

Product-Category Rules (PCR)
for Preparing an Environmental Product
Declaration (EPD) for
Smartphone
PCR 2011:1.0

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&
GIGA-BYTE Technology Corporation

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1. General Information

This document is to be used as the product category rules (PCR) for the global production and manufacturing of Smartphone. The requirements specified in this PCR are intended to be used for EPDs certified in accordance with ISO 14025 standard. This document shall be valid until December 31, 2013.

This PCR was prepared by Compal Communications, Inc. & GIGA-BYTE Technology Corporation. Representatives from major Taiwanese manufacturers of similar products and stakeholders were invited by the Taiwan Electrical and Electronic Manufacturers Association (TEEMA) to the open consultation meeting on December 6, 2011, to participate in the discussion and review of this PCR. Environment and Development Foundation (EDF) then reviewed and approved this PCR.

This PCR is applicable to products with the Harmonized System (HS) Code of 8525.10, 8525.20, and 8525.40.

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2. Company and product description

The EPD shall include information about the manufacturing company/organization. The information may include manufacturing process related information, and environmental related information, such as the environmental management system information. The information may also include special issues which the company/organization would like to emphasize, such as the products meeting certain environmental criteria, or environmental safety and health related information.

This PCR is applicable to both business to consumer/customer (B2C) and business to business (B2B) communications. While conducting certification of product related environmental impacts, the inventory shall also include product accessories and packaging.

2.1 Product group function

Smartphone are a type of telecommunication device with an installed operating system (Android, Windows OS, iOS, Palm, RIM, Symbian, WM, etc), thus capable of offering general mobile phone capabilities, as well as providing expanded open system applications and functions through wireless technology or other means in order to increase the users' convenience and quality of service.

Smartphone' applications include:

- Basic communication functions: e.g., access to voice calls, send and receive SMS, etc.;
- Multimedia and entertainment features: e.g., listen to music, watch movies and photos, play games, etc.;
- Work-related functions: send/receive e-mails, surf the Web;

- Download application software: each operating system typically has its own online app store offering various application software (apps).

2.2 Product components

The smart phone's main components include the following:

- PCB
- ICs: e.g., CPU, power management, RF, etc.
- Random Access Memory (RAM), flash memory
- LCM & touch panel
- Optical module
- Wireless transmission module
- Chassis assembly parts
- Battery
- Charger/Adapter
- Input /output interface device
- Antenna
- Packaging material

The smart phone may also include but not limited to the following components:

- Expansion boards function (e.g., memory card expansion);
- Multi-sensor module (e.g., GPS, gyroscope);
- Headphone
- Tough pen/stylus
- Block charger
- Other components: e.g., cable

The data quality requirements for the main components are described in Section 9 on calculation rules and data quality requirements. The EPD shall also include the other components of the product, but their data quality requirements are different from those of the main components.

2.3 Product technical description

The product technical description part of the EPD may include but not limited to the following information:

- Product Name and Model Name
- Operation System
- Product Outline Dimension & Product Weight
- CPU Type Code

- Storage and Memory Size
- Battery Capacity
- Network Interface Module
- Touch Function Specifications
- Display Resolution
- External and Internal Interface Device Specification
- Design Using Life or Guarantee Life
- Others

3. List of materials and chemical substances

The contents of the following materials and substances in the product shall be declared:

- All materials of the product (excluding packaging material) with weight ratio (material weight/product weight (excluding packaging)) $\geq 1\%$;
- All materials of the packaging with weight ratio (material weight/packaging weight) $\geq 1\%$;
- All materials/substances in the product (including packaging) regulated by legal, customer and environmental requirements;
- The following materials in the product components: flame retardants, lead content in solder, lead and flame retardant content in solder masking agent, and substances regulated by EU's RoHS Directive (the latest version).

The declaration of halogen-free flame retardants, lead-free solders and no RoHS-regulated substances may only be made when appropriate evidences are available (for example, test reports from accredited laboratories/testing facilities). The following organizations may provide accreditation for testing facilities: Taiwan Accreditation Foundation (TAF), (Asia Pacific Laboratory Accreditation Cooperation (APLAC), International Laboratory Accreditation Cooperation (ILAC) or ILAC Mutual Recognition Arrangement (ILAC MRA). For definitions of testing methodology and confirmations of regulated hazardous substances based on the accredited laboratories' product testing methods, please refer to IEC 62321 Standard.

4. Declared unit

The declared unit is one unit of smart phone. The screen size shall also be included in the declaration. This unit is chosen because the smart phone products are marketed and sold in such a unit.

5. System boundaries

The main system boundaries for the declared product system are presented as follows:

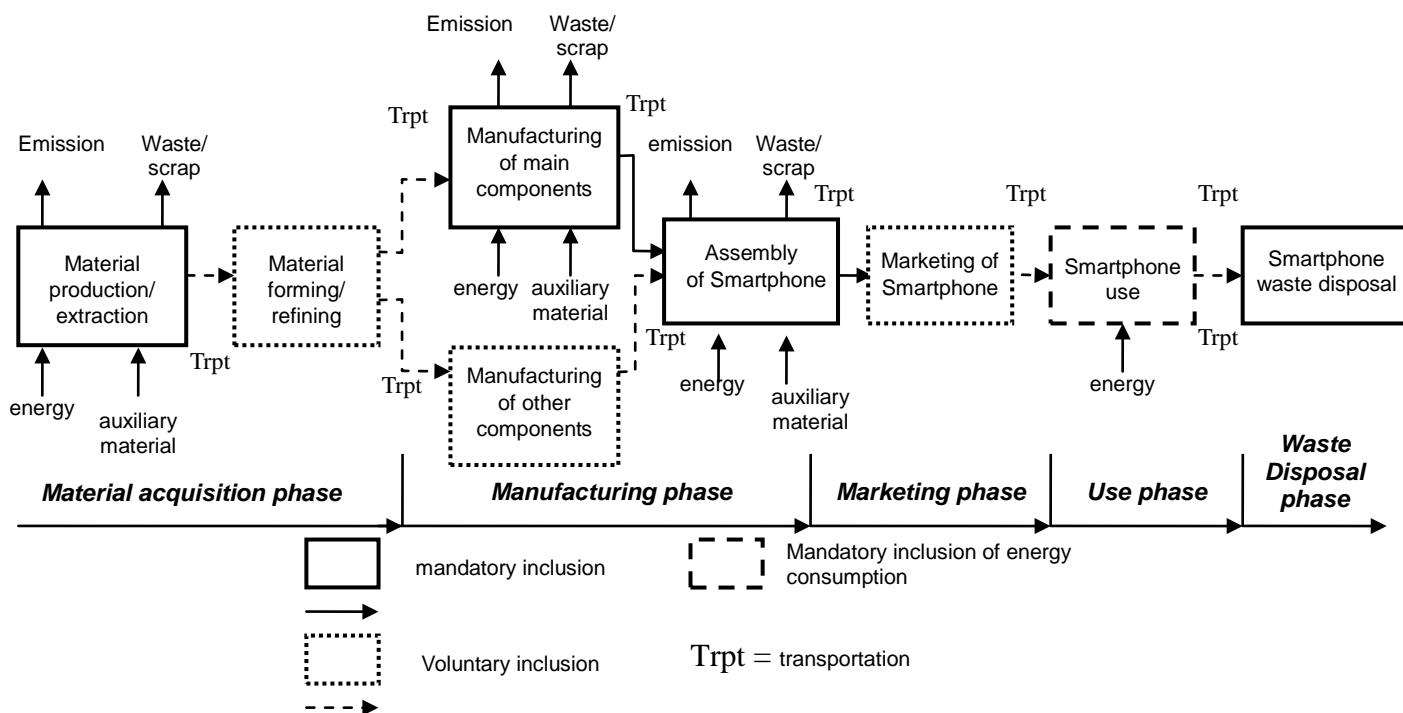


Figure 1 System boundary of the product system

As noted in Figure 1 above, the life cycle of a smart phone covers five life cycle stages: raw material acquisition, product manufacturing, distribution, product use and waste disposal. The data quality requirements for the main components and other components are described in Section 9 on calculation rules and data quality requirements.

Raw Materials Acquisition Stage

The LCA shall include information for the following unit processes:

- Material extraction and manufacturing of main components and other components;
- Production/generation of energy used for raw material manufacturing.

The inclusion in the LCA the information on the forming and refining of raw materials and transportation of raw materials is optional (voluntary).

Manufacturing Stage

The LCA shall include information for the following unit processes:

- Manufacturing of main components and generation of associated process waste;
- Assembly of products and generation of associated process waste;
- Transportation of main components to product assembly plant.

The inclusion in the LCA the information on the input/output of packaging material during main components manufacturing process and the manufacturing of minor/secondary components/parts is

optional (voluntary).

Distribution and Marketing Stage

The LCA shall include information for the following unit processes:

- Transportation of products to the distribution sites or customer designated locations;
- Inventory and reporting of energy/resource input and waste generation during the marketing process is optional (voluntary);
- Inventory and reporting of transportation from sales/distribution sites to users is optional (voluntary).

Use Stage

The definitions of energy consumption, test standard and product usage scenario are described as follows.

(1) Daily time and usage scenario

The assumption of daily time of usage under each function may be based on the “An Analysis of Power Consumption in a Smartphone¹” report presented at the 2010 USENIX Annual Technical Conference. In this report, the daily time of usage under each mode is presented in Table 1 below.

The product shall declare its power consumption during idle mode, phone call mode, audio playback mode, video playback mode, SMS mode, Email mode (3G or WiFi), and web browsing mode (3G or WiFi). The test shall be conducted based on the latest version of the ENERGY STAR computer specification or other applicable international standards. Definitions of the power consumption modes and usage scenario are described as follows:

Table 1 Usage Scenario and Average Time of Use under each Mode

Usage Mode	Power (P = mW)	Average Usage Time (hr) (assumed fixed time)	Power consumption (W = mWh)
a. Idle mode	P_a	$T_a = 18.97$	$A = P_a * T_a$
b. Phone call mode	P_b	$T_b = 2.00$	$B = P_b * T_b$
c. Audio playback mode	P_c	$T_c = 1.00$	$C = P_c * T_c$
d. Video playback mode	P_d	$T_d = 0.42$	$D = P_d * T_d$
e. SMS mode	P_e	$T_e = 0.60$	$E = P_e * T_e$
f. Email-WiFi	P_f	$T_f = 0.315$	$F = P_f * T_f$
g. Email-3G	P_g	$T_g = 0.315$	$G = P_g * T_g$
h. Web-WiFi	P_h	$T_h = 0.19$	$H = P_h * T_h$
i. Web-3G	P_i	$T_i = 0.19$	$I = P_i * T_i$

Notes:

- Idle mode: During idle mode, the mobile phone is awake but not running any applications and the the backlight is off.

¹ Aaron Carro & Gernot Heise, An Analysis of Power Consumption in a Smartphone, USENIX Annual Technical Conference, 2010.

- Music: Playback 12.3MiB, 537 second stereo 44.1kHz MP3 music with the backlight off, GSM on and repeat 10 times.
- Video: Playback 5 minutes, 12.3 MB H.263 encoded video clip (silent) with the backlight on, and repeat 10 times.
- SMS: Input 55 words in 62 seconds with the backlight on, repeat 10 times.
- Talk: From dialing to speaking for 77 seconds, with the backlight on.
- Email (WiFi): Open, download and read five email (60 KiB image), reply two emails with backlight on, repeat 10 times.
- Email (3G): ibid.
- Web browsing (WiFi): View the web 490 seconds, including open web application, select page, and download the content to browse BBC News website, open state, repeat 10 times.
- Web browsing (WiFi): ibid.

Based on the time spent in each mode, measure the power consumption for each mode and add up the total power consumption for all modes to calculate the total daily power consumption as follows:

$$\text{Total power consumption each day (mWh)} = A+B+C+D+E+F+G+H+I \quad (I)$$

(2) Battery charging condition and power consumption calculation

As the specifications of batteries and AC adapter/chargers vary, the number of battery charging required and total charging power consumption each year will also be different, thus the battery discharge efficiency and AC adapter charging efficiency shall be based on actual measurement. The specifications for the battery and AC adapter can be summarized in the following table (Table 2):

Table 2 Specifications of Battery and AC Adapter

Battery Specification	
Discharge cut-off voltage	$V_{dc}(B)$
Charging cut-off voltage	$V_c(B)$
Cut-off current	mA(B)
Battery capacity	mAh(B)
Battery discharge efficiency	Dc % (B)
Battery charging efficiency	C% (B)
Battery total energy	mWh(B)
AC Adaptor Specification	
Efficiency	Ad%
No-load energy efficiency	mW(Ad)

(3) Rules for charging scenario:

Assume each charging time is a fixed 8 hours, which includes time for a full charge of battery and

cell phone connected to charger after full battery charge. The battery charging efficiency is calculated based on manufacturer's actual measured efficiency.

Table 3 Calculation of Energy Consumption for Each Battery Charging

Calculation of Energy Consumption for Each Battery Charging				
Total power consumption during each battery charge (8hr, mWh)	A: Power consumption to charge battery from 0% to 100% (mWh)	B: Charging time to reach 100% (hr)	C: Power consumption after battery fully charged but still connected to AC adapter (mW)	D: Time connected to AC adapter after 100% charged (=8-B hr)

Notes:

- A: Power consumption to charge battery from 0% to 100% (mWh) = $\frac{mAh(B) \times V_{dc}(B)}{Ad\% \times C\%(B)}$ (II)
- C: Power wattage consumption when battery fully charged, but still connected with AC adaptor (mW) = $\frac{mA(B) \times V_c(B)}{Ad\% \times C\%(B)} + mW(Ad)$ (III)
- Total power consumption for each battery charge (8hr, mWh) = (II) + (III) * (Time connected with AC adapter after battery fully charged). (IV)

(4) Rule for calculation conducted after the above steps

A. Battery's sustainable power supply time (hr) = total battery energy (mWh) / total power consumption during each day 's usage cycle (mWh) × 24 hours (V)

B. Smart phone's usage cycle (hr) = Battery sustainable power supply time + each charging time (8 hrs) (VI)

C. Number of charging within one year = 365 days × 24 hours / smart phone's usage cycle (VII)

In summary:

Total energy consumption during each smart phone's expected life (kW-hr) = Total power consumption during each battery charging (mWh) × 10⁻⁶ × number of charge cycles within one year × typical life of a smart phone (2 years to reach recycling/disposal stage) (VIII)

Recycling/end-of-life Stage

The LCA shall include information for the following unit processes:

- Transportation of end-of-life product to waste/resource treatment or recycling facility.
- Reporting of recycling information (such as recycling and dis-assembly report or information on recycling channels) is mandatory in the EPD. Also, the environmental impact shall be calculated based on the declared recycling rate.

5.1 Specification of different boundary settings

Boundary in time

The validity period for the LCA results presented in the LCA report shall be defined.

Boundary towards nature

If the manufacturing processes are located within Taiwan, the solid waste categories as defined in Taiwan's Waste Disposal Act shall be adopted. If the processes are located in other countries, equivalent legal requirements shall be considered.

The natural boundary of the system shall describe the boundary where the materials and energy resources flow from nature into the system, and where the water and air emissions and waste are released out of the system.

Only the waste which is required to be disposed of needs to be considered; land filling process does not need to be included. If the waste is generated through wastewater treatment or incineration process, such waste should be included into the wastewater treatment or incineration process.

Boundaries in the life cycle

The boundaries in the product life cycle are described in Figure 1. The construction of the site and infrastructure, as well as the production of manufacturing equipment and activities of the workers, does not need to be included.

Boundaries towards other technical systems

Boundaries towards other technical systems describe the inputs of material and other components towards other systems, as well as outputs of materials towards other systems. For the inputs of recycled materials and energy towards the product manufacturing stage, the transportation between the recycling process and use of recycled materials shall be included in the data set. For the production of recyclable products during the manufacturing stage, the transportation towards the recycling process shall be included.

(Note: Further explanations are provided in Section 7 on open-loop recycling)

Boundaries regarding geographical coverage

The manufacturing stage may cover manufacturing processes located on any sites around the world. For processes located in a specific region, the data used should be representative of the region. The data for the main components shall be the specific regional data for the region where the process takes place (see Section 9). For ease of comparison, no matter where the emissions are generated, the same environmental impact parameters should be used for life cycle impact assessment (see Section 10).

6. Cut-off rules

For any impact category, if the sum of various impacts from a specific process/activity is less than 1% of the impact equivalent in that category, such a process/activity may be neglected during the inventory analysis. Nonetheless, the accumulated impact of neglected process/activity may not exceed 5%. Components and materials omitted from the LCA shall be documented.

(Note: This judgment for this "1% Rule" is based on the environment relevance assessment of material input to the system, and does not consider special and exceptional environmental impacts.)

7. Allocation rules

The main allocation rules shall be valid for the entire product system. For other secondary processes, other allocation rules may be defined; however, the use of these rules should be justified.

Product-specific information should be preferentially collected in order to avoid the need for allocation. While selecting allocation rules, the following principles are recommended.

- **Multi-output:** The allocations are based on the changes in the resource consumption and pollutant emissions (for example, adopted quantity allocation for some main component, or surface allocation for some components), following the changes in the studied system's output product or function or economical relationship.
- **Multi-input:** The allocation is based on actual relationship. For example, the manufacturing process's emissions may be affected by the change in waste flow input.
- **Open loop recycling:** For the input of recycled materials or energy during the manufacturing stage of the product system, the transportation between the recycling process and the recycling to material use shall be included in the dataset. For the product which shall be recycled during the manufacturing stage, the transportation towards the recycling process shall be included.

Notes:

- *Allocation may be avoided through avoidance of dividing processes, for example as described in Section 6.3 of ISO/TR 14049; or through expansion of system boundary (for example as described in Section 6.4), so that the amended system shares the same product exchanges as the original system.*

8. Units

The base units and derived units of the International System of Units (SI, *Système International d'unités*) shall be used preferentially.

Power & energy units:

- power unit: W
- energy unit: J

Specification units:

- length unit: m
- capacity unit: m³
- area unit: m²
- weight unit: kg

If necessary, prefixes may be used before the SI units.

- 10⁹ = giga, symbol "G"
- 10⁶ = mega, symbol "M"
- 10³ = kilo, symbol "k"
- 10⁻² = centi, symbol "c"
- 10⁻³ = milli, symbol "m"
- 10⁻⁶ = micro, symbol "μ"
- 10⁻⁹ = nano, symbol "n"

9. Calculation rules and data quality requirements

Date quality requirements for the raw material acquisition stage

- Generic data may be used for the acquisition, production, forming and refining of raw materials used for the components of the smart phone products. Please refer to Appendix I for the common sources of generic data.

Date quality requirements for the manufacturing stage

- Site specific data (for example, specific data for manufacturing plant or transportation) shall be used for the manufacturing of major components and assembly of the smart phone products. If other types of information are used, description of the information and rationale for using the information shall be provided. For site specific data of main component manufacturing plants, specific data from a plant representative of such a site may be used.
- Generic data may be used for the manufacturing of other components for the smart phone products, and based the calculation on actual consumption. Please refer to Appendix I for the common sources of generic data.
- When generic data are used, the equivalence between the chemical and/or physical process of referred systems shall be considered. Moreover, it is also recommended to consider the date or geographic aspects of the data quality when feasible.
- Generic data may also be used when suppliers refuse to provide specific data, or when even if generic data are used in place of specific data, there is only minor impact to the results. The general rule is that if generic data are used in place of specific data, their combined contribution for all life cycle stages shall not be greater than 20% of total impacts for each impact category. But there may be certain exception to specific products, and such exceptions shall be explained.
- The data shall be representative for the average of a specific year. If the average data for a specific time period of less than one year is used, the reason for using such data shall be provided.
- The electricity mix for the manufacturing stage should be site specific data. If site specific data cannot be obtained, the official electricity mix for the country where the site is located may be used as approximate value. The electricity mix should be documented.
- For the definition of hazardous waste, the definition as defined in Taiwan's Waste Disposal Act shall be used for sites located in Taiwan. For sites located outside Taiwan, legal requirements for the host country shall be observed.
- For the transportation of main components to the manufacturing plant, the actual transportation modes used and distance traveled shall be considered.

Date quality requirements for the distribution and marketing stage

- For the transportation of products to the distribution sites or retailer sites, the actual mode of transportation and distance traveled shall be considered.

Date quality requirements for the use stage

- The energy consumption of the product shall be determined based on testing methodology stipulated in applicable international, national or industrial standards of the countries/regions the product is marketed.
- For the electricity mix for the use stage, the official electricity mix for the country where the

product is exported may be used as approximate value. Please refer to Appendix I for the common sources of generic data.

Date quality requirements for the recycling/end-of-life stage

- For transportation of end-of-life Smartphone as post-consumer waste for delivery to processors or recyclers, the data from national or industry sources or consumer behavior surveys can be used. When such data cannot be obtained, evaluation based on assumed scenario can be made, and the assumptions for such a scenario shall be reported in the EPD.
- Generic data may be used during the recycling/end-of-life stage, if for specific reason the site specific data for the recycling/waste disposal system can not be obtained. Then generic data and recycling rate may be used to calculate environmental impact. Please refer to Appendix I for the common sources of generic data.

10. Parameters to be declared in the EPD

The following parameters shall be declared in the EPD:

Energy use

- The energy consumption during each product life cycle stage shall be declared. If the product is intended for end-users, the power consumption during the use stage shall also be declared.
- The following units shall be used preferentially:
kW or W for power; J or MJ for energy.

Resource use

The information on resource input during the product life cycle stages shall be declared.

Impact equivalents expressed as potential environmental impacts

-Global warming	kg CO ₂ equivalent
-Acidification	kg SO ₂ equivalent
-Photochemical oxidant formation	kg C ₂ H ₄ equivalent
-Eutrophication	kg PO ₄ ³⁻ equivalent
-Ozone depletion	kg CFC-11 equivalent

Note: For characterization factors of each impact category, please refer to *EPD Supporting Annexes*, Version 1.0 (2008-02-29), The International EPD Cooperation, downloadable from www.environdec.com.

Additional information

- Recyclable materials (optional)
- Information on secondary materials (optional)
- Waste (classification):

- Hazardous waste as defined in Taiwan's Waste Disposal Act. Follow host countries' laws for sites outside Taiwan.
- Other waste.
- Plastic parts marking: Where technologically possible, plastic parts of the smart phone weighing ≥ 25 g shall be marked in accordance with the ISO 11469 and ISO 1043 Part 1/2/3/4, SPI or other international standard label to facilitate their identification and recovery at the end of life.
- Plastic packaging materials marking: The Plastic packaging materials shall be labeled on the parts with SPI or other international standards for ease of sorting.

11. Recycling information

The recycling information shall include information such as dis-assembly instructions, which parts/components are suitable for recycling (such as metal cases) or not suitable for recycling. The information which the EU WEEE Directive requires the end product manufacturer to provide may also be included in the product declaration information for smart phone products.

If practical, information for the parts which can not be recycled and therefore should be disposed of properly during the end-of-life stage may also be included.

12. Other environmental information (Optional)

The EPD may cover information including technology adopted, site of product manufacturing and assembly, as well as information on other working environment, health and risk-related aspects.

If this PCR is to be used for product carbon footprint declaration purpose, in the declaration, information regarding commitment on GHG reduction should be included and shall ensure that the commitment is measurable, reportable and verifiable. The organization may also list environmental and energy management related information, such as awards, commendations and system certifications (e.g., ISO 14001, ISO 14064-1, IECQ HSPM) etc.

14. References

The EPD shall make reference to the following documents:

- EPD General Program Instructions, Version 1.0 (2008-02-29), The International EPD Cooperation, downloadable from <http://www.environdec.com/>;
- Relevant PCR documents;
- The underlying LCA report.

When available, the following documents shall also be referenced:

- Other documents and recycling instructions which verify and complement the EPD.

Aaron Carro & Gernot Heise, An Analysis of Power Consumption in a Smartphone, USENIX Annual Technical Conference, 2010.

Appendix I – Generic Data Sources to Refer to

For processes located within Taiwan, Taiwan generic data or the data published by the commercial, industrial and energy competent authorities of the Republic of China (ROC) government, may be used. However, for other regions (such as EU), if there are more relevant generic data available, these data should be used instead. The following generic databases are recommended for use.

Material	Database
Packing materials, transport, Waste treatments	BUWAL 250
Steel, Primary copper, Copper products, Electricity, Fuels, Aluminum, Chemicals, Transports, Waste management	ELCD EIME (Environmental Information and Management Explorer) EcoBilan
Plastics	PE Plastics Europe (Association of Plastics Manufacturers in Europe) ELCD EIME (Environmental Information and Management Explorer) EcoBilan
Electronic components	ELCD EIME (Environmental Information and Management Explorer) EcoBilan
General Database	Ecoinvent The Boustead Model PE-GaBi DoITPro(Taiwan)

Appendix II – Reporting Format for the EPD

This appendix provides guidance information for the titles of sections, types of data and required information to be reported in the mandatory reporting part of the EPD. As a generic reporting template, the following titles and sub-titles are recommended:

(Refer to the PCR manual for the section numbering, the information in Italics are the recommended data/information for inclusion)

Introductory part

Each EPD should have an introduction part on the top part of the EPD which includes the following information:

- *Company/organization name*
- *Product name*
- *EPD registration number*

Description of the company/organization and product/service

Company/Organization

- *Description of company/organization*
- *Description of overall working environment, existing quality system and environmental management system*

Product and services (see Section 2)

- *Product's main applications*
- *Description of product specification, manufacturing process, manufacturing sites (if there are several sites)*
- *For product's environmental performance aspects, characteristics which may improve the usefulness of product*
- *Other types of relevant information, for example, special manufacturing processes with special advantages to the environment*

List of materials and chemical substances

- *Content declaration (see Section 3)*

Presentation of the environmental performance

- *Outline of the LCA methodology, for example, period of LCA, declared units, system boundaries (graphical presentation), cut-off and allocation rules, and data sources.*

Manufacturing stage (see Section 10)

Use stage (see Section 10)

- *Geographical region for product delivery*
- *Transportation data*
- *End-of-life information*

Information about Company and Certification Organization

Recycling information (see Section 11)

Other environmental information (see Section 12)

Information regarding certification

- *Names of certification and verification organizations*

- *Validity of certification certificates*
- *Compliance with legal and relevant requirements*

References (see Section 14)

- *relevant PCR documents*
- *EPD General Program Instructions, Version 1.0 (2008-02-29)*
- *underlying LCA study*
- *other supporting documents for LCA information*
- *other relevant documents regarding company/organization's environmental activities*

Appendix III Abbreviations

Acronym	Common Name
APLAC	Asia Laboratory Accreditation Cooperation
CFP	Carbon Footprint of Product
EPD	Environmental Product Declaration
ErP	Energy Related Product
ILAC	International Laboratory Accreditation Cooperation
ILAC MAR	International Laboratory Accreditation Cooperation Mutual Recognition Arrangement
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
PCR	Product Category Rule
RoHS	The Restriction of the use of certain Hazardous Substances in electrical and electronic equipment
SPI	Society of the Plastics Industry
TAF	Taiwan Accreditation Foundation
TEC	Typical Energy Consumption
Trpt	Transportation
WEEE	The Waste Electrical and Electronic Equipment Directive