

Product-Category Rules (PCR)
for preparing an environmental product
declaration (EPD) for

Memory

PCR 2010:1.0

Powerchip Technology Corporation

Environment and Development Foundation

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1. General Information

This document is to be used as the product category rules (PCR) for the global manufacturing of Memory. 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 September 01, 2013.

This PCR was prepared by the Powerchip Technology Corporation and Integrated Service Technology, Inc. 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 July 21, 2010, to participate in the discussion and review of this PCR. EDF then reviewed and approved this PCR.

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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 covers the life-cycle phases of the Memory products. This PCR is only applicable to communications between businesses and consumers (B to C).

2.1 Product function

The memory is an electronic component utilizing the change in electrical charge or magnetism for data storage purpose. It is widely used in various electronic products and can be used to store digital data, as well as expanding computing operations. The memory can generally be divided into flash memory, cache memory, RAM (Random Access Memory), etc., with practical applications in computer, communication, consumer electronic products e.g. digital cameras, digital video recorders, computers, mobile phones, satellite navigation devices. The memory typically serves as the key components for the computing process and data storage functions of the electronic products.

2.2 Product group and components

The memory's manufacturing process can be divided into three stages (memory wafer, memory package and memory module), with the components of each stage described as follows:

(1) Memory wafer: Wafer and the chip/die produced through cutting and processing the wafer.

(2) Memory package:

(2.1) Chip: The functional components cut (diced) from memory wafer.

(2.2) Substrate: The support structure in which chip/die and metal wire/metal plating/metal pillar/metal trace are mounted onto.

(2.3) Electrical connection: The metal wire/metal plating/metal pillar/metal trace and solder plating/solder ball capable of transmitting electronic signals.

(2.4) Molding compound: The compound used for protecting the chip, metal wire/metal plating/metal pillar/metal trace and the substrate.

(2.5) Adhesive/Attach: The film used for attaching the chip to the substrate.

(2.6) Other: ink, etc.

(3) Memory module

(3.1) Memory package: As described in 2.2. (2) (on memory package).

(3.2) Substrate: The support structure used for mounting the package and providing the electrical connection for electronic components, e.g., the PCB.

(3.3) Electrical connection: The component used for internal and external signal transmission, including metal wire/metal plating/metal pillar/metal trace/solder paste, and information transmission/communication module, e.g., the USB.

(3.4) Other: Other components or marking required for the normal function of the module, e.g., passive components, controller, molding compound, case/shell, ink, etc.

2.3 Product technical description

The product technical description part of the EPD shall include the following information:

(1) Memory wafer

Label the information relevant to memory wafer manufacturing in the sequence of technology node, wafer size and memory name, e.g., 70nm-300mm-1GDDR3.

(1.1) Technology node: 90nm, 70nm, 50nm, 30nm etc.

(1.2) Wafer size: 150mm (6-inch), 200mm (8-inch), 300mm (12-inch) etc.

(1.3) Memory name: 1GDDR3, 512MNOR-Flash, 2GNAND-Flash, 4GMRAM etc.

(2) Memory package

Label the important information relevant to memory packaging in the sequence of package memory capacity and name, I/O configuration, package type, metal wire name, e.g., 1Gb(1Gb*1)DDR3-3-FBGA-Au.

(2.1) Package memory capacity and name: The unit for digital data storage and program computation in the package memory, expressed as “bit” or “b”; the text in the parenthesis indicates (capacity and number of chip), e.g., 512Mb(256Mb*2)NOR-Flash, 1Gb(1Gb*1)DDR3.

(2.2) I/O configuration: The read format for memory package, express as the power of 2, e.g., express 4-bit read and write process as “2”, 8-bit process as “3”, 16-bit process as “4”.

(2.3) Package type: The technology used to package chip, e.g., FBGA, μ BGA etc.

(2.4) Metal wire name: The metal wire used to transmit signal in the memory package, expressed as symbol of metals, e.g., “Au” for gold wire, “Cu” for copper wire.

(3) Memory module

Label the important information relevant to memory module in the sequence of module memory capacity and name, memory package type and quantity, data rate, module type, e.g., 1GBDDR3-(1GbDDR3-3-FBGA-Au)*8-1333-SO DIMM.

(3.1) Module memory capacity and name: The unit for digital data storage and program computation in the memory module, expressed as “byte” or “B”, followed by memory type, e.g., 2GBDDR3, 16GB NOR-Flash.

(3.2) Memory package type and number: Express package type inside the parenthesis, followed by number of memory package, e.g., 512MbDDR2-2-FBGA-Au)*4, (8Gb NAND-Flash-3- μ BGA-Au) *4.

(3.3) Data rate: Usually expressed in the unit of Hz, e.g., 800 MHz, 1333MHz, 1666 MHz.

(3.4) Module type: Generic type for the end-use electronic products, e.g., SO DIMM for the notebook computers.

Note: The product life time shall be noted in the technical description for memory package

and memory module, expressed as MTBF (Mean time between failures) or test time, e.g., MTBF: 1000000 hr, test time 100000 hr.

3. List of parts and banned substances

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

- All parts with weight ratio (part weight/product weight) $\geq 1\%$;
- All banned substances regulated by legal and customer requirements (such as the RoHS Directive);

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.

Notes:

1. The accumulated weight of the declared main materials, auxiliary materials and packaging materials shall be greater than 99%.
2. The water and nitrogen gas used in the product process shall be calculated separately, not included in the aforementioned 99% calculation.

4. Declared unit

The declared units for the memory wafer, memory packaging and memory module are, "piece", "each", and "set", respectively. The reason for selecting the three units is because memory wafer, memory packaging and memory module are marketed and sold in such units. Due to the diversify of computing memory products, please refer to Section 2.3 on Product Technical Description for additional information on selection of the three declared units.

5. System boundaries

The main system boundaries for the manufacturing of memory wafer, memory packaging and memory modules are business-to-consumer (B to C) in nature and are presented as

follows:

Memory production boundaries (including memory life cycle)

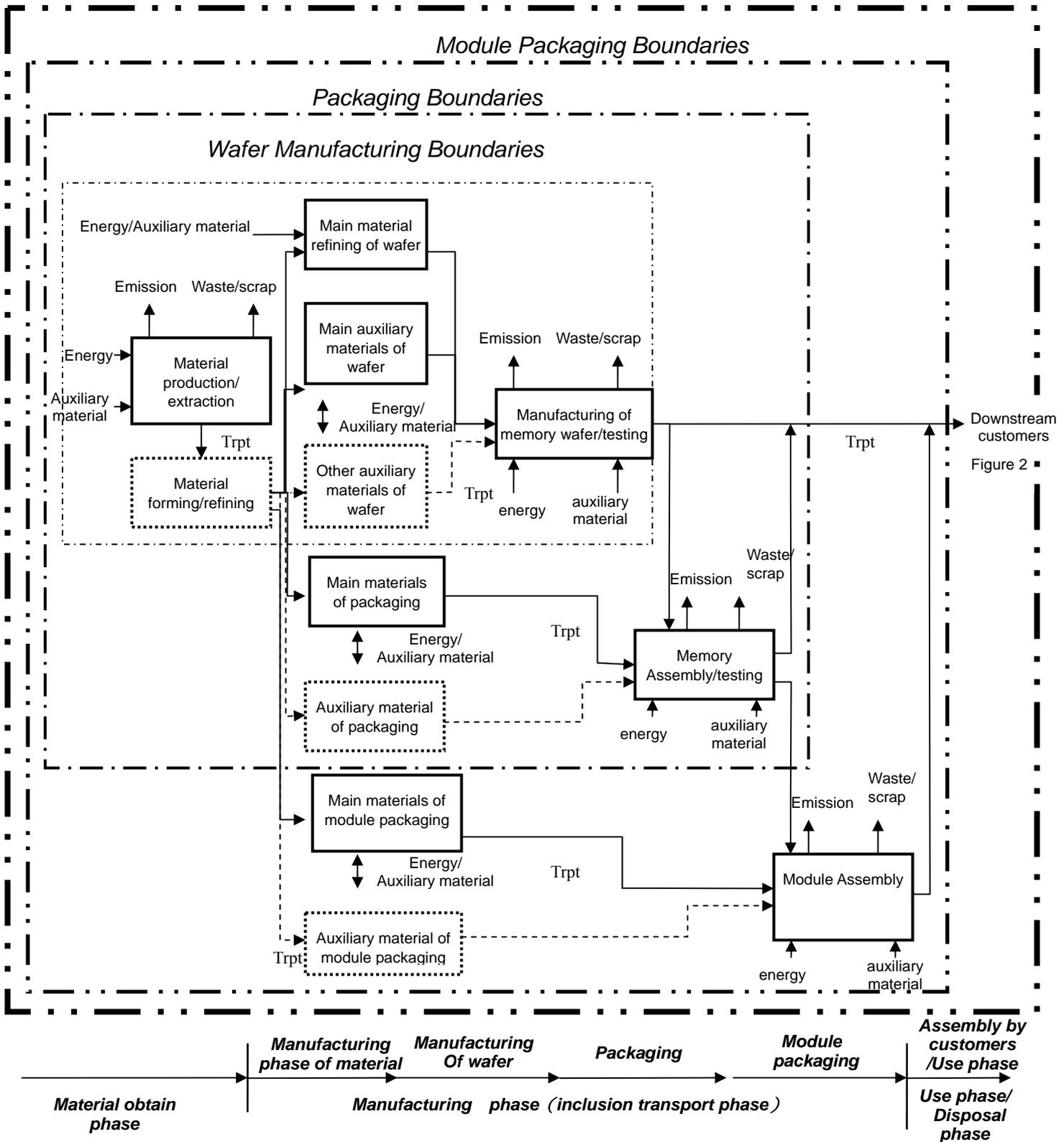


Figure 1 System boundary of the main product system

The main system boundaries for the use and recycling of memory products

(If the products are used by consumers directly, the boundaries for memory shall include use phase and final disposal phase of finished products.)

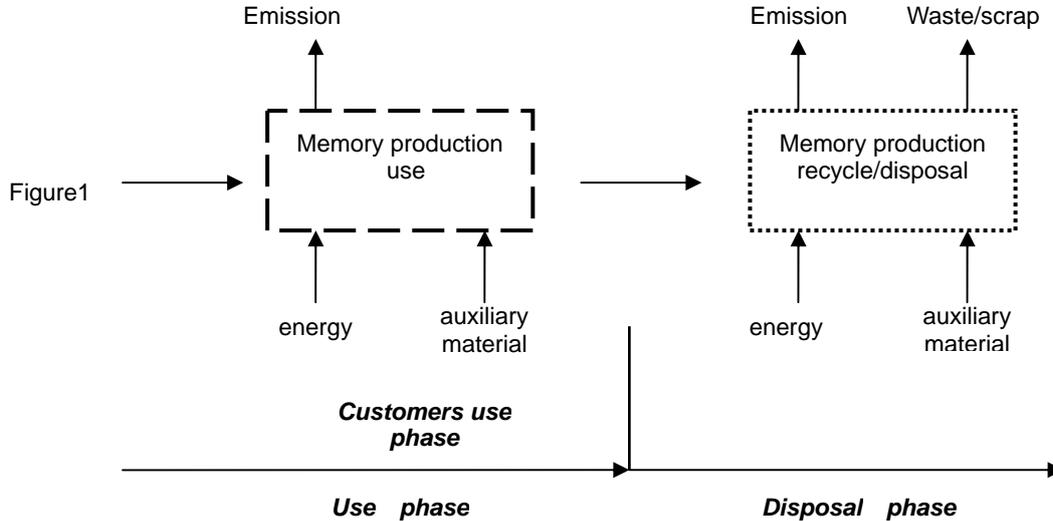
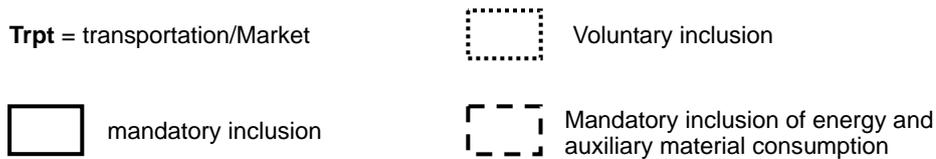


Figure 2 System boundary of the product use and final disposal system



Note:

1. The main material for wafer manufacturing means the material which remains on the wafer during the manufacturing process.
2. The main auxiliary material for wafer manufacturing means the material which is used during the manufacturing process but does not remain on the wafer after manufacturing, and its weight is greater than 1% of all auxiliary materials accumulated weight.
3. The other auxiliary material for wafer manufacturing means the material which is used during the manufacturing process but does not remain on the wafer after manufacturing, and its weight is less than 1% of all auxiliary materials accumulated weight.
4. Main assembly material means the material remaining on the memory chips or memory modules, not counting the chip/die or package.
5. Auxiliary assembly material means the material which is used during the manufacturing process but does not remain on the finished memory package products.
6. The calculation for assembly materials shall be based on the actual purchased amount.
7. If the memory product is sold to the customer in the form of memory wafer, the system boundary shall exclude the latter stage package assembly process. If the memory product is

sold to the customer in the form of memory package, the system boundary shall exclude the module assembly process. If the finished memory product is sold to the consumers, the use and waste disposal of memory product as described in Figure 2 shall be included in the system boundary.

8. The water and nitrogen consumption shall be calculated separately, and shall not be included as the total weight.

As described in Figure 1 & Figure 2 above, the life cycle of a memory product covers described phases. Provision of recycling information is of voluntary nature. (See Section 11).

Manufacturing Phase

The LCA shall include information for the following unit processes:

- Material extraction and manufacturing of main materials;
- Manufacturing of main auxiliary materials;
- Product manufacturing, assembly and packing;
- Transportation of materials and product.

The inclusion in the LCA the information on the material forming and refining and manufacturing of smaller parts is of the voluntary reporting nature. When voluntarily reported information is included, they shall be explained in the EPD.

Note:

1. The transportation is calculated as the transportation from the manufacturing site to the capital of destination country.
2. If the transportation responsibility has been predetermined, only the determined transportation is included.

Use Phase

The finished memory products are usually used on the computers, communications, consumer electronics products. Their main applications are:

- (1) If the memory is a component of the computers, communications, consumer electronics products. The memory's energy consumption is combined into the end product declared.
- (2) If the memory product is an end product by itself, the energy consumption of the product during load mode and standby mode shall be provided. The testing of such energy consumption shall be conducted in accordance with the applicable testing

method in the country where the product is used, such as ETSI EN 300019-1-3.

(2.1) Load mode: The memory is connected to the computers, communications, consumer electronics products with read-write process. Energy consumption expressed in unit of watt (W), such as 2.5W.

(2.2) Standby mode: The memory is connected to the computers, communications, consumer electronics products without read-write process. Energy consumption expressed in unit of watt (W), such as 0.45W.

Recycling/end of life

The reporting of recycling information (such as recycling and dis-assembly report and information on recycling channels) is mandatory in the EPD.

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

The classification of waste category shall be based on the local waste legislation of the product manufacturing site. If the waste will be treated through water treatment or incineration, these processes need to be included; landfilling process does not need to be included.

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.

Boundaries in the life cycle

The boundaries in the product life cycle are described in Figure 1 & Figure 2. 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 phase, 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 phase, 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 phase 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 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%. Constituents 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 phase 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 phase, 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.

The following units shall be used:

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"

Note: The dimension unit for the wafer is “inch” or “mm”.

9. Calculation rules and data quality requirements

- Site specific data (for example, specific factory data or transportation data for a specific manufacturing process) shall be for the production of main materials for wafer and packaging, and main auxiliary materials, as well as the wafer manufacturing and packaging. If other types of information are used, description of the information and rationale for using the information shall be provided.
- Generic data may be used in the manufacturing process for the minor (not main) components or materials of the products. Generic data may also be used for the production of bulk materials (see Appendix I for sources of generic data). For example, when bulk raw materials are purchased from the spot market or waste is processed during waste processing; when suppliers refuse to provide specific data; or when even if generic data are used in place of specific data, there is only minor impacts 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 phases shall not be greater than 10% of total impacts for each impact category.
- The data shall be representative for the average of a specific year.

Date quality requirements for the manufacturing phase:

- Site specific data shall be used for the production of main assembly and main components.
- The electricity mix for the manufacturing phase 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 should 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 suppliers, the transportation modes and distances used by the suppliers shall be considered.

10. Parameters to be declared in the EPD

For the manufacturing phase, the following parameters shall be declared:

Energy Use MJ

Resource Use

(1) Water resource M³

(2) Other

(2.1) Use of non-renewable resources:

(2.1.1) without energy content

(2.1.2) with energy content

Use of renewable resources:

(2.2.1) without energy content

(2.2.2) with energy content

Impact equivalents expressed as potential environmental impacts

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

Additional information

Recyclable materials (optional)

Information on secondary materials (optional)

Waste classification as defined in local waste legislation.

11. Recycling information

The recycling information shall include information such as dis-assembly instructions, which parts/components are suitable for recycling (such as printed circuit board (PCB)) or not suitable for recycling.

Information for the parts which can not be recycled and therefore should be disposed of properly during the end-of-life phase 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 shall 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., QC08000 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.gednet.org/>;
- 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.

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.

When data from the following generic databases are used, the most current and updated data should be used:

Material	Database	Published
Taiwan LCA Database	DoITPro	2008
Steel	IISI (International Iron and Steel Institute)	1998
Copper	ICA (International Copper Association)	1998
Copper semi products	ICA (International Copper Association) + IME (Institut für Metallhüttenwesen und Elektrometallurgi, Aachen)	1998 1995
Electricity	ETH (Eidgenössische Technische Hochschule) Data combined with IEA (International Energy Agency) statistics 1998	1996
Aluminum	EAA (European Aluminum Association)	2000
Plastics (and some chemicals)	APME (Association of Plastics Manufacturers in Europe)	1993-1998
Electronic components	EIME (Environmental Information and Management Explorer) EcoBilan	1998-2000
Energy	Boustead model 5.0	2007
Industrial processes	Ecoinvent 2nd edition	2007
Energy	ETH ESU 96	2004
Packaging materials, transport, waste treatments	BUwAL 250, 2nd edition	2004

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:

- *EPD system logo (LOGOTYPE)*
- *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 phase (see Section 10)

Use phase (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 13)

- *relevant PCR documents*
- *EPD Requirements, MSR 2008:1.0*
- *underlying LCA study*
- *other supporting documents for LCA information*
- *other relevant documents regarding company/organization's environmental activities*