Renovation, Modernization, Uprating & Life Extension of Hydro Power Plants

DVC Hydel Plants– Case Study

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INTRODUCTION

Normally the life of hydro-electric power plant is 30 to 35 years after which it requires renovation. In a fast changing technological environment, it has become desirable after elapse of 15 years to go for modernization in view of the new system requirements thereby enhancing the machine availability/generation with minor modifications. While renovating the machine, care should be taken to replace old items/equipment by the new technological alternatives.

Modernization is a continuous process and can be a part of the renovation program. The reliability of a power plant can certainly be improved by using modern equipment like static excitation system, microprocessor based controls, electronic governors, high speed static relays, data logger, vibration monitoring system, silt measurement devices etc.

Upgrading / Uprating of hydro plants calls for a systematic approach as there are a number of factors viz. hydraulic, mechanical, electrical parameters and further economics, which play a vital role in deciding the course of action. For techno-economic feasibility, it is desirable to consider the uprating along with Renovation & Modernization / Life extension. Recognizing the benefits of R&M of hydroelectric power projects, Govt. of India set up a National Committee in 1987 and a Standing Committee in 1998 and thereafter had identified the projects/schemes to be taken up for implementation under R&M. The National Perspective Plan document for R&M of hydroelectric power projects in the country was also prepared in C.E.A. during the year 2000, incorporating the status of various projects/schemes already identified for implementation/completion till the end of XI Plan, i.e. March, 2012.

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. 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.

From the experience, it reveals that uprating is the most cost effective way of capacity addition in a much shorter time span. As uprating is possible by changing partly or wholly the electro-mechanical equipment within the existing civil work as hydro units are designed and manufactured with liberal safety margins to meet the guaranteed parameters and specifications. The safety margins are always available between designed parameter and operating parameters. So it is possible to enhance the output of the units by about 10% to 15% by careful study and evaluation and further by utilizing the safety margins without sacrificing the basic safety factors. The technological development, computer aided
precise design technique and advancement in material science have made it possible to design the new equipment with uprated capacity without changing the existing civil structures.

**REASONS FOR RENOVATION, MODERNIZATION AND UPGRADEATION**

India though having enormous potential for hydro generation, the share of hydro sector has continually declined in the last three decades. Though Central / State Government came up with various policies in last 15 years to attract private participation and private finance for the development of hydro sector, the thermal/ hydro ratio has tilted more in favour of thermal. The highly finance intensive and riskier hydro sector has not attracted many private players till date. Of many new projects allotted to different private developers, only a few have achieved their targets.

Hence to cope up with this persisting situation of Indian power scenario, government decided to go in for Renovation, Modernization & Upgradation of old Hydro Power Plants. Utilities going for RMU of old power station have either completed their normal operative life or the technology of the existing facilities has become obsolete to such an extent that, it becomes very difficult to arrange the spares. The benefits of RMU are:

**No / Minimum clearances required**

Development of any new hydro-electric project entails following statutory clearances:

- Techno-economic clearance of the project
- Site Clearances by MOEF after feasibility studies
- Environmental Clearances based on EIA (Environmental Impact Assessment) and EMP (Environment Management Plan)
- Forest Clearances
- Land acquisition etc.
- R&R Issues

These clearances are the major risk to the development of the project as they take considerable time and effort. In case of RM&U of the old HEPs, these stages are already taken care of during its initial construction. Any clearances, as the case may be, required only if any land is to be used other than the project land, which may be meagre in quantum and can be accommodated as a parallel activity. Moreover, Rehabilitation & Resettlement issues are either nil or very less for the RM&U projects.

**Less Gestation Period**

Unlike thermal each hydro project is unique and different from other project, which are tailor made in nature. Each hydro project needs to start afresh since its inception. The geological conditions are different at different sites, which make it a very uncertain venue to invest. These uncertainties and enormous civil works could extend the gestation period of a new hydro project to over eight years, resulting in cost overruns and less return on investments.

RMU of old hydro power station has very less gestation period in comparison to an equivalent new hydro project. Proper scheduling of the works can reduce the
implementation period of any RMU project by 3-4 years and that too most of the machines of power station continue to generate during this period as the work is taken up on machines one by one.

Less Risks
New Hydro Projects are high-risk investments with geographical terrain playing major role in their successful completion. There are various major risks associated with the development of any new hydro project such as clearance risks, geographical risk, construction risk, regulatory risk, resettlement & rehabilitation risk, social risk etc. These risks not only increase the gestation period of the project but also delay the return on the investments, causing hydro sector as less lucrative sector to work with. However, these risks are not at all associated with the RMU of old HEPs. The return on investments would be far earlier as compared to any new hydro project.

Less investment as against equivalent new project

Cost of development of any new hydro-electric project may range from Rs. 10 to 12 Crore per MW, whereas, depending on the scope of RMU, the cost of development of RMU of old HEPs may range from Rs. 2 to 7 Crore per MW. Arrangement of finance for the project is a major hurdle for any management. Lesser cost lessens the risk and easier it becomes for arrangement of finance as financial institutions readily make available the required funds based on lesser risk associated with the RMU projects vis.-a-vis. new projects. This also lowers the equity requirement as any management has to arrange 30% as equity of total project cost.

Improper River Basin Development

Most of the river basins of India have not been properly developed as far as hydro sector is concerned. One of the best example is Ganges River Basin & rivers flowing in the North Eastern part of India. The development of hydro power plant in the upstream of any existing hydroelectric project would provide sufficient and regulated water for its Upgradation.

In DVC’s case, water of Barakar River from THS station (4MW) is released, which drives MHS station (63.2MW).

Technological Advancement

Ever changing technology in Hydro sector is bringing redundancy in 10-15 years. Obsolescence of the equipment only leads to unavailability of the spare parts. Continuous R&D in this sector is providing new products at regular intervals. For example, there is improvement in technology to Class F insulation (instead of Class B), High Velocity Oxy Flame (HVOF) coating on the runner and underwater parts.

Some of the auxiliaries such as excitation system, governor, control & instrumentation, which may be of old design and technologies can be modernized with latest microprocessor based SEE / AVR, Governors, Control & Instrumentation, SCADA, Online monitoring systems etc. This would not only help in increasing the availability of machines but also will be helpful in proactive maintenance of the equipment and spares can be availed from
the market in minimum time.

**Safety Margins and Overload Margins in the Old design**
Most of the old hydroelectric power stations are very pessimistically designed. At times the safety margins of the civil structure is to the tune of 200% to 400%. Also overload margins of old hydro stations are on higher side, which can be usefully exploited to get about 10 - 15 % additional capacities. These margins can be optimized by enhancing the parameters responsible for the generation of energy.

**SALIENT FEATURES OF RMU**

- Some parts of machine like core stampings, rim, spider, poles, shafts, servo motors, valves, steel embedded parts, bearing etc. have very long life as compared to parts like AVR, stator and rotor windings etc. Therefore, instead of complete replacement, refurbishment of those parts that have outlived their useful lives or frequent trouble is considered a cheaper option as its cost is restricted to the extent of refurbishment. Moreover, government is also willing and providing grants for this kind of refurbishment of old outlived components of the hydro plants through tariff benefits. The old Excitation system and Governors replaced by state of art Static Excitation Equipment and Digital Governors will alone bring enormous changes in reliability & efficiency.

- In old machines, stator and rotor winding is of class B insulation having higher thickness than present day class F insulation. So if the insulation of old machine is replaced, the copper area in the existing slots can be increased by about 30%. This increases the capacity of stator and rotor. If the capacity of other parts viz. turbine & shaft etc. is adequate, then the unit can be upgraded by about 20 – 30 %. It also gives extension to the life of machine as it is the winding of the machine, which deteriorates first.

- On reservoir based power plants, gross available head and quantity of water during monsoons increases. While this is kept in view at the initial stages of designing of power stations, yet some enhanced output may become possible during high head period by replacing some components. Margins in turbine are always available as it is designed on weighted average head.

- Sometimes by replacing generator, runner and some other parts by better designed equipment and retaining under water parts; additional capacity can be achieved.

- All the above factors not only make the RMU of old HEP as a lucrative business but also help in life extension of the project along with mitigating the imbalance of the energy mix in India.

**CHALLENGES IN R&M & LE OF EXISTING FACILITIES**

Inspite of all the benefits associated with the various RMU & LE measures, various factors affecting the effective implementation of R&M project lead to increased uncertainties and
variation of parameters from those of RMU DPR. Amongst these are:

1. **Management Risk**: Risks associated with the incorrect/lack/delay in initiating decisions or actions by the management of the company. Such risks may impact the overall project outcome.

2. **Technical Risk**: Risks associated with inadequate technical assessment of the R&M projects. This includes risks such as occurrence of technical surprises, non-achievement of post R&M guarantees etc.

3. **Operational Risk**: Risk arising due to internal system processes of the company i.e. due to limited capacity and skills of the personnel of the generating companies in undertaking R&M works.

4. **Institutional Risk**: Risks associated with weak governance framework. This includes risks related to socio-political considerations that may result in delay in obtaining the shutdown for undertaking both technical studies and execution of R&M projects.

5. **Market Risk**: Risks arising primarily due to the actions or inaction of suppliers in the market and the overall market conditions which are beyond the control of the generating company. This includes risks pertaining to limited participation of suppliers in the bidding for R&M works, higher than expected price discovery, delay in supply of material by the supplier etc.

6. **Regulatory Risk**: Risks arising due to regulatory uncertainty or change in regulations. This includes risk associated with the disapproval of the investment made by the generating company in undertaking R&M works.

7. **Contractual Risk**: Risks associated with the uncertainty arising from the contractual disputes or interpretation due to weakly defined scope of works and inability to devise a mechanism to resolve them constraining the overall execution.

8. **Funding Risk**: Risks associated with mobilization of funds for undertaking R&M project.

9. **Socio-Environment Risk**: Risks arising due to the insensitivity towards the habitations surrounding the power plant and compliance to the environmental norms.

**CHALLENGES ASSOCIATED WITH RLA & LE STUDIES**

The systematic way of checking the conditions of health of every component of the old hydro power station is done by **Residual Life Assessment and Life Extension (RLA & LE)** studies. RLA studies are helpful in determining which component of the plant to retain and which one to discard and replace. But the accuracy & reliability of technical & financial predictions of RLA & DPR becomes most of the times a toss-up due to various factors described above as well as specified below.

i. While delay of RMU after machine has reached end of its life can cause irreparable loss, early renovation for the sake of modernization is a luxury. A proper techno- economic balance should be struck.

ii. Uprating of unit capacity is governed by capacity of both generator and turbine,
which in turn is dictated by capacity of each of their components. The reliable life of machine is dictated by the life of worst component. Final decision is thus arrived at after checking each and every part. Coordination of RMU work of generator and turbine can reduce outage time.

iii. Major, equipment viz. generator stator, rotor can undergo very little change in outer dimensions as these are to fit in existing barrel. Runner, head cover etc. cannot undergo any change in outer dimensions as clearances between these & water path is already of the order of 1-2 mm.

iv. Higher output of generator will mean more losses and temperature rise for which, better heat dissipation shall have to be done by some major / minor modifications in ventilation system.

v. Higher output by turbine shall mean higher quantity of water and hence more guide vane opening. This shall increase run away speed of machine, axial thrust, speed and pressure rise on tripping.

vi. Earlier electromagnetic relays and controls and dial type instruments were used. With the advancement of technology, very fast acting, accurate, compact reliable microprocessor based control systems and relays are available. These can be considered at the time of Renovation and Upgradation.

The overall effect of uprating usually specified in DPR under different options is as follows:

a) Uprating without changing winding reduces short circuit ratio, energy constant and transient stability.

b) Uprating without modification of exciter and hence some ceiling voltage reduces the exciter response ratio.

c) Uprating with or without major changes increases short circuit torque.

EXPERIENCE OF DVC IN RMU & LE

DVC undertook RMU of Maithon Hydel Power Station (MHS) in the past. For Panchet Hydel Power Station (PHS), RLA study & DPR reports were prepared in 2007 for undertaking R&M of PHS Unit 1 of 40MW capacity in the 10th Plan.

<table>
<thead>
<tr>
<th>Hydel Unit</th>
<th>Manufacturer</th>
<th>Original Capacity(MW)</th>
<th>Present Capacity(MW)</th>
<th>Commissioning Year</th>
<th>Feature</th>
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<tbody>
<tr>
<td>MHS U2</td>
<td>NEYPRIC</td>
<td>20</td>
<td>23.2</td>
<td>Mar’58</td>
<td>HORIZONTAL FRANCIS</td>
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<tr>
<td>PHS U1</td>
<td>NOHAB</td>
<td>40</td>
<td>40</td>
<td>Dec’59</td>
<td>VERTICAL KAPLAN</td>
</tr>
</tbody>
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Maithon Hydel Power Station (MHS)

MHS Unit 2(1958) was taken up for RMU in year 2003-2006 period, on OEM basis by engaging M/s Alstom. The unit capacity was uprated to 23.2 MW from installed capacity of 20MW.

The Scope of work consisted of (but not limited to):

- Replacement of Generator Transformer: Transformer uprated from 25MVA to 33.35MVA.
- Refurbishment and uprating of Generator: Uprated from 20MW to 23.2MW. Replacement of stator winding with class F insulation.
- Replacement of generator Air coolers.
- Replacement of excitation system by static excitation system.
• Replacement of Governing system by Digital (Neypic ADT1000)
• Gate Refurbishment: Intake Emergency / Intake Service Gate / Tailrace Gates
• Replacement 11KV Bus duct, Line Side cubicles and Neutral Earthing cubicle
• Replacement of protection system with Microprocessor relays.
• Replacement of Auxiliary Panels and Switchgears.
• Replacement of UAT: Class of insulation changed to class H, glass fiber reinforced epoxy resin.
• Refurbishment of 2X57.5 T EOT Crane In Under Ground Power House.

EXPERIENTIAL LEARNING

The RMU was taken up due to increased forced outages, completion of 50 years and non-availability of OEMs/spares. Cracks were observed in turbine runner, which was replaced.

• Not able to raise full load to uprated level with all the three units running simultaneously
  – Probable cause: raised tailrace level.
• Problem facing just after ten years due to no guaranteed technical support for expected R&MU life of 25 years. Guaranteed performance could not be exhibited after R&M.
• Black start not possible after RMU: Not exhibited/ intimated by Vendor
  – Absence of facility of synchronizing in dead bus as breaker closure not possible.

Panchet Hydel Power Station (PHS)

The problems in PHS units are predominantly due to the ageing of units and obsolescence of originally supplied components. Several problems that have cropped up in the electrical, mechanical, hydro-mechanical equipment and civil structure of these units, which need comprehensive program for trouble free operation and to add life to these veteran units of DVC.

The Unit 1 was taken up for RLA study by engaging MECON & NHPC prepared DPR in the year 2007 for the R&M without Uprating. However the work could not materialize as the tendering job for the same was not undertaken. However it has been now decided that the same will be undertaken by after getting the DPR & RLA vetted by CEA.

Meanwhile DVC recently tried to undertake need based R&M by prospective bidders. The R&M scope of Work(SOW) was adopted from NHPC DPR with a philosophy to undertake need based R&M in view of DVC’s present Financials. Nevertheless, the SOW was structured in such a way that its execution would have led to, apart from availing the availability of the existing infrastructure, only selective replacement/ renovating of critical components of turbine runner, generator winding with class F insulation, excitation system, governor etc. This would led to increase in efficiency, peak power and energy availability apart from giving a new lease on life to the Unit/ equipment for safe sustainable & reliable operation of PHPS Unit No-1 at the designed load besides the estimated increase in the economic life of the generating unit by around 10-15 years.

Some of the problems encountered and facilities requested after experiential learning from
RMU of MHS and RLA, DPR preparation & budgetary offer procurement from various vendors for PHS are being enumerated below:

- Indian market lacks expertise for Scope determination for undertaking RMU.
- Inspite of best efforts on part of DVC & CEA also pitching in, NHPC did not undertake part 2 of Consultancy work which included tendering work for R&M.
- It is not possible to engage any manufacturer for undertaking RLA & LE studies & report preparation, since it would debar him from participation in tender for execution.
- No standard benchmarks.
- No standard Tender Document formats for calculation/ imposition of Guarantee & Penalty conditions. Different Utilities have different clauses for the same.
- Dearth of experience in Consultants undertaking RLA & LE studies.
- Issues related to copyright of OEMs.
- Change of ownership at OEMs.
- Non availability of initial project documents.
- No standard norms & procedure availability at CEA & CERC for following during implementation of RMU.
- No standard Arbitration clauses & procedure in place, should a need arise.
- No specific cost standard per MW for undertaking RMU.
- Non-Level playing field with Solar & Wind: Benefits for solar such as Renewal Purchase Obligation(RPO), Sales tax exemption, Concessional custom duty exemption, 100% Excise Duty exemption, Priority sector lending Low interest loan should be passed to Hydel R&M expenditure also irrespective of capacity.
- Cumbersome process of clearances for R&M tariff benefit from CERC.
- Stringent Hydropower Purchase Obligation(HPO):-Introduction of HPO and linking of the same to any kind of subsidiary being given to fossil fuel generation.
- Absence of qualifying of more than 25MW Hydropower as Renewable Energy thereby extending of benefits at par with Solar/wind by making Hydropower into Renewable Purchase Obligation irrespective of capacity (presently Hydro of capacity upto 25 MW qualify RPO).
- Policies for Hydro projects R&M financing: Creation of National Hydro Fund for R&M/ special hydropower financing schemes through soft loan. Suitable regularity framework for use of long term financial instruments.
- Hydro Tariff: Flexibility w.r.t. Long Term PPA/Extension of PPA. Time-of-Day(TOD) Tariff (Differential tariff and off peak hours). Preferential TOD tariff for hydro plants with uprating after R&M.
- Packaging for R&M w.r.t Hydro Mechanical(HM), Turbo-Generator(TG), Balance of Plant(BOP) etc. vis.-a-vis. technical spec. standardization for R&M, JV formation & technical issues.
- Financial & technical reasons for time & cost run over.
- To ensure for complete scope of work as per RLA recommendation with essential SCADA/Data loggers and to avoid for need base SOW only.
- Water cess & Green cess by states.
- R&M Specific skill development and technology driven regular training & brain-
storming sessions.

CONCLUSION

Improvising implementation strategies and effective project management along with suitable financial package holds the key to RMU success in our country.

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