Hypertec

LIFE CYCLE ASSESSMENT (LCA) 2024

AND CARBON FOOTPRINT ASSESSMENT REPORT: CIRCULAR ECONOMY PERSPECTIVE

HYPERTECHNOLOGIE CIARA INC.

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PART I: LIFE CYCLE ASSESSMENT

1. GENERAL ASPECTS

This study is divided into three main parts, as outlined in Part I – Life Cycle Assessment, Part II – Corporate Greenhouse Gas Emissions, and Part III – Corporate Greenhouse Gas Emissions from Product Transport. The study was conducted in accordance with the requirements of ISO 14040, ISO 14044, and the GHG Protocol. Additionally, Hypertec Ciara referenced ISO 14025, ISO 14065, and ISO 14067 to support related reports and work towards best practices and compliance.

Hypertechnologie Ciara Inc. has allocated internal resources to conduct the LCA of sixteen devices (micro-PC, laptops, desktops small-form, desktops mini-tower, and high-performance workstations) that were commercialized in 2024. The report has been validated by a qualified third party. More details regarding the personnel involved can be found in Section 8 and eventual annexes.

The decision to embrace a circular economy approach and language has been key to promoting cultural change at Hypertec Ciara. This strategy focuses on using resources more efficiently, reducing waste, and extending product lifecycles, demonstrating our strong commitment to environmental responsibility and northing initiatives for new products, construction and supply chain management decisions. Current contracts with recycling partners ensure proper end-of-life management for our devices, while our supply chain follows strict sustainability guidelines to minimize environmental impact.

Additionally, the upcoming state-of-the-art building, announced in 2024, is designed to prioritize innovation and sustainability, further reinforcing our dedication to eco-friendly practices. These initiatives position Hypertec Ciara as a leader in creating a greener, more responsible technology sector.

2. GOAL OF THE STUDY

Hypertechnologie Ciara Inc. is committed to enhancing its environmental performance and positively contributing to the planet. By focusing on reducing resource consumption and minimizing ecological impact, the company is actively shaping a more sustainable future. A key component of this initiative is the pursuit of EPEAT certification for its general-purpose devices, underscoring its dedication to meeting global environmental standards.

In alignment with ISO 14040 and 14044 requirements, the goal of this LCA study is to meet customer requirements related to EPEAT 4.8. The intended audience includes stakeholders, customers, and anyone seeking transparency regarding our environmental impact.

The results of this study serve multiple purposes: supporting internal decision-making, providing transparency to governments, agencies, and stakeholders, and informing the development of additional sustainability reports and carbon footprint-related content. These standards enable us to support our stakeholders as we strive to reduce emissions, design eco-friendly products, and empower consumers to make more sustainable choices.

2.1 Context and Objectives

This report adheres to EPEAT criteria (IEEE 1680.1:2018, Section 4.8) and ISO 14040, ISO 14044 guidelines, ensuring that Hypertechnologie Ciara Inc. provides transparent and reliable information on the environmental impact and carbon footprint of its products. Our teams conduct a comprehensive Life Cycle Assessment (LCA) to highlight the environmental benefits of our devices and maintain our EPEAT certifications. This reinforces Hypertechnologie Ciara Inc's dedication to eco-friendly innovation and sustainability, meeting customer expectations and the global market's demand for responsible technology.

2.2 Intended application

The LCA of these sixteen devices is a critical step for Hypertechnologie Ciara Inc to fulfill EPEAT standard requirements, offering transparent environmental impact data. These findings will also address inquiries from customers and third parties. The LCA report includes six key environmental impact indicators, such as the global warming potential (carbon footprint), and one inventory indicator. The six selected impact indicators are globally recognized, well-established in the market, and supported by consistent, reliable data. They ensure comprehensive environmental analysis, credible reporting, and alignment with industry standards.

2.3 Target Audience

This report is intended for stakeholders involved in the EPEAT certification process. The findings will also be shared with clients and business partners to underscore Hypertechnologie Ciara Inc commitment to sustainability.

2.4 Disclaimer of Uncertainty

Although the results are based on the ecoinvent 3.8 database and openLCA software, alongside several expert assumptions, variations may arise from using different LCA tools, datasets, or assumptions, potentially affecting the carbon footprint and other indicators.

2.5 Comparability

This LCA study is not intended for direct comparison with other studies, as differences in system boundaries, functional units, data sources, and assumptions can significantly influence the results. While this study adheres to established LCA standards, any comparisons should account for these factors to ensure an accurate interpretation.

3. SCOPE OF THE STUDY

The scope of this study outlines the boundaries, processes, and key parameters considered in this Life Cycle Assessment, ensuring a comprehensive evaluation of the environmental impacts associated with the production, use, and disposal of Hypertechnologie Ciara Inc devices, consisting of the products manufactured and sold in the year 2024. The device types cover the micro-PCs, laptops, desktop small-Form, desktop mini-Tower, high-performance workstations, presented in detail per device model and quantity in section 3.3, table 01.

3.1 Function

The devices in this study support a wide range of IT functionalities for administrative and office use, for private corporations and government institutions. While they serve various purposes, examples of their functions include office software processing, data research, database management, and spreadsheet calculations as well any other applicable high-performance software and systems if applicable.

Micro-PCs: Compact and energy-efficient, micro-PCs are ideal for office environments requiring space-saving solutions for everyday computing tasks such as document management, web browsing, and email communication.

Laptops: Designed as *High-Performance Multi-Task both Professional and Educational Laptops*, they offer consistent processing capabilities for demanding business and educational applications while remaining energy-efficient and portable.

Desktop Small-Form: Balancing performance and size, small-form desktops are tailored for users needing reliable devices for multitasking, data analysis, and moderate computing workloads.

Desktop Mini-Tower: Mini-tower desktops provide scalable computing power, making them suitable for intensive applications like graphic design, video editing, and light gaming in professional or creative settings.

High-Performance Workstations: Designed for demanding workloads, high-performance workstations excel in tasks like 3D rendering, simulation modeling, and advanced computational research.

3.2 Functional Unit

The functional unit for this LCA is: "use of a Hypertechnologie Ciara Inc. device in an office setting over five years." This reflects the typical lifespan of a computer device and aligns with industry standards and this LCA's range of the scope (see Table 01).

The period of 5 years considered in this study reflects the market practices and Hypertec's policies for extended warranty, as stated at https://ciaratech.com/products/computers-products/

3.3 Sales for 2024

This LCA covers the following devices sold by Hypertechnologie Ciara Inc:

Table 01: Hypertechnologie Ciara Inc's Devices Sold In 2024 for LCA Analysis		
Range of the Scope | Device Type	**Device Model**	**Units Sold**
1 | micro-PC	Astro PN64 Astro PW64-T	130 30
3 | desktop small-Form	Horizon D11750 Horizon D12170 Horizon D12750	543 3057 1463
4 | desktop mini-Tower	Horizon T11750 Horizon T12170 Horizon T12760 Horizon T12750 Horizon T13560	72 909 3 4421 373
5 | high-performance workstations	Kronos 540 Kronos 540 – G2 Kronos 545 Kronos 545 – G2	4 48 2 1
2 | laptops	Crius CO100-G1 Crius N320-G1	11063 14

3.4 Technical Information

This chapter presents the technical specifications and relevant details for the Hypertechnologie Ciara Inc devices included in this Life Cycle Assessment, providing a comprehensive understanding of their functionalities and performance characteristics.

Table 02 : Technical Information for Hypertechnologie Ciara Inc's Devices				
Device Type	**Device Model**	**Max RAM**	**Weight**	**Lifespan**
micro-PC	Astro PN64	64 GB	1.16kg	5 years
	Astro PW64-T	64 GB	1.47kg	
desktop small-Form	Horizon D11750	64 GB	5.77kg	5 years
	Horizon D12170	64 GB	5.77kg	
	Horizon D12750	64 GB	5.77kg	
desktop mini-Tower	Horizon T11750	64 GB	6.48kg	5 years
	Horizon T12170	64 GB	6.48kg	
	Horizon T12750	64 GB	6.48kg	
	Horizon T12760	64 GB	6.61kg	
	Horizon T13560	64 GB	4.17kg	
high-performance workstations	Kronos 540	128 GB	12.25kg	5 years
	Kronos 540 – G2	2 TB	12.25kg	
	Kronos 545	128 GB	12.25kg	
	Kronos 545 – G2	2 TB	12.25kg	
laptops	Crius CO100-G1	64 GB	1.28kg	5 years
	Crius N320-G1	64 GB	1.7kg	

3.5 Product Composition

Herein, we provide an overview of the material composition of Hypertechnologie Ciara Inc devices, detailing the components and resources utilized in their manufacture to assess their environmental impact throughout the life cycle.

Table 03.1: Product Composition of Hypertechnologie Ciara Inc's Desktops Component Mass (Kg)							
Device Model	Chassis	Memory	Power Supply	Mounted Mainboard	SSD Drive	Cable	Total
Astro PN64	0.47	0.02	0.44	0.2	0.01	0.03	1.16
Astro PW64-T	0.78	0.02	0.44	0.2	0.007	0.03	1.47
Horizon D11750	3.2	0.03	1.93	0.51	0.01	0.09	5.77
Horizon D12170	3.2	0.03	1.93	0.51	0.01	0.09	5.77
Horizon D12750	3.2	0.03	1.93	0.51	0.01	0.09	5.77
Horizon T11750	3.6	0.04	2.22	0.51	0.01	0.11	6.48
Horizon T12170	3.6	0.04	2.22	0.51	0.01	0.11	6.48
Horizon T12750	3.6	0.04	2.22	0.51	0.01	0.11	6.48
Horizon T12760	3.6	0.04	2.22	0.51	0.01	0.11	6.48
Horizon T13560	2.7	0.03	1.04	0.29	0.007	0.09	4.7
Kronos 540	7.13	0.08	3.6	1.27	0.01	0.16	12.25
Kronos 540-G2	7.13	0.08	3.6	1.27	0.01	0.16	12.25
Kronos 545	7.13	0.08	3.6	1.27	0.01	0.16	12.25
Kronos 545-G2	7.13	0.08	3.6	1.27	0.01	0.16	12.25

Table 03.2: Product Composition of Hypertechnologie Ciara Inc's Laptops Component Mass (Kg)									
Device Model	Chassis	Memory	Battery	PCBA	SSD Drive	AC Adapter	Display	Keyboard	Total
Crius CO100-G1	0.45	0.01	0.23	0.12	0.008	0.16	0.26	0.03	1.28
Crius N320-G1	0.72	0.01	0.30	0.12	0.008	0.16	0.33	0.03	1.70

3.6 Packaging Composition

The following chapter presents the packaging composition of Hypertechnologie Ciara Inc devices, detailing the mass of each component to provide insights into the materials used and their implications for sustainability and waste management.

Table 04: Packaging Composition of Hypertechnologie Ciara Inc's Devices Component Mass (Kg)					
Device Type	Cardboard	Wood Pallet	BEPF[1]	WEPF[2]	Total
micro-PC	0.14	0.20	0.10	0.15	0.59
desktop small-Form	1.41	0.21	0.11	0.17	1.89
desktop mini-Tower	1.41	0.21	0.12	0.18	1.92
high-performance workstations	1.73	0.60	0.13	0.20	2.66
laptops	0.14	0.04	0.00	0.00	0.18

3.7 System Boundaries

In this section of the report, we outline the system boundaries defined for this Life Cycle Assessment, detailing the life cycle stages included in the study as well as those deemed not applicable.

For this Life Cycle Assessment, the system boundaries were set to cover the life cycle stages from raw material (A1) through Energy Consumption for Device Usage (B) (see Table 05).

Our Life Cycle Assessment (LCA) provides a comprehensive 'cradle-to-grave' analysis of our products' environmental footprint throughout their life cycle, covering pre-manufacturing (A1 and A2), manufacturing and packaging (A3), shipping (A4), product use (B), and waste management for

[1] Black Expanded Polyethylene Foam

[2] White Expanded Polyethylene Foam

device packaging (A5). By examining these stages, we identify opportunities to reduce our carbon footprint, make better strategic decisions and enhance our sustainable practices.

It is relevant to highlight:

- The C1, C2, C3 and C4 (End-of-life treatment) and D (Recycling) stages were intentionally not applied due to the nature of the stages, as the final disposal lays exclusively on our customer we lack data for the analysis.
- For Energy use, stage B, we did not consider the extended life of our devices, as well as maintenance and services, as it represents less than 2%.

Furthermore, Hypertechnologie Ciara Inc. is committed to defining a sustainable strategy for its supply chain, supported by existing agreements with recycling centers. This commitment ensures that the LCA report accurately reflects our ongoing efforts to align with industry standards and practices.

3.7.1 Life Cycle Stages

Our LCA evaluates the life cycle stages of Hypertechnologie Ciara Inc.'s devices, covering raw material extraction (A1), transportation (A2), manufacturing (A3), and distribution (A4). Components are sourced from East Asia (China, Taiwan, Vietnam, and Malaysia) and transported via ocean freight, rail, truck to our assembly facility in St-Laurent, QC.

During assembly, we emphasize resource efficiency, utilizing electricity, natural gas, and minimal freshwater exclusively for building operations and human consumption. Finished devices are shipped across Canada and the USA exclusively via truck and designed for a five-year usage period (as explained in section 3.2).

While no maintenance or operational impacts are anticipated during the energy use (Stage B), we exclude it from the system boundaries as it is covered in the warranty and the maintenance may vary from a fix in software to a full replacement of a barebone, due to the lack of consistent data it was not considered, as well as it represents less than 2% of the devices.

The end-of-life phase (C) was excluded from the system boundaries (stages C1, C2, C3, and C4). Stages C1 (deinstallation) and C2 (transport to a treatment facility) were not included because the associated energy use is considered negligible. Hypertec has contractual agreements with certified recycling partners who assume full responsibility for the collection, transport, and treatment of waste materials. All end-of-life activities occur at the recyclers' facilities; therefore, no operational data are available from Hypertec's side to accurately quantify related impacts.

Similarly, stages C3 (waste processing) and C4 (final disposal) were excluded due to the absence of primary data, as these processes are entirely managed by recycling partners and final disposal responsibilities rest with customers. Stage D (potential environmental benefits beyond system boundaries resulting from recycling) was also excluded because of the same data limitations.

Packaging materials are included under stage A5, as they are typically disposed of at end-of-life.

Our system boundaries align with our functional unit, reinforcing our commitment to transparency and accountability in sustainability. The following table summarizes the life cycle stages included in this analysis.

Table 05: Life Cycle Stages of Hypertechnologie Ciara Inc's Devices in the LCA[3]									
Raw materials and components manufacturing	Transport of components to assembly site	Device assembly and packaging Energy Usage for manufacturing	Transport to client	Waste management of device packaging	Energy consumption for device use	Dismantling at treatment	Transport to treatment facility	Waste Processing Disposal	Environmental benefits related component recycling
A1	A2	A3	A4	A5	B	C1	C2	C3_C4	D
Applicable						Not Applicable			

3.7.2 Included processes

Considering the system boundaries and life cycle stages presented for this study, in this section we can understand the internal and external processes that are included in each life cycle stage.

Table 06: Inputs and Outputs Included in the System Boundary		
Life Cycle Stage		Process Description
A1	Raw materials and components manufacturing	Chassi manufacturing
		Memory manufacturing
		Power supply manufacturing
		Mounted mainboard manufacturing
		SSD drive manufacturing
		Cable manufacturing
		Component and raw materials Packaging
A2	Transport of components to assembly site	Transport of components and materials by truck
		Transport of components and materials by boat
		Transport of components and materials by train

A3	Device assembly and packaging Energy Usage for manufacturing	Electricity consumption
		Natural gas consumption
		Freshwater consumption
		Gasoline consumed by CIARA's fleet
		Diesel consumed by the generator at CIARA's plant
		Transport of packaging to CIARA's assembly site
		Packaging manufacturing
A4	Transport to client	Transport to the final user by truck
A5	Waste management of device packaging	Transport of waste packaging to waste management site
		Landfill of waste packaging
B	Energy consumption for device use	Electricity consumption for device use

3.7.3 Excluded processes

To define the system boundaries, rules for the inclusion and exclusion of processes were established, please see Section 3.8 for cut-off criteria. Certain elements that contribute only marginally to the results were excluded, as explicitly on Table 06.

Table 07: Processes Excluded from the System Boundary		
Life Cycle Stage		Process Description
A3	Device assembly and packaging Energy Usage for manufacturing	Garbage (coffee cups, newspapers, and other items) destined for landfill. This waste is estimated to represent 5% of the total waste destined for recycling, which is considered negligible.
B	Energy consumption for device use	No significant maintenance or operational impacts are expected during the device's five-year usage period. As per internal data.

C1 C2 C3 C4	Waste Processing Disposal	Waste processing and final disposal are not applied in this LCA as the responsibility for these lies exclusively with our customers. Additionally, due to the lack of data, we are unable to perform a comprehensive analysis.
D	Environmental benefits related to component recycling	Potential environmental benefits from recycling and reuse were not applied in this LCA due to the complexity and variability in recycling processes. The environmental impacts of recycling and reuse depend on numerous factors beyond the control of Hypertechnologie Ciara Inc., and the necessary data for a consistent analysis is not currently available.

3.7.4 Assumptions

Conducting an LCA often involves making assumptions to reproduce common scenarios of complementing incomplete data. The following assumptions were made for this study:

Energy Mix for Electricity Production:

- Since Hypertechnologie Ciara Inc's assembly site is in Quebec, the flow "market for electricity, low voltage | electricity, low voltage | Cutoff, S - CA QC" was used to model electricity consumption during the assembly of the devices.
- The use of electric forklifts is considered part of the electricity consumption during device assembly.
- The devices covered in this study are primarily sold across Canada and the United States. To calculate the impact of electricity consumption during the use phase, the energy mix was modeled according to Hypertechnologie Ciara Inc.'s actual sales distribution. For Canadian shipments, 41% of the total volume is delivered domestically, with 91% destined for Quebec and 7% for Ontario. For U.S. shipments, which represent 59% of total sales, the distribution is predominantly concentrated in Mississippi (85%), followed by New York (9%). Accordingly, provincial and state-specific electricity mixes were applied proportionally in the life cycle assessment. For the U.S. regions, the "market group for low voltage cutoff, U-US" dataset was used when applicable.

Other Assumptions:

- For devices not sold in 2024, which fall outside the scope of this study, resource consumption (freshwater, natural gas, and electricity) was allocated, but this data is not presented in the report. Additionally, the provincial sales distribution, used to calculate the average transport distance to the client and determine the applicable energy mix, was unavailable, as these devices were not shipped to customers.

- Energy consumption was assumed to be the same as other devices in the same category (see Table 11). Based on lead time, we used worked hours to estimate consumption for the units sold.
- The use of electric forklifts is considered part of the electricity consumption during device assembly.
- The samples shipped were excluded from the calculations as they represent less than 1%.
- In the absence of primary data concerning the packaging of components and raw materials, it was assumed to be equivalent to the packaging of the final product and modeled accordingly.
- It is estimated that less than 2% of devices are returned by clients for replacement. The components from these returned devices are reused, disposed or destinated as determined by the team at Hypertechnologie Ciara Inc's assembly facility. All waste destined for recycling (e-waste, paper, cardboard, metal) is considered to have monetary value on-site. As such, it is assumed that this waste does not contribute to the environmental burdens of the device's lifecycle, as it belongs to a separate lifecycle.
- All assumptions have been verified with relevant stakeholders, and sensitive data has been handled in accordance with confidentiality agreements.
- For the chassis calculation, the percentage for the acrylonitrile-butadiene-styrene copolymer was adjusted to match the total chassis weight per device type (see Table 03).
- For freshwater calculation the formula follows:
    - Volume (m3) = [Mass (kg)/Molar Mass (kg/mol)] × Molar Volume (m3/mol)

3.7.5 Cut-off Criteria

The cut-off criteria and the 95% inclusion rule are essential for creating an efficient, accurate, and transparent LCA. They ensure that the study focuses on the most impactful elements while maintaining a level of detail that is practical and aligned with international standards. The reference to exclusions ensures clarity about the scope and limitations of the assessment, enhancing its credibility and utility for decision-making were defined by Hypertec as the parameters for this study.

Efficiency in Analysis

- Simplifies the LCA process: By excluding processes or flows that contribute less than 1% of the total mass or energy, the study avoids the excessive complexity and effort required to account for inconsequential details.
- Focuses on critical elements: This allows the analysis to concentrate on processes that significantly affect the results, ensuring that the key drivers of environmental impacts are thoroughly evaluated.

Accuracy and Completeness

- 95% inclusion ensures robustness: Including at least 95% of the mass and energy flows ensures that the analysis captures the overwhelming majority of the product's environmental footprint. This high threshold provides confidence that the results are representative and comprehensive, even with minor exclusions.
- Balancing practicality and detail: While LCA aims for a detailed assessment, there is always a trade-off between detail and feasibility. By setting clear criteria, the study remains both accurate and manageable.

The exclusions of life cycle stages and processes are explained in sections 3.7.1 and 3.7.3 (see Table 06).

3.8 Third party Verification & Compliance

All background data, processes, and results presented in this report [including the Life Cycle Assessment (LCA), Corporate Greenhouse Gas (GHG) Emissions, and GHG Emissions from Product Transport] have been independently verified by a third-party organization to ensure accuracy, reliability, and compliance with relevant standards.

The verification is in-progress and conducted by **Marie Bellemare Consulting**, a certified organization specializing in LCA validation, ensuring alignment with ISO 14040/14044 requirements and methodologies.

The official verification statement and full credentials of the verifier will be available as an Appendix.

4. LIFE CYCLE INVENTORY ANALYSIS

This chapter provides a detailed account of the inputs and outputs associated with each phase of the product's life cycle, laying the foundation for assessing the environmental impacts of Hypertechnologie Ciara Inc 's devices.

Transportation Mode

- Please note that the transportation mode may vary depending on the parts and device types. For example, the chassis for desktop small-form, desktop mini-tower, and high-performance workstations may be transported by train from the west coast to Montreal, and then by truck to our assembly facility, while other parts may use different transportation modes.

4.1 Packaging Composition

The data collection process was conducted by Hypertechnologie Ciara Inc in the first quarter of 2025. It involved listing the quantities of materials, freshwater, and energy consumed within the system boundaries, using an Excel Model spreadsheet. Given that the quality of this LCA heavily relies on the quality of the data used, special attention was given to collecting the most representative and reliable data available. Data quality was assessed for its reliability and representativeness in terms of time, geography, and technology, see Section 4.3 and 4.5.

4.2 Description of Unit Processes

The following table details the unit processes used to model the life cycle of the desktop mini-Tower Horizon T13560, which serves as a representative example of the devices under study, as it follows the same processes as the other devices. The remaining devices in the assessment were modeled using the same approach, with only the quantities differing.

Table 08: Description of Unit Processes for the LCA of Horizon T13560		
A1 - Raw materials and components manufacturing		
Amount	Unit	Process
0.0748	kg	acrylonitrile-butadiene-styrene copolymer production | acrylonitrile-butadiene-styrene copolymer | Cutoff, U - RoW
0.2992	kg	acrylonitrile-butadiene-styrene copolymer production | acrylonitrile-butadiene-styrene copolymer | Cutoff, U - RoW
0.0046	kg	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U - RoW
0.0184	kg	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U - RoW
1.6923	m	cable production, connector for computer, without plugs | cable, connector for computer, without plugs | Cutoff, U - GLO
0.0530	kg	market for copper, cathode | copper, cathode | Cutoff, U - GLO
1.6198	kg	market for corrugated board box | corrugated board box | Cutoff, U - CA-QC

0.2069	Item(s)	market for EUR-flat pallet | EUR-flat pallet | Cutoff, U - RoW
0.0122	Item(s)	hard disk drive production, for desktop computer | hard disk drive, for desktop computer | Cutoff, U - GLO
0.8014	kg	hot rolling, steel | hot rolling, steel | Cutoff, U - RoW
2.3530	kg	hot rolling, steel | hot rolling, steel | Cutoff, U - RoW
0.0748	kg	injection moulding | injection moulding | Cutoff, U - RoW
0.2992	kg	injection moulding | injection moulding | Cutoff, U - RoW
0.0380	kg	integrated circuit production, memory type | integrated circuit, memory type | Cutoff, U - GLO
0.0230	kg	metal working, average for aluminium product manufacturing | metal working, average for aluminium product manufacturing | Cutoff, U - RoW
0.0436	Item(s)	plug production, inlet and outlet, for computer cable | plug, inlet and outlet, for computer cable | Cutoff, U - GLO
0.0117	kg	polyethylene production, high density, granulate | polyethylene, high density, granulate | Cutoff, U - RoW
0.1210	kg	market for polyethylene, linear low density, granulate | polyethylene, linear low density, granulate | Cutoff, U - GLO
0.1815	kg	polymer foaming | polymer foaming | Cutoff, U - RoW
0.0192	kg	polymer foaming | polymer foaming | Cutoff, U - RoW
0.0075	kg	polypropylene production, granulate | polypropylene, granulate | Cutoff, U - RoW
0.8895	Item(s)	power supply unit production, for desktop computer | power supply unit, for desktop computer | Cutoff, U - RoW
0.2870	kg	printed wiring board production, mounted mainboard, desktop computer, Pb containing | printed wiring board, mounted mainboard, desktop computer, Pb containing | Cutoff, U - GLO
0.8014	kg	steel production, converter, unalloyed | steel, unalloyed | Cutoff, U - RoW
2.3530	kg	market for steel, unalloyed | steel, unalloyed | Cutoff, U - GLO
A2 - Transport of components to assembly site		
Amount	Unit	Process
16877.6820	kg*km	market group for transport, freight train | transport, freight train | Cutoff, U - GLO
53.9498	kg*km	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
48441.8902	kg*km	transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, U - GLO
A3 - Device assembly and packaging - Energy Usage for manufacturing		
Amount	Unit	Process
1.6198	kg	market for corrugated board box | corrugated board box | Cutoff, U - RoW
100.3500	kWh	market for electricity, low voltage | electricity, low voltage | Cutoff, U - CA-QC

0.2069	Item(s)	market for EUR-flat pallet | EUR-flat pallet | Cutoff, U - RoW
0.3211	MJ	heat production, propane, at industrial furnace >100kW | heat, district or industrial, other than natural gas | Cutoff, U - CA-QC
0.0000	h	market for machine operation, diesel, >= 74.57 kW, generators | machine operation, diesel, >= 74.57 kW, generators | Cutoff, U - GLO
0.1210	kg	market for polyethylene, linear low density, granulate | polyethylene, linear low density, granulate | Cutoff, U - GLO
0.1815	kg	polymer foaming | polymer foaming | Cutoff, U - RoW
0.1684	kg	market for tap water | tap water | Cutoff, U - CA-QC
42.5839	kg*km	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
0.0439	km	transport, passenger car, large size, petrol, EURO 4 | transport, passenger car, large size, petrol, EURO 4 | Cutoff, U - RoW
A4 - Transport to client		
Amount	Unit	Process
750.8794	kg.km	transport, freight, lorry 16-32 metric ton, EURO4 - RoW
A5 - Waste management of device packaging		
Amount	Unit	Process
212.9197	kg*km	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
1.6198	kg	treatment of waste paperboard, sanitary landfill | waste paperboard | Cutoff, U - RoW
0.3025	kg	treatment of waste plastic, mixture, sanitary landfill | waste plastic, mixture | Cutoff, U - RoW
2.4828	kg	treatment of waste wood, untreated, sanitary landfill | waste wood, untreated | Cutoff, U - RoW
212.9197	kg*km	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U - RoW
B - Energy consumption for device use		
Amount	Unit	Process
1095.0000	kWh	market for electricity, low voltage | electricity, low voltage | Cutoff, S - CA ON

4.3 Sources

This table outlines the various sources of data utilized in the assessment, providing a comprehensive overview of the information that supports the Life Cycle Assessment of Hypertechnologie Ciara Inc's devices.

Table 09: Data Sources for The LCA Of Hypertechnologie Ciara Inc's Devices	
Data Type	**Source**
Primary Data	Primary data was provided by CIARA for the period spanning from January to December 2024 and included: • Supply chain data, considering the main suppliers per component and per device type. Mainly in China, shipped via boat in most part of the way to the facility. Data compiled in Tab "distances • " in the "LCAData&Model_2024" • Factory consumption for direct and indirect emissions (Diesel, Gasoline, Freshwater, Natural Gas, Electricity). in Tab "Factory" in the "LCAData&Model_2024", based on invoicing and internal consumption tracker. • Annual Report of Sales Data, that determines the distances to transport to client, energy consumption and data modeling for electricity and waste, this report is available at the ERP "Pilot", as well transferred to "LCAData&Model_2024", in tab "Nb Products".
Secondary Data	Secondary data from the ecoinvent version 3.8 "cut-off" database was used to provide reliable, standardized, and comprehensive environmental impact data for processes where primary data was unavailable.

4.4 Calculation Procedures

4.4.1 Energy Consumption for Device Use

The amount of electricity required for device use was estimated by Hypertechnologie Ciara Inc, considering a power consumption of 100 watts for a desktop / 50 watts for a laptop and a usage time of 6 hours per day. As for the question related to electricity consumption, here is the reference we based ourselves: Energy consumption calculator | kWh calculator (rapidtables.com)[4]

The following formula was used:

$$E_{(kWh/day)} = P_{(W)} \times t_{(h/day)} / 1000_{(W/kW)}$$

Thus, the estimated electricity consumption of the device during its entire considered lifetime (5 years as described previously) is 1,095 kWh for the Desktop and 547.5 kWh for the laptop.

Due to equipment efficiency, the reference is the certification Energy Star Rev.8 [5], the device use is also considered in the sensitivity analysis, where the device proves its efficiency.

4.4.2 Transport to Client

The transport distance to the end-user was estimated based on Hypertechnologie Ciara Inc.'s sales distribution across Canada and the USA.

This was calculated as a weighted average of sales per region, the transport distance from the company's plant in St-Laurent to clients, with deliveries primarily to government locations in each provincial capital, same applied to the USA data.

The transportation distances in this assessment were calculated using GPS tracking and logistics data to ensure accuracy. These distances reflect real transport routes based on supplier locations, distribution hubs, and customer destinations. The methodology ensures consistency and reliability by using weighted averages based on sales distribution and transport modes, improving the precision of impact calculations.

Detailed information is available in tab "Distances" Detailed information is available in tab "Distances" in the "LCAData&Model_2024", upon request.

Transportation Mode

- The mode of transportation used for delivery is 100% by truck (road, lorry).

[4] https://www.rapidtables.com/calc/electric/energy-consumption-calculator.html

[5] https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Computers%20Version%208.0%20Final%20Specification%20Rev.%20July%202022.pdf

4.5 Data Quality Assessment

This chapter evaluates the quality of data used in the Life Cycle Assessment (LCA) to ensure the reliability and accuracy of the findings. The evaluation is based on the Data Quality Pedigree Matrix outlined by A. Edelen and W. Ingwersen in their Guidance on Data Quality Assessment for Life Cycle Inventory Data (EPA, 2016), with the addition of indicators for Flow Reliability (in Table 10 represented by **Q1**) and Flow Representativeness (in Table 10 represented by **Q2**). These indicators are assessed on a scale from 1 to 5, where 1 represents the lowest quality and 5 represents the highest.

Table 10: Data Quality for The LCA Of Hypertechnologie Ciara Inc's Devices

Representativeness	Evaluation	Q1 (1-5)	Q2 (1-5)
Geographical	The primary data represents the life cycle stages of the device in East Asia and Canada. Secondary data was selected to ensure geographical context was as representative as possible. For processes related to resource consumption during device assembly in Quebec (Canada), data reflective of the Quebec context was used. Regarding electricity consumption, data representing each Canadian province was applied. For packaging processes, data from Quebec (Canada) and global sources were used. Overall, the data is considered to have good geographical representativeness.	4	5
Temporal	The primary data is representative of 2024. Life cycle inventory data is sourced from the ecoinvent version 3.8 (2021) database, which is based on version 3.0, released annually since 2013. Some secondary data from version 3.0 dates back to earlier versions (1991-2012), with data on device components from 2002. Therefore, this data is considered average in terms of temporal representativeness.	3	4
Technological	The primary data accurately reflects the technologies used throughout the device's life cycle. Secondary data was selected to represent these technologies as accurately as possible, including energy mix, components, and transport. However, secondary data for components is based on the "computer production, desktop" process, which dates back to 2002. As such, this data is considered to have average technological representativeness.	3	4
Data Collection Method	Data collection methods include the use of the ecoinvent v3.8 database (2021), which compiles data from a variety of sources and includes both primary and secondary data. These data were selected based on the most reliable methods available, but some older secondary data (pre-2013) introduces some uncertainty. The collection methods are considered generally reliable.	4	4
Completeness	All processes with mass and energy flows exceeding the cut-off threshold of 1% were included in the LCA. The study ensures that the data covers all relevant life cycle stages, from resource extraction to end-of-life disposal.	5	5

Legend for Flow Reliability and Flow Representativeness:

Flow Reliability (Q1): This indicator evaluates how reliable the data is based on the consistency and precision of the flows used in the LCA. A score of 5 indicates highly reliable data with minimal uncertainty, while a score of 1 indicates poor reliability.

Flow Representativeness (Q2): This indicator assesses how well the data represents the real-world flows across different regions, technologies, and temporal contexts. A score of 5 indicates that the data is highly representative, while a score of 1 indicates that the data is not very representative of the real-world flows.

Conclusion:

In this assessment, the data show a good balance of representativeness and reliability. However, there are some limitations related to the age of the secondary data, particularly in terms of its temporal and technological relevance, which may affect the accuracy of the results. For future assessments, incorporating more up-to-date and specific data would enhance the robustness of the LCA.

4.6 Sensitivity Assessment

To analyze the influence of certain processes and life cycle stages on the overall impacts and refine the system boundary, sensitivity assessments were performed. The influence of specific parameters in the modeling was evaluated by determining the differences between the impact assessment results for each parameter.

Two parameters were considered in this sensitivity assessment:

- **Total mass of the components and materials**: To analyze the influence of this parameter, the total life cycle impact results were compared with those considering a 30% increase in the mass of the components and materials used in the device. This increase represents the observed average in the worst-case scenario, accounting for factors such as rework, human errors, potential supply chain disruptions, market fluctuations, currency exchange rate changes, or any other factors that could stress the supply chain and lead to a need for additional raw materials.
- **Electricity used during device operation**: To assess the influence of increased energy usage, the impact of consuming twice as much electricity per device was analyzed. This scenario models a situation where the device is used for extended periods, such as in a two-shift operation or with working hours increased from 6 to 12 hours per day. The results were compared to those based on the electricity consumption assumed in this assessment, effectively doubling the energy usage per unit. This analysis helps to understand the potential environmental impact in cases of prolonged device usage, reflecting more intense operational demands.

The results of the sensitivity assessment are presented in Section 5.5.

4.7 Allocation

To calculate the impact of freshwater, electricity, and natural gas consumption during the assembly of devices at Hypertechnologie Ciara Inc's plant, an allocation was performed. Resources were allocated per device type: desktops small-form or mini-tower, micro-PC, and high-performance workstations.

The allocation method used was based on the number of hours required to assemble each device in a given product range (product lead time), compared to the total hours spent assembling all devices across product ranges in 2024. The total resource consumption (freshwater, natural gas, and electricity) for each product range was then divided by the number of devices produced in that range during 2024 to calculate the resource consumption per device.

The following table illustrates the assembly time-based allocation used in the assessment.

Table 11: Assembly Time Allocation for Resource Consumption by Device Type

Process Description	Device Type	Manufacturing Leadtime (hours)	% of Device Manufacture time / Total Manufacture time (hours/hours)
6,810 Hours	micro-PC | laptop	1.6	0.000235
	desktop small-Form	3.6	0.000529
	desktop mini-Tower	3.9	0.000573
	high-performance workstations	3.9	0.000573

5. LIFE CYCLE IMPACT ASSESSMENT (LCIA)

5.1 LCIA Procedure

The life cycle impact assessment (LCIA) was conducted using the ecoinvent 3.8 database and inventory data provided by Hypertechnologie Ciara Inc., with OpenLCA 2.5.0 as the software tool. The TRACI 2.1 impact assessment method, widely used in North America, was applied to evaluate environmental impact. The six selected impact categories are globally recognized and well-established in the market, supported by consistent and reliable data. These categories ensure thorough environmental analysis, credible reporting, and alignment with industry standards, making them essential for this study.

- Fossil Fuel Depletion Potential (FFDP)
- Ozone Depletion Potential (ODP)
- Global Warming Potential (GWP)
- Eutrophication Potential (EP)
- Acidification Potential (AP)
- Smog Potential (SP)

The life cycle assessment results regarding freshwater consumption (FWC) are also presented in this report. For this category, the inventory flows were based on a reference guide, considering freshwater consumption during the A3 stage (manufacturing) of the life cycle. The freshwater used in the process is sourced from tap water supplied by the municipal system in Quebec, which is used for human consumption and building operations.

For the environmental impact of freshwater consumption, the AWARE (Available Water Remaining) impact assessment method was used in our study, as it is recognized for its precision and accuracy in quantifying water scarcity impacts. This method provides a reliable assessment of water use, ensuring that the impact on freshwater resources is accurately represented.

- Water, lake | Water, river | Water, unspecified natural origin | Water, well | Water, well, in ground

5.2 LCIA Results

The total LCIA results according to the functional unit can be found in the following table for each model of Hypertechnologie Ciara Inc device studied. The LCIA results are relative expressions and do not predict impacts on category endpoints, exceeding thresholds, safety margins, or risks.

Table 12: LCIA Results per Hypertechnologie Ciara Inc's Devices Type TRACI 2.1

Device Model	FFPD		ODP		GWP		EP		AP		SP		FWC	
Astro PN64	677.6260	MJ Surplus	4.85E-05	kgCFC-11eq	654.098	kg CO2 eq	4.1848	kg N eq	2.2485	kg SO2 eq	23.5245	kg O3 eq	8.46E-01	m3 freshwater
Astro PW64-T	692.3184	MJ Surplus	4.99E-05	kgCFC-11eq	666.371177	kg CO2 eq	4.2370	kg N eq	2.3321	kg SO2 eq	24.7491	kg O3 eq	1.43E-05	m3 freshwater
Crius CO100-G1	368.8796	MJ Surplus	2.82E-05	kgCFC-11eq	360.438101	kg CO2 eq	2.3532	kg N eq	1.3222	kg SO2 eq	13.9088	kg O3 eq	9.95E-09	m3 freshwater
Crius N320-G1	160.3113	MJ Surplus	1.49E-05	kgCFC-11eq	175.362161	kg CO2 eq	1.3686	kg N eq	0.8578	kg SO2 eq	9.5147	kg O3 eq	2.50E-03	m3 freshwater
Horizon D11750	451.2335	MJ Surplus	4.18E-05	kgCFC-11eq	559.02758	kg CO2 eq	3.5508	kg N eq	3.2261	kg SO2 eq	32.9761	kg O3 eq	5.97E-01	m3 freshwater
Horizon D12170	276.2768	MJ Surplus	3.01E-05	kgCFC-11eq	305.66296	kg CO2 eq	2.4524	kg N eq	1.6987	kg SO2 eq	21.2722	kg O3 eq	5.97E-01	m3 freshwater
Horizon D12750	730.0687	MJ Surplus	5.85E-05	kgCFC-11eq	721.9747	kg CO2 eq	5.0084	kg N eq	2.9033	kg SO2 eq	32.7746	kg O3 eq	5.97E-01	m3 freshwater
Horizon T11750	746.6246	MJ Surplus	6.04E-05	kgCFC-11eq	726.9526	kg CO2 eq	4.9947	kg N eq	2.9814	kg SO2 eq	33.8635	kg O3 eq	5.97E-01	m3 freshwater

Table 12: LCIA Results per Hypertechnologie Ciara Inc's Devices Type TRACI 2.1														
Device Model	**FFPD**		**ODP**		**GWP**		**EP**		**AP**		**SP**		**FWC**	
Horizon T12170	397.2116	MJ Surplus	3.84E-05	kgCFC-11eq	417.76067	kg CO2 eq	3.1344	kg N eq	2.0695	kg SO2 eq	25.0313	kg O3 eq	5.97E-01	m3 freshwater
Horizon T12750	264.4215	MJ Surplus	3.00E-05	kgCFC-11eq	297.4709	kg CO2 eq	2.3934	kg N eq	1.7334	kg SO2 eq	21.7163	kg O3 eq	5.97E-01	m3 freshwater
Horizon T12760	188.2938	MJ Surplus	1.92E+00	kgCFC-11eq	221.61851	kg CO2 eq	1.9210	kg N eq	1.2779	kg SO2 eq	16.5692	kg O3 eq	5.97E-01	m3 freshwater
Horizon T13560	327.2306	MJ Surplus	3.06E-05	kgCFC-11eq	280.813959	kg CO2 eq	1.7930	kg N eq	1.5404	kg SO2 eq	18.5125	kg O3 eq	1.68E-05	m3 freshwater
Kronos 540	18106.8767	MJ Surplus	1.60E-04	kgCFC-11eq	6443.44822	kg CO2 eq	10.1215	kg N eq	20.6330	kg SO2 eq	244.4817	kg O3 eq	5.98E-06	m3 freshwater
Kronos 540-G2	18278.0049	MJ Surplus	1.70E-04	kgCFC-11eq	6571.5123	kg CO2 eq	10.8659	kg N eq	21.2658	kg SO2 eq	250.2323	kg O3 eq	5.98E-06	m3 freshwater
Kronos 545	18106.8767	MJ Surplus	1.60E-04	kgCFC-11eq	6443.44822	kg CO2 eq	10.1215	kg N eq	20.6330	kg SO2 eq	244.4817	kg O3 eq	5.98E-06	m3 freshwater
Kronos 545-G2	18693.5812	MJ Surplus	1.97E-04	kgCFC-11eq	6975.44221	kg CO2 eq	13.3484	kg N eq	22.1829	kg SO2 eq	259.8555	kg O3 eq	5.98E-06	m3 freshwater

5.3 GWP (Carbon Footprint) Results per Life Cycle Stage

The Global Warming Potential (GWP), expressed as the carbon footprint per life cycle, can be found in the following table for each model of Hypertechnologie Ciara Inc device studied.

Table 13: LCIA Results per Hypertechnologie Ciara Inc's Devices Type
TRACI 2.1

Device Model	Total lifecycle	A1	A2	A3	A4	A5	B	Unit
Astro PN64	654.1	99.11	2.25	2.23	0.48	0.35	551.66	kg CO2 eq
Astro PW64-T	666.4	101.78	0.41	10.44	0.25	1.82	551.66	kg CO2 eq
Crius CO100-G1	360.4	83.08	0.29	0.51	0.53	0.20	275.83	kg CO2 eq
Crius N320-G1	175.4	92.12	0.38	0.51	0.26	0.20	81.89	kg CO2 eq
Horizon D11750	559.0	235.47	2.28	3.55	0.79	0.93	314.99	kg CO2 eq
Horizon D12170	305.7	235.47	2.28	3.55	0.46	1.93	61.96	kg CO2 eq
Horizon D12750	722.0	235.47	2.28	3.55	0.58	1.93	478.15	kg CO2 eq
Horizon T11750	727.0	248.80	2.57	3.59	2.98	1.93	467.08	kg CO2 eq
Horizon T12170	417.8	248.80	2.57	3.59	1.35	1.93	159.52	kg CO2 eq
Horizon T12750	297.5	248.80	2.57	3.59	0.33	1.93	40.25	kg CO2 eq
Horizon T12760	221.6	185.59	1.99	3.57	0.31	1.93	28.23	kg CO2 eq
Horizon T13560	280.8	187.19	1.66	6.44	0.13	2.20	83.20	kg CO2 eq
Kronos 540	6443.4	6399.66	4.41	7.93	0.57	2.64	28.23	kg CO2 eq
Kronos 540-G2	6571.5	6399.66	4.41	7.93	1.30	2.64	155.57	kg CO2 eq
Kronos 545	6443.4	6399.66	4.41	7.93	0.57	2.64	28.23	kg CO2 eq
Kronos 545-G2	6975.4	6399.66	4.41	7.44	9.63	2.64	551.66	kg CO2 eq

Chart Legend: A1 -Raw materials and components manufacturing; A2 - Transport of components to assembly site; A3 - Device assembly and packaging -Energy Usage for manufacturing; A4 - Transport to client; A5 - Waste management of device packaging; B - Energy consumption for device use.

5.4 LCIA Results per Life Cycle Stage and Main Contributors

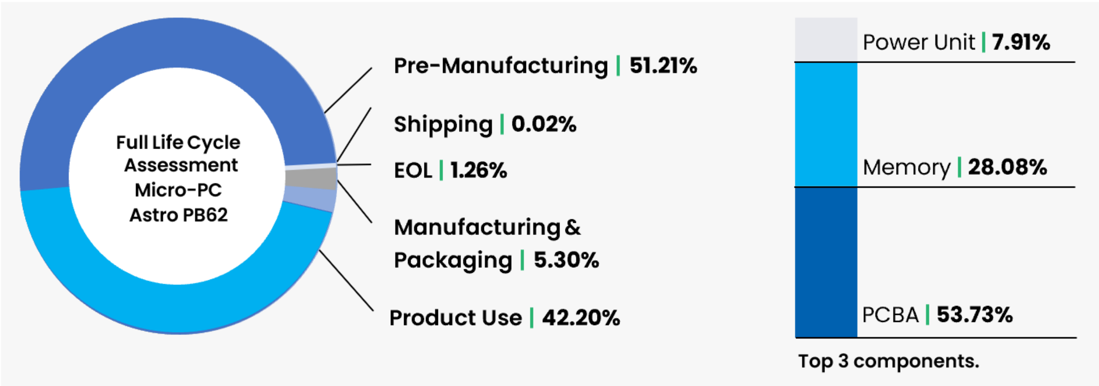
The LCIA results for each life cycle stage of one of each device type are presented in this section, with a focus on the Global Warming Potential (GWP) impact category. These four devices were selected as representative examples from the four different ranges of device types under study to demonstrate distinct result profiles.

For the high-performance workstation, the GWP impact is primarily driven by the raw materials and components manufacturing stage. In contrast, the desktop small-form and the desktop mini-tower, the product use stage has made a more significant contribution to the GWP results. For the micro-PC it is noticeable that the balanced results between pre-manufacturing and energy consumption; this difference is largely due to sales distribution, as the electricity use impact varies by province, and in some cases, it can exceed the impacts of raw materials and component manufacturing.

The following figures show the contribution of each life cycle stage to the overall impacts, with GWP chosen as the representative impact category.

Table 14: LCIA Results for GWP Impact Sampling Section 5.4.1 To 5.4.4		
Device Type	**Sample Device Model**	**Total GWP**
micro-PC	Astro PN64	654.10 kg CO2 eq
desktop small-Form	Horizon D12170	305.66 kg CO2 eq
desktop mini-Tower	Horizon T12750	297.47 kg CO2 eq
high-performance workstations	Kronos 545 – G2	6975.44 kg CO2 eq
laptops	Crius CO100 – G1	360.44 kg CO2 eq

5.4.1 Micro-PC GWP Impacts



5.4.2 Desktop Small-Form GWP Impacts

5.4.3 Desktop Mini-Tower GWP Impacts

5.4.4 High-Performance Workstation GWP Impacts

5.4.5 Laptop GWP Impacts

5.4.6 Contribution of Each Life Cycle Stage to GPW Impacts

This section examines how different life cycle stages contribute to the Global Warming Potential (GWP) impacts for various device types assessed in this study. The devices include desktop small-form systems, desktop mini-towers, high-performance workstations, and laptops. These categories differ in physical size, motherboard configuration, and chassis, each affecting environmental impacts uniquely.

Larger devices, such as desktop mini-towers and high-performance workstations, typically have higher power consumption due to their size and more complex components. Their larger motherboards and robust chassis are designed for enhanced performance, which translates into greater energy demand during usage. Conversely, smaller devices, including desktop small-form systems and laptops, are more energy-efficient. Their compact design and lower power requirements result in a reduced environmental footprint during the usage phase.

The analysis uses a functional unit representing a device's operation over five years. This functional unit highlights variations in energy consumption and related GWP impacts depending on device type. While smaller devices generally have a lower environmental impact due to their efficiency, larger devices, designed for high performance, contribute disproportionately to GWP during the usage phase because of their elevated energy needs.

This trade-off between performance, device size, and eco-efficiency is a crucial consideration when assessing environmental impacts. Larger devices provide higher computational power and capabilities, but this comes with a higher environmental cost. In contrast, smaller devices achieve better eco-efficiency but are limited in power and functionality. Balancing these trade-offs is essential for designing devices with minimized environmental impacts.

Table 15: Impact of Each Life Cycle Stage and Process on The Global Warming Potential (GWP) of a Micro-PC – Astro PN64		
Process	**Contribution (%)**	**Amount (kg CO2 eq)**
Full LCA – Micro-PC – Astro PN64	**100.00**	**654.08**
A1 - Raw materials and components manufacturing	**15.20**	**99.11**
printed wiring board production, mounted mainboard, desktop computer, Pb containing	8.2600	53.9946
integrated circuit production, memory type	4.3100	28.2213
power supply unit production, for desktop computer	1.2200	7.9502
aluminium production, primary, cast alloy slab from continuous casting	0.3600	2.3510
market for EUR-flat pallet	0.3300	2.1425
market for corrugated board box	0.1400	0.9234
market for copper, cathode	0.0992	0.6487
market for steel, unalloyed	0.0927	0.6061
acrylonitrile-butadiene-styrene copolymer production	0.0672	0.4396
metal working, average for aluminium product manufacturing	0.0529	0.3462
market for polyethylene, linear low density, granulate	0.0435	0.2843
steel production, converter, unalloyed	0.0378	0.2475
cable production, connector for computer, without plugs	0.0367	0.2400
hard disk drive production, for desktop computer	0.0360	0.2356
polymer foaming	0.0274	0.1794
injection moulding	0.0214	0.1397
hot rolling, steel	0.0202	0.1320
plug production, inlet and outlet, for computer cable	0.0032	0.0211
polypropylene production, granulate	0.0011	0.0072
polyethylene production, high density, granulate	0.0008	0.0052
A2 - Transport of components to assembly site	**0.04**	**0.25**
transport, freight, sea, container ship	0.0362	0.2370
transport, freight, lorry 16-32 metric ton, EURO4	0.0014	0.0091
A3 - Device assembly and packaging **Energy Usage for manufacturing**	**0.34**	**2.23**
market for EUR-flat pallet	0.2500	1.6481
market for polyethylene, linear low density, granulate	0.0334	0.2187
market for corrugated board box	0.0214	0.1400
polymer foaming	0.0205	0.1342
market for electricity, low voltage	0.0124	0.0811
transport, passenger car, large size, petrol, EURO 4	0.0006	0.0037
heat production, propane, at industrial furnace >100kW	0.0003	0.0186
transport, freight, lorry 16-32 metric ton, EURO4	0.0003	0.0020
market for tap water	0.000002	1.6613

A4 – Transport to client	**0.07**	**0.48**
transport, freight, lorry 16-32 metric ton, EURO4	0.0731	0.4783
A5 – Waste management of device packaging	**0.05**	**3.47**
treatment of waste paperboard, sanitary landfill	0.0255	0.1665
treatment of waste wood, untreated, sanitary landfill	0.0227	0.1487
treatment of waste plastic, mixture, sanitary landfill	0.0034	0.0221
transport, freight, lorry 16-32 metric ton, EURO4	0.0015	0.0100
B – Energy consumption for device use	**84.30**	**551.66**
electricity, low voltage – U - US	84.3000	551.6647

Table 16: Impact of Each Life Cycle Stage and Process on The Global Warming Potential (GWP) of a Desktop Small-Form – Horizon D12170

Process	Contribution (%)	Amount (kg CO2 eq)
Full LCA – Desktop Small-Form – Horizon D12170	**100.00**	**305.66**
A1 - Raw materials and components manufacturing	**77.00**	**235.47**
printed wiring board production, mounted mainboard, desktop computer, Pb containing	44.8000	136.8763
integrated circuit production, memory type	15.6000	47.6941
power supply unit production, for desktop computer	10.9000	33.1902
market for steel, unalloyed	2.1000	6.4206
market for EUR-flat pallet	0.7300	2.2164
acrylonitrile-butadiene-styrene copolymer production	0.6200	1.9057
steel production, converter, unalloyed	0.5100	1.5732
hot rolling, steel	0.4000	1.2338
market for corrugated board box	0.3300	0.9960
cable production, connector for computer, without plugs	0.2900	0.9000
injection moulding	0.2000	0.6057
aluminium production, primary, cast alloy slab from continuous casting	0.1700	0.5250
market for copper, cathode	0.1300	0.3971
market for polyethylene, linear low density, granulate	0.1000	0.3127
hard disk drive production, for desktop computer	0.0771	0.2356
polymer foaming	0.0693	0.2117
metal working, average for aluminium product manufacturing	0.0358	0.1095
polyethylene production, high density, granulate	0.0099	0.0303
plug production, inlet and outlet, for computer cable	0.0069	0.0211
polypropylene production, granulate	0.0063	0.0192
A2 - Transport of components to assembly site	**0.75**	**2.28**
transport, freight train	0.4700	1.4454
transport, freight, sea, container ship	0.2700	0.8232

transport, freight, lorry 16-32 metric ton, EURO4	0.0044	0.0135
A3 - Device assembly and packaging Energy Usage for manufacturing	**1.1600**	**3.55**
market for EUR-flat pallet	0.5600	1.7049
market for corrugated board box	0.4700	1.4459
market for polyethylene, linear low density, granulate	0.0787	0.2405
polymer foaming	0.0483	0.1476
transport, freight, lorry 16-32 metric ton, EURO4	0.0021	0.0064
market for electricity, low voltage	0.0019	0.0058
transport, passenger car, large size, petrol, EURO 4 | transport, passenger car, large size, petrol, EURO 4 | Cutoff, U - RoW	0.0001	0.0003
heat production, propane, at industrial furnace >100kW	0.0000481	0.0013
market for tap water	0.0000003	1.1726
A4 – Transport to client	**0.15**	**0.46**
transport, freight, lorry 16-32 metric ton, EURO4	0.1500	0.4610
A5 – Waste management of device packaging	**0.63**	**1.93**
waste paperboard	0.5600	1.7197
waste wood, untreated	0.0503	0.1539
transport, freight, lorry 16-32 metric ton, EURO4	0.0105	0.0321
waste plastic, mixture	0.0079	0.0243
B – Energy consumption for device use	**20.30**	**61.96**
electricity, low voltage | U - US	11.6000	35.5505
electricity, low voltage | CA-QC	8.6400	26.4124

Table 17: Impact of Each Life Cycle Stage and Process on The Global Warming Potential (GWP) of a Desktop Mini-Tower – Horizon T12750

Process	**Contribution (%)**	**Amount (kg CO2 eq)**
Full LCA – Desktop Mini-Tower – Horizon T12750	**100.00**	**297.47**
A1 - Raw materials and components manufacturing	**83.60**	**248.80**
printed wiring board production, mounted mainboard, desktop computer, Pb containing	46.0000	136.8763
integrated circuit production, memory type	18.0000	53.6206
power supply unit production, for desktop computer	13.0000	38.6220
market for steel, unalloyed	2.4300	7.2141
market for EUR-flat pallet	0.7500	2.2164
acrylonitrile-butadiene-styrene copolymer production	0.7200	2.1409
steel production, converter, unalloyed	0.5900	1.7678
hot rolling, steel	0.4700	1.3863
market for corrugated board box	0.3800	1.1279
cable production, connector for computer, without plugs	0.3700	1.1000

injection moulding	0.2300	0.6805
aluminium production, primary, cast alloy slab from continuous casting	0.2000	0.5890
market for copper, cathode	0.1500	0.4459
market for polyethylene, linear low density, granulate	0.1200	0.3440
hard disk drive production, for desktop computer	0.0792	0.2356
polymer foaming	0.0784	0.2334
metal working, average for aluminium product manufacturing	0.0413	0.1229
polyethylene production, high density, granulate	0.0115	0.0341
polypropylene production, granulate	0.0072	0.0215
plug production, inlet and outlet, for computer cable	0.0071	0.0211
A2 - Transport of components to assembly site	**0.86**	**2.57**
transport, freight train	0.5500	1.6371
transport, freight, sea, container ship	0.3100	0.9163
transport, freight, lorry 16-32 metric ton, EURO4	0.0050	0.0149
A3 - Device assembly and packaging Energy Usage for manufacturing	**1.21**	**4.54**
market for EUR-flat pallet	0.5700	1.7049
market for corrugated board box	0.4900	1.6658
market for polyethylene, linear low density, granulate	0.0889	0.4996
polymer foaming	0.0546	0.2646
transport, freight, lorry 16-32 metric ton, EURO4	0.0022	0.2292
market for electricity, low voltage	0.0018	0.1623
transport, passenger car, large size, petrol, EURO 4	0.0001	0.0072
heat production, propane, at industrial furnace >100kW	0.0000465	0.0025
market for tap water	0.0000003	0.0016
A4 – Transport to client	**0.11**	**0.33**
transport, freight, lorry 16-32 metric ton, EURO4	0.1100	0.3314
A5 – Waste management of device packaging	**0.65**	**1.93**
waste paperboard	0.5800	1.7197
waste wood, untreated	0.0517	0.1539
transport, freight, lorry 16-32 metric ton, EURO4	0.0110	0.0326
waste plastic, mixture	0.0090	0.0267
B – Energy consumption for device use	**13.5**	**40.25**
electricity, low voltage | CA-QC	9.2300	27.4590
electricity, low voltage | U - US	2.9800	8.8596
electricity, low voltage | CA-NS	1.0200	3.0432
electricity, low voltage | CA-ON	0.2300	0.6775
electricity, low voltage | CA-AB	0.0698	0.2076

Table 18: Impact of Each Life Cycle Stage and Process on The Global Warming Potential (GWP) of a High-Performance Workstations – Kronos 545 – G2		
Process	**Contribution (%)**	**Amount (kg CO2 eq)**
Full LCA – High-Performance Workstations – Kronos 545 – G2	**100.00**	**6975.44**
A1 - Raw materials and components manufacturing	**91.70**	**6399.66**
acrylonitrile-butadiene-styrene copolymer production	83.9000	5852.6756
printed wiring board production, mounted mainboard, desktop computer, Pb containing	4.9200	342.8657
integrated circuit production, memory type	1.6200	112.8854
power supply unit production, for desktop computer	0.7900	55.1042
market for steel, unalloyed	0.2000	14.2050
market for EUR-flat pallet	0.0921	6.4274
steel production, converter, unalloyed	0.0499	3.4809
hot rolling, steel	0.0391	2.7296
market for copper, cathode	0.0379	2.6419
cable production, connector for computer, without plugs	0.0234	1.6301
aluminium production, primary, cast alloy slab from continuous casting	0.0218	1.5212
market for corrugated board box	0.0173	1.2045
injection moulding	0.0133	0.9298
market for polyethylene, linear low density, granulate	0.0054	0.3784
metal working, average for aluminium product manufacturing	0.0045	0.3168
polymer foaming | polymer foaming | Cutoff, U - RoW	0.0041	0.2828
hard disk drive production, for desktop computer	0.0034	0.2356
polyethylene production, high density, granulate	0.0011	0.0731
polypropylene production, granulate	0.0008	0.0528
plug production, inlet and outlet, for computer cable	0.0003	0.0214
A2 - Transport of components to assembly site	**0.06**	**4.41**
transport, freight train	0.0433	3.0205
transport, freight, sea, container ship	0.0195	1.3609
transport, freight, lorry 16-32 metric ton, EURO4	0.0004	0.0289
A3 - Device assembly and packaging Energy Usage for manufacturing	**0.11**	**7.44**
market for EUR-flat pallet	0.0709	4.9442
market for corrugated board box	0.0255	1.7789
market for polyethylene, linear low density, granulate	0.0042	0.2910
polymer foaming	0.0026	0.1786
heat production, propane, at industrial furnace >100kW	0.0019	0.1318
market for electricity, low voltage	0.0011	0.0757
transport, passenger car, large size, petrol, EURO 4	0.0004	0.0261
transport, freight, lorry 16-32 metric ton, EURO4	0.0001	0.0091

market for tap water	0.0000002	0.00001
A4 – Transport to client	**0.14**	**9.63**
transport, freight, lorry 16-32 metric ton, EURO4	0.1400	9.6330
A5 – Waste management of device packaging	**0.04**	**2.64**
waste paperboard	0.0303	2.1157
waste wood, untreated	0.0064	0.4462
transport, freight, lorry 16-32 metric ton, EURO4	0.0006	0.0453
waste plastic, mixture	0.0004	0.0294
B – Energy consumption for device use	**7.91**	**551.66**
electricity, low voltage | U - US	7.9100	551.6647

Table 19: Impact of Each Life Cycle Stage and Process on The Global Warming Potential (GWP) of a Laptop – Crius CO100 – G1

Process	Contribution (%)	Amount (kg CO2 eq)
Full LCA – Laptop – Crius CO100 – G1	**100.00**	**360.44**
A1 - Raw materials and components manufacturing	**23.10**	**83.08**
market for printed wiring board, mounted mainboard, laptop computer, Pb free	16.2000	58.2733
market for integrated circuit, memory type	3.9100	14.1107
market for power adapter, for laptop	0.8000	2.8761
aluminium production, primary, cast alloy slab from continuous casting	0.5700	2.0488
market for battery cell, Li-ion	0.4800	1.7355
acrylonitrile-butadiene-styrene copolymer production	0.4400	1.5685
injection moulding	0.1500	0.5531
market for EUR-flat pallet	0.1300	0.4713
metal working, average for aluminium product manufacturing	0.1200	0.4274
market for hard disk drive, for laptop computer	0.1000	0.3784
market for steel, unalloyed	0.0531	0.1913
market for polyethylene, high density, granulate	0.0445	0.1606
market for acrylonitrile-butadiene-styrene copolymer	0.0323	0.1165
market for corrugated board box	0.0263	0.0948
polyethylene production, high density, granulate	0.0089	0.0320
hot rolling, steel	0.0072	0.0259
polymer foaming	0.0036	0.0128
market for polymer foaming	0.0014	0.0049
A2 - Transport of components to assembly site	**0.08**	**0.29**
transport, freight, sea, container ship	0.0725	0.2615
transport, freight, lorry 16-32 metric ton, EURO4	0.0069	0.0249

A3 - Device assembly and packaging Energy Usage for manufacturing	**0.14**	**0.51**
market for EUR-flat pallet	0.1000	0.3626
market for corrugated board box	0.0388	0.1400
transport, freight, lorry 16-32 metric ton, EURO4	0.0010	0.0035
market for electricity, low voltage	0.0003	0.0012
heat production, propane, at industrial furnace >100kW	0.0001	0.0003
transport, passenger car, large size, petrol, EURO 4	0.00001170	0.00004203
market for tap water	0.00000001	0.00000002
A4 – Transport to client	**0.15**	**0.53**
transport, freight, lorry 16-32 metric ton, EURO4	0.1500	0.5275
A5 – Waste management of device packaging	**0.06**	**0.20**
waste paperboard	0.0462	0.1665
waste wood, untreated	0.0091	0.0327
transport, freight, lorry 16-32 metric ton, EURO4	0.0009	0.0031
B – Energy consumption for device use	**76.5**	**275.83**
electricity, low voltage | U - US	76.5000	275.8324

5.4.7 Key Findings from Life Cycle Analysis

Detailed analyses for representative devices (Micro-PC Astro PN64, Desktop Small-Form Horizon D12170, Desktop Mini-Tower Horizon T12750, High-Performance Workstations Kronos 545-G2 and Laptop Crius CO100 – G1) offer insights into the contribution of life cycle stages to GWP impacts.

Raw Materials and Component Manufacturing (A1):

- For the Desktop Small-Form Horizon D12170, A1 accounts for 77.0% of total GWP (235.47 kg CO_2 eq), driven primarily by printed wiring board (PWB) production (44.8%), integrated circuits and memory components (15.6%), and power supply unit (PSU) manufacturing (10.9%).
- The Desktop Mini-Tower Horizon T12750 shows a similar profile, with 83.6% of total GWP (248.80 kg CO_2 eq) attributed to A1, again dominated by PWB manufacturing (46.0%), memory and integrated circuits (18.0%), and PSU production (13.0%).
- For the High-Performance Workstation Kronos 545-G2, A1 represents 91.7% of the total GWP (6399.66 kg CO_2 eq). The results indicate a strong dominance of enclosure and structural materials, particularly acrylonitrile-butadiene-styrene (ABS), which alone accounts for a substantial share of the total emissions. This highlights the significant influence of material intensity and enclosure design on high-performance systems.
- In contrast, the Laptop Crius CO100-G1 shows a more balanced distribution, with A1 contributing 23.1% (83.08 kg CO_2 eq), mainly associated with the laptop mainboard (16.2%), memory components (3.9%), and the lithium-ion battery (0.5%).
- The Micro-PC Astro PN64 exhibits the lowest relative A1 contribution at 15.2% (99.11 kg CO_2 eq), with impacts driven by the mounted mainboard (8.26%) and memory components (4.31%).

Energy Consumption During Use (B):

- Energy consumption during the use phase (B) is the primary driver of GWP for compact and mobile devices, and a secondary contributor for desktops and workstations.
- For the Micro-PC Astro PN64, the use phase accounts for 84.3% of total GWP (551.66 kg CO_2 eq), making it the dominant life cycle stage. Similarly, the Laptop Crius CO100-G1 shows 76.5% of total GWP (275.83 kg CO_2 eq) associated with electricity consumption during operation.
- For desktop systems, the contribution of the use phase is lower but still relevant. The Desktop Small-Form Horizon D12170 attributes 20.3% of its GWP (61.96 kg CO_2 eq) to energy consumption during use, while the Desktop Mini-Tower Horizon T12750 shows 13.5% (40.25 kg CO_2 eq).
- In the case of the High-Performance Workstation Kronos 545-G2, the use phase contributes 7.9% of total GWP (551.66 kg CO_2 eq). Although significant in absolute terms, its relative contribution is lower due to the high manufacturing impacts associated with material intensity.
- These findings highlight that assumptions related to device lifetime, operational power demand, and regional electricity mixes are critical parameters, particularly for Micro-PCs and laptops, where the use phase dominates total emissions.

Device Assembly and Packaging (A3):

- The device assembly and packaging stage (A3) contributes marginally to total GWP across all device categories, ranging from 0.11% to 1.21%.
- This reflects the relatively low energy demand of assembly operations and the limited environmental burden associated with packaging materials when compared to component manufacturing and electricity consumption during use.

Transportation (A2, A4):

- Transportation impacts, including component transport to the assembly site (A2) and distribution to the client (A4), are consistently low, contributing less than 1% of total GWP across all assessed devices.
- The predominance of freight by sea and rail, combined with optimized logistics and consolidated shipments, limits the relative contribution of transportation to overall climate impacts.

Waste Management (A5):

- End-of-life management of packaging materials (A5) represents a negligible share of total GWP, generally below 0.7% for all device types. The results reflect the low mass of packaging materials and the relatively short transport distances assumed for waste treatment.

Comparative Highlights

The High-Performance Workstation Kronos 545-G2 exhibits the highest total GWP (6975.44 kg CO_2 eq), largely driven by material intensity and enclosure-related impacts during manufacturing.

Among desktop systems, the Horizon D12170 and Horizon T12750 show comparable total GWP values (305.66 kg CO_2 eq and 297.47 kg CO_2 eq, respectively), with differences primarily linked to component mass and power supply configurations.

The Laptop Crius CO100-G1 demonstrates a total GWP of 360.44 kg CO_2 eq, with emissions predominantly driven by electricity consumption during use.

The Micro-PC Astro PN64, despite its compact form factor, shows a higher total GWP (654.08 kg CO_2 eq) due to the dominant influence of the use-phase energy consumption assumptions.

5.5 Sensitivity Assessment Results

The sensitivity assessment was conducted using two parameters outlined in Section 4.6, with the Desktop Mini-Tower Horizon T13560 as the subject of analysis. The results of this assessment are presented in the table below:

Table 20: Sensitivity Assessment Results for The Desktop Mini-Tower Sample, Horizon T13560

Impact category	**Unit**	**Deviation from the initial scenario**	
		Scenario considering + 30% component and materials mass	Scenario considering twice the use electricity consumption
FFPD	MJ surplus	+43%	+43%
ODP	kg CFC-11 eq	+31%	+31%
GWP	kg CO2 eq	+30%	+30%
EP	kg N eq	+11%	+11%
AP	kg SO2 eq	+22%	+22%
SP	kg O3 eq	+20%	+20%

This sensitivity assessment was conducted to test the robustness of the Life Cycle Impact Assessment results and to validate the key drivers identified in Section 5.4.7 (Key Findings from Life Cycle Analysis). The Desktop Mini-Tower Horizon T13560 was selected as a representative product, as its life-cycle profile reflects both material-intensive manufacturing processes and relevant use-phase energy consumption.

Two parameters were evaluated due to their demonstrated influence on Global Warming Potential (GWP) and other impact categories:

- Component and materials mass, and
- Electricity consumption during the use phase.

Sensitivity to Component and Materials Mass

Consistent with the findings in Section 5.4.7, where raw materials and component manufacturing (A1) were identified as a dominant contributor to GWP for desktop devices, the sensitivity assessment confirms that material mass is a key determinant of environmental impact.

A scenario assuming a 30% increase in component and material mass resulted in proportional increases across all assessed impact categories (Table 20), with the most significant deviations observed for all indicators.

These results reinforce the conclusions presented in Section 5.4.7, demonstrating that electronic components, power supply units, and structural materials are the primary contributors to manufacturing-related impacts. The near-linear relationship between increased mass and environmental impact highlights the importance of material efficiency (better sourcing and increase use of PCR plastic content), optimized component design.

Although a substantial portion of the supply chain is in Asia, the increase in transportation-related impacts remains limited. This reflects the use of efficient transportation modes, including maritime shipping and rail freight, as well as optimized container utilization and consolidated shipments to the assembly facilities. As such, reductions in material mass deliver direct environmental benefits without being offset by disproportionate logistics-related emissions.

Sensitivity to Electricity Consumption During Use

In alignment with Section 5.4.7, which identified the use phase (B) as a significant contributor to GWP for several device categories, the sensitivity assessment confirms that electricity consumption during operation is a critical parameter influencing life-cycle impacts.

A scenario assuming twice the baseline electricity consumption during use resulted in increases identical to those observed for the material mass scenario across all impact categories.

These results demonstrate that variations in operational energy demand can significantly affect overall life-cycle performance, particularly for impact categories directly linked to energy production and fossil fuel use. The findings further validate the conclusions, emphasizing that accurate energy modeling, realistic use-phase assumptions, and power-efficient product design are essential to ensuring credible and representative LCA results.

Strategic Alignment with Key Findings

Taken together, the sensitivity assessment corroborates the primary environmental indicators:

- Manufacturing impacts are highly sensitive to component and material mass, confirming the importance of material efficiency and sustainable sourcing.
- Use-phase impacts are highly sensitive to electricity consumption, reinforcing the role of energy efficiency in reducing overall GWP.

These findings support a strategic focus on:

- Lightweight product design and material optimization;
- ENERGY STAR certification to control operational energy consumption and reduce GWP, FFPD, and ODP impacts;
- Supplier collaboration to improve packaging efficiency, shipment consolidation, and logistics planning;
- Robust inventory management, avoiding unnecessary material waste or high-impact expedited shipments.

5.6 Limitations

The assessment relies primarily on secondary life cycle inventory data from recognized databases and modeled use-phase scenarios. While this introduces uncertainty, the sensitivity analysis demonstrates that the relative importance of key environmental drivers remains consistent, supporting the robustness of the conclusions.

Continuous improvement initiatives, including supplier engagement and enhanced primary data collection, are expected to further strengthen result accuracy over time.

Uncertainty in Secondary Data for Component Modeling

The LCA relies primarily on secondary data sourced from the ecoinvent v3.8 database, including datasets for electronic components and materials that may not fully reflect recent technological advancements, manufacturing efficiencies, or supplier-specific practices. This limitation is particularly relevant for component-intensive devices, where manufacturing impacts (A1) dominate total GWP, as identified in Section 5.4.7.

The sensitivity assessment confirms that component and material mass is a critical parameter, meaning that uncertainties in component mass, material composition, or dataset representativeness can significantly influence results. Consequently, improvements in primary data quality, such as supplier-specific material declarations and mass verification, would directly increase the robustness of the LCA outcomes.

Assumptions Related to Electricity Consumption During Use

Electricity consumption during the use phase is based on modeled scenarios rather than direct field measurements. Assumptions related to device lifetime, operational profiles, standby behavior, and regional electricity mixes introduce uncertainty, particularly for device categories where the use phase is a dominant contributor to GWP, as demonstrated in Section 5.4.7.

The sensitivity assessment in Section 5.5 confirms that variations in electricity consumption have a substantial influence on GWP, FFPD, and ODP. As a result, uncertainties in use-phase modeling represent one of the most influential limitations of this study. Incorporating real-world usage data and refined energy consumption profiles would significantly enhance result accuracy.

Data Availability and Representativeness

The rapid evolution of IT hardware technologies presents an inherent challenge to maintaining fully representative life cycle inventories. While conservative and widely accepted datasets were used, some discrepancies between modeled processes and actual manufacturing conditions may remain.

The sensitivity analysis demonstrates that, despite these limitations, the relative importance of key drivers remains consistent, supporting the validity of the comparative conclusions drawn across device types.

Taken together, the limitations identified do not undermine the core conclusions of the assessment. Instead, they reinforce the importance of the two primary drivers validated through sensitivity analysis: Material and component mass, and Electricity consumption during use.

5.7 Relationship of the LCIA Results to the Goal and Scope

The LCA was conducted in compliance with ISO 14044, ISO 14040, standards, presenting the environmental impact results for the twelve devices within the scope across their entire life cycle for the year 2024. These results will support compliance with EPEAT, Energy Star, and other applicable requirements. Therefore, it can be concluded that the LCIA results align with and satisfy the defined goal and scope of the assessment.

5.8 Relationship of the LCIA results to the LCI results

The following analysis focuses on the environmental impacts of the Desktop Mini-Tower Horizon T13560, as derived from the Life Cycle Inventory (LCI). Table 20 highlights the elementary flows that most significantly contribute to each of the six impact categories evaluated in the Life Cycle Assessment (LCA). This table is based on the TRACI 2.1 methodology, ensuring relevance and applicability to the North American context. The contributions reflect the materials and processes involved in the production and life cycle of the device. By identifying the key contributors, this analysis aims to inform strategies for improving the sustainability of the device through targeted interventions in design, manufacturing, and resource use.

Table 21: Highest Contributors for Each Impact Category - Desktop Mini-Tower Sample (Horizon T13560)

Impact category	Unit	Elementary flow with the highest contribution to each impact category	
		Flow	Contribution %
FFPD	MJ surplus	Gas, natural, in ground	76%
ODP	kg CFC-11 eq	Methane, bromotrifluoro-, Halon 1301	40%
GWP	kg CO2 eq	Carbon dioxide, fossil	65%
EP	kg N eq	Phosphate	77%
AP	kg SO2 eq	Sulfur dioxide	47%
SP	kg O3 eq	Nitrogen oxides	56%

The analysis of the Horizon T13560: Desktop Mini-Tower reveals key environmental impacts driven by specific elementary flows in its life cycle. Fossil fuel depletion (FFPD), accounting for 76% of the category impact due to natural gas consumption, underscores the significant reliance on non-renewable energy in manufacturing and logistics. Similarly, global warming potential (GWP), with carbon dioxide contributing 65%, highlights the role of fossil fuel combustion across production and transportation processes. Eutrophication potential (EP) is largely influenced by phosphate emissions (77%), likely from material extraction or wastewater discharges, while sulfur dioxide (47%) and nitrogen oxides (56%) drive acidification (AP) and smog potential (SP), respectively, emphasizing the environmental burdens associated with industrial and energy-related emissions. Methane, bromotrifluoro-, contributes significantly to ozone depletion potential (ODP) at 40%, pointing to the need for better refrigerant and chemical management.

Addressing these environmental challenges requires a strategic approach to improving energy efficiency, material selection, and production processes. Substituting harmful chemicals like Halon 1301 with environmentally friendly alternatives will mitigate ODP, while better wastewater treatment. Cleaner combustion technologies and the use of low-sulfur fuels will help lower contributions to AP and SP. By implementing these measures, Hypertechnologie Ciara Inc. can minimize its environmental footprint, enhance the eco-efficiency of its devices, and demonstrate its commitment to sustainable production practices.

6. CONCLUSION

The sensitivity assessment underscores the need for accurate input data and robust design strategies to minimize environmental impacts across the product portfolio. For Hypertechnologie Ciara Inc., prioritizing energy efficiency, material optimization, and supply chain collaboration is essential to achieving sustainability objectives and maintaining competitiveness in an increasingly eco-conscious market.

By integrating energy-efficient design, sustainable material choices, and optimized logistics, the company can effectively reduce life cycle environmental impacts while delivering high-performance, environmentally responsible IT solutions.

PART II: CORPORATE GREENHOUSE GAS EMISSIONS

In order to comply with EPEAT certification, Hypertechnologie Ciara Inc has assessed its corporate greenhouse gas emissions and chosen to follow the requirements of The Greenhouse Gas Protocol – Revised Edition. Scope 3 emissions were calculated using the device LCA compliant with ISO 14040 and ISO 14044. The object of the assessment is the Saint-Laurent plant, for which Hypertechnologie Ciara Inc has significant responsibility, as the company owns and fully manages the facility. The reference year is 2024, and the number of sold devices is presented in Table 1. This GHG inventory is the first completed by the company. The assessment was carried out using the best available data, and no GHG emissions were deliberately excluded. The chosen boundaries are Scope 1, 2, and 3, which encompass the following:

- **Scope 1:** Direct GHG emissions from sources owned by Hypertechnologie Ciara Inc. This includes on-site combustion of natural gas and emissions from the three vehicles Hypertechnologie Ciara Inc owns and uses for its operations and customer services. GHG emissions from the diesel generator have been included. Hypertechnologie Ciara Inc does not own forklifts powered by fossil fuels and did not register any refrigerant leaks.
- **Scope 2:** Indirect GHG emissions from electricity, which result from the purchase of electricity by Hypertechnologie Ciara Inc. These emissions are sourced from the site where the electricity is produced.
- **Scope 3:** Other indirect emissions are those resulting from Hypertechnologie Ciara Inc's activities but from sources not owned or controlled by the company. Scope 3 includes emissions from the life cycle stages of the sixteen devices considered in the life cycle assessment. These stages include raw materials and components manufacturing, transportation of components to Hypertechnologie Ciara Inc's assembly site, Hypertechnologie Ciara Inc's device assembly site (excluding scopes 1 and 2, such as freshwater consumption and packaging), transportation to the final user, waste management of device packaging, energy consumption during device use, transportation to the treatment facility, and dismantling. Transportation of employees to and from work, business travel, the purchase of office furniture and supplies, and garbage generation (e.g., coffee cups, newspapers) were not considered.
- **Scope 1 and 2:** We have established 2024[6] as our base year for Scope 1 and 2 emissions calculations. This aligns with the best practices in greenhouse gas (GHG) reporting and provides a consistent reference point for tracking our progress over time.
- **Scope 3:** Our calculations for Scope 3 emissions began in 2021, which serves as the baseline year for this category. The latter start date for Scope 3 reflects the complexities involved in collecting and verifying data across our entire value chain.
- **For a detailed overview** of our emissions profile, please refer to our Environmental Data Disclosure 2024. This report presents our most extensive scope of work to date, including our progress towards emissions reduction targets and other environmental metrics: https://ciaratech.com/epeat/ , https://hypertec.com/about-us/ .

[6] The baseline year has been revised from 2019 to 2024 to reflect the relocation of our operations to a new facility at 5555 Cypihot. The new site presents a significantly different energy profile and operational setup compared to the previous location, making 2024 a more accurate reference point for future comparisons.

The following table presents the Scope 3 categories included, excluded, or not applicable to the study, in accordance with the Greenhouse Gas Protocol Technical Guidance for Calculating Scope 3 Emissions:

Table 22: Scope 3 Categories for Hypertechnologie Ciara Inc's Corporate Carbon Footprint

Scope 3 category	Included	Excluded	Not Applicable
1. Purchased goods and services	x		
2. Capital goods		x	
3. Fuel- and energy-related activities (not included in scope 1 or scope 2)	x		
4. Upstream transportation and distribution	x		
5. Waste generated in operations	x		
6. Business travel		x	
7. Employee commuting		x	
8. Upstream leased assets			x
9. Downstream transportation and distribution	x		
10. Processing of sold products			x
11. Use of sold products	x		
12. End-of-life treatment of sold products	x		
13. Downstream leased assets			x
14. Franchises			x
15. Investments			x

The Capital Goods, Business Travel, and Employee Commuting categories have been excluded from the current report due to the lack of sufficient data for accurate emissions calculation. At present, we do not have the necessary metrics or tracking systems in place to effectively measure the emissions associated with these activities.

However, we acknowledge the importance of capturing the full scope of our indirect emissions and are committed to improving our data collection processes. We are actively working to enhance our tracking mechanisms, with the goal of including these categories in future reports. This will enable us to assess our environmental impact more comprehensively and take informed actions to reduce our carbon footprint.

Furthermore, the categories Upstream leased assets, Processing of sold products, Downstream leased assets, Franchises, and Investments are not applicable in our case.

7. GHG EMISSIONS PER SCOPE AND TOTAL

The GHG emissions for each scope were calculated by multiplying the total quantity of resources consumed annually (based on available billing data) by the corresponding GHG emission factors.

For Scope 1 and Scope 2, the GHG emission factors provided by the Quebec government or, where applicable, Canadian sources, were used[7].

For Scope 3, the GHG emissions per unit of each device model (Astro, Crius Horizon, Kronos) were calculated by multiplying the emissions per unit by the number of units sold during the reference year (2024) as shown in Table 01. To avoid double-counting, emissions from Scope 1 and Scope 2 were subtracted from the total Scope 3 emissions.

Regarding our calculation of Scope 3 emissions, emission factors related to materials and component manufacturing, transportation, electricity production and distribution, and waste management were sourced from the ecoinvent database. as it is the most widely used database in the manufacturing sector.

Table 23: Greenhouse Gas Emissions per Scope and Total GHG Emissions

Scope	Element	Quantity (m3)	CO2 (kg)	CH4 (kg)	N2O (kg)	HFC (kg) *	PFC (kg) *	SF6 (kg) *	eCO2 (kg)	GHG Emissions (ton CO2 eq)
1	Natural Gas	279.48	538.2791	0.0115	0.0098	0	0	0	541.4821	0.5415
	Diesel	0	0	0	0	0	0	0	0	0
	Gasoline	11.37	26.2396	0.0016	0.003	0	0	0	26.3539	0.0263
2	Electricity	4,088.52	4.0885	0.0008	0.0004	0	0	0	4.2308	0.0042
3	See Part I	22,133[8]					See Part I			8,602.8993
Total										**8,603.4714**

*As part of our Life Cycle Assessment (LCA), we have evaluated potential emissions of all greenhouse gases, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). After thorough assessment, we have concluded that emissions of these gases are negligible or zero for our company, for the following reasons:

- Electric HVAC System: Our heating, ventilation, and air conditioning (HVAC) system primarily operates on electricity, which significantly reduces the risk of direct emissions of these gases.
- Regular Maintenance: We maintain a rigorous maintenance program for our HVAC system, which minimizes the risk of leaks from refrigerants containing HFCs.
- Absence of PFCs and SF6: Our equipment and processes do not use PFCs or SF6, which are typically associated with specific industrial applications do not present in our company.

[7] Ministry-Environment_Conversion-Table-GHG

[8] Total quantity in units, according to sale of 2024. Reference Table 01.

- Regulatory Compliance: We strictly adhere to Quebec regulations regarding refrigerant gas management and greenhouse gas emission reporting.

While emissions of these gases are considered negligible in our operational context, we continue to monitor and regularly evaluate our systems to ensure optimal environmental performance and ongoing compliance with current standards.

Conclusion:

The greenhouse gas emissions presented in this LCA report focus exclusively on the studied products, as required by EPEAT standards. The total emissions calculated for these products amount to **8,603.47 tons of CO2 equivalent**, covering Scope 1 (direct emissions), Scope 2 (electricity-related emissions), and Scope 3 (indirect emissions). It is important to highlight that this scope is limited to the products analyzed in this report and does not represent the company's overall emissions. For a complete overview of the organization's total greenhouse gas emissions, including all commercialized products, readers can refer to our Environmental Data Disclosure 2024, available on our websites: https://ciaratech.com/epeat/ , https://hypertec.com/about-us/ .

This specific analysis provides a clear understanding of the environmental impact of the selected products while demonstrating our commitment to meeting EPEAT requirements and promoting transparency in sustainability reporting.

PART III: GREENHOUSE GAS EMISSIONS FROM PRODUCT TRANSPORT

To comply with EPEAT certification, Hypertechnologie Ciara Inc has assessed its greenhouse gas emissions from product transport. The methodology used for calculating and reporting transport emissions follows a well-to-wheel, performance-based assessment utilizing a mode-based approach. This calculation is based on the weight of freight and the transport distance for each transportation mode.

The chosen methodology aligns with the GLEC Framework, the global standard for calculating and reporting logistics and transport emissions. Hypertechnologie Ciara Inc. utilized GHG emission factors provided by the GLEC Framework[9] to assess its logistics-related greenhouse gas emissions.

Average transport distances from Hypertechnologie Ciara Inc to end customers were determined based on sales data provided by Hypertechnologie Ciara Inc

These distances were calculated from Hypertechnologie Ciara Inc's assembly facility in Saint-Laurent, QC, Canada, to final users located in the capitals of each Canadian province. Since Hypertechnologie Ciara Inc's clients are provincial governments, the distances were measured between the plant and the clients' postal codes in provincial capitals.

The transportation distances in this assessment were calculated using GPS tracking and logistics data to ensure accuracy. These distances reflect real transport routes based on supplier locations, distribution hubs, and customer destinations. The methodology ensures consistency and reliability by using weighted averages based on sales distribution and transport modes, improving the precision of impact calculations.

All devices are transported exclusively by truck, as confirmed by Hypertechnologie Ciara Inc's sales operations team. Additionally, Hypertechnologie Ciara Inc does not require a distribution center, as deliveries are made directly from the assembly facility to the final user.

[9] Global Logistics Emissions Council (GLEC) Framework for Logistics Emissions Accounting and Reporting, Version 3.2

Table 24: Number of Units Sold and Mass*Distance			
Device Model	**Sales for 2024 (qty)**	**Mass of Unit[10] (kg)**	**Mass*Distance[11] Kg.km**
Astro PN64	130	1.75	4,230.87
Astro PW64-T	30	3.25	3,304.52
Crius CO100-G1	11063	1.46	3,537.77
Crius N320-G1	14	1.88	1,090.45
Horizon D11750	543	7.66	5,055.71
Horizon D12170	3057	7.66	3,577.30
Horizon D12750	1463	7.66	4,534.82
Horizon T11750	72	8.39	4,968.15
Horizon T12170	909	8.39	10,255.20
Horizon T12750	4421	8.39	2,509.25
Horizon T12760	3	8.53	2,345.03
Horizon T13560	373	6.30	1,134.03
Kronos 540	4	14.91	4,099.96
Kronos 540-G2	48	14.91	12,553.34
Kronos 545	2	14.91	4,099.96
Kronos 545-G2	1	14.91	68,953.89
Total	**22133**	**130.96**	**136, 250.26**

[10] Mass of unit including packaging in kg.
[11] Calculation of Mass*Distance for all devices.

The GHG emission factors were sourced from the GLEC Framework for Logistics Emissions Accounting and Reporting, Version 3.2[12] (Table 40). The emission factor used for the calculation is based on a well-to-wheel (WTW) approach and represents transport using an LTL (less-than-truckload) dry van. The WTW emission factor is divided into two sub-categories: well-to-tank (WTT) and tank-to-wheel (TTW). These sub-categories were used to calculate product transport GHG emissions by scope, see Table 26.

Table 25: GHG Emission Factors for Road Transport		
Transportation Mode	**Amount**	**Unit**
LTL/Dry Van WTW	**0.218**	**(kg CO2 eq/tone-kilometer)**
LTL/Dry Van WTT	0.038	(kg CO2 eq/tone-kilometer)
LTL/Dry Van TTW	0.180	(kg CO2 eq/tone-kilometer)

Note: WTW emissions are the sum of the WTT and TTW emissions. Therefore, the WTW factor used in this section is calculated as the sum of the WTT and TTW factors: 0.038 + 0.180 = 0.218 kg CO_2 eq/tone-kilometer.

Table 26 presents the Well-to-Wheel (WTW) greenhouse gas (GHG) emissions for each device model. These emissions were calculated by applying the WTW emission factor to the product of total mass and distance for the sold units of each model.

[12] Global Logistics Emissions Council (GLEC) Framework for Logistics Emissions Accounting and Reporting, Version 3.2,P.99.

Table 26: Product Transportation Emissions Inventory – Calculation Methodology GLEC Framework v3.2										
Device Model	**TCE**	**TCO**	**Mode Coverage**	**Fuel Type**	**Transport Route**	**Distance *Mass*Qty Kg.km**	**Emission Intensity WTW kg CO2e/t-km**	**Total Emissions Kg CO2eq**	**Quality Data**	**Data Source**
Astro PN64	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent, QC To Mississippi	550,013.17	0.218	119.90	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Astro PW64-T	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Michigan	99,135.75	0.218	21.61	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Crius CO100-G1	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Mississippi	39,138,391.99	0.218	8,532.17	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Crius N320-G1	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec/ Alberta/ California/ Illinois	15,266.25	0.218	3.33	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon D11750	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Nova Scotia/ Ontario/ Quebec/ Arizona/ Louisiana/ Colorado/ Missouri / North Carolina	2,745,249.38	0.218	598.46	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon D12170	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec/Idaho/Kansas/Connecticut/Mississippi	10,935,794.89	0.218	2,384.00	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals

Table 26: Product Transportation Emissions Inventory – Calculation Methodology GLEC Framework v3.2										
Device Model	**TCE**	**TCO**	**Mode Coverage**	**Fuel Type**	**Transport Route**	**Distance *Mass*Qty Kg.km**	**Emission Intensity WTW kg CO2e/t-km**	**Total Emissions Kg CO2eq**	**Quality Data**	**Data Source**
Horizon D12750	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Alberta/Ontario/Quebec/Missouri/New York	6,634,436.92	0.218	1,446.31	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon T11750	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Ontario/California/Colorado/Texas	357,706.85	0.218	77.98	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon T12170	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec/Idaho	9,321,979.61	0.218	2,032.19	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon T12750	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Alberta/Nova Scotia/ Ontario/Quebec/Illinois/Missouri/New York	11,093,402.29	0.218	2,418.36	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon T12760	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec	7,035.10	0.218	1.53	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Horizon T13560	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Ontario	422,992.91	0.218	92.21	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals

Table 26: Product Transportation Emissions Inventory – Calculation Methodology GLEC Framework v3.2										
Device Model	**TCE**	**TCO**	**Mode Coverage**	**Fuel Type**	**Transport Route**	**Distance *Mass*Qty Kg.km**	**Emission Intensity WTW kg CO2e/t-km**	**Total Emissions Kg CO2eq**	**Quality Data**	**Data Source**
Kronos 540	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec	16,399.85	0.218	3.58	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Kronos 540-G2	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec/Ontario/Nova Scotia/British Columbia/Alberta	602,560.12	0.218	131.36	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Kronos 545	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To Quebec	8,199.92	0.218	1.79	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
Kronos 545-G2	TCE3: Road-Truck	Truck-Palletized Dry Van LTL	Truck (LTL)	Diesel	From Saint-Laurent QC To California	68,953.89	0.218	15.03	Good	Sold & Mass unit: internal data Average Distances: the plant and the clients' postal codes in provincial capitals
						Total emission Ton CO2eq		**17.88**		

Analysis of Product Transportation Emissions Inventory Results:

Total Emissions: Product transportation generated 17.88 tonnes of CO2eq in 2024, representing the overall carbon footprint of the company's logistics operations.

Model Variability: Emissions vary significantly across models. The Crius CO100-G1 accounts for the largest share of emissions (8.53 tonnes CO2eq), while the Horizon T12760 generates only 0.001533 tonnes CO2eq.

Long-Distance Impact: Models shipped to distant destinations, such as Mississippi, Missouri or California, tend to have higher emissions.

Reduction Opportunities: Models with the highest emissions, such as Crius CO100-G1 and Horizon T12750, could be prioritized for emission reduction initiatives.

This analysis provides a solid foundation for assessing the environmental impact of logistics operations and identifying opportunities for improvement to reduce the carbon footprint of product transportation.

Emission Reduction Goal:

We are committed to continuously reducing our greenhouse gas (GHG) emissions related to product transport. Our goal is to reduce transport-related emissions by **15% annually**.

The table below presents our transport emissions performance, including the total emissions from product transport, the number of products sold, and the emissions per product (tCO_2eq/product). To achieve our reduction target, we are focusing on optimizing shipment loads to maximize transportation efficiency and minimize emissions.

Table 27: Product Transport Emissions Performance

Year	Total Emission Transport	Products Sold	Ratio (tCO2eq/product)	Target
2023	7.62	6563	0.0012	0.00099
2024	17.88	22133	0.0008	0.00102

The results of our product transport emissions and performance, along with additional details on our sustainability initiatives, are publicly available on our website.: https://ciaratech.com/epeat/ .

8. TEAM

The success of this report is a testament to the importance of collaboration and synergy within a dedicated team. By leveraging diverse expertise and working cohesively, the Hypertechnologie Ciara Inc team ensured the delivery of a document that aligns with the company's commitment to quality, sustainability, and innovation. Each team member brought their unique skills and perspective, contributing to a report that not only meets industry standards but also supports Hypertechnologie Ciara Inc's strategic goals.

Anizio Neto, Quality Assurance Project Lead: With extensive experience and a specialization in strategy deployment and sustainable practices across industries such as oil and gas, mining, ports, and transportation, Anizio led the project with a detail-oriented approach and strategic oversight. His expertise in circular economy, sustainability, and product certification ensured that the report met the highest standards of quality and compliance.

Aziza Benabbas, Sustainability Project Specialist: Aziza contributed her in-depth knowledge of sustainability practices, ensuring the integration of eco-friendly principles and compliance with international standards.

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