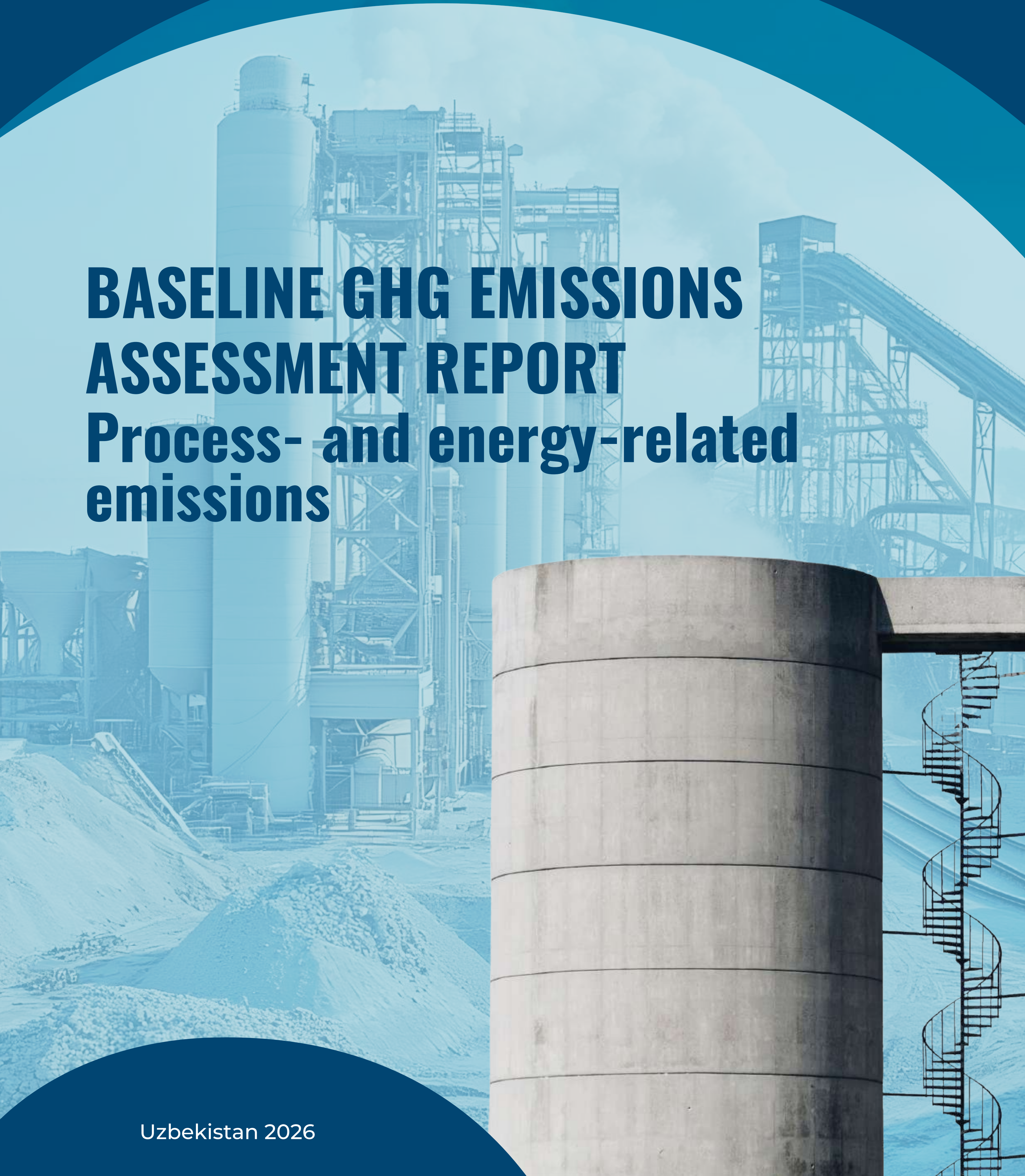
BASELINE GHG EMISSIONS ASSESSMENT REPORT

Process- and energy-related emissions



Uzbekistan 2026

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Acknowledgement

This report was prepared by the Center for Economic Research and Reforms (CERR) under the Administration of the President of the Republic of Uzbekistan within the framework of the UNDP project "Decarbonizing Cement Industry: Accelerating Policy and Practical Actions for GHG Reduction in Uzbekistan" implemented under UNDP's Climate Promise initiative.

The study assesses the baseline level of greenhouse gas emissions in the cement industry, analyses the operational and energy performance of cement plants, and identifies key directions for the sector's further decarbonization.

We acknowledge the representatives of CERR — ***Dr. Abdurashid Bozorov*** and ***Bakhtiyor Ismailov*** for preparing the study and conducting the analytical work.

Special thanks are extended to UNDP Uzbekistan, particularly ***Akiko Fujii, Anas Fayyad Qarman, Bakhadur Palvaniyazov, Bekzat Anarbekov, Isomiddin Akramov*** and ***Valeria Hutter***, for their overall guidance, expert support and recommendations throughout the preparation of the report.

We also thank the Association "O'zsanoatqurilishmateriallari" and the cement industry enterprises for supporting data collection, providing the necessary information and participating in consultations.

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Contents

LIST OF ABBREVIATIONS

BAT	Best available technologies
$CaCO_3$	Calcium carbonate, limestone
CaO	Calcium oxide, quicklime
CERR	Center for Economic Research and Reforms
CLF	Clinker-to-cement factor
CO_2	Carbon dioxide
CSI	Cement Sustainability Initiative
ES	Emission Survey
EU	European Union
GHG	Greenhouse gases
GNR	Getting the Numbers Right, the cement industry performance database
GS	Green Survey
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JSC	Joint-stock company
kcal/kg	Kilocalorie per kilogram
kt CO_2	Kilotonnes of CO_2
kWh/t	Kilowatt-hour per tonne of cement
LLC	Limited liability company (Uzbek: mas'uliyati cheklangan jamiyati, MCHJ)
$MgCO_3$	Magnesium carbonate
MgO	Magnesium oxide
MWh	Megawatt-hour
NCV	Net calorific value
NDC	Nationally determined contributions
RDF	Refuse-derived fuel
SCM	Supplementary cementitious materials
t CO_2/t	Tonnes of CO_2 per tonne of product
TS	Technical Survey
TSR	Thermal substitution rate
UN	United Nations
UNDP	United Nations Development Programme
WHR	Waste heat recovery
capacity utilization factor	The ratio of actual output to installed capacity
EN 197-1	European standard for common cements
ISO 50001	International standard for energy management systems

1. Introduction

1.1 Background and context

Over the past decade Uzbekistan has seen a substantial expansion of cement production capacity, driven by the country's construction boom and by state industrialization programmes. The sector is one of the most energy- and carbon-intensive industries in the country and contributes materially to national greenhouse gas (GHG) emissions, both through the chemical decomposition of limestone (calcination) and through the combustion of fossil fuels in rotary kilns. As Uzbekistan works to meet its commitments under the Paris Agreement and its updated Nationally Determined Contributions (NDCs), addressing emissions from the cement industry is at once a priority and a significant challenge.

With the support of the United Nations Development Programme (UNDP) in Uzbekistan, the Center for Economic Research and Reforms is carrying out analytical work on reducing greenhouse gas emissions in the cement industry. The project provides for a comprehensive assessment of the sector, including a quantification of the baseline level of emissions, the identification of abatement opportunities, and the development of a decarbonization roadmap for the industry in line with international best practice.

1.2 Purpose of this report

The "Uzsanoatqurilishmateriallari"Association's industry register lists 43 production facilities. This assessment covers the 24 enterprises that actually produced cement in 2025, including 19 large plants that remain technically operable. The limited production activity of the remaining enterprises reflects intensifying competition on the domestic market together with regulatory changes associated with the switch from natural gas to coal.

Total installed cement production capacity in the country is estimated at 41.5 million tonnes per year, while actual annual output is approximately 22 million tonnes. This corresponds to an average capacity utilization factor of roughly 53%. The relatively low utilization rate reflects a combination of structural and economic factors, including outdated production technology at some plants, high operating and fuel costs, and competitive pressure in local markets, which together constrain full-capacity operation across the sector.

In addition, 19 cement plants are currently not producing cement, having ceased operations at various times. Their present status can be summarized as follows:

- 4 plants have already been converted from cement production to other industrial activities;
- 4 plants intend to change their production profile and discontinue cement manufacture;
- 3 plants are under reconstruction with a view to expanding production capacity;
- 8 plants have fully suspended operations, mainly because of investment and financing difficulties.

According to the data collected to date, cement production in Uzbekistan is carried out entirely by the dry process. In terms of fuel supply, virtually all cement plants in the country use coal as their principal energy source.

This report presents a baseline assessment of greenhouse gas emissions in Uzbekistan's cement industry. The analysis comprises an inventory of GHG emissions at the 24 operating cement enterprises, broken down by principal source — industrial process, fuel combustion and purchased grid electricity. It also benchmarks the energy efficiency and specific emissions of the enterprises against international best available technologies reference values. Particular attention is given to the structural characteristics of the industry, including ownership arrangements, technologies in use, the geographical distribution of plants and their readiness to implement decarbonization projects.

1.3 Scope and coverage

The assessment covers all 24 cement plants that were actually in operation in Uzbekistan during the 2025 reporting period. Of these, 23 are integrated plants producing both clinker and cement. Kuvasoycement operates solely as a cement grinding facility and purchases clinker from third-party suppliers. The Jizzakh Cement Plant also operated in grinding-only mode in 2025, and its emissions were therefore limited to Scope 2, associated with electricity purchased from the public grid. The analysis is national in scope and covers enterprises located in 10 regions of the country.

The assessment covers the principal sources of greenhouse gas emissions arising in cement manufacture. Direct process emissions (Scope 1) are generated during the calcination of carbonate raw materials in clinker production. Direct energy emissions (Scope 1) comprise emissions from the combustion of coal, natural gas, petroleum coke and other fuels in kilns and ancillary equipment. Indirect energy emissions (Scope 2) relate to the consumption of electricity purchased from the public grid. Value-chain emissions (Scope 3), including emissions from the transport of raw materials and products and from the extraction and supply of fuel, are not included in the baseline assessment, since the analysis focuses on emissions directly associated with the production activity of the cement enterprises.

1.4 Structure of the report

The remainder of the report is organized as follows. Chapter 2 describes the methodological framework, including data sources, the IPCC calculation method, emission factors and the criteria used for benchmarking. Chapter 3 presents an overview of Uzbekistan's cement industry, covering its structure, production capacity, ownership composition and workforce. Chapter 4 sets out the detailed baseline GHG inventory, disaggregated by source, enterprise and region. Chapter 5 provides plant-level benchmarking covering thermal energy efficiency, electricity consumption, the clinker-to-cement ratio and overall specific emission intensity. Chapter 6 analyses the influence on emissions performance of factors such as waste heat recovery, plant age, ownership (foreign or domestic) and production scale. Chapter 7 compares Uzbekistan's sectoral indicators with international BAT benchmarks. Chapter 8 assesses environmental decarbonization readiness on the basis of the barrier analysis from the Green Survey. Chapter 9 sets out the conclusions and recommendations.

2. Methodology

2.1 Data collection approach

Source data were collected and processed in accordance with IPCC methodological approaches. In building the calculation base, priority was given to actual production and energy data supplied by the enterprises. The list of indicators was determined by the structure of the emissions calculation and comprised the parameters that directly affect the final estimate. Where individual data points were unavailable, the default factors and reference values provided for by the IPCC methodology and other specialist sources were applied. For every calculation parameter, the source, the value applied and the assumptions made were recorded, ensuring transparency, comparability and reproducibility of the results.

Three collection instruments. Over 2025–2026, three purpose-designed questionnaires were distributed among cement plant operators, each with its own objective.

The Emission Survey (ES) is the principal instrument from which the calculation base is derived. Enterprises were asked precisely for the indicators that enter the calculation formulas directly: cement and clinker output, fuel consumption and fuel type, electricity consumption, and the chemical composition of the raw material (CaO and MgO content, which determines specific emissions from kiln firing). Complete responses were provided by 12 of the 24 operating plants.

The Green Survey (GS) addresses a question that production figures cannot reveal: what prevents enterprises from reducing emissions. Respondents — 16 plants — assessed the importance of decarbonization for their competitiveness and ranked specific obstacles: the cost and availability of finance, the absence of alternative fuel supply, regulatory constraints and skills shortages. The results form the basis of the barrier analysis.

The Technical Survey (TS) is an in-depth review of equipment. Assessing the technical readiness of plants for modernization required information found neither in reporting nor in the other two questionnaires: the composition of equipment by process section, installed capacity, the type and age of units, the level of automation and the state of maintenance. Such a review is conducted individually and requires the participation of the enterprise's technical services; within the project, 7 plants were examined in detail. TS data do not enter the emissions calculation.

For enterprises that provided an incomplete data set, production volumes were determined on the basis of the official statistics of the Uzsanoatqurilishmateriallari association, and missing process parameters were filled with default values. Actual enterprise data took unconditional priority and were replaced by estimated values only where they were absent. This procedure made it possible to include all 24 operating cement enterprises in the calculation base and to achieve full sectoral coverage by production volume.

2.2 IPCC methodology

Greenhouse gas emissions were calculated in accordance with the 2006 IPCC Guidelines. These documents define the internationally recognized approach to emissions accounting for cement manufacture and allow for different levels of calculation depth depending on the completeness of the available data — from the application of generic default values (Tier 2) to calculation using the actual indicators of a specific enterprise (Tier 3). In this assessment, enterprise data were used where these were provided, with default values applied in the remaining cases.

2.2.1 Process emissions (Scope 1)

Process emissions from clinker production were calculated by two methods, depending on the completeness of the source data. For enterprises that submitted chemical analysis results under the Emission Survey, the chemical composition method (Tier 3) was applied — plant-specific emission factors were calculated from the calcium oxide (CaO) and magnesium oxide (MgO) content of the clinker, on the basis of the stoichiometry of CO_2 release during the thermal decomposition of $CaCO_3$ and $MgCO_3$ in the kiln. Such data were provided by 12 plants, for which specific factors were obtained in the range of 0.5154 to 0.5463 tonnes of CO_2 per tonne of clinker. For the remaining enterprises, the IPCC default emission factor of 0.5273 tonnes of CO_2 per tonne of clinker was applied (Tier 2).

2.2.2 Energy emissions (Scope 1)

Emissions from fuel combustion were calculated using the Tier 2 method, based on the net calorific value (NCV) of each fuel type and IPCC emission factors. Where the Emission Survey provided the data, installation-specific NCV values were applied; otherwise, the values adopted for the assessment were used: coal 24.0 GJ/t, coke 28.0 GJ/t, natural gas 36.0 GJ per 1,000 m^3. The following emission factors were applied: coal (sub-bituminous) — 96.1 kg CO_2/GJ, natural gas — 56.1 kg CO_2/GJ, coke oven coke — 107.0 kg CO_2/GJ.[1]

2.2.3 Indirect emissions (Scope 2)

Scope 2 indirect emissions associated with electricity purchased from the public grid were calculated using the emission factor of Uzbekistan's power system (IEA, 2024) of 0.569 tonnes of CO_2 per MWh. Total electricity consumption for each plant was calculated from specific electricity consumption (kWh per tonne of cement) and annual production volume. For the four plants equipped with Waste Heat Recovery (WHR) systems, the reported grid electricity consumption represents net purchases after deducting the electricity generated on site from recovered heat, which results in substantially lower Scope 2 emissions[2].

2.3 Benchmarking framework

The indicators of each plant were compared against threshold values for four parameters — specific thermal energy consumption, specific electricity consumption, the clinker-to-cement ratio and greenhouse gas emission intensity. Using four parameters rather than a single composite indicator makes it possible to establish the reasons for each plant's underperformance and to identify the corresponding measures.

1 IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Volume 2: «Energy,» Chapter 2: «Stationary Combustion,» Tables 2.2 (default NCV values) and 2.3 (default emission factors for CO_2 by fuel type).
2 IEA Emission Factors database (2024 edition). CO2 emission factor specific to electricity generation in Uzbekistan. Source: https://www.iea.org/data-and-statistics/data-product/emissions-factors-2025

Table 2.1. Benchmark values by performance tier

Indicator	BEST	GOOD	AVERAGE	POOR
Specific thermal energy consumption, kcal/kg clinker	≤ 764	≤ 900	≤ 1 050	> 1 050
Specific electricity consumption, kWh/t cement	≤ 80	≤ 95	≤ 110	> 110
Clinker-to-cement ratio	≤ 0,75	≤ 0,82	≤ 0,90	> 0,90
GHG emission intensity, t CO_2/t cement	≤ 0,60	≤ 0,70	≤ 0,80	> 0,80

The thermal energy thresholds correspond to kiln equipment types. The 764 kcal/kg threshold, or 3.2 GJ per tonne of clinker, corresponds to a dry-process kiln with a preheater and precalciner and falls within the best available technologies range of 717–788 kcal/kg (IEA, 2018). The 900 kcal/kg threshold corresponds to a kiln without a precalciner and exceeds the world average level of 836–860 kcal/kg. The 1,050 kcal/kg threshold corresponds to a long kiln without a preheater; higher values indicate either wet-process operation or equipment wear.

The electricity thresholds are defined by grinding equipment type: 80 kWh/t corresponds to vertical roller mills against a best available techniques benchmark of 65 kWh/t (IFC, 2017), 95 kWh/t to the world average level, and 110 kWh/t to closed-circuit ball mills.

The clinker-to-cement thresholds are established on the basis of European cement product standards

(EN 197-1), which makes them verifiable through the product range manufactured. A value of 0.75 corresponds to composite cements with a clinker content of 65–79% (CEM II/B) and at the same time to the average level of EU plants (JRC, 2020). A value of 0.82 corresponds to cements with a clinker content of 80–94% (CEM II/A). A value of 0.90 corresponds to cement produced with a minimal proportion of mineral additions. The world average is 0.71 and the best available techniques benchmark is 0.65.

Emission intensity is a derived indicator, and its thresholds are aligned with the three preceding ones. The thresholds correspond to international benchmarks: 0.60 t/t reflects the average level of European Union plants, and 0.70 t/t the world average with a technological margin (JRC, 2020; GCCA GNR).

The BEST tier reflects the performance of modern plants in developed countries. Best available technologies limit values are presented in Chapter 5 as a long-term benchmark for the industry. The POOR tier identifies plants requiring equipment modernization.

2.4 Sample representativeness and data quality

To establish the reliability of the baseline inventory, the representativeness of the primary data sample was assessed against the full population of 24 plants. Of the 24 plants, 12 provided complete responses to the enterprise survey (the Emission Survey), including plant-specific data on production volumes, fuel consumption, clinker chemical composition (CaO and MgO content) and energy consumption. These 12 directly responding plants account for approximately 78% of total sectoral output (17,300 of 22,045 thousand tonnes), so that verified primary data predominate in the weighted average indicators.

The 12 responding plants included representatives of all key categories: 4 of the 6 foreign-invested plants and 8 of the 18 domestic plants; one plant operating by the wet process (Kuvasoycement); 4 plants equipped with waste heat recovery (WHR) systems; and a range of fuel types (coal, natural gas) was likewise represented.

3. Overview of the cement industry

3.1 Industry structure and scale

There are 43 cement plants in Uzbekistan in total, of which 19 are currently not producing cement, having ceased operations at various times. Two plants are modernizing their production facilities, in particular by switching from natural gas to coal as the fuel for clinker burning.

Table 3.1. Full classification of enterprises
(all 24 operating enterprises, sorted by production volume)

#	Plant	Region	Capacity, ths. t/yr	Output, ths. t/yr	WHR	Electricity, kWh/t	Utilization	GHG, t/t
1	CESam	Samarkand	3,000	2,782.8	No	66.4	0.750	0.6779
2	Ohangaron	Tashkent	2,400	2,188.0	No	92.7	0.895	0.858
3	Kizilkumcement	Navoi	5,700	2,094.0	No	90.0	0.820	0.673
4	Toshkent Conch	Tashkent	2,500	2,081.3	Yes	30.8	0.797	0.739
5	Huaxin Jizzakh	Jizzakh	2,000	1,940.8	No	80.3	0.737	0.7501
6	Shangfeng	Andijan	2,500	1,853.1	Yes	33.3	0.694	0.691
7	Qarshi Conch	Kashkadarya	1,600	1,563.0	Yes	40.0	0.713	0.708
8	Andijan WCC	Andijan	2,500	1,331.0	Yes	57.2	0.730	0.748
9	Namangancement	Namangan	1,250	1,056.2	No	80.0	0.850	0.709
10	Fargona Yasin	Fergana	2,000	1,034.0	No	81.5	0.998	0.901
11	Karakalpakcement	Karakalpakstan	1,400	1,019.3	No	85.0	0.857	0.770
12	Jizzakh Cement MCJ	Jizzakh	2,000	648.0	No	80.0	0.820	0.812
13	Bekabadcement	Tashkent	1,600	607.1	No	90.0	0.820	0.818
14	Reco Brend	Andijan	1,200	480.4	No	80.0	0.750	0.832
15	Kuvasoycement	Fergana	1,080	306.4	No	40.0	—	0.023
16	Jizzakh CP	Jizzakh	1,000	192.4	No	45.0	—	0.0256
17	Toshbuloq	Namangan	600	176.4	No	80.0	0.820	0.752
18	Jomboy Cement	Samarkand	1,000	167.0	No	80.0	0.820	0.752
19	Shaffof Sement	Fergana	360	136.0	No	80.0	0.820	0.752
20	Samarqand Afrosiyob	Samarkand	165	112.3	No	80.0	0.820	0.812
21	Turon Eco	Fergana	700	105.2	No	100.0	0.820	0.824
22	Pop Sement	Namangan	350	98.5	No	95.0	0.867	0.847
23	Surhancement	Surkhandarya	360	56.6	No	98.0	0.833	0.839
24	Dal Teknik Zomin	Jizzakh	100	15.0	No	90.0	0.820	0.840

Source: Technical Survey (TS), Emission Survey (ES), Green Survey (GS), CERR analysis, 2025.

Uzbekistan's cement sector comprises 24 operating enterprises with a combined installed production capacity of 37,025 thousand tonnes per year. In 2025, total cement output reached 22,044.7 thousand tonnes, corresponding to a weighted average capacity utilization factor of approximately 59.5%. The industry produced 17,132.3 thousand tonnes of clinker, with an average clinker-to-cement ratio of 0.811 (simple average across plants; the ratio of total clinker to total output is 0.795).

The industry has a dual structure. On the one hand, 13 large plants (each with annual output above 500 thousand tonnes) account for approximately 91.4% of total output. On the other, the remaining share of production is supplied by 8 medium-sized plants (100–500 thousand tonnes) and 3 small plants (below 100 thousand tonnes). One of the smallest enterprises, Kuvasoycement, does not produce clinker and operates solely as a grinding facility, purchasing clinker externally for blending and grinding into finished cement.

3.2 Ownership structure

A defining feature of Uzbekistan's cement industry is the prominent role of foreign-invested enterprises. Six enterprises with foreign capital currently operate in Uzbekistan. Their combined output is 11,552.0 thousand tonnes of cement, equal to 52.4% of total national production. These plants are Toshkent Conch Cement, Huaxin Cement Jizzakh, China Energy International (CESam), Qarshi Conch Cement, Shangfeng Bridge of Friendship and Andijan WCC Cement.

Foreign-invested enterprises are generally distinguished by more modern equipment, higher production volumes and the adoption of waste heat recovery (WHR) systems. Four of the six foreign-invested plants are equipped with WHR systems, which recover thermal energy from kiln exhaust gases to generate electricity, thereby reducing dependence on the grid and the associated indirect energy emissions (Scope 2).

3.3 Technologies and production methods

The overwhelming majority of plants (22 of 24) use the dry process for clinker production, which is more energy-efficient than the wet or semi-dry methods. Two older plants, Bekabadcement (its now operating using the dry method) and Kuvasoycement, were historically equipped with wet-process kilns; however, Kuvasoycement has ceased clinker production and now operates solely as a grinding facility. A presidential decree requires all new cement enterprises to adopt the dry process using energy-saving technologies[3].

The principal fuel is coal, used by 22 plants. One plant (Kizilkumcement, the second-largest producer) continues to use natural gas — a shutdown and conversion to coal firing is planned for 2026 — while the Dal Teknik Zomin plant uses petroleum coke. The switch from gas to coal is a state policy priority, driven by the need to redirect natural gas supplies to households and power generation.

3.4 Regional distribution

Cement production is concentrated in a few key regions. Tashkent region leads with three plants whose combined output represents the largest share in the country, the main contribution coming from the large Ohangaroncement and Toshkent Conch enterprises. Andijan region, home to the Shangfeng, Andijan WCC and Reco Brend plants, is the second-largest production cluster. Samarkand region hosts the large CESam plant. Jizzakh region has Huaxin Jizzakh and the Jizzakh Cement Plant, while Namangan region has Namangancement and two smaller producers.

3 Resolution of the President of the Republic of Uzbekistan No. PP-4335 of 23.05.2019 «On additional measures for the accelerated development of the building materials industry» https://www.lex.uz/uz/docs/7571918

Figure 3.1. Distribution of cement production and emissions by region

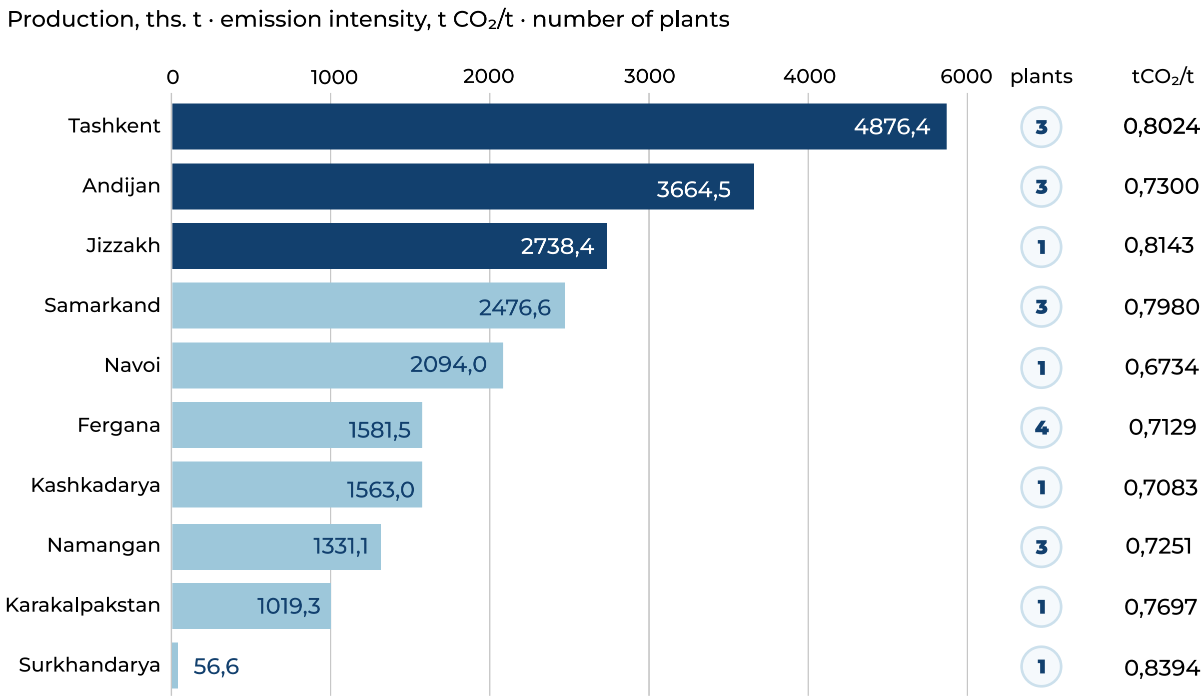


Table 3.2. Distribution of cement production and emissions by region

Region	Plants	Production (ths. t)	GHG (kt CO_2)	Intensity (t/t)	Employees
Tashkent	3	4876.4	3913.0	0.8024	2322
Andijan	3	3664.5	2675.0	0.7300	1679
Jizzakh	4	2738.4	2229.7	0.8143	1263
Samarkand	3	2476.6	1976.4	0.7980	437
Navoi	1	2094.0	1410.2	0.6734	2132
Fergana	4	1581.5	1127.4	0.7129	1374
Kashkadarya	1	1563.0	1107.1	0.7083	400
Namangan	3	1331.1	965.2	0.7251	1227
Karakalpakstan	1	1019.3	784.6	0.7697	592
Surkhandarya	2	56.6	47.5	0.8394	328

Source: Emission Survey (ES) database, CERR 2025–2026.

3.5 Workforce and employment

The cement industry employs 11,754 workers across its 24 plants. The distribution of the workforce varies substantially by enterprise size and ownership. The largest employer, Kizilkumcement, has 2,132 staff, whereas several newer plants have considerably smaller workforces. Average labour productivity across the industry is approximately 1,821 tonnes of cement per worker per year. Plants built with foreign investment show markedly higher labour productivity — an average of 4,065 tonnes per worker, compared with 1,195 tonnes at domestic integrated plants. This gap is explained by more modern technology, a high level of automation and larger production scale at the foreign-invested enterprises.

Table 3.2. 10 largest cement producers by production volume (2025)

Rank	Plant	Production (ths. t)	Share, %	Employees	Ownership
1	CESam	2,782.8	12.6	214	Foreign-invested
2	Ohangaron	2,188.0	10.2	1,093	Domestic
3	Kizilkumcement	2,094.0	9.8	2,132	Domestic
4	Toshkent Conch	2,081.3	9.7	429	Foreign-invested
5	Huaxin Jizzakh	1,940.8	8.8	563	Foreign-invested
6	Shangfeng	1,853.1	8.7	750	Foreign-invested
7	Qarshi Conch	1,563.0	7.3	400	Foreign-invested
8	Andijan WCC	1,331.0	6.2	486	Foreign-invested
9	Namangancement	1,056.2	4.9	914	Domestic
10	Fargona Yasin	1,034.0	4.8	439	Domestic

Source: Emission Survey (ES) database and the Uzsanoatqurilishmateriallari Association, CERR, 2025–2026.

3.6 Differences in labour productivity

Labour productivity, measured in tonnes of cement per worker, varies considerably across the sector. The industry average is approximately 1,821 tonnes per worker per year. At foreign-invested plants, average productivity reaches 4,065 tonnes per worker, roughly 3.4 times the average for domestic plants of 1,195 tonnes per worker.

This productivity gap is driven by several interrelated factors: a higher degree of automation at foreign-invested plants, larger production scale, more modern equipment with greater reliability and throughput, and leaner staffing models. This has important implications for decarbonization policy, as plants undergo modernization and automation. A workforce transition will be required, and it will need to be managed through upskilling programmes, redeployment and social protection measures.

Table 3.3. Summary employment data by ownership and size

Category	Plants	Employees	Production (ths. t)	Output (tonnes per worker)
Foreign-invested	6	2,842	11,552.0	3,838
Domestic	18	8,912	10,492.7	1,177
Large (>500 ths. t)	13	8,813	19,555.3	2,219
Medium (100–500 ths. t)	8	2,382	1,676.0	704
Small (<100 ths. t)	3	559	170.1	304
Sector total	24	11,754	22,044.7	1,821

Source: Emission Survey (ES) database, CERR 2025–2026.

4. Baseline GHG emissions inventory

4.1 Total sectoral emissions

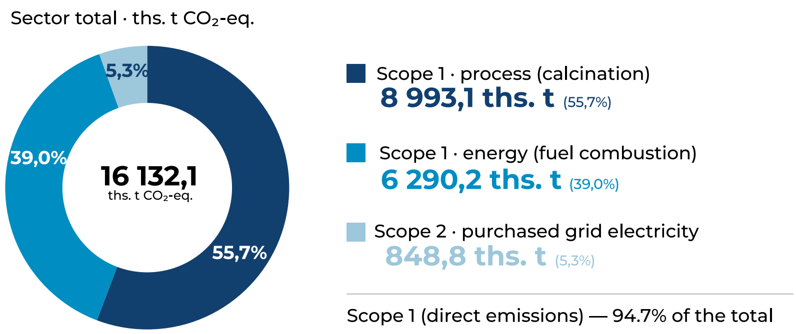
Total greenhouse gas emissions from Uzbekistan's cement industry in 2025 are estimated at 16,133.0 thousand tonnes of CO_2 equivalent. The weighted average specific emission factor is 0.7318 tonnes of CO_2 per tonne of cement produced. This emission intensity exceeds both the world average (approximately 0.63 t CO_2/t) and the European Union average (approximately 0.61 t CO_2/t), reflecting a combination of factors: high clinker content, limited use of supplementary cementitious materials (SCM), the predominance of coal in the fuel mix, and the absence of alternative fuels.[4]

4.2 Structure of emission sources

The sector's emissions are dominated by Scope 1 sources, which together account for 94.7% of total emissions. Process emissions from clinker calcination represent 55.7% of the total (8,993.1 kt CO_2) and emissions from fossil fuel combustion 39.0% (6,290.2 kt CO_2). Scope 2 emissions, associated with electricity purchased from the public grid, account for the remaining 5.3% (848.8 kt CO_2).

The relatively high share of process emissions reflects the high clinker-to-cement ratio prevailing in Uzbekistan: domestic cement products contain a greater proportion of clinker than international norms. Reducing this ratio through wider use of supplementary cementitious materials (SCM) such as fly ash, slag and limestone filler is one of the most cost-effective routes to lowering emissions in the industry.

Figure 4.1. Structure of greenhouse gas emission sources



4 World average (0.63 t CO_2/t): IEA and WBCSD, «Technology Roadmap: Low-Carbon Transition in the Cement Industry,» 2018 (total emissions including Scope 2; according to the IEA «Cement Tracking 2023» report, direct emission intensity is 0.58 t CO_2/t of cementitious material). EU average (0.61 t CO_2/t): Cembureau Activity Report 2021; JRC, «Deep Decarbonisation of Industry: The Cement Sector,» 2020.

Table 4.1. Structure of greenhouse gas emission sources

Emission source	Emissions (kt CO_2)	Share (%)
Process emissions (calcination)	8,993.1	55.7
Energy emissions (fuel combustion)	6,290.2	39.0
Scope 2 (purchased grid electricity)	848.8	5.3
Total	16,132.1	100.0

Source: calculations performed in accordance with the 2006 IPCC Guidelines methodology.

4.3 Emissions by enterprise

The distribution of emissions across plants is highly uneven, reflecting the concentration of production in a small number of large enterprises. The five largest emitters together account for 50.6% of total sectoral emissions. CESam (1,886.4 thousand t) followed by Ohangaroncement leads (1,877.5 thousand t CO_2), Toshkent Conch (1,538.8 thousand t), Huaxin Jizzakh (1,455.8 thousand t) and Kizilkumcement (1,410.2 thousand t). At the other end of the range is Kuvasoycement which, as a grinding facility, generates only 7.0 thousand t of CO_2 emissions, entirely attributable to indirect energy emissions (Scope 2).

Figure 4.2. GHG emissions by enterprise (sorted by total emissions)

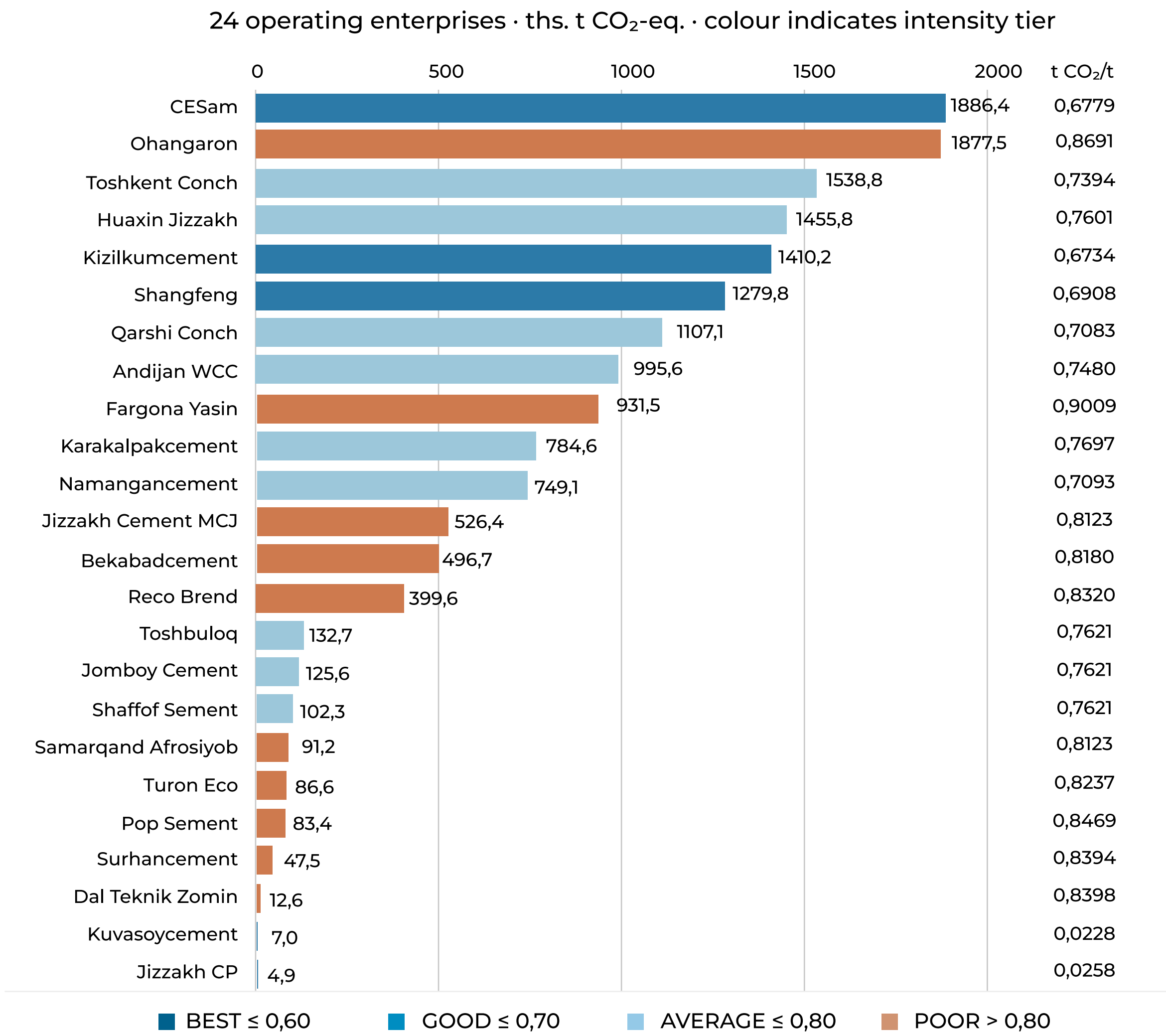


Table 4.2. GHG emissions by enterprise (sorted by total emissions)

No.	Plant	Output (ths. t)	S1 — process	S1 — energy	S2 — grid	Total (ths. t)	Intensity
1	Ohangaron	2188.0	1022.6	739.5	115.4	1877.5	0.8581
2	CESam	2782.8	950.1	709.5	100.0	1886.4	0.6779
3	Toshkent Conch	2081.3	859.4	642.9	36.5	1538.8	0.7394
4	Huaxin Jizzakh	1940.8	792.9	629.7	90.3	1455.8	0.7501
5	Kizilkumcement	2094.0	905.4	397.5	107.2	1410.2	0.6734
6	Shangfeng	1853.1	672.2	572.4	35.1	1279.8	0.6906
7	Qarshi Conch	1563.0	588.7	482.8	35.6	1107.1	0.7083
8	Andijan WCC	1331.0	513.1	439.2	43.3	995.6	0.7480
9	Fargona Yasin	1034.0	549.7	333.9	48.0	931.5	0.9009
10	Karakalpakcement	1019.3	465.4	269.9	49.3	784.6	0.7697
11	Namangancement	1056.2	463.1	238.0	48.1	749.1	0.7093
12	Jizzakh Cement MCJ	648.0	280.2	216.7	29.5	526.4	0.8123
13	Bekabadcement	607.1	262.5	203.0	31.1	496.7	0.8180
14	Reco Brend	480.4	196.8	181.0	21.9	399.6	0.8320
15	Jizzakh CP	192.4	0.0	0.0	4.9	4.9	0.0256
16	Toshbuloq	176.4	76.3	48.4	8.0	132.7	0.7521
17	Jomboy Cement	167.0	72.2	45.8	7.6	125.6	0.7521
18	Shaffof Sement	136.0	58.8	37.3	6.2	102.3	0.7521
19	Samarqand Afrosiyob	112.3	48.6	37.6	5.1	91.2	0.8123
20	Turon Eco	105.2	45.5	35.2	6.0	86.6	0.8237
21	Pop Sement	98.5	44.0	34.1	5.3	83.4	0.8469
22	Surhancement	56.6	24.5	19.8	3.2	47.5	0.8394
23	Dal Teknik Zomin	15.0	6.5	5.3	0.8	12.6	0.8398
24	Kuvasoycement	306.4	0.0	0.0	7.0	7.0	0.0228

Source: Emission Survey database and the register of the Uzsanoatqurilishmateriallari Association, CERR, 2025–2026. All values are expressed in kt CO_2.

4.4 Analysis of emission drivers at the largest emitters

Understanding why certain plants have high emission levels requires decomposing their total emissions into the underlying drivers: production volume, the clinker factor (clinker-to-cement ratio, CLF), thermal energy efficiency and fuel type. The analysis below examines the five largest emitters, which together account for approximately 51% of total sectoral emissions.

- **Ohangaron** (1,878 kt CO_2, intensity 0.858 t/t) is the largest producer with the highest emission intensity. Its elevated emissions are driven primarily by a very high CLF (0.895), indicating almost no use of supplementary cementitious materials, combined with moderate thermal energy consumption of 939 kcal/kg. Had Ohangaroncement reduced its CLF to the world average of 0.71, process emissions alone would have fallen by approximately 21%.
- **CESam** (1,886 kt CO_2, intensity 0.678 t/t) is the largest producer by volume (2,783 kt). Despite foreign ownership and modern equipment, the plant shows above-average emission intensity because of a CLF of 0.750 and thermal energy consumption of 810 kcal/kg — both above the sector average. The absence of a waste heat recovery (WHR, which is started and expected to be complete by the end of 2026) system results in higher Scope 2 emissions (105 kt CO_2).

- **Toshkent Conch** (1,539 kt CO_2, intensity 0.739 t/t) has the lowest emission intensity among the five largest emitters, thanks to a WHR system that reduces grid electricity consumption to 30.8 kWh/t. Its CLF of 0.797 is also the lowest of the top five. The WHR system alone reduces Scope 2 emissions by approximately 72 kt CO_2 per year.
- **Huaxin Jizzakh** (1,456 kt CO_2, intensity 0.750 t/t) shows elevated emission intensity despite being a newer facility built by a Chinese company. This is driven by the highest thermal energy consumption among the top five (1,017 kcal/kg) and a CLF of 0.737. The absence of a WHR system results in relatively high Scope 2 emissions (89 kt CO_2).
- **Kizilkumcement** (1,410 kt CO_2, intensity 0.673 t/t) has the lowest emission intensity in the sector while being the third-largest producer. The plant runs on natural gas (emission factor 56.1 kg CO_2/GJ against 96.1 for coal), which reduces combustion emissions by approximately 42% relative to a hypothetical coal-fired scenario. Process emissions account for 64% of its total, the highest share among the top five, reflecting the relatively greater weight of calcination where combustion emissions are lower.

The driver analysis shows that CLF is the dominant factor determining differences in emission intensity between plants, followed by fuel type and thermal efficiency. Among the five largest emitters, CLF ranges from 0.797 (Toshkent Conch) to 0.895 (Ohangaroncement), which translates directly into a 12% divergence in the intensity of process emissions alone. Policy measures aimed at reducing CLF through mandatory SCM addition requirements will have the greatest effect on the highest-emitting plants.

5. Plant-level benchmarking

5.1 Overview of the benchmarking method

Each of the 24 plants was assessed against four performance parameters: thermal energy efficiency (specific heat consumption), electricity efficiency (specific electricity consumption), the clinker factor (clinker-to-cement ratio) and overall greenhouse gas emission intensity. Each parameter is divided into four performance tiers: BEST, GOOD, AVERAGE and POOR. This multi-parameter approach ensures that the assessment captures the full range of factors influencing a plant's carbon performance rather than relying on a single composite indicator.

5.2 Thermal energy efficiency

Specific thermal energy consumption (expressed in kilocalories per kilogram of clinker) is the principal indicator of kiln efficiency. Across Uzbekistan's integrated plants, the production-weighted average is approximately 961 kcal/kg of clinker (the ratio of total thermal energy to total clinker is 954 kcal/kg; the simple average across plants is 960 kcal/kg). This level is markedly above the global BAT benchmark of 720 kcal/kg and the world average of approximately 850 kcal/kg, indicating substantial potential for improving thermal efficiency.[5,6]

The benchmarking results show that, of the 22 integrated plants, only 1 achieves the highest rating (BEST, below 764 kcal/kg), 6 plants are rated GOOD, 10 AVERAGE and 5 POOR (above 1,050 kcal/kg); the two grinding facilities are excluded from the specific heat comparison. The most thermally efficient plants are Namangancement (658.9 kcal/kg) and Karakalpakcement (767.8 kcal/kg). A number of plants with older equipment or sub-optimal kiln operation show specific heat consumption above 1,100 kcal/kg, including Reco Brend (1,248.4 kcal/kg), Andijan WCC (1,123.3 kcal/kg) and Shangfeng (1,106.3 kcal/kg).

5.3 Electricity efficiency

Sector-average specific electricity consumption is 76.5 kWh per tonne of cement. The distribution is, however, distinctly bimodal because of the plants with waste heat recovery (WHR) systems, which report substantially lower grid electricity consumption. Among the 14 plants rated BEST (80 kWh/t or below), several are foreign-invested enterprises equipped with WHR systems. These

5 European Commission, Joint Research Centre. Best Available Techniques (BAT) Reference Document for the Production of Cement, Lime and Magnesium Oxide. Industrial Emissions Directive 2010/75/EU. Luxembourg: Publications Office of the European Union, 2013. BAT-associated emission level (BAT-AEL) for dry-process kilns with a multi-stage preheater and precalciner: 3,000 MJ/t clinker (approximately 717 kcal/kg).

6 IEA and WBCSD. Technology Roadmap: Low-Carbon Transition in the Cement Industry. Paris: International Energy Agency, 2018; GCCA «Getting the Numbers Right» (GNR) database, 2022. World average specific thermal energy consumption: approximately 3,500 MJ/t clinker (approximately 836 kcal/kg).

include Toshkent Conch (30.8 kWh/t), Shangfeng (33.3 kWh/t) and Qarshi Conch (40.0 kWh/t), whose low grid consumption reflects on-site generation from recovered waste heat. A further 9 plants are rated GOOD and 2 AVERAGE. No plant exceeds the 110 kWh/t threshold corresponding to a POOR rating.

5.4 Clinker-to-cement ratio

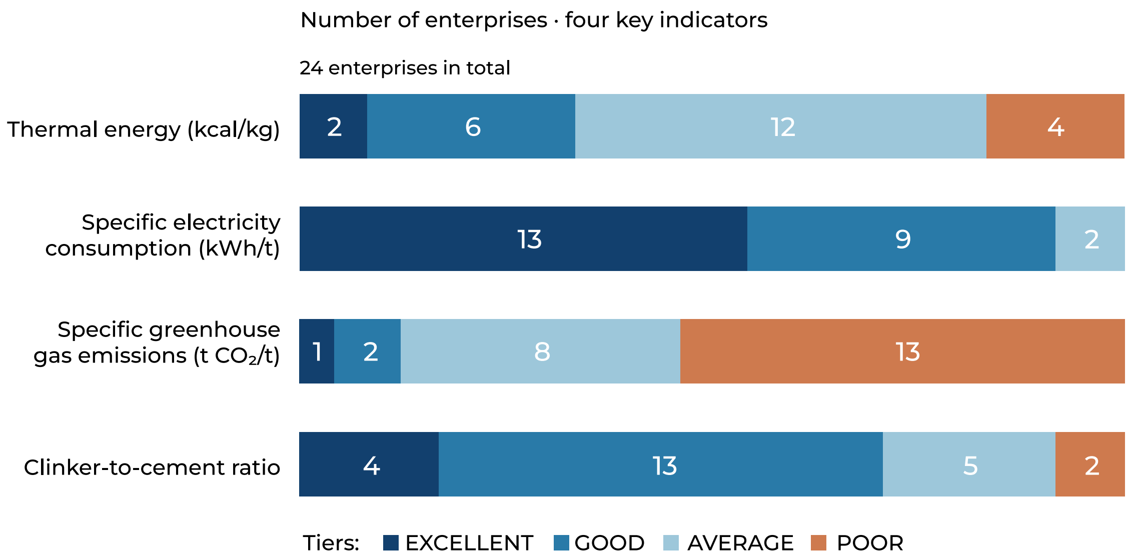
The clinker-to-cement factor (CLF) is a key determinant of both process emissions and overall carbon intensity. The sector-average CLF is 0.811, considerably above the global best available techniques (BAT) benchmark of 0.65 and the world average of approximately 0.71. This indicates that Uzbekistan's cement products contain a high proportion of clinker with limited use of mineral additions such as fly ash, granulated blast furnace slag or limestone filler. In total, 18 plants achieve a CLF of 0.82 or below (6 rated EXCELLENT and 12 GOOD), 5 plants fall within the AVERAGE range (0.82–0.90), and 1 plant has a CLF above 0.90 (rated POOR).[7,8]

Reducing clinker content is widely recognized as one of the most effective and least capital-intensive routes to decarbonizing cement production. However, the limited availability and quality of mineral additions — as confirmed by the barrier analysis in Chapter 8 — currently prevent producers in Uzbekistan from exploiting this lever fully.

5.5 Overall greenhouse gas emission intensity

When emissions across all three scopes are aggregated, plant-level specific greenhouse gas emissions range from a minimum of 0.0228 t CO_2/t (Kuvasoycement JSC) to a maximum of 0.858 t CO_2/t (Ohangaroncement JSC), excluding the two grinding facilities — Kuvasoycement JSC and the Jizzakh Cement Plant. Two plants achieve the best rating (BEST, below 0.60 t/t), three are rated GOOD (below 0.70 t/t), nine AVERAGE (below 0.80 t/t), and a substantial number — 10 plants — fall into the low-performance category (POOR, above 0.80 t CO_2/t). This distribution underlines that the specific emissions of most cement plants in Uzbekistan exceed international benchmarks.

Figure 5.1. Distribution of benchmark ratings across enterprises



7 IEA and WBCSD. Technology Roadmap: Low-Carbon Transition in the Cement Industry. Paris: International Energy Agency, 2018. A clinker-to-cement ratio of 0.65 is the best available techniques (BAT) benchmark, corresponding to the target of the IEA Net Zero Emissions scenario for 2030.
8 GCCA «Getting the Numbers Right» (GNR) database, 2022; IEA Cement Tracking Report, 2023. World average clinker-to-cement ratio: 0.71 (2022).

Table 5.1. Distribution of benchmark ratings across enterprises

Indicator	Excellent	Good	Average	Poor
Thermal energy (kcal/kg)	2	6	12	4
Specific electricity consumption (kWh/t)	13	9	2	0
Specific greenhouse gas emissions (t CO_2/t)	1	2	8	13
Clinker-to-cement ratio	4	13	5	2

Source: CERR calculations based on the enterprise survey (Emission Survey), 2025–2026.

5.6 Cross-parameter comparative analysis

To link the benchmarking results to enterprise characteristics, the multidimensional analysis below compares average performance indicators across key structural categories.

By enterprise size: Large enterprises (13 enterprises, output above 500 thousand t/yr) achieve a production-weighted specific thermal energy consumption of 972 kcal/kg and specific GHG emissions of 0.766 t/t. Medium-sized enterprises (7 enterprises, 100–500 thousand t/yr) average 1,008 kcal/kg and 0.815 t/t. Small enterprises (3 enterprises, below 100 thousand t/yr) average 1,007 kcal/kg and 0.844 t/t. The correlation between size and specific emissions reflects economies of scale in kiln operation, better process control and higher capacity utilization rates at larger facilities.

By ownership: At Chinese-invested enterprises (6 enterprises), production-weighted specific GHG emissions are 0.715 t/t, compared with 0.786 t/t at domestic integrated enterprises — a difference of 9.0%. The advantage of the Chinese-invested enterprises is driven primarily by a lower clinker factor (0.762 against 0.850), the presence of waste heat recovery systems (at 4 of the 6 Chinese-invested enterprises against 0 of the 18 domestic ones) and more modern kiln technology. Thermal energy consumption at the Chinese-invested enterprises is not, however, consistently lower, owing to differences in capacity utilization.

By fuel type: At coal-fired enterprises (22 enterprises), average specific GHG emissions are 0.780 t/t, whereas at the single gas-fired enterprise (Kizilkumcement) the figure is 0.673 t/t. The 13.7% specific-emissions advantage of gas over coal is explained by the lower carbon content per unit of thermal energy (56.1 against 96.1 kg CO_2/GJ). It should be noted, however, that the gas-fired enterprise also benefits from large production scale (2,094 thousand t/yr) and a moderate clinker factor (0.820).

By technology age: Enterprises commissioned within the past 5 years (13 enterprises) achieve lower average specific emissions (0.753 t/t) than older facilities, reflecting more modern kiln designs and better thermal integration. Nevertheless, several recently commissioned domestic enterprises show specific emissions above 0.80 t/t because of sub-optimal clinker factors during the initial ramp-up period.

6. Comparative and structural analysis

6.1 The effect of waste heat recovery on energy consumption and emissions

Four plants in Uzbekistan are equipped with waste heat recovery (WHR) systems: Toshkent Conch, Qarshi Conch, Shangfeng and Andijan WCC. All four were built with Chinese investment and are the most modern in the industry. WHR systems capture thermal energy from kiln exhaust gases and convert it into electricity using steam turbines, thereby displacing purchases from the public grid and reducing Scope 2 emissions. Combined annual electricity generation by the WHR systems at these four plants is estimated at approximately 203,000 MWh.

The effect of WHR systems on grid electricity consumption is substantial. Plants equipped with WHR report average specific grid electricity consumption of 40.3 kWh per tonne of cement, whereas integrated plants without WHR report 86.1 kWh per tonne. This represents a reduction in specific grid electricity consumption of approximately 53 per cent, leading to a proportionate reduction in Scope 2 CO_2 emissions.

It should be noted, however, that WHR systems do not reduce Scope 1 emissions: the recovered thermal energy is generated in any case during clinker production, and its use for electricity generation is a co-benefit rather than an abatement measure as such. The principal benefit of WHR lies in reducing Scope 2 emissions and improving energy self-sufficiency, which is particularly valuable given the constraints on Uzbekistan's national grid.

Figure 6.1. Performance comparison of plants with and without WHR

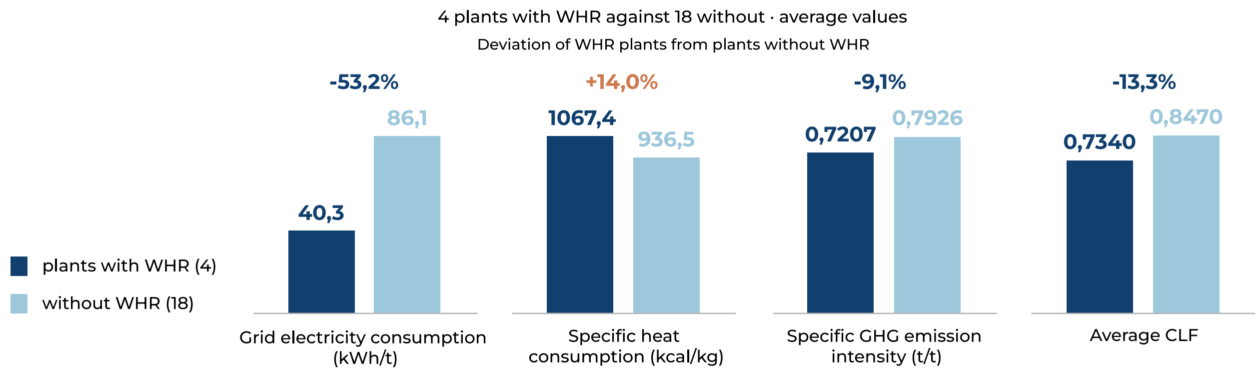


Table 6.1. Performance comparison of plants with and without WHR

Indicator	With WHR (4 plants)	Without WHR (18 plants)
Average grid electricity consumption (kWh/t)	40.3	86.1
Average specific heat consumption (kcal/kg)	1,067.4	936.5
Average specific GHG emission intensity (t/t)	0.7207	0.7926
Average CLF	0.734	0.847

Source: Emission Survey (ES) database and the register of the Uzsanoatqurilishmateriallariy Association, CERR 2025–2026.

6.2 Comparative performance of foreign-invested and domestic enterprises

Plants built with foreign investment show markedly different performance from domestic enterprises. The six foreign-invested plants have a weighted average greenhouse gas emission intensity of 0.7153 t CO_2/t of cement, while the 16 domestic full-cycle plants record 0.7862 t CO_2/t. Emission intensity at the foreign-invested enterprises is therefore approximately 9.0% lower.

This performance gap is explained by several factors. All foreign-invested enterprises are newer (commissioned after 2020) and are equipped with modern equipment, including precalciner kilns and advanced heat recovery systems, and they benefit from larger production scale, which allows more efficient kiln operation. Average specific electricity consumption at the foreign-invested enterprises is 54.3 kWh/t, substantially below the domestic average of 86.5 kWh/t, mainly because of waste heat recovery systems. In addition, the foreign-invested enterprises generally have a lower clinker-to-cement ratio — an average of 0.762 against 0.850 at domestic full-cycle plants — indicating more extensive use of supplementary cementitious materials and more effective blending technologies.

Figure 6.2. Comparative performance of foreign-invested and domestic enterprises

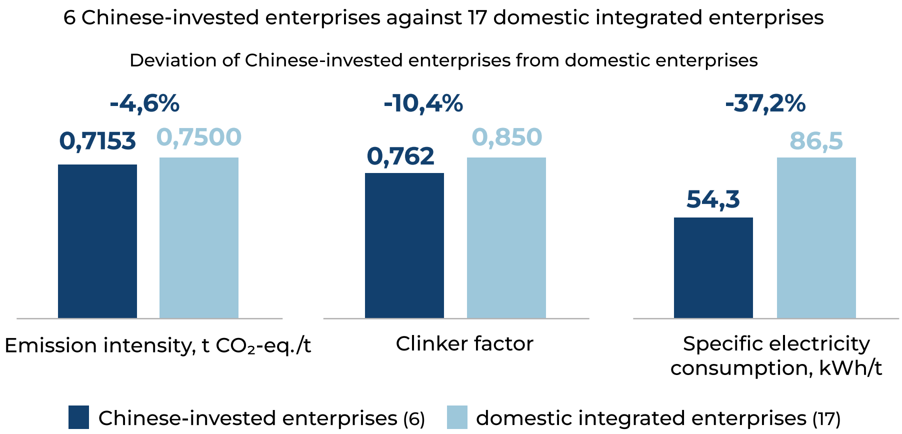


Table 6.2. Comparative performance of Chinese-invested and domestic enterprises

Indicator	Foreign-invested (6 plants)	Domestic integrated (17)	Sector total
Production volume (ths. t)	11552.0	10492.8	22044.7
GHG emissions (ths. t CO_2-eq.)	8262.6	7869.5	16132.1
Average specific GHG emission intensity (t/t)	0.7153	0.7500	0.7318
Average electricity consumption (kWh/t)	54.3	86.5	76.5
Average CLF	0.762	0.850	0.811

Source: Emission Survey database, 2026. Kuvasoycement is excluded from the domestic integrated group.

6.3 Plant age and emissions

Plant age, used in this analysis as a proxy for technology generation, shows a clear correlation with emissions performance. The analysis classifies enterprises into four age groups by year of commissioning: legacy (over 30 years), established (10 to 30 years), recent (5 to 10 years) and new (under 5 years).

Figure 6.3. Performance indicators by plant age group

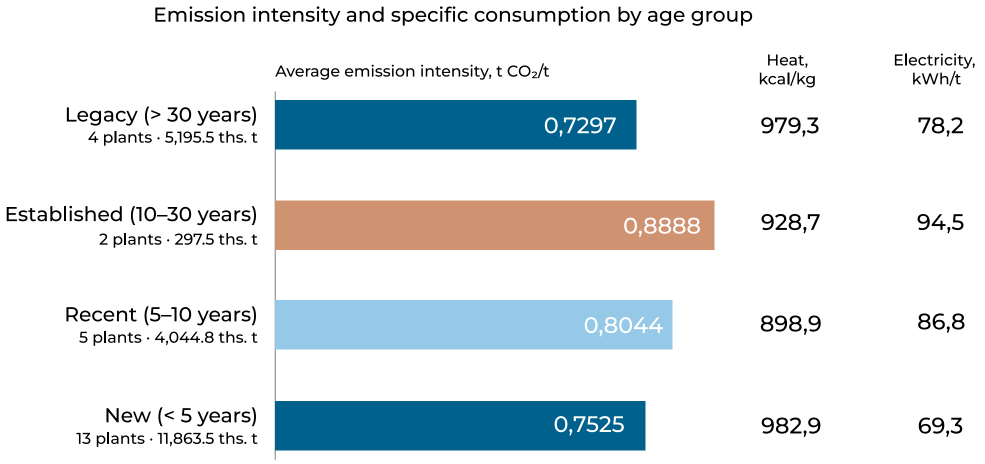


Table 6.3. Performance indicators by plant age group

Age group	Plants	Production (ths. t)	Average GHG emission intensity (t/t)	Average specific heat consumption (kcal/kg)	Average electricity consumption (kWh/t)
Legacy (> 30 years)	4	5195.5	0.7297	979.3	78.2
Established (10–30 years)	2	297.5	0.8888	926.7	94.5
Recent (5–10 years)	5	4044.8	0.8044	898.9	86.8
New (< 5 years)	13	11863.5	0.7525	982.9	69.3

Source: Emission Survey (ES) database and the register of the Uzsanoatqurilishmateriallariy Association, CERR, 2025–2026.

The results confirm that newer plants generally have lower specific emission intensity, reflecting advances in kiln technology, improved process control and the adoption of waste heat recovery (WHR) systems. The relationship is not strictly linear, however, since some recently commissioned domestic plants show relatively high emission intensity because of a sub-optimal clinker factor or operating difficulties during the ramp-up to design capacity.

6.4 Scale and efficiency

Enterprise size also correlates with emissions. Large enterprises (with capacity above 500 thousand tonnes per year) benefit from economies of scale in kiln operation, more advanced process control systems and better access to technical specialists. Medium-sized and small enterprises generally operate at lower capacity utilization and under less optimized kiln conditions, which results in higher specific energy consumption and greater emission intensity.

7. Comparison with global best available technologies

This chapter compares the performance of Uzbekistan's cement industry with international benchmarks, including the European Commission's best available techniques (BAT) reference values and the world average performance figures compiled in the Getting the Numbers Right (GNR) database of the Cement Sustainability Initiative.

Figure 7.1. Comparison of Uzbekistan's performance with global BAT

BAT benchmark, world average, Uzbekistan average and best in Uzbekistan

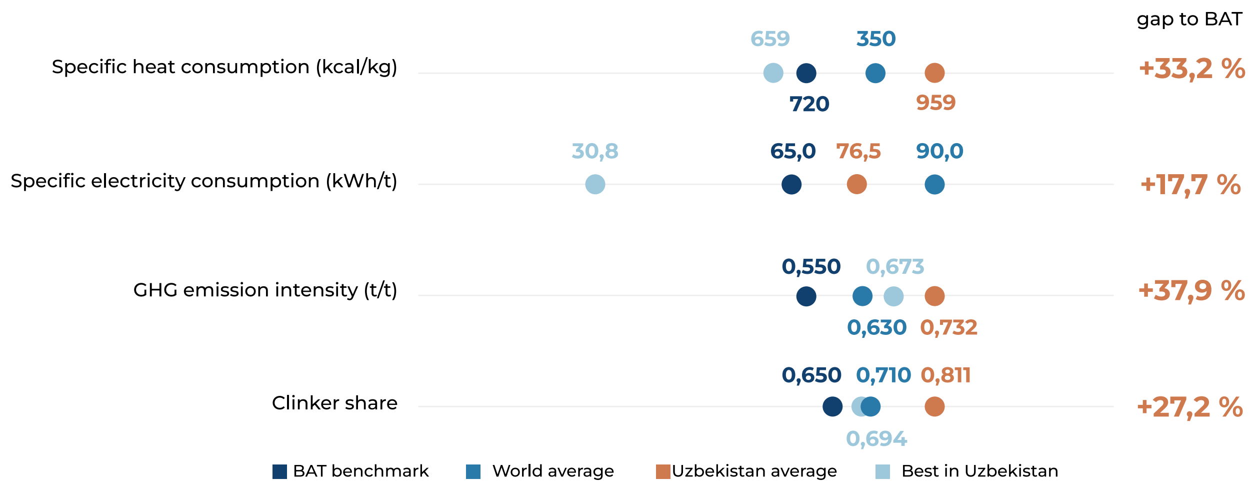


Table 7.1. Comparison of Uzbekistan's performance with global BAT

Indicator	Global BAT	World average	Uzbekistan average	Best in Uzbekistan	Gap to BAT (%)
Specific heat consumption (kcal/kg)	720	850	959.3	658.9	33.2
Specific electricity consumption (kWh/t)	65	90	76.5	30.8	17.7
GHG emission intensity (t/t)	0.550	0.630	0.7318	0.6734	37.9
Clinker share	0.650	0.710	0.811	0.694	27.2
Thermal substitution rate (%)	30	5	0	0	N/A

Source: BAT values from the EU Best Available Technologies Reference Document (2013); world average values from the CSI/GNR database.[9]

The gap analysis reveals several key findings. Average specific heat consumption in Uzbekistan exceeds the global BAT figure by 33.2%, indicating scope for a significant improvement in thermal efficiency through kiln optimization, preheater and precalciner upgrades, and better raw material preparation. Average specific GHG emissions exceed the BAT figure by 37.9%, reflecting the combined effect of high heat consumption, elevated clinker content in cement and dependence on coal. Perhaps most strikingly, the thermal substitution rate (TSR) — the share of energy obtained from burning alternative fuels in the kiln (such as refuse-derived fuel and biomass) — is effectively zero across the entire sector, whereas the world average is approximately 5% and the BAT benchmark 30% and above. This represents a substantial untapped opportunity both for reducing emissions and for securing co-benefits in waste management.[10]

7.1 Roadmap for the adoption of alternative fuels (RDF and biomass)

The industry's thermal substitution rate (TSR) is taken as zero against a global BAT benchmark of 30% and above. The enterprise survey records the absence of an alternative fuel supply chain as barrier No. 1 (average score 3.94 out of 5).

Proposed mechanism: (a) infrastructure for the collection and preparation of RDF and biomass; (b) a guaranteed offtake mechanism to reduce investment risk; (c) simplified permitting procedures for co-processing pilot projects.

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9 Table 7.1. Sources: Specific GHG emissions (BAT): 0.550 t/t (IEA Technology Roadmap, 2018); Specific electricity consumption (BAT): 65 kWh/t (IFC, «Improving Thermal and Electric Energy Efficiency at Cement Plants,» 2017); World average specific electricity consumption: approximately 90 kWh/t (GCCA GNR database, 2022); World average specific GHG emissions: 0.630 t/t (IEA, «Cement Tracking,» 2023, including Scope 2).

10 World average TSR: 5–6% (IEA, «Cement Tracking Report,» 2023; in 2022 alternative fuels accounted for approximately 6% of global thermal energy in cement kilns, while fossil fuels retained a 90% share). TSR (BAT): 30%+ (IEA and WBCSD Technology Roadmap, 2018); the best EU plants exceed 80% (EU BAT Reference Document, 2013).

8. Environmental readiness assessment

8.1 Overview of the environmental survey

The Green Survey (GS) was conducted among 16 cement plant operators to assess their perception of barriers to decarbonization, the level of environmental awareness and readiness for green investment. The study used a structured questionnaire covering 13 aspects that may act as barriers, each rated on a five-point Likert scale (where 1 is «not a barrier» and 5 is «a severe barrier»). The results represent operators' own assessment of the obstacles they consider most significant when making investments in emissions reduction.

The response rate of 67 per cent (16 of 24 plants) provides a representative sample covering all the main regions, ownership types and production scales. The participating plants account for approximately 75 per cent of total sectoral output, ensuring that the views of the most significant operators are reflected in the barrier assessment.

8.2 Barrier assessment results

The barrier analysis reveals a hierarchical structure. The most severe barriers relate to the supply-side infrastructure for decarbonization, while barriers associated with in-house knowledge and technology are perceived as less significant. The three most significant barriers are:

Figure 8.1. Assessment of barriers to decarbonization (n = 16 enterprises)

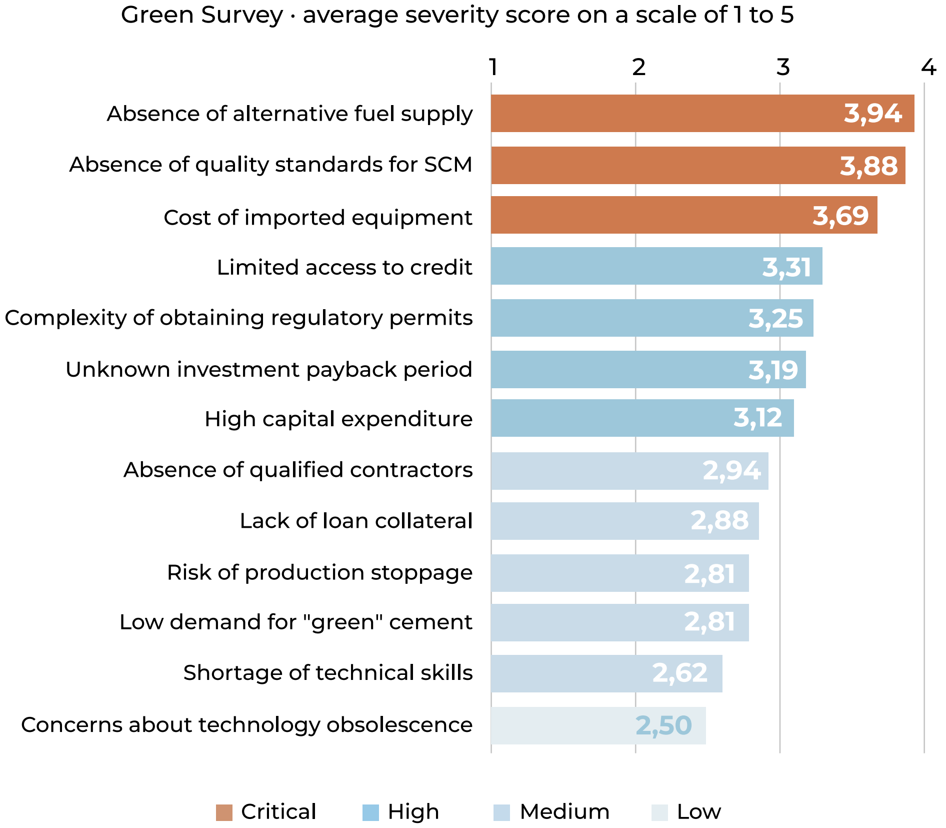

Table 8.1. Assessment of barriers to decarbonization (n = 16 enterprises)

Barrier	Average score (1–5)	Severity level
Absence of alternative fuel supply	3.94	Critical
Absence of quality standards for SCM	3.88	Critical
Cost of imported equipment	3.69	Critical
Limited access to credit	3.31	High
Complexity of obtaining regulatory permits	3.25	High
Unknown investment payback period	3.19	High
High capital expenditure	3.12	High
Absence of qualified contractors	2.94	Medium
Lack of loan collateral	2.88	Medium
Risk of production stoppage	2.81	Medium
Low demand for "green" cement	2.81	Medium
Shortage of technical skills	2.62	Medium
Concerns about technology obsolescence	2.50	Low

Source: Green Survey, 2025–2026. Severity level: Critical (≥3.5), High (3.0–3.5), Medium (2.5–3.0), Low (<2.5).

The absence of alternative fuel supply chains (score 3.94 out of 5.0) was identified as the most severe obstacle. At the same time, the assertion of a zero sector-wide thermal substitution rate (TSR) is contradicted by the Technical Survey data, in which Ohangaroncement reported 60% and Shaffof Sement 20%; until the primary questionnaires have been reconciled, the figure of TSR = 0% should be treated as unconfirmed. This finding is consistent with the fact that no plant in Uzbekistan currently uses alternative fuel and that the country lacks an organized system for converting waste into fuel or supplying it. Without a domestic alternative fuel industry, plants cannot displace fossil fuel in the kiln, which is a key lever in international cement decarbonization strategies.

The absence of quality standards for supplementary cementitious materials (SCM) (score 3.88) is the second most significant obstacle. Although potential SCM are available in Uzbekistan (for example, fly ash from thermal power plants and granulated slag from metallurgical works), the lack of national quality standards and testing protocols for their use in cement production impedes their wider adoption. This barrier directly constrains the scope for reducing the clinker factor.

The high cost of imported equipment (score 3.69) reflects dependence on imported technology for kiln modernization, the installation of waste heat recovery (WHR) systems and emissions monitoring equipment. The cost of imported equipment, combined with customs duties and logistical difficulties, increases the capital expenditure required for decarbonization investment.

8.3 Financial and institutional barriers

Financial barriers — including limited access to credit (3.31), high capital expenditure requirements (3.12) and uncertain investment payback periods (3.19) — form a group of moderately severe obstacles. These findings indicate that, although plant operators recognize the potential benefits of green investment, perceived financial risk and the limited availability of affordable long-term finance remain material deterrents. The complexity of regulatory permitting processes (3.25) further complicates investment decisions.

By contrast, barriers relating to internal capability — such as a shortage of technical skills (2.62), concerns about technology obsolescence (2.50) and the risk of production stoppage (2.81) — are rated lower. This indicates that plant operators do not regard their in-house technical capability as the principal constraint. This finding may be considered somewhat encouraging, as it suggests that, with appropriate external support (finance, supply chains, standards), internal readiness for decarbonization may prove greater than the readiness of infrastructure and the regulatory framework.

8.4 Environmental management practices

The Technical Survey provides additional information on environmental management practices. Of the 14 enterprises surveyed, only a minority have implemented formal environmental management systems. Only 4 enterprises hold ISO 50001 certification (energy management), and fewer than half of respondents report greenhouse gas emissions systematically. Self-assessed BAT compliance varies widely: some Chinese-invested enterprises claim performance close or equivalent to BAT levels, while a number of domestic enterprises acknowledge moderate to critical gaps relative to international best practice.

The environmental readiness assessment therefore indicates that the industry recognizes the need for decarbonization but that its capacity is substantially constrained by gaps in supply-side infrastructure, financial barriers and the absence of enabling regulatory standards. Overcoming these barriers will require coordinated action by government, international development partners, financial institutions and the industry itself.

9. Data quality and uncertainty analysis

9.1 Parameter-level uncertainty assessment

In accordance with IPCC good practice guidance on managing uncertainty in national GHG inventories, the following parameter-level uncertainty estimates were produced for the baseline inventory.

Process emissions (S1P), estimated uncertainty: 5 to 7 per cent. This estimate reflects the application of a Tier 2/3 approach using CaO and MgO content data for 8 specific plants. Typical analytical precision in determining oxide content is plus/minus 1–2 per cent, combined with uncertainty in clinker production volumes of plus/minus 3–5 per cent. For the 10 plants using the IPCC default emission factor (0.5273 t CO_2/t clinker), the additional uncertainty associated with that factor is estimated at plus/minus 2–3 per cent.

Fuel combustion emissions (S1E), estimated uncertainty: plus/minus 7–10 per cent. The principal sources of uncertainty are: reported fuel consumption volumes (plus/minus 3–5 per cent); net calorific value (plus/minus 2–5 per cent for coal, which varies substantially by batch and source, local coal having lower energy content, and plus/minus 1–2 per cent for natural gas); and IPCC default emission factors (plus/minus 3–5 per cent). The net calorific value (NCV) of coal was identified as the single parameter with the greatest uncertainty, since plant-level NCV testing is not standardized across the industry.

Indirect emissions (S2), estimated uncertainty: plus/minus 10–15 per cent. This estimate reflects uncertainty in electricity consumption data (plus/minus 2–5 per cent) and in the grid emission factor (plus/minus 5–10 per cent), which depends on the actual generation mix during the reporting period. For plants with WHR systems, the allocation of electricity between on-site generation and grid purchases introduces additional uncertainty into the estimate of WHR output of approximately plus/minus 5 per cent.

The combined uncertainty for the sector-wide baseline figure is estimated at plus/minus 6–8 per cent using the error propagation method. This is fully consistent with the range considered acceptable for Tier 2 national GHG inventories under IPCC guidance.

9.2 Recommendations for improving data quality

The following data quality improvement measures are recommended for future inventory updates: (1) Introduce mandatory annual third-party laboratory analysis of CaO and MgO content in clinker for all 24 plants. This would provide full Tier 3 coverage and remove the need for a national default emission factor. (2) Implement standardized protocols for determining the net calorific value (NCV) of coal at all coal-fired plants, with quarterly sampling and analysis to capture batch variability. (3) Install continuous electricity metering with sub-metering of on-site generation at all 4 enterprises equipped with waste heat recovery (WHR) systems. (4) Request annual disclosure of fuel consumption and production volumes from all 24 plants as a condition of their operating licences, in order to achieve 100 per cent primary data coverage. (5) Commission periodic updates of the national grid emission factor using actual dispatch data from the national grid operator, ideally on a monthly or quarterly basis.

10. Conclusions and recommendations

10.1 Key findings

This baseline assessment produced a comprehensive inventory of greenhouse gas emissions from Uzbekistan's cement industry, covering all 24 operating plants. In 2025, total sectoral emissions amounted to 16,133.0 thousand tonnes of CO_2, with a weighted average specific emission intensity of 0.7318 tonnes of CO_2 per tonne of cement. Process emissions from calcination account for 55.4% of the total, energy-related emissions from fuel combustion for 39.3%, and indirect energy emissions (Scope 2) from purchased grid electricity for 5.2%.

Plant-level benchmarking reveals substantial heterogeneity in performance. Plants built with foreign investment, which account for more than half of production, show lower average specific emission intensity and higher labour productivity, driven by more modern technology, waste heat recovery (WHR) systems and lower clinker content in cement. Long-established domestic plants, particularly those with outdated kiln technology and a higher clinker factor, are the highest-priority targets for efficiency measures.

The gap between Uzbekistan's cement sector and global best available technologies (BAT) is significant across every parameter assessed. The complete absence of alternative fuel use (thermal substitution rate = 0%) represents the largest unrealized opportunity for emissions reduction. The high average clinker factor (0.811) points to the need to develop blended cement production and to standardize its quality. The thermal energy consumption gap of more than 30% relative to BAT indicates potential for kiln optimization and modernization.

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