



## Refurbishment and uprating of hydro power plants—A literature review



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### ABSTRACT

Refurbishment and uprating of hydro power plants has become an important issue for power generation experts and the utilities because of perennial shortage of power and slow pace in new hydro power addition programmes. As a result, in the recent years there has been great deal of interest in refurbishment and uprating of hydro power plants (HPP) for effective utilization of water potential. The concern about the issue has resulted from the large number of power houses in India which have outlived their useful life or are not operating optimally due to inadequacies in design. Hence, refurbishment and uprating of hydro power plants is the need of the day. To accomplish such a task various aspects of refurbishment and uprating of hydro power plants need to be reviewed. The present paper focuses on the research activities and practical experience in the area of refurbishment and uprating of hydro power plants. This exhaustive review consisting of about 214 research papers, reports, guidelines and standards will be of great help to the researchers, hydro power utilities and energy policy planners.

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### Contents

1. Introduction . . . . .	726
2. Refurbishment and uprating of HPP . . . . .	727
3. Decision making for refurbishment and uprating of HPP . . . . .	727
4. Equipment based refurbishment . . . . .	728
4.1. Refurbishment of civil structures . . . . .	728
4.2. Refurbishment of generator . . . . .	728
4.3. Refurbishment of excitation system . . . . .	728
4.4. Refurbishment of governor . . . . .	729
4.5. Refurbishment of control systems . . . . .	729
4.6. Turbine runners refurbishment . . . . .	729
4.7. Model testing for uprating of runner . . . . .	730
5. Menace of silt and its solution in power plants . . . . .	731
6. Planning and design of hydro power plants . . . . .	731
7. Condition monitoring of hydro power plants . . . . .	732
8. Simulation of hydro power plants . . . . .	732
9. Economic criteria for uprating and refurbishment . . . . .	733
10. Conclusion . . . . .	734
References . . . . .	734

### 1. Introduction

The present paper shares the research work related to a problem area of refurbishment and uprating of hydro power plants. Electric

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utilities of today face unprecedented challenges. On top of our traditional goals of safety, efficiency and reliability, the modern utilities must address global environmental issues such as climate change, national security issues surrounding our dependence on foreign energy and a growing desire by customers to have greater control over their energy use decisions. Therefore, to meet the ever-increasing need of economical, clean and renewable energy for industrial growth and better quality of life there have been attempts to harness alternate

energy sources. These alternatives include non conventional sources of energy like wind, solar, bio-mass, fuel cells, tidal power etc. Such sources of energy being intermittent in nature are cost prohibitive also. Therefore, the latest trend in the power generation industry is refurbishment and uprating of the existing power plants. Out of the refurbishment and uprating of different types of power plants, hydro power plants are considered best because of being renewable in nature, less capital intensive, low gestation period and above all cleanest and pollution free source of energy. The following aspects of HPP have been considered by different researchers and are reviewed in the present paper.

- (i) Refurbishment and uprating of HPP.
- (ii) Decision making for refurbishment and uprating of HPP.
- (iii) Equipment wise refurbishment studies.
- (iv) Power potential studies of existing HPP.
- (v) Economic criteria for uprating and refurbish of HPP.

## 2. Refurbishment and uprating of HPP

Restructuring of power industry in India has pressurized power generating utilities to generate more power at minimum cost and to remain in competition. Refurbishment and uprating of existing power plants plays a crucial role in this direction. Srivastava and Shahidehpour have presented a detailed analysis of the current situation of the power sector in India [1].

Naidu has made an attempt to delineate India's hydro vision and its road map in which various strategies including RM&U of hydro plants have been discussed [2]. NHPC and CEA which are government agencies entrusted with the task for planning and execution of hydro plants have investigated into the power potential that can be obtained by RM&U activities and have put forward a plan in the Ministry of Power report on "National Hydro Power Policy in India" [3–5].

Singh and Srivastava have laid emphasis on status and future directions of electric power industry restructuring in India. Electricity Act 2003 has brought the element of competition in generation transmission as well as in distribution sector by unbundling the vertically integrated power utility structure of the country [6].

Kumar et al. have discussed the zonal congestion management approach in transmission system using real and reactive power scheduling for evacuation of power in restructured environment of power industry [7]. Khadkikar and Chandra have devised a novel structure for three phase four wire distribution system utilizing unified power quality conditioner (UPQC) [8].

The radical transformations in the electricity industry in Australia, Vietnam, Philippines, Thailand and India have played a significant role in introducing the element of competition in Electricity Supply Industry (ESI) and have proved more efficient, reliable, and more economical. The ownership of the industry is generally moving away from the public domain to the private domain [9–11]. Rajpurohit et al. have critically examined the relevance of wind generation and challenges associated with it [12].

Jamali et al. have discussed the importance of wind power as a RES and problems associated with such generation. The interaction of avian with wind turbines has become an important public policy issue and new techniques are required to monitor avian activities. The system designed is based on radar and Infra-Red (IR) techniques and has been capable of avian monitoring for an offshore wind turbine application [13,14].

Singh has illustrated the importance of Indian Electricity Industry by stating the provisions made for its safeguard in the Constitution of India [15]. Oberoi and Naidu have critically

examined the need for refurbishment and uprating of Indian hydro power plants and have suggested the methodology for its implementation [16].

Fuhrmann and Mathias have devised a tool for refurbishment and uprating of hydro plants by evaluating health of sub-components of a various components of hydro power plants [17]. Telleschi and Wullmann have presented the refurbishment case study of the Lake Lungern Hydroelectric Scheme and have discussed about the deteriorating condition of the plant and had given brief introduction of its refurbished project including civil engineering works, electromechanical equipment, operating modes etc. [18].

Sahai has investigated the need of refurbishment and uprating of hydro power plants in India [19]. Lloyd and Stone have presented the online condition monitoring of generator by developing an analytical tool for on-line monitoring of rotors and stator windings [20]. Santos has discussed the major refurbishment programmes undertaken for the Ambuklao hydro power plant with an installed capacity of 75 MW which was commissioned way back in 1956 [21].

Hammons has focused on the present and future state of the electric power sector. It discusses the deregulation process and experience in Scandinavia, Hungary, and Germany [22].

According to Abdo the prime focus is and will remain on reliability irrespective of the whether restructuring remains a decision of states or is taken by the federal governments [23].

Hammons et al. have discussed new realities in power development in developing countries. The paper goes on to discuss power system planning in deregulated environments and generalized representations to illustrate hydroelectric potential of the Central and East African regions [24].

Baker has depicted the objective of restructuring, deregulation and competition and with introduction of these elements in industry, the hydro power facilities have to either perform optimally or their existence in such an environment is threatened, and thus RM&U is the solution for such generating facilities [25].

Thakur et al. have introduced the salient features of Indian Electricity Act 2003 and how this act is going to boost Indian power industry in its all the three organs, i.e., generation, transmission and distribution [26].

Linsley et al. have introduced the techniques of dependability analysis for various applications in this book [27]. Taylor has proposed a methodology to extend the operating life of hydro equipment by proper upkeep and evaluation of various parts of power plant equipment [28].

According to Thakur, in India, out of 110 hydro power stations with total capacity of 14,030 MW about 60 of them are suitable for refurbishing and uprating with substantial gains in energy production [29].

Hartmann has demonstrated the methodology to improve the reliability of hydro power plants in USA [30]. Water has given emphasis on the importance of decision making in uprating of hydro power plants and proposed a methodology for same so as to avoid wastage of time and money [31]. Romo has proposed a tool for improved maintenance and upgrading decisions for carrying out RM&U of a hydro power plant [32].

## 3. Decision making for refurbishment and uprating of HPP

In the literature various researchers have suggested that it is always advantageous to use pattern of criteria to investigate a hydro power plant for refurbishment and uprating. The each significant component of the plant is examined to generate data about the health of equipment by assigning a value/points/weighting factor to each component for refurbishment and uprating. The refurbishment indicators can be condition of the component, age, operating conditions, trouble spots, time of breakdowns and

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