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EDITORIAL ANALYSIS

Between Coal, Chaos and Green Power

DOWN TO EARTH

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CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

linkedin.com/in/epicbharat

Between Coal, Chaos and Green Power

Down to Earth 20 May 2026 GS3

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INTERVIEW ANGLE

"India's coal sector employs over 700,000 workers (direct + contract) — how should India balance grid flexibility needs with just-transition commitments made at COP26 and COP28?"

EDITORIAL SUMMARY:

Down to Earth's Sunita Narain argues that India's April 25, 2026 record grid peak of 256 GW — where renewables supplied 30% at noon but coal still ran at its 55% technical floor — reveals that the energy transition has reached a systems crisis, not a capacity shortfall. The editorial contends that India must simultaneously retrofit coal plants for flexible low-load operation, mandate co-located battery storage for new renewable projects, build domestic green-tech manufacturing to avoid a new import dependency, and introduce real-time pricing — while funding a just-transition plan for coal workers and royalty-dependent states.

THE RECORD THAT DEMANDS AN EXPLANATION

On **April 25, 2026**, India's power grid recorded its **highest-ever peak demand: 256 GW**. Grid-India (the Grid Controller of India Limited — formerly POSOCO, renamed in November 2022) managed the demand without major load-shedding. The Ministry of Power declared it a success.

It was — and it was not. The headline number conceals a structural contradiction that Sunita Narain, Down to Earth's editor, identifies with characteristic directness: at **noon on April 25**, India's expanding solar fleet was generating approximately **30% of total grid supply**. By any metric, that is a genuine achievement — India's installed solar capacity of approximately **150 GW** (as of March 2026) is large enough to meaningfully shape daytime supply on sunny April days.

But at that exact noon moment, India's **coal plants were still running at approximately 55% of their installed capacity**. Not because demand required it — solar was flooding the grid — but because **55% is the technical minimum below which coal plants in India cannot safely operate**. The boiler

thermodynamics, turbine mechanics, and operational parameters of India's thermal fleet were designed for baseload continuous generation. They cannot simply be throttled down to 30–40% output when solar is abundant without risking operational damage.

This is the **flexibility paradox**: India's grid is simultaneously drowning in midday solar and locked into a coal floor it cannot lower. Every additional gigawatt of renewable capacity added without addressing this paradox deepens the problem rather than solving it.

THE DUCK CURVE ARRIVES IN INDIA

Energy systems analysts call this the **duck curve** — named for the shape of a power grid's net demand (total demand minus solar generation) plotted across the hours of a sunny day.

- **Mid-morning to mid-afternoon:** solar floods in, net demand drops steeply — the duck's belly
- **Late afternoon to evening:** solar fades, demand surges from cooling, cooking, and industrial loads — the duck's neck ramps sharply upward
- **Evening peak:** coal and gas must ramp up fast from whatever low-output state they were managing during the solar surplus hours

The ramp rate — how quickly coal plants can increase output from their minimum to full capacity — is the critical parameter. Indian coal plants were not built for this. **Rapid ramp cycling** stresses boiler components, reduces thermal efficiency, and increases emissions per unit of output. A coal plant cycling through a severe duck curve is simultaneously less economical and dirtier than one operating at steady baseload.

The countries that have managed the duck curve — California, Germany, South Australia — did so through **grid-scale battery storage** that absorbs the midday solar surplus and discharges it into the evening ramp. India's grid-scale storage is approximately **4–5 GW**. The **Central Electricity Authority (CEA)** has estimated India needs approximately **60 GW** of grid-scale storage by 2030 to manage the intermittency of the planned renewable mix. The gap between 4–5 GW and 60 GW is the measure of India's transition unpreparedness.

THE STORAGE GAP: TARGETS VS. REALITY

India's storage targets are stated. The gap to reality is large.

STORAGE TYPE	OPERATIONAL (2026)	TARGET (2030)	GAP
Battery Energy Storage Systems (BESS)	~4–5 GW	47 GW (Budget 2023)	~42–43 GW
Pumped Storage Hydro	4.7 GW	Potential 96 GW identified	91 GW (geographically constrained)
Green Hydrogen (as storage)	Negligible	Pilot scale by 2030	Policy framework being developed

The **PLI scheme for Advanced Chemistry Cell (ACC) batteries**, announced with an outlay of **Rs 18,100 crore** and a target of 50 GWh of domestic manufacturing, has progressed slowly. Key manufacturers selected under the scheme — including Ola Electric, Reliance New Energy, and Rajesh Exports — are in various stages of commissioning. Operational domestic capacity remains a fraction of the 50 GWh target. India still imports the majority of its battery cells, predominantly from Chinese manufacturers.

Meanwhile, the **pumped storage hydro** option — India's cheapest long-duration storage at 4.7 GW operational — is geographically constrained. Suitable sites require specific topography (reservoir height differential), water availability, and transmission connectivity. The technical potential of **96 GW** identified by CEA cannot be realised uniformly — it is concentrated in specific river basins and hill states, requiring transmission investment and environmental clearances that add years to development timelines.

THE IMPORT DEPENDENCY RISK

Down to Earth's argument reaches beyond the technical grid challenge to a structural concern that Narain has raised repeatedly: **India's green energy transition risks replicating the fossil fuel import dependency it is supposed to eliminate**.

IMPORT DEPENDENCY CATEGORY	CURRENT SHARE	PRINCIPAL SOURCE
Solar cells and modules	>80% imported	China (dominant)
Battery cells (Li-ion)	Predominantly imported	China
Rare earth magnets (wind turbines)	Predominantly imported	China

India's solar industry is built on imported panels. The **PLI for solar modules** (Rs 24,000 crore outlay, targeting approximately 48 GW of domestic integrated manufacturing across two tranches) was designed to build a domestic supply chain — but progress has been slower than targets, and the 2030 renewable capacity goal will almost certainly require continued large-scale imports in the interim.

The **geopolitical risk** of this dependency is clear. In 2020, the India-China standoff prompted a sharp re-examination of technology supply chain dependencies. Solar panels and battery cells from China are not subject to the same strategic sensitivity as semiconductors or defence electronics — but a scenario in which India's clean energy transition is dependent on a single foreign supplier for its primary generation and storage components is a vulnerability that cannot be ignored.

COAL'S TECHNICAL MINIMUM: THE RETROFIT IMPERATIVE

The solution to the flexibility paradox is not rapid coal retirement — that is neither technically feasible nor socially advisable at this stage of India's transition. The solution is **coal flexibility retrofitting**.

The technology exists. Flexible operation retrofits for thermal plants involve:

- **Boiler control system upgrades** to manage lower and more variable steam temperatures
- **Turbine modifications** for wider power output range (lowering minimum stable load from 55% to 30–40%)
- **Enhanced monitoring and diagnostics** to detect mechanical stress from rapid cycling
- **Revised operational protocols** to manage start-stop cycles more frequently

Several countries have executed this at scale. Germany retrofitted significant portions of its coal fleet for flexible operation during the rapid growth of wind and solar from 2010 to 2018. The **Central Electricity Regulatory Commission (CERC)** in India has discussed flexibility standards but has not yet mandated them for the existing fleet.

Narain's argument is that the **National Mission on Enhanced Energy Efficiency** and the **National Electricity Plan** should be amended to include a mandatory flexible operation standard for all coal plants above **500 MW** — with a retrofit subsidy to reduce the capital cost barrier for state-owned generating companies, many of which have constrained balance sheets.

THE JUST TRANSITION DIMENSION

Any honest reckoning with coal flexibility must confront the employment reality.

WORKFORCE CATEGORY	ESTIMATED SIZE
Coal India direct employees	~214,000 (as of January 2026)
Contract workers in coal sector	~500,000
Coal-dependent ancillary employment (transport, processing)	Several hundred thousand additional

The **coal royalty-dependent states** — Jharkhand, Odisha, and Chhattisgarh — derive significant fiscal revenue from coal extraction. A rapid transition away from coal would threaten both employment and state finances simultaneously in regions that have the least economic diversification and social safety net capacity to absorb such shocks.

India made **just-transition commitments at COP26 (Glasgow, 2021)** as part of its nationally determined contribution (NDC) and the Just Energy Transition Partnership framework. At **COP28 (Dubai, 2023)**, India joined the global commitment to transition away from fossil fuels in energy systems. But the domestic policy architecture for honouring these commitments — a funded just-transition corpus, retraining programmes for coal workers, alternative livelihood pipelines for coal-dependent states — remains underdeveloped.

Narain's position is that coal flexibility retrofitting, rather than premature retirement, is actually the more transition-compatible approach: it preserves employment in the medium term, gives the storage pipeline time to scale, and avoids the grid reliability crisis that would follow if coal capacity is retired before adequate dispatchable clean alternatives exist.

DTE'S RECOMMENDATIONS

Down to Earth's editorial synthesises four simultaneous interventions:

1. Mandatory coal flexibility standards. Require all coal plants above 500 MW to achieve minimum stable load of 35% by 2028. Fund retrofits through the National Mission on Enhanced Energy Efficiency. Operationalise through CERC's must-run status regulations.

2. Co-located battery storage mandate. Every new renewable project above 100 MW must include co-located BESS equivalent to 30% of nameplate capacity. This converts every new solar farm into a partially dispatchable resource rather than an intermittent one. Grid-India (formerly POSOCO) should be empowered to dispatch storage ahead of coal during solar-ramp hours.

3. Domestic cell manufacturing before scale-up. The 500 GW 2030 target should be sequenced against domestic manufacturing milestones. Approve a battery cell import substitution target analogous to the solar module PLI — with clear PLI disbursement timelines tied to operational capacity, not announced capacity.

4. Real-time pricing for industrial consumers. Time-of-use tariffs (high tariffs during evening peak, low tariffs during midday solar surplus) should be introduced for **HT (High Tension) industrial consumers** — which account for approximately 40% of commercial and industrial electricity consumption. This shifts load from peak-coal hours to solar surplus hours, flattening the duck curve at the demand end without any additional investment in storage or generation.

UPSC MAINS ANALYSIS

GS Paper 3 — Environment, Energy, Economy: India's Energy Transition

GS Paper 1 — Geography: Energy resources and their distribution

PAPER	ANGLE
GS3 — Energy	Duck curve, coal flexibility, grid-scale storage, just transition, import dependency
GS3 — Economy	PLI for batteries, manufacturing policy, energy security
GS3 — Environment	India's NDC, COP commitments, coal phase-down sequencing
GS1 — Geography	Distribution of coal reserves (Jharkhand, Odisha, Chhattisgarh); pumped hydro geography

Mains Keywords: duck curve India, 256 GW peak demand 2026, coal technical minimum 55%, battery storage gap, PLI Advanced Chemistry Cell Rs 18,100 crore, Grid-India formerly POSOCO, pumped hydro 4.7 GW, solar import dependency China, Coal India employment, just transition COP26 COP28, CERC flexibility standards, real-time pricing HT consumers, flexible coal retrofitting, Down to Earth Sunita Narain, National Electricity Plan, BESS co-location mandate, coal royalty Jharkhand Odisha Chhattisgarh

256 GW — highest in India's history; previous record 250 GW set in May 2024; managed by Grid Controller of India Limited (Grid-India), formerly POSOCO (Power System Operation Corporation of India), renamed November 2022; driven by heatwave cooling loads and industrial demand; solar contributed approximately 30% at noon peak; coal ran at 55% technical minimum despite solar abundance.

Thermal coal plants in India cannot safely operate below approximately 55% of installed capacity; below this threshold, boiler instability, turbine efficiency loss, and emission spikes occur; retrofitting for flexible operation can lower this to approximately 35%, but requires capital investment in boiler controls, turbine modifications, and enhanced monitoring systems.

Solar ~150 GW installed (crossed 150 GW milestone March 2026); Wind ~56 GW; total non-fossil ~275 GW; target 500 GW non-fossil by 2030; coal installed capacity exceeds 200 GW and remains the dominant source of dispatchable evening and night power.

India's BESS target is 47 GW by 2030 (Budget 2023 announcement); actual installed ~4–5 GW (predominantly pumped hydro); PLI for Advanced Chemistry Cell (ACC) batteries: Rs 18,100 crore outlay, targeting 50 GWh domestic manufacturing; CEA Optimal Generation Mix estimates ~60 GW storage needed by 2030.

India operational: 4.7 GW; identified technical potential: 96 GW (CEA); cheapest long-duration storage but geographically constrained to specific river basins and hill terrain with transmission connectivity.

India imports >80% of solar cells and modules (predominantly from China); battery cells predominantly Chinese; rare earth magnets for wind turbines predominantly Chinese; PLI for solar modules: Rs 24,000 crore; target approximately 48 GW domestic integrated manufacturing.

~214,000 direct employees (as of January 2026; down from ~276,000 in FY2015 due to mechanisation and attrition); ~500,000 contract workers; key royalty-dependent states: Jharkhand, Odisha, Chhattisgarh; Coal India Ltd (CIL) is the world's largest coal mining company by output.

Power System Operation Corporation of India (POSOCO) renamed Grid Controller of India Limited in November 2022; manages real-time national grid balancing; operates Regional Load Despatch Centres (RLDCs) and the National Load Despatch Centre (NLDC).

Named by California ISO (CAISO) in 2013 after NREL analysis; describes the net demand curve shape on a solar-heavy grid — deep trough at midday (solar surplus), steep evening ramp (solar disappears + demand peaks); ramp rate stress is the primary operational challenge for coal and gas plants not designed for rapid cycling.

COP26 (Glasgow, 2021): India submitted updated NDC — 500 GW non-fossil by 2030, 50% electricity from non-fossil by 2030, net zero by 2070; COP28 (Dubai, 2023): India joined commitment to transition away from fossil fuels in energy systems; domestic just-transition corpus for coal workers and states not yet funded.

Sunita Narain's argument is structurally distinct from the standard green-energy optimism that points to falling solar costs and accelerating capacity additions. Her insight is that cheap solar without flexible coal, mandatory storage, domestic manufacturing, and real-time pricing is not a transition — it is an accumulation of contradictions that will eventually manifest as grid crises. The April 25 record was a warning: India's energy system passed the stress test of that particular April day, but the structural misalignment between its renewable ambition and its grid architecture is widening with every new gigawatt of solar added without a corresponding gigawatt of storage or demand flexibility. The transition that India needs is not just from coal to renewables — it is from a rigid baseload paradigm to a flexible, storage-mediated, demand-responsive grid that can actually use the solar and wind it is paying to build.

Sources: Down to Earth , PIB , Central Electricity Authority

KEY ARGUMENTS AT A GLANCE

India can no longer treat renewable capacity addition as an energy policy — the April 25 grid crisis reveals that without coal flexibility retrofits, mandatory co-located storage, domestic green-tech manufacturing, and real-time pricing, adding more megawatts simply deepens the transition paradox.

✓ **SUPPORTING**

- India's record 256 GW peak demand (April 25, 2026) exposed the flexibility paradox: renewables supplied 30% at noon, yet coal still ran at its 55% technical minimum because no storage or flexible-dispatch system existed to absorb the solar surplus and release it at the evening peak.
- India's battery storage target of 47 GW by 2030 stands against actual installed capacity of ~4–5 GW — the PLI for Advanced Chemistry Cells (Rs 18,100 crore) has not translated into operational manufacturing at scale, creating a storage gap that grows more dangerous with every gigawatt of renewable addition.
- India imports over 80% of solar cells and modules from China, and battery cells are predominantly Chinese — the green energy transition risks replicating the fossil fuel import dependency it is supposed to eliminate.
- Coal India's ~214,000 direct employees (as of January 2026) and ~500,000 contract workers in royalty-dependent states (Jharkhand, Odisha, Chhattisgarh) mean premature

coal retirement without a funded just-transition plan would create social instability inconsistent with India's COP26 commitments.

⚠ COUNTER

The counter-argument holds that retrofitting coal for flexibility is throwing good money after bad — capital that should go into storage, green hydrogen, and demand management instead of prolonging a dirty asset; better to accept short-term curtailment and push harder on the storage pipeline.

→ WAY FORWARD

Retrofit coal plants above 500 MW for flexible ramp operation; mandate co-located battery storage (BESS) with every new renewable project above 100 MW; build domestic cell manufacturing capacity before 500 GW renewable scale-up creates a new import dependency; introduce real-time pricing to shift industrial load away from peak-coal hours; and fund a just-transition corpus for coal-dependent states and workers.

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✍ MAINS ANSWER FRAMEWORK

INTRODUCTION

India's power grid recorded its highest-ever peak demand of 256 GW on April 25, 2026 — a figure that would seem to validate the country's renewable energy ambition. But the composition of that 256 GW told a more uncomfortable story: solar contributed 30% at noon, yet coal plants were running at their 55% technical minimum, unable to back off further, while battery storage to bridge the afternoon surplus to the evening ramp was almost entirely absent.

BODY

The April 25 event crystallises what Down to Earth, under Sunita Narain's editorial direction, has consistently argued: India's energy transition challenge is no longer about adding renewable megawatts — it is about redesigning the entire electricity system for flexibility. Coal plants in India were designed for baseload operation and cannot safely drop below approximately 55% of their installed capacity; at

lower outputs, boiler stability, turbine efficiency, and emission profiles all deteriorate.

Yet when solar is abundant at midday, the grid requires coal to back off precisely to that 30–40% range — which existing plants cannot do. The result is either solar curtailment (wasting clean energy) or coal overcrowding (blocking clean energy from entering the grid).

India's battery storage target of 47 GW by 2030 remains aspirational: actual installed capacity is approximately 4–5 GW, the PLI for Advanced Chemistry Cell batteries (Rs 18,100 crore) has not produced the manufacturing scale needed, and pumped storage hydro — at 4.7 GW operational against a potential of 96 GW — is geographically constrained. Beyond the technical problem is the import dependency risk: India imports over 80% of solar cells and modules from China and sources battery cells predominantly from Chinese manufacturers; the green transition, if unaccompanied by domestic manufacturing, will trade oil import bills for solar panel and battery import bills — a dependency substitution, not independence.

The just-transition dimension compounds this: Coal India's approximately 214,000 direct employees (as of January 2026) and approximately 500,000 contract workers are concentrated in Jharkhand, Odisha, and Chhattisgarh — states whose fiscal position depends heavily on coal royalties. Premature coal retirement without a funded just-transition corpus would create both social disruption and fiscal stress in states that have the least capacity to absorb either.

CONCLUSION

Narain's argument is not anti-renewable — it is pro-coherence. Retrofitting coal for flexibility, mandating co-located storage, building domestic cell manufacturing, and introducing real-time pricing are not alternatives to the energy transition; they are its prerequisites.

Without this systems architecture, India will keep adding renewable capacity and keep discovering, on the next record-demand summer day, that coal remains indispensable.

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CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

linkedin.com/in/epicbharat

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