Low-Carbon Hydrogen Integration into DRI Operations

Partial syngas substitution, coal-gasification transition, renewable energy and electrolyser linkage

1,000 Nm^3/hr
green H_2 injected, Phase I

5 MW
alkaline electrolyser, live May 2026

1.8 MTPA
Midrex MxCol DRI shaft furnace



Jindal Steel Limited (JSL), Angul, Odisha
CII National Award for Environmental Best Practices 2026 | Category: Technological Advancement
CII Waste & Resource Management Summit 2026

JSL Angul at a glance: a coal-syngas DRI route moving to hydrogen

12 MTPA

integrated steel complex, Angul, Odisha

1.8 MTPA

Midrex DRI shaft furnace, first MxCol configuration on coal syngas

1,000 Nm^3/hr

Green hydrogen injected presently (Phase I, 5 MW)

6,000 Nm^3/hr

renewable PPA behind the Phase I & Phase II, 30 MW

Strategic objective

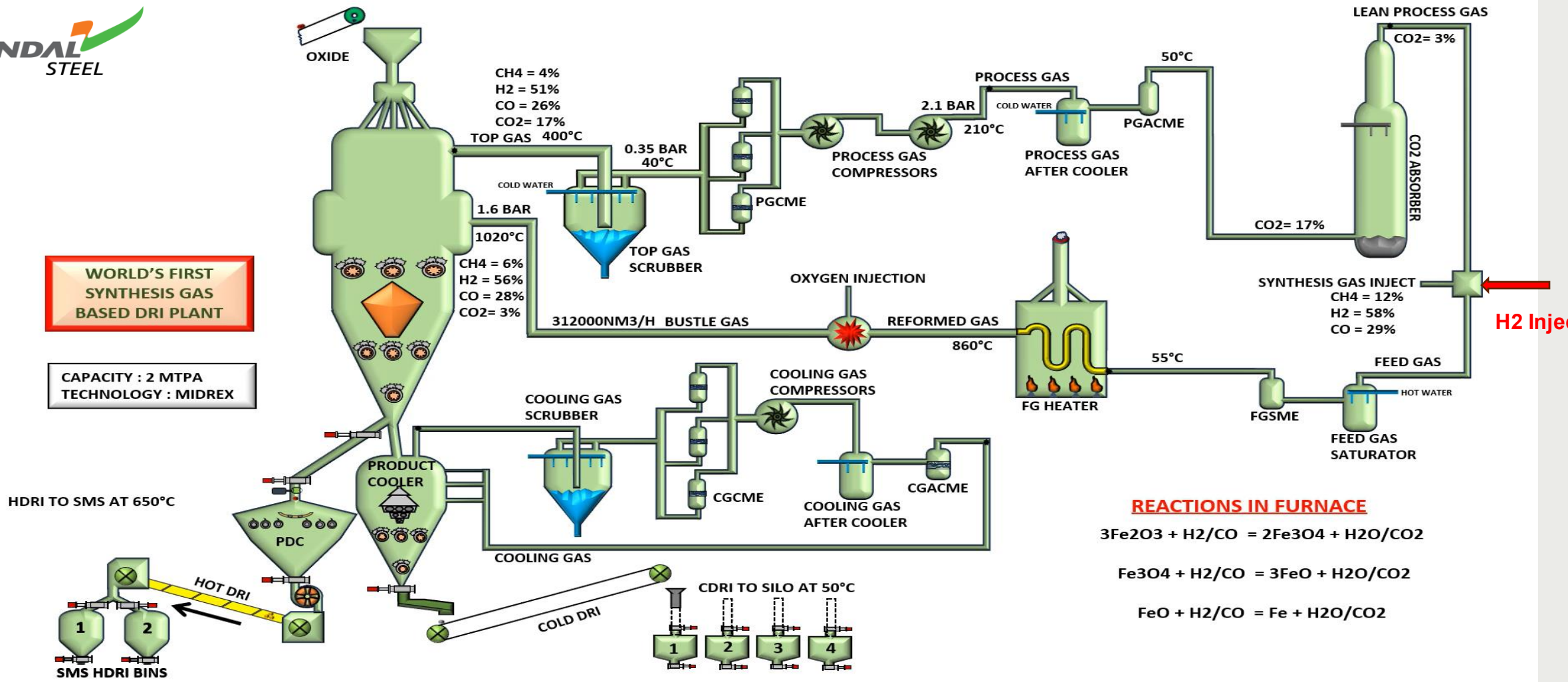
- Blend green hydrogen online to partially replace coal-based syngas in the DRI furnace
- Pilot deep-process decarbonisation on the world's first MxCol (coal gasification + Midrex) route
- Anchor assets: India's largest blast furnace (4.25 MTPA) and the coal gasification plant

Net Zero

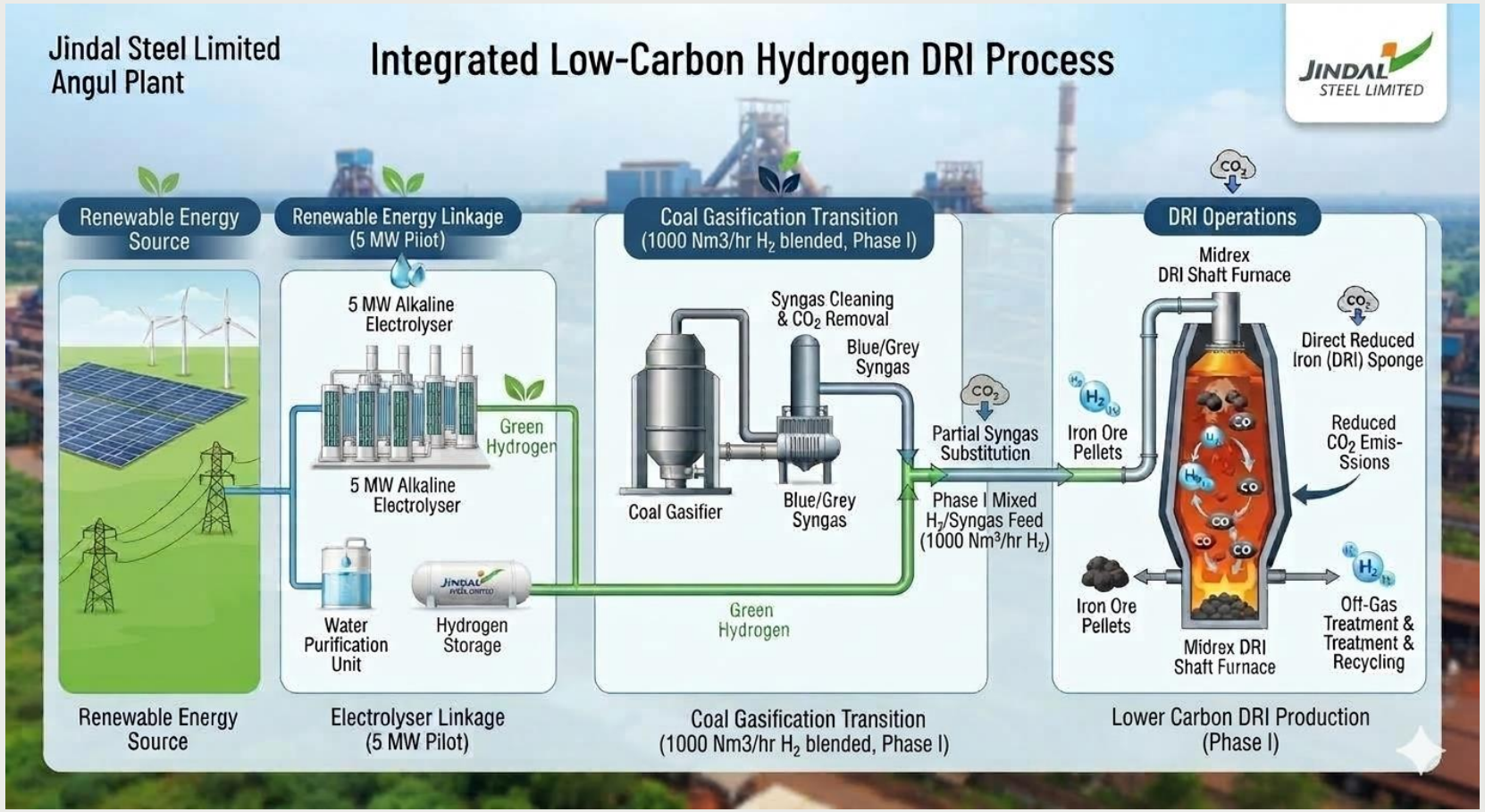
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JSL corporate aspiration

DRI-Angul Process Overview with H2 blending



Process architecture: green hydrogen blended into processed syngas



Online blending

H_2 joins syngas downstream of the turbo-expander and pressure-reduction skid

930 to 1,020 °C

mixed feed gas heated in a fired gas heater before furnace injection

Top gas < 5% CO_2

recycled furnace top gas is treated and blended back into the loop

Phase I: 5 MW alkaline electrolyser, 1,000 Nm³/hr green H_2

Hydrogen scales in steps up to 6,000 Nm³/hr without stopping furnace operation.

Why Angul is different: hydrogen into a coal-syngas DRI route

Typical H_2-DRI references

- Reducing gas from reformed natural gas
- Hydrogen replaces a hydrocarbon-derived stream
- Peers cite up to ~5,000 Nm^3/hr of H_2 injection
- Needs a natural-gas supply that coal-rich regions lack

JSL Angul MxCol route with H2

- Reducing gas from coal-gasification syngas
- H_2 blended online with syngas and top-gas recycle
- Phase I: 1,000 Nm^3/hr = 5.0 Nm^3 H_2 per tonne DRI
- Blueprint for coal-based DRI worldwide

Conventional Coal-Based Routes

• Highly dependent on solid coal combustion loops (like traditional rotary kilns).

• Suffers from extreme raw process emission intensities (2500 to 3100 kg CO2/t sponge iron).

• Product yields lack optimized metallization.

JSL Angul Mx-Col route with H2

• **Novelty**: Co-located high-efficiency syngas loop

•**Bed Cooling Solution**: Targeted oxygen injection to permanently prevent material fusion and cluster sticking issues.

•**Downstream Product Boost**: Delivers a rock-solid 93% metallization rate.

Project Roadmap: Phase I is live; Phase II multiplies injection six-fold

COMPLETE

2024 to 2025

Design & approvals

Detailed engineering by Fichtner, P&ID, and DPR validation by the IIT Kharagpur.

LIVE

May 2026

Phase I: pilot POC

5 MW alkaline electrolyser injecting 1,000 Nm^3/hr green H_2. Operating under trials, data tracking and baseline analysis.

PLANNED

July 2027

Phase II: full set-up

30 MW electrolyser delivering 6,000 Nm^3/hr pure H_2 injection for full-scale commercial deployment.

Hydrogen injection rate (Nm^3/hr)



Metallurgy Benefits: 30.33 Nm^3 H_2 displaces 32.5 Nm^3 syngas per tonne of DRI

Phase I (today)

5.0 Nm^3 H_2 / t DRI displaces **≈ 5.4 Nm^3 syngas / t**

Phase II (design)

30.33 Nm^3 H_2 / t DRI displaces **32.5 Nm^3 syngas / t**

12.06 Nm^3 of syngas displaced per kg of hydrogen injected

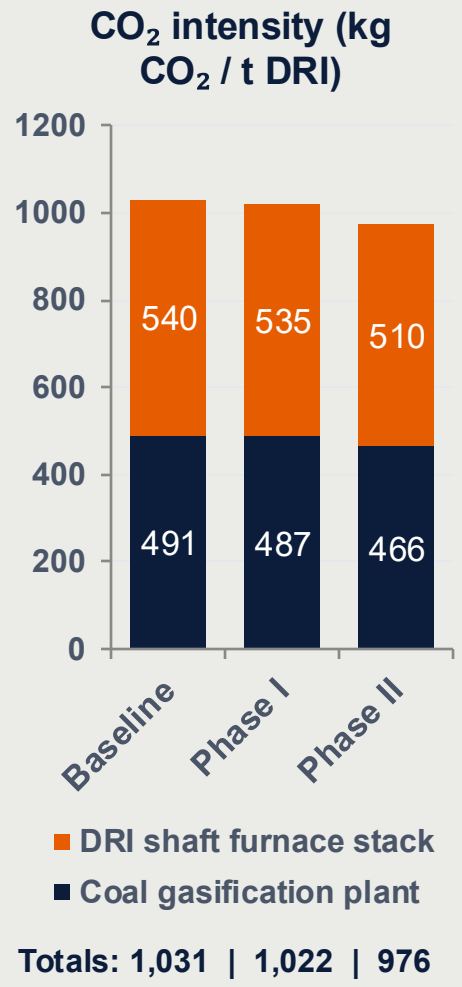
Why it works

- **Kinetic shift**:
- **High reducing potential**
- **Clean end product**

GHG Emissions Savings (CO2 reduction benefit): 9 kg CO_2/t saved at Phase I, 55 kg/t at Phase II

Basis: per hour and per tonne DRI	Phase I	Phase I + Phase II
H_2 injection rate (Nm^3/hr)	1,000	6,000
H_2 per tonne DRI (Nm^3)	5.0	≈ 30
H_2 mass flow (kg/hr)	89.9	539
Syngas displaced (Nm^3/hr)	≈ 1,070	≈ 6,400
Water condensed (t/hr)	0.80	4.8
CO_2 avoided (t/day)	44	264

Parameter	Baseline (syngas route)	Phase I: 1,000 Nm^3/hr	Phase I + Phase II: 6,000 Nm^3/hr
Coal gasification plant (kg CO_2/t DRI)	491	487 (−4)	466 (−25)
DRI shaft furnace stack (kg CO_2/t DRI)	540	535 (−5)	510 (−30)
Total carbon intensity (kg CO_2/t DRI)	**1,031**	**1,022 (−9)**	**976 (−55)**
Reduction vs baseline	Reference	0.9% lower	5.3% lower
CO_2 saved per day	Reference	≈ 44 t / day	264 t / day



Totals: 1,031 | 1,022 | 976

Basis: 4,800 t/day DRI. Phase I reduction = Phase II reduction × (1,000 ÷ 6,000).

Techno-economics benefits: $2.71/kg hydrogen with strong policy support – Govt of Odisha & Ministry of Steel, NGHM

$2.71 / kg

levelised cost of hydrogen (LCOH)

~79%

of lifetime opex is renewable power tariff

40%

grant on downstream piping & skids (MoS Scheme C)

30%

capital machinery subsidy

₹3 / kWh

power tariff reimbursement for 20 years

93%

metallisation, with 1.2 to 1.4% carbon for EAF melting yield

Design basis: 5 MW ÷ 1,000 Nm³/hr ≈ 5.0 kWh per Nm³ of hydrogen at Phase I.

Intangible Benefits: Operational & Human Impact

Socio-Environmental & Regional Ecosystem Capital

- Reducing coal reliance;
- This strengthens the company's "Social License to Operate" among surrounding communities.

Technical Skill Upgradation

- Promotes deep technological ownership;
- cross-functional training, and
- specialized knowledge building.

Increased Asset Availability & Insulation from Volatile Energy Geopolitics

- Instant fuel switchovers, ensuring continuous furnace operation.
- Sovereign energy control.

Industry Leadership Positioning

- Solidifies JSL's reputation as a globally recognized green manufacturing pioneer.

Challenges overcome: learnings that de-risk 6,000 Nm^3/hr

Endothermic cooling & clustering

Challenge

Hydrogen reduction is highly endothermic. It cools the furnace bed and causes material fusion and sticking.

Solution

Strategic oxygen injection triggers micro-combustion and holds bustle gas at 1,050 °C.

Embrittlement & leak risk

Challenge

Low gas density raises leak and flash-escape risk, and hydrogen embrittles standard carbon-steel pipe.

Solution

Hydrogen-compatible metallurgy across a 4.00 km pipe rack, with fast-acting interlock valves tied to Yokogawa PLC and Honeywell SCADA.

These controls are not scale-dependent: the same metallurgy, interlocks and temperature control carry over to Phase II implementation.

Safety and standards: independently validated end to end

1 PESO Compliance

Engineering layout, pipeline rack and pressure-reduction skid designs conform to PESO requirements.

2 HAZOP, Risk matrix

Hazard maps audited on a Severity (S0 to S4) and Frequency (F0 to F4) matrix.

3 Detailed Engineering by Fichtner, DPR approval by IIT Kharagpur

Validation by the Ministry of Steel-appointed Project Approval Committee.

4 LCA alignment

Emissions boundary matches international life-cycle guidelines for clean-steel classification.

Replicable now, scalable by July 2027

Definitive Proof of Concept: Phase I successfully confirms that clean green hydrogen can safely blend into heavy coal-gasification loops without disrupting asset stability.

Replication potential

- Parallel lines at Angul and Raigarh clusters
- Blueprint for steel plants in coal-rich, natural-gas-scarce regions
- Existing syngas or gas-based shaft furnaces can add H_2 loops without changing core reactor zones

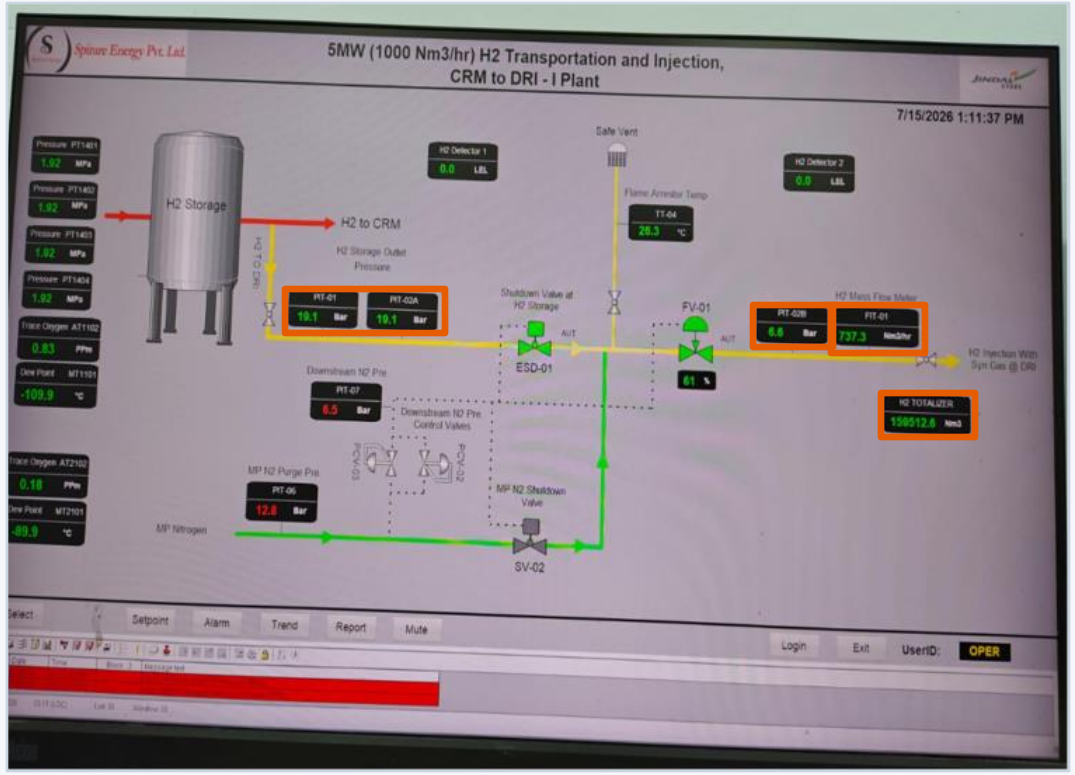
Key takeaways

First	hydrogen injection into a coal-syngas MxCol DRI
Proven	safe blending at 1,000 Nm^3/hr: 5.0 Nm^3 H_2/t, 9 kg CO_2/t saved
Scaling	6,000 Nm^3/hr and 55 kg CO_2/t by July 2027

Sustainable Synergy: Formally demonstrates that rigorous industrial growth, financial viability, and ambitious carbon stewardship can seamlessly align to drive net-zero goals.

DCS monitoring: hydrogen injection tracked live from CRM to DRI

CRM side: hydrogen plant control page



737.3 Nm³/hr

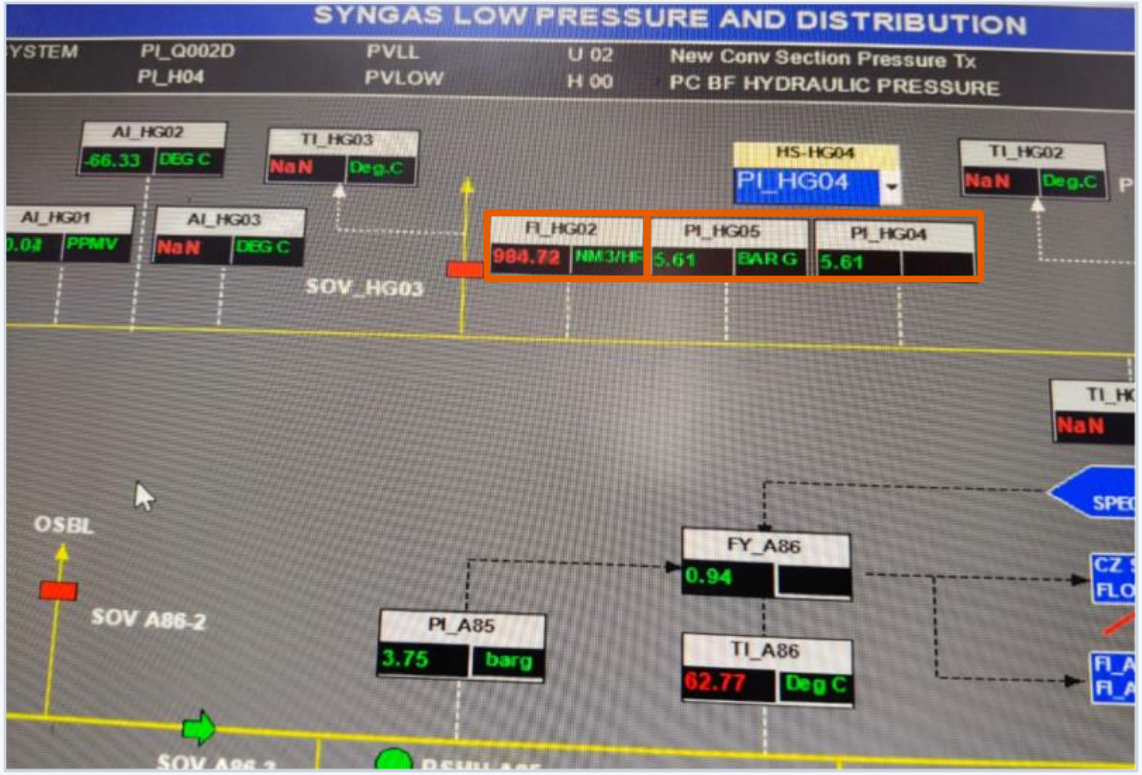
H_2 flow to DRI (FIT-01), 1,000 rated

19.1 → 6.6 bar

storage outlet to injection (PIT-01, PIT-02B)

On screen: ESD-01 shutdown valve, flame arrestor, H_2 detectors 0.0 LEL, N_2 purge.

DRI side: syngas distribution control page



984.72 Nm³/hr

flow indication FI_HG02 on the DRI page

5.61 barg

pressure indication PI_HG05 and PI_HG04

Instantaneous DCS values; CRM page timestamp 15 Jul 2026, 13:11.

Field arrangement: instrumented hydrogen skid and 4 km pipe rack

Hydrogen storage and valve skid



Pipe rack with instrument stations



Storage side

H_2 vessels beside the valve skid

Instrumentation

Fully automated control system

Gas control

Emergency Isolation and control valves on the line

Pipe rack

H_2 line on supports through the plant

Instruments

Integrated with the Honeywell DCS in DRI

Safe blending

Integration with Syn-gas