

# India's Power Market Design Needs to Evolve

## *Competition Is Key to a More Liquid, Dynamic and Efficient Power Market*

### Executive Summary

The rise in India's renewable energy generation capacity through variable sources like solar and wind is throwing up new challenges for the country's electricity grid. India's power market design needs to mature to address the challenges and optimum utilisation of existing resources. Policymakers may consider accelerating several pilot programmes aiming to reform power scheduling and dispatch, potentially saving billions of dollars for electricity distribution companies (DISCOMs). We also believe that a larger shift to open markets will allow competition and add dynamicity to electricity trading. Concerning grid stability, Frequency Control and Ancillary Services (FCAS) should move from un-requisitioned coal-generation capacities to battery storage and pumped hydro storage (PHS) systems. The new regulations for Ancillary Services aim to procure grid management services through the open market mechanism and allow for batteries and PHS to take part in it. This is because battery storage and PHS with faster ramp-up and ramp-down rates are much better for FCAS.

India's power market is transitioning with great momentum, especially in adding renewable energy capacity. India installed a record 15 gigawatts (GW) of renewable energy capacity in the fiscal year (FY) 2021/22. As a result, renewables form roughly a quarter of India's total installed capacity, with 115GW on the grid.

Further growth in variable renewables will pose challenges to grid integration. Managing the variability of supply on a grid with higher penetration of variable renewables, controlling the fluctuations in frequency and voltage, and maintaining system strength and inertia will require new technical and financial solutions. Therefore, India's power market design needs to evolve to optimise the utilisation of existing resources and incentivise new technological solutions.

This report reviews the current market design and structure for scheduling, dispatching and financial settlements for India's power trade and grid management services. Additionally, we refer to structural aspects of other foreign electricity markets to provide learnings for the Indian market.

Currently, 90% of the electricity traded is through long-term power purchase agreements (PPAs). However, the two-part tariff structure of thermal power PPAs has locked electricity distribution companies (DISCOMs) into long-term capacity payments. Combining this with self-scheduling of power dispatch at a regional-level results in a sub-optimal outcome for the DISCOMs.

Policymakers have identified this issue and are actively exploring its solutions.

A Security Constrained Economic Dispatch (SCED) pilot pooled 58.1GW of inter-regional thermal power stations. It recorded a saving of Rs20.7 billion (US\$260 million) between April 2019 and February 2022. Policymakers have also proposed a Market-based Economic Dispatch (MBED) mechanism to pool all the generation resources, potentially reducing power procurement costs by Rs120 billion (US\$1.6 billion) annually. Further, they proposed a year-long pilot to explore this mechanism in FY2021/22, but there is no publicly available update regarding the same.

India's Ministry of Power also aims to increase the share of open market platforms in the country's electricity market to 25% by FY2023/24 from the current 10%. The introduction of competitive day-ahead and term-ahead markets to trade clean power on open market platforms has been quite successful. In our view, a larger shift to open markets will allow competition and add dynamicity to electricity trading. More importantly, they provide a time-of-day price signal for energy storage technology solutions, such as utility-scale batteries, pumped hydro storage (PHS), as well as demand-side management.

**In our view, a larger shift to open markets will allow competition and add dynamicity to electricity trading.**

These solutions are also crucial for future rise in grid management requirements to deal with frequency and voltage fluctuations.

Since solar generation only happens during the day and wind patterns are highly seasonal and intermittent, the power system needs to evolve and modernise to respond to grid stability challenges, particularly as the share of variable renewable energy rises in India's energy system.

Increased frequency and voltage variability on the grid requires supporting services, broadly defined as Frequency Control and Ancillary Services (FCAS). These services mainly support the grid operation in maintaining the grid's power quality, reliability and security.

Under the current mechanism, FCAS use the un-requisitioned<sup>1</sup> capacities of coal-fired power plants.

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<sup>1</sup> Un-requisitioned surplus means the reserve capacity in a generating station that has not been requisitioned and is available for dispatch. It is computed as the difference between the declared Capacity of the generation station and its total schedule under long-term, medium-term and short-term PPAs with Discoms, as per the relevant regulations of the Commission.

The new regulations for Ancillary Services aim to procure ancillary services through the open market mechanism to make it more cost competitive. Also, it makes way for storage assets more suitable for fast frequency response than coal-fired power plants.

Batteries and PHS can dispatch power during grid events. They can also absorb electricity from the grid to manage its frequency. On the other hand, traditional thermal generation assets and gas peakers can provide these services by dispatching or backing down the power but cannot absorb the power from the grid. Therefore, grids with higher renewable energy penetration will require storage assets to absorb the excess power to avoid curtailments of cheaper clean energy sources.

India's grid ancillary service market needs modernising and deepening to incentivise these solutions.

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## Introduction

The Indian government's plan to commission 450GW of renewable energy capacity by 2030 has set the country's power market on a transitional path. Already, ultra-low-cost renewables have been highly disruptive to the Indian power market.

The technological disruption has affected the expensive and emission-intensive coal-fired power generation assets. However, their legacy continues to constrain India's clean energy transition.

India's state-owned power distribution sector has been the most troubled value chain segment for over a decade. The key reason for the ailing financial health of India's state-owned power distribution companies (DISCOMs) is high power procurement costs and lower revenue recovery because of high technical and commercial losses, state-imposed cross-subsidy burdens on tariffs and other operational inefficiencies.

India's DISCOMs face the challenge of adhering to contractual obligations of legacy coal-fired PPAs even as solar and wind power are available at Rs2-2.5/kilowatt-hour (kWh) (US\$26-32/MWh) in the market. In fact, solar and wind power is roughly 40%-50% cheaper than coal-fired power.

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The response to this challenge by the DISCOMs has been regressive to a large extent, in our view. They have cancelled auctions that resulted in already low-cost renewables striking deals at even lower prices. In some cases, DISCOMs have even cancelled PPAs or forced developers to negotiate to bring tariffs lower than the signed PPAs. This has significantly derailed India's near-term target of 175GW of renewable energy capacity by FY2021/22; the renewables capacity stood at about 113GW as of May 2022.

## *Current Market Design and Bottlenecks*

Currently, more than 90% of the electricity trading in India is through long-term bilateral contracts or PPAs between the DISCOMs and independent power producers (IPPs) for as long as 25 years. The PPAs for thermal power entail a two-part tariff structure — fixed charges that comprise capital and operational costs of the plant and variable charges that mainly include fuel costs.

DISCOMs need to pay fixed charges (capacity charge) to thermal plants for the capacity contracted, regardless of the amount of power drawn from the plant. The

variable charges are only for the quantity of electricity taken from the plant. Contrastingly, renewables have a fixed contracted tariff with no variable charge.

Once the DISCOMs have committed the sunk cost of the fixed charges, it is about choosing the lowest variable cost for getting power. Therefore, even if renewable energy sources have zero variable charges, slightly higher fixed charges make them more expensive than contracted coal-fired plants.

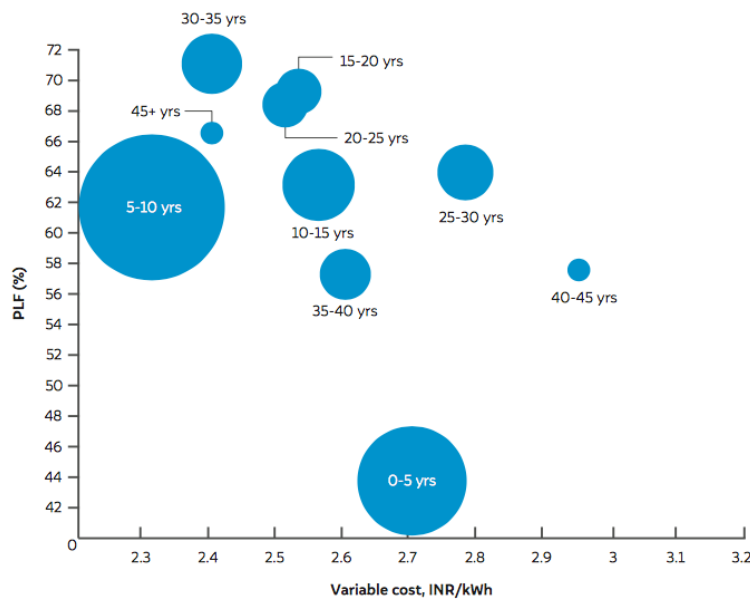
The legacy structure of long-term PPAs inhibits DISCOMs from procuring cheaper renewables.

Moreover, the current model of optimising dispatch schedule at a regional level does not result in the least-cost outcome for a nationally connected grid.

### Legacy Issue

A study from June 2021 by the think tank Council for Energy Environment and Water (CEEW) found that the newer coal-fired power plants (commissioned between five and 10 years ago) had lower plant load factors (PLF) in the 30 months leading up to the COVID-19 pandemic in India. This was despite the plants having lower variable costs than some of the oldest coal-fired power plants (between 20 and 35 years old).<sup>2</sup> Similarly, plants younger than five years old operated at PLFs roughly 20% lower, despite having a lesser variable cost than some of the oldest plants. (See Figure 1.)

**Figure 1: Coal Power Plants Age, PLFs, Variable Costs**



Source: CEEW

Note: The bubble size represents the capacity share of each age group

<sup>2</sup> CEEW. Coal Power's Trilemma. July 2021.

CEEW notes that the fact that partially contracted plants dispatch only to the extent of their contracts explains the underutilisation of newer coal power plants. Such plants sell the uncontracted capacity on the exchange or through other open market mechanisms. The open market transactions contribute about 10% of the total procurement of electricity in the country.

### *Self-Scheduling Issue*

DISCOMs in India currently schedule generation on a day-ahead basis from their portfolio of contracted generators. Self-scheduling has proven to be a sub-optimal outcome for the power system in the country, with ratepayers (DISCOMs) and, eventually, consumers bearing the relatively higher costs. There are also some instances where the states have violated their merit dispatch orders.

Self-scheduling restricts the DISCOMs from sharing the generation resources across the country. Unfortunately, this also leads to technical constraints on the amount of renewable energy a state can deploy within its boundaries.

The Indian grid is nationally connected. However, the current mechanism of self-scheduling constrains optimal utilisation of network infrastructure.

Therefore, the current market structure dominated by bilateral contracts and regional dispatch of power results in a sub-optimal and inefficient outcome for procuring the least-cost power.

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### *Increasing Grid-Balancing Requirements*

Higher penetration of variable renewables into India's grid would increase the grid-balancing requirements. Conventional thermal assets lack the required ramp-up/ramp-down capabilities to respond to voltage and frequency fluctuations. Battery energy storage systems (BESS) and pumped-hydro storage (PHS) systems can better deal with these fluctuations. These technologies add dynamicity to the grid by absorbing and dispatching power when required. However, the current regulations do not incentivise these technologies to operate viably.

India's market structure for power delivery in the short-to-medium term, financial settlements and grid management-related services need to evolve significantly to make room for the cheapest cost renewables. A more dynamic market design would incentivise new technologies, such as battery storage, virtual power plants and energy storage warehousing for energy and grid management services.

## India's Move Towards Generation Resource Optimisation

In the past few years, policymakers, regulators and system operators have recognised the need for a better market design for optimising resource utilisation while minimising the cost of power dispatch in India.

### *Security Constrained Economic Dispatch (SCED)*

India's national power network operates as a single grid. This has led to a situation where some interstate coal power generation stations have contracts to supply power to as many as 15 beneficiaries across the country. On the other hand, some states have a share of more than 40 interstate coal power generation stations in their portfolio.

In September 2018, Power System Operation Corporation Limited (POSOCO) proposed a Security Constrained Economic Dispatch model to optimise the utilisation of coal-fired power plants in the country.<sup>3</sup>

SCED aimed to aggregate all the interstate coal power generation stations whose tariff the Central Electricity Regulatory Commission (CERC) determines or adopts for their full capacity. POSOCO aimed to operate the pilot without violating the grid security while adhering to existing scheduling practices prescribed in the Indian Electricity Grid Code.

POSOCO ran the SCED pilot between April 2019 and February 2022 with a total of 58.1GW. The resource optimisation resulted in a total saving worth Rs20.7 billion (US\$260 million) and Rs19.4 million/day (US\$243.5 thousand/day).<sup>4</sup>

### **Figure 2: Highlights of SCED Pilot (April 2019 to February 2022)**

Total capacity under SCED pilot	58.1GW
Reduction in total variable cost due to SCED	Rs2,070 crore
Variable cost range of SCED participating units	Rs0.95/kWh (Daripali) – Rs4.43/kWh (Dadri-I)
Reduction in average cost of generation due to SCED	Rs0.021/kWh

Source: POSOCO

POSOCO reported that the pilot led to more certainty and higher utilisation rates in power plant operations for generators with low variable costs. This brought down the power costs. Since the start of the SCED operation, the reduction in cumulative megawatt (MW) change and the number of instructions is 28% and 41%, respectively. Therefore, the SCED facilitated the ease of generators' operations by reducing the change in generation schedule.

<sup>3</sup> CERC. Pilot on Security Constrained Economic Dispatch (SCED) of Inter-state Generating Stations (ISGS) Pan India.

<sup>4</sup> POSOCO. [SCED Detailed Feedback Report](#). March 2022.



Centralised market-based scheduling and dispatch will ensure enlargement of the balancing area from the state boundaries to regional or national borders. It will also bring the desired flexibility for reliably deploying much higher levels of renewables.

### *Market-Based Economic Dispatch (MBED)*

In January 2021, the CERC proposed a market operating mechanism to optimise all the generating assets in the country.

The proposed MBED will function on day-ahead scheduling of all generation on economic merit basis, subject to plant and network constraints.

By moving away from just state-level pooling of resources and dispatching power through a central clearing mechanism, MBED aims to reduce power procurement costs by Rs120 billion (US\$1.6 billion) annually.<sup>5</sup>

**Pooling of sell and buy bids**—Seller (generator) and buyer (DISCOM) would submit their bids one day in advance; the sell and buy offers based on quantum and prices will be pooled.

**Price discovery, scheduling and dispatch**—The sell and buy offers will form the basis of preparing a national merit order stack. Discovery of a Market Clearing Price (MCP) would be per the merit order for 15-minute time blocks (96 blocks per day) for the delivery day.

**Payments and settlement**—The payment settlement in MBED will partially move to the power exchange while adhering to the contracted tariffs of the PPAs.

Cleared buyers would pay the MCP to the power exchange, which would, in turn, pay the MCP to the cleared sellers. Final settlements would be per contract for the portion of demand cleared in relation to contracted megawatts (MW). The buyers would continue to pay the fixed costs outside the market. If there are gains realised from the sale of surplus power over the scheduled quantum, it would be shared between the beneficiaries, as stipulated by CERC.

### *Financial Implications of MBED*

As the market becomes more competitive, cheaper plants will get dispatched first, raising the stranded asset risk on expensive thermal power plants.

As the settlements move to the open market, DISCOMs will initially require financial support for the increased cash flow requirements. However, gradually, this mechanism's efficiency and competitiveness would ensure lower power purchase costs and improve DISCOMs' financial position by moderating their liquidity requirements.

We believe the MBED mechanism will significantly benefit all generation assets by reducing payment delays and adding more protection to contracts. This will

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<sup>5</sup> Ministry of Power. [Discussion Paper on Market Based Economic Dispatch \(MBED\)](#). May 2021.

improve the bankability of new renewable energy PPAs and potentially lower the cost of capital, reducing the cost of renewable energy.

CERC initially proposed to run the MBED pilot between April 2021 and March 2022. However, there is no update on this pilot to date.

## Open Market Platforms

Electricity trade in many global electricity markets occurs through centralised power exchange platforms. These exchanges provide a platform for transparent, real-time and competitive electricity and energy trading.

More importantly, the open market platforms provide a time-of-day price signal to generators and consumers to put a dynamic value on dispatch and consumption of power at different times of the day. For example, wholesale prices can go negative on open market platforms. Effectively, consumers could be, in fact, paid to absorb the power when there is an excess of renewable energy available on the grid to restrict the grid frequency from rising above a desirable level.

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### *European Power Exchange*

European Power Exchange (EPEX SPOT) SE, operating in 16 European countries, traded 615 terawatt-hours (TWh) of electricity in 2020, roughly half of India's total electricity traded annually.<sup>6</sup>

EPEX SPOT operates day-ahead power markets across Austria, Belgium, Denmark, Finland, France, Germany, Luxemburg, Great Britain, the Netherlands, Norway, Poland, Sweden and Switzerland.

It organises these day-ahead markets through an auction process, matching once-a-day supply and demand curves and thus fixing prices anonymously, transparently and securely. Members of the exchange enter their orders for hourly quantities of power into the order book, which closes at 11am for Switzerland and at 12pm for all other markets. EPEX SPOT calculates the offer and demand curves and their intersection for each hour of the following day. It publishes the results from 9.30am GMT (Great Britain), 11.10am (Switzerland) and 12.55pm (all other markets).

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<sup>6</sup> EPEX Spot.

## National Electricity Market (NEM) of Australia

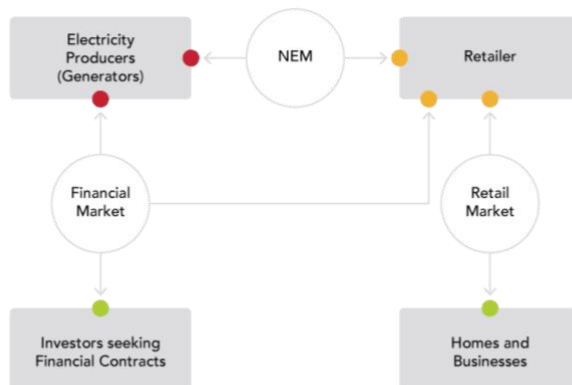
The National Electricity Market (NEM) supplies around 200TWh of energy to businesses and households annually. Three key markets underpin this system: the National Electricity Market, the Retail Market, and the Financial Market.<sup>7</sup>

The NEM is a wholesale market involving exchanges between electricity producers (generators) and retailers (companies that purchase electricity from generators and then sell it to homes and businesses).

The Retail Market involves electricity retailers selling the energy they have purchased wholesale (via the NEM) to homes and businesses.

The Financial Market describes various contracts between electricity producers, retailers and investors, which act as insurance policies by reducing the significant risk of financial exposure faced by market participants due to the potential volatility in electricity prices. These financial contracts may lock in a firm price for electricity production or consumption at a given time in the future.

**Figure 3: NEM Australia**



Source: Australian Energy Market Operator

## Open Market Platforms in India

There has been notable growth in open market trade for electricity in India in the last couple of years. Power Exchange India Limited (PXIL) and Indian Energy Exchange Limited (IEX) are the two open market platforms currently facilitating spot market trade for electricity in the country.

<sup>7</sup> Australian Government – Department of Industry, Science, Energy & Resources.

IEX saw a year-on-year (YoY) volume growth of 17% in June 2022, with a total of 8,276 million units (MU) traded on the exchange.<sup>8</sup> The traded volumes grew by 10% YoY to 23,437MU for the first quarter of FY2022/23.

The Ministry of Power has expressed an ambitious intention to expand the reach of competitive markets to 25% of the total power purchased by the end of FY2023/24.<sup>9</sup>

In June 2022, CERC approved another power exchange named Hindustan Power Exchange (HPX). The Bombay Stock Exchange Group, PTC India and ICICI Bank back the new platform.<sup>10</sup> This marks a strong push for competitive trade of electricity through open market platforms in the country.

IEX and PXIL both facilitate a real-time market (RTM) for trading electricity, giving generators and consumers a view of prices closer to the actual time of power delivery. In the real-time market, the price discovery happens an hour in advance through double-sided closed auctions with buy and sell bids for 15-minute time blocks.

The RTM provides DISCOMs with an alternate mechanism to access the larger market at a competitive price as generators with un-requisitioned capacity also participate. If a DISCOM has any power requirement after the end of the right to revision of the dispatch schedules, it could access the RTM at real-time prices.

The power exchanges also operate Green Term Ahead Markets (GTAM) and Green Day Ahead Market (GDAM) for renewable energy trading, enabling consumers a clean and sustainable choice for power procurement.

The exchanges operate markets that provide advance visibility of prices, ranging from a week to just half an hour before power delivery. IEX also facilitates the cross-border trade of electricity. Currently, India trades electricity with neighbouring countries such as Nepal, Bhutan and Bangladesh. With the Indian government's objective to expand cross-border electricity trade under the aegis of One Sun One World One Grid (OSOWOG), these platforms will play a vital role in settling physical and financial contracts for power delivery.

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<sup>8</sup> IEX. [IEX Power Market Update June 2022](#).

<sup>9</sup> The Hindu Business Line. [Govt eyes 25% power purchase in spot market](#). 22 December 2021.

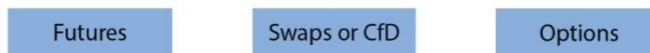
<sup>10</sup> Saur Energy. [Hindustan Power Exchange Gets CERC Nod For India's Third Power Trading Exchange](#). 29 June 2022.

**Figure 4: Power Exchanges in India**

**Short-term physical market:**



**Short-term financial market:**



Source: IEEFA<sup>11</sup>

### OTC Platforms

In August 2021, CERC also released guidelines to set up Over-the-Counter (OTC) platforms to allow electricity trade directly between sellers and buyers.<sup>12</sup>

The OTC platforms will differ from the power exchanges as they allow direct interaction between buyers and sellers. They will provide even more visibility to market participants by integrating rooftop solar capacities and inter-state and inter-regional market participants.

OTC platforms will provide an electronic platform with the information of potential buyers and sellers of electricity. They would maintain a repository of data related to buyers and sellers and provide such historical data to market participants. Further, they will also offer valuable information services, such as advanced data analysis tools, to market participants.

### Need for Financial Products for Hedging

Expanding open market platforms will mean higher exposure to merchant risk for power sellers and price volatility risk for buyers and sellers. Using financial products of derivatives reduces the risk and uncertainty in the spot market. The derivative products derive value from the long-term price of the underlying commodity – electricity, in this case. Electricity derivatives lock in firm prices for electricity production or consumption at a given time in the future.

<sup>11</sup> IEEFA. *Deepening India's Short-Term Power Market with Derivatives*. June 2021.

<sup>12</sup> CERC. *The Draft Guidelines for Registration and Filing Application for Establishing and Operating Over the Counter (OTC) Platform*. August 2021.

They would provide revenue certainty for the generators and incentivise investment in new generation assets. Similarly, they protect buyers from unexpected price spikes as the prices for power delivery are under contract.

India's Supreme Court settled a long-standing dispute for owning the jurisdiction of derivative contracts between CERC and the Securities and Exchange Board of India (SEBI). The Supreme Court ruled that CERC will regulate all the physical delivery-based forward contracts, whereas SEBI will handle the financial derivatives.<sup>13</sup>

The growth of India's renewable energy capacity has benefited from long-term PPAs. Bankers have been comfortable lending to solar and wind projects with PPAs underwritten by government agencies, such as Solar Energy Corporation of India (SECI) or NTPC. As the environment for renewable energy continues to become more conducive for investments, the developers are willing to take more merchant risk for better returns through the spot markets. The asset owners are happy to hedge a balance between contracted capacity and merchant capacity for their assets. Therefore, the growth of spot markets is imminent.

Lenders becoming comfortable with more merchant risk is the key shift required for electricity trade in the open market to flourish. This requires further endorsement and advocacy from the Ministry of New and Renewable Energy (MNRE).

## Competitive Grid Services Market

Solar generation is only available during the day, and wind patterns are highly seasonal and intermittent. As a result, the power system needs to evolve and modernise to respond to grid stability challenges as the share of variable renewable energy (VRE) generation continues to increase in India's energy system.

Increased frequency and voltage variability on the grid requires supporting services, broadly defined as Frequency Control and Ancillary Services (FCAS). These services mainly support the grid operation in maintaining the grid's power quality, reliability and security.

Achieving effective frequency control requires some form of capacity reserve. Accordingly, different frequency reserves fall in various grid codes worldwide—i.e., primary reserves or equivalent, secondary reserves or equivalent, and tertiary reserves or equivalent—based on their

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<sup>13</sup> The Economic Times. *SC settles 10-year long CERC, SEBI dispute; paves way for power derivatives, futures*. 07 October 2021.

speed and accuracy of response, duration of output, and timing to maintain grid supply-demand balance.

Other essential services include active power support for load following, reactive power support, black start and other such services defined in the Grid Code.

System operators organise these reserves for a response mechanism in an event where the frequency on the grid deviates from 50Hz, or the grid-specific normal frequency level specific.

Contingent events can occur in seconds, resulting from causes such as intermittency, outages or inclement weather. Responding to such challenges requires a reliable and responsive resource to ensure the grid's security and integrity.

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Regulators generally design these reserves so that even in case of failure of the biggest link—the biggest generator or transmission link— system operators can signal the reserves to ramp up or down in sufficient time to prevent grid collapse.

Some countries follow a system of Frequency Response Obligation (FRO, expressed in MW/Hz, or at times in MW)<sup>14</sup> in their grid code that outlines the required level of reserves to arrest undue large frequency variations. The primary goal of the FRO system is to control frequency change so that it remains within the designed frequency band to prevent tripping and, at worst, blackouts.

Delivering the FRO depends on the resources and capacity of ancillary services allocated under primary reserves (PRAS), secondary reserves (SRAS) and tertiary reserves (TRAS), each operating at different control points. The underlying principle of having reserves is as follows:

During contingent events or instances of imbalances in generation and demand, the hierarchy of reserves is PRAS, then SRAS and finally TRAS. TRAS can be flexible and may come through re-dispatch following the merit order of the scheduling timeframe. However, keeping an effective reserve ready should be a consideration to protect against the risk of unavailability.

The integration of variable renewable energy resources, specifically solar and wind, necessitates an increase in the reserve resources, particularly for PRAS and SRAS, to manage deviations in the frequency. This is because of the intermittency of renewable energy sources. It is one of the most critical factors driving the

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<sup>14</sup> University of Pennsylvania. [A Market for Primary Frequency Response. A Role of Renewables, Storage and Demand. A working Paper by Thomas Lee.](#) August 2020.

importance and growth of ancillary services around the globe with different system operators.

### *Current Frequency Response Service Mechanism in India*

The current mechanism uses the un-requisitioned<sup>15</sup> capacities of coal-fired power plants for FCAS.

CERC formulated the Ancillary Services Operation Regulations in August 2015.<sup>16</sup> The objective of the regulation is to help restore the synchronous frequency level to 50Hz and to relieve congestion in the transmission network.

**The current mechanism uses the un-requisitioned capacities of coal-fired plants for FCAS.**

POSOCO, alternatively known as the National Load Dispatch Centre (NLDC), is the central nodal agency for implementing reserve regulation ancillary services.

Power plants that are regional entities (inter-state power plants with PPAs with multiple states), and whose tariffs the CERC determines, can provide Reserve Regulated Ancillary Services (RRAS).

Generating stations need to provide monthly details about fixed charges, variable charges and any other statutory charges to the regional power committees that report to the NLDC.

Regulators categorise the services as regulation up (injecting power) and regulation down (backing down power) services. The grid requires regulation up service when the frequency level drops below 49.90Hz continuously for five minutes. On the other hand, the grid needs regulation down services when the frequency level goes above 50.05Hz continuously for five minutes.

NLDC creates merit dispatch orders on a day-ahead basis based on the variable cost of power plants. For regulation up (power dispatch service to increase the frequency), NLDC stacks up un-requisitioned surplus capacities of inter-state generating stations from lowest to highest variable cost plants. For frequency down (in which dispatch needs to back down power to reduce the frequency), NLDC stacks the merit order from highest to lowest variable cost plants.

For regulation up services, payments come from the Deviation Account Settlement Mechanism (DSM) Pool for fixed, variable and with a mark-up on fixed costs.

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<sup>15</sup> Un-requisitioned surplus means the reserve capacity in a generating station that has not been requisitioned and is available for dispatch. It is computed as the difference between the declared Capacity of the generation station and its total schedule under long-term, medium-term and short-term PPAs with Discoms, as per the relevant regulations of the Commission.

<sup>16</sup> CERC. [Ancillary Services Operation regulations](#). 13 August 2015.



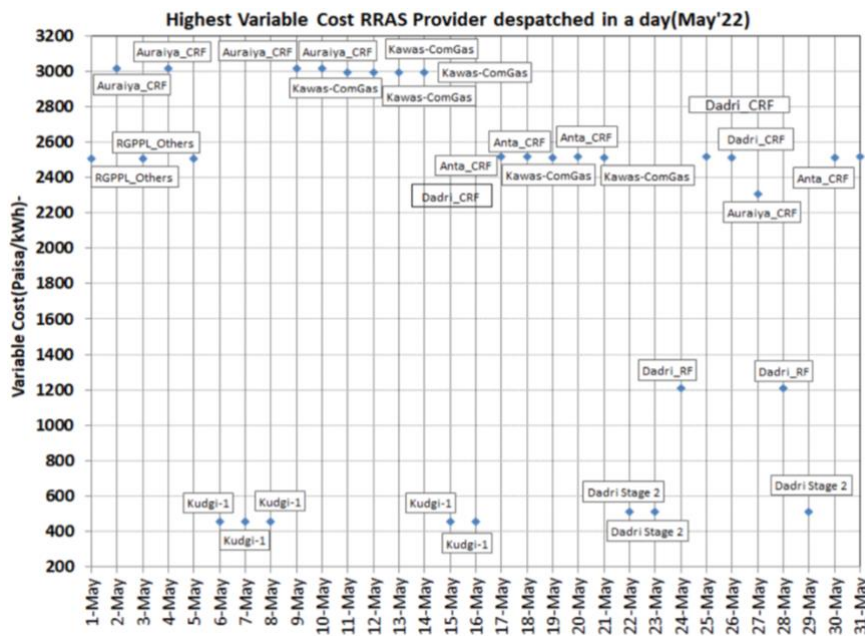
Regulation up service providers then need to adjust the fixed charges (paid to them from DSM pool) payments they receive from the DISCOMs under their PPAs.

Regulation down service providers need to pay 75% of the variable charge to the DSM pool as they reduce their generation per NLDC's instructions.

In May 2022, generators received Rs7.26 billion (US\$91.1 million) from the DSM pool for providing regulation up services. On the other hand, generating stations that provided regulation down services paid Rs1.15 billion (US\$14.4 million) to the DSM pool in May 2022.<sup>17</sup>

The variable cost for RRAS providers was as high as Rs30/kWh in May 2022.

**Figure 6: Highest Variable Cost of RRAS Providers in May 2022**



Source: POSOCO

### Amendment to FCAS Regulations in India

In January 2022, CERC finalised new regulations for Ancillary Services.<sup>18</sup> As opposed to the previous mechanism for frequency response services, the new regulations aim to procure ancillary services through the open market mechanism to make it more cost competitive. Also, it makes way for storage assets more suitable for fast frequency response than coal-fired power plants.

<sup>17</sup> POSOCO. Implementation of the RRAS Mechanism Report for May 2022.

<sup>18</sup> CERC. Central Electricity Regulatory Commission (Ancillary Services) Regulations, 2022 — Statement of Objects & Reasons (SOR) Thereof.

CERC's new regulation has recognised energy storage and demand response, which are digitally controllable, as dispatchable energy and power resources that can respond rapidly and accurately to maintain grid frequency within close boundaries of 50Hz.

The state and national load dispatch centres—SLDCs and NLDC—will plan for the quantum of the required SRAS and TRAS on a day-ahead basis. They would also assess any incremental requirement on a real-time basis.

The SRAS capacity should be at least 1MW, and resources need to either dispatch power into the grid or draw power out within 30 seconds of receiving a grid signal. Resources must be capable of providing their entire capacity obligation within 15 minutes and sustain the obligation for another 30 minutes.

Meanwhile, TRAS participants need to respond and provide frequency regulation within 15 minutes and sustain it for at least 60 minutes. TRAS can be used to replenish secondary reserve resources deployed continuously for 15 minutes for more than 100MW, as well as in response to other Grid Code-specified events.

The regulation also provides performance-based incentive payments for SRAS based on its response and accuracy.

### *Grid Tools for Frequency Response*

Energy storage systems such as utility-scale lithium-ion batteries or PHS can be important grid tools for frequency control operations. The technologies can dispatch power during grid events as well as absorb energy from the grid to manage grid frequency. On the other hand, traditional thermal generation assets and gas peakers can provide these services by dispatching or backing down the power but cannot absorb the power from the grid. Grids with higher renewable energy penetration will require storage assets to absorb the excess power to avoid curtailments of cheaper clean energy sources.

**Energy storage systems such as utility-scale lithium-ion batteries or PHS can be important grid tools for frequency control operations.**

Moreover, accuracy and response speed are critical to ensuring the frequency response operation. Both factors contribute to the systemwide cost of controlling grid frequency. Generators can differ dramatically in their ability to follow the system operator's commands or respond automatically and precisely to frequency changes.

The following table compares various frequency response assets' flexibility and response time.

**Figure 7: Comparison of Flexibility Parameters and Response Time**

Plant Type	Hard Coal	Lignite	CCGT	Pumped Storage	Batteries
Load range (%)	40% to 90%	40% to 90%	40% to 90%	NA	0% to 100%
Minimum Load (%)	40% / 25% / 10%	60% / 40% / 20%	50% / 40% / 30%	10%	-100%
Ramp rate (%/min)	2% /4% / 9%	2% /4% / 8%	4% / 8% / 12%	>40%	100%
Start-up time - hot start (within less than 8 hours)	3h / 2h / 1h	6h / 4h / 2h	1.5h / 1h / 0.5h	<0.2h	<1 second
Start-up time - cold start (after more than 48 hours)	7h / 4h / 2h	8h / 6h / 3h	3h / 2h / 1h	<0.2h	<1 second

Source: GIZ,<sup>19</sup> IEEFA estimates.

Note: CCGT is combined cycled gas turbine (gas-fired generation).

Utility-scale batteries have the fastest response time—less than a second—in frequency response operations. Also, batteries can either charge up to 100% of capacity or dispatch 100% of capacity, if required, to maintain the frequency.

## Global FCAS Markets

### Australia

Renewable energy penetration of about 25% in Australia's National Electricity Market (NEM) has increased requirements for grid management-related services.

The Australian Energy Market Operator (AEMO) has two distinct subsets of the FCAS market – Regulation and Contingency – in the NEM.

Regulation frequency control is for correcting the supply-demand imbalance in response to minor deviations in either load or generation. On the other hand, the NEM continually uses regulation services to correct minor changes in the supply-demand balance. Whereas contingency frequency control corrects imbalance following major events, such as the loss of a generating unit or a large transmission line.

The NEM's frequency control standards classify eight FCAS requirements, leading to eight different FCAS markets.

Participants must register with AEMO for each distinct FCAS market within which they wish to participate. Once registered, a service provider can operate in an FCAS market by submitting an appropriate offer or bid for that service via AEMO's market management systems.

<sup>19</sup> USAID – Greening the Grid. [Keeping Flexibility at the centre stage of India's energy transition](#). October 2020.

**Figure 8: FCAS Markets in National Electricity Market Australia**

FCAS Categories	8 FCAS Requirements	Technologies
Regulation Frequency Control Services	Regulation raise Regulation lower	Provided by generators on Automatic Generation Control (AGC)
Contingency Frequency Control Services	Fast raise (6-second raise) Fast lower (6-second lower) Slow raise (60-second raise) Slow lower (60-second lower) Delayed raise (5-minute raise) Delayed lower (5-minute lower)	Provided by: Generator Governor Response Load Shedding Rapid Generation Rapid Unit Uploading

Source: AEMO

### *FCAS Markets Settlements in the NEM*

The NEM Dispatch Engine determines a clearing price for each of the eight FCAS markets for each five-minute market dispatch interval. Settlements then use this price to determine payments to each FCAS provider.

Market participants remunerate the FCAS providers themselves according to the set regulations.

A “causer pays” factor methodology forms the basis for recovering payment for regulation services. Under this methodology, market operators monitor the response of measured generators and loads to frequency deviations and use it to determine a series of factors.

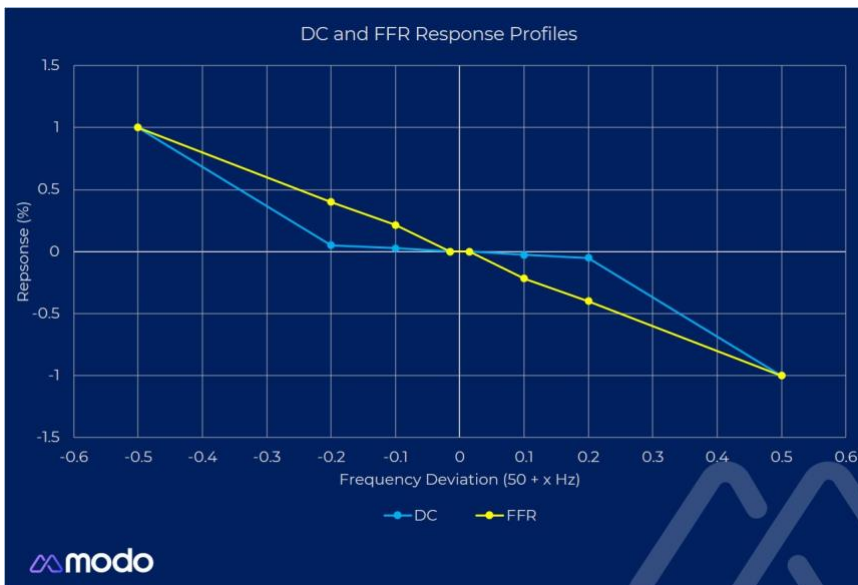
Contingency raise services are there to manage the loss of the largest generator on the system. As a result, the three contingency raise services recover all payments from the generators. On the other hand, contingency lower requirements are for managing the loss of the largest load/transmission element on the system. This is why all payments for the three contingency lower services come from customers.

### *The UK's Dynamic Containment Response*

The UK is another big electricity market that is undergoing a huge transformation. In 2020, the UK replaced firmed frequency response (FFR) service with faster acting services for grid management during supply-demand imbalances. Dynamic Containment (DC), designed to arrest the frequency deviation of +/-0.2Hz to +/-0.5Hz, is the fastest.

DC provides frequency response ‘post-fault,’ i.e., after frequency breaches specific upper or lower limits. However, there is also a requirement for a small response inside those limits. Comparing DC to the existing FFR product, the response profile for DC effectively extends the existing FFR boundaries, which require little to no response, while decreasing the response time required from assets.

Figure 9: DC vs FFR Response Profiles



Source: modo

### FCAS Regulations to Drive Up Battery Deployments

India's battery storage market is slowly picking up with projects under construction and multiple tenders rolled out by entities such as SECI, NTPC and Gujarat's state-owned DISCOM – Gujarat Urja Vikas Nigam Ltd (GUVNL).

SECI and NTPC have launched tenders to procure 1,000 megawatt-hours (MWh) and 5,00MWh of standalone battery storage systems, respectively.<sup>20</sup> In addition, in June 2022, GUVNL announced a 500MW renewable energy plus 250MWh energy storage tender.<sup>21</sup>

SECI will ensure payment for a fixed capacity charge for 60% of the battery storage capacity for availability and a set variable charge for units procured. However, for the remaining 40% of united battery capacity, asset owners will have to find buyers in the open market.

In this case, the asset owners will need to look for buyers either on open market platforms or tie up the remaining capacity with commercial or industrial customers through the open access route. As India looks to add 27GW/108 gigawatt-hours (GWh) (CEA Optimum Generation Mix Report 2020) worth of storage assets by 2030, a competitive FCAS market will open up an important revenue stream for energy storage assets.

<sup>20</sup> Energy Storage News. [Solar Energy Corporation of India launches 'first-of-its-kind' 1,000MWh battery storage tender](#). 14 April 2022.


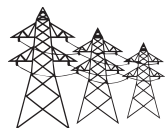
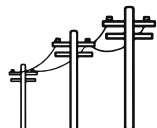


<sup>21</sup> Mercom India. [GUVNL Issues RfS to Buy Power from Renewable Projects with Energy Storage](#). 15 June 2022.

There also are more than 4GW of operational PHS projects with roughly 3GW under construction. The tariffs for the operational PHS projects exceed Rs7/kWh, and, typically, states operate them to meet peak demand.

Long-term price signaling could support batteries and PHS projects, which would predominantly operate to shave peak-demand loads. The profitability of these battery assets relies on price arbitrage—charging during low-price periods and dispatch during the high-price, peak demand periods.

The presence of a competitive FCAS market puts value and merit on accuracy and speed of response to grid management requirements, further improving grid reliability. In addition, it would eliminate the grid operator's cheapest avenue of managing the grid in adverse grid events—load shedding.

**Figure 10: Value Streams of Utility-Scale Battery Storage Assets**

Energy & Capacity	Ancillary Services	Transmission & Distribution	Inertia	Black Start
<p><b>Arbitrage:</b> Charging the battery when energy prices are low and discharging during more expensive peak hours</p> <p><b>Firm capacity:</b> peak shaving and capacity adequacy</p> 	<p><b>Grid management services:</b> frequency and voltage regulation.</p> <p><b>Ramping services:</b> rapidly charge or discharge in a fraction of a second to manage grid imbalances.</p> 	<p>Act as virtual transmission and distribution systems.</p> <p>Defer the need for expensive transmission and distribution network upgrades.</p> 	<p>Provide synthetic inertia for stability in the grid as the large thermal power plants with spinning machines will phase out.</p> 	<p>After a grid-failure, large conventional generators need a source of electricity to start up. This is called a Black Start. BESS can replace traditionally used diesel generators to provide these services.</p> 

Source: IEEFA

## Way Forward

India's power market design needs to evolve to transition faster to an ultra-low-cost renewable energy-based electricity system. The manner of power scheduling and trading needs to evolve, firstly, to optimise the existing power sector resources and, secondly, to make room for new cheaper cost sources.

POSOCO's SCED pilot has illustrated that there could be significant savings through the optimal scheduling of inter-state coal-fired power plants. DISCOMs have locked themselves into long-term contracts with coal-fired power plants that burden them with expensive capacity payments. Optimisation of thermal resources would probably make the best out of a bad situation.

CERC's proposed MBED mechanism recommends pooling all the generation resources in the country. It endorses a settlement model for the capacity charges under the existing PPAs between thermal IPPs and DISCOMs to maintain the status

quo. DISCOMs will have the visibility of the lowest variable cost generation resources across the country, and a central system or power exchange will help settle the variable costs. There has been no update on the proposed pilot of the MBED mechanism. If CERC has not yet staged the pilot, it should do so at the earliest as it has the merit to significantly improve cost and resource efficiency.

Renewable energy procurement also needs a refresh. India's power sector has tasted decent success in deploying and operating renewable energy assets. As the renewable energy sector continues to be more conducive for more investments, regulators should allow new capacities more merchant exposure. The developers have shown an appetite for such exposure in pursuit of higher financial returns. Bankers and financial institutions also need to get comfortable with assets having some amount of merchant exposure. In our opinion, the Indian government needs to endorse and advocate for a balance between contracted capacity and merchant capacity. This will support the growth of volumes in the spot market, which eventually will result in more liquidity, dynamicity and competition in the system.

**In our opinion, the Indian government needs to endorse and advocate for a balance between contracted capacity and merchant.**

The imminent growth of the spot markets will need to be supported by the development of electricity derivative products to reduce the financial risk involved in the spot market volatility. The Supreme Court's ruling over the ownership of the jurisdiction of physical and derivative contracts has ended the conflict. In addition, it has provided much-needed clarity for developing financial products.

System operators in India still procure the grid ancillary services from the un-requisitioned surplus capacity of coal-fired power plants. Battery energy storage technologies and PHS, which have significantly shorter response times and higher ramp-up and ramp-down rates, can provide these services better than coal-fired power plants. CERC's regulation for frequency control ancillary services paves the way for a competitive and modern mechanism. India should move to the new mechanism sooner rather than later.

Higher variability caused due to variable renewables will require higher spinning reserves too. Policymakers need to accommodate this in the market design planning.

The Indian government-backed agencies, such as SECI and NTPC, support the growth of energy storage systems by offering long-term PPAs. However, the PPAs only tap one value stream of energy storage systems – energy dispatch to meet the

peak demand. The industry touts Battery Energy Storage Systems as the Swiss army knife of the power systems as they can provide multiple services.

A faster move to competitive and open market-based electricity and FCAS market will unlock all the revenue streams for energy storage systems that are crucial for higher growth of renewable energy.

The government and the regulators have been proactive in laying out the framework to transform the market to be more modern and efficient. However, it now needs a faster implementation process to reap the desired benefits.



## About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. [www.ieefa.org](http://www.ieefa.org)

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