III-4 Mini/Micro Hydropower (Balsapuerto in Loreto Region)

III-4.1 Natural Conditions

The project site is Balsapuerto, which is located in southwest area of Loreto region near a region border between Loreto and San Martin. The nearest city from Balsapuerto is Yurimaguas located in approximate 50 km east in a crow line. Although the access from Yurimaguas to Balsapuerto is available by a boat (necessary time: 2 days (in dry season)) or a light plane (necessary time: 15 minutes), it is impossible to use any vehicles due to lack of roads. The project site is located at heights of 200 m to 400 m above sea level and the surrounding area is in the midst of mountains of maximum 1,000 m height in a border of Mountain and Amazon area (refer to Fig. III-4.5.1-1).

Table III-4.1-1 Project Site

Region	: Loreto
Province	: Alto Amazonas
District	: Balsapuerto
Village	: Balsapuerto, etc.

III-4.2 Social and Economic Conditions and Gender Issues

1. Community (Localidad) and Population

- Communities in Balsapuerto District lie along the Rio Cachiyacu that discharges into Rio Paranapura, then Rio Huallaga, one of tributaries of the Amazon.
- Six of these communities in the river basin were chosen as the planning siets after the Pre-FS. Community survey was executed in Canoapuerto, one of the six communities. List of communities to be covered by Pre-FS and the number of households is as follows (source: National Census 2007).

Canoapuerto.....66	Nueva Luz.....26	San Lorenzo.....44
Balsapuerto.....140	Buenos Aires.....31	Nuevo Cachiyacu.....50

- There is a primary school, a high school (secondary school), a health post and a satellite telephone using solar panel in Balsapuerto town. There is a primary school in Canoapuerto, San Lorenzo, Nuevo Cachiyacu, too (as for Nueva Luz and Buenos Aires, no data was given during the Pre-Fs period as the target communities had not been decided).
- Transportation from the watershed area to the other areas is difficult and takes time due to the low and instable water level of the Rio Cachiyacu.
- This area is widely considered as ‘nativo’ area and an ethnic minority group, Chahui, occupies there. This term means that the inhabitants live in the traditional way and the government

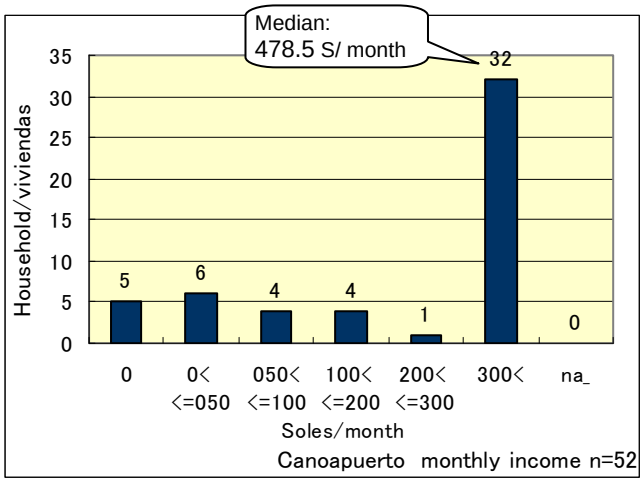
intervened to them for only last two decades in the fields of education and health. Now children go to primary school and people use the health post established at Balsapuerto Town.

- In spite of the recent government assistance, the Chahui continue to follow the tradition of ancestors in their daily life (such as nutrition): for example, they do not eat traditionally prohibited crops and fruits (such as papaya etc). Almost all women cannot understand Spanish due to the lack of the chance of receiving public education. On the other hand, male persons who go to Yurimaguas for trade can speak broken Spanish but cannot read and write it.
- Even though inhabitants know electricity (in Balsapuerto and Yurimaguas), they do not show strong intention to be electrified.

2. Industry and Main Income Sources

Communities of Balsapuerto District are located at the changing point between mountain and river basin. Inhabitants plant crops such as maize and collect tropical fruits, especially banana.

- The main income source of inhabitants living in the rural communities (except Balsapuerto town) is sale of agricultural products, mainly banana, rice and maize. They sell these crops at the markets of Balsapuerto and Yurimaguas (the capital of Province). On the other hand, cassava is main and only one staple food for inhabitants.
- Though some inhabitants talked about job-less and famine, the result of the community survey indicates that the income of inhabitants of Canoapuerto (estimated by accumulation of product sales) is the highest among the Pre-FS sites.
- Some people say that they gain money every month by selling banana at the market of Yurimaguas (it takes more than two days to go there).
- District governments give job opportunity (construction works) to some jobless families.

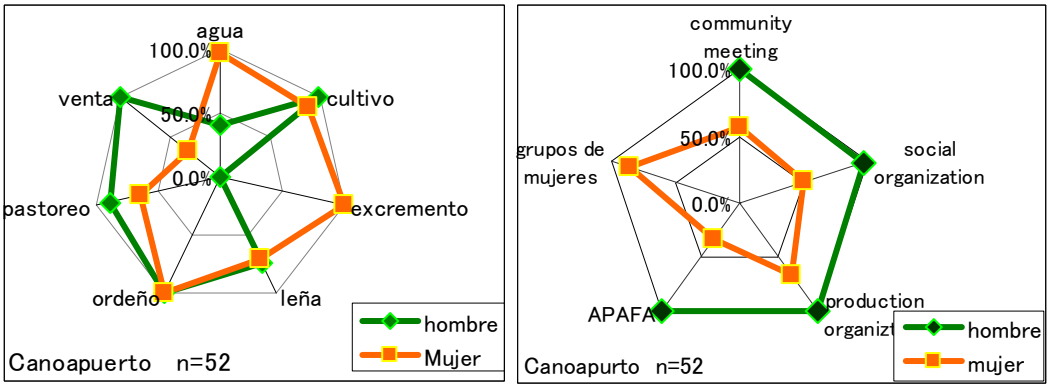


Source: JICA study team, 2008

Fig. III-4.2-1 Income Distribution in Canoapuerto (one of the communities in Balsapuerto)

3. Gender

Different from other Pre-FS sites, communities in Balsapuerto shows labour division and social activities between women and men. Trade is exclusively men's work. According to their tradition, women have to follow men, cannot manage money and have less right than men of social and community activity. As the result of the survey shows, the degree of women's participation in social activity is half of that of men in any field, which is the lowest in the four Pre-FS sites. Also, literacy rate and understanding of Spanish language is much lower for women than men.



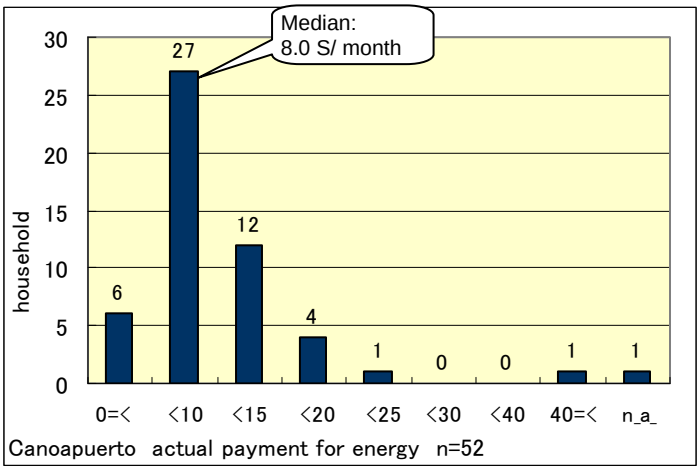
Source: JICA study team 2008

Fig. III-4.2-2 Gender Distribution in Daily Livelihood Activity (left) and Social Activity (right)

III-4.3 Demand of Electricity and Affordability

1. Actual Energy Use

- Inhabitants of Canoapuerto uses kerosene lamp as lighting.
- No household possesses television set but 61.5% of the interviewed households possess radio.
- Actually, a household of Canoapuerto pays 8.0 Soles (in median) for energy every month.

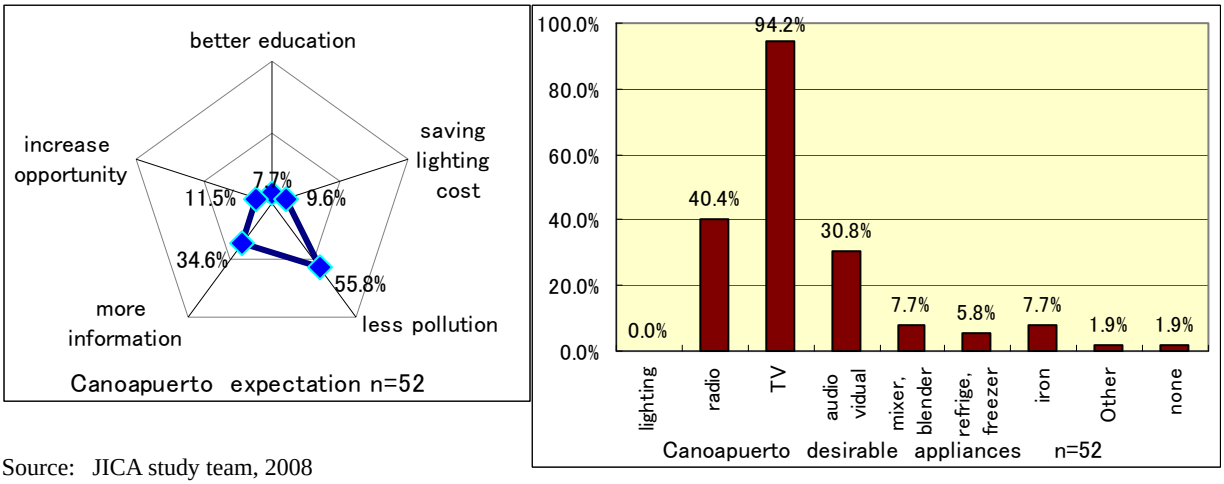


Source: JICA study team 2008

Fig. III-4.3-1 Actual Payment for Energy

2. Intention of Electrification

- Loreto Regional Government, to which Balsapuerto District belongs, made a plan of electrification project covering nine communities in this area. Then they did the Profile study for it in the communities and register the result to the SNIP (SNIP 56959.) In August 2007, they requested to MEM to execute the Pre-FS (and implementation) and MEM agreed with it.
- One problem is that the social survey for the Profile study was not done on site (it is possible according to the SNIP procedure). The study concluded that the inhabitants afford to pay but did not mention the reason of this judgment.
- 44.2% of the respondents of the community survey said that they knew renewable energy, but even so, they need to get more information about it if their education level and other 'civilized or modernized community' are considered and compared.
- According to the community survey, most important expectation of the respondents is reduction of air pollution caused by kerosene lamp. Improvement of learning condition and reduction of energy cost are not considered as important. More than 90% of the respondents want to buy and watch television if they get electricity.
- They did not mention about the productive use of electricity.



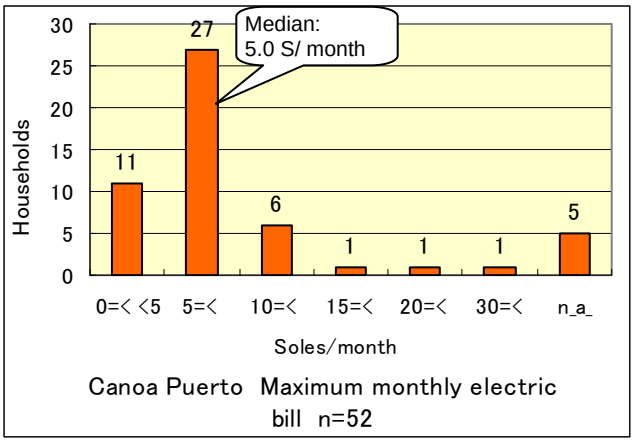
Source: JICA study team, 2008

Fig. III-4.3-2 Expectation of Electrification (left) and Desirable Electric Appliances (right)

3. Affordability

- The result of the community survey shows that the amount of electricity charge that the respondents in Canoapuerto can pay at maximum is 5.0 Soles in median per month. Some inhabitants may know that the monthly electricity bill in Balsapuerto Town is 8 Soles for household, but their answer is less than that.
- 53.8% of the respondents want to pay electricity bill every month, while 25.0% of them replied to pay once a year.

➢ Distribution of maximum affordable amount of monthly electricity bill is shown in Fig. III-4.3-3.



Source: JICA study team, 2008

Fig. III-4.3-3 Maximum Affordable Monthly Electric Bill

III-4.4 Comparison of Initial Investment Amount by Electrification Method

JICA study team studied the electrification method most suitable to the location, taking the number of the households as parameter. The assumption is as follows;

<Assumption>

[Village Information]	Number of Localidad	:	14
	Number of User	:	534
	Connecting Rate	:	0.8
[Hydro Power]	Linea Primarias	:	8,100 (US$/km)
	Redes Primarias	:	140 (US$/User)
	Redes Secundaria	:	260 (US$/User)
	Hydro Power (Electric)	:	1,000 (US$/kW)
	Hydro Power (Civil)	:	2,000 (US$/kW)
	Length of Linea Primarias	:	37.28 (km)
[Photovoltaic]	PV	:	780 (US$/User)
[Grid Extension]	Length of Linea Primarias from end of Existing Grid	:	31.25 (km)

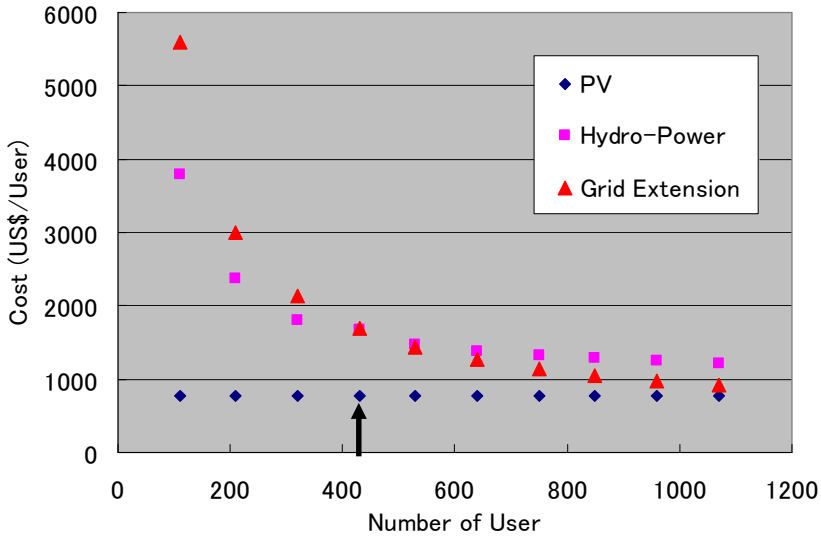


Fig. III-4.4-1 Comparison of Initial Investment Amount by Electrification Method (4)

The number of the households targeted to be electrified at this location is 427 (Household: 534, Target rate: 0.8). As Fig. III-4.4-1 shows, PV is more preferable to grid extension or hydropower for electrification method in terms of initial investment amount.

Furthermore, not only initial investment amount but operation & maintenance expense, future power usage expected in a productive manner, and future socio- economic development at this location should be studied to decide the most appropriate method of electrification.

III-4.5 Design and Cost

III-4.5.1 Design

1. Target Villages

The target villages are mainly Balsapuerto and its surrounding 13 villages which do not have any grid extension plans. The target villages and the number of households are shown in Table III-4.5.1-1. The data regarding the number of households come from GIS data in DPR and Census data in 2007 which was obtained by site survey in Table III-4.5.1-1. The prior data is the latter one and the former one is adopted in the case of no data in the latter one.

Table III-4.5.1-1 Target Village and Number of Households

No.	ID	Region	Province	District	Villages	Household	
						DEP (GIS)	Census 2007
1	1602020001	Loreto	Alto Amazonas	Balsapuerto	Balsapuerto	94	**140**
2	1602020075	Loreto	Alto Amazonas	Balsapuerto	Canoa Puerto	61	**66**
3	1602020071	Loreto	Alto Amazonas	Balsapuerto	Nueva Luz	40	**26**
4	1602020072	Loreto	Alto Amazonas	Balsapuerto	Puerto Libre	37	**16**
5	1602020048	Loreto	Alto Amazonas	Balsapuerto	Monte Alegre	28	**19**
6	1602020029	Loreto	Alto Amazonas	Balsapuerto	Nueva Esperanza	56	**59**
7	1602020064	Loreto	Alto Amazonas	Balsapuerto	Buenos Aires	12	**31**
8	1602020066	Loreto	Alto Amazonas	Balsapuerto	Nuevo Jerusalen	14	**10**
9	1602020070	Loreto	Alto Amazonas	Balsapuerto	San Marcos	**14**	**-**
10	1602020047	Loreto	Alto Amazonas	Balsapuerto	Santa Clara	42	**26**
11	1602020060	Loreto	Alto Amazonas	Balsapuerto	Nuevo Cachiyacu	35	**50**
12	1602020046	Loreto	Alto Amazonas	Balsapuerto	Nueva Reforma	38	**19**
13	1602020065	Loreto	Alto Amazonas	Balsapuerto	San Lorenzo	7	**44**
14	1602020078	Loreto	Alto Amazonas	Balsapuerto	Nueva Zaramiriza	9	**14**
					Total		**534 (357)**

Numbers in parentheses: Number of households in the first stage.

The development of this hydropower station will be planned in two stages because there are a few households in the surrounding villages depending on the distance from Balsapuerto and the willingness to pay which is expected from the site survey will be small. Consequently, the target villages were selected from villages including Balsapuerto based on the concepts below.

The first stage: Although Balsapuerto, its near villages and villages near the powerhouse are covered in this plan, some of villages which have a few households will not be covered. Consequently, 3 villages near Balsapuerto (colored green) and 3 villages near the powerhouse (colored yellow) were selected. However, 4 villages (colored red) based on the above criteria was not selected due to few households.

The second stage: Extension of distribution lines to the target villages excluded from the first stage and installation of a turbine and generator will be done.

2. Project Parameters

This project is so designed that a weir and intake will be installed in Buen Paso, which is confluent to Cachiyacu river, river water will be conveyed from the intake to 1.9 km downstream approximately and then electric power will be generated by use of about 120 m height. The project parameters are shown in Table III-4.5.1-2. Since the amount of water is 0.056 m^3/s and its capacity is 50 kW in the first stage and also the amount of water is 0.090 m^3/s and its capacity is 80 kW finally according to two-steps development, it will be necessary for extension of transmission and distribution lines and installation of a turbine and generator (30 kW) in the second stage.

Table III-4.5.1-2 Project Parameters

Catchment Area	: 26.5 km^2	
Name of River	: Buen Paso	
Length of Canal	: 1.9 km	
Length of Penstock	: 145 m	
Intake	: E.L 425 m	
Tailrace	: E.L 300 m	
Gross Head (Effective Head)	: 125 m (121.7 m)	
Discharge	: 0.090 m^3/s	First stage: 0.056 m^3/s
Installed Capacity	: 80 kW	First stage: 50 kW

3. Electricity Demand

(1) General Demand

Electricity demand at this project was estimated under the following conditions. At first, it was assumed that electricity demand /month /household will be 15 kWh, and then business demand like restaurants, stores and small industries and public illuminations were allocated by a rate based on the household demand (15 kWh/month/household).

This value is equal to 40 W light × 2 (6 hours), 20 W radio × 1 (4 hours) in one day equivalent. The growth rate of population for 20 years from this time was assumed to be 1.5%/year, the connection rate to distribution lines was also assumed at 80% in consideration of existing households far from distribution lines. In addition, the plant factor was assumed at 25% corresponding to 6 hours/day because peak demand in the near term is expected for lights and radio use during the nighttime.

1) Second Stage (for the entire villages)

Estimating conditions of electricity demand in the second stage was assumed as shown below.

Table III-4.5.1-3 Estimating Conditions of Electricity Demand

(a) Number of household	: 534
(b) Electricity demand /household	: 15 kWh/ month
(c) Business demand (Restaurant, store, etc.)	: 10% of total household electricity demand
(d) Small industries demand	: 10% of total household electricity demand
(e) Public illuminations	: 5% of total household electricity demand
(f) Others (Public facilities)	: 10% of total household electricity demand
(g) Backup	: 15% of total household electricity demand
(h) Transmission and distribution loss	: 10% of [(c) + (d) + (e) + (f) + (g)]
(i) Growth rate of population (20 years)	: 1.5%
(j) Connection rate (Peak)	: 80%
(k) Plant factor	: 25%

Necessary capacity was estimated as shown in the following table based on the above conditions.

Table III-4.5.1-4 Estimation of Necessary Capacity

(a) Number of target households (after 20 years)	: $0.8 \times 534 \times (1+0.015)^{20} \cong 575$ users
(b) Total household electricity demand (kW)	: $P = \frac{E}{t \times f_c} = \frac{15 \times 575 \times 12}{8{,}760 \times 0.25} = 47.3$ $E = P \times t \times f_c$ E = Energy, t = Time, f_c =charge factor
(c) Business demand (Restaurant, store, etc.) (kW)	: $P \times 0.10 = 47.3 \times 0.10 = 4.73$
(d) Small industries demand (kW)	: $P \times 0.10 = 47.3 \times 0.10 = 4.73$
(e) Public illuminations (kW)	: $P \times 0.05 = 47.3 \times 0.05 = 2.37$
(f) Others (kW)	: $P \times 0.10 = 47.3 \times 0.10 = 4.73$
(g) Backup (kW)	: $P \times 0.15 = 47.3 \times 0.15 = 7.10$
(h) Subtotal (kW)	: (b) + (c) + (d) + (e) + (f) + (g) = 70.96
(i) Transmission and distribution loss (kW)	: $(h) \times 0.10 = 70.96 \times 0.10 = 7.10$
Total	: (b) + (c) + (d) + (e) + (f) + (g) + (i) = 78.06 ≒ **80 kW**

2) First Stage (for a part of villages)

Estimating conditions of electricity demand in the first stage was assumed below.

Table III-4.5.1-5 Estimating Conditions of Electricity Demand

(a) Number of household	: 357
(b) Electricity demand /household	: 15 kWh/ month
(c) Business demand (Restaurant, store, etc.)	: 10% of total household electricity demand
(d) Small industries demand	: 10% of total household electricity demand
(e) Public illuminations	: 5% of total household electricity demand
(f) Others (Public facilities)	: 10% of total household electricity demand
(g) Backup	: 15% of total household electricity demand
(h) Transmission and distribution loss	: 10% of [(c) + (d) + (e) + (f) + (g)]
(i) Growth rate of population (20 years)	: 1.5%
(j) Connection rate (Peak)	: 80%
(k) Plant factor	: 25%

Necessary capacity was estimated the following table based on the above conditions.

Table III-4.5.1-6 Estimation of Necessary Capacity

(a) Number of target households (after 20 years)	: $0.8 \times 357 \times (1+0.015)^{20} \cong$ 384 users
(b) Total household electricity demand (kW)	: $P = \frac{E}{t \times f_c} = \frac{15 \times 384 \times 12}{8{,}760 \times 0.25} = 31.6$ $E = P \times t \times f_c$ E = Energy, t = Time, f_c =charge factor
(c) Business demand (Restaurant, store, etc.) (kW)	: $P \times 0.10 = 31.6 \times 0.10 = 3.16$
(d) Small industries demand (kW)	: $P \times 0.10 = 31.6 \times 0.10 = 3.16$
(e) Public illuminations (kW)	: $P \times 0.05 = 31.6 \times 0.05 = 1.58$
(f) Others (kW)	: $P \times 0.10 = 31.6 \times 0.10 = 3.16$
(g) Backup (kW)	: $P \times 0.15 = 31.6 \times 0.15 = 4.74$
(h) Subtotal (kW)	: (b) + (c) + (d) + (e) + (f) + (g) = 47.40
(i) Transmission and distribution loss (kW)	: $P \times 0.10 = 47.4 \times 0.10 = 4.74$
Total	: (b) + (c) + (d) + (e) + (f) + (g) + (h) = 52.14 ≒ **50 kW**

(2) Productive Demand

In this study, there is room for demand during the daytime because peak demand is assumed to be general demand for the nighttime. Therefore, productive demands in the future will be able to consider public facilities like a school, hospital and agriculture like an irrigation, milling, converted timber, milk pump, etc. depending on intended use.

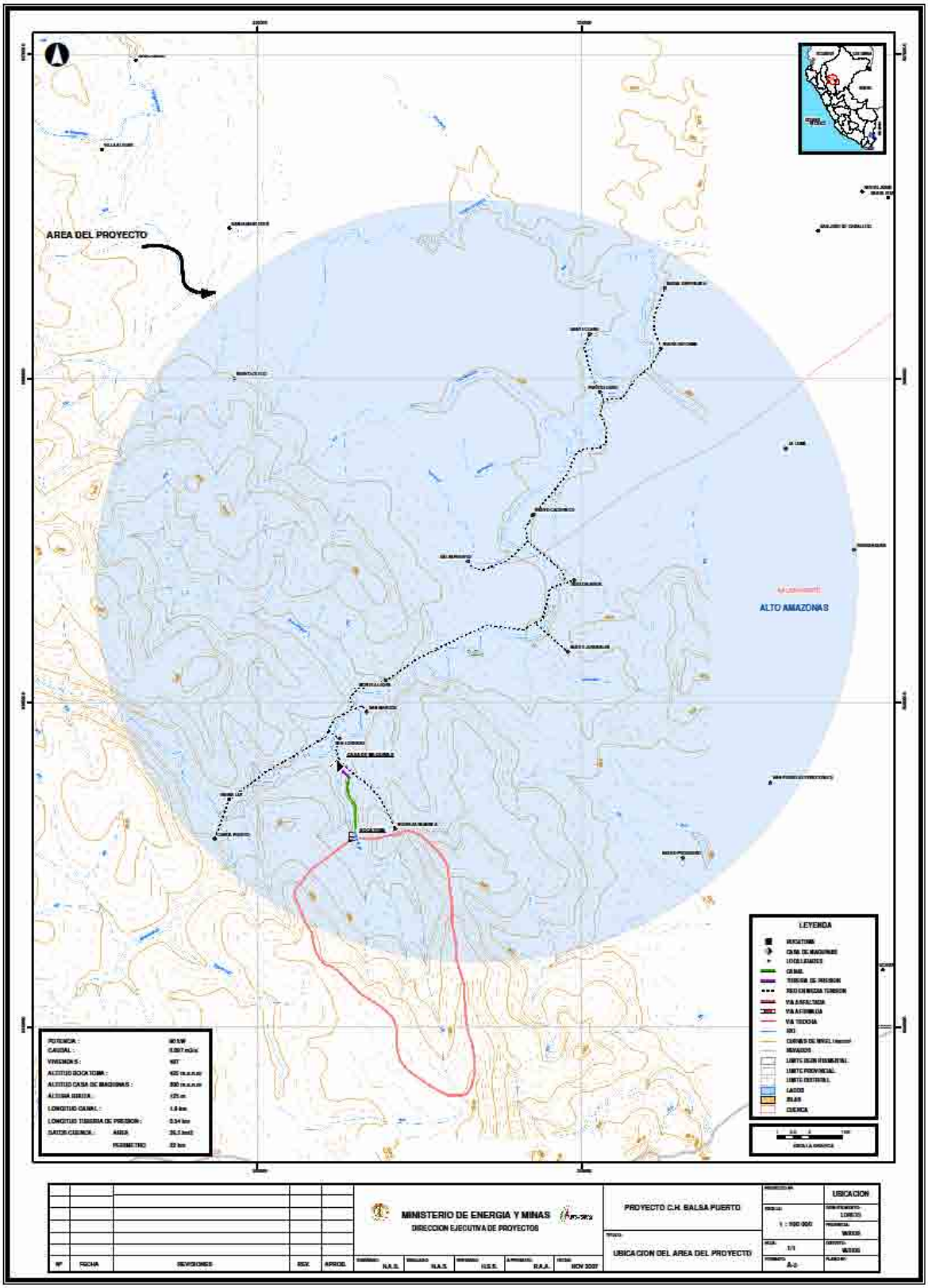


Fig. III-4.5.1-1 Planned Location of Power Station

4. Site Survey

(1) Surrounding Topography and Geology

This site is located in the altitude of 200 to 400 m and a border area between Mountain and Amazon area with the maximum altitude of 1,000 m approximately. The location of project site is Buen Paso river, which is confluent to Cachiyacu river, and the distance from Balsapuerto to the site is supposed to be approximately 10 km using the route along Cachiyacu river (refer to Fig. III-4.5.1-2). The sand grounds can be seen around Balsapuerto and these are sediments which were transported from Cachiyacu and other rivers. Sand around here is expected to include some silt-size fraction with less than dozens of micron (μ) judging from ground conditions with mud after rainfall. Consequently, sedimentation problems should be considered sufficiently around the intake.

Photo III-4.5.1-1 Center of Balsapuerto

Photo III-4.5.1-2 River Condition (Cachiyacu)

Photo III-4.5.1-3 Ditto (Upstream)

(2) Site Survey

The site survey was carried out from Balsapuerto to the project site in order to confirm the location of powerhouse, surrounding topography, river discharge and access route. However, it was canceled at the impassable point shown in Fig. III-4.5.1-2 because the survey route was closed due to land slide (refer to Photo III-4.5.1-4). Consequently, it was impossible to confirm topography conditions of the powerhouse planned site in this survey. Meanwhile, the distance and time from Balsapuerto to the impassable point were totally 5.6 km, 2 hours and 30 minutes (from Balsapuerto to Nuevaluz: 2 km, 30 minutes, from Balsapuerto to Canoapuerto: 3.6 km, 1 hour, from Balsapuerto to Impassable point: 5.3 km, 2 hours and 30 minutes). The road is relatively wide until Canoapuerto (refer to Photo III-4.5.1-5) and up-and-down conditions can be seen many times. A narrow path which is not usually used continues after Canoapuerto (refer to Photo III-4.5.1-6). It will be necessary to improve the road from Balsapuerto to Canoapuerto, 6.7 km, in order to transport materials, operate and maintain the station during the construction and after operation.

In addition, the locations of Nuevaluz and Canoapuerto shown in Fig. III-4.5.1-2 were confirmed in this site survey by GPS but these locations are different from those in Fig. III-4.5.1-1 obtained from DPR. According to DPR, Fig. III-4.5.1-1 was made by official data in Peru but these will be necessary for confirmation in the future.

(3) Simplified Measurement for River Discharge

As shown in the Pre-F/S report of Yerba Buena, it is one of the most important factors to grasp the river discharge in hydropower planning. To obtain the data regarding discharge was one of the important purposes but a trial was made to estimate the discharge in the project river by carrying out flow measurement at the tributary shown in Fig. III-4.5.1-2 (Flow Measurement Point) and comparing ratio between those catchment areas because it was impossible to access to the project site as mentioned above.

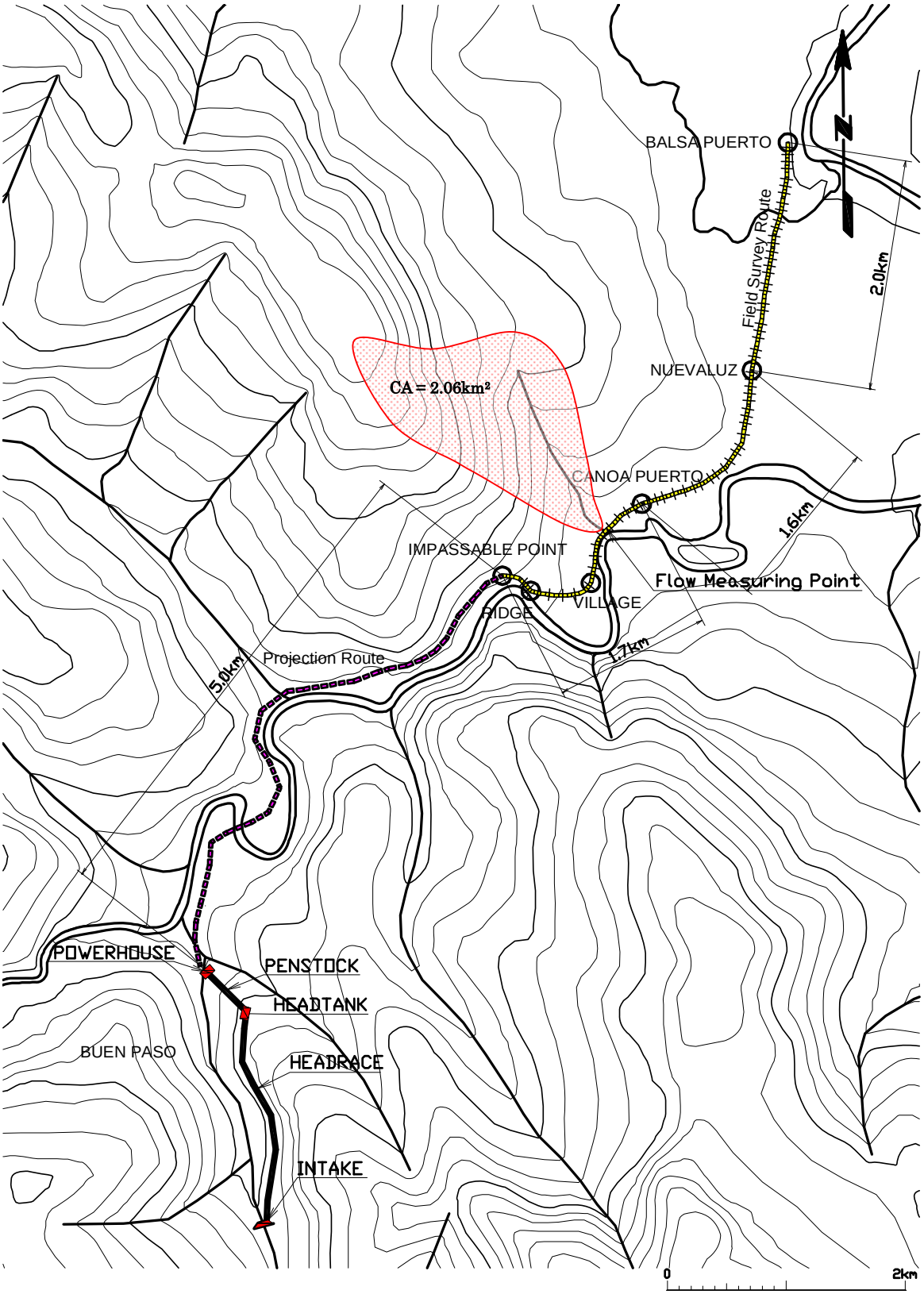


Fig. III-4.5.1-2 Route of Site Survey

Photo III-4.5.1-4 Land Slide on Route

Photo III-4.5.1-5 Road Condition near Canoapuerto

Photo III-4.5.1-6 Road Condition after Canoapuerto

The results are shown below. Buen Paso is close to the river where flow measurement was carried out, so the condition of both sites is very similar regarding rainfall, vegetation and geology. For this reason, The estimated discharge in Buen Paso was 1.70 m^3/s from the ratio of catchment area which is obtained by each catchment area 2.06 km^2 (refer to Fig. III-4.5.1-2) and 26.5 km^2. However, the estimated value should be used as reference because the value range below is generally applied in many cases.

0.5< (Catchment area/ Catchment area of measured river) <**2**

The situations of site survey are shown in Photo III-4.5.1-7 and Photo III-4.5.1-8.

[Balsapuerto Site]
(The result of measurement for river crossing and current velocity)

Location	S: 05°51'47.4", W: 076°34'24.8" (Altitude=201 m)
Velocity (No.1)	V_1 = 5 m / 19.28 sec = 0.259 m/sec
Velocity (No.2)	V_2 = 5 m / 20.21 sec = 0.247 m/sec
Velocity (No.3)	V_3 = 5 m / 16.31 sec = 0.307 m/sec
Velocity (No.4)	V_4 = 5 m / 13.91 sec = 0.359 m/sec
Velocity (No.5)	V_5 = 5 m / 22.56 sec = 0.221 m/sec
Velocity (No.6)	V_6 = 5 m / 21.69 sec = 0.231 m/sec
Average Velocity	V = 0.271 m/sec
River Section	Measurement result (unit:m) Distance 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 5.8 Depth 0 0.15 0.1 0.12 0.16 0.13 0.1 0.08 0.15 0.15 0.15 0.08 0 Average Depth = 0.105 m A = 5.8 × 0.105 = 0.611 m^2
Calculated discharge	Q = A × V = 0.611 × 0.271 × 0.8 = **0.132 m^3/s**

Photo III-4.5.1-7 Situation of River Discharge Measurement

Photo III-4.5.1-8 Ditto

5. Civil Design

(1) Design Condition

<Estimation of Usable Discharge>

1) Results of Site Survey

The river discharge of Buen Paso is expected as shown in Table III-4.5.1-7 from the results of the simplified measurement mentioned above.

Table III-4.5.1-7 Estimated Discharge

(a) River discharge from measurement result	: 0.132 m^3/s
(b) Catchment area of measurement river	: 2.06 km^2
(c) Catchment area of Buen Paso	: 26.5 km^2
(d) Estimated discharge of Buen Paso	: (a) × (b) / (c) = 0.132 × 26.5 / 2.06 = **1.7 m^3/s**

The site survey and collecting data without interruption are necessary for final determination of river discharge as well as Yerba Buena site.

2) Hydrological Analysis

The river discharge was studied by using analytical method from monthly average precipitation and temperature data in addition of site survey results. The monthly average precipitation and temperature data come from the data of Balsapuerto and Yurimaguas, which are the nearest from the project site among existing data (SENAMHI). The precipitation data for 10 years from 1964 to 1973 and temperature data for 11 years among 1964 to 1994 were adopted as the latest one that can be obtained. The monthly average precipitation and temperature is shown in Fig. III-4.5.1-3 and Table III-4.5.1-8. The following figure and tables show that the dry season is from May to September. The change of average temperature is from 1 to 2°C; this difference is not so much throughout the year. The total average precipitation/year is 3,200 mm approximately.

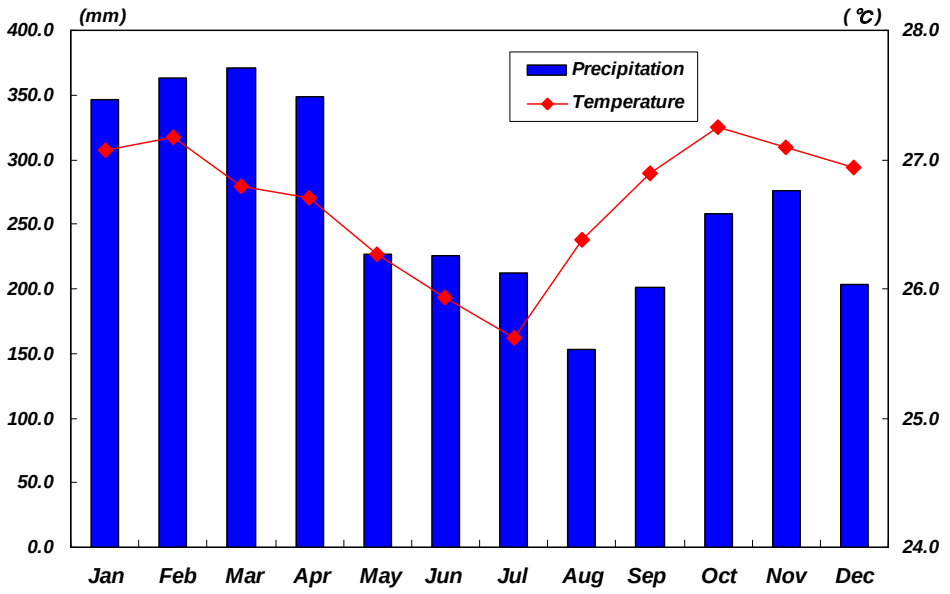


Fig. III-4.5.1-3 Monthly Average Precipitations and Temperature (Balsapuerto/Yurimaguas)

Table III-4.5.1-8 Monthly Average Precipitations and Temperature (Balsapuerto/Yurimaguas)

Precipitation Data of Balsapuerto (Balsapuerto) **Unit: mm**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1964	N/A	N/A	316.7	364.0	250.0	N/A	N/A	221.0	156.0	334.6	373.0	244.0
1965	133.0	212.0	97.0	44.0	111.0	162.0	210.0	168.0	160.0	433.0	359.0	56.0
1966	N/A	47.5	N/A	184.0	194.0	36.0	100.0	20.0	6.1	174.0	366.2	238.4
1967	112.0	427.5	114.9	252.2	189.6	261.4	117.5	93.0	64.8	235.9	255.6	361.8
1968	289.2	454.5	217.4	185.6	102.6	72.3	56.4	105.7	302.4	250.0	142.0	85.5
1969	279.9	217.0	N/A	282.0	74.2	156.0	195.0	150.7	289.0	277.3	197.0	170.2
1970	425.5	313.0	591.0	613.0	576.0	491.0	190.0	67.0	214.0	332.0	201.0	N/A
1971	583.0	694.0	642.0	738.0	410.0	448.0	434.3	247.6	277.3	211.8	383.9	327.4
1972	643.9	356.0	581.9	219.0	172.0	228.0	264.0	226.7	169.3	70.0	203.1	146.1
1973	304.7	547.1	402.8	600.0	189.0	180.4	341.5	236.0	366.8	N/A	N/A	N/A
Average	**346.4**	**363.2**	**370.5**	**348.2**	**226.8**	**226.1**	**212.1**	**153.6**	**200.6**	**257.6**	**275.6**	**203.7**

Temparature Data of Balsapuerto (Yurimaguas) **Unit: ℃**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1964	33.2	33.1	31.4	31.4	30.0	30.0	30.4	31.8	32.3	32.0	32.1	32.6
	22.6	23.0	22.3	21.9	21.5	20.9	19.8	20.6	21.3	22.2	21.7	21.2
1965	32.6	32.9	31.2	31.1	30.4	29.4	30.1	32.1	31.4	32.5	30.9	31.7
	21.7	21.4	21.6	21.3	21.3	21.1	20.6	20.1	21.7	22.2	22.0	21.8
1966	31.7	32.4	31.9	31.3	30.3	31.4	29.8	31.1	32.0	32.2	31.2	30.9
	22.3	22.1	21.8	22.0	21.2	20.1	20.1	20.3	20.9	22.0	22.2	22.0
1967	31.5	30.6	30.5	30.6	30.6	30.2	30.5	31.7	34.0	32.5	31.9	32.3
	21.9	22.1	21.8	21.2	21.7	20.9	20.7	21.1	21.2	22.0	22.3	22.0
1968	31.4	32.2	30.9	31.3	30.7	31.0	31.1	31.8	31.4	33.4	33.8	32.7
	21.8	22.3	21.6	21.7	20.7	21.2	21.3	21.4	21.8	22.4	22.4	22.3
1969	34.1	33.6	33.0	33.6	32.0	31.9	31.8	31.5	32.8	31.8	31.6	32.1
	22.5	22.6	22.9	23.0	22.6	21.8	20.2	21.4	22.3	21.7	22.3	22.8
1970	32.2	32.6	31.8	31.2	31.7	31.0	30.5	33.0	32.4	32.9	32.5	31.4
	22.6	22.7	22.5	22.6	22.0	21.6	20.4	21.0	21.6	22.4	22.5	22.4
1971	31.0	30.2	30.6	30.5	30.7	30.0	31.1	31.6	32.3	31.2	32.1	31.2
	22.2	21.9	22.2	21.8	21.5	21.5	21.1	20.9	21.7	21.8	21.9	21.9
1972	30.7	31.6	30.6	31.0	31.2	30.6	31.0	31.4	31.3	32.5	31.8	31.5
	21.9	22.2	22.5	22.2	22.5	21.5	21.1	21.5	22.0	22.6	22.9	23.0
1973	30.8	31.2	31.6	31.3	30.6	30.6	29.4	31.7	32.2	32.2	31.2	31.2
	23.0	23.0	23.1	23.0	22.1	22.1	21.7	21.7	21.7	22.7	22.6	21.9
1994	32.1	30.5	31.2	31.4	31.7	30.9	31.8	32.7	32.4	32.9	32.9	31.9
	23.1	22.0	21.0	22.0	21.6	20.9	21.4	20.6	21.6	22.2	21.6	21.6
Average *1	**27.6**	**26.2**	**26.1**	**26.7**	**26.7**	**25.9**	**26.6**	**26.7**	**27.0**	**27.5**	**27.2**	**26.8**
Average *2	**27.1**	**27.2**	**26.8**	**26.7**	**26.3**	**25.9**	**25.6**	**26.4**	**26.9**	**27.2**	**27.1**	**26.9**

*Upper stand: Maximum temperature in each year
*Lower stand: Minimum temperature in each year
*1 Average of 1994
*2 Average from 1964 to 1973

The study was implemented in the same way of Yerba Buena but the coefficient of monthly consumption by vegetation, 0.6, was used in conformity with the standard as the different point from Yerba Buena. The estimated discharge in this project site is shown in Table III-4.5.1-9 and Table III-4.5.1-10.

Table III-4.5.1-9 Results of Estimated Potential Evapotranspiration

Month	(1)*1 Temparature °C	(2)*2 P (%)	(3) BlaneyCriddle (mm)	(4) Precipitation (mm)	(5)*3 Actual evaporation (mm)
Jan	27.1	8.75	143.52	346.4	143.5
Feb	27.2	7.83	128.64	363.2	128.6
Mar	26.8	8.51	138.62	370.5	138.6
Apr	26.7	8.12	131.99	348.2	132.0
May	26.3	8.27	133.20	226.8	133.2
Jun	25.9	7.96	127.15	226.1	127.1
Jul	25.6	8.16	129.50	212.1	129.5
Aug	26.4	8.25	133.15	153.6	133.2
Sep	26.9	8.18	133.65	200.6	133.6
Oct	27.2	8.61	141.69	257.6	141.7
Nov	27.1	8.43	138.24	275.6	138.2
Dec	26.9	8.79	143.74	203.7	143.7

*1 Average value
*2 The monthly rate regarding time of possible exposure to sunlight for the year
*3 Minimum value between (3) and (4)

Table III-4.5.1-10 Results of Estimated Discharge

Month	(6) Run-off (mm) (4)-(5)	(7) Direct run-off (mm) (6)×0.75	(8) Base run-off (mm) A_1	(9) Monthly run-off (mm) (7)+(8)	(10) Avg. monthly run-off (m^3/s) A_2
Jan	202.9	152.2	47.7	199.9	1.978
Feb	234.5	175.9	43.1	219.0	2.399
Mar	231.8	173.9	47.7	221.6	2.193
Apr	216.2	162.1	46.2	208.3	2.130
May	93.6	70.2	47.7	118.0	***1.167***
Jun	99.0	74.2	46.2	120.4	***1.231***
Jul	82.6	61.9	47.7	109.7	***1.085***
Aug	20.4	15.3	47.7	63.1	***0.624***
Sep	66.9	50.2	46.2	96.4	***0.985***
Oct	115.9	87.0	47.7	134.7	1.333
Nov	137.4	103.1	46.2	149.3	1.526
Dec	59.9	45.0	47.7	92.7	0.917

The monthly average discharge from May to September, dry season, is 1.02 m^3/s from the results of Table III-4.5.1-10. The monthly average discharge in October is 1.33 m^3/s and this value approximately corresponds to the estimated discharge of Buen Paso 1.70 m^3/s as well. According to these observed data, the average discharge in Balsapuerto site is five times as much as Yerba Buena but according to the observed data regarding precipitation as well, the average rainfall of Balsapuerto in dry season is 1,000 mm approximately and this value is seven times as much as the average 140 mm of Yerba Buena. Therefore, the result of Table III-4.5.1-10 is considered to be an acceptable one in consideration of difference about runoff characteristic depending on vegetation and geology between the sites.

3) Head Loss

Head loss was estimated by each facility as shown in Table III-4.5.1-11. That is to say, friction loss was allocated in proportion as distance of headrace, penstock and tailrace and entrance and exit loss was also allocated between settling basin and turbine, etc.

Table III-4.5.1-11 Head Loss

Facilities	*Loss*	
(1) Headrace	1,900 x 1/1,000 =	1.9 m
(2) Intake, Settling Basin, Inlet Loss, Outlet Loss		0.05 m
(3) Penstock	177m x 1/200 =	0.885 m
(4) Tailrace	2m x 1/1,000	0.002 m
(5) Others (Inlet of Turbine)		0.6 m
(6) Total Loss		**3.4 m**

4) Plant Discharge

Effective head was decided as shown in Table III-4.5.1-12 from head loss in Table III-4.5.1-11. The altitude of intake and tailrace was taken from the value obtained from the topographical map.

Table III-4.5.1-12 Effective Head

(7) Intak water level	E.L	425 m
(8) Tailrace water level	E.L	300 m
(9)Total Head	(7) - (8) =	125 m
(10) Effective Heaed	(7) - (8) - (6) =	**121.6 m**

In addition, necessary plant discharge was decided based on combined efficiency 75%. Its result is shown in Table III-4.5.1-13. The plant discharge is 0.090 m^3/s, less than minimum discharge 1.02 m^3/s in dry season; therefore, plant discharge will be sufficient. Furthermore, if the construction of this power station is performed in two stages in accordance with the plan mentioned above, necessary discharge will be 0.056 m^3/s for the capacity 50 kW in the first stage.

Table III-4.5.1-13 Plant Discharge

Install Capacity (P)		80 kW
Efficiency of generator and turbine (η)		75 %
Necessary discharge (Q)	$Q = P/ 9.8 \times H \times \eta$ =	**0.090 m^3/s**

(2) Preliminary Design

The contents of this preliminary design are shown below. In the site survey, the detailed topography could not be confirmed, so the study was carried out based on some assumptions. The detailed topography and so on are needed to confirm in the future. The rough drawings are shown in Fig. III-4.5.1-4 to Fig. III-4.5.1-7.

1) Weir

- The intake site should be selected in consideration of topographic and geological conditions with stable river bed and narrow river width as much as possible. The river width is assumed at 11 m approximately from local resident's interview (same as Yerba Buena).
- The height of weir was assumed to be 50 cm in order to secure necessary water depth at the intake.
- The level of water in the case of flood will be as shown below.

[Estimated Design Flood] *by Creager Curves*

$$Q_f = q \times A$$
$$q = a \times A^{(A^{(-0.05)} - 1)}$$

Where,

Q_f : Design flood discharge (m^3/s)
q : Specific discharge ($m^3/s/km^2$)
a : Regional coefficient (refer to Table III-3.5.1-14)
A : Catchment area (=26.5 km^2)

Therefore,

$$q = a \times A^{(A^{(-0.05)} - 1)} = 51.19\ m^3/s/km^2$$
$$Q_f = q \times A = \mathbf{1{,}356.54\ m^3/s}$$
$$V = \frac{1}{n} \times R^{\frac{2}{3}} \times I^{\frac{1}{2}} \quad , Q = AV$$

$I = 0.14$, $n = 0.03$, $L_\theta = 30°$, $R_\theta = 30°$

h = 3.79 m (more)

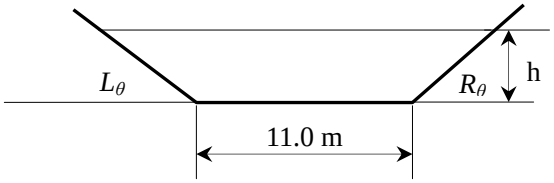


Table III-4.5.1-14 Annual Precipitation and Regional Coefficient

Region	**H**	T	Ka	Ki	S
Region coefficient (a)	**17**	34	48	41	84
Precipitation/year (mm)	**1,080**	1,360	1,710	1,440	2,280

2) Intake

- The intake is installed at adjacent upstream of the weir and also a gate and screen should be installed in order to control the amount of water intake and prevent garbage.

- The intake width should be designed to be 1.00 m, so that water velocity at the intake is less than 1.0 m/s.

3) Settling Basin

- The settling basin should be installed at the downstream of the intake because there are a lot of sand around this site and sedimentation problems may occur.
- The length of settling basin should be designed, so that average velocity is less than 0.2 m/s and water depth is 1.0 m. As well, the end of the settling basin will be installed sand flushing equipment.

4) Headrace

- The method of buried PVC should be selected in consideration of sand ground.
- The length of headrace is estimated at 1,900 m approximately.

5) Head Tank

- The head tank is installed at the entrance of penstock.
- The volume of head tank should secure the amount of water that can compensate plant discharge for 1 minute.
- The inlet valve is installed at the end of penstock without a gate at the inlet of head tank.
- The spillway in the form of overflow is installed at a side of head tank.
- The sand flushing gate is installed in order to remove sand.

6) Penstock

- Steel and PVC pipes are applied for penstock from a viewpoint of cost saving because the head of this site is 120 m approximately.
- The length of penstock will be 177 m (steel: 20 m, PVC: 157 m) and PVC will be installed under the ground.
- Velocity in the penstock should be designed to be less than 3.5 m/s (penstock φ = 30 cm).
- In addition, an air vent is necessary for prevention of negative pressure in PVC pipe in some cases.

7) Powerhouse

- The powerhouse should secure a space to take apart and inspect turbine and generator.
- The concrete foundation should be applied for powerhouse in order to prevent damage from bounding stones, etc. and wooden structure is applied for the upper building of powerhouse.
- In addition, a hoist according to weight of electrical equipment is necessary for its installation and maintenance.

8) Tailrace and Outlet

- The tailrace is not constructed due to adjacence of the powerhouse and the river.
- The layout of outlet should consider the river shape and the flow direction.

9) Others (Access Road)

- The length of access road which is needed for material transportation and maintenance of the power station is shown in Table III-4.5.1-15 in accordance with the route shown in Fig. III-4.5.1-2.

Table III-4.5.1-15 Access Road

	Location	Distance (km)	Remarks
Access Road (1)	Balsapuerto - Canoapuerto	2.0 + 1.6 = 3.6 km	Repairing work for existing road
Access Road (2)	Canoapuerto - Powerhouse	5.0 + 1.7 = 6.7 km	Construction of road (3.0 m Width)
Access Road (3)	Powerhouse - Intake Site	2.0 × 2 = 4.0 km	Construction of footpath (1.0 m Width)

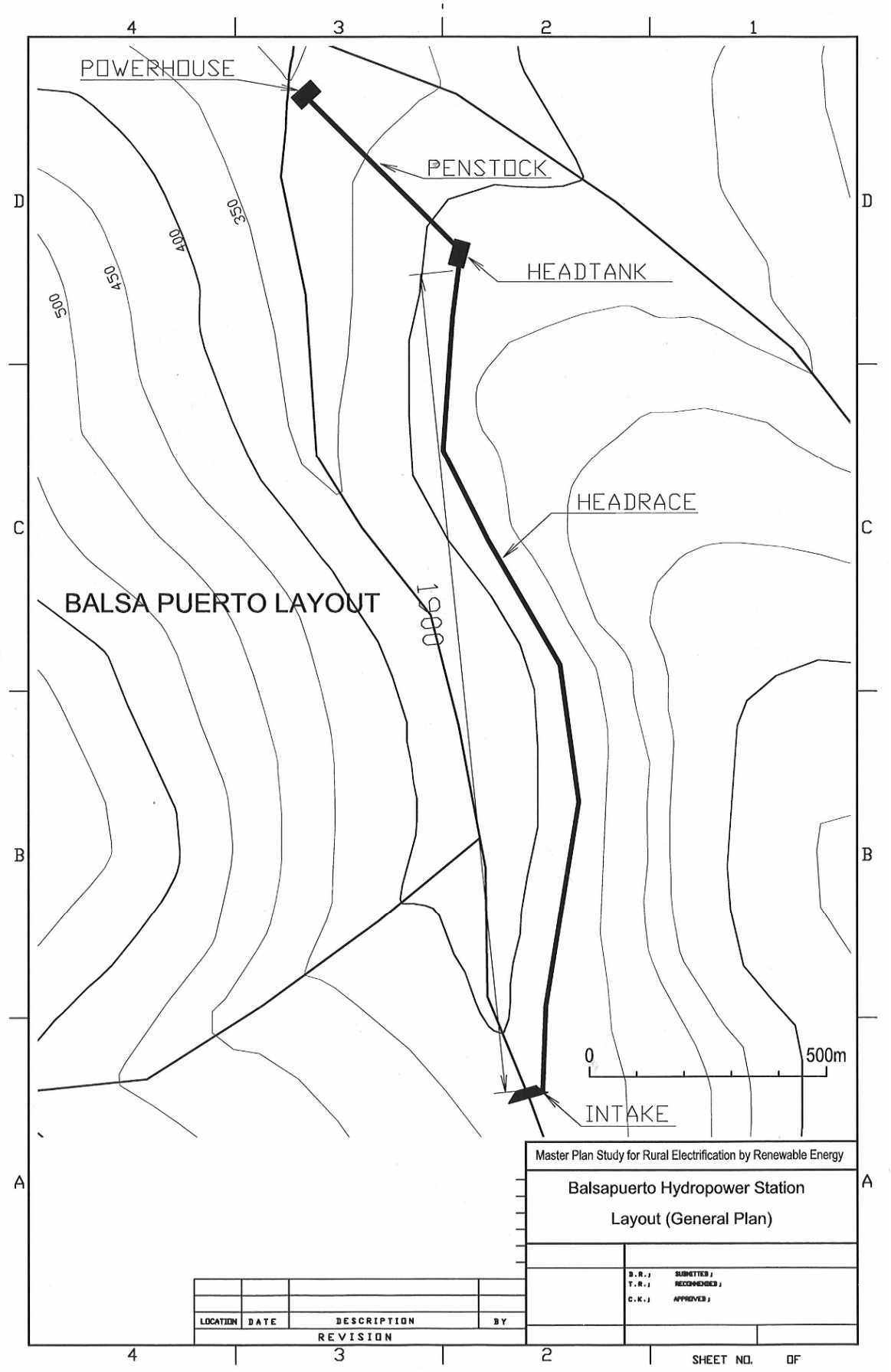


Fig. III-4.5.1-4 Layout of Power Station (Plan)

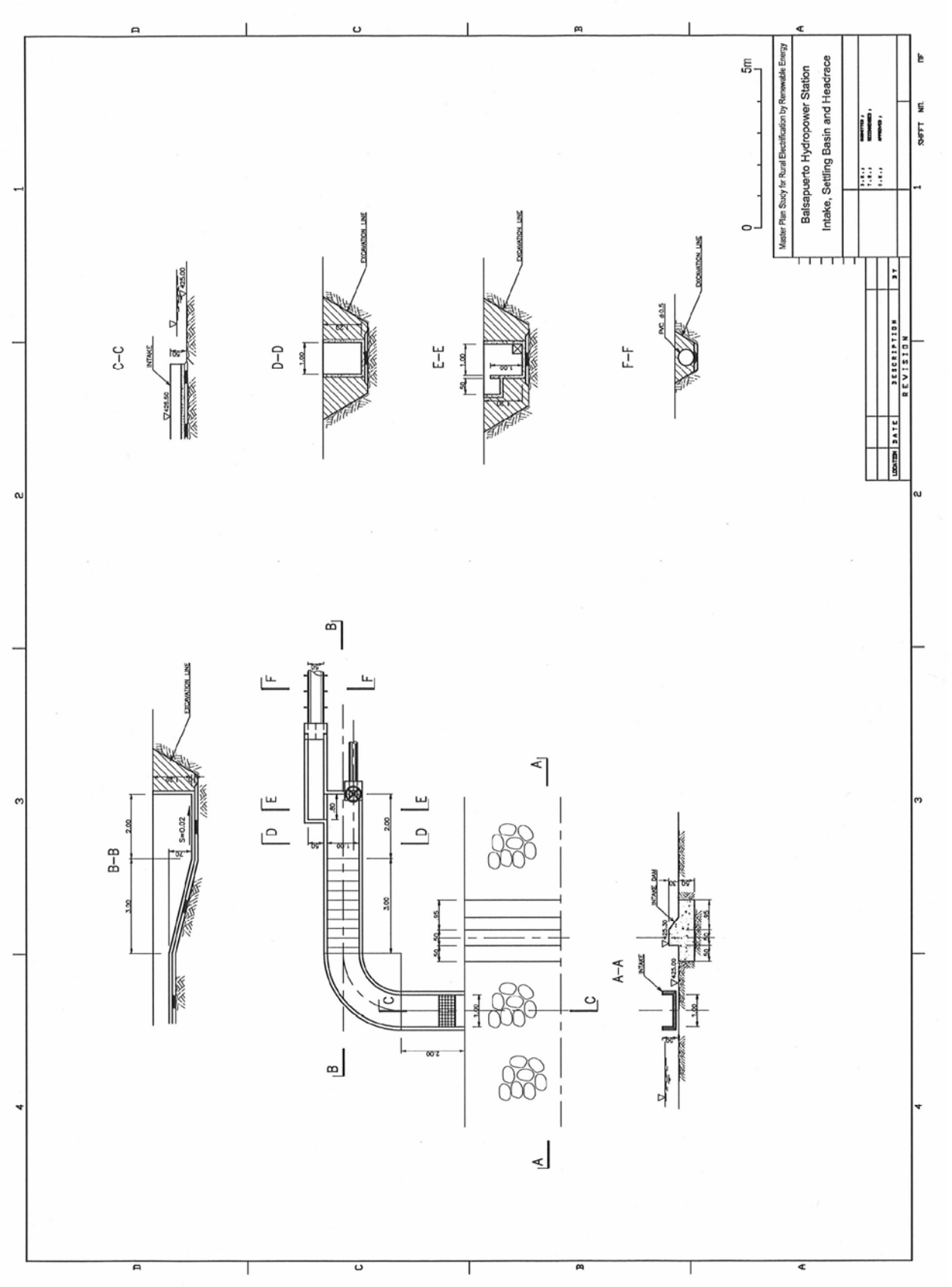


Fig. III-4.5.1-5 Rough Design Drawings of Intake, Settling Basin and Headrace

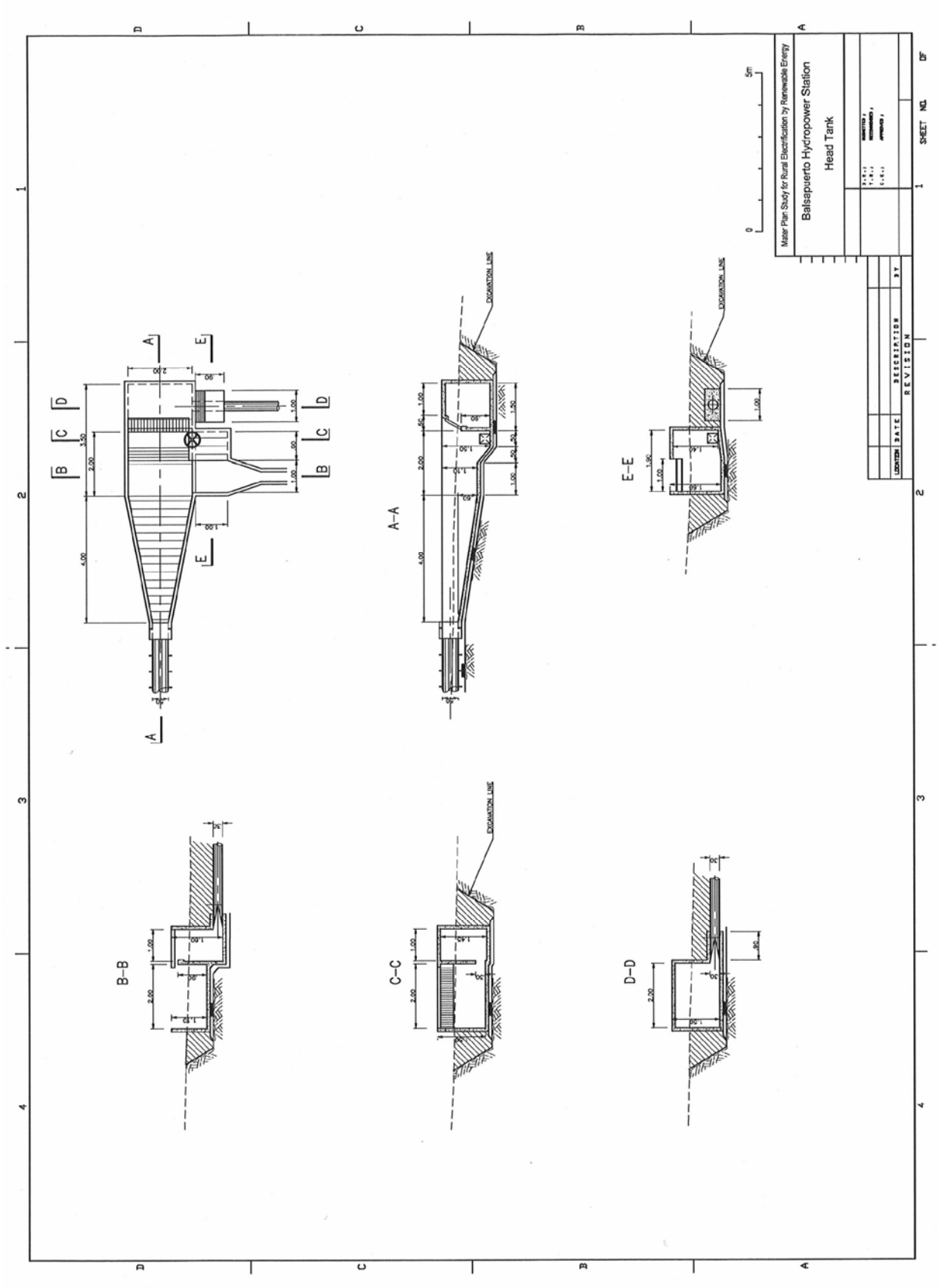


Fig. III-4.5.1-6 Rough Design Drawings of Head Tank

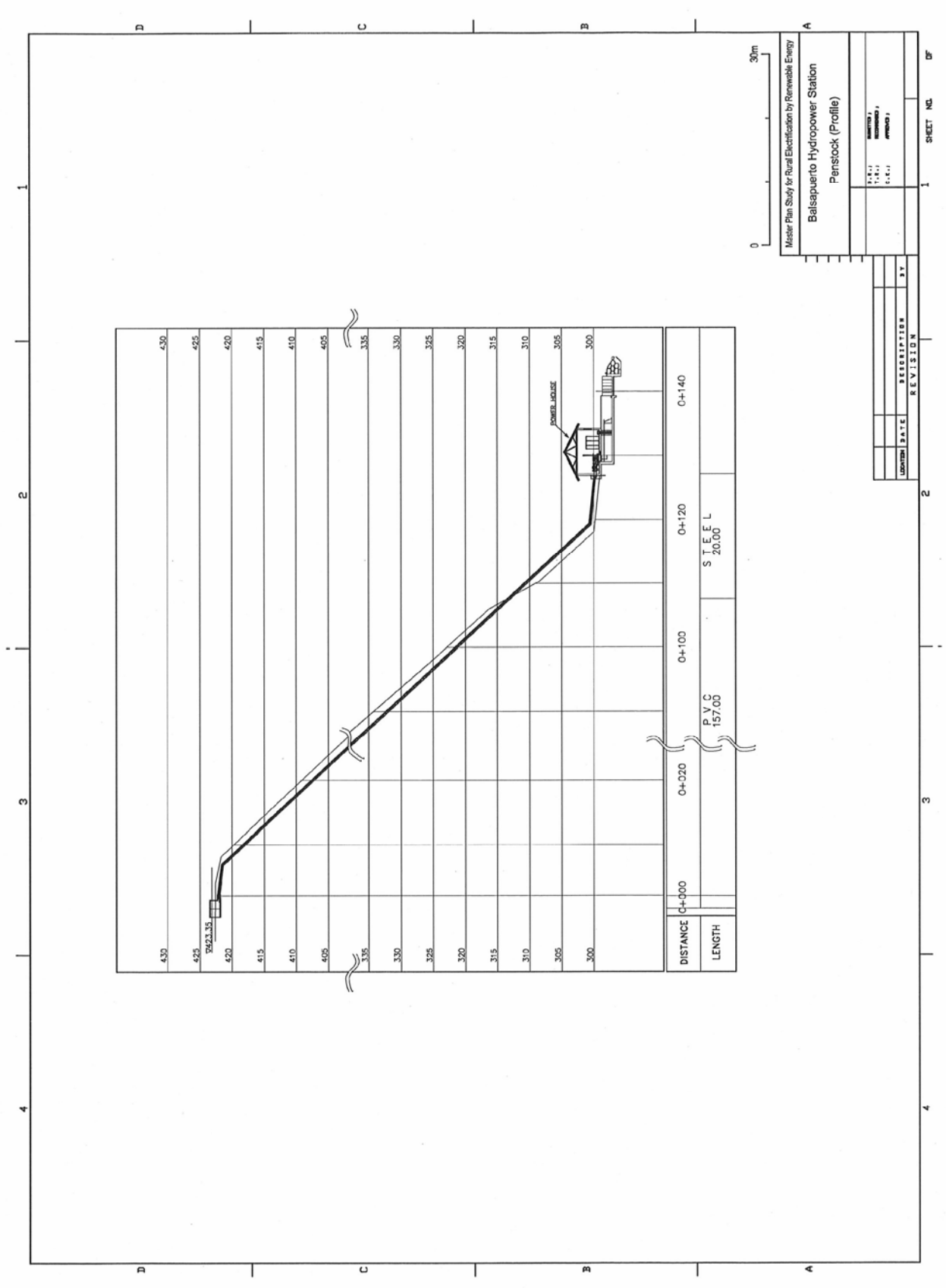


Fig. III-4.5.1-7 Rough Design Drawings of Penstock (Profile)

6. Electrical Design

(1) Choice of Hydro-Turbine Type

JICA study team decided the hydro-turbine type following the chart below and taking the net head and the waterfall volume into consideration.

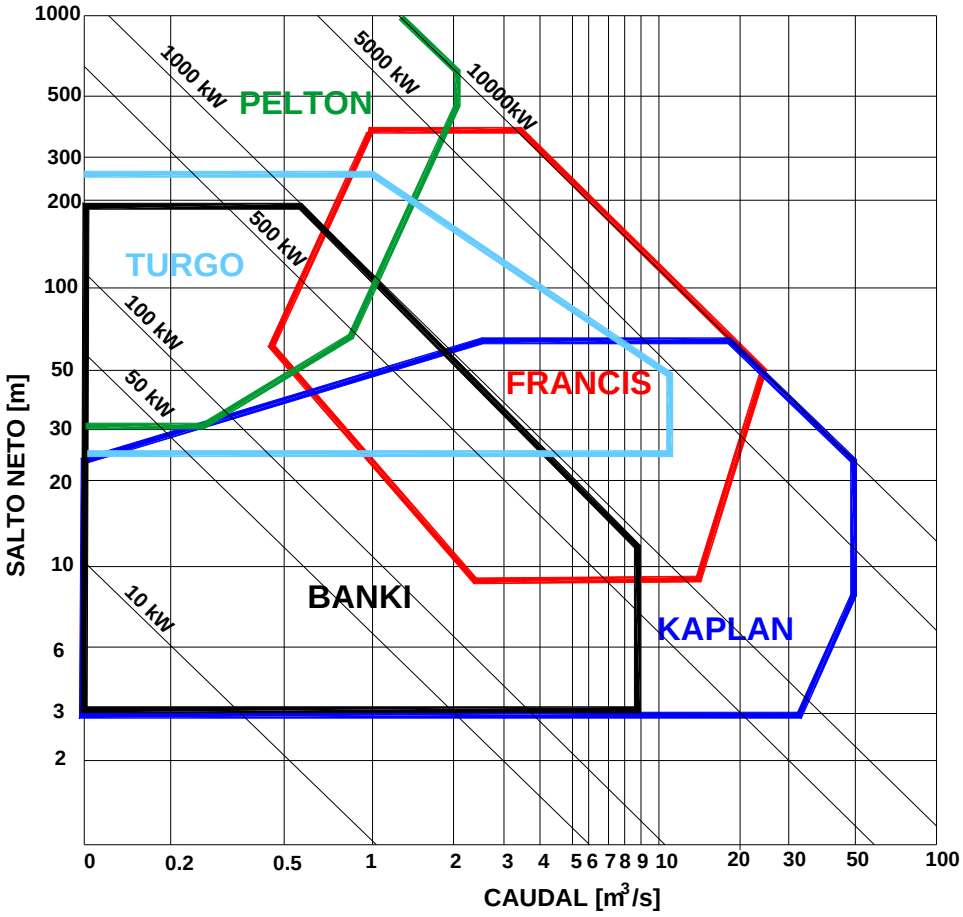


Fig. III-4.5.1-8 Hydro-turbine Type Selection Chart

<Balsapuerto>

- Judging from the net head of 121.7 (m) and the waterfall volume of 0.09 (m^3/S), BANKI, TURGO, and PELTON are applicable.
- Compared to TURGO and PELTON, BANKI type has a simple structure enough to make operation and maintenance easy, and has high efficiency to waterfall change.
- Therefore, BANKI type is preferable for this location.

(2) Transmission and Distribution

14 villages, or 534 households, are targeted in Balsapuerto.

Table III-4.5.1-16 List of Un-Electrified Villages

	LOCALIDAD	VIVIENDAS
1	BALSAPUERTO	140
2	CANOA PUERTO	66
3	NUEVA LUZ	26
4	PUERTO LIBRE	16
5	MONTE ALEGRE	19
6	NUEVA ESPERANZA	59
7	BUENOS AIRES	31
8	NUEVO JERUSALEN	10
9	SAN MARCOS	14
10	SANTA CLARA	26
11	NUEVO CACHIYACU	50
12	NUEVA REFORMA	19
13	SAN LORENZO	44
14	NUEVA ZARAMIRIZA	14
	Total	**534**

The distribution map and the total length of the distribution lines are separately shown below.

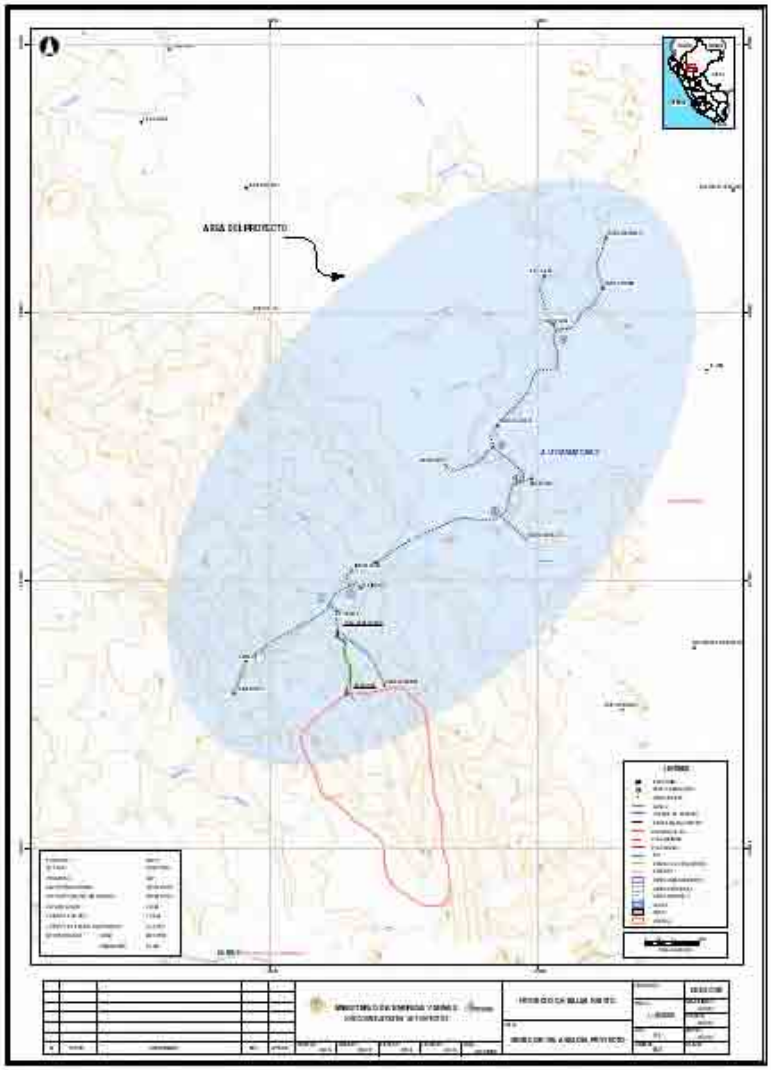


Fig. III-4.5.1-9 Distribution Map of Balsapuerto

Table III-4.5.1-17 Total Length of Distribution Lines (Phase I)

From	To	Length of Primary Lines
CASA DE MAQUINAS	SAN LORENZO	0.77
SAN LORENZO	Branch①	0.42
Branch①	NUEVA LUZ	3.74
NUEVA LUZ	CANOA PUERTO	1.30
	Sub Total	6.23
Branch①	Branch②	1.05
Branch②	MONTE ALEGRE	1.65
MONTE ALEGRE	Branch③	5.12
Branch③	Branch④	1.73
Branch④	BUENOS AIRES	0.29
Branch④	Branch⑤	1.79
Branch⑤	BALSAPUERTO	2.24
Branch⑤	NUEVO CACHIYACU	0.89
NUEVO CACHIYACU	Branch⑥	4.73
	Sub Total	19.49
	Total	25.72

Table III-4.5.1-18 Total Length of Distribution Lines (Phase II)

From	To	Length of Primary Lines
CASA DE MAQUINAS	NUEVA ZARAMIRIZA	2.92
	Sub Total	2.92
Branch②	SAN MARCOS	0.58
Branch③	NUEVO JERUSALEN	1.35
Branch⑥	PUERTO LIBRE	0.26
PUERTO LIBRE	SANTA CLARA	1.94
Branch⑥	NUEVA REFORMA	2.55
NUEVA REFORMA	NUEVA ESPERANZA	1.96
	Sub Total	8.64
	Total	11.56

III-4.5.2 Cost

1. Hydropower Station

The construction cost of this hydropower station was estimated based on the above study. The estimation method is based on a guide manual (Guide Manual for Development Aid Programs and Study, New Energy foundation 1996) which is generally used in Japan. The detailed contents are shown in Appendix.

Table III-4.5.2-1 Construction Cost for Balsapuerto (in the case of PVC)

I. Summary of Construction Cost for Balsapuerto Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**123,973**	
(1) Service Road	65,597	
(2) Facilities for Construction Office	4,199	Cost of Civil Works x 0.05
(3) Transportation cost	54,177	Tarapoto to the site, 410ton x $132/ton
2. Cost for Environmental Mesures	**839**	Cost of Civil Works x 0.01
3. Civil Works	**83,995**	
(1) Weir	3,248	
(2) Intake	4,919	
(3) Settling Basin	3,811	
(4) Headrace	28,563	
(5) Head Tank	9,109	
(6) Penstock & Spillway Channel	19,551	
(7) Power House	12,483	
(8) Outlet	2,311	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**150,000**	
(1) Gate & Screen	3,158	
(2) Penstock	1,751	
(3) PVC (φ630)	113,373	
(4) PVC (φ315)	6,816	
(5) Others	24,902	
5. Electrical Equipment	**33,000**	
6. Direct Cost	**391,807**	1.+2.+3.+4.+5.
7. Engineering Cost	**39,181**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**39,012**	6. x 0.100
9. IGV	**89,300**	19.00%
10. Total Cost	**559,300**	

In addition, the construction cost is shown in Table III-4.5.2-2 below in the case of open channel (simplified channel) for headrace. In this case, the construction cost can be reduced by 17% approximately compared with PVC for headrace.

Table III-4.5.2-2 Construction Cost for Balsapuerto (in the case of open channel)

I. Summary of Construction Cost for Balsapuerto Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**178,799**	
(1) Service Road	65,597	
(2) Facilities for Construction Office	5,028	Cost of Civil Works x 0.05
(3) Transportation cost	108,174	Tarapoto to the site, 410ton x $132/ton
2. Cost for Environmental Mesures	**1,005**	Cost of Civil Works x 0.01
3. Civil Works	**100,561**	
(1) Weir	3,248	
(2) Intake	4,919	
(3) Settling Basin	3,811	
(4) Headrace	45,129	
(5) Head Tank	9,109	
(6) Penstock & Spillway Channel	19,551	
(7) Power House	12,483	
(8) Outlet	2,311	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**14,000**	
(1) Gate & Screen	3,158	
(2) Penstock	1,751	
(3) PVC (φ630)	0	
(4) PVC (φ315)	6,816	
(5) Others	2,275	
5. Electrical Equipment	**33,000**	
6. Direct Cost	**327,365**	1.+2.+3.+4.+5.
7. Engineering Cost	**32,737**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**31,899**	6. x 0.097
9. IGV	**74,480**	19.00%
10. Total Cost	**466,480**	

2. Transmission and Distribution

JICA study team studied the construction cost of the distribution lines of this location, based on its unit price obtained from DPR.

Table III-4.5.2-3 Unit Price of Distribution Line Construction

	Cost
Linea Primaria	8,100 (US$/km)
Redes Primarias	140 (US$/User)
Redes Secundarias	260 (US$/User)

The construction costs in Phase I are as follows:

Linea Primaria : 8,100 (US$/km) × 25.72 (km) = 208,332 (US$)
Redes Primaria : 140 (US$/User) × 357 (User) = 49,980 (US$)
Redes Secundaria : 260 (US$/User) × 357 (User) = 92,820 (US$)

Then, the sub-total of Phase I is 351,132 (US$).

The construction costs in Phase II are as follows:

Linea Primaria : 8,100 (US$/km) × 11.56 (km) = 93,636 (US$)
Redes Primaria : 140 (US$/User) × 177 (User) = 24,780 (US$)
Redes Secundaria : 260 (US$/User) × 177 (User) = 46,020 (US$)

Then, the sub-total of Phase II is 164,436 (US$).

Consequently, the total amount of distribution line construction is 515,568 (US$).

III-4.6 Organization of Construction, Operation and Management and Cost

As the capacity is less than 100 kW, the construction will be done by the villagers. Supervised by the experts of university or NGOs, etc, the construction will be done with the initiative of villagers. Through this activity the villagers can also understand the basics of the system. However, if the capacity exceed 500 kW, it will be necessary to have contractors for construction, as the larger the scale the more difficulty arises.

Operation will be done by selected and trained villagers as a form of micro enterprise. The micro enterprise will be registered legally.

Those who assume the work of the enterprise will be publicly selected from villagers who are willing to undertake the business. As the revenue size of the enterprise is small, the operators of the enterprise will be in principle two; one commercial manager and one technical staff[5].

Before selection, around 10 candidates will be selected from the village who express interests in undertaking the operation and management, and all of them will be trained equally. By doing such, back up staff can be secured and if the final selected members will not continue, the remaining people can substitute.

[5] If the service coverage size or revenue is very small, it could be single operator assuming both commercial side and technical side.

The training will be held on site in principle. In the case of micro/mini hydropower, it is scheduled to have initial villagers sensitization, two times of civil work, equipment , and distribution line training each, and three times of management training. So, both technical and administration training will be held. After starting operation, within 6 months, it is scheduled to have back-stop training for those undertaking the business. In addition, in order to secure sustainability it should have at least three times of monitoring (acompaniamiento) by the trainers after operation.

In order to secure corporate governance, the enterprise must record accounts with revenues and expenditures. A user organization (junta de usuarios) will be created and the enterprise shall be responsible for periodical reporting of their operation to the user organization. With this, the enterprise will be defined as open enterprise to users and at the same time, the users will be able to monitor each other, as the enterprise can only be sustained with users' equal participation and assuming responsibility.

Micro enterprise will make a contract with ownership holder (propietario) in order to undertake the public service. It is a kind of concession contract (sesion en uso). In addition, the enterprise will make contracts with users in order to provide service. By binding contracts, the rights and obligations of the enterprise will be secured together with those of users.

The costs needed are shown below. The costs necessary for power generation including spare parts are excluded

Initial investment	:	US$	500
Project assistance and monitoring	:	US$	30,000
Annual operation and management	:	N Soles	1,000

III-4.7 Economic and Social Evaluation

III-4.7.1 Evaluation Method

In this Master Plan study, the analysis method established by SNIP will be applied on the condition that public finance will be used to implement the projects.

In the methodology of SNIP, a financial analysis comparing the costs and benefits using the market price is called economic analysis (Análisis Económico), while an economic analysis comparing them using the economic price is called social analysis (Análisis Social). In order to have consistency with the Peruvian system, the SNIP terms will be used in this report.

The basic flow of the analysis is as follows:

1. Economic Analysis

In Economic Analysis, the expected amount of net benefit will be calculated with the estimates of costs and benefits, using the market price.

- Estimation of costs at market price
- Preparation of a cash flow for capital investment
- Preparation of a cash flow for O&M cost
- Calculation of incremental costs in comparison with "without project"
- Estimation of benefits at market price
- Calculation of incremental benefits in comparison with "without project".
- Calculation of net benefit (Net Present Value)

2. Social Analysis

In Social Analysis, the expected amount of net benefit will be calculated with the estimates of costs and benefits, using the social price which excludes the distorted factors due to economic policy such as taxes and subsidies.

- Estimation of costs at social price
- Preparation of a cash flow for capital investment
- Preparation of a cash flow for O&M cost
- Calculation of incremental costs in comparison with "without project"
- Estimation of benefits at social price
- Calculation of incremental benefits in comparison with "without project"
- Calculation of net benefit (Social Net Present Value)

3. Sensitivity Analysis

Sensitivity analysis tests the impact on the project in the case of varying important input items such as investment amount, electricity tariff, benefit, etc.

III-4.7.2 Assumptions

The following assumptions are used for evaluating the projects:

1. Discount Rate

- Economic analysis 12%
- Social analysis 11%

2. Conversion Factor

Market price is considered to be distorted due to several economic policies such as taxes or tariff duty. In order to obtain real price, i.e. social price, conversion factors are used.

- domestic goods 1.00
- imported goods 0.90
- skilled labors 0.87
- unskilled labors 0.49 (Selva)

- transportation 1.00
- engineering cost 1.00
- IGV 0.00

3. Service Life

The service life of each facility shall be as follows:

Item	Period (years)
Civil works	40
Electromechanical equipment, transmission lines	20
Diesel Generator	10

4. Evaluation Period

The evaluation period for the project shall be 20 years.

5. Alternative Project

Alternative projects to supply electricity to Balsapuerto are as follows:

Item	Contents
Alternative 1	Electrification with micro hydropower
Alternative 2	Electrification with diesel generator

III-4.7.3 Project cost and Benefit of Alternative 1 (Micro Hydropower Project)

1. Construction Cost

The construction cost of the project, using open channel, is estimated as follows:

Table III-4.7.3-1 Initial Investment

(US$)

Item	Amount	Remarks
1. Engineering	32,737	Study and supervision
Environment	1,005	
2. Construction		
1) Civil Works		
Materials	119,589	Domestic products
Transportation	108,174	Including items 2)
2) Electro mechanical equip.		
Materials	25,080	All imported
Installation	7,920	Skilled labor: 70%
Transportation	0	Estimated in civil works
3) Transmission and distribution lines		
Materials	189,865	
Installation	138,402	Skilled labor: 70%
Transportation	22,865	
4) Contingency	31,899	
IGV	128,371	
Total	**806,267**	

The breakdown of the transmission and distribution lines is as follows:

(US$)

Item	Total	Linea Primaria	Red Primaria	Red Secundaria
Materials	189,865	94,374	31,573	63,953
Installation	138,402	98,333	14,544	25,526
Transportation	22,865	15,625	3,898	3,342

2. O&M Cost

The annual technical operation and maintenance cost is calculated using the following percentage:

Item	Factor (%)	Remarks
Mini hydropower plant	1.5	
Transmission/distribution	2.0-2.5	1st year-20th year

3. Power Demand

As to the power demand, the following values in the Chapter III-4.5.1 were adopted. The number of connections other than household is calculated with the following assumption of the monthly energy volume per user.

	Total Demand (% of household demand)	Monthly kWh/month/user	Connection (1st to 20th year)
Household		15	290~385
Commercial	10	45	10~13
Small industry	10	150	3~4
Public light	5		
Other use	10	75	6~7
Reserve	15		

4. Benefit

(1) Economic Benefit

The economic benefit is electricity sale revenue. In order to avoid excessive estimation, the unit rate calculated from the electricity tariff (BTB5) dated February 1, 2008, Pliego Tarapoto-Moyobamba, by ElectroOriente, which serves Loreto.

Purpose	Power	Energy	Rate
Domestic	1.25	01851	0.110
Commercial	1.25	0.4936	0.079
Industrial	1.25	0.4936	0.206
Other use	1.25	0.4936	0.129
Public lighting		0.4481	0.184

(2) Social Benefit

The social benefit is taken from the date of "Beneficios Económicos de la Electricidad en Areas Rurales del Perú" (NRECA, 1999). 80% of the following values are adopted.

Area	Selva
Illumination	US$102.24/year × 0.8 = 81.79
Radio & TV set	US$ 57.96/year × 0.8 = 46.37
Refrigeration	US$138.84 × 0.8 = 111.07
Others	US$ 0.15109/kWh × 0.8 = 0.12087

III-4.7.4 Alternative 2 (Diesel Generation Project)

1. Initial Investment

(1) Diesel Generator

A diesel generator of 50 kW will be installed, and the cost is estimated below. The generator currently used in Balsapuerto is nearing to the service life, therefore, it will be replaced by a new one.

Item	Generator	Transportation (10%)
Price	US$16,355	US$1,636

(2) Transmission and Distribution Lines

The breakdown of the cost of transmission and distribution lines required for grid extension is as follows:

(US$)

Item	Total	Línea Primaria	Red Primaria	Red Secundaria
Materials	200,983	105,492	31,537	63,953
Installation	149,987	109,917	14,544	25,526
Transportation	24,706	17,466	3,898	3,342
IGV	71,378	44,246	9,496	17,636
Total	**447,053**	**277,121**	**59,476**	**110,456**

2. O&M Cost

The technical operation and maintenance cost is calculated using the percentage as follows:

Item	Annual Cost (US$)	Remarks
Fuel cost	26,719	Consumption rate: 12 kWh/galon; Annual consumption: 6,457 gallons; Unit cost: 12 Soles/gallon
Oil cost	54	Consumption rate: 1,500 kWh/galon; Annual consumption: 52 gallons; Unit cost: 3.03 Soles/gallon
O&M cost	3,271	US$16,355 × 20%
Operator cost	3,724	S/.450/month × 2 persons × 12 months/2.9
T&D	---	2.0~2.5%; 1st to 20th year

3. Energy Demand

The same demand volume was used as the Alternative 1.

4. Benefit

The same benefit was used as the Alternative 1.

III-4.7.5 Evaluation

It is found out that the larger benefit is expected with the electrification by the micro-hydropower project than the diesel generation. The former has a larger IRR, as compared to the criteria of 11% established by SNIP, therefore, it can be judged that the hydropower project should be implemented in Balsapuerto.

(US$)

	Alternative 1	Alternative 2
NPV (IRR)	–814,146 (n.a.)	–828,638 (n.a.)
SNPV (IRR)	7,931 (11.2%)	–64,055 (8.7%)

III-4.7.6 Sensitivity Analysis

As to the sensitivity analysis, the following items are tested to see the variation of net present value of the project.

Item	Contents
(1) Investment cost	10% increase, 10% decrease
(2) Revenue	10% increase, 10% decrease
(3) Social benefit	10% increase, 10% decrease

1. Investment Cost

(US$)

		Alternative 1	
		NPV	SNPV
	10%	–902,123	–57,643
Base Case	0%	–814,146	7,931
	–10%	–726,170	73,505

2. Electricity Sale Revenue

(US$)

		Alternative 1	
		NPV	**SNPV**
	10%	–807,277	7,931
Base Case	0%	–814,146	7,931
	–10%	–821,016	7,931

3. Social Benefit

(US$)

		Alternative 1	
		NPV	**SNPV**
	10%	–814,146	74,623
Base Case	0%	–814,146	7,931
	–10%	–814,146	–58,761

As a result of the sensitivity analysis, it has been revealed that the change in investment cost has a greater impact than in power sale revenue as to the NPV. On the other hand, impact by change in social benefit is greater than that in investment cost, but not so much different.

Table III-4.7-1 Incremental Costs to Each Alternative (Private Cost) - Alternative 1

R U B R O	P E R I O D O																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A) COSTO DE INVERSION																					
1. Intangibles																					
Engineering cost	32,737																				
Costo de medio ambiente	1,005																				
IGV [19%]	6,411																				
2. Construccion																					
1) Obras Civiles	271,038																				
- Suministro de Equipos, Materiales, etc.	119,589																				
Origen Nacional	119,589																				
Origen Importado	0																				
- Montaje	0																				
M.O. Calificado	0																				
M.O. No Calificado	0																				
- Transporte	108,174																				
- IGV [19%]	43,275																				
2) Obras Electromecanicas	39,270																				
- Suministro de Equipos, Materiales, etc.	25,080																				
Origen Nacional	0																				
Origen Importado	25,080																				
- Montaje Electromecanico	7,920																				
M.O. Calificado	5,544																				
M.O. No Calificado	2,376																				
- Transporte	0																				
- IGV [19%]	6,270																				
3) Instalacion de Lineas y Redes	417,847																				
- Suministro de Equipos, Materiales, etc.	189,865																				
Origen Nacional	70,311																				
Origen Importado	119,554																				
- Montaje Electromecanico	138,402																				
M.O. Calificado	96,882																				
M.O. No Calificado	41,521																				
- Transporte	22,865																				
- IGV [19%]	66,715																				
4) Imprevistos (con IGV)	37,959																				
5) Subtotal inversion	766,114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B) COSTOS DE OPERACION Y MANTENIMIENTO																					
Central hidroelectrica	0	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289
Lineas / Redes Distribucion	0	7,023	7,106	7,190	7,274	7,360	7,447	7,535	7,624	7,714	7,806	7,898	7,991	8,085	8,181	8,278	8,375	8,474	8,575	8,676	8,778
Operacion de servicios electricos	500	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345
C) TOTAL COSTOS CON PROYECTO	806,767	9,656	9,739	9,823	9,908	9,994	10,081	10,169	10,258	10,348	10,439	10,532	10,625	10,719	10,815	10,911	11,009	11,108	11,208	11,310	11,412
D) COSTOS DE OPERACION Y MANTENIMIENTO SIN PROYECTO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E) TOTAL COSTOS INCREMENTALES	806,767	9,656	9,739	9,823	9,908	9,994	10,081	10,169	10,258	10,348	10,439	10,532	10,625	10,719	10,815	10,911	11,009	11,108	11,208	11,310	11,412

Table III-4.7-2 Incremental Costs to Each Alternative (Social Price) - Alternative 1

R U B R O		P E R I O D O																				
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A) COSTO DE INVERSION																						
1. Intangibles																						
Engineering cost	1.00	32,737																				
Costo de medio ambiente	1.00	1,005																				
IGV [19%]	0.00	0																				
2. Construccion																						
1) Obras Civiles		227,763																				
- Suministro de Equipos, Materiales, etc.		119,589																				
Origen Nacional	1.00	119,589																				
Origen Importado	0.90	0																				
- Montaje Electromecanico		0																				
M.O. Calificado	0.87	0																				
M.O. No Calificado	0.41	0																				
- Transporte	1.00	108,174																				
- IGV [19%]	0.00	0																				
2) Obras Electromecanicas		28,369																				
- Suministro de Equipos, Materiales, etc.		22,572																				
Origen Nacional	1.00	0																				
Origen Importado	0.90	22,572																				
- Montaje Electromecanico		5,797																				
M.O. Calificado	0.87	4,823																				
M.O. No Calificado	0.41	974																				
- Transporte	1.00	0																				
- IGV [19%]	0.00	0																				
3) Instalacion de Lineas y Redes		302,085																				
- Suministro de Equipos, Materiales, etc.		177,909																				
Origen Nacional	1.00	70,311																				
Origen Importado	0.90	107,599																				
- Montaje Electromecanico		101,311																				
M.O. Calificado	0.87	84,287																				
M.O. No Calificado	0.41	17,023																				
- Transporte	1.00	22,865																				
- IGV [19%]	0.00	0																				
4) Imprevistos (sin IGV)	1.00	31,899																				
5) Subtotal inversion		590,116																				
B) COSTOS DE OPERACION Y MANTENIMIENTO																						
Cental hidroelectrica		0	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219
Lineas / Redes Distribucion		0	5,584	5,650	5,717	5,785	5,853	5,922	5,992	6,063	6,135	6,207	6,280	6,355	6,430	6,506	6,582	6,660	6,739	6,818	6,899	6,980
Operacion de servicios electricos	1.00	500	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345	345
C) TOTAL COSTOS CON PROYECTO		590,616	8,149	8,215	8,281	8,349	8,417	8,487	8,556	8,627	8,699	8,771	8,845	8,919	8,994	9,070	9,147	9,225	9,303	9,383	9,463	9,545
D) COSTOS DE OPERACION Y MANTENIMIENTO SIN PROYECTO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E) TOTAL COSTOS INCREMENTALES		590,616	8,149	8,215	8,281	8,349	8,417	8,487	8,556	8,627	8,699	8,771	8,845	8,919	8,994	9,070	9,147	9,225	9,303	9,383	9,463	9,545

Table III-4.7-3 Incremental Costs to Each Alternative (Private Price) - Alternative 2

RUBRO	PERIODO																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A) COSTO DE INVERSION																					
1. Intangibles																					
Engineering cost (17%)	79,639																				
2. Construccion																					
1) Planta Termica	21,409																				
- Grupo electrogeno	16,355										16,355										
- Transporte	1,636										1,636										
- IGV [19%]	3,418																				
2) Instalacion de Lineas y Redes	447,053																				
- Suministro de Equipos, Materiales, etc.	200,983																				
Origen Nacional	73,646																				
Origen Importado	127,337																				
- Montaje Electromecanico	149,987																				
M.O. Calificado	104,991																				
M.O. No Calificado	44,996																				
- Transporte	24,706																				
- IGV [19%]	71,378																				
3) Subtotal inversion	468,462	0	0	0	0	0	0	0	0	0	17,991	0	0	0	0	0	0	0	0	0	0
B) COSTOS DE OPERACION Y MANTENIMIENTO																					
Compra de Combustible y Lubricante	0	26,773	27,175	27,583	27,996	28,416	28,842	29,275	29,714	30,160	30,612	31,071	31,538	32,011	32,491	32,978	33,473	33,975	34,485	35,002	35,527
Planta termica	0	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995
Lineas / Redes Distribucion	0	8,941	9,047	9,154	9,262	9,371	9,482	9,594	9,707	9,822	9,938	10,055	10,174	10,294	10,416	10,539	10,663	10,789	10,917	11,046	11,176
C) TOTAL COSTOS CON PROYECTO	548,100	42,709	43,217	43,731	44,253	44,782	45,319	45,864	46,417	46,977	65,536	48,122	48,707	49,300	49,902	50,512	51,131	51,759	52,397	53,043	53,698
D) COSTOS DE OPERACION Y MANTENIMIENTO SIN PROYECTO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E) TOTAL COSTOS INCREMENTALES	548,100	42,709	43,217	43,731	44,253	44,782	45,319	45,864	46,417	46,977	65,536	48,122	48,707	49,300	49,902	50,512	51,131	51,759	52,397	53,043	53,698

Table III-4.7-4 Incremental Costs to Each Alternative (Social Price) - Alternative 2

RUBRO		PERIODO																				
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A) COSTO DE INVERSION																						
1. Intangibles																						
Engineering cost (17%) sin IGV	1.00	66,923																				
2. Construccion																						
1) Planta Termica		17,991																				
- Grupo electrogeno	1.00	16,355																				
- Transporte	1.00	1,636																				
- IGV [19%]	0.00	0																				
2) Instalacion de Lineas y Redes		335,479																				
- Suministro de Equipos, Materiales, etc.		200,983																				
Origen Nacional	1.00	73,646																				
Origen Importado	0.90	114,603																				
- Montaje Electromecanico		109,790																				
M.O. Calificado	0.87	91,342																				
M.O. No Calificado	0.41	18,448																				
- Transporte	1.00	24,706																				
- IGV [19%]	0.00	0																				
3) Subtotal inversion		353,469	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B) COSTOS DE OPERACION Y MANTENIMIENTO																						
Compra de Combustible (sin IGV)	0.84	0	22,499	22,836	23,179	23,526	23,879	24,237	24,601	24,970	25,344	25,725	26,110	26,502	26,900	27,303	27,713	28,128	28,550	28,979	29,413	29,854
Planta termica	1.00	0	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995	6,995
Lineas / Redes Distribucion		0	6,710	6,789	6,869	6,950	7,032	7,115	7,199	7,284	7,371	7,458	7,546	7,635	7,725	7,816	7,909	8,002	8,097	8,192	8,289	8,387
C) TOTAL COSTOS CON PROYECTO		420,392	36,203	36,620	37,043	37,472	37,907	38,348	38,795	39,250	39,710	40,177	40,651	41,132	41,620	42,115	42,617	43,126	43,642	44,166	44,697	45,237
D) COSTOS DE OPERACION Y MANTENIMIENTO SIN PROYECTO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E) TOTAL COSTOS INCREMENTALES		420,392	36,203	36,620	37,043	37,472	37,907	38,348	38,795	39,250	39,710	40,177	40,651	41,132	41,620	42,115	42,617	43,126	43,642	44,166	44,697	45,237

Table III-4.7-5 General Analysis of the Demand

a) Variables importantes		**Supuesto**	**Fuentes de Información**
Crecimiento anual de la población	:	**1.5%**	Mision
Porcentaje de abonados domésticos	:	**80%**	Inspecciones de campo.
Porcentaje de pérdidas de energía (en BT y MT)	:	**10%**	Osinerg
Factor de carga	:	**25%**	Mision

b) Proyección

	AÑOS																				
UNIDADES	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Número de hogares	357	362	368	373	379	385	390	396	402	408	414	421	427	433	440	446	453	460	467	474	481
Número de conexiones domesticas		290	294	299	303	308	312	317	322	327	331	336	341	347	352	357	362	368	373	379	385
Número de abonados comerciales		10	10	10	10	10	10	11	11	11	11	11	11	12	12	12	12	12	12	13	13
Número de abonados pequeñas industriales		3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
Número de abonados de otro uso		6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7
Consumo anual por abonado doméstico		180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
Consumo anual por abonados comerciales		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Consumo anual por ab. pequeñas industrias		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Consumo anual por ab. alumbrado publico		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Consumo anual por otro uso		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Consumo anual de abonados domésticos		52,179	52,962	53,756	54,563	55,381	56,212	57,055	57,911	58,779	59,661	60,556	61,464	62,386	63,322	64,272	65,236	66,215	67,208	68,216	69,239
Consumo anual de abonados comerciales		5,218	5,296	5,376	5,456	5,538	5,621	5,705	5,791	5,878	5,966	6,056	6,146	6,239	6,332	6,427	6,524	6,621	6,721	6,822	6,924
Consumo anual de peq. Industrial		5,218	5,296	5,376	5,456	5,538	5,621	5,705	5,791	5,878	5,966	6,056	6,146	6,239	6,332	6,427	6,524	6,621	6,721	6,822	6,924
Consumo anual de alumbrado público		2,609	2,648	2,688	2,728	2,769	2,811	2,853	2,896	2,939	2,983	3,028	3,073	3,119	3,166	3,214	3,262	3,311	3,360	3,411	3,462
Consumo anual de otro uso		5,218	5,296	5,376	5,456	5,538	5,621	5,705	5,791	5,878	5,966	6,056	6,146	6,239	6,332	6,427	6,524	6,621	6,721	6,822	6,924
Consumo total (KWh)		70,442	71,498	72,571	73,659	74,764	75,886	77,024	78,179	79,352	80,542	81,751	82,977	84,222	85,485	86,767	88,069	89,390	90,730	92,091	93,473
Pérdidas de energía (MT y BT)		7,044	7,150	7,257	7,366	7,476	7,589	7,702	7,818	7,935	8,054	8,175	8,298	8,422	8,548	8,677	8,807	8,939	9,073	9,209	9,347
Energía al ingreso del sistema (KWh)		77,486	78,648	79,828	81,025	82,241	83,474	84,727	85,997	87,287	88,597	89,926	91,275	92,644	94,033	95,444	96,875	98,329	99,804	101,301	102,820
Factor de carga		25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Potencia al ingreso del sistema (KW)		**35.38**	**35.91**	**36.45**	**37.00**	**37.55**	**38.12**	**38.69**	**39.27**	**39.86**	**40.46**	**41.06**	**41.68**	**42.30**	**42.94**	**43.58**	**44.24**	**44.90**	**45.57**	**46.26**	**46.95**

Table III-4.7-6 Incremental Benefits to Each Alternative (Private Price) - Alternative 1

	PERIODO																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.- Situación con Proyecto / With Project																					
Venta de energía / Energy Sales																					
- domésticos / domestic		918	931	945	960	974	989	1,003	1,018	1,034	1,049	1,065	1,081	1,097	1,114	1,130	1,147	1,165	1,182	1,200	1,218
- comerciales / commercial		66	67	68	69	70	71	72	73	74	75	76	77	79	80	81	82	83	85	86	87
- pequeno Industrial / samll industry		172	174	177	179	182	185	188	190	193	196	199	202	205	208	211	215	218	221	224	228
- uso general / general use		107	109	110	112	114	115	117	119	120	122	124	126	128	130	132	134	136	138	140	142
- alumbrado público / public lighting		480	487	494	502	509	517	525	532	540	549	557	565	574	582	591	600	609	618	627	637
Subtotal ventas de energía / Subtotal enery sales		1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
2.- Situación sin Proyecto / Without Project																					
Beneficios sin proyecto / Benefit without project		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.- Beneficios Incrementales (1) - (2) / Incremental Benefit																					
Total ventas de energía / Total energy sales		1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311

Variables importantes:	PERIODO																				
(Important variables)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Tarifa de venta de energía / Energy sale tariff																					
- domestico / domestic	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
- comerciales / commercial	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
- industriales y otros / industry and others	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
- otros / others	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
- alumbrado / public lighting	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184
2. Período de depreciación (años) / Depreciation (year)																					
Obras Civiles / Civil Works	**40**																				
Electromecanico /Electromechanical	**20**																				
3. Tasa de impuesto a la renta (Income tax rate)	**30%**																				

Estado de pérdidas y ganancias:	PERIODO																				
Profit and Loss Statement	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Total ventas de energía / Total energy sales		1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
2. Compra de energía / Energy purchase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Otros costos de OyM / O&M cost		-9,656	-9,739	-9,823	-9,908	-9,994	-10,081	-10,169	-10,258	-10,348	-10,439	-10,532	-10,625	-10,719	-10,815	-10,911	-11,009	-11,108	-11,208	-11,310	-11,412
4. Depreciación Obras civiles / Civil works		-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990	-2,990
Electromecanico / Electromechanical		-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747	-10,747
5. Utilidad antes de impuestos / Profit before tax		-21,652	-21,709	-21,766	-21,824	-21,883	-21,942	-22,002	-22,062	-22,123	-22,185	-22,247	-22,310	-22,374	-22,438	-22,503	-22,569	-22,635	-22,702	-22,770	-22,838
6. Impuesto a la renta (solamente cuando hay incremento de utilidades) Income tax		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table III-4.7-7 Incremental Benefit to Each Alternative (Private Price) - Alternative 2

	PERIODO / PERIOD																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.- Situación con Proyecto / With Project																					
Venta de energía																					
- domésticos / domestic		918	931	945	960	974	989	1,003	1,018	1,034	1,049	1,065	1,081	1,097	1,114	1,130	1,147	1,165	1,182	1,200	1,218
- comerciales / commercial		66	67	68	69	70	71	72	73	74	75	76	77	79	80	81	82	83	85	86	87
- pequeno Industrial / small industry		172	174	177	179	182	185	188	190	193	196	199	202	205	208	211	215	218	221	224	228
- uso general / general use		107	109	110	112	114	115	117	119	120	122	124	126	128	130	132	134	136	138	140	142
- alumbrado público / public lighting		480	487	494	502	509	517	525	532	540	549	557	565	574	582	591	600	609	618	627	637
Subtotal ventas de energía		1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
(Subtotal energy sales)																					
2.- Situación sin Proyecto / Without Project																					
Beneficios sin proyecto / Benefit without project		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.- Beneficios Incrementales (1) - (2) / Incremental Benefit																					
Total ventas de energía		1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
(Toal energy sales)																					

Variables importantes:	PERIODO																				
(Important Variable)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Tarifa de venta de energía																					
- domestico / domestic	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
- comerciales / commercial	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
- industriales y otros / industry and others	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
- otros / others	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
- alumbrado / public lighting	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184
2. Período de depreciación (años) / Depreciation (years)																					
PSE / Small Electric System	**20**																				
Grupo / Diesel generator	**10**																				
3. Tasa de impuesto a la renta	**30%**																				
(Income tax rate)																					

Estado de pérdidas y ganancias:	PERIODO																				
Profit and Loss Statement	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Total ventas de energía / Total energy sales	0	1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
2. Compra de energía /Energy purchase	0	-26,773	-27,175	-27,583	-27,996	-28,416	-28,842	-29,275	-29,714	-30,160	-30,612	-31,071	-31,538	-32,011	-32,491	-32,978	-33,473	-33,975	-34,485	-35,002	-35,527
3. Otros costos de yM (O&M cost)	0	-8,941	-9,047	-9,154	-9,262	-9,371	-9,482	-9,594	-9,707	-9,822	-9,938	-10,055	-10,174	-10,294	-10,416	-10,539	-10,663	-10,789	-10,917	-11,046	-11,176
4. Depreciación / Depreciation	0	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685	-11,685
5. Utilidad antes de impuestos	0	-45,657	-46,138	-46,626	-47,121	-47,623	-48,133	-48,649	-49,173	-49,704	-50,243	-50,790	-51,345	-51,907	-52,478	-53,056	-53,643	-54,239	-54,843	-55,455	-56,077
(Income before tax)																					
6. Impuesto a la renta (solamente cuando hay incremento de utilidades) Income tax		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table III-4.7-8 Incremental Benefit to Each Alternative (Social Price) - Alternative 1 and 2

	PERIODO / PERIOD																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.- Situación con Proyecto / With Project																					
Beneficio económico iluminación (Economic benefit of illumination)		25,673	26,029	26,390	26,756	27,128	27,506	27,971	28,359	28,754	29,155	29,643	30,056	30,557	31,064	31,495	31,933	32,378	32,829	33,369	33,834
Voluntad de pago por radio y televisión (Willingness to pay of radio and television)		14,554	14,756	14,960	15,168	15,379	15,593	15,857	16,077	16,301	16,528	16,805	17,039	17,323	17,610	17,855	18,103	18,355	18,611	18,917	19,181
Voluntad de pago por refrigeración (Willingness to pay of refrigieration)		34,864	35,347	35,837	36,334	36,840	37,352	37,983	38,512	39,048	39,592	40,255	40,815	41,495	42,184	42,770	43,365	43,969	44,582	45,315	45,946
Beneficio económico otros usos (Economic benefit of other uses)		1,261	1,280	1,300	1,319	1,339	1,359	1,379	1,400	1,421	1,442	1,464	1,486	1,508	1,531	1,554	1,577	1,601	1,625	1,649	1,674
Sub total beneficios económicos (Subtotal economic benefit)		76,352	77,412	78,487	79,578	80,685	81,810	83,190	84,348	85,523	86,717	88,167	89,396	90,883	92,389	93,674	94,979	96,303	97,647	99,250	100,635
2.- Situación sin Proyecto / Without Project																					
Beneficio económico sin proyecto (Economic benefit w ithout project)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.- Beneficios Incrementales (1) - (2) / Incremental Benefit																					
Beneficios económicos incrementales (Incremental economic benefit)		76,352	77,412	78,487	79,578	80,685	81,810	83,190	84,348	85,523	86,717	88,167	89,396	90,883	92,389	93,674	94,979	96,303	97,647	99,250	100,635

Table III-4.7-9 Actual Value of Benefits to Each Alternative (Private Price)

	PERIODO / PERIOD																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.- Beneficios Incrementales - Privados / Incremental Benefit - Private																					
ALTERNATIVA 1	0	1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
ALTERNATIVA 2	0	1,742	1,768	1,794	1,821	1,849	1,876	1,904	1,933	1,962	1,991	2,021	2,052	2,082	2,114	2,145	2,178	2,210	2,243	2,277	2,311
2.- Costos Incrementales - Privados / Incremental Cost - Private																					
ALTERNATIVA 1	806,767	9,656	9,739	9,823	9,908	9,994	10,081	10,169	10,258	10,348	10,439	10,532	10,625	10,719	10,815	10,911	11,009	11,108	11,208	11,310	11,412
ALTERNATIVA 2	548,100	42,709	43,217	43,731	44,253	44,782	45,319	45,864	46,417	46,977	65,536	48,122	48,707	49,300	49,902	50,512	51,131	51,759	52,397	53,043	53,698
3.- Beneficios Netos Totales - Privados / Total Net Benefit - Private																					
ALTERNATIVA 1	-806,767	-7,915	-7,972	-8,029	-8,087	-8,146	-8,205	-8,265	-8,325	-8,386	-8,448	-8,510	-8,573	-8,637	-8,701	-8,766	-8,832	-8,898	-8,965	-9,033	-9,101
ALTERNATIVA 2	-548,100	-40,968	-41,449	-41,937	-42,432	-42,934	-43,443	-43,960	-44,484	-45,015	-63,544	-46,101	-46,655	-47,218	-47,788	-48,367	-48,954	-49,549	-50,153	-50,766	-51,387

	NPV	IRR
ALTERNATIVAS	**VAN (12%)**	**TIR**
ALTERNATIVA 1 (CH)	-868,570	#DIV/0!
ALTERNATIVA 2 (CT)	-883,062	#DIV/0!

Table III-4.7-10 Actual Value of Benefits to Each Alternative (Social Price)

	PERIODO / PERIOD																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.- Beneficios Incrementales / Incremental Benefit																					
ALTERNATIVA 1	0	76,352	77,412	78,487	79,578	80,685	81,810	83,190	84,348	85,523	86,717	88,167	89,396	90,883	92,389	93,674	94,979	96,303	97,647	99,250	100,635
ALTERNATIVA 2	0	76,352	77,412	78,487	79,578	80,685	81,810	83,190	84,348	85,523	86,717	88,167	89,396	90,883	92,389	93,674	94,979	96,303	97,647	99,250	100,635
2.- Costos Incrementales / Incremental Cost																					
ALTERNATIVA 1	590,616	8,149	8,215	8,281	8,349	8,417	8,487	8,556	8,627	8,699	8,771	8,845	8,919	8,994	9,070	9,147	9,225	9,303	9,383	9,463	9,545
ALTERNATIVA 2	420,392	36,203	36,620	37,043	37,472	37,907	38,348	38,795	39,250	39,710	40,177	40,651	41,132	41,620	42,115	42,617	43,126	43,642	44,166	44,697	45,237
3.- Beneficios Netos Totales / Total Net Benefit																					
ALTERNATIVA 1	-590,616	68,204	69,197	70,205	71,229	72,268	73,323	74,633	75,721	76,825	77,945	79,322	80,477	81,889	83,319	84,527	85,754	87,000	88,264	89,787	91,090
ALTERNATIVA 2	-420,392	40,149	40,792	41,444	42,106	42,779	43,462	44,394	45,098	45,813	46,539	47,516	48,264	49,263	50,274	51,057	51,853	52,661	53,481	54,553	55,398

	NPV	IRR
ALTERNATIVAS	**VAN (11%)**	**TIR**
ALTERNATIVA 1 (CH)	7,931	11.2%
ALTERNATIVA 2 (CT)	-64,055	8.7%

III-4.8 Electricity Tariff Setting and Fund Mechanism

1. Electricity Tariff Setting

There are two types of electricity tariff system: one is the metered rate system; the other is the flat-rate system. In the former case, the following actions are made: installation of electricity meter, periodical meter inspection, submission of electricity bill, according to the energy consumption. For these activities, a person in charge of inspection and tariff calculation is required. Thus, it would be a time-consuming and less-effective job especially in a low population area. On the other hand, the flat-rate system does not involve such fiddly procedure, and an electricity bill with a constant price will be issued to the consumers. This would save much cost in paperwork.

Item	Advantage	Disadvantage
Metered rate system	Fair in cost sharing	Fiddly for meter inspection
Flat-rate system	No need for meter inspection	Unfair to the small consumer

In this project, it is expected to establish a local micro-enterprise, which will be the service provider of electricity, as a part of bottom up approach. Therefore, it can be considered that a pursuit of business efficiency would contribute equally to all the consumers concerned. From this viewpoint, the flat-rate system is adopted in this study.

<Items for Examination and Conditions>

In order to examine the level of electricity tariff, the following items will be referred. Basically, the tariff should cover the operation and maintenance cost from a viewpoint of sustainability. It also should be set at an affordable level to the most of the local people. In the case that the tariff rate thus calculated is expensive in comparison with the level of current tariff rate level, application of a certain subsidiary system should be considered.

(1) O&M cost
(2) Current level of electricity tariff
(3) Willingness to pay
(4) Connection rate

Each item is examined as follows:

(1) O&M Cost

As with the past examples in rural electrification projects in Peru, it is expected that the initial investment cost will be completely subsidized. Therefore, a calculation will be made to figure out a tariff rate to cover the operation and maintenance cost required for project operation. The operation and maintenance cost will consist of the following: (1) O&M cost for power plant, (2) O&M cost for transmission/distribution lines, and (3) operation cost of the micro-enterprise for electricity service

Item	Amount/month (US$)	Remarks
(1) O&M cost of power plant	191	1.5% of investment cost
(2) O&M cost of T/D lines	585	2.0% of investment cost
(3) Operation of micro-enterprise	29	S/.1,000 / year
Total	**805**	

(2) Current Level of Electricity Tariff

The unit rate calculated from the electricity tariff (BTB5) dated February 1, 2008, Pliego Tarapoto-Moyobamba, by ElectroOriente, which serves Loreto, is adopted.

With the estimated monthly consumption at Balsapuerto being 15 kWh/month (for a household), a monthly rate is calculated as follows:

Fixed charge : 2.19 Soles
Energy charge : 6.756 Soles = 0.4504 × 15 kWh

Total : 8.946 Soles (with IGV: 10.646 Soles)
(With FOSE, S/.5.568 and S/.6.630 respectively)

(3) Willingness to Pay

A willingness to pay mentioned here refers to the value of the current energy expenditure, obtained by an inquiry conducted for local people as a part of social study. It is not the value obtained as "willingness to pay" in the inquiries.

Table III-4.8-1 Willingness to Pay: Balsapuerto

	(Nuevos Soles)
Max	80.0
Min	10.0
Average	29.3
Median	23.0

(4) Connection Rate

This project contemplates to serve 80% of the households in the target area. Therefore, it is desirable to set a tariff also affordable to more than 80% of the households. In order to achieve this level, it would require introduction of a certain system of subsidiary.

<Result of Examination>

A tentative calculation of average electricity tariff required to recover the cost for electricity service, with a condition that the micro-enterprise does not earn any profit.

As a result, the level of electricity tariff was calculated as follows:

No subsidy to initial investment	34.10 Soles
100% subsidy to initial investment	6.77 Soles

A tariff to cover the operation and maintenance cost for this project is calculated as 6.47 Soles/month. There is no much difference with the current electricity tariff in the neighboring area.

Under the condition that the initial investment is totally subsidized, the subsidy level to recover the O&M cost was calculated in the following cases:

1) Median value : 23.00 Soles
2) 80% of the willingness to pay : 15.00 Soles
3) Grid tariff (with FOSE) : 6.63 Soles

(unit: Nuevos Soles)

Unit rate/month	Subsidy amount	Annual amount	Remarks
23.00	0.00	0	WtP Medium
15.00	0.00	0	WtP Coverage 80%
6.77	0.00	0	Base rate
6.63	0.14	487	0.14 × 290 HH × 12

2. Fund Procurement

(1) Construction Cost

The initial investment cost required for the project shall be procured from the SPERAR Fund, as well as the fund of the local government (e.g. CANON).

(2) Training Cost

The cost required for providing training for project management shall be procured form the SPERAR fund.

(3) Operation and Maintenance Cost

The operation and maintenance cost shall basically be borne by the consumer as an electricity tariff. The operation cost of a micro-enterprise to be established by local people shall also be covered with this fund.

(4) Subsidy

Subsidy is indispensable in order to secure stably a certain level of revenue. At least, it is desirable to set the electricity tariff at a similar level with the neighboring area electrified with a grid. For this purpose, it is important for a micro-enterprise to register as an electricity serving company in MEM, and apply to OSINERGMIN for a provision of cross subsidy based on FOSE.

III-4.9 Social and Environmental Consideration

The following table shows the result of evaluation and measures to the environmental factors that are supposed to give impact on natural and social environment in Balsapuerto.

Table III-4.9-1 Result of Environmental Survey and Measures

Items	Rating	Result of the survey	Measures
Misdistribution of benefit and damage	C	People with lower income in the community will not be able to use the electrical service after the electrical system is introduced. It is anticipated that misdistribution of benefit will be occur among inhabitants.	The master plan proposes that MEM/DPR should establish the financial supporting system in order that the poor people can use electricity.
Local conflicts of interest			
The poor, indigenous and ethnic people	C	- Inhabitants in Balsapuerto area are the ethnic minority Chahui. Their educational level and degree of social development is almost lowest in Peru. Thus, it is anticipated that outsiders like local government will take the initiative and inhabitant's intension may not reflected in the detailed planning and operation. - Almost 100 % of inhabitants in Balsapuerto are the Chahui. It is supposed that the project implementation will not cause benefit disparity by ethnic groups.	It is necessary to explain the project to the inhabitants at the beginning of the project so that they clearly understand it. At the meeting, communication and teaching materials need to be in Chahui language. Inhabitant's own problem analysis and planning by participatory approach is effective.
Gender	C	As women may be highly difficult to participate in the dissemination, training and management organization that the master plan proposes to give to inhabitants, it is anticipated that electrification fixes the inequity between both genders relating to social development.	The master plan proposes that the implementer should recommend and support inhabitants that women must be given dissemination and training as well as have possibility of candidate of the management organization. Participatory approach and continuous monitoring are effective.

Items	Rating	Result of the survey	Measures
Water pollution	D	Materials like concrete used for construction of hydropower plants contain chemical ingredients. If they are disposed in the river water, it may cause water pollution.	The implementer makes a construction plan that minimizes water pollution. At construction stage, the implementer should be obliged to supervise contractor's engineering work from environmental point of view.
Solid wastes	D	As there is no legal framework for control, it is anticipated that water pollution and dust pollution might occur during the construction.	Though the scale of construction is small, implementer must supervise construction contractor properly. And, as the need arises, MEM/DPR is recommended to give administrative directives to violators.
Flora, fauna and biodiversity	D	The area of the facilities construction is in the jungle of the foot of Andean mountains. It is not inside the protected area of INRENA and the area is very small, but it is supposed that the project will give impact to a certain extent on flora and fauna.	At the time of the study of pre feasibility level, it was impossible to see the place of facilities construction due to the collapse of road. The ecological survey of the site must be carried out at the project implementation. If specific varieties are discovered, implementer needs to discuss with INRENA.
Topography and geological features	D	According to the basic design, the project includes the construction of facilities for power generation (weir, intake, headrace 1.9 km, penstock 177 m, power house etc.). The planned construction site of the power house is located more than 6 km from the nearest community, among which 5 km is actually impassable due to the collapse of road. It is indispensable to repair and construct road for material transportation and operation in this section. However, this access road is planned as the same scale as those used in near communities. Thus, it is not anticipated that the road will give remarkable impact on topography.	Implementer should supervise the construction design and construction work properly for avoiding erosion and other damages.

Note: Evaluation classification
A: Serious impact is expected.
B: Impact is expected to a certain extent.
C: Not strong impact is expected but impact sometimes occurs.
D: Low level impact may happen. More minute investigation and evaluation are required at the FS.
Source: JICA study team, 2008