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Revision of EU Green Public Procurement (GPP) criteria for Imaging Equipment

Preliminary Report

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GLOSSARY

AHWG	ad-hoc Working Group
BAT	Best Available Technology
BBP	Butyl phthalate
BREF	Reference Document on Best Available Techniques
CEN TC	European Committee for Standardization Technical Committee
CMR	carcinogenic, mutagenic or toxic for reproduction
CO_2	Carbon dioxide
dB	deciBell
DIBP	Diisobutyl phthalate
DIDP	di-isodecyl phthalate
DINP	di-isononyl phthalate
DNOP	di-n-octyl phthalate
DS	Dye Sublimation
DT	Direct Thermal
ECMA	European Computer Manufacturers Association
EEE	Electric and electronic equipment
EMC	Electromagnetic compatibility
EP	Electrophotography
EPA	United States Environmental Protection Agency
EU	European Union
GPP	Green Public Procurement
H	Hazard statement
IJ	Ink Jet
ISO	International standardisation organisation
ipm	images per minute
IT	Information technology
ISO	International Standardisation Organisation
LCA	Life cycle assessment
MFDs	multifunctional devices
MFPs	multifunction / multifunctional products
MS	Member State
NACE	Nomenclature Générale des Activités Économiques dans les Communautés Européennes
PBBs	polybrominated biphenyls
PBDEs	polybrominated diphenyl ethers
PCs	Personal computers
PJ	Peta Joule
R	risk phrase
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
Sbw	monochrome printing/copying speed
SCCP	short chain chlorinated paraffins
SDS	Safety Data Sheets
SI	Solid Ink
TBBPA	Tetrabromobisphenol-A
TT	Thermal Transfer
TVOC	Total volatile organic compounds
UBA	German Federal Environment Agency

1 INTRODUCTION

This draft task report is intended to provide the background information for the revision of the EU Green Public Procurement (GPP) criteria for Imaging Equipment.
The EU GPP assists public authorities seeking to procure environmentally friendly goods and services with a reduced environmental impact along their life cycle. The GPP criteria are based on the requirements addressed in the Communication COM (2008) 400 "Public Procurement for a better Environment"[1].
The criteria for Imaging Equipment (printers, copiers and multifunctional devices) will be revised on the basis of the environmental information derived from Life Cycle Assessment and product oriented environmental performance assessment studies. However, safety, technical and functional aspects will be also considered.
The study is carried out by the Joint Research Centre's Directorate B - Growth and Innovation (JRC) with input from the project team which is a consortium from six consulting companies. The work is being developed for the European Commission's Directorate General for the Environment.
The revision of the GPP criteria is done through a stepwise process consisting of four tasks and several reports:

Preliminary report (this report)

Task 1: Scope and definition
Task 2: Market analysis
Task 3: Technical analysis, including environmental, technical and functional aspects of imaging equipment

Technical report

Task 4: Draft criteria proposal

The technical report will be revised along the stakeholders consultation process and several versions will be published.
An important part of the process for revising the GPP criteria is the involvement of stakeholders through, firstly, the collection of their feedback about the scope, definitions, criteria and applicability of the current criteria by an online stakeholders' survey[2]. Secondly, by the publication of and consultation on draft technical reports and through stakeholder involvement in working group meetings.
It is important to note that the recent fitness check of EU Ecolabel Regulation has led to the discontinuation of the EU Ecolabel for imaging equipment product group. However, considering the correlation between the EU Ecolabel and GPP criteria, an assessment of the EU Ecolabel scope and criteria has been considered relevant during the GPP revision. Therefore, in addition to the GPP scope and criteria, the EU Ecolabel is assessed and covered to certain extent in the following tasks.

Below is a brief description of the single tasks (1 to 3) covered by this preliminary report.

1.1 Aim of task 1: Scope and definition

The aim of task 1 is to provide an overview of existing statistical and technical categories, relevant legislation and standards, and to propose on that basis the scope and definition of the product for the revised criteria. In a second step, feedback has been gathered from stakeholders regarding the practicability of the proposed product group definition and scope as well as the revised criteria. Based on this stakeholder feedback, the product group definition and scope is confirmed, or a revised scope and definition of the product group is proposed.

[1] *COM(2008) 400 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, Public procurement for a better environment, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0400:FIN:EN:PDF*
[2] *Published online and sent to stakeholders on the 10th of March 2017.*

In chapter 2.1, the existing product scope, categorisation and definitions used in current GPP is compared to any updates on related products' classification in statistical sources like Prodcom, NACE and Common Procurement Vocabulary (CPV). This comparison is then cross-checked against recent legislation, standards, voluntary agreements and procurement criteria.
Afterwards, an overview of applied metrics to measure environmental performance in recent legislation, standards, voluntary agreements and procurement criteria is presented in chapter 2.4 with the aim of summarising the environmental requirements on imaging equipment and/or associated consumables covered in each of the other existing initiatives.
The scope and definition assessment is supplemented with feedback gathered from stakeholders from the online survey (see chapter 2.5).
Finally, the recommended revised product scope and definitions are presented as the main outcome of this task 1 in chapter 2.6. However, further modifications might be proposed at a later stage in response to further information and discussions with stakeholders. In addition, preliminary recommendations on the criteria coverage for this revision will be presented based on the assessment of other initiatives.

1.2 Aim of task 2: Market analysis

The aim of task 2 is to collect key market data for imaging equipment, including the information that affect public procurement practices in order to be confident that the proposed criteria developed are up-to-date and relevant.

The first step is to establish the current technical state-of-play of imaging equipment products currently on the EU market. These include production, use, management and end-of-life practices, as well as important aspects related to the products' lifetime relevant for the development of the GPP criteria. This analysis is presented in chapter 3.1.

The second step is to establish an overview of the procurement practices in the EU focusing, on public procurement including best practice. This overview is presented in chapter 3.2.

The third step is to identify the key actors in the value chain, with particular emphasis on those involved in public procurement. This is presented in chapter 3.3.

The fourth step is to establish the market size of the imaging equipment products identified scope in task 1, with a focus on public procurement. This is presented in chapter 3.4.

The fifth step is to assess the life cycle costs of imaging equipment products to investigate where the highest costs during their life cycle incur, and if there are differences between the different technologies and the different amount of printouts delivered that are delivered per device. This is presented in chapter 3.5.

Finally, the conclusions and recommendations are presented, focusing on any potential change to the scope proposal presented in task 1.

1.3 Aim of task 3: Technical analysis

The aim of task 3 is to identify systematically, quantitatively and qualitatively the key environmental hotspots arising during the life cycle of imaging equipment products, which serves as the basis to establish improvement options considering other best practices by other schemes and initiatives and by best available technologies in the market.

The first step is to perform a comprehensive review of LCA studies by selected reports and articles with the aim of identifying the main sources of environmental impacts throughout the life cycle of imaging equipment products, including their consumables. This review is presented in chapter 4.1.

The second step is to look at the key environmental performance indicators that other environmental schemes and initiatives currently use. These serve as best practices and complement to the hotspots identified in chapter 4.1. This overview is established in chapter 4.2.

The third step is to look at the best available technologies in the market, concerning energy and material efficiency aspects. These complement the best practices and hotspots from chapters 4.1 and 4.2. This overview is presented in chapter 4.3.

The fourth step is to present an overview of the stakeholder survey and assess the inclusion or exclusion of aspects the stakeholders consider relevant/irrelevant, once the rest of the information has been collected to assess appropriateness. This is presented in chapter 4.4.

The fifth step is to identify the improvement options according to the information collected. This is presented in chapter 4.5.

Finally, the conclusions and recommendations are presented, focusing on the identification of the hotspots, best practices and improvement options. This is presented in chapter 4.6.

2 TASK 1: SCOPE DEFINITION AND REVIEW OF ENVIRONMENTAL INITIATIVES

2.1 Review of existing product categorisation

2.1.1 Existing scope, product categorisation and definitions in current EU Green Public Procurement (GPP) for imaging equipment

The scope of the current EU GPP criteria[3] on imaging equipment is harmonised with the scope of the current EU Ecolabel criteria[4] for imaging equipment. Imaging equipment categorisation in the EU GPP criteria also mirrors that of the EU Ecolabel.

The current scope covers a wide range of products designed for use in office and domestic environments. They are based on the product scope and categorization found in the ENERGY STAR v2.0 specification for imaging equipment, which has also been adopted, in part, for use in the EU Voluntary Agreement on imaging equipment. Using the ENERGY STAR scope and categorization as a basis provides a useful degree of harmonization for these international traded products.

The GPP defines the scope as the "*procurement actions for the purchase and the leasing of imaging equipment".*

GPP defines 'imaging equipment' product group as the products which are marketed for office or domestic use, or both, and whose function is one or both of the following:

(a) to produce a printed image in the form of paper document or photo through a marking process either from a digital image, provided by a network/card interface or from a hardcopy through a scanning/copying process ;

(b) to produce a digital image from a hard copy through a scanning/copying process.

This set of criteria also applies to products which are marketed as printers, copiers and multifunctional devices (MFD)"

The current definitions included in the EU GPP document are as follows:

*'**Printer**' means a commercially available imaging product that serves as a hard copy output device, and is capable of receiving information from single-user or networked computers, or other input devices, where the unit is capable of being powered from a wall outlet or from a data or network connection;*

***'Large format printing equipment**' means printing equipment designed for printing on A2 media and larger, including those designed to accommodate continuous-form media above or equal to 406 mm wide"*

*'**Copier**' means a commercially available imaging product whose sole function is the production of hard copy duplicates from graphic hard copy originals, where the unit is capable of being powered from a wall outlet or from a data or network connection;*

*'**Multifunction device**' means a commercially available imaging product which is a physically integrated device or a combination of functionally integrated components that performs two or more of the core functions of copying, printing, scanning, or faxing, where the unit is capable of being powered from a wall outlet or from a data or network connection and the copy functionality is distinct from single sheet convenience copying offered by fax machines;*

The following definitions are used in order to distinguish the energy use in standby mode:

[3] *EU GPP Criteria for Imaging Equipment, available from http://ec.europa.eu/environment/gpp/pdf/criteria/imaging/EN.pdf*

[4] *COMMISSION DECISION of 17 December 2013 establishing the ecological criteria for the award of the EU Ecolabel for imaging equipment (notified under document C(2013) 9097) (Text with EEA relevance) (2013/806/EU), available from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D0806*

'***Networked equipment***' *means equipment that can connect to a network and has one or more network ports;*

'***Network port***' *means a wired or wireless physical interface of the network connection located at the equipment through which the equipment is able to be remotely activated;*

'***Imaging equipment with high network availability functionality***' *(imaging equipment with HiNA functionality) means imaging equipment with the functionalities of a router, network switch, wireless network access point or combination thereof.*

Whilst the GPP has a broad scope there are several types of imaging equipment that are excluded from scope, namely: fax machines, digital duplicators, mailing machines and scanners. Other types of imaging equipment (called "large products" in the GPP document) are also removed from scope where they meet one of the following conditions:

"The criteria do not cover the following product types:

- fax machines, digital duplicators, mailing machines and scanners.

- large products which are not typically used in offices if they meet one of the following technical specifications:

- *standard black and white format products with maximum speed over 66 A4 images per minute;*
- *standard colour format products with maximum speed over 51 A4 images per minute*
- *products designed for A2 media and larger; or*
- *products marketed as plotters.*

(speed to be rounded to the nearest integer)."

In addition to imaging equipment, the criteria include certain requirements for ink and toner consumables and substances contained in them, but it does not cover consumables (for instance ink or toner cartridges) as separate product categories.

2.2 Product categorisation in statistical sources: PRODCOM, NACE, Common Procurement Vocabulary (CPV) and Common Nomenclature (CN)

There are several product categorisation systems used within the EU which could be used to provide statistical information about imaging equipment within scope of the EU GPP criteria.

Figure 1 provides an overview of how the categorisation systems discussed below interrelate.

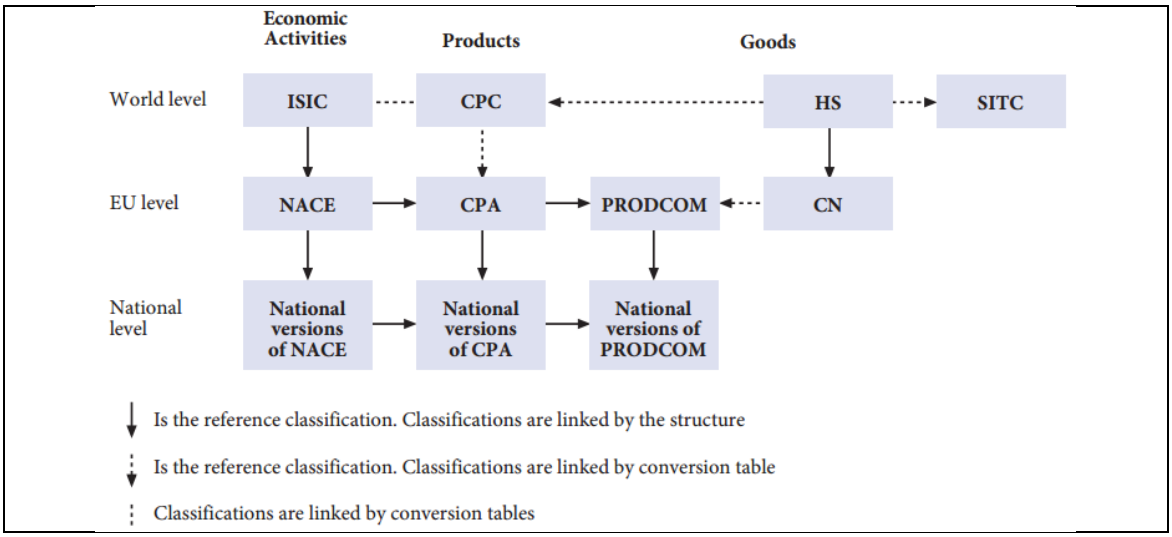

Figure 1. Overview of categorisation in statistical sources[5]

2.2.1 Prodcom – statistics by product

PRODCOM, derived from the French "PRODuction COMmunautaire" (Community Production) for mining, quarrying and manufacturing is the system used in Eurostat for the collection and dissemination of statistics on the production of manufactured goods. It is based on a product classification scheme which consists of about 3900 headings relating to manufactured products[6]. The classification of the products in PRODCOM follows the statistical classification of economic activities in the European Community known as NACE (Nomenclature des activités économiques dans la Communauté Européenne). Products are defined by an eight-digit code in which the first four digits refer to the NACE classification.
There are relatively few PRODCOM codes that relate to domestic and office imaging equipment and associated products that may be within scope of any potential future update to the EU GPP criteria on imaging equipment. The products covered under these categories are listed in Table 1.

[5] *Eurostat, NACE Rev. 2, Statistical classification of economic activities in the European Community, available from http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF/dd5443f5-b886-40e4-920d-9df03590ff91?version=1.0*
[6] *European Commission, Eurostat - Prodcom - statistics by product, available from http://ec.europa.eu/eurostat/web/prodcom*

Table 1. Prodcom code and description for imaging equipment in scope

Product group	Prodcom code and description
NACE 26.20: Manufacture of computers and peripheral equipment	26.20.16.40
	Printers, copying machines and facsimile machines, capable of connecting to an automatic data processing machine or to a network (excluding printing machinery used for printing by means of plates, cylinders and other components, and machines performing two or more of the functions of printing, copying or facsimile transmission)
	26.20.18.00
	Machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network
NACE 28.23: Manufacture of office machinery and equipment (except computers and peripheral equipment)	28.23.21.00
	Photo-copying apparatus incorporating an optical system or of the contact type and thermo-copying apparatus
	28.23.26.00
	Parts and accessories of printers of HS 8443 3
NACE 20.30: Manufacture of paints, varnishes and similar coatings, printing ink and mastics	20.30.22.73
	Organic composite solvents and thinners used in conjunction with coatings and inks; based on butyl acetate
	20.30.22.79
	Organic composite solvents and thinners used in conjunction with coatings and inks (excluding those based on butyl acetate)
	20.30.24.50
	Black printing inks
	20.30.24.70
	Printing inks (excluding black)

Given the broad-brush nature of the PRODCOM codes, they are unlikely to be able to provide an accurate picture of the production quantities of different types of imaging equipment. For example, the first code "26.20.16.40" covers a very wide range of imaging equipment, some of which is unlikely to be covered under the scope of the EU GPP criteria, covering products as diverse as battery operated mobile printers to some types of production printer. In addition, there is some uncertainty around the inclusion of substances used in ink and toner and so it is unclear which PRODCOM codes are relevant for the EU GPP criteria in these instances.

2.2.2 NACE – Statistical classification of economic activities

The NACE codes are also used for statistical classification of economic activities in the European Community.[7] NACE is the acronym used to designate the various statistical classifications of economic activities developed since 1970 in the European Union. NACE provides the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment, national accounts) and in other statistical domains. Table 2 illustrates the NACE economic activity codes that are relevant for the EU GPP criteria on imaging equipment.

[7] *Eurostat, Glossary: Statistical classification of economic activities in the European Community (NACE), available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)*

Table 2. NACE economic activity codes relevant to the EU Ecolabel and EU GPP criteria on imaging equipment

Section	Division	Group	Class	Description
SECTION C — MANUFACTURING	20	20.3	20.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
	26	26.1	26.11	Manufacture of electronic components
		26.2	26.20	Manufacture of computers and peripheral equipment
		26.3	26.30	Manufacture of communication equipment
		26.4	26.40	Manufacture of consumer electronics
		26.7	26.70	Manufacture of optical instruments and photographic equipment
	33	33.1	33.13	Repair of electronic and optical equipment

As with the other classification systems, the NACE economic activity codes do not provide a sufficient level of detail to clearly identify economic activities associated with imaging equipment.

2.2.3 Common Procurement Vocabulary (CPV)

The common procurement vocabulary (CPV) establishes a single classification system for public procurement aimed at standardising the references used by contracting authorities and entities to describe procurement contracts[8]. There are approximately 10,000 CPV codes in total covering a wide range of products and services that are procured by EU governmental organisations. The use of CPV codes is mandatory when publishing public procurement contracts through the Official Journal of the EU.[9] The CPV codes that are likely to be relevant for the EU GPP criteria are shown in Table 3.

Table 3. CPV code and description for imaging equipment in scope

CPV code	CPV description
30120000-6	Photocopying and offset printing equipment
30121000-3	Photocopying and thermocopying equipment
30121100-4	Photocopiers
30121200-5	Photocopying equipment
30121300-6	Reproduction equipment
30121410-0	Faxswitch machines
30121420-3	Digital senders
30121430-6	Digital duplicators

[8] *COMMISSION REGULATION (EC) No 213/2008 of 28 November 2007 amending Regulation (EC) No 2195/2002 of the European Parliament and of the Council on the Common Procurement Vocabulary (CPV) and Directives 2004/17/EC and 2004/18/EC of the European Parliament and of the Council on public procurement procedures, as regards the revision of the CPV, available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:074:0001:0375:EN:PDF*

[9] *SIMAP (système d'information pour les marchés publics), Codes and nomenclatures – CPV, available from https://simap.ted.europa.eu/cpv*

CPV code	CPV description
30124000-4	Parts and accessories of office machines
30124100-5	Fusers
30124110-8	Fuser oil
30124120-1	Fuser wiper
30124130-4	Fuser lamps
30124140-7	Fuser cleaning pad
30124150-0	Fuser filters
30124200-6	Fuser kits
30124300-7	Drums for office machine
30124400-8	Staple cartridges
30124500-9	Scanner accessories
30124510-2	Endorsers
30124520-5	Scanner document feeders
30125000-1	Parts and accessories of photocopying apparatus
30125100-2	Toner cartridges
30125110-5	Toner for laser printers/fax machines
30125120-8	Toner for photocopiers
30125130-1	Toner for Data-processing and Research and Documentation centres
30131700-3	Stamp cancelling machines
30131800-4	Stamp affixers
30141300-2	Printing calculators
30174000-9	Label making machines
30192112-9	Ink sources for printing machinery
30192113-6	Ink cartridges
30192340-6	Facsimile ribbons
30232100-5	Printers and plotters
30232110-8	Laser printers
30232120-1	Dot-matrix printers
30232130-4	Colour graphics printers
30232140-7	Plotters
32552200-9	Teleprinters
32581200-1	Fax equipment
48773100-8	Print-spooling software package
48824000-0	Printer servers

There are many CPV codes that reflect the range of products within the current scope of the EU ecolabel and EU GPP criteria on imaging equipment. Whilst some CPV codes are very product specific (e.g. 30124200-6 Fuser kits), the codes can also be ambiguous in terms of which type of imaging equipment product they are covering (e.g. 30232100-5 Printers and plotters). The codes could also cause some confusion where multifunctional devices (MFDs) are concerned since they do not readily fit under any of the codes. Despite the imperfect nature of the CPV codes they provide further product differentiation of the PRODCOM codes.

2.2.4 Combined Nomenclature

When goods are imported or exported within the EU they need to be classified according to the Combined Nomenclature (CN).[10] The CN code is also used in intra-Community trade statistics. The CN is comprised of the Harmonized System (HS) nomenclature, which is managed by the World Customs Organisation (WCO), with further Community subdivisions. Most trading nations around the world use this systematic list of commodities as they form the basis for international trade negotiations. The CN also includes additional notes on CN subdivisions to provide further clarity on what is covered under each code. Each CN subdivision is made up of an eight-digit code number (i.e. the CN code) followed by a description.
Table 4 illustrates the CN codes that are likely relevant for the EU GPP criteria on imaging equipment.

Table 4. CN code and description for imaging equipment in scope

CN Product group	CN code and description
8443 Printing machinery used for printing by means of plates, cylinders and other printing components of heading 8442; other printers, copying machines and facsimile machines, whether or not combined; parts and accessories thereof:	8443 19 70
	Other - Other printers, copying machines and facsimile machines, whether or not combined
	8443 31 00
	Machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data-processing machine or to a network
	8443 32
	Other, capable of connecting to an automatic data-processing machine or to a network
	8443 32 10
	Printers
	8443 32 80
	Other
	8443 39 00
	Other - Parts and accessories
3707 Chemical preparations for photographic uses (other than varnishes, glues, adhesives and similar preparations); unmixed products for photographic uses, put up in measured portions or put up for retail sale in a form ready for use:	3707 90 21
	Thermoplastic or electrostatic toner cartridges (without moving parts) for insertion into apparatus of subheadings 8443 31, 8443 32 or 8443 39
3215 Printing ink, writing or drawing ink and	3215 11 10

[10] *European Commission, Taxation and Customs Union, The Combined Nomenclature, available at https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/combined-nomenclature_en*

CN Product group	CN code and description
other inks, whether or not concentrated or solid:	(Printing Ink) (Black 3215 11)- Ink cartridges (without an integrated print head) for insertion into apparatus of subheadings 8443 31, 8443 32 or 8443 39, and incorporating mechanical or electrical components
	3215 19 10
	(Printing Ink) (Other 3215 19) - Ink cartridges (without an integrated print head) for insertion into apparatus of subheadings 8443 31, 8443 32 or 8443 39, and incorporating mechanical or electrical components
	3215 90 20
	(Other 3215 90) Ink cartridges (without an integrated print head) for insertion into apparatus of subheadings 8443 31, 8443 32 or 8443 39, and incorporating mechanical or electrical components; solid ink in engineered shapes for insertion into apparatus of subheadings 8443 31, 8443 32 or 8443 39

The CN codes provide a clear distinction between printers and multi-functional devices but do not allow distinctions to be made between different types of printers or multi-functional devices. For example, whilst it would be possible to distinguish a printer from a MFD it would not be possible to distinguish a laser based printer from an inkjet printer.

2.2.5 Summary of findings from product categorisation in statistical sources

Whilst each statistical source provides some insight into imaging equipment categorization, none of the statistical sources discussed above provides a perfect solution. For each of the statistical categorization systems, there is often a large degree of ambiguity in terms of which category a particular type of imaging equipment would fit within. This ambiguity would result in a significant amount of uncertainty if using the statistical categorization approaches to inform decisions around savings from the EU GPP criteria. Other data sources, such as those published by market research organisations or as part of other environmental initiatives may provide enhanced data that is more targeted towards imaging equipment.

2.3 Scope, product categorisation and definitions in legislation, standards and other voluntary agreements and procurement schemes for imaging equipment

Household and office based imaging equipment products are covered under a number of other environmental initiatives. This section of the report introduces each of the main initiatives and identifies the imaging equipment scope and product categorization approach used within each.

2.3.1 Ecodesign Standby Regulation

In 2008 the European Commission implemented a horizontal regulation on standby and off mode power demand ((EC) No 1275/2008) which covered a broad range of products including some imaging equipment.[11] In 2013 the Commission published the Ecodesign Regulation (EC) No 801/2013 which is an amending regulation introducing requirements for networked standby into the existing Regulation (EC) No 1275/2008.[12] In addition to changes around the power demand requirements in various power states, the revised regulation also included an amended product scope. Some of these amendments in scope concern imaging equipment.

The requirements of Regulation (EC) No 1275/2008 only apply to products that are intended primarily for use in the domestic environment, i.e. EMC Class B IT equipment.[13] The definition of 'information technology equipment' and 'domestic environment' is identical to EN 55022 or EN55032 covering essential requirements of the EMC Directive. This includes products intended for use in offices and other areas not being homes. All products designated EN55022/EN55032 EMC Class A, especially commercial and industrial products, are out of the scope of the regulation.

In terms of imaging equipment this means that products that are unlikely to be used in a domestic environment will likely not be covered under the standby regulation. However, for many imaging equipment products there is no clear line between "domestic" and "non-domestic" products as even some relatively high specification imaging equipment may be used in domestic premises.

The Ecodesign Regulation (EC) No 801/2013 includes exemptions from some requirements for imaging equipment meeting the following definitions:

- "large format printing equipment" means printing equipment designed for printing on A2 media and larger, including equipment designed to accommodate continuous-form media of at least 406 mm width, for which "printing equipment" means equipment that generates paper output from electronic input. Printing equipment may have additional functions and may be marketed as a multifunctional device or multifunctional product.

Large format printers are exempted from the network standby requirements until the 31st December 2018.

[11] *COMMISSION REGULATION (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment, available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:0052:en:PDF*

[12] *COMMISSION REGULATION (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0801*

[13] *European Commission, November 2014, Guidelines accompanying Commission Regulation (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions, available from https://ec.europa.eu/energy/sites/ener/files/documents/Guidance%20document_Lot%2026_Networked%20Standby_clean%20FIN.pdf*

2.3.2 US Regulation on External Power Supplies

In April 2014, the US Department of Energy (DoE) published an updated regulation dealing with the energy efficiency of external power supplies (EPS).[14] The regulation refers to the EPS definition[15] below which dictates the EPS in scope:

(A) In general.—The term "external power supply" means an external power supply circuit that is used to convert household electric current into DC current or lower-voltage AC current to operate a consumer product.

(B) Active mode.—The term "active mode" means the mode of operation when an external power supply is connected to the main electricity supply and the output is connected to a load.

(C) Class A external power supply.—

(i) In general.—The term "class A external power supply" means a device that—

(I) is designed to convert line voltage AC input into lower voltage AC or DC output;

(II) is able to convert to only 1 AC or DC output voltage at a time;

(III) is sold with, or intended to be used with, a separate end-use product that constitutes the primary load;

(IV) is contained in a separate physical enclosure from the end-use product;

(V) is connected to the end-use product via a removable or hard-wired male/female electrical connection, cable, cord, or other wiring; and

(VI) has nameplate output power that is less than or equal to 250 watts.

(ii) Exclusions.—The term "class A external power supply" does not include any device that—

(I) requires Federal Food and Drug Administration listing and approval as a medical device in accordance with section 360c of title 21; or

(II) powers the charger of a detachable battery pack or charges the battery of a product that is fully or primarily motor operated.

The definition illustrates that EPS shipped with imaging equipment would likely be in scope of the US regulation. However, it should be noted that most non-domestic imaging equipment products are shipped with internal power supply (IPS) units rather than EPS. However, the trend towards more mobile products may influence the market technological trend and may influence also imaging equipment products, especially those on the cheaper range.

2.3.3 Ecodesign External Power Supplies Regulation

In 2009, the European Commission adopted a Regulation on the energy efficiency of EPS.[16] The Commission is currently at the stage of reviewing this Regulation.

The current Ecodesign EPS Regulation is limited in scope to single voltage EPS with rated output powers below 250W. Most, but not all, EPS shipped with imaging equipment would likely fall within scope of the current Ecodesign Regulation on EPS.

[14] *US Department of Energy, 2014-02-10 Energy Conservation Program: Energy Conservation Standards for External Power Supplies; Final Rule, available from https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0219*

[15] *42 U.S.C. United States Code, 2010 Edition Title 42 - THE PUBLIC HEALTH AND WELFARE CHAPTER 77 - ENERGY CONSERVATION SUBCHAPTER III - IMPROVING ENERGY EFFICIENCY Part A - Energy Conservation Program for Consumer Products Other Than Automobiles Sec. 6291 -Definitions https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap77-subchapIII-partA-sec6291.htm*

[16] *COMMISSION REGULATION (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009R0278*

2.3.4 ENERGY STAR

ENERGY STAR is a primarily US based energy efficiency initiative covering a wide range of energy using and energy related products and services. Since 2001, there has been an agreement in place between the US and EU to cooperate on the development of ENERGY STAR specifications covering office equipment.[17] The EU-US agreement expired on 20 February 2018 and has not been renewed.

The latest version of the ENERGY STAR specification for imaging equipment (ENERGY STAR v2.0) was developed during 2011 to 2013 with implementation of the specification occurring in January 2014 in the US[18] and May 2014 in the EU[19]. The ENERGY STAR v2.0 specification covers a wide range of domestic and office based imaging equipment.

The ENERGY STAR v2.0 specification for imaging equipment includes detailed definitions for products in scope:

- Printer: A product whose primary function is to generate paper output from electronic input. A printer is capable of receiving information from single-user or networked computers, or other input devices (e.g., digital cameras). This definition is intended to cover products that are marketed as printers, and printers that can be field-upgraded to meet the definition of an MFD.
- Scanner: A product whose primary function is to convert paper originals into electronic images that can be stored, edited, converted, or transmitted, primarily in a personal computing environment. This definition is intended to cover products that are marketed as scanners.
- Copier: A product whose sole function is to produce paper duplicates from paper originals. This definition is intended to cover products that are marketed as copiers, and upgradeable digital copiers (UDCs).
- Facsimile (Fax) Machine: A product whose primary functions are (1) to scan paper originals for electronic transmission to remote units, and (2) to receive electronic transmissions for conversion to paper output. A fax machine may also be capable of producing paper duplicates. Electronic transmission is primarily over a public telephone system, but may also be via a computer network or the Internet. This definition is intended to cover products that are marketed as fax machines.
- Multifunction Device (MFD): A product that performs two or more of the core functions of a Printer, Scanner, Copier, or Fax Machine. An MFD may have a physically integrated form factor, or it may consist of a combination of functionally integrated components. MFD copy functionality is considered to be distinct from single-sheet convenience copying functionality sometimes offered by fax machines. This definition includes products marketed as MFDs, and "multi-function products" (MFPs).
- Digital Duplicator: A product sold as a fully-automated duplicator system through the method of stencil duplicating with digital reproduction functionality. This definition is intended to cover products that are marketed as digital duplicators.
- Mailing Machine: A product whose primary function is to print postage onto mail pieces. This definition is intended to cover products that are marketed as mailing machines.

The ENERGY STAR v2.0 specification for imaging equipment also includes detailed complementary definitions for the marking technologies (i.e. the type of technology used to place an image on the output media), the media format sizes (i.e. the size of the paper or other media that can be used with the imaging equipment product), power modes and additional functionalities found in imaging equipment. The definitions of the various marking technologies are included in Appendix 1.

The ENERGY STAR v2.0 specification includes a detailed categorization process but with two main overarching categories of called "TEC" (Typical Electricity Consumption) and "OM"

[17] *http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.114.01.0068.01.ENG*
[18] *https://www.energystar.gov/products/office_equipment/imaging_equipment/partners*
[19] *http://www.eu-energystar.org/specifications.htm*

(Operational Mode). Most, but not all, thermal based imaging equipment (i.e. those that use significant amounts of heat to deposit an image) are defined as TEC products and products that use no, or little heat, are classed as OM products. There are exceptions to this general rule however. Further sub-categories of product types are defined underneath these two overarching categories of "TEC" and "OM" based on other technical features such as imaging speed.

2.3.5 EU Voluntary Agreement

The Ecodesign Directive states that certain priority product groups must be covered by either a mandatory implementing measure (i.e. a Commission Regulation) or a self-regulation measure (e.g. a voluntary agreement concluded by industry).

Industry groups can propose a self-regulation, commonly known as a "Voluntary agreement" (VA), as an alternative to a Regulation. Any VA must comply with specific criteria including requiring that signatories account for a large share of the market in the product group and expected savings should be comparable to those expected by a Regulation.

Imaging equipment is covered by such a VA in the EU. The Commission adopted the first VA on imaging equipment[20] in February 2011 and a second iteration in June 2015.[21]

The scope of the VA is a truncated version of the product scope found in the ENERGY STAR v1.1 specification (for products placed on the market before 1st January 2015) and the ENERGY STAR v2.0 specification (for products placed on the market on or after the 1st January 2015), with some additional aspects included like the design for reuse and recycling of cartridges. The definitions and categorization system used within the VA is borrowed from the same ENERGY STAR specifications.

The first and second VA on imaging products include the following product scope:

Household and office equipment limited to:

- Standard black & white (BW) format products with maximum speed < 66 A4 images per minute
- Standard Colour format products with maximum speed <51 A4 images per minute

Product categories:

- Copiers
- Multifunction Devices (MFDs)
- Printers
- Fax machines

Marking technologies:

- Electrophotography (EP)
- Inkjet (IJ), including high performance IJ
- Solid Ink (SI)

Cartridges:

- Cartridges produced by or recommended by the original equipment manufacturer (OEM) for use in the products within the scope

2.3.6 EPEAT

EPEAT is a green procurement scheme aimed at promoting the development and dissemination of multi-criteria specifications for a range of ICT products.[22] The programme is managed by the Green Electronics Council and supported by the US EPA and US DoE. The programme is based in the US but is active internationally with manufacturers able to register products separately in 42 countries around the world.

[20] *http://www.eurovaprint.eu/fileadmin/eurovaprint_files/pdfs/Lot4_VA-version_4.pdf*
[21] *http://www.eurovaprint.eu/fileadmin/eurovaprint_files/pdfs/VA_version_5.2_April.pdf*
[22] *EPEAT, A program of the Green Electronics Council, available from http://www.epeat.net/about-epeat/*

The EPEAT scheme adopts all scope, definitions, categorization and requirements from the IEEE 1680.2 standard. The IEEE 1680.2 standard, and therefore the EPEAT scheme, currently includes a specification for imaging equipment which adopts the ENERGY STAR v2.0 scope and categorisation process. The reference to ENERGY STAR is dynamic, meaning that if the US EPA updates the ENERGY STAR specification then the IEEE 1680.2 standard automatically references the new ENERGY STAR specification.
The EPEAT scope is slightly wider than ENERGY STAR in that consumables (cartridges as well as toner material) and packaging are also within scope.

2.3.7 Blue Angel

The Blue Angel[23], a German based eco-label, includes specifications for many products and services on the EU market. The eco-label includes detailed specifications for several key pieces of information technology equipment.
The Blue Angel criteria are developed by a multi stakeholder group consisting of government bodies, environmental and consumer associations, trade unions, industry and academia.
There are two Blue Angel specifications that are relevant for the Voluntary Agreement on imaging equipment: the Blue Angel on imaging equipment (RAL-UZ 205)[24] and the Blue Angle on "Remanufactured Toner Modules" (RAL-UZ 177)[25].
In order to be considered within scope of the current Blue Angel specification on imaging equipment products need to:

- offer at least printing or copying as their primary function,
- capable of producing monochrome or colour printouts on standard paper with a density of 60 to 80 g/m2
- capable of processing media of up to a maximum format of DIN A3+,
- use either electro photographic (LED or laser technology) marking technologies with the use of toner or use inkjet marking technology with the use of inks, gels or waxes
- have noise emissions (declared A-weighted sound power levels) that do not exceed 75 dB during printing or copying.

As well as including imaging products in scope, the Blue Angel specification also includes additional components in scope including:

- Consumable Materials
- Photoconductor Drums
- Packaging

The Blue Angel categorisation process is based on technical attributes of the products. Products are categorised based on:

- Colour capability
- Marking technology
- Consumable type

The Blue Angel eco-label uses the ENERGY STAR v1.1[26] product definitions with the following amendments:

- Base Unit: This is the most basic version of a device that is actually sold as a fully operational model. The base unit can be designed and shipped as a single piece or as a combination of functionally integrated components.
- Ink(jet) Device: This is a device which transfers data onto paper or similar materials by using inks, gels or solid inks (waxes).

[23] *https://www.blauer-engel.de/en/blue-angel/who-is-behind-it*
[24] *Office Equipment with Printing Function (Printers and Multifunction Devices) DE-UZ 205, available online at: https://www.blauer-engel.de/en/products/electric-devices/drucker-und-multifunktionsgeraete*
[25] *Blue Angel, Remanufactured Toner Modules for Electrophotographic Printers, Copiers and Multi-Function Devices RAL-UZ 177, available from https://www.blauer-engel.de/en/companies/basic-award-criteria; available online at: https://www.blauer-engel.de/en/products/paper-printing/tonermodule*
[26] *The ENERGY STAR v1.1 product definitions were not changed significantly in ENERGY STAR v2.0*

- Monochrome Printing Device: This is a device which can transfer data onto paper or similar materials by monochrome printing only.
- Colour Printing Device: This is a device which can transfer data onto paper or similar materials by colour printing.
- Multifunction Device: Restricted to devices with a print functionality.

2.3.8 Nordic Swan

The Nordic Swan Ecolabel is the official eco-label of the Nordic countries (Denmark, Norway, Sweden, Finland and Iceland).[27] Nordic Swan scheme includes specification for over 60 product groups, including imaging equipment[28] and remanufactured OEM cartridges[29].
The Nordic Swan specification (v6.3) for imaging equipment was implemented in June 2013 and has an effective end date of the 31st December 2019. The scope of the Nordic Swan imaging equipment specification extends to the following product types:

- Copiers
- Digital duplicators
- Facsimile machines (Fax machine)
- Multifunction devices (MFD)
- Printers
- Scanners

In addition to the main product groups listed above, the Nordic Swan also includes consumable products and material in scope, namely:

- OPC (Optical Photosensitive Conductor) kits
- Drums
- Toner powder
- Toner cartridges

The Nordic Swan includes the following product definitions:

- Copier: A commercially-available imaging product whose sole function is the production of hard copy duplicates from graphic hard copy originals. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as copiers or upgradeable digital copiers (UDCs).
- Digital duplicator: A commercially-available imaging product that is sold in the market as a fully-automated duplicator system through the method of stencil duplicating with digital reproduction functionality. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as digital duplicators.
- Facsimile machine (Fax machine): A commercially-available imaging product whose primary functions are scanning hard copy originals for electronic transmission to remote units and receiving similar electronic transmissions to produce hard copy output. Electronic transmission is primarily over a public telephone system, but also may be via computer network or the Internet. The product also may be capable of producing hard copy duplicates. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as fax machines.
- Multifunction device (MFD): A commercially-available imaging product, which is a physically-integrated device or a combination of functionally-integrated components, that performs two or more of the core functions of copying, printing, scanning, or faxing. The copy functionality as addressed in this definition is considered to be distinct from single sheet convenience copying offered by fax machines. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as MFDs or multifunction products (MFPs).
- Printer: A commercially-available imaging product that serves as a hard copy output device, and is capable of receiving information from single-user or networked computers, or other input devices (e.g., digital cameras). The unit must be capable of

[27] *http://www.nordic-ecolabel.org/about/*
[28] *http://www.nordic-ecolabel.org/Templates/Pages/CriteriaPages/CriteriaGetFile.aspx?fileID=1791*
[29] http://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=008.

being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as printers, including printers that can be upgraded into MFDs in the field.

- Scanner: A commercially-available imaging product that functions as an electro-optical device for converting information into electronic images that can be stored, edited, converted, or transmitted, primarily in a personal computing environment. The unit must be capable of being powered from a wall outlet or from a data or network connection. This definition is intended to cover products that are marketed as scanners.

The Nordic Swan imaging equipment environmental requirements are largely harmonised with the Blue Angel eco-label but also the ENERGY STAR label (on energy related impacts); the categorisation approach is also harmonised.

As well as having a detailed environmental specification for imaging equipment, the Nordic Swan has also developed a specification for remanufactured toner cartridges.[30] The Nordic Swan remanufactured cartridge specification was implemented in June 2012 and has an effective end date of June 2018. The scope is limited to toner cartridges with no further categorization.

2.3.9 Korea Ecolabel

The Korean eco-label covers a wide range of product types including several different specifications for imaging equipment and related consumables.[31] The Korea eco-label has specification in place for:

- Printers (revised Feb 2013) – including laser and inkjet printers as well as multi-functional devices. The scope appears to extend to all types of office and domestic printers with the exemption of products which meet any of the following requirements:
    - printers that use continuous roll-type paper and have a printing speed higher than 60 PPM
    - printers with printing speed higher than 70 PPM
    - large format printers shall be excluded.
- Fax machines – thermal and inkjet based (revised Feb 2013)
- Photocopiers (revised Feb 2013)
- Toner Cartridges (revised July 2016)

The Korea Ecolabel does not contain detailed definitions for the imaging equipment in scope. The label does contain definitions for consumables in scope of the consumables specification:

- *All-in-one toner cartridge of optical drums: All-in-one typed toner cartridge to be operated in one instrument all functions (except settlement function) of general print process*
- *Separate type toner cartridge of optical drums: As (a toner cartridge) not including optical drums and relevant functions in all-in-one typed one, toner cartridge with functions directly providing a toner to optical drums*
- *Note A: structure with a magnetic roller is a common and an optical drum can be installed within a printer body or separate cartridge.*
- *Container type toner cartridge: Toner cartridges only for use to be transferred to the previous step to provide toner with an optical drum within a container or general toner container*

[30] *Nordic Swan, Remanufactured OEM Toner Cartridges, http://www.nordic-ecolabel.org/Templates/Pages/CriteriaPages/CriteriaGetFile.aspx?fileID=1329*

[31] *Korea Eco-label, Certification Criteria, available from http://el.keiti.re.kr/enservice/enpage.do?mMenu=2&sMenu=1*

- *Original toner cartridges: Toner cartridges applicable for product models of output devices and the production process works by manufacturers directly or on consignment.*
- *Regenerated toner cartridges: After removing wasted toner remained by disassembling used toner cartridges and replacing or repairing some components, the toner cartridges to be reusable by filling a new toner. Note: It includes replacing or repairing components drums and wiper blade inappropriate for being damaged or reusable.*

2.3.10 Summary

Imaging equipment is covered by a large range of initiatives with much commonality in terms of scope and categorisation approaches.
Whilst ENERGY STAR appears to have a strong influence on the scope and categorisation approaches used by other initiatives, the ENERGY STAR scope is often truncated when copied into other initiatives. Table 5 illustrates the percentage of models within the EU ENERGY STAR v2.0 database that are within scope of each of the voluntary initiatives. The analysis involved detailed assessment of the product scope within each policy initiative and then comparison with the product scope of the ENERGY STAR specification. It is important to consider that the results are indicative of products scope on a model not sales basis. The results suggest that the Nordic Swan has the widest product scope with the EU voluntary initiative having the narrowest scope.

Table 5. Comparison of Imaging Equipment Scope compared to ENERGY STAR v2.0 Registered Models[32]

Initiative	% ENERGY STAR v2.0 Scope (Model based)					
	Overall	Laser Printer	Laser MFD	Inkjet Printer	Inkjet MFD	Others
EU Ecolabel/EU GPP	67.6%	85.3%	86.0%	40.8%	95.1%	26.4%
EU Voluntary Agreement	25.8%	33.7%	35.5%	19.7%	51.5%	0.6%
Blue Angel[33]	68.4%	86.6%	88.6%	38.7%	95.1%	3.0%
Nordic Swan	98.5%	100.0%	100.0%	100.0%	100.0%	94.8%
Korea Ecolabel	62.4%	86.6%	88.6%	38.7%	95.1%	28.2%

Most of the specifications are somewhat aged with most having been developed around 2013. The ENERGY STAR specification for imaging equipment is currently under review, with this review process set to revisit the approach to scope and categorization. The ENERGY STAR v3.0 specification for imaging equipment is expected to be completed sometime in 2018. The revision of the ENERGY STAR specification may promote additional initiatives (e.g. EPEAT, Nordic Swan, etc.) to also update their scope and categorisation approaches on imaging products.

The product definitions used by the different initiatives are often taken directly from ENERGY STAR or are based on the ENERGY STAR definitions with alterations made. In some cases, such as in the Blue Angel and Korea Ecolabel there are more significant differences with the ENERGY STAR definitions.

[32] *Values based on analysis of the EU ENERGY STAR database on the 20th March 2017*
[33] *https://www.blauer-engel.de/en*

With regards to consumables, Table 6 presents a comparison of definitions found in the relevant environmental schemes, which helped developing the definition used for the purpose of the GPP.

Table 6 Definitions of consumables in several environmental schemes

Scheme	Definition
Blue Angel[34]	**Module for Colourant:** a complex module (of a printer, copier or a fax) which in addition to a container for colourants can include other components for transferring the colourant onto the media such as, for example, a photo semiconductor, a charging unit, a cleaning unit, an excess toner reservoir or an inkjet print head with nozzles and one or more integrated ink tanks. **Container for Colourant**: Containers for colourants such as toners (e.g. toner bottles), inks (e.g. ink tanks) etc.
Eco Mark for original and remanufactured toner cartridges[35]	**Original toner cartridge**: toner cartridge manufactured or commissioned by a manufacturer of an equipment manufacturer of a main body and distributed. **Recycled toner cartridge**: toner cartridge recycled by refilling used toner cartridges with toner and replacing expendable parts, as necessary. **Toner cartridge**: a cartridge for printing composed of two or more of the following; drum, photo development unit, and toner container filled with toner.
Eco Mark for original and remanufactured ink cartridges[36]	**Original ink cartridge**: ink cartridge manufactured or commissioned by a manufacturer of an equipment manufacturer of a main body and distributed. **Recycled ink cartridge**: ink cartridge recycled by refilling used toner cartridges with toner and replacing expendable parts, as necessary. **Ink cartridge**: a cartridge for printing filled with ink and designed to integrally work with the main body when printing. The term refers to both cartridges with a head incorporated or those without a head.
Eco Mark for imaging equipment such as coppiers, printers, etc.[37]	**Container for colourant**: containers for colourants such as toner or inks etc.

[34] *Basic Criteria for Award of the Environmental Label for Office Equipment with Printing Function (Printers and Multifunction Devices), RAL-UZ 205, Version 1.0, January 2017.*

[35] *Toner Cartridges Version 2.2, Certification criteria, Eco Mark Product Category No. 132, Application scope: A. Original Toner Cartridges, B. Recycled Toner Cartridges, Expiration date July 31, 2022.*

[36] *Ink cartridges Version 2.2, Certification criteria, Eco Mark Product Category No. 142, Application scope: A. Original Ink Cartridges, B. Recycled Ink Cartridges, Expiration date July 31, 2022.*

[37] *Imaging Equipment such as Copiers, Printers, etc., Certification criteria, Eco Mark Product Category No. 155, Version 1.3, Applicable scope: copiers, printers, fax (facsimile machines), scanners and multifunctional devices thereof, Expiration date July 31, 2021.*

EPEAT	**Consumable**: a product integral to the functioning of the imaging equipment product with the intent, when depleted or worn, to be replaced or replenished by the user during the normal usage and life span of the imaging equipment product. *[Note: consumables may include: toner, toner containers, toner bottles, toner cartridges, waste toner cartridges, ink cartridges, ink heads, ink sticks, ribbon ink, thermal paper, copy paper, imaging units, transfer belts, transfer roller, fusers, drum maintenance units, and other associated items. Items not intended to be replaced or replenished by the user would not be considered consumable supplies, but rather "spare parts"].* **Cartridge**: a consumer replaceable module with printing-related functionality that includes integrated components or moving parts integral to the imaging equipment product's function beyond holding the toner/ink and fitting onto/into the product. *[Note: examples of cartridges are toner, drum, and print-head cartridges. Moving parts in a toner cartridge may include, e.g. transport roller, charging unit, or photoconductor drum].* **Container**: a consumer replaceable module that holds toner or ink and that fit onto/into or emptied into the imaging equipment. *[Note: containers may be constructed of plastics or recycled plastics composite and do not contain integrated components or moving parts integral to the imaging product's function. Examples of such containers are toner cylinders, toner containers, toner bottles, ink tanks, and solid ink modules].* **Non-manufacturer cartridge**: a cartridge not sold by registering manufacturer and is manufactured and/or refilled. **Non-manufacturer container**: a toner or ink container not sold by registering manufacturer and is manufactured and/or refilled.
Korea eco-label for toner cartridges[38]	**All-in-one optical drum type toner cartridges**: all-in-one type toner cartridges to perform functions in one apparatus during a general printing process except the fixing function **Optical drum detachable toner cartridges**: toner cartridge that excludes optical drums and related functions and that has, at least, the function of directly supplying a toner to an optical drum in an all-in-one type toner cartridge structure. *[Note: the structure including up to a magnetic roller is common, and the optical drum may be installes in the main body of a printer or in a separate cartridge].* **Container type cartridges**: toner cartridges with the structure that has only the function of transferring the toner in a simple toner container or a container to the stage prior to supplying the toner to the optical drum. **Original toner cartridges**: toner cartridge that is produced by the printer manufactured directly or in a consignment and applicable for each printer model. **Regenerated toner cartridges**: toner cartridge which is made to be reused by filling a new toner after disassembling the used completed toner cartridge to remove the remaining waste toner, and replacing or repairing the limit parts. *[Note: it includes replacing or repairing components, drums and wiper blades that are damaged or inadequate for use].*
Nordic Ecolabelling for remanufactured toner cartridges[39]	**Scope of the criteria**: Toner cartridges that may carry the Nordic Swan Ecolabel are originally manufactured by the OEM (Original Equipment Manufacturer), and then they are remanufactured and reassembled with toner powder, drum and the necessary drive mechanism. Remanufactured OPC units (Optical Photosensitive Conductor cartridges containing only drum) are also included in the product group. The cartridges are used for monochrome and colour electrophotographic printing and similar reproduction processes.
Nordic Ecolabelling for imaging equipment[40]	**Extra equipment**: The above mentioned products also include various consumer durables, such as OPC (Optical Photosensitive Conductor) kits, drums, toner powder and residual toner cartridges. If extra equipment shall use the Nordic Swan Ecolabel they must be listed in a valid licence and the extra equipment must belong to the ecolabelled imaging equipment. **Combined toner cartridge**: Drum, developer and toner in one unit.

[38] *Toner cartridges, Korea Eco-laber Certification Standards, EL 104, revised on 25 May 2017.*
[39] *Nordic Ecolabelling of Remanufactured OEM Toner Cartridges, Version 5.4, 15 June 2012 – 31 December 2022.*
[40] *Nordic Ecolabelling for Imaging equipment, Version 6.5 20 June 2013 – 31 December 2020.*

2.4 Environmental metrics in legislation, standards and other voluntary agreements and procurement schemes for imaging equipment

All the environmental initiatives introduced in the previous section of the report include environmental requirements on imaging equipment and/or associated consumables. This section of the report briefly summarises the requirements found in each of the initiatives. A further description of the environmental criteria addressed by all the relevant schemes is included in Task 3 (technical analysis).

2.4.1 Ecodesign Standby Regulation

The Ecodesign Regulation includes a range of power demand and power management requirements that are applicable to imaging equipment. These requirements are listed in Table 7 and Table 8 below.

Table 7. Ecodesign Standby Regulation Network Standby Requirements Relevant to Imaging Equipment

Requirement Area	Scope	Implementation Date and Requirement			Exemptions
		January 2015	January 2017	January 2019	
Network Standby Requirements	HiNA[41] Equipment	12W	8W	8W	Large format printing device;
	Other Networked Equipment	6W	3W	2W	

Table 8. Ecodesign Standby Regulation Standby and Off Mode Requirements Relevant to Imaging Equipment

Requirement Area	Scope	Power Demand Requirement (W)	Information or status display Allowance (W)	Exemptions
Standby Power Demand	All domestic imaging equipment	0.5	0.5	None
Off Mode Power Demand		0.5	0	

The EU Ecodesign Regulation on standby power demand also includes a wide range of power management requirements (requirements details in Commission Regulation 1275/2008).

[41] *High Network Availability*

Individual requirements that are relevant for the EU Ecodesign and EU GPP criteria will be discussed in more detail in the task 3 (technical analysis) and later technical reports.

2.4.2 Ecodesign External Power Supplies Regulation[42]

The Ecodesign Regulation on external power supplies (EPS), an implementing Regulation under the Ecodesign Directive (2009/125/EC), incudes no-load condition electric power demand and average active efficiency for all external power supplies (EPS) with an output of less than 250 W and supplying only one output voltage at a time. The EPS Regulation only applies to EPS that are intended to be used to power household and office electrical and electronic equipment (requirement details in Commission Regulation No. 278/2009).

2.4.3 ENERGY STAR

The ENERGY STAR v2.0 specification for imaging equipment includes detailed energy efficiency requirements for many types of domestic and office based imaging equipment. The full ENERGY STAR v2.0 specification for imaging equipment can be found in the ENERGY STAR's website[43]. Individual requirements that are relevant for the EU GPP criteria will be discussed in more detail in the task 3 (technical analysis) and later technical reports.
As previously mentioned the ENERGY STAR v3.0 specification for imaging equipment is currently being developed with completion expected in 2018. It is likely, though not certain, that requirements will be based on a similar approach to those in the current ENERGY STAR v2.0 specification.

2.4.4 Blue Angel

The Blue Angel criteria on imaging equipment (RAL-UZ 171)[44] contains a broad range of requirements across multiple environmental category areas. In particular, the Blue Angel specification addresses:

- Energy efficiency
- Lifetime extension
- Recyclability
- Long-life and recyclable design
- Hazardous material content
- Particle emissions
- Noise emissions

The Blue Angle has also developed a set of criteria on "Remanufactured Toner Modules" (RAL-UZ 177).[45] The remanufactured toner module criteria include requirements on the following areas:

- Collection and Disposal
- Documentation of collection process
- Remanufacturing process
- Requirements for Housing Parts
- Heavy Metal content
- Azo Colorant content

[42] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:093:0003:0010:EN:PDF*
[43] *https://www.energystar.gov/products/spec/imaging_equipment_specification_version_2_0_pd*
[44] *Blue Angel, Office Equipment with Printing Function (Printers, Copiers, Multifunction Devices) | RAL-UZ 171, available from https://www.blauer-engel.de/en/products/office/printers-copiers-and-multifunction-devices-2012*
[45] *Blue Angel, Remanufactured Toner Modules for Electrophotographic Printers, Copiers and Multi-Function Devices RAL-UZ 177, available from https://www.blauer-engel.de/en/companies/basic-award-criteria*

- Emissions
- Quality

The full details of each set of criteria can be viewed on the Blue Angel website[46].

2.4.5 Nordic Swan

The Nordic Swan criteria are very similar to those found in the Blue Angel. The following requirements on imaging equipment are included:

- Energy efficiency
- Disassembly
- Ensuring cartridges are not designed to prevent re-use
- Ability to use remanufactured cartridges
- Take back system for consumables
- Marking of plastics in casings and their components
- Single plastic casing parts in casings and their components
- Limitations on different types of plastic in small parts
- Chlorinated polymer restrictions
- Flame retardants restrictions
- Phthalates in external power cable
- Chemicals used during production
- Plastic materials in packaging
- Re-cycled material in packaging
- Availability of spare parts
- Duplex printing
- Consumable page yield efficiency
- Chemical Emissions
- Noise Emissions
- Product quality

The Nordic Swan criteria on remanufactured toner cartridges includes requirements on:

- Hazardous material restrictions in toner
- Working conditions
- Chlorinated polymer restrictions
- Plastic materials in packaging
- Minimum weight recycled parts
- Take-back system
- Waste from production
- Production quality
- Print quality
- Measurable yield

The full details of each set of criteria can be viewed on the Nordic Swan website[47].

2.4.6 Korea Eco-label

The Korea ecolabel criteria on imaging equipment include requirements on:

- Energy efficiency
- Duplex printing
- Hazardous substance restrictions

[46] *https://www.blauer-engel.de/en/products/office/drucker-kopierer-und-multifunktionsgeraete-2012*
[47] *http://www.nordic-ecolabel.org/*

- Chemical Emissions
- Noise Emissions
- Take-back system
- Marking of plastics in casings and their components
- Limitations on different types of plastic in parts
- Plastic materials in packaging
- Disassembly
- Reusability of cartridges
- Safety criteria
- Broadcasting and communication quality
- Information ozone filter
- Information on disposal and recycling
- Information on product warranty

The Korea ecolabel criteria on toner cartridges include requirements on:

- Recycled paper support
- Hazardous substance restrictions
- Reusability
- Packaging requirements
- Take back requirements
- Ease of disassembly
- Ability to reuse
- Toner emissions
- Disposal requirements
- Measurable yield
- Minimum yield requirements
- Print quality
- Toner melting point requirements
- Consumer information reporting

The full details of each set of criteria can be viewed on the Korea Ecolabel website[48].

2.4.7 Voluntary Agreement for Imaging Equipment under the Ecodesign Regulation

The VA includes requirements on a number of environmental impact areas including energy use, design for recyclability, cartridge design and information provision. Signatories to the VA need to ensure that pre-determined percentages of the products, within scope of the VA, which they place on the EU market, meet the VA requirements.

The agreement aims to reduce the environmental footprint of imaging equipment – both by design and by helping customers make informed choices during purchase and usage of the equipment:

- Design requirements relate to energy consumption, default delay times, recto-verso printing, the ability to print several pages on one sheet of paper, recycling and cartridge reuse. Machines must be designed for easy recycling of plastic and other materials and must be able to accommodate non-OEM ink and toner cartridges.
- Information requirements cover: resource and energy efficiency, paper usage and cartridge disposal. Business and retail customers must be provided with accurate, detailed and transparent information.

[48] *http://www.ecolabelindex.com/ecolabel/korean-ecolabel*

2.4.8 EPEAT

The EPEAT criteria are taken from standards that are developed either through IEEE or more recently NSF International (an independent, accredited organization that develops standards in the USA)[49]. The managing entity of EPEAT initiates the standards development process in all cases. The EPEAT specification for imaging equipment covers a broad range of environmental performance criteria for the design of imaging equipment products and associated processes. The scheme is intended to provide a tool for government, institutional, corporate, and consumer purchasers to identify products that demonstrate environmental leadership.

The EPEAT initiative contains a large number of criteria that address various environmental impact categories associated with imaging equipment, consumables and surrounding processes such as recycling. The impact areas addressed by the EPEAT specification include:

- Reduction/elimination of environmentally sensitive material
- Materials selection
- Design for end-of-life
- Product longevity/life-cycle extension
- Energy conservation
- End-of-life management
- Corporate performance
- Packaging
- Consumables
- Indoor air quality

2.4.9 Other Initiatives

There are number of other initiatives at the EU level which, whilst not directly referencing imaging equipment, are likely to have some influence on the environmental aspects of imaging equipment sold within the EU. These include:

EU Directive (2012/19/EU) - WEEE Directive [50]

The Waste Electrical and Electronic Equipment (WEEE) Directive implements the principle of "extended producer responsibility" where producers of EEE are expected to take responsibility for the environmental impact of their products at the end of life. As such, the WEEE Directive aims to reduce environmental impacts through setting targets for the separate collection, reuse, recovery, recycling and environmentally sound disposal of WEEE.

As EEE, imaging equipment and many associated products fall under the scope of the WEEE Directive.

EU Regulation (1907/2006/EC) - REACH Regulation [51]

The Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) addresses chemicals, and their safe use, and aims to improve the protection of human health and the environment through a system of Registration, Evaluation, Authorisation and Restriction of Chemicals. The REACH Regulation places greater responsibility on industry to manage the risks from the chemicals they manufacture, import and market in the EU. Companies are required to demonstrate how substances can be used safely and risk management measures must be reported to users. The REACH Regulation also establishes procedures for collecting and assessing information on the properties and hazards of substances and requires that companies register their

[49] *http://www.nsf.org/about-nsf/*

[50] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0019&from=EN*

[51] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1907-20140410&from=EN*

substances in a central database. The entries in the database are then assessed to determine whether the risks of the substances can be managed. The REACH Regulation allows for some chemicals to be determined "substances of very high concern (SVHC)" due to their large potential negative impacts on human health or the environment. The European Chemicals Agency must be notified of the presence of SVHCs in certain products and the use of SVHCs may then be subject to prior authorisation. Substances can also be banned were risks are deemed to be unmanageable. As such, REACH encourages substitution of the most dangerous chemicals when suitable alternatives have been identified.
As REACH applies to all chemical substances, in theory, it also covers the chemicals that are used in imaging equipment and associated products.

EU Directive (2011/65/EU) - RoHS Directive [52]
The Restriction of Hazardous Substances (RoHS) Directive aims to reduce hazardous substances from electrical and electronic equipment (EEE) that is placed on the EU market. A number of hazardous substances are listed in the Directive along with maximum concentration values that must be met. The RoHS Directive does contain some exemptions where it has been decided that it may not be possible to manufacture some products without the use of one or more of the banned substances.
The RoHS Directive explicitly states that "IT and telecommunications equipment" are within scope and so imaging equipment and associated products that are within scope of the EU GPP are also likely within scope of the RoHS Directive.

EU Directive (2004/108/EC) - Electromagnetic Compatibility Directive [53]
The Electromagnetic Compatibility Directive (EMC) Directive has the primary aim of protecting the electromagnetic spectrum. The Directive requires that products must not emit unwanted electromagnetic interference and must be protected against a normal level of interference. The vast majority of complete electrical products must comply independent of whether they are mains or battery powered. The EMC Directive does contain exemptions for a range of components with no intrinsic function and some products that already covered by other directives such as medical, military and communications equipment.
The new EMC directive (2014/30/EU) has been published and came into force on the 20th April 2016.54 Most home and office based imaging equipment is likely to be covered by the EMC Directive.

EU Directive (2006/95/EC) - Low Voltage Directive [55]
The Low Voltage Directive (LVD) ensures that electrical equipment that operates within certain voltage limits provides a high level of protection. The LVD Directive covers all health and safety risks of electrical equipment operating with a voltage of between 50 and 1000 volts for alternating current and between 75 and 1500 volts for direct current. Consumer goods with a voltage below 50 for alternating current or 75 for direct current are covered by the General Product Safety Directive (GPSD) (2001/95/EC).
The new Low Voltage Directive (2014/35/EU) came into force on the 20th April 2016[56]. Many home and office based imaging equipment models and some associated products that are within scope of this review project would fall under the scope of the LVD Directive.

[52] *http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065&from=EN*
[53] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:en:PDF*
[54] *http://ec.europa.eu/growth/sectors/electrical-engineering/directives/index_en.htm*
[55] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:en:PDF*
[56] *http://ec.europa.eu/growth/sectors/electrical-engineering/directives/index_en.htm*

2.4.10 Summary

The number and type of environmental criteria covered under each of the main initiatives can vary considerably. Some of the initiatives, such as ENERGY STAR, concentrate on product energy use, whereas other initiatives, such as EPEAT, address a broad range of the environmental aspects associated with imaging equipment and consumables.
Table 9 provides an overview of the different environmental aspects areas addressed within each initiative. Those marked with blue are aspects of the criteria covered by the different initiatives (unmarked areas represent no criteria coverage).
The assessment of the environmental aspects presented in this chapter is used as the starting point to revise the existing GPP criteria. Further description of the environmental criteria addressed by the different schemes is included in the task 3 (technical report).

Table 9. Overview of environmental impact areas addressed within the initiatives

Environmental Aspect Areas		EU GPP coverage	Enviromental initiative coverage							
Area	Sub-area		ENERGY STAR v2.0	EU Ecolabel (Discontinued)	Ecodesign VA	Blue Angel	Nordic Swan	EPEAT/IEEE 1680.1	Korea Ecolabel	Ecodesign Standby
Energy/ Power in Use	Energy in Use (multiple power states)									
	Power Demand in low power modes									
	Power Management									
	Maximum wake times									
	Internal Power Supply Efficiency									
	External Power Supply Efficiency									
	Life-cycle assessment (LCA)									
Paper Use	Automatic duplex									
	N-up printing									
	Use recycled paper									
Hazardous substances	Restrictions									
Safer alternatives	Inventory of intentionally added chemicals									
Recycled content	Postconsumer recycled plastic content (declaration)									
	Postconsumer recycled plastic content (inclusion)									
Bio based plastic material content	Bio based plastic materials content (declaration)									
	Bio based plastic materials content (inclusion)									
Product weight	Weight declaration									
Recyclability	Ease of disassembly									
	Limits plastic type per plastic part									
	Manual separation and marking of plastics									
	Restriction surface coatings									

Environmental Aspect Areas		EU GPP coverage	Enviromental initiative coverage							
Area	Sub-area		ENERGY STAR v2.0	EU Ecolabel (Discontinued)	Ecodesign VA	Blue Angel	Nordic Swan	EPEAT/IEEE 1680.1	Korea Ecolabel	Ecodesign Standby
	Identification hazardous substances/special handling needs									
	Design for reusability									
	Reusable/recyclable minimums									
End-of-life analysis and planning	Product end-of-life characterization report									
Product Lifetime extension	Early failure process/Guarantee									
	Spare parts availability									
	Upgradeability									
Product take-back	End-of-life processing requirements									
Corporate performance	Environmental management system									
	Public disclosure of key environmental aspects									
	Public disclosure of supply chain toxics									
	Working conditions									
Manufactu-ring Impacts	Chemicals used/ emitted during production									
Packaging	Substance restrictions									
	Recyclable materials									
	Separable materials									
	Compostability/ recyclability									
	Recycled content									
	Plastics marked									
	Take-back service									
Consuma-bles	Use of non-manufacturer cartridges/containers									
	Cartridge/Container Design for Recycling									
	Cartridge/Container Design for Reuse									
	Cartridge/Container Take-back Offered									
	Toner/Ink Recycling Conducted									
	Reporting take-back statistics									
	Reuse of materials from take-back scheme									
	Consumable imaging yield efficiency									
	Measured cartridge yield									
	Minimum cartridge yield									
	Cartridge durability									
	Cartridge print quality									

Environmental Aspect Areas		EU GPP coverage	Enviromental initiative coverage							
Area	**Sub-area**		ENERGY STAR v2.0	EU Ecolabel (Discontinued)	Ecodesign VA	Blue Angel	Nordic Swan	EPEAT/IEEE 1680.1	Korea Ecolabel	Ecodesign Standby
	Cartridge remanufacturing/ recycling process requirements									
	Restrictions number plastics									
	Marking plastic parts									
	Substance restrictions									
	Ease of disassembly									
Emissions	Chemical Emissions (reporting)									
	Chemical Emissions (limits)									
	Noise Emissions (reporting)									
	Noise Emissions (limits)									
Safety	Safety requirements									

2.5 Main outcomes from stakeholder survey in relation to product scope and definition

An online survey was performed to collect input from stakeholders concerning the scope, definitions and criteria of the EU Ecolabel and the EU GPP criteria. The survey was done before a decision was made to discontinue the EU Ecolabel of Imaging Equipment. Thus, questions related to both schemes are covered and are presented both in this chapter and in chapter 4.4.

2.5.1 Questionnaire feedback initial analysis

As of 27 March 2017, 24 responses to the survey were received. The distribution of responses by organisation type is shown in Figure 2. All organisation types have been represented.

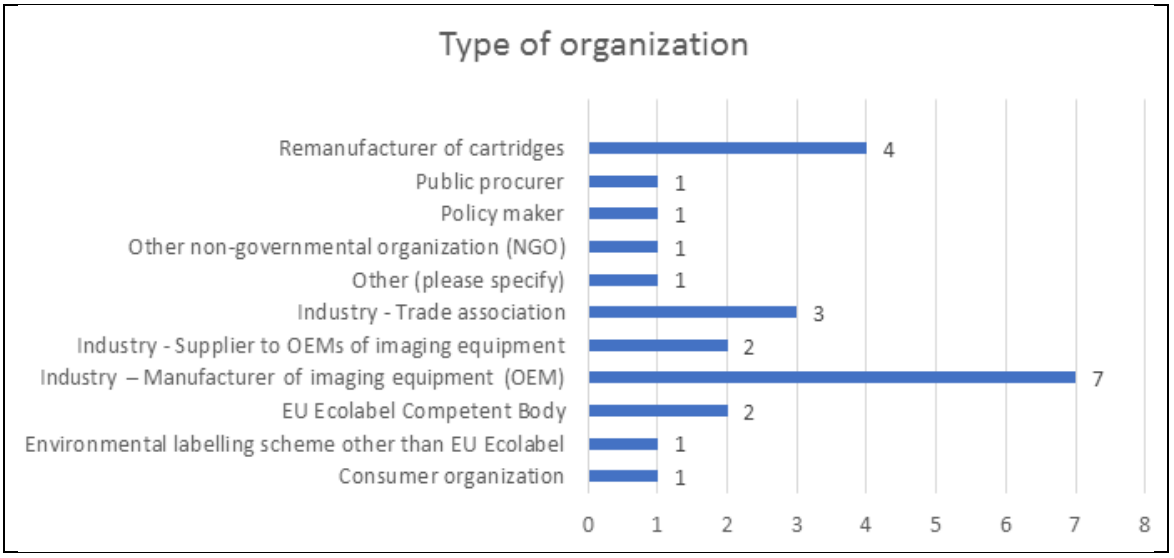

Figure 2. Number of responses by organisation type

All of these organisations have been involved in some degree of ecolabel activities (see Figure 3), and about half of the respondents have been involved in the development of the previous EU GPP/Ecolabel criteria57.

[57] *Please keep in mind that multiple responses were possible.*

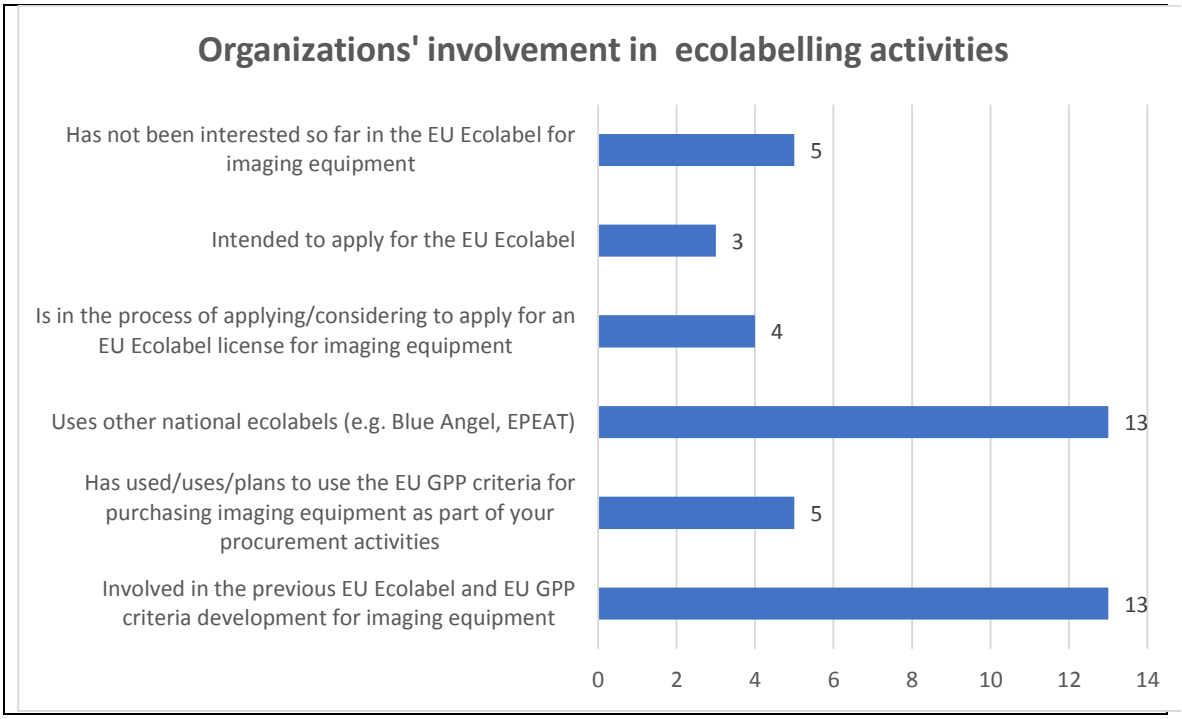

Figure 3. Organisations' involvement in eco-labelling activities

However, most of the respondents did not express interest in using the EU GPP/Ecolabel criteria for imaging equipment since they think the criteria are too difficult to comply with or do not see a competitive advantage (see Figure 4).

When asked what would encourage them to uptake EU GPP and EU Ecolabel criteria the responses indicated that a crucial issue is the competitive advantage of having a label (it must be considered as added value for the company). Another very important factor would be "real" use of the label as a verification proof for compliance in public procurement activities (see Figure 5).

Furthermore, the possibility to label consumables also seems to encourage the uptake of these criteria.

Based on these responses it can be assumed that the main barriers to the uptake of the EU Ecolabel for IE are the criteria are too difficult to comply with, and there is no perceived added value of marketing imaging equipment products with the EU GPP/Ecolabel.

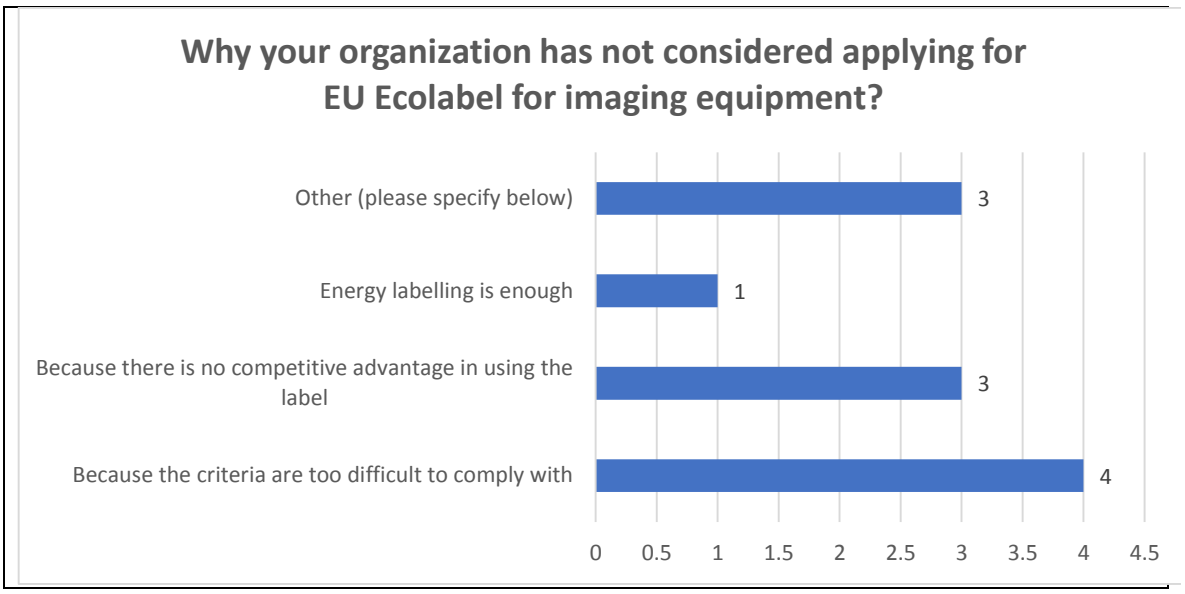

Figure 4. Main reasons why the organization has not considered applying for the EU Ecolabel for imaging equipment

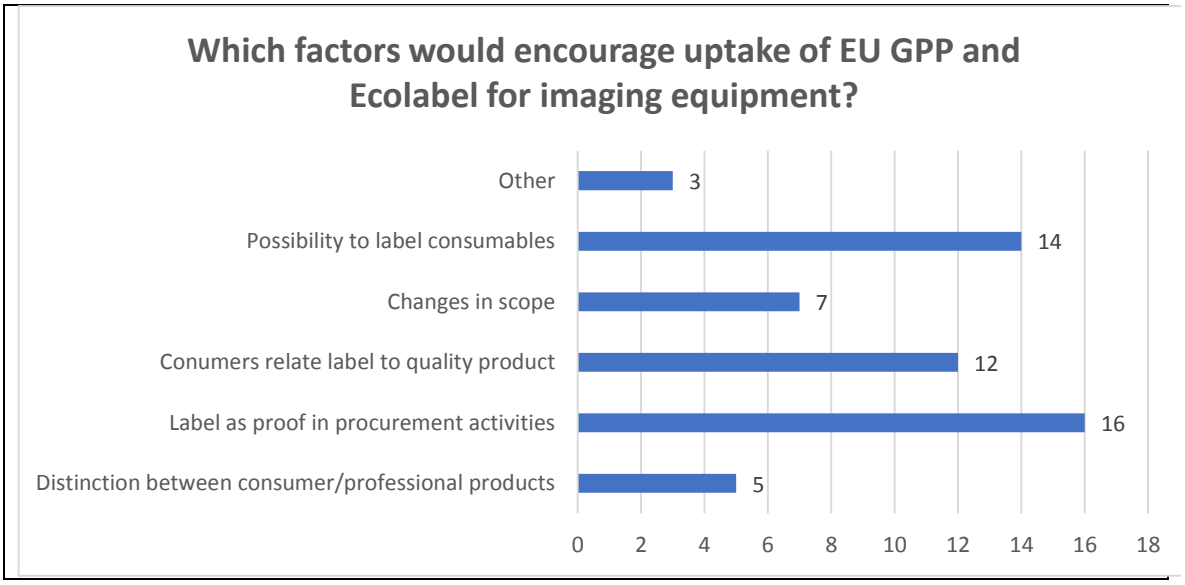

Figure 5. Factors that would encourage uptake of EU GPP and Ecolabel for imaging equipment

In the following section, an assessment of the responses that are relevant to the **definition of the scope** is presented. This assessment will help to support the refinement of the scope and definitions during the revision process.

2.5.2 Responses to scope questions

In answer to the question "Should the scope be changed?" most respondents (out of 18 who provided their feedback) indicate that the scope in both GPP and Ecolabel criteria could be modified (namely nine and eight for EU Ecolabel and GPP, respectively), even though some considered the scope, as it is defined at present, to be appropriate (see Figure 6).

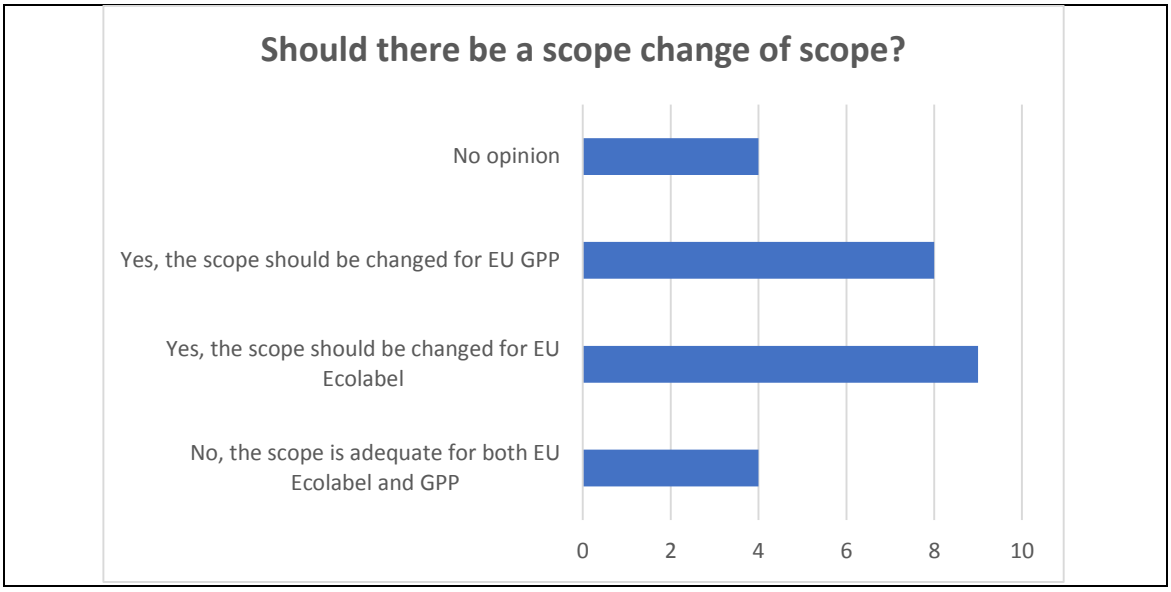

Figure 6. Stakeholder's opinion as to whether the scope should be changed

When asked how the scope should be changed, three respondents thought that cartridges and/or consumables should be included, (implied for both GPP and Ecolabel) while one respondent felt that reused/remanufactured cartridges should have their own separate EU Ecolabel and GPP criteria. One respondent felt that the GPP criteria should not cover products designed for domestic use while another had the wish to develop specific criteria for professional equipment used in printing companies. Three felt that the speed restriction was unnecessary while two of them asked that this should be aligned with the Blue Angel criteria.
In answer to the question "Should any of the currently excluded products be considered for inclusion under the revised scope?" there were 35 responses (multiple choice allowed), distributed as shown in Figure 7. There is some overlap with responses to the previous question, as the majority of the respondents want to have higher speed printers which are currently excluded. The respondents specified these printers as a product with a growing market share and two expressed their concern over their higher energy consumption, which makes them suitable for inclusion in the Blue Angel. Although it isn't shown in Figure 7, three respondents said in response to the open question that consumables should also be included. Furthermore, when asked specifically whether consumables should be included more respondents said they should (see Figure 8), and those who supported this gave the following reasons:

1. The cartridges and consumables make up a significant proportion of the environmental impact of the total product; in some cases they may even make the dominant impact.
2. Increasing the offer to consumers, giving them the opportunity to choose cheaper and/or more environmentally friendly consumables (i.e. ink and toner cartridges).
3. Including consumables could make the EU Ecolabel and GPP competitive in relation to other labels such as The Blue Angel.

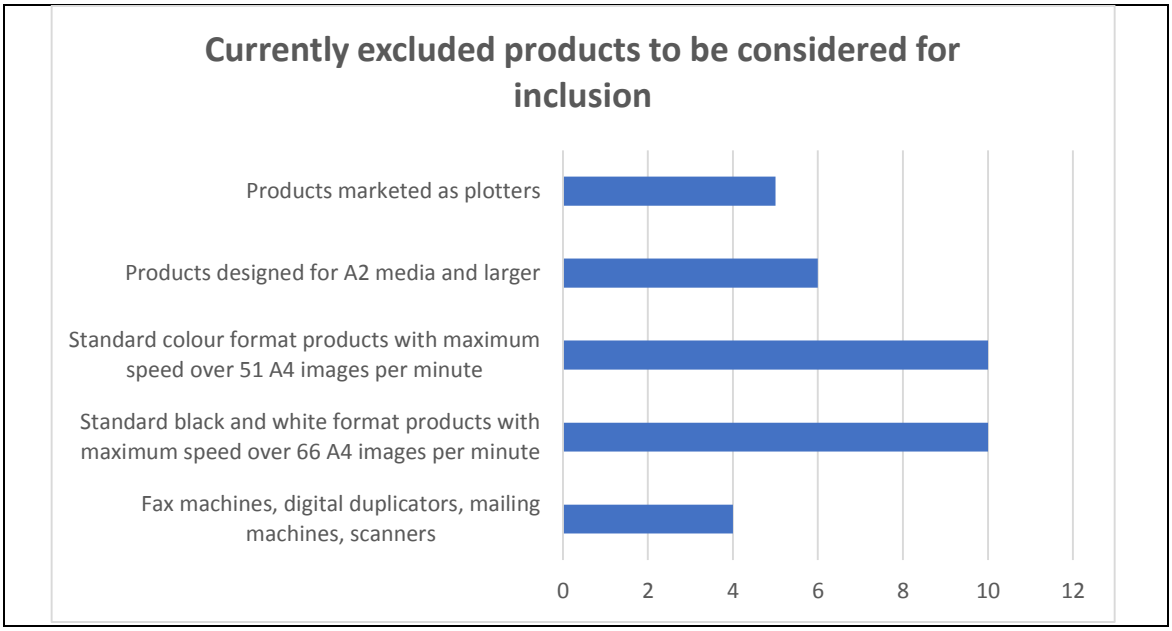

Figure 7. Overview of currently excluded products be considered for inclusion

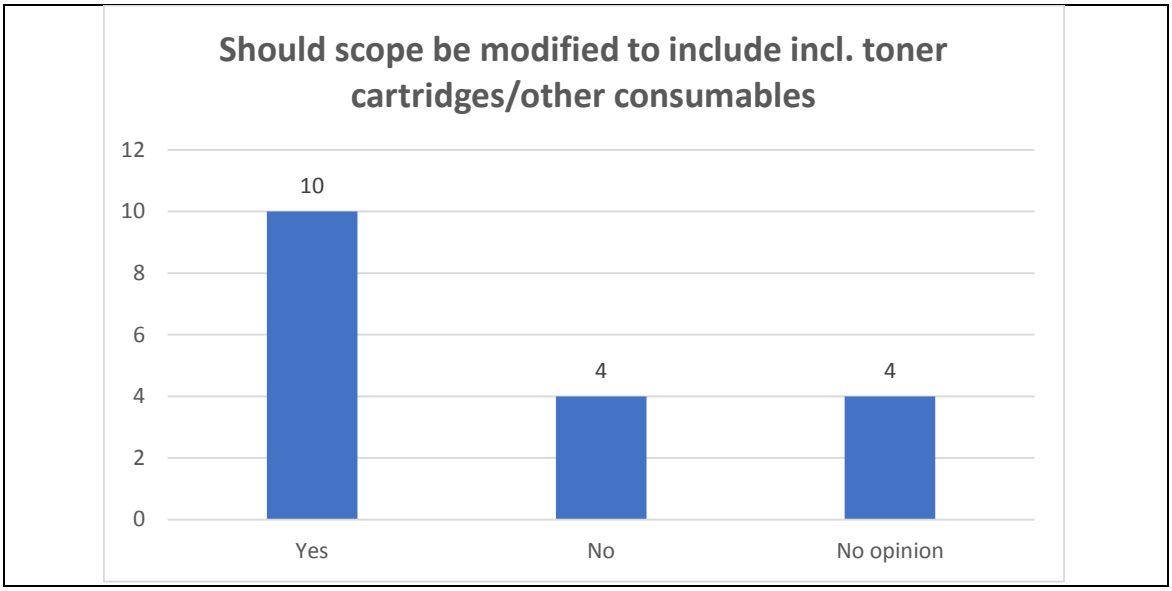

Figure 8. Should scope be modified to include ink, toner cartridges/other consumables

2.5.3 Other environmental labelling schemes used

Next question asked was if the respondents use other environmental labels like Blue Angel and EPEAT? If yes, they were asked to specify which ecolabels they use and what are the reasons or their advantages if compared with EU Ecolabel.

13 out of 24 respondents answered the questions and all of them were using other environmental labels or schemes. They mentioned 10 different schemes. Most commonly used label is Blue Angel (mentioned 12 times), then Nordic Swan Ecolabel and EPEAT (6 times both). Less commonly used schemes are NF Environment (2 respondents), Japanese Ecomark (2), China ecolabel (2), IT Eco Declarations (according to the ECMA-370 standard, mentioned once), Korea KOECO (1), Taiwan Green Mark (1), and Austrian Ecolabel (1). Reasoning or additional advantages were not given.

2.5.4 Substances and mixtures in imaging equipment

When asked what the main obstacles were to the uptake of the EU Ecolabel, 13 respondents mentioned the criterion on substances and mixtures; this criterion is considered as one of the main obstacles in the uptake of the EU Ecolabel for this product group. The following reasoning or statements were provided:

- The material requirements are too complex and require documentation that is too complex. The criterion should be changed or removed.
- When considering complex electronic and electrical devices, it is difficult to get complete information on materials.
- Industry does not have hazard data to cover 37 hazard statements for all additives in plastic parts.
- It is impossible for any manufacturer to meet the requirements because it does not designate specific substances.
- This requirement was originally laid down for chemicals and mixtures, any manufacturers for finished product cannot meet it because of lack of information on chemical identity of their parts or components.
- Suggest follow a similar approach as it was implemented in the EU Ecolabel for computers and electronic displays.

Five stakeholders stated they would be willing to share their best practices on chemicals in products in order to support the improvement of the current criterion, which is clearly understood as being too difficult to be met in its current formulation. Suggested examples to look at in order to improve and make the current criterion more workable were:

- Consult the Japan information platform of chemical substances, Joint Article Management Promotion-consortium (JAMP) JAMP: http://www.jamp-info.com/english.
- The work should focus on substitutions, i.e. to set minimum hazard criteria for at least flame retardants and plasticisers.
- Get in touch with the TCO Development organisation to get an input to their work with the GreenScreen system for safer chemicals assessment methodology.
- Harmonise the criteria with the respective ones in the Blue Angel RAL-UZ 205 which is widely used by the industry and which manufacturers are familiar with.
- Investigate LGA ecological product testing.

2.5.5 Summary of stakeholder survey feedback

In spite of the low uptake of the current EU GPP and the discontinued EU Ecolabel criteria, the respondents to the survey have been involved in ecolabelling activities and provided some valuable information.

The respondents agreed that some of the criteria are too difficult to comply. The criterion on hazardous substances is seen as a major barrier in particular. Lack of consumer demand and the fact that the EU Ecolabel is not easy to use as proof of compliance in public procurement activities are understood as main reason why the companies do not see much added value in using the criteria.

The majority of the respondents agree that a change in scope is needed (by extending the scope). The **inclusion of consumables and of printers with higher speed** were the main suggestions, and a couple mentioned the inclusion of printers used for professional use. Ink and toner cartridges were the consumables of greatest concern due to their perceived significant environmental impact over the whole product's life cycle, and due to the lack of transparency and choice in terms of environmental impact and cost to the consumers. Some respondents think the lack of consumables criteria blocks any initiative to promote remanufactured cartridges or those causing a lower environmental impact.

Finally, the respondents referred several times to the **Blue Angel criteria as an example of the extension of the scope** to printers with higher speed and to consumables. They mentioned a change of EU GPP/Ecolabel scope in this way would make the criteria more competitive.

2.6 Conclusions and recommendations for product scope revision

Section 2.3 of this report identified the product definitions and categorization that are included in the main environmental initiatives which address imaging equipment and their consumables. This analysis shows that different initiatives present a considerable variation in their scope, with ENERGY STAR covering a wider scope of imaging equipment products than any other initiative. In this chapter, the proposed scope is presented, structured by imaging equipment products, imaging equipment consumables and imaging equipment printing services.

2.6.1 Imaging equipment

The US based EPEAT scheme shares the same scope as the ENERGY STAR specification for imaging equipment as they are both tied to US public procurement commitments. That is, US federal bodies are required, in most cases, to procure products that both meet ENERGY STAR and EPEAT specifications.[58,59] By ensuring that the scope of EPEAT and ENERGY STAR is the same, EPEAT, with its wider environmental scope, can act as a single source of verification data for US public procurers.

As there is a similar requirement in the EU for public bodies to procure products that comply with energy efficiency requirements not less demanding than those laid down under EU ENERGY STAR specifications[60] (i.e. where ENERGY STAR specification exist for a product) it would be advantageous if the EU GPP criteria had the same product scope, definitions and categorisation as EU ENERGY STAR. Whilst some of the products covered under ENERGY STAR may not be procured on a regular basis, they are still likely to be procured at some point and as such should be covered under the EU GPP criteria.

ENERGY STAR specification for imaging equipment is at present under review and current scope, definitions and categorisation may change within the revised ENERGY STAR v3.0 specification. However, the outcomes of this review are not yet available, so the assessment of the GPP scope has only considered ENERGY STAR (v2.0), among other initiatives presented in chapter 2.3.

The suggestion is that for the moment the ENERGY STAR v2.0 scope and definitions are used, with some additional exceptions, which are Digital Duplicators and Mailing machines due to their expected low sales and specialised applications (see chapter 3.4 for a further discussion on market volumes).

Therefore, the main differences with the scope of the current EU GPP criteria are (see Table 10 for proposed scope and definitions of imaging equipment products):

- Large format printing equipment are proposed to be covered under the definition of printers
- Scanners are proposed to be in the scope for harmonizing with other important voluntary schemes (ENERGY STAR and Nordic Swan) and due to their market significance, which is at the same level as that of copiers (see Table 19 in chapter 3.4 on Market analysis).

It is important to note that mono imaging equipment with maximum imaging speeds over 66 A4 images per minute, colour format imaging equipment with maximum speed over 51 A4 images per minute and imaging equipment with A2 and larger media capabilities are covered

[58] *US EPA, Electronic Product Environmental Assessment Tool (EPEAT), available from https://www.epa.gov/greenerproducts/electronic-product-environmental-assessment-tool-epeat*

[59] *US Federal Register, Executive Order 13123 of June 3, 1999, Greening the Government Through Efficient Energy Management, available from https://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/Req-EO13123greengovt.pdf*

[60] *DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, available from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN*

within the proposed scope of imaging equipment products shown in Table 10. They all fit the definition of printer. This is aligned to the stakeholders feedback (see chapter 2.5.5) and in the conclusions of the market analysis (see chapter 3.6).

Table 10. Suggested EU GPP scope and definitions for imaging equipment products

Product	Definition
Printer	A product whose primary function is to generate paper output from electronic input. A printer is capable of receiving information from single-user or networked computers, or other input devices (e.g., digital cameras). This definition is intended to cover products that are marketed as printers, and printers that can be field-upgraded to meet the definition of an MFD.
Copier	A product whose sole function is to produce paper duplicates from paper originals. This definition is intended to cover products that are marketed as copiers, and upgradeable digital copiers (UDCs).
Multifunction Device (MFD)	A product that performs two or more of the core functions of a Printer, Scanner, Copier, or Fax Machine. An MFD may have a physically integrated form factor, or it may consist of a combination of functionally integrated components. MFD copy functionality is considered to be distinct from single-sheet convenience copying functionality sometimes offered by fax machines. This definition includes products marketed as MFDs, and "multi-function products" (MFPs).
Scanner	A product whose primary function is to convert paper originals into electronic images that can be stored, edited, converted, or transmitted, primarily in a personal computing environment. This definition is intended to cover products that are marketed as scanners.

In addition, it is suggested to include in the revised text the complementary definitions used in ENERGY STAR v2.0 specification in relation to marking technologies, media format sizes, power modes and additional functionalities found in imaging equipment in order to clearly indicate to which specific technology apply the different criteria. These additional definitions are listed in Appendix 1.

2.6.2 Imaging equipment consumables

The current GPP criteria focus only on imaging equipment products. However, as the products are becoming more efficient, the importance of consumables is becoming more evident showing 20-30% contribution to Global Warming Potential and Primary Energy Demand in the LCA studies reviewed (for the main life cycle assessment outcomes regarding environmental impacts, see Technical Report). Furthermore, other widely used schemes such as the Blue Angel, EPEAT and the Nordic Swan consider consumables in their certification criteria concurring on their importance which is also pointed out by the stakeholders answering the survey (see chapter 4.4).

It is therefore proposed to extend the scope of the GPP criteria to include consumables.

Whilst the ENERGY STAR v2.0 specification could provide suitable product definitions, scope and categorisations for imaging equipment models it may not support the same for consumables.

The proposed scope and definitions for consumables have been aligned to EPEAT, Blue Angel, Nordic Swan and the Korea eco-label discussed in chapter 2.1. Based on this, a definition of imaging equipment consumables is proposed as:

"A replaceable product that is essential to the functioning of the imaging equipment product. Consumables are replaced or replenished by either the end user or service provider during the normal usage and life span of the imaging equipment product. Examples of consumables include, but are not limited to: toner, toner containers, toner bottles, toner cartridges, waste toner cartridges, ink cartridges, ink heads, ink sticks, ribbon ink, thermal paper, office paper, imaging units, transfer belts, transfer roller, fusers and drum maintenance units. Items that are not intentionally designed to be normally replaceable are considered to be spare parts."

Proposed scope and definitions of imaging equipment consumables are shown below.

Imaging Equipment consumables scope
A replaceable product that is essential to the functioning of the imaging equipment product. It can be replaced or replenished by either the end user or service provider during the normal usage and life span of the imaging equipment product. Imaging equipment consumables covered under the scope of this EU GPP include: a) Containers, b) Cartridges, c) Drum units, d) Fusers units, e) Transfer kits.

Table 11. Suggested EU GPP scope and definitions for imaging equipment consumables

Imaging equipment consumables	Definition
Container	An end-user replaceable product that holds toner or ink and that fits onto or into or is emptied into an imaging equipment product. Containers do not contain integrated components or moving parts integral to the imaging product's function.
Cartridge (Ink/toner)	An end-user replaceable product, which fits into or onto an imaging equipment product, with printing-related functionality that includes integrated components or moving parts integral to the imaging equipment's function beyond holding the ink or toner material.
Drum units	An end-user replaceable product, which fits into an imaging equipment product and which includes a photosensitive drum.
Fusers units	An end-user replaceable product, which fits into an imaging equipment product and which consists of a pair of heated rollers that fuse toner onto output media.
Transfer unit	An end-user replaceable product, which fits into an imaging equipment product, and which supports the transfer of toner onto output media ahead of a fusing process.

Supplementary definitions useful in the context of imaging equipment consumables are included in Table 12.

Table 12. Supplementary definitions

Product	Definition
Non-OEM-manufacturer cartridge	A cartridge not manufactured by the OEM imaging equipment manufacturer which can be is remanufactured and/or refilled
Non-OEM-manufacturer container	A toner or ink container not manufactured by the OEM imaging equipment manufacturer which can be is remanufactured and/or refilled.
Remanufactured cartridge	A cartridge that has been used, repaired by replacing wear parts and filled with new toner or ink (incl. solid ink)
Remanufactured container	A container that has been used, repaired by replacing wear parts and filled with new toner or ink (incl. solid ink)
Refilled cartridge	A cartridge that has been used and filled with new toner or ink (incl. solid ink).
Refilled container	A container that has been used and filled with new toner or ink (incl. solid ink).

2.6.3 Printing services

The analysis of public tenders shown in chapter 3.2 suggests that a trend to increase the use of purchased service agreements through managed service print services is expected. Therefore, it is proposed to extend the scope to include also printing services. These can include a leasing agreement for printing and scanning or selling the products including a service agreement covering maintenance and even optimised document output through a managed printing service (MPS). It is expected that these services develop further into established services offered to non-domestic users, and this needs to be taken into account in the revision of the current EU GPP criteria.

The proposed scope and definitions for printing services is based on industry practices. Many schemes and business models exist for the provision of these services, so the proposed classification and definitions are somewhat generic in order to cover all these possibilities.

The proposed relevant definitions of printing services are shown below.

Print services

Service agreements where the price is linked to the quantity of printed pages. These agreements can include the supply of IE products and /or consumables, maintenance, end of life activities and optimisation of organisation's document output.	
Other relevant definitions related to printing services	
Managed Print Services (MSP)	The Managed Print Services Association (MPSA)[61] defines MPS as "***the active management and optimization of document output devices and related business processes***". MPS covers the following service areas: • *Assessment*: which involves a review of existing print environment of an organization and aims to provide recommendations for better device management, • *Optimization*: which entails consolidating and rationalizing devices and business processes to develop a comprehensive MPS strategy, • *Management*: which covers systematic reviews, monitoring of service level agreement (SLA) and remote management. It aims to improve ongoing process and workflows.

[61] *For more information see the website of the organisation: http://yourmpsa.org/*

3 TASK 2: MARKET ANALYSIS

3.1 Technical state-of-play of imaging equipment

3.1.1 Product and service

There is a large amount of variability in terms of the types of imaging equipment that are placed on the EU market.

The products included in the scope of the existing EU GPP project range from small desktop inkjet based printers to large commercial laser based multi-functional devices. The products at the extreme ranges of the product scope share few technical similarities apart from being able to place an image on a piece of paper. Despite these technical differences all types of imaging equipment, being electronic products, have environmental impacts associated.

The imaging equipment market can be roughly split into "**domestic**" and "**commercial**" with some overlap amongst mid-range products. Both the domestic and commercial markets are constantly changing due to a myriad of factors such as customer demands and the drive for manufacturers to maximise revenue and profit.

In recent years, there has been a gradual decline in the number of imaging equipment sales in the EU[62]. Despite this general slow-down, certain trends in product changes continue. The increased demand for multifunction devices (MFDs) and larger format professional print imaging equipment has led to increased sales in these product types.

Whilst laser based imaging equipment has long dominated the office market, improvements in inkjet technology, coupled with reduced printing costs, have increased demand for this marking technology in business premises. Conversely, reductions in the prices of laser based imaging equipment have encouraged more sales of this product type, replacing inkjet sales, into domestic and small business premises.

The speed of devices continues to increase as more business users turn to faster devices to deliver shared printing.

More businesses are bringing **professional print in-house** (i.e. conducting their own professional printing) which has led to an increase in imaging equipment capable of supporting A3 or even larger media.

There has also been an increase in demand for printing on different types of media, other than paper, which impacts the types of products that are sold into both domestic and business premises.

Overall volumes of printing are expected to continue decreasing for several reasons. Firstly, people are more likely to view content on digital devices rather than hard copy output, supported by the improved quality of displays used in domestic and business premises. Perhaps more importantly, larger numbers of organisations now accept electronic copies of documents, such as travel tickets, reducing the need for printers in domestic environments.

Some major changes are occurring in the commercial sector as **managed print services (MPS)**, where the customer buys an imaging service rather than buying the imaging equipment, continues to expand into new types of businesses and current offerings evolve. Integrated services related to MPS, such as scanning, storage, hybrid mail (mail that is

[62] *Print IT, 2017, Printer sales down again in Q3 2016, despite revenue gains in Western Europe, available from http://www.printitmag.co.uk/printer-sales-down-again-in-q3-2016-despite-revenue-gains-in-western-europe/*

delivered using a combination of electronic and physical delivery) and workflow solutions are becoming more popular as businesses demand joined up solutions from a single provider. This could have the effect of reducing the number of manufacturers and service providers in the market place as service requirements become more complex.

Cloud based printing, which enables imaging equipment to be accessed over a network through cloud computing, is also likely to become more commonplace as businesses become more mobile.

Many manufacturers and vendors are changing to a **'walk in and takeover' (WiTo) approach** rather than the older **'rip and replace' approach**. This means that the lifetimes of imaging equipment already deployed in businesses may increase over time. This approach has encouraged most imaging equipment manufacturers to offer 'brand agnostic' MPS programs which are partnered with cartridge remanufacturers. This change in the market is likely to increase the need for cartridges that can be remanufactured because they need access to cartridges to fit in older machines that are not theirs.

3.1.2 Mode of operation

The majority of the imaging equipment included within the scope of this revision study converts digital content onto physical media such as paper. Some of the imaging equipment types in scope can convert content on physical media into digital format (e.g. scanners and MFDs).

A number of different marking technologies are used within imaging equipment to place content onto physical media. A detailed list of marking technologies employed by imaging equipment is provided in Appendix 1. The most common marking technologies used in imaging equipment are **Electro-photographic (EP) (Laser)** and **Ink Jet (IJ).**

The EP marking technology is characterized by the illumination of a photoconductor in a pattern representing the desired output image via a light source, development of the image with particles of toner using the latent image on the photoconductor to define the presence or absence of toner at a given location, transfer of toner to the final print media, and fusing to cause the output to become durable. Colour EP products simultaneously offer three or more unique toner colours which are blended to provide the desired colour output. **EP based products utilise cartridges or containers which contain toner powder.**

Ink Jet marking technology is characterized by the deposition of colorant in small drops directly to the print media in a matrix manner. There are a number of **sub-types including Piezo-electric (PE) IJ, IJ Sublimation, and Thermal IJ** which largely dictate the way in which ink is removed from a container or cartridge and placed on the output media. **IJ based products utilise cartridges or containers which contain ink**.

Energy use in imaging equipment can vary considerably between different models and is strongly correlated to the level of functionality provided. **Imaging equipment products that utilise thermal technologies, such as laser, tend to use more energy than inkjet based products.** Energy use also varies significantly even within distinct product types such as laser printers.

Figure 9 illustrates the strong correlation between energy use and imaging speed amongst laser printers registered in the EU ENERGY STAR database. The "Max" line in the chart illustrates the maximum amount of energy used per speed bracket by products in the EU ENERGY STAR database, with the "Min" line showing the opposite.

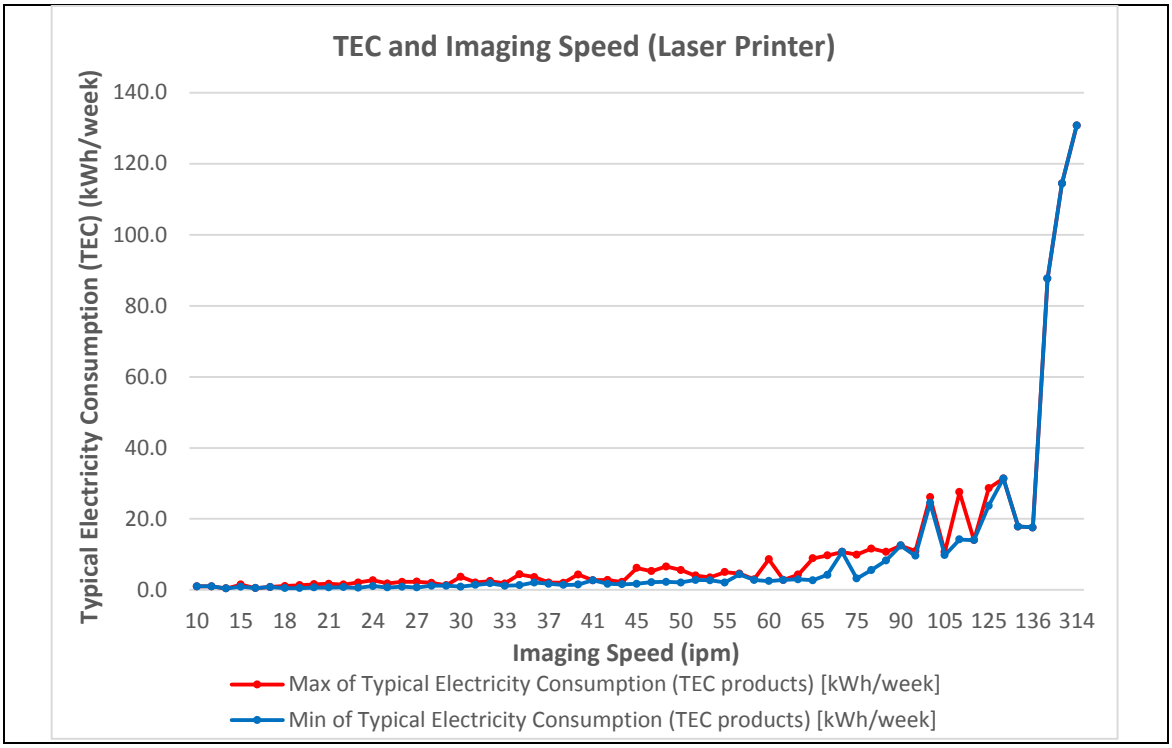

Figure 9. Energy use in ENERGY STAR Registered Laser Printers[63]

3.1.3 Management

In the vast majority of cases imaging equipment sold into domestic premises is sold as a product rather than service. Some repair services may be provided with domestic product purchases but on-going site based support is unlikely to be provided. In the commercial sector, there are many organisations, including manufacturers, which offer a broad range of imaging equipment services. Where imaging equipment services are employed these may include management of the imaging equipment from cradle to grave as well as full management of any consumables.

[63] *European Commission, EU ENERGY STAR program, available from http://www.eu-energystar.org/*

3.2 Procurement practices

Imaging equipment is purchased by a broad range of individuals and organisations. At one end of the scale it may be the purchase of inexpensive inkjet printers without significant consideration of technical specifications or environmental impacts, while on the other end it maybe the purchase of high speed/volume equipment linked with detailed consideration of technical specifications and environmental impacts of the products being purchased by highly committed private customers or public authorities.
For public organisations, the individual public purchase of imaging equipment products is typically below threshold that requires that EU procurement rules are followed. But more often products are bought via a framework contract whereby delivery of products and services over several years are agreed.
There is a variety of purchasing and tendering approaches among public organisations, including:

- The public institution, such as a municipality, makes its own tender
- Several institutions form a group and offer a common tender
- Specific purchasing organisations (such as SKI in Denmark), agree framework contracts for specific products/services with selected suppliers that the individual public organisations can use without further tendering
- Governmental organisations use a tender for specific product and services to select supplier(s) which the individual state institution is then obliged to use

Typically, a larger tender in a public organisation involves the following types of experts:

- Procurement experts, who are experts in the tendering process, contractual aspects etc., but with less technical knowledge of the products
- IT professionals, who know the products and services and the main technical requirements for meeting the technical needs
- Representatives of the users, who work with the products and services
- Sometimes also environmental staff (mainly if the organisation has set climate objectives and/or green purchasing requirements), who assist in adding environmental criteria to the tender

In any case, the typical buyers are professional and experienced technical purchasers. Although these buyers may have the competences to choose energy efficient and environmentally sound products and services, typically they do not include the environmental parameters as important purchasing requirements but rather focus on other aspects.
This market failure in terms of economic sound (over the lifetime) purchasing decision is due to division between budgets for purchasing (typically a specific IT budget) and running costs (typically part of an administrative budget), lack of functional information, and a perceived complexity by public procurers for assessing the Total Cost of Ownership (TCO).

3.2.1 Overall mapping

The large variance in types of imaging equipment in the scope of this review means that procurement practices will also vary significantly.
Lack of data means that it is not possible to give the exact purchasing patterns used by consumers and businesses. Household consumers and many small to medium sized businesses mostly buy imaging equipment through physical and internet based retail. Many businesses, especially larger businesses, purchase imaging equipment products or imaging equipment services directly from imaging equipment manufacturers. There are also many imaging equipment resellers which are also focussed on the larger business market.

Government purchasing patterns are more easily identified due to the requirement for public disclosure of information. The European Commission Tenders Electronic Daily (TED) website includes records of how government bodies throughout the EU purchase imaging equipment.[64] TED is the supplement to the Official Journal of the EU where all public procurement contracts over set financial thresholds (shown in Table 13) are mandatorily published. Questioning the TED database shows that in 2016 public institutions in the EU published 384 contract award notices for contracts which included products meeting the CPV code 30232100 (Printers and plotters).

Table 13. EU public institution procurement thresholds

Type of Authority	Type of contract		Threshold (€)
Central Government authorities	Works contracts, subsidised works contracts		5,225,000
	All services concerning social and other specific services listed in Annex XIV		750,000
	All subsidised services		209,000
	All other service contracts and all design contests		135,000
	All supplies contracts awarded by contracting authorities not operating in the field of defence		135,000
	Supplies contracts awarded by contracting authorities operating in the field of defence	Concerning products listed in Annex III	135,000
		Concerning other products	209,000
Sub-central contracting authorities	Works contracts, subsidised works contracts		5,225,000
	All services concerning social and other specific services listed in Annex XIV		750,000
	All other service contracts, all design contests, subsidised service contracts, all supplies contracts		209,000

Table 14 shows the types of purchasing procedures that EU institutions, of varying type, used when purchasing printers and plotters in 2016, based on the TED data.

Whilst the use of the open procedure is by far the most common type of procedure used when purchasing imaging equipment, there are several types of procedure that are used in public procurement[65]:

- **Open procedure** - In an open procedure any business may submit a tender. The minimum time limit for submission of tenders is 35 days from the publication date of the contract notice. If a prior information notice was published, this time limit can be reduced to 15 days.
- **Restricted procedure -** Any business may ask to participate in a restricted procedure, but only those who are pre-selected will be invited to submit a tender. The time limit to request participation is 37 days from the publication of the contract notice. The public authority then selects at least 5 candidates with the required capabilities, who then have 40 days to submit a tender from the date when the invitation was sent. This time limit can be reduced to 36 days, if a prior information notice has been published. In urgent cases the public authority may set a time limit of

[64] *http://ted.europa.eu/TED/misc/aboutTed.do*

[65] *European Commission, Tendering rules and procedures, available from http://europa.eu/youreurope/business/public-tenders/rules-procedures/index_en.htm*

15 days to receive participation requests (if the notice is sent electronically, this can be reduced to 10 days) and 10 days for the submission of the tenders.

- **Negotiated procedure –** In a negotiated procedure the public authority invites at least 3 businesses with whom it will negotiate the terms of the contract. Most contracting authorities can use this procedure only in a limited number of cases, for example for supplies intended exclusively for research or testing purposes. The contracting authorities in sectors such as water, energy, transport or postal services may use it as a standard procedure. The time limit to receive requests to participate is 37 days from the publication of the contract notice. This can be reduced to 15 days in extremely urgent cases, or 10 days if the notice is sent electronically. Under certain conditions this procedure can be chosen even without publication of a contract notice, for example:
    - where no tenders were submitted in an open or restricted procedure
    - in extremely urgent cases
    - in cases where, for technical reasons, the contract can be carried out only by a single business
- **Competitive dialogue –** This procedure is often used for complex contracts such as large infrastructure projects where the public authority cannot define the technical specifications at the start. After the publication of the contract notice, interested businesses have 37 days to request participation. The public authority must invite at least 3 candidates to a dialogue in which the final technical, legal and economic aspects are defined. After this dialogue candidates submit their final tenders. Competitive dialogue cannot be used by public services providers in the water, energy, transport and postal services sectors.

It is important to note that government purchasing of imaging equipment under the set thresholds may not be recorded in the TED database as there is no requirement to publish the contract through TED. This means that contracts from smaller government bodies are more likely to be missed from this analysis.

Table 14. EU Public Institution Procurement Procedure Types covering CPV 30232100 in 2016

Type of Procedure	Regional or local authority	Regional or local Agency/ Office	Ministry or any other national or federal authority	Utilities entity	National or federal Agency/ Office	Body governed by public law
Contract award without prior publication	1		1			
Competitive procedure with negotiation	2					1
Negotiated procedure without a call for competition	1		3	1	1	2
Open procedure	108	4	83	7	8	140
Negotiated procedure	1			13		2
Competitive dialogue			1			1
Restricted procedure						3
All	**113**	**4**	**88**	**21**	**9**	**149**

Table 15 shows that there was significantly more supply (i.e. product purchasing) contracts than service (i.e. products plus product management services) contracts awarded for imaging equipment purchased through TED in 2016.

Table 15. EU Public Institution Contract Types covering CPV 30232100 in 2016

Type of Contract	Contract award prior without publication	Competitive dialogue	Competitive with procedure negotiation	Negotiated procedure without a call for competition	Open procedure	Restricted procedure	Negotiated procedure
Supplies	2	1		3	303	3	14
Services		1	3	5	45		2
Works					2		

Table 16. Types of EU Public Institution and Contract Types covering CPV 30232100 in 2016

Type of Contract	Ministry or any other national or federal authority	National or federal Agency/ Office	Regional or local authority	Regional or local Agency/ Office	Utilities entity	Body governed by public law
Supplies	79	7	92	3	16	129
Services	9	2	19	1	5	20

Works			2			

Table 17 provides further detail about the type of imaging equipment included in EU government wide procurement contracts during 2016. No firm conclusions can be drawn about the most popular type of imaging equipment product due to the overarching CPV code 30232100 being used in many contract award notices as well as the fact that procured volumes cannot be identified.

Table 17. Number of EU wide government contract awards in 2016 for imaging equipment

			Number of Contracts Awarded 2016		
Procuring Authority Type	**CPV Code**	**CPV Name**	**Supplies**	**Services**	**Works**
National or federal Agency/Office	30232100	Printers and plotters	3	2	
	30232110	Laser printers	7		
	30232130	Colour graphics printers	3		
	30232150	Inkjet printers	1		
Ministry or any other national or federal authority	30232100	Printers and plotters	29	6	
	30232110	Laser printers	48	5	
	30232120	Dot-matrix printers	2		
	30232130	Colour graphics printers	7	2	
	30232140	Plotters	6		
	30232150	Inkjet printers	17	1	
Regional or local authority	30232100	Printers and plotters	56	11	1
	30232110	Laser printers	55	11	1
	30232120	Dot-matrix printers	1	2	
	30232130	Colour graphics printers	12	4	
	30232140	Plotters	2		
	30232150	Inkjet printers	9	5	
Body governed by public law	30232100	Printers and plotters	13	52	
	30232110	Laser printers	9	86	
	30232120	Dot-matrix printers		3	
	30232130	Colour graphics printers	1	10	
	30232140	Plotters	1		
	30232150	Inkjet printers	3	17	
Utilities entity	30232100	Printers and plotters	13	4	
	30232110	Laser printers	6	2	
	30232120	Dot-matrix printers	1		
	30232130	Colour graphics printers	1	1	
	30232140	Plotters	1		
	30232150	Inkjet printers	3	1	

Attempting to delve deeper into the data to identify how environmental aspects are considered in the contracts is complicated by the fact that the information is not available within the search functionality in the TED website. The environmental considerations used in some public contracts for imaging equipment can be viewed by visiting the appropriate contracting authority's website and downloading the original tender documentation. Given the large number of contracts in the area, across many EU languages, it was not possible to conduct a full review for the purposes of this project. Some contracts include simple broad statements concerning compliance with EU and national environmental laws but not product environmental specification listed (e.g. EU GPP criteria on imaging equipment).[66] Conversely at least one large framework contract[67] on multi-functional devices included several pages of environmental requirements, albeit with some environmental requirements that may be incompatible with the EU public procurement directives.

3.2.2 National and regional public procurement schemes

In 2003, EU Member States were asked by the European Commission in its Communication on Integrated Product Policy (IPP), to develop publicly available National Action Plans (NAPs) for reducing the environmental impacts associated with the products and services that were procured by their public bodies. The NAPs were required to identify the current state of affairs in terms of green public procurement and set ambitious targets for quantifiable improvements. Whilst the NAPs are not mandatory it was envisaged that they would increase awareness of green public procurement within member states and in turn provide political impetus.

In November 2016, the European Commission undertook a review of the EU Member States NAPs. So far, they have been adopted in many of the member states (see Table 18).

Table 18. Presence of green procurement national action plans amongst member states

NAP adopted or not	Country
National Action Plan or equivalent document adopted	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK
No existing NAP	Estonia, Greece, Hungary, Luxembourg, Romania

Many national and regional government bodies, in the EU and outside, have their own green procurement specifications in place which cover imaging equipment. Some of the most notable are:

- UK Government Buying Standards (GBS) – bespoke specifications based on the ENERGY STAR specification scope and categorization
- US Public Procurement – primarily using the EPEAT scheme for specifications and ENERGY STAR (for Federal procurement)
- Korea - through the use of the Korean eco-label specifications

[66] *Department of Foreign Affairs and Trade, https://irl.eu-supply.com/app/rfq/publicpurchase_frameset.asp?PID=104673&B=ETENDERS_SIMPLE&PS=1&PP=*

[67] *Crown Commercial Service, Framework schedule 2: Goods and Services and Key Performance Indicators - Part A: Goods and Services, Lot 2 – Multifunctional Devices (MFD's) and Print Management Software and Services, https://ccs-agreements.cabinetoffice.gov.uk/contracts/rm3781*

However, it is important to note that it is difficult to assess the extent to which these initiatives are being enforced within public contracts for imaging equipment. Public procurement in the EU is very fragmented across the many different procuring bodies. This fragmentation makes it difficult to identify the extent to which environmental considerations are included in contracts.
By accessing the TED database, it was found that in 2016 public institutions in the EU published 384 contract award notices for contracts which included products meeting the CPV code 30232100 (printers and plotters). Table 15 shows the types of purchasing procedures that EU institutions, of varying type, used when purchasing printers and plotters in 2016.

3.2.3 Ownership and forms of sale

As previously mentioned, domestic purchasers and smaller organisations are more likely to procure products whereas larger organisations will trend towards buying services.

Public bodies may buy imaging equipment products through "supplies contracts" whereby imaging equipment is purchased as part of a larger imaging service (i.e. where an external organisation manages the imaging equipment on site).

Many purchasing decisions concerning imaging equipment are made at departmental or individual, rather than at the organisational level. This can result in a surplus of imaging equipment products, especially lower specification desktop based devices (e.g. small inkjet printers, scanners and/or multifunctional devices), which also leaves larger centralised imaging equipment underutilised. This situation can result in increased costs for procuring authorities due to the need for increased support and inefficient use of resources. A lack of visibility and understanding over the Total Cost of Ownership (TCO) of printing drove the imaging equipment market to recognise the need for better management of imaging equipment and to provide imaging equipment management services.

Suppliers which provide imaging equipment services rather than products are described as "service providers". Imaging equipment service provision is most commonly called "Managed Print Services (MPS)", which are services offered by an external provider to optimize or manage an organisation's document output[68]. The main components of an MPS are:

- Hardware provision: This may include different types of imaging equipment such as printers, multi-functional devices (MFDs), fax machines, photocopiers and scanners. MPS suppliers tend to aim to consolidate existing imaging equipment on clients' premises and install newer technology to replace older, less efficient, devices. However, legacy equipment may be left in situ depending on clients' needs.
- Software: MPS suppliers and imaging equipment manufacturers typically provide a wide range of software to help manage print and document environments and improve document processes. These software applications are used to help integrate the imaging equipment on a client's premises to enhance effectiveness or add additional functionality and services. These can include:
    - Print management software – to control and continuously monitor/audit the print environment;
    - Document creation – variable data printing, document collaboration and conversion;
    - Document management software – document archive, retrieval and workflow;
    - Integration – third party integration for seamless user interaction between device, documentation and back office systems;
    - Print room – managing the in-house print room;
    - Remote monitoring – to provide proactive alerting and device monitoring capabilities;
    - Support services (helpdesk).

[68] *The document's output refers to a price per printed document or per a certain amount of printed documents*

MPS normally also include additional support services including the day-to-day technical or administrative support of end-users, service and maintenance of imaging equipment (both remote and on-site), supply of devices and consumables (e.g. printer cartridges, paper, fuser kits etc.) as well as billing and reporting of usage statistics. These are often referred as 'service agreements'.

MPS suppliers are moving beyond cost cutting to solutions which help drive innovation within organisations. MPS suppliers recognise that office environments and working practices are changing, with increasing adoption of mobile working and cloud services. This has led to MPS changing, moving from a solely cost focus to a focus on both costs and innovation. Newer MPS solutions move beyond simply managing the printers in an office to also managing the print room, business processes and the overall IT infrastructure. This more integrated approach to MPS provides an infrastructure where users can securely input, obtain or output information when and wherever needed.

3.2.4 Best procurement practices

The level of environmental conditions laid down in public procurement contracts varies significantly.[69] Most of these include simple broad statements as mentioned previously but one large framework contract[70] on multi-functional devices included several pages of environmental requirements. Some examples are:

- Compliance with all relevant environmental legislation
- Comply and operate to the standard ISO 14001; Eco-Management and Audit Scheme (EMAS) or a nationally recognised agreed equivalent accredited standard for the scope of the Product Range
- Work co-operatively and aid Contracting Authorities to support the Government's environmental policies including associated reporting requirements
- Work proactively with Contracting Authorities in relation to but not limited to, the following areas: noise reduction, removal of unwanted consumables and reduced heat production in confined spaces
- Collection and disposal of all packaging, materials and redundant or replacement spare parts in accordance with WEEE Regulations
- Take steps to encourage the reuse of any WEEE generated in the delivery of the Product Range
- Ensure that all toner bottles and cartridges are capable of reuse or, as a minimum, recycling
- Provide containers to Contracting Authorities which are suitable for the accumulation of used Consumables and redundant parts
- Provide a financial credit incentive for Contracting Authorities who return spent toner bottles and cartridges
- Provide information on the resource and energy efficiency impacts of all imaging equipment, including but not limited to:
  - compliance with requirements in a number of environmental initiatives;
  - operational energy consumption and energy efficiency Data;
  - recycled content in product build;
  - recycle ability of the device to minimise landfill/incineration.
- Provide, when requested by Contracting Authorities, the following information:

[69] *The evaluation focussed on recently tenders published within TED that included imaging equipment (supplies or service) and where contract documentation was openly available without the need to contact procuring authorities. No more than 20 tenders were reviewed.*

[70] *Crown Commercial Service, Multifunctional Devices, Managed Print and Content Services and Records and Information Management, http://ccs-agreements.cabinetoffice.gov.uk/contracts/rm3781*

    - the proportion, by weight, of post-consumer and non-post-consumer recycled material in the equipment and in the packaging;
    - the weight and volume of packaging applicable to equipment received by Contracting Authorities;
    - details around the management of the imaging equipment at end of life.
- Complete annual Corporate Social Responsibility (CSR) assessments upon request from Contracting Authorities.

Further requirements related to product features were also included as mandatory considerations:

- Ensure that all imaging equipment can operate effectively with 100% post-consumer waste recycled paper
- Ensure that all imaging equipment complies with the requirements of the (UK) Government Buying Standards (GBS) for Imaging Products, Energy Star Rating and Article 6 of the Energy Efficiency Directive (EED) Standards
- Minimise the amount of packaging required for safe transportation and delivery of Equipment

The ability to verify product compliance against environmental criteria included in public procurement contracts is an important consideration. The process of verifying compliance to environmental criteria in tender documents varies, depending on the type of criteria which are being verified. For example, product specific environmental criteria, such as pre-defined levels of energy efficiency, may be verified through a number of routes including:

- Manufacturer self-declarations (e.g. Ecma 370 declarations)
- Eco-label registrations (e.g. ENERGY STAR database entry, Blue Angel registration)
- Declarations of conformity
- Third party test reports

Verification of product environmental criteria is often easier where the same criteria can be found in multiple environmental initiatives. Harmonization of criteria across environmental initiatives can therefore assist public procurers by providing multiple resources to verify product compliance. Furthermore, harmonization of criteria across the various public procurement organisations nationally and at EU level will help the bidders to provide precise and correct data and information without extensive efforts, which again will secure the public organisations with a larger selection of compliant products. Some EU based green public procurement initiatives ensure that all criteria included in product environmental specifications are found in multiple environmental initiatives. For example, the UK Government Buying Standards (GBS) for IT products were developed in such a way that procurers could reply on the commonly available Ecma-370 declarations as well as the EPEAT database in order to verify compliance.

The use of bespoke product environmental criteria in procurement contracts can cause issues with verification but this depends of how they are formulated. For example, bespoke criteria that describe an enhanced level of environmental performance in comparison to other schemes, such as more stringent energy efficiency targets, are still likely to be easily verifiable where an established and harmonised test procedure is used which is comparable. Conversely, bespoke criteria that address a new environmental impact area may be more difficult to verify unless it is known that product manufacturers have conducted tests according to an established test methodology.

Verification of environmental criteria that relate to company environmental performance may be verified in a similar method to product based specifications but this largely depends on which company environmental performances are being addressed. For example, verifying whether a company has an environmental management system is relatively easy to do given that this information is widely communicated and verification documents exist. However, bespoke or service specific company based environmental performance requirements are likely to be more difficult to verify. Where environmental contract performance conditions are placed on suppliers, on-going verification will be required throughout the duration of the contract. This will require procuring authorities to continually monitor suppliers' activities in order to verify that contract performance conditions are being met.

Many public bodies throughout the EU address the environmental impacts associated with imaging equipment and consumables within their procurement contracts. Best practice in the area is somewhat difficult to identify as not all public procurement contracts are readily available via the EU tendering system. The inability to review all contracts, and the associated environmental conditions laid down in those contracts, means that it is not possible to be certain about what constitutes current best practice. Some examples of good practice in the field of procurement have been identified which may reflect current best practice. These examples are provided in the following sections.

3.2.4.1 Examples of public procurement of imaging equipment – the Scottish Government

The Scottish Government currently runs a large framework contract for imaging equipment products and services[71]. Various Scottish public bodies are entitled to procure services from vendors that have been pre-selected through the framework contract. The framework contract itself lays down a number of environmental requirements on imaging equipment products and services. These include:

- **Minimum product environmental performances:**
  - Mandatory compliance to either the UK Government Buying Standards (GBS) or the EU GPP criteria
- **Additional Requirements During Service Provision**
  - Contractors increase the sourcing of components that reduce adverse effects on the environment, whilst ensuring no degradation to the product quality.
  - Contractors are expected to assist Framework Public Bodies, where relevant, to be energy efficient, manage waste in accordance with the waste hierarchy, minimise emissions in service delivery, deliver circular economy outcomes and extend equipment useful life, through appropriate measures such as product design that enables disassembly and ease of repair or upgrade, take back of products aligning with Framework Public Bodies replacement cycles, re-use of equipment or parts or re-conditioning of equipment and associated consumables and the provision of pre-owned or used equipment with appropriate certification to quality standards.
  - Contractors encouraged to demonstrate continual improvement in environmental performance above the minimum standards including through innovative solutions. Where a product does not operate to a minimum environmental standard Contractors will be required to demonstrate how environmental criteria are being addressed.
  - Contractors to provide a range of remanufactured products under this Framework Agreement. These products can be provided on a lease or capital purchase basis, but products and documentation supplied must be clearly identified as being remanufactured.
  - Contractors will be required to ensure that any remanufactured products supplied must perform to a comparable standard and quality required of a new product.
  - Contractors to provide a range of refurbished products under this Framework Agreement. These products can be provided on a lease or capital purchase basis, but products and documentation supplied must be clearly identified as being refurbished.
  - Contractors required to ensure that any refurbished products supplied must perform to a comparable standard and quality required of a new product.
  - Contractors required to demonstrate how they assess the likelihood of conflict minerals within products, and what measures they have undertaken to minimise and eliminate, where practical, such minerals. The Contractor is required to comply with any new and emerging legislation and/or self-certification system.

[71] *Secured through personal communications with Scottish Procurement, The Scottish Government*

- Contractors required to support a reduction in packaging under this Framework Agreement. This must not hinder the safe delivery of products. Minimisation of waste will be achieved through the principles of sustainably sourced materials as well as reduction, re-use and re-cycling methods, such as through the use of creative packaging design, innovative environmentally friendly materials, and re-usable packaging. Contractors must ensure that plastics used for product packaging do not contain halogen containing polymers. Packaging should contain recycled content, or, as an alternative, be sustainably sourced packaging. Contractors will be responsible for the removal of all packaging.
- Cardboard packaging used will consist of at least 80% recycled content.
- All packaging components will be easily separable by hand into individual materials to facilitate recycling.
- No packaging is to contain any plant based material that was illegally sourced from its country of origin. Contractors will be expected to be able to verify legal sourcing of relevant materials.
- Contractors are responsible for ensuring that all packaging is of adequate size and of substantial quality to prevent damage to the goods and with regard to the environment. Each delivery must be accompanied by a delivery note, in a plastic sleeve
- Contractors encouraged to demonstrate continual improvement in energy efficiency above the minimum standards including through innovative solutions. Where a product does not operate to a minimum energy efficiency standard Contractors will be required to demonstrate how energy efficiency is being addressed.

3.2.4.2 Example of Public procurement of imaging equipment – the UK Government

The UK Government has also run a large framework procurement exercise on imaging equipment for some time[72]. Again, the framework contract includes product specific mandatory minimum environmental performance criteria as well as sustainability criteria related to service provision. The framework contract states that suppliers must:

- Comply and operate to the standard ISO 14001; Eco-Management and Audit Scheme (EMAS) or a nationally recognised agreed equivalent accredited standard for the scope of the Product Range.
- Work co-operatively and provide assistance to Contracting Authorities to support the Government's Agenda to meet the Greening Government Commitments (GGC), including associated reporting requirements
- Effectively manage the Product Range supplied under this Framework Agreement, in order to minimise any impact on the environment. Where appropriate, the Supplier shall work proactively with Contracting Authorities in relation to but not limited to, the following areas: noise reduction, removal of unwanted Consumables and heat production in confined spaces.
- Minimise the amount of packaging required for safe transportation and delivery of Equipment. When requested by Contracting Authorities, the Supplier shall provide evidence of how this is achieved including the purpose for each piece of packaging and whether the packaging originates from recycled / sustainable sources.
- Be responsible for the collection and disposal of all packaging, materials and redundant or replacement spare parts in accordance with WEEE Regulations
- Take steps to encourage the reuse of any WEEE generated in the delivery of the Product Range, as promoted by the WEEE Directive. This shall include, but is not limited to,

[72] *Crown Commercial Service, Multifunctional Devices, Managed Print and Content Services and Records and Information Management,* http://ccs-agreements.cabinetoffice.gov.uk/contracts/rm3781

consideration of the application of PAS 141:2011 Re-use of Used waste Electrical and Electronic Equipment (UEEE and EEE).

- **Return of Consumables and Redundant Parts**
  - ensure that all toner bottles and cartridges are capable of re-use or, as a minimum, recycling. When requested by Contracting Authorities, the Supplier shall demonstrate the full re-use or recycling streams for toner bottles and cartridges.
  - provide containers to Contracting Authorities which are suitable for the accumulation of used Consumables and redundant parts including but not limited to: spent toner bottles, cartridges, waste toner, developer liquids/powder, replaceable units such as a fuser or developer, broken parts and packaging. The Supplier shall arrange collection and replacement of the containers, no later than three (3) working days after a request is received from Contracting Authorities and this shall be provided at no additional cost to Contracting Authorities.
  - provide a financial credit incentive for Contracting Authorities who return spent toner bottles and cartridges, which shall be paid to Contracting Authorities quarterly in arrears.
  - expected to demonstrate acceptable operational use of recycled toner to the Contracting Authorities in the event that Contracting Authorities request the use of recycled toner as part of their requirements.

- **Information Provision**

When requested by the Authority and/or Contracting Authorities, provide information on the resource and energy efficiency impacts of all Devices, including but not limited to:

- compliance with current Government Buying Standards (GBS);
- Energy Star, European Carton Makers Association (ECMA), Electronic Product Environmental Assessment Tool (EPEAT), certifications confirming such compliance;
- operational energy consumption and energy efficiency data;
- recycled content in product build;
- recyclability of the Device to minimise landfill/incineration.

When requested by the Authority and/or Contracting Authorities, provide the following information:

- the proportion, by weight, of post-consumer and non-post-consumer recycled material in the Equipment and in the packaging;
- the weight and volume of product packaging applicable to Equipment received by Contracting Authorities;
- the management of the Equipment at end of life. This shall include details for every component of the Devices in terms of future use or location. For example, this may include, but is not limited to, re-use, recycle, landfill or any other possible eventuality in the management of components from end of life Devices;
- the energy and carbon footprint / impact of making and delivering the Product Range received by Contracting Authorities.

3.2.4.3 Example of Public procurement of imaging equipment – the Italian Government

The Italian Government have also launched framework contracts for imaging equipment and managed print services which contain extensive environmental requirements[73]. The Italian Government requirements are structured similarly to the EU GPP criteria with both core and

[73] *Consipe, Acquisti Verdi, https://www.acquistinretepa.it/opencms/opencms/programma_acquistiverdi.html*

award criteria. They are further sub-divided according to whether they are product or service specific. The criteria used include requirements on:

- Collection and Disposal
- Automatic duplexing
- Electrical and electronic waste management
- Energy Efficiency
  - ENERGY STAR Compliance
  - Better than ENERGY STAR Requirements
- Provision of Instruction Manual
- Noise Emissions
- Packing Requirements
- Recycled Paper Support
- Provision of product information including:
  - maximum energy consumption associated with the different operating modes;
  - waste collection and treatment service;
  - service and maintenance service.
- Design for recyclability
  - Marking of plastic parts
  - Recyclable polymer or just one polymer.
- Resource Consumption Reductions:
  - "Green Printing Policy" to optimize printing processes in compliance with both the specific needs of users and the best practices in environmental sustainability.
  - The Policy to highlight the economic and environmental benefits related to the implementation, for each type of equipment, of every single "green" option highlighting the differences in terms of consumption of material/ energy and cost.
  - The policy should include:
    - Automatic shutdown of the office equipment as a result of predetermined time of inactivity and setting the timer to switch off the office equipment during week-end with a huge energy saving derived from usage;
    - Draft printing mode set as the default requirement;
    - Automated management of print output and print queue, monitoring and control of the output of the office equipment, even remotely;
    - Analysis of the economic and environmental benefits associated with the implementation of every single green option.
- Noise Emissions
- Substances Emissions
- Toner and Inks, Dangerous Substances and Heavy Metals: Limits and Exclusions
- Use of toner cartridges and regenerated ink.
- Warranty on spare parts

3.2.4.4 Example of Public procurement of imaging equipment – the Danish Government

The Danish Government has two public procurement programmes: The Central Procurement Programme under the Modernization Agency (part of Ministry of Finance), which is mandatory for Government organisations with very few exceptions, and SKI, which is voluntary and offered to municipalities and regional authorities. Requirements in current and recent contracts for imaging equipment for these two programmes are briefly described in the following.

The Central Procurement Programme

The award criterion in this programme is the lowest total cost, including costs for operating expenses and electricity consumption i.e. TCO (Total Costs of Ownership).

Technical specifications:

- The products must comply with developments in market best practices, including those for multifunction devices' environmental impact, such as behavioural power management.
- Energy efficiency:
  - Energy Star: The multifunction devices offered must comply with the criteria for Energy Star certification as set out in "ENERGY STAR Program Requirements for Imaging Equipment: Version 1.1".
  - TEC (Total Energy Consumption) values: The TEC values of the multifunction device offered may not increase during the duration of the Framework Contract. This minimum requirement also applies in case of product replacement.
- Resource consumption reductions:
  - It should be possible to use 100% recycled paper and transparencies in A4 format.
  - The multifunction devices offered must be set as default on delivery for duplex copying and printing.
  - Colour machines must be set by the supplier on delivery for monochrome printing default for both copy and print.
- Design for recyclability:
  - Plastic Components: Plastic components weighing more than 25 g must be provided with a permanent marking of the material in accordance with ISO 11469 or equivalent standard.
  - Module Assembly: The multifunctional equipment offered must be built up of modules so that different materials without the use of special tools can be disassembled by recycling (gluing and welding of different material types must be avoided).
  - Toner cartridges: Offered toner cartridges must be recyclable.
- Substances:
  - Batteries: Batteries contained in the supplied multifunction machines must contain no more than 5 ppm of mercury, 20 ppm of cadmium and 100 ppm of lead in relation to the weight of the battery.
  - Toner cartridges: Toner cartridges must comply with the Nordic Swan Criteria for the absence of environmentally harmful substances in toner cartridges, cf. criteria document "Nordic Ecolabelling of Remanufactured OEM Toner Cartridges, Version 5.1", Chapter 2. It is not a minimum requirement that the toner cartridges are Nordic Swan labeled.
  - Packaging: Packaging must not contain polyvinyl chloride (PVC).
  - Use of PVC: The multifunction devices offered must not contain polyvinyl chloride (PVC). This minimum requirement does not apply to cables and wires.
  - Phthalates: The offered multifunctional devices must not contain phthalates DEHP (di (2-ethylhexyl) phthalate, DBP (dibutylphthalate) and BBP (butylbenzylphthalate) and DIBP (Diisobutylphthalate).
  - Mercury: The display of the multifunctional device offered shall be without mercury.
  - Flame retardants: The multifunction devices offered must not contain additive addition of brominated flame retardants in more than 0.1%. of the homogeneous individual parts.
- Lifetime extension:
  - Spare parts: The supplier must be able to deliver spare parts for the offered multifunctional devices for five years from the date of delivery.

SKI Procurement Programme

The award criterion in this programme is the lowest total cost, including costs for operating expenses and electricity consumption i.e. TCO (Total Costs of Ownership). Because this tender was a framework tender, where selected companies were awarded a contract under which the individual public organisation can order products, the TCO calculation for the award

criterion was calculated for a sample of products listed in the tender requirements and with a usage pattern also given by the tender requirements. The electricity consumption was calculated for the operating modes: Print (88 hours), standby (1314 hours), hibernation (1664 hours), and auto-off (5694 hours), over 5 years.
Technical specifications:

- All machines have to comply with the criteria in the Danish Energy Agency's purchasing guide.
- All machines have to comply with the Nordic Swan criteria.

3.3 Key actors in imaging equipment value chain

3.3.1 Manufacturers and trade associations

There is a relatively small number of imaging equipment manufacturers placing products on the EU market. Indeed, a total of 14 manufacturers account for over 95% of all imaging equipment sold in the EU.[74] These manufacturers are:

- Brother International Europe
- Canon
- Epson
- HP
- Konica Minolta Business Solutions Europe
- KYOCERA Document Solutions Europe B.V.
- Lexmark International
- OKI (UK) Ltd.
- Panasonic Europe Ltd.
- Ricoh Europe PLC
- Samsung Electronics Europe
- Sharp Electronics Europe Ltd (SEE)
- Toshiba TEC Germany Imaging Systems
- Xerox

The number of large imaging equipment manufacturers is also reducing as buyouts and mergers between the existing manufacturers occur. For example, in September 2016 Hewlett-Packard (HP) purchased Samsung's imaging equipment business.[75]

Relevant international trade associations are:

- AGORIA[76]
- DIGITALEUROPE[77]
- German Electrical and Electronic Manufacturers' Association[78]
- THE JAPAN ELECTRICAL MANUFACTURERS' ASSOCIATION[79]

3.3.2 Service providers

Most of the large imaging equipment manufacturers also provide imaging services (e.g. MPS) as well as hardware. In addition, there are many non-manufacturer service providers in the imaging equipment market. These range from large corporations that provide MPS into the business sector to single employee organisations providing remanufactured cartridges or imaging equipment repair services.

[74] *http://www.eurovaprint.eu/pages/our-members/*
[75] *http://www.wired.co.uk/article/hp-samsung-printer-business-deal*
[76] *https://www.agoria.be/*
[77] *http://www.digitaleurope.org/Welcome*
[78] *https://www.zvei.org/en/association/about-us/*
[79] *http://www.jema-net.or.jp/*

3.3.3 Users

Given its wide scope, imaging equipment has a diverse set of users. These range from the largest corporate enterprises to individual consumers. Whilst some types of imaging equipment (e.g. large format laser printers) will almost exclusively be used in large organisations or professional print business, some smaller products (e.g. standard format laser printers) may be used by a diverse set of users.

3.3.4 Segmentation and expected trends in public procurement

There are many different types of public body throughout the EU which actively procure imaging equipment products and supplies. These range from small public bodies to large central government departments.

The European Commission states that total general government expenditures on works, goods, and services (TGGPPE), excluding utilities, was 2015.3 billion euros in 2015, 4.2% higher than in 2014. The Commission estimates that the value of tenders published in TED during 2015 (including utilities and defence) amounted to 450.21 billion euros, 6.9% more than in 2014.[80] Due to the fragmented nature of EU public procurement, no single source of information could be found detailing public procurement expenditure on imaging equipment. The European Commission DG GROW (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs) publishes a subset of annual Tenders Electronic Daily (TED) data covering most important fields from contract award notices[81]. The DG GROW files contain CPV codes and contract values. However, many contracts have multiple CPV codes listed and so it is not always possible to identify the percentage of contract values that can be attributable to imaging equipment products and services.

There are a number of likely trends in public procurement going forward. For instance the Commission has published an action plan on public procurement which sets out a series of initiatives aimed at helping Member States to improve the performance of both administrations and beneficiaries in applying public procurement for EU investments during the 2014-2020 programming period.[82]

A number of the key actions of the Commission plan may have a positive impact on imaging equipment public procurement activities. These include:

- Comprehensive reform plans for countries non-compliant with the public procurement
  - This could result in more public bodies laying down mandatory environmental requirements in public contracts such as those detailed in the Energy Efficiency Directive.[83]
- A stock-taking study on administrative capacity in the field of public procurement
  - This could encourage a better understanding of capabilities to support green procurement within EU procuring authorities.
- A guide to support public officials across the EU to avoid the most frequent errors and adopt best practices
  - Green procurement practices could be introduced in this guide, including product specific guidance.

[80] *European Commission, 2016,"Public Procurement Indicators 2015 DG GROW G4 - Innovative and e-Procurement", available from http://ec.europa.eu/DocsRoom/documents/20679*

[81] *European Commission, Tenders Electronic Daily (TED) (csv subset) – public procurement notices, available from https://data.europa.eu/euodp/en/data/dataset/ted-csv*

[82] *http://ec.europa.eu/regional_policy/en/policy/how/improving-investment/public-procurement/*

[83] *Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, available from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN*

- Development of tools to improve transparency and accountability in public procurement
  - Could provide greater insights into how products and services are currently being procured, allowing for more tailored green procurement support.
- A new index for rating contracting authorities according to their performance
  - Environmental performance could be included in the rating index, potentially stimulating greater interest.
- Analysis of data and interoperability of a public procurement database
- Targeted support to specific Member States and exchange of good practices
  - Good environmental practice in procurement could be included alongside other good practice support.

As well as the Commission leading changes in public procurement there are other trends, identified during the course of this project, that may take place in the area. This may include:

- Many public bodies around the EU are increasingly attempting to reduce their costs. This may result in less imaging equipment being purchased or could change the type or way in which imaging equipment is purchased.
- Public bodies in some EU member states, are increasingly target driven meaning that imaging equipment service provides could be required to perform more tasks within contracts and to a better standard. This may result in further moves by public bodies to drive environmental policies through service contracts.
- Public procurement has traditionally been a somewhat difficult market for small and medium sized enterprises (SMEs) to enter. There are many initiatives around the EU which seek to open the public procurement market to SMEs. This could drive changes in the types of imaging equipment and consumables that are purchased and alter the types of service companies that operate in the area.
- Digitalisation overall is reducing the amount of prints done in office spaces, as more documents and files are shared electronically. However, this trend may be happening at a slower pace in public offices.
- There are also drivers to reuse existing equipment rather than purchase new. This again could result in less imaging equipment products being sold into public bodies.
- Interoperability and transferability are also becoming more important considerations in public procurement and public bodies are avoiding them being locked in to any particular supplier or proprietary technologies within new contracts. A move in the direction could encourage greater interoperability between imaging equipment from different manufacturers.
- There is also a trend towards partnering, collaboration and service sharing among local authorities and other public sector entities. Collaboration on procurement contracts can provide public bodies with more negotiating power when dealing with suppliers and help to cut costs due to economy of scales. The added influence on suppliers afforded through collaboration on procurement contracts could also help to reduce environmental impacts associated with products and services.

3.4 Market volumes

3.4.1 EU annual sales

Sales of printers and multi-functional devices (MFDs) steadily increased up to 2005. After 2005, a trend was observed of the sales of inkjet printers started to decrease due to the shift to MFDs, as purchasing one MFD is more convenient than purchasing printers, scanners and copiers separately. This trend was supported by the data from impact assessment, undertaken in the context of the voluntary ecodesign scheme for imaging equipment,[84] and ENERGY STAR market penetration report[85]. Meanwhile the sales of laser printers remained more or less flat until 2010 and began to decrease later on. Sales of inkjet and laser MFDs have increased and are expected to steadily increase in the future and have replaced most of the single function printers by 2030.

Although scanning is a function often included in the MFDs, the sale of scanners relative to those of printer has increased significantly in the past several years. It is estimated that the global document scanner market will grow at a compound annual growth rate (CAGR) of 13.85% during the period 2016-2020[86]. This is due to the growing demand for archiving a large volume of physical documents into digital form. It is also assumed that by 2025, the market would not be growing anymore and the sales would be relatively flat until 2030.

The sales of copiers decreased between 2005 and 2010, however according to the impact assessment of imaging equipment[84], sales data were expected to increase from 2011 onwards due to the shift from monochrome to colour copiers and assuming a recovery after economic crisis.

The sales of fax machines are decreasing gradually as they are becoming nearly obsolete. However, it is expected that some (low) sales are maintained until 2020, and from then on it is assumed they would be nearly zero.

Digital duplicators have generally very low sales, less than 10,000 units, and are therefore expected to have no sales in 2020.

Mailing machines are in scope of current review study as well as of ENERGY STAR for imaging equipment but sales data is not available. However, it is considered that this is a minority product with very low sales.
The calculated annual sales for imaging equipment in scope, based on data sources presented above, are shown in Table 19 and Figure 10.

[84] *COMMISSION STAFF WORKING DOCUMENT. Impact Assessment - Accompanying the document REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the voluntary ecodesign scheme for imaging equipment. 2013, available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0015&from=en*
[85] *(2017) Interim Report Q3-Q4 2015: Survey of the Market Penetration of Energy Efficient Office Equipment under the EU ENERGY STAR Programme*
[86] *http://www.businesswire.com/news/home/20161014005477/en/Global-Document-Scanner-Market---Analysis-Technologies*

Table 19. Estimated annual sales in the EU of imaging equipment products in million units

Product	2000	2005	2010	2015	2020	2025	2030
Inkjet printers	10.10	12.33	9.66	0.96	0.86	0.77	0.70
Laser printers	4.01	4.44	4.64	3.82	2.66	1.85	1.29
Inkjet MFDs	8.29	10.11	12.46	14.82	18.62	21.89	25.17
Laser MFDs	1.05	2.09	2.30	4.18	5.34	6.81	8.70
Scanner	0.04	0.13	0.23	0.46	0.88	1.69	1.69
Copier	1.60	1.47	1.13	1.36	1.47	1.58	1.64
Facsimile (Fax) Machine	6.68	4.17	0.80	0.40	0.00	0.00	0.00
Digital Duplicator	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mailing Machine	-	-	-	-	-	-	-
Total	**31.78**	**34.74**	**32.07**	**26.01**	**29.82**	**34.60**	**39.17**

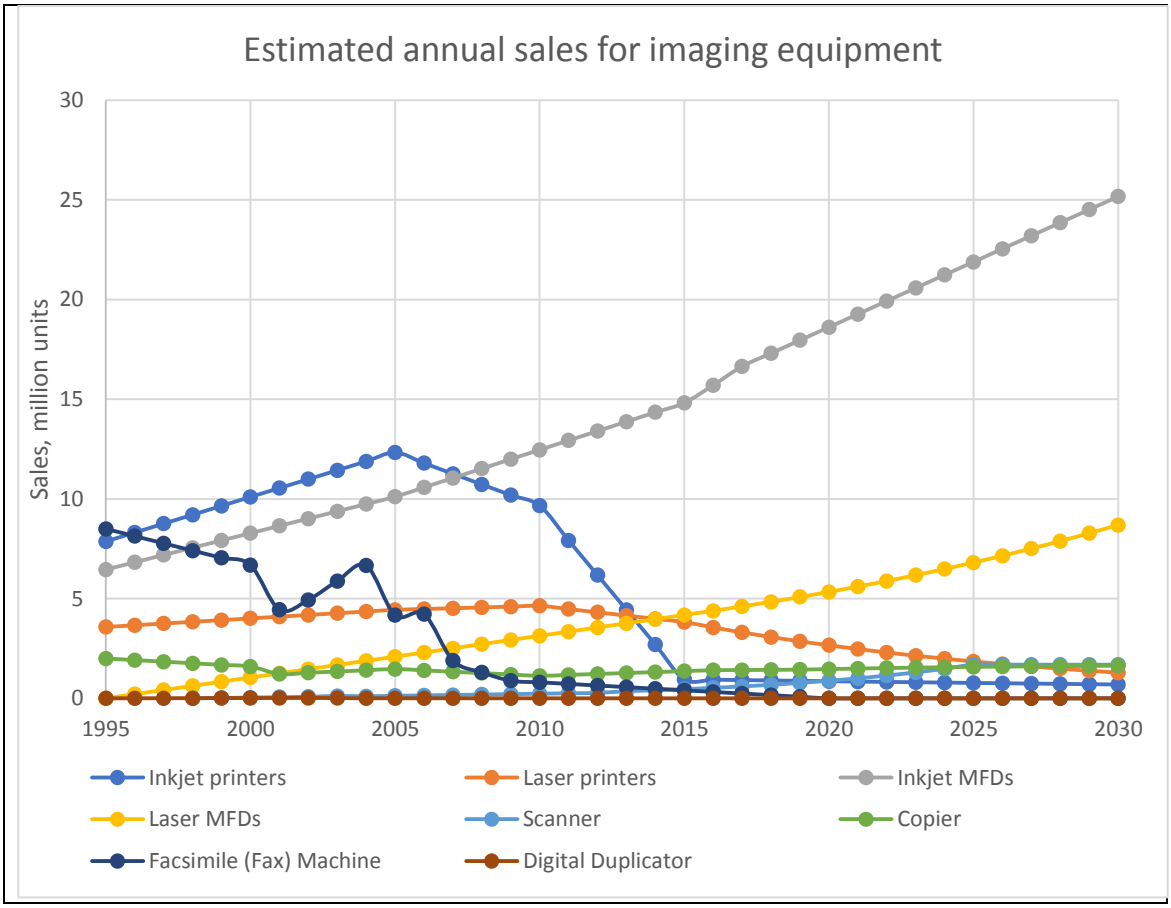

Figure 10. Estimated annual sales for imagine equipment in million units, 1995 -2030

3.4.2 Methodology for estimating sales

The annual sales for imaging equipment has been estimated based on several data sources (see Table 20). Most recent data for printers and MFDs come from ENERGY STAR market penetration report[87], and the historical sales were interpolated based on the key figures from EU impact assessment of imaging equipment[87] for 1995, 2005 and 2010. For inkjet MFDs, interpolation was used between 2017 and a 2030 projection 2030. Printers and MFDs sales

[87] *ENER/C3/2014-561 Support for Energy Star Impact Assessment and Market Penetration Survey. Interim Report 3: Q3-Q4 2015: Survey of the Market Penetration of Energy Efficient Office Equipment under the EU ENERGY STAR Programme (not publicly available).*

were estimated based on market information, which states that both inkjet and laser MFDs have increased sales by six and five percent respectively in the first quarter of 2017, while sales of single function printers dropped by seven percent for lasers and by twenty one percent for inkjet. This growth was assumed also for 2015 – 2016.

Scanners data was mainly based on online research of various sources. The estimate was based on the sales of western European market which was 105,116 units in 2004[88]. Based on IDC data for 2013, the sales were estimated at approx. 356,000 units for western Europe[89]. The sales for the period of 2016-2020 were estimated based on the growth of 13.85%[90]. Projection onwards was based on expert estimation that the growth will slow down and eventually remains constantly by 2025.

Sales data for copiers was based on key figures from impact assessment and the Ecolabel-GPP criteria report[91], for 1996 and 2030 with interpolations between the key dates.

Approximately 8,5 million fax machines were sold in Europe in 1992 and the same sales were assumed for 1995. Sales data for fax machines in Ecolabel GPP criteria report was used for 2000–2009, and interpolated with expert estimation that the sales will approach zero by approx. 2020. The same method was applied to digital duplicators, and the sales data from Ecolabel GPP report was used to establish the very slight decline per year for the future sales.

Table 20. Data sources for sales of products in scope

Product	Sales data source
Inkjet printers	(2017) Interim Report Q3-Q4 2015: Survey of the Market Penetration of Energy Efficient Office Equipment under the EU ENERGY STAR Programme
Laser printers	
Inkjet MFDs	
Laser MFDs	
Scanners	Online research
Copiers	Imaging equipment Impact Assessment and (2011) Development of European Ecolabel and Green Public Procurement Criteria for Imaging Equipment: Economic and Market Analysis
Facsimile (Fax) Machines	Online research and (2011) Development of European Ecolabel and Green Public Procurement Criteria for Imaging Equipment: Economic and Market Analysis
Digital Duplicators	
Mailing Machines	No data available

3.4.3 Sales split between domestic and non-domestic use

The sales split between domestic and non-domestic market is important, because the non-domestic sales are relevant to the GPP criteria, whereas both the domestic and non-domestic sales were relevant to the Ecolabel.
In general it is assumed that there is an overall increase in the proportion of sales to non-domestic users, as domestic consumer needs for imaging equipment reduces. All products in scope, apart from MFD laser, are estimated to have an increase in non-domestic sales. The earlier GPP report[92] gave the ratio of images produced at work and at home as approximately 20 to 3; (it is assumed that this is true for 2014, the date of the report). This is used as the

[88] *http://www.dekyo.or.jp/tbf/seika/pdf/29-11_Presentation.pdf*
[89] *https://www.rtmworld.com/2d/news/idc-finds-western-european-document-scanner-market-grew-in-2q2013/*
[90] *http://www.businesswire.com/news/home/20161014005477/en/Global-Document-Scanner-Market---Analysis-Technologies*
[91] *Development of European Ecolabel and Green Public Procurement Criteria for Imaging Equipment. JRC IPTS Draft Preliminary Study. Draft Task 2. Economic and Market Analysis. February 2011.*
[92] *Green Public Procurement for Imaging Equipment Technical Background Report, 2014*

basis for estimating the non-domestic and domestic market shares for scanners and copiers. The market shares of printers and MFDs are based on the partial sales data from one Member State, and based on expert assumptions projected up to 2030. Fax machines were assumed to be 100% non-domestic in 1995, and afterwards the domestic market grew up to early 2000s, returning to mainly non-domestic afterwards. Digital duplicators are assumed to be a non-domestic product. See Table 21 for the market shares in percentage and Table 22 for the estimated annual sales for non-domestic users based on this split.

Table 21. Estimated non-domestic market share (as percentage of annual sales)

Product	2000	2005	2010	2015	2020	2025	2030
Inkjet printers	38%	38%	38%	38%	42%	46%	50%
Laser printers	85%	85%	85%	86%	87%	87%	88%
Inkjet MFDs	54%	54%	54%	53%	57%	61%	65%
Laser MFDs	96%	96%	96%	98%	98%	98%	98%
Scanners	97%	93%	90%	87%	87%	87%	87%
Copiers	97%	93%	90%	87%	87%	87%	87%
Facsimile (Fax) Machines	75%	83%	91%	98%	100%	100%	100%
Digital Duplicators	100%	100%	100%	100%	100%	100%	100%
Mailing Machines	100%	100%	100%	100%	100%	100%	100%
Total	**61%**	**60%**	**60%**	**68%**	**69%**	**72%**	**75%**

Table 22. Estimated non-domestic market in million units of annual sales

Product	2000	2005	2010	2015	2020	2025	2030
Inkjet printers	3.82	4.66	3.65	0.36	0.36	0.35	0.35
Laser printers	3.41	3.77	3.94	3.28	2.30	1.62	1.13
Inkjet MFDs	4.46	5.44	6.70	7.89	10.64	13.37	16.36
Laser MFDs	1.01	2.01	3.02	4.09	5.21	6.65	8.49
Scanners	0.04	0.12	0.21	0.40	0.77	1.47	1.47
Copiers	1.54	1.37	1.01	1.19	1.28	1.37	1.43
Facsimile (Fax) Machines	5.01	3.45	0.73	0.40	0.00	0.00	0.00
Digital Duplicators	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mailing Machines	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**19.30**	**20.83**	**19.27**	**17.60**	**20.56**	**24.84**	**29.23**

The estimated annual sales for the domestic market are shown in Table 23. The domestic market share is the remainder left by the non-domestic market.

Table 23. Estimated domestic market in million units of annual sales

Product	2000	2005	2010	2015	2020	2025	2030
Inkjet printers	6.28	7.67	6.01	0.60	0.50	0.42	0.35
Laser printers	0.60	0.67	0.70	0.54	0.36	0.24	0.15
Inkjet MFDs	3.83	4.67	5.76	6.93	7.97	8.52	8.81
Laser MFDs	0.04	0.08	0.12	0.10	0.12	0.16	0.20
Scanners	0.00	0.01	0.02	0.06	0.12	0.22	0.22
Copiers	0.05	0.10	0.12	0.18	0.19	0.21	0.21
Facsimile (Fax) Machines	1.67	0.72	0.08	0.01	0.00	0.00	0.00
Digital Duplicators	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mailing Machines	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Product	2000	2005	2010	2015	2020	2025	2030
Total	12.48	13.91	12.80	8.41	9.26	9.76	9.95

3.5 Life Cycle Costs (LCC) analysis

The Life Cycle Costs (LCC) of imaging equipment products covered under the scope have been established in order to get an overview of the most important costs to consumers, which in this case are the public procurers. The LCCs are also used as the starting point to identify whether certain criteria would incur on significant costs to the procurers, during the development of the draft criteria.

LCCs account for the products' total cost of ownership. All life cycle stages considered relevant during the revision of the current GPP criteria for imaging equipment products shall be taken into account. These link to the following costs:

- Purchase cost
- Running costs for operation (i.e. costs for electricity, paper, and toner/ink cartridges)
- Running costs for repair and maintenance
- End of life costs

Installation costs are considered negligible. Even though larger machines require professional installation, the cost level for this is still marginal compared to the cost of the machine.

Printers and MFDs come in different sizes with very different purchase and operating costs in the market. Three sizes based on printing speed were identified during the data collection, which can be seen in Table 24.

Table 24. Printers and MFDs categories based on size (defined by printing speed)

Size	Printing speed (Pages per minute – ppm)
Small	1-20
Medium	21-40
Large	>40

Furthermore, prices and costs also vary widely depending on whether the printing is colour or monochrome. Therefore, costs data is split throughout this chapter not only on size but on type of printing.

Scanners do not show these differences, and they are therefore grouped in one product category without further categorization.

All aspects of the LCC analysis, except electricity consumption, were established based on data collected from online retail prices, including costs of consumables, purchasing costs, and maintenance.

3.5.1 Purchase cost

Purchase costs for imaging equipment products can vary depending on the technology, brand and the capability. They range from less than 100 EUR for small inkjet printers, up to 10000 EUR for large MFD printers (see Figure 11).

Average purchase prices have been established based on 82 data points and their standard deviation can be seen in Figure 11. The larger ranges of prices are observed in inkjet MFDs, as well as scanners and laser monochrome MFDs.

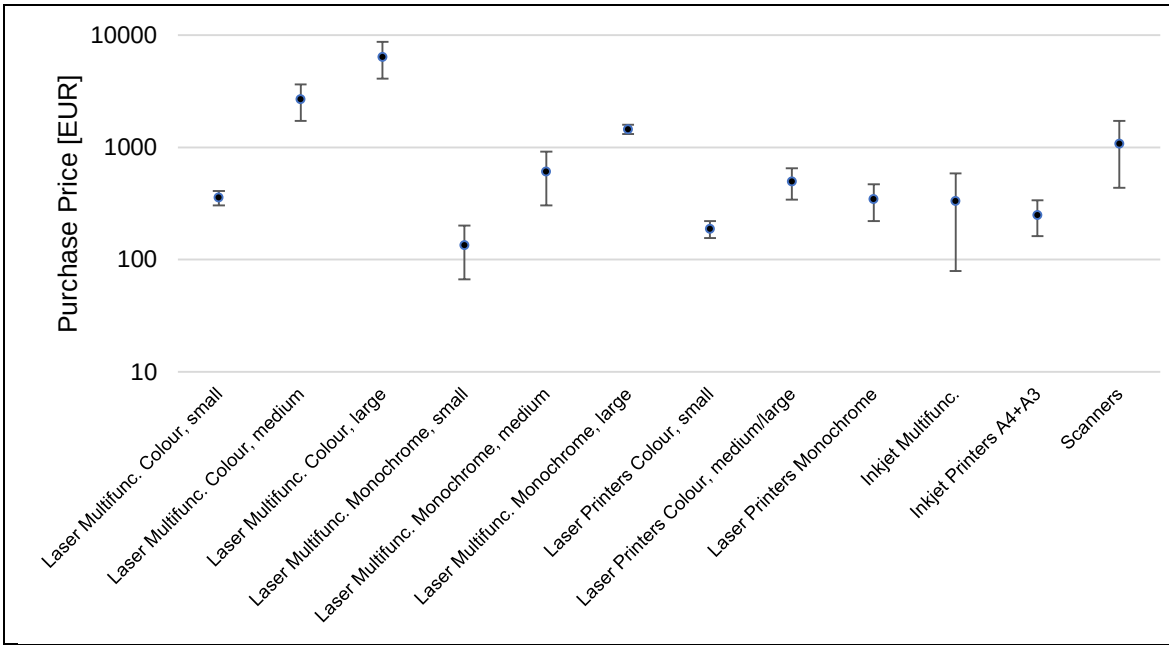

Figure 11. Average purchase prices for imaging equipment products from online collected data[93]

3.5.2 Running costs for operation

Running costs for operation of imaging equipment typically consist of the costs of electricity and the cost of consumables such as paper, toner and ink cartridges.
The costs vary for different technologies, sizes and brands as well. The costs identified below represent averages based on desk research and literature reviews.

3.5.2.1 Electricity

ENERGY STAR office equipment calculator[94] has been used for finding the annual electricity consumption of MFDs, printers and scanners, including active, sleep and standby modes (84 hours weekly in sleep and 84 hours in standby). These are default values used in the office equipment calculator for these products, which are used in calculating energy savings from purchasing energy efficient products by public tenders in the USA[94].
The lifetime is assumed 6 years for laser printers and MFDs and 4 years for inkjet printers, MFDs and scanners, which are those used as default in this calculator and that are also in agreement with the results of the analysis done in this study shown in chapters 3.4 and 4.1.

Electricity price for offices in the EU-28 is assumed to be 0.2087 EUR/kWh in 2015[95].

The typical electricity costs for MFDs, printers and scanners calculated (considered representative of an average product in the EU market), are shown in Table 25.

[93] *A total of 82 data points where used, evenly distributed between categories. Error bars indicate standard deviation. Logarithmic scale.*
[94] *https://energy.gov/eere/femp/purchasing-energy-efficient-imaging-equipment*
[95] *Page 5, http://ec.europa.eu/energy/sites/ener/files/documents/com_2016_769.en_.pdf*

Table 25. Typical MFDs calculated annual costs from electricity use

	Standard format[96]				Large format[97]	
	Laser colour	Laser monochrome	Inkjet	Other colour	Inkjet	Other
Sleep mode, W	1.4 + 2.0 wireless adder				15.0	30.0
Standby mode, W	1.0				1.0	1.0
Annual electricity consumption, kWh	574	417	19	574	70	136
Annual electricity costs for offices (EUR)	120	87	4	120	15	28

Table 26. Typical printers calculated annual costs from electricity use

	Small	Standard format[96]				Large format[97]	
	-	Laser colour	Laser monochrome	Inkjet	Other colour	Inkjet	Other
Sleep mode, W	9.0 + 2.0 wireless adder	6.0 +2.0 wireless adder				19.0 + 2.0 wireless adder	
Standby mode, W	1.0	1.0				1.0	
Annual electricity consumption, kWh	53	459	183	11	459	79	74
Annual electricity costs for offices (EUR)	11	96	38	2	96	16	15

Table 27. Typical scanners calculated annual costs from electricity use

	Standard format
Sleep mode, W	4.3 + 2 wireless
Standby mode, W	1
Annual electricity consumption, kWh	32
Annual electricity costs for offices (EUR)	7

3.5.2.2 Consumables

3.5.2.2.1 Paper

Paper consumption per printer is varying with the size of the printers. This is an obvious trend, as offices with large printing requirements tend to buy larger printers. Using the same size reference, the paper consumption and thus the average printed sheets per month is

[96] *Standard Format: Products designed for standard-sized media (e.g., Letter, Legal, Ledger, A3, A4, B4), including those designed to accommodate continuous-form media between 210 mm and 406 mm wide. Standard-size products may also be capable of printing on small-format media.*

[97] *Large Format: Products designed for A2 media and larger, including those designed to accommodate continuous-form media greater than or equal to 406 mm wide. Large-format products may also be capable of printing on standard-size or small-format media.*

calculated as 2500, 8000, and 25000 pages for small, medium, and large sized printers respectively[98].

The costs of paper were found to be 0.042 EUR/sheet for A4 paper, and 0.062 EUR/sheet for A3 paper, based on retail prices of 20 manufactures. Note that the prices may vary a lot, as many types of paper exists with different weights, finishes, and paper type (recycled or not, for instance). Capturing all these variations in these LCC calculations is not considered to be of relevance for the purpose of this specific LCC.

3.5.2.2.2 Cartridges

Cost of toner or ink cartridges vary greatly based on type and capacity. Small laser and inkjet printers tend to have the highest price of EUR/printed sheet, while large laser MFDs tend to have the lowest. There are differences in cartridges prices from colour to monochrome observed in data collected (see Table 28). These differences lie in the fact that three to four cartridges with different colours are needed (Cyan/Magenta/Yellow for instance) to produce colour prints, while only one black cartridge is needed for monochrome printing. Generally, OEM produced cartridges are much more expensive than remanufactured and non-OEM cartridges.

Table 28. Collected price data for toner and inkjet cartridges for MFDs and printers

Printing technology	Cartridge manufac-turer	Color/mo-nochrome	Price range (EUR)	Yield range (pages/ lifetime)	Cost per page range (EUR)
Laser	OEM	Black	49-269	1400-50000	0.002-0.054
		Colour	67-326	1000-55000	0.002-0.067
	Remanufac-tured	Black	26-67	1000-44000	0.002-0.050
		Colour	20-105	1000-38000	0.002-0.021
Inkjet	OEM	Black	6-37	300-2500	0.011-0.058
		Colour	24-26	1020-1500	0.017-0.024
	Remanufac-tured	Black	9-20	560-1200	0.017-0.032
		Colour	n.a.[99]	n.a.	n.a.

Toner prices in EUR/sheet are highly dependent on size of the machine. Small units are ~10 times as expensive in terms of price per printed sheet. This is likely due to the toner itself not being the expensive part of the cartridge, but that manufacturing and distribution of the cartridge is the major expense in production. The price of toner for large printers and MFD devices is on average 0.004 EUR/sheet. For small devices this figure is 0.037 EUR/sheet. Inkjet cartridges show no difference between sizes. They cost on average 0.026 EUR/sheet.

3.5.3 Running costs for repair and maintenance

Service agreements can often be set up with the companies which sell the printers, MFDs, copiers and other type of imaging equipment, or with companies that are dedicated at repair and maintenance of office equipment.

[98] *Bousquin, Justin & Gambeta, Eni & Esterman, Marcos & Rothenberg, Sandra. (2012). Life Cycle Assessment in the Print Industry. Journal of Industrial Ecology - J IND ECOL. 16. . 10.1111/j.1530-9290.2012.00471.x.*

[99] *n.a. = data not available for cartridges that were compatible to the MFDs/printers where price data were collected*

The average repair cost has been found via desk research, which is approx. $60 (52 EUR). The costs observed can vary from $40 to $90[100] (34 to 78 EUR).
In the USA, one-year on-site service costs approx. $199 (170 EUR)[101] for printers and the same service costs approx. $299 (260 EUR) for copiers. The costs in the EU are sometimes slightly higher than in the USA assumed to be because of higher labour costs. Large MFD devices can cost up to 700$ (595 EUR) a year for a service subscription, and down to 9$ (8 EUR) a year for smaller devices[101].

3.5.4 End of life costs

End of life costs can include the costs for disposal of imaging equipment, costs of purchasing services from recycling companies, or transportation costs to recycling stations or WEEE stations. As most office imaging equipment are relatively easy to uninstall, the costs of decommissioning can probably be considered negligible. WEEE recycling costs can vary depending on the EU countries, in the UK, it can cost from 80 EUR+VAT, and higher depending on the number of manual labour and transportation capacity[102]. Since these costs are likely to vary quite widely across different Member States due to the differences on how WEEE is implemented across the EU, and because the costs range are insignificant compared to the purchase and running costs, the end-of-life costs have been neglected.

3.5.5 Total Life Cycle Costs

Considering all the information, assumptions and data presented in previous sections of this chapter, the total LCCs were established (see Figure 12). The error bars primarily originate from the large variation in the costs of paper.

Generally, the paper is the dominant cost for medium/large laser MFDs and printers, while for small laser MFDs and printers the toner is also. These total LCCs represent a wide variation of pages printed per lifetime based on the calculated average prints per month presented in section 3.5.2.2.1 (i.e. 2500, 8000, and 25000 for small, medium and large products). This has a direct influence on the calculated total LCCs, as large products show higher paper costs.

[100] *https://www.thumbtack.com/p/printer-repair-cost , accessed July 2017.*
[101] *http://www.office.xerox.com/perl-bin/product.pl?product=SERVICE&page=pric , accessed July 2017.*
[102] *https://www.envirowaste.co.uk/commercial/weee-recycling-and-it-disposal/ , accessed July 2017.*

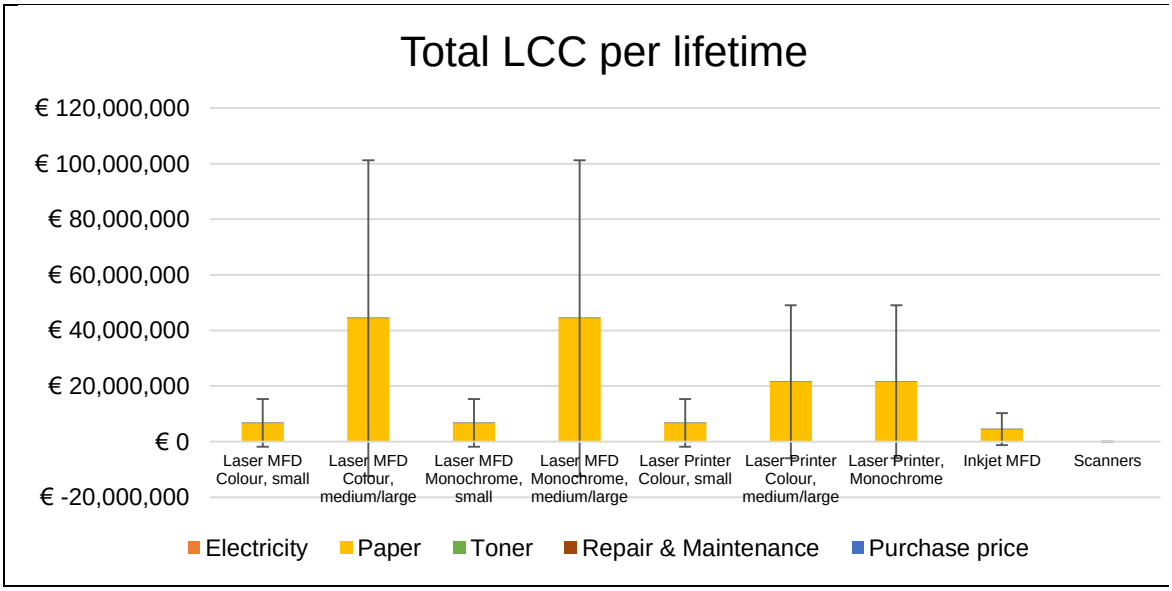

Figure 12. Total Life Cycle Costs for product lifetime

Figure 12 also shows that the toner costs differ greatly between small and medium / large laser MFDs and printers. This is because the allocated cost of toner per printed page is larger for smaller devices. In spite of the fact that the purchase price for toner cartridges of larger devices is higher, it is not linearly proportional to the toner page yield. So toners for larger devices, tend to cost cheaper per page. This effect becomes more evident the larger the printing requirements are (see Figure 13, Figure 14 and Figure 15).

Figure 13, Figure 14 and Figure 15 assume a fixed number of pages printed each month, and compare the total LCC of the different devices for their whole lifetime. This can hence be used to compare total LCC when buying new devices, if the required number of pages printed each month is known. Note that the Inkjet MFD devices have a lower number of total pages printed, due to its lifetime being shorter than the Laser printers.

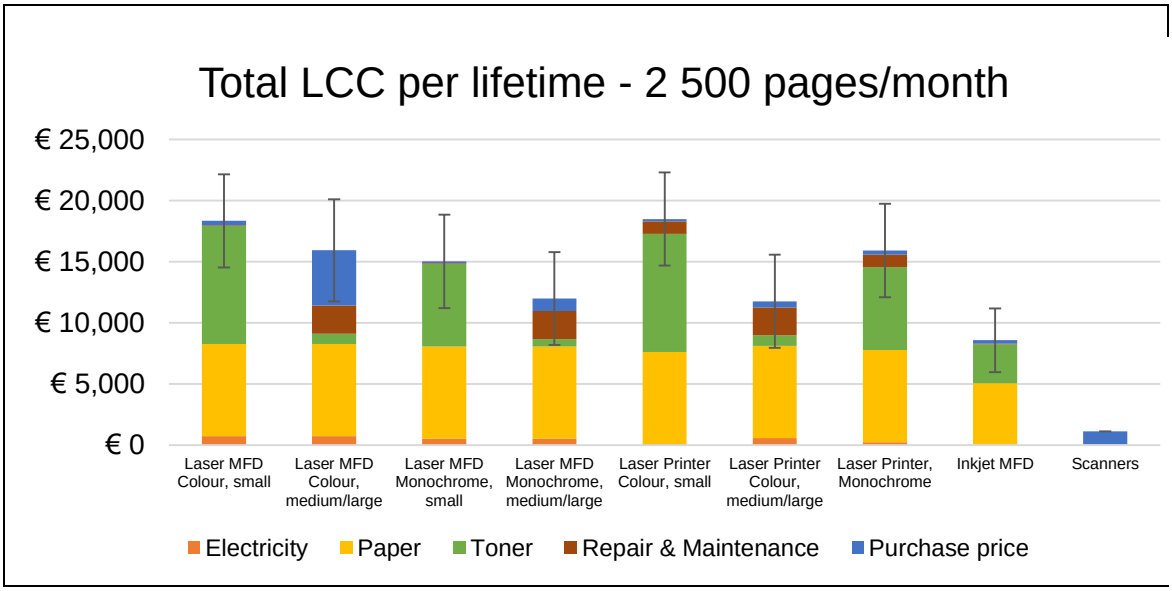

Figure 13. Total Life Cycle Costs for product lifetime assuming 2500 printouts/month

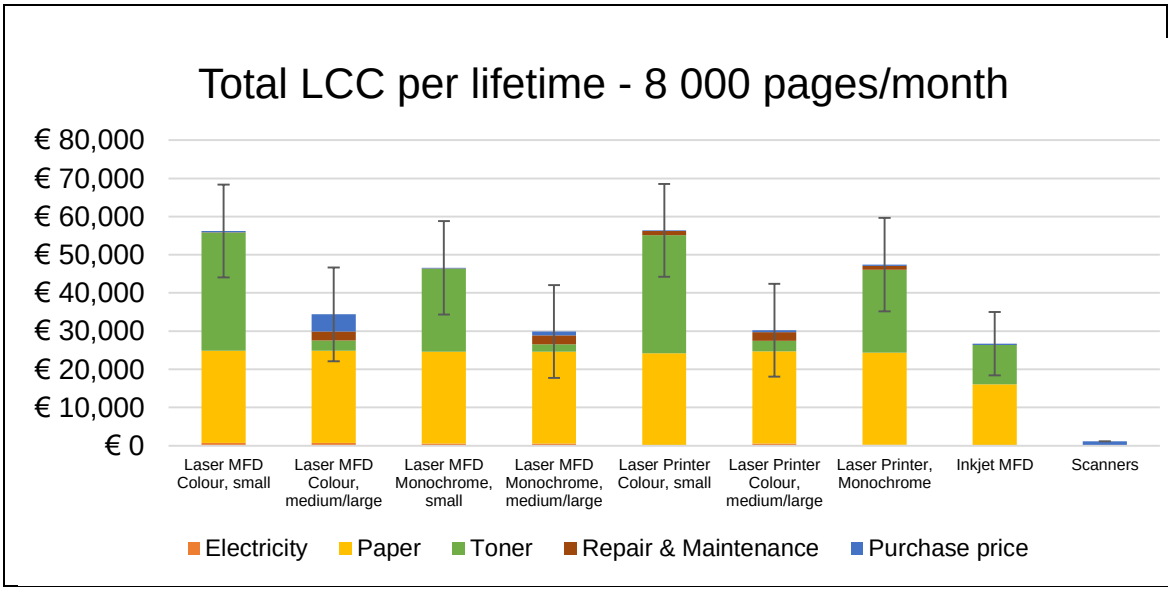

Figure 14. Total Life Cycle Costs for product lifetime assuming 8000 printouts/month

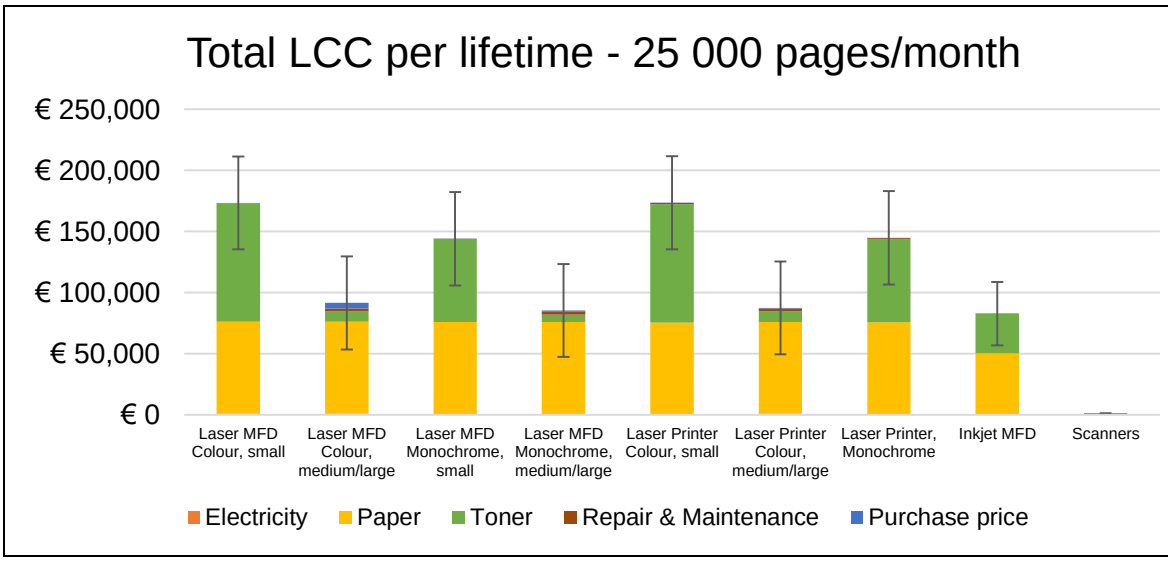

Figure 15. Total Life Cycle Costs for product lifetime assuming 25000 printouts/month

The figures show that if the printing requirements of an office are at or close to 2500 pages per month, the differences in life cycle costs across different sizes of MFDs are not as large as when the printing requirements of an office are higher (8000 and 25000 pages per month). For the printers, the differences are similar. When printing 2500 pages per month, other costs such as purchase price and repair/maintenance costs are important.

When above 2500 pages, large devices tend to be dominantly cheaper than smaller devices. This is mainly because the allocated cost per page is higher for toner cartridges of smaller devices, as explained before.

3.6 Conclusions and recommendations derived from market analysis

Task 2 provided an overview of the current trends in the market for imaging equipment products, starting with an outlook to the technological trends, the procurement practices, in particular those by the public institutions, and finalising with an overview of the key players in the market as well as the current and predicted sales. The predicted sales are necessary to assess the effect of future criteria.

The market for imaging equipment products can be distinguished between the domestic and non-domestic. The non-domestic covers products for office use as well as for larger scale professional use. Those for office use can also be used in households, especially since the technology for inkjet based printers and MFDs has improved significantly without involving much higher prices. However, it is possible to make assumptions to split the products used in the domestic and in the non-domestic markets.

Concerning the non-domestic market, there is a tendency by business to perform their own professional printing, supported by the reductions in the prices of laser based imaging equipment products. This can be seen from the overview of the procurement practices, where still mostly supply contracts are awarded by public authorities at EU level over a threshold of 135 000 EUR for some public organisations. This, however, does not tell whether the absolute number of imaging equipment products is higher for supply rather than service contracts, but according to the annual sales estimated, the amount of imaging equipment units in the non-domestic market is indeed much larger (i.e. 68% in 2015 and predicted to grow to 75% in 2030).

The analysis of public tenders suggests that most contracts are for purchasing products and not leasing and services; however the trend is expected to be an increased use of purchase service agreements through managed service print services. These can include a leasing agreement or selling the products including a service agreement covering maintenance and even optimised document output. It is expected that these services develop further into established services offered to non-domestic users, and this needs to be taken into account in the revision of the GPP criteria.

The market volume data can inform the discussion on scope undertaken in task 1. The data show that some single function imaging equipment products such as inkjet printers, laser printers, digital duplicators and fax machines are or will be relatively insignificant compared to multifunctional devices (MFDs, both inkjet and laser). Furthermore, that already in 2015, the sales are close to zero for fax machines, and are zero for digital duplicators and mailing machines. This evidence reinforces the proposed scope in chapter 2.6 which covers MFDs, printers, copiers and scanners (differently to ENERGY STAR v2.0). Copiers and scanners will remain with stable annual sales due to the digitalisation of documents but all in all the MFDs will be dominant, not only in the non-domestic market and the domestic market. Furthermore, it is expected that the non-domestic market for imaging equipment products will continue to grow, and thus the non-domestic market should be the focus of the efforts for developing the EU GPP criteria.

As expected from the review of the scope in task 1, the market volumes of fax machines, digital duplicators and mailing machines are expected to be (close to) zero in 2015 according to the assumptions presented in this chapter. It is therefore suggested to continue with the suggested exclusion of digital duplicators and mailing machines, and to exclude also fax machines from the current scope.

The Life Cycle Costs analysis shows that the use of paper is a critical parameter in the life cycle costs of printers and multi-functional devices, in particular for the larger products. Use of cartridges is also very important, in particular for the smaller products. However, this is

considering the devices provide different amounts of printouts per month according to their size. When removing this consideration and assuming the public offices rent imaging equipment products and services to deliver a fixed amount of printouts per month, the costs of cartridges, repair and maintenance practices would become important. Furthermore, the larger printers become a better option than the smaller when increasing the amount of printouts per month. This is solely because of the differentiation between costs of toner/ink cartridges for small and for large devices. Scanners Life Cycle Costs are almost negligible compared to those from the printers and multi-functional devices.

4 TASK 3: TECHNICAL ANALYSIS

The key environmental aspects for imaging equipment products identified in previous study for developing the GPP and Ecolabel criteria have been reviewed considering newer developments since the time of the report's publication.

In order to **identify the key environmental aspects**, a stepwise approach was followed:

1. Comprehensive LCA review: Presenting an overview of recent LCA studies was performed, departing from the outcomes of the current criteria development in 2014[103]. The aim of this overview was to identify whether other sources of environmental impacts arise from the life cycle of imaging equipment products and consumables, or whether the relative significance of the previous identified impacts has changed since.
2. Assessment of other environmental aspects in environmental schemes: Analysing of other aspects not assessed by the reviewed LCA studies, but that according to different environmental schemes are important. The aim of this task was to complement other aspects not covered by LCA studies.
3. Analysis of Best Available Technologies (BAT): Presenting a review of environmental aspects considered by imaging equipment products at the top range, considered best available in terms of energy and material efficiency.
4. Analysis of stakeholder survey: Summarizing the environmental aspects the stakeholders consider important for the revision of the GPP criteria.
5. Identification of priority improvement options. Identifying those options which present a potential for improvement, based on real-life conditions on how imaging equipment products and consumables are used. This was done based on expert knowledge of this product group.
6. Conclusions and recommendations.

[103] *Green Public Procurement for Imaging Equipment. Technical Background Report. Authors: Jiannis Kougoulis, Renata Kaps, Dritan Osmani, Malgorzata Kowalska, Miguel Gama Caldas, Oliver Wolf. 2014.*

4.1 Comprehensive LCA review

4.1.1 Overview of LCA studies on imaging equipment

Relevant Life Cycle Assessment (LCA) literature regarding the life cycle environmental assessment of imaging equipment products and consumables was compiled, with the aim of assessing whether other hotspots than those identified for the development of the current criteria have been identified in the more recent years. Therefore, the studies reviewed for current criteria development were used as starting point.

In principle, the Product Environmental Footprint[104] (PEF) methodology can be used as benchmark for identifying hotspots in order to set criteria for GPP, due to the harmonisation the methodology will provide which makes environmental assertions comparable. The application of PEF for IT equipment has produced a Product Category Rules document published in April 2018, known as PEFCR[105]. However, the application of this PEFCR document is still limited[106] and specific LCA studies for imaging equipment products are still following diverse LCA methodologies. Furthermore, only nine studies were selected for the comprehensive review which describe at least how most of the elements specified in the ISO 14040 series[107] standards for performing LCAs were assessed, in particular those specified in ISO 14044:2006[108]. The ISO 14044 provides a methodological framework to carry out LCA studies. However, it gives also the freedom to apply it since it does not go in such a level of detail on defining which, e.g., LCI and LCIA methodologies to follow. This flexibility creates diversification and it makes comparisons difficult in particular when making assertions on whether one product is better than others. However, LCA studies following the ISO 14044 standard assure a minimum level of comprehensiveness and can be used to identification of hotspots at a whole product level such as imaging equipment products and consumables. This review has therefore focused on LCAs, presenting the elements described in the ISO 14044 standard and, until the extent possible, those requested by PEF. This can be done since there are some similarities concerning the methodological framework, although PEF requires the application of certain LCIA and LCI methodologies while the ISO 14044 doesn't. A comprehensiveness score has been given to each LCA study based on their relevance and completeness.

Their relevance was assessed comparing the study goal with the aim of this review, which is to identify the life cycle environmental hotspots of imaging equipment products and consumables.

Their completeness was assessed based on the description of the main LCA elements according to the ISO 14044 standard, which are:

1. Results and conclusions shall be completely and accurately reported without bias to the intended audience, which in this case, is the general public as the studies are publicly available.
2. Results, data, methods, assumptions and limitations shall be transparent and presented in sufficient detail.
3. Results and interpretation shall be consistent with the goal(s) of the study.

[104] *Commission recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations.*
[105] *http://ec.europa.eu/environment/eussd/smgp/documents/PEFCR_ITequipment.pdf*
[106] *In spite IT equipment is one of the pilot projects for the application of PEF methodology, the Product Environmental Footprint Category Rules (PEFCR) for this product group are not yet published (expected in 2018 according to public information: https://cdn.nimbu.io/s/gcj6927/channelentries/y8wch12/files/Galatola_G-STIC.pdf?23l4i1m).*
[107] *https://www.iso.org/standard/37456.html*
[108] *ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines.*

Additionally, other aspects relevant only to studies to be third-party verified according to the ISO 14044 standard were also assessed but with a lower degree of ambition, with the aim of integrating aspects that provided more objectivity:

4. Goal of the study shall be defined.
5. Reference flow, i.e. subject of the study, shall be defined.
6. The whole life cycle shall be defined as system boundary, since this is usually necessary when identifying hotspots.
7. Allocation method selected shall be described.
8. Cut-off criteria shall be defined, which in the PEFCR guidance v6.1[109] is specified as contributing to at least 80% of the most relevant impact categories.
9. Should be relevant to aim of this review concerning technological, geographical and time representativeness.
10. Number of life cycle environmental impact categories used shall be defined, which according to PEFCR guidance v6.1 shall exclude toxicity related impact categories[110].

To define a score, each aspect was equally weighted and provided an aggregated score from 0 to 10.

4.1.1.1 Main hotspots identified for current GPP criteria

The technical background report for the existing GPP criteria in force assessed two comprehensive studies of imaging equipment products[111,112] (i.e. S1 and S2, see Table 29) when identifying key environmental areas. These studies are shown in Table 29, together with the LCA qualitative aspects describing the comprehensiveness of the LCA studies. Both studies are simplified (attributional based) and streamlined LCAs, whereas the second (i.e. S2) followed the MEErP Ecodesign methodology.

Table 29 shows that in spite most of the LCA aspects were not equal, it was possible to draw conclusions on the life cycle environmental hotspots. This is acceptable as the aim of such a review was to identify the hotspots, which are very similar to each other in both studies (see Table 30 for a summary of the main findings). The only difference is that the second study identifies the manufacturing as an additional hotspot (for MFDs).

The technical background report for the current GPP criteria concludes, based on the review of these two studies that the life cycle environmental hotspots are:

1. Paper consumption
2. Energy efficiency in the use phase
3. Toner and ink cartridges consumption

Additionally, based on the conclusions of the two LCA studies it can be concluded that:

4. Manufacturing is also a hotspot for MFDs
5. The utilisation of low power management functionalities in the printers and MFDs could reduce their environmental impacts.

Both background studies have included a range of life cycle environmental impact categories. However, only the second study (S2) performs a more detailed analysis of the hotspots, and during this analysis the study looks only at primary energy demand.

[109] *Product Environmental Footprint Category Rules Guidance v6.1, 2017.*
[110] *All selected LCA studies used LCIA methodologies that are widely recognized in the LCA academy (i.e. CML, ReCiPE, Eco-Indicator, IPCC), in addition to other indicators such as particulate matter.*

Table 31 shows the aggregated score of these two studies, being 10 the maximum score. Both studies score relatively low since technological and time scopes are not very relevant any longer to today's technology. Furthermore, the environmental impacts from the use stage may be different today, as the average electricity grid mix in Europe was different (i.e. higher share of fossil fuels). Furthermore, the cut-off criteria were not described which is important as some important materials, components and processes over the life cycle may have been omitted. Finally, one of the studies does not describe if allocation was performed and in such case which method was applied, which has an influence on the results as the methodology determines how the inputs and outputs are allocated in the different processes of the life cycle stages which are the source of the environmental impacts.

Table 29. Overview of main elements of LCA studies used for development of current GPP criteria

Study ID	Goal of the study	Subject of the study	Functional unit (FU)	System boundaries**	Geographical scope	Time scope	Other data quality aspects	Environmen-tal impact categories
S1[111]	To perform an assessment of imaging equipment products in the EU focusing on non-energy related environmental impacts.	Printers used as a proxy for copiers, faxes, and MFDs. Computers used as proxy for scanners adding the glass and light source.	1kg printed paper; 1 laser printer; 1 unit of information.	Raw materials, Manufacturing, Distribution, Use, End of Life (excl. use of paper).	EU-27	Operation during 2008.	Allocation not performed for foreground processes and cut-off criteria not described. Technology representative-ness limited.	GWP, ODP, POFP, Respiratory organics and inorganics, AP, Human, aquatic and terrestrial toxicity, Ionizing radiation, Non-renewable energy, Mineral extraction, Nature occupation
S2[112]	Establish the environmental profiles of the different product types typical technologies in the EU (i.e. base cases) and identify life cycle environmental hotspots.	Base cases for office use[113] and household use[114] at EU-level.	Operation during their whole lifetime.	Full life cycle.	EU-27	Operation during 2006, with product lifetimes varying from 4 to 6 years.	Allocation and cut-off criteria not described. Good geographical and technological representativeness.	GWP, AP, ODP, EP, PED, Water (process and cooling), Waste (hazardous and non-hazardous), VOCs, POPs, Heavy metals (air and water), PAHs, PM

[111] *Environmental Screening and Evaluation of Energy-using Products (EuP) Final Report. Marianne Wesnaes, Jesper Thestrup, Arne Remmen. 2009.*
[112] *EuP Preparatory Studies Imaging Equipment (Lot 4). Final Report on Task 5:Definition of Base Cases. Fraunhofer IZM and PE Europe. 2007.*
[113] *Monochrome electro-photographic MFD-copiers (medium speed of 26 ipm); Colour electro-photographic MFD-copier (medium speed of 26 ipm);Mono-chrome electro photographic printer (high speed of 32 ipm); Colour electrophoto-graphic printer (high speed of 32 ipm); Colour inkjet MFD-printer (low speed 20 ipm).*
[114] *Colour inkjet MFD printer (low speed 20 ipm). Typical technologies in EU-27.*

Table 30. Overview of main conclusions from LCA studies used for development of current GPP criteria

Study ID	Main conclusions
S1	• Life cycle environmental hotspots of imaging equipment are the consumption of paper, the consumption of toner and the electricity consumption during use, including their embodied impacts. • For monochromatic laser printers, the dominant source of environmental impacts (excl. use of paper) is the use of toner cartridge (incl. production), from about 73% to about 98% across all impacts. The rest derives from the use of electricity (incl. production). • For colour laser printers, there is a split division between use of electricity and use of toner cartridges (incl. production). Concerning human toxicity potentials and minerals extraction, the use of toners contributes to about 90% and 85% respectively. Concerning acidification, ecotoxicity (terrestrial) and use of non-renewable energy, both sources of impact are split with about 50% each. This indicates that the use of non-renewable energy for electricity production is an important contributor to all the impacts. • Under real life conditions, the energy efficiency potential of imaging equipment is not necessarily fully exploited due to a potentially suboptimal use by the consumer (i.e. not utilising properly the power management functions which can reduce the energy consumption during use by switching sooner to low power modes). • The focus should be put on designing toners with the lower overall environmental impacts.
S2	• For the majority of the environmental impact categories, the contribution of the use phase is dominant, followed by the manufacturing phase. • From the environmental performance perspective, paper consumption (large demand of energy in the paper production phase) has the highest contribution, followed by energy consumption in the use phase (most of this energy is not consumed during image reproduction but during the inactive mode (standby losses), except for MFDs. • When excluding the use of paper, the contribution of the use of cartridges and electricity to primary energy demand are dominant, except for colour printers where the production of the printer is about the same, and for MFDs where the primary energy demand from the production of the machines is larger. • Concerning manufacturing, those that contribute the most are: for MFD-copier, significant contributions are related to galvanised steel (the modelling input in the MEEuP method is '21-St sheet') and polystyrene (5-PS) due to their significance in the product weight.

Table 31. Score applied to LCA studies used for development of current GPP criteria

Study	Score	Missing elements
S1	7.3	• Results are presented briefly without explaining some important underlying assumptions • Since the focus was on non-energy inputs, using computers as proxies for scanners and the representation of other products with Swiss datasets was too superficial • Time scope is old (2008) • Technology scope (2008) is old and several important components of IE products were not assessed in necessary level of detail • Cut-off criteria not specified
S2	7.6	• Technology scope is old (2006) • Allocation method not specified • Cut-off criteria not specified

4.1.1.2 Main hotspots identified from more recent LCA studies

Seven more recent Life Cycle Assessment (LCA) studies were reviewed to assess whether the sources of life cycle environmental impacts have changed. One of these is a critical review of twelve studies performed in a time period of 9 years before 2012 and published in a journal, and thus this was considered to bring insight into a wide spectrum of good quality LCA studies to be used for the identification of the hotspots. Furthermore, three LCA studies were included which assessed the life cycle environmental impacts of cartridges, with the aim to identify where their life cycle hotspots are which can be used as one of the starting points for defining GPP criteria. These studies are shown in Table 32, together with the LCA qualitative aspects describing their comprehensiveness. These aspects are the same shown for the background studies reviewed for the current GPP criteria, in order to make their comparison possible.

A wide range of products and functional units have been looked at throughout these studies, one performing a review and the rest assessing specific imaging equipment products and technologies. The last three studies (S7, S8 and S9) show results of LCA studies comparing single cycle vs. remanufactured/refilled cartridges. All LCAs are full attributional studies with the exception of S6, which is a streamline LCA.

There is not a trend on the environmental impact categories to look at when performing the LCA studies. Three of the seven studies look beyond Primary Energy Demand (PED) and Global Warming Potential (GWP). One of these is the critical review study which also indicates that most studies look actually at PED, GWP, waste generation, ecotoxicity and air emissions. Five of the studies assess the whole life cycle, one excluding manufacturing and transport since it is focused on the disposal of cartridges and another being the critical review where only two of its reviewed studies excluded production and use. Even if the functional units differ (i.e. refer to products lifetime or to specific units of printing or scanning), the fact that most of the studies assess the whole life cycle provides solid basis to use them all for the identification of key environmental areas.

Finally, in spite allocation and cut-off criteria are not indicated in most cases, the fact that most are full LCAs and adhere to international standards, it is concluded that they are all comprehensive enough to identify the hotspots of imaging equipment products and consumables.

Table 32. Overview of main elements of LCA studies used for review of current GPP criteria

Study ID*	Goal of the study	Subject of the study	Functional unit (FU)	System boundaries	Geographical scope	Time scope	Other data quality aspects	Environmental impact categories
S3[115]	To systematically compare the reviewed studies and look for similarities and differences applying the ISO 14040 principles.	Printers, copiers and MFDs, incl. their associated consumables and remanufactured printers.	Diverse[116] (a review with different FUs).	Diverse: From only Raw materials and Manufacturing to full life cycle	Diverse: operation of the products in the USA, EU and Australia.	Diverse: lifetime of products, unit of printing and annual operation. From 2001 to 2010.	Allocation and cut-off criteria not described. Data generally from databases, in some cases estimated, or excluded.	Diverse: Energy use Water use EP, AP, GWP, Ecological toxicity Emissions to air (PM, VOCs) Waste generation.
S4 (OEM)[117]	To quantify the differences in environmental impact between current models of two printing technologies: Solid ink and Colour laser.	Multifunction devices with 2 printing technologies.	7500 prints per month over a 4-year lifetime of the printers (360 000 prints).	Full life cycle excl. use of paper.	Manufacturing in Korea and Japan, used in USA and EU (60%/40% respectively).	A four year use period before 2011.	Peer reviewed with detailed description of data sources and assumptions[118]. Allocation and cut-off criteria not described.	Cumulative Energy Demand, Global Warming Potential.
S5 (OEM)[119]	To quantify the differences in environmental impact between current models of two printing technologies: Solid ink and Colour laser.	Multifunction devices with 2 printing technologies.	7500 prints per month over a 4-year lifetime of the printers (360 000 prints).	Full Life Cycle excl. use of paper.	Manufacturing in Malaysia and China, used in USA and EU (60%/40% respectively).	A four year use period before 2010	Peer reviewed with detailed description of data sources and assumptions[120]. Allocation and cut-off criteria not described.	Cumulative Energy Demand, Global Warming Potential.
S6 (OEM)[121]	To identify areas of environmental hotspots in order to focus improvement efforts and meet EPEAT LCA requirements.	Scanners manufactured by KODAK.	1000 scans over lifetime (not specified).	Full life cycle	Used in the USA, Germany and China (manufacturing location not specified).	2012 (use period not specified)	Following ISO 14044 but with no allocation nor cut-off described. Detailed description of data sources and assumptions[122].	ReCiPe[123] weighted single score endpoint (human health, ecosystems, and resource depletion); GHG emissions (IPCC

[115] *Life Cycle Assessment in the Print industry. Justin Bousquin, Eni Gambeta, Marcos Esterman, and Sandra Rothenberg. Journal of Industrial Ecology, April 2012.*

[116] *This literature review has analysed different studies with different functional units, mostly focusing on the number of X pages/printed images or a period time (e.g. over lifetime; X pages or printed images; 1 unit of information; product lifetime (5 years); X amount toner; x amount of printer waste; average pages/job).*

[117] *Life Cycle Assessment of a Solid Ink Multifunction Printer Compared with a Colour Laser Multifunction Printer. Total Lifetime Energy Investment and Global Warming Impact. Meagan Bozeman, Wendi Latko, Ashley DeVierno, Chris Schafer, Daniela Makowski. November 2011.*

[118] *Manufacturing and transport data modelled using ecoinvent databases. BOMs sourced from manufacturer. End-of-life used US EPA Waste Reduction Model (WARM). Assumed 25% of laser consumables recycled locally and none from solid ink.*

[119] *Life Cycle Assessment of a Solid Ink Multifunction Printer Compared with a Color Laser Multifunction Printer. Total Lifetime Energy Investment and Global Warming Impact. Debra Koehler, Wendi Latko, Anne Stocum. April 2010.*

[120] *The analysis was conducted using ecoinvent database. Direct manufacturing data was used when available, with industry average data from the database being used when direct data were unavailable. Direct data were used for toner, solid ink production, some device and consumable manufacturing. The material inputs to the manufacturing process and the remaining manufacturing activities were based on industry averages.*

[121] *Life Cycle Assessment Summary Report. KODAK i2800, i2600, i2400 Scanners. ISO 14044 Protocol. Roy Wood, Kodak Health Safety Environment & Sustainability. May 16, 2012.*

[122] *Primary data for BOM, assuming ecoinvent database for materials production and manufacturing, and different scenarios for varying user behaviour, user location, and transportation. No End of Life data specified. Modelled with Simapro version 7.3.2.*

Study ID*	Goal of the study	Subject of the study	Functional unit (FU)	System boundaries	Geographical scope	Time scope	Other data quality aspects	Environmental impact categories
								2007 GWP 100a Version 1.02).
S7 (OEM)[124]	To compare the environmental impacts of Original HP LaserJet toner cartridges with remanufactured cartridges sold as substitutes.	OEM HP LaserJet toner cartridges vs. remanufactured cartridges sold as substitutes.	The printing of 100 usable monochrome one-sided pages.	Full life cycle	Used in the USA (manufacturing location not specified).	2014 (allocation of cartridge per FU done based on testing data available).	Adheres to ISO 14040/44 guidelines. Allocation and cut-off not described. Detailed description of data sources and assumptions[125]	GWP, PED, AP, EP, Human toxicity POFP, Terrestrial ecotoxicity, Fossil depletion
S8[126]	To evaluate environmental impacts of EOL pathways for an inkjet cartridge and determine whether consumer behaviours influence these impacts.	Retail refilled & remanufactured inkjet cartridge vs. new inkjet cartridges.	Five use cycles achieved either by purchasing new cartridge or by refilling.	Raw materials, Use and End-of-Life (EOL), incl./excl. paper use.	Used in the USA	2014	Using ISO 14040/44 as guidance. Allocation performed for transport of consumers to do refilling. Detailed description of data sources and assumptions[127].	Cumulative energy demand (CED) version 1.07, GWP 100 years.
S9 (OEM)[128]	To carry out a carbon footprint study of two toner cartridges in order to provide answers to questions frequently posed by users.	A single-cycle cartridge (SSC), a short-life cartridge (SLC) for 1-3 refilling cycles and a long-life cartridge (LLC) for about 15 refilling cycles.	1 printing cycle	Full life cycle	Used in the EU (SLC and LLC manufactured in the UK).	2008	Using GHG Protocol, ISO 14064 and PAS 2050 as guidelines. Allocation and cut-off not described. Detailed description of data sources and assumptions[129]	GWP

[123] *ReCiPe is a method for the impact assessment (LCIA) in a LCA. See more at: http://www.rivm.nl/en/Topics/L/Life_Cycle_Assessment_LCA/ReCiPe*

[124] *Life Cycle Assessment Original HP LaserJet toner cartridges compared with remanufactured cartridges. HP, April 2014.*

[125] *Primary industry data (HP) for OEM cartridges (BOMs, printing specifications, recycling practices). Secondary data from Info trends for remanufactured cartridges recycling practices. An external laboratory was used to determine the number of pages required to attain 100 usable printed pages, which is the basis for the comparison and the functional unit. The results from the lab study show that the remanufactured cartridges have to print more pages to reach the needed quality for printed documents for external use. BOMs and average disposal scenarios for the USA. Upstream and downstream aggregated processes from ecoinvent v2.2 database using SimaPro 7.3.*

[126] *When consumer behavior dictates life cycle performance beyond the use phase: case study of inkjet cartridge end-of-life management. Mark Krystofik & Callie W. Babbitt & Gabrielle Gaustad. International Journal of Life Cycle Asssessment, 2014.*

[127] *Primary industry data (HP) for BOMs and average disposal scenarios for the USA. Upstream and downstream aggregated processes from ecoinvent v2.2 database using SimaPro 7.3.*

[128] *Carbon Footprints and Ecodesign of Toner Printer Cartridges. UKCRA 2008.*

[129] *Primary data for remanufactured cartridges and industry data for BOM of OEM SSC cartridge.*

Table 33 shows the main conclusions from the LCA studies. The main findings are presented separately for imaging equipment products and for imaging equipment consumables. They are discussed in detail in later sections of this chapter.

Table 33. Overview of main conclusions from LCA studies on imaging equipment products and consumables

Study ID	Main conclusions
S3	• Standardization of the functional unit and the assumptions that are interwoven within it may have a high potential to increase quantitative comparability across studies. • User behaviour has a major role on the products environmental performance, specially concerning use of paper. However, use of industry averages and test methodologies such as ENERGY STAR when performing comparisons reduce this bias. • Generally energy use and GWP are the most applied environmental impact categories to quantify life cycle impacts. • There was little agreement on how materials are disposed. Assumptions about share for reuse, remanufacture, recycling, incineration (with or w/o energy recovery), archived, or landfilled are all variable. These differences can lead to different results, especially when disposing of paper.
S4	• For the laser MFD, the contribution from the use phase was only about 25% while for solid ink MFD was about 55%. For laser MFD the replacement of consumables contributes with about 25% whilst for solid ink MFD it does with about 8%. For laser MFD the contribution from the manufacturing is about 18% while for solid ink MFD is about 23%. • Over the product life cycle, the Solid Ink printer studied exhibited approximately 17% lower Cumulative Energy Demand and 13% lower Global Warming Potential than the laser printer and created approximately 90% less post-consumer waste.
S5	• For the laser printer, the contribution from the use phase was only about 25% while for solid ink printer was about 60%. For laser printer the replacement of consumables contributes with about 30% whilst for solid ink printer it does with about 12%. For laser printer the contribution from the printer manufacturing is about 15% while for solid ink printer is about 15%. • Over the product life cycle, the solid ink printer studied had approximately 30% lower Cumulative Energy Demand and Global Warming Potential and approximately 90% less post-consumer waste than a comparable laser product.
S6	• Impacts are largely from the scanner materials and manufacturing and electricity consumption. • Majority of impacts are from climate change and fossil fuel depletion. • Consumer use behaviour has the biggest influence on environmental impact per scan.
S7	• Paper consumption during printing is the largest contributor to the environmental impact of the print cartridge across all phases of the life cycle for both the HP Original Equipment Manufacturer (OEM) cartridge and the remanufactured alternative. • OEM cartridges have a lower overall environmental impact than the remanufactured alternative, although the differences are quite marginal (+10% for climate change and total energy demand). • For the OEM cartridges, the hotspots looking at Climate change are the use (79%) and production (20%), while for remanufactured cartridges it is the use (94%).
S8	• Cartridge refills present the lowest environmental impact, offering a 76 % savings in global warming potential compared to production and purchase of a new inkjet cartridge. • When looking at the GWP hotspots per cartridge cycle, the production is the dominant for the scenarios that don't use paper (78%-86%). When paper is included, the contribution is as much or less than the contribution from use (16%-40% from production and 26%-57% from use). • When looking into the CED from production, the hotspots are from manufacturing the cartridge (36%), from the embodied impacts of the housing (27%) and the print head (20%). • When looking into the five cycles (i.e. the FU) of the refilled cartridges, the impact from the consumer transport becomes the dominant.
S9	• The carbon footprint reduction from using a SLC is about half in comparison to use a SSC for each of the three cycles. • This reduction is about 60% when using a LLC instead of a SSC for each of the 15 cycles.

Table 34. Score applied to reviewed LCA studies for revision of current GPP criteria

Study	Score	Missing elements
S3	7.7	• 3 of the reviewed studies miss some important life cycle stages (e.g. use, end of life, transport) • Technologies assessed relatively old (2012)
S4	6.3	• OEM study comparing own with generic technology but not justified with data quality comparisons and LCIA indicators[130] • Comprehensive dataset for OEM but generic for the other technology which can produce biased results • Only GWP and PED reported not enough to claim one product is better • Technology (2011) and geography (USA) not as relevant for this review
S5	5.5	• OEM study comparing own with generic technology but not justified with data quality comparisons, LCIA indicators and sensitivity analyses[130] • Comprehensive dataset for OEM but generic for the other technology which can produce biased results • Specific generic technology not fully described • Only GWP and PED reported not enough to claim one product is better • End of life not assessed • Technology (2011) and geography (USA) not as relevant for this review
S6	6.0	• OEM study not explaining main assumptions and limitations applied • Location not mentioned and relatively old technology • Weighted results difficult to interpret
S7	7.5	• OEM study not justifying the amount of reusing cycles (i.e. only one) for remanufactured cartridges nor the definition of the functional unit[130] • Data quality for the remanufactured cartridge dataset not fully assessed[130] • Technologies for remanufactured cartridges in the USA may differ to those in the EU
S8	8.5	• Study based on USA refilling patterns which may be different to those in the EU
S9	7.8	• Technologies assessed old (2008)

Table 31 and Table 34 show no LCA studies with a maximum score (i.e. 10), not those reviewed for the existing GPP criteria nor those for this review. This is because most of them do not describe the allocation of impacts applied (e.g. if for some transportation patterns they allocated fuel used only to refill cartridges), nor the amount of energy and materials included (i.e. the cut-off criteria). Both are important elements to indicate the comprehensiveness of LCA studies. Only one study (S8) described the allocation applied. Three out of eleven studies score low (i.e. under 7) in comprehensiveness. Two of these lack of description of main assumptions and limitations and one does that only for their own product. These may bring biased results, especially considering these are OEM studies (see those which are OEM in

[130] *Required when performing comparative assertions shown to public according to ISO 14040*

Table 29 and Table 32). However, these LCA studies identify the same hotspots are the others (i.e. use, manufacturing and consumables).

In general, the OEM studies reviewed in this section miss further clarification concerning the data quality for the technology/product they are using to compare their own. Using specific datasets for OEM products and average datasets for generic technologies may bring uncertainties when comparing, as OEM datasets may tend to be more comprehensive.

In spite of their differences concerning functional unit, scope, system boundaries and environmental impacts assessed, their level of comprehensiveness established based on the ISO 14044 standard is relatively similar (except S4, S5 and S6). Furthermore, Table 30 and Table 33 show that the main hotspots have not changed much since the review performed for the development of the current GPP criteria. However, it is becoming more common to exclude the use of paper from the system boundaries which emphasizes the importance of consumables and manufacturing. Details on this can be found in the next two sections.

4.1.1.2.1 Imaging equipment products

The literature review study (S3 in Table 33) indicates that the wide diversity of functional units used in LCA studies prevents from establishing precise quantitative comparisons between LCA studies of imaging equipment products. This is becoming even more difficult with the introduction of networked technologies where MFDs perform other ICT functions. They mention that by applying a functional unit such as 'a unit of information', could enable comparisons of imaging equipment products with communication media other than print. However, this would introduce uncertainty on establishing the amount of data needed to provide a typical printing service so they could be made comparable, e.g. from printing an A4 page with average coverage[131]. Considering the age of this proposal (2012) and the fact of no further development to use this as a functional unit, it is recommended to use to 'x amount of prints' as functional unit for printers and MFDs (which can also be used for copiers). This is also what recommended by the latest Product Category Rules (PCRs) for printers and MFDs Environmental Product Declarations (EPDs) in the USA (i.e. 'simplex printing of 1000 pages in either monochrome or color'), developed by a group of consultants, universities and several major manufacturers such as HP, Xerox, Lexmark and Samsung[132].

Total energy use (i.e. Primary Energy Demand) and Global Warming Potential (GWP) are the most applied environmental impact categories to quantify life cycle impacts (S4, S5 and S8 in Table 32 and Table 32 only use GWP and PED, while S9 only use GWP). This differs from the Product Category Rules[133] set for printers and MFDs[134], where at least six environmental impact categories[135] are recommended when performing LCAs of these products. Even though GWP and Primary Energy Demand are good indicators of life cycle environmental performance, other environmental aspects are important and relevant for the life cycle hotspots identification. Other environmental impacts such as resource depletion potential may also be needed when comparing different product and/or service imaging equipment

[131] *According to reviewed LCA study in S3: Ebner, F., S. Chang, J. Knapp, V. Deyoung, and W. Latko. 2009. Development of a green scorecard to identify research projects for eco-efficient print engines. In IEEE international symposium on sustainable systems and technology. Tempe, AZ, USA: IEEE Xplore.*

[132] *Product Category Rules for preparing an environmental product declaration (EPD) for printers and MFDs according to ISO 14025: 2012 to 2017.*

[133] *Product Category Rules for Environmental Product Declarations (EPD) are LCA methodologies recommended for performing LCAs of specific product groups with the aim of making comparability and interpretation possible. They were traditionally developed for creating EPDs based on type III environmental declarations ISO 14025 standard, but more recently they are being used to develop methodological basis for testing the EU Product Environmental Footprint methodology.*

[134] *Product Category Rules for preparing an environmental product declaration (EPD) for PRINTERS AND MULTI-FUNCTION PRINTING UNITS. Program operator: UL Environment. Developed in 2012 and valid until end of 2017.*

[135] *Climate Change/Global Warming Potential, Ozone Depletion Potential, Acidification Potential, Eutrophication Depletion Potential, Fossil Fuel Depletion Potential, Mineral Resource Depletion Potential*

solutions, since they measure life cycle benefits from material efficiency strategies and measures. Furthermore, the review study (S3 in Table 32) also shows that waste generation, ecotoxicity and air emissions have been used in several studies to indicate environmental performance. The LCA study of scanners (S6 in Table 32) indicates their environmental performance across a range of indicators, being a requirement to comply with EPEAT.
The review of these studies present more diverse results than the older (and broader) LCA studies presented in the previous GPP/Ecolabel criteria report (S1 and S2 in Table 30).
S4 in Table 33 shows that for some technologies (e.g. OEM MFDs using solid ink printing technologies), the contribution of the use phase is still dominant. However, for other more efficient technologies (e.g. average MFDs with laser technologies), the contribution from the cartridges is as important as the contribution from energy during use. Furthermore, for these technologies the contribution from manufacturing is also important (about 20%), indicating manufacturing is also a hotspot for more efficient MFDs. Considering that the data used for modelling the manufacturing of solid ink technology is more representative of the specific technology since it is from a primary source (i.e. the OEM), a possibility exists that the contributions from manufacturing are more uncertain.
When looking at printers (S5 in Table 33), the difference of environmental performance between more/less efficient technologies is more evident. For average laser printers, the contribution of the cartridges is twice as much as the contribution from the energy in use, while for OEM solid ink technologies the contribution of the energy in use is five times more than that of the cartridges. It is important to notice that these studies, comparing solid ink with laser printing technologies for MFDs and printers, did not look at paper use during the use phase, else the major hotspot would be paper use as another LCA study has shown (i.e. when using wood free uncoated paper and lightweight coated paper).
For OEM scanners, the LCA study (S6 in Table 33) shows that energy in use is still the dominant hotspot. However, if the scanner is used in low power modes for longer periods, the contribution from manufacturing is higher. However, since the study is presumably done in the USA (geographical scope not mentioned in the summary document), the contribution from use in active state in EU would decrease considering the average electricity mix in the USA presents generally higher GWP, PED, acidification and eutrophication potentials per kWh than the average electricity mix in the EU. Therefore, manufacturing may be also an important hotspot.
It can be concluded that the life cycle environmental hotspots are:

- Use of electricity for printers and MFDs, particularly for those with less efficient printing technologies.
- Use of electricity for scanners, which can be reduced if consumer utilises low power modes for longer periods.
- Use of consumables, particularly paper and cartridges (for printers and MFDs).
- Manufacturing of printers, MFDs and scanners, particularly for the more efficient printing technologies (i.e. laser technologies).

4.1.1.2.2 Imaging equipment consumables

Two LCA studies of a wide range of cartridges used both in the EU (S9 in Table 32) and the USA (S8 in Table 32) and one comparing OEM vs. remanufactured used in the USA (S7 in Table 32) commissioned by the OEM, agree that cartridge refills present significant reductions in environmental impacts compared to single use inkjet cartridges. This reduction increases when the single use cartridge (called 'single cycle cartridge') is compared to long life cartridges (which run up to 15 refilling cycles) instead of short life cartridges (which run up to 3 refilling cycles). Furthermore, when performing 5 refill cycles or more, the importance of consumer transport to do the refilling becomes also a hotspot. However, this could vary widely depending on the fuel allocated per trip per refill of cartridge, as the consumer would most likely use the trip to carry out other activities. Generally, as more refills as less the contribution of manufacturing to the environmental impacts. In some cases, depending on the

allocation for consumer transport, the more refills the more overall reductions of carbon footprint are observed (about 60% carbon footprint reduction for cartridges that can take 15 refills or more, according to S9 in Table 33).
S7 and S8 in Table 33 show that the amount of paper a cartridge can last for is also a key parameter. They show that, when the use of paper is included, the cartridge's ability to deliver printouts with high quality determines whether one cartridge is better than other. Cartridges delivering lower quality print outs turned to have slightly higher life cycle environmental impacts due to the need of to use more paper in order to achieve the quality desired. S8 shows that when paper use is excluded from the system boundaries, the production of the cartridges is the hotspot (from the embodied impacts of the housing, the print head and the manufacturing of the cartridge).
S7 in Table 33 shows lower environmental impacts for OEM cartridges (although this study was commissioned by the OEM). However, the differences are marginal and thus subject to doubt for making final conclusions as this variation could be drastically reduced when changing some of the assumptions, e.g. the allocation of extra trips done for remanufactured cartridges. Furthermore, considering the limitation of the remanufactured cartridge to be refilled only once by the definition of the functional unit in the study, the impacts from remanufactured cartridges may be even lower. This study shows that for OEM cartridges, the hotspots looking at GWP are the use stage (79%) and production (20%), while for remanufactured cartridges it is only the use stage (94%).

It can be concluded that the life cycle environmental hotspots are:

- Manufacturing of cartridges, in particular of the housing and print head, which can be greatly reduced if cartridges can be refilled; the more refills the less contribution from manufacturing.
- The amount of paper the cartridge uses to deliver the printouts at the desired quality; the higher the quality the more the reductions of environmental impacts by using less paper.
- The consumer transport for refilled cartridges; the more refills the higher the contribution of transport for the total environmental impacts. However, this is subject to great variability depending on the allocated fuel used per trip per refilling.

4.2 Assessment of other environmental schemes: Other environmental aspects

Life Cycle Assessments (LCAs) focus typically on assessing direct impacts to the environment. Aspects such as safety and specific sources of human and eco-toxicity from specific substances of concern are not addressed in many cases. Safety is typically addressed by other working environment methods. Substances of concern are by risk assessment.

Moreover, the aim of reviewing LCA studies in chapter 3.6 was to identify hotspots. This means that the focus was on average technologies and practices found on the market. The impact of specific best practices on the environment throughout the life cycle of imaging equipment products and services was not investigated. In order to know what these practices could be, an overview of the key performance indicators (KPIs) used by different environmental initiatives and schemes was collected (see Table 35). These KPIs can be used as starting point to identify what are the important parameters other schemes and initiatives focus on, in order to reduce imaging equipment environmental impacts. Some of these KPIs are similar to the hotspots identified in chapter 3.6, reassuring their importance. Furthermore, their influence in the market is also presented to know their overall impact.

Table 35. Environmental initiatives on imaging equipment and market influence

Initiative/ Scheme	KPIs addressed	Market influence
EU ENERGY STAR (v2.0)	Energy Use, Paper Use	3433 products registered in EU database. Background specifications mandatory requirement in EU member state central Government procurement contracts
EU Ecolabel (Discontinued since December 2017)	Energy Use, Paper Use, Hazardous substances, Recyclability, Product Lifetime extension, Packaging, Consumables, Emissions	Currently no registered products
EU GPP Criteria	Energy Use, Paper Use, Product Lifetime extension, Consumables	Specification suggested requirement in EU member state Government procurement contracts
Ecodesign VA	Energy Use, Paper Use, Recycled content, Recyclability, Product Lifetime extension, Consumables	Between 70% and 90% of products in scope and on the EU market need to meet requirements
Blue Angel	Energy Use, Paper Use, Hazardous substances, Recyclability, Product Lifetime extension, Product take-back, Packaging, Consumables, Emissions	1421 products registered (RAL-UZ 171) 0 products registered (RAL-UZ 205)[136]
Nordic Swan	Energy Use, Paper Use, Hazardous substances, Recycled content, Recyclability, Product Lifetime extension, Corporate performance, Manufacturing Impacts, Packaging, Consumables, Emissions	170 imaging equipment models registered (Denmark, Norway & Sweden) 149 imaging equipment models registered (Finland)

[136] *Version published in 2017*

Initiative/ Scheme	KPIs addressed	Market influence
EPEAT/IEEE 1680.1	Energy Use, Paper Use, Hazardous substances, Safer alternatives, Recycled content, Bio-based plastic content, Product weight, Recyclability, End-of-life analysis and planning, Product Lifetime extension, Product take-back, Corporate performance, Manufacturing Impacts, Packaging, Consumables, Emissions	1832 products registered in EPEAT database (registered in USA). Mandatory consideration in US Government Procurement contracts.
Korea Ecolabel	Energy Use, Paper Use, Hazardous substances, Recyclability, Packaging, Consumables, Emissions, Safety	Unclear
Ecodesign Standby	Energy Use	Mandatory requirement for all imaging equipment in scope and placed on the EU market

4.2.1 Material choice

The number, type and quantity of materials contained in imaging equipment vary considerably due to the broad scope of this product group. Whilst the main materials are plastics and metals (e.g. PS (HI-PS), ABS, PC, steel copper, aluminium etc.), imaging equipment can also contain various materials regarded as critical in the EU (e.g. antimony, palladium, rare earths such as neodymium) and metals with high intrinsic economic value (gold, silver, palladium) or with environmental impacts (e.g. aluminium or steel). Figure 16 illustrates the spread of product weights of EPEAT registered imaging equipment. The lightest product in the EPEAT database weighs 0.4kg and the heaviest 1035.4kg. There is a clear trend of increased amount of materials with the increased product weight, which is important for the GPP criteria as public institutions require usually larger products.

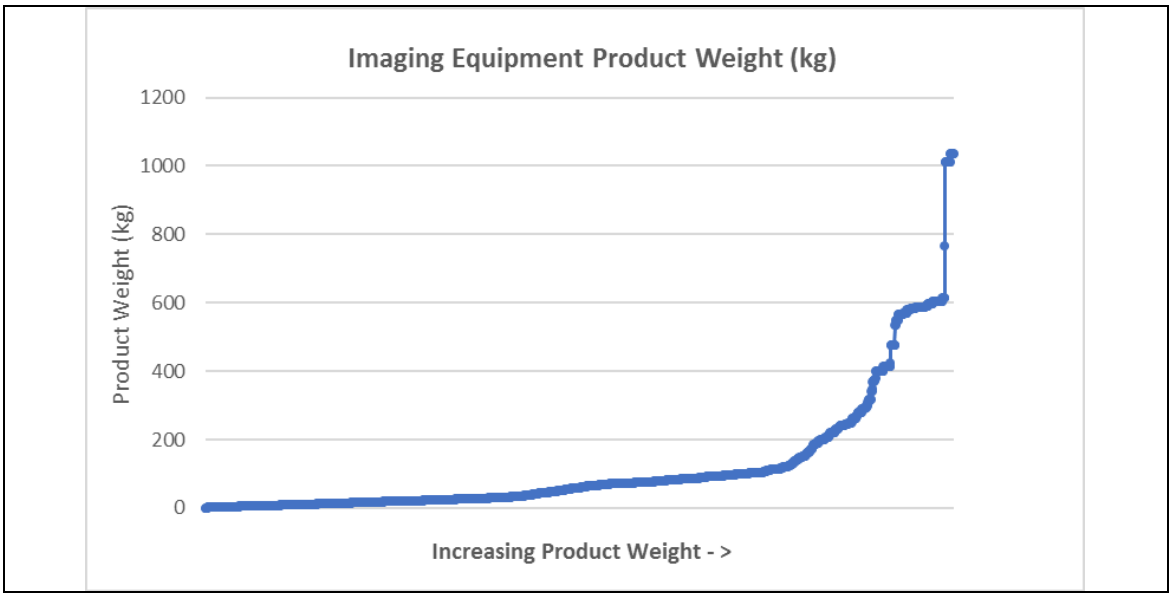

Figure 16. Product weight of EPEAT registered imaging equipment[137]

[137] *http://www.epeat.net/documents/manufacturer-resources/MM_Archive/Manufacturer_Monday_121514.pdf*

To reduce the potential environmental impacts from increasing amount of materials in larger products, some strategies are identified such as material separation and recovery, post-consumer plastic content and durability, where the availability of spare parts and guarantee issues are implicit.

4.2.2 Hazardous substances

Most electronic products, including imaging equipment, contain at least some hazardous ingredients. Of particular concern are for instance heavy metals (e.g. mercury, cadmium, lead) and flame retardants in plastics (e.g. pentabromophenol, polybrominated diphenyl ethers (PBDEs), tetrabromobiphenol-A (TBBPA)). A number of other substances found on the Candidate List of Substances of Very High Concern (SVHC)[138] and REACH Annex XIV (List of Substances Subject to Authorization)[139] are also likely to be present in some imaging equipment products.

Most of these hazardous ingredients are unlikely to be emitted to the environment during a product's useful life as they are found in internal components. Nevertheless, in some cases hazardous substances may be emitted to the environment during end-of-life processing. Levels of emissions during end-of-life processing will be dependent on both the amount and type of initial hazardous content and the specific end-of-life processing which takes place[140].

Different forms of end-of life processing emitting hazardous substances (and their associated risks) include:

- Mechanical shredding: can cause the release of hazardous substances such as BFRs as well as any other chemicals contained within finely granulated material, such as dust, that escapes the immediate processing area.
- Pyrometallurgical treatment: thermal treatment of materials to enable recovery of valuable metals can cause gaseous emissions of heavy metals. Pyrometallurgical treatments may also result in the creation of halogenated dioxins and furans where plastic containing BFRs is heated.
- Incineration: when plastics from electronic products are incinerated, it can cause the formation and release of hazardous compounds such as brominated dioxins and furans. The extent to which these compounds are generated and released depends highly on how they are incinerated, although the Industrial Emissions Directive IPPC regulates the limits of pollutants emitted from incineration.
- Landfill: some of the waste plastics emanating from imaging equipment recycling are deposited in landfills which can result in heavy metal and BFR contaminated leachate. Modern landfills will provide some capability to contain this hazardous leachate.

Both toner and ink used in consumables can also contain hazardous substances, although levels can be low. Toner for example can contain substances such as some heavy metals, azo-colourants and other hazardous chemicals.[141] The type of ink used in ink cartridges and containers varies considerably. There are three main chemical bases used in inkjet ink, the most popular being water and petrochemical solvents with oil based inks being more popular in wide-format commercial printers. The colourants added to ink are either dye or

[138] *European Chemicals Agency (ECHA). Candidate List of substances of very high concern, https://echa.europa.eu/candidate-list-table*
[139] *European Chemicals Agency (ECHA). List of substances included in Annex XIV of REACH ("Authorisation List", https://echa.europa.eu/addressing-chemicals-of-concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list*
[140] *The EU has taken a number of initiatives to address the hazardous waste issues. E.g. the RoHS Directive 2002/95/EC, the Stockholm convention, the Waste Shipment Regulation and the original and revised WEEE Directives*
[141] *https://www.blauer-engel.de/en/products/office/toner-modules/toner-modules*

pigmentation. The dyes used consist of small molecules blended into water bases. Pigmented colorant is typically insoluble in water, and consists of larger molecules than those of dye. Hybrid ink which consists of both dyes and pigmentation is also used. As well as the chemical base and colorant, inks contain additional additives including:

- alcohols
- buffering agents (to control pH levels)
- resins
- humectants
- fungicides
- surfactants
- biocides

Imaging equipment does have the potential to emit hazardous substances during operation, in the form of dust, volatile organic chemicals (VOCs), ozone, benzene, particulate matter and semi-volatile organic compounds (SVOCs).

Some older studies in the early 2000[142,143,144] reported levels of VOCs indicating laser printers had higher emission levels than inkjet printers, specially operating units rather than idle units. Overall for all imaging equipment products, the emission rates from photocopiers were much higher than for printers and multi-functional devices. But one of the studies refers to high variability of results obtained, ranging over three orders of magnitude for some chemicals, e.g., toluene and styrene. Despite this, there are some consistencies between the studies that show that chamber concentrations of styrene, xylenes and ozone are increased in printing process of the laser printer, and pentanol is detected from the ink-jet printer. The emission rates of laser printers were the highest and found to be about six times that of ink-jet printers.

4.2.3 Durability and guarantee

Durability of imaging equipment varies considerably depending largely on product type, intended use and expected useful lifetime. For example, a domestic inkjet printer is unlikely to be designed with as much durability as a large format laser multi-functional device (MFD). In most cases the large format laser MFD will be designed to ensure that it is durable enough to perform a significant amount of imaging over an extended period of time, and in some cases retain useful value at the end of life to facilitate reuse or remanufacturing. Actual lifetimes of products in years are difficult to quantify given the large variability. The EU preparatory study on imaging products, conducted in 2007, attempted to identify average imaging equipment product lifetimes. The study team estimated the average life of laser based imaging equipment to be 6 years and inkjet based equipment 4 years and assessed these lifetimes are still valid.[145]

In relation to availability of spare parts to support durability, some environmental initiatives contain requirements that manufacturers must offer extended guarantee or spare parts availability for a defined number of years. Other initiatives, rather than requiring an actual guarantee, require that manufacturers publicly state their processes for dealing with early

[142] *Destaillats, Hugo, Randy L Maddalena, Brett C Singer, Alfred T Hodgson, and Thomas E Mckone. 2008. "Indoor Pollutants Emitted by Office Equipment: A Review of Reported Data and Information Needs." Atmospheric Environment 42: 1371–88. doi:10.1016/j.atmosenv.2007.10.080.*

[143] *Naoki Kagia, Shuji Fujiib, Youhei Horibab, Norikazu Namikic, Yoshio Ohtanic, Hitoshi Emic, Hajime Tamurad, and Yong Shik Kime. 2007. "Indoor Air Quality for Chemical and Ultrafine Particle Contaminants from Printers." Building and Environment 42: 1949/1954.*

[144] *S.C. Lee, Sanches Lam ∗, Ho Kin Fai. 2001. "Characterization of VOCs, Ozone, and PM10 Emissions from Office Equipment in an Environmental Chamber." Department of Civil and Structural Engineering 36: 837/842.*

[145] *EuP Preparatory Study Lot 4 (IE) Final Report Task 3 12th November 2007, EuP Preparatory Studies "Imaging Equipment" (Lot 4) Final Report on Task 3 "Consumer Behavior and Local Infrastructure" Compiled by Öko-Institut and Fraunhofer IZM*

failure in products. Both approaches aim to encourage manufacturers to build durability into products to save costs stemming from the need to replace products that have failed after a short lifetime.
The amount of materials used within consumables over the life of an imaging equipment product is not insignificant. Consumables, such as toner and ink cartridges, are less likely to be designed in order to facilitate ease of disassembly and recyclability due to concerns over leakage and potentially the wish to reduce the ease of cartridge remanufacturing (for commercial reasons). Some imaging equipment manufacturers have taken steps to reduce the number of materials used in printer cartridges in order to facilitate more effective material recovery.[146]

4.2.4 End-of-life practices

There are several inherent problems with imaging equipment that can negatively impact recycling at end of life. Firstly, many of the plastics used in imaging equipment contain Brominated Flame Retardants (BFRs), which need to be removed from any separately collected WEEE and disposed of or recovered separately. Secondly, waste plastics containing BFRs may not be suitable for reuse in new products. Other issues relate to some difficulty in ensuring materials can be collected within separate streams in such a manner that they are suitable for reuse.

As electronic products, imaging equipment falls within the scope of the Waste Electrical and Electronic Equipment (WEEE) 2012/19/EU Directive.[147] The WEEE-Directive regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment, which includes imaging equipment within category 3 “IT and telecommunications equipment".

The WEEE Directive sets collection, recycling and recovery targets for all types of electrical goods, which EU member states are obligated to achieve. The WEEE Directive currently (as of August 2015) requires that for WEEE imaging equipment 80% is recovered and 70% is prepared for re-use and recycling. The targets are set to change in August 2018 with 80% of WEEE imaging equipment needing to be recycled.

EU member states are also obligated to ensure that EEE producers such as imaging equipment manufacturers and resellers, finance the collection, treatment, recovery and environmentally sound disposal of WEEE, through extended producer responsibility schemes.

In addition to the other WEEE requirements, the Directive also requires that certain substances, mixtures and components must be removed from any collected WEEE for selective treatment. The following substances, mixtures and components are relevant for imaging equipment:

- polychlorinated biphenyls (PCB) containing capacitors
- mercury containing components, such as switches or backlighting lamps
- batteries
- printed circuit boards of electronic devices if the surface of the printed circuit board is greater than 10 square centimetres
- toner cartridges, liquid and paste, as well as colour toner
- plastic containing brominated flame retardants
- gas discharge lamps

[146] *https://www.kyoceradocumentsolutions.com.au/environment/Pages/ECOSYSOzoneSafeTechnology.aspx*
[147] *European Commission, Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE), available from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0019*

- liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres and all those back-lighted with gas discharge lamps
- external electric cables
- electrolyte capacitors containing substances of concern (height >25 mm, diameter >25 mm or proportionately similar volume)

The European Commission has provided guidance stating that printer cartridges with electronic components, and which are dependent on electric currents or electromagnetic fields to operate, can be considered EEE and therefore can be considered as being within scope of the WEEE Directive (2012/19/EU). This Commission guidance is non-mandatory and so member states are free to decide whether printer cartridges are to be treated as WEEE. The UK for example has taken the position that printer cartridges are to be treated as WEEE (even when collected separately) and as such they need to be processed in the same manner as any other WEEE. [148]

Actual end-of-life practices for imaging equipment and WEEE in general, vary both across the EU and within individual member states. Within the WEEE recycling industry, recyclers use a variety of common methods for recycling waste imaging equipment including:

- Fully manual segregation: involves the segregation of imaging equipment from other WEEE streams followed by manual dismantling
- Fully manual segregation with re-use: process the same as above but with the reuse of certain components
- Semi-automated with commercial shredding: involves the mechanical shredding of WEEE to aid with the recovery of ferrous and non-ferrous metals. Manual picking operations undertaken to recover PCBs and other components.
- Semi-automated with commercial smashing: involves the manual removal of WEEE requiring manual recovery. Remaining WEEE is then spun and smashed into smaller components with magnetic separation and final manual picking lines.

Large amounts of imaging equipment WEEE is produced each year in the EU with IT and telecommunication equipment being the second largest category for WEEE collection, accounting for approximately 550,000 tonnes per year.[149] Despite the WEEE Directive being in force, collection and recycling rates remain low across much of the EU.

The recycling process for imaging equipment which is collected via established WEEE schemes takes the following steps:

- Preparation for reuse
- Pre-processing/dismantling (including detoxification)
- End-processing and final disposal

Some of the major imaging equipment manufacturers undertake a significant amount of remanufacturing of used equipment.[150] This is especially true for larger business machines which retain greater value at end of life compared to domestic products.

A significant amount of cartridge remanufacturing and reuse also takes place, with some sources estimating that between 20 to 30% of all cartridges sold worldwide are remanufactured.[151] Cartridge remanufacturing is undertaken by a range of organisations from small companies to the major imaging equipment manufacturers themselves.

[148] *https://b2bcompliance.org.uk/2016/04/printer-cartridges-now-in-scope-from-q1-2016/*

[149] *Eurostat, Waste statistics - electrical and electronic equipment, available from http://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics_-_electrical_and_electronic_equipment*

[150] *https://www.xerox.com/corporate-citizenship/2016/sustainability/sustainable-products.html*

[151] *EITRA, Key facts about the cartridge remanufacturing market, available from http://www.etira.org/cartridge-remanufacturing/key-facts/*

It is unclear where waste imaging equipment which does not enter into the WEEE stream goes. It is likely that many end-of-life imaging equipment products are stored in owners' premises, disposed of via municipal waste streams or exported as used or end-of-life equipment to non-EU countries.

4.2.4.1.1 Material separation and recovery

To increase material recovery rates and aid separation of components with special waste treatment needs, many imaging equipment models include design features which facilitate easier disassembly and separation of components and materials. Examples of these common design features include:

- Limitations on the number of plastics used in each part/component
- Labelling of plastic parts to identify plastic type
- External enclosures, chassis, and electronic subassemblies designed to be removable with commonly available tools or by hand.
- Utilization of commonly used fasteners for joining components, subassemblies, chassis and enclosures
- Ensuring access to points of connection is adequate
- Avoidance of non-separable connections (e.g. glued or welded) between different materials
- Easy removal by hand, or commonly available tools, of wiring and cables

The majority of products registered within the EPEAT database (1832) would exhibit the above design features.

4.2.4.1.2 Post-consumer plastic content

Whilst there are some technical and functionality challenges facing the inclusion of post-consumer recycled plastic in many types of electronics, some already show this in their design features. Of the 1832 imaging equipment models registered in the EPEAT database (US registrations) 12% contain a minimum of 5% to 10% postconsumer recycled plastic, with a further 1.4% of the products containing at least 25% postconsumer recycled plastic.

4.3 Review of Best Available Technologies (BAT) and best procurement practices

There is a considerable range of environmental performances found within imaging equipment. Much of this variance is due to differing levels of functionality provided by products. Nevertheless, environmental performance can also vary significantly amongst imaging equipment that provides similar levels of performance.

Environmental performances can also vary across different environmental impact areas. This means that where a product could be described as BAT on one environmental aspects (e.g. energy use) it does not necessarily mean that the same product would perform at the BAT level across other environmental aspects (e.g. recyclability).

This section of the report investigates some of the best available technologies in terms of environmental performance found in imaging equipment on the EU market. In addition, the section investigates some of the best practices used in procurement to ensure the minimisation of environmental impacts from imaging equipment.

4.3.1 BAT in Energy use

The EU ENERGY STAR database was used to help identify BAT energy/power values for some of the most common types of imaging equipment as it includes a large amount of data on imaging equipment models for sale on the EU market.

The amount of energy used by imaging equipment is strongly correlated to the level of performance provided. To assess what can be considered as BAT in imaging equipment it is necessary to separate products based on marking type (i.e. the technology that is used to place an image on a piece of paper) and whether they provide a single or multiple function (i.e. printer or multi-functional device). This separation aids in removing the influence that functionality has on the energy use of products.

Figure 17 to Figure 21 illustrate, by way of the blue line, the lowest (i.e. BAT) amount of energy or power used by common types of imaging equipment in the EU ENERGY STAR database. The red line on each of the charts illustrates the highest amount of energy or power used by a comparable product in the EU ENERGY STAR database.

Figure 17 shows energy used per unit of imaging (i.e. printed sheet) for laser MFDs in the EU ENERGY STAR database. The chart shows that there is a correlation between energy used per printed sheet of paper and product speed (i.e. the images per minute, ipm), which becomes stronger as product speeds extend beyond 80 ipm. The correlation between imaging speed and energy used per printed sheet of paper is significantly weaker for products offering between 10 ipm and 60 ipm. This suggests that where higher speed imaging equipment is required there is little additional energy impact per printed sheet of paper unless product speed is above around 80 ipm.

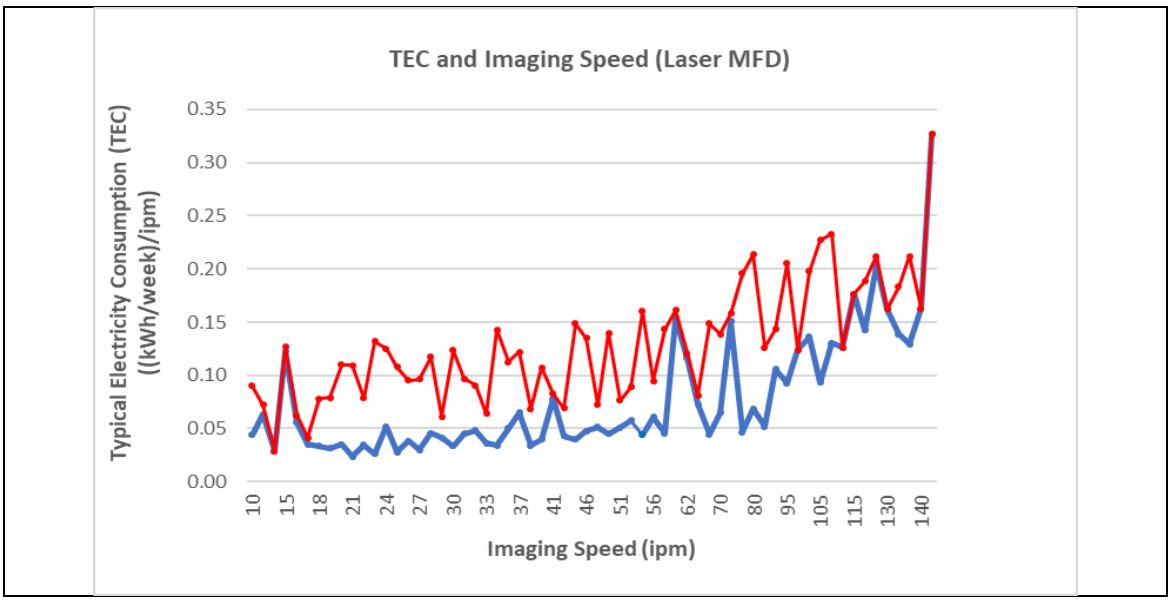

Figure 17. BAT TEC per image against imaging speed for Laser MFDs

Figure 18 shows the energy used per week by Laser MFDs according to the ENERGY STAR v2.0 test procedure (that is assuming a certain (constant) number of images printed per week). Again, there is a correlation between energy use and product speed which grows in strength as product speed increases. The correlation between energy use and product speed is stronger in Figure 17 compared to Figure 18 to the consideration of total product energy use (for a given number of images printed) rather than energy used per printed sheet of paper.

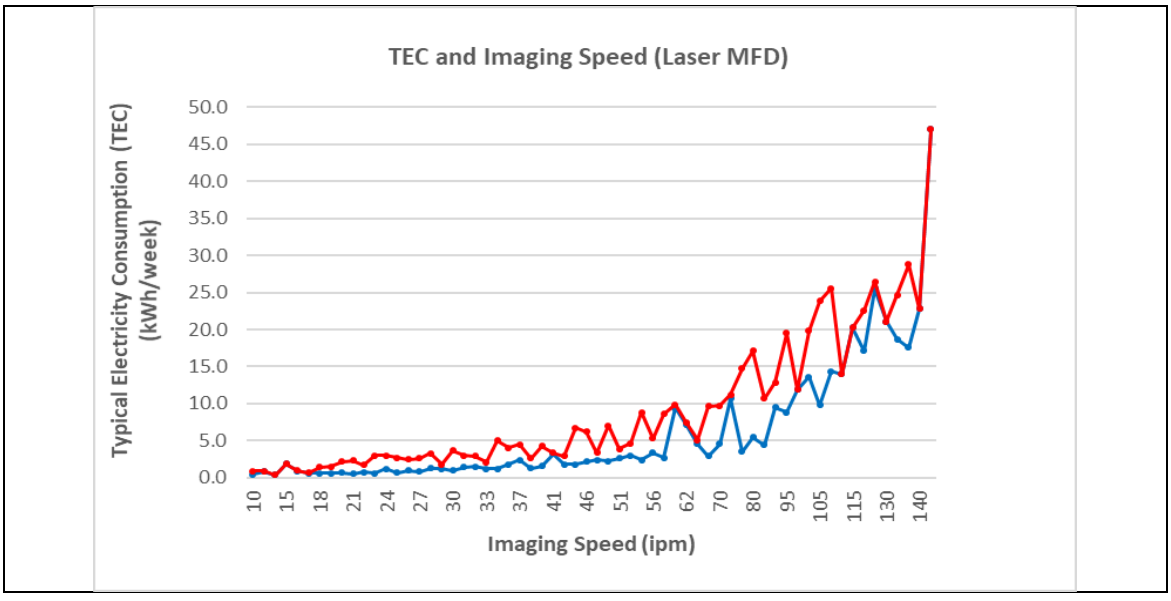

Figure 18. BAT TEC against imaging speed for Laser MFDs

Figure 19 summarises the extent of the differences between the BAT TEC (Typical Electricity Consumption) values and the maximum TEC value for that speed of product seen in the EU ENERGY STAR database. The chart shows that some BAT Laser MFDs use considerably less energy than the highest energy using product within the EU ENERGY STAR database (i.e. for products with the same speed).

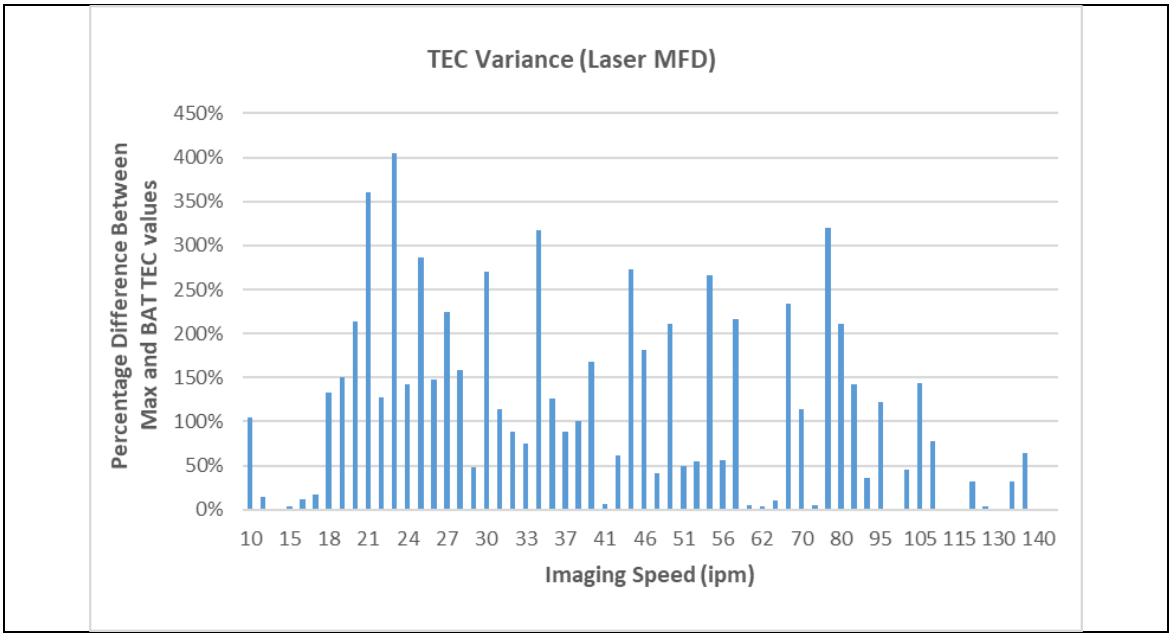

Figure 19. TEC Variance of Laser MFDs

Figure 20 and Figure 21 show the TEC per image and total TEC for laser printers in the EU ENERGY STAR database. Again, the amount of energy used by the products is correlated to product speed, with this correlation increasing in strength as product speed increases.

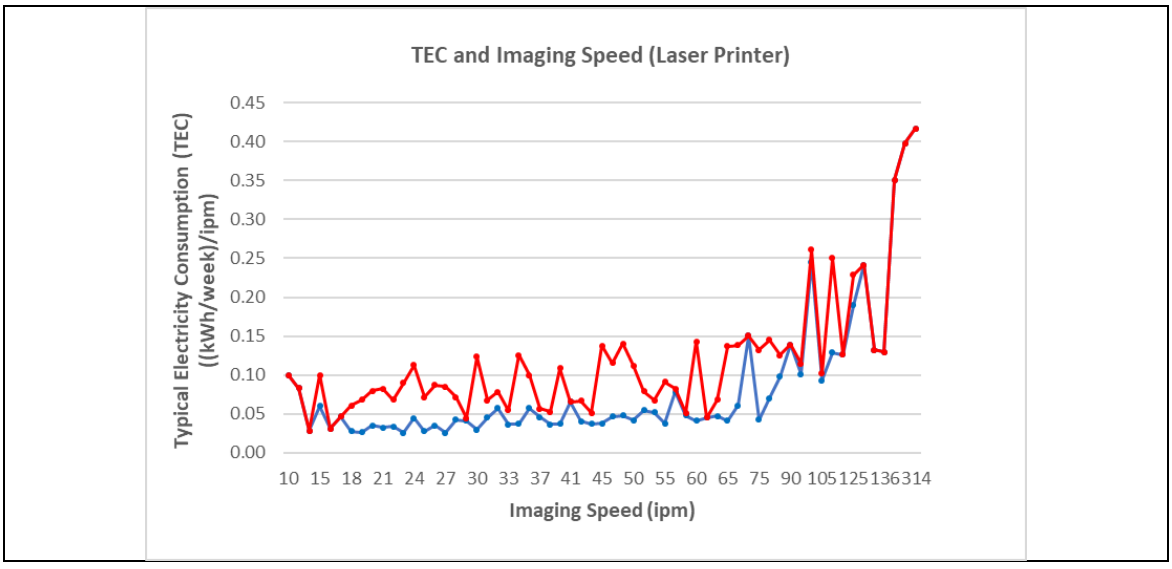

Figure 20. BAT TEC per image against imaging speed for Laser Printers

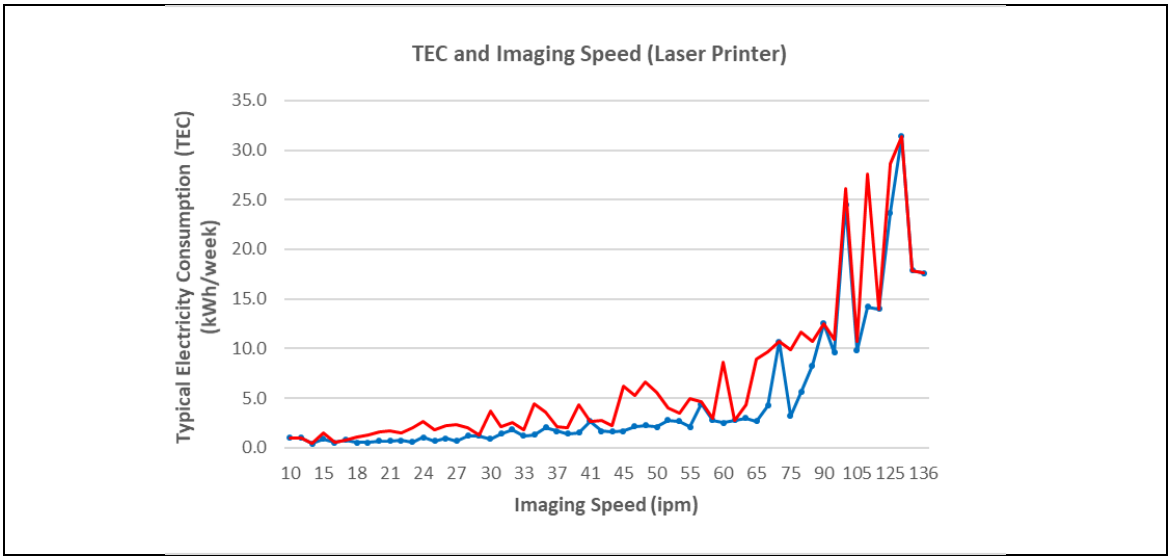

Figure 21. BAT TEC against imaging speed for Laser Printers

Figure 22 and Figure 23 show that the difference in the energy used between the BAT laser printers at each speed can be significantly lower than the maximum energy using product for that speed category.

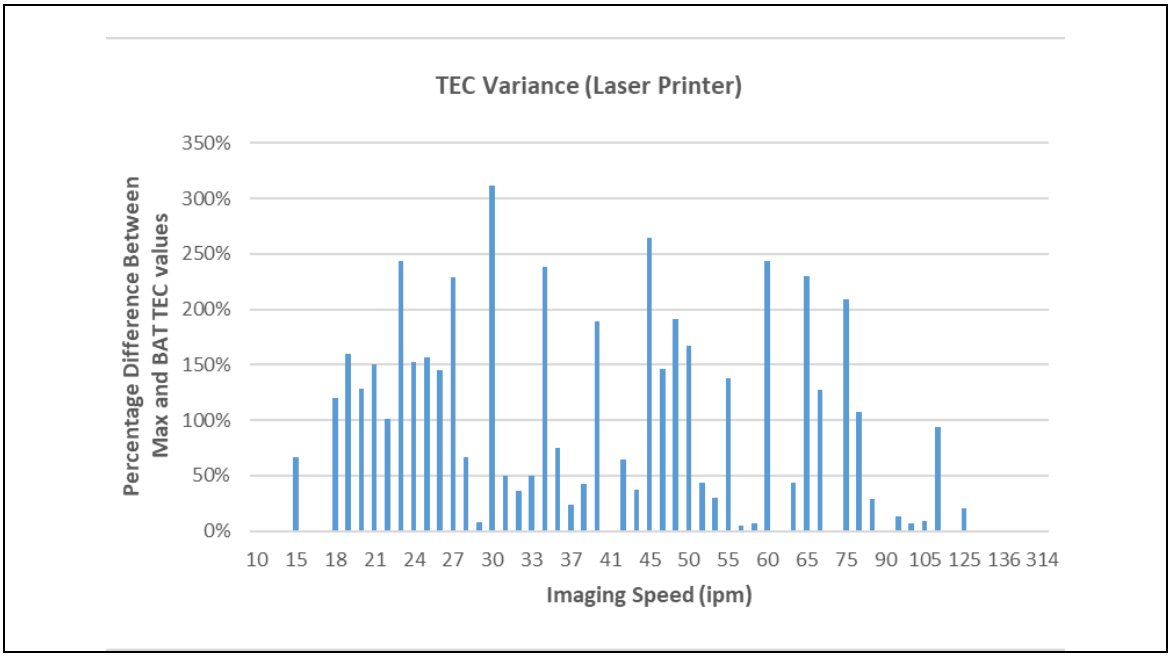

Figure 22. TEC Variance of Laser Printers

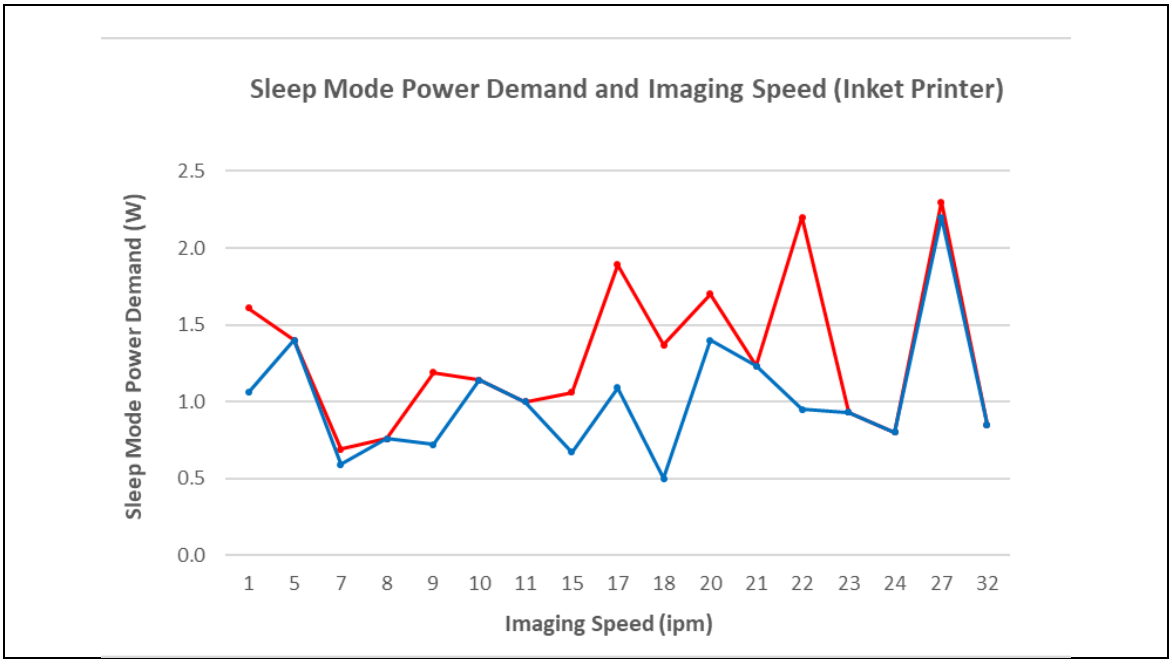

Figure 23. BAT Sleep Mode Power Demand against imaging speed for Inkjet Printers

Figure 24 shows the BAT sleep mode power demand values for inkjet printers found in the EU ENERGY STAR database. There is little correlation between imaging speed and sleep mode power demand. This is because a single network is active in each product under test and so there are few functionality differences. This shows that for many products there is no difference in sleep mode power demand between the BAT and maximum energy using product. This is because there are relatively few inkjet printers registered under the ENERGY STAR scheme as a result of declining popularity in favour of inkjet MFDs. Where there are multiple products of the same speed registered the divergence is low. This is because the ENERGY STAR scheme places limits on sleep mode power demands effectively capping allowed power demand at a relatively low level.

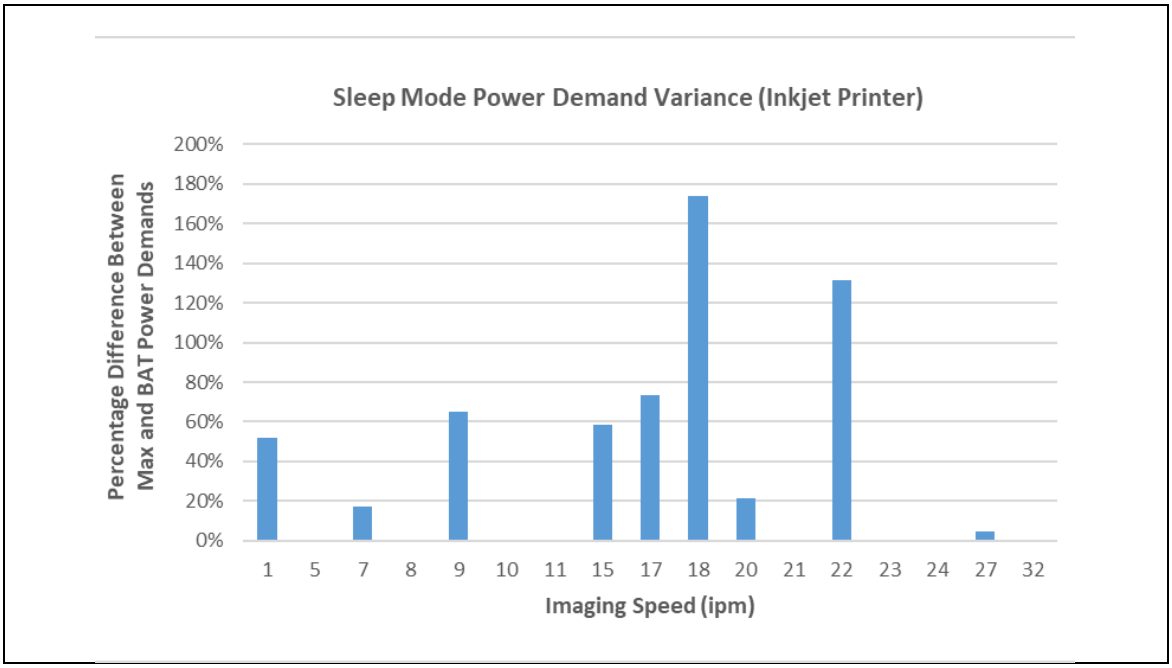

Figure 24. Sleep Mode Power Demand Variance of Inkjet Printers

Figure 25 shows the BAT sleep mode power demand values for EU ENERGY STAR registered inkjet MFDs. Again, there is little correlation between imaging speed and sleep mode power demand due to the fact that products are tested in a low power mode with just one network connection activated.

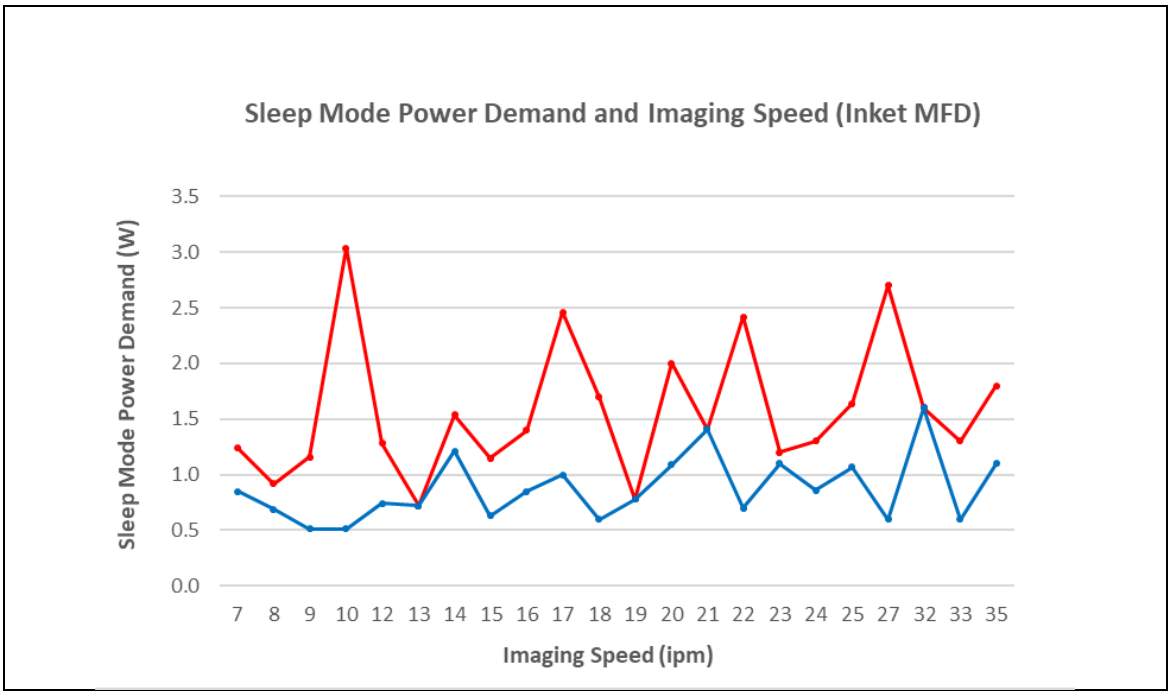

Figure 25. BAT Sleep Mode Power Demand against imaging speed for Inkjet MFDs

Figure 26 illustrates that the extent of divergence between BAT and maximum identified sleep mode power demand is highly variable.

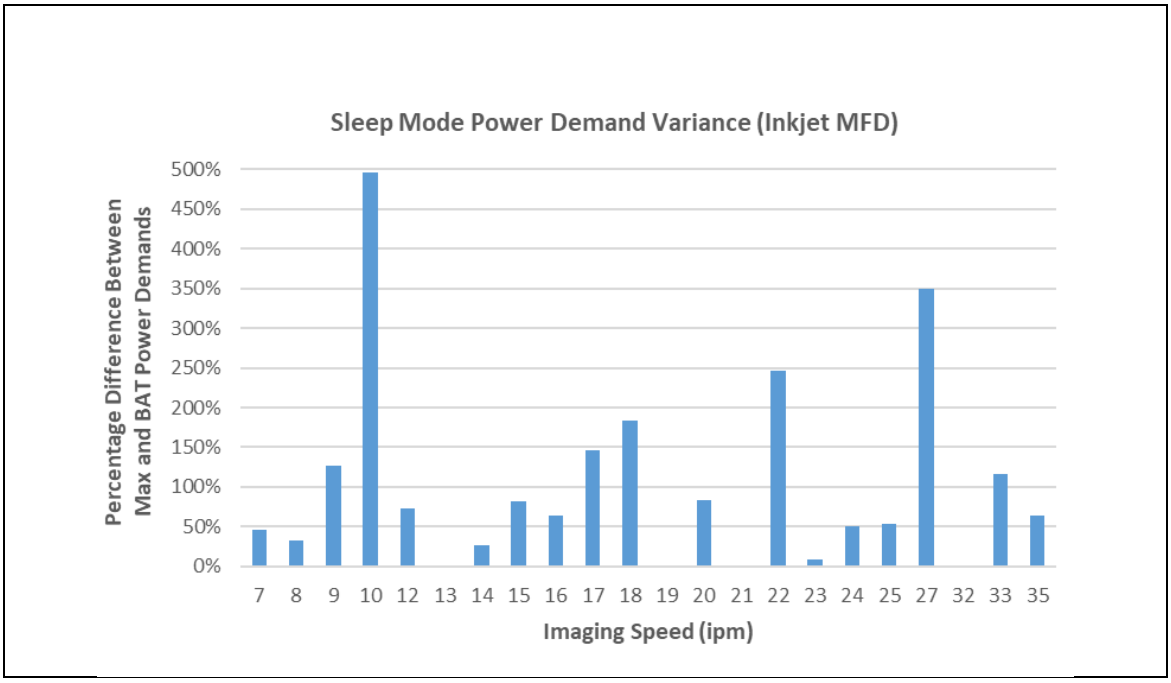

Figure 26. Sleep Mode Power Demand Variance of Inkjet MFDs

Figure 27 and Figure 28 show the BAT and maximum observed standby power demand levels for inkjet printer and inkjet MFDs respectively.

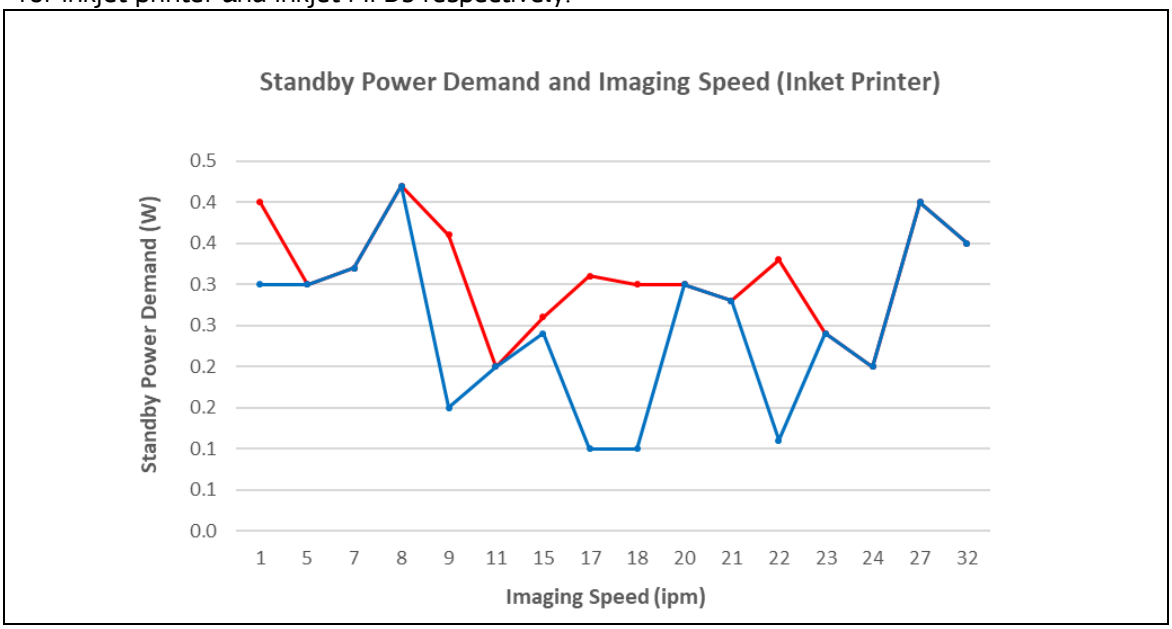

Figure 27. BAT Standby Power Demand against imaging speed for Inkjet Printers

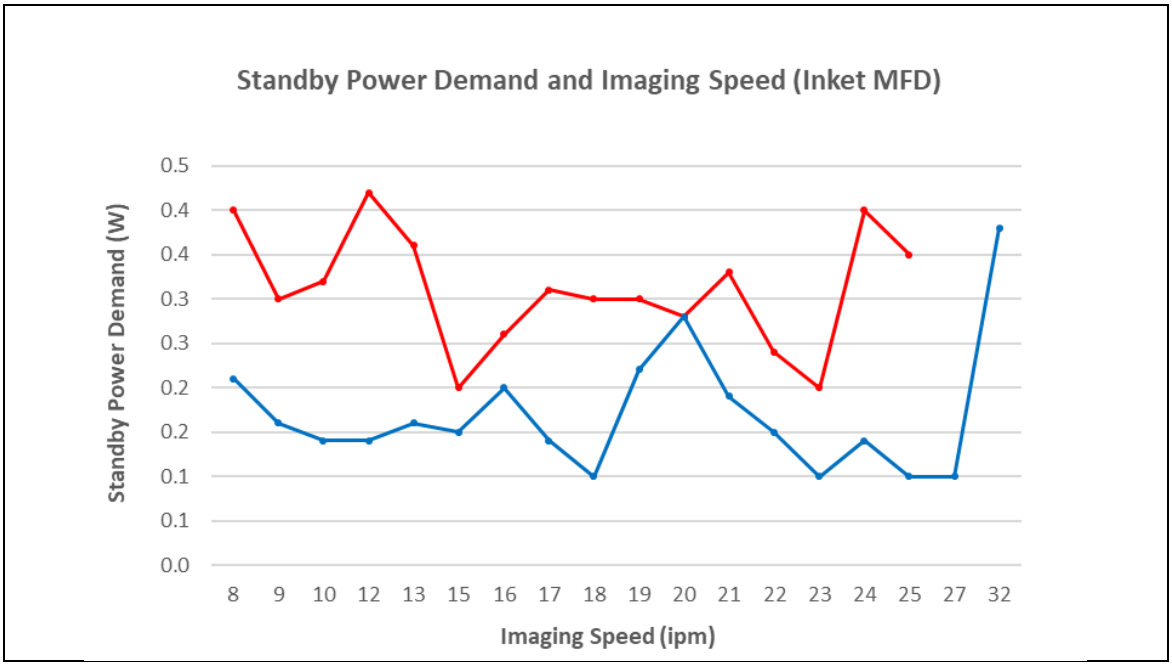

Figure 28. BAT Standby Power Demand against imaging speed for Inkjet MFDs

Figure 29 and Figure 30 show the variance between the BAT and maximum observed standby power demand figures in percentage terms. As can be seen from the charts, the absolute variance between BAT and maximum observed standby power demands is small. This is due to the fact that both ENERGY STAR and the Ecodesign Regulation on standby power demand include relatively stringent requirements on standby power demand.

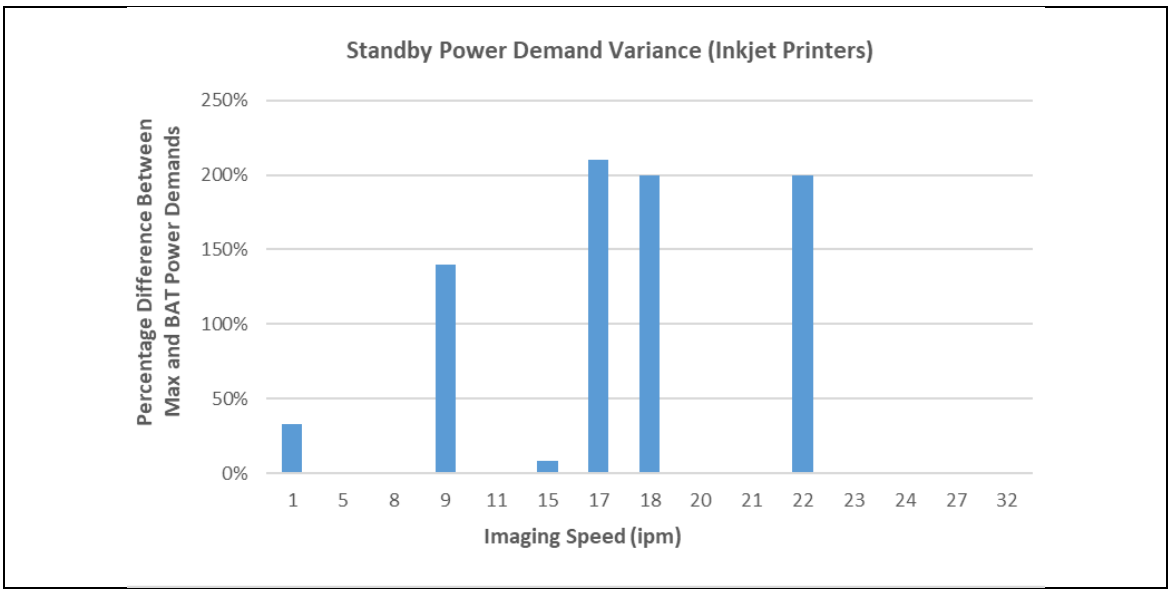

Figure 29. Standby Power Demand Variance of Inkjet MFDs

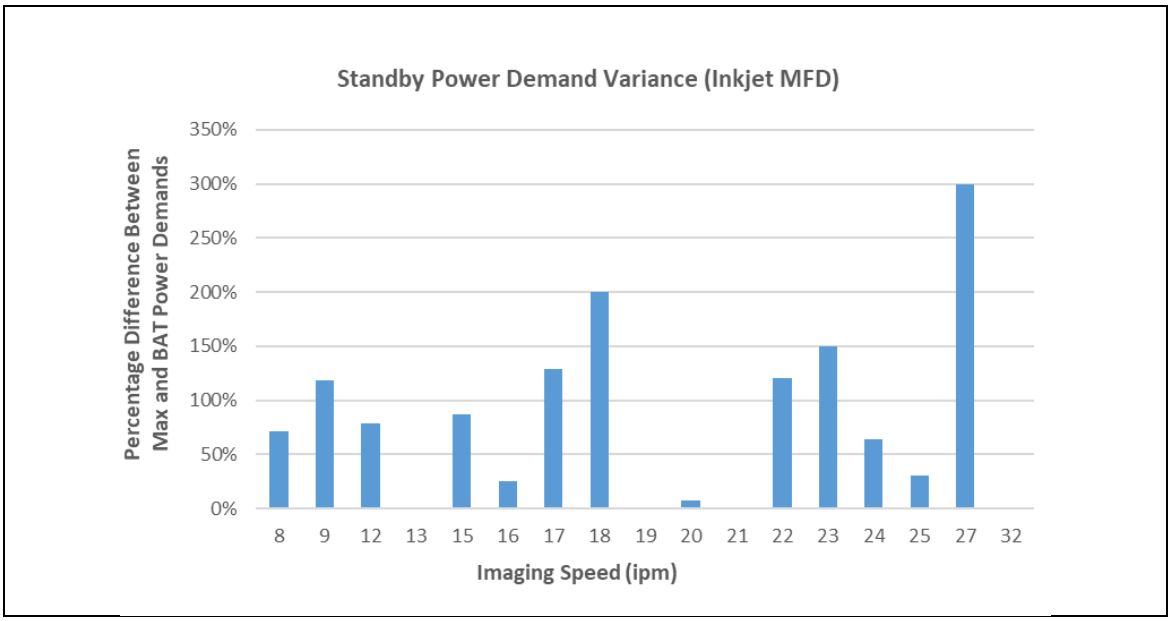

Figure 30. Standby Power Demand Variance of Inkjet MFDs

The results above show that imaging equipment which can be described as BAT for energy efficiency can offer substantial energy savings in comparison to even other ENERGY STAR registered products. The variance between the BAT levels and maximum observed energy use amongst ENERGY STAR registered products is largest amongst the laser based products and relatively minor in the inkjet based products. This suggests that any initiative seeking to optimise for energy efficiency could concentrate activities on the laser based products rather than inkjet based products.

4.3.2 BAT in non-Energy use aspects

The environmental impacts associated with imaging equipment are not limited to energy used during operation but extend into many other environmental aspects. This section of the report investigates potential BAT levels in some of the other environmental aspects.

4.3.2.1 Paper use

Most imaging equipment included within the scope of this project outputs images onto paper. The embedded energy associated with the paper use within imaging equipment can be so large as to overweigh the impacts associated with the energy used by the product itself. As such, the efficient use of paper in imaging equipment is an important consideration in defining a BAT product.
Imaging equipment can include a number of technical features which are designed to help reduce energy use:

- Automatic duplexing – enables the production of images on both sides of an output sheet without the need for users to manually turn and refeed paper into the imaging equipment product. Automatic duplexing is more common on faster laser based products which are designed to output higher volumes of images. Most environmental initiatives which cover imaging equipment include requirements on the presence of automatic duplexing in products.
- N-Up printing - allows the production of multiple pages onto a single piece of paper. N-Up printing can save a considerable amount of paper but its use is generally reserved for draft copies of files or notes due to the reduction in size of each page on the sheet of paper.
- Recycled paper – many imaging equipment products on the market are certified by manufacturers to be able to accept recycled paper, providing that it meets certain quality standards (e.g. in EN 12281). Recycled paper can have substantially lower environmental impacts than virgin paper and so the confirmed ability to be able to use this paper can be described as BAT.
- Low weight paper – the paper used in imaging equipment is often graded according to its weight in grams per square meter (g/m2). This g/m2 value therefore dictates the amount of paper fibre that is used per sheet of paper. Many imaging equipment models on the market are certified by manufacturers to be able to accept paper with a rating of 64 g/m2. The ability to be able to function with 64 g/m2 can be described as BAT.
- Pull printing – a printing feature where print jobs are stored on a server or user's computer until a user physically attends the imaging equipment product to start the print job. This technology can help to reduce unintended and impulse printing and so reduce impacts associated with both paper and printing energy.
- Print Awareness Tools – some manufacturers provide software tools that provide information about users printing habits and provide ways in which the impacts can be reduced. Such tools can also inform users about organisational policies on printing.

4.3.2.2 Content of hazardous substances

Imaging equipment and their consumables (i.e. print cartridges, print containers, fuser units, drum kits, transfer kits etc) can contain hazardous substances. In chapter 4.1 it is identified that many environmental initiatives include restrictions on hazardous substances found in imaging equipment and consumables.
BAT in terms of hazardous substances content is difficult to identify due to the multiple materials that may be found in imaging equipment and consumables as well as manufacturer confidential information. Some indications of what can be considered BAT in

terms of hazardous content can be inferred from compliance to applicable criteria in environmental initiatives such as Blue Angel, Nordic Swan, EPEAT and the Korean Ecolabel (see Table 35).

These include:

- Low levels or no halogenated polymers and halogenated organic compounds as flame retardants.
- No PBBs (polybrominated biphenyls), PBDEs (polybrominated diphenyl ethers) or chlorinated paraffins in printed circuit boards.
- No additional intentionally added hazardous materials in plastics which meet the hazard classes detailed in Table 36
- No intentionally added substances shown in

- Table 37 within colourants (i.e. such as those used in toners, inks, solid inks etc.).
- No heavy metals (i.e. mercury, cadmium, lead, nickel or chromium-VI-compounds) added to toners and inks
- No azo dyes added to toner and inks that can release carcinogenic aromatic amines
- No selenium, lead, mercury or cadmium (or any of their compounds as constituent substances) added to photoconductor drums
- Restrictive use of biocides in inks
- No mercury content in light sources

Table 36. Restrictions of compounds in plastics meeting defined hazard codes

Hazard class	Hazard category	CLP-regulation (EC) No. 1272/2008
Carcinogenicity	Carc. 1A, 1B	H350 May cause cancer
Carcinogenicity	Carc. 1A, 1B	H350i May cause cancer if inhaled
Germ cell mutagenicity	Muta. 1A, 1B	H340 May cause genetic damage
Reproductive toxicity	Repr. 1A, 1B	H360 May damage fertility or the unborn child

Table 37. Restrictions of compounds in colourants meeting defined hazard codes

Hazard class	Hazard category	CLP-regulation (EC) No. 1272/2008
Carcinogenicity	Carc. 1A, 1B	H350 May cause cancer
Carcinogenicity	Carc. 1A, 1B	H350i May cause cancer if inhaled
Carcinogenicity	Carc. 2	H351 Suspected of causing cancer
Germ cell mutagenicity	Muta. 1A, 1B	H340 May cause genetic damage
Germ cell mutagenicity	Muta. 2	H341 Suspected of causing genetic defects
Reproductive toxicity	Repr. 1A, 1B	H360 May damage fertility or the unborn child
Reproductive toxicity	Repr. 2	H361 Suspected of damaging fertility or the unborn child
Specific target organ toxicity Single exposure	STOT SE 1	H370 Causes damage to organs
Specific target organ toxicity Single exposure	STOT SE 2	H371 May cause damage to organs
Specific target organ toxicity Repeated exposure	STOT RE 1	H372 Causes damage to organs through prolonged or repeated exposure
Specific target organ toxicity Repeated exposure	STOT RE 2	H373 May cause damage to organs through prolonged or repeated exposure
Substances on the so-called candidate list according to REACH Article 59.		

4.3.2.3 Material selection

Consideration of non-hazardous material content in imaging equipment and supplies is also an important consideration in identifying BAT. Material content mostly impacts recyclability of products and so is covered in more detail in chapter 4.1. Hard plastics such as PET, HDPE or ABS are more easily recycled due to the high volume of waste streams in end of life facilities, the absence of BFRs or other substances that hinder their recycling. However, plastics used in electronic products often have flame retardants to reduce risk of fire.
There are some material criteria issues that do not necessarily directly impact the recyclability of a product so are defined separately. The most notable of these is the use of postconsumer recycled plastic in products. Whilst there are some challenges in verifying the use of postconsumer recycled plastic in imaging equipment, some products are claimed to contain at least 25% postconsumer recycled plastic.

4.3.2.4 Emissions

The process of printing can result in both chemical and noise emissions. Some of the major environmental initiatives covering imaging equipment and consumables address these issues. The Blue Angel initiative includes the most comprehensive emissions restrictions and so the best performing Blue Angel certified products can be considered as BAT[152]. Blue Angel eco-labelled printers, copiers and MFDs all make particularly low contributions to indoor air pollution at the workplace or in private households. For better indoor quality, strict requirements on air emissions are set for low content of harmful substances. In addition,

[152] https://www.blauer-engel.de/en/products/office/drucker-kopierer-und-multifunktionsgeraete-2012

strict requirements are made for fine and ultrafine particle release during laser printer operation. Currently, Blue Angel has 1468 registered products.

4.3.2.5 Product recyclability

The way in which imaging equipment is designed to facilitate easier recycling and enhance material recovery rates is another important attribute in identifying BAT. Environmental initiatives include many criteria that are designed to encourage BAT levels of product design in this area. BAT includes product features such as:

- External enclosures, chassis, and electronic subassemblies removable with commonly available tools or by hand.
- Designed to provide ease of access to materials with special handling needs
- Design for disassembly requirements
- Use of single recyclable plastic type per plastic part
- Restriction on materials not compatible with reuse and recycling
- Manual separation and marking of plastics
- Notification regarding the identification of both materials and components that have hazardous characteristics or special handling needs

4.3.2.6 Product and component longevity

Imaging equipment that can be described as exhibiting BAT should be include product design features that facilitate extending the life of the product. These design features can include attributes such as:

- Guarantees on product lifetime under normal usage conditions
- Provision of spare parts for pre-defined number of years
- Consumer replaceable parts
- Pre-defined repair options

4.3.2.7 Ability to accept remanufactured cartridges

Under many circumstances the use of remanufactured cartridges over virgin cartridges can result in resource efficiency improvements. To ensure that these resource efficiency savings can be realised it is important that imaging equipment allows the use of remanufactured cartridges and that no functionality loss occurs as a result. BAT in this area is therefore the ability for users to use remanufactured cartridges with no loss of functionality.

4.3.2.8 Cartridge design

The use of resources associated with the cartridges and containers used to hold toner and ink can be considerable over the lifetime of an imaging equipment product, especially where that imaging product is designed for intensive use. Design features of cartridges and containers used in imaging are therefore important considerations in identifying BAT levels. The most common design features used to reduce resource use of cartridges and containers include:

- Avoidance of technical features which limit the ability to remanufacture cartridges
- Use of common cartridge or container form factors across multiple imaging equipment models
- Use of containers (i.e. simple toner/ink vessels) rather than cartridges (i.e. components which include technical features needed for imaging as well as the toner/ink storage vessel)
- Increase of toner/ink amounts to increase cartridge yield (i.e. number of pages that can be printed)

4.3.2.9 Provision of recycling services

BAT technologies associated with imaging equipment extend beyond the product design into the recycling solutions that are provided by manufacturers. Whilst, manufacturers may not have control over the final destination of end-of-life imaging equipment and consumables (i.e. final destination may depend on customer choice) it is important that any recycling systems provided by imaging equipment vendors can be described as BAT.

4.3.2.9.1 Product Recycling System

To be described as BAT product recycling systems should meet performance conditions. The EPEAT scheme includes a number of requirements on product recycling systems including:

- Recycling system meets recycling standard and is certified by independent certification bodies. The standard should cover the following areas:
  - Documented management plan for dealing with materials of concern
  - Environmental, health and safety management system developed, documented and regularly reviewed
  - Restrictions on exporting hazardous waste material
  - Equipment/components identified for reuse, repair or refurbishment tested ahead of exporting
  - Restrictions on incineration and waste-to-energy for materials that contain mercury, halogenated compounds and beryllium.
  - Control, documentation and tracking the material flow of all covered equipment, components and materials that pass through recycling process
  - All materials of concern tracked to final disposition

4.3.2.9.2 Cartridge/Container take back service and recycling

Many imaging equipment manufacturers offer cartridge/container take back services for end of life cartridges and containers. There has been much concern that many of the plastic materials entering EU based cartridge recycling systems are incinerated or sent for waste to energy recovery rather than being reused in other applications. To be described as BAT cartridge take back systems should not resort to incinerating plastics.

4.4 Main outcomes from stakeholder survey in relation to criteria

4.4.1 Main outcomes from stakeholder survey in relation to EU Ecolabel criteria

Upon completing the first part of the survey, 17 participants chose to also answer questions about Ecolabel criteria (see Figure 2 for an overview of the type of organisations responding to the survey). For some questions, multiple answers were allowed, resulting in more than 17 answers to one question.

4.4.1.1 Paper management

Most respondents either agreed that the criteria on operating speed for monochrome printing and/or copying of 19 images per minute (ipm) or the criterion on duplex printing is up-to-date (7), or had no opinion on the topic (8). However, 12 out of 17 agreed or strongly agreed that the paper management criteria are important for environmental savings and have added value by differentiating products on the market, signifying that this is important. As to whether additional aspects of paper management shall be added to differentiate products on the market e.g. print on demand, printing cancelation etc., the stakeholders had split opinions. However, overall most stakeholders agreed that additional aspects should be added.

4.4.1.2 Energy efficiency

The stakeholders were asked if it was their experience that most imaging equipment products available on the market today are already compliant with the current Energy Star 2.0 and thus believe the energy criteria should be made more stringent. To this, 8 responded yes, 4 responded no, while the remaining 5 had no opinion. In other words, the overall tendency is towards believing that criteria should be more stringent. This is followed by the stakeholders' responses of their products efficiency and comments on the energy efficiency criteria:

- *OEMs use the Energy efficiency to push for early equipment replacement and this is against established hierarchy of reuse and remanufacture*
- *Lower speed products (< 30 IPM) are ~ 90% of the TECMax. Higher Speed Products (> 40 IPM) are ~ 60% of TECMax.*
- *More than 95% of the devices sold in the EU in 2016 were ES 2.0 compliant.*
- *The NEW Blue Angel criteria are around 30% more stringent than the old criteria*
- *A max off-mode power-consumption may be added.*

4.4.1.3 Indoor air emissions

Most of the stakeholders agree that it is appropriate that restrictions on indoor emissions should be different for different power modes (i.e. ready mode and printing mode). The stakeholders also agree that the emission rates for ready mode are strict enough, although their opinions are slightly more split on this question. The same is true for the question of whether the emission rates for printing mode are strict enough; 3 respondents strongly disagree with this, while most of the rest agree.
Likewise, most of the respondents agree that the test method of Blue Angel RAL UZ 171 method is still up-to-date.

4.4.1.4 Noise emissions

The majority of the respondents either have no opinion on whether the A-weighted sound power levels for monochrome printing are strict enough or whether the A-weighted sound power levels for colour printing are strict enough. Their answers indicate that there are no significant issues with the current noise emission requirements. When prompted for additional comments on this EU Ecolabel criteria, or experience with other requirements on noise emissions, the three replies were all in regard to taking into account Blue Angel criteria (RAL-UZ 205).

4.4.1.5 Design for disassembly of products and design for recycling and/or reuse of cartridges

This section covers both criterion 9 and 10 in the existing EU Ecolabel. Note that criterion 10 comes under ink and toner consumables in the Ecolabel criterion, but is included here instead since stakeholders' answers were referring to both products and cartridges.
Criterion 9 regards the design for disassembly while criterion 10 regards the design for recycling and/or reuse of toner and/or ink cartridges. The existing wording of these two criteria is very general. The stakeholders were asked whether they have experience with requirements on material efficiency or design for reuse and recycling of imaging equipment and its consumables and if they would share best practices or examples of respective requirements. Overall, there were several stakeholders who think these criteria are important, in particular for late models where disassembly is not a feature available. However, the criteria seem to be outdated and they provide some suggestions and/or best practices as examples which are summarised below:

- Criterion 10: The wording should promote reusability of cartridges in a positive way and always take into account positive criteria like "quality" and "free take back systems" OEM producers try to block remanufacturing of ink and toner cartridges by adding high level of chips to products. We are often not able to reset these chips, meaning that remanufactured products cannot fully achieve the same level of customer experiences as OEM products.
- Some examples of best practices were mentioned, such as Blue Angel, DIN, STMCm ISO/IEC 29142 and Nordic Ecolabel
- EU Ecolabel should include a measurable target to promote reused cartridges of high quality proposing the same warranty as OEM cartridges

When asked to provide examples of practices and devices that would prevent reuse of toner and/or ink cartridges, the main answers were:

- Firmware, which main objective seems to be third-party cartridge malfunctioning
- Low capacity cartridges from several brands, which cannot be extended to a high capacity remanufactured product because of physical constraints
- Intellectual property rights (patents) and aggressive legal actions against remanufacturers
- Cartridges are not designed to allow reuse
- No sharing of information on how to remanufacture
- Denial of honoring of warranties
- Closed-shop customer supply programs and collection programs for used cartridges
- Cloud functionality available only with OEM cartridges.

4.4.1.6 Ink and toner consumables

Criterion 11 regards toner and/or ink take-back requirement. The stakeholders were asked to share examples of best practices and details of the systems to further specify this requirement. They responded take-back of OEM cartridges for its re-use and for plastic materials re-use in a closed loop as best practice. They specified that take back systems can happen through the retail channels and from end-users. However, logistical costs are an issue in this matter combined with the fact that cartridges are more and more being sold through internet. It was highlighted that used cartridges should be able to be returned without any extra cost and direct from end-users. They mentioned an initiative carried out in Japan where ink-cartridge take-back system boxes are installed at 3600 post offices, facilities, and municipalities. Finally they expressed that the Nordic Ecolabel has a requirement for remanufactured toner cartridges.
Criterion 12 regards substances in ink and toners. Most of the stakeholders (10) had no opinion regarding whether the list of substances contained in inks and toners is up-to-date, suggesting that this criterion is not of great importance to the stakeholders overall. However, there were three stakeholders who strongly agree and two who disagree that the list is up-to-date.

4.4.1.7 Other criteria

Packaging (Criterion 13) is of low relevance in the life cycle of the imaging equipment product. 9 of the stakeholders agreed that in order to focus on the main environmental aspects this requirement should be removed, while 4 disagreed and the remaining 4 had no opinion. The overall tendency among the stakeholders is that criterion 13 should be removed in order to focus on the other criteria.
The stakeholders have split opinions on whether the requirement of guarantee for repair or replacement (Criterion 14) of minimum 5 years is strict enough: 8 agreed, while 5 disagreed.
Likewise, there was no unanimous opinion amongst the stakeholder regarding criterion 15 on whether the user information would contribute to reducing environmental impacts and resource use. 8 stakeholders agreed with the statement, while 5 disagreed and the rest had no opinion. They were asked which user information was considered the most important to support efficient and environmentally friendly use of imaging equipment. They specified that information on standardization of supplies, on re-utilization of parts and components and repair instructions, information on the bad impact of clones, on the possibility to use of third party/non-OEM cartridges, and finally, information on paper use should be included in the criteria.
Upon completing the first part of the survey, 13 out of 24 participants chose to also answer questions about GPP criteria. For some questions, multiple answers were allowed, resulting in more than 13 answers to one question.

4.4.1.8 Technical specifications of core and comprehensive criteria

4.4.1.8.1 Double side printing

The stakeholders agree that the operating speed for monochrome printing and/or copying of 25 images per minute or more in the criterion on double side printing is appropriate for **core** criteria, while they have split opinions on whether it is appropriate for **comprehensive** criteria, two more stakeholders disagreeing than agreeing with this.

4.4.1.8.2 Multiple images on single sheet of paper

In answer to the question “Which of the technical specifications criteria (core and comprehensive) are important in your opinion considering multiple aspects: environment,

consumers' preferences, and marketing opportunities", 13 stakeholders replied with multiple choices allowed. Just over half (7 out of 13) stakeholders chose "Multiple images on single sheet of paper", indicating that this is an important criterion, if, not the most important one.

4.4.1.8.3 Energy efficiency for use mode

Criterion 3 regards energy efficiency for use mode. The stakeholders have split opinions on whether most imaging equipment products available on the market today are already compliant with the current Energy Star 2.0 and that the criteria should be made more stringent. When asked to elaborate on this and provide information on their products' efficiency, they mentioned that the new Blue Angel criteria (valid from 2017-2020) are around 30% more stringent than the old criteria, and around 70% of Blue Angel certified products in 2015 meet these criteria. It was also noted that Energy Star V3.0 is under development and this will most probably bring stricter requirements.

4.4.1.8.4 User instructions for green performance management

The opinions of the stakeholders are also split regarding whether the criterion on user instructions for green performance management is practicable and useful: 5 respondents agreed, while 5 disagreed or strongly disagreed.

4.4.1.8.5 Product longevity and warranty

The stakeholders largely agree that the requirement of product longevity and warranty for a minimum of 5 years is strict enough for **core** criteria, while also agreeing, although not as pronounced, on this in regard to **comprehensive** criteria.
The stakeholders disagreed that use of the set of GPP criteria is likely to result in the purchase of products with higher purchase costs, while some have no opinion on the topic. Furthermore, the stakeholders overall (strongly) agree that using GPP criteria will instead result in the purchase of products with overall lower environmental impacts.

4.4.1.8.6 Resource efficiency for cartridges: Design for reuse of toner and/or ink cartridges

Criterion 6 regards resource efficiency for cartridges. The stakeholders were asked to share their best practices and examples of respective requirements. They suggested that c*artridge reuse should be mandatory. They mentioned that the resource efficiency for cartridges is undermined by cloned and counterfeit cartridges. Easy product disassembly, limited use of different plastics, use of standardized parts, or framework agreement for print and copy services including a implementation plan for the reduction of printing hardware and environmental management were also mentioned as best practices. A stakeholder suggested to include a comprehensive criteria which requires that the producer refurbish the equipment parts and components.*
Finally, some stakeholders highlighted the *obstacle to cartridge reuse and recycling and they refer to the* use of *chips* by *several producers of original cartridges* to prevent reuse of toner and/or ink cartridges.

4.4.1.9 Award criteria

4.4.1.9.1 Higher energy efficiency in use mode

Regarding the questions of whether the higher energy efficiency (than ENERGY STAR) in use mode criterion is easy to meet or verify, 10 out of 13 stakeholders had no opinion.

4.4.1.9.2 Double side printing (only comprehensive)

As to whether the comprehensive criterion on double side printing for slower (below 25 ipm) products is still ambitious, 7 out of 13 stakeholders had no opinion, while 4 stakeholders agreed that the criterion was still ambitious.

4.4.1.10 Answers on general GPP aspects

As to the questions of whether the core as well as comprehensive set of award criteria are likely to result in the purchase of products with overall lower environmental impacts, the stakeholders mainly either agreed or had no opinion.
The stakeholders were asked which of the technical specification criteria (core and comprehensive) are most important considering both environment, consumers' preferences and marketing opportunities. The most popular choice amongst the stakeholders was double sided printing (22%). This was followed by energy efficiency of the use mode (17%) and resource efficiency for cartridges (17%). The stakeholders also chose multiple images on single sheet of paper (15%), user instructions for green performance management (15%) and product longevity and warranty (13%).
6 out of 10 stakeholders answered "yes" to whether there are any other requirements or areas for further research which should be taken into consideration in the revision of these EU GPP criteria. When asked which, the stakeholders replied:

- Recycled material contents
- NBCs (new-build compatible cartridges) should be mentioned in a current or new criterion
- Cartridges take-back systems
- In-depth investigation on the overall cost for the procurer of awarded products compared to others: rate of equipment replacement, rate of consumable use, energy consumption, as well as the total cost for the community along the life cycle: waste treatment cost, sanitary costs, employment impacts

Furthermore, 6 out of 13 answered "yes" to having experience with use of Life Cycle Costing for Imaging equipment. As to whether the stakeholders considered that there are other environmental requirements which will allow better differentiation among products, the replies were:

- *Use of post-consumer recycled plastics (around 5% requirement might be feasible)*
- *Use of biomass plastics*
- *Information about indicative product carbon footprints*

In summary, the stakeholders' overall opinion on the existing GPP criteria is that they are strict enough, and that using GPP criteria will result in the purchase of products with overall lower environmental impacts. However, the stakeholders also call for renewal within the criteria and want to include more wide-ranging criteria. They refer to the Blue Angel criteria as guidelines several times, in respect to core criteria as well as comprehensive and award criteria. The stakeholders provide a list of suggestions of how to optimize the resource efficiency for cartridges, indicating a significant opportunity for improvement in respect to this criterion

4.5 Identification of improvement options

Considering the hotspots identified in the LCA review, additional aspects covered by environmental schemes and initiatives, design features included in BAT and the results of the stakeholder survey, improvement options for imaging equipment products and services as well as consumables have been identified.

4.5.1 Priority improvement options for products

The use of electricity for printers and MFDs is still one of the main environmental hotspots according the LCA review, although not a hotspot when performing the Life Cycle Costs showing consumables as a major hotspot. The presence of this KPI in all the environmental schemes and initiatives presented in chapter 4.2 reiterates their importance. Therefore, it is proposed to keep the focus of the current GPP criteria on promoting energy efficiency both in active state and in the low power modes. This is of more importance for laser printing technologies, where even ENERGY STAR products present larger variation in energy consumption between BAT and the worst-performing products.

The manufacturing of imaging equipment products is becoming a more important source of environmental impacts whilst the equipment becomes more energy efficient. The LCA studies reviewed in chapter 4.1 do not assess in detail the sources of impacts during manufacturing of printers, MFDs and scanners. Since these products are complex they contain a wide diversity of materials, some listed in Table 30. Steel, copper and aluminium have high embodied environmental impacts (i.e. from resource extraction to production) and it is likely they are important source of impacts of the LCA studies reviewed. If recycled, these impacts can be greatly reduced. Steel is nowadays highly recyclable and it is seldom found without recycled content in the pool of available materials. Aluminium is moving towards that direction. However, the recycling of plastics is nowadays still limited and imaging equipment products contain high amounts of this material. The limitation of recycling plastics comes from poor sorting at the waste streams and the lack of demand of recycled plastics. One improvement option could be to incentivise their use through public procurement. Modular designs of imaging equipment products would facilitate their repair and thus prolong their useful lifetimes but would also facilitate the recovery of plastics and metals at the products end of lives.

Emissions from hazardous substances pose risks to humans and ecosystems mainly during the use phase, and thus it is suggested to focus restrictions on their emissions mainly during the operation of the imaging equipment products. Hazardous substances emitted are mainly VOCs, ozone, benzene, particulate matter and SVOCs (see section 4.3.2.4).

None of the LCA studies reviewed discusses the importance of end of life practices, and in some cases they just assume the average in the country/region of assessment. However, the cartridges LCA studies emphasize the importance of refilling to reduce life cycle environmental impacts but also to reduce the amount of waste generated. Aspects concerning reuse and prolongation of the imaging equipment's lifetime could be solved to certain extent by the use of leasing agreements rather than purchasing of products, in particular in small office environments. However, there is no quantitative evidence that shows one is better than the other at the whole life cycle perspective.

4.5.2 Priority improvement options for consumables

The use of consumables and in particular of paper and cartridges is a hotspot for printers and MFDs. Paper use is also a KPI in 8 out of the 9 environmental schemes and initiatives presented in chapter 4.1. However, given that printing hard copy is in decrease in some office activities due to digitalisation, it can be assumed that in the future the importance of direct paper use will decrease but it will still be relevant for public organisations where printing may

happen more than in the private sector. At the same time, the volume of paper use is affected by the printing quality, and thus the cartridges become as crucial as the printers to assure less paper is wasted by undesired printing quality. BAT on the market point out at some features in the product design that can contribute to reduce the use of paper. These are automatic duplexing, N-up printing, certified use of recycled and low weighted paper, pull printing, offering of printing awareness tools.
Use of consumables, in particular cartridges, is in 7 out of the 9 environmental schemes and initiatives presented in chapter 4.1 and it is thus a widely known KPI. Durability aspects are crucial to reduce their environmental impact as explained in chapter 4.1, particularly the possibility to refill them. On the other hand, their capacity is also important to ensure public offices get their needs covered without having to refill the cartridge many times. To avoid that multiple refills detriment the printing quality, the cartridges are remanufactured. It is very important remanufactured cartridges are of good quality. Moreover, the cartridges design could be more homogeneous to prevent locking the printers to OEM cartridges limiting their remanufacturing. This could include the use of materials or designs as presented in chapter 4.3.2.8.

4.5.3 Priority improvement options for services

Although there are no data giving an indication of the range of environmental benefits and costs savings from procuring printing services, opportunities exist to better control some of the major hotspots identified from the products and consumables: energy consumption, manufacturing of imaging equipment products, use of paper and use of cartridges. Some examples of priority improvement options for using printing services compared to owning equipment are:

- A 'walk in and takeover' (WiTo) approach rather than the older 'rip and replace' approach, which extend the lifetimes of imaging equipment and encourage manufacturers to offer 'brand agnostic' MPS programs which are partnered with cartridge remanufacturers. This change in the market is likely to increase the need for cartridges that can be remanufactured because they need access to cartridges to fit in older machines that are not theirs.
- Managed Print Services managing and/or optimizing document output (i.e. price per printed document or per a certain amount of printed documents), which includes hardware provision and software applications. This gives also the possibility to report statistics of usage of consumables since their supply is often included in the service.
- Newer MPS solutions move beyond simply managing the printers in an office to also managing the print room, business processes and the overall IT infrastructure. This more integrated approach to MPS provides an infrastructure where users can securely input, obtain or output information when and wherever needed.
- Integrating policies at organisational level such as printing optimisation policy, automatic shutdown of equipment, provision of printing statistics information to employees.

4.5.4 Summary

Summarizing, the recommended areas to focus on in order to reduce environmental impacts of imaging equipment products and services, as well as ink and toner consumables along their life cycle are:

- Limiting the use of energy, both in active state and in low power modes
- Promote the use of recycled materials in imaging equipment products
- Promote modular designs which facilitate repair and recycling
- Restrict the indoor use emissions, in particular of hazardous substances such as VOCs

- Measuring and reporting the impacts of manufacturing of imaging equipment products
- Limiting the use of paper and promote the use of recycled paper and printing features in the printer such as automatic duplexing, N-up printing, certified use of recycled and low weighted paper, pull printing, and printing awareness tools
- Encouraging the use of refilled cartridges, and of remanufactured cartridges rather than limiting to the use of OEM cartridges
- Promote the contracting of leasing agreements or other printing service schemes to increase product durability and reduce amount of waste
- Encouraging take back systems for cartridges and for products
- Encouraging design of cartridges for reuse and remanufacturing
- Encouraging more recycling and reuse at the end of life

4.6 Conclusions derived from the technical analysis

4.6.1 Imaging equipment products

The review of LCA studies has identified the following hotspots for imaging equipment products:

- Use of electricity for printers and MFDs, particularly for those with less efficient printing technologies.
- Use of electricity for scanners, which can be reduced if consumer utilises low power modes for longer periods.
- Use of consumables, particularly paper and cartridges (for printers and MFDs).
- Manufacturing of printers, MFDs and scanners, particularly for the more efficient printing technologies (i.e. laser technologies).

Other KPIs used by other environmental schemes and initiatives are:

- Energy use
- Availability of low power modes and power management functions
- Use of cartridges
- Manufacturing impacts
- Recyclability
- Recycled content
- Product weight
- Product lifetime extension
- Content of hazardous substances

Furthermore, the BAT review indicates that the best products on the market concerning energy and material efficiency aspects are:

- Energy efficient both for active state and low power modes
- Designed for recycling
- Accepting of remanufactured cartridges
- Limiting the content of hazardous substances

4.6.2 Imaging equipment consumables

The review of LCA studies has identified the following hotspots for imaging equipment consumables:

- Manufacturing of cartridges, in particular of the housing and print head, which can be greatly reduced if cartridges can be refilled; the more refills the less contribution from manufacturing.
- The amount of paper the cartridge uses to deliver the printouts at the desired quality; the higher the quality the more the reductions of environmental impacts by using less paper.
- The consumer transport for refilled cartridges; the more refills the higher the contribution of transport for the total environmental impacts. However, this is subject to great variability depending on the allocated fuel used per trip per refilling.

Other KPIs used by other environmental schemes and initiatives are:

- Paper use
- Manufacturing impacts
- Possibility to refill cartridges
- Indoor emissions
- Furthermore, the BAT review indicates that the products on the market incentivizing the reduction of energy and materials for their consumables are: Promoting more common cartridges designs which promote the use of remanufactured cartridges

- Accepting refilled cartridges
- Reducing use of paper
- Limiting the indoor emissions from the use phase
- Limiting the content of hazardous substances

4.6.3 Imaging equipment services

At organization level, contracting of leasing agreements could enhance product durability and reduce the amount of waste by encouraging take-back systems and managed printing services.
Take-back systems reduce the amount of waste and promote reuse and recycling of imaging equipment products and of cartridges. Managed printing services can encourage the use of remanufactured cartridges by encouraging manufacturers to offer brand agnostic services, can reduce the amount of paper used by optimizing document output, can integrate other office service areas to optimize the use of equipment and can improve employers education in terms of the products and consumables environmental impacts.

4.6.4 Summary

Considering information collected for imaging equipment, related services and its consumables identified improvement options are shown in Table 38.

Table 38. Identified improvement options based on environmental analysis

Imaging equipment category	Key environmental aspects
Imaging equipment products	1. Limiting the use of energy, both in active state and in low power modes 2. Promote the use of recycled materials in imaging equipment products 3. Promote modular designs which facilitate repair and recycling 4. Restrict the indoor use emissions, in particular of hazardous substances such as VOCs 5. Accepting of remanufactured cartridges 6. Limiting the content of hazardous substances 7. Measuring and reporting the impacts of manufacturing of imaging equipment products 8. Limiting the use of paper and promote the use of recycled paper and printing features in the printer such as automatic duplexing, N-up printing, certified use of recycled and low weighted paper, pull printing, and printing awareness tools
Imaging equipment consumables	1. Encouraging the use of refilled cartridges, and of remanufactured cartridges 2. Promoting more common cartridges designs which promote the use of remanufactured cartridges 3. Accepting refilled cartridges 4. Reducing use of paper 5. Limiting the indoor emissions from the use phase 6. Limiting the content of hazardous substances

Imaging equipment category	Key environmental aspects
Imaging equipment services	1. Promote the contracting of leasing agreements to increase product durability and reduce amount of waste 2. Encouraging take back systems for cartridges and for products 3. Encouraging more recycling and reuse at the end of life

5 APPENDIX 1. ADDITIONAL ENERGY STAR V2.0 DEFINITIONS

The ENERGY STAR v2.0 specification for imaging equipment also includes detailed complementary definitions for the marking technologies (i.e. the type of technology used to place an image on the output media), the media format sizes (i.e. the size of the paper or other media that can be used with the imaging equipment product), power modes and additional functionalities found in imaging equipment:

Marking technologies:

- Direct Thermal (DT): A marking technology characterized by the burning of dots onto coated print media that is passed over a heated print head. DT products do not use ribbons.
- Dye Sublimation (DS): A marking technology characterized by the deposition (sublimation) of dye onto print media as energy is supplied to heating elements.
- Electro-photographic (EP): A marking technology characterized by the illumination of a photoconductor in a pattern representing the desired output image via a light source, development of the image with particles of toner using the latent image on the photoconductor to define the presence or absence of toner at a given location, transfer of the toner to the final print media, and fusing to cause the output to become durable. For purposes of this specification, Colour EP products simultaneously offer three or more unique toner colours, while Monochrome EP products simultaneously offer one or two unique toner colours. This definition includes Laser, Light Emitting Diode (LED), and Liquid Crystal Display (LCD) illumination technologies.
- Impact: A marking technology characterized by the formation of the desired output image by transferring colorant from a "ribbon" to the print media via an impact process. This definition includes Dot Formed Impact and Fully Formed Impact.
- Ink Jet (IJ): A marking technology characterized by the deposition of colorant in small drops directly to the print media in a matrix manner. For purposes of this specification, Colour IJ products offer two or more unique colorants at one time, while Monochrome IJ products offer one colorant at a time. This definition includes Piezo-electric (PE) IJ, IJ Sublimation, and Thermal IJ. This definition does not include High Performance IJ.
- High Performance IJ: An IJ marking technology that includes nozzle arrays that span the width of a page and/or the ability to dry ink on the print media via supplemental media heating mechanisms. High-performance IJ products are used in business applications usually served by electro-photographic marking products.
- Solid Ink (SI): A marking technology characterized by ink that is solid at room temperature and liquid when heated to the jetting temperature. This definition includes both direct transfer and offset transfer via an intermediate drum or belt.
- Stencil: A marking technology characterized by the transfer of images onto print media from a stencil that is fitted around an inked drum.
- Thermal Transfer (TT): A marking technology characterized by the deposition of small drops of solid colorant (usually coloured waxes) in a melted/fluid state directly to print media in a matrix manner. TT is distinguished from IJ in that the ink is solid at room temperature and is made fluid by heat.

Media format sizes:

- Large Format: Products designed for A2 media and larger, including those designed to accommodate continuous-form media greater than or equal to 406 mm wide. Large-format products may also be capable of printing on standard-size or small-format media.
- Standard Format: Products designed for standard-sized media (e.g., Letter, Legal, Ledger, A3, A4, B4), including those designed to accommodate continuous-form media between 210 mm and 406 mm wide. Standard-size products may also be capable of printing on small-format media.

- A3-capable: Standard Format products with a paper path width equal to or greater than 275 mm
- Small Format: Products designed for media sizes smaller than those defined as Standard (e.g., A6, 4"x6", microfilm), including those designed to accommodate continuous-form media less than 210 mm wide.
- Continuous Form: Products that do not use a cut-sheet media format and that are designed for applications such as printing of bar codes, labels, receipts, banners, and engineering drawings. Continuous Form products can be Small, Standard, or Large Format.

Power states:

- On Mode:
  - Active State: The power state in which a product is connected to a power source and is actively producing output, as well as performing any of its other primary functions.
  - Ready State: The power state in which a product is not producing output, has reached operating conditions, has not yet entered into any lower-power modes, and can enter Active State with minimal delay. All product features can be enabled in this state, and the product is able to return to Active State by responding to any potential inputs, including external electrical stimulus (e.g., network stimulus, fax call, or remote control) and direct physical intervention (e.g., activating a physical switch or button).
- Off Mode: The power state that the product enters when it has been manually or automatically switched off but is still plugged in and connected to the mains. This mode is exited when stimulated by an input, such as a manual power switch or clock timer to bring the unit into Ready State. When this state is resultant from a manual intervention by a user, it is often referred to as Manual Off, and when it is resultant from an automatic or predetermined stimuli (e.g., a delay time or clock), it is often referred to as Auto-off.1
- Sleep Mode: A reduced power state that a product enters either automatically after a period of inactivity (i.e., Default Delay Time), in response to user manual action (e.g., at a user-set time of day, in response to a user activation of a physical switch or button), or in response to external electrical stimulus (e.g., network stimulus, fax call, remote control). For products evaluated under the TEC test method, Sleep Mode permits operation of all product features (including maintenance of network connectivity), albeit with a possible delay to transition into Active State. For products evaluated under the OM test method, Sleep Mode permits operation of a single active network interface, as well as a fax connection if applicable, albeit with a possible delay to transition into Active State.
- Standby: The lowest power consumption state which cannot be switched off (influenced) by the user and that may persist for an indefinite time when the product is connected to the main electricity supply and used in accordance with the manufacturer's instructions.[1,2] Standby is the product's minimum power state. For Imaging Equipment products addressed by this specification, the "Standby" Mode usually corresponds to Off Mode, but may correspond to Ready State or Sleep Mode. A product cannot exit Standby and reach a lower power state unless it is physically disconnected from the main electricity supply as a result of manual manipulation.
  ([1] - For the purposes of this specification "mains" or the "main electricity supply" refers to the input power source, including a dc power supply for products that operate solely off dc power).
  ([2] - IEC 62301 Ed. 1.0 – Household electrical appliances – Measurement of standby power).

Additional terms that are required for the interpretation of allowances for the products in scope:

- Automatic Duplexing: The capability of a copier, fax machine, MFD, or printer to produce images on both sides of an output sheet, without manual manipulation of

output as an intermediate step. A product is considered to have automatic duplexing capability only if all accessories needed to produce duplex output are included with the product upon shipment.

- Data Connection: A connection that permits the exchange of information between the Imaging Equipment and one external powered device or storage medium.
- Default Delay Time: The time set by the manufacturer prior to shipping that determines when the product will enter a lower-power mode (e.g., Sleep, Auto-off) following completion of its primary function.
- Digital Front-end (DFE): A functionally-integrated server that hosts other computers and applications and acts as an interface to Imaging Equipment. A DFE provides greater functionality to the Imaging Equipment.
    - A DFE offers three or more of the following advanced features:
        - Network connectivity in various environments;
        - Mailbox functionality;
        - Job queue management;
        - Machine management (e.g., waking the Imaging Equipment from a reduced power state);
        - Advanced graphic user-interface (UI);
        - Ability to initiate communication with other host servers and client computers (e.g., scanning to email, polling remote mailboxes for jobs); or
        - Ability to post-process pages (e.g., reformatting pages prior to printing).
    - Type 1 DFE: A DFE that draws its dc power from its own ac power supply (internal or external), which is separate from the power supply that powers the Imaging Equipment. This DFE may draw its ac power directly from a wall outlet, or it may draw it from the ac power associated with the Imaging Equipment's internal power supply. A Type 1 DFE may be sold standard with the Imaging Equipment product or as an accessory.
    - Type 2 DFE: A DFE that draws its dc power from the same power supply as the Imaging Equipment with which it operates. Type 2 DFEs must have a board or assembly with a separate processing unit that is capable of initiating activity over the network and can be physically removed, isolated, or disabled using common engineering practices to allow power measurements to be made.
    - Auxiliary Processing Accelerator (APA): A computing expansion add-in card installed in a general-purpose add-in expansion slot of the DFE (e.g., GPGPU installed in a PCI slot).
- Network Connection: A connection that permits the exchange of information between the Imaging Equipment and one or more external powered devices.
- Functional Adder: A data or network interface or other component that adds functionality to the marking engine of an Imaging Equipment product and provides a power allowance when qualifying products according to the OM method.
- Operational Mode (OM): For the purposes of this specification, a method of comparing product energy performance via an evaluation of power (measured in watts) in various operating states, as specified in Section 9 of the ENERGY STAR Imaging Equipment Test Method.
- Typical Electricity Consumption (TEC): For the purposes of this specification, a method of comparing product energy performance via an evaluation of typical electricity consumption (measured in kilowatt-hours) during normal operation over a specified period of time, as specified in Section 8 of the ENERGY STAR Imaging Equipment Test Method.
- Marking Engine: The fundamental engine of an Imaging Equipment product that drives image production. A marking engine relies upon functional adders for communication ability and image processing. Without functional adders and other components, a marking engine cannot acquire image data for processing and is non-functional.

- Base Product: The most fundamental configuration of a particular Product Model, which possesses the minimum number of functional adders available. Optional components and accessories are not considered part of a base product.
- Accessory: A piece of peripheral equipment that is not necessary for the operation of the Base Product, but that may be added before or after shipment in order to add functionality. An accessory may be sold separately under its own model number, or sold with a base product as part of a package or configuration.
- Product Model: An Imaging Equipment product that is sold or marketed under a unique model number or marketing name. A product model may be comprised of a base product or a base product plus accessories.
- Product Family: A group of product models that are (1) made by the same manufacturer, (2) subject to the same ENERGY STAR qualification criteria, and (3) of a common basic design. Product models within a family differ from each other according to one or more characteristics or features that either (1) have no impact on product performance with regard to ENERGY STAR qualification criteria, or (2) are specified herein as acceptable variations within a product family. For Imaging Equipment, acceptable variations within a product family include:
  - Colour,
  - Housing,
  - Input or output paper-handling accessories,
  - Electronic components not associated with the marking engine of the Imaging Equipment product, including Type 1 and Type 2 DFEs.

6 APPENDIX 2. DETAILED OVERVIEW OF REVIEWED LCA STUDIES

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodology	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
Life Cycle Assessment in the Print Industry. A Critical Review. 2012.	Diverse: Printers, copiers and MFDs, incl. their associated consumables Toner Printer waste Remanufactured printer	Diverse: X pages/ period time (over lifetime) X pages one/double sided X printed images Unit of information X product(s) over lifetime (5 years) X amount toner Printer waste Average pages/job	Diverse, from including only materials, distribution and use to full cradle to grave LCAs	2012. Diverse time periods depending on time it takes to perform a specific amount of images/unit of information/pages/generate waste/use an amount of toner to one year to a lifetime (i.e. 3, 4, 5, 10 years). USA, Australia and EU	Diverse: Attributional LCA used for single products and for comparisons Consequential LCA used for comparisons Carbon Footprint	Diverse: Energy use Water use Eutrophication potential (EP) Acidification potential (AP) Global Warming Potential (GWP) Ecological toxicity Emissions to air (PM, VOCs) Waste generation	Diverse: Raw materials data generally from databases, sometimes estimates and in some cases excluded; Production data generally either from databases or estimates and in some cases excluded; Transportation generally from databases and in some cases excluded; Use generally from databases in some cases estimated or excluded; End of life generally from databases and in some cases excluded; Packaging generally from databases or estimated and in three cases excluded.	The analysis suggests that comparisons across studies are significantly hampered by variability in scope, transparency, data sources, and assumptions; of particular concern was the definition of a functional unit which can vary significantly depending on the capabilities and use patterns of a printer. Caution to not define imaging device functions by paper usage allows for comparison to alternative media. Standardization of the functional unit and the assumptions that are interwoven within it have a high potential to increase quantitative comparability across studies Generally energy use and GWP are the most applied environmental impact categories to quantify LC impacts. Most studies did consider all life cycle stages to some degree. There was little agreement on how materials are disposed. Assumptions about share for reuse, remanufacture, recycling, incineration (with or w/o energy

[153] *Data quality assessment, external critical review and/or article in peer reviewed journal*

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodology	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
								recovery), archived, or landfilled are all variable. These differences can lead to very different results, especially when disposing of paper.
Danish Ministry of the Environment, Environmental Protection Agency. Environmental Screening and Evaluation of Energy-using Products (EuP). Final Report, 2009.	Printers used as a proxy for copiers, faxes, and MFDs. Computers used as proxy for scanners and adding the glass and the light source part.	Use of the printer per kg of printed paper OR production: 1 laser printer	Cradle to grave excluding the use of paper	2009 EU-27	Simplified LCA (attributional based)	Global warming Ozone layer depletion Photochemical Ozone formation Respiratory organics Photoch. Ozone form. Respiratory inorganics Acidification Terrestrial eutrophication Aquatic eutrophication Human toxicity, carcinogens Human toxicity, non-carcinogens Aquatic ecotoxicity Terrestrial ecotoxicity Ionizing radiation Non-renewable energy Mineral extraction Nature occupation	Ecoinvent database version 2	The environmental impact of imaging equipment comes from the consumption of paper, the consumption of toner and the electricity consumption during use. Under real life conditions, the energy efficiency potential of imaging equipment is not necessarily fully exploited due to a potentially suboptimal use by the consumer. The focus should be put on designing toners with the lower overall environmental impacts.
DG TREN Preparatory Study for Eco-Design Requirements of EuPs. LOT 4.	Six representative products. **For office use:** Monochrome electro-	One lifetime of each representative product	Cradle to grave	2007 EU-27	Streamlined life cycle assessment approach. MEEuP Ecodesign	GWP, AP, Ozone depletion potential (ODP), EP, Primary Energy (gross energy), Water	Old data and emission factors (2007) with BOMs from 2006 and older.	For the majority of the environmental impact categories and aspects, the contribution of the use phase is dominant, followed by the manufacturing phase. From the environmental

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodology	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
'Imaging Equipment'. Final Report (task 5). 2007.	photographic MFD-copiers (medium speed of 26 ipm); Colour electro-photographic MFD-copier (medium speed of 26 ipm);Mono-chrome electro photographic printer (high speed of 32 ipm); Colour electrophoto-graphic printer (high speed of 32 ipm); Colour inkjet MFD-printer (low speed 20 ipm). **For household use:** Colour inkjet MFD printer (low speed 20 ipm);				methodology	(process and cooling), Waste (hazardous and non-hazardous), VOCs, Persistent organic compounds (POPs), Heavy metals (in air and water), Polycyclic aromatic hydrocarbons (PAHs), PM		performance perspective, paper consumption (large demand of energy in the paper production phase) has the highest contribution, followed by energy consumption in the use phase (most of this energy is not consumed during image reproduction but during the inactive mode (standby losses). Concerning manufacturing, those that contribute the most are: for MFD-copier, significant contributions are related to galvanised steel (the modelling input in the MEEuP method is '21-St sheet') and polystyrene (5-PS) due to their significance in the product weight.
LCA Summary Report KODAK i2800, i2600, i2400 Scanners ISO 14044 Protocol. 2012.	Scanners	1000 scans	Cradle to grave	2012 USA, Germany and China (use of scanners)	Streamlined LCA	ReCiPe H weighted single score endpoint (human health, ecosystems, and resource depletion) + Greenhouse Gas Emissions (IPCC 2007 GWP 100a Version 1.02).	Primary data for the Bill of Materials (BOM), assuming ecoinvent database for materials production and manufacturing, and different scenarios for varying user behaviour, user location, and Transportation. No End of Life data specified. Modelled with Simapro version 7.3.2.	Impacts are largely from the scanner materials and manufacturing, air transport, and electricity consumption. Majority of impacts are from climate change and fossil fuel depletion. Consumer use behaviour has the biggest influence on environmental impact per scan.

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodology	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
Life Cycle Assessment of a Solid Ink Multifunction Printer compared with a Colour Laser Multifunction Printer. 2011.	Multifunction device. Two printing technologies: Solid Ink and conventional colour laser.	7500 prints per month over a 4-year lifetime of the printers (360 000 prints).	Cradle to grave including consumables (laser printer: print cartridges, fusers, transfer kits, toner collection bottles; solid ink printer: ink, drum maintenance kits). Paper was not included.	2011 60% USA / 40% EU (use) and manufactured in Korea (solid MFD), Japan (laser MFD) and Japan (cartridges).	Attributional LCA based on ISO 14040/44 stds	Cumulative Energy Demand, Global Warming Potential	The analysis was conducted using SimaPro 7 and ecoinvent databases with the exception of BOMs which were sourced from Xerox. The impact of end-of-life was calculated using the US EPA Waste Reduction Model (WARM). It was assumed 25% of laser consumables recycled locally. Although solid ink consumables can be recycled, to be conservative in this comparison, it was assumed that none were.	For the laser MFD, the contribution from the use phase was only about 25% while for solid ink MFD was about 55%. For laser MFD the replacement of consumables contributes with about 25% whilst for solid ink MFD it does with about 8%. For laser MFD the contribution from the manufacturing is about 18% while for solid ink MFD is about 23%. Over the product life cycle, the Solid Ink printer studied exhibited approximately 17% lower Cumulative Energy Demand and 13% lower Global Warming Potential than the laser printer and created approximately 90% less post-consumer waste.
LCA of a Solid Ink Printer compared with a Color Laser Printer. 2010.	2 Color Laser Printers: 40 ppm color solid ink printer and a comparable 42 ppm color laser printer	7500 prints per month over a 4-year lifetime of the printers (360 000 prints).	Cradle to grave including consumables (laser printer: print cartridges, fusers, transfer kits, toner collection bottles; solid ink printer: ink, drum maintenance kits). Paper was not included.	2010 60% USA / 40% EU (use) and manufactured in Malaysia (solid printer), China (laser printer) and Japan (cartridges).	Attributional LCA based on ISO 14040/44 stds	Cumulative Energy Demand, Global Warming Potential	The analysis was conducted using SimaPro 7 and ecoinvent databases with the exception of BOMs which were sourced from Xerox. The impact of end-of-life was calculated using the US EPA Waste Reduction Model (WARM). It was assumed 25% of laser consumables recycled locally. Although solid ink consumables can be recycled, to be conservative in this	For the laser printer, the contribution from the use phase was only about 25% while for solid ink printer was about 60%. For laser printer the replacement of consumables contributes with about 30% whilst for solid ink printer it does with about 12%. For laser printer the contribution from the printer manufacturing is about 15% while for solid ink printer is about 15%. Over the product life cycle, the solid ink printer studied had approximately 30% lower Cumulative Energy Demand and

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodolo-gy	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
							comparison, it was assumed that none were.	Global Warming Potential and approximately 90% less post-consumer waste than a comparable laser product.
Scanning LCA of Printed and E-paper Documents based on the iRex Digital Reader. 2009.	iRex Reader (tablet/Kindle type) and "regular office printer" (Ecoinvent)	The service of one year of office paper use. 2 alternatives: 1. printing is done on LWC (light-weight coated) paper, 2. printing is on woodfree uncoated paper. 2 scenarios: an office worker either prints 2000 pages/year, or 12480 pages/year, (max. amount possible for 30 office workers).	Cradle to grave including packaging	2007-2009 Netherlands (use phase)	Screening LCA	GWP (CO2-eq.)	A detailed analysis of assumptions was made for primary data (electricity consumption, use of consumables, BOMs), and for end of life the Dutch scenario was used for disposal of the different material fractions at that point in time. For modelling the environmental impacts, aggregated datasets were used from ecoinvent 2.0.	iRex Digital Reader may be a sound alternative to regular office paper use, when it comes to impacts on climate change. Under the average annual office paper use of 10,000 pages per year, all other environmental indicators – such as resource depletion and toxicity indicators – are lower for the digital reader. The break-even points are about 5000 prints per year for woodfree uncoated paper and slightly over 3000 prints per year for LWC paper.
LCA OEM HP LaserJet toner cartridges compared with remanufactured cartridges. 2014.	OEM HP LaserJet toner cartridges vs. remanufactu-red cartridges sold as substitutes	The printing of 100 usable monochrome one-sided pages.	Cradle to grave	2014 USA	Attributional LCA based on ISO 14040/44 standards	Climate change Total energy demand Terrestrial acidification Freshwater eutrophication Human toxicity Photochemical oxidant formation Terrestrial ecotoxicity Fossil depletion	Primary industry data (HP) for OEM cartridges (BOMs, printing specifications, recycling practices). Secondary data from Info trends[154] for remanufactured cartridges recycling practices. An external laboratory was used to determine the number of pages required to	The study finds that, as in previous studies, paper consumption during printing is the largest contributor to the environmental impact of the print cartridge across all phases of the life cycle for both the HP Original Equipment Manufacturer (OEM) cartridge and the remanufactured alternative. In addition, the study shows that the HP cartridge has a lower overall

[154] http://store.infotrendsresearch.com/

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodolo-gy	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
							attain 100 usable printed pages, which is the basis for the comparison and the functional unit. The results from the lab study show that the remanufactured cartridges have to print more pages to reach the needed quality for printed documents for external use. BOMs and average disposal scenarios for the USA. Upstream and downstream aggregated processes from ecoinvent v2.2 database using SimaPro 7.3.	environmental impact than the remanufactured alternative, although the differences are quite marginal (+10% for climate change and total energy demand). For the OEM cartridges, the hotspots looking at Climate change are the use (89%) and production (20%), while for remanufactured cartridges it is the use (94%).
When consumer behavior dictates life cycle performance beyond the use phase: case study of inkjet cartridge end-of-life management. 2014.	Retail refilled & remanufactured inkjet cartridge vs. new inkjet cartridges	Multiple reuse cycles achieved either by refilling or by purchasing new cartridges = "five use cycles".	Production (BOM based), use and disposal, with and without the use of paper.	2012 USA	Attributional LCA based on ISO 14040/44 standards	Cumulative energy demand (CED) version 1.07, GWP 100 years.	Primary industry data (HP) for BOMs and average disposal scenarios for the USA. Upstream and downstream aggregated processes from ecoinvent v2.2 database using SimaPro 7.3.	Cartridge refills present the lowest environmental impact, offering a 76 % savings in global warming potential compared to production and purchase of a new inkjet cartridge. When looking at the GWP hotspots per cartridge cycle, the production is the dominant for the scenarios that don't use paper (78%-86%). When paper is included, the contribution is as much or less than the contribution from use (16%-40% from production and 26%-57% from use).

Title/authors of the study and year of publication	Subject of the study	Functional unit	System boundary	Time and geographical boundaries	LCA methodolo-gy	Impact categories and environmental aspects	Data quality aspects[153]	Main conclusions
								When looking into the CED from production, the hotspots are from manufacturing the cartridge (36%), from the embodied impacts of the housing (27%) and the print head (20%). When looking into the five cycles (i.e. the FU) of the refilled cartridges, the impact from the consumer transport becomes the dominant.
Carbon Footprints and Ecodesign of Toner Printer Cartridges. UKCRA 2008.	Three toner cartridges: A single-cycle cartridge (SSC), a short-life cartridge (SLC) for 1-3 refilling cycles and a long-life cartridge (LLC) for about 15 refilling cycles.	1 printing cycle	Full life cycle expect use phase (assumed the same for three cartridges)	EU (production data from Asia and Australia)	Attributional LCA with system expansion at the end of life.	Carbon footprint	Primary data for remanufactured cartridges and industry data for BOM of OEM SSC cartridge.	The carbon footprint reduction from using a SLC is about half in comparison to use a SSC for each of the three cycles. This reduction is about 60% when using a LLC instead of a SSC for each of the 15 cycles.

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