Preliminary Estimate of the Cost of a Mini/Micro Hydropower Installation

6

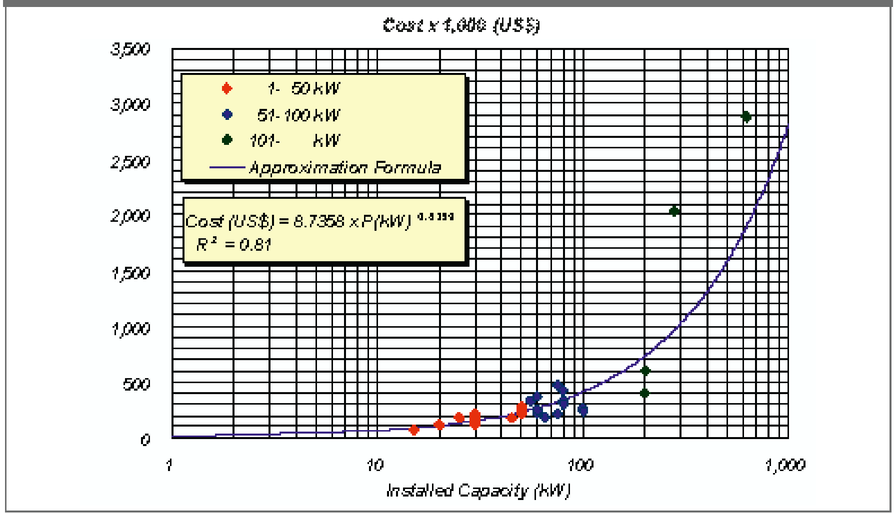
6.1 Installation and Generation Costs for a Mini/Micro Hydropower Unit

6.1.1 Cost of Civil Engineering Work

Figure 65 shows the relation between the cost of hydropower station and installed capacity (kW).

The cost includes the cost of turbine and generator but does not include the cost of transportation and construction cost of access road.

FIGURE 65. COST OF MINI/MICRO HYDROPOWER (INCLUDING TURBINE AND GENERATOR)



Source: JICA, The master plan study on rural electrification by renewable energy in the republic of Peru, 2008

6.1.2 Cost of Electromechanical Equipment

Table 19.20. Reference costs for electromechanical equipmente for mini and micro hydropower installations (US$)

TABLE 19. REFERENCE COSTS FOR ELECTROMECHANICAL EQUIPMENT FOR MINI AND MICRO HYDROPOWER INSTALLATIONS (US$)

kW	With Pelton turbine	With Cross Flow turbine	With Francis turbine	With Kaplan turbine
10	10.000	9.500		13.000
12	10.500	9.975		13.650
15	11.500	10.925		14.950
20	13.000	12.350		16.900
25	15.000	14.250		19.500
30	16.500	15.675		21.450
40	21.000	19.950		27.300
50	26.000	24.700		33.800
60	29.000	27.550		37.700
75	33.000	31.350	37.950	42.900
90	35.000	33.250	40.250	45.500
100	38.000	36.100	43.700	53.200
125	41.000	38.950	47.150	57.400
150	53.000	50.350	60.950	74.200
200	71.000	67.450	81.650	99.400
250	85.000		97.750	119.000
300	98.000		112.700	137.200
400	120.000		138.000	168.000
500	140.000		161.000	196.000

6.1.3 Costs of Transport and Erection of Electromechanical Equipment

TABLE 20. REFERENCE COST OF TRANSPORT AND ERECTION OF ELECTROMECHANICAL EQUIPMENT (US$)

kW	Packing and transport	Erection
10	500	800
12	600	1.000
15	900	2.000
20	1.000	2.500
25	1.100	3.000
30	1.300	3.000
40	1.500	3.500
50	1.600	3.500
60	1.600	3.500
75	1.800	3.500
90	2.000	4.000
100	2.100	4.000
125	2.600	4.200
150	3.000	4.500
200	3.900	5.000
250	5.000	6.000
300	6.000	7.000
400	8.000	9.000
500	10.000	11.000

6.2 Costs of Overhead Transmission Line

6.2.1 General Points

The investment costs associated with the acquisition and installation of generating systems, transmission and distribution lines, transformers, insulators and, in general, everything involved in the building of an electricity supply system.

The operation and maintenance costs are the result of operating each system. These include the cost of generating and conveying energy and power.

The administrative costs incurred by the company in operating each system include meter reading, invoicing, distribution of bills and collecting payment.

6.2.2 Electrical Distribution System

Determining the voltage and cross section of the conductor as a function of distance or the length of the electrical distribution system, as well as the power to be carried, using technical considerations established during the process of determining the technical characteristics of the mini or micro hydropower generating plant.

Considering that the output of a mini or micro hydropower unit is less than 500 kW, the recommended conductor cross section is generally 25 mm2 made of AAAC aluminium alloy, as this is more economical and meets the required technical standards.

Posts shall be of treated timber 12 m long, cross pieces of treated timber, horizontal insulators of class 56-3 porcelain and suspension insulators of class 53-2 porcelain. Depending on the type of construction used in the transmission line, the following estimated costs apply.

6.2.3 Investment in Rural Electrification

These indicators represent a reference for the costs of investment in conventional electricity systems and can be used in the profile phase of rural electrification projects to quantify the investment required.

Although the evaluation of such projects also require social and financial indicators, the investment indicators are important tools for identifying opportunities for optimising the design and reducing costs, which increases the profitability of these projects.

TABLE 21. INVESTMENT INDICATORS

Indicator	Description	Average indicator
US$ / km - primary line	Investment in primary line per km (not including VAT)	US$ 6.200
US$ / connection - primary line (LP)	Investment in primary line per connection (not including VAT)	US$ 305
US$ / connection - primary network (RP)	Investment primary network per connection (not including VAT)	US$ 85
US$ / connection – secondary network (RS)	Investment secondary network (not including VAT)	US$ 250
US$ / connection - (LP + RP + RS)	Total investment per connection (not including VAT)	US$ 640
US$ / connection	Investment per domestic connection (connection and meter, not including VAT)	US$ 89
KVA (MT-BT) / connection BT	Installed power in distribution substations per connection	0,31 KVA
Inhabitants / connection	Number of inhabitants per connection	5,00

N.B. LP = primary line; RP = primary network; RS = secondary network; MT = medium tension; BT = low tension.

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Considering only the costs of investment in distribution systems — primary line, primary network, secondary network and domestic connection - 640 United States dollars are required for one rural electricity connection in Peru. On average, the investment cost per km of primary line is estimated at 6,200 United States dollars. Furthermore, the cost of investment per primary line connection is estimated at 305 United States dollars and for primary network at 85 United States dollars, whilst the cost per connection to the secondary network is 250 United States dollars. The installed kVA in the MT / BT distribution transformers represents the capacity for which the system was designed. On average, small electrical systems are designed to meet a simultaneous demand of 0.31 kVA (0.25 kW) per connection. The average number of inhabitants per connection is 5.0. Nevertheless, in smaller electrical systems this figure may be lower because of the greater number of communal buildings compared to inhabitants.

Operation and Maintenance 7

7.1. Organization

A hydropower plant has an advantage that it does not need fuel for its operation as compared with oil or thermal power plants. However, there are no differences between both type of plants on the proper application of operation and maintenance (O&M) activities that are essential for their long-term operation. A power plant can be operated for longer period if its facilities are properly operated and maintained. It is suggested, however, to effective utilize hydropower because aside from being an indigenous energy resource, it is also renewable.

We have to operate and maintain micro-hydropower plants with strict compliance to the operation and maintenance manuals. In general, operators of micro hydropower plants should be trained to understand the following.

(1) Operators must efficiently conduct operation and maintenance of the micro-hydropower plant with strict compliance with the O and M rules and regulations.

(2) Operators must familiarize themselves with all the plant components and their respective performance or functions. Furthermore, they should also be familiar to measures against various accidents for prompt recovery.

(3) Operators must always check conditions of facilities and equipment. When they find some troubles or accidents, they must inform the person in charge and try to recover it.

(4) Operators must try to prevent any accidents. For the purpose, they should repair or improve facilities preventively as necessary.

Operation and maintenance manual should basically be prepared for each plant individually before the start of its operation. Following is the general manual of operation and maintenance for micro hydropower plants.

7.2. Operation

The operation of micro-hydropower plants is not only to generate electric power but also to control generation equipment and to supply electricity of stable quantity and quality to consumers and maintaining all facilities in good condition.

The micro-hydropower plant facilities and equipment were installed depending on site conditions and budget, but there are various ways of proper operation for these plant always have to control the equipment except in case of starting, stopping and during emergency cases. And in case automatic stopping and recording systems are installed, it is not necessary for operators to stay in the power plant most of the time.

However, most of micro-hydro plants for rural electrification are not provided with automatic control system and protection equipment because of budget limitation. In this case, it is necessary for operators to stay at or near the plant to monitor control equipment and to undertake immediate measures in case of emergency, in the observance of proper operation practice.

General ways of micro-hydro operations are as follows:

7.2.1. Basic Operation

(1) Check points before starting operation

Before starting operation of the power plant, operators must check the following facilities are in good condition for operation. Especially in the case of after long term operation, they should be checked thoroughly.

- Transmission and distribution line
  - ✔ Damages of lines and poles
  - ✔ Approaching branches
  - ✔ Other obstacles
  - ✔ Waterway facilities
  - ✔ Damages of structures
  - ✔ San sedimentation in front of the intake
  - ✔ Suspended trash at screens
  - ✔ San sedimentation in the settling basin and the forebay
- Turbine, generator and controller
  - ✔ Visual inspection
  - ✔ Wear of brush
  - ✔ Insulation resistance of circuits

(2) Starting operation

After checking the tubine and generator are okay for operation.

Procedure of starting operation is as follows:

(Preparation)

- Close the flushing gate of the intake weir
- Open the intake gate and intake water into the waterway system

(Starting operation)

- Open the inlet valve gradually
- If there is a guide vane, open the inlet valve fully, and then open the guide vane gradually
- Confirm that voltage and frequency or rotating speed increase up to the regulated value
- Turn the load switch on (parallel in)
- Control inlet valve or guide vane so that voltage and frequency are within the regulated range

(3) Role of operators during operation

Operators must control equipment in order to supply electricity of good quality keeping equipment normal and safe as follows:

- Control the inlet valve or guide vane so that voltage and frequency are within the regulated range
- Check vibration and noise of equipment, and then stop operation if necessary
- Check temperature of equipment
- Check any abnormal condition of equipment, and then stop operation and take a measure if necessary
- Record result of operation and condition of equipment according to fixed format

(4) Stopping operation

In order to avoid longer runaway speed of the turbine and the generator, the procedure of stopping operation is as follows:

- Close the inlet valve or the guide vane
- Cut load switch off (load rejection)
- Close the inlet valve and the guide vane completely
- Close the intake gate

When load is suddenly cut due to an accident, operator must close the inlet valve or the guide vane immediately to avoid runaway speed of the turbine and the generator for long time.

7.2.2. In Case of Emergency

(1) In case of flood

In general, micro hydropower plants can be operated even in the case of flood, however, when the river becomes muddy and if there is possibility that sand and soil will enter into the facilities, operation of the plant should be stopped by closing the intake gate. After flood, operators must inspect all facilities first prior to resumption of operation.

(2) In case of earthquake

Since an earthquake affects all facilities of plants, operators must inspect facilities after a big earthquake as follows:

- Check damages of structures
- Misalignment of the shaft of the turbine and the generator
- Damages of other electrical equipment
- Others.

(3) In case of shortage of water

There is a applicable range of water discharge for each turbine. Therefore, a turbine should be operated within the range.

Micro hydropower plant should basically be designed along water discharge in the dry season. However, in case of shortage of water that is beyond of our expectations, operators must stop operation because continuous operation under such condition will damage the turbine.

(4) In case of accident

In case of accident, operators must stop operation, investigate the cause and try to recover operation as soon as possible. Operator's roles are as follows:

- Immediately inform the accident to the person in charge
- Investigate accident in detail
- Look into the causes of accident
- Recover operation as soon as possible if operators can prove the causes and repair by themselves
- Contact makers or suppliers of equipment and request them to repair if the operators cannot find the causes and cannot repair by themselves

What operators should prepare in advance are as follows:

- Discuss with maker or supplier of equipment on possible measures in case of equipment trouble
- Present to the company administering a report on the management of the cost of recovery

- Inform the company administering regarding the accident

7.2.3. Others

(1) Filling water in waterway system

Procedure of filling water into the waterway system is as follows:

- Confirm all flushing gates and valve of the water system are open
- Open the intake gate partially, and intake small volume of water
- Close the flushing gate of the settling basin after cleaning the settling basin
- Close the flushing gate of the forebay after cleaning the headrace and the forebay
- Close the drain valve of the penstock after cleaning the penstock
- Fill the penstock with water gradually
- Open the intake gate fully after filling up the penstock

(2) Flushing sand in front of intake

If sand sedimentation reaches the intake level, sand will be carried into waterway system and it will affect the penstock and turbine blades. Therefore, in order to prepare against outflow of sand and soil during flooding, operators must keep the intake approach open. For the purpose, operators should sometimes flush or remove sand that settled in front of intake.

If flushing gate is installed at the intake weir, operators can flush sand out by water flow opening the gate during flooding. However, incase of having no flushing gate, operators must remove sand out of the weir manually.

(3) Control of intake water

Volume of intake water changes according to water level of river. Normally excess water should be spilled out at spillway, which is located at settling basin or headrace. If the excess water reaches the spillway of the forebay for long time, it may possibly wash out the structure due to lack of spillway capacity. Therefore, operators must control the intake gate so as avoid too much water spill.

7.3. Maintenance

In order to operate micro hydropower plants in good condition for long period, waterway facilities, electric equipment, transmission and distribution line should be maintained adequately. Operators must try to observe even a small trouble and prevent accident of facilities. For the purpose, daily patrol and periodic inspection are essential and recording and keeping of those data are also important.

Though items and frequency of patrol and inspection should be decided considering condition of facilities and ways of use, general maintenance of micro hydropower plants is as follows:

7.3.1. Daily Patrol

In order to check if there is anything strange at waterway facilities, electric equipment, transmission and distribution line, operators daily conduct patrol along the course that has been fixed in advance. Operators must record result of patrol and take a measure if necessary.

Items of daily patrol are as follows:

Facilities and Equipment	Checking Point	Measures
Intake and Waterway	Suspended Trash at screen	To remove it at any time
	Water leakage from weir and gate	To record it To repair it if necessary
	Sand sedimentation	To flush it out as necessary
	Deformation or Crack in structure	To record it To repair it if necessary
Sedimentation Basin	Sand sedimentation	To flush it out as necessary
Facilities and Equipment	Checking Points	Measures
Headrace	Suspended materials along canal	To remove it at any time
	Sand sedimentation	To flush it out as necessary
	Leakage, deformation and Crack in structure	To record it To repair it if necessary
	Land slide along headrace	To remove sand and rocks after confirming safety
Headtank	Suspended Trash at screen	To remove it at any time
	Overflow from Spillway	To reduce water intaken if overlowing water is too much.
	Water leakage	To record it To repair it if necessary
	Sand sedimentation	To flush it out as necessary
	Deformation or Crack in structure	To record it To repair it if necessary
Penstock	Leakage and deformation	To record it
Turbine	Strange sound and vibration	To record it To check the causes of it
Generator	Strange sound and vibration	To record it To check the causes of it
	Temperature	To record it
	Damage of belt	To replace if necessary
Load stabilizer	Performance of load stabilizer	To check the performance
	Damage of heater	To replace if necessary
Transformer	Leakage of oil	To replace if necessary
Transmission and Distribution line	Suspended material	To remove after stopping the operation
	Approaching branch	To cut it as necessary

7.3.2 Periodic Inspection

Operators must conduct inspection periodically to check if there are any troubles in facilities and equipment. Operators, preferably, should be able to perform repair works in case there are troubles during inspection, if necessary.

Items and frequency of periodic inspection are as follows:

Facilities and Equipment	Checking Points	Frequency	Measures
Intake – Penstock and Tailrace	Leakage, deformation and Crack in structure	6 months	To record it
	Deformation or Crack in structure	6 months	To record it
Turbine	Supply grease to bearing	6 months	
	To replace bearing	3 years	
	Bolt connection	1 year	To fix them
Generator	Supply grease to bearing	6 months	
	To replace bearing	3 years	
	Winding insulation resistance	6 months	To replace generator
	Bolt connection	1 year	To fix them
	Damage of belt	6 months	To replace if necessary
Load stabilizer	Performance of load stabilizer	6 months	To replace if necessary
Inlet valve	Leakage	1 year	To replace if necessary
Transformer	Leakage of oil	1 month	To replace if necessary
Transmission and Distribution Line	Approaching branch	1 month	To cut it as necessary

7.3.3 Special Inspection

In case of earthquake, flood, heavy rain and accident, operators must stop operation and inspect facilities.

7.4 Recording

Operators must keep a record of the operation and maintenance of the micro-hydropower plant. Records will provide much help to operators in monitoring the conduct of the regular or scheduled activities for the operation and maintenance.

It also provides good data in determining the causes of trouble in case of accident.

A sample of operation record and daily patrol check sheet is shown in the next page.

Check Sheet

Civil Construction

Month: ____________________ Year: ____________________

N°	Description	Daily Checking																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
I	Dam																															
1	Construction																															
2	Stop Log																															
II	Settling Basin																															
1	Construction																															
2	Stop Log																															
IV	Forebay tank																															
1	Construction																															
2	Screen																															
V	Penstock																															
1	Penstock																															
2	Foundation																															
VI	Power House																															
1	Construction																															
2	Sanitation																															
VII	Tailrace																															
1	Construction																															
Damage Note																																
Cause of Damage																																
Repairing Note																																
Repaired by																																

Remarks: Fill the column as the actual condition such as: (N) Normal, (B) Bad, (R) Broken

Acknowledge Checker

_______________ _______________

Chairman Operator

Check Sheet

Mechanical and electrical

Month: ________________ Year: ________________

N°	Description	Daily Checking																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
I	Turbine																															
1	Runner																															
2	Bearing turbine																															
3	Plummer Block Bearing																															
4	Pull Turbine																															
5	Cover pulley																															
6	Coupling																															
II	Panel control																															
1	Meter																															
2	Lightning rod																															
3	Ballast Load																															
4	Main Board																															
Damage Note																																
Cause of Damage																																
Repairing Note																																
Repaired by																																

Remarks: Fill the column as the actual condition such as: (N) Normal. (B) Bad. (R) Broken

Acknowledge　　　　Checker

________________　　　　________________

Chairman　　　　Operator

LOG BOOK

Date	Time		Operation		Opening of Guidevane %	Frequency meter (Hz)	Volt			Ampere			Watt			Output Total	Remarks
	Start	Stop	Hour	Day			R-N(V1	S-N(V2	T-N(V3)	A1	A2	A3	V1xA1	V2xA2	V3xA3	Watt	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
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29																	
30																	
31																	

Note: Fill the column after installation to the house

Calculation of power output = (A1+A2+A3) x 220 on condition ballast 0 (zero) volt

Economic and Financial Evaluation 8

8.1. Introduction

The objective of this chapter is to provide basic guidelines for an economic financial analysis of a specific investment project – Micro Hydroelectric Power Plants (MHPP).

As in all projects, the purpose of this analysis is to guide the decision regarding whether or not the project should be implemented.

To conduct the evaluation, various criteria must be used to identify the advantages and disadvantages that would be obtained by making the investment. These criteria are profit indicators whereby the potential profitability of a project can be determined, based on the estimated cash flow. In order to obtain a more consistent idea of a project's profit potential so that an accurate decision can be taken, it is advisable to use various indicators. In this case, the Current Net Value (CNV), the Internal Rate of Return (IRR) and the Cost/Benefit Ratio (CBR) will be used.

In the specific case of Micro Hydroelectric Power Plants (MHPP) – which are usually implemented in isolated areas, consideration should also be given to the social role placed by the MHPP in improving the standard of living of the population, particularly as the driving force behind economic activities based on the productive use of electric power.

The Economic Evaluation of the project is based on the cash flow. Its purpose is to determine the profitability of the project itself, without including financing. It consists of identifying and valuing the costs and benefits created by the project throughout its life [1], so that a suggestion can be made regarding whether it is worth implementing the project or not.

On the other hand, the Financial Evaluation measures the profitability of the project, also taking financing into account, which means that apart from the return on the investment, loans and financial expenses must be paid. Only in the hypothetical case that the investor does not request any loan, the current economic value will be the same as the financial value.

From a Financial point of view, the estimated cash income and expenditure during the project's lifetime is evaluated. The decision to implement the project must be based on a cash flow that covers the servicing of the debt.

Given the nature of this kind of project, in many cases the social benefits anticipated (release of funds, more services available, more social activity, better productivity, etc.) will justify the implementation of the project. The State might even provide incentives or subsidise part of the project so that it can be implemented through local or regional governments. Within this context, the Social Evaluation of a project, which is usually conducted under the guidelines of the National Public Investment System (SNIP) [2] can determine the suitability of implementing a project, taking into consideration an economic evaluation at social prices [3].

It must be stressed that, when drawing up the Project Profile, the following should be considered first, or at least at the same time:

1 The estimated project life of a MHPP is usually 20 years.

2 The National Public Investment System (SNIP) is used in several Latin American countries.

3 Correction factors are used to adjust private prices, removing direct and indirect taxes; this is also applied to assets and manpower.

a) Technical Feasibility. This consists of determining whether the area in which the plant is to be implemented has the hydro power potential to cover the energy demand.

b) Legal Evaluation. This involves anticipating any service-management difficulties that may arise with respect to the ownership of the property in which the plant will be installed.

c) Institutional Evaluation. When a project is implemented with the participation of the community, it is important to incorporate community criteria in the evaluation process, both in terms of the institutional aspect and the potential impact on economic and financial aspects. More so if a municipality participates.

d) Environmental Impact Evaluation. Although water is the power generating source and therefore "clean energy" will be generated, the construction of the infrastructure (conveyance ditch, forebay tank, powerhouse, etc.) will create an impact on the environment, therefore measures to reduce that impact must be taken into consideration. An adequate environmental management tends to guarantee a long and efficient useful life of the construction work, conditioned by the environmental system it is immersed in (full reservoirs, sediment pressure, etc.).

e) Organization and Management Capacity. This is a very important aspect for an energy project administered by a group of producers or a municipality, as it will have a direct impact on the sustainability of the project.

8.2. Basic Concepts

Economic and financial indicators are used to evaluate the project, therefore it is necessary to remember a few economic and financial concepts, including intermediate terms:

Interest.- The price paid over a specific period for the use of borrowed capital, equivalent to the difference between the original capital received and the final amount returned.

Simple Interest.- In a simple interest operation, the capital generated by the interest remains constant throughout the duration of the operation.

Capital Gain.- This is the initial capital plus the interest generated regularly, usually on a monthly basis, which is finally added to the initial capital.

Compound Interest.- This takes capital gain into consideration and is the interest rate that financial entities work with.

Nominal Interest Rate.- A referential interest rate that does not take capital gain into account.

Effective Interest Rate.- The nominal interest plus capital gain. Financial entities use the Effective Annual Interest Rate, based on which they deduct the monthly interest rate.

Discount Rate.- This is the profit rate of the best investment alternative with the least risk conditions. Usually the average interest rate for fixed term deposits is used. For the practical case described below, 5% was used (taking the average passive interest rate in Peru of 4.41% as of March 2008).

Future Value.- The future value of capital K, with i as an effective annual interest for a period of n years, expressed by the following equation:

$$VF = K(1+i)^n$$

Where:

VF	=	Future value of the investment
K	=	Current value of the investment
i	=	Interest rate
n	=	Number of periods

Current Value.- Also referred to as Present Value, it is the current value of a future investment VF, i.e. the amount that must be allocated today at interest rate i for n years in order to obtain the VF amount, expressed as follows:

$$VA = \frac{K\,F}{(1+i)^n}$$

Where:

VA	=	Current value
VF	=	Future value
i	=	Interest rate
n	=	Number of periods

Current Net Value (CNV). Also referred to as Present Net Value (PNV), it is the current value of the net benefits generated by the project. It thus "measures, in today's currency, how much better off the investor will be by investing money in the project instead of in an activity in which the profit depends on the discount rate [4].

The discount rate applied to the CNV represents the Opportunity Cost, which is the profit the money would earn if it was invested in the best investment alternative.

Mathematically, the CNV is defined as the difference between the sum of the current value of the benefits and the sum of the current value of the costs, less the investment made during period zero, represented as follows:

$$VAN = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} - I_0 = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} - I_0$$

$$VAN = \sum_{t=0}^{n} \frac{BN_t}{(1+i)^t} - I_0$$

Where:

VAN	=	Current Net Value
B_t	=	Benefits of the period (t)
C_t	=	Costs of the period (t)
BN_t	=	Net benefits of the period (t)
i	=	Discount rate (interest rate or Opportunity Cost of capital)
I_0	=	Investment during period zero
n	=	Useful life of the project

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4 Discount Rate: Usually the weighted average of the capital to be invested, considering the best investment alternatives; in our case, 5% was considered.

When the value obtained is more than zero, it is advisable to make the investment.

Internal Rate of Return (IRR).- The internal rate of return is a percentage rate that indicates the average annual profit generated by the remaining capital invested in the project.

The IRR is the discount rate applied when the CNV is equivalent to zero.

An indicator of a worthwhile investment is when the IRR is higher than the discount rate.

Residual Value.- This is the value of the assets in the last year of the project's useful life. It is determined based on the depreciation of assets due to wear and tear during the project. In the case of a MHPP, some authors estimate a useful life of 50 years for the Civil Works and 30 years for the Electromechanical Equipment. In practice, the useful life varies depending on the type of infrastructure or equipment. As an example, the figures established by the Internal Tax Service for the energy sector in Chile may be referred to.

Asset	Useful life
Power generating equipment	10 years
Hydraulic civil works and others related to power generation - Intake weirs, reservoir walls - Forebay tanks, penstocks - Canals	 50 years 20 years 18 years

the other hand, in the Regulations of the Electricity Concessions Law, OSINERGMIN[5] considers 20 years for power generating equipment. In the case referred to herein, periods based on the practical experience were considered.

Cost/Benefit Ratio.- This is the ratio between the current value of income (benefits) and the current value of the project's costs (including the investment). A ratio higher than one indicates that the project is worthwhile.

In short, as a general rule an investment is worthwhile when the CNV is more than zero, the Cost/Benefit Ratio is more than one and the IRR is higher than the discount rate.

Correction Factors.- As far as this Handbook is concerned, this refers to the factors applied when a product is socially evaluated under the standards of the Peruvian State system SNIP. They are used to determine social prices, based on private prices and eliminating the effect of direct and indirect taxes, because they create distortions. These factors are pre-established by the Ministry of Economy and Finance:

Correction factor (Non-tradable assets[6]): $FC_{BNT} = \dfrac{1}{(1+0.19)}$ = 0.8403

Correction factor (Tradable assets[7]): $FC_{BT} = \dfrac{1.08}{(1+0.19)}$ = 0.9076

Optic Correction factor for skilled manpower : $FCmc = \dfrac{1}{1.15}$ = 0.8696

Correction factors for unskilled manpower:

Region	Urban	Rural
Metropolitan Lima	0.86	-
Rest of the coast	0.68	0.57
Highlands	0.60	0.41
Jungle	0.63	0.49

5 OSINERGMIN: The Organization Supervising Energy and Mining Investments in Peru.

6 Goods or services are non-tradable when their domestic price is determined by the domestic supply and demand. In order to calculate the social prices of non-tradable assets, market prices must be used, excluding all taxes and subsidies.

7 An importable or exportable asset is tradable when an increase in production that cannot be absorbed by the domestic demand is exported, or when an increase in the domestic demand that cannot be covered by the local production is imported.

In this case, the project is located in the rural jungle region; therefore, the following factors should be applied:

FC mc = 0.8696

FC nc = 0.49

Estimating social economic benefits – NRECA Methodology[8].

According to NRECA (1999), the demand for electricity can be divided into four categories: (a) lighting, (b) information (radio and television), (c) refrigeration and (d) all other uses. Experience shows the percentages used in households that obtain the electricity service.

Consumer categories in Peruvian households[9]

Demand category	% presence in electrified households		
	Coast	Highlands	Jungle
Lighting	100%	100%	100%
Radio and television	More than 50%	More than 50%	More than 50%
Refrigeration	15 to 50%	0%	15 to 50%

NRECA estimated the annual consumption and benefits obtained by rural dwellers in terms of lighting, radio, television, refrigeration and others. In the case of lighting, the economic benefits were estimated based on a World Bank methodology, whereas for radio, television and refrigeration, the estimates were based on the users "willingness to pay" when they use an alternative source of energy.

According to NRECA (May 1999), the economic benefits are a point of reference for quantifying, in monetary terms, the benefits for the country of a rural electrification project.

The economic benefits of a consumption of kWh in addition to lighting, radio, television and refrigeration, are valued at the current rate paid by the final user in the distribution system.

The following table shows the results obtained by NRECA in estimating the economic benefits based on field work in rural areas of Peru.

Region	Lighting	Radio and Television	Refrigeration	Per additional kWh
Highlands	120,5	60,48	0,00	Final rate
Jungle	154,8	57,96	138,84	Final rate
Coast	97,6	87,40	231,12	Final rate
Country	132,4	64,80	110,04	

Source: NRECA (1999).

Social Discount Rate (SDR).- This is the cost incurred by society when the public sector uses funds from the economy to finance its projects. It is established by the Ministry of Economy and Finance, supported by an up-to-date study. It is used to transform the future flows of a particular project's benefits and costs into a current value. A single discount rate is used to compare the current net value of public investment projects.

The Nominal Social Discount Rate is defined as the SDR adjusted by inflation. The Social Discount Rate is equivalent to 11%[10] and the Nominal Social Discount Rate is 14%.

If the project is evaluated at actual or constant prices, the Social Discount Rate should be used. If it is evaluated at nominal or current prices, the Nominal Social Discount Rate should be used.

8 NRECA, International, Ltd. – SETA "Overall Rural Electrification Strategy", 1999.

9 It is advisable to confirm these values with the places involved in the areas covered by the project.

10 According to RD N° 006-2006-EF-68.01, the SDR varied from 14% to 11%, and the Nominal Social Discount Rate from 17% to 14%.

8.3. Development of a Practical Case: Lambayeque MHPP – District: Chirinos – San Ignacio - Cajamarca – Peru

8.3.1. Beneficiaries

Direct beneficiaries : 280 local families

Indirect beneficiaries : 300 families from nearby areas

8.3.2. Owners

Owned by a town, supported by the district municipality.

8.3.3. Analysis of the Demand

Domestic demand : 56 kW

0.20 kW/family x 280 families = 56 kW

Public Lighting : 6.16 kW

88 mercury steam lamps x 0.070 kW = 6.16 kW

Institutional demand : 3.0 kW

The intention is to provide energy to two sites that are providing services to the population, including a school, a community building, a chapel and others to be built in the future. To this end, a consumption of 3.0 kW is estimated.

Industrial Demand : 9.0 kW

There is no such demand at present, however once the project is implemented it will create a captive demand for small-scale services for the local population and surrounding areas (battery-charging, coffee de-pulping, carpentry workshops, etc.). To this end, a demand of 9 kW is estimated.

Total Demand

Taking simultaneity and utilization factors into consideration, the following have been estimated:

Current maximum night-time demand : 39.56 kW.

Current maximum daytime demand : 18.64 kW.

Based on the current maximum demand, consider a 10% loss in transmission grids and a 2.5% increase within a 20 year period to obtain an estimated maximum demand of 71.30 kW. (See the table for details).

Demand		Demand Daytime			Demand Night		
Type	Quantity	F.S.[11]	F.U.[12]	D.M.[13]	F.S.	F.U.	D.M.
Domestic	56.00	0.40	0.50	11.20	0.80	0.70	31.36
Public Lighting	6.16	0.00	0.00	0.00	1.00	1.00	6.16
Institutional	3.00	0.70	0.80	1.68	0.40	0.50	0.60
Industrial	9.00	0.80	0.80	5.76	0.40	0.40	1.44
TOTAL	74.16			18.64			39.56

Maximun Demand Night: =39.56 kW x 1.10 x $(1.025)^{20}$ = 71.30 kW

8.3.4 Analysis of the Supply

Based on the technical evaluation, the MHPP could potentially generate 85 kW, which would cover the demand requirements.

8.3.5 Balance Between the Supply and the Demand

As there is no alternative electrification service in the area, the MHPP would have a captive demand from the families involved. For purely comparative purposes and in order to determine the "willingness to pay for electricity", it is worth evaluating the monthly expenses incurred by the population on alternative sources of energy: lighting (kerosene, candles and batteries), information and entertainment (batteries) and others (diesel).

8.3.6 Data for the Economic-Financial Evaluation

8.3.6.1 Investments and financing

The investment structure shown in Table 1 is based on the corresponding budget, duly drawn up by qualified experts who then determine the basic characteristics obtained in the field, the design of the MHPP with all its components: civil works, electromechanical equipment, powerhouse and transmission networks, including the administration of the service (management model). Obviously, all these characteristics vary depending on the area in which the project will be implemented.

Costs.- These are sub-divided into two groups: investment costs and operating and maintenance costs, which can be broken down as follows:

Investment costs.-

11 Simultaneity Factor: Refers to the percentage of electricity loads used simultaneously. Their value is estimated in accordance with the area.

12 Use Factor: also referred to as the demand factor: it is the average percentage of the allocated electricity load that users are expected to use.

13 Maximum Demand.

a) Fixed Assets.- Comprised of:

Civil Works.- Typically these could include

- Intake weir
- Conveyance Ditch
- Settling Basin
- Forebay Tank
- Penstock foundation
- Power house
- Discharge channel
- Complementary works

Electromechanical equipment.- which would typically include

- Penstock
- Turbine and electronic regulator
- Power generator and accessories
- Outlet Sub-station
- Primary Grid (Transmission Line)
- Secondary Grid (Distribution Sub-Station)

b) Intangible Assets.- Comprised of:

- Pre-Investment Studies
- Technical Advice and Supervision
- General Expenses
- Interest (if financing is involved)
- Management Model

Operating and Maintenance Costs.-

1. Operating Costs
    a. Personnel Expenses
    b. Lubricants and Grease
    c. Safety Equipment and Implements
    d. Office Materials
    e. Miscellaneous Expenses
2. Maintenance Costs
    a. Power generating, transformation and transmission materials and spares
    b. Tools
    c. Others

The total investment is US$ 196,490.00, of which 91.76% (US $ 180,300.00) will be financed and 8.24% (US $ 16,190.00) is the community's contribution in the form of manpower.

Table 1 details the project's investment structure. As can be appreciated, 86.51% corresponds to Tangible Assets (physical, palpable assets), which in our case are the civil works, penstock, electromechanical equipment and transmission networks. On the other hand, intangible assets (13.49%), which add value to the project, correspond to pre-operational expenses, with the exception of the management model which corresponds to the transfer of a business management package that is essential to guarantee the sustainability of the project over time.

TABLE 22. INVESTMENT STRUCTURE

ITEM		CONTRIBUTIONS (US$)		Total	%
		LOAN	POPU-LATION		
I. FIXED INVESTMENT					
1.1.	TANGIBLE ASSETS				
	Intake	21.000	6.300	27.300	13,89%
	Aqueduct canal	16.500	4.950	21.450	10,92%
	Head tank and settling basin	4.500	1.350	5.850	2,98%
	Pressure pipe and fittings	6.500	1.100	7.600	3,87%
	Anchorage and foundation	3.800	1.140	4.940	2,51%
	Powerhouse	4.500	1.350	5.850	2,98%
	Electromechánical equipment	70.000	0	70.000	35,63%
	Primary Electrical Network	9.000	0	9.000	4,58%
	Secundary Electrical Network and domiciliary connection	18.000	0	18.000	9,16%
	TOTAL TANGIBLE ASSETS	153.800	16.190	169.990	86,51%
1.2.	INTANGIBLE ASSETS				
	Mounting and starting	10.000	0	10.000	5,09%
	Operating expenses	5.000	0	5.000	2,54%
	Technical supervision	5.000	0	5.000	2,54%
	Managements methods	6.500	0	6.500	3,31%
	TOTAL INTANGIBLE ASSETS	26.500	0	26.500	13,49%
	TOTAL INVESTMENT	180.300	16.190	196.490	100,00%

Table 23 – Investment Structure – Private Prices and Social Prices: this was included for the purpose of illustrating the distortion caused by taxes sustaining the social profitability of many projects that would probably not be socially profitable privately. Tangible assets were affected by the correction factor that eliminates the General Sales Tax (IGV) from non-tradable materials. In the case of intangible assets, the skilled and unskilled labour required for the assembly were assumed to be 20% and 80% respectively, creating a weighted correction factor. Technical Supervision and the implementation of the management model are affected by the correction factor for skilled manpower.

TABLE 23. INVESTMENT STRUCTURE PRIVATE AND SOCIAL PRICES

ITEM		Private Prices	Correction factor	Social Prices
I. FIXED INVESTMENT				
1.1.	TANGIBLE ASSETS			
	Intake	27.300,00	0,8403	22.940,19
	Aqueduct canal	21.450,00	0,8403	18.024,44
	Head tank and settling basin	5.850,00	0,8403	4.915,76
	Pressure pipe and fittings	7.600,00	0,8403	6.386,28
	Anchorage and foundation	4.940,00	0,8403	4.151,08
	Powerhouse	5.850,00	0,8403	4.915,76
	Electromechanical equipment	70.000,00	0,8403	58.821,00
	Primary Electrical Network	9.000,00	0,8403	7.562,70
	Secondary Electrical Network and domiciliary connection	18.000,00	0,8403	15.125,40
	TOTAL TANGIBLE ASSETS	169.990,00		142.842,61
1.2.	INTANGIBLE ASSETS			
	Mounting and starting	10.000,00	0,56592	5.659,20
	Operating expenses	5.000,00	1,00000	5.000,00
	Technical supervision	5.000,00	0,8696	4.348,00
	Managements methods	6.500,00	0,8696	5.652,40
	TOTAL INTANGIBLE ASSETS	26.500,00	3,31	20.659,60
	TOTAL INVESTMENT	196.490,00	3,31	163.502,21

Table 24 refers to the financing structure, which is not applicable in the case of a SNIP project, based on the concept that the investment, regardless of the financing source, should be inverted in accordance with the provisions established by the SNIP.

TABLE 24. FINANCIAL STRUCTURE

ITEM	ENTRY	CONTRIBUTIONS (US$)		TOTAL
		LOAN	POPULATION	US$
I	I. CIVIL WORK	56.800,00	16.190,00	72.990,00
1,1	Intake	21.000,00	6.300,00	27.300,00
1,2	Aqueduct canal	16.500,00	4.950,00	21.450,00
1,3	Head tank and settling basin	4.500,00	1.350,00	5.850,00
1,4	0	-	-	-
1,5	0	-	-	-
1,6	Pressure pipe and fittings	6.500,00	1.100,00	7.600,00
1,7	Anchorage and foundation	3.800,00	1.140,00	4.940,00
1,8	Powerhouse	4.500,00	1.350,00	5.850,00
II	II. ELECTROMECHANICAL EQUIPMENT	80.000,00	-	80.000,00
2,1	Electromechanical equipment	70.000,00	-	70.000,00
2,2	Mounting and starting	10.000,00	-	10.000,00
III	III. ELECTRICAL NETWORK	27.000,00	-	27.000,00
3,1	Primary Electrical Network	9.000,00	-	9.000,00
3,2	Secundary Electrical Network and domiciliary connection	18.000,00	-	
	VI. PROJECT IMPLEMENTATION	16.500,00	-	
6,1	Operating expenses	5.000,00	-	
6,2	Technical supervision	5.000,00	-	
6,3	Managements methods	6.500,00	-	
	T O T A L	180.300,00	16.190,00	196.490,00
	FINANCIAL PERCENTAGE	91,76%	8,24%	100,00%

Financing Plan

Three basic components are considered in a Financing Plan: the interest rate (usually annual, e.g. 9% Annual Effective Rate), the payment method (monthly, quarterly or annual) and the term (in months or years, which could include periods of grace). In addition, particularly for long term loans, commissions, equal quotas, decreasing quotas, advance payments, etc. may be defined.

(See Table 25: Financing Plan)

Loan of US$180,300.00 at 9% AER, usable in two annual disbursements of US$ 56,800.00 and US$ 123,500.00 respectively. The loan is payable over 10 years with a period of grace of 2 years, when only interest rates are paid.

Table 25. FINANCING PLAN (in thousands of US$)

CONCEPT	YEARS											
	0	1	2	3	4	5	6	7	8	9	10	11
DISBURSEMENTS	56,8	123,5										
Committed balance	123,5											
SERVICING OF THE DEBT												
0.2% commitment fee		0,2										
1st Disbursement												
Interest		5,1	5,1	5,1	5,1	4,7	4,1	3,6	3,0	2,3	1,6	
Amortization		-	-	5,2	5,6	6,1	6,7	7,3	7,9	8,6	9,4	
Surplus Capital	56,8	56,8	56,8	51,7	46,0	39,9	33,3	26,0	18,1	9,4	-	
2nd Disbursement												
Interest			11,1	11,1	10,1	9,0	7,8	6,5	5,1	3,5	1,9	
Amortization		-	-	11,2	12,2	13,3	14,5	15,8	17,2	18,8	20,5	
Surplus Capital	0,0	123,5	123,5	112,3	100,1	86,8	72,3	56,5	39,3	20,5	-	
Total Interest and Commissions	-	5,4	16,2	16,2	15,2	13,7	12,0	10,1	8,1	5,9	3,5	-
Total Amortizations	-	-	-	16,3	17,8	19,4	21,2	23,1	25,1	27,4	30,0	-
TOTAL DEBT SERVICING		5,4	16,2	32,6	33,0	33,1	33,1	33,2	33,2	33,3	33,4	-
SURPLUS CAPITAL	56,8	180,3	180,3	164,0	146,2	126,7	105,6	82,5	57,4	30,0	-	-

8.3.6.2. Income and Expenditure Budget

In order to determine the project's payment capacity, constant income and expenditure throughout the project life was considered.

8.3.6.3. Income Budget

There will be no income during the first two years, as that is the MHPP construction and installation period. From year three, income will be obtained from the sale of energy at differential rates, depending on whether it is for domestic, industrial, institutional or commercial purposes (Table 26).

TABLE 26. INCOME BUDGET (thousands of US$)						
ITEMS	YEARS					
	1	2	3	4-5	6-10	11-20
Energy sales*	-	-	18,84	18,84	20,73	25,91
Productive use and special loads **	-	-	6,50	6,50	7,16	8,94
Municipal contribution (period of grace and operating costs)	5,36	16,23	17,03	17,03	8,00	-
TOTAL	5,36	16,23	42,37	42,37	35,88	34,85

* Domestic service to 252 homes, at a cost of S/.20.00 per home.

** 14 Special loads and productive uses: 28 users at S/.62.14. (Battery-charging, workshops, institutions, etc.)

Bearing in mind that there are no official reference rates for less than 100 kW of power, the proposed rate is based on the users' willingness to pay, depending on what they spend on alternative sources of energy like fuel, flashlight batteries, car batteries and candles. For the example, the monthly domestic rate is estimated at US$ 6.23 and the industrial/institutional/commercial rate at US$ 19.36.

The local municipality makes its contributions during the project's initial period until the tenth year when the financing period ends.

8.3.6.4 Monthly Expenditure Budget

The following have been estimated as operating costs:

Operating Costs: US$ 1,652.53 a year (Table 6)

TABLE 27. OPERATING COSTS		
ITEMS	YEARS	
	3-5	6-20
Direct manpower 1	1121,50	1121,50
Maintenance and repair services.	471,03	471,03
Cleaning materials and appliances	60,00	60,00
TOTAL	1.652,53	1.652,53

Administrative Expenses: US $ 17,080.00 a year, including the depreciation of fixed tangible assets and the amortization of intangible assets (Tables 28 and 29).

TABLE 28. DEPRECIATION AND AMORTIZATION OF INTANGIBLES				
ITEMS	**VALUE**	**USEFUL LIFER**	**RESIDUAL VALUE**	**DEPREC. &AMORT.**
Intake weir	21.000,00	20	1.050,00	1.050,00
Conveyance ditch	16.500,00	5	3.300,00	3.300,00
Forebay tank and settling basin	4.500,00	18	250,00	250,00
Piping and accessories	6.500,00	10	650,00	650,00
Anchors and foundation	3.800,00	10	380,00	380,00
Powerhouse	4.500,00	10	450,00	450,00
Electromechanical equipment	70.000,00	10	7.000,00	7.000,00
Electricity grids	27.000,00	20	1.350,00	1.350,00
Amortization of intangibles	26.500,00	10		2.650,00
TOTAL	180.300,00		14.430,00	17.080,00

TABLE 29. ADMINISTRATIVE EXPENSES			
ITEMS	**YEARS**		
		3-12	**13-20**
Office supplies	60,00	60,00	
Service administration and collection services. [14]	93,46	1.121,50	
Depreciation and amortization of intangibles	17.080,00		
TOTAL	17.233,46	1.181,50	

14 S/.300.00 was considered as a salary for the Administrator. (he works part-time)

8.3.7. Result of the Economic-Financial Evaluation

Results of the Economic-Financial Evaluation (Tables 30 and 31).

TABLE 30. ECONOMIC-FINANCIAL EVALUATION

Discount Rate = 5%

Years	Inves-tment Cost	O&M	Total Cost	Benefit	Economic Flow	Discount Factor	Current Value
0	-73.0	0.0	-73.0	0.0	-73.0	1.00000	-73
1	-123.5	0.0	-123.5	5.4	-118.1	1.05000	-113
2	0	-1.8	-1.8	16.2	14.4	1.10250	13
3	0	-1.8	-1.8	42.4	40.6	1.15763	35
4	0	-1.8	-1.8	42.4	40.6	1.21551	33
5	0	-1.8	-1.8	42.4	40.6	1.27628	32
6	0	-1.8	-1.8	35.9	34.1	1.34010	25
7	0	-1.8	-1.8	35.9	34.1	1.40710	24
8	0	-1.8	-1.8	35.9	34.1	1.47746	23
9	0	-1.8	-1.8	35.9	34.1	1.55133	22
10	0	-1.8	-1.8	35.9	34.1	1.62889	21
11	0	-1.8	-1.8	34.9	33.0	1.71034	19
12	0	-1.8	-1.8	34.9	33.0	1.79586	18
13	0	-1.8	-1.8	34.9	33.0	1.88565	18
14	0	-1.8	-1.8	34.9	33.0	1.97993	17
15	0	-1.8	-1.8	34.9	33.0	2.07893	16
16	0	-1.8	-1.8	34.9	33.0	2.18287	15
17	0	-1.8	-1.8	34.9	33.0	2.29202	14
18	0	-1.8	-1.8	34.9	33.0	2.40662	14
19	0	-1.8	-1.8	34.9	33.0	2.52695	13
20	0	-1.8	-1.8	34.9	33.0	2.65330	12
CURRENT NET ECONOMIC VALUE (CNEV)							200.0
Internal Rate of Return (Economic) (EIRR)							9.80%
Benefit/Cost Ratio (Economic)							3.74

Notes:

1) Revenues are seen since Year 1, by the contributions being made by the municipality.

2) These contributions economic affect the economic flow and financial flow, respectively.

Economic Evaluation

Current Net Economic Value (CNEV)	US $	200.0
Internal Economic Rate of Return (EIRR)		9.80%
Cost/Benefit Ratio		3.74 times the total investment

From an economic point of view, the investment indicators reflect the feasibility of implementing the project, because EIRR is greater than opportunity cost of capital (5%) and the CNEV is greater then zero.

TABLE 31. FINANCIAL EVALUATION

Discount Rate = 5%

Years	Operating Income	Opera-ting Cost	Principle Payment	Interest/ Comission	Financial Flow	Discount Factor	Current Value
0	-21.5	0.0	0.0	0.0	-21.5	1.00000	-21.5
1	5.4	0.0	0.0	5.4	0.0	1.05000	0.0
2	16.2	1.8	16.3	16.2	-18.1	1.10250	-16.5
3	42.4	1.8	17.8	16.2	6.5	1.15763	5.6
4	42.4	1.8	19.4	15.2	5.9	1.21551	4.9
5	42.4	1.8	21.2	13.7	5.7	1.27628	4.5
6	35.9	1.8	23.1	12.0	-0.9	1.34010	-0.7
7	35.9	1.8	25.1	10.1	-1.2	1.40710	-0.8
8	35.9	1.8	27.4	8.1	-1.4	1.47746	-1.0
9	35.9	1.8	30.0	5.9	-1.8	1.55133	-1.1
10	35.9	1.8	0.0	3.5	30.6	1.62889	18.8
11	34.9	1.8	0.0	0.0	33.0	1.71034	19.3
12	34.9	1.8	0.0	0.0	33.0	1.79586	18.4
13	34.9	1.8	0.0	0.0	33.0	1.88565	17.5
14	34.9	1.8	0.0	0.0	33.0	1.97993	16.7
15	34.9	1.8	0.0	0.0	33.0	2.07893	15.9
16	34.9	1.8	0.0	0.0	33.0	2.18287	15.1
17	34.9	1.8	0.0	0.0	33.0	2.29202	14.4
18	34.9	1.8	0.0	0.0	33.0	2.40662	13.7
19	34.9	1.8	0.0	0.0	33.0	2.52695	13.1
20	34.9	1.8	0.0	0.0	33.0	2.65330	12.5
CURRENT NET FINANCIAL VALUE (CNFV)							75.9
Internal Rate of Return (Financial) (FIRR)							10.34%
Benefit/Cost Ratio (Financial)							4.52

Financial Evaluation

Current Net Financial Value (CNFV)	US $	75.9
Financial Internal Rate of Return (FIRR)		10.34%
Cost/Benefit Ratio	4.52 times the owner's contribution	1.95 times the total investment

The indicators obtained in the financial evaluation reflect the feasibility of implementing the project with partial financing (US$ 16,190.00), because FIRR is greater than the expected interest rate (9%) and the CNFV is also greater then cero. In addition, the coverage indicators show how the servicing of the debt is covered.

In general, it is recommended that in both economic and financial terms, the project should be implemented based on the theories assumed in the financial estimates.

8.3.8 Sensitivity Analysis

A sensitivity analysis of the changes in relevant variables should be available for every project evaluation, so that the variation in the profitability of the project as a result of those changes can be determined. It is necessary to be aware of at least the private discount rate, total income - including the energy consumption and the service rate (in the case of non-regulated rates agreed upon) and total costs.

For this example, the discount rate – which in this case is equivalent to the annual effective rate of fixed term deposits in U.S. dollars – is increased up to 30%, which would be equivalent to a 6.5% rate. On the other hand, total income is reduced up to 5%, only, making it the variable most sensitive.

In practical terms the variation of the analyzed variables should be within the range of ± 10%, except for the discount rate, which could be within a variation rate of ± 20%.

Items for sensibility analysis may include the following:

- Construction cost
- Operating cost
- Energy sales income
- Financial Condition

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IV-2.5　財務

本章のマニュアルは、村落住民や地方政府が、料金設定と補助金手続き及び料金回収と会計に関する必要な知識を与えることを目的としており、これらの要素は電化プロジェクトの持続性に必須のものである。

IV-2.5.1　料金設定と補助金申請のためのプロジェクト承認手続き

(1)　料金設定

料金設定に当たっては、利用者負担が大前提とされるが、以下の相反する 2 つの原則を考慮した上で検討を行う必要がある。

1) プロジェクト実施に必要とされる費用を回収しうる水準に設定すること。

2) 便益を受ける住民が負担可能な料金水準であること。

ただし、1)については、プロジェクトによっては、政府補助等別途の予算で建設段階までの各種費用が負担されることになる場合もありうるので、電気料金で回収すべき費用がどの段階までのものなのかをはっきりさせることが重要である。

2)については、出来るだけ多くの住民が電気供給サービスを受けられるような水準とすべきである。一方、都会から離れて充分な産業も発達していない地域においては将来的に住民の所得水準の上昇が予想されがたいことも考慮したうえで、長期的視点からの料金設定を行う必要がある。

電気料金には大きく分けて、従量制と定額制の二種類がある。従量制においては、電力量メーターを導入して、定期的な検針を行って、一定期間内に消費した電力量に応じて料金が計算され、需要家に請求される。このために、検針および料金計算を行う担当者が必要となる。人口密度の薄いところでは、その検針の手間は非常に大きなものとなる。一方、定額制においては従量制のような煩雑な手続きが不要で、一定期間に定額の料金が需要家に請求される。このため、各戸を訪問する必要が生じず、事務手続きの簡素化が図れる。

項　目	メリット	デメリット
従量制	料金負担が公平	検針に伴う手間がかかる
定額制	検針不要	少量消費者には不公平

電気料金を設定するためには一般的に以下の項目の検討を行う。

1. プロジェクト費用
2. 需要家の支払い意思額
3. 需要家数
4. FOSE 適用

1. プロジェクト費用

プロジェクト費用についてはプロジェクト計画段階から運用段階までに要する費用を算定する。その算定項目としては以下のものが含まれる。

- プロジェクト調査費
- 初期投資額
- プロジェクト管理費（マイクロ企業等の運営経費）
- 機器取替費
- 運転維持費（補修費を含む）
- 適正な水準の利潤（マイクロ企業の場合）

ただし、調査費や初期投資に対して政府からの補助がなされる場合には、これらの費用に関しては料金算定をするためのコストからは除外する。また、特に補修に関しては何を徴収料金から負担し、何を個人負担してもらうのかに関する充分な議論を行い、住民間でのコンセンサスを得ておくことが重要である。

基本的にはこの費用をベースとして、単位（例えば 1 ヵ月）あたりどの程度の費用が必要とされるかについて計算を行う。

2. 需要家の支払い意思額の推定

現状で灯油ランプや乾電池等エネルギー関連のために支出している費用をもとに、プロジェクト対象地区における需要家の支払い意思額の推定を行う。当然ながら需要家によって支出金額にはばらつきがあるため、設定される料金の水準によっては限られた数の需要家のみがサービスを受けることができることになる。この推定を行うためには対象地区におけるアンケート調査が不可欠である。

3. 需要家数

プロジェクトの対象地区に存在する世帯のうち、どの程度の世帯が電気サービスの需要家となるための一定額の料金負担が可能であるのかに関する推定を行う。サービスを提供するマイクロ企業等を立ち上げる場合においても、一定数以上の需要家が集まらない場合には、一需要家あたりの単価を上げる以外に企業を運営するための原資を捻出することが極めて困難になるということにつながるため、できるだけ多くの需要家がサービスを受けられるようにすることが望ましい。

4. 一世帯あたりの単価算出

プロジェクト費用を需要家数で除した一世帯あたりの単価を算出する。この単価と需要家の支払い意思額との比較を行い、大多数の需要家がサービスを受けられる水準の単価であるかどうか

確認を行う。万一、世帯あたりの単価が高く、一部世帯にしか負担できない水準である場合には、FOSE の適用を考慮する。

また、単価水準が高い場合には持続性を損ねない範囲で費用積算の見直しを行う。

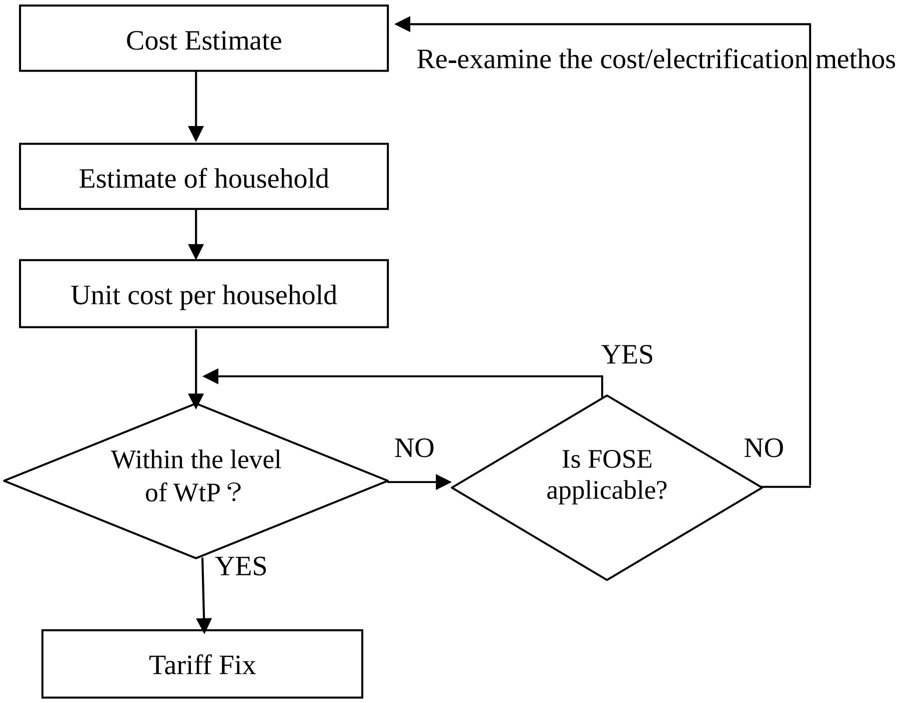


Fig. IV-2.5.1-1　料金設定フロー

(2)　プロジェクト承認手続き

プロジェクト実施に当たっては通常３つのステージ（投資前、投資、投資後）があり、これがプロジェクトサイクルとなってより良い投資につなげることができる。

Pre-Investment 段階	各種調査（Profile、PreF/S、F/S）を実施し、実施可能性を確認。
⇩	
Investment 段階	設計、工事、研修を実施。
⇩	
Post-Investment 段階	維持管理、研修、事後評価を実施。

この手続きは、公共投資システム（SNIP：Sistema Nacional de Inversión Pública）と呼ばれており、経済財務省がシステムの運用を担当している。SNIP においてはプロジェクトの目的から始まり、需給見通し、費用、便益、環境への影響、持続性等の多方面の観点から、公的予算を使用し

て実施すべきプロジェクトであるかどうかを確認すること(= viability の宣言取得)を目的として、その要求される調査精度に応じたレベルの調査（Profile、Pre-Feasibility、Feasibility）を実施することになっている。なお、最終的にどのレベルの調査が必要とされるかに関してはプロジェクト金額により決定されるが、最終レベルの調査を実施するためにはそれ以前のレベルの調査を完了していることが条件となる。

Study Level	Project Amount
Profile	3~6M Soles
Pre-Feasibility Study	6~10M Soles
Feasibility Study	10M Soles or more

SNIP における実施可能性確認のための書類手続きのフローを次ページに示す。ここでは外国借款の入らないプロジェクトの手続きとした。まず実施部隊が Profile レベルの調査報告書を作成し、プロジェクトリストに登録する。この登録により、鉱山動力省、州政府あるいは地方政府に設置された計画投資局（OPI: Oficina de Programación e Inversión）のうち、どの OPI が評価を担当するかが自動的に決定される。これに基づき、実施部隊は OPI に書類を提出する。OPI はその内容を評価し、以下のどれに相当するかを決定する。

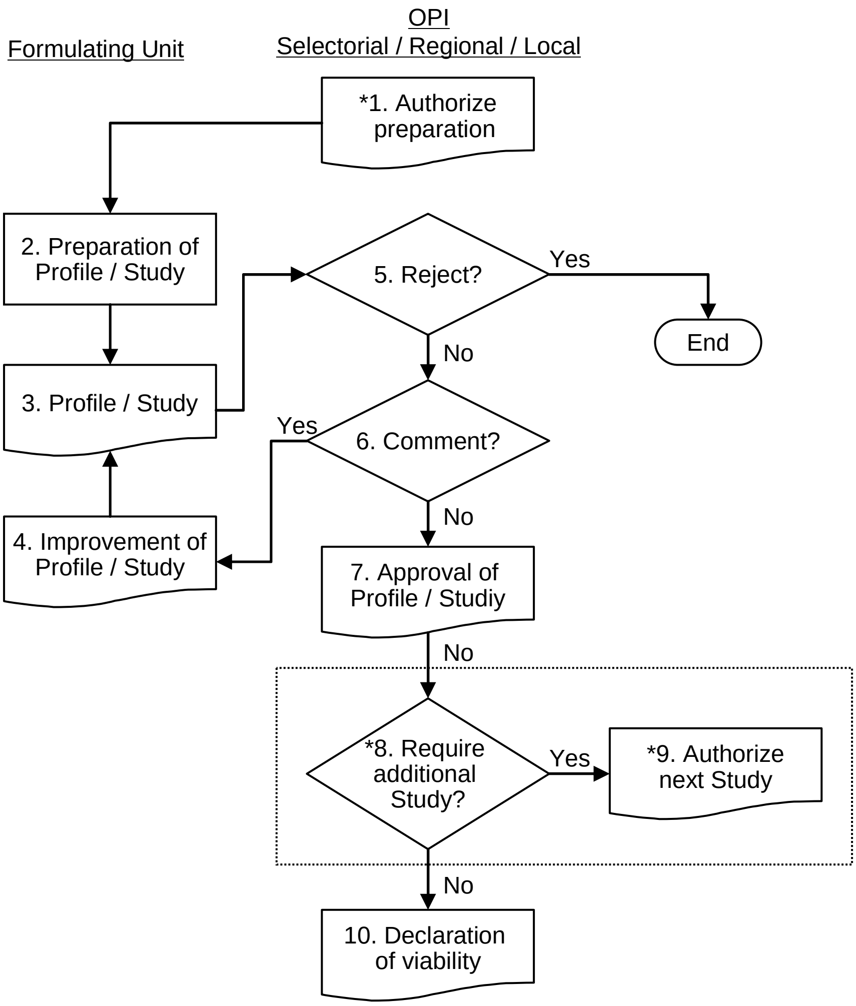
a) Profile を承認して次段階の調査（Pre-FS）を認める、

b) Viability の宣言をする、

c) コメントを付けて調査報告書を実施部隊に差し戻す、

d) 調査報告書を却下する。

c)の場合にはコメントを取り入れて書類を OPI に再提出して、再び内容の審査を受けることになる。OPI での評価日数は 20～30 労働日と定められている。Pre-FS や FS 段階の調査でも Profile と同様の手続きが取られる。



Nota: *1 : Not applicable in case of Profile.
*8 and *9 : Not applicable in case of Feasibility Study.

Source: Directiva General del SNIP

Fig. IV-2.5.1-2 SNIP によるプロジェクト承認フロー

IV-2.5.2 料金回収と会計

(1) 料金回収

料金徴収マニュアルの目的は、料金徴収にあたってどのような項目に注意を払うべきかに関する情報を提供することである。基本的に料金支払いは受益者が公平に電気供給サービスを享受するための最低限の義務であるといえる。

1) オリエンテーションの実施

- オリエンテーションにおいては以下の項目を含む情報提供を行う。
- 料金支払いの必要性
- 料金に含まれている費用、
- 料金に含まれていない費用
- 料金の決定方法

- 料金支払いがなされない場合にはどうなるのか
- 料金の使途
- 透明性がどのように確保されているのか
- 料金の支払い方法

2) 料金徴収頻度

地方における収入、特に現金収入については必ずしも毎月定期的なものが得られるとは限らない。従って、その地域の実情を充分に反映した上で、徴収頻度を決定することが重要である。一方、徴収のインターバルが長くなる場合には、住民が有料サービスを受けているという意識を喪失させないようにする必要がある。

3) 料金徴収方法

基本的にはコミュニティ内部に事務所を設けてそこに受益者が定期的に電気料金を支払いに来るという形式が望ましい。ただし、その地域の実情を充分に考慮し、場合によっては巡回徴収という形式も考慮する。

料金徴収にあたっては、料金受領書を発行し、台帳に記載する。

4) 支払い遅延者に対する処置

支払いが遅延している受益者に対しては、公平性確保の観点から電気供給サービスを停止するという必要が生じる場合がある。このため、最低限以下の項目に関しては事前に受益者に趣旨を徹底しておく。

- どの時点で督促をするのか？
- どのような場合にどの程度支払いが猶予されるのか？
- 支払い期限が経過した場合、どのような対応がなされるのか？

本件については取り扱いが恣意的にならないように、定められた手続きに従って対応をする必要がある。

(2) 会計

目的

会計マニュアルの目的は、どのような項目を管理すべきかに関する情報を提供することである。基本的に複雑なものとはせず、既存のノートを活用して作表が可能なものとする。

記載事項

以下の項目に関して詳細な記録を作成する。長期的な記録を作成することにより、料金水準の妥当性を検討する基礎資料となり、持続性を高めるための一助とすることができる。

1. 収入
   1.1 料金収入
   1.2 FOSE 収入
   1.3 その他（金利収入等）
2. 支出
   2.1 管理費
      −オフィス運営費用
      −人件費
      −消耗品費
      −通信費･交通費
   2.2 技術的費用
      −技術経費
      −機器取替費

1. 収入の部

マイクロ企業等による電気供給サービス提供に伴う収入を整理する。

1.1 料金収入

定期的な収入金額を把握するため、料金回収台帳を作成する。料金回収台帳には、料金収入単価、利用者名、支払い額、支払い年月日を記載する。

1.2 FOSE 収入

MEM に対して電気事業者として登録を行い、OSINERGMIN に対して FOSE の支給を申請し、相互補助を受け取る場合には、何月分をいくら、何時受領したのかを記載する。

1.3 その他

料金収入や FOSE 等の収入を金融機関に預金する場合、その利息を管理する。また、これら以外の収入がある場合にはその摘要、金額および受領日を記録する。

これらの収入に関しては、一月（あるいは一定期間）ごとに集計を行い、月間の平均収入額を常に把握する。

2. 支出の部

マイクロ企業等運営および継続的電気供給サービスのために必要な支出を整理する。

2.1 管理費

ここではマイクロ企業等運営に関する費用を整理する。それには、事務所借り上げ費用、マイクロ企業等で雇用するスタッフの人件費、事務処理を進めるために必要な消耗品購入費、地方政府や地方電化のための再生可能エネルギーセンター(CERER)等との通信に必要となる郵便代や電話代、近くの町まで出かけるための交通費等が含まれる。

2.2 技術的費用

ここでは継続的電気供給サービスに関する費用を整理する。それには経常的保守費用、機器点検に技師派遣が必要な場合の費用、これに加えて定期的な機器取り替え費用が含まれる。

なお、どのような費用をマイクロ企業が負担して、どのような費用を個人負担とするのかに関しては事前に合意を取り付けておく必要がある。

会計帳簿活用法

マイクロ企業等における収入および支出を定期的に把握することにより、資金面からのプロジェクト運営の実態を把握する。

1) 現行の料金水準の妥当性チェック

料金支払いが順調に行われているのかをチェックする。支払い遅延者がいる場合にはどのように支払いを督促するのかを事前に決めておくと良い。

電気料金は必要な支出総定額をもとに算出されるものであるが、想定外の支出や物価上昇はプロジェクト実施につきものである。従って、現在徴収している料金で管理費用を賄えるのかどうかを常にチェックして、必要があれば電気料金の見直しを行うこととする。

2) 技術費用支出実態チェック

どのような理由による技術費用の支出が行われているのかのチェックリスト代わりとする。万一、特定の理由による技術費用の支出が頻繁に行われるようであれば、必要に応じて住民に対して研修を行う等事前予防措置を講じることとする。