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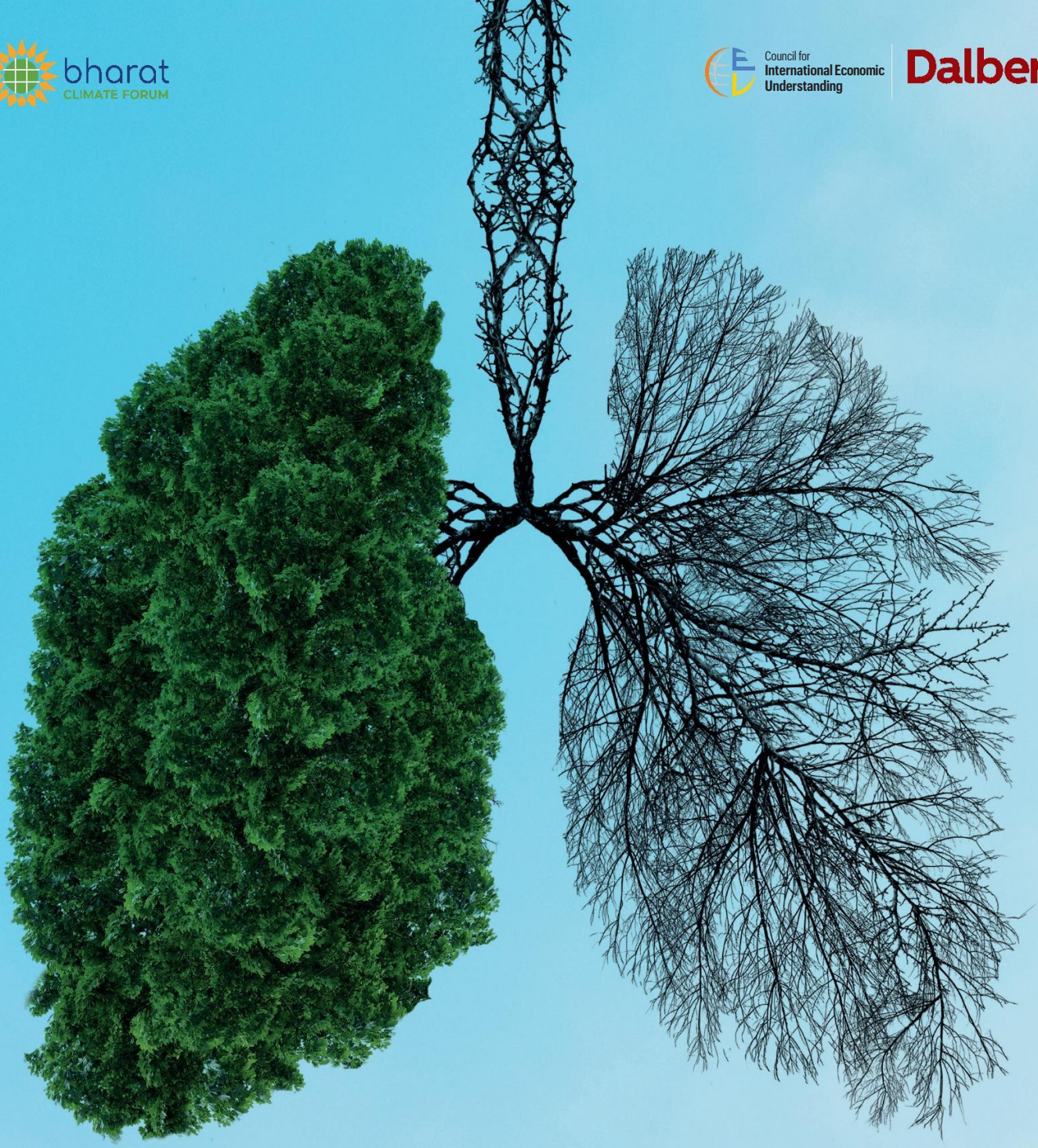

Aironomics 2025

Unlocking India's Blue Skies Economy

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

Smoke and Power

Retrofitting India's Energy Backbone

Context and rationale

Thermal power plants are a major contributor to air pollution in India. Power generation, including power generated from thermal power plants, contributes to 12% of air pollution in India.[1] In regions like Delhi-NCR, emissions from thermal power plants alone account for 8% of the region's total pollution load.[2]

SO_2 emissions from the thermal power plants are largely responsible for the high PM 2.5 levels from the sector. In 2022, India emitted 11.2 million tonnes of SO_2, making it the largest in the world and accounting for over 20% of the world's anthropogenic emissions. This is primarily due to India's heavy reliance on coal for electricity generation, with five of the top ten SO_2 emission hotspots from coal and power generation located in India.[3] SO_2 is a critical precursor to PM 2.5 formation, contributing significantly to air pollution. SO_2 reacts with meteorological factors like sunlight and humidity, converting into fine particulate matter i.e., PM 2.5.

Globally, Flue Gas Desulphurization (FGD) has emerged as a commercially viable and scalable technology to curb SO_2 emissions from thermal power plants. Several countries have successfully deployed FGD, a technology that removes SO_2 from flue gases, thereby curbing SO_2 emissions from power plants. China adopted FGD in the 2000s, achieving ~95% SO_2 reduction post-installation. Despite China's coal consumption being ~5 times higher than India's, its SO_2 emissions are ~12% lower than India's, due to an FGD penetration rate of over 90%.[4] Even countries like the US, Indonesia, and Poland, have realized a ~92-95% SO_2 reduction post FGD installation.[5]

Recognizing this, India has strict emission standards in place, requiring FGD installation across thermal power plants. The Ministry of Environment, Forest and Climate Change (MoEF&CC) introduced strict emission norms for coal-fired plants in 2015. The norms vary by plant age, with the most stringent limit of 30 mg/Nm³ PM 2.5, 100 mg/Nm³ SO_2, and 100 mg/Nm³ NO_x for units installed on or after January 1, 2017.[6] The deadlines for compliance have been staggered with plants in densely populated or highly polluted areas (Category A) to comply by December 2027, those in critically polluted or non-attainment cities (Category B)

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[1] Environmental Science & Technology, Source Contributions to Fine Particulate Matter and Attributable Mortality in India and the Surrounding Region
[2] TERI, Cost effectiveness of interventions for control of air pollution in Delhi
[3] CREA, Increased SO_2 emissions from coal-fired power plants: FGD installation should not be delayed further
[4] Dalberg analysis
[5] Ibid.
[6] CPCB, Thermal Power Plants

by December 2028, and all others (Category C) by December 2029. For compliance with SO_2 emission norms, thermal power plants across India are installing FGD.[7]

Figure 1: Emission norms for thermal power plants in India

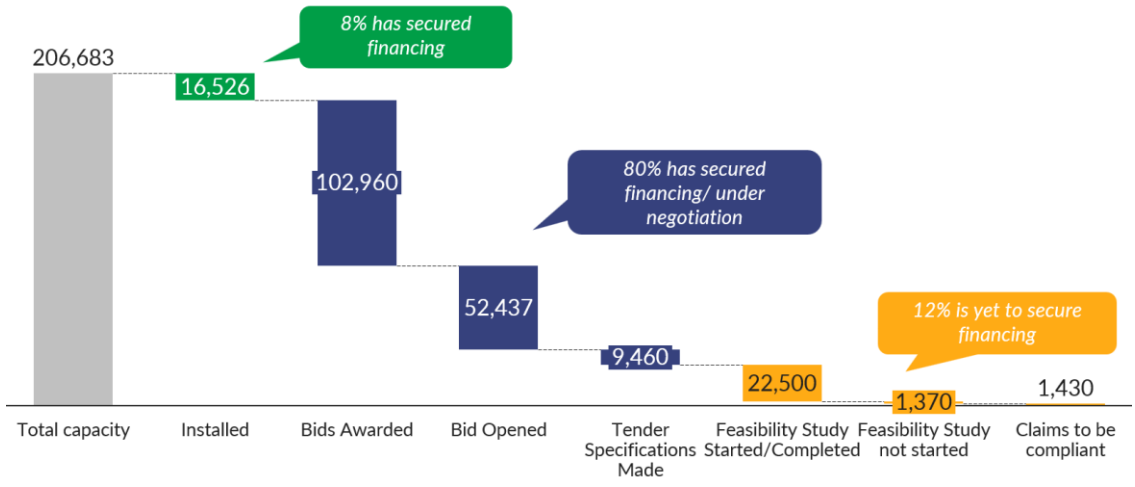
Date of installation	PM	SO2	NOX
Before 31 Dec 2003	100 mg/Nm^3	600 mg/Nm^3 for <500 MW 200 mg/Nm^3 for >=500 MW	600 mg/Nm^3
Afte 1 Apr 2004 & upto 31 Dec 2016	50 mg/Nm^3	600 mg/Nm^3 for <500 MW 200 mg/Nm^3 for >=500 MW	300 mg/Nm^3
On or after 1 Jan 2017	**30 mg/Nm^3**	**100 mg/Nm^3**	**100 mg/Nm^3**

However, FGD implementation remains slow, with ~ only 12% penetration, with other ~3% with CFBC. Only 49 thermal power plant units with a capacity of 25.6 GW have installed FGD, approx 12% of the total capacity. Almost half of the capacity (~85 GW) is in the nascent, pre-bid awarded stages of the FGD installation process i.e., bid opened, tender specification made, feasibility study started/completed/not started stages.[8]

While FGD installation requires a significant capital outlay, access to finance is not the key barrier. FGD installation is expensive, with costs increasing more than double in the last decade from Rs 0.4 crore to over Rs 1 crore per MW.[9] However, access to finance is not the core challenge, as 8% of total capacity have already secured financing and installed FGDs, and 80% in bid awarded, bid opened, and tender specification made stages, indicating financing has likely been secured or under negotiation.[10] Thermal power plant players like CLP and NTPC have demonstrated the financial viability of FGD through syndicated and consortium loans. For instance, CLP's Jhajjar power plant raised Rs 3,900 crore from a banking consortium of 15 banks,[11] while NTPC secured $750M in syndicated loans from Japanese banks for its pan-India FGD rollout.[12]

[7] DownToEarth, Thermal power plants get another extension for SO_2 compliance norms — it's time we reassess ongoing delays
[8] Central Electricity Authority, January 2025
[9] DownToEarth, A central meeting showed pushback against tech in power plants to reduce SO2 emissions. Here's why
[10] CREA, Emission Watch: Tracking the implementation of emission standard notification for coal-based power plants in India
[11] CLP, CLP Concludes Financing Arrangements for Jhajjar Power Plant in India
[12] NTPC, India's largest power generator NTPC Limited has raised syndicated Japanese yen loan worth USD 750 million

Figure 2: Status of financing for FGD across thermal power plants in India by capacity (MW)



Demand-supply constraints are largely responsible for thwarting FGD implementation. India faces limited domestic manufacturing capacity as SO_2 norms were only introduced in 2015, giving little lead time for local industries to develop. With FGD being a relatively new technology in India, there are a limited number of vendors with limited capacity. This is compounded by a high import dependency, with around 30% of FGD components currently imported, and the ramp-up of domestic capabilities expected to take years. Simultaneous demand from 537 thermal units (>200 GW) under government mandates has further created bottlenecks. Finally, the tight compliance timelines combined with long installation periods (~36 months) have constrained the ability to fine-tune technical specifications and execute projects smoothly.[13,14] While it's been approximately 10 years since the notification and the availability of FGD manufacturers has increased compared to 2015, this limitation should not be a limiting factor for FGD installations.

The government can adopt a dual approach of stronger enforcement and incentive-based mechanisms to drive faster FGD installation by taking inspiration from other countries and sectors. China presents a compelling precedent where it imposed strict penalties for non-compliance and provided 20% capital subsidies, driving FGD penetration from 30% in 2006 to 93% by 2015.[15] India can take this a step further by linking the subsidies to domestic manufacturing content requirements, as done in the PM Surya Ghar Mufti Bijli Yojana for solar panels, to reduce import dependence. Strong monitoring can further expedite installation, with countries like the US and Indonesia achieving over 90% FGD penetration by leveraging robust, real-time monitoring through Continuous Emission Monitoring Systems (CEMS).

Accelerating FGD implementation can unlock substantial economic benefits through capital investment, domestic manufacturing, and job creation. There is an opportunity to unlock over Rs 35,000 cr in capital investment for installing FGD in the units which are in the

[13] Central Electricity Authority, A review report on new SO2 norms
[14] Ministry of Power, Status of FGD installation in thermal power plants
[15] DownToEarth, How China is cleaning the highly-polluting coal power sector

pre-tendering stage, which can create significant employment across engineering, procurement, construction (EPC), commissioning, and ongoing operation and maintenance (O&M). With 30% import dependency, there is an additional opportunity to strengthen domestic manufacturing and advance India's Atmanirbhar goals.

This roundtable, "***Smoke and Power: Retrofitting India's Energy Backbone*",** will bring together key stakeholders from government, industry, and finance to identify pathways for accelerating FGD implementation, strengthen enforcement mechanisms, and unlock the full economic and environmental potential of SO_2 reduction in India's power sector.

Potential Opportunities and Challenges

The potential to accelerate FGD installation to reduce SO_2 emissions from thermal power plants is underscored by multiple emerging opportunities, across economic investment and job creation, supportive policy momentum, and access to sustainable financing.

- **Reducing SO_2 and PM 2.5 emissions to drive clean air gains:** Global benchmarks from countries like China, the US, Indonesia, and Poland show ~90–95% reduction in SO_2 post-FGD installation. Accelerating FGD adoption in India thus offers significant potential to curb SO_2 emissions and up to 8% PM 2.5 reduction in hotspot regions like Delhi-NCR.
- **Scaling up domestic manufacturing to reduce import dependence and support Atmanirbhar Bharat:** Currently, around 30% of FGD system components are imported, due to limited lead time for domestic industry development post-2015 regulation. Incentivizing and scaling up domestic production of FGD (e.g., through domestic production requirement (DCR) linked subsidies) can help advance India's Atmanirbhar ambitions.
- **Strengthening monitoring and enforcement by learning from global models:** China achieved 93% FGD penetration by 2015 through strict penalties and 20% capital subsidies. Similarly, the U.S. and Indonesia paired mandates with real-time monitoring via CEMS to ensure compliance and achieved 92-93% penetration, offering a strong precedent for India to emulate.
- **Leveraging sustainable financing mechanisms to ease capital burden:** FGD installation is capital-intensive (Rs 1 crore/MW), but financing models adopted by projects such as CLP's Jhajjar TPP and NTPC's pan-India rollout demonstrate the viability of syndicated/consortium loans and international financing.
- **Unlocking large-scale capital investment and job creation:** With over 35 GW of capacity still in pre-tendering stages, India stands to unlock over Rs 35,000 crore in capital investments through FGD implementation and a significant number of jobs across engineering, procurement, construction (EPC), commissioning, and ongoing operation and maintenance (O&M).

At the same time, several implementation challenges limit the acceleration of FGD installation:

- **Limited vendor capacity driving supply constraints:** FGD is a relatively new technology with limited future specially looking at the energy transition and net zero

goals in India, with the vendor ecosystem still developing, a clear pathway to meet the demand seems missing.

- **Simultaneous demand from hundreds of units overwhelming implementation timelines:** nearly 500 thermal power units (~180 GW) are pursuing FGD tenders within overlapping timelines, straining the system's ability to meet EPC needs, resulting in clogged tender pipelines and delayed on-ground execution. The initial phasing plan to ensure uninterrupted power supply and have a staggered timelines seems to have taken a backstage with only three broad categories for compliance timelines putting pressure on manufacturing by having ~80% of the capacity with one common deadline under category C.
- **Long installation timelines delaying environment benefits:** Since FGD systems can take 36-44 months for installation, even if supply constraints and vendor bottlenecks are resolved, the tangible SO_2 and PM 2.5 reductions are likely to materialize only after a few years.
- **Repeated deadline extensions delaying implementation:** Despite existing mandates for emission norm compliance, deadlines have been extended four times in almost a decade,[16] with the repeated extensions diluting the urgency and accountability to install FGDs.

Key Focus for Discussion

With the aim of unlocking clean air benefits by accelerating FGD adoption for SO_2 control, this session will explore:

- What **policy and implementation levers can India adopt from international examples** like China or the U.S. to strengthen enforcement, such as penalties and enhanced use of CEMS?
- What mechanisms, such as **DCR-linked subsidies**, can India deploy to **incentivize domestic manufacturing** of FGD components and reduce import dependence?
- What **role can performance-linked mechanisms play in accelerating implementation**, such as linking capital subsidies to SO_2 reduction outcomes or domestic manufacturing components?
- How can **different financing instruments**, such as syndicated loans, blended finance, or interest subvention, be leveraged to **reduce upfront capital burden**? What **role can MDBs, commercial banks, and green finance facilities play** in unlocking this capital?
- How can **FGD implementation be prioritized based on environmental and operational criteria** such as proximity to pollution hotspots like Delhi-NCR and remaining operational life?
- What **capacity-building measures** or ecosystem support are needed to **strengthen the domestic FGD vendor base** and accelerate readiness for large-scale installations?

[16] DownToEarth, Thermal power plants get another extension for SO_2 compliance norms — it's time we reassess ongoing delays

- What role do the regulatory mechanisms such as Merit Order Dispatch (MOD) and tariff pass on to the consumer etc. play in helping expedite the FGD installations?

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