



Government of India
Ministry of Power
Central Electricity Authority

GUIDELINES FOR RENOVATION & MODERNISATION/LIFE EXTENSION WORKS OF COAL/LIGNITE BASED THERMAL POWER STATIONS



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/ LIFE EXTENTION WORKS

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STATIONS

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Thermal Project Renovation and Modernisation Division

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1.0 BACKGROUND

1.1 Coal based thermal power contributes a major share in the total power available in the country. More than 73% of total generation comes from coal/ lignite based power plants. The first 200 MW unit was installed at Obra in 1977 and the first 500 MW unit was commissioned way back in 1984 in Trombay. Prior to that, the units were of smaller size and many of these were of non-reheat type with lower efficiency. Over a period of past few decades there has been growth in the size of thermal units and in steam parameters resulting in better plant efficiency.

1.2 Renovation and Modernisation (R&M) and Life Extension (LE) have been recognized as cost effective options to achieve additional generation from existing units at low cost and in shorter period. However, new environmental norms which have come into existence post 2015 and increase in penetration of renewables, the R&M cannot be limited to the improvement of performance only. There needs to be all-inclusive approach for R&M of thermal power plants.

1.3 A centrally sponsored R&M Programme was launched in 1984 as Phase-I programme for which financial assistance for implementing R&M works was provided by Govt. of India. The R&M programme continued albeit in a different form subsequently during 9th, 10th, 11th and 12th plan periods which resulted in improved performance from thermal generating units.

1.4 In the 12th plan, the R&M/LE work of 37 units of capacity 7202 MW has been completed and presently 71 units of 14,929 MW capacity has been identified for R&M/LE work for the subsequent five year period (2017- 2022). The old and small size units of early post-independence period were based on technology as available at that time having a very low efficiency. These units are therefore near obsolescence. The LMZ Russian design of larger size units (200/210 MW) and initial KWU design machines are now in fag end of their economic life span. These groups of 200/210 MW machines (LMZ design and early KWU design machines) constituted a major chunk of R&M/LE programme in the 11th and 12th plan.

1.5 There is almost 10,000 MW out of total installed capacity of 46,000 MW of 500 MW units which has been in operation for more than 20 years which would need R&M/LE intervention.

2.0 INTENT OF RENOVATION & MODERNISATION (R&M)/LIFE EXTENSION (LE) PROGRAMME

There has been substantial increase in capacity addition in the successive five year plans of the country which has significantly reduced gap between demand and availability of power in past few years and in between there has been periods of surplus capacity. Due to the rising environmental concerns, it is driving the policy frame work in a direction so as to reduce the thermal power plant emissions.

The integration of RE power requires balancing support from the existing thermal power generators. The earlier role of R&M as maximizing/optimal utilization of the existing generation resources needs to be revised considering the above. Thus R&M domain has to expand to make the plants flexible in an efficient manner with lower emission.

2.1 The new installation being capital intensive, it is considered prudent to maximise the generation from the existing power stations to ensure optimal utilisation of resources. R&M's main role of replacement of the existing obsolete items of equipment in operation with those with more efficient and of latest designs incorporating the state-of-the-art technologies and improved metallurgy would however continue.

2.2 Many thermal power stations in the country were designed for a given quality of coal, which has deteriorated over a period of time. The capacity of the raw coal feeding system, pulverizers, primary air fan system, ash handling system etc., for these power stations may have to be augmented to maintain the rated capacity of the boiler with optimum/improved efficiency, provided the furnace size is adequate to burn the coal of deteriorated quality.

2.3 The environmental regulations are becoming stringent. For the first time emission norms for SO₂, NO_x, mercury levels and water consumption have been notified in Dec 2015. The plants which were designed earlier were provided with environmental systems which may not meet the present day emission standards, requiring either refurbishing the systems or complete replacement.

2.4 India has made the commitments to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level and to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030. Hence renewable energy will be playing important role in meeting the energy requirement of the country. As per the plan, the renewables installed capacity is going to be 175GW by 2022. The integration of this high level of renewable capacity in the power system would require lowering the minimum load (upto 40%) and adopting high ramp rate from the thermal power plants. Hence, the power plants may have to be refurbished to meet the new operational regime i.e. changing from base load to flexible mode of operation. In the CEA report *“Flexible operation of thermal plant for integration of renewable generation (January 2019)”*, the requirement of flexibilisation by the existing thermal units has been broadly identified under various categories.

2.5 To bring down the variable cost of energy to the consumers, Merit Order Dispatch is being adopted at plant level which may require R&M for improving the operating performance.

2.6 In view of new operating regimes, it will lead to part load operation of the plants which were earlier operating as base load stations. Hence, R&M intervention may be needed for the refurbishments to improve plant efficiency at part load operation also.

2.7 The R&M/LE programme may be designed in such a way so as to improve the plant operational performance, availability/reliability, efficiency and emission reduction in light of the above.

3.0 NEED FOR REVISED POLICY GUIDELINES

3.1 The generation maximisation with efficiency enhancement and plant uprating was an integral part of the R&M/ Life extension programme. The Government of India have accorded high priority to meet the new environment norms by all thermal power stations and integration of 175GW of renewable power resources by 2022. With this the objective of R&M is shifting from the 'generation maximization' to 'efficient flexible operation with lower emissions'.

3.2 Previously, guidelines were framed mainly for units of capacity 100MW or less with non-reheat type & for 200/210 MW Units of LMZ or earlier design of KWU units. Since the framing of these guidelines many thermal plant units of higher capacities like 250 and 500MW also have outlived their useful lives as such guidelines need to be modified and units which are due for R&M activity need to be identified.

3.3 The need has been felt to revise the above guidelines due to the following:

- (I) There have been delays in achieving the desired completion targets.
 - (ii) Constraints are being experienced in supply of materials resulting in time/cost overruns.
 - (iii) A large number of units of 500MW capacity are becoming due for R&M/LE works, necessitating need for more agencies to carry out R&M/LE works.
 - (iv) Need for new emission control equipment installations in power plants for environmental compliance.
 - (v) Dynamic operation of thermal plants for flexibilisation would need high level of automation, refurbishment of boiler, turbine, mills, etc. It will require technology to monitor which will help in reducing the depletion of plant life due to cyclic load variation and frequent start/stop operation.
 - (vi) Biomass utilisation for power generation through co-firing in thermal power plants.
 - (vii) Converting the Coal fired plant to Biomass firing power plants.
 - (viii) Lowering the water consumption in Coal fired power plants.
 - (ix) Due to uncertainties in future operational regime of thermal power generation, life extension for shorter duration may have to be considered based on techno-economic analysis.
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3.4 The above requirements demand new approach towards implementation of R&M/LE works by the utilities, proper identification of R&M options, preparing realistic time schedules and encouraging increased participation from various executing agencies including private sector.

Accordingly, the existing guidelines have been revised to account for meeting the above challenges.

4.0 CONCEPT OF RENOVATION AND MODERNISATION AND LIFE EXTENSION PROGRAMME OF THERMAL (COAL/LIGNITE BASED) POWER STATIONS

4.1 RENOVATION AND MODERNISATION (R&M) PROGRAMME

4.1.1 The main objective of R&M of power generating units is to make the operating units well equipped with modified/augmented equipment/components/systems, with a view to improve their operating performance, reliability and availability to the original design values, reduction in maintenance requirements, ease of maintenance and enhanced efficiency, meeting the latest emission levels and achieving flexibility in generation.

4.1.2 However, R&M is not a substitute for regular annual or capital maintenance/overhaul which forms a part of operation and maintenance (O&M) activity. Middle life R&M come up preferably after 100,000 hrs. of operation. RLA study and R&M of thermal units which were designed for base load operation may be required even before due to participation in flexibilisation.

4.1.3 The R&M programme is primarily aimed at generation sustenance and overcoming problems arising due to:

- Generic defects.
- Design deficiencies.
- Inefficient operation
- Non-availability of spares because of obsolescence of equipment/components.
- Deterioration in quality of coal as compared to design coal.
- Major replacements of equipment on account of unforeseen failures and/or generation sustenance not covered under regular O&M.
- Stringent environmental norms for PM, SO₂, NO_x, Mercury and Water consumption.
- low availability of flexible power
- Safety requirements, etc.

4.2 R&M PROGRAMME WITH LIFE EXTENSION (LE) & UP RATING (U)

4.2.1 The equipment subjected to fatigue stresses and creep due to high temperatures such as turbine rotor and casings, HP piping, boiler headers, Boiler drum, main steam piping and valves, feed discharge lines etc. are designed for a given fatigue life of about 25-30 years of operation. However, many equipment/ components might become prematurely weak metallographically due to various operational stresses like frequent temperature and pressure excursions, full load trippings, frequent start and stops etc. and accordingly there is need to check the remaining life of these components after about 20 years of life or 1,60,000 hours of operation lest it may result into serious failures.

A systematic study called the Residual Life Assessment (RLA) study involving non-destructive and destructive tests would reveal the remaining life of various critical components of plants and equipment so as to take steps to extend the life of the plant by a further period of about 15-20 years by appropriate repairs/replacements. A RLA study may be carried out earlier, say after 1,00,000 hours of operation if the plant condition so necessitates and as stipulated in IBR 391 A.

RLA study and R&M may be required even before the above said period due to participation in flexibilisation.

4.2.2 The LE programme is a major event in the thermal power station's history, as it envisages extension of life over a considerable period of time beyond its designed life. At this time it is a good practice to examine whether a plant requires a viable modernisation which has not been carried out earlier so that during the extended life the plant operates efficiently and delivers the rated or higher capacity with improved heat rate. Adoption of improved and proven technology can play an important role in plant upgraded output & higher efficiency. There are cost effective options to up rate the machines for higher output and improved efficiencies thus making it economically viable to integrate life extension programme with up rating.

4.3 R&M PROGRAMME FOR MEETING ENVIRONMENT NORMS

Earlier the R&M needs for meeting the environmental norms were limited to upgradation of ESP. However, stringent New environmental norms regarding Particulate matter PM, SO₂, NO_x, Mercury and Water consumption for thermal Power Stations were notified in December 2015. The TPPs may be required to take measures like, augmenting ESP to meet the particulate matter norms, installing Flue gas desulphurising (FGD) for meeting the new SO₂ norms, carrying out combustion optimization/ modification/ DeNO_x retrofit at their units to meet the NO_x norms.

Feasibility study for R&M/LE should also include the various options for meeting new environment norms.

4.4 R&M PROGRAMME FOR FLEXIBILISATION

The flexible operation of thermal plants will be required to balance the variability and intermittency of renewable generation. It may require to conduct study/test runs on thermal units for lowering the minimum load and improving the ramp rate, to do necessary measurements for optimization of the existing controls, conducting thermal feasibility study and stress analysis. Based on the study conducted, it may require installation of condition monitoring system, upgrading C&I system, combustion optimization, steam/flue gas management system, condensate throttling, mill scheduler, etc.

Feasibility study for R&M/LE should also include modifications required for low load operation/ high ramping for the flexible operation.

The flexibilisation capabilities developed shall have to be demonstrated to the satisfaction of grid operators by conducting proper performance tests.

4.5 WORKS NOT RELATING TO R&M / LIFE EXTENSION:

4.5.1 In general, works usually done under routine maintenance and annual or capital maintenance do not fall under the purview of R&M Programme. The repetitive nature of activities having the frequency once in five year or less is covered under O&M.

4.5.2 The following works should not be included as a part of R&M / LE programme:

- I. Infrastructural development work such as township, welfare measures etc. general civil works within the plant such as boundary wall, roads, drainages etc. However, technological structure works required for equipments /structure based on RLA done as per design criteria (such as turbine deck, foundation etc.) shall be part of LE.
- II. Procurement of spare equipments.
- III. Routine repairs/replacements during annual/capital overhauls.

The expenditure on such works which are of O&M in nature is to be met from O&M charges recovered through tariff for sale of electricity as notified by regulatory commission. O&M ought to be attended on a regular basis lest the condition of the unit should deteriorate to such an extent resulting in major breakdowns requiring huge expenditure.

5.0 RETIREMENT OF VERY OLD UNITS:

A few small size units of 100 MW or less capacity are in operation. The average Plant Load Factor of most of these units is very low, even less than 50%. These units are of non-reheat type having very low design efficiencies. Further, because of their ageing & technological obsolescence, these units are performing at further lower efficiency than their design value. Such units need to be retired in a phased manner. The following approach for non-reheat units and other higher size reheating units may be followed for the purpose:

- Consider for retirement of all non-reheat units of 100MW or less rating. However, those units on which major R&M/LE activities have been undertaken and are performing well, such units may continue to operate for another 10 years from the date of post R&M/LE to enable them to recover the expenditures incurred.
- Larger size units (upto rating 110MW reheat, 200/210MW) can also be considered for retirement on economically non-viability on case to case basis.
- The retirement may be prioritized according to their level of performance, say unit heat rate deviating more than 20% to be retired first and subsequently those units with deviation of 15% & 10% from their design heat rate after considering the correction factor for not getting design grade of coal.

6.0 METHODOLOGY OF IMPLEMENTATION OF R&M AND LE&U SCHEMES

6.1 R&M Works

It has been observed that the power utilities are adopting following two main variants in implementation of R&M programme.

- (i) As a rolling plan in which the whole scope of work is conceptualized based on conditions assessment, plant operation data & feedback from O&M engineers / OEM / Consultant recommendations or compliance to statutory norms. Thereafter, the various activities/schemes, so identified are implemented in phases depending on the availability of particular system/unit shutdown. Such approach results in minimizing unit shut down requirement and thereby loss in generation. However, it results in extended execution over a long period of time and benefits accrued cannot be co-related with the activities carried out and investment made.
- (ii) A comprehensive scheme is implemented in a single stretch and taking unit's planned shutdown after ensuring all inputs and supply of materials.

The methodology for implementation is to be decided by the utility. However, the option of comprehensive scheme is preferable due to well definable & quantifiable benefits. R&M required for meeting the environment norms have to be time bound as per the deadline identified by appropriate agency.

- (iii) Based on the analysis carried for the delays experienced in the various R&M projects, following recommendations are suggested:
 - (a) Separate R&M team to be formed by the utilities for the smooth execution of work.
 - (b) Time gap between DPR/RLA studies and zero/award date should not exceed 6-8 months.

- (c) The source of financing R&M/LE works and availability of funds needs to be ensured beforehand to avoid delays.
- (d) ICB/DCB mode of tendering should be preferred especially for the R&M of BTG.
- (e) Bulk tendering of multiple units may be adopted for accruing benefits in price and implementation.
- (f) L1/L2 schedule to be finalized with the suppliers. Sequential supply of material to be tied up with contractor to avoid dumping of material.
- (g) Clarity in scope of work, contractual clauses and price escalation to avoid misinterpretation during execution.
- (h) The underground existing facilities shall be identified by the owner in the contract and the scope of removal of existing scrap/debris in the work areas should be clearly specified to avoid delays.
- (i) Delays in completion of work by contractor should accrue penalties and suitable penalty clause shall be included in the contract.
- (j) Areas prone of technical surprise to be identified in the contract if need arises. The unit rates of the most of the works should be identified in the contract to avoid new work items and delays in the negotiations.
- (k) Shutdown period to be managed by proper planning. It should not be more than 3-8 months depending upon the scope of work.
- (l) R&M/LE works with shutdown requirement of less than 3 months shall be taken up along with capital overhaul/annual maintenance.
- (m) PG test to be completed within three months after the unit gets stabilized. Utilities shall ensure availability of the unit at full load for the PG test and schedule for the flexibilisation (low load/ramp) test. Adequate penalties for the shortfall from the contract to be specified.
- (n) To avoid obsolescence the executing agency shall have to ensure the critical spare support for a minimum period of ten years and should cover the period of life extension after completion of R&M/LE works.

6.2 LE&U Works

In order to implement LE&U works following methodology may be adopted.

- (I) In order to facilitate the implementation of LE&U works, utilities may appoint reputed consultant for rapid life assessment study, condition assessment, energy auditing, thermal performance test, environmental
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study, preparation of DPR etc. RLA studies to be conducted on the major plant and equipment through agencies of repute.

- (ii) Based on DPR a detail technical specification & contract document may be prepared. The contract document, inter-alia shall include provisions of changed scope of work which may come up when the machine / equipment is opened or are identified during detailed RLA studies (as a part of scope of work) to meet the stipulated performance guarantees.
- (iii) Foundations of equipment's such as Boiler/TG foundation/Bottom ash hopper/Fan/Coal mill foundations may need to be included in RLA study.
- (iv) While uprating the unit, the dynamic forces/margin of equipment's need to be considered to ensure safety and reliability.
- (v) The auxiliary system capacity and BOP system should be evaluated to avoid any mismatch while uprating.
- (vi) Utilities should consider Govt. Inputs/policy decision with regard to implementation of LE&U works. They should also share data/information to MoP/CEA. The responsibilities of various agencies with regard to implementation of LE&U works shall be as specified as under:

Consultant(s): To assist the utilities, if required, to carry out RLA, energy audit, preparation of DPR, bid specifications, selection of executing agency, implementation & performance evaluation. One or more qualified consultants may be engaged by the utilities depending on the scope of work.

Financial Institutions: To provide funds as loans.

Executing Agency: To carry out the field work.

vii) The following time frame may be adopted for implementing the LE&U schemes:

- a) Appointment of consultant by utilities - 3 months.
- b) RLA/ Energy Audit –3 months.
- c) Freezing the scope of work/ activities for LE&U – 3 months.
- d) Preparation of DPR - 3 months.
- e) Placement of order of LE&U - 6 months.
- f) Shut down of unit - 3 to 8 months depending on the scope of work.
- g) Implementation time after LOA - 18-26 months.
- h) Supply of critical spares - 16 to 20 months from placement of order.

The above requirements call for a new approach towards implementation of R&M/LE works by the utilities by revisiting the existing procedures being adopted by each utility/ stake holders/ approving authority and to simplify them to meet the compressed time schedule and encouraging increased participation from various executing agencies.

- (viii) The utility shall appoint a Nodal Officer of the rank of Chief Engineer who will be responsible for monitoring & coordination with all concerned relating to LE&U scheme.
- (ix) The selection of the executing agency/bidder may be carried through the process of competitive bidding.
- (x) The Life Extension & Uprating work will be declared complete on successful continuous running of the unit for 14 days and at least 72 hours at full rated / uprated capacity after recommissioning of the unit.
- (xi) Life Extension work without the element of uprating (rated capacity and / or efficiency improvement beyond original design values) may be undertaken only in specific cases where uprating is not found techno economically viable.
- (xii) The utilities may approach the Government for additional allocation of power to the extent possible from unallocated quota of central sector power stations during the period of shut down of units for comprehensive life extension works.

6.3 MONITORING THE PROGRESS OF IMPLEMENTATION OF R&M/LE SCHEMES.

- (i) R&M / LE&U schemes shall be monitored by MOP/CEA.
- (ii) The utility shall also have a system of close monitoring of the physical and financial progress of various activities to ensure timely implementation of R&M/LE&U programme.
- (iii) Physical and financial progress report in prescribed format shall be submitted to CEA regularly on quarterly basis.

7.0 COST ESTIMATES

7.1 The estimated cost of the R&M/LE&U scheme has to be worked out based on the estimated cost of the identified individual works. The estimated cost should be, as far as possible, realistic and should be based on current market rates/budgetary offers from the supplying agencies including all taxes and duties. The import content along with the country from where the equipment etc. imported, should be identified. The source of funding is also to be mentioned. The yearly phasing of funds required for implementation of the scheme will have to be given which would help in monitoring the physical and financial progress of the scheme.

7.2 The cost of LE&U works shall not exceed 50% of the EPC cost of a new generating unit of indigenous origin (BHEL). If the LE&U works is limited to BTG, the cost ceiling shall be restricted to 50% of the new BTG unit only. However, a detailed study should be carried out to ensure its techno-economic viability. The payback period may be limited to 5 to 10 years.

7.3 In cases, where the cost is estimated to exceed the above limits, a detailed cost comparison & cost benefit analysis shall be carried out between the R&M/LE work and that of setting up a new green field plant.

8.0 COST BENEFIT ANALYSIS

8.1 The investment decision on R&M/LE&U scheme should be driven by economic sensitivity analysis on cost of generation. The benefits in term of increase in PLF (including additional generation and availability, reduction in forced outages), increase in efficiency, reduction in auxiliary power consumption and fuel consumption, improvement in plant safety and environmental up-gradation expected to be achieved after implementation of R&M/LE&U scheme should be clearly brought out. The techno-economic viability will be established in terms of internal rate of return, net present value, payback period etc. The payback period for R&M / LE&U should be about 5 to 10 years.

Due to new environmental norms power utilities are mandated to install new systems involving huge expenditure. The Payback period for recovery of capital expenditure will be determined by the CERC/SERC and it will vary from project to project since it depends upon the amount of capital expenditure of R&M works, balance capital cost of project, life and the projected PLF.

The flexibilisation operating cost for the plant operation at minimum load and higher ramp rate shall have to be realized from the compensation offered by CERC/SERC for the degraded heat rate, higher maintenance cost. Compensation for operating unit's up to 55% load and incentives for ramp rates in excess of 1% have already been notified by CERC. The regulatory authorities CERC/SERC's shall have to notify the compensation for operating thermal plants below the 55% load as and when the grid requires for flexibilisation.

8.2 The Empowered sub-Committee of the Committee on Infrastructure in its meetings held on 11th January, 2008 and 2nd April 2008 under the chairmanship of the then Deputy Chairman, Planning Commission has included R&M of power stations under the definition of infrastructure. All kind of financial concessions / relaxation towards infrastructure projects as notified by Ministry of Finance from time to time shall also be applicable for R&M / LE&U works.

9.0 PARTICIPATION OF PRIVATE SECTOR IN LE&U PROGRAMME

9.1 In view of the liberalized economic policy of Government of India, private investment including foreign investment, are now allowed in all areas of the power sector. Following alternative options appear practical and feasible for private investment in R&M schemes. However, states/ power utilities may have other innovative options which could also be considered.

(i) Option 1:- Lease, rehabilitate, operate and transfer (LROT)

Under this option, the private promoter (PP) would take over the power station on a long-term lease, say 10 years or more. PP would invest and carry out the R&M of the power station and would take over its operation and maintenance. Normally, the station would revert to the power utility after completion of the contracted period of lease or may be renewed on terms to be specified. However, legal title and ownership of the plant will remain with the utility throughout. This option would require a detailed lease agreement covering all aspects of financing, performance parameters, use of existing resources, sale of generated power etc.

(ii) Option 2:- Sale of Plant

Power utilities could offer power stations for outright sale to private parties. The present worth of the plant would have to be assessed which could be the reserve price for the sale.

(iii) Option 3:- Joint Venture between Power utility and public or private company.

In this option, a new company will be formed as a joint venture (JV) of the state power utility/ State Government and selected private/public collaborator. The JV company would undertake the R&M/ LE works and own, operate and maintain the power station. The private collaborator could also be an equipment supplier. Each partner shall hold minimum 26% equity in the JV company.

(iv) Option 4:- Service Model

In this option the implementation of R&M can be done by defining the baseline and awarding the contractor for a specified duration over which phased performance improvement can be achieved and sustained with flexible payment models.

9.2 As a general rule, choice of private promoter should be made through competitive bidding. The above modes are illustrative. Any other mode as may be found suitable by the utility with in the above broad principles may be adopted by the utility.

9.3 Depending on the options preferred by the power utility, the detailed procedure and bid documents may be prepared by the utility/consultant in line with their procurement policies.

10. DEEMED AVAILABILITY

The thermal units under outage on account of the approved programme of renovation/upgradation should be considered deemed to be available for the period approved in advance by the concerned authorities.

11. AWARD SCHEME

As a recognition of the efforts put up for the timely completion of R&M/LE&U work, award needs to be commissioned intended to encourage and motivate the utilities/agencies.

