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The environmental impact of reuse vs. recycling of toner and inkjet cartridges

OEM print cartridges are environmentally preferable across their entire lifecycle

Executive summary

Conventional wisdom holds that remanufacturing is always the most environmentally-sustainable end-of-life treatment for toner and inkjet cartridges. However, life cycle assessments of non-Original Equipment Manufacturer (OEM) remanufactured print cartridges show that issues with print quality, reliability, and end-of-life management practices offset the benefits accrued through reuse. Therefore, superior print quality and reliability combined with material recycling can yield the best environmental outcome for print cartridges.

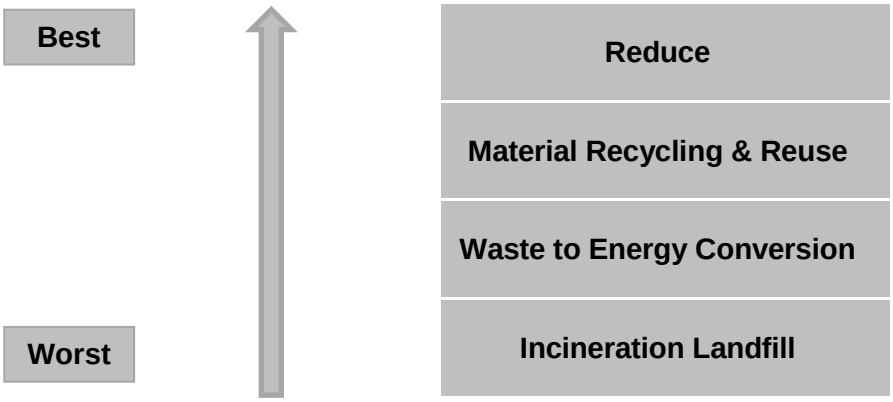
This position paper lays out the environmental costs and benefits of reuse versus recycling of toner and inkjet cartridges across the full product lifecycle using data from life cycle assessments. The main conclusions and policy recommendations are as follows:

- **The quality and reliability of print cartridges are the most important factors that determine the overall life cycle environmental impact** because low print quality will increase paper consumption.
- **Good environmental public policy for printers and cartridges considers all life cycle phases** in addressing the interconnected challenges posed by landfill waste, carbon emissions and natural resource depletion.
- **Life cycle assessments show that non-OEM remanufactured and refilled print cartridges are not environmentally preferable to original OEM cartridges across the entire life cycle.** Public policy that simply favours non-OEM print cartridge remanufacturing and refilling will not benefit the environment.
- **All producers of ink and toner cartridges, including non-OEM remanufacturers and refillers that put cartridges on the EU market under their own trademark, are responsible for the take back and environmentally-sound treatment of their cartridges at the end of their life as recently clarified the European Commission.** Given the inclusion of print cartridges within the scope of the new Waste Electronic and Electrical Equipment (WEEE) Directive, non-OEM remanufacturers and refillers must comply with the requirements of the Directive, including take-back, proper treatment and achievement of the recovery rates.

How to best assess the environmental performance of recycled and remanufactured cartridges?

1. The Waste Hierarchy is a useful starting point

In order to put the end-of-life impacts of toner and inkjet cartridges into proper perspective, it is necessary to first examine the hierarchy of possible end-of-life processing outcomes. At the bottom of the hierarchy is landfill disposal, the least desirable option. At the top is reduce, which offers the greatest sustainability benefit, but the next most beneficial options are reuse and recycling.



- **Landfill deposit or incineration**, as occurs in a typical municipal solid waste management scenario, is the least desirable outcome, increasing a product's environmental footprint through the release of additional carbon emissions. These processes also increase the industry's dependence on new raw materials due to loss of potentially usable post-consumer feedstock. Most OEMs apply a "zero landfill" practice for all cartridges.

- **Waste to Energy Conversion**, is a form of recovery in which the energy generated from the incineration is captured and used as energy.

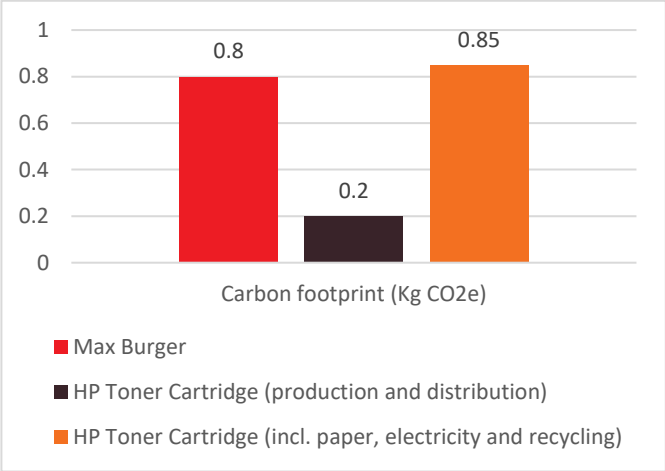
- **Material recycling** is desirable from a sustainability perspective because it cuts landfill waste by recycling used products into new raw materials or recycled feedstock and thus helps alleviate depletion of virgin raw materials. The recycled materials are then used in production of the same product ("closed-loop"), in production applications that preserve the value of the original materials, or lower the value ("down-cycling").

- **Reducing** the amount of resources used in a product's lifecycle through re-evaluating product design is the most beneficial option from a waste hierarchy point of view, but once a product that uses cartridges is put on the market, the most optimal outcomes for a cartridge at end-of-life are material recycling or reuse. The re-use principle can also be applied to the equipment's use of energy and paper, and these can be minimized by reducing unnecessary printing.

Reuse and remanufacturing can, under certain conditions, offer the greatest potential to avoid environmental impact. However, in contrast to material recycling, the reuse of a toner cartridge does not end the product's life cycle. Quality and reliability during use of a non-OEM remanufactured cartridge and its ultimate end-of-life management are crucial factors that shape the full life cycle footprint of not only the cartridge but also energy and paper consumption. Issues with cartridge print quality, reliability or inadequate end-of-life handling can quickly offset the benefits of materials reuse. The following section illustrates the importance of these factors using carbon footprint measurements of original OEM cartridges and non-OEM remanufactured cartridges.

2. LCA must be used to assess the environmental performance of recycled and remanufactured cartridges

OEMs strive to understand the environmental impact of their cartridges so that they can identify opportunities to improve them and measure progress. To this end, they employ life cycle assessment (LCA) – a holistic technique for examining the environmental impact of a product or service throughout its lifespan- production, distribution, use and end-of-life. These studies adhere to the ISO14040 series standards to ensure that they are accurate and reputable.



A plain hamburger from the environmentally-minded Swedish fast food chain "Max Burger". Max Burger states that the carbon footprint of one of their plain hamburgers is 0.8 kg CO2e, almost four times that of the toner cartridge. Including the paper and electricity associated with the use of that cartridge, as well as the recycling of the cartridge, the cartridge's life cycle footprint is just 6% more than a Max Burger.

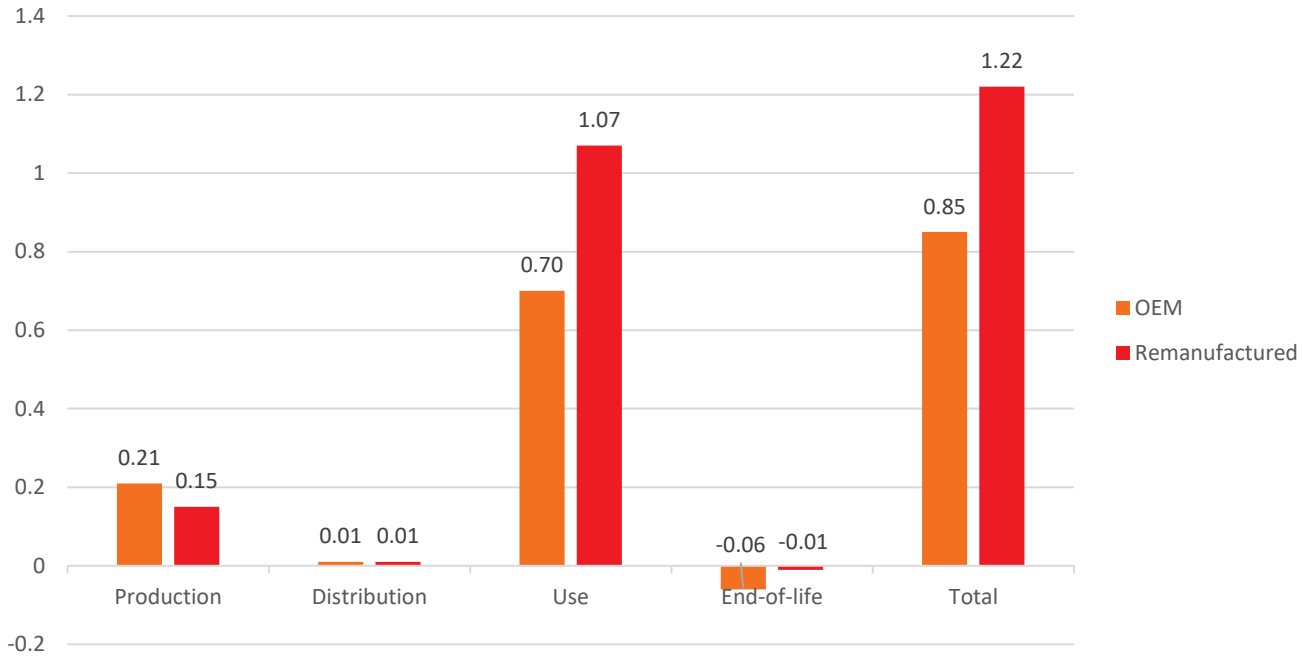
Several OEMs have used LCA to compare original OEM print cartridges with non-OEM remanufactured and refilled alternatives. The results reveal that the originals have a lower carbon footprint and less overall environmental impact. For example, an LCA study of an HP toner cartridge commissioned by HP and conducted by Four Elements Consulting demonstrates that the non-OEM remanufactured cartridges have a 42% larger carbon footprint than the original OEM cartridge[1].

OEMs represented by EuroVAprint are working towards circular business models, as described by the Ellen MacArthur Foundation, and LCA is a robust and science-based tool to achieve this objective and to eliminate waste through careful design.

What does LCA tell us? A comparison between the life cycle carbon footprints of OEM vs. non-

[1] 2016 Four Elements Consulting LCA study, commissioned by HP, compared Original HP 80A and 83A monochrome toner cartridges with a sample of remanufactured alternatives across eight environmental impact categories.
The LCA leverages a SpencerLab 2016 study, commissioned by HP, comparing Original HP LaserJet toner cartridges with six brands of non-HP toner cartridges sold in EMEA.

OEM remanufactured toner cartridges



OEM print cartridges are environmentally preferable across their entire lifecycle

The Four Elements Consulting study highlights the importance of the cartridge use phase because it contributes significantly to the overall environmental impact. This result may surprise some, but the use phase must be considered when comparing OEM to recycled cartridges because the non-OEM remanufactured cartridges did not have consistent print quality. Low-quality prints from non-OEM remanufactured cartridges lead to paper and energy wastage. In contrast, the consistent reliability and superior print quality of OEM toner cartridges mean fewer reprints and less waste.

This is why the OEMs heavily invest in research and development to ensure each and every cartridge delivers the highest level of print quality and reliability possible. Non-OEM remanufactured cartridges often cannot attain these levels[2]. Finally, the OEMs offer free and easy return options for their products in many of the countries where they are sold, while most non-OEM remanufacturers surveyed in a study failed to collect their own products.

Print OEMs design their cartridges to improve their environmental performance across the entire product life cycle. They do this by maximising material recovery during design and end-of-life and minimising waste due to issues with print quality and reliability during use. Although remanufacturing a cartridge does avoid most of the environmental impacts of producing a new one, this saving can be

[2] 2016 SpencerLab Monochrome Reliability study, commissioned by HP, compared Original HP mono cartridges with eight brands of non-HP cartridges sold in Europe, Middle East, and Africa for the HP Pro M127 and Pro 400 printers, HP 83A and 80A cartridges. See

more than offset by lower print quality and reliability and inadequate end-of-life practices on the part of many remanufacturers.

1. DESIGN: Foresighted engineering reduces overall impact

Eliminating waste through the use of recycled plastic:

- HP's ink cartridges contain up to 70% recycled content and toner cartridges up to 20%[3].
- Lexmark's toner cartridge product line contains an average of 18% post-consumer recycled (PCR) plastic content with some models utilising more than 25%.

Using plastic recycled from old ink and toner cartridges draws the circular economy loop even tighter than the use of multi-source plastic. This plastic is called 'closed-loop' and is a significant engineering innovation given the stringent technical requirements of the cartridge application, and results in an efficient, circular use of materials that reduces environmental impact.

A 2014 life cycle assessment demonstrates that the closed-loop recycled PET plastic used by one OEM has a carbon footprint up to 33% smaller than that of virgin plastic, reducing fossil fuel consumption by 54%, and water consumption by 75%[1].

Eliminating waste by reducing the complexity of the consumable:
Another OEM approach, adopted by Kyocera, is to focus on reducing the complexity of the consumable and therefore the number of components that have to be regularly replaced as part of the consumable cartridge. By increasing the durability of components such as the print drum and developer, these can become either a permanent part of the printer or replaceable at a much longer interval than the toner powder which is supplied in a simple plastic cassette. These "toner only" consumables use fewer resources and result in less waste, an innovation acknowledged in WEEE2 which puts "toner-only" consumables out of scope. The environmental benefit of reusing these "toner-only" consumables cannot be assumed to be the same as for cartridges, however the terms "cartridge" and "consumable" tend to be used interchangeably in many policy documents, which can be misleading.

OEM cartridges are designed with the circular economy in mind. Parts greater than 25 grams in weight are marked with internationally-recognised ISO symbols to facilitate the identification of specific materials. Furthermore, OEMs have reduced the average number of parts in cartridges by more than half, which simplifies the recycling and reuse processes.

Incorporating design criteria from recognised environmental labels:
Most original OEM toner cartridges are compliant with the criteria of the Blue Angel eco label at the time of their market introduction. The Blue Angel eco label requires print cartridges to be designed to facilitate recycling and not to prevent reuse.

In addition, when a new OEM printing system (printer and cartridges) is launched, the printing system with the original OEM toner cartridges meets or exceeds indoor air quality standards established by eco-labels like Blue Angel and EPEAT[4]. It cannot be assumed that the same printing system meets those

[3] Percentage of recycled and recovered material is based on empty cartridge weight and may vary by model and over time.
[4] Electronic Product Environmental Assessment Tool (EPEAT), managed by the Green Electronics Council of the International Sustainability

indoor air quality standards when an alternative toner is substituted.

Eliminating waste thanks to new business models

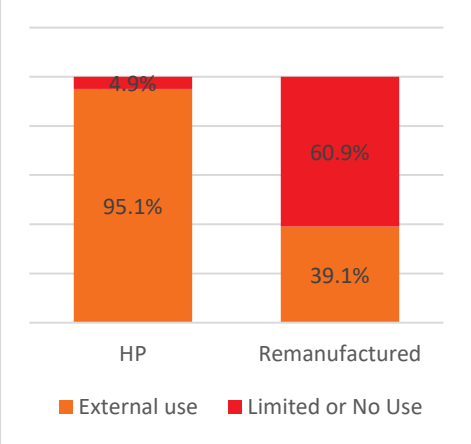
Finally, a circular economy also calls for a 'functional service' model in which the manufacturer retains the ownership of its products and acts as a service-provider – selling the use of products, not their one-way consumption. Print OEMs are active in this area as well by providing managed print services to their customers. With managed print services, the provider owns the equipment and cartridges and charges the user per page printed. This arrangement ensures that the customer has the right amount of energy efficient printers and that the printers and cartridges are properly managed at the end of their use.

2. USE: Print quality and reliability determines the environmental impact of a print cartridge

Consistent print quality saves paper

The reliability and quality of toner and inkjet cartridges both have significant consequences for the environment. Over 100 OEM lifecycle assessment studies show that paper has the largest environmental impact across the life cycle of a printing system. Superior and consistent print quality, dependable page yield, and overall reliability are key criteria in a toner cartridge's carbon footprint because consistent prints mean less wasted paper and the need for fewer cartridges.

Lexmark conducted an LCA on its MX711DE monochrome multifunctional laser device and found that the impact of paper accounts for almost 87% of the global warming potential across the product's life cycle. Looking at it another way, far more energy is consumed producing and distributing a single sheet of paper than is used to print on it. The production of a single sheet of paper consumes about 17 watt-hours, which is approximately 50 times the amount of energy needed to print a single page.



OEM cartridges deliver the print quality users expect from their printing (see graph showing the results of a 2016 HP toner cartridge reliability study by SpencerLab).

Pages with print quality issues, which cannot be used for the intended purpose, must be reprinted, which wastes toner or ink and paper. Compared to an original HP toner cartridge, non-OEM remanufactured toner cartridges can lead to the use of up to twenty-seven times the amount of paper for reprinting due to inconsistent print quality.

Development Foundation (ISDF). For printing systems the IEEE Standard for Environmental Assessment of Imaging Equipment (IEEE Std 1680.2-2012) is applied.

Stiftung Warentest – a leading German consumer organisation – provides third-party confirmation that original OEM print cartridges deliver superior print quality. In the June 2015 issue of its magazine[5], Stiftung Warentest gave all OEM ink cartridges tested (from Brother, Canon, Epson and HP), the highest overall rating after testing them against their respective competition from third-party brands. Original OEM cartridges showed significantly better results in page quality, which includes print quality and print permanence, compared to third-party brand cartridges, which was also found in the March 2014 issue.

Good cartridge reliability avoids premature replacement

Finally, additional studies show that original OEM cartridges from HP have significantly better reliability than non-OEM cartridges:

- The HP cartridges showed 100% reliability; in contrast, one in four non-OEM toner cartridges and 40% of non-OEM ink cartridges exhibited reliability problems like "dead on arrival" or failing prematurely during use. These reliability problems waste the energy and materials put into remanufacturing and distributing the cartridges.
- Additionally an average of 48% of the non-OEM reman toner cartridges tested produced low quality prints which means that a total of 73% of the no-OEM reman cartridges tested may have needed to be replaced immediately or shortly after purchase.

This situation is confirmed by those in close contact with the printers: a recent survey of Europe Middle East and Africa printer technicians finds that using non-OEM toner supplies in OEM printers from HP can damage the printer[6].

- One in three of the technicians surveyed said they replace the maintenance kits and other parts of the HP printers studied at least twice as often when non-OEM toner cartridges are used.
- Four in five printer technicians stated that using non-OEM cartridges in the OEM printers shortens the life of the printer due to problems such as toner leaks, printer mechanism breakdowns, toner sticking to the fuser, and dirt and dust in the printer.

The repair and replacement of printers damaged by faulty cartridges will negatively impact the environment as additional energy and materials will be used to build the replacement parts and printers.

Good cartridge reliability reduces use-phase energy consumption

Notwithstanding the fact that energy consumed in manufacturing paper exceeds that consumed by the hardware during use, device energy consumption has become the focus of product environmental labels, in particular Energy Star. The environmental benefit of selecting a product based on its energy efficiency will be undermined if the use of unreliable cartridges results in the product being more heavily used.

[5] Stiftung Warentest, June 2015: Zutritt verweigert. 15 ink cartridges were tested on Brother, Canon, Epson and HP printers. The following HP cartridges were tested: HP 932 XL black, yellow, cyan and magenta.

[6] A 2016 Market Strategies International study commissioned by HP. Results based on 252 surveys from HP Service One Partners who have at least 6 months of experience servicing HP monochrome and/or Color LaserJet printers with HP Original cartridges and non-HP toner cartridges installed in the past 12 months. Study was conducted in 27 countries: UK, IE, FR, DE, IT, LU, AT, CH, BE, PT, ES, NL, SE, RU, UA, PL, HU, CZ, HR, RO, ZA, SA, AE, EG, MA, QA, and TR.

3. END OF LIFE: OEMs offer free cartridge take-back and recycling programmes

OEMs provide free and convenient recycling of empty cartridges

According to a 2016 Infotrends study[11], few non-OEM remanufacturers surveyed collect their own products, whereas OEMs provide free collection of cartridges, and recycling and reuse in many of the countries where their supplies are sold.

OEMs ensure that returned cartridges are recycled in compliance with ISO 14001 and 9001 certified processes, as well as the WEEE Directive. This means that the cartridges OEMs collect are not disposed of in landfills and that the plastic recovered in the process is used to manufacture original OEM cartridges with the same quality and reliability, as well as other products.

In contrast, the 2016 Infotrends study states that 25% of ink and 17% of toner cartridges collected by non-OEM remanufacturers were unusable for remanufacturing. Of those, 16% of ink and 13% of toner cartridges go to landfill because many remanufacturers do not have a recycling process[11].

As clarified in September 2017 by the European Commission, all producers of ink and toner cartridges, including non-OEM remanufacturers and refillers that put cartridges on the EU market under their own trademark, are responsible for the free take-back and environmentally-sound treatment of their cartridges at the end of their life. Given the inclusion of print cartridges within the scope of the WEEE Directive[7], non-OEM remanufacturers should comply with the requirements of the WEEE Directive, including take-back, proper treatment and achievement of the set recovery rates. However, in the UK at least, many non-OEM remanufacturers operate under the T16 exemption which allows them to store and process up to 150 tonnes of cartridges at any one time without having to operate to the more costly and onerous standards demanded of the Authorised Treatment Facilities (ATFs) and Approved Authorised Treatment Facility (AATFs) that OEMs are obliged to use.

Finally, contrary to some common arguments, the environmental benefit of recycling the plastics, metals and other materials from cartridges back into the industrial materials stream can outweigh the additional transportation and energy emissions involved in the recycling process. For example, recycling high- density polyethylene plastic versus landfill can reduce the overall carbon emissions of that material by 30% or more[8]. In recognition of this sustainability benefit, most major OEMs offer free cartridge take-back and recycling programs, diverting millions of cartridges from landfills and responsibly recycling tens of millions of kilograms of ink and toner cartridge materials annually[9].

[7] Under the new WEEE Directive (2012/19/EU) the European Commission has decided that printer cartridges with electronic components can be considered Electronic and Electrical Equipment (EEE) and should therefore be in scope of the new Directive. The guidance provided by the European Commission concerning printer cartridges is non-legally binding. Therefore, adoption of such guidance and timing of such adoption may vary from Member State to Member State.

[8] Calculated using EPA WARM calculator. Percentage difference between CO2 eq emissions from tons landfilled versus tons recycled.

[9] See: HP 2015 Sustainability Report, Lexmark 2015 Corporate Social Responsibility Report, Xerox 2015 Global Citizenship Report

Conclusion: Good environmental policy for printers and cartridges considers all life cycle phases

Using data from product Life Cycle Assessments, this paper has demonstrated that in order to effectively address today's sustainability challenges, product environmental policy for toner and inkjet cartridges must consider a wide range of product attributes and life cycle impacts beyond just the potential benefits of materials reuse. The main conclusions from this paper are:

- **The quality and reliability of print cartridges as well as how they are handled at final end-of-life are the most important factors that determine the overall life cycle environmental impact** because issues with print quality will increase paper consumption.
- **Life cycle assessments show that non-OEM remanufactured and refilled print cartridges are not environmentally preferable to original OEM cartridges.**

Given these conclusions, the OEMs recommend considering the following when it comes to potential future regulations or standards in order to improve the environmental impact of the print cartridges while ensuring fair competition in the printing supplies market:

- ✓ **Public policy should not only emphasise non-OEM print cartridge remanufacturing and refilling, but should also factor in quality, reliability, safety or environmental standards and final product end-of-life.**
- ✓ **Good environmental public policy for printers and cartridges considers all life cycle phases** in addressing the interconnected challenges posed by landfill waste, carbon emissions and natural resource depletion.
- ✓ **Non OEM Remanufacturers and refillers should be responsible for the free take-back and environmentally sound treatment of their cartridges at the end of their life, and for providing the same level of data on material content and environmental standards as OEMs.**

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ABOUT EuroVAprint

EuroVAprint ASBL is a non-profit association consisting of the major manufacturers of imaging equipment that operate in Europe. The association supervises the implementation and monitoring of a set of binding commitments made by its members in 2011 and endorsed by the European Commission. These commitments are enshrined in a voluntary agreement which represents the industry's contribution to the EU's 2020 agenda and more particularly the Energy Efficiency Action Plan and the Resource Efficiency Roadmap. The agreement, which was negotiated under the auspices of the European Commission, also constitutes an implementing measure under the EU's Energy related products Directive.

These commitments are aimed at curbing the environmental footprint of the manufacturing and use of

imaging equipment for home and office use – copiers, printers, fax machines and multifunction devices using laser, inkjet and solid ink technologies. Our website provides further information on our recent news and activities: http://www.eurovaprint.eu/home/

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