شركة أسمنت الإتحاد(ش.م.خ.)
UNION CEMENT COMPANY (Pr.J.S.C)

SUPPLEMENTARY BINDER

ENVIRONMENTAL PRODUCT DECLARATION

GROUND GRANULATED BLAST FURNACE SLAG

In accordance with ISO 14025 & EN 15804:2012+A2:2019/AC:2021

EPD Program	Title	Details
International Climate Intelligence System 71-75 Shelton Street Covent Garden, London, WC2H 9JQ United Kingdom office@climateintell.com	Registration Number	ICIS-202603-129
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INTERNATIONAL CLIMATE INTELLIGENCE SYSTEM
EPD VERIFIED

Union Cement Company (Pr.J.S.C)
Khor Khwair Industrial Area,
Ras Al Khaimah, UAE
www.uccrak.com

INTERNATIONAL CLIMATE INTELLIGENCE SYSTEM EPD

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With world-leading clinker capacity, Union Cement Company defines strength

TABLE OF CONTENTS

OVERVIEW

This Environmental Product Declaration (EPD) presents verified and transparent environmental performance data for Ground Granulated Blast Furnace Slag (GGBFS) manufactured by Union Cement Company at its production facility in Ras Al Khaimah, United Arab Emirates, for the reporting period April 2024 to March 2025. The declared unit for this assessment is 1 metric ton of Ground Granulated Blast Furnace Slag (GGBFS).

The Life Cycle Assessment (LCA) has been conducted in accordance with the requirements of ISO 14025 and EN 15804:2012 + A2:2019/AC:2021, covering all relevant life cycle stages within the defined system boundary. This EPD provides consistent, third-party-verified environmental information to support architects, engineers, developers, contractors, and sustainability professionals in embodied carbon assessment, green building certification schemes, and transparent procurement decision-making.

PRODUCT INFORMATION

Product Name

Ground Granulated Blast Furnace Slag (GGBFS)

Product Type

Supplementary cementitious material for concrete and mortar

Declared Unit

1 metric ton

PCR & Version

ICIS PCR 2026:18 v1.2.6 (EN 15804 + A2 aligned)

Scope

Cradle-to-Gate with options (A1-A4, C1-D)

Production Route

Drying and grinding of Granulated Blast Furnace Slag (GBFS)

Recycled Content

Not intentionally added (inherent recycled content only)

Electricity Mix

UAE grid mix from Ecoinvent 3.11 (cut-off). Natural Gas (89.42%), Nuclear (7.06%), Oil (0.60%), Solar (0.18%) and others.

LCA Tool and Database

Air.e.LCA v3.20.1.0 and Ecoinvent v3.11 (Cut-Off)

Geographical Scope

United Arab Emirates

PRODUCT INFORMATION

Verification

International Climate Intelligence System
71-75 Shelton Street, Covent Garden
London, WC2H 9JQ
United Kingdom
office@climateintell.com
www.climateintell.com

Product Group Classification

UN CPC 37450 - Slag Cement

Environmental Performance Summary (A1-A3)

Indicator	Result	Unit
Climate change (GWP) - total	1.56E+02	Kg CO_2e
Climate change (GWP) - fossil	1.56E+02	Kg CO_2e
Ozone Depletion (ODP)	1.08E-05	Kg CFC-11e
Abiotic depletion of fossil resources	1.88E+03	MJ

Hotspot Summary

Process	Share of Total GWP (%)
Raw Material Supply (A1)	2.48
Raw Material Transportation (A2)	56.55
Manufacturing (A3)	25.57
Remaining Modules (A4, C1-C4)	15.4

PRODUCT INFORMATION

Where This Adds Value

Scheme / Area	Relevance to Ground Granulated Blast Furnace Slag (GGBFS)
LEED v4.1 (USGBC) – Material Disclosure & Whole-Building LCA	LEED projects prioritize materials with product-specific Environmental Product Declarations to support MR credits and whole-building life cycle assessments. GGBFS is widely used as a supplementary cementitious material in low-carbon concrete mixes, enabling designers to reduce embodied carbon while improving durability performance in structural concrete systems.
Estidama Pearl Rating System (Abu Dhabi)	Pearl-rated infrastructure and building projects emphasize material transparency and reduced environmental impacts. The availability of a verified EPD for GGBFS supports embodied carbon assessments for concrete used in buildings and infrastructure and aligns with Estidama objectives for durable and resource-efficient construction materials.
Oman Green Building Guidelines (OGBG)	Sustainability-driven construction projects in Oman increasingly incorporate materials with verified environmental data. GGBFS contributes to improved durability and reduced clinker content in concrete mixtures, supporting consultant benchmarking and material transparency in projects following OGBG sustainability practices.
BREEAM International (UAE & GCC Projects)	BREEAM encourages the use of products with verified environmental declarations to support Life Cycle Assessment-based building design. The use of GGBFS in concrete mixtures contributes to reduced embodied carbon and improved durability, assisting project teams in meeting responsible sourcing and material impact assessment requirements.
Low-Carbon Concrete & Embodied Carbon Reduction	GGBFS enables significant reductions in clinker content when used as a partial replacement for Portland cement in concrete. By lowering the overall carbon intensity of concrete production while improving long-term durability, GGBFS supports project-level embodied carbon reduction strategies in buildings, marine structures, and infrastructure.

PRODUCT INFORMATION

Infrastructure & Marine Construction	Concrete containing GGBFS exhibits enhanced resistance to chloride ingress, sulfate attack, and alkali–silica reaction, making it well suited for marine structures, bridges, ports, and coastal infrastructure. The availability of verified environmental performance data assists engineers and consultants in specifying durable and sustainable materials for long-life infrastructure projects.
Government & Infrastructure Procurement	Public-sector infrastructure projects increasingly request environmental product declarations to support sustainable procurement policies. The availability of a verified EPD for GGBFS strengthens Union Cement Company's position in infrastructure tenders requiring low-carbon construction materials and transparent environmental performance documentation.
Concrete Producers & Construction Supply Chains	Ready-mix producers, precast manufacturers, and contractors increasingly incorporate GGBFS in concrete mix designs to improve durability and reduce embodied carbon. Product-specific LCA data from a verified EPD enables supply chain partners to model environmental impacts more accurately and meet sustainability reporting requirements.

ABOUT UNION CEMENT

Founded in 1972, Union Cement Company (UCC) is a pioneering cement manufacturer headquartered in Ras Al Khaimah. Operating one of the world's highest-capacity single clinker production lines, UCC produces over 13,500 tonnes per day. The company manufactures OPC, SRC, PLC, GGBFS, DrillWell cement, and clinker, supporting large-scale infrastructure, energy, transport, and industrial development projects with reliable, performance-driven manufacturing excellence.

UCC operates a fully integrated cement manufacturing facility in Ras Al Khaimah, covering:

- High-capacity dry-process clinker production with preheater–precalciner kiln technology.
- Large-scale cement grinding and dispatch operations serving UAE and Oman.
- Bulk and bagged cement supply to ready-mix, precast, and infrastructure sectors.
- Advanced laboratory testing and continuous process monitoring.
- Optimised fuel and raw material management systems.

UCC's production infrastructure is engineered for efficiency, consistency, and reliability — ensuring uninterrupted supply for major construction and infrastructure projects.

UCC maintains internationally recognised management systems and product compliance standards, including:

- ISO 9001 – Quality Management System.
- ISO 14001 – Environmental Management System.
- ISO 45001 – Occupational Health & Safety Management System.
- Compliance with EN standards and relevant GCC regulatory requirements.
- Product conformity aligned with regional construction specifications.

UCC continues to invest in operational excellence, sustainability performance, and technological optimisation to meet the evolving demands of large-scale construction and infrastructure development across the UAE and Northern Oman.

Through world-leading clinker capacity, disciplined quality control, and responsible manufacturing practices, UCC remains a cornerstone supplier to the region's structural growth.

PRODUCT DESCRIPTION

Ground Granulated Blast Furnace Slag (GGBFS) is a finely ground supplementary cementitious material produced by drying and grinding granulated blast furnace slag, a glassy by-product generated during the manufacture of iron in a blast furnace, conforming to BS EN 15167-1:2006 and ASTM C989. Supplied as a fine off-white to light grey powder, it is blended with Portland cement or directly incorporated into concrete mixes to form durable cementitious systems with improved long-term strength development and reduced permeability. Its composition is characterised by reactive calcium silicates and aluminosilicate phases formed during rapid quenching of molten slag, providing latent hydraulic properties that enhance durability and chemical resistance in hardened concrete.

The product is designed for use in structural and infrastructure concrete where durability and long-term performance are critical. Ground Granulated Blast Furnace Slag improves resistance to chloride ingress, sulfate attack, and alkali–silica reaction while reducing the clinker content and embodied carbon of cementitious systems. Typical applications include marine and coastal structures, bridges, foundations, mass concrete works, and infrastructure exposed to aggressive environmental conditions. The material is supplied in bulk and jumbo bag formats, enabling efficient batching and controlled use in ready-mix, precast, and large-scale construction projects.

Sectors & Corresponding Uses

Sector	Application / Use Case
Structural Concrete Construction	Partial replacement of Portland cement in structural concrete mixes to improve long-term strength development, reduce permeability, and enhance durability of load-bearing building components
Marine & Coastal Infrastructure	Concrete production for marine structures, ports, and coastal facilities requiring resistance to chloride ingress, sulfate exposure, and aggressive saline environments
Bridges & Transportation Infrastructure	Use in bridge decks, foundations, and highway structures where reduced permeability, improved durability, and extended service life are critical performance requirements
Mass Concrete & Foundations	Concrete for large foundation elements, raft slabs, and dam structures where reduced heat of hydration and controlled thermal cracking behaviour are required
Precast & Ready-Mix Concrete Production	Integration in ready-mix and precast concrete systems to enhance durability, optimise workability, and support low-carbon concrete production for infrastructure and building projects

PRODUCT DESCRIPTION

Technical Specifications

Parameter	Details / Specification
Product Type	Supplementary Cementitious Material (Ground Granulated Blast Furnace Slag – GGBFS)
Standard Compliance	Conforming to BS EN 15167-1:2006 and ASTM C989
Form	Fine off-white to light grey powder
Main Constituent	Granulated blast furnace slag from iron production
Hydraulic Behaviour	Latent hydraulic material activated by Portland cement hydration products
Strength Development	Contributes to long-term compressive strength in blended cement and concrete
Durability Characteristics	Improved resistance to chlorides, sulfates, and alkali–silica reaction
Density (True)	Approx. 2.85–2.95 g/cm³
Fineness	Typically 400–500 m²/kg (Blaine)
Supply Format	Bulk tanker or Jumbo Bags

MANUFACTURING DETAILS

The production of Ground Granulated Blast Furnace Slag (GGBFS) begins with the receiving and inspection of granulated blast furnace slag sourced from iron manufacturing facilities. The material is delivered to the plant in a granulated, glassy form produced through rapid quenching of molten slag during blast furnace operations. Upon arrival, the slag undergoes strict quality verification to ensure conformity with defined chemical composition, moisture content, and physical characteristics prior to storage and processing. The accepted granulated slag is transferred to receiving hoppers and storage systems designed to protect the material from contamination and excessive moisture prior to further processing.

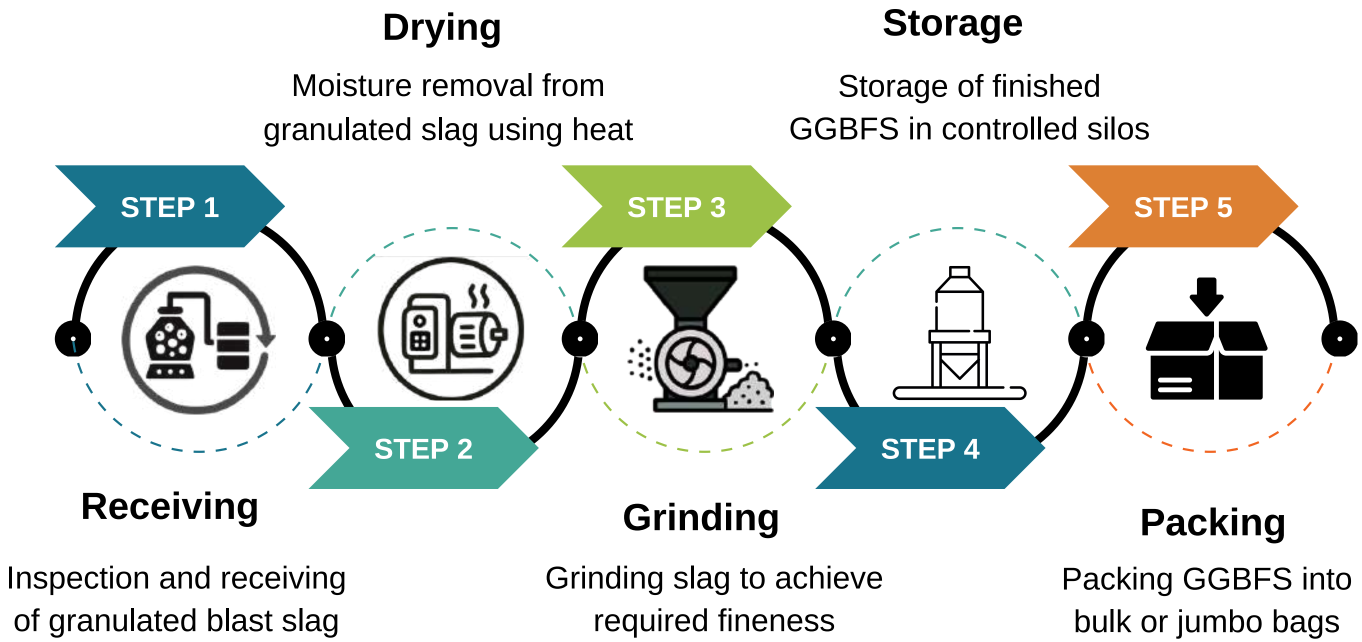
Following receiving operations, the granulated slag is directed to the drying stage where residual moisture is removed to ensure stable and efficient grinding performance. Controlled drying is carried out using hot gas systems to achieve the required moisture levels while preserving the glassy structure responsible for the material's latent hydraulic properties. The dried slag is then transferred to the grinding system where it is finely milled in high-efficiency grinding mills to produce Ground Granulated Blast Furnace Slag with the required fineness and reactivity. The grinding process determines the final particle size distribution and influences the performance of GGBFS when used as a supplementary cementitious material in concrete.

After grinding, the finished GGBFS is conveyed to storage silos where it is held under controlled conditions prior to dispatch. The stored material undergoes comprehensive quality control testing to verify compliance with the requirements of BS EN 15167-1:2006 and ASTM C989, including fineness, chemical composition, and physical performance parameters. Once approved, the product is transferred either for bulk loading into tanker trucks or directed to packing systems where it is filled into jumbo bags (FIBC) for distribution. These handling and packaging systems ensure efficient supply to ready-mix concrete producers, precast manufacturers, and infrastructure projects requiring durable and sustainable cementitious materials.

For a visual representation of the full manufacturing workflow, refer to the illustrated flow chart on the next page. A screenshot of the process flow as modeled in the LCA software is provided on the page that follows.

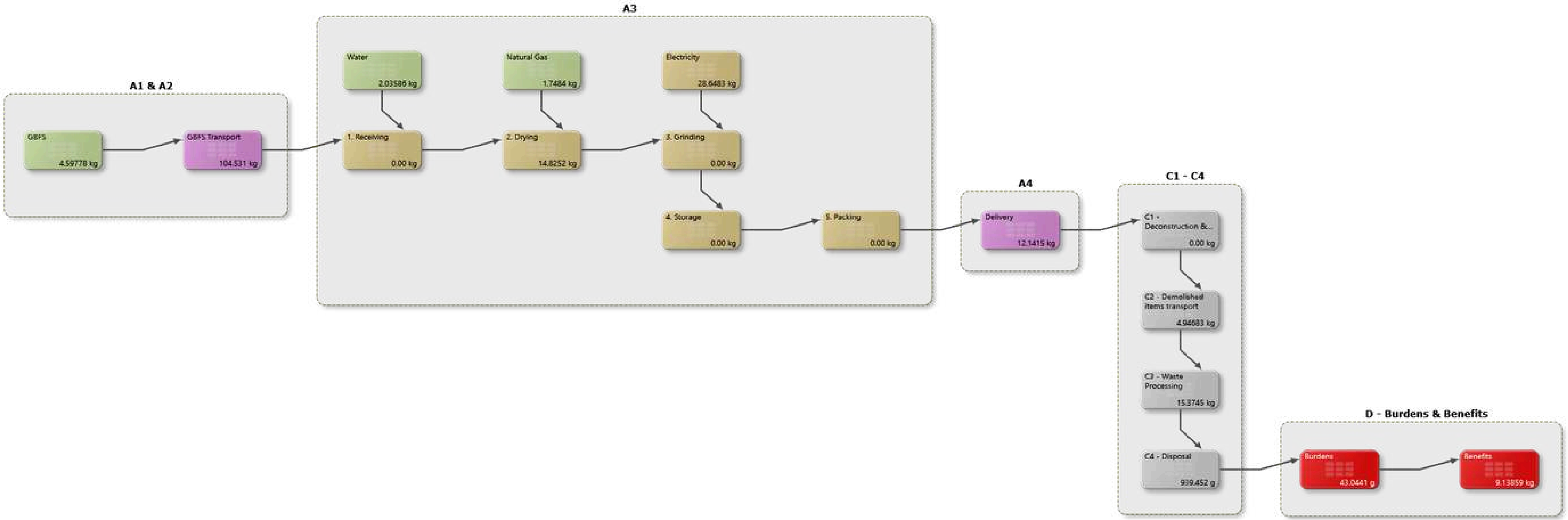
MANUFACTURING DETAILS

Schematic overview of Ground Granulated Blast Furnace Slag (GGBFS) manufacturing process



MANUFACTURING DETAILS

Screenshot of Ground Granulated Blast Furnace Slag (GGBFS) LCA model from LCA software



CONTENT DECLARATION

The content declaration provides a transparent breakdown of the constituent materials present in Ground Granulated Blast Furnace Slag (GGBFS), expressed per 1 metric ton of product. The material consists entirely of Granulated Blast Furnace Slag (GBFS) generated during iron production and subsequently dried and finely ground to achieve the required fineness and reactivity for use as a supplementary cementitious material in concrete. The total of all listed constituents equals 1 metric ton, matching the declared unit and ensuring complete material accounting in accordance with EN 15804 and ISO 14025 requirements.

Component	Weight (kg/Declared unit)	Post-consumer recycled (%)	Pre-consumer recycled (%)	Biogenic Content (%)	Biogenic Carbon (kg C/DU)
GBFS	1000	0	0	0	0
Total	**1000**	**0**	**0**	**0**	**0**

Substances of Very High Concern (SVHC)

According to the requirements of the ECHA Candidate List of Substances of Very High Concern (SVHC), Ground Granulated Blast Furnace Slag (GGBFS) contains no substances listed above the 0.1% (w/w) threshold in the final product.

The material consists entirely of granulated blast furnace slag produced during iron manufacturing and subsequently dried and finely ground for use as a supplementary cementitious material. Based on supplier declarations and available safety data sheets, no SVHCs are present in concentrations exceeding the regulatory reporting thresholds.

Packaging Material Declaration

Packaging materials used for GGBFS include jumbo bags (FIBCs), wooden pallets, pull tie cords, sling bag caps, PVC binding straps, and LDPE protective sheets. Each component performs a defined function within the supply chain—jumbo bags contain and protect the powder product, pallets enable stable stacking and mechanical handling, binding straps and LDPE sheets secure palletised loads during transport, and auxiliary components such as pull ties and caps ensure closure and lifting integrity.

All packaging materials are included in the life cycle assessment, as they contribute to upstream manufacturing impacts and form recoverable or disposable material streams at end-of-life in accordance with EN 15804 requirements.

CONTENT DECLARATION

Packaging Material	Biogenic Content (%)	Biogenic Carbon Fraction (kg C/kg material)	Notes & References
Wooden Pallet	~100% (solid wood)	0.50 kg C/kg	IPCC (2006) Guidelines — wood contains ~50% carbon by dry mass.
Jumbo Bags (PP - FIBC)	0%	0 kg C/kg	Polypropylene is petroleum-based; contains no biogenic carbon.
Pull Tie Cord (PP)	0%	0 kg C/kg	Polypropylene accessory component; fossil-based polymer.
Sling Bag Caps (PP)	0%	0 kg C/kg	Injection-moulded polypropylene; fossil-based carbon.
Binding Strap (PVC)	0%	0 kg C/kg	PVC is petroleum-based; no biogenic carbon content.
LDPE Sheet	0%	0 kg C/kg	Low-density polyethylene is fossil-based; contains no biogenic carbon.

For GGBFS, wooden pallets contain significant biogenic carbon, as they originate from lignocellulosic biomass derived from solid wood. In contrast, jumbo bags (polypropylene), pull tie cords, sling bag caps, binding straps (PVC), and LDPE protective sheets are fossil-based polymer materials and therefore do not contain biogenic carbon.

These biogenic fractions are reported transparently to reflect the temporary storage of renewable carbon within the packaging system. Their modelling and reporting in the LCA follow EN 15804+A2 requirements, with biogenic carbon flows presented in the Packaging Composition and Biogenic Carbon table below.

Packaging Material	Weight (kg/Declared Unit)	Share of Packaging (%)	Biogenic Carbon (kg C/DU)	End-of-Life Handling
Wooden Pallet	5.93E-04	93.61	2.97E-04	Reuse / Recycle / Energy Recovery
Jumbo Bags (PP - FIBC)	2.93E-05	4.62	0.00E+00	Reuse / Recycle / Energy recovery

CONTENT DECLARATION

Pull Tie Cord (PP)	5.53E-07	0.09	0.00E+00	Energy recovery / Landfill
Sling Bag Caps (PP)	3.98E-07	0.06	0.00E+00	Energy recovery / Landfill
Binding Strap (PVC)	5.97E-07	0.09	0.00E+00	Recycle (limited) / Energy recovery
LDPE Sheet	9.69E-06	1.53	0.00E+00	Recycle / Energy recovery
Total	**6.34E-04**	**100**	**2.97E-04**	**-**

Note - Biogenic content in packaging materials **exceed the 5% threshold** of the total packaging weight as stated in **ICIS PCR 2026:18**. Hence, these biogenic emissions are added in **module A3 and balanced out in module A5**.

LCA KNOWLEDGE

Declared Unit

The declared unit for this EPD is 1 metric ton of Ground Granulated Blast Furnace Slag (GGBFS) at the factory gate. All material inputs, energy use, emissions, transportation, packaging, and end-of-life modelling are quantified relative to this unit. This ensures consistent comparison across life cycle stages and aligns with EN 15804+A2 requirements for construction products. No functional performance is assigned to the product in this declaration, as the EPD is based on a declared unit rather than a functional unit.

Temporal, Geographical and Technological Representativeness

Temporal Representativeness: Primary data for Ground Granulated Blast Furnace Slag (GGBFS) reflects the reporting period April 2024 to March 2025, in line with EN 15804+A2 requirements that primary manufacturing data must be no older than five years. All on-site information—including raw material consumption, energy use, water use, and waste generation—represents current operational conditions at the Ras Al Khaimah plant during the defined reporting year. Background data used in the study are consistent with the temporal validity provided in their respective datasets to ensure alignment with the modelling year.

Geographical Representativeness: The LCA model for Ground Granulated Blast Furnace Slag (GGBFS) reflects the actual manufacturing and supply conditions of Union Cement Company's Ras Al Khaimah facility in the United Arab Emirates, where all primary data was collected. The study represents production and operations within UAE, with UAE-specific or GCC-specific conditions applied wherever available—particularly for raw material sourcing patterns, electricity grid characteristics, water production, and end-of-life treatment routes.

Where UAE-specific datasets or regional factors were not available, GCC-appropriate or globally representative datasets were used. All transport distances, energy consumption figures, and end-of-life scenarios are based on realistic practices in the UAE, ensuring geographical relevance of the final results.

Technological Representativeness: The manufacturing process modelled for Ground Granulated Blast Furnace Slag (GGBFS) accurately reflects the grinding-based production technology used at Union Cement Company's facility. Production includes receiving of Granulated Blast Furnace Slag (GBFS) sourced from iron manufacturing operations, followed by controlled drying to remove residual moisture, fine grinding in high-efficiency grinding mills to achieve the required fineness and reactivity, storage in dedicated silos, and final dispatch through bulk loading or packing systems. The process does not involve high-temperature clinker formation; instead, it relies on mechanical size reduction of the granulated slag to produce a reactive supplementary cementitious material.

LCA KNOWLEDGE

The technological assumptions applied in the LCA represent a modern slag grinding installation consistent with industrial-scale GGBFS production facilities. Energy inputs associated with drying operations, grinding electricity consumption, internal material conveying, storage handling, and final packing are included to reflect actual plant conditions. The modelling approach therefore represents real industrial slag grinding technology and ensures that the results are aligned with site-representative manufacturing practice.

LCA Software and Database

The life cycle model for Ground Granulated Blast Furnace Slag (GGBFS) was developed using Air.e.LCA v3.20.1.0, with all background inventory data sourced from Ecoinvent v3.11 (Allocation, cut-off by classification). The software was used to structure process flows, assign datasets, calculate environmental indicators, and perform all module-by-module inventory tracking. The database provides consistent, peer-reviewed life cycle inventories for raw materials, energy supply, transportation, and waste management processes. All datasets selected reflect technologies and supply chains relevant to the product and regional context, ensuring reliable integration of foreground data with established international life cycle inventories.

System Boundary

This EPD covers all product stages from “cradle to gate with options”, i.e. this LCA covers Production stage A1-A3, Transportation A4, End-of-life stages C1-C4 and Resource recovery stage D according to EN 15804:2012 + A2:2019 / AC:2021.

The procedures that are not controlled by the company, but are included in this environmental study, are:

- The extraction and production of fuels and electricity.

All related direct and indirect environmental impacts related to these elements have been calculated and were included in the LCA and this EPD. Personnel-related processes, such as transportation of employees to and from work is excluded. Also, the production and end-of-life processes of infrastructure or capital goods used in the product system are excluded.

Module A1 - Raw Material Supply

Module A1 encompasses all upstream processes associated with the supply and preparation of Granulated Blast Furnace Slag (GBFS) used in the production of Ground Granulated Blast Furnace Slag (GGBFS). The principal constituent—Granulated Blast Furnace Slag (GBFS) generated during iron manufacturing—is sourced from international suppliers and delivered to Union Cement Company’s facility for further processing, ensuring traceability and conformity with defined plant quality specifications. Packaging materials are procured from suppliers located in the United Arab Emirates, Oman, and India and include jumbo bags (FIBC), wooden pallets, pull tie cords, sling bag caps, binding straps, and LDPE protective sheets. Activities included within this module comprise blast furnace slag generation and granulation at the steel plant, upstream material handling, electricity generation, packaging material production, and the manufacture of auxiliary inputs required for GBFS supply and preparation prior to grinding.

Module A2 - Raw Material Transportation

Module A2 covers the transportation of all raw and packaging materials to the Union Cement Company facility in Ras Al Khaimah, United Arab Emirates. The principal raw material Granulated Blast Furnace Slag (GBFS)—is sourced from international suppliers and transported by sea freight bulk carrier from the exporting port to Mina Saqr Port in Ras Al Khaimah. Upon arrival, the material is transported from Mina Saqr Port to the Union Cement Company facility using >32-ton Euro 6 lorry, representative of bulk mineral transport within the region. Packaging materials are sourced from suppliers located in the UAE, Oman, and India. Materials from the UAE and Oman are transported by >32-ton Euro 6 lorry, while packaging materials imported from India are transported via sea freight container ship to Mina Saqr Port and subsequently delivered by >32-ton Euro 6 lorry to the Ras Al Khaimah facility.

Environmental impacts in this module arise from diesel combustion in heavy-duty road transport and marine fuel combustion in container shipping. Transport distances, load factors, and logistics modelling reflect realistic GCC supply chain conditions, ensuring representative accounting of both domestic and international inbound transport to the Ras Al Khaimah cement plant.

Module A3 - Manufacturing

Manufacturing impacts cover all processes required to convert Granulated Blast Furnace Slag (GBFS) into finished Ground Granulated Blast Furnace Slag (GGBFS) at the Union Cement Company production facility in Ras Al Khaimah. Production follows a continuous processing sequence comprising five stages: Receiving, Drying, Grinding, Storage, and Packing. These stages ensure controlled material handling, moisture removal from the granulated slag, efficient grinding to achieve the specified fineness and reactivity, and final storage and packing to meet the performance requirements for use as a supplementary cementitious material in concrete.

Environmental loads in this module include electricity consumption for slag drying systems, grinding mills, and material handling equipment, together with thermal energy from natural gas combustion used to generate hot gas for drying incoming Granulated Blast Furnace Slag (GBFS). Based on plant operating conditions, approximately 900 MMBtu/day of natural gas is consumed to produce 2,000 tonnes of GGBFS with an average moisture content of 10%, corresponding to the evaporation of moisture using an estimated heat of evaporation of 1,200 kcal/kg of water.

LCA KNOWLEDGE

Internal transport via conveyors and mobile equipment, and auxiliary energy inputs associated with plant operations, are also included. Unlike clinker production, the GGBFS process does not involve high-temperature kiln reactions or calcination, and therefore no process-related CO_2 emissions occur during manufacturing. Additional impacts include direct emissions from natural gas combustion, minor solid waste generation from dust collection systems and routine maintenance activities. All direct emissions associated with electricity use, fuel combustion, equipment operation, and plant processes are included within the A3 system boundary.

Module A4 - Delivery

Module A4 accounts for the transportation of finished Ground Granulated Blast Furnace Slag (GGBFS) from the Union Cement Company manufacturing facility in Ras Al Khaimah, United Arab Emirates, to customer locations. The product is supplied to ready-mix concrete producers, precast manufacturers, and infrastructure projects across the UAE and Northern Oman, including Dubai, Abu Dhabi, Sharjah, Ajman, Fujairah, Umm Al Quwain, Al Ain, Sohar, and Musandam. Outbound transport is modelled using >32-ton Euro 6 lorry, representing typical bulk cementitious material and palletised bag transport within the GCC regional road network.

GGBFS is delivered primarily in bulk form or in jumbo bags for concrete production and infrastructure construction applications. Transport modelling assumes high load utilisation consistent with industrial cementitious material distribution practices in the region. Environmental impacts in this module include diesel consumption, tailpipe emissions, and distance-based fuel use associated with road transport from the Ras Al Khaimah facility to customer sites across the UAE and Northern Oman corridor.

Scenario details	Description
Vehicle used for transport	Euro 6, >32 ton truck
Vehicle capacity	>32 tons
Fuel type and consumption	Diesel, 0.38 liters per km
Capacity utilization	100% as assumed in Ecoinvent v3.11
Bulk transportation	Mass of the transported product

LCA KNOWLEDGE

Module C1 - Deconstruction and Demolition

Module C1 includes the environmental impacts associated with activities required to deconstruct or demolish a building or infrastructure element at the end of its service life. Ground Granulated Blast Furnace Slag (GGBFS) is used as a supplementary cementitious material in concrete, mortar, and grout. During hydration, GGBFS reacts with calcium hydroxide and becomes chemically bound within the hardened cementitious matrix, forming part of the integrated concrete structure. Once incorporated into concrete, GGBFS does not remain as a separable material component.

At the end of the service life of a structure, demolition occurs at the level of the structural element (e.g., reinforced concrete slabs, columns, beams, and foundations) using conventional mechanical demolition equipment such as excavators fitted with hydraulic breakers, crushers, or shears. These demolition processes are driven by the structural characteristics of the concrete element and reinforcement layout rather than by the individual cementitious constituents within the concrete matrix. The presence of GGBFS within the cementitious binder does not alter demolition techniques, energy requirements, or operational procedures.

Because GGBFS remains chemically bound within the hardened concrete and cannot be separated or removed as an individual material at end-of-life, no specific demolition activities can be attributed directly to GGBFS as a standalone product. Demolition impacts occur at the level of the concrete structural system in which the material is incorporated. Therefore, environmental burdens associated with Module C1 are assigned a value of zero for GGBFS within the scope of this product-level assessment.

Module C2 - Transport to Waste Processing

Module C2 accounts for the environmental impacts associated with transporting demolition waste from the demolition site to waste processing or disposal facilities. At the end of the service life of concrete structures GGBFS, the material remains fully integrated within the hardened concrete matrix. Following demolition, the GGBFS fraction forms part of mixed mineral construction and demolition (C&D) waste consisting primarily of crushed concrete and other inert mineral materials.

Based on prevailing construction and demolition waste management practices across the United Arab Emirates and Northern Oman (Sohar and Musandam), it is assumed that 85% of the concrete demolition waste is transported to authorised C&D recycling facilities, while the remaining 15% is transported to inert landfill sites. This assumption reflects the established recycling infrastructure and diversion policies implemented across the region, including dedicated

LCA KNOWLEDGE

C&D recycling facilities operated by Dubai Municipality, Tadweer (Abu Dhabi Waste Management Center), and BEEAH in Sharjah, which collectively support the recovery and reuse of mineral construction waste (Dubai Municipality, 2022; Tadweer, 2023; BEEAH Group, 2023). The UAE Ministry of Climate Change and Environment has also promoted the use of recycled aggregates in infrastructure projects through regulatory guidance and sustainability initiatives (MOCCAE, 2019).

For benchmarking purposes, mineral C&D waste recycling rates in advanced economies typically range between 70% and 90%, with some jurisdictions exceeding 90% recovery under strong regulatory frameworks (European Commission, 2018; European Environment Agency, 2020). The adopted 85% recycling rate therefore represents a realistic and regionally appropriate assumption reflecting high diversion performance in major UAE emirates while accounting for comparatively lower recovery levels in smaller regional markets.

A one-way transport distance of 50 km is assumed from the demolition site to recycling facilities and landfill locations. This distance represents typical transport ranges within UAE and Northern Oman construction corridors where demolition waste is transferred to authorised treatment or disposal facilities. Transport is modelled using a >32-ton heavy-duty lorry, representative of bulk mineral waste transport vehicles operating in the region.

Module C2 therefore includes only the environmental burdens associated with the transport of mixed mineral demolition waste containing GGBFS to recycling and landfill facilities.

Type	Capacity utilization	Type of vehicle	Average distance
Truck	92%	Euro 6, >32 ton truck	50 kms

Module C3 - Waste Processing

Module C3 includes the processing of mineral construction and demolition (C&D) waste directed to recycling facilities. After transportation from the demolition site, concrete rubble containing GGBFS is delivered to authorised C&D recycling plants where it undergoes mechanical treatment to recover usable mineral materials.

At the recycling facility, the demolition waste is first subjected to inspection and preliminary sorting to remove oversized contaminants and non-mineral materials. The concrete rubble is then processed through primary crushing equipment such as jaw or impact crushers to reduce the size of the fragments. Following this initial size reduction, magnetic separation systems are used to remove embedded ferrous metals, including reinforcing steel. The mineral fraction is subsequently subjected to secondary crushing and multi-stage screening processes to produce graded recycled aggregate fractions and fine mineral materials.

All treatment processes involved in recycling mineral demolition waste are mechanical in nature and typically include crushing, screening, and metal separation operations. No thermal or chemical treatment processes are required. The GGBFS component remains chemically bound within the hydrated cement matrix and behaves as part of the inert mineral fraction of the crushed concrete during recycling.

The processed material is typically recovered as recycled aggregate suitable for infrastructure applications such as road base layers, sub-base materials, backfilling, and other construction uses. Module C3 therefore accounts for the environmental burdens associated with the mechanical processing operations required to convert concrete demolition waste containing GGBFS into usable recycled mineral materials.

Module C4 - Waste Processing

Module C4 covers the final disposal of the fraction of construction and demolition (C&D) waste that is not directed to recycling. For the purposes of this assessment, it is assumed that 15% of the mineral demolition waste containing GGBFS is transported to authorised inert construction and demolition landfill facilities within the United Arab Emirates and Northern Oman.

The disposed material consists primarily of crushed concrete and other inert mineral debris. Within this material stream, the GGBFS component remains chemically bound within the hardened cementitious matrix formed during concrete hydration. As a result, the material behaves as part of the stable mineral fraction of the demolished concrete and does not undergo further chemical transformation under landfill conditions.

Construction and demolition landfill sites in the region are designed specifically for inert mineral waste streams. Disposal operations typically involve unloading of the waste material, controlled placement within engineered landfill cells, mechanical compaction, and periodic covering to maintain landfill stability and operational safety. Since mineral construction waste is non-biodegradable, it does not generate landfill gas and exhibits negligible biological degradation.

Module C4 therefore includes the environmental burdens associated with inert landfill operations for the 15% fraction of non-recycled mineral demolition waste, while no additional emissions are attributed specifically to the GGBFS component due to its chemically stable and inert nature after incorporation into the concrete matrix.

D - Reuse, Recovery and Recycling Potential

Module D reports the net environmental benefits and burdens associated with material recovery processes that substitute primary production outside the system boundary, in accordance with the provisions of EN 15804+A2.

Mineral Fraction (Concrete Containing GGBFS)

At the end of the service life of concrete structures containing Ground Granulated Blast Furnace Slag (GGBFS), the material remains chemically bound within the hardened cementitious matrix of the concrete. Following demolition and transport to authorised recycling facilities, the concrete rubble undergoes mechanical processing operations including crushing, magnetic separation, and screening to produce recycled aggregate fractions.

Based on regional construction and demolition (C&D) waste management practices across the United Arab Emirates and Northern Oman, 85% of the mineral demolition waste is assumed to be directed to recycling facilities. The processed mineral material is typically recovered as recycled aggregates used in infrastructure applications such as road base layers, sub-base materials, backfilling, and general construction works.

The recovered recycled aggregates are modelled as substituting virgin crushed aggregate on a 1:1 mass basis. This substitution approach reflects the primary recovery pathway for recycled concrete materials within regional infrastructure projects and aligns with regulatory frameworks supporting the use of recycled aggregates in construction applications in the UAE (MOCCAE, 2019; Dubai Municipality, 2022). Similar substitution modelling approaches are widely applied in international construction LCA studies and C&D waste recovery protocols (European Commission, 2018).

Module D therefore includes the avoided environmental burdens associated with the extraction, processing, and transport of primary natural aggregates that are replaced by recycled aggregates derived from processed concrete waste containing GGBFS.

Packaging Materials

Packaging materials associated with the product are modelled with recovery rates reflecting industrial source-segregated collection practices and regional waste management infrastructure across the United Arab Emirates and Northern Oman. The assumed recovery rates are based on regional waste management frameworks and supported by international recycling benchmarks for similar packaging materials.

Wooden Pallets – 95% Recovery

Wooden pallets are assumed to be reused or recycled at a rate of 95%, reflecting established industrial reuse markets and high recovery rates reported by pallet industry studies (National Wooden Pallet & Container Association, 2016). Regional segregation frameworks in the UAE support recyclable wood recovery through licensed waste operators (Dubai Municipality, 2022).

Jumbo Bags (FIBC – Polypropylene) – 75% Recovery

Flexible Intermediate Bulk Containers (FIBCs) are reusable industrial packaging products made of polypropylene fabric. A 75% recovery rate is assumed, reflecting industrial reuse practices and the recyclability of polypropylene materials (PlasticsEurope, 2023). Regional waste operators in the UAE and Oman maintain plastic recycling capacity for segregated industrial streams (BEEAH Group, 2023).

Pull Tie Cord (Polypropylene) – 10% Recovery

Small plastic accessory components such as pull tie cords are assigned a 10% recovery rate due to limited segregation in construction waste streams. International plastic packaging recycling statistics indicate lower capture rates for small plastic components compared to bulk packaging (Eurostat, 2023).

Sling Bag Caps (Polypropylene) – 5% Recovery

Detached plastic caps are assumed to have minimal recovery (5%) due to their small size and low likelihood of source separation within C&D waste management systems.

Binding Strap (PVC) – 15% Recovery

PVC binding straps are assigned a 15% recovery rate, reflecting limited recycling capture for flexible PVC packaging materials. International plastic recovery data indicate moderate-to-low recycling rates for such materials without dedicated take-back schemes (PlasticsEurope, 2023).

LDPE Sheet – 95% Recovery

LDPE sheets are assumed to be recovered at 95% under an industrial source-segregated collection scenario. The UAE maintains plastic recycling infrastructure capable of processing LDPE materials (BEEAH Group, 2023), and LDPE film exhibits high recycling potential when clean and segregated (PlasticsEurope, 2023).

LCA KNOWLEDGE

Process	Unit (metric ton)
Collection process specified by type	
GGBFS in concrete collected as mixed mineral C&D waste	1
Recovery system specified by type	
Mineral demolition rubble sent for reuse / recycling as aggregate	0.85 (85%)
Mineral demolition rubble sent for energy recovery	Not applicable
Disposal specified by type	
Mineral demolition rubble sent to inert landfill	0.15 (15%)
Transportation assumptions	
Transport to recycling and landfill sites	50 km transport by Euro 6, >32 ton truck

LCA KNOWLEDGE

System Boundaries Illustration

	Product stage			Construction process stage		Use stage							End of life stage				Resource recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction / installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction & Demolition	Transport	Waste Processing	Disposal	Reuse, Recovery & Recycling potential
Module	**A1**	**A2**	**A3**	**A4**	**A5***	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Modules Declared	X	X	X	X	X	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X
Geography	UAE	UAE	UAE	GLO	-	-	-	-	-	-	-	-	GLO	GLO	GLO	GLO	GLO
Share of specific data	GWP > 90%			-		-	-	-	-	-	-	-	-	-	-	-	-
Variation - products	0%			-		-	-	-	-	-	-	-	-	-	-	-	-
Variation - sites	0%			-		-	-	-	-	-	-	-	-	-	-	-	-

X - Included, ND - Modules not declared.

**Module A5 is included to balance out biogenic emissions from packaging.*

LCA KNOWLEDGE

Cut-Off Rules

All relevant material and energy flows contributing to the manufacture of Ground Granulated Blast Furnace Slag (GGBFS) have been included in the LCA model. More than 99% of the total mass, energy use, and environmental relevance is captured. Negligible flows—those that do not influence the overall results—are excluded.

The Polluter Pays Principle and the Modularity Principle are applied to ensure that impacts are assigned to the processes where they occur and that each life cycle stage is reported independently. No known data gaps or exclusions are expected to influence the robustness of the results.

Allocation

Allocation was applied only where shared energy inputs were used across multiple cement product lines. Natural gas use, electricity consumption, water use, and diesel for internal handling were allocated using a mass-based approach, reflecting each product's proportional share of total annual production at the Ras Al Khaimah facility.

Raw material inputs—including Granulated Blast Furnace Slag (GBFS) as the sole constituent—and all associated transport flows were modelled using product-specific primary data, as these inputs are directly used for the production of Ground Granulated Blast Furnace Slag (GGBFS) and do not require allocation. No economic allocation was applied, as the plant does not generate co-products within the slag grinding process.

Electricity

Electricity consumption in the LCA model is based on the UAE grid mix as represented in Ecoinvent v3.11 (Allocation, cut-off by classification). The UAE electricity supply is predominantly generated from natural gas, supplemented by nuclear power, oil, solar energy, and minor imports from neighbouring GCC countries. The modelled grid composition is as follows:

Energy Source	Share (%)
Natural Gas - Combined Cycle Power Plant	51.31%
Natural Gas - Conventional Power Plant	38.11%
Nuclear - Pressure Water Reactor	7.06%
Hard Coal	2.09%

Oil	0.60%
Import from Saudi Arabia	0.44%
Import from Oman	0.20%
Solar Thermal (Parabolic Trough)	0.18%
Wind (<1 MW, Onshore)	0.00003%

The climate impact associated with this electricity mix is 5.81E-01 kg CO_2e per kWh, and this factor is applied consistently to all electricity use across modules A1–A3 and relevant downstream stages. This approach ensures that electricity-related impacts accurately reflect UAE operational conditions and the energy landscape relevant to Union Cement Company's Ras Al Khaimah facility.

Calculation Rules

The LCA model for Ground Granulated Blast Furnace Slag (GGBFS) uses foreground data collected directly from Union Cement Company's Ras Al Khaimah manufacturing facility, combined with background datasets sourced from Ecoinvent v3.11 (Allocation, cut-off by classification). These datasets provide emission factors for key inputs, including Granulated Blast Furnace Slag (GBFS) as the sole constituent, fuel combustion (natural gas), electricity generation, packaging materials, and transportation. Regionally representative conditions—such as UAE electricity mixes, supplier distances, and GCC end-of-life practices—were incorporated where relevant to ensure representativeness.

Transport activities for raw material supply, packaging procurement, and finished product delivery are included based on actual supplier-to-plant and plant-to-customer road distances. Road distances were measured using Google Maps, while sea freight distances for packaging imported from India were determined using portdistance.com. Exclusions are limited to items of negligible relevance (<1%), such as administrative activities, office utilities, and capital equipment maintenance. Transport flows are therefore fully represented within the defined geographical scope.

Byproducts Assignment

No by-products are generated during Ground Granulated Blast Furnace Slag (GGBFS) manufacturing. The only outputs are finished cement and process emissions from fuel combustion and calcination. Therefore, no allocation is required.

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ENVIRONMENTAL PERFORMANCE

In the following tables, the environmental performance of the declared unit “1 metric ton of Ground Granulated Blast Furnace Slag (GGBFS)” is presented for the Union Cement Company. Environmental impacts are calculated using EF-3.1, (ILCD).

ENVIRONMENTAL PERFORMANCE

Core Environmental impact indicators

The estimated impact results are only relative statements, which do not indicate the endpoints of the impact categories, exceeding thresholds values, safety margins or risks.

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Climate change (GWP) - fossil	Kg CO_2e	4.55E+00	1.04E+02	4.72E+01	1.56E+02	1.21E+01	0.00E+00	0.00E+00	4.94E-03	1.53E+01	9.39E-01	-9.06E+00
Climate change (GWP) - biogenic	Kg CO_2e	0.00E+00	0.00E+00	1.09E-03	1.09E-03	0.00E+00	-1.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Climate change (GWP) - LULUC	Kg CO_2e	1.35E-02	4.52E-02	5.99E+00	6.05E+00	5.83E-03	0.00E+00	0.00E+00	2.38E-06	2.18E-02	5.34E-04	-1.75E-02
Climate change (GWP) - total	Kg CO_2e	4.60E+00	1.05E+02	4.73E+01	1.56E+02	1.21E+01	0.00E+00	0.00E+00	4.95E-03	1.54E+01	9.39E-01	-9.10E+00
Ozone depletion	Kg CFC-11e	5.66E-08	9.75E-07	9.77E-06	1.08E-05	1.62E-07	0.00E+00	0.00E+00	6.60E-08	2.44E-07	2.61E-08	-1.04E-07
Acidification	mol H+e	3.00E-02	3.10E+00	7.07E-02	3.20E+00	2.88E-02	0.00E+00	0.00E+00	1.17E-02	1.18E-01	6.57E-03	-6.16E-02
Eutrophication, aquatic freshwater	kg PO_4^{3-} eq	3.69E-03	5.00E-03	6.33E-03	1.50E-02	2.84E-03	0.00E+00	0.00E+00	1.16E-03	2.27E-02	2.52E-04	-8.40E-03
Eutrophication, aquatic freshwater	Kg P eq	1.20E-03	1.63E-03	2.06E-03	4.90E-03	9.25E-04	0.00E+00	0.00E+00	3.77E-04	7.41E-03	8.22E-05	-2.74E-03
Eutrophication, aquatic marine	Kg N eq	8.56E-03	7.73E-01	1.72E-02	7.99E-01	7.69E-03	0.00E+00	0.00E+00	3.13E-03	4.17E-02	2.53E-03	-1.67E-02
Eutrophication, terrestrial	mol N eq	9.13E-02	8.59E+00	1.79E-01	8.86E+00	8.27E-02	0.00E+00	0.00E+00	3.37E-02	4.52E-01	2.76E-02	-1.96E-01
Photochemical ozone formation	Kg NMVOC eq	3.25E-02	2.30E+00	1.12E-01	2.45E+00	4.58E-02	0.00E+00	0.00E+00	1.86E-02	1.44E-01	9.95E-03	-6.10E-02
Abiotic depletion, minerals & metals	Kg Sb eq	2.02E-05	3.56E-05	2.94E-05	8.52E-05	3.63E-05	0.00E+00	0.00E+00	1.48E-05	3.48E-05	1.37E-06	-6.45E-05
Abiotic depletion of fossil resources	MJ	6.63E+01	1.04E+03	7.77E+02	1.88E+03	1.66E+02	0.00E+00	0.00E+00	6.74E+01	2.37E+02	2.30E+01	-1.19E+02
Water use	m^3 depr.	2.01E+00	1.73E+00	3.43E+00	7.17E+00	9.79E-01	0.00E+00	0.00E+00	3.99E-01	5.14E+01	1.02E+00	-1.37E+01

The results of the environmental impact indicators — Abiotic depletion, Water use, and all optional indicators except Particulate matter and Ionizing radiation, human health — shall be used with care, as the uncertainties on these results are high or there is limited experience with the indicator. Reading example: 1.57E-03 = 1.57×10^{-3} = 0.00157.

ENVIRONMENTAL PERFORMANCE

Additional environmental impact indicators

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Particulate matter	Incidence	7.21E-07	3.20E-06	4.28E-07	4.35E-06	1.24E-06	0.00E+00	0.00E+00	5.05E-07	8.81E-06	1.51E-07	-1.28E-06
Ionizing radiation, human health	Kbq U-235 eq	1.75E-01	3.17E-01	2.84E+00	3.33E+00	1.59E-01	0.00E+00	0.00E+00	6.47E-05	3.73E-04	1.38E-02	-3.82E-01
Ecotoxicity (freshwater)	CTUe	2.52E+01	6.37E+01	5.36E+01	1.42E+02	2.27E+01	0.00E+00	0.00E+00	9.24E+00	7.71E+01	1.66E+00	-4.07E+01
Human toxicity, cancer effects	CTUh	2.85E-08	1.68E-08	8.10E-09	5.34E-08	2.03E-09	0.00E+00	0.00E+00	8.26E-10	3.37E-09	1.70E-10	-2.90E-08
Human toxicity, non-cancer effects	CTUh	4.37E-08	2.85E-07	8.85E-08	4.17E-07	1.21E-07	0.00E+00	0.00E+00	4.91E-08	1.32E-07	3.83E-09	-8.87E-08
Land use related impacts/soil quality	Dimensionless	2.64E+03	1.79E+02	1.60E+01	2.83E+03	1.90E+02	0.00E+00	0.00E+00	7.75E+01	2.57E+02	4.52E+01	-2.59E+03

This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure, or radioactive waste disposal in underground facilities. Potential ionizing radiation from soil, radon, and some construction materials is also not measured by this indicator.

GWP-GHG Indicators

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
GWP-GHG	Kg CO_2e	4.60E+00	1.05E+02	4.73E+01	1.56E+02	1.21E+01	1.09E-03	0.00E+00	4.95E-03	1.54E+01	9.39E-01	-9.10E+00

This indicator includes all greenhouse gases, excluding biogenic carbon dioxide uptake and emissions, as well as biogenic carbon stored in the product, as defined by IPCC AR6 (2021). The indicator aligns closely with the Global Warming Potential (GWP) outlined in EN 15804:2012+A2:2019, incorporating updated characterization factors and environmental impact indicators.

Resource Use Indicators

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Renewable PER used as energy	MJ	3.65E+02	5.04E+00	5.14E+00	3.75E+02	2.55E+00	0.00E+00	0.00E+00	1.04E+00	6.74E+00	2.17E-01	-3.51E+02
Renewable PER used as materials	MJ	1.46E-02	0.00E+00	3.94E-02	5.40E-02	0.00E+00	-5.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-3.39E-02

ENVIRONMENTAL PERFORMANCE

Total use of renewable PER	MJ	3.65E+02	5.04E+00	5.18E+00	3.75E+02	2.55E+00	-5.40E-02	1.04E+00	6.74E+00	2.17E-01	-3.51E+02	1.04E+00
Non-renewable PER used as energy	MJ	6.63E+01	1.04E+03	7.77E+02	1.88E+03	1.66E+02	0.00E+00	6.74E+01	2.37E+02	2.30E+01	-1.19E+02	6.74E+01
Non-renewable PER used as materials	MJ	3.31E-06	0.00E+00	4.50E-06	7.81E-06	0.00E+00	-7.81E-06	0.00E+00	0.00E+00	0.00E+00	-8.92E-04	0.00E+00
Total use of non-renewable PER	MJ	6.63E+01	1.04E+03	7.77E+02	1.88E+03	1.66E+02	-7.81E-06	6.74E+01	2.37E+02	2.30E+01	-1.19E+02	6.74E+01
Use of secondary materials	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of net fresh water	m^3	0.00E+00	0.00E+00	4.53E-01	4.53E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Waste Indicators

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Hazardous waste	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-hazardous waste	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E+02	0.00E+00
Radioactive waste	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Output Flow Indicators

Impact Category	Unit	A1	A2	A3	A1-A3	A4	A5	C1	C2	C3	C4	D
Components for reuse	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.52E+02
Materials for recycling	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E+02	0.00E+00	8.52E+02

ENVIRONMENTAL PERFORMANCE

Materials for energy recovery	Kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy - electricity	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy - thermal	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Biogenic carbon content

Details	Unit	A1-A3
Biogenic carbon content in product	Kg C	0.00E+00
Biogenic carbon content in accompanying packaging	Kg C	2.97E-04

Note: 1 kg biogenic carbon is equivalent to 44/12 kg CO2. "Reading example: 1.57E-03 = $1.57*10^{-3}$ = 0.00157"

Disclaimer: “According to the **EN 15804:2012+A2:2019** standard, the LCIA results are relative expressions translating impacts into environmental themes such as climate change, ozone depletion, etc. (midpoint impact categories). Thus, the LCIA results do not predict impacts on category endpoints such as impact on the extinction of species or human health. In addition, the results do not provide information about exceeding thresholds, safety margins or risks”.

ENVIRONMENTAL PERFORMANCE

Interpretation

The life cycle results for Ground Granulated Blast Furnace Slag (GGBFS) demonstrate a transport- and processing-driven environmental profile, with Module A2 accounting for 56.55% of total GWP, followed by Module A3 at 25.57%. This distribution is technically consistent with GGBFS production where the principal constituent, Granulated Blast Furnace Slag (GBFS), is sourced from overseas suppliers and transported over long distances before drying and grinding at the Union Cement Company facility. Under the cut-off approach, the upstream steelmaking burden is not allocated to GBFS, and therefore the environmental profile is governed primarily by international logistics and grinding-related electricity rather than high-temperature clinker formation or calcination. The dominance of A2 confirms that marine freight and associated inland transport from source to Ras Al Khaimah are the main carbon hotspots in the product system.

Module A1 (2.48%) remains comparatively low, which is methodologically appropriate for GGBFS modelled using a burden-free secondary material approach under the cut-off system model. Its contribution is limited to upstream activities associated with slag handling, packaging materials, and background energy datasets rather than primary mineral extraction or process emissions. The low A1 share clearly differentiates GGBFS from clinker-based cement products such as OPC or Oil Well Cement, where raw material calcination and kiln fuel combustion dominate the footprint. In contrast, the GGBFS profile reflects the environmental advantage of using an industrial by-product as the sole principal constituent.

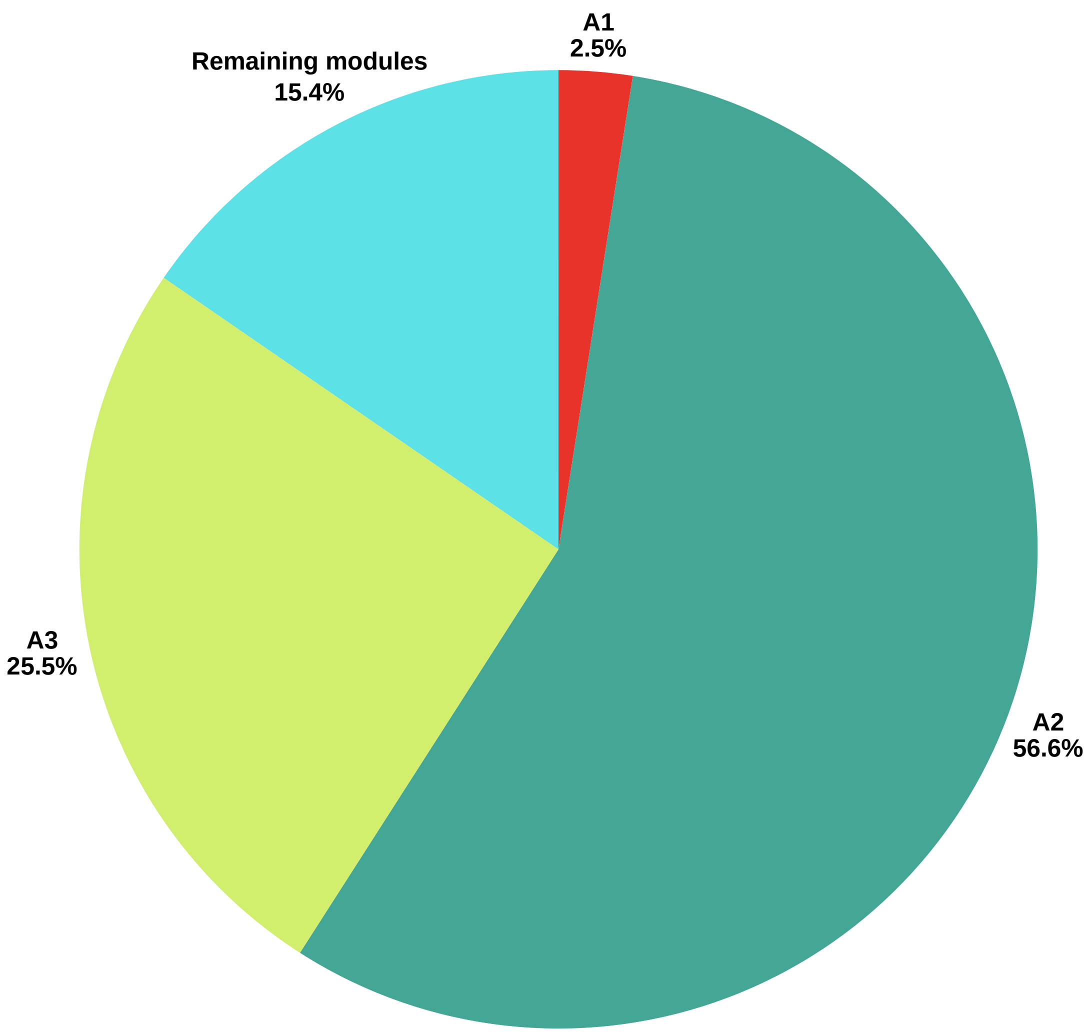
Module A3 (25.57%) represents the second major hotspot and reflects electricity and auxiliary energy used for drying, grinding, storage, and packing at the Ras Al Khaimah facility. This contribution is technically plausible for GGBFS, since the manufacturing process is based on mechanical drying and size reduction rather than thermal clinker production. The absence of calcination and kiln reactions means that no process-related CO_2 emissions occur during manufacturing, and the A3 burden is therefore driven mainly by electricity consumption for grinding systems and associated plant operations. Module A4 (6.57%) remains moderate and reflects outbound transport of finished GGBFS to customers across the UAE and Northern Oman; its relatively limited share confirms that downstream regional distribution is materially smaller than the upstream international transport burden associated with imported GBFS.

The end-of-life profile is also technically coherent for a supplementary cementitious material used in concrete applications. Module C1 is zero, as GGBFS becomes chemically bound within the hardened concrete matrix and cannot be separated as an independent material during demolition. Modules C2 (0.003%), C3 (8.32%), and C4 (0.51%) show that end-of-life impacts are driven almost entirely by mechanical waste processing rather than demolition or disposal, with

ENVIRONMENTAL PERFORMANCE

C3 reflecting crushing, separation, and screening operations used to recover recycled aggregate from demolished concrete. This distribution confirms that the environmental profile of GGBFS is shaped primarily by imported raw material logistics and on-site grinding energy, while end-of-life burdens remain comparatively modest and consistent with mineral construction materials incorporated into recyclable concrete systems.

Life Cycle Stage Contribution to GWP (kg CO_2e per 1 metric ton of Ground Granulated Blast Furnace Slag)



ENVIRONMENTAL PERFORMANCE

Mandatory Statements

Explanatory materials are available from the EPD Owner and/or LCA Author. The verifier and Program Operator make no claims and bear no responsibility regarding the legality of the study. Sole ownership, liability, and responsibility for the EPD lie with the EPD Owner. The LCA Author is not liable for manufacturer-provided information, life cycle data, or supporting evidence.

EPDs within the same product category, but issued by different EPD programs, may not be comparable. For valid comparison, both EPDs must be based on the same PCR (including version number), or on fully-aligned PCRs. Products must have identical function, technical performance, and use cases (e.g. the same declared or functional unit); share equivalent system boundaries, data descriptions, and data quality standards; use comparable collection methods and allocation rules; include matching content declarations; and be valid at the time of comparison.

Information related to EPD of multiple products

This is not an EPD of multiple products.

Information related to Sector EPD

This is not a sector EPD.

Differences vs previous versions

This is the first version of the EPD.

REVIEW AND VERIFICATION

Program Operator	International Climate Intelligence System 71-75 Shelton Street Covent Garden London, WC2H 9JQ United Kingdom
Registration Number	ICIS-202603-129
Publication Date	26-03-2026
Valid Until	25-03-2031
Geographical Scope	United Arab Emirates (UAE)
Product category rules (PCR): PCR 2026:18 Construction products (EN15804:2012+A2:2019/AC:2021) Version 1.2.6 dated 21-Jan-2026	
PCR review was conducted by: International Climate Intelligence System	
Independent verification of the declaration and data, according to ISO 14025:2006 and ISO 14040: EPD Process Certification (internal) ☑ EPD Verification (external)	
Third party verifier: Constantine Stephen, International Climate Intelligence System (ICIS)	

CONTACT DETAILS

EPD Owner

Nitin Asnani
Process Manager

Union Cement Company (Pr.J.S.C)
Khor Khwair Industrial Area, RAK
P.O Box 170, United Arab Emirates

Email - info@uccrak.com
Website - www.uccrak.com

EPD Author

Alan Beski Christopher
Sustainability Manager

GCAS Quality Certifications
P.O Box 65561
Dubai, United Arab Emirates

Email - info.dubai@gcasquality.com
Website - www.gcasquality.com

EPD Verifier

Constantine Stephen
Glasgow, United Kingdom

Accredited by
International Climate Intelligence System
71-75 Shelton St, London WC2H 9JQ, United Kingdom

Program Operator

Email - office@climateintell.com
Website - www.climateintell.com

ACRONYMS

Acronym	Meaning
kg CO_2e	Kilograms of carbon-dioxide equivalent
kg CFC-11e	Kilograms of Chlorofluorocarbon-11 equivalent
mol H+e	Moles of hydrogen ion equivalent
kg PO_4^{3-} eq	Kilograms of phosphate equivalent
kg P eq	Kilograms of phosphorus equivalent
kg N eq	Kilograms of nitrogen equivalent
mol N eq	Moles of nitrogen equivalent
kg NMVOC eq	Kilograms of non-methane volatile organic compound equivalent
kg Sb eq	Kilograms of antimony equivalent
MJ	Megajoules
m^3 depr.	Cubic meters of water deprived
incidence	Unit representing human health impact related to particulate matter exposure
Kbq U-235 eq	Kilo-becquerels of Uranium-235 equivalent
CTUe	Comparative Toxic Unit for ecosystems
CTUh	Comparative Toxic Unit for humans
dimensionless	Unitless characterization factor — used for land-use/soil quality impacts
kg C	Kilograms of biogenic carbon contained in product or packaging

STANDARDS AND REFERENCES

Standards & Methodological Frameworks

- EN 15804:2012 + A2:2019 / AC:2021 – Sustainability of construction works – Core rules for environmental product declarations of construction products.
- ISO 14025:2006 – Environmental labels and declarations – Type III environmental declarations – Principles and procedures.
- ISO 14040:2006 – Life cycle assessment – Principles and framework.
- ISO 14044:2006 – Life cycle assessment – Requirements and guidelines.

PCR & Program Documents

- PCR 2026:18 Construction Products, Version 1.2.6 – International Climate Intelligence System (EN 15804+A2 aligned).
- EPD General Program Instructions (GPI) of International Climate Intelligence System, v2.0, 2023.

Databases, Tools & Modelling Sources

- Ecoinvent v3.11, system model: Allocation, cut-off by classification.
- Air.e.LCA Software v3.20.1.0 by Solid Forest – Used for LCA modelling and impact calculations.
- IPCC AR6 (2021) Characterization Factors – Applied for GWP indicators (where relevant).
- EF 3.1 (Environmental Footprint 3.1 method) – Used for all midpoint impact indicators.

Transport Calculation Tools

- Google Maps – Road transport distance calculations.
- PortDistance.com – Maritime transport distance calculations.

End-of-Life & Recycling

- BEEAH Group (2023). Waste Recycling and Processing Operations in the UAE. BEEAH Group, Sharjah, United Arab Emirates.
- Dubai Municipality (2022). Waste Segregation and Construction & Demolition Waste Recycling Guidelines. Government of Dubai, United Arab Emirates.
- European Commission (2018). EU Construction and Demolition Waste Management Protocol. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Brussels, Belgium.
- European Environment Agency (2020). Construction and Demolition Waste Statistics and Recycling Performance in Europe. EEA, Copenhagen, Denmark.
- Eurostat (2023). Packaging Waste Statistics – Recycling Rates in the European Union. Statistical Office of the European Union, Luxembourg.

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- Ministry of Climate Change and Environment (MOCCAE), UAE (2019). Resolution on the Use of Recycled Aggregates from Construction and Demolition Waste in Infrastructure Projects. Government of the United Arab Emirates.
- National Wooden Pallet & Container Association (2016). U.S. Pallet Recycling Study. NWPCA / Virginia Tech Study, United States.
- PlasticsEurope (2023). Plastics – The Facts 2023: An Analysis of European Plastics Production, Demand and Waste Data. PlasticsEurope, Brussels.
- Tadweer (Abu Dhabi Waste Management Center) (2023). Construction and Demolition Waste Recycling Operations and Diversion Practices. Abu Dhabi, United Arab Emirates.


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