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EDITORIAL ANALYSIS

How to Make a Solar-Heavy Grid Stable and Affordable

INDIAN EXPRESS

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How to Make a Solar-Heavy Grid Stable and Affordable

The Indian Express 26 August 2026 GS3

INTERVIEW ANGLE

"India can now generate more solar power at noon than it can use. Is the answer to store it, or to move the country's electricity consumption to noon?"

Source: Original editorial ↗ The Indian Express

Every fact web-verified against primary sources

THE LIFT LINE

India can now make more electricity at noon than it wants at noon. Storage moves the power to the people. It is cheaper to move the people to the power.

WHY THIS EDITORIAL MATTERS FOR YOUR EXAM

Renewable energy is examined constantly, and answers almost always stop at installed capacity and targets. Grid stability is the next-stage problem and almost nobody prepares it, which makes it a strong differentiator.

GS Paper 3: Infrastructure, energy; conservation and environment; science and technology developments.

CONCEPT	MEANING	WHY IT IS TESTABLE
Grid inertia	Kinetic energy stored in rotating synchronous generators, resisting sudden frequency change	Why a high renewable share creates a stability problem
Short-circuit ratio	A measure of grid strength at a connection point	The technical indicator the column cites
Time-of-day tariff	Electricity priced differently by hour to shift consumption	The cheap instrument for demand shifting

BACKGROUND AND CONTEXT

Where India Stands

INDICATOR	POSITION
Non-fossil capacity installed	283 GW, about 275 GW renewable plus about 9 GW nuclear
Non-fossil capacity commitment	50 per cent, met five years early
Four-hour BESS tender, Uttar Pradesh	About ₹6.45 per unit, after viability gap funding
Coal average power purchase cost, as cited by the column	About ₹4.67 per kWh
Solar tariff, as cited by the column	About ₹3.65 per kWh

India's updated **Nationally Determined Contribution**, submitted in **2022**, committed to about **50 per cent cumulative installed electric power capacity from non-fossil sources by 2030**, alongside the widely cited target of **500 GW non-fossil capacity by 2030**.

The Physics in One Paragraph

A conventional power plant turns a very heavy rotor. That spinning mass stores kinetic energy, and when demand suddenly exceeds supply the rotor slows fractionally, releasing energy and slowing the frequency drop. This buys operators seconds. A solar panel has no rotor. It connects through an **inverter**, which converts direct current to alternating current electronically and contributes **no inertia**. Replace enough rotors with inverters and the grid loses its shock absorber.

The Institutions

BODY	ROLE
Grid Controller of India (Grid-India)	National load despatch and grid operation
Central Electricity Authority (CEA)	Technical planning and standards under the Electricity Act, 2003
CERC and SERCs	Tariff regulation at central and State level
SECI	Solar Energy Corporation of India, renewable procurement

THE ANALYSIS

1. Capacity statistics conceal the actual problem. India met its non-fossil capacity target early, which is genuinely creditable and tells us nothing about stability. **Installed capacity measures what can be generated; inertia measures what happens when something goes wrong.** These are different questions and only the first has been answered.

2. The cost comparison is the column's strongest evidence. Storing solar power at about ₹6.45 a unit when the solar itself costs about ₹3.65 per kWh means **storage nearly triples the delivered cost**, and even exceeds coal at about ₹4.67. Building storage sufficient to shift a full day's solar into the evening peak would be an expensive way to avoid changing when electricity is used.

3. Demand shifting is cheap because it requires rules, not assets. Time-of-day tariffs, industrial scheduling and shifting agricultural pumping into daylight need metering and regulation rather than capital expenditure. India's smart-metering rollout and existing time-of-day tariff provisions mean the instruments already exist.

4. Agricultural load is the largest and most shiftable block. Irrigation pumping is a substantial share of Indian electricity consumption, is frequently supplied at night to manage load, and is comparatively indifferent to the hour at which it occurs. Moving it to daylight aligns a large, flexible load with peak solar generation, and **PM-KUSUM** already points in this direction by solarising agricultural pumps directly.

5. The counter-argument sets a real ceiling. Household evening load reflects when people are home; industrial load reflects shifts and order books. Neither is fully price-responsive. Storage also provides **fast frequency response and black-start capability** that no demand measure can supply, and its costs are falling. The honest conclusion is that demand shifting is the cheaper first tranche, not a complete substitute.

DATA AND INSTITUTIONS VAULT

PRELIMS-GRADE FACTS:

Non-fossil capacity: 283 GW, comprising about 275 GW renewable plus about 9 GW nuclear; the 50 per cent non-fossil capacity commitment was met five years early.

UPPCL four-hour BESS tender, 375 MW and 1,500 MWh under VGF Tranche II, cleared at about ₹6.45 per unit. Comparators as cited by the column: coal average power purchase cost about ₹4.67 per kWh, solar about ₹3.65 per kWh. These comparators are the column's figures, not official published tariffs.

India's updated NDC (2022): about 50 per cent cumulative installed capacity from non-fossil sources by 2030; 500 GW non-fossil capacity target.

Grid inertia comes from rotating synchronous machines; inverter-based renewables supply none.

Electricity Act, 2003 governs the sector; CEA handles technical planning; CERC and SERCs regulate tariffs; Grid-India operates the grid.

PM-KUSUM solarises agricultural pumps.

> *The* **50 per cent non-fossil target refers to installed capacity, not to generation**. *Because solar and wind have lower capacity utilisation factors than coal, the share of electricity actually generated from non-fossil sources is considerably lower than the capacity share. Conflating the two is a common and costly error.*

THE DEBATE

FOR (shift demand first): Storage costs more per unit than the solar it stores, and more than coal. Demand shifting requires rules and meters rather than capital. Agricultural pumping is a large, flexible load naturally suited to daylight operation.

AGAINST (storage is not optional): Household and industrial load are only partly price-responsive. Storage uniquely supplies fast frequency response, black-start capability and ancillary services. Its costs have fallen steeply and will continue to, so present prices understate its long-run case.

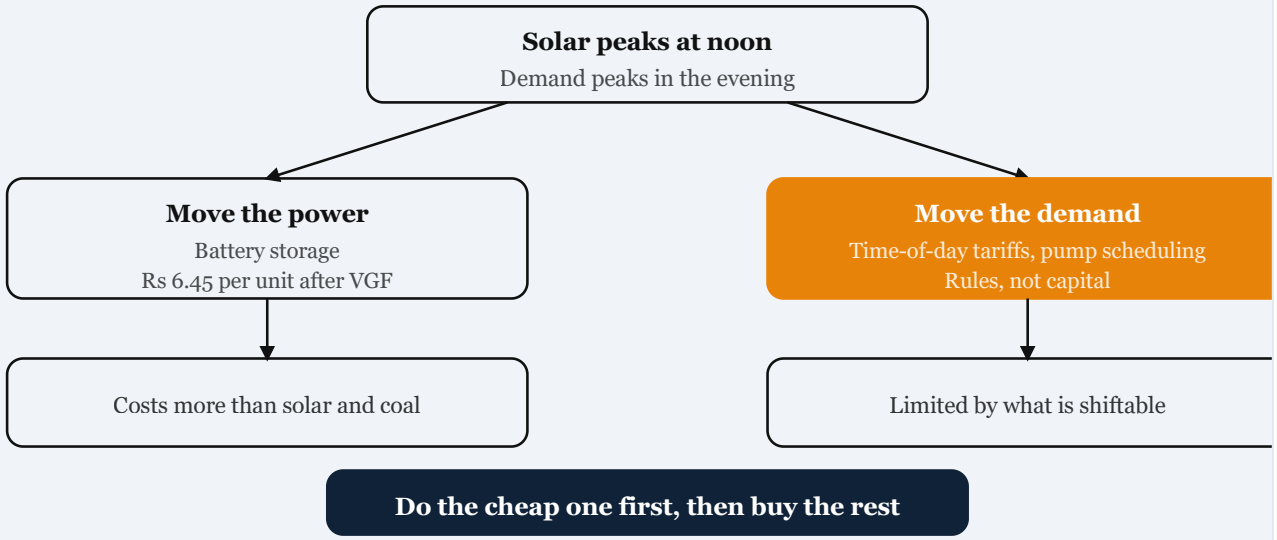
Balanced verdict: These are complements to be **sequenced by cost**, not alternatives. Exhaust the cheap tranche first through time-of-day tariffs, industrial scheduling and agricultural load shifting; procure storage **selectively**, for the ancillary services and fast frequency response demand management cannot provide rather than for bulk energy time-shifting; and mandate **grid-forming inverter** capability in new renewable capacity, which allows inverters to contribute synthetic inertia and addresses the stability problem at source rather than compensating for it downstream.

HOW TO THINK ABOUT THIS

When a system faces a mismatch between supply timing and demand timing, there are always two candidate solutions: **move the supply** or **move the demand**. Engineering instinct reaches for the first because it is a buildable asset with a clear owner; economics usually favours the second because it requires only a price signal.

The general rule is to compare the cost of storage against the cost of flexibility, and to note that flexibility is almost always cheaper where the demand is genuinely shiftable. The corollary matters as much: identify which parts of demand are actually shiftable before assuming any of it is. Agricultural pumping is; a household cooking dinner is not. Sorting demand by shiftability, rather than treating it as a single block, is what makes this analysis useful rather than glib.

DIAGRAM-IN-WORDS



Both branches close the same gap. One requires capital and one requires rules, and only one of them costs more than the electricity it is moving.

TAKEAWAY BOX

India can now make more electricity at noon than it wants at noon. Storage moves the power to the people. It is cheaper to move the people to the power.

283 GW non-fossil capacity, about 275 GW renewable plus about 9 GW nuclear; 50 per cent non-fossil capacity target met five years early; UP four-hour BESS at about ₹6.45 per unit after VGF against coal APPC ₹4.67 and solar ₹3.65 per kWh; updated NDC 2022 and the 500 GW target; grid inertia comes from synchronous machines, not inverters; Electricity Act 2003, CEA, CERC, Grid-India; PM-KUSUM.

Should agricultural consumers, who receive heavily subsidised power, be required to shift their consumption to hours that suit the grid?

Connects to past UPSC Mains questions on renewable energy targets, energy security, and the challenges of grid integration.

"India has met its renewable capacity target and inherited a grid stability problem it did not plan for." Critically examine.

Source: How to Make a Solar-Heavy Grid Stable and Affordable — Ujiyari.com | Free UPSC & State PCS Editorial Analysis

KEY ARGUMENTS AT A GLANCE

Writing in The Indian Express, the argument is that with 283 GW of non-fossil capacity installed and the 50 per cent non-fossil target met five years early, India has solved the easy problem of deployment but now faces inverter-based generation lowering short-circuit ratios and creating frequency-stability risk, while battery storage remains costly, so the most direct fix is demand-side, shifting electricity consumption into peak renewable generation hours rather than buying storage to move the power to existing consumption hours.

✓ SUPPORTING

- Conventional thermal and hydro plants provide inertia through the physical rotation of large synchronous machines, which resists sudden frequency change, whereas solar and wind connect through power electronics that supply no equivalent inertia, so a rising renewable share mechanically reduces the grid's ability to absorb a disturbance.
- The cost comparison is stark on the column's own figures: the UPPCL four-hour battery tender of 375 MW and 1,500 MWh, concluded under viability gap funding Tranche II, cleared at about Rs 6.45 a unit, against a coal average power purchase cost of Rs 4.67 per kWh and solar at Rs 3.65 per kWh, so storing solar power costs considerably more than the power itself.
- Shifting demand into daylight hours requires tariff and scheduling changes rather than capital assets, which makes it faster to implement and far cheaper than building storage capacity sufficient to move a whole day's solar generation into the evening peak.

⚠ COUNTER

The counter-view is that demand-side shifting has firm limits, because household evening consumption is driven by when people are at home and industrial load by shift patterns and order books, neither of which responds fully to price signals. Storage is also not purely a cost item: it provides fast frequency response, black-start capability and ancillary services that no amount of demand shifting supplies, and its costs have fallen steeply and continue to do so.

→ WAY FORWARD

The two are complementary and should be sequenced by cost: exhaust the cheap demand-side options first through time-of-day tariffs, industrial and agricultural load shifting into solar

> hours and smart-meter-enabled scheduling, while procuring storage selectively for the ancillary services and fast frequency response that demand management cannot provide, and mandating grid-forming inverter capability in new renewable capacity so that stability is built in rather than bought later.

✍ MAINS ANSWER FRAMEWORK

QUESTION

India has met its non-fossil capacity target ahead of schedule but faces new grid-stability challenges. Examine these challenges and evaluate demand-side management against storage as a response. (250 words)

INTRODUCTION

India's renewable energy debate has been organised around installed capacity, and by that measure it has succeeded, meeting its non-fossil capacity commitment well ahead of schedule. Writing in The Indian Express, the argument is that the binding problem has now moved from how much capacity exists to whether the grid can remain stable while carrying it.

BODY

The technical issue is inertia. Conventional thermal and large hydro plants generate through massive synchronous machines whose physical rotation stores kinetic energy, and that stored energy resists sudden changes in system frequency, giving operators seconds to respond to a fault.

Solar and wind connect to the grid through power electronic inverters, which supply no comparable inertia. As the inverter-based share rises, the system's short-circuit ratio falls and frequency becomes more volatile after a disturbance, which is a stability problem rather than a supply problem and does not appear in any capacity statistic.

The obvious answer is storage, and here the column supplies the cost objection: a four-hour battery energy storage tender in Uttar Pradesh cleared at about Rs 6.45 a unit even after viability gap funding, against a coal average power purchase cost of about Rs 4.67 per kWh and solar at about Rs 3.65 per kWh. Storing solar therefore costs substantially more than generating it, and building enough storage to shift a full day of solar output into the evening peak would be an expensive way to preserve existing consumption habits.

The alternative is to move the consumption instead. Time-of-day tariffs, industrial load scheduling and agricultural pumping shifted into daylight hours require regulatory and metering change rather than capital assets, and India has the institutional instruments for this in time-of-day tariff rules and the smart-metering programme.

CONCLUSION

A balanced answer should recognise that demand shifting has real limits, since household evening load reflects when people are at home and industrial load reflects shift patterns, and that storage supplies fast frequency response and black-start capability that no demand measure provides. The correct approach is sequencing by cost: exhaust cheap demand-side options first, procure storage for the services only it can deliver, and mandate grid-forming inverter capability in new capacity.

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