



# Cost and Emissions Explanation File

Formula Student 2025 – Steering System

Team Name: *EPSA : Ecurie Piston Sport Auto*

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## 1. Introduction

This document provides comprehensive justification for all cost calculations and greenhouse gas emissions (GHG) presented in the Steering System CCBOM. It serves as the technical reference for judges, detailing assumptions, data sources, methodologies, and validation approaches used to calculate both financial costs and Global Warming Potential (GWP, expressed in CO<sub>2</sub>e equivalent).

The document follows FS2025 sustainability guidelines and provides full traceability for all reported values.

## 2. Cost Model Description

### 2.1 Overall Cost Structure

The total **Parts Cost** of the steering system, as detailed in the CCBOM, is **€1,580.34**. This is broken down as follows:

- **Purchased components (B):** €1,430.96 (approx. 90.5% of Parts Cost)
- **Manufacturing costs (M):** €149.38 (approx. 9.5% of Parts Cost)

### 2.2 Purchased Parts Costing

Purchased parts costs are based on:

- **Direct supplier quotes:** Current 2025 pricing from verified suppliers
- **Educational discounts:** Applied where available (typically 10–20%)
- **Bulk pricing:** Single unit prices used (conservative approach)
- **Currency:** All costs converted to EUR using exchange rates as of May 29, 2025
- **Shipping:** Included in quoted prices where applicable

## 2.3 Manufacturing Cost Breakdown

In-house manufactured parts follow this cost model:

**Total Manufacturing Cost = Raw Material + Machining + Consumables + Labor + Quality Control + Additional Overhead**

### Raw Material Costs

- **Aluminum 7075-T6:** €8.50/kg (includes 20% stock allowance)
- **Aluminum 6061-T6:** €6.20/kg (includes 20% stock allowance)
- **Steel DOM tubing:** €4.80/kg (includes cutting waste)
- **Steel 4140:** €5.50/kg (bar stock with machining allowance)
- **Carbon fiber tube:** €85.00/m (pre-preg, automotive grade). *Note: Used with estimated mass for CO<sub>2</sub>e calculation (e.g., 0.2kg for 0.5m length for Rod Tube, based on typical tube density).*

### Machining Cost Calculation

Machine rates based on university workshop operating costs:

- **CNC milling machine:** €25.00/hour
- **CNC lathe:** €20.00/hour
- **Rates include:** Machine depreciation, maintenance, tooling wear, and facility overhead directly attributable to machine operation.
- **Labor cost:** €0.00/hour (student volunteer work) – *Note: This reflects direct wages. Associated workshop overheads from labor are integrated into other cost categories like "Quality Control" and "Additional Overhead."*

### Consumables and Overheads

- **Electricity (for machines):** Calculated based on Power (kW) × Hours × €0.12/kWh. *This is integrated into the "Machine Cost" portion of the overall cost calculation for each part.*
- **Tooling wear:** Included in machine hourly rates
- **Quality control:** 5% of total manufacturing cost (Raw Material + Machining + Consumables + Labor) for each part (Tensile test: stretch rod until it break)
- **Additional Overhead:** 0.00 EUR per "Made" part (general workshop costs assumed covered by labor or QC).

## 2.4 Note on Identical Part Costs

For certain “Made” components, such as the *Insert sup*, *Wedge*, and *Insert middle* within the Tie Rod Assembly, and the *Half moon top/bottom* and *Left/Right brackets* in the Rack Support Assembly, identical cost values are reported. This reflects their **identical geometric design, material usage, and standardized machining times** for batch production, which result in uniform manufacturing costs per unit based on our defined cost model.

## 3. Carbon Emissions Methodology (GWP)

### 3.1 System Boundary and Approach

The LCA follows a **cradle-to-gate** approach with the following boundaries:

- **Included:** Raw material production, transportation to facility, manufacturing processes (including electricity consumption), and general workshop overhead attributable to made parts.
- **Excluded:** Purchased component manufacturing (supplier responsibility, thus CO<sub>2</sub>e for unmodified bought parts is not reported), packaging, use phase, end-of-life, and transportation from supplier for purchased parts (assumed minimal/excluded as per limitations).
- **Functional unit:** One complete steering system for FS vehicle
- **Reference standards:** ISO 14040/14044, GHG Protocol

### 3.2 Material Emission Factors

Emission factors sourced from Ecoinvent v3.8 and European ELCD databases:

Material	GWP Factor	Data Source
Aluminum 7075-T6	13.1 kg CO <sub>2</sub> e/kg	Ecoinvent v3.8
Aluminum 6061-T6	11.8 kg CO <sub>2</sub> e/kg	Ecoinvent v3.8
Steel DOM (1020)	2.3 kg CO <sub>2</sub> e/kg	ELCD v3.2
Steel 4140 (alloy)	2.8 kg CO <sub>2</sub> e/kg	ELCD v3.2
Carbon fiber prepreg	29.0 kg CO <sub>2</sub> e/kg	Industry average

Table 1: Material GWP Emission Factors

### 3.3 Manufacturing Process Emissions

Process emissions calculated using French electricity grid mix (56g CO<sub>2</sub>/kWh = 0.056 kg CO<sub>2</sub>e/kWh):

Process	Power (kW)	Emissions Rate (kg CO <sub>2</sub> e/h)	Typical Time/Part
CNC milling (3-axis)	4.5	0.252	20–45 min
CNC turning	3.2	0.179	15–30 min
Manual sawing	1.8	0.101	5–10 min
Assembly operations	0.5	0.028	10–20 min

Table 2: Manufacturing Process Emission Rates (Calculated at 56g CO<sub>2</sub>e/kWh)

### 3.4 Mass Estimation Methodology

Component masses calculated using:

- **CAD volume extraction:** Catia mass properties tool
- **Material densities:** Standard handbook values
- **Verification:** Physical weighing of prototype parts where available
- **Tolerance:**  $\pm 5\%$  accuracy for complex components,  $\pm 2\%$  for simple shapes

### 3.5 Assumptions for Purchased Components

Purchased components (steering rack, bearings, shafts) are assumed to have no CO<sub>2</sub>e contributions in this report *unless modified*, due to supplier data unavailability and standard FS competition rules focusing on manufacturing emissions only for such parts.

## 4. Summary and Validation

- The total reported steering system cost matches the sum of all components and manufacturing operations.
- GWP estimations align with latest EU environmental data sources and reflect realistic production scenarios.
- Cost and CO<sub>2</sub>e values were cross-checked against prototype invoices and power meter readings during machining.
- Any deviation from supplier data or estimation assumptions is flagged and justified in notes.

## 5. References

- Ecoinvent v3.8 Database, 2024
- European Life Cycle Database (ELCD) v3.2, 2023
- Formula Student 2025 Sustainability Rules Document
- Manufacturer Datasheets for Steering Components