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INDUSTRIAL DEVELOPMENT ORGANIZATION



Technical Guidelines for the Development of Small Hydropower Plants **DESIGN**

Part 9: Project Cost Estimates

SHP/TG 002-09:2019



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Technical Guidelines for the
Development of Small Hydropower Plants
DESIGN

Part 9: Project Cost Estimates

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Further recommendations and suggestions for application for the update would be highly welcome.

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Foreword

The United Nations Industrial Development Organization (UNIDO) is a specialized agency under the United Nations system to promote globally inclusive and sustainable industrial development (ISID). The relevance of ISID as an integrated approach to all three pillars of sustainable development is recognized by the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), which will frame United Nations and country efforts towards sustainable development in the next fifteen years. UNIDO's mandate for ISID covers the need to support the creation of sustainable energy systems as energy is essential to economic and social development and to improving quality of life. International concern and debate over energy have grown increasingly over the past two decades, with the issues of poverty alleviation, environmental risks and climate change now taking centre stage.

INSHP (International Network on Small Hydro Power) is an international coordinating and promoting organization for the global development of small hydropower (SHP), which is established on the basis of voluntary participation of regional, subregional and national focal points, relevant institutions, utilities and companies, and has social benefit as its major objective. INSHP aims at the promotion of global SHP development through triangle technical and economic cooperation among developing countries, developed countries and international organizations, in order to supply rural areas in developing countries with environmentally sound, affordable and adequate energy, which will lead to the increase of employment opportunities, improvement of ecological environments, poverty alleviation, improvement of local living and cultural standards and economic development.

UNIDO and INSHP have been cooperating on the World Small Hydropower Development Report since year 2010. From the reports, SHP demand and development worldwide were not matched. One of the development barriers in most countries is lack of technologies. UNIDO, in cooperation with INSHP, through global expert cooperation, and based on successful development experiences, decided to develop the SHP TGs to meet demand from Member States.

These TGs were drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of these TGs may be subject to patent rights. UNIDO and INSHP shall not be held responsible for identifying any such patent rights.

Introduction

Small Hydropower (SHP) is increasingly recognized as an important renewable energy solution to the challenge of electrifying remote rural areas. However, while most countries in Europe, North and South America, and China have high degrees of installed capacity, the potential of SHP in many developing countries remains untapped and is hindered by a number of factors including the lack of globally agreed good practices or standards for SHP development.

These Technical Guidelines for the Development of Small Hydropower Plants (TGs) will address the current limitations of the regulations applied to technical guidelines for SHP Plants by applying the expertise and best practices that exist across the globe. It is intended for countries to utilize these agreed upon Guidelines to support their current policy, technology and ecosystems. Countries that have limited institutional and technical capacities, will be able to enhance their knowledge base in developing SHP plants, thereby attracting more investment in SHP projects, encouraging favourable policies and subsequently assisting in economic development at a national level. These TGs will be valuable for all countries, but especially allow for the sharing of experience and best practices between countries that have limited technical know-how.

The TGs can be used as the principles and basis for the planning, design, construction and management of SHP plants up to 30 MW.

- The Terms and Definitions in the TGs specify the professional technical terms and definitions commonly used for SHP Plants.
- The Design Guidelines provide guidelines for basic requirements, methodology and procedure in terms of site selection, hydrology, geology, project layout, configurations, energy calculations, hydraulics, electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions.
- The Units Guidelines specify the technical requirements on SHP turbines, generators, hydro turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems.
- The Construction Guidelines can be used as the guiding technical documents for the construction of SHP projects.
- The Management Guidelines provide technical guidance for the management, operation and maintenance, technical renovation and project acceptance of SHP projects.

Technical Guidelines for the Development of Small Hydropower Plants-Design

Part 9: Project Cost Estimates

1 Scope

This part of the Design Guidelines specifies how to formulate cost estimations for small hydropower (SHP) projects and details how to prepare cost estimation documents.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

SHP/TG 001, *Technical guidelines for the development of small hydropower plants—Terms and definitions*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in SHP/TG 001 apply.

4 General provisions

4.1 Cost estimations of projects shall be formulated according to the price and policies in the formulation year. In the case of major changes to the design plan, quantities of items and cost level in the commencement year of the project, the cost estimation shall be revised accordingly.

4.2 Investment for social and environmental protection (including the fees of land acquisition, resettlement, environmental protection, soil and water conservation, etc.) shall be calculated in accordance with relevant provisions of social and environmental impact assessment, and then included in the total project investment.

4.3 Investment for transmission engineering between a hydropower station to the substation of the power grid shall not be incorporated in the total project investment.

4.4 The project cost estimation at the feasibility study stage shall be prepared in accordance with the provisions of Chapters 5 to 8 of this document, and the investment estimation at the pre-feasibility study stage shall be prepared in accordance with the provisions of Chapter 9 of this document.

5 Project division

5.1 Overview

Cost estimations of a hydropower project may be divided into the construction part and social and environmental protection part, of which the construction part may include construction of temporary works, construction of civil works, electromechanical equipment and installation, hydro mechanical structure and installation, and miscellaneous costs, as shown in Figure 1:

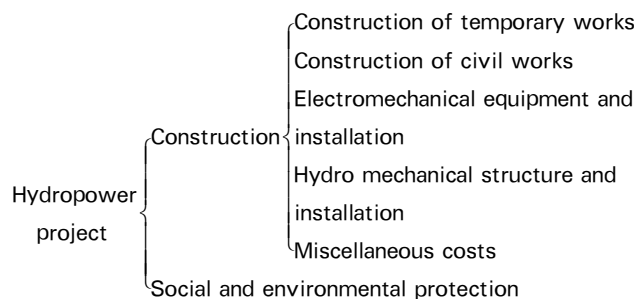


Figure 1 Division of cost estimation of hydropower project

5.2 Composition of the construction part

5.2.1 Construction of temporary works

This refers to the temporary works built to assist the construction of the main works, which can be composed of the following components:

a) River diversion

This may include open diversion channel, diversion tunnel, bottom diversion outlet, construction cofferdam (including river closure), reservoir impoundment and temporary downstream water supply works during storage period, hydro mechanical structure and installation, etc.

b) Transportation for construction

The temporary transportation facilities within and outside the construction site serving the project construction may include highways, bridges, construction adits, waterway works, bridge and culvert and road reinforcement, aerial cableways, ramp hoist ways, and the maintenance and management of permanent transportation works and temporary transportation facilities dur-

ing the construction period of the power station.

c) Power supply for construction

This may include high-voltage transmission lines supplying power from the existing power grid to the construction site, transmission lines of 10 kV and above on the construction site, and power supply facilities works of 10 kV and above of the outgoing lines, etc. The power supply facilities may include the construction of substations, substation equipment and installation, as well as the supporting facilities.

d) Houses for construction and construction management

This refers to the housing construction projects and supporting facilities required for the construction and construction management during the project construction; it may include site levelling, construction warehouses, auxiliary processing plant, working and living camp, outdoor works, as well as the maintenance and management of permanent and temporary buildings during the construction period of the power station. These are specified as follows:

- 1) Site levelling refers to earth-rock excavation, filling, masonry and other works within the planned area for the purpose of construction and construction management of houses and outdoor works.
- 2) Construction warehouses includes general warehouses and special warehouses. General warehouses are used for equipment, materials and tools, and special warehouses are used for oil depots and explosives depots.
- 3) Auxiliary processing plant includes wood processing plant, rebar processing plant, steel pipe processing plant, hydro mechanical structure processing plant, mechanical repair plant and concrete precast components plant.
- 4) Working and living camp refers to the houses and supporting facilities built on the construction site for working and living of the personnel involved in construction management, supervision, and design and construction. All the associated rental expenses incurred on the construction site during the construction period shall be included in this item.

e) Other construction temporary works

This refers to all temporary works other than those listed above, and mainly includes construction water supply (large pump houses and mains pipes), air supply, aggregate production system, concrete mixing and pouring system, installation and removal of large heavy machinery, flood prevention, ice prevention, drainage system and communication. Other temporary construction projects included in the project, such as high cost or large quantities may be listed separately according to the actual needs of the project.

5.2.2 Construction civil works

Construction civil works refers to the main civil structures and other permanent structures, which are composed of the following items, among which items a) to i) are the main construction works:

a) Water retaining (impoundment) structure

This includes all kinds of dams (weirs/barrages/storage dams) and foundation treatment engineering to retain water in the river.

The dam section of the intake, the spillway section, the seepage proofing of dam foundation and abutment, and the seepage proofing engineering of the reservoir bank are all listed under this item. The non-overflow dam section, the discharge dam section, the intake dam section and the foundation treatment engineering shall be listed respectively under concrete dam (sluice); the water-retaining dam section, dam body drainage structures, and foundation treatment engineering shall be listed respectively under earth (rockfill) dam. The slope excavation and support stabilization within the excavation area of water retaining (impoundment) structures are included in this item.

b) Drainage and energy dissipation structure

This includes structures for flood discharge such as spillway, flood discharge tunnel, sediment flushing tunnel and pressure relief holes (in tunnels), as well as the energy dissipation and anti-erosion structures along the side slopes of the intake and outlet, the slope and banks of the spillway and downstream of the drainage facilities behind the dam. Energy dissipation and anti-erosion structures can be divided into energy dissipation engineering (plunge pool and stilling basin), auxiliary energy dissipation engineering (baffle blocks, stilling tooth and auxiliary weir), apron extension, anti-scouring trench, pre-excavation and bank slope protection, etc.

c) Water conductor structure

This includes open diversion channels, water inlets (including gate chambers), diversion tunnels, surge chambers (shafts) or pressure forebays, penstocks, tail water surge chambers (shafts), tail water tunnels (channels), tail water outlets and other structures.

d) Power generation structure

This includes powerhouse foundations, powerhouse, grouting tunnels, drainage tunnels, ventilation tunnels (shafts) and other structures for the various power generation works on the surface and underground.

e) Substation structure

This includes substation (surface or underground), bus tunnels, ventilation tunnels, outgoing line tunnels (well), outgoing field structures (or switchyard buildings), etc. If there is a converter station project, it shall be placed parallel to the substation project as a first-level project. The steel frame of the substation structures is included in this item.

f) Fish passage

This may be listed separately according to the layout of the main structures. The part combined with the barrage may also be a part of the barrage engineering.

g) Headwork of the irrigation channel

These can be listed separately according to the layout of the main structures. The part combined with the barrage can also be a part of the barrage engineering.

h) Treatment project of the slope near the dam bank

This mainly includes the treatment of the slope near the dam bank and landslides that have an impact on the safety of hydraulic structures, as well as the downstream bank slope protection works affected by the dissipation and scouring of discharged water and tailwater. The treatment of the large accumulation body, landslide body, high slope and mudslides should be listed separately.

i) Transportation

This includes the transportation works for new roads, bridges, tunnels, waterways and other permanent traffic projects accessing to the dam the powerhouse and the outside, as well as the reconstruction and reinforcement of the existing roads and bridges.

j) Housing construction

This refers to the construction of permanent housing for on-site production, operation and management services, including site levelling, ancillary workshops, warehouses, office buildings, on-duty apartments and ancillary facilities and outdoor works.

k) Other construction works

Other construction works include safety monitoring facilities, power lines, lighting lines, communication lines, and public facilities including water supply, heating and drainage within the plant and dam area, labour safety and industrial hygiene facilities, hydrological and sediment monitoring facilities, automatic water regime monitoring system and others. These are specified as follows:

- 1) Safety monitoring facilities refer to all civil works carried out to complete the permanent safety monitoring system.
- 2) Power lines engineering refers to the overhead power lines and cable trench engineering from the powerhouse to each production site. The power cables from the powerhouse to each production site shall be included in the electromechanical equipment and installation engineering.
- 3) Lighting line engineering refers to lighting lines and the facilities in the plant and dam area (including the lighting of outdoor substations), excluding the lighting facilities which have been listed respectively in the details of hydraulic structures, such as barrage dams, spillways, and diversion and power generation systems.
- 4) Communication line engineering includes internal and external overhead communication lines and outdoor communication cable engineering, as well as the special communication line engineering from the project to the hydrologic station and weather station subordinate to the power station (reservoir).
- 5) Labour safety and industrial hygiene facilities refer to the permanent labour safety and industrial hygiene construction facilities specially built to avoid hazards and harmful factors during the production and operation period, mainly including safety signs, safety protection facilities, operating-environment safety-testing instruments, noise control and emergency facilities.

5.2.3 Electromechanical equipment and installation

Electromechanical equipment and installation refers to all the electromechanical equipment and installation works that constitute the fixed assets of the power station, including:

a) Power generation equipment and installation

This may include turbine generator units and ancillary equipment, main valves, lifting equipment, hydraulic machinery auxiliaries, electrical equipment, control and protection equipment, communication equipment and installation.

b) Substation equipment and installation

This may include main transformer, high voltage electrical equipment and primary cable connection and installation.

c) Public utilities and installation

This may include communications equipment, ventilation and heating equipment, mechanical re-

pairing equipment, computer monitoring system, industrial television system, management automation system, earthing and protection network for the whole plant, elevators, feed equipment in the dam area, water supply, drainage and heating equipment in the plant and dam area, hydrology and sediment monitoring equipment, automatic water regime monitoring system, video security monitoring equipment, safety monitoring equipment, fire safety equipment, labour safety and industrial hygiene equipment, transportation equipment, and other equipment and installation.

5.2.4 Hydro mechanical structure and installation

Hydro mechanical structure and installation refers to all the hydro mechanical equipment and installation works that constitute the fixed assets of the power station. The components of the hydro mechanical equipment and their installation shall correspond to the components of the construction project, including gates, hoists and trash racks, the fabrication and installation of penstocks, valves and other hydro mechanical equipment and installation.

5.2.5 Miscellaneous expenses

Miscellaneous expenses shall include construction management fees, scientific research and experiment expenses, design fees, engineering survey fees, construction supervision fees, economic and technological consultancy fees, project insurance premium and anti-terrorism measures expenses, etc.

5.3 Division of the construction part

The division of the construction part of the project shall comply with the provisions of Appendix A.

6 Costs and unit price

6.1 Overview

The composition of costs for the construction part is shown in Figure 2:

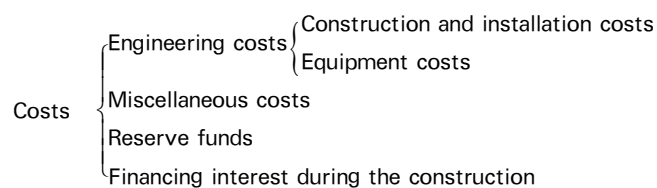


Figure 2 Composition of cost estimates for construction

6.2 Construction and installation costs

6.2.1 Direct costs

Direct costs refer to the labour and capital directly consumed in the construction and installation projects. They shall be composed of basic direct costs and other direct costs. Basic direct costs shall include labour costs, material costs and construction machinery costs. Other direct costs shall include additional costs for construction during winter and rainy seasons, additional costs for construction at night, additional costs for construction in special areas, amortization costs for small and temporary facilities, measure expense of safety and civilization construction, etc.

a) Basic direct costs

1) Labour costs

This refers to various costs incurred by production workers directly engaged in the construction and installation. The production workers are generally composed of self-owned workers (skilled workers) of the construction company and local workers (general workers). Therefore, the unit cost of labour shall be calculated according to the proportion of the number of self-owned workers and local workers.

2) Material costs

Material estimated price shall be formulated for the key materials consumed in large quantities and/or which have a considerable influence on the project investment, such as steel, timber, cement, asphalt, admixture, oil, fire work products, cables and bus bars. Material estimated price = [material's original price + packing expenses + (freight and miscellaneous expenses × gross weight coefficient)] × (1 + procurement and storage cost rate) + transportation insurance premium – packaging recycling value, where:

- 1) Original price refers to the market transaction price of the nearby large material supply company, material trading center, of the factory price of the manufacturer selected according to the design requirements in the project area.
- 2) Packing expenses shall be calculated according to the type, specification, packing cost and normal depreciation amortization of packing materials. Where the original price of materials does not cover the packing expenses, but the materials that must be packed in the course of transportation and storage shall be included in the packing costs. Transportation insurance premium refers to the insurance premium for materials in transportation, which is calculated according to the relevant regulations of the insurance company or market survey.
- 3) Freight and miscellaneous expenses refer to the total costs incurred in moving materi-

als from the designated delivery place to the warehouse or equivalent stockpile areas, including transportation, loading and unloading, dispatching and other incidental costs.

- 4) The gross weight of materials refers to the transport weight of materials including the weight of packages. The ratio of the gross weight to the net weight of materials is the gross weight coefficient. Material procurement and storage costs refer to all the costs incurred during the process of material procurement, supply and storage.
- 5) Packaging recycling value refers to the recycling costs of packaging, such as cement bags, car stakes, cable reels, etc.
- 6) The other material estimated price may be determined by referring to the actual price of materials of similar hydropower projects in the same region.

3) Construction machinery costs

This refers to the depreciation, maintenance, and power fuel costs of the construction machinery used in construction and installation works. It may include the basic depreciation expenses, the equipment repair expenses, the installation and disassembly expenses, the on-board labour expenses and the power fuel expenses, where:

- 1) Basic depreciation expenses refer to the depreciation and amortization expenses of the recovery of the original value of the construction machinery within the specified period of use.
- 2) Equipment repair expenses refer to the costs of repairing and replacing equipment, and the attachments of equipment and tools, lubricating materials required for daily maintenance, cleaning accessories and machinery storage costs incurred to maintain the normal function of the construction machinery.
- 3) Installation and disassembly expenses refer to the amortized costs for installation and disassembly of the construction machinery, test run, on-site transfer and auxiliary facilities coming in and out the site.
- 4) On-board labour expenses refer to the expense of the personnel assigned to the operation of the construction machinery.
- 5) Power fuel expenses refer to the costs of air (compressed air), water, electricity, oil and coal required for normal operation.

b) Other direct expenses

This may include additional costs for construction during winter and rainy seasons, additional

costs for construction at night, additional costs for construction in special areas, amortization costs for small and temporary facilities, measure expense of safety and civilization construction, etc.

- 1) Additional costs for construction during winter and rainy seasons refer to the additional costs required to guarantee engineering quality and safe production during the winter and rainy seasons, including the costs for additional construction processes, the construction of rainproof, heat preservation and drainage facilities, the increased power and fuel consumption and the increased costs due to the decrease of labour and mechanical efficiency.
- 2) Additional costs for construction at night refer to the subsidy fees for night shifts incurred due to the construction during the night, amortization of construction lighting equipment on the construction site and construction roads, as well as lighting electricity costs.
- 3) Additional costs for construction in special areas refer to the increased costs for construction in special areas such as high altitude, natural forest, hot weather and sandstorms.
- 4) Amortization expenses of small and temporary facilities refer to the amortization expenses of small and temporary facilities used at work areas during the normal construction of the project, including erection and dismantling of scattered scaffolds, scattered site levelling, installation and removal of air, water and electricity distribution lines, on-site construction drainage, maintenance of service roads, and erection and dismantling of temporary duty rooms.
- 5) Measure expenses of safety and civilization construction refer to the costs incurred by the construction enterprises when purchasing safety protective appliances, implementing safety construction measures, improving safety production conditions and strengthening safety production management.
- 6) Other costs include construction tools and instruments usage fees, inspection and test expenses, engineering positioning and retesting expenses (construction measurement and control network expenses), expenses for project delivery and acceptance, cleaning expenses upon completion, maintenance costs incurred before the project handover.

Construction tools and instruments usage fees refer to the procurement, amortization and maintenance costs for the required production tools, test and inspection instruments which are not included within the fixed assets, as well as the subsidy fees for the use of tools owned by the workers, where:

- 1) Test and inspection expenses refer to the costs of general identification and inspection of buildings, materials, components and installations conducted by construction enterprises, in accordance with relevant standards, including the costs of materials used by external laboratories.

- 2) Other direct costs shall be calculated based on direct engineering costs, and the calculation rate shall be 5 per cent to 8 per cent; the rate shall be selected according to the complexity of the main engineering project and the temporary facilities.

6.2.2 Indirect expenses

This refers to the administrative expenses of construction enterprise management personnel carrying out office work, training, travel, labour protection, foreign affairs activities, performance guarantee and work permits for foreign personnel.

6.2.3 Profit

This refers to the profit that shall be included in the construction and installation costs according to the market conditions of hydropower construction project.

6.2.4 Taxes

This refers to business tax, value added tax or other related costs that shall be included in the construction and installation costs in accordance with the national tax law and relevant provisions.

6.3 Equipment expenses

Equipment costs may include the original price of the equipment, domestic transportation expenses and transportation insurance premium in equipment manufacturing country, international transportation expenses and insurance premium, tariffs and other costs, local transportation costs and insurance premium, and procurement and storage costs. If the equipment is purchased directly from the domestic market, only local transportation costs and insurance premium, and procurement and storage costs are calculated.

6.4 Formulation of unit cost of construction and installation engineering

The unit price of construction and installation project shall be calculated using the comprehensive unit price method. The unit price of construction and installation project shall include direct costs, indirect costs, profit and tax. Direct costs, indirect costs, profit and tax shall be listed in the unit estimation table. The unit price of construction and installation works shall be calculated according to the following procedures:

a) Direct costs

Basic direct costs include labour costs, material costs and machinery costs.

Other direct costs = direct engineering costs × other direct cost rate.

- b) Indirect costs = direct costs × indirect cost rate
- c) Profit = (direct costs + indirect costs) × profit rate
- d) Tax = (direct costs + indirect costs + profit) × tax rate
- e) Unit price of construction project = direct costs + indirect costs + profit + tax

7 Engineering budget preparation

7.1 Construction temporary works

7.1.1 River diversion

This shall be calculated according to the design work quantity multiplied by the unit price.

7.1.2 Transportation for construction

This shall be calculated according to the design work quantity multiplied by the unit price, and it may also be formulated using an escalated unit cost index, according to the cost index in the project area or related actual data.

7.1.3 Power supply for construction

This may be calculated according to the design work quantity multiplied by the unit price, and it may also be formulated using an escalated unit cost index, by adopting the cost index in the project area or by analysing related actual data according to the design voltage grade, line erection length and the requirements of transformer distribution facilities.

7.1.4 Houses for construction and construction management

The site leveling project costs shall be calculated according to the design work quantity multiplied by the unit price. Construction warehouse and auxiliary processing plant costs shall be calculated according to the design work quantity multiplied by the unit cost index. The construction area of houses may be determined by the construction planning. The unit cost index of building construction may employ the cost index of temporary houses in the region where the project is located, or be determined based on the analysis of actual data. Investment in working and living camp shall be determined by the design work quantity multiplied by the unit cost index.

7.1.5 Other construction temporary works

Other construction temporary works shall be calculated according to the percentage rate of the in-

vestment in construction and installation projects (excluding other construction temporary works); a rate of 2 per cent to 3 per cent should be adopted. If there is a project with high cost and large amount of work, it shall be listed separately according to the actual requirements of the project, and the percentage rate mentioned above should be decreased accordingly.

7.2 Construction project

7.2.1 Main construction project

Construction of the main structure shall be formulated according to the designed work quantities multiplied by unit price.

7.2.2 Transportation project

This shall be calculated according to the designed work quantities multiplied by unit price, or formulated with the escalated unit cost index according to cost index in the project area or related actual data.

7.2.3 Housing construction project

7.2.3.1 The unit cost index for permanent houses shall be determined according to the corresponding local construction cost level.

7.2.3.2 Outdoor housing construction works should generally be calculated as 15 per cent to 20 per cent of the investment in housing construction project.

7.2.4 Other facilities

The cost of safety monitoring facilities shall be calculated according to the design information. If the design information is not available, the cost should be calculated on the basis of the percentage of the investment in the construction of the main construction project according to the dam type or other engineering type.

Dam built with local materials: 0.9% to 1.1%

Concrete dam: 1.1% to 1.3%

Diversion hydropower station (diversion structures): 1.1% to 1.3%

The investment of transmission lines, lighting lines and communication lines shall be calculated by multiplying the designed work quantities by the unit price, or the escalated unit cost index shall be adopted.

All the other items shall be analysed and calculated according to the design requirements.

7.3 Electromechanical equipment and installation project

7.3.1 Equipment cost

Equipment cost is mainly composed of the following items:

- a) Original cost of equipment refers to the factory price or the inquiry made by the design unit after analysis and demonstration.
- b) Domestic freight and miscellaneous costs of equipment in its production country refer to all the transportation costs of equipment shipped from the manufacturer to a domestic port, mainly including transportation expenses, vehicle dispatching expenses, loading and unloading expenses, packing and binding expenses, nitrogen charging expenses for transformers and other possible incidental costs.
- c) Domestic transportation insurance premium refers to the insurance premium arising from the transportation process of the equipment. Transportation insurance premiums of the equipment shall be calculated based on the percentage of the original price of the equipment, and the insurance rate shall be calculated according to the provisions of relevant authorities.
- d) International transportation costs refer to all the transportation costs incurred by the equipment shipped from the supplier port to the relevant project port.
- e) International transportation insurance premium refers to the insurance expenses arising from the international transportation of the equipment.
- f) Tariff and other costs refer to the tariff, value-added tax, bank finance expenses, foreign trade commission, import commodity inspection expenses and port charges imposed on the import of the equipment.
- g) Local freight and miscellaneous costs refer to all the transportation costs incurred by the equipment shipped from the domestic port (or the manufacturer) to the project site.
- h) Local transportation insurance premium refers to the insurance expenses of the equipment in the transportation process, which shall be calculated according to the market survey.
- i) Procurement and storage expense refer to all the costs arising from the procurement and storage of the equipment, mainly including procurement expenses, warehouse expenses, site storage expenses, depreciation costs of miscellaneous fixed assets, measure costs for technical safety, and the cost of equipment inspection and testing.

j) Other considerations:

- 1) Due to the weak economic foundation of many countries where SHP projects are carried out, attention shall also be paid to whether the relevant port in the country has sufficient loading and unloading capacity, whether additional hoisting machinery is needed and whether the road infrastructure of the country meets the requirements for transporting large equipment.
- 2) The field assembly and processing costs for the components of the main frame, after being transported to the site, shall be included in the original price of the equipment. If an assembly yard needs to be set up, its construction cost shall also be included in the original price of the equipment.
- 3) If the equipment is purchased directly from domestic market, only the local transportation and insurance premium, and procurement and storage expenses, need to be calculated.

7.3.2 Installation project expenses

Investment in installation projects shall be calculated by multiplying the quantity of the equipment by the unit price the installation.

7.4 Hydro mechanical structure and installation

The formulation method is the same as that in 7.3.

7.5 Miscellaneous costs

Miscellaneous costs are mainly composed of the following items:

- a) Construction management expenses refer to the management expenses required for the entire process, from project preparation to completion acceptance, in order to conduct a normal construction project. They may include the preliminary project inspection, form of construction organization, management equipment and equipment purchase, management staff wages and benefits, and other management costs. Consensus-building costs with stakeholders (including local residents and communities) may be included within construction management expenses. They are included in the cost estimation on the basis of actual costs incurred, and may also be calculated as 2 per cent to 3 per cent of the investment covered by 7.1 to 7.4 if there is no relevant information.
- b) Scientific research and experiment expenses refer to the costs required to carry out necessary scientific research and tests during the construction process to solve technical problems associ-

ated with the project. It is included in the cost estimation on the basis of actual costs incurred, and it may be calculated as 0.5 per cent of the investment in construction and installation covered by 7.1 to 7.4 if there is no relevant information.

- c) Design expenses include the costs of the provision of schemes, pre-feasibility study and cost estimation, feasibility study and cost estimation, detail design drawings and bills of quantities, technical presentation, handling of design problems during construction, preparation of as-built drawings and other services, as well as the costs of external design review and travel costs for design personnel. It shall be included in the cost estimation on the basis of actual costs or by reference to similar projects.
- d) Engineering investigation expenses refer to the costs of engineering geological exploration and surveying and mapping, which shall be included in the cost estimation on the basis of actual costs or with reference to similar projects.
- e) Construction supervision expenses include the costs of the complete supervision and control service for construction quality, safety, progress and the cost of the parts of the project under direct supervision, as well as the costs of on-site construction supervision engineers, which are included in the cost estimation, on the basis of actual costs or with reference to similar projects.
- f) Economic and technical consultancy costs refer to the costs incurred by entrusting qualified institutions or employing experts to carry out consultation, review and evaluation on the special project technology, economy and law, such as the safety, reliability, advancement and economy of the project construction, according to the project-management objectives. It shall include special consultation on surveys and design outcomes, engineering safety and technical appraisal, special examination of construction and design changes, special assessment of quality problems during the construction and warranty period, labour safety and industrial hygiene testing and evaluation, final accounts of completion and post-project evaluation reports, and other consulting costs.
- g) Project insurance premium refer to the insurance premium for construction, equipment and installation works during the construction period in order to obtain economic compensation for the losses caused by natural disasters such as fire, flood and accidents. It shall be included in the cost estimation on the basis of actual costs incurred, and it may be calculated as 0.5 per cent of the investment covered by 7.1 to 7.4 if there is no relevant information.
- h) Anti-terrorism measures fee refers to the expenses of security personnel and safety facilities designed to guarantee the personal and property safety of the engineering, technical and management personnel, depending on the national safety requirements.

7.6 Reserve funds and financing interest during construction period

7.6.1 Reserve funds

a) Basic reserve fund

The basic reserve fund mainly covers the increased investment in design changes and the adjustment of relevant technical standards during construction, as well as the losses caused by general natural disasters, and the costs of measures adopted for prevention of natural disasters. It may be calculated as 5 to 10 per cent of the total investment of the project covered by 7.1 to 7.4.

b) Reserve fund for price differences

The reserve fund for price differences mainly covers the increased investment during the construction process due to the increase in labour wages, materials and equipment prices and the adjustment of expense standards. Depending on the construction period, the static investment (including the basic reserve funds) shall be taken as the calculation base and calculated by the following formulas.

- 1) When the annual cost indices are the same, the reserve fund for annual cost difference is calculated by the following formula:

$$E_i = F_i [(1 + p)^{i-1} - 1] \dots\dots\dots (1)$$

- 2) When the annual cost indices are different, the reserve fund for annual cost difference is calculated by the following formula:

$$E_i = F_i [(1 + p_2) (1 + p_4) \dots (1 + p_i) - 1] \dots\dots\dots (2)$$

- 3) The reserve fund for price differences is the sum of annual reserve funds for cost differences:

$$E = \sum_{i=1}^N E_i \dots\dots\dots (3)$$

where

E is the reserve fund for cost differences;

E_i is the reserve fund for cost difference in the i^{th} year;

N is the construction period;

i is the years of construction;

F_i is the annual investment in the i^{th} year (including basic reserve fund);

p is the average price index (applicable to the same annual price indices);

p_i is the price index in the i^{th} year (applicable to different annual price indices).

The reserve fund for cost difference shall be calculated from the next year of the cost level year adopted to formulate budgets.

7.6.2 Financing interest during the construction period

It shall be calculated on the basis of the sum of annual investment, basic reserve fund and reserve fund for price difference covered by 7.1 to 7.4 according to the reasonable construction period and the financial policies and capital system.

Estimation formula:

$$S = \sum_{n=1}^N \left[\left(\sum_{m=1}^n F_m b_m - \frac{1}{2} F_n b_n \right) + \sum_{m=0}^{n-1} S_m \right] i \quad \dots\dots\dots (4)$$

where

S is the financing interest during construction period;

N is the reasonable construction period;

n is the construction years;

m is the interest repayment years;

F_n, F_m is the investment of the n^{th} and m^{th} year in the capital flow table during construction period;

b_n, b_m is the proportion of the financing amount for each construction year invested in the same year;

i is the financing interest rate during construction period;

S_m is the interest repayment amount in the m^{th} year.

Other financing costs such as commission fee, commitment fee, administrative fee, and credit insurance premium incurred through the financing of debt shall be analysed and calculated according to

relevant provisions and shall be included in financing interest during the construction period.

8 Composition of cost estimate documents

8.1 Preparation instructions

8.1.1 Project profile shall include:

- a) The river system where the project is located, construction site, accessibility, project scale, project benefit, project layout, work quantities of main structures, main material consumption, total construction period and schedule for power generation of the first (batch) unit.
- b) The project profile shall explain the sources of the investment for project construction and the proportion of the investment.
- c) The profile shall explain the total investment and static investment of the project, reserve fund for cost differences, financing interest during the construction period, investment per kW, investment per unit of electricity, and the total investment and static investment when the first (batch) unit starts power generation.

8.1.2 Preparation principle and basis shall include:

- a) The relevant national and regional laws and regulations adopted in the preparation of the cost estimation;
- b) The relevant regulations, norms and provisions used in the preparation of the cost estimation;
- c) The price-level year for the preparation of the cost estimation;
- d) Design documents and drawings;
- e) Other relevant provisions.

8.1.3 Basic price shall include:

- a) Estimated unit costs of labour, the estimated cost of the main materials, and the basic unit costs of electricity and water used for construction;
- b) Prices of major equipment;
- c) Expense calculation standards.

8.1.4 Other considerations shall be listed in the preparation of the cost estimation.

8.1.5 Summary table of the main technical and economic indices:

The main technical and economic indices of the project shall be listed in this table.

8.2 Project cost estimate table

The project cost estimate table shall include the general cost estimate table, construction temporary work cost estimate table, cost estimate table for the construction project, cost estimate table for equipment and installation project, cost estimate table for miscellaneous expenses, annual investment summary table and the summary table of the main technical and economic indices. See Appendix B for the form of tables and requirements.

9 Preparation of investment estimation for the construction part

9.1 Preparation method and calculation standards

9.1.1 Basic unit cost

The preparation of the basic unit cost shall be the same as that used in budgetary estimation.

9.1.2 Unit cost of construction and installation projects

The preparation method for unit cost of construction and installation projects shall be the same as that used in budgetary estimation.

9.1.3 Preparation of subunit project estimations

Estimation of subunit projects may be divided into three parts, namely temporary construction projects, the construction project, and the electromechanical equipment and installation project. The preparation method shall meet the following requirements:

- a) For temporary construction projects, the preparation method and calculation standards are essentially the same as those used in the cost estimation.
- b) For construction projects, the preparation of the investment estimation for the main construction works, transport engineering and building construction shall be basically the same as that in cost estimation. Other projects may be estimated as 2 per cent to 4 per cent of the investment in the main construction works, depending on the particular nature and scale of the project.
- c) For electromechanical equipment and installation, the method for preparation of estimation of

major electromechanical equipment and installation works shall be the same as that in the cost estimation. The equipment and installation costs of other electromechanical equipment may be calculated according to the percentage of the main electromechanical equipment cost or unit kilowatt index. Major electromechanical equipment includes turbines and ancillary equipment, generators and ancillary equipment, main valves, lifting equipment, generator circuit breakers, busbars, main transformer and high voltage electrical equipment (which includes high voltage circuit breakers, high voltage combined electrical equipment, and high voltage power cables). Other electromechanical may include hydraulic machinery ancillary equipment, electrical equipment, control and protection equipment, communications equipment, ventilation and heating equipment, mechanical repair equipment, other substation equipment, elevators, feeder equipment in the dam area, water supply and drainage and heating supply equipment in the plant and dam areas, permanent hydrological telemetry equipment, permanent safety monitoring equipment, labour safety and industrial hygiene equipment, firefighting equipment, transportation equipment, plant earthing, etc.

- d) For the hydro mechanical structure and installation works, the preparation method and calculation standards shall be essentially the same as those used in cost estimation.
- e) For miscellaneous expenses, the preparation method and calculation standards shall be essentially the same as those used in cost estimation.

9.2 Reserve funds and financing interest during the construction period

The requirements for the calculation of reserve funds and financing interest during the construction period are as follows:

- a) Basic reserve funds: a rate of 10 per cent to 15 per cent may be used, with consideration of different design depth.
- b) Reserve fund for cost differences: the calculation method is the same as that used for cost estimation.
- c) Financing interest during construction period: the calculation method here is the same as that used for cost estimation.

9.3 Composition of investment estimation documents

The investment estimation documents are composed of the preparation instructions and the investment estimation table. The table form and contents are essentially the same as those used in the cost estimation.

NOTE: The project investment estimation shall be prepared to make an informed decision for the development of the project in the early stages of the project. Investment estimation is essentially the same as preparing the cost es-

timation in terms of contents, project division and expenses composition. However, due to the different levels of detail in these two kinds of estimations, the preparation methods and estimation standards for each are different. Investment estimation shall therefore simplify, merge and adjust some of the content used for the preparation of the cost estimation.

Appendix A
(Normative)
Project division in construction part

Table A.1 Item 1—Temporary construction project

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
I	Diversion project			
1		Open diversion channel project		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* / (t, m, m ²)
			Reinforced gabion	* /m ³
			Composite geomembrane	* /m ²
2		Diversion tunnel		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Plugging concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m

Table A.1 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Grouting	* / (t, m, m ²)
			Waterstop	* / m
			Others	
3		Diversion bottom tunnel		
4		Earth-rock cofferdam project		
			Earth excavation	* / m ³
			Rock excavation	* / m ³
			Weir filling	* / m ³
			Stone masonry	* / m ³
			Concrete	* / m ³
			Fabrication and placement of re-bar	* / kg
			Seepage proofing	
			Removal of weir body	* / m ³
			Closure	
			Others	
5		Concrete cofferdam project		
			Earth excavation	* / m ³
			Rock excavation	* / m ³
			Concrete	* / m ³
			Fabrication and placement of re-bar	* / kg
			Seepage proofing	
			Removal of weir body	* / m ³
			Others	
6		Downstream temporary water supply during the impoundment period		
7		Hydro mechanical structure and installation		
II	Construction transportation project			
1		Road		* / km
2		Railway		* / km

Table A.1 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
3		Bridge		* /m
4		Construction adit		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Blocking concrete	* /m ³
			Fabrication and placement of re-bar	* /kg
			Shotcrete	* /m ³
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* / (t,m,m ²)
			Others	
5		Aerial ropeway		* /m
6		Slope hoisting way		* /m
7		Reinforcement of bridge and culvert and roads		* /km
8		Railway transfer station		* /Item
9		Waterway		* /Item
10		Maintenance and management of facilities		* /Item
III	Construction power supply project			
		High voltage power supply lines		* /km
		Substation		* /each
IV	Houses for construction and construction management			
		Site levelling		* /m ²
		General construction warehouse		* /m ²
		Explosive storage		* /Item

Table A.1 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
		Oil depot		* /Item
		Auxiliary processing plant		* /m ²
		Working and living camp		* /m ²
		Outdoor project		* /Item
		Maintenance and management of facilities		* /Item
V	Other temporary construction project			

NOTE: “*” indicates the currency unit

Table A.2 Item 2—Construction civil works

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
I	Water retaining (impoundment) structures			
1		Concrete dam (gate)		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Cutoff wall trenching	* /m ²
			Cutoff wall concrete	* /m ³
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Grouting orifice pipe	* /m

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Drainage hole	* /m
			Steel plate lining	* /kg
			Hoist room	* /m ²
			Temperature control measures	* /m ³ (concrete)
			Detail structure	* /m ³
2		Earth (rock) dam		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth filling	* /m ³
			Sand-gravel filling	* /m ³
			Sloping (core) wall earth filling	* /m ³
			Filter material and graded material filling	* /m ³
			Dam rock filling	* /m ³
			Blanket filling	* /m ³
			Geomembrane	* /m ²
			Stone masonry	* /m ³
			Asphalt concrete	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Waterstop	* /m
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Cutoff wall trenching	* /m ²
			Cutoff wall concrete	* /m ³
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Detail structure	* /m ³
3		Reservoir bank seepage proofing project		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Cutoff wall trenching	* /m ²
			Cutoff wall concrete	* /m ³
			Drilled grout hole	* /m
			Grouting	* /(t, m, m ²)
			Grouting orifice pipe	* /m
			Drainage hole	* /m
II	Drainage and energy dissipation structures			
1		Spillway		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Steel plate lining	* /kg
			Temperature control measures	* /m ³ (Concrete)
			Detail structure	* /m ³
2		Flood discharging tunnel		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Steel plate lining	* /kg
			Detail structure	* /m ³
3		Scouring outlet (tunnel)		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Drainage hole	* /m
			Detail structure	* /m ³
4		Relieving hole (tunnel) project		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Detail structure	* /m ³
5		Plunge pool, auxiliary weir and stilling basin		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Steel plate lining	* /kg
			Detail structure	* /m ³
III	Water conductor structures			
1		Open diversion channel		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drainage hole	* /m
			Detail structure	* /m ³
2		Inlet (intake) project		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Detail structure	* /m ³
3		Diversion tunnel	Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* / (t, m, m ²)
			Drainage hole	* /m
			Detail structure	* /m ³
4		Surge shaft (chamber)	Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Grouting	* /m ²
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* / (t, m, m ²)
			Drainage hole	* /m
			Detail structure	* /m ³
5		Forebay		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Concrete	* /m ³

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Detail structure	* /m ³
6		Penstock		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³
			Fabrication and Placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Detail structure	* /m ³
7		Tailwater tunnel		Refer to diversion tunnel engineering series
8		Tailwater surge chamber (shaft)		Refer to surge shaft (chamber) series
9		Tailrace		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Detail structure	* /m ³
10		Tailwater outlet		Refer to the listed items of inlet (intake) project
IV	Power generation structures			
1		Surface powerhouse		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Temperature control measures	* /m ³ (concrete)
			Structure decoration	* /m ²
			Detail structure	* /m ³
V	Substation structures			

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
1		Surface substation		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Brick masonry	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Structure decoration	* /m ²
			Detail structure	* /m ³
VI	Irrigation canal head works			
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Drainage hole	* /m
			Detail structure	* /m ³
VII	Slope protection (near the dam)			
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Stone masonry	* /m ³
			Concrete	* /m ³
			Fabrication and placement of reinforcement	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Drainage hole	* /m
			Others	
VIII	Transportation projects			
1		Roads		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Earth-rock filling	* /m ³
			Stone masonry	* /m ³
			Concrete	* /m ³
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /each
			Protective mesh	* /m ²
			Others	
2		Railway		* /km
3		Bridge		* /m
4		Access tunnel (including access tunnel to the plant)		
			Earth excavation	* /m ³
			Rock excavation	* /m ³
			Concrete	* /m ³

Table A.2 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Fabrication and placement of rebar	* /kg
			Shotcrete	* /m ³
			Wiremesh rebar	* /kg
			Anchor bolt (beam)	* /each
			Anchor cable	* /eachk
			Drilled grout hole	* /m
			Grouting	* /(t,m,m ²)
			Detail structure	* /m ³
5		Waterway		* /Item
IX	Houses construction project			
		Site levelling		* /Item
		Auxiliary manufacturing plant		* /m ²
		Warehouse		* /m ²
		Office		* /m ²
		On-duty apartment and ancillary facilities		* /m ²
		Outdoor projects		%
X	Other construction projects			
		Safety monitoring facilities		
		Power line		* /km
		Lighting line		* /km
		Communications line		* /km
		Labour safety and industrial hygiene facilities		
		Water level and sediment monitoring facilities		
		Automatic water regime monitoring system		
		Others		
NOTE “*” indicates the currency unit				

Table A.3 Item 3—Electromechanical equipment and installation project

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
I	Generating equipment and installation project			
1		Turbine equipment and installation		
			Turbine	* /Unit
			Governor	* /Unit
			Oil pressure device	* /Set
			Automation element	* /Set
			Turbine oil	* /kg
2		Generator equipment and installation		
			Generator	* /Unit
			Excitation system	* /Set
			Automation element	* /Set
3		Main valve equipment and installation		
			Butterfly valve	* /Unit
			Spherical valve	* /Unit
			Oil pressure device	* /Set
4		Hoisting equipment and installation		
			Bridge crane	* /Unit
			Balance beam	* /kg (Pair)
			Track	* /Pair 10 m
			Track blocker	* /kg
			Trolley conductor	* /Three phase 10 m
5		Hydraulic machinery auxiliary equipment and installation		
			Oil system	
			Compressed air system	
			Water system	
			Hydraulic measuring system	
			Pipeline (pipe, fittings and valve)	* /kg

Table A.3 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
6		Electrical equipment and installation		
			Power generation voltage device	
			Variable frequency starting device	
			Busbar	* /Single phase 100 m
			Plant service power supply system	
			Testing equipment	
			Power transmission cable	* /km
			Cable tray (cable and busbar)	* /kg
			Others	
7		Control protection equipment and installation		
			Computer monitoring system	
			Protection system	
			Industrial video system	
			Direct current system	
			Control and protection cable	* /km
			Others	
8		Communication equipment and installation		
			Satellite communication	
			Optical fibre communication	
			Microwave communication	
			Carrier wave communication	
			Mobile communication	

Table A.3 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
			Manufacturing dispatching communication	
			Manufacturing management communication	
II	Substation equipment and installation			
1		Main transformer equipment and installation		
			Transformer	* /Unit
			Track	* /Pair 10 m
			Track blocker	* /kg
2		High voltage electrical equipment and installation		
			High voltage circuit breaker	* /Unit
			Current transformer	* /Unit
			Voltage transformer	* /Unit
			Isolation switch	* /Unit
			Lightning arrester	* /Unit
			High voltage combined electrical equipment	* /Interval
			High voltage power cable	* /Three phase 100 m
			Fabrication and installation of high voltage power cable head	* /Three phase set
3		Primary cable connection and other installation works		
III	Safety monitoring equipment and installation project			
IV	Hydrological telemetry equipment and installation project			
V	Firefighting equipment and installation project			

Table A.3 (continued)

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
VI	Labour safety and industrial hygiene equipment and installation project			
VII	Other equipment and installation project			
1		Elevator equipment and installation		
2		Feeder equipment in dam area and installation		
			Transformer	* /Unit
			Power distribution device	
3		Water supply and drainage equipment in plant and dam area and installation		
4		Heating equipment in plant and dam area and installation		
5		Ventilation and heating equipment and installation		
6		Machinery repair equipment and installation		
7		Traffic equipment		* /Vehicle (Unit)
8		Plant earthing		* /kg
9		Others		* /Item
NOTE “*” indicates the currency unit				

Table A.4 Item 4-Hydro mechanical equipment and installation project

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
I	Water retaining (impoundment) structures			
1		Gates and installation		
			Plain batten gate	* /kg
			Arch gate	* /kg
			Embedded parts	* /kg
			Gate weights	* /kg
2		Hoist equipment and installation		
			Winch hoist	* /Unit
			Gantry crane	* /Unit
			Oil pressure hoist	* /Unit
			Track	* /Pair 10 m
			Track blocker	* /kg
3		Trash holding equipment and installation		
			Trash rack	* /kg
			Trash remover (cleaner)	* /kg (Set)
II	Drainage and energy dissipation structures			
1		Gates and installation		
2		Hoist equipment and installation		
3		Trash holding equipment and installation		
III	Water conductor system			
1		Gates and installation		
2		Hoist equipment and installation		
3		Trash holding equipment and installation		
4		Steel pipe (penstock) fabrication and installation		
IV	Switchyard structures			
		Steel framework		* /kg
V	Structures at head of irrigation channel			
1		Gates and installation		
2		Hoist equipment and installation		
NOTE “*” indicates the currency unit				

Table A.5 Item 5—Miscellaneous costs

No.	Level-1 project	Level-2 project	Level-3 project	Technical and economic index
1	Construction management expense			
2	Scientific research testing expense			
3	Design expense			
4	Engineering survey expenses			
5	Construction supervision expenses			
6	Economic and technical consultation expenses			
7	Insurance premium of project			
8	Anti-terrorism measures expenses			

NOTE 1 In the project division, three levels—Level-1, Level-2 and Level-3—are completed for each item; these can be tailored to the project requirements, but Level-1 and Level-2 items shall not be merged. Items not specified in the table can be listed depending on actual project requirements.

NOTE 2 Only representative sub-items are listed under Level-3 items. When the design budgetary estimation is prepared, the following items shall be subdivided as necessary:

- ① Open excavation and underground excavation, earth excavation, and sand and gravel excavation shall be listed separately under earth excavation.
- ② Open excavation and underground excavation, as well as the excavation of adits, inclined shafts and vertical shafts shall be listed separately under rock excavation.
- ③ Earth filling and rock filling shall be listed, respectively, under earth-rock filling.
- ④ Different construction positions, different strength levels and different grades of the concrete works shall be listed, respectively.
- ⑤ Dry stone masonry, cement-laid stone masonry, riprap and wire (reinforcement) cage block stone shall be listed, respectively, under stone masonry.
- ⑥ Borehole grouting shall be listed separately according to the purposes and the different drilling machines employed.
- ⑦ Grouting projects shall be listed according to different grouting types, such as contact grouting, consolidation grouting, curtain grouting and backfill grouting.
- ⑧ Shotcrete-bolt support work, steel fibre shotcrete and plain shotcrete, anchor bolt and anchor cable, as well as any different specifications among them, shall be listed separately.
- ⑨ Electromechanical equipment and installation, as well as hydro mechanical structures and installation, shall be listed one by one, according to the equipment list required by the design and the item division requirements.
- ⑩ General steel pipe, branch pipe, and different pipe diameters and thicknesses shall be listed separately for steel pipe fabrication and installation.

NOTE 3 The composition of each part of the ecological substation shall be included within the corresponding items of the main project, according to their attributes.

NOTE 4 “*” indicates the currency unit

Appendix B
(Normative)
Project cost estimate table

Table B.1 Total cost estimate table

Unit: *

No.	Description of project or expense	Construction and installation expense	Equipment procurement expense	Miscellaneous expense	Total
I	Investment in the construction part				
1	Temporary construction works				
2	Construction				
3	Electromechanical equipment and installation				
4	Hydro mechanical equipment and installation				
5	Miscellaneous expenses				
	Total investment: Item 1 to Item 5				
	Basic reserve fund				
	Total capital investment				
II	Social and environmental protection part				
	Investment in social and environmental protection				
	Basic reserve fund				
	Total capital investment				
III	Total investment in engineering (Total of I and II)				
	Total capital investment				
	Reserve fund for price differences				
	Financing interest during construction period				
	Total investment				
NOTE “*” indicates the currency unit					

**Table B.2 Cost estimate table of temporary construction project
(or construction civil works)**

Unit: *

No.	Description of project or expense	Unit	Quantity	Unit price	Total

NOTE 1 Level III items are listed in this table according to the project division, and this table is applicable to temporary construction projects and construction civil works.

NOTE 2 “*” indicates the currency unit

Table B.3 Cost estimate table for equipment and installation projects

Unit: *

No.	Description and specification	Unit	Quantity	Unit price		Total	
				Equipment	Installation	Equipment	Installation

NOTE 1 Level III items are listed in this table according to the project division and this table is applicable to electro-mechanical equipment and installation as well as hydro mechanical equipment and installation projects.

NOTE 2 “*” indicates the currency unit

Table B.4 Cost estimate table for miscellaneous expense

Unit: *

No.	Description of project or expense	Estimation formula	Amount

NOTE “*” indicates the currency unit

Table B.5 Unit cost estimate table

Unit price No.				
Project name				
Construction method				
Items	Unit	Unit price (*)	Quantity	Total price (*)
Labour				
...				
Material				
...				
Construction machinery				
...				
Subtotal of basic direct expenses	*			
Other direct expenses	*	%		
Indirect expenses	*	%		
Profit	*	%		
Tax	*	%		
Total	*			
Unit price	*			
NOTE “ * ” indicates the currency unit				

Table B.6 Annual investment summary table

Unit: *

No.	Description of project or expense	Total	Construction period (year)			
			1	2	3
I	Investment in construction part					
1	Construction temporary works					
2	Construction civil project					
3	Electromechanical equipment and installation					
4	Hydro mechanical structure and installation					
5	Miscellaneous expenses					
	Total investment: total of Items 1 to 5					
	Basic reserve fund					
	Total capital investment					
II	Social and environmental protection part					
	Investment in environmental protection					
	Basic reserve fund					
	Total capital investment					
III	Total investment of project (total of I and II)					
	Total capital investment					
NOTE “*” indicates the currency unit						

Table B.7 Main economic and technical index table

River system			Power station	Type		
Construction location				Size of powerhouse (length × width × height)		m × m × m
Designer				Turbine model		
Project owner				Installed capacity (unit capacity × set)		kW
Reservoir	Normal pool level	m		Guaranteed output		kW
	Total pool capacity	m ³		Annual output		kW · h
	Live capacity	m ³		Annual utilization of hours		h
	Submerged cultivated land	Hectare		Construction engineering investment		*
	Resettlement of residents	Person		Construction engineering per unit kW index		* /kW
	Resettlement cost	*		Investment in power generation equipment		*
	Unit index	* /Person		Power generation equipment per unit kW index		* /kW
River weir (Gate)	Type		Engineering quantities of main construction	Excavation	Open earth-rock excavation	m ³
	The maximum of dam height/length of dam crest	m			Rock excavation in tunnel	m ³
	Dam volume	m ³		Filling	Earth and rock	m ³
	Investment	*			Concrete	m ³
	Unit index	* /m ³		Cement		t
Diversion tunnel	Type		Quantity of main materials used	Rebar and steel		t
	Diameter	m		Timber		m ³
	Length/Number			Fly ash		t
	Investment	*		Explosives		t
	Unit index	* /m		Fuel material		t
Static total investment in the engineering		*	Total number of personnel	Personnel in peak period		Person
Total investment of project		*		Average		Person
Capital investment in unit kW		*		Total labour hours		Labour hours

Table B.7 (continued)

Investment of unit annual output	*	Total construction progress	Project preparation period	Month
Capital investment in the first turbine generator unit for power generation	*		Construction preparation period	Month
Total investment in the first turbine generator unit for power generation	*		Main construction period	Month
Interest during construction	*		Project completion period	Month
Investment in transmission engineering	*		Construction period for power generation of the first turbine generator unit	Month
Production Department Personnel	Persons		Total construction period	Month
NOTE “*” indicates the currency unit				