Life Cycle Assessment of a Solid Ink MFD Compared with a Color Laser MFD

A White Paper on Total Lifetime Energy Investment and Global Warming Impact

General Conclusion:
A life cycle assessment (LCA) of a 50 ppm color solid ink multi-function device (MFD) and a comparable 51 ppm color laser multi-function device under similar operating conditions was conducted by Xerox Corporation and underwent peer review by the Rochester Institute of Technology to confirm that it adhered to generally-accepted LCA methodologies. The study assessed the total life-time energy invested in the manufacture, transportation, and use of the two devices. Global warming impacts were also studied. The assessment concludes that the solid ink MFD studied has 9 % lower life cycle energy demand and 10 % less global warming impact than the laser MFD.

This document summarizes a life cycle assessment of a color solid ink multi-function device and a comparable color laser multi-function device.

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Executive Summary:

This report summarizes the life cycle assessment (LCA) of a 50 ppm color solid ink multi-function device (MFD) and a comparable 51 ppm color laser MFD under similar operating conditions. The study was conducted by Xerox Corporation and underwent peer review by the Rochester Institute of Technology to confirm that it adhered to generally-accepted LCA methodologies. The assessment concludes that over the product lifecycle, the solid ink MFD studied exhibited 9% lower lifecycle Cumulative Energy Demand and 10% lower Global Warming Potential than the laser MFD.

Introduction:

Laser printing technology creates an image by fusing powdered toners to paper. Color laser MFDs typically include replaceable parts such as photoconductors, transfer rollers, fuser rollers, fuser oilers, and supplies such as toner cartridges and waste toner bottles. The life expectancy of these replaceable parts and supplies is dependent on either the number of pages printed or the amount of each color used per print. Typically in the life of a laser MFD, multiple sets of the replaceable parts and supplies are required.

Solid ink printing technology is a relatively new technology, with the first commercial printer introduced in 1991. It creates an image by applying melted ink to paper where it instantly solidifies. Solid ink sticks are melted into the printhead which jets the ink onto the print drum. Paper is passed between a roller and the print drum under pressure and the image is transferred from the print drum to the paper. Since the ink sticks are solid, there is no need to contain the ink in a cartridge, leaving nothing to dispose of when the ink stick has been consumed. The drum maintenance unit is the only replaceable item in the solid ink MFD. All remaining parts, including the printhead, are designed to last the lifetime of the device. The result: solid ink technology produces up to 90% less post-consumer waste, and requires fewer replacement parts and supplies than laser technology, thus reducing the number of items that need to be manufactured, transported to the customer and ultimately disposed of.

Objective:

In order to quantify the differences between the printing technologies, a study was undertaken to compare the environmental impacts of a solid ink MFD to a conventional color laser MFD using a transparent, internationally recognized LCA method. Prior internal assessments have indicated that paper use and energy consumption are the two largest contributors to the environmental impacts of office printing. Based on this understanding, the primary purpose of this study was to evaluate the Cumulative Energy Demand (CED) and Global Warming Potential (GWP) impacts of these technologies. Cumulative Energy Demand is the total life-time energy invested in the manufacture, transportation, and use of a product. Global Warming Potential is a measure of greenhouse gas contribution to global warming of these same activities and is expressed as carbon dioxide equivalents. While the impacts of the paper cycle are important, they were excluded from the analysis as this was assumed to be equivalent for both devices.

Methodology:

A LCA is an evaluation of the environmental impacts of a product or service over all stages of its life. An LCA model typically begins with the extraction of raw materials to create the components of a product, and continues through its manufacture, use, and end-of-life disposition, including transportation steps along the way. Various categories of environmental impacts are typically evaluated, including energy demand, global warming potential, ecological and human toxicity, impacts to air and water quality, and depletion of raw materials.

A LCA is a well-recognized technique with international standards defining its use. There are four distinct steps of an LCA:

1. Goal definition and scope.
2. Life cycle inventory of the inputs and outputs that flow to and from the environment during every step of the product's life.
3. Impact assessment that characterizes the effect of the inputs and outputs on the impact categories.
4. Interpretation of results to determine major contributors to the outcome, as well as sensitivity and uncertainty analysis.

Scope

The scope of the assessment included the inputs and outputs associated with the manufacturing of the printing device and consumables, the use of the device, and the packaging and transport of the consumable items (such as cartridges) and their reuse and recycling. The model excluded the inputs and outputs associated with the end-of-life disposal of the devices themselves and their non-consumable replacement parts. Service activities during the active life of the product were also excluded. The inputs and outputs associated with these excluded steps were assumed to be roughly equivalent between the solid ink and laser MFDs.

While the impacts of the paper cycle are very important, they were excluded from the analysis as this was assumed to be equivalent for both devices.

Assumptions

Both MFDs were assumed to have equal print quality, monthly volumes, and lifespans: 25,000 prints per month over a four year life. Based on market distribution data for these types of products, a 60 % US/40 % European split was assumed, with energy mix and transportation distances determined accordingly. In the model, the solid ink MFD is manufactured in Malaysia, while the laser MFD is manufactured in Japan.

End-of-life disposition of cartridges was estimated from US Environmental Protection Agency (US EPA) statistics and competitive information, with 10 % remanufactured in the aftermarket, 25 % recycled, and 65 % landfilled. Packaging for both products was assumed to be 60 % recycled content and 40 % virgin content, based on the Paper Industry Association Council statistics. For packaging, 70 % was modeled as recycled at end of life, with 30 % going to landfill.

Data Sources

The analysis was conducted using SimaPro7, a commercially available and widely used software tool. Direct manufacturing data was used when available, with "industry average" data from the tool database being used when direct data were unavailable. Direct data were used for toner and solid ink production and some device and consumable manufacturing. The material inputs to the manufacturing process and the remaining manufacturing activities were based on industry averages.

Operating energy consumption was calculated for both machines using the US EPA's ENERGY STAR® Typical Energy Consumption (TEC) test method, which is designed to simulate the energy consumption patterns during a typical office work week. The TEC test procedure job length was modified to achieve the average monthly print volume of 25,000 images, but otherwise followed the EPA protocol and utilized actual energy consumption values for both machines.

Impacts Studied

Prior internal assessments have indicated that paper use and energy consumption are the two largest contributors to the environmental impacts of office printing. This led to the primary purpose of this study being to evaluate the cumulative energy demand (CED) and global warming potential (GWP) impacts of these devices. Because equal print volumes (and thus paper use) were defined for the two MFDs, paper use impacts were assumed to be equal and were excluded from the analysis.

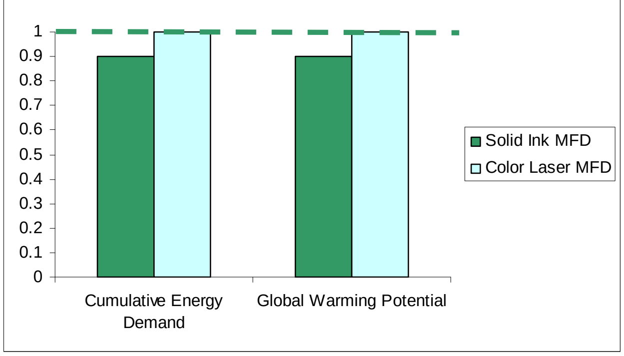
Results:

Impact Assessment

The Impact Assessment (IA) is used to convert the Life Cycle Inventory (the inputs and outputs of the two systems modeled) to indicators that describe the impact on the environment. Consistent with the objective of the study, two measurements were chosen - Cumulative Energy Demand (CED) and Global Warming Potential (GWP).

Figure 2 shows the relative contribution of the CED and GWP from each MFD. The dashed line indicates a ratio of one, the normalized impact of the color laser MFD. The Solid Ink MFD shows reduced Cumulative Energy Demand and Global Warming Potential compared to the color laser MFD. Expressed as percent difference, the solid ink MFD exhibited 9% lower CED than the laser MFD and 10% lower GWP.

Figure 2. Relative Contribution of Solid Ink MFD Compared to Color Laser MFD (Color Laser MFD=1)



The relative contribution of CED and GWP varies across the life cycle stages between the two products. Figure 3 and Figure 4 show the relative contribution of the CED and GWP expressed across these life cycle stages: 1) MFD: the material acquisition and manufacturing of the device itself (excluding consumables and packaging), 2) CRU: the material acquisition and manufacturing of the customer replaceable units including consumables (ink, toner and cartridges, etc.), 3) Packaging: the material acquisition and manufacturing of the packaging for both the MFD and replaceable units, 4) Transport of goods and parts and 5) Use-phase operating electricity consumption.   Uncertainty analysis, which is a recognized aspect of LCA and accounts for the potential effect of variation in the data, supported these results.

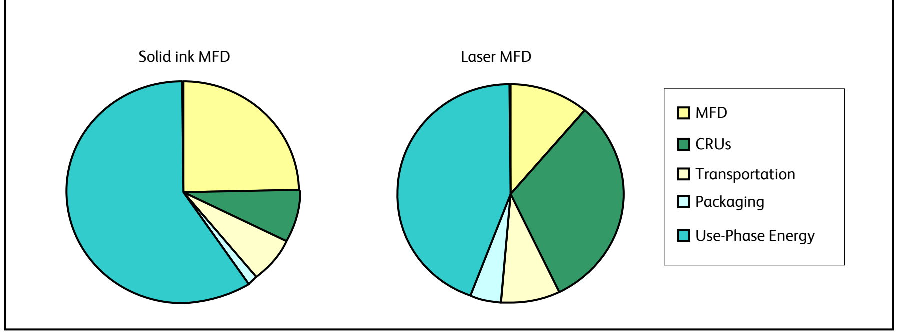


Figure 3: Relative Contribution of Cumulative Energy Demand by Category

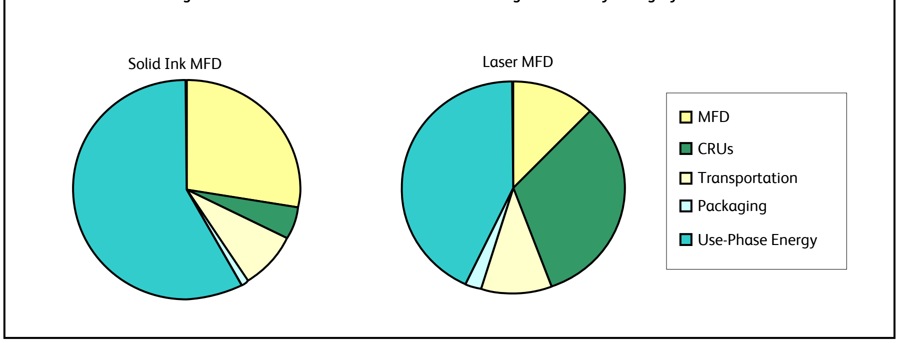


Figure 4: Relative Contribution of Global Warming Potential by Category

Solid Waste

In addition to the lifecycle assessment, the total post consumer waste, which represents the total amount of waste that the customers have to dispose of either through recycle, cartridge return or municipal waste, was also evaluated.   The solid ink printer creates approximately 90 % less post-consumer waste than the laser printer (Figure 5).

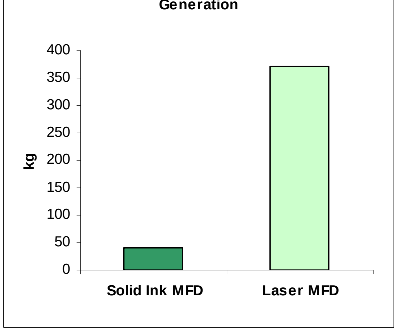


Figure 5. Post Consumer Waste Generation

Conclusions:

Over the product lifecycle, the solid ink MFD studied has 9 % lower Cumulative Energy Demand and 10 % lower Global Warming Potential. This conclusion was supported by an uncertainty analysis.

The post consumer solid waste generated by the solid ink MFD was approximately 90 % less than the comparable color laser MFD. All of these results are primarily driven by the design of the solid ink MFD which does not require a cartridge or carrier for the ink, therefore using less energy and materials over the lifecycle, and producing less waste in the customer environment.