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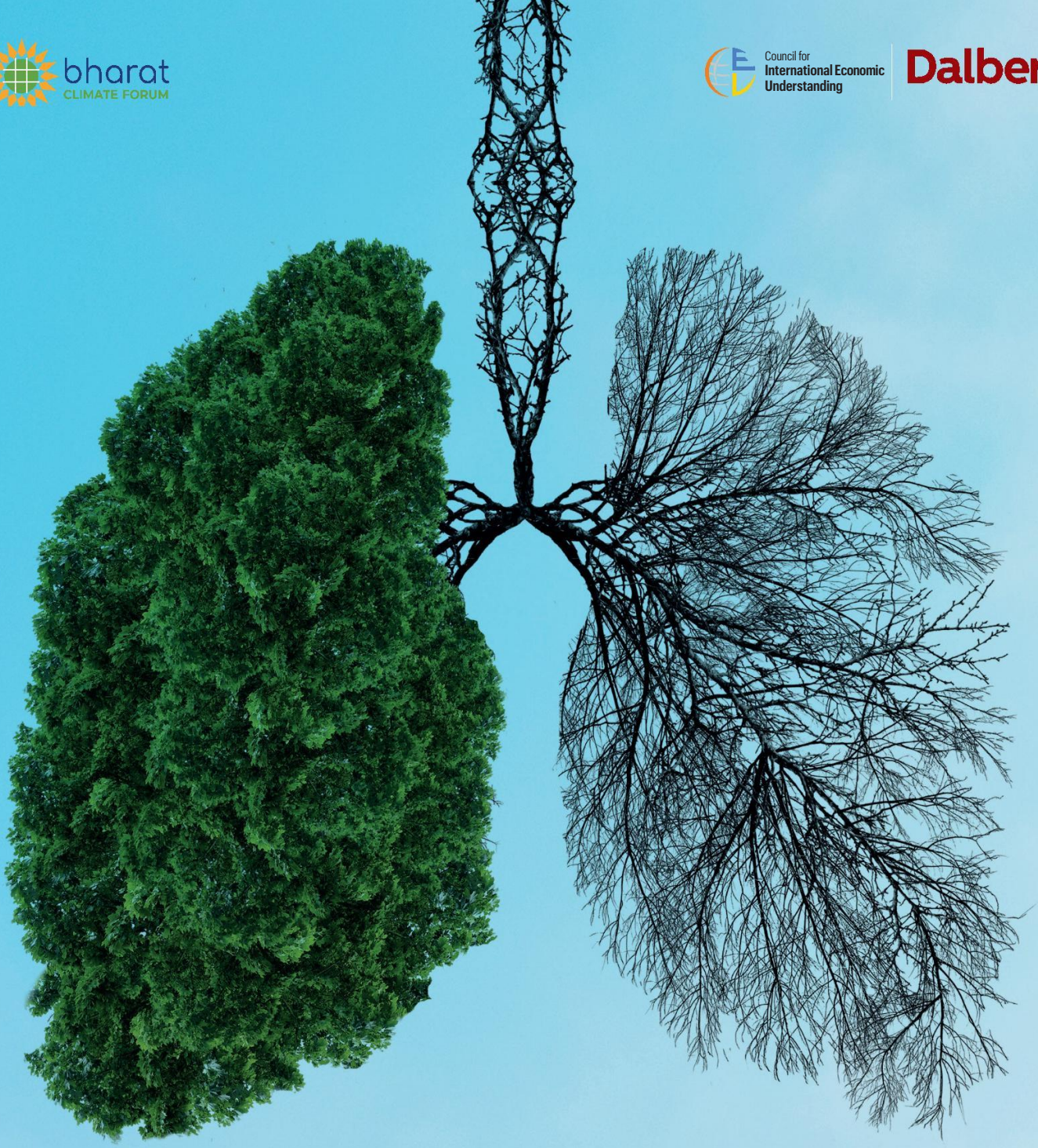

Aironomics 2025

Unlocking India's Blue Skies Economy

Date: May 31, 2025 | **Location:** ITC Maurya, New Delhi

Factories of the Future

Clean Production and Competitive Industries for a Cleaner India

Context and rationale

Industrial pollution remains one of the largest contributors to the air quality crisis. Major sources include heavy industries such as cement and steel, which rely on energy-intensive processes like clinker production and blast furnace operations that emit large volumes of particulate matter, SO_2, and NO_x. For example, in places like Delhi-NCR, industries contribute to ~48% of the PM 2.5 emissions.[1] Small and medium enterprises (SMEs), such as brick kilns, foundries, and stone crushers—also contribute significantly due to due to lack of resources with smaller players. Fugitive emissions from chemical processing, solvent use, and hazardous waste handling further compound the pollution load.

A suite of pollution control technologies and market mechanisms is already shaping India's industrial emissions landscape. Air pollution control technologies, such as flue gas desulfurization (FGD) units for power plants, selective catalytic reduction (SCR) systems for NO_x control, and electrostatic precipitators (ESPs) for particulate capture, are increasingly mandated across key sectors. Additionally, energy efficiency upgrades, including waste heat recovery systems, process optimization, and fuel switching to cleaner alternatives like natural gas, are being deployed in high-emitting industries. Green hydrogen is also gaining momentum, particularly in hard-to-abate sectors like steel and cement, offering reductions in both carbon dioxide and air pollutants when replacing coal or pet coke. SMEs have also embraced cleaner production technologies like zigzag kiln technology in the brick sector, which has demonstrated a 30-40% reduction in particulate emissions.[2]

[1] TERI. (2019). Cost effectiveness of interventions for control of air pollution in Delhi.
[2] Centre for Science and Environment. (2018). Brick kiln performance assessment: A roadmap for cleaner brick production in India. New Delhi: CSE.

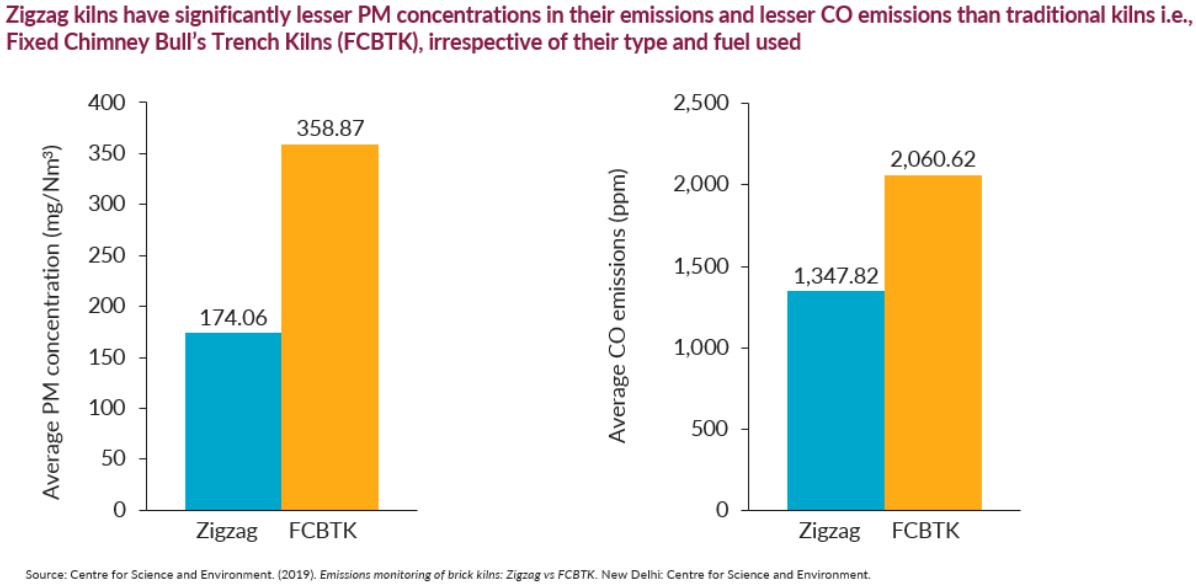

Figure 1: Difference between PM and CO emissions by zigzag kilns vs FCBTKs

However, inconsistent enforcement of regulations, lack of technical expertise, and financial constraints undermine the effectiveness of these solutions. Fragmented enforcement across state pollution boards (SPCBs), coupled with weak coordination with industrial associations, erodes the effectiveness of these measures. Emissions standards, while established, suffer from patchy enforcement and delayed uptake across sectors. Further, many small industries, particularly brick kilns, operate informally and outside the purview of formal regulation. Sectors such as cement and steel are also highly capital-intensive, have long investment and asset replacement cycles, and have a high cost of air pollution and GHG mitigation. The Mission Possible Partnership estimates that commercialization and deployment of NZE compatible technologies in the steel sector alone would require about USD 10 billion in additional investments globally between 2030 and 2050.[3] Market-based instruments like emissions trading schemes (ETS) remain limited in scale and impact due to weak monitoring infrastructure and verification systems, which require sustained financial and technical investment. SMEs frequently lack access to affordable finance, with about 87% of Indian SMEs being self-financed[4], and the technical know-how needed to transition to cleaner technologies, leading many to continue operating with outdated and highly polluting equipment. A balanced approach, incentivizing cleaner practices beyond compliance and offering real-time technical support, can help address these challenges.

Combatting industrial air pollution at scale requires a convergence of regulatory ambition, financial innovation, and technological partnerships to accelerate adoption. Strengthening sector-specific emissions benchmarks, granting industrial approvals conditional on pollution compliance, and introducing green procurement mandates can create stronger regulatory signals. For large industries such as steel and cement, transitioning to

[3] Mission Possible Partnership. (2021). Net-Zero Steel: Sector Transition Strategy.
[4] World Bank. (2017). Innovative Early Stage Financing for SMEs in India.

cleaner production systems will require a mix of mandates and market-pull measures, such as Production-Linked Incentive (PLI) schemes for air pollution control technologies, performance-based subsidies, or preferential treatment in public procurement linked to emissions intensity. China's Ultra-Low Emission (ULE) policy for coal-fired power plants, introduced in 2014, mandated retrofits for dust, SO_2, and NO_x control across 71% of plants within five years, cutting SO_2 emissions by nearly 65% and PM emissions by 72% in the sector.[5] In the brick sector, where most units operate informally and lack technical capacity, access to finance needs to be paired with targeted technical assistance—supporting kiln owners with training, design guidance, and service networks to adopt cleaner designs.

Financial innovation must address the limited access to affordable capital through instruments such as concessional credit lines, results-based financing, and risk-sharing mechanisms that enable investment in clean technologies. Globally, green bonds for pollution control raised over $50 billion in 2023 alone[6], with countries like Indonesia channeling sovereign green bond proceeds into pollution abatement technologies.[7] Market-based instruments such as emissions trading schemes (ETS), piloted in Gujarat, can provide new and more effective mechanisms for pollution reduction. India's emerging National Green Credit Programme and State Pollution Control Board (SPCB) funds could also be mobilized to finance retrofits and cleaner processes.

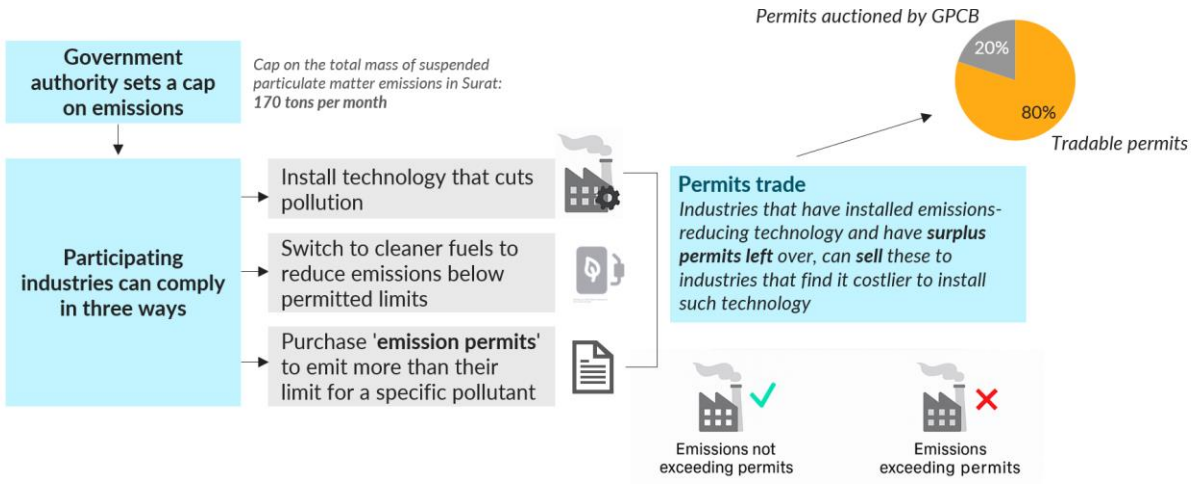

Figure 2: The working of Gujarat's Emissions Trading Scheme (ETS)

Proven technology solutions like zigzag kilns in brick manufacturing and drive adoption of energy-efficient and emissions-control technologies can further be scaled through public–

[5] International Energy Agency. (2020). Air quality and climate policy integration in China: From planning to implementation. Paris: IEA.
[6] Bloomberg. (2024, January 8). Green bonds reached new heights in 2023. Bloomberg Professional Services.
[7] Republic of Indonesia. (2023). Green Sukuk Allocation and Impact Report 2023. Ministry of Finance, Directorate General of Budget Financing and Risk Management.

private partnerships. EU's Industrial Emissions Directive (IED) exemplifies how coordinated deployment of best available techniques (BAT)—such as high-efficiency ESPs or low-NO_x burners—has significantly reduced industrial air pollution across Europe.[8] Digital platforms for real-time emissions monitoring, satellite-based tracking, and AI-enabled source attribution can strengthen compliance infrastructure and support the expansion of market-based tools such as emissions trading schemes.

This roundtable, '***Factories of the Future: Clean Production and Competitive Industries for a Cleaner India'*** will bring together government regulators, industry leaders, financiers, and technology providers to explore pathways for reducing industrial air pollution at scale. The discussion will focus on strengthening enforcement of emission norms, unlocking finance for cleaner technologies, and leveraging digital innovations to enhance compliance and transparency across sectors.

Potential Opportunities and Challenges

India has an opportunity to build a next-generation industrial emissions control ecosystem that is real-time, verifiable, and scalable. Realizing this vision will require addressing systemic challenges across financial, policy, operational, technological, and environmental domains to drive sustained reductions in industrial air pollution.

- **Unlocking a ~$15 billion industrial retrofit market through green finance and innovation:** India's drive for cleaner industry—spurred by NCAP targets, ESG mandates, and supply chain pressures—can catalyze a $15 billion market by 2030 for retrofits like FGDs, SCRs, low-NO_x burners, and clean kiln technologies.
- **Mainstreaming emissions compliance into India's digital public infrastructure:** Embedding real-time emissions dashboards into platforms like PM Gati Shakti and ULIP can institutionalize compliance within industrial zone planning and freight corridors, making air quality a core metric in national development efforts.
- **Expanding regional emissions trading schemes (ETS) across industrial clusters:** Scaling ETS pilots into multi-state regional carbon markets across the Indo-Gangetic Plain can create incentives for emissions reductions, leveraging regional air quality gains and industrial competitiveness.
- **Deploying AI-driven emissions intelligence for compliance and hotspot detection:** Combining CEMS, satellite data, drones, and IoT sensors, AI-powered platforms can deliver real-time compliance alerts and source attribution, covering 80% of industrial emissions by 2030, similar to China's Blue Sky and Europe's E-PRTR.
- **Unlocking climate-air quality co-benefits through sectoral transition pathways:** Coordinated action in power, steel, cement, and brick kilns can reduce $PM_{2.5}$ by 30–40% in key regions. While technologies like FGDs and SCRs target air pollutants, broader gains come from combining them with low-carbon measures like energy efficiency, fuel switching, and green hydrogen. This approach supports net-zero goals and can tap into $100 billion in global transition finance.

[8] European Environment Agency. (2018). Best available techniques to cut the use and impact of hazardous chemicals.

At the same time, several financial, technological and operational challenges limit the scalability and effectiveness of industrial pollution control solutions in India:

- **High capital costs of air pollution control devices, coupled with limited cost pass-through, discourage industrial investment in cleaner solutions.** In sectors like cement, steel, and metal, installing devices such as electrostatic precipitators (~₹25 lakh) or cyclone separators (~₹5 lakh) represent a significant upfront expense. Without the ability to recover these costs due to regulatory constraints or competitive market pressures, industries are often reluctant to adopt such technologies.
- **Absence of sector-specific emissions intensity benchmarks hinders differentiated policy action.** Without tailored $PM_{2.5}$ or SO_2 emission intensity (per tonne of output) benchmarks across sectors (e.g., cement, steel, brick kilns), policies risk applying uniform standards that overburden SMEs or under-regulate heavy polluters. China's differentiated ULE benchmarks by plant size and technology type offer a model India has yet to adopt.
- **SMEs face a structural financing gap that impedes pollution control upgrades**. High collateral requirements, limited credit histories, and low awareness of subsidy or credit schemes constrain uptake. As a result, critical upgrades—such as energy-efficient boilers or emission scrubbers—remain out of reach, undermining sector-wide pollution reduction goals.
- **Operations & maintenance non-compliance leads to 20-30% downtime in pollution control equipment across industrial clusters.** Audits by SPCBs indicate that many industries, especially SMEs, operate pollution control devices (e.g., bag filters, scrubbers) intermittently to save on running costs—undermining regulatory efforts despite installed infrastructure.
- **Technological fragmentation across vendors leads to incompatible CEMS platforms.** With dozens of unstandardized CEMS suppliers across India, data integration remains challenging, hindering real-time analytics or centralized oversight. Europe's E-PRTR mandates standardized reporting formats and centralized platforms—something India's current system lacks.

Key Focus for Discussion

- What will it take for financiers to view industrial pollution control as a **bankable investment**, not just a compliance cost? Are there **successful models** (from other sectors or countries) that we can adapt to **de-risk such investments** in India?
- How do we align the economic interests of industries, regulators, and financiers to drive pollution control at scale—especially in sectors where cost pass-through is politically sensitive? Can we explore **shared savings models, subsidies, or tariff adjustments**?
- What are the **operational bottlenecks** that prevent **pollution control equipment** from functioning consistently, and how can we improve long-term operations and maintenance?

- In what ways can we **overcome the financial and operational constraints faced by SMEs** in adopting pollution control measures, and what role can aggregation, technical assistance, or innovative financing structures play in enabling scale?
- How can **emissions compliance** be **better integrated** into broader industrial and infrastructure **planning**, such as through PM Gati Shakti or state industrial policies, to make air quality a core consideration in industrial development?
- Should India consider **differentiated emissions standards** based on sector, size, and technology maturity—as China has done—or will that complicate enforcement?

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