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# Renewable Grid Integration — India's Biggest Clean Energy Challenge

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16 March 2026

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# Renewable Grid Integration — India's Biggest Clean Energy Challenge

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GS3

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The Indian Express

MAINS RELEVANCE:

GS Paper 3



## INTERVIEW ANGLE

*"India has added renewable capacity rapidly but grid integration lags. What structural reforms are needed in India's power sector to absorb 500 GW of renewables by 2030 without compromising grid stability?"*

## WHY IN NEWS

India's renewable energy installed capacity has crossed 200 GW, but grid operators are increasingly curtailing solar and wind power during peak generation hours because the transmission and storage infrastructure cannot absorb it — revealing that capacity addition without grid modernisation is leaving clean energy potential wasted.

## INDIA'S RENEWABLE ENERGY LANDSCAPE

India has set one of the world's most ambitious renewable energy targets:

**500 GW** non-fossil fuel capacity by 2030 (announced at COP26, Glasgow 2021)

**50% of cumulative electric power** from non-fossil fuel sources by 2030

Net zero emissions by **2070**

As of early 2026, India's total installed power capacity is approximately **1,000 GW**, with renewables (solar + wind + hydro + others) accounting for over **200 GW** of solar and wind alone.

## THE GRID INTEGRATION PROBLEM

### What Is Grid Integration?

The electric grid must balance supply and demand in real-time. Fossil fuel plants can be ramped up or down on demand. Solar and wind energy are **variable renewable energy (VRE)** — output depends on weather, not operator commands.

Grid integration refers to the technical, regulatory, and operational adjustments needed to incorporate high proportions of variable renewables without destabilising the grid.

### The Duck Curve Problem

As solar penetration rises, the daily load curve takes a “**duck curve**” shape:

Time	Grid Situation
Midday (peak solar)	Grid flooded with solar power → prices crash, sometimes go negative → thermal plants must ramp down
Evening (sunset)	Solar disappears suddenly → thermal plants must ramp up extremely fast → risk of shortage
Night	Demand continues, no solar → entirely dependent on thermal/hydro/storage

India is already experiencing this in solar-heavy states like **Rajasthan, Gujarat, and Tamil Nadu**.

### Renewable Energy Curtailment

**Curtailment** is when grid operators instruct wind/solar plants to reduce or stop generation even when the resource is available — because the grid cannot absorb it. India’s curtailment rates have been rising, meaning clean electricity is wasted while coal plants keep running for grid stability reasons.

## INFRASTRUCTURE GAPS

### Transmission Network Deficits

**ISTS (Inter-State Transmission System):** run by Power Grid Corporation of India Ltd (PGCIL)

Major RE zones (Rajasthan, Gujarat, Tamil Nadu, Karnataka) are geographically distant from load centres (Delhi, Mumbai, Kolkata)

Transmission lines take **4–7 years** to build — far slower than solar farms (1–2 years)

**Green Energy Corridors Phase I & II:** dedicated transmission lines for RE zones, but progress has lagged

**ISTS charges and losses:** RE developers were given an exemption from inter-state transmission charges (waived till 2026, subsequently extended) to make RE projects more competitive.

## Storage Deficiency

India has minimal grid-scale battery storage relative to its RE ambition:

Current grid-scale **Battery Energy Storage System (BESS)** capacity: negligible vs need

**MNRE** has tendered ~4 GWh of BESS (2024-25), but target is 250 GWh by 2030

**Pumped Hydro Storage (PHS):** India has ~4.7 GW installed; 96 GW potential identified (Ministry of Power)

PHS projects take 6–10 years to build

## POLICY LANDSCAPE

### Key Schemes and Regulations

Scheme / Policy	Purpose
Renewable Purchase Obligations (RPO)	Mandates DISCOMs/bulk consumers to buy a % of power from RE
Green Energy Open Access	Allows consumers >100 kW to buy RE directly from producers
PM-KUSUM	Solar pumps for farmers; reduces daytime grid load
Green Hydrogen Mission	Uses RE for H <sub>2</sub> production; a long-term storage/export solution
ISTS charge waiver	Makes inter-state RE economically viable
Central Electricity Regulatory Commission (CERC)	Sets RE integration grid codes

### Demand-Side Solutions

**Time-of-Day Tariffs:** charge less during peak solar hours to shift demand (e.g., run industries midday)

**Electric Vehicle charging:** if EVs charge during the day, they act as controllable RE load — a major emerging tool

**Green Hydrogen electrolysis:** excess midday solar can split water → hydrogen storage

## STATE-LEVEL CHALLENGES

**DISCOMs (Distribution Companies):** most state DISCOMs are financially stressed; reluctant to sign long-term Power Purchase Agreements (PPAs) with RE developers

**AT&C losses:** Aggregate Technical and Commercial losses in India's distribution sector remain ~15–20%, reducing the commercial viability of RE procurement

**Land acquisition:** large RE parks in Rajasthan, Andhra, Ladakh face land rights and revenue disputes

## UPSC RELEVANCE

**Prelims:** ISTS, PGCIL, RPO, CERC, BESS, pumped hydro, duck curve concept, 500 GW target year (2030), Green Energy Corridors.

**Mains GS-3:** “India's renewable energy targets are ambitious, but grid integration remains the weakest link. Discuss the technical and policy challenges, and suggest a roadmap.”

## ★ FACTS CORNER — KNOWLEDGEPEDIA

### INDIA'S RE TARGETS:

- 500 GW non-fossil capacity by 2030 (COP26 pledge)
- 50% electricity from non-fossil sources by 2030
- Net Zero by 2070
- Current total installed capacity: ~1,000 GW (2025-26)
- Solar + wind alone: ~200+ GW

### GRID INTEGRATION CONCEPTS:

- Duck curve: the demand shape when midday solar reduces net load and evening creates a steep ramp-up need
- Curtailement: instructing RE plants to reduce output due to grid constraints
- VRE: Variable Renewable Energy (solar, wind)
- Balancing: real-time matching of supply and demand on the grid

### TRANSMISSION:

- PGCIL: Power Grid Corporation of India Ltd (Navratna PSU); operates ISTS
- Green Energy Corridors Phase I: ~3,200 circuit km; Phase II: ~20 RE parks connected
- ISTS charge waiver: exempts inter-state RE from wheeling charges

### STORAGE:

- Pumped Hydro Storage installed: ~4.7 GW; potential: 96 GW
- BESS target: 250 GWh by 2030 (MNRE); current deployment: minimal
- MNRE: Ministry of New and Renewable Energy

### POLICY:

- RPO: Renewable Purchase Obligation; set by SERC (State Electricity Regulatory Commissions)
- Green Energy Open Access Rules: notified June 2022; allows 100 kW+ consumers to buy RE
- PM-KUSUM: Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
- CERC: Central Electricity Regulatory Commission; regulates wholesale power market

### OTHER RELEVANT FACTS:

- India's 2030 target was upgraded at COP26 from earlier 450 GW target
- India ranks 4th globally in total RE capacity (after China, USA, Germany)
- DISCOM losses: ~₹6-7 lakh crore cumulative (major barrier to energy transition)
- UDAY scheme (2015): attempted DISCOM financial turnaround
- Green Hydrogen target: 5 MMTPA by 2030 (National Green Hydrogen Mission, Jan 2023)

Sources: Indian Express, Ministry of New and Renewable Energy, Power Grid Corporation

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