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# **Product Carbon Footprint Analysis Report**

**\*\*Product:\*\*** Fuel 95

**\*\*Functional Unit:\*\*** 1.0 liter

**\*\*Protocol Data (Accounting Standard):\*\*** ISO 14064

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Disclaimer: This report is generated based on available data and industry standards. While efforts have been made to ensure accuracy and adherence to ISO 14064 principles, specific primary data may vary. This report serves as a high-level analysis intended for informational and strategic planning purposes.

# Product Carbon Footprint Report: Fuel 95

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## Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for 1.0 liter of Fuel 95, developed in accordance with the ISO 14064 standard. The analysis adopts a cradle-to-grave system boundary, encompassing all significant lifecycle stages from crude oil extraction to the combustion of the refined fuel. With a geographic focus on European supply chains and final production in Hungary, this assessment aims to identify key emission hotspots and provide an audit-ready overview of the environmental impact. The total carbon footprint for 1.0 liter of Fuel 95 is calculated to be approximately **3.204 kg CO<sub>2</sub>e**. The use phase, specifically the combustion of the fuel, accounts for the most significant portion of these emissions.

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## 1. Scope Definition

The initial step in any robust carbon footprint analysis is a clear definition of the study's scope, ensuring relevance, completeness, and consistency with established accounting principles, particularly ISO 14064.

### 1.1 Functional Unit

- The functional unit for this PCF analysis is defined as **1.0 liter of Fuel 95**. This unit serves as the reference basis to which all input and output data are normalized, allowing for consistent quantification and comparison of environmental impacts.

## 1.2 System Boundary

- The system boundary for this analysis is defined as "**lifetime**" (**cradle-to-grave**). This encompasses all stages of the product's life cycle, specifically:
  - **Upstream (Cradle-to-Gate):**
    - Crude Oil Extraction and Production
    - Transportation of Crude Oil to Refinery
    - Crude Oil Refining
  - **Midstream:**
    - Transportation of Refined Fuel 95 to Distribution Centers/ Filling Stations
  - **Downstream (Use Phase):**
    - Combustion of Fuel 95 by the end-user (e.g., in vehicle engines).
  - **End-of-Life:** For combustible fuels, the end-of-life emissions are predominantly captured within the use phase (combustion emissions). No further end-of-life processing is typically relevant beyond the use phase.

## 1.3 Geographic Scope

- **Final Production Country:** Hungary
- **Supply Chain Focus:** Europe Focused. This implies that upstream activities (e.g., crude oil sourcing, initial transport) and midstream activities (e.g., refined fuel distribution) are assumed to originate from or occur within Europe where feasible, influencing the selection of data and emission factors.

## 1.4 Accounting Standard

- This Product Carbon Footprint analysis strictly adheres to the principles and requirements of **ISO 14064-1:2018**, which provides requirements and guidance for quantifying and reporting greenhouse gas (GHG) emissions and removals at an organizational level. While ISO 14064-2 and ISO 14064-3 relate to projects and verification, respectively, the core principles of accuracy, consistency, completeness, relevance, and transparency from ISO 14064-1 are applied to ensure an audit-ready PCF.

## 1.5 Allocation

- For multi-output processes, allocation has been applied based on mass for raw material inputs and refining processes where multiple products are co-produced. For example, crude oil yields various fractions, and emissions from refining are allocated to gasoline based on typical refinery output proportions and mass-based methodologies.

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## 2. Lifecycle Mapping (LCI Inventory Stages) & 3. Data Collection

The lifecycle of Fuel 95 is mapped into distinct stages, and relevant primary and secondary data points are collected to quantify the material and energy inputs and outputs, as well as associated emissions.

### 2.1 Materials and Energy Inputs Breakdown

The primary "material" input for Fuel 95 is crude oil. Other materials are indirectly involved in the form of infrastructure and catalysts for refining, but the focus of this product-level PCF is on the direct material and energy flows.

**Table 1: Key Material and Energy Inputs per 1.0 Liter of Fuel 95**

Input Category	Details	Quantity (per 1.0 L Fuel 95)	Notes
Crude Oil (Raw Material)	Density: 0.88 kg/L	~2.15 L (1.892 kg)	Based on average refinery yield of gasoline from crude oil.
Energy for Extraction	Mechanical energy, heat, electricity for drilling, pumping, and initial processing.	Indirectly captured in '\Crude Oil Extraction Emissions\'.	Energy intensity varies significantly by crude oil type and extraction method.
Energy for Transportation	Fuel (e.g., Heavy Fuel Oil for ships, diesel for pipelines/		Dependent on distance, mode,

<b>Input Category</b>	<b>Details</b>	<b>Quantity (per 1.0 L Fuel 95)</b>	<b>Notes</b>
	trucks) and electricity for various transport modes.	Indirectly captured in '\Transportation Emissions\'.	and vehicle efficiency.
Energy for Refining	Heat, electricity, steam for distillation, cracking, reforming, and other refinery processes.	Indirectly captured in '\Crude Oil Refining Emissions\'.	Refineries are highly energy-intensive operations.
Additives (e.g., Octane Enhancers)	Chemical compounds added to improve fuel performance and stability.	Minor quantities (not quantified in detail for this high-level PCF).	Emissions typically negligible compared to main fuel components.

## 2.2 Lifecycle Inventory Stages

The following table outlines the lifecycle stages considered and the type of data collected for each.

**Table 2: Lifecycle Inventory Stages and Data Collection**

<b>Lifecycle Stage</b>	<b>Description</b>	<b>Primary Data (Example)</b>	<b>Secondary Data (Sources)</b>	<b>Assumptions Made</b>
<b>Crude Oil Extraction &amp; Production</b>	Activities related to locating, extracting, and initially processing crude oil.	N/A (secondary data used)	Scientific literature, industry reports (e.g., IEA, CarbonChain, Stanford studies).	Average emissions based on global/ European crude oil production mix, allocated per liter of crude oil.

<b>Lifecycle Stage</b>	<b>Description</b>	<b>Primary Data (Example)</b>	<b>Secondary Data (Sources)</b>	<b>Assumptions Made</b>
<b>Transportation of Crude Oil to Refinery</b>	Transport of crude oil from extraction sites to the refinery in Hungary.	N/A (secondary data used)	EEA, McKinnon reports, industry averages for different transport modes (sea, pipeline).	Assumed average transport distance (e.g., 1000 km sea, 500 km pipeline) and mode split representative for European supply to Hungary. Crude oil density 0.88 kg/L.
<b>Crude Oil Refining</b>	Processing of crude oil into Fuel 95 at a Hungarian refinery.	N/A (secondary data used)	Concawe reports, Ecoinvent/DEFRA proxies for refining processes.	Emission factor per tonne of gasoline based on typical EU refinery processes.
<b>Transportation of Refined Fuel 95 (Distribution)</b>	Transport of Fuel 95 from the refinery to distribution centers and filling stations.	N/A (secondary data used)	GLEC, McKinnon reports, specific road freight emission factors for Europe.	Assumed average distribution distance (e.g., 200 km by road) within Hungary. Gasoline density 0.75 kg/L.
<b>Combustion (Use Phase)</b>	Burning of Fuel 95 in internal combustion engines by the end-user.	N/A (secondary data used)	Natural Resources Canada, US EPA, Ecoinvent/DEFRA for gasoline combustion.	Direct emission factor for CO <sub>2</sub> e per liter of gasoline combusted, including CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O.

## 4. Emissions Calculation (Activity \* Emission Factor = CO<sub>2</sub>e)

This section details the quantification of greenhouse gas emissions (CO<sub>2</sub>e) for each lifecycle stage of Fuel 95, using activity data and industry-standard emission factors. All emissions are expressed in kilograms of carbon dioxide equivalent (kg CO<sub>2</sub>e) per 1.0 liter of Fuel 95.

### 4.1 Key Parameters and Assumptions

- **Functional Unit:** 1.0 liter of Fuel 95.
- **Gasoline Density:** 0.75 kg/L.
- **Crude Oil Density:** 0.88 kg/L.
- **Crude Oil Yield for Gasoline:** Approximately 74 liters of gasoline are produced from 1 barrel (159 liters) of crude oil. Therefore, to produce 1 liter of gasoline, approximately 2.15 liters of crude oil are required (159 L crude / 74 L gasoline).

### 4.2 Stage-by-Stage Emissions Calculation

**Table 3: Emissions Calculation Summary per 1.0 Liter of Fuel 95**

Lifecycle Stage	Activity Data	Emission Factor	Calculated CO <sub>2</sub> e (kg)	Source/ Notes
<b>Crude Oil Extraction &amp; Production</b>	2.15 L crude oil required for 1 L Fuel 95	50.5 kg CO <sub>2</sub> e/barrel of crude (Well-to-Refinery-Entrance) Equivalent to 0.3176 kg CO <sub>2</sub> e/L crude (50.5 kg / 159 L)	0.3176 kg CO <sub>2</sub> e/L crude * 2.15 L crude = <b>0.683</b>	Includes upstream methane leakage and flaring.
<b>Transportation of Crude Oil to Refinery</b>	1.892 kg crude oil (for 1 L Fuel 95)	<ul style="list-style-type: none"> <li>• Sea: 0.003 kg CO<sub>2</sub>e/tonne-km (Assumed 1000 km)</li> <li>• Pipeline: 0.005 kg CO<sub>2</sub>e/tonne-</li> </ul>	(0.001892 tonnes * 1000 km * 0.003 kg/t-km) + (0.001892 tonnes * 500 km * 0.005 kg/t-	Assumes 1000 km sea, 500 km pipeline for European supply to Hungary.

Lifecycle Stage	Activity Data	Emission Factor	Calculated CO2e (kg)	Source/ Notes	
		km (Conservative estimate, lower than other modes)	km) = <b>0.0104</b>		
<b>Crude Oil Refining</b>	0.75 kg Fuel 95 produced	0.2687 t CO2/t gasoline (Concawe average) Equivalent to 0.2687 kg CO2/kg gasoline	0.2687 kg CO2/kg gasoline * 0.75 kg gasoline = <b>0.2015</b>	Based on average energy consumption and processes in EU refineries.	
<b>Transportation of Refined Fuel 95 (Distribution)</b>	0.75 kg Fuel 95 distributed	0.062 kg CO2e/ tonne-km (Road freight, Europe) (Assumed 200 km)	0.00075 tonnes * 200 km * 0.062 kg/t-km = <b>0.0093</b>	Assumes average road distribution within Hungary.	
<b>Combustion (Use Phase)</b>	1.0 liter Fuel 95 combusted	2.3 kg CO2e/L gasoline	<b>2.300</b>	Direct emissions from the oxidation of carbon and other elements during combustion.	
<b>TOTAL PRODUCT CARBON FOOTPRINT (PCF)</b>				<b>3.2042 kg CO2e</b>	Sum of all lifecycle stage emissions.

## 5. Review & Report

The final stage of the PCF analysis involves reviewing the results, identifying emission hotspots, and discussing the reliability of the data and any limitations.

### 5.1 Emission Hotspots

The analysis clearly identifies the following emission hotspots for 1.0 liter of Fuel 95:

- **Combustion (Use Phase):** At 2.300 kg CO<sub>2</sub>e, this stage dominates the overall PCF, representing approximately 71.8% of total emissions. This is typical for fossil fuels, where the release of stored carbon through combustion is the primary contributor to greenhouse gas emissions.
- **Crude Oil Extraction & Production:** This upstream stage contributes significantly, at 0.683 kg CO<sub>2</sub>e (approximately 21.3% of total emissions). Emissions here are driven by the energy intensity of extraction methods, as well as methane flaring and fugitive emissions.
- **Crude Oil Refining:** The refining process adds 0.2015 kg CO<sub>2</sub>e (approximately 6.3%) to the PCF, reflecting the energy-intensive nature of converting crude oil into refined products.

### 5.2 Reliability and Limitations

This PCF analysis maintains a high level of detail and is designed for audit-readiness. However, certain aspects inherently involve assumptions and reliance on secondary data:

- **Data Sources:** While industry-standard emission factors from reputable sources (e.g., Concawe, GLEC, scientific literature) have been used, these are often based on averages and may not perfectly reflect the specific operations of every single actor in a complex supply chain.
- **Geographic Specificity:** Although focused on Europe and Hungary, precise primary data for every refinery and transport route within the specified geographic scope were not available. Generic European or global average emission factors were applied where specific data for Hungary was not found, which could introduce minor variations.

- **Transport Assumptions:** Assumed distances and mode splits for crude oil and refined fuel transport are representative estimates. Actual distances and transport efficiencies can vary.
- **System Boundary:** While "cradle-to-grave" is comprehensive, certain highly indirect impacts (e.g., manufacturing of refinery equipment, maintenance of transport infrastructure) are typically excluded from product-level PCFs to maintain a manageable scope and avoid double-counting.
- **Dynamic Nature:** Emission factors and industry processes are subject to change over time due to technological advancements, regulatory changes, and shifts in energy mixes. The data used reflects the most current publicly available information at the time of report generation.

To further enhance the accuracy and audit-readiness of future PCF analyses, the collection of primary data from direct suppliers and logistics partners is recommended.

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