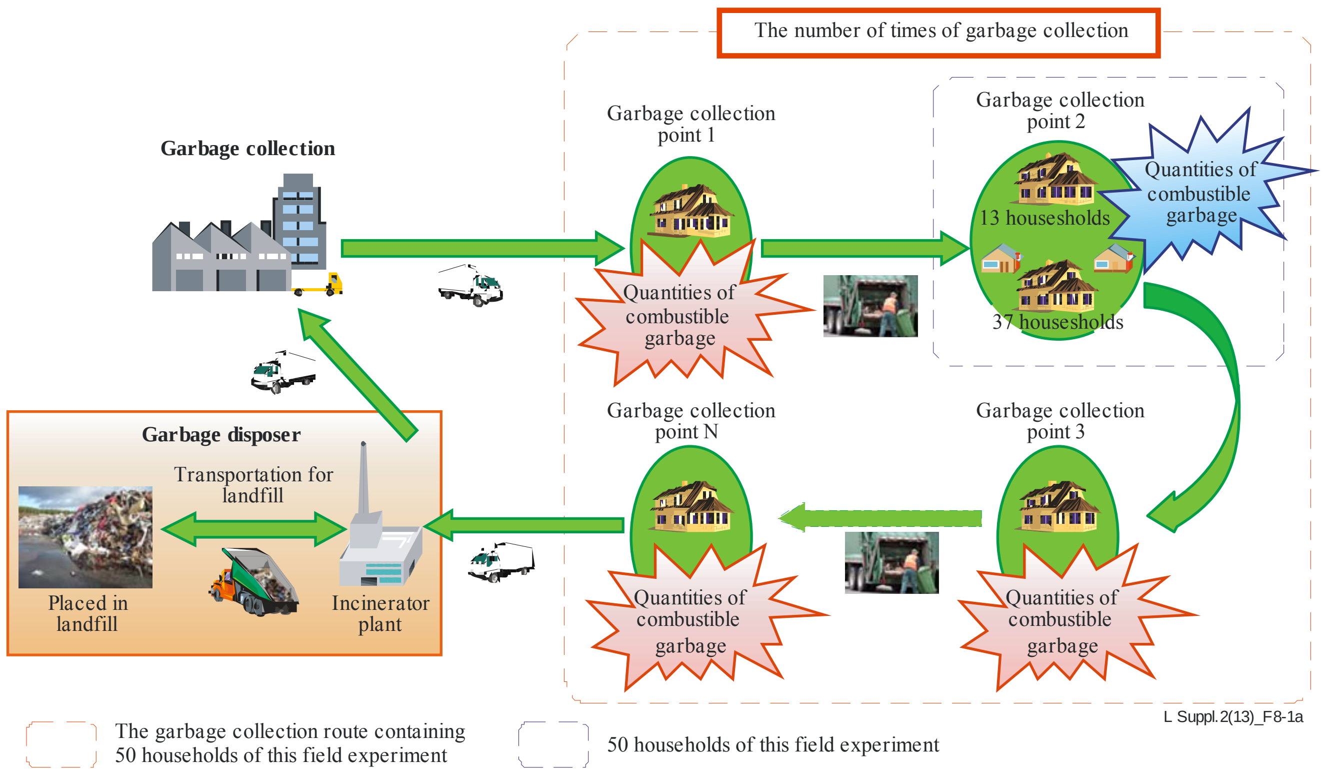


Figure 8-1a – Reference product system

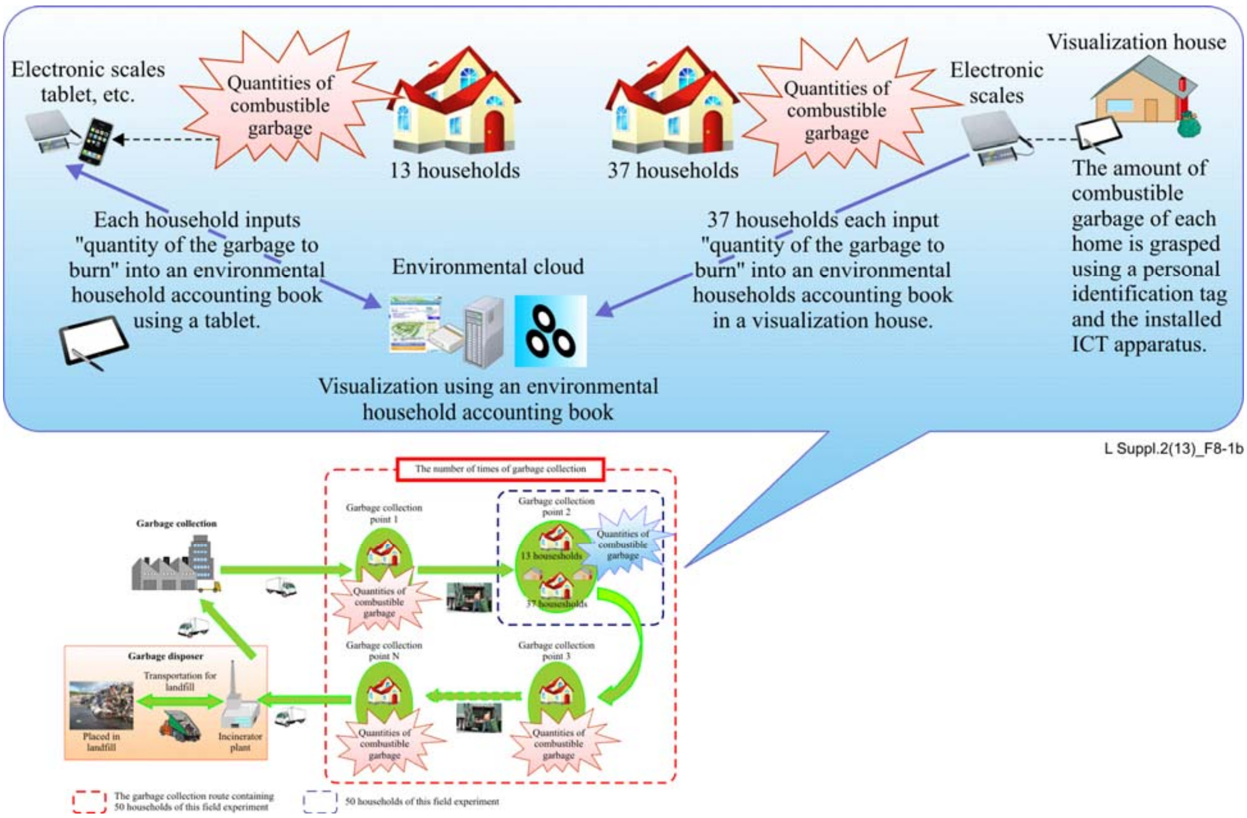


Figure 8-1b – ICT product system

8.1.3 Functional unit

Annual service usage.

For a service including combustible waste collection and processing of household waste produced in Obihiro City, during one year, by 50 households, with 148 residents.

8.1.4 System boundaries

8.1.4.1 General

In this case study, evaluations were made of CO_2 emissions from the processes of combustible waste collection and processing of the households.

The detailed system boundaries are shown below.

Reference product system

Regular collection (i.e., twice per week) of combustible waste from each household is carried out.

Combustible waste is incinerated and then the ash is landfilled.

ICT product system

The system which visualizes the amount of discharge of combustible waste is used.

Thirteen households record the quantity of combustible waste in their "Environmental Household Accounting Book".

Thirty-seven households record the quantity of combustible waste in the "Environmental Household Accounting Book" in a visualization house.

8.1.4.2 Eight items to consider and data list

Table 8-1 indicates the system boundary of before/after the ICT systems introduced based on eight items considered in the study.

Table 8-1 – Mapping of checklist items on life cycle stages in comparative assessment

Category	Raw material acquisition	Production	Use	End-of-life treatment
ICT hardware	√	√	√	√
ICT software	√	√	–	–
Consumables and other supportive products	√	√	–	√
Site infrastructure	√	√	√	√
Transport (movement of goods)	–	–	√	–
Travel (movement of people)	–			
Storage of goods	–	–	√	–
Working environment	–			

Table 8-2 depicts the primary data items acquired in this case study necessary to perform the assessment.

Table 8-2 – Data list

Necessary information		Primary data acquisition items
Category	Items	
ICT hardware	Server, PC, IC tags, etc.	Model number (price, weight, electricity consumed), number of devices, number of hours used, allocation
	Communications network devices	Volume of network information
ICT software	Environmental household accounting book software, etc.	Development work volume, allocation rates
Consumables and other supportive products	Garbage bag	Capacity, number of bags used
Site infrastructure	Electronic scales	Model number (price, weight, electricity consumed), quantity
	Air conditioner for ICT hardware	Volume of network information
Transport (movement of goods)	Truck	Transporting weight, transporting distance, truck vehicle class
Travel (movement of people)	–	–
Storage of goods	Incinerator	Energy used, weight of waste incinerated
	Landfill	Energy used, weight of ashes
Working environment	–	–

8.1.4.3 Lifetime

This study assumed that the GNS were used during the statutory useful life in Japan, and were allocated a year's worth of CO_2 emissions.

8.1.4.4 Handling of software

This study calculated the CO_2 emissions of software introduced in the server.

8.1.4.5 System of ICT GNS product system

ICT goods

Table 8-3 indicates the ICT goods introduced into the ICT product system.

Table 8-3 – ICT goods

ICT goods	Number of goods	Remarks
IC tag	37	1 per household
IC tag reader	2	1 per visualization house
Network device (home side)	13	1 per household
Tablet terminal (home side)	13	1 per household

Table 8-3 – ICT goods

ICT goods	Number of goods	Remarks
Network device (visualization house side)	2	1 per visualization house
Tablet terminal (visualization house side)	2	1 per visualization house

ICT networks

This study calculated the CO_2 emissions of ICT networks using a value of CO_2 emissions per unit amount of data.

ICT services

The software for the Environmental Household Eco-Accounting Book is installed in the server.

8.1.4.6 Life cycle stages

The processes, from raw material acquisition to production, are calculated together.

8.1.5 Data quality requirements

The amount of combustible waste which comes out of each household is based on data gathered in 2011.

8.2 Life cycle inventory

Table 8-4 describes the method of data collection and the calculations of CO_2 emissions from data used to perform the assessment in this case study.

Table 8-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
ICT hardware	• Server, PC, IC tags, etc. <Raw material acquisition and production> Prices of the hardware ×emission factor of hardware in CO_2. <Use> Power consumption ×the operating time of the hardware ×emission factor of electric power in CO_2. <End-of-life treatment> Total weight of the hardware × emission factor in CO_2. • Communication network devices <Raw material acquisition and production, use and end-of-life treatment>	Prices and operating time of the hardware (source: survey) Power consumption and total weight of the hardware (source: catalogue) Emissions factor of hardware for raw material acquisition and production and end-of-life treatment in CO_2 (source: Japanese Input-Output Table) Emissions factor of electric power in CO_2 (source: FEPCO) *This case study uses the emission factor of the total life cycle of tablet device in CO_2e because there is no such factor in CO_2.

Table 8-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
ICT software	<Raw material acquisition and production> Development work volume ×emission factor of software development in CO_2. <Use and end-of-life treatment> No emission.	Development work volume (source: survey) Emission factor of software development in CO_2 (source: Japanese Input-Output Table)
Consumables and other supportive products	<Raw material acquisition and production> Capacity and number of bags used × emission factor of garbage bag in CO_2e. <Use> No emission. <End-of-life treatment> Capacity and number of bags used × Emission factor of garbage bag in CO_2e.	Capacity and number of bags (source: survey) Emission factor of garbage bag in CO_2e (source: Japanese CFP Pilot Project) * This case study used the emission factor of garbage bag in CO_2e because there is no emission factor of garbage bag in CO_2.
Site infrastructure	• Electronic scales <Raw material acquisition and production > CPrices of the electronic scales × emission factor of electronic scales in CO_2. <Use> Power consumption of the electronic scales × emission factor of electric power in CO_2. <End-of-life treatment> Total weight of the electronic scales × emission factor of electronic scales in CO_2. • Air conditioning for ICT hardware <Raw material acquisition and production> Volume of network information × emission factor of communication network devices in CO_2. <Use> Volume of network information × emission factor of communication network devices in CO_2. <End-of-life treatment> Volume of network information ×emission factor of communication network devices in CO_2. (Note 1)	Emission factor of electronic scales in CO_2 (source: Japanese Input-Output Table) Volume of network information (source: survey) Emission factor of communication network in CO_2 (source: Society draft)

Table 8-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
Transport (Movement of goods)	<Raw material acquisition and production> Outside the scope of this study. <Use> Volume of transport weight and transport distance × Emission factor of the truck in CO_2. <End-of-life treatment> Outside the scope of this study.	Transport weight and transport distance (source: survey) Emission factor of the truck in CO_2 (source: IDEA*) * refer to clause 8.3.1
Storage of goods	• Incinerator <Raw material acquisition and production > Outside the scope of this study. <Use> Energy used and weight of waste incinerated × Emission factor of energy in CO_2. <End-of-life treatment> Outside the scope of this study. • Landfill <Raw material acquisition and production > Outside the scope of this study. <Use> Energy used and weight of ashes ×emission factor of energy in CO_2. <End-of-life treatment> Outside the scope of this study. (Note 2)	Energy used and weight of waste incinerated (source: survey) Emission factor of energy in CO_2 (source: Ministry of the Environment Government of Japan, FEPCO) Energy used and weight of ashes (source: survey) Emission factor of energy in CO_2 (source: Ministry of the Environment Government of Japan, FEPCO)
NOTE 1 – In this case study, the subjects "Communication network devices" and "Air conditioning for ICT hardware" were included in this category. NOTE 2 – The total life cycle of combustible waste from the viewpoint of carbon neutrality is out of the assessment boundary of this case study.		

8.2.1 Data collection

This study used background data from IDEA for transportation (i.e., waste collection) by truck. (See [b-JEMAI].) (See Note.)

NOTE – LCI database installed in MiLCA, created by JEMAI. (See [b-JEMAI].)

The National Institute for Environmental Studies Japan 3EID was used to calculate manufacture and EoLT of ICT goods and ICT services.

The electric energy of the visualization house was actually measured. This study has adopted the value of 0.413 kg- CO_2 /kWh, fiscal year 2010, by FEPCO.

8.2.2 Data calculation

The data calculation was conducted based on the conditions required by [ISO 14040], [ISO 14044] and [ITU-T L.1410].

This study calculated CO_2 emissions from the transportation of combustible waste on the basis of the following equation:

Collected weight of combustible waste (t) × transportation distance (km) × environmental burden per unit (t-CO_2/tkm)

8.2.3 Allocation procedure

This study allocated CO_2 emissions from the server to each user. Allocation was based on the number of users.

8.3 Results of the evaluation and discussion

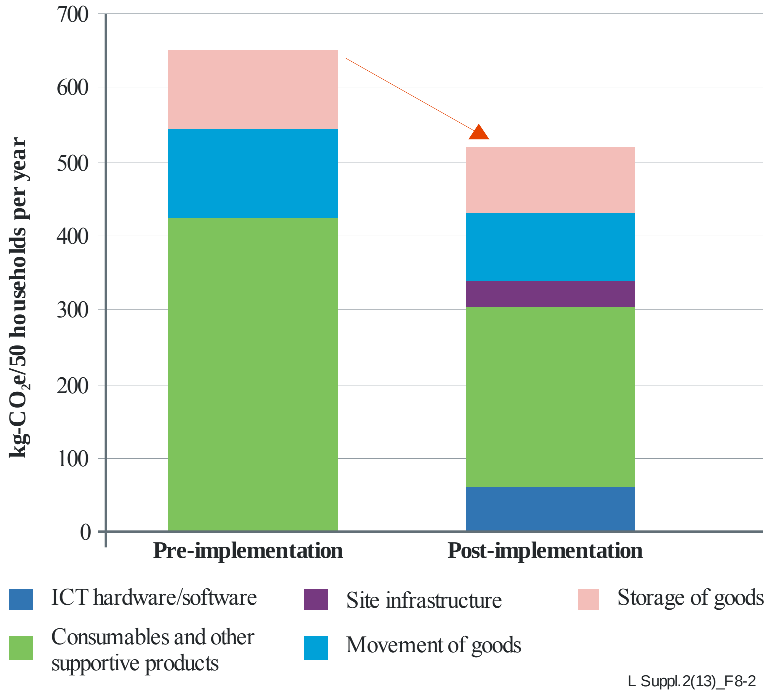
8.3.1 Results

After the new system was implemented, combustible waste volume was reduced. Consequently, CO_2 emissions were reduced by 128 kg-CO_2/year (i.e., 20 per cent).

Looking at the results by category, CO_2 emissions from ICT hardware and ICT software were increased by about 65 kg-CO_2/year. However, CO_2 emissions from consumables and other supportive products such as garbage bags were reduced by 182 kg-CO_2/year, CO_2 emissions from transport (movement of goods) were reduced by 23 kg-CO_2/year, and CO_2 emissions from the storage of goods at incineration processing and landfill were reduced by 21 kg-CO_2/year. Due to the high volume of CO_2 emissions from combustible waste incineration, the data on consumables and other supportive products such as garbage bags show a high level of CO_2 emissions.

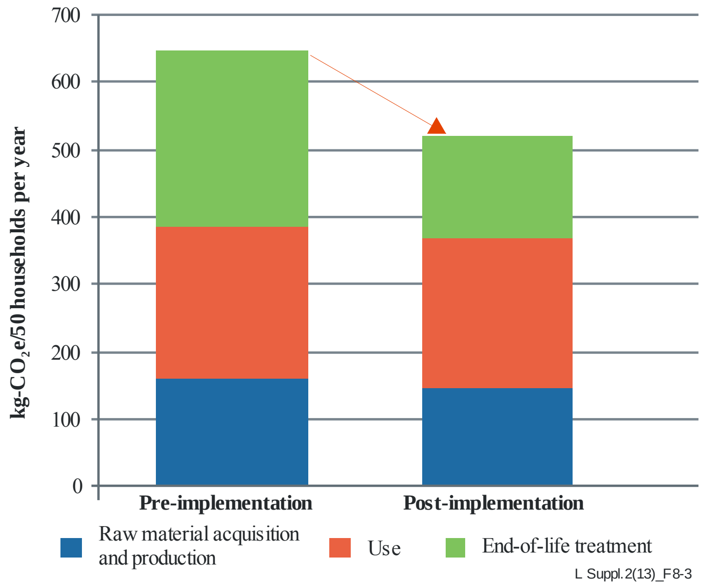
From the life cycle perspective, these results show the greatest rate of reduction at the EoLT phase: 43 per cent. This is the effect of reduced CO_2 emissions from garbage bag incineration.

As this study did not consider greenhouse gases other than CO_2, in particular CH_4 related to landfill, further studies are required to make reliable conclusions.



	ICT hardware/ software	Consuma-bles and other supportive products	Site infrastruc-ture	Movement of goods	Storage of goods	Total
Pre-implementation	0.00	422.80	0.00	117.91	108.07	648.78
Post-implementation	65.18	240.95	33.84	94.60	86.61	521.18
Rate of reduction	–100%	43%	–100%	20%	20%	20%

Figure 8-2 – Assessment results by category (unit: kg-CO_2/50 households per year)

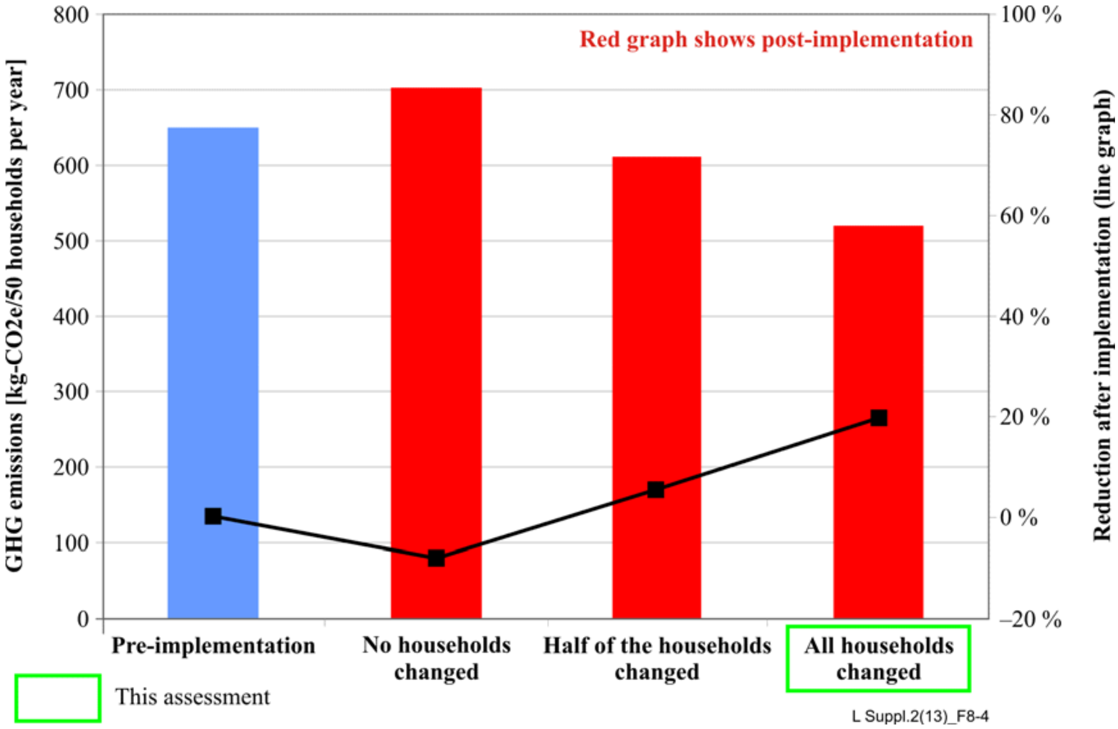


	Raw material acquisition and production	Use	End-of-life treatment	Total
Pre-implementation	160.66	225.98	262.13	648.78
Post-implementation	144.91	226.52	149.75	521.18
Rate of reduction	10%	0%	43%	20%

Figure 8-3 – Assessment results by life cycle analysis (unit: kg-CO_2/50 households/year)

8.3.2 Sensitivity analysis

Prior to the implementation of the waste production visualization system, all 50 households used 20-litre garbage bags. However, after the implementation, it was determined from the onsite interviews that all of these households had begun using 10-litre bags. The analysis reflects this finding. Two types of sensitivity analyses were performed regarding variations in the size of the garbage bags used.

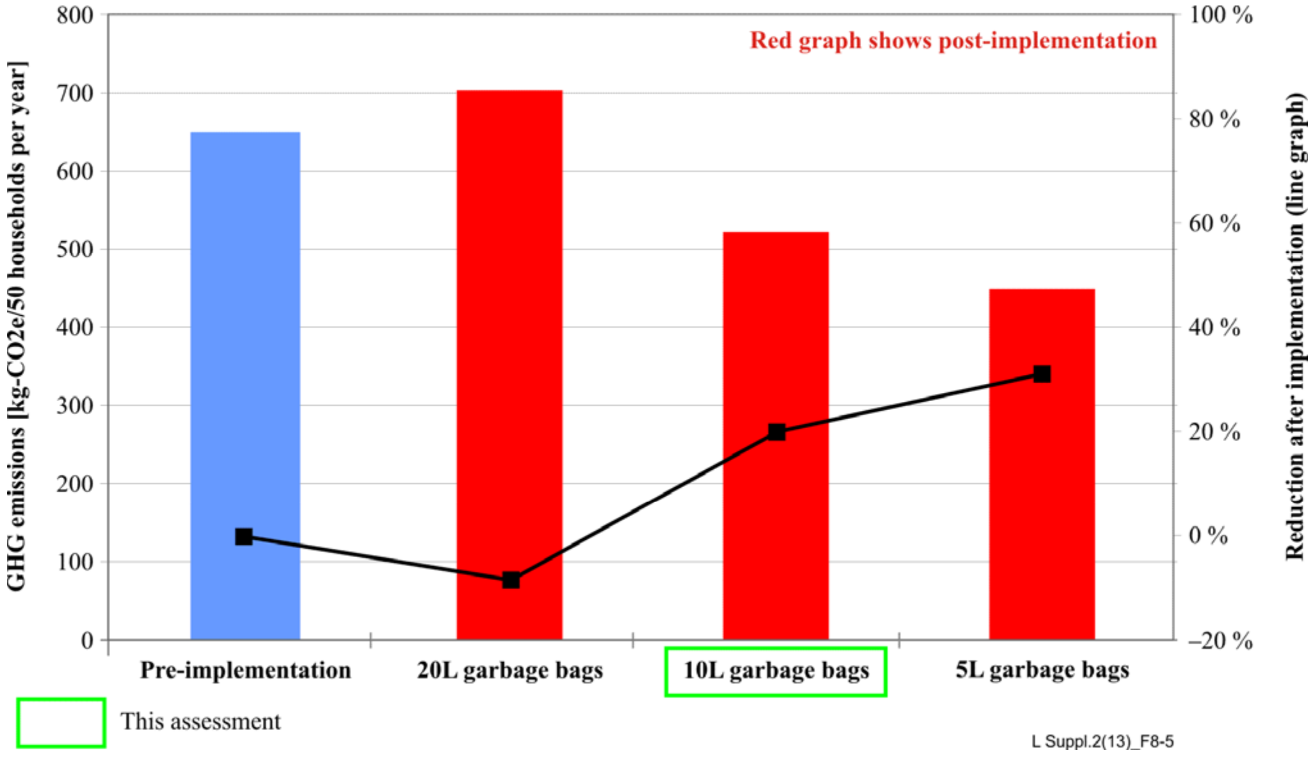


	CO_2 emissions [kg-CO_2/50 households per year]	Reduction after implementation
Pre-implementation	649	–
No households changed	703	–8%
Half of the households changed	612	6%
All households changed	521	20%

Figure 8-4 – Results of sensitivity analysis (a)

Figure 8-4 shows the results of the sensitivity analysis (a), the estimated CO_2 emissions for different percentages of households using 10-litre bags instead of 20-litre bags.

The volume of combustible waste was reduced after the visualization system was implemented. However, unless the use of 20-litre garbage bags was changed, CO_2 emissions for the 50 households would actually increase by approximately 54 kg-CO_2/year (eight per cent) due to the added ICT.



	CO_2 emissions [kg-CO_2/50 households per year]	Reduction after implementation
Pre-implementation	649	–
20L garbage bags	703	–8%
10L garbage bags	521	20%
5L garbage bags	448	31%

Figure 8-5 – Results of sensitivity analysis (b)

Figure 8-5 shows the results of the sensitivity analysis (b), the estimated CO_2 emissions for different sized garbage bags (50 households).

Through the use of the visualization system, it can be determined that, if all households were to change to 5-litre garbage bags from 20-litre bags, CO_2 emissions for the group of 50 households would be reduced by 30 per cent, or approximately 201 kg-CO_2/year.

Looking at the results from sensitivity analyses (a) and (b), even when the volume of the combustible waste is reduced by implementation of the visualization system, CO_2 emissions will increase unless smaller-sized garbage bags are used.

8.3.3 Cut-off

CO_2 emissions factors below one per cent were used as the cut-off in this case study.

CO_2 emissions from the batteries of electronic scales were less than one per cent of the total and therefore were cut off.

8.3.4 Potential

Potential effects of CO_2 emission reduction indicated by this analysis and the results are described in Table 8-5 below.

Table 8-5 – Potential

Potential	Field test and results		
	(1) Pre-implementation ($kg\text{-}CO_2$ year)	(2) Post-implementation ($kg\text{-}CO_2$/year)	Difference (1)-(2) ($kg\text{-}CO_2$/year)
Travel (movement of people)	–	–	–
Transport (movement of goods)	Combustible waste collection trucks, landfill transport trucks 118	Combustible waste collection trucks, landfill transport trucks 95	Combustible waste collection trucks, landfill transport trucks 23
	Not assessed: acquisition of raw materials, production or end-of-life treatment		
Site infrastructure	Space for ICT hardware 0	Space for ICT hardware 10	Space for ICT hardware –10
Storage of goods	–	–	–
Working environment	–	–	–

Consolidated services, such as regular delivery and public transportation, and space are not reduced immediately even if user demand decreases. This study considered these kinds of effects, which are not reduced immediately, but can be expected do diminish in the future when ICT will become popular, considered as potential reductions. Space includes structures, air-conditioner, lighting, etc.

8.4 Life cycle interpretation

It was found that, even when combustible waste volume was reduced, CO_2 emissions could potentially increase due to the increased load of ICT use. The results of the sensitivity analysis show that the actual size of garbage bags is an important factor in the overall reduction of household emissions. The sharing of such information, among all households, is therefore, an important action in favour of sustaining the environmental load reduction.

8.5 Critical review

An internal critical review was conducted and a blue ribbon panel discussion group was created to ensure the objectivity of the assessment.

9 Case study 4: Building an energy management system

This study describes the evaluation results of reduction of CO_2 emissions through introduction of automatic power saving systems into four buildings with six different divisions.

9.1 Goal and scope

9.1.1 Goal of the study

The aim of this study is to indicate an evaluation method of reduction of CO_2 emissions utilizing the automatic power-saving system that controls the devices in offices. The system includes power-saving elements such as lighting based on information about the office worker's presence/absence from Wi-Fi tags, etc.

This study also carried out field experiments to make a comparative evaluation using the indicated evaluation method. [ITU-T L.1410] requires the calculation of six GHGs, but only CO_2 emissions were calculated in this study mainly because of the difficulty in acquiring adequate high-quality data.

9.1.2 ICT services

These services are about the reduction of energy consumption by switching off lighting and PCs when not in use. The ICT functions introduced are as follows:

- Lighting (for common use): The system automatically turns off the ceiling lights when it has detected that all of the registered office workers are absent.
- PCs (for personal use): If the office workers who use PCs or monitors are absent, the system automatically enables sleep mode for PCs or turns off monitors, etc.

Figure 9-1 below shows the reference product system and the ICT system.

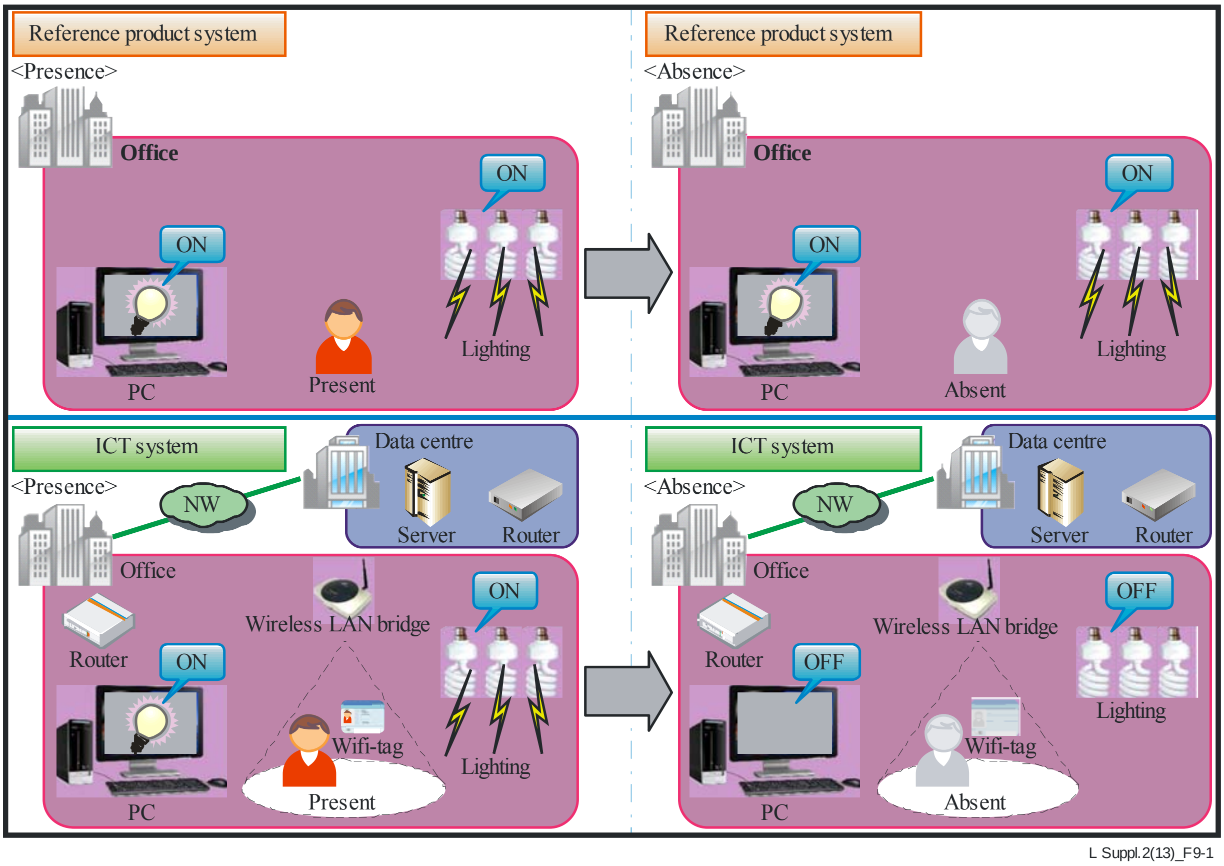


Figure 9-1 – The reference product system and the ICT system of automatic power saving control

9.1.3 Functional unit

Daily service usage.

9.1.4 System boundaries

9.1.4.1 General

Evaluated processes are those in which the amount of CO_2 emissions changes.

9.1.4.2 Eight categories to consider

The eight categories considered in this case study are shown in Tables 9-1 and 9-2 below.

Table 9-1 – Mapping of checklist items on life cycle stages before the ICT system introduced

Life cycle stage/ category	Raw material acquisition Production	Use	EoLT
ICT hardware	–	–	–
ICT software	–	–	–
Consumables and other supportive products	–	–	–
Site infrastructure	–	–	–
Transport (movement of goods)	–	–	–
Travel (movement of people)	–	–	–
Storage of goods	–	–	–
Working environment	–	√	–

Table 9-2 – Mapping of checklist items on life cycle stages after the ICT system introduced

Life cycle stage/ Category	Raw material acquisition Production	Use	EoLT
ICT hardware	√	√	√
ICT software	√	–	–
Consumables and other supportive products	–	–	–
Site infrastructure	√	√	√
Transport (movement of goods)	–	–	–
Travel (movement of people)	–	–	–
Storage of goods	–	–	–
Working environment	–	√	–

9.1.4.3 Lifetime

This study considered both the ICT hardware and ICT software as being available for the statutory useful life in Japan, and then allocated and calculated the amount of CO_2 emissions for one day.

9.1.4.4 Handling of software

This study calculated the CO_2 emission of software introduced in the server.

9.1.4.5 System of ICT GNS product system

ICT goods

The lists below indicate the major ICT devices that have been installed.

In the cloud

- server…1 (for sharing with other services, the emissions were allocated from the using ratio)
- router…1 (for sharing with other services, the emissions were allocated from the using ratio)

In the building – See Table 9-3.

Table 9-3 – ICT goods in the building

	Osaki	Yokohama	Minamioi	Kyushu
Router*	1	1	1	1
Switching hub (See Note)	1	2	2	1
Wireless LAN bridge*	3	3	2	2
Cell phone with Wi-Fi tag*	15	–	–	–
Wi-Fi tag	8	92	35	21
Motion sensor	3	0	4	0
Automatic control apparatus for lighting	64	85	22	29
Measuring machine	27	94	29	16
NOTE – The ICT goods are sharing with other services, so the emissions were allocated from the using ratio.				

ICT networks

All items, i.e., customer premises, access network equipment and core network, were calculated as ICT networks except for the terminal equipment on customer premises.

ICT services

The automatic power-saving control requires lighting shut-off when related workers are absent or inactive for more than 10 minutes. The number of related workers varies, and is dependent on the case. It also involves a PC shut-off when a related worker is absent for more than 10 minutes. The number of related workers is fixed at one person.

9.1.4.6 Life cycle stages

In this case study, the life cycle stage of "raw materials acquisition" to "production" is regarded as the life cycle stage of "manufacture" for the reason that CO_2 emissions are assessed by the law of inter-industrial relationship. Therefore, the life cycle stages are "Manufacturing", "Use" and "EoLT".

9.2 Life cycle inventory

Table 9-4 depicts how data were collected and used to calculate the CO_2 emissions in order to perform the assessment in this case study.

Table 9-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
ICT hardware	<Raw material acquisition and production> Prices of the hardware × Emission factor of hardware in CO_2. <Use> Power consumption and the operating time of the hardware × emission factor of electric	Prices and operating time of the hardware (source: survey) Power consumption and total weight of the hardware (source: catalogue) Emission factor of hardware for

Table 9-4 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
	power in CO_2. <End-of-life treatment> Total weight of the hardware × emission factor of hardware in CO_2.	raw material acquisition and production and end-of-life treatment in CO_2 (source: Japanese Input-Output Table) Emission factor of electric power in CO_2 (source: FEPCO)
ICT software	<Raw material acquisition and production> Price of the software × emission factor of software development in CO_2. <Use and End-of-life treatment> No emission.	Price of ICT software (source: survey) Emission factor of software development in CO_2 (source: Japanese Input-Output Table)
Consumables and other supportive products	Outside the scope of this study.	
Site infrastructure	<Raw material acquisition and production> Volume of network information × emission factor of communication network devices in CO_2. <Use> Volume of network information × emission factor of communication network devices in CO_2. <End-of-life treatment> Volume of network information × Emission factor of communication network devices in CO_2. * In this case study, appropriated "ICT networks" were appropriated into this category.	Volume of network information (source: survey) Emission factor of communication network devices in CO_2 (source: Society draft)
Transport (movement of goods)	Outside the scope of this study.	
Storage of goods	Outside the scope of this study.	
Working environment	<Raw material acquisition and production> Outside the scope of this study. <Use> Power consumption of the hardware ×emission factor of electric power in CO_2. <End-of-life treatment> Outside the scope of this study.	Power consumption of the hardware (source: survey) Emissions conversion factor of electric power in CO_2 (source: FEPCO)

9.2.1 Data collection

In this study, the actual measured value of electric power consumption, or the data stated in the specifications, was used to calculate the CO_2 emissions for the "Use" stage.

Data from the National Institute for Environmental Studies Japan 3EID were used to calculate the CO_2 emissions for the "Manufacturing" and "EoLT" stages.

Each amount of CO_2 emissions for "Manufacturing", "Use" and "EoLT" of ICT networks was quoted from [b- Mitsuhiro].

This study adopted the value of 0.413 kg-CO_2/kWh, fiscal year 2010, by FEPCO to calculate the CO_2 emissions for the "Use" stage.

9.2.2 Data calculation

The data calculation was conducted on the basis of [ISO 14040], [ISO 14044] and [ITU-T L.1410].

9.2.3 Allocation procedure

Because the servers and routers used in the cloud provided other field locations besides the field-experiment areas with the building energy management system (BEMS) functioning, this study allocated CO_2 emissions from them by the numbers of control/measure points and the amount of information, respectively.

9.3 Results of the evaluation

The results of the evaluation for each location in this case study are indicated in Table 9-5 below.

Table 9-5 – The results in the four buildings of LCA per functional unit

			Before	After		The effectiveness of CO_2 emissions	
			Use [kg-CO_2/day]	Use [kg-CO_2/day] (Note 1)	manufacture・EoLT [kg-CO_2/day] (Note 2)	Amount of reductions [kg-CO_2/day]	Reduction -rate [%]
Osaki	Lighting	Development	19.66	16.84	0.56	2.27	11.52
	Sockets	Development	4.41	4.07	0.28	0.06	1.44
	Total		24.08	20.91	0.84	2.33	9.67
Yokohama	Lighting equipment	Sales	6.59	6.72	0.20	–0.33	–5.01
		General affairs	25.55	25.73	0.48	–0.65	–2.54
		Sub total	32.14	32.45	0.67	–0.98	–3.05
	Sockets	Sales	2.21	1.80	0.28	0.13	5.67
		General affairs	12.01	11.40	0.68	–0.08	–0.63
		Sub total	14.22	13.20	0.97	0.05	0.35
	Total		46.37	45.65	1.64	–0.93	–2.00
Minamioi	Lighting	Electric design and construction	34.00	32.73	0.92	0.35	1.02
	sockets	Electric design and construction	5.24	4.26	0.57	0.41	7.80
	Total		39.25	36.99	1.50	0.76	1.93
Kyushu	Lighting	Sales	7.53	7.00	0.09	0.44	5.89
		Development	8.36	7.17	0.14	1.05	12.51
	Total		15.89	14.17	0.23	1.49	9.38

NOTE 1 – The amount of CO_2 emissions includes the introduced ICT system at the stage of Use.
NOTE 2 – The amount of CO_2 emissions for installing ICT systems at the stage of Manufacturing and EoLT.

As this study did not consider greenhouse gases other than CO_2, further studies are required to make reliable conclusions.

9.4 Life cycle interpretation

Based on the information from the Wi-Fi tag of each office worker, the automatic power-saving system detects human presence or absence in the working zone and controls the equipment in the following ways:

– Lighting (for common use):

  It automatically turns off the ceiling lights when it detects that all of the registered office workers are absent.

– PCs (for personal use):

  If the office workers who use PCs or monitors are absent, the system automatically turns on sleep mode (for PCs) or it turns off (for monitors, etc.).

Thus, the reduction of CO_2 emission for the lighting equipment differs depending on the number of office workers registered for the equipment.

As shown in Table 9-6, the reduction in CO_2 emissions, by the automatic power-saving control for lighting, was more effective when the number of office workers related to each lighting-equipment N was small.

Table 9-6 – The difference of expected reduction of CO_2 emission by numbers of office workers related to each lighting equipment

	Numbers of office workers related to each lighting-equipment N (person/location)	
	Small (3 to 5 persons)	**Large (8 to 15 persons)**
Reduction of CO_2 emissions	more than 10%	= 0%

No sensitivity analysis was performed.

9.5 Critical review

The results were reviewed three times by a group of experts consisting of university academics, ICT vendors and a carrier.

10 Case study 5: Home energy management system

The field experiment results in three households, each demonstrating a reduction of CO_2 emissions through simultaneous introduction of automatic power-saving control and visualization, are shown below.

10.1 Goal and scope

10.1.1 Goal of the study

The aim of the study is, on the basis of field experiments, to assess reduction of CO_2 emissions following simultaneous introduction in residencies of automatic power-saving control and visualization. This comparative evaluation is a case study intended for the general public. [ITU-T L.1410] requires the calculation of six GHGs, but only CO_2 emissions were calculated in this study, mainly because of the difficulty in acquiring adequate high-quality data.

10.1.2 ICT services

Automatic power-saving control, which performs automatic shut-off through absence detection by a motion sensor, was applied to an air conditioner and a TV in a residence. Visualization informed residents about electricity consumption.

The ICT goods in a residence and a server in the data centre were connected via networks. The server accumulated the electricity consumption and the history of automatic power-saving control, and then disclosed the information to residents.

Figure 10-1 shows the reference product system and the ICT system automatic power-saving control. Figure 10-2 shows the reference product system and the ICT system of visualization.

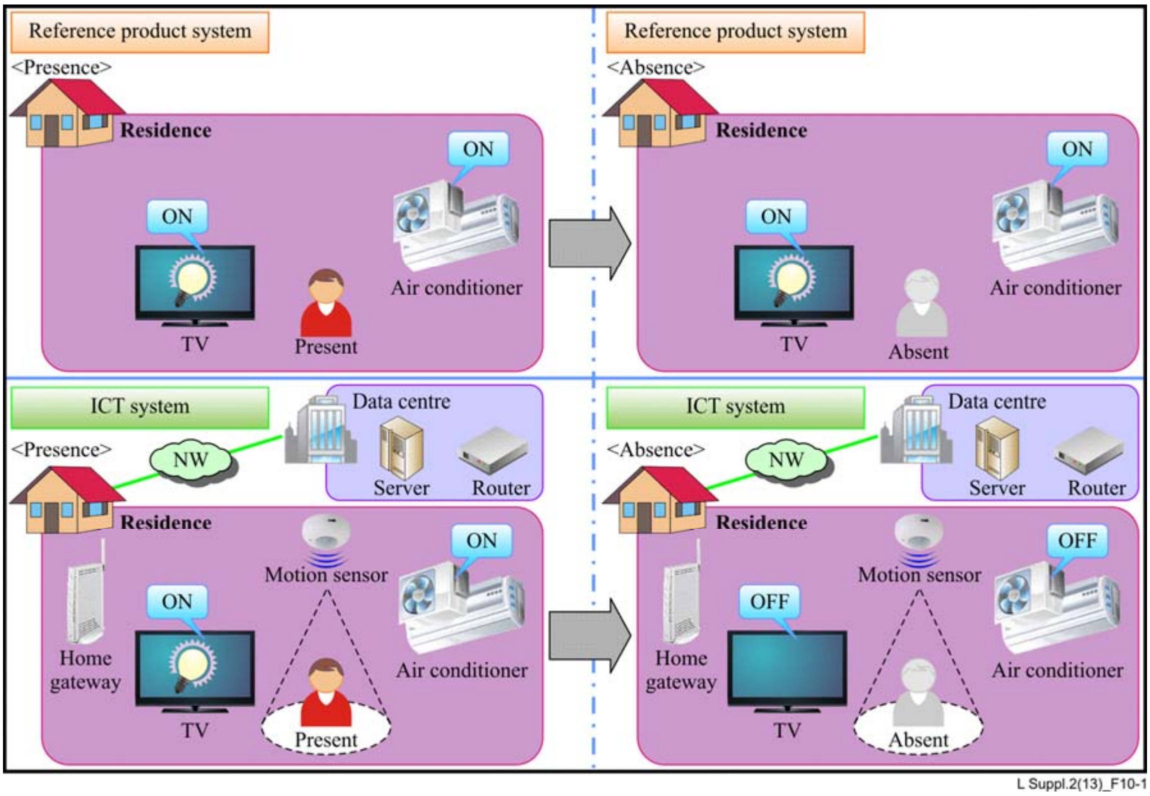


Figure 10-1 – The reference product system and the ICT system of automatic power saving control

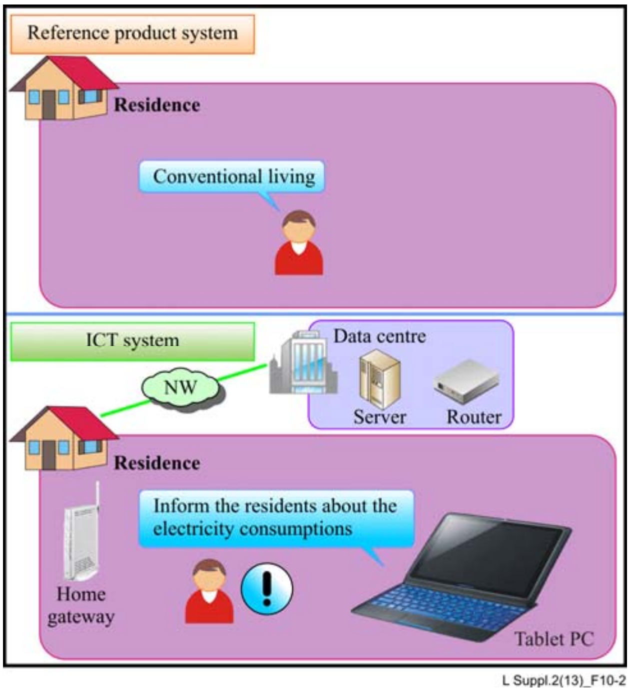


Figure 10-2 – The reference product system and the ICT system of visualization

10.1.3 Functional unit

Weekly service usage.

10.1.4 System boundaries

10.1.4.1 General

The field experiment was performed during the winter when an air conditioner is used as a heater. It is, consequently, outside the system boundary of the case study that was defined for an air conditioner. Furthermore, the scope of the evaluation only considered processes which observed differences before and after introduction of the ICT systems.

10.1.4.2 Eight items to consider

Tables 10-1 and 10-2 indicate the system boundary before and after introduction of the ICT systems, based on eight items considered in the study.

Table 10-1 – Mapping of checklist items on life cycle stages before introduction of the ICT system

Life cycle stage/ category	Raw material acquisition Production	Use	EoLT
ICT hardware	–	–	–
ICT software	–	–	–
Consumables and other supportive products	–	–	–
Site infrastructure	–	√	–
Transport (movement of goods)	–	–	–
Travel (movement of	–	–	–

Table 10-1 – Mapping of checklist items on life cycle stages before introduction of the ICT system

Life cycle stage/ category	Raw material acquisition Production	Use	EoLT
people)			
Storage of goods	–	–	–
Working environment	–	–	–

Table 10-2 – Mapping of checklist items on life cycle stages after the ICT system introduced

Life cycle stage/ category	Raw material acquisition Production	Use	EoLT
ICT hardware	√	√	√
ICT software	√	–	–
Consumables and other supportive products	–	–	–
Site infrastructure	√	√	√
Transport (movement of goods)	–	–	–
Travel (movement of people)	–	–	–
Storage of goods	–	–	–
Working environment	–	–	–

10.1.4.3 Lifetime

This study considered that the ICT goods and services were used during statutory useful life in Japan and were allocated a week's worth of CO_2 emissions, respectively.

10.1.4.4 Handling of software

This study calculated the CO_2 emissions of software introduced in the server.

10.1.4.5 System of ICT GNS product system

ICT goods

The list below indicates the ICT goods introduced.

- Server: 1 (for sharing with the other services)
- Storage: 1 (for sharing with the other services)
- Router: 1 (for sharing with the other services)
- Switch: 1 (for sharing with the other services)
- Home gateway: 1 per household
- Notebook PC: 1 per household
- Tablet PC: 1 per household (for sharing with the other the services)
- Motion sensor: 1 per household

- Remote controller: 1 per household
- Measuring machine: 14 per household.

ICT networks

All items within customer premises, access network equipment and the core network were calculated as ICT networks with the exception of the terminal equipment on customer premises.

ICT services

The automatic power-saving control refers to an air conditioner that is shut off when there is inactivity for more than 15 minutes, as well as a TV that is powered off when there is inactivity for more than five minutes.

A system of visualization informed residents about the total electricity consumption of the residence as well as some household appliances. The study assumed that the PC tablet was used 40 minutes a day for visualization.

10.1.4.6 Life cycle stages

The processes from raw material acquisition to production are calculated together.

10.1.5 Data quality requirements

In the field experiment, power consumptions were acquired in the integral value of every 10 minutes. In addition, the precision of measured power is approximately ±1% (full scale).

10.2 Life cycle inventory

Table 10-3 shows how to collect data and calculate the CO_2 emissions from the data in order to perform the assessment in this case study.

Table 10-3 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
ICT hardware	<Raw material acquisition and production> Price of the hardware × emission factor of hardware in CO_2. <Use> Power consumption and the operating time of the hardware × emission factor of electric power in CO_2. <End-of-life treatment> Total weight of the hardware × emission factor in CO_2.	Price and operating time of the hardware (source: survey) Power consumption and total weight of the hardware (source: catalogue) Emissions conversion factor of hardware for raw material acquisition and production and end-of-life treatment in CO_2 (source: Japanese Input-Output Table) Emissions conversion factor of electric power in CO_2 (source: FEPCO)
ICT software	<Raw material acquisition and production> Price of ICT software × emission factor of software development in CO_2. <Use and end-of-life treatment> No emission.	Price of ICT software (source: survey) Emission factor of software development in CO_2 (source: Japanese Input-Output Table)
Consumables and other supportive products	Outside the scope of this study.	

Table 10-3 – How to calculate the CO_2 emissions from collected data

Category	How to calculate the CO_2 emissions	Collected data and sources
Site infrastructure	• ICT networks <Raw material acquisition and production> Volume of network information × Emission factor of communication network devices in CO_2. <Use> Volume of network information × emission factor of communication network devices in CO_2. <End-of-life treatment> Volume of network information × emission factor of communication network devices in CO_2. * In this case study, "ICT networks" in included in this category. • Household appliances <Raw material acquisition and production> Outside the scope of this study. <Use> Power consumption of the household appliances × emission factor of electric power in CO_2. <End-of-life treatment> Outside the scope of this study.	Volume of network information (source: survey) Emission factor of communication network devices in CO_2 (source: Society draft) Power consumption of the household appliances (source: survey) Emissions conversion factor of electric power in CO_2 (source: FEPCO)
Transport (movement of goods)	Outside the scope of this study.	
Storage of goods	Outside the scope of this study.	
Working environment	Outside the scope of this study.	

10.2.1 Data collection

The National Institute for Environmental Studies Japan 3EID was used to calculate manufacture and EoLT of ICT goods and ICT services.

In the use stage, the electricity consumptions of ICT goods installed in a residence as well as household appliances were measured, and the information used for calculations. The electricity consumptions of ICT goods installed in the data centre were calculated from the value of specification. This study has adopted the value of 0.413 kg-CO_2/kWh, fiscal year 2010, by FEPCO.

10.2.2 Data calculation

The data calculation was conducted on the basis of the conditions for data calculation required by [ISO 14040], [ISO 14044] and [ITU-T L.1410].

This study calculated each reduction of CO_2 emissions in cases of simultaneous introduction of automatic power-saving control and visualization, as below:

(Reductions in electricity consumption by introduced ICT systems (Wh)) =
(Reductions in electricity consumption by automatic power saving control (Wh)) +
(Reductions in electricity consumption by visualization (Wh))

(Reductions in electricity consumption by automatic power saving control (Wh)) =
(the time during automatic shutting off of power by automatic power saving control (hour)) ×
(Electricity consumption under normal operation by household appliances (W))

(Reductions in electricity consumption by visualization (Wh)) =
(Reductions in electricity consumption by introduced ICT systems (Wh)) –
(Reductions in electricity consumption by the automatic power saving control (Wh))

10.2.3 Allocation procedure

The following describes the allocation procedure.

1 Allocation of service

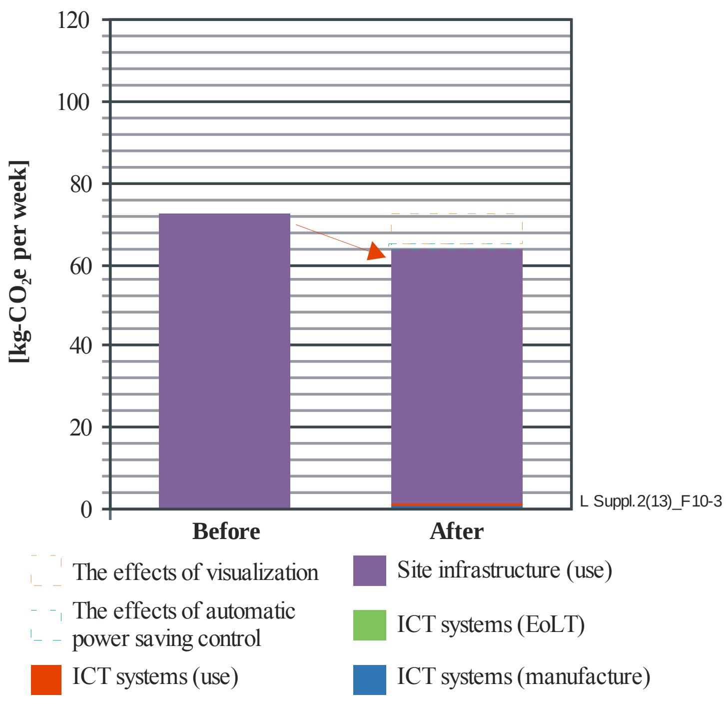
In the field experiment, ICT goods and services were shared with the other services. The study, therefore allocated CO_2 emissions to this service and the others by the amount of management data ratio between them.

2 Allocation of specific function

The study allocated CO_2 emissions to the functions of automatic power-saving control and visualization per residence to clarify each CO_2 emissions separately. Allocation was based on the amount of management data ratio.

10.3 Results of the evaluation

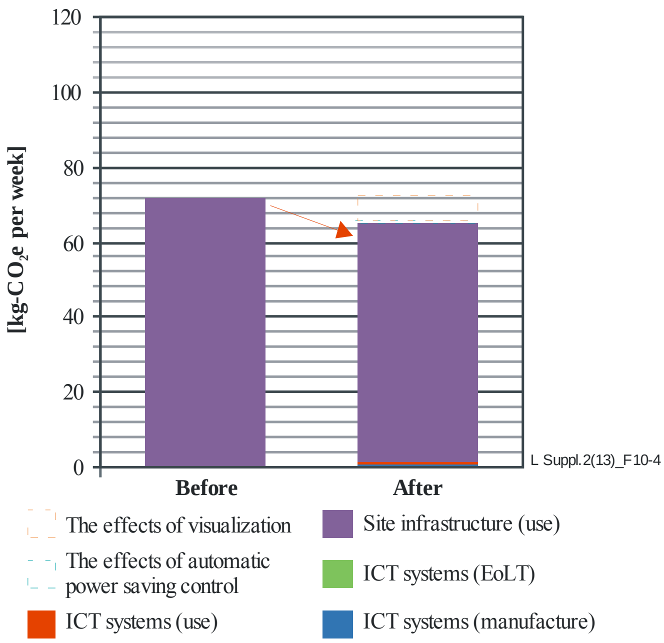
Figures 10-3, 10-4 and 10-5 show the results of three residences.



	Before	After
ICT systems (manufacture)	0	1.04
ICT systems (use)	0	0.17
ICT systems (EoLT)	0	0.01
Site infrastructure (use)	72.54	62.97
Total	72.54	64.19

Effectiveness of automatic power saving control	0.97
Effectiveness of visualization	7.38
Reduction of CO_2 emissions	8.35

Figure 10-3 – The results in Residence 1 of LCA per functional unit separating life cycle stages (unit: kg-CO_2 per week)



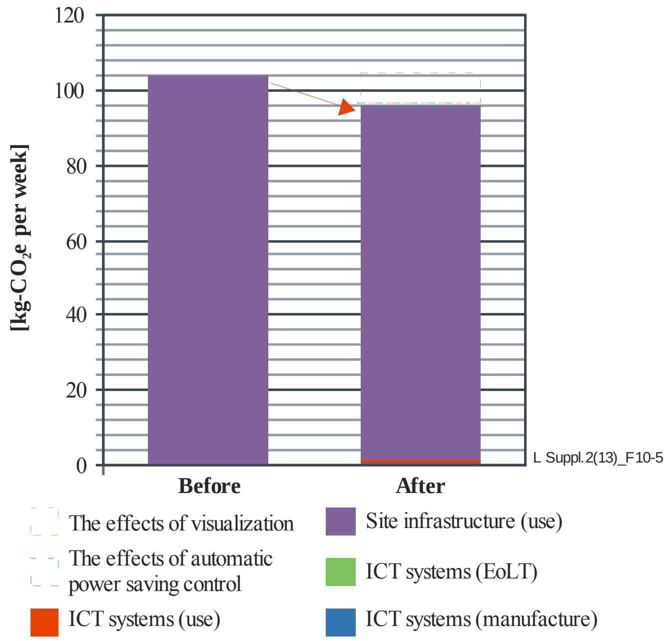
Unit: kg-CO_2 per week

	Before	After
ICT systems (manufacture)	0	1.04
ICT systems (use)	0	0.17
ICT systems (EoLT)	0	0.01
Site infrastructure (use)	72.01	64.16
Total	72.01	65.38

Unit: kg-CO_2 per week

Effectiveness of automatic power saving control	0.93
Effectiveness of visualization	5.69
Reduction of CO2 emissions	6.63

Figure 10-4 – The results in Residence 2 of LCA per functional unit separating life cycle stages (unit: kg-CO_2 per week)



Unit: kg-CO_2 per week

	Before	After
ICT systems (manufacture)	0	1.04
ICT systems (use)	0	0.17
ICT systems (EoLT)	0	0.01
Site infrastructure (use)	104.63	94.12
Total	104.63	95.35

Unit: kg-CO_2 per week

Effectiveness of automatic power saving control	0.37
Effectiveness of visualization	8.92
Reduction of CO_2 emissions	9.29

Figure 10-5 – The results in Residence 3 of LCA per functional unit separating life cycle stages (unit: kg-CO_2 per week)

From these figures, the reduction of CO_2 emissions by visualization contributes 88 per cent in Residence 1, 86 per cent in Residence 2 and 96 per cent in Residence 3. These results indicate that the introduction of visualization is more effective than automatic power-saving control. As this study did not consider greenhouse gases other than CO_2, further studies are required to make reliable conclusions.

10.4 Life cycle interpretation

Table 10-4 indicates the comparison categories in the study.

Table 10-4 – Comparison category

Comparison categories	Items	Reduction of CO_2 emissions
Consumption of goods	No notices	–
Energy consumption	power consumptions of household electric appliances and ICT goods	(i) 9.41 kg-CO_2
		(ii) 14.87 kg-CO_2
		(iii) 11.66 kg-CO_2
Movement of people	–	–
Movement and storage of goods	–	–
Improved work efficiency	–	–
Waste	No notices	–

This case study illustrates a reduction of CO_2 emissions by automatic power-saving control and separate visualization.

The method to clarify each effect of simultaneous introduction of two ICT systems will therefore provide useful information for people who are considering introducing an ICT system in the future.

No sensitivity analysis was performed.

10.5 Critical review

The assessment was reviewed by a group of experts consisting of academics and ICT vendors.

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