STANDARDS/MANUALS/ GUIDELINES FOR SMALL HYDRO DEVELOPMENT

1.5
General – Guidelines for Project Cost Estimation

Sponsor:

Ministry of New and Renewable Energy
Govt. of India

Lead Organization:

Alternate Hydro Energy Center
Indian Institute of Technology Roorkee

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PREAMBLE

There are series of standards, guidelines and manuals available on electrical, electromechanical aspect of moving machines and hydro power related issues from Bureau of Indian Standards (BIS), Rural Electrification Corporation Ltd (REC), Central Electricity Authority (CEA), Central Board of Irrigation & Power (CBIP), International Electromechanical Commission (IEC), International Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME) and others. But most of these are developed keeping in view the large water resources/ hydropower projects. Use of the standards/guidelines/manuals is voluntary at the moment. Small scale hydropower projects are to be developed in a cost effective manner with quality and reliability. Therefore a need to develop and make available the standards and guidelines specifically developed for small scale projects was felt.

Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee initiated the exercise of developing standards/guidelines/manuals specifically for small scale hydropower projects under the sponsorship of Ministry of New and Renewable Energy, Government of India, in 2006. The available relevant standards / guidelines / manuals were revisited to suitably adopt them for small scale hydro projects. These have been prepared by experts in their respective fields. Wide consultations were held with all stake holders covering government agencies, government and private developers, equipment manufacturers, consultants, financial institutions, regulators and others through web, post and meetings. After taking into consideration the comments received and discussions held with the lead experts the standards/guidelines/manuals are now prepared and presented in this publication.

The experts have drawn some text and figures from existing standards, manuals, publications and reports. Attempts have been made to give suitable reference and credit. However, the possibility of some omission due to oversight cannot be ruled out. These can be incorporated in our subsequent editions.

These standards / manuals / guidelines are the first edition. We request users of these to send their views / comments on the contents and utilization to enable us to review these after about one year of its publication.

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GUIDELINES FOR PROJECT COST ESTIMATION

1.0 SCOPE

This guideline has been prepared for estimating the cost of various components of small hydropower project to arrive at total installation cost of the project. This guideline enumerates the different items for estimating the cost of various components of the project and the project as a whole with reasonable accuracy. While estimating the cost, general trend in cost obtained at a large number SHP plants may be taken into consideration.

2.0 REFERENCES

R1	IS: 4877-2005	Guide for preparation of estimate for river valley projects.
R2	CEA, 2012	Guidelines For Formulation of Detailed Project Reports for Hydro Electric Schemes, their Acceptance And Examination For Concurrence, New Delhi
R3	IREDA, 2006	Study Report on Costing Bench Mark of Small Hydro Power Projects-by AHEC, IIT Roorkee
R4	Gordon JL, 2003	Determining Ballpark Costs for a Proposed Project, HRW, March pp1-6
R5	Gordon JL, 1983	Hydropower Cost Estimates, Water Power and Dam Construction, November , pp 30-37
R6	Aggidis GA, Luchinskaya E, Rothschild R and Howard DC, 2010	The Cost of Small – Scale Hydro Power Production: Impact on the Development of Existing Potential, Renewable Energy, 35, 2632-2638
R7	Singal SK and Saini RP, 2008	Analytical Approach for Development of Correlations for Cost of Canal Based SHP Schemes, Renewable Energy, 33, 2549-2558

3.0 INTRODUCTION

Small Hydropower projects are investigated, planned and feasibility reports prepared by different organizations. Cost estimates form an important part of the report since these affect the viability of the project. In order that various alternatives of the same project or different similar projects may be compared, it is necessary to have uniformity in the method of cost estimation of various components of the project.

While preparing an estimate, it is necessary to keep in view that all of the essential items have been included and none of such item is scantly estimated. With this view, list of items, though not very exhaustive for various types of structures have been indicated in the present guide line, so that it may serve as check list. It is just possible that all the items mentioned herein may not be relevant to every project being SHP project site specific or all of the items for a particular component of a project may have not been covered in the list but detailed listed herein would be useful as a general guideline.

The degree of details into which various components of a project should be estimated depends upon the magnitude of the project, its importance in relation to site condition.

4.0 TYPES OF SMALL HYDRO POWER SCHEMES AND THEIR COMPONENTS

Broadly, the small hydro power schemes are categorized as run of river, reservoir based and canal fall based schemes.

4.1 Run of River Schemes

Run of river small hydro power schemes are those, in which water is diverted from a river without creating any storage in the river. In these schemes, power is generated from flowing water and available head. The output of a run of river plant is subject to the instantaneous flow of the river.

4.2 Canal fall Based Schemes

Canal based small hydro power scheme is one which is planned to generate power by utilizing the fall and discharge available in the canal. Falls in the canals are available due to difference in canal slope and topographical slope. These schemes may be planned in the canal itself or in the bye-pass channel.

4.3 Reservoir Based Schemes

Reservoir based schemes are those in which water is stored in the river by constructing a dam across the river for the desired use like irrigation, drinking, flood control. Power is generated at the time of release of water from the dam for the derived use of water. Dam toe power houses can be easily extended at existing dams where power generation was not planned earlier. In dam toe scheme, the intake system forms the part of the main dam. Water is conveyed to the turbine through penstocks installed directly through the body of the dam.

5.0 COMPONENTS OF SHP PROJECTS

Broadly the components of a SHP project can be divided in two parts i.e. civil works and electro-mechanical equipment

The components of a typical SHP scheme under civil works are as follows:

(i) Diversion / storage structure /pipe and intake works
(ii) Feeder channel
(iii) Desilting tank
(iv) Power channel (and/or tunnel or pipe)
(v) Forebay or balancing reservoir/ surge tank
(vi) Spill channel/ byepass arrangement
(vii) Penstock and supports
(viii) Powerhouse building
(ix) Tail race channel
(x) Civil works for switchyard
(xi) Approach road(s)

In different type of schemes, different combination of civil works components can be there as per site conditions.

However, electro-mechanical component are similar irrespective of type of scheme. Turbine and generator are the major Electro-mechanical equipment. Transformer, switchyard

equipment and station auxiliaries including mechanical as well as electrical auxiliaries are other equipment. Some hydro-mechanical equipment such as gates, valves and trash racks are generally considered along with civil works wherever required.

6.0 COST ESTIMATES

There are various methods for cost estimation of components of SHP projects which can be used depending upon the stage of development.

6.1 Preliminary Estimates

During pre-feasibility study stage, only preliminary reconnaissance survey details are available, thus broad cost estimates are required during this stage, which can be estimated considering broad sizes of the components and prevailing item rates in the area. Under this stage cost estimation is done generally on per kW installed capacity basis using trend of cost on such projects installed in the area. For estimations following guidelines may be adopted:

i) Cost of channel, tunnel and penstock can be determined on the basis of cost of unit length of such components (having similar sizes) prevailing in the area.
ii) By collecting budgetary quotes from leading manufacturers / suppliers for electro-mechanical equipment
iii) Cost of other components can be estimated on the basis of cost of similar components in the project area.

6.2 Formula Based Cost Estimates

In hydropower projects, cost of components depend upon their type and physical sizes, type of terrain, remoteness of the area, availability of infrastructural facilities etc. The physical sizes of civil works components are mainly governed by their discharge carrying capacity which is based on head and capacity of the project. The sizes of electro-mechanical components are governed by head and capacity of the project. Thus head and capacity are the main cost influencing parameters. There are many formulas available in the literature which can be used for assessment of the cost based on these cost influencing parameters. Some of these are included in the list of references. These formulas can be used for preliminary cost estimates only as these are not sensitive to the local site conditions.

6.3 Detailed Cost Estimates

At the detailed project report (DPR) stage, detailed itemized cost estimation need to be done. The estimated cost of the project in the DPR are expected within ±10% of the cost as executed. The following guidelines can be used for determination of cost of various components constituting cost. Detailed itemized cost estimate may be time consuming but gives realistic estimates.

7.0 CLASSIFICATION OF BUDGET HEADS CONSTITUTING COST

7.1 Broadly the cost estimate is covered under the following minor heads classified as direct and indirect charges.

7.1.1 Direct charges

I. Works
II. Establishment

III Tools and Plants
IV Receipts and recoveries on capital account

7.1.2 Indirect charges

These include the followings:

(i) Capitalized value of abatement of land revenue
(ii) Audit and account charges

7.1.3 Other costs

These include the followings:

(i) Financing cost
(ii) Local area development assistance (LADA) cost
(iii) Interest during construction

8.0 PROJECT COST

8.1 To work out the total cost of project, the itemized cost of various sub heads should be determined and complied in a tabular form according to various sub-heads giving total cost.

8.2 Cost of Works shall be sub divided under the following sub heads

i) Preliminary
ii) Land
iii) Civil works
iv) Buildings
v) Plantations
vi) Maintenance
vii) Special tools and plants
viii) Communication
ix) Miscellaneous
x) Power plant and electrical system (Electro-mechanical equipments)
xi) Transmission line
xii) Environment and Ecology

8.2.1 Preliminary

The items under this sub head consists of detailed survey and investigations including topographical survey, geological investigation, construction material survey, model tests etc. Expenditure on preparation of all planning reports such as pre-feasibility report, detailed project report and model studies are included in preliminary expenditure. Preliminary expenditure should not be more than 2% of project works cost (I-works).

8.2.2 Land

The expenditure incurred on acquisition of land by purchase / lease include lease rent.

The land required for locating various components of the project need to be assessed and areas of land is to be divided based on owner of the land and land use. The rate of land

under each category need to be assessed to arrive at realistic cost. The compensation for following items also need to be assessed. The provision under cost should be made as per actual.

(i) Cost of existing structures such as building, road and bridges, if any
(ii) Standing crops
(iii) Trees
(iv) Archaeological monuments
(v) Prospective mineral deposits
(vi) Processing charges for transfer of land rights
(vii) Relocation charges for mean of communication such as road, railway line, telephones and rehabilitation cost for buildings, displaced persons etc.

8.2.3 Civil works

Execution cost of all the civil works such as diversion structure, water conductor system, power house building etc are covered under this head. The cost of each component is determined by computing quantities of various items and multiplying by prevailing item rates. For estimating cost of civil works, unit costs of labour, materials and equipment has to be be determined. Current unit cost shall be used in all estimates and price level of the project estimate shall be mentioned. The analysis of rates for various items shall be worked out taking into consideration the cost of materials, carriage-handling-storing, labour and share of machines involved in executing various items of the work and overhead charges. The unit cost of various materials may be taken as those prevalent in the State/ region. The appropriate cost for freight, unloading, cartage, storage, inspection and testing should also be included. The wages of workers are periodically revised by the State under the statutory labour laws. Daily wage rates, therefore, shall be taken as those prevalent in the State at the time of formulation of the project. The quantitative assessment of material requirement has to be made based on the drawings/data available at per site condition or other projects. Provision for contingencies and work-charged establishment is generally considered about 3% of the cost of component in the detailed works estimates.

The major items are as follows:

(i) Earthwork in excavation; The quantities need to be calculated in different types of soils and rate be applied accordingly based on type of soil, lead and lift.
(ii) Earthwork in filling
(iii) Plain cement concrete (PCC): The quantities need to be calculated for PCC work at different locations having different grades of concrete
(iv) Reinforced cement concrete (RCC): The quantities need to be calculated for RCC work at different locations having different grades of concrete
(v) Reinforcement Steel
(vi) Fabricated Structural Steel Items: Such as steel beams, girders, pipes, trash rack, gates, trusses etc.
(vii) Brick/ stone masonry in different ratio of cement sand mortar
(viii) Protection works such as stone pitching, energy dissipation works etc.
(ix) Building items in power house building such as damp proofing treatment, dewatering, doors, widows, floor finishing, plastering, sanitary and water supply works, drainage, fencing and paintings

The cost of civil works components such as diversion/intake structure, desilting arrangement, forebay, spillway and powerhouse building depends on discharge carrying capacity. Discharge depends on head and installed capacity. The cost of other components such as water conductor system (including power channel, tunnel), penstock and tail race channel and tail race channel depends on discharge carrying capacity as well as length of these components. The length of these components is site specific due to topography. The costs of the civil works associated with the power station building are largely dependent on the head. Higher head needs less expensive powerhouse buildings. For same installed capacity, the physical size of the powerhouse building and costs of higher head installations tend to reduce.

8.2.4 Buildings

The provision under this head is made for permanent and/or temporary buildings required for residential and non residential purpose of the construction and thereafter operation and maintenance staff and stores. The provision under the head should be limited to 3-5% of the project works cost (I-works).

8.2.5 Plantation

To compensate loss of greenery in the project area due to construction of project components, new plantation should be done along the road side, water conductor system and power house. The provision under this head should be limited to 0.5% of the project works cost. However, if any additional expenditure is required under statutory / recommended nature, the same should be provided.

8.2.6 Maintenance

The construction period of SHP projects may be one to five years depending on sizes of components, availability of resources, clearances, site problems, and remoteness of the site. When construction period is more than one year, some maintenance of executed works is required. The provision under this head should be 1% of cost of civil works and buildings.

8.2.7 Special tools and plants

The construction of civil works, procurement, erection and commissioning of electro-mechanical equipment is generally carried out through specialized agency on contracting basis. The construction equipment required for execution of the projects is also arranged by the contractor. So majorly such items are not required by the project authorities but some items such as vehicles for supervising staff, compressor etc may require for supervision of execution and operation and maintenance on project completion. Thus provision limited to 2-3% of project works cost should be made under this head.

8.2.8 Communication

The construction of following access roads and works are covered under this head.

1. Approach ready to work site including, intake, water conductor and power house building.
2. Haul road and connecting roads in the project area
3. Shifting of railway line / existing roads

4. Quarry road
5. Remodeling / shifting of existing roads, bridges cross and drainage works

The provision under this head is site specific and may be taken accordingly.

8.2.9 Miscellaneous

There are many items of minor nature needed in execution of the project as given below. These are covered under miscellaneous items.

(i) Petrol, oil and lubricants (POL) and maintenance of transport vehicles 2 vehicles for construction period
(ii) Power supply to work sites and power bills
(iii) Photography, Vediography
(iv) Telephone connections to work sites, installation charges and running bills
(v) Medical aid and health sanitation
(vi) Printing technical literature and publicity
(vii) Workmen compensation
(viii) Security arrangements
(ix) Foundation stone laying, inauguration and other ceremonies
(x) Award to workers
(xi) Entertaining guests & invitees

Suitable provisions shall be made for cost of these items depending upon site requirement limited to 3% of project works cost.

8.2.10 Electro-mechanical equipment

The cost of electromechanical equipments is determined by the operating head on the hydraulic plants and selection of turbine type to optimise the generation. As the head falls, not only the size of runner diameter increases, but also cost of generator increases due to reduction in shaft speed. It is understood that site-specific equipment design have been avoided by standardised equipments to reduce the cost. The cost of electromechanical works includes cost of turbine, generator, valves, controls switchyard and other accessories but excluding cost of transmission line. The cost of electromechanical equipment depends on unit capacity, head, type of equipment and number of units. The cost is determined taking the prevailing market prices obtained from different manufacturers into consideration. The manufactures/ suppliers give complete package of electro-mechanical equipment instead of individual component. The components under electro-mechanical equipment are categorized as follows;

(i) Turbines with governing system
(ii) Generator with excitation system
(iii) Electrical and mechanical auxiliary
(iv) Transformer and switchyard

8.2.11 Transmission line

The cost of transmission lines depends on the amount of power to be evacuated from the powerhouse, voltage level, types of conductor, types of poles and the length of transmission line. The cost of transmission line is assessed per km basis depending on capacity of the line such

as 11 kV, 33 kV, 132 kV and 220 kV, etc. The cost of executing transmission line has to be shown as a separate item as providing transmission line for power evacuation may be the responsibility of the state utility.

8.2.12 Environment and ecology

The environmental impact assessment (EIA) and environment mitigation plan (EMP) has to be carried out as per guidelines of Ministry of Environment and Forest, Govt. of India. Accordingly the provision under the head be made.

8.3 Establishment

The provision for detailed engineering designs, supervision and administrative establishment are covered under this head. The charges under this head should be 8 to 10 % of project works cost excluding cost of land.

8.4 Losses on Stock

The provision under this head be made 0.25% of the cost of civil works and buildings.

8.5 Tools and Plants

The instruments for survey and investigation, field measurements and other tools are covered under this head. The provision under this head be kept limited to 1% of the project works cost.

8.6 Receipts and Recoveries

The amount receivable on resale of temporary buildings, tools and plants and other items which are no more required after completion of the project is considered under this head. An amount equivalent to 15% of the cost of buildings and special T&P be taken under this head which is to be deducted from the cost of the project.

8.7 Indirect Charges

The following expenditure are included in indirect charges

(i) Capitalised abatement on land revenue: The provision under this head is taken as per actual depending on land revenue. Charges for capitalisation of abatement of cost of land revenue may be taken as 5% of the culturable land cost or 20 times of the annual revenue cost.

(ii) Audit and account charges: The provision under this head be taken as 0.5% of project works cost.

8.8 Local Areas Development Assessment (LADA) Cost

Due to construction activities for a longer period, there is lot of inconvenience to the local habitats on account of increase in sound pollution, air pollution, detouring of routs, loss of open area, presence of labour and other outside people involved in construction activities etc.

Thus an amount about 1.5% of the total project cost be kept for utilising in the project area for the development / welfare.

8.9 Financing Cost

The project cost is met through loan, equity and grant in aid. Financial institutions get the techno-economic appraisal done with in house sources or by engaging expert independent agencies to ensure the financial soundness of the project. The financial institutions charge, for processing of loan and techno-economic appraisal. The provision under this head is taken as 1% of project cost.

8.10 Interest during Construction (IDC)

During the construction period, the interest accrued on the loan amount i.e. interest during construction (IDC) is added to the project cost.

8.11 Cost Escalation

During construction period, if it is more than one year, there may be appreciable change in the cost of material and labour. Thus provision of cost escalation may be made based on wholesale consumer price index.

9.0 ABSTRACT OF COST (FORMATS)

Based on the details described in para 7, cost of each item is determined and shown in separate tables. For guidance, formats of such tables are given as Table 1 to 8.

Table 1: Abstract of Project Cost

S. No.	Particular	Cost
I	Works	
1.	Preliminary (Table-2)	
2.	Land (Table-3)	
3.	Civil Works (Table-4)	
4.	Building (Table-5)	
5.	Plantation	
6.	Maintenance	
7.	Special T&P (Table-6)	
8.	Communication	
9.	Miscellaneous (Table-7)	
10.	Power plant and electrical system (Electro-mechanical equipments) (Table-8)	
11.	Transmission Line (Table-9)	
12.	Environment and Ecology	
I	**Sub Total (1 to 12) (I – works)**	
II	Establishment	
III	Ordinary T&P	
IV	Losses on Stock	

S. No.	Particular	Cost
V	Receipt and Recoveries	(-)
VI	Capitalised abatement on land revenue	
VII	Audits and accounts	
VIII	Financing Charges	
IX	Local Area Development Charges	
X	Interest during construction (IDC)	
	Grand Total (I to X)	

Table 2: Preliminary Expenses

S. No.	Description	Cost
1	Topographical Survey of the Project Area	
2	Hydrological Investigations	
3	Geological Investigations	
4	Miscellaneous Surveys, Investigations and Data Collection	
5	Preparation of Pre-Feasibility Report	
6	Preparation of Detailed Project Report	
7	Geo-technical Investigations	
	Total (1 to 6)	

Table 3: Land

S. No.	Description	Unit	Cost
1	Government Land Belonging to Various Departments	Ha	
2	Forest Land	Ha	
3	Private Land	Ha	
	Total (1 to 3)		

Table 4: Cost of Civil Works

S. No.	Description	Cost
A	Civil Works	
1	Diversion Weir & Intake	
2	Feeder Channel	
3	Desilting Tank	
4	Power Channel	
5	Head Race Tunnel	
6	Surge Tank	
7	Penstock	
8	Power House Building	
9	Tail Race Channel	
10	Muck Disposal	
	Sub Total A (1 to 10)	
B	Escalation on Cost of Civil Works	
	Total (A+B)	

Table 5: Buildings

S. No.	Description	Unit	Plinth Area	Rate	Cost
1	Permanent Building	Sqm			
2	Temporary non-residential Building	Sqm			
3	Temporary residential Building	Sqm			
	Total (1 to 3)				

Table 6: Miscellaneous

S. No.	Description of Item	Amount
1.	Transport vehicle POL and maintenance	
2.	Power supply to work sites	
3.	Photography, Vediography	
4.	Telephone connections to work sites	
a).	Installation charges	
b).	Running and maintenance charges	
5.	Medical aid and health sanitation	
6.	Printing technical literature and publicity	
7.	Workmen compensation	
8.	Security arrangements	
9.	Foundation stone laying, inauguration and other ceremonies and project inauguration	
10.	Award to workers	
11.	Entertaining guests & invitees	
	Total (1 to 11)	

Table 7: Special Tools and Plants

S. No.	Description of Item	Quantity	Amount
1.	Air Compressor		
2.	Concrete Mixture		
3.	Concrete Vibrator		
4.	Rock Drills and Tripod		
5.	Light Vehicle		
6.	Workshop Machines and Tools		
	Total (1 to 6)		

Table 8: Cost of Electrical and Mechanical Works

SI. No.	Description	Quantity	Amount
1.0	**GENERATING PLANT AND EQUIPMENT**		
1.1	Turbine (Giving broad specifications)		
1.2	Generator (Giving broad specifications)		
1.3	Control System (Giving broad specifications)		
1.4	Governor (Giving broad specifications).		
1.5	Main inlet valve		
1.6	Spares for 5 years operation		
	Sub-Total (1.0)		
2.0	**STATION AUXILIARIES**		
2.1	**Mechanical Auxiliaries**		
2.1.1	EOT / HOT Crane		
2.1.2	Air-conditioning and Ventilation system		
2.1.3	Fire Protection System		
2.1.4	Cooling water system		
2.1.5	Compressed air system		
2.2	**Electrical Auxiliaries**		
2.2.1	Power and Control cables		
2.2.2	Lighting in the power house and appurtenant works		
2.2.3	Battery and Charger		
2.2.5	L.T. Distribution Board including MCCBs/MCBs of adequate capacity alongwith local distribution system for appurtenant works.		
2.2.6	Internal Communication system with electronic telephone exchange, subscribers and multipair copper cables etc.		
2.2.7	Earthing of power house equipment including earthmat.		
2.2.8	D.G. set		
2.2.9	Unit auxiliary transformer		
2.3	**Mandatory spares & tools**		
	Sub-Total (2.0)		
3.0	**SWITCH YARD EQUIPMENT**		
3.1	Step up Transformers		
3.2	AN Station Transformer		
3.3	Vacuum Circuit Breakers		
3.4	Bus Isolators		
3.5	Line Isolators		
3.6	Current Transformers		
3.7	Potential Transformers		
3.8	Lightning Arresters		
3.9	Fuse sets		
3.10	Post insulator		
3.11	Control/metering panel		

SI. No.	Description	Quantity	Amount
3.12	Switch Yard Structures, Hardwares, Conductor, Insulators, Clamps & Connectors etc.		
3.13	Transmission line from Power House to Sub-station		
	Sub-Total (3.0)		
4.0	Foundations of Transformers, equipment, Bus/Terminal gantries, trenches with covers etc.		
5.0	Earthing of switchyard		
6.0	Pale Fencing with gate etc		
7.0	Freight, Sales Tax, Insurance and octroi charges on (1) to (3) @ 6% or as applicable		
8.0	Erection & Commissioning on (1) to (3) @ 8%		
9.0	Service Tax as applicable on Item 8.0		
	Total (1 to 9) E&M Works		