SBI CAPS
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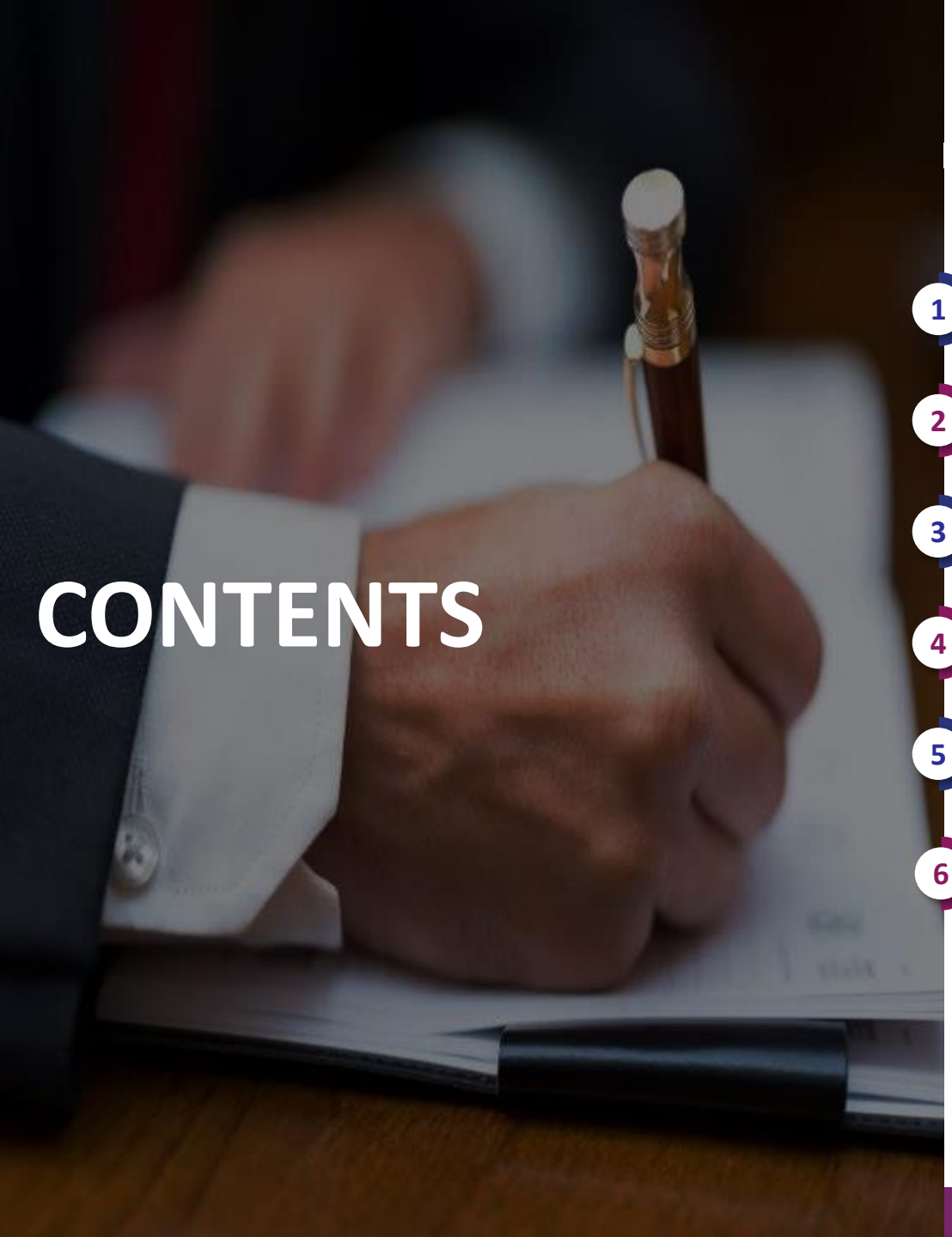
REPORT ON ENERGY STORAGE SYSTEMS

STORAGE ABILITY FOR GRID STABILITY

05 NOVEMBER 2024



CONTENTS

EXECUTIVE SUMMARY (1/2)

The green imperative is propelling the power sector towards a variable renewable energy (VRE) dominant future. By FY32, VRE's contribution to generation is set to triple. Unless the power system undergoes a commensurate transformation, this could destabilise the grid. Our Report explores the role of Energy Storage Systems in navigating this energy transition...

Increasing share of VRE in the power grid could impact stability if not accompanied by energy storage systems to quash the diurnal duck curve

- The inherent mismatch between VRE generation and power demand profiles can lead to grid instability, surplus capacity, and a persistent reliance on fossil fuels. Energy Storage Systems (ESS) offer a solution by storing excess VRE energy during peak production periods and releasing it during non-solar hours, thereby smoothing the VRE generation curve
- *India is poised to significantly augment its energy storage capacity, with a projected 12-fold increase to ~60 GW by FY32, outpacing the already impressive growth pencilled in for RE sources. The evolving landscape of RE tenders reflects this trend, with a substantial uptick in the proportion of projects incorporating storage solutions, from 5% in FY20 to 23% in FY24*
- The decreasing cost of energy storage technologies is a pivotal factor driving their widespread adoption. Recent tenders have witnessed storage projects securing tariffs below the levelised cost of thermal power generation and the implicit time-of-day differential (diurnal range of exchange price of power), making them a financially attractive proposition

Battery Energy Storage Systems (BESS) and Pumped Storage Projects (PSP) emerge as a dynamic duo, being two key and complementary technologies

- Two storage methods are expected to capture virtually 100% of the pie. *BESS will be the dominant technology*, helped by its locational flexibility, promise of technological improvements dipping tariffs further, improving discharge characteristics, and rapid response time
- Despite PSP's long gestation period, asset life-PPA period mismatch exacerbating stranded asset risks, and time-consuming clearance processes, they too will see a stellar growth owing to their low variable operating costs, absence of e-waste, and ability to generate reactive power which improves grid stability. PSPs will primarily be used for peak shaving

Thus, while BESS will see an astronomical surge of 375x to 42 GW, PSP too won't be far behind, growing 4x to 19 GW, by FY32, from FY24 levels

Reduction in BESS tariffs requires addressing constraints including the domestication of battery cell manufacturing and building the component ecosystem

- Batteries and associated components make up ~80% of the cost of a BESS. Currently, battery cells and their upstream ecosystem are highly concentrated in China, making India vulnerable to imports in times of geopolitical complexity
- The indigenisation imperative has been recognised by the government, which has come out with a PLI for Advanced Cell Chemistry (ACC), which envisages the set-up of 55 GWh of capacities, with a special carve out of 5 GWh for technologically advanced systems. Winners till now consist of a motley mix of captive and third-party cell manufacturers
- Close to ~120 GWh of cell capacities have been announced by major players, and this will barely be enough to meet projected demand in the next 2-3 years – thus, more could be on the way. A cascading effect is also expected in the cell components ecosystem, with major players in cathodes, anodes, electrolytes, and separators, all having announced copious capex.

Thus, the sector is set for a boom across the value chain – from BESS projects, to cell manufacturing, down to components of cells. This would be aided by helpful government directives on waiver of ISTS transmission charges and ESO/RPO trajectory creating a steep trajectory for DISCOMs to adhere to, the latter boosting demand

EXECUTIVE SUMMARY (2/2)

Funding of BESS ecosystem a Rs. 3.5 trn opportunity till FY32, with a Rs. 800 bn medium term kicker provided by upcoming cell manufacturing capex

- Clearly, the funding opportunity is vast in this segment, both at project level and for the upstream ecosystem. The *critical variables which lenders may consider while funding BESS projects include the presence of a firm PPA/PSA agreement from a credible DISCOM (and its shortfall in ESO/RPO target), project model (co-location/standalone), and cell technology in use*
- Obsolescence risk in BESS projects arise owing to expectations of a reduction in battery prices and infiltration of 4h- and 6h- batteries in place of currently ubiquitous 2h- batteries. These stand mitigated in great measure since most DISCOMs are well short of their ESO and RPO targets, current tariffs remain competitive, and project life is comparable to PPA tenure
- Battery manufacturing will be another source of heady capex as both traditional and new players muscle it out to gain scale. Given the technological innovations rife in this sector, M&A opportunities also reign supreme

PSPs will play a subordinate but complementary role – addressing challenges related to time/cost overruns may help realise their Rs. 1.2 trn investment potential by FY32

- Historically, PSP development has been funded through equity from the Government and debt from MLIs or other sources of foreign funding. This is owing to the long gestation period of these projects, further compounded by delays of over one decade seen in projects, and a mismatch between PPA and asset life increasing stranded asset risk
- Nevertheless, *recent awards of PSPs have seen some private sector interest*, with several corporates signing MoUs with State governments, though the nomination process is dominant. Going forward, debt funding too is expected to diversify with some domestic banks and key FIs showing interest, even as foreign funding will remain an important
- *States with copious potential for both VRE and PSP are Andhra Pradesh and Maharashtra – these could see the highest viability*. For the others, there could be additional need for transmission networks – something which is also acknowledged in the latest National Electricity Plan

> ***A concomitant expansion in grid infrastructure such as storage systems is imperative if we are to prevent renewables from becoming "too much of a good thing". Mitigating the temporal disparity between supply and demand is crucial to ensure grid stability. While current energy storage capacities are modest, the sector is poised for exponential growth in the ensuing decade, with BESS emerging as the dominant paradigm and PSPs playing a supportive role. Critical to this will be indigenisation and cradle-to-grave approach for the battery ecosystem, towards which PLI schemes have already made a first step. This will aid in further reducing tariffs which have already crossed the threshold of viability and go a long way towards promoting energy security. Together, these moves can help realise the over Rs. 5 trn investment opportunity in this emergent sector.***

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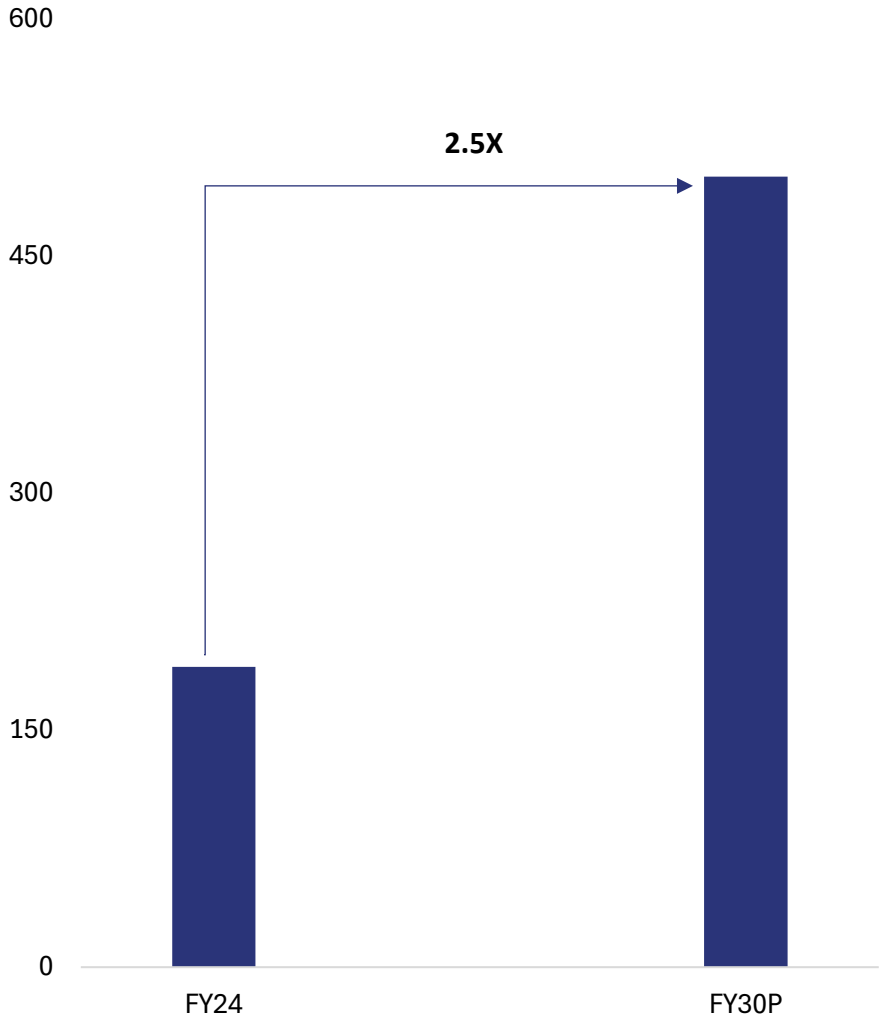
01

QUASHING THE DUCK CURVE: STORAGE AS THE ANSWER

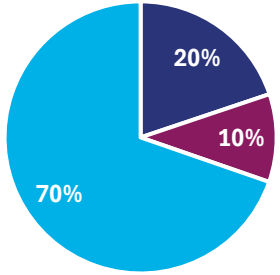
SHARE OF RENEWABLES IN THE GRID ABOUT TO SOAR IN THIS DECADE

INDIA RE CAPACITY (GW)

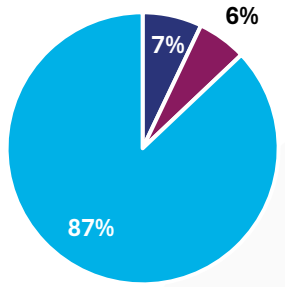


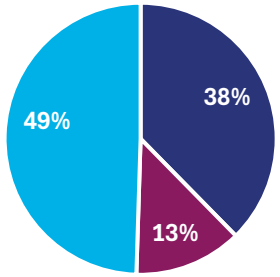
CURRENT[1]

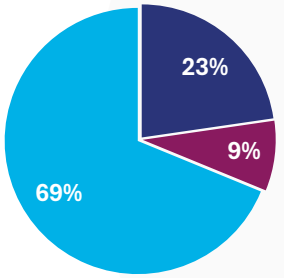
CAPACITY



GENERATION







Solar Wind Others

FY32

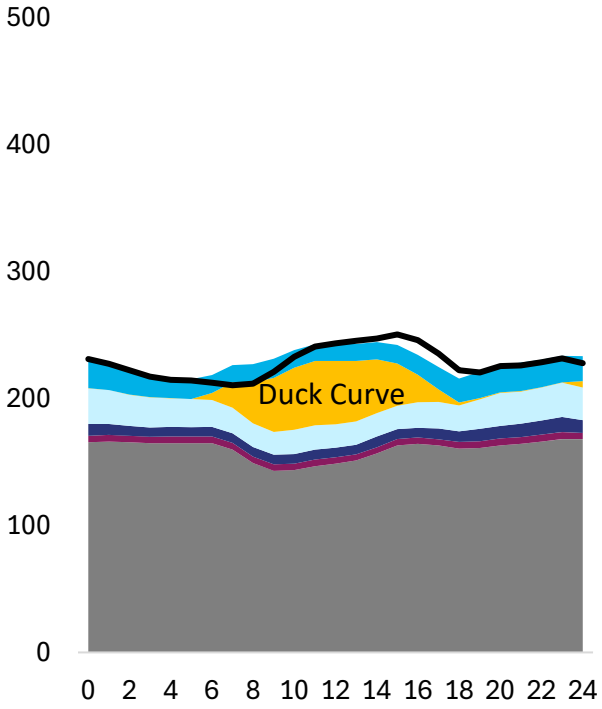
- Globally, variable renewable energy sources (VRE), chiefly wind and solar capacities, will grow at a CAGR of 7-9% for wind and solar between CY23 and CY30 (NZE by CY50 scenario), as per the IEA
- Growth of REs in India will mirror this monumental global growth, with a lion's share resting with solar and wind, and a significant chunk being hydro
- Even as the share of VRE in energy demand grows, their share in peak demand remains low as of now

Source: CEA, SBICAPS, 1 Capacity as of 30 Sep'24, Generation for H1FY25

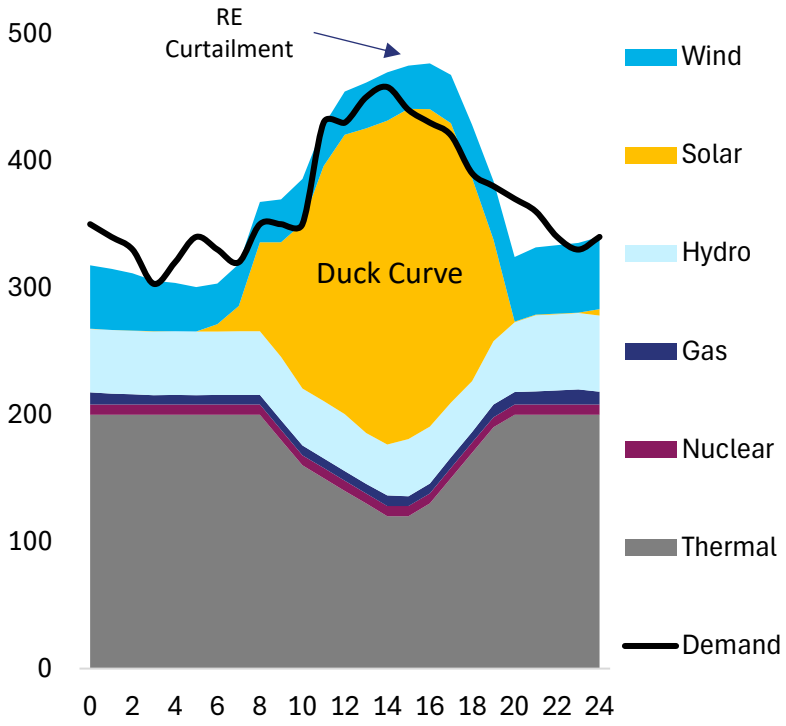
AS THEIR SHARE RISES, DIURNAL VARIABILITY OF RE SOURCES CAN CAUSE ISSUES

PEAK POWER DEMAND VS SUPPLY –> WHEN CURVES THROW A CURVEBALL…

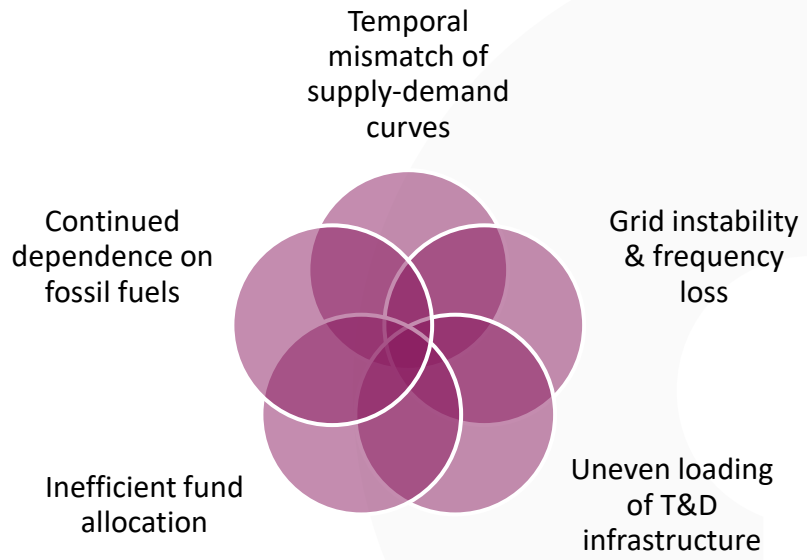
CURRENT[1]



FY32



… FIVE PROBLEMS ARE GENERATED



WHAT IS THE DUCK CURVE?
A duck curve is a graph of power production over the course of a day that shows the timing imbalance between the demand profile and solar generation. It is so named due to its resemblance to a "duck"

WHEN DO THESE EFFECTS COME INTO THE PICTURE?
At 20% penetration, grid stability issues become more frequent. At 30% penetration, grid becomes unstable, affecting other generators as well

Source: CEA, SBICAPS, 1 For 31 May'24 (which saw peak demand in YTDFY25)

FIVE PROBLEMS… ONE SOLUTION -> ENERGY STORAGE

RENEWABLE GENERATOR

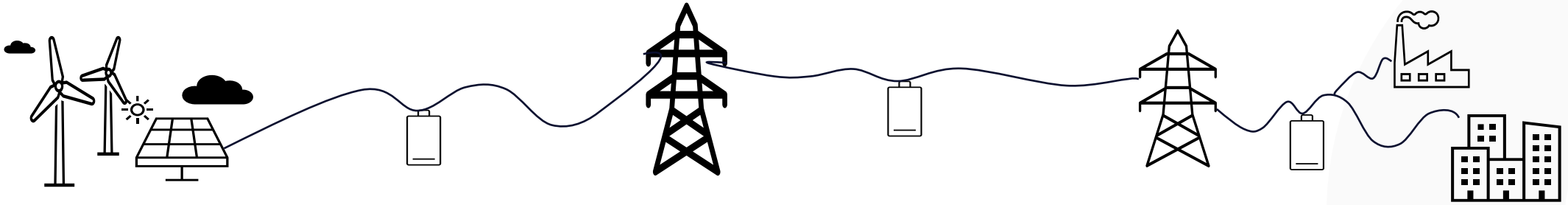
- Reduced renewable curtailment
- Peak demand management
- Meeting RPO targets

SYSTEM OPERATION

- Grid Stability and Frequency regulation
- Supply-Demand matching for accurate pricing
- Flexible ramping, Black start services
- Operating microgrids

INVESTMENT DEFERRAL

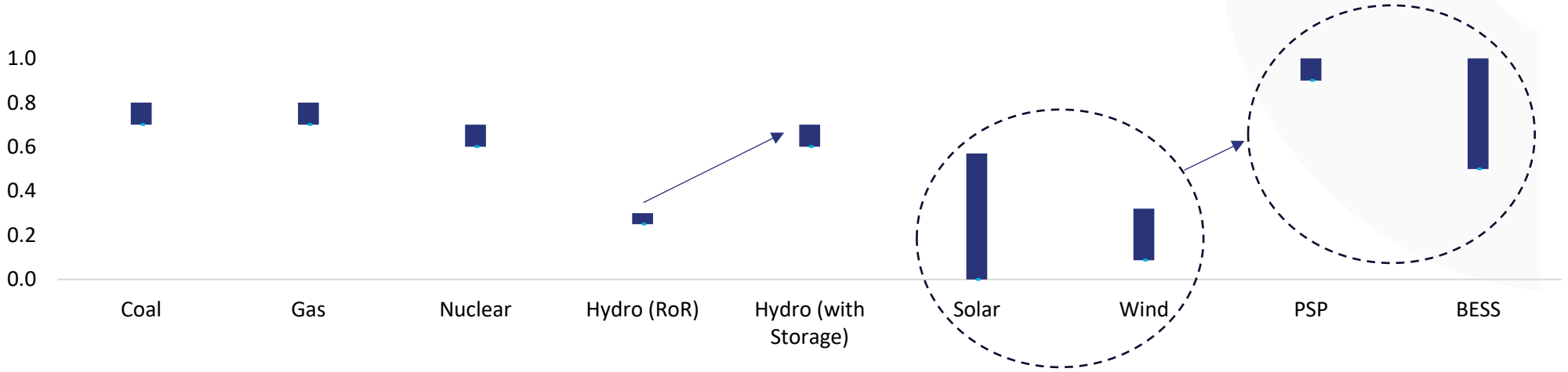
- Transmission and distribution congestion relief
- Energy shifting and capacity investment deferral
- Reduced oversizing of projects



Renewable generators | Transmission networks | Distribution networks

STORAGE IMPROVES CAPACITY CREDIT OF VRE SOURCES…

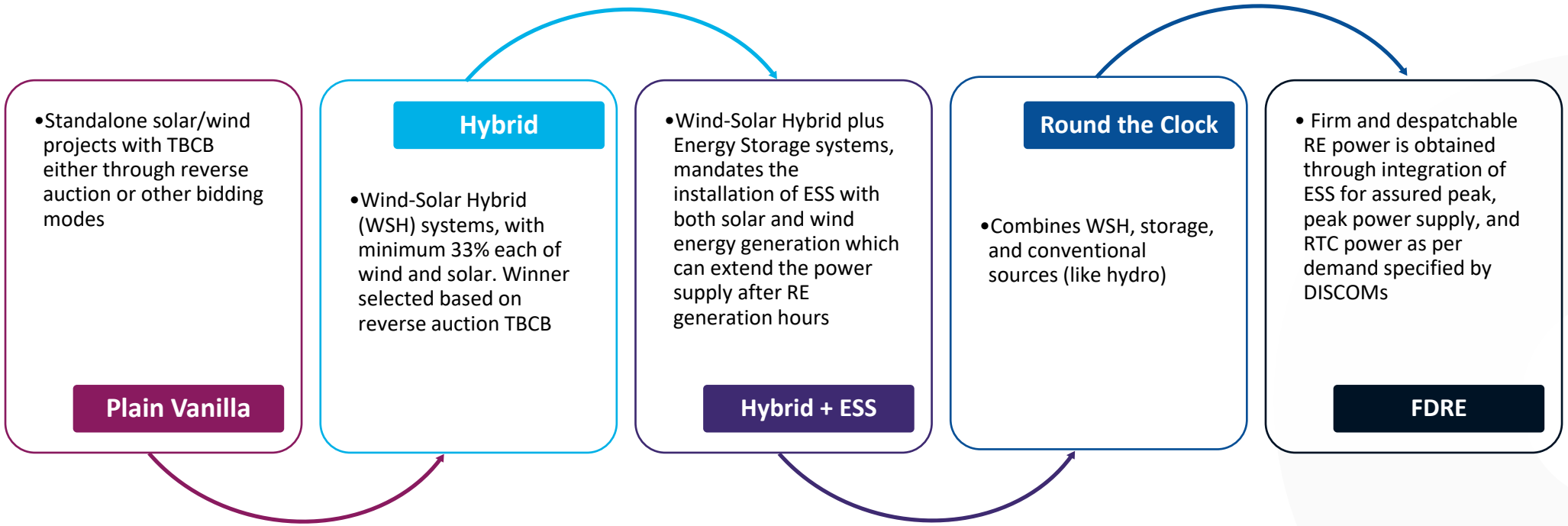
Note: Capacity credit is the contribution of a source in meeting peak demand



Source: CEA, SBICAPS

STRUCTURE OF RENEWABLE AWARDS CHANGING TO INCORPORATE STORAGE

EVOLUTION OF RENEWABLE ENERGY TENDERS

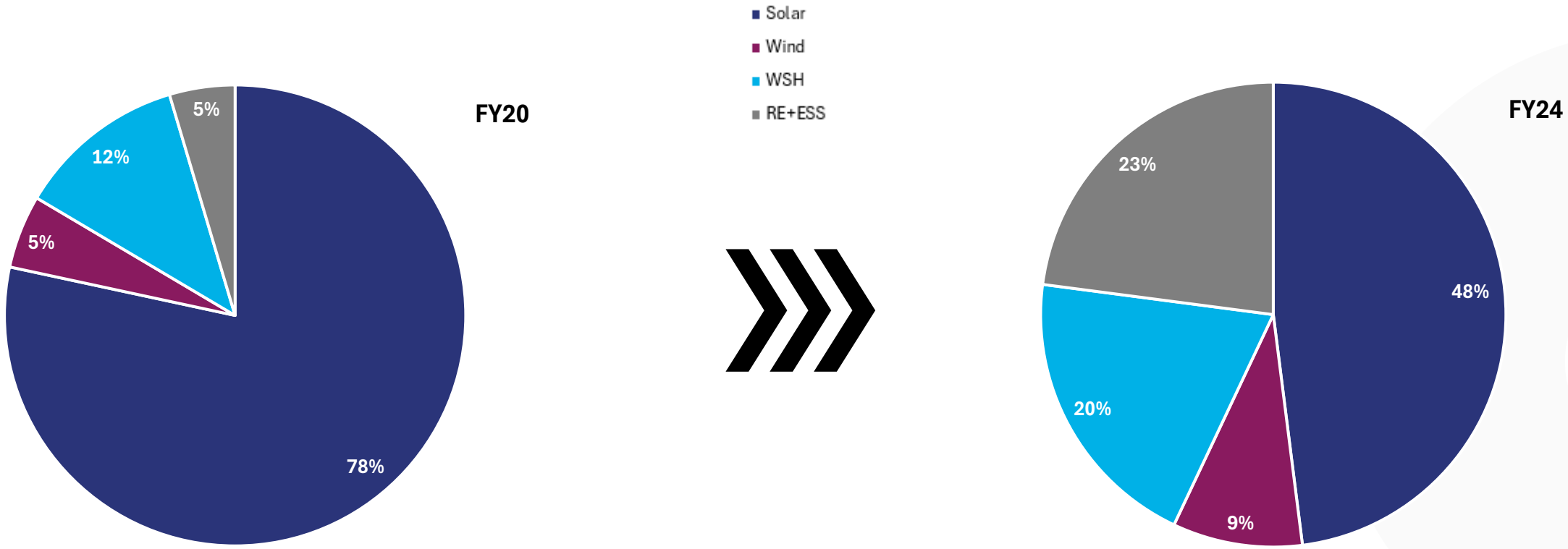


	Plain Vanilla	Hybrid	Hybrid + ESS	Round the Clock	FDRE
Pros	• Straight forward and clear bidding criteria • Lowest tariff	Reduced intermittency leading to higher CUF and higher capacity credit	• Reduced intermittency at night • Reduced oversizing	Optimized levelized cost of with true 24h availability	Reduced oversizing as need to maintain availability during low demand times is removed
Cons	• Low CUF increasing transmission costs • Low capacity credit causing grid instability	• Oversizing & high tariff • Low capacity credit at night	• Lack of coupling with conventional sources • Higher tariffs than plain vanilla	Lacks coupling with actual load profile, leading to oversizing and high tariff	Higher tariffs than plain vanilla

Source: SECI, SBICAPS

GREATER PRIORITY IS BEING GIVEN TO STORAGE BASED PROJECTS

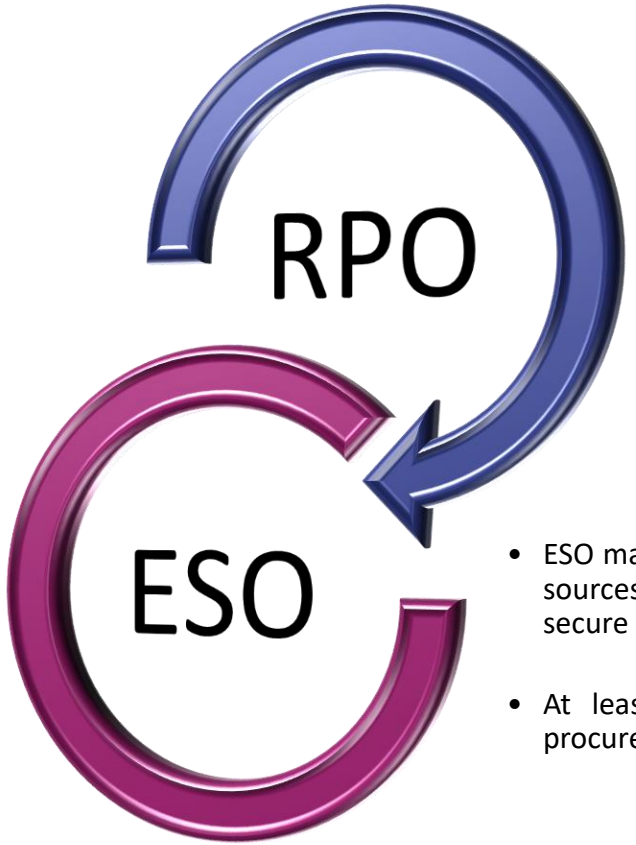
SHARE OF TENDERS BY TYPE



With nearly a quarter of tenders requiring the energy storage, the demand for ESS is gaining momentum…

Source: IEEFA, SBICAPS

USING RENEWABLES AND STORAGE ALSO GOES HAND-IN-HAND FOR DISCOMS

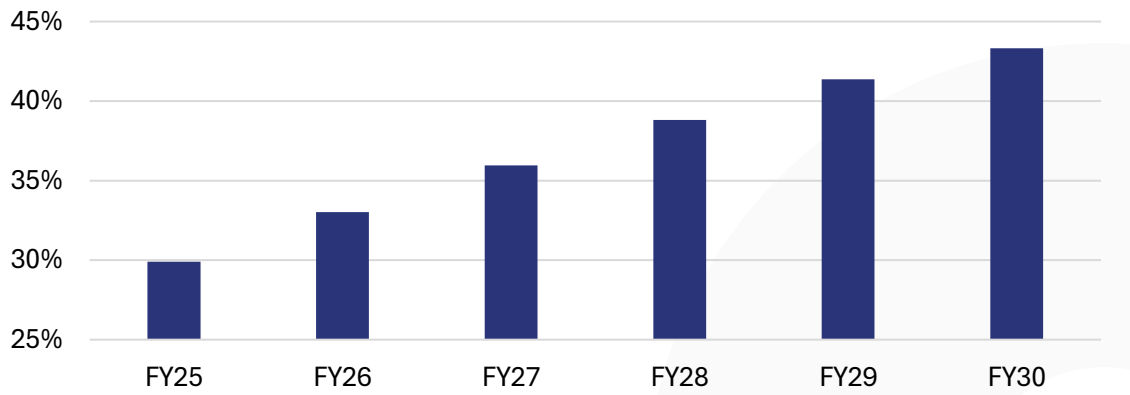


- RPO mandates specified percentage of electricity to be sourced from RE sources for DISCOMS
- States can utilize the tradable RE certificate to meet target, failure to meet target will lead to penalties

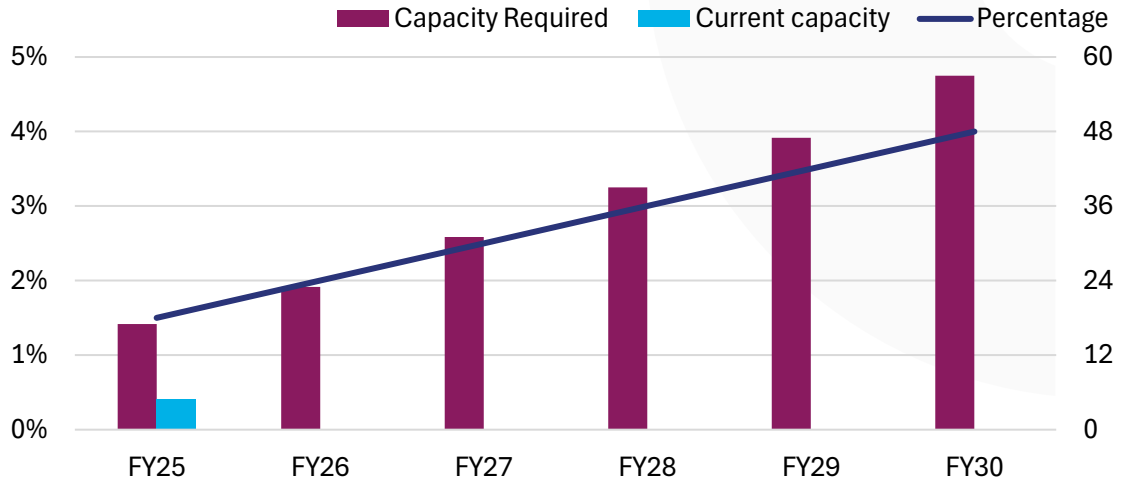
- ESO mandates proportion of energy consumed from RE sources, incorporating energy storage capabilities to secure grid stability
- At least 85% of the total energy stored must be procured from RE sources

The high share of RE in grid envisaged by RPO can only be fulfilled with effective ESS, else it will lead to grid instability

RENEWABLE PURCHASE OBLIGATION (% of ELECTRICITY PURCHASED BY DISCOMS)



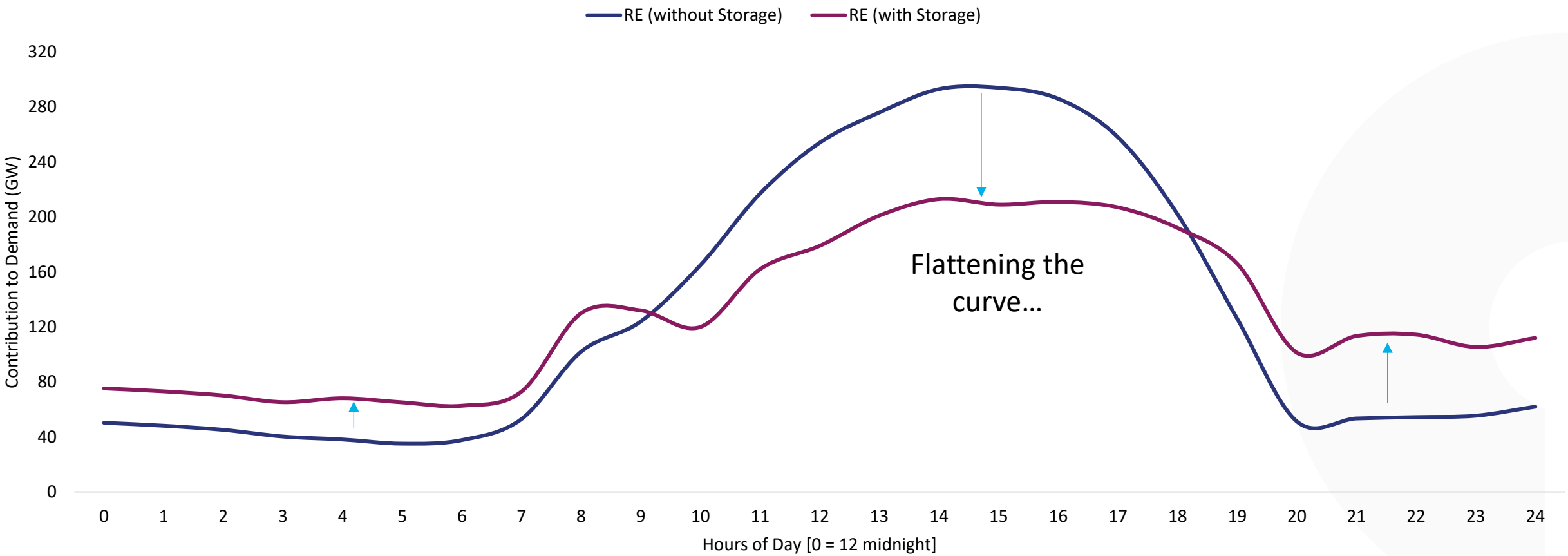
ENERGY STORAGE OBLIGATION (% of ELECTRICITY PURCHASED BY DISCOMS [%, LHS], CAPACITY REQUIRED AND CURRENT CAPACITY [GW, RHS]



Source: CEA, NITI Aayog, SBICAPS

QUASHING THE DUCK CURVE IN INDIA THROUGH STORAGE

IMPACT OF STORAGE ON GENERATION PROFILE OF WIND AND SOLAR ENERGY (TYPICAL DAY IN FY32)

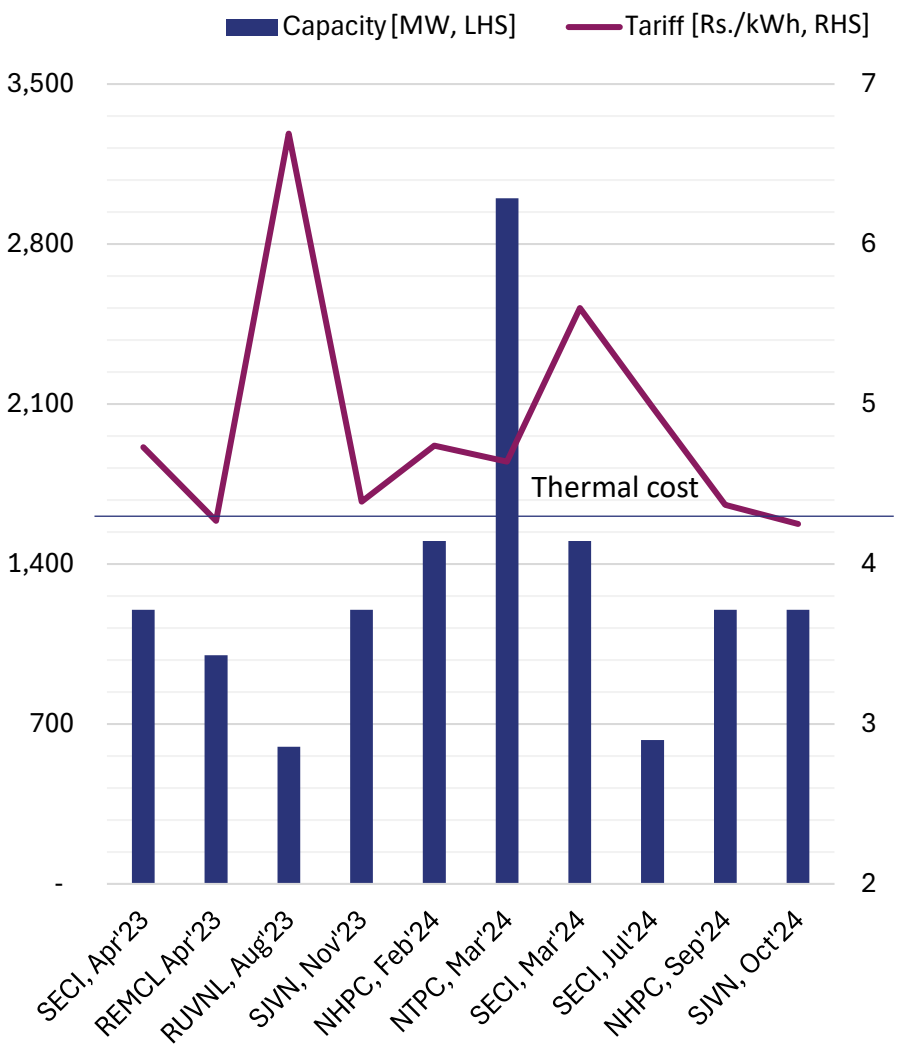


By absorbing excess energy produced during daytime (especially solar), and releasing the same during non-solar hours, storage helps flatten the duck curve

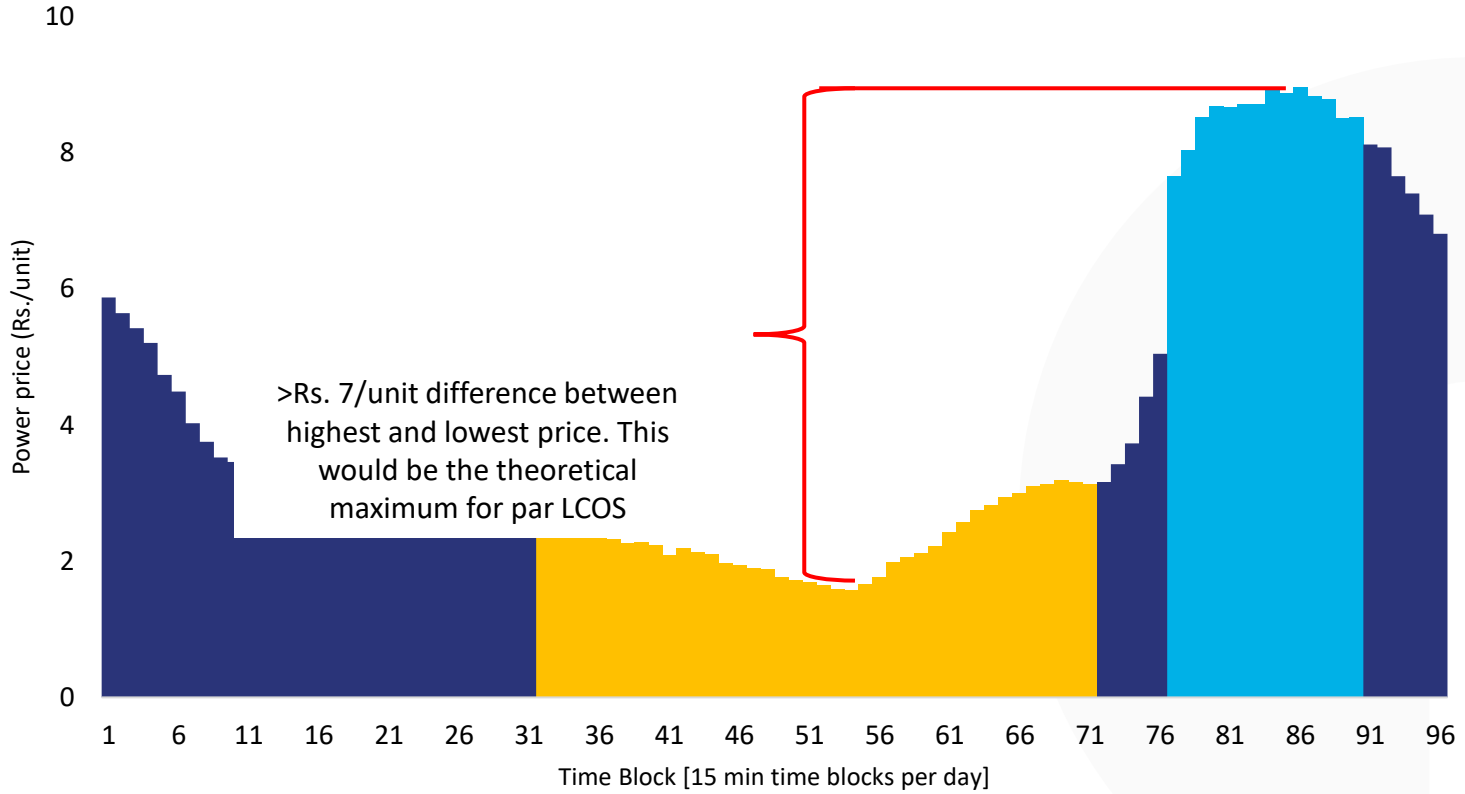
Source: CEA, SBICAPS

COMPETITIVESS OF ESS SET IN STONE IN RECENT TENDERS

RECENT FDRE DEALS



AVERAGE DAM PRICES THROUGHOUT THE DAY (Rs./kWh)



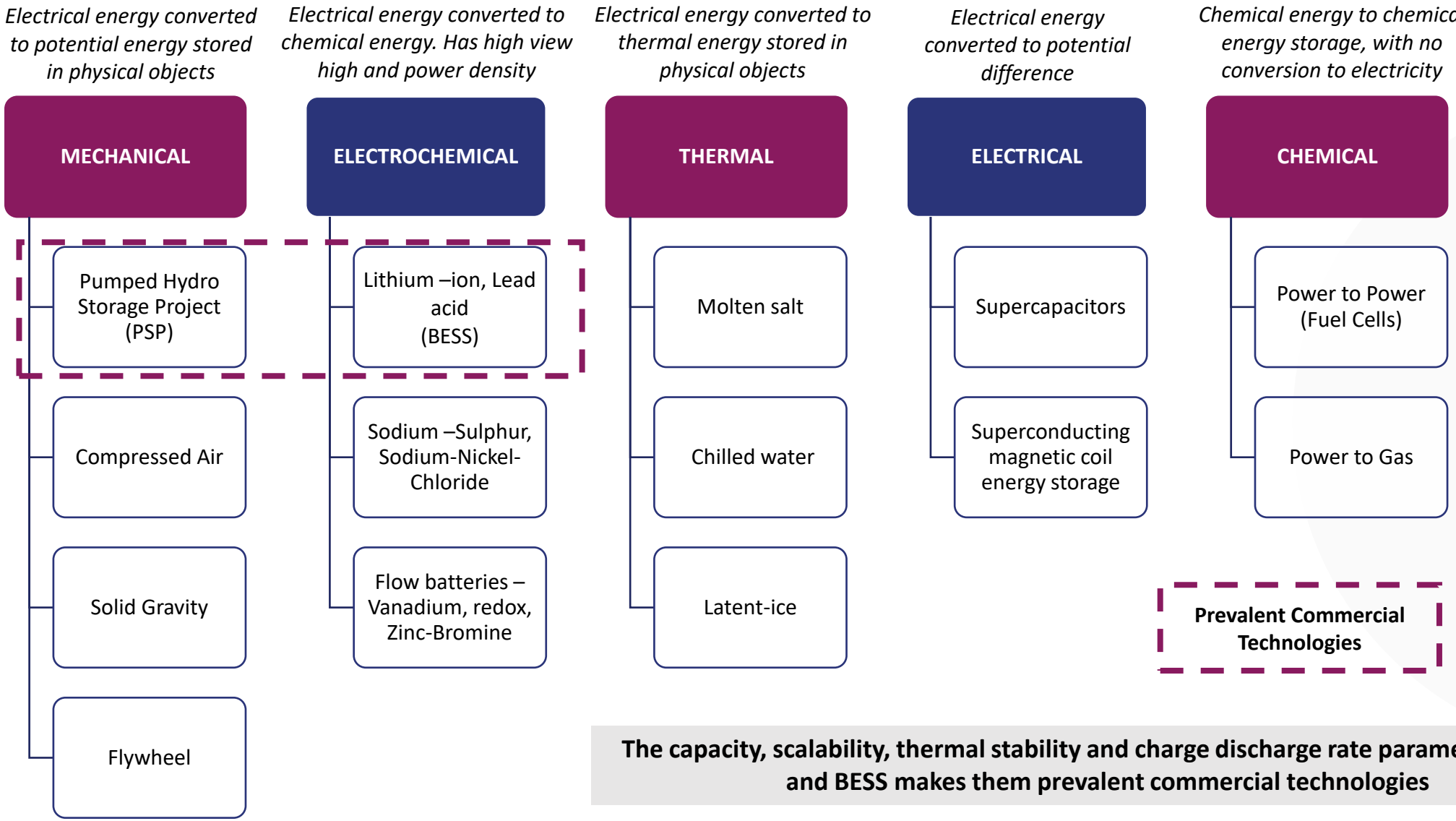
- The time-of-day tariff is not well developed in India, which means that evening peak – where solar production is minimal, sees exchange tariffs reach high levels. The differential between this and the tariff during solar hours represents the upper bound of LCOS
- The competing source for storage as far as peak demand is concerned is thermal, and recent FDRE tariffs are near the cost of thermal power

Source: CEA, News Articles, NITI Aayog, IEX, SBICAPS

02

A COMPLEMENTARY APPROACH TOWARDS STORAGE

MULTLIPLE STORAGE TECHNOLOGIES EXIST, BESS AND PSP DOMINATE



The capacity, scalability, thermal stability and charge discharge rate parameters of PSPs and BESS makes them prevalent commercial technologies

Source: CEA, NITI Aayog, SBICAPS

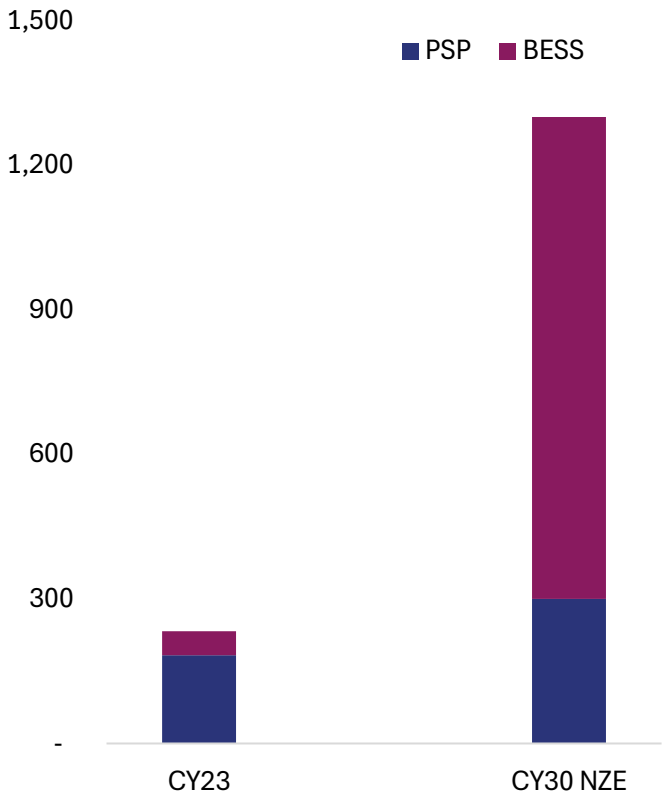
PSPS AND BESS HAVE THEIR OWN PROS AND CONS

PARAMETERS	PUMPED STORAGE	BATTERY STORAGE
MATURITY	Highly mature and commercialised	Evolving, partially commercialised
LIFESPAN	Long, often more than 40 years	Short, around 8 years
OUPUT QUALITY	Moderate, 8 hours/day with ~1.5 cycles/day. Produces both active and reactive power. Quick ramping time	Low, 2-4 hours discharge cycle. Produces only active power. Response within seconds
IMPORT DEPENDENCE	Low to Moderate, many components shared with hydro plants for which capability exists in India	High, inadequate cell (and its components) capacity makes it reliant of imports. Rare earths needed are globally disparate
ESG IMPACT	Moderate, impacts land use, natural flow of river, and may need eco-sensitive and tribal areas	Moderate, mining ecosystem is wrought with issues. E-waste and its disposal remains a challenge
LCOS	Moderate, unlikely to reduce further	Moderate, likely to reduce further
WHILE PSP APPEARS ATTRACTIVE, DIFFICULTIES IN PROJECT SETUP ARE A FATAL FLAW WHICH MAKE PSP LESS VIABLE VS. BESS		
PROJECT SETUP	High gestation period involving complex clearances Takes up a vast area, potential is in specific remote locations	Low gestation period Can be set up anywhere with low space requirement
THE VERDICT	**Smaller share but essential for peak shaving. A greater share of government/PSU interest is expected in this space**	**Dominant due to rapid response time, flexibility, and lower future LCOS. Likely to see extensive private participation**

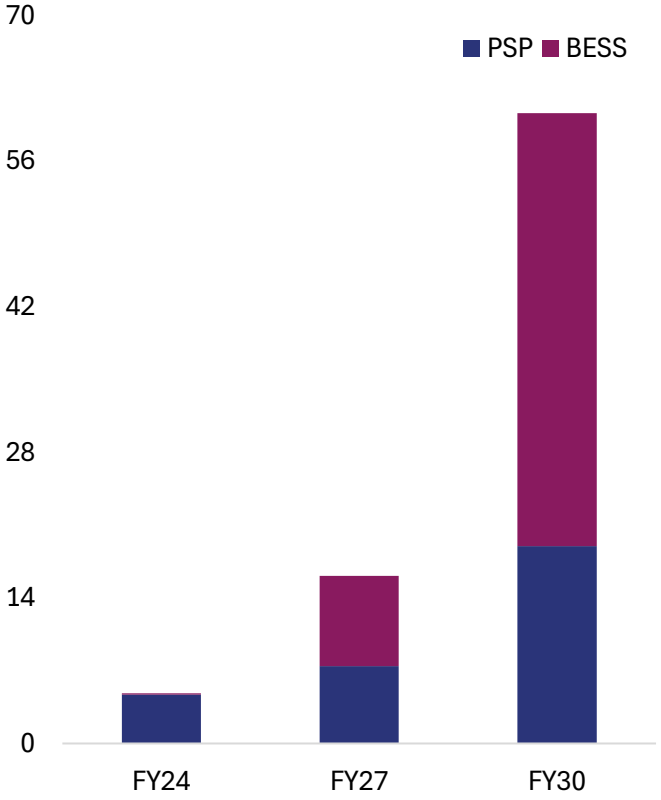
Source: News Articles, SBICAPS

PSPS AND BESS WILL COMPLEMENT RATHER THAN COMPETE

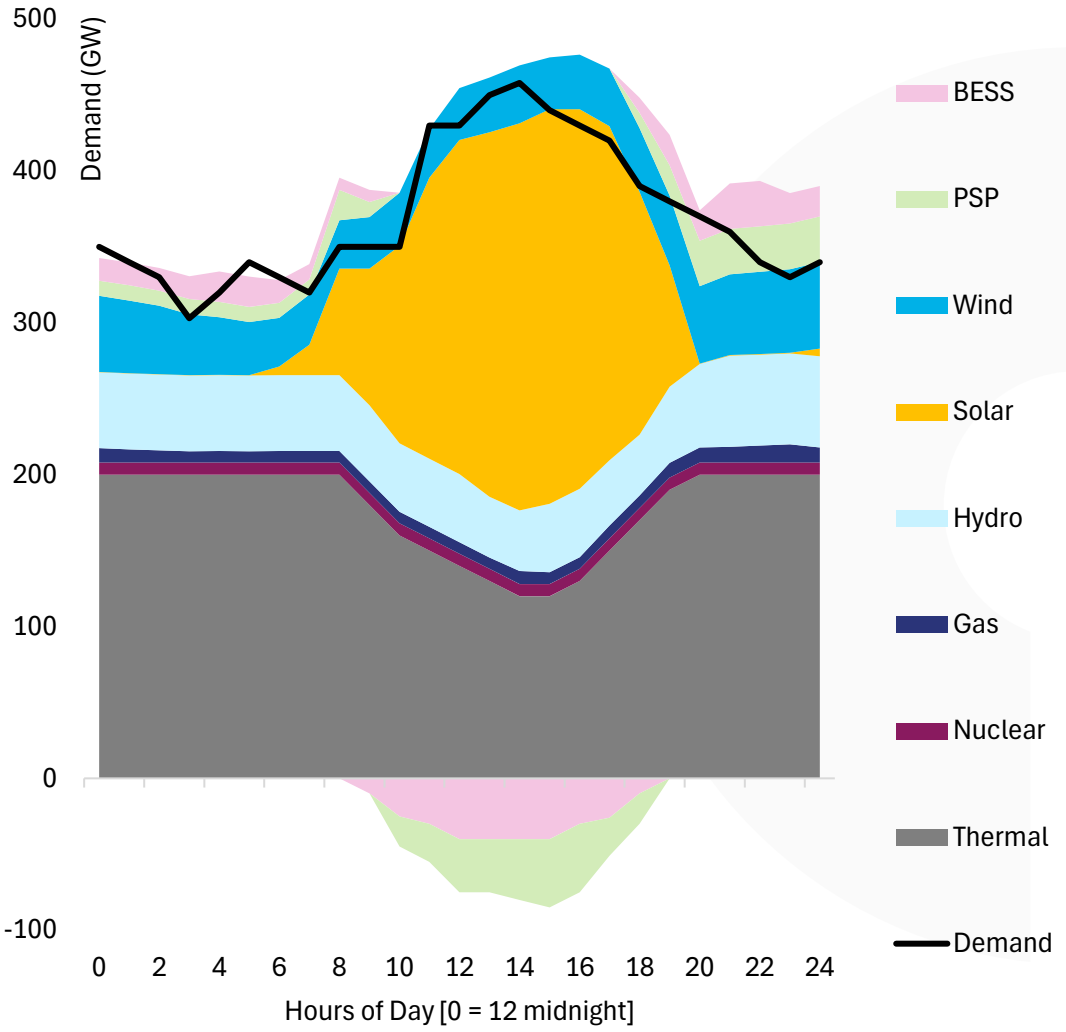
GLOBAL STORAGE CAPACITY (GW)



INDIA STORAGE CAPACITY (GW)



EXPECTED CONTRIBUTION ON A PEAK DAY IN FY32



- Storage capacity in India will grow faster than both Indian RE capacity and global storage capacity. This is due to low penetration of storage in India
- While PSP currently dominates the small capacity, this will soon change, with BESS constituting a lion's share by FY30. This mirrors global trends

Source: IEA, CEA, SBICAPS; *NZE= Net Zero Emissions by CY50 Scenario

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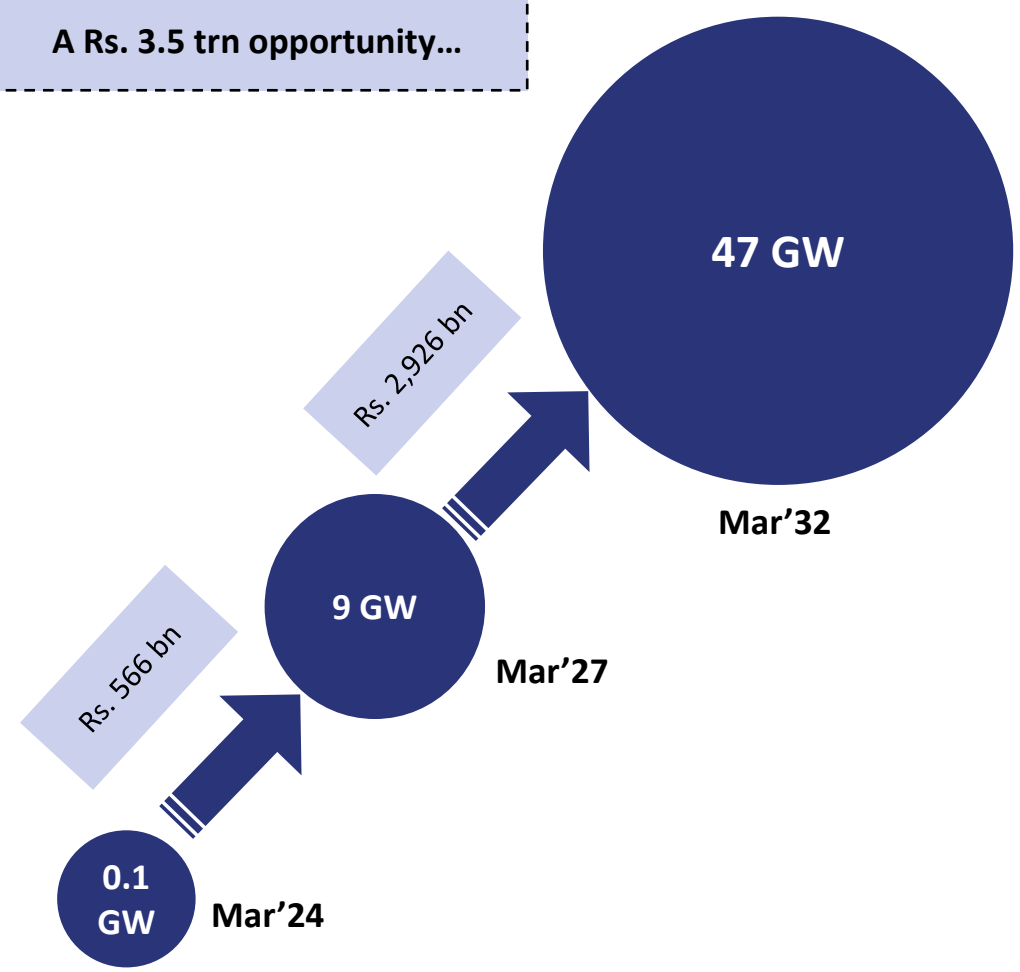
03

BESS TO LEAD THE CHARGE

NASCENT BESS NEEDS TO TACKLE CONSTRAINTS TO REALISE POTENTIAL

BESS CAPACITY AND INVESTMENT TARGETS

A Rs. 3.5 trn opportunity…



WHAT COULD BE THE CONSTRAINTS IN REACHING THIS TARGET?

Battery Related
High cost, unavailability of long discharge cells, dependence on imports for batteries and raw materials, e-waste disposal

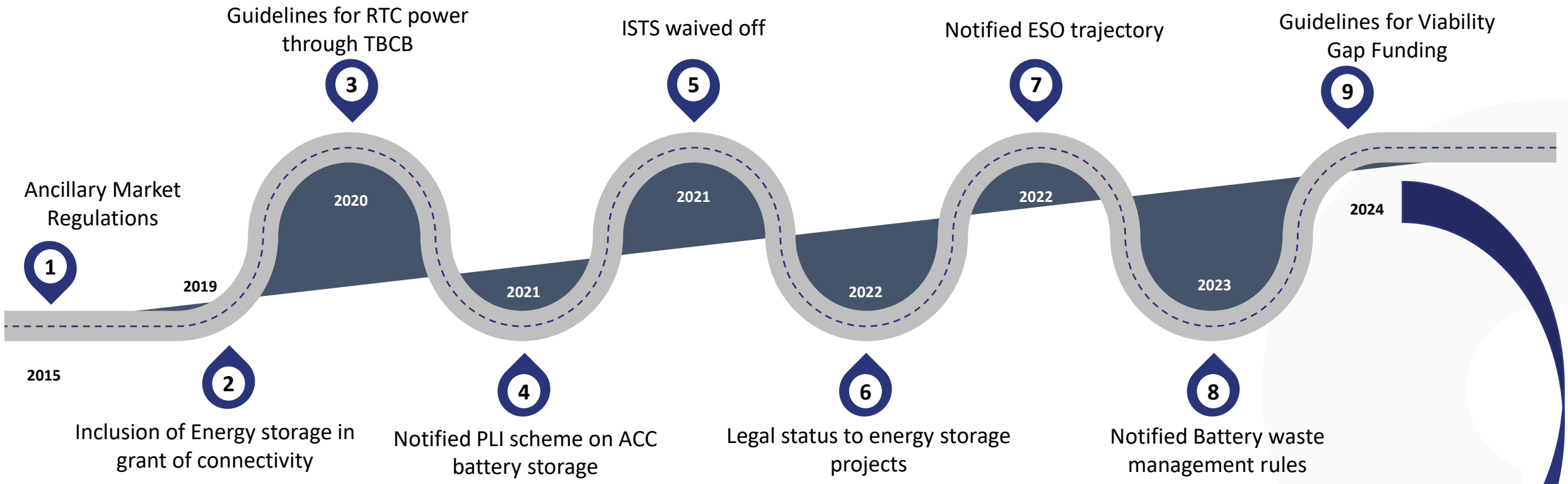
Inadequate and high-cost T&D infrastructure surging LCOS

Insufficient demand for storage facilities

Limited funding opportunities

Source: CEA, MERCOM, SBICAPS

GOVERNMENT EFFORTS ARE SOLVING SOME OF THESE CONSTRAINTS



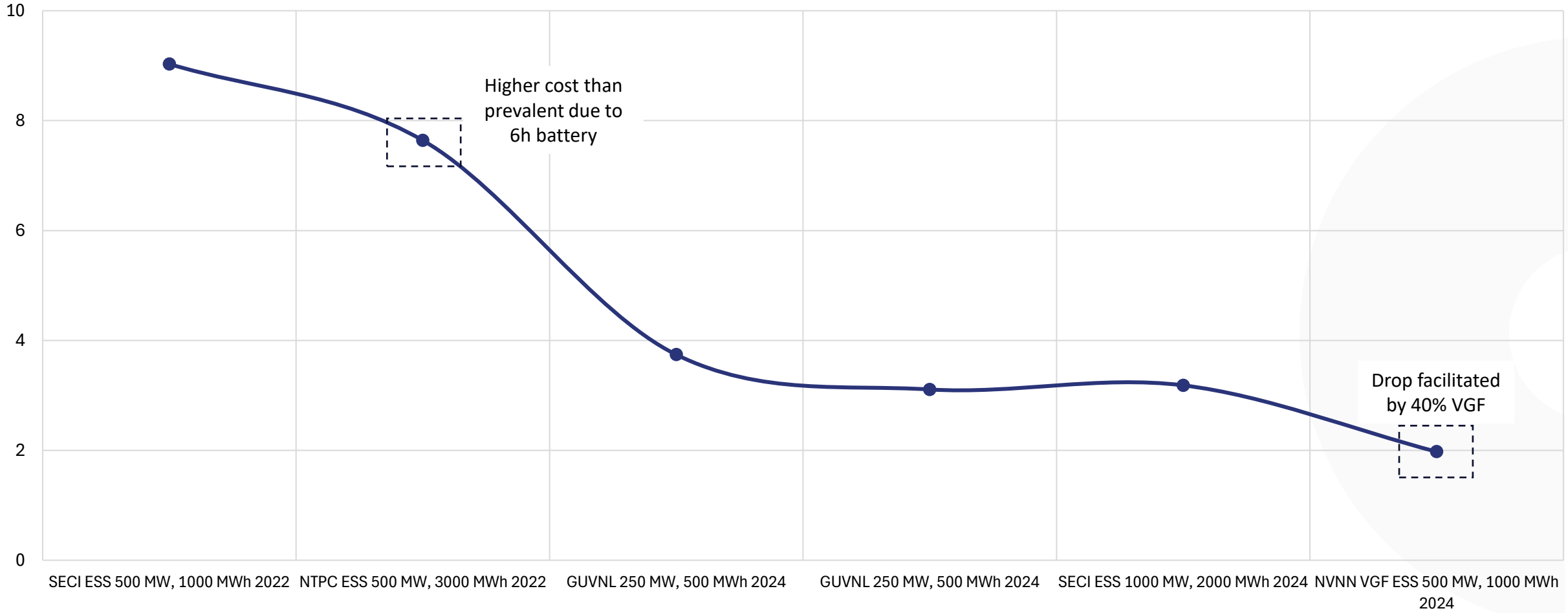
KEY POINTERS FROM GUIDELINES FOR VIABILITY GAP FUNDING

- Development of 4 GWh of BESS projects by FY31
- Financial support of up to 40% of the capital cost as budgetary support
- Initial outlay of Rs.94 bn including a budgetary support of Rs. 37.6 bn
- Targets achieving a LCOS of Rs. 5.5-6.6/unit
- Disbursement in five tranches linked with the various stages of implementation
- Minimum of 85% of the capacity will be made available to DISCOMs

Source: MNRE, SBICAPS

BESS TARIFFS ARE DIPPING INTO THE REGION OF VIABILITY

TARIFFS FOR STANDALONE BESS PROJECTS (Rs./kWh)

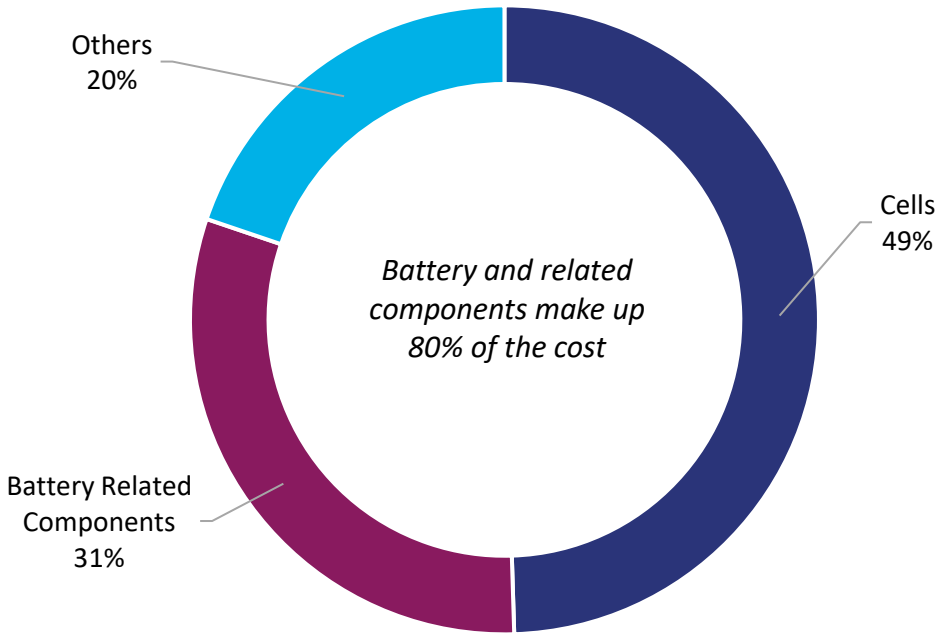


Along with government initiatives, a key driver of reducing BESS tariffs in a dip in battery prices, which is discussed subsequently…

Source: CEA, News Articles, SBICAPS

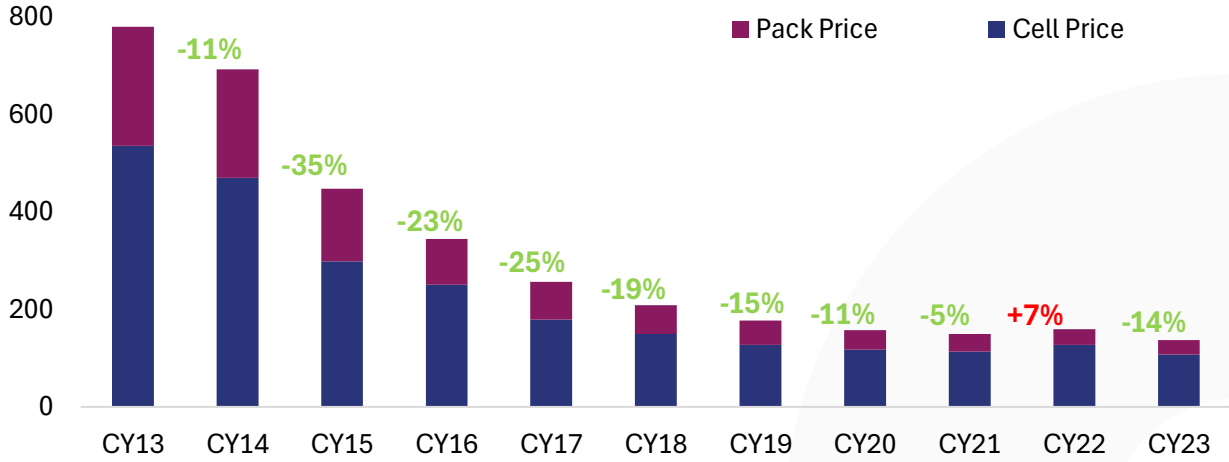
FURTHER REDUCTION IN BATTERY PRICES & TECH PROGRESS WILL SQUEEZE TARIFFS

COST BREAKUP OF BESS

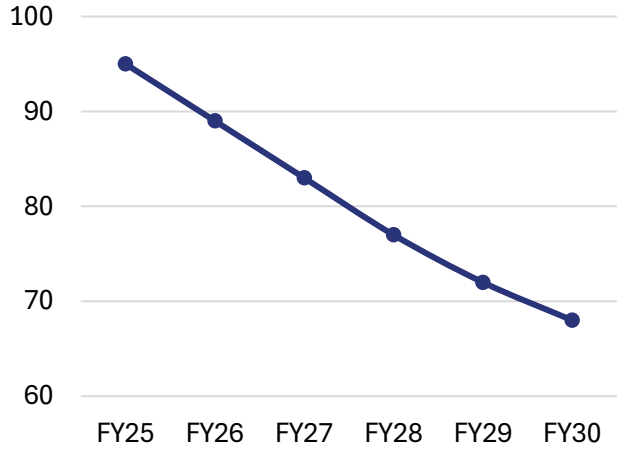


- Over the past 10 years, battery costs have fallen by a dramatic 82%, helped by economies of scale and improvements in technology which increased life and discharge periods. A cheaper battery leads to lower LCOS
- It is expected that battery prices will crash further, and there will be increased puissance of higher capacity 4h- and 6h- batteries vs. 2h batteries which are in vogue today. These will be contingent on building scale for which a complete domestic ecosystem is needed

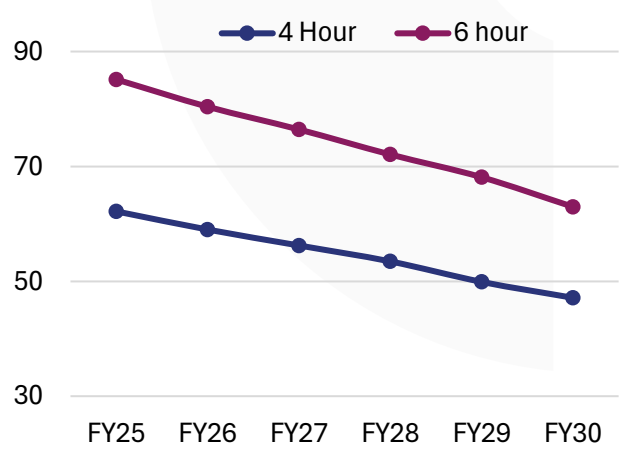
BATTERY PRICES (USD/kWh)



ESTIMATED BATTERY (CELL + PACK) PRICES (USD/kWh)



ESTIMATED CAPEX FOR BESS (Rs. bn/GW)[1]



Source: IEA, CEA, News Articles, SBICAPS; 1 Hours refer to discharge time

COMMON ECOSYSTEM WITH EV WILL GIVE BESS SYNERGIES AND SCALE

	Li - NMC	Li - LFP
CATHODE	Nickel-Manganese-Cobalt alloy as cathode	Lithium iron phosphate is cathode
ENERGY DENSITY	Higher energy density makes ideal for applications where low weight, space are critical factors	20% - 30% Lower energy density makes them suitable for applications where weight, space are not issues
LIFE CYCLE	Lower cycle life and can degrade with heavy use	Excellent cycle life better for stationary storage where longevity is prioritized
STABILITY	More susceptible to thermal runway under extreme conditions	Higher thermal stability and less prone to overheating makes safer for stationary storage
C RATE	Support fast charging required for EV	Slower charge discharge rate more acceptable to stationary storge applications
RECYCLING	Recycling industry will have more incentive to recycle as it uses higher value material	Less incentive to recycle
	BEST FOR ELECTRIC MOBILITY	BEST FOR BESS

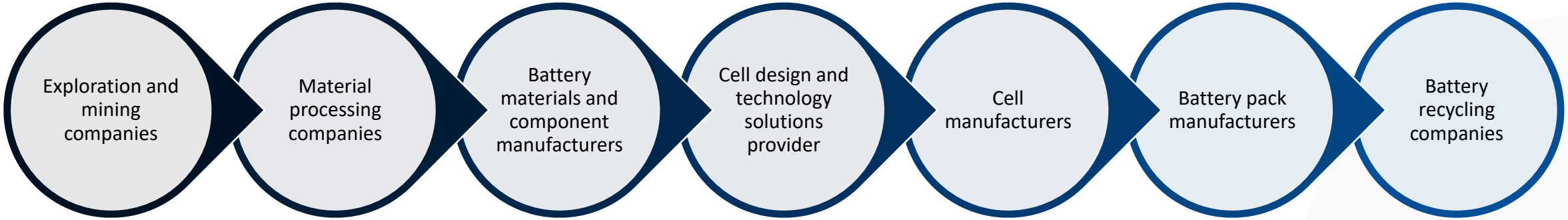
- There is a global shift towards LFP, 65% in CY22 to 80% in CY23 of battery market
- EV batteries after recycling can be used for BESS. Further, there are multiple common supply chain elements

UPCOMING MAJOR CAPEX	Ola Cell Technologies Private Limited (NMC); Agartas Energy Storage Solutions Private Limited (LFP); Amara Raja Advanced Cell Technology Private Limited (LFP+NMC); Reliance New Energy Battery Storage Limited (LFP), GODI India Private Limited (NMC+LFP); Exide Energy Solutions Limited (NMC+LFP+LTO); International Battery Company (NMC); ACC Energy Storage Private Limited (LFP); TDS Lithium-Ion Battery Gujarat Private Ltd (LTO); JBM Green Energy Systems Private Limited (NMC); Log 9 Materials Scientific Private Limited (LFP+LTO); Nsure Reliable Power Solutions (LFP)

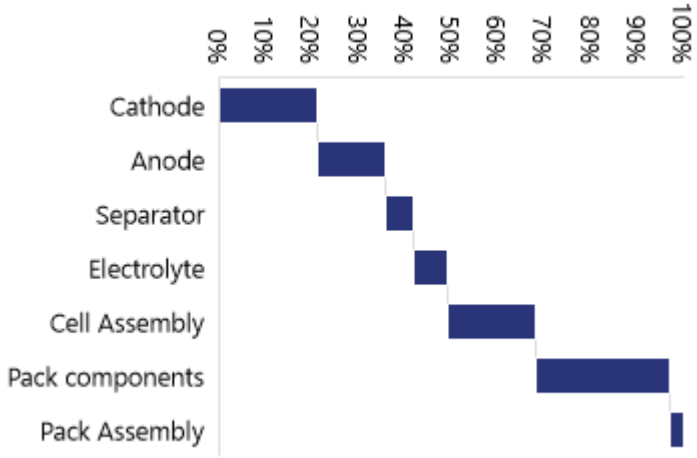
Source: NITI Aayog, News Sources, Company Disclosures, SBICAPS

BATTERY SUPPLY CHAIN IS LONG, COMPLEX, AND GLOBAL

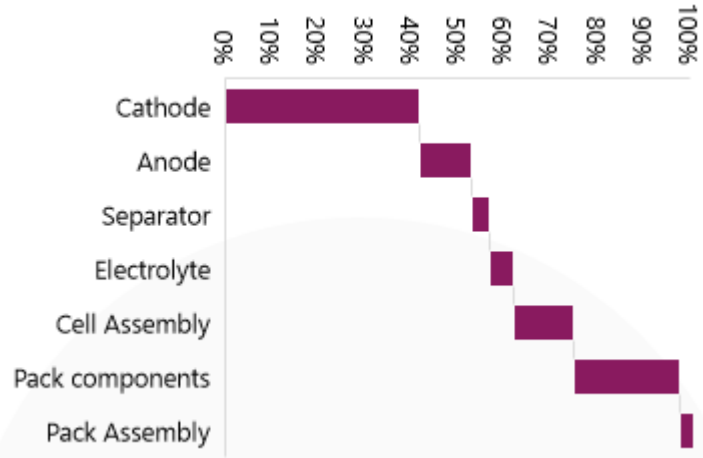
KEY LINKS IN THE BATTERY SUPPLY CHAIN



LFP BATTERY COMPONENT VALUE



NMC BATTERY COMPONENT VALUE

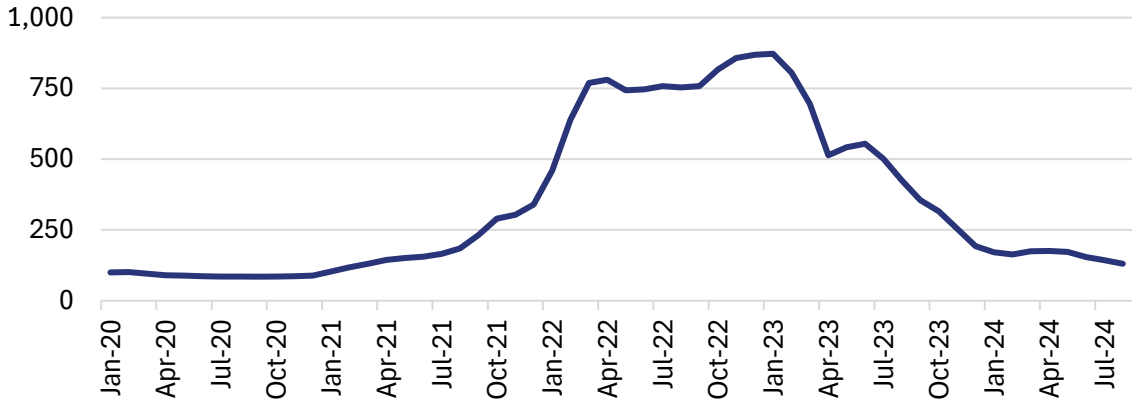


As per NITI Aayog, India is poised to capture 69-90% of LFP's and 43% of NMC's cell value through fostering domestic cell manufacturing ecosystem

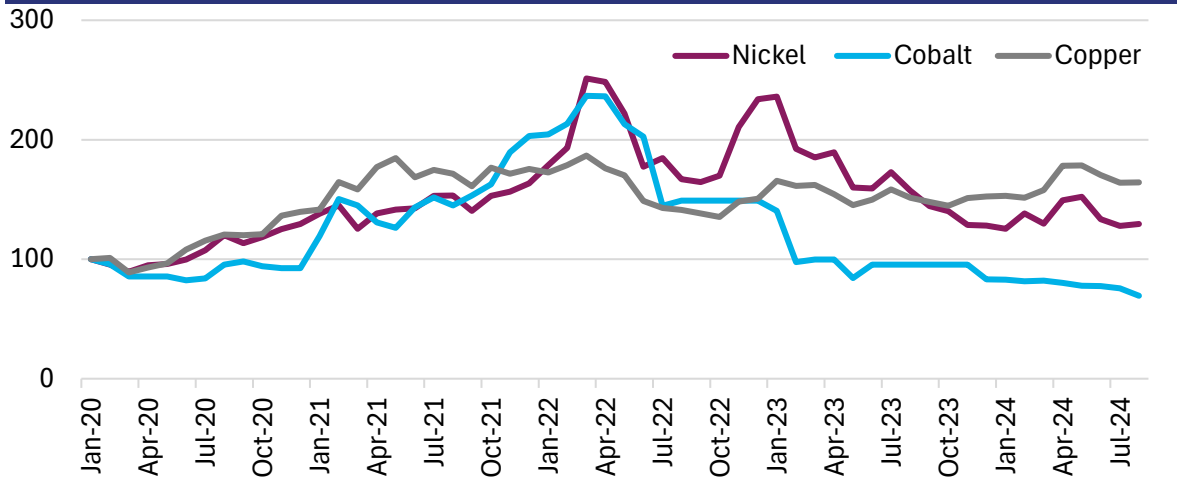
Source: NITI Aayog, SBICAPS

CUTTING IMPORT DEPENDENCE ON BATTERY RAW MATERIALS CRITICAL

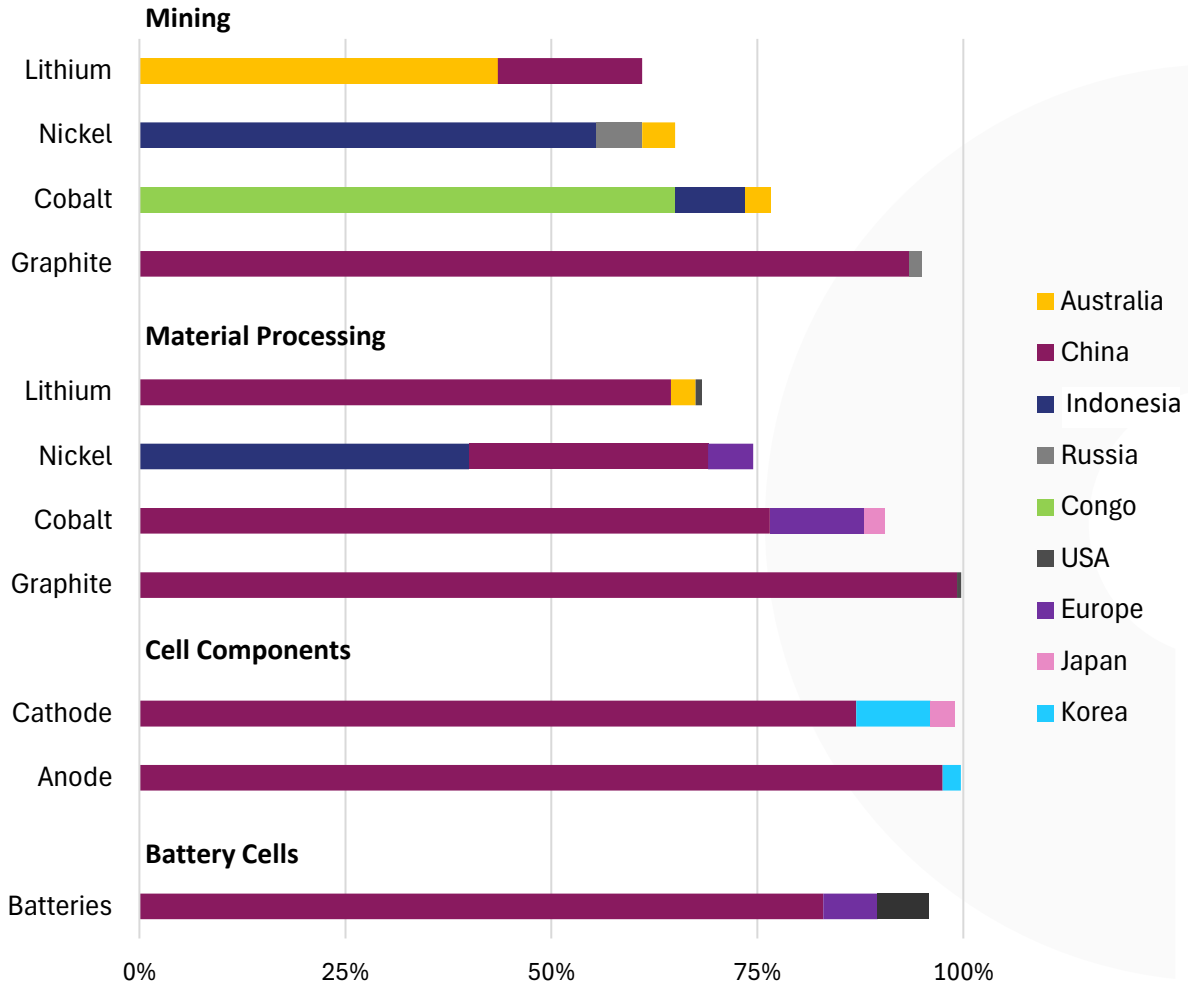
LITHIUM PRICE INDEX



RAW MATERIAL PRICE INDEX



GEOGRAPHICAL DISTRIBUTION OF GLOBAL BATTERY SUPPLY CHAIN



China dominates the global supply chain either directly or through tie-ups

Source: IEA, Bloomberg, SBICAPS; *Prices are indexed, with Jan'20 set to 100

SPECIAL PLI SCHEME PRIORITISES DOMESTIC VALUE ADDITION IN CELLS

PRODUCTION LINKED INCENTIVE FOR ADVANCED CELL CHEMISTRY (ACC)

1

Setting up of:
- ACC manufacturing capacity of 50 GWh
- Additional cumulative capacity of 5 GWh for Niche ACC technologies

2

Facility to be commissioned within a period of 2 years

The subsidy will be disbursed thereafter over a period of 5 years

3

The beneficiary must ensure achieving a domestic value addition of at-least 25% and incur the mandatory investment (Rs. 2.25 bn /GWh) within 2 Years (at the Mother Unit Level)

4

Raise it to 60% domestic value addition within 5 Years, either at Mother Unit, in-case of an Integrated Unit, or at the Project Level, in-case of “Hub & Spoke” structure.

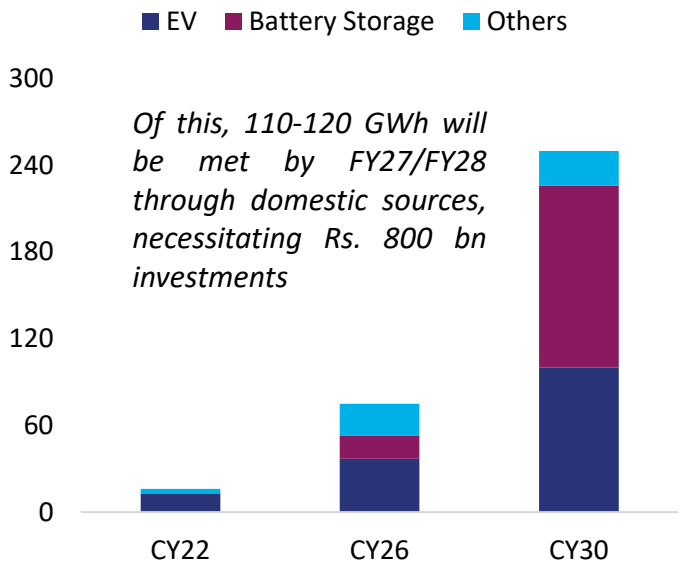
To achieve 60% of domestic value addition, companies need to localise manufacturing of anode, cathode, electrolytes, and separator

Cell Component Manufacturing → **Cell Manufacturing** → **Cell Packaging or Pack Manufacturing**

Source: MNRE, PIB, SBICAPS

ADDRESSING CONCERNS WILL SUPERCHARGE CELL & COMPONENT MANUFACTURING

BATTERY DEMAND* (GWh/YEAR)



TECH-FORWARD M&A GALORE

Reliance Industries Limited → Acquired battery tech provider for EUR 100 mn → faradion

AMARA RAJA (Gotta be a better way) → Acquired stakes through funding of USD 40 mn → LOG 9

CATHODE

- epsilon CARBON: Envisages investment of Rs. 50 bn for cathode plant over 6 Years
- ALLOX: Expansion on investment outlay of Rs. 7.5 bn of Cathode LFP
- Himadri: Plans to produce 20,000 mn tonnes LFP cathode material catering 100 GWh

ANODE

- HEG: Plans to invest Rs. 20 bn to manufacture anode to cater 12 GWh of cell manufacturing
- Himadri: Plans to produce and expand to 100,000 tonnes anode material by CY28
- epsilon ADVANCED MATERIALS: Plans for 100 KTPA synthetic and 50 KTPA natural graphite by CY30.

ELECTROLYTE

- NEOGEN CHEMICALS LTD.: Plan of Rs 4.5 bn initial investment for 10,000 tonnes electrolyte capacity and to increase to 32,000 tonnes by FY26
- GFL GUJARAT FLUOROCHEMICALS (VALUE THROUGH GREEN CHEMISTRY): Planned to expand electrolyte salt capacity in phases and over investment of Rs. 50 bn in battery supply chain

SEPARATOR

- DAREX: Aggressive plans for separators manufacturing once local demand increases
- ENTEK: Exploring to establish manufacturing plant for AGM battery separator
- NEOGEN CHEMICALS LTD.: Plans to establish a manufacturing capacity ranging from 1.2 -2.4 kTPA

*Source: NITI Aayog, News Articles, SBICAPS; *Demand as per accelerated approach*

IMPROVING FUNDING ACCESS TO BESS: UNDERSTANDING THE PARTS

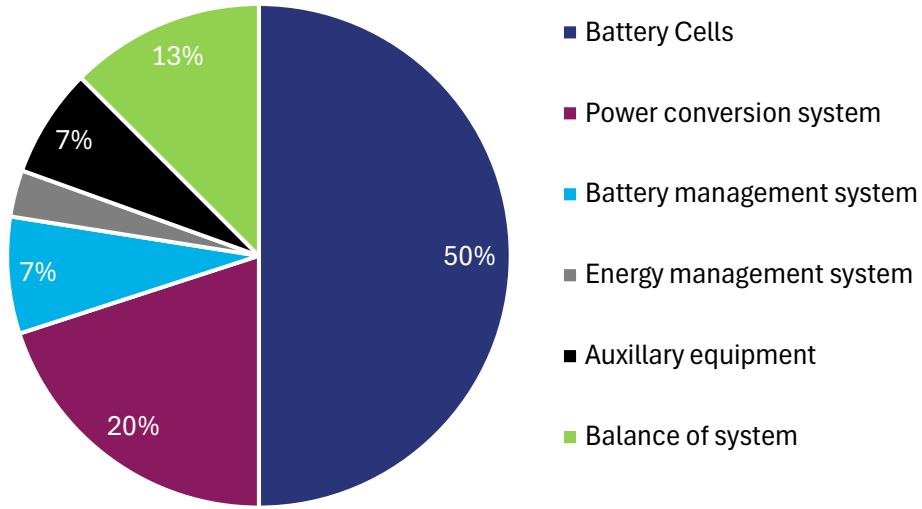
COST OF TYPICAL BESS PROJECT

2h discharge
Rs. 13
mn/MWh

4h discharge
Rs. 18
mn/MWh

6h discharge
Rs. 18.5
mn/MWh

COST BREAKUP OF TYPICAL BESS PROJECT



KEY FINANCING PARAMETERS FOR BESS PROJECTS

- Availability of Land and Necessary Project Approvals
- Cell Cost, Technology, Discharge Period/Life-cycles
- PPA tenure & tariff
- Counterparty/ Receivable Risk
- Counterparty compliance to ESO and RPO targets
- Cost of Input Power
- Distance from Input/Output (Co-location), Presence of Transmission Ecosystem
- Synergies with Group

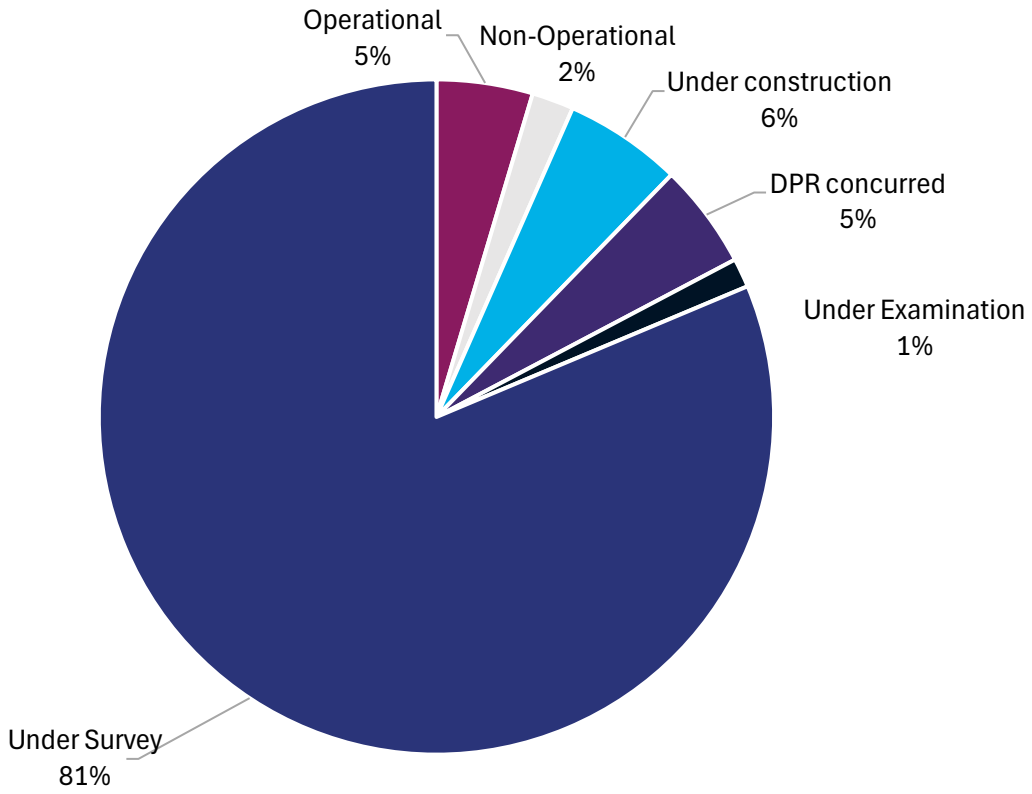
Source: CEA, Ember Energy-TERI, SBICAPS

04

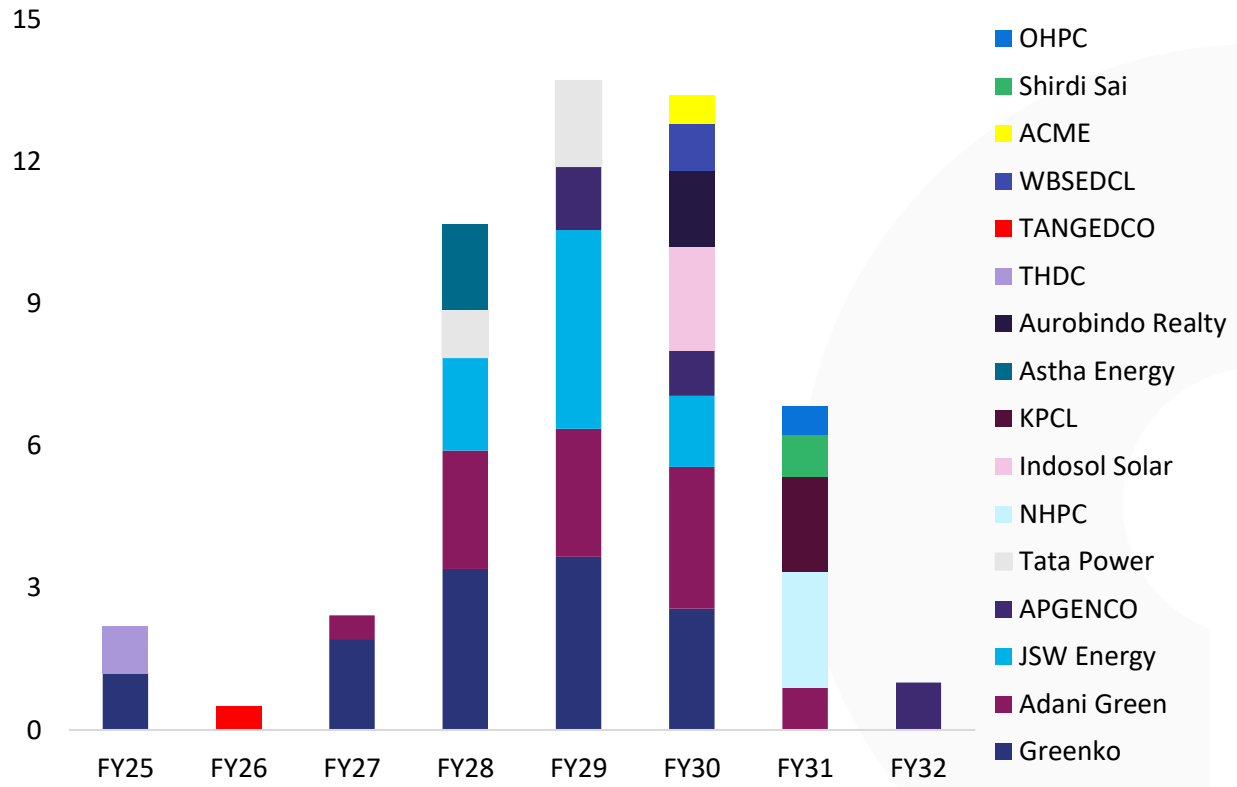
PSP TO COMPLETE THE CIRCUIT

PSP ARE ESSENTIAL FOR PEAK SHAVING…

STATUS OF PUMPED STORAGE PROJECTS (TOTAL = 71.7 GW)



PSP CAPACITY ADDITION PLAN (GW)



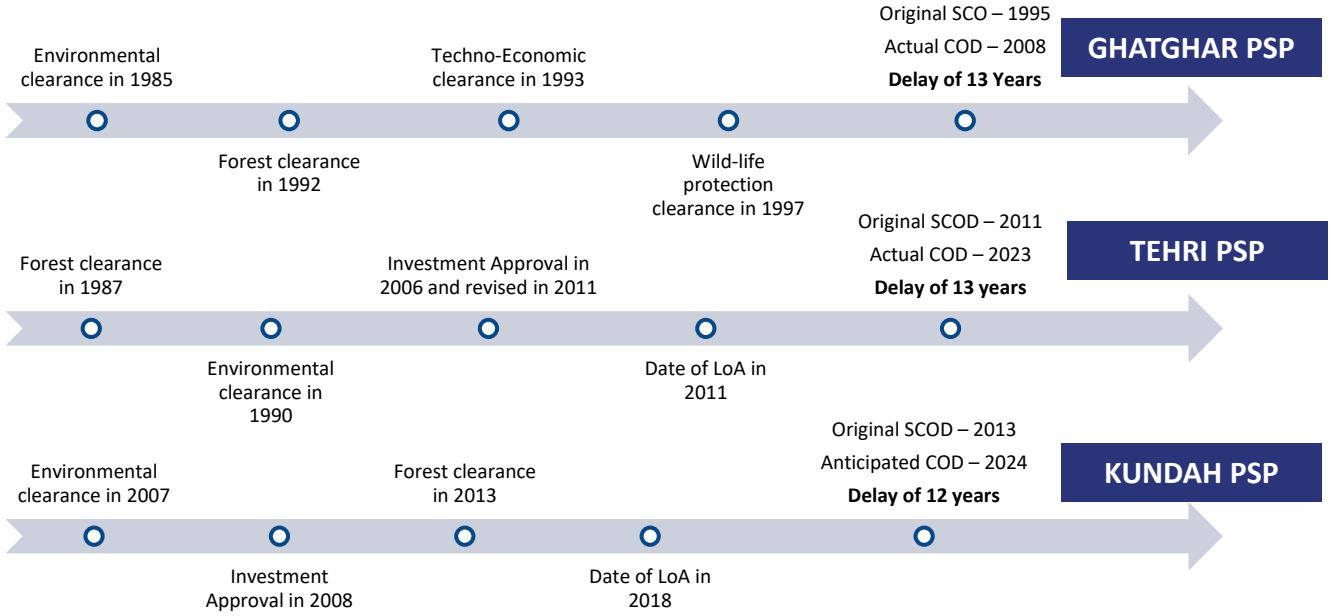
- Currently, PSPs with aggregate capacity of 4 GW are under construction in the country and another 64 GW is under various stages of development. It is projected that PSP capacity shall increase from 4.7 GW to around 55 GW by FY32

Source: CEA, PIB, SBICAPS

… HOWEVER, PSP ARE WROUGHT WITH MULTIPLE STRUCTURAL ISSUES…

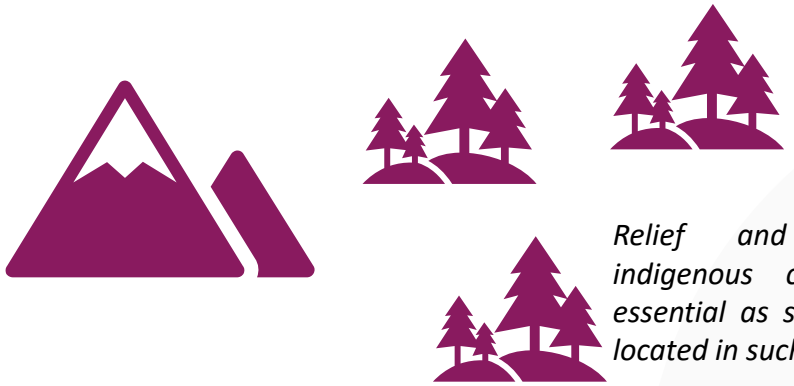
REQUIREMENT FOR MULTIPLE COMPLEX CLEARANCES LEADS TO TIME OVERRUNS…

Clearance	Key Agencies
Environmental Clearance	Union Government & Nodal Agencies, State Government
Forest Clearance	State and Union Government
Wildlife Clearance	Wildlife Advisory boards
Water Resources Clearance	CPCB, SPCB
Air Pollution Clearance	State and Union Government
Land Acquisition Clearance	Union Government



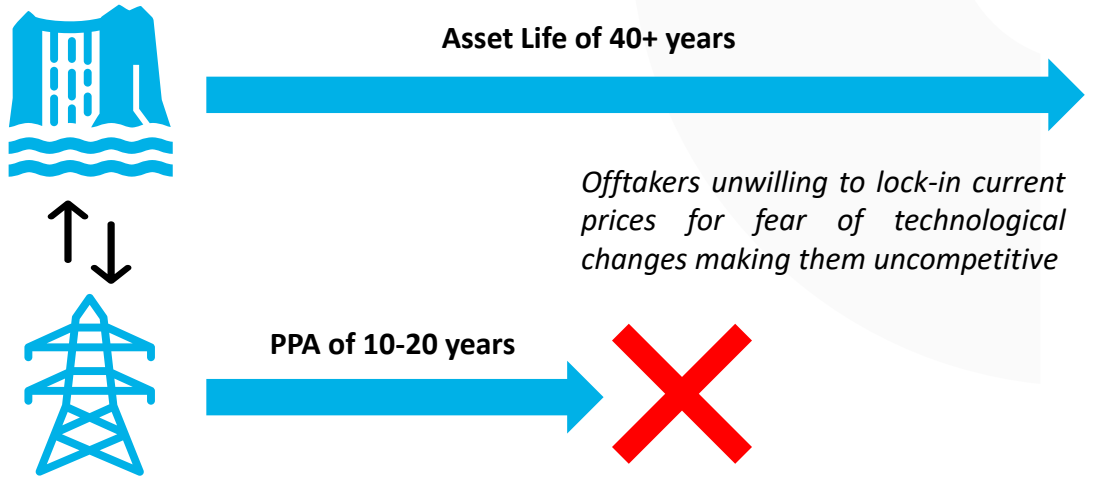
… WHICH ULTIMATELY BURGEON COST OVERRUNS AND SQUEEZE RETURNS

PRESENCE IN TRIBAL ZONES OFTEN CREATES SOCIAL TENSIONS



Relief and Rehabilitation of indigenous communities becomes essential as such projects are often located in such areas

MISMATCH OF ASSET LIFE AND PPA TENURE CREATES STRANDED ASSET RISK



Source: CEA, IESA, News Articles, SBICAPS

… WHICH LIMITS THEIR POTENTIAL VIS-À-VIS BESS

STANDALONE PSP ESS TENDERS

TENDER	COMPANY	CAPACITY	TARIFF (Rs./kWh)
PCKL	JSW Energy	300	5.06
PCKL	Greenko	700	5.05
MSEDCL	Torrent Power	1,500	6.77

IMPROVING VIABILITY

Increasing Efficiency
Can be done through improving the efficiency of any of the five component efficiencies: hydraulic efficiency of water conductor system between upper reservoir and lower reservoir in generation mode viz -a-viz pumping mode, motor and pump in pumping mode, turbine and generator in generating mode

Boosting number of cycles per day
Ensuring the PSP runs at 1.5 cycles instead of 1 cycle per day increases its throughput. At the input power cost of Rs. 2-3/unit, this increase in cycles can reduce LCOE by 13%-17%

Reducing cost of debt funding
A 1% reduction in interest cost leads to a dip of ~2% of tariff. This component is especially critical given the long gestation period which bulges the interest-during-construction component, and ample project life in general

SOME RECENT MoU

MoU of 7.3 GW in Maharashtra

MoU of 0.5 GW in Odisha

MoU of 6.8 GW in Maharashtra of Rs. 336 bn

MoU of 2.8 GW in Maharashtra of Rs. 130 bn

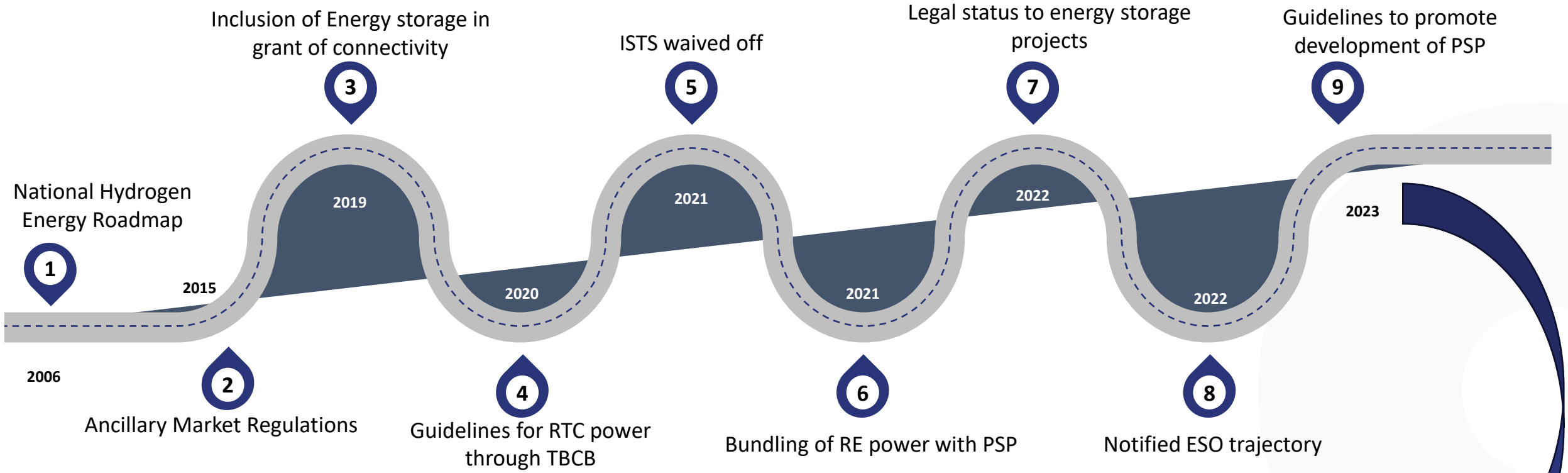
MoU of 1.2 GW in Maharashtra of Rs. 50 bn

MoU of 5.7 GW in Maharashtra

- The regulatory challenges lead to preference of nomination-based allocation by PSP players instead of tariff based competitive bidding
- This means that the presence of government/PSUs in this space will be greater, with more modest private sector participation

Source: CEA, News Articles, SBICAPS

POLICY SUPPORT HELPS ALLEVIATE SOME STRUCTURAL ISSUES



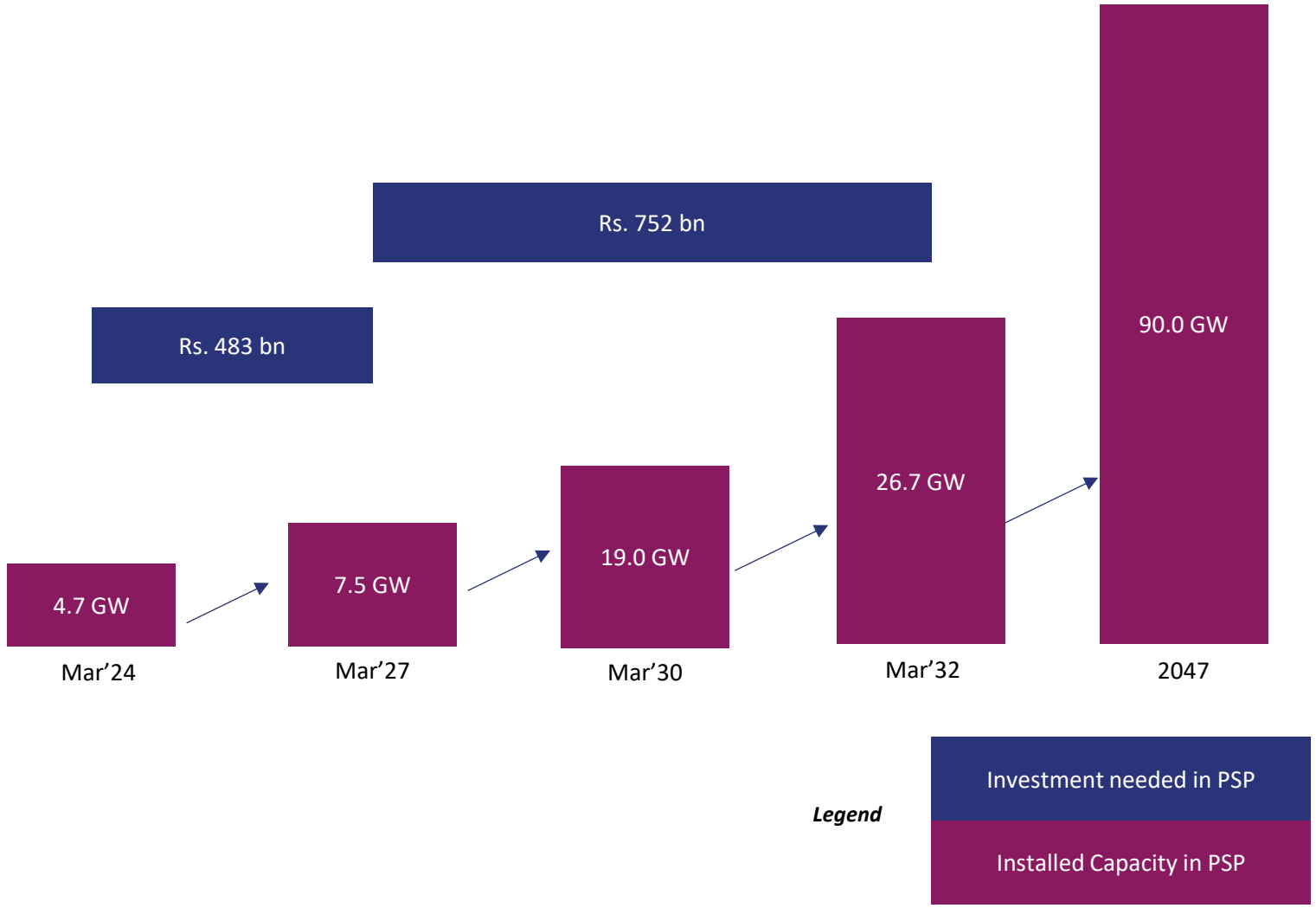
KEY POINTERS FROM GUIDELINES TO PROMOTE DEVELOPMENT OF PSP

- Monetisation of Ancillary services
- B2 Category classification for certain plants
- No liability of free power
- Exemption of land stamp duty and registration fee
- Benchmark cost of storage
- Exploring utilization of discarded mines
- Participation in HP-DAM
- Access to Green Finance

Source: MNRE, SBICAPS

WATER BATTERIES: A RS. 1.2 TRN OPPORTUNITY

FUNDING REQUIREMENT FOR ENERGY STORAGE SYSTEM (Rs. bn)



FILLING THE VOIDS: PUMPED HYDRO PROPOSALS COULD SEE NEW INVESTORS

COSTS BENCHMARKS

SR. NO.	STATUS	COST PER MW (Rs. mn)
1	Both Existing reservoir	40 – 43
2	One Existing Reservoir	49 – 52
3	No Reservoir Existing	60 - 70

KEY FINANCING PARAMETERS FOR PSP

Presence of all necessary Approvals

Environmental and Social Impact Assessment

PPA tariff and length vs. project life

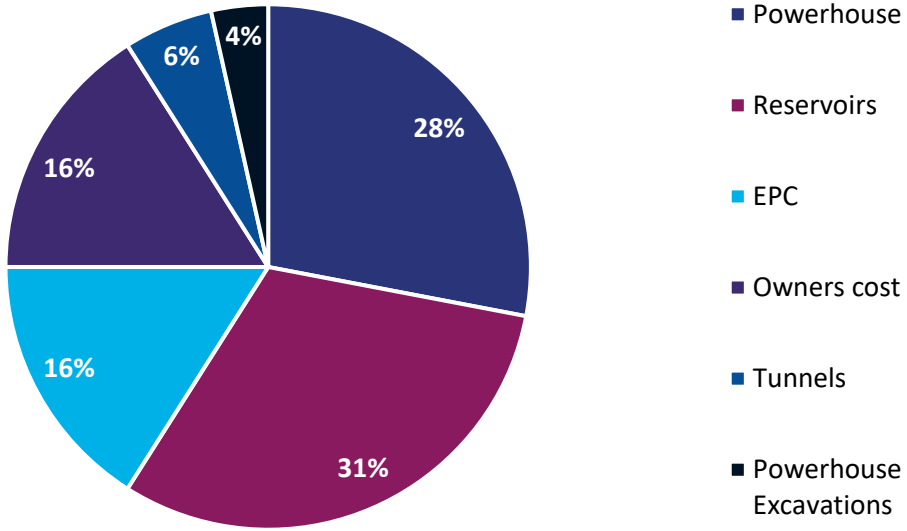
Presence of Existing Reservoirs

Potential of the Location

Water Availability

FUNDAMENTAL ISSUES IMPACTING PROJECT VUABILITY

COST BREAKUP FOR PSP WITH NO EXISTING RESERVOIRS



FUNDING PRACTICES IN PSP

Capital Investment

- Historically, projects took more than anticipated time resulting into increased capital cost
- Historically, external borrowings played extensive role in funding, with key FIs giving initial nudge
- In recent projects, there has been bank interest and key FI in construction phase, with refinance through bond markets post operations
- Equity: Through GoI infusion historically, currently seeing some private participation

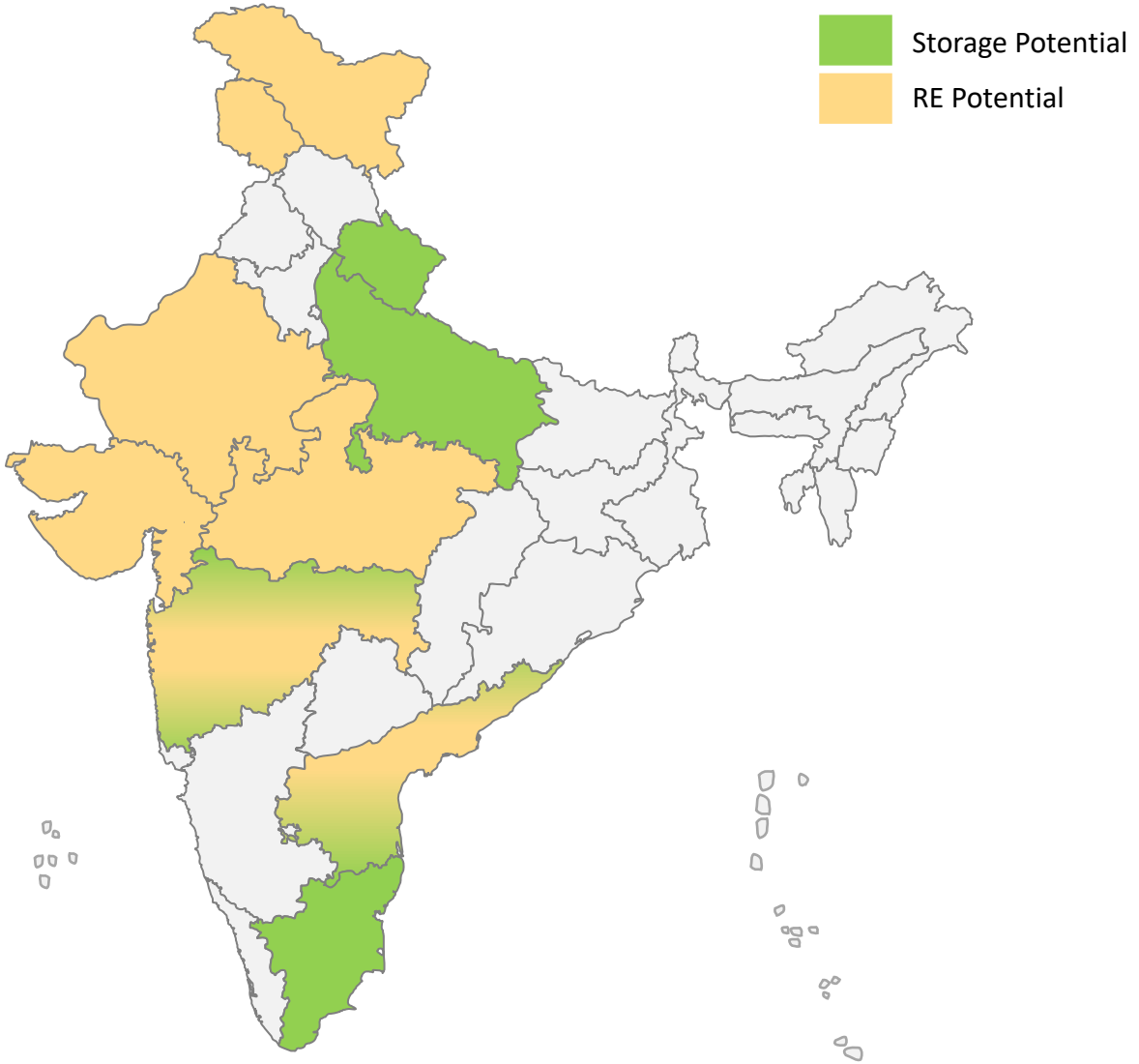
Working Capital

- For Maintenance spares, O&M expenses, receivables (DSRA), generally small component
- Largely by Banks

Source: CEA, MNRE, SBICAPS

ADDITIONAL TRANSMISSION OPPORTUNITY DUE TO POTENTIAL DIFFERENCE

RELATION BETWEEN RE POTENTIAL AND PUMPED HYDRO STORAGE



PLANNED TRANSMISSION INFRASTRUCTURE

No.	STATE	CAPACITY (MW)
1	Andhra Pradesh	8,750
2	Uttar Pradesh	5,940
3	Rajasthan	5,560
4	Karnataka	3,600
5	Maharashtra	2,580
6	Madhya Pradesh	1,920
7	Uttarakhand	1,000
8	West Bengal	1,000
9	Tamil Nadu	500

- Potential for both RE and storage is there in select states such as Maharashtra and Andhra Pradesh, which are expected to see lowest LCOE
- For other states, additional transmission infrastructure will be needed from remote PSP sites to demand centres

Source: CEA, SBICAPS

05

ANNEXURE

GLOSSARY

Item	Explanation
ACC	Advanced Cell Chemistry
APGENCO	Andhra Pradesh Generation Corporation Limited
BESS	Battery Energy Storage System
bn	Billion
CAGR	Compounded Annual Growth Rate
Capex	Capital Expenditure
CEA	Central Electricity Authority
CUF	Capacity Utilisation Factor
CY	Calendar Year
DISCOM	Distribution Company
DSRA	Debt Service Reserve Account
ESO	Energy Storage Obligation
ESS	Energy Storage System
EV	Electric Vehicle
e-waste	Electronic Waste
FDRE	Firm Despatch Renewable Energy
FI	Financial Institution
FY	Financial Year
GoI	Government of India
GUVNL	Gujarat Urja Vikas Nigam Limited
GW	Gigawatt
GWh	Gigawatt-hour
h	Hour

Item	Explanation
H1	First Half
IEA	International Energy Association
IEEFA	Institute for Energy Economics and Financial Analysis
ISTS	Inter State Transmission System
JBM	Jay Bharat Maruti
KPCL	Karnataka Power Corporation Limited
kWh	kilo Watt-hour
LCOE	Levelised Cost of Electricity
LCOS	Levelised Cost of Storage
LFP	Lithium Ferrous Phosphate
Li	Lithium
LTO	Lithium Titanium Oxide
M&A	Merger and Acquisition
MLI	Multilateral Lending Institutions
mn	Million
MNRE	Ministry of New and Renewable Energy
MoU	Memorandum of Understanding
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MW	Megawatt
NMC	Nickel Manganese Cobalt
NVVN	NTPC Vidyut Vyapar Nigam Limited
NZE	Net Zero Emissions
O&M	Operations and Maintenance
OHPC	Odisha Hydro Power Corporation

Item	Explanation
PCKL	Power Company of Karnataka Limited
PIB	Press Information Bureau
PLI	Production Linked Incentive
PPA	Power Purchase Agreement
PSA	Power Supply Agreement
PSP	Pumped Storage Project
PSU	Public Sector Undertaking
RE	Renewable Energy
RoR	Run of River
RPO	Renewable Purchase Obligation
Rs.	Rupees
RTC	Round The Clock
RUVNL	Rajasthan Urja Vikas Nigam Limited
SECI	Solar Energy Corporation of India
T&D	Transmission and Distribution
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
TBCB	Tariff Based Competitive Bidding
TDS	Toshiba Denso Suzuki
trn	Trillion
USA	United States of America
VGF	Viability Gap Funding
VRE	Variable Renewable Energy
WBSEDCL	West Bengal State Electricity Distribution Company Limited
WSH	Wind-Solar Hybrid
YTD	Year Till Date

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