HYDRO POWER

Strong policy focus on pumped storage hydro schemes to encourage rapid development

March 2023

Highlights

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With growing share of RE, the hydro segment, especially pumped storage hydro, remains systemically important from the grid stability perspective.

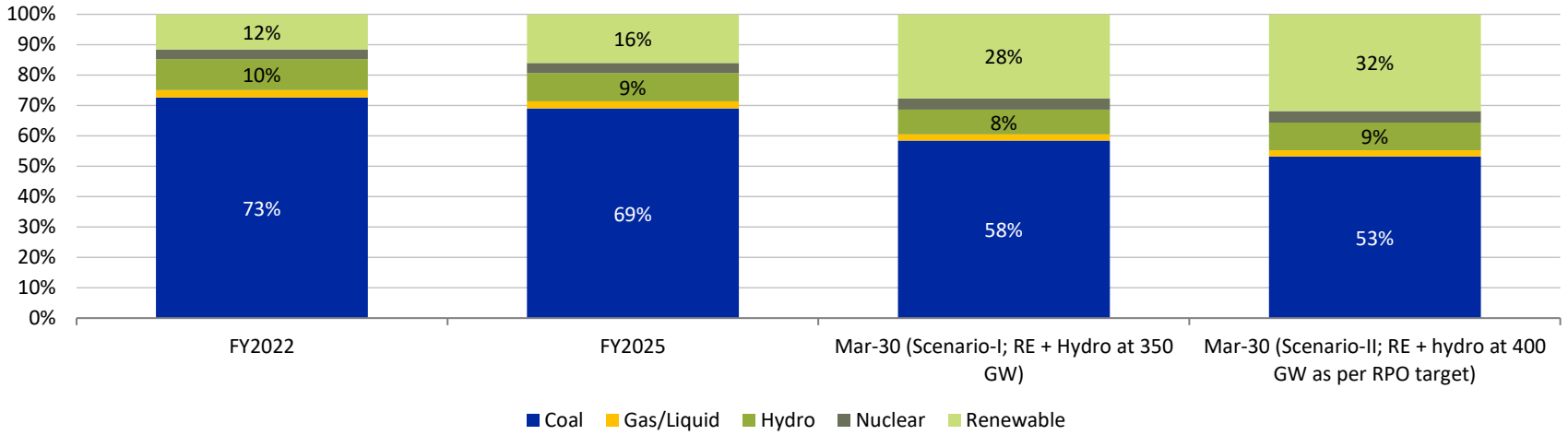
Strong policy focus needed with series of measures notified for demand as well as supply push.

Mature and indigenous technology a necessity with long life and competitive cost compared to BESS.

- With increase in installed renewable energy capacity, the share of RE power in electricity generation is expected to increase from 11.5% in FY2022 to 28% by FY2030. Increasing sources of intermittent power (wind and solar) would necessitate higher storage capacity for maintaining grid stability.
- Pumped storage hydro projects (PSPs) offer significant benefits in the form of frequency regulation, storage/ time shifting, ramping capability, black start capability, peak shaving, reactive power and voltage control, and spinning reserves. They are, therefore, best suited for supporting grid operations.
- The Ministry of Power (MoP) in Feb 2023 has announced draft guidelines to promote development of pumped storage projects in the form of proposals in respect of monetisation of ancillary services, exemption from double taxation, state GST reimbursement, and rationalization of environment clearance. On the demand side, energy storage obligation norms (ESOs) have already been notified by MoP.
- The levelised tariff for pumped storage hydro projects in the base case (capital cost of Rs 6.5 crore per MW and 16.5% return on equity) is estimated at Rs 4.98 per unit while the landed tariff including cost of energy required for pumping is estimated at Rs. 8.92 per unit. Timely implementation of market reform proposals as highlighted in the draft guidelines also remains important to improve the financial viability of PSPs.
- Pumped storage hydro projects have a long economic life of 40 years, are based on very mature and indigenous technology and are efficient. They are also cost competitive. The levelised cost (capital cost of 250 USD/kwh) using BESS is estimated at Rs. 11.1 per unit which is twice the base case cost estimate (conversion) of Rs. 4.98 per unit for pumped storage hydro projects.

Growing share of RE in electricity generation banks on need for storage capacity

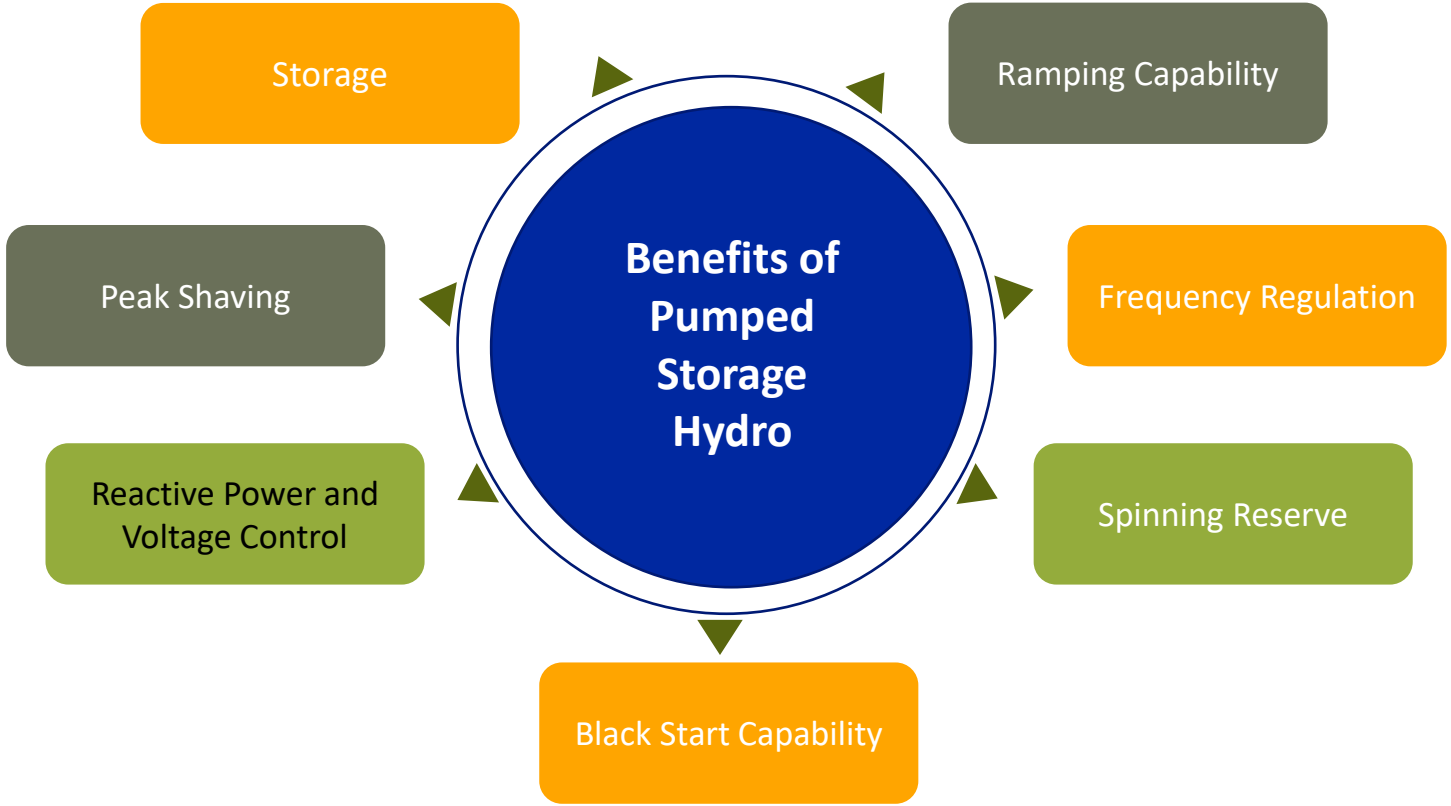
EXHIBIT 1: Projected electricity generation mix by FY2025 and FY2030



- The rise in the installed RE capacity over the next decade is estimated to increase the share of RE power in the overall electricity generation mix from 11.5% reported in FY2022 to 28% in FY2030 in ICRA's base scenario. The share, including that of large hydro, would increase to 36% in FY2030 from 22% in FY2022.
- In an optimistic scenario as per the RPO targets prescribed, the share of RE plus hydropower is estimated to reach ~42% of the generation mix by FY2030. Apart from easing challenges related to capacity addition, achieving such high level of RE share would require augmentation of grid infrastructure and storage capabilities to manage the intermittency associated with the wind and solar power.

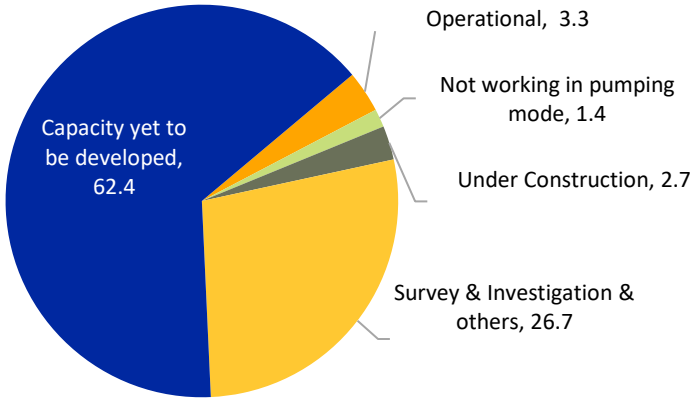
Source: ICRA Research, CEA and National Power Portal; ICRA has considered annual demand growth of 5.0% over FY23-30 and considered a gradual improvement in PLF levels for solar and wind plants based on efficiency gains and use of higher AC:DC ratio for solar plants

Pumped storage hydro – The great stabilizer



Pumped storage hydro projects (PSPs) – The opportunity and challenges

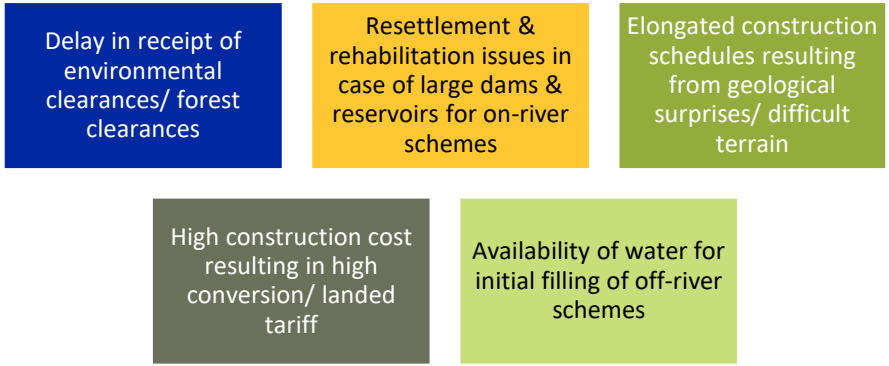
Exhibit 2: Current status of PSP development; Capacity in MW



Source : ICRA Research, CEA

- Despite mature and largely indigenous technology, the operational capacity at present remains very low at 3.3 GW because of high costs of development and inherent challenges in construction of pumped storage schemes.

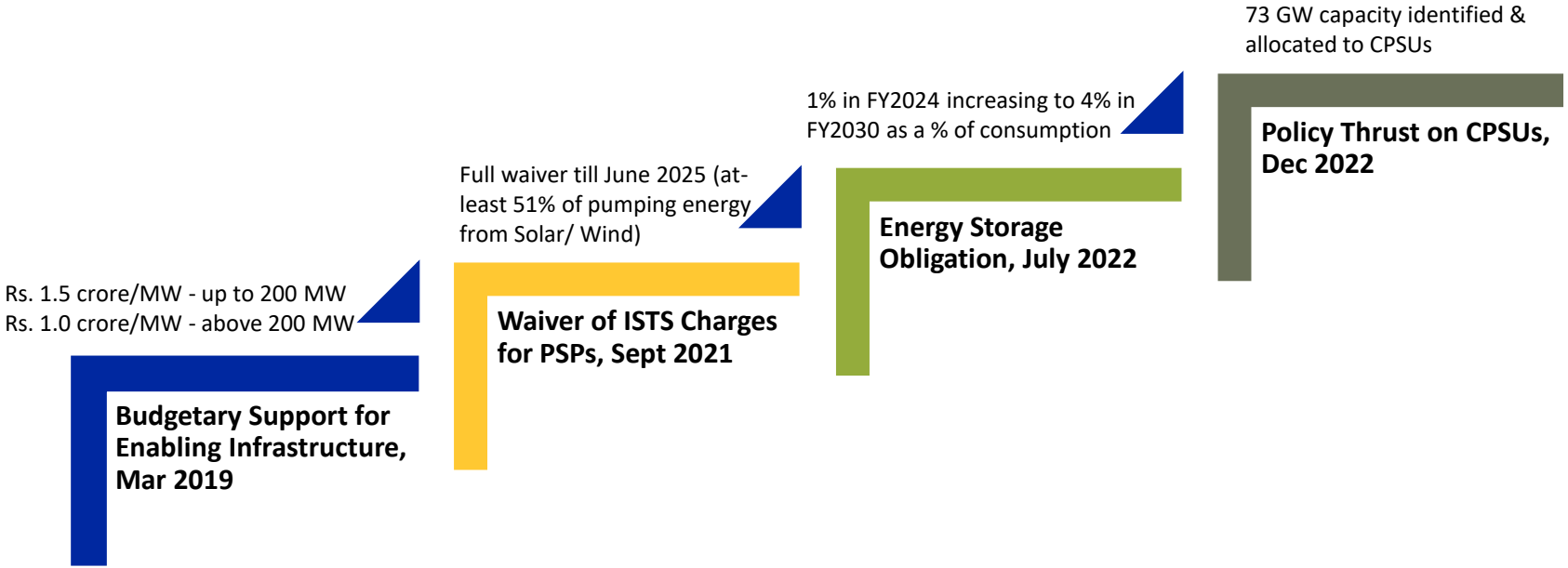
Exhibit 3: Factors hindering development



Source : ICRA Research, CEA

- Considering the huge potential of 96.5 GW, the untapped potential is 62.4 GW and capacity not yet working in pumping mode/ under survey and investigation remains high at 27.8 GW.
- Strong policy focus, which addresses these concerns and incentivises project development is, therefore, needed.

Policy focus on development of PSPs – Measures already taken

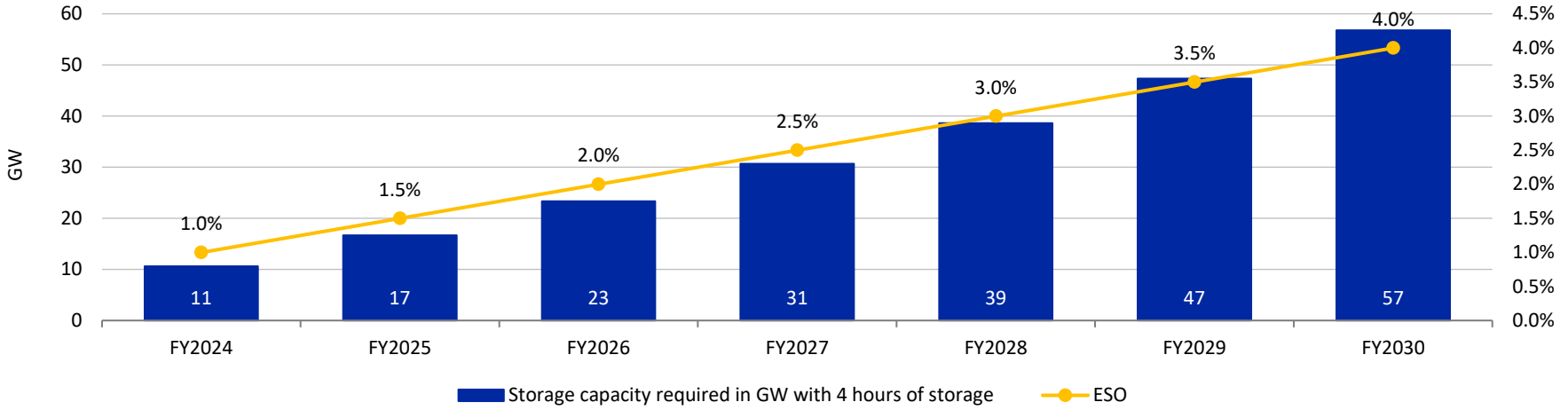


- Measures such as introduction of energy storage obligation should result in increased demand for pumped storage hydro projects, while supply push will come from budgetary support, waiver of ISTS charges.
- Moreover, with strong project management capabilities, past experience in development of large-scale projects and access to competitive cost of capital, CPSUs are most suited for development of hydro power projects, including pumped storage schemes. The MoP has identified project sites aggregating 73 GW capacity and allocated these to CPSUs for faster roll-out of capacities.

Source: CEA, ICRA Research

Impetus on storage capacity development through ESO

Exhibit 4: ESO trajectory notified by MoP and the expected storage capacity requirement to meet the targets



- The notification of the Energy Storage Obligation (ESO) trajectory for meeting a portion of the energy requirement through energy storage is expected to aid in promoting the development of storage capacity in the country, over the next few years. As depicted in the Exhibit above, the country requires a storage capacity of close to 50-60 GW with 4 hours of storage by FY2030 to meet the 4.0% ESO target, assuming a 5% growth in electricity consumption.
- The storage capacity is expected to be used to meet the evening peak demand, when solar power is not available and enable the grid operators to manage the variable generation associated with solar and wind resources. However, the development of storage capacities requires timely adoption and compliance to the ESO norms at the state level and improvement in cost economics for storage technologies like battery / pumped hydro.

Source: ICRA Research, ESO trajectory notified by MoP; Storage capacity estimates are based on 5% electricity consumption growth between FY2023-FY2030

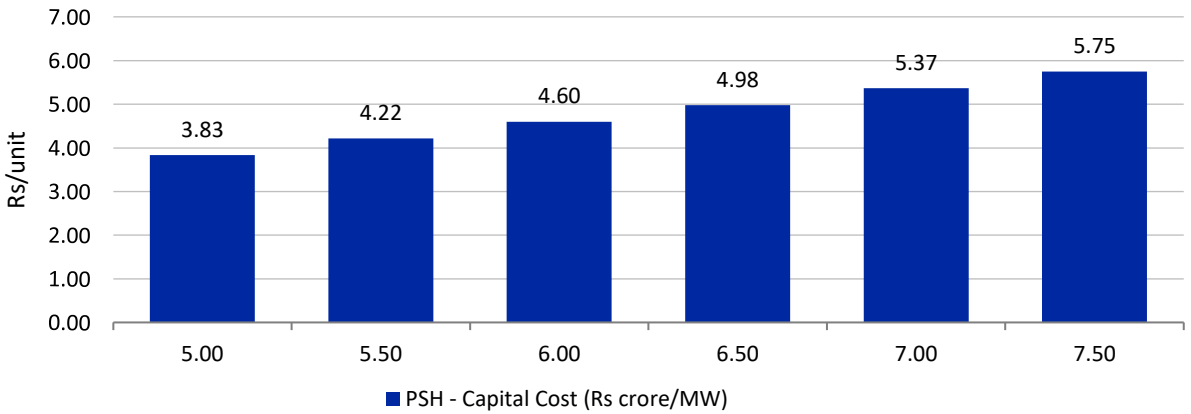
Draft guidelines for development of PSPs introduced in Feb 2023

	Reform	Impact
1	**Guidelines for Allotment of project sites** ▪ On nomination basis to CPSUs/ Through competitive bidding/ Tariff based competitive bidding	Impetus to public and private sector participation in development of PSPs
2	**Market Reforms** ▪ Monetisation of ancillary services ▪ Notification of Peak and Off-Peak tariffs for Generation ▪ Participation in HP-DAM (High Price – Day Ahead Market*) ▪ Transfer of un-contracted capacity to interested parties	To improve financial viability of PSPs and help bring down conversion tariff
3	**Financial Viability** ▪ Notification of benchmark cost for projects developed under Section 62 of Electricity Act, 2003 ▪ Reimbursement of SGST by State Govt, exemption of stamp duty and registration charges for land, govt land made available at concessional rates ▪ Exemption from free power, Local area development fund, double taxation	To enhance investment decision making To lower capital/ operating costs
4	**Additional Measures** ▪ Utilisation of exhausted mines to develop PSPs ▪ Rationalisation of Environmental Clearances for off-river PSPs ▪ Access to Green Finance	Increase available sites for development Reduce construction timelines Improve access to capital

**HP-DAM : CERC in its order dated 16th Feb 2023 has approved the introduction of HP-DAM in the Integrated Day Ahead Market segment in the Power Exchange*

Sensitivity of levelised cost of conversion of pumped storage hydro to capital cost

Exhibit 5: Sensitivity of levelized cost of conversion (does not include cost of energy required for pumping) to capital cost



- The generated energy and capital cost, key determinants of levelised tariff, cannot be standardised for pumped storage projects as the same depend upon the site-specific infrastructure, reservoir capacity, available head, size of machines and number of cycles.
- The conversion tariff should essentially be lower than the difference of peak and off-peak rates for the storage cost to be economical for the off-taker.
- For a project under cost-plus tariff guidelines which allow for an assured return of 16.5% and recovery of fixed costs subject to maintaining round-trip efficiency of 75%, the cumulative DSCR is estimated to remain comfortable i.e. above 1.55x in base case.

Assumptions:

Capacity	1000 MW
Generation Duration	8 hr
Storage Capacity	8000 MWhr
Annual Generation	2,508 MU
Round trip efficiency	75.0%
Days of operation	330
Aux Cons	1.20%
Project Life	40 years
Capital cost per MW	6.5
Debt: Equity	70:30
Cost of debt	9.00%
Debt repayment	12
Return on equity	16.5%
O&M Cost	3.5% of initial project cost
O&M Cost escalation	4.77% annually
Annual availability	95.0%

Source: ICRA Research / Industry sources

Source: ICRA Research

Sensitivity of DSCR of pumped storage hydro to conversion tariff and interest rates

EXHIBIT 7: Sensitivity of cumulative DSCR of pumped storage hydro to conversion tariff (including pumping energy) and interest rates

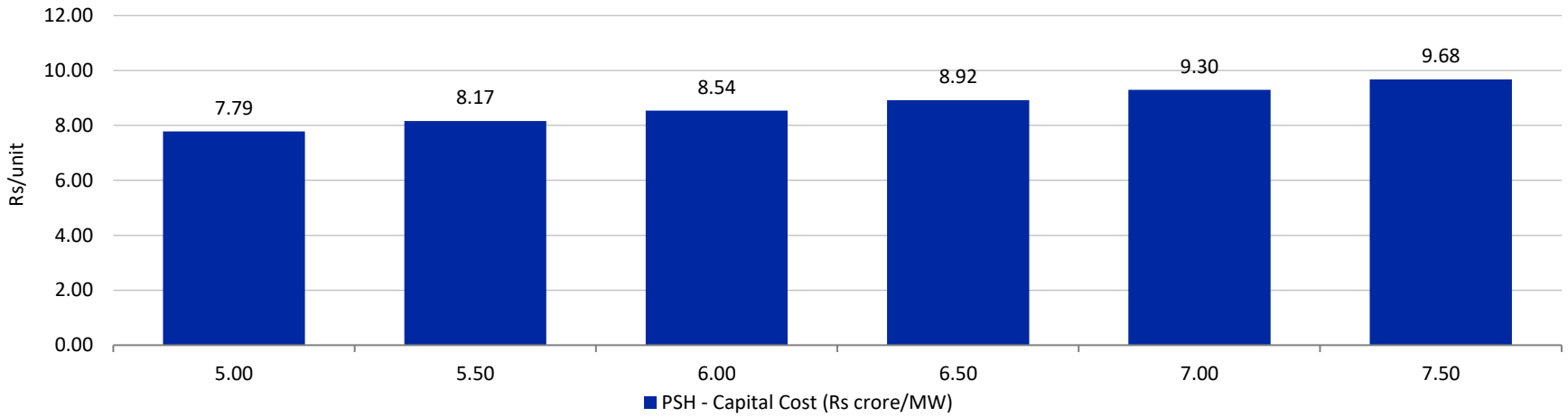
Cumulative DSCR		Interest Rates					
		8.0%	8.5%	9.0%	9.5%	10.0%	10.5%
Conversion tariff (does not include cost of energy required for pumping)	3.00	0.90	0.89	0.88	0.87	0.86	0.85
	3.50	1.06	1.05	1.04	1.03	1.01	1.00
	4.00	1.23	1.21	1.20	1.18	1.17	1.15
	4.50	1.40	1.38	1.36	1.34	1.32	1.30
	5.00	1.56	1.54	1.52	1.49	1.47	1.45
	5.50	1.73	1.70	1.68	1.65	1.63	1.60

- The exhibit here illustrates the sensitivity of cumulative DSCR of pumped storage hydro project over a 40-year period to varying levels of conversion tariff (does not include cost of energy required for pumping) and interest rates.
- Implementation of market reforms such as the regulatory clarity on the monetisation of various ancillary services as well as availability of energy exchange market for sale in High Price – Day Ahead Market (HP-DAM) if implemented, should further benefit the PSPs to improve their financial viability.

Source: ICRA Research; Assumptions: Tariff based on varying conversion tariff, Pumping energy at Rs 3.0 per unit and nil transmission charges; other assumptions same as shown earlier

Sensitivity of cost of storage of pumped storage hydro to capital cost per MW

EXHIBIT 8: Sensitivity of levellised cost of storage (including cost of energy required for pumping) with the capital cost of pumped storage hydro



- The exhibit here illustrates the levellised cost of storage over a 40-year period with respect to capital cost per MW. The cost of storage includes the cost of conversion as well as the cost of energy required for pumping operation. On a landed basis, the same is significantly higher than the average power purchase cost of distribution companies. However, this power will essentially be utilised for meeting peak demand and hence the tariff remains comparable.
- Implementation of measures proposed in the draft guidelines for pumped storage hydro projects will bring down the initial capital cost, provide additional revenue streams through monetisation of ancillary services and reduce operating costs (exemption from free power, double taxation). This will result in improvement in the competitiveness of the storage tariff.

Source: ICRA Research; Assumptions: Tariff based on CERC principles with storage capacity of 8000 MWhr, Pumping energy at Rs 3.0 per unit and nil transmission charges; other assumptions same as shown earlier

Sensitivity of cost of storage of pumped storage hydro to generation duration and capital cost per MW

EXHIBIT 9: Sensitivity of levellised cost of storage (including pumping energy) with the capital cost of pumped storage hydro project

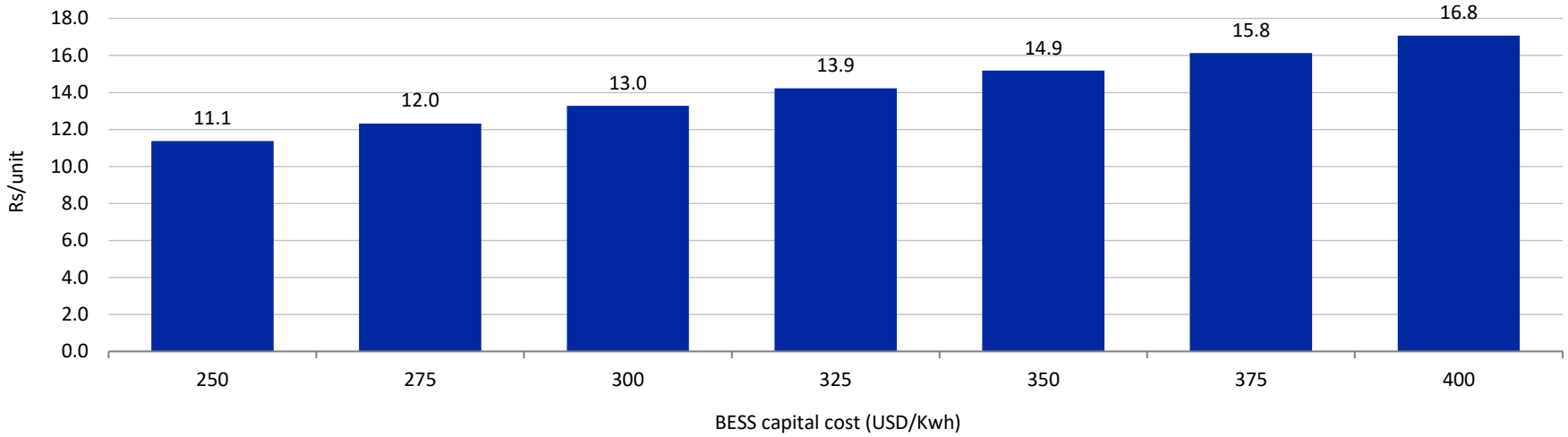
Levelized cost of storage (including cost of energy required for pumping)		Capital cost per MW					
		5.00	**5.50**	**6.00**	**6.50**	**7.00**	**7.50**
Generation Duration	**5.00**	11.63	11.75	11.88	12.01	12.16	12.31
	6.00	10.41	10.48	10.56	10.66	10.76	10.87
	7.00	9.53	9.57	9.63	9.69	9.76	9.83
	8.00	8.88	8.89	8.92	8.96	9.01	9.06
	9.00	8.37	8.37	8.38	8.39	8.42	8.46
	10.00	7.96	7.94	7.94	7.94	7.95	7.97

- The exhibit here illustrates the sensitivity of levelised cost of storage (including cost of energy required for pumping) of pumped storage hydro project over a 40-year period to varying levels of generation duration and capital cost per MW.
- It is to be noted that with the same reservoir capacity, higher generation can be achieved with multi-cycle operations and hence the increase in capital cost per MW would not be correlated with increase in generation duration.

Source: ICRA Research; Assumptions: Pumping energy at Rs 3.0 per unit and nil transmission charges; other assumptions same as shown earlier

Cost of storage remains relatively high at prevailing battery prices

EXHIBIT 8: Sensitivity of levellised cost of storage (over a 25-year period) with the capital cost of BESS



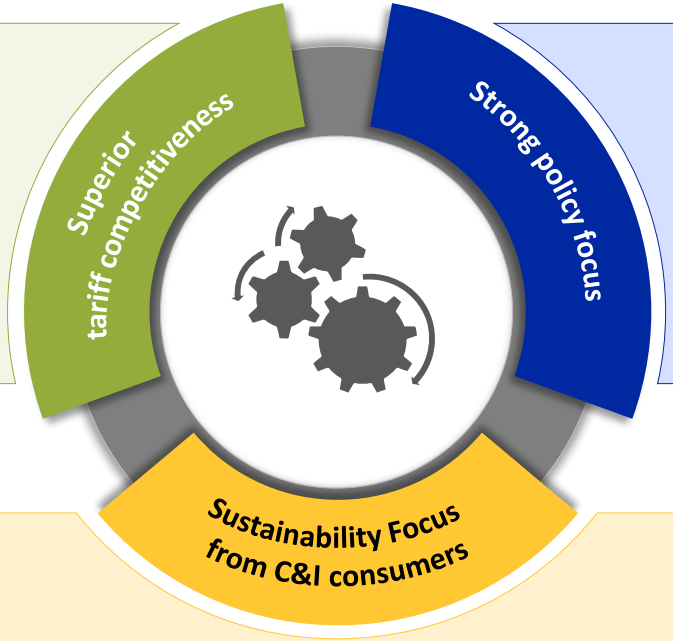
- The exhibit here illustrates the levelised cost of storage over a 25-year period using a BESS project at varying capital costs. Also, this assumes a return on equity of 15% to the equity holders and replenishment capex of 25% of initial capital cost at the end of the eighth year and 20% of initial capital cost at the end of the 16th year. This capex is assumed to be funded through a mix of debt and internal accruals. Overall, the cost of storage remains relatively high considering the prevailing cost of BESS.

Source: ICRA Research; Assumptions: Debt & equity funding of 75:25 with cost of debt at 9.0% and repayment over 18 years; O&M cost for BESS at 1% of capital cost; USD-INR at 80; round trip efficiency for BESS at 90%; replenishment capex assumed at the end of 8th and 16th year at 25% and 20% of initial capex

ICRA's outlook for renewable energy sector is Stable

Bid tariffs in solar & wind energy segment remain competitive (less than Rs. 3/unit) from discoms' perspective; lower against the marginal cost of power purchase for the discoms

RE tariffs (wind & solar) also remain competitive against high grid tariffs for C&I consumers



Highly supportive policy & regulatory framework. Government has set a target to achieve 500-GW non-fossil capacity by FY2030. Strong policy focus towards storage projects given the rising share of renewables and grid stability requirements. RPO and HPO trajectory notified till FY2030

Untapped solar, wind and PSP potential remains large at 748 GW, 695 GW and 62 GW respectively.

The presence of strong intermediate procurers like SECI and NTPC is supporting the growth of solar, wind and storage capacities despite the challenges associated with discoms' finances. Payment discipline from the discoms improved in recent past post the implementation of LPS rules

Sustainable initiatives by commercial & industrial users (C&I) to increase their consumption of green power is driving demand for RE capacity

Execution challenges, elevated module prices, supply chain concerns on equipment availability and interest rate hardening are the key headwinds for the developers in the near term

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Thank You!