From Solar Tariffs to Firm Renewable Supply: *Indian Procurement Lessons for SAARC*

SAARC Energy Centre

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Outline of the Presentation

- Why lessons from India are important
  - Scale, Competition and move towards Complex Auctions
- Recent SEC workshop (October 5–7 workshop in Colombo) established project-finance and modelling foundations
  - This talk will build on that.

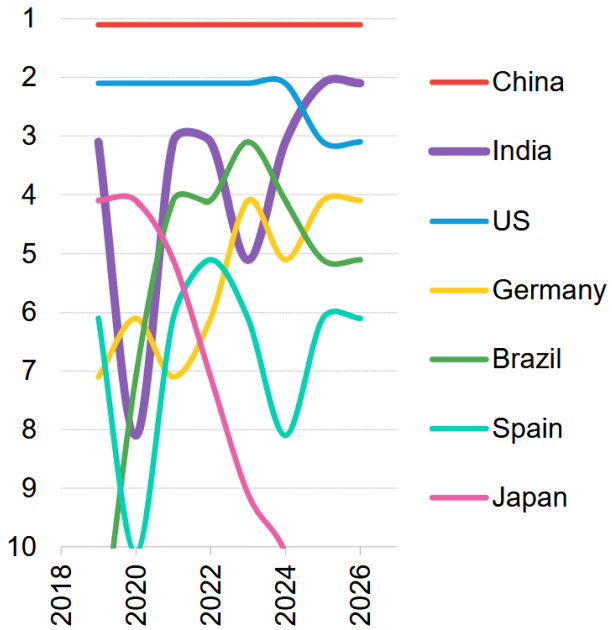
- History of Wind and Solar Tariff Modelling/Setting in India
- Evolution towards competitively bid tariff discovery
- Learnings

Scale – Very Large Market

Energy transition leadership

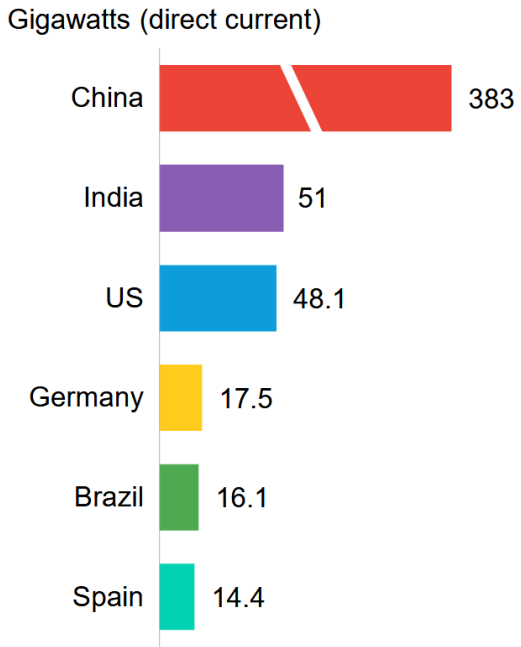
India is the world's second-largest solar market for annual capacity additions

Global ranking based on solar capacity commissioned by year



Source: BloombergNEF. Note: 2026 is a forecast.

Top five markets by solar capacity commissioned in 2025



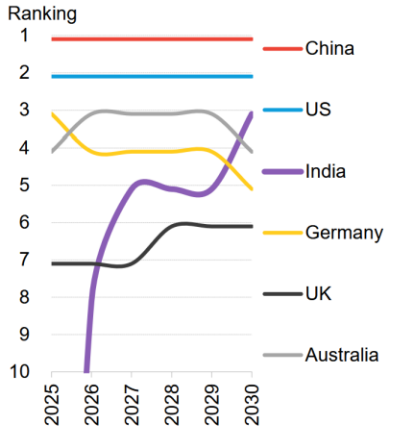
Source: BloombergNEF

Source: India Transition Factbook, Bloomberg, 2026

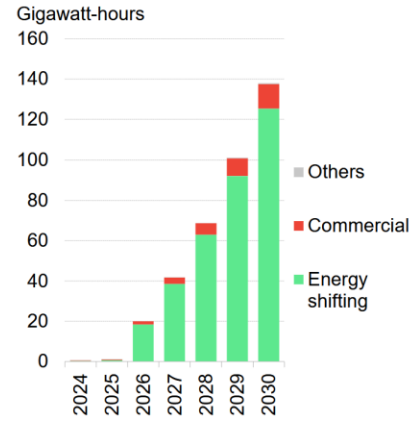
Energy transition leadership

India will be third-largest energy storage market in 2030

Cumulative capacity ranking based on storage capacity



India's cumulative energy storage by application

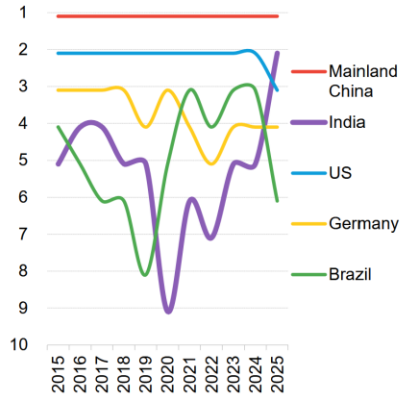


Source: BloombergNEF. Note: Ranking measured in gigawatt-hours and excludes pumped hydro projects.

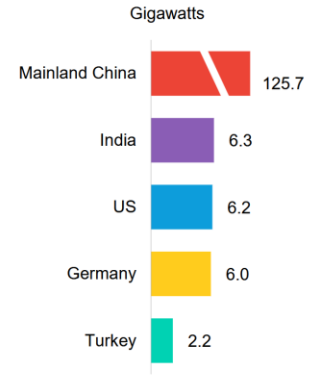
Energy transition leadership

India was the biggest market outside China for wind build in 2025

Global ranking based on wind capacity commissioned by year



Top five markets by wind capacity commissioned in 2025



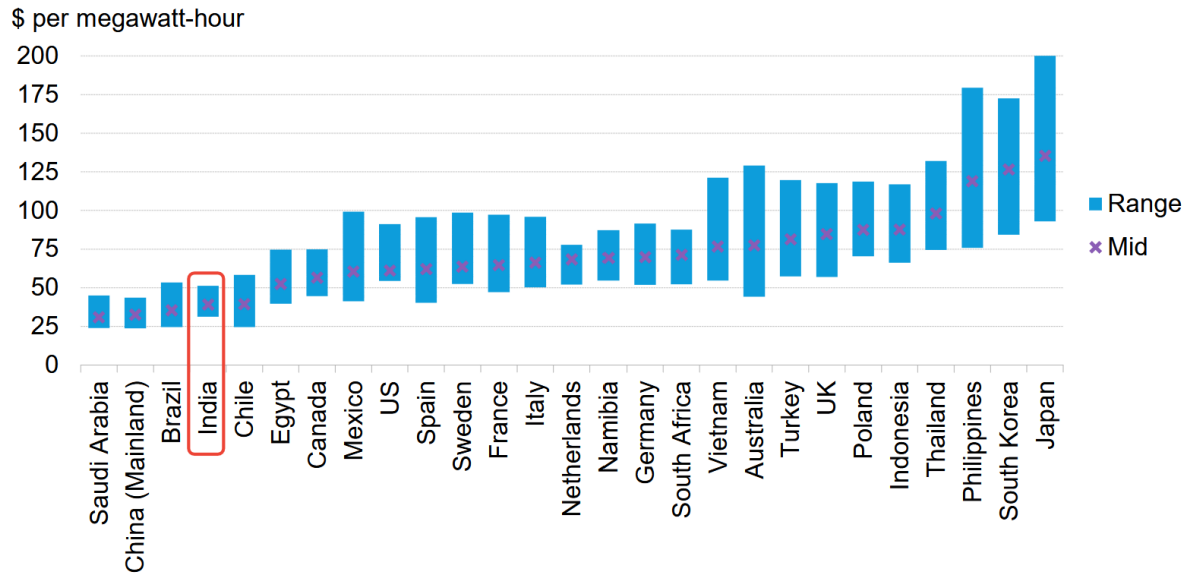
Source: BloombergNEF

Hyper-Competitive Tariffs

Clean power

India's wind power is among the most cost-competitive globally

Levelized cost of electricity (LCOE) for onshore wind in selected markets, 2H 2025

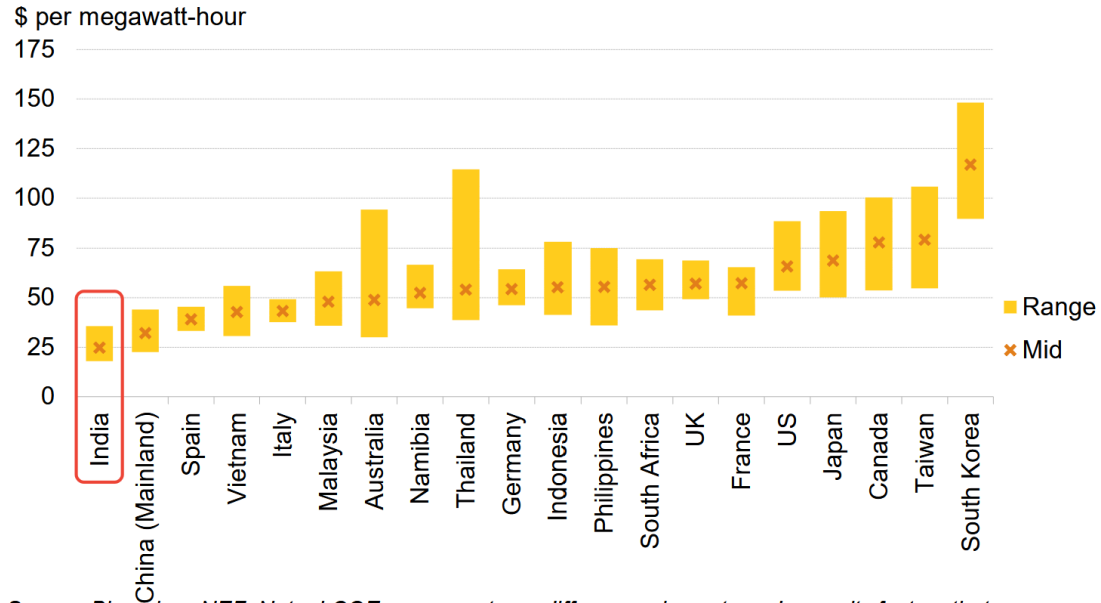


Source: BloombergNEF. Note: LCOE range captures differences in costs and capacity factors that are typically observed within each market.

Clean power

India has the world's lowest-cost utility-scale solar power

Levelized cost of electricity for utility-scale solar in selected markets, 2H 2025



Source: BloombergNEF. Note: LCOE range captures differences in costs and capacity factors that are typically observed within each market.

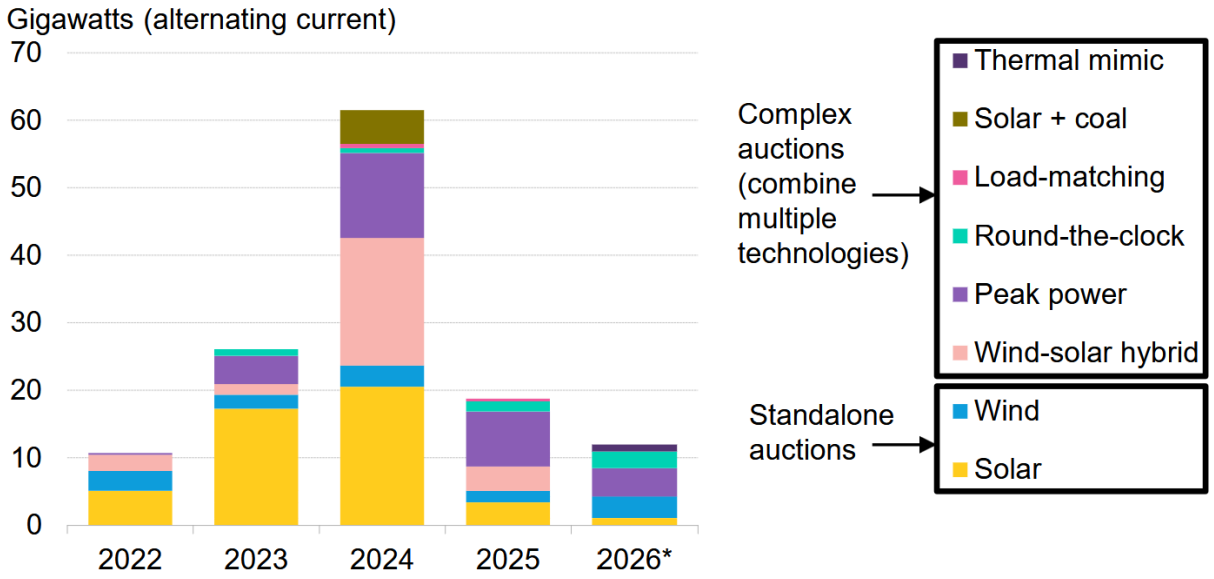
Source: India Transition Factbook, Bloomberg, 2026

Shift from Plain Vanilla Solar/Wind to Complex Auctions

Clean power

India's clean power auctions shift toward firm, dispatchable output

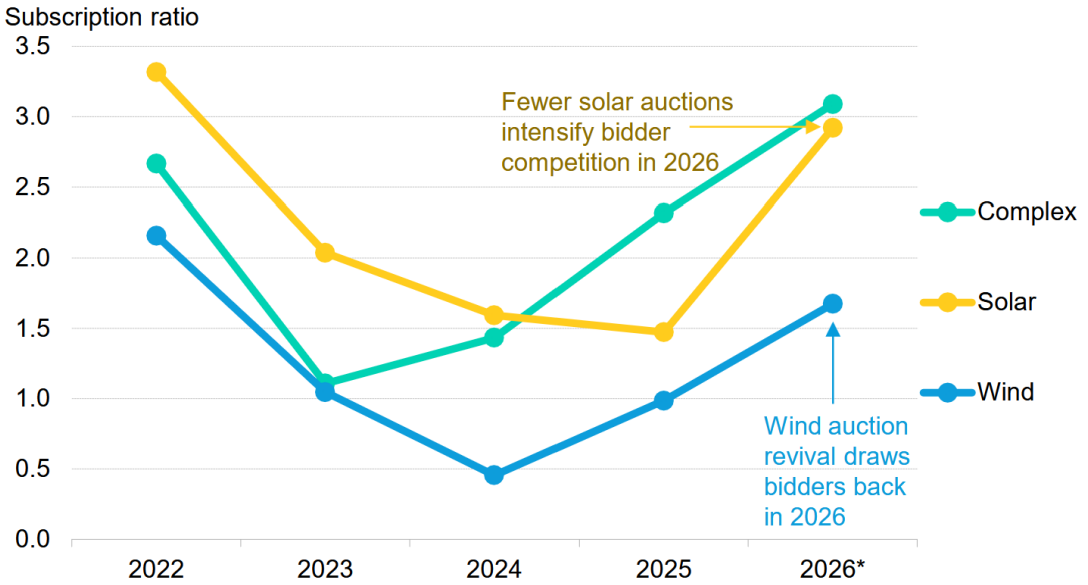
India annual renewable energy auction volumes



Clean power

India's renewable energy auctions are highly competitive and over-subscribed

Annual subscription ratio in renewable energy auctions, by auction type



*Source: BloombergNEF. Note: Subscription ratio is the ratio of bid volume to capacity on offer. *Data through August 2026.*

Source: India Transition Factbook, Bloomberg, 2026

Tariff Setting and Design; Era prior to 2017-2020

- Cost plus, regulated/administratively set tariffs for solar and wind power
  - Annual exercise by Regulator; tariff guaranteed for 25 years.
  - Significant Information Asymmetry; Problem esp. for wind (resource quality) and expected cost of solar/BESS 6-12 months down the line.

- India's transition was gradual: Solar auctions began under the National Solar Mission in 2010–11, while Wind's decisive auction transition occurred in 2017.
  - From FY 2017–18, CERC discontinued annual generic wind and solar tariffs, as competitive bidding became the principal route for large utility-scale procurement.
  - State regulators too progressively shifted towards competitive bidding, during 2017–19.
    - Generic tariffs did not cease uniformly: some states retained them as bidding ceilings, linked small-project tariffs to auction results, or continued cost-based tariffs for smaller projects.

Template for Wind/Solar PV

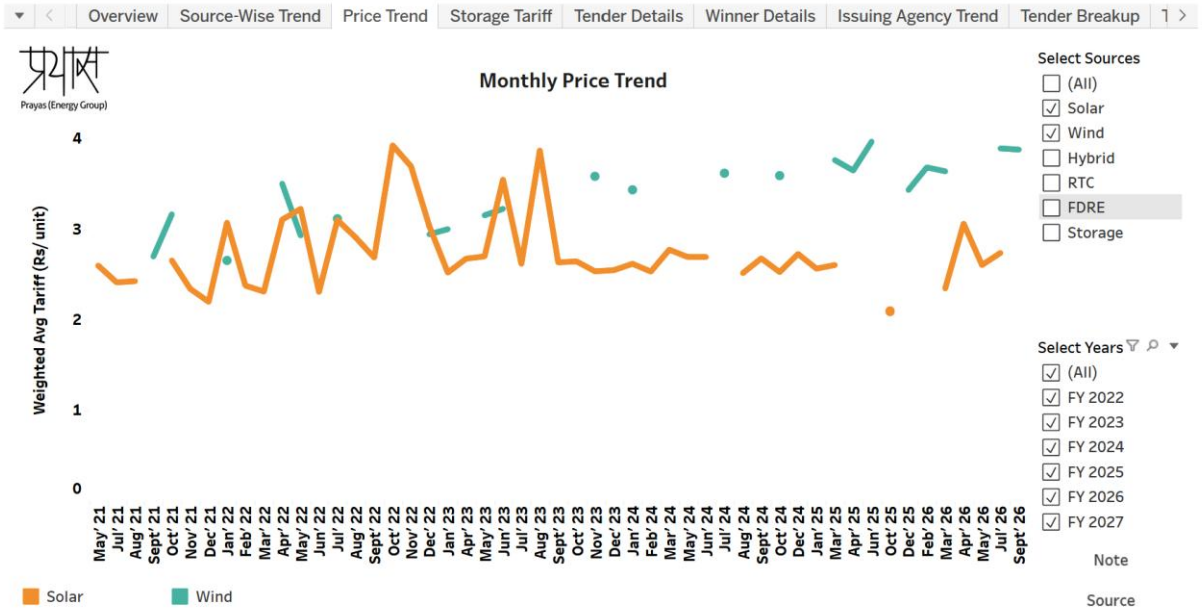
- Basic financial model calculation.
- Must-run status, energy is scheduled as per its resource profile and not according to any specific need from the procurer.

Cost and energy inputs	Annual calculation
Capital cost and funding	Depreciation, loan interest and equity return
Operating and collection requirements	O&M and working-capital interest
Capacity, CUF, losses and auxiliaries	Eligible net energy for tariff recovery
Useful life and discounting	Levelised tariff using the applicable methodology

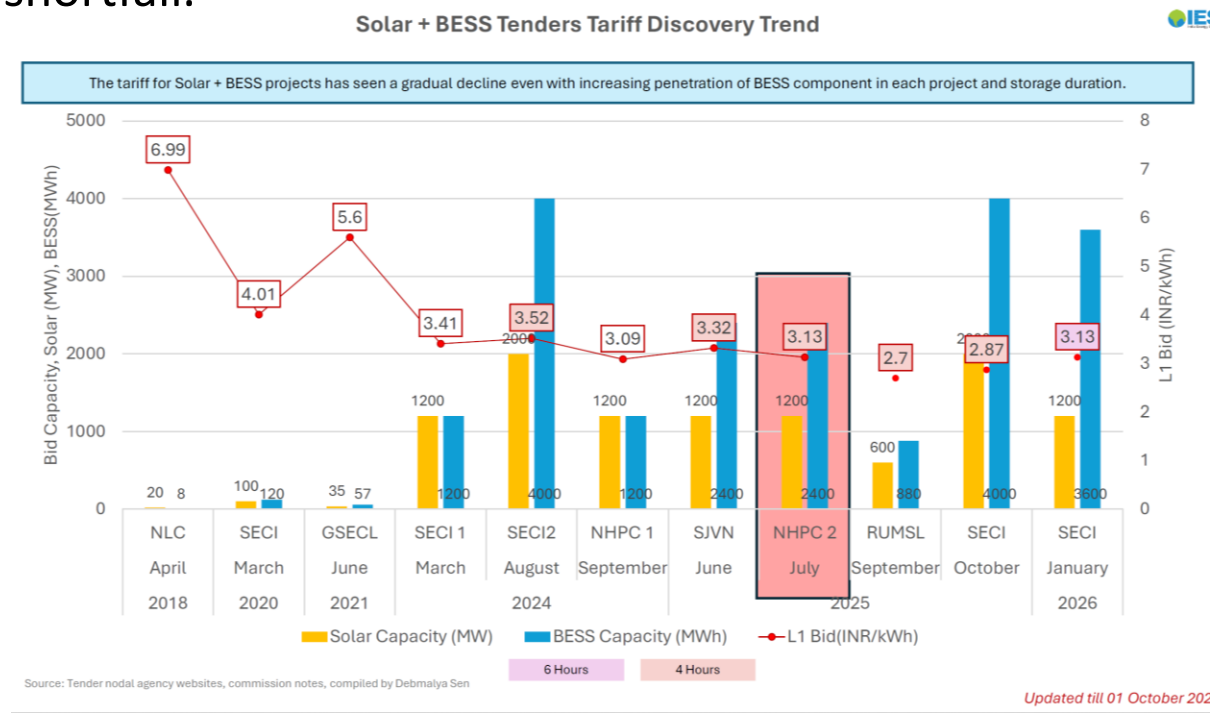
Sl. No.	Assumption Head	Sub-head	Sub-head (2)	Unit	Parameter
1	Power Generation	Capacity	Installed Power Generation Capacity	MW	
			Capacity Utilization Factor (CUF)	%	
			Auxiliary Consumption	%	
			Commercial Operation Date (COD)	dd/mm/yyyy	
			Useful Life	Years	
2	Project Cost	Capital Cost	Normative Capital Cost	Rs. Crore/ MW	
			Capital Cost	Rs. Crore	
			Capital Subsidy, if any	Rs. Crore	
			Net Capital Cost	Rs. Crore	
3	Financial Assumption	Debt Equity	Tariff Period	Years	
			Debt	%	
			Equity	%	
		Debt Component	Total debt amount	Rs. Crore	
			Total equity amount	Rs. Crore	
			Loan Amount	Rs. Crore	
			Moratorium Period	Years	
			Repayment Period (incl moratorium)	Years	
			Interest Rate	%	
		Equity Component	Equity Amount	Rs. Crore	
			Return on Equity for First 20 years	% p.a.	
			Return on Equity after 20 years	% p.a.	
			Discount Rate	%	
		Depreciation	Dep Rate for 1st 15 years	%	
			Dep rate 16th year onwards	%	
		Incentives	GBI, if any	Rs. Crore	
			Period for GBI	Years	
4	O& M Expenses	Normative O&M Expense		Rs. Lakh/MW	
		O&M Expenses p.a.		Rs. Crore	
		Escalation Factor		%	
5	Working Capital	O&M Expenses		Month	
		Maintenance Spares	% of O&M Expenses	%	
		Receivables		Days	
		Interest on Woking Capital		% per annum	

Tariff Discovery for Wind, Solar and Solar+BESS in India in the last few years

- Solar+BESS
- Includes an assured peak-supply obligation.
- 2/4/6 hrs chosen by buyer usually between **6pm-9am**
- Peak shortfalls are assessed against: **70% of required monthly peak energy & 85% of required annual peak energy**. Penalty at **1.5 times the PPA tariff** on shortfall.



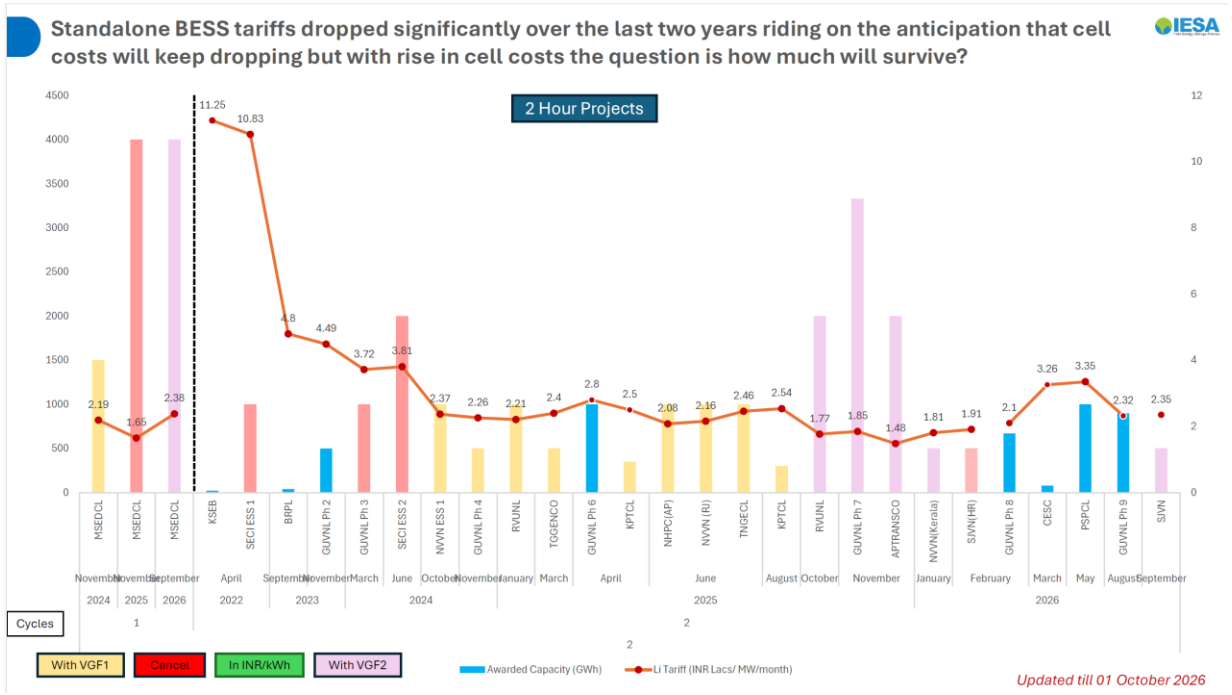
Source: Prayas (Energy Group)

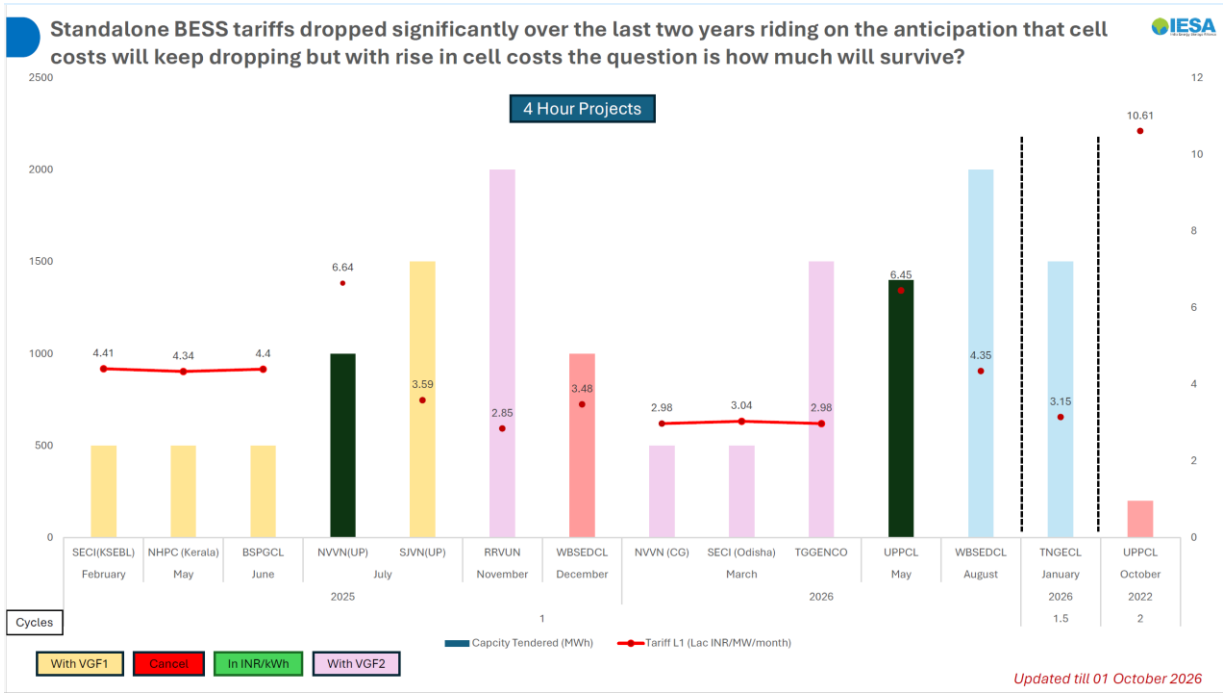


Source: India Energy Storage Association

Stand Alone BESS tariffs (2/4 hours)

- Usually set up as tolling arrangement with **capacity payments in Rs Lakhs/MW/Yr** for 12-20 years
- Energy for charging and discharging schedules – procurers responsibility.
- Apart from CapEx, round trip efficiency, degradation, usable capacity, DoD limits, cycle life, calendar life, augmentation, aux consumption etc. important parameters for modelling tariff.





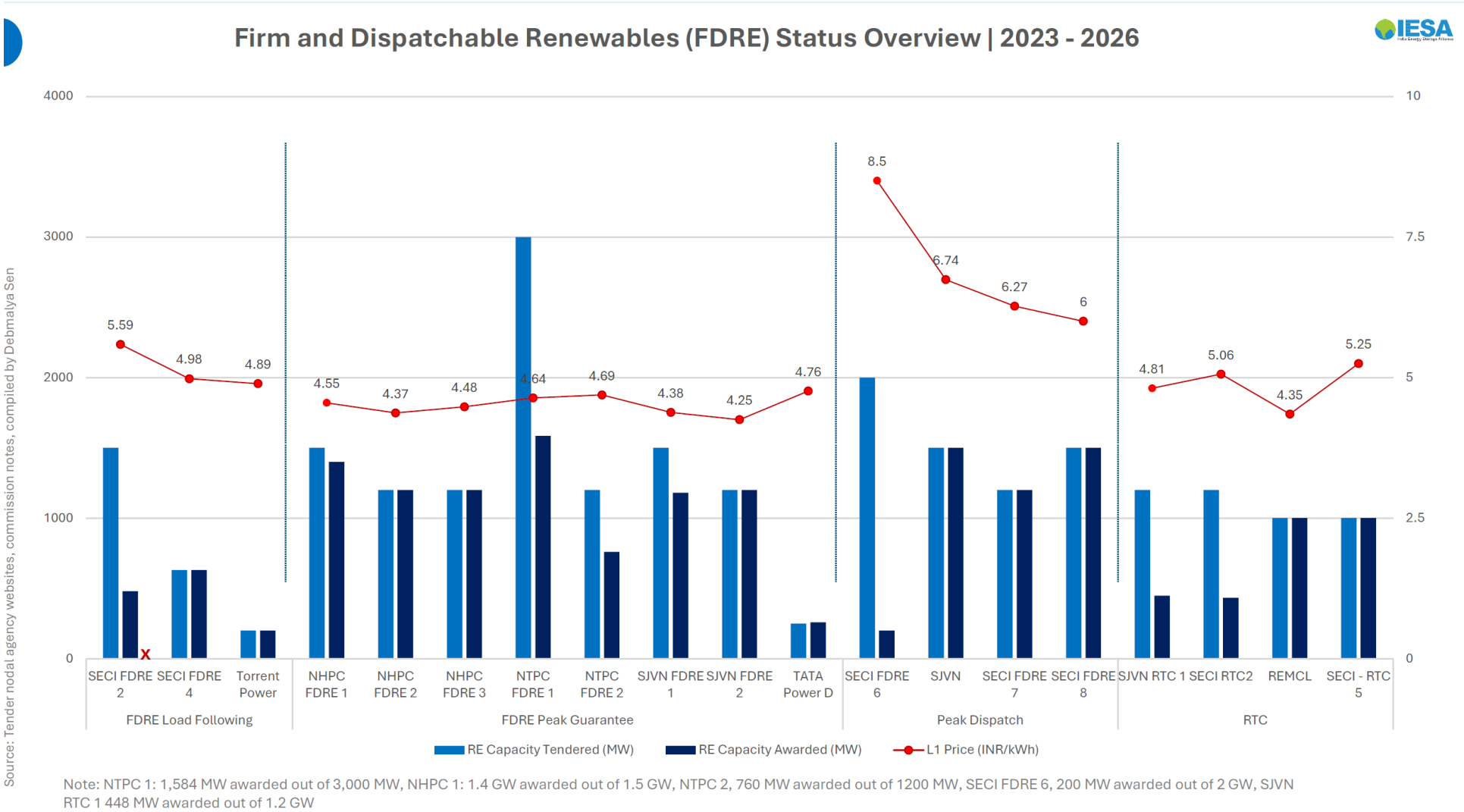
Source: India Energy Storage Association

Next modelling challenge is matching required delivery profile

New Taxonomy: Firm and Dispatchable Renewable Energy (FDRE)

- *Load Following*
- *Peak Supply*
- *Round-The-Clock (RTC)*
- *Thermal Mimic*

- Each having it own unique constraints, conditionalities and incentive-penalty structures.



Note: NTPC 1: 1,584 MW awarded out of 3,000 MW, NHPC 1: 1.4 GW awarded out of 1.5 GW, NTPC 2, 760 MW awarded out of 1200 MW, SECI FDRE 6, 200 MW awarded out of 2 GW, SJVN RTC 1 448 MW awarded out of 1.2 GW

Source: India Energy Storage Association

Updated till 01 October 2026

Types of supply constructs

Product	Delivery requirement	Additional modelling need
Solar / wind / hybrid	Energy and declared performance	Yield, losses and eligible annual sales
Solar plus BESS	Storage specification and/or delivery window	Power, energy, charging and losses
Peak-only / assured peak	Supply in nominated peak hours	Daily recharge, window and nomination risk
Demand-following FDRE	Match the specified demand profile	Demand Fulfilment Ratio calculation and chronological deficits
RTC / thermal-mimic	Period averages or minimum block supply	Seasonal balance and sustained deficits
RE plus actual thermal	Composite supply and renewable share	Fuel, capacity charges and thermal constraints

Learnings for SAARC Countries

- What changes in the tariff model when procurement moves from variable renewable energy and the buyer starts specifying when, and how reliably renewable electricity must be delivered?

  - Not just annual analysis, but chronological, block-wise (15 min) analysis of all resources (wind, solar, BESS)
  - Modelling delivery, flexibility and contractual risk.
    - Variation in wind/solar profiles over multiple years.
    - Degradation in solar/BESS; cycle life etc.

Recommended Model Framework

- The settlement interval determines the model's required time resolution.
- Multiple weather years and forecasts should feed a contract-resolution dispatch model.
- Settlement accounts for eligible supply, distinct shortfall and deviation liabilities, external purchase limits and surplus rights.
- Financing consumes the resulting cash flows. An annual cost model alone cannot establish intraday delivery.

Layer	Calculations	Outputs passed onward
1 Physical operation	Generation, charging, discharge, state of charge and network limits	Delivered energy and deficits by time block
2 Contract settlement	DFR, eligible purchases, surplus rights, penalties and compensation	Contracted revenue and balancing costs
3 Project finance	O&M, augmentation, working capital, debt, tax and returns	Required tariff, DSCR and investor cash flow

Capacity Utilisation Factor (CUF) vs Demand Fulfilment Ratio (DFR)

- CUF describes how much energy the plant produces.
- Demand Fulfilment Ratio (DFR) describes how well the portfolio meets the contracted requirement at the required times.
  - DFR = Scheduled Power/Required Power; max=1.
  - The calculation and averaging rules determine how demanding and expensive that promise is.

  - Avg DFR = 90%
  - If avg DFR needed at 90% on monthly basis, no penalty
  - If min DFR = 90% on block-wise basis, shortfall in block 4 leading to penalty.

Equal-duration block	1	2	3	4
Required MW	100	100	100	100
Scheduled MW	100	100	100	60
DFR	100%	100%	100%	60%

Network access and schedule deviations

- Transmission pricing implications, possible waivers/concessions for renewables/BESS.
  - Choice of location, siting decision
  - Also depends on resource quality and transmission access framework
- How much connectivity to procure
  - Injection cannot exceed connectivity in any time-block.
- Forecasting/Scheduling – Deviation Settlement Mechanism
  - Balancing schedules and actuals, penalties for deviation from schedules.
  - Changes in allowable deviation bands, increasing penalties, retrospective applicability.

Curtailment risks

- Risk of curtailment and implications of types of curtailment
  - System Constraints: load-generation imbalance leading to frequency imbalance. No payment for curtailment, only beyond ~175 hours/yr.
  - Tertiary Reserve Ancillary Service Emergency-Down Curtailment: Full payment to developer.
  - Transmission Evacuation Infra not fully available; risk of delayed connectivity, no compensation for loss of generation.
    - Partial evacuation through Temporary-GNA
    - BESS; suitable site selection
- Other risks
  - Delay in signing PPAs
  - Grid availability esp. for solar projects connected to the LV distribution grid.
  - Surplus sales and replacement purchases

Procurement Choices which will lead to tariff modelling

- Define the hours and seasons in which additional reliability has value.
- Allocate risks to parties able to manage them, including charging-energy and network risks.
- Match contract complexity to local forecasting, metering and settlement capability.
- Track financial closure, commissioning, actual delivery and collections after the auction.
- Local hydro, storage, demand response and permitted regional trade can offer different flexibility options.
- Compare bundled firm-renewable procurement with separate energy and flexibility procurement.

Likely paths ahead

- Invest in tracking, monitoring – seeing outcomes on ground vs only in tariff models or bid results.
- Storage likely to get mandatory in all geographies over time, as share of solar increases.
  - Move away from plain solar/wind projects to hybrid projects designed to meet specific user/procurer demand profiles.
- Evolved auction designs that value when power is delivered reliably rather than only the lowest electricity cost, while maintaining competition.
- Given the dynamic nature of the sector and inherent information asymmetry between regulators and industry, better to move from cost-plus, regulator determined tariffs to competitively bid, discovered and regulator approved tariffs.

THANK YOU

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