



भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
नवीकरणीय ऊर्जा उद्भव विकास प्रभाग
Renewable Energy Source Development Division
**** ** ****

No. CEA/PIg/RES-30/2017

Dated: 17-07-2017

विषय: मौजूदा पंप स्टोरेज संयंत्रों (पीएसपी) के संचालन हेतु और अन्य संबंधित मुद्दों के बारे में 28-06-2017 को नई दिल्ली में आयोजित बैठक के **मिनट्स (कार्यवृत्त)**.

Subject: **Minutes** of the meeting regarding operationalization of **existing pump storage plants (PSPs)** and related issues **held in New Delhi (at NRPC) on 28-06-2017**– reg.

महोदय/Sir,

Minutes of the meeting regarding operationalization of **existing pump storage plants** held on **28th June, 2017 at NRPC, New Delhi**, under the Chairmanship of **Member (Planning), CEA**, are enclosed herewith for your kind information and further necessary action.

Copies of the presentations made during the meeting are being sent on emails only.

बैठक के दौरान की गई प्रस्तुतियों की प्रतियां केवल ईमेल पर भेजी जा रही हैं .

कृपया पत्र की पावती दें/ Kindly acknowledge the receipt of the letter.

भवदीय/Yours faithfully

अशोक कुमार राजपूत/(Ashok Kumar Rajput)

Chief Engineer(RES Dev.)

Convener and Member Secretary

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To:

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2. Sh. P. Suresh Babu, Chief Engineer, SLDC & Telecom, TSTRANSCO
3. Sh. B.B. Mehta, Chief Engineer, State Load Despatch Centre, Gujarat
4. Sh. A K V Bhaskar, SE, State Load Dispatch Centre, A.P. Transco
5. Sh. P.A.R. Bende, Chief Engineer, SLDC, MPPTCL
6. Sh. Manoj Kumar, General Manager (BD&JV), NHPC Ltd.
7. Sh. Atulya Kumar Naik, AGM (Power Systems), SECI
8. Dr. P.C. Maithani, Adviser and Sh. J. K. Jethani, Scientist-D, MNRE
9. Dr. Subir Sen, COO (CTU-Plg & SG), CTU/Powergrid
10. Sh G. Chakraborty, DGM, NLDC (POSOCO)
11. Sh. S.S. Mishra, AGM (PE-Solar), and Sh. A.K. Sinha, AGM (OS-SIIS), NTPC Limited
12. Chief Engineer (IRP), CEA
13. Chief Engineer (PSP&A-I), CEA
14. Chief Engineer (PSP&A-II), CEA
15. Chief Engineer (HE&TD), CEA
16. Chief Engineer (TE&TD), CEA
17. Chief Engineer (GM), CEA
18. Chief Engineer (FM), CEA
19. Chief Engineer (F&CA), CEA
20. Secretary, CERC, New Delhi.
21. Member-Secretary (NRPC, WRPC, SRPC, ERPC & NERPC)

Copy for kind information to:

- 1) PPS to Secretary (Power), New Delhi
- 2) PPS to Secretary (MNRE), New Delhi
- 3) PPS to Joint Secretary (Ms Jyoti Arora), Ministry of Power, New Delhi
- 4) Joint Secretary (Dist), MoP, New Delhi
- 5) SA to Chairperson, CEA,
- 6) SA to Member (Hydro), CEA
- 7) SA to Member (GO&D), CEA
- 8) SA to Member (Power System), CEA
- 9) SA to Member (E&C), CEA
- 10) SA to Member (Thermal), CEA
- 11) Sr.PPS to Member (Planning), CEA

Minutes of meeting regarding operationalization of existing pump storage plants (PSPs) and related issues held at NRPC, New Delhi on 28-06-2017

In the meeting of the Technical Committee (held on 13th June, 2017 at NRPC, New Delhi) constituted by CEA under the chairmanship of **Member (Planning), CEA** for “Study of optimal location of the various types of balancing energy sources / energy storage devices to facilitate grid integration of Renewable Energy Sources (RES) and associated issues”, it was decided that a specific meeting on the operational issues of existing pump storage plants (PSPs) will be held. Accordingly, this meeting was held on 28th June, 2017 at NRPC, New Delhi, under the Chairmanship of **Shri Pankaj Batra, Member (Planning), CEA**. List of participants is given at **Annexure-1**.

Member (Planning), CEA welcomed **Member (E&C), CEA** and the participants. **The Chair** briefed the participants that in view of the increasing penetration of power from Renewable Sources of Generation (RES), having variability of generation, there is a requirement of balancing power. There could be various types of balancing sources, including the Battery Energy Storage system (**BESS**). BESS of adequate capacity could be installed near the RES pooling stations to relieve the transmission system. Depending upon the feasibility, balancing power could be sourced from Thermal Power Plants (**TPPs**) having capability of flexible load operation, **gas based** power plants and of course from operational management of various types of Hydro Power Plants (**HPPs**). Pumped Storage Power Plants (**PSPs**) offer the unique advantage of acting as generator or a load depending on the requirement of the grid. He stated that uniform Renewable Purchase Obligations (**RPOs**) have been prescribed for all the States. As RE resources are concentrated in certain states, it would be fair that the balancing cost is not shared by those states alone, but it is shared on prorata basis by all the states. Keeping this aspect in view the representatives of Electricity Regulatory Commissions (**ERCs**) were also invited in the meeting of the Technical committee held on 13-06-2017. Balancing could be done at the **state level, regional level or national level or even through balancing power sources of neighboring countries**.

The Chair stated that the option of **flexible load operation** of thermal power stations could also be used. Coal based units have lower ramp rate as compared to that of gas based plants. Hydro plants have an even faster ramp rate. He stated that ideally functional requirements for balancing services should be given and all plants who could provide these services should be allowed to compete for ensuring cheapest cost to consumer. **Member (E&C)** mentioned about a need to assess the cost economics of the options to be implemented.

Shri A K Rajput, Member Secretary of the Committee and Chief Engineer (RES), CEA welcomed **Member (Planning), Member (E&C), CEA** and the participants. He invited participants for making presentations and requested to deliberate particularly on the following aspects:

- i. Role of Hydro Power Generating sources in “**balancing power requirement**” in view of the increased penetration of RE.
- ii. Operationalization of existing pump storage plants (PSPs), which are not operational and Integrated operation of hydro power plants.

CE (HEPR), CEA made a presentation, highlighting that Nagarjunasagar, 700 MW (Revised-705.6 MW) in Andhra Pradesh is the first PSP of India (commissioned during 1980-85), but is not working in pumping mode due to delay in tail pool dam construction.

A potential of 96,524 MW (63 schemes) in the Country has been identified for pumped storage scheme on main rivers and their tributaries by Central Electricity Authority (**CEA**). It does not include the pumped storage schemes on small streams /Nallah and schemes that could be taken up on the existing reservoir schemes in operation, where pumped storage plant could be set up by constructing another reservoir upstream or downstream. Western Region (**WR**) in the Country has the highest potential for PSPs. He stated that the **basin wise review** has been taken up and would be completed in about 2 years' time. He stated that for effective development of Power system, and in particular hydro power development, there is a need to think at **National level**, rather than only at the state level.

At present, there are 9 (nine) PSPs in the Country with an installed capacity of 4785.6 MW. However, for various reasons, only 5 plants (2600 MW) are being operated in PSP mode. In case of **Panchet Hill** 1x40 MW plant of DVC, Tail Pool Dam could not be constructed due to land acquisition problem.

He stated that **Tamil Nadu** has prepared DPR of **Kundah PSP** (500 MW) and 5 projects have also been identified on existing sites. **Karnataka** has identified 2 PSPs on existing projects. In **Kerala** 3 schemes namely Sholayar-I (810 MW), Sholayar-II (390 MW) and Pringalkuthu (80 MW) have been identified on existing conventional schemes, however survey and investigation (S&I)/implementation could not be taken up for want of forest clearance. A scheme, namely Warasgaon (1200 MW) in **Maharashtra**, is under DPR stage. DPR of Malshej Ghat (700 MW) has been prepared by THDC for which implementation agreement is to be signed with the State Govt. S&I (Survey and Investigation) and preparation of DPR for Humbarli PSS (400 MW) is likely to be awarded shortly. The S&I on Chikhaldara (400MW) is in progress. In case of **West Bengal** S&I of Turga PSS (1000 MW) is completed and DPR has been concurred by CEA. The project is likely to be taken up for development after obtaining necessary clearances from Central/State Govts. S&I on Bandhu PSS (900 MW) is in progress. In **Jharkhand** S&I on Lugupahar Pumped storage Project (2800 MW) is likely to be taken up by DVC after getting permission from State Govt.

He stated that to make PSP commercially viable, there is a need of differential tariff for peak hours. He also suggested to consider Pumped storage schemes as “**Grid Element**” instead of Energy Generation Source alone. **Market based mechanism of operation through Regulatory treatment** will help in commercial viability of PSPs.

CE (HEPR), CEA stated that the funding required for operationalization of existing non-operating PSPs and future development of PSPs may be supported from Power System Development Fund (**PSDF**) or National Clean Energy and Environment Fund (**NCEEF**). Some of the identified schemes, particularly, in Western Region are located in areas which have been declared as **Wild Life Sanctuaries**. The State/Central Governments are required to take necessary action to **de-notify** such areas required for development of PSPs. State Governments should be encouraged to allocate the identified pumped storage schemes to prospective developer for

implementation of PSPs, as **Water and 'Water Power' is a State subject**. It would be more cost effective to locate a pumped storage scheme where one of the reservoir i.e. upper / lower reservoir, is already existing / under construction. The presentation made by CE (HEPR), CEA is at **Annex-A**.

Member Secretary, NRPC shared the operating experience of Sardar Sarovar Power Project (**SSP**). He expressed that for reservoir operation there is '**filling period**' and a '**depletion period**' and there is a need to follow **Rule Curve** and finalize Reservoir Operation Table (**ROT**) in advance. He emphasized on availability of **real time data acquisition**. Each Hydro Project should establish, maintain and operate a system of flood forecasting and flood control.

He expressed concerns about power house operation constraints like '**ten daily limit**' set by Reservoir Regulation Committee, '**Environmental Release**', demand of beneficiary states, irrigation demand and breach in canal etc.

He suggested that the scheduling of the generation at SSP should be done on "Best Fit Schedule (**BFS**)" and energy consumed by SSP during Pumping mode should be distributed among beneficiary States in the ratio of their shares in SSP. He stated that **Tribunal Orders/Awards** are also binding, posing another constraint. He summarised his presentation as below:

- i. Simultaneous Pumping and Straight generation not to be permitted.
- ii. Sharing of operation and maintenance (O&M) expanses, to be agreed apriori among beneficiaries.
- iii. Separate energy account for Straight generation, pumping energy & power generation from pumped water.
- iv. Separate water account to be maintained for pumped water and inflow water.
- v. Peak hours may be different for beneficiary States. Generation from pumped water to be scheduled keeping in view the grid requirement.

There are inter-state issues in operationalization of SSP in Pump Storage Mode. In order to resolve the issue of operationalization of SSP in PSP mode, it was decided to have a focused **meeting on the issues of SSP in CEA** where all stakeholders need to deliberate the issue. **Hydro Wing CEA to coordinate this meeting**. Presentation made by MS, NRPC is at **Annex-B**.

Representative of **THDC** made a presentation and salient features of Tehri Hydro Power Complex, were highlighted:

Tehri Hydro Power Complex (2400 MW) is a multipurpose project, stores water, meets irrigation requirement of Uttar Pradesh (UP) and drinking water requirement of UP & Delhi in addition to provide peaking support to Northern Grid.

Tehri reservoir stores water during monsoon period whereas Koteshwar reservoir in downstream serves the purpose of daily regulation of water released from Tehri. After commissioning of Tehri PSP, Koteshwar reservoir will also function as lower reservoir for PSP. During non-monsoon period (about 270 days) seven (7) hours of pumping has been estimated while during monsoon due to spillage, there is no requirement of pumping. For Integrated operation of Tehri PSP, Tehri HPP and Koteshwar HEP, total time required in one cycle is 11 hours (4 hours in generating mode and 7 hours in pumping mode). He informed that PSP is good option and proven technology for large scale storage and grid stability and helps in mitigating the intermittency of renewable energy. He mentioned that scheduling shall entirely

depend on margin available in balancing reservoir instead of daily basis, hence provision for **flexible scheduling** needs to be devised in Indian Electricity Grid Code (**IEGC**) for PSP. He further added that there should be provision of flexible scheduling in case of multipurpose project. The presentation made by THDC is at **Annex-C**.

A presentation was made by **Dr Anoop Singh, Professor, Deptt. of Industrial and Management Engineering Indian Institute of Technology Kanpur** on Economic Value of Pumped Storage in a Power System with Solar PV. He mentioned that in a generic sense, all the technologies could compete with each other, but certainly there are economic advantage of PSPs. The following are the highlights of the presentation:

In order to redress the issue of variability of renewable generation (VRE) the focused approach could be - Better RE forecasting, Better load forecasting, Load shifting from peak to off peak of the load curve, and Energy Storage Systems (ESS) that could store the surplus generation and utilize it during times of low or no generation. A case study was presented, in which a unit commitment power system model is setup to analyse the impact of ESS for VRE sources. Pumping facility of a hydro unit adds value, depending on case to case basis. The Summary of study highlights that power system (society) is losing economic benefit of investments made in PSPs, if these are not operated in an economic manner. PSPs can assist Greater penetration for Variable Renewable Energy (VRE) in the system. The presentation made by Dr Anoop Singh is at **Annex-D**.

Representative of **SRLDC** made a presentation and stated that in the Southern Region, Hydro Power is highly Monsoon Dependent, Hydro is mostly utilized for the morning and the evening peak ramping requirements. Presently pumped storage installed capacity in Southern Region is 2005 MW at **Srisailem Left Bank (Lb), Nagarjunsagar** and **Kadamparai**.

He expressed that in case of **Srisailem Left Bank**, there is a generation constraint. The Dam is under the control of Krishna Irrigation Department. In case of additional requirement due to grid conditions, special permission is to be obtained. It cannot be Operated at less than 110 MW due to Vibration problem.

Pump Operation at **Srisailem Left Bank** is dependent on **Nagarjunsagar Dam** level, as Srisailem Tail Race WEIR is under repair. 540 ft water level is required at Nagarjunsagar for pump operation at Srisailem. Water above this level is available only for about 2-3 months a year. The weir between Srisailem Reservoir and Nagarjunsagar Reservoir, which is used for pumping operation is not operational, since last two years. Attempts to repair the weir have not been successful. He stated that during the monsoon, water from Maharashtra (Narayanpur side) comes in huge quantity, all of a sudden, and it is one of the cause of damage of the said weir. The issue of damage and need to repair the weir had been taken up with CEA/CWC also. ***It was decided that SRPC should write to CEA (Member Hydro) indicating the specific issues, and at the same time Andhra Pradesh and Telangana should also write to Member Hydro, CEA to resolve the issue of weir repair and strengthening.*** Each unit takes around 20 – 30 minutes from standstill to pumping mode. He stated that other constraints are -shifting of lift irrigation pumps to avoid possible submergence. 7 TMC of water is required in the Tail Pond Reservoir for pumping operation, out of which, 6 TMC was dead storage while one (1) TMC could be utilized for pumping operation. For pumping mode, the level required in Tail Pond

Reservoir was higher than the MDDL for 2x25 MW generating station under APGENCO, TSGENCO suggestion us that APGENCO station may operate its unit when water level is above the level required for pump mode and whenever discharge was there from main Nagarjunasagar Reservoir. Vibration was observed when generation is less than 65 MW for Unit#1 & 55 MW for Unit#2 to 8.

SRLDC presented the constraints in operation at **Kadamparai**, which are due to low voltage at 230 kV level, due to which the stator draws more current, which can damage the windings. There is water shortage also during non-monsoon months. The presentation made by SRLDC is at **Annex-E**.

The representative of **SRPC** made a presentation and indicated **that of total Capacity of 2005 MW of PSPs in Southern Region, only 1300 MW is operational (at Srisailem and Kadamparai). For pump mode Operationalization of Nagarjunasagar, there are certain issues between Andhra Pradesh and Telangana, main being discharge quantum and time duration. It was decided that the mechanism for enabling pump mode operation/utilization of the water pumped back could be referred to CEA for further guidance and suitable directions.**

SRPC stated that Commercial framework and an incentive scheme may be designed for **Regional balancing. Andhra Pradesh (AP)** is preparing DPR for Pumped Storage Scheme of 1000 MW at Upper Sileru, which is at finalisation stage. **KPCL (Karnataka)** through WAPCOS Ltd got prepared a project report on **Sharavathy** Pumped Storage Scheme, Pre-feasibility Report (PFR) has indicated the capacity of 2000 MW. PFR has been submitted to Ministry of Environment and Forest (MOEF) for first stage clearance. PFR for **Varahi** Pumped Storage scheme is also under preparation. The presentation made by SRPC is at **Annex-F**.

SLDC Chennai gave a presentation about **Kadamparai** Pumped Storage Scheme, in which during non-peak hours water from Upper Aliyar Dam is pumped to Kadamparai dam. Prior to 2002, grid was operated at low frequency (i.e. between 48.5 Hz & 49.0 Hz) and almost no surplus power was available during off peak time for pumping.

For pump mode operation, **Kadamparai** plant is designed between 49.5 Hz and 50.5 Hz. The motor input required is about 110 MW. If all the four units are operated as pump, then the power input required at station end is about 440 MW. First time, on 12-02-2003 only, all the four units were put on pump mode, though the station was commissioned in 1989. **At present due to failure of monsoon the water level at Kadamparai is very low, hence it cannot be used in generating mode and due to very less storage in Upper Aliyar it also cannot be used as pump mode effectively.** This leads to difficulty in absorption of Renewable Energy (RE). Because of less hydro storage due to failure of monsoon, the cheapest hydro sources in Tamilnadu are used as peaking stations only. The presentation made by SLDC of Tamilnadu is at **Annex-G**.

Representative of **GSECL (Gujarat)** expressed that in year 2004-05, **Kadana** Hydro Electric Project (KHEP) units were run in pumping mode, but the machine did not operate smoothly and some problems were observed such as high eddy current drawn in reactor, frequent rotor earth fault resulting in puncture of slip ring insulated bolts, vibration at the dam and penstock area, Rise of TGB (Turbine Generator Bearing) temperature and machine vibration.

GSECL held a meeting with M/s BHEL at Bhopal on 6/08/2015 regarding feasibility of pump mode operation of KHEP units, where it was advised by BHEL that keeping in view the past experience, the machines should not be operated in pump mode operation. As per requirement of SLDC, KHEP again asked to M/s. BHEL and OEM M/s CKD Balnsko (Czechoslovakia) for the budgetary offer for the pump mode operation of KHEP units. M/s Voith Hydro Noida has also been requested by them to submit their budgetary offer. OEM M/s CKD Balnsko had plan to visit KHEP during 11/7/2017 to 20/7/2017. BHEL would also be participating. The presentation made by GSECL is at **Annex-H**.

Representatives of **Maharashtra** and **TATA Power** made a joint presentation. It was stated that at present Ghatghar, Paithan & Bhira Hydro Pumped Storage Plants are in operation in Maharashtra. Ghatghar is used in generation mode operation in morning peak hours and Evening peak hours (2x125 MW) or whenever required and to reduce over drawl from grid during low frequency. In Ghatghar, units are available within 15 minutes of giving instructions and once taken as generator, the unit is operated for a minimum of 1 (one) hour. Further, its capacity is very less compared to what is required to meet the peak demand. But it is useful in relieving congestion or constraints, in case of line or unit tripping and can also provide support during black start.

Bhira Pumped Storage Plant is designed to pump water from Bhira Tail Race Pickup (**BTRP**) pond to Mulshi lake. Problems faced in Bhira Hydro Pumped Storage Plant are that pumping would be possible only during off peak hours and when Bhira Old Power House and Rawalje Power House are not generating and Rawalje pickup pond level should be a minimum of 94.4 m during starting and more than 93.85 m throughout the pumping operation.

The following measures were suggested to resolve the issue of tail race level:

- To control the water level in pick-up pond a gate has to be provided in between the forebay and pick-up pond.
- An agreement for design of gated bypass channel and coffer dam for the BTRP project has been made with Central Design Organization, Nashik.

The presentation made by Maharashtra is at **Annex-I**.

The representative of **WBSEDCL, West Bengal** made a presentation, citing the problem of RE integration due to fluctuating RE generation in West Bengal, where major share of generation is from thermal energy. They suggested development of additional pumped storage hydro project, to take care of the fluctuating RE generation.

He stated that the **Purulia** PSP (900 MW) project provides several benefits in managing the grid. He stated that for a stable grid, the ratio of peak load plant to base load plant should be 40:60. He stated that bulk energy storage would promote development of RE. It was suggested that in order to compensate for the losses due to cycle efficiency, there should be incentives in tariff to the PSP and a grant of 15% of project cost. The presentation made by West Bengal is at **Annex-J**.

The representative of **BHEL** presented the contribution of BHEL in Hydro Power development and presented BHEL's manufacturing capabilities. Though BHEL has not directly supplied PSPs, but in association with other companies, they have executed the projects. BHEL has got experience of high capacity pumps. BHEL proposed themselves as a qualifier for PSPs tenders in future. BHEL has contracted 5877 MW of pumps for various lift Irrigation Schemes. Largest pump is of 145 MW unit rating. It was informed that their State of the Art turbine model testing Laboratory is at Bhopal and they are the only hydro equipment manufacturer in India having a model test lab. They have been recognized by the Department of Scientific & Industrial Research (**DSIR**), Government of India as in-house R & D group for Hydraulic Design & Development of Hydro Turbines. Advance Research is undertaken by BHEL in the field of hydraulic machinery. They mentioned that Hydro pumped storage systems shall play an important role in providing storage of power and maintaining grid stability and most of the developed countries are following this route. Hydro pump storage system is the only long term technically proven solution without any restriction of Unit capacity, is cost-effective, highly efficient and provides operationally flexible energy storage on a large scale and is available on short notice.

BHEL requested for consideration on following points and also requested for modifying the Qualification requirements.

- i. Even though BHEL has been associated in execution of Six PSS projects, BHEL does not possess the qualification requirements, as orders were placed on foreign manufactures, with BHEL as partner.
- ii. BHEL over the years, has developed its own technology and is capable of supplying PSS schemes.
- iii. BHEL is already a leader in design, engineering & supply of large size pumps for Lift Irrigation Schemes.
- iv. In view of forthcoming requirement of PSS, it would be in the interest of all stakeholders to qualify BHEL for future PSS tenders.
- v. E&M package to be a standalone Package (excluding any civil works); Alternatively, E&M works vendor can be a nominated sub-vendor to the civil party.
- vi. Options for qualification should be available to companies like BHEL, who have earlier executed reversible Pump-Turbine sets in India in association with established Pump-Turbine manufacturers.

The presentation made by BHEL is at **Annex-K**.

The conclusions from the meeting are summarized below:

1. **Saradar Sarovar Project** - It was decided to have a focused meeting on the issues of SSP in CEA where all stakeholders need to deliberate the issue. **Hydro Wing of CEA** may coordinate this meeting.
2. **Srisaillam Left Bank** - It was decided that SRPC should write to CEA (Member Hydro) indicating the specific issues and at the same time Andhra Pradesh and Telangana should also write to Member Hydro, CEA to resolve the issue of weir repair and strengthening.

3. **Nagarjunasagar** - For pump mode Operationalization of Nagarjunasagar there are certain issues between Andhra Pradesh and Telangana, main being discharges quantum and time duration. It was decided that the mechanism for enabling pump mode operation/utilization of the water pumped back could be referred to CEA for further guidance and suitable directions.

The meeting ended with a vote of thanks to the Chair.

Annexure-1

List of participants of meeting regarding operationalization of existing pump storage plants (PSPs) and related issues held in New Delhi (at NRPC) on 28-06-2017

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