

CUSTOM REPORT

INDIA ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET

Domain: **Energy and Power**

Base Year: **2025**

Study Period: **2026-2031**

Market Intelligence/Advisory



+1 617 765 2493



info@mordorintelligence.com



www.mordorintelligence.com

TABLE OF CONTENTS

1. INTRODUCTION

- 1.1 Study Assumptions and Market Definition
- 1.2 Scope of Study

2. RESEARCH METHODOLOGY

- 2.1 Research Framework
- 2.2 Secondary Research
- 2.3 Primary Research
- 2.4 Data Triangulation and Insight Generation
- 2.5 Project Process and Structure
- 2.6 Engagement Frameworks

3. EXECUTIVE SUMMARY

4. MARKET LANDSCAPE

- 4.1 Market Drivers
 - 4.1.1 Increasing Regulatory Mandates for Refuse-Derived Fuel (RDF) Utilization
 - 4.1.2 Growing Decarbonization Targets in the Cement Industry
 - 4.1.3 Rising Availability of Municipal Solid Waste and Industrial Waste
 - 4.1.4 Carbon Credit and Fuel Cost-Saving Opportunities
 - 4.1.5 Expansion of Cement Manufacturing Capacity
- 4.2 Market Restraints
 - 4.2.1 Low AFR Adoption and Technical Integration Challenges
 - 4.2.2 High Capital Intensity Requirements
- 4.3 Porter's Five Forces Analysis
 - 4.3.1 Bargaining Power of Suppliers
 - 4.3.2 Bargaining Power of Buyers
 - 4.3.3 Threat of New Entrants
 - 4.3.4 Threat of Substitutes
 - 4.3.5 Intensity of Competitive Rivalry

4.4 Key Market Trends

- 4.5 Insights on Government Initiatives and Regulations
- 4.6 Recent Developments in the Industry
- 4.7 SWOT Analysis of the Major 3 Players
- 4.8 Engineering Solutions Analysis
 - 4.8.1 Waste Processing Systems
 - 4.8.2 Bulk Material Handling Systems

5. MARKET SEGMENTATION ANALYSIS - VALUE IN USD BILLION - GROWTH, TRENDS, AND FORECAST (2026-2031)

- 5.1 By AFR System Type
 - 5.1.1 Liquid AFR Firing Systems
 - 5.1.2 Solid AFR Co-Processing Systems
- 5.2 By Waste/Fuel Stream (AFR Input Category)
 - 5.2.1 Municipal Solid Waste
 - 5.2.2 Biomass & Agricultural Waste
 - 5.2.3 Industrial Waste
 - 5.2.4 Others
- 5.3 By End-User Industry
 - 5.3.1 Cement Industry
 - 5.3.2 Waste-to-Energy Plants
- 5.4 By Deployment Model
 - 5.4.1 Greenfield Installations
 - 5.4.2 Brownfield Retrofit
 - 5.4.3 Turnkey Projects
- 5.5 By Region
 - 5.5.1 North
 - 5.5.2 West
 - 5.5.3 South
 - 5.5.4 East

6. COMPANY PROFILE – PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED)

TABLE OF CONTENTS

7. FINANCIAL BENCHMARKING ANALYSIS

8. CURRENT ECONOMIC SCENARIO

8.1 Indian Economic Scenario

8.2 Global Economic Scenario (covering a broad overview of the major 4-5 countries, market size, and demand forecast for global market and top 4-5 countries)

9. APPENDIX

9.1 Glossary of Key Terms

9.2 List of Key Abbreviations

9.3 Key Organizations in India's AFR and Co-Processing Ecosystem

9.4 Complete Source List

10. ABOUT US

10.1 Industry Coverage

10.2 List of Clients

10.3 Our Customized Research Capabilities

1 INTRODUCTION

1.1 STUDY ASSUMPTIONS AND MARKET DEFINITION

BASE CURRENCY

The United States dollar (USD) is considered the base currency.

BASE YEAR, REVIEW, AND FORECAST PERIOD

The base year is identified based on the availability of annual reports and secondary research information. The base year considered for this study is 2025. The review period considered for this study is from 2021 to 2025. The CAGR is for the forecast period 2026–2031.

FORECAST TERMS

Market-size estimations for the forecast years are in real terms.

PRIMARY RESEARCH

The distribution of the primary interviews conducted is based on the regional share of the market and the presence of key players in each of the demographics pertinent to the market studied.

Note: Company revenues are mentioned as per the fiscal year in the company's headquarters, and currency conversion is as per the account closure date of the company.

DEFINITION

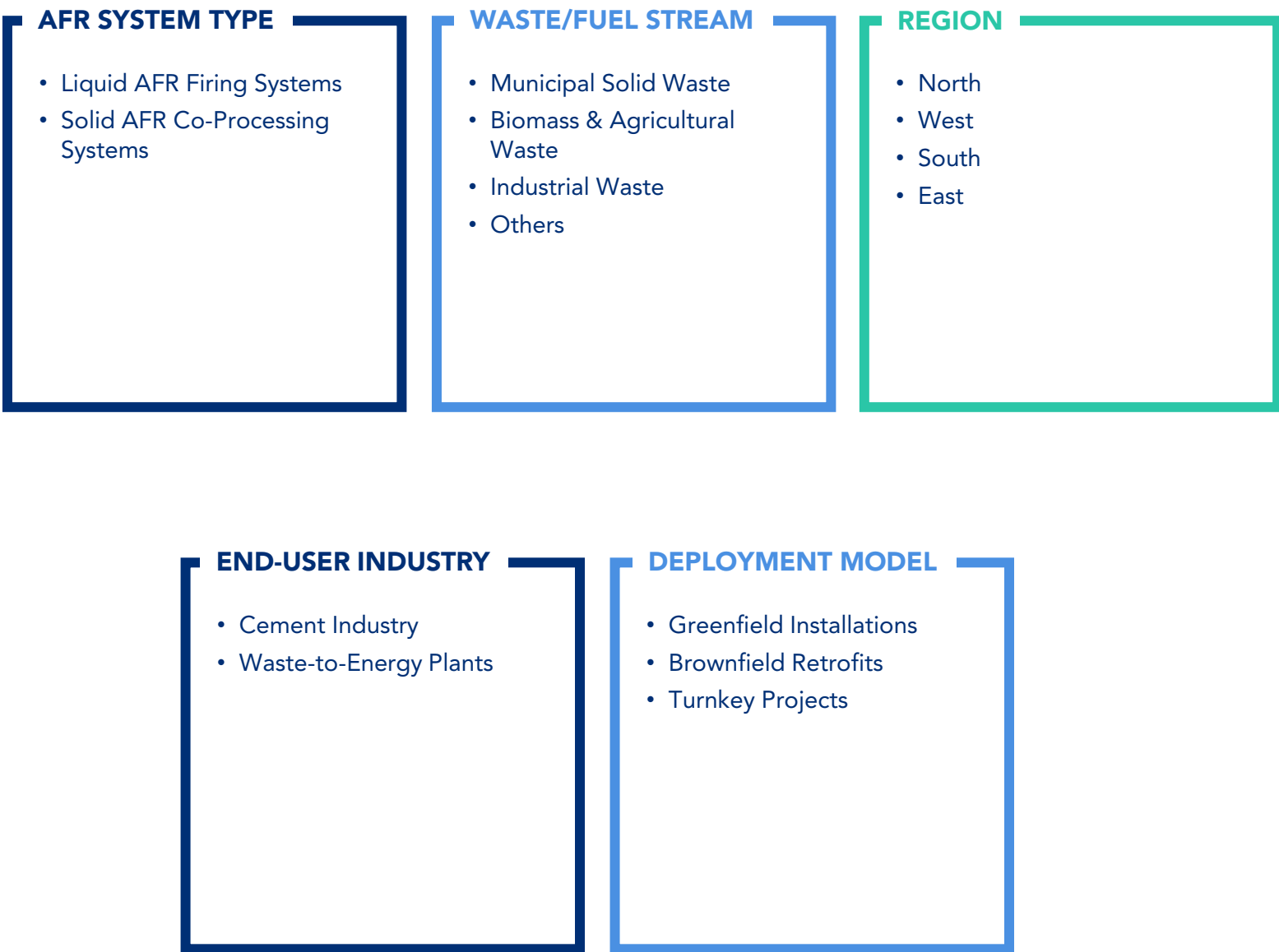
An Alternate Fuel and Raw Materials (AFR) firing system is an integrated mechanical, electrical, and automation solution that receives, stores, conveys, meters, and injects solid or liquid alternative fuels and raw materials into industrial combustion systems. These systems enable industries to replace conventional fossil fuels with waste-derived or renewable fuel streams while ensuring safe handling, stable combustion, regulatory compliance, and reduced greenhouse gas emissions.

SCOPE OF THE REPORT

The India AFR firing systems market covers revenue from new AFR systems deployed across different end-user industries. This includes handling, storage, conveying, dosing, metering, injection, automation, and fire protection. The market excludes alternative fuel sales, waste processing and logistics, and conventional firing systems without AFR capability.

The India engineering solutions market considers the overall market for waste processing systems and bulk material handling systems deployed across various end-user industries, including for AFR applications.

1.2 SCOPE OF THE STUDY

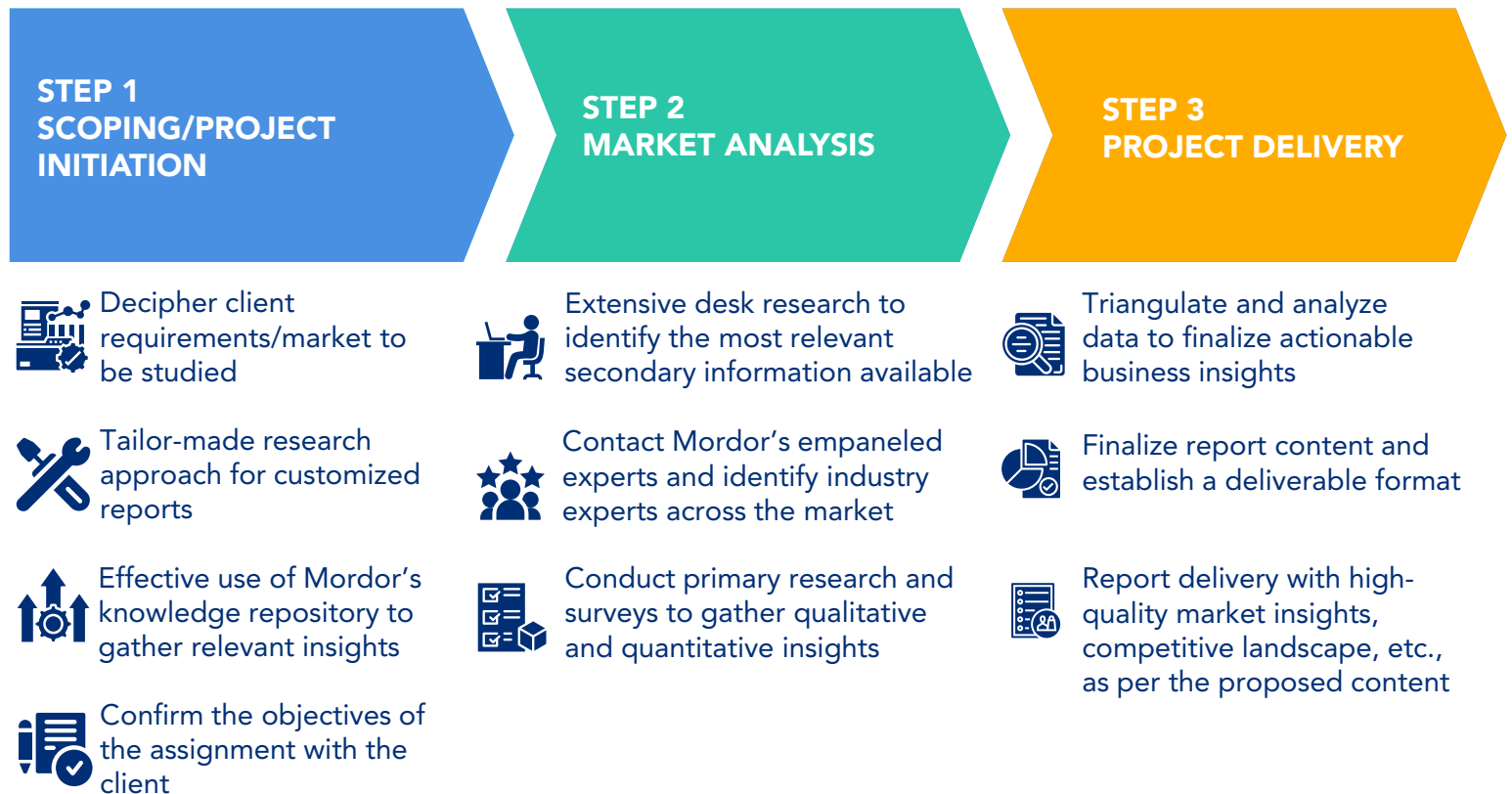


2 RESEARCH METHODOLOGY

2.1 RESEARCH FRAMEWORK



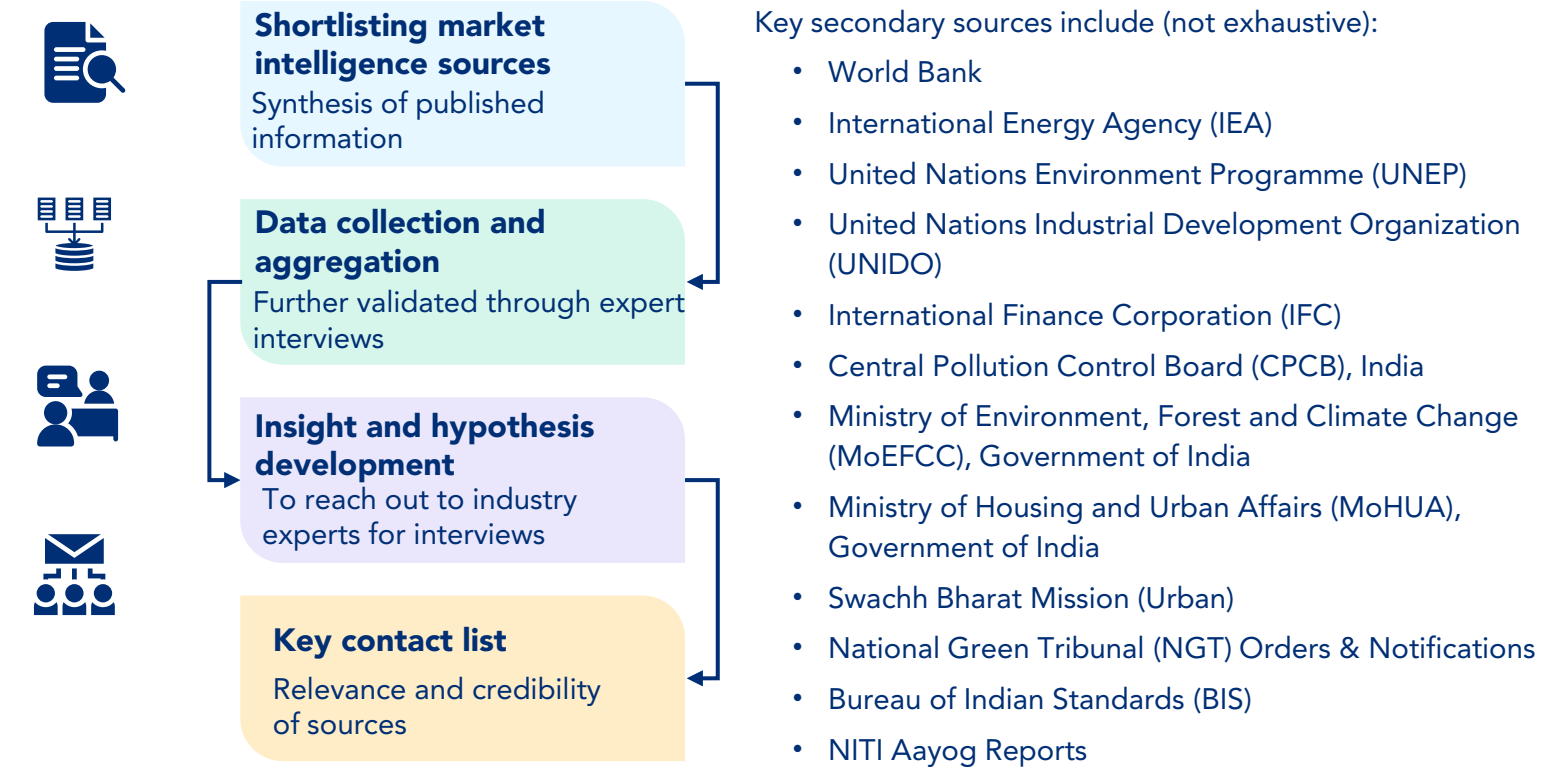
- Mordor Intelligence (MI) advocates an appropriate mix of secondary and primary research to meet client objectives.
- MI translates market insights (market dynamics, competition, varying consumer demands, and regulations) into actionable business insights.
- The following phases are practiced at Mordor Intelligence for efficient delivery of various syndicated and consulting assignments.



2.2 SECONDARY RESEARCH & 2.3 PRIMARY RESEARCH

OBJECTIVE

Hypothesis and insight building to get factual data



STAKEHOLDER CATEGORIES Company executives, OEM procurement managers, component suppliers, government policymakers, and industry association representatives	INTERVIEW APPROACH Structured questionnaires tailored for the Draft Red Herring Prospectus (DRHP) preparation focusing on market dynamics, competitive positioning, and regulatory compliance requirements
GEOGRAPHIC COVERAGE Pan-India research across major manufacturing hubs including Chennai, Bengaluru, Pune, Delhi NCR, and emerging clusters	LANGUAGE CONSIDERATIONS Interviews conducted in English and Hindi to ensure comprehensive stakeholder coverage across different regions

- INPUTS COLLECTED
- Raw data and intelligence
 - Insights into market dynamics
 - Market model and other data validations
 - Strategy-related inputs

2.4 DATA TRIANGULATION AND INSIGHT GENERATION

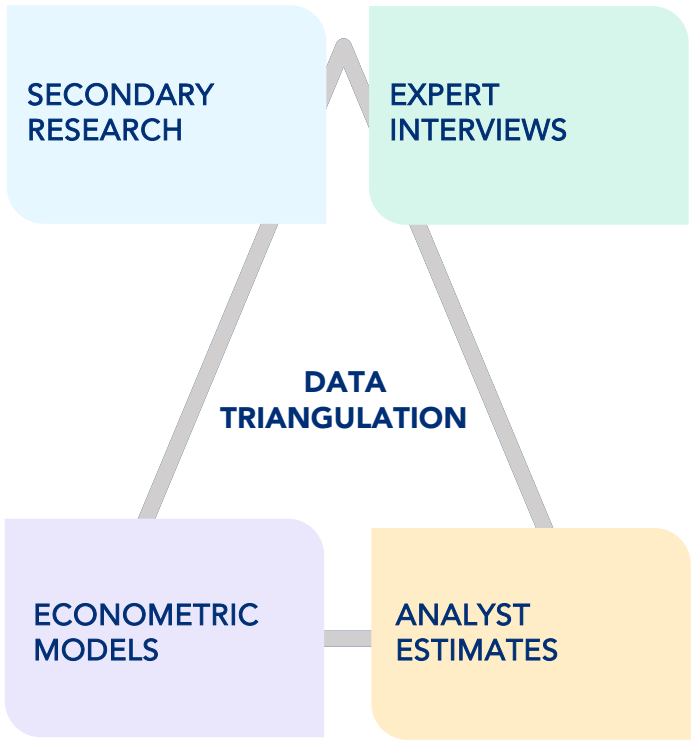
OBJECTIVE	Logical checks and sanity of information
-----------	--

TRIANGULATION AND TRANSFORMATION OF INFORMATION EXTRACTED

Based on the factors identified that are endogenous and exogenous in nature and collected during the secondary and primary phases, our in-house subject-matter experts transform the quantitative data extracted and use it for inferential purposes.

VALIDATION FOR MARKET ASSESSMENT ESTIMATES

- Market size estimations are carried out through 'bottom-up' and 'top-down' approaches.
- Our top-down and bottom-up approaches are integrated into our 'In-house Model sheets,' which are used to generate market estimates and growth rates (depending upon the historical trends of the respective markets, along with the various factors like drivers, restraints, and recent developments in the market) of the product segment in the respective country.



2.5 PROJECT PROCESS AND STRUCTURE & 2.6 ENGAGEMENT FRAMEWORKS

Foundation & Framework

Activities: Market scope definition · source ID & credibility scoring · stakeholder mapping · hypothesis development · regulatory calendar

Quality Gate: Scope sign-off

Output: Research brief · source registry · interview guide

Data Gathering & Validation

Activities: Secondary research (regulatory, corporate, association, trade) · primary interviews across 5 cement belts · real-time validation · regulatory updates

Quality Gate: Source diversity (10+ domains/section) · citation verification

Output: Annotated data files · primary transcripts · discrepancy log

Analysis & Synthesis

Activities: Market sizing · competitive landscape mapping · segment demand assessment · TSR scenario analysis

Quality Gate: Primary calibration complete

Output: Market model · segment estimates · competitive matrix

Report Creation & Delivery

Activities: Section writing (Intro to Appendix) · cross-reference consistency · executive summary synthesis · PPT structure optimization · quality review

Quality Gate: Citation audit · terminology check · analyst note completeness

Output: Final report · executive slide deck

Immediate Demand - *Compliance-driven*

Procurement triggered by Solid Waste Management (SWM) Rules 2026 (Refuse-Derived Fuel [RDF] utilization mandate at 6%, escalating to 10% and 15% over six years) and Carbon Credit Trading Scheme (CCTS) Form A submission obligations (July 31, 2026, deadline, now passed). Plants within 400 km of operational RDF facilities face the earliest compliance obligations under Rule 11 of the SWM Rules 2026.

Medium-Term Demand - *Capacity-expansion-driven*

Linked to the 160-170 MTPA of new kiln capacity through FY2028. Every new integrated plant or kiln addition requires AFR infrastructure investment to meet the 15% TSR mandated by the NITI Aayog roadmap, an estimated INR 4,000 crore or more in new-kiln-driven AFR system demand.

Long-Term Demand - *Performance-optimization-driven*

Performance optimization and system upgrades as early-generation AFR installations reach lifecycle thresholds; CCTS carbon credit monetization economics incentivize TSR improvement beyond minimum compliance; emerging opportunities in hydrogen co-firing and advanced biomass systems aligned with global technology frontiers.

3. EXECUTIVE SUMMARY

3 EXECUTIVE SUMMARY AND KEY FINDINGS

**USD
40.32 Million**

Market Size
in 2026

**USD
67.19 Million**

Market Size
in 2031

LARGEST END-USER

88.85%

Revenue Share, Cement Industry, 2026

LARGEST WASTE/FUEL STREAM

57.24%

Revenue Share, Municipal Solid
Waste, 2026

9.11%

CAGR
(2021-2026)

10.75%

CAGR
(2026-2031)

The cement industry segment is estimated to dominate the market for India's alternate fuel and raw materials (AFR) firing systems in 2026.

The municipal solid waste segment is estimated to dominate the market for India's alternate fuel and raw materials (AFR) firing systems in 2026.

LARGEST AFR SYSTEM TYPE

94.54%

Revenue Share, Solid AFR Co-Processing
Systems, 2026

Solid AFR co-processing system is expected to hold a dominant market share of the India alternate fuel and raw materials (AFR) firing systems market in 2026.

FASTEST GROWING DEPLOYMENT MODEL

11.95%

CAGR, Brownfield Retrofit,
2026-2031

The brownfield retrofit deployment model segment is expected to grow fastest in the India alternate fuel and raw materials (AFR) firing systems market during the forecast period.

MAJOR MARKET PLAYERS

- PH1 Industries Limited (formerly known as PH1 Industries Private Limited)
- Frigate Technologies Pvt. Ltd.
- Fornnax Technology Pvt. Ltd.
- BEUMER India Private Limited
- Alfa Therm Limited
- Maxin India Machinery Manufacturers Pvt. Ltd.

4. MARKET LANDSCAPE

4.1 MARKET DRIVERS

4.1.1 INCREASING REGULATORY MANDATES FOR RDF UTILIZATION

- India's regulatory framework for refuse-derived fuel (RDF) utilization has become a key structural demand driver for alternate fuel and raw materials (AFR) firing systems across the country's cement industry. The Solid Waste Management (SWM) Rules, 2026, notified by the Ministry of Environment, Forest and Climate Change (MoEFCC) in January 2026 and effective from April 2026, replaced the 2016 framework with legally enforceable obligations requiring industrial users of solid fuels to include RDF in their fuel mix. The rules shift RDF utilization from a voluntary environmental initiative to a statutory compliance requirement, compelling cement producers to invest in AFR receiving, storage, handling, metering, and feeding systems capable of processing alternative fuels reliably.
- Rule 11 of the SWM Rules, 2026, is the principal demand catalyst. It introduces a mandatory fuel substitution schedule for industrial units, including cement plants and waste-to-energy facilities located within a specified distance of RDF production facilities. The regulation requires RDF or other approved combustible fractions to replace conventional solid fuels at 5% during FY2026-27, rising to 10% after three years and 15% within six years. This phased compliance roadmap creates a predictable investment cycle, as cement manufacturers must upgrade kiln infrastructure with automated extraction systems, sliding floors, weigh feeders, belt conveyors, rotary feeders, double flap valves, and injection equipment to handle higher RDF volumes accurately while maintaining kiln stability.
- The digital compliance and enforcement framework reinforces the regulatory mandate. The SWM Rules, 2026, require industrial facilities, waste processors, and bulk waste generators to register on a centralized Central Pollution Control Board (CPCB) online portal, enabling digital tracking of waste generation, collection, processing, transportation, and utilization. Annual reporting, online monitoring, and certification-based compliance have replaced the earlier self-declaration approach. The rules also introduce environmental compensation based on the "Polluter Pays" principle for non-compliance. These provisions increase the need for automated AFR firing systems that provide traceable fuel consumption data, controlled dosing, and auditable operational records for regulatory reporting.
- The regulatory framework also improves the long-term availability and quality of RDF feedstock, supporting the business case for AFR infrastructure investments. The SWM Rules, 2026, mandate four-stream segregation of municipal waste into wet, dry, sanitary, and special-care waste, assign clearer responsibilities to bulk waste generators, and accelerate land allocation for waste-processing infrastructure. These provisions aim to increase the production of higher-quality RDF with more consistent calorific characteristics, improving combustion performance in cement kilns and reducing operational risks associated with alternative fuels. The strengthened waste-processing ecosystem gives cement manufacturers greater confidence to deploy dedicated AFR handling and firing systems for sustained RDF utilization rather than intermittent co-processing.

4.1.2 GROWING DECARBONIZATION TARGETS IN THE CEMENT INDUSTRY

- India's cement industry has entered a compliance-driven decarbonization phase, with regulatory emission reduction targets accelerating investments in alternate fuel and raw materials (AFR) firing systems. The key policy development was the notification of the Greenhouse Gases (GHG) Emission Intensity Target Rules, 2025, on October 8, 2025, under the Carbon Credit Trading Scheme (CCTS), 2023. For the first time, the government introduced legally binding GHG emission intensity targets for the cement sector, replacing voluntary carbon reduction initiatives with mandatory compliance obligations. Cement is one of four sectors covered in the first phase of the scheme, making AFR technologies a primary pathway for reducing fossil fuel consumption and improving plant-level carbon intensity.
- The regulations set quantified GHG emission intensity reduction targets based on the FY2023-24 baseline, requiring obligated cement plants to reduce emissions during the FY2025-26 and FY2026-27 compliance period. Plants that fail to meet their assigned targets must purchase carbon credit certificates from compliant entities through the Indian Carbon Market or face environmental compensation under the regulatory framework. This creates a direct financial incentive to increase alternative fuel use, as AFR systems allow cement manufacturers to substitute coal and petcoke with refuse-derived fuel (RDF), biomass, industrial waste, and other low-carbon fuels while maintaining kiln performance. Investment priorities are shifting toward high-capacity AFR receiving, storage, conveying, dosing, and combustion systems capable of delivering higher thermal substitution rates (TSR).

Sources: Mordor Intelligence; Ministry of Environment, Forest and Climate Change



4.1 MARKET DRIVERS

- The first Carbon Credit Trading Scheme (CCTS) compliance cycle covers 186 cement plants, representing the largest single industry cohort under the initial implementation phase. These facilities include production units operated by UltraTech Cement, Dalmia Bharat, Shree Cement, JK Cement, ACC, and Ambuja Cements, creating a concentrated market for AFR firing system suppliers. With compliance timelines limited to the first two-year cycle, cement producers are prioritizing turnkey AFR projects that can be commissioned quickly and deliver measurable carbon intensity reductions through higher alternative fuel utilization.
- Government and industry decarbonization roadmaps further support AFR technology adoption. NITI Aayog's Cement Sector Decarbonization Roadmap, released in January 2026, identifies a cumulative 264 MtCO₂e emission reduction potential across the regulated cement sector and assigns plant-specific greenhouse gas (GHG) intensity reduction targets ranging from 0.85% to 7.6%, depending on cement type and operating characteristics. Facilities with higher reduction obligations require more extensive AFR infrastructure deployment to increase conventional fuel substitution.

4.1.3 RISING AVAILABILITY OF MUNICIPAL SOLID WASTE AND INDUSTRIAL WASTE

- The expansion of municipal solid waste (MSW) processing and industrial waste generation across India is increasing the availability of alternative fuel feedstocks for cement kilns, creating a supply-side driver for alternate fuel and raw materials (AFR) firing systems. As waste processing infrastructure expands and more combustible waste streams become commercially available, cement manufacturers are investing in dedicated AFR receiving, storage, conveying, dosing, and injection systems capable of handling multiple fuel types with varying physical and calorific characteristics. The growing diversity and consistency of feedstock supply are shifting investment priorities from securing waste sources to expanding kiln-side infrastructure that can use these materials efficiently.
- India currently generates approximately 62.4 million tons of MSW annually. This volume is projected to increase to 165 million tons by 2031 and nearly 436 million tons by 2045, driven by continued urbanization. This expanding waste base is creating a larger supply of refuse-derived fuel (RDF) suitable for cement kiln co-processing. Cement plants currently have access to around 13,600 tons of RDF per day, equivalent to nearly 4.96 million tons annually, produced from approximately 15% to 20% of municipal waste after segregation and processing. Feedstock availability expanded considerably in 2024, when 50 new RDF processing plants were commissioned across India, increasing national AFR preprocessing capacity by nearly 25% within a single year. As RDF production capacity expands faster than kiln-side handling infrastructure, cement plants require high-capacity extraction systems, sliding floors, belt conveyors, weigh feeders, and precision feeding equipment to process larger RDF volumes without disrupting kiln operations.
- India's urban waste management ecosystem is improving the quality of alternative fuels supplied to the cement industry. Under Swachh Bharat Mission-Urban 2.0 (SBM-U 2.0), urban waste processing is expected to increase from 16% in 2014 to 81% by the end of 2026, supported by approximately 2,900 operational material recovery facilities (MRFs) with a combined preprocessing capacity of 67,000 tons per day. Higher levels of waste segregation and preprocessing produce cleaner, more homogeneous RDF with improved calorific consistency, enabling cement manufacturers to increase reliance on automated AFR conveying, metering, and combustion systems designed for continuous operation with standardized fuel quality.
- The feedstock pipeline is expected to strengthen further through the Ministry of Housing and Urban Affairs' Dumpsite Remediation Accelerator Program (DRAP), introduced in November 2025, which targets the elimination of legacy dumpsites by September 2026. Scientific remediation of accumulated municipal waste creates an additional source of combustible material suitable for RDF production, expanding the long-term availability of waste-derived fuels for cement kilns. The continued increase in processed waste volumes supports sustained investment in AFR receiving, storage, and feeding infrastructure designed to accommodate higher throughput and diversified feedstock streams.

4.1.4 CARBON CREDIT AND FUEL COST-SAVING OPPORTUNITIES

- India's carbon market and the rising financial value of alternative fuel use are strengthening the investment case for alternate fuel and raw materials (AFR) firing systems across the cement industry. Earlier investments primarily focused on fossil fuel substitution.

Sources: Mordor Intelligence; Ministry of Environment, Forest and Climate Change



4.1 MARKET DRIVERS

- AFR systems now deliver broader financial benefits, including carbon credit generation, energy efficiency incentives, tipping fee revenues, and protection against conventional fuel price volatility. This shift is driving investments in higher-capacity, automated AFR receiving, handling, dosing, and combustion systems that can sustain higher thermal substitution rates and improve returns.
- The operationalization of the Carbon Credit Trading Scheme (CCTS) remains the key catalyst. Under the Greenhouse Gas (GHG) Emission Intensity Target Rules, 2025, cement plants that outperform assigned emission reduction targets can generate tradable carbon credit certificates on the Indian Carbon Market (ICM). Higher use of refuse-derived fuel (RDF), biomass, industrial waste, and other alternative fuels directly reduces fossil fuel-derived carbon emissions, making AFR firing systems critical for generating surplus carbon credits. This creates a revenue stream linked to AFR infrastructure and encourages investment in advanced solid and liquid AFR systems that can operate continuously at higher thermal substitution rates.
- ICRA ESG Ratings estimates that, at an assumed carbon price of USD 10 per ton of CO₂, cement companies that fail to meet emission intensity obligations could face profitability erosion of up to 19% by FY2027. The assessment identifies alternative fuel use as a key strategy for reducing compliance costs and generating surplus carbon credits. As a result, investments in AFR handling, storage, and firing infrastructure help protect operating margins and create monetizable environmental assets through carbon certificate generation.
- The Bureau of Energy Efficiency's (BEE) Perform, Achieve and Trade (PAT) Scheme complements the carbon market by providing an additional financial incentive for AFR deployment. Cement plants that achieve prescribed energy intensity improvements under the PAT framework receive tradable Energy Saving Certificates (ESCs). By replacing conventional fossil fuels with waste-derived alternatives, AFR systems help improve specific energy consumption and support emission reduction targets. Tradable carbon certificates under the CCTS and ESCs under the PAT Scheme represent two independent regulatory incentive mechanisms, improving the financial viability of AFR system investments and strengthening the case for integrated fuel handling and combustion infrastructure.
- Fuel cost optimization further supports demand for AFR systems by reducing exposure to volatile coal and petcoke prices. Many Indian cement plants depend on imported petcoke, which exposes operating costs to international commodity price fluctuations and foreign exchange movements. Alternative fuels, such as RDF and selected industrial waste streams, reduce this dependence. Hazardous waste co-processing also generates tipping fee revenues from waste generators seeking environmentally compliant disposal. Under the Central Pollution Control Board's (CPCB) hazardous waste co-processing framework, pharmaceutical and chemical manufacturers pay authorized cement plants to use waste as kiln fuel.

4.1.5 EXPANSION OF CEMENT MANUFACTURING CAPACITY

- India's ongoing cement manufacturing expansion is creating a strong greenfield demand opportunity for alternate fuel and raw materials (AFR) firing systems. The current investment cycle is defined by the scale of new cement capacity additions and the integration of AFR infrastructure into plant engineering from the design stage. Unlike older facilities that adopted alternative fuels through brownfield retrofits, new cement plants are increasingly incorporating dedicated AFR receiving, storage, conveying, dosing, and combustion systems before commissioning. This trend is creating sustained procurement opportunities for turnkey AFR system suppliers.
- India's cement industry is expected to invest approximately INR 1.2 trillion from FY2026 to FY2028 to add 160 to 170 million tons per annum (MTPA) of production capacity. This represents the country's largest cement capacity expansion program and directly expands the addressable market for AFR firing systems, as every new integrated clinker line requires engineered infrastructure for alternative fuel handling. New projects are increasingly incorporating complete AFR packages, including extraction systems, conveyors, storage silos, dosing equipment, precalciner feeding systems, automation, fire protection, and emission control, from the procurement stage instead of planning future retrofits. This approach reduces long-term compliance costs and improves operational flexibility.
- The investment pipeline is supported by aggressive expansion strategies among India's largest cement producers. UltraTech Cement Limited achieved 200.1 MTPA of domestic capacity and 205.5 MTPA of consolidated global capacity in April 2026. The company has announced an expansion program worth INR 160 billion to increase capacity to 242.5 MTPA by FY2028.

Sources: Mordor Intelligence; Ministry of Environment, Forest and Climate Change



4.1 MARKET DRIVERS

- The construction of multiple integrated cement facilities is expected to generate demand for high-capacity solid AFR co-processing systems that can support alternate fuel utilization from the start of commercial operations. This reflects the industry's transition toward standardized AFR-ready plant configurations.
- Other leading manufacturers are also adding capacity. Ambuja Cements, following the consolidation of ACC and Orient Cement, increased installed capacity to approximately 118 MTPA by the end of FY2026 while pursuing a long-term expansion strategy toward 155 MTPA. Similarly, Shree Cement is investing approximately USD 223 million in a new 2 MTPA greenfield plant at Chandrapur, Maharashtra, as part of its strategy to expand capacity from 68 MTPA to 80 MTPA by 2028, with a longer-term objective of reaching 100 MTPA. These greenfield developments create opportunities for integrated AFR installations, as new kiln lines can incorporate dedicated receiving, storage, conveying, and firing infrastructure during construction and avoid operational disruptions from later retrofits.
- Expansion activity spans multiple regional markets. Dalmia Bharat has announced investments of approximately USD 400 million for a 3.6 MTPA clinker plant and a 3 MTPA grinding unit at Belagavi, Karnataka, along with a 3 MTPA greenfield plant at Pune, Maharashtra. These investments support capacity targets of 75 MTPA by FY2028 and 110 to 130 MTPA by FY2031. In addition, JK Cement has approved an investment of INR 48.05 billion for a 7 MTPA greenfield cement project at Jaisalmer, Rajasthan. Each integrated project represents a potential procurement opportunity for complete AFR firing systems, particularly high-throughput solid AFR installations designed for precalciner injection, automated process control, and continuous alternate fuel handling.



4.2 MARKET RESTRAINTS

4.2.1 LOW AFR ADOPTION AND TECHNICAL INTEGRATION CHALLENGES

- Low AFR adoption is likely to constrain demand growth for AFR firing systems across India, as regulatory pressure has not yet driven broad plant-level implementation. Although India's national average Thermal Substitution Rate (TSR) has reached approximately 6% to 7%, American Council for an Energy-Efficient Economy (ACEEE) (June 2026) and Global Cement and Concrete Association (GCCA) India indicate that most of the country's 270+ operational cement kilns remain below 5% TSR. This gap between leading producers and the broader kiln base indicates that a large share of potential demand for AFR firing systems remains unrealized, particularly at plants that continue to rely primarily on coal and petcoke.
- Limited plant-level technical capability further delays equipment procurement. Cement plants using conventional fuels must manage the variability of heterogeneous AFR, including differences in calorific value, moisture, and particle characteristics. This variability requires Programmable Logic Controller (PLC)-based dosing adjustments, controlled feeding, and emissions monitoring, increasing the perceived technical risk of retrofitting AFR systems. For plant operators focused on kiln availability, feed inconsistency and potential kiln instability can discourage investment, even when AFR offers economic and environmental benefits.
- This constraint is more pronounced among independent and smaller cement producers, which often lack the dedicated sustainability and environmental engineering resources available to major groups such as UltraTech, Adani, Shree, and Dalmia. The challenge is greater in Chhattisgarh, Odisha, and Northeast India, where AFR awareness and feedstock supply chains remain comparatively underdeveloped, according to the Indian Cement Review. As a result, demand for complete AFR firing systems is likely to remain concentrated initially among technically capable large cement groups rather than expanding uniformly across India's kiln population.
- ACC Jamul illustrates the technical learning curve associated with AFR adoption. PH1 Industries Limited (formerly known as PH1 Industries Private Limited) documented a phased increase in TSR from 2.5% to 12.5% through mechanized feeding before commissioning an onsite shredder targeting 20% TSR. This progression indicates that higher AFR utilization requires sequential investment in feeding, preprocessing, and material handling infrastructure rather than a single equipment purchase. For brownfield plants, this increases project complexity and can extend procurement and commissioning timelines for AFR firing systems.
- Low baseline TSR and uneven technical readiness are therefore likely to moderate demand for AFR firing systems from FY2026 to FY2029. The diffusion of operating knowledge and reference installations should gradually reduce procurement hesitation. However, adoption is likely to remain uneven, with technically mature integrated producers progressing faster than regional and independently operated cement plants.

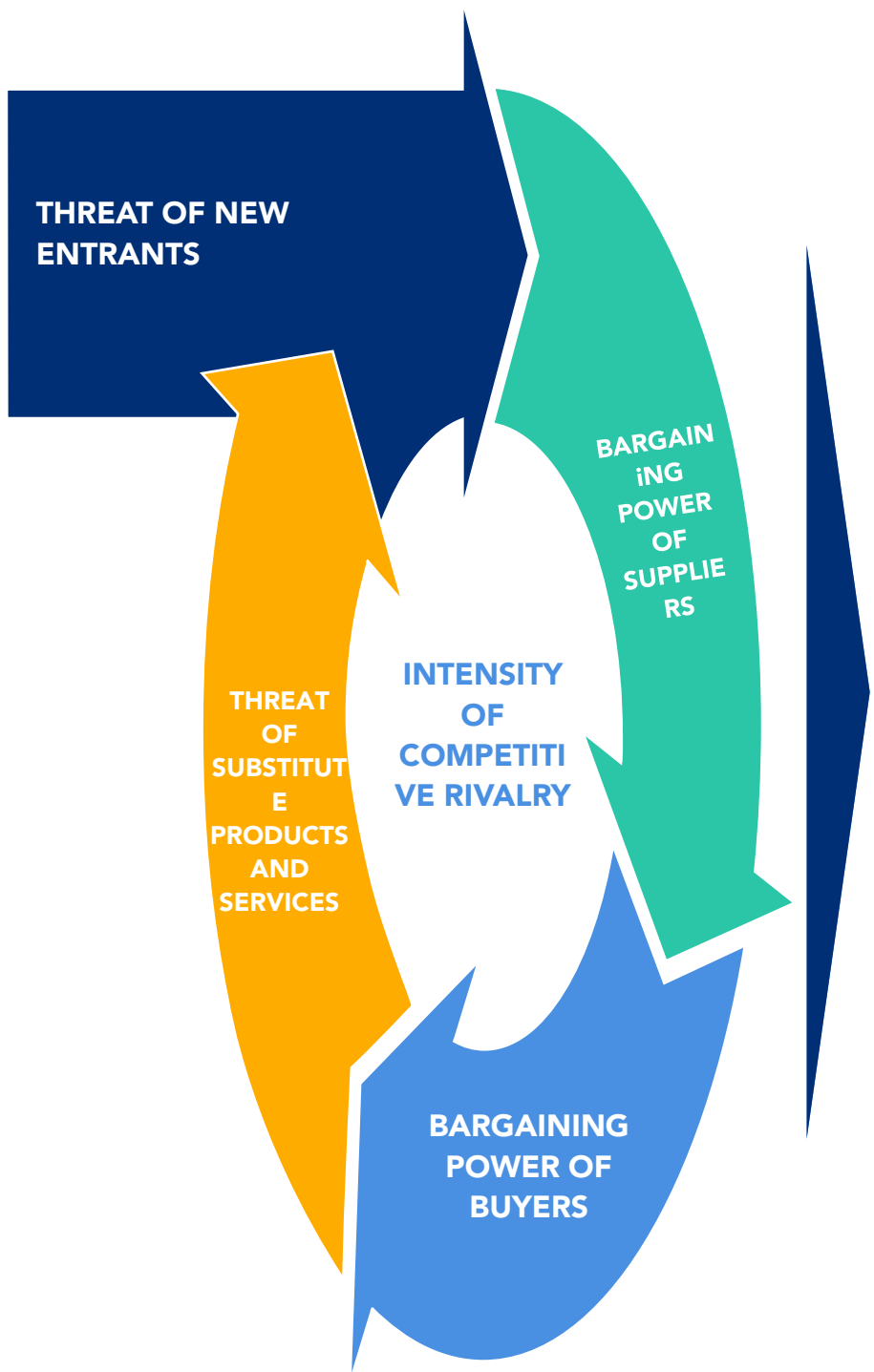


4.2 MARKET RESTRAINTS

4.2.2 HIGH CAPITAL INTENSITY REQUIREMENTS

- High capital intensity is likely to restrain AFR firing system demand growth across India, as investment requirements extend beyond core firing equipment. A basic solid AFR feeding upgrade can require INR 5 crore to INR 15 crore, while integrated systems covering solid and liquid AFR handling, preprocessing, storage, automation, emission control, and fire protection can require INR 50 crore to INR 80 crore or more. This creates a high entry threshold for cement plants evaluating AFR for the first time, particularly when management must commit capital before establishing reliable fuel availability and operating performance.
- This constraint is likely to be most pronounced among mid-tier cement producers, regional operators, and smaller industrial users. India's largest groups, including UltraTech, Adani/Ambuja/ACC, Shree, Dalmia, and JK, have stronger internal cash generation and financing access, enabling them to absorb large environmental and process efficiency investments. In contrast, the 30 to 40 mid-tier producers operating plants in the 2 MTPA to 10 MTPA capacity range must allocate limited annual capital expenditure across competing requirements, such as kiln modernization, capacity expansion, maintenance, and energy efficiency projects. As a result, these producers may defer AFR systems even when long-term fuel cost and emissions benefits are attractive.
- The breadth of required infrastructure further increases the investment hurdle. Plants seeking only solid AFR substitution may initially require feeding modifications, but higher substitution rates can require additional preprocessing, storage, and material handling infrastructure. Liquid AFR adds equipment for receiving, pumping, dosing, and safety management. Consequently, operators may need to finance an interconnected infrastructure package before achieving meaningful fuel substitution.
- Access to external financing also remains a constraint. Although green bonds, sustainability-linked loans, and National Bank for Agriculture and Rural Development (NABARD) climate financing windows can support AFR-related investments, these mechanisms require specialized documentation and project finance capabilities, which can disadvantage smaller cement companies that lack dedicated sustainability finance teams. Perform, Achieve and Trade (PAT) Energy Saving Certificates and future CCTS carbon credit revenues have not yet gained sufficient acceptance as conventional collateral or predictable debt servicing streams, limiting their immediate ability to improve financing availability.
- The emerging Indian carbon market could eventually reduce this constraint by creating an additional revenue stream for plants that lower emissions through AFR substitution. However, carbon credit price discovery and market liquidity are still developing, and operators cannot yet treat future carbon revenues as a sufficiently certain financing source when making current equipment decisions.
- Overall, high capital intensity is likely to lengthen AFR investment payback periods and delay procurement decisions, particularly among financially constrained regional producers. Demand should develop faster among large, well-capitalized cement groups, while smaller operators are more likely to adopt AFR systems incrementally as financing conditions, carbon market revenues, and demonstrated operating returns improve.

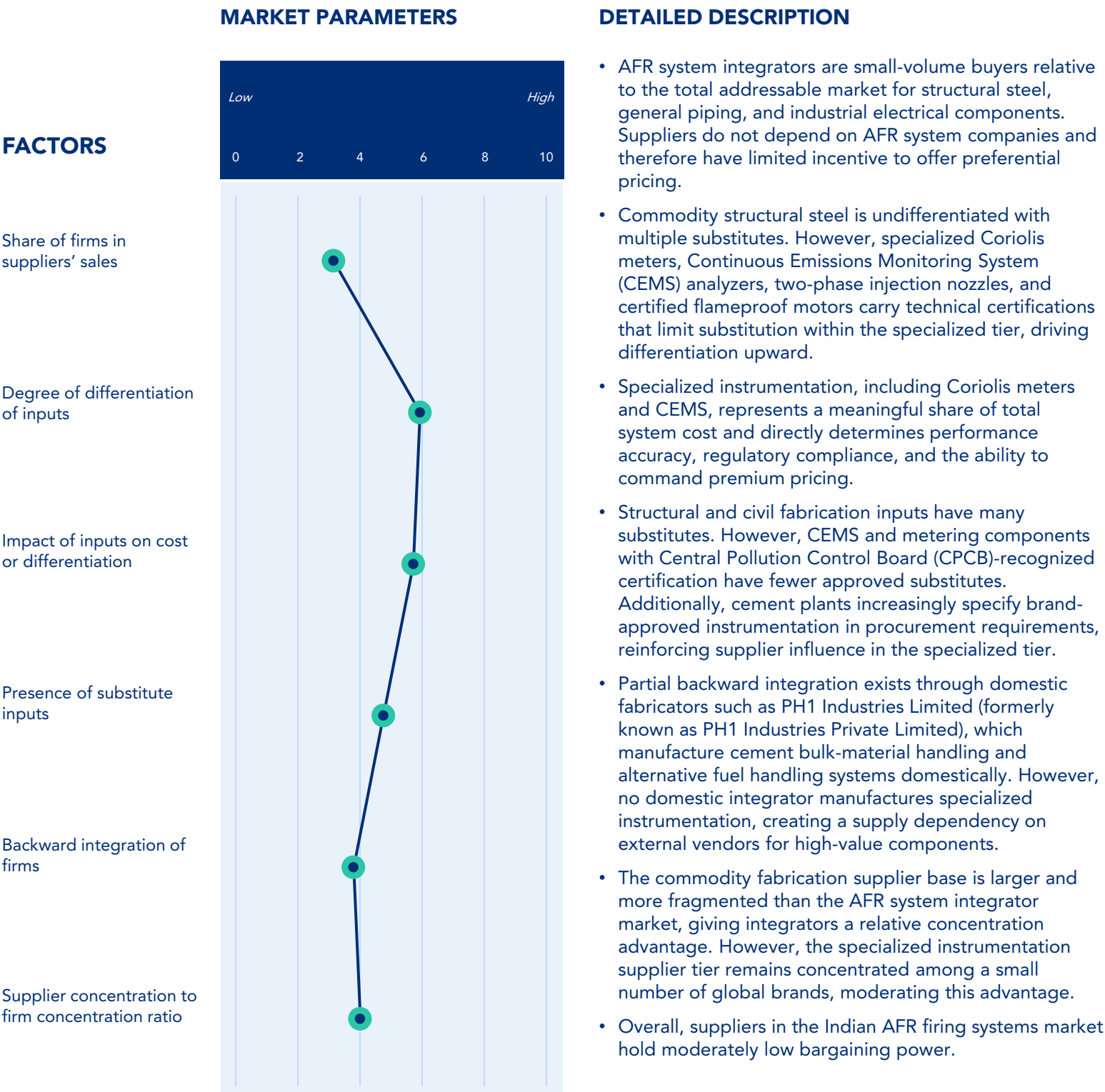
4.3 PORTER'S FIVE FORCES ANALYSIS



- The bargaining power of the suppliers in the market studied is expected to be **moderately low** during the forecast period.
- The bargaining power of the buyers is expected to be **moderate** during the forecast period.
- The threat of new entrants is expected to be **moderately low** during the forecast period.
- The threat of substitutes is likely to be **moderately low** in the future.
- The intensity of competitive rivalry is anticipated to be **moderate** during the forecast period.

Source: Mordor Intelligence

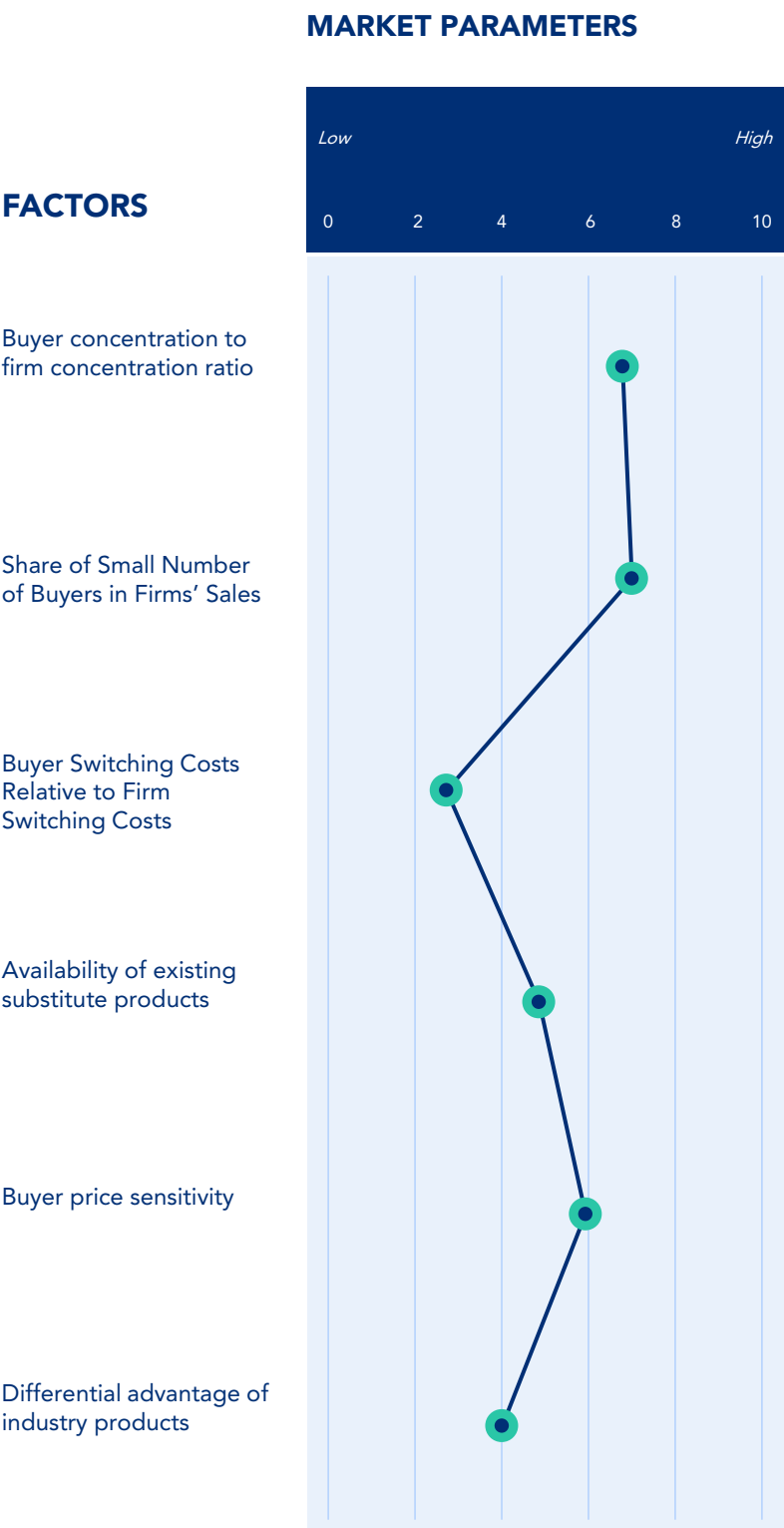
4.3.1 BARGAINING POWER OF SUPPLIERS



Source: Mordor Intelligence



4.3.2 BARGAINING POWER OF BUYERS



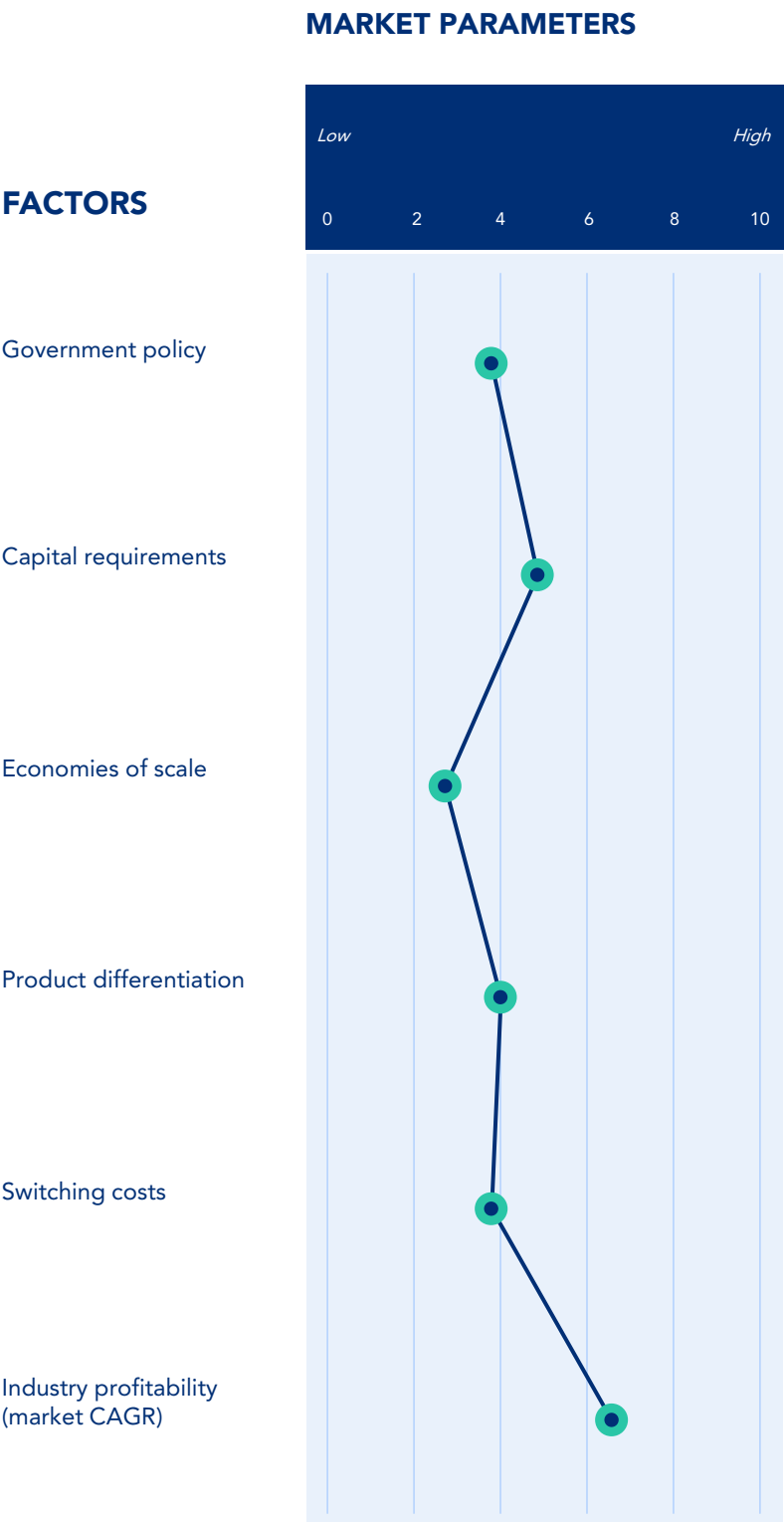
DETAILED DESCRIPTION

- India's cement capacity is concentrated among a small number of large groups, including UltraTech, Ambuja/ACC (Adani Group), Shree Cement, Dalmia Bharat, and JK Cement/JK Lakshmi, while the AFR system integrator landscape remains fragmented. This asymmetry favors buyers, particularly for multi-plant and framework-level engagements.
- Given this capacity concentration, a handful of major cement groups account for a large share of total AFR systems demand. This amplifies individual buyer leverage over supplier pricing, payment terms, and warranty commitments.
- Plant-specific system design, State Pollution Control Board (SPCB) authorization linked to specific AFR equipment, and embedded operational knowledge create high switching costs for buyers post-installation. These switching costs result in post-installation lock-in, limiting the buyer's ability to exercise leverage once a supplier is commissioned.
- International Original Equipment Manufacturers (OEMs), including KHD Humboldt Wedag, FLSmidth, BEUMER Group, and Fives, offer competing pyro-processing and AFR firing systems, providing buyers with alternatives during procurement. However, Indian market expertise and local service presence remain important differentiators for domestic integrators, moderating supplier pricing authority.
- India's cement industry operates on thin margins, driving capital expenditure discipline. ICRA ESG's April 2026 analysis found that cement companies could face profitability impacts of up to 19% by FY2027 under the Carbon Credit Trading Scheme, creating compliance-driven urgency that partially offsets pure price sensitivity for plants facing tightening targets.
- Domestic integrators such as PH1 Industries and other domestic specialists, alongside international OEMs with established combustion engineering capabilities, offer meaningful differentiation, reducing buyer power by limiting direct price comparisons. However, technically sophisticated cement buyers can often evaluate systems against multiple specifications.
- Overall, buyers in the Indian AFR firing systems market hold moderate bargaining power.

Source: Mordor Intelligence



4.3.3 THREAT OF NEW ENTRANTS



DETAILED DESCRIPTION

- CPCB co-processing authorization requirements under GSR 497(E), CEMS integration standards, Hazardous and Other Waste Rules compliance create high institutional-knowledge barriers. New entrants must navigate multi-agency regulatory processes on behalf of clients, a competency that requires years to develop.
- New entrants can commence operations without owned fabrication facilities by using third-party job shops, which moderates the direct capital barrier. However, establishing large-scale fabrication capacity comparable to that of established domestic players requires significant capital investment. Additionally, economies of scale in engineering talent and regulatory documentation give incumbents a modest but real cost advantage.
- Established players have differentiated systems backed by documented TSR performance records. For instance, JSW Cement's Nandyal and Shiva plants raised group-wide TSR from 6.9% to 16.5% in FY2024-25, and Ambuja/ACC's Geoclean co-processing arm raised its blended TSR to 8.5% in FY2024, with newly commissioned ACC Jamul and Ambuja Marwar facilities individually elevating plant-level TSR to 15%. New entrants without comparable reference-plant performance data lack the credentials required to displace incumbents in competitive procurement.
- Once an AFR system is installed and SPCB authorization is linked to a specific system configuration, plant operators face high switching costs, including regulatory re-documentation and system-specific recalibration. These switching costs protect incumbents and make displacing established relationships difficult, even when competitive pricing is offered.
- The compliance-driven demand environment under the Carbon Credit Trading Scheme and the SWM Rules, 2026 mandatory RDF substitution schedule makes the market attractive to new entrants, particularly international original equipment manufacturers seeking to leverage existing cement industry relationships. NITI Aayog's Cement Decarbonization Roadmap, which targets a 20% sector TSR by 2030, signals a sustained, policy-backed growth trajectory that is expected to attract new capital into the market.
- The threat of new entrants in the market is moderately low.

Source: Mordor Intelligence



4.3.4 THREAT OF SUBSTITUTES

MARKET PARAMETERS

FACTORS

Buyer propensity to substitute

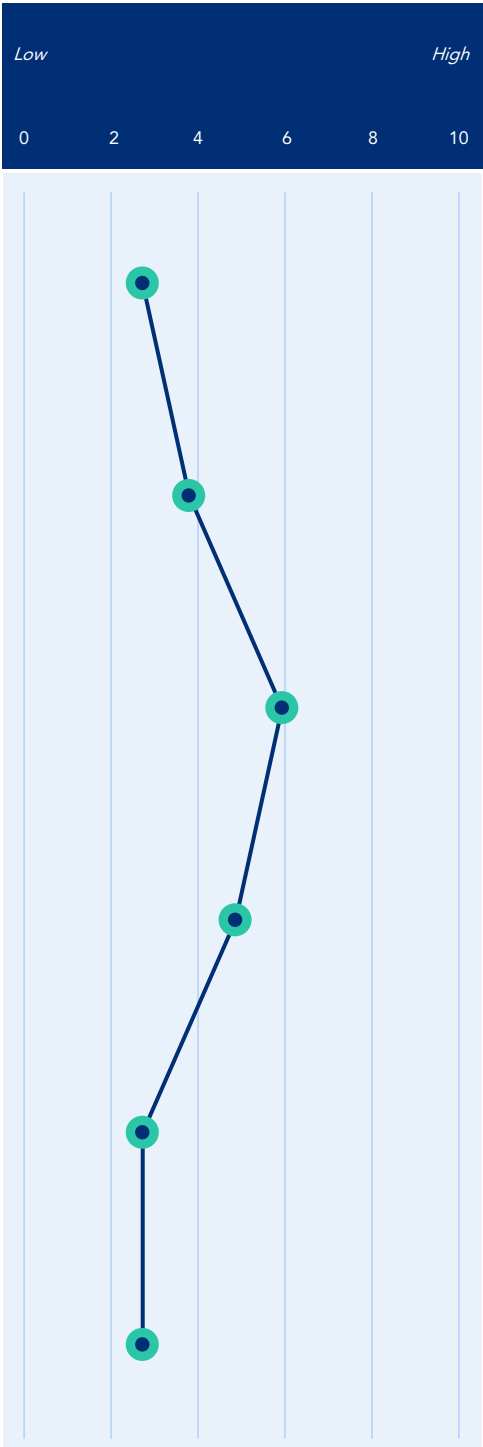
Relative price performance of substitute

Buyer switching costs

Number of substitute products available in the market

Ease of substitution

Availability of close substitutes



DETAILED DESCRIPTION

- Under the CCTS compliance framework and SWM Rules 2026, cement companies face a dual legal obligation requiring physical AFR adoption. Alternative pathways are not viable, as financial instruments such as carbon credit purchasing do not fulfill the SWM Rules' physical substitution mandate.
- Carbon credits are available but become progressively more expensive under FY2027 tightening targets, with ICRA ESG estimating a profit impact of up to 19% for some cement companies. Green hydrogen remains pre-commercial at India's cement plant scale, giving AFR co-processing a clear price-performance advantage in the near term.
- High sunk costs in the AFR system installation deter any shift toward substitutes. Capital deployed in storage infrastructure, conveying systems, CEMS integration, and SPCB authorization represents a multi-crore INR commitment, and abandoning co-processing would strand these investments entirely.
- Multiple pathways theoretically exist, including direct carbon credit purchasing, blended cement expansion, green hydrogen, carbon capture, and energy efficiency optimization. However, none delivers the combination of regulatory compliance, physical fuel substitution, and favorable near-term economics that AFR co-processing provides.
- Replacing an operational AFR co-processing system with carbon capture or green hydrogen requires fundamentally different capital infrastructure, and neither technology is commercially deployable in India at cement plant scale in the near term. Additionally, direct carbon credit purchasing becomes financially unattractive at the volumes required for material emission-intensity reduction under FY2027 tightening targets.
- No current technology simultaneously satisfies CCTS emission-intensity targets, SWM Rules 2026 RDF mandates, and favorable unit economics as AFR co-processing does. Carbon capture and green hydrogen remain longer-horizon options, while blended cement functions as a complementary rather than a substitute lever for the Indian cement sector.
- Overall, the threat of substitute products in the Indian AFR firing systems market is moderately low.



4.3.5 INTENSITY OF COMPETITIVE RIVALRY

MARKET PARAMETERS

FACTORS

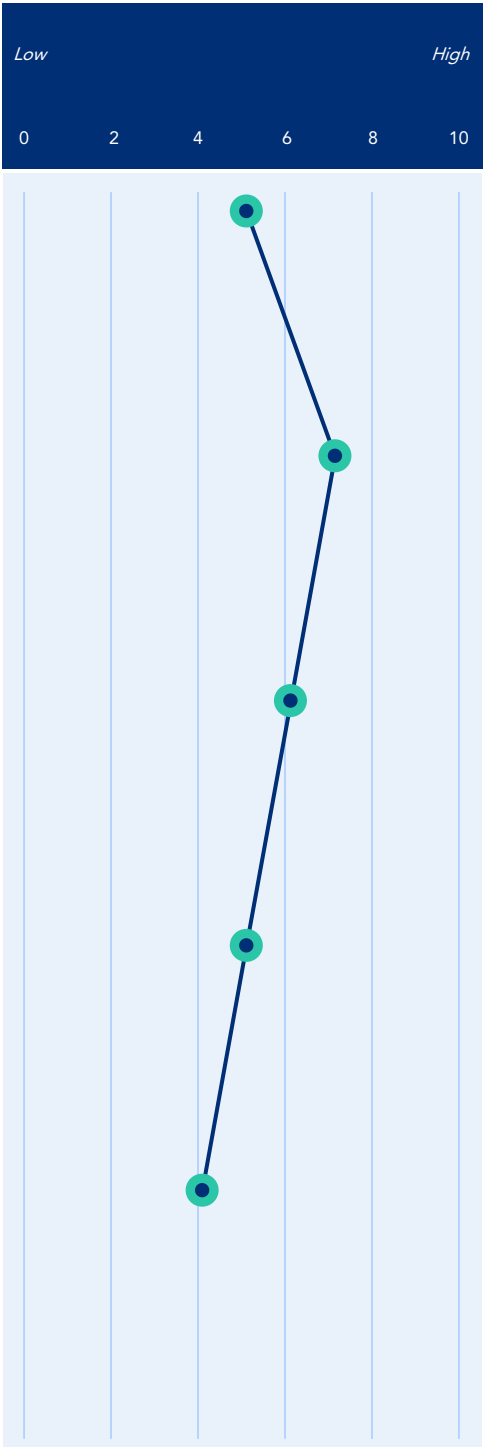
Sustainable competitive advantage in the future through innovation

Consumer switching costs

Geographic presence

Firm concentration

Fixed costs



DETAILED DESCRIPTION

- Innovation is occurring at a steady pace. KHD Humboldt Wedag's Pyrorotor rotary combustion reactor enables cement plants to burn coarse, low-quality alternative fuels, including whole tires, with minimal pre-processing. The technology has been deployed across multiple installations in Asia and Europe, most recently at Conch Group's Baoshan plant in China in December 2025. Such advances are evolutionary rather than disruptive, and no single innovation has created an insurmountable technology lead.
- High post-installation switching costs, arising from plant-specific engineering documentation, SPCB authorization linkages, and embedded operational knowledge, significantly moderate rivalry intensity. Incumbents at any given cement plant have a strong retention advantage, reducing the effective competitive battlefield to greenfield installations and new plant expansions rather than the displacement of installed systems.
- Credible competitors operate nationally across India's major cement-producing clusters in Rajasthan, Madhya Pradesh, Andhra Pradesh, Telangana, Karnataka, and Gujarat. International OEMs maintain regional service offices, while domestic specialists such as PH1 Industries and emerging domestic integrators operate with site-specific project teams. Geographic coverage is a baseline requirement rather than a differentiator. However, the depth of SPCB relationships in specific states provides a state-level competitive advantage.
- The market has a moderate concentration level, with a small number of dominant domestic specialists and several credible international OEM participants, including KHD Humboldt Wedag, FLSmidth, BEUMER Group, and Fives, active in any major procurement process. The presence of both domestic and international competitors maintains competitive tension, particularly for larger framework procurements by the top cement groups.
- The custom engineering services business model results in a relatively low fixed-cost base compared to capital-intensive product manufacturers. Primary costs are engineering labor, project-specific fabrication, and instrumentation, which scale with revenue rather than compelling firms to maintain high throughput. This moderates rivalry from a cost-structure perspective.
- Overall, the intensity of competitive rivalry remains moderate.

Source: Mordor Intelligence



4.4 KEY MARKET TRENDS

Under the Solid Waste Management (SWM) Rules, 2026, notified by the Ministry of Environment, Forest and Climate Change (MoEFCC) on 28 January 2026 and effective from 1 April 2026, industrial units including cement plants and waste-to-energy plants using solid fuel are required to substitute it with refuse-derived fuel (RDF), with the substitution rate rising from 5% to 15% over six years. This converts Alternate Fuel and Raw Materials (AFR) firing-system adoption from a cost and sustainability decision into a compliance obligation across India's cement manufacturing base.

**RDF SUBSTITUTION
CONVERTS FROM
VOLUNTARY TO
REGULATORY MANDATE**

**PRECALCINER FIRING IS THE
PREFERRED INJECTION
POINT FOR HIGHER TSR**

Precalciner injection is preferred over main-burner firing because the maximum thermal substitution rate achievable through RDF is 80–100% in the calciner, compared to 50–60% when fired through the kiln burner. This difference is directing AFR capital toward precalciner and tertiary-air-duct injection hardware, as calciner firing tolerates lower-grade, higher-moisture RDF without destabilizing clinker chemistry.

The NITI Aayog Roadmap for Cement Sector Decarbonization (January 2026) targets a 20% thermal substitution rate (TSR) by 2030, while peer-reviewed industry literature places India's current TSR at approximately 4–5%. This four-to-five-fold gap between the current and targeted TSR is the primary structural driver of long-term capital expenditure on AFR firing systems.

**INDIA'S NATIONAL TSR
REMAINS A FRACTION OF
THE 2030 GOVERNMENT
TARGET**

**CARBON PRICING IS
EMERGING AS A SECOND
FINANCIAL DRIVER FOR
AFR**

Under the MoEFCC's Greenhouse Gas Emission Intensity Target Rules, 2025, 186 cement entities are legally required to meet sector-specific emission intensity reduction targets ranging from 4.7% to 7.6%. Covering the compliance periods FY2025-26 and FY2026-27, entities that exceed these targets earn tradable Carbon Credit Certificates under the national Carbon Credit Trading Scheme.

4.5 INSIGHTS ON GOVERNMENT INITIATIVES AND REGULATIONS

Attribution	Description
Solid Waste Management Rules	Notified by MoEFCC on 28 January 2026 and effective 1 April 2026, the SWM Rules, 2026 supersede the SWM Rules, 2016. Cement plants and waste-to-energy plants using solid fuel must replace it with RDF, with the substitution rate rising from 5% to 15% over six years. RDF is fuel produced by shredding and dehydrating municipal solid waste, primarily comprising non-recyclable plastic, paper, and textiles. The rules also mandate four-stream waste segregation at source, a CPCB-administered online portal for tracking waste facility registration and audits, and buffer-zone and land-allocation norms for processing facilities exceeding 5 tonnes per day capacity.
NITI Aayog Roadmap for Cement Sector Decarbonization	Released in January 2026 by NITI Aayog with technical support from World Resources Institute (WRI) India, the roadmap was developed following more than 20 stakeholder consultations and a field visit to Indore's municipal solid waste and material recovery facilities. It identifies increased RDF usage from municipal solid waste as one of three high-impact decarbonization solutions, estimating that a 20% thermal substitution rate by 2030 could deliver approximately 80 MtCO ₂ e in cumulative emission reductions. The estimated intervention cost is INR 4,100 crore, with the potential to catalyze INR 15,000 crore in additional capital investment.
CPCB Co-Processing Framework for Hazardous and Industrial Waste	Co-processing of hazardous and other wastes in cement kilns operates under CPCB guidelines issued pursuant to co-processing notification GSR No. 497(E) dated 10 May 2016 (Environment Protection Rules, 1986). Such waste does not require environmental clearance under MoEF&CC Notification S.O. 3518(E). Cement plants may co-process pre-processed hazardous waste from Treatment, Storage, and Disposal Facilities (TSDFs) or captive pre-processing facilities only after obtaining State Pollution Control Board authorization. This framework allows industrial waste and hazardous liquid waste AFR input categories to be fired into kiln/precalciner systems.
Carbon Credit Trading Scheme (CCTS)	Notified in June and December 2023 under the Energy Conservation Act, 2001 (as amended in 2022), the CCTS operates through a compliance mechanism for obligated large emitters and a voluntary offset mechanism, implemented in phases as a successor to the Perform, Achieve and Trade (PAT) scheme. Under the associated Draft Greenhouse Gas (GHG) Emission Intensity Target Rules (April 2025), 186 cement entities have emission intensity reduction targets for FY2025-26 and FY2026-27.
Gobardhan National Circular Bioenergy Scheme	Approved by the Union Cabinet on 6 August 2026 with a total outlay of INR 23,731 crore, the scheme runs from FY2026-27 to FY2035-36. It aims to increase domestic compressed biogas production nearly tenfold through assured offtake, with a blending obligation rising from 3% in FY2027 to 5% from FY2029, capital assistance of up to INR 2 crore per tonne per day of installed capacity, and a stable administered price of INR 2,110/MMBtu. Although not specific to the cement sector, the scheme directly affects the biomass and agricultural waste category of AFR inputs by formalizing competing feedstock-aggregation infrastructure.

State-Level Authorization Complexity Map

State	State Pollution Control Board (SPCB) Processing Efficiency	Key Alternate Fuel and Raw Materials (AFR)-Relevant Permissions	PH1 Installed Base Presence
Rajasthan	Moderate	Co-processing authorization, hazardous waste transport	HIGH - Shree Cement Ras, Nawalgarh; JK Nimbahera; Ambuja Marwar
Andhra Pradesh	Moderate	CPCB hazardous liquid authorization, pharma waste	HIGH - Bharathi Cement Kadapa, Maha Cement Kurnool, HeidelbergMaterials Sitapuram
Chhattisgarh	Moderate	Co-processing for industrial sludge and RDF	HIGH - ACC Jamul, Nuvoco Risda, Ambuja Bhatapara
Tamil Nadu	Favorable	Biomass and MSW co-processing	HIGH - Chettinad Cement (5 plants)
Madhya Pradesh	Moderate	Chemical industry liquid waste	HIGH - UltraTech Dhar, JK Cement Panna
Maharashtra	Variable by district	Common Effluent Treatment Plant (CETP) sludge, chemical liquid AFR, plastic waste	GROWING - ACC Chanda
Telangana	Moderate	Pharma liquid hazardous waste (Hyderabad belt)	MODERATE - HeidelbergMaterials Yerraguntla
Karnataka	Favorable	MSW/RDF, biomass	GROWING - Shree Cement Kodhla

Source: Mordor Intelligence



4.6 RECENT DEVELOPMENTS IN THE INDUSTRY

UltraTech Cement: AFR and Green Power Mix Expansion

In its results for the quarter and full year ended March 31, 2026, UltraTech reported its green power mix rising to 43% of total power consumption, up from 34.4% in the prior year. An expanded alternative fuel and raw material (AFR) mix and improved conversion ratios contributed to a 3% year-on-year decline in energy costs. Domestic gray cement capacity crossed 200 MTPA during the year, with company management targeting an 85% green power share by FY30.

Dalmia Bharat: Alternate Raw Material Utilization Scale-Up

Dalmia Bharat's Integrated Annual Report for FY2024-25 disclosed an 84% low-carbon blended-cement production share, supported by 11.87 million tonnes of alternate raw materials utilized. The company recorded a carbon footprint of 456 kg CO₂/tonne of cementitious material. Note: This company-reported figure covers alternate raw material utilization (clinker substitutes) specifically, rather than alternate fuel consumption.

JK Lakshmi Cement: Sirohi Plant Thermal Substitution Rate Retrofit

JK Lakshmi Cement has been implementing a phased project to raise the thermal substitution rate at its Sirohi cement plant (Rajasthan) from 4% to 16%. This disclosure has been repeated consistently across Q4 FY25, Q1 FY26, Q2 FY26, Q4 FY26, and Q1 FY27 results. Renewable power share in the overall power mix has ranged between 46% and 50% across these quarters.

Fornnax Technology Launches R-MAX3300 Refuse-Derived Fuel Shredder

Fornnax Technology launched the R-MAX3300, a single-shaft secondary shredder, at IFAT India 2025 in Mumbai on October 14, 2025. Built on the R-Series platform, the equipment is designed to process low-density waste streams, including municipal solid waste, commercial and industrial waste, construction and demolition debris, and bulky/legacy waste, into refuse-derived fuel and solid recovered fuel within a 30-50 mm particle-size range. The primary targets for this equipment include cement AFR plants and waste-to-energy facilities. The launch event was attended by representatives from Prism Johnson's cement division, Shree Cement, and Mangalam Cement.

UltraTech Cement: INR 10,255 Crore Capacity Expansion

On October 18, 2025, UltraTech Cement's board approved a fresh investment of INR 10,255 crore to expand cement production capacity by 22.8 MTPA, including subsidiary India Cements, through a mix of brownfield and greenfield projects. Commercial production is expected to come online in a phased manner from FY2028, taking UltraTech's total global cement capacity to 240.76 MTPA. This expansion follows more than INR 50,000 crore invested by the company over the preceding five years. Each new integrated unit commissioned under this cycle represents an additional site requiring AFR firing-system design from inception.

4.7 SWOT ANALYSIS OF THE MAJOR 3 PLAYERS (PH1 INDUSTRIES LIMITED [FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED])

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• PH1 Industries Limited (formerly known as PH1 Industries Private Limited) has executed 80+ projects, including ACC Jamul, Shree Cement, JSW Cement, UltraTech, Ambuja, Heidelberg Materials India, Nuvoco, Chettinad, and JK Cement. This represents the broadest reference portfolio among India-headquartered AFR specialists. • The company is the only domestic company offering fully integrated liquid and solid AFR systems under a single engineering platform, covering waste receiving, storage, filtration, pumping, injection, and multi-point precalciner/TAD/main burner injection. Its 400 m³ (2×200 m³) hydraulic extraction storage configuration is the largest AFR storage installation in India. • The company holds a dominant share in India's liquid AFR firing systems market.	• An in-house fabrication throughput limit of approximately 2,400 MT per annum restricts the company's ability to execute multiple large-scale turnkey installations concurrently. • Reliance on a narrow base of end-user industrial segments exposes revenue to regulatory delays and seasonal demand fluctuations due to limited diversification into other heavy industries. • A smaller capital base relative to large multinational OEMs limits the company's ability to independently pursue multi-plant, large-scope enterprise projects without external consortia.	• Upcoming regulatory requirements, including the CCTS GHG Intensity Target Rules (October 2025) covering 282 facilities and the SWM Rules 2026 RDF substitution schedule, will drive a procurement cycle extending through 2031. PH1 is well-positioned to secure brownfield retrofit contracts as plants transition from Phase 1 (5% TSR) toward Phase 3 (15–20% TSR), with demand expected to peak between 2028 and 2030. • India's projected 160–170 MTPA greenfield cement capacity additions by FY2028 are expected to generate INR 4,000–5,000 crore in turnkey AFR system demand at a 15% TSR capability level. • The NITI Aayog decarbonization roadmap targets 15–20% TSR by 2030. Combined with a track record of processing 2 million tons of waste across 80+ projects, PH1 has a strong foundation to scale operations into South Asia, Southeast Asia, and East Africa.	• Multinational OEMs, including BEUMER Group (INR 200 crore Jhajjar facility, December 2025) and Fuller Technologies Inc. (erstwhile FLSmidth Cement), are competing for integrated AFR contracts at Tier-1 cement groups. • Domestic entrants such as Alfa Therm Ltd (400 TPD AFR pre-processing line at JK Cement, Green Innovation of the Year, Indian Cement Review Awards 2025) are establishing competitive reference projects that could erode the company's differentiation in waste pre-processing. • Revenue realization depends on cement capital expenditure (CAPEX) deployment, which is vulnerable to construction slowdowns, interest rate cycles, and environmental clearance delays. These factors could extend the interval between regulatory mandates and actual procurement.

Source: Mordor Intelligence, Company Website, Annual Report, News Articles

4.7 SWOT ANALYSIS OF THE MAJOR 3 PLAYERS (FRIGATE TEKNOLOGIES PVT. LTD.)

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Incorporated on 14 March 2008 and ISO-certified, Frigate Teknologies Pvt. Ltd. has 18 years of experience in engineering, procurement, construction, and project management within India's cement sector. Its portfolio covers bulk material handling systems, cement plant equipment, AFR co-processing systems, and EPC/consultancy services for greenfield and modernization projects. • In bulk material handling, Frigate has 50+ bucket elevator installations in India and abroad, with chain configurations up to 90 m, belt configurations up to 200 m, and conveying capacities up to 2,000 TPH. Its cement plant equipment includes loading/unloading systems, silo feeding/extraction systems, clinker grinding plants (300–2,000 TPD turnkey), and rotary kilns for mini/mid-size plants. • Frigate's AFR capability covers the pre-processing and co-processing value chain for solid and semi-solid fuels, including shredding, segregation, foreign-body removal, and kiln-feed management.	• Frigate has not publicly disclosed cement-plant specific AFR project references, system capacities, or TSR improvements, limiting benchmarking against competitors such as PH1 Industries (35+ cement plants) or Alfa Therm (400 TPD at JK Cement). • The AFR portfolio is focused on solid/semi-solid streams only; there is no evidence of liquid AFR firing systems (storage tanks, filtration, Coriolis-metered pumping, kiln injection), restricting Frigate from competing in integrated liquid-solid turnkey contracts. • Headquartered in Faridabad, Haryana, Frigate's published references are concentrated in North India clusters. There is limited evidence of execution in South India's high-TSR markets (AP, Telangana, Tamil Nadu, Karnataka), where rivals like PH1 Industries and Alfa Therm have documented installations.	• The SWM Rules 2026 and the October 2025 Carbon Credit Trading Scheme (CCTS) GHG Intensity Target Rules covering 186 cement plants are creating demand for AFR and bulk handling systems. Frigate's proximity to Rajasthan, Uttar Pradesh, Haryana, and Himachal Pradesh positions it well for brownfield retrofits during 2026–2031. • India's planned 160–170 MTPA greenfield cement capacity additions by FY2028 — including JK Cement's INR 48.05 bn Jaisalmer plant and JSW Cement's 3.3 MTPA Nagaur plant — present EPC opportunities in Frigate's North India territory, with its clinker grinding plant capability of up to 2,000 TPD as a natural entry point. • Rising demand for specialized AFR bulk handling for TSR upgrades in the 10–20% range allows Frigate to apply its EPC civil and mechanical integration competency to capture higher project value.	• Competitors with larger cement-plant references — PH1 Industries (35+ plants, 80+ projects), BEUMER Group (INR 2 bn Jhajjar facility), ATS Group (award-winning dosing systems) — hold advantages in verifiable performance and engineering scale. • International OEMs expanding Indian manufacturing, such as BEUMER's Jhajjar facility (Dec 2025), erode Frigate's domestic cost/lead-time advantage in bulk handling and AFR systems. • Frigate's diversification into aviation, marine, and solar provides resilience but dilutes its cement-sector AFR focus. Competitors like Alfa Therm and Fornnax Technology are building specialized, award-recognized AFR product lines, widening the capability gap under evolving CPCB co-processing guidelines.

Source: Mordor Intelligence, Company Annual Report, News Articles

4.7 SWOT ANALYSIS OF THE MAJOR 3 PLAYERS (MAXIN INDIA MACHINERY MANUFACTURERS PVT. LTD.)

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
- Established in 2014 and headquartered in Coimbatore, Tamil Nadu, Maxin India has 26-50 employees and a turnover of INR 5-25 crore. The company has documented AFR/RDF shredder installations at Chettinad Cement (Keezhapalur and Ariyalur, Tamil Nadu), Bharathi Cement (Kadapa, Andhra Pradesh), and Kalburgi Cement (Karnataka), though claims related to Heidelberg Materials and Shree Digvijay could not be independently verified. Exports account for 20-40% of revenue, with customers in Nepal, Bangladesh, Botswana, Sri Lanka, and the USA. Its machines process AFR, Municipal Solid Waste (MSW), RDF, metal scrap, organic waste, and plastics, aligning with Central Pollution Control Board (CPCB) guidelines for RDF feedstock. - The Hodis H1000 Dual series features 200 HP (two 100 HP motors), a 1,000 × 900 mm cutting area, and a weight of approximately 13,000 kg, with variants available in 150 HP and 240 HP configurations. Key features include heavy alloy steel cutters, overload protection, auto-reverse, and asynchronous shaft control.	- With 26-50 employees and a turnover of INR 5-25 crore, Maxin India operates at a smaller scale than integrators such as PH1 Industries or global OEMs such as BEUMER Group, which inaugurated an INR 200 crore facility in India in December 2025. - The company's portfolio is concentrated on shredders only, with no capability in downstream conveying, dosing, storage, or kiln injection systems. - Public records reference ISO 9001:2008 certification, with no evidence of ISO 9001:2015 or later certifications. - No independently documented throughput or calorific compliance results have been published.	- The SWM Rules 2026 mandate waste segregation and prohibit waste below 1,500 kcal/kg in incinerators, creating demand for RDF meeting defined calorific thresholds (Grade I: above 4,500 kcal/kg; Grade II: 3,750-4,500 kcal/kg). - Installations at Chettinad Cement and Bharathi Cement provide strong references among South India's largest cement consumers, supporting further cement sector engagement. - Urban local bodies and AFR facilities are expanding centralized shredding hubs with capacities of 15-50 TPH. Maxin India's Hodis series is technically suited for smaller contracts in this segment. - Existing export channels in Bangladesh, Nepal, and Sri Lanka align with early AFR mandates in those markets.	- Domestic competitors present a growing challenge. Fornnax Technology launched the R-MAX3300 at IFAT India 2025, targeting cement AFR plants with 30-50 mm RDF output. Alfa Therm Limited installed a 400 TPD AFR pre-processing line at JK Cement and was recognized at the Indian Cement Review Awards 2025. - BEUMER Group's INR 200 crore facility in Jhajjar expands the supply of integrated AFR equipment in India, increasing pricing pressure and reducing scope for specification differentiation. - CPCB co-processing guidelines emphasize documented RDF quality, particle size control, and feedback systems, favoring suppliers with advanced automation and research and development capabilities.

Source: Mordor Intelligence, Company Annual Report, News Articles

4.7 SWOT ANALYSIS OF THE MAJOR 3 PLAYERS (ALFA THERM LIMITED)

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• The company has over three decades of operating history in India's waste management and AFR equipment manufacturing space. • Its Refuse-Derived Fuel (RDF)/AFR pre-processing line won the Green Innovation of the Year award at the 9th Indian Cement Review Awards 2025, held on 14 November 2025 at Yashobhoomi Convention Centre, New Delhi. Fuller Technologies Inc. (erstwhile FLSmidth Cement) and Navozzo Materials were also recognized in the same category. • A company-disclosed reference project includes an AFR pre-processing line commissioned at JK Cement with a capacity of 400 tonnes per day (TPD) at a particle size of under 50 mm. The company also exports to Saudi Arabia, the UAE, Iraq, Libya, Sudan, Kenya, Germany, Hungary, and several other markets.	• The company is privately held and does not publicly disclose financial information, making it difficult to benchmark its capacity and revenue against listed companies or multinational peers. • Its core offering is concentrated in pre-processing, including shredding, incineration, and air pollution control, rather than kiln or precalciner-side combustion and injection engineering. • The flagship JK Cement project figure of 400 TPD and the manufacturing facility size of 125,000 sq ft are based on the company's own disclosures rather than independent third-party reporting.	• Throughput capacity of up to 40 tonnes per hour (TPH) at under 35 mm sizing positions Alfa Therm to serve larger cement plants targeting higher Thermal Substitution Rate (TSR) under NITI Aayog's 20%-by-2030 roadmap. • Its November 2025 Indian Cement Review Award strengthens its credibility for pursuing similarly scaled RDF/AFR contracts with other Indian cement majors as the SWM Rules 2026 mandate phases in. • Export relationships across South/West Asia and Africa provide a base for regional expansion as those markets adopt comparable co-processing mandates.	• Newer entrants such as Forrnax, which launched the larger-capacity R-MAX3300 shredder, could compete directly for large cement-plant retrofit contracts. • Multinational entrants establishing local manufacturing, such as BEUMER Group's new Haryana facility, could compress pricing on large integrated-system contracts. • Tightening emissions norms on incineration and pre-processing equipment may require continuous capital reinvestment to maintain compliance.

Source: Mordor Intelligence, Company Annual Report, News Articles

4.8 ENGINEERING SOLUTIONS ANALYSIS

4.8.1 WASTE PROCESSING SYSTEMS - OVERVIEW

- India's AFR Firing Systems market is fundamentally driven by engineering solutions that enable compliance with the Solid Waste Management (SWM) Rules 2026 and the Carbon Credit Trading Scheme. These mandates cannot be met through policy intent alone; they require physical infrastructure capable of converting heterogeneous waste into consistent fuel, ensuring reliable transport, and maintaining kiln operations within emission standards.
- The market's capability requirements are defined by three interconnected solution categories: Waste Processing Systems, Bulk Handling Systems, and Emission Control and Fire Safety Systems. Each category faces distinct demand trajectories and engineering challenges, from technology configurations for waste homogenization to safe combustion management, collectively shaping the sector's growth and compliance potential.

Demand Analysis

- India's Waste Processing Systems form the most critical yet underdeveloped link in the AFR infrastructure chain. Industry studies highlight that pre-processing inadequacy, rather than waste supply or kiln technology, is the key constraint on scaling the Thermal Substitution Rate (TSR). The country's municipal solid waste is highly heterogeneous, with 40–50% moisture during monsoons, high inert content like sand and glass, and variable particle sizes. These characteristics demand specialized engineering solutions distinct from European-designed equipment, which dominates the global market but is ill-suited to Indian conditions.
- Demand for India-specific processing systems is accelerating between 2026 and 2031, driven by three reinforcing forces. First, the calorific value thresholds mandated under SWM Rules 2026 (Grade I > 4,500 kcal/kg; Grade II 3,750–4,500 kcal/kg) necessitate precise RDF quality. Second, NITI Aayog's cement decarbonization roadmap sets ambitious TSR escalation targets. Third, the commissioning of 50 new RDF plants in 2024 has created a precedent for commercial-scale investment. Together, these drivers are shaping a robust demand trajectory for tailored waste processing infrastructure, positioning it as the linchpin of India's AFR market evolution.

Engineering Architecture: Two-Stage Pre-Processing

- India's cement industry has reached a technical consensus that achieving 15–20% TSR requires a two-stage pre-processing architecture. In Stage 1, Primary Shredding reduces large-format raw waste into ~150 mm particles, with machines designed to withstand abrasive inerts, moisture-heavy fractions, and hard inclusions. Capacity needs for large plants range from 40–70 tonnes per hour (tph), with Fornnax's SR-MAX2500 and upcoming SR-MAX3600 dual-shaft shredders representing current commercial offerings. Their R-MAX3300 single-shaft secondary shredder, launched in 2025, targets 30 tph with finer 30–80 mm output.
- Stage 2 involves Secondary Shredding, Screening, and Separation, where primary shredder output is processed through disc screens, magnetic and non-ferrous separators, air sifters, and secondary shredders to achieve kiln-compatible 30–80 mm fuel. Systems also include weighing, sampling, and blending before storage. Alfa Therm Limited offers integrated pre-processing lines with feeders, trommel screens, ballistic separators, and shredders, delivering installation timelines of 8–10 weeks, a crucial advantage in India's compliance-driven procurement environment. This staged architecture ensures consistent RDF quality, reliable throughput, and alignment with emission and calorific value mandates.

Demand Analysis

- India's advanced waste processing systems extend beyond the two-stage shredding core, incorporating auxiliary components that ensure compliance and reliability. Drying systems are critical for managing high-moisture fractions such as monsoon-season food waste and sludge-heavy industrial residues. By integrating solar dryers and low-temperature mechanical drying, plants can elevate calorific values above RDF grade thresholds, directly influencing compliance tiers and downstream performance. Moisture management here is not optional but a decisive factor in achieving regulatory calorific benchmarks.

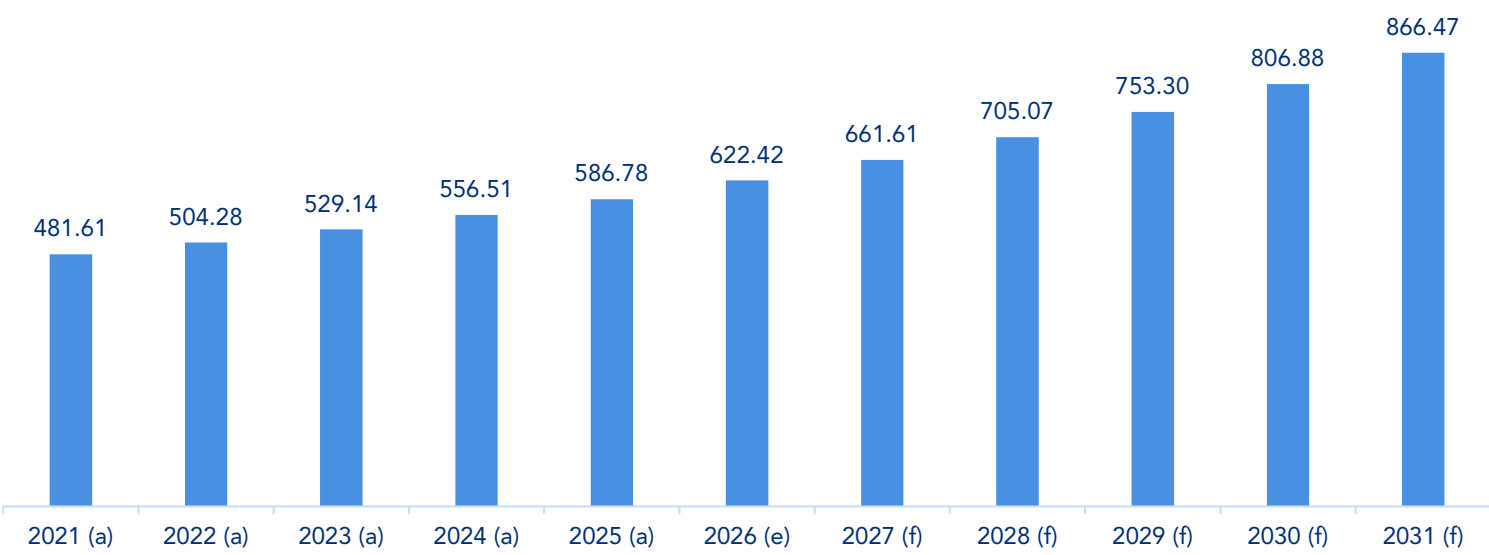
4.8 ENGINEERING SOLUTIONS ANALYSIS

- Equally vital is foreign body removal, which eliminates stone, glass, and PVC through air density and electrostatic separation. These steps protect cement kilns from chloride-induced refractory damage and alkali-silica reactions that compromise clinker quality. Complementing this, impregnation and blending systems allow precise mixing of hazardous liquid waste with solid RDF, balancing calorific value while controlling chloride and sulfur loads. This ensures kiln chemistry remains stable, enabling safe and efficient substitution of coal with AFR.
- The frontier of sophistication lies in quality monitoring and feedback loops. Advanced installations deploy online sampling, laboratory analysis, and digital control systems to continuously track calorific value, moisture, ash, and heavy metals. Automated feedback adjusts shredder throughput and blend ratios to maintain consistent fuel quality. This digital quality assurance layer is increasingly demanded by cement operators seeking verified emission intensity documentation under carbon credit schemes, positioning it as the defining feature of next-generation pre-processing infrastructure in India.

Demand Trajectory

- India’s demand for waste processing systems is set on a strong upward trajectory through 2031, structured across three distinct market layers. The largest near-term pool lies in retrofit pre-processing additions, where existing cement plants with basic kiln-side feeding systems at Phase 1 TSR (0–5%) must invest in upstream pre-processing to comply with SWM Rules 2026. This retrofit demand is compliance-driven and represents the most immediate opportunity for suppliers.
- The second layer is greenfield integrated pre-processing, where new cement plants incorporate AFR handling from the design stage, enabling optimized layouts and Phase 3–4 TSR readiness from day one. The third layer is standalone RDF pre-processing facilities, driven by Urban Local Bodies (ULBs) and waste management firms adopting centralized hub models to serve multiple cement plants. These facilities create large-scale demand independent of cement plant capital cycles but involve longer contracts and regulatory coordination. Together, these three layers define a diversified and accelerating demand landscape for India-specific pre-processing infrastructure.

WASTE PROCESSING SYSTEMS MARKET SIZE AND DEMAND FORECAST, IN USD MILLION, INDIA, 2021–2031
CAGR (2026 TO 2031): 6.84%



Source: Mordor Intelligence, IBEF

4.8 ENGINEERING SOLUTIONS ANALYSIS

4.8.2 BULK HANDLING SYSTEMS

Demand Context

- Bulk handling systems form the operational backbone of AFR co-processing, bridging processed fuel output to kiln injection. While pre-processing ensures fuel quality, handling systems guarantee delivery reliability, enabling continuous, controlled, and accurately metered flow at TSR levels of 15–20%. Conventional coal handling equipment cannot manage AFR's unique properties, low bulk density, residual moisture, variable particle size, hopper bridging tendencies, and abrasive wear behavior, making purpose-built solutions essential for performance stability.
- The demand trajectory is reinforced by both greenfield capacity expansion and brownfield compliance retrofits, creating opportunities across plant sizes and operational contexts. Greenfield projects integrate AFR handling into design layouts, while retrofits respond to SWM Rules 2026 mandates, ensuring compliance and operational continuity. Together, these forces are driving sustained growth in specialized AFR bulk handling systems, positioning them as indispensable to India's cement decarbonization roadmap and long-term TSR escalation.

Core System Architecture: Receiving to Injection

- **Receiving and Unloading Infrastructure:** The first stage of AFR bulk handling involves receiving and unloading infrastructure. AFR arrives in trucks, bulk bags, or ISO containers, requiring specialized tipping pits, moving floor trailers, and hydraulic press systems to unload safely. These systems must control dust, odor, and leachate at the plant boundary while accommodating diverse vehicle mixes and access frequencies. Increasingly, unmanned and remotely operated stations are preferred, as plant workers are reluctant to manually handle AFR, making automation a key reliability factor.
- **Storage Systems:** Dedicated storage systems provide the buffer between supply variability and kiln demand. Typically housed in enclosed sheds with concrete leachate barriers, they include automated cranes and hydraulic extraction devices. Plants require 5 to 7 days of storage capacity to ensure operational continuity while maintaining fire safety compliance. PH1's 400 m³ (2×200 m³) unit, as India's largest, highlights the scale needed for high-TSR plants, positioning storage as a critical backbone of AFR reliability.
- **Conveying Systems:** Once stored, AFR is moved to the kiln injection point through conveying systems. Belt conveyors manage horizontal transport, drag chain conveyors handle dusty or odorous materials, and bucket elevators or steep conveyors lift AFR vertically to preheater towers. Designs must address abrasive wear, bridging tendencies, and dust generation, with wear-resistant linings and vibration devices. BEUMER Group's integrated system spans unloading through weighing, offering single-vendor responsibility that reduces interface risks and simplifies project execution.
- **Specialized Conveying Solutions:** For complex plant layouts, specialized conveying solutions provide flexibility. ATS Group's Sidewalls Conveyor enables steep or vertical transport, while its Air Floating Conveyor minimizes spillage and investment for long-distance transport. Tripcon offers complete Indian configurations, covering unloading, storage halls with cranes, and dosing systems. These innovations allow plants to adapt AFR handling without extensive structural modifications, ensuring reliable delivery to kiln injection points even in challenging layouts.
- **Weighing and Dosing Systems:** The final control stage is weighing and dosing systems, which ensure precise gravimetric feeding before kiln injection. BEUMER's BG OptiFeed weigh feeder, and ATS Group's award-winning Twin Doseahorse exemplify advanced solutions, enabling simultaneous feeding to multiple kiln points. Accurate dosing is critical, as errors directly impact kiln stability, specific heat consumption, and TSR achievement. This stage acts as the direct interface between bulk handling and kiln process reliability, making dosing precision indispensable for high-substitution operations.
- **Robotic and AI-Integrated Feeding:** At the frontier, robotic and AI-integrated feeding is redefining sophistication in AFR handling. UltraTech Cement has deployed robotic feeding combined with AI computer vision to monitor AFR on conveyors in real time. The system assesses particle size and composition, sending automated signals to adjust fuel mix before kiln entry. This integration ensures consistent quality and stable combustion, marking the trajectory of India's AFR bulk handling systems toward digitalized, intelligent process control aligned with global best practices.

Source: Mordor Intelligence, IBEF



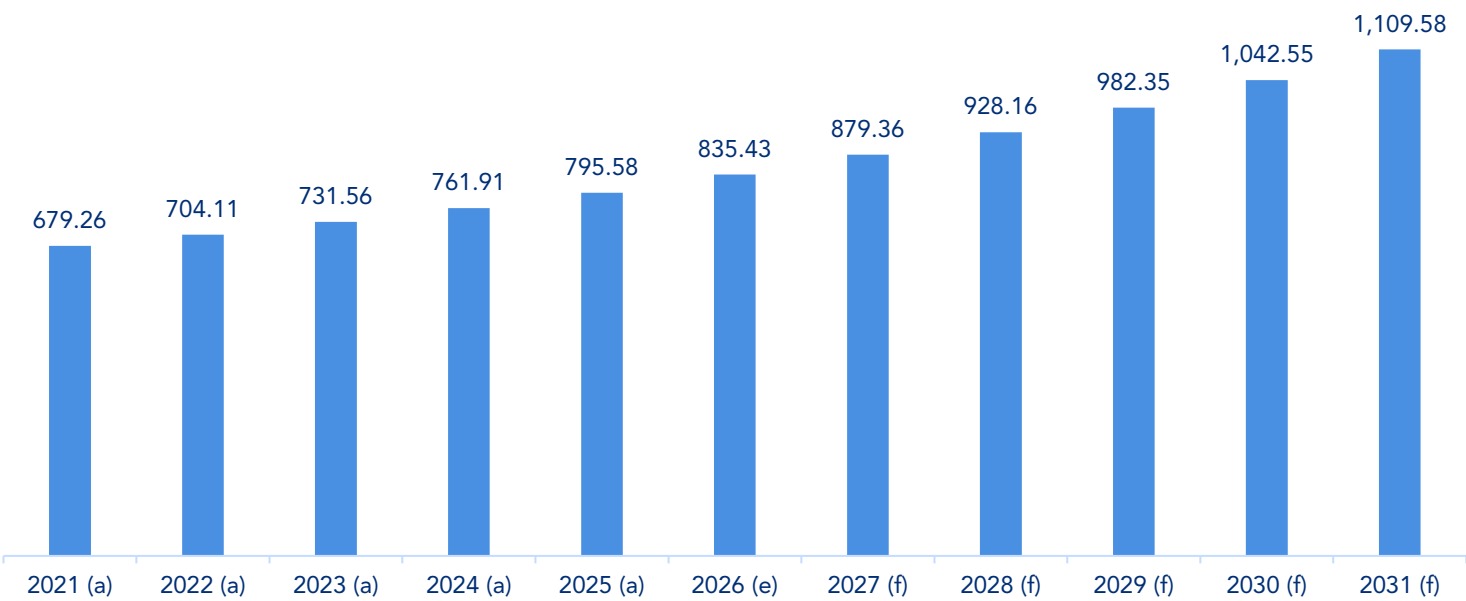
4.8 ENGINEERING SOLUTIONS ANALYSIS

Demand Trajectory

- Bulk handling system demand closely follows cement plant capacity expansion and AFR investment cycles, with a slight lag since bulk handling is typically the last capital item finalized after pre-processing and kiln injection points are set. One major driver is Phase 3–4 TSR upgrades, where plants operating at 5–10% TSR aim to reach 15–20%. This requires reinvestment in upgraded conveyors, higher-capacity dosing systems, and multi-injection feeding capability. With SWM Rules 2026 mandating a six-year escalation schedule, this upgrade wave is forecast to peak between 2028 and 2030, creating a defined reinvestment cycle.
- The second demand vector is greenfield multi-stream systems. New cement plants are increasingly designed to handle multiple AFR streams simultaneously: solid RDF, liquid AFR, biomass, and tire-derived fuel. This requires dedicated conveyors, storage, and dosing systems for each fuel type, representing a significantly larger scope per project compared to single-stream brownfield retrofits. Such integrated designs allow plants to achieve higher TSR levels from day one, positioning greenfield projects as a major growth driver in India’s AFR infrastructure landscape.
- A third vector is centralized AFR hub logistics, where large-scale pre-processing hubs manage 50–150 TPH of RDF internally and load outbound trucks with consistent, metered fuel. These hubs create demand for industrial bulk handling engineering outside cement plant gates, requiring robust systems for internal movement and external dispatch. This emerging segment introduces longer contract structures and regulatory coordination, while offering providers with large-scale system expertise a new commercial opportunity beyond traditional cement plant installations.

BULK MATERIAL HANDLING SYSTEMS MARKET SIZE AND DEMAND FORECAST, IN USD MILLION, INDIA, 2021-2031

CAGR (2026 TO 2031): 5.84%



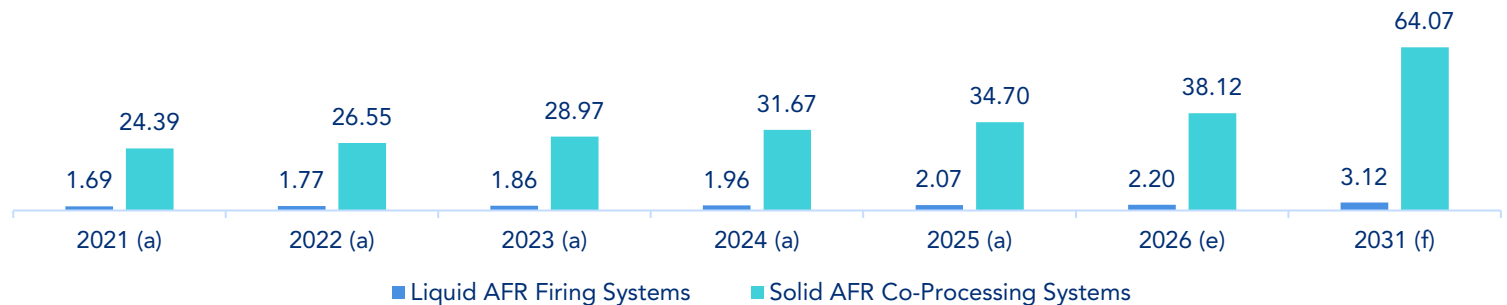
Source: Mordor Intelligence, IBEF

5. MARKET SEGMENTATION

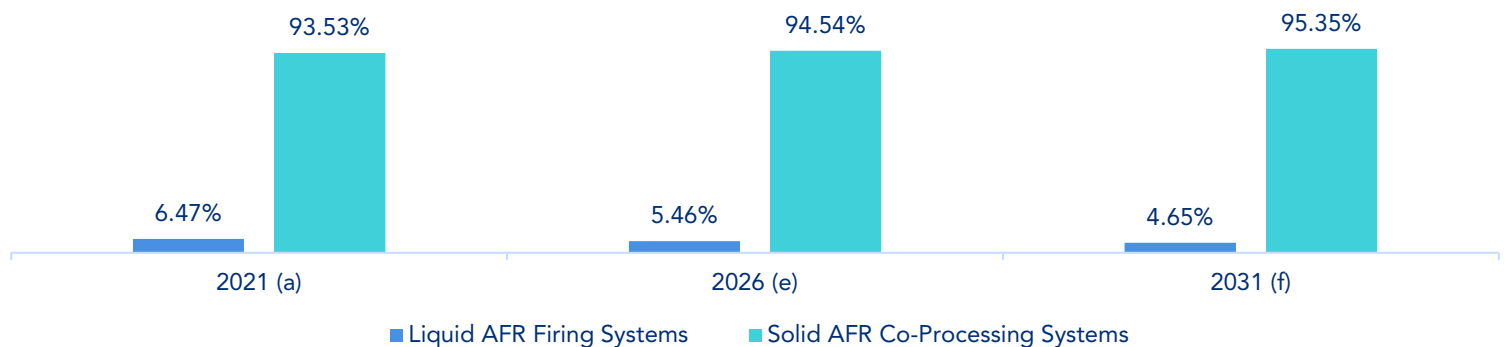
5.1 AFR SYSTEM TYPE

ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY AFR SYSTEM TYPE, INDIA, 2021-2031

CAGR (2026 TO 2031): 10.75%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY AFR SYSTEM TYPE, INDIA, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY AFR SYSTEM TYPE, INDIA, 2021-2031

AFR System Type	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
Liquid AFR Firing Systems	1.69	1.77	1.86	1.96	2.07	2.20	2.35	2.51	2.69	2.89	3.12	7.22%
Solid AFR Co-Processing Systems	24.39	26.55	28.97	31.67	34.70	38.12	42.09	46.58	51.68	57.48	64.07	10.94%
Total	26.07	28.32	30.82	33.62	36.77	40.32	44.44	49.09	54.37	60.37	67.19	10.75%

Source: Mordor Intelligence

5.1.1 LIQUID AFR FIRING SYSTEMS

Industrial hazardous waste availability expands addressable demand for liquid AFR systems

- Established adoption base supports brownfield deployment: Cement producers in India have deployed liquid AFR firing systems for more than 16 years, with installations across more than 35 cement plants. PH1 Industries Limited commissioned systems across more than 11 cement plants from 2009 to 2017. This operating base provides references for producers evaluating liquid waste co-processing systems and supports brownfield procurement.
- Industrial clusters create localized liquid AFR feedstock opportunities: Pharmaceutical and solvent residues from Hyderabad, Ahmedabad, Pune, and Baddi; refinery and petrochemical wastes from Gujarat and Maharashtra; and paint, agrochemical, and distillery residues from major industrial regions create diverse feedstock sources. These sources support demand for receiving, storage, pumping, and injection systems at cement plants located near industrial waste-generation clusters.
- Growing hazardous waste availability supports long-term feedstock demand: CPCB estimates indicate that India generates approximately 6.2 million tonnes of hazardous waste annually, including around 0.41 million tonnes classified as incinerable, which is the primary target pool for liquid AFR systems. The expansion of India's industrial base creates opportunities for cement plants to use liquid waste as a controlled alternative fuel.

Customized firing architecture increases demand for specialized AFR equipment

- Highly variable liquid waste requires engineered handling systems: Pharmaceutical residues, solvents, refinery sludge, paint sludge, and Effluent Treatment Plant (ETP) wastes require customized equipment rather than standardized firing packages. Systems with 1.5 mm standard filtration, viscosity-matched screw or membrane pumps, storage-tank agitation, and corrosion-resistant components increase equipment requirements for each installation.
- Precision metering and injection support higher thermal substitution rates: Coriolis flow meters that measure flow rate, density, and temperature, combined with Programmable Logic Controller (PLC)-based dosing and two-phase nozzles, enable controlled Thermal Substitution Rate (TSR) accounting and combustion. Operators can configure injection at the main burner, tertiary air duct, or precalciner, creating procurement opportunities for integrated feeding and combustion packages rather than standalone burners.
- High-calorific feedstocks improve the value proposition: Carbon black generated through tire-pyrolysis applications has a calorific value of 29 to 32 MJ/kg, compared with 22 to 25 MJ/kg for coal. Such high-energy-value streams can contribute disproportionately to fossil-fuel substitution, encouraging investment in specialized liquid and high-calorific AFR feeding infrastructure where consistent feedstock is available.

Regulatory compliance and carbon-reduction requirements accelerate procurement

- CPCB/State Pollution Control Board (SPCB) authorization increases demand for compliance-ready systems: Liquid AFR utilization requires site-specific regulatory approvals covering permitted waste types, quantities, and injection parameters. CPCB's co-processing framework requires authorization for hazardous waste utilization and sets requirements for storage, handling, transportation, manifests, and reporting, making regulatory-support capability an important supplier differentiator.
- CCTS compliance increases the incentive for higher TSR: The October 8, 2025, Carbon Credit Trading Scheme (CCTS) emission-intensity framework covering 186 cement plants has introduced additional carbon-cost pressure. Cement producers have a greater incentive to reduce fossil-fuel consumption through AFR, including concentrated liquid streams, supporting procurement of liquid firing and dosing systems.
- Greenfield and brownfield cement expansion create installation opportunities: India's announced cement-capacity expansion toward 830 to 838 Million Tonnes Per Annum (MTPA) by FY2028 creates two demand channels: greenfield plants can incorporate liquid AFR infrastructure during initial engineering, while existing plants can retrofit receiving, storage, pumping, metering, and kiln-injection systems. Liquid AFR complements solid AFR by providing a higher-energy-value fuel stream for plants pursuing higher TSR.

5.1.2 SOLID AFR CO-PROCESSING SYSTEMS

Municipal Waste Growth and RDF Infrastructure Expansion Drive Revenue

- Rising MSW volumes are expanding the addressable feedstock base: India generates approximately 62.4 million tons of MSW annually, and this volume is projected to reach 165 million tons by 2031. This increasing waste burden, combined with the national objective of reducing landfill dependence, is driving demand for RDF processing and downstream solid-AFR feeding systems at cement plants.
- Rapid RDF processing capacity additions are strengthening the supply pipeline: RDF processing infrastructure around cement clusters expanded by approximately 4.96 million tons per year of capacity, with 50 new RDF plants commissioned in 2024, representing a 25% capacity addition. This expansion has increased the supply of processed solid fuel for cement kilns and supported procurement of receiving, storage, shredding, conveying, and dosing systems.
- Cement producers are increasingly integrating solid AFR into operating strategies: JSW Cement increased TSR from 7% to 16.5% in FY2025 while co-processing 157,000 tons of RDF. This indicates that solid AFR is moving beyond pilot-scale environmental initiatives toward systematic fuel-substitution programs, which may encourage other cement producers to invest in dedicated solid-AFR infrastructure.

Advanced Pre-Processing and Automated Feeding Requirements Increase System Value

- Heterogeneous RDF is driving demand for complete pre-processing lines: Solid AFR systems require multiple stages, including walking-floor/tipping-hall receiving, shredding, magnetic and eddy-current separation, moisture management, and density classification, to prepare inconsistent waste streams for kiln use. The requirement for a particle size of 30 mm or less for pneumatic feeding further increases equipment integration needs compared with conventional solid-fuel handling.
- Precision dosing is becoming critical to stable kiln operation: Weigh-feeder systems designed around approximately 1% TSR accuracy help operators control thermal substitution despite variations in RDF quality. Pneumatic systems for fine material and gravimetric belt-and-gate systems for coarser fractions allow suppliers to tailor feeding architecture to individual kiln configurations.
- Automation is creating an additional upgrade opportunity: Advanced installations increasingly use AI-based combustion controls that respond to kiln inlet temperature, oxygen levels, and volatile-balance conditions. Indian cement producers reportedly achieved 2 to 3 percentage-point TSR improvements in FY2026 following automation upgrades, supporting demand for controls, sensors, and automated AFR optimization alongside mechanical feeding equipment.

SWM Rules 2026 Create Mandatory Procurement and Compliance-Driven Demand

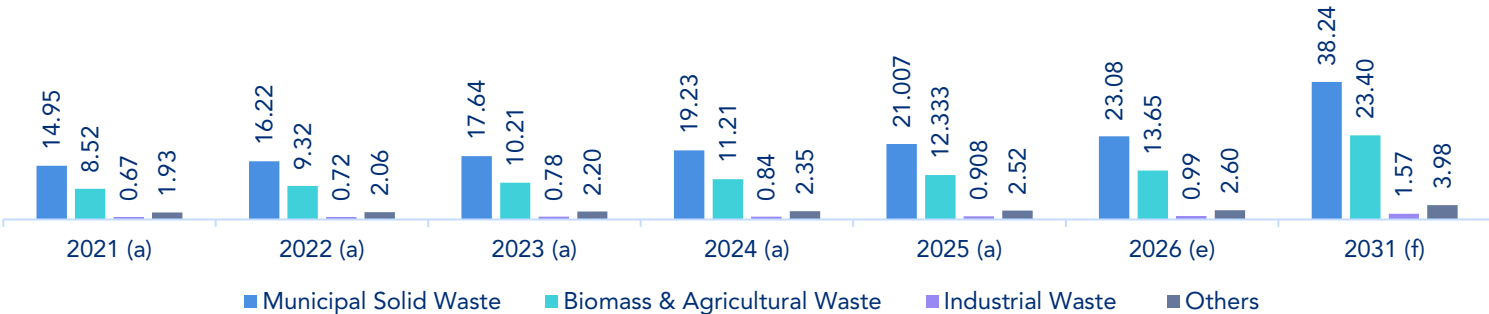
- Mandatory RDF substitution requirements are changing procurement decisions: The SWM Rules 2026, notified on January 27, 2026, and effective April 1, 2026, require industrial units, including cement plants, to progressively increase RDF use, with fuel substitution rising from the existing 5% level to 15% over six years. This converts solid-AFR infrastructure from a discretionary sustainability investment into a compliance-linked requirement.
- Source segregation and digital tracking strengthen the RDF supply chain: The rules mandate four-stream source segregation and online tracking of collection, transportation, processing, and disposal through a centralized portal. Improved segregation should increase the availability of combustible dry waste for RDF production, supporting downstream demand for solid-AFR receiving and feeding infrastructure.
- Landfill restrictions and processing-facility oversight reinforce co-processing: The 2026 framework strengthens restrictions on landfilling, introduces environmental compensation for non-compliance, and requires audits and reporting for waste-processing facilities. These measures reinforce the policy pathway from waste generation to RDF production to industrial utilization, supporting continued investment in engineered solid-AFR systems.



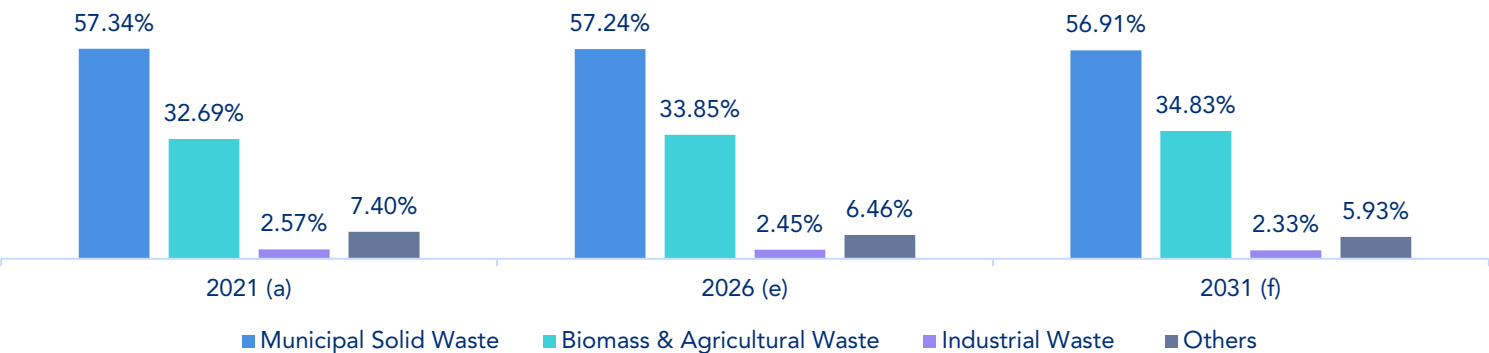
5.2 BY WASTE/FUEL STREAM

ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY WASTE/FUEL STREAM, INDIA, 2021-2031

CAGR (2026 TO 2031): 10.75%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY WASTE/FUEL STREAM, INDIA, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY WASTE/FUEL STREAM, INDIA, 2021-2031

Waste/Fuel Stream	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
Municipal Solid Waste	14.95	16.22	17.64	19.23	21.01	23.08	25.41	28.04	31.02	34.40	38.24	10.62%
Biomass & Agricultural Waste	8.52	9.32	10.21	11.21	12.33	13.65	15.13	16.81	18.73	20.91	23.40	11.39%
Industrial Waste	0.67	0.72	0.78	0.84	0.91	0.99	1.08	1.18	1.29	1.42	1.57	9.66%
Others	1.93	2.06	2.20	2.35	2.52	2.60	2.82	3.06	3.33	3.64	3.98	8.87%
Total	26.07	28.32	30.82	33.62	36.77	40.32	44.44	49.09	54.37	60.37	67.19	10.75%

Source: Mordor Intelligence



5.2.1 MUNICIPAL SOLID WASTE

Expanding Municipal Waste Streams and RDF Processing: Creating a Larger AFR Feedstock Base

- Rising urban waste generation is expanding the potential RDF feedstock pool: India's municipal solid waste (MSW) generation is projected to increase substantially through 2031 as urbanization expands across Tier I, Tier II, and Tier III cities. Growth in combustible, nonrecyclable waste is increasing the need for RDF conversion and dedicated RDF receiving and feeding systems at nearby cement plants.
- Expansion of RDF processing infrastructure is improving fuel availability: 50 new RDF processing plants were commissioned during 2024, expanding the processing base around cement clusters. This strengthens the link between municipal waste collection and industrial fuel utilization, creating demand for systems that can receive, store, convey, and meter RDF.
- Government recognition of RDF as an industrial fuel is strengthening the supply chain: The SWM Rules 2026 formally define RDF as a high-calorific fuel produced by shredding and dehydrating MSW, primarily comprising nonrecyclable plastic, paper, and textiles. The rules also recognize material recovery facilities (MRFs), strengthening the pathway from municipal waste sorting to RDF production.

RDF Quality Requirements Driving Demand for Advanced Processing and AFR Feeding Systems

- Different RDF grades require application-specific kiln feeding systems: Grade I RDF, with a calorific value above 4,500 kcal/kg, is used for higher-value applications such as main burner injection, and Grade II RDF, with a calorific value of 3,750 to 4,500 kcal/kg, is used for precalciner or tertiary air duct applications. This differentiation encourages cement plants to deploy feeding configurations suited to RDF quality and injection location.
- Variable MSW composition increases preprocessing requirements: Differences in moisture, plastics, organics, and inorganic content across cities make direct kiln utilization difficult. Producing higher-quality RDF requires shredding, magnetic separation, air classification, drying, and secondary sizing, creating additional equipment demand upstream of the AFR firing system.
- Proven operating performance is encouraging higher RDF substitution: JSW Cement increased its thermal substitution rate (TSR) from 7% to 16.5% in FY2025, supported by the co-processing of 157,000 tons of RDF across its Nandyal and Shiva clinker units. This provides an industry reference for other cement producers seeking to move from low-level RDF trials to higher, operationally managed substitution rates.

Regulatory Requirements Accelerating RDF Utilization in Cement Kilns

- SWM Rules 2026 establish RDF as a structurally supported industrial fuel: The rules require industrial units using solid fuel, including cement plants, to progressively increase RDF use from 5% to 15% over six years. This creates a predictable demand pathway for RDF-compatible receiving, dosing, and kiln injection equipment.
- Source segregation is improving the quality of the RDF stream: The framework mandates four-stream segregation of wet, dry, sanitary, and special care waste at source. Better separation of dry waste increases the potential to recover combustible fractions suitable for RDF production and reduces contamination entering downstream AFR systems.
- Digital monitoring is formalizing RDF procurement and utilization: SWM Rules 2026 require online tracking of collection, transportation, processing, and disposal, and RDF processing facilities must comply with reporting and audit requirements. Greater traceability supports structured RDF offtake arrangements and encourages cement plants to invest in controlled, measurable AFR feeding systems.



5.2.2 BIOMASS & AGRICULTURAL WASTE

Abundant Agricultural Residues and Crop Disposal Pressures Drive AFR Feedstock Availability

- Large, geographically dispersed residue availability: India's extensive agricultural base generates diverse biomass streams, including rice husk, sugarcane bagasse and press mud, cotton and jute stalks, coconut shells, groundnut shells, and wood processing residues. This broad feedstock base enables cement plants across agricultural regions to develop localized biomass sourcing arrangements for AFR firing.
- Crop residue burning creates an additional incentive for productive use: The supplied data identifies field burning, particularly across North India, as a major disposal issue during harvest periods. Government policy also identifies crop residue burning as a significant contributor to winter air quality deterioration in North India. Converting residues into cement kiln fuel transforms an environmental liability into an industrial fuel stream.
- Biomass characteristics support fossil fuel substitution: Residues offer commercially usable energy values. According to the supplied data, rice husk provides approximately 3,200 to 3,500 kcal/kg, coconut and groundnut shells provide 3,800 to 4,500 kcal/kg, and wood chips provide 3,500 to 4,200 kcal/kg. This diversity allows cement producers to blend biomass with conventional fuels based on availability and kiln requirements.

Preprocessing, Storage, and Gasification Requirements Shape AFR System Investments

- Moisture management creates demand for specialized biomass handling: Fresh agricultural residues can contain substantial moisture, reduce effective calorific value, and cause combustion instability. The supplied data identifies rotary drying and controlled feeding as prerequisites for meaningful substitution, creating demand for dryers, covered storage, conveyors, and metering systems.
- Seasonality drives investment in dedicated storage infrastructure: Rice residue availability peaks around October to November and April to May, while sugarcane crushing in Maharashtra and Uttar Pradesh operates mainly from October to March. Cement plants require mechanized, covered stockyards capable of maintaining 30 to 60 days of inventory, increasing demand for biomass receiving and storage systems.
- On-site gasification opens a new technology pathway: Sow & Reap Chara Private Limited's 10-year agreement with Sagar Cements Limited to establish biomass gasification facilities at the Mattampally plant in Telangana uses cotton waste sourced within a 20 km radius. According to the supplied data, each unit is designed to process 15,000 tons of biomass annually, produce approximately 3,750 tons of biochar, and avoid nearly 8,000 tons of CO₂ per year. This model reduces the logistics penalty associated with transporting low-density residues and supports demand for integrated gasification to kiln thermal systems.

Carbon Reduction Policies and Supply Chain Formalization Support Long-Term Demand

- Government bioenergy programs strengthen the biomass utilization ecosystem: Ministry of New and Renewable Energy's (MNRE) National Bioenergy Program includes dedicated support for biomass briquette and pellet manufacturing and energy recovery from agricultural wastes and residues. This support helps develop infrastructure that can improve the availability and handling of standardized biomass fuels.
- Government-supported residue management expands collection infrastructure: Under the Crop Residue Management initiative, the government reported more than 42,000 custom hiring centers and over 3.24 lakh crop residue management machines established or supplied through 2025-26. This strengthens the physical ecosystem for collecting and handling agricultural residues that can potentially enter organized biomass supply chains.
- Biomass gasification receives formal policy recognition: MNRE's Waste to Energy Program explicitly supports projects that use agricultural wastes and residues to generate producer gas or syngas, including financial assistance for biomass gasifiers used in electrical and thermal applications. This policy supports the cement sector gasification model and increases the feasibility of deploying biomass conversion equipment alongside AFR firing infrastructure.

5.2.3 INDUSTRIAL WASTE

Waste Availability and Co-Processing Economics Supporting AFR Demand

- Rising industrial waste generation is broadening the addressable AFR feedstock base: Pharmaceutical, chemical, refinery, paint, tire, Fast-Moving Consumer Goods (FMCG), and wastewater-related residues represent important industrial waste streams. This diversity allows cement plants to source multiple waste categories rather than depend on a single feedstock, supporting demand for flexible AFR receiving, storage, and feeding systems.
- High-calorific industrial residues improve AFR utilization economics: Tire-derived materials provide approximately 29 to 32 MJ/kg, compared with 22 to 25 MJ/kg for coal. This energy-density advantage strengthens the case for dedicated feeding systems capable of handling tire chips, crumb rubber, and other high-energy industrial residues, while reducing dependence on conventional fossil fuels.
- Co-processing provides a disposal route alongside fuel substitution: Central Pollution Control Board (CPCB) guidance recognizes materials such as effluent treatment plant (ETP) sludge, paint sludge, refinery sludge, toluene diisocyanate (TDI) tar, used oil, and solvents as potential co-processing streams, subject to suitability assessment and trial procedures. The ability to derive both energy and material value from waste strengthens the commercial rationale for cement plants to expand AFR handling capabilities.

Industrial Waste Diversity Driving Demand for Specialized AFR Handling Infrastructure

- Multiple physical forms require customized receiving and feeding systems: Industrial AFR can arrive as solid, liquid, or semi-solid material, with significant differences in viscosity, particle size, and composition. CPCB guidance notes that some wastes can be delivered directly, while others require pre-processing to achieve suitable conditions, increasing demand for blending, homogenization, storage, and specialized feeding equipment.
- High-value waste streams are concentrated around industrial clusters: Pharmaceutical and chemical activity in Gujarat and Maharashtra, together with refining, tire, and manufacturing activities, creates concentrated waste-generation zones. Where these clusters are located away from cement plants, longer transportation distances increase the importance of regional aggregation and pre-processing infrastructure, encouraging cement producers to establish systems capable of receiving multiple approved waste categories.
- Cement plants are increasingly positioned as integrated waste-management facilities: CPCB's co-processing framework requires waste to be received, stored, handled, and, where necessary, pre-processed before controlled kiln utilization. This expands equipment requirements beyond the burner itself to include dedicated storage areas, transfer systems, homogenization equipment, and controlled feeding arrangements.

Regulatory Formalization and Extended Producer Responsibility (EPR) Obligations Supporting AFR Demand

- Mandatory authorization is creating a structured procurement pathway: Under the hazardous and other wastes framework, utilization of hazardous and other wastes for co-processing requires authorization from the relevant state pollution control board, based on CPCB procedures and guidelines. This formalization encourages cement plants to develop compliant infrastructure rather than rely on ad hoc waste handling.
- CPCB suitability requirements are increasing demand for controlled feeding technology: CPCB specifies that high-calorific wastes should be introduced into appropriate high-temperature combustion zones, and that feed points must be selected according to the waste's physical, chemical, and toxicological characteristics. As a result, cement plants handling diverse industrial wastes require engineered feed systems capable of directing different materials to suitable kiln injection points.
- EPR-driven waste flows are expanding the pool of material requiring compliant disposal: Tightening EPR requirements for plastic and tire waste represent an additional source of industrial waste requiring certified treatment. This supports further development of cement-kiln co-processing capacity and associated AFR receiving and feeding infrastructure.



5.2.4 OTHERS

Diversification of High-Value AFR Feedstocks

- The "Others" AFR input category is gaining importance as Indian cement plants move beyond conventional RDF, biomass, and industrial waste toward specialized streams that improve fuel and disposal economics.
- Tire-derived fuel is driving demand for specialized solid-feeding systems: End-of-life tires provide a high-calorific fuel of approximately 29-32 MJ/kg, compared to 22-25 MJ/kg for coal. Cement plants in Rajasthan, Madhya Pradesh, and Andhra Pradesh have incorporated tire chips into regular AFR portfolios, creating demand for shredding, magnetic separation, and controlled kiln-feeding equipment.
- High-energy tire waste supports blended-fuel strategies: Tire-Derived Fuel (TDF) can be blended with lower-calorific RDF or biomass to maintain fuel quality. This increases the value of AFR systems that handle multiple feedstocks, particularly as cement plants seek to stabilize thermal substitution despite variability in municipal and agricultural fuels.
- Pyrolysis is creating a new source of high-value AFR material: Gujarat is emerging as a center for tire-pyrolysis infrastructure. Pyrolysis produces carbon black and pyrolysis oil, with carbon black offering approximately 28-30 MJ/kg under high-temperature processing. This creates an additional pathway for cement plants to procure engineered, high-calorific AFR streams.

Municipal and Industrial Sludge Expanding the Addressable Feedstock Base

- Wastewater infrastructure is generating additional sludge for co-processing: The expansion of municipal wastewater treatment under the Smart Cities Mission, AMRUT, and Namami Gange is increasing the quantity of sewage sludge requiring compliant disposal. Dried sludge typically provides 1,500-2,500 kcal/kg, making it less valuable as a fuel but commercially attractive when disposal costs and tipping-fee economics are considered.
- Industry adoption demonstrates technical feasibility: Shree Cement has incorporated dried sewage sludge alongside RDF, rubber, and plastic waste in its co-processing basket, confirming that sludge can be integrated into a diversified AFR blend. This supports demand for systems that receive, condition, and feed lower-calorific materials alongside higher-energy fuels.
- Industrial sludge adds further feedstock diversity: Sludge from paper mills, textile effluent treatment plants, and food-processing facilities can be incorporated into blended AFR formulations. Because these materials vary in quality, their utilization favors equipment with controlled dosing, blending, and feed-rate management capabilities rather than basic single-feed systems.

EPR Obligations and Emerging Waste Streams Supporting Multi-Fuel AFR Systems

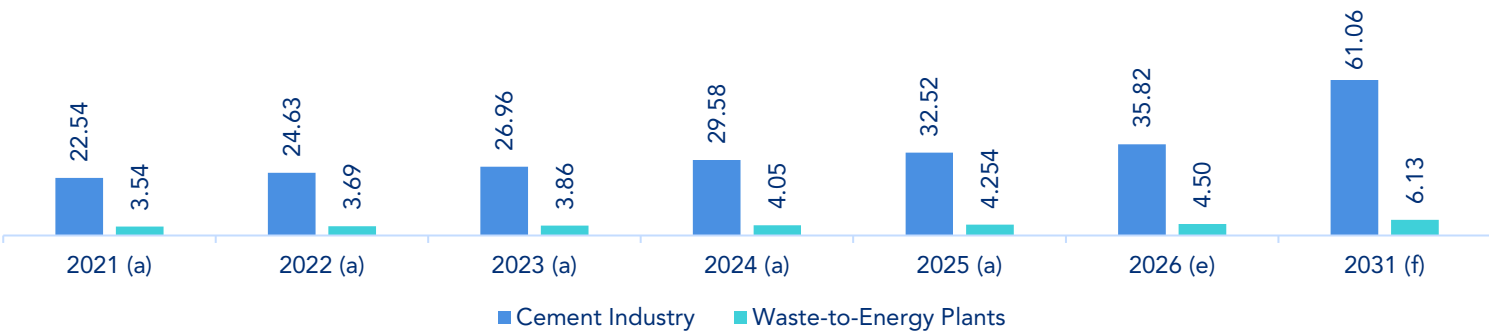
- Tire EPR is strengthening the long-term supply pipeline: India's expanding tire-recycling industry is linked to EPR obligations on tire manufacturers. As more end-of-life tires enter formal recycling channels, cement plants can access additional tire-derived fuels and pyrolysis products, supporting investment in flexible AFR receiving and feeding infrastructure.
- Expired Fast-Moving Consumer Goods (FMCG) products create a specialized destruction application: Off-specification and expired Fast-Moving Consumer Goods (FMCG) products require controlled destruction, and cement kilns provide a disposal route that avoids conventional disposal and ash generation. This creates niche demand for receiving and feeding arrangements that handle packaged or heterogeneous material.
- Wood waste provides localized fuel opportunities: Wood chips from sawmill waste, demolition activities, and urban tree-trimming programs can supplement AFR baskets in regions such as Madhya Pradesh, Chhattisgarh, Jharkhand, and Northeast India. Their localized availability supports smaller, decentralized feed-handling systems and reduces dependence on a single centralized AFR source.



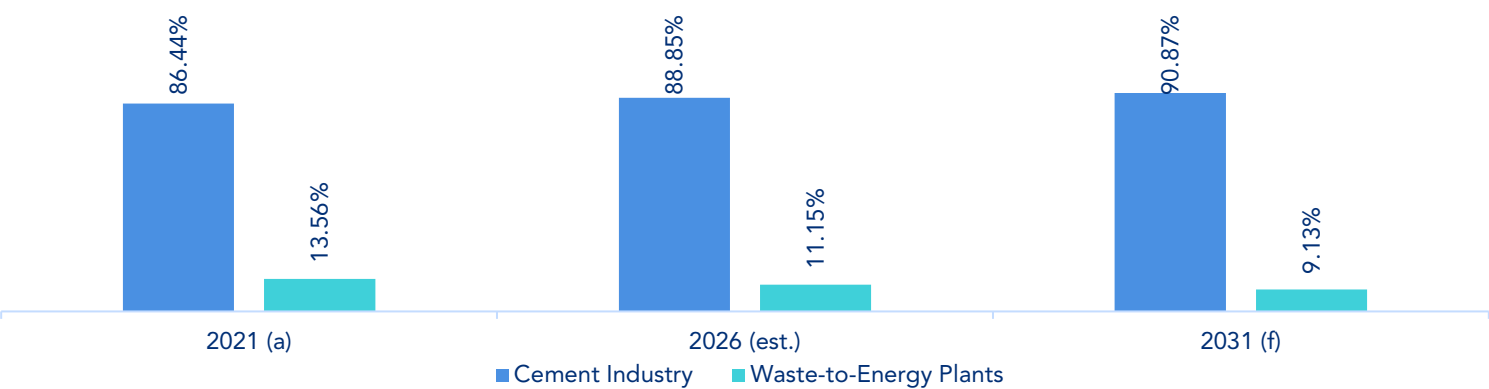
5.3 BY END-USER INDUSTRY

ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY END-USER INDUSTRY, INDIA, 2021-2031

CAGR (2026 TO 2031): 10.75%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY END-USER INDUSTRY, INDIA, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY END-USER INDUSTRY, INDIA, 2021-2031

By End-User Industry	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
Cement Industry	22.54	24.63	26.96	29.58	32.52	35.82	39.68	44.04	49.00	54.64	61.06	11.25%
Waste-to-Energy Plants	3.54	3.69	3.86	4.05	4.254	4.50	4.76	5.05	5.38	5.74	6.13	6.40%
Total	26.07	28.32	30.82	33.62	36.77	40.32	44.44	49.09	54.37	60.37	67.19	10.75%



5.3.1 CEMENT INDUSTRY

MARKET TRENDS

- The AFR firing system market across northern Indian states, primarily Rajasthan, Haryana, Punjab, Himachal Pradesh, and Uttar Pradesh, has expanded rapidly. Severe winter smog and high agricultural residue generation support demand for biomass and crop-stubble (Parali) co-processing, positioning the region as a key market for cement kiln alternative fuel systems.

Market Profile and Cement Industry Concentration

- **Clinker Capacity Base:** North India, covering Rajasthan, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Uttarakhand, Delhi NCR, and Jammu and Kashmir, represents India's largest cement-producing region by clinker capacity. Rajasthan's high-purity limestone deposits across the Aravalli Range anchor this capacity. The state hosts several high-capacity integrated cement plants, driving major demand for AFR co-processing infrastructure.
- **Major Capacity Expansions:** Shree Cement's Jaitaran (Beawar) complex expanded with RAS Unit-11, adding 3.65 MTPA of clinker capacity and 3 MTPA of cement capacity. According to CemNet, plants in the region process tens of thousands of tons of raw materials daily, supporting demand for high-capacity AFR feeding, dosing, and firing systems.
- **Greenfield Project Pipeline:** JK Cement's INR 480.5 crore greenfield expansion includes a 4 MTPA clinker unit and a 3 MTPA cement grinding unit at Jaisalmer, Rajasthan, plus two 2 MTPA split grinding units in Rajasthan and Punjab. The Jaisalmer location strengthens logistics efficiency and creates large-scale demand for new AFR systems.
- **Upcoming Integrated Capacity:** JSW Cement's greenfield integrated plant at Nagaur, Rajasthan, includes 3.3 MTPA of clinker capacity and 2.5 MTPA of cement capacity, commissioned in March 2026. The plant serves Haryana and Punjab. The company also approved a 2.5 MTPA grinding expansion targeted for commissioning by January 2028.

AFR Supply Dynamics: RDF, Biomass, and Agricultural Waste

- **RDF Supply from Urban Waste:** Three major streams shape North India's AFR supply base. Municipal solid waste from Delhi NCR, Jaipur, Lucknow, Agra, Kanpur, and other cities generates substantial RDF volumes within 400 km of cement plants in Rajasthan, Haryana, and western Uttar Pradesh, creating compliance obligations under the SWM Rules 2026 for plants in these zones.
- **Agricultural Biomass Availability:** Agricultural biomass, led by rice straw from Punjab and Haryana, sugarcane bagasse from Uttar Pradesh's sugar industry, and wheat straw, forms India's largest biomass AFR pool. Crop-residue burning worsens post-harvest air quality across the Indo-Gangetic Plain, increasing regulatory and environmental pressure to scale alternative utilization pathways, including cement co-processing.
- **Industrial Waste Streams:** Industrial waste from pharmaceutical manufacturers in Haridwar, chemical industries in Noida and Panipat, and automotive manufacturing clusters across NCR and Haryana provides liquid and solid hazardous AFR streams. These materials support SPCB-authorized co-processing and strengthen demand for compliant handling, storage, pre-processing, and kiln-feeding systems across North Indian cement plants.



5.3.2 WASTE-TO-ENERGY PLANTS

Market Trends

- India's waste management industry is shifting from conventional waste disposal toward the production of refuse-derived fuel (RDF) and solid recovered fuel (SRF) for industrial energy applications. As municipalities and waste management companies establish alternate fuel recovery facilities to process municipal, industrial, plastic, textile, and packaging waste into standardized fuel products, demand is growing for specialized AFR infrastructure, including shredding, storage, extraction, weighing, conveying, and feeding systems. These facilities use technologies such as box extractors, sliding floor systems, weigh feeders, Solidose units, conveyors, and automated Programmable Logic Controller (PLC)-based controls to ensure consistent fuel quality and reliable supply to cement plants, power stations, steel plants, and other energy-intensive industries.

Municipal RDF Offtake Agreements Driving Demand for AFR Material Handling Systems

- In December 2025, Bengaluru Solid Waste Management Ltd. signed an agreement with Dalmia Cement to supply an additional 200-250 tons/day of RDF from Bengaluru's municipal waste stream to Dalmia Cement's Kadapa cement plant in Andhra Pradesh. Dalmia Cement indicated it could accept as much as 1,000 tons/day of RDF, highlighting the growing scale of RDF production and consumption networks in India. Such high-volume RDF movements require dedicated AFR infrastructure, including storage bunkers, extraction systems, sliding floors, weigh feeders, conveyors, and dispatch systems to ensure consistent fuel quality and throughput.
- The agreement demonstrates how waste-to-energy and RDF-processing operators are increasingly developing long-term fuel supply partnerships with industrial users, creating demand not only for waste processing equipment but also for downstream AFR handling and feeding systems capable of maintaining continuous RDF flow from production to end-use facilities.

Regulatory RDF Mandates Supporting New AFR Facility Investments

- In January 2026, the Government of India notified the new Solid Waste Management (SWM) Rules, 2026, which came into force from April 1, 2026, replacing the SWM Rules, 2016, and introducing stronger circular economy and extended producer responsibility provisions. Industries including cement plants and waste-to-energy facilities must progressively increase the use of RDF, with fuel substitution rates rising from 5% to 15% over six years, supporting resource recovery and reducing landfill dependence. The regulation establishes a graduated substitution framework, creating structural demand for RDF production and associated AFR infrastructure.
- The regulatory push is expected to accelerate investments in AFR recovery facilities, RDF preparation plants, storage bunkers, extraction systems, and automated feeding equipment, as RDF producers must deliver more consistent fuel quality to meet growing industrial demand. This is expected to benefit suppliers of box extractors, sliding floors, weigh feeders, and automated material handling systems.

Large-Scale RDF Co-Processing Projects Driving Investment in AFR Feeding Systems

- During FY2024-25, JSW Cement co-processed approximately 157,000 tons of RDF across its Nandyal Integrated Cement Plant and Shiva Grinding Unit, achieving a 16.5% thermal substitution rate (TSR) and avoiding nearly 120,000 tons of CO₂ emissions. The scale of RDF utilization highlights the growing requirement for reliable AFR logistics, storage, extraction, metering, and dosing infrastructure capable of delivering a uniform fuel stream to industrial consumers. As RDF throughput grows from pilot-scale to industrial-scale consumption, operators increasingly require automated systems such as sliding floor extractors, weigh feeders, Solidose units, and PLC-controlled handling systems to ensure fuel consistency and stable combustion performance.

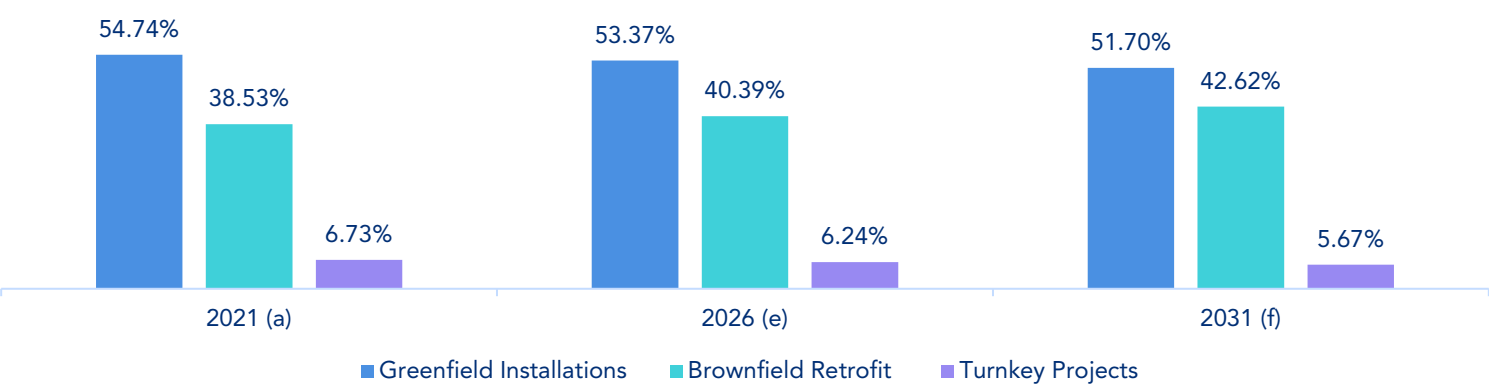
5.4 DEPLOYMENT MODEL

ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY DEPLOYMENT MODEL, INDIA, 2021-2031

CAGR (2026 TO 2031): 10.75%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY DEPLOYMENT MODEL, INDIA, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY DEPLOYMENT MODEL, INDIA, 2021-2031

Deployment Model	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
Greenfield Installations	14.27	15.42	16.69	18.10	19.68	21.52	23.57	25.88	28.48	31.42	34.74	10.05%
Brownfield Retrofit	10.05	11.02	12.12	13.36	14.76	16.29	18.14	20.26	22.68	25.46	28.64	11.95%
Turnkey Projects	1.75	1.88	2.01	2.16	2.33	2.52	2.72	2.95	3.21	3.49	3.81	8.67%
Total	26.07	28.32	30.82	33.62	36.77	40.32	44.44	49.09	54.37	60.37	67.19	10.75%

Source: Mordor Intelligence



5.4.1 GREENFIELD INSTALLATION

MARKET TRENDS

Greenfield AFR Installations as a Key Revenue Stream in India's Capacity Expansion

- Greenfield AFR installations represent the highest-value single-project category in India's AFR firing systems market. They involve complete, purpose-designed infrastructure engineered as an integrated component of a new cement plant.
- UltraTech targets 242.5 MTPA by FY2028 with INR 16,000 crore in capital expenditure. Ambuja/ACC targets 155 MTPA, though the timeline may slip to FY2030. Shree Cement's Nawalgarh plant has contracted Fuller Technologies Inc. for AFR systems. JK Cement has announced INR 4,805 crore for a 7 MTPA plant in Jaisalmer. The planned 160-170 MTPA of new capacity by FY2028 represents an AFR infrastructure investment opportunity of INR 4,000-5,000 crore, based on INR 25-30 crore per MTPA for 15% Thermal Substitution Rate (TSR) capability.
- In November 2025, the Adani Group secured approvals from the West Bengal Industrial Department to establish a new 5 MTPA greenfield cement facility in Kharagpur. Spanning over 198 acres, the plant will incorporate advanced automation equipment. This follows the Group's broader directive to increase its AFR utilization target to 30% by FY2028.

Technical and Commercial Advantages of Greenfield AFR Integration

- Greenfield AFR integration allows engineers to design receiving bays, pre-processing areas, and storage facilities with optimal spatial layouts, accommodating waste reception logistics, leachate management, and multi-injection-point capability. Dust containment, odor control, fire detection, and automated safety systems are budgeted from the outset, avoiding costly retrofits.
- AFR storage sheds, typically 60-80 m long with 3 m reinforced concrete walls and 15 m clear height for 5,000-8,000 m³ storage volumes, are straightforward to build in greenfield settings. Multi-point injection capability covering the precalciner, Tertiary Air Duct (TAD), and main burner is designed as an integrated system, avoiding piecemeal brownfield upgrades.

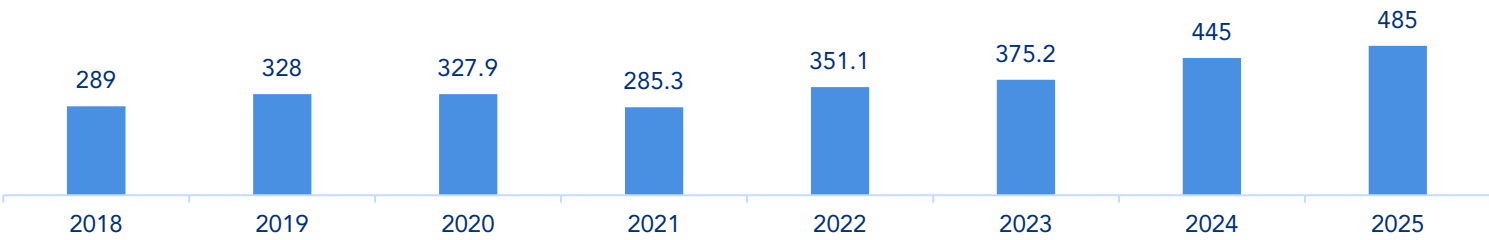
Regulatory Advantages of Greenfield Projects in Obtaining State Pollution Control Board (SPCB) Co-Processing Consent

- Greenfield projects can obtain SPCB co-processing consent as part of the initial consent-to-establish application, avoiding the more time-consuming amendment process required for brownfield plants. Cement companies are increasingly seeking pre-authorization for a broad portfolio of AFR categories during the initial consent process, ensuring operational flexibility from the first day of commercial production. This approach reflects the industry's shift from treating AFR as a supplementary add-on to incorporating it as a core fuel supply strategy from inception.

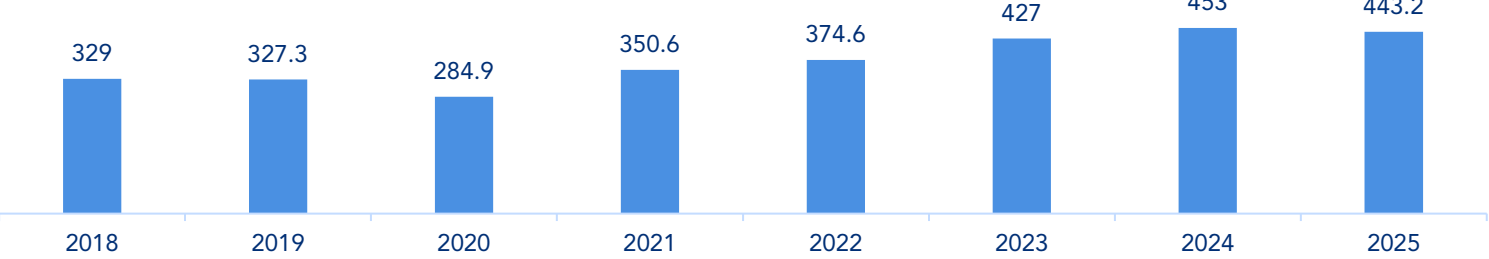


5.4.1 GREENFIELD INSTALLATION

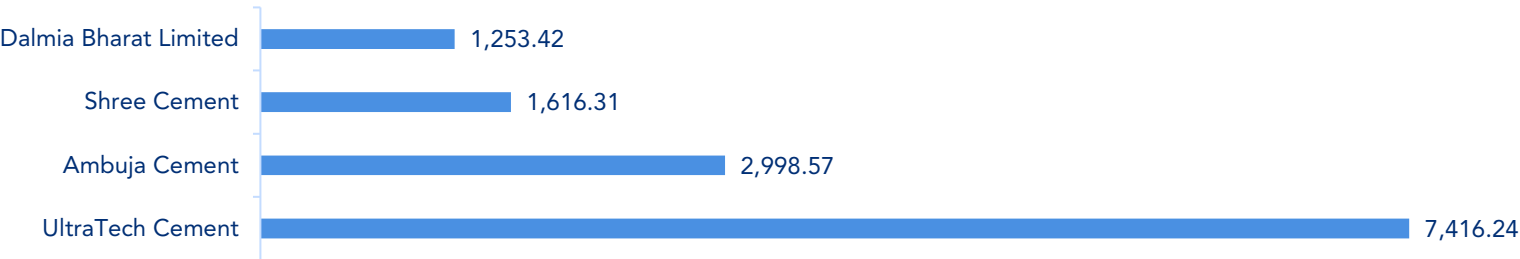
CEMENT CONSUMPTION IN MILLION TONS, IN INDIA, 2018-2025



CEMENT PRODUCTION IN MILLION TONS, IN INDIA, 2018-2025



TOP CEMENT PRODUCERS IN INDIA, IN USD MILLION, NET SALES IN Q3 NINE-MONTH ENDING FY2026



MAJOR GREENFIELD PROJECTS & AFR FIRING DEPLOYMENTS (AS OF JULY 2026)

Plant Name	Project Status	Location	AFR Technology
Shree Cement - Meghalaya Integrated Greenfield Project	Board Approved / Advancing to Site Preparation (April 2026)	Daistong Village, East Jaintia Hills District, Meghalaya	Shree Cement is targeting over 25% Thermal Substitution Rate (TSR) in its newer production lines. Due to its geographic positioning in the northeast, this greenfield installation is designed to utilize local industrial waste, biomass, and regional alternative fuel sources from the outset.
Tier-1 Producer - Vidarbha Limestone Belt Persona	Environmental Clearance (EC) issued by Forest and Climate Change (MoEFCC) in July/August 2026.	Nagpur District, Maharashtra	This is a 3 MTPA greenfield integrated plant being set up by a Tier-1 Indian cement company. The pre-feasibility and environmental metrics for this plant include fully enclosed automated storage for hazardous waste, high-efficiency calciner firing systems, and automated shredder links to process Refuse-Derived Fuel (RDF) and industrial waste.

Source: Mordor Intelligence, IBEF

5.4.2 BROWNFIELD RETROFIT

MARKET TRENDS

- **Brownfield Retrofit Dominates by Project Count and Near-Term Market Priority**

- Brownfield retrofit is the largest deployment model by project count in India's AFR firing systems market. India's 668 MTPA of installed cement capacity consists largely of operating plants with no AFR infrastructure, limited early-generation systems requiring upgrades, or Thermal Substitution Rate (TSR) targets exceeding current installed capacity. With 186 cement plants under CCTS's first compliance cycle and Solid Waste Management (SWM) Rules 2026 mandatory from April 2026, plants not at target TSR levels face urgent retrofit requirements within a two-to-four-year compliance window.

- **Brownfield Retrofits Are More Technically Complex and Costly Than Greenfield Installations**

- Brownfield AFR system retrofits are technically more complex and costlier per ton of AFR capacity than greenfield installations. Existing plant layouts, civil structures, and operational continuity requirements constrain installation. A typical retrofit begins with a kiln audit assessing combustion compatibility, calciner gas residence time, preheater chlorine tolerance, and available civil space. A phase 1 retrofit targeting 5% TSR, covering basic precalciner feeding, enclosed storage, and conveying, costs INR 5 crore to INR 8 crore. A phase 3 upgrade targeting 15% to 20% TSR costs INR 25 crore to INR 40 crore for a 3,500 Tonnes Per Day (TPD) kiln.

- **Industry Practice Favors a Stepwise Brownfield Implementation Approach**

- India's AFR practitioners recommend a stepwise brownfield implementation approach: phase 1 establishes basic infrastructure and regulatory compliance; phase 2 builds operational experience and procurement contracts; phase 3 deploys multi-point systems, pre-processing lines, and digital controls; phase 4 introduces chlorine bypass, Hotdisc or Pyrorotor technology, and AI-based kiln optimization. Phase 4 investment justification requires demonstrated phase 2 and phase 3 performance data. PH1 Industries' portfolio across 35+ cement plants, spanning phase 1 through phase 3 installations, reflects the commercial dominance of brownfield work in India's AFR market.

CORPORATE UPDATES & RETROFIT TARGETS

- **UltraTech Cement: AFR Integration Across Acquired and Organic Assets**

- UltraTech Cement has maintained cost discipline by integrating AFR systems across its acquired and organic asset base.
- Energy Cost Reduction: The company recorded a 3% year-on-year decline in energy costs, driven by expanding its AFR fuel basket and increasing its green power consumption mix.
- Capacity Expansion and M&A Integration: As UltraTech executes its capacity expansion targeting 240.76 MTPA, newly acquired assets, including those from India Cements, are being evaluated for brownfield AFR retrofits to standardize operating margins across its portfolio.

- **Ambuja & ACC (Adani Cement): Brownfield Retrofits to Debottleneck Legacy Lines**

- Following an internal directive to balance rapid growth with technical stability, Adani Cement is executing targeted brownfield retrofits.
- Science Based Targets Initiative (SBTi) and Decarbonization Frameworks: Both Ambuja and ACC have had their net-zero targets validated by the Science Based Targets initiative (SBTi). To meet these targets, legacy plants are retrofitting multi-fuel dosing gates.
- Margin Resilience: Ambuja increased its green power share to 34%, reducing production costs by INR 206 per ton sequentially. The company relies on brownfield clinker factor improvements, reaching 63.7% year-on-year, through targeted alternate fuel and raw materials (AFR) substitutions.

- **Dalmia Bharat and Shree Cement: TSR Exceeding 25% on Retrofitted Lines**

- Line-Specific Milestones: Dalmia Bharat and Shree Cement have sustained a Thermal Substitution Rate (TSR) greater than 25% on several of their retrofitted production lines.
- Capacity Safeguards: Dalmia is combining its capacity expansion to 66.7 MTPA with third-party structural and lifting equipment inspections to ensure retrofitted high-elevation precalciner AFR feeding tubes comply with safety norms.

Source: Mordor Intelligence, UltraTech, News Articles



5.4.3 TURNKEY PROJECTS

MARKET TRENDS

Turnkey AFR projects follow a delivery model in which a single systems integrator assumes complete responsibility for design, engineering, procurement, civil construction, installation, commissioning, and regulatory documentation of an end-to-end AFR firing system. Cement companies prefer this model to minimize internal project management burdens, ensure single-point accountability for performance guarantees, and accelerate project execution compared to multi-vendor coordination required in conventional supply models.

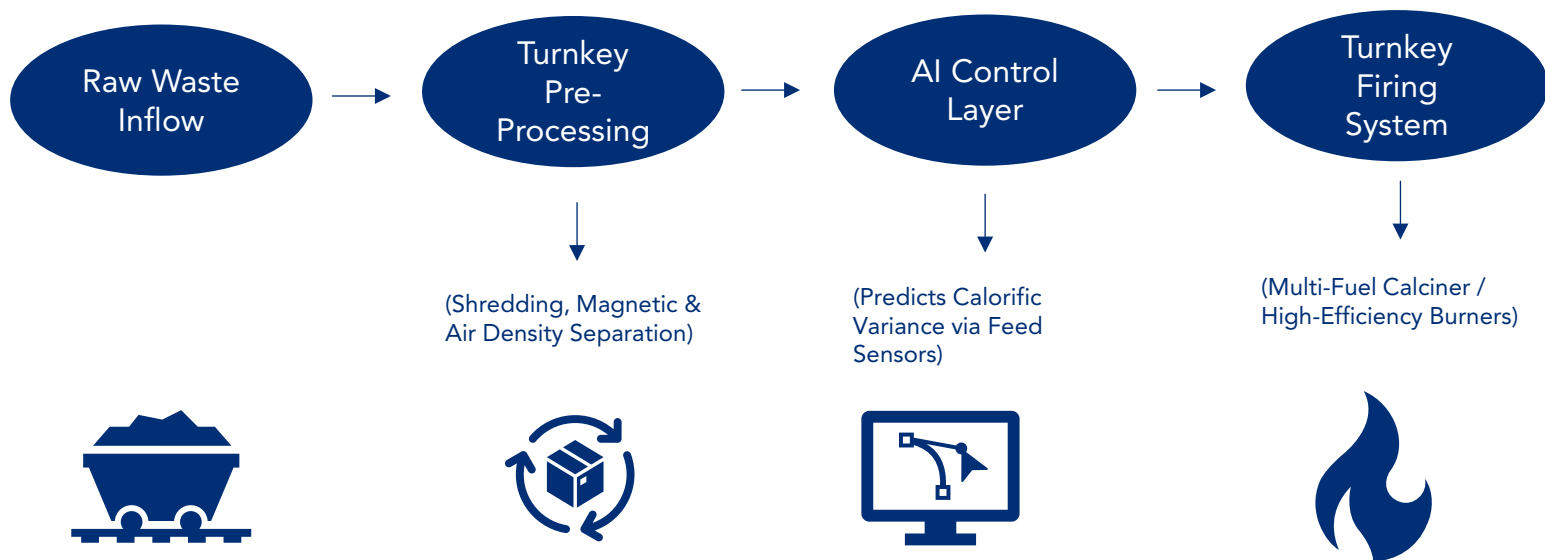
Financial and Commercial Dimensions of Turnkey AFR Contracts

Turnkey AFR contracts command a premium over supply-only equipment contracts, compensating the integrator for project risk, interface management, and regulatory compliance coordination. A typical contract for a 15% Thermal Substitution Rate (TSR) solid AFR system at a 3,500 TPD cement plant covers civil construction, mechanical equipment supply, electrical and instrumentation systems, Continuous Emissions Monitoring System (CEMS) integration, fire safety systems, and State Pollution Control Board (SPCB)-established authorization protocol management. Delivery timelines typically run 8 to 14 months from award to commissioning, driven by regulatory compliance deadlines and Carbon Credit Trading Scheme (CCTS) compliance cycles.

Competitive Positioning and Client Relationship Dynamics in Turnkey AFR Delivery

PH1 Industries' 70+ projects across 35+ cement plants demonstrate the compounding commercial effect of turnkey project delivery, with initial installations generating repeat business as clients expand operations or seek process optimization support. International providers such as FLSmidth and KHD compete in the turnkey space for integrated pyroprocessing and AFR packages at major greenfield projects.

Flow of Turnkey Projects in India

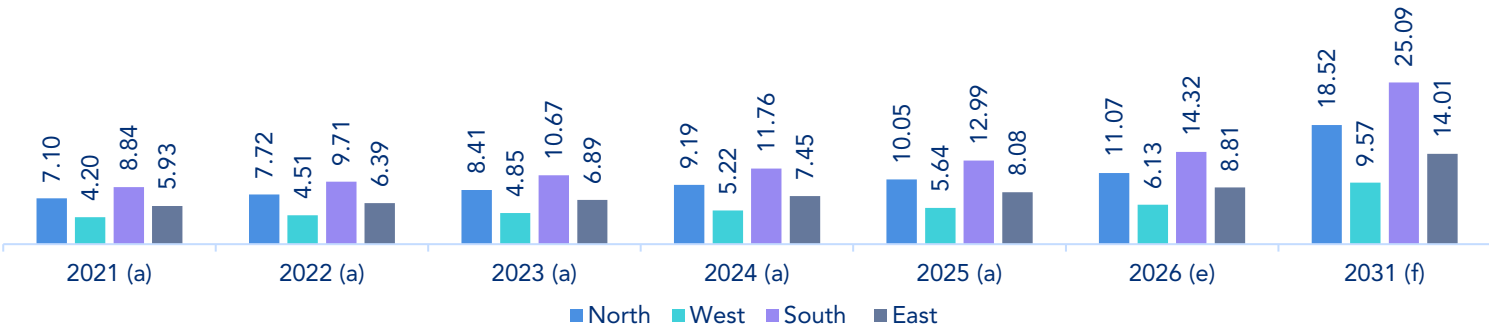


Source: Mordor Intelligence, Adani Cement, PH1 Industries, News Articles

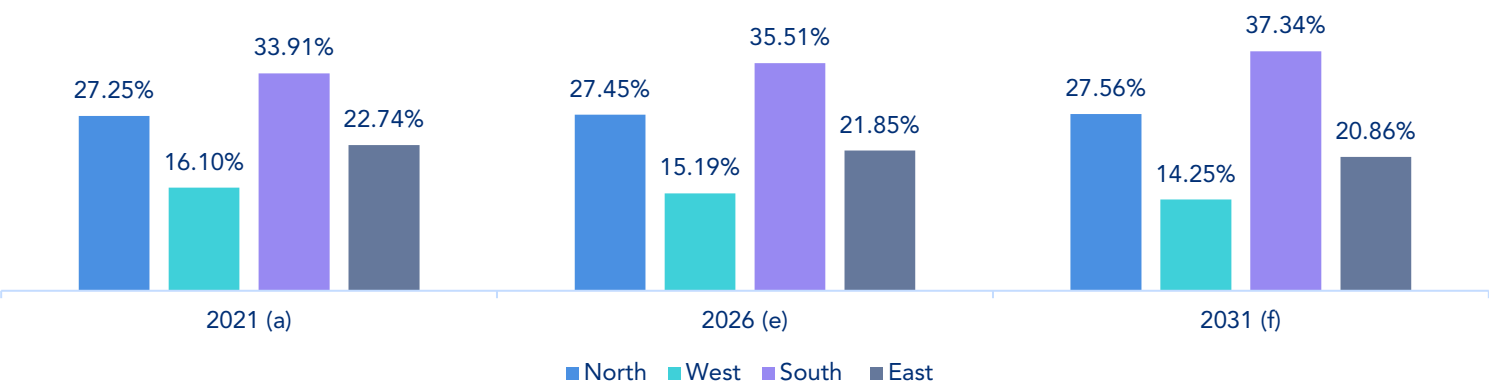
5.5 BY REGION

ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY REGION, INDIA, 2021-2031

CAGR (2026 TO 2031): 10.75%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY REGION, INDIA, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY REGION, INDIA, 2021-2031

Region	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
North	7.10	7.72	8.41	9.19	10.05	11.07	12.21	13.50	14.96	16.62	18.52	10.84%
West	4.20	4.51	4.85	5.22	5.64	6.13	6.67	7.27	7.95	8.71	9.57	9.33%
South	8.84	9.71	10.67	11.76	12.99	14.32	15.94	17.79	19.90	22.32	25.09	11.87%
East	5.93	6.39	6.89	7.45	8.08	8.81	9.62	10.53	11.56	12.71	14.01	9.73%
Total	26.07	28.32	30.82	33.62	36.77	40.32	44.44	49.09	54.37	60.37	67.19	10.75%

Source: Mordor Intelligence



5.5 BY REGION

CEMENT COMPANIES' CAPACITY BY STATE, AS OF JULY 2026, IN INDIA

Region	State	Installed Cement Capacity (Million Tonnes Per Annum (MTPA))	Installed Captive Power Unit Capacity (MW)
North	Uttar Pradesh	40-45	200-205
	Haryana	10-15	-
	Himachal Pradesh	10-15	20-25
	Punjab	5-10	20-25
	Rajasthan	85-90	965-970
West	Maharashtra	50-55	275-280
	Gujarat	45-50	385-390
South	Andhra Pradesh	75-80	300-305
	Karnataka	55-60	550-555
	Telangana	30-35	370-373
	Tamil Nadu	45-50	460-465
East	West Bengal	35-40	-
	Odisha	30-35	80-85
	Jharkhand	20-25	20-25
	Bihar	10-15	-

Source: Mordor Intelligence, Cement Manufacturers' Association



5.5.1 NORTH

Market Profile and Cement Industry Concentration in North India

- North India, spanning Rajasthan, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Uttarakhand, Delhi NCR, and Jammu & Kashmir, is India's largest cement-producing region by clinker capacity. This industrial footprint is anchored by Rajasthan's extensive, high-purity limestone deposits distributed across the Aravalli Range. Rajasthan alone hosts several of India's highest-capacity integrated cement plants, making it the most critical geography for Alternate Fuel and Raw Materials (AFR) co-processing infrastructure demand.
- The scale of operations in this region is illustrated by Shree Cement's integrated manufacturing complex at Jaitaran (Beawar), which expanded following the commissioning of RAS Unit-11, adding 3.65 Million Tonnes Per Annum (MTPA) of clinker and 3 MTPA of cement capacity. At these production volumes, individual plants require the daily processing of tens of thousands of tonnes of raw materials. JK Cement is executing an INR 4,805 crore greenfield expansion that includes a 4 MTPA clinkerization unit and a 3 MTPA cement grinding unit at Jaisalmer, Rajasthan, alongside two 2 MTPA split grinding units in Rajasthan and Punjab. This expansion directly drives large-scale demand for new AFR handling systems. JSW Cement commissioned its greenfield integrated plant at Nagaur, Rajasthan, in March 2026. This facility features a 3.3 MTPA clinker and 2.5 MTPA cement line, serving the Delhi NCR, Haryana, and Punjab markets, with an additional 2.5 MTPA grinding expansion approved for commissioning by January 2028.

AFR Supply Dynamics: RDF, Biomass, and Agricultural Waste

- Refuse-derived fuel (RDF): Municipal solid waste generated by major urban centers—including Delhi NCR, Jaipur, Lucknow, Agra, and Kanpur—provides substantial RDF volumes within a 400 km logistics radius of cement plants in Rajasthan, Haryana, and western Uttar Pradesh. This proximity supports compliance obligations as manufacturing facilities adapt to the evolving implementation timelines of India's solid waste management (SWM) framework.
- Agricultural biomass: This represents the region's largest biomass AFR pool, consisting primarily of rice straw from Punjab and Haryana harvests, sugarcane bagasse from Uttar Pradesh's sugar industry, and wheat straw. The seasonal open-field burning of crop residues triggers severe air quality crises across the Indo-Gangetic Plain, making cement co-processing an important alternative utilization pathway with significant environmental and policy implications.
- Industrial and hazardous waste: Industrial clusters supply a steady volume of specialized solid and liquid AFR streams. These include pharmaceutical manufacturing residues from Haridwar, chemical industry by-products from Noida and Panipat, and hazardous waste from automotive manufacturing hubs across Haryana and Delhi NCR, all operated under state pollution control board (SPCB) authorizations.

CCTS Compliance and TSR Targets

- Cement assets in North India feature prominently in the first compliance cycle of the carbon credit trading scheme (CCTS). High-performing facilities are scaling up their thermal substitution rates (TSR) alongside the deployment of large-scale waste heat recovery systems (WHRS). JK Cement's regional operations have progressively prioritized alternative waste management, increasing corporate TSR milestones toward long-term decarbonization targets.
- Shree Cement's North Indian plants, including the Ras and Nawalgarh facilities, operate at plant-level TSR ranges from 5% to over 20%. The greenfield plant at Nawalgarh has integrated AFR capabilities directly into its engineering design from inception, establishing a benchmark for next-generation integrated plants.
- At the corporate level, Shree Cement reported a company-wide TSR of 2.41% in its FY2024-25 ESG disclosures. This figure reflects a near-term strategy that prioritizes renewable electricity (RE) over AFR substitution, with green power accounting for 56.09% of the company's electricity mix. The difference between the 2.41% corporate baseline and the higher plant-level TSRs at locations such as Ras reflects how localized infrastructure readiness and regional waste availability influence execution. Over the forecast period, investment in AFR infrastructure in North India is projected to remain disproportionately high to support both greenfield integrations and brownfield compliance upgrades.

5.5.2 WEST

- **MARKET TRENDS:** The AFR firing system market across Western Indian states, primarily Maharashtra and Gujarat, operates under distinct regional conditions. Unlike Northern India, which focuses on agricultural biomass, Western India functions as a dense industrial corridor. This positioning makes the region a national hub for hazardous industrial waste, refinery by-product optimization, and municipal plastic waste co-processing.
- **Regional Characteristics and Industrial Ecosystem:** Western India, covering Gujarat, Maharashtra, and Goa, has a distinctive AFR market profile shaped by high industrial waste generation, strategic port access for alternative fuel imports, and the co-location of major pharmaceutical, chemical, petrochemical, and cement clusters. Gujarat's Vadodara-Surat-Dahej industrial chemical corridor generates pharmaceutical residues, solvent waste, petroleum refining sludge, and specialty chemical waste for liquid AFR use.
- **Liquid AFR Dominance in Western India:** The availability of high-calorific industrial waste streams within permitted transport distances makes Western India the most liquid-AFR-intensive region in India. Cement plants in the region typically allocate a higher share of their AFR portfolio to liquid firing systems than plants elsewhere in the country, supported by steady waste flows from Gujarat and Maharashtra's industrial clusters. The pharmaceutical and chemical industry belt linking Vadodara, Ahmedabad, Vapi, Surat, Pune, and Nashik generates India's most concentrated and highest-calorific liquid AFR supply outside dedicated hazardous waste treatment facilities. PH1 Industries, which pioneered liquid AFR firing systems in India in 2009, is well-positioned in Western India through client relationships with UltraTech and Ambuja/ACC facilities in Gujarat and Maharashtra.
- **Cement Capacity and Expansion Activity:** Western India's cement capacity is anchored by major limestone deposits in Gujarat, including Kutch, Saurashtra, and Banaskantha, and in Maharashtra, including Vidarbha and Marathwada. Ambuja Cements' Sanghi plant in Kutch, India's single largest cement plant site with 6.6 MTPA clinker capacity, is advancing a commercial-scale demonstration of Low Emissions Intensity Lime And Cement (LEILAC) carbon capture and hybrid electric heating technology with UK-based LEILAC Limited. Sanghi Industries has proposed expansion at Motiber, Kutch, targeting 17.5 MTPA of clinker capacity and 18.6 MTPA of cement capacity, subject to environmental clearance. Shree Cement announced an INR 2,000 crore (USD 223 million) investment in Chandrapur, Maharashtra. Dalmia Bharat's Pune greenfield split grinding unit and Belagavi brownfield clinker expansion further strengthen the regional capacity pipeline.
- **New Grinding Capacity Additions in Gujarat:** Nuvoco Vistas commissioned 2 MTPA of grinding capacity at its Limla plant in Surat, Gujarat, in July 2026. The addition expands the company's Western India presence and creates new AFR system requirements in the Gujarat industrial belt, where cement producers can access industrial waste streams from nearby chemical, petrochemical, and pharmaceutical clusters.
- **Regulatory Maturity and Authorization Timelines:** The hazardous waste authorization process managed by the Maharashtra Pollution Control Board (MPCB) and Gujarat Pollution Control Board (GPCB) is among the most developed in India. Established authorization protocols reduce authorization timelines compared with less experienced state pollution control boards (SPCBs), enabling incremental liquid AFR capacity additions in Western India with fewer approval delays than in newer co-processing geographies.
- **Petcoke Import Constraints Driving AFR Adoption in Western India:** Western Indian cement plants, which have traditionally relied on imported petroleum coke through major maritime gateways such as Mundra, Kandla, and Dahej, are reducing import volumes significantly. Geopolitical tensions in the Middle East and restricted global refinery runs have tightened supply, prompting cement producers to reassess fuel procurement strategies across the region and prioritize near-term operational stability. Major cement producers in Gujarat and Maharashtra have increased the use of domestic alternative fuels and raw materials to reduce exposure to foreign exchange movements and fuel price volatility. UltraTech Cement has lowered petroleum coke use in its kiln fuel mix and is replacing it with hazardous waste from nearby chemical and manufacturing zones.
- **Pre-Processing Infrastructure Supporting AFR Supply Chain Expansion:** Major environmental waste aggregators in hubs such as Karad, Maharashtra, now handle and process over 1,000 tonnes of alternative fuel per day for cement kilns. Automated storage networks test incoming automobile, textile, and pharmaceutical waste streams for physical and chemical consistency, supporting compliant, reliable delivery to kiln gates. This capacity reflects a stronger pre-processing infrastructure. Logistics firms are partnering with civic bodies, including the Ahmedabad Municipal Corporation, to conduct large-scale biomining at legacy dumpsites. These facilities extract plastic waste and convert it into refuse-derived fuel (RDF), supplying approximately 400 tonnes of RDF per day per plant to nearby cement kilns in western India, strengthening regional alternative fuel availability.

Source: Mordor Intelligence, Adani Cement, IBEF, News Articles



5.5.3 SOUTH

MARKET TRENDS

Cement Cluster Density and Market Maturity:

- Regional cement base: South India, covering Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, and Kerala, is India's second-largest cement-producing region and the most policy-active geography for alternative fuels and raw materials (AFR) adoption. Andhra Pradesh mandated a minimum 15% refuse-derived fuel (RDF) use for cement kilns near urban local bodies before any national framework was established.
- Key cement assets: The region's cement industry is anchored by JSW Cement's Nandyal integrated plant in Andhra Pradesh, which achieved a 16.5% thermal substitution rate (TSR) in FY2025, primarily through 157,000 tonnes of RDF co-processing, according to the Climate Bonds Initiative. Other key assets include ACC Wadi, UltraTech Tadipatri, Ramco Cements, Chettinad Cement, KCP Cement, and Nagarjuna Cement.

Recent Capacity Additions and AFR Infrastructure Investment

- Dalmia Bharat Kadapa project: Dalmia Bharat's Kadapa greenfield plant involves an investment of INR 31 billion (approximately USD 321 million). With 6.1 million tonnes per annum (MTPA) clinker capacity and 9.6 MTPA cement capacity, the plant targets commissioning by Q3 FY2028 and is positioned to become Dalmia's largest integrated plant in southern India, creating a significant AFR system opportunity in Kadapa district.
- Shree Cement Kodla expansion: Shree Cement commissioned a 3.7 MTPA clinker section at its Kodla plant in Karnataka in February 2026, increasing total Kodla clinker capacity to 7.2 MTPA. This addition makes Kodla a large demand center for AFR system upgrades and related fuel substitution infrastructure.
- Ramco Cements capacity additions: Ramco Cements' Kalvatala expansion in Andhra Pradesh, including a Loesche grinding plant scheduled for commissioning in December 2026, and debottlenecking at Ramasamy Raja Nagar in Tamil Nadu and Jayanthipuram in Andhra Pradesh, will add grinding capacity. Although these assets lack clinker lines, they support AFR fuel cost optimization at integrated parent plants.

AFR Supply Chain: RDF Logistics and Karnataka Challenges

- Karnataka RDF performance: South India highlights both the potential and limitations of RDF co-processing at scale. Karnataka's cement industry, despite the solid waste management (SWM) rules framework in place since 2016, reported RDF TSR levels of around 5% after eight years, primarily due to inconsistent waste collection, poor source segregation, and RDF quality below grade II specifications from several municipal suppliers.
- Andhra Pradesh policy model: Karnataka's underperformance demonstrates that mandates alone do not ensure AFR adoption. Cement producers and municipal stakeholders require stronger supply chain investment and pre-processing infrastructure. Andhra Pradesh combines a mandatory utilization directive with a joint technical committee for producer support, resulting in better early outcomes, as reflected in JSW Nandyal's RDF co-processing performance.

UltraTech Cement's Southern Expansion

- Acquired asset overhaul: Following its acquisition of The India Cements Limited (ICL), UltraTech is auditing legacy plants in Tamil Nadu, including Sankar Nagar, and Andhra Pradesh, including Chilamkur. The company is deploying its standard AFR approach across these kilns and retrofitting advanced precalciner feeding loops to meet corporate cost-efficiency benchmarks.
- Energy cost reduction: Supported by high-volume alternative fuel substitution across its existing south zone lines, UltraTech recorded a 3% year-on-year decline in overall energy costs, strengthening its position against regional price volatility in southern India.

Penna Cement Integration (Adani Group)

- AFR-led turnaround: Following its acquisition by the Adani Group, Penna Cement's plants in Andhra Pradesh, including Tadipatri, and Telangana are being fast-tracked for modernization. Adani is implementing major automation upgrades to increase the thermal substitution rate (TSR), aligning these assets with the group's target of reaching 30% AFR utilization by FY2028.



5.5.4 EAST

- **MARKET TRENDS: East India, covering** Chhattisgarh, Odisha, Jharkhand, West Bengal, Bihar, Assam, and the northeastern states, has India's lowest per capita cement consumption and the fastest demand growth on that basis. Jindal Cement expects regional demand to grow by 7% to 8% in 2026, supported by higher government spending, housing construction, and infrastructure investments.
- **Capacity Expansion and Investment Activity:** Cement producers are expanding capacity to capture eastern India's demand growth. Adani Group announced a USD 225 million cement plant near Cuttack, Odisha, within a USD 3.53 billion state investment package. Nuvoco Vistas is adding 4 MTPA of grinding capacity across Arasmeta, Jojobera, Panagarh, and Odisha, while Dalmia Bharat is expanding in Assam and Bihar.
- **AFR Adoption and Compliance Baseline in East India:** East India's cement plants have adopted AFR more slowly than plants in Rajasthan and South India, mainly due to limited Refuse-Derived Fuel (RDF) supply from lower urbanization and a focus on bulk volume growth. UltraTech's Rawan cement works in Chhattisgarh reported 4.34% Thermal Substitution Rate (TSR) in FY2024-25, using dolochar as non-hazardous AFR, supported by a 65 t/h shredder.
- **CCTS Compliance Requirements:** ACC Jamul in Chhattisgarh and Ambuja Bhatapara are covered under the Carbon Credit Trading Scheme (CCTS) and subject to Greenhouse Gas Emission Intensity (GEI) targets. These plants face the same carbon compliance timeline as comparable cement facilities in other regions. The framework requires TSR improvement by FY2027, increasing the need for alternative fuel use and stronger AFR processing capabilities.

MAJOR CORPORATE PROJECT UPDATES

Adani Cement (Ambuja & ACC East Hubs)

- **Kharagpur greenfield approval:** The Adani Group secured formal approvals to establish a 5 MTPA greenfield cement facility in Kharagpur, West Bengal, across more than 198 acres. The facility was designed to integrate automated AFR pre-processing systems and multi-fuel feeding loops from the outset, supporting Adani's target of achieving a 30% AFR utilization rate by FY2028.
- **Project execution focus:** Adani Cement has optimized its ongoing capital expenditure across East India by focusing on active project sites. Project teams are integrating high-efficiency AFR lines and green-power setups before advancing additional unannounced greenfield projects, supporting operational readiness, fuel flexibility, and alternative fuel adoption across the company's eastern manufacturing network.

Dalmia Bharat (Strong Eastern Footprint)

- **TSR Benchmark Above 25%:** Dalmia Bharath maintains a Thermal Substitution Rate (TSR) of more than 25% across optimized production lines in the eastern region. This performance reflects the company's focus on alternative fuel use, kiln efficiency, and operational consistency across key assets in one of India's most active cement markets.
- **Capacity and Safety Measures:** Dalmia is scaling toward a capacity target of 66.7 MTPA by FY2028 while deploying automated AFR precalciner feeding tubes. The company is conducting third-party structural and lifting tool inspections across its eastern plants, including Rajgangpur in Odisha, to maintain safety compliance during high-elevation alternative fuel firing operations.

UltraTech Cement (East Zone Optimization)

- **Acquisition-Driven Upgrades:** Following large-scale domestic M&A expansion, UltraTech is auditing and standardizing material feeding lines across newly acquired eastern assets. The company is aligning operational systems, fuel-handling infrastructure, and AFR integration practices to improve process consistency, reduce commissioning risks, and support higher alternative fuel utilization across its expanded manufacturing footprint in eastern India.
- **Energy Cost Reduction:** UltraTech expanded its localized alternative fuel basket, including chemical waste from the Haldia industrial belt, and recorded a 3% year-on-year decline in overall energy costs. This strengthened the company's cost position and improved resilience against freight and fuel volatility across its eastern cement operations.

Source: Mordor Intelligence, Adani Cement, IBEF, News Articles



6. COMPANY PROFILE

6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) - COMPANY OVERVIEW



56.493 Crore

Revenue from Operations in INR
FY 2025-26 (All Segments)
The financial year ended in
March 2026

BUSINESS SEGMENTS

ALTERNATE FUEL AND RAW
MATERIAL (AFR) SYSTEMS
BULK MATERIAL HANDLING
(BMH) SYSTEMS

GLOBAL OVERVIEW

PH1 Industries Limited (formerly known as PH1 Industries Private Limited) is an Indian engineering and technology company specializing in alternative fuels and raw materials (AFR) firing systems, material handling solutions, waste processing systems, and environmental pollution control technologies.

PH1 Industries Limited (formerly known as PH1 Industries Private Limited) has been serving industrial customers and has developed strong expertise in customized fuel handling and combustion solutions.

The company primarily serves the cement industry, while also catering to the pharmaceutical and chemical sectors. The company has successfully commissioned numerous AFR projects, supporting industrial decarbonization initiatives.

**040-2307 7585/
230 7586**

Contact Details

2015

Founded

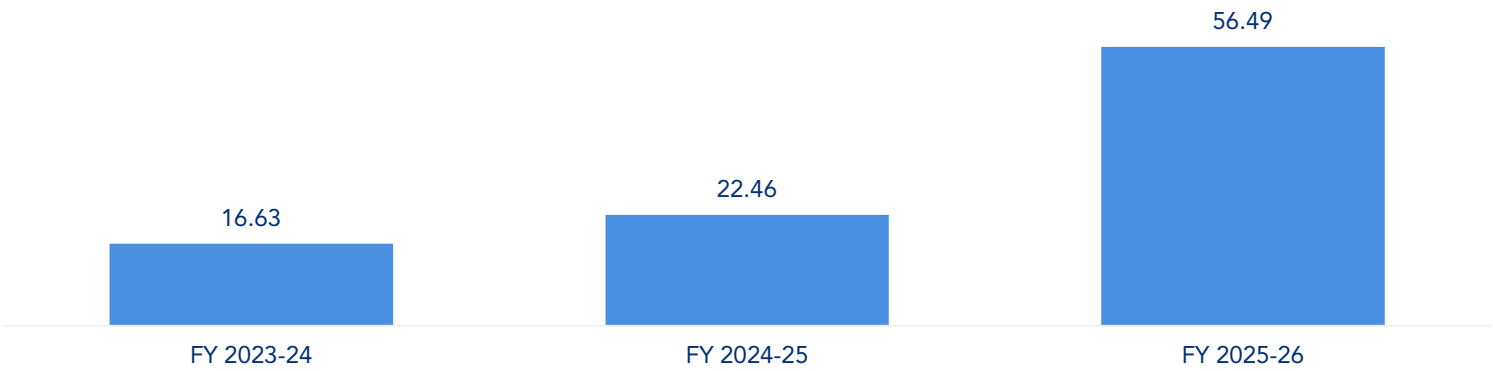
**Hyderabad,
Telangana, India**

Headquarters



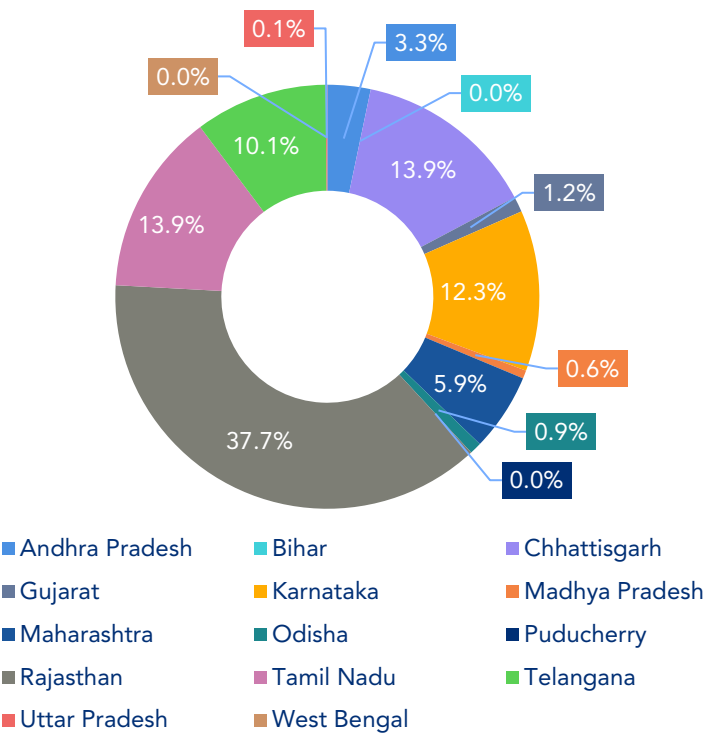
6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) - FINANCIALS

REVENUE IN INR CRORE, FY 2023-24 – FY 2025-26

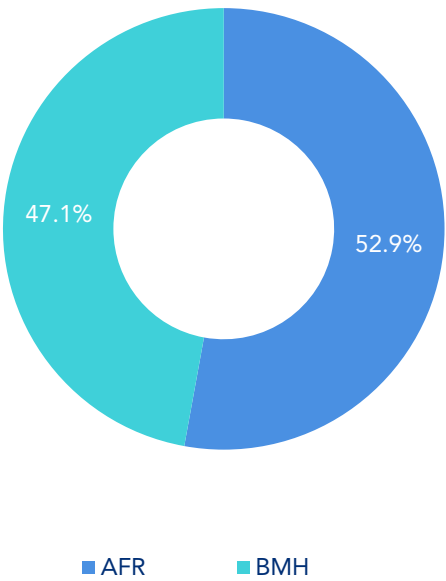


Note: Fiscal Year Ended on March 31, 2026

REVENUE BREAKDOWN BY GEOGRAPHY, IN %, FY 2025-26



REVENUE BREAKDOWN BY BUSINESS SEGMENT, IN %, FY 2025-26



Source: Financial Report FY 2025-26



6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) - OPERATIONS IN THE TARGET MARKET

COMPETITIVE POSITIONING

- PH1 Industries Limited (formerly known as PH1 Industries Private Limited) is a specialized alternate fuel and raw material (AFR) firing systems integrator that helps cement plants use alternative fuels and raw materials safely and efficiently at high thermal substitution rates (TSR).
- **PH1 Industries Limited (formerly known as PH1 Industries Private Limited) is the leading liquid AFR system manufacturer in India with over 75% of the market share in this segment.**
- Unlike conventional material handling suppliers, the company provides end-to-end AFR solutions through a single platform, covering waste processing, storage, extraction, conveying, dosing, firing, automation, and emission control. It handles liquid and solid AFR streams, including hazardous, low-flash-point, high-viscosity, and heterogeneous fuels.
- With installations across India and international markets, PH1 Industries Limited (formerly known as PH1 Industries Private Limited) helps cement producers increase TSR, reduce coal dependency, and meet sustainability goals through reliable AFR firing systems.

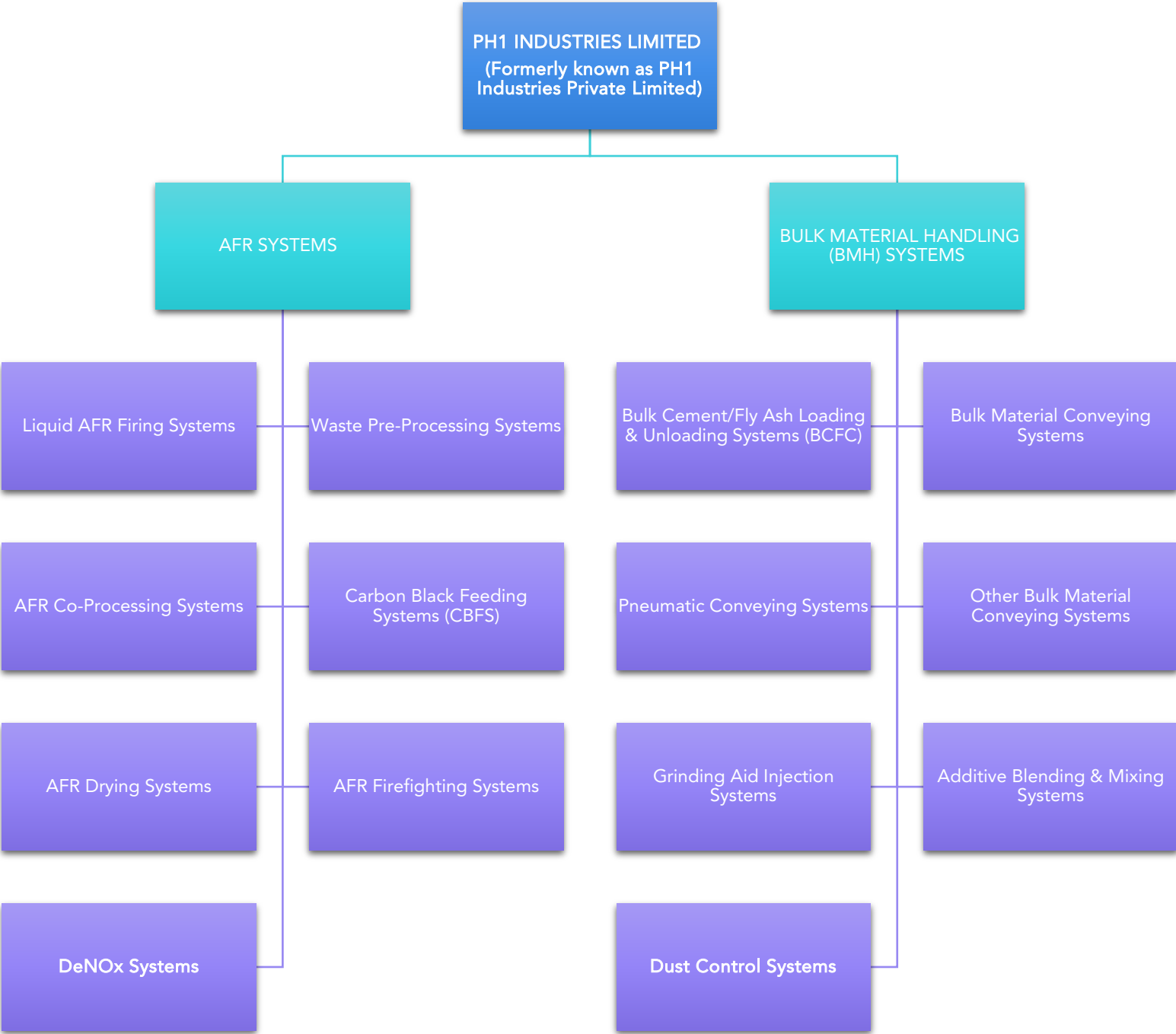
Core Solutions and Product Offerings

- **AFR Systems:** PH1 Industries Limited (formerly known as PH1 Industries Private Limited) specializes in the design, engineering, manufacturing, and turnkey delivery of alternate fuel and raw material (AFR) firing systems for cement industry. Its portfolio covers liquid AFR firing systems, including storage tanks, pumping skids, anti-static and corrosion-resistant pipelines, automated Programmable Logic Controller (PLC) controls, flow control stations, self-cleaning filters, and firing nozzles with auto retractors. For solid fuels, the company offers integrated co-processing and firing systems comprising extraction units, weighing systems, conveying solutions, dosing equipment, and kiln/calcliner feeding technologies. The systems are engineered to handle a wide range of hazardous, viscous, low-flash-point, and heterogeneous fuels while ensuring stable combustion. Safety-focused features such as ATEX-compliant instrumentation, electronic grounding systems, flame arresters, and automated firefighting systems are incorporated throughout the firing chain.
- **BMH Systems:** PH1 Industries Limited (formerly PH1 Industries Private Limited) is an engineering and technology company specializing in the design, manufacturing, and turnkey delivery of integrated Bulk Material Handling (BMH), Process Conveying, and Industrial Logistics Systems. PH1 develops high-capacity mechanical and pneumatic conveying systems, including Troughed Belt Conveyors with capacities of up to 4,000 TPH, Apron Conveyors operating in temperatures up to 600°C, Chain Conveyors, Screw Conveyors, and Bucket Elevators. Pneumatic solutions include Dense Phase and Lean Phase Conveying Systems and Air Slide Conveyors for fine, dry materials. The company also provides material loading and unloading solutions such as Ship Loading and Unloading Equipment, BCFC Wagon Unloading Systems, and Bulker Unloading Units. Additional offerings include Additive Blending and Mixing Systems with automated dosing and PLC-based recipe management, and flow-control equipment, including Guillotine Dampers, Butterfly Dampers, Slide Gates, Divertor Gates, and Dosing Valves.

Key Operations Analysis

- PH1 Industries Limited (formerly known as PH1 Industries Private Limited)'s operational strength lies in its ability to provide end-to-end AFR firing infrastructure, from fuel reception and storage to controlled combustion inside cement kilns. The company has completed more than 80 commissioned installations across multiple geographies. Its firing systems are designed to manage difficult fuels with varying viscosities, calorific values, particle sizes, and moisture content without compromising kiln stability. Automated PLC-Distributed Control System (DCS) integration, precision flow control, and real-time monitoring support dosing accuracy and combustion efficiency. Safety is a core operational focus, supported by anti-static designs, flameproof equipment, grounding systems, and automated fire suppression solutions. The company uses corrosion-resistant materials and low-maintenance designs to improve equipment durability and reduce life cycle costs for plant operators.

6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) – PRODUCTS & SERVICES



6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) – PRODUCTS & SERVICES

AFR SYSTEMS PRODUCT PORTFOLIO

PRODUCTS/BRANDS/SERVICE LINES	DESCRIPTIONS
Liquid AFR Firing Systems	Integrated systems for handling liquid alternative fuels such as waste oils and solvents. These systems ensure safe storage, filtration, and precise dosing into kilns or furnaces for efficient combustion.
Waste Pre-Processing Systems	Facilities designed to sort, crush, and shred municipal or industrial waste. These systems convert raw waste into standardized Refuse-Derived Fuel (RDF) or Solid Recovered Fuel (SRF) suitable for energy recovery.
AFR Co-Processing Systems	Specialized feeding and multi-channel injection setups that introduce solid and semi-solid wastes directly into high-temperature processes. This neutralizes hazardous elements while maximizing thermal energy extraction.
Carbon Black Feeding Systems (CBFS)	Dust-free pneumatic conveying and micro-dosing systems for carbon black powders. These systems ensure safe transport of volatile materials to combustion points without contamination or wastage.
AFR Drying Systems	Thermal units that use recycled factory waste heat to reduce moisture in alternative fuels. This improves combustion efficiency and increases the net calorific value of the fuel.
AFR Fire Fighting Systems	Safety systems for waste storage zones, using inert gases such as CO ₂ or N ₂ and thermal scanners. These systems suppress early fire risks in AFR silos.
DeNOx Systems	Emission control systems using Selective Non-Catalytic Reduction (SNCR) technology. These systems inject reagents into flue gases to reduce nitrogen oxide emissions before release into the atmosphere.

BULK MATERIAL HANDLING (BMH) SYSTEMS PRODUCT PORTFOLIO

PRODUCTS/BRANDS/SERVICE LINES	DESCRIPTIONS
Bulk Cement / Fly Ash Loading & Unloading Systems (BCFC)	High-efficiency transport terminals using fluidizing systems and telescoping discharge chutes. Designed for dust-free, rapid loading and unloading of road tankers, rail bulkers, and cargo ships.
Bulk Material Conveying Systems	Heavy-duty transport lines with custom belt conveyors, enclosed bucket elevators, and rugged transfer chutes. Built to move large volumes of raw minerals over long distances.
Pneumatic Conveying Systems	Pressurized pipeline networks using dense-phase or lean-phase pneumatic technology. These systems transport fragile or powdery materials across facilities using clean air currents.
Other Bulk Material Conveying Systems	Secondary mechanical movers such as drag chain conveyors, screw conveyors, and air slides. Designed for confined spaces or use with abrasive raw materials.
Grinding Aid Injection Systems	High-precision, chemical-resistant dosing skids that spray grinding aids into mills. These systems improve grinding efficiency and prevent raw material particles from clumping.
Additive Blending & Mixing Systems	Industrial batching systems that weigh, mix, and homogenize minerals, additives, or chemicals. These systems ensure uniform manufacturing standards across production.
Dust Control Systems	Air-filtration systems with pulse-jet bag filters and localized extraction hoods. These systems capture particulate matter at the source, maintaining plant air quality.

Source: Mordor Intelligence



6 PH1 INDUSTRIES LIMITED (FORMERLY KNOWN AS PH1 INDUSTRIES PRIVATE LIMITED) – STRATEGIC INITIATIVES

Corporate Strategy	PH1 Industries Limited (formerly known as PH1 Industries Private Limited)'s corporate strategy focuses on supporting industrial decarbonization through AFR firing technologies that reduce dependence on coal and conventional fossil fuels. The company pursues growth through customized engineering solutions, turnkey project delivery, and long-term customer partnerships. Continuous investment in research, development, and process innovation enables PH1 Industries Limited (formerly known as PH1 Industries Private Limited) to address evolving fuel and environmental challenges. Automation, safety, and sustainability form the foundation of its solution development strategy. The company aims to strengthen its position as a preferred technology partner for waste-to-energy utilization and alternative fuel adoption across industrial sectors.
Brand Repositioning	PH1 Industries Limited (formerly known as PH1 Industries Private Limited) operates as a specialized engineering and technology company offering AFR firing systems focused on reliability, safety, and environmental compliance. The company's positioning is built on customized solutions, technical expertise, and project execution rather than standard equipment supply. Its "Concept, Create & Culminate" philosophy reflects end-to-end project ownership, from design through commissioning. The company's experience in hazardous fuel handling, environmental compliance, and automation supports its credibility among industrial customers. PH1 Industries Limited (formerly known as PH1 Industries Private Limited) positions itself as a sustainability-focused partner that helps industries convert waste streams into usable thermal energy.
Channel Strategy	PH1 Industries Limited (formerly known as PH1 Industries Private Limited) primarily uses a direct technical sales and project consulting approach targeting cement manufacturers and other process industries. Customer engagement typically begins with feasibility studies, process evaluations, and engineering consultations before progressing to turnkey project execution. The company's channel strategy relies on engineering relationships with plant management, operations teams, and project departments. Long-term support services, commissioning assistance, and operational optimization help generate repeat business and customer retention.
Product & Innovation Strategy	PH1 Industries Limited (formerly known as PH1 Industries Private Limited)'s innovation strategy focuses on developing safer and more efficient AFR firing systems through engineering customization and automation. The company integrates Programmable Logic Controller-Distributed Control System (PLC-DCS) platforms, intelligent instrumentation, process monitoring, and advanced safety interlocks to enhance operational performance. Product development targets the handling of increasingly diverse liquid and solid alternative fuels while ensuring stable combustion and accurate dosing. Continuous improvements in corrosion resistance, fire protection, material handling, and emission-control integration support system reliability and sustainability. By combining in-house engineering expertise with rapid solution development, PH1 Industries Limited (formerly known as PH1 Industries Private Limited) aims to maintain technological differentiation in the AFR firing systems market.

Source: Mordor Intelligence

7. FINANCIAL BENCHMARKING ANALYSIS

7 FINANCIAL BENCHMARKING ANALYSIS

Company	Location	Focus Area	Key Equipment
Frigate Teknologies Pvt. Ltd.	Faridabad, Haryana	Pre-Processing & System Integration	Material reception stations, hydraulic truck unloading platforms, storage silos, air sifters, cyclone loops, bag filters
		Co-Processing & Kiln Feeding	High-incline apron feeders, heavy bucket elevators (AFR series), rotary air locks, pneumatic shut-off gates
Maxin India Machinery Manufacturers Pvt. Ltd.	Coimbatore, Tamil Nadu	Mechanical Size Reduction (Primary & Secondary)	Twin-shaft shredders (Hodis H1000), dual-shaft RDF shredders, continuous cutting lines
Alfa Therm Limited	New Delhi	Turnkey Sorting & Density Classification	Apron feeders, trommel screens, ballistic & air classifiers
		Ferrous/Non-Ferrous Separation & Safety	Overband magnetic separators, eddy current systems, online weigh feeders
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	Hyderabad, Telangana	AFR System: Turnkey engineering of safe handling loops for volatile, hazardous, and viscous liquid alternative fuel streams prior to kiln deployment, High-precision volumetric flow extraction and dosing for heterogeneous dry waste fractions to calciner injection points.	AFR System: AFR firing modules, sludge blending hoppers, and automated dosing skids, Dense-phase pneumatic conveying systems, dosing valves, and drag chain conveyors.
		BMH Systems: Mechanical and pneumatic conveying systems for continuous plant logistics and abrasive material transfer.	BMH Systems: Troughed belt conveyors (up to 4,000 TPH), bucket elevators (up to 600 TPH), apron/screw feeders, lean-phase vacuum systems, guillotine dampers, slide gates, and port/rail unloading systems.

OPERATING MARGIN, IN %, PH1 INDUSTRIES LIMITED AND COMPETITORS, FY 2022-23 – FY 2025-26

Company Name	FY2022-23	FY2023-24	FY2024-25	FY2025-26
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	6.73%	6.92%	10.23%	21.63%
Frigate Teknologies Pvt. Ltd.	6.49%	10.21%	12.25%	NA
Maxin India Machinery Manufacturers Pvt. Ltd.	3.62%	2.65%	3.60%	NA
Alfa Therm Limited	18.17%	14.77%	NA	NA

RETURN ON EQUITY AND RETURN ON CAPITAL EMPLOYED, IN %, PH1 INDUSTRIES LIMITED AND COMPETITORS, FY 2022-23 – FY 2025-26

Company Name	Return on Equity (%)				Return on Capital Employed (%)			
	FY 22-23	FY 23-24	FY 24-25	FY 25-26	FY 22-23	FY 23-24	FY 24-25	FY 25-26
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	56.25%	7.94%	18.85%	59.50%	46.94%	14.36%	23.08%	68.21%
Frigate Teknologies Pvt. Ltd.	-16.65%	-87.00%	2463.98%	NA	-17.97%	-114.53%	224.61%	NA
Maxin India Machinery Manufacturers Pvt. Ltd.	13.59%	19.29%	21.97%	NA	16.20%	17.65%	19.26%	NA
Alfa Therm Limited	37.57%	48.15%	NA	NA	54.21%	60.28%	NA	NA

REVENUE FROM OPERATIONS, INR CRORE, PH1 INDUSTRIES LIMITED AND COMPETITORS, FY 2023-24 – FY 2025-26

Company Name	FY2022-23	FY2023-24	FY2024-25	FY2025-26
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	49.46	16.63	22.46	56.49
Frigate Teknologies Pvt. Ltd.	13.93	11.83	12.36	NA
Maxin India Machinery Manufacturers Pvt. Ltd.	14.06	15.04	17.23	NA
Alfa Therm Limited	73.52	87.93	NA	NA

Sources: Ministry of Corporate Affairs, Company Website, Mordor Intelligence



7. FINANCIAL BENCHMARKING ANALYSIS

7 FINANCIAL BENCHMARKING ANALYSIS

WORKING CAPITAL, IN INR CRORE, PH1 INDUSTRIES LIMITED AND COMPETITORS, FY 2023-24 – FY 2025-26

Company Name	FY2022-23	FY2023-24	FY2024-25	FY2025-26
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	2.44	-0.26	0.31	6.36
Frigate Teknologies Pvt. Ltd.	-1.18	-2.28	-1.22	NA
Maxin India Machinery Manufacturers Pvt. Ltd.	1.35	0.84	1.33	NA
Alfa Therm Limited	-4.07	9.34	NA	NA

WORKING CAPITAL ANALYSIS, PH1 INDUSTRIES LIMITED AND COMPETITORS

- PH1's net working capital (NWC) increased from INR 2.44 crore in FY22-23 to INR 6.36 crore in FY25-26, following a temporary decline to negative INR 0.26 crore in FY23-24 and a recovery to INR 0.31 crore in FY24-25. The FY25-26 increase coincided with revenue expansion from INR 22.46 crore to INR 56.49 crore, reflecting higher working capital requirements at increased operating scale.
- The negative NWC position in FY23-24 occurred alongside a 66.37% revenue contraction, while days payable outstanding (DPO) increased sharply from 42.68 days to 234.67 days, indicating greater reliance on supplier credit during the period of lower operating scale.
- Peer companies exhibited materially different working capital structures. Frigate reported negative NWC of INR 1.18 crore, INR 2.28 crore, and INR 1.22 crore during FY22-23 to FY24-25, while Maxin maintained positive NWC of INR 1.35 crore, INR 0.84 crore, and INR 1.33 Cr. Alfa Therm showed significant variation, moving from negative INR 4.07 crore to INR 9.34 crore between FY22-23 and FY23-24.
- PH1's FY25-26 NWC of INR 6.36 crore, equivalent to 11.26% of revenue, reflects its current operating scale and normalized supplier credit position, making FY25-26 the most relevant historical reference point for forward working capital funding assessment.

CASH CONVERSION CYCLE (CCC), IN DAYS, PH1 INDUSTRIES LIMITED AND COMPETITORS, FY 2022-23 – FY 2025-26

Company Name	FY2022-23	FY2023-24	FY2024-25	FY2025-26
PH1 Industries Limited (formerly known as PH1 Industries Private Limited)	11.40	-21.45	13.50	41.89
Frigate Teknologies Pvt. Ltd.	128.89	-138.84	-149.25	NA
Maxin India Machinery Manufacturers Pvt. Ltd.	80.75	84.65	153.92	NA
Alfa Therm Limited	5.99	-9.85	NA	NA

CASH CONVERSION CYCLE (CCC) ANALYSIS, PH1 INDUSTRIES LIMITED AND COMPETITORS

- PH1's cash conversion cycle (CCC) moved from -21.45 days in FY23-24 to 41.89 days in FY25-26, following a normalization from 13.50 days in FY24-25. This movement reflects changes in receivables, inventory, and supplier credit utilization across the period.
- The negative CCC of -21.45 days in FY23-24 was primarily driven by a DPO of 234.67 days, which exceeded the combined days sales outstanding (DSO) of 141.74 days and days inventory outstanding (DIO) of 71.47 days, resulting in supplier credit more than offsetting the cash tied up in receivables and inventory.

7 FINANCIAL BENCHMARKING ANALYSIS

- The increase in CCC occurred despite improvements in operating cycle metrics: DSO declined from 141.74 days in FY23-24 to 43.82 days in FY25-26, while DIO declined from 144.27 days in FY24-25 to 103.51 days in FY25-26. However, DPO also normalized from 200.33 days to 105.44 days, with the reduction in supplier credit more than offsetting the improvements in DSO and DIO.
- Peer comparisons indicate that CCC is heavily influenced by payable policies and operating cycle structure. Frigate's CCC of -149.25 days in FY24-25 was supported by a DPO of 355.58 days, while Maxin's CCC of 153.92 days was driven by a DSO of 110.32 days and DIO of 161.46 days. This highlights the importance of evaluating CCC alongside DSO, DIO, and DPO.

PROJECTED REVENUE AND NWC - CONSERVATIVE GROWTH SCENARIO OF PH1 INDUSTRIES LIMITED, INR CRORE, TILL FY 2030-31

Fiscal Year	Projected Revenue (CAGR of 10.75%)	Required NWC at 11.26%	Incremental NWC vs FY25-26 Base
FY2025-26 (Base)	56.49	6.36	-
FY2026-27	62.56	7.04	0.68
FY2027-28	69.29	7.80	1.44
FY2028-29	76.74	8.64	2.28
FY2029-30	84.99	9.57	3.21
FY2030-31	94.12	10.60	4.24

PROJECTED REVENUE AND NWC - HIGH-GROWTH SCENARIO OF PH1 INDUSTRIES LIMITED INR CRORE, TILL FY 2030-31

Fiscal Year	Projected Revenue (CAGR of 20%)	Required NWC at 11.26%	Incremental NWC vs FY25-26 Base
FY2025-26 (Base)	56.49	6.36	-
FY2026-27	67.79	7.63	1.27
FY2027-28	81.35	9.16	2.80
FY2028-29	97.61	10.99	4.63
FY2029-30	117.14	13.19	6.83
FY2030-31	140.57	15.83	9.47

WORKING CAPITAL REQUIREMENT FOR IPO

- FY2025-26 reported revenue of INR 56.49 crore, NWC of INR 6.36 crore, and NWC intensity of 11.26% in FY25-26, providing the baseline for the working capital projection analysis.
- Based on the projected 10.75% CAGR of the India Alternate Fuel and Raw Materials (AFR) Firing Systems Market during 2026-2031 and PH1's FY25-26 NWC intensity of 11.26%, the estimated incremental NWC funding requirement reaches INR 4.24 crore by FY30-31. Projected revenue increases to INR 94.12 crore, while required NWC rises to INR 10.60 crore.
- Under a higher-growth scenario of 20% revenue CAGR, projected revenue reaches INR 140.57 crore by FY30-31, resulting in required NWC of INR 15.83 crore and an estimated incremental NWC funding requirement of INR 9.47 crore over the FY25-26 base.



7 FINANCIAL BENCHMARKING ANALYSIS

PH1 Industries Limited (formerly known as PH1 Industries Private Limited)

Financial Year	FY2022-23	FY2023-24	FY2024-25	FY2025-26
Revenue	49.46	16.63	22.46	56.49
Revenue Growth % (Y-o-Y %)	236.92%	-66.37%	35.04%	151.50%
Operating Profit	3.33	1.15	2.30	12.22
Operating Margin %	6.73%	6.92%	10.23%	21.63%
Working Capital (NWC)	2.44	-0.26	0.31	6.36
Debt-Equity Ratio	1.08	1.19	1.20	0.80
Return on Equity	56.25%	7.94%	18.85%	59.50%
Return on Capital Employed	46.94%	14.36%	23.08%	68.21%
EBITDA	3.42	1.41	2.80	12.70
EBITDA Margin	6.91%	8.45%	12.45%	22.48%
Days Sales Outstanding (DSO)(Days)	41.69	141.74	69.56	43.82
Days Inventory Outstanding (DIO) (Days)	12.39	71.47	144.27	103.51
Days Payable Outstanding (DPO) (Day)	42.68	234.67	200.33	105.44
Cash Conversion Cycle (CCC) (Days)	11.40	-21.45	13.50	41.89

Frigate Teknologies Pvt. Ltd.

Financial Year	FY2022-23	FY2023-24	FY2024-25	FY2025-26
Revenue	13.93	11.83	12.36	NA
Revenue Growth % (Y-o-Y %)	125.03%	-15.09%	4.46%	NA
Operating Profit	0.90	1.21	1.51	NA
Operating Margin %	6.49%	10.21%	12.25%	NA
Working Capital (NWC)	-1.18	-2.28	-1.22	NA
Debt-Equity Ratio	-0.14	-0.54	45.84	NA
Return on Equity	-16.65%	-87.00%	2463.98%	NA
Return on Capital Employed	-17.97%	-114.53%	224.61%	NA
EBITDA	0.20	0.74	0.65	NA
EBITDA Margin	1.41%	6.29%	5.26%	NA
Days Sales Outstanding (DSO)(Days)	128.89	165.38	203.94	NA
Days Inventory Outstanding (DIO) (Days)	NA	3.79	2.39	NA
Days Payable Outstanding (DPO) (Day)	0.00	308.01	355.58	NA
Cash Conversion Cycle (CCC) (Days)	128.89	-138.84	-149.25	NA

Sources: Ministry of Corporate Affairs, Company Website, Mordor Intelligence



7 FINANCIAL BENCHMARKING ANALYSIS

Maxin India Machinery Manufacturers Pvt. Ltd.

Financial Year	FY2022-23	FY2023-24	FY2024-25	FY2025-26
Revenue	14.06	15.04	17.23	NA
Revenue Growth % (Y-o-Y %)	44.31%	6.93%	14.57%	NA
Operating Profit	0.51	0.40	0.62	
Operating Margin %	3.62%	2.65%	3.60%	NA
Working Capital (NWC)	1.35	0.84	1.33	NA
Debt-Equity Ratio	1.32	1.05	0.81	NA
Return on Equity	13.59%	19.29%	21.97%	NA
Return on Capital Employed	16.20%	17.65%	19.26%	NA
EBITDA	0.55	0.62	0.64	NA
EBITDA Margin	3.93%	4.13%	3.70%	NA
Days Sales Outstanding (DSO)(Days)	62.15	68.83	110.32	NA
Days Inventory Outstanding (DIO) (Days)	88.44	97.88	161.46	NA
Days Payable Outstanding (DPO) (Day)	69.84	82.06	117.86	NA
Cash Conversion Cycle (CCC) (Days)	80.75	84.65	153.92	NA

Alfa Therm Limited

Financial Year	FY2022-23	FY2023-24	FY2024-25	FY2025-26
Revenue	73.52	87.93	NA	NA
Revenue Growth % (Y-o-Y %)	48.73%	19.59%	NA	NA
Operating Profit	13.36	12.99	NA	NA
Operating Margin %	18.17%	14.77%	NA	NA
Working Capital (NWC)	-4.07	9.34	NA	NA
Debt-Equity Ratio	0.16	0.18	NA	NA
Return on Equity	37.57%	48.15%	NA	NA
Return on Capital Employed	54.21%	60.28%	NA	NA
EBITDA	16.24	30.17	NA	NA
EBITDA Margin	22.09%	34.31%	NA	NA
Days Sales Outstanding (DSO)(Days)	79.49	74.75	NA	NA
Days Inventory Outstanding (DIO) (Days)	24.81	73.24	NA	NA
Days Payable Outstanding (DPO) (Day)	98.31	157.84	NA	NA
Cash Conversion Cycle (CCC) (Days)	5.99	-9.85	NA	NA

Sources: Ministry of Corporate Affairs, Company Website, Mordor Intelligence



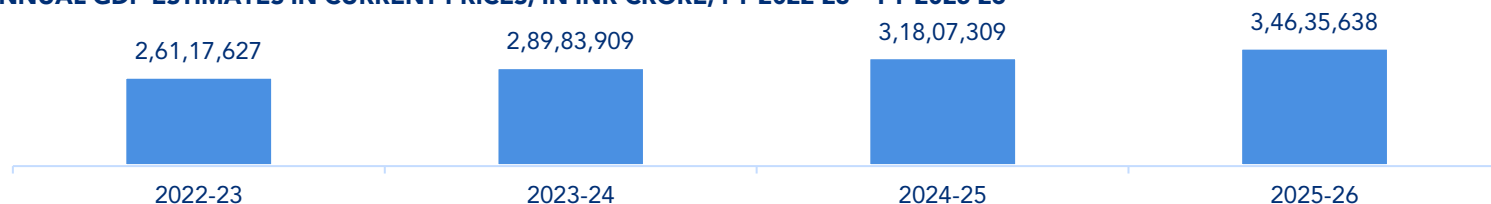
8. CURRENT ECONOMIC SCENARIO

8.1 INDIAN ECONOMIC SCENARIO

MACROECONOMIC FOUNDATION: A DEMAND ENGINE IN FULL OPERATION

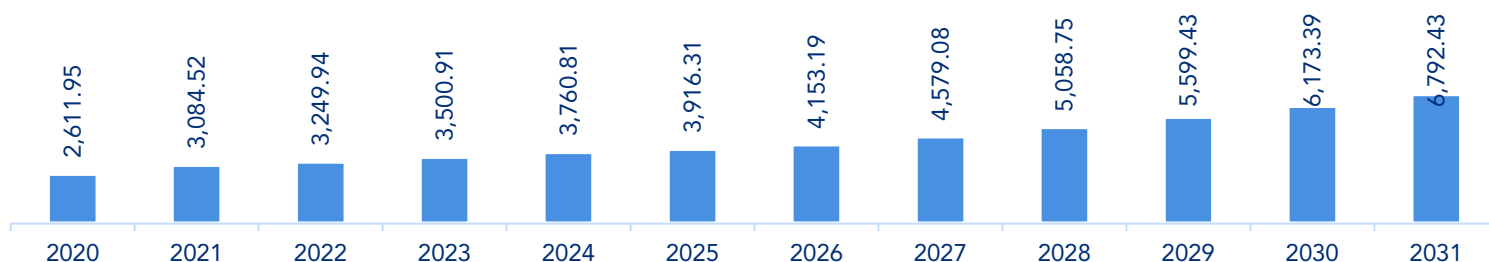
- India's macroeconomic environment in FY2025-26 provided the strongest backdrop in a decade for cement and industrial infrastructure growth. GDP expanded at 7.7% in real terms, the fastest pace in six quarters. The National Statistical Office confirmed India as the fastest-growing major economy globally for the second consecutive year, reinforcing confidence in sustained demand momentum across construction and industrial sectors.
- Looking ahead, FY2026-27 growth is projected at 7.8% under the revised GDP series. This sustained expansion underpins elevated demand for construction materials, industrial equipment, and waste management infrastructure. The growth trajectory ensures that cement and AFR system investments remain closely tied to macroeconomic performance, with strong policy and consumption support driving sectoral resilience.
- Private consumption expanded 8.7% year-on-year in Q3 FY2025-26, highlighting durable household-driven demand alongside public sector spending. This dual engine of consumption and investment creates a robust demand environment for cement, infrastructure, and waste processing systems. Together, these macroeconomic fundamentals establish a powerful demand engine, positioning India's cement sector for accelerated AFR adoption and capacity expansion through the remainder of the decade.

ANNUAL GDP ESTIMATES IN CURRENT PRICES, IN INR CRORE, FY 2022-23 – FY 2025-26

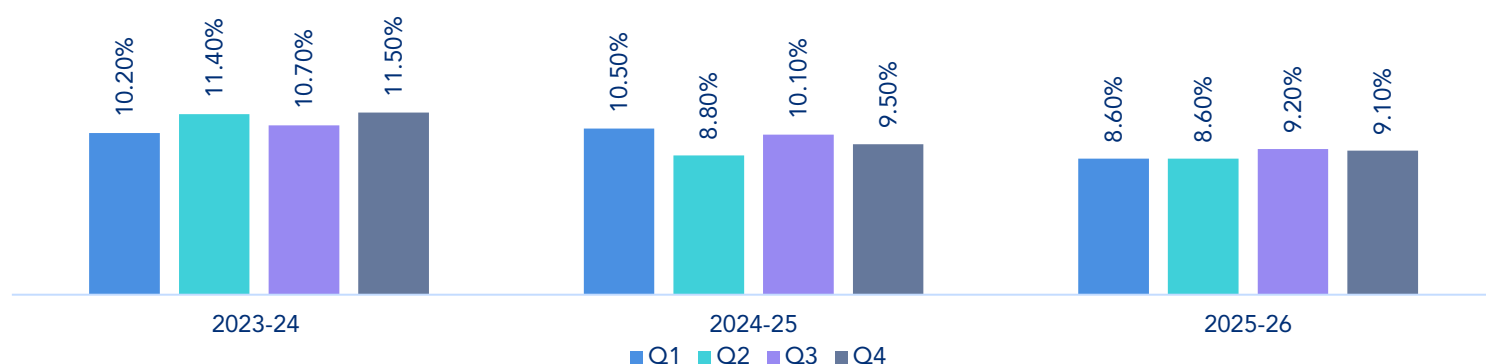


Source: Ministry of Statistics and Programme Implementation, Government of India, Mordor Intelligence

GROSS DOMESTIC PRODUCT (GDP) IN CURRENT PRICES, IN USD BILLION IN INDIA FROM 2020 TO 2031



QUARTERLY GDP GROWTH RATE, IN %, INDIA, FY2023-24 – FY2025-26

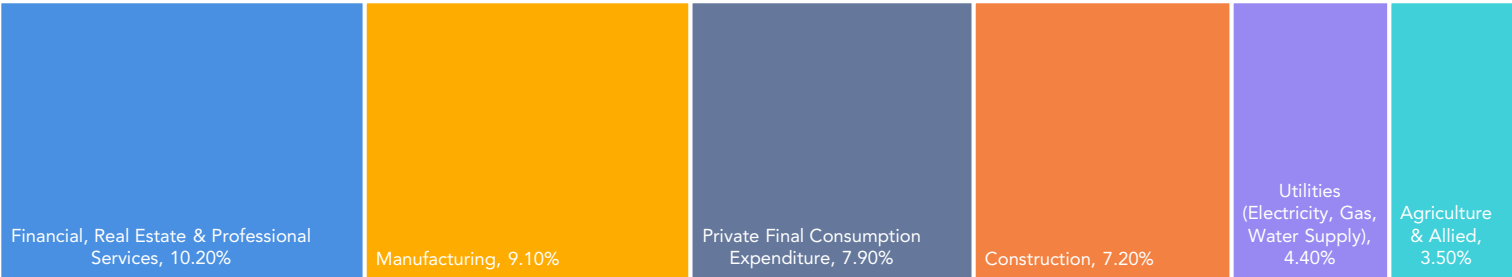


Source: International Monetary Fund, Mordor Intelligence

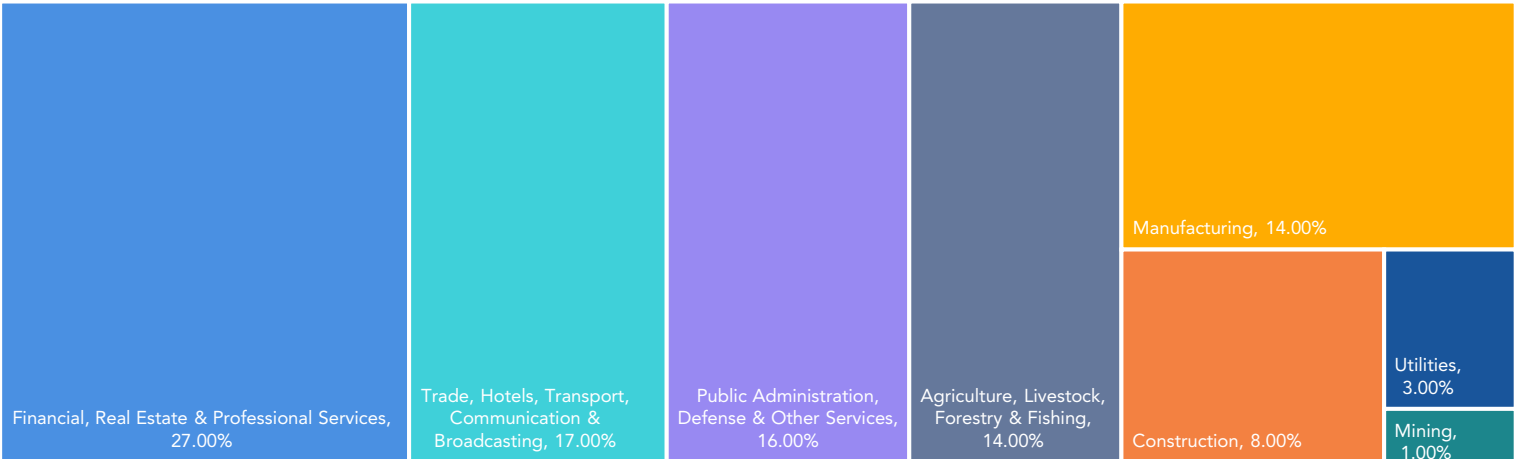


8.1 INDIAN ECONOMIC SCENARIO

GDP CONTRIBUTION SHARE, BY KEY SECTOR, FY2025 – 26 (Q2)



GDP COMPOSITION SHARE, BY KEY SECTOR, FY2025 – 26 (Q2)



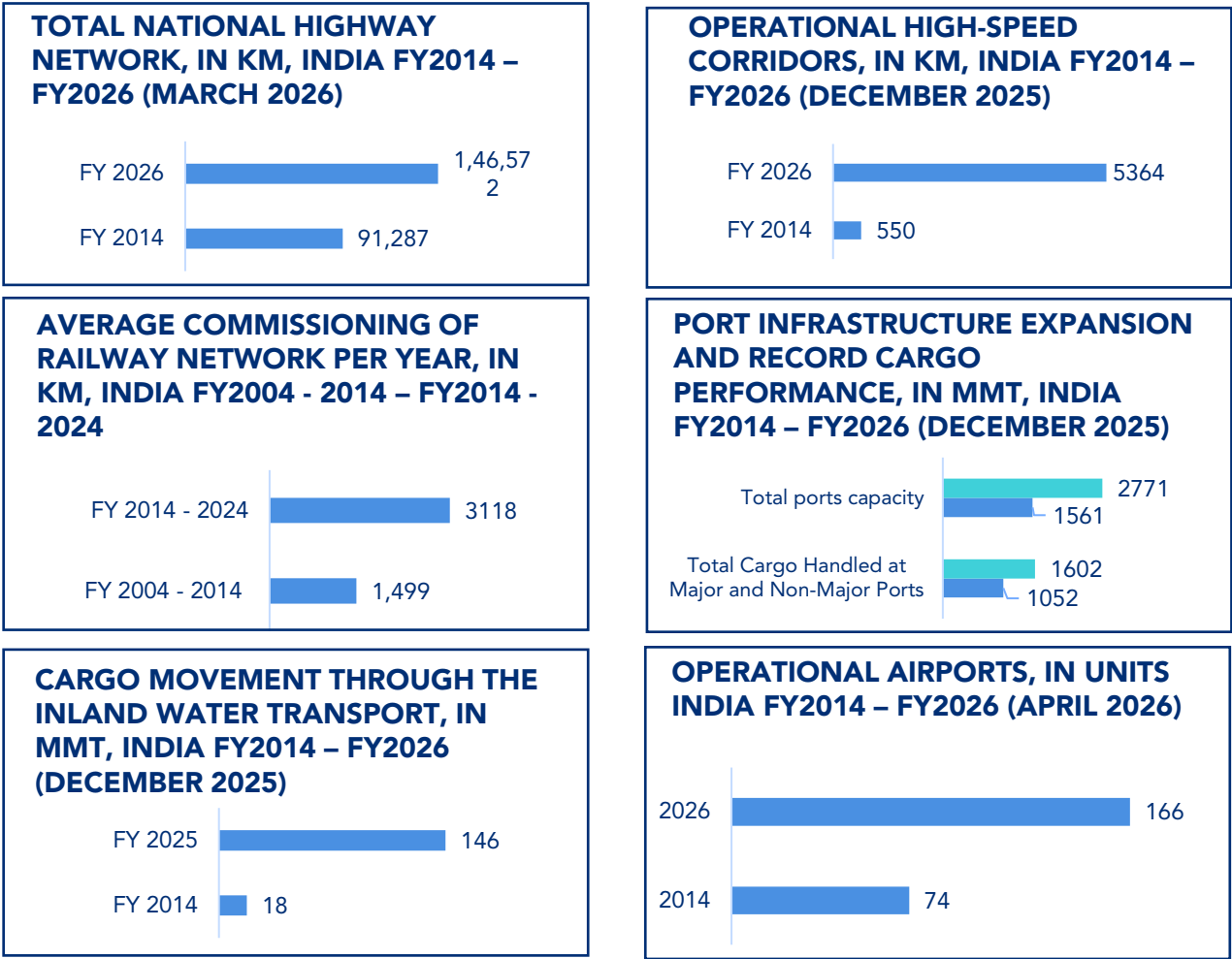
MACROECONOMIC FOUNDATION: A DEMAND ENGINE IN FULL OPERATION

- Construction Sector: Sector Growth and Cement Linkage – India's construction sector grew 7.1–8.4% in FY2025-26 and is projected to sustain 7.0–7.5% growth through FY2026-27, consistently outpacing the long-term CAGR of 6.5%. GDP from construction hit INR 7,178.60 billion in Q1 FY2026, an all-time high, reflecting accelerated public project execution after the FY2025 slowdown. Cement production rose 8.7%, the highest in six years, directly tied to road, railway, housing, and industrial park projects. Each percentage point of construction growth adds 5–7 million tons of cement demand, expanding the addressable market for Alternate Fuel and Raw Materials (AFR) retrofits and greenfield installations.
- The Infrastructure Capex Multiplier: The Union Budget 2026-27 announced record public capital expenditure of INR 12.2 lakh crore, up 9% from the prior year, representing 4.4% of GDP. Roads and highways received INR 2.87 lakh crore, the largest allocation, driving demand for bulk cement in Tier 2 and 3 markets. Railways secured INR 2.55 lakh crore, sustaining demand for precast concrete and tunnel liners. The PM Gati Shakti program covers 434 projects worth INR 11.17 lakh crore, including an Energy, Mineral, and Cement corridor, cementing long-term structural demand. Housing allocations under Pradhan Mantri Awas Yojana – Gramin (PMAY-G) and Pradhan Mantri Awas Yojana – Urban (PMAY-U) further reinforce cement consumption growth.

Source: Economic Survey 2025-26, Ministry of Ports, Shipping and Waterways, Ministry of Aviation, Ministry of Road Transport and Highways, Ministry of Statistics and Programme Implementation, Government of India, Mordor Intelligence



8.1 INDIAN ECONOMIC SCENARIO



Source: Economic Survey 2025-26, Ministry of Ports, Shipping and Waterways, Ministry of Aviation, Ministry of Road Transport and Highways, Mordor Intelligence

MACROECONOMIC FOUNDATION: A DEMAND ENGINE IN FULL OPERATION

- **City Economic Regions and Urbanization:** The City Economic Regions (CERs) initiative targets Tier 2 and 3 cities with populations above 5 lakh, accelerating urbanization in underserved regions. This expansion drives demand for housing, commercial spaces, and supporting infrastructure, creating new cement consumption hubs. By extending growth beyond metros, CERs diversify demand sources and ensure cement sector resilience. The initiative also strengthens the case for AFR adoption in smaller plants, as regional demand surges require scalable and compliant fuel systems.
- **Cement Demand: Structural Growth:** India’s cement demand is projected to grow at a 7–8% CAGR over the medium term, equivalent to 1.0–1.2 times real GDP growth. Infrastructure accounts for 29–31% of demand, the fastest-growing segment, followed by urban housing supported by interest rate reductions and Pradhan Mantri Awas Yojana (PMAY) execution. Cement demand is structurally underpinned by India’s per capita consumption of 289 kg, far below the global average of 510–560 kg, indicating significant headroom for expansion. This underpenetration ensures long-term capacity growth and sustained AFR system demand.
- **Housing Finance and Private Demand:** Individual housing loans crossed INR 37 lakh crore in March 2025, representing 11% of GDP, up from 8% a decade ago. This reflects the growing financialization of housing and a durable private demand signal. With housing demand rising alongside infrastructure projects, cement consumption is set to remain robust. The linkage between housing finance growth and cement demand reinforces the AFR opportunity, as kiln capacity expansion driven by private housing directly increases the market for AFR firing systems and emission control retrofits.

8.1 INDIAN ECONOMIC SCENARIO

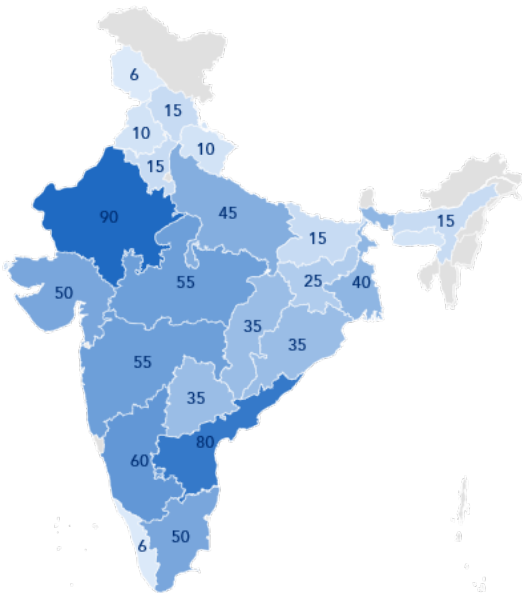
HOUSING & URBAN DEVELOPMENT PROGRAMS (2014–2026)

Program	Launch Year	Key Allocations / Corpus	Achievements / Status	Social Impact
PMAY-U	2015 (PMAY-U 2.0 in 2024)	INR 8.77 lakh crore	125.31 lakh houses sanctioned; 98.10 lakh completed by May 2026	96% allotted to women; improved access to sanitation, water, electricity
PMAY-G	2016	Target: 4.95 crore houses by 2029; 2 crore additional approved (2024–29)	3.91 crore sanctioned; 3.06 crore completed by June 2026	75% of beneficiaries are women; improved rural housing security
CLSS under PMAY-U	2015	INR 59,318 crore interest subsidy disbursed	Beneficiary-led construction, affordable housing partnerships	Enhanced affordability for urban families
SWAMIH Fund	2019	INR 15,531 crore corpus	63,000 homes delivered; 1,01,443 homes portfolio	Revived stalled projects; benefited 2.52 lakh people
AMRUT & AMRUT 2.0	2015	INR 2.79 lakh crore sanctioned (2015–26)	7,943 projects completed; 2.53 crore tap water connections	Strengthened water, sewerage, drainage, green spaces, mobility
JnNURM	Pre-2015	INR 62,983 crore sanctioned	Predecessor to AMRUT	Limited scope compared to AMRUT

MACROECONOMIC FOUNDATION: A DEMAND ENGINE IN FULL OPERATION

- Regulatory Tailwinds Amplifying Economic Signals: The Solid Waste Management Rules 2026 and Carbon Credit Trading Scheme (CCTS) have created a regulatory enforcement framework that compels AFR adoption. Rule 11 mandates Refuse Derived Fuel (RDF) utilization at 6%, 10%, and 15% over six years, forcing cement plants within 400 km of RDF facilities to integrate AFR systems. CCTS covers 186 cement plants, with non-compliance risking up to 19% profit erosion, driving immediate investment in AFR to reduce GHG intensity and earn Carbon Credit Certificates. NITI Aayog’s January 2026 roadmap commits INR 20,000 crore to co-processing infrastructure, targeting 15–20% TSR by 2030. Meanwhile, Swachh Bharat Mission Urban 2.0 achieved 81% urban waste processing by 2026, with Dumpsite Remediation Accelerator Programme (DRAP) aiming for zero dumpsites by September 2026. Together, these regulatory and waste-management initiatives amplify economic signals, ensuring AFR demand growth is both structurally and policy-driven.

ESTIMATED INSTALLED CEMENT CAPACITY, BY KEY STATES, IN MTPA, INDIA, 2025



Capacity Expansion as the Direct AFR Demand Driver

- Capacity Expansion as the Direct AFR Demand Driver: India’s installed cement capacity reached 668 MTPA in March 2025, with CRISIL projecting an addition of 160–170 MTPA by FY2028, a 75% jump compared to the previous three-year period. UltraTech Cement is expanding from 200+ MTPA to 240 MTPA with an INR 16,000 crore capex, making it the largest producer outside China.
- Ambuja/ACC under Adani is targeting 155 MTPA by FY2030, while Shree Cement, Dalmia Bharat, JSW Cement, and JK Cement collectively add 40+ MTPA across regions.
- Each MTPA of new clinker capacity requires INR 25–30 crore in AFR infrastructure to achieve 15% Thermal Substitution Rate (TSR), translating to over INR 4,000 crore in potential AFR system demand by FY2028.
- This direct linkage between capacity expansion and AFR adoption makes new projects the single largest driver of system investment.

Source: Press Information Bureau (PIB), Mordor Intelligence

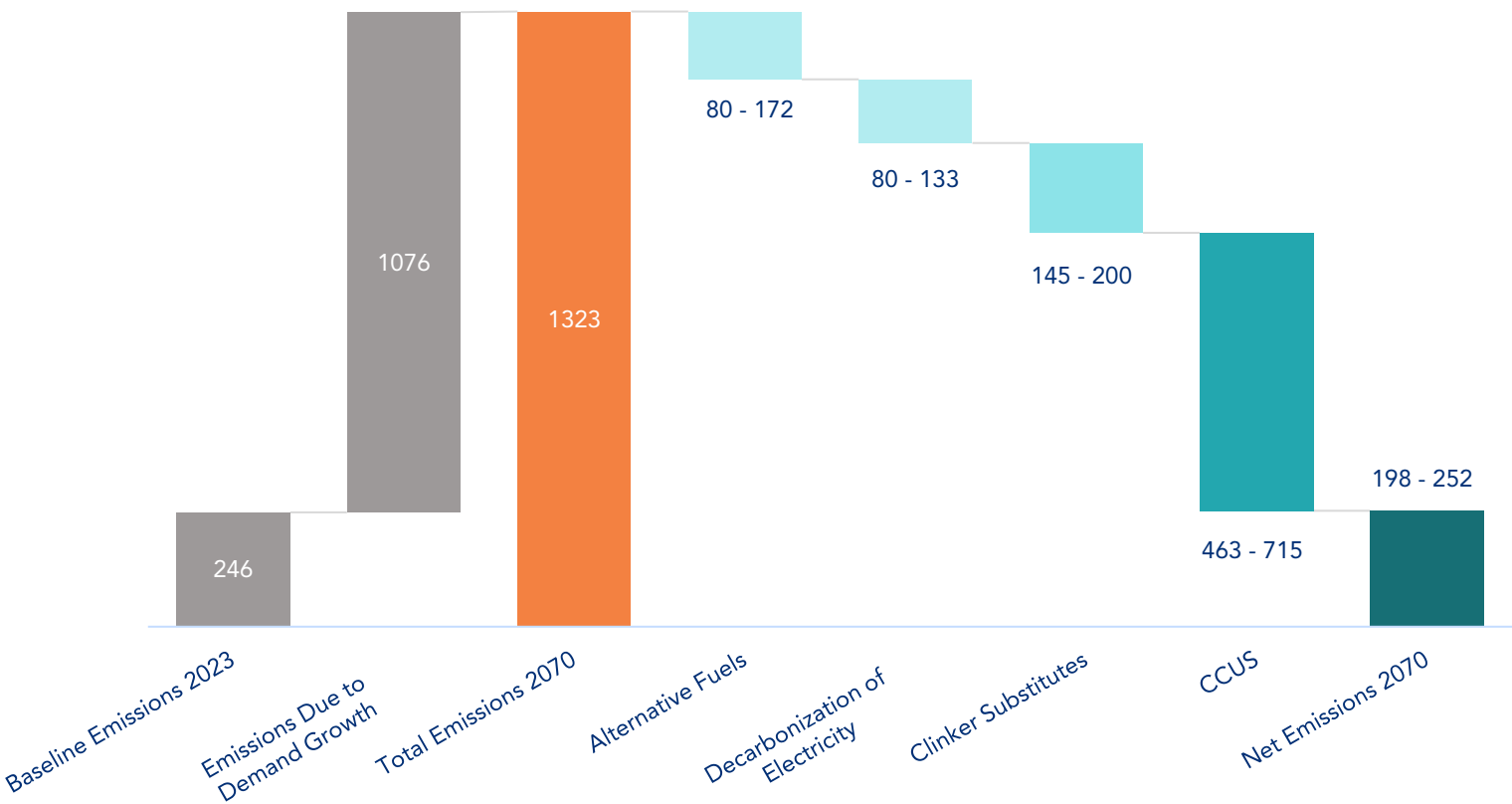


8.1 INDIAN ECONOMIC SCENARIO

MACROECONOMIC FOUNDATION: A DEMAND ENGINE IN FULL OPERATION

- CCUS and Decarbonization Linkage: Budget 2026-27 introduced a dedicated INR 20,000 crore allocation for Carbon Capture, Utilization, and Storage (CCUS), directly relevant to cement industry decarbonization. This investment strengthens the economics of AFR adoption by aligning emission reduction with national climate goals. The initiative supports cement plants in scaling Thermal Substitution Rate (TSR) while integrating CCUS, positioning AFR systems as part of a broader decarbonization strategy. Together with infrastructure spending, CCUS funding ensures that cement demand growth is matched by sustainable technology adoption.

EMISSIONS ABATEMENT BY KEY LEVER, IN MILLION TCO2E PER ANNUM, CEMENT, INDIA, TILL 2070

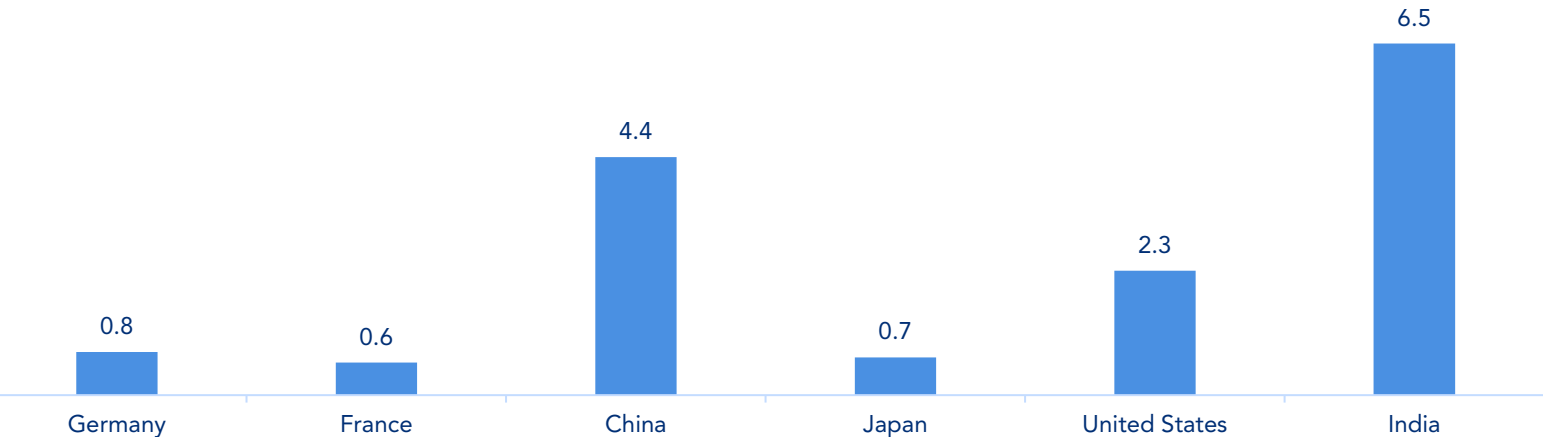


Source: Cement Manufacturers' Association, Press Information Bureau (PIB), NITI Aayog, Based on Data from WBCSD Reports, IBEF, Powerline, CEEW, Mordor Intelligence

8.2 GLOBAL ECONOMIC SCENARIO

Country	AFR Maturity / TSR	Key Data Points	Regulatory / Policy Drivers	Technology / Industry Examples	Strategic Implications for India
Germany	>70% TSR (Global benchmark)	Highest TSR globally; Geocycle Germany processes 800,000 tons AFR annually	Circular Economy Act, Landfill Ordinance, Industrial Emissions Directive; EU ETS carbon pricing	Mature RDF/SRF ecosystem; Heidelberg Materials targets 45% AFR globally, 20% biomass by 2030	Shows >70% TSR achievable with decades of investment; India ~15–20 years into trajectory
France	55–60% TSR	Holcim France reported 59% AFR use (50% biomass); carbon intensity at 490 kg CO ₂ /ton cement; 1.1 million tons of demolition waste recycled; ECOPlanet cement at 41% of sales	France Ciment Roadmap targets halving emissions by 2030; EU ETS compliance; French Climate Law mandates clinker reduction	Holcim CaptureLab (Martres-Tolosane); Recygenie project (100% recycled clinker concrete); ECOPlanet cement in Toulouse Metro Line C	France validates >55% AFR thermal substitution rates; biomass integration relevant for India's high-moisture RDF; demolition waste recycling a model for India's urban market
China	5–8% national average	World's largest producer (>2 billion tons annually); Huaxin facility >60% TSR; Huaxin avg 26.7% (2024); Taiwan Cement 19%; Conch ~8%; CNBM 7%, Jidong 11.58%	GB/T 33650-2025 standard: Class A ≥30% TSR; national plan targets 30% kiln lines AFR by 2025	Huaxin best practice; Conch used 6.77 million tons AFR in 2024	Mirrors India's pre-2026 barriers; India's SWM Rules 2026 and CCTS stronger interventions
Japan	15–28% TSR (2022–2026)	Co-processes ~22 million tons of waste annually (5% of total waste); consumed 5 million tons slag, 6 million tons coal ash, 1.7 million tons FGD gypsum	JCA benchmarking FY2025; ETS launch FY2026	UBE-Mitsubishi ammonia co-combustion demo (30% coal replacement); SCM ratio revision (5%→10%)	Roadmap for complex waste streams and frontier fuels; ETS mirrors India's CCTS
United States	16% TSR (2023)	Up from 14.6% in 2022; compared to EU avg 58%; 87 plants, 60 below 20% TSR, 39 below 5% TSR	ACA roadmap projects 50% TSR with policy support (NHSM permitting, RDF infra, landfill diversion)	Hazardous waste & TDF dominate AFR mix; ATS Walter USA supplying AFR systems	Large addressable market; policy reforms could accelerate TSR; India can learn from US permitting gaps
India	3–5% TSR (current average)	Cement installed capacity 668 MTPA (2025); projected +160–170 MTPA by FY2028; UltraTech expanding to 240 MTPA	SWM Rules 2026 mandate RDF use (6%, 10%, 15% over six years); CCTS covers 186 plants; NITI Aayog roadmap targets 15–20% TSR by 2030	Early AI-enabled AFR feeding pilots (UltraTech); limited bypass/NO _x systems installed	Huge headroom vs global leaders; regulatory push + capacity expansion expected to drive rapid TSR growth

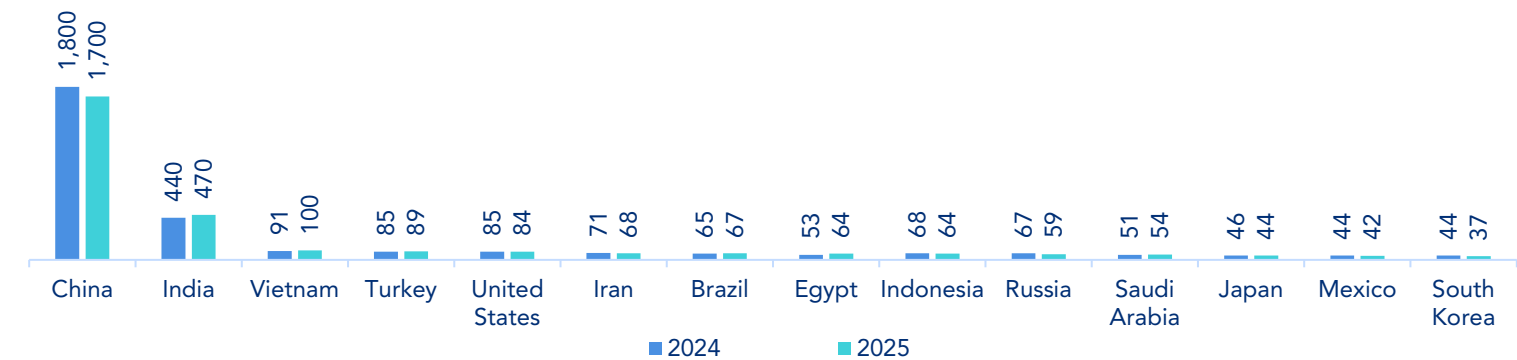
REAL GDP GROWTH, IN %, BY KEY COUNTRIES, 2026



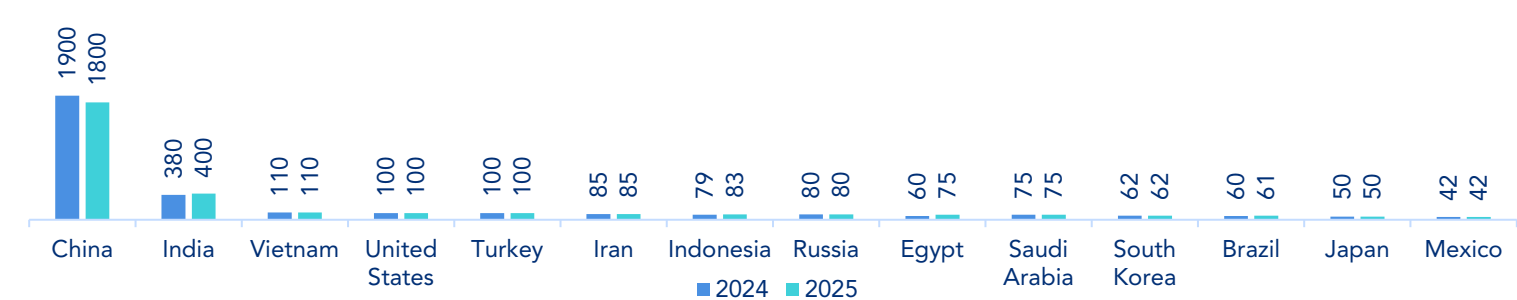
Source: International Monetary Fund (IMF), Energy Partnership China-Germany, PBL Netherlands Environmental Assessment Agency, Global Cement, American Cement Association (ACA); ATS Walter USA, Mordor Intelligence

8.2 GLOBAL ECONOMIC SCENARIO

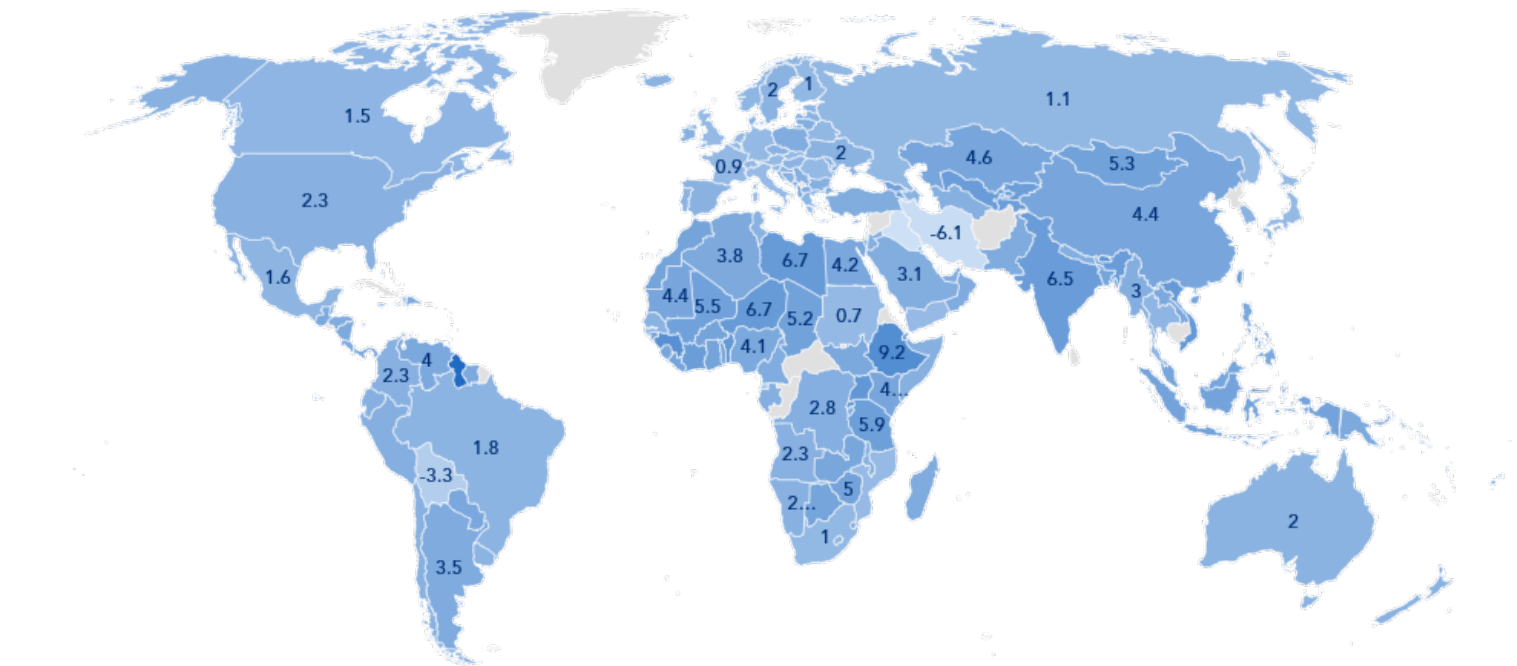
CEMENT PRODUCTION CAPACITY, KEY COUNTRIES, IN MILLION TONS, GLOBAL, 2024 - 2025



CLINKER PRODUCTION CAPACITY, KEY COUNTRIES, IN MILLION TONS, GLOBAL, 2024 - 2025



REAL GDP GROWTH, BY COUNTRY, IN %, GLOBAL, 2026

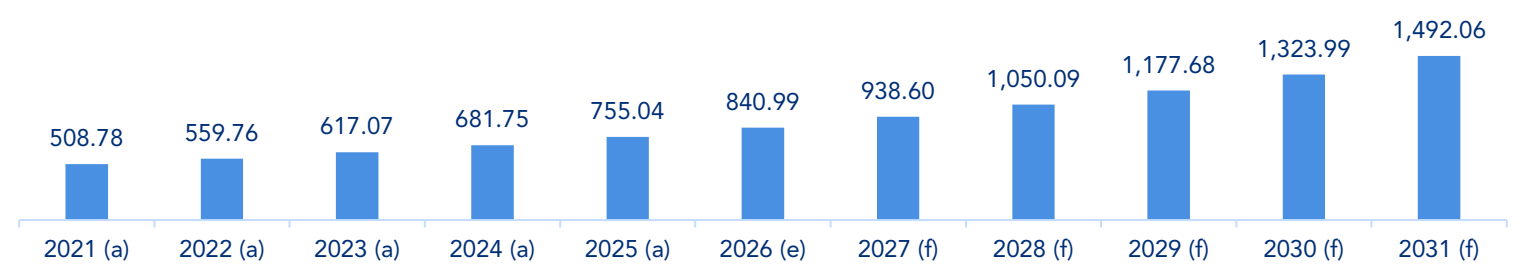


Source: U.S. Geological Survey, Mineral Commodity Summaries, February 2026, Mordor Intelligence

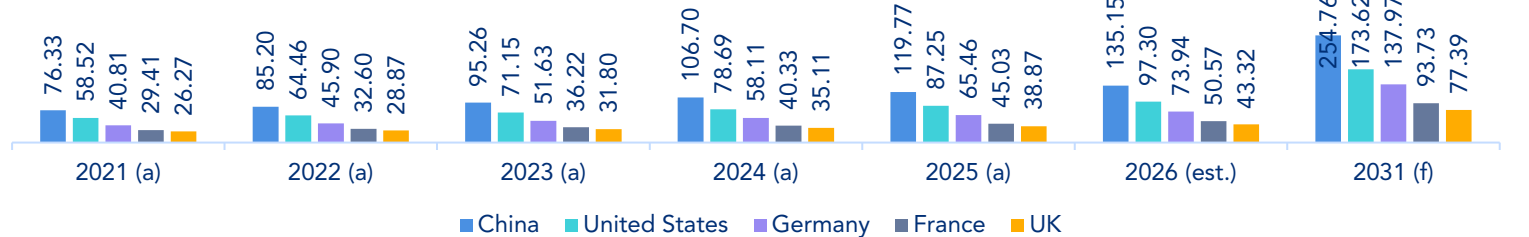


8.2 GLOBAL ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET (AFR) FIRING SYSTEMS MARKET

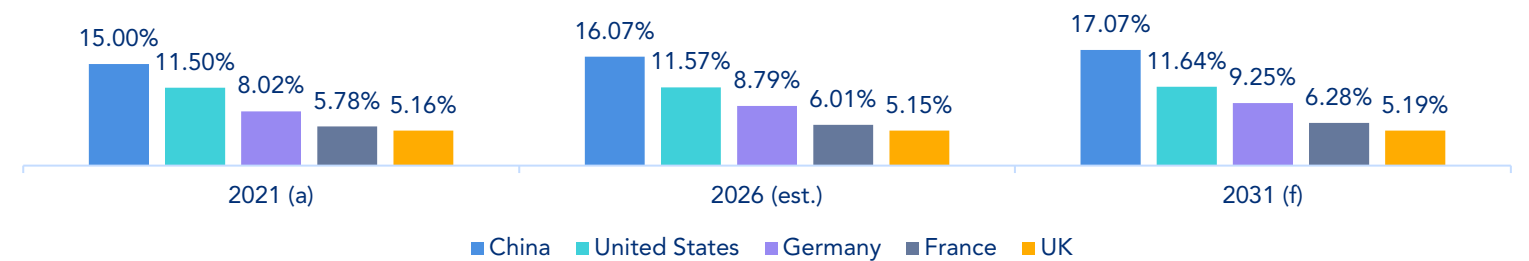
ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, GLOBAL, 2021-2031
CAGR (2026 to 2031): 12.15%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY KEY COUNTRY, GLOBAL, 2021-2031
CAGR (2026 to 2031): 12.15%



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET REVENUE SHARE (%), BY KEY COUNTRY, GLOBAL, 2021-2031



ALTERNATE FUEL AND RAW MATERIALS (AFR) FIRING SYSTEMS MARKET SIZE AND DEMAND FORECAST IN USD MILLION, BY KEY COUNTRY, GLOBAL, 2021-2031

Key Country	2021 (a)	2022 (a)	2023 (a)	2024 (a)	2025 (a)	2026 (est.)	2027 (f)	2028 (f)	2029 (f)	2030 (f)	2031 (f)	CAGR (2026 - 2031)
China	76.33	85.20	95.26	106.70	119.77	135.15	152.77	173.05	196.44	223.47	254.76	13.52%
United States	58.52	64.46	71.15	78.69	87.25	97.30	108.72	121.77	136.73	153.89	173.62	12.28%
Germany	40.81	45.90	51.63	58.11	65.46	73.94	83.57	94.57	107.13	121.50	137.97	13.29%
France	29.41	32.60	36.22	40.33	45.03	50.57	56.92	64.24	72.67	82.43	93.73	13.13%
UK	26.27	28.87	31.80	35.11	38.87	43.32	48.38	54.18	60.85	68.53	77.39	12.31%

Source: Mordor Intelligence



9. APPENDIX

9. APPENDIX

9.1 GLOSSARY OF KEY TERMS

Term	Full Form / Definition
AFR	Alternative Fuels and Raw Materials: umbrella term for non-conventional fuels (waste-derived or biomass-based) and non-primary raw materials used in cement kiln operations to partially replace fossil fuels and virgin minerals
TSR	Thermal Substitution Rate: the percentage of total thermal energy demand in a cement kiln supplied by alternative fuels, expressed as a percentage; the primary metric for measuring AFR adoption
RDF	Refuse-Derived Fuel: a solid fuel processed from non-recyclable municipal solid waste (MSW) by shredding, sorting, and screening to achieve defined calorific value and moisture specifications
SRF	Solid Recovered Fuel: higher-specification RDF complying with EN 15359 quality standards; used interchangeably with RDF in the Indian context but implies more stringent quality controls
Co-processing	The simultaneous use of waste as both an energy source and a raw material in the clinker kiln process; a zero-waste process unique to cement manufacturing because both organic and mineral fractions are utilized
MSW	Municipal Solid Waste: solid waste generated by households, commercial establishments, and institutions within a municipal area
GCV / NCV	Gross Calorific Value / Net Calorific Value: measures of energy content of a fuel; GCV includes latent heat of water vapor, NCV does not; cement kilns typically specify fuels by NCV
Precalciner	The reactor vessel installed between the preheater and rotary kiln in a modern cement plant; the optimal injection point for solid AFR due to residence times of 2 to 5 seconds at 800 °C to 900 °C and high turbulence
Main Burner / Primary Firing	The burner at the discharge end (hot end) of the rotary kiln; used for high-calorific-value solid and liquid AFR injection requiring direct flame exposure
TAD	Tertiary Air Duct: a duct transferring hot air from the clinker cooler to the calciner; a secondary injection point for AFR in facilities with constrained precalciner access
HAZMAT / HW AFR	Hazardous Materials / Hazardous Waste used as Alternative Fuel: includes spent solvents, waste oils, halogenated organics; requires special handling, storage, and injection systems with enhanced emissions monitoring
Liquid AFR	Alternative fuels in liquid or slurry form: spent oils, chemical waste liquids, emulsified waste, paint sludge; injected through burner nozzles or dedicated lances
CHWIF	Channelized Hazardous Waste Incineration Facility: a CPCB-authorized facility receiving Scheduled Hazardous Waste; co-processors (cement kilns) may receive waste streams from CHWIFs
Scheduled Waste	Hazardous waste categories listed in Schedule I of the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; requires manifest tracking, TSDF routing, or co-processor authorization
TSDF	Treatment, Storage, and Disposal Facility: a permitted facility for hazardous waste management; cement kilns with co-processing authorization are recognized as an alternative to incineration in TSDFs
CCTS	Carbon Credit Trading Scheme: India's mandatory greenhouse gas emission intensity reduction scheme, notified October 8, 2025 under the Energy Conservation Act, 2001 (as amended 2022); covers 186 cement plants in the initial phase
CCC	Carbon Credit Certificate: the tradeable instrument issued under CCTS upon verified GHG intensity reduction; trading begins October 2026
GHG	Greenhouse Gas: principally CO ₂ in the cement sector context; clinker process (calcination of limestone) contributes approximately 60% of total GHG, fuel combustion approximately 30%
Clinker Factor	The ratio of clinker content to total cement in a final cement product; lower clinker factors reduce both process CO ₂ and fuel CO ₂
SCM	Supplementary Cementitious Materials: industrial by-products (fly ash, ground granulated blast furnace slag, silica fume, calcined clays) used to partially replace clinker in cement blends
SWM Rules 2026	Solid Waste Management Rules 2026: notified January 27, 2026 (Gazette Notification S.O. 508(E)); effective April 1, 2026; mandates RDF utilization by cement plants within 400 km of RDF production facilities
RDF Grade I	As defined under SWM Rules 2026: NCV >4,500 kcal/kg; suitable for main burner injection or precalciner injection in high-performance configurations
RDF Grade II	As defined under SWM Rules 2026: NCV 3,750 to 4,500 kcal/kg; suitable for precalciner injection as primary AFR type
CPCB	Central Pollution Control Board: the national regulatory body under the Ministry of Environment, Forest and Climate Change (MoEFCC); issues emission standards, co-processing authorizations, and environmental compliance orders
SPCB	State Pollution Control Board: state-level environmental regulatory body; issues consent to operate (CTO) for cement plants and AFR co-processing facilities
MoEFCC	Ministry of Environment, Forest and Climate Change: the apex national body for environmental regulation; issues co-processing guidelines and hazardous waste management rules
BIS	Bureau of Indian Standards: the national standards body; issues specifications for cement grades, RDF quality parameters, and testing methodologies

Source: Mordor Intelligence



9. APPENDIX

9.1 GLOSSARY OF KEY TERMS

Term	Full Form / Definition
MTPA	Million Tons Per Annum: standard unit of cement production capacity measurement in India
kcal/kg	Kilocalories per kilogram: unit of calorific value; 1 kcal/kg = 4.187 kJ/kg; typical coal NCV is 5,500 to 6,500 kcal/kg for reference
MJ/kg	Megajoules per kilogram: SI unit of calorific value; 1 MJ/kg = 238.85 kcal/kg
Tipping Fee / Gate Fee	The fee paid by a waste generator or municipality to a co-processor (cement plant) for accepting and disposing of waste; a primary revenue stream for AFR-enabled cement plants beyond fuel cost savings
NITI Aayog	National Institution for Transforming India: the Government of India's policy think-tank; published the January 2026 co-processing roadmap targeting 15 to 20% TSR by 2030
CMA	Cement Manufacturers' Association of India: the national industry body for Indian cement producers; member of GCCA; advocates for AFR policies and publishes co-processing guidance
GCCA	Global Cement and Concrete Association: the international industry body; publishes global TSR data including India's 6 to 7% average (2024)
LECA / LEILAC	Low Emissions Intensity Lime And Cement: a European CCUS pilot technology being trialed at Ambuja Sanghi Kutch (India)
CCUS	Carbon Capture, Utilization, and Storage: post-combustion or oxyfuel-based technology to capture process and fuel CO ₂ from cement kilns; early-stage in India; Union Budget 2026-27 allocated INR 20,000 crore

9.2 LIST OF KEY ABBREVIATIONS

Abbreviation	Expansion
ACC	Associated Cement Companies Limited (now part of Adani Group)
ADB	Asian Development Bank
AFR	Alternate Fuel and Raw Materials
AP	Andhra Pradesh
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CAGR	Compound Annual Growth Rate
CATF	Clean Air Task Force
CCC	Carbon Credit Certificate
CCTS	Carbon Credit Trading Scheme
CHWIF	Channelized Hazardous Waste Incineration Facility
CMA	Cement Manufacturers' Association (India)
CO ₂	Carbon Dioxide
CPCB	Central Pollution Control Board
CRISIL	Credit Rating Information Services of India Limited (a subsidiary of S&P Global)
CSTEP	Centre for Study of Science, Technology and Policy
CCUS	Carbon Capture, Utilization, and Storage
ETS	Emissions Trading Scheme
EU ETS	European Union Emissions Trading System
FD	Forced Draft
FGD	Flue Gas Desulfurization
FY	Financial Year (April to March in India)
GCV	Gross Calorific Value
GCCA	Global Cement and Concrete Association
GHG	Greenhouse Gas
GOI	Government of India
GVA	Gross Value Added
HAP	Hazardous Air Pollutant
HW	Hazardous Waste
IEA	International Energy Agency
INR	Indian Rupee
IoT	Internet of Things
IRC	Indian Road Congress
JCA	Japan Cement Association

Source: International Monetary Fund (IMF), Mordor Intelligence

9. APPENDIX

9.2 LIST OF KEY ABBREVIATIONS

Abbreviation	Expansion
LCPD	Large Combustion Plant Directive
LECA	Low Emissions Cement Alliance
LEILAC	Low Emissions Intensity Lime And Cement
MJ	Megajoule
MoEFCC	Ministry of Environment, Forest and Climate Change
MoSPI	Ministry of Statistics and Programme Implementation
MTPA	Million Tons Per Annum
MSW	Municipal Solid Waste
NCV	Net Calorific Value
NDRC	National Development and Reform Commission (China)
NHSM	Non-Hazardous Secondary Materials
NITI	National Institution for Transforming India
NO _x	Nitrogen Oxides
NSO	National Statistics Office
OEM	Original Equipment Manufacturer
PAT	Perform, Achieve and Trade (BEE scheme)
PH1	PH1 Industries Limited (formerly known as PH1 Industries Private Limited)
PM	Particulate Matter
PMAY	Pradhan Mantri Awas Yojana
PMAY-G	Pradhan Mantri Awas Yojana: Gramin (Rural)
PMAY-U	Pradhan Mantri Awas Yojana: Urban
PPE	Personal Protective Equipment

Abbreviation	Expansion
RDF	Refuse-Derived Fuel
SCM	Supplementary Cementitious Materials
SOP	Standard Operating Procedure
SO ₂	Sulfur Dioxide
SPCB	State Pollution Control Board
SRF	Solid Recovered Fuel
SWM	Solid Waste Management
TAD	Tertiary Air Duct
TDF	Tire-Derived Fuel
TPD	Tons Per Day
TSDF	Treatment, Storage, and Disposal Facility
TSR	Thermal Substitution Rate
UBC	Ultra-Blended Cement
USD	United States Dollar
VFD	Variable Frequency Drive
WDF	Waste-Derived Fuel (generic term inclusive of RDF and SRF)
WTE	Waste-to-Energy
DRAP	Dumpsite Remediation Accelerator Program
ESCert	Energy Savings Certificate (BEE PAT scheme)
MoHUA	Ministry of Housing and Urban Affairs
NIP	National Infrastructure Pipeline
PMGS	PM Gati Shakti National Master Plan
SBM-U	Swachh Bharat Mission Urban

9.3 KEY ORGANIZATIONS IN INDIA'S AFR AND CO-PROCESSING ECOSYSTEM

Organization	Type	Role in AFR Ecosystem
CMA India (Cement Manufacturers' Association)	Industry Association	Represents 95%+ of Indian cement capacity; advocates AFR policies; publishes co-processing technical guidance; key interlocutor with MoEFCC and BEE on CCTS and SWM Rules
CPCB (Central Pollution Control Board)	Regulatory Body	Issues co-processing authorizations for cement plants; sets emission standards; monitors compliance with hazardous waste co-processing conditions
MoEFCC (Ministry of Environment, Forest and Climate Change)	Government Ministry	Notifies SWM Rules, Hazardous Waste Rules, and emission standards; policy owner for co-processing regulatory framework
BEE (Bureau of Energy Efficiency)	Government Agency	Administers CCTS and PAT (Perform, Achieve and Trade) scheme; issues GHG intensity targets for cement sector; receives Form A disclosures from covered cement plants
NITI Aayog	Government Think Tank	Authored January 2026 Co-processing Roadmap; coordinates inter-ministerial AFR policy; champions 15–20% TSR target by 2030
MoHUA (Ministry of Housing and Urban Affairs)	Government Ministry	Implements Swachh Bharat Mission Urban 2.0 (SBM-U 2.0) achieving 81% urban waste processing by 2026; administers Dumpsite Remediation Accelerator Program (DRAP) targeting Zero Dumpsites by September 2026; oversees urban MSW management policy and 2,900 operational MRFs with 67,000 TPD capacity, directly controls the upstream RDF supply pipeline that feeds cement kiln co-processing demand
GCCA (Global Cement and Concrete Association)	International Body	Tracks global TSR data; India member; provides benchmarking data including India's 6–7% average TSR (2024); co-authors decarbonization guidance
CSTEP (Centre for Study of Science, Technology and Policy)	Research Institution	Publishes detailed analysis of SWM Rules 2026 and readiness gaps; advises government on policy design-to-implementation bridging
Indian Cement Review	Trade Publication	Primary trade media for cement sector; publishes AFR project announcements, regulatory updates, and TSR benchmarking
IRC (Indian Road Congress)	Technical Body	Sets standards for road construction materials; indirectly influences cement demand through infrastructure specification requirements
SPCB Networks (State Pollution Control Boards)	State Regulatory Bodies	Issue Consent to Operate for cement plants; local enforcement of SWM Rules 2026 RDF mandate; variable capacity across states

Source: Mordor Intelligence



9. APPENDIX

9.4 COMPLETE SOURCE LIST

Government and Regulatory Sources

- Ministry of Environment, Forest and Climate Change (MoEFCC) / PIB: Solid Waste Management Rules 2026 Notification: pib.gov.in
- MPCB: SWM Rules 2026 Full Text (including RDF grade specifications): mpcb.gov.in
- Bureau of Energy Efficiency / Ministry of Power: CCTS GHG Intensity Rules: business-standard.com
- ICAP Carbon Action: CCTS Compliance Obligations: icapcarbonaction.com
- NITI Aayog: Co-processing Roadmap and Policy: niti.gov.in
- Ministry of Statistics and Programme Implementation (MoSPI): GDP Provisional Estimates FY2025-26: mospi.gov.in
- Asian Development Bank (ADB): Asian Development Outlook April 2026: India: adb.org

Industry and Trade Association Sources

- Cement Manufacturers' Association (CMA India): Circular Economy through Co-processing: cmaindia.org
- CMA India: Cement Energy and Environment Report: cmaindia.org
- Global Cement and Concrete Association (GCCA): Cement Industry Progress Report 2024/25 (India TSR 6-7%): gccassociation.org
- GCCA / CEMBUREAU: Co-processing Q&A: gccassociation.org
- GCCA: Cement Breakthrough Policies for Waste as Alternative Fuel: gccassociation.org

Financial and Rating Agency Sources

- CRISIL Ratings: India Cement Capacity Addition 75% Jump FY2026-28: crisilratings.com
- ICRA: Indian Construction Industry Outlook: icra.in
- ICRA: Cement Firms Profit Hit by CCTS (19% erosion): business-standard.com
- Business Standard: Budget 2026-27 cement sector boost: business-standard.com
- CareEdge Ratings: India Cement Sector Report (180-200 MTPA new capacity FY2026-FY2028): careratings.com

Company and Project Sources

- UltraTech Cement: World's Largest Outside China, INR 16,000 crore capex: business-standard.com
- Fuller Technologies: Shree Cement Nawalgarh Greenfield: fuller-technologies.com
- Dalmia Bharat: Kadapa Greenfield (INR 3,100 crore): thehindubusinessline.com
- Climate Bonds Initiative: JSW TSR 16.5% (Financing Steel-Cement Transition Report August 2026): climatebonds.net
- PH1 Industries Limited (formerly known as PH1 Industries Private Limited): Liquid AFR Projects: ph1.in
- EnWaste Expo: PH1 Industries Limited Profile (2M tons waste processed): enwastexpo.com

Policy and Research Institution Sources

- ACEEE: India Cement Decarbonization (NITI Aayog TSR targets): aceee.org
- CSTEP: SWM Rules 2026 Analysis: cstep.in
- Global CCS Institute: CCUS in Indian Cement Industry: globalccsinstitute.com
- EY: CCTS Accelerating Decarbonization: ey.com
- Reclimatize: CCTS Compliance Operations MRV CCC: reclimatize.in
- Mondaq: SWM Rules 2026 Analysis: mondaq.com
- Clean Air Task Force (CATF): US Cement Decarbonization Policy: catf.us

Trade Media and News Sources

- Indian Cement Review: AFR and Circular Resource Use: indiancementreview.com
- Indian Cement Review: Cement's 700 MTPA Vision: indiancementreview.com
- Indian Cement Review: Cementing Circularity: indiancementreview.com
- Indian Cement Review: Cement's Next Fuel Shift: indiancementreview.com
- Live Mint: Alternative Fuel and Co-processing India: livemint.com
- Global Cement: India Cement Sector Decarbonization: globalcement.com
- Global Cement: AFR in US Cement Industry (October 2025): globalcement.com
- Global Cement: Japan Cement Update (October 2025): globalcement.com
- Global Cement: Andhra Pradesh RDF Mandate: globalcement.com
- CemNet: India Cement INR 1.2 trillion Expansion: cemnet.com
- Renewable Watch: AFR/RDF in Karnataka Cement: renewablewatch.in
- The Economic Times: Cement Demand 7-8% CAGR: economictimes.indiatimes.com

International Sources

- Energy Partnership China-Germany: AFR Comparative Analysis (April 2026): energypartnership.cn
- PBL Netherlands Environmental Assessment Agency: Dutch Cement Decarbonization Options: pbl.nl
- Geocycle Germany: Co-processing Network: geocycle.com
- Heidelberg Materials: AFR Policy: heidelbergmaterials.com
- Mitsubishi UBE Cement Corporation: Ammonia Co-combustion Demo (world's first): mu-cc.com
- Holcim: Innovation Accelerating Decarbonization (50% TSR by 2030): holcim.com
- Panacea Enviro: About (Indian AFR co-processor): panaceaenviro.com
- Reuters: India GDP FY2025-26 (7.8% Q4): reuters.com
- NITI Aayog: Cement Sector Decarbonization Roadmap PDF (January 2026): niti.gov.in
- UltraTech Cement: Sustainability-Linked Bond (SLB) FY25 Performance Report (TSR 5.7%, 1.5 MT waste as AF): ultratechcement.com
- Shree Cement: ESG Databook FY2024-25 (company-wide TSR 2.41%, green electricity 56.09%): shreecement.com
- Tribune India / MoHUA: SBM-U 2.0 Achievement: 81% Urban Waste Processing (2026): tribuneindia.com
- PIB / MoHUA: Dumpsite Remediation Accelerator Program (DRAP) Zero Dumpsites by September 2026: static.pib.gov.in
- NDTV Profit / Economic Survey 2026: PM Gati Shakti: 434 projects, INR 11.17 lakh crore, Energy-Mineral-Cement corridor: ndtvprofit.com
- UNFCCC: India NDC 2031-35 (submitted April 24, 2026; CCUS and industrial decarbonization pillars): unfccc.int
- TERI / GCCA: Net-Zero Cement Roadmap for India 2070 (AFR Phase 1, SCM Phase 2, CCUS Phase 3): teri.in
- BEE India: PAT Scheme Cement Sector (PAT VII: 707 DCs, 8.485 MTOE target): beeindia.gov.in
- Down to Earth: India CCTS: First-Ever GHG Emission Intensity Targets Per Plant (0.85%-7.6%): downtoearth.org.in
- IETA: India CCTS Business Brief (per-plant target ranges, penalty = 2x carbon price): ieta.org

Source: Mordor Intelligence

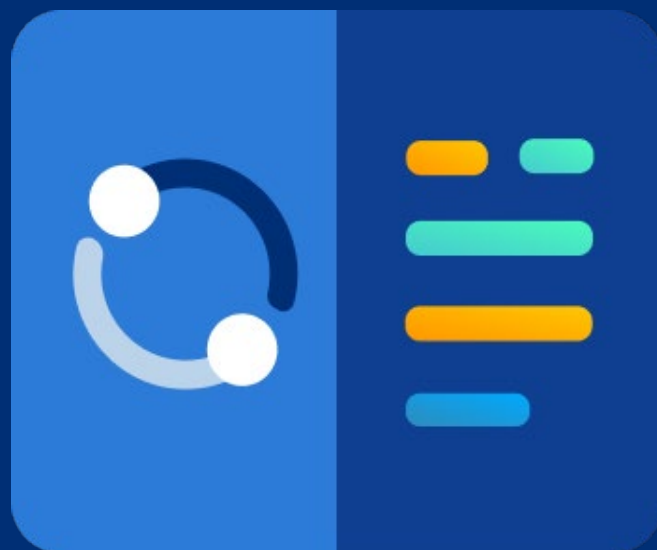


10: ABOUT US

10.1 Industry Coverage

10.2 List of Clients

10.3 Our Customized Research Capabilities



ABOUT US

+1-617-765-2493
info@mordorintelligence.com
www.mordorintelligence.com



OVER A DECADE OF
CLIENT SUCCESS



HANDCRAFTED
RESEARCH SOLUTIONS



IN-DEPTH
CONSULTATION



REAL-TIME INDUSTRY
TRACKING



DEDICATED
ANALYST SUPPORT

SNAPSHOT

On-the-ground industry experts
IN 100+ countries





5500+
Clients served globally

10000+
Projects delivered





550+ In-house analysts

10.1 OUR ENERGY AND POWER COVERAGE



Power



Oil and Gas



Renewable
Energy



Battery &
Battery
Recycling



Power
Equipment



Offshore
Support
Vessels



Environment
Control
Solutions



Energy
Storage
Technologies



Power
Machinery



Industrial
Machinery

10.2 LIST OF CLIENTS



10.3 OUR FULL SUITE OF CUSTOMIZED RESEARCH SERVICES IN THIS MARKET



FOR MORE INFORMATION, PLEASE CONTACT



11th Floor, Rajapushpa Summit, Nanakramguda Rd, Financial District,
Gachibowli, Hyderabad - 500032, India



+1 617 765 2493



info@mordorintelligence.com



www.mordorintelligence.com



Mordor Intelligence