UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Technical Guidelines for the
Development of Small Hydropower Plants

DESIGN

Part 10: Economic Appraisal

SHP/TG 002-10: 2019

DISCLAIMER

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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 10: Economic Appraisal

1 Scope

This part of the Design Guidelines sets forth the principles, contents, methods and parameters of the economic appraisal of small hydropower (SHP) projects.

This document is applicable to the economic appraisal at the pre-feasibility study and feasibility study stages of SHP projects.

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 The economic appraisal shall be consistent with the national laws and regulations as well as the provisions of the national social, economic and financial policies.

4.2 The economic appraisal shall include both economic cost benefit and financial evaluation.

a) Economic cost benefit evaluation: On the premise of rational allocation of resources and in the overall interests of the national economy, assess and calculate the economic contribution of the project, analyse the economic efficiency, effectiveness and social influence of the project, as

well as the economic rationality of the project.

b) Financial evaluation: Based on the prevailing national fiscal and taxation systems and price indices relevant to the project, calculate the financial benefits and expenses within scope of the project, analyse the project's profitability and liquidity, and evaluate the financial feasibility of the project.

4.3 The conclusions of the economic appraisal for the project shall meet the following conditions:

a) If both the conclusions of the economic cost benefit and financial evaluation are feasible, the economic appraisal for the project is feasible.

b) If both the conclusions of the economic cost benefit and financial evaluation are not feasible or only the financial evaluation is feasible, the economic appraisal for the project is not feasible.

c) If the conclusion of the economic cost benefit evaluation is feasible while the conclusion of the financial evaluation is not, a proposal containing details of financial preferential policies may be presented, such as adjusting the tariff, providing low-interest loans or tax incentives, so as to meet the conditions of financial feasibility.

4.4 The economic appraisal shall accord with the principle that the cost and benefit calculations employ the same parameters. The time value of capital shall be mainly evaluated with dynamic analysis, and supplemented with static analysis.

4.5 The calculation period of economic appraisal for the project shall include the construction period and the operation period.

a) Construction period: Reasonably determined with reference to the reasonable construction period of the project or the construction schedule of the project, from the beginning of the construction to the normal operation of the main project.

b) Operation period: From the formation of the design production capacity of the project to the end of the operation period. For economic calculation, the operating period may be generally 20 to 50 years (lower values for micro scale and higher values for small scale).

c) The benchmark for the calculation of the time value of capital shall be fixed at the beginning of the first year of the construction period, and the inputs and outputs shall be calculated at the end of the year, except for the loan interest.

4.6 The main parameters for the economic appraisal (social discount rate and benchmark yield) shall be the parameters being used by relevant departments of the state currently.

5 Cost calculation

5.1 The cost for the project shall include the construction investment, cost, taxes, etc.

5.2 The investment calculation in the economic appraisal for the construction project shall meet the following requirements:

a) The construction investment used in the economic cost benefit evaluation shall be adjusted by deducting the internal transfer taxes, loan interests and various subsidies on the basis of the project design evaluation investment. In some cases, subsidies are available under different conditions after the start of the project; in that case they may be taken into account for tariff calculation.

b) The investment used in the financial evaluation shall be the sum of the static investment and the reserve funds, including the basic reserve funds and the reserve fund for price difference.

5.3 The total cost of power generation shall be the total cost of the hydropower station in the normal operation year after reaching its designed production capacity, it includes:

a) Annual operating expenses can be calculated as 1.5 to 2 per cent of the original value of the fixed assets of the construction project, or item-by-item, according to the actual situation. The sub-items include maintenance and repair costs, wages and welfare expenses, material costs and insurance premium, water rate (including water resources fees), reservoir funds and other expenses. When the construction project includes the investment of power supply, the annual operating cost of the power supply (the cost of the power supply minus the depreciation fee) shall be added to the overall operating cost.

b) Depreciation expenses refer to the compensation for the wear and loss value of fixed assets of the construction project during the operating process.

c) Amortization expenses refer to the expenses incurred as a result of the amortization of intangible assets and deferred assets.

d) Interest expenses include interest on fixed asset investments and interest expenses on current capital.

5.4 The calculation of annual operating expenses shall comply with the following conditions:

a) Calculation method for annual operating expenses of the project in the financial evaluation:

1) The expenses shall be determined by comparing and analysing statistical data from similar completed projects, but the number of employees and wages shall be determined according

to the fixed personnel and fixed staffing standard, and the impact of other individual fixed expenses on price changes shall be included.

2) The expenses shall be calculated item-by-item, according to the composition of the annual operating expenses of the project.

b) The annual operating cost for the power supply may be calculated by the annual unit operating cost of the power supply in the year, multiplied by the generated units of electricity from the project.

c) The annual operating expenses in the economic cost benefit evaluation are based on those in the financial evaluation, with adjustments based on the ratio of investment in economic and environmental benefits to the investment in the financial evaluation.

5.5 Taxes and additional insurance premium shall be included in the financial evaluation according to prevailing policies and conditions; they shall not be included in the economic cost benefit evaluation.

5.6 The depreciation expenses of the project shall be calculated based on the depreciation rate of the sub-items according to the relevant national regulations.

5.7 For a project involving multi-purpose comprehensive utilization and development, the following cost distribution principles shall be followed:

a) For a project with SHP development as the main purpose, supplemented by comprehensive utilization, and where there are few additional costs and benefits incurred from water conservation facilities, a cost distribution may not be necessary, and all costs may be accounted for within the SHP project itself.

b) If water-resource development is the priority and SHP development is the secondary, the SHP project shall share the investment in common facilities in proportion to the benefits.

c) If SHP development and water-resource development both have considerable importance, the cost shall be shared in proportion to the respective benefits.

5.8 The investment of a construction project involving multi-purpose, comprehensive utilization and development may be divided as follows:

a) Investment in shared facilities (such as dams, spillway facilities, and reservoir inundation relocation) for each beneficiary sector is a shared investment.

b) Investment intended to compensate the adverse impacts of the project (such as environmental protection, ship locks, fish ladders, and raft sluices).

c) For investment in a project that replaces some shared facilities (such as the water-retaining powerhouse of a riverbed power station, which may be a replacement for a dam), although it benefits a certain sector only, the part that is used to replace shared facilities shall be considered a shared investment, and the remainder is a dedicated investment.

d) The special facility investment required by each beneficiary shall be considered as a dedicated investment.

5.9 Shared investments may be distributed in the following ways:

a) In proportion to physical quantity indicators (such as storage capacity) used by each beneficiary sector.

b) In proportion to the benefits obtained by each beneficiary sector.

c) In proportion to the investment in the equivalent optimal alternative option of each beneficiary sector.

d) Any other reasonable method.

5.10 The investment share borne by each beneficiary sector shall be the sum of the shared investment and the dedicated investment. The total cost may be checked for rationality from the aspects below. However, if the result is found unacceptable, appropriate adjustments may be made until it becomes acceptable.

a) The investment share borne by any beneficiary shall not be greater than the investment in an equivalent optimal alternative project.

b) The investment share borne by any beneficiary shall not be less than its dedicated investment.

c) The investment share borne by any beneficiary shall deliver reasonable economic effects.

5.11 The distribution of operating expenses and depreciation expenses may follow the principle in 5.7 and the methods in 5.9. The share borne by each beneficiary sector may also be calculated with a uniform annual operating rate and depreciation rate, on the basis of the respective distributed investments.

6 Benefits calculation

6.1 The benefits of the project shall include economic, social and environmental benefits.

a) Economic benefits, including power generation benefit, comprehensive utilization benefit and

multiple operational benefits, shall be quantified and referred to as revenue.

b) Social and environmental benefits shall be quantified, while the benefits that cannot be quantified shall be described qualitatively.

6.2 The power generation benefit of the project shall be calculated according to the Formula (1):

Power generation revenue = Effective power generation × (1 − Power consumption rate) × (1 − Powe grid loss rate) × Calculated tariff ……(1)

where

Effective power generation: Calculated generating capacity that can be used by the system through system load forecasting, system power balance, and factoring in equipment overhaul and forced outages;

Power consumption rate: Determined according to the specific conditions of the project or determined with reference to the statistical analysis of similar projects;

Power grid loss rate: Determined according to the actual comprehensive grid loss rate of the grid in the most recent year, with due consideration to factors such as improving management and reducing grid loss during the construction period.

6.3 The calculated tariff for financial evaluation shall be based on the prevailing market price or the estimated tariff that satisfies the conditions for loan repayment. The calculated tariff for economic cost benefit evaluation shall be the average on-grid tariff or the comprehensive tariff.

6.4 If the simplified calculation method is allowed, effective power generation may be estimated using the Formula (2), and the effective power coefficient may be selected from Table 1.

Effective power generation = Design generating capacity × Effective power coefficient ……(2)

Table 1 Effective power coefficients for different types of power stations

Power station type	Effective power coefficient
Annual or multi-year regulated grid-connected power station	0.95～1.00
Quarterly regulated grid-connected power station	0.90～0.95
Monthly, weekly and daily regulated or unregulated grid-connected power station	0.85～0.90
Daily regulated and unregulated power station operating independently	0.70～0.85

6.5 The comprehensive operating revenue of the project shall be analysed and calculated on the principle that the input and output use the same parameters.

7 Economic cost benefit evaluation

7.1 The economic cost benefit evaluation for the project shall be based on indicators such as economic internal rate of return (EIRR), economic net present value (ENPV) and economic benefit-to-cost ratio (R_{BC}).

7.2 The basic statement for the economic cost benefit evaluation is the cost-benefit flow statement of the project investment (Table A.1), in which economic investment benefit flow and cost flow are used to calculate EIRR, ENPV and R_{BC}.

7.3 The calculation of various benefits and expenditures in the economic cost benefit evaluation shall be based on the computed financial evaluation and adjusted according to the difference from the current price. For the investment part, the total investment shall be adjusted first, and then the investment for different years shall be adjusted with the same factor as the total investment. During the design stage, separate adjustments may be made according to the actual situation. The annual operating costs may also be adjusted accordingly.

7.4 The calculation of power generation revenue in the economic cost benefit evaluation shall follow the principle of "pricing by quality", and different tariff shall be calculated for different periods and time periods.

7.5 EIRR is the discount rate at which the present value of the economic net benefit flow is cumulatively equal to zero during the calculation period. It is calculated using the Formula (3).

$$\sum_{t=1}^{n} (B - C)_t (1 + EIRR)^{-t} = 0 \qquad \cdots\cdots (3)$$

where

B is the inflow of economic benefits, in the currency unit;

C is the outflow of economic cost, in the currency unit;

n is the calculation period;

t is the serial number of each year in the calculation period, and the serial number of the base-year taken as 1;

$(B - C)t$ is the economic benefit flow of the t-year, in the currency unit.

In the economic cost benefit evaluation, when the EIRR is greater than or equal to the social discount rate (i_S), it is considered that the economic cost benefit evaluation is feasible.

The social discount rate (i_S) of an SHP project is determined according to the actual level of development of the country, and is generally taken as 6%.

7.6 ENPV is the sum of the net benefit flows of all years in the calculation period converted to the present value at the beginning of the construction period at the social discount rate, and calculated using the Formula (4). The calculated net present value shall be greater than or equal to zero.

$$ENPV = \sum_{t=1}^{n} (B - C)_t (1 + i_S)^{-t} \quad \cdots\cdots (4)$$

where

i_S is the social discount rate.

7.7 R_{BC} is the ratio of the present value of the project benefit to the present value of the cost and is calculated using the Formula (5).

$$R_{BC} = \frac{\sum_{t=1}^{n} B_t (1 + i_S)^{-t}}{\sum_{t=1}^{n} C_t (1 + i_S)^{-t}} \quad \cdots\cdots (5)$$

where

R_{BC} is the benefit-to-cost ratio;

B_t is the benefit of the t-year;

C_t is the cost of the t-year.

The economic rationality of the project shall be determined according to the benefit-to-cost ratio. The project is economically justified when the benefit-to-cost ratio is greater than or equal to 1.0.

8 Financial evaluation

8.1 The financial evaluation of the project shall be carried out on the basis of project financial benefit and cost estimate, and shall comply with the following conditions:

a) Financial evaluation shall prepare financial statements, calculate financial indicators, analyse the profitability, solvency and financial feasibility of the project, and determine the financial viability of the project to provide a basis for project investment decision-making.

b) Financial evaluation may be divided into pre-financing evaluation and post-financing evaluation. The pre-financing evaluation shall be carried out first. If the pre-financing evaluation conclusion meets the requirements, a financing plan shall be developed initially, and the post-financial evaluation shall follow.

c) The pre-financing evaluation shall involve the calculation of dynamic indicators such as the IRR and the NPV of the investment, as well as indicators for the static-investment payback period in order to reflect the time required to recover the project investment.

d) The profitability analysis after financing shall include the financial IRR and financial NPV of the project investment, the financial IRR of the project capital, the investment recovery period, the total investment rate of return and the net profit rate of the project capital.

e) The solvency analysis shall be done by calculating indicators such as interest coverage ratio, debt service coverage ratio and asset-liability ratio.

f) In addition to calculating and evaluating the indicators above, technical and economic indicators such as unit kilowatt investment, unit energy investment and unit energy cost shall be calculated.

8.2 The basic statements used in the financial evaluation shall include the financial cash flow statement, the profit and loss statement, the statement of sources and application of funds, the statement of loan repayment and the balance sheet; these shall comply with the following conditions:

a) Financial cash flow statement reflects the annual cash receipts and payments for the project during the construction and operation period and is used to calculate dynamic and static appraisal indicators for project profit analysis. Specifically, it may be divided into the total investment financial cash flow statement (Table B.1) and the capital financial cash flow statement (Table B.2).

b) Profit and loss statement (Table B.3) is used to calculate the annual cost and profit, the income tax and the after-tax profit distribution of the construction project during the calculation period, as well as the investment profit rate, the investment profit-tax rate and the capital-profit rate.

c) Source and application of funds (Table B.4) is used to calculate the annual surplus or shortage of funds during the construction and operation period according to the financial conditions of the project in order to select a financing plan and develop a loan repayment plan.

d) Statement of loan repayment (Table B.5) is a specific loan repayment schedule depending on the repayment funding sources.

e) Balance sheet (Table B.6) reflects the increase or decrease of assets, liabilities and owners' equity of the construction project at the end of each year during the calculation period, to examine the structure of assets, liabilities and owners equity of the project; it is used to calculate indica-

tors such as asset-liability ratio and conduct solvency analysis.

8.3 The project profitability analysis shall include the following key indicators:

a) Financial Internal Rate of Return (FIRR) refers to the discount rate at which the present value of net cash flow is cumulatively equal to zero during the calculation period, expressed using the Formula (6). In the financial evaluation, when the FIRR is greater than or equal to the SHP benchmark financial rate of return (i_f), it is considered that the financial evaluation for the construction project is feasible. The FIRR for investment in the SHP project and the FIRR for project capital are both based on the Formula (6), but the cash inflow and the cash outflow are different. The benchmark financial rate of return (i_f) of the SHP project is determined according to the actual development level of the country; it is generally taken as 8% and should not less than the interest rate for bank loans.

$$\sum_{t=1}^{n} (CI - CO)_t (1 + FIRR)^{-t} = 0 \qquad \cdots\cdots (6)$$

where

CI is the cash inflow, in the currency unit;

CO is the cash outflow, in the currency unit;

n is the calculation period;

t is the serial number of each year of the calculation period; the serial number of the base-year is 1;

$(CI - CO)_t$ is the net cash flow for the t-year, in the currency unit.

b) Financial Net Present Value (FNPV) is the sum of net cash flows during the calculation period of the project at the discount rate set (which may be the benchmark financial rate of return i_f). It is calculated using the Formula (7). Under normal circumstances, the financial profitability evaluation only includes a calculation of the FNPV of the project investment, and the calculation of NPV before or after income tax as required. The project is considered financially feasible if the FNPV, calculated at the discount rate set, is greater than or equal to zero.

$$FNPV = \sum_{t=1}^{n} (CI - CO)_t (1 + i_f)^{-t} \qquad \cdots\cdots (7)$$

where

i_f is the discount rate set (which may be the benchmark financial rate of return).

c) Project investment payback period (P_t) is a period of time required to recover the project investment from net income, measured in years. The project investment payback period starts from the beginning year of the project construction and is calculated using the Formula (8). It may also be calculated by means of the project investment cash flow statement in which the timepoint when the accumulated net cash flow changes from negative value to zero is the investment payback period. In this case, it is calculated using the Formula (9). A short payback period indicates fast investment recovery and strong anti-risk potential for the project.

$$\sum_{t=1}^{Pt} (CI - CO)_t = 0 \qquad \cdots\cdots(8)$$

where

P_t is the investment payback period, in years.

$$P_t = T - 1 + \frac{\left| \sum_{i=1}^{T-1} (CI - CO)_i \right|}{(CI - CO)_T} \qquad \cdots\cdots(9)$$

where

T is the number of years when the accumulated net cash flow of all years is positive or zero for the first time, in years.

d) Return on Investment (ROI) indicates the return or the profitability of the total investment, which is the ratio of the annual earnings before interest and tax (EBIT) in a normal year after the project reaches the design capacity or the annual average EBIT during the operation period to the total investment (TI). It is calculated according to the Formula (10).

$$ROI = \frac{EBIT}{TI} \times 100\% \qquad \cdots\cdots(10)$$

where

EBIT is the annual earnings before interest and taxes in a normal year or annual average earnings before interest and taxes during the operation period of the project, in the currency unit;

TI is the total investment of the project, in the currency unit.

e) Return on Equity (ROE) indicates the profit level of the project capital, which is the ratio of the annual net profit in a normal year after the project reaches the design capacity or the annual average net profit (NP) during the operation period to the economic capital (EC). The ratio is cal-

culated according to the Formula (11). When the ROE of the economic capital is higher than the reference ROE in the same industry, it indicates that the profitability expressed by the ROE of the economic capital meets the requirements.

$$ROE = \frac{NP}{EC} \times 100\% \qquad \cdots\cdots (11)$$

where

NP is the annual net profit in a normal year or annual average net profit during the operation period of the project, in the currency unit;

EC is the economic capital of the project, in the currency unit.

8.4 The project solvency analysis shall include the following key indicators:

a) Interest Coverage Ratio (ICR) is the ratio of EBIT for each year in the loan repayment period to the payable interest (PI) for that year. It is calculated using the Formula (12). A high ICR indicates a high guarantee level of interest payment. The ICR shall be greater than 1 and determined in conjunction with the creditor's request.

$$ICR = \frac{EBIT}{PI} \qquad \cdots\cdots (12)$$

where

EBIT is the earnings before interest and taxes, in the currency unit;

PI is the payable interest charged to cost, in the currency unit.

b) Debt Service Coverage Ratio (DSCR) is the ratio of the funds used to repay the principal and interest of all years in the loan repayment period (EBITDA-T_{AX}) to the amount of the principal and interest payable (PC) for that year. It is calculated using the Formula (13). If the project involves a renovation cost during the operation period, it shall be deducted from the fund available for repayment of principal and interest. The DSCR shall be greater than 1 and determined in conjunction with the creditor's request.

$$DSCR = \frac{EBITDA - T_{AX}}{PC} \qquad \cdots\cdots (13)$$

where

EBITDA is the earnings before interest and taxes plus depreciation and amortization;

T_{AX} is the Income tax, in the currency unit;

PC is the amount of the principal and interest payable, including the principal amount and all interest included in the total cost. The short-term loan principal and interest during the operation period shall also be included in the calculation.

c) Liability on Asset Ratio (LOAR) is the ratio of total liabilities to total assets at the end of each period. It is calculated using the Formula (14).

$$LOAR = \frac{TL}{TA} \times 100\% \qquad \cdots\cdots(14)$$

where

TL is the total liabilities at the end of period, in the currency unit;

TA is the total assets at the end of period, in the currency unit.

9 Uncertainty analysis

9.1 The economic appraisal of the project shall make an uncertainty analysis, including sensitivity analysis and break-even analysis.

9.2 Sensitivity analysis of SHP projects only analyses the impact of single factor (investment, return, construction period, etc.) changes on IRR. Sensitive factors vary between ±(10%～20%).

9.3 Break-even analysis shall analyse the balance between project cost and income by calculating the break-even point in a production year, and judge the adaptability and risk-resistance ability of project to income changes. The break-even analysis is used for financial analysis only. The break-even point (BEP) shall be calculated by using the Formulas (15) to (17) or the break-even chart.

$$BEP_{\text{Production capacity rate}} = \frac{\text{Annual fixed cost}}{(\text{Annual operating income} - \text{Annual variable cost} - \text{Annual sales tax and surcharge})} \times 100\% \qquad \cdots\cdots(15)$$

$$BEP_{\text{Production}} = \frac{\text{Annual total fixed cost}}{(\text{Unit product price} - \text{Unit product va riable cost} - \text{Unit product sales tax and surcharge})} \times 100\% \qquad \cdots\cdots(16)$$

$$BEP_{\text{Product selling price}} = \left(\frac{\text{Annual total fixed cost}}{\text{Design production capacity}} + \text{Unit product variable cost} + \text{Unit product sales tax and surcharge} \times 100\% \right. \qquad \cdots\cdots(17)$$

10 Methods of scheme comparison

10.1 Various schemes shall be screened out, and the selected ones shall be economically evaluated for decision-making. The comparison of schemes may be done through economic cost benefit evaluation.

10.2 The scheme comparison shall guarantee the comparability of all the schemes. In the comparison, the total inputs and outputs of each scheme may be comprehensively compared; or relative differences may be calculated, based on the different factors that influence the choice of the scheme for local comparison.

10.3 The scheme comparison should employ the NPV comparison method or the IRR on differential investment comparison method, and shall meet the following requirements:

a) NPV comparison method is to compare the NPV of the alternative options, and select the candidate project with the largest NPV. The same discount rate shall be used in NPV comparison.

b) Differential investment IRR comparison method is to calculate the differential investment IRR of the alternative options, that is, the discount rate at which the sum of the present value of the net cash flow differences between any two proposals is equal to zero. It is calculated using the Formula (18). If the differential investment IRR (ΔIRR) is greater than or equal to the social discount rate (i_S), the proposal with a larger investment shall be selected; otherwise, the one with a smaller investment shall be selected.

$$\sum_{t=1}^{n} [(B-C)_2 - (B-C)_1]_t (1+\Delta IRR)^{-t} = 0 \quad \cdots\cdots\cdots\cdots\cdots\cdots (18)$$

where

$(B-C)_1$ is the annual net benefit flow of the proposal with a smaller investment, in the currency unit;

$(B-C)_2$ is the annual net benefit flow of the proposal with a larger investment, in the currency unit;

ΔIRR is the differential investment internal rate of return.

10.4 The comparison of proposals shall not only involve calculation of economic appraisal indicators, but also involve quantitative and qualitative analysis of social and environmental benefits.

Appendix A
（Normative）
Economic cost-benefit evaluation form

Table A.1 Economic cost-benefit flow statement for project investment Unit：*

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Benefit flow							
1.1	Direct benefit							
1.2	Residual value of recycled fixed assets							
1.3	Recycled current capital							
1.4	Indirect benefit of project							
2	Cost flow							
2.1	Fixed asset investment							
2.2	Current capital							
2.3	Annual operating cost							
2.4	Renovation cost							
2.5	Indirect expenses of project							
3	Net benefit flow							
4	Cumulative net benefit flow							

NOTE 1 Evaluation indicators：Economic internal rate of return EIRR（%）
Economic net present value ENPV（i_s = %）
Economic benefit-to-cost ratio R_{BC}（i_s = %）
NOTE 2 “*” indicates the currency unit

Appendix B
（Normative）
Financial evaluation form

Table B.1 Total investment financial cash flow statement

Unit：*

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Cash inflow							
1.1	Operating income							
1.2	Residual value of recycled fixed assets							
1.3	Recycled working capital							
1.4	Subsidy income							
2	Cash outflow							
2.1	Fixed asset investment							
2.2	Current capital							
2.3	Annual operating cost							
2.4	Sales tax and surcharge							
2.5	Renovation investment							
3	Net cash flow before income tax							
4	Net cash flow before accrued income tax							
5	Adjusted income tax							
6	Net cash flow after income tax							
7	Net cash flow after accrued income tax							

NOTE 1 Calculated indicators：Before income tax，After income tax
Total financial internal rate of return FIRR（%）
Total financial net present value FNPV（i_f = %）
Total investment payback period（years）

NOTE 2 “*”indicates the currency unit

Table B.2 Capital financial cash flow statement

Unit: *

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Cash inflow							
1.1	Operating income							
1.2	Residual value of recycled fixed assets							
1.3	Recycled current capital							
1.4	Subsidy income							
2	Cash outflow							
2.1	Project capital							
2.2	Loan principal repayment							
2.3	Loan interest payment							
2.4	Annual operating cost							
2.5	Sales tax and surcharge							
2.6	Income tax							
2.7	Renovation investment							
3	Net cash flow							

NOTE 1 Calculated indicator: capital financial internal rate of return (%)

NOTE 2 "*" indicates the currency unit

Table B.3 Profit and loss statement (cost-profit statement)

Unit: *

No.	Item	Operation period			Total
			$n-1$	n	
1	Sales revenue				
1.1	Including: power generation revenue				
2	Sales tax and surcharge				
3	Total cost				
3.1	Including: operating cost				
4	Total profit				
5	Income tax				
6	Net profit				
7	Surplus accumulation fund				
8	Profit available for distribution				
9	Profit distribution				
10	Undistributed profit				

NOTE "*" indicates the currency unit

Table B.4 Source and application of funds

Unit: *

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Fund source							
1.1	Sales profit							
1.2	Depreciation expense							
1.3	Amortization expense							
1.4	Fund for fixed-asset investment							
1.4.1	Self-funding							
1.4.2	Superior grant							
1.4.3	Bank loan							
1.5	Residual value of recycled fixed assets							
2	Fund application							
2.1	Investment in fixed assets							
2.2	Loan interest during construction period							
2.3	Income tax							
2.4	Payable profit							
2.5	Withdrawal of public accumulation fund							
2.6	Loan principal repayment							
3	Surplus fund							
4	Accumulated surplus fund							

NOTE "*" indicates the currency unit

Table B.5 Statement of loan repayment

Unit: *

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Loan repayment							
1.1	Outstanding balance of borrowing at the beginning of the year							
1.1.1	Principal							
1.1.2	Interest							
1.2	Borrowing in the year							
1.3	Accrued interest in the year							
1.4	Principal and interest repayment in the year							

Table B.5 .7（*continued*） Unit：*

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1.4.1	Including：principal repayment							
1.4.2	Interest payment							
2	Source of repayment fund							
2.1	Undistributed profit							
2.2	Depreciation expense							
2.3	Amortization expense							
2.4	Interest expense charged to cost							
2.5	Other funds							
NOTE “*”indicates the currency unit								

Table B.6 Balance sheet Unit：*

No.	Item	Construction period			Operation period			Total
		1	2			$n-1$	n	
1	Assets							
1.1	Total current assets							
1.1.1	Current assets							
1.1.2	Accumulated surplus fund							
1.2	Construction in progress							
1.3	Net value of fixed assets							
2	Liabilities and owners’ equity							
2.1	Total current liabilities							
2.2	Construction investment loan							
2.3	Current fund loan							
2.4	Subtotal of liabilities							
2.5	Owners，equity							
2.5.1	Capital fund							
2.5.2	Capital reserve							
2.5.3	Accumulated surplus accumulation fund							
2.5.4	Accumulated undistributed profit							
	Liability on asset ratio（%）							
NOTE “*”indicates the currency unit								