LIFE CYCLE ASSESSMENT

LASER PRINTER MX321DN

According to ISO 14040 and ISO 14044

Lexmark's innovative imaging solutions and technologies help customers worldwide print, secure and manage information with ease, efficiency and unmatched value. Lexmark simplifies the complex intersection of digital and printed information.

As part of the commitment to our customers, Lexmark performs Life Cycle Analysis on our products. The results of the LCA analysis continues to assist Lexmark in reducing the environmental impact of the hardware, software and services offered to our customers.

Rated print speeds of up to 38 [36] ppm, plus scan, and copy functions come together in the MX321dn, powered by a 1-GHz dual-core processor, a full gigabyte of memory and automatic document feeder. There's standard USB, ethernet and Wi-Fi for easy connectivity and secure networking. Start with the 350 sheets of standard input and expand it up to 900. You'll stop less for service thanks to long-life 60,000-page imaging units**** and replacement toner cartridges that print up to 3,000 pages**.

This document is the summary of an LCA study aiming to represent the product properties, related assumption, impact categories and potential environmental impact results of Lexmark's MX321dn printer product. Lexmark generates LCAs for a series of printers and multi-functional devices. The LCAs are critically reviewed by an independent expert. Each LCA is created using the same software model and workflows while changing only printer-specific data points via parameter settings. Each LCA submitted for critical review will then be accompanied by a brief technical summary of the relevant data points, as well as a methodology report.

This LCA study is carried out based on ISO 14040 and ISO 14044, and generally follows the requirements of the Product Category Rules (PCR) Guidance for the product category printers and multi-function printing units, version 2, published by UL Environment (ULE) in April 2018. This LCA study has a few deviations from the PCR, including the following:

- The PCR bases the images per day calculation on the Version 2.0 of the Imaging Equipment ENERGY STAR® Program Requirements. However, using this estimation method results in a calculated printing volume that greatly exceeds actual customer usage. In this study, the images per day calculation has been replaced by actual customer printing data, Average Monthly Print Volumes (AMPV), per product family. The new methodology aligns with realistic customer printing.
- The PCR requires using ReCiPe 2016 or TRACI 2.1 as the impact assessment methodology. This study selects TRACI 2.1 as it is currently the only impact assessment methodology framework that incorporates US average conditions to establish characterization factors (Bare, 2012) (EPA, 2012). For global warming potential, the TRACI characterization factors are not the most current, therefore it is assessed based on the current IPCC characterization factors taken from the 6th Assessment Report (IPCC, 2021) for a 100-year timeframe (GWP100) as this is currently the most commonly used metric.
- Sphera updated paper dataset is selected to replace dataset developed based on information from the American Forest and Paper Association (NCASI, 2010).

COMPANY	Lexmark
PRODUCT SYSTEM	Laser Printer MX321dn
REFERENCE STANDARD	*ISO 14044: Environmental management – Life cycle assessment – Requirements and guidelines.* Geneva: International Organization for Standardization.
DATE OF ISSUE	11/21/2024
CONTENTS OF THE REPORT	Product definition Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and critical review
This life cycle assessment was independently reviewed in accordance with ISO 14044 by:	Thomas Gloria, Indust. Ecology Consultants

Product Description

Product Type	Mono Laser Printer
Printer Model	MX321dn
Maximum Print Speed	38 pages per minute
Intended use	primarily office
Range of applications	print images or text in mono onto paper or paper-like media
Product Lifetime	5 years
Introduction Date	4/17/2018
Product Specifications	https://www.lexmark.com/en_xc/printer/11840/Lexmark-MX321adn
Functional Unit	The functional units has been defined as (1) a 1,000 page simplex job; (2) lifetime page simplex job
Product Characterization	A solutions-capable, network-ready mono laser printer that features two-sided scanning, and copy functions, a multi-core processor, and 1GB of standard memory that prints up to 38 ppm mono (letter). The printer fuses to a medium (such as paper) to create hard copy images from electronic or hard copy originals. The printer product delivered to the customer consists of the printer, a power cord, printed setup instructions, a CD/DVD that includes the User Guide and Printer Drivers and an initial set of product supplies. The printer is delivered in packaging that can be recycled locally and is not needed for product operation. Product supplies include toner cartridges, imaging kits and the fusing mechanism. The power supply is internal to the product and the imaging kit and fusing mechanism are installed at the factory. Only the toner cartridges must be installed by the customer. The printer can be setup by the customer without outside assistance.

Lexmark

Laser Printer MX321dn

Printers and multi-functional printing units

According to ISO 14040 and ISO 14044

Technical Data

Product specifications	Lexmark MX321adn	Lexmark MX321adw	Lexmark MX421ade
Printing			
Display	2.4-inch (60 mm) Color LCD display		Lexmark e-Task 4.3-inch (10.9 cm) color touch screen
Print Speed: Up to[6]	Black: 38 ppm		Black: 42 ppm
Time to First Page: As fast as	Black: 6.5 seconds		Black: 6.25 seconds
Print Resolution	Black: 1200 IQ (1200 x 600 dpi), 1200 x 1200 dpi, 2400 IQ (2400 x 600 dpi), 600 x 600 dpi		
Memory	Standard: 1024 MB / Maximum: 1024 MB		
Hard Disk	Not Available		
Recommended Monthly Page Volume[2]	500 - 6000 pages		1000 - 10000 pages
Maximum Monthly Duty Cycle: Up to[3]	50000 pages per month		100000 pages per month
Copying			
Copy Speed: Up to[6]	Black: 38 cpm		Black: 42 cpm
Time to First Copy: As fast as	Black: 6.5 seconds		Black: 6.25 seconds
Scanning			
Scanner Type / ADF Scan	Flatbed scanner with ADF / Simplex		Flatbed scanner with ADF / RADF (Reversing Duplex)
A4/Ltr Duplex Scan Speed: Up to	Black: N/A sides per minute / Color: N/A sides per minute		Black: 20 / 20 sides per minute / Color: 10.5 / 10.5 sides per minute
A4/Ltr Simplex Scan Speed: Up to	Black: 42 / 45 sides per minute / Color: 20 / 22 sides per minute		
ADF Paper Input Capacity: Up to	50 pages 20 lb or 75 gsm bond		
Faxing			
Modem Speed	ITU T.30, V.34 Half-Duplex, 33.6 Kbps		
Supplies[7]			
Laser Cartridge Yields (up to)[1]	6,000-page Cartridge, 15,000-page High Yield Cartridge		6,000-page Cartridge, 15,000-page High Yield Cartridge, 20,000-page Extra High Yield Cartridge
Imaging Unit Estimated Yield: Up to	60000 pages, based on 3 average letter/A4-size pages per print job and ~ 5% coverage		
Cartridge(s) Shipping with Product[1]	2,500-page Return Program Toner Cartridge		3,000-page Return Program Toner Cartridge
Paper Handling			
Included Paper Handling	250-Sheet Input, 100-Sheet Multipurpose Feeder, 150-Sheet Output Bin, Integrated Duplex		
Optional Paper Handling	250-Sheet Tray, 550-Sheet Tray, 550-Sheet Lockable Tray		
Paper Input Capacity: Up to	Standard: 350 pages 20 lb or 75 gsm bond / Maximum: 900 pages 20 lb or 75 gsm bond		
Paper Output Capacity: Up to	Standard: 150 pages 20 lb or 75 gsm bond / Maximum: 150 pages 20 lb or 75 gsm bond		
Media Types Supported	Card Stock, Envelopes, Paper Labels, Plain Paper, Transparencies, Refer to the Paper & Specialty Media Guide		
Media Sizes Supported	10 Envelope, 7 3/4 Envelope, 9 Envelope, A4, A5, DL Envelope, Executive, Folio, JIS-B5, Legal, Letter, Statement, Universal, Oficio, A6		
General Information[4]			
Standard Ports	USB 2.0 Specification Hi-Speed Certified (Type B), Gigabit Ethernet (10/100/1000)	USB 2.0 Specification Hi-Speed Certified (Type B), Gigabit Ethernet (10/100/1000), 802.11b/g/n Wireless	USB 2.0 Specification Hi-Speed Certified (Type B), Gigabit Ethernet (10/100/1000), Front USB 2.0 Specification Hi-Speed Certified port (Type A)
Optional Network Ports	N/A		Marknet N8372 WiFi Option
Noise Level: Operating	Print: 54 dBA / Copy: 54 dBA / Scan: 55 dBA		Print: 55 dBA / Copy: 55 dBA / Scan: 55 dBA
Specified Operating Environment	Humidity: 8 to 80% Relative Humidity, Temperature: 10 to 32°C (50 to 90°F), Altitude: 0 - 5000 Meters (16,404 Feet)		
Limited Warranty - See Statement of Limited Warranty	1-Year Advanced Exchange, Next Business Day		
Size (in. - H x W x D) / Weight (lb.)	18.4 x 15.7 x 16.9 in. / 42.8 lb.		

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[1]Average standard page yield value declared in accordance with ISO/IEC 19752. [2]"Recommended Monthly Page Volume" is a range of pages that helps customers evaluate Lexmark's product offerings based on the average number of pages customers plan to print on the device each month. Lexmark recommends that the number of pages per month be within the stated range for optimum device performance, based on factors including: supplies replacement intervals, paper loading intervals, speed, and typical customer usage. [3]"Maximum Monthly Duty Cycle" is defined as the maximum number of pages a device could deliver in a month using a multishift operation. This metric provides a comparison of robustness in relation to other Lexmark printers and MFPs. [4]Printers are sold subject to certain license/agreement conditions. See www.lexmark.com/printerlicense for details. [5]Actual Yield may vary based on other factors such as device speed, paper size and feed orientation, toner coverage, tray source, percentage of black-only printing and average print job complexity. [6]Print and copy speeds measured in accordance with ISO/IEC 24734 and ISO/IEC 24735 respectively (ESAT). For more information see: www.lexmark.com/ISOspeeds. [7]Product functions only with replacement cartridges designed for use in a specific geographical region. See www.lexmark.com/regions for more details.

Declaration of Basic Materials

The printer consists of mechanical, electromechanical, and electronic components. Its material composition can be described using the basic material fractions given below. Please note that the category 'Electronics' also includes all wiring.

Material	Mass (kg)
Plastics (recyclable)	8.17
Plastics (non-recyclable)	1.48
Ferrous Metals	7.6
Aluminum	0
Copper	0.00898
Glass	0.677
Electronics	1.06
Other Materials	0.152
Total	19.1

Table 1: Basic Material Declaration

Product Supply Chain

The printer is manufactured and assembled in Southeast China. The cartridges for the North American market are manufactured and assembled in Juarez, Mexico.

Life Cycle Assessment Results

The following sections describe the printer's cradle-to-gate resource use and potential environmental impacts over the full printer life cycle. These represent the typical impacts for an average system sold in the North American market. All impacts are presented per functional units.

Printer Manufacturing Resources Use

Table 2 displays the use of material resources (kg) and of non-renewable as well as renewable primary energy demand necessary for printer manufacturing, but excludes other life cycle stages of the printer (cradle-to-gate). Likewise, material and energy consumption associated with printer packaging, cartridges, and paper is excluded here.

Use of Material Resources [kg]	
Non-Renewable	1.03E003
Renewable (excl. water)	1.19E003
Water	1.1E009
Use of Non-Renewable Primary Energy [MJ]	
Crude Oil	362
Hard Coal	892
Lignite	20.6
Natural Gas	687
Uranium	97.6
Use of Renewable Primary Energy [MJ]	
Biomass	2.83E-005
Geothermal	4.54
Solar	143
Wind	66.8
Hydropower	80.4

Table 2: Use of Material and Energy Resources for Printer Manufacturing (Cradle-to-Gate)

Energy Consumption During Utilization

Based on the ENERGY STAR® Typical Energy Consumption (TEC) test methodology, the printer is expected to have the following power consumption for an assumed average job load.

	Per 1,000 page	Per product lifetime
Energy Consumption During Utilization [kWh]	2.06	135

Table 3: At-wall power consumption during utilization

Life Cycle Impact Assessment

The following provides an overview of the potential printer life cycle impacts with emissions classified and characterized to standard environmental impact metrics based on TRACI 2.1 method. Global warming potential is evaluated based on IPCC AR6. Ecotoxicity and human toxicity are not included in this study, due to their respective uncertainties.

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
IPCC AR6 GWP 100, excl biogenic CO2 [kg CO2 eq.]	7.30E00	4.19E00	4.78E02	2.74E02
AP [kg SO2 eq.]	3.72E-02	2.27E-02	2.44E00	1.49E00
EP [kg N eq.]	8.46E-03	9.82E-04	5.54E-01	6.43E-02
ODP [kg CFC 11 eq.]	4.65E-09	4.65E-09	3.05E-07	3.05E-07
RDP [MJ surplus energy]	9.77E00	5.61E00	6.40E02	3.68E02
SFP [kg O3 eq.]	5.05E-01	2.26E-01	3.31E01	1.48E01

Table 3: Summary of Life Cycle Impact Assessment Results

Interpretation of Results

Dominance Analysis

Due to the 5 year lifetime and the number of pages printed per day based on the actual customer printing information, the use phase with paper heavily dominates the life cycle impacts. The below tables and charts display the results of the dominance analysis for each impact category addressed in Table 3. The first row in each table, labeled Printer, is the printer manufacturing phase which includes raw material extraction and manufacturing.

Global Warming Potential

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	2.11E00	2.11E00	1.38E02	1.38E02
Use phase <LC>	5.16E00	2.05E00	3.38E02	1.34E02
EoL phase <LC>	2.56E-02	2.56E-02	1.68E00	1.68E00

Table 4: GWP100 dominance analysis [kg CO2 equiv]

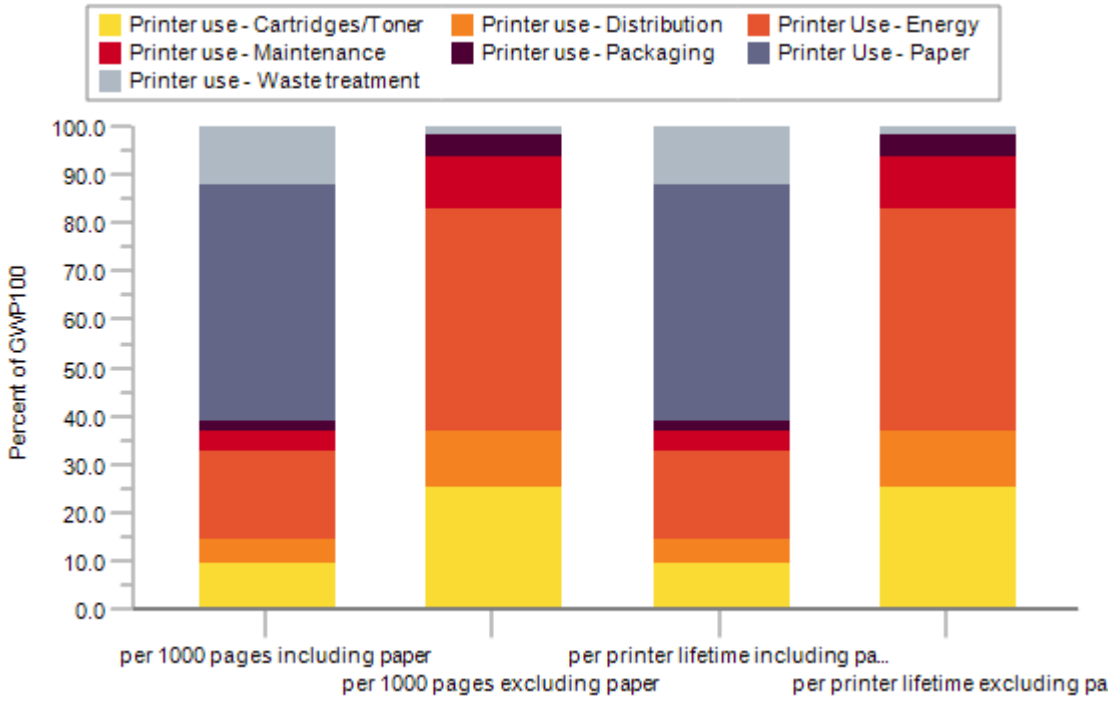

Figure 1: GWP100 dominance analysis of the life cycle stage

Total lifetime distribution: 32.98 kg CO2eq

Ozone Depletion Potential

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	1.03E-09	1.03E-09	6.73E-08	6.73E-08
Use phase <LC>	3.63E-09	3.62E-09	2.38E-07	2.38E-07
EoL phase <LC>	1.82E-16	1.82E-16	1.19E-14	1.19E-14

Table 5: ODP dominance analysis [kg CFC-11 equiv]

Acidification Potential

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	1.46E-02	1.46E-02	9.57E-01	9.57E-01
Use phase <LC>	2.25E-02	8.01E-03	1.47E00	5.25E-01
EoL phase <LC>	1.24E-04	1.24E-04	8.15E-03	8.15E-03

Table 6: AP dominance analysis [kg SO_2 equiv]

Eutrophication Potential

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	4.90E-04	4.90E-04	3.21E-02	3.21E-02
Use phase <LC>	7.96E-03	4.81E-04	5.22E-01	3.15E-02
EoL phase <LC>	1.08E-05	1.08E-05	7.05E-04	7.05E-04

Table 7: EP dominance analysis [kg N equiv]

Resource Depletion Potential (fossil fuel)

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	2.40E00	2.40E00	1.57E02	1.57E02
Use phase <LC>	7.33E00	3.16E00	4.80E02	2.07E02
EoL phase <LC>	4.76E-02	4.76E-02	3.12E00	3.12E00

Table 8: RDP dominance analysis [MJ surplus energy]

Smog Formation Potential

	per 1000 pages including paper	per 1000 pages excluding paper	per printer lifetime including paper	per printer lifetime excluding paper
Printer	1.04E-01	1.04E-01	6.79E00	6.79E00
Use phase <LC>	3.99E-01	1.19E-01	2.61E01	7.82E00
EoL phase <LC>	2.84E-03	2.84E-03	1.86E-01	1.86E-01

Table 9: SFP dominance analysis [kg O_3 equiv]

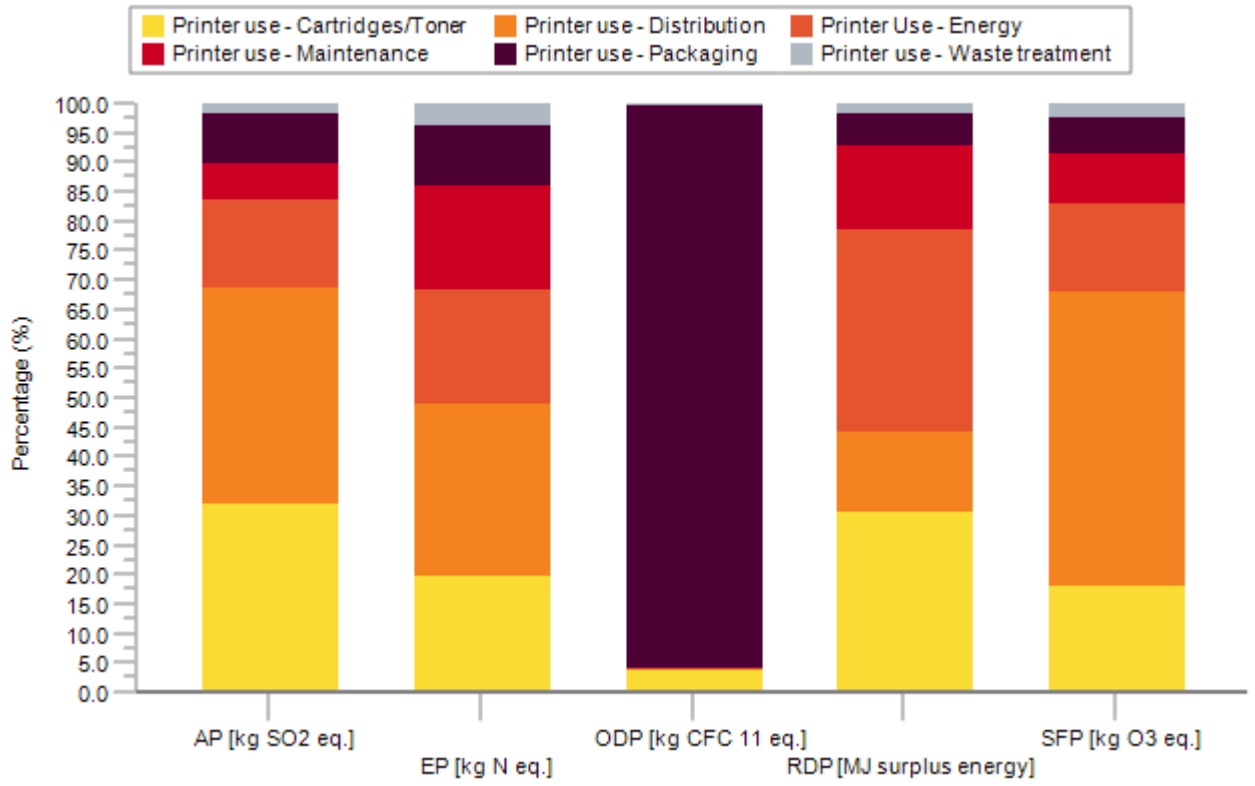

Figure 2: Contribution analysis of the use phase (per 1000 pages excluding paper)

Assumptions and Estimations

Assumptions and estimations are documented in the methodology report, which was provided for critical review purposes alongside this document. The LCA results represent the specific printer model as sold in the North American market.

The model assumes a printer lifetime of five (5) years. The printer is modeled to print an average pages per day

based on actual customer printing information. The printer further possesses an automatic mechanical duplexing feature.

Power consumption figures are based on ENERGY STAR® testing of the printer using the average job load described above. Consumables rate of consumption is based on the market-average yield across all available cartridge capacities. In addition, market-average use of remanufactured cartridges is taken into account, as applicable.

Transportation distances to the end consumer are based on their points of origin and the population-weighted average distance to the 100 most populous cities in the continental US based on 2020 census data. The printer as well as replacement fuser kits and waste toner bottles are manufactured in China and shipped to the point of use from the distribution center near Jeffersonville, IN, while the cartridges and the imaging unit are shipped from Ciudad Juarez, MX to Jeffersonville, IN.

The paper dataset developed by Sphera represents European and used as proxy in lieu of current US data.

The End-of-Life treatment for the printer is based on the assumption that 90 % of the printers are either recycled or remanufactured, while the remainder is disposed of through local waste streams, where the metal fractions are assumed to be recycled and the remainder landfilled. The EoL cartridges are assumed to be split as such: 80% to remanufacturing or recycling, and 20% landfill.

In accordance with the cut-off methodology, materials sent to End-of-Life recycling are considered to cross the system boundary without any further transformation. Only the impacts associated with waste transportation and disposal are included in the results.

Description of Data and Period Under Consideration

All primary data is based on technical documentation and sales data accessed in 2024. All background data is taken from the MLC 2024-10.9.0.31 Databases. No primary data is collected from the Original Equipment Manufacturer's manufacturing plant.

Data Quality

Manufacturing data of printers and consumables is based on a combination of Bills of Material and teardown analyses and is considered to be of overall high quality with low uncertainty. Distribution from printer manufacturing to the end consumer is representative of logistical data from Lexmark and best estimates of US average shipping distances, and is of moderate quality and high uncertainty.

Printer power consumption represents measured power consumed during printer operation. The electricity consumed is calculated based on TEC specification, and is of high quality and moderate uncertainty. Toner cartridge use is based on expected yields based on the ISO test standards for cartridge use, and is of high quality and low uncertainty. Replacement rate for consumable parts is based on part design specifications, and is of high quality and moderate uncertainty.

The disposition of the printer and consumables at End-of-Life is based on best-available information by the respective experts at Lexmark. This data is of average quality and moderate uncertainty.

Background Data

All background datasets relevant to production, power generation, transportation, and material disposal were taken from Sphera's MLC 2024-10.9.0.31 Databases.

The additional use of third-party background data from industry associations (e.g., worldsteel) is documented in the methodology report. They represent the latest LCI data as available in the MLC 2024-10.9.0.31 Databases.

Allocation and Methodological Principles

No significant allocations have been considered for the production of the printer. Allocation of production or use impacts across the various functions of a multi-function system is not included (i.e., allocation of production impacts to the provision of scanning services) and the impacts from all life cycle stages are considered within the system boundaries for the printing system.

Treatment of recycled or resold material is not considered in the body of the LCA, in accordance with the cut-off methodology.

References and Standards

Bare, J. (2012). Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - Software Name and Version Number: TRACI version 2.1 - User's Manual. Washington, D.C.: U.S. EPA.

EPA (2021) ENERGY STAR® Program Requirements for Imaging Equipment – Test Method (Rev. Nov-2021) https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Imaging%20Equipment%20Version%203.2%20Final%20Specification.pdf

ISO (2006a) ISO 14025: Environmental labels and declarations – Type III environmental declarations – Principles and procedures. International Organization for Standardization. Geneva.

ISO (2006b) ISO 14040: Environmental management - Life cycle assessment – Principles and framework. International Organization for Standardization. Geneva.

ISO (2006c) ISO 14044: Environmental management - Life cycle assessment – Requirements and guidelines. International Organization for Standardization. Geneva.

NCASI (2010) Life Cycle Assessment of North American Printing and Writing Paper Products – Final Report. Prepared for the American Forest and Paper Association (AF&PA) and the Forest Products Association of Canada (FPAC) by the National Council for Air and Stream Improvement, Inc. Research Triangle Park, NC

Sphera. (2025) *LCA for Experts Documentation*. Retrieved from Sphera Solutions, Inc.: https://sphera.com/solutions/product-stewardship/life-cycle-assessment-software-and-data/lca-for-experts/

ULE (2018) Product Category Rules for preparing an environmental product declaration (EPD) for printers and multi-function printing units (v2.0). UL Environment. Washington, DC. Expired in April, 2023.

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LIFE CYCLE ASSESSMENT

Lexmark

Letter of Equivalency

LCA Model Evaluated: MX321dn

Equivalent Models: MB2338adw, MX321adw

Life Cycle Assessments (LCA) are in accordance with ISO 14040 and ISO 14044. Life Cycle Assessments provide information on a number of environmental impacts of products over their life cycle. LCAs may be used equivalently for programs with multiple configurations if the differences in configurations are evaluated and determined to be negligible to the global warming impact. Printer configurations with the same parameters for mass, typical electricity consumption (TEC), rated pages per minute are considered equivalent. In many cases, several configurations are identical, but the model names are different among various sales channels. For printer configurations that have slight differences, they are determined to be equivalent only when those differences are considered to have a negligible contribution to the LCA results.

Accuracy of Results and Comparability: LCAs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. LCAs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. LCAs from different programs may not be comparable.

Exclusions: LCAs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. LCAs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Full details are documented in the LCAs methodology report, which was provided for verification purposes alongside the LCA. Assumptions and estimations generally follow the governing PCR on printing equipment. The LCA results represent the specific printer model as sold in the North American market.