ABSTRACT

Energy is one of the most important inputs in the process of development for a nation. With the growth of industrialization, there is increase in the demand of energy for trade and commerce on the one hand and demand of transport sector for energy on the other. As regards the primary sector of Indian economy i.e. agriculture and allied sectors are concerned, the demand for electricity and Diesel consumption have also increased on account of increased intensive activities. The domestic energy demand for meeting fuel and lighting requirements has also increased during the past three decades on account of rapid increase in population and improvement in the living standard of the people. After independence large hydro power projects have been executed in India, some of them are still under construction and some have been planned for future. Hydro power stations have inherent ability for instantaneous starting, stopping and load variations and also help in improving reliability of power system.

However, economic and environmental factors seriously restrict the exploitation of hydro power through conventional large capacity projects. Due to these constraints renewable energy resources such as solar, wind, biomass and small hydro power (SHP), which India has in abundance are being considered to meet the energy demand in environmentally benign manner. Among all the renewable energy sources, small hydro power which is defined by plant capacity up to 25 MW is considered as one of the most promising source. In India, it has been estimated that a potential of 15,000 MW exists in small hydro out of which only 2,045 MW has been installed so far.

Large potential of untapped hydro energy is available in flowing streams, river slopes, canal falls, drainage works and irrigation and water supply dams. Most of these hydro power sites come under low head range i.e. from 3 to 20 m. High head and medium head small hydro power schemes, are mainly run of river schemes. These

schemes are site specific and their installation cost is governed by the cost of civil works. However, low head schemes are mainly canal based schemes. Run of river in low terrains and dam toe schemes also considered under low head schemes.

Literature survey reveals that a number of studies have been carried out to optimise various components of small hydro power specifically. In low head SHP schemes relatively large discharges are handled, thus size of machines become bigger. The cost of such projects depend on both civil works as well as electro-mechanical equipment. It is therefore, there is a scope for cost optimisation for such schemes. However, no study was reported so far, for cost optimisation of low head small hydro power installations.

Keeping this in view the present study is carried out covering the following aspects ;

(i) Study of various components of low head small hydro power schemes.

(ii) Carry out the sizing of various components under civil works and selection of electro-mechanical equipment for different schemes.

(iii) Computation of cost of different components, based on determined sizes for low head small hydro power schemes.

(iv) Development of correlations for cost of various components for different schemes under different conditions in order to determine the total installation cost.

(v) Financial analysis for cost optimisation of different schemes based on developed correlations for cost.

In order to achieve the above objectives, a detailed study of different SHP schemes and their components has been carried out. There are three types of schemes under low head hydro power i.e. (i) canal based (ii) run of river and (iii) dam toe. These schemes have two basic components i.e. civil works and electro-mechanical equipment.

Most of the components are similar in different type of schemes. Out of these, hydro turbines play an important role which can be said as a heart of small hydro power station. The type and specification of other components of low head SHP installations depend upon the type of hydro turbines as it affects civil works on one side and electrical equipment on other side.

In the present study, an attempt has been made to develop a methodology for assessment of cost of the project for determination of its techno-economical viability before undertaking detailed investigations, so that only feasible projects are undertaken for detailed investigations and implementation. The cost of SHP schemes is site specific, based on type of scheme, type of components, land and infrastructrual facilities required for execution. The components considered under civil works, were intake, channel, desilting tank, forebay, penstock and powerhouse building. Various alternatives under different schemes such as location of power house, type of soil, type of turbine and generator and number of generating units have been considered for cost analysis

The sizes of civil works have been determined based on discharge carrying capacity which is based on head and capacity of the scheme. The head range is considered from 3 to 20 m and the unit size from 1 MW to 5 MW with total installed capacity upto 25 MW for electro-mechanical equipment, turbine and generator are considered as major equipment. Axial flow turbines i.e. tubular, vertical and bulb type and type of generator as synchronous and induction have been considered under the present study. Runner diameter and speed of the turbine have also been determined based on head and capacity of the scheme.

Based on the correlations developed, installation cost (total project cost) has been computed for different low head SHP schemes. The total project cost includes cost of civil works, cost of electro-mechanical equipment, cost of miscellaneous items and other indirect costs. Establishment related cost including designs, audit and account, indirect charges, tools and plants, communication expenses, preliminary expenses on report preparation, survey and investigations and cost of land were considered under miscellaneous and indirect costs. In order to validate the correlation developed for installation cost a comparison has been made with the actual cost data of recently developed plants obtained from the developers. Maximum deviation in cost has been found as ±12% for canal based schemes, ±12.5 % in case of run of river schemes and ±11% for dam toe schemes. The deviation in the costs is considered within reasonable limits.

It has been found that the electro-mechanical equipment constitute major part in the cost of low head SHP schemes in canal based schemes. As a typical example, cost of electro-mechanical equipment is found to be 54.5% for a plant having installed capacity of 2,000 kW at 3 m head and 50.3% at 20 m head. The similar trend has been observed in case of dam toe schemes. However, in case of run of river scheme, cost of civil works constitutes major part in total installation cost in higher range of head.

Financial analysis has been carried to determine the optimum layout under different type of schemes based on type of turbines, type of generators and plant load factor. Different layouts were evaluated for cost optimisation based on installation cost, generation cost, benefits cost (B-C) ratio, net present value (NPV) and financial internal rate of return (FIRR).

It is found that these financial parameters follow the same trend for the optimum layout, leading International financial institutions (World Bank, Asian development bank) evaluate development projects based on FIRR. Thus FIRR has been considered as financial parameter to determine the optimum layout.

For a typical canal based scheme of 2,000 kW capacity at 3 m head, tubular turbine with propeller runner and coupled with induction generator is found optimum layout as it has minimum installation cost and maximum FIRR value at 90% load factor. However, for load factors 60%, 70% and 80%, tubular turbine having semi Kaplan runner coupled with induction generator results in the maximum FIRR values which is considered as optimum layout. At load factor 50%, bulb turbine with Kaplan runner coupled with induction generator is found to be the optimum layout as it has maximum FIRR. It has been found that low head SHP layouts under run of river and dam toe schemes also follow the similar trend for optimum layouts.

Methodology for determination of optimum installation based on financial parameters has been employed to compare different alternatives, which can be used by developers to plan investment in low head SHP schemes. The financers may also use these cost correlations for appraisal of such schemes for financing.