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Modelling Investment Potential for Pumped Storage hydro Power (PSP) projects for Optimization and Grid Balancing

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Drivers for Pumped Storage hydropower Plants (PSP) installations

- *PSP installations world-wide (~168 GW) accounts for more than 96% of energy storage capacity*

- **Drivers for increasing number of PSP installations worldwide:**

  - Policy push for carbon-free generation

  - Integration of intermittent renewable energy (wind and solar) and enabling time-shift in their operations to balance peak & off-peak

  - In-adequate response time of existing base-load capacities to accommodate sharpening portion of daily load curve

  - Strong enabling environment (market for ancillary services, energy arbitrage opportunities as well as adequate compensatory tariffs in some geographies)

Why PSPs in India?

Increasing penetration of renewable energy, in-adequate response time and less flexibility of thermal capacities necessitated for storage solutions to support ancillary as well as time-shift operation of RE

Expected Demand-Supply Scenario necessitates the time-shift

Investment potential of nearly INR 150,000 Crores (Euro 2000 millions) for PSPs in select seven states (against 15 GW)

- *Andhra & Telangana : 2 GW*
- *Kerala : 3 GW*
- *Maharashtra : 2 GW*
- *Karnataka : 4 GW*
- *M.P : 2 GW*
- *T.N : 2 GW*

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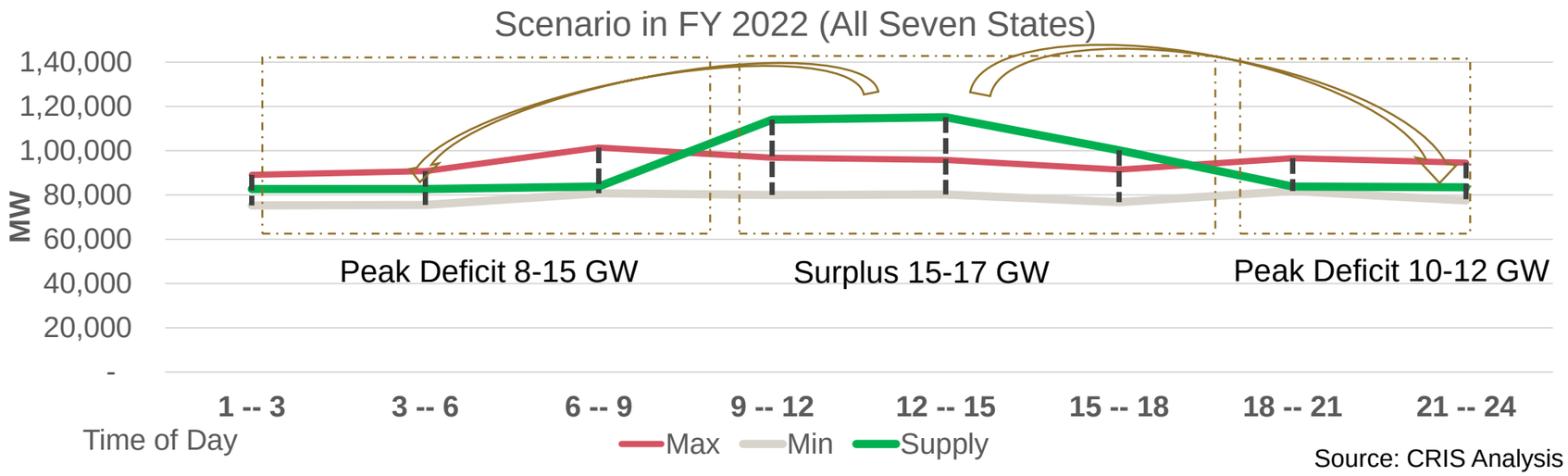
- **Demand-Supply scenario in select seven states (A.P., Telangana, Kerala, Maharashtra, Karnataka, M.P., and T.N.)**



Source: CRIS Analysis

- Considerable potential to shift surplus RE power (generating during off-peak) to meet peak demand (ranging from 1 GW to 4 GW)
- Extent of such shift can be matched with peak deficit
- Can be best managed at regional level to absorb surplus and return for ancillary & accommodate sharpening peaking curve

How much PSPs in select seven states?

15 GW of grid-scale storage preferably PSPs in select seven states (combined) required to absorb intermittency of RE by 2022

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Cost and Benefit of PSPs in Indian Scenario

- *PSPs able to utilise the surplus power (higher than the defined grid frequency) which is available during 10-15 minutes time slot*
- *Opportunity cost of not setting up a new peaking plant also plays a driving role for PSPs*

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Costs of PSPs

- Without PSPs, Power procured during off-peak period would not be a remunerative proposition (cost higher than recovery).
- PSPs can provide adequate time-shift from off-peak to peak thereby incentivizing utilities for peaking power management and grid balancing.

Cost Benefit Analysis (INR per unit)	Scenario 1	Scenario 2	Scenario 3
Two way transmission charges (max.)	1.60	-	1.60
Fixed Cost towards plant (CERC norms)	5.93	5.93	7.12
Total Cost per unit	**7.53**	**5.93**	**8.72**
	With transmission charges	**Without transmission charges**	**Higher Capital Cost (20%)**

Source: CRIS Analysis
Cost of PSP considered at Rs.10 Cr/ MW

- Cost of peaking source such as gas plants ranges from Rs.5.50 to 8.50/unit

Measure that can enable development of PSPs?

Recognition of role of storage, PSP could be made viable if two way transmission charges are waived off and strong push to develop ancillary service market

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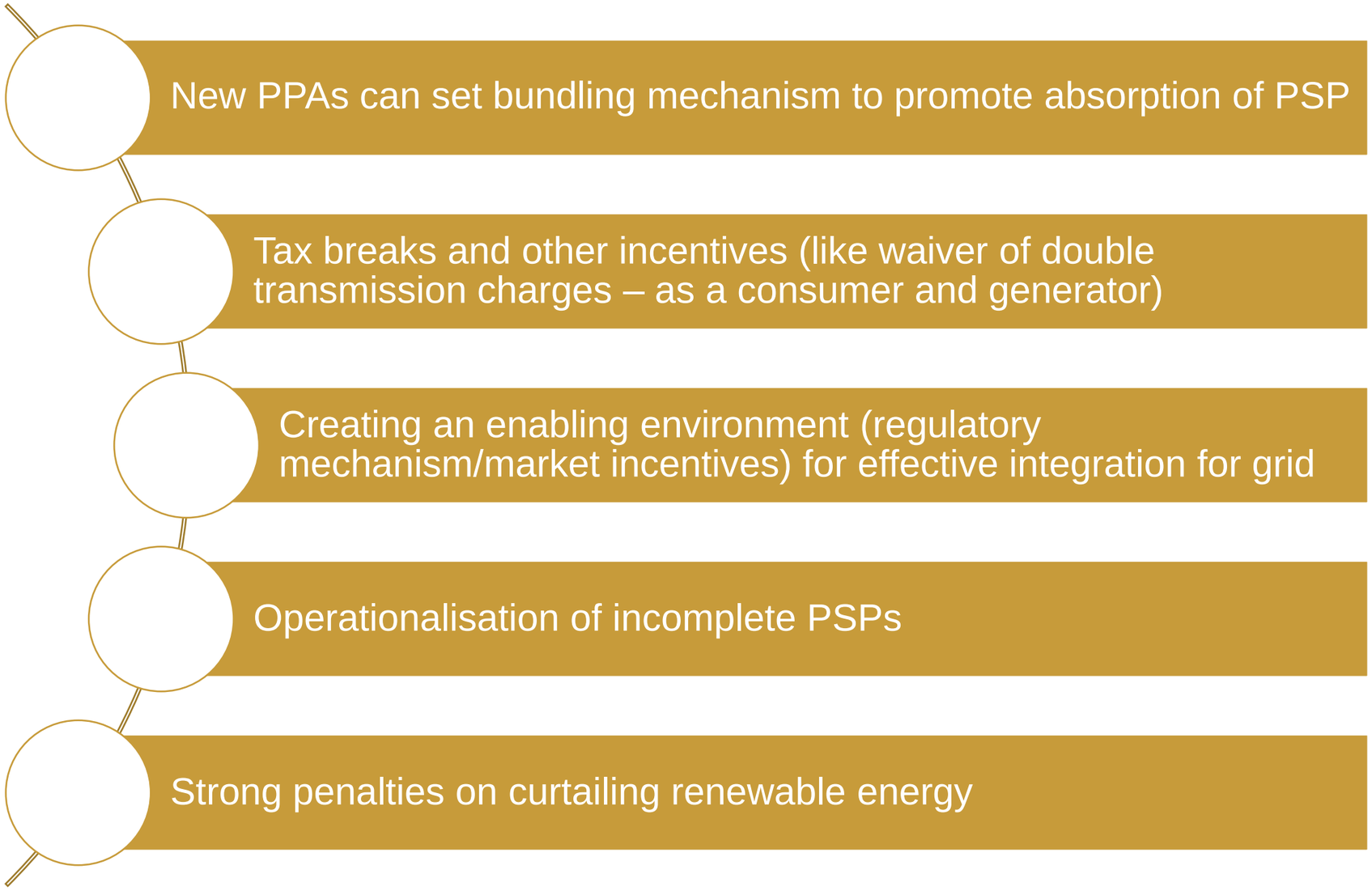
Identified measures

Creating an enabling environment and strong policy push help in developing storage market



Thank you

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Why storage and PSP in India ?

With considerable capacity addition in Renewables in the coming 5 years, the grid would require storage solutions to provide the much needed flexibility

- Renewable energy generated during off-peak hours need to be shifted during times of peak demand.
- Base load capacities are preferred for round-the clock supply and to maintain stable operations of grid especially in states with excess supply of wind (during night time) and solar (during day time).
- Decarbonizing sector requires new market design (i.e. critical aspect of RE integration is to maintain adequate reserves)
- Ancillary services growing as an important layer of centralised market to stabilise power network. Presently thermal power plants providing those services but takes about an hour to ramp-up.
- With increasing variability in the grid (~20% to 30%), there is a strong need for balancing of power requirement during peak and off-peak hours. Simultaneously maintaining a clean reserve (instead of thermal) to support ancillary services as well as back-up to store and return power.
- Adequate amount of power (above 50.02 Hz) is available at almost zero rate under 10-15 minutes slot that cause induction of reactive power in the grid. PSP can absorb reactive power/ return power to stabilise frequency and strengthen the grid.

Drivers for high PSP installations in key geographies

- Historically, considered for meeting fluctuating power demands in conjunction with nuclear power plants
- Strong policy push for carbon free generation
- Growth of variable renewable energy (~20% in power portfolio) warrants back-up
- Adequate compensation for performance (time-shift and ancillary services)

Particulars	Japan	China	USA	Europe
PSP Installations (in GW)				
Capacity	~ 27 GW	~23 GW	~ 22 GW	~51* GW
Drivers for development of Pumped storage plants				
Less-flexibility of nuclear	+	−	+	−
Integration of Renewable energy	+	+	+	+
Varied role in power network system	+	+	+	+
Defined ancillary service markets	−	−	+	+
Subsidies/Incentives	+	−	−	−
Policy support and Government push	+	+	+	+
Tariffs/Fixed rates to compensate PSP	+	+	−	−
Energy arbitrage	−	−	+	+

*Except Germany, grid fees for newly constructed PSP will be dropped for first ten years; While some have enacted above market rates feed-in tariffs to compensate for electricity generated from renewable sources