Analysis of CO_2e emission savings from Aluminium deoxidation briquette production compared to Aluminium pyramid production

for:

FENEGA

NEW LIFE FOR METALS

GENERAL INFORMATON

Company information	
Company name	FENEGA, s.r.o.
Address	Kracunovce 51, 087 01 Kracunovce, Slovakia
Website	www.fenega.sk
Product name	Deoxidation briquette
Product description	Deoxidation briquette is an aluminium product made from recycled aluminum by mechanical means without the use of thermal processes. The briquette serves as a deoxidizer in the steel production process and is a full replacement for Al pyramids or other deoxidizing additives.

FENEGA, s.r.o. was established in 2005 as a family company focused on trading metal waste and non-ferrous metals.

Over time, new challenges in the field of recycling arose, where we strive to set an example. We began sharing our years of experience in waste management with steel companies. In accordance with their requirements, we modified the metal waste in terms of chemical composition, shape, and strength to ensure its suitability for various metallurgical processes such as deoxidation and desulfurization. This is how we became a partner in process optimization, cost savings, and ecological production improvements. We are very pleased to be able to give new life to metal waste and thus contribute to improving ecology on the planet. Most of the metal waste is processed into a final product in our company, where the legislation allows us, through a certified process, to end the state of waste (EOW). The company also provides, thanks to its unique know-how in cooperation with partners, ecological disposal and recycling of hazardous waste and electrical transformers "turnkey", ranging from low-voltage transformers to large transformers from power plants.

All the mentioned aspects make us a dynamically developing company, flexibly responding to market needs and adjusting our activities accordingly.

Standards and author information		
Reference standard	ISO 14040:2021 and 14044:2021	
Product category rules (PCR)	PCR 2022:08 v.1 – BASIC ALUMINIUM PRODUCTS AND SPECIAL ALLOYS	
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1. INTRODUCTION

The production of aluminium-based materials plays a crucial role in industrial manufacturing, particularly in steel production, where aluminium is used as a deoxidizing agent. However, the environmental impact of aluminium production varies significantly depending on the method used. The Global Warming Potential (GWP) of aluminium products, measured in CO_2 equivalent emissions (CO_2e), differs based on the raw material sources and the processes involved in manufacturing.

This report provides an in-depth analysis of the CO_2e emissions associated with three types of aluminium deoxidation products:

- aluminium deoxidation briquettes produced from recycled aluminium using hydraulic press technology,
- aluminium pyramids produced from recycled aluminium through thermal process,
- aluminium pyramids made from primary aluminium.

The analysis is based on a cradle-to-gate Life Cycle Assessment (LCA) conducted by ARPenviro, s.r.o. on behalf of FENEGA s.r.o., which was verified by an independent third-party in accordance with ISO 14040 and ISO 14044 standards. Additionally, an Environmental Product Declaration (EPD) was prepared and published on the International EPD® System.

The results from the LCA indicate a stark contrast in the GWP of these products. **The aluminium deoxidation briquettes exhibit the lowest GWP at 0.219 kg CO_2e per kilogram**, making them the most environmentally friendly option. In comparison, **pyramids produced from recycled aluminium through thermal processes have a significantly higher GWP of 1.45 kg CO_2e per kilogram**.

The most carbon-intensive process is the production of **aluminium pyramids from primary aluminium, with a GWP of 8.47 kg CO_2e per kilogram.** The significant variation in emissions among these products underscores the environmental benefits of using aluminium briquettes over other options.

This report will evaluate the CO_2e emissions of each production method, analyze the reasons for the different GWP values, and highlight the advantages of aluminium briquettes for steel producers. The discussion will incorporate detailed insights from the datasets used in the LCA, providing a comprehensive understanding of the impact of aluminium deoxidation products on sustainability.

2. CO_2e EMISSIONS FOR DIFFERENT ALUMINIUM DEOXIDIZER PRODUCTION METHODS

Deoxidation briquettes from recycled aluminium scrap

Aluminium deoxidation briquettes are produced by compressing aluminium scrap and waste materials that have finished their original function (end of life scraps) using a hydraulic press. This method does not require a thermal process, which significantly reduces energy consumption and emissions. The production of these briquettes involves collecting and processing aluminium scrap without remelting or refining, making it a highly efficient and low-emission alternative to other aluminium deoxidation products.

Detailed information on the product and its production process is provided in the LCA report of this product. The LCA has been performed in compliance with ISO 14040:2021 and ISO 14044:2021. The LCA refers to the PCR 2022:08 for "Basic aluminium products and special alloys" UN CPC 4153.

Foreground data used in this study have been collected in the production plant by a company representative or derived from registered company reports and documents. All quantities derive from primary data, as recommended by data quality requirements of reference PCR. The main data are referred to a specific monitoring period 2024), considered as representative period for all production processes.

The dataset used in the LCA includes the aluminium waste pre-treatment (upstream process) which represents the treatment of mixed metal scrap from separate collection, i.e. a source-segregated municipal solid waste fraction, through sorting for recycling. Sorting of waste tinplate, ferrous metal, and aluminium from residues and from each other, yielding individual material fractions for ferrous scrap and aluminium. The mixed metal scrap is sorted using magnetic and eddy current separators.

The core processes include the manufacturing of the briquettes which consists of the following steps:

- The recycled material (aluminum shavings, cans, foils, granules, and other similar aluminum materials) is first tested to verify its chemical and mechanical properties.
- Then the material is cleaned, separated, and processed (e.g., shredded) into a fraction suitable for further processing. Different types of recycled aluminum materials are mixed in specific proportions to achieve the desired mechanical, chemical, and other parameters according to customer requirements.
- The mixed material is then dosed into the hoppers of the pressing lines, where it undergoes homogenization and is subsequently dosed into the presses. In the presses, using only hydraulic pressure, the final product – the briquette – is created.

Deoxidation pyramids from recycled aluminium scrap

Unlike briquettes, aluminium pyramids from recycled aluminium are produced through a thermal recycling process that involves remelting the scrap in high-temperature furnaces. This process consumes substantial amounts of energy, contributing to a significantly higher GWP than the hydraulic press method. The dataset used to analyze this process includes information on the treatment of aluminium scrap at refiners. The refining process involves the use of rotary and reverbatory furnaces, with approximately 64% of recycled aluminium being processed in rotary furnaces and 36% in reverbatory furnaces.

The dataset further includes data from the European Aluminium Association (EAA) and the Ecoinvent 3.10.1 database, which cover emissions from refining processes such as alloying, melting, and casting. The treatment of aluminium scrap requires high temperatures, primarily achieved using fossil fuels such as natural gas. The refining process also results in the generation of dross, a by-product that requires additional processing. Although the dataset does not include emissions from salt slag and dross recycling due to data limitations, estimates indicate that these factors contribute an additional 10-20% to the total environmental impact.

The higher GWP of 1.45 kg CO_2e per kilogram of pyramids from recycled aluminium is attributed to the high energy intensity of the remelting process. In addition to direct energy consumption, material losses further contribute to increased emissions. When aluminium scrap is melted, some of the metal is lost due to oxidation, necessitating additional raw material input to compensate for the losses. This increases the overall emissions per kilogram of finished product. Compared to briquettes, which require no thermal processing, the additional steps in recycled pyramid production lead to a much higher environmental burden.

Deoxidation pyramids from primary aluminium

The production of aluminium pyramids from primary aluminium involves the extraction of bauxite, the refining of aluminium oxide through the Bayer process, and the electrolytic production of aluminium through the Hall-Héroult process. Each stage of this process contributes significantly to emissions, resulting in a **total GWP of 8.47 kg CO_2e per kilogram,** making it the least sustainable option.

The dataset used to evaluate this process includes three key components: the market for bauxite, the production of aluminium oxide, and the production of primary aluminium ingots. The market for bauxite represents the global supply chain for this raw material, including emissions from extraction, transport, and losses during handling. The aluminium oxide production dataset provides information on the Bayer process, which involves the refining of bauxite into aluminium hydroxide and its subsequent calcination to produce alumina (Al_2O_3). This step alone is highly energy-intensive, requiring large amounts of fuel for high-temperature processing.

The most significant emissions arise from the production of primary aluminium ingots through the Hall-Héroult process. This electrolytic process requires an immense amount of electricity. The use of carbon anodes in electrolysis results in direct CO_2 emissions, further increasing the overall GWP. Additional emissions are generated during the alloying and casting stages, where various metals such as magnesium, silicon, and manganese are added to achieve specific properties.

The emissions from primary aluminium production are significantly higher than those of recycled aluminium due to the necessity of extracting and processing virgin materials. Unlike scrap aluminium, which bypasses these energy-intensive steps, primary aluminium production demands substantial natural resources and results in a considerable environmental footprint.

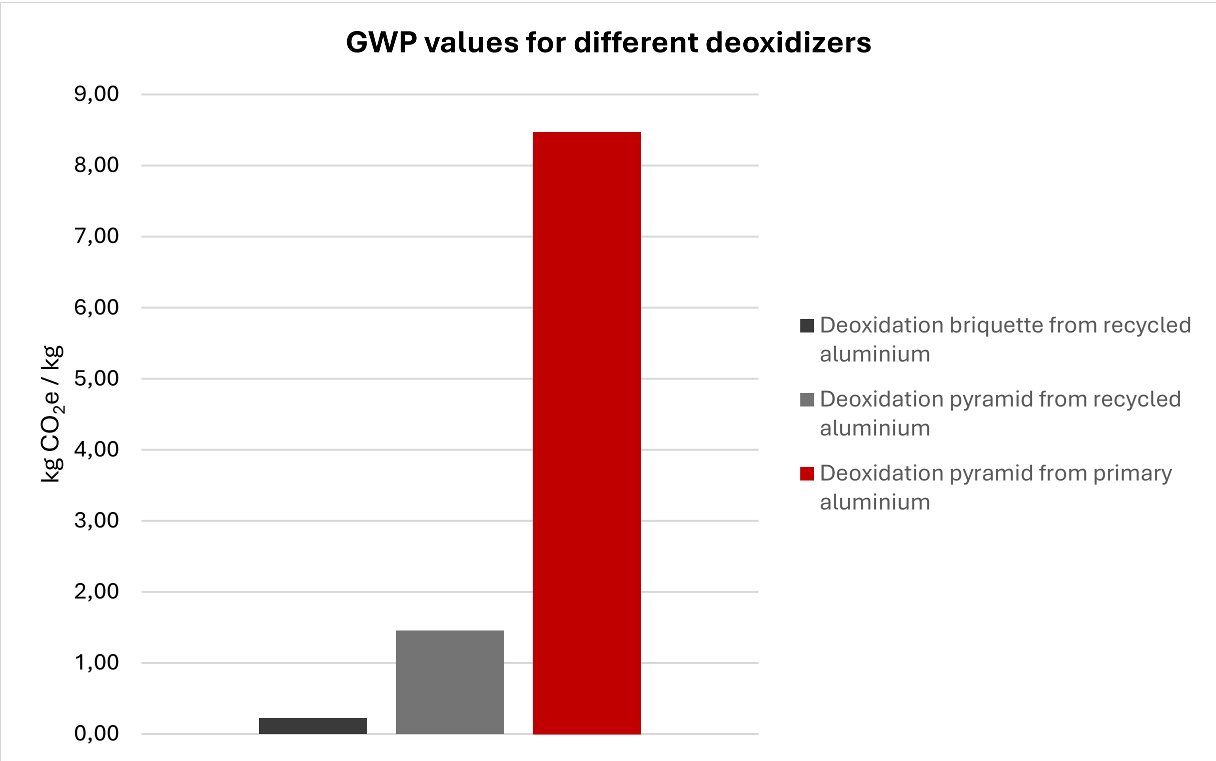
3. REASONS FOR DIFFERENT GWP VALUES

The differences in GWP values among the three production methods can be attributed to several key factors.

First and foremost, energy consumption plays a crucial role in determining emissions. The hydraulic press method used for briquettes requires minimal energy, whereas the thermal processing of scrap aluminium pyramids demands significant amounts of fossil fuel-based energy. The highest energy consumption occurs in the production of primary aluminium, where electrolysis alone accounts for a major portion of the emissions.

Another factor is the material efficiency of each process. Aluminium briquettes are highly efficient in terms of raw material utilization, with minimal losses during production. In contrast, recycled aluminium pyramids experience losses due to oxidation during remelting, increasing the demand for additional raw material. Primary aluminium production is the least efficient, as it involves not only material losses during refining but also significant waste generation in the form of red mud, a by-product of the Bayer process.

The carbon intensity of electricity used in the production processes also has a significant impact. Primary aluminium production is often powered by electricity from coal or gas-fired power plants, leading to extremely high emissions. Recycled aluminium processes have a lower but still substantial carbon footprint, while aluminium briquette production requires little to no electricity beyond the hydraulic pressing operation.



4. CONCLUSION

The significantly lower GWP of aluminium briquettes presents substantial advantages for steel producers, particularly in reducing their environmental impact and operational costs. By using briquettes instead of aluminium pyramids, steel manufacturers can significantly lower their carbon footprint while improving efficiency in their operations.

Aluminium briquettes provide cost savings due to their lower energy consumption and higher material efficiency. The absence of melting and refining steps eliminates the need for expensive energy inputs, reducing production costs. Additionally, the compact and uniform shape of briquettes improves handling and transportation efficiency, leading to further logistical benefits.

From a sustainability perspective, the adoption of aluminium briquettes aligns with global carbon reduction targets and regulatory compliance. As industries face increasing pressure to minimize their greenhouse gas emissions, switching to lower-emission alternatives such as aluminium briquettes can help steel manufacturers meet their sustainability goals while maintaining high-quality production standards.

Product	GWP (kg CO_2e/kg)	Main process	Energy Intensity	Material Loss	Sustainability
Briquettes from recycled aluminium	0.219	Hydraulic press	Low	Minimal	High
Pyramids from recycled aluminium	1.450	Thermal (recycling)	Medium	Moderate	Moderate
Pyramids from primary aluminium	8.470	Thermal (primary production)	High	High	Low

The CO_2e savings in the production of deoxidation briquettes from recycled aluminium compared to deoxidation pyramids from recycled aluminium, are approximately 1.231 kg CO_2e/kg, while compared to the production of deoxidation pyramids from primary aluminium, they are approximately 8.251 kg CO_2e/kg.

In conclusion, the use of aluminium briquettes represents a highly sustainable and cost-effective solution for steel producers, offering significant environmental and economic benefits over traditional aluminium pyramids.

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