Product life cycle analysis

TEKNOSLIM

Revision control					
Review	**Date**	**Changes**	**Elaborated**	**Revised**	**Approved**
00	03/12/20	Initial version	MF	JE	MY

INDEX

REFERENCE STANDARDS

UNE-EN ISO 14040:2006	Environmental management. Life Cycle Analysis. Principles and reference framework
UNE-EN ISO 14044:2006	Environmental management. Life Cycle Analysis. Requirements and guidelines
UNE-EN ISO 14064-1:2019	Greenhouse gases. Part 1: Specification with guidance, at the organization level, for the quantification and reporting of greenhouse gas emissions and removals
UNE-EN ISO 14067:2019	Greenhouse gases. Carbon footprint of products. Requirements and guidelines for quantification
UNE-EN 16258:2013	Methodology for the calculation and declaration of energy consumption and greenhouse gas emissions in transport services (freight and passenger transport)
IEEE 1680.1 (2018)	IEEE Standard for Environmental and Social Responsibility Assessment of Computers and Displays

ACRONYMS

LCA	Life cycle analysis
AECOC	Manufacturers and Distributors Association
CML	Center for Environmental Studies in Leiden
VOC	Volatile Organic Component
EICV	Life Cycle Impact Assessment
GWP	Global Warming Potential
ICV	Life Cycle Inventory Analysis
ILCD	International Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
ICAO	International Civil Aviation Organization

DEFINITIONS

Life cycle

"Consecutive and interrelated stages of a product system, from raw material acquisition or generation from natural resources to final disposal" ISO 14040 §3.1.

Life cycle analysis

"Collection and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle. ISO 14040 §3.2.

Life Cycle Inventory Analysis

" Phase of the life cycle analysis that involves the collection and quantification of inputs and outputs for a product system throughout its life cycle. " ISO 14040 §3.3.

Life Cycle Impact Assessment

"Phase of the life cycle analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system throughout the product life cycle. ISO 14040 §3.4.

Assignment

"Distribution of the flows in or out of a product, but which does not constitute a part of the product. ISO 14040 §3.17.

System Limit

"Set of criteria that specify which of the unitary processes are part of a product system. ISO 14040 §3.32.

Impact category

"Class representing environmental issues of interest to which the results of the life cycle inventory analysis can be assigned. ISO 14040 §3.39.

Biogenic Carbon

Emissions related to the natural carbon cycle, as well as those resulting from the combustion, harvesting, digestion, fermentation, decomposition or processing of bio-based materials

SUMMARY

In order to meet EPEAT criteria and understanding how product life cycle analysis can help the development of more sustainable products, Teknoservice has developed an analysis for its product TEKNOSLIM. The objectives for this study, conducted in accordance with ISO 14040 and ISO 14044 include

- Analysis of the life cycle of TEKNOSLIM through its entire lifespan.
- Determination of the most relevant points during the life of the product.
- Publication of the results for the knowledge of the general public
- Comply with EPEAT requirements.

The study systems have been carried out from the extraction of the raw material to the end of the equipment's useful life. In the case of products supplied by Teknoservice, a useful life of 5 years has been estimated, with consumption associated with that calculated for Energy Star certification.

This study has been carried out taking as a base the year 2019 and considering Spain as its geographical scope.

For this study, the global warming index is the most robust and used impact category, in addition to primary energy consumption and water consumption, in line with the requirements set out in criterion 4.8.1.1 of the IEEE 1680.1-2018.

From the analysis of the data, it is concluded that the largest portion of the impact is derived from the manufacture of components and the use of the equipment.

1. OBJECTIVE OF THE STUDY

This LCA study aims to know the potential environmental impacts of TEKNOSLIM in order to obtain the Gold category of the EPEAT environmental label. The results of the LCA will be published on the Teknoservice website so that it can be seen by consumers of electrical and electronic products. It is not intended to use the results of this study in comparative claims intended for public disclosure.

In addition, there are the following secondary objectives:

- Analysis of the life cycle of TEKNOSLIM through its entire lifecycle.
- Determination of the most relevant points regarding the environmental performance of the product throughout its life cycle.
- Publication of the results for the knowledge of the general public.

The analysis complies with the requirements set out in the following standards:

- UNE-EN ISO 14040:2006. Environmental Management. Life Cycle Analysis. Principles and reference frameworks.
- UNE-EN ISO 14044:2006. Environmental Management. Life Cycle Analysis. Requirements and guidelines.

2. SCOPE OF THE STUDY

2.1. System definition

Teknoslim is a small format computer equipped with 8 GB of RAM, a 500 GB SSD hard disk and an Intel Core i5-8500 processor, with a consumption of 300 W.

2.2. Functional unit

The functional unit is 1 TEKNOSLIM unit and its life expectancy is 5 years. The average consumption of this unit, according to Energy Star certifications, is 81.76 kWh/year.

2.3. System Limits

It has been included in the analysis:

- Raw material extraction
- Manufacture of components
- Transport to assembly point
- Employee travel
- Assembly
- Transport to customers
- Use of the equipment
- End of life
- Removal of equipment

It has been excluded from the analysis:

- Production of auxiliary equipment (factories, tools, etc.)
- Components for repair
- Reuse of parts
- Packaging
- Equipment recycling

Each one of the components of the product have been evaluated, without excluding any, and are shown in the table in section 3.2.1.

The reason for these exclusions is that the impact on the life cycle of the product has been estimated to be low, and that some of the data required to conduct an appropriate study cannot be obtained.

The following assumptions have been made in this study:

- The information provided by suppliers is reliable.
- The final use of the equipment and waste treatment is in Spain.

2.3.1. Temporary coverage

The year 2019 has been established as the base year for this study.

2.3.2. Technology coverage

This study assesses the impacts of the product from the extraction of the raw material to the end of the product's life, based on a global production and technology mix. The data related to primary production has been collected through Teknoservice and its collaborators. Data associated with equivalencies or other estimates have been collected from official agencies or databases certified by third parties.

2.3.3. Geographical coverage

The following conditions have been considered:

- The product is assembled in Spain
- The origin of the production of each of the components has been considered
- The intended use of the equipment is in Spain, according to the sales volume

2.4. Limitations

All energy and material flows have been considered for input into the model. In case there are no data for a certain flow, representative data have been used, considering the environmental impact, and using public or accredited sources to establish them.

2.5. Selection of impact assessment methodology and impact categories

The global warming index categories are based on the 2006 IPCC characterization for a 100-year interval GWP(100), which is the most common metric to express this index.

The following are the selected impact categories:

- Global Warming Index (GWP100) [kg CO_2 equivalent]: Measurement of greenhouse gases such as CO_2 and methane. These emissions cause an increase in the absorption of radiation emitted by the earth, increasing the effects of greenhouse gases.
- Primary energy demand [MJ]: Energy demanded by the product throughout its life cycle.
- Water consumption [m^3]: Water demand required by the product throughout its life cycle.

2.6. Interpretations

The results of the LCA and the LCI will be interpreted according to the objective and scope. The interpretation includes the following topics:

- Identification of significant findings, such as major processes, materials or emissions that contribute to the overall results
- Evaluation of integrity, sensitivity and consistency to justify the exclusion of data from the system boundaries
- Conclusions, limitations and recommendations.

2.7. Data quality requirements

The data used to create the inventory model should be accurate, comprehensive, consistent and as representative as possible of the objective and scope of the study.

- The primary data measured are of the highest precision, followed by the calculated data, the bibliographic data and finally the estimated data.
- Completeness is evaluated according to the inputs and outputs of the process units and the integrity of the processes themselves. The objective of this point is to capture all relevant data.
- Consistency refers to the choice of model and data sources. The objective is to ensure that differences in results show differences between product systems and are not due to inconsistencies between chosen models, data sources or emission factors.
- Reproducibility expresses the degree to which third parties may be able to reproduce the results of the study based on the information contained in this report.
- Representativeness expresses the degree to which the data corresponds to the geographical, temporal and technological requirements defined in the objectives and scope.

2.8. Critical evaluation

The study has been reviewed by Jenny Lorena Victoria E. (*Solar Projects*) to verify that this document complies with the requirements of UNE-EN ISO 14044.

3. LIFE CYCLE INVENTORY ANALYSIS

3.1. Data collection procedure

The primary data collected has been obtained from the list of materials, which has identified the breakdown of products, identification of materials, weight and size of packaging.

Data regarding distribution, product use and end of life has been collected through communications with suppliers and consultation with reputable sources.

The data related to energy and water consumption have been obtained from the invoices issued by each of the suppliers.

3.2. Product system

3.2.1. Composition of the product

The supply of the components from the manufacturing site to the delivery at Teknoservice facilities has been considered. The shipment of these components is made by ship, being by road the transport from the factory of origin to port and from port to destination. For the calculation of these emissions associated with the shipment from the supplier, standardized calculation methods have been used and validated by third parties.

The detail of the components is included in the following table:

Table 1. Product components

Component	Weight (g)
Power cable Advance	205
Intel Core i5-8500 processor	31,1
RAM 8 GB Crucial CT8G4DFD824A	15,83
Crucial SSD Hard Drive CT500MX500SSD1 SSD 500GB 2.5" SATA MX500	47,7
Asus 90MB0XB0-M0EAYM PRIME H310T motherboard	275
Inwin Power Supply IP-P300GF7-2	1.090
Inwin CE685 Chassis	3.680
TOTAL	5.344,63

The following figure includes the manufacturing scheme of the Teknoslim product:

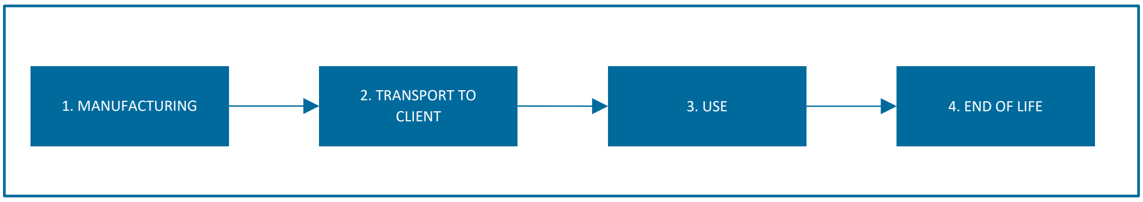

Figure 1. Life Cycle Inventory

3.2.2. Manufacturing

The final product is manufactured at Teknoservice's facilities in Bollullos de la Mitación (Seville). All direct and indirect consumption derived from the manufacture of the products has been considered in the life cycle analysis.

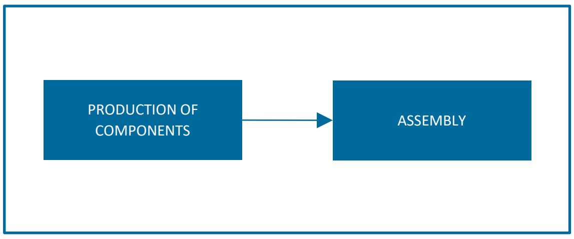

Figure 2. Teknoslim manufacturing phase

The detail of component production is divided into 7 plans, as shown in the figure below:

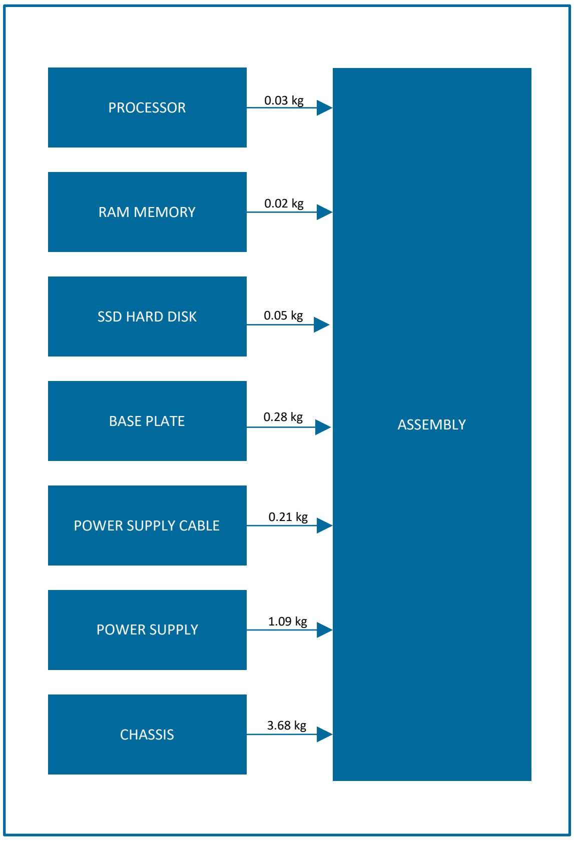

Figure 3. Detail of Teknoslim production

For each of these plans, there is a transportation phase, as shown in the figure below, which represents the shipment of the components to Teknoservice, where they are assembled. This calculation has been adjusted according to the transport distance and the transport method.

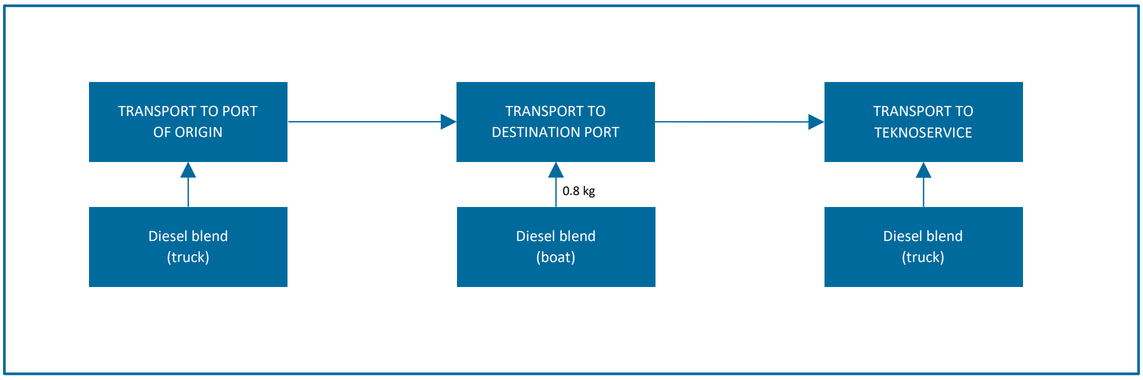

Figure 4. Transport of goods

The following figure shows the manufacturing process of the equipment in terms of energy contribution:

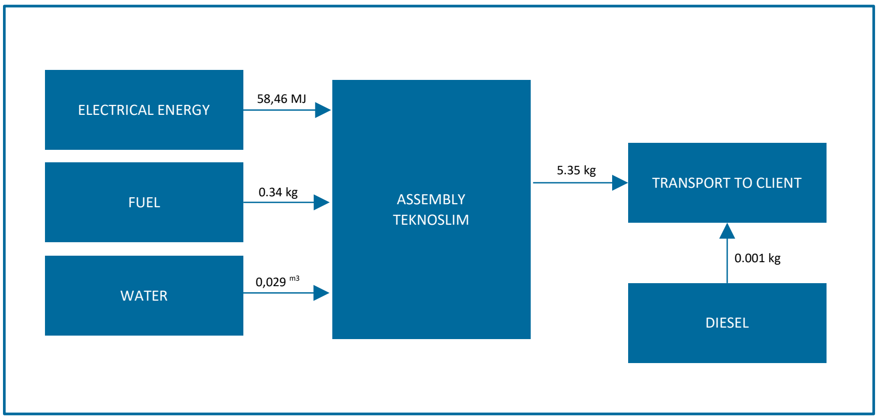

Figure 5. Energy contribution in manufacturing

3.2.3. Distribution

For the transport of Teknoservice to its customers has been calculated through the average delivery distance of this product, being 583 km, based on deliveries made in 2019. The transport of the finished products to the customer is done by road.

3.2.4. Use

For this study, the TEKNOSLIM has estimated a consumption of 81.76 kW/year, corresponding to the equipment's Energy Star certification.

The useful life has been estimated at 5 years, which is the warranty period that Teknoservice usually gives for this product.

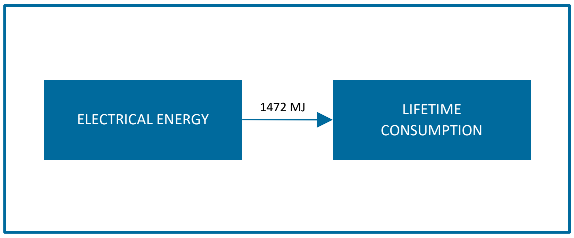

Figure 6. Consumption during use phase

3.2.5. End of life

It has been assumed that at the end of the element's useful life, the end user will make an adequate segregation of it, sending it to waste managers or returning it to Teknoservice for its management as electronic waste. The possibility of reuse has not been considered, since it will be the end consumer who determines this.

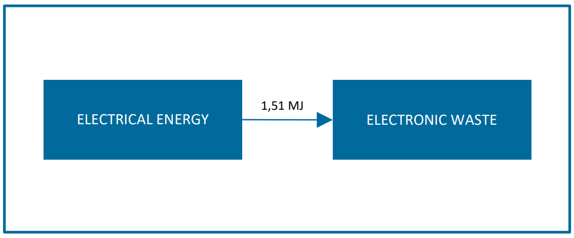

Figure 7. End of product life

3.3. Sources of calculation

3.3.1. Fuels and Energy

Energy consumption has been calculated according to the average electricity mix provided by the National Commission for Markets and Competition, with this value being 0.31 kg CO_2 eq/kWh for 2019.

This information can be found in the following report provided by the Ministry for Ecological Transition and the Demographic Challenge.

3.3.2. Raw materials and processes

The data corresponding to suppliers have been calculated according to the information provided by them. Regarding the manufacturing processes of Teknoservice, as they are of little complexity in terms of material and energy balances, they have been calculated through the consumption of resources produced at the facilities.

3.3.3. Transportation

The emissions associated with the transport of goods from the supplier to Teknoservice have been calculated using DHL Carbon Calculator, which is validated as a recognized system for emissions calculation by SGS. This tool can estimate the CO_2 eq emissions associated with a shipment considering weight, volume, origin and destination depending on the type of transport used (sea, land, air or a combination of these).

The emissions associated with the transport of goods supplied to the customer have been made by calculating the average delivery distance of the equipment, which is 583 km. The transport is carried out by road, so that the CO_2 eq emitted can be estimated with respect to the equivalence factors included in table A1 of the UNE-EN 16258 and with respect to the composition of the transport agency's vehicle fleet and its associated fuel consumption.

The data on fuel consumed by type of vehicle has been extracted from the technical guide for calculating the carbon footprint of road freight transport, issued by the AECOC.

3.3.4. Travel

Teknoservice personnel transfers derived from their professional activity have been included as part of the emissions calculation. International travel has been estimated through the ICAO calculation tool. Emissions derived from the travel of workers to the work center have also been considered based on the average distance from the home and the number of employees and weighted to the total number of products manufactured.

3.3.5. End of life

The end of life of the product has been estimated through the equivalent $_{CO2}$ emission rates provided by the carbon footprint calculation tool created by the Basque Government.

It has therefore been considered that the treatment of 1 Tn of electrical and electronic waste produces 21 Tn of CO_2 eq considering its treatment in a landfill.

4. RESULTS

This chapter contains the results of the LCA study. It should be remembered at this point that the category of impact reported represents a potential impact, it approximates those of the environmental impact that may occur. The inventory only includes the fraction of the environmental load of the selected unit. The results of the LCIA therefore are only relative ion considerations and do not predict actual impacts.

4.1. Overall results

Overall, the results of this study exemplify that the manufacture of computer equipment has a high impact on the environment during its useful life, especially in terms of energy consumption, and there is a great margin for improvement in this regard. We must also highlight the energy sources, since a commitment to cleaner origins would have a global impact on the carbon emissions produced by electronic products.

All this analysis leads to a series of recommendations:

- Promote improvements in the supply chain, seeking the optimization of manufacturing processes, using renewable sources of energy.
- Promote the efficiency of power supplies, seeking to achieve the same functionality of the product using less energy during the use of the equipment.
- Opting for clean energy sources, especially at the point of use of the equipment, as it accounts for 56% of the product's overall emissions.

4.1.1. Global Warming Index

For the Teknoslim product, the result of the carbon footprint, classified into 5 categories according to ISO 14064-1 are as follows:

Table 2. Teknoslim carbon footprint categories

Category	Emissions (kg $_{CO2}$ eq)	TOTAL (kg $_{CO2}$ eq)
1. Fuel consumption in manufacturing	1,284	147,6
2. Electricity consumption in manufacturing	5,034	
3. Transport to the customer	10,997	
4. Supply of components	47,109	
5. End of life	83,180	

From the values analysed, it can be concluded that 87.7% of the emissions associated with the product come from the component manufacturing, use and end-of-life phases. On the other hand, Teknoservice's direct contribution to the product barely represents 4.4% of the total. It is therefore concluded that it is necessary to influence the calculation of emissions represented by third parties, reaching the origin of the extraction of raw materials to have a real representation of the impact of a product.

By making a detail of the components used in the product, the following emissions data are obtained:

Table 3. Component Emissions

Component	Manufacturer	Manufacturing emissions (kg CO_2 eq)	Transport emissions (kg CO_2 eq)	Total emissions (kg CO_2 eq)
Power cable	Preview	0,86	0,030	0,88
Processor	Intel	9,00	0,003	9,00
RAM memory	Crucial/Micron	5,55	0,035	5,59
SSD hard disk	Crucial/Micron	19,98	0,035	20,02
Base plate	Asus	9,30	0,02	9,32
Power supply	Inwin	0,70	0,0004	0,70
Chassis	Inwin	1,11	0,49	1,60

Figure 8 shows the results of the GWP index for each of the phases of the product life cycle. Phase 1 corresponds to the obtaining of raw materials, phase 2 to the emissions derived from energy consumption during manufacturing, phase 3 to the emissions derived from the transport of materials, phase 4 to the manufacturing of components and phase 5 to the use and recycling of the product.

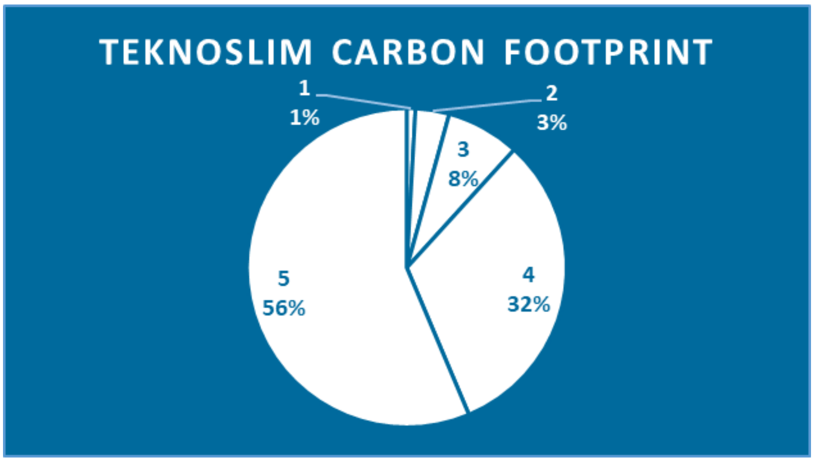

Figure 8. Result of the GWP indicator of the Teknoslim life cycle

Within the category of impact by component, the vast majority of the impact comes from the SSD hard disk, motherboard and RAM memory, which account for 81% of the emissions associated with the components of the equipment. The main source of these emissions is in the manufacture of this equipment, and there are no major contributions related to transport to Teknoservice's facilities.

4.1.2. Primary energy demand

The following table summarizes the primary energy consumption of the Teknoslim product:

Table 4. Primary energy consumption

Category	Primary energy consumption (MJ)	TOTAL (MJ)
Manufacturing	73,83	2228,38
Components	681	
Use	1472	
End of life	1,51	

Proportionally, this analysis highlights the demand for primary energy during the use of the equipment compared to the other phases of the product life cycle.

4.1.3. Water consumption

The following table summarizes the water consumption of Teknoslim product:

Table 5. Water consumption

Category	Water consumption (L)	TOTAL (L)
Manufacturing	2,9	9,1
Components	6,2	
Use	0	
End of life	0	

5. INTERPRETATION

5.1. Identification of significant findings

- The use phase accounts for 56.5% of the total emissions of the product during its life cycle. During this phase the energy source determines the environmental impact.
- Manufacturing by Teknoservice only contributes 8.7% of the total product footprint.
- The transport of components from suppliers to Teknoservice has a minimum weight in relation to the overall product.
- Considering only the manufacturing phase of components, the emissions associated with the SSD, as well as those corresponding to the processor and the motherboard, stand out. These 3 components alone account for 81.3% of the emissions associated with the products.

5.2. Data quality assessment

The data inventory is evaluated for its accuracy (measured, calculated or estimated), completeness (unreported emissions), consistency (degree of uniformity of the methodology used) and representativeness (graphical, temporal and technological).

To meet these requirements and ensure reliable results, direct data provided by industry and official sources have been used.

5.2.1. Accuracy and Integrity

- Accuracy: As most of the data is based on direct sources or information sources from the owner of the technology, it is considered suitable considering the objective and scope of this study. All data extracted from official databases are documented.
- Integrity: All processes in the foreground have been verified through a material balance, in addition to the emissions inventory. Only the packaging has been deliberately omitted, which being a 100% recyclable element and the possibility of various forms of shipment can distort the values obtained. The integrity of the evaluated data is considered to be high.

5.2.2. Consistency and Reproducibility

- Consistency: To ensure data consistency, all data has been collected with the same level of detail, always using official or validated sources.
- Reproducibility: Reproducibility is supported through the disclosure of input and output data, the choice of data sources and the calculation models used in the report.

5.2.3. Representativeness

- Temporary: All the main data has been extracted from the year 2019. Secondary data is extracted from recent official or public sources, which is highly representative.
- Geographic: All data have been collected from the countries or regions under study. All possible origins of goods and places of use of the equipment have been considered. Geographical representativeness is considered high.
- Technology: All primary and secondary data have been modelled to be specific to the technology under study. Where no specific data exists, approximations have been made. The technological representativeness is good.

5.3. Model integrity and consistency

5.3.1. Integrity

All relevant process stages have been considered for each product system, and modelled to represent each specific situation. The process line is considered sufficiently complete and detailed with respect to the objectives and scope of this study.

5.3.2. Consistency

All assumptions, methods and data are consistent with each other and with the objective of the study and scope. System boundaries, assignment rules, and impact assessment methods have been consistently applied in the study.

6. BIBLIOGRAPHY

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ICAO Carbon Emissions Calculator: https://applications.icao.int/icec 2016.

CRITICAL REVIEW STATEMENT

Life Cycle Analysis of a TEKNOSLIM

Made by:
TEKNOSERVICE S.L.

Commissioned by:
TEKNOSERVICE S.L.

Reviewed by:
Jenny Lorena Victoria Escobar (Solar Projects, Spain)

References:

- ISO 14040 (2006): Environmental Management - Life Cycle Assessment- Principles and Framework
- ISO 14044 (2006): Environmental Management - Life Cycle Assessment - Requirements and Guidelines
- ISO/TS 14071 (2014): Environmental Management - Life Cycle Assessment- Critical Review Processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006

Scope of critical review:

This critical review verifies that:

- The methods used to perform the LCA are consistent with the international ISO standards
- 14040 and ISO 14044.
- The methods used to perform the LCA are scientifically and technically valid
- The data used are adequate and reasonable in relation to the objective of the study.
- The interpretations reflect the limitations identified and the objective of the study.
- The study report is transparent and consistent.

This revision is valid for the final version of the LCA report dated 03/12/2020 with its calculation annex. The evaluation of individual data sets is outside the scope of the critical review.

2. Critical review process

The process has been developed according to ISO 14040 (2006) section 7 and ISO 14044 (2006) section 6.
The critical review process was developed in three phases. In the first and second phase, the review was conducted via email exchange and the third phase was a review via video conference. The review process began after the completion of the first version of the LCA and took place between October and December 2020. In the first review, 17 comments were issued, classified as general (ge), technical (te), and editorial (ed). For each comment, the respective recommendation was indicated and the page number, section, paragraph/table/figure corresponding to the first version of the LCA was provided. These comments were sent to Teknoservice on October 27 and the following day they were answered including the delivery of the Excel file that supports the calculations. This first revision

generated the second version of the LCA report received on November 19. Phase 2 consisted of the review of this second LCA report, which yielded 20 comments that were sent to Teknoservice on December 1st. Teknoservice responded to the comments the next day and delivered the third version of the report. Phase 3 consisted of consultations that the reviewer made to Teknoservice about the data in the Excel file that supports the calculations, this was done on December 3 by videoconference. No changes were made to the LCA report in this review.

General Evaluation

The main purpose of the LCA study is to comply with the *optional* criterion 4.8.1.1 of "*Optional-Product life cycle assessment and public disclosure of analysis*" of the international standard IEEE 1680.1 *Standard for Environmental and Social Responsibility Assessment of Computers and Displays (IEEE 1680.1 Standard for Environmental and Social Responsibility Assessment of Computers and Displays)*, in its 2019 version, to obtain the Gold category of the EPEAT ecolabel for the Tecknoslim manufactured by Teknoservice. The functional unit and the objective are clearly defined. The limit of the system includes the stages of obtaining materials, production, distribution, use and final disposal. The data used to evaluate the impact of global warming and energy demand in the product life cycle, as well as direct water consumption are appropriate for the purpose of the study.

Teknoservice made an effort to collect information from primary sources and in those cases where it was necessary to make assumptions were argued, as the life of the product of 5 years, this being reasonable with respect to the life of electrical and electronic equipment in the range.

The person responsible for responding to comments was always willing to clarify all issues raised during the review process in a transparent and timely manner.

Conclusion

The study was conducted in accordance with ISO 14040 and ISO 14044. The critical review has concluded that the methodology followed and its execution are adequate for the purposes of this study. The results and interpretations reached by the study are transparent and in accordance with the objective of the study.

Signed by:

Jenny Lorena Victoria Escobar.
Solar Projects
December 3rd, 2020