Guidance on Calculating GHG Emission Reduction Contributions of Electronic Components

Ver.2

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Japan Electronics and Information Technology Industries Association

Electronic Components Board,

ESG Committee,

Subcommittee on Electronic Components Technology Environment,

Electronic Components LCA-WG

＜Note＞

This guidance was voluntarily prepared by Electronic Components Board, ESG Committee, Subcommittee on Electronic Components Technology Environment of Japan Electronics and Information Technology Industries Association for the purpose of being used by each company in the case of calculation of GHG reduction contributions of electronic components. Consequently, users are kindly reminded that any decisions concerning the use of this guidance should be taken under their own responsibility.

It should also be noted that this guidance can be revised without previous notice in case of amendment of legislation herein referenced, or when important relevant items having a different context of what is stated here are announced.

Table of contents

1. Introduction (Background and purpose)

It is concerned that climate change due to global warming may have serious impacts in the near future. Under such conditions, each developed country has started addressing realization of the low carbon society.

Industries in Japan so far have contributed to prevention of global warming by improving energy-use efficiency in production activities. Lately, however, in addition to conventional activities, they are addressing GHG emission reductions by means of the development and provision of products and services based on new technologies.

There are two reasons, can be pointed out as the background, why industries in Japan have started addressing such activities.

First, because of heightening of environmental awareness, general consumers have become sensitive to energy consuming products and negative environmental impacts of factories. In reality, although consumers are enjoying benefits of using products and take such for granted, the negative side alone gains prominent attentions. Therefore, it is necessary to show positive impacts on the environment. Second, it is important to allege the superiority by quantifying and showing the advantages of products and energy efficiency of the production line in Japanese companies.

As a result of such activities, GHG emission reductions by products and services in the use stage have become recognized widely as contribution to society due to business efforts of the companies. Furthermore, standardization is going on through preparations and publications of guidelines, etc., by International Electrotechnical Commission (IEC), the Institute of Life Cycle Assessment, Japan and some industry associations.

Although many companies and organizations in electrical and electronics industries in Japan have already published actual or prospective numerical value of GHG reduction contributions, companies and organizations committing such activities will increase by the improvement of social recognition and the progress of foundation development described above.

Purposes of this guidance are to show the basic idea and methods to calculate GHG reduction contributions of electronic components and to avoid confusions due to massive reductions figures calculated by various methods and decreases in credibility of numerical value.

2. Terms and definitions

・Amount of activity

The degree of company's activities expressed by indicator.

(Ex: number of units sold, amount of sales, amount of energy used, etc.)

・Baseline

Reference product or value in the comparison to calculate the amount of GHG emission reduction contributions

・Contribution ratio

The ratio for calculating the amount of GHG reduction contributions attributable to the target product depending on the degree of its contribution.

・CO_2 emission coefficient

Numerical data to indicate how much CO_2 is emitted to supply 1kWh. They are expressed by units such as kg-CO_2/kWh, t-CO_2/MWh, etc.

・Double count

It means counting some overlapped values in aggregate calculation.

・GHG : Greenhouse gas

Seven greenhouse gases are subject to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol: Carbon dioxide (CO_2), Methane (CH_4), Dinitrogen monoxide (N_2O), Hydrofluorocarbon (HFCs), Perfluorocarbon (PFCs), Sulfur hexafluoride (SF_6), Nitrogen trifluoride (NF_3).

This Guidance particularly targets at energetic origin CO_2.

・GHG emission intensity

The amount of GHG emitted in the production processes per unit. It is expressed by units such as t-CO_2/million yen, t-CO_2/t, etc.

・IEC TR62726

The guidance for calculation of GHG reduction contributions of electrical and electronic products issued by International Electrotechnical Commission (IEC).

"Guidance on quantifying greenhouse gas emission reductions from the baseline for electrical and electronic products and systems"

・Lifecycle

Processes from the birth to the death of products and services from raw material acquisition or generation of natural resources to the final disposal.

・Lifecycle stage

Each stage of raw material production, assembly of end products, disposal, etc., in the lifecycle.

・Lifetime

Period from the start of use to the end of use for the products. Product lifetime. Service life.

・Load factor

Load ratio of practical usage to maximum design capacity.

・Primary data

The newly collected data for specific purposes.

・Secondary data

The data already collected for other purposes.

・Target product

The product(s) that is/are subject to calculation of GHG emission reduction contributions.

・Target year

The year subject to the accumulation of emission reduction contributions. In the accumulation of the lifetime, the number of products sold in the target year, and in the annual accumulation, the number of products in the market in the target year including the products sold in the past is to be figured out.

・Value chain

A chain consisting of a sequence of values related to products and organizations from the stage of raw material procurement through the use of the product(s) to the disposal. Consumers using the product(s) are included in the value chain.

3. GHG reduction contributions by products or services

As mentioned in the introduction, as to calculating GHG reduction contributions, policies have been expressed by several standards, industry guidelines, etc. The common concept of these standards is that the GHG emission reductions are derived from the comparison between target product and the baseline. Therefore, in calculation of emission reduction contributions, it is important to see the technical superiority of the target product in connection with environment load reductions.

The image of GHG reduction contributions quoted from IEC TR62726[1)] is shown in Figure I −1.

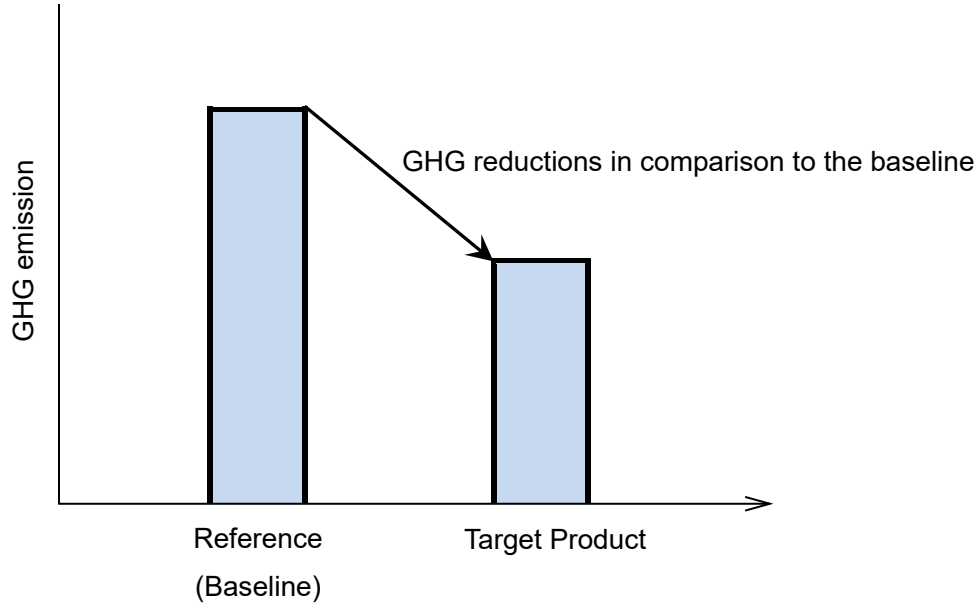

Figure Ⅰ−1　Image of GHG emission reduction contributions

4. GHG reduction contributions by electronic components

Technological efforts in developments and productions for electronic components lead to environmental load reductions. Impacts of these efforts to the environment through the lifecycle of electronic components are shown in Table Ⅰ−1.

From Table Ⅰ−1, we can see technological efforts in development and production of electronic components contribute to environmental load reductions at various stages of the lifecycle.

As a specific example, downsizing of electronic components contributes to resource and energy savings at the production stage and contributes to energy savings at upper stream of the value chain as well. Accordingly, it contributes to GHG emission reductions.

In this guidance, the GHG reduction contributions through electronic components is defined as “GHG emission reduction realized at the stages other than its own business areas in lifecycle through technological efforts in development and production of electronic components.”

Table Ⅰ−1 Impacts and range given by technological efforts concerning development and production of electronic components

Lifecycle stage / Technical approach	Raw material production	Electronic component production	Electronic component transportation	Final product assembly	Final product use	Final product disposal
Downsizing*1	Energy /Resource saving	Energy /Resource saving	Energy saving	Energy /Resource saving	Energy saving*5	Energy saving
Function improvement*2	Energy /Resource saving	Energy /Resource saving	Energy saving	Energy /Resource saving		Energy saving
Efficiency improvement*3					Energy saving	
Extending lifetime*4	Energy /Resource saving	Energy /Resource saving	Energy saving			

*1 Downsizing： to make external dimensions smaller with functions as it stands

*2 Function improvement： to improve functions with external dimensions as it stands.

*3 Efficiency improvement： to make the necessary power to execute functions smaller.

*4 Extending lifetime： to extend the product life with functions as it stands.

*5 In the case where the end product is transport equipment alone.

5. Contribution in the use stage

5.1 Difficulties in calculating contribution of electronic components

Electronic components behave as key parts for varieties of equipment such as home electric appliances, IT equipments, vehicles, industrial machinery, etc. and thereby they contribute to energy saving through such equipment.

In IEC TR62726[1)], it is recommended to assess final products in order to calculate GHG reduction contributions by electronic components. However, in the case of development and supply of intermediate products such as an electronic component, at the same time of improvement of the target product, design of the final product is to be changed as well, and furthermore, improvements of other intermediate products often go together. Accordingly, it is difficult to calculate GHG emission reductions by electronic components alone.

In the consideration of possibility to calculate GHG reduction contributions, as for devices used at electric power transmission route such as the power supply unit, transformer, and DC/DC converter, it is possible to directly calculate contributions. Because it is possible to directly calculate them from the power consumption reduction effects of the electronic component itself. On the other hand, as for the components contribute to the operation control for energy saving for equipment, or passive components such as chip ceramic capacitor which do not directly contribute to energy saving of the equipment and yet indispensable for forming the electronic circuit, it is difficult to directly quantify its contribution.

5.2 Basic idea of calculation of contribution

The calculation method of energy-derived CO_2 emission reduction contribution amount of electronic components can be organized into the following three according to the characteristics of electronic parts and how they are involved in the reduction contributions of final products. [2)]

(a) Calculation based on the reduction of power consumption of electronic components
(b) Calculation based on the energy consumption reduction of the final product due to the effect of electronic components
(c) Calculation based on the contribution ratio of electronic components to the contribution of the final product

(a) is mainly applied to electronic components that convert electric power or voltage, and the performance of these electronic components affects the power utilization efficiency of the final product. (b) is mainly applied to cases of improvement in fuel or electricity efficiency of transportation equipment by reducing the weight of electronic components, but other cases are expected to increase. (C) is applied when the amount of CO_2 emission reduction contributions of the target electronic component cannot be calculated by either method (a) or (b).

The basic formula for calculating the contribution amounts directly from the energy consumption of electronic components or final products by the methods (a) or (b) is as follows (1).

$$Contribution\ amount\ of\ electronic\ components = Amount\ of\ reduced\ electricity\ or\ fuel \times CO_2\ emission\ factor \times Sales\ volume \quad (1)$$

The basic formula for indirectly calculating the contribution amount by the method (c) is as shown in formula (2).

$$Contribution\ amount\ of\ electronic\ components = Contribtion\ amount\ of\ final\ product \times Contribution\ ratio\ of\ electronic\ components \times Sales\ volume \quad (2)$$

Hereafter, contribution derived from (1) is called as the "Direct contribution" and contribution derived from (2) is called as the "Indirect contribution"

5.3 Calculation of the direct contribution

The formula (1) shown in 5.2 is rewritten into formula (3), which is more practical when calculating the contribution amount directly from the power consumption of electronic components.

$$Direct\ contribution\ amount = (Wbl_r - Wt_r) \times L \times H_{op} \times Coef \times S \quad (3)$$

Wbl_r: Electric power consumption of baseline at rated condition

Wt_r: Electric power consumption of target product at rated condition

L: Load factor

H_{op}: Hours of operation

$Coef$: CO_2 coefficient

S: Sales volume

In the next clause, based on formula (3), the procedures to calculate annual contribution of a product will be explained.

5.3.1 Procedures to calculate direct contributions

Step1 Defining the target product

Define the product subject to the calculation of contribution. In what follows, this product is called the target product.

Step2 Setting of functional units

Set the functional units of the target product. The functional units are the values

to express basic functions of electronic components. As examples, as for the power supply unit, it is rated output ○○W, as for the inductor, it is inductance △△μH.

The functional unit can also be set to a numerical value in consideration of the usage state in the final product.

Step3 Defining the baseline

Set the baseline, as the benchmark for comparison in the calculation of contributions. In the case where the baseline is a product, the item having functional units as with the product set in step 2 to be assessed is to be chosen. In the case where the baseline is the values set by laws and systems such as power consumptions, etc., the values set for the product having the same functional units is to be chosen as well. Examples of the baseline are shown below.

《Examples of the baseline》

- In-house old products
- Other products having equivalent functions
- The product of the highest market share
- Average value of the industry
- Standard values set by laws or systems

The baseline may vary depending on the country / region where the target products are populated. According to "*Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions Ver.2*"[3], if a product that provides the same function is not distributed in the region / country, the baseline should be defined with the consideration that other product which is popular in other country / region and provide the same function might be procured.

In addition, when target products are sold to multiple regions / countries, the popular products may differ in each region / country. In such cases, it is desirable to define a baseline for each region / country where sales are made and calculate the amount of reduction contribution for each. However, if it is difficult to grasp information related to the defining of baselines in some regions / countries, the baseline with the least reduction contribution amount could be defined as the baseline for those regions / countries.

Step4 Identifying improvement effects

Identify improvement effects lead to reductions of power consumption in use of electronic components. As typical examples of improvement effects are the improvement of the conversion efficiency of the power supply unit and the transformer, and lowering-resistance values of passive components such as inductors.

Step5 Calculation of difference in rated power consumption

Setting detailed calculation formula based on improvement effects identified in step 4, then calculate the differences of rated power consumption between the target product and baseline. (Examples will be shown in Part II.)

Step6 Setting of load factor

In order to reflect actual operation status to contribution, setting the load factor and multiply difference in power consumption under the rated conditions derived from step 5. Taking the load factor in calculation, over-counting of contribution can be avoided.

Load factors are set based on information obtained through hearing from engineers and publicly known literatures and data, etc.

Step7 Identifying the final products and setting operating time

Identify the final product in which target product is built-in. By identifying the final products, the annual operating time can be set. The value derived in step 6 (Differences in power consumption) multiply by operating time. The value derived here is electrical energy of unit Wh. (The operating time of major final products will be shown in Part II.)

In the case where there are plural final products having the built-in target product, contribution is to be calculated for each of them. In the case where it is difficult to calculate all the final products, calculation can be carried out by selecting representatives. However, in this case, it is necessary to clarify specific reason for such selection.

In identifying the final product for electronic components, there is a possibility that the incorporated product will be incorporated into a larger system. In such cases, the product whose CO_2 emission reduction amount can be calculated independently is regarded as the final product.

Step8 Setting of CO_2 emission factor: Calculation of contribution per product

Contribution per product is calculated multiply the annual electric energy reduction derived in Step 7 by CO_2 emission factor of electricity. Contribution is expressed as CO_2 reduced quantity (g-CO_2, kg-CO_2, t-CO_2, …).

It is recommended to use the CO_2 factor of the year to be accessed in the area where the final products are used. However, in the case where it is difficult to identify the area where the final products are used, or in the case where the CO_2 factor in identified area is unclear, the values published by Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA), etc., are uses as representative values. In the case external communications or internal

communications, sources of CO_2 emission factors need to be specified.

Step9 Identifying the sales volume: Calculation of contribution to society

Identify the volume of sales of the target product in the target year. Contribution to society is calculated by multiplying contribution per product by the volume of sales.

In evaluating the contribution of parts and materials, it may be difficult to grasp the sales volume for each application or for each country / region. Regarding this point, "*Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions Ver.2*"[3] allow the calculation, after showing the rationale, based on assumptions of grouping similar regions / countries together or setting representative regions / countries.

5.3.2 Accumulation method

Procedures to calculate annual contribution are shown in 5.3.1, however, electrical and electronics products are durable goods, so they contribute for several years after being bought by consumers. Because of these characteristics of the electrical and electronics products, the following two aggregate calculation methods are shown in IEC TR62726[1].

① Accumulation based on lifetime GHG reductions

The method to sum up contributions through lifetime.

Multiply the annual contribution calculated in 5.3.1 by the lifetime of the target product.

The lifetime of the product is set based on legal durable years, average repurchase period in market, physical life, etc.

② Accumulation based on annual GHG reductions

The method to sum up the annual contribution in the target year. Multiply annual contribution calculated in 5.3.1 by the amount of target product in the market. This amount includes the target product sold in the target year and sold in past but yet stay in the market because they are still within product lifetime.

The image quoted from IEC TR62726[1] is shown in Figure I −2.

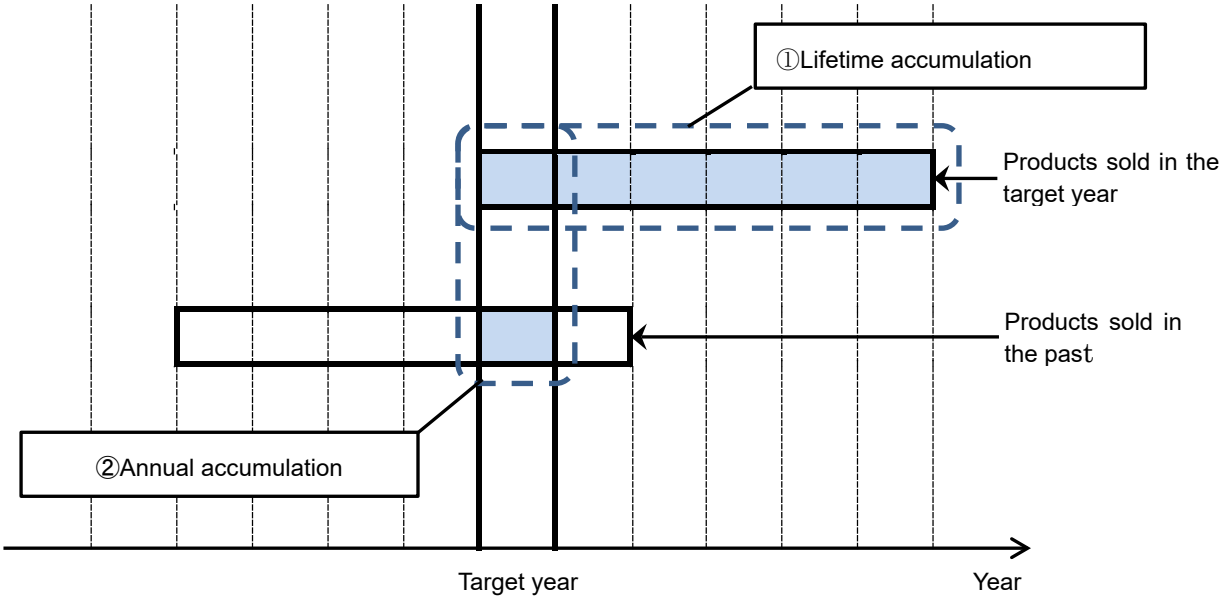

Figure Ⅰ−2　Image of accumulation of contribution

5.3.3 Product grouping

Even within the same product group, the product names of electronic components are subdivided according to size and characteristics, and it is difficult to individually calculate the amount of contribution for all product names. In such cases, as proposed by The Institute of Life Cycle Assessment, Japan[4)], a method of grouping products and calculating the contribution amount is effective. The procedure for calculating the amount of contribution by grouping is as shown below. At this time, it is necessary to clarify the criteria for grouping and the basis for selecting representative products.

① Group products from the perspective of function, final product, etc.
② Determine the representative product for each group and calculate the emission reduction contributions amount of the representative product.
③ Estimate the reduction contributions amount of the entire product group from the sales volume or sales amount of the group.

5.4 Calculation of the indirect contribution

5.4.1 Estimation methods for indirect contribution

As mentioned in 5.1, in calculation of contribution of electronic components, in some cases, it is impossible to calculate because of technical or theoretical reasons. In this case, GHG reduction contributions of the target product are to be estimated in indirect method. As for the estimation methods, information from the final product

manufacturers, estimation of effects of target product alone by means of simulations and calculation based on the contribution ratio are available.

5.4.2 Existing guideline/guidance

"*The guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions Ver.2*"[3] shows the method of allocating the GHG emission reduction contribution amount of final products to stakeholders on the value chain according to the contribution ratio.

Electrical and electronics industries in Japan published case studies of "*Green IT Promotion Council Survey Analysis Committee Comprehensive report (2008 - 2012) ～ Contribution of green IT toward the low-carbon society～*"[5] and "*A calculating method to estimate semiconductors and electronic components contribution to other industries' CO_2 reduction*"[6]. In these precedent cases, as examples of indicators for determining the contribution ratio, the amount of money (cost / value), the environmental load at the stage of use (CO_2 emissions, etc.), the amount of resources / energy input in the supply chain, etc. are shown as examples.

The image of allocation by contribution ratio is shown below.

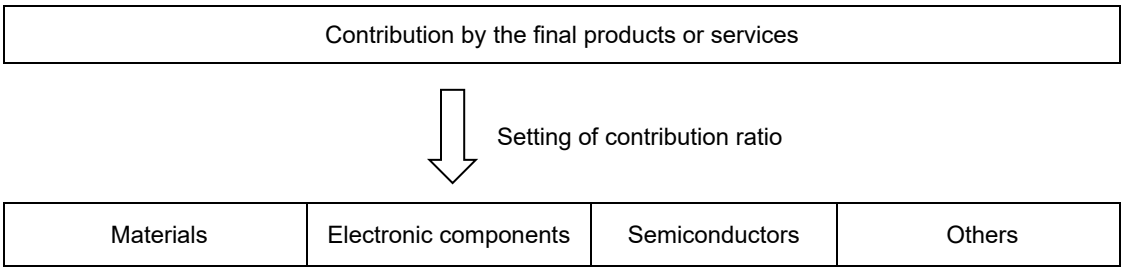

Figure Ⅰ-3　Image of quantification of indirect contribution by contribution ratio

6. Contribution other than the use stage

In lifecycles of the final products, energy consumptions at the use-stage are largest. Accordingly, calculation of contribution is carried out with a focus on the use-stage. However, in the case of intermediate products such as electronic components used built-in final products, GHG emission reduction effects due to technological efforts may appear at the upper stream of the value chain.

Effects of downsizing and extending lifetime mainly come from the GHG emission reductions due to reductions of production energy and resources consumptions at the

lifecycle stages upper than the electronic components production stage.

Calculation of contribution, preferably, is to be carried out getting and using all primary data. However, data collection through the value chain, in some cases, may be formidable work. In such cases, contribution can be estimated by using materials purchase data (primary data) and the secondary data showing GHG emission original units.

7. Key points to keep in mind in communications

7.1 Subtraction from GHG emissions

When communicating using contributions, you must be careful not to mislead stakeholders. In particular, there is a concern that the method of subtracting the amount of emission reduction contributions from the amount of GHG emissions of organization may be regarded as greenwash. Under these circumstances, many companies use a method of expressing the amounts of emissions and contributions side by side.

7.2 Positioning of indirect contribution

As introduced in 5.4, the purpose of calculation of indirect contribution is to calculate contribution of each constituent within the contribution of the final products, and it is not to separate contribution of the final products.

Therefore, in the case where contribution of electronic components, constituent of the final products, is claimed, the fact that the resultant values are partial values of contribution of the final product has to be kept in mind.

Furthermore, in communications using indirect contribution based on contribution ratio, method to identify contribution ratio and its basic idea shall be shown.

7.3 Avoidance of double counting

Cautions in calculation of contribution are double counting.

As a result of calculation of amounts of CO_2 emission reduction contributions, if the contribution of the electronic components exceeds contribution amount of final products in which the target product is built-in, it is theoretically contradictory. Furthermore, if the values of reduction contribution calculated by each company and industry associations are exorbitant ratio compare to those of whole world, credibility of values goes down and eventually meaning of the reduction contribution itself would break down. Therefore, the double count of contribution is to be eliminated as far as possible.

Double counting may take place in communications in various scenes such as inter-industry, inter-company (in-industry), inter-divisions (in-house), etc.

8. References

1) International Electrotechnical Commission (IEC) (2014) : TR62726 Guidance on quantifying greenhouse gas emission reductions from the baseline for electrical and electronic products and systems

2) TDK Corporation（2021）: A Case Study on Quantifying the Amount of CO_2 Emission Reduction of Electronic Components（Journal of Life Cycle Assessment, Japan. Vol.17 No.2 April 2021, 95-102）*

3) The Institute of Life Cycle Assessment, Japan (2015): Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions Ver. 2*

4) Mizuho Research & Technologies, Ltd.（2021）: Introduction to Guidelines on the Assessment and Disclosure of Organizational Contribution to the Avoided Emissions（Journal of Life Cycle Assessment, Japan. Vol.17 No.2 April 2021, 68-73）*

5) JEITA Green IT Promotion Council Survey Analysis Committee（2013）: Green IT Promotion Council Survey Analysis Committee Comprehensive report (2008 - 2012) ～Contribution of green IT toward the low-carbon society～*

6) Japan Electronics and Information Technology Industries Association (JEITA), Electronic Components Board, Subcommittee on Electronic Components Technology Environment, and Semi-Conductor Board (JSIA), Semiconductor Environment Committee (2012): Concept of calculating the contribution ratio of semiconductors and electronic components to the amount of CO_2 emission reduction contributions of products*

* written in Japanese

Part Ⅱ Calculation formula

This part shows, necessary information and calculation formula. As mentioned in Part Ⅰ, the amount of GHG emission reduction contribution is calculated in the comparison between target product and baseline.

1. Basic formula

The formula (1) for calculating the amount of direct contribution shown in Part I is expressed as the following formulas (4) and (5) for electrical and electronic products and for transportation equipment, respectively. The content of equation (4) is basically the same as that of equation (3) shown in 5.3.

【Electrical and electronic products】

$$C_d = \Delta W_r \times L \times H_{op} \times Coef_e \times S \qquad (4)$$

C_d : Amount of direct contribution (kg-CO_2)

ΔW_r : Power consumption reduction under rated conditions (kW)

L : Load factor

H_{op} : Hours of operation (h)

$Coef_e$: CO_2 emission factor of electricity (kg-CO_2/kWh)

S : Sales volume

【Transportation equipment】

$$C_d = \Delta E \times D_{op} \times EF \times S \qquad (5)$$

ΔE : Reduction of fuel / power consumption per mileage (ℓ/km, kWh/ km)

D_{op} : Mileage (km)

EF : CO_2 emission factor of fuel or electricity (kg-CO_2/ℓ, kg-CO_2/kWh)

S : Sales volume

2. Necessary information

Table below shows necessary information to calculate direct contribution.

Table Ⅱ-1

Item	Description
Target product	Product to be assessed to calculate GHG reduction contributions

Item	Description
Functional unit	Function of product which is quantified by specific unit.
Baseline	The base of comparison in the calculation of contributions. Baseline is a product which might be used if target product has not been exists, or is a value set by law or initiative. Functional unit of baseline shall be equal to target product.
Improvement effect	Effect of improvement leads to GHG emission reductions.
Load factor	Ratio of actual load to rated condition in the use phase.
Operating hour	Hours of operation in the specific term (e.g. 1 year). Operating hour of electronic components is determined by final product in which electronic components built-in.
Sales volume	Volume of target product sold in specific term.
CO2 emission coefficient	Coefficient to convert the amount of energy into CO_2-e.
Contribution ratio	Raito of contribution by electronic components to the contribution of final product.

3. List of operating hour

Table below shows operating hour of electrical appliances.

Table Ⅱ-2

Category	Appliance	Duration (y)	Annual operating hour (h)	Lifetime operating hour(h)	Quotation source
Home appliance	TV set	10	1,643	16,425	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "TV set"
	Refrigerator	10.4	8,760	91,104	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Refrigerator"
	Air conditioner	6	3,276	19,656	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Air conditioner"

Category	Appliance	Duration (y)	Annual operating hour (h)	Lifetime operating hour(h)	Quotation source
	Lighting equipment	10	2,000	20,000	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Light equipment"
	Microwave oven	10	91	913	Top Runner Program (Japan)
	Washing machine	9.1	164	1,495	JIS C 9921-4 : 2009
	DVD player	8	821	6,570	Top Runner Program (Japan)
PC/IT	PC	5	712	3,560	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Client PC"
	HDD	5	8,322	41,610	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Magnetic disk drive"
	IT equipment	5	8,322	41,610	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Server PC"
	Routing equipment	5	8,760	43,800	Action Plan for Commitment to a Low-Carbon Society, implementation guide "Routing equipment"
	Printer, PPC, Scanner	5	2,080	10,400	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide "Printer"
Industry/ Infrastructure	Industrial and Infrastructural machinery	11	8760	96,360	Official durable years table in Japanese tax law
Automobile	Automobile	10	433	4,334	Report of Ministry of Land, Infrastructure, Transport and Tourism, Japan
	Audio and Visual set for automobile	10	433	4,334	Report of Ministry of Land, Infrastructure, Transport and Tourism, Japan
	EV,HEV	10	433	4,334	Report of Ministry of Land, Infrastructure, Transport and Tourism, Japan
Renewable energy	Solar power system	20	8,760	175,200	Japan Electrical & Electronics industries' Action Plan for Commitment to a Low-Carbon Society, implementation guide " Solar power system"

4. Detailed calculation formula

This part shows examples of improvement points which lead to GHG emission reduction contributions and detailed calculation formulas.

Ex.1: Internal power supply unit

Functional unit: Rated power (out-put)

Improvement point: Improving efficiency of conversion

Calculation formula

$$C_d = \left(\frac{1}{Eff_{bl}} - \frac{1}{Eff_t}\right) \times P_r \times L \times H_{op} \times Coef_e \times S$$

C_d: Amount of direct contribution（kg-CO_2）

Eff_{bl}: Conversion efficiency of baseline

Eff_t: Conversion efficiency of target product

P_r: Rated power (out-put)（kW）

L: Load factor

H_{op}: Operating hours（h）

$Coef_e$: CO_2 emission coefficient of electricity（kg-CO_2/kWh）

S: Sales volume

Ex 2：DC-DC converter for EV/ PHEV/HEV

Functional unit: Rated power (out-put)

Improvement points：①Improving conversion efficiency

②Weight saving

Calculation formula ①：Improving conversion efficiency

$$C_d = \left(\frac{1}{Eff_{bl}} - \frac{1}{Eff_t}\right) \times P_r \times L \times H_{op} \times Coef_e \times S$$

C_d: Amount of direct contribution（kg-CO_2）

Eff_{bl}: Conversion efficiency of baseline

Eff_t: Conversion efficiency of target product

P_r: Rated power (out-put)（kW）

L: Load factor

H_{op}: Operating hour（h）

$Coef_e$: CO_2 emission coefficient of electricity（kg-CO_2/kWh）

S: Sales volume

Calculation formula ② : Weight saving

$$C_d = (w_{bl} - w_t) \times E_e \times D_{op} \times Coef_e \times S$$

C_d: Amount of direct contribution (kg-CO_2)

W_{bl}: Weight of baseline (kg)

W_t: Weight of target product (kg)

E_e: Electricity consumption coefficient of EV/PHEV (kWh/km/kg) (Notice 1)

D_{op}: Mileage (km)

$Coef_e$: CO_2 emission coefficient of electricity (kg-CO_2/kWh) (Notice 2)

S: Sales volume

Notice1: Fuel consumption coefficient shall be used for HEV, because energy source of HEV is fuel like a gasoline, light oil or etc.

Notice2: CO_2 emission coefficient of fuel shall be used for HEV, because energy source of HEV is fuel like a gasoline, light oil or etc.

Ex.3 Inductor for power circuit

Functional unit: Inductance

Improvement point: Reducing direct current (DC) resistance

Calculation formula

$$C_d = \{(R_{bl} - R_t) \times (I \times L)^2\} \times H_{op} \times Coef_e \times S$$

C_d: Amount of direct contribution (kg-CO_2)

R_{bl}: DC resistance of baseline (Ω)

R_t: DC resistance of target product (Ω)

I: Rated amperage value (A)

L: Load factor

H_{op}: Operating hour (h)

$Coef_e$: CO_2 emission coefficient of electricity (kg-CO_2/kWh)

S: Sales volume

5. Examples of calculation

This part shows case studies of Internal power supply unit with one final product and with multiple final products.

Notice: All numerical value in this part is the one of supposition and is different from the actual numerical value.

Case1: Final product is single

Target product: Internal power supply unit

Functional unit: Rated power (out-put) 150W

Final product: Industrial machinery

《Calculation condition》

Improvement point: Improving conversion efficiency

Before improvement: 80%

After improvement: 85%

Load factor: 70%

Annual operation hour: 8760 hours

Lifetime: 11 years

CO_2 emission coefficient: 0.475 kg-CO_2/kWh

(Source: IEA CO_2 emissions from fuel combustion 2021)

Sales volume: 10,000 unit

Calculation condition is applied to next formula for a case of improving conversion efficiency of internal power supply unit

$$C_d = \left(\frac{1}{Eff_{bl}} - \frac{1}{Eff_t}\right) \times P_r \times L \times H_{op} \times Coef_e \times S$$

C_d: Amount of direct contribution（kg-CO_2）

Eff_{bl}: Conversion efficiency of baseline

Eff_t: Conversion efficiency of target product

P_r: Rated power (out-put)（kW）

L: Load factor

H_{op}: Operating hour（h）

$Coef_e$: CO_2 emission coefficient of electricity（kg-CO_2/kWh）

S: Sales volume

Calculation under a supposition (Lifetime accumulation) is

$$C_d = \left(\frac{1}{0.80} - \frac{1}{0.85}\right) \times (150 \times 10^{-3}) \times 0.70 \times (8760 \times 11) \times 0.475 \times 10000$$

$= 3.5 \times 10^6$ kg-CO_2

Case2: Final products are plural

Target product: Internal power supply unit

Functional unit: Rated power (out-put) 150W

Final products: TV set, PC, Printer

In this case, firstly calculating the amounts of contributions for each final products, then accumulate all contributions.

《Calculation condition : TV set》

Point of improvement: Improving conversion coefficient

Before improvement: 80%

After improvement: 85%

Load factor: 70%

Annual operating hour: 1643 hours

Lifetime: 10 years

CO_2 emission coefficient: 0.475 kg-CO_2/kWh

(Source: IEA CO_2 emissions from fuel combustion 2021)

Sales volume: 50,000 units

Calculation formula for TV set (Lifetime accumulation) is

$$C_d = \left(\frac{1}{0.80} - \frac{1}{0.85}\right) \times (150 \times 10^{-3}) \times 0.70 \times (1643 \times 10) \times 0.475 \times 50000$$

$$= 3.0 \times 10^6 \text{ kg-}CO_2$$

《Calculation condition: PC》

Point of improvement: Improving conversion efficiency

Before improvement: 80%

After improvement: 85%

Load factor: 70%

Annual operating hour: 712 hours

Lifetime: 5 years

CO_2 emission coefficient: 0.475 kg-CO_2/kWh

(Default value set by Japanese law)

Sales volume : 10,000 units

Calculation formula for PC (Lifetime accumulation) is

$$C_d = \left(\frac{1}{0.80} - \frac{1}{0.85}\right) \times (150 \times 10^{-3}) \times 0.70 \times (712 \times 5) \times 0.475 \times 100000$$
$$= 1.3 \times 10^6 \text{ kg-}CO_2$$

《Calculation condition: Printer》

Point of improvement: Improving conversion efficiency

Before improvement: 80%

After improvement: 85%

Load factor: 70%

Annual operating hour: 2080 hours

Lifetime: 5 years

CO_2 emission coefficient: 0.475 kg-CO_2/kWh

(Source: IEA CO_2 emissions from fuel combustion 2021)

Sales volume: 30,000 units

Calculation formula for Printer（Lifetime accumulation）is

$$C_d = \left(\frac{1}{0.80} - \frac{1}{0.85}\right) \times (150 \times 10^{-3}) \times 0.70 \times (2080 \times 5) \times 0.475 \times 30000$$
$$= 1.1 \times 10^6 \text{ kg-}CO_2$$

Therefore, total contribution amount of power supply unit is

$$C_d: \text{total} = (3.0 + 1.3 + 1.1) \times 10^6$$
$$= 5.4 \times 10^6 \text{ kg-}CO_2$$

《Issuance / revision history》

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