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Green Public Procurement for Imaging Equipment
Technical Background Report

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Abbreviations

AHWG	– Ad-hoc Working Group
BAT	– Best Available Techniques
BFR	– BFR Brominated flame retardant
BREF	– Reference Document on Best Avalable Techniques
CEN TC	– European Committee for Standardization Technical Committee
CO_2	– Carbon dioxide
DT	– Direct Thermal
DS	– Dye Sublimation
EP	– Electrophotography
EMAS	– Eco-Management and Audit Scheme
EPA	– United States Environmental Protection Agency
EU	– European Union
EuP	– Energy Using Products
GPP	– Green Public Procurement
IJ	– Ink Jet
ISO	– International Standardisation Organisation
kWh	– Kilowatt hour
LDPE	– Low-density polyethylene
LCA	– Life Cycle Assessment
LCC	– Life Cycle Costing
MFD	– Multifunctional devices
LCIA	– Life Cycle Impact Assessment
MS	– Member State
OM	– Operational mode
OEM	– Original Equipment Manufacturers
PBB	– Polybrominated biphenyls
PBDE	– Polybrominated diphenyl ethers
PVC	– Polyvinyl chloride
PER	– Particulate matter emission rate
s	– Second
SI	– Solid Ink
SVOCs	– Semivolatile organic compounds
TT	– Thermal Transfer
UBA	– German Federal Environment Agency
UPM	– Ultrafine particulate matter
VOC	– Volatile organic compound
UNEP	– United Nations Environment Programme
WEEE	– Waste Electrical and Electronic Equipment

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1 INTRODUCTION

Green Public Procurement (GPP) is defined in the Commission Communication on Public procurement for a better environment as “a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured”. Green Public Procurement is a voluntary instrument, which basic concept relies on "having clear, verifiable, justifiable and ambitious environmental criteria for products and services, based on a life-cycle approach and scientific evidence base". The European Commission has presented so far several sets of recommended GPP criteria for a range of different products and services, which are available at the especially dedicated website: http://ec.europa.eu/environment/gpp/gpp_criteria_en.htm.

The GPP criteria for imaging equipment[1] have been developed in parallel with the EU Ecolabel criteria development[2]. The EU Ecolabel is an element of the European Commission’s action plan on Sustainable Consumption and Production and Sustainable Industrial Policy adopted on 16 July 2008. This is a voluntary scheme established to encourage manufacturers to produce goods and services with reduced environmental impact.

The primary goal of establishing EU Ecolabel and GPP criteria for imaging equipment is to stimulate efficient paper management and to promote energy efficient products during the use phase. Other ecological aspects related to the product’s life cycle, which improvement can bring environmental benefits, are also considered.

Establishing ecological criteria for imaging equipment will contribute to greener product purchases, which shall in the first place reduce the paper and energy consumption. Besides this, they should also result in other environmental benefits, like lower quantity of waste generated, higher waste reuse and recycling, lower air emissions (due to decreased energy consumption for paper manufacturing and for direct use), lower resource consumption and higher resource efficiency (in relation to materials, longevity and recyclability issues), etc. Finally, the environmentally friendlier products should also bring private and public customers direct cost savings (e.g. lower energy bills, paper savings).

The following Technical Report substantiates the rationales behind the final proposal for EU GPP criteria for "Imaging Equipment". It provides background information on the environmental impacts of the analysed product group, describes market situation, and analyses the main life cycle cost considerations. Besides that, the most important European legislation and labelling schemes relevant for this product group are also addressed.

[1] http://ec.europa.eu/environment/gpp/pdf/criteria/imaging%20equipment.pdf.

[2] OJ L 353. 28.12.2013. p.53.

2 PROJECT BACKGROUND

This study is being carried out for the European Commission's Directorate General for the Environment, by the Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) and in cooperation with all interested parties. All the results are presented on a dedicated website: http://susproc.jrc.ec.europa.eu/imaging-equipment/stakeholders.html.

In the framework of the criteria development process two open working group meetings took place:

- 1st open working group meeting held on in March 2011 in Seville,
- 2nd open working group meeting held on in January 2012 in Brussels.

The purpose of these meetings was the presentation of the study results along with the information exchange between all interested parties. The discussion and stakeholders' feedback received during the meetings and additionally in a written form within the open consultation phase aided drafting of the proposed EU GPP criteria.

The following tasks have been performed in the frame of the project:

1) Scoping and product group definition,
2) Economic and market analysis,
3) Key environmental impact assessment,
4) Cost analysis,
5) Analysis of existent environmental schemes for the product group,
6) Legislation and policy analysis

The main findings of each task are addressed in the present report establishing the evidence-base for the development of EU GPP criteria for imaging equipment[3].

[3] Further information on the project may be found at: http://susproc.jrc.ec.europa.eu/imaging-equipment/index.html

3 DEFINITIONS AND SCOPE

The Imaging equipment product group covers products marketed as office printers, copiers, multifunctional devices (MFDs), scanners, digital duplicators, fax and mailing machines.

An important point in determining the product group scope was to set the limit between:

a) office imaging equipment devices which are used typically in a work or private environment and

b) imaging equipment devices which are designed to address special commercial or professional needs.

In the latter category the devices are very large in volume and their market sales are considerably lower than in case of a). Based on the market analysis[4], technological trends, and stakeholders feedback it was decided to address the products of: common office use (household and professional devices), high market volumes, and whose sales trend is positive. As agreed during the 1st AHWG Meeting, the product group of imaging equipment is defined by adopting the definition used in the Energy Star Labelling of imaging equipment[5], as well as the respective ones used in the frame of the Ecodesign Directive (EU Ecodesign Preparatory Study for imaging equipment[6] and respective Industry Voluntary agreement[7]).

For the purposes of the EU GPP criteria, the product group of "Imaging equipment" shall comprise products which are marketed for office or domestic use, or both and of which the 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 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).

The definitions of the products in the scope of this product group 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

[4] See: http://susproc.jrc.ec.europa.eu/imaging-equipment/docs/Ecolabel%20GPP%20Imaging%20Equipment%20Task%202.pdf.

[5] O.J. L 39 13.2.2008 p. 1

[6] DG TREN Preparatory Study for Eco-Design Requirements of EuPs. LOT 4. 'Imaging Equipment'. Final Report http://www.ecoimaging.org/doc/Lot4_T1_Final_Report_2007-11-12.pdf.

[7] COM(2013) 23 final, COM(2013) 23 final, Report from the Commission to the European Parliament and the Council on the voluntary ecodesign scheme for imaging equipment

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 (MFD)" 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 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 stand-by mode:

"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.

4 MARKET OVERVIEW

This chapter summarizes the main conclusions of a detailed market analysis carried out by the JRC-IPTS for the EU Ecolabel and GPP criteria. This analysis can be found in the report "Task 2 Economic and Market Analysis" and is available at the project website[8]. The reader interested in an in-depth analysis is therefore referred to that document.

The analysis is based on Eurostat, PRODCOM and EU-27 Trade databases. The analysis is undertaken at product level by grouping several database codes into the category of printers, copiers, MFDs, fax machines and digital duplicators. Data on scanners were only available within large aggregated categories and hence it was not possible to use them. Eurostat data are not always complete, several data gaps and significant uncertainties are expected. Therefore this analysis should serve mainly for general indications.

Generic market and economic analysis

The sector of imaging equipment is dominated by non-EU companies (mainly from the US, Japan and other far-eastern countries), manufacturing outside Europe (see Table 1). Production in Europe is low, reaching in 2009 an overall annual average of approximately 5 million devices (which corresponds to a bit more than EUR 1.5 billion). Indicatively, in year 2000 the overall annual production was three times higher.

Among the different types of imaging equipment, printers, copiers and MFDs have a higher production volume (approximately 90 %) followed by fax machines (approximately 10 %). Digital duplicators represent a negligible share of production in terms of EURO volume. The main European producers are France, Germany, Italy and the United Kingdom. In addition, Poland has a significant production volume for printers. In general there are numerous Member States in which imaging equipment are produced though in low volumes and for specific years. The main European companies include Olivetti, OGP International, CAB, Triumph-Adler, Utax, Philips and Océ.

Table 1: Manufacturers of imaging equipment (not an exhaustive list)

Manufacturers of imaging equipment			
Brother JPN	Fuji Xerox USA/JPN	NEC JPN	Samsung Korea
cab GmbH Germany	Fujifilm JPN	Nikon JPN	Sanyo JPN
Canon JPN	Fujitsu JPN	NRG (Ricoh) UK (JPN)	Sharp JPN
Copystar USA	Hewlett-Packard USA	Océ NL	Tally Genicom USA
CPG International Italy	Hitachi JPN	Oki JPN	TA Triumph-Adler DE
Datamax USA	IBM USA	Olivetti Italy	Toshiba JPN
Dell USA	Konica Minolta JPN	Panasonic JPN	Toshiba TEC JPN
AMT Datasouth USA	Kyocera Mita JPN	Philips NL	Utax Germany
Eastman Kodak USA	Lanier Ricoh USA/JPN	Pitney Bowers USA	Xerox USA
Epson JPN	Lexmark USA	Printronix USA	
Olympus	Polaroid	Ricoh JPN	
Source: Ecodesign Preparatory Study on Imaging Equipment[6] and self-performed research			

The market analysis shows that despite the numerous imaging equipment manufacturers the market is, up to 70 %, dominated by 5 producers, namely: Hewlett-Packard, Canon, Epson,

[8] See: http://susproc.jrc.ec.europa.eu/imaging-equipment/stakeholders.html.

Lexmark and Brother. All of these key market actors have some products bearing the Blue Angel or Nordic Swan ecolabel.

The imports of imaging equipment into EU-27 are generally much higher than exports generating a negative trade balance in the EU-27. During the period between 2000 and 2009 the trade balance in the case of MFDs and printers reached values in the range of 10 to 20 million units whereas for copiers it was always under 7.5 million. A positive trade balance for the EU-27 was found only in the case of digital duplicators. However, this positive balance is only for a few years and the overall traded value compared with the respective ones of the rest of the imaging devices is very low. For trade within the EU community market printers, copiers and MFDs are again the products with the most significant trade volumes. The internal trade compared to the external one is much lower both in terms of value and volume.

The calculated indicative overall average price of imaging equipment shows a clear decline over the years and in 2009 was lower than EUR 250. However, in the past the average price varied among the different devices.

The analysis shows that printers and MFDs are, in terms of apparent consumption (production + imports – exports), the most important products in this product group (see Figure 1). Apparent consumption in the EU for copiers is almost 3 times lower than for printers, while fax machines (as SFDs) are approximately 13 times lower. The apparent consumption of digital duplicators is extremely low and cannot be currently determined with a generic economic model approach.

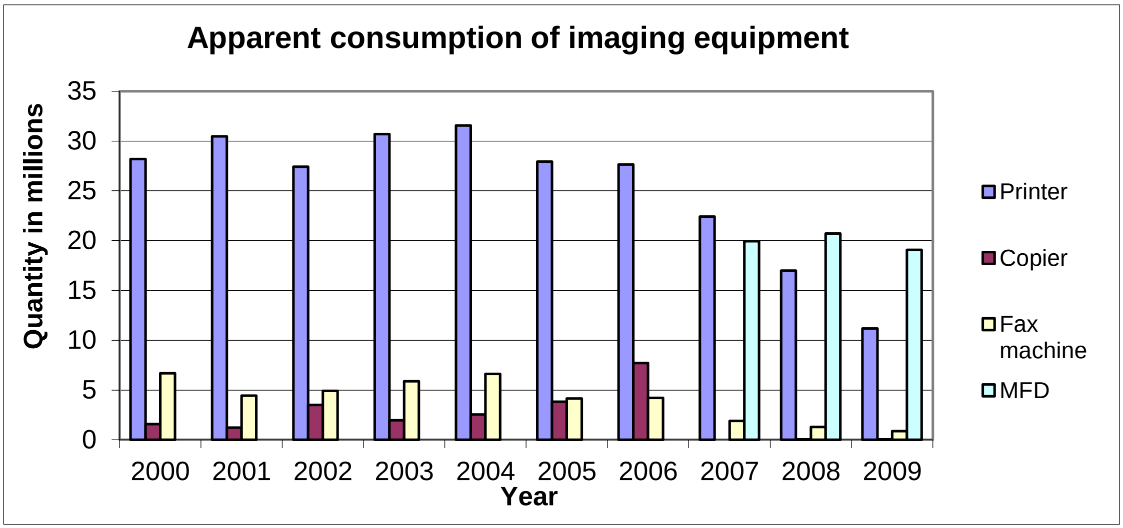

Figure 1: EU-27 apparent consumption of imaging equipment (2000 – 2009)
Source: EUROSTAT

The overall annual sales of printers either as SFDs or as MFDs range from 25 million to 29 million units, in line with apparent consumption, and show a smooth increase during the years 2003 to 2009. Printers' sales as SFDs decrease over time while at the same time a respective increase of MFD printers is detected. In 2006 the sales of SFD and MFD printers were almost equal while in 2009 twice as much MFD printers were sold compared to SFD printers.

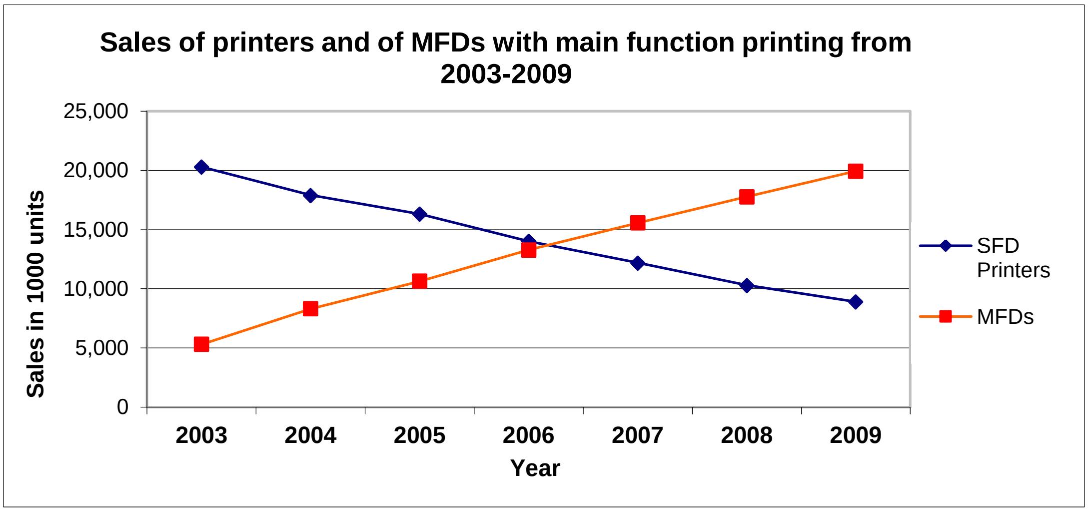

Figure 2: Sales of printers and MFDs with printing as the main function from 2003 – 2009 based on data on the Ecodesign Preparatory Study6.

Stock of imaging equipment

Regarding market distribution data, the overall stock of imaging equipment in Europe is estimated at approximately 145 million (in 2009), having a reduction of 25 % since 2005. This situation was generated mainly due to the fact that generally one MFD substitutes multiple SFD units. The stock of MFDs shows a continuous increase in this period. As to 2009, MFDs contributed to 54 % of the stock shares, followed by printers to 39 %, copiers to 4 %, and fax machines to 3 %.

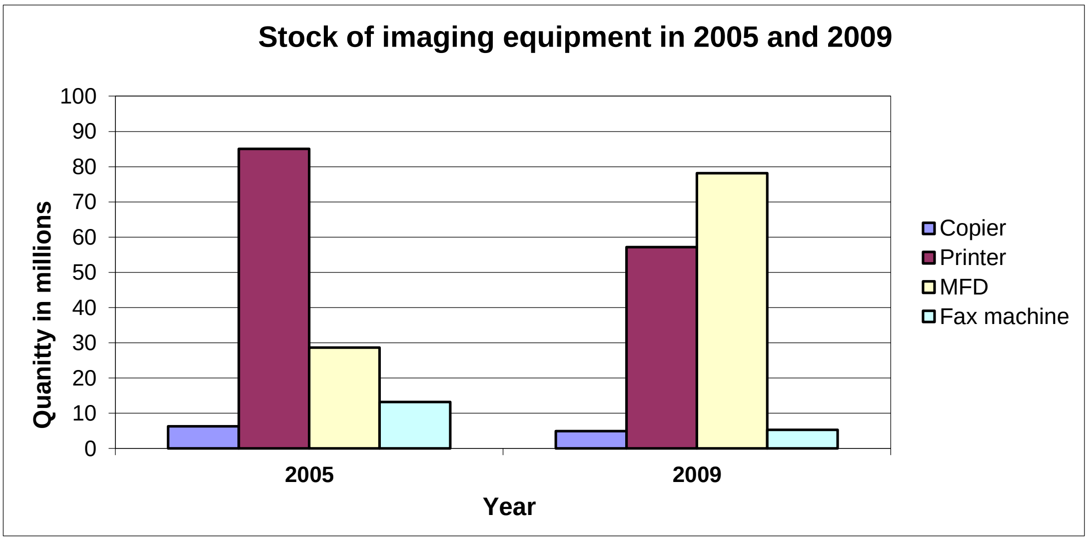

Figure 3: Stock of imaging equipment in 2005 and 2009 based on market research data.
Source: Ecodesign Preparatory Study[6].

Image creation volume

For private use, the larger share in image creation is found in inkjet printers with 86 % followed by fax machines at 8 %. EP printers are hardly in use at home. However, the picture is much different regarding image creation in a working environment. In this case, the prints of EP printers reach more than 75 % of the total and are followed by copiers with 20 %. However, as the ratio between images created at work and at home is approximately 20:3, in the overall image creation share, EP printers are responsible for 68 % of the total, followed by copiers with 18 % and leaving inkjet printers with only 12 % of the share.

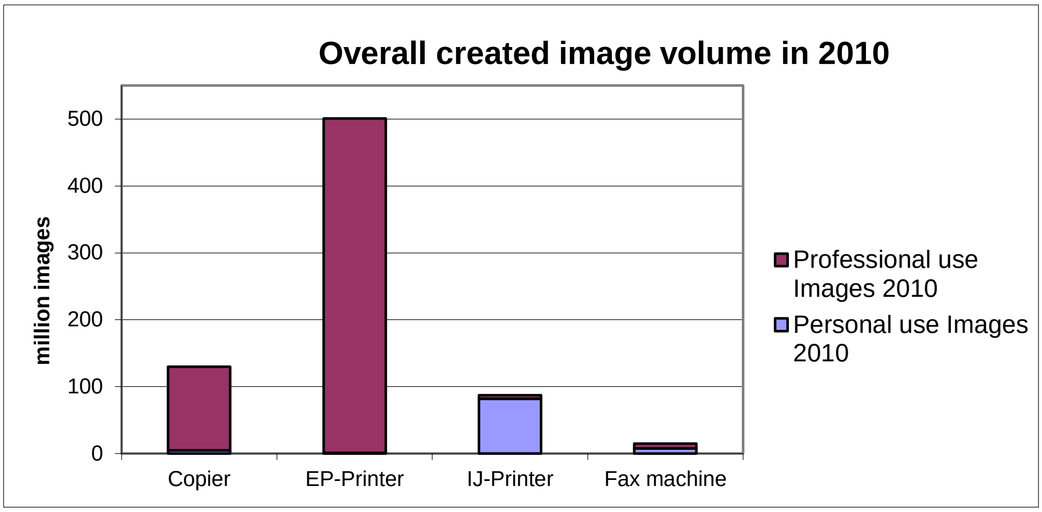

Figure 4: Overall created image volume in 2010 for private users and for professional use

NB: EP = electro-photographic technology; IJ = inkjet.

Source: InfoTrends Data[9]

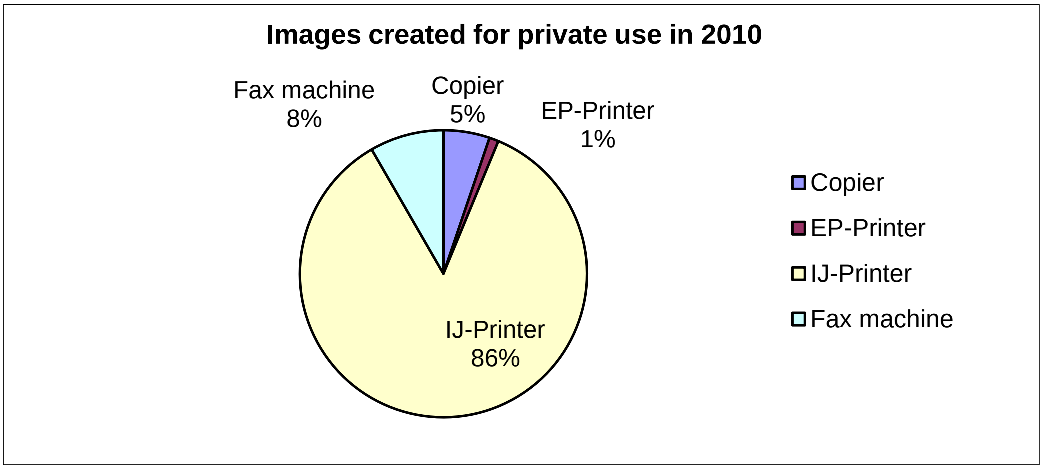

Figure 5: Images created for private use in 2010

NB: EP = electro-photographic technology; IJ = Inkjet.

Source: Ecodesign Preparatory Study[6]

[9]GPP Training Toolkit Background Product Report Office IT equipment http://ec.europa.eu/environment/gpp/pdf/toolkit/office_IT_equipment_GPP_background_report.pdf,

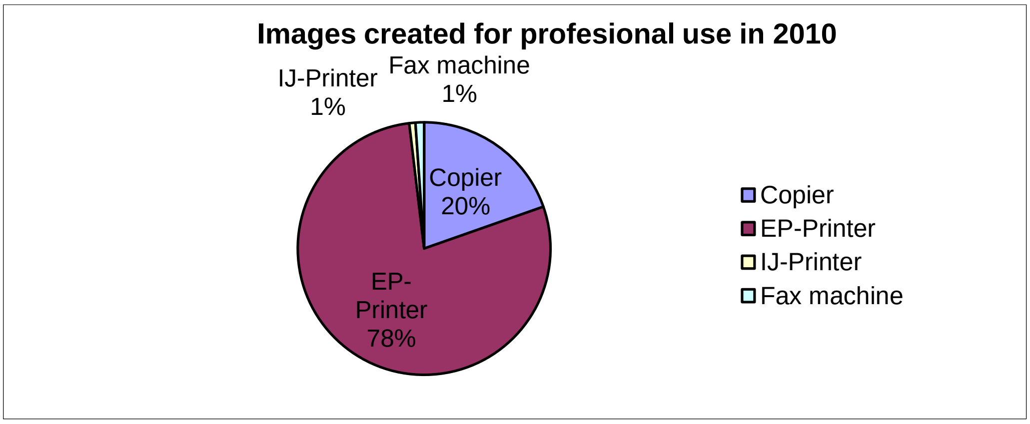

Figure 6: Images created for professional use in 2010

NB: EP = electro-photographic technology. IJ = inkjet.

Source: InfoTrends Data[9]

These figures strongly highlight the importance of the development of Green Public Procurement criteria, which are applicable to the working environment, for this product group. The overall environmental savings that can be achieved with the application of this policy tool are evident. Clearly, for GPP criteria, EP-printers and copiers have a particular importance as the most professional use images are created using these products.

Market and technological trends

Multifunctional devices (MFDs) tend to substitute single functional devices thus showing an important raise in the market demand/availability for imaging equipment. Another market trend is the increased gain in market share of colour printers, such as: colour EP printers, EP copiers and MFDs. Devices applying the EP technology (often known as laser printers/copiers) also increase their sales due to their price reduction. Moreover, the market of small colour photo inkjet printers for private use is expected to increase. The trend over the years shows that SFD scanners and SFD fax machines will be fully substituted by MFD in the midterm.

Regarding technological trends, the most important is the miniaturisation and the digitalisation. These trends have a direct effect on the reduction of the electronic waste volume coupled by more efficient monitoring of the device's functions. However, regarding reuse and recycling, miniaturisation could make it more complicated.

5 KEY ENVIRONMENTAL IMPACTS

In this chapter an analysis of the environmental performance of imaging equipment is presented. First, the key environmental impacts from the life cycle perspective are identified and described. In later chapters, aspects which may be not comprehensively (or not at all) addressed through LCA methodology are analysed, among them:

- indoor air emissions,
- release of hazardous substances,
- end-of-life management,
- noise emission.

5.1 Environmental performance of imaging equipment with life cycle assessment

The LCA-based environmental assessment of a product covers all environmental impacts of processes which are directly or indirectly involved in the product life cycle from cradle to grave. This includes the phases of raw material extraction, production, distribution, use, recycling/raw material recovery and disposal. As such, not only the environmental performance of a single product but also the environmental performance of the product system (or more precisely of product systems which, together combined, provide the determined function) are investigated. In the case of imaging equipment, the investigated function is one or more of the following: printing, copying, sending and/or receiving a fax, and creating a digital image via scanning. Furthermore, in the product life cycle the product systems (from cradle to gate) of the imaging equipment device and of the consumed paper, energy and ink or toner in use are actually investigated.

In this section the main findings of the Ecodesign Preparatory Study on imaging equipment[6] in which a life cycle based assessment is made as well as the recent findings of a streamlined LCA on imaging equipment made on behalf of the Danish Environmental Agency[10] are presented. It is important to highlight that both studies refer to the environmental performance of the overall EU-27 stock of imaging equipment (assessed based on an analysis of representative average products).

5.1.1 Findings of the Eco design preparatory study on imaging equipment

The environmental performance of the product group was assessed using a streamlined life cycle assessment approach. In the environmental assessment, the outcomes are calculated referring to the actual product lifetime in use and the European stock. The environmental assessment undertaken by the Ecodesign study follows the methodology of MEEuP[11].

The following environmental impact categories and environmental aspects (as given in Table 2) were investigated:

[10] Danish Ministry of the Environment, Environmental Protection Agency, Wesnæs, M., Jesper Thestrup, J., Remmen,A. Environmental Screening and Evaluation of Energy-using Products (EuP). Final Report, 2009

[11] MEEuP: Methodology for Ecodesign of Energy-related Products developed to allow investigating whether and which ecodesign requirements are appropriate for products under the Ecodesign Directive

Table 2: Environmental impact categories and environmental aspects investigated in Ecodesign Preparatory study.

Environmental Impact Categories	Environmental aspects
Global warming potential Acidification potential Ozone depletion emissions Eutrophication	Energy (gross energy requirement, electricity and feedstock) Water (process and cooling) Waste (hazardous and non-hazardous) Volatile organic compounds (VOC) Persistent organic compounds (POP) Heavy metals (in air and water) Polycyclic aromatic hydrocarbons (PAH) Particulate matter (PM)

It should be taken into account that the MEEuP methodology focuses on energy consumption and the product use phase identified as the most relevant issue for the analysed product group. However, some aspects were not integrated, for instance the ink production (due to data gaps) or advanced material composition, because the assessment is made on a representative typical product.

Moreover, the environmental impacts are expressed in both environmental impact categories, and environmental impact aspects. In the first case, the impacts on equivalent values of the indicator used are calculated, e.g. as CO2-equivalents for global warming potential. In the second case they are calculated as mass values of materials and/or hazardous substances, e.g. water volume, PAHs, PM, etc. Thus, interpretation of the outcomes and especially the comparison between impact categories and impact aspects is not always straightforward. However, the results give a good general overview of the important thematic areas regarding the environmental performance of this product group.

Six representative imaging equipment products were investigated (selected based on functionality (SFDs and MFDs), user pattern (private use or professional use) and performance characteristics – image colour, image creation speed and technology):

1. Monochrome electro-photographic MFD-copiers for use in working environments (medium speed of 26 ipm)
2. Colour electro-photographic MFD-copier for use in working environments (medium speed of 26 ipm)
3. Monochrome electro photographic printer used in working environments (high speed of 32 ipm)
4. Colour electro-photographic printer used in working environments (high speed of 32 ipm)
5. Colour inkjet MFD-printer used in a personal environment (low speed 20 ipm)
6. Colour inkjet MFD-printer used in a working environment (low speed 20 ipm).

It is important to emphasise at this point that the base cases represent average products found in the Community market and not the best performing products[12]; thus the outcomes of the study could serve as a reference baseline for the identification of key environmental thematic areas to which the Ecolabel and GPP criteria shall refer. However, the performance

[12] Bill of materials for each case study; available online at: http://susproc.jrc.ec.europa.eu/imaging-equipment/docs/Ecolabel%20Imaging%20Equipment%20criteria%20WorkDoc%20ANNEX.pdf

of ecolabelled products that meets the EU GPP requirements needs to exceed the environmental performance of the base cases.

An excerpt from the environmental performance of the investigated MFD-copier as performed in the Ecodesign study using MEEuP is given in Figure 7. Similar outcomes are also available for the other base cases. Investigated environmental aspects are given for two situations: the first considers paper consumption during the product life cycle whereas the second neglects these impacts. This differentiation was made because the very high environmental impact of office paper would hamper a deeper investigation of the impacts of other parameters. The results are presented as share contribution of each product life cycle phase per investigated environmental impact category and aspect.

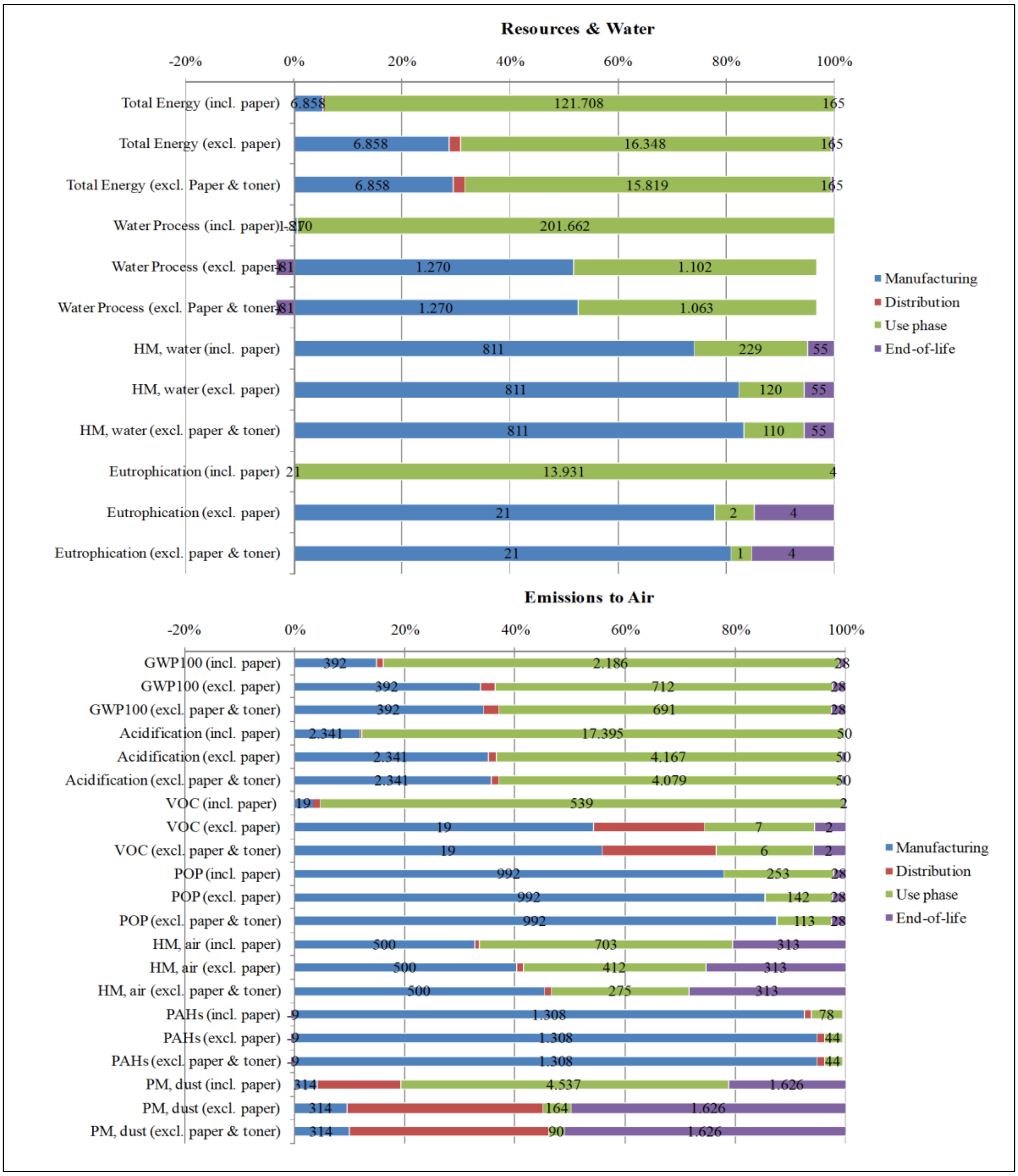

Figure 7: Environmental assessment of an MFD-copier life cycle based on the MEEuP Ecodesign methodology

Source: Ecodesign Preparatory Study[6]

At this point it is important to highlight the fact that based on the outcomes of the different base cases, and despite the fact that the profile of the environmental performance among the different base cases differ, the identified key environmental thematic areas are the same.

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 performance perspective, **paper consumption** has the highest contribution, **followed by energy consumption in the use phase**. The high importance of paper consumption is related to **large demand of energy in the paper production phase**. The consumption of paper is responsible for 80 % (or 586 PJ) of the total EU energy consumption related to the life cycle of imaging equipment. This immense contribution from paper production (and related consumption) to the overall quantity energy used affects substantially other environmental impact categories (as significant environmental impacts are related to energy production) which emphasises the importance of efficient use of paper.

One possibility to reduce **paper consumption** is to print and copy on both paper sides (**duplex image reproduction**). This aspect is taken into account in all Ecolabel schemes by setting one Ecolabel criterion on the basis of the feasibility of duplex printing and/or copying. However, we should emphasise the fact that the consumption of paper is a parameter which largely depends on user behaviour and less on the design of a printer or a copier. For instance, despite the automated duplex printing and copying capability of imaging equipment, it is eventually up to the user to apply this function or not.

The next most important aspect regarding the life cycle environmental performance of imaging equipment as found in the preparatory Ecodesign study is **energy consumption in the use phase**. It was assessed that energy consumption in the use phase accounts for approximately 2/3 of the total energy consumption of imaging equipment during product lifetime (energy consumption related to paper use is not considered). Thus, a better environmental performance can be achieved by energy efficient products. The consumption of less energy is also beneficial with respect to the other investigated environmental aspects, due to the lower pollutant emissions in the energy production phase. An additionally important aspect on this is that most of this **energy is not consumed during image reproduction but during the inactive mode (standby losses)**. Among the different types of imaging equipment, especially high standby losses are found from fax machines as they reach up to 90 % of the total electricity consumption during their lifetime.

The electricity consumption in the use phase depends on the product design (different from the aforementioned strong user dependent paper consumption aspect). Therefore for all currently available imaging equipment, Ecolabel criteria of Member States (e.g. Blue Angel and Nordic Swan) and of third countries (e.g. EcoMark, etc.) as well the GPP criteria have a special focus on the **energy efficiency requirements** of the product. As presented later in Chapter 7 the majority of the different Ecolabel schemes require compliance with the energy efficiency requirements of the Energy Star label.

In addition, it is important to identify which **materials or processes** used in the manufacturing process contribute the most to the environmental impacts of the imaging equipment life cycle, i.e. for the MFD-copier, significant contributions are related to galvanised steel (the modelling input in the MEEuP method is '21-St sheet') and polystyrene (5-PS). In this case study, galvanised steel (used for frame structures, rollers and other mechanical parts) amounts to almost 36 kg and 56 % of the total product weight.

According to the MEEuP methodology, the 'non-hazardous waste' category reflects the waste generation during ore extraction and metal processing. On the other hand, ferrous metals have a high recycling potential, which partly compensates their overall environmental impacts. In particular, galvanised steel shows considerable emissions to air. The concentration of steel in the product dominates the POP (94 %), GWP (33 %), and VOC (33 %) impact categories.

Polystyrene (PS) (in which both PPE and PPS are included) is the second largest material fraction by weight. PS amounts to 7.5 kg or roughly 12 % of the total product mass. The environmental impact of PS is strongly related to the high PAH (polycyclic aromatic hydrocarbons) concentration, which is an indicator for toxicity, measured in Ni equivalents. In this case study, polystyrene amounts to 70 % of the total PAHs emissions.

5.1.2 Danish Environmental Agency LCA study on imaging equipment

A study of the Danish Environmental Agency[10] (conducted by environmental and LCA specialists) was undertaken in 2009 in which environmental screening LCAs for different product groups with available preparatory Ecodesign studies were made. Among these studies was also the Ecodesign Preparatory Study on Imaging Equipment.

A streamlined LCA was performed using the LCA software tool SimaPro, referring to process data from the LCI Ecoinvent database and investigating a number of environmental impact categories (the LCIA "stepwise 2006" method covering 15 environmental impact categories was applied). The study was conducted based on the main assumptions made in the respective Ecodesign study. Thus, referring to an average imaging devices and not the best performing products.

Regarding the environmental screening of the imaging equipment product group this study concludes that the environmental impact of imaging equipment comes from the **consumption of paper**, the **consumption of toner** and the **electricity consumption during use**. The environmental impacts associated with the consumption of toner differ based on whether the toner is for black/white or colour printing.

Moreover, another outcome highlighted in this report is that 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. Furthermore, it is suggested that the focus should be put on designing toners with the lower overall environmental impacts.

The overall environmental impacts for several environmental impact categories during the life cycle of a laser printer for black/white and respectively colour printing are indicatively presented in Figure 8 and Figure 9. In general these outcomes referring to the environmental performance of printers are also considered to be applicable for copiers and MFDs. These findings are presented referring to the use of the printer per kg of printed paper and not referring to the total consumption of paper within the imaging equipment life cycle. This is because the overall environmental impacts associated with paper consumption are immense compared with the impacts associated with other factors. Nevertheless, expressing the outcomes per kg of consumed paper makes an investigation of other contributing parameters feasible.

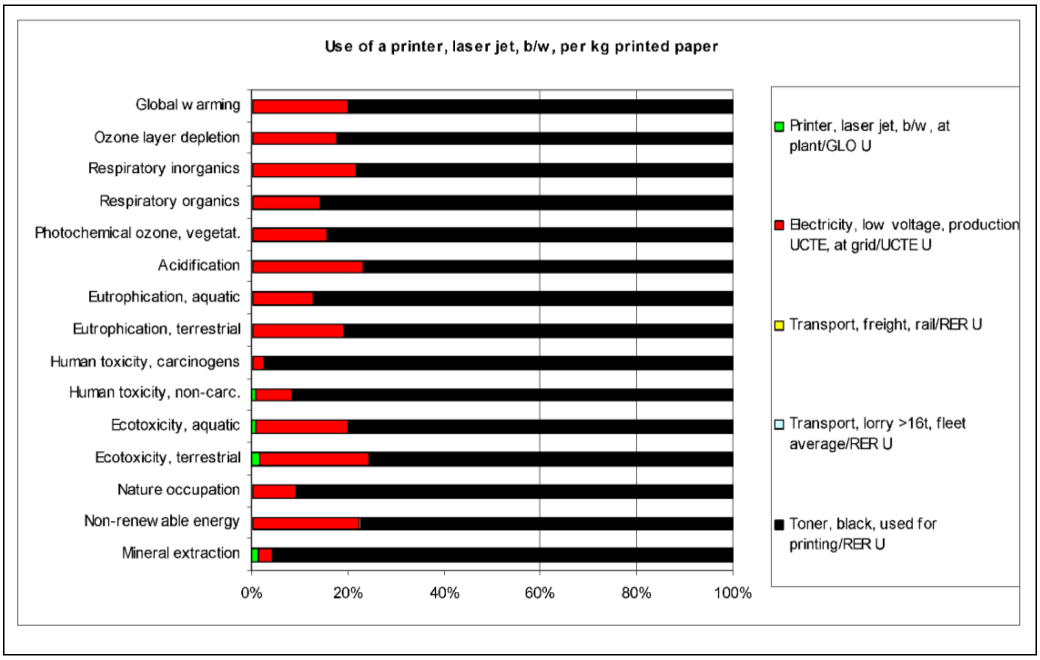

Figure 8: Environmental impacts for the life cycle of a laser printer for black/white printing per kg of printed paper.

Source: Danish Environmental Agency[10]

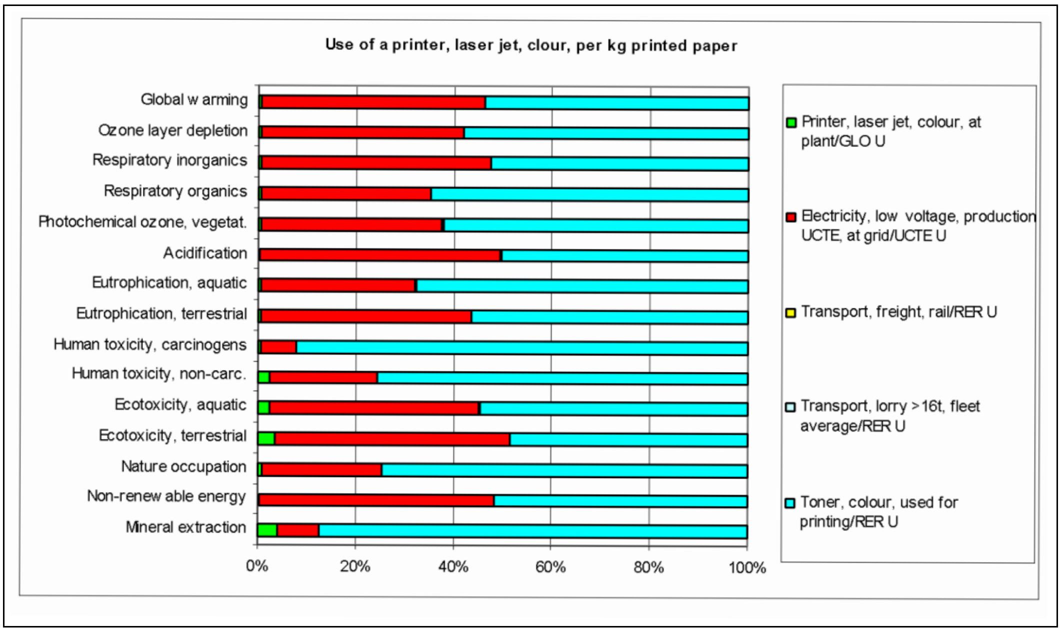

Figure 9: Environmental impacts for the life cycle of a laser printer for colour printing per kg of printed paper

Source: Danish Environmental Agency[10]

It can be concluded that the electricity consumption is significant for most of the environmental impacts. The significance of the **production of the printer** itself is considered relatively low, whereas the environmental impacts associated with the **toner** are relatively high originating mainly from the production of the toner module, the toner (powder), as well as aluminium and electricity for toner manufacturing.

Table 8 presents the environmental impacts associated with the production of a laser printer for black/white printing. It gives the contribution per environmental impact category of each process involved.

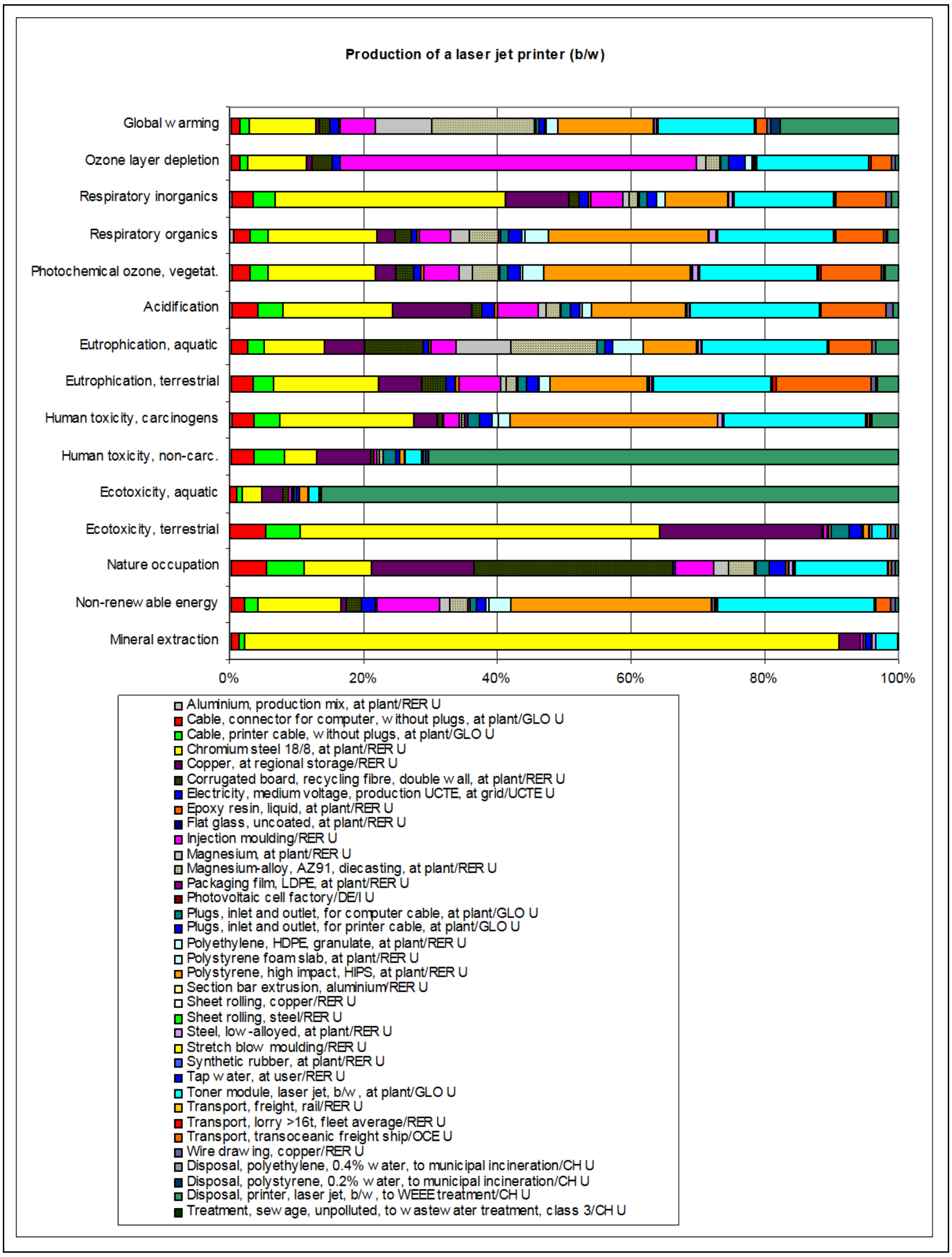

Figure 10: Environmental impacts for the production of a laser printer and contribution of each involved process

Source: Danish Environmental Agency[10]

The study concludes that the environmental impacts from the production of a printer come mainly from the production of chromium steel (18/8), polystyrene and the toner module. Chromium steel (marked with yellow) is a major contributor to the impact categories of mineral extractions, to terrestrial ecotoxicity and to respiratory organics. Polystyrene (marked in with orange) contributes significantly to the impact category of human toxicity/carcinogens, to photochemical ozone and to non-renewable energy. Moreover, the impacts associated with the toner module (marked with green colour) dominate the categories of aquatic, human toxicity/non-carcinogens. In addition injection moulding contributes significantly to ozone layer depletion. The final disposal of the printer contributes significantly to human toxicity (non-carcinogen) and ecotoxicity (aquatic). These contributions are mainly due to emissions of antimony, dioxins, arsenic and copper.

It can be concluded that based on the findings of the Danish Environmental Protection Agency, the environmental performance of imaging devices along the life cycle is strongly related to the **paper consumption**, the **energy efficiency** of the device and the consumption of **toner or ink** (which was a factor not covered in the Ecodesign study).

At this point it should be mentioned that, apart from substituting hazardous materials used in the toner or ink, another well-established strategy to reduce the overall environmental impacts associated with these consumables is refilling and/or remanufacturing toner and ink cartridges. In this case, the design of the cartridges has a significant role. Both aspects are an area of focus in the development of EU Ecolabel and GPP criteria.

5.1.3 Conclusions of life cycle assessment findings

LCA is a decision-support tool in which alternative options can be compared in a system approach which covers the entire product life cycle. The main advantage of determining the environmental performance with an LCA approach is that it avoids shifting environmental problems between product life cycle stages (e.g. better performance in the production phase but worse in the use or recycling phase, etc.) as well as between environmental impact categories.

The analysed studies assessed the overall environmental performance of imaging equipment, identifying the areas of significant environmental concern that can be summarised as:

- **paper consumption,**
- **energy efficiency in the use phase,**
- **consumption of toner and ink.**

The most significant factor is paper consumption followed by the energy efficiency during operation and the impacts associated with toner and ink consumables.

These two LCA studies also identify the materials and processes which have a major contribution to the overall environmental impact of the life cycle product system. In particular these are the production of **chromium steel** (18/8), **polystyrene and the toner module**. In addition, injection moulding which contributes to ozone layer depletion and the disposal of the product contributes significantly to human toxicity (non-carcinogen) and ecotoxicity (aquatic). The contributions to these are mainly due to emissions of **antimony, dioxins, arsenic and copper**. In addition, based on the Ecodesign Study, the galvanised steel and polystyrene (as modelled in MEEuP 21-St steel and 5-PS, in the latter are PPE and PPS included) as well as **electronics** are the materials with considerable overall contribution. Polystyrene has a significant impact in the category of polycyclic aromatic hydrocarbons (PAHs) emissions while galvanised steel in persistent organic compounds (POP), in global warming potential (GWP) and volatile organic compounds (VOC). Electronics despite their very low weight in the final imaging device their environmental impacts in the manufacturing phase dominate in 9 out of the 16 investigated environmental categories in the Ecodesign LCA analysis.

5.2 Environmental performance of imaging equipment with respect to indoor air emissions

As previously mentioned, using LCA for the environmental performance avoids shifting environmental problems between product life cycle stages as well as between environmental impact categories and therefore supports sound decisions in product environmental management. However, the current lack of knowledge and data especially regarding some specific environmental impact categories does not allow a LCA to capture all environmental impacts. LCAs investigate the major environmental impact categories in a generic way for all the processes involved in the product system life cycle.

In the case of the environmental performance of imaging equipment, one relevant environmental impact category not covered through a common LCA based approach is indoor air emissions. LCA researchers recognised the importance of indoor air exposure concluding that the indoor exposure should be routinely addressed within the LCA. Thus, there are currently ongoing activities on establishing the methodological framework for integrating the environmental impact category of indoor air quality in an LCA.

It has been reported that imaging equipment is a source of indoor air pollutants. There are several reports and investigations worldwide on indoor emissions related to imaging equipment. Office equipment has been found to be a source of ozone, particulate matter, volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs).

In a review study of Destaillats et.al.[13] laser and inkjet printers, MFDs, and photocopiers were investigated with respect to their emitted indoor pollutants. In this study volatile organic chemicals (VOCs), ozone, particulate matter and semi-volatile organic compound (SVOCs) emission data are reported[14]. Emissions are reported for both idle and operation mode of the imaging device.

Laser printers and photocopiers have been found to generate ozone in varying amounts while toner and paper dust from printing devices may become airborne, generating respirable particles that include ultrafine aerosols. Printers and photocopiers have also been reported as sources of VOCs, which are derived, at least in part, from the toner that is heated during printing. Among all emissions presented in Table 2, reported levels of VOCs have been highest from laser printers and, although the difference is generally small, the levels were higher during operation than in idle mode. Toxicological effects or potentially significant consequences due to these emission have been described in the literature e.g. ozone and particulate matter have been associated with occupational symptoms such as eye, nose or throat irritation, headache and fatigue. Similar results were also reported from other researchers[15].

Finally, following the most recent consultation with manufacturers and experts from academia in the framework of the development of the environmental label of Germany, the Blue Angel, restrictions on the release of ultrafine particulate matter (UPM) from imaging equipment was decided. The threshold values in the latest criteria version reach 3,5* 10^{11} (particle/10min printing), PER_{10PW}[16] for both monochrome and colour printing[17].

[13] Destaillatsa et al. 2008. Indoor pollutants emitted by office equipment: A review of reported data and information needs", Atmospheric Environment, 42,

[14] For details see Appendix - Tables

[15] Recent findings from investigations in indoor air emissions from imaging equipment are summarized in Table 3 in Chapter 12 (Appendix – Tables). These results detail the different parameters which affect the indoor emissions from imaging devices.

[16] PER = Particulate matter emission rate

[17] Blue Angel, Office Equipment with Printing Function (Printers, Copiers, Multifunction Devices) (RAL-UZ 171) version July, 2012, http://www.blauer-engel.de/de/produkte_marken/vergabegrundlage.php?id=259.

5.3 Environmental performance of imaging equipment with respect to release of hazardous substances and post consumption lifecycle phase (reuse, recycling, end-of-life management)

In the framework of the criteria development also the substitution of hazardous substances by safer alternatives has been considered. This substitution can be as such or via the use of alternative materials or designs, wherever it is technically feasible. In the case of changes in the product design, environmental impacts may be reduced due to increased durability of the product or its increased reusability and recycling of parts of it.

Background information for this section was gathered from different sources research reports from governments, manufacturers of imaging equipment, producers of ink and toners and independent experts in research institutes and universities. Scientific evidence on the aspects of imaging equipment reuse, recycling, end-of-life management as well as on the identification of hazardous substances (and the associated problems) is presented in the following section.

5.3.1 Release of hazardous substances from imaging equipment

There are a number of substances that are either identified as hazardous in the final product or they can be released in the end-of-life phase of imaging equipment. Substances that are of relevance are heavy metals (e.g. mercury, cadmium, lead), additives in plastic parts providing flame retardancy properties e.g. pentabromophenol, polybrominated diphenyl ethers (PBDEs), tetrabromobiphenol-A (TBBPA), and others.

Certain common components and/or parts of electrical and electronic appliances contain these substances as listed in Table 3. The list is non-exhaustive and presents the main hazardous components and substances commonly found in imaging equipment as reported by Tsydenova et al[18].

Table 3: Main hazardous components and substances commonly found in electronic and imaging equipment waste streams as published in literature

Component	Substance of concern	Device and /or product part
Gas discharge lamps	Hg in phosphors	Backlights of LCDs
Printed circuit boards	Pb, Sb in solder Cd, Be in contacts Hg in switches BFRs in plastics	In several parts
Plastics	PVC, BFRs	Wire insulation, plastic housing, circuit boards
Batteries	Cd in Ni–Cd batteries, Pb and Hg	Batteries
Source: Tsydenova et al.[18]		

Discarded electrical and electronic products (often called e-waste) are recognised as one of the fastest growing waste streams. Based on estimations these items already constitute 8 % of municipal waste. The imaging equipment product category together with its consumables

[18] Tsydenova et al. 2011, Waste Management 31

are also covered by the category of e-waste. The increasing volumes of e-waste, in combination with the complex composition of these items and the resulting difficulties in treating them properly, are causes of concern. The hazardousness of e-waste is well recognised and the knowledge on these hazards and the resulting risks associated with different treatment options is expanding.

In a recent study by Tsydenova, et al.[18] the chemical hazards associated with the treatment of electrical and electronic equipment waste including imaging equipment have been investigated. The reviewed studies collectively reveal that e-waste contains a number of hazardous substances. Heavy metals and halogenated compounds are of particular concern. Hazardous substances are often concentrated in certain e-waste components and/or parts. Thus, improper handling and management of e-waste during recycling as well as other end-of-life treatment options may pose potentially significant risks to both human health (e.g. in the working environment of recycling facilities) and the environment.

In the case of recycling facilities, improper handling and management of e-waste pose potentially significant environmental risks. The current scientific evidence suggests that the major hazards during e-waste recycling are associated with the size reduction, the separation and the pyrometallurgical treatment steps[18]. Shredding causes the formation of dust originated from plastics, metals, ceramic, and silica (glass and silicon dust). Additive chemicals like BFRs used as flame retardants embedded in electrical and electronic equipment are also released during shredding. Pyrometallurgical treatment generates fumes of heavy metals (especially low melting point metals such as Hg, Pb, Cd, etc.). Besides, if the feedstock contained PVC or other plastic with flame retardants like BFRs (PBDEs, TBBPA, PBBs, HBCDs, etc.), pyrometallurgical treatment may lead to the formation of mixed halogenated dioxins and furans (PXDD/Fs, where X = Cl, Br).

The data on emissions of the chemicals of concern in the indoor air working environment at e-waste recycling facilities are currently limited, thus generalisations cannot be made. Nevertheless, there is evidence that workers of electronic dismantling sites are exposed to higher levels of BFRs than the general population as a result of processing BFR treated plastics[18].

End-of-life treatment options for e-waste, i.e. incineration and landfilling are associated with potential risks. Examples are the formation of polyhalogenated dioxins and furans and the emissions of metal fumes during the incineration of e-waste while in leaching or gases of landfills, various hazardous substances, mainly heavy metal are detected.

For instance, Townsend et al.[19] analysed lead concentrations in the leachates from tested printers and found that it exceeded the rate of 5 mg/litre in at least one case. The authors of this publication concluded that the results provided sufficient evidence that discarded electronic devices which contain printer wiring boards with lead-bearing solder have a potential to be hazardous wastes source of lead. Moreover, Osako et al.[20] investigated the presence of BFRs in leachate from landfills. Higher concentrations of BFRs (PBDEs and TBBPA) were detected in the landfills that had crushed e-waste. Besides the leaching of substances in landfills, there is also a risk of the vaporisation of hazardous substances. This can occur in the case of mercury in which both the leaching and vaporisation of metallic mercury and methylated mercury are of concern. Dimethyl mercury, which is an organic form of mercury,

[19] Townsend et al 2004), RCRA Toxicity Characterization of Computer CPUs and Other Discarded Electronic Devices, State University System of Florida, Florida Center for Solid and Hazardous Waste Management

[20] Osako et al. 2004, Leaching of brominated flame retardants in leachate from landfills in Japan, Chemosphere 57

has been detected in landfill gas at levels 1 000 times higher than the background reference concentration measured in the open air.

Among the substances and materials which raise environmental concerns in the end-of-life of the imaging equipment products brominated aromatic flame retardants used in plastic parts (excluding printed circuit boards) are considered of special concern. The discussion around the use of brominated aromatic flame retardants in imaging devices is related to their negative impacts and potential human and environmental risks in the end-of life of the products. An analysis of different end-of-life scenarios and the associated problems follows[21]:

Incineration of plastics containing aromatic brominated flame retardants

A large proportion of brominated flame retarded materials are combusted. Depending on the quality of combustion, high levels of brominated dioxins and furans can be formed and released as a result of the dioxin precursor properties of aromatic brominated flame retardants. In particular, open burning of e-waste is estimated to globally generate polybrominated and polyhalogenated dibenzo-p-dioxins and dibenzofurans (PBDD/PBDFs and PXDD/PXDFs) on a scale of tons and for many geographical areas can be considered as common practice[22,23]. While brominated flame retardants in plastics can be destroyed with high efficiency if the plastics are treated in incinerators constructed and operating with best available techniques (BAT) and according to best environmental practices (BEP). However, in this case the costs per tonne of incinerated material are considered high (in the order of EURO 80/t).

Disposal of plastics containing aromatic brominated flame retardants at landfills

Additionally, a large portion of BFR-treated products end up in landfills, and there is growing evidence and concern that brominated flame retardants including POPs/PBDEs are leaching from landfills and contaminating the environment in industrial countries as well as in developing/transition countries. Only in engineered landfills with bottom liners, leachates that escape to the environment can be collected and treated to reduce the flow of contaminants to ground and surface water for some time but such treatments are expensive and not a common practice in the entire EU yet. Because of their persistence, POPs/PBDEs will remain in landfills for decades and probably centuries and are expected to be eventually released to the environment as the landfill engineering systems (basal/capping liners, gas/leachate collection systems) will inevitably degrade and lose their ability to contain the contaminants. Therefore, landfilling does not appear to be a sustainable solution for long-term containment of BFR-treated materials[22,23,24].

[21] Additional information is provided in:

Kougoulis et al. 2012, Promoting the frontrunners - EU ecolabel criteria requirements on the use of substances for printers, copiers and multifunctional devices (MFDs), republished in: Institute of Electrical and Electronics Engineers (IEEE) Xplore digital

and

Weber et al. 2012, Brominated aromatic substance and substances with inherent hazardous properties in environmental label – case study printers and copiers, Organohalogen Compounds, Vol. 74, p.1517-1520,

[22] UNEP 2010, Technical review of the implications of recycling commercial penta and octabromodiphenyl ethers. (UNEP/POPS/POPRC.6/2) and Annex (UNEP/POPS/POPRC.6/INF/6)

[23] Shaw et al. 2010, Reviews on Environmental Health 25(4): 261-305

[24] Weber R et al. 2011, Waste Management & Research 29 (1): 107-121.

Recycling of plastics containing aromatic brominated flame retardants

Finally, plastic containing brominated aromatic substances has a negative influence on the recycling of imaging equipment as the plastic fraction containing BFRs needs to be removed from any separately collected WEEE and disposed of or recovered with specific requirements based on the provisions of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)[25].

The challenges which arise with regard to reuse and recycling of polymers from imaging equipment were highlighted and discussed along the criteria development process. It has been analyzed whether a proposal of requiring a minimum of total 10 % of reused and/or recycled polymers used in manufacturing of the imaging equipment products, which should be the frontrunners from the environmental point of view, is feasible. It has been identified that reuse is not a common practice yet, despite the fact that there are companies operating e.g. in Japan which have managed for certain models marketed business-to-business to achieve a reuse rate of up to 80 %. In the framework of the analysis conducted it has been seen that, although imaging equipment manufacturers emphasize that recycling is considered a desirable approach, that the proposed 10 % threshold is currently high. Further, leading manufacturers in the sector of electronic equipment highlighted in this respect that plastic containing brominated flame retardants are currently not recycled back to be used again in imaging equipment products, mainly due to RoHS regulation and the presence of restricted PBDEs in WEEE polymers. A member of the Bromine Science and Environmental Forum (BSEF) mentioned that from a technical perspective BFR-containing plastics can be recycled. Nevertheless, the common praxis is that currently WEEE polymers and in particular bromine containing polymers are often down-cycled partly in sensitive uses e.g. toys[23].

5.3.2 Improved environmental performance of imaging equipment due to reuse, recycling and end-of-life management

Reuse, recovery or recycling of an entire product or parts of it (i.e. remanufacturing) contributes to more efficient use of resources. Remanufactured products and/or product components, in principle, serve the same function and are of the same quality as new products[26].

Through utilising recovered product parts it is possible to reduce the environmental and economic costs of a product or its components. With remanufacturing, a much smaller fraction of the end-of-life resources goes to disposal and/or to material recycling. In addition, intelligent remanufacturing systems provide the opportunity for product upgrades. Therefore, apart from resource conservation, remanufacturing also has a positive effect on extending product life (durability of the product).

However, it is often the case that the level of reduction in resource intensity that could be achieved by efficient and intelligent remanufacturing systems is not quantified taking into account the product life cycle. Furthermore, remanufacturing also has additional system requirements that are not always taken into account. For example, additional packaging and transport are necessary to return products for remanufacturing. Energy, water and materials are also required during the remanufacturing process. Therefore it is essential to consider the entire product life cycle system when assessing and quantifying the environmental benefits of remanufacturing.

[25] OJ L 197 24.7.2012 p.33
[26] Centre for Remanufacturing and Reuse: http://www.remanufacturing.org.uk/

In a study of Xerox Corporation's remanufacturing system with the example of a photocopier, the overall life cycle environmental benefits of remanufacturing are investigated and analysed as presented by Kerr and Ryan[27] In this case it is reported that remanufacturing can reduce resource consumption and waste generation over the life cycle of a photocopier by up to a factor of 3[28], with the greatest reductions if a product is designed for disassembly and remanufacturing.

In particular, in this study, four remanufactured and non-remanufactured Xerox photocopiers were compared throughout their life cycle. The investigation covered both a copier with a modular design for disassembly and remanufacturing (copier modules); and a copier model which was not explicitly designed for remanufacturing. The environmental impacts results are delivered on a life cycle inventory level (e.g. waste going to landfill, water consumption, energy consumption, etc.) without applying LCIA methods in which the inventory results are linked to environmental impact categories (e.g. human toxicity, eutrophication).

The results of this remanufacturing case study of Kerr and Ryan[27] are summarised in Table 4 in which it can be seen that for the modular designed copier, the environmental savings range from 38 to 68 % among the different environmental impact aspects investigated whereas for the other photocopier model, savings are in the range of 19 to 35 %. The success of applying the modular remanufacturing strategy on imaging equipment by Xerox was the reason for its further development and wider scale implementation, which is reported in the 2009 Environmental, Health & Safety Report of Xerox.

Table 4: Environmental savings by the remanufacturing of copiers[27]

Environmental impact aspect	**Photocopier non-modular design**		**Photocopier modular design**	
	Product life cycle with remanufacturing compared to product life cycle without remanufacturing		**Product life cycle with remanufacturing compared to product life cycle without remanufacturing**	
	Environmental savings %	**Reduced by a factor of**	**Environmental savings %**	**Reduced by a factor of**
Materials consumption (kg)	25	1.3	49	1.9
Energy consumption (MJ)	27	1.4	68	3.1
Water consumption (L)	19	1.2	38	1.6
Landfilled waste (kg)	35	1.5	47	1.9
CO_2 equivalents (kg)	23	1.3	65	2.9

[27] Kerr and Ryan, 2001, Eco-efficiency gains from remanufacturing: A case study of photocopier remanufacturing at Fuji Xerox Australia, Journal of Cleaner Production 9

[28] See: http://susproc.jrc.ec.europa.eu/imaging-equipment/stakeholders.html.

5.4 Environmental performance of imaging equipment with regard to noise

Noise pollution is an environmental impact category which, similar to the case of indoor air pollution, cannot be captured by a product environmental assessment based on a life cycle assessment. The sources of noise as well as the modelling of noise pollution when this is investigated for complex large product systems is currently not sufficient enough and therefore is considered non-operational in the context of LCA methodology.

Nevertheless, in the frame of developing ecological criteria for the EU Ecolabel and GPP noise pollution was considered relevant for the product group of imaging equipment. In this case noise pollution – restricted to the noise produced during the operation of an imaging device – was taken into account. Acoustics of a product are recognised as an important parameter for both end-users and product designers and are related to sound and vibration. Quiet operation of imaging equipment should not be considered only as a single advantage of the product. Noise is often an underestimated threat that can cause a number of short and long term health problems.

In common use, the word noise means any unwanted sound. Noise pollution can affect health, yet the effects are very difficult to quantify. Some of the potential adverse effects can be summarised as follows:

- Annoyance. It creates annoyance to the receptors due to sound level fluctuations.
- Physiological effects. The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are effected.
- Loss of productivity. Noise has negative impacts on cognitive performance. For attention and memory, a 5 dB(A) reduction in average noise level results in approximately a 2 – 3 % improvement in performance.
- Nervous system. It causes pain, ringing in the ears, feeling of tiredness, thereby effecting the functioning of human system.
- Sleeplessness. It affects sleepiness by inducing people to become restless and lose concentration during their activities.

Annoyance is the most widespread problem caused by environmental noise. Annoyance reflects the way that noise affects daily activities. It has been estimated by the WHO that 20 % of the population is exposed to levels exceeding 65 dB(A) during the daytime which is a value close to the noise levels caused by operating printers and/or copiers. Some groups are more vulnerable to noise. Chronically ill and elderly people are more sensitive to disturbance. The noise exposure time is also a significant parameter which becomes even more important if we consider working environments with many imaging devices operating at the same time, e.g. copy/print centres as then the overall effective sound level is higher.

The effects of noise on humans indoors and in low levels similar to the ones produced by imaging devices are not easily quantifiable but are possible to be detected. In a study of Gary W. Evans[29], et. al low-level noise in open-style offices was investigated. The findings indicate higher levels of stress and lower task motivation of the participants exposed to noise. However, the participants did not perceive their stress.

Noise levels for office environments recommended by the WHO or similar organisations are not available at present. However, the WHO guidelines for community noise recommend less

[29] Gary W. Evans, Dana Johnson, "Stress and Open-Office Noise", Journal of Applied Psychology, 85, 2000.

than 30 A-weighted decibels (dB(A)) in bedrooms during the night for a sleep of good quality and less than 35 dB(A) in classrooms to allow good teaching and learning conditions. In addition, for night noise the WHO recommends less than 40 dB(A) of annual average outside of bedrooms to prevent adverse health effects from night noise. In the past several years, epidemiological evidence was accumulated supporting the hypothesis that persistent noise stress increases the risk of cardiovascular disorders including hypertension and ischaemic heart disease.

Although noise impacts are very difficult to quantify, in many Ecolabel schemes, one of the environmental impact categories addressed is noise. For instance in the EU Ecolabel criteria for the product group of imaging equipment one criterion which was developed together with experts by the German Environmental Agency refers to noise requirements during operation. Blue Angel and Nordic Swan Ecolabel criteria for imaging equipment also include noise as an environmental impact category area.

It is also worth noticing that imaging equipment manufacturers have already focused their efforts on reducing unwanted noise caused during product’s operation, e.g. by introducing a feature that allows users to adjust the sound level of the printer. Some printers have the option of quiet mode in which the operating noise level of printers can be additionally lowered by three decibels. Other alternatives are to avoid beep sounds while typing hard-on buttons.

5.5 Environmental thematic areas addressed in Ecolabel schemes and other relevant schemes

Based on the analysis regarding the Ecolabel schemes at the Member State level, the key actors are Blue Angel from Germany and Nordic Swan from the Nordic countries. These two schemes together with the Japanese Eco Mark are also considered among the most important ones globally. Moreover, it was found that in many other Ecolabel schemes, criteria originating from these two schemes are used by cross-referencing. Ecolabel criteria of Blue Angel, Nordic Swan and Eco Mark are harmonised.

Furthermore another relevant activity undertaken in the US is the development of the IEEE 1680.2. This standard defines environmental performance standards for imaging equipment and is currently under development. Similar to the Ecolabel scheme this standard intends to provide a clear and consistent set of performance criteria for the design of imaging equipment, and to provide an opportunity to secure market recognition for efforts to reduce the environmental impact of these electronic products. The US Environmental Protection Agency (EPA) manages this activity. This label is based on self-declaration, but after the product enters into the market a third party verification system is foreseen.

In Table 5 the thematic areas addressed by the Blue Angel and Nordic Swan Ecolabel Schemes with the thematic areas addressed in the IEEE 1680.2 on imaging equipment are listed.

Table 5: Thematic areas addressed in the Ecolabel schemes of Member States and in relevant international standards

Blue Angel and Nordic Swan Ecolabel	US IEEE 1680.2 Standard
Energy in use phase Substance emissions – Electrophotographic devices – Inkjet devices – User information on substance – Products of identical design Noise General requirements – Recyclable design – Material requirements – Marking of plastics – Batteries – Printing paper – Double-sided printing and copying – Photoconductor drums – Guarantee of repairs – Maintenance of equipment – Product take-back – Packaging Requirements for toners and inks as well as for modules and containers for toner and ink – Modules and containers for toner and ink – Material-related requirements for toners for use in electrophotographic devices and inks for use in inkjet devices	Energy conservation – Energy Star and others Environmentally sensitive material – Compliance with RoHs and others Material selection – Recycled content Design for end-of-life – Easy for recycling Product longevity/lifecycle extension – Warranties, spare parts Packaging – Recyclable and recycled content End-of-life management – Take-back and recycling Corporate performance – EMS, environmental policy report

A comparison of the two columns in the above table shows large overlaps. For example the common overall thematic area of energy conservation is addressed in both schemes. Checking the subcategories of IEEE 1680.2 standard we can find that almost all the areas are also included in the Member states' Ecolabels. One exception is the category of the corporative performance criteria which are not considered relevant for an Ecolabel ISO type II declaration. Acoustic performance as well indoor air emissions from imaging equipment are found to be considered relevant in the Ecolabel schemes, contrary to the current form of the IEEE 1680.2 criteria considerations.

5.6 Environmental thematic areas addressed by imaging equipment manufacturers

Table 6 presents the environmental thematic areas related to the performance of imaging equipment as addressed by main manufacturers.

Table 6: Indicative thematic areas addressed in environmental reports of imaging equipment manufacturers

Manufacturer	Environmental thematic areas addressed	Efforts, innovation and achievements
Ricoh	New material design	Development of biomass resins Since 2002 began developing biomass plastic components as materials for copiers. In 2005 was used plastic with 50 % biomass content in the main component of a multifunctional digital copier. In 2008 released a model which employs a newly developed plastic component with roughly 70 % biomass content In 2009 released a model, equipped with a biomass toner (25 % biomass content)
	Easy to recycle design	Material design easy-for-recycling Marking of plastics. Requirements of surface cover. Promotion of recycled copier business. Recycling information system
	Material design, reuse and recycling	Reduction in size/weight of products and a longer product lifecycle, enhancement of reuse and recyclability, promotion of closed loop material recycling, increasing production and sales of recycled copiers and the reduction of packaging materials. Increased quantity of reused parts, resources collected from used products and re-circulated. Commercialise biomass toners. Inner loop recycling. Recycling rate in 2009 for copiers 98 % and toner cartridges 99 % (data is not restricted to Europe)
	Energy efficiency	"Quick start up technology". The recovery time from the energy-saving mode is reduced to less than 10 seconds For monochrome multifunctional copiers,
	Paper consumption	PO BOX printing
	Reduce the use of environmentally sensitive substances	Achieved Blue Angel Ecolabel indoor air emissions criterion requirements for 17 copiers released in 2009
Canon	New material design	Use of biomass plastics with high flame retardance level
	Material design, reuse and recycling	Introduction of returnable packaging material Closed-loop packaging recycling. Packaging is collected and reused after unpacking. Use recycled plastics for internal parts.
	Energy efficiency	Canon on demand fixing technology
	Reduced package size	Example inkjet printers packaging 11 %reduced
	Promotion of toner cartridge collection and recycling	

Manufacturer	Environmental thematic areas addressed	Efforts, innovation and achievements
Lexmark	Energy efficiency	Use of "Instant Warm-Up Fusing" technology into the color laser products. New products use 28 to 50 % less energy Eco-Mode, optimizes energy efficiency Energy efficient galvo printhead.
	Paper consumption	
	Toner cartridge efficient use	High-yield and extra high-yield cartridges
	Product recyclability and chemicals in product components	Complies with international legislation that restricts the use of substances such as lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE) flame retardants as outlined (RoHS). Since 2006 all Lexmark products, including the ink and toner cartridges (which are not included in the scope of the RoHS), have been fully compliant with the RoHS directive. Efforts to substitute 98 % of PVC packaging of inkjet cartridges To date, Lexmark has safely eliminated the use of brominated flame retardants in the covers and chassis of our laser and inkjet printers A minimal concentration of solvents is used in inks. Methyl alcohol or ethylene glycol are not used in inks.
	Product acoustics	All of Lexmark's laser printing products meet the noise requirement in the Blue Angel Ecolabel specification. All laser products announced in the fall of 2008 were designed with a Quiet Mode feature that allows users to adjust the sound level of their printer to meet their personal preferences
	Product packaging	
	End of life	Product durability and upgradeability Product take-back and collection strategies. Cartridge collection program and reuse and material recovery
Brother	Energy efficiency	Improve energy conservation during use
	Reuse and Recycle	Collection and recycling Easy to recycle at the end of life
	Packaging and distribution	Reducing product packaging and waste. Reducing CO_2 emissions in distribution and transport
	Hazardous materials	Products do not contain hazardous materials as defined under the European RoHS directive and in accordance to the Brother Group hazardous chemical listing in the Green Procurement Standard. Products are made via eco-friendly processes.
	End of life management	Areas of focus: size and weight, parts reuse/recyclability, disassembly/dismantling, avoidance of difficult-to-disassemble structures, integration of resin materials, packaging materials' size, weight and recyclability. Material labelling

Manufacturer	Environmental thematic areas addressed	Efforts, innovation and achievements
Epson	Commitment to Recycling	Benefits of reusing the main unit. Inclusion of all products in the resource reuse and recycling loop
	Energy-saving design	The power consumed during use accounts for a large portion of a product's total environmental impact across its life cycle. With this in mind, we set energy-saving performance goals for each product and work to ensure steady progress
	Resource saving	Environmental goals are set for: recyclable rates (the ratio of total product weight calculated as recyclable based on a product’s design drawings), reducing the cost of disassembly and sorting and finding ways to reduce impacts by making products smaller and lighter.
	Elimination of harmful substances	Epson standards specify substances that are prohibited from inclusion in products and substances whose inclusion must be controlled. Information on these substances is gathered in a database to help ensure safety in all processes, from design and procurement to mass production. REACH Compliance.
	Reducing transport CO_2 emissions	Green Purchasing of Production Materials
	Product design	The PX-W8000 large-format printer uses nearly odourless water-based ink, meaning it can be used in any office without a special ventilation system and is compliant with the Energy Star programme
		The TM-T88V thermal receipt printer consumes approximately 15 % less total power per year*1 than the TM-T88IV (2006) Paper-saving features*2 reduce paper use by up to 30 %
	Paper consumption	Save paper by not printing Scans images directly to a memory card and transfers them to a PC. Creates a double-sided print from two source sheets. Prints up to four pages on a single sheet with double-sided, and multi-page printing Reduces paper waste. Fits web pages to the width of the paper. Save energy. Prints directly from a memory card, no PC required
	Collection and Recycling	Epson's applies a toner and ink cartridge collection system, and "used ink cartridge pick-up"

Manufacturer	Environmental thematic areas addressed	Efforts, innovation and achievements
Xerox	Energy efficiency	80 % of eligible new products launched met the 2007 Energy Star (version 1.0) standard.
	Reducing hazardous materials	Worldwide hazardous waste volumes were decreased 10 % from 2007 and 96 % was beneficially managed. Reduced the use of PBTs in Xerox supply chain through adherence to Xerox's chemical use standards for all suppliers and Electronic Industry Citizenship Coalition's. Code of Conduct requirements for xerox's 50 key global suppliers, representing 90 % of cost, by 2012. In 2009, developing systems and processes to provide a complete accounting of materials throughout the value chain that will support progress toward zero PBT
	Ink/toner cartridge design	Investing in "cartridge-free" solid ink technology that produces up to 90 % less waste from supplies and packaging than conventional office color printers
	Reuse and recycling	Maintaining over 90 % reuse or recycling of recovered Xerox equipment and supplies offerings. Xerox achieved >90 % reuse or recycle rate for 106 million pounds of postconsumer equipment and supplies waste, bringing the total landfill avoidance to 2.2 billion pounds since 1991

Note. The list is indicative and not exhaustive[30]
Source: Kerr & Ryan[27]

Comparing the thematic areas addressed in environmental reports of imaging equipment manufacturers we can conclude that all of them pay special attention to:

- Energy efficiency,
- Prevention and/or restriction of hazardous substances,
- Develop recycling and reuse of materials and components, end of life management,
- Ink and/or toner design and packaging.

In the majority of the cases the thematic areas of noise and paper consumption are also addressed.

[30] For more information on this issue please refer to Technical Background Report – Key Environmental Areas – Technical Analysis. J Kougoulis, R Kaps, Oliver Wolf, December 2011

5.7 Conclusions on key environmental thematic areas for imaging equipment

Based on the outcomes of the study, we can identify from the LCA based studies that key environmental areas are:

- Paper consumption (of very high importance)
- Energy efficiency during operation (important)
- Ink and toner consumables

Furthermore, based on product oriented environmental investigations we can identify the following key environmental thematic areas:

- Indoor air emissions
- Noise emissions during operation

Moreover, we can identify that regarding the product design developments in all the Ecolabel criteria for imaging equipment, in similar schemes (e.g. EPEAT program in US) and in the environmental management programs undertaken by the imaging equipment manufactures additional key environmental areas are:

- Substitution of hazardous substances and materials
- Promotion of reuse, recycling and sound end of life management

The scientific findings given in this study have been presented and consulted with stakeholders involved in the criteria revision/development process. On the basis of the scientific and technical information and the outcomes of the consultation process the Green Public Procurements criteria for the product group of imaging equipment have been proposed. They are presented in Chapter 11. We would like to explain here that some of the identified in the study environmental thematic areas have finally not been addressed within the frame of these GPP criteria due to various reasons:

- Noise emissions during operation have not been addressed. Based on outcomes of the consultation with manufacturers and the efforts made and addressed in the respective sustainability reports it seems that there is a general trend on new products that are performing with regards to acoustic emissions equally to or better than previous models. Moreover, the presence of noise emissions requirements in environmental labels of MS is for more than 7 years in place and many products are considered to comply. Therefore, with the objective to simplify the GPP criteria, no requirement has been set.
- Indoor air emissions are also not addressed, as it was considered to be difficult to formulate criteria to be used in public procurement that are easy to verify and do not put an excessive burden on manufacturers. This reflects also the objectives of a simplification of the criteria set.
- In spite of the importance of hazardous substances, it has been decided after an intensive discussion with stakeholders that currently requirements on chemicals in the criteria document cannot be included within this GPP criteria set, as it is very difficult to formulate criteria that are easily implementable and verifiable in public procurement; more work is planned to be undertaken by DG Environment of the Commission in the year 2014 on how to best formulate chemicals criteria in GPP.

6 COST CONSIDERATIONS

6.1 Imaging equipment life cycle costing overview

In order to allow public procurers to select the most cost-effective products, it is essential to use a product life cycle perspective and apply a life cycle cost (LCC) approach. LCC considers the entire (physical) life cycle of a product, from production to disposal. Depending on the perspective taken in the LCC assessment, costs of different stages can be calculated with more or less detail. The use phase of the life cycle is very relevant for the public procurers as e.g. the production cost of the product to be purchased does not need to be calculated in detail, as the relevant cost element for the purchasing authority would be integrated in the final product price. In this respect, from the LCC perspective we can identify the following costs categories for imaging equipment:

- Purchase cost
- Running costs for operation (i.e. costs for electricity, paper and toner/ink)
- Running costs for repair and maintenance
- Installation costs (if applicable)
- Costs for disposal
- Costs due to inflation and interest rates (if applicable)

The actual running costs of operation of imaging equipment shall be calculated on the basis of average time for different operation modes as well as the average amount of consumables materials (i.e. paper, toner or ink cartridges) needed for their specific operation and the actual specific printout images produced (e.g. colour image differs from a monochrome one and not every colour printout needs the same amount of ink etc).

Further, power consumption depends on the product and on the time period the product is in each mode (ready-mode, sleep mode, off mode etc.). The total energy consumption can be calculated summing up the multiplied assumed operation times for which each single mode with their respective power consumption. The resulting electricity consumption in kWh then needs to be multiplied with the electricity costs in order to determine the running costs for operation (as regards electricity). For procurers a good practical solution for getting an approximation on this issue is to use, when applicable, the assumptions and the user patterns applied in the Energy Star label and the calculated TEC values.

As mentioned above, imaging equipment devices can usually enter various power modes with different power consumption values. According to Energy Star, one can differentiate between:

- Active mode: Power state in which the product is connected to a power source and is actively producing output, as well as performing any of its other primary functions.
- Ready mode: Power state when the product is not producing output, has reached operating conditions, has not yet entered into any low-power modes, and can enter 'active mode' with minimal delay. All product features can be enabled in this mode and the product is able to return to active mode by responding to any potential inputs. Potential inputs include external electrical stimulus (e.g. network stimulus, fax call or remote control) and direct physical intervention (e.g. activating a physical switch or button).
- Sleep mode: Reduced power state entered automatically after a period of inactivity. All product features can be enabled in this mode and the product must be able to enter 'active mode' by responding to any potential inputs; however, there may be a delay. The product must maintain network connectivity while in 'sleep mode', waking up only if necessary.
- Stand-by mode: Lowest power consumption mode which cannot be switched off (i.e. 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. For imaging equipment products, the stand-by power level usually occurs in the 'off mode', but can occur in 'ready' or 'sleep mode'. A product cannot exit the 'stand-by mode' and reach a lower power state unless it is physically disconnected from the main electricity supply as a result of manual manipulation.

- Off mode: 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 mode'.

The distribution (i.e. how much time a printer spends in each mode) depends on the power management, pre-setting of the device (how fast it changes into or 'wakes up' from a lower power mode) and on the user behaviour (frequency, distribution and volume of print jobs).

The definitions of the standardised Energy Star test procedure for the 'Typical Electricity Consumption' (TEC) can be used for the calculations. The TEC focuses on the quantity of electricity consumed by a product during a representative period of time (one week). For measuring the TEC, Energy Star defines a certain number of jobs per day and images per job depending on the imaging speed of the printer, a test image and a measurement procedure. To take into account power management default-delay times, the product has to be measured according to the configuration as shipped and recommended for use. The TEC-specifications might differ from real usage; however, they guarantee different imaging equipment devices being measured under same conditions and thus being comparable. To qualify for the Energy Star label, certain limit values have to be met by the devices.

In order to calculate the running costs for consumables, the average amount of produced imaging output over a certain period of time needs to be defined. In this respect efficient paper management and high energy efficiency of the device becomes very important.

Available functionalities of the imaging equipment that support reduced use of paper are the ones which allow the user:

- printing on both sides of a paper sheet,
- printing of multiple pages on one side of a paper sheet (N-up printing function),
- quick cancellation of unwanted printout.

Similarly energy-efficient products allow decreasing running costs and also contribute to reduction of various environmental impacts related to energy generation.

Consumption of paper and energy is also the most cost-intensive for this product group, depending on the application of the device (e.g. whether it is a personal or professional, i.e. office equipment).

Further significant costs are related to the product consumables like inks and toners, which also have a high share in the overall costs and at the same time are associated with certain environmental impacts (e.g. use of hazardous substances). It is considered that ink and toner cartridges contribute significantly to the overall waste volume produced in the lifecycle of the imaging equipment devices. The number of ink and toner cartridges which end up in the waste over the life cycle of an imaging device depends on several parameters, e.g. user environmental awareness, take-back system by tenders etc.

Considering a certain demand of printouts along the product life cycle for the calculation of the waste volume associated with the use of cartridges it is important to know how many times the ink and toner cartridges are re-used. It is not considered resource efficient to use the cartridges only once while this also raises the overall costs for disposal.

Regarding the costs for disposal these are often not directly linked to the purchaser but to the manufacturer. Part of these costs is eventually borne by the municipality authorities responsible for the waste disposal as a certain number of products and product parts (cartridges) ends up in municipal waste.

The presence of certain substances in imaging equipment is of importance for the overall disposal costs. Following a sound environmental management the presence of hazardous substances causes the need of separate treatment i.e. separation of mercury contained in backlights. Another example is the use of brominated flame retardants. Following the WEEE directive (which is the case if the imaging equipment is treated within the EU) the parts containing brominated flame retardants need to be separated from the waste stream. Further, in case of incineration (under best available practice (BAT) conditions) the plastic parts containing brominated flame retardants and PVC affect negatively the costs of the incinerator operational costs due to the high costs related to the treatment of the created flue gas. However, these costs are often not covered by the procurer therefore will not be further analysed in this phase.

6.2 Imaging equipment life cycle costing calculation

A user friendly tool for calculating the life cycle costs for public procurers of imaging equipment is available in the EU Energy Star website under http://www.eu-energystar.org/en/en_009.shtml.

Imaging equipment devices are divided into numerous classes based on their functionalities and performance characteristics. The life cycle costs for the typical classes of imaging equipment can be calculated directly using the default settings. Moreover, the performance of alternative choices can be compared.

Several parameters related to the equipment functionalities, to the product operation mode and the user behaviour (i.e. use of double side printing option), to the product life time, to the overall number of printouts (and other aspects) are incorporated in this calculation. The procurers, depending on their needs, may determine these parameters in order to make the lifecycle costing calculation more appropriate for a particular undertaken procurement. The use of average values is also possible (i.e. use of the default assumptions) when procurers find difficulty on determining all these parameters.

In the following figures, based on the settings of the EU Energy Star cost calculator for the several imaging equipment devices, following parameters are modelled:

a. Costs of printing for monochrome and colour printing for several imaging equipment (Figure 11).

b. Comparison of the overall lifetime costs related to paper and ink or toner consumption versus the purchase cost of the equipment (Figure 12).

c. Comparison of the overall lifetime costs related to energy consumption versus the purchase cost of the equipment (Figure 13).

d. Comparison of the overall lifetime costs related to related to paper and ink or toner consumption versus energy consumption (Figure 14).

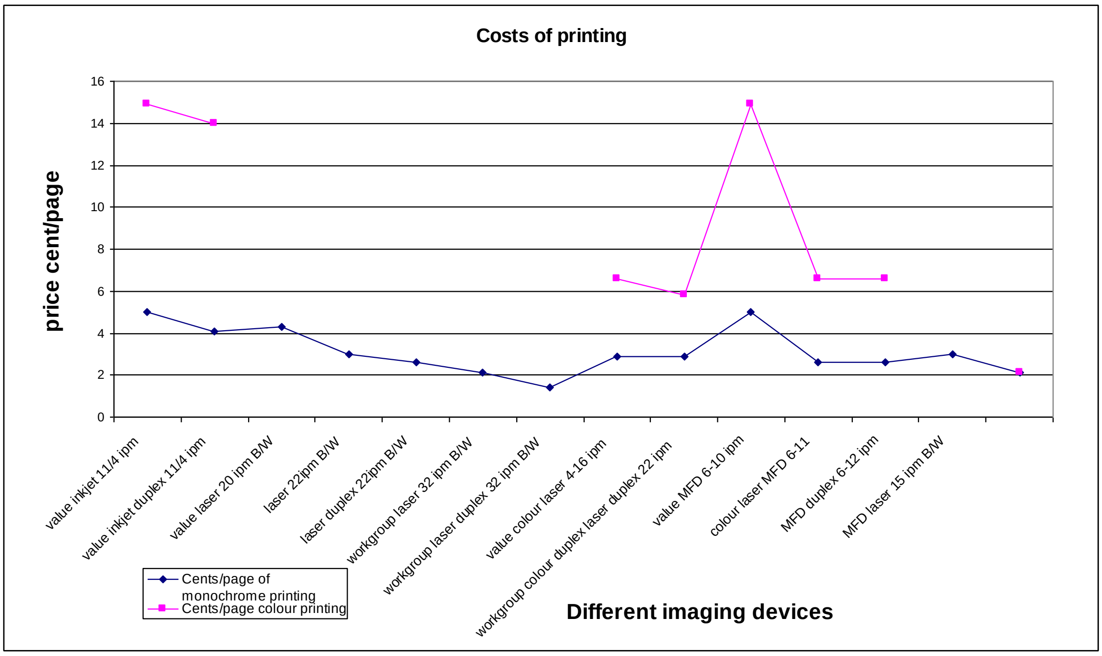

Figure 11: Costs of printing for monochrome and colour printing for several imaging equipment

Source: EU Energy Star calculator[31]

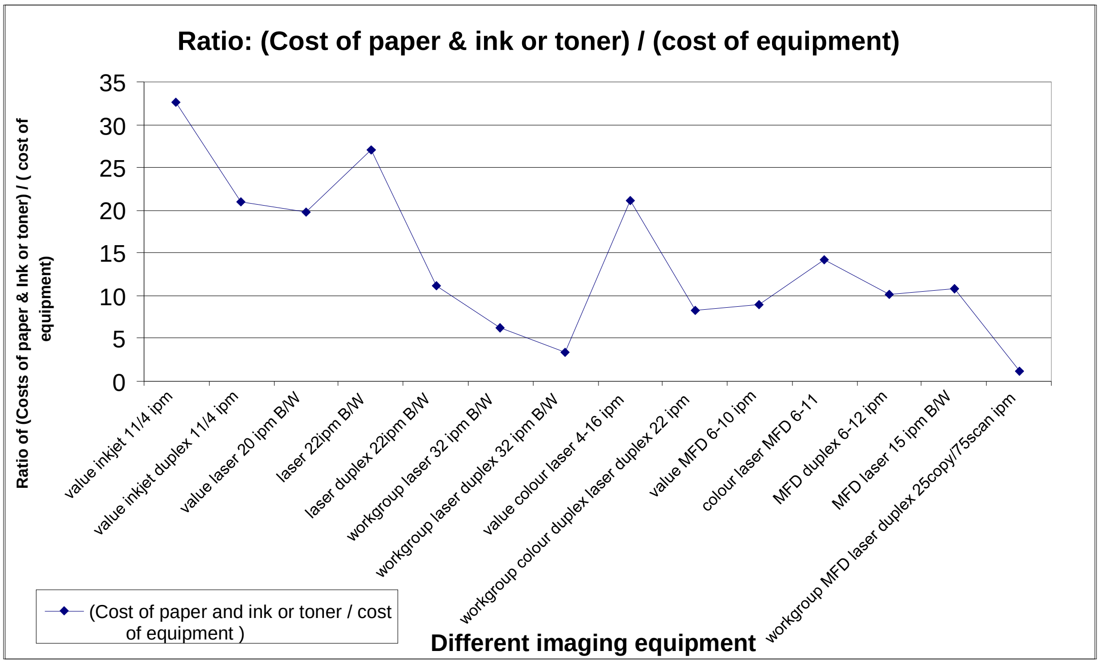

Figure 12: Comparison of the overall lifetime costs related to paper and ink or toner consumption versus the purchase cost of the equipment.

Lifetime is modelled with the default assumptions undertaken in EU Energy Star costs calculator

Source: EU Energy Star calculator[31]

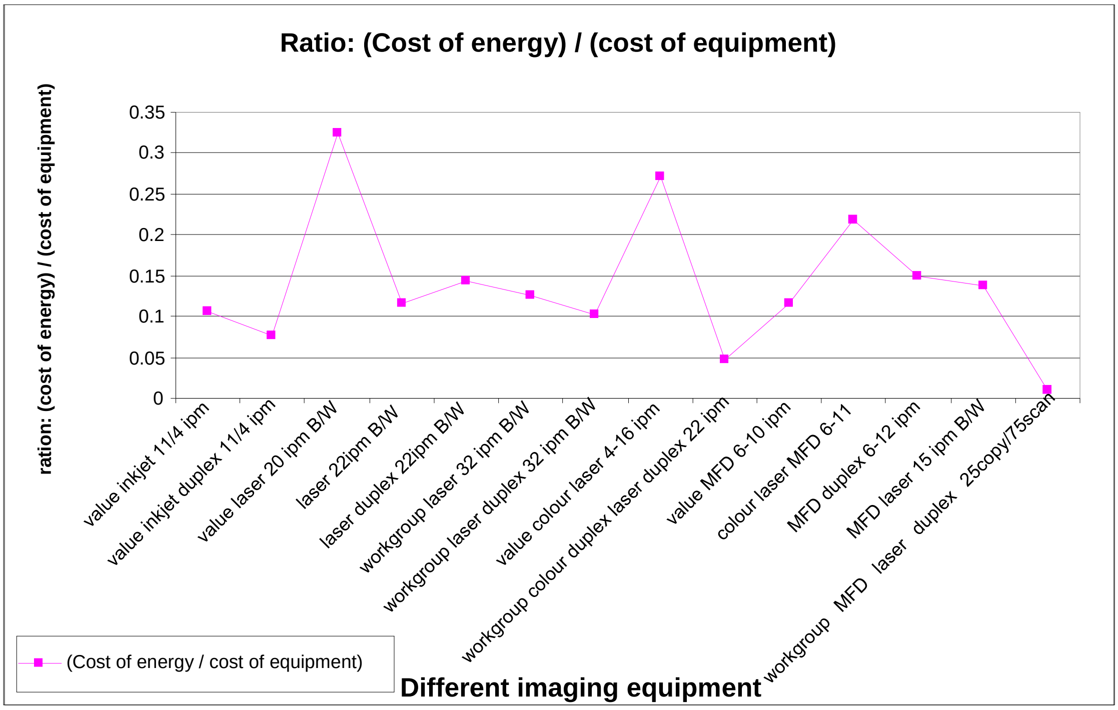

Figure 13: Comparison of the overall lifetime costs related to electricity consumption versus the purchase cost of the equipment.

Life time is modelled with the default assumptions undertaken in EU Energy Star costs calculator

Source: EU Energy Star calculator[31]:

[31] http://www.eu-energystar.org/en/en_009.shtml

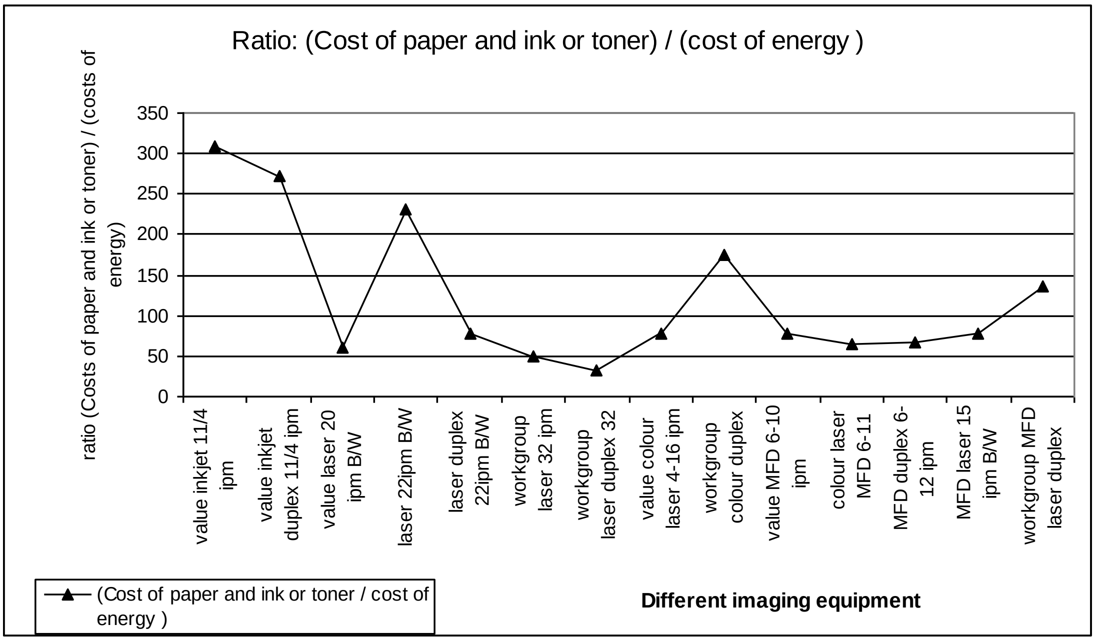

Figure 14: Comparison of the overall lifetime costs related to related to paper & ink or toner consumption versus electricity consumption.

(Life time is modelled with the default assumptions undertaken in EU Energy Star costs calculator)

Source: EU Energy Star calculator[31]

In conclusion, practical points in the comparison of the life cycle costs of the equipment are:

1. The costs related to the paper and ink or toner along the product life time is much higher than the costs related to the energy consumed or the product purchase (see 6). Therefore, the potential of the overall costs reduction via the purchase of ink or toner cartridges of lower price is crucial.
2. The price per printout is also a cost that varies significantly among the different devices (see Figure 11). This parameter is important to be taken into account.
3. The Watt consumption in different modes varies among different devices. For example, for the electrophotographic (laser) technology in the printing mode, an average of over 400 Watt can be expected, whereas in inkjet devices, the average can be as low as 15 Watt (values based on energy star toolbox calculator).
4. The situation is similar for the sleep mode. There are devices with a sleep mode consumption of 1 watt to 4 watt, others in the range of 7 to 15 Watt, whereas devices with sleep mode consumption of 40 Watt (3 to 10 times more than the previous ones) can also be found. More improvement can be expected because of upcoming Ecodesign requirements.

In Figure 14 we identify that the contribution to the overall life time cost of imaging equipment of paper and ink or toner cartridges related to energy consumption varies among the different imaging devices but in the most of the cases it is more than 50 times higher (hence, energy efficiency contributes less to cost reduction than paper management and low cost of cartridges).

7 PUBLIC PROCUREMENT NEEDS

The overall stock of imaging equipment in the EU was estimated to be around 145 million products[32] demonstrating the high relevance of this product group for the public procurers. The ratio of images produced at work and at home, is approximately 20 to 3. Additionally, the total number of images produced for work purposes by EP printers equals to 75 %, whereas the one generated by copiers is equivalent to 20 %. Consequently, it is assumed that the interest of public procurers will focus on printers, copiers, and multifunctional devices (MDF), as reflected in the EU GPP criteria scope and definition.

Furthermore, the most relevant characteristic of the unit for the public procurers are identified as follows:

1. Price;
2. Technical characteristic and features required for the intended application, such as, need for high speed devices, a certain quality of printouts, double printing, energy consumption, etc.
3. Service and maintenance.

As extensively analysed in the Chapter 3) energy and paper consumption contribute to most environmental and financial impacts along the product's life cycle costs. Nevertheless, it should also be highlighted that these aspects are to a certain extent influenced by the end-user behaviour.

The criteria considered most important for this product group are:

- Paper management supporting functions,
- Energy efficiency,
- Resource efficiency for cartridges: Design for reuse of toner and/or ink cartridges.

[32] DG TREN Preparatory Studies for Eco-Design Requirements of EuPs. LOT 4. 'Imaging Equipment'. Final Report on Task 1 'Definition'. http://www.ecoimaging.org/doc/Lot4_T1_Final_Report_2007-11-12.pdf

8 VERIFICATION ISSUES

Verification of the GPP core and comprehensive criteria can be conducted using respective products certification, test reports, and/or supporting documents from manufacturers and/or supplier, where appropriately.

Growing environmental consciousness among both producers and consumers and increasing importance of sustainability in policy development at various levels contributes to increasing importance to establish in companies environmental management systems and/or to certify products with labels indicating preferable environmental performance.

The certification process for awarding a product with Type I Ecolabel consists of fulfilling a set of requirements developed for a specific product group. Assessment and verification used to check the compliance with the criteria are indicated for each criterion separately. Products awarded EU Ecolabel for Imaging Equipment are deemed to comply with GPP requirements. If GPP criteria are based on the other Type I Ecolabel, the compliance may be proved through demonstration of owning the relevant label, provided that this Ecolabel complies with given requirements. Otherwise, contracting authorities shall ask bidders to submit additional documents confirming compliance with the criteria.

Applicants usually have to submit to the awarding authority documents in form of declarations of compliance by the producer or by the supplier, technical and/or product safety sheets; laboratory tests results, etc.

The respective verification and assessment requirements are specified for each individual criterion in the final GPP criteria document for "Imaging Equipment"[33].

[33]http://ec.europa.eu/environment/gpp/pdf/criteria/imaging%20equipment.pdf

9 EXISTING ECOLABELS & GPP SCHEMES

The environmental product policy instruments applicable to the analysed product group in the EU-28 are: Ecolabel, Energy label, Green Public Procurement and Ecodesign. The Ecolabel and Green Public Procurement deal with products which show a higher environmental performance compared to the market average. They are voluntary instruments.

9.1 EU Ecolabel objective and requirements

The EU Ecolabel is introduced under Regulation (EC) of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel[34]. The EU Ecolabel scheme is part of the sustainable production and consumption policy of the Community that aims at promoting products with high level of environmental performance. Therefore, the EU Ecolabel criteria are based on the best products available on the market in terms of environmental performance throughout the life cycle. They target to correspond indicatively to the best 10 - 20 % of the products, and are required to be based on the latest scientific knowledge considering the whole life cycle of the products and taking into consideration the latest technological developments. Special importance is given to the avoidance of substances with inherent hazardous properties where this is technically feasible. The criteria should also be harmonised with existing legislation applicable to the product group when considering definitions, test methods and technical and administrative documentation. The EU Ecolabel criteria for imaging equipment were adopted in 2013 and published in Commission Decision (2013/806/EU)[35]. Criteria for awarding the EU Ecolabel to imaging equipment cover: Paper management, energy efficiency, indoor air emissions, noise emissions, substances and mixtures in imaging equipment, reuse, recycling and end-of-life management, ink and toner consumables and corporate criteria. The list of criteria is: 1) Availability of N-up printing 2) Duplex printing 3) Use of recycled paper, 4) Energy efficiency criteria, 5). Restriction on indoor emissions, 6) Noise emissions, 7) Excluded or limited substances and mixtures: (a) Hazardous substances and mixtures, (b) Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006, 8) Mercury in light sources, 9) Design for disassembly, 10) Design for recycling and/or reuse of toner and/or ink cartridges, 11) Toner and/or ink cartridge take-back requirement, 12) Substances in ink and toners, 13) Packaging, 14) Warranty, guarantee of repairs and supply of spare parts, 15) User information and 16) Information appearing on the EU Ecolabel

[34] O.J. L 27 30.1.2010 p.1
35 O.J. L. 353/53 28.12.2013

9.2 Overview of the existing Ecolabelling schemes

The information presented below is the summary of the extent analysis of the currently available Ecolabeling schemes applicable to the product group of imaging equipment[36].

The Ecolabels could be divided into two large groups: the European and the non-European Ecolabels. The overview of the products covered in the Ecolabeling schemes is summarized in Table 7.

The available European Ecolabel schemes are:

- Blue Angel from Germany,
- Nordic Swan from the Nordic countries,
- Umweltzeichen from Austria,
- TCO '99 from Sweden.

The Ecolabels from non-European countries are:

- EcoMark from Japan,
- EcoLogo CM from Canada,
- Korea Ecolabel,
- Environmental Choice Australia,
- Environmental Choice New Zealand,
- China Environmental United Certification Center HBC,
- Singapore Green Labelling scheme,
- Green Label Thailand,

The Nordic Swan and the Blue Angel are of high relevance as their criteria are partly or fully adopted by other national schemes. The Ecolabel criteria of Nordic Swan and Blue Angel are compliant with the standard norm EN ISO 14024[37] and thus could be used for applying the EU Ecolabel regulation in a shortened procedure regarding EC 66/2010, Annex I.B[34]. The Austrian Umweltzeichen criteria are in line with the Blue Angel requirements based on a bilateral agreement with Germany.

The Nordic Swan covers almost all imaging equipment product types (mailing machines are the only exception), and in addition covers related consumable products, i.e. reprocessed toner cartridges. On the other hand, Blue Angel Ecolabel criteria are restricted to the larger three product groups such as: copiers, printers and multifunctional devices. Between these two schemes the Ecolabel criteria for imaging equipment are harmonised. Reprocessed toner cartridges are also covered by Blue Angel; nevertheless these criteria are not harmonised with the respective ones of Nordic Swan.

Furthermore, it is of importance to mention that the criteria concerning energy consumption though harmonised are not identical between these two Ecolabel schemes. Blue Angel defines and determines threshold values using in house research whereas Nordic Swan gives two options. As to the first one, similarly to the majority of Ecolabel schemes, Nordic Swan refers to compliance with the Energy Star label requirement. Secondly, it refers to the harmonisation with Blue Angel requirements.

Another available European label ''TCO'99 for printers'' does focus on environmental aspects and its latest version is outdated (since 2005). Hence, the TCO'99 label is considered of rather limited importance.

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[36] See: http://susproc.jrc.ec.europa.eu/imaging-equipment/docs/Revised%20Technical%20Background_17May.pdf.

[37] EN ISO 14024 Environmental labels and declarations – Type I environmental labeling – Principles and procedures (BS ISO 14024:1999)

Regarding non-European Ecolabel schemes the ambitious level of the established criteria varies among the different countries. Of relevance for this study is the harmonization between Japanese EcoMark and the New Zealand's Environmental Choice criteria with the requirements introduced by Nordic Swan and Blue Angel. The EcoLogo of Canada, the EcoLabel of Korea as well as the other Asian Ecolabels (from China, Singapore, Taiwan and Thailand) criteria are based to a large extend on standards set by Blue Angel, Energy Star and in compliance with to EU regulations, i.e. RoHS. These criteria might be useful for specific issues as they could provide insight into areas which are not covered by the European labels.

With respect to the consumable parts of imaging equipment these items are less frequently covered than imaging equipment itself (fewer ecolabels on cartridges). It is important to emphasise that the reused cartridges are claimed to be more environmentally friendly compared with new ones thus there is not always found agreement if Ecolabelling of cartridges shall cover both new and reused products as this may in the end mislead consumers. It is important to note that regarding the criteria for consumable parts, the Austrian Umweltzeichen additionally covers reprocessed ink cartridges, while printing ink Ecolabels are covered under the Japan EcoMark and the Korean Ecolabel.

Besides the above described Ecolabels two other environmental schemes for imaging equipment are considered as being of relevance:

- IEEE 1680.2 Standard for Environmental Assessment of Imaging Equipment,
- Electronic Product Environmental Assessment Tool EPEAT.

IEEE standard constitutes a part of the 1680 Family of Standards, managed by the IEEE Standards Association (IEEE-SA), which is developed based on stakeholders' consultation. IEE 1680.2 consists of "environmental criteria and other materials which refer specially to imaging equipment devices" and it sets performance criteria for the design of these products. IEEE targets the product with leading environmental performance.

EPEAT is a scheme managed by the Green Electronics Council, a non-profit organization based in the USA, which sets criteria for design, production, energy use and recycling. EPEAT is developed through a stakeholder consensus process. It is a scheme which provides an environmental assessment tool for consumers. Products, depending on the performance, are then ranked as gold, silver or bronze.

Energy Star scheme which is a voluntary program to identify and promote energy–efficient products and buildings will be referred in Section 9.3.

Table 7: Overview of the products covered in the Ecolabeling schemes, the Ecodesign Preparatory Study and the Energy labels regarding the 'imaging equipment' product group

Products		Copiers	Printers	MFDs	Digital duplicators	Fax machines	Scanners	Mailing machines	Reprocessed toner cartridges	Reprocessed toner cartridges	Original toner cartridges	Printing ink
Ecodesign		X	X	X	X	X	X	X				
European Ecolabels	EU Ecolabel	X	X	X								
	Nordic Swan	X	X	X	X	X	X					
	Blue Angel (Germany)	X	X	X					X			
	Umwelt zeichen (Austria)	X	X	X					X	X		
	TCO (Sweden)		X									
Non-European Ecolabels	EcoLogo (Canada)	X	X	X		X		X	X			
	Env. Choice (Australia)	X	X	X		X	X					
	Env. Choice (N. Zealand)	X	X	X		X			X		X	
	Eco Mark (Japan)	X	X		X							X
	Eco Label (Korea)	X	X			X			X		X	X
	China Label		X			X						
	Green Mark (Taiwan)		X	X	X	X					X	
	Green Label (Singapore)		X	X		X						
	Green Label (Thailand)	X	X			X						
Energy label	Energy Star (US)	X	X	X	X	X	X	X				

9.3 Other GPP schemes and programmes

There are several country specific GPP (or Sustainable Public Procurement, according to the country in question) programs that address specifically imaging equipment, both intra and extra community. An indicative summary of the main features of some countries' GPP schemes is provided in Table 8.

This high number of GPP schemes indicates the high potential to reduce the environmental impact that public entities procurement practices can have both on account of the sheer volume of procured goods and services and on account of the capacity that public procurers have to influence market trends as key market players.

Some practically ubiquitous aspects can be identified in all programs, namely:

1) Paper consumption and energy efficiency are the main concerns. Under these aspects double side printing and energy consumption, both in use and standby modes, are particularly frequently addressed.
2) The programs refer mainly to printers (both laser – or electrophotographic – and inkjet) and photocopiers. There are cases that MDFs providing printing and copying functions are also covered under these schemes.

Additional conclusions that can be drawn from the analysis is summarised below:

1) Fax machines and scanners seem to attract far less attention than the previously mentioned products.
2) Second order concerns about sustainability for these kind of products include
   - Acceptance of recycled paper
   - Product design (including used materials, emissions and tonner and ink concerns)
   - Maintainability (e.g., spare parts availability and ease of maintenance)
   - End of life / Disposal / take back options
   - Packaging concerns
   - Noise

Table 8: Indicative summary of other GPP/SPP programmes. Not an exhaustive list.

Country	Products	Published documents	Key issues	More information
Austria	• Laser printers • Inkjet printers • Photocopiers	• Criteria doc.	• Paper consumption • Energy efficiency • Maintainability	http://www.nachhaltigebeschaffung.at
Belgium	• Printers • Photocopiers • Faxes • Scanners	• Criteria doc.	• Paper consumption (including acceptance of recycled paper) • Energy efficiency • Noise • Product design (including emissions) • Maintainability • Packaging	http://gidsvoorduurzameaankopen.be/fr
Canada	• Photocopiers and MFDs • Printers • Document scanners • Managed Print Solutions	• Scorecards: criteria doc.	• Paper consumption • Energy efficiency • Packaging • Disposal / Hardware take back • EMS • Manufacturer certifications	http://www.tpsgc-pwgsc.gc.ca/app-acq/index-eng.html
Denmark	• Photocopiers • Printers	• Background doc. • Criteria doc.	• Paper consumption • Energy efficiency • Product design (including emissions) • Maintainability	http://www.miljoevejledninger.dk/
Finland	• Photocopiers	• Criteria doc.	• Paper consumption (including acceptance of recycled paper) • Energy efficiency • Noise • Product design (including emissions) • Maintainability • Packaging	http://www.ymparisto.fi/en-US/Consumption_and_production/Public_procurement
France	• Photocopiers • Printers	• Etat Exemplaire: Criteria doc.	• Paper consumption • Energy efficiency • Noise • Packaging	http://www.developpement-durable.gouv.fr/Etat-exemplaire,34309.html
Germany	• MFDs • Laser printers • Inkjet printers • Photocopiers	• Tendering recommendation : Criteria doc.	• Paper consumption (including acceptance of recycled paper) • Energy efficiency • Product design (including tonner and ink) • Noise • Packaging • Maintainability	http://www.umweltbundesamt.de/themen/wirtschaft-konsum/umweltfreundliche-beschaffung
Hong-Kong	• Printers • MFDs • Scanners	• Criteria doc.	• Energy efficiency • Product design (including emissions)	http://www.epd.gov.hk/epd/english/how_help/green_procure/green_procure1.html
Japan	• Photocopiers • MFDs • Inkjet MFDs	• Criteria doc.	• Energy efficiency • Product design • Maintainability • Packaging	http://www.env.go.jp/en/laws/policy/green/
Netherlands	• Photocopiers	• Criteria doc.	• Paper consumption • Energy efficiency	http://www.senternovem.nl/mmfiles/

Country	Products	Published documents	Key issues	More information
Norway	• Photocopiers	• Criteria doc.	• Energy efficiency • Maintainability • Noise	http://anskaffelser.no/dokumenter/ikt-produkter-miljokriterier
UK	• Ink jet MFDs • Laser MFDs • Laser printers • Scanners	• Criteria doc.	• Paper consumption (including acceptance of recycled paper) • Energy efficiency • Maintainability • Product design • Noise	http://www.defra.gov.uk/sustainable/government/advice/public/buying/products/
US	• Copiers • Digital Duplicators • Fax Machines • Mailing Machines • MFDs • Printers • Scanners	• Criteria doc.	• Energy efficiency • Product design (Consumables and emissions) • End of life • EMS • Packaging	http://www.gsa.gov/portal/category/26433?utm_source=OCM&utm_medium=print-radio&utm_term=HP_13_SpecialTopics_gogreen&utm_campaign=shortcuts and http://www.epeat.net/resources/criteria/

10 RELEVANT EUROPEAN LEGISLATION AND POLICIES

This section gives an overview of the European legislation and policies of the main relevance to the product group "Imaging Equipment".

10.1 Ecodesign

Ecodesign aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle: Directive 2009/125/EC of 21 October 2009 establishes a framework for the setting of ecodesign requirements for energy-related products[38].

A product shall be covered by Ecodesign implementing measures when it represents a significant volume of sales and trade, indicatively more than 200.000 units a year within the Community[38].

10.1.1 Ecodesign for imaging equipment

The Ecodesign Preparatory study for imaging equipment proposes implementing measures for short term application regarding the energy consumption based on the Energy Star Tier 1 criteria. From a medium term perspective two approaches are investigated within the course of this study. The first is to determine energy requirements based on a correction factor applied to the updated thresholds of the Energy Star criteria. The second considers setting the threshold values on newly developed and uniformly agreed terms and measurements on standby[39].

After finalising the preparatory study on imaging equipment, the industrial voluntary agreement was worked out in line with the Recitals 18-20 and Annex VIII as being acceptable alternatives to implementing measures in the context of the framework Ecodesign Directive 2009/125/EC. The Report from the Commission to the European Parliament and the Council on the voluntary ecodesign scheme for imaging equipment was published on January, 2013[40]. The agreement covers printers, copiers, multifunctional devices and fax machines. Accordingly, each signatory undertook that at least 90 % of all imaging equipment models it places on the market would comply with the minimum efficiency requirements in terms of TEC (typical energy consumption) and OM (operational mode). Furthermore, all printing products should offer the ‘N-up printing’ capability as a standard feature and should comply with the requirements for cartridges (e.g. the design should not prevent the reuse/recycling and use of cartridges of other producers). All new products should also comply with the requirements for recycling (e.g. easy disassembly and marking of plastics). Finally, the signatories undertook to comply with the specific information requirements (e.g. information on resource and energy efficiency).

[38] O.J. L 285. 31.10.2009. p. 10

[39] DG ENER Preparatory Studies for Eco-Design Requirements of ErPs. Lot 26 Networked standby losses project homepage: http://www.ecostandby.org/documents.php, accessed on 7th October 2010

[40] COM(2013) 23 final

10.1.2 Standby and Off-mode Regulation

Commission Regulation (EC) No 1275/2008[41] of 17 December 2008 implements 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. According to the point (8) of the Regulation, its application should be limited to products corresponding to household and office equipment intended for use in the domestic environment, which, for information technology equipment, corresponds to class B equipment as set out in EN 55022:2006. The requirements introduced by Regulation are considered relevant to the current study.

Stage 2 of the Regulation is applicable for products placed on the market after 7th January 2013, and requires lower power consumption for standby- and off-mode compared to Stage 1 as summarized in Table 9. In addition, the unit should be accommodated with power management or similar function that automatically switches the product into either standby or off-mode or another low energy mode satisfying stricter maximum energy consumption levels, except where all these functions are considered inappropriate for the intended use of the product.

Table 9: Requirements for energy consumption in standby and off-mode according to Commission Regulation (EC) No 1275/2008

Mode	Stage 1 (as of January 7, 2010)	Stage 2 (as of January 7, 2013)
Off-mode	1.00 W	0.50 W
Standby mode without display	1.00 W	0.50 W
Standby mode with display	2.00 W	1.00 W

On 22 August 2013 the European Commission adopted Regulation (EU) No 801/2013[42] amending Regulation (EC) 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment. Article 1 of the Regulation 801/2013 introduces the modification of Regulation 1275/2008 which is relevant to networked electrical and electronic household and networked office equipment (hence covering imaging equipment). The main requirements for networked equipment relevant for the analysed product group include:

- Possibility of deactivating wireless network connections (as of 1 January 2015)
- Power management for networked equipment (as of 1 January 2015)
- Compliance with standby mode(s) requirements, if any stand-by mode, for all networked equipment and networked televisions,
    - when all network ports are deactivated (as of 1 January 2015)
    - when all wired network ports are disconnected and when all wireless network ports are deactivated (as of 1 January 2017)
- Compliance with power management requirements for networked equipment other than HiNA* equipment,
    - when all network ports are deactivated (as of 1 January 2015)

[41] O.J. L 339 18.12.2008 p. 45
[42] O.J. L 225 28.8.2013 p.1

- when all wired network ports are disconnected and when all wireless network ports are deactivated (as of 1 January 2017)

- Product information requirements on manufacturer's freely accessible websites for networked equipment except for networked televisions (as of 1 January 2015)

Regarding power consumption in a condition providing networked standby:

- HiNA: *Stage 1: 12W (as of 1 January 2015)*
  Stage 2: 8W (as of 1 January 2017)
- Equipment other than HiNA
  Stage 1: 6 W (as of 1 January 2015)
  Stage 2: 3W (as of 1 January 2017)
  Stage 3 2W (as of 1January 2019)

The basis of setting the above requirements was built up on the preparatory work of Lot 26 Ecodesign Preparatory study. During the consultation with manufacturers in the background paper of Digital Europe generic figures on market availability of products with various network standby energy consumption were presented[43]. Based on these figures approximately 25 % of the market share of equipment with HiNA functionality operates at the level equal to or lower than 4 Watt, while 20 % of the market – with energy consumption in standby mode equal to or lower than 3 Watt. Moreover, the market share for products without HiNA functionality that perform equal or lower to 2 Watt is 40%, whereas in the case of 1.5 Watt.it is 30%.

[43] Digital Europe, Background paper on printers: consequences of the proposals for imaging equipment 18 October 2011
http://www.digitaleurope.org/Portals/0/Documents/ENV/EcoDesign/Lot26/Background%20paper%20printers%20on%20DE%20Lot%2026%20position%2018102011.pdf

10.2 Energy Labelling Directive

Directive 2010/30/EU[44] of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products amends the European Energy Labelling Directive (ELD) approved by the European Council in September 1992 (92/75/EEC). The Directive establishes the framework for the setting of an energy label for household appliances. The primary goal of the programme is to persuade consumers to buy more energy-efficient products by giving them information to help them readily identify the best performing models. At present the EU energy labelling of imaging equipment uses the label of Energy Star as agreed bilaterally between EU and US (see section 10.3).

[44] OJ L 153, 18.6.2010, p. 1

10.3 Energy Star labelling programme for imaging equipment

The European Energy Star Programme is a voluntary energy labelling programme for office equipment. The Energy Star logo helps consumers identify office equipment products that save energy and money. Manufacturers, assemblers, exporters, importers and retailers willing to place the Energy Star label on products meeting or exceeding energy-efficiency guidelines are invited to register with the European Commission.

The Communication from the Commission on the implementation of the ENERGY STAR programme in the European Union in the period 2006 – 2010[45] concludes that the Energy Star programme in the European Union is successful. It specifies that '*The dynamism and voluntary nature of Energy Star make it a policy tool particularly well suited for ICT products*'. It illustrates this by showing the estimated impact of Energy Star on the estimated electricity consumption reduction of the installed base of computers, displays and imaging equipment in the EU by more than 30 % by 2020. Furthermore, COM(2011)337 specifies that *the penetration of Energy Star models has grown faster in some product areas than others. It has typically been high in the monitor and imaging equipment products market where Energy Star model penetration is generally high.*

The Energy Star programme adapted to a new agreement[46] between the Government of the United States of America and the European Union on the coordination of energy-efficiency labelling programmes for office equipment is implemented under the Regulation (EU) No 174/2013[47] of the European Parliament and of the Council of 5 February 2013 amending Regulation (EC) No 106/2008[48] which was the recast of Regulation (EC) No 2422/2001.

According to the Regulation, the Energy Star shall be coordinated, as appropriate, with other Union labelling schemes such as, in particular, the EU Ecolabel, established by Regulation (EC) No 66/2010[49]; the indication established by Energy Labelling Directive 2010/30/EU[50], and measures implementing Ecodesign Directive 2009/125/EC[51].

In line with revised Article 6 and 7 of the Regulation (EU) No 174/2013, central government authorities, the European Commission and the other Union institutions shall specify energy-efficiency requirements not less demanding than the Common Specifications listed in Annex C of the Agreement 2013/107/EU[52], and, as determined by Article 11 of the Regulation, subjected to the technical revision. Contracting authorities at regional and local level shall be encouraged by Member States to use those requirements.

The latest version of criteria for the Energy Star Requirements for Imaging Equipment is version 2.0[53]. Based on data analysis on EU Energy Star board level (see Section 12.2) commercial (TEC and some OM) imaging equipment models that meet the Energy Star Version 2.0 requirements are on average 44 % more energy efficient than conventional models[54]..

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[45] COM(2011)337

[46] international Agreements 2013/107/EU

[47] O.J. L 63 6.3.2013 p.1

[48] O.J. L 39 13.2.2008 p. 1

[49] OJ L 27, 30.1.2010, p. 1

[50] OJ L 153, 18.6.2010, p. 1

[51] OJ L 285, 31.10.2009, p. 10

[52] OJ L 63 6.3.2013. p.5-81

[53] ENERGY STAR. Program Requirements for Imaging Equipment Eligibility Criteria Version 2.0 http://www.energystar.gov/products/specs/sites/products/files/Final%20Version%202 %200 %20Imaging%20Equipment%20Program%20Requirements%20Jun-2013.pdf from June 26, 2013.

[54] Calculation based on the data obtained from ENERGY STAR Final Version 2.0 Imaging Equipment Savings Analysis March 2013

Energy Star is the most used label worldwide in this area with up to 4 443 imaging equipment qualified products available in the EU[55], more precisely: 2 244 multifunctional device, 1 256 printers, and 666 scanners. 186 copiers, 58 digital duplicators, 23 fax machines, 10 mailing machines. The Energy Star criteria focus on different requirements, among them: typical electricity consumption (TEC), operational mode (OM) and digital front end (DFE). The typical energy consumption (TEC) can be measured following the guidelines given in the respective test standard. Regarding the operational mode there is also a respective standard established together with the standard regarding the test conditions.

The energy-efficiency labelling programme complements measures taken in the context of Directive 2005/32/EC on ecodesign requirements for energy-using products. It is therefore necessary to ensure consistency and coordination between the Energy Star programme and the ecodesign scheme.

[55] http://www.eu-energystar.org/en/database.shtml (last access January, 2014)

10.4 Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

The European chemicals Regulation REACH 1907/2006/EC[56] entered into force on 1st of June 2007. Under the REACH Regulation, certain substances that may have serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHCs). The identified substance is added to the Candidate List, which includes candidate substances for possible inclusion in the Authorisation List (Annex XIV). Those SVHC, that are included in Annex XIV become finally subject to authorisation. By this procedure REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible.

In this regard, REACH also introduced new obligations concerning general information requirements on substances in articles. Producers and importers of articles that contain substances of very high concern (SVHC) included in the candidate list, will be required to notify these to the Agency (ECHA) if both of the following conditions are met:

- The substance is present in those articles in quantities totalling over 1 t/y per producer or importer;
- The substance is present in those articles above a concentration of 0.1 % weight by weight (w/w).

Notification will not be required in case the SVHC has already been registered for this use by any other registrant (Article 7(6)), or exposure to humans or environment can be excluded (Article 7(3)).

In addition, Article 33(1) requires producers and importers of articles containing more than 0.1 % w/w of an SVHC included in the candidate list, to provide sufficient information to allow safe handling and use of the article to its recipients. As a minimum, the name of the substance is to be communicated.

The provisions of Article 33(1) apply regardless of the total amount of the SVHC used by that actor (no tonnage threshold) and regardless of a registration of that use. Furthermore, this information has to be communicated to consumers, on request, free of charge and within 45 days (Article 33(2)).

[56] OJ L 396 30.12.2006. p. 1

10.5 Classification, labelling and packaging of substances and mixtures Regulation (CLP)

The Regulation (EC) No 1272/2008[57] of the European Parliament and the Council of 16 December 2008 on the classification and packaging of substances and mixtures entered into force on 20 January 2009.

The purpose of the so called CLP-Regulation is to identify hazardous chemicals and to inform their users about particular threats with the help of standard symbols and phrases on the packaging labels and through safety data sheets. The purpose of the globally harmonised system (UN-GHS) is to make the level of protection of human health and the environment more uniform, transparent and comparable as well as to simplify free movement of chemical substances, mixtures and certain specific articles.

Substances had to be classified until 1 December 2010 pursuant to Directive 67/548/EEC and preparations until 1 June 2015 pursuant to Directive 1999/45/EC. Differing from this provision, the classification, labelling and packaging of substances and mixtures could already be used before 1 June 2015 in accordance with the provisions of the CLP-Regulation.

[57] OJ L 353 31.12.2008 p.1

10.6 Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2011/65/EU[58] (commonly referred to as the RoHS-Directive) restricts the use of six hazardous substances in electrical and electronic equipment to be sold in the EU. The Directive 2011/65/EU replaces Directive 2002/95/EC, which entered into force on 1st July 2006. The RoHS-Directive covers the following substances:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ether (PDBE)

The RoHS-Directive limits the use of these substances to concentrations not exceeding 0.1 % by weight of homogenous material. For Cadmium the threshold level is at 0.01 %. Exemptions from these provisions are only possible if at least one of the following reasons applies:

- Substitution is not possible from a scientific and technical point of view;
- The negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the benefits;
- The reliability of substitutes is not ensured.

Applications for exemptions have to be submitted to the European Commission and require a justification including comprehensive information on the substance-application and possible substitutes. All applications undergo a technical analysis as well as a stakeholder consultation.

[58] OJ L 174 1.7.2011 p. 88

10.7 Waste electrical and electronic equipment Directive (WEEE)

The Directive on waste electrical and electronic equipment (WEEE) 2012/19/EU[59] (commonly referred to as WEEE-Directive) regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment. Directive 2012/19/EU replaces Directive 2002/96/EC of 27 January 2003, which entered into force on 1st of July 2006. The WEEE-Directive classifies EEE in various categories. In this system, Imaging equipment forms part of category 3 “IT and telecommunications equipment".

Amongst others, Directive 2012/19/EU requires Member States to achieve quantitative recovery targets for different product categories, and to ensure that producers provide for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE (Article 12). More precisely, according to Annex V of the Directive, the recovery targets for imaging equipment are: 75 % for recovery and 65 % for recycling. From 15th of August 2015, these targets will be raised to 80 % for recovery and 70 % for recycling.

Furthermore, Annex VII of the Directive specifies substances, mixtures and components that have to be removed from any collected WEEE for selective treatment. Regarding imaging equipment , the following components are of particular relevance:

- Toner cartridges, liquid and paste, as well as colour toner,
- Batteries,
- Printed circuit boards of mobile phones generally, and of other devices if the surface of the printed circuit board is greater than 10 square centimetres,
- Plastic containing brominated flame retardants,
- External electric cables.

[59] OJ L 197 24.7.2012 p.33

11 EU GPP CRITERIA FOR IMAGING EQUIPMENT

The current EU GPP criteria have been built on the base of EU Ecolabel criteria for Imaging Equipment according to the Commission Decision 2013/806/EU[60]. Reference is also made to the Energy Star v.2.0 scheme[53] (or if applicable the most recent one).

Within the core and comprehensive criteria, specifications are proposed for the various stages of the procurement process as appropriate: selection criteria, and award criteria, as outlined in the following table and explained in more detail below.

- The core criteria are those suitable for use by any contracting authority across the Member States and address the key environmental impacts. They are designed to be used with minimum additional verification effort or cost increases, thus being characterized by a comparatively lower ambition level.
- The comprehensive criteria are for those who wish to purchase the best products available on the market being in line with EU Ecolabel criteria. These may require additional verification effort or a slight increase in cost compared to other products with the same functionality.

Table 10: Overview of the EU GPP criteria for imaging equipment together with key environmental aspects addressed

Criterion	Criterion type			Key area addressed
	Core	Comprehensive	Award	
Double side printing	X	X	X	Paper management
Multiple images on single sheet of paper	X	X		Paper management /Resource efficiency
Energy efficiency for the use mode	X	X	X	Energy efficiency
User instruction for green performance management	X	X		Environmental awareness
Energy efficiency in standby mode			X	Energy efficiency
Product longevity and warranty	X	X		Resource efficiency
Resource efficiency for cartridges	X	X		Resource efficiency

The detailed criteria set is given in a separate document "EU GPP Criteria for Imaging Equipment" available at http://ec.europa.eu/environment/gpp. A brief description of rationale for their setting, highlighting, where appropriate, differences between core and comprehensive requirements, is presented separately for every criterion in the following sub-chapters. Also a reference to the recently adopted (December 2013) EU Ecolabel for imaging equipment is made and indicating similarities as well as differences between both schemes. Finally, the environmental aspects and impacts analysed along the criteria revision and consultation process, which, due to various reasons, have not been addressed in the final criteria set are presented together with explanation for this decision.

Conclusions drawn from the analysis of the **key environmental impact areas (Chapter 5)** related to the product group of imaging equipment[61] substantiate the requirements proposed for the Green Public Procurement. The main environmental aspects addressed are:

[60] OJ L 353. 28.12.2013. p.53.
[61] see Chapter 5 Key Environmental Impacts for details.

- Paper management,
- Energy efficiency,
- Toner and Ink cartridges.

According to the LCAs of imaging equipment the key environmental impacts of this product group originate from the use phase, in particular the energy and paper consumption. Therefore, the use of GPP criteria is expected to result in respective savings generated mainly by introducing the criteria on energy efficiency and paper management, coupled by lengthening the lifetime of cartridges and product longevity and warranty to ensure resource efficiency and lifetime extension of the device.

Other environmental aspects, which could not be easily or not at all captured through LCA analysis, are described in Chapters 5.2 to 5.4. Feasibility of setting requirements for them in the framework of the GPP scheme is also briefly presented in Chapter 5.7.

In comparison with the EU Ecolabel for Imaging Equipment, the GPP criteria set no specific requirements on air and noise emissions and on excluded or limited substances and mixtures in order to adopt the requirements to the specific situation of public procurement, while still focussing on the main environmental impacts. The ambition level of the criteria is supported by the current state-of-the art and market situation for imaging equipment, analysed in Chapter 4. The imaging equipment should also be covered by 5 years warranty to ensure its longevity.

11.1 Criteria on paper management

The consumption of paper shows significant contribution to the overall environmental impact of this product group. The requirements that support the reduction of paper consumption for printing/copying activities are as follows:

- Criterion 1 – Double side printing and
- Criterion 2 – Multiple images on single sheet of paper

11.1.1 Criterion 1 – Double side printing

Double side printing (or so called **duplex printing**) requirement is proposed as **core and comprehensive criterion**. Imaging equipment shall be equipped with an automatic double-side print/copy unit. The duplex printing and/or copying function shall be set as default in the original software provided by the manufacturer.

The proposed formulation is based on the recently adopted EU Ecolabel criteria for imaging equipment[62]. Such a requirement is also found in all investigated Ecolabel schemes. Requirements on duplex printing are also addressed in the Energy Star label. The duplex printing function is considered to be very effective for the reduction of paper consumption, especially when it is set as a default mode.

For the EU Ecolabel criteria which targets the best 10-20 % environmental performing products a threshold of 19 ipm is proposed in this criterion[63]. Nevertheless, due to the currently still low market availability, the double-side printing criterion has been set as core and comprehensive one only for these imaging equipment that are capable to reach and/or exceed monochrome printing/copying speed of 25 images per minute for A4 size paper. In order to additionally reward manufacturers who offer duplex printing also for equipment with speed less than 25 images per minute analogous requirement was also established as a **comprehensive award criterion**.

11.1.2 Criterion 2 – Multiple images on single sheet of paper

For both **core and comprehensive** criteria imaging equipment shall offer as a standard feature the capability to print and/or copy two or more pages of a document on one sheet of paper when the product is managed by original software provided by the manufacturer (printer driver). This requirement is in line with EU Ecolabel criteria for imaging equipment.

Such a printing function is considered to be very effective for the reduction of paper consumption as the user has the opportunity to control and reduce the paper consumed based on his needs. It is advisable for public authorities to give employees a recommendation to use this function.

A requirement on multiple pages printing and/or copying in one paper sheet is included in the "Industry voluntary agreement for lot 4 Imaging Equipment"[64] with regard to the EU Ecodesign Directive 2005/32/EC for energy using products.

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[62] In the EU Ecolabel criteria called "Duplex printing".

[63] In the EU Ecolabel for imaging equipment additionally the following requirement is set: "For the devices receiving a printing order from a computer, a message should be formulated by the manufacturer and displayed on the computer screen of the user when the default setting is changed into one-side printing. The content of this message should highlight the fact that one-side printing mode will contribute to significantly higher environmental impacts than double-side printing".

[64] For more information please see: http://www.eceee.org/ecodesign/products/imaging_equipment.

11.1.3 Award Criterion 2 – Double side printing

The **award criterion** is established as the **comprehensive** criteria set in order to reward the manufacturers who offer in their tenders duplex printing function for imaging equipment with a maximum monochrome printing/copying speed of less than 25 images per minute for A4 size paper.

11.2 Criteria on energy efficiency

From the life cycle perspective, energy consumption in the use phase is, after paper usage, the next most important aspect of imaging equipment environmental performance. As already presented in Chapter 5 it is estimated that energy consumption in the use phase can account for approximately 2/3 of the total energy consumption during product lifetime (energy consumption related to paper use is not considered).

It is important to remember that electricity consumption in the use phase is dependent on the product design. It is a key aspect for the EU Ecolabel and GPP criteria. A requirement on energy efficiency was already included in the previous GPP criteria for IT office equipment[65].

Energy efficiency is also one of the main environmental goals set by the manufacturers. The development of the electronic sector is vast and the trend of producing more energy efficient products is very high.

Energy Star is considered the most successful energy label with a high number of applications and it is also the EU Energy label for the product group of imaging equipment. Therefore, as discussed along the consultation process, it is important to refer to the latest Energy Star version. For procurement by central government bodies, the purchase of equipment at least as efficient as set out under Energy Star is an obligation, thus it represents the minimum ambition level for the EU criteria.

In the current GPP proposal two criteria (**core and comprehensive**) regarding energy efficiency are proposed: the first one – regarding the use mode and the second one – regarding the standby mode. Additionally, one **award criterion** on energy efficiency in the use phase is proposed for manufacturers who achieve even more ambitious level.

11.2.1 Criterion 3 – Energy efficiency for use mode

Based on the above written, the following requirement is proposed for both – core and comprehensive criteria set: The energy consumption in the use mode of the product shall fulfil as a minimum the energy efficiency requirements of Energy Star v.2.0 criteria for imaging equipment. This version of Energy Star, published in 2013, is the most recent version of the Energy Star label.

11.2.2 Award Criterion 1 – Higher Energy Efficiency in use mode

As the innovation cycle of the product regarding the energy efficiency is very short it is considered that products with higher efficiency than the one of Energy Star 2.0 should be rewarded. With this in mind, **core and comprehensive award criteria** are proposed in which additional points will be given to the tenderer for providing better performing products.

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65 Previous version of GPP criteria for IT office equipment covered also imaging equipment devices (See: http://ec.europa.eu/environment/gpp/pdf/toolkit/office_IT_equipment_GPP_product_sheet.pdf) .

Points should be awarded for every 5 % of lower energy consumption than specified in the technical specifications for the use mode measured according to the Test Method for Determining Imaging Equipment Energy Use Version 2.0.

11.2.3 Award Criterion 3 – Energy efficiency in standby mode

The implementing measures on network standy-by under Ecodesign Directive 2009/125/EC[66] set out, for the future, limitations on energy consumption in standby mode (see Section 10.1.2). While the (more ambitious) Ecolabel criteria have included these values in the final set of the GPP criteria high energy efficiency in this field is proposed as an criterion in order to give highly efficient products an advantage without limiting competition too much.

11.3 Criterion 4 – User instructions for green performance management

Criteria related to information for the user are very important as they raise the user environmental awareness and subsequent behaviour. It happens very often that the product has functions which could reduce significantly the overall environmental impacts of the device during its use; the user however is not always aware of the "green" features of the device and therefore may not apply them.

The current formulation (for both **core and comprehensive** criteria) is based on similar Ecolabel criteria. It requires that a guide shall be provided with instructions on how to maximise the environmental performance of the particular imaging equipment (covering paper management functions, energy efficiency functions and of any consumables such as ink and/or toner cartridges). It can be provided in written form as a specific part of the user manual and/or in digital form accessible via the manufacturer's website.

11.4 Criterion 5 – Product longevity and warranty

It is required in both **core and comprehensive** criteria that repair or replacement of the product shall be covered by the warranty terms for minimum five years. Moreover, the tenderer shall further ensure that genuine or equivalent spare parts are available for at least five years from the date of purchase.

If a product has a shorter lifetime, especially because there are no spare parts, then this has also environmental implications as this contributes to increased environmental impacts associated to the production and manufacturing as well as directly to the category of resource depletion.

11.5 Criterion 6 – Resource efficiency for cartridges: Design for reuse of toner and/or ink cartridges

This criterion addresses the area of reuse of cartridges. Reuse of cartridges is resource efficient but can be also associated with economic benefits as the price of reused items is generally lower than the price of new ones. This can be of special importance as in the

[66] For details see section in Chapter 10.1.2 on standby losses implementing measures.

analysis of cost consideration for this product group the life cycle costs for the procurers are strongly influenced by the cost of inks/toners.

The aim of this criterion is to facilitate reuse and recycling of materials (thus reducing in this way the amount of new resources which have to be used if the waste materials are not recovered) and to give the incentive to manufacturers to design their products in this way.

The reference point for this criterion is the respective requirement set in the EU Ecolabel criteria proposal. Main outcomes of the consultation with manufacturers and ink or toners remanufacturers (questionnaire feedback), which allow a better insight in the importance of this criterion, are given below:

- with regard to cartridge waste volumes and reuse rates of cartridges, stakeholders suggest that:
  - 300-500 million ink cartridges and 10-20 million toner cartridges are annually sold in the EU-27;
  - an estimated 20 % (at least) of these cartridges are reused.
  - A few OEM producers are involved in remanufacturing activities whereas many are involved in recycling activities;
  - It is estimated that in total volume per year the 40 -70 % of the cartridges end up in landfills and/or incinerators.
- with regard to the cartridge reuse circles stakeholders suggest that:
  - It is estimated that ink and toner cartridges can be reused at least once but on average 2-3 times, and printing quality remains sufficiently good at this level of reuse;
  - Toner cartridges can be remanufactured more easily than ink cartridges and there are examples of even up to 25 reuse cycles;
  - Some parts break down easier and have to be changed in the remanufacturing process;
  - The number of reuse circles depends on the model and the condition of the collection of the cartridge.
- with regard to parameters affecting the cartridge reuse cycles stakeholders suggest that:
  - This is a very complex area and there are several parameters affecting the reuse of the cartridge which vary based on the type and model of the cartridge. In cases of remanufacturing of OEM cartridges via cartridge return programs there are obviously no problems. However, for cartridge remanufacturing by third parties the identified technical parameters (which can limit/influence this process) are as follows:
    - presence of clever/killer/smart chips;
    - design features that hamper remanufacturing i.e. welding, glue, blind screws or conjoined parts to fit cartridge-parts together;
    - weaker print heads.

In conclusion, the potential for achieving environmental savings and resource conservation via reusing cartridges is high as the majority of them are disposed after the first use. Reuse has either better or equal environmental benefits as recycling, thus it shall be prioritised as an option. This is in line with the waste management hierarchy and with priorities set in the MS Ecolabel criteria for imaging equipment and for remanufactured cartridges.

Hence, in the current **core and comprehensive criteria** it is proposed to support design of the cartridges for reuse. Freedom given to the designer on how to achieve this goal is considered of importance as no eco-innovation shall be hampered.

12 APPENDIX

12.1 Information tables for indoor air emissions

Table 11: Review of reported data on indoor air emissions of laser, inkjet printers and MFDs

Chemical	Laser printers([a,b])		Ink-jet printers([a])		All-in-one office machines([a])	
	Chamber concentration (ppbv)		Chamber concentration (ppbv)		Chamber concentration (ppbv)	
	Idle	In operation	Idle	In operation	Idle	In operation
VOCs						
Freon 12	0.48—0.52	0.61—0.66	0.36	0.43	0.3	0.45
Methyl chloride	0.53—0.60	0.71—0.82	0.48	0.55	0.52	0.62
Freon 11	0.24—0.29	0.25—0.28	0.23	0.24	nd.	0.27
Methylene chloride	0.38—0.42	0.46—0.58	0.57	0.61	0.69	0.74
Chloroform	0.96—1.07	1.17—1.31	0.81	0.94	0.74	0.96
Benzene	0.52—0.57	0.77—0.84	0.42	0.41	0.52	0.52
Toluene	14—15	15—16	6.22	6.43	7.9	8.2
Tetrachloroethene			0.23	0.21	0.52	0.43
Ethylbenzene	1.4—2.1	2.0—3.0	1.2	1.26	1.5	1.6
m.p-Xylene	1.2	1.6—1.7	0.86	0.92	0.9	0.9
Styrene	2.7—4.0	3.2—5.3	1.14	1.43	1.2	1.9
o-Xylene	0.9—1.0	2.0—2.3	0.69	0.68	0.58	0.58
1,4-Dichlorobenzene			0.34	0.32	0.34	0.35
1,3-Dichlorobenzene			0.34	0.32	0.34	0.35
1,2-Dichlorobenzene			0.21	0.21	0.26	0.22
1,2,4-Trichlorobenzene			0.86	0.63	0.23	0.2
Hexachlorobutadiene			0.37	0.36	0.88	0.64
ΣVOC		300—1 400 (20—60m)				
Ozone						
Ozone		9—10 1—13 (20m)		5—6		6
Aerosol particles						
PM_{10}		65		20—38		41

When available, the duration of operation (min) is indicated in parenthesis.
([a])Lee et al. 2001, Characterization of VOCs,ozone, and PM10 emissions from office equipment in an environmental chamber. Building and Environment 36
([b]) Smola et al. 2002, Health hazards from laser printers? Gefahrstoffe Reinhaltung der Luft 62,

Source: Destaillats et.al.

Table 12: Review of reported data on indoor air emissions of copiers

	Emission rate (µg h^{-1} unit^{-1})	Chamber concentration (µgm^{-3})		Reference
		Idle	In operation	
VOCs				
Toluene	110—760			(a)
	540—2 000			(b)
Ethylbenzene	<50—28 000			(a)
	23 000—29 000			(b)
		4.1	552—608	(c)
m, p-Xylene	100—29 000			(a)
	22 000—29 000			(b)
		4.5	467—515	(c)
o-Xylene	<50—17 000			(a)
	12 000—15 000			(b)
Styrene	300—12 000			(a)
	6 300—8 400			(b)
Styrene+o-Xylene		3.1	354—390	(c)
Isopropylbenzene	150—160			(b)
n-Propylbenzene	<50—2 100			(a)
	360—460			(b)
		<0.4	7.8	(c)
Benzaldehyde	<100—3 800			(a)
	980—1 500			(b)
		1.3	25—26	(c)
α-Methylstyrene	<50—330			(a)
	500—730			(b)
		1.3	16—18	(c)
1,2,4-Trimethylhenene		0.6	3.6—4.2	(c)
ButylbenLene		<0.4	14—15	(c)
Acetophenone		1.6	11—13	(c)
Methoxyethylbenzene		0.9	6.6	(c)
C9-ester		<0.5	23	(c)
Butenylbenzene		1.1	28—37	(c)
n-Decane	<50—450			(a)
2-Ethyl-1-hexanol	130—14 000			(a)
Limonene	<50—1 100			(a)
n-Nonanal	1 100—3 900			(a)
n-Undecane	62—2 000			(a)
n-Dodecane	75—960			(a)
Formaldehyde	<500—2 600			(a)
	1 900—3 200			(b)
Acetaldehyde	<500—1 200			(a)
	510—1 300			(b)
Acetone	<100—2 800			(a)
Propionaldehyde	<100—260			(a)
2-Butanone	<100—380			(a)
	n.d.—600			
Butyraldehyde	<100—840			(a)
	n.d.—410			(b)
Valeraldehyde	<100—540			(a)
n-Hexanal	100—1 200			(a)
	n.d.—950			(b)
ΣVOC		49	1 630—1 900	(c)
Ozone				
Ozone	1 300—7 900			(a)
	1 700—3 000			(b)
Aerosol particles				
PM (respirable fraction)	1 420—2 950	6—11	19—22	(c)

(a) Leovic, K.W., Sheldon, L.S., Whitaker, D.A., Hetes, R.G., Calcagni, J.A., Baskir, J.N., Measurement of indoor air emissions from dry-process photocopy machines. Journal of Air and Waste Management Association 46, 1996

(b) Leovic, K., Whitaker, D., Northeim, C., Sheldon, L., Evaluation of a test method for measuring indoor air emissions from dry-process photocopiers. Journal of Air and Waste Management Association 48, 1998

(c) Brown, S.K.,. Assessment of pollutant emissions from dry process photocopiers. Indoor Air 9, 1999

Source: Destaillats et.al.]

Table 13: Recent investigations and findings in indoor air emissions from imaging equipment

Summary	Reference
Lee et al investigated different types of imaging equipment including fax machines, laser printers, inkjet printers, scanners and photocopiers. Several pollutants were analysed covering volatile organic compounds (VOCs), total VOCs, ozone and respirable particles (PM_{10}). The VOCs were further analysed and separated in fractions of toluene, ethylbenzene, m,p-xylene and styrene. The emissions varied from 0.2 to 7.0 μg/print.	S.C. Lee, Sanches Lam, Ho Kin Fai, "Characterization of VOCs, ozone, and PM10 emissions from office equipment in an environmental chamber", *Building and Environment*, 36, 2001
Naoki Kagi et al. in their study on laser and inkjet printers confirmed the emissions of VOCs, ozone and ultrafine particles. The results in this research confirmed an increase in the concentration of ozone from 1.5 to 1.6 ppb and ultrafine particle during printing. Especially for the case of around 50nm particles, particulate concentration increased greatly during printing. Styrene and ozone were detected from the laser printer and alcohols were detected from the inkjet printer. The concentrations on styrene and xylenes slightly increased to 200 – 3 000 mg/m^3 in the printing process for the laser printer. The source of styrene from the laser printer was the toner and the source of pentanol from the ink-jet printer was the ink.	Naoki Kagi, Shuji Fujii, Youhei Horiba, Norikazu Namiki, Yoshio Ohtani, Hitoshi Emi, Hajime Tamura, Yong Shik Kim, "Indoor air quality for chemical and ultrafine particle contaminants from printers", *Building and Environment*, 42, 2007
Antti J. Koivisto et al. in a recent study on ultrafine particle emissions from printing by simulating the indoor air conditions suggested that a print job increases ultrafine particle concentrations to a maximum of 2.6 x 10^5 cm^{-3}.	Antti J. Koivisto, Tareq Hussein , Raimo Niemelä, Timo Tuomi, Kaarle Hämeri, " Impact of particle emissions of new laser printers on modeled office room", *Atmospheric Environment,* 44, 2010
In the research of *Congron He et al* a positive correlation between the laser printer emissions of $PM_{2,5}$ and the temperature of the printer's roller was confirmed. Based on the results of this study which was carried out on 30 laser printers almost all printers were shown to be high particle number emitters (e.g. over 1.01 x10^{10} particle/min) and ozone while colour printing generated more $PM_{2,5}$ than monochrome printing.	Congrong He, Lidia Morawska, Hao Wang, Rohan Jayaratne, Peter McGarry, Graham Richard Johnson, Thor Bostrom, Julien Gonthier, Stephane Authemayou, Godwin Ayoko, "Quantification of the relationship between fuser roller temperature and laser printer emissions" *Journal of Aerosol Science,* 41, 2010

12.2 Energy savings calculation

The following calculations are input received by EU Energy Star Board and was conducted in the frame of the revision of Energy Star requirements for imaging equipment in 2013.

Facts & Sources

- 27 million electrophotographic (laser) and ink jet MFDs and printers to be shipped in 2014 [2013 IDC forecast]
- 0 copiers to be shipped in 2014 [2013 IDC forecast]
- 275 thousand scanners to be shipped in 2014 [2010 IDC forecast]
- Electric Rate (U.S. residential): $0.1151 / kWh [2012 ENERGY STAR Data Book]
- Electric Rate (U.S. commercial): $0.0997/ kWh [2012 ENERGY STAR Data Book]
- Emissions factor: 1.54 pounds CO_2E / kWh [2012 ENERGY STAR Data Book]

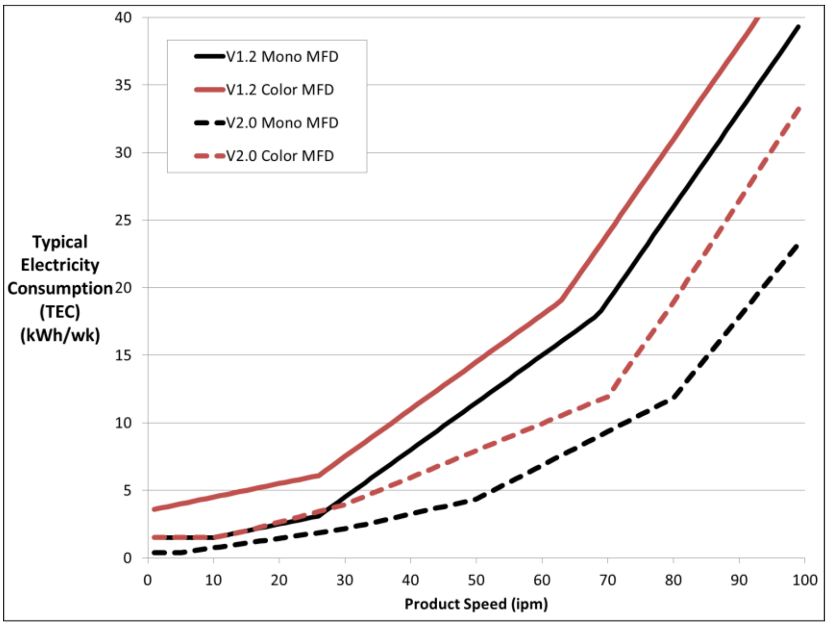

Figure 15: Comparison of Version 1.2 and Version 2.0 Sleep Mode Allowances for Typical Electricity Consumption (TEC) MFDs

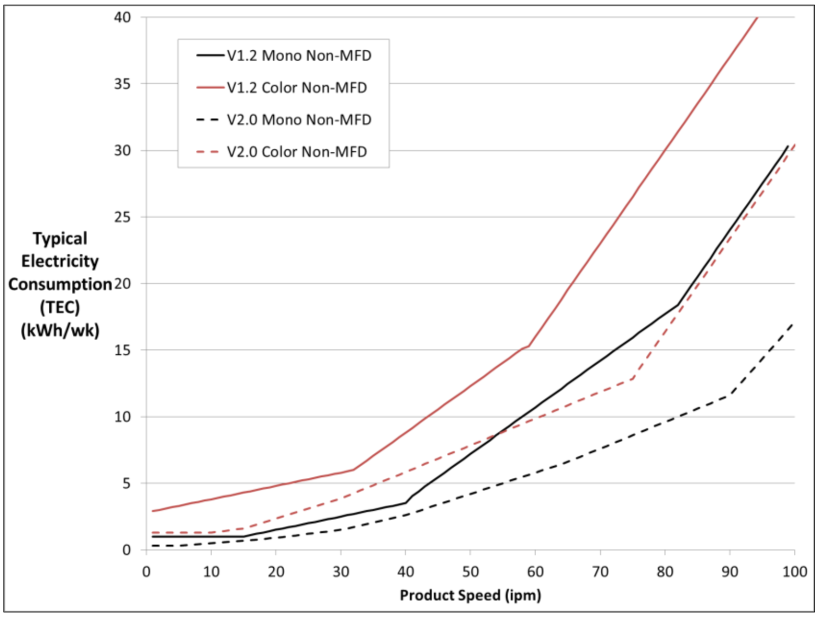

Figure 16: Comparison of Version 1.2 and Version 2.0 Sleep Mode Allowances for Typical Electricity Consumption (TEC) Non-MFDs

Table 14: Comparison of Version 1.2 and Version 2.0 Sleep Mode Allowances for Operational Mode (OM) Products

OM Category	Version 1.2 Base Allowance (W)	Final Draft Version 2.0 Base Allowance (W)	Percentage Decrease (%)
Standard Format IJ	1.4	0.6	-57%
Scanners	4.3	2.5	-42%
Standard Format Impact Printers	4.6	0.6	-87%
Mailing Machines	7	5	-29%
Small Format Printers	9	4	-56%
Large Non-ink Jet Printers	14	2.5	-82%
Large Ink Jet Printers and MFDs	15	4.9	-67%
Large Non-ink Jet MFDs and Copiers	30	8.2	-73%
Average			**-62%**

Table 15: Per-unit Energy Savings for Commercial Products

Color Capability	Size	Marking Technology	Product Type	Count of Non-ENERGY STAR V4.1 Models	Count of ENERGY STAR V4.1 Models	Annual Energy Consumption of Non-ENERGY STAR V4.1 Models (kWh/yr)	Annual Energy Consumption of ENERGY STAR V4.1 Models (kWh/yr)	Annual Unit Energy Savings of ENERGY STAR V4.1 Models (kWh/yr)
Mono	Std	Electro-photography (EP)	Printers	281	122	240	164	75
Mono	Std	Electro-photography (EP)	MFDs	533	380	301	173	128
Mono	Std	Electro-photography (EP)	Copiers	86	36	469	240	228
Mono	Std	Other	All	8	89	30	137	-107
Color	Std	Electro-photography (EP)	Printers	197	116	258	179	79
Color	Std	Electro-photography (EP)	MFDs	315	306	1,304	197	1,108
Color	Std	Electro-photography (EP)	Copiers	6	0	838	N/A	N/A
Both	Std	Impact	Printers	34	14	25	8	16
Both	All	All	Mailing Machines	34	11	35	20	15
Both	Sml	All	Printers	406	30	43	7	36
Both	Lrg	Non-ink Jet	Printers	40	21	46	10	36
Both	Lrg	Ink Jet	Printers & MFDs	87	38	59	20	39
Both	Lrg	Non-ink Jet	MFDs & Copiers	22	12	94	15	79
Color	Std	Other	All	32	15	652	485	167
Weighted Average						**441**	**174**	**267**
Total				**2,081**	**1,190**			

Assumptions:
Annual energy consumption for TEC products is TEC × 52 weeks
Annual energy consumption for OM products is Sleep Mode power for 12 hours/day + Off Mode power for 12 hours/day × 365 days

Table 16: National Energy, Cost, and Emissions Savings for Commercial Products — Simple Model

Color Capability	Size	Marking Technology	Product Type	Annual National Energy Savings of ENERGY STAR V2 Models (kWh/yr)	Annual National CO2 Savings of ENERGY STAR V2 Models (MMT CO2)	Annual National Electricity Cost Savings of ENERGY STAR V2 Models (2012 US$)
Mono	Std	Electro-photography (EP)	Printers	172,861,624	0.1	$17,234,304
Mono	Std	Electro-photography (EP)	MFDs	270,190,354	0.2	$26,937,978
Mono	Std	Electro-photography (EP)	Copiers	0	0	$0
Mono	Std	Other	All	N/A	N/A	N/A
Color	Std	Electro-photography (EP)	Printers	35,528,454	0.0	$3,542,187
Color	Std	Electro-photography (EP)	MFDs	1,076,850,076	0.8	$107,361,953
Color	Std	Electro-photography (EP)	Copiers	N/A	N/A	N/A
Both	Std	Impact	Printers	N/A	N/A	N/A
Both	All	All	Mailing Machines	N/A	N/A	N/A
Both	Sml	All	Printers	N/A	N/A	N/A
Both	Lrg	Non-ink Jet	Printers	N/A	N/A	N/A
Both	Lrg	Ink Jet	Printers & MFDs	N/A	N/A	N/A
Both	Lrg	Non-ink Jet	MFDs & Copiers	N/A	N/A	N/A
Color	Std	Other	All			
Weighted Average						
Total				**1,555,430,508**	**1.1**	**$155,076,422**

Assumptions:

- Shipments, where available, come from 2012 IDC U.S. Peripherals 2012–2016 Forecast and Analysis
- Copiers are forecast to have 0 shipments in 2014
- Electricity cost savings assume commercial rates
- Simple model calculates savings by multiplying unit savings by annual shipments

Table 17: National Energy, Cost, and Emissions Savings for Commercial Products— Complex Model

Color Capability	Size	Marking Technology	Product Type	Qualification Rate to Version 2.0	Assumed Qualification Rate at End of 2014	Annual National Energy Savings of ENERGY STAR V2 Models (kWh/yr)	Annual National CO2 Savings of ENERGY STAR V2 Models (MMT CO2)	Annual National Electricity Cost Savings of ENERGY STAR V2 Models (2012 US$)
Mono	Std	Electro-photography (EP)	Printers	30%	61%	52,330,318	0.04	$5,217,333
Mono	Std	Electro-photography (EP)	MFDs	42%	83%	112,456,007	0.08	$11,211,864
Mono	Std	Electro-photography (EP)	Copiers	30%	59%	0	0	$0
Mono	Std	Other	All	92%	100%	N/A	N/A	N/A
Color	Std	Electro-photography (EP)	Printers	37%	74%	13,167,095	0.01	$1,312,759
Color	Std	Electro-photography (EP)	MFDs	49%	99%	530,621,777	0.37	$52,902,991
Color	Std	Electro-photography (EP)	Copiers	0%	0%	N/A	N/A	N/A
Both	Std	Impact	Printers	29%	58%	N/A	N/A	N/A
Both	All	All	Mailing Machines	24%	49%	N/A	N/A	N/A
Both	Sml	All	Printers	7%	14%	N/A	N/A	N/A
Both	Lrg	Non-ink Jet	Printers	34%	69%	N/A	N/A	N/A
Both	Lrg	Ink Jet	Printers & MFDs	30%	61%	N/A	N/A	N/A
Both	Lrg	Non-ink Jet	MFDs & Copiers	35%	71%	N/A	N/A	N/A
Color	Std	Other	All	32%	64%	N/A	N/A	N/A
Weighted Average				**38%**	**76%**			
Total						**708,575,197**	**0.49**	**$70,644,947**

Assumptions:

- Complex model calculates savings by assuming that qualification rate doubles by end of 2014, and multiplying the difference in qualification rates by 2014 shipments.

Table 18: Per-unit Energy Savings for Residential Products

Color Capability	Size	Marking Technology	Product Type	Count of Non-ENERGY STAR V4.1 Models	Count of ENERGY STAR V4.1 Models	Annual Energy Consumption of Non-ENERGY STAR V4.1 Models (kWh/yr)	Annual Energy Consumption of ENERGY STAR V4.1 Models (kWh/yr)	Annual Unit Energy Savings of ENERGY STAR V4.1 Models (kWh/yr)
Both	Std	Ink Jet	Printers	77	47	12	8	4
Both	Std	Ink Jet	MFDs	149	94	18	8	10
Both	All	N/A	Scanners	170	81	18	9	9
Weighted Average						**17**	**8**	**9**
Total				**396**	**222**			

Assumptions:

- Annual energy consumption for OM products is Sleep Mode power for 12 hours/day + Off Mode power for 12 hours/day × 365 days

Table 19: National Energy, Cost, and Emissions Savings for Residential Products

Color Capability	Size	Marking Technology	Product Type	Annual National Energy Savings of ENERGY STAR V2 Models (kWh/yr)	Annual National CO2 Savings of ENERGY STAR V2 Models (MMT CO2)	Annual National Electricity Cost Savings of ENERGY STAR V2 Models (2012 US$)
Both	Std	Ink Jet	Printers	5,398,949	0.004	$621,419
Both	Std	Ink Jet	MFDs	195,772,361	0.137	$22,533,399
Both	All	N/A	Scanners	2,516,223	0.002	$289,617
Weighted Average						
Total				**203,687,534**	**0.142**	**$23,444,435**

Assumptions:

- Shipments, where available, come from 2012 IDC U.S. Peripherals 2012 – 2016 Forecast and Analysis and 2010 IDC U.S. Flatbed Scanner 2010–2014 Forecast
- Electricity cost savings assume residential rates
- Simple model calculates savings by multiplying unit savings by annual shipments

Table 20: National Energy, Cost, and Emissions Savings for Residential Products

Color Capability	Size	Marking Technology	Product Type	Qualification Rate to Version 2.0	Assumed Qualification Rate at End of 2014	Annual National Energy Savings of ENERGY STAR V2 Models (kWh/yr)	Annual National CO2 Savings of ENERGY STAR V2 Models (MMT CO2)	Annual National Electricity Cost Savings of ENERGY STAR V2 Models (2012 US$)
Both	Std	Ink Jet	Printers	38%	76%	2,046,376	0.001	$235,538
Both	Std	Ink Jet	MFDs	39%	77%	75,730,872	0.053	$8,716,623
Both	All	N/A	Scanners	32%	65%	812,008	0.001	$93,462
Weighted Average				**39%**	**77%**			
Total						**78,589,256**	**0.055**	**$9,045,623**

Assumptions:
- Complex model calculates savings by assuming that qualification rate doubles by end of 2014, and multiplying the difference in qualification rates by 2014 shipments.

General conclusions:

-Residential (some OM) Imaging Equipment models that meet the proposed ENERGY STAR Version 2.0 requirements are on average 55 percent more energy efficient than conventional models.

-Commercial (TEC and some OM) Imaging Equipment models that meet the proposed ENERGY STAR Version 2.0 requirements are on average 44 percent more energy efficient than conventional models.

-If all Imaging Equipment sold in the United States in a year met the new ENERGY STAR requirements, Americans would save over $1.7 billion in electricity costs while reducing annual greenhouse gas emissions equivalent to those of more than 240 thousand cars.

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Abstract
The report proposes and substantiates the EU Green Public Procurement criteria for the product group of 'Imaging Equipment". Green Public Procurement criteria allow public authorities to integrate environmental aspects in their purchasing decisions. The report contains the criteria proposal itself, the underlying scientific evidence regarding the environmental impacts of imaging equipment, and it describes the most important European legislation and labelling schemes relevant for this product group. Discussions with stakeholders from industry, NGOs and Member States have supported the development of the criteria. These contributions are also reflected in the analysis presented in this report.

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