Coal Gasification in India: From Policy Support to Bankable, Circular Carbon Value Chains

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Coal Gasification Conference 2026:Scaling Up Technology for High Ash India Coal

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3. India's Strategic Vulnerability

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INDIA'S DEPENDENCE ON IMPORTS

- **~87%** crude oil imported
- **LNG** imports increasing
- **Methanol** imports
- **Ammonia** imports
- **Petrochemical** feedstock imports

CRITICAL QUESTION

Can domestic coal become a strategic carbon resource?

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COMPARISON OF COAL AND ITS ORIGIN

India's Coal is Different. Hence, Our Technology Must Be Different.

ASH CONTENT COMPARISON

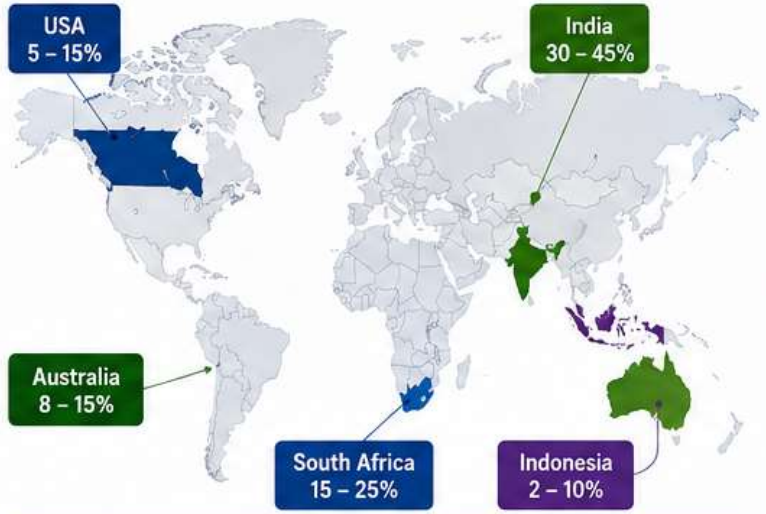
COUNTRY	ASH CONTENT (%)
India	30 – 45
Australia	8 – 15
USA	5 – 15
South Africa	15 – 25
Indonesia	2 – 10

WHY IT MATTERS?

Higher ash in Indian coal leads to unique challenges:

- **Higher Slag Formation** — More ash leads to more slag, causing operational difficulties.
- **Higher Ash Fusion Temperature** — Requires robust high-temperature materials and design.
- **Lower Gasifier Efficiency** — Impacts syngas quality and carbon conversion.
- **More Frequent Ash Handling** — Leads to higher wear, maintenance and operating cost.
- **Catalyst Deactivation** — Ash minerals poison catalysts, reducing life and performance.

ORIGIN OF DIFFERENT COALS



KEY IMPLICATION

This is why technologies developed in Australia, USA, or China **cannot simply be copied for India.**

INDIAN COAL REQUIRES INDIGENOUS TECHNOLOGY SOLUTIONS

- Tailored Gasifier Design
- Advanced Ash Management
- Robust Materials & Coatings
- Ash-Tolerant Catalysts
- Process Intensification

Indigenous Innovation for Atmanirbhar Bharat

UNDERSTAND OUR COAL. DESIGN OUR TECHNOLOGY. SECURE OUR FUTURE.

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TYPES OF COAL IN INDIA

Two Types, Two Roles – Powering India's Present and Shaping Its Future

1 THERMAL (NON-COKING) COAL

~85–90%
of reserves

USED FOR:

- Power generation
- Gasification
- Methanol
- Ammonia
- Coal-to-chemicals

Abundant, widely available and the backbone of energy security and future carbon conversion in India.

2 COKING COAL

~10%
of reserves

Only about 10% of reserves.

MAINLY IN:

- Jharia
- Bokaro
- Raniganj

Used for steel production.

INDIA IMPORTS LARGE QUANTITIES OF PREMIUM COKING COAL FROM:

AUSTRALIA | CANADA | USA

THERMAL COAL FUELS OUR ENERGY TODAY. COKING COAL BUILDS OUR STEEL TOMORROW.
SMART UTILISATION. STRATEGIC IMPORTS. SUSTAINABLE FUTURE.

4. India's Coal Wealth

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India's Carbon Advantage

Geological reserves: ~390 billion tonnes

2nd largest coal producer

Top 5 coal reserve holder

MAJOR COAL-BEARING STATES

- Odisha
- Jharkhand
- Chhattisgarh
- West Bengal
- Madhya Pradesh
- Telangana
- Maharashtra

NEW PARADIGM

Coal = Strategic Carbon Reserve

(Not merely a fuel)

Coal Gasification in India

- **Coal gasification not merely as a clean-coal technology, but as a chemical-engineering platform for converting domestic carbon into strategic industrial molecules**
- **100 million tonnes of coal gasification by 2030.**
- July 2026: **22.6 MTPA** operational or under implementation:
- 8 MTPA at Jindal Steel,
- 2.6 MTPA at Talcher Fertilisers
- 12 MTPA through eight projects under the

GOI: Strong policy platform

- **₹37,500-crore Surface Coal/Lignite Gasification Scheme.**
- **75 MMT of additional coal/lignite utilisation,** provides financial support of up to **20% of eligible plant and machinery cost,** and extends coal-linkage tenure to **30 years.**
- **₹2.5-3 lakh crore of investment**
- **50,000 direct and indirect jobs**

But government incentive is necessary—not sufficient—for FID.

Proposition 1: Move from coal-to-energy to coal-to-molecules

Coal → Gas → Energy is NO GOOD

Coal → Syngas → H_2 + CO → Molecules → Chemicals + Materials

- **Methanol**
- **Ammonia / urea**
- **Ammonium nitrate**
- **DME**
- **Synthetic natural gas**
- **Hydrogen**
- **Reducing gas for steel**
- **Synthetic fuels**
- **Chemical Intermediates**

Stop treating coal only as a fuel. Through gasification, coal becomes a carbon feedstock

P2: High-ash Indian coal requires Indian solutions

- high ash;
- variable ash chemistry;
- slagging and fouling;
- mineral matter;
- feed variability;
- ash handling;
- oxygen consumption;
- syngas cleaning;
- water management

The technology must be proven not merely at commercial scale, but on the actual Indian coal that will feed the plant

P3: No universally best gasifier

- **Coal + Product + Scale + Water + Carbon + Economics**
- rather than simply asking:
- **Fluidized bed or entrained flow?**

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BEST COAL GASIFICATION TECHNOLOGIES FOR HIGH-ASH INDIAN COALS

Choosing the Right Technology for India's Abundant but Challenging Coal Resources

INDIAN COAL – THE CHALLENGE

- High Ash: 30–45%
- High Mineral Matter
- Variable Ash Fusion Temperatures
- Lower Calorific Value
- High Tendency for Slagging, Fouling and Erosion

India has no large commercial coal-to-chemicals complex operating at the scale seen in China.

There are:

- Pilot Gasifiers
- Demonstration Units
- Fertilizer Gasification Units under Construction
- Sponge Iron Gasifiers
- Captive Industrial Gasifiers

But not yet a mature commercial coal chemicals industry.

COMPARISON OF COAL GASIFICATION TECHNOLOGIES FOR INDIAN HIGH-ASH COAL

TECHNOLOGY	1. BHEL PRESSURISED FLUIDISED BED GASIFIER (PFBG)	2. PRESSURISED FLUIDISED BED (HTW/WINKLER TYPE)	3. MOVING BED (LURGI TYPE)	4. ENTRAINED FLOW (SHELL, GE, SIEMENS, ECUST, ETC.)	5. UNDERGROUND COAL GASIFICATION (UCG)
					
SUITABILITY FOR INDIAN COAL	★★★★★	★★★★☆	★★★☆☆	★★☆☆☆	Site-Specific
ASH HANDLING	High ash tolerance (30–45%), dry ash removal	High ash tolerance, good for low-rank coals	Handles coarse coal, moderate ash tolerance	Low–moderate ash tolerance (requires beneficiation/blending)	No ash handling (in-situ gasification)
CARBON CONVERSION	High	High	Medium	Very High	
TAR IN SYNGAS	Low–Moderate	Moderate–High	High	Very Low (Tar-free)	
OPERATING TEMPERATURE	800–950 °C	800–950 °C	950–1,100 °C	1,200–1,600 °C	700–1,000 °C (underground)
OXYGEN REQUIREMENT	Lower	Lower–Moderate	Lower	High	
KEY ADVANTAGES	• Developed for Indian coal • Wide coal quality window • Dry ash removal • Lower operating temperature • Lower refractory wear • Ideal for chemicals & H_2	• Excellent heat transfer • Good for high ash & low-rank coal • High cold gas efficiency	• Proven, reliable • Handles coarse coal • Good methane yield • Simple operation	• Highest carbon conversion • Tar-free syngas • Suitable for large-scale methanol, FT synthesis	• No mining required • Suitable for deep, unmineable seams
KEY LIMITATIONS	• Technology at early commercial stage	• Tar formation • More complex gas cleanup	• Tar formation • Lower throughput • Not ideal for very high ash/fines	• High oxygen demand • High refractory wear • Slagging risk with high-ash coal • Requires fine coal	• Geological uncertainty • Environmental risk • Difficult process control
OVERALL SUITABILITY	**EXCELLENT** Best Indigenous Option for India	**VERY GOOD** Well Suited for Indian Coal	**MODERATE** Suitable with Limitations	**LOW** Less Suitable for High-Ash Indian Coal	**SITE-SPECIFIC** Suitable Only for Selected Deposits

CURRENT STATUS OF MAJOR COAL GASIFICATION PROJECTS (MID-2026)

PROJECT	OWNER	PRODUCT	COAL CONSUMPTION	STATUS	TECHNOLOGY
Talcher Fertilizers, Odisha	Talcher Fertilizers Ltd (CIL-GAIL-RCF-FCIL)	1.27 MMTPA urea	2.5 – 3.0 Mt/y	Under construction	Entrained-flow (licensed)
BCGCL, Jharsuguda	BHEL + Coal India	2,000 TPD ammonium nitrate	~1.3 – 1.5 Mt/y	EPC awarded	BHEL Pressurised Fluidised Bed Gasifier (PFBG)
Coal Gas India Ltd (Raniganj)	Coal India + GAIL	SNG (~80,000 Nm^3/h)	1.9 Mt/y	DPR stage	Entrained-flow (licensed)

STRONG POLICY PUSH BY GOVERNMENT

NATIONAL COAL GASIFICATION MISSION

- Launched to promote coal gasification for chemicals, fuels, fertilisers and clean energy.
- Focus on technology development, projects and infrastructure.

₹37,500 CRORE INCENTIVE SCHEME

- Approved to accelerate commercial coal gasification projects.
- Viability gap funding support to reduce risk and attract investment.
- Steps towards Atmanirbhar Bharat in chemicals & fuels.

EMERGING & NEXT-GENERATION TECHNOLOGIES FOR INDIA

- Plasma-assisted Gasification
- Chemical Looping Gasification
- Sorption-enhanced Gasification
- Co-gasification (Coal + Biomass + Plastics + CO_2)
- Oxygen-blown Pressurised Gasification
- Advanced Hot Gas Cleanup
- AI-driven Process Control & Digital Twins
- High-temperature Materials & Ceramic Filters
- Integration with Green H_2 and Circular Carbon Refinery

INDIA'S STRATEGIC OPPORTUNITY

India should not aim merely to be a user of coal gasification technologies; it should become a **GLOBAL DEVELOPER AND EXPORTER** of high-ash coal gasification technologies tailored to the world's most challenging coal resources.

VISION FOR INDIA: CIRCULAR SMART CARBON REFINERY

High-Ash Indian Coal → Gasification → Syngas → Green H_2 Integration → Methanol / Ammonia / Fuels → Chemicals & Materials → Value Added Products

Energy Security • Import Reduction • Environment Protection • Economic Growth • Atmanirbhar Bharat

THE WAY FORWARD

- Deploy indigenous, high-ash coal gasifiers
- Scale up pilot → demonstration → commercial
- Strengthen R&D, materials and catalysts
- Promote partnerships & export technology
- Build circular carbon economy for a sustainable future

RIGHT TECHNOLOGY • RIGHT COAL • RIGHT POLICY • RIGHT EXECUTION = ENERGY, CHEMICAL & ECONOMIC SELF-RELIANCE FOR INDIA

P3: Which Gasifier: Basic Questions

Parameter	Question
Feedstock	Can it handle Indian high-ash coal reliably?
Syngas	What H_2/CO ratio is produced?
Efficiency	What is the overall coal-to-product efficiency?
Oxygen	What is the O_2 requirement?
Water	What is water consumption per tonne of product?
Ash	What happens to the ash?
Scale-up	Is the technology commercially demonstrated?
Carbon	Can CO_2 be captured economically?
Product	Is there flexibility between products?
Economics	What is the levelised cost and sensitivity to coal/product prices?

P4: FID is fundamentally a risk-allocation exercise

Risk allocation should be explicit:

- **Coal supply risk → Coal company**
- **Technology risk → Technology provi**
- **EPC/construction risk → EPC contra**
- **Operating risk → O&M partner**
- **Product/offtake risk → Anchor cust**
- **Financing risk → Financial consort**
- **Policy/regulatory risk → Government**
- **Carbon-management risk → Project consortium +**

A project becomes bankable when every major risk is allocated to the party best capable of managing it.

The ultimate destination is not merely coal gasification. It is intelligent carbon management.

P5: Do not build the gasifier first and find the customer later

- **Customer → Product specification → Offtake agreement → Feedstock → Technology → EPC → Financing → FID**

Rather than: Coal → Gasifier → Syngas → "Who will buy it?"

- **Coal gasification → ammonia → fertiliser company**
- **Coal gasification → methanol → chemical/refinery customer**
- **Coal gasification → reducing gas → steel plant**

P6: Carbon management must be designed from Day One

- **Gasification**
- ↓
- **Syngas conditioning**
- ↓
- **H_2 + CO**
- ↓
- **Products**
-
- **CO_2 separation**
- ↓
- **CCS / CCU**
- The objective should progressively move from:
- **Carbon capture**
- to
- **Carbon utilisation**
- to
- **Circular carbon management**

P7: Build a coal + biomass + waste pathway

- Why should the future plant necessarily remain **100% coal?**

- We should investigate:
- **Coal + biomass**
- **Coal + agricultural residues**
- **Coal + suitable waste-derived feedstocks**
- Potentially **net-negative carbon systems.**
- It also connects coal gasification with India's broader **waste-to-wealth and circular-economy agenda.**

P8: Water can become the hidden FID constraint

- **Every project should undergo a Water–Energy–Carbon–Land Nexus Assessment before FID.**

- water consumption per tonne of coal;
- water consumption per tonne of final product;
- quality of water required;
- potential use of treated municipal wastewater;
- cooling-water strategy;
- zero-liquid-discharge requirements;
- water availability during drought years.

- **A project that is financially bankable but water-insecure is not truly bankable**

Energy Import and Coal Policy

- India imported about **₹2.77 lakh crore** worth in FY2025 of products
- that are potentially substitutable through coal/lignite gasification, including LNG, urea, ammonium nitrate, ammonia, coking coal, methanol and DME.
- Import dependence of **more than 50% for LNG, around 20% for urea, nearly 100% for ammonia and about 80–90% for methanol.**
- **Use domestic carbon strategically to reduce vulnerability in critical industrial supply chains.**

Questions to Stakeholders

- **Question 1 – To Government**

We now have a ₹37,500-crore incentive framework. What are the remaining three barriers that prevent a promoter from reaching FID?”

- **Question 2 – To industry and financiers**

What would make a coal-gasification project bankable without perpetual government support?”

- **Question 3 – To technology providers**

- **Can you guarantee performance on Indian high-ash coal at commercial scale, rather than simply demonstrating the technology on another coal**

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RESEARCH IMPACT

139	576	22000+	51	117	164
Patents	Publications	Citations	PDFs	Ph Ds	Masters

RESEARCH LEADERSHIP HIGHLIGHTS

- Advanced Process Systems Engineering & Optimization
- Energy, Environment & Sustainability
- Catalysis, Reaction Engineering & Green Chemistry
- Institution Building & Human Capital Development
- Translating Research into Industrial Impact

AWARDS & RECOGNITIONS

Rasayan Maharatna Award
by Indian Chemical Society
2025

Eminent Engineer Award
by Engineering Council of India
2025

Fellow, Canadian Academy of Engineering (CAE)
(First Indian)
2026

GLOBAL HONOURS

International Member
US National Academy of Engineering (NAE)
2022

Fellow
US National Academy of Inventors (NAI)
2023

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