Ecodesign preparatory study for product specific measures on scarce, environmentally relevant and critical raw materials and on recycled content

Final Study Report

Phase 2: Preparatory Study

Imaging Equipment

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Acronyms

A	Allocation factor in the CFF
ABS	Acrylonitrile butadiene styrene
AEC	Annual Electricity Consumption
Ag	Silver
Au	Gold
BoM	Bill of Materials
CFF	Circular Footprint Formula
CR	Commission Regulation
CRM	Critical Raw Material
CRMA	Critical Raw Materials Act
Cu	Copper
EC	European Commission
EEE	Electric and Electronic Equipment
EEI	Energy Efficiency Index
EIA	Ecodesign Impact Accounting
EFSA	European Food Safety Authority
EoL	End-of-Life
EPR	Extended Producer Responsibility
EPREL	European Product Registry for Energy Labelling
Erec	Environmental impact of recycled raw material
ERT	EcoReportTool
ESPR	Ecodesign for Sustainable Products Regulation
Ev	Environmental impact of virgin raw material
FCA	Food Contact Article
FCM	Food Contact Material
GMP	Good Manufacturing Practice
GPPS	General Purpose PolyStyrene
GWP	Global Warming Potential
HIPS	High-Impact PolyStyrene
HIPS ESCR	high impact polystyrene with enhanced environmental stress cracking resistance
IA	Impact Assessment
MDI	Methylene diphenyl diisocyanate (used for PUR foam)
NIAS	Non-intentionally added substances
ODP	Ozone depletion
PCB	Printed Circuit Board
PCR	Post-consumer recycled
Pd	Palladium
PET	PolyEthylene Terephthalate
PP	PolyPropylene
PPWR	Packaging and Packaging Waste Regulation
Pt	Platinum
PU(R)	PolyUrethane (Rigid)
R1	Recycled content in the CFF (section 5.2)
R2	Recycling output rate in the CFF (section 5.2)
RC	Recycled Content
R&M	Repair and Maintenance
r-HIPS	Recycled HIPS
SAN	Styrene acrylonitrile resin
WEEE	Waste Electric and Electronic Equipment

1. MEErP Task 1, Scope

1.1. Scope

The product scope for this study is aligned with the scope proposed in the 2024 JRC Preparatory Study on Imaging Equipment[1], however consumables were excluded from the analysis. In other words, the scope of this study of critical raw materials (CRMs), recycled content and recyclability is only on the equipment itself, not the cartridges, containers, drums or other consumables associated with imaging equipment.

The table below sets out the scope proposal in the JRC report (JRC, 2024), with one significant modification on consumables. Definitions for the terms used in this table appear in section 1.2 of this report.

Table 1. Scope of coverage of this CRM and Recycled Content Study

Device	In Scope	Out of Scope
General	Devices intended for household and office use	Devices intended for professional use or other than household and office use
Printers, multi-function printers and copiers	Standard format (up to A3)	Large format Devices designed to operate on three-phase power
Scanner	All scanners	
Fax Machine	All fax machines	
Digital duplicators		All digital duplicators
Mailing Machine		All mailing machines
Consumables		All consumables

The scope of this study is devices that are primarily used in an office or a household environment. For this reason, Table 1 shows that products intended to be used in professional environments or environments other than in offices and households have been excluded. Professional equipment are generally large machines, weighting at least 180 kg, with features such as large format printing, high volume throughput, high resolution, high weight paper, and potentially with other features such as hole punching, stapling and so-on. This combination of features draws a clear distinction between professional equipment and typical products used today in offices and households. Furthermore, the patterns of use of professional equipment is different from imaging equipment used in consumer and office environments.

Document scanners and fax machines are considered to be within scope, since their use is primarily in households and offices. However, digital duplicators and mailing machines are excluded from the scope because their intended market / use is primarily professional applications where the use patterns will differ from household and office products.

[1] European Commission, Joint Research Centre, Bernad Beltran, D., Alfieri, F. and Spiliotopoulos, C., Imaging equipment and its consumables. Preparatory Study for Ecodesign., Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/389662 , JRC134590.

Finally, for this mini-study evaluating CRM, recycled content and recyclability, every consumable designed to be installed into, used with, or emptied onto any of the devices included in the scope shown in Table 1 is excluded from the scope. In other words – all the consumables (including cartridges, containers, drums, waste toner containers, fuser units and transfers units) – are out of scope of this mini-study.

1.2. Definitions of Categories of Imaging Equipment

The following definitions are from the 2024 JRC report and are provided to clarify the scope of coverage and use of terminology in this mini-study. To review the development of these definitions from the various source documents, please see JRC, 2024.

Imaging equipment device (or ‘device’) – a product for office or domestic use, or both, and whose function is one or both of the following: (a) to produce a printed image, either from a digital image or from a hardcopy, through a scanning/copying process; or (b) to produce a digital image from a hard copy through a scanning/copying process.

Printer – a device intended to apply ink or toner to a substrate in response to a digital signal.

Multi-function printer – a printer with an operating part to apply ink or toner on a substrate, and also providing additional functions such as faxing, scanning or copying.

Copier - a device whose sole function is to produce paper duplicates from paper originals

Scanner - a device whose primary function is to convert paper originals into electronic images

Fax machine (or ‘fax’) - a device whose primary functions are scanning hard copy originals for electronic transmission to remote units and receiving similar electronic transmissions to produce hard copy output

Professional imaging product – a device marketed as intended for producing deliverables for sale, with all of the following features:

a) Supports paper with basis weight greater than or equal to 141 g/m2;
b) A3-capable;
c) Print speed: if product is monochrome, monochrome product speed equal to or greater than 86 ipm; or if product is colour, colour product speed equal to or greater than 50 ipm;
d) Print resolution of 600 x 600 dots per inch or greater for each colour
e) Weight of the base model greater than 180 kg;

And five of the following additional features for colour products or four for monochrome products, included standard with the Imaging Equipment product or as an accessory:

f) Paper capacity equal to or greater than 8,000 sheets;
g) Digital front-end (DFE);
h) Hole punch;

i) Perfect binding or ring binding (or similar, such as tape or wire binding, but not staple saddle stitching);

j) Dynamic random access memory (DRAM) equal to or greater than 1,024 MB.

k) Final-party colour certification (e.g., IDEAlliance Digital Press Certification, FOGRA Validation Printing System Certification, or Japan Colour Digital Printing Certification, if product is colour capable); and

l) Coated paper compatibility.

Standard format – products designed for standard-sized media (e.g., Letter, Legal, Ledger, A3, A4, B4), including those designed to accommodate continuous form media between 210 mm and 406 mm wide. Standard-size products may also be capable of printing on small-format media. (A3-capable: Standard Format products with a paper path width equal to or greater than 275 mm)

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

1.3. Definitions of Circularity Concepts

The JRC 2024 preparatory study sets out definitions of key circularity aspects for imaging equipment, some of which are relevant to this mini-study. The list below provides the relevant terms and definitions from that source (JRC, 2024).

Durability - Ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached (EN45552:2020)

Reliability - Probability that a product functions as required under given conditions, including maintenance, for a given duration without limiting event (EN45552:2020)

Repair - Process of returning a faulty product to a condition where it can fulfil its intended use (EN45552:2020)

Upgrade - Process of enhancing the functionality, performance, capacity, or aesthetics (EN45552:2020)

Reuse - Process by which a product or its parts, having reached the end of their first use, are used for the same purpose for which they were conceived (EN45552:2020)

Remanufacturing and refurbishing - Industrial process which produces a product from used products or used parts where at least one change is made which influences the safety, original performance, purpose or type of the product. (EN45553:2020)

> Note 1 to entry: The product created by the remanufacturing process may be considered a new product when placing on the market. Refer to the EU Blue Guide [1] for additional information.

Note 2 to entry: Refurbishing is a similar concept to remanufacturing except that it does not involve substantial modifications influencing safety, original performance, purpose or type of the product. It is not covered by this standard.

Remanufactured Imaging Equipment: Products … which has been returned to a “like new” state of the base model, including energy performance, by the manufacturer, utilizing new and/or reused components from the original equipment manufacturer (Energy Star v3.2)

Recycling - Recovery operation of any kind, by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes excluding energy recovery (EN45555:2019)

Critical Raw Materials - Critical raw material CRM materials which, according to a defined classification methodology, are economically important, and have a high-risk associated with their supply (EN45558:2019)

Post-consumer recycled content - the amount of post-consumer recycled material that goes into the manufacturing of a new product (EN45557:2020)

Among the definitions listed above, it is important to highlight how product modification by refurbishing and remanufacturing processes can influence the consideration of products as legally as “new products” or as “second hand products”. This distinction has an effect on the applicability of ecodesign and energy labelling requirements, which are only applicable at the moment of placing products on the market.

1.4. Standards

The following are a sample of standards included in the JRC 2024 study which are applicable to the imaging equipment being evaluated in this study.

IEC 60068-2-31:2008. Environmental testing - Part 2-31: Tests: Rough handling shocks, primarily for equipment-type specimens.

This standard establishes a test procedure for simulating the effects of rough handling shocks, primarily in equipment-type specimens, the effects of knocks, jolts and falls which may be received during repair work or rough handling in operational use. This procedure does not simulate the effects of impacts received during transportation as loosely constrained cargo and does not simulate the effects of shock applied to installed equipment.

EN 45552:2020. General method for the assessment of the durability of energy-related products.

This standard provides a comprehensive framework for assessing the durability of products, ensuring they meet the highest standards of quality and longevity. The standard establishes a general method for evaluating the durability of energy-related products. Durability not only affects the product's performance and reliability but also its environmental impact and cost-effectiveness. By adhering to the guidelines set forth in this standard, manufacturers can ensure that their products are designed to last, reducing waste and promoting sustainability.

EN 45553:2020. General method for the assessment of the ability to remanufacture energy-related products.

This standard provides a comprehensive framework for assessing the remanufacturability of energy-related products. The standard offers a structured approach to evaluate the potential for remanufacturing, ensuring that products can be reused, refurbished, and reintroduced into the market with minimal environmental impact. This not only helps in reducing waste but also in conserving resources, ultimately leading to cost savings and increased profitability.

EN 45554:2020. General methods for the assessment of the ability to repair, reuse and upgrade energy-related products.

This standard provides a comprehensive framework for assessing the ability to repair, reuse, and upgrade energy-related products. This standard is an essential tool for manufacturers, engineers, and sustainability experts who are committed to enhancing the lifecycle of their products while minimizing environmental impact. This standard outlines general methods for evaluating the repairability, reusability, and upgradability of energy-related products. It provides detailed guidelines and methodologies that help stakeholders in the energy sector to improve product design and lifecycle management.

EN 45555:2019. General methods for assessing the recyclability and recoverability of energy-related products.

This standard provides comprehensive guidelines and methodologies for evaluating the recyclability and recoverability of energy-related products, ensuring that they meet the necessary environmental standards and contribute to a circular economy. It helps to provide a structured approach to assess their potential for recycling and recovery. By following the guidelines in this standard, companies can ensure that their products are designed with end-of-life considerations in mind, promoting a more sustainable approach to product development.

EN 45557:2020. General method for assessing the proportion of recycled material content in energy-related products.

This standard provides a comprehensive methodology for assessing the proportion of recycled material content in energy-related products. It is an essential tool for companies aiming to enhance their environmental responsibility and transparency. The standard offers a structured approach to evaluate and report the recycled material content, thereby supporting manufacturers in their efforts to reduce the ecological footprint of their products. This standard not only aids in compliance with environmental regulations but also enhances the marketability of products by aligning them with consumer demand for sustainable solutions.

EN 45558:2019. General method to declare the use of critical raw materials in energy-related products.

This standard is intended to provide a means for information on the use of CRMs to be exchanged up and down the supply chain and with other relevant stakeholders. The standard is intended for use by any public, private or social enterprises involved in the production of energy-related products (including SMEs) and other organisations in the product supply chain. It is also relevant to European market surveillance and trade authorities as well as European policy makers. This standard is horizontal in nature, and can be applied directly to any type of energy-related product. This document sets out a standardised format for reporting use of CRMs in energy-related products.

prTS 50752:20YY Design for recycling guidelines for styrenics and polyolefins products and parts in electrical and electronic equipment, with focus on ABS, PP and PS

This draft technical specification describes the best practices and technical solutions that manufacturers of electrical and electronic equipment (EEE) can adopt during the design phase, to enable consistent and effective recycling of styrenics and polyolefins plastics composing the equipment, during the Waste of Electrical and Electronic Equipment (WEEE) management.

IEEE 1680.2 Standard for Environmental Assessment of Imaging Equipment

A set of environmental performance criteria for the design of imaging equipment, enabling suppliers to gain market recognition for efforts to reduce the environmental impact of EEE. Also intended to support government, professional and consumer purchasers in the identification of products that demonstrate environmental leadership. This standard is available free of charge on this link. This standard is referenced by EPEAT and Blue Angel.

EN/ISO 11469 Generic Identification and Marking of Plastics Products

This standard specifies a system of uniform marking of products fabricated from plastic. This marking system is intended to help identify plastics products for subsequent decisions concerning handling, waste recovery or disposal. Generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043-1, ISO 1043-2, ISO 1043-3 and ISO 1043-4.

1.5. Legislation

As a product group, imaging equipment has had a Voluntary Agreement (VA) under the Ecodesign Directive since 2013. The Commission, however, evaluated the benefits of regulating imaging equipment and concluded that it was appropriate to do so (see Ecodesign and Energy Labelling Working Plan 2022-2024[2]). That decision was followed by a Preparatory Study published by the JRC in 2024 and – at the time of this writing – an on-going analytical study to develop those requirements, which this analysis on CRMs, recycled content and recyclability will directly support.

In addition to the on-going work under Ecodesign, there are other relevant regulations and voluntary instruments that are also applicable to some aspects of the life cycle of imaging equipment. In particular:

- Standby Regulation
- RoHS Directive
- REACH Regulation
- WEEE Directive

[2] Ecodesign and Energy Labelling Working Plan 2022-2024, DG Energy, European Commission. Published 30 March 2022. Link: https://energy.ec.europa.eu/publications/ecodesign-and-energy-labelling-working-plan-2022-2024_en

1.5.1 Standby Regulation

Commission Regulation (EU) No 2023/826[3] of 17 April 2023 set down ecodesign requirements for off mode, standby mode, and networked standby energy consumption of electrical and electronic household and office equipment. The energy-efficiency requirements are set out in Annex III of (EU) 2023/826 and enter into force on 9 May 2025. These standby requirements are set out below:

1. Energy efficiency requirements:

(a) Power consumption in off mode: Power consumption of equipment in off mode shall not exceed 0,50 W. Two years after the application of this Regulation, the power consumption of equipment in off mode shall not exceed 0,30 W.

(b) Power consumption in standby mode: The power consumption of equipment in any condition providing only a reactivation function, or providing only a reactivation function and an indication of enabled reactivation function, shall not exceed 0,50 W.

The power consumption of equipment in any condition providing only information or status display, or providing only a combination of reactivation function and information or status display, or providing only a reactivation function and an indication of enabled reactivation function and information or status display shall not exceed 0,80 W, except for household tumble driers covered by Commission Regulation (EU) No 932/2012 (1) for which this value shall be 1,00 W.

Networked equipment that has one or more standby modes shall comply with the requirements for those standby modes when all wired network ports are disconnected and all wireless network ports are deactivated.

(c) Power consumption in networked standby: The power consumption of HiNA equipment or equipment with HiNA functionality, in networked standby shall not exceed 8,00 W. Two years after the application of this Regulation, the power consumption of HiNA equipment or equipment with HiNA functionality in networked standby shall not exceed 7,00 W.

The power consumption of networked equipment, other than HiNA equipment or equipment with HiNA functionality, in networked standby shall not exceed 2,00 W.

The power consumption limits shall not apply to:
— large format printing equipment;
— desktop thin clients, workstations, mobile workstations, and small-scale servers as defined in Regulation (EU) No 617/2013.

Imaging equipment within the scope of this review study will fall within the requirements of this updated standby regulation, (EU) No 2023/826. Also, it should be noted that "large format printing equipment"[4] is not covered in the scope of the standby power regulation.

[3] Commission Regulation (EU) No 2023/826 of 17 April 2023 laying down ecodesign requirements for off mode, standby mode, and networked standby energy consumption of electrical and electronic household and office equipment pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulations (EC) No 1275/2008 and (EC) No 107/2009; Link: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0826

[4] The definition of this term is provided in (EU) No 2023/826: "Large format printing equipment' means printing equipment designed for printing on A2 media and larger, including equipment designed to accommodate continuous-form media of at least 406 mm width."

An industry association commented in response to this that EuroVAPrint[5] (EVAP) provided data by model classification to the commission in 2024 that demonstrated a minimum standby mode of 1.5W for Imaging Equipment is the best that can be achieved. For larger A4 and A3 devices it is not possible to achieve the stated 0.8W in standby mode.

This issue will be investigated further by the Team conducting the Review Study of Imaging Equipment.

1.5.2 RoHS Directive

The RoHS Directive (RoHS 3, EU Directive 2015/863) aims to prevent the risks posed to human health and the environment related to the management of electronic and electrical waste. It does this by restricting the use of certain hazardous substances in products that can be substituted by safer alternatives. These restricted substances include heavy metals, flame retardants and plasticizers.

The RoHS Directive 2011/65/EU[6] currently restricts the use of ten substances: lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP).

All products with an electrical and electronic component, unless specifically excluded, have to comply with these restrictions. The scope of the Restriction of Hazardous Substances Directive 2011/65/EU (RoHS) fully applies to the imaging equipment covered in this study.

1.5.3 REACH Regulation

The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006 (European Commission, 2006) aims to improve the protection of human health and the environment from the risks that can be posed by chemicals. REACH establishes procedures for collecting and assessing information on the properties and hazards of substances. REACH applies to all chemical substances, including those in articles such as electrical appliances.

REACH calls for the progressive substitution of the most dangerous chemicals (referred to as "Substances of Very High Concern") when suitable alternatives have been identified. SVHCs are defined as:

1. Substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction (CMR) category 1A or 1B in accordance with the CLP Regulation.

2. Substances which are persistent, bio-accumulative and toxic (PBT) or very persistent and very bio-accumulative (vPvB) according to REACH Annex XIII.

[5] EuroVAprint ASBL is a non-profit association established in 2011 that brings together all of the major manufacturers of imaging equipment that operate in Europe. The association provides the legal and administrative means to supervise the implementation and monitoring of the Imaging Equipment Voluntary Agreement aimed at curbing the environmental footprint of imaging equipment.

[6] Consolidated text: Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) (Text with EEA relevance), Link: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02011L0065-20250101

3. Substances on a case-by-case basis, which cause an equivalent level of concern as CMR or PBT/vPvB substances.

Once a substance is identified as an SVHC, it is included in the Candidate List of substances of very high concern for Authorisation.[7] ECHA regularly assesses the substances from the Candidate List to determine which ones should be included in the Authorisation List (Annex XIV). Once a substance is included in an Authorisation List, this can be used/produced only with authorisation under certain circumstances for defined applications.

A Restrictions List (Annex XVII) is also periodically revised. Once a substance is included in the Restrictions List, specific or general uses of such substance are prohibited.

Article 33 of REACH establishes the right of consumers to be able to obtain information from suppliers on substances in articles. Suppliers of articles are obliged to provide industrial/professional users or distributors with certain pieces of information on articles containing substances with irreversible effects on human health or the environment.

1.5.4 WEEE Directive

The WEEE Directive (Directive 2012/19/EU) lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipment (WEEE) and by reducing overall impacts of resource use and improving the efficiency of such use in accordance with Articles 1 and 4 of Directive 2008/98/EC (the ‘general’ waste directive).

The WEEE Directive explicitly cross-references the Ecodesign Directive 2009/125/EC directly in Article 4, and sets out other relevant requirements for products covered within the scope of this study on imaging equipment.

- **Article 4. Product Design**

  EU member states shall take appropriate measures so that the ecodesign requirements facilitating re-use and treatment of WEEE established in the framework of the Ecodesign Directive are applied and producers do not prevent, through specific design features or manufacturing processes, WEEE from being re-used, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements (WEEE, Art. 4).

[7] Candidate List of substances of very high concern for Authorisation; published in accordance with Article 59(10) of the REACH regulation, European Chemicals Agency (ECHA), Link: https://echa.europa.eu/candidate-list-table

- **Article 5. Separate Collection**

  1. *Member States shall adopt appropriate measures to minimise the disposal of WEEE in the form of unsorted municipal waste, to ensure the correct treatment of all collected WEEE and to achieve a high level of separate collection of WEEE, notably, and as a matter of priority, for temperature exchange equipment containing ozone-depleting substances and fluorinated greenhouse gases, fluorescent lamps containing mercury, photovoltaic panels and small equipment […]* [8]*.*

  2. *For WEEE from private households, Member States shall ensure that:*

     (a) *systems are set up allowing final holders and distributors to return such waste at least free of charge. […]*

     (b) *when supplying a new product, distributors are responsible for ensuring that such waste can be returned to the distributor at least free of charge on a one-to-one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment […].*

     (d) *[…] producers are allowed to set up and to operate individual and/or collective take-back systems for WEEE from private households provided that these are in line with the objectives of this Directive;*

- **Article 7 Collection rate**

  From 2019, the minimum collection rate to be achieved annually shall be 65 % of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85 % of WEEE generated on the territory of that Member State.

- **Article 11 Recovery targets**

  1. *Regarding all WEEE separately collected in accordance with Article 5 (see above) and sent for treatment […], Member States shall ensure that producers meet the minimum targets set out in Annex V (see below).*

  2. *The achievement of the targets shall be calculated, for each category, by dividing the weight of the WEEE that enters the recovery or recycling/preparing for re-use facility, after proper treatment* [9] *[…] with regard to recovery or recycling, by the weight of all separately collected WEEE for each category, expressed as a percentage.*

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[8] Definitions from Directive 2008/98/EC, article 3:

'municipal waste' means: (a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture; (b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households;

'collection' means the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility

'separate collection' means the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment;

[9] Proper treatment, other than preparing for re-use, and recovery or recycling operations shall, as a minimum, include the removal of all fluids and a selective treatment in accordance with Annex VII.

- **Article 15 Information for treatment facilities**

  1. *In order to facilitate the preparation for re-use and the correct and environmentally sound treatment of WEEE, including maintenance, upgrade, refurbishment and recycling, Member States shall take the necessary measures to ensure that producers provide information free of charge about preparation for re-use and treatment in respect of each type of new EEE placed for the first time on the Union market within one year after the equipment is placed on the market. This information shall identify, as far as it is needed by centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this Directive, the different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE. It shall be made available to centres which prepare for re-use and treatment and recycling facilities by producers of EEE in the form of manuals or by means of electronic media (e.g. CD-ROM, online services).*

- **Annex VII, Selective treatment for materials and components of WEEE**

  1. *As a minimum the following substances, mixtures and components have to be removed from any separately collected WEEE:*

     — polychlorinated biphenyls (PCB) containing capacitors […] [10]*,*

     — mercury containing components, such as switches or backlighting lamps,

     — 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,

     — toner cartridges, liquid and paste, as well as colour toner,

     — plastic containing brominated flame retardants,

     — asbestos waste and components which contain asbestos,

     — cathode ray tubes,

     — chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC),

     — gas discharge lamps,

     — liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres and all those back-lighted with gas discharge lamps,

     — external electric cables,

     — components containing refractory ceramic fibres […],

     — components containing radioactive substances […],

     — electrolyte capacitors containing substances of concern (height > 25 mm, diameter > 25 mm or proportionately similar volume).

[10] Single phase induction motors used in fridges need capacitors for starting (and some use them also for running). The capacitors are usually electrolytic, and the older ones can contain polychlorinated biphenyls (PCBs). PCBs were banned in Europe in 1987, so by now, very few fridges should arrive to recyclers with PCB containing capacitors.

Electrolytic capacitors can contain CRMs depending on the type: aluminium, tantalum, niobium, manganese oxide or titanium oxide, silver, graphite, paper, rubber, electrolyte e.g. ethylene glycol (EG) or γ-butyrolactone (GBL). For motor starting, aluminium electrolytic capacitors with non-solid electrolyte seem to be most frequently used.

These substances, mixtures and components shall be disposed of or recovered in compliance with Directive 2008/98/EC.

2. The following components of WEEE that is separately collected have to be treated as indicated:

— cathode ray tubes: the fluorescent coating has to be removed,

— equipment containing gases that are ozone depleting or have a global warming potential (GWP) above 15, such as those contained in foams and refrigeration circuits: the gases must be properly extracted and properly treated. Ozone-depleting gases must be treated in accordance with Regulation (EC) No 1005/2009,

— gas discharge lamps: the mercury shall be removed.

3. Taking into account environmental considerations and the desirability of preparation for re-use and recycling, points 1 and 2 shall be applied in such a way that environmentally-sound preparation for re-use and recycling of components or whole appliances is not hindered.

1.6. Voluntary schemes

This summary of the voluntary schemes is adapted from the JRC's Preparatory Study (JRC, 2024). This presents the different aspects covered in voluntary schemes for imaging equipment.

1.6.1 Voluntary Agreement for Imaging Equipment

In the context of the Ecodesign Directive, a Voluntary Agreement is established when manufacturers agree to abide by a common level of environmental performance. Voluntary Agreements are entered into when such actions are likely to deliver the policy objectives faster or in a less costly manner.

Imaging equipment has been regulated with such a Voluntary Agreement (VA) under the Ecodesign Directive since 2013. However, in the most recent Ecodesign and Energy Labelling Working Plan 2022-2024, the Commission's analysis found that mandatory requirements were warranted:

> *"Regarding imaging equipment, the Commission has assessed the revision of the Voluntary Agreement proposed by representatives of the sector and concludes that accepting this revision would not achieve the objectives considered in the Circular Economy Action Plan (CEAP), and cannot be considered compliant with the guidelines on self-regulatory instruments in particular regarding the possible re-use of consumables. As announced in the CEAP, the Commission will launch the preparation of regulatory measures for this product group."*

The 2020 Circular Economy Action Plan (European Commission, 2020) referred to this product group, stating that 'Printers and consumables such as cartridges will be covered [by the upcoming Ecodesign Working Plan] unless the sector reaches an ambitious voluntary agreement within the next six months'.

Between 2019 and 2021, the industry made a new VA proposal, including cartridges and containers, as well as other recommendations made by different stakeholders, including material efficiency requirements. This proposal was published in April 2021. The VA proposed by the imaging equipment industry in 2021 (Eurovaprint, 2021) was evaluated by the JRC on behalf of DG Environment (DG ENV). In this evaluation (Bernad-Beltrán and Alfieri, 2022), DG JRC identified various improvements from the current VA, such as the inclusion of cartridges within the scope of the document and the enhancement of resource efficiency commitments applicable to printers, including design for dismantling rules and a comprehensive list of spare parts. However, the analysis also identified some issues of concern regarding compliance with self-regulation criteria and with the level of ambition required by the CEAP.

Based on evaluation conducted by the DG JRC, the European Commission considered that the VA proposal, despite the improvements introduced, had not reached the ambitious objectives in terms of circularity mandated by the CEAP and decided to work on mandatory regulatory measures under the Ecodesign Directive. Based on this decision, the imaging equipment was included in the list of new measures under the Ecodesign and Energy Labelling Working Plan 2022-2024 (European Commission, 2022).

Despite not endorsing the VA proposed by the industry in 2021, the JRC identified several aspects that may the basis for the development of new implementing measures in this sector, such as:

- Energy consumption requirements, default delay times and automatic duplexing capability, at the same level as in Energy Star v3.2
- Availability of n-up printing
- Design for recycling and for easy dismantling of devices
- Availability of spare parts for devices
- Availability of software and firmware updates
- Cartridge design requirements, in terms of reusability
- Product information requirements

1.6.2 The EU GPP Criteria for Imaging Equipment

EU Green Public Procurement (GPP) is a voluntary instrument. It relies on the purchasing power of public authorities to promote environmentally friendly goods, services and works. Currently, there is EU GPP criteria for a number of products groups, including imaging equipment (Kaps et al, 2020).

The scope of the GPP Criteria for imaging equipment includes products marketed for office or domestic use, or both, and whose function is one 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

The Criteria explicitly exclude devices such as digital duplicators, mailing machines and fax machines.

The GPP Criteria for imaging equipment include 26 Technical Specifications, divided between Core (minimum level of ambition) and Comprehensive (highest level of ambition). It also contains 9 Award Criteria and 7 Contract Performance Clauses.

The criteria are focused on both the environmental performance of devices and consumables. As a few relevant examples, it contains Technical Specifications on topics such as:

- Post-consumer recycled content: The percentage of postconsumer recycled plastic content, calculated as a percentage of total plastic (by weight), must be declared.
- Device firmware updates: Any firmware update must not prevent the use of reused/remanufactured consumables.
- Reusability of consumables: cartridges or containers must not be designed to limit the ability to reuse/remanufacture. Examples of features which are deemed to limit the ability to remanufacture, or promote non-reuse, include, but are not limited to: cartridges or containers covered by patents or licence agreements which include statements that seek to limit remanufacturing; statements on the cartridge or container, or packaging, which declare, or imply, that the product is not designed to be remanufactured.
- Printing quality: any cartridges or containers must meet all requirements behind at least one widely recognised cartridge/container quality standard

Beyond those, there is also criteria on topics such as energy efficiency, design for disassembly, substance and noise emissions, hazardous substances, warranties, take-back systems, etc.

1.6.3 Critical Raw Materials Act

Annex I of the Critical Raw Materials Act [8] lists the strategic raw materials, and Annex II the critical raw materials. The list is presented in the table below.

According to the Phase 1 analysis that looked at prioritising the products to be evaluated in Phase 2, the five most important critical raw materials for imaging equipment are Palladium, Bismuth, Bauxite/Aluminium, Antimony and coking coal (in that order).

Table 2: List of strategic and critical raw materials (source: Critical Raw Materials Act [8], annex I and II)

Raw Material / Element	Critical Raw Material	Strategic Raw Material
Antimony	x	
Arsenic	x	
Bauxite/alumina/aluminium	x	x
Baryte	x	
Beryllium	x	
Bismuth	x	x
Boron	x	x (metallurgy grade)
Cobalt	x	x
Coking coal	x	
Copper	x	x

Raw Material / Element	Critical Raw Material	Strategic Raw Material
Feldspar	x	
Fluorspar	x	
Gallium	x	x
Germanium	x	x
Hafnium	x	
Helium	x	
Heavy rare earth elements [11]	x	
Light rare earth elements [12]	x	
Rare earth elements for permanent magnets (Nd, Pr, Tb, Dy, Gd, Sm, & Ce)		x
Lithium	x	x (battery grade)
Magnesium	x	x (metal)
Manganese	x	x (battery grade)
Graphite	x	x (battery grade)
Nickel – battery grade	x	x
Niobium	x	
Phosphate rock	x	
Phosphorus	x	
Platinum group metals [13]	x	x
Scandium	x	
Silicon metal	x	x
Strontium	x	
Tantalum	x	
Titanium metal	x	x
Tungsten	x	x
Vanadium	x	

[11] The CRM Act does not further define this, but heavy rare earth elements should include Y (Yttrium), Gd (Gadolinium), Tb (Terbium), Dy (Dysprosium), Ho (Holmium), Er (Erbium), Tm (Thulium), Yb (Ytterbium), and Lu (Lutetium)

[12] The CRM Act does not further define this, but light rare earth elements should include La (Lanthanum), Ce (Cerium), Pr (Praseodymium), Nd (Neodymium), Pm (Promethium), Sm (Samarium) and Eu (Europium).

[13] The CRM Act does not further define this, but platinum group metals (PGM) should include: Pd (Palladium), Pt (Platinum), Rh (Rhodium), Ru (Ruthenium), Ir (Iridium) and Os (Osmium).

Among the provisions of the CRM Act there are two which are directly relevant for this study on imaging equipment[14]:

Paragraph (52)

> *(52) Member States retain important competences in the field of circularity, for example in the area of waste collection and treatment systems. Those competences should be used to increase collection and recycling rates for waste streams with a high potential for recovery of critical raw materials, including electronic waste, making use for example of financial incentives such as discounts, monetary rewards or deposit-refund systems while preserving the integrity of the internal market. With a view to increasing the use of secondary critical raw materials, this could also include differentiated producer responsibility fees, provided such fees exist in national law, to benefit products containing a larger share of secondary critical raw materials recovered from waste recycled in accordance with environmental standards established in Union law. Such secondary critical raw materials recovered from waste should include recovery carried out in accordance with third-country standards that offer an equivalent protection to Union standards. Member State authorities should also make a difference as buyers of critical raw materials and of products containing them, and national research and innovation programmes provide significant resources to increase the state of knowledge and technology for critical raw materials circularity as well as material efficiency. Finally, Member States should promote the recovery of critical raw materials from extractive waste by improving the availability of information and by addressing legal, economic and technical barriers. A possible solution that Member States should look into are risk-sharing mechanisms between operators and the Member State to promote recovery from closed waste facilities. The Board should also facilitate the exchange of best practices between Member States, on the design and implementation of their national programmes.*

- ***Article 26, National measures on circularity***

  1. Each Member State shall, […], adopt […] measures designed to:

  […]

  (c) increase the collection, sorting and processing of waste with relevant critical raw materials recovery potential [15], <u>including metal scraps</u>, and ensure their introduction into the appropriate recycling system, with a view to maximising the availability and quality of recyclable material as an input to critical raw material recycling facilities.

  (d) <u>increase the use of secondary critical raw materials</u>, including through measures such as taking recycled content into account in award criteria related to public procurement or financial incentives for the use of secondary critical raw materials.

  (e) increase the technological maturity of recycling technologies for critical raw materials and <u>promote circular design, materials efficiency and substitution of</u>

[14] The following are extracts or summaries of the legal text. See the act itself for the precise text. Link: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401252

[15] The Commission has to define by May 2025 which products, components and waste streams shall at least be considered as having a relevant critical raw materials recovery potential.

critical raw materials in products and applications, at least by including support actions to that effect under national research and innovation programmes.

5. *Member States shall identify separately, and report, the quantities of components containing relevant amounts of critical raw materials removed from waste electrical and electronic equipment and the quantities of critical raw materials recovered from such equipment.*

1.6.4 EPEAT Ecolabel

EPEAT is a non-profit organisation that works to accelerate the adoption of sustainable electronics globally. It is owned and operated by the Global Electronics Council and has received formal recognition for meeting the requirement of ISO 14024, the international standard for ecolabels. EPEAT offers a free online Registry which identifies thousands products from across a broad range of manufacturers. EPEAT qualification criteria are developed through a voluntary consensus process with a balance of stakeholders. The criteria look across the entire electronics life cycle, from materials extraction to end-of-life, including climate change, chemicals of concern, circularity and sustainable use of resources, and responsible sourcing. Manufacturers and/or brands interested in participating in EPEAT must first work with a conformity assurance body to prove they meet EPEAT criteria before their products are listed in the Registry.

Consumers can freely search the EPEAT Registry for products based on product category, manufacturer, the country in which the product is expected to be used, and/or by EPEAT tier level (Bronze, Silver, and Gold). The EPEAT Bronze, Silver and Gold tiers make it easier for consumers to find sustainable options and while also fostering innovation and healthy competition between participating brands. EPEAT Gold identifies that products meet the most stringent criteria for sustainability. Products in the EPEAT Silver and Bronze tiers also must meet a broad, robust set of criteria, making them more sustainable products.

The EPEAT Registry for Imaging Equipment is available on this link, and as of 1 July 2025 has 3855 models listed in the database.

1.6.5 Blue Angel: Environmentally Friendly Printers and Multifunction Devices (DE-UZ 219)

The Blue Angel – the environmental label from the German federal government – has been working since 1978 to set stringent standards for environmentally friendly, healthy and durable products and services. The Blue Angel is Germany‘s best known environmental label and offers consumers a high level of trust that the products receiving this label are more environmentally sustainable. Blue Angel defines a set of criteria and manufacturers apply to the programme to gain certification for their products. For imaging equipment, the specific design criteria for the current scheme (DE-UZ 219) can be found on this link. That page also provides a searchable database of compliant products, which as of 1 July 2025 contains 1451 models.

Blue Angel describes its label as follows:

> *Printers and multifunction devices are complex devices with a diverse range of functions and are used on a daily basis in both a private and work environment. The low energy consumption of devices certified with the Blue Angel supports climate change mitigation. The contribution of electrophotographic devices to indoor pollution by ultrafine dust is small*

in the workplace or at home and will be further reduced gradually. In addition, the devices must comply with strict requirements with respect to the selection of materials and the recyclable design of the products. The criteria for the selection of materials in the devices also stipulate that a minimum level of recycled plastic must be used. Low-pollutant materials must also be used in the plastic parts to reduce the impact on the environment and the risks to human health. Furthermore, these devices have a low energy consumption and thus make a significant contribution to climate protection. Last but not least, those companies who sell printers and multifunction devices certified with the Blue Angel are also obligated to gradually fulfil ambitious social standards during the production process and comply with due diligence requirements in the supply chains for conflict materials by 2024 at the latest.

2. MEErP Task 2, Markets

This section offers a very brief look at the market data estimates for imaging equipment, derived from the Ecodesign Impact Accounting (EIA) study. This EIA gathers data from all products regulated by Ecodesign and Energy Labelling regulations. It provides estimates of sales, stock, volumes, efficiencies, electricity consumption, GHG emissions, prices, costs, business revenues and jobs.

EIA data are based on EU28 data from the 2019 Impact Assessment [5], the 2016 review study [4] and the underlying Excel file, converted to EU27 by applying Brexit factors (see the EIA annual report). The data until 2015-2018 [16] can be considered 'historical', while data for later years are projections made at the time of the last study.

2.1. Imaging Equipment Sales and Stock

Table 3 presents the estimated sales of imaging equipment in five-year increments from 2010 through 2050. These data are presented in thousands of units and show an anticipated reduction in sales. Between 2025 and 2050, overall sales are projected to decrease by approximately 23%. Within that time period, monochromatic laser printers are projected to reduce sales by 81% while colour laser printers do the opposite, they are expected to increase sales by 15%. All other categories are expected to reduce by 23 to 24%.

[16] The 2016 review study used data available in 2015. The 2019 impact assessment used these data but may have updated some of the data up to 2018.

Table 3. Sales of Imaging Equipment by Type, EIA 2024 (BAU, thousands of units)

Type	2010	2015	2020	2025	2030	2035	2040	2045	2050
Inkjet Printer	8,306	822	786	748	711	674	640	605	571
Inkjet MFD	10,669	12,740	12,186	11,588	11,021	10,481	9,970	9,460	8,950
Laser Printer mono	2,954	2,034	1,545	1,217	978	768	587	406	226
Laser Printer colour	1,142	1,332	1,669	1,840	1,929	1,999	2,038	2,078	2,117
Laser Copier mono	828	204	-	-	-	-	-	-	-
Laser Copier colour	166	298	-	-	-	-	-	-	-
Laser MFD mono	1,379	1,843	1,760	1,674	1,592	1,512	1,436	1,361	1,286
Laser MFD colour	1,380	1,844	1,761	1,675	1,593	1,516	1,440	1,365	1,290
TOTAL	**26,825**	**21,117**	**19,707**	**18,741**	**17,823**	**16,949**	**16,112**	**15,276**	**14,439**

Table 4 presents the estimated installed stock of imaging equipment in five-year increments between 2010 and 2050. These data are presented in thousands of units, and show a projected reduction in the installed stock despite an expected increase in the number of households in the EU-27 over that same time period. Between 2025 and 2050, the overall stock is expected to decrease by 22%. Within that anticipated reduction, monochromatic laser printers are projected to reduce by 78% while colour laser printers are expected to increase in stock by 20%. All other categories are expected to reduce by 20 to 23%

Table 4. Stock (EU-27) of Imaging Equipment by Type, EIA 2024 (BAU, thousands of units)

Type	2010	2015	2020	2025	2030	2035	2040	2045	2050
Inkjet Printer	36,002	15,619	4,008	3,815	3,628	3,445	3,269	3,096	2,923
Inkjet MFD	40,004	53,944	62,117	59,125	56,227	53,483	50,873	48,322	45,771
Laser Printer mono	12,115	10,585	8,645	6,790	5,396	4,260	3,297	2,393	1,489
Laser Printer colour	3,981	6,253	9,077	10,476	11,277	11,784	12,111	12,347	12,583
Laser Copier mono	3,761	2,243	490	-	-	-	-	-	-
Laser Copier colour	592	1,567	1,018	-	-	-	-	-	-
Laser MFD mono	6,843	9,648	10,816	10,299	9,794	9,309	8,844	8,393	7,942
Laser MFD colour	6,852	9,656	10,823	10,305	9,800	9,325	8,868	8,416	7,964
TOTAL	**110,149**	**109,515**	**106,994**	**100,809**	**96,121**	**91,606**	**87,262**	**82,967**	**78,672**

2.2. Imaging Equipment Usage in the EU-27

Table 5 presents the estimated number of pages printed across the EU-27 in five-year increments between 2010 and 2050. These data are presented in billions of pages, and project a reduction in number of pages over the time period shown. Between 2025 and 2050, the overall number of printed pages is expected to reduce by approximately 35%.

Table 5. Images (pages) printed per year by EU Stock, by Type, EIA 2024 (BAU, billions of pages)

Type	2010	2015	2020	2025	2030	2035	2040	2045	2050
Inkjet Printer	29.0	9.0	1.7	1.3	1.1	1.0	0.9	0.8	0.8
Inkjet MFD	32.3	31.0	25.9	19.6	16.8	15.4	14.2	13.2	12.5
Laser Printer mono	273.6	170.1	101.0	63.0	45.3	34.2	25.7	18.3	11.4
Laser Printer colour	89.9	100.4	106.1	97.2	94.6	94.7	94.5	94.6	96.0
Laser Copier mono	84.9	36.0	5.7	-	-	-	-	-	-
Laser Copier colour	13.4	25.2	11.9	-	-	-	-	-	-
Laser MFD mono	154.5	155.0	126.4	95.6	82.2	74.8	69.0	64.3	60.6
Laser MFD colour	154.7	155.1	126.5	95.6	82.2	75.0	69.2	64.5	60.7
TOTAL	**832.3**	**681.8**	**505.2**	**372.4**	**322.2**	**295.1**	**273.4**	**255.9**	**241.9**

2.3. Electricity Consumption of Imaging Equipment in the EU-27

Table 6 presents the estimated electricity consumption of the installed stock of imaging equipment in five-year increments between 2010 and 2050. These data are presented in terawatt-hours per annum, for the business as usual scenario. Due to the reduction in stock and improving performance of the products themselves, the electricity consumed by imaging equipment is expected to reduce over this time period, from 10.94 TWh in 2025 to 8.99 TWh in 2050. This represents a reduction of 18% over that time period in the business as usual case.

Table 6. Electricity Consumption of EU Stock, by Type, EIA 2024 (BAU, Terawatt-hours per year)

Type	2010	2015	2020	2025	2030	2035	2040	2045	2050
Inkjet Printer	0.53	0.18	0.05	0.04	0.04	0.04	0.04	0.04	0.03
Inkjet MFD	0.88	0.95	1.09	1.04	0.99	0.94	0.89	0.85	0.80
Laser Printer mono	2.31	1.76	1.44	1.13	0.90	0.71	0.55	0.40	0.25
Laser Printer colour	1.18	1.63	2.36	2.72	2.93	3.06	3.15	3.21	3.27
Laser Copier mono	1.15	0.60	0.13	-	-	-	-	-	-
Laser Copier colour	0.21	0.49	0.32	-	-	-	-	-	-
Laser MFD mono	2.09	2.58	2.89	2.75	2.62	2.49	2.36	2.24	2.12
Laser MFD colour	2.47	3.05	3.41	3.25	3.09	2.94	2.80	2.65	2.51
TOTAL	**10.81**	**11.23**	**11.69**	**10.94**	**10.57**	**10.18**	**9.79**	**9.39**	**8.99**

3. MEErP Task 3, Product usage

In this task, the review study would look at how much the product being evaluated is used. However, for the purposes of the work being conducted in this study of critical raw materials, recycled content and recyclability, the usage of the product is less relevant.

The upcoming review study on imaging equipment will provide updates on product usage in their analysis, it is therefore not included in this report.

4. MEErP Task 4, Technologies

In this task, the review study would assess both current and anticipated technological improvements in the product being evaluated. For the purposes of the work being conducted in this study, apart from product re-design to incorporate recycled content, development of more efficient printers and improvements in print quality are outside of scope. Thus, for this study on critical raw materials, recycled content and recyclability, the degree of technological innovation of imaging equipment is less relevant.

The upcoming review study on imaging equipment will provide updates on technological innovation in their analysis, and this is therefore not included in this report.

5. MEErP Task 5, Environment and Economics

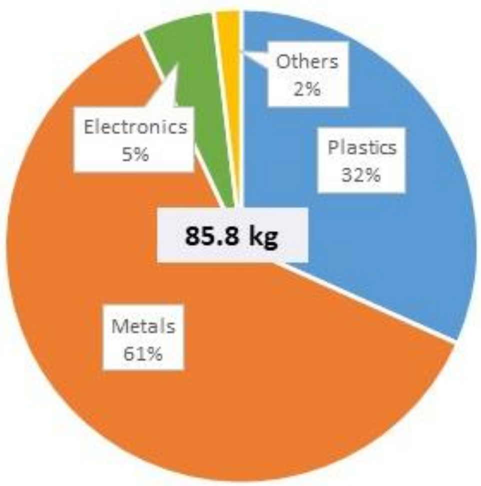
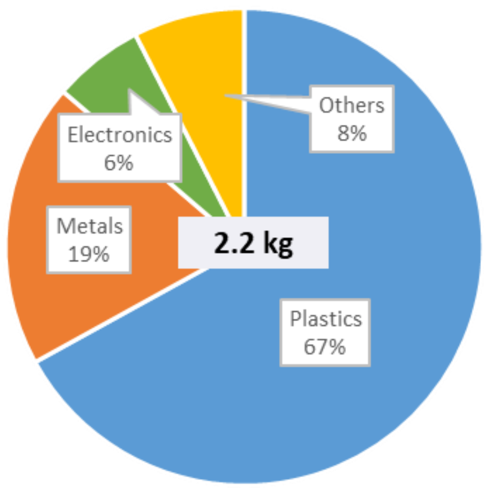
5.1. Bill-of-Materials for base cases

In the review of imaging equipment, seven base case representative models are being developed for analysis:

- BC1: Small Office, Laser A4 colour printer, 26 ipm
- BC2: Small Office, Laser A4 mono printer, 42 ipm
- BC3: Large Office, Laser A4 colour printer, 52 ipm
- BC4: Large Office, Laser A4 mono printer, 70 ipm
- BC5: Large Office, Laser A3 colour printer, 80 ipm
- BC6: Large Office, Laser A3 mono printer, 90 ipm
- BC7: Household, Inkjet A4 colour printer, 15 ipm

For the CRM and recycled content mini-study, the team selected two of base case models that are under consideration by the Review Study Team. These two models were selected in order to represent a popular model used in the professional environment and a popular model used in the household setting. For the professional (office) environment, the base case model BC5 – Large Office, Laser A3 colour printer, 80 ipm was selected. For the household (domestic) setting, the only base case model from this sector was used, base case model BC7 – Household, Inkjet A4 colour printer, 15 ipm. The table below provides a high-level breakdown / comparison between the different material types found in the two representative models selected for these two product groups.

Table 7: Materials Weight Allocation for the two Basecase Models Evaluated for Imaging Equipment

BC5: Large Office A3 Colour Laser	BC7: Household A4 Colour Inkjet
	
For the large office A3 colour laser printer (BC5), the total weight of the printer is 85.8 kg, excluding packaging material used in shipping. Breaking down the printer into groups of	For the household A4 colour inkjet (BC7), the total weight of the printer is 2.2 kg, excluding any packaging material used in shipping. Breaking down the printer into its material types,

material types, metals represent 61% of the mass (52.6 kg), plastics are 32% (27.2 kg), electronics are 5% (4.4 kg), and other materials are 2% (1.6 kg).	the largest share is plastics, which represent 67% of the mass (1.6 kg), followed by metal at 19% (0.5 kg), other material at 8% (0.2 kg) and electronics at 6% (0.1 kg).

This study uses the new 2024 EcoReportTool (ERT)[17], developed for use in assessing products under the Ecodesign for Sustainable Products Regulation (ESPR). A representative model of a product group is selected, and the bill of materials associated with that representative model is matched with items within the ERT. The matched items have unit environmental impacts provided which are part of the assessment, and recycled material options available. In the new ERT, there is virgin material (V) and recycled material (R), each with their own dataset of unit environmental impacts. Table 8 and Table 9 present the BoM for the large office A3 colour laser printer and household A4 colour inkjet printer, respectively. For the factors R1 (recycled content), R2 (recyclability or recycling output rate) and A (allocation factor), see section 5.2.

[17] MEErP _Ecoreport tool_v1.7.xlsx; European Commission, Joint Research Centre, Eynard, U., Ardente, F., Gama Caldas, M., Spiliotopoulos, C. and Mathieux, F., Ecoreport tool - Manual, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/473257, JRC133597.

Table 8: Bill of Materials for Large Office A3 Colour Laser Printer and corresponding entries in the EcoReportTool

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
PA 6.6	197.13	Plastics	11-Nylon 6 fiber extrusion into fiber production mix, at plant 5% loss, 3,5 MJ electricity	31-Nylon fibre, recycled, mechanical, post-consumer washing, drying, shredding, drum rotating spinning production mix, at plant Erec/ErecEoL, efficiency 90%	0%	0%	50%
PA 6.6-GF30	40.8	Plastics			0%	0%	50%
polyketone GF30	16.5	Plastics			0%	0%	50%
PET	28.47	Plastics	12-Polyethylene terephthalate (PET), petrochemical based polymerisation of ethylene glycol and terephthalic acid production mix, at plant petrochemical based	41-Polyethylene terephthalate (PET) granulate secondary ; no metal fraction from post-consumer waste, via washing, granulation, pelletization production mix, at plant 90% recycling rate	0%	0%	50%
PET-(GF+MD)40 FR(17)	26.4	Plastics			0%	0%	50%
PET-(GF+MD)40FR(17)	157.7	Plastics			0%	0%	50%
PMMA	101.5	Plastics	13-Polymethyl methacrylate (PMMA) granulate bulk polymerisation, from methyl methacrylate production mix, at plant 1.18 g/cm3	40-Recycling of post-consumer waste polypropylene (PP) collection, sorting, transport, washing, granulation, pelletization production mix, at plant 48,9% recycling rate	0%	0%	50%
PC	188.76	Plastics	14-Polycarbonate (PC) granulate Technology mix, dipenyl carbonate route and phosgene route production mix, at plant 1.20–1.22 g/cm3	33-Polycarbonate (PC), recycled, post-consumer chemical recycling, depolymerisation, hydrolysis production mix, at plant Erec/ErecEoL, efficiency 80%	0%	0%	50%
PC-GF20	96.2	Plastics			0%	0%	50%
PP	14.89	Plastics	16-Polypropylene (PP), petrochemical based polymerisation of bio-fossil propylene production mix, at plant petrochemical based	35-Polypropylene, recycled, post-consumer washing, drying, shredding, pelletizing production mix, at plant Erec/ErecEoL, efficiency 90%	0%	0%	50%
PPE+PS-GF20	476.9	Plastics	17-Polystyrene production, high impact polymerisation of styrene production mix, at plant 1.05 g/cm3	40-Recycling of post-consumer waste polypropylene (PP) collection, sorting, transport, washing, granulation, pelletization production mix, at plant 48,9% recycling rate	0%	0%	50%
PS-HI	672.3	Plastics			0%	0%	50%
(ABS+PC)-GF20 FR(40)	47.2	Plastics	1-Acrylonitrile Butadiene Styrene (ABS) emulsion polymerisation, bulk polymerisation or combined processes production mix, at plant	36-Recycling plastic Acrylonitrile-butadiene-styrene (ABS), waste management, technology mix	0%	0%	50%
ABS	17752.23	Plastics			0%	0%	50%
ABS+PC	3780.76	Plastics			0%	0%	50%
ABS+PC FR(40)	1511	Plastics			0%	0%	50%
ABS-GF20	694.6	Plastics			0%	0%	50%
Thermoplastic polyurethane elastomer	15.11	Plastics	20-Polyurethane flexible foam reaction of toluene diisocyanate (TDI) with long-chain polyether polyol and foaming production mix, at plant 18- 53 kg/m3	not available	0%	0%	50%
POM	1189.69	Plastics	300-Polyoxymethylene (POM) {GLO} | polymerisation of formaldehyde and	not available	0%	0%	50%
POM-CD10	7.9	Plastics			0%	0%	50%

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
POM-GF25	60.1	Plastics	polymerisation of trioxane with a small volume of co-polymer | production mix, at plant | petrochemical based | LCI result		0%	0%	50%
chloroprene rubber	4.46	Plastics	304-Chloroprene rubber (Neoprene) based {GLO} | emulsion polymerisation of chloroprene | production mix, at plant | petrochemical based | LCI result	305-Recycled Chloroprene rubber (Neoprene) based {GLO} | emulsion polymerisation of chloroprene | production mix, at plant | petrochemical based | LCI result	0%	0%	50%
isoprene rubber	44.5	Plastics	306-Isoprene rubber (IR) {GLO} | solution process reaction between formaldehyde and isobutylene | production mix, at plant | petrochemical based | LCI result	307-Recycled Isoprene rubber (IR) {GLO} | solution process reaction between formaldehyde and isobutylene | production mix, at plant | petrochemical based | LCI result	0%	0%	50%
PBT-GF30	5.5	Plastics	308-Polybutylene terephtalate (PBT) {GLO} | polymerisation of terephthalic acid (TPA) and 1,4-butanediol (BDO) | production mix, at plant | petrochemical based | LCI result	309-Recycled Polybutylene terephtalate (PBT) {GLO} | polymerisation of terephthalic acid (TPA) and 1,4-butanediol (BDO) | production mix, at plant | petrochemical based | LCI result	0%	0%	50%
Liquid Crystal Polymer	36	Plastics	316-polyphenylene sulfide production	317-Recycled polyphenylene sulfide production	0%	0%	50%
PPS	0.4	Plastics			0%	0%	50%
PPS-(GF+MD)65	9.8	Plastics			0%	0%	50%
PPS-GF30	18.2	Plastics			0%	0%	50%
EPDM Rubber	0.26	Plastics	6-Ethylene propylene dien elastomer (EPDM) copolymerization of ethylene and propylene production mix, at plant 69% ethylene, 38% propylene	39-Recycling of post-industrial waste EPDM rubber	0%	0%	50%
LDPE	14	Plastics	9-LDPE granulates Polymerisation of ethylene production mix, at plant 0.91- 0.96 g/cm3, 28 g/mol per repeating unit	29-Low density polyethylene (LDPE), recycled washing, drying, shredding, pelletizing production mix, at plant Erec/ErecEoL, efficiency 90.3%	0%	0%	50%
Bronze	64	Metals	310-Bronze {GLO} | copper ore mining and processing, electrolysis, alloying | single route, at plant | CuSn10 | LCI result	311-Recycled Bronze {GLO} | copper ore mining and processing, electrolysis, alloying | single route, at plant | CuSn10 | LCI result	0%	0%	50%
Aluminum	814.66	Metals	52-Aluminium ingot mix (high purity) primary production, aluminium casting single route, at plant 2.7 g/cm3, >99% Al	123-Recycling of aluminium into aluminium ingot - from post-consumer collection, transport, pretreatment, remelting production mix, at plant aluminium waste, efficiency 90%	0%	50%	20%
copper	64.97	Metals	61-Copper Concentrate (Mining, mix technologies); copper ore mining and processing; single route, at plant; Copper - gold - silver - concentrate (28% Cu; 22.3 Au gpt; 37.3 Ag gpt)	124-Recycling of copper from clean scrap; collection, transport, pretreatment; production mix, at plant; copper content in input scrap 90%, copper losses 1%	30%	50%	20%
copper	0.1	Metals			30%	50%	20%
Copper Wire (0.6 mm)	461.25	Metals			30%	50%	20%
AlNiCo magnet (estimation)	487.57	Metals		not available	0%	0%	20%

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
Iron oxide (ferrite) (Fe2O3)	6.62	Metals	68-Ferrite (iron ore) iron ore mining and processing production mix, at plant 5.00 g/cm3		30%	50%	20%
stainless steel	179.4	Metals	86-Stainless steel hot rolled hot rolling production mix, at plant stainless steel	126-Secondary steel slab electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
stainless steel spring wire	462.21	Metals			30%	50%	20%
low carbon steel bar	13647.04	Metals	87-Steel cold rolled coil blast furnace route single route, at plant carbon steel	126-Secondary steel slab electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
steel wire rod	8.64	Metals	88-Steel electrogalvanized coil steel sheet electrogalvanization single route, at plant 1.5 mm sheet thickness, 0.02 mm zinc thickness	126-Secondary steel slab electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
steel sheet EG	5788.03	Metals	90-Steel sheet cold rolling - thickness 2.5mm steel cold rolling process single route, at plant thickness 2.5 mm	126-Secondary steel slab electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
steel sheet zinc coated	30598.23	Metals			30%	50%	20%
Cable 1-core power 18AWG PVC (16 g/m) D2.9	447.88	Electronics	132-Cable, high current technology mix production mix, at plant high current, 1m, 13 g/m	176-End of life of cable, high current Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Cable 1-core signal 24AWG PVC (4.5 g/m) D1.4	1469.7	Electronics			0%	0%	50%
16 AWG (PVC) = 100 g / m (3 core wire)	402	Electronics	133-Cable, three-conductor cable technology mix production mix, at plant three-conductor cable, 1m, 60 g/m	177-End of life of cable, three-conductor cable Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Cable 3-core mains power 10A/13A 16AWG PVC (100 g/m) D8	97.5	Electronics			0%	0%	50%
Capacitor Ceramic	0.00	Electronics	134-Capacitor ceramic technology mix production mix, at plant capacitor, mlcc, 6 mg	178-End of life of capacitor ceramic Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Capacitor Ceramic	0.00	Electronics			0%	0%	50%
Capacitor Ceramic	0.01	Electronics			0%	0%	50%
Capacitor Ceramic	0.00	Electronics			0%	0%	50%
Capacitor Ceramic	0.19	Electronics			0%	0%	50%
Capacitor Ceramic	0.37	Electronics			0%	0%	50%
Capacitor Ceramic	0.59	Electronics			0%	0%	50%
Capacitor Ceramic	0.39	Electronics			0%	0%	50%
Capacitor tantal SMD E	0.93	Electronics	135-Capacitor SMD technology mix production mix, at plant SMD capacitor, 12.5 g	179-End of life of Capacitor SMD Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Capacitor Al-Elko axial THT	0.7	Electronics			0%	0%	50%
Capacitor Al-Elko radial THT	1.35	Electronics			0%	0%	50%

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
Diode power DO214/219 (93mg) 4.3x3.6x2.3	0.16	Electronics	143-Diode Metal electrode leadless face (mMELF) front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 40 mg	186-End of life of Diode Metal electrode leadless face (mMELF) Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Diode signal DO214/219	0.04	Electronics			0%	0%	50%
Diode signal SOD123/323/523	0.01	Electronics			0%	0%	50%
Diode signal SOD123/323/523	0.06	Electronics			0%	0%	50%
Coil multilayer chip 0402	0.02	Electronics	144-Flat chip resistor technology mix production mix, at plant 1 piece of resistor flat chip 1206 (9.2mg)	187-End of life of flat chip resistor Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Coil multilayer chip 1812	0.1	Electronics			0%	0%	50%
Resistor flat chip	0.00	Electronics			0%	0%	50%
Resistor flat chip	0.01	Electronics			0%	0%	50%
Resistor flat chip	0.13	Electronics			0%	0%	50%
Resistor thick film flat chip	0.02	Electronics			0%	0%	50%
Resistor thick film flat chip	0.12	Electronics			0%	0%	50%
Resistor thick film flat chip	0.15	Electronics			0%	0%	50%
Resistor thick film flat chip	0.23	Electronics			0%	0%	50%
Resistor THT MBB	0.98	Electronics			0%	0%	50%
Resistor THT MBE	0.70	Electronics			0%	0%	50%
Thermistor SMD PTC	0.1	Electronics			0%	0%	50%
LED SMD low-efficiency max 50mA	0.05	Electronics	151-Light Emitting Diode (LED) front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 5 mm, 350 mg	190-End of life of Light Emitting Diode (LED) Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
LED SMD high-efficiency max 0.5A	0.01	Electronics	153-Light Emitting Diode (LED), low power front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 59 mg	192-End of life of Light Emitting Diode (LED), low power Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Transistor signal SOT223 8 leads	0.81	Electronics	155-Medium power transistor semiconductor front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 4.8 g	193-End of life of Medium power transistor semiconductor Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Transistor signal SOT23 3 leads	0.39	Electronics			0%	0%	50%
Transistor signal SOT23 8 leads	0.33	Electronics			0%	0%	50%

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
Diode power THT DO35 (150mg) D1.76x3.77	1.29	Electronics	163-Plastic axial diode, Semiconductor front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 1.12 g	194-End of life of Plastic axial diode, Semiconductor Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Printed Wiring Board 1-layer rigid FR4 with HASL finish (Subtractive method)	177.35	Electronics	164-Printed wiring board (PWB) (2-layer) via the subtractive method (as opposed to additive method) production mix, at plant 2-layer, 1.32 kg	195-End of life of Populated Printed wiring board (PWB) (2-layer) Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Printed Wiring Board 2-layer rigid FR4 with HASL finish (Subtractive method)	37.69	Electronics			0%	0%	50%
Populated printed wiring board	803.6	Electronics	165-Printed wiring board (PWB) (8-layer) via the subtractive method (as opposed to additive method) production mix, at plant 8-layer, 3.08 kg	196-End of life of Populated Printed wiring board (PWB) (8-layer) Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95-98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Printed Wiring Board 4-layer rigid FR4	158.90	Electronics			0%	0%	50%
Printed Wiring Board 8-layer rigid FR4	134.44	Electronics			0%	0%	50%
Coil miniature wound SDR0302	1.29	Electronics	167-SMD coil technology mix production mix, at plant 1 piece of Coil miniature wound SDR1006 (1.16g) D9.8 x 5.8	198-End of life of SMD coil Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Coil miniature wound SDR1006	0.27	Electronics			0%	0%	50%
Coil miniature wound SRR0804	1.81	Electronics			0%	0%	50%
Key switch Dip (79mg) 11.39x4.5x1.5	0.11	Electronics	170-Switch < 1 Ampere technology mix production mix, at plant < 1 Ampere, 79 mg	201-End of life of Switch < 1 Ampere Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Key switch tact (242mg) 6.2x6.3x1.8	0.46	Electronics	171-Switch > 1 Ampere technology mix production mix, at plant > 1 Ampere, 242 mg	2End of life of Switch > 1 Ampere Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
IC BGA 144	0.34	Electronics	312-Generic IC	313-Recycled Generic IC	0%	0%	50%
IC BGA 144	0.63	Electronics			0%	0%	50%
IC BGA 256	2.92	Electronics			0%	0%	50%
IC QFP 32	0.20	Electronics			0%	0%	50%
IC SO 8	1.36	Electronics			0%	0%	50%
IC SSOP 14	0.13	Electronics			0%	0%	50%

A3 Laser (BC5) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
IC SSOP 24	0.18	Electronics			0%	0%	50%
IC TQFP 32	1.50	Electronics			0%	0%	50%
IC TQFP 44	0.95	Electronics			0%	0%	50%
IC TSSOP 8	0.04	Electronics			0%	0%	50%
IC WLP CSP 196	0.78	Electronics			0%	0%	50%
Coin cell (Li/Poly-carbonmonofluoride - RB0.8; RS0.65)	3.2	Electronics	318-battery cell, Li-ion, LiMn2O4	319-Recycled battery cell, Li-ion, LiMn2O4	0%	0%	50%
10.1" Liquid Crystal Display (LCD)	594	Electronics	320-liquid crystal display production, unmounted	321-Recycled liquid crystal display production, unmounted	0%	50%	50%
Micro Speaker (2g, dynamic, Nd magnet, SMD)	15.49	Electronics	322-electronic component production, passive, mobile, earpiece and speaker	323-Recycled electronic component production, passive, mobile, earpiece and speaker	0%	0%	50%
IC TSSOP 16	0.39	Electronics	326-IC, DRAM (50% of SoC)	327-Recycled IC, DRAM (50% of SoC)	0%	0%	50%
IC TSSOP 8	0.45	Electronics			0%	0%	50%
Glass	1618.12	Others	222-glass fiber technology mix production mix, at plant 1 kg	not available	0%	0%	50%
Oscillator crystal (500mg) 11.05x4.65x2.5	3	Others	324-Metal body quartz oscillator {GLO} | technology mix | production mix, at plant | 1 piece of Oscillator crystal (750mg) 11.35x4.65x3.6 | LCI result	325-Recycled Metal body quartz oscillator {GLO} | technology mix | production mix, at plant | 1 piece of Oscillator crystal (750mg) 11.35x4.65x3.6 | LCI result	0%	0%	50%

Table 9: Bill of Materials for A4 Colour Inkjet Printer (BC7) and corresponding entries in the EcoReportTool

A4 Inkjet (BC7) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
PC	32	Plastics	14-Polycarbonate (PC) granulate Technology mix, dipenyl carbonate route and phosgene route production mix, at plant 1.20–1.22 g/cm3	33-Polycarbonate (PC), recycled, post-consumer chemical recycling, depolymerisation, hydrolysis production mix, at plant Erec/ErecEoL, efficiency 80%	0%	0%	50%
PP	2	Plastics	16-Polypropylene (PP), petrochemical based polymerisation of bio-fossil propylene production mix, at plant petrochemical based	35-Polypropylene, recycled, post-consumer washing, drying, shredding, pelletizing production mix, at plant Erec/ErecEoL, efficiency 90%	0%	0%	50%
ABS	1,276	Plastics	1-Acrylonitrile Butadiene Styrene (ABS) emulsion polymerisation, bulk polymerisation or combined processes production mix, at plant	36-Recycling plastic Acrylonitrile-butadiene-styrene (ABS), waste management, technology mix	0%	0%	50%
Cable PVC	208.6	Plastics	22-PVC granulates, low density polymerisation of vinyl chloride production mix, at plant 62 g/mol per repeating unit	37-Recycling plastic (PVC), waste management, technology mix, at plant	0%	0%	50%
Silicate	2	Plastics	26-Silicone, high viscosity hydrolysis and methanolysis of dimethyldichloro silane production mix, at plant >30 000 centi Poise	not available	0%	0%	50%
PPO	28	Plastics	2-Aramid fiber low-temperature solution polymerisation of m-phenylene diamine with isophthaloyl chloride production mix, at plant petrochemical based	40-Recycling of post-consumer waste polypropylene (PP) collection, sorting, transport, washing, granulation, pelletization production mix, at plant 48,9% recycling rate	0%	0%	50%
POM	42	Plastics	300-POM	not available	0%	0%	50%
Epoxy	6	Plastics	4-Epoxy plastic polymerisation of liquid epoxy resins with a latent hardener (amine) production mix, at plant petrochemical based	not available	0%	0%	50%
Rubber	4	Plastics	6-Ethylene propylene dien elastomer (EPDM) copolymerization of ethylene and propylene production mix, at plant 69% ethylene, 38% propylene	39-Recycling of post-industrial waste EPDM rubber	0%	0%	50%
Copper	8	Metals	61-Copper Concentrate (Mining, mix technologies); copper ore mining and processing; single route, at plant; Copper - gold - silver - concentrate (28% Cu; 22.3 Au gpt; 37.3 Ag gpt)	124-Recycling of copper from clean scrap; collection, transport, pretreatment; production mix, at plant; copper content in input scrap 90%, copper losses 1%	30%	50%	20%
Cable copper	89.4	Metals			30%	50%	20%
Ferrite	10	Metals	68-Ferrite (iron ore) iron ore mining and processing production mix, at plant 5.00 g/cm3	not available	0%	0%	20%
Stainless steel	54	Metals	85-Stainless steel cold rolled hot rolling production mix, at plant stainless steel	128-Steel cast part alloyed electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%

A4 Inkjet (BC7) Component	Weight (grams)	Material Category	Virgin material dataset	Recycled material dataset	R1	R2	A
Galvanized steel	280	Metals	88-Steel electrogalvanized coil steel sheet electrogalvanization single route, at plant 1.5 mm sheet thickness, 0.02 mm zinc thickness	128-Steel cast part alloyed electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
Spring steel	20	Metals	90-Steel sheet cold rolling - thickness 2.5mm steel cold rolling process single route, at plant thickness 2.5 mm	128-Steel cast part alloyed electric arc furnace route, from steel scrap, secondary production single route, at plant carbon steel	30%	50%	20%
Cables	81.6	Electronics	133-Cable, three-conductor cable technology mix production mix, at plant three-conductor cable, 1m, 60 g/m	177-End of life of cable, three-conductor cable Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Components	1.3	Electronics	135-Capacitor SMD technology mix production mix, at plant SMD capacitor, 12.5 g	179-End of life of Capacitor SMD Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Other	0.1	Electronics	145-Glass SMD diode front-end and back-end processing of the wafer, including Czochralski method of silicon growing production mix, at plant 130 mg	188-End of life of Glass SMD diode Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
LCD	20.3	Electronics	154-Liquid Crystal Display (LCD)	204-End of life of TFT LCD display panel, color Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Printed Wiring Boards (PWB)	44.4	Electronics	164-Printed wiring board (PWB) (2-layer) via the subtractive method (as opposed to additive method) production mix, at plant 2-layer, 1.32 kg	195-End of life of Populated Printed wiring board (PWB) (2-layer) Recycling of copper and precious metals (Ag, Au, Pd, Pt) from electronics production mix, at plant recycling processes: 95- 98% efficiency, scrap incineration: 11.0 MJ/kg NCV	0%	0%	50%
Glass	180	Others	222-glass fiber technology mix production mix, at plant 1 kg	not available	0%	0%	50%

5.2. Recycling parameters for the EcoReportTool

5.2.1 Simplified Circular Footprint Formula

The 2024 ERT calculates the environmental impacts of raw materials, excluding the end-of-life (EoL) phase, using a simplified version of the Circular Footprint Formula (CFF) [18] [19]:

(1-R1) x Ev + R1 x (A x Erec + (1-A) x Ev).

The impacts at end-of-life due to material recycling are computed from:

(1-A) x R2 x Erec.

The benefits at end-of-life due to material recycling (avoidance of virgin material use) are computed from:

For non-electronics: - (1-A) x R2 x Ev

For electronics: - CF x Amount x (1-A) x R2 x SUM (Credits for Cu, Au, Pd, Pt, Ag)

where:

Ev the virgin material impact for the environmental parameter, computed as the total input material mass (kg) multiplied by the unit impact for the applicable virgin material dataset for the environmental parameter (impact/kg).

Erec the recycled material impact for the environmental parameter, computed as the total input material mass (kg) multiplied by the unit impact for the applicable recycled material dataset for the environmental parameter (impact/kg).

R1 (recycled content): the proportion of material in input to the production that has been recycled from a previous system.

R2 (recycling output rate): the proportion of the material in the product that will be recycled in a subsequent system. R2 considers the efficiencies in the collection and recycling processes. R2 shall be measured at the output of the recycling plant.

A the allocation factor apportions the burdens and credits between supplier and user of recycled materials. The “A” factor in the CFF allocates impacts and/or benefits between use of recycled materials as input (i.e. recycled content) and recycling at the end-of-life (i.e. recycling output rate). It avoids a situation of potential double counting due to recycled materials coming from these products being subsequently used in other products, or vice versa.

For electronics, a more complex formula is used to compute recycling benefits:

[18] MEErp _Ecoreport tool_v1.7.xlsx
European Commission, Joint Research Centre, Eynard, U., Ardente, F., Gama Caldas, M., Spiliotopoulos, C. and Mathieux, F., Ecoreport tool - Manual, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/473257, JRC133597.

[19] The ERT does not consider the impacts from incineration (with or without heat recovery), nor of landfilling, fugitive, or missing masses at EoL.

- For electronics, the amount of material in input to the production is often defined in square metres, linear metres or items. A conversion factor CF is used to convert the amount to a mass in kg.
- Each virgin material dataset for electronics has material credits defined for copper (Cu), gold (Au), palladium (Pd), platinum (Pt) and silver (Ag). These credits can be interpreted as mass shares. E.g. for dataset 133 (cable), the credit for copper is 0.195.
- Each material credit is multiplied by the unit impact for the considered parameter in the virgin material dataset for Cu (61), Au (75), Pd (81), Pt (82) or Ag (84), and the sum is multiplied by the recycled mass share CF x Amount x (1-A) x R2.
- Hence, for electronics, the recycling benefit is not related to e.g. avoided virgin cables, PWBs or LEDs, but to avoided virgin Cu, Au, Pd, Pt and Ag.

The ERT provides default values for R1, R2 and A that the user can accept or overwrite. The values for these parameters are discussed in the following sections. The values used are shown in Table 8.

5.2.2 Allocation factor A

The current study uses the default values for allocation factor A, which are 20% for metals and 50% for all other material types. Hence, for recycling of metals, only 20% of the benefits are assigned to the production phase, and 80% to the EoL phase. For plastic, electronics, and other materials the allocation is 50% production and 50% EoL.

5.2.3 Factor R1, recycled content

Plastics

For plastics, the ERT default value for factor R1 (recycled content) is 0%. PlasticsEurope [20] states that EEE products consumed 3.1 Mt of plastics in 2022, of which 3.2% (0.1 Mt) came from post-consumer recycled plastic. It is uncertain if this share would also be representative for imaging equipment, although many of the major brands are working on developing pioneering models that incorporate post-consumer recycled plastic (e.g. Epson, Hewlett Packard, Lexmark).

For the base case A3 colour laser printer, plastics constitute 32% or about 27.2 kilograms of the total mass of the machine. Table 10 provides a breakdown by type of plastic, including mass in kilograms, percentage of total plastic mass and percentage of total mass of all materials. Of these, Acrylonitrile Butadiene Styrene (ABS) is the most common, at 87.4% of the mass and 23.8 kilograms. Next is Polyoxymethylene (POM) at 4.6% of mass and 1.26 kilograms. Polystyrene (PS) is the third most common at 4.2% and 1.15 kilograms. Next is polycarbonate (PC) at 1.0% and 0.28 kilograms, followed by Nylon at 0.9% and 0.25 kilograms. Polyethylene terephthalate (PET) and other remaining plastics are all less than 1% of the mass of plastic. For all the plastics, the default assumption is 0% recycled plastic content, which when viewed across the whole industry seems reasonable and thus has been used as the reference scenario.

[20] https://plasticseurope.org/wp-content/uploads/2024/11/PE_TheFacts_24_digital-1pager.pdf
https://plasticseurope.org/knowledge-hub/the-circular-economy-for-plastics-a-european-analysis-2024/

Table 10. Plastics used in the basecase A3 Colour Laser Printer (BC5) mass and percentages

Plastic Type	Mass of Plastic [kilograms]	Percent Total Plastic Mass of A3 Colour Laser	Percent of Total Mass of A3 Colour Laser
Acrylonitrile Butadiene Styrene (ABS)	23.8	87.4%	27.7%
Polyoxymethylene (POM)	1.26	4.6%	1.5%
Polystyrene (PS)	1.15	4.2%	1.3%
Polycarbonate (PC)	0.28	1.0%	0.3%
Nylon	0.25	0.9%	0.3%
Polyethylene terephthalate (PET)	0.21	0.8%	0.2%
Other plastic	0.26	1.0%	0.3%

For the base case A4 colour inkjet printer, plastics constitute 67% of the total mass of the machine, or approximately 1.60 kilograms. Of these, Acrylonitrile Butadiene Styrene (ABS) is the most common, at 80% of the mass and 1276 grams. PVC is second at 13% and 209 grams, followed by Polyoxymethylene (POM) at 2.6% and 42 grams. Polycarbonate is next at 2.0% and 32 grams, and the remaining plastics are 2.6% in total, and 42 grams. As for the A3 colour laser printer, the default assumption is 0% recycled plastic content (R1), which when viewed across the whole industry seems reasonable and thus has been used as the reference scenario.

Table 11. Plastics used in the basecase A4 Colour Inkjet Printer (BC7) mass and percentages

Plastic Type	Mass of Plastic [grams]	Percent Total Plastic Mass of A4 Colour Inkjet	Percent of Total Mass of A4 Colour Inkjet
Acrylonitrile Butadiene Styrene (ABS)	1,276.0	79.7%	53.4%
Polyvinyl chloride (PVC)	208.6	13.0%	8.7%
Polyoxymethylene (POM)	42.0	2.6%	1.8%
Polycarbonate (PC)	32.0	2.0%	1.3%
Nylon	28.0	1.7%	1.2%
Other plastic	14.0	0.9%	0.6%

In ECO scenarios, differing percentages of recycled plastic content (R1) were considered, with the percentages increased (i.e., 10%, 30%, 100%) and the differences in environmental impacts were recorded.

Metals

For the base case A3 colour laser printer, metals are the heaviest overall material in the product, constituting 61% of the total mass of the printer, or 52.6 kilograms of metal. Of these, steel is the most common metal, with 50.7 kilograms or about 96.4% of the metal content. Aluminium is the second most common at 0.81 kilograms or 1.5% of total mass of metals. Next is copper, at 0.53 kilograms or about 1%. Iron is the fourth most common metal at 0.49 kilograms or about 0.9% of the metals. The remaining metals are 0.07 kilograms which is 0.1% of the total mass of metals. In the basecase (reference) scenario, it is estimated that 30% of the steel, aluminium, copper and iron are derived from recycled sources. All other metals are either 0% recycled or do not have a recycled option.

For the base case A4 colour inkjet printer, metals constitute 19% of the total mass of materials at 0.46 kilograms. Of the various types of metal in this printer, the largest quantity is steel at approximately 0.35 kilograms or 77% of the total mass of metals. Copper is the second most common metal at 0.10 kilograms or 21.1%. Iron is third at 0.01 kilograms and 2.2% of mass.

In the ECO scenarios analysed for this study, adjustments were made to the recycled content of the metals (R1 values). Eurostat (End-of-Life Recycling Input Rates (EOL-RIR))[21] publishes estimates of rate at which certain materials are incorporating recycled content. The report doesn't cover all the materials of interest, however it does cover some of the important ones. The published value of recycled content (R1) in the Eurostat report for 2019 and 2022 (the most recent year available) are shown in the table below. The ERT had default values for copper and iron is 0%, even though Eurostat found that these metals did incorporate recycled content. The table below presents the Eurostat values for 2019 and 2022, the default values for the ERT analytical tool, and finally the values that were used in this analysis for imaging equipment: 30% for aluminium, copper and iron.

Table 12. End-of-life recycling input rates, Eurostat, EcoReport Tool and Imaging Equipment

Metal	Eurostat estimate for 2019	Eurostat estimate for 2022	EcoReport Tool v.1.7 default values	Imaging Equipment (R1 values used)
Aluminium	12%	32%	30%	30%
Copper	17%	55%	0%	30%
Iron	32%	31%	0%	30%

Electronics

For the base case A3 colour laser printer, the electronics are approximately 5% of the mass, or 4.37 kilograms. Of all the electronic parts, the wiring in the printer is the heaviest, constituting 55% of the total mass of the electronics (2.4 kilograms). Printed wiring boards (PWB) are the next heaviest component, representing 30% of the mass of electronics (1.3 kilograms). The third most heavy electronics component is the LCD display which is 13.6% or

[21] Eurostat, 2023. “Contribution of recycled materials to raw materials demand - end-of-life recycling input rates (EOL-RIR)”, online data code: cei_srm010 DOI: 10.2908/cei_srm010; last updated 11/05/2023. Accessed February 2025. Link: https://ec.europa.eu/eurostat/databrowser/view/cei_srm010$defaultview/default/table?lang=en

0.59 kilograms. The remaining components are less than 1% of the electronic mass, and are just 0.04 kilograms.

For the base case A4 colour inkjet printer, the electronics are the lightest component constituting just 6% of the total mass of the machine (0.15 kilograms). Of all the electronic parts in this printer, the wiring is the heaviest, constituting 55% of the total mass of the electronics, or 0.08 kilograms. Printed wiring boards are the second heaviest electrical item, at 30% of the electronics, or 0.04 kilograms. The third most heavy electronics component is the LCD display which is 13.8% or 0.02 kilograms. The remaining components are less than 1% of the electronic mass, and are just 1.4 grams.

For both the A3 colour laser printer and the A4 inkjet printer, the working assumption is that all the electronics being incorporated into the printers are new, therefore the R1 recycled content is set to 0% for all components on both basecase printers. This is a reasonable assumption, as new machines placed on the market are built with new components.

Other

Both bills of material for the A3 colour laser printer and the A4 inkjet printer contain other components which constitute a very minor part of the overall mass of the respective printers. For the A3 colour laser printer, glass fibre is nearly 100% of the total mass (1.62 kilograms) and for the A4 colour inkjet, glass fibre is 0.018 kilograms. Both are assumed to have 0% recycled content (R1).

5.2.4 Factor R2, recycling output rate

The ERT specifies that the value for R2 (recycling output rate) shall take into account the efficiencies in the collection and recycling processes.

Plastics

Based on bill of materials for the two base case model printers (i.e., A3 colour laser and A4 colour inkjet), the most popular plastic – by far – used in printers is Acrylonitrile Butadiene Styrene (ABS). Beyond this plastic, there is some use of POM, PVC, PS and PC, but these are all much smaller fractions of the plastic used in the printers. In the ERT, all three of these plastic types have their recycling output rates (R2) set to 0%. In the absence of any evidence to the contrary, this was the value used for all plastic types. The other plastic types that are used are only found in trace amounts and thus it would not seem worthwhile to separate them at end of life, thus these are also assumed to have nothing recycled, i.e., R2=0%.

Metals

Based on the bill of materials, the most important metal in imaging equipment is steel – by a wide margin (77% and 96% for the A3 colour laser printer and A4 colour inkjet printer, respectively). On a mass of metal basis, copper is important and there is some aluminium in the A3 colour laser, but these are all much less than steel portion of the metals.

For aluminium and steel, the ERT gives a default value of the recovered (recycled) output rate, R2, of 85%. The ERT's default R2 values for magnesium is “n.a.” for not available and for copper it is set to 0%. However, it should be noted that if a printer is being recycled to recover the metals, the recycler would also work to recover the copper – which has a good value - so this assumption is incorrect.

For imaging equipment, in our reference scenario, we have set the recycling rate (R2) for these metal types, steel, aluminium and copper at 50% which is aligned with the ERT recovery rate (R2) for electronics.

<u>Electronics</u>

For all electronics, the ERT establishes a default value of recovery of electronics (R2) at 50%. This includes the LCD display, printed wiring boards, connectors, cables, capacitors, coils and other parts. This default collection rate (R2) in the ERT seems reasonable for the sector and therefore has not been adjusted.

5.3. Mass distributions for the baseline

Figure 1 shows the distribution of masses over all the material types for the A3 colour laser printer BC5, based on the bill of materials presented in section 5.1.

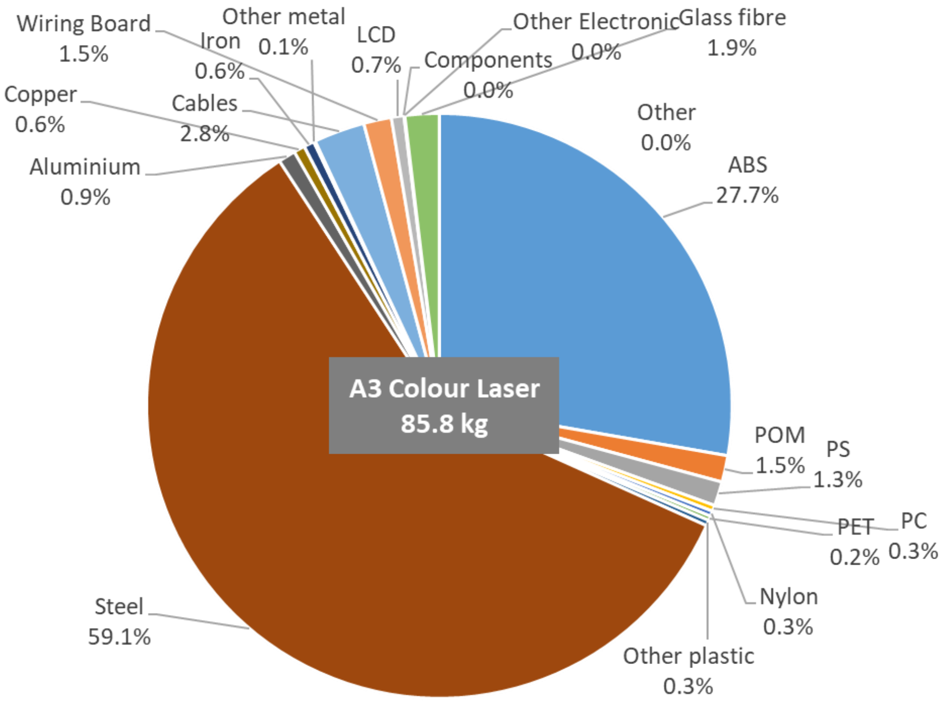


Figure 1: Percentage of total mass per material type for the A3 colour laser printer, BC5

Applying the baseline factors R1 (recycled content) of section 5.2.3 to the A3 colour laser printer (BC5j), approximately 15.8 kilograms, or about 18% of the materials in the printer are derived from recycled sources, all from metals. Figure 2 shows the proportions of virgin (blue) and recycled (orange) materials used in the A3 colour laser printer.

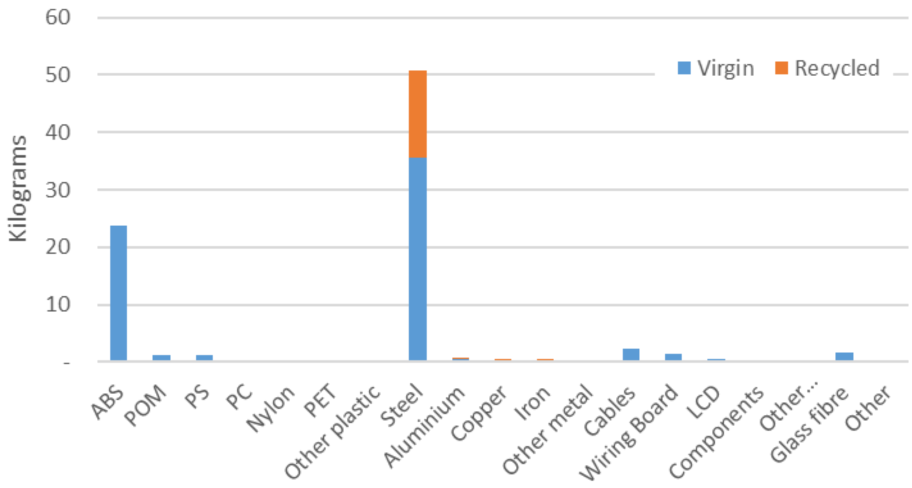


Figure 2: Virgin and recycled material inputs for A3 colour laser printer, BC5

Due to the scale of the y-axis to show the steel component in the printer, the following figure zooms in on the other materials, setting the y-axis to a limit of 4 kilograms so the other materials can be viewed.

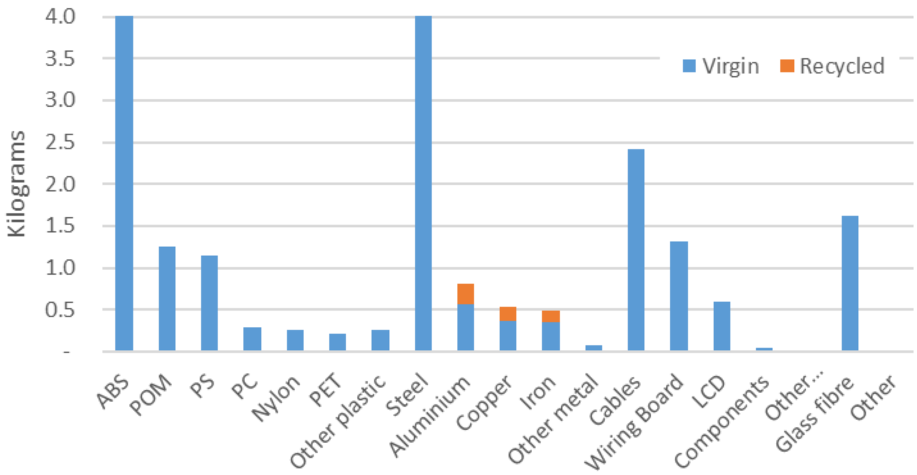


Figure 3: Zoom-in on input virgin and recycled materials for A3 colour laser printer, BC5

Applying the baseline factors R2 (recycled at end of life) of section 5.2.4, approximately 29.2 kilograms, or about 34% of the materials in the laser printer, are recovered at end of life. Figure 4 presents the total material inputs (purple) to the recycling outputs (green). The main sources of recycling output are steel and some electronics.

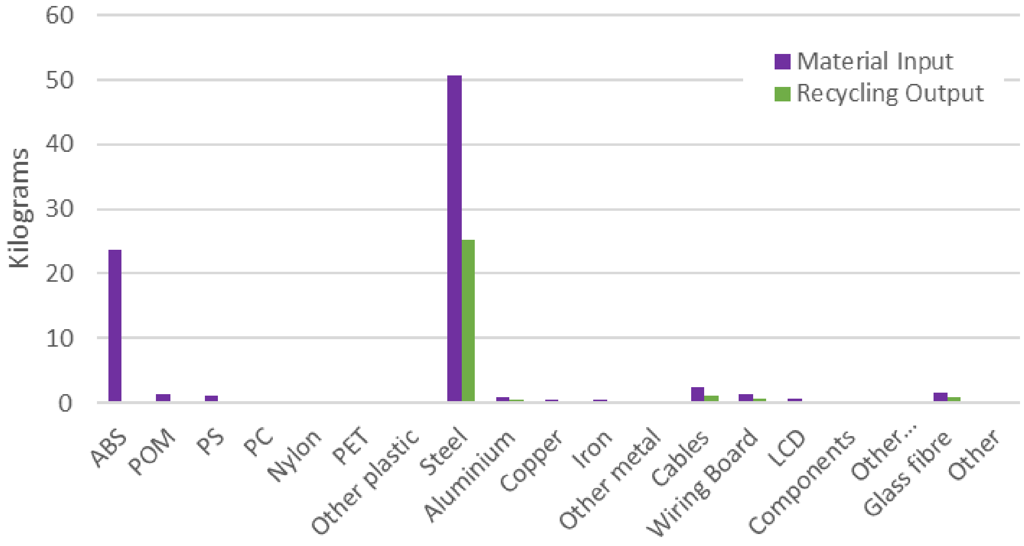


Figure 4: Total material input and recycled material output for A3 colour laser printer, BC5

Due to the scale of the y-axis to show the steel component in the printer, Figure 5 zooms in, setting the y-axis to a limit of 4 kilograms so the other materials can be viewed.

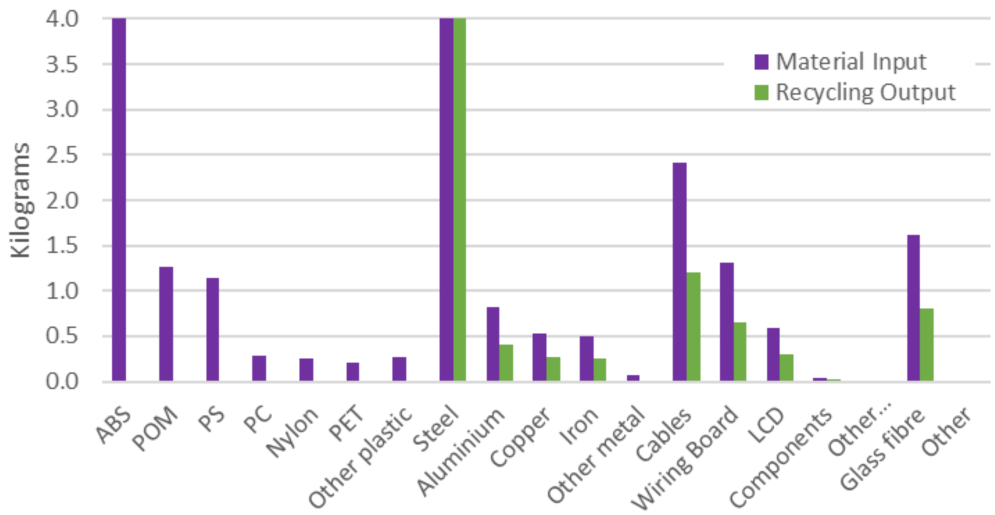


Figure 5: Zoom-in on total material input and recycled material output for A3 colour laser printer, BC5

Figure 6 shows the distribution of masses over all the material types for the base case A4 colour inkjet printer, BC7, based on the bill of materials presented in section 5.1.

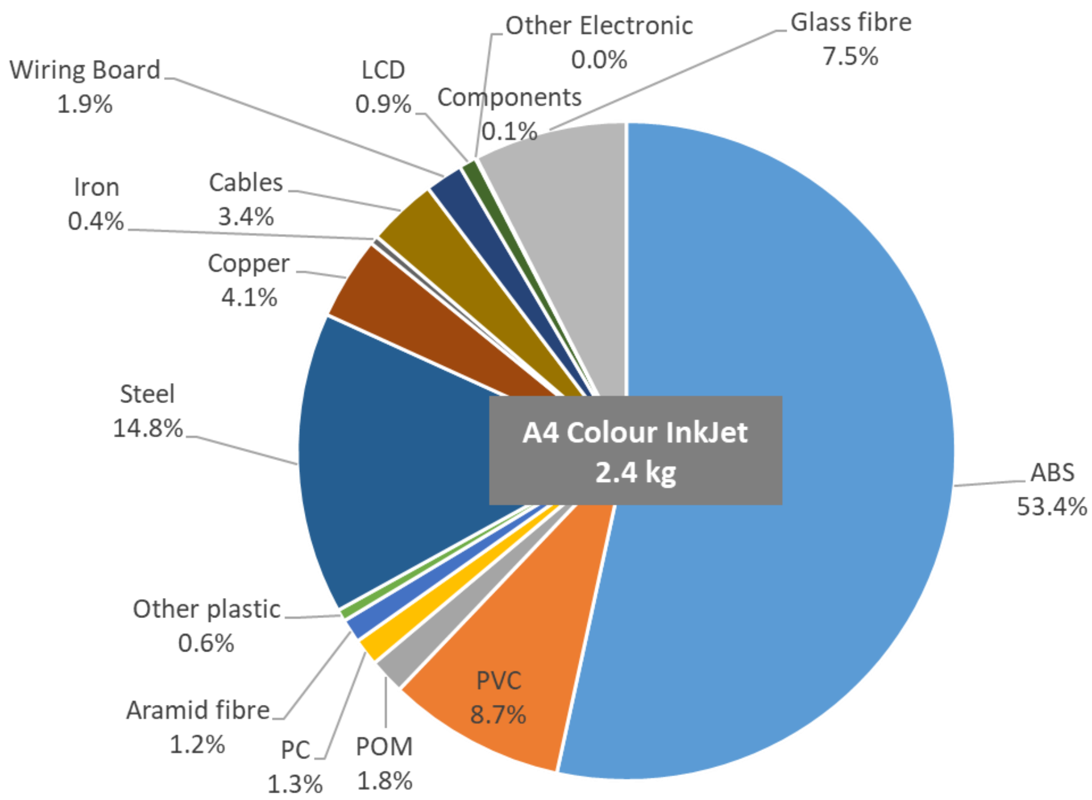


Figure 6: Percentage of total mass per material type for the base case A4 colour inkjet printer, BC7

Applying the baseline factors R1 (recycled content) of section 5.2.3 to the base case A4 colour inkjet printer (BC7), approximately 0.14 kilograms, or about 6% of the materials in the printer are derived from recycled sources, all from metals. Figure 7 shows the proportions of virgin (blue) and recycled (orange) materials used in the inkjet printer.

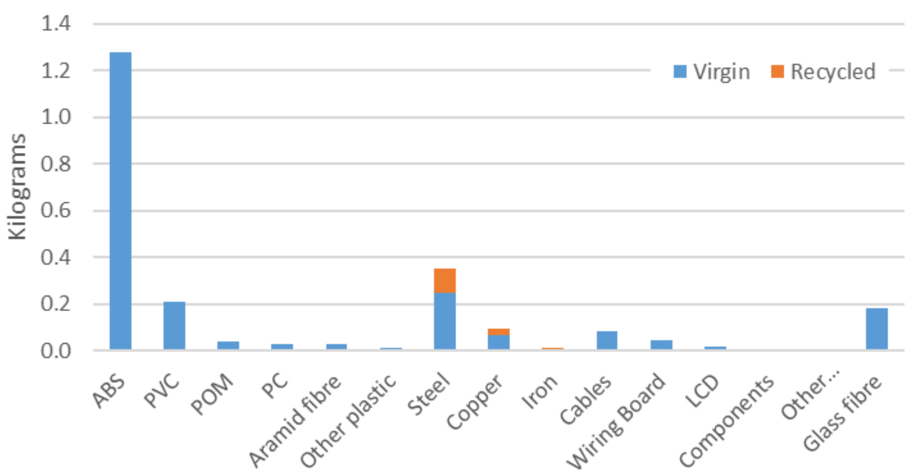


Figure 7: Virgin and recycled material in input, A4 colour inkjet printer, BC7

Applying the baseline factors R2 (recycled at end of life) of section 5.2.4, approximately 0.39 kilograms, or about 17% of the materials in the inkjet printer, are recovered at end of life. Figure 8 presents the total material inputs (purple) to the recycling outputs (green). The main sources of recycling output are steel, copper, cables, and glass fibre.

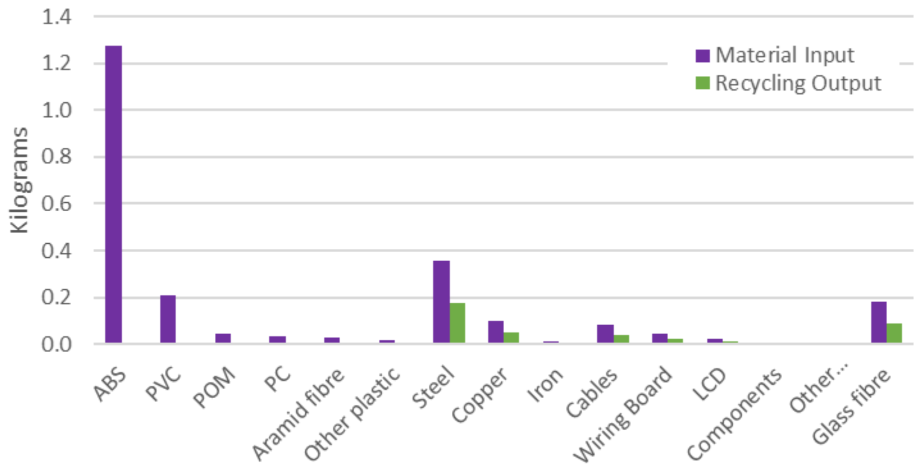


Figure 8: Total material input and recycled material output, A4 colour inkjet printer, BC7

5.4. Environmental impacts for the baseline models

The baseline environmental impacts for the base case A3 colour laser printer (BC5) have been computed using the 2024 EcoReportTool version 1.7. They are based on the BoM and factors R1, R2 and A of Table 8. Only impacts from raw materials and end-of-life impacts and credits have been considered [22].

Figure 9 gives the shares of each material category in the environmental impacts for raw materials and end-of-life impacts and credits for the reference scenario. Although electronic components (PCBs, cables, LED) represent only 5% of the weight of the laser printer, they have the highest environmental impact shares for most parameters (green shaded bars). The two exceptions are 'ozone depletion' (primarily from other, which is glass), and 'land use' (primarily from metals). For 'land use' the impact from electronics is reported as negative, which is considered an error, so it has been zeroed out.

[22] The current study focuses on material aspects. The impacts from manufacturing, distribution, use and repair and maintenance will be added later in the ongoing review study. They are assumed not to change due to requirements on recycled material content.

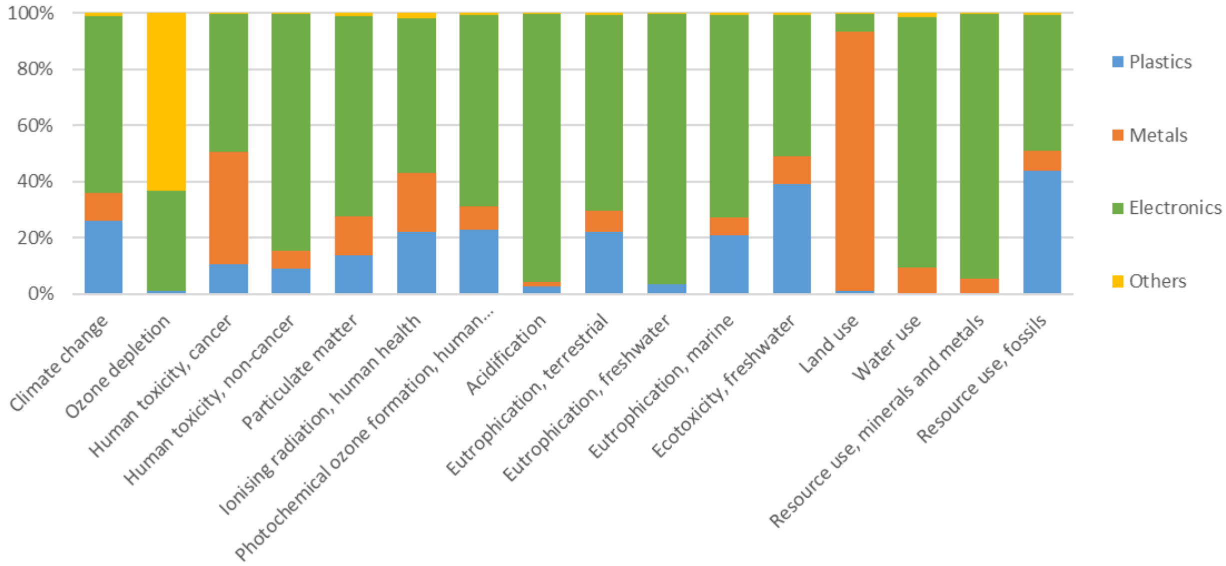


Figure 9: Shares of environmental impacts by material category for A3 colour laser printer (BC5)

To provide more detail on these impacts, the results are presented in tabular form below with the percentages of impact directly underneath the values. Due to the number of environmental indicators, the results are divided into two parts. The first part gives the mass and the impacts for the first 8 environmental parameters; the second part gives the impacts for the remaining 8 parameters [23]. Table 13 shows the total impacts, i.e. the sum of raw material impact, EoL impact and EoL credit for virgin material avoidance (negative impact), and the impact shares, per material category. Impact shares larger than 50% have been shaded in light blue.

[23] Impacts for 'primary energy consumption' are not shown, because here they are the same as for 'resource use, fossil'.

Table 13: Reference Environmental impacts for A3 colour laser printer (BC5), computed using 2024 ERT, including impacts from raw materials and end-of-life impacts and benefits

Material	Mass	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photo-chemical ozone formation, human health	Acidifi-cation
Units	*kg*	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
Plastics	27.21	86.234	0.000	0.000	0.000	0.000	3.365	0.203	0.218
share	31.7%	26.0%	1.1%	10.5%	8.9%	13.6%	21.9%	23.1%	2.6%
Metals	52.58	33.662	0.000	0.000	0.000	0.000	3.236	0.073	0.132
share	61.3%	10.2%	0.1%	40.0%	6.5%	14.1%	21.1%	8.3%	1.6%
Electronics	4.37	208.402	0.000	0.000	0.000	0.000	8.441	0.597	7.965
share	5.1%	62.9%	35.7%	49.2%	84.4%	71.2%	55.0%	67.9%	95.7%
Others	1.62112	3.060	0.000	0.000	0.000	0.000	0.304	0.006	0.010
share	1.9%	0.9%	63.1%	0.2%	0.2%	1.1%	2.0%	0.7%	0.1%
Total	**85.78**	**331.36**	**0.000**	**0.000**	**0.000**	**0.000**	**15.346**	**0.879**	**8.326**

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxi-city, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
Plastics	0.680	0.001	0.069	1151.63	120.96	0.000	0.000	2255.658
share	22.1%	3.4%	20.8%	39.2%	1.3%	0.0%	0.2%	43.7%
Metals	0.235	0.000	0.022	286.40	8595.6	6.003	0.001	384.294
share	7.6%	0.1%	6.5%	9.8%	92.0%	28.2%	5.1%	7.5%
Electronics	2.140	0.043	0.240	1481.67	619.9	0.000	0.020	2476.470
share	69.6%	96.4%	72.1%	50.4%	6.6%	0.0%	94.6%	48.0%
Others	0.020	0.000	0.002	17.542	4.684	0.939	0.000	41.231
share	0.7%	0.2%	0.6%	0.6%	0.1%	4.4%	0.1%	0.8%
Total	**3.076**	**0.044**	**0.333**	**2937.25**	**9341.2**	**21.28**	**0.021**	**5157.65**

Figure 10 gives the shares of each material category in the environmental impacts for raw materials and end-of-life impacts and credits for the A4 colour inkjet printer (BC7) reference scenario. Although electronic components (PCBs, cables, LED) represent just 6% of the total materials weight of the inkjet printer, they have a very significant environmental impact across the various indicators (green shaded bars). The other major environmental impacts are caused by the plastics used in the printer (blue shaded bars), however the plastic represents nearly 70% of the total materials weight. For ‘land use’ the impact from electronics is reported as negative which is considered an error, so this result has been zeroed out.

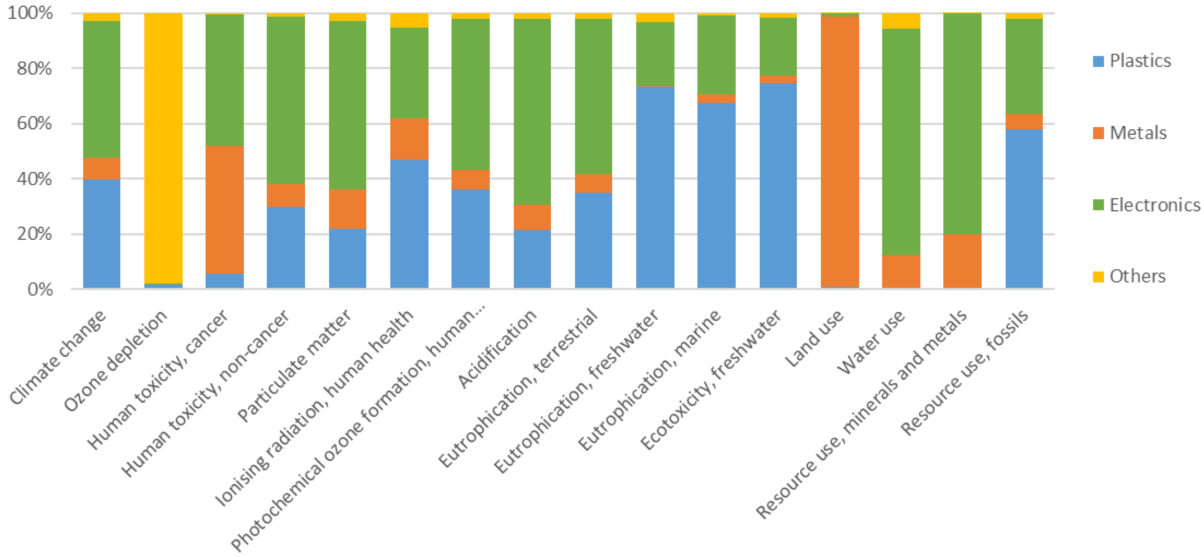


Figure 10: Shares of environmental impacts by material category for A4 colour inkjet printer, BC7

To provide more detail on these impacts, the results are presented in tabular form below with the percentages of impact directly underneath the values. On the following page, Table 14 shows the total impacts, i.e. the sum of raw material impact, EoL impact and EoL credit for virgin material avoidance (negative impact), and the impact shares, per material category. Impact shares larger than 50% have been shaded in light blue.

Table 14: Reference Environmental impacts for A4 colour inkjet printer, BC7, computed using 2024 ERT, including impacts from raw materials and end-of-life impacts and benefits

Material	Mass	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photo-chemical ozone formation, human health	Acidifi-cation
Units	*kg*	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
Plastics	1.60	5.637	0.000	0.000	0.000	0.000	0.337	0.013	0.014
share	67.0%	43.1%	1.7%	6.6%	32.7%	23.7%	49.5%	39.3%	23.8%
Metals	0.46	0.990	0.000	0.000	0.000	0.000	0.096	0.002	0.005
share	19.3%	7.6%	0.0%	45.9%	8.0%	14.0%	14.2%	6.5%	8.9%
Electronics	0.15	6.130	0.000	0.000	0.000	0.000	0.213	0.018	0.038
share	6.2%	46.8%	0.2%	47.2%	58.2%	59.6%	31.4%	52.3%	65.5%
Others	0.18	0.333	0.000	0.000	0.000	0.000	0.033	0.001	0.001
share	7.5%	2.5%	98.0%	0.3%	1.0%	2.7%	4.9%	1.9%	1.8%
Total	**2.39**	**13.091**	**0.000**	**0.000**	**0.000**	**0.000**	**0.680**	**0.034**	**0.059**

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxi-city, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
Plastics	0.043	0.000	0.016	102.171	8.052	0.000	0.000	136.616
share	37.9%	76.0%	70.7%	77.4%	0.8%	0.0%	0.6%	61.4%
Metals	0.007	0.000	0.001	3.180	961.415	0.000	0.000	11.605
share	6.4%	0.4%	2.9%	2.4%	97.9%	0.0%	19.2%	5.2%
Electronics	0.060	0.000	0.006	24.717	12.231	0.000	0.001	69.835
share	53.7%	20.8%	25.4%	18.7%	1.2%	0.0%	80.0%	31.4%
Others	0.002	0.000	0.000	1.929	0.513	0.000	0.000	4.499
share	2.0%	2.8%	0.9%	1.5%	0.1%	0.0%	0.2%	2.0%
Total	0.113	0.000	0.023	131.998	982.212	0.000	0.001	222.554

5.5. Material costs for virgin vs. recycled plastic

According to information gathered during stakeholder interviews (see Figure 11) the price difference between virgin and post-consumer recycled plastic has varied over the last five years. Virgin plastic is linked to the global price of oil while recycled plastic is linked to plastic recovery rates from waste streams and capacity within the recycling industry to process and prepare recyclates. Figure 11 provides the virgin and post-consumer recycled resin price for Acrylonitrile Butadiene Styrene (ABS) and High Impact Polystyrene (HIPS). The graph shows that by the end of 2024, the differences between virgin and post-consumer recycled ABS and HIPS material costs were small.

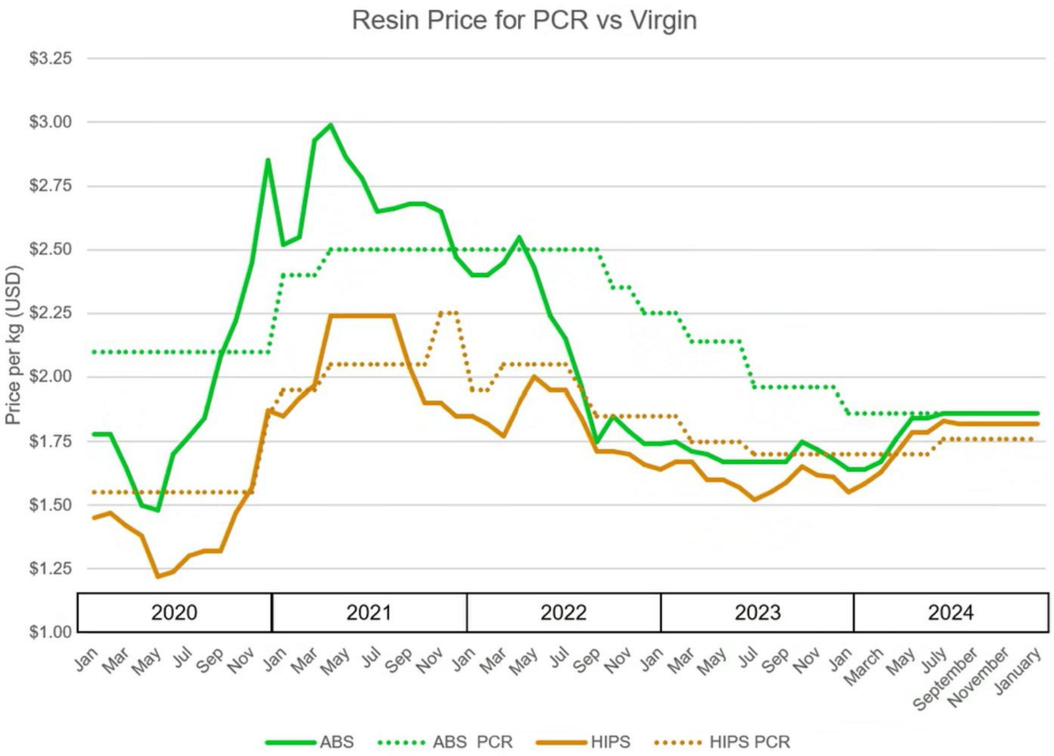


Figure 11: Comparison of prices for virgin and post-consumer recycled HIPS and ABS plastics

Figure 12 provides a comparison of four different plastics between the recycled price and the virgin price, presented in Euros per tonne for December 2024. For HDPE, injection moulding quality, the recycled plastic is €970 Euros/tonne while the virgin material is €1690 Euros/tonne. This represents a 42% reduction per tonne for the post-consumer recycled HDPE per tonne when compared to virgin HDPE.

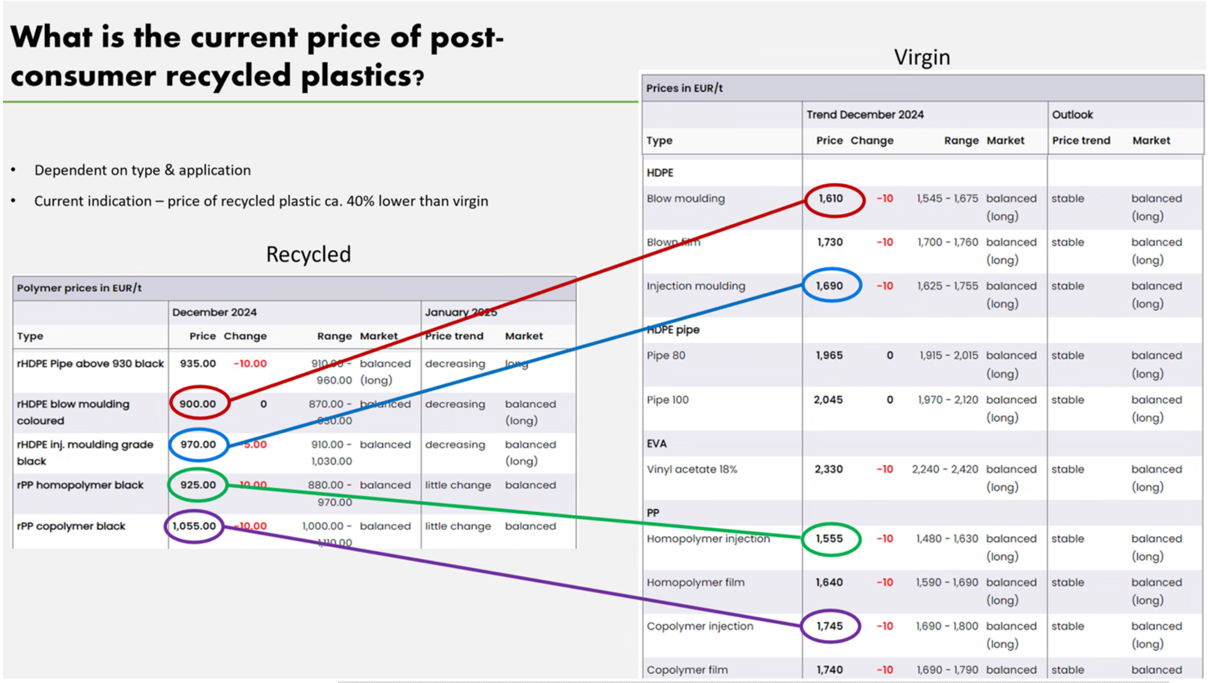


Figure 12: Comparison of prices for virgin and post-consumer recycled plastics

Additional pricing information on virgin and recycled plastics was gathered from [Plastics Information Europe](#) (PIE) and [Market Report Plastics](#) (MRP). These data confirmed the price differences shown in Figure 12. Table 15 provides a comparison of the virgin and post-consumer prices for recycled plastics in the EU from February 2025. Where comparisons can be made, the cost per ton is lower for recycled material.

For polystyrene (PS), the Plastics Information Europe (PIE) price of virgin material ranges from 2090 to 2250 Euro, whereas the recycled price is from 1020 to 1150 Euro, representing a reduction of approximately 50% per ton when comparing recycled to virgin material. According to Market Report Plastics (MRP), polystyrene ranges from 1660 to 1810 Euro per ton, while the recycled polystyrene is 610 to 840 Euro, or approximately 60% less expensive per ton.

For polypropylene (PP), the MRP price of virgin material ranges from 1380 to 1510 Euro per ton, while the recycled is 240 to 870 per ton, a cost per ton reduction of 60-80%, depending on which one is selected.

For polyvinylchloride (PVC), the MRP price of virgin material ranges from 1110-1340 Euro per ton, while the recycled is priced at 290 to 410 Euro per ton, for PVC-P regrind and PVC-U regrind, respectively. This represents a savings of 67-76% when comparing the price of virgin plastic with recycled.

Table 15 Comparison of prices for virgin and post-consumer recycled plastics, February 2025
Source: Plastics Information Europe (PIE) and Market Report Plastics (MRP)

Prices in EUR/ton Jan/Feb 2025	PIE [24], virgin	MRP [25], virgin	PIE, recycled	MRP, recycled
Polystyrene (PS)	€ 2090-2140 (GPPS)	€ 1660-1710 (PS crystal clear)		€ 610 (regrind)
	€ 2160-2240 (HIPS injection)	€ 1790-1810 (HIPS)	€ 1020-1150 (black rHIPS)	€ 840 (granulate)
	€ 2180-2250 (HIPS film/sheet)			
Polypropylene (PP)		€ 1380-1460 (homopolymer)		€ 240 (bale goods)
		€ 1430-1510 (copolymer)		€ 550 (regrind)
				€ 870 (granulate)
Acrylonitrile Butadiene Styrene (ABS)			€ 1620-1690 (industrial, black)	€ 650 (regrind)
				€ 1220 (regranulates)
Polyvinylchloride (PVC)		€ 1110-1210 (tube grade)		€ 290 (PVC-P regrind)
		€ 1240-1340 (film/cables)		€ 410 (PVC-U regrind)

During the interviews with manufacturers who are designing new models of imaging equipment to incorporate post-consumer recycled plastic, one of the engineers said their company was motivated to incorporate PCR plastic into their product lines for two principal reasons: (1) it helps with marketing their products to environmentally concerned consumers; and (2) it reduces their bill of materials since recycled plastic is less expensive per tonne. The engineer also commented on some of the differences in quality between virgin and recycled plastic that can occur, particularly for lighter shades of plastic including potential colour shifts or speckles of darker plastic. One solution to that issue was to use inks to dye the plastic to a dark shade such that any impurities causing colour variation in the recycled plastic are no longer visible to the end-user. Another engineer indicated that they were studying the potential to apply a thin layer of virgin plastic over parts made from PCR, and thereby avoiding any aesthetic issues associated with unwanted variability in the appearance of PCR.

While these represent published prices of post-consumer recycled plastic, in response to this draft report several stakeholders commented that these prices do not represent the final prices of recycled compounds ("recompounds") that are suitable for use in imaging equipment and other appliances. Stakeholders noted that, particularly in the cases of ABS and PP, a stabilisation process is needed, and mechanical properties must be adjusted and enhanced through blending with a certain amount of virgin material or the addition of fillers. The additional

[24] Plastics Information Europe (PIE), website visited April 2025: https://pieweb.plasteurope.com/default.aspx?pageid=200

[25] Plasticker, the home of Plastics, website visited April 2025: https://plasticker.de/preise/marktbericht_en.php

processing steps and ingredients results in a higher final price than that of the initial regrinds and regraulates published in the MRT. While a price of <1000€ per tonne might be correct for crude raw material from recycled feedstocks, a recompounded PCR technical engineering plastic ready for use in Imaging Equipment (or other appliances) would have to take into account further refining steps that would affect the final pricing. They estimated that the compounding process incurs a surcharge of at least 300-500€ per tonne with additional costs depending on the desired additive content, filler content and qualification process.

Another stakeholder provided a similar comment, noting that the analysis should be based on the overall costs rather than a simple price comparison. They find that direct comparisons of recyclates and virgin materials is not appropriate because it doesn't reflect the higher costs of recycled material including (1) logistics and collection, (2) investment in new technology, (3) energy consumption, (4) market dynamics, (5) cost levels and competitiveness and (6) quality and processing. These comments are broadly in line with the earlier ones, that a more robust comparison around the incorporation of recycled plastic into imaging equipment would be advantageous.

A European industry association commented the recycled material prices questioning whether these data actually relate to the same plastic materials being used in imaging equipment. They note that there are many grades of plastic material even within the same resin type which are used for different functions, quality and any other factors. These grades that are suitable for use in imaging equipment are limited, and they request that the Team – when conducting its full analysis - compare virgin materials and recycled materials of the same (or suitably similar) grade for imaging equipment to confirm the feasibility of the recycled material contents requirement. Additionally, the associated commented that in reality, recycled materials are more expensive than virgin, noting that example that polystyrene is 2090-2250 EUR/tonne while recycled polystyrene is around 3000 EUR/tonne. They also noted that recycled materials have issues with strength, colour and moulding defects, contributing to higher material and manufacturing costs.

An industry association commented that in their experience, recycled plastic is more expensive than virgin material due to: (1) complex supply chain and quality control; (2) addressing chemical substance regulations (not knowing what is contained in the materials recovered from consumers); and (3) parts for imaging equipment must be highly flame resistant because they are potential ignition and heat sources inside the products.

Given the points stakeholders made on the draft report for Imaging Equipment, the team conducting the review study for imaging equipment will gather improved estimates of final, comparable prices of recycled plastic to use in their analysis of potential policy options for the regulation.

5.6. Critical Raw Materials

The most recent list of Critical Raw Materials (CRMs) and Strategic Raw Materials (SRMs) were amended most recently by Regulation (EU) 2024/1252. The CRM list consists of raw materials meeting the requirements according to the published EU criticality methodology, while the Strategic Raw Materials (SRM) are primarily relevant for the green and digital transition as well as defense and aerospace applications. The updated list of CRMs and SRMs is given below. All materials listed are CRMs and those marked with a star ("*") are also SRMs:

> Antimony; arsenic; bauxite/alumina/aluminum; baryte; beryllium; bismuth*; boron*; cobalt*; coking coal; copper*; feldspar; fluorspar; gallium*; germanium*; hafnium;

helium; heavy rare earth elements*; light rare earth elements*; lithium*; magnesium; manganese*; graphite*; nickel — battery grade*; niobium; phosphate rock; phosphorus; platinum group metals*; scandium; silicon metal*; strontium; tantalum; titanium metal*; tungsten* and vanadium.

Other non-CRM materials with high environmental impacts are e.g. gold, lead, molybdenum, rhenium, selenium, silver, tellurium and zinc.

The prioritization scores for environmental impacts have been examined for all materials together and separately per material category (plastics, ferrous metals, non-ferrous metals, coating / plating, electronics and miscellaneous).

For imaging equipment, the Phase 1 analysis identified the top five CRMs in this order:

- Palladium
- Tin
- Bismuth
- Bauxite/Aluminum
- Antimony

Imaging equipment have most of their CRMs contained in the materials used on printed circuit boards (PCBs) inside the machines. However, PCBs are challenging to recycle because of the variety of materials they contain, including precious metals (e.g., gold, silver, and palladium), base metals (e.g., copper, aluminum, and tin), and hazardous substances (e.g., lead, mercury, epoxy resin containing brominated flame retardants)[26] Corroborating these findings. Other researchers[27] found that PCBs contain the following:

- Antimony: found in some lead-containing solders;
- Beryllium: small amounts found in connectors using as a copper-beryllium alloy (typically 98% copper, 2% beryllium);
- Cadmium: small amounts used in plated contacts and switches;
- Chlorine and/or Bromine: brominated and inorganic flame retardants may be in the PCBs; and
- Lead: found in solder and some electronic components.

Researchers found that mechanical treatment and separation of PCBs is essential for effective resource recovery and recycling, for both economic viability and environmental protection.[28] According to one study that looked at material composition, waste PCBs contained approximately 30% metallic material, 40% organic resin materials and about 30% glass fibers used to reinforce the boards.[29] Of these, the metallic material consists of metals bound up in

[26]Hosseini, Pooya; Klauson, Artur; Hendrickx, Brent; Goljandin, Dmitri; Duflou, Joost R. (2024): Sustainable e-waste recycling: environmental impact assessment of novel waste PCBs separation. In: 2024 19th Biennial Baltic Electronics Conference (BEC): IEEE, S. 1–7.

[27] Tsydenova, Oyuna & Bengtsson, Magnus. (2009). Environmental and Human Health Risks Associated with the End-of-Life Treatment of Electrical and Electronic Equipment; Institute for Global Environmental Strategies (IGES), Integrated Waste Management and Resource Efficiency Project, 2108-11 Kamiyamaguchi, Hayama, Kanagawa, 240-0115, Japan. Link: https://www.researchgate.net/publication/281368370_Environmental_and_Human_Health_Risks_Associated_with_the_End-of-Life_Treatment_of_Electrical_and_Electronic_Equipment

[28] Hosseini, Pooya; Klauson, Artur; Hendrickx, Brent; Goljandin, Dmitri; Duflou, Joost R. (2024): Sustainable e-waste recycling: environmental impact assessment of novel waste PCBs separation. In: 2024 19th Biennial Baltic Electronics Conference (BEC): IEEE, S. 1–7.

[29]Ionela Birloaga, Ida De Michelis, Francesco Ferella, Mihai Buzatu, Francesco Vegliò; Study on the influence of various factors in the hydrometallurgical processing of waste printed circuit boards for copper and gold recovery; Waste Management, Volume 33, Issue 4,, 2013, Pages 935-941, ISSN 0956-053X, https://doi.org/10.1016/j.wasman.2013.01.003.

the circuitry (mainly copper), solder and lead frames (tin, iron and lead) and integrated circuits (gold, silver and palladium).[30] As an illustration of this, one paper found that a waste PCB from a computer contains 20% copper as well as 250 grams of gold and 110 grams of palladium per ton of waste PCBs.[31]

At this point in time two CRMs - namely, copper and aluminum, are regularly recovered from waste streams and re-introduced to the supply chain, offsetting virgin (mined) copper and aluminum. A number of research projects have been looking at recovery of CRMs from waste PCBs, and in particular, the recovery of palladium and antimony. Indeed, there specialist recycling companies who have started to recover palladium, as it can be collected as a by-product of the copper recovery process without significant extra cost. Therefore, beyond copper and aluminum which are already recovered, a third CRM that might be promoted by policy measures that support its recovery and reuse is palladium.

[30] Ibid.

[31] Martinez-Ballesteros, Guadalupe; Valenzuela-García, Jesus Leobardo; Gómez-Alvarez, Agustin; Encinas-Romero, Martin Antonio; Mejía-Zamudio, Flerida Adriana; Rosas-Durazo, Aaron de Jesús; Valenzuela-Frisby, Roberto (2021): Recovery of Ag, Au, and Pt from Printed Circuit Boards by Pressure Leaching. In: Recycling 6 (4), S. 67. https://doi.org/10.3390/recycling6040067

6. MEErP Task 6, Design Options

6.1. Introduction and Timeline

This chapter describes the assessment of design options, linked to potential future Ecodesign requirements that would be considered by the study team conducting the review of the regulations for imaging equipment. These design options include:

- Recycled plastic content in imaging equipment;
- Recyclability of imaging equipment at end of life; and
- Recycled content and recyclability of Critical Raw Materials used in imaging equipment

This mini study on recycled content, recyclability and CRM for imaging equipment had a limited schedule and budget, therefore it relied primarily on interviews with stakeholders, preliminary data collection and EcoReport Tool analyses that will be handed over to the review study team working on imaging equipment for DG Environment. It is expected that the parallel review study team will conduct further investigations into these and other policy options, conduct additional data collection and analysis, and address any comments received from this stakeholder consultation, incorporating the final recommendations into the Commission's Working Document for a new regulation on imaging equipment.

6.2. Design options for recycled plastic content in products/parts

In order to support the development of a circular economy, it is desirable to require the use of recycled plastics in new products. Ideally, these recycled plastics would be derived from post-consumer recycled (PCR) sources. Under these circumstances, requiring the use of PCR plastic is likely to stimulate post-consumer waste collection and investment in recycling capacity by increasing demand for recycled materials. Other sources of recycled plastic include post-industrial recycled (i.e., at the end of the manufacturing line, but before the plastic leaves the factory) and pre-consumer (i.e., before the consumer purchases the product).

Several stakeholders called for including post-industrial recyclates (PIR) as well as pre-consumer recyclates, if the only alternative is incineration. These sources of recycled plastic are less contaminated, are more attractively priced, and offer some environmental and economic benefit over virgin material, in particular a reduction in CO_2 emissions. While it is recognised that this approach would provide flexibility in the supply chain, the introduction of mandatory pre-consumer waste recovery practices are not expected to benefit from additional requirements. To a large extent, manufacturers already recover and reuse PIR off-cuts and sprues[32] in order to off-set the use of virgin materials in their production lines and to avoid waste disposal (or incineration) costs. Furthermore, allowing for PIR to be used in lieu of PCR will not stimulate investment in the PCR industries and therefore will not transition Europe toward its circular economy objectives.

[32] A sprue is an excess piece of plastic that remains attached to a plastic part in an injection mould system. This excess plastic is made up of the same plastic in the finished part and must be trimmed off before the part can be used.

Instead, the analysis conducted in this mini-study focused on PCR plastics and is aligned with article 7 of the packaging and packaging waste regulation (PPWR)[33] and article 29 of the Critical Raw Materials Act[34].

If they have not already done so, recyclers would have to set up and maintain an accounting system of incoming waste materials, such that they could provide documentation on the traceability of the origins of recycled material from post-consumer waste streams. Such traceability would be important for market surveillance authorities later when recycled plastic requirements are in place and need to be verified.

Finally, one stakeholder commented that if the Commission were to consider requirements based on recycled plastic – whether post-consumer and/or post-industrial recyclates – then the definitions of these terms need to be improved. This stakeholder commented that they find that the definitions provided in international standards, such as EN 17615:2022, DIN SPEC 91446 (June 2021, Chapter 6.2), or EN 45557:2020, to be ambiguous and leave suppliers with considerable room for interpretation. In some cases, this could result in unscrupulous suppliers to misnaming or even greenwashing their products. The review study team for imaging equipment should take note of this concern and consult with relevant stakeholders on how to improve the definitions of post-consumer recyclates and/or post-industrial recyclates to try and mitigate this risk of regulatory circumvention.

An industry association requested that the Commission consider accepting reused parts and biobased plastics in place of PCR. They noted that the re-use of components or assemblies was not given sufficient consideration in either the main report or the specific imaging equipment report, and that reuse could be an alternative to recycled and biobased plastics, providing an example from the EPEAT ecolabel requirement: “post-consumer reused OR recycled AND/OR biobased plastic content divided by the total weight of plastic in the product”.

The Study Team conducting the review of imaging equipment will investigate the potential for the reuse of parts and assemblies in imaging equipment, and in particular consumables such as toner cartridges. The scope of this mini-study did not include consumables, where it is understood a lot of reuse and remanufacturing / refurbishing of used cartridges exists.

6.2.1 Policy Options for recycled plastic content requirements

There are four possible approaches that could be used to set out requirements on recycled plastic content of imaging equipment:

1. Based on the total mass of the finished product;
2. Based on the total mass of plastic in the finished product;
3. Based on the total mass of plastic in a specific component or part in the product; or
4. Based on specific type(s) of plastic used in the finished product.

Stakeholders provided comments on which of these they thought would be the most appropriate. Those comments are discussed below, after an example of each of these options. While these examples are written as single level on a certain date, these same options could also be given in two or more stages of a regulatory measure if the requirements were

[33] REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, Brussels, 4 December 2024, PE-CONS 73/24

[34] Critical Raw Materials Act: REGULATION (EU) 2024/1252 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020, OJ 3.5.2024

drafted to phase-in gradually over time. The phrase "new imaging equipment models" was selected to reflect the fact that the requirements would apply to new models that are first placed on the market on or after the date given. In other words, the requirement(s) would not apply to products that were first placed on the market prior that date and are still offered for sale.

Option 1: Based on the total mass of the finished product

For this option, the requirements could be drafted to read as follows:

> Starting on 1 January 20XX, any new imaging equipment models placed on the market shall contain at least XX% of recycled plastic recovered from post-consumer waste. This percentage of recycled plastic shall be calculated as the mass of post-consumer recycled plastic contained in the product divided by the total mass of the product as sold, excluding packaging.

Option 2: Based on the total mass of plastic in the finished product

For this option, the requirements could be drafted to read as follows:

> Starting 1 January 20XX, any new imaging equipment models placed on the market shall contain at least XX% of recycled plastic recovered from post-consumer waste. This percentage of recycled plastic shall be calculated as the mass of post-consumer recycled plastic contained in the product divided by the total mass of plastic (both virgin and recycled) contained in the product as sold, excluding packaging.

Option 3: Based on the total mass of plastic in a specific component or part in the product;

For this option, the requirements could be drafted to read as follows:

> Starting 1 January 20XX, any new imaging equipment models placed on the market shall contain at least XX% of recycled content in the plastic used for the casing of the imaging equipment.

The casing of the imaging equipment could be replaced with, for example, the paper tray, the structural frame or other easily identifiable component part.

Option 4: Based on specific type(s) of plastic used in the finished product

For this option, the requirements could be drafted to read as follows:

> Starting 1 January 20XX, any new imaging equipment models placed on the market shall contain at least the following percentages of recycled content recovered from post-consumer waste, for the plastic types indicated, if they are present in the product:
>
> - Polystyrene (PS), any type XX%
> - Polypropylene (PP) YY%
> - Acrylonitrile butadiene styrene (ABS) ZZ%
>
> The percentage recycled content shares shall be computed as the mass of post-consumer recycled plastic contained in the product for the plastic type concerned divided by the total plastic mass contained in the imaging equipment as placed on the market, for the plastic type concerned, excluding packaging.

As noted above, stakeholders provided feedback on these four possible approaches setting mandatory recycled plastic content in imaging equipment. All comments received recommended the selection of Option 2, whereby the recycled content is determined on the basis of the total mass of plastic in the finished product. Some of the reasons provided for this include: (1) it provides flexibility to the manufacturer in terms of the plastic they choose to substitute; (2) it is already calculated using IEEE 1680.2 for EPEAT and Blue Angel; and (3) it is aligned with the approach already followed in the Packaging and Packaging Waste Regulation (PPWR). One industry association endorsed Option 2 stating that the requirements and procedures for calculating should align with EPEAT and Blue Angel, and the regulation should begin with the disclosure (information) about the PCR (Post-Consumer Recycled) content.

One commenter noted that polymer-specific quotas must be avoided (Option 4) because it restricts the economic scope of the manufacturers and other actors in the supply chain. It was also noted by another manufacturer that "finished product" should be defined as the model as sold, excluding consumables because consumables have their own targets. Other commenters also rejected this Option for similar reasons.

One of the industry associations commented that they believe the ecodesign requirement should be information disclosure only, and that remanufacturing and parts reuse should be recognised as an alternative to recycling. They call for a mechanism to be incorporated that would recognise reused parts as a contribution to the recycled percentage. They believe that the tiered approach should begin with the implementation of information disclosure regarding the use of PCR plastic.

A manufacturer of imaging equipment commented that if any mandatory requirement is introduced, it should be very modest and implemented gradually over time following a tiered approach. Having a gradual approach would ensure suppliers have sufficient time to adjust their production processes and sourcing strategies to avoid significant disruptions. Progressive tiers will enable companies to incorporate higher percentages of PCR as technologies and supply-chains improve. This allows for continuous improvement and adaptation, enabling businesses to meet evolving environmental goals effectively.

Another stakeholder commented that they do not support the introduction of a standard for recycled plastic content at this stage. They believe that the priority should be on the improvement of transparency through disclosure of information. That said, they also noted that their preference of the options above would be for the calculation based on the total mass of plastic in the finished product.

The Study Team conducting the review of Imaging Equipment will conduct further investigations into these options, taking into account all of the above input and comments.

6.2.2 Impact reduction due to recycled content

This section discusses the reduction in environmental impacts for a unit product when the post-consumer recycled content (factor R1) for plastics is raised from 0% (baseline) to 10% and to 30%. These levels have been selected as being representative of realistic levels for recycled content for imaging equipment – and specifically, printers. Data are for a unit product of base case A3 colour laser printer (BC5) and A4 colour inkjet (BC7) with the BoM presented earlier in this chapter. As the reduction increases linearly with the recycled content, these data can later be multiplied by a factor to simulate the effect of higher recycled content requirements (see chapter 7 on scenario analysis).

Like the previously reported impacts for the baseline, only impacts from input materials, EoL impacts and EoL benefits are considered (no manufacturing, distribution, use, repair and maintenance). Please see section 7.1 in this report for a comparison of the material and EoL impacts relative to energy-in-use.

Compared to the baseline, only the factors R1 for recycled content have been changed. Factors R2 (recycling output) and A (allocation factor) remain the same. This implies that EoL impact and EoL benefit do not change compared to the baseline: only the impact of materials in input to the production changes with R1. Table 16 provides the top-level reduction of environmental impacts compared to the reference case, when 10% and 30% recycled content (instead of 0%) is used for plastics. As before, the table is split in two parts, showing results for different impact categories.

The total mass of the A3 colour laser printer is 85.8 kg, of which about 32% is plastic. When the plastic in that printer is replaced with 10% and 30% post-consumer recycled plastic, the environmental impact of the printer reduces by a few percent. The reason for this limited impact is due to the significant amount of metal in the printer (61% of the total materials) and the high environmental impact of the electronics.

Table 16: Summary of the reduction of environmental impacts compared to the baseline, when using 10% and 30% recycled content in input to the production for plastics for A3 colour laser printer (BC5)

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemical ozone formation, human health	Acidification
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
10% recycled plastic (R1)								
Change:	3.86	0.00	0.00	0.00	0.00	0.10	0.01	0.01
Reference	331.36	0.00	0.00	0.00	0.00	15.35	0.88	8.33
% change	1.16%	0.02%	0.42%	0.47%	0.68%	0.67%	1.03%	0.13%
30% recycled plastic (R1)								
Change:	11.58	0.00	0.00	0.00	0.00	0.31	0.03	0.03
Reference	331.36	0.00	0.00	0.00	0.00	15.35	0.88	8.33
% change	3.49%	0.05%	1.25%	1.40%	2.04%	2.02%	3.08%	0.40%

Material	Eutrophication, terrestrial	Eutrophication, freshwater	Eutrophication, marine	Ecotoxicity, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
10% recycled plastic (R1)								
Change:	0.03	0.00	0.00	53.21	4.97	-2.15	0.00	108.82
Reference	3.08	0.04	0.33	2,937.3	9,341.2	21.28	0.02	5,157.65
% change	1.04%	0.15%	0.99%	1.81%	0.05%	-10.12%	0.25%	2.11%
30% recycled plastic (R1)								
Change:	0.10	0.00	0.01	159.62	14.91	-6.46	0.00	326.47
Reference	3.08	0.04	0.33	2,937.25	9,341.2	21.28	0.02	5,157.65
% change	3.13%	0.44%	2.96%	5.43%	0.16%	-30.36%	0.75%	6.33%

Table 17 provides the top-level reduction of environmental impacts of the A4 colour inkjet printer compared to the reference case, when 10% and 30% recycled content (instead of 0%) is used for plastics. As before, the table is split in two parts, showing results for different impact categories.

The total mass of the inkjet printer is 2.4 kg, of which about 67% is plastic. When the plastic in that printer is replaced with 10% and 30% post-consumer recycled plastic, the environmental impacts per printer reduces by a few percentage points. The reason this impact is more significant than some of the other basecase models is because plastic represents such a significant part of the printer's material.

Table 17: Summary of the reduction of environmental impacts compared to the baseline, when using 10% and 30% recycled content in input to the production for plastics for A4 colour inkjet printer, BC7

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemical ozone formation, human health	Acidification
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
10% recycled plastic (R1)								
Change:	0.23	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Reference	13.09	0.00	0.00	0.00	0.00	0.68	0.03	0.06
% change	1.79%	0.03%	0.26%	1.37%	0.80%	1.62%	1.57%	0.94%
30% recycled plastic (R1)								
Change:	0.70	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Reference	13.09	0.00	0.00	0.00	0.00	0.68	0.03	0.06
% change	5.36%	0.09%	0.78%	4.10%	2.41%	4.86%	4.71%	2.81%

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxicity, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
10% recycled plastic (R1)								
Change:	0.00	0.00	0.00	4.81	0.29	-0.14	0.00	6.21
Reference	0.11	0.00	0.02	132.00	982.21	-0.18	0.00	222.55
% change	1.59%	3.07%	3.36%	3.65%	0.03%	77.33%	0.02%	2.79%
30% recycled plastic (R1)								
Change:	0.01	0.00	0.00	14.44	0.86	-0.41	0.00	18.62
Reference	0.11	0.00	0.02	132.00	982.21	-0.18	0.00	222.55
% change	4.76%	9.20%	10.08%	10.94%	0.09%	231.98%	0.05%	8.37%

6.3. Design options for recyclability

Another measure to support the development of a circular economy in Europe is to promote design options that facilitate recyclability of products at the end of life. This includes techniques such as designing products to be more easily disassembled, for parts and materials to be individually marked to facilitate sorting (and potential re-use), and to easily identify and recover any critical raw materials (CRMs) from the waste stream.

The overall recyclability calculation for the EU market is based on two key factors – the collection rate of used imaging equipment and the percentage of that recovered used equipment that can ultimately be separated, sorted and recycled. In the EcoReport Tool, the percentage recyclability referenced only takes into consideration the second of these factors – namely, the amount of material that can be recovered from a unit at the end of life. The levels discussed in Chapter 5 contemplate 10% and 30% recyclability, meaning that 10% or 30% of the material contained in the finished product at end of life is recovered for reuse.

For imaging equipment, recyclers will make a decision on separation before shredding mainly on economic grounds. If a component or material is valuable and easy to access and separate, this will be done, otherwise it will be shredded together with the rest, and the materials will be recovered from post-shredder separation processes. The advantage to separating before shredding is that it will enable the recycler to isolate or increase the concentration of a desired material as opposed to having it diluted with all the other material of the product. Another reason to separate before shredding can be that a component could cause problems in the shredder (e.g. high-energy Li-ion batteries can cause a fire in the shredder).

Product separation of parts such as PCB boards or metal frames can be useful especially if the separated components or materials are subsequently processed on separate recycling lines or sold to a specialist recycler. If the separated components are processed in-house, additional parallel processing lines may be necessary, or the main processing lines would alternately have to process the different material types.

To provide an indication of how this approach could be implemented in a policy context – that is, increasing the recyclability of the imaging equipment at its end of life – Table 18 sets out a system by which products are designed for disassembly. This is a point scoring system based on the approach set out in the draft on study to create a recyclability index for photovoltaic panels and inverters. This could result in a set of policy options that the review study team could look into establishing for imaging equipment, for example having a minimum required score or potentially an information requirement with a view that requirement being made mandatory in the next review of the imaging equipment regulation.

Table 18. Overview of approaches to address recyclability at end of life for imaging equipment

Type	#	Parameter	Principle	Benefit
Service-related Parameters	1	Information on presence (or absence) of substances of concern	Scoring based on presence of clear and durable information on presence (or absence) of substances of concern	Easy ID of substances that might hinger recycling or need special care
	2	Dismantling information and condition for access	Scoring based on information provided (e.g., a dismantling map, step-by-step instructions for priority parts)	Manufacturer facilitates dismantling and further recovery of materials
	3	Information on composition	Scoring based on disclosure of material composition of the product; points based on percentage of mass of product disclosed	Recyclers get valuable information regarding expected yield
	4	Information on CRMs and SRMs	Scoring based on disclosure of the quantity and location of CRMs and SRMs in the product	Recyclers get valuable information regarding expected yield
Dismantling Related Parameters	5	Number of steps for the dismantling of priority parts (dismantling depth)	Scoring based on the number of dismantling steps (N) to reach and remove specific priority parts	Number of steps to dismante a component can be a proxy of the disassembly complexity
	6	Type of tools needed to dismantle priority parts	Level of complexity in terms of tools needed for dismantling a priority part, from low to high complexity. No tools, basic tools, commercial tools, proprietary tools.	Tools needed to dismantle a component can be a proxy of the disassembly complexity
Material based parameters	7	Level of concentration of hazardous substances and other substances affecting the recycling process	Scoring based on different concentration levels of substances (e.g. Antimony or F-containing materials, brominated flame retardants). Scores from maximum in case of total avoidance to lower scores based on the level of presence.	Avoid / reduce the cost and risks linked to depollution activities
	8	Selection of materials based on recyclability complexity	Score based on positive design for recyclability / easiness to be recycled.	Materials that by themselves are easy to recycle and reduce costs at the end of life
	9	Combination of materials used / homogeneity	Scoring based on the way different materials are combined in single parts and aims to award design based on homogeneous or separable materials	Different materials in a component can mean more difficult material separation for recycling

The design options considered are intended to facilitate the recovery of materials at the end of life – including critical raw materials (CRMs) – and thereby achieve the targets modelled in in the EcoReport Tool for the assumed recyclability rates.

Measures for consideration include:

- Design for disassembly – enable the separation of different material types used in a single part or component;
- Require marking the different types of plastic to facilitate sorting (similar to what is done for packaging);
- PCBs larger than 10 cm² and boards containing batteries or wet capacitors should be easily removable for recyclers;
- Forbid the use of halogenated flame retardants, and require a marking for plastics containing flame retardants, like the regulation for electronic displays

Recyclers seem to be in favour of measures that facilitate the identification and separation of components before shredding. Recyclers may support this approach because it will afford them more options in the future, and could increase the economic viability of further process automation.

Industry provided a general remark on the dismantling procedure, required tools and recyclability discussed in this section. From pilot studies conducted by the industry association, it was concluded that the recovery of high-quality feedstocks for WEEE plastic recycling does indeed benefit from dismantling processes prior to appliance shredding. However, the association expressed concern that manual dismantling and pre-processing has two disadvantages: (1) it is primarily a manual labour activity which increases costs, making the reclaimed material uncompetitive; and (2) waste treatment must be suitable at large scale operations, and that is not feasible with largely manual processes. The industry association concluded that waste treatment operators rely on their established technologies and infrastructure, which does not include a high degree of pre-processing of the products and therefore these targets would be challenging.

One stakeholder commented that no substances, especially those considered hazardous, are added in excess in a product. The concentrations of these substances correspond to minimum required levels to ensure safety and proper functioning of the product. This stakeholder also called for clarification as to which of these substances might be considered to hinder recycling, noting that emerging technologies to deal with end-of-life such as gasification could be applied to these substances and thereby address the barrier to recycling. Finally, they note that its necessary to consider available alternatives and substitutes for these substances, because in some cases there are no alternatives available on the market.

Another stakeholder commented that the Commission should consider harmonising to requirements already identified in the Blue Angel programme for Imaging Equipment (DE-UZ 219[35], Chapter 3) which includes: (1) requirements regarding design for disassembly, (2) requirements concerning a material selection for recyclability and (3) reusability of components and assemblies. This section also covers energy consumption, particle emissions, noise and other aspects relating to the use and impact of this equipment in an office or home. Furthermore, this stakeholder noted that where possible, it is advantageous for the Commission to harmonise with programmes and processes already in please from voluntary schemes like Blue Angel because there are many manufacturers already participating in the programme, thus reducing burden on industry while enabling the EU to achieve its sustainability objectives.

[35] Link to DE-UZ 219: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20219-202101-en%20Criteria-V4.pdf

It should be noted that the Blue Angel scheme offers guidance on the treatment of halogenated polymers and halogenated organic compounds added as flame retardants to plastics. For convenience, this section setting out this section (only) of the Blue Angel voluntary requirement for imaging equipment is reproduced below. For the full section, please follow the hyperlink to DE-UZ 219.

3.2.1 Hazardous substances in casings and casing parts: Material requirements for plastics

Halogenated polymers and halogenated organic compounds added as flame retardants are not permitted.

The following shall be exempt from this rule:

- *fluoroorganic additives (e.g. anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed a proportion of 0.5 percent by mass;*
- *fluorinated plastics such as e.g. PTFE;*
- *plastic parts with a mass of less than or equal to 25 g. However, they must not contain PBBs (polybrominated biphenyls), PBDEs (polybrominated diphenyl ethers) or chlorinated paraffins. (this exemption does not apply to control panel keys.)*
- *Special plastic parts located close to heating and fuser elements. However, they must not contain PBBs, PBDEs or chlorinated paraffins.*
- *Large-sized plastic parts that are verifiably reused and are marked according to 3.1.1.2, [sic], no. 9. However, they must not contain PBBs, PBDEs or chlorinated paraffins.*

The flame-retardant materials used in plastic parts with a mass greater than 25 grams must be communicated to RAL gGmbH in confidence and identified using their CAS numbers.

In addition, no substances must be added to the plastics as constituent components that meet at least one of the conditions stated in Table 6:

Table 6: Conditions for the exclusion of substances from materials in casings and casing parts

Hazard class	**Hazard category**	**CLP Regulation (EC) No. 1272/2008**
Carcinogenicity	Carc. 1A, 1B	H350 May cause cancer.
Carcinogenicity	Carc. 1A, 1B	H350i May cause cancer if inhaled.
Germ cell mutagenicity	Muta. 1A, 1B	H340 May cause genetic defects.
Reproductive toxicity	Repr. 1A, 1B	H360 May damage fertility or the unborn child.
Substances included in the so-called "list of candidates" in accordance with Article 59 of the REACH Regulation. The version of the list of candidates at the time of application is valid.[16]		

The stated requirements also apply to any recycled materials used.

An industry representative recommended that the Commission look into the treatment of halogenated flame retardants in the Green Public Procurement (GPP) criteria for Imaging Equipment. This stakeholder commented that Halogenated Flame Retardants are critical in certain situations to ensure safety and manufacturing, noting that fusers operate at extremely high temperatures and require flame retardants to safely operate. The GPP criteria are set out in a Commission Staff Working Document, SWD(2020) 148 final, "EU green public procurement criteria for imaging equipment, consumables and print" and can be downloaded on this link.[36] The GPP criteria set out certain exemptions which are broadly aligned with the Blue Angel criteria.

An industry association commented that (alternative) non-halogen flame retardants can have technical issues such as:

- Problems with thermal stability and processability: They are easily decomposes during high-temperature molding, causing discoloration, gas generation, and failure in molding.
- Insufficient flame-retardant performance: To obtain the same flame-retardant performance, non-halogenated frame retardants are needed to be added more than that in the case of halogen-based flame-retardants.

This association continues to note that given the large amount of non-halogenated flame-retardant required to meet flame-retardancy standards such as UL94 V-0 and LOI, it is sometimes difficult to achieve the necessary flame resistance. They conclude that these problems are the part of reasons why they believe it is impossible to find substitutes for halogenated flame-retardants.

Taking into account all of the above, the study team conducting the review of the Imaging Equipment regulation will look into these issues further and investigate the potential for alignment with existing voluntary ecolabel schemes, in particular, Blue Angel and the Green Public Procurement criteria.

6.3.1 Impact reduction due to recyclability of plastic

This section discusses the reduction in environmental impacts for a unit product when the recyclability at end of life (factor R2) for plastics is raised from 0% (baseline) to 10% and to 30%. Data are for a unit product of base case A3 colour laser printer (BC5) and A4 colour inkjet printer (BC7) with the BoM presented earlier in this chapter. As the reduction increases linearly with the recycled content, these data can later be multiplied by a factor to simulate the effect of higher recycled content requirements (see chapter 7 on scenario analysis).

Like the previously reported impacts for the baseline, only impacts from input materials, EoL impacts and EoL benefits are considered (no manufacturing, distribution, use, repair and maintenance).

Compared to the baseline, only the factors R2 for recyclability have been changed. Factors R1 (recycled content) and A (allocation factor) remain the same. Table 19 provides the top-level reduction of environmental impacts compared to the reference case, when 10% and 30% recyclability (instead of 0%) is used for plastics. As before, the table is split in two parts, showing results for different impact categories.

The total mass of the A3 colour laser printer is 85.8 kg, of which about 32% is plastic. When the plastic in that printer is recovered at the end of life, the environmental impacts per A3 laser printer reduce by a few percent. The reason for this small change is due to the small quantity of plastic in the base case reference A3 laser printer and the high environmental impact of the electronics.

[36]Link to the Imaging Equipment GPP criteria: https://circabc.europa.eu/ui/group/44278090-3fae-4515-bcc2-44fd57c1d0d1/library/a57a14a0-f4db-425b-8f72-4b5c8d874162/details

Table 19: Summary of the reduction of environmental impacts compared to the baseline, when the recyclability of plastics is increased to 10% and 30% by mass for A3 colour laser printer (BC5)

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemical ozone formation, human health	Acidification
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
10% recyclability of plastic (R2)								
Change:	3.9774	0.0000	0.0000	0.0000	0.0000	0.1814	0.0090	0.0110
Reference	331.3575	0.0000	0.0000	0.0000	0.0000	15.3462	0.8786	8.3255
% change	1.20%	0.02%	0.42%	0.44%	0.67%	1.18%	1.02%	0.13%
30% recyclability of plastic (R2)								
Change:	11.9323	0.0000	0.0000	0.0000	0.0000	0.5443	0.0270	0.0329
Reference	331.3575	0.0000	0.0000	0.0000	0.0000	15.3462	0.8786	8.3255
% change	3.60%	0.05%	1.25%	1.32%	2.02%	3.55%	3.07%	0.39%

Material	Eutrophication, terrestrial	Eutrophication, freshwater	Eutrophication, marine	Ecotoxicity, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
10% recyclability of plastic (R2)								
Change:	0.0319	0.0001	0.0033	72.9156	3.7652	-2.0581	0.0000	111.1428
Reference	3.0764	0.0442	0.3332	2,937.25	9,341.2	21.2760	0.0214	5,157.6523
% change	1.04%	0.14%	0.98%	2.48%	0.04%	-9.67%	0.01%	2.15%
30% recyclability of plastic (R2)								
Change:	0.0958	0.0002	0.0098	218.747	11.295	-6.1742	0.0000	333.4283
Reference	3.0764	0.0442	0.3332	2,937.25	9,341.2	21.276	0.0214	5,157.65
% change	3.11%	0.43%	2.95%	7.45%	0.12%	-29.02%	0.03%	6.46%

Table 20 provides the top-level reduction of environmental impacts compared to the reference case, when 10% and 30% recyclability of plastics (instead of 0%) is used. As before, the table is split in two parts, showing results for different impact categories.

The total mass of the inkjet printer is 2.4 kg, of which about 67% is plastic. When the plastic in that printer is recovered at end of life at two different levels - 10% and 30% - the environmental impacts per printer reduces by a few percentage points. Part of the reason for this relatively small change is due to the high environmental impact of the electronics.

Table 20: Summary of the reduction of environmental impacts compared to the baseline, when the recyclability of plastics is increased to 10% and 30% by mass for A4 colour inkjet printer, BC7

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemi-cal ozone formation, human health	Acidification
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
10% recyclability of plastic (R2)								
Change:	0.2338	0.0000	0.0000	0.0000	0.0000	0.0110	0.0005	0.0005
Reference	13.0907	0.0000	0.0000	0.0000	0.0000	0.6798	0.0337	0.0586
% change	1.79%	0.03%	0.26%	1.37%	0.80%	1.62%	1.57%	0.94%
30% recyclability of plastic (R2)								
Change:	0.7013	0.0000	0.0000	0.0000	0.0000	0.0330	0.0016	0.0016
Reference	13.0907	0.0000	0.0000	0.0000	0.0000	0.6798	0.0337	0.0586
% change	5.36%	0.09%	0.78%	4.10%	2.41%	4.86%	4.71%	2.81%

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxi-city, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
10% recyclability of plastic (R2)								
Change:	0.0018	0.0000	0.0008	4.8146	0.2861	-0.1375	0.0000	6.2074
Reference	0.1126	0.0003	0.0228	131.9978	982.212 0	-0.1778	0.0007	222.5542
% change	1.59%	3.07%	3.36%	3.65%	0.03%	77.33%	0.02%	2.79%
30% recyclability of plastic (R2)								
Change:	0.0054	0.0000	0.0023	14.4437	0.8584	-0.4125	0.0000	18.6223
Reference	0.1126	0.0003	0.0228	132.0	982.21	-0.1778	0.0007	222.554 2
% change	4.76%	9.20%	10.08%	10.94%	0.09%	231.98%	0.05%	8.37%

6.4. Impact reduction from both recycled content and recyclability of plastic

This section discusses the reduction in environmental impacts for a unit product when both the recycled content (R1) factor and the recyclability at end of life (R2) factor for plastics are increased from 0% (baseline) to 10%, 30% and 100%. Like the previously reported impacts for the baseline, only impacts from changing the material inputs (i.e., plastic) and the EoL impacts and the EoL benefits are considered (no manufacturing, distribution, use, repair and maintenance). Compared to the baseline, both factors R1 and R2 have been adjusted. The A (allocation factor) remains the same.

Figure 13 presents the results for two of the sixteen environmental indicators, Climate change and Ecotoxicity Freshwater. Plastic constitutes 32% of the total mass of the printer, therefore the impacts of increasing recycled content and recyclability have a measurable effect on the overall environmental impact of the materials used in this laser printer.

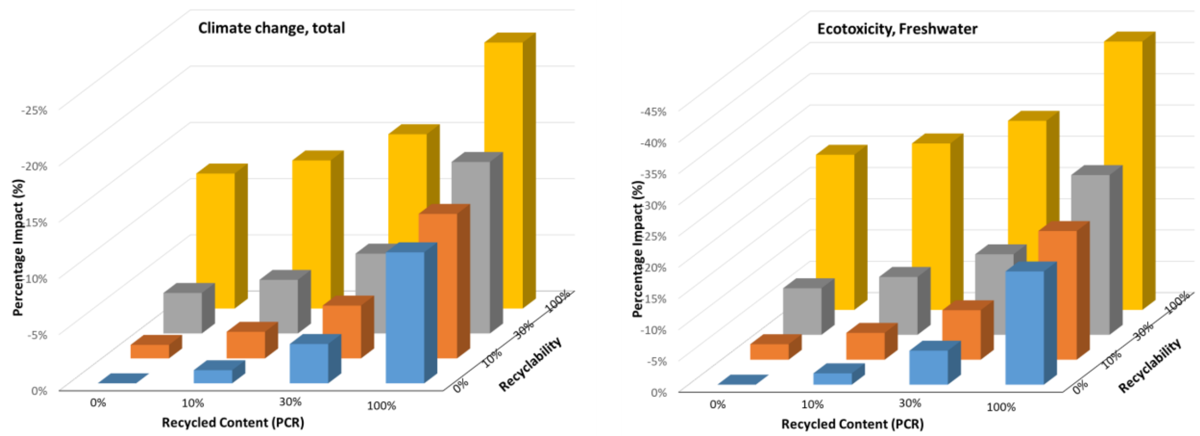


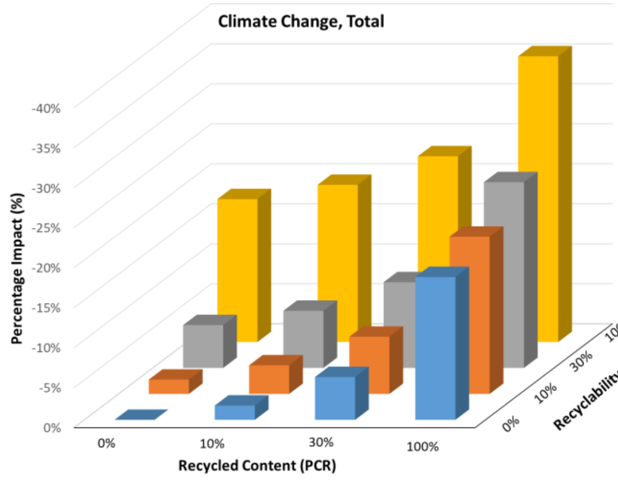
Figure 13: Impact Improvement of Climate Change and Ecotoxicity (Freshwater) for increasing recycled content and recyclability of the basecase A3 colour laser printer (BC5)

Table 21 presents the numerical results for all environmental indicators for the basecase A3 colour laser printer. There are a range of impacts, with the ones most improved including resource use fossil, ecotoxicity freshwater, climate change, eutrophication terrestrial and photochemical ozone formation. The water use metric increases consumption however, the only one of the metrics to go in the higher impact direction. In general, however, most of the environmental indicators indicate modest changes with the increasing quantities of recycled plastic and higher levels of recyclability.

Table 21: Environmental indicators for recycled / recyclability plastic for A3 colour laser printer (BC5)

PEF Impact categories	Content 0%, recyclability 0%	Content 10%, recyclability 0%	Content 30%, recyclability 0%	Content 100%, recyclability 0%	Content 0%, recyclability 10%	Content 10%, recyclability 10%	Content 30%, recyclability 10%	Content 100%, recyclability 10%	Content 0%, recyclability 30%	Content 10%, recyclability 30%	Content 30%, recyclability 30%	Content 100%, recyclability 30%	Content 0%, recyclability 100%	Content 10%, recyclability 100%	Content 30%, recyclability 100%	Content 100%, recyclability 100%
Climate change, total	0.0%	-1.2%	-3.5%	-11.6%	-1.2%	-2.4%	-4.7%	-12.8%	-3.6%	-4.8%	-7.1%	-15.2%	-12.0%	-13.2%	-15.5%	-23.6%
Ozone depletion	0.0%	0.0%	0.0%	-0.2%	0.0%	0.0%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.2%	-0.3%
Human toxicity, cancer	0.0%	-0.4%	-1.2%	-4.2%	-0.4%	-0.8%	-1.7%	-4.6%	-1.2%	-1.7%	-2.5%	-5.4%	-4.2%	-4.6%	-5.4%	-8.3%
Human toxicity, non-cancer	0.0%	-0.5%	-1.4%	-4.7%	-0.4%	-0.9%	-1.8%	-5.1%	-1.3%	-1.8%	-2.7%	-6.0%	-4.4%	-4.9%	-5.8%	-9.1%
Particulate matter	0.0%	-0.7%	-2.0%	-6.8%	-0.7%	-1.4%	-2.7%	-7.5%	-2.0%	-2.7%	-4.1%	-8.8%	-6.7%	-7.4%	-8.8%	-13.5%
Ionising radiation, human health	0.0%	-0.7%	-2.0%	-6.7%	-1.2%	-1.9%	-3.2%	-7.9%	-3.5%	-4.2%	-5.6%	-10.3%	-11.8%	-12.5%	-13.8%	-18.6%
Photochemical ozone formation, hu	0.0%	-1.0%	-3.1%	-10.3%	-1.0%	-2.1%	-4.1%	-11.3%	-3.1%	-4.1%	-6.2%	-13.3%	-10.2%	-11.3%	-13.3%	-20.5%
Acidification	0.0%	-0.1%	-0.4%	-1.3%	-0.1%	-0.3%	-0.5%	-1.5%	-0.4%	-0.5%	-0.8%	-1.7%	-1.3%	-1.5%	-1.7%	-2.7%
Eutrophication, terrestrial	0.0%	-1.0%	-3.1%	-10.4%	-1.0%	-2.1%	-4.2%	-11.5%	-3.1%	-4.2%	-6.2%	-13.5%	-10.4%	-11.4%	-13.5%	-20.8%
Eutrophication, freshwater	0.0%	-0.1%	-0.4%	-1.5%	-0.1%	-0.3%	-0.6%	-1.6%	-0.4%	-0.6%	-0.9%	-1.9%	-1.4%	-1.6%	-1.9%	-2.9%
Eutrophication, marine	0.0%	-1.0%	-3.0%	-9.9%	-1.0%	-2.0%	-3.9%	-10.9%	-3.0%	-3.9%	-5.9%	-12.8%	-9.8%	-10.8%	-12.8%	-19.7%
Ecotoxicity, freshwater	0.0%	-1.8%	-5.4%	-18.1%	-2.5%	-4.3%	-7.9%	-20.6%	-7.4%	-9.3%	-12.9%	-25.6%	-24.8%	-26.6%	-30.3%	-42.9%
Land use	0.0%	-0.1%	-0.2%	-0.5%	0.0%	-0.1%	-0.2%	-0.6%	-0.1%	-0.2%	-0.3%	-0.7%	-0.4%	-0.5%	-0.6%	-0.9%
Water use	0%	10%	30%	101%	10%	20%	40%	111%	29%	39%	59%	130%	97%	107%	127%	198%
Resource use, minerals and metals	0.0%	-0.2%	-0.7%	-2.5%	0.0%	-0.3%	-0.8%	-2.5%	0.0%	-0.3%	-0.8%	-2.5%	-0.1%	-0.3%	-0.8%	-2.6%
Resource use, fossils	0.0%	-2.1%	-6.3%	-21.1%	-2.2%	-4.3%	-8.5%	-23.3%	-6.5%	-8.6%	-12.8%	-27.6%	-21.5%	-23.7%	-27.9%	-42.6%

For the representative A4 colour inkjet printer (BC7), Figure 14 presents the results for two of the sixteen environmental indicators, Climate change and Ecotoxicity, Freshwater. Plastic constitutes 67% of the total materials mass of the printer, thus the impacts of increasing recycled content and recyclability have a more noticeable impact.



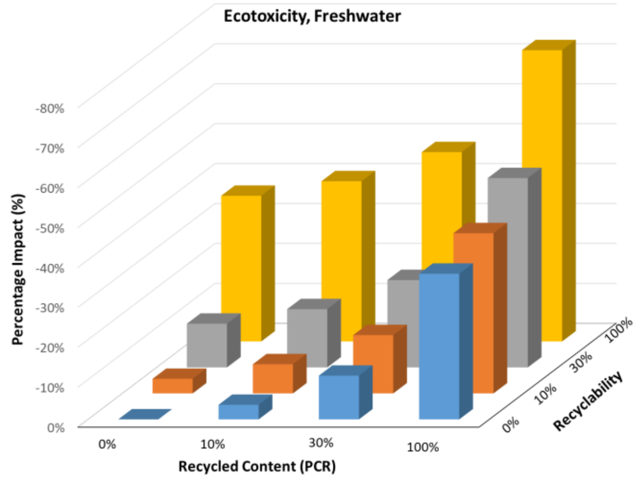


Figure 14: Impact Improvement of Climate Change and Ecotoxicity (Freshwater) for increasing recycled content and recyclability of the basecase A4 colour inkjet printer (BC7)

Table 22 presents the numerical results for all environmental indicators for the basecase inkjet printer. The range of impacts varies from more environmentally damaging (e.g., Ozone depletion, Water use) to being more environmentally friendly (e.g., Ecotoxicity freshwater; Photochemical ozone formation; Eutrophication, terrestrial and marine). In general, however, most of the environmental indicators indicate improvements (less impact) with the increasing quantities of recycled plastic and higher levels of recyclability. The results for water consumption need to be investigated separately and are perhaps uncertain due to the ERT tool being used.

Table 22: Environmental indicators for recycled / recyclability of plastic in A4 colour inkjet printer (BC7)

PEF Impact categories	Content 0%, recyclability 0%	Content 10%, recyclability 0%	Content 30%, recyclability 0%	Content 100%, recyclability 0%	Content 0%, recyclability 10%	Content 10%, recyclability 10%	Content 30%, recyclability 10%	Content 100%, recyclability 10%	Content 0%, recyclability 30%	Content 10%, recyclability 30%	Content 30%, recyclability 30%	Content 100%, recyclability 30%	Content 0%, recyclability 100%	Content 10%, recyclability 100%	Content 30%, recyclability 100%	Content 100%, recyclability 100%
Climate change, total	0.0%	-1.8%	-5.4%	-17.9%	-1.8%	-3.6%	-7.1%	-19.6%	-5.4%	-7.1%	-10.7%	-23.2%	-17.9%	-19.6%	-23.2%	-35.7%
Ozone depletion	0.0%	0.0%	-0.1%	-0.3%	0.0%	-0.1%	-0.1%	-0.3%	-0.1%	-0.1%	-0.2%	-0.4%	-0.3%	-0.3%	-0.4%	-0.6%
Human toxicity, cancer	0.0%	-0.3%	-0.8%	-2.6%	-0.3%	-0.5%	-1.0%	-2.9%	-0.8%	-1.0%	-1.6%	-3.4%	-2.6%	-2.9%	-3.4%	-5.2%
Human toxicity, non-cancer	0.0%	-1.4%	-4.1%	-13.7%	-1.4%	-2.7%	-5.5%	-15.0%	-4.1%	-5.5%	-8.2%	-17.7%	-13.7%	-15.0%	-17.7%	-27.3%
Particulate matter	0.0%	-0.8%	-2.4%	-8.0%	-0.8%	-1.6%	-3.2%	-8.8%	-2.4%	-3.2%	-4.8%	-10.4%	-8.0%	-8.8%	-10.4%	-16.0%
Ionising radiation, human health	0.0%	-1.6%	-4.9%	-16.2%	-1.6%	-3.2%	-6.5%	-17.8%	-4.9%	-6.5%	-9.7%	-21.1%	-16.2%	-17.8%	-21.1%	-32.4%
Photochemical ozone formation, hu	0.0%	-1.6%	-4.7%	-15.7%	-1.6%	-3.1%	-6.3%	-17.3%	-4.7%	-6.3%	-9.4%	-20.4%	-15.7%	-17.3%	-20.4%	-31.4%
Acidification	0.0%	-0.9%	-2.8%	-9.4%	-0.9%	-1.9%	-3.7%	-10.3%	-2.8%	-3.7%	-5.6%	-12.2%	-9.4%	-10.3%	-12.2%	-18.7%
Eutrophication, terrestrial	0.0%	-1.6%	-4.8%	-15.9%	-1.6%	-3.2%	-6.3%	-17.5%	-4.8%	-6.3%	-9.5%	-20.6%	-15.9%	-17.5%	-20.6%	-31.7%
Eutrophication, freshwater	0.0%	-3.1%	-9.2%	-30.7%	-3.1%	-6.1%	-12.3%	-33.7%	-9.2%	-12.3%	-18.4%	-39.9%	-30.7%	-33.7%	-39.9%	-61.3%
Eutrophication, marine	0.0%	-3.4%	-10.1%	-33.6%	-3.4%	-6.7%	-13.4%	-37.0%	-10.1%	-13.4%	-20.2%	-43.7%	-33.6%	-37.0%	-43.7%	-67.2%
Ecotoxicity, freshwater	0.0%	-3.6%	-10.9%	-36.5%	-3.6%	-7.3%	-14.6%	-40.1%	-10.9%	-14.6%	-21.9%	-47.4%	-36.5%	-40.1%	-47.4%	-72.9%
Land use	0.0%	0.0%	-0.1%	-0.3%	0.0%	-0.1%	-0.1%	-0.3%	-0.1%	-0.1%	-0.2%	-0.4%	-0.3%	-0.3%	-0.4%	-0.6%
Water use																
Resource use, minerals and metals	0.0%	0.0%	0.0%	-0.2%	0.0%	0.0%	-0.1%	-0.2%	0.0%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.2%	-0.3%
Resource use, fossils	0.0%	-2.8%	-8.4%	-27.9%	-2.8%	-5.6%	-11.2%	-30.7%	-8.4%	-11.2%	-16.7%	-36.3%	-27.9%	-30.7%	-36.3%	-55.8%

6.4.1 Analysis of the Impacts of Different Types of Plastic

This section conducts a comparison of the different types of plastic to understand which types are the most important for imaging equipment according to the actual amount of plastic in the two basecase models analysed.

Table 23 shows the types of plastic that are used in the two base case models analysed, the A3 colour laser printer and the A4 colour inkjet. Both printers have a majority of Acrylonitrile Butadiene Styrene (ABS). For both printers, Polyoxymethylene (POM) is the second most common plastic – but only constitutes less than 5% of the plastic incorporated into these basecase models.

Table 23: Plastic used in the base case A3 colour laser (BC5) and A4 colour inkjet (BC7) printers

Types of Plastic	A3 Colour Laser [grams]	A3 Colour Laser (% plastics)	A4 Colour Inkjet [grams]	A4 Colour Inkjet (% plastics)
Acrylonitrile Butadiene Styrene (ABS)	23,786	87.4%	1,276	79.7%
Polyoxymethylene (POM)	1,258	4.6%	42	2.6%
Polyvinyl chloride (PVC)	--	--	209	13.0%
Polystyrene (PS)	1,149	4.2%	--	--
Polycarbonate (PC)	285	1.0%	32	2.0%
Nylon	254	0.9%	28	1.7%
Polyethylene terephthalate (PET)	213	0.8%	--	--
Other	265	1.0%	14	0.9%
TOTAL:	27,209	100%	1,601	100%

Two scenarios that were analysed with the ERT v.1.7 on the A3 Colour Laser Printer (BC5):

- Scenario 1: 30% post-consumer recycled plastic and 30% recyclability at end of life (see Table 24)
- Scenario 2: 100% post-consumer recycled plastic and 100% recyclability at end of life (see Table 25)

As before, the results table is split in two parts, showing all the results across the various impact categories. If a particular metric increased instead of decreasing, it was given an “n/a” for not applicable. The percentages shown for the different plastics are the percentages reduction in environmental impact relative to reference case. In general, there is no significant difference between the reduction in environmental indicators for the different types of plastic.

Table 24: Summary of the percentage change in environmental impacts compared to the baseline, when using 30% recycled content and 30% recyclability for the basecase A3 Colour Laser Printer (BC5)

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemi-cal ozone formation, human health	Acidification
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
30% recycled plastic (R1) and 30% recyclability (R2)								
ABS	27%	10%	29%	29%	25%	12%	25%	26%
POM	30%	30%	30%	30%	30%	30%	30%	30%
PS	9%	151%	32%	27%	44%	115%	37%	42%
PC	22%	n/a	26%	23%	24%	44%	29%	28%
Nylon	n/a	n/a	n/a	n/a	n/a	25%	n/a	n/a
PET	24%	30%	29%	29%	30%	n/a	29%	29%
Other plastic	7%	0%	16%	7%	4%	21%	6%	7%

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxicity, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
30% recycled plastic (R1) and 30% recyclability (R2)								
ABS	27%	25%	27%	29%	21%	n/a	26%	28%
POM	30%	30%	30%	30%	n/a	30%	30%	30%
PS	35%	9%	36%	30%	9%	16%	32%	38%
PC	28%	n/a	28%	29%	n/a	25%	n/a	30%
Nylon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4%
PET	29%	29%	29%	29%	26%	28%	30%	28%
Other plastic	8%	1%	8%	2%	3%	1%	1%	16%

Table 25: Summary of the percentage change in environmental impacts compared to the baseline, when using 100% recycled content and 100% recyclability for the basecase A3 Colour Laser Printer (BC5)

Material	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer	Particulate matter	Ionising radiation, human health	Photochemical ozone formation, human health	Acidifi-cation
Units	*kg CO2 eq*	*kg CFC-11 eq*	*CTUh*	*CTUh*	*disease incidence*	*kBq U235 eq*	*kg NMVOC eq*	*mol H+ eq*
100% recycled plastic (R1) and 100% recyclability (R2)								
ABS	89%	32%	95%	97%	83%	41%	82%	87%
POM	100%	100%	100%	100%	100%	100%	100%	100%
PS	31%	502%	107%	91%	148%	383%	122%	139%
PC	72%	n/a	85%	78%	82%	148%	95%	92%
Nylon	n/a	n/a	n/a	n/a	n/a	83%	n/a	n/a
PET	80%	99%	98%	97%	99%	n/a	98%	98%
Other plastic	23%	1%	53%	23%	13%	70%	20%	24%

Material	Eutrophi-cation, terrestrial	Eutrophi-cation, freshwater	Eutrophi-cation, marine	Ecotoxicity, freshwater	Land use	Water use	Resource use, minerals and metals	Resource use, fossils
Units	*mol N eq*	*kg P eq*	*kg N eq*	*CTUe*	*pt*	*m3 water eq. of deprived water*	*kg Sb eq*	*MJ*
100% recycled plastic (R1) and 100% recyclability (R2)								
ABS	89%	85%	89%	97%	72%	n/a	87%	93%
POM	100%	100%	100%	100%	n/a	100%	100%	100%
PS	115%	31%	119%	100%	30%	52%	105%	127%
PC	94%	n/a	95%	98%	n/a	82%	n/a	101%
Nylon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	13%
PET	98%	98%	98%	97%	88%	92%	100%	94%
Other plastic	26%	2%	26%	5%	10%	3%	3%	55%

In response to the analysis presented in this section, a manufacturer of imaging equipment commented that responsibly sourced bio-based plastic content should also be included among different types of plastics. They noted that in the February Communication on the Clean Industrial Deal, the section addressing the Circular Economy Act includes a clear endorsement of bio-based materials.

This comment will be provided to the Review Team conducting the study of Imaging Equipment. One approach would be to look at the respective life-cycle assessment (LCA) impacts of bio-based plastic compared to alternatives.

6.5. Design options for Critical Raw Materials

Critical Raw Materials (CRMs) and Strategic Raw Materials (SRMs) are found mainly in the electronic components of and the electric motors contained in imaging equipment. The economic value of these components is limited and consequently they are not always being removed before shredding. However, where they are separated prior to shredding, they can be delivered to companies specialising in processing and recycling them.

Recyclers have stated that before setting recycled content requirements on CRMs, the economics of their recycling should be addressed.

For the moment no recycled content requirements for CRMs and SRMs have been assessed in this study. For copper and aluminium such requirements are not necessary, these two CRMs are already recovered and recycled as much as economically justified.

For the moment no recyclability requirements for CRMs and SRMs have been assessed in this study. Recyclability of CRMs and SRMs from depends on collection rates (which are beyond the scope of this study), and to a lesser extent on the recycling rate of printed circuit boards. Recyclers state that the latter is already high.

Considering the lack of information on the types and quantities of CRMs and SRMs, setting information requirements could be relevant, however, considering the expected small quantities, and the considerable traceability effort for recyclers, it requires further evaluation.

An industry association commented in response to this conclusion that they fully agree with the fact that no measures are proposed on the recycled content requirements or recyclability requirements for CRMs and SRMs. They believe that mandatory recycled content targets are not appropriate for non-ferrous metals, many of which already achieve high recycling efficiency, and the market demand is expected to grow significantly under the EU Green Deal. The association noted that unlike other materials, primary and secondary metals are of identical quality and value, and are often processed together for technical reasons, making fixed recycled content targets impractical. They conclude that recycled content is highly sector-specific and must be supported by a mature, available secondary market. For metals, uptake is already driven by market demand and material availability. Imposing mandatory thresholds could unintentionally divert recycled materials between sectors, disrupting existing circular value chains.

7. Estimates of Magnitude of Impacts

7.1. Comparison of Materials vs. Energy in Use

Estimates of product lifetime and power consumption and operating hours in various energy consumption modes were derived from a 2019 report published by the European Commission, "Revision of Voluntary Agreement on Imaging Equipment, Task 1-7 Final Report".[37] Using those estimates, the total electricity consumption over the lifetime of the product was estimated in order to compare the environmental footprint of the materials used in the product with the energy in use phase.

The values for lifetime, and the hours in operation and power consumed in on-mode, standby-mode and off-mode were input into ERT. The electricity mix selected in the ERT was 243-Electricity grid mix 1kV-60kV technology mix consumption mix, to consumer 1kV-60kV. The inputs for the two base case models are shown in the table below. These estimates may be revised in the future and are only being used in this study to provide a basis for comparison. The annual operating hours in on-mode for the laser printer is estimated at 200 hours, which is approximately 45 minutes per day on average for a working year (i.e., 260 weekdays per year). The annual operating hours in on-mode for the inkjet printer is estimated at 12 hours, which equates to approximately 2 minutes per day on average, spread over the whole year (i.e., 365 days per year).

Table 26: Service life, power consumption and operating hours for base case imaging equipment

Modelling input estimate	A3 Colour Laser, BC5 (Office use)	A4 Colour Inkjet, BC7 (Domestic)
Product (service) life in years	6 yrs	5 yrs
On-mode power consumption (watts)	500 W	50 W
On-mode number of hours per year	200 hr	12 hr
Standby-mode power consumption (watts)	3 W	1.1 W
Standby-mode number of hours per year	2000 hr	1200 hr
Off-mode power consumption (watts)	0.1 W	0.1 W
Off-mode number of hours per year	6560 hr	6000 hr
Hard off-mode power consumption (watts)	0 W	0 W
Hard off-mode number of hours per year	0 hr	1548 hr
Annual energy consumption (kWh/yr)	**106.7 kWh/yr**	**2.5 kWh/yr**

Given the above inputs, the ERT estimates the environmental impacts of the materials and end-of-life (including impacts and credits) and the environmental impacts of the energy consumed while in use, assuming an average electricity mix. The figures below present the results for the basecase (for plastic, 0% recycled content, 0% recyclability) scenario. The orange shaded portions of the environmental impact represent the impact from energy-in-use

[37] Revision of Voluntary Agreement on Imaging Equipment, Task 1-7, Final Report, Baijia Huang, Peter Martin Skov Hansen, Larisa Maya-Drysdale, Jonathan Wood (Viegand Maagøe A/S), contract no.: ENER/C3/FV 2017-438/16/FWC 2015-619 LOT3/07/SI2.777115, October 2019. Link to publication.

and the blue shaded portions represent the impact from the materials and end-of-life treatment. These impacts are over the whole lifetime of the printers, as defined from the estimates in the table above (6 years for the A3 colour laser printer and 5 years for the A4 colour inkjet). The relative share of the impacts vary substantially with the different environmental indicators.

Figure 15 shows that the environmental impacts for an A3 colour laser printer are slightly greater for the materials than the energy-in-use over its six year lifetime. For some indicators, energy-in-use dominates, while for others, its materials and end-of-life treatment.

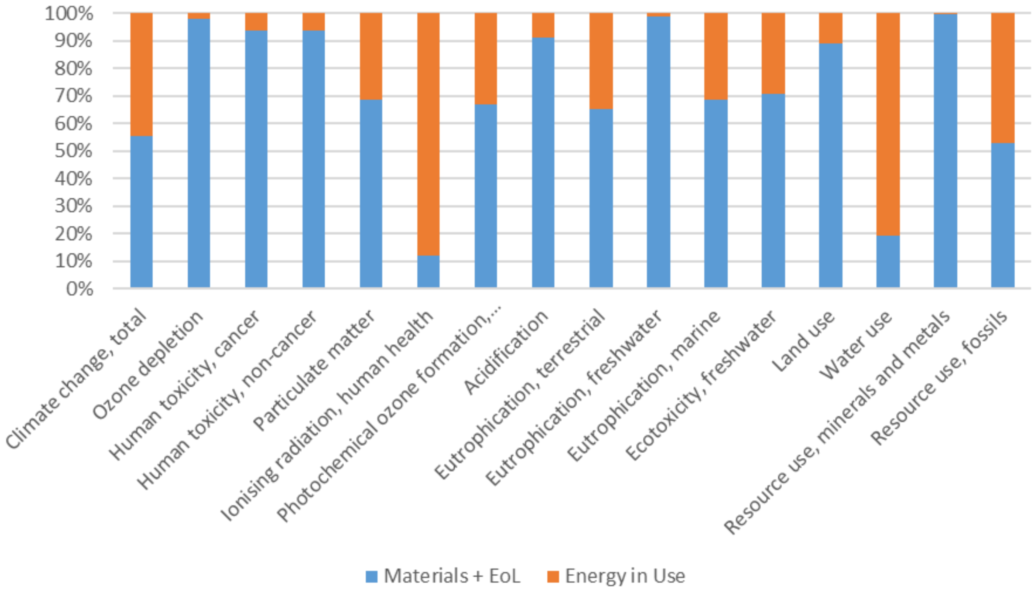


Figure 15: Environmental impacts comparison for materials and end-of-life and energy-in-use for the basecase A3 colour laser printer (BC5)

For the A4 colour inkjet printer, the same comparison was made and is shown in Figure 16. Due to the fact that the wattage consumption on an ink jet printer is very low and the operating hours in the domestic setting are also low, the total energy consumption in a given year is only 2.5 kilowatt-hours. This means that the environmental impacts of the inkjet printer in this end-user setting are dominated by the materials, not the energy consumption.

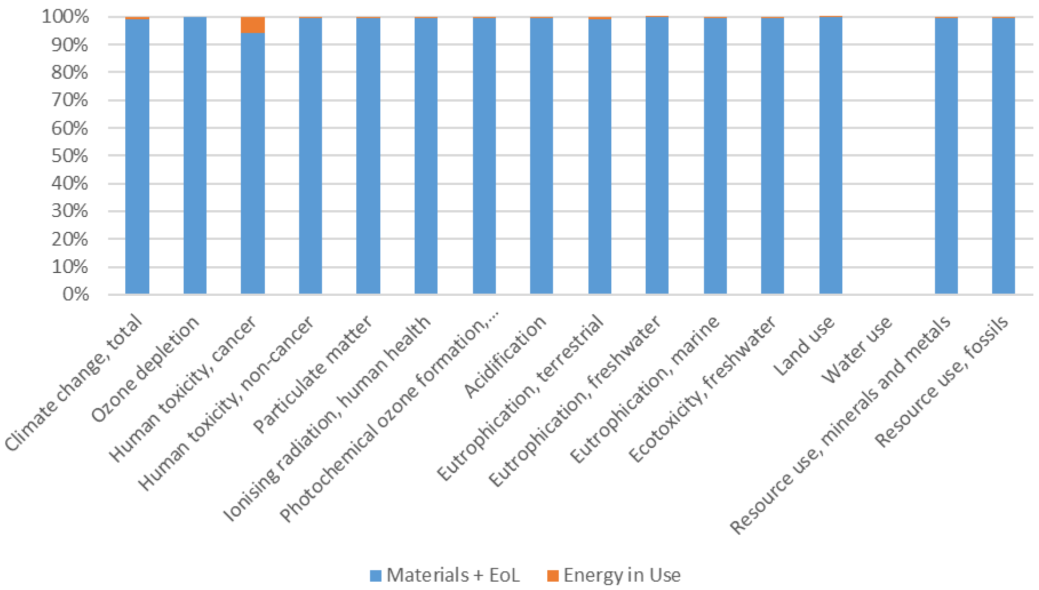


Figure 16: Environmental impacts comparison for materials and end-of-life and energy-in-use for the basecase A4 colour inkjet printer (BC7)

7.2. Savings Potential Compared to Sales & Stock in 2030

This section provides an estimate of relative order of environmental benefit for the measures considered in recycled plastic and recyclability of plastic for the sales and stock of the two base case printers in 2030. These benefit calculations consider two conditions: 10% recycled plastic content with 10% recyclability at end of life, and 30% recycled plastic content with 30% recyclability at end of life. The benefits calculated for the representative base case inkjet printer and laser printer are then multiplied by the projected sales and stock in 2030 to estimate the magnitude of the savings potential overall from these two measures. Adjustments can easily be made to these estimates. From the table of sales and stock, we have combined the plain printers and the multi-function devices (MFDs) in each format, as these are both popular models.

Table 27: Sales and Stock estimates in 2030 for inkjet and laser basecase printers

Type	**2030 Sales** *[units]*	**2030 Sales** *[percent]*	**2030 Stock** *[units]*	**2030 Stock** *[percent]*
Inkjet Printers and MFDs	11,732,000	66%	59,855,000	62%
Colour Laser Printers and MFDs	3,522,000	20%	21,077,000	22%
Other types of Printer and MFD	2,570,000	14%	15,190,000	16%
Totals	17,824,000		96,122,000	

Given the above shipment and stock estimates, the ERT provides estimates the environmental impacts of the materials and end-of-life (including impacts and credits). Considering these estimates and only adjusting the two parameters – the recycled plastic content and the recyclability at end of life – per unit benefits were calculated for the base case printers. While there are sixteen environmental indicators in the ERT, we have selected carbon dioxide emissions as our reference point because it is considered more easily comparable to other analyses and policy measures.

The table below presents these values, which are 0.47 kg of CO_2 savings for the 10%/10% scenario for the A4 colour inkjet model, and approximately 3 times larger at 1.40 kg/CO2 savings for the 30%/30% scenario. The larger A3 colour laser printer has more plastic, and therefore has more savings per unit, with 7.84 kg CO_2 savings for the 10%/10% scenario and 23.51 kg CO_2 savings for the 30%/30% scenario. Now, multiplying each of these individual (per unit) savings by the sales and stock of printers and MFDs in 2030, an estimate of the overall order of magnitude from these measures is quantified and shown in the table below.

Table 28: CO2 savings estimates in 2030 for the inkjet and laser basecase printers

Policy Scenario	**GHG Savings / unit** *[kg CO_2 eq]*	**2030 Sales** *[tonnes CO_2 eq]*	**2030 Stock** *[tonnes CO_2 eq]*
A4 Inkjet: 10% PCR plastic content & 10% recyclability at end of life	0.47	5,485	27,984
A4 Inkjet: 30% PCR plastic content & 30% recyclability at end of life	1.40	16,455	83,953
A3 Laser: 10% PCR plastic content & 10% recyclability at end of life	7.84	27,598	165,157
A3 Laser: 30% PCR plastic content & 30% recyclability at end of life	23.51	82,794	495,470

Combining the savings from both basecase models analysed, approximately 33,000 metric tonnes of CO_2 would be saved for the 10%/10% scenario if all sales in 2030 incorporated those requirements. If (hypothetically) the entire stock of inkjet and laser printers switched overnight to incorporate this measure, the combined savings would be approximately 190,000 metric tonnes of CO_2 savings. It is recognised, however, that the in reality the change in stock would happen gradually over time as the models are replaced, also taking into account the possibility of over-compliance (i.e., products designed to contain more recycled content than required).

The values for the 30% / 30% scenario approximately triple those estimates for 10% / 10% scenario, with approximately 99,000 metric tonnes of CO_2 savings for the 2030 sales and approximately 580,000 metric tonnes of CO_2 savings for the 2030 stock.

Table 29: Estimates of Virgin Plastic Avoided through use of PCR Plastic

Policy Scenario	**Virgin Plastic avoided per Annum in 2030** *[kilotonnes]*	**Virgin Plastic avoided in Stock in 2030 if 100% converted** *[kilotonnes]*
10% PCR plastic content for A4 colour inkjet and A3 colour laser printers	11.5	66.9
30% PCR plastic content for A4 colour inkjet and A3 colour laser printers	34.4	200.7

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