

Life Cycle Assessment of a Solid Ink Multifunction System Compared with a Colour Laser Multifunction System

Total Lifetime Energy Investment and Global Warming Impact

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Executive Summary

This report summarises the Life Cycle Assessment of a 50 ppm colour solid ink multifunction system and a comparable 51 ppm colour laser multifunction system 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 Life Cycle Assessment methodologies. The study assessed the total life-time energy invested in the manufacture, transportation and use of the two systems. Global warming impacts were also studied. The assessment concludes that over the product life cycle, the solid ink multifunction system studied exhibited 9% lower life cycle Cumulative Energy Demand and 10% lower Global Warming Potential than the laser multifunction system.

Introduction

Laser printing technology creates an image by fusing powdered toners to paper. Colour laser multifunction systems 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 colour used per print. Typically in the life of a laser multifunction system, 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 multifunction system. 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 multifunction system to a conventional colour laser multifunction system using a transparent, internationally recognised Life Cycle Assessment 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 and Global Warming Potential 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 Life Cycle Assessment is an evaluation of the environmental impacts of a product or service over all stages of its life. A Life Cycle Assessment 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 Life Cycle Assessment is a well-recognised technique with international standards defining its use. There are four distinct steps of a Life Cycle Assessment:

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 characterises 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, the packaging and transport of the consumable items (such as cartridges), 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 multifunction systems.

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 multifunction systems were assumed to have equal print quality, monthly volumes and lifespan: 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 multifunction system is manufactured in Malaysia, while the laser multifunction system is manufactured in Japan.

End-of-life disposition of cartridges was estimated from US Environmental Protection Agency 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.

Methodology (Continued)

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, solid ink production, some device and consumable manufacturing. The material inputs to the manufacturing process and the remaining manufacturing activities were based on industry averages.

Operating energy consumption was calculated for both machines using the International ENERGY STAR® Typical Electricity Consumption test method, which is designed to simulate the energy consumption patterns during a typical office work week. The Typical Electricity Consumption test procedure job length was modified to achieve the average monthly print volume of 25,000 images, but otherwise followed the ENERGY STAR protocol and utilised 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 and global warming potential impacts of these devices. As equal print volumes (and thus paper use) were defined for the two multifunction systems, paper use impacts were assumed to be equal and were excluded from the analysis.

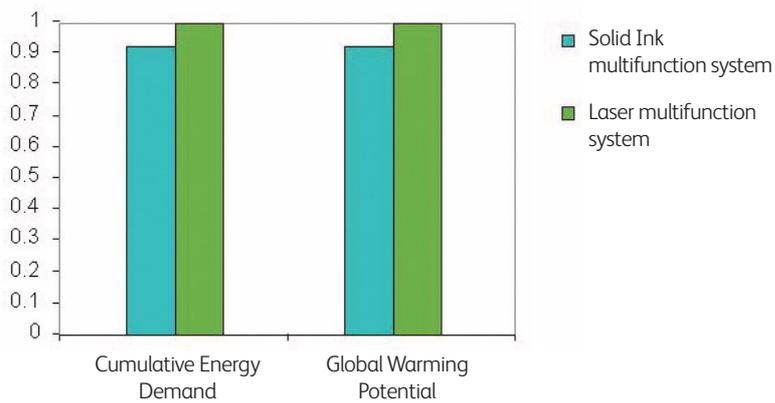
Results

Impact Assessment

The Impact Assessment 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 and Global Warming Potential.

Figure 1 shows the normalised contribution of the Cumulative Energy Demand and Global Warming Potential from each multifunction system (Laser multifunction = 1). The Solid Ink multifunction system shows reduced Cumulative Energy Demand and Global Warming Potential compared to the colour laser multifunction system. Expressed as percentage difference, the solid ink multifunction system exhibited 9% lower Cumulative Energy Demand than the laser multifunction system and 10% lower Global Warming Potential.

Figure 1: Relative Contribution of Solid Ink Multifunction System Compared to Colour Laser Multifunction System (Colour Laser = 1)



Results (Continued)

The relative contribution of Cumulative Energy Demand and Global Warming Potential varies across the life cycle stages between the two products. Figure 2 and Figure 3 show the relative contribution of the Cumulative Energy Demand and Global Warming Potential expressed across these life cycle stages:

1) Multifunction system: the material acquisition and manufacturing of the device itself (excluding consumables and packaging), 2) Customer Replacement Unit: 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 multifunction system and replaceable units, 4) Transport of goods and parts and 5) Use-phase operating electricity consumption. Uncertainty analysis, which is a recognised aspect of Life Cycle Assessment and accounts for the potential effect of variation in the data, supported these results.

Figure 2: Relative Contribution of Cumulative Energy Demand by Category

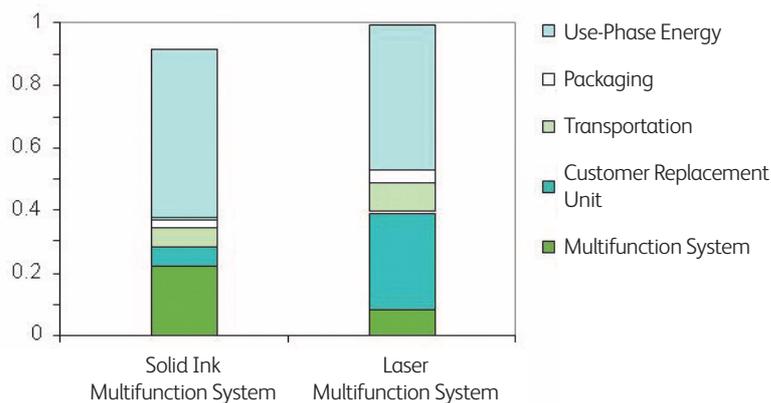
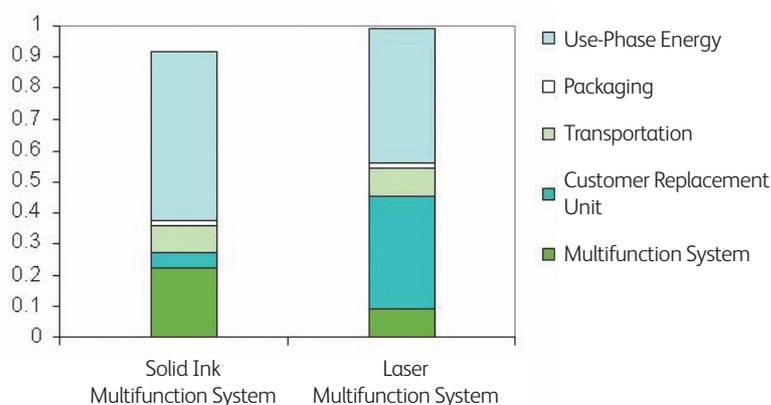


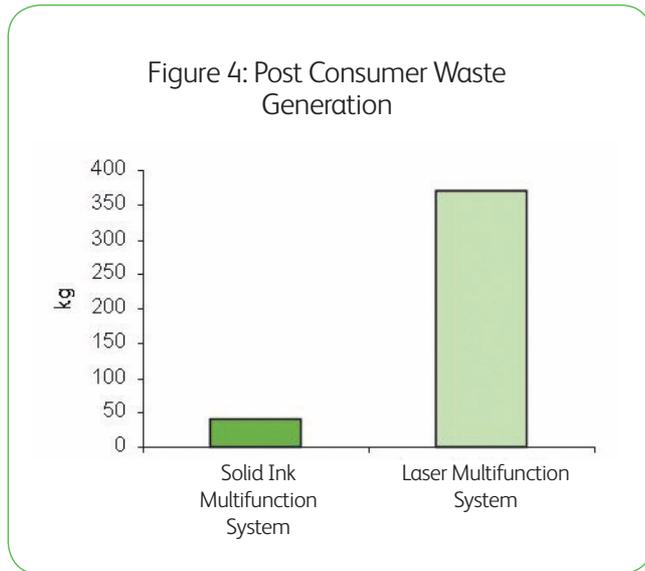
Figure 3: Relative Contribution of Global Warming Potential Across Categories



Results (Continued)

Solid Waste

In addition to the Life Cycle 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 multifunction system creates approximately 90% less post-consumer waste than the laser multifunction system (Figure 4).



Conclusion

Over the product life cycle, the solid ink multifunction system 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 multifunction system was approximately 90% less than the comparable colour laser multifunction system. All of these results are primarily driven by the design of the solid ink multifunction system which does not require a cartridge or carrier for the ink, therefore using less energy and materials over the life cycle, and producing less waste in the customer environment.

For more information on the Xerox ColorQube™ 9201 / 9202 / 9203 Multifunction System please contact your Xerox sales representative, call or visit us on the web at www.xerox.com/office

