# RENOVATION, MODERNISATION, UPRATING & LIFE EXTENSION OF HYDRO POWER PLANTS IN INDIA – An Overview

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## 1. BACKGROUND

Even after fastest ever capacity addition in recent years, India still needs lot of affordable power to augment per capita consumption, which make us realise that the capacity addition from cost effective, feasible & viable sources has to continue un-relentlessly on sustainable basis. The focus on means of power capacity addition keeps on changing based on ever evolving technologies both from conventional & renewable resources. However, it is worth mentioning that one thing which has not changed since inception is the advantage the hydro power draws over other resources of generation whether it is technical, commercial or environment related. No fuel cost, less complicated system & equipment, any time generation, quick start/stop, fast ramping, peaking support, no effluent production, silent operation, reasonable load factor and above all a very long life through RMU&LE are some of the factors which go strongly in favour of hydro plant. However, long gestation period, geological uncertainties, remote location, high initial cost, R&R issues and upcoming environmental concerns possess renewed challenges, which impede fast track development of new hydro power schemes.

The long life advantage of hydro power plants can be met through timely intervention of Renovation, Modernisation, Uprating & Life Extension of old plants. The RMU&LE has been accorded a high priority by Govt. of India as it is considered a faster and cheaper option of capacity addition in comparison to installing new units and for improvement in its operational reliability & efficiency. The utilities experience the need for RMU&LE as the plant is about to reach the end of design life and there is constant danger lurking of major breakdown resulting in unmanageable consequences. It is often seen that delay in R&M work forces plant personnel to operate plant through means which are not recommended posing constant danger to both plant personnel and environment. The R&M works of Hydro Plants always remained low profile in all these years but now due to large scale penetration of capacity addition through RES, there is renewed realization of hydro power on account of its flexible operation.

## 2. R&M WORKS IMPLEMENTED SO FAR

Under the hydro R&M programme, 65 (15 in Central and 50 in State Sector) hydro R&M schemes (13 upto the VIII Plan, 20 in the IX Plan & 32 in the X Plan) with an aggregate installed capacity of 10511 MW at a cost of Rs. 1726 crores have been completed by the end of the X Plan (i.e by 31$^{st}$ March 2007) & have accrued a benefit of 2351 MW through Life Extension, Uprating and Restoration. During the XI Plan, 21 schemes with an installed capacity of 6173 MW at an estimated cost of Rs.530 crore were planned to accrue benefit of about 826 MW. Out of these, 17 schemes (4 in central sector & 13 in state sector) with an installed capacity of 4803 MW were completed till March, 2012 at a cost of about Rs.239 Crore and have accrued a benefit of 715 MW through Life Extension, Uprating and Restoration. In addition, one scheme namely Umium St-II (18 MW) of MePGCL, scheduled during XII Plan, was completed during 2011-12. Thus, during XI Plan, a total of 18 hydro R&M schemes (4 in central sector & 14 in state sector) with an installed capacity of about 4821 MW have been completed at a cost of about Rs.295 Crore and have accrued a benefit of 735 MW through Life Extension, Uprating and Restoration. Refer Table-1 for details.

**Table - 1 : Hydro R&M Schemes Completed up to XI Plan**

| Sl. No. | Plan Period | No. of Projects | | | Installed Capacity (MW) | Estimated Cost (Rs. in Crs.) | Actual Expenditure (Rs. in Crs) | Benefit (MW) |
|---|---|---|---|---|---|---|---|---|
| | | Central Sector | State Sector | Total | | | | |
| **1.** | **VIII Plan Schemes completed** | 2 | 11 | 13 | 1282.00 | 125.57 | 127.37 | 429.00 [39.00(U) + 336.0(Res.) +54.00(LE)] |
| **2.** | **IX Plan Schemes completed** | 8 | 12 | 20 | 4892.10 | 597.84 | 570.16 | 1093.03 [339.00(U) + 331.03(Res.) + 423.00(LE)] |
| **3.** | **X Plan Schemes completed** | 5 | 27 | 32 | 4336.60 | 1016.31 | 1028.97 | 829.08 [123.40(U) + 701.25 (LE) + 4.43(Res.)] |
| **4.** | **XI Plan Schemes completed** | 4 | 14 | 18 | 4821.20 | 412.83 | 294.84 | 735 [12 (U) + 15 (Res.) + 708 (LE)] |

During XII Plan, a total of 23 hydro R&M schemes (2 in Central Sector and 21 in State Sector) having an installed capacity of about 4077 MW and which will accrue benefit of about 567 MW through uprating, life extension and restoration are expected to be completed at an estimated cost of about Rs. 1373 Crores. Refer Table-2 for details.

**Table - 2 : Hydro R&M Schemes Programmed for Completion during XII Plan** (As on 30.9.2016)

| Sl. No. | Description of Status of Scheme | No. of Projects | | | Installed Capacity (MW) | Estimated Cost (Rs. in Crs.) | Actual Expenditure (Rs. in Crs.) | Benefit (MW) |
|---|---|---|---|---|---|---|---|---|
| | | Central Sector | State Sector | Total | | | | |
| **1.** | **Programmed (Original)** | 5 | 40 | 45 | 7105.40 | 5405.85 | - | 3344.25 [182.05(U) + 3147.20(LE) +15(Res.)] |
| | **Revised** | 2 | 21 | 23 | 4076.90 | 1372.67 | 1098.63 | 566.70 [43(U) + 508.70(LE) +15(Res.)] |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2.** | **Completed** | 2 | 18 | 20 | 4014.6 | 1266.21 | 1049.39 | 534<br>[43 (U)+<br>476 (LE)+<br>15(Res.)] |
| **3.** | **Under Implementation** | 0 | 3 | 3 | 62.30 | 106.46 | 49.24 | 32.30<br>[32.3(LE)] |
| **4.** | **Under Tendering** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |

## 3. STATUS OF R&M WORKS UNDER EXECUTION

A total of 52 schemes having an installed capacity of about 9288 MW are programmed as on date for implementation during 2017-22 & beyond and which will accrue benefit of about 3609 MW. Refer Table-3 for details.

**Table – 3 : Hydro R&M schemes to be taken up during the XII Plan and Programmed for Completion during 2017-22 & beyond** (As on 30.9.2016)

| Sl. No. | Description of Status of Scheme | **No. of Projects** | | | **Installed Capacity (MW)** | **Estimated Cost#<br>(Rs. in Crs.)** | **Actual Expenditure<br>(Rs. in Crs.)** | **Benefit<br>(MW)** |
|---|---|---|---|---|---|---|---|---|
| | | **Central Sector** | **State Sector** | **Total** | | | | |
| **1.** | **Programmed** | 8 | 44 | *52 | 9288.05 | 5915.42 | 607.87 | 3608.65<br>[200.75(U) + 3407.90(LE)] |
| **2.** | **Under Implementation** | 4 | 9 | 13 | 3826.00 | 1422.70 | 536.74 | 1341.60<br>[131.20 (U)+<br>1210.40 (LE)] |
| **3.** | **Under Tendering** | 2 | 14 | 16 | 3035.10 | 3014.91 | 31.60 | 1215.55<br>[28.80 (U) +<br>1186.75 (LE)) |
| **4.** | **Under DPR Preparation/Finalisation/Approval** | 2 | 11 | 13 | 1191.95 | 1477.81 | 39.53 | 1051.50<br>[40.75(U) + 1010.75 (LE)] |
| **5.** | **Under RLA Studies** | - | 10 | 10 | 1235.00 | - | - | - |

## 4. COMPONENTS OF WORKS IN HYDRO R&M

Hydro R&M schemes are generally classified based on the scope of works. The following classifications are followed while identifying the R&M schemes:

(a) Renovation and Modernisation (R&M)
(b) Restoration (Res)
(c) Uprating (U)
(d) Life Extension (LE)

**(a) Renovation and Modernisation**

The main objective of Renovation and Modernisation (R&M) of hydro generating units is to make the operating units well equipped/modified/ augmented with latest technology equipments/ components/ systems with a view to improve their performance in terms of efficiency, output, reliability and availability to the original values, reduction in maintenance requirements and ease of maintenance. The Electro-mechanical portion of hydro plants basically contains Turbine, Governor, MIV, Generator, Excitation system, Power Transformers, Instrumentation, Control & Protection system, HV and LV switchgear, switchyard equipment and Cables. The various system in turn has active and passive components which has varying length of service life. Certain systems are prone to obsolesce with advanced models coming in with improved performance suiting the changing needs, thereby requiring early attention. The extent of R&M varies from plant to plant but in any case after R&M the plant is expected to be ready for normal operation for another 25-30 years or so before another R&M is considered. It is worth mentioning here that present regulations stipulates that while designing hydro-electric projects, the life of the civil works shall not be less than one hundred (100) years, while that of main electro-mechanical generating equipment i.e. turbine, generator, transformers, auxiliaries, etc. installed shall not be less than thirty five (35) years. However, world wide there are discussions that Dam may last much longer with proper maintenance and strengthening as required from time to time, so we have to think of RMU&LE for multiple repeats.

The Indian manufacturers have the requisite infrastructure and manufacturing facilities for supplying state-of-the-art equipment for the power plant equipment/ components. There is no technological gap on this count.

**(b) Restoration**

There may be some hydropower stations where the generating units are not operating at their rated capacities. After R&M activities, it may be possible to restore the generating units to their rated capacities and hence there may be benefits in terms of MW and MU. The hydro R&M schemes which were not giving output at their rated capacity but after carrying out R&M activities, are able to generate to their rated capacity or nearer to their rated capacity is classified as Restoration (Res) Scheme.

**(c) Uprating**

Unlike thermal power plants, hydro prime movers hold substantial potential of uprating at the time of Renovation and Modernisation, thereby making upgrading proposals cost effective. In view of the fact that hydroelectric plants are used mostly for peaking purposes, the enhancement of peaking capacity has to get due cognizance. Extra benefit in case of run of the river schemes is of course an added incentive. R&D innovations in the field of hydro dynamics make it possible to derive higher outputs from the existing hydraulic space in turbines by employing higher specific speed profiles on one hand and development of Class F epoxy insulation makes it possible to use larger conductor size in the existing stator slots for higher outputs on the other. While finalizing the R&M program of a hydropower station, emphasis has to be given for achieving higher output by virtue of rewinding of stator/rotor windings of generator with class F insulation, runner with modified/improved profile, replacement of existing governor and excitation system with latest microprocessor based governor and excitation system, augmentation of water conductor system (which may increase the discharge and hence the peaking capacity and additional generation), utilizing spilled water from the reservoir etc.

**(d) Life Extension**

The Life Extension programme is a major event in the hydropower station's history, as it envisages extension of life over a considerable period of time. At this time, it is a good practice to examine whether a power station/generating unit requires a viable modernization which has not been carried out earlier so that during the extended life, the power station operates efficiently and delivers the rated capacity. More emphasis has to be laid on LE of generating units having completed or completing in the near future normative operating life of 30-35 years. Scope of works for LE schemes has to be firmed up based on condition assessment study which includes RLA studies. Uprating, if feasible, shall also be taken up along with LE programme. RLA studies should be got conducted through competent vendors and the Detailed Project Report (DPR) for the scheme be prepared based on the findings of RLA studies. Job of RLA studies and execution of R&M works should be tendered out

separately with the later being based on the findings of the first one. The studies/experience indicate that Renovation and Modernization of units of hydropower stations is very cost effective. The cost of capacity benefit is 20 to 30% as compared to cost of installing a new generating unit. In past, R&M works were taken up in power plants to utilize design margins available in various equipments to upgrade the power plant by doing R&M in part component/ equipment of power plant. However, as more & more plants would be reaching the stage of outliving their useful life, these power plants would be shifting focus towards life extension activities which is relatively cost intensive.

## 5. APPROCH TO PROCEED FOR R&M

Though for new hydro projects complete set of systematic approach right from pre-feasibility stage investigation till commissioning of plant is established, the approach to RMU&LE works is still being developed as more and more plants are ageing and due for renovation work. Although, the approach to RMU&LE may vary from project to project, however it could be generalised to be a two part process i.e Planning for R&M and Implementation Works.

### 5.1 Planning for R&M

The old hydro plants were built with limited hydrological and geo-technical data and with operational experience of decades, the utilities get to know the actual site conditions with improvement possibilities. In addition to making best assessment of variation in inflows, the utilities get exact actual head loss parameter which directly affects the machine output. As such the collection of data is best starting point for planning which includes review of design records, O&M history records, reasons for variation in generation data, discussions with plant operators. Simultaneously, a reputed agency needs to engaged to conduct RLA studies so that extent of R&M could be accessed. Based on the results of Analysis of plant data and RLA studies, preparation of DPR is must for systematic approach. To cover details in holistic manner the DPR may be formulated as per following format:

#### 5.1.1 Section-I: Introduction, Background & Salient Features

This section should include at least following details:

- Name of the Power Station, original installed capacity, brief history of the power station, approach to power station i.e. location.
- Unit-wise rated/derated/uprated capacity, unit-wise commissioning dates and make of main equipments such as Generator, Turbine, Generator Transformer, Governor etc.,
- Technical Particulars of generating units/transformers/switchgears mentioning their type, capacity, supplier, spare available.
- Unit-wise and station wise performance data for the last 5 years containing Design Energy, Actual Energy Generation, Target Generation, Plant Availability Factor etc.
- Problems faced with the operation of the equipments, if any. Major failures/accidents occurred, major components replaced, generation problems/design deficiencies and possible solutions.
- Details of major R&M works carried out earlier and benefits/improvement achieved.
- Major forced and planned outages during last 5 years (number, duration, reasons, remedial measures taken etc.)
- Need and scope of R&M along with brief Justification.
- Benefits anticipated in terms of MW/MU after carrying out the R&M /Uprating / Restoration / Life Extension of the Power Plant.
- Expected increase in life of generating units/transformers/switchgears after R&M works.
- Techno-economic evaluation and justification.

#### 5.1.2 Section-II: Water Availability and Power Optimisation Studies

This section should include at least following details:

- River system and Basin characteristics.
- Details of Catchment, if any.
- Climatology of the Area.
- Water Availability Studies (Revised/Original).

- Inflow series and Inflow data considered for Optimisation study.
- Head loss calculations.

In this section, project authority needs to provide confirmation letter regarding levels (FRL & TWL) given in DPR for the project by State Govt. and other hydro-power projects existing/proposed on the upstream and downstream of proposed HEP along with their TWL& FRL respectively. In case, optimization studies recommendation result in uprating of plant then adequacy or its strengthening, if any, of existing water conductor system, civil/hydro-mechanical/electro-mechanical structures & components need to be assessed for meeting this requirement in subsequent Section-III as same civil structures and hydro-mechanical components are to be used.

### 5.1.3 Section-III: R&M Proposal along with Justification

This section should include complete technical details of various components in below classified categories:

- Civil
- Hydro-Mechanical (HM)
- Electro-Mechanical (E&M)

This section should include detailed justification for each equipment/item whether to be retained, refurbished or to be replaced. This section should also have all Civil, HM and E&M Drawings and General Plant Layout along with water conductor system and Dams/Barrages/Rivers/Lake/Catchment area/Single Line Diagram. Findings of RLA report should also be a part of this section.

### 5.1.4 Section-IV: Cost of R&M

This section should include complete details of cost of various equipments/ components following in following categories:

- Civil
- Hydro-Mechanical (HM)
- Electro-Mechanical (E&M)

The basis on which estimated cost has been given shall also be provided. The cost section should adjust cost recovered by selling old equipments/material.

### 5.1.5 Section-V: Economic Evaluation & Tariff

This section should contain the economic justification of the cost of R&M works in detail. It should clearly give what will be the change in unit cost of energy on account of R&M works, the final unit cost of energy in comparison to earlier/original cost, pay-back period etc.

Return on Equity (RoE), Depreciation, Operation and Maintenance charges as approved by CERC/ SERCs as applicable, Interest Rate etc. should also be there in this proposal.

### 5.1.6 Section-VI: Schedule of R&M works

Detailed tentative schedule of works in all the three categories i.e. Civil, Hydro-mechanical (HM) and Electro-mechanical (E&M) should be given in PERT Charts. In preparing schedule, care should be taken that the period in which all units are under shutdown should be minimum and maximum part of this should be covered during lean season. Completion schedule can be compressed by coordinating supply & erection/commissioning unit-wise rather than taking up erection activity only after completion of full supply, which may also cause storage and handling problems.

## 5.2 Implementation Methodology

### 5.2.1 Technical Specifications

With the approval of Detailed Project report the basic frame work for R&M sets in. The preparation of Detailed Technical Specifications and drawings is the basic activity which guides through the scope of works during bidding process and execution. It is wise to engage reputed consultants in this process

as the specifications not only should meet the basic performance parameters but also should comply the applicable regulatory provisions, which may not be applicable at the time when plant was originally erected. With large scale intrusion of renewable in future, the hydro Plants is seen as important asset for ancillary services i.e services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations. The hydro plants are also seen as grid stabilizer due to faster response and sharp ramping.

### 5.2.2 Bidding Process, Execution and Performance Evaluation

The process of award of works may happen through MoU route with original equipment manufacturer or through local/international competitive bidding. The competitive bidding route is preferred as the utility gets the best offer price, however the scope needs to clearly defined to avoid confusion during execution. The International Competitive Bidding (ICB) is generally followed when utilities sought financing through international agencies and international agencies impose stiff conditions on mode of bidding.

## 6 CONCLUSION

The hydro power plants should not merely be seen as another electricity producer but its output should be valued for services it offers to power dispatcher in providing flexibility to grid management in terms of peaking power, leading & lagging MVAr support, fast ramping, overload capacity, synchronous condenser option, black start power provider and upcoming concept of ancillary services provider to enable RES power evacuation. The R&M of hydro plants provide an opportunity to utility to upgrade the technical parameters of plant to meet power market expectations and also keep themselves ready for future grid scenario, where there would be large scale penetration of RES. With all these benefits of hydro power, the utilities should proceed for R&M of aging hydro plants in timely and systematic manner.

***Disclaimer:*** *The views expressed in this paper are personal views of author and Not of Central Electricity Authority.*

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