Microsoft Consumer Devices Life Cycle Assessment Methodology Overview

Updated in April 2024

Executive Summary

At Microsoft, we achieve reductions in the carbon footprint[1] of Surface, Xbox, and other hardware products by implementing a structured ecodesign approach that considers a balance of technical, economic, and environmental factors.

The process we use to quantify the environmental impacts of our hardware devices and measure environmental improvements is called "Life Cycle Assessment." Life Cycle Assessment, or LCA, is the systematic assessment of environmental impacts associated with all life cycle stages of the product, process, or service that is being assessed. We follow recognized procedures for conducting LCAs, which are established by ISO 14040 and ISO 14044 standards, along with additional guidance available through various initiatives, including the Product Environmental Footprint (PEF)[2] initiative driven by the European Commission.

[1] A Product Carbon Footprint is a measure of the total amount of Greenhouse Gas emissions that are directly and indirectly caused by a product throughout its life cycle. It is calculated using a method called Life Cycle Assessment (LCA) in accordance with the ISO 14040 and 14044 standards. This method considers all stages of a product's life, from raw material extraction, through production and distribution, to use and disposal. The aim is to provide a complete picture of the environmental impact of a product.
[2] Product Environmental Footprint (PEF) is a methodology by the European Commission's Joint Research Center (JRC) which is based on Life Cycle Assessment.

Life Cycle Assessment Limitations

While LCA is a powerful tool for estimating quantifiable environmental impacts, including greenhouse gas emissions and other metrics such as consumption of mineral resources, it also has its limitations:

- **Modeling impact and use of secondary datasets**
    - Modeling relies heavily on generic processes provided by commercially available databases. These processes are usually based on averages and literature data and are often outdated and not representative of the latest technologies or company-specific supply chains.
    - These models are often aggregated, preventing the LCA practitioner from incorporating company specific supply chain data.
- **Scalability is limited.**
    - Modeling a product or service using LCA software can be time consuming. Data collection is done manually through product teardowns and data is manually entered into the LCA model by an expert. This limits the ability to scale the use of LCA to a large number of products.

These limitations present challenges to the use of LCA in the decision-making processes of companies, organizational Scope 3 emissions reporting, scaling the measurement and communication of the environmental impacts across the product portfolio, and periodic quantification of suppliers' impacts and progress over time.

An innovative approach to LCA

To transform our LCAs from being a purely directional impact assessment tool to a more supply chain specific environmental impact accounting process, **Microsoft has invested in an innovative approach, leveraging internal software engineering teams and Makersite**, an Artificial Intelligence (AI) and data company specializing in digital twins[3] to power sustainable products and supply chain decisions at scale.

Our new approach was created to automate and scale the modeling of complex electronic products with a significant increase in accuracy, transparency, and representativeness. The key differentiation from common LCA practices is that Makersite's AI functionality can analyze each device's Bill of Material (BOM) and the material composition data, generated from Full Material Declarations (FMDs) collected from suppliers, to automatically model each part, component, and sub-assembly down to its actual chemical composition. A model of a representative manufacturing process is associated with each part in the BOM, using data from Makersite, Ecoinvent and IDEA and eliminating much of the manual effort from the standard LCA process, providing our LCA practitioners with a running start. Effective scaling up of this modeling is enabled by integration of our product data management system with Makersite. LCA experts are still involved in the process. However, their effort is focused on completing the modeling by providing suppliers' primary data, performing quality analysis, and ensuring the model is representative.

Building on this, we continue to make significant strides in conducting a detailed mapping of the supply chain for each product. This enables targeted interventions at the points where the environmental impacts are most significant, often referred to as "hot spots." For instance, in the case of the touch display module, our supply chain engagement extends to tier 4 suppliers. This granular approach to supply chain mapping is a testament to our

[3] A digital twin is a virtual representation of a physical object or system, integrating real-time data and simulations to mirror, predict, and optimize the object's or system's performance throughout its lifecycle.

commitment to sustainability and our belief in the power of technology to drive meaningful change.

Microsoft Devices LCA Methodology Version 2.0

We refer to the first LCA methodology developed and published using this updated approach and tooling in October 2022 as Microsoft's Devices LCA Methodology Version 2.0. The benefits of transitioning to Version 2.0 include:

- **Improved quality and representativeness**

By leveraging supplier-provided FMDs, we can model individual parts down to their chemical composition. FMDs undergo additional data quality checks and mass benchmarking through detailed product teardowns performed by Microsoft LCA practitioners.

The use of fully disaggregated models also enable progressive replacement of secondary datasets by supplier specific (primary) data such as location, energy intensity, recycled content, and process specific emissions to model materials and manufacturing processes. The percentage of the total carbon footprint calculated based on suppliers' primary data increased from an average of 20% in the previous LCA methodology (a level representative of most complete LCAs) to close to 50% with the new methodology.

- **Increased accuracy**

By leveraging Makersite's AI functionality, we can replicate modeling choices across the product portfolio and reduce inconsistencies associated with the LCA practitioners' decisions, such as choice of datasets.

- **Reduction of the modeling time**

Reduced manual intervention allows us to focus our efforts on collecting and processing suppliers' primary data and performing data quality assurance and data analysis.

- **Durability**

The LCA Methodology Version 2.0 factors in device durability by adjusting a device's typical lifespan based on Microsoft's internal device repairability scoring. Greater repairability facilitates use of the product for a longer period of time, which means the user can delay purchase of a new device and therefore avoid the associated production and distribution of a new device. If we adjust a device's lifespan or use phase to be longer for LCA purposes, then the full life cycle carbon footprint is increased compared to a scenario in which the same device has a shorter lifespan. However, when we compare this against the metric of a device fulfilling a user's computing needs for each year, we see that products with a longer lifespan result in a reduced carbon footprint overall. Where applicable, we report both metrics – full life cycle carbon footprint of the device and carbon footprint of one year of use of the device – in our Ecoprofiles. This enhancement underscores the importance of creating durable and easily repairable devices in our sustainability endeavors.

- **Better identification of environmental impact hotspots in our supply chain.**

The first LCA results conducted through this new methodology demonstrate that LCAs relying on secondary datasets rather than suppliers' primary data have a high level of uncertainty and can underestimate impacts from intensive manufacturing processes.

This lack of technological representativity of secondary datasets is true for a wide range of material, manufacturing processes and electronic components. For example, secondary data used to model Integrated Circuits is based on 12-year-old data. We also found that the Computer Numerical Controlled (CNC) machining process for mechanical parts modeled using primary data from Microsoft's supplier is up to 20 times more carbon intensive than the generic datasets available in the most recognized Life Cycle Inventory databases. This difference is due to the low technological representativity of the secondary datasets available in LCA databases.

Microsoft Devices LCA Methodology Version 2.1

Building on the foundation of Version 2.0, we made further improvements to key manufacturing process models and supply chain data collection and integration to create an updated LCA Methodology Version 2.1.

In transitioning from V2.0 to V2.1, there are notable enhancements and refinements that underscore our commitment to providing more accurate, efficient and in-depth product LCAs.

- **Integration of Interuniversity Microelectronics Centre (IMEC) life cycle inventories for semiconductors manufacturing modeling[4]**

Life Cycle Inventories are lists of all the inputs (*e.g.*, raw materials and energy) and outputs (*e.g*., emissions to air, waste) associated with the production of various technologies of semiconductors. Leveraging the IMEC Life Cycle Inventories in our new methodology offers up-to-date and representative data on the environmental impacts associated with the production of processors, DRAM, and NAND chips.

This allows us to customize our LCAs with factors like the electricity grid mix corresponding to the location of the semiconductor fabrication facility, technology node, die size, and yield, enabling us to develop LCAs that are more tailored to our actual product specifications.

The introduction of supplier FMDs to model the package of the Integrated Circuits further ensures that our LCAs represent the product's material composition, thus increasing data fidelity.

- **Enhanced Focus on Suppliers' Renewable Energy Initiatives:**

We are systematically transitioning from reliance on generic, secondary datasets to prioritization of primary data integration that captures our suppliers' purchases and use of carbon free electricity[5] (CFE) for Microsoft

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[4] The IMEC SSTS program, an initiative by the Interuniversity Microelectronics Centre (IMEC), is a specialized program aimed at advancing semiconductor technology and systems. The program brings together researchers, industry experts, and students to collaborate on cutting-edge projects, fostering innovation and technological advancement in the field of microelectronics. Please note that the specifics of the program, including its current focus areas and participants, may vary over time.

[5] Microsoft defines carbon free electricity (CFE) technologies as including technologies with zero direct emissions and biogenic technologies with life-cycle emissions equivalent to renewables. CFE technologies include wind; solar; geothermal; sustainable biomass; hydropower; nuclear; fossil with complete carbon capture, utilization, and sequestration (CCUS); and storage charged with CFE generation. Microsoft acknowledges that CFE technologies have indirect carbon

device production. This refined approach significantly sharpens the accuracy of our LCAs. Microsoft diligently verifies these carbon free electricity acquisitions, emphasizing our steadfast commitment to both endorsing and reflecting supplier carbon reduction efforts throughout our supply chain.

- **Improved Scalability and Efficiency:**

The use of IMEC datasets not only enhances representativeness but also streamlines the LCA modeling process. By automating aspects of data integration and minimizing reliance on manual efforts, we are able to focus our human capital on quality assurance, data analysis, and incorporating more supplier primary data. This also streamlines the LCA process, facilitating the assessment of more device configurations.

- **Better Identification of Environmental Impact Hotspots**

By integrating more granular and up-to-date data, we can identify and act upon key areas in our supply chain that pose the highest potential environmental impacts.

Transition to Methodology Version 2.1

Beginning in October 2023 new Ecoprofiles we release are using LCA results based on LCA Methodology Version 2.1. Because they are based on Methodology Version 2.1, they should not be compared with LCAs that were based on earlier methodologies. **It's crucial to understand that LCA outcomes using different methodology versions are not directly comparable.** To ensure consistency across our product portfolio, we will gradually recalibrate all LCA results and Ecoprofiles issued before September 2023 to reflect the new Version 2.1 methodology. Meanwhile, Ecoprofiles for products introduced before October 2023 will remain available, showing LCA outcomes as per the preceding Microsoft Devices LCA Methodology Versions

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dioxide emissions and these are accounted for in our LCAs. CFE transition in the supply chain includes the onsite generation and purchase of verified Energy Attribute Certificates (EACs) by suppliers that are allocated to Microsoft-specific production volumes.

1.2 to 2.0. Please carefully check the methodology listed on the specific LCA to identify which version was used for that LCA.

Commitment to continuous improvement

Our LCA database, while comprehensive, includes areas primed for further enhancement. With the successful integration of the IMEC Sustainable Semiconductor Technologies and Systems (SSTS) life cycle inventory, our attention is now pivoting to the refinement of models for printed wiring board manufacturing. Additionally, there is an increased emphasis on expanding the modeling of supplier-specific (primary) data, particularly carbon free electricity sources. This data is invaluable as it is relevant to assessing the accurate carbon footprint of devices, including carbon impacts associated with suppliers' energy data, manufacturing scrap rates, and recycled content. Microsoft remains committed not only to active participation in research projects like IMEC's SSTS but also to harnessing the potential of our current LCA approach. This approach enables continued improvement in our use of supplier data, enhancing the quality and precision of our LCAs.

Promoting transparency and collaboration

Microsoft's Devices LCA Methodology Version 2 is a step towards the development of a more accurate, representative, scalable, and dynamic Life Cycle Assessment approach. Supplier specific (primary) data is vital to understanding the environmental impacts of our products and is best achieved by collaborating with others in industry. Therefore, this methodology and the learnings from this new approach to LCA will be shared externally to support industry collaboration and alignment.

Additional resources

IMEC Sustainable Semiconductor Technologies and Systems (SSTS)

Microsoft Devices Ecoprofiles

Notes

This document may be updated for clarity or to reflect changes to our devices LCA methodology over time. Please refer to the most recent version of this document available on our website.