


PUMPED STORAGE PLANTS – ESSENTIAL FOR INDIA'S ENERGY TRANSITION

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FROM THE DESK OF DIRECTOR GENERAL

Pumped Storage Hydropower is a mature and proven technology and operational experience is also available in the country. CEA has estimated the on-river pumped storage hydro potential in India to be about 103 GW. Out of 4.75 GW of pumped storage plants installed in the country, 3.3 GW are working in pumping mode, and about 44.5 GW projects are at various stages of development.

TERI's discussion paper on "Roadmap to India's 2030 Decarbonization targets", July 2022, emphasizes the development of pumped storage plants in the country as the first priority amongst the energy storage systems. The paper spells out the ways in which the large-scale PSP capacity can be created in this decade to facilitate the achievement of India's ambitious goal of having 500GW of non-fossil fuel capacity by 2030.

Ministry of Power has, in April 2023, notified the guidelines to promote pumped storage projects.

The Report on "Pumped Storage Plants - essential for India's Energy Transition" recommends measures to contribute to the development of pumped storage projects in India.

Dr. Vibha Dhawan
Director General
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ACRONYMS AND ABBREVIATIONS

BBMB	Bhakra Beas Management Board
BESS	Battery Energy Storage System
BRO	Border Roads Organisation
CCEA	Cabinet Committee on Economic Affairs
CCGT	Combined-Cycle Gas Turbine
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CPSE	Central Public Sector Enterprises
CPSU	Central Public Sector Undertaking
CSS	Cross Subsidy Surcharge
CWC	Central Water Commission
DPR	Detailed Project Report
DVC	Damodar Valley Corporation
EC	Environment Clearance
ED	Electricity Duty
EIA	Environment Impact Assessment
EMP	Environment Management Plan
FC	Financing Charges
FC	Forest Clearance
FERC	Federal Energy Regulatory Commission
FRL	Full Reservoir Level
FWR	Far West Rand
GDAM	Green Day Ahead Market
GENCOs	Generating Companies
GTAM	Green Term Ahead Market
GW	Gigawatt
GWh	Gigawatt hour
HEP	Hydroelectric Power
HM	Hydro-Mechanical
HP-DAM	High price segment of the Day Ahead Market
HPO	Hydro Power Purchase Obligation
HPP	Hydro Power Projects
HRT	Head Race Tunnel
IDC	Interest During Construction
IHA	International Hydropower Association
IREDA	Indian Renewable Energy Development Agency

ISTS	Inter State Transmission System
JV	Joint Venture
kWH	Kilowatt Hour
LHPs	Large Hydro Power Projects
LoA	Letter of Award
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MNRE	Ministry of New & Renewable Energy
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MoU	Memorandum of Understanding
MU	Million Unit
MW	Megawatt
MWh	Megawatt Hour
NDC	Nationally Determined Contribution
NEEPCO	North Eastern Electric Power Corporation Limited
NEP 2023	National Electricity Plan, 2023
NHAI	National Highways Authority of India
NHPC	National Hydroelectric Power Corporation
NTPC	National Thermal Power Corporation
NTPC REL	NTPC Renewable Energy Ltd.
OCGT	Open Cycle Gas Turbine
O&M	Operation and Maintenance
PCKL	Power Company of Karnataka Limited
PFC	Power Finance Corporation
PGCIL	Powergrid Corporation of India Limited (POWERGRID)
PIB	Press Information Bureau
PMGSY	Pradhan Mantri Gram Sadak Yojana
POSOCO	Power System Operation Corporation Limited (now Grid Controller of India Limited since 9th November,2022)
PPA	Power Purchase Agreement
PSH	Pumped Storage Hydropower
PSP	Pumped Storage Project/Plant
PSU	Public Sector Undertaking
PTG	Pump-Turbine-Generator
PV	Photovoltaic
PWD	Public Works Department
R&R	Resettlement and Rehabilitation
RE	Renewable Energy
REC Limited	Formerly known as Rural Electrification Corporation Limited
REC	Renewable Energy Certificate

REO	Rural Engineering Organisation
RMB	Renminbi
RPO	Renewable Purchase Obligation
RTC	Round-the-clock
RWD	Rural Works Department
SECI	Solar Energy Corporation of India Limited
SERC	State Electricity Regulatory Commission
SGST	State Goods and Service Tax
SJVN	Formerly known as Satluj Jal Vidyut Nigam
SPV	Special Purpose Vehicle
SRRDA	State Rural Road Development Agency
TBCB	Tariff Based Competitive Bidding
TERI	The Energy and Resources Institute
THDC	Formerly known as Tehri Hydro Development Corporation Limited
TMC	Thousand Million Cubic Feet
ToR	Terms of Reference
TRT	Tail Race Tunnel
UMPP	Ultra Mega Power Project
UT	Union Territory
VRE	Variable Renewable Energy
WBERC	West Bengal Electricity Regulatory Commission
WBSEB	West Bengal State Electricity Board
WC	Wildlife Clearance

EXECUTIVE SUMMARY

India's commitment at COP26 held at Glasgow in 2021 was for creation of 500 GW non-fossil power generating capacity by 2030. In the TERI's discussion paper titled "Roadmap to India's 2030 Decarbonization targets", the creation of 500 GW non-fossil fuel capacity by 2030 was found to be feasible though challenging. The paper concluded that there is a need for large-scale energy storage, with highest priority being of Pumped Storage Projects (PSPs), which are essential for optimal utilization of the rapidly increasing solar capacity, reliable supply and grid stability.

This paper spells out the way in which the large-scale PSP capacity can be created in this decade to facilitate the achievement of the ambitious goal of having 500GW of non-fossil fuel capacity.

As per CEA, the current potential of 'on-river pumped storage' in India is 103 GW[1]. It is noted that out of 4.76 GW of installed capacity, 3.36 GW capacity is working in pumping mode, and about 44.5 GW including 34 GW off-river pumped storage hydro plants are under various stages of development. As PSPs are a cost-effective option for grid storage in India, storage may be developed through PSPs.

This Report traces the growth and status of pumped storage hydro plants in the world and India. Abandoned mine shafts in some of the countries fulfil the requirement of second reservoir for these plants. A brief account of their status in some of the countries provides the macroscopic view in this regard.

The Report suggests following measures for accelerating the development of PSPs across the country.

1. Development of on-river pumped storage plants
   a) Identification of new reservoir site for all existing hydro projects: run-of-the river and storage dams, may be examined to assess the feasibility for creating storage in the order of priority: as per cost per MW, minimal environmental impact, minimum requirement of R&R and minor structural modifications to connect it with new reservoir. Satellite/ drone based data (topographical maps using suitable scale) may be used for locating sites for reservoirs with adequate volume with minimum environmental & social effects.
   b) There is a requirement of initial thrust by State governments and central PSUs to generate momentum for PSP development.
   c) Creation of a revolving fund for project preparation through project specific SPVs would be useful for accelerating the development of PSPs.
2. Development of off-river pumped storage plants
   a) Developers may be given full freedom to identify sites and take these up for development after obtaining requisite clearances.
   b) Discarded mines including coal mines in different parts of the country could be used as hydro storage and thereby become natural enablers for the development of PSPs.
   c) Satellite-/ drone-based survey may be undertaken for locating the sites.

[1] MoP guidelines to promote development of Pumped Storage Projects, 10th April 2023

3. Bidding for competitively bid pumped storage plants
   a) For on-river PSPs, bids invited after assembling land, getting clearance from CEA for the DPR and Environmental Clearance from MoEFCC, would reduce the risk perception of the bidders, resulting in lower price bids.
   b) Capacities may be contracted through long term PPAs. The beneficiaries who have contracted the capacity also get the benefit of requisitioning despatch of contracted capacity as per their requirement of stored energy and would find this flexibility to their advantage.
   c) Bid process could adopt two alternatives: Capacity charge per MW or tariff for round-the-clock supply of electricity.
   d) Lessons learnt from SECI's bidding for RTC supply of electricity would improve bid process for RE plus PSP.
4. Off-river bid process – special features
   a) Keeping timeline as 120 days would provide the potential bidders enough time to locate sites, decide technology and optimal capacity. Increased competition will result in lower price bids.
   b) Bidders to have flexibility in capacity for which they would quote, with bid parameter remaining same: capacity charge or tariff for RTC supply of electricity.
5. The tariff for RE plus storage capacity with PSPs working out to be cheaper than new thermal power plants, these plants should assume first priority.
6. CEA has estimated a storage capacity of 74 GW by 2032. In order to achieve this target by 2032, completion of about 7,900 MW of PSPs per year is necessary. There is already sufficient interest in developers. The need is for bids to be invited and contracts awarded to ensure that storage capacities are created in time to match RE capacity creation. Standard bidding documents would put the development of pumped storage plants on fast track.

1. INTRODUCTION

At CoP 26 held in Glasgow in November 2021, India in a striking increase in its ambition over its Paris commitments declared that by 2030 it would create 500 GW of non-fossil power generating capacity. At that time India's installed generation capacity was 392 GW, its thermal capacity was 235 GW and non-fossil fuel capacity was 157 GW.

In the TERI discussion paper titled "Roadmap to India's 2030 Decarbonization Targets",* the creation of 500 GW non-fossil fuel capacity by 2030 was noted to be feasible though challenging.

The paper drew attention to the critical importance of the creation of large-scale energy storage capacity. Storage would be essential for the optimal utilization of the rapid increase in solar capacity that would need to be created. Storage would also be necessary for reliable supply and grid stability as the share of variable renewable energy (VRE) would go up sharply from the existing level of around 10%. Amongst storage options the paper concluded that Pump Storage Projects (PSPs) were the most attractive and should, therefore, be given the highest priority. This paper spells out the way in which large-scale PSP capacity can be created in this decade to facilitate the achievement of the ambitious goal of having 500GW of non-fossil fuel capacity and its optimal utilisation.

* (https://www.teriin.org/sites/default/files/files/Roadmap-to-India-2030-Decarbonization-Target.pdf

2. PUMPED STORAGE HYDROPOWER DEVELOPMENT

Pumped storage hydropower (PSH) projects were developed on a large scale in the twentieth century. These projects accounts for over 94 per cent of installed global energy storage capacity. The International Hydropower Association (IHA) estimates energy stored in the world's pumped storage reservoirs to be up to 9,000 gigawatt hour (GWh)[2].

During the period from 2014 to 2022, the Global pumped storage installed capacity increased with a CAGR of about 2.7%, as shown in Figure 1[3].

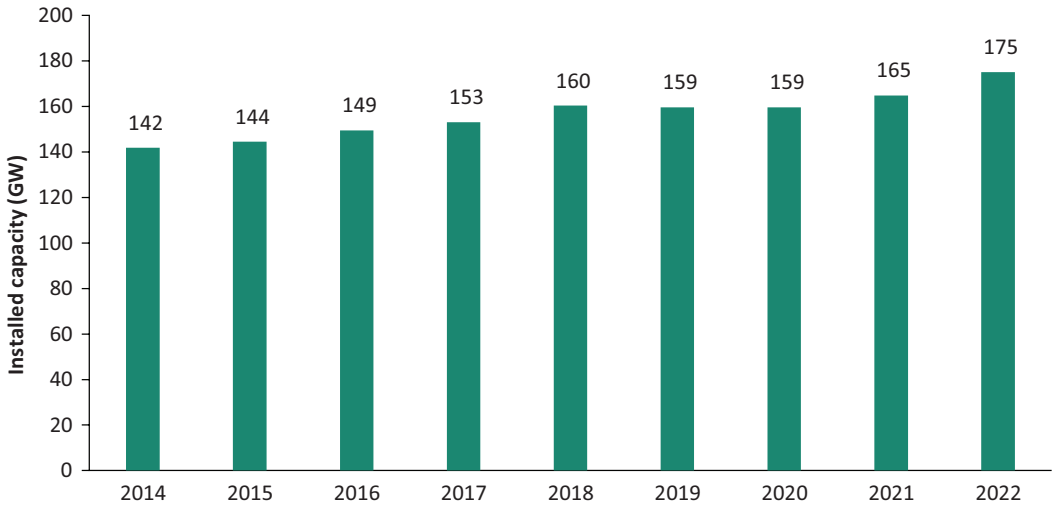

Figure 1: Growth of global pumped storage installed capacity, 2014-2022

Pumped storage hydropower is a mature and proven technology and operational experience is also available in the country. Pumped storage plants use the principle of gravity to generate electricity using water that has been previously pumped from a lower source to an upper reservoir.

The operation of pumped storage power plants requires two reservoirs viz. upper and lower reservoir. The water in the upper reservoir is used for generating power during peak demand hours. The water in the lower reservoir is pumped back to the upper reservoir during the off-peak hours and the cycle continues. The pumped storage plants are of two types: 'open loop', which has an associated natural-water source (like a river) for one or both the reservoirs; and 'closed loop' (or off-river PSH), which does not have a connected natural-water source and the same water is cycled between the two reservoirs for pumping and generation[4].

The energy storage capacity of a pumped hydro facility depends on the size of its two reservoirs and the head between the reservoirs, while the amount of power generated is linked to the size of the turbine.

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2 IHA working paper, December,2018: The world's water battery: Pumped hydropower storage and clean energy transition

3 IHA: Hydropower Status Reports

4 https://cstep.in/drupal/sites/default/files/2021-07/OP-ED%20Pumped%20Hydro%20Ammu%20and%20Rishu.pdf

2.1 Advantages of pumped storage plants[5]

Pumped storage plants can generate power continuously for long duration, depending on the storage capacity of the reservoir. These plants have a lifetime of over 40 years, and they operate with an efficiency of 70-80 per cent. Further, as compared to the conventional thermal generator, PSP has a the ability of quick start-stop as well as higher ramping capability (Table 1).

Table 1: Flexibility capabilities of typical thermal and pumped storage plants

Plant type	Pumped hydro storage	OCGT	CCGT	Coal-fired plants
Start-up time (cold start)	75 – 120 sec.	5-10 mins	120-240 mins	300-600 mins
Minimum load (% of P)	35 – 45%*	40-50%	40-50%	25-40%
Average ramp rate (% of P/min)	80 – 100%*	8-12%	2-4%	1-4%

Notes: * Minimum load and avg. ramp rate considered same as hydropower plants as no separate data for PSH is available; OCGT = open-cycle gas turbine, CCGT = combined-cycle gas turbine, P = power output

These features enable PSP to provide multiple services to the power grid. The high ramping capability helps it deal with the sudden increase of load in the power system. Furthermore, it can smoothen the sudden fluctuations in RE generation, and can also provide frequency and voltage support ancillary services.

In addition to these short-term grid services, PSH can cater to the seasonal mismatches in RE and load due to its bulk storage capability.

[5] TERI compilation from: Energies 2023: https://cstep.in/drupal/sites/default/files/2021-07/OP-ED%20Pumped%20Hydro%20Ammu%20and%20Rishu.pdf

3. GLOBAL SCENARIO

Around 175 GW of pumped hydro storage capacity is installed worldwide as of 2022, with leading countries being China with 44.7 GW, followed by Japan with 27.5 GW, and United States with 22 GW. The Figure 2 presents the status of PSH installed across countries having large storage capacities[6].

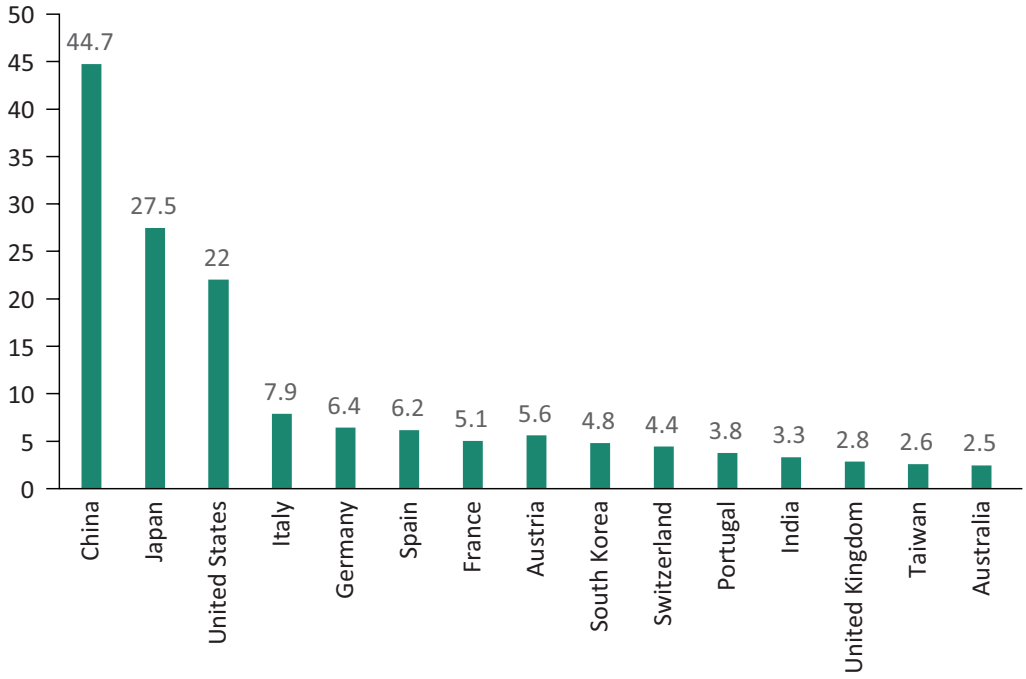

Figure 2: PSH installed across countries with large storage capacities

3.1 Role of pumped storage hydro in Japan[7]

Considering Japan's geography characterized by mountainous terrain and abundant water resources, emphasis was placed on hydroelectric and pumped storage technologies, using most available sites. Kyushu, the southernmost island among the main islands of Japan has one of the highest VRE shares in Japan. The surplus of solar energy generated is used to pump water to the upper reservoir in the island's PSH plants, and thermal power generation was curtailed to accommodate the large amount of solar energy.

As thermal power stations take anywhere from 2 to 8 hours to start, depending on the technology used, PSH hydropower generation was used during times of lower PV output to meet demand peaks. This helped maintain their efficiency and response times.

[6] Adapted from IHA: 2023 World Hydropower Outlook

[7] Adapted from "IEA: Hydropower; Energies; IRENA: Innovative Operation of PSH"

To keep the balance between supply and demand in case of VRE generation surplus, all transmission system operators in Japan have launched the so-called "Priority dispatching rule" as of 2016. The priority dispatching rule determines in what order power generation is dispatched down, or curtailed, in order to balance supply and demand. The rule consists of the following steps:

- Curtailment of fossil-fired power generation (coal, oil, and gas) and absorption of surplus VRE generation by pumping in PSH plants
- Export of VRE generation surplus to other areas through interconnection
- Curtailment of biomass power generation
- Curtailment of VRE generation (PV and wind)
- Curtailment of nuclear, geothermal and hydropower generation

In Kyushu, PSH plants have been operated following the rule to avoid curtailment of VRE generation, especially in light-load seasons (spring and autumn); pumping during day-time to absorb surplus VRE generation, and generating in the evening to provide electricity for corresponding demand. This includes variable speed PSH units, which are more flexible than conventional fixed-speed PSH plants and therefore particularly suitable for VRE integration.

The trend of pumped storage installed capacity in Japan from 2014 to 2022 is presented below.

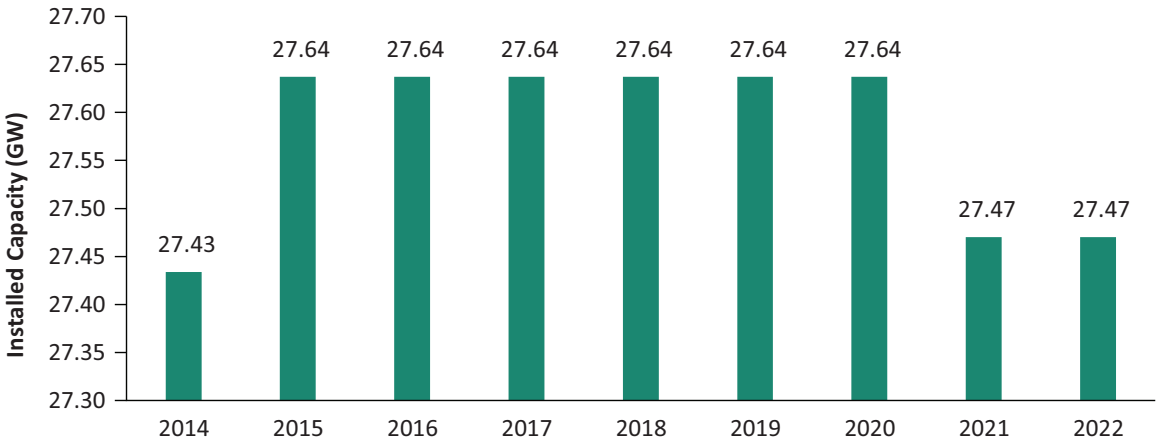

Figure 3: Trend of PSH capacity addition in Japan, 2014 to 2022

3.2 Development of pumped storage hydro in China

Policies issued by the governments and the concerned authorities at various levels placed importance on the energy storage technologies, especially pumped storage hydro. The *14th Five-Year Plan for Scientific and Technological Innovation in the Energy Sector* lists PSP technology as the primary field of innovation in energy storage technologies. It also points out that by 2025, these energy storage technologies will enter the stage of large-scale commercialization.

The National Development and Reform Commission has released a *Notice on Intensifying the Action Plan for Tariff Mechanism Reform during the 14th Five-Year Period* to accelerate the implementation of the tariff mechanism for PSH. The document titled *Opinions on Further Improving the Price Formation Mechanism of Pumped Storage* proposes competition-oriented electricity price formation and specifies the electricity price allocation mechanism for PSH.

So far, 23 provinces in China have released policies that urge the construction of energy storage facilities suitable for new energy generation. There is also a mandate for distributed energy distribution and storage. Building PSH plants in abandoned mine shafts are high on the agenda.

3.3 Current Status of PSH in Abandoned Mine Shafts in the World

The world's first PSH plant that utilizes an abandoned mine shaft was built in the Prosper-Haniel hard coal mine in Germany. This coal mine has a horizontal underground roadway that extends for approximately 25 km. The roadway depth is 1.2 km, and the water storage capacity reaches 1 million m^3. Germany also plans to build a fully underground PSH plant in Upper Harz, where an abandoned metal mine with a roadway with a diameter of 3.5m and depth of 760m is used as an underground reservoir. The reservoir capacity is estimated to be 250,000 m3, and the installed capacity is 100 MW.

In New Jersey, US, a semi-underground PSH plant of 1000MW capacity has been built in an abandoned iron-ore mine 760 m deep. The Eagle Mountain PSH project in California has been built by utilizing two abandoned mine pits, one upper and one lower, with an installed capacity of 1300 MW. The mine water inrush in the Asturian coal mine in Spain is exploited as the water source to build a semi-underground PSH plant. South Africa has converted an abandoned gold mine into a cascade PSH plant.

In China, a demonstration project was built in the Shenhua Daliuta coal mine in 2010. Thirty-two underground reservoirs have been completed by 2014, with a total capacity reaching 31 million m^3, making it the only underground reservoir group built in coal mines. In 2022, Shandong Province reportedly planned to invest a total of 3.3 billion RMB (0.46 billion USD) in building a 0.3 million-kW agro-optical complementary power station and a 0.2-million-kW PSH plant in the abandoned mine pits in Zichuan[8].

In Boston, Massachusetts-based Rye Development, a company active in hydropower sector, announced development of the 200 MW Lewis Ridge Closed Loop pumped hydropower storage project at a site of a former coalmine in Kentucky. The company has filed for a permit for the project with the Federal Energy Regulatory Commission (FERC). The company expects the FERC application process will take few years, while providing at least three-to-five-year construction process that would bring Lewis Ridge online by 2030. The project has proximity to transmission infrastructure[9].

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[8] https://www.mdpi.com/2071-1050/14/23/16012;https://www.engineering.pitt.edu/contentassets bc700956bb6044e09a12f9d4c61afe16/dazhao_gu_presentation.pdf

[9] https://www.powermag.com/former-coal-mine-will-house-new-pumped-hydro-storage-project/

4. SCENARIO IN INDIA

4.1 Status of Pumped Storage Development in India

As per CEA, the current potential of 'on-river pumped storage' in India is 103 GW[10]. It is noted that out of 4.76 GW of installed capacity, 3.36 GW capacity is working in pumping mode. About 44.5 GW including 34 GW off-river pumped storage hydro plants are under various stages of development. An overview of Pumped Storage development (on-river and off-river) as on 31st May, 2023[11] is shown in Table 2. Details of On-River and Off-River Schemes under construction are placed at Annexure-2.

Table 2: Status of Pumped Storage Development in India

Schemes	On-River		Off-River		Total	
	No. of Projects	Installed Capacity (MW)	No. of Projects	Installed Capacity (MW)	No. of Projects	Installed Capacity (MW)
1. Existing Schemes						
i. Working in Pumping Mode	6	3,306			6	3,306
ii. Presently not working in Pumping Mode	2	1,440			2	1,440
Sub-total	8	4,746			8	4,746
2. Schemes under Construction	3	1,580	1	1,200	4	2,780
3. DPRs Concurred by CEA	1	1,000			1	1,000
4. Under Examination	1	1,350			1	1,350
5. Schemes under Survey & Investigation	6	8,200	27	33,950	33	42,150
6. Schemes under Survey & Investigation held up	3	4,500	2	820	5	5,320
Grand Total	**22**	**21,376**	**30**	**35,970**	**52**	**57,346**

Nagarjunasagar, Kadana, Kadamparai, Panchet and Bhira were the earliest pumped hydro storage projects developed in the States from 1987 to 1995. Ghatghar and Purulia were developed in 2008 in Maharashtra and West Bengal respectively. Tehri PSH and Turga PSH are expected to be commissioned during 2023-24 and onwards. The details of these projects[11] are given in Table 3.

[10] MoP guidelines to promote development of Pumped Storage Projects, 10th April 2023

[11] CEA: Status of Pumped Storage Development in India, May 2023;

Table 3: Purulia, Ghatghar, Tehri & Turga Pumped Hydro Storage Projects: salient data

Sr. No.	Name of Project Capacity Agency	Capacity (MW)	Actual/Expected Commissioning	Cost of Project (Rs.Crore)	Cost of Project (Rs.Cr./MW)
1	Purulia PSH Project*, West Bengal	(4x225) = 900	2008	2952.60	3.28
2	Ghatghar PSH Project*, Maharashtra	(2x125) = 250	2008	1564.01	6.26
3	Tehri PSH Project#, Uttarakhand	(4x250) = 1000	Unit#1&2- March, 2023	4825.6	4.83
4.	Turga PSH Project**, West Bengal	(4x250) = 1000	2028-29	4800.69	4.80

Notes:

**43rd Report of the Standing Committee 2018-19;*

#THDC India Ltd. (https://thdc.co.in/en/content/tehri-pumped-storage-plant?qt-projects=0#qt-projects);

***WBERC Order dated 27.09.2021 for in-principle clearance for investment approval for installation and commissioning of 1000 MW Turga PSP*

The rate of sale of power in respect of Purulia pumped storage is Rs.6.89/kWh[12] for the year 2020-21 as approved by WBERC.

4.2 Upcoming Pumped Storage Hydropower Plants

Kurukutti PSH (1200 MW)[13] being developed by M/S Adani Green Energy and MP30 Gandhi Sagar PSP (1440 MW)[14] being developed by M/s Greenko Energies Pvt. Ltd. are planned to be set up in Andhra Pradesh and Madhya Pradesh respectively.

Kurukutti PSH: As per the Feasibility Report the proposed Kurukutti PSH envisages recycling of stored water between upper and lower reservoirs and requires filling of reservoirs only once in its lifetime. Further, a small quantity of water will be used annually to replenish the water lost due to evaporation and transit losses. The water requirement towards recuperation of losses will be done during monsoon season, when the flows are substantial.

Kurukutti PSH envisages a scheme to generate 1200 MW of peak power during week days by drawing water from the upper reservoir into reversible pump-turbine-generator (PTG) units by utilizing a gross head of about 589 m available between upper and lower reservoirs. Water will be pumped up to the upper reservoir in pumping mode during off-peak periods on week days and during extended periods on Sundays. A weekly cycle of operation of the reservoirs has been proposed for the scheme and it is found that about 11 Mm^3 of net storage is required for the weekly cycle. The tariff calculation of Kurukutti PSH project is provided at Appendix-1.

The estimated project cost is Rs.4766 crore (Rs.3.97 Cr./MW) including interest during construction (IDC) & financing charges (FC) at 2020-21 price level. The levelized cost of generation has been estimated to be Rs.7.85/kWh, considering the cost of pumping as Rs.3.0/kWh. The project is likely to be commissioned by December, 2028[15].

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12 CEA: Executive Summary on Power Sector, November 2022

13 Adapted from Feasibility Report of Kurukutti PSP (1200 MW), Andhra Pradesh-August 2021

14 Adapted from Feasibility Report of MP30 Gandhi Sagar Off-Stream PSP (1440 MW)-November 2020

15 Business Standard, June 2022

MP30 Gandhi Sagar PSH: As per the Feasibility Report, MP30 Gandhi Sagar PSH, an off-stream Pumped Storage Project of 1440 MW/ 10411.2 MWh storage capacity, will comprise of two reservoirs i.e., Gandhi Sagar lower reservoir (already existing) and MP30 Gandhi Sagar Upper Reservoir (to be constructed newly). This scheme envisages non-consumptive re-utilization of 1.22 TMC of water of Gandhi Sagar reservoir by recirculation. The water in Gandhi Sagar reservoir (existing lower reservoir) will be pumped up and stored in the proposed Off-stream Pumped Storage Project of MP30 Gandhi Sagar Upper reservoir and will be utilized for power generation. The gross storage capacity of Gandhi Sagar reservoir is 258.47 TMC. The estimated Project Cost is Rs.6991.25 crore (Rs.4.86 Cr./MW). The project is expected to be commissioned by December, 2024[16].

The features of Kurukutti PSH and MP30 Gandhi Sagar PSH are presented in Table 4.

Table 4: Features of Kurukutti and MP30 Gandhi Sagar PSH

Parameters	Kurukutti PSH	MP30 Gandhi Sagar PSH
1. Location		
i) Upper Dam & Lower Dam	Andhra Pradesh	Madhya Pradesh
2. Full Reservoir Level (FRL) (m)		
i) Upper Dam (m)	899	523
ii) Lower Dam (m)	306	400
3. Capacity		
i) Installed Capacity (MW)	5x240 = 1200	5x240+2x120 = 1440
ii) Storage Capacity (MWh)	8400	10,411.2
4. Electro-Mechanical Equivalent		
i) Pump Turbine -Type	Vertical Reversible Francis Pump Turbine	Francis type, vertical shaft reversible pump-turbine
ii) Daily hours of generation	Week days: 7 hours, Sunday: 0	7.23 hours
iii) Daily hours of pumping	Week days: 7 hours, Sunday: 8 hours	8.60 hours
iv) Expected Cycle Efficiency	76%	80%
5. Annual Power		
i) Annual generation (MU)	2527	3612
ii) Annual Pumping (MU)	3308	4515
iii) Conversion loss	24%	20%
6. Project Cost (Rs. Cr.)		
i) Civil & Hydro-Mechanical (HM) works	1279	2797.67
ii) Electro mechanical works	2400	1930.5
iii) Power Evacuation	73	-
iv) Other Costs	476	-
7. Total cost (including FC)	**4228**	**4728.17**
IDC	538	2263.08
Total cost (Rs. Cr.)	4766	6991.25
Total cost (Rs. Cr./MW)	3.97	4.86
Conversion Cost (excluding pumping cost) Levelized (Rs./kWh)	3.81	-
Conversion Cost (including pumping cost) Levelized (Rs./kWh)	7.85	-

[16] Business Standard, January 2023

4.3 PSP Development Initiatives

In order to meet India's commitment of achieving non-fossil energy-based capacity to 500 GW by 2030, various policy measures to promote growth and investments have been initiated by the Government of India and State Governments. The key initiatives are briefly described in this section.

Formulation of Detailed Project Reports for PSPs

CEA issued the "Guidelines for Formulation of Detailed Project Reports for Pumped Storage Schemes" in August, 2022, which was modified in June 2023. Potential PSP developers may follow the guidelines for speedy preparation of DPRs once the site selection has been done by them.

Proposed projects and development initiatives

The Government of Andhra Pradesh approved, in June 2022, pump storage projects proposed by Adani Green Energy with a total capacity of 3,700 MW to be set up in four districts of the state. The projects are likely to be commissioned in December 2028[17].

In December 2022, Greenko won a technology agnostic tender of NTPC Renewable Energy Ltd. (NTPC REL) to provide 500 MW/3,000 MWh of standalone storage capacity for a period of 25 years[18]. The tariff was equivalent to US$58/MWh (~Rs.4.80/kWh) on the basis of the pumped hydroelectric storage plant performing a single daily cycle. Taking into account the fact that pumped storage project can deliver more than one cycle per day without any impact on the performance, effective storage charges can be significantly lower at $29/MWh (~Rs.2.40/kWh), with two cycles of pumping per day.

In March 2023, the Power Company of Karnataka (PCKL) awarded contracts to JSW Neo Energy (JSW Energy) and Greenko KA 01 IREP (Greenko) for providing 1 GW of electricity of 8 hours per day from pumped hydro storge projects that offer continuous 5-hour discharge. JSW Neo Energy won 300 MW by quoting Rs.14.75 million, while Greenko got balance 700 MW by quoting Rs.14.76 million. The bidders will sign PPA with PCKL that are valid for 40 years[19].

In June 2023, a MoU was signed between NHPC Ltd. and the Department of Energy, Government of Maharashtra for the development of pumped storage schemes and other renewable energy projects in Maharashtra. The MoU envisages development of four pumped storage projects aggregating 7,350 MW (1,150 MW at Kalu, 2,250 MW at Savitri, 2,400 MW at Jalond and 1,550 MW at Kengadi)[20].

In August 2023, Tata Power and the Government of Maharashtra have signed a MoU to develop two large Pumped Hydro Storage projects (PHS) with a combined capacity of 2,800 MW in the state. These projects, with an estimated investment of approximately Rs.13,000 Cr. will be situated at Shirawata, Pune (1,800 MW) and Bhivpuri, Raigad districts (1,000 MW)[21].

Ministry of Power released the final guidelines to promote development of Pump Storage Projects (PSPs) in the country on 10th April, 2023 with an aim to create the framework needed to promote the development of new pumped storage projects across the country.

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17 The Economic Times, 24.07.2023

18 https://www.energy-storage.news/greenko-wins-ntpc-energy-storage-tender-in-india-with-pumped-hydro-proposal/

19 https://www.constructionworld.in/energy-infrastructure/power-and-renewable-energy/1-gw-of-pumped-storage-projects-in-karnataka-won-by-jsw-and-greenko/39811

20 https://www.powerengineeringint.com/energy-storage/nhpc-signs-pumped-storage-mou-in-maharashtra/

21 https://www.tatapower.com/media/PressReleaseDetails/2041/tata-power-signs-mou-with-the-government-of-maharashtra-for-development-of-2800-mw-of-pumped-hydro-storage-projects

As per the National Electricity Plan, 2023 (NEP 2023), the capacity of storage has been estimated as 73,930 MW by 2031-32. Considering 2,780 MW of PSPs under construction PSPs reaching the above target by 2032, will require capacity addition of about 7,900 MW per year, for which the tendering process to be accelerated to select bidders for developing PSPs.

Tata Power and NHPC's signing of MoU with Maharashtra for developing of 2.8 GW and 7.4 GW of pumped storage plants respectively, Karnataka's award for developing 1 GW of PSPs in the state and implementation of 500 MW/3,000 MWh standalone energy storage, etc., would provide meaningful learning. About 10.5 GW of on-river and about 34 GW off-river pumped storage schemes are at various stages of development. Developers will have about 45 GW of PSPs to be developed across the country. Lessons from the already awarded projects will pave way for the developers to set-up the PSPs in future.

Ministry of Power guidelines

Ministry of Power, vide Notification no.15-14/9/2022-H-II (Part) dated 10th April, 2023, released the guidelines (Annexure-3) to promote development of Pump Storage Projects (PSPs) in the country, after taking into consideration the comments/ suggestions received from the stakeholders. The salient provisions of the guidelines are given below:

1. Allotment of project sites
    a. On nomination basis to CPSUs and State PSUs
    b. Allotment through competitive bidding
    c. Allotment through tariff based competitive bidding
    d. Self-Identified off-stream Pumped Storage Projects
2. Timelines for Start of Construction work after award of Project
3. No Upfront Premium for Project Allocation
4. Market reforms
5. Financial Viability
6. Taxes and duties
7. Exemption from Free Power Obligation
8. Local Area Development Fund
9. Utilization of exhausted mines to develop PSPs
10. Rationalization of Environmental Clearances for PSPs
11. Green Finance

Environmental clearances

Ministry of Environment, Forest and Climate Change (MoEFCC) issued a notification on 18th May, 2023 amending their earlier notification of 2006 regarding requirement of prior Environmental Clearances for Pump Storage Projects. PSP developers may interact with the MoEFCC for clarifying issues related to Environmental Clearances required for developing PSPs.

5. WAY FORWARD

The following measures are recommended for accelerating the development of PSPs across the country:

A) Development of on-river pumped storage hydro projects

1. Identification of new sites

All existing hydro projects: run-of-the river and storage dams, may be examined to assess the feasibility for creating storage. These may be ranked in order of priority. The cost per MW is the natural criteria for ranking of PSPs on existing reservoirs of HEP schemes. In addition, having minimal environmental impact, minimum Resettlement and Rehabilitation (R&R) and requirement of minor structural modifications to connect it with new reservoir should also be key criterion for ranking.

Suitable sites may be located using satellite/ drone-based data (topographical maps using suitable scale) for reservoir and dam with adequate reservoir volume with minimum environmental & social effects (avoiding forests, natural parks, historical & cultural heritage sites, areas with high population density).

2. Implementation of projects

i) **Initial thrust:** State governments and central PSUs may take up a few projects through their Undertakings to generate momentum for PSH development.

ii) **Acceleration:** Competitive bidding as described in the succeding sub-sections would accelerate development of grid-scale storage projects and discovery of price based on the learning.

iii) **Creation of a revolving fund for project preparation through project specific SPVs:** A Revolving Fund may be created by the Ministry of Power through PFC and REC for site investigation, preparation of project details, assembly of land and for obtaining environment and forest clearances, etc., for river projects. These projects could then be bid out for development. The expenses incurred for project preparation may then be recovered from the selected developer. Project specific Special Purpose Vehicles (SPVs) may be created for this purpose as was done for Ultra Mega Power Projects (UMPPs).

B) Development of off-river pumped storage hydro projects

1. Facilitating implementation

The off-river projects may be easier to develop speedily. These have the advantages in terms of wider choice for sites, lower cost, shorter construction period (2-4 years) and minimal environmental impact. These should be considered as RE projects and not like the conventional hydro power projects. Developers may be given full freedom to identify sites and take these up for development after obtaining requisite clearances.

2. Utilization of exhausted mines

Discarded mines including coal mines in different parts of the country could be used as hydro storage and thereby become natural enablers for development of PSPs. Indian Bureau of Mines have already identified 82 such abandoned mines, which may be utilized as reservoirs. International experience may be gathered in this respect.

C) Bidding for pumped storage projects

1. Bidding for competitively bid PSPs

For on-river PSPs: maximum percentage of energy loss in pumping operation (or the percentage of input electricity to be supplied on demand after storage through pumping), number of pumping cycles per day, number of hours for which supply will be required on demand may be firmed up. Bids may be invited after assembling land, getting clearance from CEA for the DPR and Environmental Clearance from MoEFCC. This would reduce the risk perception of the bidders, resulting in lower price bids.

In the bid process two alternative parameters for choosing L1 could be adopted as below:

(i) Capacity charge per MW: Capacities may be contracted through long term PPAs. The O&M charges forming a part of the capacity charge may be in the form of annuity payment with annual escalation at specified levels of availability. The input electricity would be provided and stored electricity taken back by the PPA contracting party - the Discoms or the Generating Companies (GENCOs). This would reduce bidder's risk perception and should result in lower price bids. The beneficiaries who have contracted the capacity also get the benefit of requisitioning despatch of contracted capacity as per their requirement of stored energy and would find this flexibility to their advantage.

(ii) Tariff for round-the-clock supply of electricity

This would be similar to the process followed by SECI for its round-the-clock supply of electricity.

Lessons learned from the round-the-clock contracts for supply of RE power with storage may be used for improving the bid process for RE plus PSP in consultation with the prospective bidders.

D) Bidding for off-river pumped storage plants

The timeline for bidding may be kept as 120 days. This will provide the potential bidders enough time to locate sites and decide the technology and optimal capacity. This will increase competition and result in lower price bids. This will also reduce the time needed for completion of the project after the award of the contract as the site and technical details would have been finalized during the bid process.

For off-river PSPs power capacity is determined by the chosen site. To have greater competition bidders should have flexibility in the capacity for which they would quote. The bid parameter would remain the same—capacity charge or tariff for round-the-clock supply.

Hence, the bidder could bid for any capacity up to 150 MW. L1 may be chosen and contracts awarded for the capacities offered.

6. CONCLUSION

- The tariff discovered for 500 MW/ 3,000 MWh of standalone storage capacity was equivalent to Rs.4.80/ kWh on the basis of PSP performing a single daily cycle. With two cycles per day, the effective storage charge would be Rs.2.40/kWh.
- The tariff of power to be procured by SECI from a 500 MW/ 1000 MWh standalone Battery Energy Storage System (BESS) is Rs. 10.84/kWh.
- As PSPs are cheaper than BESS, grid storage may be developed through PSPs.
- The tariff of RE plus storage capacity with PSPs working out to be cheaper than the tariff of new thermal power plants, these plants should become first choice purely on commercial considerations.
- CEA has estimated the requirement of storage capacity of 74 GW by 2032. In order to achieve this target by 2032, completion of about 7,900 MW of PSPs per year is necessary. There is already sufficient interest in developers. The need is for bids to be invited and contracts awarded to ensure that storage capacities are created in time to match RE capacity creation.
- Standard bidding documents may be developed for accelerating the implementation of PSPs.

[22] CEA Monthly Report, March 2023

ANNEXURE-1

Table 5: Kurukutti PSH tariff calculation

ANNUAL GENERATION Av.Yr.(GWh)			2527.00	TOTAL COST OF PROJECT INCLUDING IDC (Rs.In Cr.)					4766.00			INTEREST RATE ON WORKING CAPITAL					10.50%
AUXILIARY CONSUMPTION (1.20%)			30.32	COST OF POWER COMPONENT INCLUDING IDC (Rs.In Cr.)					4766.00			RATE OF O&M CHARGES					3.50%
BALANCE AVILABLE AT BUS BAR			2496.68	DEBT (Rs.In Cr.)					3336.20			ANNUAL INCREMENT OF O&M CHARGES					4.77%
				EQUITY (Rs.In Cr.)					1429.80			SPARES CHARGES (In %age of O&M CHARGES)					15.00%
ENERGY AVIALABLE			2496.68	DEBT : EQUITY				70	30								
				WEIGHTED AVERAGE RATE OF INTEREST					10.50%			RATE OF DEPRECIATION					5.28%
ENERGY AVAILABLE FOR SALE			2496.68	LOAN REPAYMENT PERIOD					Match with Depreciation			RATE OF RETURN ON EQUITY(up to 18 years)					22.060%
Annual Pumping Energy (GWh)			3308.00									RATE OF RETURN ON EQUITY(After 18 years)					22.060%
Pumping Cost			3.00									DISCOUNTING FACTOR					10.45%

Sl No	OUTSTANDING LOAN	INTEREST ON LOAN	DEPRECIATION	REPAYMENT OF LOAN (HALF YEARLY BASIS)	RETURN ON EQUITY	O&M CHARGES	O&M CHARGES FOR 1 MONTH	2 (Two) MONTHS BILLING	SPARES	WORKING CAPITAL	INTEREST ON WORKING CAPITAL	PUMPING COST	TOTAL CHARGES	SALEABLE ENERGY	TARIFF (Paise/unit)	DISCOUNTING FACTOR	DISCOUNTED TARIFF (Paise/unit)
1	2	3	4	5	6	7	8	9	10	11=(8+9+10)	12	13	14	15	16	17	18
1	3326.20	336.04	251.64	251.64	315.27	147.98	12.33	347.24	22.20	381.77	40.09	992.40	2083.42	2496.68	834.48	1.00	834.48
2	3074.56	309.62	251.64	251.64	315.27	155.04	12.92	343.98	23.26	380.16	39.92	992.40	2063.89	2496.68	826.65	0.91	748.44
3	2822.91	283.19	251.64	251.64	315.27	162.43	13.54	340.78	24.37	378.69	39.76	992.40	2044.71	2496.68	818.97	0.82	671.33
4	2571.27	256.77	251.64	251.64	315.27	170.18	14.18	337.65	25.53	377.36	39.62	992.40	2025.89	2496.68	811.44	0.74	602.22
5	2319.62	230.35	251.64	251.64	315.27	178.30	14.86	334.58	26.74	376.18	39.50	992.40	2007.46	2496.68	804.05	0.67	540.28
6	2067.98	203.93	251.64	251.64	315.27	186.80	15.57	331.57	28.02	375.16	39.39	992.40	1989.44	2496.68	796.83	0.61	484.77
7	1816.33	177.50	251.64	251.64	315.27	195.72	16.31	328.64	29.36	374.31	39.30	992.40	1971.84	2496.68	789.78	0.55	435.03
8	1564.69	151.08	251.64	251.64	315.27	205.05	17.09	325.78	30.76	373.62	39.23	992.40	1954.68	2496.68	782.91	0.50	390.44
9	1313.04	124.66	251.64	251.64	315.27	214.83	17.90	323.00	32.22	373.12	39.18	992.40	1937.98	2496.68	776.23	0.45	350.48
10	1061.40	98.24	251.64	251.64	315.27	225.08	18.76	320.30	33.76	372.81	39.15	992.40	1921.78	2496.68	769.73	0.41	314.67
11	809.75	71.81	251.64	251.64	315.27	235.82	19.65	317.68	35.37	372.70	39.13	992.40	1906.08	2496.68	763.45	0.37	282.57
12	558.11	45.39	251.64	251.64	315.27	247.06	20.59	315.15	37.06	372.80	39.14	992.40	1890.91	2496.68	757.37	0.34	253.80
13	306.46	29.50	251.64	51.08	315.27	258.85	21.57	314.50	38.83	374.90	39.36	992.40	1887.03	2496.68	755.82	0.30	229.31
14	255.39	24.13	251.64	51.08	315.27	271.20	22.60	315.74	40.68	379.02	39.80	992.40	1894.44	2496.68	758.79	0.27	208.43
15	204.31	18.77	251.64	51.08	315.27	284.13	23.68	317.08	42.62	383.38	40.25	992.40	1902.47	2496.68	762.00	0.25	189.51
16	153.23	13.41	251.64	51.08	315.27	297.69	24.81	318.52	44.65	387.98	40.74	992.40	1911.15	2496.68	765.48	0.23	172.36
17	102.15	8.04	251.64	51.08	315.27	311.88	25.99	320.08	46.78	392.86	41.25	992.40	1920.49	2496.68	769.22	0.20	156.82
18	51.08	2.68	11.44	51.08	315.27	326.76	27.23	281.01	49.01	357.26	37.51	992.40	1686.06	2496.68	675.32	0.18	124.65
19	0.00	0.00	0.00	0.00	315.27	342.35	28.53	281.32	51.35	361.21	37.93	992.40	1687.95	2496.68	676.08	0.17	112.98
20			0.00		315.27	358.68	29.89	284.16	53.80	367.85	38.62	992.40	1704.97	2496.68	682.90	0.15	103.33
21			0.00		315.27	375.79	31.32	287.14	56.37	374.82	39.36	992.40	1722.81	2496.68	690.04	0.14	94.53
22			0.00		315.27	393.71	32.81	290.25	59.06	382.12	40.12	992.40	1741.51	2496.68	697.53	0.12	86.51
23			0.00		315.27	412.49	34.37	293.51	61.87	389.76	40.93	992.40	1761.09	2496.68	705.37	0.11	79.21
24			0.00		315.27	432.17	36.01	296.93	64.83	397.77	41.77	992.40	1781.60	2496.68	713.59	0.10	72.55
25			0.00		315.27	452.78	37.73	300.52	67.92	406.17	42.65	992.40	1803.10	2496.68	722.20	0.09	66.48
26			0.00		315.27	474.38	39.53	304.27	71.16	414.96	43.57	992.40	1825.62	2496.68	731.22	0.08	60.94
27			0.00		315.27	497.01	41.42	308.20	74.55	424.17	44.54	992.40	1849.22	2496.68	740.67	0.08	55.89
28			0.00		315.27	520.72	43.39	312.32	78.11	433.82	45.55	992.40	1873.94	2496.68	750.57	0.07	51.28
29			0.00		315.27	545.55	45.46	316.64	81.83	443.94	46.61	992.40	1899.84	2496.68	760.95	0.06	47.07
30			0.00		315.27	571.58	47.63	321.16	85.74	454.53	47.73	992.40	1926.97	2496.68	771.82	0.06	43.22
31			0.00		315.27	598.84	49.90	325.90	89.83	465.63	48.89	992.40	1955.40	2496.68	783.20	0.05	39.71
32			0.00		315.27	627.41	52.28	330.86	94.11	477.26	50.11	992.40	1985.19	2496.68	795.13	0.05	36.50
33			0.00		315.27	657.33	54.78	336.07	98.60	489.44	51.39	992.40	2016.39	2496.68	807.63	0.04	33.57
34			0.00		315.27	688.69	57.39	341.51	103.30	502.21	52.73	992.40	2049.09	2496.68	820.73	0.04	30.88
35			0.00		315.27	721.54	60.13	347.22	108.23	515.58	54.14	992.40	2083.34	2496.68	834.45	0.03	28.43
36			0.00		315.27	755.96	63.00	353.21	113.39	529.60	55.61	992.40	2119.23	2496.68	848.82	0.03	26.18
37			0.00		315.27	792.01	66.00	359.47	118.80	544.28	57.15	992.40	2156.83	2496.68	863.88	0.03	24.13
38			0.00		315.27	829.79	69.15	366.04	124.47	559.66	58.76	992.40	2196.23	2496.68	879.66	0.03	22.24
39			0.00		315.27	869.37	72.45	372.92	130.41	575.77	60.46	992.40	2237.50	2496.68	896.19	0.02	20.52
40			0.00		315.27	910.84	75.90	380.12	136.63	592.65	62.23	992.40	2280.74	2496.68	913.51	0.02	18.93
			4289.40	3326.20												10.37	8144.67
																(A)	(B)
															LEVELISED TARRIF (B/A)		785.33
																	7.85

(Source: Feasibility Report of Kurukutti PSH, August 2021)

ANNEXURE-2

On-River and Off-River Schemes under construction

Table 6: On-River Pumped Storage Schemes under construction

Sl. No.	Scheme	State	Installed Capacity		Remarks
			No. of units x Unit size (MW)	Capacity (MW)	
1.	Tehri St.-II	Uttarakhand	4x250	1,000	Likely commissioning by 2023-24 (Feb. 2024)
2.	Kundah (Stage-I, II, III & IV)	Tamil Nadu	4x125	500	Likely commissioning by 2024-25
3.	Koyna Left Bank	Maharashtra	2x40	80	Likely commissioning by 2027-28
			Total	**1,580**	

Table 7: Off-River Pumped Storage Scheme under construction

Sl. No.	Scheme	State	Installed Capacity		Remarks
			No. of units x Unit size (MW)	Capacity (MW)	
1.	Pinnapuram	Andhra Pradesh	4x240+2x120	1,200	Likely commissioning by 2023-25 (June 2024)
			Total	**1,200**	

ANNEXURE-3

F. No. 15-14/9/2022-H-II(Part)
भारत सरकार / Government of India
विद्युत मंत्रालय / Ministry of Power
Shram Shakti Bhawan, Rafi Marg
New Delhi - 110001, Tel: 011-23705841

Dated: 10th April, 2023

To

1. **The Secretaries of all the Ministries / Departments of Government of India**
2. **The Chief Secretaries of the State Governments & Union Territories**
3. **Principal Secretaries (Energy / Power) - All the State Governments & UTs**
4. **CMDs - PGCIL, NTPC, NHPC, SJVN, THDC, NEEPCO, Grid India, PFC, REC**
5. **The Chairman - BBMB, DVC**

Sub: Guidelines to promote development of Pump Storage Projects (PSP) - reg.

Sir / Madam,

This has reference to Ministry of Power's letter of even number dated 15th February, 2023 vide which the draft PSP Guidelines were circulated for comments / suggestions. Subsequently, a webinar was held on 23rd February 2023 on the topic of "Green Growth", wherein, inter alia, suggestions were also received on the framework for Pumped Storage Projects in the country.

2. Based on the comments / suggestions received from the stakeholders, the Guidelines to promote development of Pump Storage Projects in the country have been finalized. A copy of the PSP guidelines is enclosed herewith for information and necessary action.

This issues with the approval of Hon'ble Minister of Power and New & Renewable Energy.

Yours sincerely,

10/4/23

(Mohd. Afzal)
Joint Secretary
Email: afzal_mdp@nic.in
/hydro2-mop@gov.in
Tel.: 011-23714000

Copy to:-

1. CEO, NITI Aayog
2. Secretary, CERC / All SERCs
3. Chairperson, CEA
4. Chairperson, CWC

Copy also to:

In-charge, NIC Cell, MoP: with request to upload the Guidelines on the website of the Ministry of Power.

Guidelines on Pumped Storage Projects

1. Introduction

Energy Transition entails increasing presence of variable and intermittent Renewable Energy Sources (VREs) like solar & wind in the energy mix. This presents a grid-level challenge for stability and a need for addressing the temporal considerations in power availability. Storage and ancillary services would be the attributes that require incentivization in the power system to ensure appropriate capacity. Comprehensive storage guidelines are required to set the direction of developments in this regard. Amongst the various technologies available for addressing this requirement of storage and ancillary services, Pumped Storage Projects (PSPs) are clean, MW scale, domestically available, time tested and internationally accepted.

The positive aspects of PSPs are not limited to the attributes of storage and ancillary services. PSPs are clean, green and safe. They don't produce any poisonous/ harmful by-products or pose problems of disposal. The advantages of promoting PSPs are not only based on their usefulness in maintaining grid stability and facilitating VRE integration but also their other positive attributes when compared to other available energy storage systems.

1.1 Perspectives

Flexible Energy Generation Assets that can supply both Base Load & Peaking Power efficiently and economically are the need of the future and necessary to address the dynamically evolving energy needs of India. At present, Variable Renewable Energy Sources (VRE) such as wind and solar are being connected to the grid at a rapid pace owing to their low cost of installation and the thrust on sustainable & green energy. The energy supply from VREs can't be regulated since they are dependent on the time of the day, seasons, and the vagaries of weather. Hence, there is an ever- increasing demand for Energy Storage Assets. PSPs are best suited in the present scenario for addressing this demand. PSPs are also known as 'the Water Battery', which is an ideal complement to modern clean energy systems.

PSPs provide the necessary scale of storage and have a long service life of more than 40-50 years. This is much more than any other energy storage technology presently available. This also results in a low cost of delivered energy over the life of the projects. PSPs are also non-polluting and are more environmentally friendly. Pumped Storage Projects account for over 95 percent of installed global energy storage capacity. It is estimated that pumped hydro projects worldwide store up to 9,000 gigawatt hours (GWh) of electricity worldwide.

(a) Energy Transition Considerations

India is on the path towards a clean energy transition, guided by the Nationally Determined Contribution (NDC) targets, to reduce the emission intensity of its Gross Domestic Product (GDP) by 45% by 2030, get to 50% of installed capacity from non-fossil fuel sources by 2030 and achieve net zero carbon emissions by 2070. Given the ongoing energy transitions in the country, the development of PSPs is of paramount importance for providing greater inertia and balancing power to the grid as battery storage solutions are still being scaled up and are required for short duration storage needs in grid management, PSPs are a natural enabler for integrating greater amounts of wind and solar power. With its ability to store a large amount of energy, frequent starts/stops, and faster ramp-ups/ramp-downs, PSPs are ideally suited to address the dynamic supply and demand. PSPs can also be used for peaking operation and improve the reliability of the power system.

(b) Ancillary Services Considerations

Wind and Solar power have become one of the lowest-cost sources of renewable energy. However, their inherent variable, uncertain and intermittent nature presents a huge challenge for integrating large quantities of renewables, while maintaining grid stability. Curtailment of wind and solar power is already being witnessed in some areas although they presently constitute only around 25% of total energy capacity. With the increasing presence of VREs, the need for curtailment will be more acute if there is insufficient storage in the grid. PSPs present a viable solution to the integration issues of large RE capacities. They are best equipped for peak load requirements. PSPs can store a large amount of energy during off-peak hours and discharge over longer period. Thus, PSPs would help reduce RE curtailment and improve the plant load factor of VREs.

(c) Temporal Considerations

It is anticipated that with the increasing presence of VRE in the energy mix, the generation of wind and solar energy may be at its peak where the energy demand is the lowest. If the energy from these sources is not stored during off-peak hours in times to come, there will be an increasing need for large operating reserves from thermal power plants (typically high carbon coal and gas) to meet the peak demands of the country. PSPs provide an economical solution by off taking a large amount of energy from the grid during off-peak hours, increasing the load factor of other systems, and also providing additional capacity to meet the peak loads. Pumped hydro storage provides a dynamic response and offers critical backup during periods of excess demand along with maintaining grid stability. Without PSPs, full decarbonisation of the electricity sector will not be achievable at reasonable costs. Thus, PSPs provide 'green storage' and make VREs dispatchable by firming up the capacities.

1.2 Advantages of Pumped Storage Projects

(a) Ecologically friendly

PSPs would have minimal impact on the environment in their vicinity as they are mainly envisaged on the existing Hydro Electric Projects, reservoirs, or as off-the-river projects. All components of PSPs would be connected, operated, and maintained in an environmentally friendly manner. There are no residual environmental impacts in the case of PSPs.

(b) Atmanirbhar Bharat

The guidelines for the development of storage systems synchronize with the vision of Atmanirbhar Bharat. The PSPs primarily use indigenous technologies and domestically produced materials. Most of the electrical & mechanical parts of PSPs are also made in India. Other alternate solutions to storage such as batteries are heavily import-dependent.

(c) Tested Technology

The PSPs operate on time-tested technology thereby infusing confidence in the lending institutions for a longer duration of loans. Additionally, the cost of technologies involved in the construction has reduced rendering PSPs a viable proposition. The technological surety associated with PSPs has opened the possibility for the developers to claim a higher debt-equity ratio in the projects.

(d) Local developmental

The development of PSPs is highly capital intensive and involves the development of local transport infrastructure for the mobilization of men and materials. Local industries such as cement and steel also get impetus and drive job creation in the economy. This in turn have a salutary effect on local area development. PSPs are an ideal investment for socio-economic and regional development considerations like infrastructure up-gradation and employment generation.

(e) Longer and reliable duration of discharge

PSPs are generally designed for a longer duration of discharge of more than 6 hours to meet the peak demand or for compensating the variability in the grid due to VREs. Currently, Battery Energy Storage Systems are designed for up to 4 hours of discharge generally. The firm capacity of PSPs during peak hours is guaranteed and relatively immune to the grid conditions.

1.3 Pumped Storage Potential and Development Status

As of date, the CEA estimates regarding on-river pumped storage potential is 103 GW in India. Apart from the above, a large capacity of off-river pumped storage potential is also available which is being estimated. Suitable support is to be extended to the identification and evaluation of such potential.

As of now, 8 projects (4745.60 MW) are presently in operation, 4 projects (2780 MW) are under construction, and 27 projects (29930 MW) have been allotted by States which are under different stages of development.

1.4 Long Term Plan for Pumped Storage Hydro Development

The long-term approach to the development of pumped storage projects will be driven by various factors regarding the requirement of the grid to achieve the energy transition. As per the revised draft NEP published by the Central Electricity Authority, the country would require 26.7 GW of Pumped Storage Projects and 47.2 GW of BESS (5 hour) to integrate the RE capacity envisaged till 2032. The PSP capacity requirement may further increase if the cost of BESS does not come down as expected. The Central Electricity Authority will continue modelling and forecasting the energy demand and energy mix over the long term and providing an indication of the probable requirement of the various forms of storage. This exercise would mean factoring in the aspects of viability and technology change. The Resource Adequacy Plan will consider storage as an element of planning.

1.5 Barriers in the development of Pumped Storage Projects

(a) Environmental clearances

Presently, the environmental clearance and forest clearance process of PSPs is very cumbersome, since these projects are treated at par with the conventional hydro projects for the purpose of grant of EC and FC. The environment impact of PSPs constructed on existing reservoirs on on-the-river sites and on the off-the-river sites is much less than conventional HEPs. Further, unlike the conventional hydro projects, development of PSPs do not lead to significant displacement of the people and thus, require minimum R&R. Therefore, PSPs constructed on existing reservoirs and on off-the-river sites may be treated as a separate category for processing of clearances.

(b) Free power

PSPs are fundamentally energy storage projects designed to cater the need of grid stability during the peak hours. Unlike conventional hydro projects, PSPs do

not produce electricity. They are net consumers of electricity. Therefore, there is no question of imposing the requirement of free power on PSPs.

(c) Cost of pumping power

The cost of power from PSPs has three components - cost of storage, cost of conversion losses and cost of input power. One of the prerequisites to ensure the commercial viability of a PSP unit is availability of input power at affordable tariff. However, this constraint is likely to be overcome in near future, with the availability of solar and wind power at relatively cheaper rates

(d) Value of peak power

The importance of PSP lies in its capability to offer peaking power. Further, other services offered by PSPs, like spinning reserves, reactive support, black start ability, frequency response ancillary services and faster start-up and shutdown, which are essential for grid stability, are not adequately monetized.

2. Measures already taken by Government of India for promotion of PSPs

2.1 Utilization of financial and project execution capabilities of CPSUs

Government of India vide its order dated 08.08.2022 has indicated identified PSP sites against CPSUs to facilitate their development. A state-wise indication has also been carried out to help the States with work related to PSPs. States are encouraged to allocate the PSPs to CPSUs for early and prompt development aligned with the national interest. The present indication is at **Annexure-I**.

2.2 Energy Storage Obligation

Government of India has, vide its order dated 22.07.2022, notified the trajectory of Energy Storage Obligation for the distribution companies to ensure the capacities regarding storage as a grid element. This would create demand for storage. The present trajectory is at **Annexure-II**.

2.3 Waiver of ISTS charges for PSPs

Given the importance of facilitating RE integration in the grid and in pursuance of National Tariff Policy 2016, waiver of ISTS and other transmission charges have also been made available to Pumped Storage Projects vide Ministry of Power's Order dated 23.11.2021 which is given at **Annexure-III**.

In order to promote the development of PSPs, the waiver of ISTS charges shall be extended to all those PSPs where construction work is awarded by

30.06.2025. ISTS charges shall be levied on PSPs where construction work is awarded after 30.06.2025 as per the following trajectory:

S. No.	Award of construction work	ISTS charges
1.	01.07.2025 to 30.06.2026	25% of applicable ISTS charges
2.	01.07.2026 to 30.06.2027	50% of applicable ISTS charges
3.	01.07.2027 to 30.06.2028	75% of applicable ISTS charges
4.	From 01.07.2028	100% of applicable ISTS charges

2.4 Budgetary Support for Enabling Infrastructure

The hydro projects and PSPs are often taken up in remote areas which have infrastructure deficits. The infrastructure created for hydropower / PSP enables further development of the area as the same is available for reuse for other purposes. Given the same, the Central Government is providing budgetary support for funding the enabling infrastructure of hydropower projects. This scheme also covers PSPs. The grant for enabling infrastructure is for the creation of infrastructure facilities that have alternate developmental value. The present dispensation in this regard is at **Annexure-IV,** and also applies to PSPs.

2.5 Timelines for formulation and concurrence of Detailed Project Reports for Pumped Storage Projects

The Central Electricity Authority has issued revised guidelines for formulation and for examination & concurrence of Detailed Project Reports for Pumped Storage Projects in July 2022 and August 2022 respectively. As per revised guidelines, the timelines for preparation of DPR for PSPs has been reduced from 900 days to 720 days. CEA shall further reduce these timelines for off-stream closed loop PSPs and PSPs on existing Hydro projects (where one reservoir is available).

In addition, since no tariff / financial evaluation is required to be done by CEA for PSP projects allotted through Tariff Based Competitive Bidding or as part of integrated Renewable Energy Project or as captive plants, CEA has reduced the timeline for concurrence of such projects from 150 days to 75 days. For other PSPs, the timelines for concurrence has been reduced from 150 days to 125 days.

3. Guidelines for promotion of PSPs

The following guidelines are being issued for the promotion of Pumped Storage Projects:

3.1 Allotment of project sites

The State Governments may allot project sites to developers in the following manner:

(i) On nomination basis to CPSUs and State PSUs

For early development, States may award projects directly to hydro CPSUs or State PSUs on a nomination basis. Due consideration shall be given to the experience and financial strength of the CPSUs/State PSUs. The projects may also be allotted to Joint Ventures (JVs) between CPSUs and/or State PSUs for development of such PSPs. Further the CPSU/State PSU shall ensure that award of contracts for the supply of equipment and construction of the project, either through a turnkey or through well-defined packages, is done based on competitive bidding.

(ii) Allotment through competitive bidding

PSP project may also be awarded to private developers by following a two stage competitive bidding process. PSUs may also be allowed to participate in the bidding process. The first stage shall be for pre-qualification based on criteria of financial strength, experience of developing infrastructure projects of similar size, past track record of developing projects, turnover and ability to meet performance guarantees. In the second stage, bids are to be called based on quantifiable parameters such as concession period of the project or any other parameter as specified by the Central/State Government.

In case of allocation through modes 3 (i) & (ii) above, the home state shall have the right of first refusal upto 80% of the project capacity and tariff shall be fixed by the Appropriate Commission u/s 62 of the Electricity Act, 2003 The developer would be free to sell the balance storage space under short / medium / long term PPA, or in power markets or through bilateral contract.

(iii) Allotment through TBCB

PSPs may also be awarded on a TBCB basis to developers. For this purpose, the task of carrying out S&I and preparation of DPR may be given to an SPV under a CPSU/State PSU. SPV may be responsible for pre-construction activities such as preparation of project report, land acquisition, environment and forest clearance, etc. Such a dispensation would ensure the possibility of tariff determination based on competitive bidding. The DPR may be subsequently bid out for construction and SPV transferred to the successful bidder on the basis of:

a. Composite tariff (including the cost of input power) in case input power is arranged by the developer; or
b. Tariff for storage on a per Megawatt Hour basis if the input power is to be arranged by the procurer of the storage capacity.

The appropriate Commission shall adopt the above tariff u/s 63 of the Electricity Act, 2003.

(iv) **Self-Identified off-stream Pumped Storage Projects**

In addition to the above methods, developers may also self-identify potential off-stream sites where PSPs can be constructed. Since these sites are away from the riverine system and do not utilize the natural resources like river streams, allotment from State Governments would not be required for the development of PSP projects on such sites. Further, all statutory clearances need to be obtained from State and Central agencies before starting construction. It will help in harnessing the off-stream potential in the country at a faster pace. Projects developed in such a manner would be provided all concessions mentioned in these guidelines, subject to the directions issued by the Government from time to time.

3.2 Timelines for Start of Construction work after award of Project

Developers shall start construction work within a period of 2 years from the date of allotment of the project, failing which allotment of the project site shall be cancelled by the State. However, relaxation of 1 year may be granted to those projects where delay in start of construction is attributable to pending Environment Clearance (EC) and Forest Clearance (FC), provided that the applications are submitted to concerned authorities within timelines agreed at the time of award of the project.

3.3 No Upfront Premium for Project Allocation

In order to ensure the viability of the Pumped Storage Projects, States shall ensure that no Upfront Premium is charged for project allocation.

3.4 Market reforms

The comparison of PSPs with other conventional and VRE sources purely based on financial aspects is undervaluing and de-emphasizing the economic benefits extended by these projects. The monetization of Ancillary services provided by Pumped Storage Projects will give a much-needed boost to the sector. For this purpose, the following reforms may be undertaken:

i. The appropriate Commission shall ensure that services like spinning reserves, reactive support, black start, peaking supply, tertiary and ramping support, faster start-up and shutdown, which help in supporting grid stability are suitably monetized.
ii. Appropriate Commission shall notify Peak and Off-Peak tariffs for Generation to provide appropriate pricing signal to Peak and Base Load Generating Plants.

iii. PSPs and other storage projects shall be allowed to participate in all market segments of the power exchange, including the high price segment of the Day Ahead Market (HP-DAM) so that they can take suitable advantage of the price differential between Peak and Off-Peak tariffs.

iv. 80% power generated when PSPs operate as conventional hydro power stations during monsoon period (i.e. no pumping energy required for power generation) would be offered to the Home State at the rate of secondary energy fixed by the Central Electricity Regulatory Commission. The developer shall be allowed to sell the remaining energy to cover their Operation & Maintenance costs and other expenses.

v. In the event of capacity contracted not being fully utilized by the contracting agency, the developer would be free to transfer the usage of the capacity to other interested entities so that resources do not remain idle. The gains made shall be shared with the original beneficiary in the ratio of 50:50.

3.5 Financial Viability

The current power scenario indicates an imminent deep penetration of electricity storage in future and PSPs would be required to be operated invariably in two cycles for as long as variable RE infusion keeps on increasing. Thus, PSPs are expected to be utilized or run to their full capacities. This ensures recovery of costs in a minimum period. With high rates during peak hours in the power exchanges, PSP developers have the opportunity to optimize their operations and earn suitable returns.

To ensure that only viable PSPs are taken up for construction, the Central Government may notify a benchmark tariff of storage for investment decisions of developers considering 6-8 hours of operation of the PSP. This will be based on the prevailing and anticipated difference between peaking and non-peaking rates. Efforts would be made to ensure that only those PSP projects are taken up for development whose levelized cost of storage is within the benchmark cost of storage.

Financial institutions like PFC, REC, and IREDA shall treat PSPs at par with other renewable energy projects while extending long term loans of 20-25 years tenure. The debt equity ratio of PSP projects can be upto 80:20, in consultation with the financial institutions.

3.6 Taxes and duties

To reap the long-term benefits and socio-economic development of states due to PSP projects, State Government shall consider reimbursement of SGST on PSP project components. States may exempt land to be acquired by off-the-river PSPs from payment towards stamp duty and registration fees. Government land, if available, may be provided at a concessional rate to the developers on annual lease rent basis.

Storage is an intermediary system where energy is stored and released later. In line with the principles of double taxation avoidance, Electricity Duty (ED) and Cross Subsidy Surcharge (CSS) shall not be applicable on pumping power for charging of PSPs as PSPs are merely facilitating conversion of energy. Electricity is stored during off-peak hours and discharged during peak hours. ED and CSS may only be levied on the final consumption of electricity.

Government of India from time to time has stated that no Water Cess should be levied on Hydro Power Projects since there is no consumptive use of water. Similarly, no water cess shall be levied on PSPs.

3.7 Exemption from Free Power obligation

PSPs are energy storage schemes. They do not produce energy. They are net consumers of energy. Hence, the PSPs would be kept out of the liability of free power.

3.8 Local Area Development Fund

PSPs have a minimal environmental impact and have no R&R issues. Therefore, there will be no requirement of creation of a Local Area Development Fund.

4. Utilization of exhausted mines to develop PSPs

The discarded mines including coal mines in different parts of the country could be used as Hydro Storage and thereby become natural enablers for development of Hydro Pumped Storage Projects (PSPs). Efforts would be made to identify and develop exhausted mines / coal mines as prospective PSP sites in consultation with the Ministry of Coal, Ministry of Mines and respective State Governments.

5. Rationalization of Environmental Clearances for PSPs

The off-river PSPs, are located away from the river course and have minimum impact on the riverine ecology. Hence they need to be treated differently for grant of Environmental Clearance.

Ministry of Environment Forest & Climate Change (MoEF&CC) has already initiated action in this regard. As per draft notification issued by MoEF&CC on 11.10.2022, PSPs which meet the following criteria would be appraised under B2 category for grant of Environmental Clearance (EC) irrespective of power generation capacity:

(a) Projects which do not attract Forest Clearance (FC) and/or Wildlife Clearance (WC)
(b) Projects wherein no new Reservoir(s) is (are) created.
(c) Projects wherein the existing reservoir (s) is (are) not expanded and/or structurally modified {i.e. no increase in the capacity of reservoir(s) and no increase in submergence area of reservoir(s)}.

In addition, further liberalisation would be taken up for allowing base line data collection for one (1) season for off-stream closed loop PSPs and two (2) seasons for off-stream open loop PSPs (excluding monsoon season) for the purpose of carrying out Environment Impact Assessment (EIA) and preparing Environment Management Plan (EMP) required for EC, and for allowing collection of baseline data for carrying out EIA/EMP studies before issuance of Terms of Reference (ToR).

6. Green Finance

Pumped storage projects are essential for the integration of renewable energy sources in the grid and their utilization, thereby avoiding greenhouse gas emissions. Hence, in order to initiate and accelerate the pace of establishment, PSPs may be supported through concessional climate finance. Sovereign green bonds issued for mobilizing resources for green infrastructure as a part of the Government's overall market borrowings may be deployed in the development of PSPs which utilize renewable energy for charging.

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ANNEXURE - I

File No.15-23/3/2021-HYDEL-II(MoP)

No.15-23/3/2021-HYDEL-II(MoP)
Government of India
भारत सरकार
Ministry of Power
विद्युत मंत्रालय
****

Shram Shakti Bhawan, Rafi Marg
New Delhi, dated 08th August, 2022

To
The Chairman – BBMB, DVC
The CMDs – NTPC, NHPC, SJVN, THDCIL, NEEPCO

Subject: Revised indication of Pumped Storage Projects (PSPs) to the Hydro CPSEs / BBMB / DVC – regarding.

Sir,

In supersession of this Ministry's letter of even no. dated 06.04.2022, I am directed to enclose herewith the 'revised indication of identified PSP sites to Hydro CPSEs / DVC / BBMB' and 'revised indication of States to Hydro CPSEs / BBMB / DVC' for development of Pumped Storage Projects (PSPs).

2. The concerned utilities would be responsible to take up the matter with the concerned State Governments, carry out suitable analysis and prepare the evaluation reports expeditiously on the projects indicated. Progress made by the utilities in this regard will be reviewed by this Ministry at regular intervals.

This issues with the approval of Hon'ble Union Minister of Power and New & Renewable Energy.

Encl: as above

Yours faithfully,

(R. P. Pradhan)
Director (Hydro-II)
Email: hydro2-mop@nic.in

Copy to:
(I) The Chief Secretaries of all the State Government / UTs – with request to extend all the necessary support to the Organizations.
(II) The Chairperson, Central Electricity Authority.
(III) The Chairman, Central Water Commission.

Copy for information to:
(I) O/o Hon'ble Minister of Power and New & Renewable Energy.
(II) O/o Hon'ble Minister of State for Power.
(III) Sr. PPS to Secretary (Power) / PPS to Joint Secretary (Hydro) / PS to Director (H-I) / DD (H-II) / DD (NHPC) / DD(BBMB) / US(H-I), MoP.

Annexure-I

Indication of Identified PSP sites to Hydro CPSEs / DVC / BBMB

S. No.	Name of Project	State/UT	Probable IC (MW)	Earlier Indicated Agency	Revised indication / Changes proposed
1	Matlimarg	Jammu & Kashmir	1650	NHPC	NHPC
2	Majra	Himachal Pradesh	1800	BBMB	BBMB
3	Jaspalgarh	Uttarakhand	1935	THDCIL	THDCIL
4	Ulhas	Maharashtra	1000	NHPC	NHPC
5	Pinjal	Maharashtra	700	NHPC	NHPC
6	Kengadi	Maharashtra	1550	NHPC	NHPC
7	Jalond	Maharashtra	2400	NHPC	NHPC
8	Kolmondapada	Maharashtra	800	SJVNL	SJVNL
9	Kalu	Maharashtra	1150	NHPC	NHPC
10	Sidgarh	Maharashtra	1500	SJVNL	SJVNL
11	**Amba**	**Maharashtra**	**2500**	**THDCIL**	**NTPC**
12	Chornai	Maharashtra	2000	SJVNL	SJVNL
13	Savitri	Maharashtra	2250	NHPC	NHPC
14	**Madliwadi**	**Maharashtra**	**900**	**SJVNL**	**NTPC**
15	Baitarni	Maharashtra	1800	SJVNL	SJVNL
16	Morawadi	Maharashtra	2320	THDCIL	THDCIL
17	Gadgadi	Maharashtra	600	THDCIL	THDCIL
18	**Kundi**	**Maharashtra**	**600**	**SJVNL**	**NTPC**
19	Aruna	Maharashtra	1950	THDCIL	THDCIL
20	Kharari	Maharashtra	1050	THDCIL	THDCIL
21	Jalvara	Maharashtra	2000	SJVNL	SJVNL
22	**Tigaleru**	**Andhra Pradesh**	**1650**	**SJVNL**	**NTPC**

23	**Varahi****	**Karnataka**	**700**	**SJVNL**	**Karnataka Power Corporation Ltd. (KPCL)**
24	Nallar	Tamil Nadu	2700	THDCIL	THDCIL
25	Idukki	Kerala	300	THDCIL	THDCIL
26	Pallivasal	Kerala	600	THDCIL	THDCIL
27	Jharlama	Odisha	2500	NHPC	NHPC
28	Kulbera	West Bengal	1110	DVC	DVC
29	Panchet Hill	West Bengal	600	DVC	DVC
30	Lugupahar	Jharkhand	2800	DVC	DVC
31	Boro	Jharkhand	500	DVC	DVC
32	Tuivai	Manipur	2100	NEEPCO	NEEPCO
33	Hengtam	Manipur	2250	NEEPCO	NEEPCO
34	KhuaiLui	Assam	2100	NEEPCO	NEEPCO
35	LeivaLui	Mizoram	2100	NEEPCO	NEEPCO
36	Pakwa	Mizoram	1000	NHPC	NHPC
37	TuithoLui	Mizoram	1050	NEEPCO	NEEPCO
38	Mat	Mizoram	1400	NEEPCO	NEEPCO
39	TuiphaiLui	Mizoram	1650	NEEPCO	NEEPCO
40	Nghasih	Mizoram	1250	NEEPCO	NEEPCO
41	DaizoLui	Mizoram	2000	SJVNL	SJVNL
42	**Sandynalla**	**Tamil Nadu**	**1200**		**NTPC**
43	**Upper Bhavani**	**Tamil Nadu**	**1000**		**NTPC**
44	**Sigur**	**Tamil Nadu**	**1200**		**NTPC**
45	**Sillahalla Stage-II**	**Tamil Nadu**	**1000**		**NTPC**
46	**Netravathy Stage-I**	**Karnataka**	**1500**		**NTPC**
47	**Indira Sagar – Omkareshwar**	**Madhya Pradesh**	**500**		**NHPC**
48	**Panyor**	**Arunachal Pradesh**	**660**		**NEEPCO**

49	**Kopili**	**Assam**	**320**		**NEEPCO**
50	**CheraKhad**	**Himachal Pradesh**	**500**		**SJVNL**
51	**Dhurmu**	**Himachal Pradesh**	**1600**		**SJVNL**
52	**TaalKhad**	**Himachal Pradesh**	**135**		**SJVNL**
53	**Sadda**	**Himachal Pradesh**	**220**		**SJVNL**
54	**Purthi and Sach Khas PSP**	**Himachal Pradesh**	**190**		**SJVNL**
55	**MalshejGhat**	**Maharashtra**	**700**		**THDCIL**
56	**Humbarli**	**Maharashtra**	**400**		**THDCIL**

** Government of Karnataka has allotted the Varahi PSP to Karnataka Power Corporation Limited (KPCL) and KPCL has already prepared that PFR with installed capacity of 1500 MW.

Summary

Agency	**Number of Projects**		**Capacity (in MW)**	
	Earlier	Revised	Earlier	Revised
NHPC	9	**10**	14200	**14700**
SJVNL	10	**11**	13950	**12745**
THDCIL	9	**10**	13955	**12555**
NEEPCO	8	**10**	13900	**14880**
DVC	4	**4**	5010	**5010**
BBMB	1	**1**	1800	**1800**
NTPC	-	**9**	-	**11550**
Total	**41**	**55**	**62815**	**73240**

Annexure-II

Indication of States to Hydro CPSEs / BBMB / DVC for development of Pumped Storage Projects (PSPs)

S. No.	State	Earlier Proposed Agency	Revised Proposed Agency
	Northern Region		
1	UT of Jammu & Kashmir and Ladakh	NHPC	-
2	Himachal Pradesh	SJVN	
3	Uttarakhand	THDCIL	
4	Punjab	BBMB	
5	Haryana	BBMB	
6	Rajasthan	BBMB	
7	Uttar Pradesh	THDCIL	
	Western Region		
8	Maharashtra	NHPC, SJVN, THDCIL	NHPC, SJVN, THDCIL, **NTPC**
9	Gujarat	SJVN	-
10	Madhya Pradesh	NHPC	
11	Chhattisgarh	THDCIL	
	Eastern Region		
12	Jharkhand	DVC	-
13	Bihar	SJVN	
14	Odisha	NHPC	
15	West Bengal	DVC	
16	Sikkim	NHPC	
	Southern Region		
17	Andhra Pradesh	SJVN	**NTPC**
18	Telangana	NHPC	-
19	Tamil Nadu	THDCIL	**NTPC**
20	Karnataka	SJVN	**NTPC**
21	Kerala	THDCIL	-
	North Eastern Region		
22	NER	NHPC, SJVN, THDCIL, NEEPCO	-

ANNEXURE-D

F. No. 09/13/2021-RCM
Ministry of Power
Government of India

Shram Shakti Bhawan, New Delhi
Dated 22 July, 2022

ORDER

Subject: Renewable Purchase Obligation (RPO) and Energy Storage Obligation Trajectory till 2029-30 - regarding.

In exercise of the powers conferred under section 3(3) of Electricity Act, 2003, the Central Government had notified the revised Tariff Policy, which was published in Gazette of India, Extraordinary, Part-I, Section-1 dated 28.01.2016.

2. Para 6.4(1) of the Tariff Policy 2016 provides as follows:

> *"Pursuant to provisions of section 86(1)(e) of the Act, the Appropriate Commission shall fix a minimum percentage of the total consumption of electricity in the area of a distribution licensee for purchase of energy from renewable energy sources, taking into account availability of such resources and its impact on retail tariffs. Cost of purchase of renewable energy shall be taken into account while determining tariff by SERC's.* ***Long term growth trajectory of Renewable Purchase Obligations (RPOs) will be prescribed by the Ministry of Power in consultation with MNRE.***
>
> *Provided that cogeneration from sources other than renewable sources shall not be excluded from the applicability of RPOs."*

3. Energy from Hydro Power Projects is Renewable Energy (RE) as has been recognized world over. On 8th March 2019, the Government of India had also recognized Large Hydro Power Projects (LHPs) including Pumped Storage Projects (PSPs), having capacity of more than 25 MW, as part of RE. It was further specified that energy from all LHPs, commissioned after 8th March 2019, will be considered as part of Renewable Purchase Obligation (RPO) through a separate obligation, i.e. Hydro power Purchase Obligation (HPO).

4. Accordingly, the Ministry of Power (MoP), after detailed consultation with Ministry of New and Renewable Energy (MNRE), notified the HPO trajectory for the period from 2021-22 to 2029-30 vide order dated 29th January, 2021 and subsequent clarification dated 1st April, 2021. The revised trajectory of RPOs for Solar and Other Non-Solar power was also notified for the period from 2019-20 to 2021-22. The aforesaid order also mentioned that the RPO trajectory beyond 2021-22 will be specified later.

5. To recommend RPO trajectory beyond 2021-22, a Joint-Committee under the Co-chairmanship of Secretary, Ministry of Power and Secretary, Ministry of New and Renewable Energy, was constituted on 17th December, 2020. Based on the recommendations of the Joint Committee and further discussions with MNRE, MoP hereby specifies the following RPO Trajectory beyond 2021-22:

Year	Wind RPO	HPO	Other RPO	Total RPO
2022-23	0.81%	0.35%	23.44%	24.61%
2023-24	1.60%	0.66%	24.81%	27.08%
2024-25	2.46%	1.08%	26.37%	29.91%
2025-26	3.36%	1.48%	28.17%	33.01%
2026-27	4.29%	1.80%	29.86%	35.95%
2027-28	5.23%	2.15%	31.43%	38.81%
2028-29	6.16%	2.51%	32.69%	41.36%
2029-30	6.94%	2.82%	33.57%	43.33%

(a) Wind RPO shall be met only by energy produced from Wind Power Projects (WPPs), commissioned after 31st March 2022.

(b) HPO shall be met only by energy produced from LHPs (including PSPs), commissioned after 8th March 2019.

(c) Other RPO may be met by energy produced from any RE power project not mentioned in (a) and (b) above.

6. From F.Y. 2022-23 onwards, the energy from all Hydro Power Projects (HPPs) will be considered as part of RPO. The HPO trajectory, as has been notified earlier will continue to prevail for LHPs commissioned after 8th March 2019. All other HPPs will be considered as part of 'RPO' under category of 'other RPO'.

7. RPO shall be calculated in energy terms as a percentage of total consumption of electricity.

8. HPO obligations may be met from the power procured from eligible LHPs (including PSPs) commissioned on and after 8th March, 2019 to 31st March, 2030.

9. HPO obligation of the State/Discom may be met out of the free power being provided to the State from LHPs (including PSPs), commissioned after 8th March, 2019 as per agreement at that point of time excluding the contribution towards LADF, if consumed within the State/Discom. Free power (not that contributed for Local Area Development) shall be eligible for HPO benefit.

10. In case, the free power mentioned above is insufficient to meet the HPO obligations, then the State would have to buy the additional hydro power to meet its HPO obligations or may have to buy the corresponding amount of Renewable Energy Certificate corresponding to Hydro Power.

11. The Renewable Energy Certificate mechanism corresponding to Hydro Power to be developed by CERC to facilitate compliance of HPO Obligation would have a capping price of Rs.5.50/Unit of electrical energy w.e.f. 8th March, 2019 to 31st March, 2021 and with an annual escalation @ 5% thereafter for the purposes of ensuring HPO compliance.

12. The above HPO trajectory shall be trued up on an annual basis depending on the revised commissioning schedule of Hydro projects. The HPO trajectory for the period between 2030-31 and 2039-40 shall be notified subsequently.

13. Hydro power imported from outside India shall not be considered for meeting HPO.

14. Any shortfall remaining in achievement of 'Other RPO' category in a particular year can be met with either the excess energy consumed from WPPs, commissioned after 31st March 2022 beyond 'Wind RPO' for that year or with excess energy consumed from eligible LHPs (including PSPs), commissioned after 8th March 2019 beyond 'HPO' for that year or partly from both. Further, any shortfall in achievement of 'Wind RPO' in a particular year can be met with excess energy consumed from Hydro Power Plants, which is in excess of 'HPO' for that year and vice versa.

15. The following percentage of total energy consumed shall be solar/wind energy along with/ through storage,

F.Y.	Storage (on Energy basis)
2023-24	1.0 %
2024-25	1.5 %
2025-26	2.0 %
2026-27	2.5 %
2027-28	3.0 %
2028-29	3.5 %
2029-30	4.0 %

16. The Energy Storage Obligation in para 15 above shall be calculated in energy terms as a percentage of total consumption of electricity and shall be treated as fulfilled only when at least 85% of the total energy stored in the Energy Storage System (ESS), on an annual basis, is procured from renewable energy sources.

17. The Energy Storage Obligation to the extent of energy stored from RE sources shall be considered as a part of fulfilment of the total RPO as mentioned in para 5 above.

18. The Energy Storage Obligation shall be reviewed periodically considering the commissioning/ operation of PSP capacity, to accommodate any new promising commercially viable Energy Storage technologies and also reduction in cost of Battery Energy Storage Systems (BESS).

19. POSOCO will maintain a data related to compliance of RPO Obligations.

20. Further, the State Commissions may consider notifying RPO trajectory including HPO and Energy Storage Obligation trajectory for their respective States, over and above the RPO, HPO and Energy Storage Obligation trajectory given in para 5. Moreover, the Central Commission shall consider devising a suitable mechanism similar to Renewable Energy Certificate (REC) mechanism to facilitate fulfilment of HPO.

21. This issues with the approval of Hon'ble Minister of Power and New & Renewable Energy.

(Piyush Singh)
Joint Secretary to the Government of India
Tele No: 011-23714367

To

1. ACS/Principal Secretary/Secretary (Power/Energy), State Governments/UTs.
2. Secretary (CERC/FOR), New Delhi
3. Secretary, State Electricity Regulatory Commissions/Joint Electricity Regulatory Commissions

Copy to:

1. Secretary, MNRE, New Delhi
2. Chairperson, CEA, New Delhi

Copy also for information to;

1. PS to Hon'ble Minister for Power and NRE
2. Additional PS to Hon'ble Minister of State for Power
3. Sr. PPS to Secretary(P)/PPS to AS&FA, MoP/ PPS to AS(AT), MoP
4. PPS to All Joint Secretaries/ EA/ CE, MoP

ANNEXURE-III

No. 23/12/2016-R&R
Government of India
Ministry of Power
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Shram Shakti Bhawan, Rafi Marg,
New Delhi, 23rd November, 2021

ORDER

Subject: Waiver of inter-state transmission charges on transmission of the electricity generated from solar and wind sources of energy under Para 6.4(6) of the Tariff Policy, 2016.

1.0 In exercise of the powers conferred under section 3(3) of Electricity Act, 2003, the Central Government notified the revised Tariff Policy on 28.01.2016.

2.0 In accordance with the Para 6.4(6) of the Tariff Policy 2016, Ministry of Power issued Order No. 23/12/2016-R&R dated 30.09.2016 on waiver of inter-state transmission charges on transmission of the electricity generated from solar and wind sources of energy. This order was amended vide orders dated 14.06.2017, 13.02.2018, 06.11.2019, 05.08.2020, 15.01.2021 and 21.06.2021.

3.0 With a view to encourage faster capacity addition based on solar or wind energy sources, in supersession of aforesaid orders and in accordance with para 6.4 (6) of the Tariff Policy, 2016 and sub-rule 12 of rule 5 of the Electricity (Transmission System Planning, Development and Recovery of Inter-State Transmission Charges) Rules, 2021, the following are notified:

3.1 For the solar, wind, Hydro PSP and BESS Projects commissioned upto 30.06.2025, the waiver of inter-state transmission charges shall be applicable for the following:

(i) Solar or wind energy generation set up by any person/entity. The power generated from such sources can be self consumed or sold to any entity either through competitive bidding, Power Exchange or through bilateral agreement.

(ii) Electricity from solar and/or wind sources used by Hydro Pumped Storage Plant (PSP) and Battery Energy Storage System (BESS) projects and subject to the following conditions:

(a) atleast 51% of the annual electricity requirement for pumping of water in the Hydro Pumped Storage Plant is met by use of electricity generated from solar and/or wind power plants.

(b) atleast 51% the annual electricity requirement for charging of the Battery Energy Storage System is met by use of electricity generated from solar and/or wind power plants.

(iii) Electricity generated / supplied from such Hydro PSP and BESS power plants as mentioned in (ii) above.

(iv) For trading of electricity generated/supplied from solar, wind and sources mentioned in (ii) and (iii) above, in Green Term Ahead Market (GTAM) and Green Day Ahead Market (GDAM) are upto 30.06.2025.

(v) For Green Hydrogen production plants commissioned upto 30.06.2025. i.e Hydrogen produced using the electricity produced from solar, wind and sources mentioned in (ii) and (iii) above. This waiver shall be applicable for a period of 8 years from the date of commissioning of such hydrogen plant.

(vi) For the power generated from solar and wind energy as per RE bundling scheme issued by Ministry of Power on 16.11.2021. Provided that the evacuation of this solar and/or wind power is being made from the main substation of the Thermal/Hydro power plant and this does not lead to any additional cost in augmentation of transmission system.

Further, no transmission charges for use of Inter State Transmission System (ISTS) shall be levied, when solar and/or wind power from power plant situated at one Thermal/Hydro Generating Station is supplying to procurers of another Generating Station, of the same Generating Company, located at a different location.

3.2 In order to have long term visibility and certainty to the renewable power generation, it is also provided that ISTS charges shall be levied for the solar, wind, Hydro PSP and BESS Projects commissioned after 30.06.2025, gradually as per following trajectory:

S.No.	Period of Commissioning	Inter-State Transmission Charges
1	01.07.2025 to 30.06.2026	25 % of the applicable ISTS charges
2	01.07.2026 to 30.06.2027	50% of the applicable ISTS charges
3	01.07.2027 to 30.06.2028	75% of the applicable ISTS charges
4	From 01.07.2028	100% of the applicable ISTS charges

4.0 The waiver shall be applicable, for a period of 25 years for solar, wind and Hydro PSP or for a period of 12 years for BESS or for a period subsequently notified for future projects by the Central Government, from the date of commissioning of the power plant.

5.0 It is also clarified that waiver is allowed for Inter-state transmission charges only and not losses. However, it is clarified that waiver of losses shall be applicable for the projects whose bidding was completed upto 15.01.2021.

6.0 This order shall be applied prospectively i.e. from the date of issue of order.

7.0 This issues with the approval of Minister for Power and NRE.

(Ghanshyam Prasad)
Joint Secretary to the Govt. of India
Tel: 2371 0389

To

Secretary, CERC, New Delhi.

Copy to:

1. Secretary, MNRE, New Delhi.
2. Chairperson, Central Electricity Authority, New Delhi.
3. Secretary in charge, Power/Energy Dept., State Governments/UTs.
4. Secretary, State Electricity Regulatory Commissions/Joint Electricity Regulatory Commissions.

Copy for information to:

1. PS to Minister for Power and NRE, APS to MoSP.
2. Joint Secretaries/Chief Engineer/Economic Adviser, Ministry of Power.
3. Sr. PPS to Secretary (Power), PPS to AS (SKGR), PPS to AS (VKD), Sr. PPS to JS (R&R)

ANNEXURE- IV

No.15/2/2016-H.I(Pt.)(230620)
Government of India
Ministry of Power
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Shram Shakti Bhawan, New Delhi,
Dated, the 28th September, 2021

OFFICE MEMORANDUM

Subject: Budgetary Support towards Cost of Enabling Infrastructure, i.e., roads/ bridges - regarding.

1. Ministry of Power (MoP), vide OM no. 15/2/2016-H-I(Pt.)(230620) dated 08.03.2019, notified various measures approved by the Union Cabinet to promote Hydropower in the country. This included budgetary support for Enabling Infrastructure i.e., roads/ bridges for Hydropower projects on case-to-case basis. The basic objective of budgetary support for enabling infrastructure is to reduce tariff of Hydropower projects by ensuring that consumers are charged cost related to power components only. The budgetary support shall be provided for projects starting construction after 08.03.2019, i.e., date of notification. It was also mentioned that the budgetary support would be provided after appraisal/approval of each project by PIB/ CCEA as per the extant rules/due process and would be provided by MoP through its budgetary grants. The limit of this budgetary support for such roads and bridges would be i) Rs. 1.5 crore per MW for projects upto 200 MW and ii) Rs. 1.0 crore per MW for projects above 200 MW.

2. **Eligibility for Budgetary Support towards Cost of Enabling Infrastructure**

i. All large Hydropower projects (above 25 MW capacity) including Pumped Storage Projects (PSPs), concurred either by Central Electricity Authority (CEA) or the State Government, wherein Letter of Award (LoA) for the first major works package (Dam/ HRT/ Power House etc.) is issued after 08.03.2019, shall be eligible for budgetary support towards Cost of Enabling Infrastructure.

ii. All Roads and Bridges required to connect major components like Dam, Power House, Adits, Surge shaft, Pressure Shaft, TRT, etc. of the project to the nearest

State/ National Highway including any strengthening/ widening works shall be considered eligible for budgetary support. However, these roads/ bridges would exclude the works, for which either the Letter of Award have been issued or are currently under implementation by any Central/ State Agency like NHAI, BRO, PWD, SRRDA, RWD, PWD (Roads), REO(Rural Engineering Organisation) etc. or Central Schemes like PMGSY (Pradhan Mantri Gram Sadak Yojna), MGNREGA or State specific schemes like Mukya Mantri Sadak Yojana etc.

iii. Cost of roads and bridges normally covered under head "R-Communications" in the concurred DPR including the following related costs shall be eligible for release as budgetary support:

a. Land acquisition cost
b. All statutory taxes/ levies, duties, cess, etc.

The specifications/ requirements like carrying capacity, turning radius, vertical clearance, width and gradient etc. of the roads/ bridges shall be as per concurred DPR.

3. The grant of Budgetary Support for the 'Enabling Infrastructure' shall be in the form of 'Reimbursement' after achievement of milestones mentioned in succeeding paragraphs related to the construction of project.

4. This OM shall be applicable to all eligible hydro projects i) wherein tariff is determined by CERC/ SERC under Section 62 of the Electricity Act 2003, ii) tariff is determined through competitive bidding under Section 63 of the Electricity Act 2003 iii) projects developed by agencies like BBMB which do not approach CERC/SERC for tariff determination/ adoption.

5. **'In-principle' approval of Ministry of Power for Grant of Budgetary Support**

The procedure for obtaining 'In-principle' approval of Ministry of Power for grant of budgetary support for 'Enabling infrastructure' prior to commencement of construction is given below:

a. After the DPR is concurred by CEA/ State Govt., the developer shall submit an application for 'in-principle' approval of budgetary support to CEA in the specified format **(Annexure-I)**. For DPRs concurred before the issue of these guidelines, the developer shall submit the updated cost of Enabling Infrastructure (based on indexation issued by CWC) in the application for 'in-principle' approval.

b. CEA shall examine applications received in consultation with CWC and forward its recommendations in the specified format **(Annexure-II)** to Ministry of

Power within one month of the end of the quarter in which application is received.

c. Ministry of Power shall issue 'in-principle' approval for Budgetary Support in the specified format **(Annexure-III)** to the Developer after receiving recommendations from CEA.

The 'in-principle' approval by Ministry of Power would be only for the purpose of facilitating financial closure, etc. of projects from Banks/ FIs and will not create any obligation or commitment on part of Government to provide Budgetary Support subsequently till all the conditions for grant of the same are satisfied.

6. Procedure for Release of Grant towards Budgetary Support

The grant of Budgetary Support for the 'Enabling Infrastructure' shall be provided to the developer in the form of 'Reimbursement' as per the following procedure:

i. After achievement of 25% financial progress w. r. t. approved / original project cost, the Developer shall submit the application in the specified format **(Annexure–IV)** to CEA for Reimbursement of Budgetary Support towards Enabling Infrastructure.

ii. The developer shall submit a Bank Guarantee in specified format **(Annexure-V)** to the CEA for an amount equivalent to eligible Budgetary Support (or the Support requested whichever is less) with validity period up to the date of determination of tariff by the regulatory commission. Ministry of Power may encash the Bank Guarantee, in part or full, upon the recommendation of CEA, in cases where (a) the project is delayed by more than two years beyond the scheduled commissioning date excluding any delays attributable to force majeure conditions and (b) in cases where the funds are found being used/ diverted for works other than those related to enabling infrastructure. CEA shall maintain a proper account of the Bank Guarantee and shall be the custodian of such Bank Guarantee.

iii. The developer shall submit verification records viz., auditor's certificate, self-certification, etc. along with the application as specified in para 6 (i) above in support of his claim for release of Grant.

iv CEA shall examine the applications received during each quarter in consultation with CWC and forward its recommendations in the given format **(Annexure-VI)** to Ministry of Power within one month of end of each quarter.

v On receiving recommendation from CEA, Ministry of Power shall process and obtain the approval of the competent authority for grant as per delegation of powers and General Financial Rules issued by Ministry of Finance, GoI which would be released through budgetary Provisions of Ministry of Power.

vi The Grant shall be limited to the amount as per "In-Principle' approval or the actual expenditure incurred on Enabling Infrastructure whichever is lower under the overall ceilings mentioned in para 1 above.

7. The physical progress of the enabling infrastructure works of each of the projects shall be monitored by a Monitoring Committee to be constituted by CEA and a Status Report, in this regard, shall be submitted to MoP on quarterly basis.

8. By 15th July of every year, the CEA shall send Estimates for Annual Budgetary Grants for the next financial year to Ministry of Power. These budgetary estimates would be based on projects scheduled for completion of milestone, as specified in para 6 above, during the next year.

9. A Report on the 'In-principle' approvals granted and Budgetary Support released during the year shall be sent by CEA to Ministry of Power every year by 31st May.

10. If ownership of the project changes before the commissioning of the project, MoP and CEA would be duly informed within three (03) months of such change.

11. This issues with the approval of Hon'ble Minister for Power.

29/9/21.

(Raghuraj Rajendran)
Joint Secretary

To:

1. **Principal Secretary/Secretary (Power / Energy), State Governments/UTs.**
2. **Secretary, CERC/FOR, Chanderlok Building, Janpath, New Delhi**
3. **Secretary, State Electricity Regulatory Commissions/Joint Electricity Regulatory Commissions**

Copy to:

1. **Secretary, MNRE, CGO Complex, New Delhi**
2. **Secretary, Ministry of Jal Shakti**
3. **Chairperson, CEA, Sewa Bhawan, RK Puram, New Delhi**
4. **Chairperson, CWC, RK Puram, New Delhi**

Copy also for information to:

1. **PS to Hon'ble Minister of Power/ Ps to Hon'ble Minister of State for Power.**
2. **Sr. PPS to Secretary (Power)/ Sr.PPS to AS&FA/ PPS to AS(Hydro)/ PPS to JS(Hydro)**
3. **PPS/Ps to All Joint Secretaries/Directors/Deputy Secretaries in the Ministry of Power.**

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