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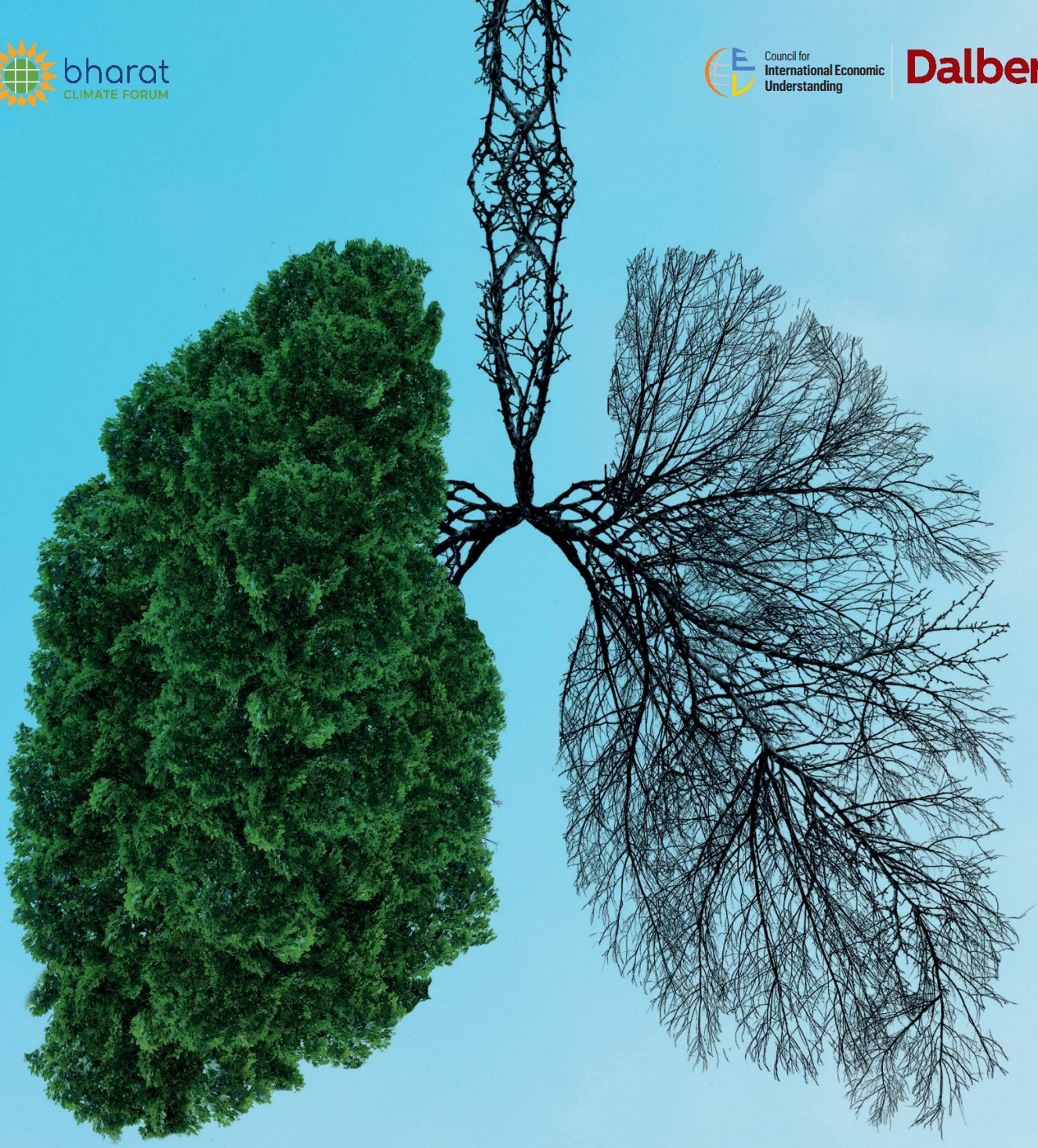


Aironomics 2025

Unlocking India's Blue Skies Economy

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

Fields of Smoke

Rethinking Agriculture for Cleaner Air

Context and rationale

Crop residue burning is a major contributor to air pollution, particularly in north India. Crop residue burning residue is the second largest contributor to air pollution in Delhi-NCR.[1] In states like Punjab and Uttar Pradesh, about 30-50% of crop residue generated annually is either partially or entirely burned, releasing pollutants that exacerbate the region's air quality crisis.[2,3]

Figure 1: Contribution of crop residue burning to air pollution in Delhi-NCR

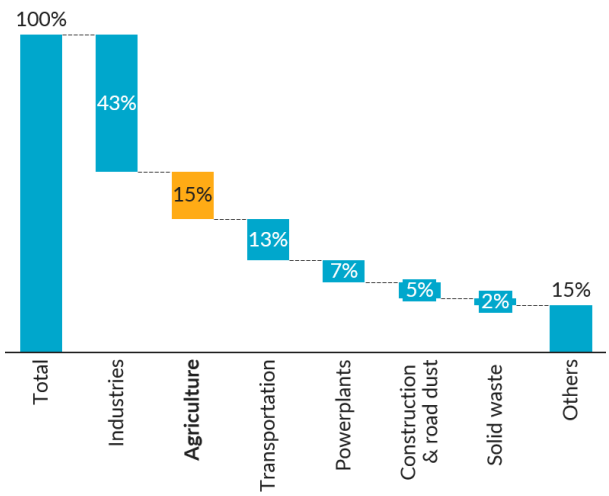
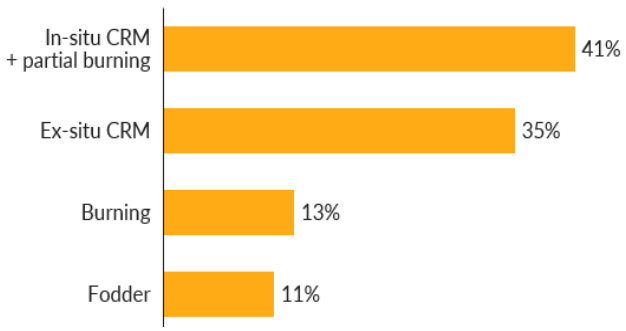


Figure 2: Crop residue management of the 20 million tonnes produced in Punjab annually



While crop residue can be managed through in-situ and ex-situ mechanisms, farmers are increasingly adopting ex-situ management of crop residue, with compressed biogas (CBG) plants emerging as the preferred solution. In-situ crop residue management involves incorporating residue back into the soil using machines like happy or super seeders, while ex-situ involves collecting and transporting residue for alternative uses such as fuel or fodder. However, farmers face challenges in adopting in-situ solutions due to limited availability of seeders due to last-mile challenges, high operational costs (Rs 2,000 – 2,500 per acre), and concerns about reduced wheat yields and pest attacks. As such, farmers are moving towards ex-situ practices, with CBG preferred by most. One-third of

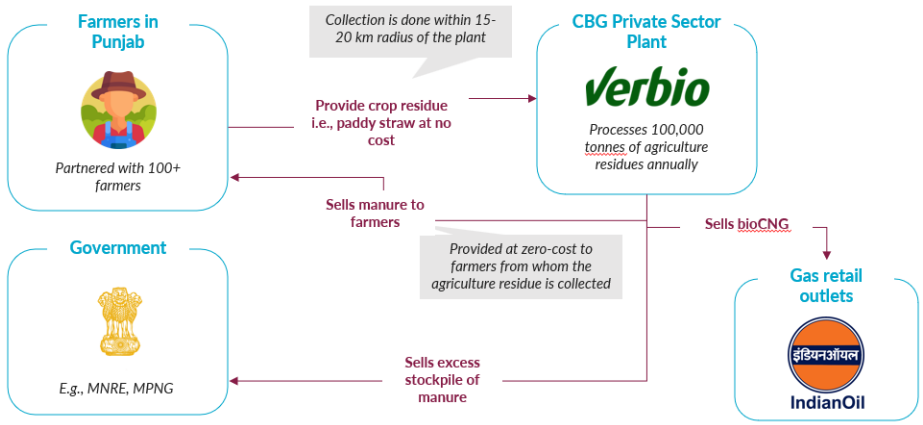
[1] TERI, Cost effectiveness of interventions for control of air pollution in Delhi
[2] CEEW, How can Punjab increase the adoption of crop residue management methods?
[3] Social and Political Research Foundation, Stubble Burning in North India: Defogging the facts

farmers in Punjab use ex-situ practices. Among these adopters, 60% prefer supplying crop residue to CBG plants, while 30% use it as fodder.[4]

Favorable government policies and initiatives, at both national and state level, are driving strong momentum in favor of CBG development. At the national level, the SATAT scheme by the Ministry of Petroleum and Natural Gas promotes the establishment of CBG plants by independent entrepreneurs. The MNRE's Waste to Energy initiative offers Central Financial Assistance for setting up CBG projects, and the Fertiliser (Inorganic, Organic or Mixed) Order, Amendment, 2025 recognizes 'Organic Carbon Enhancers' from CBG plants as fertilizers, encouraging wider adoption of organic alternatives. Additionally, MNRE's National Bioenergy Programme (2021–26) provides financial support and policy impetus for biogas, biomass, and waste-to-energy projects. At the state level, Punjab has set a target to establish seven CBG projects to process over 272,000 tonnes of paddy straw[5] and is preparing to launch a State Policy for Biofuels aimed at setting up ~300 CBG projects.[6]

CBG plants unlock win-win opportunities for all by connecting farmers with offtakers. Successful models like Verbio AG exist, which transform agricultural residues into clean energy and bio-manure at an unprecedented scale. Verbio partners with farmers within 15-20 km radius of the plant, who provide crop residue at no cost. After processing the residue, Verbio provides manure to the partnered farmers at no cost, selling bioCNG to gas retail outlets like IndianOil, and selling excess stockpile of manure to the government. The plant, India's largest, processes 100,000 tonnes of agricultural residues annually and produces 33 TPD of BioCNG and 650 TPD of bio-manure,[7] highlighting the potential for scaling CBG solutions.

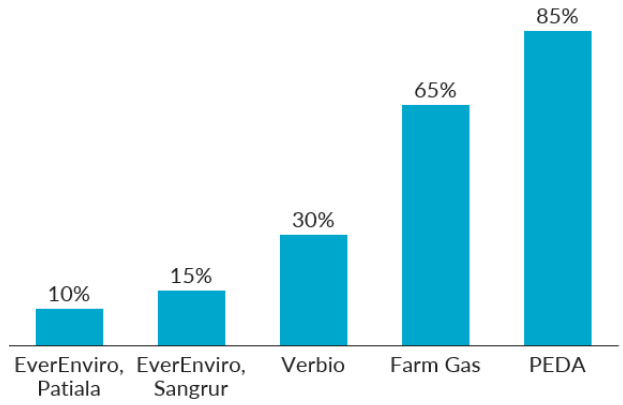
Figure 3: Case Study: Verbio's scalable CBG model



[4] CEEW, How can Punjab increase the adoption of crop residue management methods?
[5] IamRenew, 7-CBG projects to be operationalised in Punjab in 2024
[6] RenewableWatch, Harnessing CBG: Punjab's efforts to mitigate waste and generate renewable energy
[7] RenewableWatch, Verbio India: New player in India's bio-CNG sector

Despite the strong momentum, low capacity utilization and challenges in accessing finance remains a major roadblock to scaling CBG plants. Most CBG facilities operate at less than 30% capacity (Figure 4)[8] due to insufficient demand for byproducts like bioslurry. The low demand restricts scalability, as the costs and logistics associated with storing excess bioslurry pose additional hurdles. This underutilization reinforces the perception of CBG as a high-risk sector, limiting access to finance. While entities like IREDA offer up to 70% Loan-to-Value (LTV), most banks remain cautious—especially given the high upfront investment of ~Rs 200 crore needed for a plant processing ~100,000 tonnes of agri-waste annually.[9]

Figure 4: Capacity utilization of CBG projects in Punjab



Beyond the environmental imperative, CBG plants represent a massive economic opportunity waiting to be unlocked. India's biogas market is projected to grow at a CAGR of 10%, reaching approximately $3.5 billion by 2032.[10] Recognizing this potential, the government has set an ambitious target of establishing 5,000 CBG plants by 2025—requiring an estimated $20 billion in capital investment and expected to create over 4 lakh jobs across the value chain.[11] This momentum is already translating into large-scale private investments, with corporates like Reliance committing over Rs 65,000 crore to set up over CBG plants across the country[12].

This roundtable, "***Fields of Smoke: Rethinking Agriculture for Cleaner Air*****",** will bring together key stakeholders across government, CBG producers, and CBG off-takers to explore how policy and finance can accelerate the adoption of sustainable crop residue management practices and unlock the full potential of CBG as a scalable solution.

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[8] RenewableWatch, Harnessing CBG: Punjab's efforts to mitigate waste and generate renewable energy
[9] Ministry of Petroleum & Natural Gas, Compressed Bio Gas (CBG) is the need of the hour, and Government is taking all steps to promote ecosystem around it
[10] Fortune Business Insights, India Biogas Market
[11] Indian Biogas Association, Rural employment generation through biogas production in villages of India
[12] CNBC, Reliance Industries breaks ground on first of 500 CBG plants in Andhra Pradesh

Potential Opportunities and Challenges

The potential to scale crop residue management in India, especially through CBG, is underscored by multiple emerging opportunities, driven by a large domestic market, supportive policies, and advancing technologies.

- **Reducing PM 2.5 and GHG emissions through the diversion of crop residue from burning:** Redirecting the ~92 million tonnes of residue burned annually in India to CBG plants can significantly curb PM 2.5 (up to 15% in Delhi),[13] with each plant abating ~30,000 tonnes of CO_2[14] by avoiding residue burning and displacing traditional fuels.
- **Creating large-scale employment across the value chain:** The SATAT initiative's target of 5,000 CBG plants could create over 4 lakh jobs across the value chain, including 55,000 skilled engineers, 2 lakh semi-skilled construction workers, and 1.5 lakh unskilled workers for daily operations.[15]
- **Scaling biogas infrastructure as an emerging economic opportunity:** Corporates like Reliance are setting up 500+ CBG plants in states like Andhra Pradesh by investing Rs 65,000 crore,[16] signalling the large economic potential of the CBG sector.
- **Increasing capacity utilization of CBG through policy and innovative technologies like biopellets:** Policies that incentivize farmers to adopt CBG byproduct over urea can drive high capacity utilization of CBG plants while policies that increase the market price of organic manure and raise CBG procurement prices can improve the financial viability for producers. Additionally, beyond biogas, producing bio-pellets offers a promising revenue stream, especially with the growing demand for biomass cofiring in thermal power plants.
- **Monetizing carbon credits by leveraging India's upcoming carbon market:** With India's carbon market set to launch by mid-2026, by reducing carbon emissions from residue burning and traditional fuel burning, CBG plants can generate tradable carbon credits under India's Carbon Credit Trading Scheme to unlock additional sources of revenue.
- **Piloting and tapping into new carbon-sequestering products and methods like biochar:** Beyond biogas, technological innovations such as biochar production from agri-residues offer avenues for carbon sequestration, improved soil health, and additional monetization through carbon credits. Crop residues derived biochar has an estimated market value of ~$500 billion in India.[17]

[13] Ministry of Agriculture, National Policy for Management of Crop Residues
[14] Dalberg analysis
[15] Indian Biogas Association, Rural employment generation through biogas production in villages of India
[16] CNBC, Reliance Industries breaks ground on first of 500 CBG plants in Andhra Pradesh
[17] Renewable and Sustainable Energy Reviews, Biochar and its twin benefits: Crop residue management and climate change mitigation in India

At the same time, several financial and operational challenges limit the scalability of CBG solutions:

- **Huge upfront investment**: Setting up a CBG plant requires significant capital, with 1 plant processing 100,000 tonnes of crop residue requiring ~Rs 200 crore in investment.[18] With banks providing loan-to-value ratios between 25-70%, this translates into high upfront investments. Further, the capital expenditure accounts for approximately 90% of total project. These costs are significantly higher under the retail outlet model compared to pipeline injection models.[19]
- **High risk perception by commercial lenders:** Low capacity utilization driven by low demand raises risk perception of the CBG sector, with commercial lenders offering loans at high interest rates, short tenures, and low loan-to-value ratio, driving costs of debt.
- **Low Internal Rate of Return (IRR) at Smaller Scales**: Projects under 50 TPD show poor returns (IRR of only 5–7%). Project returns improve only at larger scales, making small and medium plants less attractive.[20]
- **Low capacity utilization due to weak market demand for byproducts and uncertain feedstock supply**: Most CBG plants operate at only 30–40% capacity due to limited offtake of bioslurry and organic manure. Further, lack of long-term, assured feedstock arrangements poses a major risk, with seasonal variability and logistical challenges in biomass collection affecting reliability.[21]
- **Nascent stage of bio-carbon credit market**: Tapping into additional revenue streams like carbon credits is critical to scale CBG plants, however, India's carbon market is at a nascent stage, with the Indian government launching the first carbon market by mid-2026.

Key Focus for Discussion

With the aim of unlocking clean air benefits by scaling CBG solutions for crop residue management, this session will explore:

- What are the key barriers preventing wider adoption of in-situ crop residue management, and **can ex-situ solutions like CBG plants be considered a sustainable long-term strategy**?
- What is the potential of crop residue management through **emerging solutions like biochar production and carbon sequestration** and how can they be scaled?
- What other **policy adjustments**, like the recognition of 'Organic Carbon Enhancers' from CBG plants as a fertilizer by the Fertilizer (Inorganic, Organic or Mixed) Order, Amendment, are needed **to drive higher capacity utilization** of CBG plants?

[18] Ministry of Petroleum & Natural Gas, Compressed Bio Gas (CBG) is the need of the hour, and Government is taking all steps to promote ecosystem around it
[19] PowerLine, Feedstock to Fuel: Challenges and opportunities in the CBG segment
[20] International Journal of Science and Research, Technological Challenges in CBG Manufacturing in India - A Critical Review
[21] PowerLine, Feedstock to Fuel: Challenges and opportunities in the CBG segment

- How can policies such as the Carbon Credit Trading Scheme best **support and encourage carbon credit monetization from CBG plants and enable funder discovery**?
- **What innovative financing solutions** such as credit guarantees can **reduce the perceived risks** of commercial lenders and ease high upfront costs faced by CBG operators?
- How can **co-benefits** such as livelihood creation, carbon abatement, and health benefits be **leveraged to enhance innovative financing** solutions and **what role can philanthropy play** in doing so?
- What role can **large corporate players** like Reliance play in **driving the scale-up of CBG infrastructure**, and what **operational or regulatory challenges** must be addressed to enable end-to-end value chain execution at scale?
- Can **community-based CBG models** offer a viable complement to large-scale plants, and what **enablers**—such as aggregation, localized offtake, or capacity-building—are needed to make them work in practice? Are there **any examples** of successful community-based models?

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