Automotive Precision Technology (APT)

LCA Background Report for Aluminum Automotive components and Sub-Assemblies

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Presented by-

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Executive Summary

Life Cycle Assessment (LCA) is an effective methodology for evaluating the potential environmental impacts of a product or service. This study is conducted to apply for an Environmental Product Declaration (EPD), which requires understanding and reporting the potential environmental impacts of products and materials. The focus of this study is on aluminum automotive components and sub-assemblies produced by Automotive Precision Technology. The LCA is performed in accordance with the guidelines provided under ISO 14040/14044 and the Product Category Rule. The study has evaluated various potential environmental impact categories, including Abiotic Depletion (including fossil fuels), Global Warming Potential (GWP100a), Ozone Layer Depletion (ODP), Water Scarcity, Photochemical Oxidation, Acidification, and Eutrophication. Results are presented within a "cradle-to-gate" system boundary, focusing on products categorized as 'Basic aluminum products' and special alloys. The intended time reference for the study is the 2023 Calendar year, and the geographical coverage of this study is KEZAD, Abu-dhabi UAE.

LCA has considered the environmental impacts and resource consumption in two stages, Upstream and Core in the life cycle of the products.

Aluminum accounts for 96% of the total raw materials used in producing Aluminum Automotive components and Sub-Assemblies products. The use of Aluminum extrusion significantly influences the major environmental impacts associated with raw material use. This approach helps mitigate environmental impact by reducing the need for extracting virgin raw materials and instead utilizing recycled materials.

The declared unit used in the assessment, which serves as the basis for comparisons, is a mass functional unit of 1 ton of product. Accordingly, the results of LCA are shown on a basis of 1 ton of product produced.

1. Definitions

Life Cycle: A view of a product system as "consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal" (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land, and water.

Life Cycle Assessment (LCA): "Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040:2006, section 3.2)

Life Cycle Inventory (LCI): "Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle" (ISO 14040:2006, section 3.3)

Life Cycle Impact Assessment (LCIA): "Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product" (ISO 14040:2006, section 3.4)

Life cycle interpretation: "Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations" (ISO 14040:2006, section 3.5)

Functional unit: "Quantified performance of a product system for use as a reference unit" (ISO 14040:2006, section 3.20)

Allocation: "Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006, section 3.17)

Cut-off-Criteria: specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product system to be excluded from a study" (ISO 14040:2006, section 3.17)

2. Introduction

2.1 Introduction of Organization

Automotive Precision Technology (APT) is an Abu Dhabi-based aluminum parts manufacturing subsidiary fully owned by Al Ghurair Group; a United Arab Emirates (UAE) headquartered conglomerate.

With over 20 years of experience and formerly called REFCO Metals, our origins are from the acquisition of British company Sport Carrier Ltd (founded in 1997), itself a UK-based aluminum alloy extrusion fabrication and surface treatment specialist, supplying the automotive trade.

Automotive Precision Technology (APT) operates from its purpose-built manufacturing facility spanning 98,000 square feet in KEZAD, Abu Dhabi, UAE. The original REFCO Metals Dubai plant in Jebel Ali was pioneering as the first of its kind in the UAE. At our core, we specialize in processing automotive-grade aluminum alloy extrusions from billet to finished components tailored to customer specifications, employing advanced production processes, technologies, and techniques. APT primarily sources its billets from Emirates Global Aluminum (EGA), a UAE-based supplier, which serves as an external supplier for our in-group extruder, Gulf Extrusions. With strategically located global warehousing and logistics facilities, Automotive Precision Technology (APT) is strategically positioned to supply ongoing production parts to the global market. Our typical automotive end customers, spanning mainland Europe, the UK, USA, and the GCC, include numerous global OEMs.
The company has following certifications to its credit VDA 6.1, IATF 16949: 2016, ISO 14001:2015, ISO 45001: 2018, and ISO 50001:2018.

2.2 Introduction of Products

The products included under the category name "Aluminum Automotive components and Sub-Assemblies" for which Life Cycle Assessment (LCA) study has been conducted.

Automotive Precision Technology manufactures products in various physical shapes based on customer demand, each named according to its specific shape. Examples include components for electric vehicle battery applications, sunroofs, sills and rockers, and front and rear bumper sub-assemblies. Images of these products in their different shapes are displayed below.

Figure 1 Images of product based on physical shape

The product types mentioned above are used in automobile segments. During the manufacturing process, the product undergoes various unit operations such as sawing and mitre cutting, pressing and punching, CNC milling, manual and robotic welding, profile bending, heat treatment, and sub-assembly.

2.3 Introduction of Study

This LCA report of an Aluminum Automotive components and Sub-Assemblies products describes the emissions and impacts of products through the "Cradle-to-Gate" lifecycle system boundary. The LCA of products is primarily conducted for making Environmental Product Declaration (EPD) report of Aluminum Automotive components and Sub-Assemblies products category of Automotive Precision Technology. The manufacturing facility is located at KEZAD, Adu dhabi, UAE. Along with a report for EPD, this detailed LCA report is made for internal review and analysis of emissions. This marks the company's inaugural Life Cycle Assessment (LCA) for its products, driven primarily by the objective of publishing an Environmental Product Declaration (EPD). Additionally, the company aims to grasp the scope of emissions and potential environmental impacts of its products, paving the way for actionable plans and measures to reduce its overall environmental footprint.

The information and data used in conducting this study covers the Calendar year 2023. This study meets the requirements of the international standards for Life Cycle Assessment (LCA) according to ISO 14040:2006 and 14044:2006 and Product Category Rules (PCR).

2.4 Introduction of Product Category Rule (PCR)

A PCR is a copyright document that is part of the EPD generation and contains detailed guidance to create a high-quality EPD. The PCR also provides instructions for conducting LCA studies and defines the conditions for EPD, some of which are listed below:

- System boundaries refer to the specific processes and stages of the product's life cycle that must be taken into account.

- Declared/ functional unit: the amount, weight and service life of the product being assessed.
- Defining the use phase and end-of-life options
- Impact categories that need to be assessed in addition apart from the standard set.
- The PCR used for conducting the study is “Basic aluminum products and special alloys” Product category classification: UN CPC 4153 v1.0 (2022:08)”.

2.5 Introduction to LCA

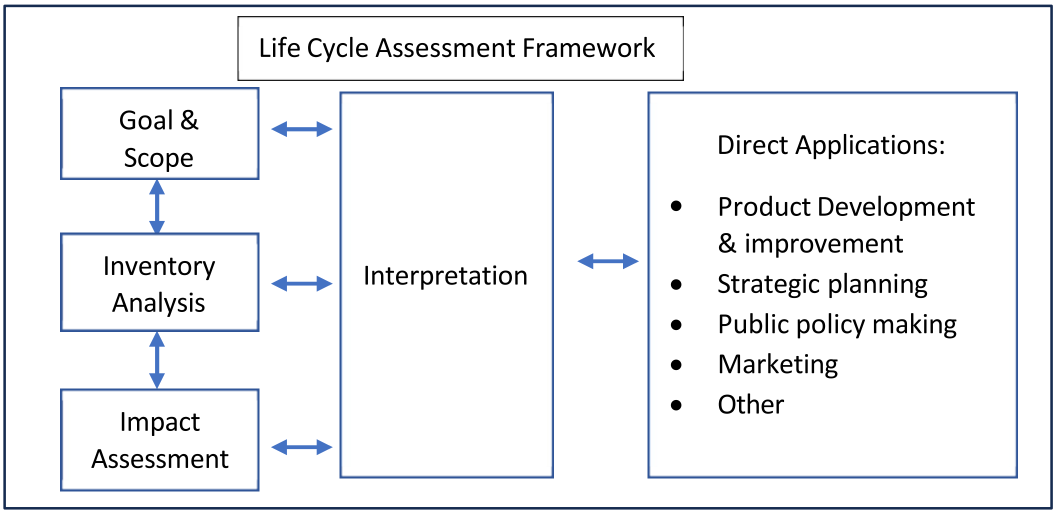
LCA is an analytical tool used to quantify and interpret the impacts as a result of flows to and from the environment (including emissions to air, water, and land, as well as the consumption of energy and other material resources), over the entire life cycle of a product or service. By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the environmental trade-offs in comparing alternatives.

For a LCA study, ISO 14040 and ISO 14044 set out a four-phase methodology framework, which is as follows:

1. Goal and scope definition,
2. Life cycle inventory,
3. Life cycle impact assessment,
4. Interpretation.

This stepwise process is followed in the LCA conducted for APT products and presented below.

Figure 2 LCA Framework (ISO14040)



3. Goal and Scope

The first phase of a LCA defines the goal and scope of the study. According to ISO 14044, the goal of the study should clearly specify the intended application, reasons for carrying out the study, the intended audience, and whether the results are intended to be disclosed to the public.

The scope of the study describes the most important aspects of the study, including the functional unit, system boundaries, cut-off criterion, allocation, impact assessment method, assumptions, and limitations.

3.1 Study Goals

3.1.1 Goals of the Study

The goal of the study is to conduct an LCA to understand the environmental impacts of products and further enable the development of an EPD according to ISO 14025 and PCR for product category "Basic aluminum product and special alloys products" as manufactured by Automotive Precision Technology (APT) in KEZAD, Abu-dhabi UAE. The study shall enable the company to understand quantified environmental impacts of their products over their entire lifecycle and to plan efforts towards reduction of these impacts in future.

3.1.2 Intended Applications and Audience

This LCA report is intended to support the development of EPD. The intended audience for the EPD include Automotive Precision Technology, their suppliers, automobile segments, and specific professional, LCA practitioners and academia, governmental organizations, policymakers and other interested value chain parties who require reliable information on Aluminum Automotive components and Sub-Assemblies products of Automotive Precision Technology.

3.1.3 Comparative Assertions

The resulting EPD based on this LCA report does not constitute comparative assertions. Environmental impact results are based on the declared unit of the product category as per the physical properties, and hence the results shall not be used for comparison purposes.

As per PCR, this LCA report shall be made available to the verifier with the requirements on confidentiality stated in ISO 14025.

3.2 Scope of Study

The scope of the study entailed developing a "cradle to gate" life cycle assessment for the product category "Aluminum Automotive components and Sub-Assemblies products" of Automotive Precision Technology for the reference production year 2023.

3.2.1 Product Functional/ Declared Unit

A functional unit identifies the primary function(s) of a system based on which alternative systems are considered functionally equivalent (ISO 14040, 2006). This facilitates the determination of reference flows for each system, which in turn facilitates the comparison of two or more systems.

A functional unit in LCA defines qualitative and quantitative aspects of the functions or functions delivered by the product system. It also determines the reference flow, which is the product flow to which all input and output flow for the processes in the product system much be quantitatively related. Based on the identified function, a mass functional unit has been chosen. The product functional/ declared unit is identified as tonne of Aluminum automotive component produced. Hence all results of this analysis are shown on a basis of 1 tonne of Aluminum automotive product and sub-assembly components produced.

3.2.2 System Boundary

System boundaries are established in LCA in order to include the significant life cycle stages and unit processes, as well as the associated environmental flows in the analysis. This lays the groundwork for a meaningful assessment where all important life cycle stages, and the flows associated with each alternative, are considered.

There are various well established System Boundaries that a LCA can consider such as Cradle to Grave, Cradle to Cradle and Cradle to Gate and so on. For the purpose of this LCA, following the product category rule “Cradle to Gate” system boundary is considered, excluding the Use, transportation and End of life of the products.

Thus, LCA conducted for Automotive Precision Technology considers the environmental impacts and resource consumption for the following stages in the life cycle of the products:

Upstream Process: It includes the extraction of raw material with transportation and transportation of raw materials to the manufacturing facility of APT.

Core Process: It includes the overall production processes involved in the manufacturing of products with different types of resources and fuel consumptions. Each sub-process in manufacturing is included, and part of the core process.

Excluded lifecycle stages: According to the product category rule, the following rule apply.

- Exclusion in Upstream Process
    - Packaging of raw materials used for the manufacturing of Aluminum alloy, as considered not relevant.

- Exclusion in Core Process

- Manufacturing of production equipment, buildings, and other capital goods.
- Business travel of personnel.
- Travel to and from work by personnel.
- Research and development activities, including the production and manufacture of laboratory equipment.

- Exclusion Downstream Process
  - The use stage of the product is excluded.
  - Transportation of finished products
  - End of life of product

The process system boundary is depicted below-

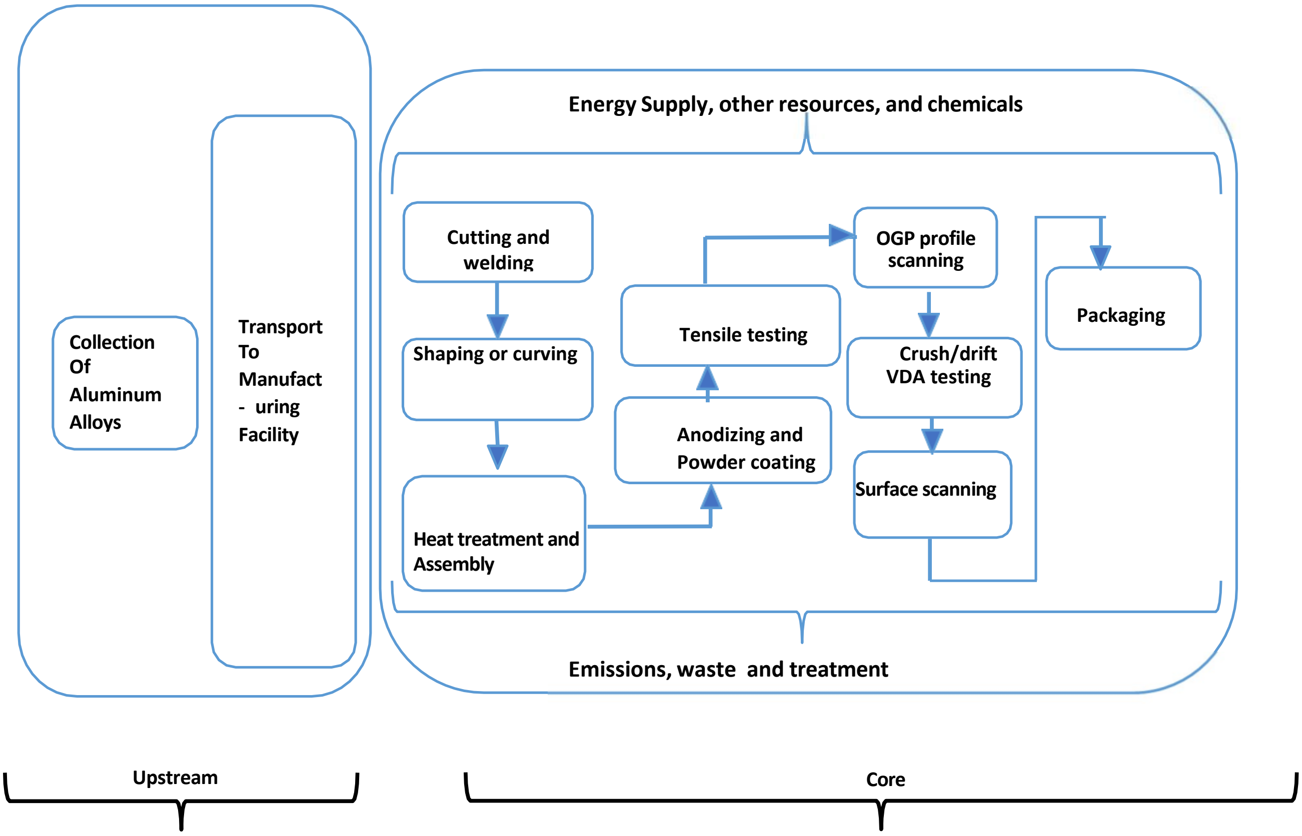


Figure 3 System Boundary

The following are other parameters based on which the scope and system boundaries for the LCA are further defined:

3.2.2.1 Time Coverage

The LCA study has been conducted for the calendar year 2023. All the data which corresponds to the assembly was collected and provided by APT for the reporting year.

3.2.2.2 Geographical Coverage

The study's geographical scope covers the Automotive Precision Technology (APT) plant located at KEZAD, Abu Dhabi, UAE, where aluminum components are manufactured.

3.2.2.3 Technology Coverage

This study assesses the “cradle-to-gate” impacts of the product based on production. Primary production data was gathered from the company and additional data related to transportation of finished product to distributor was also collected and included in the study.

3.2.3 Allocation

While conducting an LCA, if the life cycles of more than one product are connected, allocation of the process inputs should be avoided by using the system boundary expansion approach. If allocation cannot be avoided, an allocation method – based on physical causality (for example, mass or energy content) or any other relationship, such as economic value – should be used (ISO 14044 2006).

The Automotive Precision Technology manufacturing facility produces only products included in the product category for LCA study as the main product. Also, the output from the core process i.e., metal cut and wastewater are not used in the making of any of the product. The input & output are the same for all products included in the product category, hence no allocation was applied to the product manufacturing process.

3.2.4 Cut off Criteria

Cut-off criteria are often used in LCA practice for the selection of processes or flows to be included in the system boundary. No cut-off criteria are applied in this study. All reported data were incorporated and modelled using the best available LCI. No known flows are deliberately excluded. No substances with hazardous and toxic properties that pose a concern for human health and/or the environment were identified in the framework of this EPD. Any plant specific data gaps for the reference year 2023 were not identified.

All the material and energy flow inputs for all the processes and the outputs have been included and modelled in the analysis within the system boundary defined.

3.2.5 Selection of LCIA Methodology and Impact Categories

Impact assessment methods are used to convert LCI data (environmental emissions and raw material extractions) into a set of environmental impacts. ISO 14044 does not dictate which impact assessment method to use for a comparative assertion; however, the chosen method needs to be an internationally accepted method if the results are intended to be used to support a comparative assertion disclosed to the public.

Based on the PCR, default EPD impact categories acidification, eutrophication, global warming, photochemical oxidation, abiotic depletion, abiotic depletion (fossil fuel), water scarcity, and ozone layer depletion are applicable to the context of the study, are widely used and respected within the EPD community.

3.2.6 Interpretation

No grouping or further quantitative cross-category weighting has been applied. Instead, each impact is discussed in isolation, without reference to other impact categories, before final conclusions and recommendations are made.

3.2.7 Data Quality Requirements

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under the given time.

- Measured primary data measured is of the highest precision. The goal is to model all relevant processes using measured primary data.
- Completeness is judged based on the completeness of the inputs and outputs of the manufacturing process. The goal is to capture all relevant data in this regard.

An evaluation of the data quality regarding these requirements is provided in Section 4 of this report.

3.2.8 Type and Format of the Report

In accordance with the ISO requirements this document aims to report the results and consumption of the LCA to the intended audience completely, accurately, and without bias. The results, data, methods, assumptions, and limitations are presented in a transparent manner and in sufficient detail to convey the complexities and limitations to the reader. This allows the results to be interpreted and used in a manner consistent with the goal and scope of the study.

3.2.9 Assumption

The overall data used for modelling of LCA study for all input resources were retrieved from the ERP (Enterprise Resource Planning) system that captures the actual data of all types of materials and fuels consumed during the manufacturing process of Aluminum Automotive components and Sub-Assemblies product of Automotive Precision Technology. Hence, all the input data is actual and carries no assumption.

3.2.10 Limitations

One of the outputs of manufacturing processes is emissions from the oven stack, whose actual complete data was unavailable. Hence, the data of air emission from the stack due to burning of fuel in heating oven was retrieved from Ecoinvent 3.9 database.

3.2.11 Missing Data

Yearly data of stack emissions resulting from the stack of oven is missing, as the organization performs emission monitoring once a year. Hence, an available ecoinvent 3.9 database of fuel oil including data of air emissions was used in modelling.

3.3 Software and Database

The LCA model was created using the SimaPro 9.6.0.1 Software system for life cycle assessment. The SimaPro 9.6.0.1 LCI database provides the life cycle inventory data for the raw and process materials obtained from the background system.

3.4 Critical Review

A critical review of the report was not carried out, but an internal review is performed to ensure compliance and quality of results.

4. Life Cycle Inventory

The second phase of an LCA is to collect life cycle inventory (LCI) data. LCI data contains the details of the resources flowing into a process and the emissions flowing from a process to air, soil, and water.

4.1 Data Collection

Primary data of manufacturing, input/output, and transportation were collected for products included in product category for the reference year 2023. This data was collected from Automotive Precision Technology. The study made use of primary data. The LCI data was collected through a customized data collection format. The format covered the following primary data for the Calendar year 2023:

Table 1 Material Input and Output types

<table>
<tr><th>Material Input</th><th>Type of data</th><th>Validation remarks</th></tr>
<tr><td>Aluminium Alloy</td><td rowspan="7">Actual data</td><td rowspan="7">Verified through ERP/SAP system</td></tr>
<tr><td>Electricity</td></tr>
<tr><td>NG heating</td></tr>
<tr><td>Coating Mat.(Cationic Epoxy)</td></tr>
<tr><td>Packaging Cardboard</td></tr>
<tr><td>Packaging wood</td></tr>
<tr><td>Forklift LPG</td></tr>
</table>

Sources of data and database used specified in (Annex A & B)

Annexure A & B summarizes the LCI data for the product category. Data on transport of products to customers is also collected in the data collection format. Transportation activities are included consistently in the respective life cycle module. Trucking is the primary mode of transport for the input/out flows followed by sea for finished products.

4.1.1 Fuels and Energy

The fuel and electricity inputs were obtained from the ecoinvent 3.9 database. The country specific inputs are not selected for electricity consumption as unavailability of data from database. Rest of the world data has been taken in reference.

4.1.2 Raw Materials and Processes

Data for raw materials used in the processes are obtained from the ecoinvent 3.9 database.

4.1.3 Electricity Mixes

For the product, specific power use in kWh based on the rest of the world region is used from the ecoinvent 3.9 database.

As shown in Annexure A, the grid mix (Electricity, high voltage {RoW}| market for electricity, high voltage | Cut-off, S) is used for manufacturing of product. The electricity dataset includes electricity inputs produced in this region and imports from other four regional grids, the transmission network, direct emissions to air, and electricity losses during the transmission.

4.1.4 Transportation

Transportation distance and modes of transport are included for the transport of the raw materials. This information was sought by the manufacturer who provided this data.

SimaPro databases were used to model transportation. Truck transportation was modelled using freight lorry 16-32 metric ton.

4.2 Data Quality

Primary data was collected from the manufacturing unit including all materials and energy input and output. At manufacturing facility Automotive Precision Technology make use of ERP System that avoids duplication of data and internal quality assurance was maintained at different stages of the product production by a designated team involved in overall data maintenance and quality check. The team involved in the data collection and quality check include head of the departments and internal team for ensuring the data quality. The objective of this process is to ensure that the data collection, the development of the LCI model, and results are consistent with the scope of the study.

As per PCR, appropriate activity and LCI primary data were used for modelling. LCI data was as representative (technologically, geographically, and time specific), complete, consistent, and transparent as possible with regards to the goal and scope of the study. The details of collected data as per PCR and ISO 14044 requirements is provided in Annexure A & B. Data quality is assessed based on its representativeness (technology coverage, geographic coverage, time coverage), completeness, consistency, transparency, and uncertainty.

Table 2 Data Quality Requirements and Assessments

Data Quality Requirements	**Description**
Technology Coverage	Data represents the prevailing technology that is in market use. Whenever available, for all upstream and core material and processes, ecoinvent LCI database were utilized.
Geographic Coverage	The geographical region considered is KEZAD, Abu dhabi, UAE. The geographic coverage of all LCI databases and datasets is given in Annex-A & B.
Time Coverage	The intended time reference for the study is the 2023 Calendar year, which corresponds to the data provided for the assembly. Data collected from Automotive Precision Technology for this year.
Completeness	All relevant, specific processes including inputs (raw material, energy, and fuel) and outputs (emissions and production volume) were considered and modelled. The relevant background materials and processes were taken from the ecoinvent 3.9 LCI database and modelled in SimaPro Software V.9.6.0.1. The completeness of the cradle to gate process chain in terms of process steps is rigorously assessed for the product category. The LCA team conducted data check at the facility level and product level, log checks.
Transparency	Activity and LCI datasets are transparently disclosed in the LCA report, including data sources.

4.2.1 Data Validation

Primary data were validated with mass balance during the data collection process to confirm data quality requirements and completeness of the study. No data was knowingly omitted.

Further, all respective data of material and fuels consumed in manufacturing of Aluminum Automotive components and Sub-Assemblies products were validated from the ERP system maintained by Automotive Precision Technology. The electricity data was validated from the monthly electricity bills.

5. Life Cycle Impact Assessment

Life Cycle Impact Assessment (LCIA) is defined in ISO 14044 Section 3.4 as the "phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product." In the LCIA phase, the inventory of emissions is first classified into categories in which the emissions may contribute to impacts on human health or the environment. Within each impact category, the emissions are then normalized to a common reporting basis, using characterization factors that express the impact of each substance relative to a reference substance.

The LCIA phase establishes links between the life cycle inventory results and potential environmental impacts. These impact indicators provide general, but quantifiable, indications of potential environmental impacts.

Each impact indicator is a measure of an aspect of a potential impact. This LCIA does not make value judgments about the impact indicators. This means that comparison indicator values are not valid, and each impact indicator value is stated in units that are not comparable to others. For the same reasons, indicators should not be combined or added. Additionally, the LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Cradle-to-Gate environmental performance results for acidification, eutrophication, global warming, photochemical oxidation, abiotic depletion, water scarcity, and ozone layer depletion of Aluminum Automotive components and Sub-Assemblies product, shown in below Table 3. The LCIA results in these tables show the values for Upstream and Core processes.

Table 3 Analysis for 1 tonne of products

Description	kg CO_2-eq
Aluminum, cast alloy	5.901911187
Transport	0.000428
Cationic resin	0.000657654
Wood pellet	0.003241314
Corrugated board box	0.032548091
Electricity	1.624196334
Heat, NG	0.003853218
Propane (LPG)	0.001391723
Waste wood	9.79941E-05
Waste paperboard	5.16555E-05
Aluminum in car shredder residue	0.00379608

6. Life Cycle Interpretation

As defined by ISO (2006), the term life cycle interpretation is the phase of the LCA that the findings of either the LCI or the LCIA, or both, are combined consistent with the defined goal and scope in order to reach conclusions and recommendations. This phase in the LCA reports the significant issues based on the results of the presented in LCI and the LCIA of this report. Additional components report an evaluation that considers completeness, sensitivity, and consistency checks of the LCI and LCIA results, and conclusions, limitations, and recommendations.

6.1 Identification of the Significant Issues

The objective of this element is to structure the results from the LCI or the LCIA phases to help determine the significant issues found in the results and presented in previous sections of this report. A contribution analysis was applied for the interpretation phase of this LCA study. Contribution analysis examines the contribution of life cycles stages, unit process contributions in a multi-unit manufacturing process, or specific substances which contribute an impact.

6.2 Life Cycle Material Contribution Analysis

In the below Table 4, the phase-wise analysis is shown. On average, the upstream process presents the highest impact contribution to most environmental impact categories due to use of fresh Raw Material, and electricity used in manufacturing process of product.

The LCA impacts of upstream and core processes and their break-up are given below-

Results for Upstream Process

Table 4 Upstream Material Wise Impact Assessment

Impact category	***Unit***	***Aluminium, cast alloy***	***Transport, freight***
Acidification (fate not incl.)	*kg SO2 eq*	*0.033651765*	*2.08E-06*
Eutrophication	*kg PO4--- eq*	*0.010909153*	*4.67E-07*
Global warming (GWP100a)	*kg CO2 eq*	*5.869204229*	*0.000428*
Photochemical oxidation	*kg NMVOC*	*0.021099593*	*3.06E-06*
Abiotic depletion, elements	*kg Sb eq*	*6.98054E-05*	*1.8E-09*
Abiotic depletion, fossil fuels	*MJ*	*55.34192486*	*0.00581*
Water scarcity	*m3 eq*	*1.330982469*	*2.79E-05*
Ozone layer depletion (ODP) (optional)	*kg CFC-11 eq*	*3.1957E-08*	*4.6E-12*

Among upstream processes, use of Aluminum alloy followed by transportation of raw material to manufacturing facility has the highest emission.

Results for Core Process

The core phase includes manufacturing of products with use of NG, electricity and fuels. The emissions from consumption of each resource are show below:

Table 5 Core Material Wise Impact Assessment

Impact category	***Unit***	***Cationic resin***	***Wood pellet***	***Corrugated board***	***Electricity***
Acidification (fate not incl.)	*kg SO2 eq*	*3.2E-06*	*1.49E-05*	*0.000137*	*0.013818*
Eutrophication	*kg PO4--- eq*	*7.23E-07*	*6.32E-06*	*0.000105*	*0.004978*
Global warming (GWP100a)	*kg CO2 eq*	*0.000653*	*0.003241*	*0.035693*	*1.618328*
Photochemical oxidation	*kg NMVOC*	*2.18E-06*	*1.5E-05*	*0.000156*	*0.006179*
Abiotic depletion, elements	*kg Sb eq*	*9.7E-09*	*1.09E-08*	*1.16E-07*	*3.38E-07*
Abiotic depletion, fossil fuels	*MJ*	*0.011977*	*0.038824*	*0.400305*	*15.63645*
Water scarcity	*m3 eq*	*0.000368*	*0.000876*	*0.01045*	*0.129328*
Ozone layer depletion (ODP) (optional)	*kg CFC-11 eq*	*2.71E-12*	*2.62E-11*	*8.11E-10*	*2.3E-09*

Table 6 Core Material Wise Impact Assessment (Cont.)

Impact category	**Unit**	**NG,Heat**	**Propane, LPG**	**Waste wood,**	**Waste paperboard**	**Aluminium in car shredder residue**
Acidification (fate not incl.)	kg SO2 eq	2.942E-06	4.816E-06	9.473E-07	2.398E-06	1.549E-05
Eutrophication	kg PO4--- eq	6.97E-07	1.454E-06	8.381E-07	2.133E-05	5.562E-06
Global warming (GWP100a)	kg CO2 eq	0.0038263	0.0013642	9.697E-05	0.0073682	0.0037859
Photochemical oxidation	kg NMVOC	8.87E-06	9.321E-06	1.32E-06	5.469E-06	2.106E-05
Abiotic depletion, elements	kg Sb eq	1.83E-09	1.073E-08	1.694E-10	1.118E-10	1.027E-08
Abiotic depletion, fossil fuels	MJ	0.0609788	0.0700247	0.0008524	0.0005588	0.0383432
Water scarcity	m3 eq	0.000149	0.0001336	4.112E-05	1.225E-05	0.0012423
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	7.916E-11	7.327E-11	9.107E-13	5.353E-13	3.411E-11

6.3 Waste Production

Table 7 Waste generated for 1 tonne of Products

Parameter	**Unit**	**Total**
Wood waste	kg	6.299
Cardboard waste	kg	2.41
aluminium scrap	Kg	34.051

*The aluminium scrap produced during the manufacturing of components is sold 100% to the supplies for further recycling

7. Conclusion

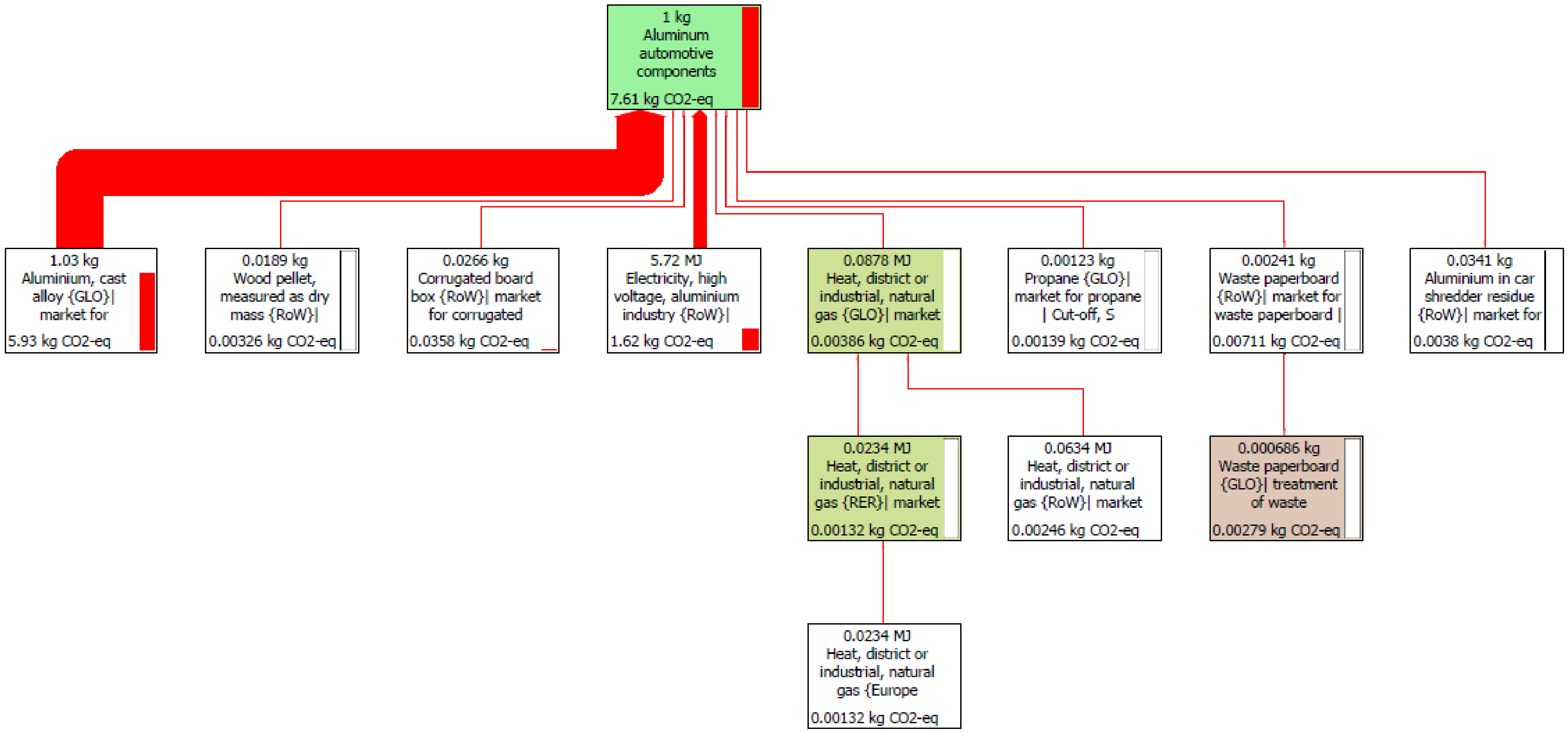
This study provides a comprehensive 'cradle-to-gate' LCA of the production of Aluminum Automotive components and Sub-Assemblies products produced in UAE. The cradle-to-gate LCA for products includes raw materials extraction, transportation of all materials and resources into the production boundary and manufacturing of products.

Total emission for Aluminum Automotive components and Sub-Assemblies products is 7.61 $KgCO_2e$. Emissions from Raw material represent the greatest contribution to over-all impact categories which is 5.93 $KgCO_2e$, while the emissions from core processes have less contribution to all impact categories. Further, as the study is only cradle-to- gate, hence avoidance of emissions is not considered in the study.

References

- PCR 2022:08 Basic Aluminum products and special alloy products, (CPC 4153) v1.0 (2022-08)
- ISO 14040: Environmental management – Life cycle assessment – Principles and framework (2006)
- ISO 14044: Environmental management – Life cycle assessment – Requirements and guidelines (2006)
- ISO 14025:2006: Environmental labels and declarations -- Type III environmental declarations – Principles and procedures.
- SimaPro software 9.6.0.1

Annexure 1- A LCA Result for Aluminum Automotive components and Sub-Assemblies Product



Annexure 2 Input and Output Screenshot from software

Outputs to technosphere: Products and co-products	Amount	Unit	Quantity	Allocation	Waste type	Category	Comment
Aluminum automotive components	1000	kg	Mass	100 %	not defined	Others\D...\APT- LCA	Final Product
Add							

Outputs to technosphere: Avoided products	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add							

Inputs

Inputs from nature	Sub-compartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add								

Inputs from technosphere: materials/fuels	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Aluminium, cast alloy {GLO}| market for aluminium, cast alloy | Cut-off, S	1034.051	kg	Undefined				
Transport, freight, lorry 3.5-7.5 metric ton, EURO3 {RoW}| market for transp	720.7505	kgkm	Undefined				
Cationic resin {RoW}| market for cationic resin | Cut-off, S	0.3734706	kg	Undefined				Cationic epoxy
Wood pellet, measured as dry mass {RoW}| market for wood pellet, measu	18.907	kg	Undefined				
Corrugated board box {RoW}| market for corrugated board box | Cut-off,	26.6296	kg	Undefined				
Add							

Inputs from technosphere: electricity/heat	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Electricity, high voltage, aluminium industry {RoW}| market for electricity, I	1.58934682	MWh	Undefined				All electricity considered
Heat, district or industrial, natural gas {GLO}| market group for heat, distric	83109.33	Btu	Undefined				NG for heat
Propane {GLO}| market for propane | Cut-off, S	1.226282	kg	Undefined				Propand for LPG used in forklift
Add							

Economic issues	Sub-compartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Add								

Outputs to technosphere: Waste and emissions to treatment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max	Comment
Waste wood, untreated {GLO}| treatment of waste wood, untreated, munic	6.299	kg	Undefined				
Waste paperboard {RoW}| market for waste paperboard | Cut-off, U	2.412474	kg	Undefined				
Aluminium in car shredder residue {RoW}| market for aluminium in car shr	34.05125	kg	Undefined				
Add							