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Office of the Energy Regulatory Commission

Session IV:

FACILITATING INNOVATIVE TECHNOLOGIES FOR ENERGY TRANSITION

Sandboxing case study on Approval for BESS investments and Market Coupling

Anish Mandal

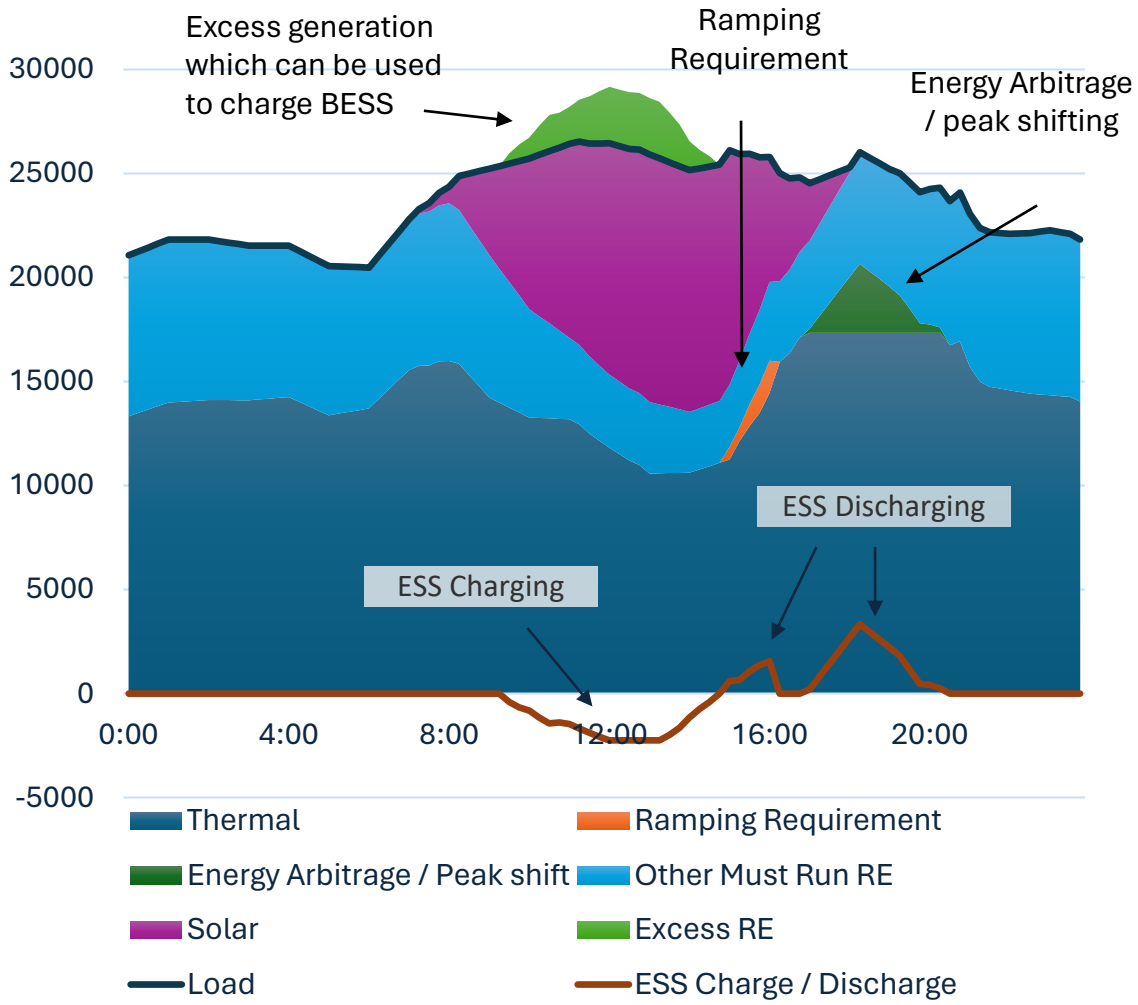
Deloitte Touche Tohmatsu India LLP

Sandboxing: Approval for BESS investments

Standalone BESS vs alternate models

1

A single BESS system can offer multiple services, which can be stacked to derive maximum economic for the asset



1	**Revenue from Energy Arbitrage/ shifting of energy:** BESS can flexibility operate to maximize revenues by charging during low-cost period and discharging during high-cost periods With increases VRES, the volatility in market prices will increase, with low-cost during high RE periods and high-costs for peaking and ramping requirement during low RE periods. ESS can also charge from a co-located/ contracted RE plant and leverage energy arbitrage which is present in the market	✓
2	**Benefits from Ancillary Support: BESS**, being a fast-acting resource, can provide frequency regulation support and provide tertiary reserves (spinning reserve services)	TRAS from 2023, SRAS ~2025
3	**Resource Adequacy: BESS**, being a firm resource, can be contracted by DISCOM or participate in Capacity Auctions to provide firm capacity and meet the Resource Adequacy Requirement of DISCOMS	From ~2025

Standalone BESS

A

- ✓ *Status check*

Analysis of recent BESS tenders in India: Summary of recent BESS tenders

BESS Procurer	Size	2021	2022		2023		2024		Comis-sioning Year	Project Duration	Discovered Tariff	Comments
		H2	H1	H2	H1	H2	H1	H2			INR/ MW/ year	
Kerala state (KSEB)	10 MW/ 20 MWh	Sep		Apr					**2025**	~36+ months	135 lakhs (w/o VGF)	• Stuck at Regulatory Approval due to high cost discovered at the tendering stage
UP state (UPPCL)	5 tenders of 10 MW/ 40 MWh			August		Auction Oct			**2025**	**~24 months**	69 lakhs (~30% VGF)	• Stuck/ delayed due to quality and experience of winning bidder
New Delhi (BRPL& GEAPP)	20 MW/ 40 MWh				June		Mar		**2024**	~12 months	58 lakhs (~17% VGF)	• LOA awarded by BRPL to winning bidder; lowest tariff discovered in India at the time • **Regulatory Approval provided in April, 2024**
Gujarat state (GUVNL)	250 MW/ 500 MWh					Nov			**2025**	**TBD**	**54 lakhs (0% VGF)**	• Bid opening in February 2024, new lowest tariff discovered in India so far • Round 2 for the same capacity announced in March 2024

EOI / Project Conceptualization

Tender/ Bid process timeline

Project Awarded (LOA signed)

Anticipated Regulatory Approval

Project GEAPP – Case Study

B

Project Overview

Summary

- BRPL sought to commission a grid-connected BESS project (**20MW/40MWh**) at their site to demonstrate the commercial and technical viability of BESS at the distribution-end by monetizing multiple BESS value streams
- The BESS system would be owned by a Special Purpose Vehicle (SPV), with O&M conducted by the system integrator for a **period of 12 years**
- The SPV would be financed by a mix of **concessional debt from GEAPP** and equity (to be provided by the project Sponsor).
- The SPV will be paid by BRPL through a **fixed tariff** (in Rs/MW/month terms). This tariff will be **approved by the DERC**

History

- The project was initially conceptualized by BRPL under **USAID's Greening the Grid** program grant in 2021 and presented to DERC for regulatory approval; however, the approval was put on hold due to **limited regulatory provisions** to monetize revenue streams.
- Following new market developments, GEAPP has re-engaged with BRPL, and have built upon the previous project to refresh the techno-commercial use-case to create a strong value proposition to secure regulatory approval for the pilot demonstration project.

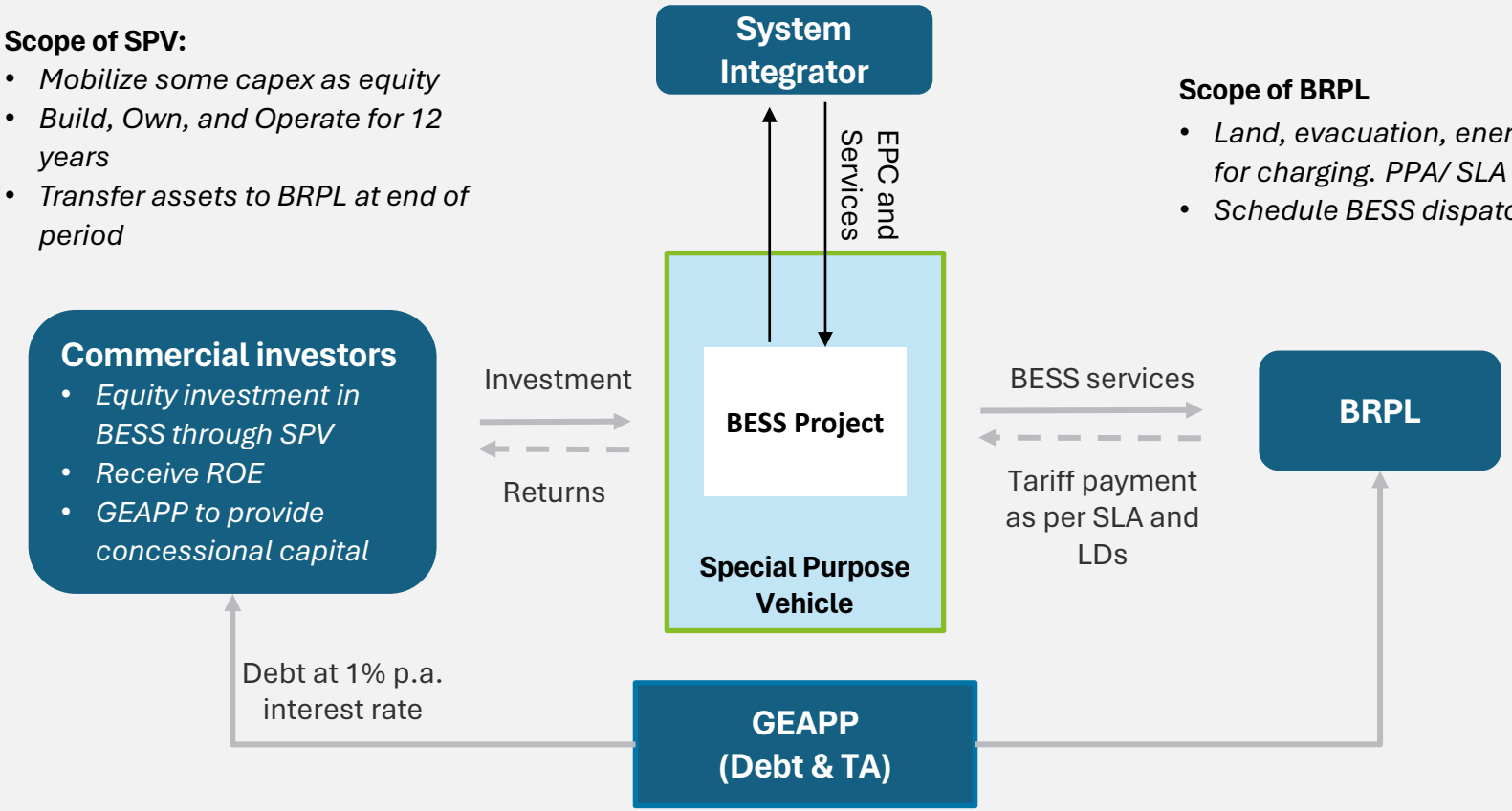
Key Parties

PARTY	ROLE	RESPONSIBILITY
BRPL	DISCOM, regulated entity, off-taker	• Land, evacuation, energy for charging. • Offtaker of the BESS through a BESS agreement • Schedule BESS dispatch
GEAPP	Concessional debt provider	• Invests 70% total project cost as concessional capital to SPV. • Receives concessional interest (1% fixed rate) and principal repayments over the life of the project.
DERC	Regulatory body	• Approves the BESS project and proposed tariff.
Deloitte	Project Consultant	• Undertaking the Project Pre-feasibility study (energy modelling, financial modelling), preparation of Report for regulatory approval, preparation of Bid documents • Project Management Support
IndiGrid & AmpereHour	Private sector developer / investor	• Invests 30% total project cost as equity in BESS through SPV. • Provides EPC and O&M services • Expected IRR of -3%

Based on the interest received from both System Integrators and Commercial Investors, it was decided that BESS would be held by an SPV, which will provide BESS as a service to BRPL

- The 20 MW / 40 MWh BESS will installed at a 33/11 kV grid substation within BRPL's license area.
- BRPL will pay a tariff (Capacity Charge) for the use of BESS as a Service
- The tariff will be discovered through a competitive bidding process. The winning bidder/ consortium will form an SPV, which will build, own and operate the BESS

Scope of SPV:
- *Mobilize some capex as equity*
- *Build, Own, and Operate for 12 years*
- *Transfer assets to BRPL at end of period*



Waterfall of payments from SPV

1. Operational and maintenance expenses to the SI
2. Interest on working capital
3. Taxes, if applicable
4. Payment of target ROE to Equity investors
5. GEAPP to provide concessional capital

Summary of Key Terms for GEAPP's Concessional debt investment

	KEY TERM	RATIONALE
Legal structure	▪ The Project will be owned by an SPV which will provide services to BRPL under the BESSA in return for a capacity-based tariff (INR/MW/year)	▪ Using an SPV is a scalable approach for future projects ▪ Capacity charge supports private sector developers participating in bid as they are paid regardless of whether the BESS utilization
Size	▪ 70% of total project cost	▪ Sized based on typical project finance structures and to support competitive tariff from private sector developers
Instrument	▪ Concessional debt	▪ GEAPP is seeking to optimize required concessionality and are providing a 1% concessional loan that would be repaid over the life of the project – to the extent additional concessionality was required,
Equity contribution	▪ The Sponsor will inject a minimum of 30% of total project cost	▪ To ensure the private sector developer has "skin in the game"
Tenor	▪ Up to 13 years depending on when COD occurs. 12 years from COD.	▪ Debt tenor matches the life of the BESSA with BRPL
Repayment profile	▪ Following a 2.5-year moratorium, equal repayments to be made on Repayment Date (quarterly).	▪ Moratorium of repayments supports competitive tariff due to more ability to pay front-ended equity
Interest rate	▪ Following a 1.5-year moratorium, a fixed interest rate of 1% is due and payable on the Interest Payment Date (quarterly).	▪ Moratorium of interest rate creates some buffer for private sector developer in case of delays etc.
Covenants	▪ Minimum 1.10x DSCR in 12-month historical and forward-looking period	▪ Creates additional buffer for GEAPP in cashflow is expected to be less than anticipated
Debt service reserve account	▪ DSRA to be included in total project cost sized to cover debt service obligations (next ensuing principal repayment and interest payment)	▪ Creates additional buffer for GEAPP in case of cashflow issues, for whatever reason
FX risk	▪ GEAPP will absorb the currency mismatch risk between INR revenue payments and USD-denominated debt service (interest and repayments), noting that the payments themselves will be in USD.	▪ GEAPP is absorbing this risk to support competitive tariff
O&M and EPC costs	▪ O&M and EPC costs will be fixed. Any cost overruns on EPC shall be borne by the project Sponsor, not the Borrower (SPV)	▪ To ensure relatively fixed cashflow profile and that the project developer takes cost risk for construction

Summary of Key BESS Agreement (BESSA) terms between SPV & BRPL

SPV obligations to BRPL

	OBLIGATION OF SPV	SECURITY MECHANISMS
Project Commissioning Timeline	Developer to ensure that the project is commissioned within 10 months of signing of the BESSA	• Performance Bank Guarantee (PBG) equivalent to 5% project capex to be funded by project developer • PBG to be encashed on per-day basis over 6 months from scheduled date of commissioning
Round-trip efficiency (RTE)	Minimum RTE at end of first year: 85% Minimum RTE at end of final year: 82%	• Deduction from monthly tariff payment/ PBG equivalent to excess energy consumption • No tariff payment for RTE below 70%
Degradation pattern of BESS	Discharge capacity at end of first year: 40 MWh Discharge capacity at end of final year: 28 MWh	• Deduction from monthly tariff payment/ PBG proportional to shortfall in available capacity of BESS vs benchmark
Deviations from DISCOM's schedules	DISCOM must match the charge/ discharge schedules provided by the Buying DISCOM	• Deduction from monthly tariff payment/ PBG as per Deviation Settlement Mechanism Rules defined by DERC
Project Default/ Exit before expiry of BESSA	SPV to provide security in case of default in services or early exit from the BESSA	• Performance Bank Guarantee (PBG) equivalent to 5% of project capex may be invoked by the Buying DISCOM

BRPL's obligations to SPV

	OBLIGATION OF BRPL	SECURITY MECHANISMS
Payment security mechanism	BRPL to ensure that all bills raised by the SPV are cleared within 60 days of submission of invoice	• Payment security to the SPV provided through Letter of credit and Payment Security Fund
Project Default/ Exit before expiry of BESSA	BRPL to provide security in case of default in services or early exit from the BESSA	• Ability for SPV to require BRPL to make whole all debt in event of default

Identifying Value Streams

C

A study of the Use Cases for BESS and Surrounding Regulatory enablers was undertaken to identify the value streams for this project

Sl	Use Case	Brief	Monetizable?	Monetization details	Future trends
1	Energy arbitrage and Ramping support	BESS can help Discoms in avoiding peak purchase as it can be charged during non-peak hours and can be discharged during time of high demand when generation is less than demand BESS can also ramp up / down almost instantaneously to meet the ramping requirement in the system following sudden decrease or increase of generation	Yes	Monetizable at **market prices** (DAM, HP DAM)	With increased renewable addition, it is expected that high RE periods would see lower prices. With sufficient RE penetration, select slots may also witness zero prices, as observed in other markets. Increased RE will also increase the steepness of the net peak curve, leading to higher market prices, increasing the scope of BESS for arbitrage / ramping
2	Ancillary services (TRAS, SRAS)	BESS can help in maintaining a reliable electricity flow in the grid by supplying power whenever required through Ancillary services market	Yes	SRAS is operational in administered mode. TRAS market expected to be operational by June 1st Ancillary Regulations also specify that the entity participating should be **connected to the Transmission network**	Ancillary Services, especially frequency regulation (SRAS) is one of the largest revenue streams for BESS, globally. The same is expected to be true in India, especially with the increased addition of renewables
3	Distribution CAPEX deferral	BESS can be utilized as non-wire alternative for transmission and distribution network planning in place of traditional investment	Yes	Benefits to the system to be demonstrated as savings Capex deferral to be only to the extent of annual charges for transformer and hub costs	Potential upside in savings due to improved efficiency of distribution assets

A study of the Use Cases for BESS and Surrounding Regulatory enablers was undertaken to identify the value streams for this project

Sl	Use Case	Brief	Monetizable?	Monetization details	Future trends
5	**Resource Adequacy (future use case)**	**BESS can help Discoms to ensure that they are compliant to regulations by ensuring that there is an adequate supply of generation or demand responsive resources to serve expected peak demand reliably**	**No**	**Rules and Regulations not yet in place**	**Resource Adequacy Guidelines are published by MoP and IEGC also specifies Resource Adequacy. Rules and Regulations are expected to be published soon**
6	Black Start and reactive power support	BESS can quickly provide support to restart parts of the grid in case of a blackout. The BESS inverter can vary its active and reactive power output to provide reactive power support. However, this reduces the power available for other use cases	No	No formal structure for black start and reactive power support. Black starts are also rare occurrences and reactive power support can reduce benefits from active power output	Not applicable
7	Carbon credits	BESS can support RE dispatchability, earning carbon credits	No	Carbon credits for BESS storage are not yet available	With the introduction of carbon markets, BESS is likely to earn another revenue stream, helping them to scale up

The benefits were estimated for value streams which are currently monetizable:

1. Energy arbitrage and Ramping support
2. Ancillary services (TRAS, SRAS)
3. Distribution CAPEX deferral

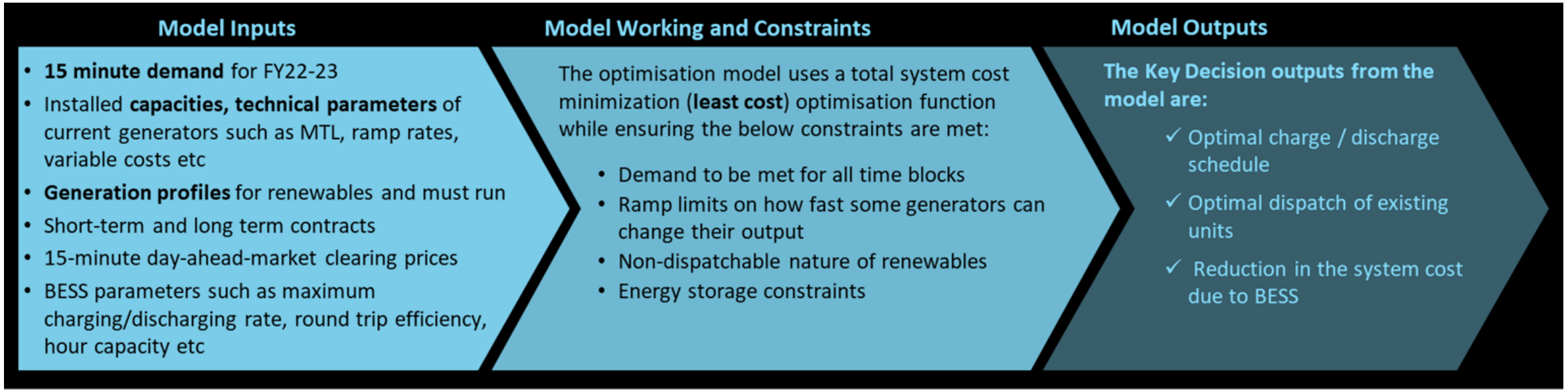
Benefits Estimation

D

Estimated basis future cash flows

Estimating benefits: Deloitte's proprietary model is run as per BRPL's schedules for the year 2022-23 to estimate potential savings

- Deloitte's production cost simulation tool undertakes **Security Constrained Economic Dispatch (SCED)** using a Linear Programming framework
- The SCED engine decides the optimal dispatch from dispatchable resources such as coal, gas, BESS, market purchase / sale such that the system cost is minimum
- The optimization is subjected to several constraints to simulate power procurement of BRPL from various generators in the portfolio (both conventional and renewable), short-term and long-term contracts, power exchange participation etc.
- The optimization model is first **run without BESS to arrive at a system cost for each time block**. The system cost consists of cost of generation from thermal plants, renewables, market purchase/sale etc.
- Then the **model is run with BESS** and the **difference between the system cost of each 15-minute time block is captured**



Estimating benefits from Energy Arbitrage :- Deloitte's proprietary model is run as per BRPL's schedules for the year 2022-23 to estimate potential savings

- The simulations showed that 20 MW/ 40 MWh BESS would operate for 602 cycles in FY 23
- The average cost of charging would be Rs 3.77/kWh and for discharging Rs 7.99/kWh
- Since HP DAM is a nascent market segment, a benchmark-based calculation was used to evaluate the benefits.
- Among the 602 cycles used for Ramp Support and Energy Arbitrage, ~ 20% of days were assumed to be used in HP DAM at a benchmark price of Rs 13.14/kWh. These assumptions were calculated considering the HP DAM data till 12 Jun 2023
- **The estimated savings in year 1 is Rs 9.9 crore**

Total No of cycles		602
No of days with HP DAM clearing (1 cycle/ day)		72
No of cycles of Ramp Support / arbitrage (DAM)		530
Total Discharge in HP DAM	*MWh*	2844
Total Discharge for Ramp Support / arbitrage (DAM)	*MWh*	20935
Total Charge (Average RTE = 84.875%)	*MWh*	28016
Per unit cost in HP DAM	*Rs/kWh*	**13.14**
Per unit cost for Ramp Support / arbitrage (DAM)	*Rs/kWh*	**7.99**
Per unit cost for charging	*Rs/kWh*	**3.77**
Total arbitrage savings	***Rs***	**9,90,18,624**
Levelized Annual benefits (over 12 years)	***Rs/MW/yr***	***65,39,732***

Estimating benefits from Ancillary Services (TRAS) : Benefits from TRAS was estimated using cost benchmarks

- Remaining cycles of BESS are used for Ancillary Services – **128 cycles** are assumed to be dispatched in TRAS (~ 0.35 cycles a day)
- MCPs in the TRAS market are expected to be linked with VC of costlier stations – BESS can bid with a certain margin, guaranteeing benefits. We have considered a margin of Rs1.5/kWh
- BESS would also receive a performance incentive of Rs 0.50/kWh.
- Participants also receive a commitment charge of up to Rs 0.20/kWh for the quantum which is cleared and not dispatched.
- With the entire quantum procured for TRAS not expected to dispatch, BESS can bid in the TRAS market when it is idle
- After factoring in time for Energy Arbitrage and cooling, we can consider around 14 hours a day where the BESS can bid in TRAS
- **The total estimated savings in year 1 is Rs 4 crore**

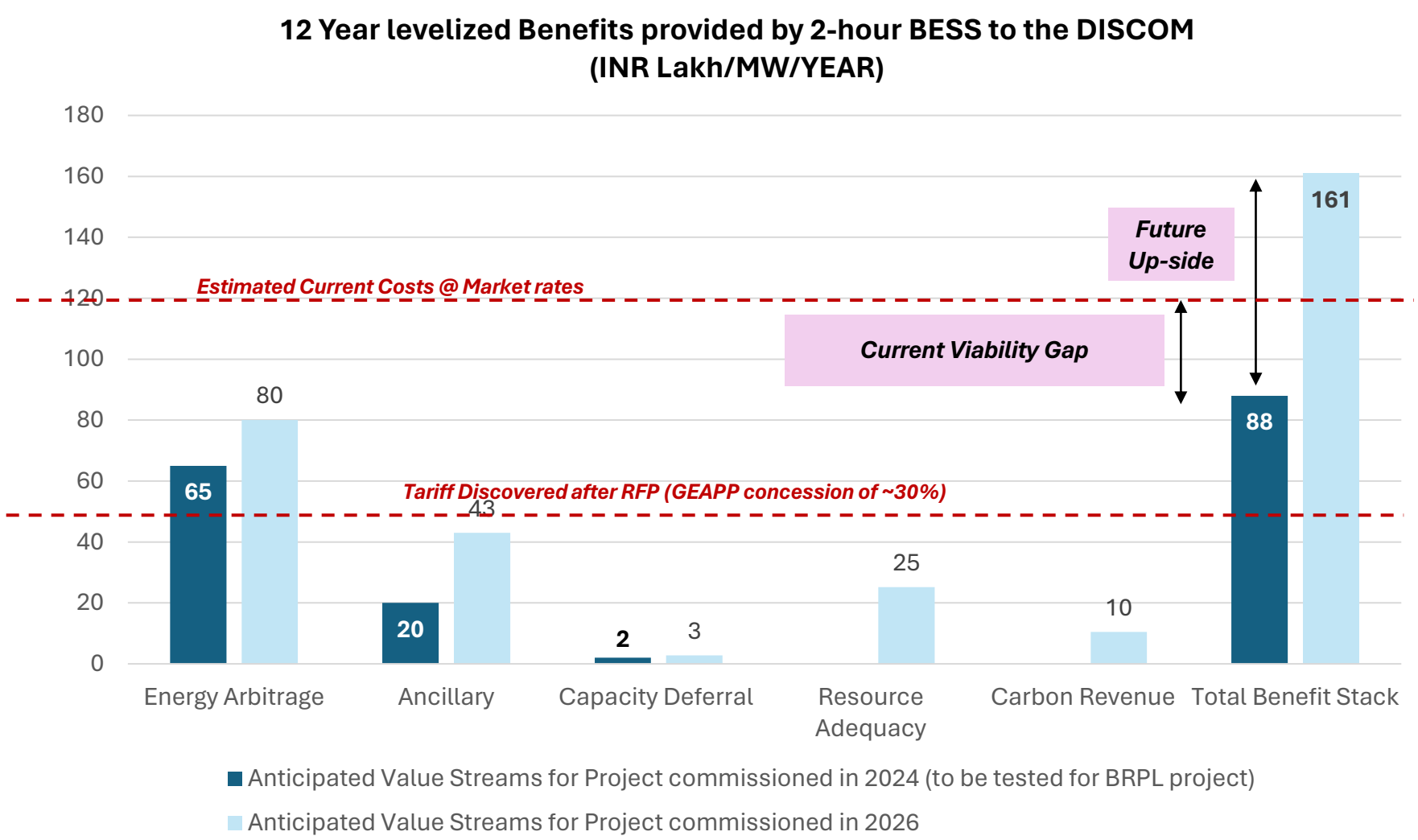
No of Days		365
Payment for dispatch		
Cycles dispatched		0.35
Dispatched Energy during LF period	*MWh*	39.5
Support the Grid by charging during HF period	*MWh*	46.53
Energy per cycle (TRAS Up + Down)	*MWh*	86
Total Energy Output	*MWh*	10,991
Bidding Margin	*Rs/kWh*	1.50
Performance Incentive	*Rs/kWh*	0.50
Benefits	*Rs*	2,19,82,972
Payment for commitment		
Total hours committed		14
Hours not cleared		12.60
Quantum not cleared	*MW*	20.00
Commitment Charge	*Rs/kWh*	0.20
Benefits	*Rs*	1,83,96,000
Total Benefits	***Rs***	**4,03,82,972**
Levelized Annual benefits (over 12 years)	***Rs/MW/yr***	***20,40,775***

Estimating benefits from Capex Deferral : A thumb-rule based approach is used to estimate the benefits from deferring distribution capex upgrades

- A thumb-rule of a 1-MW BESS being able to defer 1-MVA transformer is used
- BESS would essentially delay the investment required and hence the benefits are to the extent of carrying costs of that investment i.e., the debt service and return on equity.
- Considering the **average peak loading of the Grid of 56%**
- in FY23 and **peak demand growth rate of 8% CAGR**, **capacity deferral benefits will be realizable at Kilokari substation from year 5**

Parameter		Assumption
Transformer cost for 20 MVA	*Rs*	Rs 2,60,00,000
Debt: Equity	*%*	70:30
Debt	*Rs*	Rs 1,82,00,000
Loan term	*Years*	8
Interest Rate on debt	*%*	12% p.a.
Return on Equity	*%*	16% (post-tax)
Depreciation	*%*	5.83%
Levelized Annual benefits (over 12 years)	***Rs/MW/yr***	***1,85,981***

Current BESS costs exceed benefits; however, anticipated regulations for Ancillary Services, Carbon and Resource Adequacy will help eliminate this gap



Current Scenario

Current BESS costs exceed benefits that can be monetized, as arbitrage is the key value stream; BESS is not allowed to participate in secondary & primary ancillary services market

Future Scenario

With upcoming regulations, we expect Secondary Reserve Ancillary Services (SRAS) and Resource Adequacy, which are major value streams for BESS globally, to play significant role in enhancing BESS benefits over the next 2-4 years in India

Alternate Models of adding BESS

E

- ✓ *Smarter, yet sub-optimal way of adding BESS*

Recent opportunities around RE integrated with balancing load power procurement and stationary BESS installations

With few fresh investments expected in the thermal sector; RE integrated with balancing load (peaking power thermal, energy storage) is the key towards facilitating the DISCOMs to meet its 24x7 power supply obligations going forward

Round-the-Clock RE + non-RE

- These tenders are designed to supply Round-the-Clock firm power to DISCOMs reliably through Hybrid RE projects
- **The projects can be bundled with non-RE sources, however, RE needs to be at least 51%**
- MNRE also issued guidelines for the tariff-based competitive bidding process for RTC power projects
- SECI has phased out RTC (RE + non-RE) tenders since 2022 in favour of dispatchable RE tenders in recent months

Hybrid RE with mandated CUF

- These tenders are designed to meet the demand of DISCOMs through Hybrid RE projects
- SECI tenders have mandated that both wind and solar must constitute at least 33% capacity on MW basis
- **Recent hybrid RE tenders have started specifying minimum ESS capacity or peak hours with high CUFs**

Firm and Dispatchable RE (FDRE)

- These tenders are designed to meet the peak demand of DISCOMs **while following the net load curve**
- The tender specifies a load profile to be met through RE/ storage, **with demand typically higher in non-solar hours**
- The projects tend to have higher tariffs than hybrid RE projects due to the need for oversizing wind or adding ESS

Sandboxing – Electricity Market Reforms

2

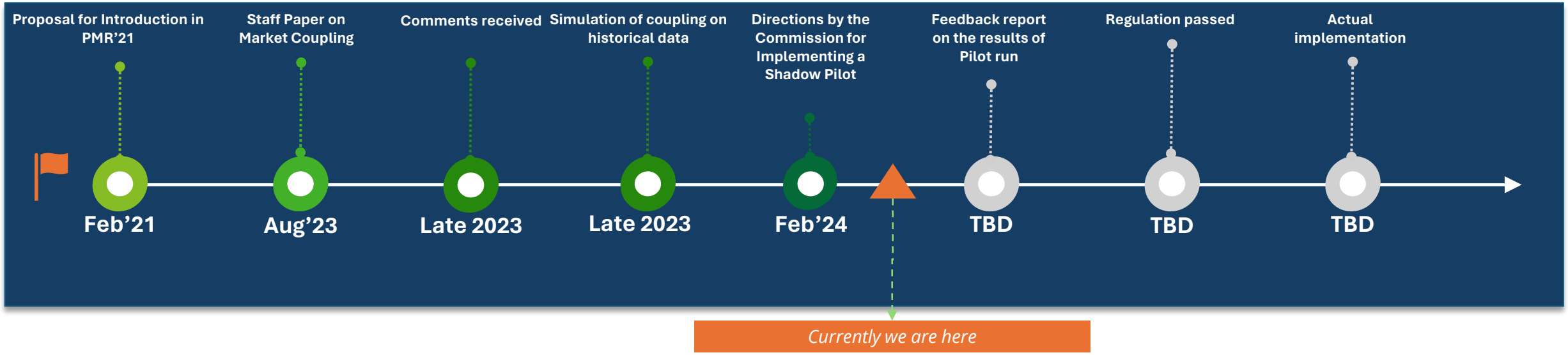
- ✓ *Case Study: Market Coupling*

Sandboxing - Power System and Cost Optimization Via Market Coupling

Key Insights:

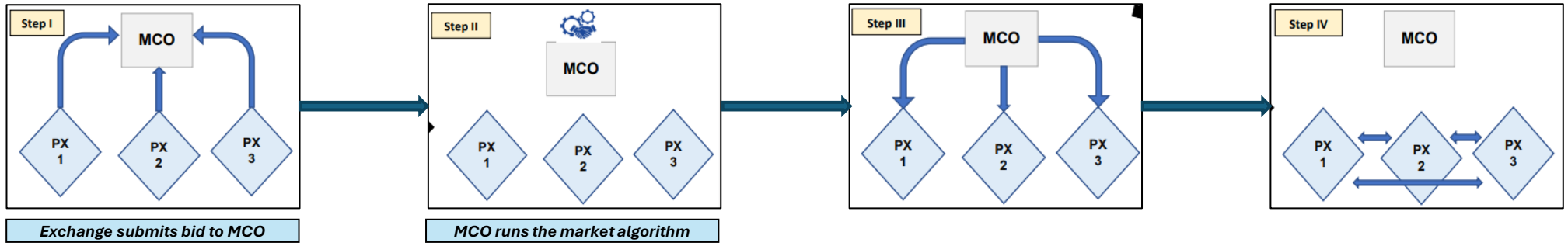
- Market Coupling matches bids from all Power Exchanges to find uniform MCP, considering bid types and market splitting and there by promoting competition
- Objective in India's context is to achieve discovery of a uniform MCP, optimal use of transmission infrastructure & maximization of economic surplus.
- Regard to recommendations of the expert committee and the provisions in PMR 2021, CERC issued a Staff (Discussion) Paper. 127 stakeholders submitted suggestions
- Commission conducted simulations using stakeholder feedback and Bid data to assess market coupling benefits.
- Ordinance for running shadow pilot is passed.

Market Coupling – Sandboxing



Sandboxing - Power System and Cost Optimization Via Market Coupling

Possible flow of information



Benefits

- **Discovery of a uniform market clearing price**
  - A uniform market clearing price discovered by the market coupling process would become the single reference price for the market
  - Deviation Settlement Mechanism (DSM) charges are currently indexed to the clearing price of DAM, a single price from market coupling would minimize the scope for any arbitrage between deviation settlement and market
- **Optimal use of transmission infrastructure**
  - The Commission had provided for the reservation of transmission corridors for the smaller power exchange (PXIL) however, it was noted that the reserved corridor remained underutilized.
  - Under the coupled market scenario, the market coupling operator would merge the bids from all the power exchanges and no reservation on the transmission corridor would be required.
- **Maximization of economic surplus**
  - Market coupling would lead to the maximization of economic surplus
- **Improvement of liquidity and prices**
  - Sell & buy bids from all exchanges are merged, more volumes would be cleared
  - MCP may be discovered at lower end with merging of bids cal

Discussion Paper - Market Surplus with Coupling

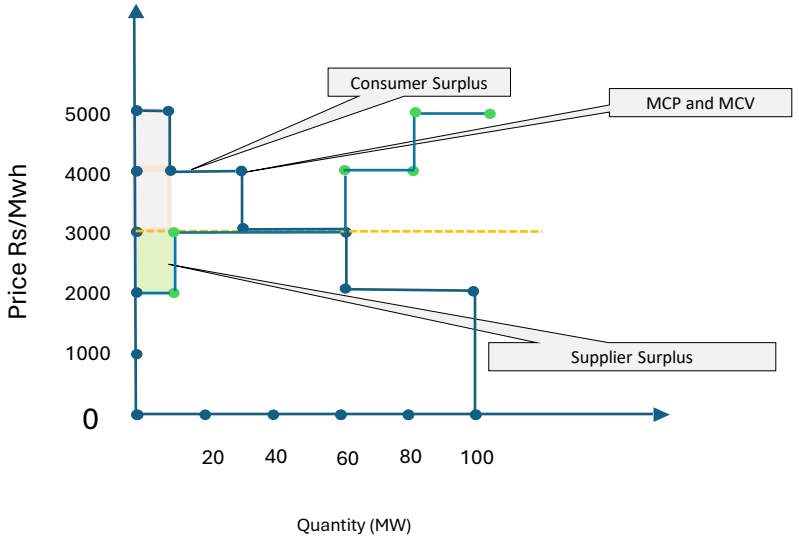
Decoupled (Current system)

Independent price discovery IEX

Buyers (B)	Price Rs/MwH	0-2000	2001-3000	3001-4000	4001-5000	5001-10000
	Qty MW	100	60	30	10	0
Sellers (S)	Price Rs/MwH	0-2000	2001-3000	3001-4000	4001-5000	5001-10000
	Qty MW	0	10	60	80	100

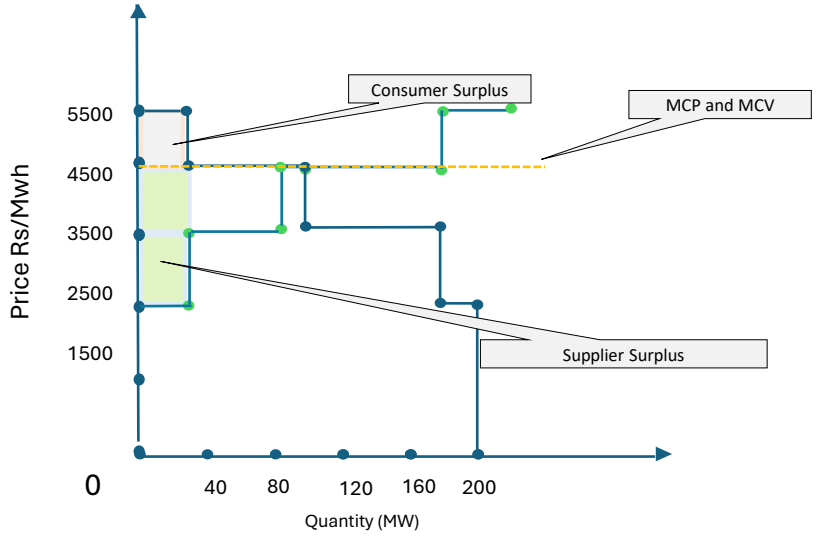
B	P	0-2500	2501-3500	3501-4500	4501-5500	5501-6500
	Q	200	180	100	30	0
S	P	0-2500	2501-3500	3501-4500	4501-5500	5501-6500
	Q	0	30	90	180	200

MCP (Rs/Mw)	3001	
MCV (Mw)	30	
Buyer Surplus (Rs.)	19,990.0	(1999*10)
Seller Suplus (Rs.)	10,000.0	(1000*10)
Total Surplus (Rs.)	29,990.0	



Independent price discovery at PXIL

MCP (Rs/Mw)	4500
MCV (Mw)	90
Buyer Surplus (Rs.)	30,000.0
Seller Suplus (Rs.)	59,970.0
Total Surplus (Rs.)	89,970.0

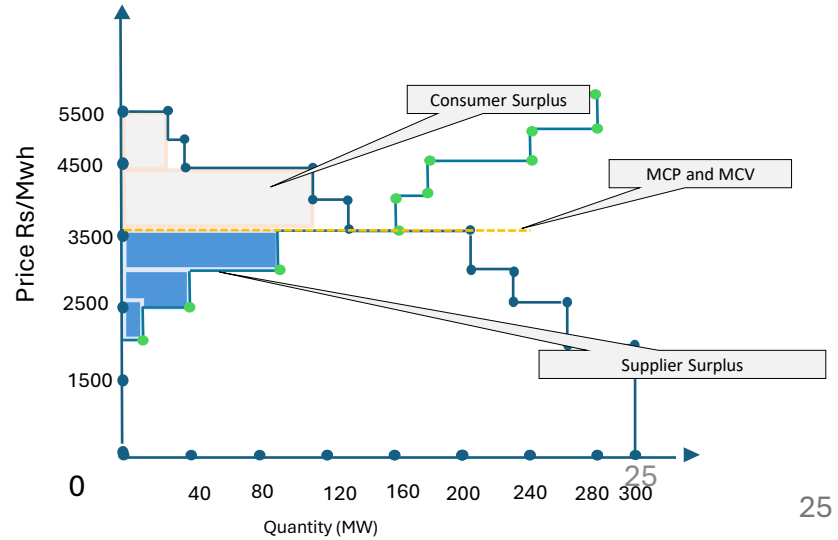


Coupled (Proposed system)

Shared price discovery for IEX and PXIL

B	P	0-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000	5001-5500	5500
	Q	300	260	240	210	130	110	40	30	0
S	P	0-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000	5001-5500	
	Q	0	10	40	90	150	180	260	280	300

MCP (Rs/Mw)	3501	
MCV (Mw)	130	
Buyer Surplus (Rs.)	1,45,000	(2000*30)+(1500*10)+(1000*70)
Seller Surplus (Rs.)	70,000	(1500*10)+(1000*30)+(500*50)
Total Surplus (Rs.)	2,15,000	



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Procedure of executing shadow Pilot

- *This Process flow chart outlines the steps for executing shadow pilot on Power exchange coupling*
- *Shadow pilot is conducted in a controlled environment without impacting the actual operations of power market exchanges*
- *Findings from pilot will inform the Commission's regulatory decisions*

Start → Commissions passes an order directing Implementing Entity (IE) to execute Shadow Pilot on Market Coupling → IE shall frame a procedure in consultation with exchanges for shadow pilot → IE develops software for running the shadow pilot → IE also establishes communication links for receiving the data from exchanges → All 3 Power exchanges shall, each day, share data of all actual Buy/Sell bids for RTM & DAM after market hours → IE shall aggregate bids received from power exchanges → IE shall execute the algorithm for coupling of RTM, DAM → Indicative savings from running the pilot are recorded. Other data points are also recorded as shown below → IE shall apprise Commission regarding experience gained while running pilot in form of **monthly report** → IE shall maintain data on :- installed/declared capacity, schedule & revisions in schedule, VC etc. → IE shall apprise Commission on final feedback report, this feedback shall be shared in public domain as well → Commission decides upon need for creating necessary regulatory framework for market coupling

Data point shared
Volume
Price

Monthly report must cover	
Bid Volume	Displacement of bids offered at power exchanges
Clearing Volume	Savings obtained on optimization via shadow pilot
Comparative Economic Surplus	Comparative Cleared Volume
Comparative Price Discovery	Cases of uncleared bids getting cleared in Shadow pilot

Implementing Entity (IE) is POSOCO
3 Power exchanges are IEX, PXIL, HPX
Commission is CERC

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