GENERAL PRINCIPLES FOR AN ENVIRONMENTAL COMMUNICATION ON MASS-MARKET PRODUCTS

PART 21: METHODOLOGY FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF REMANUFACTURED LASER-PRINTER TONER CARTRIDGES

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Technical coordination: *Edouard FOURDRIN* – **Division\Department:** Service Produits et Efficacité Matière

ADEME
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Contents

Preamble

This guide was prepared by working group WG 2 “Hardware–Equipment” attached to the “environmental communication on mass-market products” platform coordinated by ADEME (Mr. CAUDRON/Mr. FOURDRIN) with the AFNOR secretary (Mr. BALCAEN).

WG 2 coordinator: Catherine JAMMES (FICIME), replaced by Thomas ALBISSER (HOP CUBE) in 2014.

WG 1 co-coordinator: Mr FOURDRIN (ADEME)

The list of organisations involved in the follow-up, drafting and or making of this guide can be found at the end.

1. Reference data

1.1. Product category

This sector-specific guide applies to remanufactured laser-printer toner cartridges.

A remanufactured cartridge is understood to mean a cartridge manufactured from an OEM cartridge which has already been used once by a user.

This sector-specific guide concerns all-in-one printer (built-in drum) toner cartridges as well as OPC kit and toner refill kit solutions (working to the exact same functional unit). It does not include cartridges refilled directly in-shop (drill-and-fill).

The CPA code of the product family concerned is: 26.20.3 (Other units for computer and peripheral hardware).

The restricted field of the products concerned reflects the environmental information trial-project phase. Only remanufactured toner cartridges made it through the applicant selection process.

1.2. Functional unit

The essential function of laser-printer toner cartridges is to print onto a sheet of paper.

The functional unit adopted is defined as: "**Print 100 pages of A4 paper**".

The amount of pages printed by a printer cartridge is defined by international toner yield measurement standards ISO/IEC 19752 (for monochrome laser printers) and ISO/IEC 19798 (for colour laser printers).

To align with standards ISO/IEC 19752 and ISO/IEC 19798, single-sided printing is the mode considered in this guide, which therefore means that double-sided printing is not addressed here.

What?	Printing onto an A4 page
How much?	100 pages as per standards ISO/IEC 19752 and ISO/IEC 19798
How?	Single-sided printing in a print system
How much time?	Full page yield of the cartridge

1.3. Reference scenario

The reference flow associated to this functional unit shall be a fraction of toner cartridge depending on its page yield. This will make it possible to use the environmental communication to cross-compare different cartridges.

The basic hypothesis is that users use cartridges up until there is no toner left. However, this guide does integrate early replacement of the cartridge.

2. Environmental impact indicators

2.1. Selected indicators

The indicators selected are:

— Global warming

Anthropogenic activities drive increased emissions of greenhouse gases (GHGs) such as CO_2, methane CH_4 or halogenated compounds, leading to a rise in the average temperature on Earth and to climate change. These emissions are expressed in kg CO_2 equivalents and are based on IPCC models. The assessment method is IPCC 2007 in line with the recommendations set out in the general principles for an environmental communication on mass-market products (Part 0).

— Depletion of non-renewable natural resources:

The Earth has only finite amounts of natural resources such as minerals or fossil fuels, which makes it important to safeguard them and steward their use to allow future generations to meet their needs. The depletion of non-renewable natural resources is expressed in kg Sb equivalents. The assessment method is the CML, developed by Leiden University. The indicator on the depletion of non-renewable natural resources will need to be adapted in response to fresh good practice guide recommendations and the lessons learned from the trial phase.

2.2. Justification for adopted indicator choices

The indicators proposed under the environmental communication on mass-market products approach are inventoried in Annex A, which also gives the justification for the adopted environmental indicator choices.

2.3. Lifecycle inventory data at the source of the environmental impacts

Based on available environmental studies and current knowledge, the following stages have been identified as source of the above-cited environmental impacts. The life cycle inventory of a cartridge is presented in Annex B.

These items are summarized in the following table:

Environmental impacts	Impact source data
Global warming	Production of the plastic and metal component parts Production of the toner powder Collection (transportation) Re-assembly Packaging and transport Production of the electronic chips End-of-life processing
Depletion of non-renewable natural resources	Production of the plastic and metal component parts Production of the toner powder Collection (transportation) Re-assembly Packaging and transport Production of the electronic chips End-of-life processing

Figure 1 — Recap of the items at the source of the impacts

2.4. Degree of accuracy and calculation methodology

The previously identified environmental impacts shall be characterized using the environmental indicators listed in the table below. Figure 2 gives the unit of measurement, the uncertainty on the data as well as the calculation methodology for each impact indicator.

The indicators shall be expressed using ratios of the units mentioned in the table to the functional units defined earlier.

Environmental impact	Impact indicator	Unit used	Uncertainty on the data	Uncertainty on the methodology
Global warming	Greenhouse gas emissions	g CO_2 eq.	Low	Low
Depletion of natural resources	Depletion of natural non-renewable resources	g Sb eq.	Low	Low

Figure 2 — Unit, uncertainty and methodology for each indicator selected

3. Assessment scope for the selected indicators

3.1. Life cycle stages taken into account

The assessment covers the 5 stages in the life cycle of a toner cartridge, from production and collection of raw materials to manufacture, distribution and end-of-life.

Annex B gives a flowchart synopsis of the toner cartridge life cycle stages accounted for.

3.2. Exclusions

— Use-phase electricity and paper consumption:

These use-phase consumptions are excluded on a the rationale that they are independent of the cartridge used. Furthermore, trial-phase modelling of toner cartridge electricity consumption found that it generated just 1 % of total impact.

— Deinking (paper):

As deinking (paper) has only a marginal impact (< 2 % of total impact), it is excluded from the assessment scope.

— Other out-of-scope flows:

R&D and support services. Their impacts cannot viably be attributed to any modelled baseline reference.

3.3. Allocation rules

For the production phase, a per-cartridge unit-based allocation of water, detergent (used to clean remanufactured cartridges) and electricity consumption shall be accounted for in the environmental impact calculations for sites where production is one-product-only manufacture.

3.4. Conditions for taking into account end-of-life processes

There are four potential end-of-life scenarios for a cartridge:

— treatment of household waste;

— re-use (remanufacturing);

— materials recycling into a new cartridge, including in-stream (closed-loop) materials recycling on the same production site;

— out-stream (open-loop) materials recycling into another product.

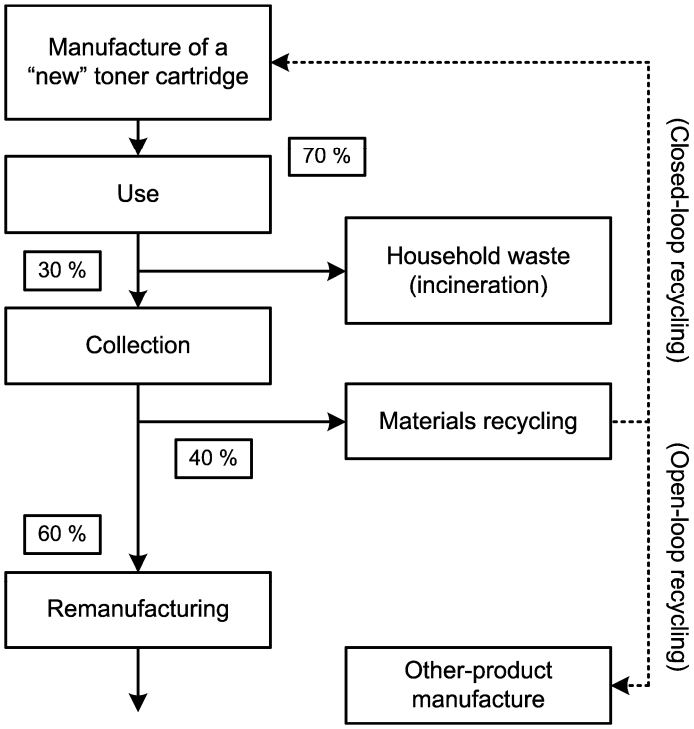


Figure 3 — Approach to accounting for end-of-life processes

Reuse is not a point addressed in the general principles for an environmental communication on mass-market products (Part 0). The methodology applied during the trial phase consists in spreading the impact of component parts manufacturing across all re-uses of the toner cartridge. This means that the impact of OEM parts manufacture is not allocated exclusively to the virgin OEM cartridge manufacturer.

The impact of collecting the used cartridges accounts for the following items:

— transport from collection to the waste sorting facility;

— product losses after the 1st round of sorting, which are then assumed to be incinerated;

— transfer to the warehousing site prior to shipment;

— transport to the production site;

— water and detergent use for cleaning the empty toner cartridges.

Energy consumption and toner powder waste on the production site are allocated to cartridge production and filling, and are thus entirely allocated to the new product.

4. Data qualification

4.1. Definitions

Primary activity data: (Definition given in the general principles for an environmental communication on mass-market products (Part 0)).

“Quantified value originating from a direct measurement or calculation from the direct measurements of an activity or a process of the product’s life cycle. This value is used, after multiplication by an emission or characterization factor, to calculate an impact category indicator.”

The primary data concerning toner cartridges are:

— masses and materials of the products and their (primary, secondary and tertiary) packaging and choice of forming processes;

— production site-related data: location, energy and water consumption, amount and treatment of waste generated, scrap rate;

— upstream and downstream transport modes and distances for the ingredients, packaging and finished products;

— number of pages each cartridge is capable of printing.

Semi-specific data: (Definition given in the general principles for an environmental communication on mass-market products (Part 0)).

This is “secondary data or generic data given by default but that may be specified by the operator to improve the environmental impact assessment. Similarly, it may be primary data or specific data that the operator needs to complete but for which a default value is given.”

Semi-specific data are data that have less influence or data that offer industry less room for manoeuvre. A set of default values is thus proposed but can readily be replaced with specific data if more precise figures are available. For example, distance travelled by downstream transport (see section 4.4 “Distribution phase”) is a category of semi-specific data.

Secondary data: (Definition given in the general principles for an environmental communication on mass-market products (Part 0)).

“Quantified value of an activity or life cycle process obtained from sources other than the direct measurement or calculation from direct measurements.”

The environmental assessment builds on secondary data sourced through the ADEME database and the ADEME/Ecoinvent database. This data focuses on the following points:

— production of component materials and energy;

— end-of-life of component materials.

Other literature, like national agency or company-specific statistics, have been used to determine:

— end-of-life of the packaging (recycling rate, fate of unrecycled packaging);

— end-of-life of the product (cartridge recovery rate, fate of unrecycled cartridges);

— used cartridge collection process.

4.2. Raw materials

The raw materials from which the product is built are either re-used parts from previously collected and cleaned cartridges, or parts produced from virgin raw materials.

The cartridges are fully disassembled and the component parts sorted into material streams and weighed. Each of these material masses is compounded with its associated material-specific, process-specific and transport-specific emission factors. These emission factors are taken from the Ecoinvent database.

The re-use scenario requires special modelling. At the time this work was undertaken, as the general principles for an environmental communication on mass-market products (Part 0) did not include the re-use formula, a specific formula was devised, as developed below, with input from the working group members.

The remanufactured toner cartridge re-uses some parts and adds new ones (toner, seam, etc.). This remanufactured cartridge thus comes with an extra added sub-scenario, i.e. part replacement, as certain parts get collected with the used cartridge but replaced by new ones and are not re-used. For these parts, the scope of impact includes collection of the OEM part that will get replaced plus its end-of-life, plus the impact of the new part manufacture and its end-of-life.

Furthermore, a given re-used part will go through a number of cycles before it finally gets eliminated. It has been decided to share the impact of this part across the entire life-cycle. The remainder of the impact will be the impact of part collection and clean-down.

In order to quantify and allocate the environmental impacts of re-use, it is necessary to stick to the formulae for the materials detailed in the general principles for an environmental communication on mass-market products (Part 0). The national-scale experimental trials employed the formula given below, which does not effectively meet the requirements set out under these general principles (see Annexe D):

$$E_{\text{part}} = \frac{1}{c} * E_{\text{new part}} + \left(1 - \frac{1}{c}\right) * E_{\text{re-used part}} + \frac{1}{c} * E_{\text{end-of-life}}$$

where:

c number of cycles completed by the part;

E_{part} impacts of the part under study;

$E_{\text{new part}}$ impacts tied to original manufacture of the part under study, based on the raw materials used. This includes raw materials production and extraction and processing into the final part;

$E_{\text{re-used part}}$ impacts tied to the collection and cleaning of the part under study;

$E_{\text{end-of-life}}$ impacts tied to the end-of-life of the product.

Number of cycles completed by the part (c):

The equation to use is developed in Annex D. A top threshold of 3 cycles has been set.

For new or replaced parts, number of cycles completed is 1. The impact of the virgin raw material is the only impact factored in.

If a cartridge manufacturer does not have its own rate figures for incoming part collection and sorting-grading, then the following secondary data can be used:

— pre-collection elimination through household waste: 70 % (in the absence of knowledge on OEM waste stream collection and recycling loops, the worst-case scenario has been adopted);

— collection: S = 0,3 (= 30 %). Fraction of cartridges entering the cartridge collection process;

— incineration or recycling after post-collection sorting = 0,4 (= 40 %);

— fraction of collected cartridges passed as remanufacture-ready, T = 0,6 (= 60 %).

NOTE These data will be revised in response to the conclusions of the framework report on participatory collection.

Electronic chip:

For the (replaced) chip, weight of the surface-mount components is estimated from the mean weights given in the Ecoinvent database.

Impact of the packaging:

The materials used to produce the packaging plus their allied processing processes and upstream transport are all accounted for.

4.3. Production phase

The production phase spans the full sequence of cartridge assembly, filling, and reconditioning as well as user-initiated advance replacement.

The production phase also covers the upstream stages of new-part and primary-packaging transport to the cartridge assembly site. Secondary-packaging (carton) and tertiary-packaging (pallet) transport are ignored.

Electricity consumption on the product site is accounted for, and the corresponding environmental impacts factor in the energy mix of the production-site host country.

Both water and detergent consumption are allocated to the cleaning process, which is the heaviest water user.

All off-spec/non-remanufacturable cartridges are accounted for in the impact of collecting used cartridges. Then, for these lost cartridges, their thermoplastic and metal ingredients go to recycling and their thermosetting polymers, foams and electronic chips go to incineration. Allocations to recycling shall apply the recommendations set out in the general principles for an environmental communication on mass-market products (Part 0).

A minor amount of toner can be recovered in a collected empty cartridge (semi-specific data to be defined on the production site). A 50/50 allocation can be used if this toner resource material is recovered for re-use.

The rate of user-initiated advance replacement shall be accounted for, via the latest reference post-sales service rates kept up to date by the manufacturers (=amount of defective cartridges / year-cumulative amount sold).

4.4. Distribution phase

The distribution phrase represents the downstream transport of finished product and its packaging from production site to the pre-distribution storage facility site in France. For storage facility sites outside France, it will be necessary to add the distance from storage site to the French border (for products put onto the French market).

In compliance with Annex B of the general principles for an environmental communication on mass-market products (Part 0), customer transportation to the point-of-sale is excluded.

4.5. Use phase

The use phase concerns printer energy consumption for print-outs. As it is excluded from the scope, this stage in the toner cartridge life cycle is not assigned an environmental impact (see 3.2 Exclusions).

4.6. End-of-life phase

The end-of-life phase is split into two streams:

— end-of-life of the packaging, which is modelled according to national percentage figures for recycling rates (for each type of material), incineration rates and landfill rates;

— end-of-life of the toner cartridge: either not recovered and thrown away with household waste, or collected for remanufacturing.

4.7. Data link-up table

See Annex C.

4.8. Integrating delayed emissions for carbon accounting

Integrating delayed emissions is not relevant to remanufactured toner cartridges as these products have only limited lifespan.

Carbon accounting is therefore done according to “default” approach stipulated in Annex B of the general principles for an environmental communication on mass-market products (Part 0).

5. Validation process for data and results

Information related to the elaboration of labelling shall be made free, transparent and accessible to all, via appropriate channels (reports, websites, etc.). This information relates to the hypotheses, the data acquisition methods, the articulation between primary and secondary data, the emissions factors and the assessment's limitations. There is no obligation to communicate the following data to consumers:

— weight of the primary packaging;

— detailed mass composition (by material) of the cartridge (metal, plastics, etc.);

— specific distances and modes of transportation for procurement channels;

— locations of production sites and characteristics of the component cartridge parts.

This data shall, however, be kept for the inspection authorities. It shall specify and retain:

— the primary data;

— the sources of the secondary data;

— the default values adopted.

The data retention period will be set later.

6. Annexes

Annex A: Impact indicator selection matrix

Annex B: Equations accounting for re-use

Annex C: Data link-up table

List of the people involved in the follow-up, drafting and/or making of this guide

List of the organizations involved in the follow-up, drafting and/or making of this guide

Companies attending the Environmental Communication platform meeting held 09-04-2014

Annex A
(informative)

Impact indicator selection matrix

	Greenhouse gas emissions	Depletion of non-renewable natural resources	Photochemical pollution	Eutrophication	Acidification	Aquatic ecotoxicity	Depletion of water resources (studied from the consumption-side perspective)	Ultimate waste production	Total primary energy consumption	Biodiversity	Ozone depletion	Human toxicity	Emission of inorganic particulates	Ionizing radiation	Ecotoxicity (terrestrial and saltwater)	Land and soil change
Relevance																
Evaluation of an environmental issue in the product category and attributable to product	Mandatory	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes						
Importance of the issue	Important	Important	Relevant	Less relevant	Relevant	Relevant	Relevant	Relevant	Relevant	Relevant						
Differentiation for a majority of products on the market (comparability)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not studied because the issue is difficult to assess						
Redundancy with other indicators	No	Yes, with indicator of primary energy use	No	No	No	No	No	No	Yes, with depletion of non-renewable natural resources	Not studied because the issue is difficult to assess						
Makes it possible to highlight eco-design options	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not studied because the issue is difficult to assess						
Implementation, feasibility																
Possibility/ease to implement for the database	Yes	Yes	Yes	Yes	Yes	Yes	No. Flow indicator.	No. Flow indicator.	No. Flow indicator.	Not studied as the characterization method has not been defined						
Accessibility to primary data required to characterize the indicator	Yes	Yes, difficult to obtain for the other non-production life cycle stages	Yes, difficult to obtain for the other non-production life cycle stages	Yes, difficult to obtain for the other non-production life cycle stages	Yes, difficult to obtain for the other non-production life cycle stages	Accessible data is a little shaky, as the challenge lies with the ink formula, elements of which remain trade secret	Yes, difficult to obtain for the other non-production life cycle stages	Yes, difficult to obtain for the other non-production life cycle stages	Yes, difficult to obtain for the other non-production life cycle stages	Not studied because the issue is difficult to assess						
Consistency																
Consistency with the recommendations of the ADEME/AFNOR platform (general platform, methodology WG, sector-specific WGs)	Yes	Yes	Yes	Yes	Yes	Yes	Yes. Only flow indicator authorized by the general principles for an environmental communication on mass-market products (Part 0)	No. General principles (part 0) emphasize the impact indicators to flow indicators.	No. General principles (part 0) emphasize the impact indicators to flow indicators.	Yes						
Life cycle scope	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not studied as the characterization method has not been defined						
Product/packaging scope	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not studied as the characterization method has not been defined						
Consistency with other indicators displayed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not studied as the characterization method has not been defined						
Robustness, reliability																
Scientific and international recognition	Yes	Present in the ILCD handbook (draft)	Present in the ILCD handbook (draft)	Present in the ILCD handbook (draft)	Present in the ILCD handbook (draft)	Present in the ILCD handbook (draft)	Present in the ILCD handbook (draft)	Not included in the ILCD handbook (draft)	Not included in the ILCD handbook (draft)	Present in the ILCD handbook (draft)						
Methodological robustness	IPCC 2007 100a	EDIP 97 (2004). Classification II in ILCD handbook (draft)	Recipe 2008. Consensus-built method	Recipe 2008. Consensus-built method	Recipe 2008. Consensus-built method	USEtox. Classification II/III in the ILCD handbook (draft)	Temporary methodology defined in general principles (part 0)	No defined methodology in general principles (part 0)	No defined methodology in general principles (part 0)	No defined methodology in general principles (part 0)						
Reliability of the modelling component (computation rule)	Good	Good	Good	Good	Good	Medium	Good	Good	Good	Not studied because the issue is difficult to assess						
Expected reliability of primary data	Good	Good	Good	Good	Good	Medium	Good	Good	Good	Not studied because the issue is difficult to assess						
Reliability of the secondary data available	Good	Good	Good	Good	Good	USEtox is a recent methodology so it is underused or unavailable in the characterized databases. In addition, the characterization factors for detergents need to be developed	Good	Good	Good	Not studied because the issue is difficult to assess						
Conclusion	Adopted	Adopted	Not adopted	Not adopted	Not adopted	Not adopted	Not adopted	Not adopted	Not adopted	Not adopted	Not adopted as not detailed in in general principles (part 0)at the time the work was completed					

Annex B
(informative)

Equations accounting for re-use

B.1 Number of cycles completed by a remanufactured cartridge

c = number of cycles completed by a remanufactured cartridge

1 : first cycle—new,

+ 1 : first cycle—remanufactured,

+ $(S \times T)$: second cycle—remanufactured,

+ $(S \times T)$ + $(S \times T)$: third cycle—remanufactured,

etc.

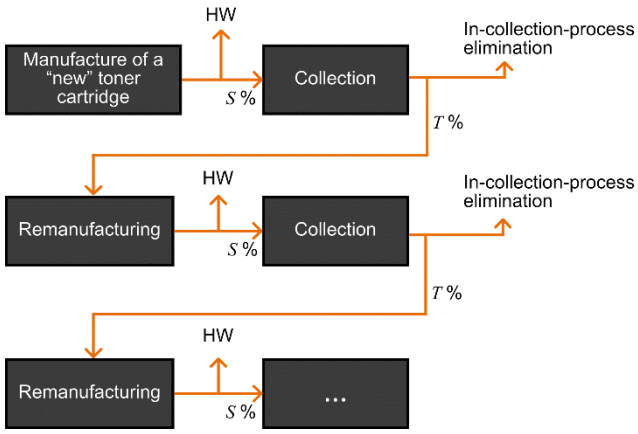
$c = 1 + 1 + (S \times T) + (S \times T)^2 + \ldots + (S \times T)^n$

$c = 1 + (S \times T)^0 + (S \times T)^1 + (S \times T)^2 + \ldots + (S \times T)^n$

$$c = 1 + \sum_{n=0}^{+\infty} (S * T)^n$$

$S*T < 1$, the geometric series $\sum_{n=0}^{+\infty} (S * T)^n$ thus converges towards $\frac{1}{1-(S*T)}$

Hence: $c = 1 + \frac{1}{1-(S*T)}$



B.2 Cartridge completing a remanufacturing cycle

The impact of the manufacture and disposal of the new cartridge is split across all the cartridge cycles. Likewise, the impact of the remanufacturing cycles is split across all the cartridge cycles.

For new cartridges that only complete one cycle, new part manufacture and disposal is fully allocated entirely to this cartridge.

For a remanufactured cartridge:

$$E_{part} = (1/c\ E_{new\ part} + (1 - 1/c)\ E_{re\text{-}used\ part} + 1/c\ E_{end\text{-}of\text{-}life})$$

Annex C
(informative)

Data link-up table

		PCR						IMPACTS BASE		
		Primary data		Semi-specific data		Secondary data				
Stage	Sub-stage	Activity-related data, to be linked to in-Base inventory data	Elementary flows and data without direct links to the Base	Activity-related data, to be linked to in-Base inventory data	Elementary flows and data without direct links to the Base	Activity-related data, to be linked to in-Base inventory data	Elementary flows and data without direct links to the Base	Generic inventory data		
								Processes	Technical representativeness	Geographical representativeness
Raw materials		- Amounts and types of materials (including, where relevant, percent recyclate) in the finished toner cartridge						- Injection / Extrusion / other processes	PP, PS, 15 % GF-PET and POM injection moulding / PUR and toner powder extrusion / aluminium, steel and electronic chip production (to be detailed for the chip)	Worldwide
		- Amounts and types of materials (including, where relevant, percent recyclate) in the finished primary packaging, secondary packaging (e.g. groupage carton) and tertiary packaging (e.g. pallets)						- Production of packaging materials Forming of packaging materials	Carton, PE sachet and wood pallet	Worldwide
		Upstream transport modes and distances						Transportation	Air, land and sea	See IMPACTS base
Production	Production	- Country				- Electricity consumption		- Electricity generation	Mean consumption figures of the energy mix	Worldwide
	Scrap					- Production waste management			- Landfilling - Incineration with energy recovery - Incineration without energy recovery	Worldwide
	Post-sale services		Planned rate of user-led replacement							
Downstream transport		Downstream transport modes and distances						Transportation	Air, land and sea	See IMPACTS base
End-of-life	Treatment of end-of-life cartridges					HW treatment scenario		- End-of-life waste treatment processes	- Landfilling - Incineration with energy recovery - Incineration without energy recovery	France
	Treatment of end-of-life packaging waste					End-of-life packaging treatment scenario		- End-of-life waste packaging treatment processes	- Landfilling - Recycling - Incineration with energy recovery Incineration without energy recovery	France

List of the people involved in the making of this guide

SURNAME Name	Company
HALLE Patrick	ARMOR
SALZAT Laurent	ARMOR
THEBAUD Régis	ARMOR
BOISANTE Sylvie	BROTHER
SICSIC Pierre	HP
THOMAS Sylvie	LEXMARK
TREMBLAY Florian	SAGEM
GIROT Caroline	SGS

List of the organizations involved in the follow-up, drafting and/or making of this guide

ACCENTURE HOLDING FRANCE SAS
ACDLEC - ASSO CTRES DISTRIBUTEURS E LECLERC
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CALOR SAS - GROUPE SEB
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CAROLINE SOREZ - CAECO
CARREFOUR
CARREFOUR CMI
CARTON ONDULE DE FRANCE
CCD - CENTRE DE LA CONSOMMATION DURABLE
CCI DE SEINE ET MARNE
CETIM

CGDD - COMMISSARIAT GAL DEVELOPPEMENT DURABLE

CLIMAT MUNDI

CODDE - CONCEPTION DVPT DURABLE ENVT

CONFORAMA FRANCE

COOPERATIVE MU

CRP HENRI TUDOR

CSO CNRS

CTIF

CTP - CENTRE TECHNIQUE DU PAPIER

DECATHLON

DECATHLON SA - B TWIN

DGCCRF

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DYSON SA

ECO CONCEVOIR

ECO FOOTPRINT

ECO SYSTEMES

ECO2 INITIATIVE

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MARION HUET
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List of organizations attending the validation of this guide (at the Environmental Communication platform meeting held 09 April 2014)

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ADEME
20, avenue du Grésillé
BP 90406 | 49004 Angers Cedex 01

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