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FROM GREY TO GREEN

Positioning India's
Cement Industry in
the Global Net-Zero
Race

Report By:

ECOPRENURE



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Introduction

ROLE OF CEMENT IN INDIA'S GROWTH

Cement is the cornerstone of India's infrastructure and urban development. As one of the most widely used construction materials, it supports housing, transportation, industrial facilities, and public infrastructure projects, directly influencing economic growth. India is the second-largest producer of cement globally, reflecting the material's critical role in nation-building. The demand for cement is driven by rapid urbanization, the government's ambitious infrastructure programs, and the expansion of smart cities and affordable housing initiatives.

Beyond construction, cement is central to India's infrastructure-driven economic policies. Mega projects such as highways, metro networks, airports, and renewable energy facilities rely heavily on cement, making it a key enabler of connectivity, employment, and regional development.

**India is the 2nd
largest cement
producer
globally.**



The industry also contributes significantly to the economy through employment, regional industrial hubs, and allied sectors such as logistics, mining, and equipment manufacturing.

As India continues to pursue its urbanization and infrastructure goals, cement remains indispensable, bridging the gap between vision and implementation. At the same time, the industry faces the dual challenge of scaling production to meet growing demand while addressing environmental sustainability and decarbonisation, positioning it at the intersection of growth and climate responsibility.



EVOLUTION, PRODUCTION CAPACITY & KEY PLAYERS

Evaluation of India's cement industry timelines structured in 4 key phases

01

Early Beginnings (1904–1935)

Evaluation: Foundation phase with survival challenges but marked by consolidation for future growth.

- 1904 – First cement factory in Madras.
- 1914 – Indian Cement Company Ltd. began production in Porbandar, Gujarat → marks the start of India's "Cement Era".
- 1920s – Faced rate wars and closures of small units
- 1936 – Formation of Associated Cement Companies (ACC) .

02

Post-Independence Expansion (1947–1990)

Evaluation: Slow but steady growth; expansion tied closely to India's planned economy.

- 1950–51 – Industry's annual capacity reached 3.28 MTPA.
- Growth driven by national infrastructure and housing needs.
- Industry remained under government regulation → price & distribution controls.

03

Liberalisation & Modernisation (1991 onwards)

Evaluation: Turning point – industry moved from regulation to free-market competition, boosting efficiency and capacity.

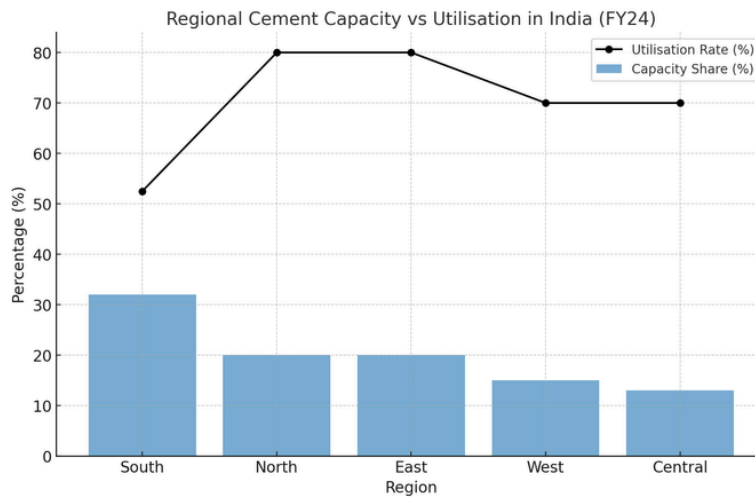
- 1991 – De-licensing of cement industry; price & distribution controls removed.
- Surge in private investments and technological advancements.
- Cement became one of the fastest-growing industries in India.

04

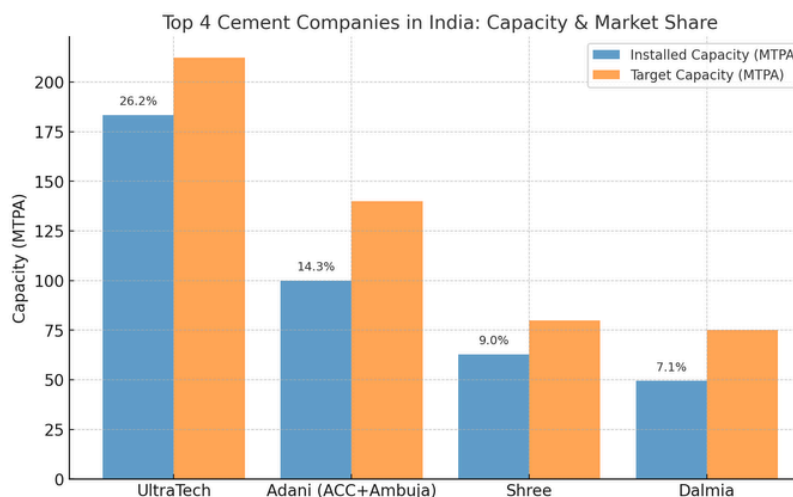
Global Leadership Phase (2000–Present)

Evaluation: Mature stage with vast capacity, regional production hubs, and global recognition.

- India emerged as the second-largest cement producer globally.
- FY24 capacity: ~553–690 MTPA.
- Regional distribution:
 1. South India – 32%
 2. North & East – 20% each
 3. West – 15%
 4. Central – 13%



- **South** → Overcapacity, intense competition, price wars, low margins.
- **North & East** → Strong demand, ~80% utilisation, balanced growth.
- **West & Central** → Relatively balanced, no major stress.
- **National utilisation** → ~65–70%.



- **Top 4 control >56% of total capacity, shaping production & pricing.**
- **Consolidation trend** → Adani's Penna acquisition (+14 MTPA), UltraTech's India Cements & Kesoram deals (+26.3 MTPA FY25).
- **Top 10 companies projected to add ~140 MTPA in 5 years.**

Strategic Implications

- **Consolidation** = fewer but stronger players → better positioned to handle financial & technological demands.
- **Decarbonisation leverage:** Big players are more capable of investing in CCUS, alternative fuels, green technologies.
- **ESG pressure & global scrutiny** → large firms set net-zero targets, issue sustainability-linked bonds, pushing industry transition.
- **South India's overcapacity** acts as a driver for M&A → smaller players being absorbed by majors.

Demand & Market Drivers

HOUSING, INFRASTRUCTURE, AND SMART CITIES

India's booming urbanisation and massive infrastructure drive are fueling unprecedented cement demand.

The consumption of cement in India is powered by a confluence of demand drivers, with a clear dominance from the housing and construction sector. Housing and real estate account for the majority of cement consumption, absorbing approximately 60-65% of total production. Infrastructure projects, including highways and ports, make up a significant 25% share, with commercial real estate contributing the remaining 15%. A key demographic factor is that rural areas alone are responsible for about 40% of the country's total cement consumption, driven primarily by individual homebuilding.

Government initiatives are instrumental in sustaining this robust demand momentum. In the housing sector, the Pradhan Mantri Awas Yojana (PMAY) plays a pivotal role by providing a major push to affordable housing, especially in rural areas, which is essential for consistent demand. For infrastructure, large-scale projects and programmes like the Bharatmala Pariyojana for highways and the Sagarmala programme for port modernisation ensure a sustained need for cement.

The National Infrastructure Pipeline (NIP) outlines a plan for investing US\$1.5 trillion in infrastructure over five years, further cementing the long-term demand outlook. Additionally, urbanisation efforts, such as the development of 100 Smart Cities, are projected to significantly boost the sector, linking urban development directly to cement consumption.



Technology & Innovation

DIGITAL TRANSFORMATION (IOT, AI, SMART MANUFACTURING)

The Indian cement industry is embracing Industry 4.0 technologies to enhance operational efficiency, reduce costs, and improve sustainability. Here are some quantitative figures highlighting these advancements:

- **Energy and Emission Reductions:** AI applications have led to a 15% reduction in energy consumption and a 10% decrease in overall greenhouse gas emissions across cement production facilities .
- **Operational Efficiency:** AI-driven process optimization has enhanced production efficiency by up to 20%, and predictive maintenance has reduced equipment downtime by up to 30%
- **Quality Control:** Implementing AI in quality control has improved product consistency by 25%, and AI-based sensors have decreased quality rejections by 18%
- **Supply Chain Optimization:** AI-enhanced logistics planning has reduced transportation costs by approximately 12%, and AI-powered automation has been implemented in over 40% of new cement plant projects worldwide.
- **Digital Transformation Initiatives:** Companies like Orient Cement have migrated to cloud-based ERP systems, such as SAP's RISE with SAP, in under 3.5 months, enabling real-time data insights and improved decision-making.

These figures underscore the significant impact of Industry 4.0 technologies in transforming the Indian cement industry, driving improvements in efficiency, sustainability, and competitiveness.

AI and Industry 4.0 are revolutionising India's cement sector, cutting energy use by 15%, boosting efficiency by 20%, and slashing downtime by 30%.



GREEN CEMENT, BLENDED MATERIALS & NEW MATERIAL SCIENCE

India's cement industry is embracing green, blended, and next-gen materials to cut CO₂ by up to 40%.

Green Cement

Procedure:

1. Reduce clinker content by using alternative raw materials.
2. Switch to alternative fuels (biomass, waste-derived fuels) in kilns.
3. Adopt energy-efficient processes & waste heat recovery systems.
4. Implement low-carbon manufacturing technologies.

⚡ 20–30% reduction in CO₂ emissions

⚡ 15–20% energy savings

♻️ Use of waste fuels reduces reliance on coal

UltraTech Cement, ACC, Ambuja Cement, JK Lakshmi Cement, Dalmia Bharat

Blended Cement / Material

1. Replace clinker with fly ash (PPC) or slag (PSC).
2. Optimize blending ratios for strength & durability.
3. Utilize industrial waste in large volumes.
4. Scale up blended cement production to reduce OPC dependence.

⚡ 25–40% reduction in CO₂ emissions (vs OPC)

⚡ 20–30% reduction in energy use

♻️ 100% utilization of fly ash & slag that would otherwise be waste

Ambuja Cement, ACC, Shree Cement, UltraTech Cement, Nuvoco

New Material Science / Advanced Construction

For LC3:

1. Replace clinker with limestone & calcined clay.
2. Use lower calcination temperature (~850°C vs 1450°C).
3. Blend for optimal performance.

⚡ LC3: Up to 30% CO₂ reduction, 20% energy savings

⚡ 3D Printing: 30–60% less material waste, 50–70% faster construction

🌍 Enables circular economy and sustainable urbanization

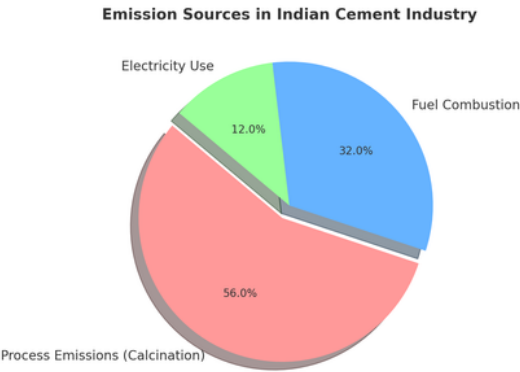
For 3D Concrete Printing:

1. Prepare special high-flow mix.
2. Print layer by layer via robotic arms.
3. Build faster with less material waste.

JK Lakshmi Cement (LC3, IIT Delhi), Tvasta (3D printing – IIT Madras & Air Force projects), LafargeHolcim (global pilots)

Decarbonisation Pathways

CARBON FOOTPRINT OF CEMENT



Cement's Emission Share 6%

The Indian cement industry contributes ~6% of the country's total GHG emissions.

Process Emissions 56%

- Result from the calcination of limestone (converting limestone into clinker).
- Largest emission source, inherent to the chemical process.

Fuel Combustion 32%

Emissions from burning fossil fuels (coal, petcoke) to heat cement kilns.

Electricity Use 12%

Emissions from burning fossil fuels (coal, petcoke) to heat cement kilns.

Key Insight:

- Majority of emissions (process-related) cannot be cut by efficiency measures alone.
- Requires a portfolio of solutions including green fuels, blended cements, carbon capture, and new material science.

ENERGY EFFICIENCY, AFR, AND CCUS

Energy Efficiency

- India's cement plants rank among the most energy-efficient globally.
- Thermal energy: 725 kcal/kg of clinker | Electricity: 75 kWh/t of cement.
- Waste Heat Recovery (WHR) systems capture kiln & cooler exhaust to generate electricity.
- WHR supplies 20–25% of plant power without extra fossil fuels.
- UltraTech Cement: 46% of power from green energy (including WHR).
- Dalmia Cement: Significant WHR investments.

AFR

AFR refers to non-conventional materials used in cement kilns to replace traditional fossil fuels (coal, petcoke, oil) or primary raw materials (limestone, clay). These include:

- Alternative Fuels: Waste-derived fuels like municipal solid waste (MSW), plastic waste, tires, biomass, industrial sludges.
- Alternative Raw Materials: Industrial by-products like fly ash, slag, rice husk ash, or other mineral wastes that can partially replace clinker or limestone.

TSR (Thermal Substitution Rate)

TSR is the percentage of conventional fossil fuels replaced by alternative fuels in cement kilns.

TSR (%)= $\frac{\text{Energy from alternative fuels} \times 100}{\text{Total fuel energy input}}$

- Most plants achieve 10–25% TSR, though global best practices reach 40–50%.
- Factors limiting TSR include fuel quality, availability, regulatory hurdles, and kiln compatibility.

Gap / Challenge	Explanation	Proposed Solution
Inconsistent AFR quality	AFR has variable calorific value, moisture, and chemical composition, affecting kiln stability.	Standardize AFR specifications; certify AFR suppliers.
Limited waste collection & segregation	MSW and industrial wastes are often mixed or poorly segregated, reducing usable fuel.	Improve municipal and industrial waste segregation; promote industrial symbiosis.
Regulatory & logistical barriers	Transport, storage, and handling regulations limit AFR adoption.	Streamline permits; provide policy incentives and subsidies for AFR use.
Kiln design & operation constraints	Older kilns may not handle high AFR percentages without affecting clinker quality.	Retrofit and upgrade kilns; install combustion monitoring systems.
Lack of technical expertise	Operators may be untrained in safe and efficient AFR handling.	Train personnel in AFR handling, combustion optimization, and safety.
Irregular AFR supply	Continuous fuel supply is challenging due to fragmented waste sources.	Establish public-private partnerships for consistent AFR sourcing.

CCUS

CCUS refers to technologies that:

- 1. Capture CO₂ emissions from industrial processes.
- 2. Utilize CO₂ in products or processes (e.g., concrete curing, chemicals).
- 3. Store CO₂ safely underground (geological storage) to prevent its release into the atmosphere.

In cement, CCUS is particularly important because process emissions from calcination of limestone contribute ~56% of total CO₂ emissions.

CCUS Gap	Explanation	Solution
High Cost	CCUS technologies involve high capital and operational expenses, making cement production more expensive and less competitive in India’s price-sensitive market.	Provide financial incentives like tax credits, grants, and carbon market support. Explore PPP models and international financing.
Technological Immaturity	Many CCUS methods (amine absorption, oxy-fuel, calcium looping) are still at pilot stages in India, lacking scalable, energy-efficient solutions tailored for Indian cement plants.	Promote collaborative R&D between industry, academia, and government. Support testbeds and pilot projects for indigenous technologies.
Lack of Infrastructure	No large-scale CO ₂ transport or storage network exists; pipelines and viable geological storage sites are missing.	Develop national CO ₂ pipeline networks, identify storage sites, and create shared industrial hubs for CCUS infrastructure.
Policy & Regulatory Vacuum	Absence of clear legal/regulatory frameworks creates uncertainty for investors regarding permits, safety, and long-term storage liability.	Establish CCUS-specific policies with safety, liability, and climate integration guidelines.
Complexity & Integration	CCUS requires multi-stage integration; cement companies lack specialized expertise in capture, transport, and storage.	Encourage cross-sector collaboration, knowledge-sharing, and centralized CCUS hubs to reduce operational complexity.

Policy, Finance & Circular Economy

NET-ZERO TARGETS & GOVERNMENT SCHEMES

Net-Zero Targets and Roadmap

- **Overall Goal:** The Indian cement industry has aligned its decarbonization efforts with the Government of India's national target of achieving Net-Zero emissions by 2070.
- **Industry Roadmap:** The Global Cement and Concrete Association (GCCA) India, in collaboration with The Energy and Resources Institute (TERI), has developed the "Decarbonisation Roadmap for the Indian Cement Sector: Net-Zero CO₂ by 2070."
- **Interim Targets:** This roadmap includes an interim target for 2047, in line with the "Viksit Bharat" vision, to achieve significant emission reductions.
- **Company Commitments:** Major Indian cement companies like ACC, Ambuja Cements, UltraTech, and Shree Cement have set ambitious, science-based targets for emission reductions, with many aiming for net-zero by 2050, ahead of the national target.

Government Schemes and Initiatives

- **Perform, Achieve, and Trade (PAT) Scheme:** A flagship government program under the National Mission for Enhanced Energy Efficiency (NMEEE) that sets energy efficiency targets for energy-intensive industries, including cement. Companies that overachieve their targets are awarded Energy Saving Certificates (ESCerts), which can be traded.
- **Infrastructure-Led Growth:** While not directly climate-focused, major government schemes like the National Infrastructure Pipeline (NIP), Pradhan Mantri Awas Yojana (PMAY), and PM Gati Shakti drive demand for cement, and thus influence the industry's need for sustainable, low-carbon production.
- **Policy Support for Technology:** Government initiatives and think tanks like NITI Aayog are focusing on policy support, financial aid, and incentives for research and development (R&D) in clean technologies, particularly for Carbon Capture, Utilization, and Storage (CCUS).
- **Green Public Procurement:** There is an ongoing push for government policies that would incentivize the use of "green cement" and other low-carbon building materials in public procurement projects.

CARBON MARKETS, ESG, RECYCLING & WASTE CO-PROCESSING

Carbon Markets

- Carbon Credit Trading Scheme (CCTS): Will cover the cement sector from FY26 to incentivize emissions reductions.
- Domestic Carbon Pricing: Helps counter EU's CBAM by retaining carbon tax revenue within India.
- Green Finance: Companies like UltraTech Cement issue sustainability-linked bonds tied to achieving emissions reduction targets (e.g., 27% reduction by 2032).

Recycling

- Industry uses Supplementary Cementitious Materials (SCMs): fly ash, granulated blast furnace slag (GBFS), and red mud.
- India generates ~150 million tonnes of C&D waste annually; most is improperly disposed of.
- Recycling converts C&D waste into aggregates, bricks, and pavement blocks, reducing virgin raw material use, landfill burden, transport costs, and GHG emissions.
- Operational recycling facilities exist in cities like Delhi and Mumbai.



ESG (Environmental, Social, Governance)

- Leading companies are driving ESG initiatives, though some still face high/severe ESG risk ratings.
- Policies like C&D Waste Management Rules 2025 mandate Extended Producer Responsibility (EPR) for bulk waste generators.
- Recycled materials mandates: 5% by 2026-27, increasing to 25% by 2030-31, creating a predictable framework for sustainability investments.

Waste Co-Processing

- Cement kilns use MSW and industrial hazardous waste as alternative fuels.
- High kiln temperatures (>1400°C) ensure complete incineration and destruction of hazardous materials.
- Improves Thermal Substitution Rate (TSR) and reduces fossil fuel dependency.
- International collaborations (e.g., SINTEF, Norway) help build technical expertise.
- Co-processing is regulated, requiring CPCB approvals after successful trial runs with specific waste streams.

Global Outlook & Way Forward

LESSONS FROM GLOBAL LEADERS & CBAM IMPLICATIONS

Lessons from Global Leaders:

- **Circular Economy & Recycling:** Companies like HeidelbergCement (Germany) and CRH Group (Europe) effectively use industrial and C&D waste, creating stable demand for recycled materials.
- **Alternative Fuels & Co-Processing:** European and Japanese cement plants adopt waste-derived fuels and co-processing, achieving high Thermal Substitution Rates (TSR) and reducing fossil fuel use.
- **Green Finance & Sustainability Bonds:** LafargeHolcim demonstrates how linking financing to emissions reduction targets accelerates decarbonisation.
- **CCUS Pilots:** Taiheiyo Cement (Japan) shows early CCS and co-processing trials reduce long-term risk and prepare for scalable deployment.
- **Policy Integration:** Strict EPR and regulatory compliance in Europe create predictable markets for recycled aggregates and waste management.

CBAM Implications for Indian Industry:

- **Export Competitiveness:** Indian exporters to the EU will face carbon border costs unless domestic emissions are reduced.
- **Incentive for Early Action:** Adoption of domestic carbon pricing, renewable energy, and CCUS can mitigate CBAM impact.
- **Revenue Retention:** Domestic carbon markets allow India to capture economic value rather than paying EU CBAM.
- **Policy & ESG Alignment:** Integrating carbon markets, recycling mandates, and green finance strengthens ESG credentials and global competitiveness.

RISKS, CHALLENGES & ROADMAP TO NET-ZERO 2070



Key Risks & Challenges

High Carbon Intensity

Cement production emits significant CO₂ from both calcination and fuel combustion, making deep decarbonisation difficult.

Technological Gaps

CCUS, alternative fuels, and low-carbon clinker technologies are still in pilot or early commercial stages in India.

Infrastructure Limitations

Lack of CO₂ transport networks, storage sites, and industrial hubs constrains large-scale CCUS deployment.

Financial Constraints

High upfront costs of low-carbon technologies and co-processing infrastructure pose economic challenges for price-sensitive markets.

Policy & Regulatory Uncertainty

Evolving carbon markets, CBAM implications, and recycling mandates require clear, predictable regulatory frameworks.

Operational Complexity

Integrating CCUS, alternative fuels, and recycled materials into existing plants requires specialized expertise and cross-sector collaboration.



Enablers such as finance, policy, technology, and collaboration will be the cornerstone of India's cement industry transition to net-zero by 2070.

ROADMAP TO NET-ZERO 2070

Achieving net-zero by 2070 for the Indian cement industry will depend heavily on a set of cross-cutting enablers that provide the foundation for long-term decarbonisation. Finance is critical, with green bonds, sustainability-linked loans, and concessional capital required to fund capital-intensive technologies such as CCUS and waste co-processing. Equally important is a predictable and robust policy framework, including clear carbon pricing under the Carbon Credit Trading Scheme, strong enforcement of recycling mandates, and regulatory clarity for CO₂ transport and storage. Technology and R&D must be advanced through close collaboration between academia, industry, and government to develop indigenous, cost-effective solutions like LC3 cements and scalable CCUS pathways. Collaboration across sectors—cement, steel, power, aluminium, oil and gas, and waste management—as well as international technology partnerships, will ensure knowledge transfer and shared infrastructure. These enablers form the backbone for a phased roadmap toward a circular, resource-efficient, and globally competitive net-zero cement industry.

Roadmap to Net-Zero 2070

PHASE 1: FOUNDATIONS (2025–2030)

- **Circular Economy:**

Mandatory adoption of C&D Waste Management Rules 2025 (5% recycled content by 2026–27 → 25% by 2030–31).

- **Blended Cements:**

Expand use of fly ash, slag, and red mud to lower clinker factor.

- **Alternative Fuels:**

Increase Thermal Substitution Rate (TSR) from current ~4% to at least 15–20%.

- **Energy Efficiency:**

Deploy waste heat recovery systems (WHRS) and digital monitoring for kilns.

- **Carbon Markets:**

Operationalize Carbon Credit Trading Scheme (CCTS) and integrate cement into India's domestic carbon pricing framework.

- **CCUS Pilots:**

Initiate 2–3 demonstration projects in partnership with global technology providers.

PHASE 2: SCALING LOW-CARBON PATHWAYS (2030–2045)

- **Clinker Substitution:**

Large-scale adoption of SCMs and new materials (calcined clay, LC3 cement).

- **CCUS Infrastructure:**

Build CO₂ pipeline corridors and identify storage basins (e.g., basalt, depleted oil fields).

- **Alternative Fuels:**

Raise TSR to 40–50% by 2040, phasing out petcoke/coal in favor of biomass, RDF, and hydrogen.

- **Carbon Pricing:**

Mature carbon market with stable pricing, enabling revenue recycling into green technologies.

- **Digital & Smart Manufacturing:**

AI-driven efficiency optimization across cement plants.

- **Policy Integration:**

Strong EPR enforcement and recycled material mandates aligned with global best practices.

Roadmap to Net-Zero 2070



PHASE 3: TRANSITION TO NEAR-ZERO CARBON (2045–2070)

- **Full CCUS Deployment:**

Commercialize CCUS at scale across major cement clusters.

- **Alternative Fuels Transition:**

Achieve >70% TSR, supported by green hydrogen and bioenergy.

- **Next-Gen Cements:**

Commercialization of novel binders and low-carbon cement formulations, reducing reliance on clinker.

- **Industrial Symbiosis:**

Deep integration with steel, power, and aluminium industries for shared waste utilization.

- **Net-Zero Clusters:**

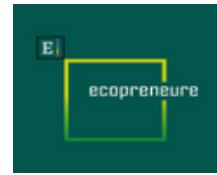
Establish dedicated "green cement industrial hubs" powered by renewables and CCUS.

- **Global Competitiveness:**

Position India as a net exporter of green cement and low-carbon building materials.



Let's Build a Net-Zero Future Together



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